COURSE NAME: INDUSTRIAL PIPING SYSTEM

LECTURE VII-WEEK VII: MATERIALS FOR PRODUCING PIPES

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OBJECTIVES

By the end of this session the learner/student will be able to:

- ✓ Identify variables to take into account when selecting pipes
- ✓ Identify ferrous metal pipes
- ✓ Identify non-ferrous metal pipes
- ✓ Identify plastic pipes
- ✓ Identify composite pipes

VII.1. Introduction

The services for which a pipe is to be used determines the material, manufacturing and assembling operation.

From those mentioned aspects pipes can be made from a variety of materials; including glass, rubber, plastic, wood, aluminum, ….

In special situations, physical properties, temperature and pressure limitations must be taken into account along with their cost.

Introduction Cont’d

The service conditions vary so widely regarding heat, strain, pressure, and chemical reactivity, the selection of pipe becomes an important factor in the design of the total system. The most of metallic pipes on the market are made from cast iron, wrought iron, and steel

Introduction Cont'd

Generally, piping materials can categorized as ferrous metal, non-ferrous metal, plastic and composite piping.

PVC is a perfectly acceptable material for the applications for which it is designed.

If you expose it to high temperature, high pressure, shock loads, or the sun, you can expect failure in a short time. The failure may be accompanied by property damage, shrieking, or worse.

VII.2 Chief variables

The chief variables that must be taken into consideration in the selection of pipe are:

- ✓Material Compatibility
- ✓Pressure and Temperature Ratings
- ✓Fluid Characteristics
- ✓Installation Method
- ✓Environmental Factors
- ✓System Design Requirements
- ✓Cost Considerations
- ✓Regulatory Compliance

Chief variables Cont’d

a. Material Compatibility

Evaluate the compatibility of the pipe material with the substance being transported.

Consider factors such as chemical resistance, temperature resistance, and potential reactions between the pipe material and the conveyed fluid or gas.

Chief variables Cont’d

b. Pressure and Temperature Ratings

Determine the maximum operating pressure and temperature requirements of the system.

Select pipes that can safely withstand the anticipated pressure and temperature conditions without failure or deformation.

Chief variables Cont’d

c. Fluid Characteristics

Analyse the properties of the fluid being transported, such as its corrosiveness, viscosity, and abrasiveness.

Choose a pipe material that is suitable for handling the specific fluid characteristics to prevent degradation or damage to the pipe.

Chief variables Cont’d

d. Installation Method

Consider the installation method, whether it involves welding, threading, or using mechanical connections.

Different pipe materials may require specific installation techniques and associated equipment.

Chief variables Cont’d

e. Environmental Factors

Assess environmental factors such as exposure to UV radiation, outdoor weather conditions, soil composition, and potential for chemical or environmental degradation.

Select pipes that are resistant to the specific environmental conditions to ensure long-term durability.

Chief variables Cont’d

f. System Design Requirements

Consider the system design requirements, including pipe dimensions, fittings, valves, and supports.

Ensure that the selected pipe material is readily available in the required sizes and compatible with the necessary fittings and accessories.

Chief variables Cont'd

g. Cost Considerations

Evaluate the cost-effectiveness of different pipe materials, considering both the initial installation cost and long-term maintenance expenses. Consider factors such as material cost, installation labour, maintenance requirements, and expected service life.

h. Regulatory Compliance

Ensure that the selected pipe material meets applicable industry standards and regulatory requirements for the intended application, such as NSF/ANSI standards for potable water systems or ASME codes for high-pressure systems.

It is important to consult industry guidelines, manufacturer recommendations, and expert advice when selecting pipes to ensure the appropriate choice for your specific application.

VII.3. Ferrous metal pipes

a. Cast Iron Pipe

Commercially manufactured cast iron contains between 2 and 6.67 percent carbon. These metals are exceptionally strong in compression, but are very brittle. They have very low ductility and malleability, and cannot be drawn, rolled, or worked at room temperature.

- Cast irons melt readily however, and can be cast into complicated shapes and machined. This property suits them for some valve bodies.

Cast Iron Pipe Cont’d

Cast iron was probably the first metal used for piping. Because it is so brittle, it is not often used for pressure piping applications, although ASME B31.3 contains Basic Allowable Stress data for grey cast iron pipe. Cast iron pipe is now used primarily for drain, waste, and vent (DWV) applications, which is also known as “soil pipe.”

Cast Iron Pipe Cont’d

Once used for water distribution piping, cast iron is now relegated to drain, waste, and vent service, due to the improved metallurgy provided by other materials, especially ductile iron. Cast iron water mains are still in service throughout the world however, in aging infrastructure. Cast iron soil pipe can be used above ground or below ground. It can support the weight of soil in underground applications.

b. Carbon Steel

Carbon steel piping is the type that is most often used in industrial applications. It has the advantage of wide availability, high strength, and myriad connection systems and fittings.

