

## **Pipe Fitting & Pipe Bending – (40 Hours Course)**



# Table of Contents

<b>Pipe Fitting &amp; Pipe Bending – (40 Hours Course)</b> .....	<b>1</b>
1. <u>Technical Mathematics for Pipe Fitters</u> .....	2
1.1 <u>Metric System</u> .....	2
1.2 <u>Inch System</u> .....	5
2. <u>Technical Drawing &amp; Symbols</u> .....	8
3. <u>Typical Materials &amp; Tools used for Pipe Fitting and for Pipe Installations</u> .....	12
3.1 <u>Pipes</u> .....	12
3.2 <u>Common Galvanized Fittings</u> .....	13
3.3 <u>Common Valves</u> .....	15
3.4 <u>Tools for laying out, fitting and installing pipes</u> .....	18
4. <u>Pipe Fitting Process for Galvanized Pipes</u> .....	19
4.1 <u>Measurement of Galvanized Steel Pipes</u> .....	19
4.2 <u>Clamping Pipes</u> .....	20
4.3 <u>Cutting Galvanized Pipes</u> .....	23
4.4 <u>Manual Pipe Threading</u> .....	25
4.5 <u>Assembling Galvanized Steel Pipes</u> .....	27
4.6 <u>Installation of Valves</u> .....	31
5. <u>Bending Principles</u> .....	36
5.1 <u>Cross-Sectional Deformation</u> .....	36
5.2 <u>Minimum Bending Radius</u> .....	37
6. <u>Cold bending of Pipes</u> .....	38
7. <u>Hot Bending of Pipes</u> .....	41
7.1 <u>Bending Pipes using Sand Filling</u> .....	41
7.2 <u>Hot Bending a double 90° bend, using a template wire</u> .....	44
7.3 <u>Hot Bending a double 90° bend, using the Calculation Method</u> .....	47
8. <u>PVC Pipes</u> .....	52
9. <u>Safety Precautions</u> .....	55



# Pipe Fitting & Pipe Bending – (40 Hours Course)

With technical assistance from:  
**GERMAN DEVELOPMENT SERVICE**



## General Survey – "Pipe Fitting & Pipe Bending" – Course

August 2000

### TARGET PARTICIPANTS

min 18 years old, at least High School graduates, experienced workers, supervisors or leadsman

### LENGTH OF COURSE

40 hours/5 days

### OBJECTIVES

At the end of the course, the participants should be able to:

- Calculate length of pipe systems using the metric and inch system
- Calculate the Volume of cylindrical forms
- Interpret drawings to fabricate pipe systems
- Identify typically used materials, tools and equipment used in Pipe Fitting & Pipe Bending
- Identify common fittings, valves, pressure gauges, flow meters
- Know the common methods to fit pipes together
- Layout, cut thread and install pipes for water supply systems
- Know different possibilities on how to bend pipes (hydraulic pipe bender and hot bending)
- Know the basics about installing a building water supply system (circular pump, different valves, flow meter, pressure gauge .....)
- Know the basics about PVC–Pipe Processing

### COURSE OUTLINE

<b>THEORY (40 %)</b>	<b>HANDS–ON TRAINING (60 %)</b>	<b>METHOD</b>
<ul style="list-style-type: none"><li>• Basic trade math (metric and inch system, calculation of circumferences and stretched length, volume)</li><li>• Basic blue print reading (pipe orientation and symbols)</li><li>• Pipe fitting material identification</li><li>• Pipe fitting process (cutting, threading)</li></ul>	<ul style="list-style-type: none"><li>• Pipe processing (laying out, cutting, threading, assembling)</li><li>• Pipe bending</li><li>• Installation of different pipe systems using different materials, fittings, valves, flow meters and pressure gauges</li><li>• Installation of a building water supply</li></ul>	<ul style="list-style-type: none"><li>• Lectures/discussion</li><li>• Practical sessions</li><li>• Teaching video</li></ul>

assembling) • Pipe bending process • Job safety	system	
---	--------	--

**Dear Reader,**

I would like to comment this handout, because otherwise you might get a little confused while studying it.

The most important thing to know is, that this handout is developed for a **non-formal** Training Center. The participating government officials and the involved companies were not interested in long-term courses. So, I had to respect the wish of my project partners for a course with this length and was limited on the most important subjects.

One or two of the modules are still under construction. Sorry for this.

**DED – Development Worker**

## 1. Technical Mathematics for Pipe Fitters

### 1.1 Metric System

Over 90 % of all countries in the world are presently using the Metric System. But there are still some countries using the Inch System (e.g. United States, Canada, and England). With the reality of global manufacturing continually expanding, the need for metal workers in both systems of measurement will continue to grow.

