TRADE OF

Industrial Insulation

PHASE 2

Module 6

Insulation & Cladding The Training Rig

UNIT: 1

Measuring the Training Rig

Produced by

SOLAS

An tSeirbhís Oideachais Leanúnaigh agus Scileanna
Further Education and Training Authority

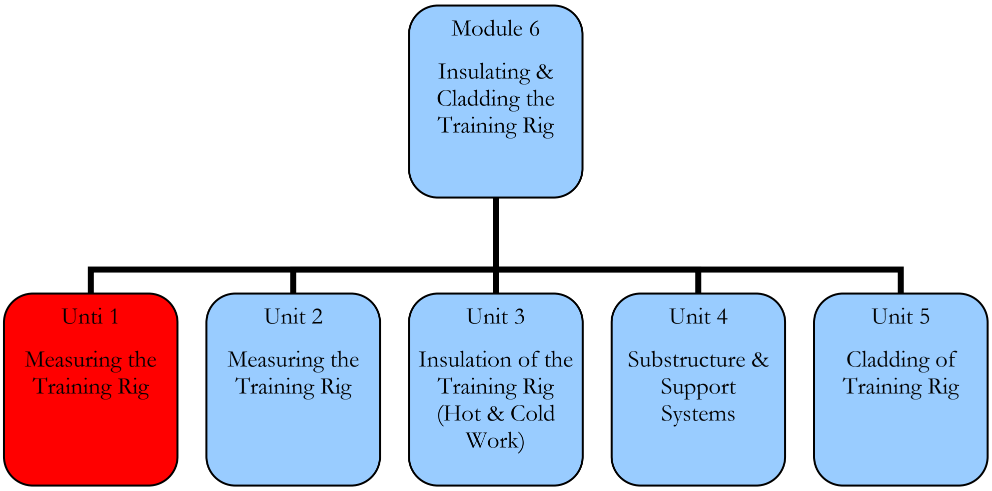
In cooperation with subject matter expert:

Michael Kelly

Table of Contents

Introduction

Pipe-work systems or pipe-lines are the arteries of Industry and through these arteries fluids, vapours, gases, slurries, powders and solids flow in a multitude of conditions imposed by plant processes. They are subjected to intense pressures imposed by temperature, pressure and the flow of substances. These systems also have to deal with the hazards such as corrosion, erosion, fire and explosion, to toxic conditions and to diverse problems involving hygiene, bacterial growth, heat and cold losses, handling of acids, alkalis, solvents and a combination of these in various combinations.



Unit Objective

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

- Measure pipe work, valves and vessels for insulation and cladding.
- Sketch various ductwork forms.
- Read and interpret a works specification and a works drawing.
- Determine the material requirements for the insulation and cladding of the training rig.

1.0 Measuring and Sketching

Key Learning Points

- Accurate bare surface measuring.

1.1 Pipe-Work Systems

A pipeline or pipe-work system is usually made up of various diameter pipes and fittings. These fittings would include 90 and 45 degree radius bends, reducers (concentric and eccentric), tees (equal and unequal), hangers and supports, and various types of valves to regulate and control flow. Pipes and fittings can be welded together or flanged and bolted. Other methods of fixing and connection pipes and fittings are also available.

Pipes and fittings are available in a wide range of materials such as stainless steel, copper, brass, bronze, aluminium, various alloys and other metals and non-metals.

1.2 Information on Pipes

Pipe is specified by stating its nominal size and it should be noted particularly that the nominal size is only approximate, and is neither the inside or the outside diameter and standard tables or manufacturers' tables should be used to ascertain exactly these two dimensions. Pipes over 14 inches (356mm) are generally specified on the outside diameter and wall thickness. To explain how this works, if you purchase a 2" pipe (this is the nominal; size), this pipe will have an outside diameter of 2.375 inches (60.325mm). For pipes up to 12 inch diameter, the nominal diameter is very loosely related to the inside diameter. As mentioned above pipes of 14 inches (356mm) and over are generally specified on outside diameter and wall thickness. It is important to mention that the wall thickness of pipes of the same diameter can be different, but the outside diameters will always be the same. This is to facilitate the connection of various parts of pipe-line systems such as bends, tees, valves etc.