Carbon steel piping is used for many liquid and gas services, both above and below ground. It is also widely used for steam systems.

It inappropriate for corrosive services but is used for caustic services. It may be used for potable water if appropriate linings are applied to prevent iron dissolution.

c. Stainless Steel Piping

Stainless steel piping is used whenever corrosion resistance is desired. The addition of chromium is primarily responsible for the corrosion resistant properties of stainless steels.

Even though stainless steel exhibits excellent corrosion protection, it would be very unusual to use it in an underground application. A more economical solution would be to use carbon steel with cathodic protection.

Stainless Steel Piping Cont'd

Stainless steel piping is used wherever iron dissolution cannot be tolerated, as in the production of foods, beverages, and pharmaceuticals. It is often used in uninsulated industrial services to avoid the need to paint the exterior of pipes.

The added cost of stainless steel piping can often be offset by the cost of painting and repainting the exterior of carbon steel pipes over the expected lifetime of the installation.

VII.4. Non-ferrous metal pipes

a. Copper pipes

Copper pipe is essentially unalloyed pure copper. Copper is a ductile material that can easily be drawn into tubing. It resists corrosion under many conditions, and is therefore a suitable material for potable water service4. Copper pipes have been found in ancient Egypt for conveying bath water. Like many metals, copper is a germicide.

Copper pipes Cont’d

- Copper tubing is an excellent material for conveying both hot and cold water, so it is used primarily for plumbing and hydronic. It frequently finds use in refrigerant piping.
- Due to its ease of fabrication and corrosion resistance, it is also used for high-purity applications such as medical gases.
- In industrial settings copper is sometimes used for instrument air, vacuum, fuel oil, or fuel gas systems.

b. Brass Pipe

Brass pipe is manufactured from an alloy of 85 percent copper and 15 percent zinc.

It is an uncommon piping material, but is sometimes used for potable water pressure pipe where hot work is impractical. It is also sometimes used for drainage due to its ability to resist specific corrosives.

Brass pipe may be threaded, flanged, or soldered.

c. Titanium Pipes

- Titanium is often thought to be an exotic material for piping systems, yet it is the ninth most common element in the earth's crust.
- Among common piping materials, only iron and aluminum are more abundant. There is approximately six times more titanium present than copper. Titanium resists corrosion, has high strength, and low weight.
- Titanium piping is used in the petrochemical, pulp and paper, food processing, and power generation industries.

d. Aluminum Pipes

- Aluminum is a lightweight metal that is approximately one-third the density of steel. It resists corrosion, and may be alloyed with magnesium, manganese, or silicon.
- Aluminum piping systems are not very common, but they are sometimes used for pneumatic conveying and compressed gas applications, including enrichment of uranium through centrifugal cascades. It resists corrosion, but is not compatible with acids, mercury, or strong alkalis.

e. Lead Pipes

Lead pipe or lead-lined pipe resists the chemical action of many acids. Therefore this type of pipe is found in chemical work and in systems that transport acids.

The lead pipe is specifically manufactured with a flat end instead of a spigot and it does not have joint gaskets. Lead pipes can also be used when the excavation work is completed by hand rather than by a machine.

VII.5. Plastic pipes

a. PVC (Polyvinyl Chloride) Pipes

- PVC is a thermoplastic polymer.
- PVC piping is used in pressure piping as well as in plumbing drainage.
- It is widely available, relatively inexpensive, and the subject of some controversy over its environmental impact.
- It is the most widely used material for plastic piping.

PVC pipes Cont’d

- PVC is widely used for cold water pressure piping and DWV piping. It is also used in many industrial applications.
- Though PVC contains stabilizers to help prevent ultraviolet degradation, PVC should be painted with latex paint if it is to be exposed to sunlight, and pipe stored outdoors should be covered with an opaque tarp.

PVC pipes Cont'd

- PVC is not suitable for hot water, since it has a maximum temperature limit of only 140°F (60°C). Being a thermoplastic, the strength drops off quickly as the temperature rises above ambient, and the working pressure must be de-rated for temperatures above 73°F (23°C).
- PVC is never to be used for compressed gases, nor is it to be tested with gases under pressure.