The metric system uses the meter and linear units based on the meter as its standards of measure. At the General Conference on Weights and Measures in October, 1983, the meter, defined as the distance traveled by light in a vacuum during  $1/299,792,458$  of a second, was approved as a world standard.

All multiples and subdivisions of the meter are directly related to the meter by a factor of ten. This makes it easy to use the decimal system for calculations involving metric units. The more often used subdivisions are the Decimeter “dm”, the Centimeter “cm” and the Millimeter “mm”.

**Kilometer**    **km**    1 km    =    1,000 m

**Meter**        **m**        1 m       =    10 dm       =    100 cm       =    1,000 mm

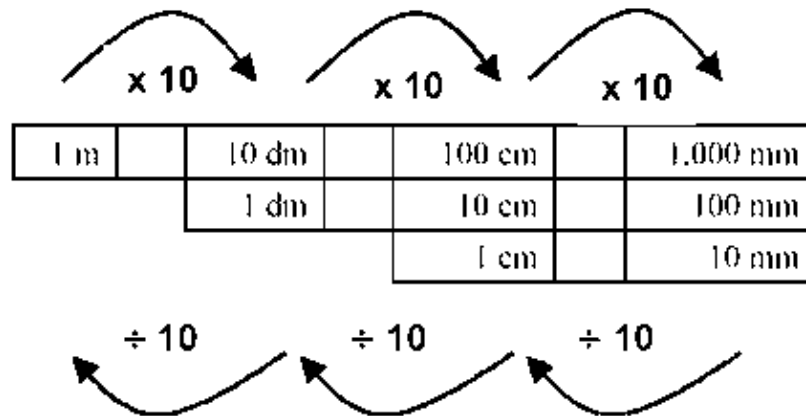
**Decimeter**   **dm**    1 dm    =    10 cm       =    100 mm

**Centimeter**   **cm**    1 cm    =    10 mm

**Millimeter**   **mm**    1 mm    =    1,000 mm

**Micrometer**   **mm**

To convert from a bigger unit to a smaller unit we have to multiply by 10



To convert from a smaller unit to a bigger unit we have to divide by 10

### EXERCISES

Convert from m to dm:

	m	=	dm
10	m	=	dm
100	m	=	dm
1.5	m	=	dm
1.1	m	=	dm
0.5	m	=	dm

Convert from dm to cm:

1	dm	=	cm
10	dm	=	cm
100	dm	=	cm
12	dm	=	cm
5	dm	=	cm
0.4	dm	=	cm

Convert from cm to mm:

1	cm	=	mm
10	cm	=	mm
100	cm	=	mm
18	cm	=	mm
2.7	cm	=	mm
0.8	cm	=	mm

Convert from dm to m:

1	dm	=	m
10	dm	=	m
100	dm	=	m
13	dm	=	m
6	dm	=	m
0.9	dm	=	m

**Convert from mm to cm:**

4	mm	=	cm
14	mm	=	cm
111	mm	=	cm
13	mm	=	cm
2.7	mm	=	cm
0.75	mm	=	cm

**Convert from cm to m:**

3	cm	=	dm
13	cm	=	dm
109	cm	=	dm
16	cm	=	dm
4	cm	=	dm
0.65	cm	=	dm

**Summing Up**

$$\begin{aligned}
 20 \text{ cm} &+ 10 \text{ dm} &+ 30 \text{ mm} &+ 25 \text{ cm} &= 1,48 \text{ m} \\
 10 \text{ cm} &+ 5 \text{ dm} &+ 28 \text{ mm} &+ 30.5 \text{ cm} &= \text{ mm} \\
 38 \text{ mm} &+ 42 \text{ cm} &+ 0.6 \text{ dm} &+ 0.9 \text{ m} &= \text{ cm} \\
 5.5 \text{ dm} &+ 122 \text{ mm} &+ 44 \text{ cm} &+ 1.2 \text{ m} &= \text{ dm} \\
 2.2 \text{ m} &+ 86 \text{ cm} &+ 77 \text{ cm} &+ 333 \text{ mm} &= \text{ m} \\
 0.1 \text{ mm} &+ 1.2 \text{ cm} &+ 9.86 \text{ cm} &+ 55.6 \text{ mm} &= \text{ mm}
 \end{aligned}$$