1.3 Tubes

It is worth mentioning that sometimes pipes are referred to as tubes and the reverse also applies. Tubes, particularly those in copper and brass and in some cases steel, nickel, and other metals and non-metals, are manufactured and marketed on the basis of actual outside diameter and wall thickness and, as they are drawn in a variety of thicknesses , both must be specified.

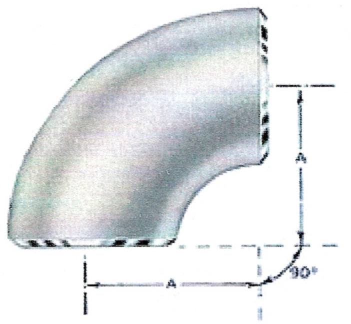
1.4 Pipe Sizes

The pipe sizes used in various Industrial and commercial installations and which need to be covered with insulation and cladding are as follows:

½"	21mm OD	7"	194mm OD
¾"	27mm OD	8"	219mm OD
1"	34mm OD	9"	245mm OD
1¼"	42mm OD	10"	273mm OD
1½"	48mm OD	12"	324mm OD
2"	60mm OD	14"	356mm OD
2½"	76mm OD	16"	406mm OD
3"	89mm OD	18"	456mm OD
4"	114mm OD	20"	508mm OD
5"	141mm OD	24"	610mm OD
6"	168mm OD		

1.5 General Information on Measuring Steel Butt-Welded Pipe Fittings

90° Long Radius Elbow



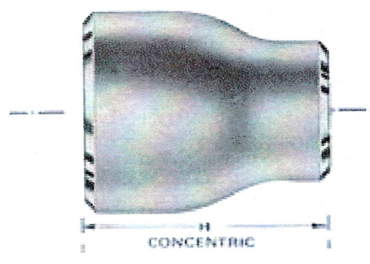
The "A" dimension is found by taking the nominal diameter of the elbow and multiplying it by 1.5.

Example: 2" (nominal diameter) x 1.5 = 3"

Convert 3" to milimeters = 3 x 25.4 = 76.2mm.

Therefore "A" = 3" or 76mm (76.2mm rounded down).

Concentric Reducer

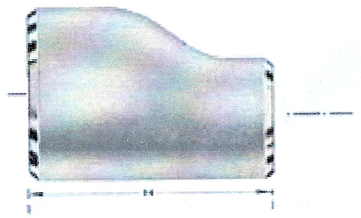


For the length “H” of the reducer it is always advised to consult the manufacturers’ catalogues.

Example: 2½" (nominal diameter) reducing to 2" (nominal diameter.

“H” = 3½" or 89mm (from manufacturers’ catalogue)

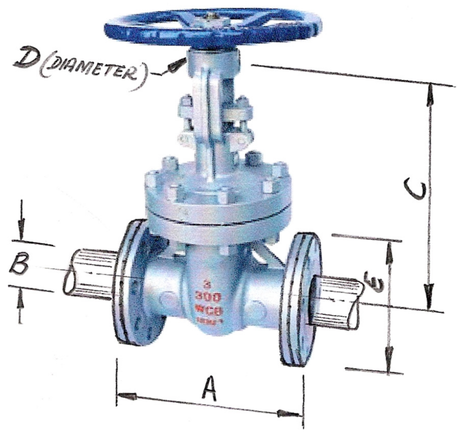
Eccentric Reducer of Flat-Back Reducer



For the length “H” of the reducer it is always advised to consult the manufacturers’ catalogues.

Example: 2½" (nominal diameter) reducing to 2" (nominal diameter.

“H” = 3½" or 89mm (from manufacturers’ catalogue)



1.6 Measuring a "Gate" Valve

Shown in the figure above is a "gate" valve. The measurements required to manufacture a valve box for this type of valve are as follows:

