TRADE OF

Pipefitting

PHASE 2

Module 4

Pipe Installation

UNIT: 2

Piping Services

Produced by

SOLAS

An tSeirbhís Oideachais Leanúnaigh agus Scileanna
Further Education and Training Authority

In cooperation with subject matter expert:

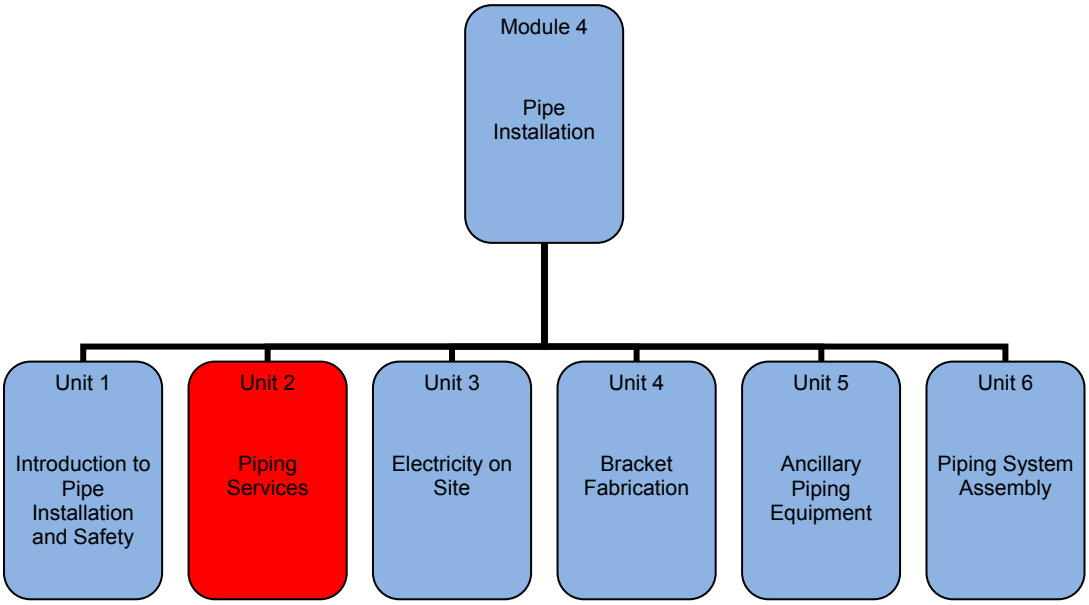
Finbar Smith

Table of Contents

Unit Objective

There are six Units in Module 4. Unit 1 focuses on Introduction to Pipe Installation and Safety, Unit 2; Piping Services, Unit 3; Electricity on Site, Unit 4; Bracket Fabrication, Unit 5; Ancillary Piping Equipment and Unit 6; Piping system assembly.

In this unit you will be introduced to the different possible piping services that you may encounter in a typical process facility and the requirements for installing and insulating these service pipe lines.



Learning Outcome

By the end of this unit each apprentice will be able to:

- List the main piping services in the pipefitting industry.
- Recognise that designations and requirements for piping system specifications differ between industries and companies.
- Describe how different piping material are used for different services.
- Outline the common hazards associated with different services e.g. Asphyxiation, Burning, Gas Explosions.
- Explain how wall thickness of pipe selected varies according to the design pressure requirements of a system.
- Explain how the design temperature requirements of a system has implications on the installation of a piping system.
- Describe the purpose of insulation and why it is used.
- Explain why different types and thickness of insulation are used on piping systems.
- Describe why pipes are placed at different centers on a pipe rack to allow for different thickness of insulation.
- Explain why insulation boxes are used at valves and piping components.