**Mixed Operations**

$$\begin{aligned}
 1 \text{ m} &+ 37 \text{ mm} &- 5 \text{ dm} &+ 40 \text{ cm} &= 937 \text{ cm} \\
 1.47 \text{ m} &- 37 \text{ mm} &- 1.8 \text{ dm} &+ 36.5 \text{ cm} &= \text{ cm} \\
 96 \text{ mm} &- 3.8 \text{ cm} &+ 1.36 \text{ m} &+ 98 \text{ dm} &= \text{ dm} \\
 0.4 \text{ cm} &- 12 \text{ mm} &+ 1.55 \text{ m} &- 8.4 \text{ dm} &= \text{ m} \\
 11 \text{ cm} &+ 11 \text{ mm} &+ 1.1 \text{ dm} &+ 1.11 \text{ m} &= \text{ m} \\
 19.4 \text{ dm} &- 87.5 \text{ cm} &+ 1.36 \text{ m} &- 94 \text{ mm} &= \text{ dm}
 \end{aligned}$$



## 1.2 Inch System

The smallest unit in the Inch System is the inch “**in**”. Other units are the feet “**ft**” and the yard “**yd**”.

$$1 \text{ yd} = 3 \text{ ft} = 36 \text{ in} \quad 1 \text{ ft} = 12 \text{ in}$$

$$1 \text{ yd} = 0.9144 \text{ m}$$

$$1 \text{ ft} = 0.30480 \text{ m}$$

$$1 \text{ in} = 25.4 \text{ mm}$$

$$1 \text{ mm} = 0.0394 \text{ inch}$$

$$1 \text{ cm} = 0.3937 \text{ inch}$$

$$1 \text{ m} = 39.37 \text{ inches}$$

### Exercise – Conversion Inch to Metric

Example for Inch to Inch Fraction:  $1/16'' = 1 \text{ divided by } 16 = \mathbf{0.0625''}$

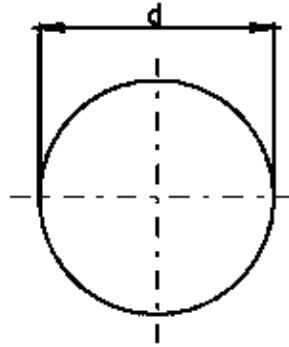
Example for Inch Fraction to mm:  $0.0625'' \times 25.4 \text{ mm} = \mathbf{1.58 \text{ mm}}$

Inch		Inch Fraction		mm
1/16	=	0.0625	=	1.58
1/8	=		=	
3/16	=		=	
1/4	=		=	
5/16	=		=	
3/8	=		=	
7/16	=		=	
1/2	=		=	
9/16	=		=	
5/8	=		=	
11/16	=		=	
3/4	=		=	
13/16	=		=	
7/8	=		=	
15/16	=		=	
1	=		=	
1 1/8	=		=	
1 1/4	=		=	
1 5/16	=		=	
1 3/8	=		=	
1 1/2	=		=	
2	=		=	

## Calculation of Circumferences

Circumference for Circles:

$$\begin{aligned} \text{Circumference} &= \text{diameter} \times \text{Pi} \\ C &= d \times \pi \\ C &= \text{mm} \times 3.1416 \end{aligned}$$



The diameter of a shaft is 95 mm. What is the circumference?

given:  
find:  
solution:

You have to fabricate a ring for a water tank with a diameter of 800 mm using G.I. sheet metal. What is the length of the G.I. sheet to be cut?

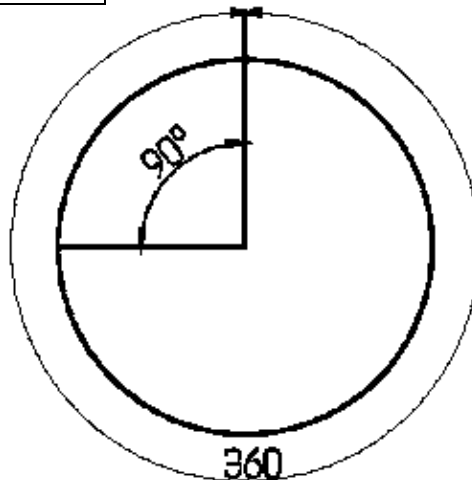
given:  
find:  
solution:

Circumference for parts of Circles:

$$\text{Circumference} = \frac{\text{diameter} \times \text{Pi} \times \text{angle}}{\text{Angle of full circle}}$$