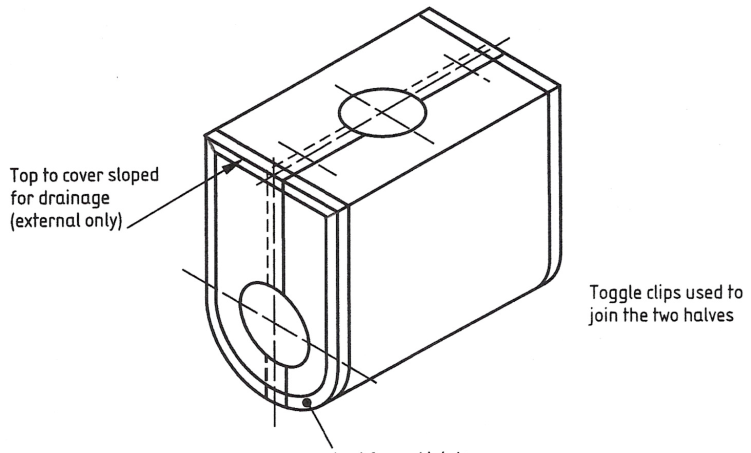
A = The length between the outside of the flanges. When we are manufacturing the valve box we have to add a clearance for the bolts to be removed in case of replacement or maintenance. We also have to add to this measurement for the thickness of the insulation.

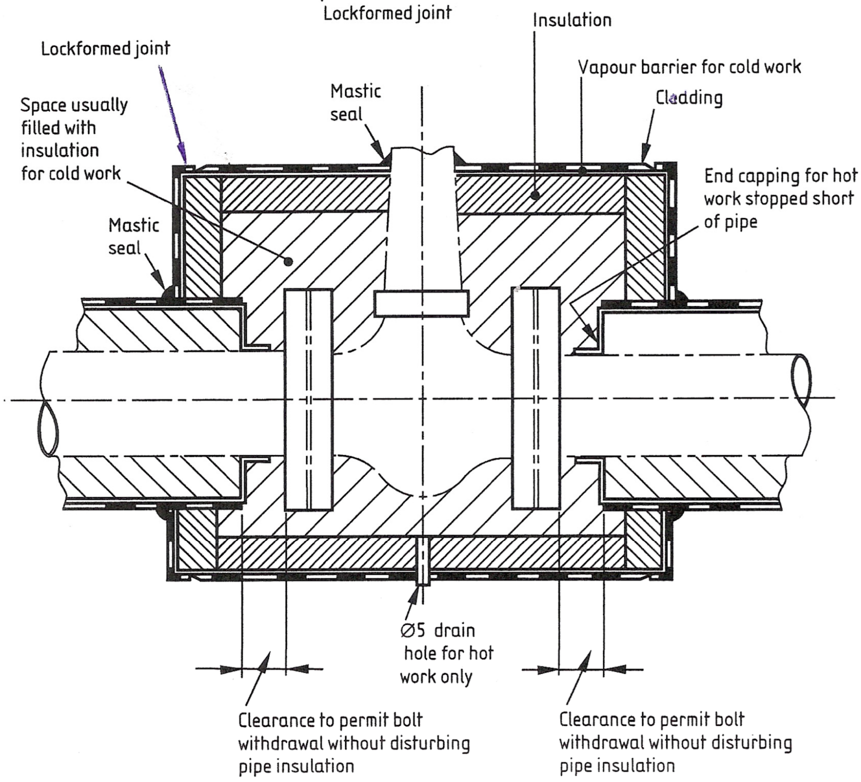
B = The diameter of the pipe. We add to this diameter the thickness of insulation (x2) fitted on the pipe plus the thickness (x2) of any cladding fitted over the insulation. Allow a small allowance on the diameter of the hole cut out of the valve box for ease of fitting over the valve.

C = Centre of the pipe to the top of the valve box. It is important to allow enough room between the hand-wheel and the valve box for ease of operation of the hand-wheel/ valve.

D = The diameter of the casting at the top of the valve. Add a small allowance to the diameter of the hole cut out of the valve box for ease of fitting of the box.

