Chapter 4-15: Mechanical Work

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4-15.01 Work Included

Division 15, *Mechanical Work*, involves most of the building mechanical items related to building occupancy. This includes basic building "plumbing" work, fire protection, sprinkler systems, and heating, ventilation, and air conditioning (HVAC) items (see Figures 4-15.1, 4-15.2, and 4-15.3). Also included are all piping systems, including natural gas, fire suppression service, potable water, and sanitary, to a point five feet beyond all buildings or structures. This also applies to accessory structures such as wash racks and fuel islands. Details of the exterior water system and liquefied petroleum gas (LPG) piping are also covered within Division 15.

This division will also include mechanical work; pipe fittings and valves; mechanical insulation; automatic fire sprinkler systems; plumbing fixtures; plumbing fixtures for the safety roadside rest areas; wheelchair accessible shower units; shower stalls; LPG systems; hydronic heating systems; boilers; and cathodic protection.

Review any Standard Special Provisions (SSPs) from Section 99[1], *Building Construction*, Division 15, *Mechanical Work,* that have been included in the project *Special Provisions*, since much of the information therein typically will not be repeated in the following sections of this chapter.

4-15.02 Tips and Suggestions to Prepare for Inspection of Mechanical Work

1. SC staff should carefully review the plans to ensure that pipe locations do not interfere with other trades or building features. Keep in mind that mechanical and electrical designs are diagrammatic, meaning they show general layouts rather than exact positions. While piping, conduit, and ductwork must be installed parallel and perpendicular to the building's structural elements, it's the prime Contractor's responsibility to coordinate their actual placement.

   Special attention should be given to penetrations through structural foundations and bearing walls. Additionally, mechanical and electrical contractors must follow numerous code requirements when determining the routing of their systems.

2. Verify the excavation for stub-outs or lines–which will be connected in the future–is performed before trenching for new work is begun.

3. Verify the size and location of sleeves required for foundations, slabs, walls, and floors. Verify sleeves are properly installed as part of the excavation, forming, and rebar installation process, prior to placement of concrete.

[1] Caltrans internal use only

4. Review the contract documents to determine any isolation or spacing that may be required between the piping and its support and/or other trades.
5. Review the contract documents to verify the pipe supports and earthquake bracing that may be required for each type of piping.
6. Review the contract documents for the location and spacing of expansion joints in piping, and confirm that they are installed as required at the building expansion joints.
7. Review and confirm the use of plugs and caps required for the various piping, both during the construction operation and at completion. The lines should be protected during construction to prevent any debris, dirt, trash, or other foreign objects from entering any of the lines. Confirm that all the lines are cleaned and thoroughly flushed after installation and before use.
8. Do not allow any cutting, coring, or boring of structural members unless they are shown on the structural drawings. Do not allow over-cutting or increases in the size of holes in any of the structural or framing members, and do not allow for penetrations to be placed in openings other than those specifically called out in the plans. Refer to the *Special Provisions* for any piping that passes through or runs parallel with the foundation systems.
9. Thoroughly review the product data bulletins and manufacturer's data for the various authorized submittals. Make sure that the materials and installation conform to the requirements of the authorized submittals.

4-15.02A Quality Control

Field quality control (QC) requires that the Contractor pressure test all piping prior to backfilling, pipe wrapping, connecting fixtures, or otherwise concealing the pipe. Depending on the nature and sequence of contract operations, this may include numerous tests of individual portions of each system. When each individual test is satisfactorily completed, it should be recorded in a daily diary or other permanent job record. Confirm whether the service provider or State Fire Marshal is required to attend or witness the pressure test.

Most plumbing fixtures and other equipment are not designed to operate under the pressures specified for testing the individual piping systems. Also, most fixtures are not in place at the time the piping is concealed. Therefore, the piping is tested at specified pressures, and the final connection to the installed fixture is tested at "system pressure" after installation is completed. When a project involves interconnecting new systems with existing piping, the Contractor should be encouraged to isolate the new piping during testing. It should be noted that a leaking, closed valve between two systems can increase pressure downstream of the valve and/or can lead to an "unexplained" loss of test pressure.

Specific requirements for operational testing of other mechanical items such as HVAC systems, fire sprinkler systems, and backflow preventers are included in the project *Special Provisions*. It is critical that the HVAC system air balance report be completed prior to the final inspection.

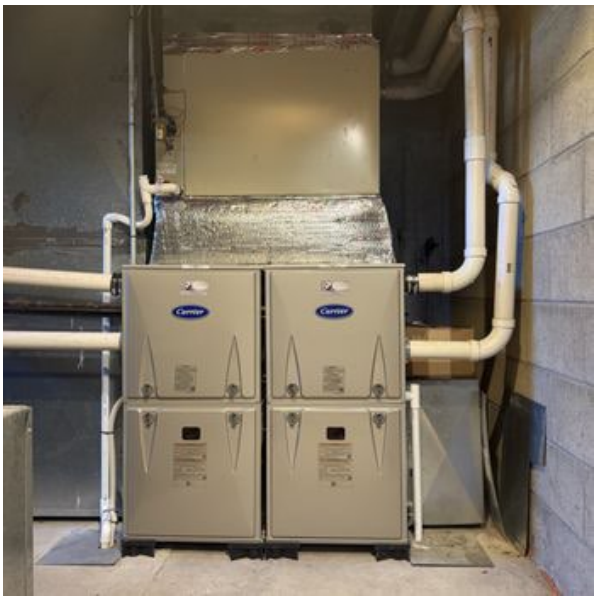


Figure 4-15.1. Twinned Furnace



Figure 4-15.2. Evaporative Cooler



Figure 4-15.3. Air Conditioning Equipment and Systems

4-15.03 Mechanical Work

Reserved.