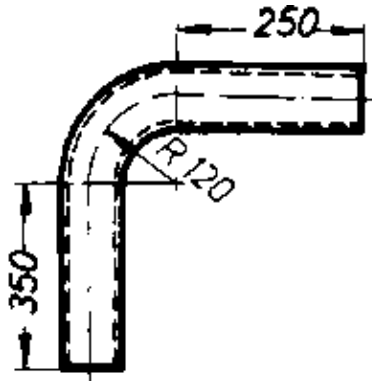
$$C = \frac{d \times \pi \times \text{angle}}{360^\circ}$$

$$C = \frac{\text{mm} \times 3.1416 \times \text{degree}}{\text{degree}}$$



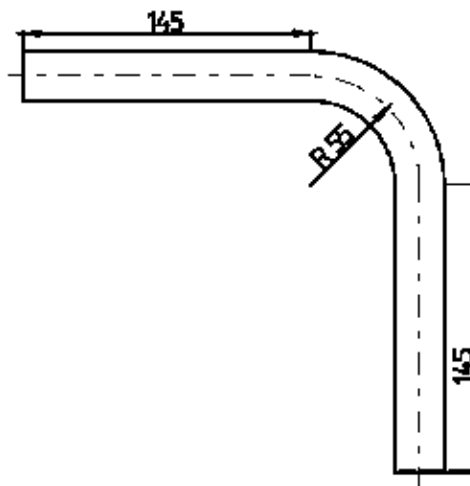
Calculate the stretched length of the pipe in the picture. Consider that diameter  $d$  is equal to  $2 \times$  radius.

given:  
find:  
solution:



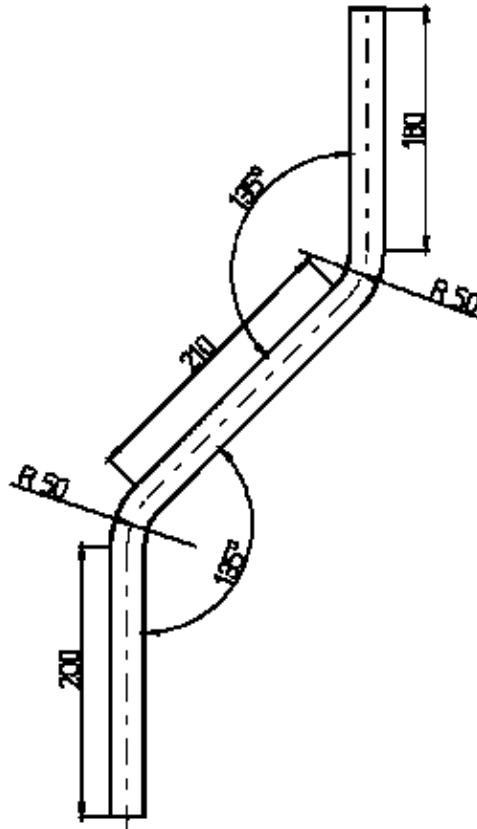
To bend the given pipe “free hand and hot”, you need to calculate the heating length.

given:  
find:  
solution:



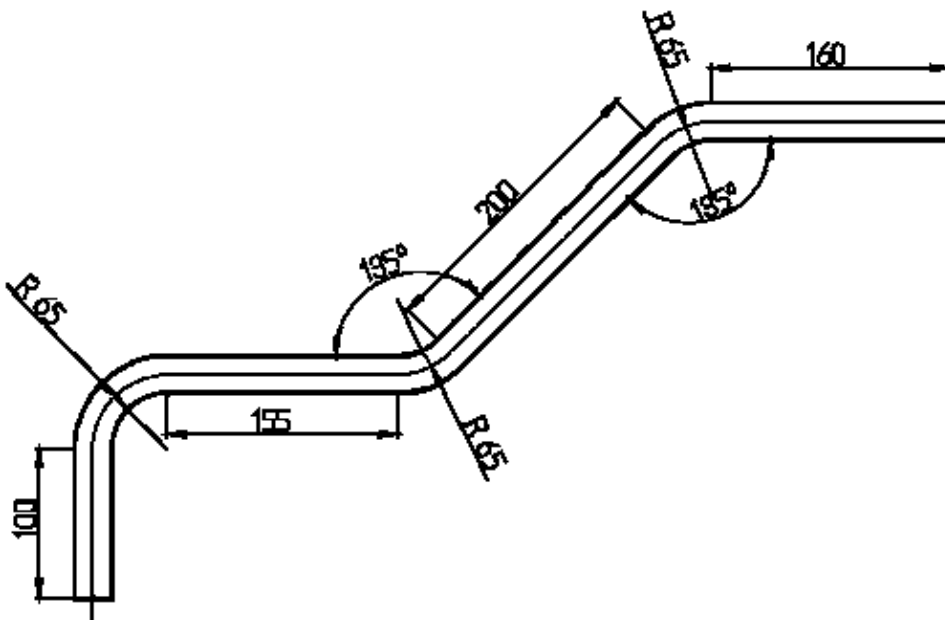
Calculate the stretched length of the pipe in the picture.