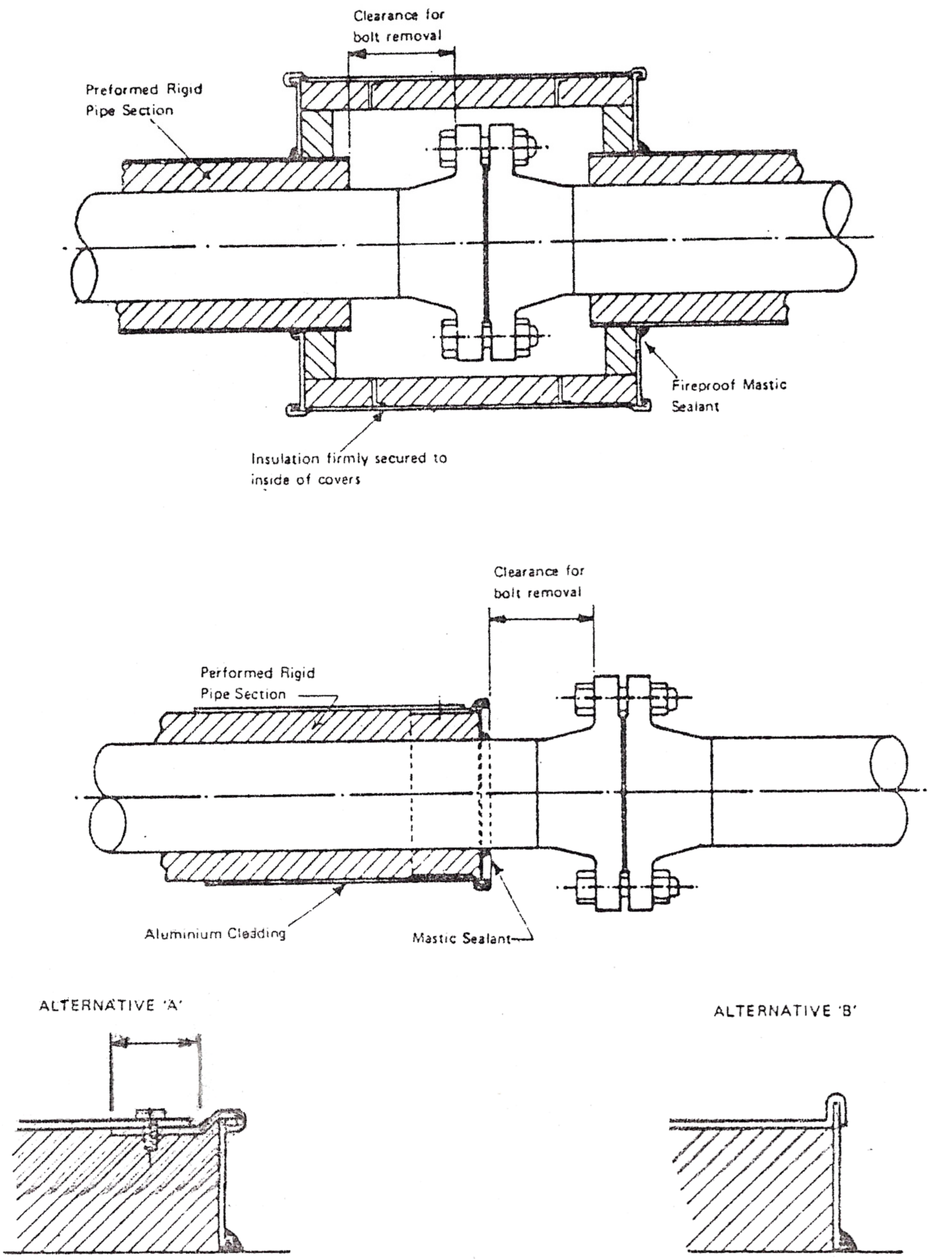
E = Diameter of flanges plus a clearance must be added for the insulation to be fitted to the inside of the box.


Top to cover sloped for drainage (external only)
Toggle clips used to join the two halves
Lockformed joint


Insulation
Lockformed joint
Vapour barrier for cold work
Cladding
Mastic seal
Space usually filled with insulation for cold work
End capping for hot work stopped short of pipe
Mastic seal
Ø5 drain hole for hot work only
Clearance to permit bolt withdrawal without disturbing pipe insulation
Clearance to permit bolt withdrawal without disturbing pipe insulation

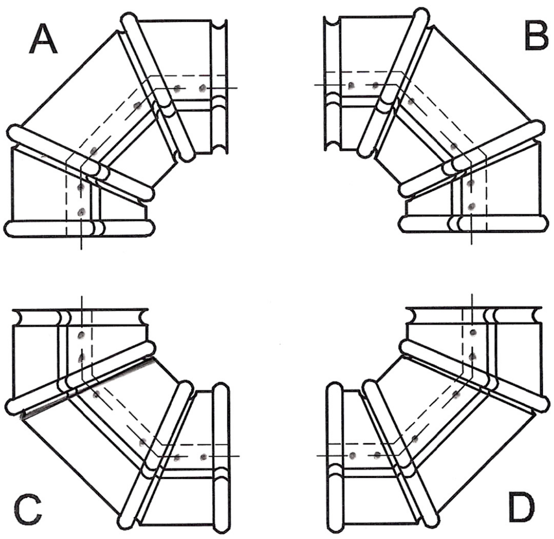
1.7 Measuring a Flanged joint/ Flange box

