TTE TRAINING LTD

Phase 1 Fabrication

Carousel 2

Thermal Insulation

COURSE NOTES

THERMAL INSULATION

1. ***Functions of Thermal Insulation***

Anything that blocks the flow of heat from one area to another may be called thermal insulation. Thermal insulation may be used to keep things warm or to keep things cool.

Thermal insulation serves three primary purposes in industry. (1) on high temperature piping, it prevents burning and reduces ambient temperatures in work areas. (2) on cold piping, it prevents condensation and freezing of water vapour. (3) it makes heating, cooling and other industrial processes more efficient and less costly by reducing the leaking of heat in or out of systems. Additionally, thermal insulation may slow down the spread of fire, reduce noise levels, and absorb vibration.

1.1 Heat Transfer

To understand how thermal insulation accomplishes its purpose – preventing the flow, or transfer, of heat from one area to another – an examination of the different types of heat transfer is necessary. Heat may be transferred in three ways: (1) radiation, (2) conduction and (3) convection.

Radiation or radiant heat transfer, is the only way heat moves through a vacuum. Similar to the propagation of radio waves or light waves, radiation is heat transfer by direct emission (Figure 1-1). All of the heat energy that the earth receives from the sun is transferred by radiation. Radiant heat energy travels through a vacuum at the speed of light; it can also be transferred through gases (like air) and some liquids and solids (such as water or glass). Radiant heat transfer can be felt by holding a hand near any hot object. The higher the temperature of the object, the more energy is released. At high temperatures, the effect may be visible; this is what happens when a piece of metal is “red hot”.

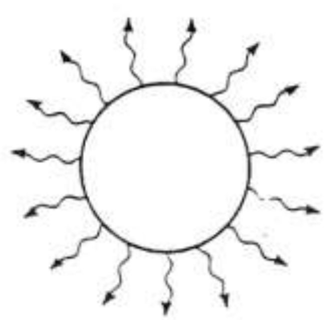

Figure 1-1. Radiation

Heat travels through solids primarily by conduction (Figure 1-2). When one portion of a solid object is heated, a temperature difference is created between the hotter and colder parts of the material: the hotter portion contains more heat energy that the colder part. This heat energy flow from the hotter area to the colder part of the material in an attempt to equalise the heat distribution within the object. The denser the solid, the faster heat will be transferred from the hottest regions to the coldest. Metals are relatively dense, so they tend to be good “conductors” of heat. Conduction is now heat from the inside of a steam pipe is transferred to the outer surface of the pipe.

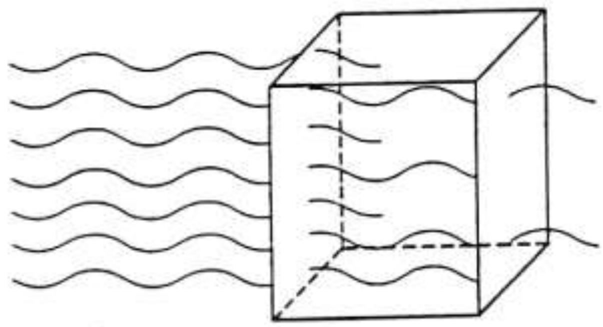

Figure 1-2. Conduction

Convection (Figure 1-3) is the way heat flows through fluids, whether they are liquids or gases. As fluids pass over hot objects, they pick up heat energy and carry it to colder areas. This convective movement cools the heat source as it heats the surrounding area.

Convective flows in liquid and gases may occur naturally, due to temperature differentials, or the flow may be produced artificially with a pump or a fan. In an enclosed space, the natural convective flow causes fluid to circulate: a heated mass rises, displacing colder fluid, which sinks down to the heat source and is heated in turn. Natural convective flow is how a stove continually warms the air in a room: heat rises, “pushing” colder air towards the stove to be heated.

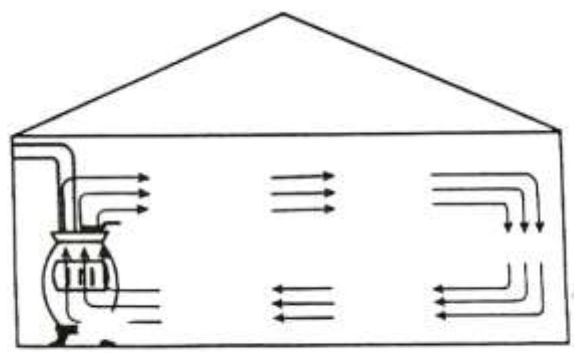

Figure 1-3. Convection

1.2 Types of Insulation

There are two basic categories of thermal insulation: (1) *mass type* insulation and (2) *reflective* insulation. Mass-type insulation reduces the amount of heat transfer by enclosing air cells within a solid material that is a relatively poor conductor of heat. Air is a good insulator as long as convection currents are eliminated. The insulation valve of mass-type insulation depends on the thermal conductivity of the material, the density of the insulation, and the thickness of the insulation. The thicker the insulation the more heat it stops. Air pockets in the material reduce its density, thus increasing its insulation valve. Thermal conductivity is a measure of how much heat can pass through a material in a given amount of time. The lower the thermal conductivity, the more efficient the insulation.