1.0 Pipe Services in the Process Industry

Key Learning Points

- Identify the common piping services that are used in the process industry served by pipe fitters
- Identify that different companies and different industry sectors have different designations of piping services

1.1 Designations of Piping Services

Piping service names are abbreviated to sets of letters to aid the transfer of information. For line lists and drawings each line can be tagged with a unique line designation tag (e.g. ACY-50-1500-SS1) which provides the following information:

- ACY = Service being carried in the line
- 50 = The line size
- 1500 = Specific line number
- SS1 = Line or material classification

Table 1 below gives a list of typical services found in a typical API pharmaceutical manufacturing plant. It also identifies the pressure and temperature ratings it's line classification and the type of piping material used for each service.

Service Symbol	Service	Design Press. Barg	Design Temp °C	Line/material Classification	Description
ACY	Acetylene	10	60	SS1	316LSSpipe
AR	Argon	10	60	SS1	316LSSpipe
CA	Clean Air	7	125	SS7	316LSS Tubing
CA	Compressed Air	10	70	CS1	Carbon Steel
CHWR	Chilled Water Return	7	-5/65	CS1	Carbon Steel
				CU1	Copper Tubing
CHWS	Chilled Water Supply	7	-5/65	CS1	Carbon Steel
				CU1	Copper Tubing
CIPR	CIP Return	7	125	SS1	316LSSpipe
				SS7	316LSS Tubing

CIPS	CIP Supply	7	125	SS1	316LSSpipe
				SS7	316LSS Tubing
CTWR	Cooling Tower Water Return	10	0/70	CS1	Carbon Steel
CTWS	Cooling Tower Water Supply	10	0/70	CS1	Carbon Steel
DF	Drain - Foul - In B1de/UG	Atm	60 •	PVC	PVC-DWV
DP	Drain - Floor- In Bldg,	2	100	FRP1	FRP
	Drain - Floor- Underground	Atm	100	FRP2	FRP Double Contained
HE	Helium	10	60	SS1	3I6LSSpipe
HPC	Condensate {High Pressure)	12	250	CS3	Carbon Steel
HPS	Steam (High Pressure)	12	250	CS3	Carbon Steel
HHWR	Heating Hot Water Return	8	90	CS1	Carbon Steel
				CU1	Copper Tubing
HHWS	Heating Hot Water Supply	8	90	CS1	Carbon Steel
				CU1	Copper Tubing
IS	Instrument Air	10	70	SS1	316LSSpipe
				SS7	316LSS Tubing
LPC	Condensate (Low Pressure)	1	150	CSS	Carbon Steel
LPS	Steam (Low Pressure)	1	150	CSS	Carbon Steel
MFC	Condensate (Medium Pressure)	5	180	CSS	Carbon Steel
MPS	Steam (Medium Pressure)	5	180	CSS	Carbon Steel
NO	Natural Gas	6	Amb	CS6	Carbon Steel
N2	Nitrogen	10	60	SS1	316LSSpipe
PA	Plant Air	10	70	SS1	316LSS pipe
				SS7	316LSS Tubing, 25M1
P	Process	7	135	SS7	316LSS Tubing, 25MI
PW	Potable Water	10	60	SS8	316LSSpipe
				CU1	Copper Tubing
PWA	Process Waste Aqueous	7	100	FRP1	FRP
PW1	Process Water- 55 deg C	10	100	SS1	316LSSpipe
PW2	Process Water - 80 deg C	10	100	SS1	316LSSpipe
SD	Storm Drain	Atm	60	PVC	PVC-DWV

SW	Softened Water	6	70	CS4	Carbon Steel Galvanized
USP	USP Purified Water	10	135	SS7	316LSS Tubing
V	Ventilation	3	70	PP(M) SS7	Polypropylene 316LSS Tubing
VAC	Vacuum	75-90 mm Hg	20	SS1	316LSSpipe

Table 1 – Designation of piping services for a multinational pharmaceutical company

1.2 Line Designations for Different Sites

The above table is not meant to be an exhaustive list and other plants will require different services while food and dairy factories normally require considerably less. It is important to note that while these acronyms are widely used and are often common between different plants, they are not governed by a standard legislative code and are therefore not site specific. It is important that pipe fitters make themselves aware of site specific piping specifications and line designations to ensure that the correct precautions and materials are used for the work in hand.