4-15.04 Pipe, Fittings, and Valves

Glued and Fusion-Welded Joints – Plastic pipes such as polyvinyl chloride (PVC) and polyethylene (PEX) are typically fusion-welded or glued. Verify that the joints are properly aligned and square and that the installation has been made in accordance with the manufacturer's recommendations. This includes cleaning of the pipe at the joint and the fittings before the joints are assembled. Refer to the product data bulletins and the manufacturer's recommendations for the gluing and fusion welding of joints.

Threaded Pipe – After threading, check the threaded end of the pipe to see that the threads are cut squarely and that the end of the pipe is reamed to remove burrs and sharp edges. The joints shall be wiped clean of the cutting oil.

Soldered Joints – The pipes should be cut with a cutting tool, the end of the pipe reamed after cutting, and the surface of the pipe brightened with sandpaper or emery cloth before the joints are fitted and soldered. Confirm that the flux and solder conform to the requirements of the authorized submittal. Any pipe or fittings that are overheated during the soldering process should be replaced. The pipe should be wiped clean of any flux runs along the joints and the pipe portion.

Brazed Joints – Brazed joints used in any fire protection systems should be checked to confirm that the joint has been prepared as required by the National Fire Protection Association (NFPA), including reaming, deburring, and brazing, without the use of flux. Current welding certificates must be submitted and authorized for any workers performing the brazing.

Welded Connections – Confirm that current welding certificates have been submitted and authorized for the welders. Also confirm that the joints are fitted and prepared in accordance with the applicable American Welding Society (AWS) guidelines.

Flanged Joints – Check to see that the joints have been properly gasketed, and that the placing and tightening of joints is completed in the procedure and manner recommended by the manufacturer.

Valves, Fittings, and Unions – Check to confirm that the pipes, valves, and unions have been properly aligned and fitted. All valves and unions must be accessible. If they are concealed in a wall, or above the ceiling, be sure that an access panel has been provided to allow access to those valves and unions. If the special provisions require the pipe to be coated or taped, then all couplings and fittings shall likewise be coated or taped.

4-15.04A Piping Layout

The contract mechanical plans will include water, drainage, and vent plumbing diagrams. The Contractor will often, and sometimes justifiably, provide a reason why the piping cannot be installed per plan. These reasons may include the physical size of pipe fittings, conflicts between fittings, framing interference, slope and elevation requirements, etc.

4-15.04A(1) Piping Placed Below Grade

Verify that the bottom of the trench and any subgrade material installed, including sand used for pipe bedding, are compacted in accordance with the requirements set forth in *Special Provisions* Divisions 2, *Sitework*, and 15, *Mechanical Work*.

Confirm the alignment and elevation of all pipes placed below grade are in accordance with the project plans.

Confirm that provisions are made for future connection or access to capped or stubbed lines installed off from the main lines as identified on the project plans.

Confirm that pipe backfill is placed as specified. This typically includes placement of sand fill directly over the pipe to both protect it during compaction and serve as a visual indicator of the pipe's location during any future excavations adjacent to its alignment. The backfill is to be compacted in accordance with the *Special Provisions*.

When specified in the *Special Provisions*, ensure that tracer tape is placed at the top of the sand fill and that it follows the line of the pipe so it can be accurately located in the future.

Review the contract documents to determine what outside agency inspections are required. Some agencies will require access to perform inspections prior to backfill placement. This is often true for piping related to fire protection systems.

4-15.04A(2) Piping Above Grade

Confirm installation of the piping as specified and that fittings, joints, valves, and couplings are installed in accordance with the previous comments on piping. Ensure that any flexible connections have been provided as specified.

Lines are to be sloped as specified.

Air vents should be installed at the high points and drains installed at the low points.

Balance and check valves, pressure gauges, and thermal elements must be installed as specified.

Confirm that the hanging and anchoring of plumbing systems include provisions for expansion and contraction, and that the piping runs are installed as specified in the contract.

Confirm that the size and type of hangers, as well as their installation and spacing, are in accordance with the contract.

Confirm the system is checked and tested for leaks, and the pressure tests have been witnessed and documented.

Confirm all insulation has been installed as required, including any vapor barriers, adhesives, banding, or other means of securing the insulation.

4-15.04B Piping Connections

4-15.04B(1) Joining Copper Pipe

The contract requires that copper piping shall be joined with wrought copper or cast bronze solder-joint pressure fittings. Additionally, solder shall be lead-free, and underground piping shall utilize brazed joints. Joints under or in building slabs are considered underground joints.

