TRADE OF

Industrial Insulation

PHASE 2

Module 3

Substructures, Advanced Cold Work and Cladding

UNIT: 3

Cold Work Insulation (Advanced)

Produced by

SOLAS

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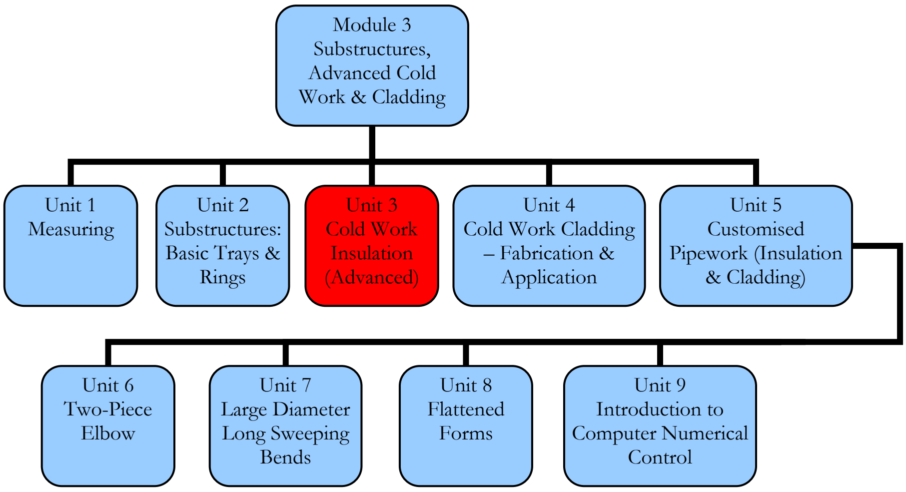
Unit Objective

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

- Identify various cold work insulating materials and sealing products.
- Select, measure and cut cellular glass and phenolic foam pipe sections.
- Apply cellular glass and phenolic foam sections to the training rig.
- Apply a vapour barrier to cold work insulation.



Introduction

The main duty of all insulation systems is the minimisation of heat-flow rates. With hot insulation, the heat-flow rate is from the object towards the ambient air, with cold insulations, the flow rate is from the ambient air to the object.

With cold insulations, there is always the danger of moisture entering the insulation material. The moisture is caused through condensation of water vapour in the ambient air. Minimisation of moisture in the insulation is the prime consideration in the design of a cold insulation. If this danger is not prevented, water and/or ice form at those parts of the insulation system where the temperature is below the dew-point temperature.

1.0 Cold Work Insulating Materials

Key Learning Points

- Identification of various cold work insulating materials and sealing products
- Selection of appropriate material to suit work specification
- Selection of the form of insulation material to be used.

1.1 Identification of Various Cold Work Insulating Materials

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 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 cosmetic plants.
- Reduce emissions of pollutants to the atmosphere.

Refer to module 1 – unit 10 – section 1 – Insulation.

1.2 Material Selection, Thickness Selection and Performance Requirements for Insulating Materials

In deciding on a certain type and thickness of insulation to be used for a particular application, a number of factors or performance requirements for the insulation system need to be considered. The selection of materials and the insulation thickness to be specified shall be determined according to the intended function of the insulation.

The performance requirements shall be specified in according with the appropriate clauses and tables of the British Standard BS5422:2001, which shall be determined from the following factors:

- System operating temperature.
- Design ambient air temperature.

- Relative humidity of the ambient air.
- Air Velocity
- Location of the plant (indoors or outdoors).
- Pipe Diameter (or flat surface dimensions).
- Orientation of pipes (horizontal or vertical).
- Vertical dimensions of flat surfaces.
- Emissivity of outer surface.

For refrigerated, chilled or other cold applications, the following performance requirements, if applicable, shall also be specified in according with the appropriate clauses and tables of this standard:

- Resistance of the insulation material to the passage of water.
- Permanence of any vapour barriers used.

Refer to BS5422:2001 page 81, for selecting the correct insulation thickness for a particular application.

1.3 Cellular Glass Product Composition, Characteristics and Forms of Supply

Cellular glass insulation composed of glass processed to form a rigid foam having a predominantly closed-cell structure. It is lightweight, rigid material composed of millions of completely sealed glass cells. Each cell is an insulation entity, which means it is totally independent of the other cells surrounding it.

Properties and Uses of Cellular Glass Insulation

- Constant insulating efficiency.
- Zero water vapour permeability.
- Moisture resistant.
- Fire protection.
- Corrosion resistant.
- Long term dimensional stability.
- Vermin resistant.