The measuring for a flange box is very straight forward. Firstly measure the diameter and total thickness of the assembled flanges and then the bolts holding them together. Space is required to permit bolt withdrawal without disturbing the pipe insulation. Allow extra space within the box for pipe insulation to be fitted. See the figure below for details of a completed flange box.



1.8 Radius Elbows

When cladding 90º radius elbows or indeed any pipe-work or fittings, ductwork, vessels etc, it is very important that joints should be arranged to shed water. The figure below shows elbows that have been cladded and how they are designed and designated "A B C D" for ease of measuring and manufacture. For elbows A and B the patterns are swaged on the head of the patterns, and for elbows C and D the patterns are swaged on the tail of the patterns. It is important to remember that the designations ABCD are when you are looking at them as shown with the longitudinal joints on the near side, however if you were looking at them from the far side the designations would change.



1.9 Measuring Vessels

Refer to module 5 – unit 7 – Vessels (storage and high pressure).

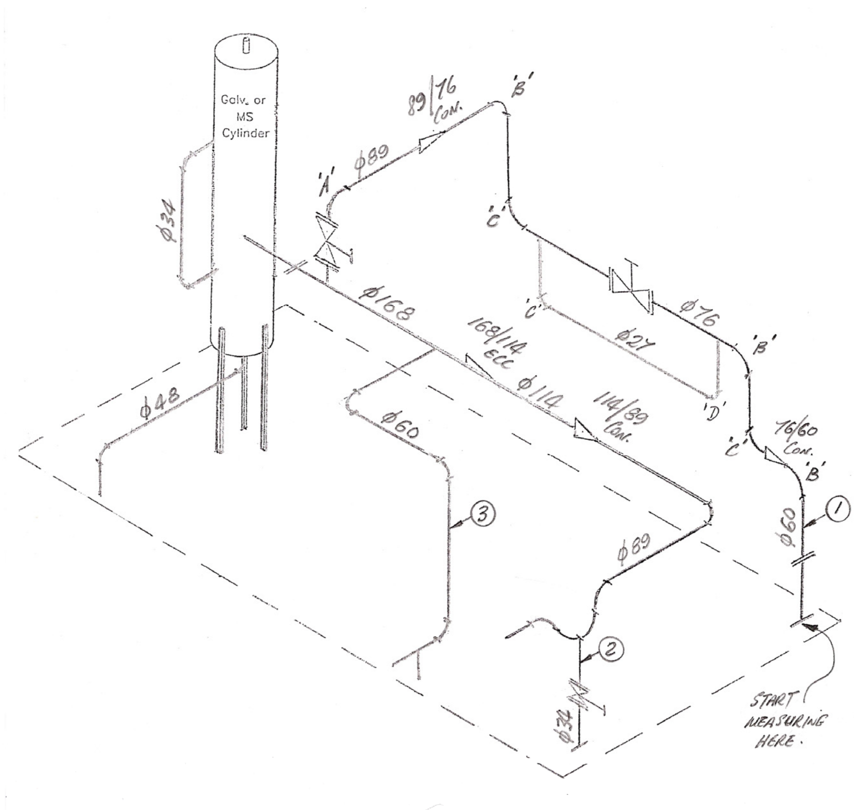
2.0 The Training Rig

Key Learning Points

- Units of measurement: metric vs imperial
- Appropriate use of tolerance on dimensions
- Use of a plumb-line and spirit level
- Calculation and application of insulation allowances
- Accurate centre finding
- 3D sketching: isometric and oblique
- Area calculation
- Joint positioning in insulation and cladding
- Obstacle location on pipe-work

2.1 Isometric Drawing of the 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:



ISOMETRIC DRAWING OF TRAINING RIG.