The majority of the copper pipe joints installed in building-type contracts are soldered. The primary differences between brazing and soldering are the temperatures at which the joining metals melt and the resulting strength of the joint, with brazing providing higher strength. Brazing is the joining of metals using a non-ferrous metal or alloy that melts at a temperature above 800 degrees F. Solder melts at a much lower temperature.

4-15.04B(2) Unions

Pipe installation specifications include the requirement that unions shall be installed where shown and at each threaded or soldered connection to equipment and tanks. Unions used for gasoline and diesel fuels, as well as natural gas and propane piping, may have special requirements. Confirm that the fittings for each of those separate piping systems are in accordance with the authorized material submittals.

4-15.04B(3) Water Hammer Arrestor

Water hammer arrestors are installed in individual water piping systems to absorb the hydrostatic shock caused whenever water under pressure is flowing through a pipe and is abruptly stopped by the fast closing of a valve or faucet (see Figure 4-15.4). This non-compressible flow of water collides with the closed valve, and the impact generates excessive pressure and hydrostatic shock waves within the piping. The pressures created by these shock waves will shorten the life of any piping system by bursting pipes, weakening joints, damaging equipment, and generally accelerating system wear and tear.



Figure 4-15.4. Water Hammer Arrestors

4-15.04B(4) Insulating Union, Dielectric Waterway, and Insulating Unions

The project plans and *Special Provisions* indicate locations where these items are to be installed. Normally, interior water systems and other piping systems are bonded to an electrical ground either inside or outside of the building. When any type of insulating connection is installed within these systems, bonding jumpers must be installed to maintain electrical continuity across the connection in accordance with the National Electrical Code.

4-15.04B(5) Compression Stops

Accessible compression stops are required at each fixture. For hose faucets, a ball valve is specified for shut-off capability. Note that faucets and valves may include built-in compression stops.

4-15.04B(6) Pipe Penetrations in Fire Rated Assemblies

In projects with fire-rated walls and ceilings, the Contractor is referred to the requirements in SSP 99-07270, *Through-Penetration Firestopping* of Division 7, *Thermal and Moisture Protection*. Penetration details should be included within the project “Architectural Plans”.

4-15.04B(7) Pipe Wrap and Primer

Steel pipe buried in the ground is typically wrapped or plastic-coated for corrosion and electrolytic protection. If taped, a compatible primer must be used, and the pipe shall be thoroughly cleaned and primed as recommended by the tape manufacturer. The primer, adhesive, and installation method for the pipe wrap are required to be submitted for review, the same as any other product. As those materials are sometimes overlooked in the submittal process, it is important to verify their authorization before the materials are installed. Installation details indicate that fittings and joints are to be wrapped over "putty tape" compounds to accommodate surface offsets. Readily available gray butyl tape works well for this.

4-15.04B(8) Fuel Piping

Review the project plans and *Special Provisions* very carefully to become acquainted with the codes and requirements that relate to the setting of any fuel systems and their associated piping. There are specific requirements for the proper sealant(s) to be used on their joints and connections and special code requirements for diesel and gasoline.

Secondary containment systems are required for fuel storage.

Fuel facilities have special requirements for associated fire protection systems.

Confirm that the required leak detection and monitoring systems are installed in conjunction with the fuel systems.

Contact the mechanical engineer for assistance.

4-15.04C Systems & Equipment

4-15.04C(1) General

Contract requirements state that "...system layouts are generally diagrammatic...exact routing of pipes, ducts, etc...is to be governed by structural conditions and obstructions."

Layout modifications are neither uncommon nor unreasonable. Any proposed modification should be discussed with, and agreed to, by the project mechanical and water & waste water designers through the resubmittal and authorization process.

4-15.04C(2) Sanitary Waste and Vent Systems

Verify that the manholes and cleanouts are located in the positions called for on the project plans. Cleanouts are to match finish grade.

Verify the elevation, slope, and alignment are as indicated in the contract documents.

Verify that the materials, including all pipes and fittings, are in accordance with the project plans and meet the requirements for type, size, and weight, and that all connections are completed as specified in the contract documents.

It is important to check the contract documents to confirm the spacing for the installation of pipe hangers for all suspended pipe systems.

Confirm floor drains and area drains are set at the proper elevations so the respective finish floors will drain as designed. Check the installation and operation of trap primers, as specified.

Cleanouts should be located to allow access for cleaning the lines.

Confirm that the rough-ins for fixtures and equipment are located in the positions shown on the project plans and as required to fit the layouts, based on the authorized product data submittals.

Inspect vent piping in concealed spaces to verify attachment of the vent stack, and to confirm that horizontal lines are sloped (see Figure 4-15.5).

Confirm that specified flashings and counter-flashings for all roof penetrations are installed in accordance with the authorized product data submittals.