Uses

- Low temperature pipe, equipment, tanks and vessels.
- Medium and high temperature pipes and equipment.
- Hot oil and hot asphalt storage tanks.
- Heat transfer fluid systems.
- Chemical processing systems.
- Above and below ground steam and chilled water pipes.
- Commercial and ductwork pipe work.
- Insulation can be multi-layered to achieve required insulation values.

Forms of Supply and Identification

Cellular glass or foamed glass insulation is manufactured in basic block form. Blocks are fabricated into a wide range of shapes, thicknesses and sizes to satisfy industrial insulation requirements.

1.4 Phenolic Foam Product Composition, Characteristics and Forms of Supply

Phenolic insulation is rigid foam insulation with a closed cell structure. The exceptionally high level of closed cells and the fine cell structure gives phenolic foam exceptional thermal properties. Closed cell phenolic foams are the most thermally efficient insulation materials commonly available. The product is manufactured in a number of forms including blocks, continuously produced flexible faced laminate, rigid faced laminates and composite panels in addition to highly specialised applications such as fire doors and moulded products. Being based on phenolic resin it has outstanding fire characteristics and extremely low smoke emission when exposed to a flame source.

Properties, Uses and Applications

The exceptionally low thermal conductivity of closed cell phenolic foam boards means that appropriate insulation efficiency can be achieved with the thinnest possible material. This can be a significant advantage in building regulations, for example, in plaster board dry wall lining systems where internal room space is maximised and in cavity wall applications where the building envelope thickness is minimised.

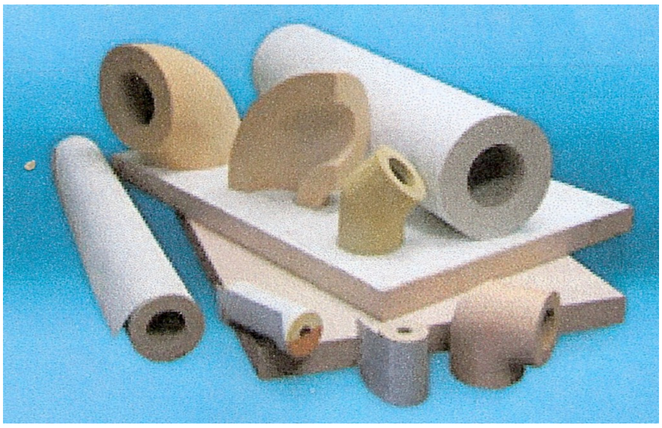
It has excellent moisture resistance as a result of low water vapour permeability and 90% closed cell structure. It is also non-fibrous which is particularly relevant for use in hospitals, food preparation areas and breweries.

Phenolic foam is also used extensively in industrial heating and ventilation applications such as pipe equipment, tanks and duct insulation. It is also used in building applications such as roofing, flooring, cavity walls and in the food processing industry for steel faced panels.

Forms of Supply

Phenolic foam is available in pipe sections, blocks, rolls and slabs.

Cut pipe sections, bends etc are available to fit all standard steel pipes up to 610mm OD and light gauge copper pipes up to 158mm OD in wall thickness up to 50mm



1.5 Use of Manufacturers' Data Sheets to Select the Appropriate Material

Up-to-date manufacturers' literature should be reviewed prior to using a particular type of material for insulation and cladding purposes so as to make sure that the material will perform to the requirements of the job specification.

