VACUUM PUMPS

- Vacuum Pumps are those devices which remove gas molecules from a sealed environment or chamber.
- This creates a partial vacuum in that environment
- Types of Vacuum Pumps
- There are broadly 3 types of vacuum pumps. They are:

POSITIVE DISPLACEMENT PUMPS

→ These pumps expand a cavity and allow the gases to flow out of the sealed environment or chamber.

→ Then they seal the cavity and cause it to exhaust it to the atmosphere.

→ These pumps are most useful for creating low vacuums.

→ Examples are: Diaphragm Pump, Piston Pump, and Scroll Pump.

- **Momentum Transfer Pumps or Molecular Pumps** –

→ These pumps use high speed dense fluids or high speed rotating blades to remove gas molecules from the sealed environment or chamber.

→ These pumps are often used along with Positive Displacement Pumps to create high vacuum chambers.

→ Examples are: Turbomolecular Pump and Diffusion Pump.

- **Entrapment Pumps** –

→ These pumps catch gases in either a solid or in an absorbed state.

→ These pumps are used along with Positive Displacement Pumps and Molecular Pumps to create ultra high vacuum chambers.

→ Examples are: Ion Pumps and Cyropumps.

APPLICATION OF VACUUM PUMPS

- Due to their specific functions, different types of vacuum pumps find their uses and applications in a variety of industrial environments. These are:
- The production of electric lamps and vacuum tubes where the device is left evacuated and is then re-filled with a specific gas or a mixture of gases.
- Medical processes needing suction.
- Analytical instrumentation to analyze solid, liquid, gas, surface and bio materials.
- Vacuum coating.
- Electron Microscopy
- Mass spectrometers to create ultra high vacuum levels between the ion source and the detector.
- Trash compacting.
- Ophthalmic Coating.
- Sewage systems.
- Automobile industries.

PERFORMANCE CHARACTERISTICS OF PUMPS

- The fluid quantities involved in all hydraulic machines are the flow rate (Q) and the head (H), whereas the mechanical quantities associated with the machine itself are the power (P), speed (N), size (D) and efficiency (h).
- Although they are of equal importance, the emphasis placed on certain of these quantities is different for different pumps.
- The output of a pump running at a given speed is the flow rate delivered by it and the head developed.
- Thus, a plot of head and flow rate at a given speed forms the fundamental performance characteristic of a pump.
- In order to achieve this performance, a power input is required which involves efficiency of energy transfer.
- Thus, it is useful to plot also the power P and the efficiency h against Q.
- **Over all efficiency of a pump (h) = Fluid power output / Power input to the shaft = rgHQ / P**
- **Specific speed of pump, $n_S = NQ^{1/2} / (gH)^{3/4}$ (it is a dimensionless number)**

Characteristic curves

- Pump action and the performance of a pump are defined interms of their *characteristic curves*.
- These curves usually supplied by pump manufacturers are for water only.
- These curves usually shows the following relationships:

