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Architecture, Engineering and Construction

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AEC Design Guidelines

Design Guidelines

Introduction to the U of M Design Guidelines

This web site contains Design Guidelines for the design and construction of facilities at the University of Michigan. The Design Guidelines that are in effect at the time that schematic design begins for a given project shall be used by all design professionals (architects, engineers, interior designers) in the preparation of construction documents for the project. The purpose of the Design Guidelines is to assure maximum quality and value in construction projects at the University of Michigan, through uniformity, system or component quality, compatibility, sustainability, functionality, and ease of maintenance. These Design Guidelines are intended to provide general direction to design professionals as a general rule for most circumstances. With the wide variety of facilities, varying life expectancies and program requirements, these Guidelines have to be specifically and correctly applied to each project by the design professional. These Design Guidelines do not replace professional design analyses. We expect the design professional to conduct independent evaluations for each project. Applications of proven technologies and systems to provide cost effective alternate design concepts are encouraged. We recognize that there will be times when deviations from these Design Guidelines may be appropriate on some projects, and in those instances, the design professional is expected to proactively and in writing, approach the University design manager for written approval to deviate from the Guidelines.

Suggestions for improving these Design Guidelines should be addressed to UMDesignGuide@umich.edu in the Architecture, Engineering and Construction Department. Revisions will be issued on a periodic, as-needed basis.

These Design Guidelines are ***only*** for use by consultants and contractors in connection with work performed for the University of Michigan. They are to be used as a guide in the preparation of design documents for University of Michigan construction projects. They are not intended to relieve the designers and contractors from their responsibility to comply with applicable codes and other contract obligations.

Design Guidelines

Sustainability for Design and Construction provides criteria for sustainable design and LEED® requirements.

The AEC Sustainability Master Plan is a comprehensive document which communicates the methodology Architecture Engineering and Construction is employing to improve building design and construction sustainability at the University of Michigan.

Special Instructions to Designers contains instructions on a wide variety of general, cross-discipline topics, including codes to be followed, and building commissioning.

Codes and Regulatory Agencies is an annotated list of all applicable building codes and standards for the University of Michigan.

Special Building Areas contains design criteria and design approach specific to certain building or room types.

Technical Sections (CSI Divisions 1 through 16) contains system specific design criteria and design approach. Sections are divided by CSI specification section number.

Preferred List of Manufacturers contains specific manufacturers that are acceptable for use on U of M projects This section is also divided by CSI number.

Office Space Guidelines enable General Fund administrative and academic units to decide more effectively how to assign and use office space when planning renovations and new construction or responding to pressing space needs. The guidelines provide space-per-person recommendations by position type, which are based on recent construction projects at the University and guidelines used by other universities and in the private sector.

UM Hospitals and Health Centers Facilities Planning and Development web page contains design guidelines that are specific to University of Michigan Hospitals and Health Centers projects.

Design Deliverables contains a matrix describing information required from contracted designers at each phase in the design process.

Effective Date - Compiled Design Guidelines by Month and Year.

Last modified: Tuesday September 14 2010

For technical inquires, comments and suggestions on the U of M Design Guidelines, please e-mail the U of M Design Guidelines Group at UMDesignGuide@umich.edu.

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Sustainability for Design and Construction

Approach to Energy Conservation and Sustainability for Design and Construction

The University of Michigan has a long history of environmental stewardship in its approach to facility design and construction. With the significant growth taking place on the Ann Arbor campus – 9 percent population increase and an 11 percent increase in building area since 2003 – incorporating energy reduction in building design is one of the most effective ways for U-M to reduce its carbon footprint. This practice not only minimizes total energy resource use, but helps moderate future energy costs and reduces carbon dioxide emissions.

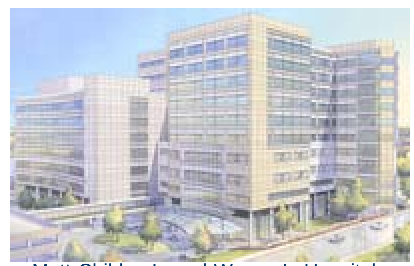
To support the implementation of sustainable design concepts for new construction, U-M has adopted Leadership in Energy and Environmental Design (LEED®) Silver certification as mandatory for all new non-clinical buildings and additions (new construction) with a construction budget of $10,000,000 or greater.

The State of Michigan currently requires new construction to meet the American Association of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standard 90.1 1999. U-M is committed to exceeding this standard on all new construction and renovation projects and recently adopted ASHRAE Standard 90.1-2007, which is more rigorous in its energy requirements. In addition, U-M has adopted the goal of exceeding ASHRAE 90.1-2007 energy code requirements by 30% for all projects with a construction budget of $10,000,000 or greater. U-M currently requires the incorporation of numerous mandatory energy conservation measures on projects, requires comprehensive

Life Sciences Institute:
2007 ASHRAE National Technology Award
Honorable Mention, New Institutional Buildings

2006 ASHRAE Region V Technology Award
First Place, New Institutional Buildings

2006 ASHRAE Detroit Chapter, Technology Award
First Place, New Institutional Buildings



Mott Children's and Women's Hospital:
Goal of LEED-NC Certification

North Quad Residential and Academic Complex:
ASHRAE +30%

Player Development Center for Intercollegiate Basketball:

evaluation of additional energy efficiency measures, and requires comprehensive modeling of energy usage for proposed projects and development of energy impact statements at each phase of design.

Currently, several sections of U-M's Design Guidelines for Design and Construction outline U-M's detailed requirements related to both energy efficiency as well as sustainable design and environmental stewardship:
[SID-D Energy and Water Conservation](#)
[SID-K Sustainable Design and LEED Requirements](#)
[SID-S Sustainable Products Portfolio](#)

AEC Sustainability Master Plan

Plan Overview

The [AEC Sustainability Master Plan](#) is a comprehensive document which communicates the methodology Architecture Engineering and Construction is employing to improve building design and construction sustainability at the University of Michigan.

The Master Plan divides sustainability into various categories, summarizing the tactics and policies that will be employed for each category.

The Plan is a living document, and will evolve as tasks are completed and policies are developed and refined. The category narrative defines the purpose of that category, describes in general terms the goals sought, and discusses the tasks necessary before the AEC Sustainability Team (or "Team") can recommend specific policies and targets for that category. As tasks are completed, policies and procedures will replace the tasks originally described in a category.

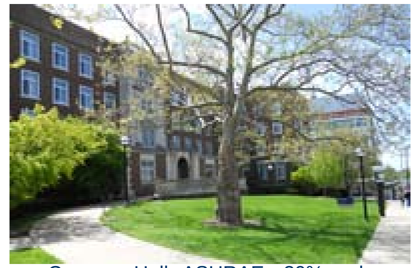
To share your ideas on AEC sustainable design and construction practices, please email the [Team](#).

Some Recent Projects and Sustainability

Numerous capital projects have focused on maximizing energy efficiency as well as

Goal of ASHRAE + 30%


Ross School of Business: LEED-NC Silver


Couzens Hall: ASHRAE +30% and Designed to Earn the ENERGY STAR® certification


Dana Building: LEED-NC Gold


Golf Practice Facility: Goal of ASHRAE +30%


Institute for Social Research Additon: Goal of ASHRAE +30% and LEED-NC Silver


Law School Academic Building: Goal of ASHRAE + 30% and LEED-NC Silver

incorporating other sustainability measures. To view the Project Profiles highlighting some of the specific measures incorporated in these recent projects click on the photos to the right.

In addition several major capital projects have pursued (or are currently pursuing) formal LEED certification.


Biomedical Science Research Building


Brehm Tower


Intercollegiate Soccer Stadium


Michigan Stadium Renovation and Addition


Palmer Drive Development


Towsley Center for Children

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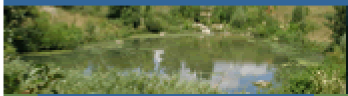

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AEC Sustainability Master Plan

Plan Table of Contents

Energy and Water Conservation describes the current approach used to achieve substantial improvements over and above what is required by current Energy Codes. Discusses planning to ensure the full implementation of ECM's and improving the usefulness of energy metering information obtained on U-M buildings.

New Sustainability Technologies explains the research which will allow us to broaden our sustainability efforts into new areas.

The Sustainable Products Portfolio includes our plan to provide a new resource for designers of U-M buildings. Anyone requesting that a product be added to or changed on the SPP must use the Request for Addition or Change to the SPP Listing form.

Site Sustainability involves a comprehensive look at what is being done to enhance site features and to provide a more sustainable site impact for our buildings.

Evaluating Sustainability Measures explains benchmarks where advantages can be calculated and where quality improvements are not measurable by hard data.

Design Guidelines housekeeping updates to our existing guidelines for ASHRAE 90.1-2007 and general updates as improvements are adopted.

Owner's Review verifies sustainability during the project design review process.

The AEC Sustainability Checklist assures that sustainable opportunities have been captured.

Commissioning describes moving from full to enhanced commissioning.

Construction Sustainability provides information on measures occurring during construction.

Post Occupancy Evaluation includes reassessment at one year's occupancy and beyond.

Getting The Word Out includes training, dissemination of the latest information and coordination with others.

Abbreviations and Acronyms

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Sustainability Master Plan

Energy and Water Conservation

The University of Michigan has a long history of implementing energy conservation measures in building designs. Currently, the University has adopted as code that all buildings be designed to comply with ASHRAE Standard 90.1-2007. The State of Michigan currently only requires that projects be built to comply with the ASHRAE 90.1-1999.

Further, all projects in excess of $10M construction cost must be designed to outperform ASHRAE 90.1 by reducing energy costs by 30% compared to projects designed to only comply with the standard's baseline requirements. This initiative is called ASHRAE +30. The methodology used to demonstrate designs achieve the 30% energy savings matches those recommended by ASHRAE and required by LEED®. Major projects that have already met this goal include North Quad, Law School Academic Building, and Couzens Hall.

AEC Design Guideline SID-D specifies global requirements for energy conservation for project designs (individual Design Guidelines often include more specific requirements). In addition to the requirements stated above, it dictates that certain *mandatory* ECMs be done on all projects, and that certain ECMs *be evaluated* for all projects. If an evaluated ECM meets the financial requirements indicated in SID-D, it must be employed on that project. SID-D also specifies certain mandatory water conservation features (e.g. dual flush toilets) and sets a required water conservation goal for projects. Detailed reports regarding ECMs and water conservation are required, as well as an Energy Impact Statement for large projects. SID-D is under continuous maintenance and will be updated as new versions of ASHRAE 90.1 are promulgated.

Examples of energy and water conservation measures incorporated into U-M projects include the following:

- The 235,000 square foot U-M Life Science Institute was the first known lab building design in the U.S. to use a “house air” system to reduce vivarium energy consumption by delivering outside air directly to ventilated animal racks. The same design was subsequently utilized in the university's 472,000 square foot Biomedical Science Research Building.
- New lab buildings at U-M routinely incorporate lab exhaust energy recovery systems.
- U-M's new North Quad Residential and Academic Complex utilizes dorm bathroom ventilation air-to-air heat recovery.
- Projects are required to utilize dual flush water closets, waterless or 1/8 gallon per flush urinals, and low flow lavatory faucets and shower heads, in new or renovated toilet rooms and bathrooms.
- Residential rooms in the new North Quad Residential and Academic Complex, as well as in the newly renovated Stockwell Hall, incorporate a user activated stand-by mode setting for the heating and cooling systems in each dorm room.
- Reduced lab air change rates have been incorporated into new lab construction. Lab air change rate minimums are typically 6 air changes per hour versus previous air change rate minimums of 10-12 per hour.
- Occupancy sensors are utilized in the new North Quad and Law School buildings as well as on other projects to not only turn lights off during unoccupied periods, but to set space ventilation rates to zero.
- Daylighting controls will be utilized in the new Law School Academic Building.
- Demand controlled ventilation is routinely used on U-M projects.
- U-M's GG Brown Addition will incorporate the extensive use of chilled beams in lab spaces.
- All large U-M projects incorporate thermal scanning of the building envelope to ensure insulation, sealant, and air barrier integrity.
- U-M requires that numerous energy efficiency measures be incorporated into lab designs when appropriate, such as variable air volume hoods, fume hood zone presence sensors, improved ventilation air flow efficiency, and manifolded exhaust systems.
- All projects are required to evaluate increased levels of envelope insulation and window performance that is above that required by code,

against financial criteria which takes into account the longevity of such improvements.
- Extensive centralization of chiller plants has increased energy efficiency by taking advantage of aggregated load diversification. This allows better matching of chiller efficiency to load. Plant centralization also provides a centralized free cooling source which individual buildings might otherwise not have available to them.

ECM Quality Control

It is imperative that ECMs accepted during the design phase of a project are verified as actually implemented by the construction phase of the project. While this might seem like common sense, normal construction QC and even Cx practices are typically not well structured to verify that ECMs were ultimately implemented during construction. For example, the normal construction QC process likely will not verify if the correct high performance glazing was installed in fenestration. DDC programming required for certain ECMs might not be implemented by the technicians doing the programming, and that lack of programming would typically be unnoticed by occupants as long as their space was comfortable. Further, it has been our experience that ECMs conceived by A/Es during early design phases are often inadvertently left out of the final design documents produced by that same A/E! The Team is convinced these problems are not unique to the University of Michigan. It is the intent of the Team to develop protocols to assure that every ECM identified for a particular project is verified as actually implemented by the time that project reaches Substantial Completion.

Submetering

As the old adage goes, if you can't measure it, you can't improve it. The University of Michigan has a long history of utilizing advanced Direct Digital Controls (DDC) to monitor mechanical and electrical systems on campus. The DDC system currently monitors in excess of 100,000 points, is staffed 24/7 by a Building Automation Services (BAS) staff, and has corrective action plans in place to address problems detected by the DDC system. For example, reliable electronic magnetic flow meters which utilize no moving parts are used on many heating and cooling systems to measure energy use and to recognize system problems which often result in wasted energy if undetected. Energy conservation organizations have long recognized that the metering of energy systems is a powerful tool for understanding where energy is being used and if it is being used efficiently. LEED® and ASHRAE's new Standard for the Design of High-Performance Green Buildings 189.1 both encourage the use of submetering for the same reason.

Even though significant submetering has been the norm on U-M projects for decades, a new initiative is being undertaken to review where additional metering is appropriate, to enhance our M&V efforts. This initiative will also require that designs specifically identify "out-limit" conditions for meters to assure appropriate actionable alarms are created in the DDC system. Results of this effort will be rolled into the U-M Design Guidelines so that design teams know exactly where additional submetering is required. Projects will be required to develop a project specific M&V plan (when appropriate) which will be integrated into the University's over-all M&V plan. Over time, this will result in an even more robust metering/monitoring system than the University already has, and result in improved energy efficiency. It will also allow better post construction evaluation of energy conservation measures and building energy use.

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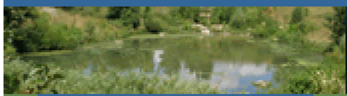

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Sustainability Master Plan

New Sustainability Technologies

The Team is researching additional energy and sustainability technologies and products for incorporation into the U-M Design Guidelines. The Team's research considers such criteria as embodied energy analyses, percentages of post-consumer and pre-consumer recycled content, use of renewable resources, on-going maintenance requirements, payback period, life-cycle assessment, regional availability, VOC levels, and warranty periods.

Research topics may be influenced by the types of construction projects for which a need has already been identified. For instance, U-M has been planning to build a new data center. The Team is already in the process of researching sustainable technologies which would be suitable for this application. Some of the identified technologies may also benefit existing data centers, and could be proposed for those facilities as well. Other research underway includes solar/photovoltaics, enthalpy wheels, advanced laboratory controls, air barriers and insulation, high-albedo and green roofs, high-efficiency fume hoods, construction QC for building envelopes, fenestrations, lighting controls, energy efficient plumbing fixtures, new light sources, exterior lighting, irrigation techniques, and low VOC materials.

Future technologies to be investigated include, but are not limited to, radiant heating and cooling, geothermal energy, under floor air displacement, LED and induction lighting, and highly energy efficient transformers and motors. The Team also plans to broaden its efforts by expanding the areas of research to include furniture and site materials, water- and energy-saving appliances, re-use of grey water, and integrated design.

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The Sustainable Products Portfolio

AEC is currently developing a Sustainable Products Portfolio (SPP). Examples of products that will be listed in the SPP are hard flooring and carpets, wall finishes, ceiling systems, wood products, plumbing products, and paints. The SPP will provide architects and engineers working on U-M projects with a menu of sustainable products that have been evaluated against U-M specific criteria.

AEC already utilizes a PML for projects as a basis of *manufacturer* selection for University projects. Criteria used for selection and evaluation for the PML include product quality and life span, value, vendor service, ease of maintenance, performance, and lead-times.

Starting with the criteria used for the PML, the Team will add sustainability screening criteria. Third party testing and standards (ANSI, BIFMA, ISO and NSF for example) will also be used as guides for identifying meaningful sustainable product criteria. More importantly, certain products will be identified for "real world" testing at the University of Michigan, and will only be added to the SPP if test results are deemed satisfactory.

The SPP will be a complementary resource to the PML for use by architects and engineers when specifying materials and products for U-M projects and will require ongoing maintenance and updates. However, rather than being manufacturer focused like the PML, it will be product focused, for example listing all floor products that U-M has determined meet U-M sustainability criteria. Although not all products included in the SPP will need to be incorporated into the PML, the criteria used by the portfolio will inform updates to the PML.

The SPP is a resource that project teams are encouraged to use to select sustainable products. The SPP is not an all inclusive list of available sustainable products and technologies. It is not intended to limit competition or replace creative sustainable design solutions. For additional information, please see SID-S Sustainable Products Portfolio.

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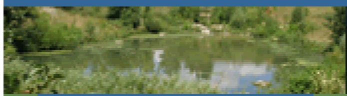

Sustainability Master Plan

Site Sustainability

Site Sustainability is a broad topic that addresses specific local and regional environmental issues related to buildings, landscape, hardscape, and exterior building and site issues. Sustainable site practices at U-M include eliminating mowing in perimeter areas, utilizing IPM techniques, removing invasive species from campus wood lots, employing alternative snow removal techniques, and administering a stormwater management and pollution prevention program. See the U-M OSEH website for additional information on the above sustainable site practices.

In an effort to enhance existing sustainable site practices, revisions to the existing design guidelines and development of a new site design guideline are underway. It will coordinate with existing regulations and recommend site specific strategies and BMPs. It will also include recommendations regarding limiting paving, utilizing porous paving materials, enhancing the existing storm water management program, and selecting sustainable site materials. Finally, additional guidelines for landscaping will be established which focus on drought tolerant vegetation, native and noninvasive species, and enhanced IPM techniques.

Other environmental impacts which have begun to be addressed by existing and proposed green building standards are noise pollution, air dispersion, light pollution, and heat island effect.

U-M’s practice is to consider both noise and air quality effects, especially for projects where large mechanical equipment is installed exterior to buildings (particularly laboratory exhaust fans and cooling towers). AEC has implemented a goal that new equipment will not produce a detectable difference in sound level, as perceived by the human ear, on surrounding U-M and private property. Further, sound pressure levels shall not exceed City Of Ann Arbor Noise Guidelines. Acoustical consultants are engaged to make recommendations regarding equipment placement, stack heights, enhancements to equipment and acoustical screening measures.

AEC routinely employs air dispersion studies for buildings with a sizable exhaust component, and those equipped with cooling towers, boilers, emergency generators, or other emission sources. These studies are utilized to ensure that emissions from buildings are properly dispersed and diluted to preserve a safe environment, prevent odors, and meet Federal and State requirements. Both analytical and wind tunnel modeling are employed. This work includes using strategies to reduce emissions at their source.

Outdoor lighting is addressed on a project-by-project basis as well as in the context of an overall campus lighting plan. All AEC projects are required to comply with exterior lighting requirements defined in Design Guidelines SID-D and 16521. U-M outdoor lighting is designed to produce light levels that enhance safety while minimizing over-lighting and glare, two major forms of light pollution. Addressing overall light pollution issues also necessitates that interior light fixtures, whose light output is visible outside the building, be selected to minimize light spillage in areas where it is not required by Code or needed for safety. A site lighting team led by AEC is currently researching appropriate methods for reducing light pollution, energy consumption, and maintenance costs. Once the outcome of these potential methods is established, the results will be incorporated into the appropriate Design Guidelines.

The Team also intends to investigate strategies for mitigating heat island effect, a condition which occurs when dark surfaces and large amounts of hard surfaces increase local temperatures. The temperature increase can in turn increase cooling loads and energy consumption. The Team's research will assess the technologies and products which make the most sense at U-M and where they should be employed for maximum effectiveness.

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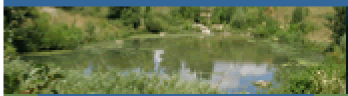

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Evaluating Sustainability Measures

Tangible Benefits

One of the prime responsibilities of U-M AEC is to be a good steward of the university's financial resources. All ECMs and many SMs related to building design can be evaluated against financial metrics appropriate to an organization. Financial metrics may not be the only criteria that should be evaluated, but when a decision can be weighed against a financial metric it is certainly proper and worthwhile to do so. Further, if an ECM or SM meets or exceeds the appropriate financial metric, the need for further justification generally stops.

The University of Michigan has developed financial metrics for ECMs; see Special Instructions to Designers SID-D. To avoid lengthy analysis during design, the financial metrics are based on simple payback criteria rather than Life Cycle Cost (LCC). These metrics work well for ECMs that have relatively short paybacks. The U-M recognizes that certain energy conservation measures, such as optimized building envelopes (extra thick insulation in walls, high performance windows, etc.) have paybacks in excess of our current financial metrics, but still bear consideration. Such ECMs have very long lives and a high level of "persistence", i.e. once the ECM is in place the energy savings are likely guaranteed for the life of the building with little or no maintenance required. For example, additional wall insulation is unlikely to wear out, requires no maintenance, and is not subject to being "undone" for some reason in the future. Therefore AEC is currently developing financial metrics that are appropriate for these types of ECMs. During this evaluation, simple payback, LCC, and other methods will be evaluated. The goal is to allow projects to rapidly evaluate multiple ECM opportunities.

The Team believes that an appropriately streamlined financial evaluation process encourages project teams to evaluate more ECMs specific to a particular project, which will propel projects toward achieving optimum energy efficiency levels. Similar financial metrics will be developed for SMs.

Intangible Benefits

Sustainable building standards such as LEED®, ASHRAE

189.1, and the IGCC are increasingly recognizing and incorporating intangible benefits related to sustainability. The majority of intangible benefits can be classified as improved indoor environmental quality, improved occupant controllability of systems, greater connectivity between indoor and outdoor environments, and increased availability of natural daylighting and ventilation. Intangible benefits also include the walkability of the project's surrounding environment, the initiation of sustainable education programs, and the incorporation of design aesthetics as well as views and visual relationship to the exterior environment.

Standard financial metrics cannot be applied directly to intangible benefits of sustainability. However, studies have connected improved indoor environmental quality benefits to personal health, worker productivity, and academic performance. In some cases, simple investments can be made during design and construction phases for a project to realize these benefits. At the same time, intangible benefits must be balanced against possible detrimental effects on other sustainable measures such as energy consumption. The Team is currently developing a methodology to allow the evaluation of intangible benefits in a systematic manner.

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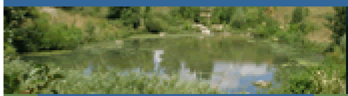

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Design Guidelines

Coordinate Compliance with the Energy Code

As noted in the Energy and Water Conservation section, U-M has recently adopted the latest version of ASHRAE 90.1 as its energy code. In order to realize the resulting energy savings from this code change as quickly as possible, the Team has given top priority to reviewing and updating all existing U-M DGs which are affected by ASHRAE 90.1. This activity is already underway.

SID-B Design Intent Document, SID-D Energy and Water Conservation and Technical Section 16500 Lighting Systems are in the process of being updated and should be ready for release by the third quarter of 2010. The remaining affected DGs will be revised by year end 2010.

Revisions for Sustainability

The Team is updating the DGs to incorporate additional sustainability requirements beyond their current content, while maintaining their original intent. Existing DGs that require immediate modification or do not presently require extensive research will take priority.

The Team has already implemented several changes to SID-D Energy and Water Conservation and SID-B Design Intent Document. The Team is reviewing and incorporating applicable energy and water conservation measures from ASHRAE 189.1-2009, IGCC, and other green building standards into the DGs. In addition, U-M has recently announced the adoption of LEED®-Silver certification requirements for all new construction projects and building additions in excess of $10M construction cost. Revisions to SID-K Sustainable Design and LEED Requirements have already been made, and the new policy has been incorporated into new projects entering the design development phase.

The following design guidelines are also under review: site work, roofing, doors and windows, fume hoods and lab ventilation. New design guidelines for air barriers and insulation, construction waste management, lighting controls, enthalpy wheels, and others are also under development; however, this list is not exhaustive.

As major updates and revisions are made by the Team to the Design Guidelines, additional training for AEC staff will be considered and scheduled as appropriate.

Please also see sections New Sustainability Technologies and The Sustainable Products Portfolio for additional information including the criteria utilized to help inform the Team's decisions for creating new DGs.

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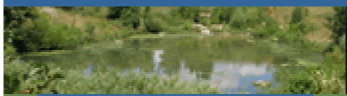

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Owner's Review

An Owner's Review is a comprehensive examination of a project's design documents by U-M stakeholders to evaluate if the design meets the Owner’s requirements. Quality design documents are vital for the sustainability of a building project. In recognition of this, AEC requires Architect/Engineers to submit their project design documents to U-M for an Owner's Review at the conclusion of the major phases of design (generally at the end of the SD, DD and CD phases).

AEC coordinates the Owner's Review by distributing the project's design documents to the Project Team and the Users for their review of the project's scope. The design documents are also distributed to other U-M departments as applicable for review of their areas of expertise. In addition, two construction experts within AEC perform plan reviews for issues including completeness, clarity and bid-ability of project scope, and constructability, maintainability and coordination between documents.

The Owner's review process is described in more detail in Design Guideline SID-L, Owner's Review. The Team will expand the process in SID-L to incorporate the review of additional sustainability issues including compliance with the energy and water conservation, and sustainability Design Guidelines, Master Specifications and the SPP.

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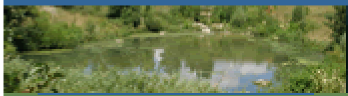

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AEC Sustainability Checklist

The Team will develop a sustainability checklist to ensure that sustainability opportunities are fully addressed during design and construction. The checklist will assist designers, Design Managers, and Project Managers. As the Sustainability Master Plan is further developed and design guidelines are updated and created, the Team will update the corresponding steps in the checklist.

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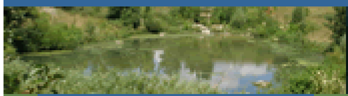

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Commissioning

Commissioning is a systematic quality assurance process to ensure a building project is designed to meet the needs of its Users, and is built, operated, and maintained as intended by its Project Team and its Users. U-M has long recognized the value of building commissioning. Thus a key component of AEC's sustainability plan is the requirement that all large or technically complex U-M building projects undergo a rigorous commissioning (Cx) process.

In a decade-long study sponsored by the U.S. Department of Energy (DOE) and published on July 21, 2009, Lawrence Berkeley National Laboratory analyzed the commissioning of 643 commercial building projects nation-wide. They concluded, "…commissioning is arguably the single-most cost-effective strategy for reducing energy, costs, and greenhouse gas emissions in buildings today." AEC agrees completely with the DOE. We believe building commissioning is vital to maximizing a building's performance and to minimizing its energy and water consumption.

U-M commissioned its first building in 1988 when the building commissioning process was still in its infancy. The results were so successful AEC established an independent building commissioning group in 1989. Our Cx process exceeds the commissioning industry's recommendations and standard practices. In general, new building and major building alteration projects undergo both design phase and construction phase commissioning. This process begins during the building's programming stage and continues through building occupancy.

Additionally, major U-M projects which are mechanically or electrically complex normally undergo an enhanced design phase commissioning process. Commissioning engineers conduct comprehensive meetings and coordinate detailed reviews throughout every step of design to assure mechanical and electrical systems are optimized in terms of energy and water efficiency, sustainability, reliability, and maintainability. AEC has recognized that enhanced design phase commissioning is necessary on complex projects to assure the Owner’s project requirements are completely captured and implemented, maximizing project sustainability in the fullest sense of the word.

The design-phase and enhanced design phase commissioning procedures have already been updated to facilitate compliance with the new requirements in SID-D and to emphasize incorporation of new sustainable technologies, methods, and products. Construction-phase commissioning procedures will be updated to address architectural issues such as the building envelope. The overall Cx process will be expanded to offer additional services including enhanced commissioning and post-occupancy commissioning.

LEED® 2009 EA Credit 3 promotes enhanced commissioning as a means of reducing the negative impact a building can have on the environment by verifying the completed project is being operated and maintained as intended. LEED enhanced commissioning consists of six activities performed by an independent Commissioning Agent: reviewing the project's design, comparing the design to the OPR and BOD, reviewing the contractor submittals, developing a systems manual, verifying that Owner training has been completed, and reviewing the building's operation with Operations and Maintenance personnel and with building occupants (CxA post occupancy review).

The U-M standard commissioning process already includes four of the six activities described by LEED as being part of enhanced commissioning. The Team will revise SID-G, the Commissioning and Plan Review Group Procedures, and the U-M Master Commissioning Specifications to add the two missing enhanced commissioning activities (systems manual and CxA post occupancy review) for projects that request LEED enhanced commissioning. The CxA will be required to develop a systems manual to provide Operations and Maintenance personnel with information they need to understand and optimally operate the building's systems and equipment. In addition, the CxA will be required to review the operation of the building with Operations and Maintenance personnel and with occupants, and develop a plan for resolving outstanding commissioning-related issues.

AEC's commissioning process is described in more detail in Design Guideline SID-G, Commissioning. In addition, U-M Master Specifications 01710 and 01715 document the Contractors' and Commissioning Agent's contractual requirements.

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Construction Sustainability

Construction sustainability encompasses practices and products affecting both indoor and outdoor environmental quality. Incorporating sustainability measures into construction management can significantly reduce a building's overall impact on the environment. Therefore, development of and updates to construction guidelines will focus on waste management, IAQ procedures, VOC reduction, and construction related energy conservation.

Construction waste management (CWM) is fundamental for sustainability because construction and demolition waste contributes as much as 40% to the solid waste stream. In recognition of the need to decrease construction waste, U-M has facilitated the development and implementation of CWM programs on several recent construction projects. In addition, an acoustical ceiling recycling program is being piloted, and its implementation will be extended to all projects if the pilot proves successful. In order to further improve construction and demolition waste practices, the Team plans to create a new guideline which will specify how construction materials and debris will be identified prior to construction start and how they will be recycled or reused once identified. Our intent is to cover the most commonly encountered materials on our construction projects. Also, a training plan for contractors will be developed to help ensure these strategies are realized.

Post-construction and pre-occupancy IAQ controls include equipment and material protection, duct protection, VOC containment, and use of filtration media. Good building IAQ starts with a proper architectural and HVAC design, and is assured by proper building maintenance. However, poor construction methods and materials can negate the intent of a good design and have a detrimental effect on post-occupancy IAQ. U-M has already instituted rigorous protection measures to assure that water, dust, and other construction debris are kept out of duct and air handling systems. Ducts are required to be stored above the floor in clean dry locations and to be continuously protected (covered) during construction. Partially installed duct must have open ends sealed when not actively being assembled. If the air handling system is used for temporary service during construction, duct openings and return grilles must be protected with filters of a quality equivalent to that used in the air handler pre-filter position (typically MERV 8 or higher), and air handlers must have a complete set of pre and final filters installed. During temporary operation, contractors must change filters at the manufacturer's recommended change-out pressure drops. Prior to final turn-over, all air handler filters must be replaced with new, clean filters. Typically, U-M's requirements exceed practices such as those recommended by LEED®.

To both protect construction workers and to ensure appropriate IAQ levels post-occupancy, the Team intends to establish guidelines for the use of low VOC products. Some of these products are incidental or used on a temporary basis, and might not be thoroughly covered in the specifications. For example, solvent based duct sealants may be appropriate for certain periods of construction and inappropriate for others. Therefore, scheduling exceptions will be considered.

Current U-M construction safety requirements include several strategies which relate closely to sustainability. Examples of these include environmental health and safety, housekeeping, and smoking policies. Please reference the Construction Safety Requirements for additional information.

Post construction practices such as building flush-out and/or air testing are recommended by some organizations such as USGBC®, to provide enhanced IAQ when the project space is first occupied. Air testing research is currently underway on a pilot U-M project to determine the advantages and disadvantages of this approach. The results of this pilot will be compared to building flush-out recommendations, and construction procedures and/or design guidelines will subsequently be developed.

AEC's contracts with Construction Managers and Contractors require that construction temporary lighting and non-essential temporary power be turned off during non-construction hours. Temporary lighting must be shielded to prevent trespass onto public right-of-way and private property, and it must be controlled by timers or scheduled manual switching to turn off the lighting when it is not required. Temporary power must be controlled by manual switching as well so electric heaters and similar tools are turned off when they are not needed. Essential tools such as pumps are allowed to remain on.

The Team intends to clarify and strengthen requirements related to the temporary heating of buildings under construction. After researching the relative merits of using existing heating infrastructure versus using portable heaters the Team will provide recommendations for future construction contracts.

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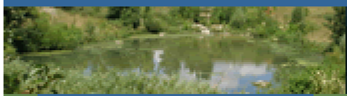

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Post Occupancy Evaluation

Sustainable Design Measures

The Team realizes that sustainability efforts should not end simultaneously with construction completion. Therefore, assumptions regarding sustainable design measures will be validated for “real world” installations to ensure that the results equal the intent. Evaluative criteria for post-occupancy measurement will be developed into a checklist which will cover the performance, functionality, productivity, user-friendliness, and maintenance requirements of the implemented materials and systems. The Team also intends to conduct performance reviews of furniture systems, lighting systems, materials and products, acoustics, thermal comfort, and indoor air quality during the project's corrective period in order to address any installation or warranty issues. Feedback and results of the post-occupancy evaluation will be used to edit the content of the SPP and DGs as needed.

Formulating a complete post occupancy evaluation plan will be a long term endeavor. The Team will coordinate with departments such as U-M Interior Design Services (IDS), Plant Engineering (UPE), and Planet Blue in order to complete this task.

Energy Conservation Measures

As an extension of the +30 energy conservation initiative, a strategy will be developed to validate the energy and water savings predicted by ECMs and water conservation measures. This will utilize “real world” utility metering and other techniques to assess the effectiveness of these measures. Additionally, maintainability, reliability, and persistence will be assessed. AEC will collaborate with Plant Operations/Plant Engineering to develop this strategy and to incorporate lessons learned into future ECMs. Evaluation methods that will be considered include DDC monitoring, portable instruments, field surveys, occupancy surveys, and submetering.

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Getting the Word Out

To Ourselves

The Team will lead efforts to disseminate knowledge within AEC regarding sustainability standards, resources and requirements.

Training on the newly revised SID-D, including the requirement for projects over $10M to exceed ASHRAE 90.1 by 30% in energy performance, is occurring during the months of May and June, 2010.

As new Design Guidelines and criteria are established, additional educational sessions will be scheduled to help familiarize employees with updates. This will facilitate the proper implementation of the sustainability guidelines into projects.

To Our Clients, the U-M Community and the General Public

The University of Michigan's commitment to environmental stewardship has been an ongoing endeavor for many years. AEC has supported the implementation of sustainable design for new construction and renovations and notes on its website, "U-M strives for increased energy efficiency as the most effective way to reduce its carbon footprint and therefore concentrates its design effort on maximizing energy efficiencies." In an effort to help design teams achieve the sustainable measures required for projects, Design Guidelines such as SID-D and SID-K were created and have been in use for more than six years. These guidelines, along with other existing and proposed design guidelines, will continue to be updated to reflect current standards and conditions.

It is a continuing goal of the Team to publicize AEC's on-going sustainability efforts and its plans for further developments in this area. For designers, the DGs will continue to offer complete information regarding sustainability requirements for U-M buildings. The Sustainability Master Plan will be an additional information source for those in the U-M community and beyond who wish to find a comprehensive up-to-date description of the goals and activities of U-M Architecture, Engineering and Construction.

Further coordination outside of AEC will also be pursued with the Office of Campus Sustainability (OCS), informing student groups, Plant Operations, and the general U-M community about the features of AEC's Sustainability Plan.

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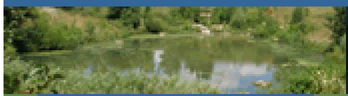

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ABBREVIATIONS & ACRONYMS

A/E - Architect/Engineer

AEC - Architecture, Engineering & Construction

ANSI - American National Standards Institute

ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers

BAS - Building Automation Services

BIFMA - Business and Institutional Furniture Manufacturer's Association

BMPs - Best Management Practices

BOD - Basis of Design

CD - Construction Documents

CWM - construction waste management

Cx - commissioning

CxA - Commissioning Agent

DD - Design Development

DDC - Direct Digital Controls

DG(s) - Design Guideline(s)

ECM(s) - energy conservation measure(s)

IAQ - indoor air quality

IDS - Interior Design Services

IGCC - International Green Construction Code

IPM - Integrated Pest Management

ISO - International Organization of Standardization

LCC - Life Cycle Cost

LED - light-emitting diode

LEED - Leadership in Energy and Environmental Design

LEED AP - LEED Accredited Professional

M&E - mechanical and electrical

M&V - measurement and verification

MERV - Minimum Efficiency Reporting Value

NSF - NSF International

O&M - operations and maintenance

OCS - Office of Campus Sustainability

OPR - Owner's Project Requirements

OSEH - Occupational Safety and Environmental Health

PML - Preferred Manufacturers List

QC - quality control

SD - Schematic Design

SID- Special Instructions to Designers

SM(s) - sustainability measure(s)

SMP - Sustainable Materials Portfolio

U-M - University of Michigan

UPE - Utilities & Plant Engineering

USGBC - United States Green Building Council

VOC - volatile organic compounds

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AEC Design Guidelines

Special Instructions to Designers

SECTION	LAST UPDATE	PREVIOUS REVISION
SID-A Design Guidelines	June 1992	
SID-B Design Intent Documents	June 2010	April 2005
SID-C Compatibility with Existing Conditions	December 1991	
SID-D Energy and Water Conservation	July 2010	May 2009
Energy and Water Conservation Report Format – Projects $2M to $10M Construction Cost	May 2010	
Energy and Water Conservation Report Format – Projects Over $10M Construction Cost	May 2010	
Energy Impact Statement	May 2010	
SID-E Owners Options	July 1990	
SID-F Codes and Regulatory Agencies	October 2010	August 2010
SID-G Commissioning	April 2005	
SID-H Construction Documents	March 2009	October 2003
SID-I Regulated and Hazardous Materials	July 2008	July 2006
SID-J University Provided Utilities	November 2005	July 1990
SID-K Sustainable Design and LEED® Requirements	June 2010	September 2004

Last modified: Wednesday October 27 2010

For technical inquires, comments and suggestions on the U of M Design Guidelines, please e-mail the U of M Design Guidelines Group at UMDesignGuide@umich.edu.

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DESIGN GUIDELINES

<u>THIS DOCUMENT CONTAINS DESIGN GUIDELINES FOR THE DESIGN AND CONSTRUCTION OF FACILITIES AT THE UNIVERSITY OF MICHIGAN. IT SHALL BE USED BY ALL A/Es IN THE PREPARATION OF CONSTRUCTION DOCUMENTS (PLANS AND SPECS).</u>

The purpose of these Design Guidelines is to assure uniformity, system or component quality, compatibility and functionality, and ease of maintenance.

The criteria for the establishment of a specific Design Guideline was:

- Does the University have a requirement for a specific system or component?
- Do standards vary between design firms?

If the answer to both questions is yes, then a Design Guideline has been prepared.

This means that these Guidelines are <u>NOT CONTRACT SPECIFICATIONS.</u> They only address aspects of equipment or systems about which we have concerns or a desire to standardize. Properly written specifications will be much broader in scope and more detailed.

Deviation from the Design Guidelines is discouraged. However, the University recognizes that deviations are inevitable because of site conditions, budget or schedule. To assure that the deviations do not detract from the functionality of the facility or create an undue burden on the Plant Operations Department THE APPROVAL OF A DEVIATION FROM THESE DESIGN GUIDELINES RESTS SOLELY WITH THE UNIVERSITY. The A/E requesting a deviation should do so to the University Project Coordinator. The requester shall specify the reasons for the deviation in detail - by providing drawings, sketches, technical information, mathematical calculations, etc. - as appropriate to allow a thorough and complete review by the University.

Throughout this document reference is made to the A/Es contact with the University as the University Project Coordinator. This title is not meant to imply any one singular person, but rather any one of a number of people who may be assigned to the project. Initially this person will be identified in the A/E Services Contract. As the project progresses through design, and then into the construction phase, the coordinator will be redesignated by the University.

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DESIGN INTENT DOCUMENTS

Related Sections

U-M Design Guideline Sections:
SID-D - Energy and Water Conservation
SID-G - Commissioning
SID-K - Sustainable Design and LEED® Requirements

Reference Documents:
ASHRAE Guideline 0-2005, "The Commissioning Process"

Summary

Beginning in the Schematic Design phase and continuing until the project is as-built, the Architect/Engineer with input from the Design Team shall develop and periodically update an Owner's Project Requirements (OPR) document and a Basis of Design (BOD) document.

The OPR is an inclusive, detailed description of the Owner's goals and requirements for the project, and the Owner's expectations on how the project will be used and operated. The BOD is an inclusive, detailed description of the Design Team's concepts, assumptions, calculations, decisions and product selections used to meet the OPR and to satisfy applicable codes, standards and guidelines. These documents will be benchmarks by which the completeness and adequacy of the project will be judged and the project will be commissioned. They will be the foundations for maintenance programs and references for future renovation projects.

Execution

Contents

The OPR shall include at least the following information:

- Summary description of the building (functions of building, high or low rise, use and occupancy classifications, anticipated hours of operation, etc.).
- Project goals, assumptions, and known limitations.
- Occupant, Donor, and Sponsor program requirements.
- Building and site accessibility, architectural, landscaping and aesthetics goals.
- Building and site flexibility and expandability requirements (spare capacities, diversity, survivability, reliability, redundancy, back-up power and utilities, etc.).
- Building envelope performance criteria.
- Environmental and sustainability goals.
- Energy and water conservation goals.
- Indoor environmental quality requirements (temperature, humidity, air change rates, acoustics, vibration, power, grounding, lighting, glare, EMF shielding, etc.).

- Indoor services and technologies requirements (clean room classifications, fume hoods, environmental rooms, furniture, marker boards, process water, gases, communications, data, security, card access control, audio/visual, etc.).
- Anticipated types, classifications, and quantities of hazardous materials to be contained within the building.
- Architectural, mechanical and electrical systems operation and maintenance expectations.
- HVAC, lighting and audio/visual controls expectations.
- Summary of sole-sourced systems and equipment.
- Summary of Owner-furnished and Owner-installed equipment.
- Occupant and Maintenance training requirements.
- Project schedule.
- Project budget (Uniformat cost estimate). The U-M Design Manager will determine whether budget information should be included in the OPR or provided separately.

The BOD shall include at least the following information:

- Project background required to understand the design, including goals, requirements and decisions which significantly affect the design.
- Regulatory, site, schedule and budget limitations which affect the design.
- Codes, standards and guidelines applicable to the project.
- Code analysis describing code requirements specific to the project, e.g. smoke evacuation systems, if manifolded exhaust is permitted, special fire protection requirements, etc.
- Requirements of governing agencies (City, State, NIH, LEED, etc.).
- Climate, site, and utilities information.
- Operational assumptions (maximum occupancy, special activities, occupancy schedules, building diversity, potential future uses, potential future renovations, etc.).
- Architectural, mechanical and electrical systems descriptions (construction classifications, design loads, fire separations, base and spare capacities, diversity and reliability assumptions, redundancy, flexibility, back-up power, sub-metering, etc.).
- Outdoor summer and winter design conditions.
- Space-by-space design conditions (temperature, humidity, air change rates, room pressurization, sound levels, light levels, etc.).
- Space-by-space equipment heat loads and utility needs (water, gas, power, data, etc.).
- Systems and equipment sequences of operation.
- Load calculations descriptions, including assumptions, software used, etc.
- Architectural, mechanical and electrical systems operation and maintenance requirements.
- Facility Condition Assessment list marked to indicate tasks included in the project.
- Appendices
  - Documentation of compliance to SID-D (see SID-D Appendices A and B for the Energy and Water Conservation Report standard format).
  - Energy Impact Statement (see SID-D Appendix C for the Energy Impact Statement standard format).
  - LEED scorecard when required by SID-K.

- Soils and utility services reports.
- Building load calculations.
- Systems and equipment sizing calculations.
- Light level and watts/square foot calculations.
- Effluent, dispersion, noise, vibration, and other studies.

Development and Updating

Develop the OPR and BOD by expanding the project's program and design concept report. Update them as the project goals and requirements are defined and clarified. Submit them at the end of the Schematic Design, Design Development and Construction Document phases along with the other Design Deliverables. Submit a final BOD after Project Award and after incorporation of the bid alternates. Each update shall incorporate the new and revised information resulting from:

- Progress in project design.
- Changes in project goals.
- Changes in project scope.
- Code interpretations.
- Input from Occupants, Construction Managers and Contractors.
- Input from Plant Operations, Department of Public Safety, OSEH, etc.
- Architectural, mechanical and electrical design coordination meetings.
- Value engineering sessions.
- Test reports on existing conditions.
- Design calculations.
- Energy and water conservation calculations and modeling.
- Equipment selections.
- Sound, effluent, dispersion, CFD, vibration, and other studies.
- Bid Alternates and Owner's Options.

Format

Organize the OPR and BOD on a system-by-system basis, preferably in order by CSI Division, using a consistent style for each section. Organize each section from the more global to the more detailed and specific. Number each section and subsection in outline format. Provide a Table of Contents. Submit an electronic file copy along with the required number of printed copies.

As-Built BOD

At the conclusion of the project, the U-M Design Manager may elect to have the final BOD updated with as-built information. The means and methods for this effort will be negotiated by the Design Manager on a project-by-project basis.

To facilitate the production of an as-built BOD document, identify changes during construction that impact the final BOD and notify the U-M Design Manager accordingly. When writing addenda, CCD's and RFI's, mark them with "Impact on BOD" if they affect the BOD.

COMPATIBILITY WITH EXISTING CONDITIONS

Design Conditions

Existing Conditions

The A/E must visit the site prior to start of design to determine existing conditions of electrical and mechanical systems. The design must be based upon the actual conditions, not initial design specifications.

Review of renovation drawings located in the Facilities Information Center of Engineering Services shall be an integral part of the design process.

If upgrading of the central system is necessary to meet the new needs, this information shall be given to the University Project Coordinator.

The updating of riser diagrams must also be included in project scope.

Utility Sources

The use of central utilities rather than stand-alone systems is encouraged. The A/E must closely communicate with the University early in the design phase of the project to determine the best probable sources of central services. The University Utilities Engineer will approve sources prior to schematic design.

Utility Capacity

As part of schematic design, the A/E must demonstrate that the project under design will not adversely affect utility availability for other spaces, nor utilize inordinate amounts of future capacity for all utilities. Provision is to be made for other planned consumers when a utility is upgraded.

Determination of capacity must be made early enough for funds to be allocated within the renovation project (prior to schematic design estimate if possible).

Existing Code Violations

As a part of schematic design, the A/E will receive, from the project coordinator, a listing of any outstanding code violations in areas to be renovated for incorporation into the project. Items uncovered during surveys and site visits are to be brought to the attention of the University Project Coordinator who will seek funding for incorporation of such items into the project. The project coordinator shall obtain the list from OSEA.

All (existing and new) openings in fire and acoustical separations are to be patched at end of the project.

Existing Deficiencies

As part of the Project's Program Statement, the A/E will receive, from the project coordinator, a listing of known and/or suspected deficiencies in the mechanical systems serving areas to be renovated. Such items are to be reviewed with the University Project Coordinator to determine which items must be incorporated into the project scope.

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Energy and Water Conservation

Related Sections

U-M Design Guideline Sections:
SID-B - Design Intent Documents
SID-F - Codes and Regulatory Agencies
SID-K - Sustainable Design and LEED® Requirements
15910 - Laboratory Ventilation
Design Deliverables

Related Documents:
Energy and Water Conservation Report Format-Projects $2M to $10M Construction Cost
Energy and Water Conservation Report Format-Projects Over $10M Construction Cost
Energy Impact Statement Format and Examples

Reference Documents:
ASHRAE 90.1-2007, "Energy Standard for Buildings Except Low-Rise Residential Buildings"
ASHRAE 189.1-2009, "Standard for the Design of High-Performance Green Buildings"
ASHRAE Handbook-2007, "HVAC Applications"
MPC, "Michigan Plumbing Code-2006"

Summary

This Design Guideline applies to new buildings, building additions, building alterations and capital equipment replacements at the Ann Arbor, Dearborn and Flint campuses. Contact the Project Design Manager to determine when it applies to leased properties.

Consider energy and water conservation in all aspects of project design. Incorporate conservation measures as described herein and as requested by the Design Manager.

Throughout the design process, meetings shall be held to evaluate how the project is meeting the project's conservation targets and to review the conservation measures specific to the project.

Energy Conservation Compliance

All projects

(a) Comply with ASHRAE Standard 90.1-2007.
(b) Incorporate the Mandatory Energy Conservation Measures (ECMs) listed herein.
(c) Evaluate the Potential ECMs listed herein and incorporate as appropriate.
(d) Incorporate the Water Conservation Measures listed herein.

Projects between $2M and $10M construction cost

In addition to the requirements applicable to all projects, perform the following:

(a) Comply with the Mandatory Provisions of ASHRAE 90.1 and utilize either the Prescriptive Path or the Energy Cost Budget (ECB) method.

(b) Utilize the United States Department of Energy's (DOE) COM*check* software (http://www.energycodes.gov/comcheck/) to demonstrate compliance.

(c) Document the impact of the ECMs in accordance with the Documentation Requirements listed herein.

Projects over $10M construction cost

In addition to the requirements applicable to all projects, perform the following:

(a) Exceed ASHRAE 90.1 baseline requirements by 30 percent (design for a total annual energy cost at least 30 percent below that of an ASHRAE 90.1 baseline building). Projects unable to meet this requirement shall apply for a variance from the Associate Vice President for Facilities and Operations.

(b) Utilize the United States Department of Energy's COM*check* software to demonstrate compliance to the Mandatory Provisions of ASHRAE 90.1.

(c) In accordance with Appendix G: Performance Rating Method of ASHRAE 90.1, use a computer energy simulation program to establish a baseline energy consumption for the entire building and to calculate the percentage energy cost saved above the baseline.

(d) Document the impact of the ECMs in accordance with the Documentation Requirements listed herein.

(e) Provide an Energy Impact Statement as described herein.

Mandatory Energy Conservation Measures

The following ECMs shall be incorporated into every project as applicable to the project's scope.

(a) Window Blinds/Shades: Provide interior blinds/shades on south and west facing windows.

(b) Occupancy Schedules: Determine anticipated occupancy schedules in consultation with the Users and indicate these in the Design Intent Documents, in the Energy Impact Statement, and in the energy simulation software output. Based on these schedules, indicate on the project control drawings the initial operating schedule for all mechanical and electrical systems and equipment.

(c) Part Load Efficiency: Design mechanical and electrical systems to run efficiently at partial loads.

(d) HVAC System Zoning: Zone HVAC systems by occupancy type, ventilation rate, and operating schedule to allow shutdown or setback during no/reduced occupancy. Utilize zoned shutdown for sections of systems where occupancy schedules vary widely and separate systems are not feasible.

(e) DDC VAV Control: Control room air volume and temperature with direct digital controlled variable air volume (VAV) assemblies.

(f) Standalone HVAC Systems: Provide standalone HVAC systems for areas that require 24/7 operation, to allow central systems to be shut down.
(g) Laboratories: See U-M Design Guideline 15910 Laboratory Ventilation for information regarding ECMs in labs.
(h) Building Envelope Thermal Scanning: For projects over $10M construction cost, perform infrared thermal scans of any existing envelope during design to identify areas needing improvement. Perform scans of the new building envelope during construction. Correct deficiencies found.
(i) Incandescent Lighting: Limit incandescent lighting to accent or special use.
(j) Lighting and Power Justification: Provide justification for any area that exceeds ASHRAE 90.1 lighting or electrical power limits.

Mandatory Evaluations of Potential Energy Conservation Measures

Evaluate the following ECMs in accordance with the Economic Evaluation of Energy Conservation Measures section of this Design Guideline. Incorporate any ECM into the project that meets the maximum payback criterion.

(a) Below-Grade Insulation: Improve the below-grade insulation R-value above the ASHRAE 90.1 required minimum.
(b) Wall Insulation: Improve the wall insulation R-value above the ASHRAE 90.1 required minimum.
(c) Roof Insulation: Improve the roof insulation R-value above the ASHRAE 90.1 required minimum.
(d) Glazing: Provide glass with reduced solar heat gain coefficients and fenestration systems with lower U values than the ASHRAE 90.1 required maximums.
(e) Server Rooms: Instead of electronic data server rooms located inside the project building, consolidate servers into data centers located outside of the project building.
(f) Chillers: Exceed ASHRAE 90.1 chiller efficiency. Include the impact of pump power reductions.
(g) Free Cooling: Where there is a year-around chilled water load in the building, use "Free Cooling" as part of the chilled water system. Free Cooling shall utilize an evaporative cooling tower coupled with a heat exchanger, closed circuit evaporative fluid coolers, or dry coolers to produce chilled water when seasonal temperatures permit. Evaporative towers should be separate or be able to be decoupled from the main cooling tower array.
(h) Heat Recovery: Where an air handling system's minimum outside air percentage is greater than 40 percent, use a heat recovery system to transfer heat from exhausted air to the outside air entering the system. Evaluate heat recovery (enthalpy) wheels, flat plate air-to-air heat exchangers, heat pipes (including pumped type), and run-around coils. Include the impact of additional pressure drop through each device type.
(i) Envelope Inspections: Increase the inspection of the exterior wall insulation and exterior fenestration systems. Energy savings evaluation to be based on a percentage reduction of the estimated annual energy consumed due to infiltration and thermal conduction through the building envelope.

(j) Lighting Controls: Where occupancy in auditoriums, classrooms, conference rooms and offices varies with time of day, provide occupancy sensing and day-lighting control to achieve minimum space lighting times and ventilation rates, and close VAV boxes to zero position if no occupancy is detected.
(k) Boilers: Exceed ASHRAE 90.1 boiler efficiency.
(l) HVAC: Exceed ASHRAE 90.1 mechanical cooling and heating equipment efficiencies.
(m) Kitchen Hoods: Provide variable volume kitchen exhaust hood systems.

Additional Energy Conservation Opportunities

Consider additional energy conservation opportunities including those listed below for application on the project.

(a) Optimum building aspect ratios (squareness and roof area vs. total area).
(b) Optimum building siting to respond to the climate. Minimize west and south facing windows. Optimize glass orientation and area. Consider double glass wall systems for south or west facades with large areas.
(c) Fenestration overhangs, setbacks, fins, or similar exterior shading devices.
(d) Light shelves to promote day lighting.
(e) Clerestories to reduce energy use while providing day-lighting, in lieu of horizontal glass surfaces or large windows.
(f) Fritted glass, in particular for atriums, winter gardens, and similar type spaces with roofs containing a large percentage of glass.
(g) High albedo, improved reflectivity roofs or green roof systems.
(h) Improved ventilation air flow efficiency by reducing the pressure drop of air system components and ductwork. In particular, consider for air systems that run continuously 24/7.
(i) Chilled beams for areas with large sensible loads and moderate ventilation air requirements.
(j) Displacement/impingement ventilation systems for large spaces with high ceilings.
(k) Heat recovery systems that recover heat from heat rejection equipment or from other available "waste" heat in the building.

Economic Evaluation of Energy Conservation Measures

It is the intent that ECMs incorporated by the project will have payback periods less than the maximum payback periods stated below. It is recognized however that projects may need to incorporate some ECMs with longer than the maximum payback periods in order to exceed ASHRAE 90.1 by 30 percent.

ECM Simple Payback Calculations and Criterion

Evaluate the financial metrics of each ECM.

(a) Calculate the simple payback period of each ECM using:

$$\textit{Simple Payback Period} = \frac{\textit{Incremental Capital Cost of the ECM}}{\textit{Annual Energy Savings} - \textit{Incremental Maintenance Costs of the ECM}}$$

(b) Determine the service life of each ECM in accordance with the ASHRAE Handbook Chapter 36, "Costs of Owning and Operating Equipment." For ECMs not covered in the ASHRAE Handbook, contact the Design Manager for U-M input on their service lives.

(c) Where the service life of two alternative systems is significantly different from each other, include the replacement cost of the shorter lived system in the analysis.

(d) Use the following table to determine whether each ECM meets the maximum simple payback criterion and should or should not be incorporated.

Service Life of ECM (years)	Maximum Simple Payback Period (years)
15	6
20 or More	8

(e) For fenestration and glazing, use a maximum simple payback period of 10 years. For membrane roof insulation, use 12 years. For all other insulation, use a maximum simple payback period of 30 years.

Energy Calculations

Utilize a computer energy simulation program for energy use calculations that meets the requirements of ASHRAE 90.1.

Energy Costs

When evaluating ECMs, use the current utility costs available at http://www.plant.bf.umich.edu/utilities/Utilities/utility_rates.php.

Maintenance Costs

Include significant maintenance cost impacts if anticipated as a result of an ECM. Submit a comparative equipment list detailing the two options being analyzed to the Design Manager and request the necessary maintenance unit and annual costs.

Water Conservation Compliance

All projects

(a) Incorporate water conservation measures that in aggregate use 20 percent less water than a baseline water use (not including irrigation) based on Energy Policy Act of 1992 fixture performance requirements (which are incorporated into the Michigan Plumbing Code).

(b) Incorporate the following mandatory water conservation measures:
- Dual flush water closets.
- Waterless or 1/8 gallon per flush urinals.
- 1/2 GPM aerators for lavatory faucets.
- 2 GPM shower heads.

(c) Incorporate additional measures as required to meet the 20 percent water conservation target.

(d) Document the impact of the Water Conservation Measures in accordance with the Documentation Requirements listed below.

Documentation Requirements

Provide documentation in accordance with Design Guideline SID-B, the Design Deliverables and as follows.

Projects between $2M and $10M construction cost

Starting at the Schematic Design (SD) phase and expanding during the Design Development (DD) and Construction Documents (CD) phases, provide the following information utilizing the Energy and Water Conservation Report Format form provided as a Related Document.

(a) A copy of a completed COM*check* compliance report.

(b) If the ECB method is used, a summary of the computer energy simulation software output and a narrative explaining how compliance was attained using the ECB method.

(c) Explanation of all ECMs evaluated for the project. Provide summary calculations demonstrating the simple payback period of each measure.

(d) Explanation of all Water Conservation Measures applied to the project and their predicted results.

(e) Explanation of which Mandatory Energy Conservation Measures and Mandatory Energy Evaluations apply to the project and how they will be implemented.

Update the CD phase report after project award to reflect accepted Alternates and Owner's Options.

Projects over $10M construction cost

As part of the program and concept design report, identify the architectural, mechanical, and electrical energy conservation technologies specific to the project that will be utilized to provide a building that exceeds ASHRAE 90.1 baseline requirements by 30 percent or more.

Provide the following information utilizing the Energy and Water Conservation Report Format form provided as a Related Document.

During the Schematic Design Phase, provide:

(a) Calculated values for the *baseline building performance*. The *proposed building performance*, and the percentage improvement is also strongly preferred but is not required at SD Phase.
(b) A copy of the completed COM*check* compliance report demonstrating compliance to the Mandatory Provisions of ASHRAE 90.1.
(c) Complete data files from the energy simulation program including a breakdown of energy usage by at least the following components: lights, internal equipment loads, service water heating equipment, space heating equipment, space cooling and heat rejection equipment, fans, and other HVAC equipment (such as pumps). The output reports shall also show the amount of time any loads are not met by the HVAC system for the *baseline building design* and the *proposed building design*. The proposed building design shall not have more "unmet hours" than the baseline building.
(d) An explanation of any error messages noted in the simulation program output.
(e) Explanation of which Mandatory Energy Conservation Measures and Mandatory Energy Evaluations apply to the project and how they will be implemented.
(f) Explanation of all other ECMs to be applied to the project. Include summary calculations demonstrating the simple payback period of each measure (see the "Economic Evaluation of Energy Conservation Measures" section of this Guideline). List ECMs planned for the *proposed building design* and indicate the relative contribution each will make toward attaining the required 30 percent improvement over ASHRAE 90.1. This list shall document all energy features that differ between the *baseline building performance* and the *proposed building performance* calculations.
(g) Explanation of all Water Conservation Measures applied to the project and their predicted results.

During the Design Development and Construction Document phases, provide:

(a) Calculated values for the baseline building performance, the proposed building performance, and the percentage improvement.
(b) Updates of all the energy and water conservation documentation required to be submitted at the SD phase.

Update the CD phase report after project award to reflect accepted Alternates and Owner's Options.

Energy Impact Statement

For projects over $10M construction cost, provide an Energy Impact Statement. Utilize the form provided as a Related Document.

ENERGY AND WATER CONSERVATION REPORT FORMAT
PROJECTS BETWEEN $2M AND $10M CONSTRUCTION COST

Utilize the following report format to indicate compliance to U-M Design Guidelines Special Instructions to Designers SID-D. Supplemental narratives and tables may be provided in addition to the information required below, but for the required tables indicated below, do not change the table explanations, format, headings, footnotes, or the order in which the tables are presented. The data in the tables is for illustrative purposes only.

Cover Page

Provide a cover page with the project name, project number, date and report version: SD, DD, CD, or FINAL. Provide similar information in the report footer.

Executive Summary

Energy conservation measures (ECMs) were evaluated per the requirements of U-M Design Guidelines Special Instructions to Designers SID-D. The total estimated cost savings and first cost of the recommended ECMs for this project are summarized below:

Estimated Annual Energy Cost Avoidance w/ECMs:	$152,300
Total Estimated First Cost of ECMs:	$1,210,000
Over-all Simple Payback (years):	7.9

A requirement of U-M Design Guidelines Special Instructions to Designers SID-D is for designs to use 20% less water compared to designs that exactly meet the building code. The estimated water savings for this project are summarized below:

Estimated Total Annual Water Savings:	41,000 gallons
Annual Water use w/o Water Conservation Measures:	200,000 gallons
Percent Savings Versus Code Requirement:	21%

Table 1: Summary of ECM Evaluations

Table 1 summarizes every energy conservation measure evaluated by the design team for this particular project, along with various ECM financial metrics.

Table 1: Summary of ECMs Evaluated

ECM No.	Description	First Cost Estimate	Annual Costs Savings	Simple Payback	ROI	Persistence[1] H/M/L	Accepted Yes/No	Comments
1a	Additional 0.75" Wall Insulation	$180,000	$14,000	12.9	7.8%	H	**N**	
1b	Additional 1" Wall Insulation	$300,000	$16,500	18.2	5.5%	H	**N**	
1c	Additional 1.5" Wall Insulation	$350,000	$18,400	19.0	5.3%	H	**Y**	
2a	Glass SHGC =0.38	$186,000	$7,500	24.8	4.0%	M	**N**	
2b	Glass SHGC =0.33	$190,000	$8,000	23.8	4.2%	M	**Y**	
2c	Argon Filled Triple Glazed Glass SHGC = 0.26	$265,000	$13,400	19.8	5.1%	L	**N**	Seal life guaranteed only 10 years. Slight gray tint.
3	Day Lighting Sensors, Atrium	$42,000	$12,000	3.5	28.6%	M	**Y**	
4	Desiccant Wheel	$200,000	$40,000	5.0	20.0%	M	**Y**	
5	Exterior Shades, South Façade	$78,000	$15,000	5.2	19.2%	H	**Y**	
6	Increase Thermostat Deadband	$0	$7,000	N/A	N/A	L	**Y**	
7	Free Cooling Process Load	$350,000	$55,000	6.4	15.7%	H	**Y**	
8	Shower Heat Recovery Device	$24,000	$3,000	8.0	12.5%	L	**N**	Maintenance issues

Note 1: Persistence represents an opinion of the probability that the estimated energy savings will be fully realized.

Table 2: Water Conservation Measures and Predicted Results

Table 2 indicates the water saving measures and resulting percent water savings predicted for this project versus a project constructed to meet building code requirements (building code requirements are based on Energy Policy Act of 1992 fixture performance dictates). The requirement of U-M Design Guidelines Special Instructions to Designers SID-D is for designs to provide projects that use 20% less water than projects designed to exactly meet the building code.

Table 2: Water Conservation

Water Conservation Measure	Estimated Annual Savings (Gallons)
Dual Flush Water Closets	7,000
Waterless or 1/8 Gallon Per Flush Urinals	5,000
1/2 GPM Aerators for Lavatory Faucets	8,000
2 GPM Shower Heads	12,000
Gray Water Recovery	9,000

Estimated Total Annual Water Savings:	**41,000**
Annual Water use w/o Water Conservation Measures:	**200,000**
Estimated Percentage Savings:	**21%**

Tables 3 and 4:

U-M Design Guideline Special Instructions to Designers SID-D requires that all projects implement certain "mandatory" energy conservation measures, and it requires that other energy conservation measures be "evaluated" for every project. Tables 3 and 4 indicate which of the mandatory and evaluated measures were found applicable to the project.

Table 3: Review of Mandatory Energy Conservation Measures

Mandatory ECM No.	Description	Implemented Yes/No	Comments	ECM Cross Ref.
a	Window Blinds/Shades	Y		ECM 9
b	Occupancy Schedules	Y		
c	Part Load Efficiency	Y		
d	HVAC System Zoning	Y		ECM 8
e	DDC VAV Control	Y		
f	Standalone HVAC Systems	N	No process areas.	
g	Laboratory ECMs	N	Not a lab building.	
h	Building Envelope Thermal Scanning	Y		ECM 4
i	Limit Incandescent Lighting	Y		
j	Lighting and Power Justification	N		

Table 4: Review of Mandatory Energy Evaluations

Mandatory Evaluation No.	Description	Implemented Yes/No	Comments	ECM Cross Ref.
a	Additional Below-Grade Insulation			
b	Additional Wall Insulation			
c	Additional Roof Insulation			
d	Improved Glazing (1)			
e	Eliminate Server Rooms			
f	High Efficiency Chiller (1)			
g	Free Cooling			
h	Heat Recovery			
i	Increased Envelope Inspections			
j	Occupancy/Daylight Sensing			
k	High Efficiency Boiler (1)			
l	High Efficiency HVAC Equipment (1)			
m	Variable Volume Kitchen Hoods			

Note 1: Performance/efficiency better than required by code.

Table 5: Energy Cost Assumptions:

Table 5 reports the energy cost assumptions utilized for energy cost calculations.

Table 5: Energy Costs Assumptions

Energy Type	Cost	Comments
Electricity	$0.079 /kwh	DTE Direct Purchase Rate
Natural Gas	$0.842/therm	MichiCon Direct Purchase Rate
District Steam	$1.90/therm	U-M Utility Rate
District Chilled Water	$1.07/therm	U-M Utility Rate

Attach the following to this report in the order indicated:

- *Completed COMcheck compliance report demonstrating compliance to ASHRAE Standard 90.1.*
- *If the ECB method is used, complete data files from the energy simulation program. Include the name of the simulation program(s) used. The output reports shall also show the amount of time any loads are not met by the HVAC system for the baseline building design and the proposed building design. The proposed building design shall not have more "unmet hours" than the baseline building.*
- *An explanation of any error messages noted in the simulation program output.*

Energy and Water Conservation Report Format
Projects Over $10M Construction Cost

Utilize the following report format to indicate compliance to U-M Design Guidelines Special Instructions to Designers SID-D. Supplemental narratives and tables may be provided in addition to the information required below, but for the required tables indicated below, do not change the table explanations, format, headings, footnotes, or the order in which the tables are presented. The data in the tables is for illustrative purposes only. Provide a cover page with the project name, project number, date and report version: SD, DD, CD, or FINAL. Provide similar information in the report footer.

Executive Summary

Energy conservation measures (ECMs) were evaluated using ASHRAE 90.1 Appendix G procedures. Appendix G requires estimated savings be compared to a *Baseline Building* that exactly meets ASHRAE 90.1 energy code requirements. U-M Design Guidelines require projects reduce energy cost by 30% compared to the ASHRAE 90.1 *Baseline Building*.

The version of the ASHRAE standard that this project was evaluated against was ASHRAE 90.1-*XXXX <insert year>*

The estimated total annual cost savings by implementing the recommended ECMs is *<insert dollars>*, **which is equivalent to an annual percent savings of** *<insert percentage>* **compared to a ASHRAE 90.1 *Baseline Building*.**

The estimated total annual water savings by implementing the recommended water conservation measures is *<insert gallons>*, **which is equivalent to an annual percent savings of** *<insert percentage>* **compared to a building complying with the Michigan Plumbing Code.**

Table 1: Recommended ECMs (ECM Interactions Not Accounted For)

Table 1 lists all the ECMs that are recommended for implementation on this project. It indicates the savings potential for each ECM without regard to the impact ECMs may have upon one another. Because of such "interactions", the actual cost savings for some ECMs will be less than when they are analyzed on a stand-alone basis. For example, the savings from an ECM that reduces lighting energy will be partially offset by increased space heating requirements due to less light energy heating the space. Table 2 accounts for such ECM interactions.

Table 1: Recommended ECMs (ECM interactions not accounted for)

ECM No.	Description	Dollars/Year Savings	First Cost
1c	Increase Wall Insulation to 2.75"	$18,400	$350,000
2b	Improved Window Performance, SHGC = 0.33, U = 0.44	$8,000	$190,000
3	Day Lighting Sensors, Atrium	$12,000	$42,000
4	Desiccant Wheel	$40,000	$200,000
5	Exterior Shades, South Façade	$15,000	$78,000
6	Increase Thermostat Deadband	$7,000	$0
7	Install Free Cooling System	$55,000	$350,000
	Total First Cost:		$1,210,000
	Total Savings (no interactions accounted for):	**$155,400**	

Table 2: Summary ECM Savings (with ECM Interactions)

Table 2 reports the total estimated ECM savings with ECM interactions taken into account. Where combinations of ECMs are listed, it indicates that those ECMs interact with one another and therefore had to be analyzed as a group.

Table 2: Summary ECM Savings (with ECM interactions)

ECM No.	Description	Dollars/Year Savings
Combo 1	Combines ECMs 1c,2b,3,5	$50,300
ECM 4	Desiccant Wheel	$40,000
ECM 6	Increase Thermostat Deadband	$7,000
ECM 7	Install Free Cooling System	$55,000
	Total Savings (interactions accounted for):	**$152,300**

Table 3: Energy Conservation Predicted Results

Table 3 indicates the percent savings for *<insert the building/project name>* versus a similar building constructed to exactly meet energy code requirements. The estimated annual energy cost for the building without the recommended ECMs is presented first; the energy cost for the same building with the recommended ECMs implemented is presented second. The requirement of U-M Design Guidelines Special Instructions to Designers SID-D is for designs to provide buildings that cost 30% less to operate versus buildings designed to exactly meet the energy code.

Table 3: Energy Conservation Predicted Results[1]

Estimated Energy Costs w/o ECMs[2]	Dollars/Year
ASHRAE Base Building	$420,000
Elevators	$15,000
Process Cooling	$12,000
Outdoor Lights	$4,200
Total Energy Cost w/o ECMs:	$451,200
Estimated Annual Energy Cost Avoidance w/ECMs:	**$152,300**
Estimated Percentage Cost Avoidance:	**34%**
Total Estimated First Cost of ECMs:	**$1,210,000**
Over-all Simple Payback (years):	**7.9**

Note 1: Compared to a baseline ASHRAE building using ASHRAE 90.1 Appendix G methodology. Actual energy use and savings may vary due to occupancy levels, occupancy schedules, utility rates, and other factors different than assumed in the analysis.
Note 2: Energy use break-down reported per ASHRAE 90.1 Appendix G requirements.

Table 4: Summary of ECM Evaluations

Table 4 summarizes every ECM evaluated by the design team for this particular project, along with various ECM financial metrics. For a detailed description and analysis of individual ECMs, please see the Appendices.

Table 4: Summary of ECM Evaluated

ECM No.	Description	First Cost Estimate	Annual Costs Savings	Simple Payback	ROI	Persistence[1] H/M/L	Accepted Yes/No	Comments
1a	Additional 0.75" Wall Insulation	$180,000	$14,000	12.9	7.8%	H	**N**	SD design/estimate included insulation 1" thicker than required by code.
1b	Additional 1" Wall Insulation	$300,000	$16,500	18.2	5.5%	H	**N**	
1c	Additional 1.5" Wall Insulation	$350,000	$18,400	19.0	5.3%	H	**Y**	
2a	Glass SHGC =0.38	$186,000	$7,500	24.8	4.0%	M	**N**	
2b	Glass SHGC =0.33	$190,000	$8,000	23.8	4.2%	M	**Y**	
2c	Argon Filled Triple Glazed Glass SHGC = 0.26	$265,000	$13,400	19.8	5.1%	L	**N**	Seal life guaranteed only 10 years. Slight gray tint.
3	Day Lighting Sensors, Atrium	$42,000	$12,000	3.5	28.6%	M	**Y**	
4	Desiccant Wheel	$200,000	$40,000	5.0	20.0%	M	**Y**	
5	Exterior Shades, South Facade	$78,000	$15,000	5.2	19.2%	H	**Y**	
6	Increase Thermostat Deadband	$0	$7,000	N/A	N/A	L	**Y**	
7	Free Cooling Process Load	$350,000	$55,000	6.4	15.7%	H	**Y**	
8	Shower Heat Recovery Device	$24,000	$3,000	8.0	12.5%	L	**N**	Maintenance issues

Note 1: Persistence represents an opinion of the probability that the estimated energy savings will be fully realized.

Table 5: Water Conservation Measures and Predicted Results

Table 5 indicates the water saving measures and resulting percent water savings predicted for this project versus a project constructed to meet building code requirements (building code requirements are based on Energy Policy Act of 1992 fixture performance dictates). The requirement of U-M Design Guidelines Special Instructions to Designers SID-D is for designs to provide projects that use 20% less water than projects designed to exactly meet the building code.

Table 5: Water Conservation

Water Conservation Measure	Estimated Annual Savings (Gallons)
Dual Flush Water Closets	7,000
Waterless or 1/8 Gallon Per Flush Urinals	5,000
1/2 GPM Aerators for Lavatory Faucets	8,000
2 GPM Shower Heads	12,000
Gray Water Recovery	9,000
Estimated Total Annual Water Savings:	**41,000**
Annual Water use w/o Water Conservation Measures:	**200,000**
Estimated Percentage Savings:	**21%**

Appendix A

Table A1: Energy Cost Assumptions:

Table A1 reports the energy cost assumptions utilized for energy cost calculations.

Table A1: Energy Costs Assumptions

Energy Type	Cost	Comments
Electricity	$0.079 /kwh	DTE Direct Purchase Rate
Natural Gas	$0.842/therm	MichiCon Direct Purchase Rate
District Steam	$1.90/therm	U-M Utility Rate
District Chilled Water	$1.07/therm	U-M Utility Rate

Table A2: Accepted ECMs (no ECM interactions) Additional Information

Table A2 presents the estimated annual cost and energy savings, and the relative contribution each ECM contributed toward total savings.

Table A2: Accepted ECMs (no ECM interactions) Additional Information

ECM No.	Description	Dollars/Yr Savings	% of Total $ Savings	MBTU/Yr Savings	% of Total MBTU Savings	First Cost
1c	Increase Wall Insulation to 2.75"	$18,400	11.8%	450	16.8%	$350,000
2b	Improved Window Performance, SHGC = 0.33, U = 0.44	$8,000	5.1%	183	6.8%	$190,000
3	Day Lighting Sensors, Atrium	$12,000	7.7%	350	13.1%	$42,000
4	Desiccant Wheel	$40,000	25.7%	600	22.4%	$200,000
5	Exterior Shades, South Façade	$15,000	9.7%	224	8.4%	$78,000
6	Increase Stat Deadband	$7,000	4.5%	170	6.4%	$0
7	Install Free Cooling System	$55,000	35.4%	700	26.1%	$350,000

Total First Cost: **$1,210,000**

Total Cost Savings: **$155,400**

Total Energy Savings: **2,677**

Tables A3 and A4:

U-M Design Guidelines Special Instructions to Designers SID-D requires that all projects implement certain "mandatory" energy conservation measures, and it requires that other energy conservation measures be "evaluated" for every project. Tables A3 and A4 indicate which of the mandatory and evaluated measures were found applicable to the project.

Table A3: Review of Mandatory Energy Conservation Measures

Mandatory ECM No.	Description	Implemented Yes/No	Comments	ECM Cross Ref.
a	Window Blinds/Shades	Y		ECM 9
b	Occupancy Schedules	Y		
c	Part Load Efficiency	Y		
d	HVAC System Zoning	Y		ECM 8
e	DDC VAV Control	Y		
f	Standalone HVAC Systems	N	No process areas.	
g	Laboratory ECMs	N	Not a lab building.	
h	Building Envelope Thermal Scanning	Y		ECM 4
i	Limit Incandescent Lighting	Y		
j	Lighting and Power Justification	N		

Table A4: Review of Mandatory Energy Evaluations

Mandatory Eval. No.	Description	Implemented Yes/No	Comments	ECM Cross Ref.
a	Additional Below-Grade Insulation			
b	Additional Wall Insulation			
c	Additional Roof Insulation			
d	Improved Glazing (1)			
e	Eliminate Server Rooms			
f	High Efficiency Chiller (1)			
g	Free Cooling			
h	Heat Recovery			
i	Increased Envelope Inspections			
j	Occupancy/Daylight Sensing			
k	High Efficiency Boiler (1)			
l	High Efficiency HVAC Equipment (1)			
m	Variable Volume Kitchen Hoods			

Note 1: Performance/efficiency better than required by code.

Appendix B

Detailed ECM descriptions and analysis:

Provide a detailed description and evaluation for each ECM. Each evaluation shall include the summary table indicated below, located at the beginning of the ECM. Number similar ECMs -a,-b,-c etc. as per the example.

ECM No.	Description	First Cost Estimate	Dollars/Year Savings	Simple Payback	MBTU/Year Savings
1a	Additional 0.75" Polystyrene Wall Insulation	$180,000	$14,000	12.9	
1b	Additional 1" Polystyrene Wall Insulation	$300,000	$16,500	18.2	
1c	Additional 1.5" Polystyrene Wall Insulation	$350,000	$18,400	19.0	

Description:

The base building wall insulation requirement,
Per ASHRAE 90.7 2007 =

R = 11.9 hr-ft^2-F/Btu

U value = 0.084 Btu/(hr-ft^2-F)

This ECM would increase the insulation thickness as follows:

Increase 1.25" thick insulation to 2.0" Thick

R = 15.87 hr-ft^2-F/Btu

U value = 0.063 Btu/(hr-ft^2-F)

Increase 1.25" thick insulation to 2.25" Thick

R = 17.2 hr-ft^2-F/Btu

U value = 0.058 Btu/(hr-ft^2-F)

Increase 1.25" thick insulation to 2.75" Thick

R = 19.9 hr-ft^2-F/Btu

U value = 0.050 Btu/(hr-ft^2-F)

Construction Costs:

Describe the basis of the first cost estimate.

Appendix C:

Include the following in report Appendix C (in the order indicated):

- *Energy Impact Statement.*

- *A breakdown of energy usage by at least the following components: lights, internal equipment loads, service water heating equipment, space heating equipment, space cooling and heat rejection equipment, fans, and other HVAC equipment (such as pumps)*

- *Completed COMcheck compliance report demonstrating compliance to the mandatory provisions of ASHRAE Standard 90.1.*

- *Complete data files from the energy simulation program. Include the name of the simulation program(s) used. The output reports shall also show the amount of time any loads are not met by the HVAC system for the baseline building design and the proposed building design. The proposed building design shall not have more "unmet hours" than the baseline building.*

- *An explanation of any error messages noted in the simulation program output.*

ENERGY IMPACT STATEMENT

For all projects with a construction budget over $10 million, complete an Energy Impact Statement as required by the Design Guidelines SID-B, SID-D and the Design Deliverables. Refine and update the Energy Impact Statement throughout the three design phases as more detailed information regarding the project becomes available. For comparison, prior estimates are to be shown on subsequent updates of the Energy Impact Statement.

The following describes the general methodology to be used for each utility section. Provide supporting information with the Energy Impact Statement for each phase where required.

Legend:

ALL:	Requirement for each phase
SD:	Schematic Design Phase
DD:	Design Development Phase
CD:	Construction Document Phase

Electrical:

ALL:	Describe methods and assumptions used to calculate electrical estimates.
SD:	Can use watts per square foot. Identify any unusual loads. Estimates can be a developed using a computer simulation or a spread sheet listing peak demand, estimated diversity and annual consumption.
DD & CD:	Estimates based on actual design and not watts per square foot. Estimates can be a developed using a computer simulation program or a spread sheet listing peak demand, estimated diversity and annual consumption. Indicate diversity assumptions or include schedules from computer simulation.

Low Pressure Steam:

ALL:	Describe methods and assumptions used to calculate low pressure steam estimates. Provide list of significant loads showing peak demand and annual consumption.
SD:	Heating consumption estimate can be developed using ASHRAE Degree Day Formula or Bin Estimate Method.
CD & DD:	Develop heating consumption estimates using a computer simulation program utilizing 8,760 hours per year analysis such as Trane Trace, Carrier HAP or Elite EZDOE.

60 PSI Steam:

ALL:	Describe methods and assumptions used to calculate 60 PSI steam estimates. Provide list of significant loads showing peak demand and annual consumption.

Chilled Water:

ALL:	Describe methods and assumptions used to calculate chilled water estimates. Provide list of significant loads showing peak demand and annual consumption.
CD & DD:	Develop chilled water cooling estimates using a computer simulation program utilizing 8,760 hours per year analysis such as Trane Trace, Carrier HAP or Elite EZDOE.

Domestic Cold Water:

ALL:	Describe methods and assumptions used to calculate domestic cold water estimates. Provide fixture count summary and site source for estimating peak diversified demand.

Domestic Hot Water:

ALL:	Describe methods and assumptions used to calculate domestic hot water estimates. Provide fixture count summary and site source for estimating peak diversified demand.

Natural Gas:

ALL:	Describe methods and assumptions used to calculate natural gas estimates.

Storm Drainage system:

ALL:	Describe methods and assumptions used to calculate storm drainage estimates.

Building Description and Assumptions:

Provide a brief narrative describing various building related items and assumptions used to complete the Energy Impact Statement. Among these are the following:

a. Building Gross Floor Area
b. Building Hours of Operation (breakdown for various key areas as required)
c. Utilities Required
d. Mechanical Systems Description
e. Chilled Water Design Entering and Leaving Temperatures
f. Assumed Design Residual Pressure for the Domestic Cold Water System
g. Electrical System Description

ENERGY IMPACT STATEMENT
BLANK FORM

Project Name: <insert project name> U of M Project No.: <insert project number>

Building Energy Summary:	Schematic Phase	Design Development Phase	Construction Document Phase
Project Affected Gross Area, (GSF)			
Annual Building Energy Consumption All Energy Input Converted to BTU, (MBTU/year)			
Annual Building Energy Consumption per GSF, (BTU/year/GSF)			

Electrical:

Maximum Demand, (kW)			
Annual Consumption, (kWH/year):			
Lighting	*Not Required*		
Miscellaneous Power	*Not Required*		
HVAC Equipment	*Not Required*		

Low Pressure Steam:

Peak Load, (lbs/hr):			
Summer			
Winter			
Annual Consumption, (MLB/yr):			
Heating	*Not Required*		
Humidification	*Not Required*		
Air Conditioning	*Not Required*		
Domestic Water Heating	*Not Required*		
Process	*Not Required*		

60 PSI Steam:

Peak Load, (lbs/hr):			
Summer			
Winter			
Annual Consumption, (MLB/yr)			

Project Name: <insert project name> U of M Project No.: <insert project number>

Chilled Water:	**Schematic Phase**	**Design Development Phase**	**Construction Document Phase**
Peak Load, (tons/hour):			
Summer			
Winter			
Annual Consumption, (ton-hours/year)			

Domestic Cold Water:

Peak Cold Water Demand, (GPM)			
Peak Sanitary Demand, (GPM)			
Annual Consumption, (million gallons/year):			
Sanitary Sewer	*Not Required*		
Cooling Tower Evaporation	*Not Required*		
Cooling Tower Blowdown	*Not Required*		

Domestic Hot Water:

Peak Demand, (GPM)			
Annual Consumption, (million gallons/year)			

Natural Gas:

Peak Demand, (CCF/hour)			
Annual Consumption, (CCF/year)			

Storm Drainage system:

Design Storm Peak Volume, (GPM)			

ENERGY IMPACT STATEMENT
SAMPLE

Building Description and Assumptions:

General:
- Central Campus building with mix of offices and classrooms. Some small labs.

Building Gross Floor Area:
- 40,000 GSF (4 Stories @ 10,000 GSF each)

Building Hours of Operation (breakdown for various key areas as required):
- 7 a.m. – 6 p.m. and as further defined in the attached calculations and computer simulation input schedules.

Utilities Required:
- Low pressure steam from Central Power Plant.
- High pressure steam from Central Power Plant.
- Domestic hot water from Central Power Plant.
- Domestic cold water from City of Ann Arbor.
- Natural gas from MichCon.
- Electricity from Central Campus sub-station.

Mechanical Systems Description:
- Single low pressure steam absorption water chiller.
- Roof mounted cooling tower.
- Two air handling units located in the basement mechanical room.
- VAV boxes with hot water reheat coils.
- Hot water perimeter heating via steam/hot water heat exchanger.
- Gas fired unit heaters at Loading Dock.
- High pressure steam for autoclaves.
- 44 F Entering Chilled Water Temperature, 56 F Leaving Chilled Water Temperature.
- Assumed design residual pressure for the Domestic Cold Water System is 30 psi.

Electrical System Description
- Electrical feed will come from Central Campus feeder 21-2.
- No emergency generator is required.

Project Name: XXXXXX Addition & Renovation U of M Project No.: Project No. P0000XXXX

Building Energy Summary:	Schematic Phase	Design Development Phase	Construction Document Phase
Project Affected Gross Area, (GSF)	40,000 *(See Exhibit A, 1.1)*	40,000 *(See Exhibit B, 1.1)*	40,000 *(See Exhibit C)*
Annual Building Energy Consumption All Energy Input Converted to BTU, (MBTU/year)	14,518 *(See Exhibit A, 1.2)*	12,781 *(See Exhibit B, 1.2)*	12,781 *(See Exhibit C)*
Annual Building Energy Consumption per GSF, (BTU/year/GSF)	363,000 *(See Exhibit A, 1.3)*	319,500 *(See Exhibit B, 1.3)*	319,500 *(See Exhibit C)*

Electrical:

Maximum Demand, (kW)	480 *(See Exhibit A, 2.1)*	474 *(See Exhibit B, 2.1)*	474 *(See Exhibit C)*
Annual Consumption, (kWH/year):	800,000 *(See Exhibit A, 2.2)*	786,545 *(See Exhibit B, 2.2)*	786,545 *(See Exhibit C)*
Lighting	*Not Required*	346,080 *(See Exhibit B, 2.3)*	346,080 *(See Exhibit C)*
Miscellaneous Power	*Not Required*	212,367 *(See Exhibit B, 2.4)*	212,367 *(See Exhibit C)*
HVAC Equipment	*Not Required*	228,098 *(See Exhibit B, 2.5)*	228,098 *(See Exhibit C)*

Low Pressure Steam:

Peak Load, (lbs/hr):			
Summer	6,400 *(See Exhibit A,3.1)*	6,080 *(See Exhibit B, 3.1)*	6,080 *(See Exhibit C)*
Winter	1,552 *(See Exhibit A, 3.2)*	1,403 *(See Exhibit B, 3.2)*	1,403 *(See Exhibit C)*
Annual Consumption, (MLB/yr):	9,743 *(See Exhibit A, 3.3)*	8,404 *(See Exhibit B, 3.3)*	8,404 *(See Exhibit C)*
Heating	*Not Required*	2,436 *(See Exhibit B, 3.4)*	2,436 *(See Exhibit C)*
Humidification	*Not Required*	9 *(See Exhibit B, 3.5)*	9 *(See Exhibit C)*
Air Conditioning	*Not Required*	5,957 *(See Exhibit B, 3.6)*	5,957 *(See Exhibit C)*
Domestic Water Heating	*Not Required*	2 *(See Exhibit B, 3.7)*	2 *(See Exhibit C)*
Process	*Not Required*	0 *(See Exhibit B, 3.8)*	0 *(See Exhibit C)*

60 PSI Steam:

Peak Load, (lbs/hr):			
Summer	400 *(See Exhibit A, 4.1)*	250 *(See Exhibit B, 4.1)*	250 *(See Exhibit C)*
Winter	400 *(See Exhibit A, 4.2)*	250 *(See Exhibit B, 4.2)*	250 *(See Exhibit C)*
Annual Consumption, (MLB/yr)	200 *(See Exhibit A, 4.3)*	125 *(See Exhibit B, 4.3)*	125 *(See Exhibit C)*

Chilled Water:	Schematic Phase	Design Development Phase	Construction Document Phase
Peak Load, (tons/hour):			
Summer	320 *(See Exhibit A, 5.1)*	304 *(See Exhibit B, 5.1)*	304 *(See Exhibit C)*
Winter	100 *(See Exhibit A, 5.2)*	82 *(See Exhibit B, 5.2)*	82 *(See Exhibit C)*
Annual Consumption, (ton-hours/year)	320,000 *(See Exhibit A, 5.3)*	297,856 *(See Exhibit B, 5.3)*	297,856 *(See Exhibit C)*

Domestic Cold Water:

Peak Cold Water Demand, (GPM)	200 *(See Exhibit A, 6.1)*	200 *(See Exhibit B, 6.1)*	200 *(See Exhibit C)*
Peak Sanitary Demand, (GPM)	231 *(See Exhibit A, 6.2)*	231 *(See Exhibit B, 6.2)*	231 *(See Exhibit C)*
Annual Consumption, (million gallons/year):	9.53 *(See Exhibit A, 6.4)*	9.53 *(See Exhibit B, 6.3)*	9.53 *(See Exhibit C)*
Sanitary Sewer	*Not Required*	11.53 *(See Exhibit B, 6.4)*	11.53 *(See Exhibit C)*
Cooling Tower Evaporation	*Not Required*	2.04 *(See Exhibit B, 6.5)*	2.04 *(See Exhibit C)*
Cooling Tower Blowdown	*Not Required*	0.37 *(See Exhibit B, 6.6)*	0.37 *(See Exhibit C)*

Domestic Hot Water:

Peak Demand, (GPM)	75 *(See Exhibit A, 7.1)*	75 *(See Exhibit B, 7.1)*	75 *(See Exhibit C)*
Annual Consumption, (million gallons/year)	3.01 *(See Exhibit A, 7.2)*	3.01 *(See Exhibit B, 7.2)*	3.01 *(See Exhibit C)*

Natural Gas:

Peak Demand, (CCF/hour)	5 *(See Exhibit A, 8.1)*	4 *(See Exhibit B, 8.1)*	4 *(See Exhibit C)*
Annual Consumption, (CCF/year)	2,500 *(See Exhibit A, 8.2)*	2,000 *(See Exhibit B, 8.2)*	2,000 *(See Exhibit C)*

Storm Drainage system:

Design Storm Peak Volume, (GPM)	286 *(See Exhibit A, 9.1)*	302 *(See Exhibit B, 9.1)*	302 *(See Exhibit C)*

ENERGY IMPACT STATEMENT
SAMPLE EXHIBIT A - SCHEMATIC DESIGN PHASE CALCULATIONS

In accordance with the Design Phase Deliverables; at the Schematic Design Phase, complete the following items which contribute to the development of the Energy Impact Statement:

- ***Reviewed energy code requirements.***
- ***Typical building elevations with window placement .***
- ***Roof layout.***
- ***Typical floor plans with identified area uses and resulting area square footage.***
- ***Identified all needed HVAC systems with one-line flow diagrams.***
- ***Conceptual plumbing and piping layout.***
- ***Electric one-line diagrams based on conceptual electric requirements.***

Item No.	**Building Energy Summary**	**Descriptions & Calculations**
1.1	Project Affected Gross Area, (GSF)	40,000 Sq. Ft. per Schematic Design Phase Space Programming.
1.2	Annual Building Energy Consumption, (MBTU/year)	All Energy Input Converted to MBTU/year Electric = 2,730.4 MBTU/year [See Item 2.2] Low Pressure Steam = 11,301.0 MBTU/year [See Item 3.3] 60 PSI Steam = 236.4 MBTU/year [See Item 4.3] Natural Gas = 250.0 MBTU/year [See Item 8.2] Total All Sources = 14,519 MBTU/year
1.3	Annual Building Energy Consumption per Sq. Ft., (BTU/year/GSF)	14,519 MBTU/year / 40,000 SF = 363,000 Btu/year/SF

Item No.	**Electrical**	**Descriptions & Calculations**
2.1	Maximum Demand, (kW)	Assume: Lighting @ 2 Watts/SF Misc. Electric @ 5 Watts/SF HVAC @ 5 Watts/SF Results in 480 kW Peak Summer Load
2.2	Annual Consumption, (MWH/year)	Assume Annual consumption @ 20 kWH/year per SF. 20 kWH/year per SF X 40,000 SF = 800,000 kWH/year.
2.3	Lighting	*Breakout value not required for this item in Schematic Phase.*
2.4	Miscellaneous Power	*Breakout value not required for this item in Schematic Phase.*
2.5	HVAC Equipment	*Breakout value not required for this item in Schematic Phase.*

Item No.	Low Pressure Steam	Descriptions & Calculations
3.1	Summer Peak Load, (lbs/hr)	Cooling load assumed to be 125 SF/ton @ 40,000 SF = 320 tons/hr. Steam consumption for absorption chillers is approximately 20 lb/hr at 9 psi. Therefore, 320 tons X 20 lbs/hr = 6,400 lbs/hr.
3.2	Winter Peak Load, (lbs/hr)	Heating load assumed to be 45 Btu/SF X 40,000 SF Gross Floor Area /1160 BTU per lb @ 9 psi = 1,552 lbs/hr.
3.3	Annual Consumption, (MLB/yr)	Cooling Consumption = 320,000 ton-hours/year [see Chilled Water, Item 4.3] X 20 lb-hour / 1000 lbs per MLB = 6,400 MLB/year. Heating Consumption = Using Heating Degree Day Method: (((1,552 lbs/hr peak load / (-10 ^{o}F - 72 ^{o}F)) X 6,258 Heating Degree Days [from ASHRAE 1984 Fundamentals, pg 24.25] X 24) / 1000 lbs per MLB = 2,843 MLB/year. Humidification + Domestic Water Re-Heating + Miscellaneous Steam Loads is assumed to be 500 MLB/year. Total Annual Consumption = Cooling + Heating + Miscellaneous = 6,400 + 2843 + 500 = 9,743 MLB/year.
3.4	Heating	*Breakout value not required for this item in Schematic Phase.*
3.5	Humidification	*Breakout value not required for this item in Schematic Phase.*
3.6	Air Conditioning	*Breakout value not required for this item in Schematic Phase.*
3.7	Domestic Water Heating	*Breakout value not required for this item in Schematic Phase.*
3.8	Process	*Breakout value not required for this item in Schematic Phase.*

Item No.	60 PSI Steam	Descriptions & Calculations
4.1	Summer Peak Load, (lbs/hr)	Four Autoclaves: Assume 4 X 100 lbs/hour of 60 PSI steam required = 400 lbs/hour.
4.2	Winter Peak Load, (lbs/hr)	Same as Summer Peak Load = 400 lb/hr.
4.3	Annual Consumption, (MLB/yr)	Four Autoclaves: Assume 4 X 100 lbs/hour of 60 PSI steam required / 1000 lbs/hour per MLB/hr X 2 cycles/day X 250 days/yr = 200 MLB/year

Item No.	Chilled Water	Descriptions & Calculations
5.1	Summer Peak Load, (tons/hour)	Cooling load assumed to be 125 SF/ton @ 40,000 SF = 320 tons/hr.
5.2	Winter Peak Load, (tons/hour)	Assume winter peak load for computer server rooms and miscellaneous year-round cooling needs at 100 tons.
5.3	Annual Consumption, (ton-hours/year)	Using Equivalent Full Load Hours Method: 320 tons peak load X 1000 hours equivalent full load operation [from ASHRAE 1984 Fundamentals, pg 28.5] = 320,000 ton-hours/year. Using Cooling Degree Day Method: (320 tons peak load/92 ^{o}F - 72 ^{o}F) X 687Cooling Degree Days [from ASHRAE 1984 Fundamentals, pg 28.6] X 24 = 219,840 ton-hours/year. Conclusion: Use 320,000 ton-hours/year. Note: winter cooling load is handled by winterized cooling towers via free cooling system.

Item No.	Domestic Cold Water	Descriptions & Calculations
6.1	Peak Demand, (GPM)	Based on a review of the International Building Code, 2000 and International Plumbing Code, 2000 to determine maximum building occupancy levels and resulting minimum number of plumbing facilities, as well as a review of similar building types on campus, it was determined that the domestic cold water peak demand be based on 750 fixture units. From Table E102 of the International Plumbing Code, 2000, the resulting domestic cold water peak demand is 177 GPM. Additionally the cooling tower has an estimated peak domestic cold water demand of 23 GPM [Calculated using "Marley Cooling Tower Fundamentals"]. Total DCW Peak Demand = 177 + 23 = 200 GPM.
6.2	Peak Sanitary Demand, (GPM)	Peak Sanitary Demand = Domestic Cold Water Demand [Item 5.1] + Domestic Hot Water Demand [Item 6.1] – Cooling Tower Make-up [Item 5.1] = 177 + 77 – 23 = 231 GPM.
6.3	Annual Consumption, (gallons/year):	Occupied DCW: 177 GPM X 25% Diversity X 2,000 hours/year = 5.31 million gallons/year. Unoccupied DCW: 177 GPM X 2.5% Diversity X 6,760 hours/year = 1.80 million gallons/year. Cooling Tower Make-up: 23 GPM X 20% Diversity X 8,760 hours/year = 2.42 million gallons/year. Total = 5.31 + 1.80 + 2.42 = 9.53 million gallons/year.
6.4	Sanitary Sewer	*Breakout value not required for this item in Schematic Phase.*
6.5	Cooling Tower Evaporation + Drift	*Breakout value not required for this item in Schematic Phase.*
6.6	Cooling Tower Blowdown	*Breakout value not required for this item in Schematic Phase.*

Item No.	Domestic Hot Water	Descriptions & Calculations
7.1	Peak Demand, (GPM)	Based on a review of the International Building Code, 2000 and International Plumbing Code, 2000 to determine maximum building occupancy levels and resulting minimum number of plumbing facilities, as well as a review of similar building types on campus, it was determined that the domestic hot water peak demand be based on 250 fixture units. From Table E102 of the International Plumbing Code, 2000, the resulting domestic hot water peak demand is 75 GPM.
7.2	Annual Consumption, (million gallons/year):	Occupied: 75 GPM X 25% Diversity X 2,000 hours/year = 2.25 million gallons/year. Unoccupied: 75 GPM X 2.5% Diversity X 6,760 hours/year = 0.76 million gallons/year. Total = 2.25 + 0.76 = 3.01 million gallons/year.

Item No.	Natural Gas	Descriptions & Calculations
8.1	Peak Demand, (CCF/hour)	Two Gas Fired Unit Heaters in Loading Dock: Assume 2 X 250,000 BTU/hr = 500,000 BTU/hr / 100,000 BTU/CCF = 5 CCF/hour.
8.2	Annual Consumption, (CCF/year):	Two Gas Fired Unit Heaters in Loading Dock: Assume 2 X 250,000 BTU/hr X 2000 hours/year operation x 25% diversity / 100,000 BTU/CCF = 2,500 CCF/year.

Item No.	Storm Drainage System	Descriptions & Calculations
9.1	Design Peak Storm Volume, (GPM)	From 2000 International Plumbing Code, Section 1106: Assume roof area of 10,000 sf @ 2.75 inches/hr (100 year rainfall) = 286 GPM.

ENERGY IMPACT STATEMENT
SAMPLE EXHIBIT B - DESIGN DEVELOPMENT PHASE CALCULATIONS

In accordance with the Design Phase Deliverables; at the Design Development Phase, complete the following items (in addition to those completed during the Schematic Design Phase) which contribute to the further refinement of the Energy Impact Statement:

- ***All building elevations with window placement and wall sections .***
- ***Roof and drainage plan.***
- ***All floor plans with identified area uses and resulting area square footage.***
- ***Design criteria for each mechanical system.***
- ***Equipment schedules for major mechanical items.***
- ***Overall building airflow diagram.***
- ***Conceptual control diagrams for all mechanical and plumbing systems.***
- ***Preliminary calculations for HVAC systems.***
- ***Design criteria for each plumbing system, including set points, etc.***
- ***One-line diagrams for all plumbing systems.***
- ***Plumbing and piping plans.***
- ***Typical lighting plans.***
- ***Lighting fixture schedule.***
- ***Review of lighting energy code requirements.***
- ***Normal power riser diagram.***
- ***Power panel schedules.***
- ***Electric load estimates.***

Item No.	Building Energy Summary	Descriptions & Calculations
1.1	Project Affected Gross Area, (GSF)	40,000 GSF per Design Development Phase Space Programming.
1.2	Annual Building Energy Consumption, (MBTU/year)	All Energy Input Converted to MBTU/year Electric = 2,684 MBTU/year [See Item 2.2] Low Pressure Steam = 9,749 MBTU/year [See Item 3.3] 60 PSI Steam = 148 MBTU/year [See Item 4.3] Natural Gas = 200 MBTU/year [See Item 8.2] Total All Sources = 12,781 MBTU/year
1.3	Annual Building Energy Consumption per GSF, (BTU/year/GSF)	12,781 MBTU/year / 40,000 GSF = 319,522 kBtu/year/GSF

Item No.	Electrical	Descriptions & Calculations
2.1	Maximum Demand, (kW)	Data from Design Development Phase lighting and power panel schedules was input into a computer simulation program. See Table B.1, "Billing Details – Electric" for maximum electric demand. The maximum electric demand of 474 kW occurs in June.
2.2	Annual Consumption, (MWH/year)	Data from Design Development Phase lighting and power panel schedules was input into a computer simulation program. See Table B.1, "Billing Details – Electric" for annual electric consumption. The annual electric consumption for all components is 786,545 kWH.
2.3	Lighting	For electrical consumption by component, see Table B.2, "Energy Budget by System Component". This table shows electrical energy as kBTUs. The estimated annual electrical consumption for lighting is listed under "Site Energy" as 1,181,170 kBTU per year. This converts to 346,080 kWH per year.
2.4	Miscellaneous Power	For electrical consumption by component, see Table B.2, "Energy Budget by System Component". This table shows electrical energy as kBTUs. The estimated annual electrical consumption for miscellaneous power is listed under "Site Energy" as 724,809. This converts to 212,367 kWH per year.
2.5	HVAC Equipment	For electrical consumption by component, see Table B.2, "Energy Budget by System Component". This table shows electrical energy as kBTUs. The estimated annual electrical consumption for HVAC is listed under "Site Energy" as the sum of the air system fans, pumps and cooling towers, or 536,896 + 53,690 + 187,913 = 778,499. This sum converts to 228,098 kWH per year.

Item No.	Low Pressure Steam	Descriptions & Calculations
3.1	Summer Peak Load, (lbs/hr)	Data from Design Development Phase was input into a computer simulation program to determine the estimated summer peak steam demand. See Table B.3, "Hourly Simulation – Summer Chiller Plant" for details. The peak summer steam demand includes steam for the absorption chiller. The peak summer steam demand of 6,080 lbs/hr occurs at 4:00 pm on July 22.
3.2	Winter Peak Load, (lbs/hr)	Data from Design Development Phase was input into a computer simulation program to determine the estimated winter peak steam demand. See Table B.5, "Hourly Simulation – Heating Plant" for details. The peak winter steam demand includes all heating loads plus humidification loads. The peak winter steam demand of 1,628 MBH or 1,403 lbs/hr occurs at 7:00 am on January 15.
3.3	Annual Consumption, (MLB/yr)	Total Annual Consumption = Heating [Item 3.4] + Humidification [Item 3.5] + Air Conditioning [Item 3.6] + Domestic Water Reheating [Item 3.7] = 2,436 + 8.94 + 5,957 +2 = 8,404 MLB/year.
3.4	Heating	For steam consumption by component, see Table B.2, "Energy Budget by System Component". This table shows steam energy as kBTUs. The estimated annual steam consumption for heating is listed under "Site Energy" as 2,825,760. This converts to 2,436 MLB per year.
3.5	Humidification	For steam consumption by component, see Table B.2, "Energy Budget by System Component". This table shows steam energy as kBTUs. The estimated annual steam consumption for humidification is listed under "Site Energy" as 107,228. This converts to 8.94 MLB per year.
3.6	Air Conditioning	For steam consumption by component, see Table B.2, "Energy Budget by System Component". This table shows steam energy as kBTUs. The estimated annual steam consumption for air conditioning (steam absorption) is listed under "Site Energy" as 6,910,259. This converts to 5,957 MLB per year.
3.7	Domestic Water Heating	Domestic hot water is supplied from the Central Power Plant. Supplemental reheating of the domestic hot water is done with Plant steam to maintain the discharge water temperature set point. The annual consumption is estimated at 2 MLB per year.
3.8	Process	None required for this building

Item No.	60 PSI Steam	Descriptions & Calculations
4.1	Summer Peak Load, (lbs/hr)	During the Design Development Phase two autoclaves were eliminated. From the equipment schedules, the two remaining autoclaves require 125 lbs/hour. 2 X 125 lbs/hour of 60 PSI steam required = 250 lbs/hour.
4.2	Winter Peak Load, (lbs/hr)	Same as Summer Peak Load = 250 lbs/hr.
4.3	Annual Consumption, (MLB/yr)	Assume 2 X 125 lbs/hour of 60 PSI steam required / 1000 lbs/hour per MLB/hr X 2 cycles/day X 250 days/yr = 125 MLB/year

Item No.	Chilled Water	Descriptions & Calculations
5.1	Summer Peak Load, (tons/hour)	Data from Design Development Phase was input into a computer simulation program to determine the estimated peak chilled water demand. See Table B.3, "Hourly Simulation – Summer Chiller Plant " for details. The peak summer chilled water demand of 3,648 MBH or 304 tons occurs at 4:00 pm on July 22.
5.2	Winter Peak Load, (tons/hour)	Data from Design Development Phase was input into a computer simulation program to determine the estimated peak chilled water demand. See Table B.4, "Hourly Simulation – Winter Chiller Plant" for details. Winter free cooling operation (absorption chillers off) is assumed to occur between October and April. The peak winter chilled water demand of 984 MBH or 82 tons occurs at 2:00 pm on April 28.
5.3	Annual Consumption, (ton-hours/year)	Data from Design Development Phase was input into a computer simulation program to determine the annual chilled water consumption. See Table B.2, "Energy Budget by System Component" for details. The estimated annual chilled water consumption is listed under "Site Energy" as 3,574,272 kBTU. This converts to 297,856 ton-hours per year. Note: winter cooling load is handled by winterized cooling towers via free cooling system.

