

TRADE OF
Industrial Insulation

PHASE 2

Module 3

Substructures, Advanced Cold Work and Cladding

UNIT: 2

Substructures:
Basic Trays and Rings

Produced by

SOLAS

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Further Education and Training Authority

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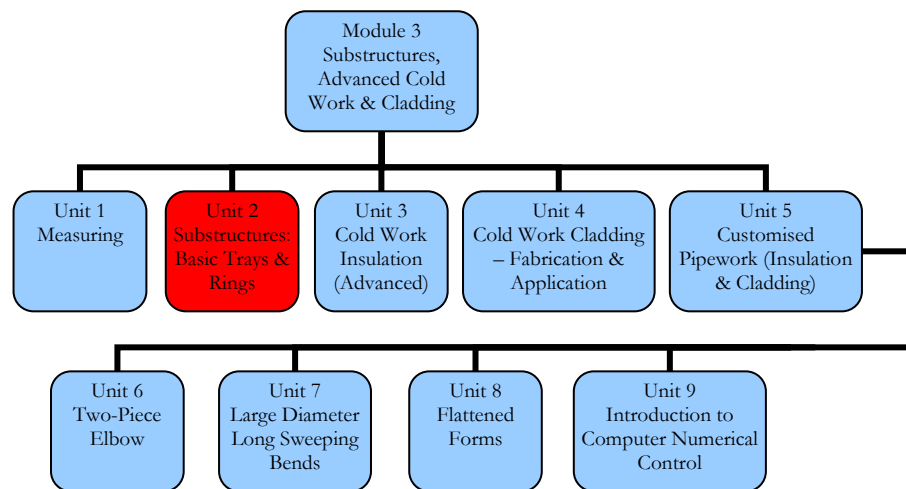
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Unit Objective

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

- Identify areas of insulating situations where substructures support systems are required.
- State and describe the function of support systems.
- Explain why thermal bridging occurs.
- Describe the difficulties in using incompatible metals.
- State the basic rule of thermal expansion and the need for moving joints.
- Fabricate a spacer tray and a spacer ring structure.



Introduction.

Trays and rings are used on industrial pipe-work and hvac systems to hold the insulation in place and also to act as an anchoring or fixing point for cladding. Supports systems are an integral part of the overall pipe-work or ductwork insulation system. On large vessels and tanks the support systems are usually included as part of the manufacturing process. On ventilation ductwork systems, the support structures are generally installed during the insulation and cladding process and come in the form of “Z” bars or folded angle sections

1.0 Pipe-Work Support Systems and Substructures

Key Learning Points

- Functions of support systems for insulation and cladding
- Fabrication of spacer trays substructure
- Folding allowances on spacer rings
- Problem solving in substructure design

1.1 Functions of Substructures and Support Systems

Substructures and support systems are used on vertical and horizontal pipe-work, ductwork systems, vessels and equipment. They can be in the form of trays, rings (usually welded to the structure), cleats, angles and studs. The spacing of these attachments can be varied to suit the insulation and cladding and also to control thermal movement in the system.

Welding of substructures and support systems should be carried out in the workshop by the manufacturer. Site welding of securing and fixing devices should not be undertaken without first consulting the engineer or owner of the equipment.

The function of substructures and support systems include:

- They provide a secure base for secondary angle rings.
- They provide support for insulation sections on pipe-work and ductwork.
- They reduce sagging of insulation on large ductwork sections and vessels.
- They provide a fixing point for metal cladding sheets.

1.2 Substructures and Support Systems

Refer to module 5 – unit 8 – Moving joints and support systems.

1.3 Fabrication of Spacer Trays

Refer to module 1 – unit 4 – Notching, Folding and Joining.

1.4 Problem Solving in Substructure Design

Refer to module 5 – unit 7 – section 3.4

2.0 Thermal Expansion

Key Learning Points

- Thermal bridging: reasons why hot and cold bridges occur
- Avoidance of thermal bridging
- Thermal expansion: co-efficient of linear expansion
- Operation of expanding joints, or moving joints

2.1 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”.

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.

2.2 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.

If a bar of steel is heated uniformly in a furnace it will expand naturally in all directions if it is not restrained in any way. If allowed to cool evenly and without restraint, it contracts to its original shape and size without distortion. If the original dimensions, the rise in temperature, and the expansion of the metal block are measure, it will be found that they are related to each other. Thus, for a given metal:

- (a) The expansion is proportional to the rise in temperature.
- (b) The expansion is proportional to the original size of the component.

Expressed mathematically this gives the formula:

$$x = l \alpha t$$

Where:

X = increase in size,

L = original length,

α = coefficient of linear expansion.

t = rise in temperature.