Reflective insulation helps to prevent radiant heat transfer by reflecting the heat waves like a mirror reflects light. The insulation is typically made of bright metal. Used in layers, with dead air spaces in between or in conjunction with mass-type insulation, reflective insulation can help to prevent convective and conductive losses as well as those caused by thermal radiation.

2. ***Calcium Silicate Insulation***

Calcium silicate is a light, strong, moulded, high temperature, mass type insulating material. Any insulating material with a maximum temperature rating over 200˚ Fahrenheit (94˚ Celsius) is classified as high temperature insulation. White and chalky in appearance, calcium silicate has a maximum temperature rating of approximately 1000˚F (540˚C), making it especially useful for insulating high temperature water and steam lines. Calcium silicate is available in blocks for insulating ducts and large tanks as well as in preformed sections for piping installations.

2.1 Safety precautions

Calcium silicate insulation prevents several hazards to those involved in its installation and removal. Calcium silicate is *dusty* – especially when it is being cut or trimmed to fit. Persons exposed to dust from any kind of insulating material must wear a filter mask and eye protection (Figure 2-1).

Figure 2-1. Filter Mask and Eye Protection

Certain types of older calcium silicate insulation present an additional hazard to insulation worker. Calcium silicate insulation formerly contained asbestos fibres increased insulation value. Recently, asbestos has been found to cause cancer and contribute to other respiratory problems. For this reason, calcium silicate is no longer formulated with asbestos. In older installations however, much of the insulation may contain asbestos. Workers involved in repair or replacement of insulation containing asbestos must take extra precautions in addition to a filter mask and eye protection.

Special equipment may be used to measure the concentration of asbestos particles in the air, and any used insulation containing asbestos must be disposed of by burying in sealed plastic bags labelled “ASBESTOS WASTE”. Loose dust should be vacuumed off the floor and the worker’s clothing. (See Section 5 for more information on working with asbestos).

2.2 Installation

One common application of calcium silicate insulation is to prevent loss of heat from hot water or steam piping systems. The insulation is installed in preformed sections, wired on, and covered with a metal jacket or a heat resistant cloth called *lagging.* Typically, straight runs are jacketed, while elbows and other fittings are often covered with lagging cloth. Since insulation systems often require repair or replacement, maintenance personnel need to be familiar with installation techniques. The material, tool and protective equipment requirements are summarised in Table 2-1.

TABLE 2-1 MATERIALS, TOOLS AND PROTECTIVE EQUIPMENT FOR INSTALLATION OF JACKETED CALCIUM SILICATE INSULATION.

Materials	Tools	Protective Equipment
Calcium Silicate	Wire Cutters	Filter mask
Pipe sections	Metal snips	Goggles
Jacketing material	Banding tool	Gloves
Banding material	Crosscut saw	
Wire	Keyhole saw	
	Knife	
	Tape measure	

Calcium silicate insulation for piping systems is usually in the form of half-sections that fit around the pipe. The half-sections are staggered, as shown in Figure 2-2, in a manner similar to that used in the construction of a brick wall. This staggered joint construction serves two purposes: it prevents concentrated heat leaks, and it strengthens the installation by locking the sections together down the length of the run. To prevent heat leaks when double layers of insulation are used, the top layer is lined up so that none of its joints occur at the same places as those of the bottom layer.

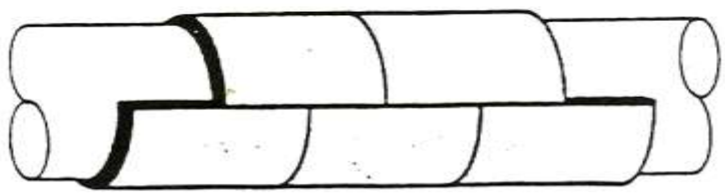

Figure 2.2. Staggered joint construction

At the start of the run, one half-section must be cut to half its length to begin the staggered joint construction. A crosscut saw is the best tool for this task (keyhole saws and knives are used for trimming). The short half section is mounted opposite a long half-section and wired on. Wires should be placed at 12 inch (30 cm) intervals. At first, the wires are loosely twisted on by hand; then they are twisted tight with a pair of pliers or wire cutters (Figure 2-3). A few taps on the wire with the side of the wire cutters embeds the wire into the surface of the insulation; the ends should be trimmed and tapped into the surface so that no wire protrudes.

Figure 2-3. Wiring on the insulation

When the entire run has been covered with insulation, metal jackets are mounted. Jacketing material often comes in a roll from which jackets should be measured, and the jacket should be cut to allow for a 4 inch overlap. Special trimming with metal snips is often required for pipe hangers and other irregularities. When the jackets have been cut to size, they are wrapped around the insulation and wired on by hand. These initial wires are used to hold the jackets in place while they are banded. Before the jackets are banded, the entire length of the run should have jackets loosely wired on so that they overlap each other by approximately 4 inches.