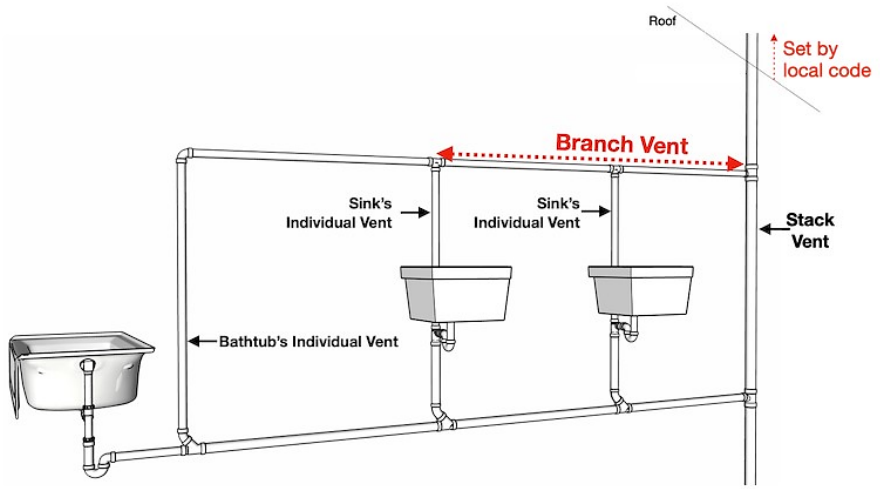


Figure 4-15.5. Sanitary and Vent Piping

4-15.04C(3) Water Supply Systems

Confirm the required materials are of the type, size, and conform to the required specifications in the contract documents. Non-leaded solder is to be used for all soldered joints in potable water systems.

Exterior, underground water lines should be installed at the proper elevation, bedded in sand cushion, and have thrust blocks installed as called for on the project plans. Coordination with the local utilities may be required for the setting of the water meters, provision of shut-off valves, and installing of fire hydrants and valve boxes.

Shut-off valves are normally designed for each building; confirm that they have been installed in the proper locations.

Confirm that all overhead water systems can be drained at their lowest point. Drain valves shall be labeled as identified on the project plans.

Water hammer arrestors are designed to prevent water hammering of the system. Confirm that they are installed at the locations shown on the project plans.
Verify the installation of dielectric waterways or insulating unions to separate dissimilar metals at all locations shown on the project plans. Confirm that any vibration and sound isolators have been installed if required.

All systems must be pressure-tested in accordance with the project *Special Provisions,* and the test results approved before insulating, concealing, or backfilling any of the lines.

If identification of the various lines is specified in the special provisions*,* confirm that they have been identified as required.

All potable waterlines are required to be flushed and chlorinated before use. Check the special provisions for the required procedures, time requirements, final flushing, and testing.

4-15.04C(4) Gas Piping Systems

Confirm the location, elevations, alignment, and coating or wrapping specified for pipes located at the exterior of the building.

Confirm that piping located inside the building is installed using the proper sleeves and complies with the applicable code requirements for the ventilation of the space in which the piping is installed.

Meters, shutoff valves, etc., should be located in a position and/or protected so that they cannot be damaged by vehicular equipment; this applies to both inside and outside the buildings (see Figure 4-15.6).



Figure 4-15.6. Natural Gas Service

4-15.04C(5) Liquid Heat Transfer Units

Confirm the locations, facing, and sizing for all required sleeves, inserts, anchor bolts, foundations, pads, and openings in the floors and walls are coordinated with all of the trades involved.

Verify there is sufficient space and headroom to complete installation of the equipment as well as accessibility for the operation, servicing, and repair thereof. Confirm that floor drains are located properly to collect condensate and lighting is sufficient for working around the equipment.

Ensure that all nameplates and identification remain on the equipment and are not covered by insulation or painted over.

Confirm there is sufficient room for cleaning the heat exchanger, and that the required clearances are maintained for all electrical equipment panels.

4-15.04C(6) Other Systems and Equipment

Verify the location of bollards, hose connections, and pumper connections used to supplement the system. These are normally located on the outside of the building.

Confirm that all fire extinguishers and cabinets are installed at the locations shown on the project plans. Verify that visual alarms, audible alarms, manual pull stations, and other fire-life-safety devices are installed in accordance with the authorized submittals by the Authority Having Jurisdiction (AHJ), such as the National Fire Protection Association or the State Fire Marshal, and conform to the project specifications.

Required alarm systems are typically specified by Caltrans in Division 16, *Electrical Work*.

Alternative fire extinguisher systems may be required for computer equipment rooms or special storage areas. Refer to the authorized submittals for unique installation requirements of any alternative fire extinguishing systems.

4-15.05 Mechanical Insulation

Applications of mechanical insulation include insulating ductwork carrying conditioned air (heated or cooled), hot water piping, sink drain piping, and piping where there is a potential for freezing or sweating.

All materials must bear the label of Underwriters Laboratories (UL) or other approved testing laboratory, indicating that the materials proposed for use comply with the required fire hazard ratings.

Insulation material must not be installed until all pipes or surfaces to be covered are tested for leaks, cleaned and dried, and foreign materials such as rust have been removed.

4-15.06 Automatic Fire Sprinkler System

Fire sprinkler systems are designed and built by subcontractors certified and licensed by the California Department of Consumer Affairs. Those designs will be submitted to the State Fire Marshal and the appropriate Caltrans designer or Project Architect for review and approval.