given:  
find:  
solution:



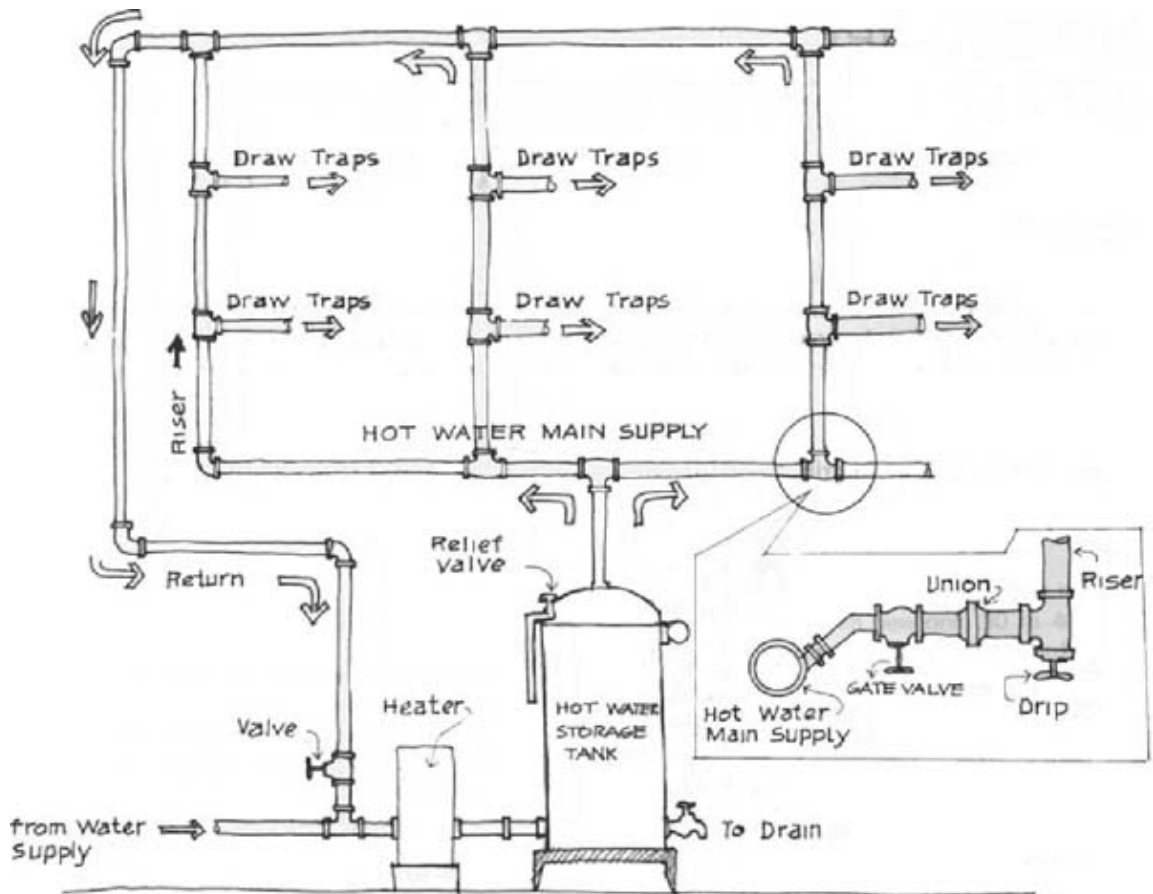
Calculate the stretched length of the pipe in the picture.

given:  
find:  
solution:

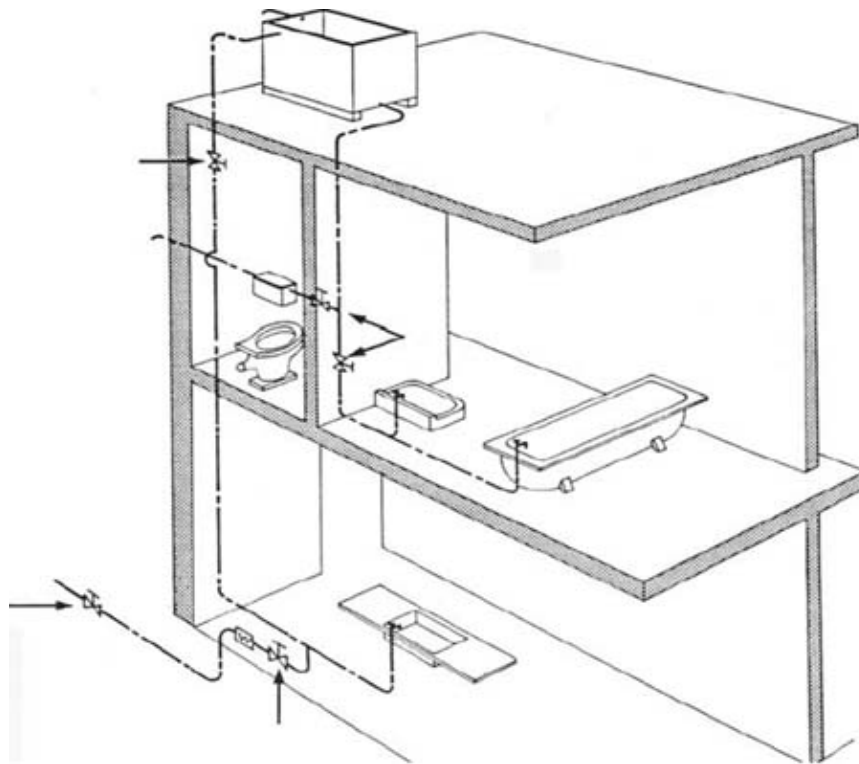


## 2. Technical Drawing & Symbols

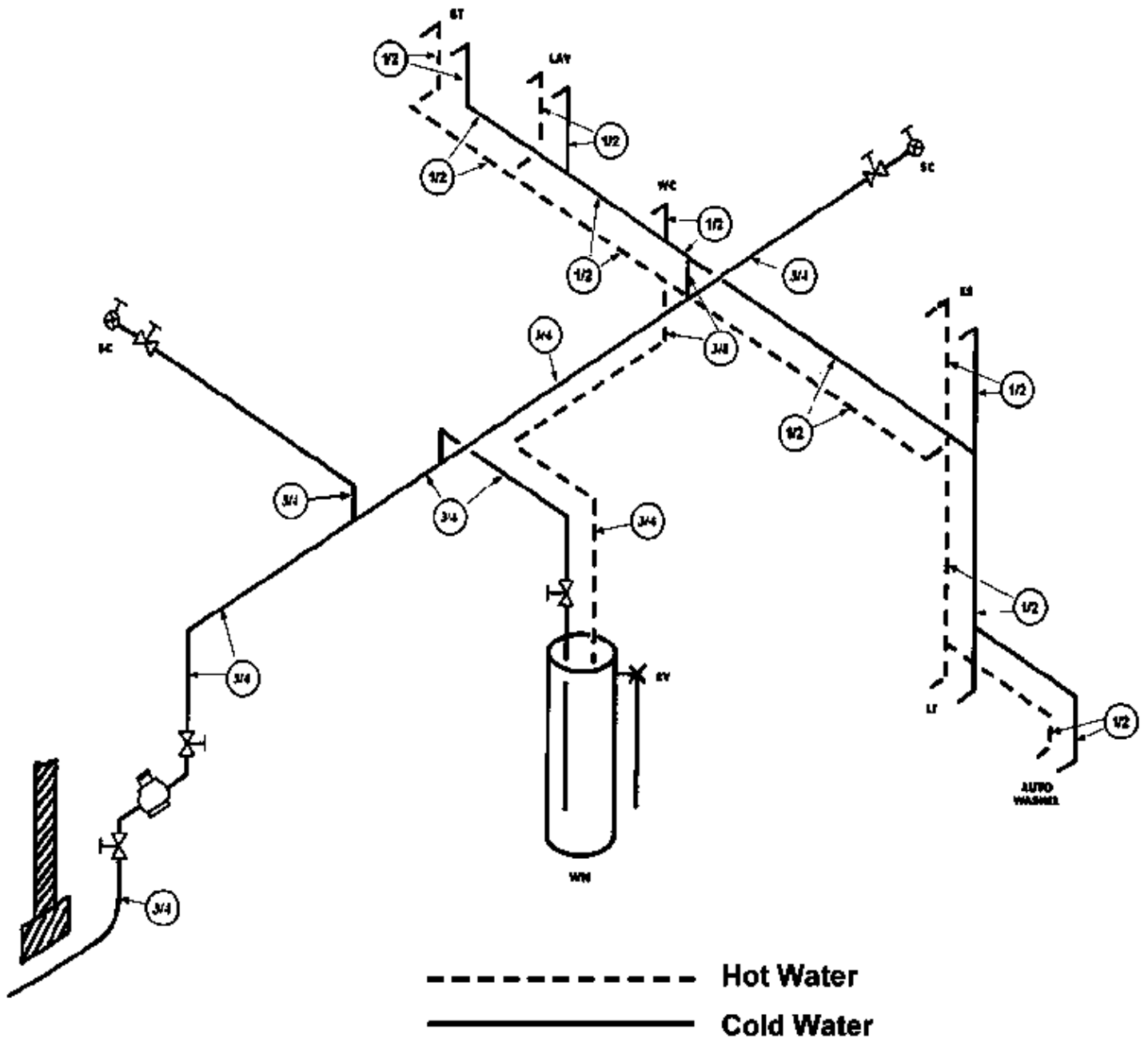
There are several ways to draft or illustrate a pipe system. Depending on the difficulty of the job the best suiting will be chosen.