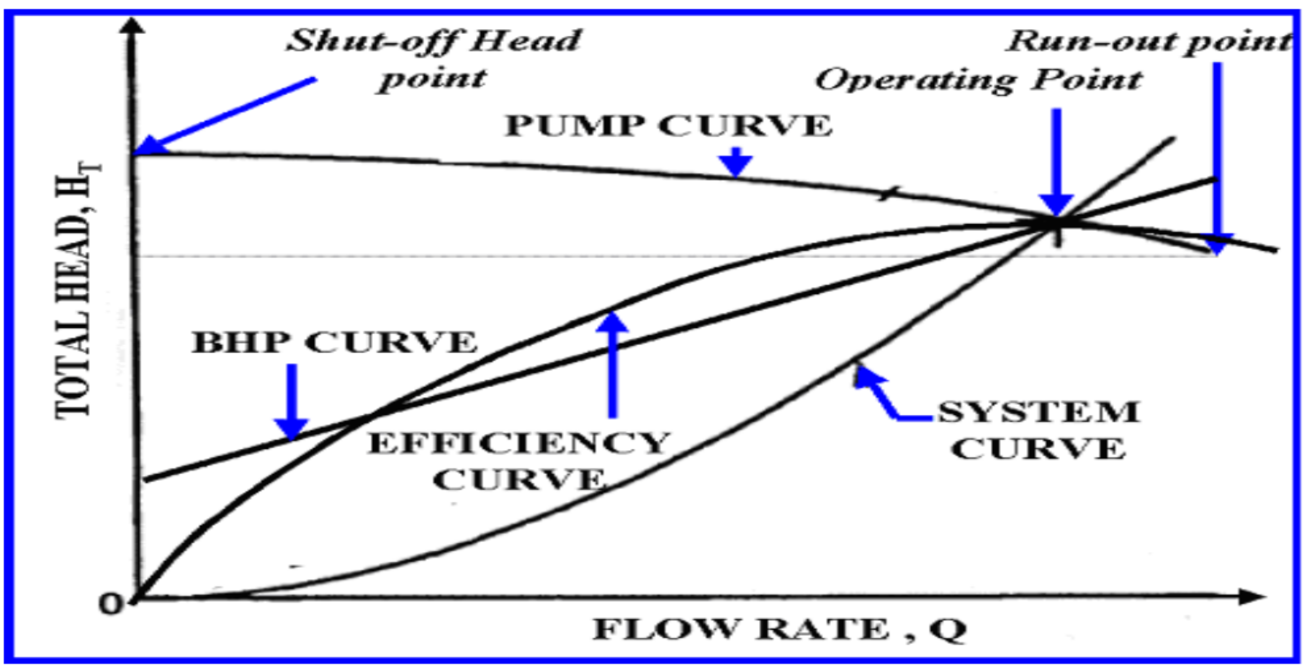
a) A plot of capacity versus differential head.

b) Differential Pressure-pressure between the suction and discharge.

c) The pump efficiency as a percentage versus capacity.

d) The horsepower of the pump versus capacity.

e) The net positive suction head (NPSH) required by the pump versus capacity. The required NPSH for the pump-determined by the manufacturer.



→ This curve is plotted for a constant speed (rpm) and a given impeller diameter (or series of diameters).

→ It is generated by tests performed by the pump manufacturer.

→ Pump curves are based on a specific gravity of 1.0.

→ Other specific gravities must be considered by the user.

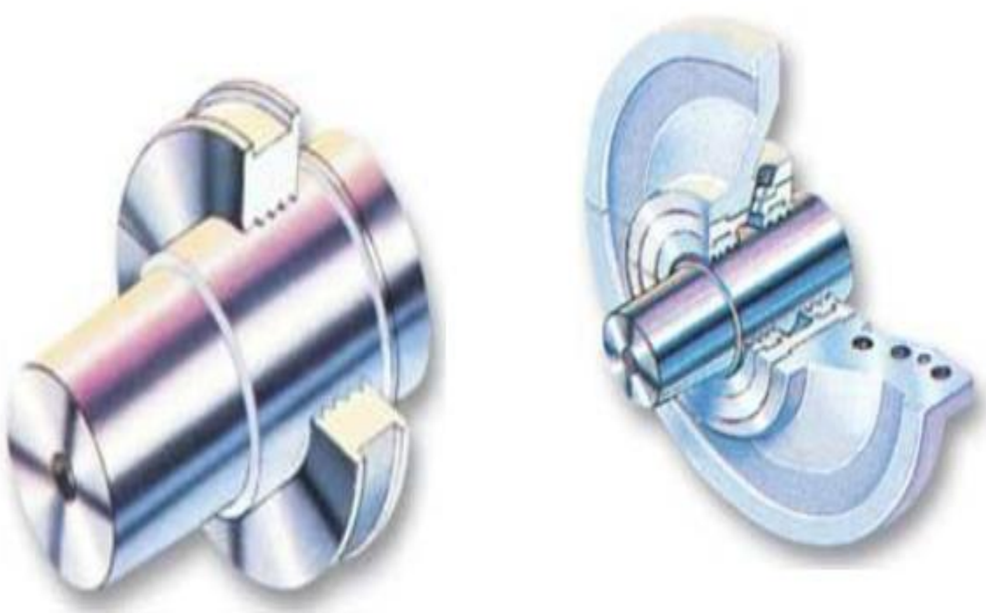
LUBRICATION IN COMPRESSORS

- Nearly all compressors require a form of lubricant to either cool, seal or lubricate internal components.
- Only static jet compressors (ejectors) and late 20th- and early 21st-century oil-free machines with rotors suspended in magnetic or air bearings are exempt from the need for some type of lubrication.