Since the fire sprinkler system is an item in the building contract classified as Deferred Submittals, it requires a separate authorization process; refer to Chapter 3, Section 3-8.02, *Contract Administration – State Fire Marshal Deferred Submittals*. Deferred submittals use a different review procedure to improve coordination and reduce the risk of conflicting approvals; the revised procedure includes the following:

1. Deferred submittals should first be submitted to the Division of Engineering Services (DES) for review and conditional approval, subject to final approval by the SFM.
2. Once DES has completed its review for contract compliance, the Contractor submits the deferred submittal (with conditional approval stamped) to the State Fire Marshal for review of fire and life safety code requirements.
3. Once SFM issues final approval for the deferred submittal, the Contractor is required to submit the final drawings to DES that are stamped with “APPROVED” by the SFM.

Note: It’s a good idea to invite the State Fire Marshal to the preconstruction conference. The project Structure Representative needs to address the importance of the timely design of the system and the required review time from the State Fire Marshal. Also note that while SC generally prefers to use “authorization” for submittals, the SFM uses “approved” when their requirements are satisfied.

Confirm the type, spacing, and size of hangers and/or attachments are in accordance with the authorized shop drawings.

Confirm that fittings, connections, bracing, and seismic braces for both vertical and horizontal runs are installed in accordance with the authorized shop drawings.

Review the shop drawings for the riser diagram to become familiar with the components specified for the system on your project. The risers will normally include special valving, pressure gauges, flow switches and indicators, flow alarm devices, and audible and visual alarm devices. All of those components will be clearly indicated on the riser diagram submittal.

The blowdown and drain system should provide for complete drainage of the system. Confirm the inspection/test connections and blowdown are installed at the low point of the system. Inspection/test connections are specific points in the system designed for inspection and testing.

Where pipes pass through fire-rated walls, floors, or ceiling assemblies, the penetration must be protected in accordance with SSP 99-07270, *Through-Penetration Firestopping*.

Confirm that sprinkler heads are installed at the locations shown on the authorized shop drawings. For example, when there are hoods in a lab setting, check authorized shop drawings for specified hood suppression systems. Ensure that they are installed per the manufacturer's specifications and that they are not shielded by hood ducts or HVAC obstructions.

Most systems for Caltrans projects will be wet-pipe systems. For dry-pipe systems, additional checks will be required to confirm the proper installation of the air compressor and pressure tanks.

The Contractor, in accordance with the National Fire Protection Association (NFPA), Chapter 13, *Installation Requirements for CMSA Sprinklers*, will test water flow alarm signals in wet-pipe systems. The tests are to be witnessed by the State Fire Marshal and the Structure Representative.

The Contractor, in accordance with NFPA Chapter 13, will test alarm signals in dry pipe systems. The tests are to be witnessed by the State Fire Marshal and the Structure Representative.

Confirm spare sprinkler heads and wrenches have been provided and stored per the authorized shop drawings.

The State Fire Marshal representative for your local area will make the inspection of the system at all stages during construction and will observe the final test. The system cannot be accepted, and the project completed, until after the State Fire Marshal has completed final testing and accepted the fire sprinkler system.

4-15.07 Automatic Fire Sprinkler System with Tank and Pump

Reserved.

4-15.08 Plumbing Fixtures

Figure 4-15.7 below depicts an installation meeting ADA accessibility standards. The requirement specifies that the flush mechanism be located on the open (wide) side of the water closet (toilet). Initial ADA compliance introduced issues because many flush mechanisms were only manufactured on the left side. Additionally, flush controls must be operable with one hand, require no more than 5 pounds of force to activate, and be located within the standard operable parts reach range. Toilet seats must be 17 to 19 inches above the finished floor. Urinals and lavatories follow parallel requirements– urinal rims no higher than 17 inches, with reachable and low-force flush controls, and lavatory faucets operable with no more than 5 pounds of force. Refer to the "2010 ADA Standards" and your project's Standard Drawings and "Accessibility Standard Details" in the architectural plans for all layout and accessory dimensions.



Figure 4-15.7. ADA-Compliant Water Closet

Confirm that the proper blocking, backing, and bracketry have been installed to receive the fixtures. This includes chairs and carriers as may be specified for all wall-mounted fixtures.

Confirm that angle stops or shutoffs for each fixture are installed where shown on the project plans. Confirm vacuum breakers are installed where hose faucets or fixtures to which a hose can be connected are installed.

Confirm the installation of all cover plates, flanges, and escutcheons at locations where piping penetrates a finished surface.

Confirm that accessible fixtures have been set at the proper clearances from walls and at the correct height. Confirm that flush valves for fixtures designated as accessible are oriented so that the valve handle is on the widest side of the toilet space.

All fixtures should be cleaned upon completion. Confirm operation of faucets, trim, and flushing devices.

4-15.09 Plumbing Fixtures (Safety Roadside Rest Area Buildings)

Reserved.

4-15.10 Wheelchair Accessible Shower Unit

Requirements beyond a standard shower unit include: specific dimensions (see architectural plan sheets for requirements); equipped with a bench; two shower heads (one fixed and one on a glide bar); no threshold; and a mixing valve for the showerhead plumbed through a diverter valve to select which head is active (see Figure 4-15.8).