Figure 2-5. "S" Clip

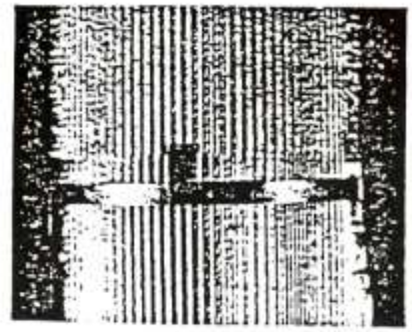

Figure 2-6. Three clips support the jacket.

Insulation on elbows and special fittings is often covered with lagging cloth instead of metal jackets. Lagging cloth is made of fibreglass or canvas and is highly resistant to heat. When lagging is used, insulation is wired on in a manner similar to that described above; then the cloth is cut to fit and cemented over the insulation.

Table 2-2 summarises the installation requirements for lagged calcium silicate insulation.

TABLE 2-2 MATERIALS, TOOLS AND PROTECTIVE EQUIPMENT FOR INSTALLATION OF LAGGED CALCIUM SILICATE INSULATION.

Materials	Tools	Protective Equipment
Calcium silicate pipe Sections	Wire cutters	Filter mask
Lagging cloth	Crosscut saw	Goggles
Insulating cement	Keyhole saw	Cloth gloves
Finishing cement	Knife	Rubber gloves
	Scissors	
	Tape measure	
	Trowel	
	Paint brush	
	Bucket	

Bands should be placed 12 inches (30 cm) apart all the way down the length of the run (Figure 2-4). Many types of bands and banding tools are available. The important consideration is the composition of the banding material: it should be made of the same metal as the jacket. Otherwise, bands or jackets may corrode, or bands may snap when the pipe expands due to the heat.

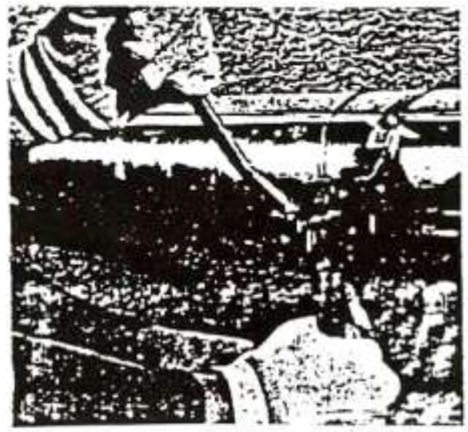

Figure 2-4. Using a banding tool

When vertical runs are jacketed, special provisions must be made to keep the jackets from sliding down to the bottom of the run. To solve this potential problem, “S” clips are used to support the jackets. “S” clips may be made of banding material with two sharp bends, forming a double hook, as shown in Figure 2-5. Three clips are hung on the upper edge of a jacket. The clips support the weight of the next jacket up, as shown in Figure 2-6 to the outer-most parts of the elbow. When the lagging cloth is cut to the correct shape, finishing cement is liberally brushed onto the cloth. The lagging can then be placed over the insulation (Figure 2-8), smoothed down, and trimmed to fit. The completed installation is then coated with finishing cement to stiffen the cloth and give the installation a neat appearance (Figure 2-9).

Figure 2-8. Covering Insulation with Lagging cloth.

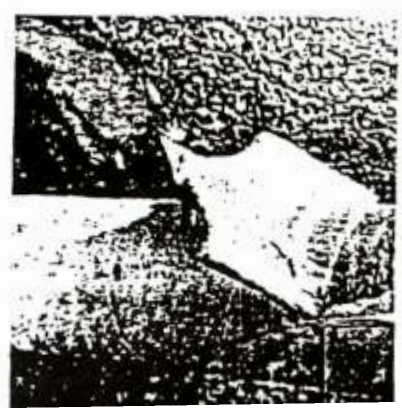

Figure 2-9. Applying finishing cement

2.3 Removal and Repair

Insulation must often be removed and replaced for repairs to piping systems and insulation itself may also require patching from time to time as sections are damaged. The removal and repair of calcium silicate insulation involves some of the same skills as does its installation. Special precautions are needed, however, when working on older installation that may contain asbestos. In addition to the tools needed for removal (knife, wire cutters and metal snips), plastic bags and drop cloths are required in order to catch debris as it falls. (See Section 5 for more information on working with asbestos).

Metal jackets are removed from the insulation by cutting the bands with a pair of metal snips. The jackets will then easily slip off the insulation when they are opened up; however, personnel should exercise care to avoid being cut on sharp edges. When the insulation is exposed, the tie wires are cut and the sections are separated and lifted off the pipe. Where insulation is lagged instead of jacketed, the lagging is slit with a knife and peeled away from the insulation. Where insulating cement was used to prevent heat leaks, it must be chipped away to expose the tie wires. All used insulation containing asbestos must be disposed of in sealed plastic bags.

A common insulation maintenance job involves the replacement of one or more racked or crushed sections. When this sort of repair job is required, the damaged Sections should be removed as described above, and replaced with new sections, as discussed in Section 2.2.

