DESIGN GUIDELINE 5.9
TUNNELS

Scope

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.

Related Sections

U-M Design Guideline Sections:
4.6 SID – Utilities for University Buildings

U-M Design Guideline Technical Sections:
336330 – Utility Tunnels - Steam & Condensate Distribution Systems
221113 - Basic Piping Materials and Methods

U-M Master Specification Sections:
For Steam & Condensate Systems:
336330 – Utility Tunnels - Steam & Condensate Distribution Systems
For Domestic Hot Water & Compressed Air:
221113 – Piping Materials & Methods
220523 – Valves
220516 – Pipe Expansion Joints
220719 – Mechanical Systems Insulation
260533 – Electrical Materials & Methods

U-M Standard Details:
Tunnel Toolkit

U-M Utilities Tunnel Access/Use Protocol

General

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 Manager.

All tunnel related projects shall be designed with 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 requirement.

Tunnel/Building Utility Ownership Delineation Points

Points of delineation have been established for each utility system to provide direction to the Architect/Engineer (A/E) of which specifications, guidelines and tool kit drawings should be utilized when developing the design. To reduce confusion during construction these delineation points shall be clearly shown on all drawings associated with the Utility owned systems.

- Steam (HPS & LPS) – first valve in the building (Utilities owns the valve)
    - First valve in the building should be located as close to possible to where the steam service enters the building
    - If a steam meter in place of a condensate meter is installed on the building service
        - Utilities owns/maintains the steam meter and associated piping/valves to isolate the steam meter
- Condensate – inlet side of the condensate receiver/pump station
    - Locate Utility owned condensate receiver/pump station so that all building steam components discharge into a common receiver before entering the Utility owned condensate return system.
    - All components (i.e. pumps, valves, meters) downstream of the inlet connection of the receiver to the connection point to the Utility condensate return system will be maintained by Utilities
    - This condensate receiver/pump should be located as close as possible to the steam service entrance into the building
- Steam Pressure Reducing Valve (PRV) Stations – ownership/delineation point to be established via conversation with Utilities representative
    - In general if a PRV station provide redundancy to the low pressure steam system will be owned and maintained by Utilities
- Domestic Hot Water Supply / Return – first valve in the building (Utilities owns the valve)
    - First valve in the building should be locate as close to possible to where the hot water service enters the building
- Compressed Air – first valve in the building (Utilities owns the valve)
    - First valve in the building should be locate as close to possible to where the compressed air service enters the building

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, typically one branch line per service for each building.

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. Use of a box trench system for utility piping must be approved by Utilities representative..

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 Utilities representative
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 Utilities-Tunnels department.

Tunnel Piping Utilities

The tunnel system was designed for the following piping utilities that emanate from the Central Power Plant: Low Pressure Steam, High Pressure Steam, Steam Condensate, Domestic Hot Water, Domestic Hot Water Return and Compressed Air. These utility systems are operated and maintained by the Utilities – Tunnels department. The utility properties guaranteed at the point the utility enters the building are defined in U-M Design Guideline 4.6 Utilities for University Buildings. Most pipe materials and design considerations for these utilities are described in referenced U-M Design Guidelines and Master Specifications listed above. Additional considerations within the tunnel system are noted below:

- Low Pressure Steam (LPS) – Design pressure of 15 psig
  - All building lateral take offs should be in a three valve tee arrangement.
  - Design Utility owned LPS piping for expansion associated with an excursion temperature of 450F with a duration of not more than one hour and not more than 80 hours per year.
  - Cast iron, malleable iron, brass and bronze components are prohibited in the LPS system.
  - Do not connect LPS steam traps directly to the Utility owned pumped condensate return system. Direct condensate trap discharge to a vented condensate return unit receiver and/or flash tank.

- High Pressure Steam (HPS) – Design pressure of 80 psig
  - All building lateral take offs should be in a three valve tee arrangement.
  - Design Utility owned HPS piping for expansion associated with an excursion temperature of 450F with a duration of not more than one hour and not more than 80 hours per year.
  - Cast iron, malleable iron, brass and bronze components are prohibited in the HPS system.
  - Do not connect HPS steam traps directly to the Utility owned pumped condensate return system. Direct condensate trap discharge to a vented

condensate return unit receiver and/or flash tank.
  - Pressure Reducing Valves are used in some locations from the HPS system to the LPS system, for back-up and pressure maintenance during peak conditions. PRVs should be provided for critical buildings such as hospital, medical clinics, research labs, special use facilities and large scale housing. For buildings that do not fit these criteria, a business case may be made to Utilities by the building occupants for a PRV backup. For establishing the capacity of the PRV backup, 60% of total connected load is recommended. PRV should be a tandem style layout where as two or more PRVs, capable of independent operations, are piped in series and set at or below the safe working pressure of the equipment and piping systems served. When this type of installation is used a safety relief valve is not required which elevates the associated cost of routing the safety discharge pipe to an adequate location to prevent harm to personal or property. .

- Steam Condensate Return System
  - All building lateral take offs should be in a three valve tee arrangement.
  - The steam condensate is typically metered at individual buildings and pumped into the steam condensate return system. While the system is under some backpressure at certain points, it'sgenerally considered to be a low-pressure gravity return system.
  - Condensate return units (CRUs).
    - A combination of electric and air pressurepowered CRUs are used in the tunnels.
    - CRU pumps should be designed to overcome 40psi of static head at the designed flow rate. This is critical so that condensate can be directed multiple ways in the case that a section of the condensate return system needs to be isolated for maintenance.