Item No.	Domestic Cold Water	Descriptions & Calculations
6.1	Peak Demand, (GPM)	Based on a review of the International Building Code, 2000 and International Plumbing Code, 2000 to determine maximum building occupancy levels and resulting minimum number of plumbing facilities, as well as a review of similar building types on campus, it was determined that the domestic cold water peak demand be based on 750 fixture units. From Table E102 of the International Plumbing Code, 2000, the resulting domestic cold water peak demand is 177 GPM. Additionally the cooling tower has an estimated peak domestic cold water demand of 23 GPM [Calculated using "Marley Cooling Tower Fundamentals"]. Total DCW Peak Demand = 177 + 23 = 200 GPM.
6.2	Peak Sanitary Demand, (GPM)	Peak Sanitary Demand = Domestic Cold Water Demand [Item 5.1] + Domestic Hot Water Demand [Item 6.1] – Cooling Tower Make-up [Item 5.1] = 177 + 77 – 23 = 231 GPM.
6.3	Annual Consumption, (million gallons/year):	Occupied DCW: 177 GPM X 25% Diversity X 2,000 hours/year = 5.31 million gallons/year. Unoccupied DCW: 177 GPM X 2.5% Diversity X 6,760 hours/year = 1.80 million gallons/year. Cooling Tower Make-up: 23 GPM X 20% Diversity X 8,760 hours/year = 2.42 million gallons/year. Total = 5.31 + 1.80 + 2.42 = 9.53 million gallons/year.
6.4	Annual Sanitary Sewer, (million gallons/year)	Annual sanitary sewer volume is estimated as: The sum of the annual domestic cold water (DCW) consumption + annual domestic hot water (DHW) consumption + annual cooling tower blowdown. Occupied DCW = 5.31 million gallons/year. [Item 6.3] Unoccupied DCW = 1.80 million gallons/year. [Item 6.3] Occupied DHW = 2.25 million gallons/year. [Item 7.2] Unoccupied DHW = 0.76 million gallons/year. [Item 7.2] Cooling Tower Blowdown = 0.37 million gallons/year. [Item 6.6] Total = 5.31 + 1.80 + 2.25 + 1.80 + 0.37 = 11.53 million gallons/year.
6.5	Cooling Tower Evaporation + Drift, (million gallons/year):	Peak cooling tower evaporation is calculated using "Marley Cooling Tower Fundamentals" as: E=R/10/100 X Circulation Water Volume Where: E=Evaporation, GPM R=Tower temperature range. In this case 100 F – 85 F = 15 F. Circulation water volume is 4 GPM per ton of absorption chilling or 4 GPM X 320 Tons = 1,280 gallons of circulating water. E=15/10/100 X 1,280 = 18.1 GPM Peak cooling tower drift is calculated as: D=0.1% X Circulation Water Volume D=0.1% X 1,280 = 1.3 GPM

		Annual cooling tower evaporation + drift is estimated as: (18.1 GPM + 1.3 GPM) X 20% Diversity X 8,760 hours/year = 2.04 million gallons/year. Note: This water volume is not included in the sanitary sewer calculation as it does not go to the sanitary sewer.
6.7	Cooling Tower Blowdown, (million gallons/year):	Peak cooling tower blowdown is calculated using "Marley Cooling Tower Fundamentals" as: B=(((R/10) / (CC-1)) – 0.1) /100) X Circulating Water Volume Where: B=Blowdown, GPM R=Tower temperature range. In this case 100 F – 85 F = 15 F. CC=Concentration cycles. In this case 5 cycles is assumed. Circulation water volume is 4 GPM per ton of absorption chilling or 4 GPM X 320 Tons = 1,280 gallons of circulating water. B=((15/10) / (5-1)/100) X 1,280 = 3.5 GPM Annual cooling tower blowdown is estimated as: 3.5 GPM X 20% Diversity X 8,760 hours/year = 0.37 million gallons/year. Note: This water volume is included in the sanitary sewer calculation as it does go to the sanitary sewer.

Item No.	Domestic Hot Water	Descriptions & Calculations
7.1	Peak Demand, (GPM)	Based on a review of the International Building Code, 2000 and International Plumbing Code, 2000 to determine maximum building occupancy levels and resulting minimum number of plumbing facilities, as well as a review of similar building types on campus, it was determined that the domestic hot water peak demand be based on 250 fixture units. From Table E102 of the International Plumbing Code, 2000, the resulting domestic hot water peak demand is 75 GPM.
7.2	Annual Consumption, (million gallons/year):	Occupied: 75 GPM X 25% Diversity X 2,000 hours/year = 2.25 million gallons/year. Unoccupied: 75 GPM X 2.5% Diversity X 6,760 hours/year = 0.76 million gallons/year. Total = 2.25 + 0.76 = 3.01 million gallons/year.

Item No.	Natural Gas	Descriptions & Calculations
8.1	Peak Demand, (CCF/hour)	Two Gas Fired Unit Heaters in Loading Dock: From the Design Development Phase mechanical equipment schedules, the two gas fired unit heaters were downsized two at 200,000 BTU/hr each. 2 X 200,000 BTU/hr = 400,000 BTU/hr / 100,000 BTU/CCF = 4 CCF/hour.
8.2	Annual Consumption, (CCF/year):	Two Gas Fired Unit Heaters in Loading Dock: Assume 2 X 200,000 BTU/hr X 2000 hours/year operation x 25% diversity / 100,000 BTU/CCF = 2,000 CCF/year.

Item No.	Storm Drainage System	Descriptions & Calculations
9.1	Design Peak Storm Volume, (GPM)	Roof area from Design Development Phase Roof Plan is 10,560 SF. From 2000 International Plumbing Code, Section 1106: 10,560 SF @ 2.75 inches/hr (100 year rainfall) = 302 GPM.

ENERGY IMPACT STATEMENT
SAMPLE EXHIBIT C - CONSTRUCTION DOCUMENT PHASE CALCULATIONS

In accordance with the Design Phase Deliverables; at the Construction Document Phase, complete the following items (in addition to those completed during the Design Development Phase) which contribute to the further refinement of the Energy Impact Statement:

- ***Complete specification.***
- ***One-line diagrams for all mechanical systems.***
- ***Duct layout and air flow volumes for each space.***
- ***Detailed control drawings with sequences of operation.***
- ***All design calculations.***
- ***Lighting plans for all areas.***
- ***Electrical power load summary.***
- ***Electrical panel schedules.***

Because the majority of the information needed for accurate estimates in the Energy Impact Statement is available in the Design Development Phase, most projects will require very little modification of the Energy Impact Statement in moving to the Construction Document Phase. Also, there is no change in the methodology used to determine estimates in moving from the Design Development Phase to the Construction Document Phase.

For these reasons, it is assumed that (for this example) there is no change in the Energy Impact Statement. Estimates shown in the Design Development Phase column of the Energy Impact Statement are repeated in the Construction Document Phase column.

It is not unusual for projects to change significantly in moving from Design Development Phase to Construction Document Phase (usually due to budget constraints). In these cases there may be significant changes to the Energy Impact Statement which the Design Professional will be expected to document.

OWNER'S OPTIONS

General

The University requires that specific vendor's products be used in many cases to assure job quality through reliability, ease of maintenance, manufacturers proven maintenance and warranty support, and control of stock.

Even so, the University is always looking for better, less expensive systems and components. Accordingly, the Contractor may submit alternates, at the discretion of the University Project Coordinator, as OWNER'S OPTIONS. However, in doing so it is the responsibility of the manufacturer to demonstrate to the University's satisfaction that equivalency of quality/reliability in fact exists. When equivalency to the existing standard cannot be reasonably assured, and yet the product appears to have promise, the University may choose to establish a "Pilot" project to evaluate the product through field test.

Typically this could consist of the incorporation of the new product in a future small renovation project in a non-critical facility (a facility that does not directly support the mission of the University).

Use of the phrase "or equal" after any specific vendor's product identification is to be avoided.

01/25/00 08:47 AM

CODES AND REGULATORY AGENCIES

Introduction

The University of Michigan is a State of Michigan constitutional corporation, governed by a Board of Regents elected by the People of the State of Michigan and has a great deal of regulatory autonomy. It is exempt from local building and zoning ordinances and subject to State of Michigan laws and regulations that are clearly intended to apply to universities. In lieu of local building ordinances and State of Michigan laws and regulations that do not apply at the University, the University chooses to require that new construction adhere to a number of well-established building codes and standards, as listed in this Section.

Regardless of origin or enforcing agency, all of the applicable building codes and standards listed below are to be followed. Note, for instance, that compliance with the State of Michigan Bureau of Fire Safety rules for schools and/or dormitories does not eliminate the need to also comply with the Michigan Building Code, and that compliance with the Uniform Federal Accessibility Standards does not eliminate the need to comply with the barrier free provisions of the Michigan Building Code. Additional codes may apply for particular situations, such as for Medical Center construction; these are to be considered on the case-to-case basis. Many times adherence to narrow scope codes and/or standards is required by the general codes listed below.

New editions of building codes are published from time to time. For each project, the edition of building codes cited in this section from which the University of Michigan is listed as the "Enforcing Agency" is to be as follows:

The edition of building codes is to be as listed in this section as of the beginning of the design development phase of a project unless construction documents are submitted to the University for final review more than one year after initiation of design development. If more than one year transpires between the beginning of design development and the submission of construction documents to the University for final review, the edition of the building codes listed in this section as of submission of construction documents applies.

The University employs building inspectors, who are the authority having jurisdiction for mechanical and electrical work on all University property.

For University of Michigan Hospitals and Health Centers projects refer to the University of Michigan Hospital Design Guidelines Codes and Regulatory Agencies. Web site:

http://www.med.umich.edu/facilities/planningdevelopment/ae/dg/doc/spe/SID-F-H.pdf

BUILDING CODES FOR UNIVERSITY OF MICHIGAN CONSTRUCTION

Michigan Building Code 2006 (adopted August 1, 2008) promulgated by the State of Michigan Department of Consumer & Industry Services Bureau of Construction Codes. Including rule 408.30401 Rule 401 as printed on the interior cover of the Michigan Building Code.
By local rule, the following exceptions/modifications are applied to the Michigan Building Code article 716.5.3.1, article 907.9.1.4, and article 1008.1.8.7:

Article 716.5.3.1 add exception number 5:

Exception 5. In other than I or H occupancies or University of Michigan Hospitals and Health Center owned and/or occupied facilities, when equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1, smoke dampers are not required at shaft enclosures unless specifically required by other sections of the code. Instead, provide smoke dampers at locations and to function as prescribed in the 2002 edition of NFPA 90A - 'Standard for the Installation of Air-Conditioning and Ventilating Systems'.

Article 907.9.1.4 Group R-2 reference the following interpretation of the use of the word "capability":

> In the sentence "all dwelling units shall be provided with the capability to support visible alarm notification appliances…". Capability of the fire alarm system shall be addressed by the spare capacity already required in all U of M fire alarm circuits and fire alarm panels. This spare capacity in the circuits (raceways, and installed conductoring), shall be available immediately after the fire alarm system is commissioned. The spare capacity at the panel, may be in the form of power supplies sized for the expansion, and/or in the form of sufficient (spare) mounting space in the panel for the additionally needed power supplies. Refer to U of M Design Guideline and master specifications for spare capacity requirements.

Article 1008.1.8.7 add the following:

"Exception 4. Selected doors on stair enclosures shall be permitted to be equipped with hardware that prevents reentry into the interior of the building, provided that egress is maintained and:

(a) There are at least two levels where it is possible to leave the stair enclosure; and
(b) There are not more than four stories intervening between stories where it is possible to leave the stair enclosure; and
(c) Reentry is possible on the top or next to top story permitting access to another exit; and
(d) Doors permitting reentry are identified as such on the stair side of the door; and
(e) Doors not permitting reentry shall be provided with a sign on the stair side indicating the location of the nearest door, in each direction of travel, permitting reentry or exit.
(f) Doors that prevent reentry from the stair must be capable of being unlocked simultaneously without unlatching upon a signal from the fire command center, if present, or a signal by emergency personnel from a single location inside the main entrance to the building

Article 1301.1.1 add the following:

"Comply with ASHRAE Standard 90.1 2007 version."

Chapter 32 Encroachments into the Public Right of Way: Within the public right of way adhere to City of Ann Arbor standards and specifications refer to the following web site for requirements: http://www.a2gov.org/government/publicservices/project_management/privatedev/Pages/StandardSpecificationsBook.aspx

The following regulations take precedence over conflicting requirements in the Michigan Building Code:

Chapter 13 Energy Efficiency comply with ASHRAE Standard 90.1 2007 – Effective February 1, 2009.

State of Michigan Elevator Code.

State of Michigan Mechanical Code 2009 and Michigan Plumbing Code 2009.

State of Michigan Electrical Code incorporating "NFPA 70 --National Electrical Code", 2005 edition with University of Michigan modifications.

"NFPA 13 2002 -- Sprinkler Systems".

"NFPA 45 2004-- Fire Protection for Laboratories Using Chemicals".

"NFPA 72 -- National Fire Alarm Code", 2002 edition with University of Michigan modifications.

"Guide for Care and Use of Laboratory Animals" promulgated by US Dept of Health & Human Services.

Enforcing Agency -- University of Michigan Architecture, Engineering and Construction.

Enforcing Agency for Barrier Free -- State of Michigan Department of Labor and Economic Growth Bureau of Construction Codes. Variances from barrier free design provisions must be requested of the Barrier Free Design Board once approved by the University of Michigan Architecture, Engineering and Construction for submission.

Web site for Michigan Barrier Free Design Board:
http://www.michigan.gov/dleg/0,1607,7-154-10575_17551-46783--,00.html

Uniform Federal Accessibility Standards (April 1, 1988) as required to comply with Section 504 of US Rehabilitation Act of 1973 and Title II of Americans with Disabilities Act. Also note that the University maintains a space-by-space database of non-compliance with UFAS. Contact Architecture, Engineering and Construction for database information. Notice of UFAS corrections are to be reported to Architecture and Engineering Services for the purpose of updating the database.

Enforcing Agency -- All federal agencies (on complaint basis) for U.S. Rehabilitation Act of 1973, U.S. Department of Justice and Architectural and Transportation Barriers Compliance Board (on complaint basis) for Americans with Disabilities Act.

Web site for UFAS:
http://www.access-board.gov/ufas/ufas-html/ufas.htm

State of Michigan Dormitory Fire Safety Rules for Schools, Colleges and Universities (filed December 21, 1999) promulgated by the State of Michigan Bureau of Fire Services (incorporating by reference NFPA 101 – Life Safety Code 1997). Note that this standard applies only to fire compartments of buildings which contain dormitories. A listing of Ann Arbor campus buildings that contain dormitory space is included at the end of this section.

Enforcing Agency --

State of Michigan Department of Energy, Labor & Economic Growth
Bureau of Fire Services, Fire Safety Plan Review Division
525 W Allegan 4th Floor
Lansing, MI. 48913-0001
(517) 241-8847
Administrative rules web site:
http://www.state.mi.us/orr/emi/admincode.asp?AdminCode=Single&Admin_Num=02902001&Dpt=LG&RngHigh=

Application forms under Bureau Fire Services:
http://www.michigan.gov/documents/dleg_bccfs_plrvwinsp_87149_7.pdf

State of Michigan Fire Safety Rules for Schools, Colleges and Universities (filed July 14, 1989) promulgated by the State of Michigan Bureau of Fire Services (incorporating by reference NFPA 101 – Life Safety Code 1997). Note that this standard applies only to fire compartments of buildings which contain instructional space (classrooms and/or instructional laboratories). A listing of Ann Arbor campus buildings that contain instructional space is included at the end of this section.

Enforcing Agency --

State of Michigan Department of Energy, Labor & Economic Growth
Bureau of Fire Services, Fire Safety Plan Review Division
525 W Allegan 4th Floor
Lansing, MI. 48913-0001
(517) 241-8847
http://www.state.mi.us/orr/emi/admincode.asp?AdminCode=Single&Admin_Num=02901901&Dpt=CI&RngHigh=

Application form Bureau of Fire Services:
http://www.michigan.gov/documents/dleg_bccfs_plrvwinsp_87149_7.pdf

State of Michigan Human Services for Child Care in a Child Care Center promulgated by the State of Michigan Human Services. Note that this standard applies only to fire compartments of buildings which contain child care centers. A listing of Ann Arbor campus buildings that contain Child Care Centers is included at the end of this section.

Enforcing Agency --

State of Michigan Department of Human Services
PO Box 30759
Lansing, MI. 48909-8150
(517) 241-2488

Administrative rules:
http://www.state.mi.us/orr/emi/admincode.asp?AdminCode=Single&Admin_Num=40005101&Dpt=HS&RngHigh

State of Michigan Department of Labor & Economic Growth

Bureau of Fire Services, Child Care Section
300 N. Washington Square, 4th Floor
Lansing, MI. 48913

Application form for Child Care Plan Review:
http://www.michigan.gov/documents/cis/BFS13_child_care_app1_172799_7.pdf

Michigan Rehabilitation Code 2006

Enforcing Agency -- University of Michigan Architecture, Engineering and Construction.

State of Michigan Occupational Safety and Health Standards (MIOSHA) (filed many different dates) Contact U of M Department of Occupational Safety and Environmental Health for projects involving toxic and/or hazardous materials.
Additional information is at web site: http://www.oseh.umich.edu/pdf/guideline/guide_ep002.pdf
Enforcing Agency--

State of Michigan Department of Consumer & Industry Services
Bureau of Safety and Regulation
MIOSHA Standards Division
7150 Harris Drive (PO Box 30643)
Lansing, Michigan 48909-8143
(517) 322-1845

Web Site: http://www.michigan.gov/cis/0,1607,7-154-11407_15368---,00.html

United States Occupational Safety and Health Standards (OSHA) (filed many different Dates), which is Title 29 Part 1910 of the Code Federal Regulations. Contact UM Department of Occupational Safety and Environmental Health for projects involving toxic and/or hazardous materials.

Enforcing Agency -- United States Department of Labor.

State of Michigan Elevator Code (Adopted June 21, 2010)
(incorporating by reference the 2007 edition of ANSI A17.1– Safety Code for Elevators and Escalators and the safety rules for platform lifts and stairway chair lifts ASME A18.1 -2008, the safety code standard for inspection of elevator, escalators, and moving walks ASME A17.2 – 2007, the safety code standard for belt manlifts, ASME A90.1-2003, and the American National Standards Institute ANSI A10.4-2007 for personnel hoists and employee elevators for construction and demolition operations.)

Enforcing Agency --

State of Michigan Department of Labor & Economic Growth
Bureau of Construction Codes
Elevator Safety Division
Calvin W. Rogler, Chief Elevator Inspector
PO Box 30254
Lansing, MI. 48909
(517) 241-9337

Refer to Design Guidelines for additional requirements on Elevators.
Web site for State of Michigan Elevator codes:

http://www.michigan.gov/cis/0,1607,7-154-10575_17394_17420---,00.html

State of Michigan Mechanical Code 2009 Part 9a Mechanical Code Rules (Adopted Oct 21, 2010) (incorporating International Mechanical Code 2009 and Michigan amendments) promulgated by State of Michigan Department of Consumer & Industry Services, Bureau of Construction Codes.

Enforcing Agency -- University of Michigan Architecture, Engineering and Construction.

Web site for Part 9a:
http://www.state.mi.us/orr/emi/admincode.asp?AdminCode=Single&Admin_Num=40830901&Dpt=CI&RngHigh=

State of Michigan Plumbing Code 2009 Part 7 Plumbing Code Rules (Adopted Aug 20, 2010) (Incorporating International Plumbing Code 2009 and Michigan amendments) promulgated by State of Michigan Department of Consumer & Industry Services, Bureau of Construction Codes.

Enforcing Agency -- University of Michigan Architecture, Engineering and Construction.

Web site for Part 7:
http://www.state.mi.us/orr/emi/admincode.asp?AdminCode=Single&Admin_Num=40830701&Dpt=CI&RngHigh=

NFPA 13 – 2002 Sprinkler Systems. The 1996 edition of NFPA 13 is incorporated by reference in the edition of NFPA 101 incorporated by the current State of Michigan Bureau of Fire Services rules for Schools, Colleges, Hospitals, and Universities. The Bureau of Construction Codes and Fire Safety permits use of more current versions of NFPA 13 with some limitations. Contact the Bureau of Fire Services for specifics.

Enforcing Agency --

Project jurisdiction NFPA 101:
State of Michigan Department of Labor & Economic Growth
Bureau of Fire Services, Plan Review/Fire Safety
300 N. Washington Square
Lansing, MI. 48913
(517) 241-8847

Project jurisdiction MBC: University of Michigan Architecture, Engineering and Construction

NFPA 99C – Gas and Vacuum Systems (2005 edition): 99C Gas and Vacuum Systems contains the rules related to gas and vacuum piping systems from the NFPA 99

Enforcing Agency -- University of Michigan Architecture, Engineering and Construction.

State of Michigan Electrical Code 2008 Part 8 Electrical Code Rules (incorporating NFPA 70 – National Electrical Code (2008 edition) and Michigan amendments (adopted January 1, 2010) By local rule the following exceptions/modifications are applied to the Michigan Electrical Code:

Article 80: Article 80 of the Michigan Electrical Code does not apply..

Article 695.3: The requirements for power to electrically driven fire pumps, and the requirements for 'reliable power' will be determined by the University's High Voltage Engineer, on a case-by-case basis.

Articles 700.27 and 701.27: The University may deviate from full selectivity (coordination of emergency generator distribution systems in order to lower arc-flash energy levels for worker safety. All such deviations from full selectivity will be designed by, and reviewed by, registered professional engineers.

"Article 110.26©(3): The words "less than 7.6 m (25 ft) from the nearest edge of the working space" shall be deleted from this paragraph. The working space egress doors (the first door on each egress path) from equipment rated 1200 amps or more shall open outward and be equipped with a panic bar, even if it is 25 feet or more away."

"Article 310.15(B)(2)(c) and Table 310.15(B)(2)(c): The requirement for adjusting the ampacities of conductors in conduits exposed to sunlight on rooftops shall not be applied."

Enforcing Agency -- University of Michigan Architecture, Engineering and Construction.

Web site for Part 8:
http://www.michigan.gov/documents/dleg/dleg_bcc_electrical_code_rules_part8_2008_print_version_295688_7.pdf

NFPA 72 – National Fire Alarm Code (2002 edition)
The 1996 edition of NFPA 72 is incorporated by reference in the edition of NFPA 101 incorporated by the current State of Michigan Bureau of Fire Services Administrative Rules for New and Existing School, College, and University Fire Safety and Dormitory Fire Safety. The Bureau of Fire Services allows the use of new versions of NFPA 72 with some limitations. Contact the Bureau of Fire Services for specifics

Enforcing Agency --

Project jurisdiction NFPA 101:
State of Michigan Department of Labor & Economic Growth
Bureau of Fire Services, Plan Review/Fire Safety
300 N. Washington Square

Lansing, MI. 48913
(517) 241-8847

By local rule, smoke detectors that initiate an elevator recall are not to be connected to the fire alarm system. By local rule, smoke and heat detectors are not required above suspended ceilings.

Enforcing Agency –
Project jurisdiction MBC: University of Michigan Architecture, Engineering and Construction

Guide for the Care and Use of Laboratory Animals NIH Publications No. 86-23, revised 1996, promulgated by United States Department of Health and Human Services. Regulations of the Federal Animal Welfare Act 9, CFR Parts 1, 2 and 3.

Enforcing Agency -- University of Michigan Unit for Laboratory Animal Medicine.

Web site for Federal Animal Welfare Act 9 CFR Parts:
Parts 1 and 2: http://www.nal.usda.gov/awic/legislat/awafin.htm
Part 3: http://www.nal.usda.gov/awic/legislat/awadog.htm

Web site for the guide for the Care and Use of Laboratory Animals:
http://www.nap.edu/catalog.php?record_id=5140#toc

Refer to "Animal Facilities Design Criteria and Special Requirements" contained in The University of Michigan Design Guidelines.

State of Michigan Rules for Soil Erosion & Sedimentation Control Promulgated by the State of Michigan Department of Environmental Quality (MDEQ) Soil Erosion and Sedimentation Control Part 91 of Public Acts 451 of 1994 as amended. The University of Michigan Occupational Safety and Environmental Health (OSEH) department is approved by the MDEQ as an 'Authorized Public Agency' to enforce the soil erosion and sedimentation control on University of Michigan property. Refer to University of Michigan Design Guidelines Section 2 - Soil Erosion and Sedimentation Control for additional requirements.
Enforcing Agency:--
University of Michigan OSEH
Environmental & Hazardous Materials Management
1239 Kipke
Ann Arbor, MI. 48109-1010
(734) 763-4568

Corresponding web sites:
Soil Erosion and Sedimentation Control:
http://www.oseh.umich.edu/stormwater/emsec.html

BUILDINGS STANDARDS FOR UNIVERSITY OF MICHIGAN CONSTRUCTION THAT ARE REQUIRED FOR SUBSEQUENT LICENSING OF THE FACILITY

State of Michigan Rules for Construction or Renovation of Food Service Facilities
Promulgated by the State of Michigan Department of Agriculture (Food and Dairy Division). Act 92, Food Law of 2000 which incorporates by reference chapters 1 through 8 of the 2005 Food and Drug Administration Food Code. Visit the University of Michigan Department of Occupational Safety and Environmental Health website http://www.oseh.umich.edu/foodservice-planreview.html for instruction sheet information and a copy of the Plan Review Packet and Worksheet that must be completed prior to starting a project. The University of Michigan Occupational Safety and Environmental Health (OSEH) department is the enforcing agency with authorization provided by the Washtenaw County Environmental Health Department.

Enforcing Agency --

University of Michigan OSEH
Operational Safety & Community Health
1239 Kipke
Ann Arbor, MI. 48109-1010
(734) 647-1142

MDA Food Code and Food Law Information:
http://www.michigan.gov/mda/0,1607,7-125-50772_51200---,00.html

State of Michigan Rules for Construction or Renovation of Swimming Pools
Promulgated by the State of Michigan Department of Environmental Quality (Water Division). Michigan's Public Health Code, Public Act 368 of 1978, Part 125. Contact University of Michigan Department of Occupational Safety and Environmental Health for information. The University of Michigan Occupational Safety and Environmental Health (OSEH) department is the enforcing agency with authorization provided by the Washtenaw County Environmental Health Department

Enforcing Agency --

University of Michigan OSEH
Operational Safety & Community Health
1239 Kipke
Ann Arbor, MI. 48109-1010
(734) 647-1142

MDEQ Swimming Pool Information:
http://www.michigan.gov/deq/0,1607,7-135-3313_51087_3732---,00.html

Also see 15010 "Basic Mechanical Requirements" for additional codes and standards applicable to mechanical work on University projects.

State of Michigan Department of Natural Resources and Environment (MDNRE) (filed many different dates) Contact U of M Department of Occupational Safety and Environmental Health for information on environmental regulatory requirements. All project specific communication with the enforcing agency must be through or coordinated with the U of M Occupational Safety and Environmental Health department.

Coordinating Agency--

University of Michigan OSEH
1239 Kipke

Ann Arbor, MI 48109-1010
(734) 763-4568

OSEH Web Site: http://www.oseh.umich.edu//

Enforcing Agency--
Michigan Department of Natural Resources and Environment
525 West Allegan Street
P.O. Box 30473
Lansing, MI 48909-7973
(517) 373-7917

MDEQ Web Site: http://www.michigan.gov/deq

United States Environmental Protection Agency (USEPA) (filed many different dates), which is Title 40 of the Code Federal Regulations. Contact UM Department of Occupational Safety and Environmental Health for information on environmental regulatory requirements. All project specific communication with the enforcing agency must be through or coordinated with the U of M Occupational Safety and Environmental Health department.

Coordinating Agency--
University of Michigan OSEH
1239 Kipke
Ann Arbor, MI 48109-1010
(734) 763-4568

OSEH Web Site: http://www.oseh.umich.edu//

Enforcing Agency –
United States Environmental Protection Agency
Region 5 (IL, IN, MI, MN, OH, WI)
77 West Jackson Boulevard
Chicago, IL 60604-3507
(312) 353-2000

USEPA Web Site: http://www.epa.gov/

UNIVERSITY OF MICHIGAN BUILDINGS THAT CONTAIN INSTRUCTIONAL SPACE

SID-F

(Based on M-Pathways GQL database for rooms with type code 110 or 210)
Updated 6-2009

BLDG NO	BLDG NAME
5179	202 SOUTH THAYER
0332	300 N INGALLS BUILDING
0879	555 SOUTH FOREST BUILDING
0421	AERO ENG - WIND TUNNEL LAB (FA/FS only)
0425	AERO ENG - PLASMA RESEARCH (FA/FS only)
0422	AERO ENG - PROPULSION LAB (FA/FS only)
0168	ANIMAL RESEARCH FACILITY
0206	ANGELL HALL ADDITION-AUDITORIUMS
0175	ANGELL HALL ADDITION-HAVEN HALL
0197	ANGELL HALL ADDITION-MASON HALL
0152	ANGELL JAMES B HALL & TISCH HALL
0831	ARGUS II
0432	ART & ARCHITECTURE BUILDING
0395	BAGNOUD, FRANCOIS-XAVIER BUILDING
4016	BIOLOGICAL ST BLANCHARD
4010	BIOLOGICAL ST CORT LABORATORY
4018	BIOLOGICAL ST CREASER LABORATORY
4005	BIOLOGICAL ST FOREST LABORATORY
4011	BIOLOGICAL ST HOUGHTON LAB
4013	BIOLOGICAL ST HUNGERFORD LAB
4037	BIOLOGICAL ST LECTURE HALL
4019	BIOLOGICAL ST NEWCOMBE LAB
4015	BIOLOGICAL ST PETTINGILL LAB
4017	BIOLOGICAL ST REIGHARD LAB
4039	BIOLOGICAL ST SPARROW LABORATORY
4096	BIOLOGICAL ST STOCKARD LABORATORY
4012	BIOLOGICAL ST WELCH LABORATORY
5037	BIOMEDICAL SCIENCE RES BLDG (Auditorium)*
0407	BROWN, G G LABORATORY
0210	BUHL RES CEN FOR HUMAN GENETICS
0155	BURTON MEMORIAL TOWER
0226	CENTRAL CAMPUS REC BLD&BELL POOL
0158	CHEMISTRY
0443	CHRYSLER CNTR CONT ENGINEER ED
0138	COMPUTER&EXECUTIVE EDUCATION BLD
5092	COMPUTER SCIENCE & ENGINEERING BLDG
0403	COOLEY, MORTIMER E MEMORIAL
0189	DANA, SAMUEL TRASK BUILDING
0225	DANCE BUILDING
1015	DEARBORN ACADEMIC SUPPORT CENTER
1012	DB ADMIN & STUDENT ACTIVITIES BLDG
1020	DEARBORN CASL ANNEX & FAIRLANE APT
1080	DEARBORN COL ARTS SCIENCE & LETTERS
8049	DEARBORN COMMERCE PARK
1011	DEARBORN COMPUTER & INFOR SCIENCE
1013	DEARBORN ENGINEERING LAB BLDG
1076	DB ENVIRONMENTAL INTERPRET CTR
5128	DEARBORN FAIRLANE CENTER
1017	DB FIELD HOUSE AND WELLNESS CENTER
1078	DB PROFESSIONAL EDUCATION CENTER
1078	DEARBORN SCHOOL OF MANAGEMENT
1079	DEARBORN SCI BLDG-COMPUTING WING
1009	DB SCIENCE, CLASSROOM & ADMIN.MIN
1077	DEARBORN SOCIAL SCIENCES BUILDING
1060	DEARBORN UNIVERSITY CENTER
0165	DENNISON, DAVID M BUILDING
0162	DENTAL AND W K KELLOGG INSTITUTE
0447	DOW, HERBERT H BUILDING
0166	EAST HALL
0054	EAST QUADRANGLE
0221	EDUCATION, SCHOOL OF
0448	ELECTRICAL ENG & COMPUTER SCI BLDG
0424	ENGINEERING PROGRAMS BUILDING
0435	ENGINEERING RESEARCH BUILDING I
0436	ENGINEERING RESEARCH BUILIDNG II
0414	ENVIRONMENTAL & WATER RES ENG BL
1650	FLINT DAVID FRENCH HALL
1670	FLINT HARDING MOTT UNIV CENTER
1607	FLINT LAPEER ST ANNEX
1671	FLINT RECREATION BUILDING
1630	FLINT WM R MURCHIE SCIENCE BLDG
1662	FLINT UNIVERSITY PAVILION
1664	FLINT UNIV PAVILION ANNEX
1694	FLINT WILLIAM S WHITE BUILDING
0234	FRANCIS, THOMAS JR PUBLIC HEALTH
0179	HUTCHINS HALL
0429	INDUSTRIAL & OPERATIONS ENGIN BLDG
0324	KELLOGG EYE CENTER
0211	KRAUS, EDWARD HENRY BUILDING
0137	KRESGE BUSINESS ADMIN LIBRARY
0101	KRESGE HEARING RESEARCH
0183	LANE HALL
0400	LAY, WALTER E AUTOMOTIVE LAB
0150	LITERATURE SCIENCE AND THE ARTS (Third Floor)*
0188	LITTLE, CLARENCE COOK SCIENCE BLD
0059	LLOYD, ALICE C HALL
0154	LORCH HALL
8049	LP BUSINESS ADMIN 15041 COMMERCE
0406	LURIE, ANN AND ROBERT H BIOMEDICAL ENG
0982	MATTHAEI BOT GDNS RESEARCH-ADMIN
0190	MEDICAL SCIENCE UNIT I
0200	MEDICAL SCIENCE UNIT II
0207	MODERN LANGUAGES BUILDING
0440	MOORE, EARL V BLDG
0061	MOSHER-JORDAN HALL
0151	MUSEUM OF ART (Auditorium & Stair S5)*
0415	NAVAL ARCH & MARINE ENGINEERING
0178	NEWBERRY HALL
0196	NORTH HALL
5177	NORTH QUAD COMPLEX (Level 1 throughout & Level 2 North Tower)*
0851	KINESIOLOGY BUILDING (Stair S01, Rooms 1100, 2100, & 3100)*
5047	PALMER DRIVE COMMONS (SW end of 2nd floor)*
0890	PERRY BUILDING (G300)*
0442	PIERPONT COMMONS
0180	POWER CENTER FOR PERFORMING ARTS
0897	PUBLIC POLICY ANNEX
0208	RANDALL, HARRISON M LABORATORY
0813	REVELLI, WM D BAND REHEARSAL HALL
5188	ROSS SCHOOL OF BUSINESS
5120	ROSS, STEPHEN M ACADEMIC CENTER
0193	RUTHVEN, ALEXANDER G MUSEUMS BLDG
0333	SCHOOL OF NURSING BUILDING
0219	SCHOOL OF SOCIAL WORK BUILDING
0441	SPACE RESEARCH LABORATORY
5224	STAMPS AUDITORIUM
0445	STEARNS, FREDERICK BUILDING
0216	TAPPAN HALL
0209	TAUBMAN, A ALFRED HEALTH SCIENCES LIBRARY
5046	UNDERGRADUATE SCIENCE BLDG
0204	VAUGHAN, HENRY F PUBLIC HEALTH BL
5059	WALGREEN, CHARLES RJ DRAMA CENTER
5101	WEILL HALL, JOAN & SANFORD (1st & 2nd Flrs)*
0135	WYLY, SAM HALL
0167	WEST HALL

( )* Indicates compartment of jurisdiction. Note egress from compartment; fire alarm & fire suppression for entire bldg are under BFS.

UNIVERSITY OF MICHIGAN BUILDINGS THAT CONTAIN DORMITORY SPACE

(Based M-Pathways GQL database for rooms with type code 910, 919, 920, and 935)
Updated 6-2009

BLDG NO	BLDG NAME
0510	BAITS, VERA I EATON HOUSE
0511	BAITS, VERA I LEE HOUSE
0512	BAITS, VERA I PARKER HOUSE
0513	BAITS, VERA I SMITH HOUSE
0514	BAITS, VERA I STANLEY HOUSE
0515	BAITS, VERA II COMAN HOUSE
0516	BAITS, VERA II CONGER HOUSE
0517	BAITS, VERA II CROSS HOUSE
0518	BAITS, VERA II THIEME HOUSE
0519	BAITS, VERA II ZIWET HOUSE
0051	BARBOUR, BETSY HOUSE
0555	BURSLEY HALL
0120	CAMBRIDGE HOUSE (Compartment w/in MICHIGAN UNION)*
0109	COOK, JOHN P LAW QUADRANGLE
0052	COOK, MARTHA RESIDENCE
0053	COUZENS HALL
0054	EAST QUADRANGLE
0055	FLETCHER HALL
0057	HENDERSON, MARY B HOUSE
0108	LAWYERS CLUB
0059	LLOYD ALICE C HALL
0060	MARKLEY, MARY B HALL
0061	MOSHER-JORDAN HALL
0062	NEWBERRY RESIDENCE
5177	NORTH QUAD COMPLEX (North Tower levels 3 through 10)*
0040	OH GODDARD HALL
0042	OH ADELIA CHEEVER RESIDENCE
0043	OH GEDDES RESIDENCE
0044	OH JULIA E EMANUEL RESIDENCE
0046	OH L H SEELEY HALL
0045	OH PAMELA NOBLE RESIDENCE
0041	OH VANDENBERG HALL
0063	SOUTH QUADRANGLE
0064	STOCKWELL HALL
0886	TROTTER, WM MONROE HOUSE
0066	WEST QUADRANGLE

UNIVERSITY OF MICHIGAN BUILDINGS THAT CONTAIN CHILD CARE SPACE

(Based M-Pathways GQL database for rooms with type code 640, 645)
Updated 6-2009

BLDG NO	BLDG NAME
0333	SCHOOL OF NURSING BUILDING
8023	TOWSLEY CHILDREN'S HOUSE
5018	NCRC (N Campus Research Complex) B075 CHILD CARE CENTER
0390	UNIVERSITY HOSPITALS CHILD CARE CENTER
0600	NORTHWOOD COMMUNITY CENTER
1047	DEARBORN KINDERGARDEN MODULE

UNIVERSITY OF MICHIGAN BUILDINGS THAT CONTAIN PATIENT OVERNIGHT CARE SPACE

Updated 6-2009

BLDG NO	BLDG NAME
0325	W.K. KELLOGG EYE CENTER (Parkview Medical Center Building)
5102	BREHM TOWER (Eye Center Expansion) (Fourth Floor)*
0312	C.S. MOTT CHILDREN'S/WOMEN'S HOSPITALS / MCHC / HOLDEN / MOTT EXPANSION
0317	ALFRED TAUBMAN HEALTH CARE CENTER (THC)
0316	UNIVERSITY HOSPITAL (UH)
5109	CARDIOVASCULAR CENTER (CVC)
5173	C.S. MOTT CHILDREN'S HOSPITAL AND VON VOIGTLANDER WOMEN'S HOSPITAL (Scheduled opening in 2011)
0313	CONNECTOR between UH and MOTT adjacent to TOWSLEY

For more detailed boundaries for inpatient facilities in all buildings, please consult with UMHHC Design Manager.

COMMISSIONING

General

Most large or technically complex projects undergo a building commissioning process. The A/E is expected to fully support this process.

Commissioning (Cx) is a systematic process that ensures a project is designed to meet the needs of its Users, and is built, operated, and maintained as intended by its Project Team and the Users.

- Commissioning helps a project achieve its schedule, budget, and quality goals by utilizing the University's vast construction, operation, and maintenance experience to proactively identify and help resolve issues as early and inexpensively as possible.

- Commissioning verifies that completed systems and equipment perform as intended. It does not duplicate or substitute for Code Inspection. It does not provide routine quality control such as inspections for material substitutions or poor quality workmanship.

Commissioning generally begins during Programming and ends after Occupancy. The process is typically split into design-phase and construction-phase activities.

Commissioning focuses on the project's mechanical and electrical systems and equipment, and any "powered" architectural items.

The commissioning process is performed by a Commissioning Team typically consisting of the Project Director, the Design Manager during design or the Construction Manager during construction, and representatives from the A/E, General Contractor, Sub-Contractors, Users, and Plant Operations. The Commissioning Team and its activities are coordinated by a Commissioning Agent (CxA). The CxA reports to a Commissioning Supervisor (CxS) who is responsible for approving the commissioning results.

Related Sections

U-M Plant Extension Website Building Commissioning Documents:
Facilities Commissioning Specification
Generic Sample Commissioning Manual
Generic Commissioning Forms

U-M Design Guidelines Special Instructions to Designers:
SID-B - Design Intent Document

U-M Master Specification Sections:
01715 - Commissioning

Commissioning Activities

In general, new buildings and major building renovations undergo design-phase and construction-phase commissioning. Smaller projects undergo construction-phase commissioning only.

Design-Phase Commissioning

Design-phase commissioning typically begins during Programming and continues until the project is bid. The Commissioning Agent and members of the Commissioning Team:

- Participate in the mechanical and electrical (M&E) design coordination meetings and provide input to the A/E during design.
- Participate in the Owner's design reviews and provide written comments for response by the A/E.
- Participate in the value engineering effort and recommend cost saving measures.
- During the Construction Document phase, provide the A/E with a project-specific Commissioning Specification 01715. This specification lists the systems and equipment to be commissioned. The A/E shall review the list of items to be commissioned for completeness and incorporate the specification verbatim into the project technical specifications.

Construction-Phase Commissioning

Construction-phase commissioning begins as the construction documents are prepared for bid and continues through the first year of occupancy. The Commissioning Agent and members of the Commissioning Team:

- Provide the Contractor with a project-specific Commissioning Manual. This manual contains the commissioning checklists and test forms that the Contractor must complete as part of the commissioning process.
- Assist the Contractor in developing a detailed commissioning schedule. The Contractor shall incorporate this schedule into the project’s construction schedule.
- Review Contractor shop drawing submittals in parallel with the A/E. The A/E shall incorporate the Commissioning review comments as appropriate into their review comments, but not hold up the return of the shop drawings to the Contractor just for the Commissioning comments.
- Promote the use of construction mock-ups and other quality assurance techniques.
- Require adequate maintenance access to equipment.

The Commissioning Agent conducts periodic Team meetings and provides periodic commissioning reports.

The Contractor functionally tests systems in each mode of operation, under full and partial load, under normal, abnormal, and emergency conditions, and under peak seasonal conditions. The Commissioning Team witnesses and validates the functional testing. If any design-related issues are discovered, the A/E shall quickly provide resolutions.

The Commissioning Team documents quality control issues found during the commissioning process, preferably in some form of a project QC deficiency list, or otherwise in the commissioning reports. If any QC issues involve non-compliance with the design and the A/E is asked to resolve the issues, the A/E is expected to enforce the Contract Documents.

The Commissioning Agent assists with achieving Substantial Completion by coordinating the review of Operations and Maintenance Manuals and by coordinating the Owner training.

Mechanical and Electrical (M&E) Design Coordination

A few select new building projects undergo a Mechanical and Electrical (M&E) design coordination process in lieu of design-phase commissioning. In addition to the above design-phase commissioning tasks, the Commissioning Agent and members of the Commissioning Team:

- Direct the mechanical and electrical design. The A/E shall submit M&E issues to the Commissioning Agent, and the Commissioning Agent will provide M&E direction to the A/E. The Project Team shall be copied on all communications.

- Coordinate with the appropriate User, Department of Public Safety, OSEH, and Plant Operations personnel to obtain their input on the M&E design.

- Conduct M&E design coordination meetings at which the A/E's engineers present their drawings and specifications for detailed discussion. The Commissioning Agent provides the meeting agendas, invites the appropriate U-M personnel, and conducts the meetings. The A/E shall publish detailed meeting minutes for U-M review within two weeks.

- Resolve conflicting Owner’s review comments related to the M&E design, and assign action codes to the comments for resolution by the A/E.

- Identify special requests that are not cost effective or that exceed the project’s scope.

- Serve as the point of contact for the Owner's review of technical studies including studies on sound, vibration, smoke purge, effluent, and electrical capacity.

DRAWING AND CONSTRUCTION DOCUMENT STANDARDS

General

Prepare documents utilizing the standards below. Documents that the Architect/Engineer (A/E) is required to provide include but are not necessarily limited to the following:

- Construction Documents - Drawings.
- Base Drawings for Official U-M Floor Plans.
- Room Numbering Drawings.
- Record Drawings.
- Floor and Site Plans for Public Use.
- Construction Documents – Specifications.

References

University of Michigan Design Deliverables
University of Michigan Design Guidelines Preferred Manufacturers List (PML)
University of Michigan Design Guidelines Technical Sections
University of Michigan Master Specifications
University of Michigan Standard General Conditions
University of Michigan Supplemental General Conditions
University of Michigan Front End Documents
University of Michigan Standard Details

CAD Standards

The following are University of Michigan Architecture Engineering and Construction (AEC) drawing standards. At the beginning of the project coordinate specific project requirements with the Design Manager.

- Drawings shall be prepared on bond. Standard sheet size is 24 inches wide by 36 inches long. Other drawing sizes require the approval of the Manager of U-M Space Information (arranged through the Design Manager).

- CAD Format: Microstation is preferred. AutoCAD is acceptable.

- Provide one file per floor with no xrefs. Bind and insert and explode any xrefs.

- Explode/drop all attribute data to text using the Express tools or other method.

- Explode/drop all elements down to their basic element types: cells/blocks, lines, arc and polygons.

- Delete all unneeded elements from the file rather than the freezing or turning the layer off.

- Line work should be clean. There should not be duplicate or additional overlapping elements or gaps.

- Standard font is Windows True Type Tahoma 1/8” x 1/8”. The A/E must obtain approval from the Design Manager to provide a different font.

- Screening, shading, crosshatching, other indications of materials or locations, and text shall not obliterate significant information, and shall be capable of being reproduced without "bleeding" when the document is reduced to half size. Use screen patterns equal to or coarser than 50 percent, 50 line.

- • Drawing Information – include the following:

  - Include complete index to drawings on first or second sheet of the entire set and on first or second sheet of each series.

    When sheets are added or deleted during the course of construction, final Record Drawing set shall have the index updated to reflect the final documents.

  - Complete symbol and abbreviation legend(s) applicable to each series (where a series is a subset such as Architectural, Electrical, etc.) shall be included on first or second sheet of each series. It is not necessary to dedicate a whole sheet to legends. (Parts of the legend may be repeated on sheets throughout the sets or series as deemed appropriate by the A/E, but the legend on first or second sheet shall be comprehensive.

  - Scale shall be indicated by note and by graphic scale bar on each applicable drawing, detail and section. Any numbers or letters associated with the scale bar are to be a minimum 1/8 inch high. Where scale is applicable for entire drawing, scale references to be located near lower right corner of drawing.

  - Plan sheets shall have north arrows, and all plans shall be consistent in their north arrow orientation.

  - Plan sheets shall include a tagged column grid on all drawing series (civil, architectural, mechanical, etc.), at all design phases.

  - Where a portion of a plan or elevation appears on a sheet, a key plan shall be provided in the lower right portion of the drawing area to show the location of that portion relative to the whole.

  - Cross-reference all plans, elevations, sections, and details as applicable.

  - Floor live load capacities shall be listed on drawings.

  - Drawings shall clearly distinguish between existing, new, and replacement work.

- Title Block Content:
    - The University will identify the Project Title and project number, which the A/E shall put on each drawing.
    - Sheet title shall be as descriptive as possible, shall always be unique within the drawing set.
    - When submitting to the University any sheet with information not previously submitted, a note shall be included on one of the issuance lines on the title block, indicating purpose of submittal and date. This applies to design review and contract issuances as well as addenda, bulletins, etc. All such notations of issue shall remain on each sheet. In addition to the note on the issuance line, sheets which have already been released for bids shall have changes clearly delineated, by "clouding" or similar means.
    - The title block, located at the lower right corner of the sheet shall contain the following information:
        - University of Michigan building number and building name
        - University of Michigan project number and/or Plant work order number
        - Project title
        - Sheet title
- Plans and specifications issued for regulatory approval shall be sealed by the Architect or Engineer responsible for the work. Each drawing sheet is to include the name and address of the company primarily responsible for it content regardless of whether or not it is the prime design profession for the project.
- The title sheet shall list all applicable building codes for the project, including but not limited to the building code, the electrical code, the mechanical code and the plumbing code. The construction document drawings are to include all information required by the applicable codes to be present on the drawings. .

<u>Base Drawings for Official UM Floor Plans</u>

- Drawings shall be provided in CAD format.
- All full height wall lines shall be merged to a single A-WALL level, partial height walls merged to A-WALL-PRHT, all movable partitions to A-WALL-MOVE, all windows/glazing merged to A-GLAZ, all doors merged to A-DOOR etc.

- UM AEC Space Information and FIC maintains standards for Level/Weight/Color/Line. These are the only levels that should be used in floor plans. Contact the Design Manager to obtain a list of these standards.

Room Numbering Assignment Procedure

- Do not assign room numbers. UM Space Information is responsible for all room numbering. Submit floor plans for room numbers to the Design Managerr who will forward them to AEC-Floorplans@bf.umich.edu. Submittals of plans should be according to the following schedule:

- **Schematic Design:** Submit pdf's of floor plans for initial room numbering assignments. Plans should display only walls, doors, windows, structural, stairs and toilet rooms. Remove all architectural symbols, references, column lines etc.

- **Design Development/CD Phase:** Submit pdf's showing any architectural changes (walls, doors openings) along with room numbers as assigned at Schematic phase. Indicate areas that have been changed with revision bubbles.

- **Bid/construction Phase:** Provide CAD files of all architectural floor plans for UM to begin creation of official UM floor plans. Include one elevation or section drawing (CAD or pdf) indicating all floor elevations. These drawings will become the base plans for **Official UM Floor Plans (Key Plans)**.

Record Drawings

- The A/E shall require that the contractors submit "Record" drawings for the project at hand and shall revise the permanent record drawings to reflect the as-built changes.

- Submit both a bond copy and an electronic copy of record drawings.

- In addition to a record set of PDFs or TIFFs, include CAD files for all disciplines. Each file should have layers displayed as printed for the Construction Set.

Floor and Site Plans – Public Use

Floor Plans

- Floor plans ***should*** contain:
  - Walls
  - Doors
  - Windows
  - Stairs
  - Elevators.

- Floor Plans ***may*** contain:

    - Fixed furniture in class rooms, offices, conference rooms, and laboratories (but ***should not*** contain labels identifying any fixed furniture in these areas)
    - Restroom fixtures
    - Thematic room type floor plans (See Color & Label Guideline below for suggested colors and labels.)
    - Thematic department floor plans, ***with the exception of following***, all of which should be labeled as “Support Departments:”
        - Unit for Laboratory Animal Medicine (ULAM)
        - Plant Operations spaces, such as Mechanical, Maintenance, or Custodial

- Floor Plans ***should not*** contain:
    - Utility tunnel information (tunnel walls, doors to tunnels, and/or access hatches)
    - Mechanical equipment, piping layouts
    - Card access control system information (card reader and control panel locations, and wiring diagrams)
    - Security system information (security sensor, camera, video recorder and control panel locations, and wiring diagrams
    - Columns and column lines

Site Plans

Site plans should not contain any reference (visual or textual) to utility tunnels, roof access or mechanical and electrical spaces.

Document Format

- Provide one *pdf* file per floor.

- The original size should be either 8.5” x 11” or 11” x 17”.

Color & Label Guideline

A guideline is provided in the Appendix to assist A/Es and is not a requirement.

Direct questions regarding plans for public use to:

Manager, Space Information & FIC
The University of Michigan
Architecture, Engineering & Construction
(734) 615-9023

Specifications Requirements

General

AEC maintains within its Design Guidelines both a Preferred Manufacturers List and Technical Sections. These components of the Design Guidelines reflect the needs and experiences of the University in regards to the specific equipment being addressed. The A/E shall select manufacturers from the list that are able to supply the products needed for the given project and whenever possible shall include at least three acceptable manufacturers. The Preferred Manufacturers List shall not substitute for the A/E's professional judgment. In the unusual circumstance where the listed products are not suitable, the A/E must present cogent justification for using other products and must obtain the written approval for these products from the Design Manager. The A/E shall incorporate the standards in the Technical Sections in the project specifications.

University Architecture and Engineering maintains a Master Specification for use by in-house designers. A/Es may use these specifications, but must edit these specifications to make them project specific. However, they should not substitute these specifications for their professional judgment regarding the requirements of each individual project. Use of these specifications will not relieve the A/E from the obligations of the contract, stated or implied, that pertain to their performance or the performance of their product.

The general requirements (Division 1) and technical portions (Divisions 2 through 16) of the specifications may be included on drawings, or in book (project manual) form. Generally, projects with anticipated construction costs of more than 1 million dollars are required to take the project manual approach. Consult with the Design Manager.

On small projects, produce specifications on drawings as follows:

- Arrange Division 1 general requirements and Division 2 through 14 technical specifications at the head of Architectural trade drawings.
- Arrange Division 15 technical specifications at the head of Mechanical trade drawings.
- Arrange Division 16 technical specifications at the head of Electrical trade drawings.

Project manuals must contain Front End Documents in addition to general requirements and technical specifications. See paragraphs below titled "University of Michigan Standard General Conditions" and "Other Standard Documents".

Specification Standard: The University recommends compliance with the principles and practices outlined in the CSI Manual of Practice.

Use of the 3-Part Section Format is mandatory.

Use of the Page Format is encouraged, but is not mandatory.

Use the 1995 CSI MASTER FORMAT Section numbers and titles for organizing Documents and specifications within Project Manuals. Comply with guidelines for contents of each Division and Section of the specifications.

Language and Terminology

Compliance with the recommendations of Manual of Practice Chapter 4 "Specification Language" is strongly encouraged. The following requirements are mandatory:

Write specifications as if addressed to the General Contractor. Do not address specifications to "This Contractor" or "The subcontractor." Where specific parties must be referred to for clarity, use language similar to the following: "Engage a licensed Professional Engineer to perform calculations," or "Require Installer to examine substrate prior to installation."

Eliminate the term "by others" from drawings and specifications. If work is not part of the Contract, say so directly using (N.I.C.) or similar constructions. If, for example, a mechanical item is shown on an architectural sheet for clarity, use the phrase "work of Division 15" or "by mechanical trades."

Eliminate the term "or equal" from specifications. The University requires Contractors to bid only products specified as "approved." List not less than three alternative, equivalent manufacturers for each generic product specified, unless no other equivalent products exist.

University of Michigan Standard General Conditions

The University maintains its own Standard General Conditions and Supplemental General Conditions. Obtain a copy of these documents and make sure the specification writer is fully familiar with it.

In general, Special Conditions are not required. However an A/E may wish to modify language concerning shop drawing review or other items. Coordinate use of Special Conditions with the Design Manager.

Other Standard Documents

The University maintains a series of standard documents coordinated with the Standard General Conditions.
FED-A: Front End Documents - Project Manual: Introduction
FED-B: Standard FED Masters - Project Manual
FED-C: Agreement Between Contractor and Owner for Construction
Consult with the Design Manager to obtain further information.

Appendix - Thematic Floor Plan Standards

Circulation	**010**	
Classrooms	**100s**	
Classroom	110	
Classroom Service	115	
Laboratory Facilities	**200's**	
Laboratories	210, 220, 250	Do not label or distinguish between Class, Open and Research Laboratories
Laboratory Service	215, 225, 255	
Office Facilities	**300's**	
Office	310	
Office Service	315	
Conference Room	350	
Conference Room Service	355	
Study Facilities	**400's**	
Study	410	Use single color for these four room types. Use text and/or furniture layout to distinguish the room types.
Stacks	420	
Study / Stacks	430	
Processing	440	
Study Service	455	
Special Use Facilities	**500's**	
Athletic or Physical Education	520	Use text to distinguish between the different room types in this section
Spectator Seating	523	
Athletic or Physical Education Service	525	
Media Production	530	
Media Production Service	535	
Demonstration	550	
Demonstration Service	555	
Greenhouse	580	
Greenhouse Service	585	
Armory, Armory Service	510, 515	Contact UM Design Manager or Manager of Space Information for directions.
Clinic, Clinic Service	540, 545	
Field Building	560	
Animal Quarters, Animal Quarters Service	*570, 575*	*Place in Support Facilities (700's)*
General Use Facilities	**600's**	
Note: If the building is primarily a general use building (e.g., Student Union) contact the Manager for Space Information for a more detailed Color Legend.		
Assembly	610	Optional labels: Theater, Concert Hall, Chapel, etc.
Assembly Service	615	
Exhibition	620	Optional labels: Museums, Gallery, etc.
Exhibition Service	625	
Food Facility	630	Optional labels: Dining Hall, Cafeteria, Snack Bar, Restaurant, etc.
Food Facility Service	635	
Day Care	640	
Day Care Service	645	
Lounge	650	
Lounge Service	655	
Merchandising	660	Optional labels: Bookstore, Post Office, Ticket Office, Travel Office,
Merchandising Service	665	
Recreation	670	Optional labels: Exercise Room, Weight Room, Billiards Room, Game
Recreation Service	675	
Meeting Room	680	
Meeting Room Service	685	

	Support Facilities	**700's and additional Room Types**	
	Central Computer or Telecom & Service	*710, 715*	***These spaces should not be labeled nor should they contain any fixed furniture or mechcanical information.***
	Shop & Service	*720, 725*	
	Central Storage & Service	*730, 735*	
	Vehicle Storage & Service	*740, 745*	
	Central Service & Service	*750, 755*	
	Hazardous Materials & Service	*760, 765*	
	Animal Quarters & Service	*570, 575*	
	Building or Custodial Services	*020*	
	Mechanical Rooms (including void spaces)	*030*	
	Unfinished or Shell Space	*070*	
	Health Care Facilities	**800's**	
	Patient Room	810, 815, 820	Patient Room, Patient Room Service and Patient Bathrooms
	Patient Service	830, 835	Nurse Station & Service
	Patient Treatment & Examination	840, 845	Surgey & Service
	Patient Treatment & Examination	850, 855	Treatment/Examination & Service
	Patient Treatment & Examination	860, 865	Diagnostic Service Lab & Support
	Patient Treatment & Examination	870	Central Supplies
	Public Waiting Room	880	
	Residental Facilites	**900's**	

Contact UM Design Manager or Manager of Space Information

REGULATED AND HAZARDOUS MATERIALS

General

This section addresses the management and disposal of regulated and/ or hazardous materials that may be encountered in construction projects. University of Michigan (U-M) policies require proper management of regulated, hazardous and other construction waste to comply with local, state and federal regulations and to encourage environmental stewardship. Construction materials and waste included in this section are: asbestos containing materials (ACM), CFC & HCFC containing refrigerants, lead, mercury, PCBs, radioactive materials and miscellaneous regulated construction waste. A/Es should be aware that individual projects may encounter other materials requiring special handling that are not outlined in this section. The A/E shall work with the University Project Coordinator to identify a list of materials which are hazardous, regulated and/or require special handling and which are likely to be encountered during demolition and construction.

Related Sections

Design Guideline Technical Sections:
15515 - Hydronic Specialties

U-M Master Specification:
01140 - Work Restrictions
13280 - Asbestos Abatement
13281 - Abatement of Asbestos-Containing Floor Tile
13282 - Asbestos Abatement (Roofing Projects Only)
13285 - Lead Products Removal and Disposal
13286 - Lead Products Removal and Disposal (Child Care Facilities and Residential Projects)
13288 - Regulated Construction Waste Removal, Staging and Disposal
15250 - Mechanical Systems Insulation
15515 - Hydronic Systems and Specialties
16010 - General Electrical Requirements

References

United States Department of Labor, Occupational Safety and Health Administration (OSHA), 29CFR Part 1926: Asbestos in Construction Standard

U-M Occupational Safety and Environmental Health (OSEH) "Asbestos Management Program." (http://www.oseh.umich.edu/guidacm.pdf)

U-M OSEH "Spill Prevention Control and Countermeasure Plan & Pollution Incident and Prevention Plan" (http://www.oseh.umich.edu/SPCC-PIPP.pdf)
Section 2.6 "Best Management Practices for Lithium Bromide Systems."
Section 2.7 "Best Management Practices for Ethylene Glycol Systems."

U-M OSEH "Lead and Lead-Based Paint Policy and Guidelines."
http://www.oseh.umich.edu/topics_lead.html

United States Department of Labor, Occupational Safety and Health Administration, 29CFR Part 1926.62 and State of Michigan Occupational Safety and Health Administration (MIOSHA) Rule 325.51991-51992: "Lead in Construction."

United States Environmental Protection Agency EPA 40 CFR 745 "Requirements for Lead-Based Paint Activities in Target Housing and Child-Occupied Facilities;" and "Requirements for Hazard Education Before Renovation of Target Housing;" and "Identification of Dangerous Levels of Lead."

Lead Abatement Act (Michigan Part 54A).

Lead Remediation Rules (MCDH Rule 325).

ASHRAE Standard 15 and Related Revisions: Safety Code for Mechanical Refrigeration.

ASHRAE Standard 34 and Related Revisions: Number Designation and Safety Classification of Refrigerants.

United States Environmental Protection Agency (US EPA) requirements of Section 808 (Prohibition of Venting and Regulation of CFC).

MI Public Act 451, Part 121: Liquid Industrial Waste.

Michigan Department of Environmental Quality (MDEQ), Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451.

Michigan Department of Environmental Quality (MDEQ), Part 55, Air Pollution Control, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Act 451).

Asbestos and Asbestos-Containing Materials (ACM):

Introduction

The current OSHA asbestos standard requires that products used in the workplace be labeled if they contain greater than 1% asbestos and are likely to result in exposures above the permissible exposure limits during reasonable foreseeable use, handling, storage, disposal, processing, or transportation. Material Safety Data Sheets may contain one of the following synonymous names:

Chemical Name: Magnesium Silicate
Mineral Names: Chrysotile, Amosite, Tremolite, Crocidolite, Anthophyllite, Actinolite
Common Names: serpentine, amphibole, fibrous grunerite

ACM in Renovation Projects

Many U-M buildings contain ACM, particularly those constructed before the early 1980's. Prior to renovation activities all buildings, ***including those built after the 1980's,*** must be surveyed for asbestos containing materials. Contact U-M OSEH well in advance of the project to coordinate a survey of building materials for asbestos. Some U-M buildings have already been surveyed for asbestos containing materials. U-M OSEH maintains an ACM database for all U-M buildings previously surveyed for asbestos. OSEH conducts additional tests where required to identify additional ACM note already identified in the database. At U-M, some ACM is labeled in the field, but in many cases, labeling is impractical. Labeling of ACM, if deemed necessary, is generally conducted by OSEH.

In general, U-M strives to remove ACM, as opportunities present themselves. At a minimum, projects that require some abatement are responsible for minimum required abatement. In some cases abatement may be expanded to address all ACM of a certain type in a certain area. Coordinate ACM abatement scope with U-M Project Coordinator and OSEH.

In many cases asbestos abatement projects are designed and conducted by the University, and the University contracts separately for asbestos abatement. Therefore the A/E involved with the design of a renovation project may not be required to include asbestos abatement specifications in the Bid Documents. However, A/Es must make the University Project Coordinator aware if they suspect that asbestos may be encountered due to project activity. In addition, the A/E should advise the Contractor on the construction documents that asbestos may be present in the area or adjacent areas of the renovation project, and to conduct their work accordingly.

Refer to U-M Master Specification Section 15240 regarding reinsulation of abated mechanical insulation.

ACM in New Construction

U-M does not permit the use of new ACM in construction projects. A/Es should be aware that asbestos-containing products may still be legally manufactured, imported and sold in the United States, although very limited quantities are probably produced. Legal products include but are not limited to floor tile, floor tile adhesive, sealants, plaster, and roofing materials. Because of the possibility of encountering ACM, prohibitory language should be added to specification sections covering materials which might contain asbestos.

In the event that a particular performance requirement is identified that can only be satisfied by the use of ACM, the A/E should contact OSEH through the University Project Coordinator and submit a written request for authorization. Approval for new ACM usage must be obtained prior to specification and installation. If approval is received, proper documentation will be coordinated with OSEH.

CFC & HCFC-Containing Refrigerants:

The University requires that all work related to refrigerant contained in chillers, cooling coils, air conditioners, and similar equipment, including related piping, be handled in strict accordance with the referenced standards. A/Es should advise contractors of these requirements. In addition, the University has tracking procedures in place for CFC and HCFC refrigerants. When new refrigeration equipment is installed, when old refrigeration equipment is removed, or when refrigerant is disposed of, include language in the Contract Documents directing the Contractor to inform the Owner's Plant Operations Air Conditioning Shop. Refer to U-M Master Specification Section 01140. Copies of the required form are available at:
http://www.plant.bf.umich.edu/utilities/operations-engineering/CFC_Form.pdf

Recovered refrigerant shall be handled through the U-M Plant Operations Air Conditioning Shop. Direct the Contractor to contact the Plant Operations Air Conditioning Shop to properly handle the recovered refrigerant. In most cases, U-M A/C Shop will remove refrigerant for reclamation.

Ethylene Glycol

Ethylene glycol systems are used on campus in some heating, ventilation and air-conditioning systems. Ethylene glycol is regulated by the State of Michigan as a Liquid Industrial Waste. Consequently, the Contractor's disposal methods are subject to the oversight of U-M OSEH. Where mechanical devices or systems containing ethylene glycol are indicated to be demolished, direct the Contractor to legally dispose of ethylene glycol. The Contractor shall contact U-M OSEH Environmental and Hazardous Materials Management Program (734-763-4568) in the event of an accidental spill of ethylene glycol.

Refer to U-M Design Guideline Technical Section 15515 and U-M Master Specification 15515 for design and installation requirements for glycol systems.

Lithium Bromide

Lithium bromide is used on campus in most absorption chillers. Lithium bromide within these systems is contained within the machinery and does not circulate throughout the building. Where absorption chillers are indicated to be demolished, contact the U-M Plant Operations Air Conditioning Shop to determine whether the recovered lithium bromide can be used in other machinery.

If it is determined that the lithium bromide cannot be used in other machinery and it is to be disposed of, it is subject to regulation by the State of Michigan as a Liquid Industrial Waste. Direct the Contractor to coordinate removal activities with UM OSEH's tracking program and to legally dispose of lithium bromide. The Contractor must contact U-M OSEH Environmental and Hazardous Materials Management Program (734-763-4568) in the event of an accidental spill of lithium bromide.

Lead

Lead may be a component of building materials in many campus buildings. Materials likely to contain lead include latex and oil based paints (especially paints manufactured before 1978), radiation shielding materials, plumbing joints, solder, pipe wrap, flashing and other materials used as soundproofing. Construction activities that may result in lead exposure include sanding, scraping, cutting, grinding, welding and demolition. The University Project Coordinator will arrange to have a lead survey completed early in the design process, through U-M OSEH.

Procedures for working with lead-based paint (LBP) and other lead-containing material (LCM) depend on the type of work being completed and the type of building in which the work is occurring. Of particular concern are construction projects that create lead disturbances in child-occupied facilities (child care centers and family housing). For projects in or affecting child-occupied facilities, A/Es should work with the University Project Coordinator and OSEH early in the design process to develop custom specifications addressing specific project conditions and additional state and federal regulations.

For other University buildings, Master Specification Section 13285 outlines the University policy and procedures that have been developed in conjunction with OSEH to meet all applicable local, state and federal regulations for non-child occupied facilities.

Use of LCM in New Construction

The University discourages the use of new LCM in construction projects. In the event that a particular performance requirement is identified that can only be satisfied by the use of LCM, the A/E should contact OSEH through the University Project Coordinator and submit a written request for authorization. If approval is received, proper documentation will be coordinated with OSEH.

Lubricant or Other Oils

Introduction and Policy

Oils are regulated by the State of Michigan as a Liquid Industrial Waste. Consequently, the Contractor's disposal methods are subject to the oversight of UM OSEH. Where mechanical devices that contain lubricant or other oils are indicated to be demolished, direct the Contractor to legally dispose of the oils. The Contractor must contact UM OSEH Environmental and Hazardous Materials Management Program (734-763-4568) in the event of an accidental spill.

Mercury

Mercury-containing articles and equipment likely to be encountered during construction include but are not limited to controls, thermometers, thermostats, switches, manometers and gauges. Fluorescent laps also contain mercury. See paragraph below regarding lamp recycling.

Mercury-containing articles and equipment are considered regulated construction waste and must be disposed of through the OSEH Environmental and Hazardous Materials Management Program. OSEH will package, pickup and dispose of properly staged Regulated Waste at no cost to the Contractor.

A/Es should direct the Contractor to handle mercury-containing articles and equipment with extreme care to prevent the release of elemental mercury. Mercury-containing articles and equipment must be properly packaged with adequate cushioning in only OSEH-provided containers. In the case of an accidental spill of elemental mercury, the affected area must be immediately evacuated, closed to traffic and OSEH or DPS contacted for clean-up.

PCBs

Bulk Product Waste

PCB (Polychlorinated Biphenyl) bulk product waste refers to waste derived from manufactured products containing PCBs in a non-liquid state. This includes applied dried paints, varnishes, waxes, or other similar coatings or sealants. The University Project Coordinator will arrange to have a PCB survey completed by UM OSEH early in the design process.

A/Es shall direct Contractors to dispose of PCB-containing waste in coordination with OSEH. There are no specific requirements for containerizing or segregating PCB bulk product waste, if the concentration of PCB's is less than 50 parts per million (ppm). It can be disposed with other construction debris in a municipal or non-municipal non-hazardous waste landfill licensed by the State of Michigan, Department of Environmental Quality. If the concentration of PCBs in the waste is greater than 50 ppm, it must be collected by UM OSEH for disposal. Coordination is required, since OSEH must notify the landfill, 15 days in advance, of the type of waste to be disposed. A PCB concentration less than 50 ppm does not require notification.

Liquid Waste (Older Electromagnetic Ballasts)

Older electromagnetic ballasts may contain liquid PCBs. A/Es shall advise the Contractor that the University requires recycling of all fluorescent lighting ballasts, along with tubular fluorescent, compact fluorescent and HID lamps as a part of the OSEH's Environmental Stewardship program. Master specification section 16010, "Basic Electrical Requirements" outlines proper packaging and pick-up requirements for fluorescent lamps and ballasts. Leaking electromagnetic ballasts shall be packaged separately from intact ballasts to avoid contamination. Contractor shall coordinate proper handling, packaging and decontamination of surrounding materials with OSEH for all leaking ballasts. Electronic ballasts do not contain PCB's and are to be packaged separately from electromagnetic ballasts.

Radioactive Materials

Common construction waste that may contain low levels of radioactivity includes but is not limited to smoke detectors and self luminescent exit signs.

Construction waste containing any level of radioactivity must be disposed of through the OSEH Environmental and Hazardous Materials Management Program. OSEH will package, pickup and dispose of properly staged Regulated Waste at no cost to the Contractor. A/Es should advise Contractors to handle and package self luminescent exit signs with extreme care. They contain fragile glass tubes filled with a radioactive gas, and care must be taken not to break the glass during demolition and recycling. Collect the frame of the exit sign as it may contain sign specific information. For radioactive smoke detectors, collect both the top and the bottom of the unit.

There are research laboratories on campus that use radioactive materials. When a lab that uses radioactive materials relocates or discontinues radioactive research, the lab will undergo a strict decommissioning process in coordination with OSEH Radiation Safety Services. If an A/E suspects that the radioactive materials may have been present in an area which will undergo renovation, immediately notify the University Project Coordinator, who will contact OSEH in order to schedule decommissioning. This process will be completed before a construction project is undertaken.

Regulated Construction Waste

The term "Regulated Waste" refers to building equipment or materials that will be demolished as part of a renovation or construction project, but cannot be disposed of as typical construction and demolition debris. Materials include but are not limited to the following:

- Batteries, including but not limited to lead-, nickel- and or mercury-containing batteries from exit signs, smoke detectors and backup power sources.
- Containers of paint and paint related materials, cleaners, pesticides, compressed gas cylinders and portable fuel cans.
- Fire extinguishers.

OSEH will package, pickup and dispose of properly staged Regulated Waste at no cost to the Contractor, provided that the waste has actually been removed from UM buildings. A/Es should instruct the Contractor to Contact OSEH Environmental and Hazardous Materials Management Program (734-763-4568) to schedule a pickup immediately after regulated waste has been staged. Incidental Regulated Waste that is not removed from UM buildings must be properly disposed of by the Contractor.

Suspect Contaminated Soil, Groundwater, or Unknown Material

During work activities, if suspect contaminated soil, groundwater, or other unknown material is encountered, the suspect material must be characterized to determine if special handling, or disposal protocol is required. Suspect contaminated soil may exhibit chemical or unusual odors, staining, unusual coloring, and/or contain man-made debris. Suspect contaminated groundwater may exhibit chemical or unusual odors, unusual coloring, and/or sheen.

A/Es shall direct the Contractor that if suspect contaminated soil, groundwater, or other unknown material is encountered, they shall immediately cease all excavation, dewatering, transport, or disturbance of the suspect material, and they shall contact the U-M Project Manager and U-M OSEH (763-6973) immediately. Direct the Contractor not to resume activities until given direction by the U-M Project Manager.

Bulk Chemical Storage (tanks and drums)

Secondary containment is required for all chemical or oil bulk storage (drums or tanks) according to the MDEQ, Michigan Part 5 Rules and the Ann Arbor Sanitary Sewer Ordinance.

Some options for secondary containment include building a berm (curb), using double wall tanks or using spill pallets. The University considers it preferable to construct a permanent berm rather than using spill pallets.

The secondary containment must have the capacity to hold the volume of the largest container or 10% of the combined containers, whichever is larger. If the room has no floor drains, and if the required volume can be completely contained without escaping through cracks in the floor and pipe penetration, over thresholds, etc., then the room itself may be considered sufficient secondary containment. If the room is considered the secondary containment ensure there is a lip at the door so no liquids can exit the room in the event of a leak. Consider use of leak detection and alarm for the secondary containment, depending on hazard posed, and on likelihood that a leak will be observed within in reason period of time.

UNIVERSITY PROVIDED UTILITIES

General

This section describes building utilities associated with U-M facilites.

Related Sections

Special Building Areas:
SBA-H Tunnels

U-M Design Guideline Technical Sections:
15680 – Chilled Water Systems
15681 – Water Chillers

Utility Distribution Overview

The University distributes electricity to the Central, Medical, and North Campuses and parts of the Athletic/ South Campuses.

Central Campus Utilities provided by the University's Central Power Plant include:

- Electricity
- Low pressure Steam (minimum of 6 psig)
- Medium pressure steam (60 psig, 350°)
- Steam Condensate
- Compressed Air (90 psig, maximum of 20F pressure dewpoint)
- Domestic hot water (50 psig, 125°F, softened to maximum of 40 grains)

Pressures specified are at the utility building entrance.

In parts of the Athletic and South Campus, medium pressure (60 psig) steam with condensate return is provided from the University's Hoover Street Power Plant.

Other facilities may have regional or local steam systems capable of providing adequate capacities. Steam pressures may vary for these systems. Where these capacities exist, the proposed facility shall utilize them. Coordinate facility loads and intent with the U-M Project Coordinator. Utilities and Plant Engineering, through the Project Coordinator, will determine and provide the locations and capacities of existing systems.

University Provided Utilities Applications

Central Campus Steam

Low pressure steam should be used for building heating and humidification loads and for some absorption chiller cooling, because of the economy of generation and cogeneration in the Central Power Plant. Refer to Design Guideline 15680 and consult with U-M Project Coordinator before deciding on chiller type (absorption or electric).

Because of power plant economy, Central Campus Medium Pressure (60 psig) steam use is generally limited to the following applications:

- For critical buildings such as research labs and medical clinics, where sufficient 60 psig steam capacity is available, 60 psig steam via a pressure regulating valve should be used to provide redundancy to the building low pressure steam supply during interruptions.
- Special equipment, such as sterilizers.
- Multi-zoned application of “clean steam” humidifiers. “Clean steam” is defined as the steam generated from campus steam via a heat exchanger, using high purity water for makeup. Single zone clean steam shall be generated from 6 psig steam, but where multiple and separately controlled building zones must be fed from a single steam generator, 60 psig steam may be used.

60 psig steam shall not be used to boost existing nominal 6 psig steam pressure to higher pressures.

Steam Condensate

Central Campus condensate from low pressure and medium pressure steam shall be vented to atmosphere and pumped to the campus distribution system at minimum 30 psig pump pressure. South/ Athletic Campus condensate shall be similarly returned to the Hoover Boiler Plant.

Domestic Hot Water – Central Campus

New domestic hot water (DHW) connections on Central Campus should not make use of the central campus domestic hot water return (DHWR) system. Provide DHWR and return water re-heating system internal to the building, typically using low pressure steam and a shell and tube heat exchanger. Refer to Spaecial Building Areas SBA-H Tunnels. Provide RPZ backflow preventer on DHW as it enters the building.

Chilled Water - Regional Plants

Chilled water from regional chilled water plants is available at some locations on North Campus and Central Campus. Where it is available, it should be utilized. A connection fee/ Capacity Reserve Charge is required. Contact the U-M Utilities and Plant Engineering Department through the Project Design Coordinator for direction. Refer to Design Guideline Sections 15680 and 15681.

Metering

The following utilities shall be metered in accordance with methods and means specified in other sections of the Design Guidelines:

- Electricity
- Central Campus Steam Condensate
- Steam, where humidification loads are greater than 500 pounds of steam per hour.
- Chilled water from regional plants – flow and BTU metering.

Where a regional chilled plant is part of a facility, metering or sub-metering shall be provided to measure the utilities consumed by the plant separately from the building metering.

Domestic Cold Water, cooling tower make-up water and cooling tower blow down, and irrigation water shall be metered separately in accordance with the City of Ann Arbor standards.

Domestic Hot Water (from Central Campus system) does not require metering as it enters the building.

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SUSTAINABLE DESIGN AND LEED® REQUIREMENTS

Introduction

The University of Michigan is committed to environmental stewardship and promotes implementation of sustainable design concepts. Many of these concepts are incorporated directly into various sections of the U-M Design Guidelines and Master Specifications. This section addresses additional requirements with respect to sustainable design and LEED requirements.

Related Sections

U-M Design Guidelines:
Design Deliverables
SID-B Design Intent Document
SID-D Energy and Water Conservation

Related Documents:
LEED Reference Guide for Green Building Design and Construction

Sustainable Design Requirements for All Projects

Prior to beginning Schematic Design, clarify the design objectives with respect to sustainable design, in conjunction with the U-M Design Manager. It is the University's expectation that sustainability be a consideration for all projects.

Existing LEED Certified Buildings

Projects within LEED certified buildings shall be implemented so as not to jeopardize sustainable design and the LEED certification. Click here for a complete list of LEED certified buildings.

LEED Requirements

Non-Clinical Buildings and Additions over $10M construction cost (new construction only)

All new non-clinical buildings and additions with an estimated construction budget greater than $10 million will be designed to achieve a minimum of Leadership in Energy and Environmental Design (LEED) **Silver certification** using the appropriate rating system. Certification shall be obtained from the U.S. Green Building Council (USGBC®).

In rare cases, projects may be exempt based on special building considerations:

(a) Exceptions will be granted rarely and based on unusual building requirements driven by programmatic needs, such as specialized HVAC system requirements, specialized laboratories or high performance computing facilities with extreme energy requirements, and for specialty buildings outside the realm of the LEED rating systems.

(b) Requests for exemption must be justified in writing, reviewed by the Associate Vice President for Facilities and Operations, and approved by the U-M Sustainability Executive Council.

(c) Health system clinical buildings are exempt from this policy pending the availability of future LEED rating systems for healthcare facilities.

All projects pursuing LEED certification shall utilize the following checklist and communication process, in addition to other processes required for certification:

(a) At the conclusion of schematic design, develop a preliminary LEED Checklist utilizing the most current LEED Reference Guide for the appropriate rating system, including Addenda.
(b) The checklist should identify all items for which credit can be achieved, items for which credit is under consideration, and items for which no credit can be achieved.
(c) For items "under consideration", clarify steps required for this review and analysis, potential options, and potential cost and benefit. The U-M Design Manager will assist in refining this list and provide direction on further action as design progresses to DD and CD phases.
(d) At the conclusion of DD phase, update the LEED Checklist. A clear direction should be established for "under consideration" items. Items should be included in scope, deleted from consideration, or included as bid alternates.
(e) At the conclusion of CD phase, update the LEED Checklist. The updated checklist should include any additions and/or subtractions to the project scope that may have occurred during design development and affect the total score anticipated at the conclusion of DD.
(f) At the completion of the construction phase, update the LEED Checklist. The updated checklist should include any additions and/or subtractions to the project scope that may have occurred during construction and affect the total score anticipated at the conclusion of CD.

Baseline LEED Credits

The U-M Baseline LEED Checklist outlines the credits that are likely achievable by projects pursuing LEED certification. Carefully review the baseline checklist and consult with the AEC Sustainability Team before electing not to pursue any credit indicated as likely achievable.

Documentation Requirements

Provide documentation as follows:

All Projects

Document all sustainability design concepts in the project Design Intent Document.

Non-Clinical Buildings and Additions over $10M construction cost (new construction only)

Starting at the Schematic Design (SD) phase and expanding during the Design Development (DD) and Construction Documents (CD) phases, provide the project specific LEED Checklist.

OWNER'S REVIEW

General

Scope

The A/E's design documents will undergo University of Michigan (Owner) reviews at the conclusion of its major stages of design (generally at the end of SD, DD, and CD phases). The Owner's reviewers may include (but are not limited to) the U-M Project Director, U-M Design Manager, U-M Project Manager, external construction manager, UM Planner's Office, U-M user groups, U-M Dept. of Public Safety, U-M OSEH, U-M Architecture and Engineering, U-M Interior Design, U-M ADA Coordinator, U-M Commissioning and Plan Review, U-M Code Inspection, U-M Utilities and Plant Engineering, U-M Plant Operations Shops, U-M Key Office, U-M Building Services, U-M Zone Maintenance, U-M Grounds and Waste Management, U-M Parking and Transportation, U-M ITCS (telecommunications), U-M Risk Management, and Factory Mutual. The Owner's Representative (Design Manager) will coordinate the Owner's review activities.

An Owner's review is a comprehensive examination of a project's design documents to evaluate if the design generally meets the Owner's requirements. The Owner's reviews shall not serve as the A/E's design, drafting, or coordination checks. The documents shall be coordinated and checked by the A/E before being submitted to the University.

Related Sections

U-M Design Guidelines:
Design Deliverables

U-M Design Guidelines Special Instructions to Designers:
SID-B - Design Intent Document
SID-D - Energy Conservation

Execution

When the design documents are submitted to the University, the submittal shall include a Design Deliverables checklist that is marked to indicate the completeness of the design documents. The submittal shall also include an updated Design Intent Document and an updated Energy Impact Statement.

When the design documents are received, the Design Manager will distribute them for review. Comments received by the Design Manager will be assigned action codes and sent to the A/E for resolution. On large or complex projects, the Design Manager may hold meetings with the A/E and reviewers to discuss the comments before action codes are assigned.

The A/E shall:

- Incorporate all comments coded "A" (approved), or contest the comment in writing to the Design Manager.
- Provide the Design Manager with a written response to each comment coded "R" (A/E to review and reply) or "O" (other action required). Each response shall describe how the associated comment is being resolved.
- Request clarification of any comment that is not fully understood. A response similar to "Comment not understood" is unacceptable.
- Discuss with the Design Manager any comment that will significantly affect the project's schedule or budget and document these in a written summary of the review.

The Owner's reviewers will spot check the A/E responses to verify that their review comments were properly understood. The reviewers will then spot check the next revision of the design documents to verify that their comments were resolved. Comments that were ignored or not adequately resolved may be resubmitted as often as necessary until they are completely and acceptably resolved.

While the Owner's reviewers strive to provide appropriate comments as early in the design as possible, specifics of the design often do not appear in sufficient detail for complete comments until the final review. Therefore, the lack of comments on a vague or incomplete aspect of the design during the earlier reviews shall not be construed as Owner approval of any iteration of the design.

SPECIAL REQUIREMENTS

Ladders, Catwalks and Platforms

Ladders, stairs, catwalks and platforms should be provided to areas where access is required for inspection or maintenance. Of particular importance is access to fans, balancing and flow control dampers, steam traps, sanitary clean-outs, and sensors located high above suspended ceilings. Do not rely on walking across ductwork to reach these components.

Catwalks and/or platforms should be provided in accessible shafts and plenums for inspection, maintenance and/or future modifications.

In mechanical rooms arrange ceiling suspended fans with clearance below to allow access from a jack stand.

Loading Docks

Provide space for compactors and utility carts. The specific type of refuse container or compactor must be reviewed with the Grounds Department through the University Project Coordinator early in the design process. Must have access for the large 34 cubic yard trucks to service the containers.

Provide electrical outlets at the loading dock for the compactors and for other general purpose needs.

Pipe Insulation

Cold water pipes are to be insulated to prevent condensation of wter vapor in the adjacent air. Specifically call out on the construction documents the equipment in the cold water lines which also needs insulating - this includes fitting as well as pumps, tanks, strainers, valves, unions, etc.

Roof Penetrations

In any design where a roof penetration will be made, the construction documents shall clearly indicate that the cutting and patching (sealing) of the roof must be made by a roofing contractor. The Maintenance Roofing Department must be informed at least 24 hours in advance of the penetration.

Air System Design Layout

Careful consideration must be given to the feasibility of obtaining accurate measurements for all aspects of the system's performance:

- Provide manufacturer required straight inlet and discharge duct lengths at all fans, air flow stations, static pressure sensor, air blenders, air terminal boxes, humidifiers, etc.

- Do <u>not</u> locate sub-main or branch takeoffs within 7.5 equivalent duct diameters of the fan outlet.
- Lay out ductwork and dampers so that accurate flow measurements can be made at all mains, sub-mains and branches. This normally means 7.5 diameters of straight duct. Show dimensions of straight runs to assure acceptable measurement accuracy.
- Do not allow the use of splitter dampers.
- For constant volume systems, show balancing dampers on the drawings in all sub-mains and branches and specify their type using ASHRAE Standard 111-1988 as a guide.
- Make provision in the layout for measuring the amount of outdoor air at both minimum and maximum outdoor air damper conditions.
- Flow measuring stations with cfm gauges are preferred for all fans larger than 5000 cfm.
- Include system effects in total pressure calculations.

Water System Design Layout

Show all balancing stations and isolation/shut-off valves on the drawings. Typical details may be used for equipment such as pumps, coils and fin tube, sub-mains and branch line balancing stations and isolation/shut-off valves must be shown on either the floor plans or a riser diagram.

Details and plans must clearly show locations of balancing stations so that accurate flow measurements can be made at all mains, sub-mains and branches. Show dimensions of straight runs to assure acceptable measurement accuracy.

Venturis or pitot tube type measuring devices are preferred for all piping 4" and larger. Note that some venturi manufacturers require less straight piping up and downstream than do pitot tube manufacturers.

Gpm gauges are preferred for all pumps larger than 200 gpm.

Drawing Symbols

The A/E shall show the location of all equipment on the drawings using accepted symbols shown in the Legend. Do not rely on notes to instruct the Contractor to include in the project. Examples of equipment to be shown at each and every intended location are: flow control and isolation valves, all types of dampers, turning vanes, access doors, clean-outs, etc.

Suspension of Materials Above Ceilings

The A/E shall design the means of suspending systems from the slab above, and allow space for the hangers. Piping, ductwork and equipment shall have independent support systems (i.e. piping shall not be supported from ductwork supports, etc.) Do not suspend <u>anything</u> (including electrical conduit) from ductwork. Show trapeze hangers on the drawings, and provide additional details as necessary to convey the A/Es intent to the Contractor. Verify that sufficient space exists above existing suspended ceilings for the design.

In existing buildings new piping, ductwork and equipment shall not be supported from existing hangers and/or existing supplementary steel without A/E verification of existing component conditions and loading capacities.

Substitutions

The A/E should review the included approved manufacturers list provided in these Guidelines, and follow in the preparation of the specification. If the A/E believes other manufacturers should be considered they must discuss this issue with the University Project Coordinator prior to release of the construction documents. Once the documents are out for bid, the University will not allow a product by a manufacturer not in the specification. Our position should be made clear in the documents.

Fire Protection

The A/E shall provide a completed fire protection design on the construction documents. Include pipe routing and sizes. Do not rely on the fire protection engineer supporting the contractor to design the system.

Renovation Projects

Visible architectural features to match existing. Mechanical systems shall be compatible with existing unless a more energy prudent design is appropriate and/or existing systems violate requirements of applicable codes. Electrical systems to be compatible with existing.

Major Building Renovations

Provide steam to hot water converters for temporary heat during construction phase.

Ventilation

Select minimum ventilation per ASHRAE Standard 62-89, except in no case less than 15 cfm/person of outdoor air.

Coil Freeze Protection

Coil freeze-up is a frequent problem because of the large component of outside air required at many of our facilities. The design of the air handler must address this problem specifically, and include a mixing plenum design which provides good mixing, air blenders, pre-heat coils, internal face and by-pass dampers or external face and by-pass dampers. Air handling units with integral face and bypass dampers the freeze stat shall be located a minimum of 36" down stream of the dampers.

Prepackaged Spec quality units need to be closely analyzed by the A/E, and modified internally or externally as necessary to provide the necessary freeze protection.

Exterior Equipment/Elements

The University is sensitive to building appearances, and as such has an Exterior Elements Design Review Committee. A/Es designing a new building, or renovating an existing building which includes exterior elements shall obtain this Committee's approval before finalizing the design. Equipment selection shall consider concealment, aesthetics and blending in with adjacent structures.

Interruption of Services

Specify in the Design Documents that both the Utilities and Telecommunications Departments are to be notified before any digging or transportation of large/heavy equipment occurs on any of the University campuses.

Fire Dampers

The State Fire Marshal has final authority on the locations requiring fire dampers. Essentially the requirements and allowable exceptions specified in the BOCA Mechanical Code (1987) are followed. The Assistant Director of Safety, Robert Patrick (763-3434) represents the University in this matter, and should be consulted through the University Project Coordinator early in the design phase whenever the A/E requires an interpretation of the applicable codes.

Separation from Building Services

Waste and vent piping serving laboratories, research areas, or handling acid shall not be connected to the building general sanitary system.

Room Pressurization Control

Numerous rooms exist throughout the University which must maintain pressure (either positive or negative) with respect to adjacent corridors and rooms. The control system must be reliable.

Cleaning - Refuse Removal

Must have access for the large 34 cubic yard compaction trucks to service the container.

Type of refuse container or compactor must be reviewed with the Grounds Department personnel early in the design process.

A fireproof space must be planned for storage of recyclable materials.

Custodial Closets

Minimum of 1 on each floor if it is a small building. However, 2 on each floor on opposite wings is preferable. Custodial closets should not share spaces that contain mechanical equipment, exits to roof, electrical panels to which other personnel or building occupants must have access. These facilities must be capable of having security for equipment which is costly. Space for 1 month supply storage must also be available in the building. See attached diagram of central housekeeping storage area.

See Standard Details for preferred room layouts.

Natural Gas Shut Off Valves for Laboratories

Master Gas Shut-Off Valves

A readily accessible manual shut-off valve is required at the building gas supply connection. Applicable requirements of Michigan School Fire Safety Rules 29.301 through 29.321, effective July, 1989, impose NFPA 101-85 with modifications. NFPA 30, 45, 54, 58 and 90A are referenced in NFPA 101. None of these applicable codes or standards require this valve.

Previous Fire Safety Rules 29.1 - 29.298, which included a requirement for a laboratory master gas shut-off valve, have been rescinded.

While there is no code requirement for a master gas shut-off valve serving an individual laboratory The University of Michigan prefers one for any lab which has more than two gas outlets.

Point of Use Gas Shut Off Valves

NFPA 45 and 54 require readily accessible manual shut-off valves (e.g. bench top turret valves) within 6 feet of equipment being served (e.g. bunsen burners). NFPA 54 also states that the shut-off valves may not be located above ceilings.

Packaged Equipment

Specify all packaged equipment components (e.g., valves, gauges, thermometers) so that they use the same manufacturers, features and quality as the same components provided elsewhere in the project. For example, a heat exchanger package specification should either contain the same spec for valves as Section 15050 or should refer to 15050 as the requirement for all valves provided with the heat exchanger package. It is not necessary that the heat exchanger valves be the same manufacturer as the rest of the project, just that they meet the same specification.

Room Numbering

Room numbering on contract documents must conform to the Facilities Planning and Design Key Plan Group conventions. Coordinate this through the University Project Coordinator.

Mechanical Room Floors

All mechanical room floors and curbs which are not slabs on grade shall be waterproofed to prevent leakage into occupied space below.

01/25/00 12:42 PM

Note: This section is not yet complete.

STANDARD LEGENDS AND ABBREVIATIONS

Introduction

The University has mechanical and electrical symbols and abbreviations that have been used in the past, to provide consistent and understandable construction documents. Many of these were based on industry standard practice. These documents are under review, and are not yet available electronically.

Coordinate symbols, legends and abbreviations with the University Project Coordinator.

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Note: This section is not yet complete.

STANDARD DETAILS

Introduction

The University has several standard details that have been in the Design Guidelines for many years, and used successfully. These documents are under review, and are not yet available electronically.

Present Standard Detail Index includes the following:

- Construction Sign
- Sidewalk Detail
- Parking Lot Pavement Detail
- Standard Curb and Gutter Section or Standard Spillout Curb
- Standard Straight Curb
- Sidewalk Ramp Details
- Concrete Parking Bumper Drain Type
- Bollard Detail
- Manhole with Solid Cover
- Storm Inlet Detail
- Small Central Housekeeping Storage Area
- Custodial Closet
- Simplex Vacuum Pump and Piping
- Piping Sleeve through Concrete Floor

Coordinate use of University standard details with the University Project Coordinator.

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PROJECT ESTIMATES

General

The procedures described in this section pertain to construction projects with a project cost of $500,000 or more.

Professionals performing estimating services for Architecture, Engineering and Construction (AEC) are expected to use the following standard estimating formats.

- *Program Phase* – Uniformat. Estimate UniFormat.xls

- *Schematic Design through Construction Document Phases* - Construction Specification Institute (CSI). Estimate CSI Format.xls

Professionals may complete the templates as provided, or may opt to use proprietary software as long as it is formatted to match the templates. In both cases, the respective budget summary and detail sheets should be provided. Any proposed modification or deviations from these templates must be approved by the AEC Design Manager or Project Director prior to the creation of the estimate.

Execution

Cover Sheet

A cover sheet must accompany all estimates and include the following information:

- Project name, description, and project number
- Reference to documents that are the basis for the estimate including applicable drawings, specifications, sketches, area summary, meeting notes, schedules, etc., with the dates of the documents indicated.
- Construction start and completion dates upon which the estimate is based
- Detail source used for escalation and method for application (for example, “midpoint of construction”)
- List of exclusions, which might include abatement/removal of hazardous materials, potentially required utility services upgrades that are yet undefined, connection fees, permit fees, owner supplied equipment, moveable furniture, testing fees, etc.
- Other Clarifications (such as notes describing incomplete features of the drawings or unusual circumstances).

Templates: Line-Specific Information

The first portion of the estimate (A-G Uniformat and 0-16 CSI format) should account for all known direct labor and materials costs based upon applicable local market conditions at the time of the estimate. Contingency factors, general conditions, management fees, escalation, profit and other indirect costs will be factored in after the direct cost is totaled. Provide a line-specific note for line items where cost is based on an allowance rather than an estimate.

- *Design Contingency* - Suitable contingency for items or options not yet fully designed that may be incorporated as the design progresses. This is usually based on a percentage of the construction cost (Typically 10% at schematic design, 5% at design development and $0 at the end of CD phase, just prior to bid).
- *Escalation* - Suitable percentage of construction cost based on general anticipated cost increases between the time the estimate is prepared and the scheduled construction period. Factors may include anticipated rate of inflation or anticipated general increases/decreases in the cost of construction due to overall market conditions. Division specific anticipated cost increases due to factors such as material shortages should be accounted for within the specific division number and noted as such.
- *CM/GC Standard Conditions* - Construction support related costs, including trailer, fencing, signage, computers, and printing etc, usually based on a percentage of construction cost.
- *Pre-construction Services* - A fee for construction management support prior to construction (not applicable to General Contractor project delivery).
- *CM/GC Personnel* – Cost for management staff during the construction phase of the project. This may include project managers, superintendents, project engineers or estimators.
- *CM Fee/GC Profit* – Construction management or general contractor’s profit.
- *Construction Contingency* – Percentage of the construction total for unforeseen conditions and other unanticipated costs that may occur during construction.
- *Allowances* – Project cost items such as connection fees, sidewalk closure allowances, etc., that will be paid directly by the University, outside of the contract. As an option, these costs can be carried in the construction estimate during programming but should be transferred into *Related Construction Costs* of the overall project budget by the Schematic Design phase. Once the costs go to *Related Construction Costs*, the fixed limit should be adjusted downward, as appropriate. Items in this category should be coordinated with the AEC Design Manager.
- *Alternates* – Full cost for any add or deduct alternate construction items, including direct material and labor costs, plus all other indirect mark-up listed above.

BUILDING ACCESS CONTROL

General

This section addresses minimum functional and technical requirements of the Building Access Control (BAC) system on the University of Michigan Ann Arbor Campus. Functional requirements apply to General Fund buildings. Technical requirements apply to all buildings connecting to the campus BAC system.

University of Michigan Hospitals and Health Centers (UMHHC) and University of Michigan Housing (UMH) maintain their own respective access control systems, standards and hardware. For UMHHC projects, contact UMHHC Facilities Planning and Development. For UMH projects, contact Design Manager.

Related Sections

U-M Design Guideline Sections:
SID-F Codes and Regulatory Agencies
08710 Door Hardware

U-M Master Specifications:
08710 Door Hardware
16724 Security System General Requirements
16727 Access Control and Monitoring System

U-M Standard Details:
16725 Series - Request from Design Manager

Definitions

Building Access Control (BAC): Campus central electronic system (existing), local building panels, distribution and hardware that controls and monitors access to a building and areas within a building based on one or more of the following types of doors:

- *Monitored*: Use of monitoring devices to detect forced door openings and door held conditions.
- *Electronically scheduled*: Use of a central time clock to electronically schedule the locking and unlocking of doors plus functions described for monitored doors.
- *Card reader*: Use of a code, card, or other method of authentication to unlock a door plus functions described for monitored and electronically scheduled doors.
- *Card reader with auto door operator*: Use of a push button to initiate a low energy operator that is interfaced with BAC functions described for monitored, electronically scheduled, and card reader doors.

Mechanical or battery operated digital security hardware: Stand alone mechanical locks that use keypads or other local methods of authentication to gain access to a secured area.

Surveillance systems: Surveillance systems shall include any Closed Circuit Television (CCTV) system installed for the purpose of viewing and/or recording video images for security or system troubleshooting purposes.

BAC: Minimal Functional Requirements

New buildings, additions and major renovations
Evaluate the physical and programmatic layout of the building as related to BAC locations and security requirements. Pay particular attention to egress paths through secured areas, interior connections to adjacent buildings, and control points that are required by code to connect to the building fire alarm system.

Exterior Doors
Provide exterior doors that connect to the campus BAC system and meet the following minimum requirements:

- General (all doors):
  - Provide key cylinder and hardware capable of mechanical access.
  - Provide hardware that allows manually-actuated egress requiring only a single operation at all times.
- Card reader with auto door operator: At least one access point for authorized after-hour use. Coordinate location with accessible building entry.
- Card reader doors: As needed for authorized after-hour use.
- Electronically scheduled doors: All exterior entrance doors used for ingress during building hours of operations.
- Monitored doors: All remaining exterior doors including loading dock and overhead doors.
- Other door types:
  - Exterior doors that provide access to building services spaces (mechanical, electrical, and grounds rooms) but do not provide access to the building interior may not require access control capability. Review with the Design Manager.
  - Doors equipped with an intercom or other communication device to allow a momentary remote unlocking of doors is permitted in select situations only. Review with Design Manager and Department of Public Safety.

Review location and quantity of each door type described above with the Design Manager.

Special alarm systems
Contact Design Manager early in the design process to review the need for special alarm systems.

Interior Doors
Contact Design Manager early in the design process to review interior security requirements.

Elevator Doors
Do not connect elevator doors to BAC system

BAC - Technical Requirements

Contact Design Manager.

Related Systems and Hardware

Surveillance Systems
Contact the Design Manager early in the design process to review the need for surveillance systems.

Mechanical or battery operated digital security hardware
Provide stand alone mechanical or battery operated digital security hardware for select interior applications only. Contact the Design Manager to review interior security requirements.

FALL PROTECTION ON ROOFS

General

This section specifically includes design requirements and standards for fall protection measures on roofs and skylights. It does not address temporary fall protection measures to be utilized during construction. It also does not address policies and procedures for employee fall protection.

References

Comply with the following:

MIOSHA Part 45 Fall Protection Standard for Construction Industry
MIOSHA Part 2 Wall and Floor Openings, Stairways and Skylights
ANSI/ASSE Z359.1-2007, Parts 3 and 5 and Z359.2-2007, Part 5

Related Sections

UM Design Guideline Sections:
07500 Roofing Systems
SID-F Codes and Regulatory Agencies

Design Requirements

Design rooftop areas containing a fall hazard of greater than four feet with specific regard to fall protection. Comply with the following passive protection measures wherever possible:

- Locate equipment (including roof drains) a minimum of fifteen feet from the edge of the roof. This includes any pathways to or around the equipment.

- Include permanent structures such as parapet walls or guard rails together with toe boards at a height of 42" above the roof surface. Note that the guard rails can form a perimeter around the equipment rather than being mounted at the edge of the roof.

If the project budget or architectural considerations preclude using one of the two methods above, obtain the approval of the Design Manager to substitute a permanently mounted anchorage system and/or a horizontal lifeline system for personal fall arrest complying with the following:

- The anchorage system must be designed by a qualified engineer and installed under the supervision of a qualified competent individual.

- The anchorages must be located a minimum of fifteen feet from the roof edge and must be easily accessible.

- The interval between tie-offs must be spaced no more than fifty feet apart.

- Anchorages must be situated so as to minimize the fall distance and the possible damage to fall arrest lanyards from nearby sharp or rough edges.

- Anchorage points must be independent of any anchorage being used to support or suspend platforms.

Appropriate fall protection should also be provided for skylights. Guards and/or screens must comply with MIOSHA regulations.

Anchorage points are mandatory for steep pitch roofs (greater than 4:12), whether or not passive protection is also provided.

SUSTAINABLE PRODUCTS PORTFOLIO

General

The Sustainable Products Portfolio (SPP) is maintained by the Sustainability Team at the University of Michigan (U-M) Department of Architecture, Engineering & Construction (AEC). The SPP consists of a list of sustainable products that the University has evaluated and which have been found to meet our sustainable selection criteria. The SPP is a resource that project teams are encouraged to use to select sustainable products. The SPP is not an all inclusive list of available sustainable products and technologies. It is not intended to limit competition or replace creative sustainable design solutions. Sustainable products not on the SPP shall be submitted to the AEC Sustainability Team for review.

Related Sections

SID-K Sustainable Design and LEED® Requirements

Sustainability Criteria

The criteria used to determine if a product is listed in the SPP include but are not limited to the following:

- Simple to install and easy to maintain
- Long term durability
- Simple to operate
- Reliable
- Aesthetically pleasing
- Competitively priced
- Proven track record
- Replacement parts readily available and fairly priced
- Good local service
- Sustainable manufacturing process
- Sustainability claims can be validated
- Made from Renewable and/or Recycled Materials
- Locally Harvested/Extracted/Manufactured
- Low VOC content

The weight given to each selection criteria will vary from product to product as appropriate for that particular product. The SPP is updated on an ongoing basis and is meant to provide a menu of sustainable products the A/E can select from in confidence knowing such products will ultimately meet U-M's sustainability goals.

SPP Additions and Changes

Anyone requesting that a product be added to or changed on the SPP must use the Request for Addition or Change to the SPP Listing form available on the AEC website. The extent of evaluation will vary based on the product; therefore, time to evaluate requests will vary.

If an A/E desires to use a sustainable product not found on the SPP, provide information to the U-M Design Manager, who shall consult with the U-M Sustainability Team for a recommendation. A/Es should provide the information requested on the Request for Addition or Change to the SPP Listing form.

SPP Listing Categories

Products are listed in the SPP in one of three categories:

1. Approved Product (AP): Product has been evaluated and is approved for use on U-M projects
2. Conditional Product (CP):
   a) Product has been used on select U-M projects; however, post-occupancy evaluation has not been completed. UM Design Manager shall seek approval from the Sustainability Team for the intended use of the product.
   OR
   b) Product has not been used on U-M projects yet; however, a preliminary evaluation of the product indicated that the product meets the UM sustainability criteria if it performs as anticipated. UM Design Manager shall seek approval from the Sustainability Team for the intended use of the product.
3. Not Recommended (NR):
   a) Product has been used on U-M project(s) and did not perform to the required sustainability criteria. The Sustainability Team does not recommend this product.
   OR
   b) Product has not been used on U-M project(s); however results from an evaluation of the product completed by the Sustainability Team deemed that the product did not perform to the required sustainability criteria. The Sustainability Team does not recommend this product.

Special Building Areas

Always use the most recent version. Obsolete versions are for reference only.

SECTION	Date	Previous Versions
SBA-A Animal Facilities	September 2008	June 2003
SBA-B Loading Docks	May 2003	April 1995
SBA-C Telecommunication Rooms	April 2009	December 2004
SBA-D Custodial Closets	May 2003	April 1995
SBA-E Parking Structures	October 2009	June 2009
SBA-F Unit Sub-Station Rooms	October 2009	June 2009
SBA-G Personal Rooms	April 2005	
SBA-H Tunnels	November 2005	
SBA-I Unisex Toilet Rooms	November 2005	
SBA-J Fire Command Center	May 2006	

Last modified: Wednesday October 28 2009

For technical inquires, comments and suggestions on the U of M Design Guidelines, please e-mail the U of M Design Guidelines Group at UMDesignGuide@umich.edu.

University of Michigan - Architecture, Engineering and Construction
A326 East Hoover Ann Arbor MI 48109-1002 Contact Us

ANIMAL FACILITIES

Related Sections

Design Guideline 15910 Laboratory Ventilation

Requirements

The American Association for the Accreditation of Laboratory Animal Care (AAALAC) and the National Institutes of Health (NIH) have established specific criteria for the housing, handling and caring of laboratory animals. To facilitate the implementation of these criteria in a manner consistent with the construction standards of the University of Michigan, the following design criteria and special requirements have been established. If a conflict should arise during the design of a specific project, the requirements of AAALAC and NIH take precedence. Consult with the Assistant Director of the Unit for Laboratory Animal Medicine through the University Project Manager early in the Schematic Design.

Location

Separate the animal suite from offices and main pedestrian corridors to discourage unauthorized access as well as to mitigate odors.

Animal areas need to be secured to only authorized personnel. Provide access control, using the University's standard card readers, and connect the card readers to the central monitoring station. Consider the need for a closed circuit TV system.

Consider the need to provide ready access to an elevator that can be segregated and secured from the public for the transportation of animals, cages, feed, bedding, waste, etc. Consider whether there should be a dedicated elevator for the facility.

Do not locate the animal suite above electrical rooms, telephone/data rooms, or other rooms that could be damaged if water leaks down after wash-down of the animal rooms.

When positioned along a perimeter wall, do not install exterior windows in animal rooms.

House noisy species such as dogs and monkeys apart from other quieter species.

Specialized support areas (including but not limited to food and bedding storage rooms, hazardous agent storage rooms, clean and soiled cage holding rooms, cage washer rooms, refuse rooms, animal care equipment storage rooms, and animal care personnel lavatory, shower and locker rooms) shall be strategically located in relation to animal rooms to isolate the animal rooms from offices and pedestrian corridors.

Corridors

Main corridors shall be 7 feet wide. Branch corridors shall not be less than 5 feet-6 inches wide.

Surfaces

Surfaces shall be constructed of materials that are waterproof and easily sanitizable.

Epoxy painted cement block walls, epoxy painted plaster ceilings and smooth texture acid and solvent resistant monolithic floors are preferred. Water-resistant gypsum drywall-on-metal-stud partitions are acceptable with permission of the Project Manager. Vinyl-covered gypsum lay-in suspended ceiling panel ceilings in galvanized grid are acceptable with permission of the Project Manager.

Walls should be protected with guard rails. Projecting items such as thermostats are undesirable, but if absolutely necessary, shall be protected with bumpers or guards.

Exposed overhead pipes and conduits are undesirable, but if absolutely necessary, the penetrations shall be sleeved and sealed. All floor penetrations shall have sleeves and be sealed watertight.

Above-ceiling devices requiring service or maintenance are undesirable, but if absolutely necessary, shall be provided with waterproof access panels. Utility valves should be located above the corridor ceiling.

Doors

Doors shall be 42 inches wide by 84 inches high minimum, and shall open into the rooms.

Metal doors with self-sealing sweeps, tight fitting to prevent the entry and exit of small rodents, are preferred.

Doors shall be equipped with kick plates, push-pull plates (no knobs), delayed-action closers, a viewing window, and a dead bolt with a combination lock.

Ventilation Systems

See Design Guideline 15910 *Laboratory Ventilation* for vivarium ventilation requirements.

Environmental Controls

Individual room temperature shall be DDC, have remote setpoint adjustment, and maintained within plus or minus 2 degrees throughout a range of 65 - 80 degrees F.

Relative humidity within the animal suite should be maintained between 30 and 70 percent throughout the year.

Temperature and pressure within the room shall be monitored in the hallway, and contained in a flush-mounted panel. Temperature alarms should provide feedback to the U-M central BAS system.