When moulded insulation is wired over elbows or other fittings, it is often cut to only an approximate fit. Cracks between sections may allow heat to leak out unless they are plugged with some insulating material. Insulating cement accomplishes this purpose and also provides a smooth surface to which the lagging cloth can adhere. Insulating cement, also called “mud”, it usually mixed on the job in the quantities needed for the work at hand. Cement is usually supplied in powder form. A bucket is filled with water, and cement is slowly added while the mixture is stirred by hand with a rubber glove. Cement is added until the mixture attains a consistency similar to that of think mud – hence the nickname. When the “mud” has been thoroughly mixed, it is applied with a trowel in a thick coating over the entire surface of the insulation to be lagged. The insulating cement should be smoothed carefully so that, when dry, it will form a hard, even shell over the insulation (Figure 2-7).

Figure 2-7. Applying Insulating Cement

When the entire area to be lagged has been coated with insulating cement, the lagging cloth is measured, laid out and cut to fit over the insulation. The ability to select the right shape to cover an irregular fitting is a skill that comes with experience. Elbows are most easily covered with two quarter-circles of lagging cloth: the radius of the circle should equal the distance around the insulation from the innermost.

3. ***Fibreglass, Rubber and Foam Insulation***

Fibreglass, cellular rubber and plastic foam are all mass-type insulating materials that can be used for low temperature applications. Fibreglass is a dual range insulating material: it may be used for high temperatures as well as low temperatures. Cellular rubber and plastic foam are restricted to low temperature use only. These materials degrade quickly when exposed to temperatures above 200˚ Fahrenheit (94˚C) and may melt or burn at higher temperatures.

OBJECTIVES:

* Define heat tracing
* Describe the function of a vapour barrier on insulation used for low temperature applications
* Describe the technique for installation of cellular rubber and plastic foam insulation on piping.

Low temperature insulation on piping can serve a variety of purposes. On refrigeration or chilled water systems, low temperature insulation increases system efficiency by preventing the entry of heat. On any kind of cold piping, low temperature insulation prevents condensation of water vapour on the piping. Sweating and freezing of water vapour on piping can damage insulation; water dripping from pipes can damage sensitive equipment and create safety hazards sue to puddles on floors. Low temperature insulation prevents condensation by serving as an airtight barrier between the cold pipe and water vapour surrounding the area. A material that performs this function is called a vapour barrier (Figure 3-1). Some forms of low temperature insulating materials, such as cellular rubber and plastic foam, act as their own vapour barrier; others are manufactured with an external vapour barrier, and some require that a separate vapour barrier be installed with the insulation is put up.

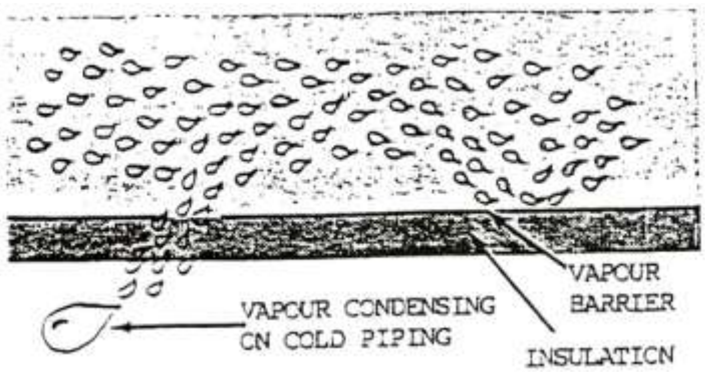

Figure 3-1. Vapour Barrier

Low temperature insulation may be used for other purposes besides preventing heat gain and condensation. One special application of low temperature insulation is on heat traced piping systems. Often, low temperature systems must be prevented from becoming too cold, especially if the piping is outdoors. Heat tracing is a method of heating the contents of a pipeline to prevent thickening and freezing in cold weather. Usually, temperatures are well below 200˚ C Fahrenheit (94˚C), so heat tracing is considered to be a low temperature application; however it may also be found on some high temperature systems. The heat tracing itself consists of an electrical resistance element or a small diameter steam line attached to or toughing the piping along the length of the run (Figure 3-2). Insulation covers both the pipe and the tracing to hold the heat in so that fibreglass is the one most often used in heat tracing applications. Cellular rubber and plastic foam are not as resistant to heat (heat tracing may present special problems when removing or repairing insulation. For details, see Section 5).