Key Components

- Compressors have a few key components that require a coolant/lubricant: gears, bearings and seals.
- To date, the majority of dynamic compressors continue to utilize oil film-lubricated seals.
- On the more conventional liquid- lubricated seals, the bearing and sealing lubricant are often the same.

Traditional compressor seal

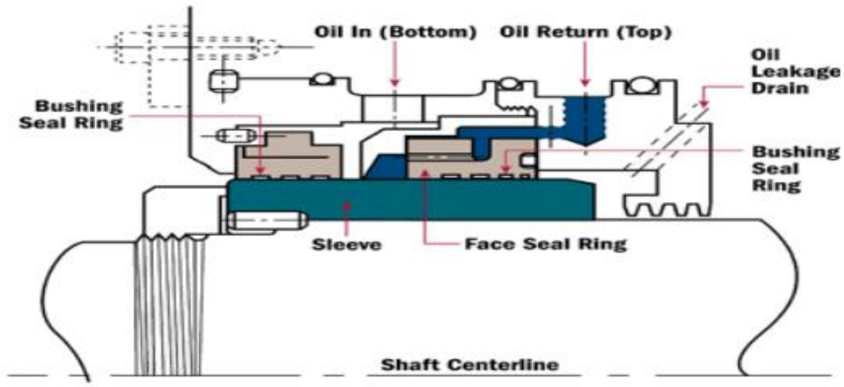


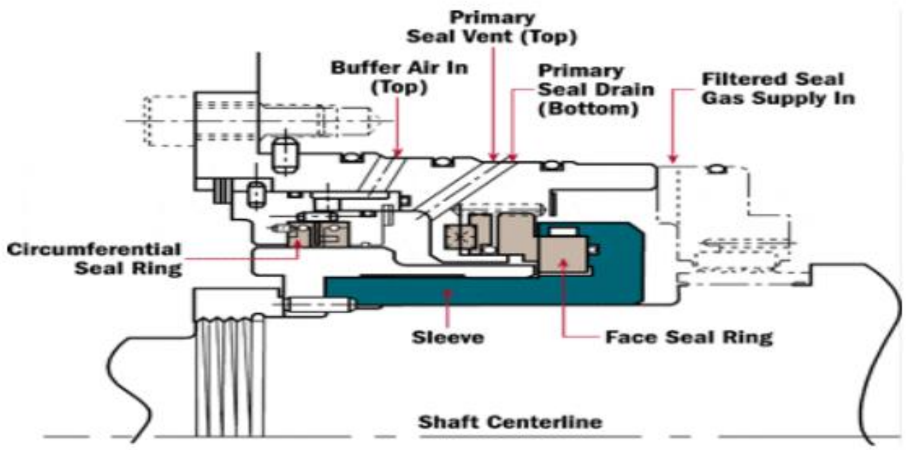
LUBRICATING OIL SYSTEM OPERATION

- The lube oil system supplies oil to the compressor and driver bearings and to the gears and couplings.
- The lube oil is drawn from the reservoir by the pumps and is fed under pressure through coolers and filters to the bearings.
- Upon leaving the bearings, the oil drains back to the reservoir.
- The reservoir is designed to permit circulation of its entire fluid volume between eight to 12 times per hour.
- Oil reservoirs often have thermal sensors for monitoring temperature levels during start-up and constant operations.
- Reservoirs also often have oil temperature controls that provide for preheating during cold start-up conditions and cooling to prevent overheating during peak operating cycles.
- An auxiliary pump serves as a standby. These two pumps generally have different types of drive or power sources.
- When both are driven electrically, they are connected to separate supply feeders.
    - Relief valves protect both pumps from the effects of excessively high pressures. Check-valves prevent reverse flow of oil through the stationary pump.
    - Heat generated by friction in the bearings is transferred to the cooling medium in the oil coolers.

Air-cooled oil coolers may be employed as an alternative to water-cooled oil coolers.