Lighting, Power, and Fire Alarm

Typically, illumination should be dual level with a high level of 100 to 140 fc (all lights on) and a low level of 50 to 70 footcandles (one half of lights on). A manual one-hour timer located just inside of the room door, under a waterproof cover, should control one half of the lights. The other one half of the lights should be controlled by the University's Building Automation System. An optical sensor (photocell) should provide feedback to the BAS for the trending of room light levels. In special rooms, one half of the lighting may require red lamps or standard lamps with red covers.

Lighting fixtures shall be sealed to prevent entry of insects and water spray from wash-down hoses. Electrical receptacles shall have waterproof covers, and may need to be explosion-proof. Provide GFCI receptacles in all areas subject to wash-down or within 6 feet of sinks.

The fire alarm devices shall be waterproof in all areas subject to wash-down. For animal suites that house mice, the fire alarm audible sound shall be a slow warble at a frequency of less than 500 Hz. If the building is a high rise, the Code-required evacuation message shall also be less than 500 Hz. Contact the AES Electrical Department through the Project Manager for the latest recommendation on audible devices. Fire alarm visual devices (strobe lights) shall be located in corridors only because animal rooms are not considered public or common spaces.

Plumbing

Animal rooms should have hot and cold water and a stainless steel wall sink with a drain board. Heavy water use areas should have hot and cold water hose bibs located under the sink.

Cappable floor drains (4") are desirable in all rooms, but may be excluded in certain circumstances (eg., rabbit and rodent rooms). Heavy water use areas shall have the floor sloped 1/4" per yard and contain rim-flush drains. Drains should have locking covers and contain a bucket trap.

Large animal (dog, pig, sheep, etc.) rooms have special plumbing requirements (eg., trench drains, flush drains).

Consider the need for an automatic animal watering system.

Operating Rooms

Operating rooms cannot be used as offices, laboratories, or storage rooms.

Air from operating rooms shall be 100% exhausted. Supply and exhaust grilles must be located to provide proper airflow within an occupied room. Typically non-aspirating (perforated) supply air diffusers should be selected and located so that incoming air does not disturb the natural thermal plume that develops over the surgical site. The room shall be maintained at a positive pressure with respect to the adjacent preparation area or corridor.

Provide a surgical light and an easily sanitizable surgical table.

Provide appropriate scavenging vacuum or alternate means of gas exhaust if gas anesthesia is used.

Oxygen is desirable. A source of hot and cold water is usually required.

Provide explosion-proof electrical receptacles and conductive flooring if explosive anesthesia is used.

Surgical Support Rooms

Provide at least 2 surgical support rooms separate from the operating room. One is for surgeons preparation, and the other for animal preparation. The former may also be used for instrument and pack preparation and the latter for post-operative recovery. However, prolonged and complex post-operative recovery should be performed in a recovery room separate from both the surgeon preparation room and the animal preparation room.

The surgeon preparation room should be contiguous with the operating room; whereas the animal preparation room need not be. An autoclave should be in close proximity.

LOADING DOCKS

General

Provide Loading Docks as described below and in accordance with the program requirements.

Architectural Design Requirements

Provide space for refuse containers, trash compactors, and utility carts. The specific type of refuse container or compactor shall be reviewed with the Grounds Department through the University Project Manager early in the design process. Provide access for the large 34 cubic yard trucks to service the containers.

Canopies which extend beyond the edge of the dock should be installed with a minimum clear height of 13'-6" above the driveway to ensure truck clearance under the canopy, lights etc. Confirm the clearance with the Project Manager. If it is not possible to achieve sufficient height, a 6" galvanized and painted steel tube shall be suspended at the leading edge of the canopy to alert drivers to impending impact. The support structure of the heads of the dock openings which are exposed to potential impact shall be sized and stabilized to withstand the impact.

Provide an overhead dock door (motorized if noted in the program statement), and an adjacent person door.

Provide dock levelers and truck restraints were required.

Mechanical Design Requirements

Provide a storm sewer catch basin in the dock well.

Electrical Design Requirements

Provide power and control circuits to motorized door openers, dock levelers, and trash compactors. Motorized overhead doors shall have keyed control stations inside and outside.

Provide GFCI duplex receptacles for other general purpose needs.

Provide an outdoor campus or emergency telephone and/or a card reader as noted in the program statement.

Provide photocell controlled metal halide lighting outdoors to light the dock area. Aim the lighting downward to prevent annoying glare.

Do not install fire alarm system control panels, security system control panels, time clocks or other electronic panels in the loading dock areas because of the potentially harsh environment and to avoid abuse from the materials being moved through the area.

TELECOMMUNICATIONS ROOMS

General

Voice and data systems for the Ann Arbor, Dearborn and Flint Campuses are provided by the U-M Information Technology Central Services, ITCom Department. Voice and data systems for University of Michigan Hospitals and Health Care (UMHHC) facilities are provided by the Medical Center Information Technology (MCIT) Division, but UMHHC projects often include ITCom involvement as well.

Coordinate with ITCom through the Design Manager and provide telecommunications rooms as described below and in accordance with the Program Documents.

Related Sections

Design Guideline Technical Sections:
SID-F - Codes and Regulatory Agencies
16010 – Basic Electrical Requirements
16050 – Basic Electrical Materials and Methods
16450 – Grounding
16740 - Voice and Data Systems

U-M Master Specifications:
16050 – Basic Electrical Materials and Methods
16740 - Voice and Data Systems

U-M Standard Details:
16740 Series - Telecommunications Room Details

References

ANSI/TIA/EIA-568-B-1	Commercial Building Standards for Telecommunications Cabling Standards
ANSI/TIA/EIA-569-A-1	Commercial Building Standards for Telecommunications Pathways and Spaces
ANSI/TIA/EIA-607-A	Commercial Building Grounding and Bonding Requirements for Telecommunications

Architectural Requirements

The Building Entrance room (BE) is the main termination point in a building for interconnecting cables external to the building (OSP cables) with cables internal to the building (ISP cables). In addition, the BE may house voice and data equipment including equipment racks, switches, routers, patch panels, terminations, and other electronic equipment.

Telecommunications Rooms (TRs) are distribution and termination rooms that serve the User stations in the immediate area. TRs also house voice and data equipment, and when permitted, electrical equipment of other systems.

1. Locate the BE near the telecommunication service entrance and relatively close to the TRs. Locate the TRs to allow star distribution of cabling.

2. Stack TRs vertically to provide short, direct, vertical paths for riser and network cables.

3. Provide a minimum of one TR per floor. Provide additional TRs to ensure:
   - One TR for every 10,000 square feet of floor area being served.
   - One TR for every 300 voice/data outlets being served.
   - The cable distance to the farthest voice/data outlet does not exceed 295'.

4. Size rooms according to the following rules:
   - Coordinate with ITCom to obtain the quantity and arrangement of equipment racks in each room. Assume each rack is 8' tall by 32.5" wide (including wire management troughs) by 30" deep. Show the rack outlines on the plan drawings.
   - Size the rooms to provide the National Electrical Code minimum working space of 3' in front, 3' in back, and 2' on one side of each rack.
   - Provide space (including NEC minimum working space) for non-rack equipment including patch panels, terminations, and other electrical equipment.
   - When a room is not square, the minimum short wall length shall be 8'.
   - Minimum size for the BE is 12' x 12'.
   - Minimum size for the TRs is:
     - 12' x 12' for 10,000 square feet served.
     - 10' x 10' for 8,000 square feet served.
     - 8' x 10' for 5,000 square feet served.

5. Minimum room height is 9'-0".

6. Leave the room ceilings open to the decks above. No ceilings are allowed.

7. Cover the walls from 6" AFF to 8'-6"AFF with ¾ inch Class B fire retardant plywood backboards (smooth side out). Backboards shall be rigidly installed.

8. Paint or seal the floors. No carpeting is allowed. Provide vinyl tile flooring only when required.

9. Doors shall be 36" wide by 80" high minimum and shall swing outward. Doors should be located near a corner of the room, and shall have storage room function hardware. Doors shall not have door sills, and double doors shall not have center posts.

10. When noted in the Program Documents, provide or prepare the doors for card readers and electric strikes.

Mechanical/Electrical Requirements

1. Ductwork, piping, and other mechanical system components are not permitted in a telecommunications room unless they serve the room.

2. Provide the BE and TR's with cooling 24 hours/day, all year around. Fan coil units located outside and ducted to the rooms are preferred. Room temperature shall be maintained between 68 degrees F (20 degrees C) and 77 degrees F (25 degrees C). Room humidity shall be maintained between 30 and 55 percent. During project programming, assume an equipment heat load of 3500 watts per room. Confirm the heat loads during design. Equipment including UPS units, fire alarm panels, security panels, card access control panels, CCTV amplifiers and Power Over Ethernet (POE) power supplies may increase the heat load. Some rooms may have a much higher heat load.

3. Provide fluorescent lighting of at least 500 lux (50 foot-candles) 3' above the floor. Connect the lighting to an emergency lighting circuit when emergency lighting circuits are available within the building. Provide manual switches for the lighting. Time controls and occupancy sensors are not allowed.

4. Conduits and/or floor sleeves (See Figure No. 1.) shall extend upward 2" AFF, shall be water tight, and shall be fire stopped. Provide spare sleeves and conduits for future use.

5. Extend conduits and cable trays a minimum of 3" into the rooms.

6. Provide the BE with one dedicated 120 volt, 20 ampere duplex receptacle on the plywood backboard. Provide one dedicated 120 volt, 30 ampere separate branch circuit and one 120 volt, 20 ampere separate branch circuit to each telecommunications equipment rack. Coordinate the rack circuit routing with the equipment rack layout. All of these outlets shall be fed by standby power circuits when generator standby power is available.

7. Provide each TR with a minimum of one dedicated 120 volt, 20 ampere duplex receptacle on the plywood backboard. Provide one dedicated 120 volt, 20 ampere separate branch circuit to each telecommunications equipment rack. Coordinate the rack circuit routing with the equipment rack layout. Coordinate with ITCom to determine if any of these circuits must be 30 ampere. All of these outlets should be fed by standby power circuits when generator standby power is available.

8. Provide a ¼" x 1" x 12" copper ground bus in each telecommunications room, and connect it to the building ground system using a #6 AWG or larger insulated copper ground wire. The resistance to building ground shall be 1 ohm maximum.

Division of Responsibilities

The following telecommunications room equipment will be provided by others.

- Telecommunications ladder-type cable racks.
- Telecommunications equipment racks and wire management troughs.
- Telecommunications equipment, patch panels, cables, splice boxes and terminations.

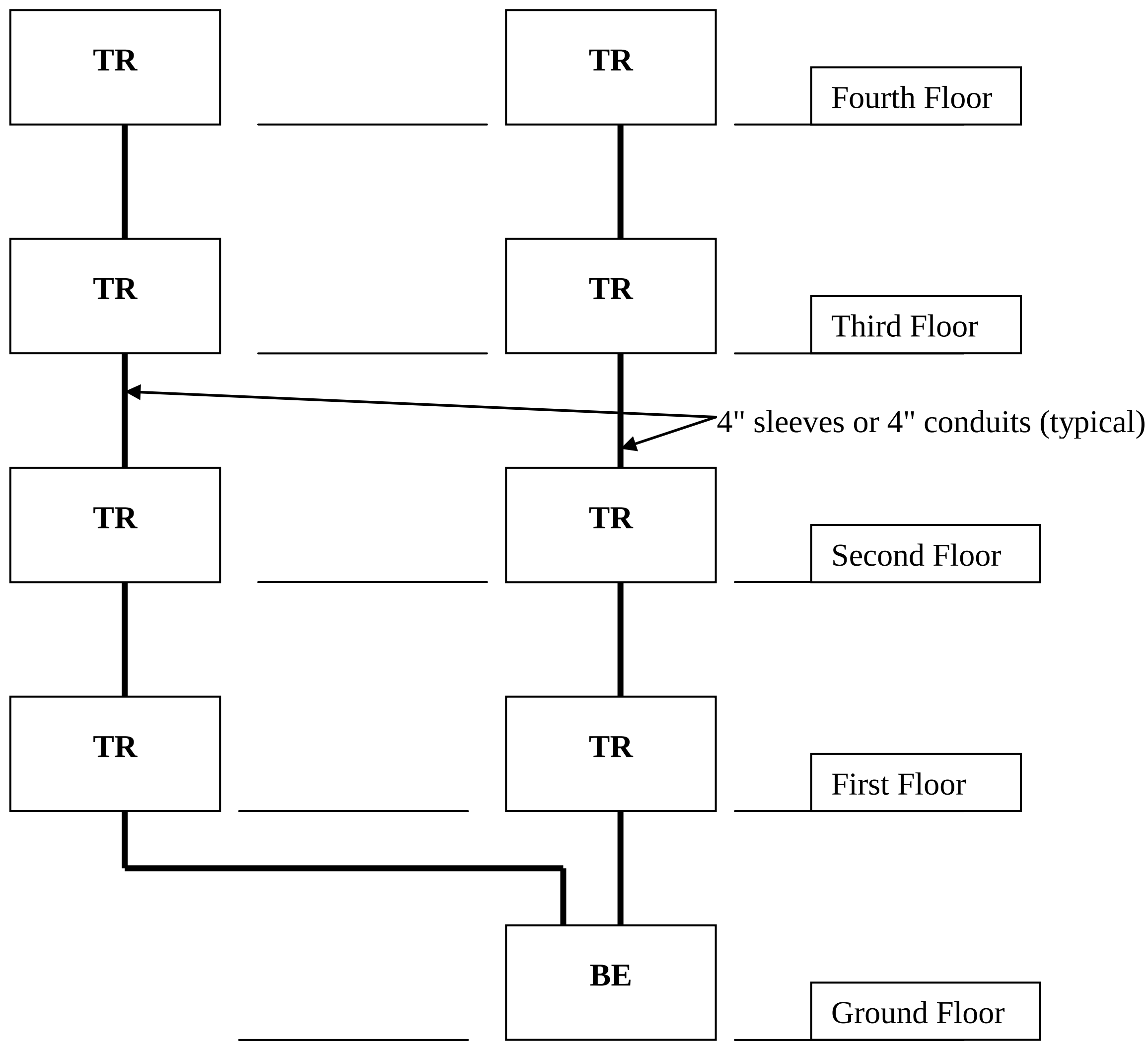

Figure No. 1 - Typical Building TR Room Riser Diagram

No Scale

Custodial Closets

General

Provide Custodial Closets as described below and in accordance with the Program Documents.

Related Sections

For preferred room layouts, see details:
SBA D01 5 03.pdf
SBA D02 5 03.pdf

Architectural Design Requirements

Provide a minimum of 1 closet on each floor if it is a small building. In larger buildings, provide at least 2 on each floor. Place them on opposite wings (ends) if possible.

Custodial closets should not share spaces that contain mechanical equipment, exits to the roof, or equipment to which other personnel or building occupants must have access. The closets shall not contain electrical panels or any other electrical devices except for the lights and receptacles required for custodial tasks. Closets must be capable of providing the needed security for equipment that is costly.

Closets must be sized for battery powered floor polishers.

In addition to closets, provide space in the building for the storage of a 1 month supply of custodial supplies.

Mechanical Design Requirements

Provide room exhaust at 2 cfm/sf, designed for 24 hr/day operation.

Provide a cast iron slop sink.

Electrical Design Requirements

Provide fluorescent lights controlled by an occupancy sensor, electrical duplex receptacles (GFCI protected within 6 feet of sinks), and a proper receptacle for the power floor polisher.

PARKING STRUCTURES

U-M Related Sections

Design Guidelines:
SBA-C – Telecommunications Rooms
SBA-F – Unit Substation Rooms
SID-F – Codes and Regulatory Agencies
14000 – Elevators
15300 – Fire Protection
16050 – Basic Electrical Materials and Methods
16120 – Wires and Cables
16231 – Engine-Generator System
16500 – Lighting Systems

U-M Master Specifications:
14210 – Electric Traction Elevators
16231 – Engine-Generator System
16313 – Indoor Single-Ended Unit Substation
16521 – Outdoor Lighting

U-M PTS Specifications:
09912 – Parking Structure Painting (Obtain from Design Manager)

U-M Standard Details:
03410 Series – Bollard Details (Obtain from Design Manager)
10400 Series – Signage Details (Obtain from Design Manager)
16500034 – Riser for 480V Power Source
16750 Series – Emergency Telephone Details

General Design Requirements

The parking structure design shall incorporate the standard requirements of this Design Guideline and any Parking and Transportation Services (PTS) requirements unique to the structure.

The U-M Design Manager shall assume the responsibility for coordinating the transfer of additional information required by the design professional to and from U-M Departments.

Identify the parking structure as an 'Enclosed Parking Garage' or a 'Ramp Access Open Parking Garage' in accordance with Code. All separations from adjacent occupancies or structures shall be clearly identified.

Obtain approval from the City of Ann Arbor for all construction/impacts within the City of Ann Arbor right-of-way that support the parking structure.

Design parking structures to provide a 75 year life.

Driver visibility shall be free of blind spots at all turning points along the drive lanes.

Bumper blocks and wheel stops shall not be used.

Provide motorcycle designated parking outside of gate-controlled parking areas. Provide a dedicated entrance for motorcycles. Incorporate PTS requirements for multi-modal (bicycle, moped, etc.) parking.

Parking spaces shall be 90 degrees to the drive lanes. Each space shall be striped on the floor with 4 inch wide yellow stripes, and shall be a minimum of 8 feet 6 inches wide when measured from center of stripe to center of stripe. Provide wider spaces for special access vehicles per PTS requirements.

Provide ADA-compliant accessible parking spaces as required by code and PTS. Accessible spaces shall be striped in yellow (not blue). Accessible parking signage shall be furnished and installed directly by PTS. Do not paint accessible parking symbols on the deck.

Architectural Design Requirements

Structure

Structures shall have a live load capacity of 70 lbs./sq. ft. minimum. Provide a minimum additional 30 lbs./sq.ft. capacity at roof levels or meet the current Code requirement for snow loads, whichever is greater.

Structure decks should be constructed with precast or cast-in-place reinforced concrete double tees and 4 inches thick minimum top of tee, not including overlay. Both precast and cast-in place structural systems shall be evaluated during schematic design. Wherever cast-in-place concrete is used for beams, parts of the deck, or other horizontal elements, provide epoxy coated reinforcing steel.

Where precast construction is used, provide galvanic anodes at shear connectors.

Decks should have a clear span of at least 62 feet wide. At grade level and below and at levels with ADA parking, provide a minimum clearance of 8 feet 2 inches from the finished floor to the underside of any building component or pipe (including lighting fixtures and fire suppression sprinklers). Above grade level, provide a minimum clearance of 7 feet 6 inches to the underside of any building component and a minimum clearance of 7 feet 4 inches to any projecting or protruding object.

Decks shall have a protective overlay of 1-5/8 inches to 2 inches latex modified concrete or micro silica flume sand on top of the precast double tees. This overlay shall not be designed as a structural member, but as a protective overlay only, and shall be able to be replaced in the future. If a micro silica overlay is selected, provide a penetrating sealer (40 percent solids, silane sealer).

Ramped floors in the structure should not exceed a 6 percent slope where vehicles park adjacent to a drive lane, and then shall not exceed a 10 percent slope for speed ramps without adjacent parking.

Interior

Provide an enclosed lobby at each elevator landing.

Lobby and stairwell doors shall be unpainted aluminum with brushed finish and safety glass vision panels except as required by Code to be fire rated. Fire rated door assemblies shall be factory painted galvanized hollow metal with safety glass vision panels of the maximum allowable dimensions. Coordinate color with PTS paint specifications. Lobby and stairwell door hardware requirements are to be as follows:

- All doors shall have quarter panel kick plates (both sides of door) and closers.
- Exterior doors shall have panic device assemblies with locks and latches.
- Interior doors shall have push/pull hardware unless otherwise required by Code.
- Provide low energy ADA compliant door operators at all ADA accessible routes into and out of the structure. Evaluate other types of automatic operators that may be required for specific PTS applications.

Provide safety glazing in lobbies and all other areas required by Code. Window sills shall be no lower than 30 inches above the finished floor. Windows should be as large as practical to provide good visibility from the outside. Perimeter windows should utilize tinted low-E glass to minimize solar heat gain.

Evaluate public safety issues that exceed code requirements, such as security cameras in stairwells and exterior glazings that provide full viewing within stairwells.

Seal all floor penetrations water tight.

Where pre-tension or post-tension construction is used, provide cast-in-place or double-cored galvanized steel sleeves flush with floor levels and concrete-filled or covered. Provide block-outs or PVC sleeves for all wall and beam penetrations.

In general, the finish on all walls, columns, and ceilings shall be white per PTS Painting Specifications. Mechanical and electrical equipment, electrical conduits, and conduit expansion joints shall not be field painted. Mask all unpainted equipment to avoid overspray. Water, gas and fire system lines shall be painted.

Paint elevator shaft interior walls with white latex ceramic wall paint per PTS Painting Specifications to insulate the shaft against heat loss and moisture damage.

Painting of floors is not required, including stair landings, stair treads, and lobby floors. Concrete stair landings, stair treads and lobbies shall have an anti slip surface consisting of a quartz aggregate sealed with either polyurethane or methacrylate. PTS will provide aggregate color and finish.

Evaluate the use of traffic topping on exposed parking levels per PTS requirements.

Protect vertical pipes, conduits and valves from vehicle damage. Protection methods shall include either steel covers painted safety yellow or galvanized steel pipe bollards filled with concrete.

Provide movable precast concrete bollards for use in controlling traffic. See the U-M Standard Details for bollard requirements.

Provide a telecommunications room. Refer to U-M Design Guidelines for room specifications.

Provide a non-public ADA accessible toilet room on the ground level.

Provide a parking structure maintenance room, preferably on the ground level. Maintenance room minimum requirements are as follows:

- Room size minimum: 500 sq. ft.
- Room depth minimum: 18 ft.
- Roll-up door minimum: 9 ft. x 7 ft. (WxH) Obtain the door specification from PTS.
- Pedestrian Door: 42 inches wide.
- Plumbing: Utility tub and janitor's sink with hot and cold water.
- Power: 4 GFCI duplex receptacles and a separate 120 volt, 20 amp compressor circuit.
- Lighting: Ceiling fluorescent lighting with occupancy sensor control.
- Heat: Heater with wall mounted thermostat to maintain room above 45 degrees F.

Entrances/Exits

If parking controls (including electronic signage, attendant booths, gates, vehicle detection loops, and Automated Vehicle Identification (AVI) equipment) are to be provided, the equipment will be furnished and installed by others and directly through PTS. Provide concrete housekeeping pads, safety bollards installed in the pads, power and communications conduits and wiring, and lighting in accordance with PTS requirements. If no parking controls are to be installed, provide conduits for power and communications for the future addition of parking controls.

If attendant booths are to be provided, they shall be a minimum of 5 feet by 7 feet and located on 6 inch concrete housekeeping pads. At least one booth shall be ADA accessible. Incorporate PTS booth and bollard cover specifications.

The structure shall have illuminated pedestrian entrances away from the drive lanes.

Signage

Provide an illuminated facility identification sign at each entrance, LED type signs over entrance and exit lanes, and a clearance pipe above each entrance in accordance with PTS requirements.

Provide facility and level identification, directional, traffic and parking control signage in accordance with PTS requirements.

Mechanical Design Requirements

Elevators

Traction elevators shall be used. Hydraulic elevators shall not be installed in parking structures.

Provide a securable ladder with slip resistant rungs to access the roof of each elevator machine room. On machine room roofs, provide appropriate fall protection as required by Occupational Safety and Health Administration regulations.

Provide rigidized stainless steel wall panels and Class I fire-rated, slip-resistant rubber flooring in the elevator cars.

Elevator hoist ways shall be heated and cooled to maintain the temperatures specified by the elevator manufacturer. Elevator lobbies shall not be heated.

Heat and air condition elevator machine rooms to maintain an ambient temperature between 55 degrees F and 90 degrees F under all weather conditions. No heating or air conditioning equipment or piping shall be located in the machine rooms, except that which serves the rooms.

Provide stainless steel elevator door headers, frames, struts, and stainless steel or nickel-silver sills.

Provide floor drains in elevator lobbies, and slope floors downward from the room and elevator doors to the floor drains.

If the elevator(s) are considered part of the parking structure's "accessible path" or if the parking structure is classified by Code as a high rise structure, then the elevators, elevator HVAC, associated lighting and receptacles shall be connected to the emergency generator. Additionally, ingress and egress from and to the elevator and between the elevator machine room and the elevator must be "safe and reasonable" as defined by the Michigan Elevator Code.

Snow Melt System

Provide a snow melt system with the chute and control equipment on the roof. Provide a concrete housekeeping pad for the system and design the structure to support the additional weight.

The snow melt system shall be natural gas fired. Size the unit to service at least the entire roof level of the parking structure. Contact the system manufacturer for electrical, water, drainage and gas pressure requirements. Verify that required gas pressure is available. Connect a control panel "trouble" output contact to the DDC panel. Provide electric heat tracing for the water supply and drain lines that are exposed to air.

Enclose the snow melt system in a wire mesh fence with sliding gates for snow melt system operation and swing gates for personnel access to the control panel. Provide a level, skid-resistant path for personnel to safely access the control panel.

Natural Gas Service

Coordinate with the local utility to provide a natural gas service large enough to serve the snow melter, generator, and any additional equipment requiring natural gas service.

Ventilation

For structure levels that require mechanical ventilation to control CO levels, provide variable speed fans controlled by CO sensors. Connect CO “high-high” alarm output contacts to the Building Automation System DDC panel.

Evaluate the need for ventilation in glass-enclosed stairways.

Controls

Unless one is available in a close-coupled building, provide a Building Automation System Direct Digital Control (DDC) panel for connection to structure systems and equipment.

Additional Plumbing

Provide one standard hose bib on each parking level outside of stair and elevator towers. Hose bibs shall be drainable for winter.

Drainage

Provide positive drainage on all decks. Provide trench drains at the bottom of ramps from the plaza or roof levels.

Drain lines shall be 4 inch minimum and shall be heat traced where exposed to air.

Elevator and stair tower roof drains shall discharge to storm drains via lines located inside of lobbies or the parking structure. Downspouts shall not discharge directly onto the roof level floor deck.

Contact the City of Ann Arbor or other Authorities Having Jurisdiction to determine sanitary and storm water drainage restrictions and requirements. These requirements may include installation of an oil separation system.

Fire Protection

Provide drainable standpipes with 2½ inch fire hose connections on each level at each egress stairway, with additional standpipes located throughout the structure such that all portions of the structure are within 100 feet of a standpipe hose connection, or as otherwise required by Code.

Standpipe risers shall be painted red. One column immediately adjacent to each standpipe hose connection shall be marked on each side with a 6-inch wide strip of reflective red tape running perpendicular to the floor, from floor to deck, and the top 24 inches of the column should be painted red. It is not necessary to mark columns located inside enclosed stairways.

Provide a fire department connection for the standpipe system as required by the Code and NFPA 14. The fire department connection shall face the street, and shall be located within 100 feet of a fire hydrant. The fire hydrant shall be located such that a temporary meter, valve, and hose assembly can be connected for use by PTS for cleaning of the structure in accordance with City of Ann Arbor requirements.

For structures that require fire protection sprinklers, provide a dry pipe system. If available, plant air should be used to pressurize the dry pipe system. The dry pipe sprinkler valve and air compressor (if needed) should be located in the maintenance room. Provide a sprinkler system electrical failsafe contact that open if the system becomes charged, and connect it to the DDC panel.

The fire protection system shall be designed with the capability of draining down a charged system into the sanitary sewer/oil separation system for proper disposal of water.

All exposed control valves for the fire protection system shall be lockable or within lockable tamper resistant boxes.

Electrical Design Requirements

Lighting

Provide the following horizontal light levels on the floor:

Area	Minimum	Average
• Egress routes while on emergency power:	Per Code	Per Code
• Interior drive lanes and parking spaces:	3fc	5fc
• Uncontrolled and unattended entrances/exits:	5fc	10fc
• Vehicle entrances and exits:	10fc	25fc
• Stairways and lobbies:	10fc	25fc
• Maintenance room:	10fc	25fc
• Top deck:	1fc	2fc

Note: Deviations from the light levels listed above may be necessary to meet the lighting power density (watts/sq.ft.) restrictions of ASHRAE 90.1-2007.

Light reflectance from painted ceilings and walls shall be used during calculation of lighting levels.

Provide light levels in elevator lobbies, cars, machine rooms, and pits in accordance with the Michigan Elevator Code.

Normal lighting should have an average-to-minimum uniformity ratio of not more than 4:1, and emergency lighting should have an average-to-minimum uniformity ratio of not more than 10:1. Deviations from these ratios may be necessary to meet restrictions set forth by ASHRAE 90.1

Provide exit signs to direct traffic toward exits and pedestrians toward stairs and pedestrian exit ways. Exit signs shall be vandal-resistant LED type. Do not provide battery-backed exit signs.

Select lighting fixture cut-off to minimize direct glare into driver's eyes and to limit the amount of light exiting the structure.

Fixtures shall be vandal-resistant, UL listed for wet locations, with gasketed, high impact polycarbonate lenses secured with vandal-resistant screws, and cold weather ballasts.

Fixtures should operate at 277 volts. Do not provide battery-backed emergency lights.

Evaluate use of the following fixture types. Obtain the currently approved fixture manufacturers and models from PTS.

- 4 foot fluorescent vandal resistant wraparound fixture. Fixture to be surface or pendant mounted, with two or three 32 watt, 3500 degrees K, rapid start, T-8 fluorescent lamps and cold weather (0 degree or lower) electronic ballast. UL listed for wet locations.

- Induction lamp parking garage type, surface or pendant mounted, with 3200-3500 degrees K, 80 CRI lamp rated 100,000 hours, and electronic ballast.

- Solid state lighting (SSL) fixtures. Note: LED lighting is an emerging technology and should be evaluated as appropriate fixtures become available.

- Obtain PTS approval of the fixture type selected.

Lighting fixtures in stairways, lobbies, and elevators shall be vandal-resistant fluorescent with 3500 degrees K lamps and cold weather rated (0 degrees F or less) electronic ballasts.

Lighting in stairways, elevator lobbies, maintenance rooms and the substation room shall be connected to emergency circuits.

Lighting fixtures shall be cord and plug connected, with cords secured to conduits. Provided photometric requirements can be met, lighting fixtures over parking spaces should be located at the drive lane end of the parking spaces such that the fixtures can be repaired or replaced even if parked vehicles are present.

Lighting fixtures on the roof deck shall be metal halide or the latest PTS-approved emerging technology, shoebox type, mounted on round, tapered, hinged, aluminum poles to allow lowering the fixtures for maintenance. Refer to U-M Master Specification 16521 for additional requirements. Minimum lighting levels shall be maintained, but fixture wattage and pole height may be reduced to minimize light trespass on surrounding areas.

Lighting Controls

Circuit the interior deck lighting fixtures in rows that parallel the outer walls. Provide daylighting controls to turn off rows of lights near the outer walls when the incoming daylight is adequate.

Provide photocell controls to turn off the top deck lights when the daylight is adequate.

Provide daylighting controls in lobbies and stairwells exposed to natural daylight to turn off unneeded lights when the incoming daylight is adequate.

Power

Provide an indoor, single-ended, 13.2 kV–480Y/277 volt unit substation utilizing U-M Master Specification 16315. Locate the substation on a 4 inch minimum concrete housekeeping pad in a separate room complying with Design Guideline SBA-F. Exception: If the parking structure is close coupled to a building having sufficient power to serve the parking structure, a secondary voltage feeder may be utilized. If this is done, the feeder shall have a separate meter installed of the type specified in Master Specification 16315.

Provide a natural gas fueled engine-generator in accordance with Design Guideline 16231 to supply emergency power. Propose a location indoors in a room or outdoors in an enclosure for approval by PTS. During schematic design, evaluate sizing the generator large enough to provide power to all lighting in the structure to avoid the costs of separate emergency lights, multiple automatic transfer switches, and two conduit and wiring systems.

Provide one 120V GFCI duplex electrical outlet in the elevator lobby on every level. Provide a hinged, lockable cover on the outlet.

Raceways

Conduit should be exposed, except conduits to parking controls and attendant booths shall be embedded. Horizontal conduit runs below structural beams and vertical conduit runs should be located near columns and away from drive lane areas. Conduits located where they may be struck by vehicles shall be guarded.

Exposed conduits shall be Schedule 80 PVC and embedded conduits shall be Schedule 40 PVC, both with matching fittings, expansion fittings, and weatherproof junction and outlet boxes. Structural support channels shall be fiberglass with fiberglass or stainless steel hardware.

Exposed ½" and ¾" conduits shall be strapped to the structure with Carlon "Snap Strap" sliding clamps every 3 feet maximum. Exposed 1" through 2" conduits shall be strapped to the structure with Carlon "Snap Strap" sliding clamps every 5 feet maximum. Conduits 2" and smaller shall not be suspended on hangers. They shall be installed so no gaps exist between the conduits and the structure large enough for someone to grip the conduits and pull them down.

Exposed conduits larger than 2" shall be strapped with standard 2-hole PVC clamps, but the clamps shall be spaced off of the structure or hanger by a nylon or PVC washer under each hole of each clamp. The washers shall be thin enough so the 2-hole clamps continue to provide conduit support, but thick enough so the conduits slide through the clamps during conduit expansion and contraction.

Expansion fittings shall be provided in sufficient quantities to accommodate the expansion and contraction of a 120 degree F temperature change. Expansion fittings shall be provided within 3 feet of lighting fixtures and within 5 feet on both sides of bends and elbows. Expansion fittings shall be installed expanded or contracted as appropriate for the specific temperature existing at the time of installation.

Drain holes ¼" in diameter shall be drilled in the bottom of exposed junction and outlet boxes.

Fire Alarm

Provide a fire alarm system only when and where required by Code. Provide fire alarm devices that are UL listed for the environment in which they will be located.

Fire alarm junction boxes, covers and fittings shall be painted red or installed in red conduit throughout. Exception: The fire alarm raceways exposed in finished areas may be painted to match wall color.

Sprinkler system water flow and trouble alarms must be monitored in accordance with Design Guideline 16720. In parking structures without a fire alarm system, the sprinkler water flow and trouble alarms shall be monitored directly through the campus MOSCAD system. Monitoring of water flow and trouble alarms in Hospital parking structures by the UMHHC Facilities Control Center may also be acceptable, in accordance with direction received from the Design Manager.

Emergency Telephones, Elevator Telephones, and Data Connections

Provide DDC monitoring and alarms in the BAS Operations Center for snow melt system trouble, exhaust fan running and shutdown, CO “high-high” level, VSD trouble, generator running and trouble, automatic transfer switch transfer to generator power, loss of natural gas pressure, sprinkler system water flow and trouble, heat tracing trouble, and trouble from any other mechanical or electrical systems.

Provide U-M standard wall-mounted emergency telephones with integrated blue lights. Kiosk-style telephones shall not be used. Provide power and communications conduits and wiring for the emergency telephones. The lights operate on 120V power. Consult the U-M Standard Details. Some redesign may be required because the existing standard details may not always apply. Installation locations shall provide for maximum visibility and accessibility.

Provide one communication line for each elevator that will serve as the emergency telephone service from the elevator to an outside monitored source. In addition, provide one telephone line for use as a modem line for each group of elevators. All communication lines must terminate in junction boxes in the elevator machine room.

Provide conduit and cable from the telecommunications room for data circuits to be used for gate control systems, programmable signage and other applications.

Provide conduit and cable from the telecommunications room to the substation for recording power meter communications.

UNIT SUBSTATION ROOMS

General

This guideline applies to rooms that contain medium voltage unit substations, and as appropriate, to rooms with large transformers, large power panels, emergency power distribution equipment or central UPS systems.

Related Sections

Design Guidelines:
SID-F – Codes and Regulatory Agencies
16010 – Basic Electrical Requirements
16050 – Basic Electrical Materials and Methods
16110 – Underground Electrical Service
16450 – Grounding
16500 – Lighting Systems
16720 – Fire Alarm System
16950 – Electrical Acceptance Tests

U-M Master Specifications:
16313 – Pre-Purchase of Indoor Single-Ended Unit Substation
16314 – Installation of Pre-purchased Indoor Single-Ended Unit Substation
16315 – Indoor Single-Ended Unit Substation
16316 – Indoor Double-Ended Unit Substation

References

International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines
NESC, "National Electrical Safety Code"

Architectural Design Requirements

Separate the substation room from occupied areas or provide sound-proofing so the 60 Hz hum cannot be heard in occupied areas.

Separate the room and large secondary feeder circuits leaving the room from occupied areas and from areas containing computers, computer servers, telecom equipment, electronic instruments and other electronic equipment which could be affected by electromagnetic fields (EMF).

- The most stringent human EMF exposure limit is published by the ICNIRP. Their published maximum limit is 833 mG. University studies have shown that EMF greater than 833 mG is possible on the face of the transformer enclosure, but that five feet away EMF has not been measured greater than 228 mG.

- University studies have shown that substation transformers and secondary feeder circuits 400 amps and larger can produce EMF of sufficient strength to impact nearby electronic equipment. Route large secondary feeders away from electronic equipment.

Extend the walls from the floor to the deck above. CMU block walls are recommended for noise mitigation and safety. Obtain permission through the Design Manager before providing gypsum board walls. Chain link fence or expanded metal walls and gates are not acceptable.

Provide a minimum of 5 feet clear above the substation primary switches and secondary switchgear. Obtain approval of primary and secondary conduit and cable tray routes and installation details before providing less clear space above this equipment.

Where required by code, provide fire-resistance rated walls and doors.

Provide the NEC-required working spaces on all sides of each piece of equipment. Provide the NEC-required dedicated equipment space above each piece of equipment. These spaces shall be free of obstructions and grounded surfaces including columns, ductwork, piping, electrical panels, lighting, ground bus bars, floor drains and water leak detectors.

Exit doors shall swing outward from the room. Provide a minimum of two exit doors on opposite ends of the room if the room contains electrical equipment rated 1200 amps or more.

- Exit doors shall be equipped with panic bars, gaskets and bottom edge door sweeps. Double doors require only a single panic bar. Door locks shall be keyed with Arrow "L Series" cores.
- One door shall be large enough for the passage of the largest shipping section of the substation. Typically, this means a minimum 8 foot tall by 7 foot wide double door.
- Where two or more doors are provided, the others may be single doors. These doors should be a minimum 36 inches wide.

Slope the floor toward the floor drain. The floor drain shall be the low point of the floor.

Provide a 4 inch minimum housekeeping pad under each piece of floor-mounted equipment.

- Pads shall conform to the footprint of the equipment and shall be the full width and depth of the equipment, but shall not extend beyond the equipment by more than 4 inches. Pad edges shall be chamfered.
- Pads shall be smooth and level within 1/8 inch overall, or shall include embedded steel leveling channels that are level to within 1/8 inch overall. Leveling channels shall have a 1/8 inch reveal above the top of the concrete and shall be located directly under the equipment support points. Pads that fail to meet these criteria shall be corrected before installation of the equipment.

Provide 2 coats of water-borne epoxy paint over a compatible primer on the concrete floor.

Provide paint or a concrete sealer on the walls and ceiling.

Provide a 10 pound Type ABC fire extinguisher at each exit door.

Provide an unobstructed route to the building exterior to permit replacement of the largest shipping section of the substation. Design the floor of the entire route for the weight of the largest transformer.

Mechanical Design Requirements

The NEC limits substation room access to Plant Operations High Voltage Electricians, making it difficult for others to perform maintenance inside the room. Avoid locating mechanical equipment including fans and fan coil units inside the room.

Ductwork, piping, clean-outs, and other mechanical system components are not permitted in the room unless they serve the room. When there is no alternative to installing foreign ductwork or piping in the room, provide an architectural barrier to segregate the foreign ductwork and piping from the room.

- Provide a minimum of a gypsum board barrier to segregate foreign ductwork.
- Provide a minimum of a waterproofed light weight concrete barrier to segregate foreign piping. Gypsum board barriers or drip pans are not acceptable to segregate foreign piping.

Provide wet sprinklers if the building will be sprinkled.

- Locate the sprinkler heads and route the piping over aisles, not over the electrical equipment.
- Provide wire guards on the sprinkler heads.

In below-grade substation rooms, provide a floor drain at the low point of the room floor. Locate the floor drain in front or behind the middle of the substation and tight to the front or rear wall. Provide a backwater check valve for the floor drain. The backwater check valve shall be located outside of the room.

When a floor drain is provided, provide a water leak detector adjacent to the floor drain and tight to the wall so it isn't a trip hazard. The leak detector shall be outside of the working space of the substation. Connect its alarm contact to the nearest Building Automation System DDC panel.

Provide ventilation to remove equipment heat and maintain equipment within their ambient temperature ratings under all weather and electrical load conditions. Typically, provide supply and exhaust fans with variable speed control to maintain the setpoint temperature. Avoid discharging unheated outside air directly into the room, which can freeze sprinkler lines. Mix return air with outside air so that tempered air above freezing is discharged into the room.

- Design for a summer design space temperature of 10 degrees F over outside ambient.
- Design for a year-around setpoint temperature of 70 degrees F (knowing the summer space temperature will rise to a maximum of 10 degrees F over outside ambient).
- Base cooling load calculations on actual equipment heat rejection data and on the projected peak diversified load for the next 10 years.
- Design the supply and exhaust to produce a slightly positive room.
- Filter the supply air to the room. Minimum filter efficiency shall be 65 percent.
- Air condition the room only if the room cannot be ventilated with outside air. If building chilled water is used, verify the chilled water system operates all year long.

Electrical Design Requirements

Avoid locating electrical equipment requiring maintenance by others in the room, including general lighting and receptacle panels, central UPS systems, Building Automation System DDC panels, fire alarm control panels, security panels, or MOSCAD panels.

Avoid locating emergency or standby power system equipment including transfer switches and panels in the room. This equipment may be required by code to be in a separate room with not less than 1-hour fire-resistance-rated fire barriers and ventilation to and from the exterior.

Provide a 1/4 inch x 2 inch solid copper ground bus bar on the wall behind each substation. Extend it the full length of the substation and mount it 18 inches AFF. Connect multiple ground bus bars together using #4/0 AWG copper ground cables. Do not wrap ground bus bars around the room doors.

- Connect both ends of each substation internal ground bus bar to its room ground bus bar using #4/0 AWG copper ground cables embedded in the housekeeping pad and floor. Connect the internal ground bus bars of other equipment to the room ground bus bar in the same manner.

- For renovation projects only where the floor is not being cut, connect the substation ground bus bar to the room ground bus bar by routing the ground cables overhead.

- Connect the room ground bus bar with #4/0 AWG copper ground cables to all available grounds including the ground grid, concrete-encased foundation rebar, building steel, incoming water services, duct bank ground conductors, lightning protection ground rods, and the ground bus bars in other electrical rooms in the building.

Terminate the incoming primary duct bank with end bells that are embedded in and flush with the inside of the room wall, and as high off of the floor as possible. Slope the duct bank away from the room. If a duct bank must enter the room from below floor level, stub it up along the inside of the wall. Obtain permission through the Design Manager before stubbing ducts up into the bottoms of the primary loop switches.

Provide 24 inch wide aluminum ladder-type cable trays with 24 inch minimum radius fittings to route the primary cables up the wall and across the ceiling of the room. Locate the trays 3 feet minimum above the primary switches, but low enough to permit cable pulling. Provide cable tray roll-outs where the cables drop down into the primary loop switches.

Provide O-Z Gedney No. R4001BO strain relief fittings where the primary cables enter the tops of the primary loop switches. Specify that the Contractor coordinate with the Utilities and Plant Engineering High Voltage Engineer (734 615-4468) or the Plant High Voltage Shop (734 615-5279) before installing the cable trays.

Provide fluorescent lighting in front of and behind each substation, and in front of other electrical equipment. Connect this lighting to emergency power. Provide a battery-backed lighting fixture or an emergency lighting battery pack in front and behind each substation. If emergency power is not available, provide battery-backed lighting fixtures or battery packs throughout the room.

Provide exit signs above the exit doors.

Label the outsides of exit doors "DANGER - HIGH VOLTAGE - KEEP OUT".

Provide duplex receptacles and connect them to emergency power.

Provide one hard-wired IT data connection to each substation watt-hour meter.

To facilitate Building Automation System monitoring of electrical power system status, connect the following devices to a DDC panel.

- Status contacts of main and tie circuit breakers in double-ended unit substations.
- Integral power metering units of the limited number of circuit breakers being monitored by BAS.
- "On generator power" status contacts of automatic transfer switches.

Provide fire alarm system rate-of-rise heat detectors and one combination audible/visual appliance in accordance with Design Guideline 16720.

Provide framed copies of the building's One Line Diagrams and Riser Diagrams on the wall in front of the unit substation.

PERSONAL ROOMS

General

The University of Michigan encourages the inclusion of private rooms for lactation, health needs and other special personal uses requiring privacy. During programming and schematic design the UM Design Manager and the project designers shall consider, in conjunction with the client unit, including one or more personal rooms in the building program. Personal rooms included in the project shall meet the minimum standards listed below.

Minimum Standards for Personal Rooms

A door which can be locked from the inside.

Electrical outlets.

Acceptable environmental requirements (heating, cooling, lighting, etc.) equivalent to what is provided in other occupied areas of the building.

Room sized to accommodate at least a comfortable chair and table (to be provided by client). Alternatively, provide a shelf, minimum 12" deep, in lieu of the table.

If a sink is not provided in the room, a clean sink should be available nearby.

Optional Features

The designer shall determine whether additional amenities, such as those indicated below, should be provided in the project's personal rooms.

Sink.

An additional electrical outlet and space to accommodate a refrigerator.

Telephone and data jacks.

Electric breast pump (to be provided by client).

Signage which includes a sign-up schedule for the room.

Access control: Consult with UM Design Manager and client unit to determine whether access control (i.e., keyed access or entry through a supervised area) shall be considered for the personal rooms. Also, determine whether a "staff bypass key provision" should be provided.

TUNNELS

General

The University of Michigan central campus has an extensive array of tunnels used for distribution of utilities, primarily from the Central Power Plant. This section identifies key design considerations for tunnel related projects.

All work in or near tunnels must be coordinated with the Utilities and Plant Engineering (UPE) – Tunnels Department, in conjunction with the U-M Project Coordinator.

All tunnel related projects shall be designed with the long-term serviceability and maintainability in mind.

Phasing and sequencing is a primary consideration for virtually all tunnel projects, due to the fact that systems operate year-round and disruption to utilities directly impacts U-M's core mission. Proposed design alternatives should consider phasing and sequencing to minimize near and long-term interruption of utilities. Construction documents must clearly define phasing and sequencing requirements. Designs must incorporate all necessary work (valves etc.) to achieve this plan.

Related Sections

Special Instructions to Designers:
SID-J – University Provided Utilities

Design Guideline Technical Sections:
01141 – Tree Preservation
02215 – Soil Erosion and Sedimentation Control
15060 – Basic Piping Materials and Methods
16050 – Basic Electrical Materials and Methods
16500 – Lighting Systems

U-M Master Specifications:
15060 – Basic Piping Materials and Methods
15100 – Valves
15125 – Expansion Joints
15250 – Mechanical Insulation
15525 – Steam and Condensate Piping Systems and Specialties
16050 – Basic Electrical Materials and Methods

Tunnel Types

Standard Utility Tunnel: Most of the tunnel system consists of racked utility piping on one side and a walkway on the other. Some include piping on both sides. Construction of existing tunnels includes poured concrete, pre-cast concrete, and brick. Typical dimensions are approximately 7 feet wide x 7 feet high, although size must be assessed on a project specific basis. Tunnel should be walkable, and allow for removal and replacement of valves, expansion joints etc. Tunnels are accessed through buildings or through sidewalk hatches.

Utility Tunnels Running Through Buildings: While most of the utility tunnel system is "outside", i.e., beyond the footprint of buildings, tunnel services continue through several buildings on campus. Special care is required in designing and installing these projects to ensure tunnel security is maintained, and to ensure piping is properly designed. Minimal connections should be made to the Utility main.

Box trench: Where cost of a standard tunnel cannot be justified, box trenches, and crawl trenches are occasionally used. Access and maintainability must be considered.

Direct Buried Piping Conduit Systems: Direct buried piping is used in some locations for utility piping. Use of a conduit system for utility piping must be approved by UPE.

Building (non-utility) Tunnel: Some buildings contain "non-utility" tunnels that fall within the footprint of a building and serve only the building it is under. Building tunnels should be treated the same as building mechanical rooms, and don't typically require coordination with the UPE-Tunnel department.

<u>Tunnel Piping Utilities</u>

The tunnel system was designed for the following piping utilities that emanate from the Central Power Plant: Low Pressure Steam, Medium Pressure Steam, Steam Condensate, Hot Water and Hot Water Return, and Compressed Air. These systems are operated and maintained by the UPE – Tunnels department. While most pipe materials, and design considerations for these systems are described elsewhere in the U-M Design Guidelines (Technical Section 15060) and U-M Master Specification Sections 15060 and 15100, considerations unique to the application of these systems within the tunnel system are noted below each system, or in paragraphs that follow:

- Low Pressure Steam (LPS) – operating pressure of 6-12 psig
    - While normally saturated, due to the fact that LPS is a byproduct of the co-generation steam turbines, this system experiences occasional temperature excursions. Temperature of the steam can reach 600F if the desuperheater fails. As such, all LPS piping in the tunnels shall be designed for expansion associated with 600F piping. Cast iron fittings are prohibited.
    - U-M maintains a flow model for the LPS distribution, and as such, generally defines required pipe sizes for LPS piping in the tunnels.
    - Use float and thermostatic (F&T) traps on LPS. Do not connect LPC from traps directly to the tunnel LPC system. Use condensate return unit to pump into the LPC main.
- Medium Pressure Steam (MPS) – operating pressure of 60 psig nominally

  - Pressure Reducing Valves are used in some locations from the MPS system to the LPS system, for back-up and pressure maintenance during peak conditions. Associated relief valves should be routed to a safe location outside the tunnel. Refer to SID-J for additional discussion on requirements for PRV's and back-up steam.

- Steam Condensate Return (LPC)

  - The steam condensate is typically metered at individual buildings, and pumped into the LPC. While the system is under some backpressure at certain points, it is generally considered to be a low-pressure gravity return system. Do not directly connect LPC from building loads or drip and traps to LPC main. Use condensate return unit.

  - Drip and traps from MPS should not be routed directly to the LPC. Use flash tank and pumped condensate return unit.

  - Condensate return units (CRUs). A combination of electric and pressure powered CRUs are used in the tunnels.

- (Domestic) Hot Water (HW) and Hot Water Return (HWR)

  - Existing piping is primarily Type-L grooved copper piping using Victaulic fittings. U-M has an ongoing program to replace remaining steel piping with copper. Unless directed otherwise, use grooved copper piping for all DHW and DHWR in tunnels.

  - U-M has experienced numerous problems with expansion joints in HW and HWR systems. Refer to U-M Master Specification 15125 – Expansion Joints for current specification requirements.

  - All flexible piping on HW and HWR shall be of all stainless steel construction. Ball valves on HW and HWR shall have stainless steel body and ball.

  - Because of hydraulic and maintenance problems within the DHWR system, all new buildings are required to have their own internal DHWR system, typically with a small shell and tube heat exchanger and pump to reheat the DHWR back to 125F. For existing building connections, where practical, connections to the tunnel DHWR system should be eliminated, and replaced with an internal return system.

- Compressed Air (CA) – operating at 90-100 psig (refer to SID-J for clarification)

  - For building take-off, include two check valves installed in series to protect tunnel piping from possible contamination, and to protect the building compressed air loads from sudden loss of pressure if compressed air is turned off.

Other Piping Considerations

Piping Expansion and Stress Analysis:
For new connections to tunnel piping, analyze piping expansion and stress, and anchoring forces up to and including first anchor on either side of new connection. Provide pipe stress calculations to prove new and existing piping is not overstressed.

Three Valve Arrangements for Building Take-Offs:
In general, branch take-offs for individual buildings should include a three valve arrangement, to allow the building to be fed from either direction in the utility loop.

B31.1 Requirements:
Refer to Master Specification Sections 15060 – Basic Piping Materials and Methods and 15525 – Steam and Condensate Piping Systems & Specialties for B31.1 welding requirements on utility piping.

Insulation:

- Aluminum jacketing is required on all insulated LPS, LPC and MPS piping in tunnels. Refer to Master Specification Section 15250 - Mechanical Insulation for materials and required thickness.

Other Piping and Utilities in Tunnels

The following services are not considered Utility Piping. Coordinate with UPE-Tunnels prior to routing these systems through tunnels.

Chilled Water (CHW): Chilled water is not generally distributed via the tunnel system, although CHW piping is routed between buildings, through the tunnels in several areas. Additional insulation will be required within the tunnel.

Fire Protection Water: In some locations, fire protection piping may be routed through the tunnels, especially where a fire pump is shared between buildings.

City Water, Sanitary, and Storm: Beyond the building footprint, these services are generally owned and maintained by the City of Ann Arbor, and should not be routed through the tunnels without approval by the City and UPE-Tunnels. Coordinate modifications to these services through the City of Ann Arbor, UPO-Civil department and U-M Project Coordinator.

Architectural and Structural Requirements and Considerations

Load bearing capacity:
Tunnels shall be designed for H-20 (Highway) loading. In general, wall and roof sections should be a minimum of 8” thick reinforced concrete. Some older sections of the tunnel

system do not meet this loading requirement and may need shoring where heavy loads must cross the tunnel. Confirm structural design requirements with U-M Project Coordinator.

Vaults:
Vaults are required in many areas at key junctions in the tunnel piping. Vault shall be designed to accommodate installation and maintenance of intersecting pipes, including flash tanks, condensate return units, etc. Provide a sump and simplex, high temperature sump pump at low point of each vault.

Waterproofing:
Top and sides of tunnels should include waterproofing, typically membrane type. Coordinate with U-M Project Coordinator for waterproofing requirements.

Separation between Buildings and Tunnels:
Appropriate separation is required between buildings and tunnels. At a minimum, a lockable door is required at the tunnel (using U-M standard core). Fire rated separation is not typically required. Confirm separation requirements with U-M Project Coordinator.

Hatches:
Hatches are often required to maintain reasonable access to sections of the tunnel system. Location of hatches must be carefully coordinated with U-M project coordinator and UPE-Tunnels. In general, hatches must be designed to allow installation of 20 foot long pipe sections. All sidewalk or grade level exits will be equipped with a crash bar type opening mechanism and sufficient lifting assistance mechanisms to allow a worker in a diminished physical state to fully open the hatch with one hand. Include steel ladder at each hatch. Refer to Master Specification Section 05500 – Metal Fabrication.

General Requirements and Design Considerations

Coordination with City of Ann Arbor:
Work on tunnels is often affected by City of Ann Arbor requirements associated with right of ways, street closings and paving, etc. Review proposed concepts and issues with the City of Ann Arbor in early stages of design. Coordinate all contact with the City through the UPO – Civil department, and U-M Project Coordinator.

Coordination with UPO-Civil:
Coordinate soil erosion control, tree protection, and staging through the UPO-Civil department and U-M OSEH department, in conjunction with the U-M Project Coordinator.

Confined Space:
Portions of the tunnel system are considered "confined space", and are therefore subject to associated U-M OSEH requirements.

Field Surveys:
Design must be based on actual field surveyed conditions. U-M has extensive records on modifications made in the tunnels. However, design must be validated by field inspection prior to release of construction documents.

Mechanical Requirements and Considerations

Ventilation:
Consider need for ventilation on all tunnel projects. Confirm ventilation needs with U-M Project Coordinator and Utilities. Tunnels are ventilated primarily with outside air, through the use of supply and/or exhaust fans. Kiosks are used extensively to house ventilation intake and relief. In some areas of campus, a more aesthetically sensitive alternative may be necessary. Design ventilation system to maintain ambient plus 10F during the summer.

Water Detection:
U-M is concerned about rapid detection and response to water leaks in the tunnel system, and has installed water sensors at several system low points. Confirm water detection requirements during design. Typically, install a water sensor at low point in any new tunnel section if any point in the new tunnel section is lower than the connection point to the existing tunnel. Water sensors should be connected to the Building Automation System.

Drains:
Tunnel system does not typically include floor drains, footing drains or sumps at regular intervals. However, a sump with a simplex high temperature sump pump should be installed at vaults and building entrances.

Electrical Requirements and Considerations

Lighting:
Lighting shall be designed to maintain a minimum light level of 25 FC at the walk surface. Fixtures shall be 24 watt minimum, compact fluorescent type, with globe glass and guard. Lighting should be controlled by 20 amp manual dial timer (12-hour) located at tunnel entrances, and at intervals of 200 feet.

Electrical Receptacles:
Duplex Receptacles are typically required throughout the tunnel system. Receptacles shall be 20 amp GFCI type with waterproof covers. They shall be installed at each tunnel entrance, and at intervals of 300 feet throughout the tunnel.

Cable Trays:
All tunnels shall include an aluminum ladder-type cable tray for future use for ITCom, and other services. Tray should be approximately 12” wide x 4” deep, with 9” rung spacing and 12” minimum bending radius, unless project specific requirements are higher. Tray should be located just outside the piping supports, near the ceiling.

Conduit:
Conduit in Utility tunnels, and box trenches shall be fiberglass-reinforced epoxy, or Schedule 80 PVC, with matching fittings. Provide expansion joints every 100 feet and on both sides of every change in direction. In utility tunnels that are completely dry, consult U-M Project Coordinator as to whether rigid galvanized steel conduit may be specified instead. Building tunnels may use EMT conduit.

Fire and Smoke Detection and Alarm:

The Utility Tunnel system does not typically require a fire alarm system or notification appliances.

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UNISEX TOILET ROOMS

General

Each new building or major renovation project requires the inclusion of at least one single occupancy unisex toilet room as part of the project. This is a University of Michigan requirement, and exceptions will be granted by U-M Design Manager only under unusual, well-documented circumstances provided in writing by the unit or division funding the project. These toilet rooms shall meet the minimum standards listed below.

Related Sections

Special Instructions to Designers:
SID-F – Codes and Regulatory Agencies

Design Guideline Technical Sections:
10810 – Toilet Accessories

Preferred Manufacturers List
Architectural

Minimum Standards for Unisex Toilet Rooms

A door with a privacy lock (lockable from the inside and openable in an emergency from the outside).

Handicap accessibility per current codes, per Codes and Regulatory Agencies.

Toilet accessories, including a changing table, shall meet U-M requirements per Section 10810 – Toilet Accessories, and Architectural Preferred Manufacturers List.

Where possible, locate the toilet room so that it is convenient for the majority of building occupants.

FIRE COMMAND CENTER

General

When designing a new high-rise building or when upgrading an existing building to a high-rise, provide a Fire Command Center for emergency operations.

Related Sections

Design Guideline Technical Sections:
10400 - Signage
14000 – Elevators
15300 – Fire Protection
16300 – Electrical Power Systems
16720 – Fire Alarm System

U-M Master Specifications:
14210 – Electric Traction Elevators
14240 – Hydraulic Passenger Elevators
15320 – Fire Pumps
16231 – Engine-Generator System
16720 – Fire Alarm System

References

MBC, "Michigan Building Code"
MMC, "Michigan Mechanical Code"

NFPA 72, "National Fire Alarm Code"

Fire Command Center Room Requirements

Locate the Fire Command Center on the ground floor and near the building entrance designated for initial Department of Public Safety (DPS) and Ann Arbor Fire Department response. Provide access to the room from the interior of the building. If possible, also provide access directly from the exterior of the building.

The room shall be a minimum of 96 square feet with a minimum dimension of 8 feet. Separate the room and its access route from the remainder of the building by not less than a 1 hour fire resistance-rated fire barrier. Ventilate the room in accordance with the MBC and MMC.

Obtain DPS approval before expanding the room to incorporate other building functions such as a reception desk, security office, or DPS mini-station.

Connect the room equipment, lighting, and duplex receptacles to the building's emergency power system.

Key the door locks with a "BA" machine room series lock that is different from the other "BA" series locks in the building. Arrange for the building's Facilities Manager to receive a copy of this unique BA series key. This will enable the DPS and Plant Operations Shops personnel with BA master keys as well as the Facilities Manager to have immediate access to the room.

Provide signage at each door with "Fire Command Center" in 1" high, bold red letters.

Fire Command Center Features

Provide a fire alarm system control panel complete with a digital annunciator, status indicating lights, audible signals, and all of the following features:

- An emergency voice/alarm communications system panel with audio generators, amplifiers, controls, indicators, and a microphone.
- A fire department two-way communications system panel with power supplies, controls, indicators, a master telephone handset, and pluggable portable handsets.
- A control and status indicator panel for air-handling systems and smoke control systems. Provide one control switch and one set of indicators for each smoke control zone as a unit, rather than one control switch and one set of indicators for each component of each zone.
- Because the fire alarm system digital annunciator indicates the status of sprinkler system flow and tamper switches, no separate sprinkler system display panel is required.
- Because the fire alarm system digital annunciator indicates the status of the fire pump, no separate fire pump status indicator is required.
- Because the fire alarm system digital annunciator stores several hundred past events, generally no printer is required.

Provide an elevator annunciator panel that indicates the location and status of each elevator.

Provide a control switch for simultaneously unlocking all non-exit discharge stairway doors that are locked from the stairway side. Do not provide a control switch for unlocking exit discharge doors that are locked by the card access control system.

Provide a telephone for Fire Department use. The telephone shall have access to the public telephone system.

Provide an emergency and standby power generator status panel for each generator. The panel shall duplicate the status indicating lights on the generator's local control panel.

Provide a green "normal power" and a red "generator power" indicating light for each emergency and standby power automatic transfer switch (ATS) to indicate the position of the ATS. Label each pair of lights to indicate the generator and ATS equipment numbers and the types of loads connected to the ATS.

Provide one Plexiglas guarded, two position, "Auto-Run" selector switch to manually start the generators and enable the ATS's to transfer. The selector switch shall have the following features:

- One Form-C maintained contact for each ATS (except do not provide a contact for a fire pump ATS that is integral to the fire pump controller). Provide control wiring from each switch contact to its ATS.

- In the "Auto" position, each switch contact shall place its associated ATS in normal stand-by mode.

- In the "Run" position, each switch contact shall simulate a loss of normal power to its ATS. This shall cause each ATS to start its generator and then transfer to generator power when its generator reaches proper voltage and frequency (except the ATS's may wait to transfer until normal power is lost if the building has multiple generators and "paralleling switchgear").

- A nameplate identifying the purpose of the selector switch.

Provide schematic building plans indicating the typical floor plan and detailing the building core, means of egress, fire protection systems, fire-fighting equipment, and fire department access. Provide storage for these building plans.

Provide a work table.

Provide a public address system, but only if one is required. Generally a public address system is not required.

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Technical Sections

CSI DIVISION	DATE OF LAST UPDATE
1 General Requirements	February 2008
2 Site Work	September 2007
3 Concrete	April 1995
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6 Wood and Plastics	April 1995
7 Thermal and Moisture Protection	August 2010
8 Doors and Windows	October 2010
9 Finishes	February 2008
10 Specialties	February 2008
11 Equipment	June 2004
12 Furnishings	April 1995
13 Special Construction	April 2003
14 Conveying Systems	February 1999
15 Mechanical	February 2010
16 Electrical	October 2009

Last modified: Wednesday October 13 2010

For technical inquires, comments and suggestions on the U of M Design Guidelines, please e-mail the U of M Design Guidelines Group at UMDesignGuide@umich.edu.

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Division 1 - General Requirements

SECTION	DATE OF LAST UPDATE	PAST VERSIONS
01040 Coordination	April 1995	
01045 Roofing Materials Cutting and Patching	April 1995	
01141 - Tree Preservation	July 2004	
01730 Operations, Maintenance and Training	February 2008	April 1995

Last modified: Wednesday July 21 2010

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COORDINATION

General

All work in ceiling spaces, mechanical rooms, reflected ceiling plans, etc. shall be coordinated to provide maximum accessibility. Consider additional drawing sections or extraordinary construction measures to assure this. Pay particular attention to this when the user and/or other design staff have consciously decided to install mechanical equipment in marginally accessible locations.

Drawing Requirements

The A/E must place notes on the drawings, as appropriate, directing the Contractors to coordinate all work to allow free access to mechanical and electrical equipment for servicing. Particular attention must be given to assure access to panels, doors, service entrances, etc. The removal of other components such as light fixtures in order to service any equipment shall be discouraged. Access routes should not encourage abuse (i.e., stepping on ductwork). The specifications should require that coordination drawings be submitted by the General Contractor for major renovation and new construction projects. These drawings shall clearly show the priority by trade required to assure access to the equipment and devices in the ceiling cavity. Of particular importance is the free access to all variable volume boxes, reheat coils and their controls -- including free and easy removal of the entire box. Nothing shall be located beneath these devices. (Fire protection or other piping is to be offset around the device footprint, etc.) The A/E must witness the construction to assure that the required accessibility is achieved.

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ROOFING MATERIALS CUTTING & PATCHING

General

In general, follow the guidelines below when specifying cutting and patching of roofing. Unless otherwise indicated, these guidelines are not intended to restrict or replace professional judgment.

The University maintains its own roofing department, licensed to repair the roofing systems of various manufacturers. The roofing department also inspects all roofing work performed at the University, from patching work to new construction.

Warranty Requirements

Important considerations to remember when specifying roofing cutting and patching are:

Warranty patching work must be performed in a manner which will not void the manufacturer's warranty. Installers must be licensed by the roofing manufacturer to perform patching work.

Patching work must be coordinated with the University's Roofing Department, regardless of the size of the patch.

Submittal Requirements

Require the following submittals in the cutting and patching specification:

Qualification data for firm engaged to perform cutting and patching of roofing system.

Quality Assurance Requirements

Include the following Standards in the Quality Assurance article in cutting and patching specification:

Perform cutting and patching work in compliance with University of Michigan Plant Roofing Department standards (phone 763-3098 for information on requirements), and with recommendations of the National Roofing Contractor's Association "Roofing and Waterproofing Manual".

Include the following requirements in the Quality Assurance article of the cutting and patching specification:

Installer Qualification:
Arrange for cutting and patching of roofing systems by firm experienced in similar work, and licensed by manufacturer of roofing system to perform required repair work.

Pre-Construction Conference:
Contractor to arrange, through the Project Coordinator, and attend meeting with the Owner's representative and a representative of Owner's Roofing Maintenance Department, and representative of roofing firm to determine procedures for cutting and patching roofing system.

Other Provisions

In the "Part 2 - Products" portion of cutting and patching specification, include your standard language conveying the following ideas:

Use materials for patching identical to existing materials. Use materials for patching that result in equal-or-better performance characteristics.

In the "Part 3 - Execution" portion of cutting and patching specification, include the following requirement:

Before cutting and patching roofing materials, obtain the Owners Representative's approval to proceed.

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TREE PRESERVATION

Introduction

This document delineates requirements for tree preservation on the University of Michigan campus.

Tree Survey

A tree survey will be done as part of the pre-design work for campus development projects. The survey will show the locations of the existing trees located within the bounds of the site, as well as on any surrounding areas that may be impacted by the project. The Design Manager (DM), together with the University Forester (UF), shall categorize the trees on the survey as follows:

- Memorial trees (including tree tag #) and their associated plaques.
- Trees to remain and be protected.
- Trees that can be relocated (transplanted).
- Significant trees that can be relocated.
- Significant trees that can be removed.
- Trees that are not significant or are of low quality.

If the preliminary survey includes significant trees or memorial trees that are to be relocated or removed, it shall be submitted to the Associate Vice President for Facilities and Operations (AVPFO) for approval. The survey shall be accompanied by a written summary prepared by the DM, the UF and the University Planner that describes the significance of the trees and the reasons for relocation and/or removal.

The tree survey as approved shall be provided to the Architect/Engineer (A/E). The A/E shall develop building and site concepts that are in accordance with the requirements identified on the survey. Deviation from the tree designations and dispositions as shown on the tree survey will not be permitted.

Protection

Existing trees that are to be preserved shall be protected during all phases of the construction project.

Specific Procedures for Protecting Trees

- The Contract Documents shall identify all trees to remain and to be protected, including those outside the construction limit line. The protective zone around each tree shall be clearly identified. The protective zone for significant trees shall not encroach on the canopy dripline unless there is a compelling reason why this is not practical. In such a situation, approval for the deviation must be obtained from the UF.
- For other trees, the protective zone shall extend to the tree canopy drip line where possible.
- The Construction Documents shall instruct the Contractor that no activity, including parking or storage of materials, will be allowed within the protective zones, and that protective fences or other methods of protection will not be moved, removed, or altered.

- Include aeration and gator bags as remediation measures for trees that have been negatively impacted by construction.

Relocation or Removal

Relocation and transplantation of existing trees will be accomplished by either tree spade or by the balled and burlapped method. The UF along with the University Planner will determine the new location.

Removal includes cutting the tree down and debris disposal

Specific Procedures for Removal and Relocation

- During design the UF and DM will decide whether the removal will be done by in-house crews or by the Contractor.
- The project responsible for removing the trees will fund the cost of transplantation or permanent removal by cutting the tree down.
- If the Contractor is removing trees, include instructions that felled trees and all associated debris shall be removed from the project site within 24 hours.
- Replacement trees will replicate the individual or cumulative caliper of the trees removed. For example, two 5" caliper trees could be replaced with one 10" caliper tree or five 2" caliper trees. The replacement trees will be planted on the project site or elsewhere on campus as determined by the UF and UP.

OPERATIONS, MAINTENANCE AND TRAINING

General

For University of Michigan Hospitals and Health Centers projects refer to Design Guideline 01730-H available at:
http://www.med.umich.edu/facilities/planningdevelopment/ae/dg/arch.html
Operations and maintenance costs are of prime concern to the University and thus the A/E shall design the systems to be both energy efficient and easily maintainable.

Where justifiable and appropriate, systems and components are to match existing. A written justification for sole-sourcing is normally required in such cases.

Systems are to be simple to operate and designed to fail in the least harmful position.

Protect mechanical and electrical services from physical abuse. Provide permanent access routes as appropriate.

Show on plan and elevation drawings required clearances at equipment needed for maintenance.

Related Sections

U-M Design Guideline Technical Sections:
Section 15010 - Basic Mechanical Requirements

U-M Master Specification Sections:
15975 Mechanical Systems Controls - for service manuals for digital control systems

Training Requirements

The A/E is responsible for meeting with the U of M Maintenance Manager (contact the University Project Coordinator) early in the design phase of the project in order to determine the number of training sessions required, and to reflect this in the construction specification. Most training should be conducted both in a classroom and at the system/equipment location.

The need for training will vary, in part depending on the complexity of a system, its uniqueness (at the U of M) and the familiarity of the area maintenance staff with that system, material or application.

For particular equipment, materials or components, the Contractor or supplier will normally conduct training. For complex systems such as HVAC systems, special lighting controls or communications systems, the A/E must conduct the training so that the design intent can be fully explained. It may be appropriate for systems training to be conducted jointly with a major vendor (e.g., the automatic temperature controls contractor may assist the A/E in presenting an HVAC training session).

Operating and Maintenance Instruction Manuals

Four sets of **job specific** operations and maintenance manuals shall be provided for each project. The construction specifications shall require the contractor to submit job specific O & M manuals a minimum of two (2) weeks prior to any scheduled training. The manuals shall be collected in indexed three ring binders and contain manufacturer's operating and maintenance literature for every equipment item furnished for the project. Generic wiring or piping schematics are NOT acceptable; they must be job specific, reflecting the actual furnished equipment, including all options and interfaces with other equipment or systems.

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Division 2 - Sitework

SECTION	DATE OF LAST UPDATE	PAST VERSIONS
02000 Sitework	September 2007	April 1995
02215 Soil Erosion and Sedimentation Control	June 2007	
02510 Walks, Roads and Parking Paving	July 2006	
02665 Water Supply Systems	April 1995	
02810 Automatic Lawn Irrigation	April 1995	

Last modified: Wednesday July 21 2010

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SITEWORK

General

In general, follow the guidelines below when designing and specifying sitework. Unless otherwise indicated, these guidelines are not intended to restrict or replace professional judgment.

Related Sections

01141 Tree Preservation
02215 Soil Erosion and Sedimentation Control
02510 Walks, Roads and Parking Paving
02810 Automatic Lawn Irrigation

Design Requirements

All work within City of Ann Arbor street right-of ways shall be in accordance with the City of Ann Arbor's standards and requirements. Permanent construction within City of Ann Arbor right-of-ways requires licensing by the City. Permanent construction on land not owned by the University may require an easement. Early in design, notify the University Design Manager of any such construction so that discussions with the City and/or other affected property owners can be initiated. Coordinate communications with the City through the University Design Manager.

All water main and sewer connections to City of Ann Arbor facilities shall be in accordance with the City of Ann Arbor's Standards and Requirements. Coordinate communication with the City Engineer regarding interpretation of these Standards and Requirements through the University Design Manager.

All materials, equipment and construction for bituminous and concrete pavements shall be in accordance with the latest version of the Michigan Department of Transportation Standard Specifications for Construction.

Granular materials shall be a minimum of MDOT Class II, compacted to 98% of an ASTM 1557 value.

All concrete shall be 4,000 pounds per square inch minimum compressive strength at 28 days, and consist of air entrained Portland cement with a total air content of not less than 4 percent, but not more than 7 percent. Cement content shall be a minimum of 6 sacks per cubic yard. The slump shall be not more than 4 inches, nor less than l-l/2 inches as determined by the slump cone test, ASTM C-l43. All flatwork concrete shall be reinforced with polypropylene fibrillated fibers at a volume of 1.5 pounds per cubic yard.

Backfill for all utility trenches that run under, or within 3 feet of, existing and proposed concrete or asphalt surfaces shall be granular material as specified in (4) above.

All regular sidewalks should be 8 feet wide, and all steps and stairs eliminated if at all possible to facilitate barrier free access, cleaning and snow removal.

Paved areas at building entrances should be adequate to accommodate refuse containers and cigarette urns.

The potential for installing an automatic lawn irrigation system should be discussed with UM Grounds Services, coordinated through the University Design Manager, early in the project, so that plumbing for the meter, back-flow equipment and a supply line to the outside of the building can be included in Mechanical work.

Wall hydrants to receive a 1 inch hose should be included in the Mechanical work even if an automatic lawn irrigation system is planned for the project.

Site Elements

The A/E shall identify on the existing conditions site plan and on the demolition plan all site elements that will be impacted by construction, to include but not limited to:

- Free-standing building ID signs
- Plaques on the grounds or on the building
- Public art works and artifacts
- Kiosks used for posting flyers
- SORC posting boards (triangular boards used for posters)
- Memorial benches
- Memorial trees

The A/E and the University Design Manager will work with the University Planner's Office to determine the appropriate disposition of these site elements. It will be the responsibility of the project to relocate, replace, or restore the elements per the instructions of the Planner's Office. The A/E will stipulate in the design documents the approved disposition/relocation/restoration of all relevant site elements.

Refuse Removal

When a project includes permanent refuse removal facilities in the Scope of Work, provision must be made to have access for the large 34 cubic yard compaction trucks to service the containers.

The specific type of refuse container or compactor selected must be approved by Grounds Services coordinated through the University Design Manager early in the design phase.

A fireproof space must be planned for storage of recyclable materials.

The A/E shall stipulate in the Design Documents that the Contractor shall remove all building materials and debris from the job site, and sub-grade the landscape areas to 4 inches below finish grade. Refuse removal during the construction phase shall be as frequent as necessary to prevent windblown debris. Unsightly pileup is also prohibited.

The construction site and valuable landscape plants shall be fenced to control Contractor parking and material storage.

Existing trees and other landscape plant materials within and outside the contract limits must be protected from soil compaction and breakage. See Design Guideline 01141 Tree Protection.

Landscape plants and materials to be removed must be approved by the University Design Manager.

SOIL EROSION AND SEDIMENTATION CONTROL

General

Soil erosion and sedimentation control (SESC) procedures are activities which are regulated by the State of Michigan on all UM project sites that implement an earth change activity.

All earth changes of one acre or more or within 500 feet of Waters of the State require a plan that is in compliance with the Soil Erosion and Sedimentation Control Part 91 of Natural Resources and Environmental Protection Act Public Acts 451 of 1994, as amended. All other projects must provide a site plan and a description of the methods being employed to control run off and the resulting sedimentation which would otherwise enter the existing storm water system.

During the design phase of the Project, the UM Design Manager, with the assistance of the A/E, will submit to UM OSEH the Project Notification Form. A blank copy of this form is available at http://www.oseh.umich.edu/stormwater/SESCAppA.pdf

Definition

"Waters of the State" includes the Great Lakes and their connecting waters, lakes, ponds and streams, which may or may not be serving as a county drain as defined by the drain code; or any other body of water that has definite banks, a bed and visible evidence of a continued flow or continued occurrence of water and wetlands regulated under Part 303 of Public Acts 451 of 1994.

Responsibilities

The A/E shall prepare the soil erosion and sedimentation control plans and specifications. Implementation of the soil erosion and sedimentation control plan including required maintenance during construction and final removal as directed in the plans, is the responsibility of the Contractor.

The University of Michigan, Occupational Safety & Environmental Health(UM-OSEH) is designated as an "Authorized Public Agency" and is responsible for administration of Part 91 of Act 451. The proposed plans for soil erosion and sedimentation control must be submitted for review and approval to the UM-OSEH & the University Planner's Office, prior to the beginning of any site work.

Reference Specifications

1. The University of Michigan Soil Erosion & Sedimentation Control Procedures.
http://www.oseh.umich.edu/stormwater/emsec.html

2. Guidebook of Best Management Practices for Michigan Watersheds
http://www.michigan.gov/deq/0,1607,7-135-3313_3682_3714-118554--,00.html

Developing and Implementing the Plan

Governing Principles for All UM Sites Involving an Earth Change Activity

The following principles should be considered when developing a soil erosion and sedimentation control plan:

- Integrate the overall construction design and activities to fit the physical and vegetative features of the site.
- Specify the staging of construction and stabilization activities to minimize the area and duration of disturbance.
- Specify control measures that will minimize erosion as a first line of defense, such as: seeding & mulching, preserving vegetative buffers, surface roughening, grade stabilization structures, check dams and controlling wind erosion by covering stockpiles or wetting exposed soils.
- Include perimeter protection controls that will prevent off-site sedimentation. Ex: perimeter barriers (silt fence), vegetative filter strips, anti-tracking pads, storm drain inlet protection, and sediment basins. Sedimentation control should not be used as a substitute for erosion control, but rather in conjunction with erosion control.
- Specify that a sweeper shall be employed to remove sediment tracked onto the pavement at least on a daily basis. Include a requirement that sweepers must be used more frequently, as needed, based on site conditions.
- Require the Contractor to establish an inspection and maintenance schedule.

Include as a minimum the following information for sites one acre or more in size or within 500 feet of Waters of the State:

- A map or maps at a scale of not more than 200 feet = 1 inch. Map shall include a legal description and site location, sketch that includes the proximity of any proposed earth change to lakes, streams or both; predominant land features including lakes, streams and wetlands; and contour intervals or slope information.
- A soils survey or a written description of the soil types of the exposed land area contemplated for the earth change.
- Description and location of physical limits of each proposed earth change.
- Description and location of existing and proposed on-site drainage and dewatering facilities.
- Timing and sequence of each proposed earth change.

- Description and location of all temporary and permanent erosion and sedimentation control measures, including timing on installation and removal of temporary measures.
- Program and schedule for maintaining all control measures.

A design and review checklist containing these required plan items is provided in Appendix B UM SESC Procedures.
http://www.oseh.umich.edu/stormwater/emsec.html

Recommended control measures for all UM sites involving earth change activity:

The following SESC measures need to be included in most plans. Other measures may also be required based on specific site conditions and projects.

- Provide inlet protection on all adjacent and down gradient storm water inlets, catchbasins, and manholes. This may be accomplished using filter fabric, regular or high flow silt sacks, or other control measures.
- Install an entrance anti-tracking pad with a minimum of 50 feet in length. A geotextile filter fabric should be placed under 6 inches of limestone aggregate.
- Install perimeter barriers adjacent to and down gradient of the disturbed area.
- Place stockpiles and other spoil piles away from the drainage system to minimize sediment transport. Keep as few stockpiles as possible during the course of the project. If the stockpile and/or spoil pile must remain on-site overnight, or if the weather conditions indicate the chance for precipitation protect the pile from erosion.
- Provide dust control.
- Provide sweeping to remove any track-out.
- Specify biodegradeable products for erosion control blankets.

Construction Sequence for all UM sites involving earth change activity:

Include a construction sequence in the plans and/or specifications. The following construction sequence is recommended:

- Install all temporary and permanent erosion and sediment control measures in accordance with the approved plan and special permit conditions.
- UM-OSEH-EM will inspect all projects at least weekly and after every significant storm events to evaluate the effectiveness of the control measures.
- Per plan and per UM-OSEH-EM, maintain all temporary and permanent control measures daily and as needed based on the site inspections.
- Complete permanent soil erosion control measures for all slopes, channels, ditches, or any disturbed land area within 5 calendar days after final grading or the final earth change has been completed.

- Remove all temporary control measures after permanent soil erosion control measures are in place and the area is stabilized.
- Notify the Project Manager for a final inspection when the project is completed.

WALKS, ROADS AND PARKING PAVING

Design Requirements

All work within City of Ann Arbor street right-of ways shall be in accordance with the current version of the City's standards and requirements. During design, the A/E shall submit plans and specifications to the City for review and approval. This process should be completed prior to the issuance of 100% CD's.

All materials, equipment and construction for bituminous and concrete pavements shall be in accordance with the current version of the Michigan Department of Transportation Standard Specifications for Construction.

Consult with the University Project Coordinator to determine the appropriate paving materials for each project.

No welded wire fabric shall be used in sidewalk construction.

Installation Requirements

Concrete shall consist of air entrained Portland Cement with a total air content of not less than 4 percent but not more than 7 percent. Cement content shall be a minimum of 6 sacks per cubic yard. Concrete shall contain polypropylene fibrillated fibers at a volume of 1.5 pounds per cubic yard

All regular sidewalks shall be 8 feet wide and 8 inches thick, and all steps and stairs eliminated if at all possible to facilitate cleaning and snow removal.

Paved areas at building entrances shall be adequate to accommodate refuse containers.

Quality Acceptance Test

Minimum concrete 28 day compressive strength shall be 4000 psi.

Slump shall be not more than 4 inches, or less than 1 1/2 inches, as determined by the slump cone test specified in ASTM C-143.

Cleanup Requirements

Concrete and asphalt work (including cutting, grinding, drilling, and hyro-demolition) washout cannot be discharged into storm drains, catch basins or to the sanitary sewer system. Direct the Contractor to utilize proper disposal and washout practices and to perform washing of concrete trucks in designated areas or offsite.

WATER SUPPLY SYSTEMS

General

The City of Ann Arbor's local plumbing codes supplement the State and National codes. Consult the City Engineer through the University Project Coordinator for specific interpretation.

The purchase of the water meter is the responsibility of the University; however, installation will be by the City. The Contractor is responsible for obtaining all necessary permits. The water use and sewer use fees for the water meter will be the responsibility of the University.

Related Sections

Tab “Special Instructions to Designers” - Section “F - Codes and Regulatory Agencies”
Tab “15” - Section “15010 - Basic Mechanical Requirements”
Tab “15” - Section “15060 - Pipe and Pipe Fittings”

Material Requirements

Materials from the City main to the entrance into the building shall meet City of Ann Arbor requirements.

Piping inside the building downstream of the City water meter should be copper. Brass nipple and/or dielectric flanges shall be used between dissimilar metals. Dielectric unions are not acceptable.

Installation Requirements

An approved backflow preventer shall be installed at the point of entry in new buildings, and at the point of take-off of new piping in renovation projects whenever the water is to be used for non potable purposes. See Section #15430. Backflow preventers shall be tested and certified upon installation of unit.

All fixtures connected to purified water systems shall contain approved vacuum breakers.

The A/E shall consult with the University Project Coordinator to determine if the existing building distribution system is sufficiently large to support the new demands.

All water pipes should be pitched to facilitate complete drainage.

Water hammer arresters should be installed at all fixture groups.

Newly installed pipes should be cleaned and chlorinated. The method used should be as set forth in AWWA Standard Specifications, latest edition, including all amendments thereto. The treatment should consist of a solution of not less than 50 ppm of available chlorine (liquid chlorine or sodium hypo chloride). After sterilization the system should be flushed with clean water until the chlorine residual is not greater than 0.2 ppm.

The high oxygen content of Ann Arbor water should be compensated for. One acceptable method is treating with sodium silicate prior to occupancy.

System must pass inspection by City of Ann Arbor.

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AUTOMATIC LAWN IRRIGATION

General

The potential for installing an automatic lawn irrigation system should be discussed with the Landscape Architect's Office through the University Project Coordinator early in the project so that plumbing for the meter, back-flow equipment, and a supply line to the outside of the building can be included in the mechanical work.

Wall hydrants with integral vacuum breakers and one inch hose connections should be included in the mechanical work even if an automatic lawn irrigation system is planned for the project.

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Division 3 - Concrete

SECTION	DATE OF LAST UPDATE	PAST VERSIONS
03300 Concrete	April 1995	

Last modified: Wednesday July 21 2010

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CONCRETE

General

In general, follow the guidelines below when designing and specifying concrete work. Unless specifically indicated otherwise, these guidelines are not intended to restrict or replace professional judgment.

Design Requirements

Structural Elements - ACI 318, designed for calculated structural requirements. A/E's may use their own office standards for details such as chamfered vs. square edges. Include the following language in specifications:

> Water shall not be added to concrete at the jobsite.

Sidewalks - Design walks to comply with the requirements of Section 02510 "Walks, Roads and Parking Paving" of these Design Guidelines.

Floors, General: The University supports the use of floor flatness and levelness “F-numbers” as described in ASTM E 1155-87 and ACI 117. Flatness and levelness specified in terms of “1/8-inch in 10 feet” or similar descriptions are difficult to enforce. Job-site quality control will be provided by a testing firm engaged and paid for by the Owner, unless otherwise determined by the University Project Coordinator.

Supported Slabs: Design slabs at least 5-1/2 inches thick, unless otherwise required by code or expected live loads. Do not use thinner slabs even if structurally feasible, without the approval of the University Project Coordinator.

Strength: As required, but not less than 3500 psi at 28 days.

Flat Slabs-On-Grade - Design slabs-on-grade to comply with the following requirements:

Vapor Barriers: Usually required. Omit vapor barriers only in consultation with University Project Coordinator. The practice of perforating vapor barriers to avoid the phenomenon of “slab curling” is not acceptable.

Thickness: Comply with the following:

- General: 4 inches, or greater if required by expected live load.
- Mechanical Rooms: 5 inches, or greater if required by expected live loads.
- Strength: As required, but not less than 3000 psi at 28 days.

Division 4 - Masonry

SECTION	DATE OF LAST UPDATE	PAST VERSIONS
04200 Unit Masonry	April 1995	

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UNIT MASONRY

General

In general, follow the guidelines below when designing and specifying clay and concrete masonry and accessories. Unless specifically indicated otherwise, these guidelines are not intended to restrict or replace professional judgment.

Masonry Design Standard

BOCA Masonry Code: ACI 530-88/ASCE 5-88 "Building Code Requirements for Masonry Structures" (adopted by reference in BOCA) contains some pitfalls for the Owner and Architect. Include a requirement in "Quality Assurance" Article of unit masonry specification section that Contractor comply with ACI 530.1/ASCE 6 "Specifications for Masonry Structures," except include the following language suggested by AIA MASTERSPEC:

> Revise ACI 530.1/ASCE 6 to exclude Sections 1.4 and 1.7; Parts 2.1.2, 3.1.2, and 4.1.2; and Articles 1.5.1.2, 1.5.1.3, 2.1.1.1, 2.1.1.2, and 2.3.3.9 and to modify Article 2.1.1.4 by deleting requirement for installing vent pipes and conduits built into masonry.

These changes are intended to avoid potential conflicts with other portions of the specifications and the unnecessary imposition of contractual responsibilities on the Owner and Architect.

Face Brick Selection

Brick Selection Process: The University Project Coordinator will coordinate brick selection with the A/E, University Planner and University Architect. Brick selection prior to bidding is required. If cash allowances must be included, be sure to provide for special shapes. Cash allowance prices must be approved by the Director of Construction Management before bidding. Typically the selection process is as follows:

Step 1 - Early in design phase, determine if a brick selection is required. Discuss with A/E, University Architect and University Planner to determine the criteria / objectives of the selection.

Step 2 - The A/E shall contact several brick suppliers and formally request a submittal that will meet the criteria/objectives determined in step 1. The brick supplier's submittal shall include a thin 1' X 2' sample and a statement of unit cost along with any necessary specification data.

Step 3 - The A/E will compile the submittal information and eliminate any submittals that clearly do not meet requirements or criteria. The remaining choices shall be reviewed at the site with the University Architect and University Planner.

Step 4 - The suppliers of the acceptable samples shall be requested to build a mock-up panel 4' X 4', at the site, for final selection.

Step 5 - Chosen samples (should seek a minimum of three) shall be included in the specification and bid as a part of the General Contractor's responsibility.

Step 6 - The specifications shall call for the supplier of choice to build a 4' X 6' mock-up panel, at the site, that will be used for confirmation of match with mock-up panel referred to in Step 4, mortar selection, and installation workmanship. This final panel will be the panel used to measure appearance and workmanship for the project. The specifications must direct the General Contractor to construct the 4' X 6' mock-up panel to match the 4' X 4' panel and to meet certain workmanship criteria. This 4' X 6' mock-up panel must be reviewed and approved by the A/E and the owner. The General Contractor is entitled to include any of the specified brick material in his bid price. In addition, specify that the General Contractor must remove all existing mock-up panels from the site by the completion of the project.

Old brick selection process replaced 4/95 by version above

Brick Selection Process: The University Project Coordinator will coordinate brick selection with the A/E, University Planner and University Architect. Brick selection prior to bidding is encouraged, but rarely possible. If cash allowances must be included, adjust price for special shapes. Typically the selection process is as follows:

- Design/Documentation Phase: Determine, with the assistance of the Project Coordinator, whether mock-up panels for final brick selection are required. Specify construction of a sufficient number of 4-foot square job mock-ups, including back-up material, with mortar joints colored and tooled.

- Construction Phase - Initial Selection: The A/E, in conjunction with University Project Coordinator and other interested parties, makes initial selection from the variety of brick sample cards submitted by Contractor. Request brick test data for each brick initially selected.

- Construction Phase - Final Selection: Select brick, in conjunction with Project Coordinator and other interested parties, from the various mock-up panels. Based on submitted test data, discuss potential durability problems (if any) with Project Coordinator.

Face Brick Specification

General**:** Brick complying with the ASTM C 216 face brick standard is not necessarily durable in this climate, nor suitable for installation in every season; nor does C 216 address the important issue of initial rate of absorption. Consequently, the University requests A/E's to modify ASTM C 216 as indicated below.

Modifications of ASTM C 216**:** Modify face brick standard as follows:

- Strength - As determined by the A/E.

- Type and Grade - Both type and grade must be clearly specified, since the ASTM C 216 default values are not acceptable:
    - Type - Suitable for architectural effect intended, but if other than FBX, coordinate with Project Coordinator.
    - Grade - SW, in all applications.
- ASTM C 216 Table 2 "Physical Requirements" - Add the following Initial Rate of Absorption requirement:
    - Initial Rate of Absorption - Not more than 22 gram/min./30 sq. in.; where cold weather installation is anticipated, not less than 6 gram/min./30 sq. in.
    - If, during selection process, face brick with an IRA higher than 22 gram/min./30 sq. in is selected in order to match existing face brick, limit the average saturation coefficient to less than 0.74, or alternatively, limit absorption to 8.4 percent. Brick outside these limits has a higher potential for durability problems.
- Coring - Modify Article 10 to delete frogged brick. Frogged brick is not permitted since incompletely filled cavities permit moisture to collect, possibly freezing, lifting brick and destroying mortar bond. A 3-core pattern is preferred over other patterns, whenever possible, for improved mechanical keying.

Waivered Brick: Where face brick that has been waivered under ASTM C 216 is selected in order to match existing face brick, require manufacturers to submit written certification of acceptable past performance in the local climate.

Finishes Over Face Brick: Do not include painting or waterproof coatings such as silicone over clay masonry units. Specify that brick units with factory applied silicone coatings are not acceptable.

Installation: Some brick exhibits a wide range of color between those brick near the outside of the stack during firing, and those near the inside. Unless masons take care to mix these brick at the site, the resultant effect may be an unpleasant grouping of dark and light colors. Consequently, for brick susceptible to this phenomenon, require that brick be broken out of pallets and intermixed on the site before installation, to ensure pattern randomness.

Cleaning: Avoid specifying acidic cleaners for masonry in areas adjacent to stone surfaces, and where existing landscaping materials may be damaged by run-off.

Concrete Masonry Units (Block)

Standards**:** No special standards beyond ASTM and ACI/ASCE requirements and as follows:

Grade: Grade N for all applications.

Type: Either Type I or II is acceptable, but design joints assuming Type II units will be supplied.

Finish Coatings**:** Block that will be exposed to weather in finished construction should be coated with block filler and paint or clear sealer equivalent to "Hydrozo." "Dry Block" and similar systems are not acceptable.

Mortar for Unit Masonry

Mortar**:** The University accepts the use of either Portland cement/lime mortar or masonry cement mortar. Calcium chloride is not permitted as an additive.

Mortar Spreading Technique**:** Specify that mortar be spread using the "beveling" technique described in BIA 21C-78. Beveling helps keep cavities free of mortar droppings, and assists in filling 3-hole brick cores.

Joints**:** Specify tooled joints in masonry exposed to weather. Avoid the use of raked, struck, or other similar joints in masonry unless units will not be exposed to weather. Require full head joints on brick masonry.

Flashing

General**:** The University accepts copper, asphalt coated copper, dead-soft stainless steel and rubberized asphalt flashing materials.

Lead and asphalt coated lead materials are not acceptable due to the reputed incompatibility of lead and mortar, and potential toxicity issues. PVC and similar plastic flashings are not acceptable due to brittleness problems caused by stress or loss of plasticizer.

Installation**:** The following requirements are based on BIA and NCMA recommendations:

Mechanically attach flashings to substrate for support. Adhesive attachment is not acceptable.

Extend flashing over openings at least 4-inches beyond opening sides and form ends into dams.

Carry flashing out of wall to ensure proper function. Because manufacturers of asphalt coated or rubberized asphalt flashings require their products to be cut off 1/2-inch behind the wall face, combination flashings consisting of rubberized asphalt sheet terminating in metal through-wall flashing pans is recommended.

Miscellaneous

Weep Holes: Construct weep holes in the head joints in exterior wythes of the first course of masonry immediately above embedded flashings and as follows:

Form weeps by keeping head joints free and clear of mortar. Cotton wicks and plastic tubes are not acceptable.

Space weep holes 24 inches o.c.

The use of brick vents for weep holes is not encouraged.

Cavity Walls: - Fill cavities with clean, sharp mason's sand. Pea pebble fill is not as desirable, since it is more easily plugged with mortar.

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Division 5 - Metals

SECTION	DATE OF LAST UPDATE	PAST VERSIONS
05100 Metals	April 1995	

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METALS

General

In general, follow the guidelines below when designing and specifying structural steel, metal deck, and metal fabrications. Unless specifically indicated otherwise, these guidelines are not intended to restrict or replace professional judgment.

Design Requirements

Codes and Standards: Comply with AISC, AWS, and BOCA codes applicable to the specific project. Comply with the most stringent of applicable OSHA and BOCA standards, as well as UFAS and Michigan Department of Labor requirements for guards, handrails, and ladders. A/E's may use their own office standards for aesthetic features and details such as connections.

Drawing Requirement

Indicate live loading capacity on structural steel design drawing.

Structural Steel

Structural Steel Lintels and Shelf Angles - Lintels and shelf angles provided for support of masonry veneers exposed to weather must comply with the following requirements:

- Units must be hot-dip galvanized after fabrication.
- Units are not required to, but may be, stainless steel.
- Leg thickness must be sized for structural loads, but not less than 3/8-inch thick.

Metal Roof Deck - All metal roof deck must be hot-dip galvanized (ASTM A 525 G60 coating).

Miscellaneous Metal Fabrications

Fire Exit Stairs - Typically, fire exit stairs are considered utility spaces where safety and economy should take precedence over aesthetics. Stair designs with straight runs are preferred over curved stairs. Scissors stairs with less than 12 inches between alternate flights are preferred over those with wider gaps, in order to avoid requiring both handrails and 42-inch high guards.

The following are minimum requirements for typical fire exit stairs. Obtain approval of University Coordinator for more elaborate solutions.

Treads must be concrete filled metal pan, not metal grating or embossed metal plate.

Standard economy railing infill may be flattened expanded metal mesh with steel channel frames. When approved by University Project Coordinator, baluster-type infill may be vertical bars complying with BOCA requirements. Rail-type horizontal bars are not permitted under any circumstances.

Show anchorage at unusual conditions, such as removable railings.

Ornamental Stairs - Designers can expect more flexibility concerning stairs with major aesthetic impact, and the design of such stairs should be coordinated with the University Project Coordinator.

Guardrails and Handrails - Specify hot-dipped galvanized steel for all exterior locations exposed to weather. Alternatively, stainless steel, bronze, anodized aluminum and other materials may be used with the approval of the University Coordinator.

Provide expansion provisions at suitable intervals, but not less than 30 feet o.c.

Handrails in concrete paving and walks may be set in sleeves or core drilled holes. Depth of core must be not less than 4-inches deep and of a diameter not less than 1-inch wider than outside pipe diameter. Set rails in non-shrink, erosion resistant grout.

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Division 6 - Wood And Plastics

SECTION	DATE OF LAST UPDATE	PAST VERSIONS

None

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Division 7 - Thermal And Moisture Protection

SECTION	DATE OF LAST UPDATE	PAST VERSIONS
07500 Roofing Systems and Accessories	August 2010	April 1995
07841 Firestopping	February 2008	May 2004

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ROOFING SYSTEMS AND ACCESSORIES

General

In general, follow the guidelines below when designing and specifying roofing systems. Unless specifically indicated otherwise, these guidelines are not intended to restrict or replace professional judgment.

Related Sections

U-M Design Guideline Sections:
SID-D Energy Conservation
SID-F Codes and Regulatory Agencies
SID-R Fall Protection on Roofs
05100 Metals
Architectural Preferred Manufacturer List

UM Master Specifications:
Section 07531 - EPDM Single-Ply Membrane Roofing (Fully Adhered)
Section 07532 - CSPE Single-Ply Membrane Roofing

Reference Documents:
ANSI/SPRI VF-1 External Fire Design Standard for Vegetative Roofs
ANSI/SPRI RP-4 2008 Wind Design for ballasted Single-ply Roofing Systems
ANSI/SPRI RP-14 Wind Design Standard for Vegetative Roofing Systems

Roofing Materials

General - Specify that roofing materials for a given project are provided by a single manufacturer, and that all accessory materials be approved by that manufacturer as necessary to obtain the manufacturer's warranty.

Preferred System - Fully Adhered, Single Ply Ethylene Propylene Diene Monomer (EPDM) is the system usually preferred by the University's Roofing Shop. Alternative systems listed below may be preferred for specific applications, such as aesthetics, condition of installation, or chemical resistance. Consult with the Design Manager for advice and consent regarding the use of other systems.

Alternative Single-Ply Systems

- EPDM, Inverted and Ballasted (IRMA) and CPE: Not acceptable.
- Hypalon (CSPE): Consider fully adhered hypalon systems when resistance to chemical attack is paramount, such as on roofs with a substantial number of fume hood exhaust stacks or where repeated exposure to oil or coolant fluid leakage is likely. Mechanically attached systems are acceptable when desirable for condition of installation.

- PVC and TPO Membranes: Acceptable under vegetative roof systems only, 60 mils thick minimum.
- APP and SBS Modified Asphalt Membranes: Not approved for use, except for small roof areas and patching.

Alternative Roofing Types - Other types of roofing systems that may be considered include natural slate, clay tile, asphalt shingle, and standing seam sheet metal roofs. There are currently no explicit University standards for these systems. Comply with manufacturer's and industry standards, and professional judgment for materials and installation.

- Composite materials with the appearance of slate or clay tile are generally not approved for use.
- Multiple-ply built-up asphalt roofing systems are not permitted on campus areas due to objectionable odors.
- Vegetative roof systems are new to the University and are used in select applications. Close coordination with Design Manager and Roofing shop is required for system selection and detailing.

Walkway Protection - For single-ply roof systems, provide walkway protection from roof access points to all roof mounted equipment requiring routine maintenance. Walkway protection should generally consist of a minimum 100-mil thick EPDM or Hypalon membrane, to match roofing material.

Insulation - Comply with SID-D requirements. Polyisocyanurate is the acceptable insulation material. Insulation products shall be 25 psi minimum. Provide insulation coverboard, 200 psi minimum.

Accessories

- Roof sumps - Specify all cast iron components.
- Roof and equipment hatches - Specify the following minimum requirements
  - Anodized aluminum hatches with insulated double wall lids and insulated double wall curb frames
  - Integral mounting flange and counter-flashing.
  - Heavy duty stainless steel hardware.
- Access ladders - Specify galvanized steel ladders fabricated from tube steel side rails with 1-3/4" tread grip rungs. Extend side rails above top rung. Paint finish optional.

Quality Assurance

Pre-Installation Conference - Require conference for all University roofing projects, including small repair or penetration work. This conference should be attended by, at least, the general contractor, the roof installer, and by a representative from the University's Roofing Department.

Warranty Requirements - Comply with the following requirements for warranties:

- New Membrane Roofs, Single-Ply Systems: Require a 15 year, single source warranty covering the full roofing system (including all accessories) for materials and labor.
- New Membrane Roofs, Vegetative Roof Systems: Require a 30 year, single source warranty covering the full membrane/waterproofing system (including all accessories) for material and labor.
- Repairs/Modifications: For roofs still under warranty, require that the original manufacturer's material be used and that the installer be approved by the manufacturer. Contractor should notify roofing manufacture with the warranty and the U-M roofing shop in writing of the changes to the roof under warranty.

Design Requirements - New and re-roofing projects

General

- Provide access to all areas of roof.
- All roof work should be watertight, on a daily basis, before contractor leaves the project site.
- Project must comply with the requirements outlined in SID-R Fall Protection on Roofs.
- Where high-albedo roofs are being considered, an energy model should be completed to determine payback and reviewed with the Design Manager.

Flat Roof Design - Generally comply with good roofing design practices outlined in the NRCA "Handbook of Accepted Roofing Knowledge". Specifically, ensure that the following conditions are met:

- Slope roof as required by Code and not less than 1/4-inch per foot. Pitch roof by either sloping structure or by using tapered insulation.
- Slopes to drain should be unobstructed by above-roof building elements, equipment curbs, or similar objects. Where such obstructions are unavoidable, provide cants, saddles or other means to restore positive pitch to drain.
- Maximize parapet heights and run single-ply roofing materials up, over the top and down the face of parapets beneath stone coping caps and beneath metal trim. Metal coping caps are not preferred.
- Specify that no EPDM single-ply membrane field seams be located within 5 feet of sumps (3 feet for Hypalon).
- Specify that no buck laps are permitted anywhere in single-ply roofing membranes.
- Specifically reference Factory Mutual 1-60, 1-75, or 1-90 roof requirements, as appropriate for the application.

Vegetative Roof Design - Generally comply with good roofing design practices outlined in the NRCA "Vegetative Roof Systems Manual". Specifically ensure that the following conditions are met:

- Limit slope design to a 2 to 12 pitch. A sloped structure is preferred to achieve necessary roof pitch in lieu of the use of tapered insulation.

- Provide a 6 foot minimum continuous fire break around roof edge, rooftop structures and rooftop equipment that contain combustible vertical surfaces. Non-vegetative fire breaks should consist of an ASTM E108, Class A system.

- Provide an 18 inch minimum continuous break around roof edge, rooftop structures and rooftop equipment that contain non-combustible surfaces.

- Comply with all manufacturer requirements to maintain warranties for underlayment systems.

- Provide access to at least one fire hydrant.

- Underlayment systems should consist of, at a minimum, a waterproof membrane system, membrane protection, root barrier, drainage/water retention layer, aeration/water retention layer, filter layer and soil substrate.

- Install indigenous and/or adaptive plantings only.

- Inverted insulation systems are not acceptable. Insulation must be installed below the waterproof membrane; the compressive strength must be appropriate for the expected dead and live loads of the selected system.

- Waterproofing membrane should be fully adhered to the substrate, not mechanically fastened or loose laid.

- Membrane flashings should be a minimum of 4 inches above the surface of the growth medium.

- For existing buildings, coordination with a structural engineer is required to determine the live load capacity of the existing structure.

- Structures supporting vegetative roofs should have a minimum live load capacity of 100 pounds per square foot or meet the requirements of the code, whichever is more strict.

- Vector mapping systems are recommended, but not required. For projects including vector mapping, coordinate with the Design Manager.

- Where tray systems are used over an existing conventional roof membrane, membrane protection is required.

- Water test(s) of waterproof membranes prior to installation of subsequent systems is required. Coordinate with the Design Manager.

<u>Equipment Supports</u> - Generally, steel support frames are preferred wherever practicable, since curbs tend to interfere with roof drainage. Coordinate the following roofing issues with mechanical engineers.

Steel Frames: Steel angle, channel or wide-flange shape frames with pipe column supports. Comply with the following requirements:

- Carry support legs down to solid structural framing (i.e. steel joists or beams, or concrete beams or deck, if analyzed and known to be structurally adequate). Do not place support legs on metal deck.
- Column supports to be round or square tubes only.
- Minimize the number of legs. For example, use 1 support centered on a gang of pipes instead of 2 wherever possible.
- Design supports for not less than 18 inches clearance above finished roofing surface. 24-inches is preferred clearance where possible and aesthetically permissible.

Curb Type Supports: Construct curbs of pre-fabricated metal or site-built, preservative treated, lumber.

- For length or width dimensions greater than 48-inches, provide a saddle at the high side of the curb (against direction of slope-to-drain) to prevent water ponding behind curb.
- Generally limit the longest dimension of curb to 60 inches. Use steel support frames where a longer dimension is required.
- Do not use open-ended (two-sided) curbs. These curbs make re-roofing beneath equipment impossible.

Special Requirements - Re-roofing Projects.

Noise and Vibration - Attachment of underlayment, insulation, and other roofing materials may cause noise and vibration problems. This is especially true for applications over concrete roof structures where the structure may transmit noise throughout the building. Consult Design Manager to determine whether special requirements for evening or weekend work are necessary.

Dust Protection - Specify the provision of dust protection over occupant's equipment and furnishings where appropriate. For example, specify protection for top floor areas that are occupied (not penthouses) and that do not have suspended ceilings. Where occupant's activities may be particularly sensitive to dust, specify protection regardless of presence of suspended ceiling. Note that dust protection should be applied and removed in coordination with occupant's operations. Consult Design Manager.

Special Requirements - Construction Projects Impacting Existing Roofs.

Quality Assurance

- Standards: Require cutting and patching work in compliance with University Roofing Department and with recommendations of the National Roofing Contractors Association "Roofing and Waterproofing Manual".
- Installer qualifications: Require that cutting and patching of existing roof systems is completed by contractor licensed by manufacturer of existing roofing system.

Temporary Protection

- Require protective measures for areas of existing roof used for construction access, work, or material storage. ¾" plywood tied together over 1 1/2" ISO insulation.
- Require filter fabric over roof drains.

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FIRESTOPPING

General

For University of Michigan Hospitals and Health Centers projects refer to Design Guideline 07841-H available at:
http://www.med.umich.edu/facilities/planningdevelopment/ae/dg/doc/a/07841H.pdf
Properly installed firestopping is critical to the successful fire performance of the building.

Specifications and details (where applicable) for firestopping should be included for both new construction and renovations, whether or not the renovation project involves new penetrations. Survey existing conditions for deficiencies in firestopping and unprotected wall openings, identifying both Code violations and other deficiencies. Present a summary to the University Project Coordinator, who will determine the extent of remediation for each project.

Firestopping Design Standards

Comply with the requirements of applicable building codes. Current applicable codes for UM buildings can be determined by referring to the Codes and Regulatory Agencies page of this web site at the following address: http://www.umaec.umich.edu/desguide/sid/sid_f.pdf

Include the Manual of Practice of the Firestop Contractors International Association (F.C.I.A.) in the "References" article of the specifications.

Firestopping Product Selection

Select products from recognized manufacturers which have been tested by one of the following three agencies: Underwriters Laboratories (UL), Omega Point Laboratories (OPL), or Intertek/Warnock-Hersey (WHI).

Include T and L ratings in addition to F ratings where applicable and/or where required by Code.