2.0 Choosing the Correct Piping Material for Different Piping Services

Key Learning Points

- Describe why different piping material is used for different services.
- Outline the common hazards associated with different services e.g. Asphyxiation, Burning, Gas Explosions.
- Explain how wall thickness of pipe selected varies according to the design pressure requirements of a system.
- Explain how the design temperature requirements of a system has implications on the installation of a piping system.

2.1 Selection of Piping Materials

Piping material is selected by optimizing the basis of design. First, eliminate from consideration those piping materials that:

- are not allowed by code or standard;
- are not chemically compatible with the fluid;
- have system rated pressure or temperatures that do not meet the full range of process operating conditions
- are not compatible with environmental conditions such as external corrosion potential, heat tracing requirements, ultraviolet degradation, impact potential and specific joint requirements

The remaining materials are then evaluated for advantages and disadvantages such as capital costs, fabrication and installation costs; complexity of support system requirements; compatibility to handle thermal cycling; and cathodic protection requirements.

The highest ranked material of construction is then selected. The design proceeds with pipe sizing, pressure integrity calculations and stress analyses. If the selected piping material does not meet those requirements, then the next ranked material is used and the pipe sizing pressure-integrity calculations and stress analyses are repeated.

2.2 Hazards Associated with Piping Services

The inherent dangers associated with installing and maintaining piping systems increase the importance of system design in designing for safety and accident prevention during project construction and throughout a facility's life cycle. There are three fundamental areas in which the system design can affect safety positively:

- System construction and methods of joining pipes
- Training and best practices construction / installation
- Inspection, and system maintainability.

By specifying safer technology and methods in greater detail, up front engineering can minimize the impact of, or possibly even eliminate the potential for, certain types of accidents and injuries. Although most injuries on job sites and in the workplace occur via material handling, falls from heights or electrocution the most significant risks — in terms of potential impact on people and businesses — are caused by fire and fume hazards.

There are many inherent hazards in manufacturing plants which contain multiple piping services, some of the obvious hazards are:

- Leaks from toxic or flammable services
- Leaks from caustic or acid services
- Leaks from high pressure compressed air services
- Fire or explosions resulting from leaks and accidental ignition
- Personnel burns from high temperature steam or condensate services
- Freeze burns from chilled water or glycol services
- Asphyxiation from leaks from inert gas services

Beyond the obvious risk of death or serious injury, explosions or fires can cause extreme property damage worth millions of Euro, cause significant lost production time, and irreversibly damage a company's reputation.

To protect people from these hazards, construction schedules should be rearranged and extended to allow out of hours work when buildings are unoccupied. Eliminating hotwork where possible reduces risk for clients, occupants, and contractors.

However the most important person responsible for a person's safety is the person themselves and it is incumbent on every person to take reasonable care to protect the health and safety of themselves and of other people in the workplace. Not to engage in improper behaviour that will endanger themselves or others and if they are unsure about any task to check with a supervisor before continuing.

2.3 Pressure Rating for Pipes

As mentioned previously in Module 3 Unit 1 Piping Materials there are many different codes and standards which control the manufacture of a wide range of pipes, tubes and fittings. Taking a simple approach welded tubes and pipes (i.e. where the longitudal seam is welded) are used on low temperature low pressure systems and seamless tube and pipe (i.e. extruded pipe, no weld seam) are used for high temperature high pressure applications. Another factor which affects the choice of pipe wall thickness is whether a corrosion allowance is required. In certain instances it is acceptable to install a heavy walled pipe knowing that it will corrode by a certain amount each year and that it will have a finite life span before it needs to be replaced.

2.4 How Design and Operating Temperatures Affect Piping Selection and Design

Design and operating temperatures of a piping system can have the following critical effects:

- Excessive stress relating to thermal expansion of a liquid or being contained by the piping system,
- Reduction of the allowable stress of a material due to elevated temperature
- Stresses caused by elongation or contraction of the metal pipe due to heating or cooling by the service liquid being carried in the pipe.
- Excessive thrust loads or bending moments at connected equipment due to thermal expansion of the metal pipe;
- Leaking at pipe joints due to thermal expansion and contraction of the metal pipes as they heat up and cool down during the manufacturing process.