Freehand drawing – Realistic Style



Sectional illustration of cold water supply – Isometric Style



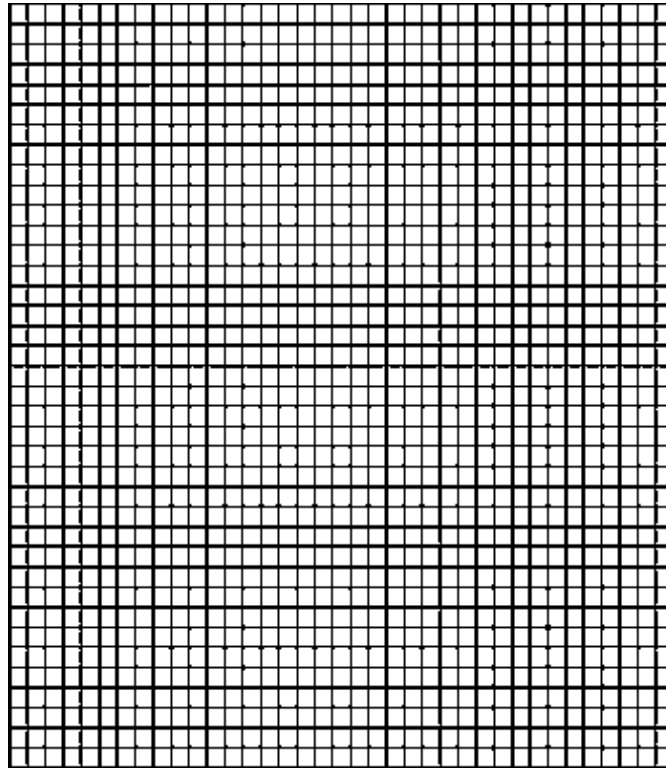
Isometric Drawing – with pipe dimensioning and valves