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 above for measuring a flange box.
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 section 1.6 above***.
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. (16) ø 76mm OD pipe x length between welds of elbows.
17. (17) 90º "B" type elbow/bend – ø 76mm OD with a centreline radius of 3¾" or 95mm.
18. (18) ø 76mm OD pipe x length between "B" type elbow/bend and concentric reducer.
19. (19) Concentric reducer - ø76/89mm x 3½/89mm long.
20. (20) ø 89mm OD pipe x length between concentric reducer and "A" type 90º elbow/bend.
21. (21) 90º "A" type elbow/bend ø 89mm OD with a centreline radius of 4½" or 114mm.
22. (22) Valve box – ***see information on measuring a valve box in section 1.6 above***.

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. (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 Units of Measurement – Metric and Imperial

Metric

10 millimetres (mm) =1 centimetre (cm)

100 centimetres (cm) =1 metre (m)

1000 millimetres (mm) =1 metre (m)

Imperial

12 inches (in or ") = 1 foot (ft or ')

British to metric Units

1 in = 2.54 cm = 25.4 mm

Metric to British Units

1 millimetre = 0.039 inch

1 centimetre = 0.394 inch

1 metre = 39.37 inches

2.3 Approximate use of Tolerance on Dimensions

Tolerance is the amount of variation permitted on a dimension. The tolerance is equal to the difference between the maximum and minimum limits of any specified dimension. For example: if the tolerance on a piece of metal cladding of 120mm diameter is ±2mm, this means that the cladding can be a maximum of 122mm diameter or 118 minimum diameter.

It is important to remember that the tolerance should not be too large on general metal cladding work (a general tolerance of ±1mm is acceptable) as the assembly and finish of the work could be sloppy.

2.4 Use of a Plumb-Line and Spirit Level

Refer to module 5 – unit 1 – Measuring: Ductwork and other large areas.

2.5 Accurate Centre Finding

Refer to module 5 – unit 1 – Measuring: Ductwork and other large areas.

2.6 Calculation and Application of Insulation Allowances

As mentioned earlier in ***section 1.1*** of this unit, the insulation/cladding diameter is calculated by taking the outside diameter of the pipe and adding two thicknesses of insulation. The diameter of the insulation can b used for the diameter of the metal cladding but it is usual practice to increase the diameter of the metal cladding to facilitate fitting of the cladding over the insulation on site. The chart below includes details of pipe size, insulation thickness and circumferences of cladding to suit various insulation thicknesses. These are suggested circumferences only and may vary.

Pipe ø	Insulation Thickness							
	25	30	40	50	60	70	80	90
21	235	265	330	390	450	520	580	650
27	260	280	350	415	475	540	595	
34	285	310	370	425	500	550	615	685
42	330	335	410	460	525	570	630	720
48	325	350	420	480	550	580	655	730
60	370	395	450	520	590	635	710	770
76	400	440	510	580	610	700	750	
89	460	485	540	610	680	735	820	850
102		520						
114	540	565	620	710	760	815	880	960
141	580	660	740	780	870	910	970	
168	710		800	870	920	1030	1070	1145
194	770		900	960	1000	1060	1160	
219	820	910	965	1040	1110	1180	1230	1290
245							1310	
273	1050	1070	1120	1190	1270	1330	1390	1470
324	1200	1260	1315	1380	1440	1490	1570	1620
356	1290	1350	1390	1470	1560	1590	1670	1720
406			1550	1620	1690	1750	1820	1880
456	1620		1720	1800	1840	1910	1975	
508	1770		1860	1950	1985	2060	2150	
610	2190		2200	2250	2360	2400	2460	

2.7 Area Calculation

Refer to module 5 – unit 1 – section 2.1.

2.8 Joint Positioning in Insulation and Cladding

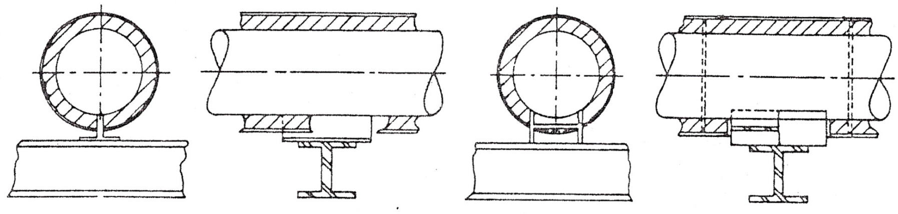
The positioning of joints in cladding applications should conform to BS 5970:2001 and to the recommendations in earlier notes.