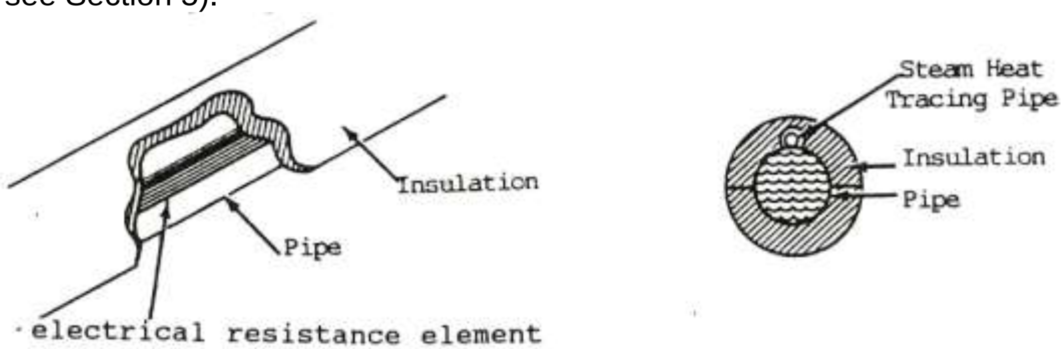

Figure 3-2. Heat Tracing

3.1 Fibreglass and Mineral Wool

Fibreglass and mineral wool are made by blowing or spinning molten material into long, thin fibres. When the fibres are pressed together, they form a low density material with many air spaces. Most types of fibreglass may be used for low temperature applications as well as high temperature applications up to 400˚ F (200˚C).

Several safety precautions are necessary when working with fibreglass insulation. Since the fibres are extremely thin, they penetrate the skin easily. Unprotected skin may be severely irritated upon contact with fibreglass so gloves and long sleeves should be work whenever fibreglass is handled. Glass fibres also irritate the lungs and upper respiratory tract when inhaled, and they penetrate eye tissues as easily as they penetrate the skin. When there is a likelihood of the presence of glass fibres in the air, such as when fibreglass insulation is cut or removed, a filter mask and goggles should be work to protect the eyes and lungs.

Fibreglass insulation is available in several forms for both low and high temperature applications. Preformed pipe sections, boards, mats and rolls are a few of the shapes in which fibreglass insulation is supplied. Fibreglass insulation intended for low temperature use may come with an attached foil vapour barrier; otherwise, a separate barrier must be installed.

Table 3-1 summarises the installation requirements for fibreglass pipe insulation.

TABLE 3-1 MATERIALS, TOOLS AND PROTECTIVE EQUIPMENT FOR INSTALLATION OF FIBREGLASS PIPE INSULATION

Materials	Tools	Protective Equipment
Fibreglass pipe sections	Knife	Long sleeves
Adhesive	Staple gun	Gloves
Staples	Brush for adhesive	Filter mask
	Tape measure	Goggles

3.2 Cellular Rubber and Plastic Foam

Cellular rubber and plastic foam are low temperature insulating materials with integral vapour barriers. The surface of these materials is impervious to water vapour, making additional vapour barriers necessary. Cellular rubber and plastic foam are often used for insulating cold water or refrigerant piping. Both materials are similar in appearance and performance. Certain differences may exist in the cellular structure of each material.

Cellular rubber and plastic foam both contain tiny cells that trap dead air, reducing the insulations density and increasing its insulation value. Two types of cell structure are possible: open cell (Figure 3-4) and closed cell (Figure 3-5).

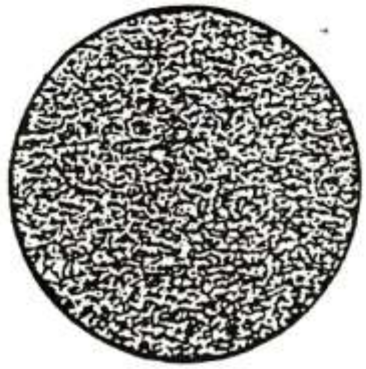

Figure 3-4. Open Cell

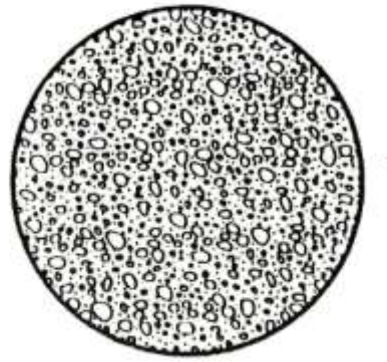

Figure 3-5. Closed Cell

The open cell structure has air pockets that interconnect throughout the material: although plenty of dead air is trapped within, there is still some room for convection currents to transfer heat from one side on the insulation to another. In the closed cell structure, the air pockets to not interconnect. This helps prevent convection currents and slows down the transfer of heat through the material. Plastic foam insulation may have either closed or open cells; cellular rubber always has a closed cell structure.

Both plastic foam and cellular rubber are available in several forms: blocks and sheets are sometimes used as well as the more common tubular sleeves for piping applications. Plastic foam has an advantage over cellular rubber in one respect: foam can be sprayed in place as a fast hardening liquid – cellular rubber cannot.

Each section covering has a flap that laps over the seam to prevent heat leaks and block the entry of water vapour. The lap should be stapled along its length to hold the insulation securely to the pipe. Staples should be placed six inches (15 cm) apart. Butt joints are secured by stapling strips of the insulations covering over the joints (Figure 3-3).