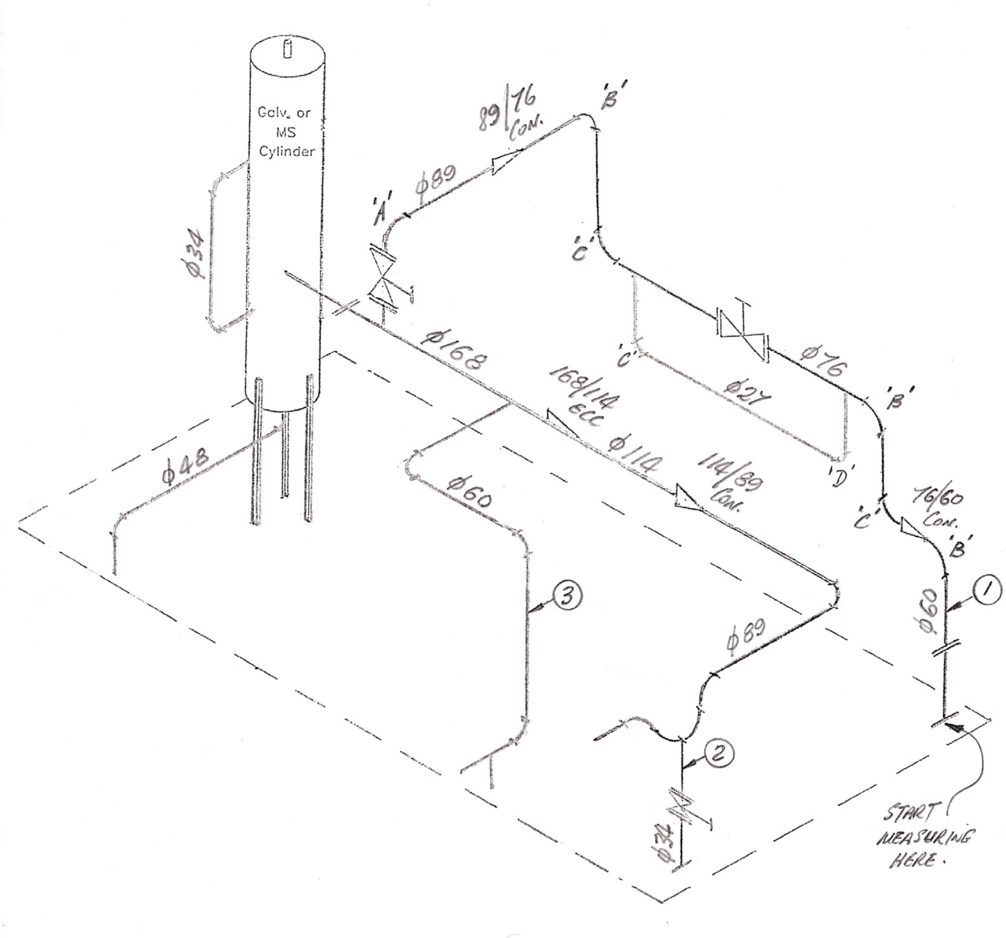
2.0 Measuring the Training Rig for Cold Work Insulation

Key Learning Points

- Measurement of the training rig for cold work insulation
- Marking out of insulation to meet job requirements
- Accurate measuring and cutting
- Job planning and sequence of operations

1. Ability to work as a team

2.1 Measuring the Training Rig



ISOMETRIC DRAWING OF TRAINING RIG.

The figure above shows an isometric drawing of the training rig. For the purpose of this exercise we will only consider leg 1 for bare surface measuring. Starting at the floor level as shown, measure:

1. Diameter of pipe (ø 60mm OD) x length of pipe from flange at floor level to flanged joint. Cladding should be shortened for bolt removal.
2. Flange diameters plus overall thickness of flanged joint.
3. Length of bolts securing flanged joint – this is to allow for the withdrawal of the bolts without disturbing the insulation and cladding.
4. Flange box - ***see information on measuring a valve box in module 1 – unit 11 – Valve and flange box fundamentals.***
5. From flanged joint to weld at ø 60mm "B" type 90º elbow/bend.
6. 90º "B" type elbow/bend ø 60mm OD with a centreline radius of 3" or 76mm.
7. Concentric reducer – ø76/60mm x 3½/89mm long.
8. 90º "C" type elbow/bend – ø76mm OD with a centreline radius of 3¾" or 95mm.
9. ø 76mm OD pipe x length between welds of elbows.
10. 90º "B" type elbow/bend – ø76mm OD with a centreline radius of 3¾" or 95mm.
11. ø 76mm OD pipe x length from "" type elbow/bend to valve.
12. Valve box ***– see information on measuring a valve box in module 1 – unit 11 – Valve and flange box fundamentals.***
13. ø 76mm OD pipe x length from valve to weld at "C" type elbow/bend.
14. ø 27mm OD pipe – we will return to this item later.
15. 90º "C" type elbow/bend – ø 76mm OD with a centreline radius of 3¾" or 95mm.
16. ø 76mm OD pipe x length between welds of elbows.
17. 90º "B" type elbow/bend – ø 76mm OD with a centreline radius of 3¾" or 95mm.
18. ø 76mm OD pipe x length between "B" type elbow/bend and concentric reducer.
19. Concentric reducer - ø76/89mm x 3½/89mm long.
20. ø 89mm OD pipe x length between concentric reducer and "A" type 90º elbow/bend.
21. 90º "A" type elbow/bend ø 89mm OD with a centreline radius of 4½" or 114mm.
22. Valve box – ***see information on measuring a valve box in module 1 – unit 11 – Valve and flange box fundamentals.***

Note: On account of the close arrangement between the 90º elbow and the valve, the valve box will have to encapsulate or enclose both the bend and the valve in the one valve box. This will simplify the cladding arrangement at this point in the pipeline.