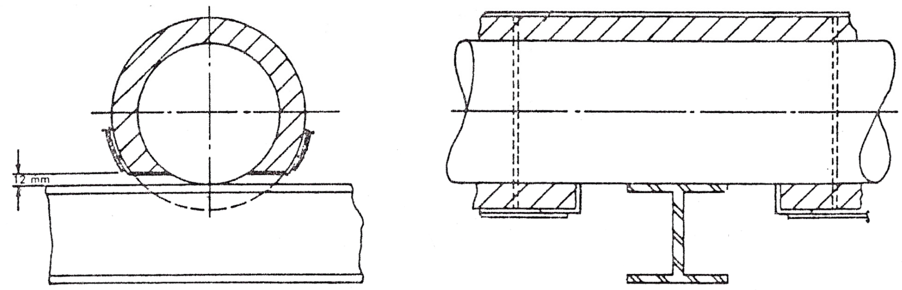
Refer to module 5 – unit 1 – section 1.8.

2.9 Obstacle Location on Pipe-Work

Obstacles on pipe-work come in many forms such as hangers, steelwork supports, other pipe-work close by or from the building structure itself. These obstacles slow down the installation of the insulation and cause extra work by way of measuring, cutting and fitting of metal cladding. The figures below show some of the obstacles which the Industrial insulator may expect to see.

Refer to module 5 – unit 1 – section 1.9.





Note: Where cladding has to be cut away it shall fit closely to the pipe and be completely waterproof.

3.0 Measuring Pipe-work and job Planning

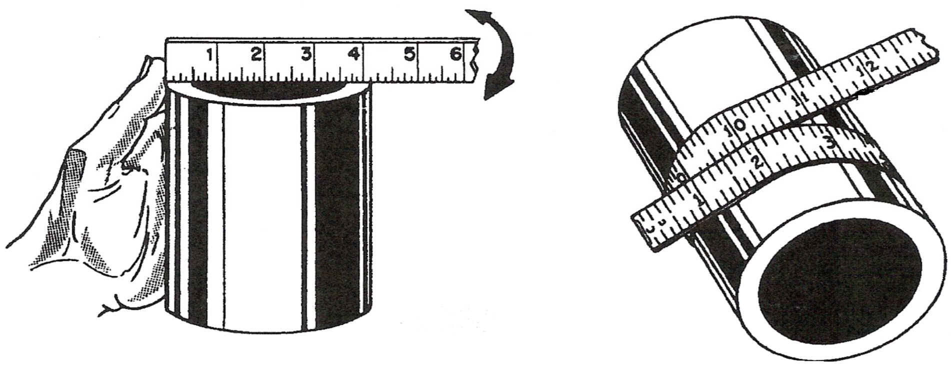
Key Learning Points

- Use and care of appropriate measuring equipment
- Job planning and sequencing
- Works specification and drawings interpretation.

3.1 Use and Care of Measuring Equipment

Industrial insulators use many different types of measuring tools in the daily performance of their duties. Where exact measurements are required a vernier calliper is used. This instrument is accurate to 0.02 of a millimetre. It is important to keep a vernier calliper clean and lightly oiled at all times. Make sure they are always stored in a case or box when not in use, to protect them from damage. Never clean any part of a vernier calliper with an emery cloth or any type of abrasive substance.

On the other hand, where accuracy is not extremely critical, a common steel rule, tape rule or folding rule will suffice for most measurements. These tools are available in various lengths and come in both imperial and metric versions. The figure below shows pipes been measured with a steel rule and a tape rule.



Measuring pipe-work with a tape rule and a steel rule(imperial measurements).

Handle steel rules and measuring tapes carefully. Lightly oil steel rules frequently to prevent rust. Never allow the edges of measuring devices to become nicked by striking them with hard edges. If a measuring tape becomes nicked or broken in any way replace it immediately to avoid injury. Keep all measuring tools in a toolbox when not in use. Avoid kinking measuring tapes by pulling them straight out of their cases – do not bend them backwards. After use, guide the tape back into its case by hand. O not use the hook as a stop. Slow the tape down as you reach the end.