The shower must be installed in accordance with the manufacturer's instructions. All joints must be sealed and caulked watertight.



Figure 4-15.8. Wheelchair Accessible Shower

4-15.11 Shower Stall

The standard shower includes a fixed shower head and mixing valve.

The shower stall must comply with the manufacturer's instructions. Installation must be sealed and caulked watertight.

4-15.12 Liquefied Petroleum Gas (LPG) System

Liquefied petroleum gas (LPG) systems include: a certified pressure tank with connections for filling, draining, pressure control, and monitoring; a pumping system for conversion to gas and transfer under pressure to vehicle fuel tanks, using appropriate hose.

The LPG tank and system components must be installed under NFPA Standard No. 58-2001, *Liquefied Petroleum Gas Code*, the manufacturer's instructions, and the authorized installation drawings.

Perform testing in accordance with SSP 99-15485, *Liquefied Petroleum Gas (LPG) System*, subsection C(2), *Construction – Field Quality Control*.

4-15.13 Heating, Ventilating and Air Conditioning Equipment and Systems

Confirm that identification nameplates remain visible and are not painted or covered by insulation. Vibration isolators, flexible connections, mounts and anchorages, and both equipment and motor noise should be verified in accordance with the previous instructions and commentary. Requirements for service access, electrical panel clearance, and combustion or make-up air provisions should be checked, along with proper fan rotation prior to making permanent electrical connection(s).

Note bearing and belt numbers before connection to the equipment and confirm belt and pulley alignment on belt-driven equipment.

Verify all guards and protective devices for belts and rotating equipment are in place.

Confirm access for service and lubrication of the unit.

Confirm roof-mounted equipment is properly flashed, counter-flashed, securely anchored to the curbs, and is accessible for servicing.

Confirm backdraft dampers and sound traps are provided if specified on exhaust fans (see Figure 4-15.9)



Figure 4-15.9. Up-blast Roof Mounted Exhaust Fan

Confirm that exhaust and supply air paths for exhaust fans are properly located, and confirm that exterior air intakes are separated by the distances required and are located to account for prevailing winds.

1. Filters and Screens

Verify the type of materials to be installed and that they are clean at the time of acceptance. Verify accessibility for removal and replacement.

Confirm any electrostatic filters specified have the required warning lights and interlocks and that ionizers have free access and no loose wires.

Confirm spare filters are provided as specified and advise the facility operators of the frequency or schedule for cleaning and/or replacing the filters in all units.

2. Ductwork

Verify the ductwork layout has been coordinated with all the other trades to avoid congestion and interference (see Figures 4-15.10 and 4-15.11). Confirm the joint connections are of the type and material specified. Check seams for breaks and cracks. Confirm that the joints provide a smooth surface on the interior of the ducts and that laps are in the direction of the airflow.

Verify that hangers, stiffeners, supports, and seismic bracing are installed in the manner and location(s) specified.

Ductwork must be installed and braced according to the latest edition of the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) *HVAC Duct Construction Standards - Metal and Flexible*.

Slopes in sides at transitions must be approximately one to five (1:5, V:H). The ductwork system must not contain abrupt changes or offsets of any kind unless otherwise shown.

Where ducts pass through walls, floors, or ceilings, galvanized sheet metal or steel angle collars must be installed around the ducts.

Confirm that volume dampers, duct dampers, registers, diffusers, and splitters are located as required and that the locations of all dampers are marked and readily accessible.

Confirm the location and operation of fire and smoke dampers. Verify they are the type specified and required by NFPA and that access is provided.

Confirm that access doors have been provided where ducts are located in concealed spaces so that fire dampers, automatic dampers, coils, heaters, filters, and thermostats are all accessible for maintenance.

Confirm all ductwork has been identified and labeled in accordance with the SSPs.

Confirm the ducts have been tested for airtightness, when specified.