When designing a piping system subject to thermal expansion due to anticipated high operating temperatures and where the piping will restrained by supports, anchors, equipment nozzles connections and wall and floor penetrations, thermal stresses and loads need to be calculated and analyzed so that they can be accounted for within the pipe routing and design.

3.0 Pipe Insulation

Key Learning Points

- Describe the purpose of insulation and why it is used.
- Explain why different types and thickness of insulation are used on piping systems.
- Describe why pipes are placed at different centers on a pipe rack to allow for different thickness of insulation.
- Explain why insulation boxes are used at valves and piping components.

3.1 The Purpose of Pipe Insulation

Insulations are defined as those materials or combinations of materials which retard the flow of heat energy by performing one or more of the following functions:

- Conserve energy by reducing heat loss or gain.
- Control surface temperatures for personnel protection and comfort.
- Facilitate temperature control of a process.
- Prevent vapour flow and water condensation on cold surfaces.
- Increase operating efficiency of heating/ventilating/cooling, plumbing, steam, process and power systems found in commercial and industrial installations.
- Prevent or reduce damage to equipment from exposure to fire or corrosive atmospheres.
- Assist mechanical systems in meeting criteria in food and pharmaceutical plants.
- Reduce emissions of pollutants to the atmosphere.

3.2 Temperature Ranges

The temperature range, within which the term "thermal insulation" will apply, is from -75°C to 815°C. All applications below -75°C are termed "cryogenic", and those above 815°C are termed "refractory".

Thermal insulation is further divided into three general application temperature ranges as follows:

A. Low Temperature Thermal Insulation

- (1). 5°C through 0°C - i.e. Cold or chilled water.
- (2). 0°C through -40°C - i.e. Refrigeration or glycol.
- (3). -40°C through -75°C - i.e. Refrigeration or brine.
- (4). -75°C through -275°C (absolute zero) - i.e. Cryogenic.

B. Intermediate Temperature Thermal Insulation

- (1). 16°C through 100°C - i.e. Hot water and steam condensate.
- (2). 100°C through 315°C - i.e. Steam, high temperature hot water.

C. High Temperature Thermal Insulation

- (1). 315°C through 815°C - i.e. Turbines, breechings, stacks, exhausts, incinerators.

3.3 Insulation Types

Insulation materials are generally divided into three main types:

- ***Fibrous Insulation*** - composed of small diameter fibres which finely divide the air space. The fibres may be perpendicular or parallel to the surface being insulated, and they may or may not be bonded together. Silica, rock wool, slag wool and alumina silica fibres are used. The most widely used insulations of this type are glass fibre and mineral wool. Glass fibre and mineral wool products usually have their fibres bonded together with organic binders that supply the limited structural integrity of the products.
- ***Cellular Insulation*** - composed of small individual cells separated from each other. The cellular material may be glass or foamed plastic such as cellular glass, phenolic foam or nitrile rubber.
- ***Granular Insulation*** - composed of small nodules which may contain voids or hollow spaces. It is not considered a true cellular material since gas can be transferred between the individual spaces. This type may be produced as a loose or pourable material, or combined with a binder and fibres or undergo a chemical reaction to make a rigid insulation. Examples of these insulations are calcium silicate and vermiculite.

3.4 Insulation Forms

Insulations are produced in a variety of forms suitable for specific functions and applications. The combined form and type of insulation determine its proper method of installation. The forms most widely used are:

- Rigid boards, blocks, sheets, and pre-formed shapes such as pipe insulation, curved segments, lagging etc. Cellular, granular, and fibrous insulations are produced in these forms.
- Flexible sheets and pre-formed shapes. Cellular and fibrous insulations are produced in these forms.
- Flexible blankets. Fibrous insulations are produced in flexible blankets.
- Cements (insulating and finishing). Produced from fibrous and granular insulations and cement, they may be of the hydraulic setting or air drying type.
- Foams. Poured or froth foam used to fill irregular areas and voids. Spray used for flat surfaces.