PVC pipes Cont’d

- PVC pipe is produced from vinyl chloride monomer which is reacted to form polymer chains. The plastic is extruded through dies into pipe of the required diameter and wall thickness.
- PVC pipe is available in both solid wall and a cellular core construction. The cellular core includes solid inner and outer layers that are simultaneously extruded around a cellular core.

b. CPVC (Chlorinated Poly-Vinyl Chloride) Pipes

- CPVC is also a thermoplastic. It is manufactured from the same resin as PVC , but undergoes an additional reaction in which chlorine replaces some of the hydrogen in the monomer.
- CPVC is used in water-distribution, less commonly for water-service. Water distribution implies both hot water and potable cold water service, as inside a building. CPVC can support temperatures up to 180°F (82°C)

CPVC pipes Cont'd

- CPVC is also used to handle corrosive fluids, and is sometimes also used in fire suppression.
- Because it offers higher strength at elevated temperatures than PVC , it may be applied in more applications in industrial services. Because it is a plastic material, it must never be used for compressed gas services.
- Like PVC , CPVC should not be installed outdoors without protection from ultraviolet exposure. While it contains UV stabilizers, manufacturers recommend painting it with latex paint to protect it from UV degradation.

c. Polyethylene (PE) and High-Density Polyethylene (HDPE) Pipes

- Polyethylene is a polymer thermoplastic that excels in certain underground applications.
- It belongs to a class of polymers known as polyolefin. It tolerates abuse and may be deformed without compromising its strength.
- HDPE is often used to convey water or low-pressure natural gas. It does not corrode, and its flow characteristics are very good, since the surfaces are so smooth.

PE and HDPE Cont'd

- The resistance to corrosion can make it a more economical choice for underground piping than coated and wrapped carbon steel, provided that the fluids are compatible with the material, and the pressures can be accommodated.
- HDPE pipe is only used above ground in installations that are regarded as temporary. Due to its extreme flexibility (low Young's Modulus) it would require extensive support for above ground installation.

d. Acrylonitrile-Butadiene-Styrene (ABS) Pipes

- ABS is another thermoplastic used primarily for DWV service. It is a rigid black (sometimes dark grey) product that is easy to work with, is inexpensive, and is therefore a popular choice for residential and commercial construction.
- ABS is acceptable for use as a water service pipe, but is most often used in DWV service.
- It is also sometimes specified for pressurized lines for crude oil, pumped waste, salt water, and irrigation applications.

ABS Pipes Cont’d

- Bare ABS pipes are not suitable for use in plenums, since their Flame Spread and Smoke Developed Indices exceed code requirements for this use.
- ABS pipes installed in plenums would have to be boxed in with gypsum board or wrapped with a suitable insulation whose properties are acceptable for use in plenums.

e. Cross-Linked Polyethylene (PEX) Pipes

Cross-Linked Polyethylene (PEX) pipes are a type of plastic piping material that is commonly used in plumbing and heating systems.

PEX pipes are known for their flexibility, durability, and ease of installation.

They are created by cross-linking polyethylene molecules, which enhances the pipe's strength, resistance to heat and chemicals, and overall performance.

Cross-Linked Polyethylene (PEX) Pipes Cont'd

One of the key advantages of PEX pipes is their flexibility, which allows for easier installation in tight spaces and reduces the need for extensive fittings and connections.

PEX pipes can be bent and curved without the need for additional joints, minimizing the risk of leaks.

The flexibility also contributes to faster installation and reduced labor costs.

VII.6. Composite pipes

Composite materials pipes are pipes that are made by combining two or more different materials to create a pipe with enhanced properties and performance.

a. Concrete Pipe

Concrete pipe may be either reinforced (RCP) or non-reinforced, and is used in pressure and gravity applications. Concrete pipe is often used for storm and sanitary sewers. Pressurized services are usually non-potable cooling or process water.

b. Fiberglass Reinforced Plastic (FRP) Pipes

- Fiberglass Reinforced Plastic (FRP) is a composite material with wide use due to its chemical resistance and strength.
- FRP piping is used to convey chemicals in liquid or vapour phases. It often finds use in fume scrubbers, ductwork, stacks, and fuel, acids, caustics, and solvents piping. It therefore is frequently used in oil field applications. It is also used to convey water in industrial applications. FRP may be used in both above and below ground installations.

c. Fiber Reinforced Polymer (FRP) Pipes

FRP pipes are made by combining a polymer matrix, such as epoxy or polyester, with reinforcing fibers, typically fiberglass.

These pipes are lightweight, corrosion-resistant, and have high strength-to-weight ratios, making them suitable for various applications, including water and wastewater systems, oil and gas pipelines, and industrial processes.

d. Carbon Fiber Reinforced Polymer (CFRP) Pipes

CFRP pipes utilize a polymer matrix, such as epoxy or vinyl ester, reinforced with carbon fibers. They offer excellent strength, stiffness, and chemical resistance.

CFRP pipes are commonly used in high-performance applications, such as aerospace, automotive, and high-pressure industrial piping systems.

Conclusion

Most failures of fluid process systems occur at or within interconnect points: the piping, flanges, valves, fittings, etc. It is, therefore, vital to select interconnecting equipment and materials that are compatible with each other and the expected environment. Materials selection is an optimization process, and the material selected for an application must be chosen for the sum of its properties. Considerations include cost and availability. Key evaluation factors are strength, ductility, toughness, and corrosion resistance.

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