23. Tee-piece – ø89mm pipe onto ø168mm pipe.

Item 14 Above

- (a) ø27mm OD pipe x length from the centre of the ø76mm OD pipe to "D" type elbow. A tee-piece will be required at this point.
- (b) 90º "D" type bend ø27mm OD with a centreline radius of 28.5mm. A square elbow bend is required here due to the tight centreline radius.
- (c) ø27mm OD pipe x length from centre of ø76mm OD pipe to "C" type bend. A tee-piece will be required at this junction.

2.2 Job Planning, Teamwork and Record Keeping

Measuring large jobs on site may require a number of people to work together to gather the information required to manufacture and install the job. It is important that these people work together as a team in order to gather the information in a systematic and precise manner. A breakdown in communication between team members can be detrimental to the success of the overall completion and quality of the job.

Measuring large jobs and recording the data gathered in a clear and concise manner is the most important task of the whole job. If the records of the data gather is not correct or presented in a clear manner, mistakes will be made. These mistakes can be very costly both in time and money.

Planning the job thoroughly from start to finish is vitally important. Team members must know from the start their exact role within the team. A team leader should be appointed from the start. This person would usually be the most experienced member and it is his/her job to delegate tasks to other members. Communication skills and the ability to communicate to people in a clear and concise manner is vitally important.

A vital part of job planning and works sequencing is understanding the works specification and interpreting the works drawings completely. Failure at this point in not fully understanding the task ahead can be disastrous. It is paramount that if a drawing or specification is unclear, that further information and clarification is sought from the engineer or architect.

2.3 Marking Out of Insulation to Meet Job Requirements

Refer to Module 2 – Geometry and Pattern Development.

2.4 Measuring, Cutting and the Efficient Use of Insulation Materials

Due to the high cost of insulation materials it is very important that they are used in a cost effective and efficient manner. This can be achieved by taking accurate measurements of the job and laying out/positioning the patterns/templates on the material in a proper manner so as to avoid unnecessary scrap. "Nesting" or positioning of the patterns on the sheet results in the material being utilised in an efficient and cost effective manner.

2.5 Uniformity of Finished Work

The overall appearance of the job is vitally important and the following points should be given great consideration:

- All joints should be properly aligned.
- Joints should be fabricated in such a way as to shed water.
- Rivets, screws and other fastening applications should b equally spaced and properly aligned.
- Finished cladding should be free from burrs and sharp edges.
- Cladding should be free from hammer marks and scratches.

3.0 Vapour Barriers

Key Learning Points

- Vapour barrier types and materials
- Application of vapour barriers
- Identify cold bridge situations
- Contraction of materials due to a drop in temperature
- Fully sealed application of insulation and vapour barrier.

3.1 The Purpose of a Vapour Barrier

The purpose of the vapour barrier is to reduce, and if possible prevent, the ingress of water vapour into the insulating material. So the barrier should always be applied to the warmer surface of the insulating material. It can take the form of a coating or sheet material resistant to the passage of water vapour, i.e. of low permeability, and the sealing of joints and overlaps should be effective.

Where the outer surface temperature of insulation is higher than the plant on which it is used, and some part of the insulation is at a temperature below the dew-point of the ambient air, there is a vapour pressure differential across the insulation. The differential will tend to force the vapour towards the cold surface of the plant where it will condense. If the plant temperature is below freezing point, the condensed water will turn into ice.

As a rough guide, the thermal conductivity of water is about 20 times that of a typical good quality dry insulating material, and that of wet ice can be up to 3.5 times that of water. This means that internal condensation and ice formation will appreciably reduce the effectiveness of the thermal insulating material. Additionally, the increase in volume of the moisture on freezing can disrupt the physical structure of the insulating material.

Insulating materials that consist of substantially closed cell posses an inherent resistance to the passage of water vapour, but open cell insulants and loose-fill porous materials are readily permeable to water vapour. Even with materials that have good resistance to the transmission of water vapour, differential movement of plant and insulation can cause joints in the insulation system to open, thus allowing moisture to penetrate towards the underlying surface. Joint sealing compounds can also fail to exclude water vapour completely, in which case the contained water or ice form strongly conducting paths from the surface of the plant to the ambient air.

As a general rule, all insulation on plant working at any time at sub-ambient temperatures should have a 'vapour barrier' layer over the outer surface (warm side) surface unless the insulation has sufficient integral vapour resistance and the joints are adequately vapour sealed.