- Domestic Hot Water Supply (DHWS) and Domestic Hot Water Return (DHWR) - Design pressure 80 psig
  - All building lateral take offs should be in a three valve tee arrangement.
  - Existing piping is primarily Type-L grooved copper piping using Victaulic fittings and peroxide-cured EPDM gaskets.
  - Unless directed otherwise, use grooved copper piping for all DHWS and DHWR piping in tunnels 2 ½" and larger. Soldered joints are acceptable for pipe diameters 2" and below.
  - U-M has experienced numerous problems with expansion joints in DHWS and DHWRsystems. Refer to U-M Master Specification 220516 – Pipe Expansion Joints for current specification requirements.

- All flexible connectors on HW and HWR shall be of all stainless steel construction.

- Valves on HW and HWR shall be constructed of 316 stainless steel.
- 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 120F. See detail "Recirculation DHW Heat Transfer Package

Detail" in "Tunnels Tunnel Tool Kit" for recommend building HW recirculation system.
- New building DHWR connections to the tunnel are prohibited.
- For existing building connections, where practical, connections to the tunnel DHWR system should be eliminated, and replaced with an internal return system.
- The DHWR system within the tunnel is designed only to keep DHWS within the tunnel within acceptable limits. (roughly 120-125F)

- Compressed Air (CA) - operating at 90-100 psig (refer to DG 4.6 for clarification)
  - All building lateral take offs should be in a three valve tee arrangement.
  - 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 System Considerations

Utility Metering Requirements:

Steam/Condensate Meter Consideration
- Typically electronic condensate meters are the primary means of calculating the amount of steam usage for a building service. These meters are generally 1" or 1 ½" vortex type meters. Mag meters are not acceptable for use in the condensate system due to the low conductivity of the condensate.
- If the building is utilizing steam for humidification a steam meter shall be installed on the LPS/HPS system at or near the building entrance.
- Utilities representative will assist with the design and placement of the steam/condensate meters.

Domestic Hot Water Supply/Return
- No utility meter required

Compressed Air
- No utility meter required

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.
- Steam and condensate Utility owned piping systems should be design to eliminate/limit the use of the expansion joints. If expansion joints are required than the preference is external pressured bellows type. Utilities approval is required prior to using slip joint type expansion joint.

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. Main line and take-off valves should be located as close to the tee as possible to allow for greater flexibility in future piping modifications. Refer toTunnel Toolkit for details.

B31 Requirements:
Refer to Master Specification Sections 221113 – Piping Materials & Methods and 336330 – Utility Tunnels - Steam & Condensate Distribution Systems for welding requirements on utility piping.

Insulation:
Areogel insulation is preferred on all pipes requiring insulation 4" and above. Fiberglass insulation is acceptable on pipe diameters smaller than 4" as long as they are located in low traffic areas where the insulation won't be easily damaged.

Aluminum jacketing is required on all insulated steam, condensate and domestic hot water supply and return piping in tunnels.

For Steam & Condensate - Refer to Master Specification Section 336330 – Utility Tunnels - Steam & Condensate Distribution Systems.
For Domestic Hot Water - Refer to Master Specification Section 221113 "Piping Materials and Methods" and Master Specification Section 220719 - Mechanical Systems Insulation for materials and required thickness.

Other Piping and Utilities in 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. If routing of CHW through tunnels is approved by Utilities, additional insulation will be required.

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 with the City of Ann Arbor through U-M University Planners Office, U-M AEC Civil department and U-M Project Manager.

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 Manager.

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, discharging to sanitary.

Waterproofing:
Top and sides of tunnels should include waterproofing, typically membrane type. Coordinate with U-M Design Manager 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 Manager.

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 Tunnel Toolkit detail.

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 U-M University Planners Office, U-M AEC Civil department and U-M Project Manager.

Coordination with U-M University Planners Office, U-M AEC Civil department:
Coordinate soil erosion control, tree protection, and staging through the U-M University Planners Office, U-M AEC Civil department and U-M OSEH department, in conjunction with the U-M Project Manager.

Tunnel Access and Confined Space:
The Tunnel Access/Use Protocols and Work Rules must be read and the Acknowledgment Form signed and returned to the Tunnel Supervisor prior to any personnel accessing the Tunnels. In addition, 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 inspectionprior to release of construction documents.

Mechanical Requirements and Considerations

Ventilation:
Provide thermostatically controlled ventilation on all tunnel projects. Confirm ventilation needs with U-M Design Manager 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 no more than 115F, based on entering outside air at 90F.

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.

Interior Tunnel Drainage:

The interior of the tunnel systems typically include sumps with high temperature pumps at all low points in the tunnels and at building entrances to deal with nuisance water. Tunnel floors shall be pitched toward these sumps when practical. These pumps will discharge to the sanitary system and must be designed to ensure sewer gases cannot enter the tunnel system.

Exterior Tunnel Drainage System:

Exterior footing drains are preferred to maintain a dry environment around the exterior of tunnel system. These drains shall outlet to the storm system. Exterior tunnel drains shall not discharge to the interior of the tunnel.

Please consult a Utilities representative if a connection to the storm system is not available or is cost prohibitive.

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, LED with globe glass and guard. Lighting should be controlled by 20 amp manual dial timer (12-hour) located at tunnel entrances. Timer locations should beat intervals no more than of 200 feet.

Electrical Receptacles:

Duplex Receptacles are typically required throughout the tunnel/vault system. Receptacles shall be 20 amp GFCI type with waterproof covers. They shall be installed at each tunnel entrance, and at intervals of 100 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 belocated 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 Design Manager as to whether rigid galvanized steel conduit may be specified instead. Building tunnels (non-Utility 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.