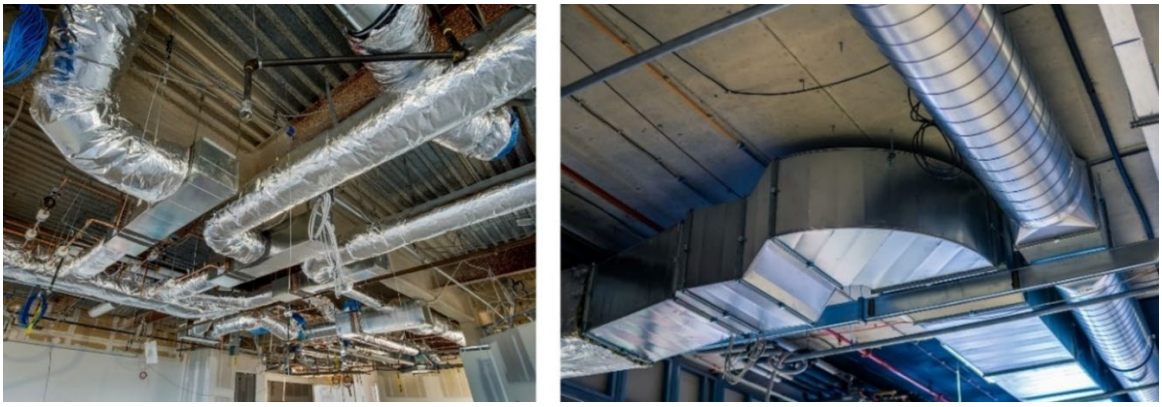


Figure 4-15.10. Examples of Ductwork

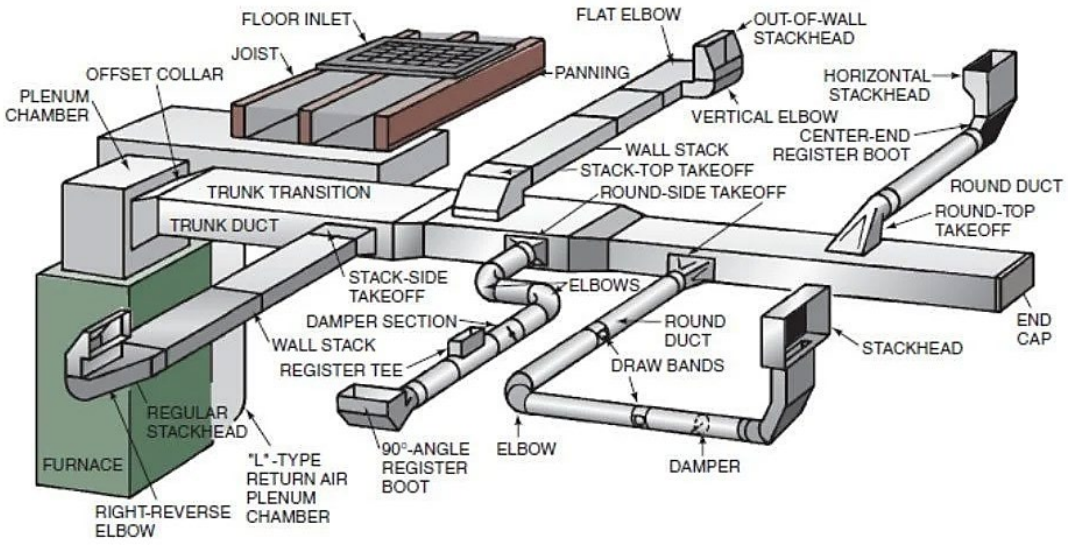


Figure 4-15.11. Schematic Illustration of Ductwork

3. Duct Layout

Contract mechanical plans include HVAC system plans and details. The Contractor may have a reason why the ductwork cannot be installed per plan. Common reasons include the physical size of required fittings, conflicts between adjacent fittings, framing interference, and conflicts between adjacent duct systems.

System layouts are generally diagrammatic, but re-routing of ducts is more critical than for water pipes. It is very important to contact the mechanical designer before any changes are made to the duct routing.

4. Outlets, Diffusers, Registers and Grills

Confirm all ducts, plenums, and equipment are thoroughly cleaned and all debris is removed before the systems are closed and started up.

Verify that all air volume control devices have been installed and are operating as specified. Confirm gaskets have been installed where necessary. Confirm that all units are securely attached and supported.

5. Balancing and Testing

Verify the system has been cleaned and flushed of all debris, and that the operation is observed in the presence of specified agencies, engineers, and inspectors.

Confirm that all balancing devices are properly labeled and located, that the system has been balanced, and that the balancing reports have been authorized and are available.

Confirm the system operates in accordance with the manufacturer's recommendations.

The project *Special Provisions* will normally require training of the facility personnel in the operation of the system. It is important to be sure that training and instruction have been completed and the facility personnel clearly understand the operation and maintenance of the system.

Confirm all bearings are lubricated, the tension of the pulleys and belts has been adjusted, all safety guards and devices are in place, and connections are complete and ready for operation.

Listen for any objectionable noise that could be caused by excessive air velocities.

4-15.13A Terminal Units

Confirm that heating, ventilating, and air handling units are properly anchored and secured, and that they have vibration isolators as specified. Access doors should be provided where necessary so that all valves and controls can be accessed.

Confirm the noise levels of unit heaters and air handlers are within the authorized ranges, and that the units are installed to provide the necessary clearances for maintenance and operation.

Where baseboard units are specified, confirm the size, mounting, and controls are as required, and verify that covers, access doors, dampers, and plates are all in place.

4-15.13B Refrigeration Equipment

Confirm the materials and equipment are provided as authorized. Ensure that all nameplates and other identification devices are in place and have not been covered by insulation or painted over.

Confirm adequate space for maintenance, operation, repair, and servicing of the equipment, and that the equipment is mounted and anchored as specified, including the installation of vibration isolators where required.

Confirm all rotating parts and belts are covered with appropriate guards or devices to prevent inadvertent access.

Confirm sufficient space for the removal and cleaning of any tubes and for general servicing of the units.

Confirm code-required clearances for all electrical panels.

4-15.13C Equipment

Confirm that air-cooled condenser airflow is not obstructed and that any required wind deflectors have been provided.