3.5 Insulating Materials-Hot and Cold Applications

The following is a general inventory of the characteristics and properties of major insulation materials used in commercial and industrial installations.

Mineral Fibre

Glass: Available as flexible blanket, rigid board, pipe covering and other pre-molded shapes. Service temperature range is up to 535°C.

Rock and Slag: Rock and slag fibres are bonded together with a heat resistant binder to produce mineral fibre or wool. Upper temperature limit can reach 1035°C.

Cellular

Available in board and block form capable of being fabricated into pipe covering and various shapes. Service temperature range is -260C to 200°C and to 650°C in composite systems. Good structural strength, poor impact resistance. Material is non-combustible, non-absorptive and resistant to many chemicals.

Calcium Silicate

Calcium Silicate is a granular insulation made of lime and silica, reinforced with organic and inorganic fibres and moulded into rigid forms. Service temperature range covered is 35°C to 815°C. Flexural and compressive strength is good. Calcium silicate is water absorbent. However, it can be dried out without deterioration. The material is non-combustible and used primarily on hot piping and surfaces. Finishing material is applied on site.

Expanded Silica or Perlite

Perlite is made from an inert siliceous volcanic rock combined with water. The rock is expanded by heating to above 535°C causing the water to vaporize and the rock volume to expand. This creates a cellular structure of minute air cells surrounded by vitrified product. Added binders resist moisture penetration and inorganic fibres reinforce the structure. The material has low shrinkage and high resistance to substrate corrosion. Perlite is non-combustible and operates in the intermediate and high temperature ranges. The product is available in rigid pre-formed shapes and blocks.

Elastomeric Foam

Foamed resins combined with elastomers produce a flexible cellular material. Available in pre-formed shapes and sheets, elastomeric insulations possess good cutting characteristics and low water and vapour permeability. The upper temperature limit is at 105°C. Elastomeric insulation is cost efficient for low temperature applications with no cladding necessary. Resiliency is high. Consideration should be made for fire retardancy of the material.

Foamed Plastic

Insulations produced from foaming plastic resins create predominately closed cellular rigid materials. "K" values or lambda values decline after initial use as the gas trapped within the cellular structure is eventually replaced by air. Check manufacturers' data. Foamed plastics are light weight with excellent cutting characteristics. The chemical content varies with each manufacturer. Available in pre-formed shapes and boards, foamed plastics are generally used in the lower intermediate temperature range. Consideration should be made for fire retardancy of the material.

Refractory Fibre

Refractory fibre insulations are mineral or ceramic fibres, including alumina and silica, bonded with extremely high temperature inorganic binders, the mechanical interlocking of fibres eliminates the need for any binder. The material is manufactured in blanket or rigid form. Thermal shock resistance is high. Temperature limits reach 1750 °C. The material is non-combustible.

Phenolic Foam

Rigid closed cell foamed insulation manufactured from phenolic resin.

Insulating Cement

Insulating and finishing cements are a mixture of various insulating fibres and binders with water and cement, to form a soft plastic mass for application on irregular surfaces. Insulation values are moderate. Cements may be applied to high temperature surfaces. Finishing cements or one-coat cements are used in the lower intermediate range and as a finish to other insulation applications. Check each manufacturer for shrinkage and adhesion properties.

3.6 *Spacing for Insulated Pipes*

As can be seen from Table 2 below different line sizes and different services require varying thickness of insulation. Piping systems must be welded and pressure tested to ensure all joints are leak free before insulation can be applied. For this reason it is important to plan the layout and installation of pipework and ensure that there is adequate spacing between pipes for the insulation material and room for the insulators to install it.