Example

A straight length of copper pipeline measures 30 metres at room temperature (15°C). After hot water has been passing through it for some considerable time, its temperature is raised to 60 °C. Calculate its increase in length.

Solution

$$\begin{aligned} x &= l \alpha t \\ &= 30 \times 0.000017 \times (60-15) \\ &= 30 \times 0.000017 \times 45 \\ &= 0.02295 \text{ metres} = 22.95\text{mm} \end{aligned}$$

Increased length = 22.95mm

2.3 Operation of Expanding Joints, or Moving Joints

Refer to module 5 – unit 8 – Moving joints and support systems.

3.0 Metal Compatibility

Key Learning Points

- Metals compatibility: effect of electro-chemical corrosion. Effect of using incompatible materials.

3.1 Metal Compatibility – Effect of Electro-Chemical Corrosion

Corrosion is the chemical change or destruction of materials, especially of metallic materials, through water and chemicals: corroding metals can form oxygen compounds (oxidation) or ionic compounds with non-metals.

The following types of corrosion are of predominant importance for industrial insulators:

- Contact corrosion.
- Surface corrosion.
- Tension cracking (stress corrosion cracking).

While low and non-alloyed steels form loose iron oxide layers, which peel off easily, other materials such as zinc, aluminium and stainless austenitic steel form firm layers of oxidation which protect the material against further oxygen corrosion. These very thin layers are also called “passivating layers”. If such layers are damaged, they are reconstituted quickly as long as oxygen is present.

Contact Corrosion

Between different metals certain reactions occur in the presence of electrically conductive fluids (electrolytes), in which the respective less-noble metal is damaged. It is therefore that e.g. rivets made of less noble metal dissolve. This process is called contact corrosion.

The total corrosive damage through contact corrosion is dependent upon:

- The two materials concerned.
- The types of electrolytes present i.e. hydrous salt solution, hydrous acids.
- The ambient conditions such as temperature, relative humidity, exposure to dangerous substances.
- The relative surface size of the metals concerned.

Example

Connections of aluminium sheets (less noble) with screws of austenitic steel (noble) are all right. On the other hand, the connection of sheets made of stainless austenitic steel with aluminium rivets cannot be recommended since a corrosive attack concentrates on the small surface of the rivet.

Avoiding Contact Corrosion

Contact corrosion can be avoided or at least be minimised by observing the following rules:

- The large-surface contact of different materials must be avoided.
- Fixings such as screw, rivets and bands must be at least as noble as the material to be connected.

The corrosive attack is then directed against the less-noble material. It is, however, very minor due to the ratio of surfaces in contact. Non-conductive layers of materials between metals can also prevent contact corrosion. Such layers would include:


- Plastic material.
- Plastic bands.
- Bitumen coatings.

3.2 Incompatible Materials – Galvanic Corrosion

Galvanic corrosion occurs when a galvanic cell is formed between two dissimilar metals. The resulting electrochemical potential then leads to formation of an electric current that leads to electrolytic dissolving of the less noble metal. This effect can be prevented by electrical insulation of the materials i.e. by using rubber or plastic sleeves or washers, keeping the parts dry so there is no electrolyte to form the cell, or keeping the size of the less-noble material significantly larger than the more noble ones.

As mentioned earlier, aluminium covers itself with a “passivating layer” which provides a protection of the metal under it from further corrosion. However the corrosion of aluminium can occur when:

- The contact point between steel and aluminium, corrosion on the aluminium occurs in the presence of an electrolyte. The combination of galvanised building components is, on the contrary, normally all right since zinc and aluminium are very close to each other on the chemical tension sequence. The contact between lead and aluminium must be avoided because of their large difference in the electrical tension sequence. This can be achieved by coatings such as bitumen.
- Aluminium and copper have an even larger difference from each other in the tension sequence. Therefore, their direct contact is especially critical and must definitely be avoided.
- Some insulation materials, e.g. calcium silicate, concrete and plaster, especially when wet, eat into aluminium. In this case, a barrier by coating or intermediate layer, such as a plastic film is absolutely needed.
- Fixing means for aluminium sheets should be of stainless austenitic steel.
- Similar to corrosion-protected steel sheets with zinc or aluminium/zinc coatings, aluminised steel sheets are available on the market which combine the surface properties of aluminium with the stability of steel sheets.



Note: The electro-chemical tension sequence which is a table showing the electro-chemical potentials of elements and alloys, allows engineers to design systems with materials that will not react and corrode each other.