Centrifugal and reciprocating compressors require special attention for alignment on the direct drives, such as discharge pressures, motor amperages, cylinder heating, noise, and vibration, etc. Confirm the inspections required with the mechanical engineer.

If a cooling tower is required on the project, confirm the inspection points required with the mechanical engineer.

Confirm all pumps are properly supported, anchored, and checked for vibration. Confirm all insulation has been properly installed and secured.

Observe the testing of the system and confirm approval of the test, as well as provisions for the training of the facility's personnel who will be operating the equipment.

4-15.14 Hydronic Heating System

Piped hot water is used to heat the flooring (see Figure 4-15.12). It is usually installed concurrent with the concrete floor slab reinforcement but can also be used under floors and in crawl spaces. Tubing is plastic and runs from a hot water supply boiler via a manifold distribution system with regulating valves to control flow rates.



Figure 4-15.12. Hydronic Heating System

Confirm the installation of all heating water supply and return pipe and tubing, which must comply with the requirements for cutting, cleaning, closing, securing, and insulating of water piping under SSP 99-15060, *Pipe, Fittings, and Valves*.

Test the piping system in the floor slab prior to placing concrete, in accordance with the special provisions.

4-15.15 Boiler

The boiler must be installed in accordance with the manufacturer's instructions.

Confirm that expansion joints have been provided for all piping, and confirm the requirement for expansion joints in the floor around the boiler.

For oil-burning equipment, confirm the size of the burner tips, location of electrodes, position of the gas or oil pilot, and clearances for removal of the burner for maintenance.

For gas-burning equipment, confirm the position of the pilot flame, if required, and sensing element, regulators, and controls. Verify that all gas vents are piped to the exterior. Note that some equipment has electronic ignition, without a pilot flame.

Forced draft fans should be checked for proper anchorage, alignment, and rotation. Verify adequate clearance and accessibility for lubrication, operation of the dampers, insulation, safety control interlocks, and airflow switches.

Oil storage tanks should be checked for capacity, proper anchorage, minimum cover, and the required clearance for tank heaters if specified. Confirm double wall or other containment for spills. Due to current sustainability and energy efficiency initiatives, these systems may be changing to electric.

Confirm the piping was installed in accordance with the contract documents. Verify provisions for expansion and contraction, pitch for horizontal runs, and provisions for dielectric connection or isolation. Hangers must be spaced and installed per the requirements of the project *Special Provisions*.

Confirm the valves are of the type and style specified and that all fittings, such as gauges, check valves, strainers, and traps, are provided.

Confirm the piping and equipment are insulated in accordance with the authorized submittals and that vapor seals are provided where required. The banding or securing of insulation should be as specified. Verify the location, type, size, and authorized materials for the placement of radiant heating coils and piping, and confirm the piping has been tested, and the test authorized, before encasement. The pressure test should be maintained while the concrete is being placed and finished.

Exposed piping should be painted and identified for flow and type of use.

Shutoffs for fuel and water are to be provided and should be clearly labeled and accessible. Confirm all safety and relief valves are provided and piped to the specified drains.

Confirm that combustion air has been provided as specified.

Confirm the locations and proper mounting and anchoring of expansion tanks, and that they are provided with specified accessories and drains.

Valves and fittings are to be insulated the same as the piping.

4-15.16 Cathodic Protection

The design of cathodic protection is a coordinated effort between the mechanical engineer and the electrical engineer. Underground metallic piping is connected to a sacrificial anode material, usually zinc (see Figure 4-15.13).

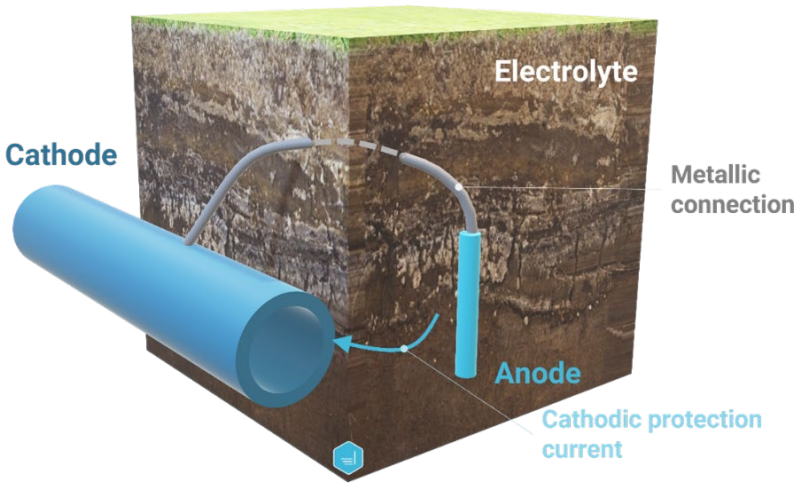


Figure 4-15.13. Cathodic Protection

The impervious wrapping around the cloth-bag-packaged anode must be removed immediately before installing the anode.

Anodes must be installed at the locations shown. The packaged anode must be thoroughly wet before backfilling. Backfill material placed to 12 inches above the anode must be native soil, free from aggregate larger than 1/2 inch in size.