Floor Sleeves for Mechanical and Electrical Penetrations

Sleeves are highly recommended for floor penetrations to protect contents on the floor below the penetration from leakage or flooding caused by pipe breaks, sprinkler discharge, etc. In deciding where floor sleeves will be required, the University Project Coordinator will evaluate the level of protection desired in the project and the likelihood of water damage. Require coordination by the firestop contractor with mechanical and electrical trades so that the proper firestopping systems are selected.

Inspection of Firestopping Installations

Normally, inspection of firestopping installations will be carried out by UM inspectors. If there are special circumstances which require an independent testing/inspection agency, direction will be given by the University Project Coordinator. If a testing agency is employed, include reference to it in the specifications.

Google Search
Web Design Guidelines

Division 8 - Doors And Windows

SECTION	DATE OF LAST UPDATE	PAST VERSIONS
08211 Flush Wood Doors	February 2008	September 2005
08370 Frames, Power Operated Doors	April 1995	
08410 Aluminum Entrance and Storefront Systems	January 2010	February 1999
08525 Aluminum Architectural Windows	January 2010	April 1995
08710 Finish Hardware	October 2010	February 2008
08800 Glazing	October 2010	May 2005

Last modified: Thursday October 28 2010

For technical inquires, comments and suggestions on the U of M Design Guidelines, please e-mail the U of M Design Guidelines Group at UMDesignGuide@umich.edu.

University of Michigan - Architecture, Engineering and Construction
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FLUSH WOOD DOORS

General

For University of Michigan Hospitals and Health Centers projects refer to Design Guideline 08211-H available at:
http://www.med.umich.edu/facilities/planningdevelopment/ae/dg/doc/a/08211H.pdf
In general, follow the guidelines below when specifying wood doors. Unless otherwise indicated, these guidelines are not intended to restrict or replace professional judgment.

Design Requirements for Flush Wood Doors

Design - Generally, aesthetic considerations are the prerogative of the architect. Consult with the University Design Manager concerning visual effects which do not correspond to general design features stated in this guideline.

Quality Standards - Either AWI or WDMA I.S.1-A should be referenced as the quality standard in the specifications. Reference the latest edition of whichever standard is used.

Construction - In general, manufacturer's standard products are acceptable, provided they comply with the following requirements:

- The University's standard interior wood door is solid core, of flush construction, and Custom grade. Consult with University Design Manager before specifying stile and rail doors or other construction grades.

- 5-ply cores are preferred, unless cost considerations are paramount, when either 5- or 7-ply will be acceptable. Consult with University Design Manager to determine appropriate quality level.

Veneers - Do not specify exotic grades of wood with potentially long lead times and significant upcharges.

Glazing - Refer to another Guideline Chapter "Glass and Glazing" for requirements related to glass. For fire doors with lites, fire-rated safety glazing is preferred to non-safety rated wire glass. Factory glazing should always be specified for fire-rated openings and is preferred for non-rated openings.

Finish - Specify factory finishing for transparent finishes. Factory finishing of adjacent wood frames is recommended to maintain a consistent appearance. Opaque finishes may be field painted but should be factory primed. Specify Medium Density Overlay in lieu of wood veneers for opaque finishes.

Fire Doors - Specify prefitting and premachining for fire doors.

ADA Requirements - Include a requirement for a flush panel of at least 12" in height at the bottom of doors to meet ADA requirements.

Warranty - Specify a warranty period lasting the life of the door for flush wood interior doors. Do not design doors which will void the warranty because of oversized cutouts or insufficiently sized stiles and rails.

FRAMES, POWER OPERATED DOORS

General

The A/E shall engineer and specify the reinforcement of door and frame required to support the power operated mount and connection.

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ALUMINUM ENTRANCE AND STOREFRONT SYSTEMS

General

In general, follow the guidelines below when specifying aluminum entrances and frames. Unless otherwise indicated, these guidelines are not intended to restrict or replace professional judgment.

Related Sections

U-M Design Guideline Sections:
SID-D Energy Conservation
SID-F Codes and Regulatory Agencies
08710 Finish Hardware
08800 Glazing

Architectural Preferred Manufacturer List

UM Master Specifications
Section 08410 Aluminum Entrances and Storefronts

Design Requirements for Aluminum Entrances

Design - Coordinate visual effects which do not correspond to general design features stated in this guideline with Design Manager.

Construction - In general, manufacturer's standard products (with the exception of hardware) are acceptable, provided they comply with the following requirements:

- Storefront System Construction: Thermally improved construction, or thermally broken where available. Exception: Mullions should not be thermally broken.
- Door Opening Frames: Applied stops only; blade stops are not acceptable.
- Doors: Medium stile (3-1/2 inch nominal) or wide stile (4 inches or more) doors. Medium stile is preferred. Do not specify thin or narrow stile doors.

Glazing - Specify glazing per design guideline 08800 and as follows:

- Storefront Glazing (Exposed to Weather): Insulating glass to match window or curtain wall systems.
- Doors (Exposed to Weather): Insulating glass to match storefront system., unless single-pane glazing required for special conditions and is permitted by current adopted ASHRAE 90.1.

- Vestibule or Interior Doors: Single pane glazing, unless insulating glass required for acoustic properties.

- Require doors to be factory-glazed where feasible.

- Minimum glass thickness for single panes or individual components of insulating glass used in door and storefront systems should be 1/4 inch.

Finish - Usually match window or curtain wall system finish. Specify either Class I anodized coating or 2-coat high-performance organic (Kynar/Hylar) coating. Require 3-coat systems for organic coatings applied to doors.

Hardware - Do not use door manufacturer's "standard" hardware for aluminum entrance doors. Comply with requirements of Guideline Chapter "Finish Hardware" and Preferred Manufacturer's List.

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ALUMINUM ARCHITECTURAL WINDOWS

General

In general, follow the guidelines below when specifying aluminum architectural windows and related items. Unless otherwise indicated, these guidelines are not intended to restrict or replace professional judgment.

Related Sections

U-M Design Guideline Sections:
SID-D Energy Conservation
SID-F Codes and Regulatory Agencies
08800 Glazing

Architectural Preferred Manufacturer List

UM Master Specifications
Section 08520 Aluminum Windows

Design Requirements

Window Grade -

- Specify "monumental" windows, minimum 1/8-inch wall thickness for frame and ventilator extrusions.

- Consider non-monumental grade (AAMA commercial or heavy commercial grades) windows for units with relatively small ventilators, in locations not likely to be subjected to vandalism or other abuse; and where cost is a predominant factor. Review with Design Manager

Standards - Specify windows based on AAMA GS-001, "Monumental" classification (preferred), or AAMA 101 "Heavy Commercial" classification modified to meet University standards.

Comply with AAMA specifications, and project requirements to determine the performance class of the window. Minimum performance class: HC-40.

Tests - Require submittal of test reports of an independent laboratory indicating compliance with requirements. Review field testing requirements with Design Manager.

Design - Coordinate visual design effects which do not correspond general design features stated in this guideline with Design Manager.

Construction - Include the following requirements:

- Specify thermally improved (thermal-break) construction without exception. The University accepts both poured and degridged thermal breaks and "insulbar" thermal breaks manufacturer Ensinger Corp. Specify "Insulbar" system where different finishes or colors and desired interior and exterior sides of window frames.

- Wall Thickness: Comply with the following:

    - Monumental Window Extrusions: Minimum 0.125-inches. If you are preparing specifications based on AAMA 101, this requirement must be stated clearly as a modification of HC class specifications.

    - Heavy Commercial or Commercial Grade Window Extrusions: Per AAMA 101.

- Frame Depth: Size ventilators to permit 2-1/2 inch maximum frame depths for appearance. Where larger ventilators are required comply with the following:

    - Inswing Ventilators: Where ventilator size exceeds 15 square feet, require frame depth of not less than a 3-1/8 inch frame depth.

    - Outswing Ventilators: Where ventilator size exceeds 12 square feet, require frame depth of not less than a 3-1/8 inch frame depth.

Glazing - Specify units for inside glazing wherever practicable. Require glass surfaces to be within 3/16" of the frame exterior surface and that adjacent glass, spandrel or filler panels be located in the same plane, with a tolerance of 1/8".

Finish - Comply with the following:

- Match existing adjacent units to the greatest extent possible, whenever doing patch or in-fill type work.

- For most new and replacement work, specify a polyvinylidene fluoride coating based on either Kynar 500 or Hylar 5000, and marketed under a variety of trade names such as Duranar and Nubelar.

- Color: In general, specify non-metallic dark bronze. Coordinate other color selections with Design Manager.

- Specify two-coat application technique; or three-coat for applicable colors/metallics.

- Siliconized polyester and similar coatings are not acceptable.

- Where window finish is a dark bronze color, specify oxidized bronze finish on handles; otherwise specify chrome finish.

- When an anodized finish is judged appropriate, specify NAAM Class 1 finish, natural or color anodized, as suited to project.

<u>Accessories</u> - Comply with the following:

- Specify ventilator units with full weather-stripping.
- Specify continuous trim anchor clips where trim length exceeds 36-inches.
- Determine requirements for type of latching and locking hardware with Design Manager.
- Except for Housing projects and for food preparation areas, insect screens are generally not required for University projects.

<u>Warranty</u> - No special warranty is required for window frames.

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FINISH HARDWARE

General

For University of Michigan Hospitals and Health Centers projects refer to Design Guideline 08710-H available at:
http://www.med.umich.edu/facilities/planningdevelopment/ae/dg/doc/a/08720H.pdf.

In general, follow the guidelines below when selecting and specifying finish hardware. Unless specifically indicated otherwise, these guidelines are not intended to restrict or replace professional judgment.

Related Sections

U-M Design Guideline Sections:
SID-D Energy and Water Conservation
SID-F Codes and Regulatory Agencies
SID-Q Building Access Control
08410 Aluminum Entrances and Storefronts

Architectural Preferred Manufacturer List

UM Master Specifications
Section 08710 Finish Hardware
Section 16724 Security System General Requirements
Section 16727 Access Control & Monitoring System

Design Requirements

General:

- Do not use cash allowance provisions for hardware.
- Include a hardware schedule on drawings or in specifications. Note key side on door schedule.
- Egress:
    - Do not specify locks of any type on fire egress stair doors without approval from Design Manager.
    - Configure doors and select hardware to mitigate the risk of chaining doors together, thus preventing egress and emergency responder access. (e.g. same handing of entrance door banks, flush mounted panic devices, etc…). Review approach with Design Manager.

- In areas of new construction, locate hardware in accordance with Door and Hardware Institute (DHI) "Recommended Locations for Architectural Hardware for Wood Flush Doors" and "Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames." In renovated areas, obtain direction from Design Manager concerning whether to match existing hardware locations or whether to follow DHI recommendations for new construction.

- Do not specify floor checks and pivots.

- Trim Styles: Unless otherwise approved by the Design Manager, trim styles used in renovation work should match hardware currently in the building. Contact the Design Manager for information regarding existing hardware.

- Finishes: Unless otherwise approved by the Design Manager, comply with the following:

  - Specify standard uniform hardware finishes throughout the project. Obtain Design Manager approval for custom finishes.

  - For renovation work, match hardware finish of existing units.

  - For aluminum entrances, match the finish color of the door.

- Do not connect door hardware to fire alarm system unless required by code or UMHHC operating procedures.

- Where interconnection with building fire alarm system is required, comply with the following:

  - Provide interposing interlocks using fire alarm system control modules. Program the control modules to change state only when the fire alarm system actuates.

  - Fire door hold-open devices: Provide normal (non-battery backed) power from fire alarm system. Upon a fire alarm system actuation or upon the loss of normal power to the fire alarm system, the door hold-open devices will be de-energized and the doors will close. This means held-open doors will close during a fire alarm 24 hour battery test. Review operational impacts with Design Manager.

  - Electrically operated door hardware: Provide power from access control system or security system. When required by code, provide relay and access control system programming to interrupt power upon a fire alarm system actuation. This means the status of door hardware devices will remain unchanged during a fire alarm 24 hour battery test, but will change upon a fire alarm system actuation. The sequences of operation for door hardware devices upon fire alarm system actuation will be defined and executed by the door access control system.

Hinges:

- Specify hinges with non-removable pins with set screw, not merely non-rising type with knurled pin.
- Specify 5 knuckle ball bearing hinges, except at aluminum entrances or where otherwise needed for increased durability as confirmed by the Design Manager.
- For aluminum entrances, specify ball bearing butt hinges or heavy-duty continuous gear hinges.

Closers:

- Specify surface mounted units only; concealed closers are not permitted (including aluminum entrance doors).
- Require closers to be mounted on least public room side of doors.
- Never specify hold-open function in conjunction with exterior building entrances and vestibules.
- Provide factory-sized closers, adjustable to meet field conditions and barrier free requirements for opening force. Installation requirements shall require that closers be installed and adjusted to meet barrier free opening force requirements.

Pulls: Through-bolt all pulls. Do not specify offset pulls on doors unless needed to match existing.

Locksets:

- Specify lever handles on each new lockset.
- Specify the following standard functions by space type:
    - Offices, laboratories, small conference rooms and other non-classrooms occupied spaces: Office lockset with thumb turn inside (ANSI F04). Specify thumb turn installation that provides vertical orientation for locked / horizontal for unlocked.
    - Classrooms: All classrooms should be lockable from inside the room and provide visual indication of door status on classroom side. Review required function with Design Manager.
        - Mortise lockset type M1 (When locked, door remains locked except by key outside or thumb turn inside): Schlage L9056 with indicator: 09-611 x XL11-986.
        - Mortise lockset type M2 (When locked, door reverts to unlocked when door is opened): Schlage L9050 with indicator: 09-611 x XL11-986.

  - Unisex restrooms: Privacy lockset with "Occupied" indicator and keyed override. Schlage L9496
  - Service areas: Service/store lockset (ANSI F07)

- Provide knurled handle surfaces on doors to hazardous areas. Hazardous areas include mechanical rooms, elevator machine rooms, electrical closets and substation rooms, and stairways.

- Attic Stock: Require attic stock to be delivered to Owner's Key Office in manufacturer's original packaging, with Project title, including building and description, and University of Michigan Project Number marked on each box. Require attic stock for each individual lock function type, provide additional locksets of the same function in the following quantities:

  - For less than 20 locksets: No attic stock.
  - For 20 locksets or more, but less than 100 locksets: 2 additional units.
  - For 100 locksets or more: 4 additional units.
  - For each 50 additional locksets over 100 units: 1 additional unit.
  - When 20 or more locksets of all function types are scheduled, but less than 20 are of a single function, provide 2 additional locksets of functions selected by the Design Manager from the range of function types included in the Project.

- Strikes: Specify curved-lip strikes; flat (reversible) strikes are not acceptable. Require extended lip strikes where required to protect door frame from being marred by latch bolt (frequently needed at wood door frames).

- Cores: Specify 7-pin small format interchangeable cores (SFIC). Refer to "Architectural Preferred Manufacturers List" for manufacturers. In existing buildings, match existing core type.

- Construction Keying: For project security, provide a construction core as determined by the Design Manager. Always include construction cores for building entrance doors with cylinders.

- Keying: Include keying and master keying. Specify that keying and master keying will be coordinated with the University Key Office. Indicate keyed side on door schedule.

Panic Hardware: Either tube-or pad type crash bars are acceptable, provided the type selected will meet the requirements of the application. Dogging, where provided, should be hex-key wrench type as opposed to key cylinder type. Exit devices with concealed vertical rods are not permitted in any application. In addition, comply with the following:

- Single doors: Select rim-type panic hardware; do not specify mortise units.
- Double doors with mullions: Provide rim-type, center latching devices.
- Double doors without mullions: Provide the following exit device types for each indicated application:
  - Aluminum Entrance Doors: Applications without mullions are not permitted.
  - Fire-rated wood and steel doors: Usually specify mortise lock device with double cylinder on one door of pair (refer to "fire-rated and securable doors" paragraph below), and exit only function vertical rod device on other door. For interior locations where fire-rating can be maintained, omit bottom rods. Where bottom rod is required, specify ADA compliant rod and latch guard.
  - Non-fire-rated wood and steel doors: Usually specify mortise lock device on one door (refer to "fire-rated and securable doors" paragraph below), and exit only function vertical rod device on other door. Omit bottom rods for interior locations without security requirements. Where bottom rod is required, specify ADA compliant rod and latch guard.
- For fire-rated doors and securable, non-fire rated doors with rim and mortise type panic device applications (requiring an active lever handle), provide an exterior-side cylinder that retracts the latch bolt (but will not unlock outside trim) in conjunction with an interior-side, separately keyed cylinder, mounted in the latch head, that will unlock the outside trim.
- Specify pulls in conjunction with panic hardware, except where levers are required for fire-rated devices, or are necessary to match adjacent trim. Never select lever handles for use on public entrance doors to buildings.
  - Where lever trim must be provided to match existing non-fire-rated hardware in a given location, specify rigid lever function only.

<u>Coordinators:</u> At all double doors without mullions include a coordinator and carry bar. Doors with a mortise lock on the active door may have an open-back strike substituted for the coordinator and carry bar as permitted by rating authority.

<u>Mullions:</u> On double doors, where a fixed mullion is not included, provide a removable mullion. Key operated mullions are preferred. Where provision of a mullion is not considered feasible, provide special exit device hardware indicated above.

<u>Thresholds</u>: Require that aluminum thresholds be cut-in around mullions, frame members, and stops, not simply butted to them, to provide a continuous surface across the full width of the opening from jamb to jamb. At exterior doors, specify thermally broken thresholds.

<u>Stabilizers</u>: Require stabilizer sets on all aluminum entrance doors and frames.

Electrified Hardware (connected to campus central electronic system):

- General:
    - Do not specify magnetic locks or delayed egress devices without prior approval of the Design Manager.
    - Specify passive infrared request to exit devices in lieu of hardware with integral REX function. Coordinate with electrical.
- Hardware types / components:
    - Electric strikes: Specify where feasible. For pairs of doors with removable center mullions, specify wiring to electric strikes with quick disconnects. Do not specify for fire rated doors.
    - Electric mortise lockset: Specify for interior applications only.
    - Electric panic device with electric latch retraction:
        - Specify battery backed local power supply. For pairs of doors or doors in close proximity, provide single power supply serving both doors.
        - Specify label in end cap of exit device indicating location of power supply.
    - Electric power transfer: Provide heavy duty mortise type only. Electrified hinges and door cords are prohibited without prior approval of the Design Manager.
    - Door contacts: Specify 1" recessed door contacts where possible.

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GLAZING

General

In general, follow the guidelines below when specifying glazing and related items. Unless otherwise indicated, these guidelines are not intended to restrict or replace professional judgment.

Related Sections

U-M Design Guideline Sections:
SID-D Energy and Water Conservation
SID-F Codes and Regulatory Agencies
08410 Aluminum Entrance and Storefront Systems
08525 Aluminum Architectural Windows
Architectural Preferred Manufacturer List

UM Master Specifications:
Section 08800 Glazing
Section 08805 Interior Glazing

Standards

IGCC/IGMA Certification for Insulating Glass Seals
GANA "Glazing Manual"
ASTM C 1036 Standard Specification for Flat Glass for annealed float glass
ASTM C 1048 Standard Specification for Heat-Treated Flat Glass—Kind HS, Kind FT Coated and Uncoated Glass for heat-treated and coated glass
ASTM C1172 - 09 Standard Specification for Laminated Architectural Flat Glass
16 CFR 1201 Safety Standard for Architectural Glazing Materials for glass in hazardous locations
ASTM E2190 - 08 Standard Specification for Insulating Glass Unit Performance and Evaluation
ASTM E1300 - 09a Standard Practice for Determining Load Resistance of Glass in Buildings
Insulating Glass Certification Council (IGCC)

Design Requirements for Exterior Glazing

General

Specify 1-inch thick, low-e coated, argon gas filled insulating glass in all vertical vision glass panels. Where spandrel glass is used, do not specify units with insulation board adhered to inside surface. Where metal filler panels are used, specify 1-inch thick aluminum sandwich panels with rigid insulation core.

Provide insulating glass units (IG) certified by the Insulating Glass Certification Council (IGCC) and Insulating Glass Manufacturers Alliance (IGMA).

Provide heat strengthened glass in standard applications, except where safety glazing is required.

Tint and Appearance

Most older University buildings, including those with recently retrofitted windows, have non-reflective, bronze tint outer panes paired with clear inner panes. The current standard is insulating units with clear outer and inner panes and solar control low-e coatings which are clear in color. Goal is to maximize visible light transmittance while minimizing solar heat gain. Use of other tints and reflective coatings is discouraged. Review aesthetic, performance and budget implications of glass selection with Design Manager.

In most retrofit projects in which current ceiling heights are lower than the window head heights, use a non-vision spandrel panel composed of a 1" insulating glass unit with an outboard lite matching the tint and coating of the outboard lites in the vision panels and an inboard light of non-tinted patterned glass.

Where bronze tint glass is specified, include bronze anodized spacers unless "warm-edge" spacers are specified. Consider other color coated spacers where appropriate and available.

For quality control purposes, include a restriction that each type of exterior glass must be supplied by a single manufacturer and fabricator.

Require the glazing contractor to submit an adequate number of samples to display the color range of the glass. Because of difficulties with color variation in clear low E glazing, the following language, which is more rigorous than ASTM C 1036 and ASTM C 1376, should be included in the Quality Assurance article of the glazing specification if this type of glazing is included in the Project:

"Sealed Insulating Glass Units: In addition to other requirements in this Section, comply with ASTM D 2244- 09b Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates. Obtain written acceptance by the Architect and the Owner's representative of permissible color tolerance between test specimen and reference and the procedure for calculating the color tolerance for each material and condition of use."

Performance

Vertical/Slope/Horizontal Glazing:

Performance characteristics for all exterior glazing types should be evaluated and selected based on the requirements of SID-D.

Other performance criteria:

- Determine whether control of UV transmittance is required to minimize damage to furnishings, draperies and/or collections. Review with Design Manager.
- Determine whether controlling visual glare is a project requirement and if so, apply appropriate methods to achieve the desired performance.

Low-e Coating

For most vertical glazing apply low-e coating to the second surface of insulating glass units.

For sloped glazing applications apply low-e coating to the third surface of insulating glass units.

Fritted Glass

Use of fritted glass to improve performance and control glare, especially in skylights, sloped, and horizontal glazing, is acceptable

Fabrication and Installation

Specify pre-glazing wherever possible.

The University does not have a preference regarding use of tapes, dry glazing or wet glazing. However, to insure that the sealants perform properly, specify pre-construction testing for sealant compatibility and adhesion.

The Drawings and Specifications should include details and requirements for each glazing condition.

Require insulating glass products to be sealed with dual seal method.

Special Warranties

Require special project warranty on insulating glass of 10 years.

Require special project warranty on coated glass of 10 years.

Require special project warranty on laminated glass and dual glazed gel-filled fire-rated units of 5 years.

Division 9 - Finishes

SECTION	DATE OF LAST UPDATE	PAST VERSIONS
09260 Gypsum Wallboard Systems	April 1995	
09510 Acoustic Ceilings	February 2008	September 2004
09650 Resilient Flooring	February 2008	April 1995

Last modified: Wednesday July 21 2010

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GYPSUM WALLBOARD SYSTEMS

General

In general, follow the guidelines below when designing and specifying Gypsum Wallboard Systems and accessories. Unless specifically indicated otherwise, these guidelines are not intended to restrict or replace professional judgment.

Design Requirements

Generally follow design practices outlined in manufacturer's literature and standard industry manuals.

Design non-loadbearing partitions in accordance with steel stud and drywall manufacturer's published recommendations regarding stud depth and gage for each application.

Incorporate steel or plywood sheet backing into gypsum board partitions where required to support equipment or furnishings, and as otherwise deemed necessary by the Project Coordinator.

Clearly mark fire-rated assemblies on drawings with either Underwriter" Laboratories or Gypsum Association design numbers, and with required fire rating in hours.

Design assemblies to provide sound control ratings established by the Project program or by the University Project Coordinator.

Plastic trim is generally acceptable for interior applications, except specify metal trim at outside corners and other locations subject to impact damage.

Material Requirements

Gypsum: Usually specify gypsum board for partition applications a minimum of 5/8-inch thick; and for suspended ceilings, soffits and fascias a minimum of 1/2-inch thick. Thinner units are acceptable where required for bending, compliance with UL or GA Design requirements, or other design requirements.

Steel Supports: Galvanized, and as follows:

- Studs: C-shaped, punched, and not less than 22 gage minimum thickness.

ACOUSTICAL CEILINGS

General

For University of Michigan Hospitals and Health Centers projects refer to Design Guideline 09510-H available at:
http://www.med.umich.edu/facilities/planningdevelopment/ae/dg/doc/a/09510H.pdf
In general, follow the guidelines below when designing and specifying Acoustical Ceilings and accessories. Unless specifically indicated otherwise, these guidelines are not intended to restrict or replace professional judgment.

Related Sections

U-M Design Guideline Special Instructions to Designers:
SID-F - Codes and Regulatory Agencies - for listings of buildings containing Instructional Space or Dormitory Space.

U-M Design Guideline Technical Sections:
15010 - Basic Mechanical Requirements - for acoustical requirements for room types.

Submittals

For buildings subject to the jurisdiction of the State of Michigan Bureau of Fire Services (Instructional Spaces and Dormitory Spaces), include requirement for Affidavits of Compliance.

Design Requirements

In general, exposed grid suspended ceilings are preferred over concealed systems. Avoid spline and other non-accessible systems when any mechanical systems or equipment will be concealed above ceiling.

There are currently no standardized product types for acoustic panels. However, the following general guidelines apply:

- 2 foot by 2 foot panels are preferred over 2 foot by 4 foot panels.
- Rabbeted edge panels are preferred except where economy is paramount.
- 3/4 inch thick panels are preferred over 5/8 inch panels.
- Fiberglass panels are not acceptable.
- Where possible, specify humidity-tolerant acoustical panels carrying a minimum 10 year warranty.

- Specify gypsum board or other washable panels and moisture resistant grid in food service areas.

Where ceiling-mounted items obstruct the regular spacing of hanger wires, design "trapeze" structures with additional steel supports to bridge the obstruction.

RESILIENT FLOORING

General

For University of Michigan Hospitals and Health Centers projects refer to Design Guideline 09650-H available at:
http://www.med.umich.edu/facilities/planningdevelopment/ae/dg/doc/a/09650H.pdf
In general, follow the guidelines below when designing and specifying resilient flooring. Unless specifically indicated otherwise, these guidelines are not intended to restrict or replace professional judgment.

Design Requirements

General - Given the wide variety of flooring materials and applications throughout the University, there are no widely applicable standards for flooring selection. Consult University Project Coordinator for specific types of flooring to be used.

Demolition - In the event that existing resilient flooring or adhesive contains asbestos, consult the University Project Coordinator.

Laboratories - Several campus units, including the Medical School and Chemistry Department, require use of sheet vinyl floors with heat welded seams and integral, coved base to contain spills in laboratories. Consult University Project Coordinator for specific types of flooring and installation standards to be used.

Installation - In all cases where spillage or flooding is possible, caulk around all new and existing through-floor pipe and sleeve penetrations. Coordinate sealing with mechanical engineer.

Cleaning - Specify that the contractor clean floors of construction debris, dirt and grease as a requirement of Substantial Completion. The contractor must not wax new flooring; the University will clean, seal and wax floors as necessary after acceptance.

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Division 10 - Specialties

SECTION	DATE OF LAST UPDATE	PAST VERSIONS
10100 Visual Display Units	April 1995	
10162 Toilet Compartments	February 2008	April 1995
10400 Signage	July 2009	February 2008
10520 Fire Extinguishers	April 1995	
10810 Toilet Accessories	February 2008	October 2003

Last modified: Wednesday July 21 2010

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VISUAL DISPLAY UNITS

General

In general, follow the guidelines below when designing and specifying Visual Display Units and accessories. Unless specifically indicated otherwise, these guidelines are not intended to restrict or replace professional judgment.

University Preferred Manufacturers

Preferred manufacturers are listed in a separate document, "Architectural Preferred Manufacturers List." Obtain current copy from the Project Coordinator.

Design Requirements

Markerboards are generally not suitable for use as projection screens where even a moderate level performance is required. If the decision is made that a dual-use unit is appropriate, select a white surfaced board. Poor prior experience indicates that silver "combination" projection screen/marker board surfaces should not be selected under any circumstances.

Consider use of white, lenticular surfaced vinyl wall covering specifically manufactured for the purpose of marker/production dual use. If this product is specified, require that installation be performed by manufacturer's own installers.

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TOILET COMPARTMENTS

General

For University of Michigan Hospitals and Health Centers projects refer to Design Guideline 09510-H available at:
http://www.med.umich.edu/facilities/planningdevelopment/ae/dg/doc/a/10162H.pdf
In general, follow the guidelines below when designing and specifying toilet compartments. Unless specifically indicated otherwise, these guidelines are not intended to restrict or replace professional judgment.

University Preferred Manufacturers

Preferred manufacturers are listed in a separate document, "Architectural Preferred Manufacturers List." Obtain current copy from the Project Coordinator.

Design Requirements

Generally, ceiling hung painted metal partitions are preferred except housing department requires cast plastic units.

Where ceiling suspended units are not feasible, provide floor supported units with headrail bracing at door openings. Wall and floor cantilevered units are generally not as stable and should be avoided. Coordinate ceiling hung units with supplemental structural steel support work. Design support steel to resist rotational forces as well as weight. Usually, unbraced channels will not provide enough support to sufficiently stabilize panels.

Latching hardware for barrier free stalls shall allow a disabled user to close and secure the door with a single motion of one hand. added in approval routing 3/29/95

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SIGNAGE

General

For University of Michigan Hospitals and Health Centers projects refer to Design Guideline 10400-H available at:
http://www.med.umich.edu/facilities/planningdevelopment/ae/dg/doc/a/10400H.pdf

In general, follow the guidelines below when designing and specifying signage and accessories. Unless specifically indicated otherwise, these guidelines are not intended to restrict or replace professional judgment.

Related Sections

U-M Design Guideline Sections:
SID-F Codes and Regulatory Agencies
SID-H Drawing and Construction Document Standards

Campus Planning Guidelines:
Campus Wayfinding and Signage Guidelines
Guidelines for Emergency Evacuation Maps/Plans

Exterior Building Signage

New construction is to include appropriate exterior signage in the form of free-standing UM standard blue and white building ID signs. Consult Design Manager for required quantity, locations and additional information regarding ID signs. All major renovations will also include the upgrade or replacement of existing building ID signs, as the condition of the existing sign(s) warrants. The design, wording, placement, materials, and installation details of exterior signage must be approved by the Unviersity Planner's Office.

Consult the Design Manager for information regarding permanent signs on buildings. The Planner's Office will provide policies and guidelines regarding allowable signage on exterior walls, doors and windows of buildings and the design, wording, number, placement and materials of such signage.

Each University facility shall identify its accessible building entrances with the international symbol for accessibility. Additionally, signage is required at inaccessible entrances to direct users to an accessible entrance or to a location at which they can obtain information about accessible facilities.

Signage Characteristics

Signage is to be provided per code requirements and as noted here. If there is a conflict between these requirements and code requirements, code requirements supersede. Permanent room numbers are to be indicated on room signs as both tactile and raised Braille characters. Indented characters are not to be used. Braille characters may be located within an incised area on the face of a sign.

For renovation projects, consult Design Manager for information regarding existing room signs and extent, type, and supplier of new room signs. Usually, where one or only a few new signs will be installed, new signs should match existing signs. However, in areas where only a few signs will be installed, designers should evaluate the feasibility of replacing old, non-compliant signs with new signs in the visibly contiguous area.

In addition to the above requirements, for large construction projects the materials and design of new signs are to be selected to be compatible with sign standards of the college or department which will manage the proposed facility.

Emergency Evacuation Maps

New construction and major renovation projects are required to include emergency evacuation maps as part of interior signage package. The University Planner's Office has established standards regarding evacuation signage and maps. Review "Guidelines for Emergency Evacuation Maps/Plans" and consult Design Manager.

Building Directories

New construction projects are encouraged to include building directories as part of interior signage package. Major renovation projects are also encouraged to upgrade existing and/or install new building directories. Consult Design Manager for guidelines and standards.

Room Number Assignments

Generally include room number signs for newly created or consolidated rooms and areas. In some cases, rooms to be remodeled and rooms within new additions cannot be assigned new numbers without renumbering rooms outside the project area. In these cases, provisions for new signage outside the project area should be included in the construction project.

Room numbers are assigned by the University's Manager for Space and Facilities Information in Architecture Engineering and Construction (AEC). Only University designated room numbers are to be indicated on construction drawings. Consult SID-H "Drawing and Construction Document Standards" and the Design Manager.

Laboratory Safety Signage

University standard laboratory safety signage is required at the entryway of each main research laboratory space where hazardous materials may be stored and used. Additionally, signage is required at special use inner rooms where hazardous materials exist, including but not limited to environmental, procedure, tissue culture, weighing, and pilot production. Safety signage is not required for dedicated waste storage/transfer rooms within large research buildings or animal holding/containment rooms which have a separate signage system developed specifically for the animal handlers. Review required locations with Design Manager.

Construction projects should include 8.5" x 11" clear acrylic holders (portrait orientation) outside of laboratories, typically located on the latch side of the door, below the room identification sign. Safety signage inserts will be provided by the academic unit, the facility management, or UM OSEH.

Some existing laboratories have 10" square safety signage. Renovation projects are required to replace old safety signage within the renovated area and are encouraged to replace old signage in the visibly contiguous area. Review with Design Manager.

FIRE EXTINGUISHERS

General

In general, follow the guidelines below when specifying fire extinguishers. Unless otherwise indicated, these guidelines are not intended to restrict or replace professional judgment.

Related Sections

Tab 15 - Mechanical ; Section 15300 Fire Protection

Design Requirements

Specify units with the following characteristics:

- Metal bodies, valve assemblies, discharge levers and carrying handles. Plastic or composite materials are not acceptable in these applications.
- Rubber hoses.
- Fully rechargeable.
- UL-listed, bearing UL "Listing Mark" for extinguisher type, rating, and classification.

Application

In addition to providing units in accordance with code requirements, provide a 4A:60BC, 10 pound (nominal) capacity unit in each individual laboratory. Mount units next to laboratory exit doors.

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TOILET ACCESSORIES

General

For University of Michigan Hospitals and Health Centers projects refer to Design Guideline 10810-H available at:
http://www.med.umich.edu/facilities/planningdevelopment/ae/dg/doc/a/10810H.pdf
In general, follow the guidelines below when designing and specifying Toilet Accessories. Unless specifically indicated otherwise, these guidelines are not intended to restrict or replace professional judgment.

University Preferred Manufacturers

Preferred manufacturers and model numbers are listed in a separate document, "Architectural Preferred Manufacturers List."

Related Sections

U-M Design Guideline Technical Sections:
Section 10162 - Toilet Compartments

Design Requirements

Hand Towel Dispenser

The University provides hand towel dispensers for installation by the Contractor. The standard unit which is provided is a plastic body accommodating towel rolls. Units should be provided in sufficient quantity for the number of lavatories, but not less than 1 unit for each 3 lavatories. The University's Project Engineer will arrange for delivery of the units to the job site in coordination with the Contractor.

Waste Receptacle

Avoid recessed or surface mounted stainless steel receptacles. Specify free-standing painted metal receptacles with vinyl bumper edge.

Feminine Napkin/Tampon Dispensers

Specify stainless steel units dispensing both products. Both recessed or surface mounted types are acceptable. Units to be with 25 cent coin operation.

Liquid Soap Dispensers

Specify dispensers in all Medical School projects; elsewhere, dispensers are optional. Consult with the University Project Coordinator. Specify stainless steel units. Plastic "stick-on" types not acceptable. Both surface mounted and counter mounted types are acceptable, provided the reservoir is easily accessible. Position units over sinks or counter where possible.

Toilet Tissue Dispensers

The University provides toilet paper dispensers for installation by the Contractor. The standard unit which is provided is a plastic body unit for "jumbo" rolls. The University's Project Engineer will arrange for delivery of the units to the job site in coordination with the Contractor.

Feminine Napkin Disposal Units

Specify stainless steel units. Surface mounted units are acceptable; through-partition units are preferred.

Grab Bars

Concealed mounting anchors are desirable.

Pull Down Shelves

Stainless steel pull down purse shelves are desirable in women's toilet compartments.

General Room Shelves

Provide at least one stainless steel shelf in each toilet room if no other provision has been made for setting down possessions.

Childcare Accessories

During the programming phase, determine whether diaper-changing stations are to be provided in toilet rooms and in which toilet rooms they are to be located. Regardless of whether changing stations are required for the project, in new construction and in renovations affecting toilet rooms, provide space for mounting a diaper-changing station in each toilet room. Reinforce the wall area at the changing station location adequately to support the changing station. Changing stations shall be fold-down type supporting a minimum of 250 lbs. of static load when opened and shall project no farther than 4" from the wall when closed.

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Division 11 - Equipment

Always use the most recent version. Obsolete versions are for reference only.

SECTION	DATE OF LAST UPDATE	PAST VERSIONS
11610 Laboratory Fume Hoods	June 2004	April 1995

Last modified: Wednesday July 21 2010

For technical inquires, comments and suggestions on the U of M Design Guidelines, please e-mail the U of M Design Guidelines Group at UMDesignGuide@umich.edu.

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LABORATORY FUME HOODS

Fume hood design and selection shall incorporate the requirements of this section taken together with the requirements of Section 15910, Laboratory Ventilation.

Related Sections

Refer to Section SID-F for code and regulatory requirements.

Refer to Technical Sections listed below for additional UM design requirements which relate to fume hoods and which are to be incorporated into the specifications.

UM Master Specifications Sections listed below contain language which is typically used on projects designed by UM Architecture and Engineering Services (AES). These specifications are available for the use of outside A/E's but should not substitute for the design professional's judgment regarding project-specific requirements, except for specific situations in the Design Guideline where it is stated that the Master Specifications are to be incorporated.

UM Design Guideline Special Instructions to Designers
Section SID-F, Codes and Regulatory Agencies

UM Design Guidelines Technical Sections
12345 - Laboratory Casework
15060 - Basic Pipe and Pipe Fittings
15910 - Fume Hood and Laboratory Ventilation
16010 - Basic Electrical Requirements
16050 - Basic Electrical Materials and Methods
16500 - Lighting System

UM Master Specification Sections
11610 - Laboratory Fume Hoods
12345 - Laboratory Casework
15060 - Basic Piping Materials and Methods
15910 - Laboratory Ventilation
16010 - Basic Electrical Requirements
16050 - Basic Electrical Materials and Methods
16120 - Cable and Wire
16140 - Wiring Devices
16511 - Interior Lighting

Fume Hood Design Requirements

Selection and Design

Proper selection of fume hood features is only possible after a thorough programming effort which includes input from the hood users. Programming should determine the types of work being conducted in the fume hood, the experience of the users, the materials which will be used in the hoods, and any special requirements for the hoods.

In the interest of obtaining a cost-effective fume hood installation, the designer should incorporate the features designated as "typical" in this Design Guideline unless a specific need or rationale has been identified during programming or design which makes an alternate selection a better choice. Alternate selections, accompanied by the reason for the selection, shall be presented to the University Project Coordinator for review.

Hood type and usage have a major impact on mechanical requirements and should be selected in close consultation with the Project Mechanical Engineer, University Project Coordinator and the University's Department of Occupational Safety and Environmental Health (UM OSEH).

Laboratory fume hoods must comply with the requirements of ASHRAE Standard 110-95 As Manufactured, and relevant portions of NFPA 45.

Types

Consult with University Project Coordinator and UM Occupational Safety and Environmental Health (OSEH) to determine type of materials to be handled, and hood requirements.

- Bench hood: designed to rest atop a counter or base cabinet, usually about 36" above the finished floor.

- Walk-in hood: used where taller apparatus is required or equipment is to be rolled into the hood. Walk-in hoods provide a minimum of 78" of working height.

- Perchloric acid hood: specially designed hoods designed to safely accommodate use of perchloric acid. Among other features, these hoods have a spray mechanism for washing down the hood and duct interiors. Perchloric acid hoods should have a label indicating suitability for use with perchloric acid procedures.

- Radioisotope (RI) hood: equipped with a welded stainless steel liner and coved stainless steel work surface

Sash Type

Typically, specify fume hoods with a vertical rising sash. Specify combination sash when justified by the type of use of the hood. Do not specify combination sash in hoods of less than six feet nominal width.

Sash Stops

All fume hoods shall be specified with sash stops. The stops shall be integral with the frame; add-on stops are not acceptable.

Height for sash stops: 14" from the work surface, with a clear opening height of 13" above the airfoil. For airfoils of unconventional design, adjust the location of the sash stop to maintain the 13" clear opening height.

Work Surfaces

Solid, Cast Epoxy Resin: For most fume hoods, specify epoxy resin tops, with recessed work area (dished to retain spills).

Stainless Steel: For specialty applications only. Usually will be specified, together with a coved stainless steel lining which is welded to the work surface to create a seamless installation, for RI and perchloric acid hoods. Specify units with adequate structural support for lead bricks or other shielding devices.

Lead Shielding: Design structural supports to support weight of shielding materials.

Linings

Linings must meet requirements of NFPA 45, paragraph 9-1.1 (flame spread less than 25). Linings which do not meet this requirement are not permitted. The following are possible choices:

- Fiberglass-Reinforced Polyester Resin Panels (FRP): This is typically the material used in fume hoods specified for UM projects. FRP is not resistant to quite as wide a variety of chemicals as cast epoxy resin and may not be appropriate for applications requiring a high heat resistance.

- Cast Epoxy Resin Panels: More resistant to chemicals and heat than fiberglass-reinforced polyester resin. Because of limited availability and high cost this material should only be specified when other materials are not suitable for the intended uses. Thin unreinforced epoxy resin liners are susceptible to damage during shipping.

- Stainless Steel: Not as chemically resistant as the resins, stainless steel should be used only in RI hoods, perchloric acid hoods and when high heat resistance is required.

- Others: Use of other liner materials is discouraged. Generally, other materials have a poor cost/benefit ratio compared with the choices listed above.

Baffles: For fume hoods to be installed in teaching labs or other locations where users may be unfamiliar with fume hood operation, UM recommends the installation of fixed baffles. In other locations, manually adjustable baffles (where available) are the recommended choice.

Alarms

Audible and visual air flow alarms are required to be installed on all chemical fume hoods. Refer to Design Guideline Section 15910.

Mechanical Service Fittings

Remote control fittings for water, gas, air, vacuum and similar services should be brass, with at least 81 percent copper content. Service fittings in fume hoods shall have a chemically resistant plastic coating. Fittings must be serviceable from the front of the fume hood.

Do not specify plastic fittings, except for deionized (purified) water outlets.

Protect the potable water supply with vacuum breakers or backflow preventers installed on the front face of fume hoods.

Specify factory piped units whenever possible. Piping within the fume hood shall match materials in Division 15 Mechanical Specifications.

Specify cupsinks which are designed to protect against spillage of chemicals into the sink. Cupsinks may be either side-mounted or mounted in the work surface (with a raised rim), depending on user needs.

Electrical Service Fittings

Lights: Specify that each hood have a UL labeled, vapor-tight light fixture equipped with two F32T8 rapid-start, multi-phosphor fluorescent lamps with a medium bi-pin base, color temperature of 3500^{O}K, and a CRI of not less than 75. Shield fixture from hood interior by 1/8 inch thick tempered glass panel. Units shall be located so that light tubes are easily replaceable from outside hood. Light switches shall be rated 120/277 volt, 20 amps, specification grade, extra heavy duty.

Receptacles: Unless there is a requirement for other voltages or configurations, specify 2 duplex outlets on the face of the hood; 125 volt, 20 amp, 2 pole, 3 wire, specification grade, extra heavy duty grounding type with nylon or Lexan bodies. Specify ground fault circuit interrupter receptacles in fume hoods and within 6 feet of fume hoods which contain sinks. GFCI receptacles shall be rated for 2000 amps interrupting capacity and trip in 25 milliseconds or less when ground currents exceed 5 milliamps.

Other Requirements: Usually specify ivory colored switches and outlets.

Additional Superstructure Components

Consider the following components where appropriate:

- Enclosure Panels: Where the gap between suspended ceiling and top of fume hood will expose ductwork and equipment, consider specifying removable enclosure panels to conceal dead space and neaten appearance. However, rooms without suspended ceilings rarely benefit from enclosure panels.

- Walk-in Hood Floors: Specify either a stainless steel or epoxy resin floor in walk-in hoods, constructed so as to retain spills, but tapered to facilitate ease of move-in for roll-in items.

Base Unit Design Requirements

Generally specify under each hood both a flammable/solvents storage base cabinet and a corrosives storage base cabinet, each equal to half the length of the hood. Where standard cabinet lengths make this impossible, or where special storage requirements dictate additional storage capacity, locate supplemental storage units elsewhere in the laboratory. If supplemental flammable/solvents storage cabinets are required, they shall not be located next to the hood superstructure. The following types of base cabinets can be provided in either wood or metal:

Corrosives Storage Units: Specify units vented external to the hood directly to the fume hood exhaust duct, and provide a detail on the Drawings illustrating this. Cabinets shall not be vented into the fume hood exhaust chamber itself. Usually include optional composition-board interior lining.

Flammable/Solvent Liquid Storage Units: Specify units meeting requirements of NFPA 30, paragraph 4-3.2.1 if metal; or NFPA 30, paragraph 4-3.2.2 if wood. Include requirements for 3-point latching mechanism (mentioned in 30-4-3.2.1, but not 30-4-3.2.2) if cabinets are constructed of wood. Flammable liquid storage cabinets should not be vented. If the client requests venting, special review with UM OSEH is necessary.

Consider possible conflicts between flammable storage base cabinets and cupsinks. Some manufacturers have this conflict resolved for their standard cupsink sizes and locations, while others do not. Non-standard placement or non-standard size of cupsinks may also cause problems. Avoid placing cupsinks over flammable storage base cabinets unless the condition can be resolved by the casework manufacturer.

Coordinate the specification of base cabinets with that of fume hoods so that a mismatch between the depths of the hood and the base cabinets is avoided.

Biological Safety Cabinets, Tissue Culture Hoods and Laminar Flow Hoods

Before specifying these units, verify with the University Project Coordinator that they are to be included as part of the fixed construction. Selection of the type, size and class of these units shall be made by the University Project Coordinator and OSEH representative in coordination with the Design Engineer.

Fume Hood Testing

Specify that laboratory fume hoods must be tested to meet or exceed ASHRAE 110-95 As Manufactured (AM) testing at breathing zone concentrations of not more than 0.05 parts per million (ppm) with a 4 liter per minute tracer gas emission rate.

The 0.05 performance level may be inadequate for lab hoods which are to be used for extraordinary purposes, such as those involving highly toxic chemicals, high production volumes, or high-hazard radioactive materials. In such cases, the University Project Coordinator and UM OSEH shall provide direction regarding alternative AM or As Used (AU) testing.

In some locations, additional As Installed (AI) testing may be required for a certain percentage of fume hoods. This is most likely to occur in new research buildings. The University Project Coordinator and UM OSEH will provide direction regarding whether AI testing is required and, if so, how many fume hoods are to be tested.

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Division 12 - Furnishings

SECTION	DATE OF LAST UPDATE	PAST VERSIONS
12345 Laboratory Casework	April 1995	
12500 Window Coverings	April 1995	

Last modified: Wednesday July 21 2010

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LABORATORY CASEWORK

General

In general, follow the guidelines below when specifying laboratory casework, fixtures and related items. Unless otherwise indicated, these guidelines are not intended to restrict or replace professional judgment.

Consult with the University Project Coordinator for general layout and specific casework requirements.

Related Sections

Tab 11 Equipment; Section 11610 Laboratory Fume Hoods

University Preferred Manufacturers

Preferred manufacturers are listed in a separate document, "Architectural Preferred Manufacturers List." Obtain current copy from Project Coordinator.

Design Requirements

Casework

Types

Specify standard laboratory grade wood or metal casework.

- Consult with the University Project Coordinator regarding selection of wood or metal.
- When wood is selected, usually specify red oak veneer.
- Seal wood casework to prevent absorption of spilled materials.

Hardware

In newer buildings, and as otherwise possible, match existing handles and hinge styles. Usually specify manufacturers' standard units.

Finish

Manufacturer's standard finish is acceptable. Unless otherwise directed by the University Project Coordinator, include following requirements for wood casework:

- Sides which will be concealed in final assembly shall be of same species and finish as exposed surfaces.

- Bottoms of cases more than 48 inches above floor shall be of same species and finish as exposed surfaces.

Topset Cove Base Molding

Base can be specified in either casework or resilient flooring sections. If base is incorporated into resilient flooring specification, take the following precautions:

- Legshoes, if any, must still be provided by the casework manufacturer, since they are not a standard item for resilient flooring manufacturers.

- Where casework will be installed in areas that will not receive new flooring, check to ensure base required for casework is included in the scope of resilient flooring work.

Miscellaneous Fillers and Scribes

Show and specify fillers at gaps between individual cabinets, and between walls and cabinets. Include closure panels below all knee spaces to conceal pipe spaces. Fillers and scribes should match adjacent materials and finishes.

Countertops

The following materials are listed as guidance for selection. Select top materials with appropriate characteristics in consultation with University Project Coordinator.

- Epoxy Resin: Most commonly used material and generally preferred in most circumstances. Usually specify 1 inch thickness.

- Stainless Steel: Specify where seamless surfaces are required, such as processing areas for highly radioactive materials.

- Plastic Laminate: Generally, avoid plastic laminate in areas around sinks or otherwise subject to becoming wet. Chemically resistant laminates should be considered, but if chemical resistance is required, another top material may be better suited to intended use.

- Resin Impregnated Sandstone: These tops are as expensive, but less resistant to wear and chemicals than epoxy resin tops. Usually not specified.

- Man-Made Stone: Not acceptable for University projects.

- Methyl Methacrylate ("Corian"): Use care when specifying Corian to ensure chemicals used in laboratory will not stain or destroy the top. Corian is often specified when a white, chemically resistant top is required. However, Epoxyn makes a white epoxy resin top which could be considered. Seam sealants may also present a weakness, since silicone is generally used in lieu of the more chemically resistant epoxy sealants used with black tops.

- Solid Hardwood: Where desired by University Project Coordinator; of suitable construction, thickness and finish for intended purpose.

Shelves and Shelf Supports

Usually 45 pound density particle board with baked-on black acid resistant coating, smooth finished both sides with all edges radiused, and 1 inch thick (Kemshield or equal). In consultation with University Project Coordinator, select epoxy resin, solid hardwood, plastic laminate or other appropriate materials.

Typically, specify "Unistrut" standards and brackets spaced not more than 36 inches on center to prevent shelf sagging. Brackets and standards should be finished as follows:

Paint standards after erection, but prior to installation of brackets. Spray apply paint and allow to dry thoroughly before installing brackets.

Brackets should be painted with spray application methods and allowed to dry thoroughly before installation

Accessories

<u>Sinks</u>

Usually select epoxy resin sinks for lab installations. Select stainless steel sinks in consultation with University Project Coordinator for appropriate uses (such as integral top and sink installations, or in plastic laminate tops). Consider including stainless steel or PVC sink in laboratories where dry ice must be disposed (dry ice can cause epoxy resin to shatter).

<u>Mechanical Service Fittings</u>

Usually show and specify mechanical service fittings such as sinks, faucets, gas, vacuum and air outlets, and similar devices as part of Section 12345, for installation by plumbing trades.

Fittings for water, gas, air, vacuum and similar services should be brass, with at least 81 percent copper content.

Water fixtures should always be specified with integral vacuum breakers in every application. Integral vacuum breakers are available for almost all types of fittings, however, in the rare case where integral vacuum breakers are not available for a required fitting, provide in-line type units.

For distilled (purified) water faucets, specify PVC units with self-closing valves and integral PVC vacuum breakers. Do not specify plastic fittings in any use, except for deionized (purified) water outlets. For deionized water consider chrome plated brass faucet with polypropylene lining.

<u>Electrical Service Fittings</u>

Usually show and specify electrical service fittings such as pedestal outlets, and outlets and switches on fume hoods as part of Section 12345, for installation by electrical trade.

Receptacles: Receptacles supplied with electrical fixtures included in this Section shall be 125 volt, 20 amp, 2 pole, 3 wire, specification grade, extra heavy duty grounding type with nylon or Lexan bodies. Provide ground fault circuit interrupter receptacles within 6 feet of fume hoods and sinks. GFCI receptacles shall be rated for 2000 amps interrupting capacity and trip in 25 milliseconds or less when ground currents exceed 5 milliamps.

Switches: Switches supplied with electrical fixtures included in this Section shall be 120/277 volt, 20 amp, specification grade, extra heavy duty type.

Coordinate electrical locations of electrical outlets, wiremold and similar electrical items with casework layout.

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WINDOW COVERINGS

General

In general, follow the guidelines below when designing and specifying window coverings. Unless specifically indicated otherwise, these guidelines are not intended to restrict or replace professional judgment.

University Preferred Manufacturers

Preferred manufacturers are listed in a separate document, "Architectural Preferred Manufacturers List." Obtain current copy from Project Coordinator.

Design Requirements

General - A University-wide standard for window coverings does not exist. Window covering is determined for each building individually, and is based on exterior and interior appearance, environment, existing window coverings in adjacent areas, use and maintenance considerations.

Aesthetics - Base standards for new buildings on both exterior and interior appearance. When designing remodeling projects within an existing building, consider using the same type of window coverings as existing adjacent areas.

Environment - Consider requirements for protecting areas from the glare and heat of the sun. Also consider the environmental conditions in which the coverings will perform, such as exposure to chemicals, humidity, dirt or grease. Review flame retarding properties of window coverings for compliance with codes and condition of use.

Use - Public and student occupied areas need to withstand significant abuse. Venetian blinds specified for these areas need heavy ladder, top slat and of bottom rail construction, good quality of slat materials, and operating mechanisms that eliminate overdrive (preventing damage to worm gear or control wand). Private offices may use blinds fabricated of lighter weight material and without overdrive protection. Consult Project Coordinator.

Maintenance - The University Building Services Department has accepted the responsibility for cleaning and maintaining horizontal metal slats and vertical metal vanes. Their ultrasonic cleaning machine accepts slats of maximum 8-foot length. No other types of window coverings are maintained by Building Services. Consult with University Project Coordinator and obtain departments' approval before specifying other types of window coverings. Select only those coverings with acceptable warranties.

Installation - The University requires that a qualified dealer purchase and install blinds or shades composed of parts from the same manufacturer (single-source responsibility for both supplier and manufacturer) and labeled as to manufacturer and brand name. This is to assist in repair or replacement either by a qualified dealer, or by Building Services.

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Division 13 - Special Construction

SECTION	DATE OF LAST UPDATE	PAST VERSIONS
13041 Package Environmental Rooms	April 2003	

Last modified: Wednesday July 21 2010

For technical inquires, comments and suggestions on the U of M Design Guidelines, please e-mail the U of M Design Guidelines Group at UMDesignGuide@umich.edu.

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PACKAGE ENVIRONMENTAL ROOMS

General

In general, follow the guidelines below when specifying package environmental rooms and related items. Unless otherwise indicated, these guidelines are not intended to restrict or replace professional judgment.

Several aspects of environmental rooms require close coordination with work of other sections. Among these are:

- Casework and shelving.
- Structural steel.
- Mechanical utilities.
- Electrical utilities.

Clearly indicate in specifications and on drawings all mechanical and electrical work which is required within the controlled environment room and which is required for connection to building utilities. Make sure that the equipment specification contains language that this work must conform to the requirements of Division 15 and 16 specification sections.

Include in the Specifications a requirement for submitting an Installation Manual (with the other project submittals) and an Operations and Maintenance Manual (prior to project completion).

Environmental rooms should be included in the list of equipment requiring commissioning in the project.

It is the Architect/Engineer's responsibility to obtain from the client and the University Project Coordinator a complete understanding of how the environmental room(s) will be utilized and occupied and the required operating conditions (including special requirements such as the need for backup power and cooling). Backup power and cooling should not be provided routinely. It should be reserved for critical operations.

Related Information from UM Web Site

U of M Master Specifications

Architectural Preferred Manufacturers List.

UM Code Requirements (SID-F).

Architectural Design Requirements

General

No University-wide standards exist for interior and exterior panel materials or finishes. Most commonly, painted aluminum exteriors are specified with either painted aluminum or stainless steel interiors.

Size unit to suit user requirements and available area. Specify height requirements as well as length and width. Manufacturers have unique standard sizes, so close tolerances will need special coordination during design. In general, avoid specifying units with less than 7.5 feet interior height (approximately 8 feet outside dimension).

Provide necessary wall reinforcement for shelving, countertops, equipment and any other wall-mounted items.

The door hardware must include a break-away type latch (with cylinder lock if needed) and inside safety release handle so that the door can be opened from the inside even if it is locked.

Provide slip-resistant flooring.

Provide adequate access, clear of any interference from other building elements, to the condensing unit and any other equipment mounted exterior to the unit. This access must incorporate a reasonable means of getting from the floor to the top of the unit (for example room for a ladder from the floor to the above-ceiling space). In most circumstances, access through a 2 x 2 ceiling grid will not be considered adequate unless portions of the grid can be easily dismantled to allow for a larger opening. Include a fluorescent light fixture, power receptacle, and switch mounted in the ceiling space to provide illumination and power for servicing at top of unit. Clearly delineate the required access on the drawings.

Consider enclosure panels around the top of units which do not meet suspended ceiling height. Panels may need to be vented and removable to accommodate roof-mounted equipment.

For environmental rooms that will be used for crystallization, provide the following special features:

- Remote mounted compressor/condenser units (not mounted on roof of environmental room).
- Self-closing and sealing doors.
- Quiet relays and switches.
- Refrigeration system piping, blower, dessicant wheel (if any) and other vibration sources mounted on vibration isolators, and not along environmental room walls.

For environmental rooms that will be used to house animals, provide quiet switches and relays.

<u>Operating Requirements</u>

Specifications should include information regarding at least the following criteria. :

- Operating temperature range.
- Control range (+/-0.2 deg. C is usually acceptable).
- Uniformity range (+/- 0.5 deg. C is usually acceptable).
- Estimated door openings per hour (usually not less than 8).
- Number of occupants (maximum at any time).
- Heating load in watts of operating equipment (scientific apparatus, etc.) within room. If this load cannot be determined during design, assume heat load will equal 50 percent of outlet power capacity.
- Humidity range if applicable. Do not specify range if special humidity control is not required.
- Ambient conditions of the space in which the room will sit. Identify the maximum adverse condition likely to be encountered.
- Temperature range of process chilled water, if a water-cooled condenser is being used.
- Temperature and humidity range of makeup air (see Mechanical Design Requirements below) being supplied to the environmental room.

<u>Furnishings and Equipment</u>

<u>Manufacturers:</u> Some casework is available from representatives of environmental rooms. To date, no casework from these sources has been approved for laboratory use. Usually use equipment of approved laboratory furniture manufacturers.

<u>Casework Materials:</u> Use metal casework in controlled environment rooms.

<u>Shelving Source:</u> Shelving is available through the suppliers of environmental rooms, and is a recommended source of shelving if no casework from another source is to be provided in the environmental room.

<u>Design:</u> If casework is to be provided in the environmental room, usually treat the design as a standard lab project.

<u>Structural Steel</u>

Structural steel support frame may be required if remote mounted condensing units are selected. For example, support frames will usually be required when mounting units on building roofs, and when condenser is to be located within the laboratory area, but not on the roof of the environmental room (occasionally necessary, due to overhead space limitations).

Mechanical Design Requirements

Coordinate utility installation, and ensure mechanical design takes into account the following:

- Makeup air to the environmental room: Provide makeup air if the room is to be occupied (rather than just used for storage of materials and samples). Follow Code requirements for ventilation. For other circumstances, the A/E must establish whether ventilation is required or advantageous. In general, if there is not a specifically identified need for ventilation, UM recommends not providing it, since makeup air may introduce unwanted humidity in environmental rooms. If makeup air is provided, exhaust or relief must also be provided. Provide ducted exhaust connections (hard pipe or thimble connection as required) to meet the requirements for both environmental room exhaust and/or dessicant dryer exhaust. Do not allow exhaust to be discharged from the environmental room into the ceiling plenum.

- Heat from condensing coil must be rejected to building exterior or a cooling loop. Water-cooled units should normally be specified. Do not specify air-cooled units which reject heat into occupied space or suspended ceiling plenum. Water-cooled units using city water as the primary cooling fluid are not permitted. However, if continuous operation of the environmental room is critical, consideration must be given to backup cooling which might include City water.

- Provide accessible filters for the evaporator coil.

- Utility piping may be factory installed and concealed in environmental room walls, or may be surface mounted in the field. Either method is acceptable, as long as appropriate coordination of factory and field work requirements is provided. Note that crystallization rooms require piping mounted on vibration isolators.

- Pipe penetrations through environmental room walls must be coordinated with room supplier. Room suppliers may, or may not, want to make the penetrations themselves. Mechanical specifications should call for coordination; leave final decision of who makes the penetration to the Contractor. Penetrations must be sleeved and sealed.

- A drain line must be shown from the evaporator unit drip pan to a safe waste (one containing an air gap). In freezer rooms, the drain line from the evaporator unit drip pan should be routed outside of the room.

- Humidification: The A/E must evaluate the most cost-effective method for providing humidification for the environmental room. If house steam can be made available cost-effectively at the room location, it should be used for humidification. If a steam generator is specified, the water quality for the steam generator must be coordinated with the manufacturer's requirements. Some manufacturers may require treated water of certain resistivity. If this is not available in the building, it may be necessary to provide additional treatment as an option for the steam generator.

- Dehumidification: The A/E should determine the most appropriate and economical method of dehumidification based upon the operating requirements and the type of equipment available from manufacturers. If a dessicant-type dryer is utilized, exhaust must be provided. See additional information regarding exhaust covered previously in this section.

Electrical Design Requirements

Coordinate utility installation, and ensure electrical design takes into account the following:

- Electrical panel and control panel must be provided by room manufacturer
- Electrical outlets and conduits may be factory installed and concealed in environmental room walls, or may be surface mounted in the field. Either method is acceptable (although concealed conduits are preferred), as long as appropriate coordination of factory and field work requirements is provided.
- Conduit penetrations through environmental room walls must be coordinated with room supplier. Room suppliers may, or may not, want to make the penetrations themselves. Electrical specifications should call for coordination; leave final decision of who makes the penetration to the Contractor. Penetrations must be sleeved and sealed.
- Refer to Specification Section 16400 for information regarding the electrical panel.
    1. The panel should feed not only the loads within the room, but also the evaporator unit, compressor unit, control panels and any other equipment associated with the operation of the environmental room.
    2. If possible, locate the electrical panel next to the control panel. Do not locate it on the roof, or remotely from the controlled environment room.
    3. The electrical panel may be incorporated into the control panel, if this is the standard for the manufacturer. If this is allowed, the panel buses shall be braced for the available fault current, and the breakers rated to interrupt the available fault current of the distribution system. The panel shall also be UL listed for the application.

Coordinate connection of refrigeration unit, room controls and recorder, lights and outlets that are specified in Division 16000.

- Lighting should be fluorescent (except incandescent for rooms with less than 0^{o} F.). Specify UL labeled, vapor-tight light fixtures equipped with two lamps. Refer to Design Guideline Section 16500, and Specification Section 16511 for information on the lamps and ballasts. Provide electronic ballasts where suitable for application.

- Refer to Master Specification Section 16140 for specification information for light switches.

- Provide a minimum of 3 receptacle circuits to the receptacle inside the unit. Refer to Specification Section 13041 and 16140 for specification information on receptacles. Provide ground fault circuit interrupter receptacles within 6 feet of sinks or other water sources. Receptacle circuits shall be 20 ampere rated, and each circuit shall serve no more than 3 duplex receptacles. Adjacent receptacles shall be fed from different circuits.

- Provide a 1" raceway path for any 'data outlet' installed inside the environmental room. Data outlets shall be two gang, deep, boxes unless installed in surface raceway. See also Section 16740

- The controller should be digital and electronic. It should be programmed to maintain the environmental room within the operating criteria. Battery backup of the controller should be considered in critical applications to maintain temperature logs during power outages or other disruptions.

- Recorders: Review with the University Project Coordinator whether the manufacturer's standard chart will be adequate. Recorders for humidity-controlled rooms must include humidity as well as temperature readings.

- Alarms: Ascertain user requirements for both local and remote alarms. For remote alarms, consult with the University Project Coordinator to determine whether alarms will be directly monitored by BAS (Building Automation System), which is typical for University Buildings, or to the Department of Public Safety (via MOSCAD) in special circumstances. At a minimum, provide the following alarms:

    - Common alarm for setpoint deviation or system trouble of temperature, humidity, etc.

    - CO_2 set point deviation alarm and automatic CO_2 safety alarm (for elevated CO_2 rooms only).

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Division 14 - Conveying Systems

SECTION	DATE OF LAST UPDATE	PAST VERSIONS
14000 Elevators	April 1995	
14420 Wheelchair Lifts	February 1999	
14425 Barrier Free Lifting Devices		

Last modified: Wednesday July 21 2010

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ELEVATORS

Table of Contents

General

In general, follow the guidelines below when specifying elevators and related items. Unless otherwise indicated, these guidelines are not intended to restrict or replace professional judgment.

Consult with the University Project Coordinator for specific requirements.

Related Sections

Tab “Special Instructions to Designers”; Section “Codes and Regulatory Agencies”

University Preferred Manufacturers and Sub-Contractors

Approved installation sub-contractors for elevator related work are listed within this section.

Preferred manufacturers are listed in a separate document, "Architectural Preferred Manufacturers List." Obtain current copy from Project Coordinator.

Design and Installation Requirements

1.0 General Guidelines for Hydraulic & Traction Elevators

1.1 Scope of Work

When project scope consists of elevator modernization or replacement; include the following in project specifications:

Two weeks prior to removal of any equipment, elevator contractor must notify U. of M. elevator dept. at 747-3246. U. of M. elevator dept. will tag any parts to be salvaged. Contractor to remove tagged parts, transport parts to building's loading dock, and notify U. of M. elevator dept. which in turn shall remove salvaged parts from site. All other equipment will become property of contractor who in return will remove same from site in accordance with all codes and regulations.

1.2 Acceptable Elevator Installers

Millar Elevator Co.
3716A Trade Center Drive, Ann Arbor 48108
Dave Flint (313)971-8242

Amtech Reliable Elevator Co.
6511 Lincoln Ave., Detroit 48202
Gerry Virzi (313)872-3001

Detroit Elevator Co
1938 Franklin St., Detroit 48207
Don Purdie (313)259-3710

Schindler Elevator Co.
11853 Belden Court
P.O. Box 9166
Livonia, MI 48151-1166
Dave Roth (313)422-8850

* Note: Above is not a list of elevator manufacturers; it is a list of INSTALLERS only. Elevator INSTALLER must provide the equipment specified. See list of acceptable products.

1.3 Requirements of Regulatory Agencies

A. Perform all work in accordance with applicable codes, the State of Michigan Elevator Code, the National Electrical Code, and the American National Standard Safety Code for Elevators, ANSI A17.1 (latest edition accepted by State of Michigan), as referenced therein and all of the provisions in the University of Michigan's Standard General Conditions dated January, 1995. Give all necessary notices, obtain all State and Municipal permits, pay all fees necessary in connection with the installation, including sales and use taxes as applicable, and make all tests as are called for by the regulations of such authorities. These tests shall be made in the presence of the authorized representative of such authorities and the Owner's representative.

B. Conform to the Americans with Disabilities Act (ADA) Guidelines.

Comply with University of Michigan Barrier Free Elevator Guidelines attached herewith.

1.4 Guarantee

The elevator subcontractor shall guarantee that the materials and workmanship of the apparatus installed by him under this specification are first-class in every respect, and that he will make good any defects not due to ordinary wear and tear or improper use or care, which may develop within one year from the date of final payment.

1.5 Operation and Maintenance Manuals

After completion of the installation, the elevator subcontractor shall furnish four (4) complete sets each of "as-built" wiring diagrams, parts catalogs and job specific service manuals to the Owner. (See 1.21.B)

1.6 Maintenance

A. After completion of the installation, maintenance and 24 hour callback service for the equipment furnished under this specification, shall be provided for a period of twelve (12) months as part of this Contract. This service shall also include regular examination (biweekly; advise U. of M. elevator dept. @ 747-3246 each time after completion of service) of the installation during regular working hours by trained employees of this Contractor, and shall include all necessary adjustments, greasing, oiling, cleaning, supplies and parts to keep the equipment in proper operation, except parts made necessary by misuse, accidents or neglect caused by others.

B. All maintenance service must be performed by the installers and not by any other services agency. Also, the installer must have an established maintenance and service organization available for performance in the City of Ann Arbor, that can provide regular and emergency service, 24 hours a day, every day of the year and respond to the job site within two hours of a call.

C. The elevator contractor shall be responsible to service and maintain all elevator emergency circuits (including the fire capture circuit, related equipment and sensors) as part of the regular elevator maintenance contract.

1.7 Electrical Requirements

A. General:

1. Refer to items titled "Elevator Machine Room" and "Elevator Hoistway and Pit" for additional requirements. Refer to 1.26 and 1.27.

2. Completely insulated wiring shall be furnished and installed to connect all parts of the equipment furnished by the elevator contractor. Wiring shall conform to the requirements of the latest edition of the National Electrical Code. Include rigid conduit or EMT, at least 1/2" diameter, and short lengths of flexible conduit. Conduit or EMT shall terminate in junction boxes. Conduit, EMT, wiring duct, conduit fittings, enclosures and junction boxes shall be galvanized steel or aluminum.

3. All wiring shall have a flame retarding moisture resisting outer cover and shall be run in metal conduit, flexible metallic tubing, or wire ducts.

4. Execution:

Install all power wiring in raceway systems. No exposed wiring or conduit shall be run in finished areas without prior written approval of owner.

Splice cables and wires only in outlet boxes, junction boxes or pull boxes. (Note - No wire splicing allowed in raceway or wireducts).

Install cable supports for all vertical feeders in accordance with the NEC. Provide Kellum GPIP type supports which firmly clamp each individual cable and tighten due to cable weight.

All terminal strip connections shall be identified with corresponding reference numbers from cable termination chart and electrical straight line diagrams.

5. Provide two dedicated telephone lines (one for emergency service and one for modem) terminated in a junction box in elevator machine room.

B. Work by Elevator Contractor (Also refer to item A. above):

1. ALL POWER WORK FROM MAINLINE DISCONNECT SWITCHES IN ELEVATOR MACHINE ROOM TO CONTROLLERS AND OTHER ELEVATOR EQUIPMENT SHALL BE PROVIDED BY THE ELEVATOR CONTRACTOR.

2. Traveling cables shall have flame retarding and moisture resisting outer cover. They shall be flexible and suitably suspended to relieve strains in the individual conductors. Provide the required quantity of conductors (including two shielded conductors for telephone per elevator) plus at least 10 percent spares. All wiring between telephone cabinet in car and a junction box in elevator machine room shall be provided by the elevator contractor. Conductors shall be numbered to correspond to numbered terminals at the car and machine room.

3. Terminal blocks shall be coded to identify the circuits. Multi-conductor cables shall have the conductor color coded and numbered.

4. Each elevator car shall be provided with a suitable lamp fitted with a wire lamp guard on top of the car and a GFCI duplex plug receptacle. Refer to 1.11.2 &3, and App. B.I

5. Unless otherwise specified, control wiring shall be minimum size #18 AWG. Wire size shall be large enough so that the voltage drop under inrush conditions will not adversely affect operation of the controls.

6. Electrical Receptacle in Car: Provide duplex GFCI electrical receptacle in car. Locate receptacle approximately 2" above finished floor below car station. Provide matching face plate on receptacle. See also 1.18.G.

7. Phase Protection: Provide 3-phase power monitor for elevator power supply which monitors phase loss, low voltage, phase reversal, phase unbalance, and has an automatic reset.

8. The elevator equipment shall be designed to limit the total harmonic distortion (THD) reflected back into the power system to the following values at any motor speed from 50 to 100 percent.

Equipment input voltage waveform: less than 3% THD

Equipment input current waveform: less than 100% THD

After startup of the system, the University will measure reflected THD. The Elevator Contractor shall provide at no additional cost any additional devices required to meet the above THD limits. See 1.8.D.

C: Work by Electrical Contractor (Also refer to item A. above):

1. Adequate power from the power mains to fused disconnect switch in machine room as required, including necessary <u>fused</u> mainline disconnect switches. Circuit breakers are not acceptable.

2. Wiring and <u>fused</u> disconnect switch for car lighting, monitoring devices and ventilation, located in elevator machine room.

3. Provide a duplex electrical receptacle (3 ft. above finished floor), light and switch in the pit. Provide a duplex electrical receptacle, light and switch within 18" of lock side of jamb in machine room. Provide duplex electrical receptacle near controller and whatever additional electrical receptacles are needed to meet ANSI 17.1 and N.E.C. Codes. Light in the pit shall be operable from bottom hoistway door opening. Provide a single tube continuous fluorescent light fixture strip (full height of hoistway) with guard. This lighting shall be operable from a switch located in the pit and at the top floor. Provide a duplex outlet within 5 feet of governor for traction elevators. (Note - All electrical receptacles shall be GFCI type). Refer to 1.26.B

4. Provide conduit with pull wire between nearest telephone closet and junction box in elevator machine room for elevator telephone. Refer to 1.21.

1.8 Selection of Type of Equipment

A. <u>For rise up to 45 feet</u> - Select hydraulic type elevator machine. Specify a dry pumping unit. That is, the pump, motor and valves should not be located in the hydraulic reservoir. (Note: Piston stabilizers not allowed)

B. <u>For rise above 45 feet</u> - Select electric traction machines.

C. <u>Elevator speed</u>

1. Electric Traction Elevators
   - Minimum: 200 ft/min.,
   - Maximum: 350 ft/min.

2. Hydraulic Freight
   - Minimum: 25 ft/min.
   - Maximum: 100 ft/min.

3. Hydraulic Passenger
   - Minimum: 100 ft/min.
   - Maximum: 125 ft/min.

D. <u>Elevator Control/Controller</u> - For both hydraulic and electric traction elevators: Specify non-proprietary microprocessor controls. In addition, electric traction elevators must have SCR drive. Specify remote diagnostics. State in specifications that controllers requiring proprietary diagnostic tools are not allowed.

The SCR Drive shall limit the total harmonic distortion (THD) reflected back into the power system to the following values at any motor speed from 50 to 100 percent.

- SCR Drive input voltage waveform: less than 3% THD

- SCR Drive input current waveform: less than 100% THD

After startup of the system, the University will measure reflected THD. The Elevator Contractor shall provide at no additional cost any additional devices required to meet the above THD limits.

E. Additional for Traction Elevators Only: Include with controller package a circuit designed to detect the failure of the brake to lift. Detection of this failure shall be by means of a mechanical switch and shall take the elevator out of service at the next stop and remain out of service until the condition is corrected.

1.9 Hydraulic Elevator Cylinder Unit

The cylinder shall be fabricated from steel pipe and provided with a removable cylinder head and packing gland at the top. The cylinder head shall have a bronze, babbitt or phenolic-lined bearing and an integral drip ring. Packing shall be of the self-adjusting type.

The exterior of the cylinder shall be treated with a corrosion resistant compound and double-lap wrapped with a commercial grade wrapping, such as Scotchwrap or Tapecoat, before installation.

Provide an outer cylinder casing using at least schedule 30 steel pipe. Provide a PVC liner between outer casing and cylinder unit, sealed at the bottom. Use only clean, dry sand to fill void between outer casing and the liner and between the liner and the cylinder unit.

1.10 Landing System

The landing system shall provide high speed stepping signals, one-floor-run stepping signals, leveling, and door zone signals. Each output signal shall be electrically isolated and shall be capable of reliably operating at 120 VAC.

The leveling and stopping accuracy of the system shall be within 1/4 inch of the floor level and shall correct for over travel or under travel to within the same accuracy, regardless of load variations or direction of travel.

NOTE: MECHANICAL TYPE OR MECHANICALLY DRIVEN SELECTORS/LANDING SYSTEMS ARE NOT ACCEPTABLE.

1.11 Hoistway Door Unlocking, Top-of-Car Inspection, and Pit Emergency Stop Devices

Furnish and install hoistway door unlocking and top-of-car inspection devices in accordance with requirements of the latest Edition (currently accepted by State of Michigan) of the American Standard Safety Code for Elevators, Dumbwaiters, and Escalators (ANSI/17.1), and as permitted by the Local Code.

The following equipment shall be furnished:

1. Hoistway door unlocking devices shall be installed at all landings with removable plugs and as required by local codes.

The hoistway door unlocking device shall unlock and permit the opening of the hoistway door from the access floors irrespective of the position if the car. The design of the device shall be such as to prevent unlocking the door with common tools. The means for unlocking the door shall be available and used only by inspectors, maintenance men, and repair men.

2. A car top inspection station shall be located between the car crosshead and hoistway door, complete with an Emergency Stop Switch, an inspection switch, and Up, Down & Safety Operating Buttons. In addition, if elevator is equipped with fireman's service, car top station must include an audible and visible indication in the event fireman's service is activated.

To operate the top-of-car operating device, the inspection switch shall be turned from "Car" to "Top" which shall transfer operation to the top-of-car device. Movement of the car shall be controlled by continuous pressure of the appropriate direction button and a safety button.

Operation from the top of the car shall not be permissible unless all electric door contacts are closed.

3. Provide a light w/guard with On-Off switch at inspection station and GFCI duplex electrical receptacle.

4. An Emergency Stop Switch in the pit. Provide a switch which meets Elevator Code and can be padlocked out.

5. Provide hoistway access features operable from top and bottom landings.

1.12 Landing Door Hangers

Each hoistway door section shall be suspended by two sheave-type hangers running on a drawn steel track. Each hanger shall consist of a polyurethane tread on a metal hub equipped with precision ball bearings mounted onto a steel bracket. The hanger sheaves shall be not less than 3-1/4 inches in diameter. The drawn steel track shall be so shaped as to permit free movement of sheaves without regard to vertical adjustment of the sheave brackets. An up-thrust roller shall be provided beneath the track and each sheave wheel, capable of withstanding a vertical thrust equal to the carrying capacity of the upper sheave. The up-thrust roller (equipped with ball bearings) shall be adjustable for fine vertical adjustment and the face of the roller shall be so shaped as to conform to the bottom face of the hanger track.

Entrances which have multiple door sections shall be provided with a suitable coordinating mechanism to transmit motion from one door panel to the other.

1.13 Door Panels

A. Door panels must be minimum of 18" wide.

B. Use single or two speed door operation only, side slide or center opening. For freight elevators use power operated, bi-parting, center opening, vertically operating freight loading type doors..

C. Each door panel shall be provided with minimum of two door guides.

1.14 Door Operation

A. Passenger and Service Elevators:

The car and hoistway doors shall be operated quietly and smoothly by an electric operator which shall open and close the car door and respective hoistway door simultaneously. The doors shall open automatically when the car is leveling at the respective floor and, when operating without an attendant, shall close after a predetermined time has elapsed. Momentary pressure on the "Open Door" button in the car shall cause the doors to remain open or, if closing, to reopen and reset the time interval.

The opening speed of doors shall be approximately 2 ft. per second, but the closing speed shall be reduced to approximately 1-1/4 feet per second.

Provide door pre-opening feature with switch to disable this function.

B. Door Protection:

Do not specify incandescent type light beams or mechanical safe edges. Specify infrared type beams only.

C. Freight Elevators:

Provide power-operated, vertical, bi-parting door operation.

1.15 Guide Rails

Minimum Rail Size - 15 pounds/ft. upgrade rails based on application.

1.16 Roller Guides for Car

A. <u>Passenger and Service Elevators</u>:

Each roller guide shall consist of minimum of three wheels (minimum roller diameter - 6") tired with a durable resilient material; each rotating on ball bearings having sealed-in lubrication; all assembled on a substantial metal base and so mounted as to provide continuous contact of all wheels with the corresponding rail surface under all conditions of loading and operations. The wheels shall run on three finished rail surfaces. The roller guides shall be properly secured at top and bottom on each side of car frame. Provide roller guides at top and bottom of car.

The roller guides shall run on dry guide rails.

B. <u>Freight Elevators</u>:

Use either roller guides or slide guides.

1.17 Signal Fixtures

A. <u>Operating Devices in Car/Car Operating Panel</u>

The operating devices in the car shall consist of a vandal resistant stainless steel flush mounted control panel. The control panel shall contain a series of push buttons with illuminated (LED type) call registration devices, numbered to correspond to the various landings serviced; <u>In Car Keyed Stop Switch</u>, <u>Alarm Button</u> (connected to a bell located on the car), and a <u>Door Close</u>, <u>Door Open</u> button for each entrance. Alarm bell shall be operated from the battery providing emergency lighting. The control panel shall also contain separate key operated switches for inspection, independent service, car lights and car fan keyed to "Adams standard keying system" (Note - Inspection key switch shall activate inspection circuit and disable automatic door operation). Auxiliary panel, if required, shall contain all floor buttons; alarm, door open and door close buttons for each entrance. Whenever key switches are required; the key switch cylinders shall be Best Co. 7-pin tumblers keyed to U of M lock system. Contractor shall contact U of M key Office through Owner's representative.

B. A gong shall be provided at the handicap floor entrance to comply with barrier-free code requirements.

C. All buttons shall conform to the University of Michigan Barrier Free Elevator Guidelines attached herewith.

D. <u>Car Telephone</u>:

Provide hands-free vandal resistant type emergency phone integral with car operating panel in car and two shielded conductors via trail cable to the machine room. Terminate phone connections in machine room in a junction box conveniently located for phone company installation.

E. <u>Hall Push Button</u>

Vandal resistant illuminating LED type hall push buttons shall be installed at each floor to permit waiting passengers to call the elevator to the floor.

Fixtures shall have up and down buttons at intermediate floors and single buttons at top and bottom floors.

Buttons shall be made of vandal resistant stainless steel with integral up or down arrows and shall illuminate to indicate a call has been registered. Button shall remain illuminated until the call has been answered.

F. Hall and Car Position Indicators

Shall be LED (Light Emitting Diode) digital type and good for a minimum of 5-years. Provide position indicators in car and at all landings.

1.18 Elevator Car Enclosure

A. Lighting

Indirect fluorescent or cove lighting (Do not use incandescent lamps). Provide standard length light fixtures and install fixtures equally on both sides of elevator cab to balance the light that is emitted.

B. Flooring

Finished floor (for passenger elevators) shall be heavy duty "sheet type vinyl" securely cemented in place or "commercial grade carpeting" or heavy duty tile.

Finished floor (for freight elevators) shall be made of 1/4" thick (minimum) checkered aluminum plate.

C. Emergency Lighting

The elevator car shall be provided with emergency lighting with a battery powered unit in compliance with code requirements. This should be integral with the car operating panel.

D. Pads and Pad Hooks (Passenger & Service Elevators only).

Provide pad hooks on walls near top 12" o.c. Provide protection pads for all walls.

E. Class of Loading for Elevator

Provide class C-3 loading for all types of elevators. (For modernizations - Discuss any exceptions with University Project Coordinator)

F. Car Telephone

See 1.17D.

G. Electrical Receptacle In Car

Provide GFCI type duplex electrical receptacle in car. Locate receptacle approximately 2" above finished floor below car station. Provide matching face plate on receptacle.

H. Ceiling Height In Elevator Car - Minimum 8'-0".

I. Elevator Enclosure

Provide a steel elevator cab enclosure. Attach all finish wall panels to the steel shell. Construct canopy from formed and reinforced 16 gauge steel. Provide an emergency exit panel in canopy.

1.19 Hoistway Entrances

A. The entrances shall consist of flush hollow metal door panels, bolted unit type frames, sills, hanger covers, fascia plates or toe guards, headers, struts, sight guards and hardware. Rubber astregals shall be provided for center opening doors.

B. Sills: Sills shall be of extruded aluminum or stainless steel construction with a non-slip wearing surface. They shall be supported on steel brackets and securely fastened to the floor. Grooves for the door guides shall have minimum clearance for the guides. For harsh environments (e.g. Parking Decks) - use corrosion resistant sills. Sills shall be designed for class C-3 loading.

C. Hanger covers: Hanger covers shall be fabricated of No. 14 gauge steel extending the full width of the hanger pocket.

D. Fascia: Fascia plates shall be constructed of No. 14 gauge steel, adequately reinforced to ensure a flat surface, spanning the width of the opening plus 6 inches, and fastened to the header and the sill above.

1.20 Accessories

1.21 Submittals

A. Shop Drawings: Submit eight (8) copies of Shop Drawings as required showing the general and detailed arrangement of all elevator equipment. Show ceiling, lighting, and signal fixtures (Including layout and conduit routing for smoke detectors).

B. Final Submittals:

Provide four complete sets (bound and properly arranged) of the parts lists and operators manuals prior to receiving final payment. Following is a brief summary of items:

1. Legible schematic wiring diagrams including all changes made during installation.

2. Description of operation of elevator system installed.

3. Hoisting machine: Including Motor, Brake, Geared Machine and associated devices such as Tach Motors or Monitors.

4. Deflector Sheaves, Governor and Governor Tail Sheaves, Safeties, Buffers.

5. Counterweight Assembly, Guide Rollers on Counterweight and Car, Cable Shackles.

6. Controller and Selector: Including parts information on Relays, Printed Circuit Boards, Reverse Phase Relays, Switches, Lamps, Electrical Cables, Monitors, Modems, Diagnostic Hardware, Diagnostic Software, Overload Protection Devices.

7. Door Assemblies: Including Hangers, Rollers, Door Motor, Door Operator, Door Clutch Assembly, Door Closers, Door Drive Arms, Related Hardware, Sheaves, Door Guides, Interlocks, Safety Door Edge.

8. Signal Equipment: Including Car Station, Hall Stations, Position Indicators, Direction Indicators, Fire Service Panel, Smoke Detectors, Keyswitches, Push-button Assemblies.

9. SCR Drive Units, Transformers, Chokes.

10. Car Top Inspection Station, Limit Switches, Solid State Leveling Control Units, Leveling Switches, Alarm Bell.

11. For Hydraulic Units - Pumps, Valves, Motors, and Cylinders.

1.22 Operating Instructions

(Ask for an Add Alternate to identify cost of this work, in Section-3 of bid documents)

On site technical training shall be held for the purpose of familiarizing University of Michigan Elevator Support Mechanics with operations and troubleshooting procedures. The session shall accommodate up to ten personnel in each session and consist of forty hours of Training (This to include two 2-day sessions and the fifth day reserved for any additional diagnostic training). Training on equipment controller shall be provided by trained factory service engineers of controller manufacturers through the elevator installers. Submit details of training with bid.

1.23 Acceptance Demonstration and Performance Test:

A. Demonstrate to Owner, or Owner's designated representative, the operation of the elevator system. Demonstration shall include:

1. Installation compliance with specifications.

2. Contract speed, capacity, and floor-to-floor performance compliance with specifications.

3. Stopping accuracy and car ride compliance with specifications.

4. Operation of signal fixtures, operation of supervisory or dispatching system and fireman's service operation.

5. Promptly remove all work rejected by the Engineer for failure to meet specifications and replace to comply with requirements, at no additional cost to the Owner. All expenses of repairing work of other Trades damaged by this replacement shall be borne by Contractor.

Rejected work which is not made good within a reasonable time, determined by the Engineer, may be corrected by the Owner at Contractor's expense.

6. Upon completion of installation and before final acceptance, conduct a running speed test with full design load to verify compliance with performance requirements including items 2 and 3.

7. Operating Instructions: Provide instructions to the Owner's personnel, including safety procedures, proper operation of the equipment, and routine maintenance procedures

1.24 Performance Guarantee

The elevator subcontractor shall assume full responsibility to furnish and provide a complete and functional elevator and to obtain and furnish the University final State Elevator Inspection approval. All costs necessary to correct code deficiencies cited by the State Elevator Inspector will be paid by the elevator subcontractor as part of this Contract at no additional cost to the Owner.

1.25 Keys

A. <u>Car Operating Keys</u>

Use manufacturer's standard keys only. Do not use high security keys (e.g. MEDECO Keys, Barrel Keys, Magnetic Keys) that cannot be duplicated locally and by U. of M.'s key office.

1.26 Elevator Hoistway and Pit

Provide the following:

A. Pit ladder.

B. Pit light and GFCI duplex receptacle 3 feet above finished floor. Refer to 1.7.C.3.

C. Provide a 16" dia. x 30" deep sump in elevator pit with steel cover plate. Evaluate need for a sump pump and provide sump pump and related electrical if needed.

D. Paint pit floor and walls (up to the sill) with two coats of light gray, gloss, oil based paint.

E. Paint all exposed metal in hoistway (except guide-rails) with two coats of rust inhibitive paint.

1.27 Elevator Machine Rooms

Provide the following:

A. Ventilation and Cooling

Provide adequate ventilation. Evaluate the need for mechanical cooling in elevator machine rooms whenever microprocessor based controllers are specified. Ambient temperature 50^{o} F - 95^{o} F.

B. Painting (Floor and Walls)

Paint elevator machine room floor with two coats of light gray gloss oil based paint.

Paint elevator machine room walls and ceiling with two coats of white paint

C. Painting (Elevator Equipment)

All exposed surfaces of machines and motors, governors, etc., shall be repainted after field installation and before acceptance by Owner with rust resisting gloss enamel paint (of color selected by Owner).

D. Lighting

Provide 30 foot candles of florescent lighting in elevator machine rooms. Lighting shall be positioned so it does not create shadows while service personnel are working on major equipment.

E. Fire Extinguisher

Appropriate classification 15 pounds fire extinguisher. Mount in elevator machine room near main entrance.

F. Door

Appropriately labeled self closing, self locking door.

G. Door Hardware

Keyed to U. of M. Best "XV" Key System. Contractor to contact U. of M.'s key office for cylinders. All costs to be included in contract.

1.28 Sensing Devices: (For Firefighter's Services)

Smoke detectors shall be photoelectric type, 120 vac, Gentex Corp. Model 8100. Submit drawings. showing locations of smoke heads and exposed conduit for owner's approval prior to installation.

APPENDIX A:

ELEVATOR GUIDELINES TO ENSURE ACCESSIBILITY BY PEOPLE WITH DISABILITIES

Elevators shall meet the guidelines of the Americans with Disabilities Act using the Uniform Federal Accessibility Standards (UFAS) relevant to elevators (Section 4.10 Elevators) as the technical requirements.

Elevators shall meet the requirements of the State of Michigan Department of Labor Building Code relevant to barrier free design and elevators. Section 512.10.

APPENDIX B:

ACCEPTABLE PRODUCTS

A. FIXTURES (Car Operating Panel, Hall Push Button): Adams Vandal Resistant Survivor Plus Series manufactured by Adams Elevator Equipment Company.

B. MICRO-PROCESSOR BASED CONTROLLER
For Traction Type Elevators: Motion Control Engineering Model with SCR Drive and remote diagnostics or O. Thompson with SCR drive and remote diagnostics. (Specify Appropriate Model No.)

For Hydraulic Elevators: Motion Control Engineering Model HMC 1000 or O. Thompson with electronic soft start features to limit inrush current and remote diagnostics. (Specify Appropriate Model No.)

C. DOOR OPERATOR & EQUIPMENT: GAL Manufacturing Corp. MOH Operator, car and hall door tracks, car and door hangers with roller assemblies. All interlocks, pickup rollers and operating linkage manufactured by GAL.

D. HOIST MACHINE: Manufacturer's standard that complies with all duty requirements of this Section and manufactured by Hollister Whitney or Titan.

E. SCR DRIVES: GE-300E or SWEO with all applicable options.

F. DOOR PROTECTIVE DEVICE: ICU/47 PLUS from Adams Elevator Equipment Company or Innovation Smart Edge Model No. 2002 with Additional Dual Eye Ray Unit.

G. TELEPHONE: Adams - Ident-i-call Model A-931P3T-01 integral to car operating panel.

H. ROLLER GUIDES: Elsco for car and on counterweights suitable for application.

I. CAR TOP INSPECTION STATION: Adams Model A-912CG with guard.

J. FLOOR ANNOUNCEMENT SYSTEM: Adams Part No. A-102A "Adams Voice", including 23 standard floor and direction messages; or voice package furnished integral with controllers noted in Item "B" above.

K. CAB MANUFACTURERS:

- G & R Elevator Mfg.
- Haunstein Burmeister
- Tyler
- Brice Southern

L. DOOR GUIDES: Nylube

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WHEELCHAIR LIFTS

General

In general, follow the guidelines below when designing Wheelchair Lift installations. Unless specifically indicated otherwise, these guidelines are not intended to restrict or replace professional judgment. These guidelines are applicable to permanent wheelchair lift installations.

Initial Determination of Suitability

In existing structures, wheelchair lifts should be provided as a means of achieving an accessible route only after all other options have been thoroughly considered and rejected. Wheelchair lift installations are difficult to successfully design and construct, and once built are prone to failure and subject to abuse by unauthorized users. The University does not permit the use of wheelchair lifts to meet accessibility requirements in new structures.

Code-Recognized Applications: Michigan Barrier Free Rules limit the use of wheelchair lifts to the following applications:

- To provide an accessible route to a performing area in an assembly occupancy.
- To comply with wheelchair viewing position line-of-sight and dispersion requirements.
- To provide access to incidental areas, not open to the general public, that are occupied by not more than 5 persons.

Exceptions to these recognized applications may be sought when existing structures make other alternatives impracticable. Inform the University Project Coordinator when an exception will be required.

Applicability To Site: Wheelchair lifts are limited by Michigan Elevator and Barrier Free laws and rules to the following:

- Total Rise: Not more than 72-inches (12 feet has been proposed by the Elevator Board).
- Number of Stops: Not more than 2.
- Through-Floor Penetrations: Not permitted.

Vertical Wheelchair Lifts

Lift Type: Generally, the University prefers vertical lifts over incline lifts.

Aesthetics: While full architectural hoistways for lifts are not required, give attention to appropriate placement of the unit and consider including screen walls or other architectural effects.

Approach: The approach path to the lift must be accessible, including the areas in front of both doors. Lifting device under-structures cause the platforms to be elevated about 3-inches above the finish floor level. Wherever practicable, depress the slab beneath the units to permit them to be accessed without a ramp at the lower landing. Where a depressed slab cannot be provided and a ramp is needed, the ramp must meet all relevant Michigan Barrier Free Rules and ADA/UFAS requirements, including those for landings at doors.

Hoistway, General: Hoistways may be either site-built architectural hoistways or manufacturer's standard hoistways that meet Michigan Barrier Free and Elevator Rules. Hoistways are required to be solid, with the lift-side smooth. If the hoistway is full height to the ceiling, a light must provided in the hoistway, along with a sprinkler head in buildings with automatic fire suppression. Lights and sprinkler heads must comply with University standards for these devices, including provision of sprinkler head shut-off valve. Lights must be fed from a night-light circuit. Additional requirements include:

- Minimum Hoistway Height (Upper Landing): 42 inches above the upper landing.
- Minimum Hoistway Height (Bottom Landing): Total rise plus 42 inches.
- Shaft Clearance At Platform Sides: 2 inches minimum.
  3 inches maximum.
- Shaft Clearance At Platform Ends: 3/8-inch min. running clearance.
  3/4-inch max. running clearance.
  3-inches max. at door.

Site-Built Architectural Hoistways: Drawbacks of site-built architectural hoistways include the coordination and code compliance problems associated with custom construction. Site-built hoistways include full or partial height doors on openings into the shaft. Highlights of code requirements and related University requirements for shaft door openings include:

- Doors must be swinging type and of solid construction. Lights in doors are permitted and the University encourages their inclusion.
- Doors must be self-closing, which may be accomplished by spring-hinges on partial height doors. On full height doors, the University encourages the inclusion of power-assisted operators. Where standard closers are included on full height doors, specify delayed-action type units.
- Door width should not be wider than the platform plus sidewalls. 36 inches is acceptable.
- The University requires push/pull type hardware.
- No hazardous protrusions are permitted. Special attention may be necessary regarding the interlock device.

Manufactured Hoistways: Manufactured hoistways have the benefit of single-source responsibility for operation and code compliance. The requirements for door openings of manufactured units are the same as those for site-built hoistways, but since manufactured units are supplied with their own doors, the level of specification detail required is lower. Usually, inclusion of requirements to comply with the Michigan Elevator Rules is sufficient. The following is a list of University-required options for manufactured units:

- Doors must be self-closing, swinging type. The University requires doors to operate quietly. Specify some combination of sound-deadened door construction, door silencers, and hydraulic closers (as opposed to spring hinges), as necessary. Power-assisted operators are not required on light-weight doors. Lights in doors are permitted and the University encourages their inclusion.

- The University requires push/pull type hardware.

- If provided, hoistways around the tower (lifting mechanism) must be designed for easy removal for access to machinery.

Lifting Devices: The lifting device consists of a platform with guards, a lifting mechanism on one side of the platform, and various electrical devices. Platform size, gate and guardrail configuration and height, control locations and type, safety devices, and other features are regulated by the Michigan Elevator Rules. Some of the lifting devices shown in manufacturer's literature do NOT comply with the Michigan Elevator Rules, even though they may comply with ANSI requirements. The following highlights of the Michigan Elevator Rules and University requirements are intended to assist the design effort, but are not a substitute for an understanding of the Rules:

- The University accepts only roped hydraulic lift mechanisms. Screw drive type units are not acceptable.

- A safety device is required at both platform ends. The only code-approved safety device approved by the University is the electric-eye type.

- The University requires that platform guards on both sides of the platform be equipped with handrails.

- The University requires paddle-type switch controls (as opposed to push buttons) for easier use.

- The Elevator Rules require a fused safety disconnect. Locate the disconnect near the lift mechanism, but not in the shaft itself, and not in a location not accessible to the public. Locate the device as unobtrusively as possible.

- The University requires that lift platforms include a side-panel-mounted, spring-loaded seat that, in retracted position, does not impinge on the required clear width of the platform.

- The University requires that lifting device structures be securely fastened to the floor, in accordance with manufacturer's recommendations.

- The University requires a load capacity of 750 pounds.

- The University requires that the minimum platform size should be 13 square feet.

Reference Codes: The following codes and rules affect wheelchair lift installations:

- Americans with Disabilities Act, Uniform Federal Accessibility Standards (ADA/UFAS).
- Michigan Department of Labor Building Code Rules, Chapter 11 - Accessibility.
- Michigan Department of Labor Elevator Rules.

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UNIVERSITY OF MICHIGAN
Architecture, Engineering and Construction

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Special Instructions to Designers
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Design Guidelines - Division 15 Mechanical (PDF)

Always use the most recent version. Obsolete versions are for reference only.

SECTION	DATE OF LAST UPDATE	PAST VERSIONS
15010 Basic Mechanical Requirements	January 2001	February 2000
15060 Basic Piping Materials and Methods	February 2010	April 1995
15100 Valves	April 1995	
15130 Thermometers and Gauges	May 2003	July 1992
15140 Pipe Hangers	April 1995	
15160 Pumps	October 2005	February 1999
15170 Motors	April 2009	January 2001
15190 Mechanical Identification and Painting	April 1995	
15240 Mechanical Sound & Vibration Control	March 2004	July 1992
15250 Mechanical Insulation	April 1995	
15300 Fire Protection	May 2003	April 1995
15430 Plumbing Specialties	March 2006	March 2004
15450 Domestic Hot Water	July 1992	
15455 Water Booster Pumps	July 1990	
15460 High Purity	December	July 1990

Water Systems	2005	
15515 Hydronic Systems and Specialties	May 2003	February 1999
15525 Steam Specialties	April 1991	
15635 Refrigerant Monitoring System	March 2004	
15680 Chilled Water Systems	October 2005	February 1999
15681 Water Chillers	October 2005	
15710 Cooling Towers	May 2003	July 1992
15780 Packaged Roof Top Air Conditioning Units	May 2003	July 1992
15784 Window Air Conditioning Units	July 1990	
15785 Computer Room Units	March 2004	July 1990
15830 Fan Coil Units and Blower Coils Units	May 2003	July 1990
15850 Air Blending Devices	July 2005	July 1990
15855 Air Handling Units	July 2005	July 1992
15860 Fans	July 1990	
15880 Grills, Registers, Diffusers and Air Balancing Accessories	April 1991	
15885 Air Filters	May 2007	July 1990
15890 Duct System Design	September 2008	February 2007
15910 Laboratory Ventilation	September 2008	December 1991
15960 Variable Speed Drives	November 2008	December 1991
15975 Mechanical Systems Controls	June 2006	
15990 Testing, Adjusting and Balancing	September 2008	
15992 Tests - Piping Systems	July 1992	

Last modified: Thursday July 22 2010

For technical inquires, comments and suggestions on the U of M Design Guidelines, please e-mail the U of M Design Guidelines Group at UMDesignGuide@umich.edu.

University of Michigan - Architecture, Engineering and Construction
A326 East Hoover Ann Arbor MI 48109-1002 Contact Us

BASIC MECHANICAL REQUIREMENTS

General

Within the scope defined by the Program Documents, perform the project mechanical design work and produce the project mechanical construction documents in accordance with these Design Guidelines.

Related Sections

Tab “Special Instructions to Designers” - Section SID-F “Codes and Regulatory Agencies”

Design Requirements - Codes and Standards

In addition to the **Codes** listed in section "Codes and Regulatory Agencies", the following **Standards** apply to mechanical projects. Use most current update. Where these **Standards** conflict with related **Codes, Code** shall take precedence.

- State of Michigan Fire Marshal Division, "Fire Damper Clarification".
- NFPA 101, "Safety to Life from Fire in Buildings and Structures".
- NFPA 90A, Installation of Air Conditioning and Ventilating Systems.
- SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- Factory Mutual loss prevention data sheets.
- NFPA 13 "Installation of Sprinkler Systems".
- ANSI/ASHRAE/IES 90A Energy Standard.
- ANSI/ASHRAE/IES 100.5 Energy Standard.
- AABC National Standards for Total System Balance.
- ACGIH Industrial Ventilation.
- ASHRAE Handbook - Fundamentals, Equipment, HVAC Systems and Applications, Refrigeration.
- ASHRAE 62 Ventilation for Acceptable Indoor Air Quality.
- SMACNA - HVAC Testing, Adjusting and Balancing.
- NEBB - Procedural Standard for Testing, Adjusting and Balancing of Environmental Systems.
- AWS D 9.1 - Welding of Sheet Metal.
- AMCA - Standards, Definitions, Terms and Test Codes for Louvers, Dampers and Shutters.
- NFPA 14 - Standpipe and Hose Systems.
- Michigan Occupational Safety and Health Act.

The enforcing authority is the University of Michigan.

Design Requirements - Future Growth, Spare Capacity, Existing Conditions

When designing new installations, consider providing spare capacity for future growth. When designing renovations to existing installations, verify the existence of spare capacity before utilizing it for the new loads. Also field verify existing conditions - do not assume that existing design drawings are complete or accurate.

Design Requirements - Maintenance Accessibility

Locate equipment requiring maintenance so that it is easily accessible. Avoid installations that require the use of lifts or scaffolding, or the removal of other equipment for routine maintenance. Provide access doors to all maintainable equipment located behind walls or above permanent ceilings.

Preferred Manufacturers

The University (Facilities Planning and Design) maintains a “Mechanical Trades Preferred Manufacturers List”. This list is updated regularly, generally in February and August. The A/E shall use this list in developing construction document specifications. Obtain a current copy from the University Project Coordinator. This list is also available through this website.

Where specific manufacturers are specified in the detailed specifications other approved manufacturers listed may be substituted provided a model with similar quality exists.

Demolition Requirements

To maximum extent feasible, remove abandoned branch piping and ductwork back to risers/mains. Remove abandoned conduit and equipment.

The A/E must caution the Contractor that all shutdowns of systems serving occupied spaces outside the area of this project shall be absolutely minimized. This will require that, for example, branch duct runs shall be capped and sealed at the time of partial duct removal to allow use of the remaining duct system until the new ducts are installed. Temporarily rebalance if pressure relationships are critical. Ducts cannot be left open unless the entire system can be taken out of service throughout the full construction period.

Other systems which are presently operating that are to be abandoned, as well as those previously abandoned should be removed.

Operating and Maintenance Instruction Manuals

Four sets of **job specific** operating and maintenance (O&M) manuals shall be provided for each project. These manuals shall be collected in indexed three ring binders and contain manufacturer's operating and maintenance literature for every equipment item furnished for the project. Typical wiring or piping schematics are NOT acceptable; they must reflect the actual furnished equipment, including all options and interfaces with other equipment or systems. O&M manuals shall include a steam trap inventory with individual trap identification, service, manufacturer and model.

A single copy of each **job specific** O&M manual shall be submitted immediately after all shop drawings have been approved. This copy will be reviewed by the A/E and University personnel, then sent back to the contractor for corrections. All four corrected copies must be received by the University two weeks prior to any scheduled training.

Mechanical System Design Criteria

Acoustic, indoor and outdoor design criteria must be stated on the drawings (first sheet of the applicable section). This should include indoor temperature, humidity and cleanliness (as applicable), outdoor temperature and humidity and Noise Criteria or Room Criteria goals for each occupancy classification. Confirm criteria with the University Project Coordinator

Outdoor Air Design Conditions

HVAC Winter:	Negative 10F & 0% RH
HVAC Summer:	92F DB / 72F WB (ASHRAE 1%) for lab/research areas 89F DB / 71F WB (ASHRAE 2.5%) for office/classrooms
Cooling Towers:	95F DB / 78F WB

Indoor Design Conditions - Acoustics

Class/Meeting rooms: NC/RC 30
Offices: NC/RC 40
Labs: NC/RC 50

Indoor Air Design Conditions - Temperature and Humidity

Design projects to produce acceptable indoor comfort. Consider the design application, all HVAC loads as well as initial and operating costs of various alternatives. To minimize cold drafts, provide new and existing buildings with perimeter radiation heat unless this requirement is specifically waived by the University Project Coordinator. At the same time, consider optimization of building skin to allow perimeter heat to be eliminated without compromising comfort.

Humidification is generally required, except where specifically waived by the University Project Coordinator. Criteria must be carefully selected to balance human comfort with building skin integrity. General winter humidification criteria for offices and classrooms: 30% RH. Several buildings have used central power plant steam for direct injection humidification. Some building occupants have complained about chemical treatment (amines) used in the central steam system. For this reason, the current standard for humidification in office areas (and other areas with relatively low outside air requirements) is to install a "clean steam" system, typically a steam to steam heat exchanger, with RO or DI make-up water. In lab areas and other high outside air environments, direct steam is still acceptable. Consult University Project Coordinator early in the design phase to clarify project specific humidification guidelines.

General Space Criteria:

Office/ Classroom:	Summer: 72-75F dbt, 50-55%RH Winter: 72-75Fdbt, 25-35% RH
Laboratories:	Summer: 72-75F dbt, 55-60%%RH Winter: 72-75F dbt, 25-30% RH

<u>Drawing Requirements</u>

The amount of outdoor air for each air handling system must be shown on the equipment schedules.

Prepare the following mechanical drawings (as applicable to the project) for use during construction:

- Demolition plans and details
- Plumbing plans, including underground (within 5 feet of the building)
- Piping plans and details, including all utility meter locations
- HVAC plans and details
- Mechanical room layouts showing free space required for maintenance
- Plumbing, piping (including specialty gases) and HVAC (SA, RA, EA) risers

The drawing shall be of high quality in accordance with the Construction Documents Section of the Special Instructions to Designers.

<u>Shop Drawings and Air/Water Test and Balance Reports</u>

The University will retain three copies of all such submittals and the A/E will retain one copy. Therefore, the Contractor will be required to submit four copies of all such submittals plus however many copies he wishes to retain.

<u>Access for Maintenance Operations</u>

Add access hatches as required to service valves, dampers, coils, VAV boxes and mechanical equipment.

<u>Structural Supports</u>

All supports for piping and equipment shall be selected so that deflection caused by the load does not exceed 1/240th of the span.

Dust Protection

All mechanical and electrical equipment shall be protected from construction dust. Before start-up, motors must be covered or enclosed in a dust free manner. After start-up the surrounding area must be kept as dust free as possible by regular and frequent cleaning, dust control compound etc.

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BASIC PIPING MATERIALS AND METHODS

General

In general, follow the guidelines below when designing and specifying pipe, pipe fittings, and accessories. Unless specifically indicated otherwise, these guidelines are not intended to restrict or replace professional judgment. Piping materials shall be compatible with systems served.

