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:
221113 - Basic Piping Materials and Methods

U-M Master Specification Sections:
221113 – Piping Materials & Methods
220523 – Valves
220516 – Pipe Expansion Joints
220719 – Mechanical Systems Insulation
232216 – Steam & Condensate Piping Specialties
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 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 UPE.

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-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 UPE – Tunnels department. The utility properties guaranteed at the 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:

- While normally saturated, due to the fact that both the HPS and LPS are a byproduct of the co-generation steam turbines, these systems experience occasional temperature excursions. Temperature of the steam can reach 450F if the desuperheater fails. As such, all HPS and LPS piping in the tunnels shall be designed for expansion associated with an excursion temperature of 450F with 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.

- Low Pressure Steam (LPS) –
  - LPS shall be designed for a Design Pressure of 15 psig. Operating pressure varies from roughly 6 psig to 12 psig depending on overall system load and location within the tunnel systems. U-M Utilities guarantees 6 psig operating pressure at building entrance.
  - 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 stainless steel inverted bucket 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.
  - All LPS valves 2-1/2 " and larger shall be metal-to-metal seated butterfly valves.

- High Pressure Steam (HPS) – Design pressure of 80 psig.
  - 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. Associated relief valves should be routed to a safe location outside the tunnel. Where no safe location is available outside the tunnel, a code compliant tandem PRV station may be provided.
  - Use stainless steel inverted bucket traps on HPS. Do not connect HPC from traps directly to the tunnel LPC system. Use an LPS flash tank and condensate return unit to pump into the LPC main.
  - All HPS valves 2-1/2 " and larger shall be metal-to-metal seated butterfly valves.

- 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 an LPS condensate return unit.
  - Drip and traps from HPS 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 air pressure powered CRUs are used in the tunnels.

- (Domestic) Hot Water (HW) and Hot Water Return (HWR) - Design pressure 80 psig
  - Existing piping is primarily Type-L grooved copper piping using Victaulic fittings and peroxide-cured EPDM gaskets. U-M has an ongoing program to replace remaining steel piping with copper. Unless directed otherwise, use grooved copper piping for all HW and HWR in tunnels.
  - U-M has experienced numerous problems with expansion joints in HW and HWR systems. 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 HWR system, typically with a small shell and tube heat exchanger and pump to reheat the HWR back to 120F. New building HWR connections to the tunnel are prohibited. For existing building connections, where practical, connections to the tunnel HWR system should be eliminated, and replaced with an internal return system. HWR system within the tunnel is designed only to keep HW within the tunnel within acceptable limits (roughly 120-125F)

- Compressed Air (CA) - operating at 90-100 psig (refer to DG 4.6 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. Refer to Tunnel Toolkit for details.

B31 Requirements:
Refer to Master Specification Sections 221113 – Piping Materials & Methods and 232216 – Steam & Condensate Piping Specialties for welding requirements on utility piping.

Insulation:
Aluminum jacketing is required on all insulated LPS, LPC and HPS piping in tunnels. Refer to 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 inspection prior 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.

Drains:
Tunnel system does not typically include floor drains, footing drains or sumps. 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 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.