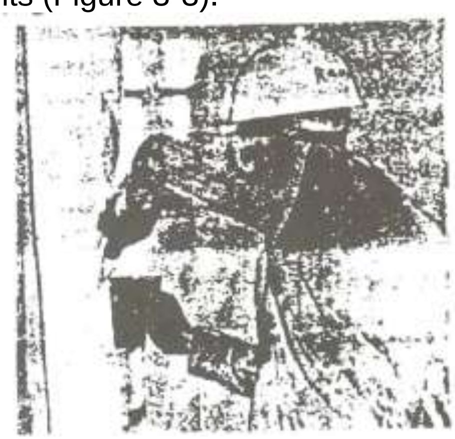

Figure 3-3. Securing lap and butt joints with staples

When fibreglass insulation is used on cold piping, punctures caused by staples penetrating the vapour barrier must be sealed to prevent the entry of water vapour. Adhesive is used to seal the punctures. The adhesive should be spread over the lap joints and the butt joints so that no points of entry remain for water vapour in the air.

When fibreglass insulation must be removed from piping for repairs to the piping system or replacement of the insulation, lap and butt joints can be re-opened by slitting the covering or the vapour barrier with a sharp knife. If only one section must be replaced, it can be removed without damaging adjacent sections. A new section can then be installed as described above.

Table 3-2 lists the tools and materials needed for installing cellular rubber and plastic foam insulation on piping.

TABLE 3-2 TOOLS AND MATERIALS FOR INSTALLING CELLULAR RUBBER AND PLASTIC FOAM INSULATION ON PIPING*

Tools	Materials
Knife	Cellular rubber or plastic foam pipe sections
Brush for adhesive	Adhesive

* No special protective equipment is necessary for installation of plastic foam and cellular rubber insulation.

Installing plastic foam or cellular rubber insulation on piping is a fairly straight forward procedure, whether the piping is installed or not. If piping has not already been installed, the tubular sleeves are simply slipped over the ends of the pipes before the pipes are put up. The sleeves easily bend around corners and elbows: no additional cutting is required. After the pipes are put up, the butt joints between sections are sealed with adhesives to prevent the entry of their length. All seams are then coated with adhesive – both sides of the long seam and butt ends. The insulation can then be slipped over the pipe (Figure 3-6). Seams and butt joints should be squeezed together with a kneading motion to ensure that the adhesive makes an airtight seal. Whenever adhesives are used, adequate ventilation is vital. Many adhesives release poisonous fumes that can poison an unprotected worker.

Figure 3-6. Installing cellular rubber insulation

When cellular rubber or plastic foam insulation must be removed from piping, the material is easily slit with a sharp knife. If only one section must be replaced, it can be cut away without damaging the rest of the insulation.

4. ***Reflective Insulation***

Highly polished metal or metal foils prevent heat transfer by reflecting radiant heat. When arranged in layers, or used along with other insulating materials, reflective insulation also reduces conductive and convective heat flow. Reflective insulation is used for both high and low temperature applications.

Aluminium and stainless steel are the two metals most often used for reflective insulation. In its simplest form, reflective insulation consists of a thin metal foil. Reflective foils are often used on the walls of refrigerated spaces to prevent heat gain from radiation; fibreglass building insulation often has reflective foil on one side. Single layers of foil are effective in reflecting radiant heat, but multiple layers also block convective heat transfer by increasing the number of dead air spaces. Figure 4-1 illustrates how convective and radiant heat flows are reduced with two and then four layers of reflective material.

In industry, most reflective insulation is used on piping system. Reflective insulation has two advantages that make it especially suitable for use in the nuclear power industry and in processing areas where dust and contamination must be kept to a minimum. First, since reflective insulation is entirely metal or entirely enclosed in metal, the insulation is clean. It creates no dusty or fibrous "fallout", which is common with mass-type insulation. Second, the insulation can be removed, cleaned and decontaminated without damage: something impossible to do with mass-type insulation.

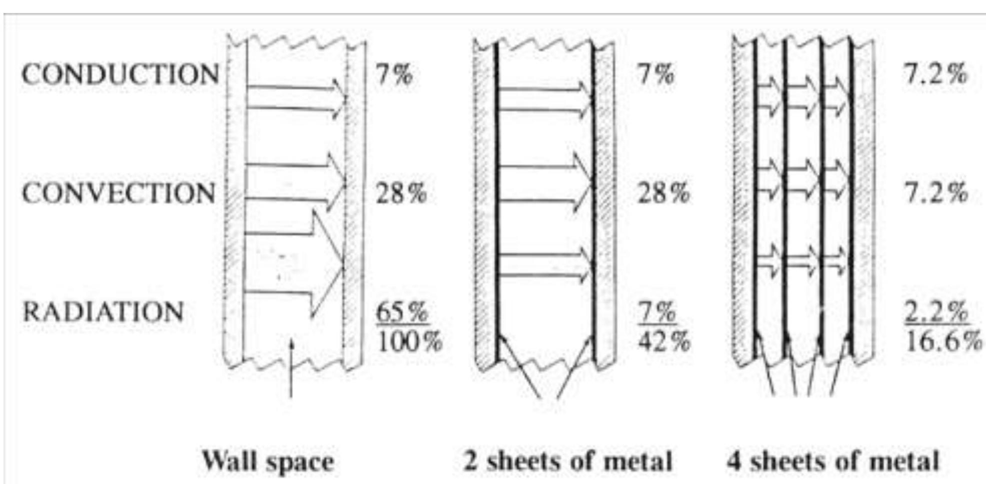

Figure 4-1. Preventing heat flows with multiply reflective layers

Reflective insulation for piping systems usually takes one of two forms: reflective layers (Figure 4-2) or mass-type insulation enclosed in a metallic skin (Figure 4-3). Both kinds open on a hinge and latch around the pipe, making removal and replacement relatively easy.