- Filters clean the lube oil before it reaches the lubrication points and a differential pressure gauge monitors the degree of fouling (flow restriction) of the filters.
- The flow of oil to each bearing is regulated individually by orifices, particularly important for lubrication points requiring different pressures.
- Temperatures and pressures are often recorded on the suction and discharge sides of each compression stage to offer the operator a sense of the health of the system.
- The readings can be taken locally or transmitted to a monitoring station.





Compressor Lubricants

- The overwhelming majority of compressors are best served by premium-grade turbine oils with ISO viscosity grades of 32 or 46.
  - However, there are many different types of compressors and each manufacturer is likely to recommend lubricants that have been used on a test stand and at controlled user facilities.
  - Premium-grade ISO VG 32 turbine oils are used more often than the heavier viscosity grades.
  - Oxidation stability should exceed 5,000 hours and the flash point should be 206ºC, or 403ºF.

These lubricants must provide the following:

- Long life without need for change-out
- Prevention of acidity, sludge, deposit formation
- Excellent protection against rust and corrosion, even during shutdown
- Good demulsibility to shed water that enters the lubrication system
- Easy filterability without additive depletion
- Good foam control
- It is not uncommon to operate these systems for many years on the initial fill of lubricant, in some cases beyond 30 years.
- These long-term lifecycles are associated with premium-grade product selection, large sumps, reasonably good contamination control.

Compressor Seals

- In general, the mechanical contact or oil face seal employs a spring-loaded stationary carbon ring in sliding contact with a rotating ring manufactured from high-quality material with a special finish.
- This type of seal is also effective when the compressor is at standstill and the oil pumps have been shut down.
- The main components of oil bushing seals are two stationary, but radially free-to-move (floating ring) breakdown bushings with small diametral clearances opposite a shaft sleeve.
- The floating ring clearance controls the flow of the seal liquid cooling the seal.

Seal Oil System Operations

- The seal oil, or seal liquid system supplies the mechanical contact and floating ring seals with an adequate flow of seal liquid at all times, correctly ensuring proper function.

- The seal oil system may be combined with the lube oil system if the gas does not adversely affect the lubricating qualities of the oil.

- There are two methods of combining lube oil and seal oil systems: booster or combined systems.
- In the booster system, the oil pressure is raised to the pressure required for lubrication purposes and then part of it is raised further to the pressure needed for sealing.
- Alternatively, in the combined system, all the oil is initially raised to the required pressure and flow, then reduced to system component requirements.

AIR RECEIVERS

An air receiver is probably the most common type of unfired pressure vessel. However, due to minimum size inspection thresholds employed by the vast majority of jurisdictions, many of the smaller air receivers will not qualify for a mandatory inservice inspection. The typical inspection threshold sizes referenced in jurisdictional regulations are 5 cubic feet or 15 cubic feet in volume as long as the maximum allowable working pressure (MAWP) does not exceed 250 psi, or 1-½ cubic feet in volume as long as the MAWP does not exceed 600 psi. The inspector must review the jurisdiction's inspection requirements to ensure compliance with the appropriate size and pressure limitations.

Air receivers are typically constructed in accordance with ASME Section VIII, Div. 1, and stamped with either the ASME "U" or "UM" symbol. Manufacturers who specialize in air receivers will construct a large number of these vessels in an assembly line process. The *Manufacturer's Data Report*, for "U" stamped vessels, and the *Manufacturer's Certificate of Compliance*, for "UM" stamped vessels, may include multiple vessels. This practice is described in ASME Section VIII, Div. 1, paragraph UG-120(a).

While most air receivers are of simple design consisting of a shell and two dished heads, some are designed to incorporate a filter or separator element within the vessel. These vessels may be "T" shaped with one bolted flat head which provides access to the filter or separator element. These uniquely shaped vessels are commonly found in use with large industrial air compressors.