Related Sections

U-M Design Guideline Technical Sections:
Division 2 - Sitework
15250 – Mechanical Insulation
15300 – Fire Protection Systems
15460 – High Purity Water Systems

U-M Master Specification:
Division 2 - Sitework
15010 – Basic Mechanical Requirements
15011 – Mechanical Submittals
15060 – Basic Piping Materials and Methods
15070 - Underground Piping in Conduit System
15071 - Underground Chilled Water Piping System
15300 – Fire Protection Systems
15515 – Hydronic Systems and Specialties
15525 – Steam Systems and Specialties
15530 - Refrigerant Piping

U-M Standard Details, Schedules and Tables:
15060D001 - Pipe Supports
T 15060 001 02 07 - Piping System Pressure Test Table

Design Phase Deliverables

General Material Requirements

Refer to U-M Master Specification for piping and accessory materials and installation requirements, including: Drainage and Vent Piping, Pressurized Plumbing Piping, Hydronic and Steam Piping, Eccentric Fittings, Tees in Welded Pipe, Solder in Copper Piping Joints, Dielectric Protection, Flanges, and Unions – previously addressed in this section. In all cases, pipe materials and accessories must be compatible with systems served (pressure, temperature, corrosion resistance). Master specifications contain extensive hidden text for the specification editor to guide decision making process. Where U-M Master Specifications are used, edit and customize on a project specific basis. Note that only the more typical piping applications are covered in the U-M master specification; assure every pipe application specific to the project is specified. Additional clarification is included in paragraphs that follow.

<u>Piping Accessories Material Requirements</u>

<u>Pipe Penetrations and Sleeves</u>

Provide pipe sleeves where required, including the following locations:

- Where required by code
- Where required as part of rated penetration, to maintain fire and smoke rating
- To support vertical piping (to support riser clamps).
- Where required to maintain water seal and prevent water penetration.
- Where pipe movement is anticipated (especially due to thermal expansion) at the penetration.

Fire Protection Piping, Compressed Air and other uninsulated piping: Sleeves are generally not required, unless required to maintain integrity of rated walls.

Chilled Water and Cold Water: Sleeves are generally required for all piping 2" and larger penetrating walls and floors.

Steam, Condensate, Heating Hot Water, and other hot insulated piping: Sleeves are required for all piping in walls and floors.

For underground exterior wall penetrations, piping penetrations must be watertight. For new construction, provide cast-in-place pipe sleeve with integral water-stop, oversized for use of linkseal between piping and sleeve. In existing concrete, where concrete can be core drilled and properly sealed with a linkseal, a sleeve may not be required.

For renovation work with existing concrete floors or for new floors where cast-in-place sleeves were not installed, pipes penetrating above grade floors typically require "double core" sleeves, especially in areas where floors are likely to get wet, and where water leaks to floors below would be disruptive to operations. Piping in stairwells does not require floor sleeves.

Include appropriate, project specific penetration and sleeve details for all conditions. Refer to U-M details, and customize as required.

<u>Pipe Hangers and Supports</u>

Refer to U-M Standard Details, U-M Master Specification 15010 and 15011 for additional hanger and support requirements previously addressed in Design Guideline Section 15140. Refer to Design Guideline Section 15010 for building attachment requirements previously included in this section.

The A/E shall include the following in piping designs:

- Pipe hanger details, including components, hanger spacing.

- Pipe hanger systems that accounts for thermal expansion of piping.

- Details of building attachments, including clarifying when support of piping from concrete slab using expansion anchors is acceptable. "C" type clamp hangers are acceptable for fire protection piping and all piping 2" and smaller when retaining clips are used.

- For large piping or where the design otherwise impacts the integrity of the building structure, indicate locations of all pipe hangers.

- For existing buildings with concrete floors, determine the extent to which vertical drill-in or similar type inserts can be used, and delineate any limitations regarding their use in the specifications. Many older buildings may not have sufficient floor thickness or integrity to allow the use of such inserts.

- Indicate locations and details of pipe anchors, guides and expansion joints or bends.

Dissimilar metal-to-metal contact between pipe and hanger is prohibited.

Hangers for piping that lacks rigidity, such as polypropylene pipe, shall be spaced, as a minimum, as recommended by the manufacturer or preferably, with a continuous support. Since the spacing is typically much closer than for other piping materials, the designer must pay close attention to the implications on the design.

For cold piping systems, design piping hangers to retain integrity of vapor barriers. Specify cal-sil or similar pre-formed inserts and insulation shields for all piping 4" to 12" requiring a vapor barrier (wood blocking is not acceptable). Insulation shields are acceptable for piping 3" and below.

<u>Design for Thermal Expansion:</u>

Account for thermal expansion when designing pipe hangers and supports. Where space allows, expansion bends fabricated from standard piping are preferred over expansion joints. Within steam tunnels, and up to building shut off valve, for LPS and medium pressure steam (MPS) design <u>expansion</u> for 600°F maximum piping temperature. Materials do not need to withstand 600°F at associated saturated pressure.

For steam tunnels, on low pressure steam (LPS), externally pressurized bellows type expansion joint shall be used. For low pressure condensate (LPC), use externally pressurized bellows type expansion joint or equal expansion bellows type expansion joint. For domestic hot water (DHW), use equal expansion type bellows joints with all Stainless steel construction (no carbon steel on wetted parts). Refer to U-M Master Specification 15125 – Expansion Joints.

Mechanical Piping Requirements

Refer to U-M Master Specification Sections for details of piping material requirements. Clarifications and exceptions are noted below.

Domestic Cold Water and Hot Water

Domestic Hot Water piping installed in the central campus tunnel system shall use exclusively Victaulic grooved copper pipe and fittings.

Storm and Sanitary Waste and Vent Piping

Vent piping shall be the same as waste piping.

Master specification includes both cast iron and PVC piping. Use cast iron unless specifically instructed by U-M Design Manager to use PVC. While PVC may have some appropriate applications in small projects, there can be smoke/fire related problems with using PVC.

Laboratory Waste and Vent Piping

For most chemistry and biology labs, dumping of acids and other corrosive chemicals is prohibited. As such the waste stream is generally dilute, within Ph limits suitable for discharge to city sanitary sewers. Therefore, in most cases, neutralization pits are not required. Confirm design philosophy on lab waste system with U-M Design Manager.

For general lab applications, above ground lab waste piping is typically specified as corrosion resistant polypropylene, Schedule 40. Joints may be mechanical type or fuse-sealed, depending on application. For new lab buildings, or renovations with extensive new drainage networks, fused joints should normally be specified. Consult U-M Design Manager. Fused joints are generally less prone to developing leaks, but may be more expensive. All sink P-traps shall be of the same material as the waste pipe, and include mechanical fittings for ease of maintenance.

Underground piping shall be polypropylene, Schedule 80. Joints shall be fused type. Consult U-M Design Manager. Double walled underground piping is not generally required.

Alternate piping material shall be considered on a case-by-case basis where high temperature waste or other factors may be present. High silicon cast iron may be considered if the application warrants the added expense. Glass piping may be considered where high temperature waste is present.

High Purity Water Piping

Design piping system to meet project specific requirements. Some applications can use PVC piping (humidifiers), while others require polypropylene (most labs). Consult U-M Design Guideline 15460 – High Purity Water Systems for detailed requirements.

Vacuum Piping

Provide a plugged cross at all turns greater than 45 degrees, slope in the direction of flow and provide hose end drain valves at all low points for cleaning the system.

Chilled Water Piping

Large underground piping should generally be uninsulated ductile iron (Class 52 with Polyethylene wrap). For small piping, consider alternate materials and need for insulation.

Hot Water Heating Piping

Underground piping shall be installed using a preinsulated piping system. Carrier pipe shall match above ground piping. Jacket pipe shall be minimum 10 gauge steel, with butt welded fittings, and a fiberglass reinforced urethane elastomeric coating. Refer to section 15250 for insulation requirements.

(Steam) Condensate Piping

Underground condensate (from steam) piping shall be schedule 80 black steel with extra heavy fittings in a preinsulated system as described for underground hot water heating piping. Condensate piping shall not be run in common jacket pipe with other carrier pipes, unless specifically approved by U-M Design Manager and Utilities Department. Generally, two underground condensate lines are installed – one spare for future use.

Condenser Water Piping

U-M is presently considering non-ferrous (stainless steel, fiberglass, ABS) piping alternatives for improved water quality. Preliminary analysis indicates that non-ferrous piping may be justifiable, especially in applications where the cooling tower is drained seasonally, and where piping is not heat traced and insulated. Schedule 10 stainless steel condenser water piping has been used on some projects. Consult U-M Design Manager.

Underground condenser water piping shall be ductile iron.

Steam Piping

Underground steam piping up to 125 psig shall be Schedule 40 black steel with butt welded fittings, in a pre-insulated system as described for underground hot water heating piping.

Civil Pipe Material Requirements

Generally, underground piping 5 feet or more from building exterior walls is considered to be “Civil Piping”. The following piping materials apply to Civil piping only, and may indicate that a change in pipe material takes place at this point. Refer to Tab 2 - Sitework for additional requirements.

Storm Sewer

Shall be reinforced concrete pipe (RCP), ASTM C-76, Class IV, with rubber gasketed joints, ASTM C-443, or High Density Polyethylene with rubber gasketed joints. For small projects with piping limited to 6" and 8", Schedule 80 PVC pipe may be used.

Sanitary Sewer

Shall be extra strength vitrified clay pipe (VCP) with O-ring joints. Sewers 15" and larger shall be reinforced concrete pipe (RCP), ASTM C-76, Class IV, with rubber gasketed joints, ASTM C-443

City Water Mains (for domestic water and fire protection)

Shall be Ductile Iron Class 52 with Polyethylene wrap.

Under Drainage Tubing

Shall be corrugated polyethylene tubing (AASHTO M 252) or corrugated polyvinylchloride tubing (ASTM F 800, with holes conforming to (AASHTO M 252)

Lawn Sprinkler Piping

Coordinate irrigation system design (including sizing water main, backflow preventer, and water meter) and installation with the University Landscape Architects Office and the U-M Plumbing shop, via the U-M Design Manager.

Dye Testing Requirements for Storm and Sanitary Piping

Dye testing is required on most new connections to new and existing storm and sanitary waste piping. Refer to Master Specification Section 15060 (including hidden notes) and OSEH Dye Testing Guidelines for Storm Water & Sanitary Systems.

Where practical, dye testing of underground piping should be done during design phase to validate that the design is in compliance with effluent discharge codes and regulatory requirements. Special attention should be paid to mechanical room floor drains and cooling tower overflow drains, both of which are now required to be routed to sanitary waste. Testing may also require services of the U-M Plumbing Shop. Coordinate with U-M Design Manager.

Require construction phase dye testing by the contractor, after final connection is made, and before system is put into service. See the U-M Master Specification Section 15060 for additional guidance. To facilitate efficient and effective testing, indicate location of appropriate validation points on plans. This is typically the first manhole outside the building.

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VALVES

General

In general, follow the guidelines below when designing and specifying valves. Unless specifically indicated otherwise, these guidelines are not intended to restrict or replace professional judgment.

Related Sections

Section 15060 - Pipe and Pipe Fittings
Section 15140 - Pipe Hangers

Preferred Manufacturers

The University (Facilities Planning and Design) maintains a "Mechanical Trades Preferred Manufacturers List". This list is updated regularly, generally in February and August. The A/E shall use this list in developing construction document specifications. Obtain a current copy from the University Project Coordinator.

Design and Application Requirements

Fire Protection

Valves for use in Fire Protection Systems shall be U.L./FM approved, NFPA rated.

Natural Gas

Natural gas shut-off valves 2" and under, shall be AGA approved ball valves. Valves 2-1/2" and larger, shall be lubricated plug valves.

Potable Water Systems

Generally, isolation valves for potable cold and hot water shall be ball or rising stem gate valves for sizes 2" and smaller. Valves 2-1/2" and larger shall be butterfly valves.

Valves at city water mains, near water meter, shall comply with City of Ann Arbor requirements.

Hydronic Systems

For Chilled Water, Hot Water Heating and Condenser Water Systems, butterfly valves are preferred for isolation service for sizes 2-1/2" and larger; ball valves are preferred for sizes 2" and smaller.

Steam and Condensate Systems

Low Pressure and Medium Pressure Steam valves shall be rated for 150 psig, and 450 ^{O}F.

For Low and Medium Pressure Steam, isolation valves 2" and smaller shall be rising stem gate valves. Valves 2-1/2" and larger shall be high performance butterfly valves (rated for steam service) or rising stem gate valves. Within tunnels, gate valves shall be used unless space confinement prohibits their installation.

Control valves for low pressure steam fired absorption chillers shall be a special low pressure drop butterfly valve. Consult "Preferred Manufacturers List".

Shut-off valves for condensate shall be rising stem gate valves.

Vacuum Systems

Specify valves rated for vacuum service in vacuum systems.

General Valve Material Requirements

Do not specify valves with plastic handles.

Compatibility with Service

All valves shall have seats, stem seals and disc materials compatible for intended fluid, temperature, pressure and service. Valve pressure ratings shall meet or exceed system pressure ratings in which they are installed. All valves on chilled water systems shall be selected for use with ethylene glycol. Although it is not common to fill chilled water systems with freeze-preventing concentrations of glycol year-round, the University does commonly fill coils with glycol during the winter. In the spring, this glycol is usually not flushed, and becomes part of the chilled water system. This results in low glycol concentrations all over campus and has caused premature valve leakage, especially for control valves.

Pipe Connections

Valves 2" and smaller shall have screwed connections for steel piping and sweated connections for copper piping. Valves 2-1/2" and larger shall have flanged connections

Repacking Under Pressure

Gates, Globe and Angle Valves shall be pressure rated and of type that can be packed under pressure whether open or closed.

Bubble-Tight Construction

Butterfly, Ball and Eccentric Plug Valves shall be of bubble-tight construction.

Chain Wheel Requirement

Within mechanical rooms, manually operated valves 4” and larger, and installed 10 feet A.F.F., or higher, shall have chain wheel operators. Chain shall reach to within 7’-0” of floor or operating platform.

Valve Material Requirements - by Valve Type

Ball and Eccentric Plug Valves

In general, ball valves shall be two piece design, with stainless steel ball. When used for isolation (not throttling or balancing), valve shall be full port construction.

Plug and ball valves 4” and larger shall have enclosed worm gear operators with position indicators.

Balancing Valves

In general, specify only valves specifically designed to be used for balancing.

Butterfly Valves

Valve body shall be of full lug construction, and allow for disconnecting piping from either direction while maintaining shut-off service.

Butterfly valves shall be high performance type where required as note above.

Manually operated butterfly valves 4” and larger shall have enclosed worm gear operators with position indicators. Manually operated valves smaller than 4” shall have levers with locking devices.

Check Valves

Check valves 2” and larger in pump discharge, and 3” and larger on water riser, shall be non-slam type.

Installation Requirements

Isolation valves shall be installed at all equipment, including all coils, pumps, heat exchangers, steam traps and expansion tanks.

Strainer blow-down valves shall always be quarter turn types, such as ball valves so that the mesh gets a sudden flow increase instead of a gradual increase. This is much more effective at breaking loose dirt.

Gate valves in risers shall have valved drain on upper side of valve.

Valves 10" and larger shall be positively proven to be new with dated certificate of manufacture.

THERMOMETERS AND GAUGES

Related Sections

U-M Master Specification:
15130 – Thermometers and Gauges.

Standard Details:
15130D01.001
15130D02.001

Equipment Requirements

Thermometers

Mercury thermometers are not to be used.

Refer to master specifications for type, range and locations desired.

Pressure Gauges

Refer to master specifications for types, ranges and locations desired.

Design Requirements

The A/E shall edit the ranges to project specific applications.

All gauges shall be readable from the floor and preferably located at eye level.

If a single gauge is used for pumps, verify range for suction and discharge.

Single pressure gauges should be used across pumps but the range for the suction and discharge should be reviewed for accuracy.

Installation Requirements

The A/E must show clearly on the drawings or details the locations for all thermometers and gauges.

Refer to specifications for additional installation requirements.

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PIPE HANGERS

General

In general, follow the guidelines below when designing and specifying pipe hangers, supports, guides, expansion joints, anchors and other accessories. Unless specifically indicated otherwise, these guidelines are not intended to restrict or replace professional judgment.

Related Sections

Section “15010 - Basic Mechanical Requirements”
Section “15250 - Mechanical Insulation”

Submittal Requirements

A/E shall submit the following to the University Project Coordinator:

- Pipe expansion and stress calculations for hot pipes (120°F and above), 6" and larger. Show compliance with ANSI piping codes.

A/E shall require that Contractor submit the following for A/E review and approval:

- Type and model for all manufactured pipe support components, including building attachments, hangers, insulation saddles and shields, expansion joints, anchors.
- Locations of anchors, expansion bends and joints.
- Locations of building attachments where deemed necessary by A/E.
- Details and supporting calculation of additional supports.

Design Requirements

Prior to beginning design, A/E shall review building design and construction and design suitable building attachment and pipe support and anchoring system, verifying that the existing building structure can support new piping loads.

The A/E shall include the following in piping designs:

- Pipe hanger details, including components, hanger spacing.
- Pipe hanger systems that accounts for thermal expansion of piping.
- Details of building attachments, including clarifying when support of piping from concrete slab using expansion anchors is acceptable.

- For large piping or where the design otherwise impacts the integrity of the building structure, indicate locations of all pipe hangers.
- Indicate locations and details of pipe anchors, guides and expansion joints or bends.

Large piping and equipment shall be independently supported from building structure, not from roof decks, etc. All piping shall be directly supported from the building, not from other piping, ductwork or equipment.

A/E shall review contractor's hanger support shop drawings and details to verify that unacceptable pipe movement during all phases of operation of the system (start-up, sudden gpm changes, or shutdown) will not occur.

Designing for Pipe Expansion

Expansion bends fabricated from standard piping are preferred over expansion joints.

Within steam tunnels, and up to building shut off valve, for LPS and medium pressure steam (MPS) design expansion for 600°F maximum piping temperature. Materials do not need to withstand 600° F at design pressure.

Pipe Hanger Shields and Preinsulated Pipe Supports

Pipe shields and preinsulated pipe supports shall be used to protect piping insulation and vapor barrier (for cold piping) as described below.

Horizontal Cold Piping (CHWS/R, CW) sizes 2" and less
Install galvanized insulation protection shields under 180 degrees of piping, between hangers and pipe insulation.

Horizontal Cold Piping (CHWS/R, CW) sizes 2 1/2 and over
Install 360 degree preinsulated welded pipe shields between piping and hanger.

For all Cold Piping Vertical Risers
Install preinsulated riser clamps.

For Hot Piping
Account for thermal expansion when designing pipe supports and shields. Where suitable install hangers directly on the pipe and bury hanger in insulation. Where necessary, install pipe saddle on pipe, preinsulated pipe shield or galvanized insulation protection shield.

PIPE HANGERS

Material Requirements

General Material Requirements

Dissimilar metal-to-metal contact between pipe and hanger is to be avoided.

"C" type clamp hangers are unacceptable except for fire protection piping.

For steam tunnels, on low pressure Steam (LPS), slip type expansion joint shall be used, with special packing ring to allow repacking from one side.   For low pressure condensate (LPC) and domestic hot water (DHW), use equal expansion type bellows joints.

Installation Requirements

Hangers for piping that lacks rigidity, such as "Whiteline" polypropylene pipe, shall be spaced as recommended by the manufacturer (as a minimum) or preferably with a continuous support. Since the spacing is typically much closer than for other piping materials, the designer must pay close attention to the implications on his design.

For cold piping systems, design piping hangers to retain integrity of vapor barriers.

Only pipe supports and anchors that have been reviewed by the A/E shall be installed.

Where piping is insulated, the pipe clevis hanger shall be sized to support the pipe directly, the insulated pipe, or the pipe covered with insulation and protection shield, as described in “Pipe Hangers Shields and Preinsulated Pipe Supports”.

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PUMPS

General

A/E shall schedule all pump data on the drawings (not within project specifications).

Select pumps and motors to be non-overloading (not into the service factor), at pump run-out (right end of published curve).

Pump efficiency at design conditions should be close to, or left of, peak pump efficiency.

Mechanical seals shall be used on all pumps except fire pumps, where stuffing boxes shall be used.

In general, specify pumps with 1800 rpm motors, unless design condition necessitates alternate motor speed.

Where remote start-stop, or status monitoring is required, use combination magnetic starter or variable speed drive (not manual starter).

Related Sections

Design Guideline Technical Sections:
15250 – Mechanical Insulation
15525 – Steam and Condensate Piping Systems and Specialties
15680 – Chilled Water Systems

U-M Master Specifications:
15060 – Basic Piping Materials and Methods
15100 – Valves
15160 – Pumps
15990 – Testing, Adjusting and Balancing

Equipment Requirements

Sump Pumps

In general, design sump pumps based on a submersible, duplex pumping system. Include slide rail on all sanitary pumps and on storm water pumps with motors larger than 5 HP, or sumps deeper than 4 feet. Include lifting lugs on pumps, automatic pump alternator and non-mercury float switches. Specify one-point common alarm (indicating high level, pump failure, or seal failure), and connect to Building Automation System.

Base Mounted End Suction Circulating Pumps

Base mounted end suction circulating pumps shall be of the centrifugal single stage type, with back pull-out design. Pump and motor shall be connected through a flexible drive coupling, with safety guard.

Pump and motor shall be properly mounted and aligned on a common, welded, rigid structural steel or cast iron base, with an enclosed perimeter with opening for grouting in place. Base shall be grouted in place, per U-M Master Specification Section 15160.

Base Mounted Double Suction Circulating Pumps

Base mounted double suction circulating pumps, shall be centrifugal, single-stage type with horizontal split case design for servicing the impeller without disruption of the piping. Vertical split case design is also acceptable, where floor space is at a premium.

Provide rigid steel grout base and grout as described for End Suction Pumps section above.

For pumps larger than 30HP, consider need for trimming impeller for improved energy efficiency, following initial testing and balancing. Consult U-M Project Coordinator.

In-Line Circulating Pumps

In-line circulating pumps shall be single stage; with cast iron body and bronze trim construction, unless special fluid handling dictates otherwise.

Vacuum Pump (Lab and Medical)

Vacuum pumps shall be bronze fitted, or all stainless steel, 1750 RPM and have mechanical seals. Vacuum pump package shall include tank with access hatch and all related controls and piping.

Coordinate equipment selection (rotary vane versus liquid ring) with U-M Project Coordinator.

System Application Requirements

Consider potential future expansion of pumped systems. Extent of expansion will be determined on a case-by-case basis. Consult with the University Project Coordinator for specific direction.

Domestic Water

Provide all bronze construction or stainless steel construction for all domestic water pump applications.

Storm and Sanitary

Use submersible sump pumps as described in Equipment Requirements above.

<u>Hydronic Systems (Chilled Water, Condenser Water, Hot Water Heating)</u>

Use end suction, double suction or in-line pumps as described in Equipment Requirements above. Typically, use base mounted pumps for all applications over 10HP.

Install fully redundant (N-1) stand-by pumps for heating systems.

For chiller and cooling tower installations, refer to Design Guideline Section 15680.

<u>Steam Condensate Pumps</u>

Typically, use electric condensate pumps for steam condensate. Consider use of air operated condensate pumps (only with U-M Project Coordinator approval) in steam tunnels, or other spaces with high ambient temperatures.

Design of condensate pumping system must consider receiver size, location, NPSH, flash area, and receiver and flash tank venting (properly sized, routed to outside). Refer to Design Guideline Technical Section 15525.

Installation Requirements

Install pumps and accessories in strict accordance with the manufacturer's requirements for maintaining satisfactory hydraulic performance.

Provide the following accessories for each pump (except sump pumps):

- Flexible connector, rated 2 times normal operating pressure, in suction and discharge lines. Refer to U-M Master Specification Section 15060. Flexible connectors are not typically required on in-line pumps (allowing pumps to be supported from adjacent piping).
- Isolation valving on both sides of the pumps. Not applicable for sump pumps. For condensate pumps, suction valve must comply with U-M Master Specification Section 15100.
- On pump discharge:
  - Triple duty valve and isolation valve, or
  - Non-slam check valve, throttling valve, approved (by U-M Project Coordinator) means of measuring flow, and isolation valve. Install flow measuring devices in strict accordance with manufacturer requirements to ensure proper performance. Throttling valve may be eliminated on variable flow (VSD) pumping applications.
- Pressure gauges on suction (prior to and after strainer) and discharge. For small, in-line pumps, pressure-temperature plugs may be used in lieu of gauges. Typically,

these three points should use manifolded ½” piping, with isolation ball valves and a single, common gauge.

Provide the following accessories for each sump pump:

- Flexible connectors are not typically required on sump pumps, except where vibration necessitates.
- Pressure gauge, check valve and isolation valve on pump discharge. Separate throttling valve is not typically required.

Provide vibration isolation as necessary to prevent excessive noise and vibration. In general, install large pumps located above grade on concrete inertia base with spring vibration isolators. Where an inertia base is used, support piping near pumps with spring hangers. Support suction diffusers and piping directly in contact with pump from inertia base.

Suction inlet pipe for all pumps should be a straight section of pipe of not less than 10 pipe diameters in direction of flow. Where space conditions will not permit suction inlet pipe of required length, provide a suction diffuser.

Base mounted pumps shall be laser aligned. Typically, this should be specified as part of factory service technician start-up services.

For vibration testing requirements, refer to U-M Master Specification Section 15990.

For insulation requirements, refer to Design Guidelines Technical Section 15250.

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MOTORS

Introduction and Scope

This sections covers requirements for most motors 200 HP and less. This section does not apply to fire pumps, elevators and sealed refrigeration motors, nor does it apply to small motors with stepped down voltage below 115V.

Related Sections

U-M Design Guideline Technical Sections:

U-M Master Specification:
15170 - Motors

U-M Standard Details:

General

U-M Master Specification Section 15170 Motors shall be used as the basis for the motor specification on all projects. The A/E shall edit (append) the U-M motor specification to make it project specific; however do not generally modify the fundamental motor attributes described in the specification. Turn on hidden text and read all spec. editor's notes when editing the specification.

Phase and Voltage

Motors 1/2 HP and larger should be three phase.

Single phase motors may be rated for 115V or 200V, depending on the application, and building power.

Three phase motors should be rated for 460V wherever possible. Where building power does not include 480V distribution, review options with the Design Manager and consider adding a step-up transformer, and using 460V motors. The long term objective in most buildings is to have three phase distribution at 480V.

Power distribution systems serving large motors (100HP and larger) should be examined to ensure across the line motor starting will not adversely impact the system. Consult the Design Manager and other appropriate University personnel in these applications.

Three Phase Motor General Requirements

For most applications, including air handlers, motor enclosures for fans and pumps should be Open Drip Proof (ODP) type. For cooling towers and other harsh environments, use Totally Enclosed Fan Cooled (TEFC) motors.

Multiple Speed Motors

With the increased viability of variable speed drives, applications for multiple speed motors are few and far between. Where three phase motors require multiple speeds, there shall be a separate winding for each speed. Coordinate electrical requirements carefully with electrical designer.

MECHANICAL IDENTIFICATION & PAINTING

General

In general, follow the guidelines below when specifying identification and painting of mechanical piping, ductwork and equipment. Unless otherwise indicated, these guidelines are not intended to restrict or replace professional judgment.

Related Sections

Tab 15 - Section 15010 - Basic Mechanical Requirements

Related References

In general it is the University's intention to follow industry practice, and to use existing standards to establish these guidelines.

- ANSI A13.1 - Scheme for the Identification of Piping Systems

Piping and Ductwork Identification

All pipes in all exposed locations shall be identified with factory fabricated, precurled labels securely attached to the pipe. Film markers are not acceptable, as they tend to wear off with time. Ductwork mains and all fume hood exhaust ductwork require labeling.

Clearly identify direction of flow in piping and ductwork with arrows. Arrows and markers shall be mounted to provide unobstructed visibility from floor level.

Pipe and Ductwork labels should indicate full name of service as indicated below. Abbreviations should be used on drawings only.

Pipe Labeling:

Pipe labels should be installed at all access panels or doors, adjacent to valves and branch connections, both sides of floors, ceilings and walls, all major changes in direction, on straight lengths of pipe every 25 feet, and at points of termination (except in occupied spaces).

Identify contents of piping system by both fluid contained and unique temperature and/or pressure (if necessary to distinguish between other systems with same fluid at different conditions); e.g., Potable Hot Water - 110^{o}F vs. Potable Hot Water - 140^{o}F.

Plumbing and Waste Pipe System Labels	Drawing I.D.	Letter and Label Color
Acid Waste	ACID	Black on Yellow
Brine	BR	White on Green
Compressed Air	A	White on Blue
Fire Protection	FP	White on Red
Hazardous Waste	HAZ	Black on Yellow
High Purity Water	DI	White on Green
Hot Water Supply, Potable	HW	Black on Yellow
Hot Water Return, Potable	HWR	Black on Yellow
Natural Gas	G	Black on Yellow
Non-Potable Water	NPW	Black on Yellow
Potable Cold Water	CW	White on Green
Radiation Waste	RAD	Black on Yellow
Sanitary Waste	SAN	White on Green
Silver Recovery	AG	Black on Yellow
Soft Cold Water	SCW	White on Green

Heating and Cooling Pipe System Labels	Drawing I.D.	Letter and Label Color
Chilled Water Return	CHWR	White on Green
Chilled Water Supply	CHWS	White on Green
Condenser Water Return	CWR	White on Green
Condenser Water Supply	CWS	White on Green
Fuel Oil Return	FOR	Black on Yellow
Fuel Oil Supply	FOS	Black on Yellow
High Pressure Condensate	HPC	Black on Yellow
High Pressure Steam	HPS	Black on Yellow
Hot Water Heating Return	HHWR	Black on Yellow
Hot Water Heating Supply	HHWS	Black on Yellow
Low Pressure Condensate	LPC	Black on Yellow
Low Pressure Steam (15#)	LPS	Black on Yellow
Medium Pressure Condensate	MPC	Black on Yellow
Medium Pressure Steam (60#)	MPS	Black on Yellow
Pumped Steam Condensate	PC	Black on Yellow

Medical Gas Pipe System Labels	Drawing I.D.	Letter and Label Color
Medical Compressed Air	MCA	Black on Yellow
Laboratory Vacuum	LVAC	White on Blue
Dental Vacuum	DVAC	White on Blue
Nitrous Evacuation	N20EVAC	White on Blue
Oxygen	OX	White on Green
Nitrous Oxide	NO	White on Blue
Carbon Dioxide	CO2	White or Black on Gray
Helium	HE	White on Brown
Nitrogen	N	White on Black
Medical Vacuum	MVAC	Black on White

Ductwork Labeling:

Ductwork labels should be installed at all access panels or doors, both sides of floors, ceilings and walls, all major changes in direction, and on straight lengths of duct every 40 feet.

For ductwork, drawing identification and label should include identification of associated equipment, eg. “Supply Air (AHU-1)” for label, and “SA (AHU-1)” on drawings.

Service/ Duct Label	Drawing	Letter and Label Color
HVAC Supply Air (Equip. #)	SA (Eq.#)	White on Green
HVAC Return Air (Equip. #)	RA (Eq.#)	White on Green
HVAC Exhaust Air (Equip. #)	EA (Eq.#)	Black on Yellow
Outdoor Air (Equip. #)	OA (Eq.#)	White on Green
Fume Hood Exhaust (Equip. #)	FHEA (Eq.#)	Black on Yellow

Equipment Identification

During design phase, A/E shall assign equipment numbers to be used in the construction documents, in conjunction with the Project Coordinator.

Numbers for major mechanical equipment such as air handlers, chillers and pumps should be unique within a building and continue the sequence established by existing equipment. As an example, if air handlers AC-1, AC-2 and AC-3 already exist, then a new air handler should be named AC-4 (not AC-1 or AHU-4 or ACU-4). Although many equipment designators are presently used throughout the University, the A/E is encouraged to use the designators listed below where possible. All major equipment shall be labeled using this designator, engraved on a plastic label and permanently affixed to the unit. Where the first equipment item on a project is not named "..-1", the equipment schedule should note that all the equipment with names preceding it are existing.

All small equipment intended to appear on test and balance reports, including VAV boxes, should be identified on design drawings with a unique number. Field labeling is not required for small equipment.

Drawing I.D. & Equip. Label	Equipment	Drawing I.D. & Equip. Label	Equipment
ACC	air cooled condenser	GEF	general exhaust fan
AHU	air handling unit	GWH	gas-fired water heater
CH	chiller	HTX	heat exchanger
CHWP	chilled water pump	HWB	hot water boiler
CP	condensate pump	HWHP	hot water heating pump
CT	cooling tower	P	pump (other than those listed)
CUH	cabinet unit heater	RF	return fan
CWP	condenser water pump	SB	steam boiler
EWH	electric water heater	SF	supply fan
FHEF	fume hood exhaust fan	UH	unit heater
FP	fire pump	VP	vacuum pump

Valve Identification

Only special use valves need be numbered on design drawings. However, all valves and regulators, except those directly serving equipment, shall be provided with 1-1/2 inch diameter brass tags with stamped numbers and letters. Tags shall indicate the system in which installed (using abbreviations listed in "Piping and Ductwork Identification" above), and valve number for systems having more than one valve.

Contractor shall provide a separate directory and drawing for plumbing, heating, and air conditioning systems. Drawing shall be scaled as required to indicate the location of each valve. A copy of the drawing shall be plastic laminated, suitable for framing, and turned over to maintenance for field use. A copy of each drawing shall be included in each copy of the Operation and Maintenance Manuals.

<u>Painting</u>

In general, painting of mechanical components is to be done where needed for component protection, housekeeping or aesthetics, not for identification of mechanical systems. All fire protection piping shall be painted red.

<u>In concealed areas, including shafts and above acoustic ceilings</u>:
Paint is not required for most piping and ductwork.

<u>In exposed areas, including mechanical equipment rooms, and labs with no ceilings</u>:
Paint uninsulated pipe and ductwork the same color as the background ceiling. Consult with architect and Project Coordinator. Insulated pipe and ductwork does not require paint, unless called for by Project Coordinator for aesthetic reasons.

<u>Exterior</u>:
Paint uninsulated pipe and ductwork the same color as the background building, or complementary color as directed by Project Coordinator. Insulated pipe and ductwork does not require paint, provided insulation material does not require paint for protection. Depending on visibility, insulated pipe and duct, and mechanical equipment may be painted to match background, as instructed by Project Coordinator.

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MECHANICAL SOUND AND VIBRATION CONTROL

General

Sound and vibration shall be carefully evaluated on all projects, for both interior and exterior impacts.

Related Sections

U-M Design Guideline Technical Sections:
15010 – Basic Mechanical Requirements

U-M Master Specification Sections
15240 – Vibration Control
15890 - Ductwork and Accessories
15990 - Testing, Adjusting and Balancing

Sound Design Requirements

Interior Sound Impacts:

Typical space noise criteria levels are listed in Design Guideline 15010. For NC/RC levels not listed in that section, levels shall not exceed those listed in Chapter 46 of the ASHRAE HVAC Applications Handbook (most current addition).

NC/RC levels are a general design criteria only. Spaces where sound is of a special concern, such as large lecture halls, theaters, etc., shall be evaluated using more rigorous criteria based on recognized guidelines. Criteria should be reflected in Design Intent Document and/or in Construction Documents.

For new buildings or major renovations, a study by an acoustical consultant should normally be performed. This study should determine expected sound levels for major space types and, where expected levels exceed established criteria, provide project specific alternative solutions. All significant sound impacts shall be evaluated, not just from mechanical and electrical equipment sources; for example, the impact of a large number of people walking on a hard surface that is located over a more sound sensitive space. For renovation projects, the study should include sample testing of existing areas.

For sound control, low cost solutions are the preference in lieu of more conservative solutions, in particular for spaces without special sound concerns. For instance, the use of acoustical flex duct (not to exceed 5') is preferred over equipping all VAV/CAV boxes with sound attenuators. Noise generating equipment should be located outside of more sensitive areas, i.e. over corridors, when possible, etc.

Duct sound liner shall not be used unless protected by a solid or perforated metal liner. Sound liner protected by perforated metal shall in addition be wrapped with an approved flexible liner. Unprotected duct liner may only be used for short transfer duct applications.

Schedules shall indicate the maximum NC levels (sound power) for terminal boxes, diffusers, lab air valves, and similar equipment. Fan and sound attenuator schedules shall indicate the sound power and attenuation levels required in each octave band. Sone levels may be listed for small fans in lieu of octave band levels.

For new buildings or very large renovations, sample sound readings (NC and dBA) for typical spaces should be taken on a post construction basis, to verify if NC levels were achieved. This testing can typically be done by the Test and Balance contractor. More extensive post construction evaluation tests should normally be performed for areas with very special sound concerns, eg. theaters, auditoriums. Further, if these special spaces were renovated, pre-construction sound readings should be taken for comparison to post construction sound levels.

Floating floors should be considered for major mechanical rooms located over sound sensitive areas.

Exterior Sound Impacts:

All new construction shall be assessed for exterior sound impacts on surrounding neighborhoods. The normal UM policy is that buildings are not to contribute a perceptible increase to the ambient noise environment. In terms of human perception, a 3 dB change (or less) would typically be considered imperceptible. However the specific characteristics of exterior sound sources shall also be considered, i.e. frequency and reverberant effects, time of day cycling, etc. In no event shall City of Ann Arbor noise guidelines be exceeded. For new buildings or improvements to existing buildings involving the addition of significant sound generating mechanical or electrical equipment to the building exterior, a study by an acoustical consultant should normally be performed. Such studies shall assess sound impacts and, where required to meet the above criteria, provide alternative project specific solutions. Such a study would typically require pre-construction field measurements of existing ambient noise levels to set baselines.

Vibration Design Requirements

Vibration impact and control shall be evaluated for specialized fixed equipment, such as MRIs, as well as building mechanical and electrical equipment.

Vibration Criteria:

The maximum allowable vibration levels in the horizontal, vertical, and axial planes for building equipment shall be specified as follows:

Pumps	0.13 in/s RMS
Centrifugal Compressors	0.13 in/s RMS
Fans (all types)	0.09 in/s RMS
Chillers	mfg. recommendation.

Specify that all equipment over ½ HP be field vibration tested. Specify that equipment found to exceed the allowable vibration levels be repaired and retested until within allowable limits, at no cost to the owner.

Vibration Isolation:

The minimum vibration isolation required for mechanical and electrical equipment shall conform to the Selection Guide for Vibration Isolation, ASHRAE HVAC Applications Handbook (most current addition).

For spaces with special vibration concerns, eg. clean rooms, theaters, certain medical or research equipment rooms, etc., an acoustical/vibration consultant should be utilized to assess impacts and recommend solutions. During project programming, ambient vibration levels should be recorded if vibration sensitive equipment is planned for buildings adjacent to significant vibration sources, i.e. heavily traveled roads. The results of these tests may dictate that special isolation be provided to accommodate sensitive equipment.

Unless specifically waived by the U-M design coordinator, large pumps and fans installed above grade shall be specified with inertia bases.

Avoid the blanket specification of expensive spring type vibration hangers for piping and duct. Typically when flexible connectors are employed at duct/pipe connections to equipment and the equipment base is properly isolated, spring hangers are only recommended for the first two hangers.

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MECHANICAL INSULATION

General

Insulation of pipe and duct systems to avoid condensation or to provide personnel protection is required. Cost-benefit analysis and ASHRAE 90A should be used to determine which additional systems should be insulated and the appropriate insulation thickness. A continuous vapor barrier jacket must be provided when condensation is possible. This normally means that hangers and riser clamps may not be in contact with the piping. Insulation of the complete system, including air separators, suction diffusers, chilled water pump casings, shot feeder, airflow measuring stations, etc., is required when condensation is possible.

For normal maintenance and inspection activities, insulation should be segmented for removal without damage to adjacent insulation.

Insulation exposed to outside shall be a weather resistant system, with durable, UV stable, waterproof finish.

Insulation exposed to high physical abuse, such as piping near the floors which is regularly walked over, shall be adequately protected with pre-molded, heavy gage, PVC covers, reinforcing shields, catwalks etc., to ensure the long-term integrity of the insulation system.

Insulation materials should meet applicable requirements of NFPA 90A, and MICA/ NIAC "National Commercial and Industrial Insulation Standards".

Related Sections

Tab SID - Section SID-F - Codes and Regulatory Agencies

Section 15060 - Basic Pipe and Fittings

Section 15190 - Mechanical Identification and Painting

Piping Insulation Materials Requirements

General:

Fiberglass pipe insulation shall be rigid, pre-molded to size of piping on which it is used.

Indoor Piping:

For "hot piping" carrying fluids at 110F and above: Insulate pipe and fittings (excluding unions and valves) using fiberglass insulation with ASJ (all service jacket, with integral vapor barrier). Closed cell expanded foam insulation (similar to Armaflex) may be used on domestic hot water piping.

For “cold piping” carrying fluids below 70F: Insulate pipe, fitting, valves, unions, flanges and all cold surfaces using fiberglass (with ASJ), or closed cell expanded foam. Ensure all cold surfaces are insulated, and that continuity of vapor barrier is maintained.

Piping carrying fluids between 70F and 110F does not require insulation. Condenser water piping should be considered “cold piping” if used for free cooling.

Indoor pipe insulation can be presized rigid board fiberglass with paintable jacket. Exposed insulation in finished areas should be painted as described in Section 15190.

Tunnel Piping:

Piping insulation in tunnels shall include dimpled aluminum jacketing.

Outdoor Piping:

For outdoor piping, use insulating materials similar to those stated for indoor use, but add aluminum jacket for fiberglass insulation and premium quality weather resistant coating for expanded foam insulation.

Outdoor compressed air piping should be heat traced and insulated if piping is in service during the winter and if the pressure dew-point is above minus 20F.

Underground Piping:

For hot piping (carrying fluid above 110F), use carrier pipe inside steel jacket pipe, with mineral wool insulation between.

For chilled water piping use carrier pipe inside PVC jacket and expanded urethane insulation between.

Refer to Section 15060 for pipe material requirements.

Ductwork Insulation Material Requirements

General:

Acoustic duct lining should not be used unless part of a double wall duct system with a mylar barrier between the inner duct wall and liner face.

Indoor Ductwork:

Indoor ductwork in concealed areas (above ceilings and in closed shafts), may be insulated with blanket type fiberglass insulation with jacket.

Indoor ductwork in exposed areas (such as mechanical rooms, labs with exposed ceilings etc.) should be insulated using rigid board fiberglass with paintable jacket. See Section 15190 for painting requirements.

Particular attention shall be paid to "cold ductwork" to ensure duct supports will not cause condensation.

Exhaust duct shall not be insulated.

Need for insulation on return air ductwork should be evaluated based on air stream and ambient conditions. Typically, air conditioned return duct in unconditioned mechanical rooms should be insulated.

Outdoor Ductwork:

Outdoor duct insulation should be high density foam plastic, or rigid fiberglass, mastic sealed and painted with weather resistant finish.

Underground Ductwork:

Requirements should be reviewed on a case by case basis with Project Coordinator

Equipment Insulation

Insulate all cold equipment to prevent condensation for the following:

- Chilled water pumps
- Chiller shells and water boxes

Insulate hot equipment as required for personnel protection and on the following equipment:

- Domestic hot water storage tanks
- Large condensate receivers

Installation Requirements

Insulation at joints should not be applied until after pipe, duct and equipment have been final installed, tested, cleaned, and inspected.

All exposed edges of insulation shall be sealed.

FIRE PROTECTION

General

All new buildings shall be protected by a hydraulically designed wet-pipe sprinkler system, designed to comply with requirements of NFPA and Factory Mutual (FM).

The University normally requires the installation of wet-pipe sprinkler systems in existing buildings undergoing major infrastructure upgrade not presently protected by fire protection systems.

In existing buildings with hydraulically designed systems, any additions, deletions and/or changes shall not compromise the integrity of the system. Water supply shall be tested and improved as required to meet requirements of NFPA , FM and City of Ann Arbor Standards. A/E shall arrange for testing by U-M Plumbing Shop through U-M Project Coordinator.

Provide standpipe system where required by code.

Related Sections

U-M Design Guideline Technical Sections:
10520 - Fire Extinguishers
16720 - Fire Alarm Systems

U-M Master Specification Sections
15300 - Fire Protection Systems
15320 - Fire Pumps

Design Requirements

Design drawings (plans) shall include, at a minimum, location of :
- In-coming water supply and fire department connection(s) (Siamese)
- Fire pump and controller, jockey pump, and test header
- All risers, standpipes, zone control valves, fire department valves and fire hose cabinets
- All mains four inch diameter and larger
- Inspector test /drain, service drains
- Sprinkler head locations, sprinkler zoning (with area and criteria stated)

Design shall include fire protection system riser diagram, with at minimum:
- In-coming Water supply and Siamese connections
- Fire pump and controller, jockey pump, and test header
- All risers, standpipes, zone control valves, flow switches, fire department valves and fire hose cabinets
- Inspector test /drain

Design shall include, at minimum, calculation, selection and detail of in-coming water service, fire department connection, fire and jockey pumps, test header, stand pipe/ inspector test/ zone control valves, pipe penetrations, and special systems.

Wet Suppression Systems:

Sprinkler density shall be per U-M Master specification.

Discharge from test connections be piped to building exterior or indirect drain of adequate capacity.

Provide dry pendant heads for any room operating at or below 40° F (including cold rooms, environmental rooms and freezers). For areas where piping is subject to freezing, use pre-action system for areas over 2,000 sq ft. and antifreeze protected system for area less than 2,000 sq ft..

Wet pipe sprinkler system shall normally be installed throughout including electrical rooms, substations, mechanical rooms, telephone closets, and computer rooms.

Fire Pumps:

Install automatically controlled fire pumps on all fire protection systems where hydraulic calculations indicate that the city water pressure is not adequate to supply the building sprinklers and/or standpipe systems. Fire pump size shall be based on the requirements of NFPA. Water supply to fire pumps shall meet the requirements of NFPA. When a fire pump may feed multiple buildings, special approval from the University Project Coordinator is required for issues related to fire alarm system coordination; possible multiple building conflagrations; and system sectionalizing.

Jockey Pumps:

Install jockey pumps on all fire protection systems where flow is detected and monitored, even if a fire pump is not required. Jockey pump head shall be adequate to maintain static pressure required at the top of the system. Size pump flow per NFPA.

Special Systems:

Special fire suppression control systems should be located outside the area served. Supply cylinders should be stored in a room or location other than the protected room. A separate room is preferred.

Dry chemical extinguishing systems should be used in all kitchen and cooking locations where grease and oil are used.

Material Requirements

Pipe material per UM Master specifications.

Installation Requirements

Shop drawings shall be forwarded to FM, the Architect/ Engineer and the State of Michigan Bureau of Construction Codes and Fire Safety. Refer to U-M Master Specification.

Install sprinkler heads in center of 2’x2’ ceiling tiles, and in center of 2’x2’ area for 2’x4’ ceiling tiles.

Pressure Testing:

Pressure test fire protection systems per NFPA and FM.

Pressure testing is not required for minor relocations of sprinkler heads.

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PLUMBING SPECIALTIES

General

In general, follow the guidelines below when designing and specifying Plumbing Specialties. Unless specifically indicated otherwise, these guidelines are not intended to restrict or replace professional judgment.

Related Sections

U-M Design Guideline Special Instructions to Designers:
SID-F - Codes and Regulatory Agencies

U-M Design Guideline Technical Sections:
15060 - Basic Pipe and Fittings

U-M Master Specification Sections
15420 - Drainage and Vent Systems
15440 - Plumbing Fixtures

Design and Installation Requirements

Water Hammer Arrestors

Primary water hammer arrestors should consist of non-ferrous elastic chambers contained in heavy steel casings with approved recoil dampeners, certified to function in accordance with PDI standard PDI-WH 201 to limit surge pressure to 150 pounds from a flow velocity of 10 fps at 60 psig through 50 feet of pipe the same size as the shock absorber.

Secondary water hammer arrestors, consisting of a section of line size air locked tubing, should be used on long branch lines containing fixtures with fast acting on-off valves.

Install ball valves for isolating water hammer arrestors for service.

Backflow Preventers

General: Indicate location of backflow preventer drain on drawings. Backflow preventers shall be the full size of required water service.

At Building Entrance: Install reduced pressure zone principal (RPZ) backflow preventer at city water main entering most University buildings. Smaller buildings and office buildings may not require reduced pressure backflow preventer. Consult with University Project Coordinator. At time of installation, certify operation of RPZ by State certified inspector.

Within Building: Install backflow preventers within building as required to isolate hazards from distribution piping.

Pressure Reducing Valve (PRV) Stations

The A/E should separate the potable water distribution risers in high-rise buildings with only the upper floors served by booster pumps to preclude the need to add PRVs to the lower floor piping.

The PRV shall be sized for 25 percent reserve capacity at a 250 psi working pressure.

As appropriate, PRVs should be equipped with a smaller auxiliary regulator to handle low demands. The valve should include a full compliment of gauges and accessories.

Cold Water PRV set points shall be coordinated with hot water system pressure and / or hot water PRV setpoints, when using Campus hot water system.

City Water Meter

Each building shall contain a water meter.

For dedicated service to devices and equipment which do not discharge into the city sewer system, (cooling towers, lawn sprinklers etc.) the A/E should install a separate water meter, if water consumption is a significant cost. This meter and its location should be approved by the Ann Arbor City Engineer as coordinated through the University Project Coordinator.

Coordinate meter installation with University Project Coordinator. Generally, meter shall be purchased by the University (include cost in project budget), from the City of Ann Arbor. Rough installation shall be performed by contractor. Final installation of meter shall be performed by the City of Ann Arbor.

Floor Drains

Generally, floor drains shall not be installed in laboratory areas or below emergency showers. Consult Project Coordinator and building users for possible exceptions. Floor drains shall be installed in mechanical rooms where necessary to assist in servicing equipment. Consider need for installing floor drains at high traffic building entrances.

Trap Primers

Trap primers are not required at the University of Michigan, regardless of Michigan Plumbing Code dictates, except for high hazard circumstances, (eg., BSL3 and BSL4 labs), and applications where a dried trap might pose an undetected IAQ problem, (eg., floor drains located inside air handling units) . Therefore trap primers should not be specified for toilet room, mechanical room, safety shower, and similar low hazard floor drains. The Designer shall identify high hazard circumstances and include trap primers for such drains. For high hazard drains requiring trap primers, the use of multi-trap primers, including electrically operated types, is permitted. Multi-trap primers should conform to ASSE 1018 or ASSE 1044, but do not have to be specifically listed as conforming to those standards, provided their design incorporates an ASSE approved back flow prevention device.

Emergency Eyewashes and Showers

Freestanding eyewashes shall be designed to drench both eyes simultaneously and have a waste line connected to the building sanitary waste system.

University preference is to install required emergency eyewashes and showers in corridors for ease of access and monitoring. Consult codes and building user for possible exceptions.

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DOMESTIC HOT WATER

Design Requirements

New Construction

Potable hot water should be obtained from the Central Campus Power House, as delivered through existing utility tunnels. The A/E should coordinate the tie-point to the existing tunnel distribution system with the University's Utilities Engineer through the University Project Coordinator. Prior to this coordination meeting, the A/E should calculate the maximum demand and average consumption requirements of the new facility.

Physically handicapped hot water should be tempered with cold water to maintain 110^{o}F water at the fixture. Provide check valves in both hot and cold connections to tempering valves. Pressure compensating designs shall always be used.

In all new facilities the hot water distribution system shall be of the continuous recirculation design.

Renovation

Potable hot water to meet the needs of new fixtures in renovation projects should be obtained from the existing building system.

The A/E must demonstrate to the satisfaction of the University Project Coordinator that the existing building distribution, primary heating and secondary heating systems are sufficiently large to support the new demands imposed due to the addition of fixtures in a renovation project without adversely affecting other users within the buildings. If the existing systems need to be enlarged, this determination should be made early enough for funds to be allocated within the renovation project.

All

Diameter shall be copper. Copper or galvanized schedule 40 steel shall be used for 4" and above.

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WATER BOOSTER PUMPS

General

Facilitate servicing of internal components without disturbing motor, piping connections or alignment.

The pump should have variable pumping capability. See Section 16156 for constant pressure control.

Consider horizontal split case type for larger pump applications.

Installation Requirements

Duplex pumps should be installed with an automatic alternating capability and with manual override.

The pressure sensor(s) used to provide the controller input of distribution pressure should be located as close to the top of the building risers as practical, but in no case closer to the pump than 2/3 the distance to the top of the most hydraulically distant riser. The sensor may be located in a small reservoir tank (approximately 5 gallon capacity) which will act as a capacitor to dampen out the impulsive pressure changes. If multiple sensors are required, a discriminator receiver controller should be installed near the pumps. This discriminator will feed the lowest pressure signal into the V-S controller.

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HIGH PURITY WATER SYSTEMS

General

This section describes design requirements for high purity water systems generally used to supply laboratory sinks and equipment, typically know as Reverse Osmosis/De-ionized (RO/DI) systems. This guideline also addresses RO make-up for clean steam humidification systems and soft water make-up for boilers.

Related Sections
U-M Design Guideline Technical Sections:
15010 – Basic Mechanical Requirements

U-M Master Specification:
15960 - Variable Speed Drives

Schematic Drawings:
RODI DG Schematic
RO DG Schematic
Softener DG Schematic

System Performance Criteria

The A/E shall determine system performance based on a careful evaluation of specific program requirements. High purity water systems typically have high first and on going operational costs, therefore the A/E shall take particular care not to "over-specify" the system. The proposed system performance will be presented no later then SD phase, for approval by the U-M Design Coordinator. It shall be updated through CD phase, as the requirements for the exact equipment served becomes more precisely determined.

The A/E shall provide the following design criteria for approval:

- Make-up rate in gpm
- Daily production in gallons per 24 hour day
- Storage tank size (gallons)
- Distribution loop flow rate (gpm) and head (ft.)
- Distribution loop temperature
- Primary DI loop (to storage) product quality: Resistivity (megohm-cm), silica, total organic carbon (TOC), sodium, chloride, sulfate.

- Distribution loop water criteria: Resistivity (megohm-cm) , silica, TOC, sodium, chloride, sulfate, oxygen, boron, particulate (maximum particle size and quantity per unit volume), bacteria (viable per ml), Ph.
- Point where distribution loop water criteria is to be achieved (e.g. at point of use, leaving post filter, etc).
- Outline calculations identifying how make-up rate and distribution flow rate and head were determined

Not all the criteria listed above will apply to a project, for instance TOC limits typically apply to semi-conductor projects, but not to generic research labs. The A/E shall explicitly indicate which criteria are not applicable when providing design criteria for approval.

Water resistivity above 10 megohm-cm (CAP-1) is not typically required for general lab use, however the A/E shall determine exact resistivity requirements based on the program.

Plans and Specification Requirements

Include a clear statement of the system performance criteria within the specification.

- This statement shall include all the system performance criteria listed above.
- Obtain the most recent city water analysis and include in the specification.
- Include the minimum expected feed-water temperature.
- Indicate that system performance be guaranteed based on the stated feed-water analysis, including temperature.

Plans shall include a detailed system schematic, showing the arrangement of major system components, instruments, meters, isolation valves, gages, etc.

The system schematic shall also indicate make-up flow rate, distribution flow rate, distribution pump GPM and head, and storage tank volume.

The system schematic shall indicate piping materials for feed water, RO water, distribution supply, and distribution return.

Typical Component Arrangement and Requirements

The following sections outline the typical RO/DI system arrangement at U-M and the requirements for individual components, starting at the feed-water input. Outline level schematics for typical RO/DI, RO, and softner systems are provided for reference under the Related Documents section of this Guideline. It is not the intent of this section to dictate exact system arrangement; the A/E shall design a project specific system to meet program requirements. However, variances from this arrangement shall be called to the attention of the U-M Design Coordinator, for approval.

Feed Water

Provide back-flow prevention (BFP) at the feed water input to the system.

Provide a pressure gage up and downstream of the BFP.

Evaluate the benefit of preheating feed water to improve RO system performance (by improving RO membrane production rate, allowing reduction in RO size). Consider mixing valve or heat exchanger. Preheating shall be evaluated on large systems (make-up rates above 10 GPM), however its use typically mandates a distribution loop cooling heat exchanger be employed as well.

Feed Water Pre-Filter

Provide simplex 10 micron cartridge (disposable element) filter with bypass. Specify minimum 20" long cartridges. Provide pressure gages across filter.

Water Softener

Duplex softener arrangement, demand (flow) initiated type, common brine tank, shall be provided. Very small systems not requiring 24/7 production may utilize a simplex arrangement. For simplex arrangements, specify demand initiated/timer based regeneration type softeners interlocked to prevent RO operation during softener regeneration cycle.

Provide a hard piped bypass around the softener arrangement.

Softeners for boiler water make-up systems shall be duplex demand initiated type.

Brine tanks shall be specified large enough to hold enough salt for 1 month's soft water production. Maximum brine tank height shall be 4 feet. Indicate that the brine tank over-flow is piped to a floor drain.

For systems with make-up rates above 15 GPM or with an estimated salt use in excess of 1000 lb.s/month, bulk brine storage system shall be provided.

Provide pressure gauges across softener bank.

Carbon Filter

Provide duplex carbon filter piping arrangement. U-M utilizes a carbon bottle exchange program where a vendor replaces expired carbon bottles, therefore back-washing type carbon filters should normally not be specified and will only be considered on extremely large systems. The design should indicate all required piping for a duplex arrangement including flexible hoses for carbon filter bottle connection. Indicate carbon filters are supplied by U-M.

Provide pressure gauges across carbon filter bank.

Reverse Osmosis Prefilter

Provide simplex 1 micron cartridge (disposable element) filter without bypass. Specify minimum 10” long cartridges. Provide pressure gages across filter.

Reverse Osmosis System

Specify a skid mounted system furnished with controls providing automatic and manual operation. RO system shall include low pressure pump cut-out, relief valve, meters to monitor product and reject flow rates (typically rotometers) and isolation valves to allow pump and membrane change-out.

Provide a resetable totalizing water meter that indicates total RO product produced.

Mixed Bed De-Ionization Bottles (Make-Up Loop)

Not normally required. A pair (or multiple pair on large systems) of mixed bed resin bottles, located upstream of the storage tanks, may be required for ultra-pure/semi projects. The same piping arrangement and bottle exchange requirements described for the distribution loop mixed beds applies. See below.

Resin Trap

If mixed bed DI bottles are provided in the make-up loop, provide a resin trap downstream consisting of a basket strainer with a 1/64” mesh opening strainer element. Provide pressure gages across the strainer.

Storage Tank(s)

The A/E shall carefully evaluate storage tank size based on program requirements. Minimum tank sizes adequate to hold a 1/2 day’s worth of production are typical.

Tanks shall be translucent with a bottom sloped to the outlet connection. Tank vents and over-flows shall be protected by suitable filters. Provide a tank drain piped to a floor drain.

Tanks shall be equipped with clear, flexible plastic tube (“tygon”) type site glasses. Provide isolation valves on site glasses. Specify external tank level sensors located in site glass piping that allows disconnecting the site glass tube to test the level controls without draining the storage tank.

Distribution Pumps

Normally provide 100% redundant distribution pumps.

Indicate isolation valves and pressure gages on the inlet and outlet of each pump, and provide a check valve on the outlet side of each pump.

Provide a means to control pump flow. Variable frequency drives (VFDs) are preferred, except for very small systems. VFDs shall comply with UM master spec section Variable Speed Drives.

Specify a low pressure cutout switch for the distribution pumps.

Due to the relatively fragile piping materials used on RO/DI systems, often at high pressures, a relief valve with discharge routed to the storage tank is recommended.

<u>Ultraviolet Sterilizers (Upstream of Distribution Loop Mixed Bed De-Ionizers)</u>

UV filtration upstream of the mixed beds is not typically required except in special circumstances, such as systems serving semi-conductor fab.s.

<u>Mixed Bed De-Ionization Bottles (Distribution Loop)</u>

U-M utilizes a mixed bed bottle exchange program where a vendor provides re-generated resin bottles as on-line bottles expire. Therefore the A/E specification should indicate that the mixed beds are provided by UM, i.e. *not* provided by the contractor. The standard bottle size utilized in this program is 3.6 cubic feet. Therefore the A/E shall design the mixed bed "farm" utilizing this bottle size. Since bottle capacity is typically 3-4 gpm/cubic foot of resin, multiple pairs of bottles are normally required. Each bottle pair shall be indicated as piped in series, with a "quality light" located between each bottle pair to indicate when the upstream bottle quality has degraded.

On extremely large systems, larger bottle sizes may be considered, not to exceed 15 cubic foot size. Larger bottle sizes must be approved by U-M Plant Engineering.

Normally Type 1 resins are utilized on U-M laboratory systems. Ultra pure systems (e.g. semi-conductor applications) may require special mixed bed resins, such as virgin semi-conductor grade. Such resin requirements shall be reviewed and approved by the U-M Design Coordinator.

<u>Ultraviolet Sterilizers (Downstream of Distribution Loop Mixed Bed De-Ionizers)</u>

Provide a simplex UV sterilizer downstream of the distribution loop mixed beds.

Provide a hard piped bypass around the UV sterilizer.

<u>Post Filters, Distribution Loop</u>

Provide simplex cartridge (disposable element) type filter with bypass, equipped with 0.2 micron absolute filter elements. Specify minimum 20" long cartridges. Provide pressure gages across filter.

Evaluate higher levels of absolute filter performance ("ultra filters") for ultra pure or critical systems (e.g. semi-conductor applications).

Heat Exchanger, Distribution Loop

Provide when the program dictates that a maximum distribution loop temperature be maintained. Evaluate if a distribution loop heat exchanger is required due to feed-water pre-heating or other factors, to maintain loop temperatures within reasonable limits. Give consideration of final RO/DI water use, pipe expansion concerns, etc. Plate and frame type heat exchangers are preferred.

Sample Ports

Provide sample ports at each location shown on the sample system diagram.

Component Redundancy

For critical systems, in addition to the minimum redundancy requirements specified in the above sections, provide:

- Multiple storage tanks (50/50 or similar type arrangement in lieu of a single tank)
- Redundant final filters

Redundancy for other components, though not typically recommended, may be appropriate. A/E shall evaluate with U-M user and U-M Design Coordinator.

Distribution Piping

RO/DI systems shall be designed for continuous circulation, without dead legs. Dead legs are defined as any dead-ended section of pipe more than 4 pipe diameters long that occurs when a valve is closed. Small less critical systems (total distance from point of use in the 100 foot range) may be non-circulating type

Provide a means of balancing and reading (gpm; rotometers one method) each major supply and return sub-loop, for example: on a floor by floor basis.

Hi purity water faucets with barbed terminations should be the recirculating type with integral back flow preventer, spring return handles preferred.

A back-pressure regulator is typically required on the system return main (near the connection to the storage tank).

Diaphragm or butterfly valves should be specified for supply piping downstream of the distribution loop mixed beds. However, in lower grade systems, carefully evaluate the benefit of diaphragm valves due to the high cost of this valve type. Ball valves may be used on returns and else where. Valve material should typically match associated piping material.

Provide pipe hanger details for hanging plastic pipe.

Bare polypropylene piping should not be run in plenum returns.

Piping Materials

Typical piping materials for RO/DI systems shall be as follows:

RO skid to Storage Tank:

- Sch 80 CPVC, solvent joints (all systems)

Storage Tank to inlet of Distribution Mixed Beds:

- Polypropylene (research labs, and ultra pure applications such as semi)

From Distribution Mixed Bed Outlet (and all RO/DI supply piping in building):

- Polypropylene/fused joints (research labs)
- PVDF/fused joints (ultra pure applications such as semi)

RO/DI distribution loop return piping:

- Polypropylene/fused joints (research labs and ultra pure applications such as semi)

The A/E shall carefully evaluate piping materials, considering specific project performance requirements. PVC/CPVC piping may be considered for low grade high purity applications.

For RO systems serving clean steam generators, piping may be Sch 80 CPVC/solvent joints. Specify stainless steel piping near clean steam generator connection point due to high temperatures in the vicinity of the generator. Provide a check valve in the make-up line near the connection to the generator.

Controls

Specify a complete, central control panel with the following features:

- Distribution loop supply water resistivity and alarm
- Total RO water produced
- Tank level control
- Distribution pump low pressure alarm light
- Distribution pumps off alarm light (activated only if both distribution pumps are statused" off")
- High storage tank level alarm light (latching, requiring manual reset).
- Low storage tank level alarm light (latching, requiring manual reset).
- Common alarm dry contact, for DDC monitoring. To activate upon any alarm condition above, or any alarm condition occurring on the RO skid.

- Panel on/off switch

Though typically not required, the A/E shall consider if other monitoring and alarm features are appropriate, based on the planned use for the system. Small low grade high purity applications may not require all the control features outlined above.

The RO skid shall utilize a PLC based controller. Specify that the vendor shall provide U-M all software, pass codes, etc. to allow U-M full access to the controller programming and settings, as well as a back-up copy of the project specific program.

Electrical

Do not specify a single point power connection for the system. Instead, indicate power connections to the individual components: Softener, RO Skid, control panel, distribution pumps, etc.

The RO vendor shall be designated as providing combination starters for the RO skid pumps, and VFDs (or combination starters) for the distribution pumps.

Start-up/Certification

The entire distribution loop piping system (supply and return) shall be sanitized (with sodium hypochlorite, similar to sanitizing domestic water systems) prior to putting the system into operation. Mixed beds shall not be connected to the distribution piping during sanitization.

The RO/DI system supplier shall provide technicians specifically trained on RO/DI system start-up, for system start-up.

During start-up, the vendor shall, in the presence of U-M, delete the PLC program and demonstrate reloading the back-up copy of the software program.

All systems shall have performance certified by an independent 3rd party, including the taking of samples. On large systems, multiple samples shall be taken, e.g. one per floor. The first sample shall be taken by dumping the system make-up rate for 24 hours, and then taking a sample at a point of use location designated by the owner. The system shall then be run 1 week, and additional sample(s) shall be taken at point of use locations designated by the owner. Specify that a certified performance report shall be provided to the owner.

Hydronic Systems and Specialties

General

This section covers requirements for hydronics systems, including chilled water, hot water heating, and condenser water systems.

Related Sections

U-M Design Guideline Technical Sections:
15060 – Basic Piping Materials and Methods

U-M Master Specification:
15060 – Basic Piping Materials and Methods
15515 – Hydronic Systems and Specialties

U-M Standard Details

Design Requirements

Compression/Expansion Tanks

Provide compression tanks on all closed loop hydronics systems. Tanks shall be diaphragm/bladder type, constructed for appropriate design pressure. The tanks should be welded steel, stamped with ASME code Section VIII for appropriate psi design. Indicate system volume, and expansion tank fill and operating pressures on design drawings.

Air Separators

Install air separators to aid removal of air from hot water heating systems and as required for chilled water systems. Separators shall be a tangential type, designed and installed per manufacturers instructions

System Fill and Pressure Relief Valves

The design shall include system fill valve and pressure relief valve with a field adjustable pressure setting.

Balancing and Measuring Devices

All hydronic systems shall have a means of measuring and balancing flow at each piece of equipment and terminal device. Balancing valves shall be sized so they are not closed more than 60% for the flow and pressure expected. Do not base sizing on pipe size alone. If numerous devices are in the project, include a schedule on the drawings.

Automatic Flow Balancing Valves

Installation of automatic flow balancing valves is permitted for terminal devices (coils, finned tube radiation etc.), in lieu of installing manual balancing valves at these locations. Suitability of each application should be carefully considered by the A/E, especially in variable volume systems, and systems where design flow is likely to change and in existing systems.

Strainers and Dielectric Separation

Refer to U-M Master Specification 15060

Glycol Systems

Use of glycol in hydronic systems is generally discouraged due to environmental concerns. Glycol should only be used where other means of freeze protection are impractical. Use only concentrations required to meet design requirements. 30% ethylene glycol is typically acceptable for freeze protection on pumped hydronics systems subject to full winter conditions. Lower concentrations may be acceptable for burst protection or higher design temperature.

Do not provide an automatic cold-water makeup for glycol filled systems. Provide packaged, glycol fill system consisting of polyethylene fill tank (to hold approximately 30 gallons of pre-mixed solution) with hinged cover, fill pump and electric controls. Fill pump is to be energized to maintain system pressure as sensed by pressure switch mounted near compression tank. Provide a two stage low water alarm in the fill tank. The first stage alarms the campus BAS system (or, if BAS is not available, energizes an audible device). The second stage shuts off the pumps and requires a manual reset. Pipe relief valve back to the glycol fill tank.

Make provisions for filling glycol filled systems that ensure reasonable convenience, such that large drums will not need to be lifted up stairs.

Pre-mixed glycol is generally preferred.

Review need for containment with U-M Project Coordinator and U-M OSEH department. At minimum, include a spill pallet below the glycol fill station.

Cooling Tower Water (Condenser Water) Systems:

Tower Water systems generally require installation of side-stream aggregate filters, or possibly centrifugal separators. Consult U-M Project Coordinator. Refer to U-M details for chemical treatment and filters.

Installation Requirements

Expansion tanks and air separators shall be supported independently from piping.

Install air vents at all high points in all hydronic systems. Generally, automatic vents should be installed only in mechanical equipment rooms. All other locations will contain manual vents. Where practical, pipe outlet from automatic air vents to floor drains. Refer to Master specification and standard details.

Flow meters shall be installed with unrestricted lengths of straight pipes as required by the manufacturer.

Install unions, isolation valves and bypass lines on devices requiring removal for maintenance.

Generally, install strainers ahead of all hydronic system control valves, flow measuring devices and pumps.

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STEAM SPECIALTIES

General

Consult with Project Coordinator whenever the quality of the steam is an issue to the A/E. See University Provided Utilities in the SID Section for steam pressures available.

Design Requirements

Where medium pressure steam (60 psig) is available, a pressure reducing station shall be provided to meet the total low pressure (5 psig) load during major breakdowns or planned maintenance.

Where intermediate steam pressure is required (e.g. 15 psig) a jet compressor should be provided to supplement the low pressure steam.

The pressure reducing valve or jet compressor should be insulated and covered with sound attenuation wrapping.

Equipment Requirements

Traps, Strainers and Meters

Float and thermostatic traps - F & T traps should have heavy cast iron bodies. The float valve mechanism should be of heavy brass and should have a variable level action to ensure quick and full opening.

The thermostatic bellows member for venting air should have not less than 10 corrugations and should be protected against damage from water hammer by a brass shield cup.

Inverted Bucket Traps - IB traps should have high-strength cast iron bodies. Bucket should be of brass and the level mechanism should be of heat treated stainless steel operating on knife edges. Removable seats and plungers should be heat treated stainless steel. Steam tight seal between seats and covers should be provided using an automotive type copper gasket.

A vertical tube should be threaded into the inlet opening and capped with a baffle to prevent condensate from impinging on the bucket.

Strainers - Strainers should be of the 'Y' type having heavy cast iron bodies with blow-off tappings in screen covers.

Sizes 1/2 inch through 1-1/2 inches should have a screen of 20 mesh Monel.

Sizes 2 inches and over should be .016 inch thick perforated stainless steel, with 324 holes 1 per square inch, each .033 inch diameter.

Steam and Condensate Meters - Where possible all steam shall be metered by gravity type condensate meters as manufactured by CADILLAC METER CO., or as approved by the University Utilities Engineer through the University Project Coordinator. Flashtanks shall be provided before the meters.

Medium pressure steam that will not be returned as condensate shall be metered directly with an orifice plate and a calibratable, differential pressure cell and transmitter with pressure compensation. "Shunt flow" or by-pass type steam meters are not acceptable.

Meters should be complete with a low voltage pulse totalizer output and a 4-20 mA output proportional to flow where appropriate for external interface with a building management system.

Steam Humidifiers

Humidification should be normally provided for each project. If required, primary humidification at the central AHU's will be provided after evaluating problems that may be caused by condensation on the perimeter glazing.

When a specific zone requires a higher humidity level than adjoining areas, the A/E should provide for the prevention of moisture migration from this high humidity zone. This will require that doors remain closed except for individual ingress/egress for Rh differentials approaching 20 percent and non-permeable floor/wall/ceiling treatment for greater differentials.

All steam humidifiers connected to the building steam supply, whether primary or secondary, should contain insulated dispersion tubes.

Installation Requirements

Size traps for twice the condensate rating unless the coil or vessel manufacturer recommends otherwise. Install multiple traps where one trap will not handle the condensate rating.

The run-out from unit being trapped should be the same size as the drain tapping.

The discharge line downstream of the pressure reducing valve or jet compressor shall be fitted with a pressure relief vented to atmosphere (outside the building) to prevent overpressurization of equipment and components.

Install strainers ahead of all controlled devices. Install a valved blow-down line for each strainer. Screens should be removable without disturbing the pipes.

Install inverted bucket traps on all steam equipment drains and all steam line condensate drains except for steam using equipment served by modulating steam control valves. For this equipment, install float and thermostatic traps.

Humidifiers to be located to assure absorption into the airstream rather than wetting of parts such as fans, turning vanes, etc. The preferred location is in the supply ductwork, with 10-12 feet of straight duct downstream. Internal lining should not be used downstream within 10 feet of humidifier.

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REFRIGERANT MONITORING SYSTEM

General

Provide a refrigerant monitoring system in accordance with ASHRAE 15-1994.

Designer to select either remote sensing (CHILLGARD-RT) or point of use sensing (CHILLGARD-L Series) system for refrigerant monitoring and alarm.

Designer to provide a system of fans and dampers to sweep the room with fresh air and exhaust to clear the room of refrigerant.

Designer to verify numbers of doors and lights required.

The supply, exhaust fans and related dampers shall be activated through hard wiring from the refrigeration monitor control panel. Provide an input to DDC system to indicate alarm condition.

No SCBA is required since U-M has a 24/7 emergency response team with trained personnel properly fitted for SCBA.

If any of the fans are driven by VSD, same shall be equipped with a bypass. Hardwire VSD to go into full speed on alarm condition.

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CHILLED WATER SYSTEMS

General

The designer shall consult with the U-M Mechanical Design Coordinator and Plant Operations before making decisions on chilled water system type and configuration.

Related Sections

Special Instructions to Designers:
SID-J University Provided Utilities
SID-D Energy Conservation

U-M Design Guideline Technical Sections:
15680 – Water Chillers

U-M Master Specification:
15680 – Centrifugal Chillers
15681 – Absorption Chillers
15515 – Refrigerant leak detection
15516 – Water Treatment
15975 – Mechanical Systems Controls
15710 – Cooling Towers

Chiller Plant Sizing, Redundancy, Diversity, Future Growth, Emergency Power

Calculate systems loads based on connected load (total of scheduled load at design condition) and peak diversified load (anticipated or measured actual peak load within a building or system that reflects diversity between loads). Base system sizing on peak diversified load (PDL). Consider potential need for future growth when calculating PDL.

Consider need for system and equipment redundancy. For critical laboratory and animal facilities and for multiple building chiller plants provide plant with multiple chillers to provide "N-1 redundancy" (capacity that can meet PDL with largest chiller, pump or cooling tower out of service). For single building chiller plants, the design shall provide at least, sufficient redundancy for the critical portion of the facility.

For building areas such as vivaria or certain hospital areas, requiring cooling operation during power outage, consider providing a smaller chiller connected to emergency power.

Redundant pumping shall be considered normal for all installations. For multiple chillers, design systems to provide a single redundant condenser water pump and a single redundant chilled water pump that can be manually valved into service for the other pumps of the same service.

Chilled Water Configuration

In general, design systems with constant volume primary chilled water (through evaporator), with a decoupled variable flow secondary, with distribution based on two-way valve control of cooling coils. The decoupler pipe shall be sized to handle the full flow of the largest chiller. Chiller staging shall be via decoupler flow volume. For chiller plants of less than 1000 tons aggregate, serving a single building, variable volume primary systems may be considered with the approval of the U-M Project Coordinator, given a proper volume-controlled bypass arrangement is provided to maintain minimum chilled water flow at the evaporator.

For multiple building chilled water plants, design should normally indicate primary pumping, secondary distribution variable pumping and tertiary building pumping. The tertiary design should indicate a decoupled pumping arrangement with a modulating valve in the secondary return leg, which will maintain the tertiary at +1°F above the distribution temperature. For plants that serve newer buildings, design for a minimum distribution temperature differential ("delta T") of 15° F (eg. 44F CHWS/ 59F CHWR). For plants serving existing buildings, the existing coil performance must be considered when defining system temperatures.

Design for Maintenance

Design piping and machine placement so that complete machine overhaul, including motor replacement, may be performed without the removal of permanent piping. Provide permanent steel rail hoistways or other approved measures for this purpose.

Where possible, locate chiller plant to minimize future work that will be required to replace the chiller.

Design for Cleaning/Flushing

Design system (include appropriate connections, etc.) such that, during construction, pipe cleaning and flushing can be conducted without contamination of the chiller. Design shall require provision of conical startup strainers at the chiller inlets and fine mesh pump startup strainers. Design shall incorporate temporary bypasses of cooling coils to avoid fouling coils during flushing and cleaning.

Water Treatment

Refer to U-M master specifications and guidelines. For systems over 400 tons, the design shall include chemical bulk storage adequate for a two month supply of chemical treatment and shall indicate a piping system for filling from a convenient grade-level loading area. Bulk systems shall be provided with double- wall storage vessels or other approved packaged base containment method. For smaller systems using 55 gallon chemical barrels, design shall include containment via a low, beveled curb that will allow wheeled hand truck passage along its length for barrel movement.

Strainers and Filtration

Basket strainers shall be provided for all cooling tower systems. In addition, provide coalescing type solids separators. Provide combination coalescing solids separator/air separators on the chilled water system. Sidestream separators shall be sized for at least one third of the full system flow.

Free Cooling and Winter Cooling

Where there is a significant winter chilled water load, consider “free cooling” (making winter chilled water utilizing a cooling tower and a plate-frame heat exchanger). Provide life cycle calculations in accordance with the Special Instructions to Designers (SID-J) Energy Conservation section. In addition to energy savings, free cooling can minimize low load short cycling. Filtration and wet-bulb approach controls shall be part of such a system.

Winter-operated cooling towers and outdoor piping shall be winterized in accordance with the Design Guildeline section 15710 - Cooling Towers. Heat-trace systems shall be DDC controlled and monitored; separate programmable controllers are not permitted. Where winter chilled water demand is less than that practical for free cooling, provide a smaller indoor air cooled chiller with remote condenser connected in parallel with the larger chillers.

Drained Condenser Water Piping

If condenser water piping is intended to be drained down during off-season, consider the use of non-ferrous piping (stainless steel schedule 10 or other) for that section of piping to be drained to eliminate off-season corrosion of empty piping. Make provisions in the design (sight glasses and testing ports) so that risers within the building may be tested to insure treated water is present year-around.

Chiller Room Noise and Vibration

Consider noise and vibration criteria in mechanical room and adjacent area. Specify machine noise and vibration limits, and specify testing procedures. Evaluate the need for noise and vibration abatement to achieve acceptable noise levels.

Controls

Use of U-M standard control diagrams and sequences is preferred.

Chillers enable, start/stop functions, sequencing, cooling tower operation and secondary pumps shall be controlled by the Building Automation System (BAS). Use of proprietary chiller or pump control packages is not permitted. Generally, primary chilled water pumps and condenser water pumps are started and stopped by the associated chiller, but where redundant pumps are provided, using BAS to start pumps can be considered.

The design shall indicate manual selector switches, providing digital inputs to BAS, located at an auxiliary panel near the chillers for the following functions:

- Select lead/lag chillers sequence.

- Where BAS starts the pumps, to functionally connect the backup pump with the applicable chiller.

Cooling tower filter or separator blow down valves shall be controlled as the first stage of tower blowdown via the water treatment panel.

Generally, absorption chillers system design shall provide fixed constant condenser water temperature per design setpoint. Centrifugal systems design shall provide condenser water temperature reset; the chiller control panel shall generate a standard 4-20ma linear reset signal output to the BAS. BAS will reset condenser water setpoint, indexed against outside air wet bulb temperature.

Water cooled chillers or chiller groups shall have full-sized condenser water three-way valve bypasses of the cooling tower. Two way valves may only be utilized where specifically approved. The valve shall be controlled by the BAS with pneumatic controlled back up. For combination absorption and centrifugal chiller plants, separate three way bypasses shall be designed to provide higher fixed temperature to absorption and resetable lower temperature to centrifugals.

Control of water treatment shall be by the specified water treatment controller, which will report conductivity to the BAS.

Metering

Metering required:

- Cooling tower make-up water metering and cooling tower blow-down metering shall be in accordance with the City of Ann Arbor requirements and these standards. Meter cooling tower makeup water separately from the building service.

- For a chilled water plant serving multiple buildings, all utilities and services serving the generation of chilled water shall be metered separately from the building in which it resides.

- Each separate building using central plant chilled water shall have chilled water BTU load metering via a magnetic flow meter in conjunction with a BTU meter and sensors with matched calibration in accordance with the U-M Master Specification section 15975 - Mechanical Systems Controls.

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WATER CHILLERS

General

Refer to SID-J, University Provided Utilities, for application of steam absorption chillers on Central Campus. Centrifugal chillers are the standard application for other campus areas. On Central Campus, generally capital replacement of absorption chillers shall be with like absorption chillers. Electric water chilling may be used for new loads.

Consult with the U-M Project Coordinator and Utilities and Plant Engineering before making decisions on chiller type. The following are general criteria:

- Air cooled packaged chillers: 100 tons and smaller.
- Water cooled screw chillers: 100 to 200 tons.
- Centrifugal and steam absorption chillers: 200 tons and larger.

Related Sections

Special Instructions to Designers:
SID-J University Provided Utilities
SID-D Energy Conservation

U-M Design Guideline Technical Sections:
15680 – Chilled Water Systems

U-M Master Specification:
15680 – Centrifugal Chillers
15681 – Absorption Chillers
15515 – Refrigerant leak detection
15516 – Water Treatment
15975 – Mechanical Systems Controls

General Requirements

Unless directed otherwise, the AE shall utilize the following U-M specifications, revising them to be project specific:

15680 – Centrifugal Chillers
15681 – Absorption Chillers
15635 – Refrigerant Monitoring System

The capacity of the machine shall be based on Standard ARI-550-98 fouling factors for the evaporator, absorber and condenser sections, as stated in the U-M Master Specification.

Normally, for centrifugal and absorption machines, marine water boxes shall be specified for condenser and evaporator. Provide accessory davit arms or hinged covers for both evaporator and condenser boxes. Where marine boxes are not feasible, design shall indicate removable spool pieces between isolation valves and chiller heads, which when removed allow tubes to be pulled or cleaned. Design shall include permanent means to hoist and remove heads and spool pieces.

Chiller or chillers shall be sized to operate efficiently over the full range of the system load profile. Special caution shall be exercised to avoid sizing that results in short cycling in low load ranges. Multiple chillers shall be used if the load profile indicates that short cycling (cycling greater than 30 occurrences during a low load day) will occur. Multiple chillers shall be used in any installation of greater than 600 tons.

For small air-cooled chillers, consider providing an indoor chiller with remote condenser or dry-cooler in lieu of roof top chillers. Air cooled chillers operating year-around shall be rated for partial load performance at -10 F°. Chillers exposed to the outside air shall be designed with antifreeze water treatment for operation down to -10°F.

Chillers shall include manufacturer's standard digital control panel. BACnet panels and interfaces shall be provided only when specifically requested by Plant Operations.

Differential pressure switches for chiller proof of water flow shall be specified, not flow switches.

Provide life cycle cost analysis to evaluate chiller options. Contact Utilities and Plant Engineering for maintenance and utilities costs. Determine the system load profile. Evaluate alternative chiller assemblies. Investigate energy-saving opportunities where additional initial investment produces an acceptable payback in accordance with SID-D Energy Conservation. Consider providing variable speed drives (VSDs) for centrifugal chillers where the load profile exhibits an opportunity for acceptable payback. Use of VSDs on chillers must be approved by U-M Design Coordinator. For chillers larger than 200 tons, the specification shall require the manufacturer to provide, as part of their bid, annual energy usage based on a defined load model or ARI standard conditions, as applicable.

Normally chillers above 200 tons should be separately purchased and assigned to the mechanical contractor for installation. This allows the AE and the University to evaluate the chillers bids from a total (life cycle) cost perspective. U-M shall participate with the AE in chiller post bid evaluations, including attendance at post bid meetings.

Consider noise and vibration criteria in mechanical room and adjacent area. Specify machine noise and vibration limits, and specify testing procedures. Evaluate the need for noise and vibration abatement to achieve acceptable noise levels. See UM Master Specification for performance testing required after installation.

Mechanical Refrigeration Chillers

Centrifugal chillers should be specified to use HCFC-123 or HFC-134A (bidder's option). Screw chillers shall use HCFC-22.

Design and specification shall indicate each chiller to be provided with reseating relief valves and rupture discs. Vent the relief to the outside. Each resetting relief valve shall be designed to provide a digital input (contact closure) to the Building Automation System (BAS) on rupture.

For chillers over 300 tons, unless the chillers are installed near a convenient on-grade entrance, provide pump – down refrigerant reclaim tank and piping with capacity equal to 110% of the largest chiller in the installation.

For low pressure chillers, provide hose connections and power outlet for portable "hot pack" unit (to allow chiller to be heated to positively pressurize for service). Coordinate with U-M Project Coordinator as to whether a portable hot pack unit should be furnished with a new chiller installation.

When removing a chiller, specify and coordinate the removal of refrigerants by Plant Operations - Air Conditioning Shop, per EPA standards.

Specify that the chiller manufacturer conduct a full load factory performance acceptance test for each chiller and provide a certified test report for approval. Indicate that the capacity tolerance shall be zero and the allowable tolerance for other performance measurements shall be per ARI 550. Specify that the chiller not be shipped until the report is approved by the owner. Witness of testing by the owner shall be at the discretion of the owner with all travel expenses paid by the owner.

Specify that the chiller be provided with, on the control panel, a separate Hand-Off-Auto (HOA) switch which will allow selection of remote chiller start/stop or local start/stop. Specify that when the HOA is placed in off or hand, remote signaling shall not be able to control the chiller. Keypad activation is not permitted as a substitute for this function.

Provide refrigerant leak detection and ventilation in accordance with current standards and codes, including ASHRAE 15, Safety Code for Mechanical Refrigeration.

Steam Absorption Chillers

Absorption chillers shall be of hermetic design, factory assembled and leak tested, and selected for 5 psi steam at the inlet to the steam control valve. Unit shall be trimmed to 5 psi. Steam shall be controlled by low pressure drop control valve, limited to maximum 1 psig. The control will be a pressure independent control valves system, controlled by the unit control panel, which will permit operation of the unit at varying pressures (5-15 psig) without going into anti-crystallization mode at higher pressures.

If the unit is supplied with an anti-crystallization device such as a positive concentration limiter (PCL) valve, it must be provided with a factory installed manual bypass switch.

The unit shall be charged at the site with lithium bromide solution with chromate inhibitor or York's Advaguard 750. The lithium bromide solution shall be delivered to the site in approved containers and installed by the manufacturer at the site. The inhibitor shall be premixed into the solution before it is charged into the machine.

Tube wall shall be 0.028” for absorber, evaporator and condenser, and 0.035” for generator. The machine shall be supplied with 95/5 cupro-nickel tubes in the absorber, 90/10 cupro-nickel tubes in evaporator and generator, and 100% copper in the condenser section.

Pay particular attention to the manufacturer’s requirement for minimum required vertical drop in the condensate piping between the concentrator outlet and steam trap inlet and proper pitch of the entire machine. Condensate lifting at the outlet of the machine is not permitted.

Instruct Contractor to arrange for a representative from the Plant Department through the University Project Coordinator to be present when the machine is initially charged with lithium bromide and water.

When an existing absorption chiller is to be removed, the lithium bromide is to be removed and legally disposed of by the contractor, with associated hazardous waste manifests filed with the U-M Project Coordinator and OSEH.

Specify that the chiller be provided with, on the control panel, a separate Hand-Off-Auto (HOA) switch which will allow selection of remote chiller start/stop or local start/stop. Specify that when the HOA is placed in off or hand, remote signaling shall not be able to control the chiller. Keypad activation is not permitted as a substitute for this function. Final trimming of absorption chillers by chiller manufacturer shall be done in conjunction with U-M Plant Operations and the Test and Balance contractor under full load conditions at the chiller. Since chiller start-up does not typically take place during peak cooling season, contractor must develop, assisted by the commissioner, a plan to fully load the chiller, either by imposing a false load or waiting to complete the contractually required trimming until a natural load can be developed. After the manufacturer trimming has been completed, manufacturer’s representative shall perform final performance verification, measuring and document chiller performance under full load, witnessed by the commissioner.

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Cooling Towers

General

This section covers requirements for forced draft and induced draft cooling towers, and related system and component requirements.

Related Sections

U-M Master Specifications

Design Requirements

Use 78^{o}F for design entering wet bulb conditions.

Cross-flow induced draft towers are preferred over forced-draft type towers due to energy consumption and ease of maintenance.

If a job requires a forced draft tower, provide adequate space for fan shaft removal.

Make provisions to protect the fill from higher temperatures on absorption chiller applications. Indicate in control sequences to shut the chillers and condenser water pumps.

Fan drive(s) should be through drive shafts and gear reducers, with motor mounted outside of the air stream. Include external oil lines and dip stick. The University discourages the use of V-belt drive cooling towers. If V-Belt drives are used, provide non-ferrous sleeves.

Cooling tower fans shall be driven by a variable speed drive.

Refer to "Editor:" notes in the Master Specifications for access platforms and handrails.

Designer shall review need for vibration isolators with the University Project Coordinator.

For winter operation, a remote, indoor sump or tank is preferred (dry cooling tower sump). Where wet cooling tower sump is used for winter operation, provide basin heater and heat tracing for all outdoor piping. Direct steam injection basin heaters are preferred. Used electric sump heater if steam is not available. Heat tracing may be steam or electric.

Cooling tower located on roof shall be supported on roof steel to provide a minimum clearance of 3 feet to the bottom of steel, to enable roof maintenance and replacement.

Acoustic testing and analysis is typically required for all cooling tower installations. Consult Project Coordinator.

Provide accessible basket strainer at inlet to cooling tower.

Designer shall account for derating factors associated with screenwalls, and reentrainment.

Pipe cooling tower overflow/ drain to sanitary waste. Discharge directly to roof is not acceptable.

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PACKAGED ROOF TOP AIR CONDITIONING UNITS

Roof top air conditioning equipment (RTUs) is not preferred and shall be used only when absolutely necessary. Specify high quality roof top air conditioning units only. Refer to list of preferred manufacturers. Where necessary, use a continuous, sound attenuating curb when no access is required to the bottom of the equipment or support the equipment 24" above the roof (18" minimum) so that roof maintenance can be performed. Provide a catwalk for service access to routinely serviced components (such as control cabinets) that will be out of reach.

Typically, rooftop units controls should be U-M standard DDC. Direct expansion compressor and refrigeration controls may be manufacturer's standard.

Generally, units with return fans are preferred to units with exhaust fans.

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WINDOW AIR CONDITIONING UNITS

General

Window units are acceptable only if specifically approved by the University Project Coordinator.

Design Requirements

The A/E is responsible for field verifying the adequacy of the existing electrical service within the space to assure that the addition of this electrical load will not overload the circuit when all other existing equipment is operating at design capacity. If a new feed is required, it should be a part of this renovation project.

Equipment Requirements

Units which will be used to supply year-round ventilation should be equipped with an electric heating coil.

Units should be furnished with a window sleeve, approved by maintenance personnel.

Installation Requirements

Units should be mounted in the upper section of windows but not through-the-wall above the window (with ductwork to the occupied spaces).

Units should normally be mounted flush with the building exterior, projecting into the room. Deviations require approval by the Exterior Elements Design Review Committee.

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COMPUTER ROOM UNITS

General

This section addresses air conditioning requirements for computer rooms (including server rooms), and requirements for computer room units.

The primary source of cooling should generally be from year-round chilled water, with an automatic switch over capability to back-up mechanical cooling systems.

Related Sections

U-M Design Guideline Technical Sections:
15010 – Basic Mechanical Requirements

U-M Master Specification:
15975 – Mechanical System Controls

Design Requirements

Cooling Loads:
Cooling loads vary widely in "computer rooms" throughout campus. The A/E shall work closely with the U-M Project Coordinator and end user to determine actual peak diversified load based on actual equipment. Consider future growth, redundancy requirements (see additional comments below in "Computer Room Unit Selection"), and seasonal changes, including seasonal limitations on the chilled water system. Clearly define all load and system design assumptions to U-M Project Coordinator, preferably in a Design Intent document.

Temperature and Humidity Criteria:
Clarify and document acceptable temperature and humidity criteria (summer and winter, including allowable range) with users and U-M Project Coordinator. While some computer rooms are primarily user workstations, and have criteria similar to office environments, a growing number of server rooms (with few or no full-time occupants) request room setpoints near 65F. U-M generally discourages humidification for dedicated computer room systems. While humidification criteria is rarely as high as it had been in years past, extremely low RH (below 15%) may not be acceptable. Carefully analyze psychrometrics and alternatives (such as discharge air reset) before including computer room humidification. If humidification is required, steam generator-type humidifiers are preferred.

Source of Cooling:
Chilled water is the preferred source of cooling. Where chilled water is not available year-round, or where the chilled water system is prone to unscheduled shut-downs (including loss of chilled water during transition from free cooling to absorption cooling), combinations of chilled water primary and mechanical cooling secondary are recommended. For these applications, the refrigeration circuit may be air-cooled (equipped with low ambient refrigerant side controls) or glycol-cooled (with remote dry cooler).

The use of potable cold water for condenser cooling is not acceptable, except for very short-term temporary or emergency applications. These rare applications should be made only with the approval of the U-M Utilities Group through the U-M Project Coordinator.

Computer Room Unit Redundancy

While some computer rooms require full "n-1" redundancy (systems that can meet all loads with loss of the single largest component), most do not require this level of redundant capacity. Conversly, most systems will require some level of back-up cooling. For rooms with loads over 5 tons, multiple units should be installed, to offer some cooling capacity in the event of unit failure.

Controls and Alarms

Units that include mechanical cooling may include manuafacturer's standard electronic controls. Units with chilled water cooling only should be DDC controlled, integrated into U-M standard DDC system. In either case, unit failure and high temperature alarms should be integrated into U-M DDC BAS system.

Where chilled water is less reliable, where system does not provide full redundancy, and other select applications, consider using high temperature warning at 5F above setpoint to implement a graceful shut-down of non-essential equipment. In this way, users can improve reliability of essential systems. This stategy is not fully adopted by all computer room users.

For units located above a raised floor and other locations where deemed necessary, install a water sensor to detect an overflowing drainpan. Connect alarm to U-M DDC BAS system.

Emergency Power Impact

Computer rooms are not typically fed from emergency power, although many will have UPS systems. In the event that they are fed from emergency power, consider need to put computer room units and all required controls on emergency power. Central chilled water systems are not typically fed from emergency power.

Additional Computer Room Unit Features

A filter should be installed at the air-return opening.

The unit should be supplied with the optional integral fused disconnect switch, and all necessary controls to provide a completely functional unit.

Installation Requirements

At a minimum, chilled water coils should be piped with a 2-way control valve, isolation valves, and individually sized balancing valve (manual or automatic).

The unit should be supported from the concrete sub-floor slab with properly rated supports. Mounting units directly on raised floors is not be acceptable.

FAN COIL UNITS AND BLOWER COIL UNITS

General

This section describes definitions, applications and design requirements for fan coil units and blower coil units.

For purposes of this section:
- Fan coil units (FCUs) refer to a variety of relatively small, unducted, floor or ceiling mounted units, used for cooling and/or heating the room in which they are located.
- Blower coil units (BCUs) refer to small to moderate-sized, ducted, floor or ceiling mounted units, used for cooling and/or heating the room in which they are located, and/or adjacent areas.

Fan coil units are one of the least preferred methods of providing air conditioning at the University. Blower coil units are generally preferred over FCUs, but less preferred than central HVAC systems.

Related Sections

U-M Master Specifications

U-M Design Guidelines Technical Sections:
15240 - Mechanical Sound and Vibration Control
15950 - Automatic Temperature Controls

U-M Standard Details

Design Requirements

For FCUs and BCUs, pay close attention to acoustic requirements of space served. FCUs and BCUs are generally not acceptable in classrooms, conference rooms.

Consider possible requirements for future additional capacity, and redundancy.

All FCUs and BCUs shall be individually scheduled and identified on the drawings.

Consider seasonal requirements and capabilities of chilled water, steam, and heating hot water.

Indicate maintenance requirements on drawings, for filter access. Account for access to all components requiring regular maintenance, including all valves.

For FCUs:
- Provide IAQ drain pan, and auxiliary drain pan
- Insulate cold piping inside and outside housing.
- Provide removable, replaceable filter.

- Provide multi-speed direct drive fans.
- Generally install floor mounted, non-recessed type. Low profile units are not acceptable due to difficulty in maintaining.
- Do not provide with integral outside air connection. Provide separate minimum ventilation air where required.

For BCUs:
- Provide IAQ drain pan, and auxiliary drain pan
- Insulate cold piping inside and outside housing.
- Provide removable, replaceable filter: 2" pleated, minimum 30% efficiency.
- Provide belt drive fans with adjustable sheaves.
- Floor mounted, non-recessed type or ceiling mounted is acceptable, depending on project requirements, provided maintenance access requirements are met.
- Do not provide with integral outside air connection. Provide separate minimum ventilation air where required. If required, outside air for minimum ventilation load may be ducted to BCU return duct, provided outside air is filtered and includes an integral damper interlocked to BCU operation. BCUs should not be used for 100% economizer cooling.
- Use of BCUs should be limited to systems below 3,000 to 5,000 cfm, and should not be used in conjunction with VAV boxes.
- The generally preferred location of ceiling mounted BCUs is above corridors to allow service without disrupting the occupied space.

For FCU and BCU controls:
- See specifications and technical section 15950 for control valve and actuator requirements.
- Do not provide factory-mounted, manufacturer standard electronic controls. Pneumatic thermostats, and manually controlled FCU fan speed are generally acceptable where there is little energy savings associated with reset controls. If setback controls are justifiable, provide U-M standard DDC controls.
- Provide removable, replaceable filter.

Installation Requirements

Specify on the construction documents that the units must be installed to allow for maintenance of all serviceable components within the unit through without removing ducts, piping or other adjacent systems such as light fixtures.

Unions and isolation valves should be installed at all water service points to facilitate unit removal without disruption of service to the remainder of the building.

AIR BLENDING DEVICES

General

The use of air blenders is strongly discouraged since U-M's experience is that such devices are ineffective in preventing stratification problems, leading to frequent nuisance freeze stat trips or more severe problems. Instead, arrange outside air and return ducts so that after combining, at least two directional changes occur prior to entering the air handler proper, or utilize blow through or other fan arrangements that completely eliminate such stratification problems. Use air blending devices only as a last resort and only with the permission of the U-M Design Coordinator.

Design Requirements

De Stratification Efficiency

Air blending unit should be factory fabricated and should consist of fixed blades capable of providing a mixed air temperature within 6^{o}F of the theoretical mixed air temperature. In a variable air volume AHU, this 6^{o}F maximum deviation should apply throughout the CFM range specified.

Size

The devices should be sized to provide a maximum pressure drop of .15 inches water, and a stratification range not exceeding $\pm 6^{o}$ from mean temperature.

Installation Requirements

The A/E should lay out the AHU to provide a plenum sized for a minimum of 1/2 blender diameter upstream between return air duct and blender, and 3 blender diameters downstream between the blender and the first air flow obstruction (filter, coil, etc.).

AIR HANDLING UNITS

General

This section describes design requirements, types, and arrangements of air handlers required, sizing considerations, and minimum air handler construction features. Testing, temporary use, and training are also covered.

Related Sections

U-M Design Guideline Technical Sections:
15010 – Basic Mechanical Requirements
15850 – Air Blending Devices
15860 – Fans
15885 – Air Filters

U-M Master Specification:
15854 – Custom Air Handling Units
15855 – Modular Air Handling Units
15975 – Mechanical Systems Controls

Design Requirements

Air handlers shall be specified using the U-M master specifications: 15854 - Custom Air Handling Units, or 15855 - Modular Air Handling Units. Edit these specification sections to make them project specific.

For all air handling equipment greater than 2000 CFM, the engineer shall provide a scaled elevation of the unit on the design drawings. This elevation shall indicate component arrangement and identify each unit component: dampers, access sections, doors (including door size), door windows, access panels, pre and final filter, coils, humidifiers, fans, blenders, eliminators, diffuser plates, lights, drain pans, flex connectors, and all significant accessories. Maximum height, width, and depth, as well as base rail height, shall also be indicated.

For all air handling equipment, the plan view drawings shall indicate the arrangement of each component, overall unit size, coil pull space, and access door swings. The plan views shall also indicate the unit's designation and the maximum unit CFM.

Units shall be labeled with sequential alpha-numeric designators. For retrofit designs, do not repeat the numerical designator of existing units; coordinate with U-M Utilities and Plant Engineering via the U-M Design Coordinator to determine the appropriate designator.

Designate adequate roof curb or housekeeping pad height to allow proper trapping of cooling coil drain pans. Provide a detail that indicates the trap height dimensions for every coil trap.

To avoid snow or rain entrainment, limit air velocity through intake louvers to 300 FPM, and limit intake plenum velocities to 500 FPM in all directions. Slope the bottom of plenum/duct connections to the louver so that water drains out the louver.

Air Handling Unit Types

For the purposes of this guideline, modular units are defined as air handlers for light to medium duty use, consisting of manufacturer's pre-engineered standard modules, with limited selections in terms of quality, features, and arrangement.

Modular units should normally be specified for applications such as offices, class rooms, and light duty lab applications (e.g. dry labs with very few or no fume hoods) where operation is generally limited to 5 days per week, 8-12 hrs/day. However for units greater than 20,000 CFM, the design should normally be based on custom units.

Custom units should normally be specified for large wet labs and dry labs, 100% outside air applications (except mechanical or electrical room ventilation), vivaria, clean rooms, 24/7 applications, and other medium to heavy duty applications.

Contact the U-M Design Coordinator early in the SD phase to establish custom versus modular AHU locations.

Roof top units are not preferred and shall not be used except when approved by the U-M Design Coordinator.

Arrangement

Fan Arrangement: Draw through units are normally preferred, except for exterior units.

Returns fan configurations shall be used. Configurations using exhaust/relief fans or no return fan should be avoided and shall be used only when dictated by unusual circumstances.

Units shall be arranged to allow proper access for routine maintenance of all components. At minimum, access shall be provided for the replacement of the following components: Filters, coils, fan shafts, bearings; without unit disassembly or partial demolition of the unit or adjacencies.

Sizing

For applications where load growth is likely to occur over the life of the unit, e.g. lab buildings, size all air handler components (fans, coils, filters, etc.) with additional capacity for future use. Determine the appropriate additional capacity in consultation with the U-M Design Coordinator.

When sizing units, assume 5% duct leakage and 1°F temperature heat gain in supply ducts.

Fans shall be sized assuming dirty filter pressure drops, which are typically 1" w.g. static pressure drop across the pre filters and 1" w.g. static pressure drop across the final filters.

Construction

Unit Casing

Solid inner walls are preferred whenever possible. Perforated walls should only be utilized when external sound attenuators or other means are found to be ineffective in meeting the required noise criteria.

The minimum wall thickness for modular units shall be 2”. The minimum wall thickness for custom units with fiberglass insulation shall be 4”, except 2” foam insulated panels are permitted if such panels match the performance of 4” thick fiberglass insulated panels. See the U-M Master Specification section 15854 for more details.

For roof top mounted units, consult the Architect and the U-M Design Manager to determine if a custom paint color or screening is required.

For units above 10,000 CFM, each access section shall be illuminated. See the U-M Master Specifications for details.

Drain Pans

Drain pans shall be designated as above floor type. Avoid floor recessed drain pans whenever possible due to the difficulty of replacement.

Drain pans shall be stainless steel. Plastic drain pans are acceptable in units of less than 2000 CFM.

Access Sections

Access sections shall be provided to allow up and down stream access to every unit component. For example, an access module shall be provided between each heating coil and cooling coil section; both the air entering and air leaving side of each coil shall be visible for inspection. The designer must accommodate these access sections when fitting units into the available space.

For large custom and modular units (> 20,000 CFM), in particular those with a large outside air component, consider (with the U-M Design Coordinator) providing an access section between the pre and final filters of adequate size to allow the final filters to be replaced from the upstream side without removing the pre-filters. As and alternative to the above, a hinged pre-filter section may be specified. For hinged pre-filter configurations, also specify a gap between the pre-filter and final filter frames to allow a static pressure tip to be installed so that a separate pressure drop reading may be taken across the pre and final filter banks.

Access Doors

Hinged access doors are required in each access section.

Minimum door widths are specified in the U-M AHU Master Specifications. For modular units, doors shall be a minimum 18” wide, but 24” width is strongly preferred. Widths narrower than 18” should be avoided and are unacceptable for sections requiring personnel (vs. inspection/arm reach only) access. For custom units, minimum door width shall be 24”. In all cases, provide doors that are the full height of the unit, maximum 6’ high.

Windows shall be provided in all access doors on units greater than 5000 CFM, and for all air handlers providing service to areas that might be compromised by opening an access door for inspection, e.g. clean room units, lab units with stringent temperature, pressure, or humidity control, etc.

Mixing Box Section/Blenders

The use of air blenders is strongly discouraged. Refer to U-M Design Guideline Technical Section 15850 - Air Blending Devices.

Coils and Face/Bypass Modules

The maximum face velocity for cooling coils in both custom and modular units shall be limited to 450 FPM. This face velocity shall be based on the actual coil face area sans any safing around the coil.

Maximum face velocities shall be based on any future capacity allowance for the AHU.

For units 10,000 CFM or greater, coil tracks and individual coil access panels shall be specified. See the U-M AHU Master Specifications for further details.

Coils shall have a maximum of six rows, and maximum fin spacing of 10 FPI. When these criteria can not be met, provide two coils piped in a series arrangement.

When multiple coils are stacked vertically, each coil in the stack shall be equipped with a balancing valve (circuit setter).

For 100% outside air units, or units with a large outside air component, “run-around” pumped hot water heating coils are preferred in lieu of steam coils (include redundant pumps for critical applications), for preheating applications. If preheat steam coils are used, multiple staged on/off steam coils shall be used, or a face/bypass arrangement may be used. For face/bypass arrangements, internal bypass or “Wing” coils shall not be utilized, rather an external coil bypass shall be utilized. The external bypass shall be routed to the downstream side of all unit coils (i.e. downstream of both the preheat coil and the cooling coil) and shall be sized to exert the same relative pressure drop on the fan as flow through the coils would exert.

Dampers

Damper construction is designated in U-M Master Specification 15975 - Mechanical Systems Controls. The U-M AHU Master Specifications also reference 15975 for damper construction. All air handler specifications shall utilize this damper specification for dampers provided by air handler manufacturers. This includes smoke and combination fire and smoke dampers that are provided by air handler manufacturers.

Filters

Units shall include pre-filters and final filters, except that very small, non-critical units or units serving spaces less susceptible to dirt, e.g. mechanical rooms, may include prefilters only.

Units serving substation rooms shall always be equipped with pre and final filters.

Pre-filters shall be 2" depth, 30% efficient, pleated panel type; final filters shall be bag type. Roll type filters shall not be used.

Filters shall be designated as face mounted with the filter seals sealing against the upstream side of the filter frame. Side slide filters shall only be used in unusual circumstances

Fans

Limit fans speeds to 1200-1400 RPM.

Forward curved fans shall not be specified accept when air foil or backward inclined fans are not available, or when a forward curved fan provides significant performance advantages. Modular units are often available with either forward curved or backward inclined/air foil fans. Determine if backward/air foil type are available and always provide a design based on same when available, except as qualified above.

When plenum fans are utilized, specify a "guard cage" around the fan for safety. The impacts on fan performance of such cages as well as impacts from any inlet mounted back draft dampers shall be evaluated when selecting such fans. Assure proper up and downstream and side-to-side (relative to plenum walls and any adjacent fan(s) in the same plenum) clearances are maintained around plenum fans to prevent system effect problems or poor air distribution across upstream components.

Extended lube lines shall be specified where bearings are difficult to access or for air handlers providing service to areas that might be compromised by opening an access door for bearing lubrication, e.g. clean room units, lab units with stringent temperature, pressure, or humidity controls, etc.

Testing, Temporary Use, Training

Factory Testing

Custom units should normally be factory tested for air volume, pressure, leakage, and sound performance. Such factory testing is normally not required for modular units, however it should be considered for air handlers that are not arranged in simple horizontal of vertical configurations, e.g. a fan section stacked on top of the coil sections. See the U-M AHU Master Specifications for further details.