3.2 Pipe Circumferences

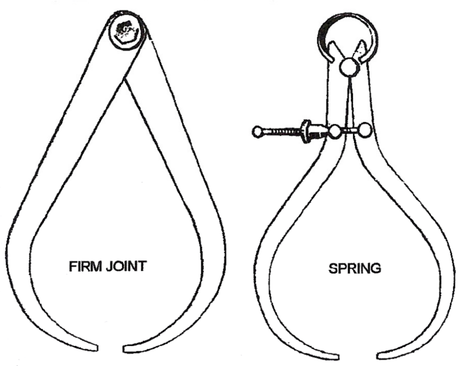
To measure the circumference of a pipe, you must use a flexible type rule that will conform to the shape of the pipe. A flexible steel tape rule is adaptable to this job. When measuring the pipe, make sure the tape is wrapped squarely around the axis of the pipe to ensure the measurement is not more than the actual circumference of the pipe. This is extremely important when measuring a large diameter pipe or vessel. Hold the rule or tape as shown in the figure above. Take the reading, using a 2" graduation, for example, as the reference point. In this case the correct reading is found by subtracting 2 inches from the actual reading. In this case the first 2 inches of the tape, serving as a handle, will enable you to hold the tape securely.

Pipe Diameters

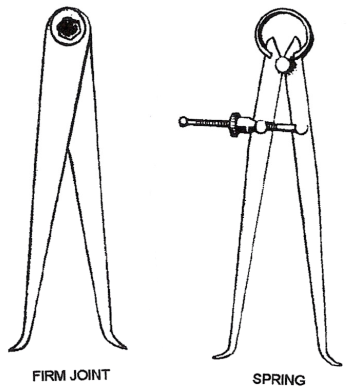
The figure above shows the end of the rule lined up with one side of the pipe, using your thumb as a stop. Then, with one end held in place, swing the rule through an arc and take the maximum reading at the other side of the pipe. For most purposes, the measurement obtained by using this method is satisfactory. It is necessary you know how to take this measurement, as the outside diameter of a pipe is very important to know as the inside diameter of the pipe insulation conforms to this size.

3.3 Callipers

Inside and outside calliper are used in conjunction with a rule to determine the thickness or the diameter of a surface, or the distance between surfaces. The figure below shows some of the callipers available:



Outside Callipers.



Inside Callipers.

A calliper is usually used in one of two ways. Firstly, take the dimension of the component using an inside or outside callipers, and measure the distance between the calliper legs using a steel rule.

Secondly, set the callipers to a certain distance and machine or work the part until it checks with the dimension set up on the calliper.

It is import that good care is taken when using callipers. Keep callipers lightly oiled, but do not over oil the joint of firm joint callipers or you may have difficulty in keeping them tight. Always store callipers in a toolbox when not in use.

3.4 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.

Summary

Industrial pie-work systems carry various substances including gases, liquids vapours and powders. These systems have to be extremely robust in order to cope with the stresses and strains imposed on them by heat, cold, acidic substances and corrosion.

A pipeline or pipe-work system is usually made up of various diameter pipes and fittings. These fittings would include 90 and 45 degree radius bends, reducers (concentric and eccentric), tees (equal and unequal), hangers and supports, and various types of valves to regulate and control flow.

Pipe is specified by stating its nominal size and it should be noted particularly that the nominal size is only approximate, and is neither the inside or the outside diameter and standard tables or manufacturers' tables should be used to ascertain exactly these two dimensions.

Various tools are used to measure both the inside and outside diameters of pipe and tube. These tools include a steel rule, a tape rule, an inside and outside callipers. Care should be taken when using these tools and regular maintenance such as the oiling of joints is important to ensure continuous operation of the tools.

Insulation and cladding is applied to pipe-work and tubes to control heat loss or gain, for protection against frost and other environmental elements and to protect personnel from injury.

Planning and organisation is vitally important when measuring a large insulation and cladding job. Communication between people and the delegation of tasks will ensure the smooth running of the job. Record keeping, filing of drawings, notes and understanding the works specification are all very important aspects of any job, and a system should be in place whereby information is available in a clear and concise and organised manner.

SOLAS
An tSeirbhís Oideachais Leanúnaigh agus Scileanna
Further Education and Training Authority

Castleforbes House
Castleforbes Road
Dublin 1