Air receivers will be installed in any facility requiring a reservoir of compressed air. Compressed air uses include:

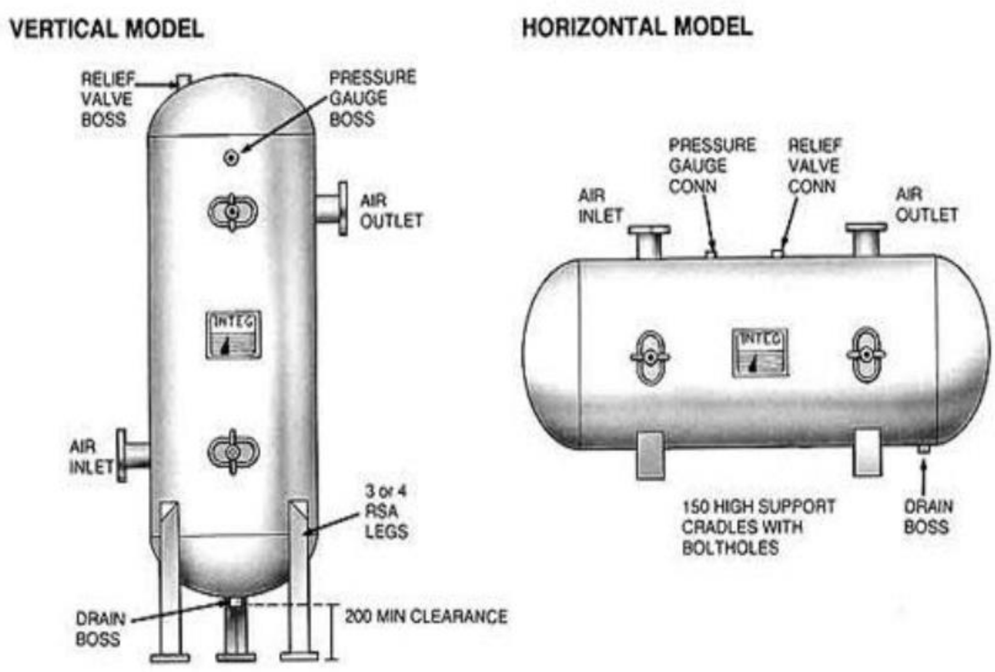
- Tire Inflation
- Air-Powered Tools
- Pneumatic Cylinders or Pistons
- Sand- or Shot-Blasting
- Painting

- Cleaning
- Air Motors
- Conveying Systems
- Pneumatic Controls
- Breathing Air

The design of a compressed air system is dictated in part by the pressure, volume, and air quality (including cleanliness and dryness) needed in any given industry or process. The size of the air receiver in the system is normally based on the volume of air produced by the compressor and the user's desire for a stated capacity in cubic feet per minute (cfm) at a specified pressure. The air receiver helps in maintaining a constant pressure in the system by minimizing the fluctuations of a compressor cycling on and off..

Since air receivers are typically constructed out of carbon steel, they are subject to internal corrosion from water which has condensed from the compressed air. ASME Section VIII, Div. 1, paragraph UG-25(f), requires a suitable drain opening in such vessels.

Air receivers with integrally mounted compressors and motors should be installed as recommended by the manufacturer. Since there is usually some vibration produced by a reciprocating-type compressor/motor unit, many manufacturers provide spring-loaded or elastic compound dampers to mount between the floor and the air receiver base.



PIPING SYSTEM

Within industry, **piping** is a system of pipes used to convey fluids (liquids and gases) from one location to another. The engineering discipline of piping design studies the efficient transport of fluid.