Temporary Use/Field Testing

The U-M AHU Master Specifications contain specific criteria regarding the temporary use and field testing of air handling units.

Training

Training is not typically required on air handlers and should not be specified unless directed to do so by the U-M Design Coordinator. Consider need for training if units include direct expansion cooling.

FANS

General

The A/E shall include such considerations as duct leakage (expect 10 percent), temperature heat gain in supply ducts (expect at least $1^{o}F$), resistance through dirty filters, and effect on inlet vanes when sizing the fans. Also consider providing additional capacity. VAV systems shall be furnished with variable inlet vanes, contain variable pitch blades (vaneaxial fans) or variable speed drive. Variable speed drives may be considered to avoid significant operating costs.

Fan wheel should have backward inclined blades of the non-overloading type.

Fan wheels over 27 inches in diameter should have air foil type backward inclined blades.

Equipment Requirements

Centrifugal Fans

The fan wheel should be steel plate, rigidly constructed, with die-formed blades securely attached.

Access doors (as large as practical) shall be provided for fans larger than 18 inches in diameter and shall be located in the lower section of the fan scroll.

Fan belt drives should be of the 'V' type and should provide for adjustment of both belt tension and alignment. Cog type posigrip belts may be considered.

VaneAxial Fans

The fans should be 'V'-belt driven with the motor mounted on an integral base having sufficient adjustability to align and tighten the belts.

The fan should have guide vanes. The hub-wheel assembly should be an integral unit with air foil blades. The wheels should be statically and dynamically balanced.

Vaneaxial fans which have adjustable blades need not have belt drives.

Require a means of access through the fan casing to service the adjustable vane mechanisms, bearings, and motors located in the air stream. Access panel size should be adequate so that disconnection of the ductwork is not required to maintain components inside the fan housing.

Propeller Fans

Fans may be belt-driven or direct-drive. Belt guards totally enclosing the drives on all four sides should be provided.

The winter stack effect in the building may preclude the use of propeller fans. When a propeller fan is selected also consider using a motorized discharge damper.

Equipment Room Exhaust Fans

Fan-type may be any of the above to fit the application.

A single fan in the exhaust duct is preferred, provided the negative static pressure at the equipment room remains within reason. For rooms deep in the building, both supply and exhaust fans will be required.

Hood Exhaust Fans

Fans should be centrifugal, with backward inclined blades.

All wetted parts of the fan should be coated with an approved covering to provide corrosion resistance.

Selection of fan should consider winter stack effect of the building.

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GRILLS, REGISTERS, DIFFUSERS AND AIR BALANCING ACCESSORIES

Design Requirements

Specify a 24 inches x 24 inches ceiling module whenever possible.

Size diffusers, registers and grills for a maximum space noise criteria of 30 in class and meeting rooms, and 40 elsewhere.

In VAV systems consider sizing to 80 percent design flow to prevent dumping at low flow.

Installation Requirements

All sub-main connections to main duct shall contain opposed blade balancing dampers. Branch connections serving individual outlets may not require dampers. However, volume control devices in or directly above diffusers should not be the primary means for system balancing.

Duct extractors and air flow equalizers should be specified as necessary to assure adequate flow and uniform air distribution.

Specify 2-way throw for corner installations and corridors. Specify 3-way throw at walls.

In rooms where heavier than air gases may be present locate one return air sidewall grill near floor level.

Locate supply diffusers and return/exhaust grills sufficiently distant to prevent short cycling. Distance between devices to be approximately 1 1/2 times the T-50 isovel throw. When this separation cannot be maintained, specify throw-reducing devices or specify a 3-way diffuser.

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AIR FILTERS

Related Sections

U-M Design Guideline Technical Sections:
15855 - Air Handling Units

U-M Master Specification:
15885 – Air Filters

U-M Standard Details:
(future)

General

This Design Guideline covers air filters for general HVAC use. It does not pertain to clean rooms or other spaces requiring High Efficiency Particulate Air Filters, or filters in laboratory equipment such as bio-safety cabinets. It does not cover specialty filter requirements that may be required for a specific project.

Filters shall be specified using U-M master specification: 15885 – Air Filters. Edit this specification section to make it project specific.

Air filters shall be scheduled on the design drawings. Minimum schedule data shall include:

- Service
- Location
- Filter type (bag, pleated, etc.)
- MERV (Minimum Efficiency Rating Value)
- Dust spot efficiency
- Filter dimensions including depth
- Clean filter pressure drop
- Dirty filter pressure drop (1” w.g. typical)

For the typical air handler, specify filters and frames capable of a dirty filter pressure drop of 1” w.g. In all cases, size air handling (and exhaust) systems so that design air volumes can be delivered at the dirty filter pressure drop condition, not at some intermediate filter drop condition.

For filter efficiencies above 30%, bag filters shall be specified. Due to problems with disposal, box style filters shall not be used except in unusual circumstances, when approved by the Design Manager.

Roll type filters shall not be used.

Washable filters shall not be used.

Filters shall be designated as face mounted with the filter seals sealing against the upstream side of the filter frame. *Side slide filters shall only be used in unusual circumstances.*

For air handling equipment above 5000 CFM, always provide a prefilter and a secondary filter, located upstream of the first coil in the unit. This includes units equipped with final filters at or in their discharge.

Design filters so that the maximum air flow velocity across the filter does not exceed 500 FPM.

In all cases the AE’s design must provide adequate access to allow changing filters. It shall not be necessary to remove fixed items, including ceiling grid, to change filters.

Filters and filter rack design should be based on the use of 24"x24" filters whenever possible. The use of 12"x24" filters to complete rack configurations is acceptable. If 24"x24" and 12"x24" modules are not possible, use industry standard filter sizes.

Filter Efficiency Guidelines

The below are guidelines only. Specific project requirements may mandate higher efficiency ratings.

Very small or non-critical air systems serving spaces less susceptible to dirt, e.g. mechanical rooms, may be designed with prefilters only.

Pre-filters shall be 2” deep, 30% efficient, MERV 8, pleated panel type. Provide pre-filters in front of any filter with a dust spot efficiency of 65% or greater.

Secondary filters for air handlers with a significant return air component shall be 65% dust spot efficient, MERV 11, bag type.

Secondary filters for continuous 100% outside air units shall be 95% efficient MERV 14, bag type.

Vivarium animal room filters used to protect exhaust Laboratory Terminal Airflow Units shall be ring panel type filters. These shall normally be mounted in the duct as opposed to on an exhaust grille face, and shall be equipped with a Magnahelic gauge.

Provide the manufacture’s standard efficiency filters for packaged terminal air conditioners, fan coils, and similar small equipment. However, when this equipment exceeds 1000 CFM, specify 2” deep 30% efficient MERV 8 filters whenever possible.

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DUCT SYSTEM DESIGN

Related Sections

U-M Design Guideline Technical Sections:
15910 - Fume Hood and Laboratory Ventilation

U-M Master Specification:
15890 - Ductwork and Accessories

U-M Standard Details:
(future)

General

A/E duct designs shall, at minimum, be in general compliance with SMACNA standards.

The A/E's duct specification shall state that duct construction shall, at minimum, meet SMACNA duct construction standards . The A/E's duct specification shall state that the Contractor shall provide their duct construction standards as their first shop drawing submittal so that the A/E can verify compliance with SMACNA standards.

Although typically SMACNA's HVAC Duct Construction Standards, Metal and Flexible, will apply, the A/E's spec. should also reference other standards if appropriate, e.g. SMACNA industrial duct standards.

The A/E shall provide a table that identifies the duct construction requirements for the project. At minimum the table shall include the following:

- Service/Location and/or System
  e.g. Fume hood exhaust upstream of laboratory terminal units
- Duct Material
  e.g. Stainless Steel (SS), Galvanized, Galvanized Plastic Coated Duct (PCD), etc.
- Pressure Classification
  e.g. -2.0" w.g.

Design

Future Capacity: The amount of future air flow capacity the duct system shall be capable of handling, if any, shall be determined in consultation with the U-M Design Manager.

For duct pressure classifications greater than +/- 2” w.g., duct velocities shall not exceed 2500 FPM without the specific permission of the U-M Design Manager.

The amount of diversity assumed in the duct design shall be stated in the Design Intent Document.

Duct aspect ratios should be limited to a maximum of 4:1.

Round duct elbows constructed with centerline radius equal to or greater than 1-1/2 duct diameter shall be specified. Gored elbows are not permitted.

For rectangular duct, the AE shall design radiused rectangular elbows with r/W ratios of 1.00 or above, to the greatest extent possible. Squared elbows with turning vanes should be indicated when radiused elbows are impractical to fit .

Transition slopes should generally be 1/3 or less.

Indicate access panels on plans wherever ducts contain devices requiring maintenance or calibration, such as air flow stations, humidifiers, fire and smoke dampers, reheat coils, etc.

Indicate maintenance access by “dashing out” no-fly-zones in front of DDC terminal equipment controllers, laboratory air flow unit controllers, filters, and at other major duct mounted components.

Flexible duct shall be properly supported and shall not exceed 8’ in length. The A/E should consider specifying flexible elbow duct supports (sample: www.flexflowelbow.com). Provide a detail demonstrating proper flex duct support.

Flexible duct connected to the inlet of terminal units shall be separated with a 24” long section of rigid metal duct located between the flex and the unit inlet. Provide a detail indicating this requirement.

Duct sound liner that is directly exposed to the air stream shall not to be used, except in exceptional circumstances and only with the permission of the U-M Design Manager. Utilize other duct design methods such as low velocities, directional changes, etc. for noise control. Double wall perforated duct with sound liner behind is permitted, provided a Tedlar or Mylar wrap is located between the sound liner and the perforated metal is specified. Sound attenuators shall be similarly specified or shall be packless type.

Materials/Construction

Galvanized duct shall be specified as G-90.

Fibrous glass duct shall not be used. Exception: This material may be used for "return boots" or short transfer ducts, i.e. for short segments of duct that are not hard connected to the duct system, used for the purpose of sound attenuation.

The A/Es specification shall define seal class as corresponding to the definitions found in SMACNA's HVAC Duct Construction Standards, Metal and Flexible. Specify the following seal classes:

- Ductwork rated for pressure of 2" w.c. or less: Class C (seal transverse joints only.)
- All other ductwork: Class A (seal all transverse joints, longitudinal seams, and duct wall penetrations).

Duct Sealant shall be specified as asbestos free.

Exhaust Duct:

The A/E shall research the specific effluent being exhausted and shall specify duct materials and duct joining systems that will cost effectively provide long life and safe operation. Determine if a dedicated exhaust system is required or if multiple effluent sources can be safely exhausted through common exhaust ducts.

For the typical general research laboratory exhausting highly dilute, low corrosivity effluent, the following materials are often selected:

- Fume Hood Exhaust to Main Lateral: PCD
- Room General Exhaust (exhausting room only, to maintain required air change rates, ***not*** exhausting specific point sources): Galvanized Duct
- Autoclaves, Glass Washer/Glass Dryers, and similar moderately steam laden exhaust, from source to Main Lateral: stainless steel, welded longitudinal joints, duct sealant at transverse joints and duct wall penetrations, sloped down and back toward source to promote condensate drainage.
- Exhaust Mains/Laterals Above Lay-In/Accessible Ceilings, conveying fume hood, autoclave, or similar exhaust that is heavily diluted with room general exhaust: Galvanized duct.
- Exhaust Mains/Laterals/Risers in Shafts: PCD

- Exhaust Mains/Laterals/Risers exposed in penthouses and machine rooms: Galvanized Duct

The A/E' specification shall indicate that duct accessories and fasteners shall match the specified duct material, e.g. SS fasteners in SS duct, plastic coated components in PCD.

Tie rods shall not be permitted in exhaust duct running in shafts.

Exhaust with a heavy steam component, e.g. vivarium cage/rack washers, shall be specified as stainless steel duct with all seams, joints, and duct wall penetrations seal welded.

For positively pressurized sections of hazardous exhaust located inside buildings, including penthouses and machine rooms, specify that all duct seams, joints, and duct wall penetrations shall be seal welded. Locating positively pressurized hazardous exhaust in such locations is poor design practice. Obtain U-M Design Manager's permission first.

See U-M Design Guideline 15910 - Fume Hood and Laboratory Ventilation for additional information on laboratory exhaust.

Installation

Duct leakage testing is required on all but very small U-M projects, and shall be specified as follows:

Leakage testing shall occur before duct is insulated or otherwise concealed.

Testing pressure shall match the duct's construction pressure class.

All ductwork with a pressure classification greater than 2" w.g. (positive and negative) or that is specified as "seal welded" shall be leak tested.

Ducts shall be leak tested per the procedures in SMACNA's HVAC Air Duct Leakage Test Manual.

Prior to testing, isolate any components that might be damaged by leak testing.

Duct leakage shall not exceed SMACNA Leakage Class 3.

Duct specified as seal welded shall demonstrate zero leakage.

Reseal and retest as required to achieve the specified leakage class.

Duct shall also pass an audible and touch test (2" from duct), conducted by the owner's representative, regardless of pressure class. All gross leaks and audible noise shall be eliminated.

2/5/2007

LABORATORY VENTILATION

Related Sections

U-M Design Guideline Technical Sections:
SBA-A Animal Facilities
11610 Laboratory Fume Hoods
15975 Mechanical Systems Controls

U-M Master Specification:
15010 Basic Mechanical Requirements
15910 Laboratory and Fume Hood Air Flow Controls

U-M Standard Details:
Laboratory Terminal Air Flow Unit Sample Schedule
Laboratory Terminal Air Flow Unit Clearances

Where this Design Guideline requires consultation with U-M Occupational Safety and Environmental Health Department (OSEH), all such contacts shall be made via the U-M Design Manager.

Quick Links To Sections In This Document:

Lab Equipment Parameters

Chemical Fume Hoods

General:

The required exhaust flow (CFM), static pressure, and hood opening area (sq. ft.) vary by fume hood manufacturer. Refer to manufacturer's data and size duct, laboratory terminal airflow units (LTAU), and fans to accommodate the highest manufacturer's requirements. Provide the hood basis of design (manufacturer and model) on the mechanical design documents.

Unless approved otherwise by the UM Design Manager, for vertical opening sashes, U-M requires sash stops be provided to restrict normal sash operation to no higher than 14" above the work surface (14” above the bench top, not the airfoil), NOT the typical 18”. (Sash stops should be of the type that can be temporarily by-passed to allow the sash to be raised to the full open position for equipment/experiment set-up and removal.)

Assure the TAB specification requires that the air balancer adjust the LTAUs to the air volume required for the particular manufacturer’s hood that is installed.

Face Velocity:

Unless low flow fume hoods have been approved for the project, the normal face velocity for fume hoods used at U-M shall be 100 FPM.

For VAV applications, hoods shall maintain an average face velocity of 100 feet per minute at any position of the sash between the fully closed position and the 14” sash stop position.

For constant volume applications, the average face velocity shall be maintained at 100 FPM at the 14” sash stop position , and at approximately 100 FPM when the sash is closed (bypass style hoods shall be used).

Fume Hood Monitor:

Exhaust monitors shall be provided on each fume hood, set to alarm when face velocity falls below 80 FPM, for hoods with a 100 FPM design face velocity. For “low flow” hoods, the alarm shall be set to alarm at the alarm face velocity recommended by the hood manufacturer.

Monitor shall have an audible and a visual alarm signal. The audible signal shall have a silence override. Designate the alarm activation setpoint on the design drawings.

Specify that the fume hood monitors are provided by the lab air flow controls contractor, NOT the hood manufacturer.

Hood and Cabinet Location in the Lab

Hoods and cabinets shall be located so they are not exposed to excessive traffic, cross drafts and air turbulence from windows, doors, or diffusers. Fume hoods shall not be located such that fire, explosion or toxic material escaping the hood would cross the immediate path of room egress. Hood shall be located away from doors. Hood locations should also follow the general recommendations in the National Institutes of Health publication *Methodology for Optimization of Laboratory Hood Containment.*

Fume Hoods in Explosion Proof Rooms

Since typical VAV controls are not explosion proof, constant volume hoods are recommended in explosion proof rooms.

Mount fume hood controls and alarm monitors outside of explosion proof rooms. Mount an explosion proof audible and visual alarm indicator inside the room, triggered by the fume hood alarm monitor.

Laboratory Fume Hoods for use with Radioactive Materials (Isotope Hoods)

Although a special fume hood is generally required for use with radioactive materials, verify the need for special filtration, or a direct exhaust duct route to the outside, with U-M OSEH. Filtration and direct exhaust are not typically required.

In all cases, delineate space for a future filter box directly above radioisotope hoods.

Solvent and Corrosive Storage Cabinets

Chemicals shall not be stored within fume hoods. Where a storage space for chemicals is required, a storage cabinet below the fume hood may be provided.

<u>Corrosive storage cabinets</u> shall be ventilated at a rate of 2 CFM exhaust per square foot of cabinet footprint. Do not duct into the fume hood bench top. Instead run a separate exhaust from the cabinet up to the exhaust duct. Connect cabinet exhausts to constant volume (CV) Laboratory Terminal Airflow Units (LTAUs). This could be a CV LTAU serving a CV hood, other nearby CV LTAUs (serving snorkels, for example), or, gang multiple cabinet exhausts on to a dedicated CV LTAU(s). Typically exhaust connections for cabinets should consist of a 2 inch polypropylene vent pipe equipped with a non-corrosive ball valve for balancing.

<u>Solvent storage cabinets</u> shall not normally be ventilated. If the lab occupant requests solvent storage cabinets be ventilated, obtain approval from U-M OSEH before doing so.

Biological Safety Cabinets (BSC) and Other Specialty Cabinets and Hybrid Hoods

Selection of the type, size, class, and manufacturers of BSCs and special "hybrid" hoods shall be made by the researcher and the U-M OSEH representative, in coordination with the Architect/Lab Planner/Mechanical Engineer.

If exhaust connection is required to a BSC, it is typically made via an indirect, hood mfg. provided, thimble (canopy) connection. Verify the type required, hard or thimble connect, with UM OSEH.

Many specialty cabinets and hybrid hoods (which often filter downflow supply air) require higher than typical exhaust flow rates (i.e. rates higher than would be suggested based on hood face area) or have high static pressure drop. Always consult the manufacturer's product manuals and design accordingly.

Environmental (Cold) Rooms

Ventilation air is required in all environmental rooms where work with volatile chemicals, compressed gasses, or continuous work activity is planned. Ventilate at 6 air changes per hour or as required by code, whichever is higher.

Ventilated environmental rooms typically require desiccant dryers to avoid excess defrost cycle times. Thus, in addition to a ventilation supply and exhaust air connection to the room, the mechanical engineer will need to provide an exhaust connection for the removal of hot, moist air rejected from the desiccant unit.

Where multiple environmental rooms are located in close proximity to one anther, consider ganging the rooms on common CV LTAUs, to provide the required supply and exhaust air.

Perchloric Acid Fume Hood Systems

Refer to Appendix B of this Design Guideline.

Lab Room Airflow Modeling

Computational Fluid Dynamic (CFD) studies are typically required when multiple hoods are located near each other and within the same room, unless this requirement is waived by the UM Design Manager.

New lab buildings with "typical" fume hood alcoves or lab modules shall have CFD modeling done for each module type. CFDs shall demonstrate hood capture effectiveness, optimize air-change-rates (ACH), and evaluate supply outlet and exhaust inlet locations.

CFD Studies shall be considered for other unique air flow arrangements where proper ventilation, air conditioning, or exhaust are considered critical.

HVAC and Exhaust Systems Design

Exhaust Dispersion Assessments

Dispersion studies ensure proper, safe, dilution of exhaust emissions. Dispersion studies shall be done by qualified firms that have a minimum of 5 years of experience performing such studies.

All new lab buildings shall have a comprehensive dispersion study performed.

All critical exhaust sources shall have a dispersion study.

Renovation projects with exhaust fan volumes ≥ 5000 cfm capacity shall have a dispersion study.

Dispersion studies shall be *considered* for all other renovation projects. For example, a project installing a new outdoor air intake on a lab building likely would justify a study.

Since the results of dispersion studies often require the A/E's initial design to be modified, they should be started as early as possible in the design process.

Design Fundamentals

General:

The specific standards that apply to a particular project should be determined during programming. The following are typical requirements:

Research labs: NFPA 45 Standard for Fire Protection for Laboratories Using Chemicals.

Hospital: All hospital projects governed by the Michigan Department of Health, Health Facilities Evaluation Section, shall comply with the Minimum Design Standards for Health Care Facilities in Michigan, and NFPA 99 Standard for Health Care Facilities.

The guidelines expressed herein are meant to supplement, not supercede, code requirements. Where conflicts exist, the AE shall review with the U-M Design Manager.

Designs may also need to comply with various U.S. Government standards or guidelines (e.g. National Institute of Health, Department of Agriculture, etc.); establish which apply during project programming phase.

Laboratory supply and exhaust air shall be dedicated to lab areas within the building and shall not be part of HVAC systems serving other building areas (offices, toilet rooms, vivariums, etc).

Lab general and fume hood exhaust shall be manifolded whenever possible, as permitted by code, to reduce first cost and improve energy efficiency and maintainability.

Supply air shall be "once through" (100% outside air); it shall not be recirculated outside a laboratory room. Air may be recirculated within the laboratory room itself, e.g. local fan coils. Some very low hazard level labs may use recirculated air when approved by U-M OSEH.

Lab minimum air changes per hour (ACH) shall be established in consultation with U-M OSEH. The use of non-DX type fan coils for sensible loads is encouraged to reduce the amount of outside air required for lab cooling. For labs affecting patient care in hospital facilities, the Minimum Design Standards for Health Care Facilities in Michigan precludes the use of recirculating fan coil units in labs unless outfitted with a HEPA filter. Evaluate the use of chilled beams as a substitute for fan coil units for new lab buildings.

HVAC systems used for laboratories, including those with chemical fume hoods, shall be designed for variable air volume (VAV) using tracking supply, general exhaust and fume hood LTAUs. While this means supply and general exhaust shall be variable flow, it does not necessarily mean fume hoods are to be variable flow:

> For purposes of initial program budget, the use of VAV fume hoods should be assumed. As the program is further developed, evaluate and justify VAV vs CV fume hoods. Consider the following when determining which type of hood is most appropriate for the design, on a lab room by lab room basis:

- Lab minimum required air change rate
- Lab heat load
- Quantity of hoods in the lab room

When analyzing the potential benefit of VAV type fume hoods, evaluate with and without automatic sash lowering devices.

- Assume fume hood sashes with automatic devices will result in an average hood air flow reduction of 30%,
- Assume fume hood sashes without automatic devices will result in an average hood air flow reduction of 10%.
- Factor out hoods where sash closure is not possible due to minimum room air change rate requirements.

Do not diversify fume hood loads relative to exhaust fan/system sizing; assume all hoods are at 14" sash position at all times .

Size supply and exhaust systems with additional capacity for future use. Determine the appropriate additional capacity in consultation with the U-M Design Manager. Minimum additional capacity: 10%.

Size fume hood LTAUs and the associated LTAU branch duct as follows: to maintain a hood face velocity of 60 FPM at the full open sash position. Specify that the LTAU shall be set to maintain a 100 FPM face velocity with the sash 14" above the bench top.

Vivariums:

Vivariums require dedicated, fully redundant air handlers. Vivarium air handlers, animal room exhaust systems, terminal units, and controls shall be fed from the emergency power system.

The air valves serving animal holding rooms shall be selected such that air flow to those rooms can be increased an additional 10% minimum, future. Size the vivarium air handler with sufficient capacity to accommodate this additional air flow capability.

Rooms and LTAUs shall be scheduled. Provide all of the information contained on the UM sample schedule Laboratory Terminal Air Flow Unit Sample Schedule.

Reheat coils shall utilize normally closed (N.C.) control valves to prevent over-heating animals upon a valve failure.

Each animal room exhaust shall be equipped with a duct mounted filter rack. Exhaust grille style filter frames are not preferred but may be used with the permission of the U-M Design Manager.

Ventilation

Lab minimum air changes per hour (ACH) shall be established in consultation with U-M OSEH, in compliance with codes, and in compliance with the Minimum Design Standards for Health Care Facilities in Michigan (when applicable). Typical minimum lab air changes per hour, room pressurization, and air flow control requirements can be found in Appendix A of this Design Guideline.

Negative or Positive Pressure

Pressurization in and out of rooms shall be indicated on plans with directional arrows and airflow quantities (CFM).

Sealing of all room penetrations and joints shall be specified to maintain space pressurization.

If a local means of adjusting space pressurization is requested (typically accomplished with a potentiometer), specify that the adjustment device be clearly labeled to identify which direction produces positive or negative pressurization adjustment. Specify a locking enclosure for the adjustment device. Local means of adjusting pressure is discouraged.

Laboratory Pressurization Gauge

Local pressure indication is not typically required for general purpose labs.

Provide room pressure indication for rooms indicated in Appendix A. Consult Appendix A for indicator requirements.

Emergency Operation

Provide emergency power for laboratory systems where a power failure endangers life safety.

Exhaust fans and corresponding supply fans shall automatically restart when power is restored after a power failure.

Fire detection and alarm systems shall not be interlocked to automatically shut down chemical fume hood exhaust. Exhaust fans shall continue to operate in the event of a failure or alarm condition of the supply air system. For example, if the supply air handler trips on freeze stat or smoke detector, the associated lab exhaust fan(s) shall not shut down. Proper door operation for egress shall be maintained when the supply system shuts down and the lab exhaust system operates, creating a pressure differential. Some large systems may require a design that automatically reduces exhaust fan volumes, to prevent excess negative pressure at egress doors.

Indicate in the Design Intent Document, exhaust system operation under all emergency conditions (loss of power, fire, supply air failure, etc.).

Laboratory Exhaust Duct

Materials

The below descriptions are considered normative for U-M lab projects; however the A/E shall give consideration to the nature of materials being exhausted and shall specify appropriate duct materials, construction methods (e.g. gasket and sealant types, etc.), and duct coatings.

Lab General Exhaust: G-90 galvanized where accessible. Specify plastic coated duct (PCD) in concealed spaces, including shafts.

Chemical Fume Hood Exhaust: PCD from hood to main lateral. If there is insignificant general exhaust flowing through the main lateral, specify PCD for the entire exhaust duct run.

Cage and rack washers, sterilizer and glass washer hoods, and any ductwork carrying moist air: "seal" welded (water leakage tight) 316 stainless steel, from hood to main lateral. Duct shall slope back toward the hood so that any condensate formed in the duct drains away from the main lateral duct. Hoods shall have drain lips, piped to a local floor drain.

Acid Exhaust: Teflon lined stainless steel duct shall be consider in lieu of FRP duct. Note: Obtain concurrence from U-M OSEH that exhaust acidity justifies these specialized materials.

Cage and rack washers shall be exhausted via a dedicated exhaust fan. Therefore the associated duct shall be stainless steel all the way to the exhaust fan, routed as directly as possible, avoiding horizontal runs. LTAUs shall not be used.

Construction

Prohibit tie-rod re-enforcement methods for PCD. Prohibit tie-rods in any duct carrying corrosive exhaust.

Exhaust ducts running on the building exterior will typically require insulation to prevent condensation formation inside the duct during cold outside air conditions. Evaluate the need for drains on exterior horizontal exhaust duct work; see "Fan Construction" for additional considerations regarding such drains.

For exhaust duct connected to animal rooms, specify riveted duct upstream of filters.

Fire and/or Smoke Dampers

Not allowed in laboratory exhaust ductwork per NFPA 45.

Exhaust Fans

Fan Capacity

Specify at least 10% additional design flow at the required system static pressure for all lab exhaust fans.

Fan Selection/Number of Fans

For lab exhaust systems over 10,000 CFM capacity, provide 100% redundant standby fans.

For systems 10,000 CFM or less, consider two fans at 50% capacity each.

For all critical exhaust systems, e.g. Biosafety Level 3 labs, provide 100% redundant standby fans.

Cage and rack washers shall be exhausted via a dedicated exhaust fan.

Fan Types

Centrifugal fan systems are preferred, provided it can shown they safely disperse the effluent. Provide direct drive fans when available.

Direct-drive, high-plume exhaust fans shall be provided on systems above 5000 CFM when no fan redundancy is provided, or when found to be required by dispersion studies.

Location and Design

Exhaust fans shall be located on a roof so that all duct in the building is negatively pressurized. If a roof location is impossible and the fan(s) must be located in a mechanical penthouse or room, design an air tight enclosure around the fan(s) and specify that the discharge duct from the fan be seal welded. Contact the U-M HVAC/Controls Mech Tech team for additional info on air tight enclosures. Provide windows in enclosures to facilitate maintenance.

The fan stack velocity shall be maintained through the use of normally-closed bleed-in dampers or other means. VSDs shall not be used to maintain stack velocity.

Orient the fan discharge duct (stack) vertically from the fan outlet. Extend stacks a minimum of 10 feet above the highest local roof. Design the stack to provide a minimum stack discharge exit velocity of 3000 FPM unless a dispersion study demonstrates a lower tip velocity achieves the required dilution target.

Fan stacks shall be self-supporting. Guy wires shall not be used without the permission of the UM Design Manager.

Fan Construction

Fan housings (centrifugal fans) shall be welded construction with a cleanout door.

Typically fans, fan blades, fan plenums, plenum access doors, and fan back-draft dampers should have a Heresite anti-corrosion coating. Specific applications may require different anti-corrosion coatings. It is the A/E/Lab Planners's responsibility to select appropriate coatings. Also specify a heavy-duty coating for the exterior surfaces that prevents corrosion.

Provide a scroll drain for centrifugal fans (drain valve with hose bib). Fans located in enclosures shall have scroll drains piped to the enclosure exterior, with the drain valve and hose bib on the outside, and the drain labeled as a hazard.

Similar to scroll drains, provide drains in exhaust plenums located outside (drain valve/hose connection/cap). Depending on the relative humidity of the space being exhausted, some exterior plenums will require drains that continuously remove routine condensation formation occurring in winter months. Such drains should be routed to termination points inside the building, and be properly trapped. Provide trap primers. Portions of such drains located outside must be heat traced. Similarly, evaluate the need for drains on exterior horizontal exhaust duct work.

Flexible Connectors

On positively pressurized duct work, flexible connectors are prohibited indoors, except for exhaust fans mounted inside enclosures. Fabric flexible connectors shall never be used. One piece flexible rubber/elastomeric connectors may be used in some low risk applications, with the approval of the U-M Design Manager

Dampers

Motorized control dampers shall be used to prevent back drafting of exhaust fans. Such dampers shall be designed to fail to the "open" position on loss of power. These same dampers shall close when the fan is turned off by normal means.

Motorized bleed-in dampers shall fail to "closed" position.

Damper actuators shall be located outside of the exhaust air stream.

A method of preventing excess negative duct/plenum pressure shall be provided.

Damper construction shall meet or exceed ductwork construction (i.e. protective coating, stainless steel, etc.)

Exhaust Filters

The installation and type of filter in the laboratory exhaust system (if any) shall be determined by The Department of Occupational Safety and Environmental Health (OSEH) or the Radiation Safety Control Department of the University of Michigan, and in compliance with requirements stated in Minimum Design Standards for Health Care Facilities in Michigan, when applicable.

Radioactive hoods typically do not require filters.

All exhaust filters shall be provided with a differential pressure gauge to indicate pressure drop across filter.

Exhaust systems with filters that require a specific stack velocity to achieve required dilution targets must include provisions to maintain stack velocities as filters load up.

Exhaust System Fan Control

Exhaust fans shall be controlled by the owners Building Automation/DDC System. See U-M Design Guideline 15975 Mechanical Systems Controls.

Laboratory Terminal Airflow Units (LTAU) and LTAU Control

Venturi valve type terminal units shall be specified. U-M Master Specification section 15910 Laboratory and Fume Hood Air Flow Controls specifies lab terminal airflow units and associated controls and shall be used as the lab controls specification on projects. The A/E shall edit U-M Master Specification 15910 to make it project specific. *On any project requiring more than 25 LTAUs, consult with the HVAC/Controls Mech Tech Team during SD Phase for specific direction regarding LTAUs/LTAU controls.*

Sizing fume hood LTAUs: See "HVAC and Exhaust Systems Design", above.

Vivarium LTAU Sizing: The air valves serving animal holding rooms shall be selected such that air flow to those rooms can be increased an additional 10% minimum, future.

Fail Mode: Generally, supply LTAUs shall be indicated to fail closed and exhaust LTAUs shall be indicated to fail open.

Coatings: Specify Heresite coating (minimum) for LTAUs serving chemical fume hoods. Specify other protective coating types, as application dictates.

Balancing Damper: Provide a stainless steel balance damper downstream of all LTAUs serving chemical fume hoods, for testing purposes.

Clearances: Utilize U-M Standard Detail Laboratory Terminal Air Flow Unit Clearances to indicate required clearances. "Dash out" required clearances at each LTAU on the plan views. Require that LTAUs be mounted no higher than 2' above the ceiling grid.

Power Requirements: Designate circuits in receptacle panels on each floor for LTAU power supplies. Work with LTAU suppliers to determine the number of 20 amp circuits required. Do not exceed 50 LTAUs per 20 amp circuit.

LTAUs Prohibited: On exhaust connected to a dedicated fan serving cage and rack washer exhaust.

Laboratory Supply Air Diffusers and Registers

Terminal Velocity

Terminal velocity of supply air near fume hoods, bio-safety cabinets, etc., is as important as hood velocity and should preferably be no more than 1/2 the hood or cabinet face velocity (near the hood). Therefore terminal throw velocities in areas with hoods or cabinets should be far less than those typical for lab air supply.

Optimize design and layout of supply air devices in consideration of all lab requirements, including velocity, throw and low flow performance.

Perforated Diffusers

To avoid cross draft problems, when supply diffusers must be located near fume hoods or other sensitive cabinets, consider perforated diffuser technology (similar to Titus RadiaTec or TriTec) that diffuses supply air in a radial manner at high volumes and low velocity.

Wall Registers

If wall registers are used in labs with hoods or cabinets, they should have double deflection louvers and shall be set for maximum deflection position away from the hood.

First Cost Optimization/Energy Conservation

Comply with U-M Design Guideline SID-D.

Provide fan coils/chilled beams or other strategies to reduce the quantity of "once-through" outside air required for cooling. Chilled beams, if proposed, shall be reviewed and approved by the HVAC/Controls Mech Tech Team.

In spaces with high once through air requirements (> 6 ACH), evaluate strategies to reduce reheat coil pressure drops, such as larger face area reheat coils or radiant heating panels or floors in lieu of duct reheat coils.

At each phase, the A/E/Lab Planner shall calculate the following and indicate the result in the Design Intent Document:

- Fume hood density per 5000 gsf of building
- Fume hood density per 5000 nsf of lab

Densities above 3 hoods per 5000 gsf shall be justified. Consider alternatives such as snorkels and chemical storage cabinets.

Evaluate the following technologies (also see "HVAC and Exhaust Systems Design", above, for required analysis parameters):

- Variable volume hoods
- Automatic sash closure systems
- Devices to reduce hood face velocity when users are not standing in front of the hoods, e.g. "zone presence sensors".
- Controls to reduce the minimum room air change rate when the lab is unoccupied.

Evaluate low flow hoods. Specific low flow hood manufacturers must be approved by U-M OSEH.

Improve ventilation air flow efficiency by reducing the pressure drop of air system components. The following targets (maximums at full design flow) shall be met for all once through air handlers that will run continuously:

- Air Handler Component Face Velocity: 400 FPM
- Total supply and exhaust duct pressure drop: 2.25 in. w.g.
- Noise Control (silencers) 0.25 in. w.g.

For manifolded exhaust systems, evaluate the energy benefit gained from additional fan staging (i.e., from smaller staging increments), by increasing the number of fans drawing air from common exhaust plenums.

Exhaust Air Heat Recovery: Evaluate heat recovery (enthalpy) wheels, flat plate air-to-air heat exchangers, heat pipes (including pumped type), and run-around coils. Include impact of additional pressure drop through each device type.

Avoid tight temperature and humidity requirements. Normal lab setpoints are:

Summer: 74 dbt minimum, humidity floating but no greater than 60% RH

Winter: 70 dbt maximum, humidity floating but no less than 25% RH.

Setpoints outside these ranges shall be justified in the Design Intent Document.

Measure comparable U-M laboratories to establish HVAC plug/equipment loads during early SD phase, and base the lab design on this measured data. For each comparable laboratory space, obtain 7 days of continuous power metering at the branch circuit panel level of all lab equipment, including plug loads and hard wired equipment, while the spaces are fully occupied. Continuous metering data shall include:

- Apparent instantaneous power
- Real instantaneous power
- Real power averaged over 15 minute intervals

The design heat load criteria shall be based on the 15 minute time averaged Real power draw of the comparable space, unless the lab user group can validate higher heat load requirements. U-M will provide the labor to take the measurements, however the A/E/Lab Planner in conjunction with the U-M Design Manager will identify comparable laboratories and analyze the collected data.

Laboratory luminance levels shall not exceed IESNA Handbook (most recent edition) foot candle levels.

Appendix A

Table 1:

Typical Minimum Air Changes, Room Pressurization, and Air Flow Control

Room Type	Occ. ACH	Un- Occ. ACH	Air Flow Control	Pressurization	Comments
Open Wet Lab- Research	6	4	V	N	
Open Wet Lab- Teaching	6	4	V	N	
Dry Lab	4	1	V	N	No significant chemical, biological or physical hazards present
Chemical Labs- Teaching	10	4	V	N	
Synthetic Chemistry	10	6	V	N	
Bio-Chem Analysis/Micro Biology/Genomics/Proteomics	6	4	V	N	
Genome DNA Processing	6	4	V	N	
Tissue Culture, or any room containing BSCs	6	4	V		Pressure relationship is dependant on project, typically negative. Provide visual pressurization indicators.
Equipment Rooms (Labs)	6	4	V	N	Rooms w/high sensible loads due to freezers and other research equipment.
Fume Hood Alcoves	6	4	CorV	N	Hoods to be CV or VV as justified by LCC analysis
Animal Holding Rooms: Ventilated Racks	6	6	C	A	If ventilated racks with rack mounted fan packs are utilized, room air change rates must be as listed for static rack rooms. Provide visual pressurization indicators.
Animal Holding Rooms: Static Racks	10	10	C	A	Provide visual pressurization indicators.
Animal Procedure Rooms	6	6	C	A	Provide visual pressurization indicators.
Laboratories affecting Patient Care in UM Hospital & Health Center Facilities	See Minimum Design Standards for Health Care Facilities in Michigan				

ACH: (minimum) Air Changes per Hour **C:** Constant Volume **V:** Variable Volume **N:** Negative
A: Adjustable

Table 1 indicates the minimum ACH, method of air flow control, and room pressurization relative to adjacent spaces, for typical laboratory and vivarium spaces at U-M. The above table is a guide only; requirements should always be validated for the specific project. Also see "Design Philosophy", below.

For variable volume systems, the minimum setting of terminal units (LTAUs)shall provide the room ACH value indicated. The A/E shall indicate this minimum setting on the drawings. The maximum settings, which shall also be indicated on the drawings, shall be as required to account for sensible and latent loads, and for exhaust make-up. Where a reduced ACH is indicated in the unoccupied column, such spaces shall, if meeting a 6 year simple payback criteria (SID-D), be provided with methods (e.g occupancy sensors, etc.) to allow un-occupied setback of the minimum ACH.

All rooms where bio-hazardous research is conducted shall be designed to provide negative pressure relative to adjacent spaces, and shall include visual pressure indication. Bio-hazardous research is defined as:

A. Recombinant research at BSL 2, 2+, or 3, as classified by the NIH office of Recombinant DNA Activities.

B. Infectious disease research at BSL 2 or 3, as classified by CDC/NIH Biosafety Guideline.

Offices contained within lab areas shall operate as positive with respect to the lab.

Where indicated, visual pressurization indicators shall be provided so that room occupants can locally verify the direction of room pressurization. Provide analog room pressurization gauges outside and above laboratory door(s) (*inside*, outside, and above the door of BSL-3 labs) to indicate pressurization. Analog gauges are preferred over the installation of "ping pong ball" style indicators. Specify a gauge range that will indicate both positive and negative pressure. Typical range: negative 0.25 to positive 0.25 inches w.c.

Design Philosophy: Typical minimum air change rates (Table 1) offer both opportunity and challenge to "right size" ventilation to appropriately meet safety needs while reducing energy waste. The "occupied" minimums listed are about half of what was once considered to be conventional for laboratory ventilation. The "unoccupied" minimums recognize that it is often prudent to reduce ventilation rates when no employees or students are present, and reliable technology is now in common use that allows this energy-saving functionality. The University of Michigan recognizes that such ventilation minimums are achievable through: (1) Progressive or innovative laboratory design – moving heavy chemical use out of the large/open laboratory spaces and into segregated fume hood alcoves; (2) Sound risk assessment – closely examining the hazardous materials and methods to be used in a given space or zone over time, and ensuring minimization or micronization of hazardous chemical quantities and processes. When such factors come into play, opportunities quickly arise. The risk assessment portion of this evaluation process must be conducted in conjunction with the U-M Department of Occupational Safety and Environmental Health to determine suitability of ventilation minimums for the proposed spaces and research or teaching they will support.

Appendix B

Perchloric Acid Fume Hood Systems

Perchloric acid fume hood designs shall be reviewed and approved by U-M Occupational Safety and Environmental Health Department (OSEH). The following are general guidelines. The designer should also adhere to the perchloric hood requirements found in NFPA 45.

Exhaust System:

Provide a dedicated exhaust system for perchloric exhaust. Do not manifold with other exhaust systems (e.g. toilet exhaust, particulate exhaust, etc.).

Terminate vertical stacks no less than 100 feet from an air intake.

Equip the ventilation system with a built-in water wash-down system. Automatic wash-down systems are normally recommended and should be reviewed with the U-M Design Manager and U-M OSEH. Ensure that the system will adequately spray all interior surfaces of the duct, plenum, fan, fan stack, and hood. Additionally, perchloric acid fume hoods shall be provided with wash down nozzles for rinsing the area behind the baffle. Service fitting controls for internal outlets and for the wash-down system shall be external to the hood. Drain(s) shall be provided to catch the wash-down water. The point of drain discharge shall be approved by U-M OSEH. Drain material shall be polypropylene. A backflow preventer shall be provided on the cold water supply to the wash-down system. Provide a frost proof hydrant near the fan/fan stack to allow manual wash-down.

Duct:

Route via the shortest and straightest route possible to the outside, with no offsets or horizontal runs. Provide positive drain back to the hood. Indicate clearly on the design drawings that the contractor may not modify the duct design without written approval from the engineer.

Duct material: acid resistant, non-reactive materials selected for the specific chemical use in the hood; typically shall be all welded 316 stainless steel. For final connections where welded joints are not possible, specify gaskets and sealants that are non-reactive and resistant to perchloric acid. Require 316 stainless steel fasteners or fasteners with corrosion resistance equivalent to the selected duct material. Specify that all duct shall be watertight.

Flexible connections shall not be used.

Provide access to permit visual inspection of duct internals.

Labeling:

Require duct, fans and stacks to be marked as follows:

<u>EXPLOSION HAZARD</u>

Do no service work or inspection on this duct without prior approval from U-M Occupational Safety and Environmental Health Department.

Locate markers near points where ductwork originates or continues into shafts, floors or walls, and at maximum 5' intervals along duct runs.

<u>Fans:</u>

Eductor type fans systems shall normally be used in lieu of conventional fan arrangements.

Specify acid resistant, non-reactive fan materials selected for the specific chemical use in the hood. Teflon or PVC coated blades can typically be used.

Specify Type A spark proof fans.

Specify fan types with fan motors located outside the duct work. Drive belts shall be non-spark conductive type and shall not be located within the ductwork.

Appendix C

Definitions

Capture Velocity

The air velocity at the hood face or capture device necessary to overcome opposing air currents, and to contain contaminated air within that device.

Face Velocity

Speed of air moving into fume hood entrance or working access opening, usually expressed in feet per minute (FPM).

Hood - Laboratory Fume

A ventilated, enclosed work space intended to capture, contain and exhaust fumes, vapors and particulate matter generated inside the enclosure. Biological Safety Cabinets are not fume hoods and the two are not interchangeable.

Hood – (Full) By-Pass Constant Volume Fume

A constant volume fume hood that maintains hood face velocities with-in an acceptable range regardless of sash position. This is typically accomplished by the use of a bypass opening located on the upper face of the hood, which opens or closes to compensate for variations in sash position. Use vertical operating sashes only on constant volume hoods because combination and horizontal operating sashes will likely cause unacceptable variances in face velocity depending on the sash position. There is no industry recognized standard definition of the terms “bypass”, “restricted bypass”, or “partial bypass” and thus hood performance attributes should be specified rather than relying on generalized terminology.

Hood - Restricted By-Pass

A hood that restricts the amount of bypass air through a bypass grille to only that amount necessary to maintain containment around the sash edges at all sash positions. There is no industry recognized standard definition of the term “restricted bypass” and thus hood performance attributes should be specified rather than relying on generalized terminology. Restricted bypass hoods are appropriate for VAV hood applications only, not constant volume types.

Hood - Variable Air Volume Fume

A fume hood that maintains a constant face velocity while generating a variable volume of exhaust air flow through the positions of a vertical, horizontal or combination operating sash.

Hood - Low Flow (“High Performance”) Fume

A fume hood that can pass ASHRAE 110 “as-manufactured” testing with face velocities typically less than 80 FPM. However, there is no industry recognized standard definition of the term “low flow ” or “high performance” and thus specific hood performance attributes should be specified rather than relying on generalized terminology

Hood - Auxiliary Air Fume

A fume hood typically using “raw” outside air for make-up air; should not be used at U-M except by special permission from the U-M Design Manager.

Laboratory Terminal Airflow Unit (LTAU)

Venturi-type terminal control valve.

Main (duct) Lateral

Large duct main running on a lab floor with multiple fume hood and general exhaust duct connections such that the large proportion of general exhaust connections is expected to result in a very dilute exhaust air stream.

Make-Up Air (Once-Through Air)

The supply of outdoor air to a building replacing air removed by exhaust ventilation systems.

Seal Welded Duct Joints

Both the longitudinal and transverse duct joints are continuously welded to form a 100% air and water tight seal.

Vivarium

A cluster of animal housing areas and support facilities. Fume hood and other exhaust accessories are often included as part of the design for these facilities, and therefore require special system design considerations.

End of U-M DG 15910

VARIABLE FREQUENCY DRIVES

Related Sections

U-M Design Guideline Technical Sections:
15960-H Supplemental Variable Speed Drive Guideline for UMHHC Facilities
16156 Variable Speed Drives

U-M Master Specification:
15170 Motors
15960 Variable Frequency Drives

U-M Standard Details:

Variable Frequency Drive Specifications

U-M Master Specification Section 15960 Variable Frequency Drives shall be used as the VFD specification on all projects. The A/E shall edit U-M VFD spec. 15960 to make it project specific. Turn on hidden text and read all spec. editors notes when editing the specification.

Pay special attention to the following when revising the spec. to make it project specific:

- VFDs used in U-M Hospital and Health Care Facilities may need to be 18 pulse type. Refer to the UMHHC Design Guideline 15960-H, and modify the specification to indicate 18 pulse VFDs when required for UMHHC facilities. See additional discussion on VFD pulse requirements, below.

- Additional editing is not typically required. Do not strike features required by the specification without the consent of the U-M Design Manager. Features listed are typically required for all VFDs, even if not immediately utilized by the subject project.

Pulse, THD, Disconnect, Early Break Contact, and Motor Requirements

U-M's master specification for VFDs requires minimum 6 pulse PWM type VFDs. With the exception of some UMHHC locations, it has been found that 12 or 18 pulse VFDs are not required provided the VFD complies with all other aspects of the U-M master spec. Therefore the AE should not indiscriminately specify higher pulse VFDs.

The U-M VFD master spec. limits the maximum current total harmonic distortion (THD) to not more than 100% of the VFD input current waveform at any VFD operating speed from 20% to 100%, and requires the manufacturer to provide minimum 3 percent AC line reactors and/or minimum 5 percent DC link reactors. It additionally specifies that if the maximum

THD is exceeded, the manufacture shall provide additional line reactors to reduce the THD to within specified limits. *Therefore the AE must include the requirement that each VFD's current and voltage THD be measured in the electrical testing section of Division 16.*

Avoid installing VFDs on the same bus as capacitors or harmonic sensitive equipment.

The U-M VFD spec. 15960 requires all VFDs to include a disconnect switch that is pad-lockable in the open position.

> For VFDs that are in sight from the motor, no separate disconnect is required between the VFD and the motor.
>
> For VFDs that are not in sight from the motor, provide a separate disconnect between the VFD and the motor that is in sight of the motor.
>
> > <u>Exception for VFDs serving air handlers</u>: If the VFD is in sight of the door that accesses the air handler section containing the motor, a disconnect is not required between the VFD and the motor. If the VFD is not in sight of that door, provide a disconnect adjacent to the door.

"In sight from the motor" is defined by the National Electrical Code as being visible from and not more than 50 feet from.

When a separate motor disconnect switch is provided, the disconnect shall include automatic "early break" auxiliary contacts that deactivate the VFD whenever the motor disconnect switch is opened. The wiring associated with the early break contacts may be run in the same conduit as the power wiring to the disconnect. Assure the electrical drawings indicate the required early break contact wiring.

U-M requires motors driven by VFDs be inverter duty rated per NEMA MG-1 part 31. Insulated motor bearings or shaft grounding brushes are not required.

<u>Redundancy and VFD Bypass Devices</u>

VFDs serving non-redundant equipment shall be scheduled with a bypass device. Examples:

- A variable volume air handler with a single supply and a single return fan: A bypass device is required on both VFDs.
- A variable volume air handler consisting of (2) supply fans and (2) return fans, each of which is sized to handle 50% of the peak load: A bypass device is required on all (4) VFDs.
- A pump set consists of (3) pumps each sized to handle 50% of the peak load, therefore a fully redundant pump has been included. None of the pump VFDs should be scheduled with a bypass device.

The electrical and mechanical systems associated with the VFD shall be sized and braced to allow the driven system to safely start and operate when the VFD is placed in bypass mode. The AE shall also include over pressure protection or similar devices that prevent damage to the driven mechanical equipment and associated components such as duct and pipe, when the motor is operated (full speed) across-the-line via the bypass device.

Although rarely required, evaluate the need to provide an automatic bypass feature that automatically connects the motor directly across the line if the VFD faults or fails. When an automatic bypass is provided, motor overload protection, run permissive, and safety circuits shall remain active with the VFD in automatic bypass.

General Design and Design Document Requirements

When a piece of equipment or a system includes multiple motors (e.g. an AHU with a supply and a return fan), provide a VFD for each motor. Do not control multiple motors with the same VFD.

The AE shall schedule the VFDs on the mechanical drawings. The following minimum information shall be indicated in the schedule: Equipment Served, Horsepower, Voltage, Short Circuit Current Rating, Input Signal (typically 4-20 mA), Bypass Device Y/N, Emergency Power Y/N.

U-M's normal convention is to have the mechanical trade furnish the VFD and the electrical trade install the VFD.

VFDs should be located indoors and as close to the driven motor as practical.

VFDs are considered motor controllers by the NEC. Do not locate piping or ductwork directly above the VFD. Maintain proper NEC clearances in front of the VFD panel, typically 42" deep.

VFDs may be mounted on walls or may be free standing. Free standing units shall be designated as mounted on a Unistrut style rack. VFDs shall not be mounted on the housings of mechanical equipment.

End of U-M DG 15960

MECHANICAL SYSTEMS CONTROLS

Related Sections

U-M Design Guideline Technical Sections:
15910 Fume Hood and Laboratory Ventilation

U-M Master Specification:
15010 – Basic Mechanical Requirements
15910 – Laboratory and Fume Hood Air Flow Controls
15975 – Mechanical Systems Controls

U-M Standard Details:
Typical DDC Panel Assembly
Differential Pressure Transmitter Installation Detail (Liquid)
Sample Control Drawings (future)

General

This Design Guideline does not apply to laboratory and fume hood air flow controls; see Design Guideline 15910 for these systems.

Direct digital controls (DDC) are the standard for control at U-M. Pneumatic or other non-DDC controls are limited to very small systems and shall only be specified with the Design Manager's permission.

U-M Master Specification Section15975 Mechanical Systems Controls shall be used as the controls specification on all projects. The A/E shall edit U-M Master Specification 15975 to make it project specific.

U-M has an extensive Building Automation System (BAS) that networks to localized DDC controls. This system utilizes propriety Siemens components as well as non proprietary generic controls. UM has negotiated pricing for the proprietary components and purchases these direct from Siemens for projects. U-M also self performs a portion of the DDC control work. Project budgets must (also) include the cost of the proprietary components and U-M's self performed work. During budget planning, the U-M Design Manager will provide information regarding how these costs are to be accounted for in the budget.

U-M vs Contractor Work Scope

The A/E should consult the first few pages of U-M Master Specification 15975 for detailed information regarding the split of control work, university versus contractor. By utilizing U-

M's control specification, proper work scope split occurs automatically and is essentially transparent to the A/E design effort. Note that non General Fund auxiliary units may handle controls differently; always consult the Design Manager. In general, the split is as follows:

U-M: Provides proprietary DDC panels, terminates inside these panels, and programs and starts-up the DDC panels. Provides application specific terminal equipment controllers (TECs) for contractor installation (e.g. DDC VAV box controllers) and room sensors for TECs.

Contractor: Supplies and installs: all field devices (transmitters, actuators, control valves, control dampers, transducers, etc.), all control wiring and tubing, all auxiliary control panels, and prepares a complete controls submittal. Mounts U-M supplied DDC panels. Installs TECs and TEC room sensors.

The detail "Typical DDC Panel Assembly" provides a graphical representation of the work split.

Using U-M Master Specification 15975

The A/E shall use U-M Master Specification 15975 as the basis for the control specification and edit it to make it project specific.

When editing this spec, assure hidden text is tuned "on" and carefully review all spec editor's notes.

Special attention should be paid to the following articles:

- Article 1.3: Edit the list of acceptable controls contractors in consultation with and as approved by the Design Manager.

- Article 2.2: Obtain approval for the type of steam condensate meter to be used, and then edit the spec accordingly.

- Article 2.3: U-M supplies application specific TECs for DDC terminal (VAV, CAV, etc.) boxes. The controls contractor is responsible for mounting these TECs on the boxes. The A/E must edit his specification for such boxes to assure the box manufacturer only supplies the components listed in article 2.3 (e.g. pneumatic damper operator and air flow arrays), NOT DDC controllers. *On the rare occasion pneumatic VAV box controllers are used, specify that the box manufacturer provide a Krueter model CSC-3011 controller, a normally open damper, and a damper operator.*

- Article 2.6: If electrical actuators are used, power for these actuators must be accounted for on drawings. Read the spec editor's note in this article for further direction.

The U-M master specification includes specifications for most types of control components. In some cases the A/E will need to add supplemental specifications for atypical components.

Control or automatic dampers (actuated dampers) are specified in Master Specification 15975. The A/E's specification should include no other control damper specifications, and specification sections requiring factory provided control dampers, e.g. air handler specifications, shall reference Master Specification 15975 for the control damper spec.

Control Drawings

The required scope of a project's controls shall be indicated by the use of control drawings. Each control drawing shall include a detailed sequence of operation.

Control drawings and sequences shall appear on the mechanical drawings; they shall not appear in project specifications.

Control drawings shall utilized U-M's standard controls symbology. Normally, U-M will provide sample control drawings in electronic format for A/E use, which will include sequences of operation. Revise these drawings to make them project specific. Revise sequences of operation to include strategies specific to the project (example: change-over to free cooling). Include all project specific setpoints and alarm values. Provide similar control drawings for systems not available from U-M's samples.

Wiring diagrams shall be provided on the control drawings that indicate the method of starting fans, pumps, and other equipment, safety interlocks, interface to manufacturer's provided controls, etc. These diagrams may be schematic in nature but shall indicate fundamentally how electrical control is accomplished.

"Point Lists" are not required and shall not be used.

DDC Panel Locations, Clearances, and Communication Wiring

The control drawings shall include system architecture diagrams specific to the project. These diagrams indicate the location and quantity of DDC and auxiliary panels. U-M will normally provide this information to the A/E, for inclusion on the project drawings.

The controls contractor will run all communication wiring between DDC panels and TECs. Communication wiring is to be indicated on the system architecture diagram, including wiring back to a telephone closet.

Each DDC panel will have one or more auxiliary panels. See "Typical DDC Panel Assembly". The A/E shall indicate the location of these panels on the plan views. For a typical assembly allow 7'of wall space; note that some panel assemblies require more space, consult with U-M. Locate panels to provide a minimum of 36" clearance in front of each panel, and designate this clearance on the drawings.

Power for Controls

DDC Panel Assemblies: Each assembly (not each panel in an assembly) shall be provided with (2) 20 amp dedicated circuits (separate circuit breakers). Indicate these circuits on the electrical drawings, home-runned to the panel assembly location.

TEC Power (DDC VAV box controllers, etc.): Designate circuits in receptacle panels on each floor for TEC transformers. Provide one 20 amp circuit for every (50) Terminal Equipment Controllers.

Actuator Power: See Master Specification 15975, Article 2.6.

Power for meters and other control accessories that are provided by the controls contractor: This is provided through a fused disconnect located in the DDC auxiliary panel and is part of the controls contractor's scope of work per U-M Master Specification 15975. Therefore the A/E does not need to typically indicate power for such items on the design drawings. See U-M Master Specification 15975, article 2.5.

Life Safety Control

U-M's DDC system is not listed for life safety use and therefore shall not be used for initiating or alarming life safety applications. Two common examples are as follows:

> Stair Pressurization Control: The building fire alarm system will initiate operation of the stair pressurization fans. Any controls required for stair pressurization shall be stand-alone from (and independent of) the DDC system.
>
> Atrium Smoke Purge: The building fire alarm system will initiate atrium smoke purge. Any controls required for smoke purge shall be stand-alone from (and independent of) the DDC system.

However, the controls contractor will provide the stand alone components (dampers, end-switches, pressure transmitters, etc.) and therefore these components shall be indicated on the control drawings and include complete sequences of operation.

Manufacturer Provided (Packaged) Controls

Chillers and boilers shall be equipped with manufacturer provided controls. Manufacturer provided controls shall typically be limited to control of the chiller (boiler) itself. Control of the chiller (boiler) plant (chiller (boiler) sequencing, etc.) shall be by U-M's DDC system. Boiler sequencing panels should not normally be specified.

Packaged controls should also be specified for equipment normally equipped that way, such as storm/sanitary pumps, RO/DI systems, vacuum pumps, air compressors, pollution control (air and water treatment) systems, refrigerant leak detection, fuel oil systems, DX systems, condensate pumps, etc. See the respective design guideline for these systems for any specific requirements for the packaged controls.

Packaged controls shall not be specified for air handlers, unless specific permission is given by the U-M Design Manager.

Control Air

For central campus projects, 90 PSIG compressed air is available from the campus steam tunnel system at +20ºF dewpoint. This air shall be utilized for control air use. U-M Master Specification 15975 requires the controls contractor to provide desiccant dryers for control air exposed to outside conditions.

For other campus locations, a control air compressor will normally be required. U-M Master Specification 15975 specifies control air compressors and accessories (PRV stations, refrigerated air dryers, etc.).

In either case, A/E drawings shall indicate the source of control air.

Electric vs. Pneumatic Actuators

Damper actuators and large control valves shall be pneumatically actuated, except for special conditions as approved by the U-M Design Manager. Small dampers and valves controlled by TECs shall utilize electric actuators, as indicated in U-M Master Specification 15975.

Smoke and combination fire/smoke dampers shall be pneumatically actuated.

Typical Alarms to be Monitored by DDC

In addition to the typical status alarms associated with DDC control, the DDC shall be indicated as monitoring the following equipment. Equipment should be specified with a common alarm contact for DDC monitoring, not separate alarm contacts for each alarm condition, except as noted:

- Sanitary and Storm Pumps (common alarm: high level, seal failure, etc)
- Cold/Warm/Environmental Rooms
- Walk-in Freezers
- Heat Trace
- Emergency Generator (trouble, start)
- Automatic Transfer Switch Status (related to emergency generators)
- Critical Unitary A/C units (for example, computer rooms)
- RO/DI Systems
- Pollution Control Systems
- Fuel Oil Systems
- Refrigerant Leak Detection Systems
- Chiller Relief Valve Status
- Domestic Water Booster Pump Systems

- Glycol Make-up Systems (separate low pressure and low level alarms)
- Substation Room Temperature

The above list is not exhaustive. The design team shall carefully consider and include alarm monitoring appropriate for the project. *The A/E shall indicate any special alarm setpoints on the control drawings* (e.g. critical humidity limits in a clean room or museum).

Miscellaneous

DDC controlled heating hot water heat exchangers shall include back-up pneumatic control.

DDC controlled cooling towers shall include a pneumatic controller to provide back-up control of the tower condenser water bypass valve arrangement .

Exterior lighting associated with new buildings shall be controlled by DDC. DDC shall turn the lights on and off, and status the lighting contactor (via a current sensing relay). The contract drawings shall indicate a contactor for exterior lighting control by DDC.

U-M utilizes a central weather station that transmits outside temperature and humidity conditions across the BAS network. Therefore local outside temperature and humidity transmitters should normally not be indicated.

Fan systems capable of developing static pressures in excess of the duct system's (air handler casing, plenums, ducts) static pressure rating (positive or negative) shall be equipped with static pressure safeties to turn off the fans prior to damage occurring from excessive pressure. The AE should not indiscriminately specify these devices but shall include them based on an evaluation of the maximum pressure the fan can develop, the pressure class of the duct system, damper pressure ratings, and the degree of risk.

In general, for air handlers, heating coils shall be designated as fail open, and cooling coils shall be designated as fail closed.

For reheat coils in zones serving animal rooms, reheat coil control valves shall be **normally closed** type. This avoids a wild coil condition from severely over-heating the animal room.

Include U-M's "Differential Pressure Transmitter Installation Detail (Liquid)" on any project utilizing liquid DP transmitters.

For all air and liquid flow measuring devices, the AE shall indicate their location on the plan views as well as on the control drawings. Design the duct or piping at the meter location to provide the manufacturer's required up and downstream straight and unobstructed lengths, and indicate these requirements on the drawings. When in doubt as to specific manufacturer's requirements, provide 10 straight diameters upstream and 5 straight diameters downstream.

End of Design Guideline 15975.

TESTING, ADJUSTING, AND BALANCING

General

This design guideline describes use of U-M's Test Adjust and Balance (TAB) specification, TAB design considerations, minimum TAB data to be shown on design documents, and the contracting of TAB work.

Related Sections

U-M Design Guideline Technical Sections:
15910 Laboratory Ventilation

U-M Master Specification:
15910 Laboratory and Fume Hood Air Flow Controls
15990 Testing, Adjusting, and Balancing

U-M Standard Details:

TAB Specifications

U-M Master Specification Section 15990 Testing, Adjusting, and Balancing shall be used as the TAB specification on all projects. The A/E shall edit U-M TAB spec. 15990 to make it project specific. Turn on hidden text and read all spec. editors notes when editing the specification.

Pay special attention to the following when revising the spec. to make it project specific:

- Scope of Work Section: Remember to include systems such as domestic hot water return, RO/DI, and process cooling water systems, if TAB work is required on such systems.
- Acoustical Testing Section: Describe the requirements for any needed special accoustical testing. This section also requires sound readings be taken in 6 rooms designated by the AE. It is recommended this requirement always be left in the spec. in case any noise trouble shooting is needed after construction is complete.
- Performance Testing Section: If required, include specific details regarding the tests required.

Review and edit as appropriate, the balancing procedures included in the specification, and add any additional procedures required for unique or complex systems (e.g. BSL3 labs, clean rooms, etc.). If requested by the construction team, participate in the pre-balance conferences described in the spec. to explain the design intent and answer questions about the appropriate TAB procedures.

Be aware that the U-M TAB spec requires submittals relative to the TAB work, including proof of TAB technician qualifications, TAB instrument type and calibration, and proposed reporting forms. The AE must approve these submittals prior to any TAB work commencing.

The U-M TAB spec. requires equipment vibration testing for all rotating equipment ½ HP and larger. If a project is limited to one or two pieces of small horsepower equipment in low risk areas such testing becomes cost prohibitive and the AE should strike it from the spec. Vibration testing should always be included on projects with large equipment or significant rotating equipment quantities.

Note that the U-M TAB spec does not cover ASHRAE 110 fume hood testing.

Note that the U-M TAB spec requires that progress TAB reports be submitted within 3 days and final TAB reports within 1 week of the completion of TAB field work.

Pre-Construction TAB Work

When appropriate, require the TAB trade to perform pre-construction and post-construction TAB work, in particular when spaces are renovated, to measure representative flows, pressures, and/or temperatures of other areas served by common systems. In some cases it may be appropriate to issue a separate contract for pre-construction TAB work.

TAB Design Documents

All required TAB data shall be clearly indicated on the design documents, including the following:

- Code minimum outside air CFM for each air handler
- Air handler supply fan/ return fan/exhaust fan CFM offset (as it relates to building pressurization)
- Dirty filter pressure drops
- Fume hood face velocity alarm point
- Room pressure offsets for rooms designed with CFM offset. Indicate the amount of offset (in CFM) with an arrow pointing in the appropriate direction, across each of the room's doors. Note that the U-M TAB spec. requires smoke-stick tests to validate the offset direction at these room types
- Room pressure offsets for rooms controlled to a setpoint (e.g., to an inches w.c. setpoint) (list on control drawings).

The scope of the TAB work shall be clearly delineated in the design documents. As appropriate, require that the entire system in a renovation project be rebalanced, in particular to assure un-renovated areas are not adversely affected by new work. Include the TAB data for both the new and unaltered portions of the system.

Note that proper architectural patching of room penetrations will be required for any room with pressure offset. The mechanical engineer is advised to assure the project documents thoroughly cover this requirement.

TAB Contracting

The University of Michigan limits TAB work to pre-approved contractors. These contractors are listed in the U-M spec. The AE shall not add or delete from the contractors listed in the spec. unless directed otherwise by U-M.

The preferred and best practice is for the TAB trade to be under contract direct to the Owner rather than as a sub-contractor to another trade. Discuss the TAB contracting arrangement with the U-M Project Manager and prepare bid documents as directed.

Air and water balance should always be done by the same TAB contractor, and is a requirement of the U-M TAB spec. If a project is so large that multiple TAB contracts are required, the scope of work split should be by building area, with one contractor doing all air and water balance for a specific area, and for all systems that serve that area. Splitting all air to one TAB contactor and all water to another TAB contractor significantly dilutes the efficacy of the TAB procedures and is never advisable.

End of U-M DG 15990

TESTS - PIPING SYSTEMS

General

The A/E shall stipulate that the contractor should be responsible for providing all test equipment required to conduct these tests. He should not rely on installed pumps or gauges. Test gases should also be provided by the contractor. Calibration certificates should be provided to the University at completion of test.

Pressure Requirements

The following pressure test and cleaning procedures shall be specified unless the A/E determines that more stringent requirements are necessary for the specific piping system under design.

System	Test Media	TestPressure*	Permissible Pressure Drop
Underground potable water	water	150 psig	0 psig in 4 hours
Above ground water	air/water	100 psig	1 psig in 2 hours
Steam to 50 psig	air/water	100 psig	1 psig in 2 hours
Steam to 125 psig	air/water	200 psig	3 psig in 2 hours
Condensate to 50 psig	air/water	100 psig	1 psig in 2 hours
Condensate to 125 psig	air/water	150 psig	2 psig in 2 hours
Compressed air	air	150 psig	2 psig in 2 hours
Natural gas	air	100 psig	0 psig in 2 hours
Fuel oil	air/water	100 psig	1 psig in 2 hours
Refrigerant	1st: dry carbon dioxide	250 psig	no leaks by soap test
	2nd: freon and CO_2	150 psig	no leaks by halide torch
	3rd:	28" vacuum	0 psig in 12 hours

*or 1 1/2 times operating pressure, whichever is greater.

Certified Test Report

For each system tested, the contractor should provide a certificate testifying that the system was satisfactorily tested as specified and passed. The certification should also provide the following information.

Identification of system tested referencing specific equipment connected to the system

- Date tested
- Test pressure and duration of test
- Recorded test pressure at end of test
- Media used for testing
- List of necessary repairs made before system passed the test
- Signature of contractor
- Signature of University mechanical inspector
- Other data as required by the A/E

Installation Requirements

Chemically clean piping system of all welding slag. Operate the system for 1 week, then drain and flush out. Replace all start-up strainers with permanent strainers and leave the system in proper working order.

Flushing of Piping Systems

In order to obtain a fluid velocity adequate for flushing (approximately 6 fps) normally the system pumps must be operated with some portions of the system sequentially isolated. Plans and specifications must detail adequate isolation valves, coil bypasses (e.g., so heat exchanger tubing is not plugged), temporary strainers, etc. so that the flushing is effective. Renovation projects (where only a portion of the system piping is replaced) should consider cleaning the entire system or specifying a means of cleaning the new portion only.

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Web Design Guidelines

Design Guidelines - Division 16 Electrical

Always use the most recent version. Obsolete versions are for reference only.

SECTION	DATE OF LAST UPDATE	PAST VERSIONS
16010 Basic Electrical Requirements	September 2009	May 2009
16050 Basic Electrical Materials and Methods	June 2003	October 2002
16110 Underground Electrical Service	October 2002	September 2000
16120 Wires and Cables	February 2005	September 2000
16140 Wiring Devices	March 2004	
16156 Variable Speed Drives	June 2003	July 1994
16231 Engine-Generator System	October 2009	April 2009
16300 Electrical Power Systems	June 2003	September 2000
16305 High Voltage Distribution	June 2003	
16310 Unit Substations	February 2005	March 2004
16400 Service and Distribution	July 2003	
16450 Grounding	March 2005	
16480 Motor Controls	March 2005	
16500 Lighting Systems	February 2004	July 2003
16521 Site Lighting	May 2008	June 2007
16550 Lighting Controls Systems	March 2004	

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For technical inquires, comments and suggestions on the U of M Design Guidelines, please e-mail the U of M Design Guidelines Group at UMDesignGuide@umich.edu.

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BASIC ELECTRICAL REQUIREMENTS

General

Scope

Prepare the project's electrical design and associated contract documents in accordance with these Design Guidelines, in accordance with the scope of work defined in the Program Documents, and within the construction budget.

Related Sections

Design Guideline Technical Sections:
Special Instructions to Designers
Special Building Areas
Division 16 - Electrical Technical Sections
Electrical Trades Preferred Manufacturers List
Design Deliverables

U-M Master Specifications:
Division 16 - Electrical Master Specifications

U-M Standard Details:
16000 Series - Electrical Standard Details

Design Scope of Work

Submit for approval at the end of each phase of design (Schematic Design, Design Development and Construction Document) the documents specified in the Design Deliverables list.

Provide flexibility for future changes in the use of the space, and provide spare capacity for future growth. Provide 20% spare capacity for that load growth unless that growth factor would require a significant power upgrade. In those special cases, provide as much spare capacity as the existing system can supply.

Field verify the existing installation and/or site. Do not rely solely on the existing drawings and/or site surveys. As a minimum, field verify the quantities, sizes, ages, conditions and spare capacities of the following:

- Power ducts, manholes, services to the building and unit substations.
- Panels, circuit breakers, disconnect switches, motor controls, raceways and wiring.
- Lighting, switches and receptacles.
- Grounding.
- Telecommunications ducts, manholes, rooms and services to the building.
- Fire alarm, security, card access and other special systems.

Coordinate with the Design Manager to obtain recent historical information from the following U-M departments:

- Key plans and electrical risers from AEC.
- Electrical usage information from the Utilities Department.
- Primary and unit substation information from the Plant High Voltage Shop.
- Maintenance information from the Facilities Manager and Zone Maintenance personnel.
- Fire alarm and security system information including fire alarm drill results from the Plant Fire Protection Shop and the Department of Public Safety.
- Card access control system information from the Plant Key Office.

Show all known below grade, below floor and in floor utilities that will be impacted by the project's work.

Use existing spare circuit breakers or existing spaces whenever possible. If necessary, combine existing lightly loaded circuits to free existing circuit breakers for the new loads. Avoid tapping buses or adding new unit substations unless absolutely necessary.

Match the existing installation whenever possible and practical.

Locate equipment requiring maintenance where it is easily accessible. Installations shall not require the use of lifts or scaffolding, or the removal of other equipment, for routine maintenance.

Provide adequately sized access panels (24" x 24" minimum to access equipment out of arm's reach) for maintaining electrical equipment located behind walls or above permanent ceilings.

Ensure that no piping or ductwork is routed in the NEC-required dedicated spaces above or working spaces around electrical equipment. Provide drip pans for existing piping routed over electrical equipment.

Correct to the greatest extent possible code violations or safety hazards in the existing facility. If existing code violations or safety hazards are discovered that are not addressed in the Program Documents, notify the Project Manager.

Short Circuit and Coordination Studies

Perform a preliminary power system short circuit study in order to specify the electrical equipment ratings.

- When the power system includes an engine-generator system with closed transition or soft-loading automatic transfer switches, include the generator fault contribution with the other power system contributions.

- Submit the study for review at the end of Design Development.

On projects providing a new or replacing an existing power distribution system, perform or arrange for a Registered Professional Engineer to perform a final power system short circuit, protective device coordination and arc flash hazard study. The Electrical Contractor shall not perform or arrange for this study.

- The final study shall be performed by an Engineer with extensive experience in the performance of these studies. It shall be signed and sealed by a Registered Professional Engineer in the State of Michigan. If performed by other than the Architect/Engineer, the Architect/Engineer shall review and approve the study.
- The final study shall be performed using shop drawings and protective device coordination time-current curves from the electrical equipment manufacturers, and actual cable sizes and lengths from the Electrical Contractor.
    - Identify devices that are inadequately rated or that do not coordinate with upstream devices.
    - Specify secondary feeder fuse sizes and circuit breaker trip settings in table format.
    - Provide phase and ground fault coordination time-current curves showing the selective coordination of the substation secondary main, tie and feeder breakers with downstream devices down to the motor controllers and branch circuit panels. Include transformer, large motor and conductor damage curves. Coordination of the U-M primary system protective devices with the unit substation primary fuses and secondary main circuit breakers will be performed by the U-M Utilities Department.
    - Specify automatic transfer switch voltage, current, time and control settings in table format.
- Provide arc flash hazard warning label information indicating the arc flash boundary and either the incident energy or Personal Protection Equipment (PPE) level from the unit substations down to the motor controllers and branch circuit panels.
- Submit the study for U-M review prior to setting and testing the unit substation secondary circuit breakers.

Design Drawings

Prepare the following electrical drawings and specifications in accordance with the Design Deliverables list and as applicable to the project, for use during construction:

- Demolition plans and details.
- Underground duct bank and manhole plans, elevations, profiles and details.
- Primary and secondary feeder conduit routing drawings.
- Normal and emergency power plans, one-lines, risers and details.
- Schematic and wiring diagrams.
- Lighting plans and details.
- Telecommunications, fire alarm, clock, card access control, security, CCTV, audio/visual, sound reinforcement and other special systems plans, risers, schematics, and wiring diagrams.

- Grounding and lightning protection plans, risers and details.
- MCC, substation, lighting control, panel, and other applicable equipment schedules.
- Systems and equipment sequences of operation.

For new electrical drawings, use the symbols and abbreviations established by the applicable nationally recognized standards association. Name equipment using U-M numbering conventions. When revising existing drawings, use the existing symbols and name equipment using the existing convention. Always provide a complete symbols legend.

When revising existing drawings, identify revisions. Circle and label revisions, or draw the revisions using a heavier line weight than used for the existing and background.

When a building feature, cable tray, conduit, or circuit continues on to another drawing, reference the continuation drawing at the point of continuation. Show reference column and row numbers for clarity.

Show the wire and conduit sizes for every feeder circuit on the riser and one-line diagrams.

Show wire and conduit sizes on the plan drawings for any circuit other than 20 amperes, single phase. Show multi-wire feeder and branch circuits requiring separate or oversized neutrals. A general note is adequate to define wire and conduit sizes for 20-ampere single phase circuits and to specify shared neutrals.

Show bus amperes, number of phases and wires, breaker/starter/fused switch/fuse sizes, and AIC ratings for all unit substations, switchboards, panels, MCC's etc.

Specify the mounting heights of electrical devices. Indicate if the devices are flush or surface mounted. Indicate if raceways are exposed or concealed. Show 4" minimum concrete housekeeping pads for floor-mounted equipment.

Show Contractor furnished electrical equipment and control wiring on the plan drawings. Include equipment required by the NEC such as motor disconnect switches if not provided by others, and include control wiring required for equipment operation if not provided by others. Do not rely solely on specification statements or general drawing notes to identify Contractor scope. Provide sufficient information so that quantities can be determined easily.

Specifications

Number specification sections in accordance with the CSI specification numbering system. Eliminate from general specifications the requirements that do not apply to the project.

Shop Drawing Review

Review Contractor submitted shop drawings and product literature. Approve submittals that comply with the contract documents, and mark up or reject submittals that do not comply. Approved submittals shall include adequate information to prove that the proposed products comply fully with the contract documents. Each copy shall be marked to indicate the specific models, sizes, types and options being provided. Submittals not so marked shall be rejected.

Testing

Specify testing in accordance with Design Guideline 16950. Request approval before specifying testing beyond what is listed in Design Guideline 16950.

Commissioning

Insert Commissioning Specification 01715 into the project specifications and refer to it when specifying commissioning requirements. Specification 01715 will be provided by the U-M Commissioning Agent near the end of the CD design phase.

Operation and Maintenance Manuals

Edit and insert Master Specification 01782 into the project specifications, and reference it when specifying operation and maintenance manual requirements. Review and approve Contractor submitted operation and maintenance manuals. These manuals shall be marked to indicate the specific models, sizes, types and options of the systems and equipment that were provided. Manuals not so marked shall be rejected.

Training

Refer to Specification 01782 when specifying Owner training requirements. Training shall not take place until the Owner's Personnel have been given 2 weeks to review the approved Operation and Maintenance Manuals. The Contractor shall notify the Project Manager 3 working days in advance of training sessions.

Record Drawings

Review and approve Contractor submitted as-built information and provide the information to the University in accordance with SID-H, "Construction Documents". The drawings shall show the locations of equipment, light fixtures, switches, receptacles and junction boxes, riser information, the sizes of conduits and conductors, circuit numbers, and deviations from the design. Buried, embedded and concealed primary and feeder conduits shall be dimensioned from permanent building features.

Products

Specify products that conform to the applicable standards of the American National Standards Institute (ANSI), the Institute of Electrical and Electronic Engineers (IEEE), the National Electrical Manufacturers Association (NEMA) and the National Fire Protection Association (NFPA).

Specify that products be listed or labeled by a Nationally Recognized Testing Laboratory. When components are combined to form a major assembly, the entire assembly shall be listed or labeled.

Specify multiple manufacturers from the Design Guidelines Preferred Manufacturers List when multiple manufacturers produce products meeting the project requirements.

Do not use the term “Or Equal” or any similar language to specify products or services.

Specify products that are known to have been used with success elsewhere. Do not specify newly developed or unproven products.

When designing new electrical systems, specify that major electrical equipment shall be from one manufacturer. When designing renovations, match the existing equipment where practical.

Specify that equipment and materials shall be provided from the manufacturers specified. Substitutions for specified products shall be acceptable only if proposed and approved in writing before the project is awarded.

Execution

Ensure all of the following additional Contractor actions are specified in the contract documents.

Temporary Services

Temporary lighting and power shall be provided as specified in the project's Supplemental General Conditions.

Permanent electrical systems or equipment used during construction shall be replaced or refurbished prior to acceptance by the University.

Electrical Coordination

The Contractor shall participate in the specified project scheduling and coordination drawing activities as specified in Division 1 of the project specifications.

The Contractor shall notify the Project Manager of power interruptions 3 working days in advance, and shall maintain power to loads outside of the work area.

The Contractor shall coordinate with the Plant High Voltage Shop at (734) 615-5279 before performing any work affecting primary power distribution circuits or unit substations.

The Contractor shall coordinate with the Plant Electrical Technical Shop at (734) 647-3275 before performing any work affecting engine-generators or variable speed drives.

The Contractor shall coordinate with the Plant Fire Protection Shop at (734) 647-2046 before performing any work affecting fire alarm systems.

The Contractor shall coordinate with the ITCom Shop at (734) 647-9954 before performing any work affecting telecommunications ducts, manholes or rooms.

The Contractor shall coordinate with the Plant Roofing Shop at (734) 764-3411 before performing any work affecting roofs.

The Contractor shall coordinate work with the other trades to ensure the NEC-required dedicated spaces above and working spaces around electrical equipment is provided, and to ensure access to equipment requiring calibration or maintenance. Working space and access shall be sufficient for an adult to perform maintenance safely without straddling or removing obstructions. Work that encroaches on working space or that impedes maintenance shall be relocated at the Contractor's expense.

For deliveries of equipment to the Owner, the Project Manager shall be notified 3 working days in advance. Deliveries shall occur on normal workdays between 8:00 AM and 2:00 PM. Deliveries that arrive without adequate notice may be rejected.

Owner furnished equipment that is shipped to the project site shall be unloaded and stored by the Contractor. Owner furnished equipment that is stored in the Owner’s warehouses shall picked up, transported, unloaded and stored by the Contractor at the project site.

Demolition

Equipment and materials designated for demolition shall be removed as follows:

- Power wiring: Remove back to the source or to the first junction box where the circuit continues on to remaining loads.
- Telecommunications wiring: Remove back to the telecommunications room.
- Conduits and boxes in walls and above permanent ceilings: Abandon in place. Install blank cover plates on boxes.
- Conduits through floors and walls, and boxes in floors: Remove completely. Patch and paint penetrations to match existing.
- Exposed and accessible conduits, wireways and boxes: Remove completely. Patch and paint surfaces to match existing, and plug unused panel and junction box holes.
- Lighting fixtures and electrical equipment: Remove and dispose of completely (unless designated for relocation).

Items designated for relocation shall cleaned and restored to a “like new” condition.

Lamp and Ballast Recycling

The Contractor shall recycle lamps and ballasts. Insert verbatim into the project specifications the recycling requirements of Master Specification 16010.

Quality Assurance

Electrical work shall be performed by licensed Journeyman or registered Apprentice Electricians. The number of Apprentices on a project shall not exceed the number of Journeymen. Electricians shall carry a copy of their license or registration while working on University projects.

The Owner's Code Inspection Department shall be contacted at (734) 764-2457 before the start of the project to arrange for periodic inspections. Normal inspections will be performed at no cost to the Contractor, but the costs for repeat re-inspections of rejected work may be deducted from the Contractor's final payment.

Electrical systems, equipment and materials shall be tested by an independent testing agency prior to final acceptance of the work. Acceptance tests shall be performed in accordance with applicable codes, standards and manufacturers' instructions.

- Notify the Project Manager 3 working days in advance of tests. The Owner shall witness the tests unless the Project Manager waives witnessing in writing.
- Notify manufacturers sufficiently in advance of tests for which the manufacturers should be present.
- Provide written test reports, signed and dated, for all tests prior to acceptance of the electrical equipment by the Owner.

Warranty

Electrical work shall be guaranteed for a period of one year from the date of acceptance of the project by U-M. A manufacturer's warranty beginning upon equipment receipt or startup shall be extended to one year from final project acceptance. A manufacturer's warranty in excess of one year shall remain in effect for its entire time period.

BASIC ELECTRICAL MATERIALS AND METHODS

General

Scope

Provide raceways for all wiring. All exposed and concealed wiring (including low voltage control, telecommunications, and power limited wiring) shall be installed in raceways.

Provide spare raceways for future use.
- From recessed lighting and receptacle panels, to the above ceiling spaces for future circuits.
- In parking structures for future CCTV cameras and entrance controls.
- In animal rooms, and at environmental rooms, for future environmental monitoring.
- Telecommunications conduits on laboratory benches for future data connections.
- Power and data conduits in wet laboratories for clusters of high-powered computers.

Related Sections

Refer to Design Guidelines Section 16110, "Underground Electrical Service", for concrete encased duct bank and direct buried duct requirements.

Conduits

Specify 1/2 inch through 4 inch diameter electrical metallic tubing (EMT) for indoor concealed, and exposed installations, not encased in concrete.

Specify galvanized rigid steel conduit or intermediate metal conduit (IMC) for:
- Indoor installations over 4 inches in diameter.
- Indoor installations embedded in concrete.
- Indoor installations of primary power cables and fire pump supply cables. Also encase these conduits in 2 inches (minimum cover) of concrete where they are routed through the building. As an alternative, NEC Type MI cable may be used without raceways for fire pump supply cables, but only with special permission.
- Outdoor installations above ground.

Specify Schedule 40 PVC conduit for installations embedded in concrete, except as noted in Section 16110.

Specify standard wall, fiberglass reinforced epoxy, conduit for installations in parking structures, tunnels and on cooling towers.

Specify flexible metallic conduit for final connections to recessed lighting fixtures. As an alternative, manufactured wiring systems or Type MC cable may be used above accessible ceilings. Manufactured wiring systems or Type MC cable shall not be used above permanent ceilings or in walls.

Specify liquid tight flexible metallic conduit for final connections to transformers, motors and other equipment subject to vibration or removal for maintenance. Final connections to transformers in electrical rooms only may be non-liquid tight flexible metallic conduit.

Connections to recessed power receptacles, and light switches, in areas with accessible ceilings:

A. In new 'metal stud and gypsum board partitions (walls)', the final connections may be made with type MC cable. This MC cable, shall:

   1. Be run to a box immediately above the accessible ceiling, and the box size shall not exceed 4-11/16" square.
   2. Conduit shall be used for the entire run, from this junction box, to the power source, load (lights), etc.
   3. No more than three circuits may be run through any given junction box.
   4. Individual conductors making up the MC cable shall be stranded copper, with separate grounding conductor, and steel corrugated armor. Individual conductors shall be color coded as required in section 16120.
   5. The MC cable is terminated using UL listed hardware intended for the cable and boxes being used, (and rated for commercial and industrial environments).
   6. The MC cable shall be secured in the wall cavity as required by NEC
   7. The MC cable shall be as short as it is necessary to serve the need and meet the Code

B. In existing 'metal stud and gypsum board partitions (walls)', where the wall is not being otherwise opened up, the final connections to new devices may be made flexible conduit and standard (separate) conductors. This flexible conduit shall:

   1. Be increased in size as necessary to maintain the proper fill for the wiring to be installed.
   2. Shall be installed and secured as required by NEC.
   3. Shall be as short as it is necessary to serve the need and meet the NEC.

C. In all other wall types and conditions use standard conduit, of the type appropriate for the wall construction.

Connections to other recessed devices, (including communication outlet boxes, junction or pull boxes, etc) shall be with standard conduit of the type appropriate for the wall constructionCable Trays

Specify ladder-type cable trays for:

- Telecommunications cables in telecommunication rooms, in laboratories, and corridors with open or accessible ceilings, and under computer room raised floors.
- Avoid installing cable trays in air plenum spaces.
- Overhead primary cables within substation rooms.
- Provide rollouts or vertical drops for routing the cables into the substation's primary switches.

Avoid specifying center spline cable trays, except where obstructions or support restrictions make installation of ladder cable tray impractical.

Surface Raceways

Where conduits cannot be concealed, specify metallic or plastic surface raceways for indoor exposed installations in finished areas to feed surface mounted outlets.

Boxes

Specify sheet steel switch and outlet boxes for use with EMT, and cast or malleable iron boxes for use with galvanized rigid steel conduit and IMC.

Specify PVC boxes for use with PVC and fiberglass reinforced epoxy conduit.

Specify compatible boxes, from the same manufacturer and of the same product line, for use with surface raceway installations.

Products

Conduits

Electrical metallic tubing shall be thin wall steel tubing, electro-galvanized or hot dipped galvanized inside and outside. Fittings and bushings shall be galvanized steel setscrew type connectors. Conduits 2" and larger will have fittings and bushings with two screw connectors.

Galvanized rigid steel conduit and intermediate metal conduit shall be hot dipped galvanized inside and outside, in 10' lengths and threaded on both ends. Fittings and bushings shall be threaded, cast or malleable iron, and hot dipped galvanized inside and outside.

PVC conduit and fittings shall be Schedule 40 and UL Labeled for 90 degrees C cables. Fittings shall be Schedule 40, solvent type, and from the same manufacturer as the conduit.

Fiberglass reinforced epoxy (FRE type) conduit shall be standard wall thickness, iron pipe size, sunlight resistant, and gray or black color. Fittings shall typically be push-fit on straight sections and solvent type at fittings and boxes. Connections of FRE conduit to PVC boxes shall be made with solvent type threaded fittings. Fittings shall be from the same manufacturer as the conduit.

Flexible metallic conduit shall be galvanized steel or aluminum. Fittings shall be of steel with cadmium or galvanized finish. Fittings shall be machine screw clamp type, single or two-piece. Self-locking, twist-in type fittings are not acceptable.

Liquid tight flexible metallic conduit shall consist of a flexible, galvanized steel core, a continuous copper ground strip and a polyvinyl chloride jacket. Fittings shall be steel liquid tight grounding type and from the same manufacturer as the conduit.

Cable Trays

Ladder type cable trays shall be aluminum with a 4-inch (minimum) rail height, and 9 inch maximum rung spacing. Rungs shall provide a flat surface for cable support of at least 5/8". The tray with a 10’ span shall be capable of sustaining a working load of 75pounds per lineal foot (50 pounds of cable per foot, plus a 250 pound person sitting at mid-span), with a load deflection of 1.0 inch maximum when tested in accordance with NEMA VE1-3.01. 'Fittings' shall be from the same manufacturer and product line as the tray, and shall also have a 9-inch maximum rung spacing, and a 12-inch minimum bend radius. The side rail (or equivalent) shall be continuous through the 'fittings'. Preferred, but not required, are pre-drilled mounting holes on the upper surface of the side rails - will facilitate conduit terminations at the tray

Center spline cable tray (when allowed) shall be aluminum with top mounted rungs, 3 inch (minimum) load depth, ¾" inch minimum (flat) rung width, and 9 inch maximum rung spacing. The tray with a 10’ span shall be capable of sustaining a working load of 75 pounds per lineal foot (50 pounds of cable per foot, plus a 250 pound person sitting at mid-span), with a load deflection of 1.0 inch maximum when tested in accordance with NEMA VE1-3.01. Fittings shall be from the same manufacturer and product line as the tray, and shall have a ¾" inch minimum rung width, a 9 inch maximum rung spacing, and a 12 inch minimum bend radius.

Tray fasteners shall be galvanized or zinc plated steel; and shall be configured and installed so no sharp, or threaded surfaces, protrude in the 'cable space'.

Surface Raceways

Surface raceways shall consist of a base and cover of. 040-inch thick minimum zinc plated or galvanized steel, or PVC, sized for the number of conductors contained within. Complete the installation with all connectors, fittings, bushings, boxes, covers and mounting hardware from the same manufacturer. All materials for a given location shall be of same color; with the color specified being one of the manufacturer's standard finishes.

Provide barriers to separate conductors of different voltages, or services.

Surface raceways shall be sized so that the installed wiring does not exceed NEC specified fills, and the minimum bend radius of the installed wiring is not violated - even at outlet box locations. [The telecommunication wiring will be Category 5E (4 pair), Category 6 (4 pair cable) and/or fiber strands, all to be installed without violating their minimum bend radius.]

Owner Installed Telecommunication Wiring

When calculating raceway fills, for telecommunication raceways assume 3, 4-pair, cables to each telecommunication outlet. This is the standard currently being used by the University

Boxes

Fixture, switch, outlet, splice and wire pulling boxes shall be cast or formed from carbon steel sheets of commercial grade steel not less than 14 gauge. Boxes shall be of one-piece construction, zinc or cadmium plated. Boxes shall be tapped for installing covers and plates as required.

Steel pull and junction boxes shall be rated NEMA 1 indoors, or NEMA 3R minimum outdoors, fabricated from galvanized or painted code gauge cold rolled carbon steel sheets. Boxes shall be of welded construction with flat, removable covers. Box covers shall be fastened in place by machine screws or hinges and latches. Self-tapping or sheet metal screws are not acceptable.

PVC pull and junction boxes shall be rated NEMA 3R minimum, molded in one piece, with integral mounting feet and flat, gasketed, removable covers. Box covers shall be fastened in place by machine screws. Self-tapping or sheet metal screws are not acceptable.

Supports

Hangers and brackets shall be made of steel pipe, channel iron, angle iron or prefabricated steel channel, and shall be galvanized or painted.

Hangers shall be of sufficient strength, and spaced, such that their deflection at any point does not exceed 1/240 of the hanger span length after the supported equipment, conduits, cable tray and cables are installed.

Anchors for heavy and large loads, mounted to gypsum board, hollow tile, block, or similar surfaces, shall be toggle bolt type. Install metal backer plates as needed for concentrated, or extra heavy, loads to be mounted to gypsum board walls. For heavy or large loads mounted to solid surfaces, use metal expansion, or epoxy anchors. Use lead shield anchors, or plastic expansion anchors, for supporting smaller loads. Powder-driven anchors shall not be used.

Execution

Raceways

Minimum power and control conduit size shall be 1/2 inch. Minimum telecommunications conduit size shall be 1 inch.

All medium (primary) voltage raceways, and any other raceways above 4", shall be rigid.

FRE raceways and PVC boxes shall be used in parking structures, tunnels, cooling tower enclosures, and all other areas with high humidity and/or corrosive environments. Tunnels sections passing through building mechanical rooms (and other related areas) are not exempted from these requirements even if non-FRE conduits are currently present.

Conduits in finished areas shall be concealed wherever possible and practical. When conduits cannot be concealed in finished areas, surface raceways shall be used.

Concealed and exposed raceways shall be installed parallel to or at right angles to building lines. Surface raceways shall be installed as close to room corners or trim features as possible to make the surface raceways less obvious. Use the surface raceway to route the wiring to a junction box above the finished ceiling whenever possible.

In renovation areas, with existing gypsum board walls, flexible conduit may be used from the new outlet box in the wall, to a junction box mounted on the wall immediately above the accessible ceiling. Size flex raceway to maintain equivalent cross-sectional area.

Raceways and other electrical equipment shall be separated from steam pipes, hot water pipes, and other hot surfaces by a minimum of 4 inch horizontally or 12 inch vertically.

Raceways and other electrical equipment shall be separated from ductwork and pipes so that they do not come into contact with each other.

Low voltage signal circuits shall be separated, or shielded, from power circuits to prevent the induction of noise into the signal circuits.

Raceway fittings and bends shall have bend radii greater than the minimum bend radii of the cables enclosed.

Metal raceways, fittings, boxes and enclosures shall be mechanically joined together to form a continuous electrical conductor providing effective electrical grounding continuity. This requirement, does not, however, negate the Guideline requirement for separate grounding conductors for all power circuits (as defined in Guideline Section 16450)

Raceway expansion fittings shall be provided at the intervals specified by the manufacturer, and all building expansion joints.

Directional changes in primary conduits above ground shall be made with 3' minimum radius sweeps and long radius elbows. Those underground shall be with 20' minimum radius bends.

Conduits entering panels located outdoors, in parking structures, in steam tunnels and on cooling towers shall enter from the sides, back, or bottom. Conduits shall not enter from the top.

Weep holes shall be drilled in the bottom of all switch and outlet boxes installed in parking structures and tunnels.

Mounting Heights

Equipment and devices shall be installed at the following heights:

- Receptacles (Wall): 18" A.F.F. to center
- Receptacles (Above Counter): 48" A.F.F. to center
- Receptacles (Unfinished Area): 48" A.F.F. to center
- Surface Raceway Receptacle Strips: 42" A.F.F. to bottom (unless noted otherwise)
- Light Switches: 48" A.F.F. to center

- Telephone Outlets (Wall Phone): 54" A.F.F. to center
- Telephone/Data Outlets: 18" A.F.F. to center
- Clock Outlets: 88" A.F.F. to center
- Fire Alarm Pull Stations: 48" A.F.F. to center
- Fire Alarm Horn/Strobes: 80" A.F.F. to bottom or 6" below ceiling (whichever is lower)
- Card Readers: 48" A.F.F. to card slot
- Security System Controls: 48" A.F.F. to center
- Thermostats/HVAC Controls: 48" A.F.F. to center
- Electrical Panels: 72" A.F.F. to top
- Safety Switches/Motor Starters: 72" A.F.F. to top (except top of handle shall not exceed 78" A.F.F.)
- Motor Control Switches/Pushbuttons: 60" A.F.F. to center

Supports

Electrical equipment and raceways shall be supported independently of supports provided by other trades.

Equipment (other than conduit) to be surface mounted to masonry or concrete walls shall first be secured to steel channels that in turn are mounted to the wall. Do not mount the equipment directly to masonry or concrete.

Equipment to be surface mounted on other wall surfaces may be directly mounted to the wall, unless the equipment's load exceeds the strength of the wall material. Where weight exceed wall capability, in finished areas, install steel backer plate in the wall. In unfinished areas install steel channels as noted above to spread the load.

Floor mounted equipment shall be secured to 4 inch thick concrete housekeeping pads. Pads to be sized 4 to 6 inches longer, than equipments length and width. Bevel edge of pads, and reinforce as appropriate.

Conduits and boxes shall be supported using steel conduit straps or 1/4-inch minimum diameter threaded rod hangers. Conduits shall be supported at intervals not exceeding 10 feet. Suspended ceiling hangers or hanger wire shall not be used (except to support manufactured wiring system cables and Type MC cables).

Cable trays shall be supported with support brackets or 3/8-inch diameter minimum threaded rod hangers at intervals not exceeding 8 feet for straight runs. Additional supports shall be provided at tray fittings.

Flexible metallic conduit to motors and similar equipment shall not exceed 3 feet in length, and shall have adequate slack to absorb the maximum vibration.

Flexible metallic conduit to lighting fixtures shall not exceed 6 feet in length. Place box and flex conduit so the light fixture can be lifted out of accessible ceilings when required, and/or long enough to place fixture in adjacent 'tile' location

Flexible metallic conduits, and manufactured wiring system cables, shall be routed parallel to or perpendicular to building lines, in a neat and workmanlike manner. Any excess cable shall be coiled and supported independently of the ceiling grid system at intervals not exceeding 3 feet. Said cables shall not lie on the ceiling tiles. These same requirements shall apply to cables placed below raised floors.

Penetrations, Sleeves and Seals

Scanning for electrical conduits shall be performed prior to core drilling concrete floors.

- Use a Hilti Ferroscan or similar impulse induction type scanner capable of detecting both metallic conduits and copper wires in PVC conduits. Tracers that scan for energized cables or that scan for injected high frequency signals are not acceptable.
- Notify the Owner's Inspection Department prior to all tests.
- Prior to core drilling, arrange for the Owner's Representative to notify building occupants of the potential for an unscheduled power outage.
- Conduits damaged during core drilling shall be restored immediately at the Contractor's expense.
- Penetrations shall be cut neatly and to the minimum size required for installation of the equipment and raceways.

Galvanized steel pipe sleeves shall be provided for conduits penetrating floors, exterior walls and roofs. As an alternative in floors, a Hilti CP680 Cast-In Firestop Device may be used.

- Extend floor sleeves above the floor a minimum of 2 inches.
- Embed sleeves in new concrete or step-core concrete and grout sleeves into existing concrete with epoxy grout.
- Seal floor sleeves using fire-sealing systems approved by a Nationally Recognized Testing Laboratory.
- Seal exterior wall and roof penetrations water tight.

Conduit penetrations in walls shall be patched on both sides to seal against the passage of air, sound, smoke, and fire.

- Seal conduit penetrations in fire rated walls using fire-sealing systems approved by a Nationally Recognized Testing Laboratory.
- Seal conduit penetrations in non-rated walls using masonry materials that match the wall construction.

Cable tray penetrations in fire rated walls shall be sealed using fire sealant bag or brick systems approved by a Nationally Recognized Testing Laboratory.

Recessed outlet boxes, located less than 24 inches apart, on opposite sides of a fire rated wall, with box openings over 16 square inches, shall both be fire sealed.

Identification

Systems and equipment shall be provided with nameplates indicating their name or number, and power source. Nameplates shall be engraved 1/8-inch thick plastic with black letters on a white background, and letters at least 1/4 inch high. Nameplates shall be attached with a minimum of two mechanical fasteners such as sheet metal screws or bolts and nuts. Embossed plastic tape labels are not acceptable.

Receptacle and switch plates shall be labeled to indicated panel and circuit serving the device. Also mark the same circuit information, inside the outlet box, using indelible ink. "Black on clear Dymo", tape markers, are acceptable for this requirement

Junction boxes and box covers of special circuits shall be color coded as follows:

- Emergency power and Fire Alarm Circuits: Red Paint
- Temperature Control Circuits: Blue Paint
- Clock Circuits: Orange Paint

Junction box covers shall be marked in indelible ink, with the panel name, and breaker numbers of the circuits contained within.

Conduits and cables in the University tunnel system shall be banded at major changes in direction, junctions, entrances to buildings and every 25 ft on straight runs. Banding shall be tape similar to Scotch #33 electrical tape, which is suitable for high temperatures.

- Electrical Power: Red
- Clock System: Red with Purple
- Radio System: Red with Silver
- Computer System: Red with Yellow
- High Voltage: Red

Details

See Details 1605001,001 through 1605010.001

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UNDERGROUND ELECTRICAL SERVICE

General

Scope

Provide concrete encased duct banks for primary (medium voltage) power distribution cables, and telecommunications cables.

Provide direct buried ducts for secondary power cables, site lighting cables, and dedicated telecommunications circuits.

Always provide spare ducts in concrete encased duct banks. When installing direct buried ducts under sidewalks, walkways and other paved areas, install a least one additional; 6" PVC sleeve for installation of future ducts without the need to re-open the paved area.

Related Sections

Design Guidelines Section 03300, "Concrete", for concrete requirements.

Design Guidelines Section 16521, "Site Lighting", for direct buried conduit requirements for site lighting, emergency telephone kiosks, illuminated signs, parking lot electric gates, and Parkmasters.

Underground Ducts

Specify Type DB PVC conduit for concrete encased duct banks, except where galvanized rigid steel conduit is required for additional strength.

Specify Schedule 40 PVC conduit for direct buried ducts, except where galvanized rigid steel conduit is required for strength or due to inadequate cover.

Under roadways, driveways, parking lots and sidewalks, and all other paved areas, specify Schedule 40 PVC conduit sleeves to enclose direct buried ducts.

Manholes and Pull Boxes

Specify reinforced concrete manholes where required to:

1. Satisfy cable routing needs, to control pulling tensions, and for cable splicing.
2. Keep duct lengths to 400 feet or less on straight runs. Longer runs are acceptable only when calculations are completed showing that pulling tensions, and sidewall pressures are not exceeded in the longer pull.
3. Keep the maximum amount of bends between manholes to no more that 180 degrees.

a. When bends are present the maximum length of the duct must be appropriately reduced so the limiting (maximum) pulling tension, and maximum sidewall pressures of the cables are not exceeded.

b. Designer shall do sufficient calculations to insure that the two, above noted, limiting factors are not violated.

c. The typical medium voltage feeder being installed is composed of 3-1/C, 350 MCM copper, 15kV (ungrounded) cables, with tape shields, and EPR insulation rated for 133% of the 15kV nominal rating.

Specify pre-cast polymer pull boxes, only in owner-approved locations, where adequate space does not exist for the installation of manholes.

Manholes and pull boxes shall be accessible on at least 3 sides by trucks, cable reel trailers and other cable pulling equipment.

Products

Underground Ducts

PVC conduit for concrete encasement shall be Type DB, 4-inch diameter minimum, UL Labeled for 90 degrees C cables. Fittings shall be Type DB, solvent type, and from the same manufacturer as the conduit.

PVC conduit for direct burial shall be Schedule 40, UL Labeled for 90 degrees C cables. Fittings shall be Schedule 40, solvent type, and from the same manufacturer as the conduit.

Galvanized rigid steel conduit shall be hot dipped galvanized inside and outside, in 10 foot lengths and threaded on both ends. Fittings and bushings shall be threaded, cast or malleable iron, and hot dipped galvanized inside and outside.

Sleeves shall be Schedule 40 PVC conduit, 6-inch diameter, UL Labeled for 90 degrees C cables. Couplings shall be Schedule 40, solvent type, and from the same manufacturer as the conduit.

Concrete shall have a minimum strength of 3,000 psi at 28 days.

Marker tape shall be plastic, vinyl, or Mylar, 6 inches wide, red for electrical power and orange for telecommunications, and labeled to indicate the type of circuit buried below.

Manholes

Manholes shall be precast, or cast in place, and shall be steel reinforced as needed, to achieve an MDOT highway loading of H-20.

Provide a cast iron frame with cover, a galvanized steel ladder, and galvanized pulling eyes embedded in the concrete opposite each duct entrance and in the floor beneath the cover.

Provide a sealed depression in the floor offset slightly from the center, for installation of a portable sump pump. Drains shall not be installed in floors.

Manholes placed in 'green-belts' and like areas shall have manhole covers with a lighter duty rating (the manholes themselves and the 'ring', however, are the same as required for the MDOT, H-20 rating)

All duct entrys into manholes shall include provisions for bell end fittings and a means to securely 'securing' the duct bank(s) to the manhole wall

1. Precast, or cast-in-place, manholes shall be delivered (or constructed) with the ducts openings cast in place.

2. Provisions for known future ducts shall have knockouts installed, with the bell end fittings included.

3. When installing multiple new ducts into manholes without proper knockouts, cut an opening in the manhole wall, rework steel reinforcing, and install ducts, all in accordance with the associated U of M standard detail.

4. Alternately, when installing multiple new ducts into manholes without proper knockouts, the duct openings may be core drilled at the proper locations. The diameter of the corings, however, shall be 2 to 4" larger than the duct being installed. This larger opening will allow proper grouting of the ducts and bell ends into the manhole wall.

Electrical Power Manholes

Electric power manholes shall have inside dimensions of 10 feet long by 10 feet wide by 7 feet high. Duct entry points shall be offset from the center of the wall to allow easier training of the cables along the walls of the manhole. Provide a grounding system for each manhole and connect this to grounds run with power duct banks. Make all grounding system connections using exothermic welds, or copper (or bronze) fittings as manufactured by Burndy Hyground System.

The frame and 36" cover for electrical power manholes shall be East Jordan Iron Works 1580C in high loading areas, or 1581-51 in green belt areas. Both have the lettering, “UM ELEC”.

Electric power manholes shall be equipped with 3 Aickenstrut (non-metallic) stanchions per wall, each bolted to the wall with stainless steel Rawl bolts. Each stanchion shall be fitted with 1 Aickenstrut (non-metallic) cable support arm.

Telecommunication Manholes

Telecommunications manholes shall have inside dimensions of 12 feet long by 6 feet wide by 6.5 feet high. Duct entry points shall be offset from the center of the wall to allow easier training of the cables along the walls of the manhole. Ducts shall only enter on the shorter end walls, not on the long walls. The frame and 27" cover for telecommunications manholes shall be East Jordan Iron Works 1805C with the lettering, “UM TELECOM”.

Telecommunications manholes shall contain 7 full height vertical concrete inserts in each long wall, and 2 in each short wall. Inserts shall be 1-5/8 inch hot dipped galvanized Unistrut type channel or Aickenstrut nonmetallic channel of equal size and strength. Corner inserts shall be equipped with 12 inch corner brackets and side inserts shall be equipped with 3 inch side brackets to support full height perforated cable support racks. Each long wall shall also be equipped with 2 copper ground bus bars, 6 inches long by 2 inches wide by 1/4 inch thick, on 2 inch metal stand-offs bolted to the concrete.

Pull boxes

Pull boxes shall be precast polymer concrete or polymer foam, heavy duty rated, bottomless, with a single piece cover. Pull boxes shall be one size larger than required to loop cables out of the opening and back in again without exceeding the minimum bend radii of the cables. Covers shall be of sufficient strength to withstand the weight of a riding lawn tractor or small truck, engraved “UM ELECTRIC”, “UM TELEPHONE”, or “UM OUTSIDE LIGHTING” as applicable, and attached with pentahead stainless steel bolts.

Grounds

Ground splices and connections at manholes and pull boxes, where required, shall be exothermic welds, or copper (or bronze) compression ground fittings, or bolted compression ground fittings.

Execution

Excavation and Backfill

Miss Dig shall be contacted at (800) 482-7171 before performing any excavation work.

Provide barricades around open holes and trenches, temporary bridges over trenches cut through major sidewalk routes. Major sidewalk routes shall not be closed to pedestrian traffic.

Trees, shrubs and plantings in the area of excavation shall be removed by the Plant Grounds Department in advance. Provide barriers to protect landscaping adjacent to the excavation area.