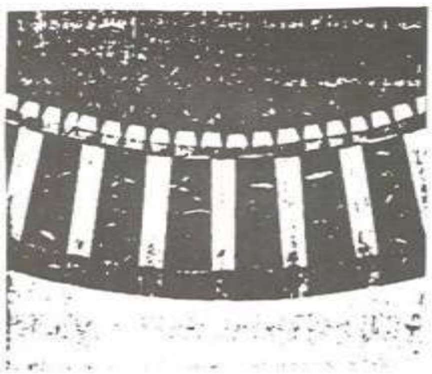

Figure 4-2 Reflective layers

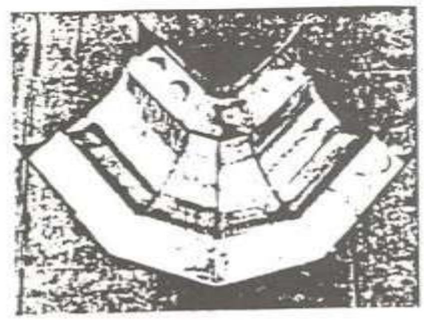

Figure 4-3. Mass-type insulation enclosed in metal

Complex reflective insulation systems are often custom-designed to fit a specific installation. Since placement of pieces for special fittings can be critical, all pieces should be numbered and labelled when being taken down for periodic cleaning or maintenance to the piping system. Without an orderly system for replacement of its components, the insulation system becomes a huge jigsaw.

Several commonsense precautions are necessary when removing or replacing reflective insulation. First, the worker must protect himself: reflective insulation may have sharp or jagged metal edges. Gloves should be worn to protect the worker's hands from cuts and scratches. Second, although reflective insulation is made of metal, it can be extremely fragile. Thin layers of foil can easily tear if handled roughly which may have a double effect: insulation value will be reduced and, in the case of encapsulated insulation, mass-type material may escape and contaminate the area.

5. ***Insulation Safety and Precautions***

Insulation workers are often exposed to a number of potential health hazards in the course of their work. In order to reduce the hazards to which workers are exposed, personnel must be aware of possible dangers and familiar with the precautions used to reduce the element of risk. Wearing the appropriate safety equipment and following correct procedures, while not eliminating risks, can reduce health hazards to a minimum.

Some of the hazards to which insulation workers are often exposed are associated with the insulating materials themselves. Many types of insulation, including fibreglass, mineral wool, calcium silicate, release ducts and fibres that can be harmful or irritating when inhaled or even when in contact with the skin. Airborne dusts and fibres tend to be most concentrated in areas where insulation is being cut or removed. Whenever workers might be exposed to airborne dusts or fibres from insulation, filter masks and goggles are required. Cotton gloves should always be work where there is a possibility of cuts, scratches, or irritation to the skin of the hands. The basic protective items for insulation work are illustrated in Figure 5-1.

Figure 5-1. Filter mask, goggles and gloves

When fibreglass insulation is handled, skin irritation is especially likely. Thin, sharp glass fibres easily penetrate exposed skin, producing a painful itch and possibly a rash on the affected area. The only way to avoid irritation when handling fibreglass is to keep the fibres off the skin. Gloves, long sleeves and a head covering (such as hard hat or a hood) all help protect insulation workers from fibreglass itch.

Many insulation products tend to drop fibres or dust when handled. When insulation is installed above the worker's eye level, these particles may fall into the eyes or be inhaled. Some form of eye protection should always be work when working with dusty or fibrous insulation overhead: goggles, face shields and safety glasses with side shields are all acceptable eye protection, depending upon the situation. When there is a possibility that particles may be inhaled, a filter mask should be work to protect the lungs and throat. Even inert substances that do not react with body chemistry may be irritating in small quantities and harmful in heavy concentrations. Other materials can cause a variety of lung diseases; some like asbestos may even cause cancer.

5.1 Asbestos

Asbestos was once used in many kinds of insulating materials, including calcium silicate insulation. Today it is used primarily for specialised applications; however persons involved in the maintenance or removal of older conventional insulation systems may be exposed to asbestos. Exposure to asbestos dust causes a long disease called asbestosis or any of several kinds of cancer. When exposure to asbestos is likely, both worker and employer are responsible for taking precautions to reduce the hazard. The employer is responsible for monitoring asbestos levels and providing protective equipment; the worker does his part by using safe work practices. Floors and work clothes should be vacuumed to prevent spreading asbestos dust. Workers should shower and change before going home to avoid exposing their families to asbestos. To make disposal of asbestos waste easy, drop cloths should be used under the work. Any remaining dust should be vacuumed up, or, if this is not possible, wetted down and swept. Asbestos waste must be disposed of by burial in sealed plastic bags.