This barrier should be resistant to the passage of water vapour and it should be applied to the dry insulation immediately after it has been fitted. The properties of the vapour barrier should have attained their values before the plant is operated.

3.2 Vapour Barrier Types and Materials

Insulation finishes are applied over the insulation to provide a vapour barrier, weather protection, protection from mechanical damage and improved aesthetics. Some finishes would include:

1. Aluminium foil.
2. Mastic and coating finishes.
3. Flexible plastic sheet or elastomers sheet.
4. Rigid PVC sheeting.
5. Sheet metal cladding.
6. Polyisobutylene sheet.

When selecting materials for use as vapour barriers, consideration should be given to the type of equipment being insulated, the design conditions, the type of insulant being used, and the environmental conditions during application and service.

Materials suitable for use as vapour barriers are as below.

- Wet applied vapour barriers comprising cut-back bitumen's, bitumen emulsions with or without elastomer latex, vinyl emulsions, and solvent based polymers. Frequently these are reinforced by means of cotton scrim cloth or open-mesh glass fabric
- Elastomeric sheets provide for contraction and other movements whilst maintaining good resistance to the transmission of water vapour. Joints should be sealed with adhesive and/or adhesive foil tape and the overlaps should be 40mm minimum.
- Polyvinyl chloride, polyethylene, Polyisobutylene, or other plastic tapes or sheets are of special value for wrapping bends on insulated pipes, or where a coloured decorative finish is required.
- Epoxy and polyester resins give good resistance against mechanical damage, together with protection against the weather and against chemical spillage.
- Metal foils, if used alone, should be sufficiently thick to exclude penetrations by 'pin holes', or they should be laminated to plastics film. The joints should have an overlap of 40 mm minimum and they should be sealed by a waterproof adhesive or mastic.
- Sheet metal can give good protection, provided that the joints are overlapped and sealed with additional securing devices to maintain the system in vapour tight condition.
- Glass fabric or tape, impregnated with lanolin or petroleum jelly, can be used, especially where removable insulation and finish is required.

- Where possible, supports for pipes and vessels should be external to the insulation and the vapour barrier.

3.3 Application of Vapour Barriers

A vapour barrier must be used over the insulation on all plant operating at temperatures below the ambient air. The vapour barrier should be applied such that it is continuous and gives protection to the whole surface of the insulation which it covers. Joints should be completely sealed so as not to allow a breakdown of the barrier or create a weak spot within the integrity of the vapour barrier. It should not be pierced or otherwise damaged. Means of load distribution must be provided at points of support as necessary. The material selected for use as a vapour barrier must be compatible with the thermal insulation which it is to protect.

3.4 Thermal Bridging

A thermal bridge is created when materials that are poor insulators come in contact with each other, allowing heat or cold to flow through the path created. Insulation around a bridge is of little help in preventing heat loss or gain due to thermal bridging; the bridging has to be eliminated, rebuilt with a reduced cross section or with materials that have better insulating properties, or with an additional insulating component such as a thermal brake. Thermal or heat bridges in building constructions are often called by their less scientific name "cold bridge".

3.5 Avoiding Thermal Bridging

In both hot and cold insulation applications, wherever a fixing or mounting point of a pipe or duct is necessary there is a risk of creating a thermal bridge i.e. energy will flow between the pipe/duct and the bracket where they are in direct contact with each other. Therefore, it is of utmost importance to guarantee a perfect insulation at these joints, ensuring the required insulation thickness and properties between the hot or cold pipe/duct and the metal parts of the fixing device.

3.6 Thermal Expansion: Co-Efficient of Linear Expansion

Thermal expansion is the tendency of matter to change in volume in response to a change in temperature. When a substance is heated, its particles begin moving and become active thus maintaining a greater average separation. Materials which contract with increasing temperature are rare; this effect is limited in size, and only occurs within limited temperature ranges. The degree of expansion divided by the change in temperature is called the materials' coefficient of thermal expansion and generally varies with temperature.

The coefficient of thermal expansion describes how the size of an object changes with a change in temperature. Specifically, it measures the fractional change in size per degree change in temperature at a constant pressure. Several types of coefficients have been developed: volumetric, area, and linear. Which is used depends on the particular application and which dimensions are considered important. For solids, one might only be concerned with the change along a length, or over some area.

Summary

Insulations are defined as those materials or combinations of materials which retard the flow of heat energy. In deciding on a certain type and thickness of insulation to be used for a particular application, a number of factors or performance requirements for the insulation system need to be considered. The selection of materials and the insulation thickness to be specified shall be determined according to the intended function of the insulation.

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