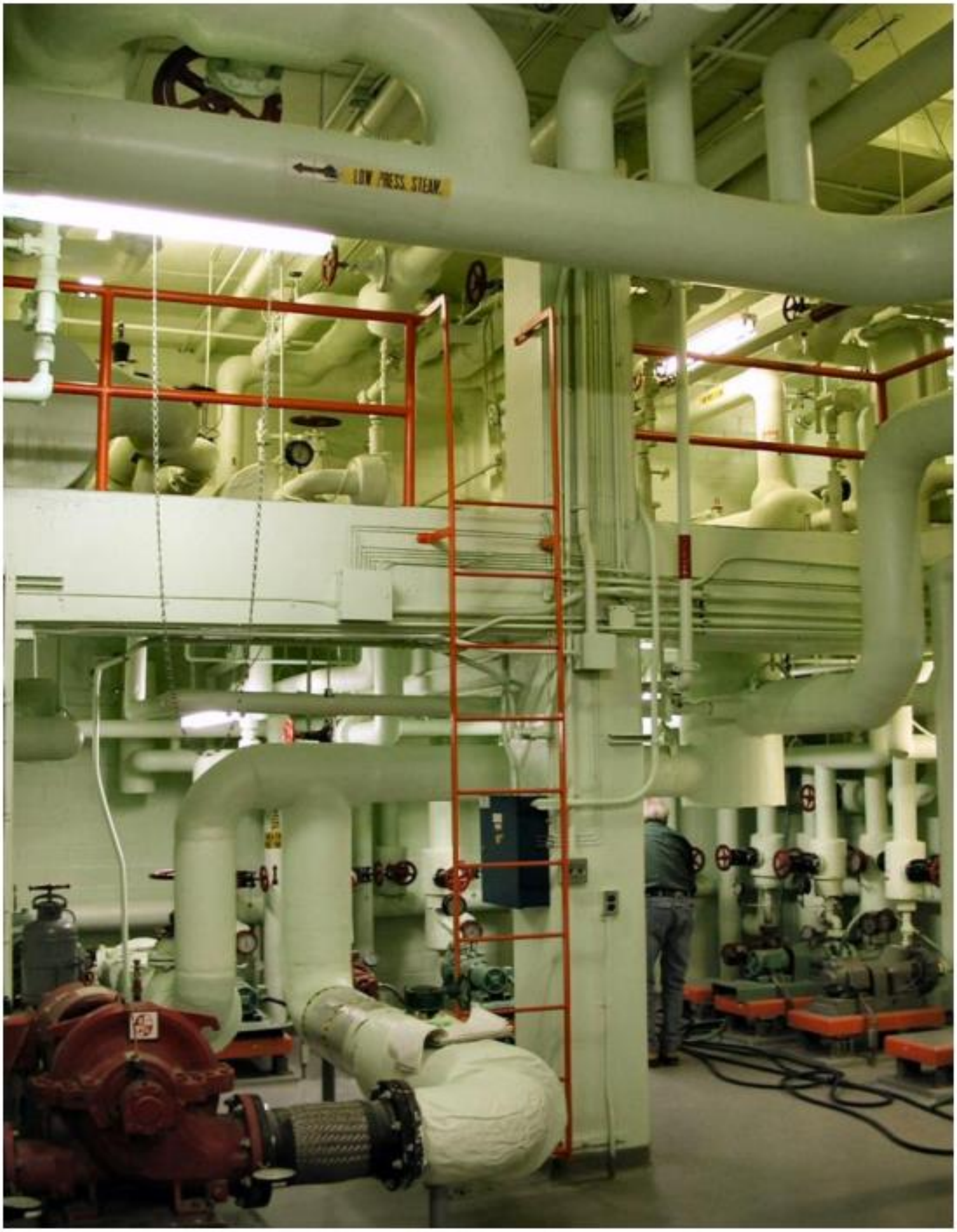
Industrial process piping (and accompanying in-line components) can be manufactured from wood, fiberglass, glass, steel, aluminum,plastic, copper, and concrete. The in-line components, known as fittings, valves, and other devices, typically sense and control thepressure, flow rate and temperature of the transmitted fluid, and usually are included in the field of Piping Design (or Piping Engineering). Piping systems are documented in piping and instrumentation diagrams (P&IDs). If necessary, pipes can be cleaned by the tube cleaning process.

"Piping" sometimes refers to Piping Design, the detailed specification of the physical piping layout within a process plant or commercial building. In earlier days, this was sometimes called Drafting, Technical drawing, Engineering Drawing, and Design but is today commonly performed by Designers who have learned to use automated Computer Aided Drawing / Computer Aided Design (CAD) software.,

Plumbing is a piping system with which most people are familiar, as it constitutes the form of fluid transportation that is used to provide potable water and fuels to their homes and businesses. Plumbing pipes also remove waste in the form of sewage, and allow venting of sewage gases to the outdoors. Fire sprinkler systems also use piping, and may transport non potable or potable water, or other fire-suppression fluids.

Piping also has many other industrial applications, which are crucial for moving raw and semi-processed fluids for refining into more useful products. Some of the more exotic materials of construction are Inconel, titanium, chrome-moly and various other steel alloys.

SEE PICTURE NEXT PAGE


LOW PRESS. STEAM