5.2 Heat stress

"Hot jobs" are an occupational hazard to insulation workers. Sometimes it is not practical to shutdown a system for insulation maintenance, and personnel may have to work where surrounding air temperatures are higher than 100˚ Fahrenheit (40˚ Celsius). When a person is in a hot environment, the body automatically acts to cool itself off: sweating and increased blood circulation are two of those responses.

With the additional stress caused by physical work, the body's cooling system may overload. The symptoms of heat stress are as follows:

- Hot dry skin
- Pale, clammy skin or warm, flushed moist skin
- Weakness, dizziness, headache, blurred vision
- Nausea, vomiting, diarrhoea
- Rapid heartbeat
- Prickly, red skin
- Muscle cramps
- Irritability

Heat stress is the reaction of the body when it is unable to cool itself adequately. Often, the reaction is related to the loss of water and salts through sweating. When surrounding temperatures are high, workers should drink water frequently, with a small amount of salt, to replace perspiration losses. A person who feels the symptoms of heat stress (dizziness, rapid heartbeat, cramps) should stop working, get to a cooler place and take frequent small drinks of water until he recovers.

Extreme cases of heat stress lead to a condition called heat stroke. Heat stroke is a reaction of the body to severe water loss. Perspiration stops and internal temperatures rise to dangerous levels. The victim may have mottled red and blue skin, experience convulsions, or is delirious. A victim of heat stroke should be taken to a cool place, wetted down, and fanned to lower his body temperature. Medical help should be called.

5.3 Other insulating hazards

Insulation workers are exposed to several types of hazards indirectly related to their jobs. For example, insulation work often takes place above floor level from ladders or scaffolds. Other hazards involve heat tracing, stress corrosion, cracking and oil-soaked insulation.

Ladders must always be inspected before use. If a ladder has missing or damaged rungs, loose stayrods, or split siderails, it should be tagged, removed from the work area and reported to a supervisor. If a damaged ladder cannot be repaired, it must be replaced. Damaged ladders should never be used.

Ladders should be positioned so that the work is within easy reach of the user. The user should keep the front of his body facing the rungs at all times, and should never stand any higher than two rungs below the top rung. Trying to reach too far can lead to dangerous falls. When straight or extension ladders are used, they must be leaned at the correct angle for maximum stability. The correct angle is determined by adjusting the foot of the ladder a distance away from the vertical equal to one-fourth the length of the ladder (Figures 5-2). Straight and extension ladders should always be braced by another person or have the top tied off to a support.

Figure 5-2. Ladder Angle

When personnel work from scaffolds or hoists, lifelines and safety belts (Figure 5-3) or harnesses are required safety equipment. Where electrical hazards and present, lifelines made of metal cable should be grounded or non-conductive lifelines made of rope should be used to reduce shock hazards. Similarly, ladders used around electrical equipment should be made of wood or fibreglass, not metal.

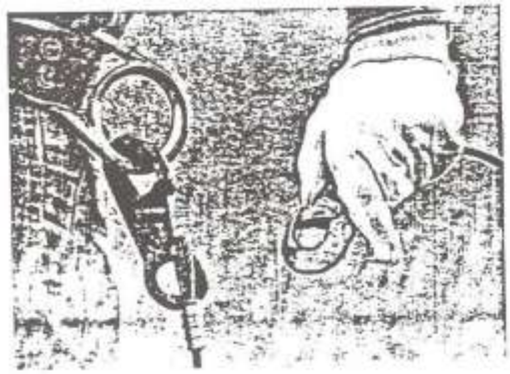

Figure 5-3. Detail of lifeline and safety belt

Working on heat-traced pipelines presents another hazard to the insulation worker: puncture of an electrical heat tracing element or a steam heat tracing line can expose the worker to electric shock or steam burns if the tracing has not been deactivated. Heat tracing should always be turned off and tagged out before work begins on a heat-traced pipe run.

Stress corrosion cracking is a kind of metal failure that takes place when stainless steel piping is insulated with a material containing chlorides. A chemical reaction between the steel and the chloride corrodes the metal, causing a network of find cracks that weakens the pipe. Stress corrosion cracking can lead to leaks and failures of entire piping systems. Stainless steel piping should be insulated only with materials known to be chloride free.

Maintenance personnel are often faced with problems that involve piping leaks. When piping leaks are discovered, insulation must be removed and the source of the leak identified and repaired.

When oil or other flammable liquids have soaked into the insulation, special precautions must be taken while the insulation is removed, especially if the piping beneath is at a high temperature. First, a helper with a fire extinguisher must be standing by in case the liquid suddenly bursts into flames. Oil fires can often smoulder under insulation, only to flare up when the insulation is removed and the smouldering material is exposed to the air. Removal should begin as far away from the affected area as possible and slowly proceed towards the source of the leak.