Remove rocks, concrete, or other debris encountered during excavation.

Where sidewalk sections must be removed for installation of underground ducts, remove the sidewalk sections (flags) completely from joint to joint.

Cut asphalt to be removed for installation of underground ducts, in two, straight, parallel lines.

Backfill excavations in 6 inch layers and mechanically compact to 98 percent compaction. Excavated materials may be used as backfill only if the backfill is sand or clean dirt that is free of rocks and debris over 3/4 inches in diameter. Dispose of clay, rocks, concrete and other debris, and replace with MDOT Class II sand.

In landscaped areas, backfill and mechanically compact to a depth of 6 inches below grade. Backfill the last 6 inches with clean topsoil, and reseed affected lawn areas.

Restore concrete sidewalks and asphalt in accordance with University Guidelines.

Underground Ducts

Slope duct banks downward, toward manholes, and away from buildings, a minimum of 6 inches per 100 feet. Duct banks shall not route water from manholes into buildings, or contain traps between manholes where water may accumulate.

Directional changes in duct banks shall be made with 20' minimum radius bends. Where this radius cannot be accommodated, perform detailed pulling tension, and sidewall pressure, calculations, to insure compliance with cable manufacturer's recommendations.

Duct banks and direct buried ducts shall be supported on undisturbed soil or on piers extending down to undisturbed soil.

Where primary voltage power, and telecommunications, duct banks run in parallel, they shall be separated by a minimum of 12 inches of soil or concrete - vertically and/or horizontally. If the services need to be placed one upon the other the (vertically stacked), the power ducts shall be above the telecommunications ducts

Primary duct banks shall include No. 4 steel reinforcing bars. Telecommunications duct banks do not require steel reinforcing.

Ground primary duct banks with a No. 4/0 AWG bare stranded copper ground wire that is run within the duct bank and is grounded at both ends. . Direct buried ducts shall be grounded by insulated, stranded copper ground wires installed in each duct. Telecommunications duct banks do not require grounding

Prior to concrete encasement, ducts, reinforcing steel and ground wires shall be secured with nonmetallic straps or cable ties to nonmetallic duct spacers at intervals not exceeding 8 feet. Duct spacers shall be sized for the ducts being held, and shall provide the minimum spacing between ducts required for concrete flow and by the NEC. Duct spacers shall be anchored to the ground using nonmetallic bands and stakes.

Duct banks shall have a minimum of 3 inches of concrete cover on all sides.

Provide bell end fittings on ducts where the ducts enter manholes or buildings. Note that the use of a coupling on the end of a length of PVC pipe, is not the equivalent of a bell end fitting - only true 'bell end fitting' shall be used to meet this requirement. The duct(s) and associated bell end fittings shall be securely grouted into the wall of the manhole and/or building.

Where duct banks enter manholes or buildings, they shall be constructed as an integral part of the wall. (Do not core-drill the wall and then install end bell fittings to the edge of core-drilled hole without prior written approval from the Utilities and Plant Engineering Department.) Duct bank shall extend to the inside surfaces of the walls, and the duct bank reinforcing shall be integrated with the wall reinforcing.

Direct buried ducts and fittings shall have bend radii greater than the minimum bend radii of the cables enclosed, and shall not be smaller than the radii of standard manufactured elbows.

Route direct buried ducts at right angles to building lines and site features, and as close to curbs and sidewalks as possible to avoid interferences with future landscaping.

Where direct buried PVC ducts cannot be buried deep enough to meet the NEC minimum cover requirements, rigid steel conduits shall be installed instead, or a concrete cover shall be poured over the ducts.

Place marker tape approximately 12 inches above duct banks or direct buried ducts for the entire length of the duct run.

Contractor shall cleanout the duct, using a flexible mandrel and a stiff bristled brush, prior to cable pulling. Leave a pulling string in the duct when cleanout is complete. This will serve as the duct identification on both ends of the run

Manholes and Pull Boxes

Manholes shall be installed on a base of pea gravel or MDOT Class II sand at least 12 inches deep. Pull boxes shall be installed on a base of pea gravel or MDOT Class II sand at least 6 inches deep.

Pull boxes shall be located in mulched areas wherever possible and shall be level with the existing grade.

Provide metal barriers in pull boxes containing circuits of two different voltages, or containing both power and telecommunications circuits.

Ducts shall enter telecommunications manholes on the short sides only. Ducts may enter primary manholes on any side, but should be positioned to permit installation of additional ducts in the future. Ducts should enter as perpendicular to the wall surface as possible.

Ground electric power manholes with four, ¾ inch diameter by 10 foot long, ground rods, one driven inside of the manhole at each corner. Connect the ground rods and any duct bank ground conductors together with a No. 4/0 AWG bare, stranded copper ground wire loop. A No. 2 AWG bare stranded copper pigtail from the ground wire loop shall be used to ground the manhole cover frame, ladder support bracket, any metallic concrete inserts and metallic cable racks, and the shields of any cables that are spliced are to be grounded in the manhole.

Sleeves

Sleeves shall be buried at a minimum depth of 24” to their top. Sleeves shall extend a minimum of 12” beyond the paved areas they pass under.

Spare sleeves shall be taped closed at both ends with duct tape.

Ends of spare sleeves shall be marked with steel stakes, pipes or conduits that are 3’ long minimum, driven vertically down at the sleeve ends to a depth of 6” below grade to their top.

A marker tape shall be buried in the backfill approximately 12 inches above the sleeves for the entire length of the sleeves.

Quality Assurance

The Owner’s Code Inspection Department shall be contacted at (734) 764-2457 before pouring concrete and before backfilling excavations.

<u>Details</u>

See Details 1611001,001 through 1611010.001.

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WIRES AND CABLES

General

Related Sections

Refer to Design Guidelines Section 16950, "Electrical Acceptance Tests", for wire and cable testing requirements.

Products

Medium Voltage Primary Cables

Primary power distribution cable shall be single conductor stranded copper, with ethylene propylene rubber (EPR) insulation rated 15kV, 90 degrees C, 133 percent insulation level, having a 5 mil thick minimum tape shield with 12-1/2 percent minimum overlap, and polyvinyl chloride (PVC) jacket. Cable shall be suitable for use on a 13.2 kV, 3 phase, 3 wire, ungrounded system. Cable shall be suitable for use in cable trays.

Medium voltage service cables of voltages other than 13.2-kV (2.4kV, 4.8-kV) shall be of the type noted immediately above. The cable and terminations will be provided, and installed, to allow possible, future, conversion of the service to 13.2-kV.

Medium voltage cables serving loads directly at voltages below 13.2-kV (2.4-kV, 4.16-kV. 4.8-kV) shall be single conductor stranded copper, with ethylene propylene rubber (EPR) insulation rated 5kV, 90 degrees C, 133 percent insulation level, and polyvinyl chloride (PVC) jacket. Cable shall be suitable for use on a 5 kV, 3 phase, 3 wire, ungrounded system. Cable shall be suitable for use in cable trays.

Wires and Cables (600 Volts and Below)

Power distribution and lighting wire for indoor use shall be single conductor stranded copper, No. 12 AWG minimum, with NEC Type THHN, or THHN/THWN-2 insulation rated 90 degrees C, 600 volts.

Power distribution and lighting wire for outdoor use, for use in parking structures and tunnels, and for underground use in conduits shall be single conductor stranded copper, No. 12 AWG minimum, with NEC Type XHHW insulation rated 90 degrees C in dry locations and 75 degrees C in wet locations, 600 volts.

Insulated power cable for use as fire pump supply cables shall be able to pass the two hour fire rated test under UL 2196 test (and shall be so labeled), be NEC Type MI rated 600-volts ,and shall be one of the following types:

1. Mineral insulated, single conductor, solid copper conductor, using compressed magnesium oxide insulation, and shall have a liquid and gas tight seamless copper

sheath. The cable is NEC Type MI. This cable is Factory Mutual (FM) approved, and may be used without need for a 'clearance from FM... Install and support as required by manufacturer and Code.

2. Ceramfied silicone insulated (Lifeline), single conductor, stranded copper conductor, cermafied silicone rubber insulated. The cable to be NEC Type RHH. This cable is not FM approved. FM must review each application before giving an approval for that project. Install cable in EMT, and install and support as required by manufacturer and Code

Control wire shall be single conductor stranded copper, No. 14 AWG minimum, with NEC Type THHN, or THHN/THWN-2 insulation rated 90 degrees C, 600 volts.

Instrumentation and special systems wire shall be in accordance with manufacturer's recommendations, but shall not be less than No. 20 AWG.

Execution

Medium Voltage Primary Cables

Cables shall be pulled in lengths not exceeding 500 feet.

Cables shall be pulled using generous amounts of compatible cable pulling lubricant.

AE shall make calculations to insure maximum cable pulling tensions, sidewall pressures and cable bend radii do not exceed manufacturer's instructions.

Cables passing through manholes shall be trained neatly in the same relative position as in the duct bank, without crossing each other, and shall be supported by porcelain or fiberglass insulators attached to manhole cable racks.

Cables shall be identified by numbered tags. Identification numbers and tagging requirements shall be coordinated with the Plant Electric Shop through the Owner's Representative.

Wires and Cables (600 Volts and Below)

All wiring, including low voltage control, telecommunications, and power limited wiring shall be installed in raceways. (Raceways include conduits, ducts, trays, surface raceways, and wireways.) The only exceptions include:

1. NEC Type MI cable.

2. Control wiring at VAV boxes, serving sensors and actuators associated with that VAV box.

3. Type MC Cable serving light fixtures.

4. Type MC cable run in hollow wall cavities

5. Manufacture prepared wiring systems associated with lighting fixtures. An example of this would be, Lithonia 'RELOC'. Said systems shall have a corrugated metal cover.

Wiring of different voltage levels shall be segregated. Wiring of different voltage levels shall not share raceways (except wiring to rooftop receptacles, rooftop motor controls and motor disconnect early break auxiliary contacts may share raceways with motor feeders).

Six hundred (600)-volt power feeder wiring shall be spliced with solderless compression butt splices or ring lugs and terminated with solderless compression ring lugs.

Branch circuit wiring, lighting wiring, and control and instrumentation wiring shall be spliced with wire nut connectors.

Control and instrumentation wiring shall be terminated with solderless compression ring or spade lugs.

NEC Type MI cable shall be supported and protected in accordance with its manufacturer's instructions to maintain its UL fire resistive listing, and shall be spliced and terminated with special fittings from the same manufacturer as the cable.

Home runs of 20 amp branch circuits that exceed 150 feet in length shall be No. 10 AWG wire.

Home runs of 480 volt or 208 volt, 20 amp or 30 amp, single phase branch circuits that feed special receptacles shall be installed using 5 wires. Terminate the spare wires to ground at both ends.

Cables and wires terminated in panels shall be uniquely identified by permanent tags.

The shields of shielded instrumentation and control cables shall be grounded at one end only. The shields at the other end shall be insulated from ground.

Color Coding

All wiring shall be color coded, continuous color coded, or tape color coded at each termination and at each intervening 'box/point. 'If no color coding system exists, Campus circuits shall be color coded as follows:

1. Three Phase Power Over 600 Volts:
   - Phase X(A): Black
   - Phase Y(B): Red
   - Phase Z(C): Blue

2. Three Phase Power 480/277 Volts:
   - Phase X(A): Brown
   - Phase Y(B): Orange
   - Phase Z(C): Yellow
   - Neutral: Gray
   - Ground: Green

3. Three Phase Power 208/120 Volts:
   - Phase X(A): Black
   - Phase Y(B): Red
   - Phase Z(C): Blue
   - Neutral: White
   - Ground: Green

4. Single Phase Power 240/120 Volts:
   - Phase X(A): Black
   - Phase Y(B): Red
   - Neutral: White
   - Ground: Green

5. Fire Alarm Wiring (Being updated and expanded for easier identification):
   - Addressable Device: #18 Shielded Twisted Pair (STP) Red with Black Stripe
   - Horn, Horn/Strobe or ZAM Positive (+) 24 VDC: #14 Red
   - Horn, Horn/Strobe or ZAM Negative (-) 24 VDC: #14 Black
   - Speakers: #18 STP Solid Red
   - Strobe Light Positive (+): #14 Solid Yellow
   - Strobe Light Negative (-): #14 Solid Blue
   - Panel Communications: #18 STP Red with Black Stripe
   - Fireman's Telephone: #18 STP Red with Yellow Stripe

6. Synchronized Clock Wiring:
   - Line: Black
   - Neutral: White
   - Clock Correction: Red

7. Less Than 120 Volts: Use Industry Standard Methods

Site lighting wire insulation shall be in solid colors to match the circuit voltage and phase color code.

All UMHS owned facilities, unless noted otherwise, (University Hospital, THC, etc.) circuits shall be color coded as follows:

1. Three Phase Power Over 600 Volts:
   - Phase X(A): Black

- Phase Y(B): Red
- Phase Z(C): Blue

2. Three Phase Power 480/277 Volts:
   - Phase X(A): Red
   - Phase Y(B): Blue
   - Phase Z(C): Black
   - Neutral: Gray
   - Ground: Green

3. Three Phase Power 208/120 Volts:
   - Phase X(A): Yellow
   - Phase Y(B): Orange
   - Phase Z(C): Brown
   - Neutral: White
   - Ground: Green

4. Less Than 120 Volts: Use Industry Standard Methods

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Wiring Devices

General

All wiring devices shall be UL -extra-heavy duty. See Preferred Manufacturer's List for specific information on acceptable products.

Devices shall have a minimum rating of 20-amperes.

Wiring devices connected to 'normal power' shall be supplied in the manufacturer's standard color closest to 'Ivory', unless noted otherwise. If Ivory is not available, in special application devices, use the manufacturer's standard brown.

Wiring devices connected to 'emergency power' shall be supplied in the manufacturer's standard color closest to 'Red', unless noted otherwise. If red is not available in special application devices use the manufacturer's standard ivory or brown. Exception: 'Special Power' receptacles installed in the Medical School shall be gray.

When multiple circuits serve a series of receptacles the circuits shall be alternated so adjacent receptacles are not on the same circuit.

Receptacles shall be installed so the ground terminal is below, or to the left of the neutral terminal. If the building standard is other than this, follow the existing building standard

All receptacles and switches shall be labeled to note the source of power.

Receptacles within 6-feet of a water source shall be GFCI type. Receptacles dedicated to sump pumps and water fountains are excluded.

GFCI receptacles shall not be wired to protect downstream standard receptacles. Each GFCI, when it operates shall only interrupt 'its own' receptacles

Coverplates shall be 'high-quality', Type 302, stainless steel unless noted otherwise.

'Futura' class devices shall not be used, unless the needed device is only available in that style, or otherwise noted.

Lighting Controls

A. General

Toggle switches shall be rated 120/277 volts, 20-amperes, single-pole, double-pole, 3-way, or 4-way as required

Dimmer switches shall be rated 1000 watts minimum, specification grade, heavy duty, with radio noise filter - UL listed for 'heavy duty' use.

Lighting control switches, serving areas 'not visible' at the switch location shall have a pilot light function.

B. Occupancy Sensors

1. Wall mounted occupancy sensors shall be rated 600 watts minimum, 180 degrees coverage, 300 sq. ft. minimum coverage, infrared type
2. Ceiling mounted occupancy sensors shall be rated 1000 watts minimum, 180 degrees coverage, 1000 sq. ft. minimum coverage, infrared type,
3. All sensors shall have adjustable range or sensitivity, and adjustable time delay.
4. Ceiling mounted sensors (especially) shall utilize low voltage control circuits and be interlocked with the switch circuit for local auto/off control.
5. Dual technology occupancy sensors shall be used in applications where false operations must be minimized. These dual technology devices shall have a power ratings of at least 1000 watts load rating, shall cover at least 180 +/- degrees (from device), 1000 sq. ft. +/- coverage, and combination ultrasonic/infrared type. The ultrasonic component shall be of a frequency compatible with hearing aids.
6. Occupancy sensors shall be of a type that does not make any noise when the sensors switch from the on state, to the off state.
7. NOTE: Some ultrasonic occupancy sensors operate at frequencies that interfere with proper hearing aid operation. Any ultrasonic sensors shall therefore be specified to operate beyond the interference frequencies with hearing aids.

C. Light Dimming Control Systems

1. The wiring devices, as applicable for the dimming system, shall be in accordance with the above requirements.

2. Such systems shall be placed, labeled, and configured to be 'user friendly and intuitive. See Section 16550 for more information.

D. Lighting control systems

1. The wiring devices, as applicable for the lighting control system, shall be in accordance with the above requirements.

2. Such systems shall be placed, labeled, and configured to be 'user friendly and intuitive. See section 16550 for more information.

<u>Receptacles</u>

Duplex and single (simplex) receptacles shall be rated 125 volts, 20 amps, 2-pole, 3-wire, NEMA Type 5-20R.

GFCI duplex receptacles shall be rated 125 volts, 20 amps, 2-pole, 3-wire straight blade type with nylon or Lexan bodies. GFCI receptacles shall trip when ground currents exceed 5-mA, shall trip in 25-milliseconds maximum, and shall have an interrupting rating of 2000 amperes.

TVSS receptacles shall clamp at 330 volts or less, and shall have visual indication of the failure of their protective circuitry.

Child resistant receptacles shall require the simultaneous insertion of both line and neutral plug blades before power is applied to the receptacle contacts.

'Special receptacles' shall be of the voltage, amperage, number of poles, number of wires, configuration, and NEMA Type required by the (to be) supplied load.

Ceiling mounted and/or critical application receptacles shall be 'twist-lock' type with the NEMA configuration required for the (to be) supplied load.

'Receptacle Strips'

Commercially available surface mounted receptacle strips shall not be used unless the receptacles meet the above noted minimum requirements. Alternately, use surface raceway with receptacles separately installed. The receptacles shall be spaced as required for the application.

Power Poles

Power poles shall be painted steel unless shown otherwise, with an internal barrier to separate power wiring from telecommunications wiring. If power outlets are installed they shall meet the minimum requirements noted above. A green ground wire shall connect all receptacles. The pole shall not be used as the ground conductor.

The poles shall be firmly affixed at the top and bottom. The power and/or telecommunications wiring shall exit the poles through separate flex conduits connected to ceiling mounted junction boxes

Floor Boxes

In general, floor boxes shall be avoided. When there is no good alternative, however, the boxes shall be of the 'Flush-Poke-Thru' type, with multi-service capability, and be UL listed for 2-hour fire resistance.

Boxes shall be have a minimum capacity of 30 cubic inches, split into 2 or 3 compartments of equal capacity by removable partitions

These 'Flush Poke-Thru' type floor boxes shall meet ADA and Accessibility Guidelines and be UL listed for scrub water exclusion.

Multi-service devices shall have the necessary channels in the insert body to provide complete separation of power & communication services.

Pin And Sleeve Connectors

Pin and sleeve connectors shall comply with IEC Standard 309. They shall consist of nylon housings with integral locking rings and cord grips that are color coded by voltage. Pins and sleeves shall be sized, arranged, and keyed to prevent incorrect assembly.

Timers

A. General

1. Acceptable manufacturers are noted in the Preferred Manufacturers List.
2. All devices shall be UL listed and labeled for the application
3. Inside mounted devices shall have a NEMA 1 enclosure. Outdoor applications shall have a NEMA 3R enclosure. In either case, the cover shall be lockable.
4. Controls shall be easy to understand, and adjust.
5. Power control contacts shall be provided, capable of switching 20-ampere, 120 or 277-volt circuits. These contacts shall be capable of controlling incandescent, fluorescent, or HID lighting.

B. 24-Hour and 7- Day Timers.

1. Where BAS control panels are not available, or too expensive to upgrade, install timers.
2. Timers shall be electronic type, with battery back up and appropriate charging circuits to keep the battery charged. The battery shall supply only the internal date, and time circuitry.
3. Timers for control of indoor lighting applications shall include automatic switching to accommodate daylight savings time changes, standard holidays, and special other specific dates.
4. Timers for control of outdoor lighting applications shall include astronomical type of controls to automatically adjust on and off times to accommodate time of year.
5. Two or more power control contacts shall be provided, as noted above.
6. Provide at least one, Form C, control contact rated for 120-volts.

C. Spring Wound Timers

1. Where an application requires a timer, to allow an erratically scheduled 'On Times' of a specific length, use manually, spring wound, timers.
2. Timer shall allow 3-way switching of lights, i.e. control of tunnel lighting from either end of the tunnel segment.
3. The construction of the timer shall be appropriate for the environment where it is to be used, i.e., hot and high humidity environments in tunnels.

Installation Requirements

D. Provide No. 10 AWG wire to NEMA Type 6-20R receptacles serving freezers, window air conditioners, or other large appliances.

E. Where circuits are supplying a high portion of non-linear load, provide a separate neutral conductor for each single-phase branch circuit. The neutrals of these single-phase circuits shall not be shared or daisy-chained.

F. Provide ground fault circuit interrupter (GFCI) receptacles for new and existing 120 volt duplex receptacles located outdoors, in toilet rooms and within 6 feet of water sources including sinks, cup sinks, fume hood sinks, faucets, hose bibs and water coolers. Standard receptacles protected by an upstream GFCI receptacle or a GFCI circuit breaker is not acceptable.

G. Provide waterproof enclosures for duplex receptacles located outdoors. Enclosures shall remain watertight even while in use.

H. Provide a label on the cover plate of new, or existing, light switches and receptacles in the project area. Identify the panel and circuit number feeding the device. Embossed plastic tape labels are not acceptable.

I. Color code junction boxes and box covers of emergency circuits with red paint.

J. Mark lighting and power junction box covers in indelible ink with the panel and breaker numbers of the circuits contained within.

VARIABLE SPEED DRIVES

General

For the purposes of these guidelines, the terms variable speed drive and VSD, can, and may be used interchangeably with the terms variable frequency drives and VFD

This electrical guideline, in large part, deals with the installation of VSD. For information dealing with the drives themselves refer to the mechanical guidelines, Section 15960.

Safety disconnect switches are not required at the motor, when the line disconnect of the VSD is lockable, and within sight of the motor. When the VSD line disconnect is not lockable, or is not in line-of-sight, a separate safety disconnect shall be installed at the motor location. All safety disconnect switches shall have pre-break (auxiliary) control contacts, (even if they are not specifically required by the VSD supplier). The wires for this control contact shall be run in the same raceway as the power conductors.

All wiring and grounding shall be in accordance with the associated electrical sections dealing with these requirements.

Harmonic Distortion Considerations

Before adding a VFD, determine the total harmonics generating load on the unit substation transformer. The new harmonic generating load shall not exceed 10 percent of the transformer base rating without approval from the University Utilities Department through the University Project Coordinator. Harmonic generating loads, as defined here, include electronic ballasts, computers and their peripherals, solid state power supplies, UPS systems, VSD drives, etc.

If the total load on the transformer, after the additions of the current project, exceed 75% of its rating; and/or if the total harmonic generating load on a substation will exceeds 50%; the A/E shall prepare a study for review by the University showing that the transformer can safely carry those loads. If the study shows the transformer inadequate, the project shall either increase the transformer size, or add additional transformers. Before adding a VSD, evaluate the possible effects of the VSD on power factor correcting capacitors or harmonic sensitive equipment on the same bus. Avoid installing a VSD on the same bus with capacitors or 'sensitive' equipment. Sensitive equipment, as defined here, are loads adversely affected by harmonic voltage distortions. These include, high sensitivity laboratory equipment, patient monitoring or treatment equipment, computers, etc.

Provide calculations per IEEE Standard 519 showing the current and voltage total harmonic distortion (THD) that will be reflected into the existing University power system, for any load exceeding 10% of the rating of the transformer serving it. Contact the University Utilities Department through the University Project Coordinator for the required power system data. The VSD shall limit the THD to the values noted below when operating at any load from zero to 100 percent.

- VSD input voltage waveform: less than 3 percent THD
- VSD input current waveform: less than 100 percent THD

After startup of the VSD, the mechanical contractor shall provide, and the electrical contractor shall install, at no additional cost to the University any additional reactors or filters required to reduce the actual THD to the calculated THD.

Maintenance Bypasses

All VSD's for motors larger than 5 HP, and/or on systems serving critical loads (as defined in program statement, shall include full maintenance bypass systems. These bypasses shall be configured to allow operation of the motor; 'across the line' mode while the drive is being repaired. Also, the bypass equipment shall be electrically isolated from the VSD drive equipment so that maintenance may be safely done with the motor running 'across the line' in through the bypass.

The electrical system serving a VSD, and the mechanical system being served by the VSD, shall be sized and braced to allow that motor (and associated mechanical system) to start and operate properly and safely when in the bypass mode - across the line. Special attention needs to be given to the affects of the voltage drops during start and the ability of the upstream overcurrent devices to carry the locked rotor current during the startup.

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ENGINE-GENERATOR SYSTEM

General

When required by code or to satisfy a special program requirement for constant electrical power, provide a natural gas fueled engine-generator system. The probability of a simultaneous failure of both the natural gas utility delivery system and power from the outside electrical utility is considered to be low. Provide a diesel engine-generator system only when a hospital code or the performance requirements cannot be met using a natural gas engine-generator.

Early in design, coordinate studies on the impacts of the unit's sound, vibration and exhaust on the building and on surrounding buildings. Often these studies will mandate design changes. See Design Guideline 15240 for the City of Ann Arbor and U-M sound and vibration criteria.

Use U-M Master Specification 16231 to specify the engine-generator and associated automatic transfer switches. Edit Specification 16231 to make it project specific.

Related Sections

Design Guideline Technical Sections:
SID-F - Codes and Regulatory Agencies
SBA-J – Fire Command Center
15240 - Mechanical Sound and Vibration Control
15300 – Fire Protection
15975 – Mechanical Systems Controls
16450 – Grounding
16950 – Electrical Acceptance Tests
Electrical Trades Preferred Manufacturers List

U-M Master Specifications:
16231 – Engine-Generator System
16950 – Electrical Acceptance Tests

U-M Standard Details:
16313004 – Maintenance Backfeed

References

Environmental Protection Agency (EPA) emissions standards for stationary internal combustion engines
NFPA-110, “Standard for Emergency and Standby Power Systems”
UL 1008, "Standard for Automatic Transfer Switches"
UL 2200, "Standard for Stationary Engine Generator Assemblies"

System Requirements

The engine exhaust emissions shall meet the current EPA emissions standards.

Evaluate locating the engine-generator in a room versus locating it in an enclosure outdoors.

- Consider factors including initial cost, ease of maintenance and major component replacement, fuel and exhaust piping routes, heat rejection, feeder cable lengths, noise, vibration, etc.
- For non-Regental projects, consult the University Planner's Office to obtain Exterior Elements Design Review Committee approval before locating an engine-generator or exhaust stack outdoors where visible to the public.

When multiple units are being provided and they will be operated in parallel, all engines shall utilize the same fuel type and all generators shall be wound with the same pitch.

When multiple units will be operated in parallel, their loads shall be divided into multiple blocks of load and prioritized so the highest priority blocks will receive power even if one unit fails.

Engine-Generator Sizing

Size the unit for 125 percent of projected peak load.

Engine controls meeting the latest EPA emissions standards cause a natural gas engine-generator to dip in voltage and frequency when accepting large steps of load. Size the unit accordingly.

- Edit Specification 16231 to specify the worst case step loading sequence and maximum allowable voltage and frequency dips that can occur. Often it is the starting of the fire pump after all other loads have been started.
- Specify an engine-generator size that can accept the worst case step loading sequence and maintain voltage and frequency within acceptable limits.
- During shop drawing submittal review, review the manufacturer's computer simulation of the step loading and verify voltage and frequency remain within acceptable limits.

Automatic Transfer Switches

Specify the automatic transfer switches (ATS's) to be provided as part of the engine-generator package. Do not specify them separately.

- Provide 3 pole ATS's except where the building's substation main breaker contains ground fault protection, where the generator feeds multiple buildings, or where required by code.
- Provide open transition ATS's to feed loads that can withstand interruptions and will restart automatically after transfer to and retransfer from the generator.
- Provide closed transition ATS's to feed loads that will reboot or will not automatically restart after retransfer from the generator.
- Provide ATS's with manual bypass.
- Ensure the ATS's are adequately rated for the full amount of fault current available, adding in the generator fault contribution if the ATS's are closed transition.

Engine-Generator Load Testing

For engine-generators 250 kW and below, provide a 100 percent rated resistive load bank for unit testing. Consider attaching the load bank to the air discharge side of the radiator.

For engine-generators over 250 kW, specify the most heavily loaded ATS as a closed transition, soft loading ATS. Only one ATS can be soft loading, usually the required standby power ATS.

- Size the soft loading ATS for at least 70 percent of generator full load. Size the ATS feeder cable from the generator, the ATS feeder cable from the substation, and the substation feeder breaker to match the ATS size. The intent is to load the generator to at least 70 percent during testing by paralleling with and backfeeding through the substation.
- Provide a shunt trip unit on the substation feeder breaker as required by the soft loading ATS manufacturers. Provide control wiring from the soft loading ATS to the shunt trip unit.
- Calculate the voltage relay, current relay, time delay and soft loading control settings of the ATS's in accordance with manufacturer’s instructions. Provide the settings in table format to U-M for approval prior to ATS startup.

Evaluate the need for a maintenance backfeed tap box to connect a portable engine-generator during engine-generator maintenance or to connect a remote load bank during engine-generator load testing. Design the tap box in accordance with Standard Detail 16313004. Locate the tap box at the loading dock or where a trailer can be parked adjacent to it.

Natural Gas Fuel System

Coordinate with DTEEnergy and obtain the natural gas pressure and BTU content available at the building. Edit Specification 16231 to state these values.

Obtain the approximate dimensions of the DTEEnergy gas meter train (often 12 feet or more in length) and locate the metering where it won’t detract from the building's appearance. Provide concrete-filled steel pipe bollards with yellow PVC jackets where appropriate to protect against vehicle impact.

Locate the DTEEnergy gas regulator as close to the engine's regulator as possible.

Size the gas piping system for negligible pressure drop at maximum gas flow.

Engine Exhaust System

Design the exhaust system in accordance with the results of the exhaust dispersion study and in accordance with engine-generator manufacturers' instructions.

- Provide a flexible section to isolate the exhaust system from engine vibration.
- Calculate the exhaust system’s expansion and contraction with temperature, and provide supports, slides and restraints as required.

- Direct the exhaust upward rather than horizontal, and away from buildings, trees, plants and anything else that is combustible.
- Provide a hinged, flapper style rain cap at the top of the exhaust stack. Do not provide a stack termination that deflects exhaust horizontally, including an inverted cone style cap.
- Provide an automatic blowdown device or automatic drain device at the low point in the exhaust system, and pipe the discharge to the floor.

Provide a hospital grade silencer with 35 dBA minimum attenuation when the engine-generator is located in or adjacent to an occupied building. Provide a critical grade silencer with 25 dBA minimum attenuation when the engine-generator located away from occupied buildings. Provide a higher attenuation silencer when required by the results of the sound study.

A natural gas engine-generator will require a 3-way catalytic converter. A diesel engine-generator may require a catalytic converter or at least a particulate filter. Integrate the catalytic converter or particulate filter with the silencer if possible. Provide access for maintenance of the catalyst or filter.

<u>Controls and Indications</u>

Provide a control panel mounted on the engine-generator no more than 6' - 6" above the finished floor to the top of the panel, including the height of the housekeeping pad.

Provide a 208 volt, three phase load center panel to feed the battery charger, battery heater, water jacket heater, electric lube oil pump, motorized dampers, lights, and receptacles. Feed the panel with standby power.

Provide a remote manual stop station in accordance with NFPA 110. Locate it on the outside of the generator room or enclosure near the latch side of the door. Label it with a laminated plastic nameplate, white letters on a red background.

When the building is classified as a high rise building and it includes a Fire Command Center, provide a remote annunciator panel in the Fire Command Center. Otherwise, provide a remote annunciator panel in a location where it will be readily visible to maintenance personnel. The remote annunciator panel shall mirror all status indicators and alarms contained on the engine-generator control panel.

When the building is classified as a high rise building and it includes a Fire Command Center, provide the generator remote “Auto-Run” switch and ATS status indicators specified in Design Guideline SBA-J.

Connect “generator running” and “generator trouble” output contacts to separate points in a Building Automation System DDC panel.

Connect in series an “on generator power” output contact in each ATS to a single point in a DDC panel. Do not connect any generator or ATS output contacts to MOSCAD or to the fire alarm system.

Generator Room Requirements

Separate the generator room from occupied areas or provide sound-proofing so engine-generator noise will have minimal impact on surrounding areas. Provide sound attenuation at intake and exhaust louvers when required by the results of the sound study.

Extend the walls from the floor to the deck above. CMU block walls are recommended for noise mitigation and safety. Where required by code, provide fire-resistance rated walls and doors.

Provide the NEC-required working spaces on all sides of each piece of electrical equipment. Provide the NEC-required dedicated equipment space above each piece of electrical equipment.

Provide a minimum of 2 exit doors on opposite ends of the room if the generator is rated 1200 amps or more.

- Exit doors shall swing outward from the room.
- Exit doors shall be equipped with panic bars. Double doors require only a single panic bar.
- One door shall be large enough for passage of the engine or generator.

Provide a 4 inch minimum concrete housekeeping pad with chamfered edges under each piece of floor-mounted equipment. The engine-generator housekeeping pad shall be steel reinforced in accordance with the engine-generator manufacturer's instructions.

Provide 2 coats of water-borne epoxy paint over a compatible primer on the concrete floor.

Provide paint or a concrete sealer on the walls and ceiling.

Provide a 10 pound Type ABC fire extinguisher at each exit door.

Provide an unobstructed route to the building exterior to permit replacement of the engine or generator. Design the floor of the entire route for the weight of whichever piece is heavier.

Provide a route to move drums of oil and other large maintenance items to the generator room.

In below-grade generator rooms, provide a floor drain tight to a side wall.

- Provide a backwater check valve for the floor drain.
- Provide a water leak detector adjacent to the floor drain and tight to the wall so it isn't a trip hazard. Connect its alarm contact to a Building Automation System DDC panel.

Provide a propylene glycol or dry pipe sprinkler system in accordance with Design Guideline 15300. A wet pipe sprinkler system shall not be used.

- Locate the sprinkler heads and route the piping over aisles, not over electrical equipment.
- Provide wire guards on the sprinkler heads.

Provide motorized dampers fed by generator power for combustion and cooling air in accordance with Design Guideline 15975 and engine-generator manufacturer's instructions.

- Size the dampers for less than 500 feet per minute air flow.
- Provide louvers exterior to the dampers when the dampers are visible to the public.

Provide generator power to controls associated with combustion air, ventilation air and other systems that must operate when the engine-generator is operating. Provide generator power to pumps providing fuel or cooling water to the engine-generator.

Provide unit heaters to maintain room temperature above 45 degrees F when the unit isn't running.

Provide grounding in accordance with Design Guideline 16450.

Provide manually-switched fluorescent lighting and connect it to emergency power. Provide a battery-backed emergency lighting fixture in front of the engine-generator control panel.

Provide exit signs above the exit doors.

Provide a fire alarm system horn/strobe or speaker/strobe.

Provide duplex receptacles and connect them to standby power.

Outdoor Enclosure Requirements

Provide the engine-generator manufacturer's standard weather-protective, non-walk in outdoor enclosure for most projects. When recommended by the results of the sound study or when the engine-generator is adjacent to an occupied building, provide an appropriately rated sound-attenuating enclosure.

- Provide a floor. Enclosures that are open on the bottom to air, grating or the concrete pad are not acceptable.
- Provide clearance above the radiator cap to permit viewing down into the radiator without using a mirror, and to permit adding coolant without using a pump.
- Provide access and clearance around the engine and generator for routine maintenance.
- When providing a walk in enclosure, provide manually-switched, cold weather starting fluorescent lighting and at least two duplex receptacles.

ELECTRICAL POWER SYSTEMS

General

The various Codes applicable to the University's electrical power system are mainly based upon a model of a single utility service, connected to a single premise. The University's electrical system, however, consists of multiple utility services, a cogeneration facility, and a comprehensive primary distribution network connected to hundreds of premises. Thus applying the codes to the University's electrical system is not straightforward as it would be in other locations.

To meet the level of safety intended by the Codes, the design the University's electrical distribution systems is as described herein.

Electrical System Description

Utility Services

The Detroit Edison Company DTE provides the following primary and secondary services to the University:

1. Three 13.2 kV primary services, from DTE's University Substation, to the Central Power Plant (CPP) on Central Campus.
2. Two 13.8 kV primary services, from DTE's Academy Substation, to the University of Michigan Hospitals (UMH) main distribution substation in University Hospital. (A possible conversion to 13.2 kV is being investigated.)
3. Two 13.2 kV and two 4.8 kV primary services, from DTE's Campus Substation, to the North Campus Switching Station.
4. Eleven 13.2 kV and 4.8 kV primary services to individual buildings having service patterns where the primary demand rate is cost effective.
5. Over 250 secondary services of various voltages to individual buildings.

Cogeneration Facility

The University produces steam, and generates electricity, at the Central Power Plant, a cogeneration facility that contains the following:

1. Three steam turbine-driven 13.2 kV generators with a total capacity of 37.5 megawatts.
2. Two gas turbine-driven 13.2 kV generators with a total capacity of 7 megawatts.

Primary Distribution Network

The University distributes power to most of the buildings connected to its medium voltage distribution system through the following types of circuits and service points:

1. 13.2 kV and 2.4 kV primary feeders from the Central Power Plant to most buildings on the Central Campus and Athletic Campus.
2. 13.8 kV primary feeders from the University Hospital's Substation to most of the UMH buildings on the Medical Campus. (A possible conversion to 13.2 kV is being investigated.)
3. One 13.2kV emergency feeder from the Central Power Plant, through a 13.2-13.8-kV autotransformer, to select UMH loads. (May be eliminated if 13.8 to 13.2 conversion is warranted.)
4. 13.2 kV and 4.8 kV primary feeders from the North Campus Switching Station to most North Campus buildings.

Application of the Codes

General

1. New electrical systems shall comply with the NEC and other noted codes on the U of M web page.
2. Existing electrical systems under addition or renovation shall be upgraded to comply with the current codes.
3. Existing electrical systems serving an area, undergoing non-electrical renovation, in general, are not required to be upgraded to comply with the current codes. However:
   a. No work of any discipline shall degrade the existing electrical distribution system in any way.
   b. Upgrade the electrical distribution systems wherever possible and practical.
4. The University's electrical system is considered "reliable" as defined in NFPA 20 Appendix A.
5. As described in NEC Section 695-3(2), the Central Power Plant could be considered an "on-site power production facility" The University, however, prefers an on-site, natural-gas-fired generator to supply the emergency power loads in a facility.

Application of NFPA 70, the National Electrical Code

1. The service points at which the Detroit Edison utility services end and the University premises wiring begin, are defined as the connections of the secondary buses or terminals at the Detroit Edison owned step-down transformers, fused cut-out switches, or service drop conductors, to the University owned cables.
2. The "source ends" (Central Power Plant or switching station ends) of the University's primary distribution cables are feeders and shall comply with NEC Article 220, "Feeders".
3. The "load ends" (building ends) of the University primary distribution cables, however, shall be treated as the utility services to the building. Install service disconnecting means and comply with all of the requirements of NEC Article 230, "Services".

4. In a like manner, a secondary-voltage feeder (or feeders) from one building to another building shall be treated as the utility's service to the building. Install service disconnecting means and comply with all of the requirements of NEC Article 230, “Services”.
5. This service entrance shall fully comply with NEC Article 230, and all other applicable sections. These requirements include, but are not limited to the following:
   a. Conductors shall be maintained outside of the building or shall be enclosed in two inches of concrete until they enter the room containing the building service disconnecting means.
   b. Primary disconnect switches, unit substation transformers and pad-mount transformers shall be treated as utility owned equipment.
      - Access shall be restricted to qualified personnel only.
      - The transformer primary switches shall not be used as the building service disconnecting means.
   c. The line side terminals of the secondary main disconnecting device(s) shall be treated as the building service point.

<u>Application of the National Electrical Safety Code</u>

In addition to complying with the NEC, the Central Power Plant, switching stations, substation rooms, manholes and other areas containing primary equipment, main service switchgear, or cables shall comply with the National Electrical Safety Code.

<u>Application of the International Building Code</u>

1. In low-rise buildings, provide emergency power for egress lighting, emergency signs, and the fire alarm system.
   a. Provide a natural gas fueled engine-generator set whenever possible because the savings in maintenance costs will offset the higher initial cost. Connect the generator using one or more automatic transfer switches. These transfer switches shall be 'close-transition', soft-start, with full, isolated maintenance bypass systems included
   b. As an alternative to an engine-generator set, consider providing a fuel cell system.
   c. Provide a central battery/inverter system with the battery system being of the flooded-wet-cell, Plante-lead-alimony, type. Provide sufficient 'installation and working' clearances around the overall system, and installed needed ventilation. (Sealed valve regulated battery systems shall be used due to their high maintenance replacement costs.)
   d. When an engine-generator set cannot be provided, provide individual battery packs.
   e. Because the normal power source is sufficiently reliable, do not connect low-rise building fire pumps, elevators, or similar equipment to the engine-generator set.
2. In high rise buildings; provide emergency power for egress lighting, emergency signs, and the fire alarm system. Provide standby power for fire pumps, elevator(s), smoke

exhaust systems, stairwell pressurization systems, and other standby systems as required by codes.

a. Provide a single natural gas fueled engine-generator set with one or multiple automatic transfer switches. These transfer switches shall be 'close-transition', soft-start, with full, isolated maintenance bypass systems included

- Provide the fire pump automatic transfer switch as an integral part of the fire pump controller.
- Provide the elevator system automatic transfer switches as part of the building's power distribution system, not integral to the elevator controllers.

b. Consider supplying more than one building from a single engine-generator set.

c. Consider installing the engine-generator set in an adjacent parking structure or lot to minimize noise and vibration.

3. Only as a temporary measure when an engine-generator set cannot be provided at the time of initial construction, provide two separate services to the building and provide multiple transfer switches.

a. Obtain one service from the University electrical system and the other from Detroit Edison.

b. Do not obtain both services from the University electrical system because both services will be connected together at times for system maintenance or load balance.

c. Do not obtain either service from a 4.8kV or 2.4kV primary circuit because these circuits are being phased out.

d. Do not obtain both services from Detroit Edison unless they originate at different Detroit Edison switching stations.

e. The University's long-range goal is to provide emergency and standby power to every high-rise building from engine-generator sets. Design the electrical distribution system so that an engine-generator set can be connected in the future.

4. In low rise and high rise buildings with special needs, special power may be required by codes or may be requested by the Owner for hazardous labs, animal rooms, freezer farms, radio transmitters, telecom switching stations or other critical loads.

a. When possible, provide the special power from the same natural gas fueled engine-generator set that supplies the emergency and standby power. Use a separate automatic transfer switch to feed the special loads.

b. If no engine-generator set exists and special power is required within minutes of a loss of normal power, provide a dedicated natural gas fueled engine-generator set.

c. If no engine-generator set exists and special power is required within a few hours of a loss of normal power, provide a University standard generator connection box for connecting a portable generator.

Electrical System Requirements

Distribution Network

The University's long-range goal is to convert the entire primary distribution network to 13.2kV.

1. Connect new unit substations to 13.2kV primary circuits, not to 4.8kV or 2.4kV circuits.

2. Coordinate with the Utilities and Plant Engineering Department to establish the specific circuits and connection points.

Unit Substations

Provide indoor unit substations consisting of primary load break switches, dry type transformers, and secondary switchgear distribution sections.

1. Provide double-ended substations with two main and one tie secondary circuit breakers Double-ended substations are typically only used for health care, and research buildings.

2. Provide single-ended substations with main secondary circuit breaker Single-ended substations are used for classroom, library, housing facility, and similar buildings. With single-ended substations provide a generator connection box on an exterior portion of building accessible to trucks. Also provide raceway and conductors from the generator connection box, to a separate circuit breaker in the substation dedicated for this generator connection.

3. Substations with a secondary voltage rating of 480/277-volts, three phase, 4-wire, are preferred.

4. Size substations only for the anticipated peak load plus spare capacity for future growth. Do not oversize the substations and thus increase initial costs and transformer losses.

HIGH VOLTAGE DISTRIBUTION

General

The Central Campus, and the Athletic Campus', primary distribution systems consist of a 13.2 kV looped system, and a 2.4 kV radial system. The 2.4 kV system is slowly being upgraded to 13.2 kV.

The North Campus primary distribution systems consist of a 4.8 kV looped system and a 13.2 kV looped system. The 4.8 kV systems will eventually be upgraded to a 13.2 kV system. All primary equipment shall be designed to accommodate the upgrade in voltage.

The Hospital's primary distribution system, in general, consists of a 13.8-kV looped system. The other Hospital buildings are fed from the Central Campus's primary distribution system, as noted above. (A 13.8- to 13.2 kV conversion is being investigated.)

In general, phase rotation shall be A-B-C.

The phasing of new installations shall be A-B-C (X-Y-Z) from top to bottom, front to back, and left to right when viewed from the front. The phasing of renovations to existing installations shall match the phasing of the existing distribution. The Contractor shall be instructed to contact the University Project Coordinator to obtain High Voltage Electric Shop assistance to determine the existing phasing. The Contractor shall correct at his own expense any problems associated with his failure to match the existing phasing.

The A/E shall perform calculations needed to insure that cable manufacturer recommendations, on pulling tensions and sidewall pressures, are not exceeded when the cables are pulled into the raceway system.

Additional information on the primary distribution system and on the primary system fault capability is available from the University Utilities and Plant Engineering Department through the University Project Coordinator.

Equipment Requirements

Primary cable shall be single conductor, stranded copper, with ethylene propylene rubber (EPR) insulation rated for 15 kV with a 133% insulation level. The cable shall be rated for 90 degrees C, have a 5 mil minimum thick tape shield with a minimum of 12 ½ percent overlap, and a Polyvinyl chloride jacket.

High voltage cable terminations shall be made with Raychem HVT heat shrink termination kits or 3M Company Quick Term cold shrink termination kits only. Provide adequate workspace in high voltage equipment for installation of the termination kits.

Lugs for terminations shall be of the two-hole, solderless, compression type.

High voltage cable splices shall be made with Raychem HVS heat shrink splice kits only.

Installation Requirements

Instruct the Contractor to identify the cable phases at all high voltage terminations. Phases shall be identified by 1-1/2 inch minimum high letters painted on the cable supports or potheads wherever possible. When painting is not possible, phases shall be identified by 1/2-inch minimum high letters on lead tags permanently attached to the cables.

Normally primary voltage cables shall not be pulled into raceways exceeding 500 feet. A/E and/or contractor shall provide calculations showing that the required cable pulls do not exceed the manufacturers' recommendations for pulling tensions, sidewall pressures, cable-bending radius, and (when absolutely necessary) pulls of greater than 500-feet.

The cables shall be supported appropriately by cable tray, conduit, or approved racking methods.

Cable tray shall be aluminum ladder type. All fittings and hardware shall be from the same manufacturer as the cable tray.

Conduit shall be galvanized rigid steel or intermediate metal conduit with cast or malleable iron threaded fittings and bushings. Except in substation rooms, and/or fire pump rooms, wherever the primary voltage conduits are run through a building, the conduits shall be encased with at least 2 inches of concrete.

Instruct the Contractor to perform testing in accordance with Section 16950, and to provide the University Project Coordinator with test reports.

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UNIT SUBSTATIONS

General

Unit substations shall be 500 kVA minimum, 1500 kVA maximum unless approved otherwise by the University. For the required configuration of University substations see Standard Electrical Detail 16313001 for single-ended substations and Standard Electrical Detail 16313002 for double-ended substations,

A system fault contribution of 750 mVA shall be used when determining the required interrupting rating for unit substation equipment.

In general, size a unit substation so that the transformer's AA rating (or the combined transformer AA ratings in a double-ended unit substation) equals roughly 150 percent of the projected peak demand.

Rooms or vaults for indoor unit substations shall be adequately ventilated for equipment cooling, and adequately sound-proofed to significantly reduce the transmission of sound to adjacent areas.

All bus bars shall be copper. All bus connections shall have at least two bolts

All medium voltage insulators shall be porcelain or cyclophatic epoxy

Provide rear access to all unit substations.

Provide drip shields for unit substations installed in areas with fire protection sprinkler systems.

Feeder breakers shall be 800-ampere minimum.

All incoming cable connectors shall be compression type, with NEMA standard lugs and bolt spacing. Two-bolt or 4-bolt connectors are required for each connection.

Incoming Line Section Requirements

Provide incoming line sections with two loop switches for the two incoming lines, and a fused load interrupter transformer primary switch. The transformer primary switch shall be key-interlocked with its associated secondary main breaker so that the secondary main breaker closes after and must be opened before the transformer primary switch.

Provide space for distribution class surge suppressors on each incoming primary line.

Primary switches shall be metal enclosed and rated as follows:

Voltage: 15 kV.

Continuous current: 600 amperes.

Momentary short circuit and fault closing current: 61,000 amperes

Basic Impulse Level: 95 kV

Primary switches shall be two position, of the quick make/quick break type and shall be bottom hinged. Switch mechanisms shall be direct coupled. Chain or cable drives are not acceptable. Exception: Powercon chain driven switches, if supplied as a complete unit (switch, operator, enclosure) by Powercon.

The phase bus bars shall be routed across the top of the switch compartments to eliminate unnecessary transition sections.

All primary cable connections shall be provided with NEMA 2-hole, solderless cable lugs. Allow space in the loop-switch cubicles for stress cones for top or bottom cable entry.

Provide a copper ground bus bar that is connected to the transformer and secondary switchgear section ground bus bars.

Transformer Requirements

Provide only dry type transformers, unless an alternate for a given project is specifically approved by the University.

Transformers (dry type) shall have a 220^{o}C insulation system, and shall be designed for a maximum temperature rise at full load of 115^{o}C above a 40^{o}C ambient.

The transformer coils shall be rigidly clamped to the core. The coil and core assembly shall mechanically and electrically isolated from the transformer frame and enclosure.

Transformers shall have primaries rated 95 kV BIL and secondaries rated 10 kV BIL.

Transformers shall either be equipped with forced air cooling fans and controls, or equipped with needed support equipment and accessories to support future forced air rating fans. The transformers FA ratings shall equal 133 percent times of their AA ratings. Control power transformers supplied with the transformers shall power the fans.

Transformers shall be equipped with temperature switches that start the fans on high (FA operating) temperature and close a dry contact on high-high (alarm) temperature.

The temperature monitor shall be mounted on a hinged front plate of a flush mounted box. The electrical connections shall be accessible and the monitor shall be removable without de-energizing the transformer.

Wiring to the temperature monitor shall be routed and supported independently of the transformer enclosure so that enclosure panels can be removed without affecting the wiring.

The temperature monitor shall include three hot spot temperature sensors, one for each transformer phase.

The temperature monitor shall start the fans at a temperature of 100 degrees C. It shall initiate an audible alarm, close an "alarm" contact, and illuminate a red alarm LED at 135 degrees C. It shall close a breaker "trip" contact and illuminate a second red alarm LED at 175 degrees C. The temperature set points shall be adjustable. The contacts shall be Form C and wired out to a terminal strip inside the box.

The temperature monitor shall include an LED or LCD display to allow reading of the hot spot temperature in each phase, and the highest temperature seen on each phase since the last reset. A reset button shall be provided to reset the maximum readings.

The temperature monitor shall include LED's indicating "power on" and "fans running".

The temperature monitor shall include an RS422 data port for future connection to a remote monitor.

A Hand-Auto control switch shall be connected in parallel with the temperature monitor fan control contacts.

Full capacity, 2.5 percent taps shall be provided on the primary winding, three below, and one above the rated voltage tap (five total taps).

Transformers for the North Campus, initially served at 4800-volts, shall be equipped with dual wound primaries; 13.2 kV and 4.8 kV. The 13.2-kV primary shall be equipped with taps as noted above.

Secondary Switchgear Section Requirements

Provide secondary main breakers in all unit substations. Secondary main, tie breakers, and feeder breakers shall be:

1. Individually mounted, draw out, metal-clad, mechanically operated, stored energy type, quick-make and quick-break air circuit breakers.
   A. Unless noted otherwise, the breakers shall be manually 'charged'.
   B. Electrically operated (electrically charged) breakers shall be supplied where called for on the drawings. Each electrically operated breaker shall be powered by a dedicated, charging motor.
2. Breakers shall be equipped with removable arcing contacts and operation counters.
3. Breakers shall be rated for 100 percent continuous duty, with frame and trip (sensor) ratings as shown on the drawings. Sensor size (and design application) will typically be 75%, or more, of the frame size
4. Breakers shall be capable of being manually racked into three positions; "connected", "test" and "disconnected". The breaker frames shall be grounded in all positions.
5. The compartment front doors shall be closable in all breaker positions and shall permit breaker operation with door open or closed. The doors shall be capable of being opened without tripping breakers in the "connected" position.

6. A breaker shall be tripped open and the stored energy in the breaker mechanism shall be discharged as the breaker is moved from one position to another.
7. Breaker compartments shall be deadfront. Shutters shall close automatically as a breaker is racked out of the 'connected' position. Control contacts shall be 'made' when breaker is in test or connected positions.
8. Breakers shall have a minimum of two spare “Form C", isolated contacts brought out to an accessible terminal strip in the compartment. The contacts shall be rated 120 volts, 10 amperes, 60 Hz.
9. Each breaker shall be equipped with three-phase and one neutral current sensor, and a microprocessor-based trip unit.
10. Where shown on the drawings, breakers shall be equipped with a flux transfer shunt-trip. The flux transfer shunt trip wiring shall be terminated on an accessible terminal strip in the compartment.
11. Breakers shall be capable of being padlocked in the “open” position.
12. A Kirk Key interlock shall be provided to prevent the operation of the fused primary switch unless the main breaker is open.

Each breaker shall be equipped with RMS sensing trip units as noted below.

1. Solid-state trip units shall be true RMS sensing, with trip ratings adjustable by removable rating plugs. The trip units shall be magnitude and time adjustable, and shall include a local indication of the cause of a trip. The trip units shall be rated as shown on the drawings.

2. The trip units shall coordinate with the primary fuses, main breaker and largest downstream feeder breakers.

3. The trip units shall allow adjustment without breaker trips and routine testing without removing the breakers from service.

4. The trip units (sensors) shall be rated for 100 percent continuous duty.

5. Trip units shall provide the following ranges and functions as a minimum. See drawings for specific requirements that vary from this configuration:

    A. Long time (L) current settings of at least 50-100 percent of the current sensor rating, divided into seven or more steps, and time delays of at least 2-22 seconds, at 600 percent of the long time current setting, divided into seven or more steps.
    B. Short time (S) current settings of at least 250-1000 percent of the long time current setting, divided into seven or more steps, and time delays of at least .1-.5 seconds, divided into seven or more steps, to include "flat response" and "I^2T response" characteristics.
    C. Instantaneous (I) settings of at least 200-1000 percent of current sensor rating. The instantaneous setting shall be applied on the feeder circuit breakers only, not on the main breaker.

D. Ground fault (G) current settings of 25-100% of current sensor rating, with a 1200 ampere maximum, divided in seven or more steps, with ground fault time delay settings of at least .1-.5 seconds, divided into five or more steps, to include "flat response" and "I^2T response" characteristics.

6. Power for operating the solid state trip unit shall be obtained from within the circuit breaker assembly itself, or it shall be provided by a separate control circuit connected to the secondary bus ahead of the main breaker. The solid state trip units shall have non-volatile memory to maintain all settings, trip indications and fault data during a power outage. Batteries to maintain the memory are not acceptable.

The A/E shall design the overcurrent protective system so it can be set in a 'selective' manner, to minimize the disruption from any given fault, to as small an area as possible. The A/E shall also prepare, and/or approve the settings for the overcurrent protective system to insure proper selectivity and coordination. The contractor shall provide test reports showing that the overcurrent system has been set and tested, before the system is commissioned

In double-ended unit substations, the two main breakers typically are interlocked with the tie breaker so that all three breakers can not be closed at the same time. The throw-over is normally done manually, unless noted otherwise

Provide ground fault protection on all breakers rated 1200 amps or more. Avoid providing unnecessary ground fault protection that may cause nuisance outages.

Bus bars shall be braced for the calculated short circuit current.

Provide a voltmeter with selector switch, and an ammeter with selector switch. Selector switches shall have also off position.

Provide a Power Measurement Limited (PML) 7330 ION three phase power, energy, demand, and harmonics meter for each transformer secondary. The PML meter shall be panel mounted with an FT (Flexi-Test) case at 60 inches above the finished floor. The meter shall be provided with an Ethernet port.

Installation Requirements

Instruct the Contractor to perform testing and do settings in accordance with manufacturer instructions and Section 16950, and to provide the University Project Coordinator with a test report. University will supply circuit breaker settings, and primary fuse sizes.

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SERVICE AND DISTRIBUTION

General

New distribution systems shall be 480/277 volts AC, and/or 208/120 volts AC, three-phase, four-wire (w/ground), unless otherwise directed by University Design Manager (UDM).

The A/E shall perform a fault and coordination study to the depth needed to insure that the specified devices will properly and safely interrupt faults and overloads, and that the system can be coordinated properly.

All breakers, fuses and electrical distribution equipment shall have interrupting ratings of at least 1.2 times the available fault current as determined by a fault current analysis performed by an engineer.

All relays, breakers, fuses, and other overcurrent protective devices shall be coordinated in order to protect electrical equipment from damage and to isolate the fault to the smallest possible portion of the distribution system..

All fault current and coordination studies (not performed by the A/E) shall be approved by the A/E before equipment energization. The approved fault current and coordination studies shall be provided to the University Project Manager (UPM) before commissioning of the distribution system can proceed.

Switchboard and Panelboard Requirements

All switchboards and panelboard breakers shall have the appropriate short circuit interrupting rating as determined by the fault current analysis. All switchboards and panelboards shall be of the safety dead front type and ruggedly constructed of sheet steel. All switchboard and panelboard doors shall have latches in addition to locks and shall be master keyed alike. All switchboards and panelboards shall have an identity designation and shall include its source identification and location. All loads shall be identified by number and load (where applicable) and a typewritten load schedule shall be protected by clear plastic and placed in a frame mounted to the inside of the door.

All breakers requiring settings such as long time pick-up, instantaneous pick up, etc. shall be set according to a coordination study performed by an engineer. The coordination study shall be submitted and approved by the project A/E before any equipment energization. The approved settings shall be placed on the breakers and records of the approved settings and coordination study shall be provided to the UPM before job closeout/ commissioning.

At job closeout, all switchboards, and panelboards, shall have a minimum of 25 percent spare capacity - split equally between breakers spares and breaker spaces~~..~~.

All current carrying parts shall be 98 percent conductivity copper and the phase buses shall be 100% rated throughout. Where a neutral bus is required (4-wire systems), it shall be

100% rated and isolated (unless it is required by the NEC to be bonded to ground, such as in the case of service equipment). The equipment ground bus shall be rated at a minimum of 50% of the phase bus capacity. Both the neutral and ground buses shall have sufficient terminals to accommodate the number of poles or devices that can be installed.

The main and feeder protective devices shall typically be bolted to the bus. Square-D, I-Line panels are an exception.

Indoor panelboards, switchboards, and safety switches, are to be NEMA 1. In areas where water spray or high humidity will be present (like a room needing occasional wash downs) use NEMA 4. Typical outdoor applications shall be NEMA 3R. In cooling towers, parking structures, or areas where water spray and/or high humidity will be present, use stainless steel NEMA 4. For other special locations, provide equipment that has NEMA type enclosures as required by the NEC.

Panelboards

Panelboards with mains (circuit breaker or fused switch) shall have these devices installed at the top or bottom of the bus. They shall not be mounted on the side like a feeder device.

In cases where significant neutral currents may be present due to non-linear loads, the panelboard shall be provided with a 200% rated neutral bus bar; the panelboard feeder neutral shall be sized at 200% and the source transformer shall be rated appropriately to serve non-linear loads (high harmonics) with a minimum K-rating of 4

For special systems, provide bus bars meeting those special system requirements.

Panelboards shall have wire gutters sized to accommodate the bending radius of all wires when fully equipped and shall not be less than 4 inches wide.

In general, panelboards in finished areas shall be flush mounted. Panelboards in electrical, mechanical and other service rooms and spaces may be surface mounted.

"Loadcenter" type panelboards are not acceptable unless specifically approved by the UDM for the specific and/or unusual application.

Switchboards

Wherever space permits, switchboards shall be of the fused switch type and equipped with peak current limiting fuses, (unless engineering requirements dictate other fuse types) so that fault current can be minimized. Where space is not available for the larger enclosures of fused switches, circuit breaker switchboards may be utilized.

Mount switchboards, whenever possible, in areas accessible only to qualified electricians. In those locations the switchboards do not need to have a door. In areas accessible to other than qualified electricians, provide a door.

In general, switchboards in finished areas' areas shall be flush mounted, in electrical, mechanical and other service rooms and spaces they may be surface mounted.

Safety Switches

Safety switches shall be fused or unfused as needed. Handles shall have provision for padlocking. In addition, safety switches shall include a maintenance bypass (open door while hot) provision.

Provide ground connection point in all safety switches. Provide neutral bar where circuit is 4-wire.

Safety switches on load side of Variable Speed Drives shall have auxiliary contacts to de-energize VSD before opening safety switch (Form C). Certain applications may require more that one auxiliary contact.

All safety switches shall be "Heavy Duty" rated.

Distribution Transformers

Generally, building distribution transformers shall be of the 480-208Y/120 volt type. Transformers shall be of the dry type, with a 220 degrees C insulation system, and designed for a maximum temperature rise at full load of 115 degrees C above a 40 degrees C ambient.

Provide terminals compatible with copper terminations and having holes drilled to accept NEMA 2 or 4-hole terminals as is appropriate for the size of the transformer. Provide a ground connection bar (or device) to accommodate at least 4-NEMA 2-hole terminals.

Transformers shall have a sound rating 3 dB below NEMA standard (42 dB for 10-50 kVA, 47 dB for 51-150 kVA, 52 dB for 151-300 kVA and 57 dB for 301-500 kVA rated transformers). As a first preference, transformers should have 6 adjustment taps, two 2 ½ percent above and four 2 ½ percent below nominal voltage. If this setup is not readily available, four adjustment taps, two 2-1/2 percent above and two 2-1/2 percent below nominal shall be acceptable.

Where substantial non-linear loads are to be served, the appropriate K-rated (K-4 minimum) transformer shall be used.

Provide vibration pads for the transformer supports.

Distribution System Requirements

Substation secondary distribution breaker frame size shall be 800 A. The minimum sensor rating shall be 800 A, which can be set to 50 percent to produce a minimum 400 A breaker rating. Exemptions to these ratings will be permitted for feeds to emergency systems.

The first tier of distribution panels downstream of the substation shall be of the fused switch type and equipped with peak current limiting fuses, (unless engineering requirements dictate other fuse types) so that fault current can be minimized.

Provide required working space according to the NEC article 110 for motor disconnects and all other electrical equipment.

All outdoor disconnects and associated electrical equipment for cooling towers shall be stainless steel and NEMA 4 rated.

Provide NEMA Type 6-20R 250 volt, 2 pole, 3 wire, 20 amp receptacle outlets on a 208 volt, single phase circuit where required for large freezers or other large appliances. All wiring for these receptacles shall be No. 10 AWG minimum so that the circuits can be upgraded later to 30 amps if required.

Provide 120 volt duplex receptacle outlets on both side walls of corridors and hallways at intervals not exceeding 20 feet.

Provide a 120 volt duplex receptacle outlet at each stairwell floor landing.

Provide a minimum of one 120 volt duplex receptacle outlet per each 100 square feet, or any fraction thereof, in each mechanical, electrical and janitorial closet.

Provide ground fault circuit interrupter (GFCI) protection for all 120 volt receptacle outlets located outdoors, in toilet areas and within 6 feet of water sources. No receptacles shall be rendered GFCI by being fed from the load side of a GFCI. Water coolers do not require GFCI and shall be fed from a simplex receptacle.

Installation Requirements

The Contractor shall provide at least five working days notice and shall coordinate service interruptions with the University Project Manager. The University must approve each service interruption in writing.

Before closeout/commissioning the contractor shall:

- Comply with all applicable codes and standards.
- Install all wiring in approved raceway.
- Install a separate equipment grounding conductor with the phase conductors in the raceway.
- Provide exothermic welded connections or *Burndy High Ground* compression connection between the Grounding Electrode Conductor and any Grounding Electrode.
- Install all distribution equipment at a height that will not place the top unit operating handle more than 6 feet and 6 inches above the finished floor.
- Identify all receptacles with circuit number and source panel.

- Identify all installed switchboards and separately mounted circuit breakers, panelboards, motor starters, disconnect switches, relays, and all other equipment used for the operation and control of electrical equipment by means of engraved laminated plastic (or equivalent) plates permanently affixed to the equipment. The information provided shall contain the identification number/label of the equipment and its power source identification and location.
- Identify all panelboard circuit breakers with permanently fixed numbers and a typewritten directory identifying the breaker loads mounted in a frame affixed to the interior of the door and protected by clear plastic.
- Perform testing in accordance with Section 16950 and provide the UPM with acceptable test reports.
- Provide all engineered coordination and short circuit studies to the UPM.
- Provide all one-lines, riser and as-built drawings to the UPM.

All exceptions to the design guidelines division 16-Electrical must be approved in writing by a U of M Electrical Engineer and submitted to the University Project Manager.

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GROUNDING

General

Provide grounding in accordance with the requirements of the NEC, these guidelines, and University Inspection Authorities.

The resistance of the completed ground system for standard installations shall not exceed 5 ohms. If any special equipment being installed requires a lower ground system resistance, that equipment manufacturer's maximum ground resistance shall apply.

The incoming power to the building shall always be considered the building's 'Service' (as defined by NEC Article 230), even if power is from another University facility. Size the bonding conductor in accordance with Article 230.

If equipment being installed requires a special or an isolated ground system, the equipment manufacturer's requirements shall be considered. Single point radial (star) ground systems are acceptable. Avoid providing an isolated ground system unless absolutely necessary to meet a manufacturer's warranty requirements.

When installing a new substation, either in an existing building or in an addition, connect the ground mats of the substations together. Also connect the new substation to building steel, the associated incoming duct bank (when a new duct bank entrance is installed), and to all water services.

Material Requirements

Grounding system conductors making up the grounding mat and associated ground risers, and/or for encasement in concrete shall be No. 4/0 AWG bare, stranded copper.

Ground conductors for all power distribution equipment, end-use equipment and all branch circuits, shall be insulated stranded copper conductors, color coded green or (a continuous) green color with 1 or more yellow stripes. The size shall be in accordance with NEC, except that none shall be smaller than No. 12 AWG.

Underground and concrete encased ground connections, all connections to and a-part-of the main substation grounding bar, and all ground connections to structural steel, shall be made using Cadweld exothermic weld-type connectors, or "Burndy Hyground" connectors.

Exposed ground connections to power generation and distribution equipment shall be made using copper compression ground fittings or compression lugs bolted to the equipment.

Splices and taps of ground conductors No. 8 AWG and larger shall be of the Cadweld exothermic weld type. Tape or coat all exposed splices and taps.

Design Requirements

Extend ground conductors from the ground system to all switchgear, transformers, unit substations, motor controllers, panelboards, control panel ground buses, and ground bars. Equipment rated above 480 volts, or 600 amperes shall be grounded by two independent grounding conductors.

The enclosures of all switchgear, transformers, unit substations, motor controls and panelboards shall be grounded by a separate grounding conductor to the ground system.

Motors rated 460 volts and below shall be securely bonded to the ground system either by means of a stranded copper ground conductor connected to building steel, or by a motor feeder ground conductor. Motors rated above 460 volts shall be bonded by 2 independent ground conductors.

A separate grounding conductor shall be used for all new feeders and branch circuits. Ground underground duct banks for primary or secondary power cables with a No. 4/0 AWG bare stranded copper ground wire that is run within the duct banks and is grounded at both ends.

Conduit shall not be used as the ground conductor.

Ground each manhole with 4 - 3/4 inch diameter by 10 feet long ground rods, one driven inside or outside of the manhole at each corner. Connect the ground rods with a No. 4/0 AWG bare, stranded copper ground wire loop. Pigtails from the ground wire loop shall be used to ground the manhole cover frame, ladder, concrete inserts or cable racks, duct ground wires, and the shields of any primary cables that are spliced in the manhole.

Ground the lightning protection system to separate ground rods. The main ground system shall not be used. Connect the lightning protection ground system, to the main grounding system, after the lightning protection system is completed and tested

Ground instrumentation and electronic devices in accordance with the NEC or the manufacturer's recommendations, whichever is stricter.

Conduits, cable trays and all other raceways shall be grounded/bonded in accordance with the NEC.

The shields of medium-voltage shielded power cables shall be grounded at both ends. The shields of shielded power cables spliced in a manhole shall also be grounded in the manhole.

The shields of shielded instrumentation cables shall have their drain wires grounded at one end only. The shield at the other end of the cables shall be isolated from ground.

Provide protection for ground conductors subject to physical damage or abuse. Where metallic conduit is used for physical protection of a ground conductor, the conductor shall be bonded to the conduit at both ends.

Installation Requirements

Instruct the Contractor to test the grounding in accordance with Section 16950, and to provide the University Project Coordinator with test reports

MOTOR CONTROLS

General

In general, motors larger than 1/3 horsepower shall be 460 volts or 208 volts, 3 phase. Motors 1/3 horsepower and smaller shall be 115 volts, single phase. Motors 200 horsepower and larger may be rated for medium voltage2,400-volts, 4,160-volts, or 4,800-volts.

When both 480/277-volts and 208/120-volts are available in a given building, connect and run all 3-phase motors at 480/277-volts.

Especially when only 208/120-volts is available in a building, carefully evaluate the degree and frequency of motor-starting voltage-drops, on the other systems in the building. Where the 'flicker limits' noted in utility system (DTE's) rate/rule books (or good engineering practice) would be violated, install 'soft starters', variable frequency drives, or other means for reducing the voltage-drop during motor-starts.

Provide a motor control center (MCC) to control motors clustered in a given area or zone of the building. Provide local (individual) combination motor starters to control one, or a small number, of motors in a given area or zone.

Avoid feeding 3 phase motors from lighting or receptacle panels. Use 'power panels', available in the building, whenever possible.

Design motor feeder circuits to limit the motor starting and running voltage drops to values within the requirements of the NEC.

Motors 50 HP and larger shall be provided with power factor correcting capacitors.

- If a VFD is the motor controller, evaluate whether or not a capacitor should be installed given the distorted waveforms often present with VFD's.
- If only 208/120-volts is available in the building, and all 3-phase motors are therefore 208-volt, evaluate and then address the affects of the non-linear loads connected to the system (computers, UPS systems, etc.)

A duplex work receptacle shall be in close proximity to all motors and motor controllers.

Distribution systems and motor feeders to 'duplex' systems shall be sized to operate both motors simultaneously - even if current plan is only operate one at a time.

Motor Controllers

Provide electrically operated, motor controllers to provide short circuit and motor overload protection, and motor disconnecting means, for all three-phase motors.

Single phase motors may be controlled by manual motor starters.

Starters shall be lockable in the open (preferably in open and closed) positions.

Combination motor starters, with fused switches, are preferred whenever possible (for their visible break).

Variable Frequency Drives, and Reduced Voltage Starters

When variable frequency drives (VFD) are specified (these are normally specified by mechanical engineer), the drive should be supplied with a disconnecting means. If none is supplied (specified), a separate disconnection means shall be provided - at the VFD. If VFD is not in line of sight of motor, or is not lockable in the open position, install a non-fused disconnect switch at the motor. That disconnect shall have 'pre-break' contacts. If the VFD controller needs this pre-break contact, wire this contact to the VFD. These control wires for the pre-break, may be run in the same conduit as the motor feeder.

Provide reduced voltage or soft motor starters when full voltage motor starting may affect voltage sensitive equipment on the same bus.

Disconnecting Means Needed in Line of Sight of Motor

If motor control (starter), and associated disconnecting means, is not in line of sight of motor and driven equipment, provide a lockable, non-fused safety switch at the motor. (This requirement applies to all types of motor control equipment.)

For critical motor loads such as many fume hoods, provide motor single-phasing-protection. Single phasing protection shall be accomplished by the use of a 'single phase detector' on a fused disconnect, or by the use of a molded case circuit breaker.

Control Circuit Requirements

In general, provide 'Hand-Off-Auto' (HOA) control switches for motors 1/2 horsepower and larger (including those controlled by variable speed drives). In the "hand" position, the motor shall run independently of most automatic start/stop controls. Only the safety and modulating controls shall remain active. In the "auto" position, all start/stop controls shall be active. Wherever possible, control circuits shall be wired so that motors automatically restart after a power disruption. Provide time delays to allow large fans and pumps to coast down before restarting after a momentary power disruption, and to prevent all of the large motors from restarting simultaneously.

High temperature detectors (firestats), smoke detectors, low temperature detectors (freezestats), flow switches and all other safety controls shall be energized and operational whenever the equipment they protect is operating.

When required, provide limit switches on dampers to prevent the associated fans from starting until the dampers are fully open.

Duct smoke Detectors

Duct smoke detectors required by code.

- Duct Smoke detector shall be supplied by, installed, and wired by the fire alarm system supplier. This detector shall be compatible with that fire alarm system.
- When fire alarm system is 'intelligent', do not directly control motor from smoke detector. See detail 16720006 noted below.
- Wire those duct smoke detector to the 'Duct Smoke Detector Interface Box' as shown on details 16720008 (for buildings without fire alarm systems, 1672007 (for buildings with 'hard-wired' fire alarm systems), or 16720006 (for buildings with addressable fire alarm systems). These interface boxes allow quicker isolation of equipment failures to either the temperature control system or the fire alarm system. Interface boxes are available from Owner.
- Fire alarm contractor and temperature control contractor will wire to these interface boxes, and test them for proper operation.
- The interface box(es) should be close to the temperature control panels.

Equipment Requirements

Medium voltage motor starters shall be of the vacuum breaker type. Coordinate the selection of medium voltage motor starters with the University Utilities Department through the University Project Coordinator.

Each MCC motor starter or combination motor starter shall consist of a fused disconnect switch or molded case circuit breaker, a magnetic motor starter with 1 overload relay per phase, and a control power transformer. Fuses shall be of the dual element, time delay, rejection type. Fused disconnects are preferred since they provide a 'visible break'.

Provide drip shields for motor control equipment installed in areas with fire protection sprinkler systems.

Installation Requirements

Instruct the Contractor to perform testing in accordance with Section 16950, and to provide the University Project Coordinator with test reports.

LIGHTING SYSTEMS

Definitions

Emergency Lighting: Lighting legally required in egress paths. (Add "EM" next to fixture type designation).

Night Lighting: Lighting installed to provide in various areas to provide a minimum level of lighting during times when the building is not normally occupied. (Add: "NL" next to fixture type designation).

Emergency and Night Lighting: Lighting installed to meet both needs as described above. (Add "EM/NL" next to fixture type designation).

Normal Lighting: Other lighting not falling into any of the above categories. (No special notation is needed next to these fixtures.)

Lighting Levels

Provide lighting levels in accordance with the following table. All noted values are at the horizontal working surface height, unless noted otherwise. If an area is encountered that is not covered below, use the IES Guideline (As defined in the 8'th Edition of the IES Lighting Handbook), with a weighting factor of +2.

Space	Average Footcandles at Working Height
Animal Holding/Research	See Design Guideline SBA-A
Auditorium	70 (Dimmable)
Building exterior at door	10
Building perimeter	2
Classroom/Lecture Hall	70
Conference/Interaction Room	70
Corridor/Hallway/Lobby	25
Drafting/Art room	80
Emergency (egress) lighting	1 fc average at the floor, with nowhere less than .1 fc. See Note 1
Night lighting	1 fc average at the floor, with nowhere less than .1 fc
Gymnasium	40
Laboratory	100
Lavatory/Bathroom	40
Library stack (at bottom shelf)	20 (Vertical Footcandles)
Mechanical/Electrical equipment room	40
Office (regardless of task lighting)	70
Parking lot	See Design Guideline 16521
Parking structure	See Design Guideline SBA-E
Reading room	60

Sidewalk	See Design Guideline 16521
Stairway	20
Street (University owned)	See Design Guideline 16521
General storage (With large and/or bulky items)	20
Special Storage (With small and/or valuable items)	40
Storage (at bottom shelf)	15 (Vertical Footcandles)
Telecommunication room (at bottom of racks)	50 (Vertical Footcandles)

Note 1: If City of Ann Arbor will be doing the inspection, follow their guideline, which is 1 fc minimum.

Design Criteria for Normal Lighting

Design lighting so that the ratio of light levels between adjacent spaces does not exceed 10:1.

Avoid specifying incandescent lighting due to its low efficiency and short lamp life.

Do not specify fiber optic lighting, except in very specialized applications, with University written approval, due to its very low efficiency and very high maintenance.

Select and locate fixtures to minimize glare especially in areas with high VDT usage. Pay special attention to fixtures located above shiny floors and stairs because their reflected light may cause falls.

Locate fixtures and remote ballasts so that they are accessible for maintenance by the use of a ladder only, or provide fixtures equipped with a lowering device. Do not locate fixtures or remote ballasts where a lift or scaffolding is required for maintenance.

Specify recessed fixtures that can be maintained from underneath unless the ceiling is accessible or a catwalk exists above the ceiling.

Locate wall and valance mounted fixtures sufficiently below the ceiling, or with large enough access opening, so that their lamps and ballasts can be removed without removing the fixtures from the walls.

Ceiling mounted fixtures shall be located so that their lenses can be removed without the need for removing adjacent mechanical or electrical equipment.

Fixtures, lamps, and ballasts shall be specified in accordance with the Electrical Trades Preferred Manufacturers List - http://www.umaec.umich.edu/desguide/prefman.html

Lamp and Ballast Recycling

Fluorescent lamps and ballasts shall be recycled in accordance with a University policy. Copy verbatim the University's lamp and ballast recycling specification from Master Specification 16010 (http://www.umaec.umich.edu/desguide/tech/csi16.html) into the project lighting specification.

Lamp Requirements

In general, linear fluorescent lamps shall be 4’ (maximum), T8, rapid start, multi-phosphor type with a medium bipin base, color temperature of 3500K, and a Color Rendering Index (CRI) of 85 minimum. Average rated life shall be 24,000 hours or greater, and lumen maintenance at end of rated life shall be 90 percent or higher.

Lamps shall be of low mercury content and designed to satisfy the Federal Toxic Characteristic Leaching Procedure (TCLP) criteria for classification as non-hazardous waste.

U-tube fluorescent lamps shall not be used.

High output T5 fluorescent lamps may be used when absolutely necessary (i.e., fixtures using T8 lamps are not available for the application) to meet special photometric requirements, but only with permission from the Project Manager. Normal output T5 lamps shall not be used.

High Intensity Discharge (H.I.D.) lamps shall conform to their applicable ANSI Codes.

Fluorescent or H.I.D. lamps in a single room or area shall produce the same color light.

Compact fluorescent lamps shall be 4-pin, 13 watt minimum with a color temperature of 3500 degrees K, a CRI of 80 minimum, suitable for use with electronic ballasts.

Light Emitting Diode (LED) lamps shall have their LED’s wired in parallel to prevent multi-lamp failure.

Do not specify self-ballasted compact fluorescent lamps except for retrofitting existing incandescent fixtures, and only for use on non-dimming circuits.

Fluorescent lamp sockets shall be white.

Provide socket extensions where necessary to optically center lamp in fixtures.

Ballast Requirements

Ballasts for T8 fluorescent lamps shall be of the electronic type, programmed rapid start, series circuited, and rated for a minimum start temperature of 0^{o} Fahrenheit. Ballasts shall be of the single, two, three, or four-lamp type, and shall only serve one fixture.

Ballasts for compact fluorescent lamps shall be electronic and shall have built-in EOL (end of life) protection.

Ballasts for H.I.D. fixtures in finished spaces shall be electronic or shall be mounted remotely so that ballast noise is not objectionable.

Ballasts shall be rated for the extremes of ambient temperature in which they are located. Specify ballasts rated for reliable starting to minus 20^{o}F for fixtures mounted outdoors.

Specify high ambient temperature ballasts to prevent overheating of fixtures mounted indoors in direct sunlight or in high ambient temperatures spaces.

Fluorescent ballasts for use in finished areas shall have a sound rating of "A" or better. H.I.D. ballasts for use in finished areas shall be of the quietest type available, or shall be mounted remote from the fixtures.

Lighting Fixture Requirements

Provide fluorescent and H.I.D. lighting rated for operation at 277 volts wherever possible. Verify the available voltage ratings before specifying fixtures.

Lighting fixtures shall be of specification grade or better, and shall be listed and labeled by Underwriters Laboratories (UL) or other approved agency. Provide fixture types that are known to have been used with success elsewhere. Do not provide newly developed or unproven fixtures.

Provide high efficiency fixtures with polished silverized reflectors and parabolic lenses wherever possible. Provide compact fluorescent fixtures in lieu of incandescent fixtures wherever possible.

Ceiling fixtures shall be designed so that trim fits close to the ceiling all around the fixture. Install white sponge neoprene gasketing as required to eliminate light leaks.

Recessed fixtures shall be thermally protected.

Recessed compact fluorescent fixtures shall not include lenses.

Lighting Control Requirements

Depending on the needs of the User the control 3 and 4 lamp fluorescent fixtures may be with either 1, or 2 switches. In cases with dual switching, the outside and inside lamps shall be switched separately. Alternately, a multi-lamp, dimming ballast and control may be installed.

Lighting (including emergency lights) in auditoriums, lecture halls, large classrooms, large conference rooms, and the larger research and teaching laboratories must be capable of being shut off for video presentations. Provide controls to turn on the emergency lights, regardless, if power fails while the emergency lights are shut off.

Provide local switches in hallways and at entry doors for control of non-emergency lighting.

Each room shall be controlled separately. Lights shall not be switched from panel circuit breakers.

Provide occupancy sensors in conference rooms, toilet rooms, and custodial closets to control the lighting. Provide occupancy sensors in classrooms and laboratories to control both the lighting and ventilation when specified in the program documents. Occupancy sensors should be of the infrared type whenever possible because ultrasonic occupancy sensors sometimes interfere with hearing aid operation.

Ambient Lighting controls

Fixtures in rooms with large windows should be oriented in rows that parallel the windows. Provide switches, and/or ambient lighting controls so that the fixtures near the windows can be turned off while the amount of incoming light is high.

Provide photocell controls to control the fixtures in skylights or atrium ceilings to turn the fixtures off when the amount of incoming light is sufficiently high.

Consider ambient light level dimming using photocell controls to dim the fixtures near large windows in rooms such as corridors, cafeterias and lounges if calculations show that the savings in energy pay back the higher cost of the lighting controls in five years or less.

Dimming Requirements

Whenever possible, specify dimmable ballasts that do not require separate control wiring. If control wiring is needed, run it in the same conduit as the power wiring when the manufacturer and Code allows. If control wiring must be run in separate conduits, this must be explicitly shown.

Design Criteria for Emergency and Night Lighting

Emergency lighting shall be on a separate circuit, and separate raceway from the normal lighting.

1. If a generator is present, connect emergency lighting to the emergency power panel.

2. If a generator is not present, install 'Bodine' (battery backed) equipment at each fixture, and connect the lighting circuit to the same panel as the normal lighting except the circuit shall be first run through a 2-gang box, adjacent to the panel. When a generator is in stalled the circuit(s) will be extended from that junction box to the emergency power panel. (Using this box will allow the circuit to be extended without using the panel as a junction box.)

3. Emergency lighting in corridor, lobby, stairway, or other public area shall be unswitched, and be on constantly. This lighting may be routed through a motion sensor that is fail-safe (The lights come on if the sensor fails.)

4. Emergency lighting in another type of space shall be switched (to allow A/V presentations, etc.), but shall come on, regardless, if power on the circuit is lost.

Night lighting shall be on a separate circuit, and wiring shall be in separate raceways from the normal lighting.

1. If a generator is present, connect to the emergency power panel.

2. If a generator is not present, install 'Bodine' (battery backed) equipment at each fixture, and connect the lighting circuit to the same panel, as the normal lighting except the circuit shall be first run through a 2-gang box, adjacent to the panel. When a generator is in stalled the circuit(s) will be extended from that junction box to the emergency power panel. (Using this box will allow the circuit to be extended without using the panel as a junction box.)

3. Night lighting in corridor, lobby, stairway, or other public area shall be one and the same as the emergency lighting - see above

4. Night lighting in another type of space shall be switched (to allow A/V presentations, etc.), but shall come on, regardless, if power on the circuit is lost

When battery backed up lighting is provided, it shall be provided, installed, and wired with an indicating, self-testing, and self-exercising remote module. This module shall be mounted in the ceiling near the fixture, or on the wall if the ceiling is too high. Modules for wall mounted fixtures shall be wall mounted near the fixture.

Whenever possible, mount the battery remote from the fixture, so the heat of the fixture does not degrade the life of the battery, and the battery is easier to access when it needs to be replaced.

When HID lighting fixtures are used, specify quartz restrike lamps in some of the fixtures, or provide some fluorescent fixtures for EEL purposes.

Exit Sign Requirements

Provide single or double faced exit signs located where required to meet egress requirements.

Also provide exit signs in all rooms where the travel path to the exit door(s) is more than 100 feet, where Code requires that there are two or more exit doors, and/or the number of occupants is 50 or more.

Exit signs shall have brushed aluminum stencil faces with red letters, and directional arrows.

Exit signs shall be LED illuminated. Self-luminous exit signs shall not be used.

Exit signs shall have die cast aluminum or polycarbonate housings with universal mounting brackets.

Power and wire exit signs as noted above for 'Emergency Lighting'.'

Emergency Egress Lighting Requirements.

Fluorescent emergency lighting battery packs shall consist of a maintenance-free, nickel cadmium, or pure lead battery, with a solid-state battery charger/inverter. The unit shall be sized to power T-8 lamp(s), or compact fluorescent lamps in the lighting fixture. Select size of unit needed to provide the lumens required, for a minimum of 90 minutes, to meet the 1 fc average lighting requirement for emergency egress lighting (also see Note 1 above).

The battery charger shall provide overload, short circuit, brownout, and low battery voltage protection. The unit shall include self diagnostic and self exercising circuitry to exercise and test itself for 5 minutes every month and for 30 minutes every 6 months.

Installation Requirements

All fluorescent lamps for use on dimming circuits shall be burned in for 100 hours minimum.

Support fixtures from building structural members. Fixture supports shall be angle iron, steel channel, or rod supports, and shall be sufficiently strong to ensure that the fixtures do not fall down during the life of the installation.

Support recessed fluorescent troffers independently of the ceiling grid system by using two safety wires minimum on diagonally opposite corners of the fixtures. Support recessed downlights by using safety wires or by rigidly attaching the fixtures to the building structure or ceiling grid system. Removable T-bar clips shall not be used to attach fixtures to the ceiling grid system.

Install fixtures level, with no gaps between adjacent fixtures or between fixtures and surrounding surfaces. Lenses, reflectors, and trims of fixtures shall be properly and uniformly aligned.

Connect emergency and night light fixtures as noted above. Mount fluorescent emergency lighting battery packs in accordance with the manufacturer's instructions. Locate the remote test/monitor modules so they are easily seen and read. Mount all of modules in a given space 'identically' they form a straight line when viewed from the end of the corridor or room. Where a suspended ceiling exists, center the modules in adjacent ceiling tiles.

Provide recessed fixtures with sufficient flexible conduit for removal of fixtures and to permit lowering of fixtures 12 inches below the ceiling. Junction boxes that service recessed fixtures shall be located within 12 inches of the fixture opening.

Install fixtures in a manner to facilitate maintenance. Any changes required as a result of the Contractor's failure to take maintenance into consideration shall be made at the Contractor's expense.

Fixtures shall have their exterior labels, and labels on reflector, removed and shall be thoroughly cleaned and properly aligned before the building or area will be accepted by the University.

Provide Owner training on the proper method of relamping and cleaning each type of fixture.

Provide green grounding conductors back to the panel ground for all new lighting circuits. Grounding conductors shall not be daisy-chained. When retrofitting existing lighting, install a ground wire from the fixture to the first point of disconnect if there is not one present.

Instruct the Contractor to perform testing in accordance with Section 16950, and to provide the University Project Coordinator with test reports.

OUTDOOR LIGHTING

General

The overall goal of the outdoor lighting (street, parking lot, pedestrian and building exterior lighting) is to improve and enhance the sense of safety and security in an efficient and sensitive manner. The lighting design shall take into consideration horizontal and vertical luminance and the uniformity of the distribution of light while minimizing glare, light pollution and light trespass. In addition, the lighting design should impart a sense of order, contribute to the overall campus aesthetic and ambience, enhance wayfinding, and strengthen U-M identity.

Related Sections

Design Guideline Technical Sections:
01141 - Tree Preservation
16010 – Basic Electrical Requirements
16050 – Basic Electrical Materials and Methods
16110 - Underground Electrical Service
16120 – Wires and Cables
16500 – Lighting Systems
16950 – Electrical Acceptance Tests

U-M Master Specifications
02935 - Lawn Repair
16521 – Outdoor Lighting

U-M Standard Details
16500 Series - Lighting Details

References

ASHRAE 90.1, "Energy Standard"
IESNA, "Lighting Handbook"
MBC, “Michigan Building Code”
NFPA 70, “National Electrical Code”
NFPA 101, "Life Safety Code"
USGBC, "LEED Rating Systems"

Design Process

This Design Guideline standardizes U-M outdoor lighting equipment and installation methods to strengthen U-M identity and to enhance lighting reliability and maintainability. However, it is not intended to limit creativity or innovation. Newer technologies and improved products will be considered, but must be submitted for approval before being used. Significant deviations from this Design Guideline may require Regental approval.

As a Design Deliverable at the end of Schematic Design, submit a preliminary site lighting plan showing the proposed outdoor lighting locations and general equipment types.

As a Design Deliverable at the end of Design Development, submit the following electronic files of plans, simulations, equipment descriptions and photometrics for U-M mock-up and approval:

- Lighting plans showing dimensioned equipment locations and luminaire type designations.

- Lighting simulations showing calculated results, including:
  - Name and version of simulation software used.
  - List of assumptions (if any).
  - Summary results for each area (maximum, minimum, average, avg./max, avg./min, etc.).
  - Average maintained horizontal illuminance on grade, shown in a grid pattern, in footcandles or lux.
  - Average maintained vertical illuminance at 5 feet/6 inches above grade in at least two directions of main travel, in footcandles or lux.

- Lighting equipment specifications and manufacturer cut sheets, including:
  - Luminaire types, descriptions, dimensions, optics, materials, and finishes with IESNA formatted photometric data files.
  - Pole and/or mounting support descriptions, dimensions, materials and finishes.
  - Lamp type for each luminaire, and lamp wattage, color temperature, color rendering index, and related life.

Design Requirements

Facilitate facial recognition through vertical illumination and careful selection of the color temperature and color rendering of the light sources.

Control light distribution to prevent direct glare to motorists, pedestrians and occupants of adjacent buildings, light pollution, and light intrusion onto adjacent private property.

Compensate for existing or planned light obstacles such as buildings and fully leafed trees.

Locate lights to emphasize specific building components and site features (i.e. building entrances, fenestration patterns, columns, pedestrian/vehicular nodes or gateways). Locate lights symmetrically at building entrances. Alternate lights on both sides of long, straight sidewalks.

Locate lights to frame important campus views and to avoid competing with existing illuminated and non-illuminated campus elements.

Locate lights on U-M property. Avoid locating lights in City right-of-way or on private property. Coordinate with the Design Manager to obtain City approval of lighting in City right-of-way.

Locate building-mounted lights 12 feet minimum above grade. Lighted bollards, hand rail lights, in-wall lights, step lights and in-ground lights are discouraged. Underwater pool and fountain lights are not allowed.

Locate lights outside the drip lines or root zones of significant (in size or age) vegetation. Request that U-M clear any significant vegetation if required.

Avoid lighting sporting and picnicking areas near Housing facilities because this encourages their use late at night.

Provide emergency power to building exterior lighting at exits when necessary to meet MBC and Life Safety Code requirements for emergency lighting at exterior exit discharges.

Provide a 100 watt quartz restrike lamp in the light nearest to each emergency telephone kiosk and bus shelter.

Provide light levels in accordance with IESNA recommendations, which are summarized for most applications in the following table.

AREA DESIGNATION	CRITERIA	ATTRIBUTE	TARGET
Pedestrian ways distant from roadway	Horizontal illuminance	Average maintained illuminance on pavement	0.5 footcandle
		Average-to-minimum uniformity	5:1
	Vertical illuminance	Average maintained illuminance at 5-feet/6-inches above grade in at least two directions (in direction of main travel)	0.5 footcandle
		Average-to-minimum uniformity	5:1
Pedestrian ways adjacent to roadways	Horizontal illuminance	Average maintained illuminance on pavement	0.5 footcandle
		Average-to-minimum uniformity	5:1
	Vertical illuminance	Average maintained illuminance at 5-feet/6-inches above grade in at least two directions (in direction of main travel)	1.0 footcandle
		Average-to-minimum uniformity	5:1
Parking lots	Horizontal illuminance	Minimum maintained illuminance on pavement	0.6 footcandle
		Average-to-minimum uniformity	4:1

Roadways	Horizontal illuminance	Average maintained illuminance on pavement	0.9 footcandle
		Average-to-minimum uniformity	4:1

Feed street, parking lot and pedestrian lights at 277 volts from a 480Y/277 volt, 3 phase, 4 wire circuit. Feed them with four No. 4 AWG conductors plus a No. 8 AWG ground conductor in a 1-1/4 inch, Schedule 40 PVC or HDPE conduit. Alternate feeder circuit phases for each successive light so that a single phase failure will not leave large areas in total darkness. Balance the load across all three phases, and limit the total load to 29 kVA. Before adding lights to an existing circuit, request that U-M provide the existing load on the circuit.

Provide a dedicated circuit for emergency telephone kiosks, illuminated signs, parking lot electric gates and Parkmasters. Feed them at 120 volts single phase with No. 10 AWG conductors plus a No. 10 AWG ground conductor in a 1 inch, Schedule 40 PVC or HDPE conduit.

Control street, parking lot, pedestrian, and building exterior lighting with lighting contactors. Lighting contactors shall be switched by a Building Automation System (BAS) Direct Digital Control (DDC) panel contact. Provide local photocell control only if BAS control is not available. Do not provide a time clock or an individual photocell in each light. Wire the control circuit so that the lighting will be energized in the event of a BAS System or photocell failure.

Products

Street and Parking Lot Lighting

In general, provide the U-M standard low profile, full cutoff, rectangular, black, aluminum shoebox fixtures with 250 watt metal halide lamps on 30 foot, round, tapered, black, aluminum poles. Lamp wattage and pole height may be reduced when necessary to minimize light trespass on surrounding areas. On the top deck of parking structures, the poles shall be hinged at the bottom so the fixtures can be maintained without the use of a bucket truck. Copy verbatim the appropriate requirements of Master Specification 16521 and Standard Detail 16500029 when specifying this equipment.

Pedestrian Lighting

Provide the U-M standard 16 inch, round globe fixtures with 6 spoke, black globe baskets, mounted singly, in doubles, or in fives on round, tapered, black, aluminum poles. Provide metal halide lamps, typically 100 watts in single globe fixtures, 70 watts in double globe fixtures, and 50 watts in five globe fixtures. As an alternative to mounting the fixtures on poles, mount them on column tops or with wall brackets. Specify pole lengths and mounting brackets to locate the horizontal center bands of the globe baskets at 12 feet, 0 inches above grade. Copy verbatim the appropriate requirements of Master Specification 16521 and Standard Detail 16500019 when specifying this equipment.

Installation Materials

Copy verbatim the appropriate requirements of Master Specification 16521 when specifying pole base materials, conduits, sleeves, wire, terminations, fuse holders, fuses, etc.

Lighting Contactors

Lighting contactors for outdoor lighting shall be NEMA 1, 3-pole, 4-wire, 480 volt, 60 amp, combination fused switch contactors with 50 amp fuses. They shall be electrically held, and include a hand-off-auto switch and a 300VA, 277:120V control power transformer. Specify that the outdoor lighting contactors will be furnished by the U-M Utilities Power and Lighting Shop (734.647.7049).

Execution

Pole Bases and Underground Work

Specify that Miss Dig (800.482.7171) be contacted before performing excavation work.

When existing lighting is being demolished, specify the following:

- Power shall be maintained to lighting on the same circuits but outside of the work area.
- Demolished lighting fixtures and poles shall be turned over to the U-M Utilities Power and Lighting Shop.
- Existing pole bases shall be removed completely and holes left by the pole bases shall be backfilled and restored. Holes in lawn areas shall be re-seeded.
- Temporary lighting shall be provided at the same lighting level as the demolished lighting until the demolished lighting is replaced. As an alternative, construction fencing shall be provided to prevent public access until the demolished lighting is replaced.

Pole bases shall be located and constructed in accordance with Master Specification 16521 and the appropriate Standard Details. Bases should not be located in sidewalks. They should be located to minimize impact on snow removal and lawn mowing, and where they will not be damaged by maintenance equipment.

Stub out a spare 1-1/4 inch conduit from every fourth or fifth pole base, and especially at corners and intersections, for expansion of the lighting circuit in the future. Select pole bases with only one or two active conduits. Aim spare conduits toward open lawn areas for easy access later.

Provide a 5/8 inch diameter x 8 foot long copper clad ground rod for each light pole base, and connect it to the pole ground lug. See the Standard Details.

Specify Schedule 40 PVC or HDPE conduits to feed in-wall and in-ground lights. Develop a detail showing the conduits entering the lights only from below.

Avoid locating in-ground junction boxes in sidewalks or driveways. Hide them in landscaping whenever possible.

Design underground conduit runs parallel to parking lot edges, sidewalks, and driveways, and adjacent to the pavement edges, to avoid interfering with future landscaping or other excavations.

When streets, parking lots, or sidewalks are cut for the installation of any underground utilities, provide a 6 inch sleeve for future outdoor lighting circuits. See the Standard Details.

Quality Assurance

Specify that the Contractor contact the U-M Code Inspection Department (734.764.2457) before pouring concrete, backfilling excavations, and energizing circuits.

Record Drawings

Specify that electronic files of record drawings or scanned mark-ups be provided at Substantial Completion for forwarding to the U-M Utilities Power and Lighting Shop. Record drawings shall show the actual locations of lighting poles, stubbed-out spare conduits, underground sleeves, and junction boxes, the circuit numbers for all circuits, and deviations from the design. Underground sleeve ends and junction boxes shall be dimensioned from permanent building or landscape features.

Lighting Controls Systems

A. Dimmer and other Light Control Systems

1. The systems shall be placed, labeled, and configured to be 'user friendly and intuitive.
2. Dimming systems shall not be 'shared' among multiple rooms, unless those rooms are separated by a movable partition.
3. When the room size is above 400 square feet, the dimming system shall have its own 'software' to schedule the lighting, or otherwise save lighting energy when the space is un-occupied. Alternately, it may be connected into the building lighting control system when one is available
4. Whenever possible, install new systems to be similar in operation and function to other systems already in the building for easier understanding and operation on 'users'.
5. In rooms with an installed A/V system, the dimming controls shall be coordinated with and integrated into the user control panel (screen) of that A/V system so all controls can be centralized for the instructor (user of the space).

B. Lighting control systems

1. Systems installed to schedule, and/or otherwise save lighting energy may serve multiple rooms.
2. All rooms larger than 400 square feet shall be connected to the lighting control system of the building, and/or have its individual controls.
3. Lighting control systems shall be integrated into the overall building control system, and the installed dimming systems
4. In rooms with more than one door, provide a full set of controls at the most frequently used door. At the remaining doors provide controls for at least portion of the lights.
5. When an energy analysis determines that room ventilation can be reduced when the room is unoccupied or fume hood flow can be reduced when nobody is standing at the hood, connect one dry contact of the occupancy sensor to the lighting system and provide a second dry contact for use by the building DDC system.

LIGHTNING PROTECTION SYSTEM

General

Early in the design of a new building, if the building will be taller than surrounding buildings and structures, provide a Lightning Risk Analysis in accordance with Appendix L of NFPA 780. The Project Team will review the Risk Analysis and determine if a lightning protection system should be provided.

Related Sections

Design Guideline Technical Sections:
16010 – Basic Electrical Requirements
16050 – Basic Electrical Materials and Methods
16450 – Grounding
16950 – Electrical Acceptance Tests

References

NFPA 70, "National Electrical Code"

NFPA 780, "Installation of Lightning Protection Systems"

UL 96A, "Installation Requirements for Lightning Protection Systems"

Lightning Protection System Requirements

If it is determined that a lightning protection system should be provided, provide a traditional type of system in accordance with the appropriate chapter of NFPA 780. Do not provide an early streamer emission system or a charge dissipation system.

Provide UL listed or labeled lightning protection components and cables. Provide copper or bronze components and cables. Aluminum components and cables are not acceptable.

Ground the lightning protection system using separate copper-clad ground rods in accordance with Design Guideline 16450. The building ground system rods shall not be used. Do not provide chemically enhanced ground rods or ground test wells.

Obtain an electrical inspection of the underground components before burying them.

Test the lightning protection system in accordance with Design Guideline 16950. After both the lightning protection system and the building ground system have been completed and tested, bond the two systems together. Obtain a final electrical inspection.

The lightning protection system shall be installed by an Underwriters Laboratories Master Label Installer in accordance with UL 96A. After the system is completed and tested, the Installer shall provide a UL Master Label suitable for mounting in the building's unit substation room.

FIRE ALARM SYSTEMS

General

Provide a fire alarm system, or expand the existing system, as required by Code, the requirements in the Special Instructions to Designers (SID) of the Design Guidelines, and/or as noted in the Program Documents.

The Department of Public Safety (DPS) remotely monitors essentially all of the University buildings on the Ann Arbor campuses. DPS monitors all of these fire alarm systems, 24-hours a day. The connection from the building to DPS is by the University MOSCAD system. This system is UL approved for Central Station monitoring, and the DPS office is considered to be a constantly attended location.

In other locations and/or when noted in the program documents, the fire alarm system shall be connected by telephone to the fire department in that jurisdiction.

Provide shop drawings for approval, and final certification reports, to the State Office of Fire Safety, and/or University of Michigan Fire Marshall (Department of Public Safety), as required by Code, and the Design Guidelines

MOSCAD (Central Station Monitoring) Connection

The fire alarm system shall have output contacts that will interconnect with the University of Michigan's MOSCAD (Motorola SCADA system) transmitting unit. Provide a minimum of three form “C” contacts in the fire alarm control panel, plus needed conduit and wiring to the MOSCAD panel, for use as Alarm, Trouble, and Supervisory inputs for the MOSCAD system. These contacts, in their normal state, shall be closed, and in the 'alarm' state they shall open. See Detail 16725012 for installation details

Note that the MOSCAD system is connected by radio to the University of Michigan's Department of Public Safety on Kipke Road on south campus. This MOSCAD system is often used to transmit other alarm messages to that central security office. These other alarms might include security, and/or monitoring points of critical systems

In new buildings and when defined in the program statement, install, wire, and connect a MOSCAD system. The MOSCAD 'RTU' , and antenna equipment will be provided by the University. Installation shall comply with the above noted standard detail, and information included in the program statement.

All wiring in the RTU, between the Alarm Junction Box and the RTU, and the wiring to the antenna, as well as all of the programming and work needed at DPS will be by the University. (*Note to U of M Design Manager, include $8000 in the project budget to pay for these U of M provided equipment and services.)*

Initiating devices

Provide adequate smoke and heat detectors where required by Code to rapidly detect a fire in any area of the building. In buildings or areas without sprinklers, provide total coverage. In fully sprinklered buildings, Code only requires automatic detectors in elevator machine rooms, in elevator lobbies, and in most elevator hoistways of high rise buildings. In all buildings, Code requires one smoke detector above the fire alarm control panel. In addition, provide supplementary initiating devices as noted below in the 'Design Requirements' section

Provide manual pull stations in all buildings at exit doors and at other locations as defined by Code.

Pull stations in residence areas of residence halls, areas where children are present, and as noted in program statement shall have vandal covers with audible alarm (when cover is lifted). Smoke and heat detectors in resident areas of residence halls, and areas with ceilings of 8'-0" or less, and as noted in program statement shall have wire screen covers that are UL listed for the fire alarm system being installed.

Notification Appliances

Provide audible notification appliances as required to meet the minimum sound levels of the applicable codes. Assume that all interior doors are closed. Take into consideration the average ambient sound level in each space, the distance from the nearest notification appliance to each space, and the sound attenuation of the intervening walls and doors. Note that many laboratories and mechanical rooms have high average ambient sound levels. Note also that alarm sound level measurements will be taken during fire alarm system testing, and audible appliances will have to be added if the alarm sound levels do not meet Code.

High rise buildings, residence halls (in general), buildings having more than 1000 occupants and/or other buildings as noted in program statement, shall have emergency voice/alarm communication systems throughout the building (including speakers in elevator cars).

Provide visual notificaton appliances in all common and public spaces as required by the applicable codes. Common and public spaces are defined as corridors, toilet rooms, auditoriums, classrooms, multi-person offices, and conference rooms and laboratories with an occupancy large enough that Code requires them to have two doors.

In addition, provide supplementary visual notification appliances as noted below in the 'Design Requirements' section.

To address UFAS (the University's ADA requirements), install a visual (or audible/visual) notification appliance adjacent to each exit sign.

Vivariums shall have special alarm audible and visual indicating appliances to accommodate the research animals. See SBA-A for the specific requirement in these areas.

Connections to Sprinkler Systems

In a building with a sprinkler system, provide water flow switches to detect sprinkler activation; and valve tamper switches at all shut off valves (including elevator machine room sprinkler shut off valves). Fire panel descriptors shall specifically note coverage area of the water flows, and the locations of the tamper switches. In a building with a fire pump, provide surveillance of the pump and its power supply.

Design Requirements

General Items

All new fire alarm systems shall be addressable with one or more panels as required by the size of the project area. In addition, all new fire alarm systems shall be installed with 25%(additional) spare capacity in all initiating circuits, notification appliance circuits,, power supplies, amplifiers, and related components of the overall system.

Whenever possible, expand and/or extend the existing system unless otherwise directed by the University. The expanded system shall also meet the 25% spare capacity requirement as noted above, limited only by the constraints of the model and vintage of that existing system.

All addressable devices shall have a unique address, this address shall be noted on the as-built drawings, and will be noted on a label for the device. Whenever possible number the heat and smoke detectors in each zone in a numerical order beginning with the detector closest to the control panel, and progressing away from the control panel.

Initiating Devices and Notification Appliances

All initiating, monitoring, and control devices shall have the addressability function built into the associated device. Non-intelligent devices with separate addressable circuit boards are not acceptable.

Monitored components such as flow switches, tamper switches, etc. shall be connected (and monitored) by addressable 'monitor module' device. Monitor modules shall be connected to the monitored device, and shall be in close proximity to that device.

Pull stations, duct smoke detectors, audible and visual notification appliances, etc. shall all be installed and spaced as required by Code, and manufacturer's requirements.

Design Issues

Initiating Devices

Buildings owned by the University without a sprinkler system shall have smoke and/ or heat detectors installed throughout the building.

In buildings with a sprinkler system, install smoke and heat detectors only in areas required by Code, as otherwise required by these guidelines, and good practice. If a building is partially sprinkled, follow the above noted guidelines in the appropriate areas.

Elevators are required by the Elevator Code to be provided with smoke detectors in the elevator machine rooms, in the elevator lobbies, and in most elevator hoistways to initiate an elevator recall. These smoke detectors will be provided with the elevator, and they shall not be connected to the fire alarm system.

When fire alarm system smoke detectors are required in elevator machine rooms and elevator lobbies, provide independent fire alarm system smoke detectors adjacent to the elevators' detectors. If the elevator hoistways are sprinklered, provide an independent fire alarm system smoke detector at the top of each elevator hoistway.

Install heat detectors, rather than smoke detectors, in high humidity locations such as bathrooms with showers and laundry areas, and/or in areas with occasional smoke present such as kitchens.

In areas where the room will be occasionally hosed down (cleaned) use devices specifically listed for such duty. For outdoor locations, use devices listed for the environment in which they will be located.

Locate all initiating devices (detectors) so that they are accessible for maintenance by the use of a ladder only. No lifts or scaffolding shall be required for maintenance. Those devices in restricted areas such as elevator shafts shall be easily accessible, from a non-restricted area, via an access doors. Avoid locating detectors above sloped auditorium floors.