Service	Cladding Finish	Insulation type	Line size & thickness					
Steam	Note 1 & 2	Fibre Glass	1" 40mm	1.5" 40mm	2" 50mm	3" 50mm	4" 60mm	6" 60mm
Condensate	Note 1 & 2	Fibre Glass	1" 40mm	1.5" 40mm	2" 50mm			
Process	Note 1 & 2	Fibre Glass	1" 25mm	1.5" 25mm	2" 25mm	3" 25mm	4" 40mm	6" 40mm

Chilled Water	Note 1,2 & 3	Phenolic Foam	1" 50mm	1.5" 50mm	2" 60mm	3" 60mm	4" 75mm	6" 75mm
Cooling Water	Note 1,2 & 3	Phenolic Foam	1" 25mm	1.5" 25mm	2" 30mm	3" 30mm	4" 40mm	6" 50mm
L.T.H.W.	Note 1 & 2	Fibre Glass	1" 25mm	1.5" 25mm	2" 30mm	3" 30mm	4" 40mm	6" 50mm
Solvent	Note 1 & 2	Foam Glass	1" 30mm	1.5" 30mm	2" 50mm	3" 50mm	4" 50mm	6" 60mm
Hot Water	Note 1 & 2	Fibre Glass	1" 25mm	1.5" 25mm	2" 25mm	3" 25mm	4" 40mm	6" 40mm
Domestic H&C Water Services	No Cladding	Closed Cell Elastomeric Foam	1" 20mm	1.5" 20mm	2" 20mm			

Table 2 – Schedule of Insulation for a multinational pharmaceutical company

External – Appenol on Piping, Valves and fittings to be clad with aluminium boxes fixed with metal banding.

Internal – Isogenopak. Valves and fittings to be clad with aluminium boxes fixed with metal banding.

Phenollic foam insulation to be sealed at all joints with Fosters 30/45. Valves, fittings and flanges to be insulated. Alufoil vapour barrier to be continuous across piping, valves, fittings and flanges. Alufoil vapour barrier to be sealed with Alufoil adhesive tape

3.7 Insulation Valve Boxes

During maintenance, insulation over pipes, valves, and fittings is often damaged or removed and not replaced. Un-insulated valves, and piping components can be safety hazards and sources of heat loss. Figure 2 below illustrates a typical valve box used on a plant steam system. Insulated valve and other piping component boxes are fitted on insulated systems for the following reasons:

- They are easy to remove for maintenance and no special tools are required, as they are usually secured by Velcro straps or quick release clips.
- Pre-molded products reduce time and labour costs associated with on-site work.
- Typical payback for pre-moulded boxes which have a high K value installed on a hot water system would be less than one year.

Figure 1 – Quick release valve insulation box for easy service access.

Exercises

- Identify 4 services that are commonly used in process manufacturing facilities and recommend what material they should be installed in?
- List 3 hazards associated with piping services and identify methods of minimizing these hazards.
- List 2 types of pipe insulation material, identify what temperature ranges they are suitable for and identify what type of services they would be typically be used on?
- Calculate the centers and the external width of 4 No. 4" Mild steel steam pipe insulated with fiber glass insulation using the information provided in this unit.

Additional Resources

Title	Author	Ref. Code
The Induction Book, "***Code of Behaviour & Health & Safety Guidelines***"	SOLAS	
Basic Welding and Fabrication	W Kenyon	ISBN 0-582-00536-L
Fundamentals of Fabrication and Welding Engineering	FJM Smith	ISBN 0-582-09799-1
Workshop processes, practices and materials, 3rd edition, Elsevier Science & Technology	Black, Bruce J 2004	ISBN-13: 9780750660730
New Engineering Technology	Lawrence Smyth & Liam Hennessy	ISBN 086 1674480

Videos:

- Understanding welding fumes
- Welder on Site…Be Aware (Vocam)
- Powered hand tool safety (Vocam)
- Industrial Ergonomics (Vocam)

Available from:

Vocam Ireland

Circle Organisation Ltd

Friar Street, Thurles, Co Tipperary, Ireland

Tel: +353 504 24666

SOLAS

An tSeirbhís Oideachais Leanúnaigh agus Scileanna
Further Education and Training Authority

Castleforbes House
Castleforbes Road
Dublin 1