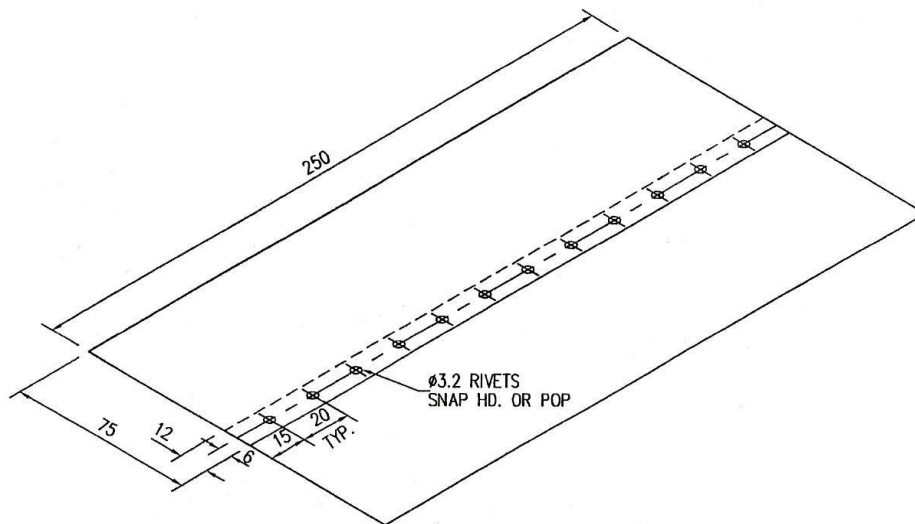
4.0 Methods of Joining Cladding Sheets

Key Learning Points

- Riveting and rivet dressing
- Use of self tapping screws and alternative fixing methods

4.1 Riveting and Rivet Dressing

Riveting is a method of making permanent joints. The process consists of drilling or punching the sheets to be riveted, inserting the rivet, and then closing it by an applied compression force so that it completely fills the hole and forms a rigid joint.

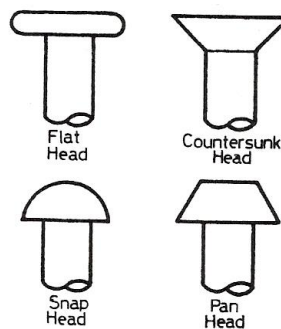


Riveting may be done by hand or by machine. When the job is performed by hand, as is usually the case in cladding work, it is done with a riveting gun.

Rivet Types

Many types of rivets are used in the industry. The most common types are the tin man’s rivets, flathead, snap head (also called roundhead) and “pop” rivets.

The countersunk is used where a flush surface is desired, and the snap head when exceptional strength is required.



Types of Rivets

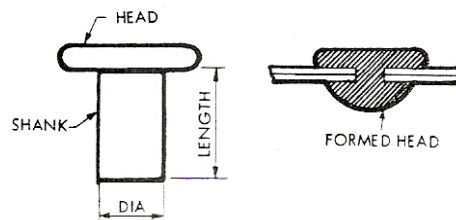
Rivet Sizes

The size of the tin man's rivets are determined by the weight of 1,000 rivets i.e. 1 lb. rivets weigh 1 lb. per thousand, 2 lb. rivets weigh 2 lb. per thousand.

Flathead rivets vary in diameter from 3/32" to 7/16" in steps of 1/32". Other rivets vary in size with 1/8" and 3/16" snap head rivets being the most popular in the sheet metal shop.

Flathead, snap head and countersunk rivets may be purchased in various lengths depending upon the thickness of the metal being joined.

There are no definite rules to follow in selecting the size of a rivet. In general the length should be sufficient to protrude through the pieces being joined, this is usually from about 1½ times the diameter of the rivet. This allows ample material for forming the head.



Refer to module 1 – unit 9 – section 4.0 – Dressing a solid rivet using a “snap” set.

4.2 Self Tapping Screws and Alternative Fixing Methods

Refer to module 1 – unit 6 – section 5 – Self tapping screws.

Refer to module 1 – unit 9 – section 5 – Operating a “band-it” tool.

Summary

Support systems and substructures form an integral part of the insulation and cladding process. Large tanks and vessels are usually manufactured with substructures already welded to them, which provide anchor points for support rings and trays. Support systems for insulation should never be welded to equipment on site without permission from the engineer or owner.

Support systems can take the form of rings, trays, cleats and angles. They keep the insulation in place around pipe-work and large areas of ductwork. They reduce the possibility of sagging of insulation and at the same time provide a fixing point for the installation of the cladding sheets.

As part of the insulation system, the support system must also allow for the thermal expansion and contraction of different materials. This expansion and contraction must be allowed for in the design of support systems and substructures.

The compatibility of materials is also a vital consideration when designing support systems and substructures. Corrosion can occur when materials which are incompatible come in contact with each other. Coatings and barriers can be used to eliminate the contact of incompatible materials.



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