Do not locate detectors at the top of atriums or skylights. In these applications use beam type where applicable. Avoid locating detectors where direct sunlight, high humidity, stagnant air, or turbulent air will cause maintenance problems.

When the need for door holders (and associated door release service devices) is defined during schematic design, the associated devices shall be connected to the fire alarm system. The needed smoke detectors shall report the fire alarm system, and the door holders are then released by the fire alarm system. Carefully coordinate associated fire system components and door hardware specified in the architectural section.

Duct Smoke Detectors

1. Locate duct smoke detectors at locations defined by manufacturer and/or by the mechanical contractor to have a laminar flow across the detector. Do not locate duct type smoke detectors downstream of humidity injection points or in outside air intake plenums. Duct smoke detectors shall 'report' to the fire alarm panel, and the fire alarm panel shall operate a 'control module' to stop the associated fan.

2. All duct smoke detector installations shall include a 'duct detector interface box' as shown in standard details 16720006, 16720007, or 16720008. The University will provide the interface box, unless noted otherwise during schematic design.

3. Locate the duct detector and the interface box so that a ladder is not needed to access them. Typically the boxes are located near the associated temperature control panel.. If the duct detector must be located where it is inaccessible or a ladder is required to access it, provide a remote indicator light and test pushbutton in a nearby accessible but non-public location.

4. If the fire alarm system is connected to a MOSCAD panel for transmission of alarm, supervisory, and trouble signals to the Department of Public Safety, program the duct detectors as supervisory rather than alarm devices. Duct dectectors shall only alarm the building if the fire alarm system is not connected to MOSCAD.

Notification Appliances

1. Audible notification appliances shall produce a slow whoop alarm tone. If an emergency voice/alarm communication system is provided, the audible evacuation alarm signal shall produce three slow whoop alarm tones followed by a pre-selected voice evacuation message. The alarm tones and voice evacuation messages shall alternate until they are silenced.

2. Size and locate visible notification appliances in strict accordance with the "Visible Characteristics, Public Mode" Section of NFPA 72. Select the strobe candela outputs in accordance with the spacing tables, and indicate their outputs on the plan drawings for all strobes greater than 15 candela. Locate strobes at the halfway distance on the longest walls as shown in the NFPA 72 figures and appendices. Do not install strobes near room corners without increasing their candela ratings appropriately.

Fire Alarm Main Panels, and Annunciators

1. Locate the fire alarm system control panel in a clean, dry, heated, and ventilated closet or electrical room near a building entrance. The panel shall not be located in a building corridor, loading dock area or other high traffic area.
2. Provide at the fire department's normal entrance a fully functional annunciator panel.
3. In areas that are not continuously occupied, automatic smoke detection shall be provided at each control unit(s) location to provide notification of fire at that location.
4. The fire alarm system annunciation shall enable responding personnel to quickly and accurately identify the location of a fire, and to indicate the status of emergency equipment or fire safety functions that might affect the safety of occupants in a fire situation. All required annunciation means shall be readily accessible to responding personnel and shall be located as required by the authority having jurisdiction to facilitate an efficient response to the fire situation.

On all buildings on the Ann Arbor Campuses, install a NEMA 3R rated, 90 to 100 candela, strobe, outside, and above the location of the 'siamese' (hose) connection devices. This is a requirement of the Ann Arbor Fire Department

Supplementary Devices and Appliances

Provide supplementary initiating devices, of the type noted, for the following applications. Provide these divices so that a small fire can be detected and extinguished before the sprinkler system actuates and destroys the energized electrical equipment. Since these are not NFPA 72 requirements, place a note on the plan by each such device noting the reason for its placement. The note is to clarify the reason for the device, and to insure that the device is being and installed and placed to 'cover' the noted equipment or space. Unless otherwise required by Code, or these guidelines, there is no need to provide 'complete room coverage' in these situations - in all other respects the installation shall meet NFPA 72 requirements

1. In substation rooms providey two heat detectors per transformer. Center them on the transverse centerline of the substation transformer, and place approximately above the front, and rear surfaces, of the transformer.
2. In BDF (BE) and LDF (TR) communication rooms, provide at least one smoke detector above the relay racks.
3. In electrical power rooms, provide at least one smoke detector.
4. In recycling and trash rooms, install one smoke detector.
5. In elevator machine rooms and elevator lobbies of low rise buildings, provide one smoke detector.

Provide supplementary notification appliances, of the type noted, for the following applications. Provide these divices to notify people in areas with a high ambient sound level of a fire. Since these are not NFPA 72 requirements, place a note on the plan drawing by each such appliance noting the reason for its placement. Unless otherwise required by Code, or these guidelines, there is no need to provide 'complete room coverage' in these situations - in all other respects the installation shall meet NFPA 72 requirements.

1. In large mechanical rooms, elevator machine rooms, and electrical substation rooms, provide visual notification appliances if it is unlikely that the audible notification appliances will produce a sound level at least 15 dBA above the average ambient sound level.

2. In laboratories containing mechanical equipment, provide visual notification appliances if it is unlikely that the audible notification appliances will produce a sound level at least 15 dBA above the average ambient sound level.

Products

The fire alarm system shall be resistant to damage from power system surges, spikes and voltage dips. The system shall be emergency battery backed, and size in accordance with Code requirements.

To reduce the possibility of damage by induced transients, circuits and equipment shall be properly protected in accordance with requirements set forth in NFPA 70, National Electrical Code, Article 800.

The fire alarm system shall be field programmable. When a special device is required to perform field programming, 1 programmer, software, and training shall be provided as part of the system unless the University already owns an appropriate programmer.

All wiring for the fire alarm system shall be installed in conduit or surface raceways. Use concealed conduit whenever possible and practical. When concealed conduit cannot be used in finished areas, provide surface raceways.

Route fire alarm system wiring in separate conduits (or surface raceways) from that of other building wiring. In addition, power, alarm, and detector wiring shall be segregated from each other as required by the system manufacturer and the applicable codes.

Execution

Instruct the Contractor to wire the detectors in each zone in numerical order beginning with the detector closest to the control panel, and progressing away from the control panel.

Instruct the Contractor to provide a typed list identifying all zones and detectors including the detector types and locations.

Inform the Contractor that the fire alarm system control panels, alarm devices, detectors, and switches shall not be painted. Junction boxes and covers, however, shall be painted red.

Detectors shall not be installed until after the construction clean up of all trades is complete and final. Detectors that have been installed prior to final clean up by all trades shall be cleaned or replaced.

> Duct type detectors shall not be installed in the ducts until after the ducts have been cleaned and the duct filters have been changed.
>
> Inform the Contractor that ceiling mounted detectors shall either not be installed prior to completion of other construction work in the area, or plastic bags shall cover the detectors until the other construction work is completed

Fire alarm system shall be connected, programmed, tested, and certified, by NICET certified fire alarm persons. Raceway, wiring, and installation shall be by licensed electricians.The fire alarm contractor shall provide the University, on floppy disk, or CD, a complete 'Windows System' compatible copy of the operational and application programs. This electronic documentation will reflect the system as configured after the certification testing is completed, and accepted.

Instruct the Contractor to perform testing in accordance with Section 16950, and to provide the University Project Coordinator with test reports.

CLOCK SYSTEM

General

Scope

For Central Campus projects, provide synchronous-wired clocks.
- The existing impulse signal type clock system is obsolete and can not be expanded.
- The existing power line carrier signal clock system is no longer reliable due to power system harmonics, and thus shall not be expanded.

For new North Campus projects, provide synchronous-wired clocks.

For North Campus renovation projects:
- Match the existing clocks if a synchronous-wired clock system already exists.
- Provide synchronous-wired clocks if the existing clocks are impulse signal type or power line carrier signal clocks.

When synchronized clocks are not required and the Owner agrees to pay the costs of resetting, maintaining and replacing stolen clocks, provide individual battery-powered clocks.

Related Sections

Refer to Design Guidelines Section 16050, “Basic Electrical Materials and Methods”, for clock conduit requirements including conduit identification requirements.

Refer to Design Guidelines Section 16120, “Wires and Cables”, for clock wiring requirements including wire color coding requirements.

Design Criteria

The University maintains two Simplex Model 6400 master time centers, one in the School of Education Building and the other in the G. G. Brown building. These units are synchronized to the Coordinated Universal Time Broadcast from Radio Station WWV in Fort Collins, Colorado. They output 24 volt DC binary coded decimal (BCD) signals for University clock synchronization.

Provide a building clock code converter to monitor the master time center and control all of the building clocks. Locate the clock code converter in the unit substation room.

Provide a telephone line connection from the nearest University master time center to the building clock code converter.

Provide one or more clock correction relays as necessary to monitor the clock code converter and produce a 120 volt AC synchronizing pulse for the building clocks. Locate the clock correction relays adjacent to the clock code converter.

Provide a three-wire with ground power and synchronizing circuit in conduit from the clock correction relays to each clock.

Products

Synchronous-Wired Clock System

Specify Simplex Model 2320-9007 clock code converters.

Specify Simplex Model 2080-9008 clock correction relays.

Specify synchronous-wired, analog, 12" round, 120 volt, 60 Hz, 3 wire connected clocks with black surface mount molded case, 12 hour Designer 1 face, Designer hands including a sweep second hand, Simplex Model 6310-9221 with Model 2310-9011 receptacle assembly.

Battery Powered Clocks

Specify battery powered, analog, 12" round clocks with a sweep second hand and capable of being reset by means of a stem that is accessible without removing the clock from the wall.

Execution

Dedicated conduits shall be provided for synchronous-wired clock system wiring.

Final connections and testing of a synchronous-wired clock system shall be performed by a manufacturer's representative.

Battery-powered clocks shall be fastened to the walls with screws to impede theft.

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TELECOMMUNICATION

General

Provide Telecommunications pathways (raceways), 'Building Entrance' (BE) rooms, and Telecommunication Room (TR) rooms, as described below, and in accordance with the Program Documents. Coordinate and confirm Telecommunications systems approach for each project with the Project Coordinator.

Typically, the University (ITCom) provides all of the tele/data cabling, equipment, and terminations, from their network backbone to the telephone/data outlet (Work Area Outlet), including the faceplate at those outlets. Exceptions to this rule will be clearly stated in the program of the project

Telecommunications systems in most of the buildings, on the Ann Arbor campuses, are operated and maintained by the U of M, ITCom Department. This design guideline was drafted in cooperation with ITCom, and addresses the University's requirements. Additional information can be obtained from U of M's ITCom through the University Project Coordinator.

IT Com is usually involved with the Telecommunications systems within the University of Michigan Health System, the U of M Dearborn and Flint Campuses, and many "off-site" locations. Unless noted otherwise in the program statement, these guidelines are to be applied to any University owned building, even if the "serving utility" is not ITCom.

Related Sections

Special Building Areas Section SBA-C - Telecommunication Rooms describes specific architectural, mechanical, and electrical features associated with Telecommunications Rooms. This section also defines Building Entrance Rooms (BE) and Telecommunication Rooms (TR) (formerly known as BDFs and LDFs respectively) and includes associated diagrams.

Refer to Section 16050 for additional conduit and cabling requirements.

Refer to Section 16110 for underground manholes and electrical duct.

General System Description

The current cable plant provides multiple 4-pair cables of copper conductors from the user (local Work Area Outlet) to the nearest telecommunications room - either a BE or TR. These cables are used for all voice; telephone set power, and essentially all data services, including point-to-point and local area networking. Separate RG cables are installed to locations noted for closed circuit TV, and/or cable TV.

All Work Area Outlet (station) wiring is home run from the user location to the nearest TR. For transmission integrity, no intermediate splices or terminals are allowed.

For renovations, where the existing cables will be too short, new cables will need to be installed and with the associated need to modify existing conduit and cable trays.

The Building Entrance Room (BE, formerly BDF) is the main termination point in a building. Telecommunication Rooms (TR, formerly LDF) are distribution and termination rooms located on each floor of a building and serve user stations within 293 cable feet (including 6 feet of slack at TR room, and 3 feet at the Work Area Outlet). If cable lengths will exceed 293 feet, multiple TR's are be required. Also, the BE may also be the TR for that floor. TR's are interconnected to the BE via backbone cables for connection to equipment or locations external to the building. See SBA-C for additional information on BEs and TR's.

Telecommunication Service Entrance

Consult with Project Coordinator and ITCom prior to proceeding with telecommunications building service entrance design.

Refer to Technical Section 16110 for Underground Electrical Duct and Section 16050 for additional conduit and cabling requirements.

Underground Service Entrance Conduits:

Except as otherwise noted, comply with conduit requirements detailed in "Telecommunications Raceway and Cabling Requirements" noted below.

Typically, provide (a minimum of) four, 4-inch conduits extending from a location specified by ITCom (typically a manhole), to the building.

Conduit and ducts shall include no more than 180 degrees of total bend or exceed 400 feet in length, and shall have a bending radius of at least 10 times the conduit diameter.

Encase conduit in concrete, except at poles. When terminating at a pole, clamp conduit rigidly to the pole at 90-degree separation from power.

Extend conduit 4" beyond terminating wall or floor. Plug open conduit with mechanical seal.

Pullboxes shall not be used for directional transitions or terminations of Outside Plant cable when entering a building. If the termination point (typically, the BE) of the Outside Plant cable is more than 50 feet inside the building, or if the cable is run through plenum areas, install the Outside Plant cable in rigid metallic conduit.

Manholes:

Refer to Technical Section 16110 for manhole and hand hole requirements

Manhole hand holes shall not be used for directional transitions in telecommunications service.

Direct Buried Telecommunications Service Entrance: *

*Direct-buried service entrances are typically allowed only for off-campus structures, and when specifically noted in the program statement of the project.

Consult ITCom for all direct-buried service entrances. Place orange warning tape in trench backfill, 18 inches above the cable.

For multi-service trenches, the minimum space requirements between Telecommunications cabling and other facilities are: 3 inches when separated by concrete, 4 inches when separated by masonry, and 12 inches where separated by well-tamped earth.

Telecommunication Raceway

Horizontal Pathways:

Horizontal pathways support and protect horizontal station cables between the work area outlet and the local Telecommunications Room (or TR). Acceptable horizontal pathways include conduit, cable tray and under floor duct systems. Horizontal pathways shall be continuous and unobstructed, accessible for maintenance and installation of additional cables with minimal disruption to building occupants, and be located at a safe working height above the ceiling grid.

Horizontal pathways shall be bonded and grounded, either at the tray, or in the TR room.

Horizontal pathways, using cable trays, should be designed to allow for future changes or additions in horizontal cabling. Cable trays shall be sized with consideration of the square footage of the area served, the number of currently planned outlets, the square inches of cable per outlet, plus 50%. Tray fill calculations shall assume, 3 4-pair Cat 5E, cables per Work Area Outlet location. These cables have a diameter of .165 inches per cable.

"J" hooks bridle rings; staples and other individual supports that inhibit cable pulling are not acceptable*, except when specifically noted in the project's program statement* for short-term leased facilities, and/or other 'temporary' facilities.

Conduit (including general requirements applicable to underground service entrance):

Conduit material, application, and installation shall comply with NEC (see SID-F) and Section 16010, and 16050.

Conduits shall be rigidly installed, and adequately supported. Conduit shall be reamed, and shall be joined and terminated with approved outlet boxes, pull boxes, fittings and bushings.

Install conduit with minimal bends and in as short a path as possible. Excessive bends, and offsets inhibit cable installation. Install adequately sized pull boxes in conduit runs every 100 feet or 180 degrees of bends. For conduit runs over 2 inches in diameter, consult ITCom on pull box size. Bends in conduits over 2 inches shall be long sweeps and no conduit radius shall be less than 10 times the internal diameter of the conduit.

Conduit entering a BE or TR shall terminate 6" inside room unless otherwise noted.

Conduit shall not be placed above or near hot pipes and equipment, including boilers, incinerators, hot water and steam lines or through areas in which flammable or other hazardous material may be stored.

Conduit shall be provided with nylon pull strings.

All conduits are to be bonded to the TC ground with #12 copper (minimum) ground wire.

Cable Tray

If cable tray is substituted for a portion of the 'home run conduit', the following items are critical to a workable installation:

- Provide adequate working space above and on 1 side of the cable tray, allowing access during the initial installation and subsequent additions.
- Place the cable tray at a safe working height above the finished floor, taking into consideration working space restrictions due to ceiling grid.
- Attach, secure, and bond station conduits to cable tray, using listed, and approved fasteners.
- The integrity of the tray shall not be compromised by the intrusion of pipes or conduits.
- Cable Tray shall not be used in place of conduit runs specified for computer room tie cables or any other riser type cable installation.

Size cable tray using the following guideline:

- A minimum of one work area outlet for every 100 square feet of useable floor space served by the cable tray.
- Standard work area outlets are served with three, four pair cables, with an average diameter of 0.165 inches each.

The maximum allowable fill for the tray is not to exceed 70% of the cross sectional area.

Surface Mounted Raceway:

Surface mounted raceway is generally not preferred, but may be used to facilitate multiple outlet locations in renovations, lab settings or for surface mount applications where conduit is inappropriate. Refer to Preferred Manufacturers List.

Conduit shall run continuously between surface mounted raceway and cable tray and TR. Conduit connection at surface mounted raceway shall be a minimum of 1 1/4". Provide conduit access to both ends of surface mounted raceway for installations with high outlet density.

Telecommunications Work Area Outlets:

Install sufficient outlet boxes to meet current and future requirements. All outlet boxes should have continuous raceway path to TR installed. ITCom will determine, and provide, outlet box faceplates.

Minimum conduit size for one outlet (workstation) is "3/4.

- Two workstations may be served by a 1". conduit, and up to three outlets may be served by a 1-1/4” conduit
- Please note that some clients (colleges, schools, and departments) still require a 1” minimum size conduit. The U of M Design Manager shall affirm needs of client in each project.
- In surface raceway applications up to four (single gang) outlets may be served by a 1-1/4” conduit

Outlet box shall be double gang, 2" deep minimum. The only exceptions to this requirement are wall telephone outlets, and data outlets in surface raceways, These may be single gang

Grounding, Bonding and Electrical Protection Requirements

All telecommunications cabling and raceway requires grounding, to protect from lightning, ground potential rises or surges, or contact with or induction from power circuits.

For each BE and TR, provide a 1/4" x 1" x 12" copper ground bus, location to be determined by ITCom through the University Project Coordinator.

Connect telecommunications room ground bus to the ground bus bar in the nearest electrical panel on the same floor with #6 or larger stranded copper ground wire. A maximum of 1 ohm to building ground is allowed.

Bond all raceways to the ground bus bar.

Provide a continuous stranded copper ground wire, minimum #6, from each telecommunications room ground bus to the Building Entrance Room and from the Building Entrance Room to the main building ground bus.

ITCom shall bond all telecommunications cabling shields to telecommunications room copper ground bus.

SPECIAL COMMUNICATIONS SYSTEMS

GENERAL

Provide special communications systems when required by the Program Documents, including intercom, public address, sound, CCTV and other special systems.

DESIGN REQUIREMENTS

Locate speakers and similar remote devices so that they are accessible for maintenance by the use of a ladder only. No lifts or scaffolding shall be required to perform maintenance.

Locate the system controls where they are convenient to the people authorized to control the system, but where they are not convenient to the general public.

EQUIPMENT REQUIREMENTS

The system shall be resistant to damage from power system surges, spikes and voltage dips.

When a special device such as a wireless remote control is required to control the system, provide at least 1 such device as part of the system.

All wiring for the system shall be in conduit or surface raceways. Use concealed conduit whenever possible and practical. When concealed conduit can not be used in finished areas, provide surface raceways.

Route the system wiring in separate conduits or surface raceways from the other building wiring.

The types of cables used shall be in accordance with the system manufacturer's instructions.

INSTALLATION REQUIREMENTS

Instruct the Contractor to protect from damage all system devices installed prior to completion of other construction in the area. The Contractor shall correct at his own expense any loss or damage occurring to system devices before completion of other construction.

Instruct the Contractor to perform testing in accordance with Section 16950, and to provide the University Project Manager with test reports.

HEATING CABLES AND MATS

General

Provide heating cables and mats to protect outdoor piping and tanks from damage due to cold weather. When required, provide heating cables and mats to prevent ice buildup on and damage to concrete slabs, roofs, gutters, and downspouts.

Provide self-regulating heat tracing products manufactured by Raychem Corporation, Process Division, Menlo Park, California or Thermon Corp, 100 Thermon Dr., P.O. Box 609, San Marcos, TX, 78667-0609.

Equipment Requirements

Provide Raychem model "Autosense M-Wire" or comparable Thermon model for protection of critical water lines (such as exposed chilled water pipes serving a computer room A/C unit).

Provide Raychem model "BTV" or comparable Thermon model for protection of non-critical hot and cold water lines (such as exposed chilled water lines to a local air conditioning unit serving a general occupied zone).

Provide Raychem model "XTV" or comparable Thermon model for steam service.

Provide Raychem model “ElectroMelt” or comparable Thermon model for concrete snow-melting and de-icing applications.

Provide Raychem model “IceStop” or comparable Thermon model for roof and gutter snow-melting and de-icing applications.

Get written approval from University Project Manager if the necessary product cannot be provided by Raychem or Thermon.

Sizing Requirements

Use the Raychem application software such as “TraceCalc” etc. or comparable Thermon application software to size and determine the heating cable wattage density and trace ratio (wraps per linear foot). For applications not covered by software, use the approved method as outlined in Raychem’s or Thermon’s applicable design guide publication.

Monitoring and Control Requirements

When available, the Building Automation/Direct Digital Control (BAS/DDC) System shall provide all control and monitoring functions. If BAS/DDC is not available, get direction from the University Project Manager. Contact University Project Manager to determine if heat trace system monitoring is necessary or desirable. Monitoring functions shall be accomplished through current sensing switches (CSS) that monitor each electrical feed phase. When providing systems with an integral monitoring conductor, contact University Project Manager for monitoring conductor connections.

Installation Requirements

Heating cables and mats shall be installed according to the manufacturer's instructions. All installations shall comply with the NEC and particularly articles 426 and 427 of the 1999 and 2002 NEC, which apply to this equipment. Per article 426-28 and 427-22, the system shall be protected by a 30mA trip ground fault protection of equipment device.

The contractor shall test the heating cables and mats in accordance with this Design Guideline, DG Section 16950 and manufacturer's recommendations before energizing or installing any insulation or covering. Contractor shall provide the University Project Manager with test reports before job closeout

Insulation Resistance (Megohmmeter) Testing for Heat Trace Cables

A. Refer to manufacturer's Design, Installation, and Maintenance Guide.

B. Perform megohmmeter test at 2500v dc.

   i. Measure the resistance between the heating cable bus wires and the grounding braid.

   ii. If the heating cable is installed on a metal/conductive surface, apply megohmmeter between the grounding braid and the surface.

   iii. Apply the voltage for one full minute.

   iv. All insulation resistance values should be greater than 1000 megohms.

   v. Resistance reading should stabilize.

   vi. If any of the above conditions cannot be met contact the Project Manager.

C. Perform megohmmeter testing prior to installation and after installation of heating cables, but prior to power connections.

ELECTRICAL ACCEPTANCE TESTS

General

This guideline defines the standard tests that all electrical systems and equipment must pass prior to final acceptance by the University. These tests are in addition to acceptance tests specified by equipment manufacturers or defined in the other Design Guidelines sections. Obtain permission through the Design Manager before specifying tests less than or in excess of these tests.

Related Sections

Design Guidelines Technical Sections: All
Electrical Trades Preferred Manufacturers List
U-M Master Specifications: All

References

ANSI/NETA ATS, "Standard for Acceptance Testing Specifications"
NFPA 70, "National Electrical Code"
NFPA 72, "National Fire Alarm Code"

Scope of Work

Acceptance tests shall be performed in accordance with the current version of ASNI/NETA ATS and by an independent testing agency. Specify only the independent testing agencies listed in the latest Electrical Trades Preferred Manufacturers List.

Tests shall be performed in accordance with applicable codes, standards, and equipment manufacturers' instructions.

The Contractor shall provide all test equipment, materials and labor necessary to perform the tests, and shall coordinate with the other trades for necessary services, such as scaffolding and the uncoupling of motors.

Tests shall consist of visual inspections, manual operations, and electrical testing under all normal and expected abnormal operating conditions.

The Owner shall be notified at least 3 working days in advance of all tests.

Tests shall be witnessed by the Owner unless such witnessing is waived in writing.

The Owner shall be provided with a written test report, signed and dated, for all tests.

Testing Criteria

High potential tests shall be performed at the AC or DC voltage listed in ASNI/NETA ATS unless specified otherwise herein. Do not perform more than one high potential test on any item without authorization from the Owner.

Dielectric absorption tests shall be performed with a 2,500 volt DC megger.

Megger tests shall be performed at a DC voltage of 1,000 volts for 600 volt rated equipment, and at a DC voltage of 500 volts for 120-300 volt rated equipment.

Continuity checks shall be performed with a low voltage DC meter, light or bell.

The resistance to ground shall be measured using either the three point method or the fall-of-potential method.

Test instruments shall be calibrated to national standards to insure the accuracy of tests. These calibration reports shall be made available to the Owner when requested. Depending upon frequency of use, the instruments shall be calibrated at least every 12 months.

Visual Inspections

Prior to manual operation and electrical testing, verify the following:

- The equipment complies with the contract documents and the shop drawing submittals.
- The equipment is completely and properly installed according to the contract documents and the manufacturer’s instructions.
- Adequate working space exists around the equipment to fully open doors and access panels, and to access all components that require maintenance.
- The equipment is free from damage and defects.
- Shipping blocks and restraints have been removed.
- The equipment has been aligned.
- The equipment has been lubricated.
- The ventilation louvers are open and unobstructed.
- Electrical connections have been tightened.
- Voltages, phases, and rotation have been identified.
- Terminations have been identified.
- Equipment labels have been installed.
- The equipment has been calibrated.
- The equipment is ready to be electrically tested.

Manual Operations

Prior to electrical testing, verify the following:

- Mechanical components operate smoothly and freely.
- Mechanical stops, limit switches, etc., are properly adjusted.

Electrical Acceptance Tests

Duct Banks

A stiff bristled brush shall be pulled through each duct to clean out dirt and debris.

A solid mandrel rated for the inside diameter of the ducts and at least 5 inches long shall be pulled through each duct to verify the absence of kinks, flat spots, and other obstructions. The Owner may require the use of the Owner's mandrel.

Medium Voltage Primary Cables

A continuity test, a 2,500 volt DC megger test, a DC high potential test, and a second 2,500 volt DC megger test shall be performed on 15 kV primary cables after the cables have been spliced or terminated. The high potential test shall be performed at 45kV on new cable installations and at 30kV on existing installations or when new cable has been spliced to existing cable.

600 Volt Power Cables

A continuity check and a 1,000 volt DC megger test shall be performed on 600 volt power cables No. 4 AWG and larger. The megger test shall be performed between each pair of conductors and from each conductor to ground. Each test shall be performed for 15 seconds or until the insulation resistance value stabilizes.

The insulation resistance between conductors, and from each conductor to ground, shall be 100 megohms minimum in one minute or less. In addition, the lowest insulation resistance value shall not differ from the highest value by more than 20 percent. If all megger readings for a given circuit are above 1000-meghoms, the 20 percent balance requirement may be waived.

Control Cables

A continuity check shall be performed on control and instrumentation wiring.

Substation Primary Switches

A continuity check, a 2,500 volt DC megger test, and a 37 kV DC high potential test shall be performed on primary switches.

Substation Transformers

A DC megger test and a turns ratio test shall be performed on unit substation transformers. The DC megger test shall be performed at 2,500 volts on coils rated over 600 volts, and at 1,000 volts on coils rated 600 volts and below. A turns ratio test shall be performed on each tap.

Verify proper setting and operation of the fan control panel to insure it and the fans are operable and functional. Temperature test the probes in each winding.

Substation Secondary Switchgear

A continuity check and a 1,000 volt DC megger test shall be performed on the buses and on the main, tie, and feeder breakers.

A ducter (contact resistance) test shall be performed on main, tie, and feeder breakers in unit-substations. Maximum readings shall not exceed manufacturer limits.

The overcurrent devices of substation breakers with electronic trip units shall be tested using the primary current injection method. Secondary current injection shall not be used.

Molded case circuit breakers with thermal/magnet trips shall not be primary current injection tested.

A 1,000 volt DC megger test and a turns ratio test shall be performed on CT's and PT's.

The metering shall be calibrated.

Engine-Generators and Automatic Transfer Switches

A continuity check and 1,000 volt DC megger test shall be performed on the generator windings, generator circuit breaker, power circuit portions of the automatic transfer switches, and the interconnecting power circuit wiring.

A continuity check shall be performed on the control wiring.

The metering and time delay relays shall be calibrated and tested.

The manufacturer's recommended normal start-up testing shall be performed.

A load bank test shall be performed on the generator with a load bank rated at 100 percent of full generator output for a period of at least 120 minutes.

If the engine is natural gas fueled and Compliant Capable rather than Certified as defined in EPA 2009 NSPS emissions standards, an EPA Initial Performance Test shall be performed. This test shall consist of three separate 1 hour runs at close to full load. It shall be performed in accordance with EPA test requirements, and the measured emissions shall be within EPA limits.

Normal power shall be shut off to each automatic transfer switch, one at a time. Each time the engine-generator shall start and the automatic transfer switches shall function according to the design intent.

Normal power shall be returned to the automatic transfer switches. The automatic transfer switches shall return to normal power and the engine-generator shall shut down according to the design intent.

Normal power shall be shut off to the entire building. The engine-generator shall start and the automatic transfer switches shall function according to the design intent. Normal power shall be returned. The automatic transfer switches shall return to normal power and the engine-generator shall shut down according to the design intent.

The generator shall be tested for voltage and frequency stability. The automatic transfer switches shall be used to apply load to the generator according to the worst case step loading sequence defined in the generator specification. The generator voltage and frequency shall remain within the values listed in the generator specification.

The ATS maintenance bypass switches shall be inspected for proper labeling and tested for proper operation in all modes.

The generator and automatic transfer switch controls, gauges, status indicators, and alarms, including remote annunciators and devices in the Fire Command Center, shall be tested for proper operation.

Alarm outputs to the fire alarm and BAS systems shall be verified.

Transformers, Reactors, Switchboards, Panelboards, and Motor Control Equipment

A continuity check and a 1,000 volt DC megger test shall be performed on distribution and isolation transformers, and on line reactors.

A 1,000 volt DC megger test shall be performed on buses, motor starters, circuit breakers, and disconnect switches. This test may be combined with the power cable megger test by testing the devices and terminated cables together.

A continuity check shall be performed on motor control circuits and control panel internal wiring.

An operational test shall be performed on the motor controls.

Motor heater sizes shall be checked for proper size.

Motors

A 1,000 volt megger test shall be performed on 460 volt motors. A 500 volt megger test shall be performed on 200 volt and 120 volt motors.

Motors shall be "bumped" to verify proper direction of rotation.

Motors shall be run to verify proper ampere draw and to verify vibration and heating are within required limits.

The Electrical Contractor shall assist the Temperature Control Contractor and the Mechanical Contractor and insure proper operation of safeties, interlocks and motor controls.

Capacitors

Capacitors shall be inspected for proper fuses before testing. A 1,000 volt DC megger test shall be performed on 460 volt capacitors, and a 500 volt megger test shall be performed on 200/240 volt capacitors. After each megger test, proper discharge shall be checked.

Grounding

The resistance to ground of each ground rod in a ground mat shall be measured before connection to the other ground rods. The resistance shall not exceed 10 ohms. If the reading exceeds 10 ohms, add one extension and drive it another 10 feet. Further testing of that rod is not needed.

The resistance to ground of the total ground system shall be measured with all connections completed. The resistance shall not exceed 2 ohms for switching stations or utility (DTE) feed point services; and shall not exceed 5 ohms for building service substations.

Ground rods for manholes and light poles need not be tested.

A continuity check shall be performed from equipment ground bus bars and ground lugs to the ground system.

Lighting Fixtures

Lighting fixtures shall be checked for proper assembly, proper louvers or lenses, proper lamps, proper ballasts, straight row alignment, proper aiming, and the absence of light leaks.

Battery-backed emergency lighting fixtures shall be checked for continuous operation for a minimum of 90 minutes.

Lighting Circuits

Lighting circuits shall be checked for proper switching, for proper circuiting according to the design documents, and for circuiting that matches the lighting panel schedules.

Lighting Controls and Dimming Systems

Lighting controls and dimming systems shall be tested to verify that they have the specified features and programmability, and that all controls are properly labeled.

Lighting controls and dimming systems shall be tested to verify that the control sequences noted in the contract documents and manufacturer's instructions are present and operable, that control and dimming are smooth and free of flicker, and that fading is properly timed.

Lighting controls and dimming systems shall be tested to verify that the emergency lights function upon a loss of normal power.

Fire Alarm Systems

Fire alarm systems shall be tested in accordance with NFPA 72.

Controls that interface with the fire alarm system shall be tested in cooperation with the Temperature Controls Contractor to insure proper operation of interfaced mechanical devices.

Alarm, supervisory, and trouble outputs to the MOSCAD and BAS systems shall be tested to insure that the signals are received by Public Safety or at Plant Operations.

Special Systems

Security systems, card access control systems, sound reinforcement systems, and other special systems shall be tested in accordance with test plans submitted by their manufacturers and approved by the Owner. These test plans shall verify compliance with specifications and proper operation including all inputs, outputs, alarms, and accessories under all modes of operation.

Heat Tracing Cables and Mats

A continuity check, a 500 volt DC megger test, and an operational test shall be performed on heat tracing circuits prior to insulation of the pipe or tank. Verify proper current draw and heating of the heat tracing.

The 500 volt DC megger test shall be repeated after the insulation is completely installed.

An operational test shall be performed on the controls and alarms.

UNIVERSITY OF MICHIGAN
Architecture, Engineering and Construction

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AEC Design Guidelines

Preferred List of Manufacturers

Preferred Manufacturers List General Procedures

DISCIPLINE	DATE OF LAST UPDATE
Architectural (Divisions 1 through 14)	January 2010
Mechanical (Division 15)	September 2009
Electrical (Division 16)	July 2010

Last modified: Thursday July 22 2010

For technical inquires, comments and suggestions on the U of M Design Guidelines, please e-mail the U of M Design Guidelines Group at UMDesignGuide@umich.edu.

University of Michigan - Architecture, Engineering and Construction
A326 East Hoover Ann Arbor MI 48109-1002 Contact Us

ARCHITECTURAL PREFERRED MANUFACTURERS LIST

General

This list is a compilation of products approved for use on University of Michigan projects. Where specific manufacturers or products are listed for a given building element, limit selection to the products listed. When, in your opinion, an unlisted product should be considered for inclusion in a project, consult with the Design Manager. Do not substitute this list for your professional judgment concerning appropriate products and materials.

Where specific products are not listed for a given building element (i.e. curtain walls), base the selection of manufacturers, types, styles, or models on your professional judgment. Wherever possible, select the products of at least 3 manufacturers. Avoid the use of open ended "or equal" statements.

This list is updated as needed. Obtain the current copy from the Design Manager.

Table of Contents

Preferred Manufacturers

Section 07530 – Single-Ply Membrane Roofing

EPDM Systems:
- Carlisle SynTec Systems, Carlisle Corporation
- Firestone RubberGard Roofing Systems, Firestone Building Products Co.
- Genflex Roofing Systems, GenCorp. Polymer Products, Building Systems Div.
- Johns Manville Roofing Systems, Johns Manville Corp.
- Versiguard Roofing Systems, Versico Incorporated.

Hypalon Systems:
- Carlisle SynTec Systems, Carlisle Corporation
- Stevens Roofing Systems Div., JPS Elastomerics Corp.

Section 08410 - Aluminum Entrances and Storefronts

Entrances, Doors and Storefront Systems:
- Arch Aluminum and Glass Co., Inc.
- Capitol Aluminum and Glass Corp.
- Cross Aluminum Products, Inc.
- EFCO Corp.
- Heritage Window and Door, Inc.
- Kawneer Company, Inc.
- Special-Lite, Inc.
- TRACO
- Tubelite, Inc.
- United States Aluminum Corp.
- Oldcastle Glass Fulton Windows, Inc.
- Oldcastle Glass Vistawall Architectural Products.
- Wausau Window and Wall Systems.

Flush Panel FRP Doors:
- Kawneer Company, Inc.
- Special-Lite, Inc.

Tubular Section Aluminum Flush Panel Doors:
- Cross Aluminum Products, Inc.
- Heritage Window and Door Inc.
- Kawneer Company, Inc.

Section 08520 - Aluminum Windows

Architectural Grade Windows (subject to availability of project-applicable products):
- Capitol Aluminum and Glass
- Custom Window Company.
- EFCO Corp.
- Graham Architectural Products Corporation.
- Heritage Window and Door, Inc.
- Kawneer Company, Inc.
- Oldcastle Glass Moduline Windows, Inc.
- Oldcastle Glass Fulton Windows, Inc.
- TRACO
- Wausau Window and Wall Systems.

Heavy Commercial Grade Windows (subject to availability of project-applicable products):

- Capitol Aluminum and Glass.
- Custom Window Company.
- EFCO Corp.
- Graham Architectural Products Corporation.
- Heritage Window and Door Inc.
- Kawneer Company, Inc.
- Oldcastle Glass Fulton Windows Inc.
- Oldcastle Glass Moduline Windows, Inc.
- TRACO
- Wausau Window and Wall Systems.

Section 08710 - Door Hardware

Butt Hinges:

- Hager
- Ives
- McKinney
- Stanley

Continuous Geared Hinges:

- Hager-Roton
- Pemko
- Select Hinges

Locksets (mechanical and electrified): See technical section 08710 for standard functions.

Corbin Russwin	ML2200
• Sargent	8200 Series
• Schlage	L Series

Electric Strike:

• Von Duprin	6000 Series
• HES	1006 and 9600 Series

Cores (in existing buildings match existing core type for ease of keying):

- Best Co.
- Medeco Keymark SFIC
- Schlage Everest SFIC

Exit Devices (mechanical and electrified):

- Sargent
- Von Duprin

Digital Locks:

• Schlage	Model CM 5596-KPI

Closers:

• LCN	4000 Series only

Overhead Holders and Stops:

- Glynn Johnson 410 Series
- Rixson 6 Series
- Rockwood 14000 Series

Local Exit Alarms (not connected to fire alarm or access control systems):

- Detex

Flush Bolts (Automatic, Constant Latching and Manual):

- Door Controls International (DCI)
- Ives
- Rockwood

Flatgoods:

- Any BHMA member

Weatherstripping/Thresholds:

- Any BHMA member

Concealed Power Transfer:

- Securitron
- Von Duprin

Section 08800 - Glazing

Primary Glass:

- AGC Flat Glass North America Guardian Industries Corp.
- Pilkington Building Products North America.
- PPG Industries, Inc.
- Zeledyne Glass Operations

Wire and Patterned Glass:

- AGC Flat Glass North America Guardian Industries Corp.
- Pilkington .

Laminated Glass:

- AGC Flat Glass North America Guardian Industries Corp.
- Interpane Glass Co.
- Oldcastle Glass.

Insulating Glass Units:

- AGC Flat Glass North America Guardian Industries Corp.
- Interpane Glass Co.
- Oldcastle Glass.
- Viracon, Inc.

Fire-Rated Glazing:
- AGC Interedge Technologies.
- Technical Glass Products (TGP).
- Pilkington Building Products North America; distributed by Technical Glass Products (TGP).
- SAFTI First; a division of O'Keeffe's, Inc.
- Vetrotech Saint-Gobain North America.

Section 10100 - Visual Display Boards

Markers and Chalkboards:
- Cig Jan Products, Ltd.
- Claridge Products and Equipment, Inc.
- Marsh Industries, Inc..
- PolyVision Corp.

Section 10155 - Toilet Compartments

- All American Metal Corp.
- Bradley Corporation; Mills Partitions.
- Flush-Metal Partition Corp.
- Hadrian Manufacturing, Inc.

Section 10801 - Toilet and Bath Accessories

- American Specialties, Inc. (ASI).
- Bobrick Washroom Equip., Inc.
- Bradley Corp.
- Elcoma Metal Fabricating (grab bars and shower seats only).
- Gamco (except for shower seats and counter mounted soap dispensers).
- Koala Kare Products (baby changing stations only)

Note: Toilet paper dispensers, paper towel dispensers (roll-type), and wall mounted soap dispensers are provided by UM, but installed by the Contractor. Coordinate with Design Manager.

Section 11610 - Laboratory Fume Hoods

Air Master Systems Corp.
- BMC Manufacturing
- Fisher Hamilton LLC.
- Kewaunee Scientific Corp.
- Labconco Corp. (Fiberglass reinforced polyester or coved stainless steel interiors only).
- Sigma Systems; Mott Manufacturing Ltd.

Base Cabinets for Fume Hoods: Refer to approved laboratory casework manufacturers list.

Section 12345 - Laboratory Casework

Metal Casework; associated suppliers:
- Air Master Systems Corp.
- BMC/Metal-Arc Inc.; BMC Industrial Educational Services.
- Fisher Hamilton Scientific Inc.; Farnell Equipment Co.
- Kewaunee Scientific Equip. Corp.; R.D. Landstra Assoc.
- Laboratory Design & Supply, Inc.
- Mott Manufacturing Ltd.

Flammable Storage: Kewaunee; Secure-All.

Wood Casework; associated suppliers:
- Campbell-Rhea Institutional Casework, Inc.
- Fisher Hamilton Scientific Inc.; Farnell Equipment Co.
- Kewaunee Scientific Equip. Corp.; R.D. Landstra Assoc.
- Laboratory Design & Supply, Inc. (Flush overlay only; lipped overlay not available)
- Mid-Canada Millwork
- Valley City Manufacturing Co., Ltd.

Epoxy Resin Tops and Sinks:
- Kemresin; Kewaunee Scientific Corp.
- Durcon, Inc.
- Epoxyn; Epoxyn Products

Stainless Steel Sinks and Tops:
- Elkay Co.
- Just Manufacturing

Fiberglass Sinks:
- Kreolab, Inc.

Shelf Standards and Brackets:
- Cooper B-Line, Inc.
- Flex-Strut, Inc.
- Kewaunee Scientific Corp.
- Unistrut Corp.

Service Fittings:
- Chicago Faucets, a Geberit Company
- T & S Brass and Bronze works, Inc.
- Watersaver Faucet Company
- Wolverine Brass, Inc.

Section 12515 - Window Treatment

Aluminum Horizontal Blinds - Public/Student Areas (1-inch or 2-inch slat width):
- Classic DustGuard Riviera (1")/Riviera DustGuard (2"); Levolor
- Model CD88 (1")/Model H282 (2"); Hunter Douglas
- Bali Classic/Bali Horizontal Aluminum School Blinds (2"); Springs Window Fashions

Aluminum Horizontal Blinds - Private Offices:
- Bali Classic; Springs Window Fashions
- CE 61; Hunter Douglas
- Monaco 6; Levolor

Wood Horizontal Blinds:
- Graber
- Hunter Douglas
- Levolor-Kirsch Window Fashions
- Nanik

Specialty Roller Shades:
- Bali Solar Shades; Springs Window Fashions
- LightBloc Flexshade; Draper Inc.
- MechoShade Systems, Inc.
- Solarfective Products Limited.

Vertical Blind Headrail for Metal Vinyl and Fabric:
- V-3000 Headrail; Laserlite
- G-71 Super-Vue Headrail; Graber.

Vertical Blind Slats (must be compatible with above headrails):
- Graber
- Hunter Douglas
- Levolor-Kirsch Window Fashions
- Louverdrape; Levolor-Kirsch Window Fashions
- Tontine, Inc.

Section 13036 – Controlled Environment Rooms

Environmental Rooms:
- Bruce Johnson Service Co., Inc.
- Environmental Specialties, a Bahnson, Inc. group company
- Environmental Growth Chambers
- Harris Environmental Systems.
- Insulated-Structures, Inc.
- Nor-Lake, Inc.

ELECTRICAL TRADES
PREFERRED MANUFACTURERS LIST

The Electrical Trades Preferred Manufacturers List identifies manufacturers and suppliers who are known to provide good quality products, meet specification and schedule requirements, provide technical support, and provide service after the sales. This list is intended to regulate product quality, standardize electrical designs, and simplify maintenance activities. It is not intended to limit competition. It is not all inclusive. It is a list of manufacturers whose products are well known to the University due to their frequent and successful use.

This List shall be used by A/E's when selecting manufacturers for specification in electrical designs. **A/E'S SHALL SPECIFY ONLY THE LISTED MANUFACTURERS THAT MEET THEIR PROJECT'S REQUIREMENTS, AND SHOULD SPECIFY A MINIMUM OF THREE MANUFACTURERS WHENEVER POSSIBLE.** A/E's may specify manufacturers not on this list to satisfy project requirements, **BUT ONLY AFTER OBTAINING UNIVERSITY APPROVAL IN ADVANCE.**

This List shall **NOT** be used by Contractors to justify making substitutions for products specified in the construction documents. **CONTRACTORS SHALL PROVIDE THE PRODUCTS SPECIFIED IN THE CONSTRUCTION DOCUMENTS UNLESS THE UNIVERSITY APPROVES THEIR PROPOSED SUBSTITUTIONS AT THE TIME OF BID IN ACCORDANCE WITH THE PROJECT'S STANDARD GENERAL CONDITIONS.**

THIS LIST DOES NOT APPLY to purchases by the University Plant Department of replacement electrical products required to match or maintain existing installations.

This List is revised as needed. Before using it, check the AEC Website for the latest revision.

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SECTION 16050 - BASIC ELECTRICAL MATERIALS AND METHODS

Cable Trays - Center Spline and Wall Mount Types (Use only where ladder and wire basket trays can not be used, and only with ITCS (Campus projects) or MCIT (UMHHC projects) approval)

B-Line
Mono-Systems
Thomas & Betts
Wiremold

Cable Trays - Ladder Type

B-Line
Chalfant
Cope
Globetray (GS Metals)
Husky
Mono-Systems
Thomas & Betts

Cable Trays – Wire Basket Type (Use only with ITCS (Campus projects) or MCIT (UMHHC projects) approval)

B-Line
Chalfant
Cablofil EZTray
Mono-Systems

Conduits, Raceways and Accessories

EMT, liquid-tight flexible metallic conduit, and/or non-liquid-tight flexible metallic conduit/raceway; plus associated accessories, fittings, junction and pull boxes, and related products

Products of all manufacturers are acceptable as long as they are electro-galvanized steel, have a smooth interior, and are NRTL labeled for the application.

Rigid (galvanized metal), and IMC (intermediate metal) conduits/raceway, plus associated accessories, fittings, junction and pull boxes, and related products

Products of all manufacturers are acceptable, as long as they are hot-dipped galvanized steel inside and out, have a smooth interior, and are NRTL labeled for the application. Boxes shall be cast, not formed. IMC may only be used when tools specifically designed for IMC are used.

PVC conduit/raceway (Type DB, Schedule 40, and Schedule 80, plus associated accessories, fittings, junction and pull boxes, and related products

Products of all manufacturers are acceptable as long as they are sunlight resistant, and NRTL labeled for the application. Products from manufacturers making both the conduit and the fittings are preferred whenever possible.

Fiberglass Reinforced Epoxy (FRE) conduit/raceways, accessories, fittings, and related products

FRE
Champion

Cord Reels

Appleton
Hubbell
Reel-O-Matic Systems
Woodhead

Electrical Enclosures

Carlon (For use with PVC raceways)
Hammond
Hoffman
Park Metal
Rittal

Fire Stop Compounds

A. D. Fire Protection Systems
Flame Safe
Hilti
Nelson
STI SpecSeal
3M Company

Structural Support Materials

Aickinstrut (Fiberglass)
B-Line
Champion (Fiberglass)
Hilti
Powerstrut
Unistrut

Surface and Underfloor Wireways

Carlon
Hubbell
Mono-Systems
Panduit
Walker (Wiremold)
Wiremold

SECTION 16110 - UNDERGROUND SERVICES

Underground Hand Holes, Junction Boxes and Pull Boxes

CDR Systems
Carson-Brooks
Quazite

SECTION 16120 - CABLES AND WIRES

Cables (Medium Voltage)

General
Kerite
Okonite
Prysmian

Cables and Wire (600 Volts)

Aetna Wire and Cable
Alan Wire
American Insulated Wire
Cerro Wire
Encore
Republic Wire
Rockbestos-Surprenant
Service Wire
United Copper Industries

MC Cables (600 Volts)

AFC
Encore
Kaf-Tech
Rockbestos-Surprenant
Service Wire
United Copper Industries

2-Hour Fire Rated Cables (600 Volts)

Lifeline by Drake USA
VITALink by Rockbestos-Surprenant

Control Cables and Wire

Belden
Coleman

Cable Splices for Medium Voltage Cable

Raychem

Cable Terminations for Medium Voltage Cable

Raychem

SECTION 16140 - WIRING DEVICES

Dimmer Switches

Leviton (Incandescent type only)
Lithonia (Incandescent and fluorescent types)
Lutron (Incandescent and fluorescent types)

Occupancy Sensors (Infrared and Combination Infrared/Microphonic Dual Technology)

Leviton
Lutron
Sensor Switch
Tork
Watt Stopper
Hubbell

Occupancy Sensors (Ultrasonic and Combination Infrared/Ultrasonic Dual Technology)

Watt Stopper (UT and DT 300 Series Only)

Pin & Sleeve Connectors

Crouse-Hinds
Hubbell
Killark
Leviton
Pass & Seymour

Power Poles

Hubbell
Mono-Systems
Steelcase
Wiremold

120-volt, 20-ampere Receptacles (GFCI, Hospital Grade, TVSS & Child Resistant)

Bryant
Cooper (Arrow Hart)
Hubbell
Leviton
Pass & Seymour

120-volt, 20-ampere Receptacles and Plugs

Bryant
Arrow Hart (Cooper)
Hubbell
Leviton
Pass & Seymour

Special Power Receptacles and Plugs

Bryant
Arrow Hart (Cooper)
Hubbell
Leviton
Pass & Seymour

120/277 Volt, 20-Ampere Light Switches

Bryant
Arrow Hart (Cooper) Hubbell
Leviton
Pass & Seymour

SECTION 16231 - ENGINE-GENERATOR SYSTEMS

Natural Gas Fired Engine-Generator Sets (Only those which require inlet gas pressures of 14 inches of water column or less)

Caterpillar (No components from Olympian)
Cummins
Generac (300 kW maximum)
Kohler

Automatic and Manual Transfer Switches

ASCO
Cummins (Open transition switches only)
Eaton/Cutler-Hammer
GE Zenith Controls (Open transition switches only)
Kohler (Open transition switches only)
Russelelectric
Square D (Open transition switches only

SECTION 16265 - STORED ENERGY EMERGENCY LIGHTING AND POWER SYSTEMS

Batteries

C & D Technologies
Chloride Plante
Enersys
Johnson Controls

Battery Chargers

LaMarche
SCI
Enersys
C & D Technologies
Hi-Tran

Uninterruptible Power Supply Systems (Battery type)

A.P.C.
Best (Individual small load units only)
Controlled Power
MGE
Mitsubishi (Totally solid-state)
Liebert

Rotary UPS Systems

Designed Power Solutions International (DPSI)

SECTION 16310 - UNIT SUBSTATIONS

Non-Current Limiting Fuses (Primary)

S & C Type SM-5SS (With high interrupting capacity adapter)
Eaton/Cutler-Hammer Type RBA-400 (With high interrupting capacity adapter)

Current Limiting Fuses (Primary)

Ferraz-Shawmut, Type CL-14

Eaton/Cutler-Hammer Type CLE
General Electric Type EJO

KWHR/Demand Meters

Power Measurement Limited (PML) 7330 ION (With options per Master Spec 16313)

15 kV Fused and Unfused Primary Switches (5kV rated switches may only be used for 5 kV (4,160 volt) class motors)

Eaton/Cutler-Hammer
Powercon
Square D

15kV Metal Clad Switchgear and/or Circuit Breakers (5kv rated circuit breakers may only be used for 5 kV (4,160 volt) class motors)

Eaton/Cutler-Hammer
General Electric
Square D

Circuit Breakers for 600-volt Class Secondary Switchgears and Switchboards

Asea Brown Boveri
Eaton/Cutler-Hammer
General Electric
Square D

Transformers

Asea Brown Boveri
Eaton/Cutler-Hammer
General Electric
MGM
Olsun
Square D

Substation Assemblers (Using components from Preferred Manufacturers only)

Controlled Power Corporation
Eaton/Cutler-Hammer
Electrical Product Sales
General Electric
Park Metal
Powercon
Pederson Power Products
Square D

Addresses of above Assemblers

Controlled Power Corporation
295 Wetmore Ave SE
Massillon, Ohio 44646
Phone: 800 321 0414
FAX: 330 834 3201

Eaton/Cutler-Hammer
McNaughton-McKay Electric Co.
4670 Runway Blvd, Ann Arbor, MI 48108
Phone: 734-327-6251
Fax: 734-327-6285

Eaton/Cutler-Hammer
Service Electric Supply Co.
15424 Oakwood Drive, Romulus, MI 48174
Phone: 734-229-9100
Fax: 734-229-9101

Electrical Product Sales
Dick Stone
(248) 583-6100

General Electric
McNaughton-McKay Electric Co.
4670 Runway Blvd, Ann Arbor, MI 48108
Phone: 734-327-6251
Fax: 734-327-6285

Olsun Electrics
HEK Inc.
6083 Lafayette
Ann Arbor, MI 48103
Phone: (734) 995-0900

Park Metal
19197 Sherwood Street, Detroit, MI 48234
Phone: 313-366-2200
Fax: 313-366-1540

Powercon/Woodlyn Sales
9357 General Drive - Suite 102, Plymouth, MI 48170
Phone: 734-453-2754
Fax: 734-453-2759

Pederson Power Products
1521 Eden Gardens Drive, Fenton, MI 48430
Phone: 810-750-3032
Fax: 810-750-9557

Square D
Madison Electric Co.
3900 Jackson Rd, Ann Arbor, MI 48106
Phone: 734-_665-6131
Fax: 734-665-9239

Square D
Wyandotte Electric Supply Co.
212 S. Wagner Rd, Ann Arbor, MI 48103
Phone: 734-769-6400
Fax: 734-769-7745

SECTION 16400 - SERVICE AND DISTRIBUTION

Bus Ducts
Eaton/Cutler-Hammer
General Electric
Siemens
Square D

Fuses (600 Volts and Below)
Bussmann
Ferraz-Shawmut
Littelfuse

Surge Protective Devices
Current Technology
Eaton/Cutler-Hammer-Tycor
Intermatic (For protection of individual loads and receptacle panels only)
L.E.A. Dynatech
Leviton (For protection of individual loads and receptacle panels only)
Liebert
Square D

Switchboards, Panelboards and Circuit Breakers
Eaton/Cutler-Hammer (Only with U of M Lugs - confirm on shop drawings)
General Electric
Industrial Electrical Manufacturing (For custom and retrofit applications only)
Siemens
Square D

Time Switches
Intermatic
Paragon
Sangamo
Tork

Transformers (Liquid Filled and Dry Pad-Mounted Type)

Eaton/Cutler-Hammer
General Electric
Olsun Electrics
Pennsylvania
Pioneer

Transformers (Distribution Dry Type)

Acme
Eaton/Cutler-Hammer
General Electric
Hammond Power Systems
Hevi-Duty
MGM
Olsun Electrics
Siemens
Square D

SECTION 16450 - GROUNDING

Ground Connections

Burndy Hyground (Proper dies must be used)
Cadweld
Thermoweld
Thomas & Betts Blackburn (Above grade only)

SECTION 16480 - MOTOR CONTROLS

Capacitors for Power Factor Correction

Aerovox
Eaton/Cutler-Hammer
General Electric
Myron Zucker
Siemens
Square D

Motor Controls (MCC's, Starters, Contactors, Disc. Switches and Control Devices

Allen-Bradley
Eaton/Cutler-Hammer
General Electric
Siemens
Square D

Motor Starters (Electronic Soft Starter Type)

Allen-Bradley
Eaton/Cutler-Hammer
Sprecher & Schuh

SECTIONS 16511 & 16521 - INTERIOR & EXTERIOR LIGHTING

Ballasts (Electronic Compact Fluorescent)

Advance Smart Mate
Aculite
Lightolier
Lutron
Prescolite

Ballasts (Electronic Rapid Start T-8 Fluorescent)

Advance Optanium
Bodine (For emergency lighting only)
Osram/Sylvania Quicktronic Professional
Universal AccuStart

Ballasts (Electronic Dimming T-8 Fluorescent)

Advance Mark X (5% dimming type)
Lightolier (1% dimming type)
Lutron Hi-Lume (1% dimming type)
Lutron ECO-10 (10% dimming type)
Osram/Sylvania (10% dimming type)

Emergency Power Ballasts (Electronic Rapid Start T-8 Fluorescent)

Bodine (For emergency lighting only)
Lithonia

Ballasts (H.I.D.)

Advance
MagneTek
Universal

Dimming Systems

AMX
E.T.C.
Lithonia
Lutron
Strand (Stage lighting only)
Leviton (Small single room systems only)

Emergency Lights

Chloride
Dual-Lite
Emergi-Lite
Exide Lightguard
Lightalarms
Lithonia
Sure-Lites

Exit Signs (LED)

- Chloride
- Dual-Lite
- Emergi-Lite
- Exide Lightguard
- Lightalarms
- Lithonia
- Morlite (High abuse areas) (Philips)
- Prescolite
- Sure-Lites

Lamps

- General Electric Ecolux
- Philips Alto
- Osram/Sylvania Ecologic
- Venture (H.I.D. only)

Lighting Fixtures (Fluorescent)

- Alkco (Philips)
- Columbia
- Day-Brite (Philips)
- Fail-Safe (Cooper)
- Finelite
- Focal Point
- Guth (Philips)
- Harris
- Holophane (Acuity)
- Hubbell
- Keene
- Kenall
- Kirlin
- Lightolier (Philips)
- Linear Lighting
- Lithonia (Acuity)
- Cooper (Metalux)
- Peerless (Acuity)
- Prudential
- Quality (Philips)
- Visa
- Williams
- Zumtobel

Lighting Fixtures (H.I.D.)

- Best
- Crouse-Hinds (Cooper)
- Day-Brite (Philips)
- Fail-safe (Cooper)
- General Electric
- Guth (Philips)
- Harris
- Holophane
- Hubbell
- Kenall
- Lightolier (Philips)
- Lithonia (Acuity)
- Lumark (Cooper)
- McGill
- Quality (Philips)
- SPI

Lighting Fixtures (Compact Fluorescent and Incandescent)

- Globe
- Gotham (Acuity)
- Halo
- Harris
- Kenall
- Kirlin
- Lightolier (Philips)
- Lithonia (Acuity)
- Omega (Philips)
- Prescolite (Hubbell)
- Quality (Philips)
- Swivelier

Lighting Fixtures (Outdoor Parking Lot and Roadway with poles by fixture supplier)
Gardco
Holophane
Lithonia Hi-Tek
McGraw-Edison
Sterner
Wide-Lite (Philips)

Lighting Fixtures (Outdoor Pedestrian Area with poles by fixture supplier)
Lumec

Photoelectric Lighting Controls
Crouse-Hinds
Holophane
Hubbell
Intermatic
Tork

SECTION 16670 - LIGHTNING PROTECTION

Lightning Protection Services
Guardian Equipment (Philip Youtsey, (734) 421-5800)
ERICO USA 34600 Solon Road (Phone: (440)-248-0100, Fax: (440)-248-0723)

SECTION 16720 - FIRE ALARM SYSTEMS

Fire Alarm Systems
GE/Edwards (through Riverside Fire and Security)
Honeywell (UMHHC only)
Simplex Time Recorder (through Simplex/Grinnell)
Vesda (For smoke sampling systems only)

SECTION 16724 - INTRUSION DETECTION SYSTEMS

Closed Circuit TV Systems
Diamond Electric
Panasonic
Sensormatic
Vicon Industries

Security Systems
ADT Security Systems
Faraday
Radionics (For small systems only)
Simplex Time Recorder

SECTION 16727 - CARD ACCESS CONTROL SYSTEMS

Card Access Control Systems
Software House (for Campus buildings)
Diebold/CBORD (for Housing facilities)

Card Access Control System Designers/Installers

Siemens (Mike Atzenhofer, 734 456-3800)
Cabling Concepts (Tim Grady, 248 363-4200)
TTI (John Rademaker, 586 864-1110)
Simplex/Grinnell (John Keith, 248 427-5050)
Electronic Security Systems, Inc. (Steven Maniaci, 586 756-8400)
Johnson Controls

SECTION 16731 - CLOCKS AND CLOCK SYSTEMS

Central Clock Systems

Primex (GPS synchronous wireless)
Simplex Time Recorder (through Simplex/Grinnell)

Clocks (Battery Powered)

Edwards
Franklin
Howard Miller

SECTION 16761 - SPECIAL COMMUNICATIONS SYSTEMS

Infrared Hearing Assistance Systems

Phonic Ear (for classroom applications)
Sound Associates (for auditorium and theater applications)

Public Announcement and Sound Systems

Aiphone Communications Systems
Atlas/Soundolier
Dukane
Rauland-Borg

Wireless Microphone Systems

Shure

SECTION 16856 - ELECTRIC HEATING CABLES

Electric Heat Tracing Cables

Raychem
Raychem Chemelex
Thermon

SECTION 16950 - ELECTRICAL ACCEPTANCE TESTS

Nationally Recognized Testing Laboratory Services

CSA
ETL (William Good at Inchcape Testing Services, (734) 761-1772)
MET Laboratories (Walt Stoddard, (517) 542-3020)
UL (Northbrook, IL)

Testing Services

Bisbee Infrared Services (Penny Wilson, (517) 787-4620)
Northern Electrical Testing (Lyle Detterman, (810) 689-8980)

Utilities Instrumentation Services (David Wheeler, (734) 482-1450)

MECHANICAL TRADES
PREFERRED MANUFACTURERS LIST

August 2009

Index of Mechanical Sections:

SECTION 15890 - DUCTWORK AND ACCESSORIES
SECTION 15910 - LABORATORY AND FUME HOOD AIR FLOW CONTROLS
SECTION 15960 - VARIABLE SPEED DRIVES
SECTION 15973 - TEMPERATURE CONTROLS - PNEUMATIC
SECTION 15975 - MECHANICAL SYSTEMS CONTROLS
SECTION 15990 - TESTING, ADJUSTING AND BALANCING

INTRODUCTION:
Manufacturers on this list fall into three categories:
Preferred Manufacturer: Listed manufacturer's product may be used on U-M projects. However, manufacturer's product must also be listed as approved in the project contract documents.
Conditional Approval: Listed manufacturer's product may be used on select U-M projects. Approval from the Technical Committee is required. Manufacturer's product must also be listed as approved in the project contract documents. Manufacturers in the Conditional Approval category have gone through successful preliminary review, but Technical Committee requires additional in-service input prior to final category listing.
Under Consideration: Listed manufacturer's product is being evaluated. The product should not be included in U-M projects.
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SECTION 15010 - MECHANICAL GENERAL REQUIREMENTS

Fasteners
Refer to UM Master Specification

Fire Stopping
3M, Hilti, Tremco, Manville

Roof Curbs
Pate
Creative Metals
Roof Curbs Engineered and Manufactured by the Manufacturer of the Equipment to be supported

SECTION 15060 - BASIC PIPING MATERIALS AND METHODS

Dielectric Fittings
Refer to UM Master Specification
Flexible Metal Hose Connectors (Stainless) Flex Hose Co., Flexonics, Mason, Metraflex
Under Consideration: Twin City Hose

Flexible Metal Hose Connectors (Copper)
Anaconda, Flex Hose Co., Flexonics, Mason, Metraflex

Flexible Connectors (Rubber)
Flex Hose Co., Flexonics, Garlock, Mason, Mercer Rubber Co., Metraflex

Hangers - Pipe
B-Line
Carpenter & Paterson

Michigan Hanger
Anvil
Shaw
Unistrut, Powerstrut, Superstrut

Piping - Grooved

Victaulic
Anvil Gruvlok

Piping - Lab Waste and Vent (Polypropylene)

Enfield, Orion, Zurn

Strainers - Steam & Water

Keckley
Yarway
Mueller
Spirex-Sarco
Metraflex
Watts
Armstrong
Victaulic (grooved water piping only)
Anvil Gruvlok (grooved water piping only)

Valves - Safety Relief

Spirax-Sarco
Watts
Leslie
Anderson-Greenwood
Conbraco
Keckley

SECTION 15070 - UNDERGROUND PIPING IN CONDUIT SYSTEM

Piping Systems - Underground

Perma-Pipe, Rovanco, Under Consideration: Urecon

SECTION 15071 - UNDERGROUND CHILLED WATER PIPING SYSTEM

SECTION 15100 - VALVES

Flow Measuring & Balancing Equipment - Manual Hydronic

PSE Inc.
ITT Bell & Gossett Circuit Setter
Taco
Ellison Annubar
Accuset
Armstrong
T & A (part of Victaulic)

Valves - Automatic Hydronic Regulating/Balancing

Auto-Flow (press. indep.)

Griswold (press. indep.)
B & G (press. indep.)

Valves - Manual Hydronic Regulating

B & G
T & A
Armstrong
Taco
Flow Design

Valves - Ball With Lever Handle

Pegler
Crane
Grinnell
Jamesbury
Watts
Jomar
Milwaukee
American Valve
Nibco
Apollo
Hammond

Valves - Butterfly

Keystone
Dezurik
Grinnell
Stockham
Fisher
Watts
Bray
Milwaukee
Crane
Nibco
Victaulic (for grooved piping)
Hammond
Under Consideration: Apollo

Valves - High Performance Butterfly

Bray, Crane Flowseal, Dezurik, Fisher, Grinnell-GHP, Jamesbury, Keystone, Milwaukee, Tri-Seal-Valve-Contromatics (formerly Watts/KF Contromatics), Xomox

Valves - Lubricated Plug

Honestead, Milliken, Resun

Valves - Gas (UL Approved)

Pegler
Jomar
Watts
Grinnell
Crane

Milwaukee "Butter Ball"
Nibco
Hammond

Valves - Gate

Watts
Crane
Milwaukee
Grinnell
Stockham
Nibco
Hammond

Valves - Swing Check

Milwaukee, Crane, Grinnell, Nibco

Valves - Silent Check

Milwaukee, APCO, Mueller, Metraflex

Valves - City Water Main (Ann Arbor) (formerly OS&Y)

Kennedy 4068
Mueller A-2380
East Jordan Series A
Other valves specifically approved by the City of Ann Arbor for this application
3 piece full port ball valve: Conbraco (rep. J.O. Galloup)

SECTION 15125 - PIPE EXPANSION JOINTS

Expansion Joints - Bellow Type

Flexonics, Metraflex, Microflex, Twin City Hose

Expansion Joints - Externally Pressurized

Hyspan, Microflex

Expansion Joints - Slip Type (Packed) For Steam Piping – no longer used

SECTION 15128 - ELECTRICAL HEAT TRACING OF PIPES

Heat Tracing

Raychem, Thermon

SECTION 15130 - THERMOMETERS AND GAUGES

Flow Measuring Devices - see master specification 15975

Pressure Gauges

Dwyer, H.O. Treice, Weksler, Marsh, Ashcroft, Weiss

Pressure & Temperature Plugs

Pete's Plug, Schrader, Sisco

Thermometers
H. O. Trerice, Weksler, Marsh, Ashcroft, Weiss, Techcontrols (light powered)

SECTION 15160 – PUMPS

Pumps - Condensate Waste
Little Giant, Hartell, Marsh, Bekette

Pumps - Double Suction - Base Mounted
Bell & Gossett (ITT), Allis-Chalmers, Weinman, Armstrong

Pumps - End Suction , Close Coupled - Base Mounted
Bell & Gossett (ITT), Allis-Chalmers, Weinman, Armstrong, Taco

Pumps - End Suction , Flexibly Coupled - Base Mounted
Bell & Gossett (ITT), Allis-Chalmers, Weinman, Armstrong, Taco

Pumps - In-Line Circulators
Bell & Gossett (ITT), Armstrong, Grunfos, Weinman, Taco

Pumps - In-Line Close Coupled - Hanger Supported
Bell & Gossett (ITT) Series 60, Grundfos, Armstrong, Weinman, Taco 1600

Pumps - In-Line Split Coupled - Base Mounted
Bell & Gossett (ITT) Series 80-SC, Grundfos, Armstrong, Weinman, Taco KS Vertical Split Coupled

Pumps - Sump Pumps
Vertiflo (B&G), Allis Chalmers, Weinman, Armstrong, Zoller, Weil
Under Consideration: Aurora / Hydromatic (K.L. McCoy)

SECTION 15170 - MOTORS

Motors - General, Premium Efficiency Type Only - 1/2 HP and above
Reliance, Baldor, Dayton, GE, Toshiba, Leeson, Marathon, U.S. Motors

SECTION 15188 - STEAM BOILER CHEMICAL WATER TREATMENT

Refer to master specification 15188

SECTION 15189 – HVAC WATER TREATMENT

Chemical Suppliers
Ques Industries, Schaefer Technologies

Chemical Shot Feeders
Bruner, Burmah, Crown Engineering, Galloup, H. V. Burton, Neptune, Venture

Corrosion Coupon Rack

Pulsafeeder

SECTION 15190 - MECHANICAL IDENTIFICATIONS

Pipe Markers

Brady Co. (Signmark Div.), Bramer, Craftmark, Kolbi, MSI (Marking Services Inc.), Seton

SECTION 15240 - VIBRATION CONTROL

Vibration Isolators

Amber Booth, Korfund, Mason, Vibration Eliminator, Vibration Isolation Co.

SECTION 15250 - MECHANICAL SYSTEMS INSULATION

Insulation - Duct/Pipe/Equipment - Fiberglass

Owens Corning
Knauf
Schullers (Johns Manville)
Armstrong
Pittsburg-Corning
Certainteed

Insulation - Flexible/Elastomeric/Polyolefin

Armstrong-Armaflex, IMCOA, Nomaco K-Flex, Rubatex

Insulation - PVC Covering, Elbows and Fittings

Proto
Zeston
Ceelco

Insulation - Removeable Jackets

Q-Master by ESI
Insulation Tech. Inc.

SECTION 15300 - FIRE PROTECTION SYSTEMS SECTION

Preaction Systems

Siemens (Pyrotronics), Notifier, Viking

Piping - Grooved

Anvil Gruvlok, Victaulic

Sprinkler Heads

Reliable
Grinnell-Gem
Viking
Victaulic

Tamper Switches

Grinnell, System Sensor, Victaulic

Valves - Fire Protection, Detector Check

Grinnell
Reliable
Viking
Victaulic

Valves - Fire Protection, Zone Control

Grinnell
Victaulic
Milwaukee
Nibco
Stockham

SECTION 15320 - FIRE PUMPS

Pumps - Fire

Allis-Chalmers
Aurora
Peerless

SECTION 15411 - WATER DISTRIBUTION PIPING

Backflow Preventers

Ames
Conbraco
Febco
Watts
Zurn-Wilkins

Hydrants - Wall Type

Woodford
Zurn
Chicago
J.R. Smith

Vacuum Breakers - Backflow Prevention

Kewaunnee
Chicago Water Saver
Bell & Gossett
Watts
Conbraco

Valves - Water Pressure Regulating

Bell & Gossett, Conbraco, Hoffman, Keckley, Leslie, Spirax Sarco, Watts

Water Hammer Arrestors

Zurn
Watts

Josam
J.R. Smith
Sioux Chief

SECTION 15420 - DRAINAGE AND VENT SYSTEMS

Drains - Roof, Floor and Trench, Grease Interceptors

Josam
J.R. Smith
Zurn
Wade
Sioux Chief

Under Consideration: MIFAB (V.E. Sales Co.)

SECTION 15440 - PLUMBING FIXTURES

Domestic Water Heaters - Gas Fired Or Electric

Lochinvar
A.O. Smith
State
Rheem
Raypak

Under Consideration: Copper Fin (Quality water & air)

Emergency Shower And Eyewash

Haws
Bradley
Speakman

Faucets - Automatic, Battery and Electric Type

Sloan
Delta
Symmons (The Taggart Company)
Technical Concepts

Under Consideration: Zurn and Josam (Quality water & air)

Faucets - Manual

Kohler
Elkay
American Standard
Moen
Chicago Faucet
Delta
Royal Brass
Speakman
Symmons
Zurn

Plumbing Fixtures - Water Closets, Lavatories, Urinals And Sinks

American Standard
Kohler

Elkay
Eljer
Just
Bradley
Crane

Pumps - Vacuum

Nash
Domestic
Sehi
Shipco

Under Consideration: Skidmore (K.L.McCoy), Busch (Kerr pump & supply)

Showers - Gang Type (All Shower Heads Must Be Provided With Pressure Equalizers)

Bradley
Leonard
Symmons

Shower Heads

American Standard
Kohler
Elkay
Moen
Delta
Chicago
Wolverine Brass
Speakman
Symmons

Toilet Room Fixture Supports

Zurn
Wade
J.R. Smith

Toilet Seats

Olsonite
Centco
Church

Valves - Flush Including Automatic Flushing System

Sloan Royal
Zurn (Aqua-Flush)
Technical Concepts (automatic only)

Under Consideration: Josam

Valves - Foot Operated

Chicago Faucet
T & S
Wolverine Brass

Valves - Shower Or Mixing For ADA Or Process Applications

Symmons
Powers
Watts
Speakman

Under Consideration: Armstrong

Water Coolers

Elkay
Haws
Halsey Taylor
Oasis
Sunroc

Water Filters - Inline Type

Cuno
Filtrine
Honeywell
Culligan
Dollinger
Bruner

SECTION 15455 - WATER SOFTENERS AND TREATMENT

Deionized Water and Reverse Osmosis Water Suppliers

Crown Equipment Co. (Ohio)
Siemens/U.S. Filter
Ionpure
Millipore

Water Treatment Equipment - Softeners

Crown Engineering
Burmah / Venture (H.V. Burton)
Bruner (K.L. McCoy)

Water Treatment Equipment

Crown Engineering
Burmah
Bruner

SECTION 15458 - MULTIMEDIA FILTRATION SYSTEM

Acceptable Manufacturers

Crown Equipment Systems, PEP Filters, Everfilt

SECTION 15481 - COMPRESSED AIR SYSTEMS

Air Compressors - Screw Type (1800 RPM)

Atlas - Copco
Quincy QSI Series

Air Compressors - Reciprocating

Quincy
Gast
Devilbliss

Air Dryers And Related Filters

Wilkinson
Zeks
Van-Aire
Hankison

Air Pressure Reducing Stations

Van-Aire
Zeks
Parker-Hannifin
Fisher

SECTION 15488 - NATURAL GAS SYSTEMS

Master Gas Valve Boxes

Ohmeda
Mueller

SECTION 15515 - HYDRONIC PIPING SYSTEMS AND SPECIALTIES

Automatic & Manual Air Vents

Armstrong, B & G, Hoffman, Wheatley, Taco

Suction Diffusers

Armstrong, B & G, Grinnell, Taco, Victaulic, Wheatley

Triple Duty Valves

Armstrong, B & G, Taco, Wheatley

Water Pressure Relief Valve

ITT B & G, ITT McDonnelL Miller, Consolidated, Watts

Water Pressure Regulating/Reducing Valve

B & G, Hoffman, Watts

Air Separators

Amtrol, Armstrong, B & G, Spirotherm, Wheatley

Coalescing Separator

Spirotherm (Spirovent Dirt HV)

Expansion Tank

Amtrol, Armstrong, Bell and Gossett, Wessel, Taco CA

Centrifugal Separator

Griswold Controls, Lakos

In-Line Filters

Bruner, Culligan, Cumo Dollinger, Honeywell

Glycol Feed Packages

Advantage Control Inc., Burmah, Crown Engineering, J.L. Wingert Co., Neptune Chemical Pump Co., Wessel Co.

Inhibited Ethylene Glycol

Dowtherm SR-1

SECTION 15525 - STEAM AND CONDENSATE PIPING SYSTEMS AND SPECIALTIES

Steam Pressure Reducing Stations

Armstrong, Jordan, Leslie, Spence, Spirax-Sarco, Watts

Steam Traps - All Types

Armstrong, Spirax Sarco, Hoffman (ITT), Watson McDaniels

Flash Tank, Vacuum Breaker, Drip Pan Elbow, Pressure Reducing Valve

See Master Specification for these items.

SECTION 15530 - REFRIGERANT PIPING SYSTEMS AND SPECIALTIES

Valves - Refrigeration

Asco, Hansen, Henry Valve, Parker, Sporlan

SECTION 15556 - CAST IRON BOILERS

Boilers

Burnham, Peerless, Weil McLain

SECTION 15557 - FIRE TUBE BOILERS

Boilers

Easco, Johnston, Superior , Conditional Approval: Hurst Boilers

Burners

Webster, Under Consideration: Viessmann

SECTION 15558 - WATER TUBE BOILERS

Boilers

Bryan, Unilux

SECTION 15575 - BREECHINGS, CHIMNEYS, AND STACKS

Boiler Stack
Metalbestos, Metal-Fab, Van Packer, Schebler

SECTION 15582 - STEAM CONDENSATE RETURN UNITS

Condensate Meters - Gravity Type - no longer used

Condensate Receiver
ITT Domestic, Skidmore, Shipco, Spirax-Sarco

Condensate Meters - Magnetic Induction
EMCO, Under Consideration: Krohne

Pumps - Boiler Feed
Skidmore, Spirax-Sarco, Shipco, Weinman

Pumps - Condensate (Condensate Receiver Must Be Cast Iron)
ITT Domestic (Hoffman), Skidmore, Spirax-Sarco, Shipco, Weinman

Pumps - Condensate, Steam Or Air Pressure Powered
Sarco, Armstrong

SECTION 15635 - REFRIGERANT MONITORING SYSTEM

Acceptable Manufacturers
MSA Corporation

SECTION 15670 - AIR COOLED CONDENSING UNITS

Air Cooled Condensers
Bohn, Dunham Bush, McQuay, Trane, York

Refrigeration Compressors
Copeland, Dunham Bush, McQuay, Tecumseh, Trane, York

SECTION 15681 - STEAM ABSORPTION CHILLER

Chillers - Absorption
Trane, York

SECTION 15682 - WATER COOLED PACKAGED CHILLERS

Chillers - Centrifugal
Trane, York

Chillers - Screw or Scroll
Dunham-Bush
York, Trane

Under Consideration: Carrier.

SECTION 15683 - AIR COOLED PACKAGED CHILLERS

Chillers - Reciprocating, Air-Cooled

Trane, York

Under Consideration: Carrier.

Chillers - Process Cooling

Filtrine, Liebert, Trane, Neslab

Refrigeration Compressors

Tecumseh, Copeland, Trane, York, McQuay

SECTION 15684 - DUCTLESS SPLIT ROOM AIR CONDITIONERS- AIR COOL

Air Conditioning Units - Ductless, Spot Coolers

Friedrich, Liebert, Mitsubishi, Sanyo, Trane

SECTION 15685 - PACKAGED TERMINAL AIR CONDITIONERS, AIR-COOLED

Air Conditioning Units - Package Type (thru the wall self-contained DX)

IslandAire, McQuay, Trane, York

Air Conditioning Units - Window Type (Flush installation with wall exterior)

Comfort-Aire, Fedders, White Westinghouse

SECTION 15710 - COOLING TOWERS

Cooling Towers

Baltimore Air Coil, Marley

SECTION 15755 - HEAT EXCHANGERS & CONVERTERS

Dry Coolers

McQuay, Trane, York, Bohn

Convertors (Shell & Tube) - Steam To Hot Water

Bell & Gossett, Taco, Armstrong, Mueller

Heat Exchanger - Plate & Frame

Alpha-Laval, Armstrong, Bell & Gossett, Mueller, Tranter

Laser Heat Exchangers - Water Cooled

Haskris
Remcor
Neslab
Laser Pure (Coherent)

SECTION 15756 - PACKAGED HEAT TRANSFER UNITS

Bell & Gossett

SECTION 15770 - PACKAGED COMPUTER ROOM AIR CONDITIONING SYSTEM

Air Conditioning Units - Computer Room
APC, Liebert, Stulz

SECTION 15810 - HUMIDIFIERS

Armstrong, Cemline, Dri-Steem, Herrmidifier, Nortec, Pure, Spirax-Sarco, Stulz

SECTION 15820 - COILS AND DRAIN PANS

Coils
Aerofin, Heatcraft, Marlo, McQuay, Trane, USA Coil, York

SECTION 15830 - TERMINAL UNITS

Baseboard Radiation, Finned Tube Radiation
Dunham-Bush, Rittling, Slantfin, Sterling Radiator, Trane, Vulcan Radiator

Panel Radiators
Jaga, Runtal Radiator

Convectors
Dunham-Bush, Rittling, Sterling, Trane

Unit Heaters
Dunham-Bush, McQuay, Modine, Reznor, Rittling, Trane, Wing

Cabinet Heaters
Dunham-Bush, McQuay, Modine, Rittling, Sterling, Trane

Unit Ventilators
American Air Filter, Trane

Electric Cabinet Heaters
Berko, Qmark, Trane

Electric Heating Coils
Brasch, Chromalux, Indeeco, Trane

Gas Fired Duct Furnaces
Modine, Reznor, Sterling, Trane

Radiant Ceiling Panel - Hot Water
Aero-Tech, Air-Tex, Sun-El

SECTION 15851 - FAN COIL UNITS AND BLOWER COIL UNITS

AirTherm, ETI, International Environmental, McQuay, Rittling, Trane

SECTION 15854 - CUSTOM AIR HANDLING UNITS

Air Flow Equipment, Buffalo, Governair, M & I, TMI
Conditional Approval: Ventrol

Gas Fired Make-Up Air Units (direct and indirect)
Rapid, Reznor, Sterling, Trane
Under Consideration: Modine (Air Design), Greenheck

SECTION 15855 - SEMI-CUSTOM AIR HANDLING UNITS

Airflow Equipment, Buffalo, Governair, McQuay, M&I, TMI, Trane

SECTION 15870 - FANS

Fans -Induction-Type Lab Exhaust
Greenheck - Vector , Strobic

Fans - Utility Set, FC, BI, Plug or AF Centrifugal & Propeller
ACME, Aerovent, Barry, Buffalo, Loren Cook, Greenheck, Penn, Trane, Twin City

Fans -FRP Construction
M.K. Plastics
Under Consideration: Harrington

Fans -Vaneaxial, TubeAxial
Buffalo, Greenheck, Joy, M & I, Trane, Woods

SECTION 15885 - AIR FILTERS

Primary Filters, Secondary Filters and Filter Housing Rack
American Air Filter, Camfarr, Eaton, Flanders, Purolator

HEPA Filters
Camfarr, Eaton, Flanders

Gas Adsorption Filters
American Air Filter, Camfarr, Charcoal Service Corp., Flanders, Purolator

Filter Gauges
Bacharach Instrument Co., Deiterich Standard Corp., Dwyer, Moeller Instrument Co.

SECTION 15890 - DUCTWORK AND ACCESSORIES

Air Blenders
Blender Products Inc., R.M. Products

Dampers - Fire/Smoke
Air Balance, American Warming & Vent, Greenheck, Nailor, Ruskin, Vent Products

Dampers - Manual Volume Control

American Warming & Vent, Arrow, Flexmaster (for round ducts, single branch takeoff only), Ruskin, Greenheck, Krueger, Vent Products, Young Regulator

Duct Flexible Connectors -

Ductmate, Duro-Dyne, Fanair, Pathway, United McGill, Ventglas

Exhaust Ductwork - PVC Coated

United McGill, Tangent

Exhaust Ductwork - FRP

Perry, Spunstrand, Tangent

Exhaust Ductwork - Teflon Coated Stainless Steel

Fab-Tech

Flexible Duct

Atco (Flex-Aire), Flexmaster, Hart & Cooley (Genflex)

Grilles & Diffusers

Carnes, E.H. Price, Krueger, MetalAire, Nailor, Titus, Tuttle & Bailey

Louvers

American W. & V., Ruskin, Vent Products

Sound Attenuators

IAC, Semco, Ruskin, United McGill, Vibro-Acoustics

VAV Boxes

Krueger , Titus, Metal Aire, Nailor, Price, Tuttle & Bailey

SECTION 15910 - LABORATORY AND FUME HOOD AIR FLOW CONTROLS

Fume Hood Monitors

Phoenix, Warrick

Laboratory Terminal Airflow Units (LTAUs)

Phoenix

SECTION 15960 - VARIABLE FREQUENCY DRIVES

Variable Speed Drives (and variable speed controllers)

Danfoss-Graham, Toshiba

Conditional Approval: ABB

SECTION 15990 - TESTING, ADJUSTING AND BALANCING

TAB Sub-Contractors

Absolut, Air Flow Testing, Enviroaire - Total Balance

Overview

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- Food Service Planning Guidelines
- **Office Space Guidelines**
- Research Space Guidelines
- Target Goals for Classroom Utilization

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office space guidelines

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Overview

The Office Space Guidelines enable General Fund administrative and academic units to decide more effectively how to assign and use office space when planning renovations and new construction or responding to pressing space needs. The guidelines provide space-per-person recommendations by position type, which are based on recent construction projects at the University and guidelines used by other universities and in the private sector.

Download

Office Space Guidelines (pdf)

FAQs

- Do these guidelines apply to all areas of the University?
- Why do we need campus-wide office space guidelines?
- How are the guidelines to be used?
- How were the square footage recommendations calculated?
- Can my unit have its own set of office space guidelines?
- My office is smaller than the recommended square footage. Can I use these guidelines to get a bigger office?
- The guidelines recommend that some positions require 30 square feet. How is that possible?
- I am in a private office, but according to the guidelines I should be in a shared space. Does that mean I must share my space?
- Do the types of positions listed in the guidelines reflect official U-M job titles or classifications?
- Who reviewed and approved these guidelines?

Do these guidelines apply to all areas of the University?

The Office Space Guidelines apply to Ann Arbor campus General Fund academic and administrative units only, though other units at the University are welcome to use the guidelines.

Why do we need campus-wide office space guidelines?

As stewards of the University's physical resources, we need to ensure that our use of all space, including offices, supports the University's academic and research missions. These guidelines provide a more consistent approach to overall space planning and assignments that supports this core mission.

How are the guidelines to be used?

For new buildings and renovations: Architecture, Engineering and Construction (AEC) refers to the guidelines when working with units and architects in designing office space.

For existing buildings: Units may use these guidelines to bring office space allocations and assignments in line with campus norms and new construction. Units are encouraged to refer to the guidelines when pressing office space needs arise.

How were the square footage recommendations calculated?

The square footage recommendations are based on recent construction projects at the University and guidelines used by other universities and in the private sector.

Can my unit have its own set of office space guidelines?

Yes, units are encouraged to have space guidelines that are tailored to specific buildings; however, unit-level office space policies or guidelines should align with the campus-wide Office Space Guidelines.

My office is smaller than the recommended square footage. Can I use these guidelines to get a bigger office?

Given the varying ages and architectural designs of our buildings, not all offices will fit in the recommended square footage ranges. Each unit must work within the constraints of current campus buildings when allocating office space.

The guidelines recommend that some positions require 30 square feet. How is that possible?

The recommended square footages for shared spaces specify the total amount of office space that should be dedicated to any one person. It does not necessarily mean the actual size of the office or cubicle will be 6 feet by 5 feet. For example, a department should designate a cumulative 120 square feet for four temporary employees (30 square feet per person); this space may or may not accommodate all four persons simultaneously.

I am in a private office, but according to the guidelines I should be in a shared space. Does that mean I must share my space?

All office space allocations and assignments are made at the unit or department level. Units and departments with pressing office space needs are encouraged to refer to these guidelines to help resolve issues and bring their allocations in line with campus norms while working within the constraints of current campus buildings. If an issue arises, a unit or department may decide, when appropriate, to place two people in an office that previously housed only one person.

Do the types of positions listed in the guidelines reflect official U-M job titles or

classifications?

No. The types of positions listed in the guidelines do not reflect official U-M job titles or classifications. They are listed strictly for the purpose of showing the relationship between role, space type, and net assignable square feet. The information is only to be used when making office space-related decisions.

Who reviewed and approved these guidelines?

The guidelines were developed with input and approval from:

- Budget administrators from various academic and administrative units
- Facilities managers from various academic and administrative units
- Space Utilization Initiative Steering Committee
- Office of the Provost and Executive Vice President for Academic Affairs
- Office of the Executive Vice President and Chief Financial Officer
- Office of the Vice President for Research
- Office of the Vice President and General Counsel
- Office of the Associate Vice President for Facilities and Operations
- Architecture, Engineering and Construction
- University Human Resources

For More Information

For more information on the Office Space Guidelines, contact space.utilization@umich.edu.

Last updated: 12/16/09

University of Michigan
Hospitals and Health Centers

Facilities Planning and Development
Architecture, Engineering, Activation,
Equipment and Interiors

UMHHC Design Guidelines

- SID - Special Instructions to Designers
- SBA - Special Building Areas
- Architectural Guidelines
- Interior Design Guidelines
- Mechanical Guidelines
- Electrical Guidelines
- Policy Papers

University of Michigan Health System
1500 E. Medical Center Dr.   Ann Arbor, MI 48109   734-936-4000

UNIVERSITY OF MICHIGAN
DESIGN DELIVERABLES
JUNE 2010

As part of the deliverables for formal UM review at each of the major phases of design listed below, the Design Professional shall submit this "Design Deliverables" document to the University's Design Coordinator. On the "Design Deliverables" document, the Design Professional shall indicate the status of each required item (a check mark is interpreted to mean that an item has been included in the deliverables). On the "Design Deliverables" document, the Design Professional shall address any item that is NOT included in the review package.

Note that design deliverables for the Design Development phase are to include all items listed in the Design Development column of the "Design Deliverables" table AND, except as specifically stated to the contrary in the table, all items listed in the Schematic Design column of the table (which are to have been further developed during Design Development).

Note that design deliverables for the Construction Document phase are to include all items listed in the Construction Document column of the "Design Deliverables" table AND, except as specifically stated to the contrary in the table, all items listed in the Schematic Design column and all items listed in the Design Development column of the table (which are to have been further developed during the Construction Document phase).

ITEM	SCHEMATIC PHASE	DESIGN DEVELOPMENT PHASE	CONSTRUCTION DOCUMENT PHASE
GENERAL DESCRIPTION	1. Scope of work narrative 2. Comparison of capacities (see "Building Interior" for area comparison) to program 3. List of applicable building codes on drawing title sheet 4. Building code review (describe means of compliance for major code issues and building systems) 5. List of anticipated building code variance requests 6. Anticipated building and space occupancy schedules *(continued)*	1. Description of construction phasing 2. Description of any proposed occupancy within construction area 3. Description of water & vapor characteristics of roof & exterior walls	1. Documentation on drawings as required by building codes (specifically to include indication of maximum allowable number of people in each room) 2. List of all code variances (on drawings cover sheet) 3. If multiple bid packages, clear indication of scope of each release 4. Identification of construction phasing, including temporary requirements during each phase *(continued)*

ITEM	**SCHEMATIC PHASE**	**DESIGN DEVELOPMENT PHASE**	**CONSTRUCTION DOCUMENT PHASE**
GENERAL DESCRIPTION (continued)	7. Life safety (egress) plans with identification of security and access control points 8. Demonstration of compliance with SID-D "Energy and Water Conservation". See SID-D for deliverables requirements 9. For projects over $10 million construction cost, Energy Impact Statement as described in SID-D “Energy and Water Conservation" 10. For new, non-clinical building projects over $10 million construction cost, application for LEED Silver (or higher) certification as described in SID-K "Sustainable Design and LEED Requirements" 11. Owner's Project Requirements and Basis of Design documents as described in SID-B “Design Intent Documents”		5. When requested by the U-M Design Manager, electronic Microstation or AutoCAD files (with or without the Design Professional's title block) of CD Phase drawings for use by U-M or the Construction Manager as backgrounds for special construction bid packs (e.g. telephone/data and audio/visual wiring bid packs)
SPECIFICATION	1. System & material narrative description	1. Outline or preliminary specifications indicating project specific features of major equipment as well as component materials, e.g. “welded Schedule 40 steel pipe”, “quarter sawn oak”, etc. w/ same section numbering as final specification	1. Complete specification including draft front end documents 2. List of items which are sole-sourced or dual-sourced and justification for not specifying three acceptable products 3. For items listed in UM's "Preferred Manufacturers List", a table of specified items that are NOT indicated in UM's PML, and the justification for specifying these items *(continued)*

ITEM	**SCHEMATIC PHASE**	**DESIGN DEVELOPMENT PHASE**	**CONSTRUCTION DOCUMENT PHASE**
SPECIFICATION (continued)			4. For door hardware sets that require electricity, indicate the proposed sequence of operations for the hardware
SITE	1. Site plans, to include the following: A. Existing conditions B. Demolition C. Building outline(s) D. Future expansion E. Site entrance F. Roads & driveways G. Parking locations H. Bus stop/shelter (if required) I. Loading dock location J. Waste/recycling collection locations K. Walkway locations L. Stairway locations M. Emergency telephone locations N. Utility requirements O. Site utilities P. Preliminary grading plan Q. Soil retention work, if needed 2. Site plan for public use (see SID-H) 3. Storm water management plan 4. Preliminary site lighting plan	1. General dimensions & elevations 2. Permanent exterior signage 3. Parking/roadway plans & elevations 4. Vehicle & pedestrian traffic controls (if required) 5. Grading plan 6. Site lighting plans, simulations, specifications, equipment cut sheets and photometrics (as defined in Design Guideline 16521) 7. Concept details of site fixtures & equipment 8. Utility plans, elevations & details for local governing agency approval 9. Sanitary sewer flow calculations for OSEH approval 10. Plan to address existing hazardous/contaminated materials, if applicable 11. Soil erosion and sedimentation control plan (for both construction and occupancy) 12. Soil erosion and sedimentation control "Design & Review Checklist" described in UM Design Guidelines Section 02215 13. Dewatering plan	1. Extent of construction area 2. Area traffic plan, if existing roads/walks are impacted 3. Site development phasing 4. Construction site access 5. Staging area 6. Construction signage 7. Site details, including hardscape 8. Profiles for underground utilities 9. Pipe sizes 10. Connection details 11. Copy of local government review comments on utilities and modifications in right(s)-of-way

ITEM	SCHEMATIC PHASE	DESIGN DEVELOPMENT PHASE	CONSTRUCTION DOCUMENT PHASE
LANDSCAPING	1. Existing conditions 2. Landscaping concept 3. Existing irrigation	1. Planting plan 2. Irrigation plan	1. Protection for existing trees and significant plantings during construction 2. Soil preparation & planting specifications 3. Guying diagrams 4. Piping diagrams 5. Pipe sizes 6. Landscape and irrigation details and legends
STRUCTURAL	1. Structural scheme plans 2. Written description	1. Foundation plan 2. Typical floor framing plan 3. Framing plans at unique features 4. Main member sizing 5. Structural sections	1. Definition of control joints 2. Beam, column & slab schedules 3. Mechanical and electrical concrete house keeping pads 4. Foundation details 5. Structural details 6. Structural notes 7. Structural calculations
BUILDING EXTERIOR ENVELOPE	1. Typical elevations 2. Fenestration layout 3. Material designations 4. Overall building cross-sections 5. Roof layout	1. All building elevations w/dimensional heights 2. Typical wall sections 3. Parapet & coping details 4. Roof & drainage plan 5. Exterior door details 6. Typical window details 7. Details of unique features 8. Expansion joint locations 9. Large scale building cross-sections	1. Roof-mounted equipment 2. Roof details 3. Exterior details 4. Flashing details 5. Control joint definition & details
BUILDING INTERIOR	1. Typical floor plans (min 1/16" scale) w/ legends 2. Floor plans for room numbering & public use (see SID-H) 3. Demolition plans *(continued)*	1. All floor plans (min 1/16" scale) 2. Enlarged plans at elevation changes (such as stairs 3. Enlarged plans at toilet rooms 4. Reflected ceiling plans 5. Wall types, fire ratings, smoke control zones *(continued)*	1. Dimensioned floor plans 2. Enlarged plans 3. Partition details 4. Interior details 5. Interior elevations 6. Finish schedules 7. Door & hardware schedules *(continued)*

ITEM	SCHEMATIC PHASE	DESIGN DEVELOPMENT PHASE	CONSTRUCTION DOCUMENT PHASE
BUILDING INTERIOR (continued)	4. All room numbers (comply with Design Guidelines Section 10400) 5. Area use identification & area in square ft. 6. Mechanical, electrical & other service closets & rooms 7. Circulation paths 8. Area tabulations compared to program requirements 9. Show flexibility for expansion & alterations 10. Preliminary layout of major spaces w/ fixed equipment	6. Plan to address existing hazardous materials, if applicable 7. Fixed seating 8. Defined seating, serving, & kitchen facilities 9. Equipment & furniture layouts 10. Important interior elevations 11. Details of unique features 12. Details of fixed equipment 13. Preliminary finish schedule 14. Preliminary door schedule 15. Informational signage	8. Room signage 9. Schedule of proposed movable equipment that is NOT indicated on documents (for reference) 10. Schedule of lab fixtures (turrets, etc.), if applicable
ELEVATORS	1. Elevator locations 2. Equipment room locations	1. Elevator shaft section 2. Equipment description	1. Dimensioned plans 2. Sections & details of hydraulic cylinder, if applicable 3. Description of shaft sump pits 4. Elevator car & equipment support details 5. Description of controls & fixtures 6. Door & frame details 7. Interior details including lighting
HVAC	1. Identify all systems 2. One-line diagrams for each air, hydronic, steam, condensate and all other HVAC related systems, and other materials as required to describe the fundamental design concept for all mechanical systems *(continued)*	1. Overall building air flow diagram indicating air handlers, exhaust fans, duct risers, and duct mains 2. Plans indicating shaft, chase, recess requirements 3. Duct layout for typical spaces 4. Equipment schedules (major equipment) 5. Equipment locations (w/enlarged mechanical plans) *(continued)*	1. Detailed piping and duct design with all sizes indicated 2. Floor plans w/ all components and required service access areas drawn to actual scale. On the plans, indicate duct sizes and air flow quantities relative to each room, including CFM in and out of all doors. Indicate location of control panels *(continued)*

ITEM	SCHEMATIC PHASE	DESIGN DEVELOPMENT PHASE	CONSTRUCTION DOCUMENT PHASE
HVAC (continued)	3. Indication of the amount of redundancy for all major pieces of mechanical equipment, e.g. "two pumps 100% capacity each" 4. Major equipment locations 5. Air intake & discharge locations 6. Gross HVAC zoning, and typical individual space zoning (e.g. VAV boxes per office =?) 7. Mechanical legend 8. Special occupancy zones	6. Indication of typical locations of fire dampers, smoke dampers, and combination F/S dampers 7. Control diagrams (concept form) for all mechanical and plumbing systems 8. Outline of major control sequences of operation 9. M/E smoke control schemes 10. Preliminary floor plans of mechanical rooms w/all components and required service access areas drawn to scale 11. Preliminary calculations 12. Meter locations and types	3. Lab air valves and volume control boxes (note that each is to be identified by a unique number assigned by the engineer). Provide a schedule that indicates the control sequence that applies to each room (room #, room descriptor, control sequence #) 4. Detailed floor plans of mechanical rooms w/ all components and required service access areas drawn to actual scale 5. Cross-sections through mechanical rooms and areas where there are installation/coordination issues (tight space, zoning of utilities). Indicate required service access areas 6. In common mechanical space, indication of space zoning by system 7. Connection to fire alarm & campus control systems 8. Equipment details, including structural support requirements 9. Penetration/sleeve details 10. Installation details 11. Duct construction schedule (on the drawings), indicating materials and pressure class for each duct system 12. Detailed controls drawings, including clear differentiation of trade responsibility for control, fire, and control power wiring *(continued)*

ITEM	SCHEMATIC PHASE	DESIGN DEVELOPMENT PHASE	CONSTRUCTION DOCUMENT PHASE
HVAC (continued)			13. Detailed sequences of operation including the specific setpoints for all control loops that will result in attainment of the required design criteria, as well as alarm setpoints and time delays 14. Design calculations
PLUMBING & PIPING	1. One-line (riser) diagrams for every plumbing system (e.g. domestic water, sanitary, storm, gas, RODI, etc.) and other materials as required to describe the fundamental design concept for all plumbing systems 2. Indication of the amount of redundancy for all major pieces of mechanical equipment, e.g. “two pumps 100% capacity each” 3. Main water supply, storm, and sanitary leads 4. Major equipment locations 5. Restroom location(s) 6. Plumbing legend	1. Updated design criteria for each plumbing system (including set points, water quality levels, etc.) 2. Preliminary piping plans (domestic & process) with indication of required service access areas 3. Meter locations 4. Back flow prevention locations 5. Fixture schedules, to include lab fixtures 6. Equipment schedules (major equipment) 7. Preliminary floor plans of mechanical rooms w/all components and required service access areas drawn to scale	1. Water riser diagram, including assumed fixture counts per floor connection 2. Waste and vent riser diagrams including assumed fixture counts per floor connection 3. Foundation drains 4. Detailed piping design with all pipe sizes indicated 5. Typical plumbing details, including structural support requirements 6. Water heating piping details 7. Penetration/sleeve details 8. Design calculations
FIRE PROTECTION (MECHANICAL)	1. One-line diagrams for each fire protection system, and other materials as required to describe the fundamental design concept for all fire protection systems 2. Report documenting adequacy of utility 3. Connection to utility *(continued)*	1. Location of test headers and fire department connections 2. Preliminary piping plans 3. Preliminary floor plans of mechanical rooms w/all components and required service access areas drawn to scale 4. Fire pump sizing calculations	1. Fire protection service entrance details 2. Fire protection plans (incl. header and riser layout) with indication of any required service access areas 3. Detailed piping design with all major pipe sizes indicated 4. Location of all sprinkler zone valves, drains, and fire hose connections 5. Zoning extents, for areas where the contractor will size the piping *(continued)*

ITEM	SCHEMATIC PHASE	DESIGN DEVELOPMENT PHASE	CONSTRUCTION DOCUMENT PHASE
FIRE PROTECTION (MECHANICAL) (continued)	4. Location of fire pump and controller, jockey pump and sprinkler valves 5. Sprinkler legend 6. Optional F.P. systems		6. Typical sprinkler installation details, including structural support details 7. Penetration/sleeve details 8. Design calculations
LIGHTING	1. Electrical symbols legend 2. General drawing notes 3. General photometric levels 4. Fixture, lamp, and controls descriptions 5. Preliminary interior lighting plans 6. Preliminary outdoor lighting plans	1. Typical interior lighting and control plans 2. Outdoor lighting and control plans 3. Fixture types and schedule 4. Control system and control device descriptions 5. Typical photometric calculations 6. Dimming, daylighting and low voltage control zones	1. Interior and exterior lighting plans, including control systems and devices, lighting panels, switching and circuiting 2. Lighting control system schematics and wiring diagrams 3. Lighting control system detailed sequences of operation 4. Installation details, including structural support details 5. Normal lighting photometric calculations 6. Emergency lighting photometric calculations on 2' grid for State BFS approval 7. General notes on conduit and wire sizes for lighting branch circuits
ELECTRICAL POWER DISTRIBUTION	1. Electrical demolition 2. One-line diagrams with equipment ratings 3. Manhole, duct bank, and building entry locations 4. Exterior equipment locations 5. Substation, generator and ATS descriptions 6. Substation, generator, and electric room locations 7. Preliminary substation and generator room plans 8. Panel numbering scheme	1. Manhole, duct bank, and building entry plans and details 2. Normal power riser diagram with circuit breaker, fuse, conduit and wire sizes 3. Emergency power riser diagram with circuit breaker, fuse, conduit and wire sizes 4. Grounding riser diagram 5. Fault current and coordination studies used to specify equipment ratings 6. Substation standard details 7. List of equipment on emergency power 8. Electrical load calculations *(continued)*	1. Details of power service to building 2. Power plans, including primary cable raceways, feeder conduits, electrical loads, duplex and special receptacles, and circuiting 3. Emergency power system plans, controls, and details 4. Connections to other building systems, including fire alarm and HVAC systems 5. Details of non-standard electrical installations 6. Conduit and wire sizes for services, feeders, and special branch circuits *(continued)*

ITEM	SCHEMATIC PHASE	DESIGN DEVELOPMENT PHASE	CONSTRUCTION DOCUMENT PHASE
ELECTRICAL POWER DISTRIBUTION (continued)		9. Panel schedules 10. Typical panel arc flash and color code labels 11. Electrical equipment location plans 12. Typical electrical outlet location plans 13. Plan for temporary power during construction.	7. General notes on conduit and wire sizes for 20 amp single phase branch circuits 8. Notes identifying locations of separate and shared neutrals 9. MCC elevations 10. Grounding details 11. Roof and floor penetration details 12. Settings for Contractor-furnished electrical equipment
FIRE ALARM	1. System description 2. FA panel locations 3. MOSCAD panel location 4. Preliminary FA device and appliance location plans	1. Riser diagram 2. MOSCAD standard detail 3. FA panel, device and appliance location plans	1. Detailed FA panel, device and appliance location plans including duct detectors, fire/smoke dampers, sprinkler flow and tamper switches, monitor and control modules, door hold-opens, door lock releases, etc. 2. Strobe light candela ratings 3. General notes on conduit and wire sizes 4. Details of connections to HVAC, fire pump, fire suppression, door hold-open, door lock, and MOSCAD systems 5. Detailed sequences of operation
COMMUNICATIONS (INCLUDING VOICE, DATA, & VIDEO SYSTEMS)	1. Manhole, duct bank , and building entry locations 2. Building Entrance (BE) and local Telephone Room (TR) locations 3. Riser diagram 4. Preliminary cable tray plans	1. BE and TR locations, sizes, and door swings 2. Backboard locations in BE and TR's 3. Raceway and grounding riser diagrams 4. Conduit and cable tray plans with conduit and cable tray sizes 5. Material cut-sheets 6. List of equipment to share telecom rooms 7. BE and TR heat loads 8. Typical voice, data and video outlet location plans 9. Emergency phone locations and types (wall or pedestal) 10. Courtesy phone locations	1. Detailed voice, data and video outlet locations 2. Details of telecommunications service to the building 3. Floor box schedule 4. Conduit, outlet box and floor box installation details 5. Power outlet locations in the BE and TR's 6. Locations of non-telecom equipment in the BE and TR's

ITEM	SCHEMATIC PHASE	DESIGN DEVELOPMENT PHASE	CONSTRUCTION DOCUMENT PHASE
SECURITY (INCLUDING CCTV AND CARD ACCESS CONTROL SYSTEMS)	1. System descriptions 2. Panel locations 3. Preliminary device location plans	1. Riser diagrams 2. Equipment location plans 3. Security office layout 4. Card access control equipment closet layout and elevations	1. Detailed equipment location plans 2. Equipment schedules 3. Concealed and exposed raceways 4. Wiring diagrams 5. Installation details 6. Detailed sequences of operation
A/V AND SPECIAL SYSTEMS	1. System descriptions 2. Panel locations 3. Preliminary device location plans	1. Riser diagrams 2. Equipment descriptions 3. A/V equipment location plans 4. Clock and other equipment location plans	1. Detailed equipment location plans 2. Equipment schedules 3. Wiring diagrams 4. Installation details (including cabinets, hangers, and connection boxes) 5. Detailed sequences of operation
OTHER GRAPHICS	1. Renderings, models, or other graphics as necessary to clearly present concept	1. Updated renderings, models and graphics required only as appropriate for design development	1. Updated renderings, models and graphics required only as appropriate for construction document preparation
COST	1. Preliminary cost estimate. For projects with cost greater than $500,000, use format described in UM Design Guidelines SID-P "Project Estimates"		
NOTES	*1. All movable furnishings and artwork are considered to be independent of the architectural design project.* *2. Submittals of deliverables for DD and CD phases are to be preceded by a complete response to UM review comments on the previous phase of design work.* *3. No individual volume of drawings is to exceed 25 lbs in weight. No individual specification book volume is to exceed three inches in thickness.*		

UNIVERSITY OF MICHIGAN
Architecture, Engineering and Construction

Sustainability for Design and
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Introduction to the U of M Design Guidelines

These Design Guidelines are *only* for use by consultants and contractors in connection with work performed for the University of Michigan. They are to be used as a guide in the preparation of design documents for University of Michigan construction projects. They are not intended to relieve the designers and contractors from their responsibility to comply with applicable codes and other contract obligations.

The purchasing contract and schedule of project details incorporate the Design Guidelines that are applicable to the project.

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September 2010

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July 2010

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For technical inquires, comments and suggestions on the U of M Design Guidelines, please e-mail the U of M Design Guidelines Group at UMDesignGuide@umich.edu.

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