# STANDARD SYMBOLS FOR PLUMBING, PIPING AND VALVES

PLUMBING	PLUMBING (continued)	PIPE FITTINGS (continued)	
Corner Bath.....	Drinking Fountain (Trough Type).....	For Welded or Soldered Fittings, use joint indication shown in Diagram A	
Recessed Bath.....	Hot Water Tank.....	Screwed	Bell and Spigot
Roll Rim Bath.....	Water Heater.....	Elbow - Long Radius.....	
Sitz Bath.....	Meter.....	Side Outlet Elbow - Outlet Down.....	
Foot Bath.....	Hose Rack.....	Side Outlet Elbow - Outlet Up.....	
Bidet.....	Hose Bibb.....	Base Elbow.....	
Shower Stall.....	Gas Outlet.....	Double Branch Elbow.....	
Shower Head.....	Vacuum Outlet.....	Single Sweep Tee.....	
Overhead Gang Shower.....	Drain.....	Double Sweep Tee.....	
Pedestal Lavatory.....	Grease Separator.....	Reducing Elbow.....	
Wall Lavatory.....	Oil Separator.....	Tee.....	
Corner Lavatory.....	Cleanout.....	Tee - Outlet Up.....	
Manicure Lavatory.....	Garage Drain.....	Tee - Outlet Down.....	
Medical Lavatory.....	Floor Drain With Backwater Valve.....	Side Outlet Tee Outlet Up.....	
Dental Lavatory.....	Roof Sump.....	Side Outlet Tee Outlet Down.....	
Plain Kitchen Sink.....	<b>PIPING</b>		
Kitchen Sink, R & L Drain Board.....	Soil and Waste.....	Cross.....	
Kitchen Sink, L H Drain Board.....	Soil and Waste, Underground.....	Reducer.....	
Combination Sink & Dishwasher.....	Vent.....	Eccentric Reducer.....	
Combination Sink & Laundry Tray.....	Cold Water.....	Lateral.....	
Service Sink.....	Hot Water.....	Expansion Joint Flanged.....	
Wash Sink (Wall Type).....	Hot Water Return.....	<b>VALVES</b>	
Wash Sink.....	Fire Line.....	For Welded or Soldered Fittings, use joint indication shown in Diagram A	
Laundry Tray.....	Gas.....	Screwed	Bell and Spigot
Water Closet (Low Tank).....	Acid Waste.....	Gate Valve.....	
Water Closet (No Tank).....	Drinking Water Supply.....	Globe Valve.....	
Urinal (Pedestal Type).....	Drinking Water Return.....	Angle Globe Valve.....	
Urinal (Wall Type).....	Vacuum Cleaning.....	Angle Gate Valve.....	
Urinal (Corner Type).....	Compressed Air.....	Check Valve.....	
Urinal (Stall Type).....	<b>PIPE FITTINGS</b>		
Urinal (Trough Type).....	For Welded or Soldered Fittings, use joint indication shown in Diagram A		
Drinking Fountain (Pedestal Type).....	Screwed	Bell and Spigot	
Drinking Fountain (Wall Type).....	Joint.....		
	Elbow - 90 deg.....		
	Elbow - 45 deg.....		
	Elbow - Turned Up.....		
	Elbow - Turned Down.....		
		Stop Cock.....	
		Safety Valve.....	
		Quick Opening Valve.....	
		Float Opening Valve.....	
		Motor Operated Gate Valve.....	

## Layout Exercise

Please take the free hand drawing from page No. 7 and translate it into a 2D-view while using the Standard Symbols given on page No. 9



### 3. Typical Materials & Tools used for Pipe Fitting and for Pipe Installations

#### 3.1 Pipes

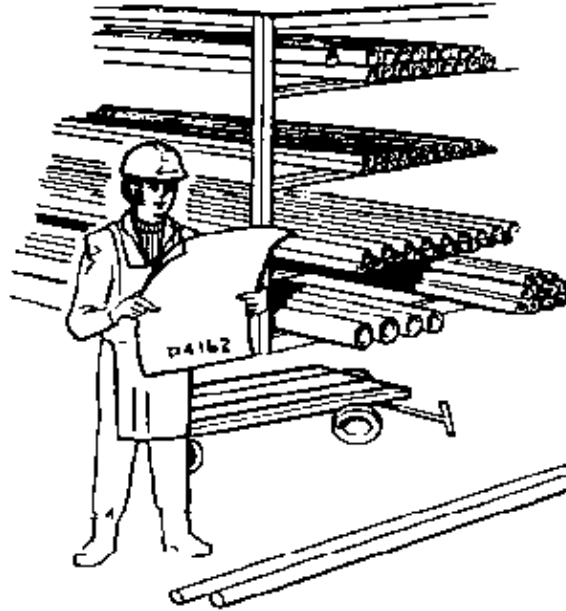
Material	Description
Black Iron (B.I.)	Made out of Mild Steel. This type of pipe will corrode quickly by alkaline and acid water. Delivery length is normally 6 m. Often used for steam pipes.
Galvanized (G.I.)	This type is better than B.I. pipe for plumbing installations, because it is more resistant. As steel pipes G.I. pipes are vulnerable to deposits of salts and lime which gradually accumulate and eventually block the flow of water. Delivery length is normally 6 m.
Cast Iron	Normally used for sewage systems. Cast iron is also affected to corrosion caused by the action of a solution of carbonic acid and sulfuric acid. It is heavy and if treated roughly the pipe and fittings can crack.
Stainless	Made of different alloys. It is commonly installed in chemical plants or in the food processing industry. Some types are highly acid resistant. Delivery length is normally 6 m.
Copper	A durable material that is extremely corrosive resistant. Easy to install by soldering but expensive. In western countries widely used for hot water systems. Also used in the aircon industry. Delivery length is normally 6 m or in coil.
Plastic or Synthetic	Plastic as a piping material has the advantages of being a lightweight, inexpensive material. It is resistant to corrosion from household chemicals, has very smooth interior walls, and is very easily joined. The disadvantages are: the low resistance to heat; the very high rate of expansion when heated; the lower pressure ratings and a lower crush resistance the metal pipes. There are generally two types of pipes: The flexible type and the rigid type.



**Flexible types:** Polyethylene (PE); Polybutylene (PB)

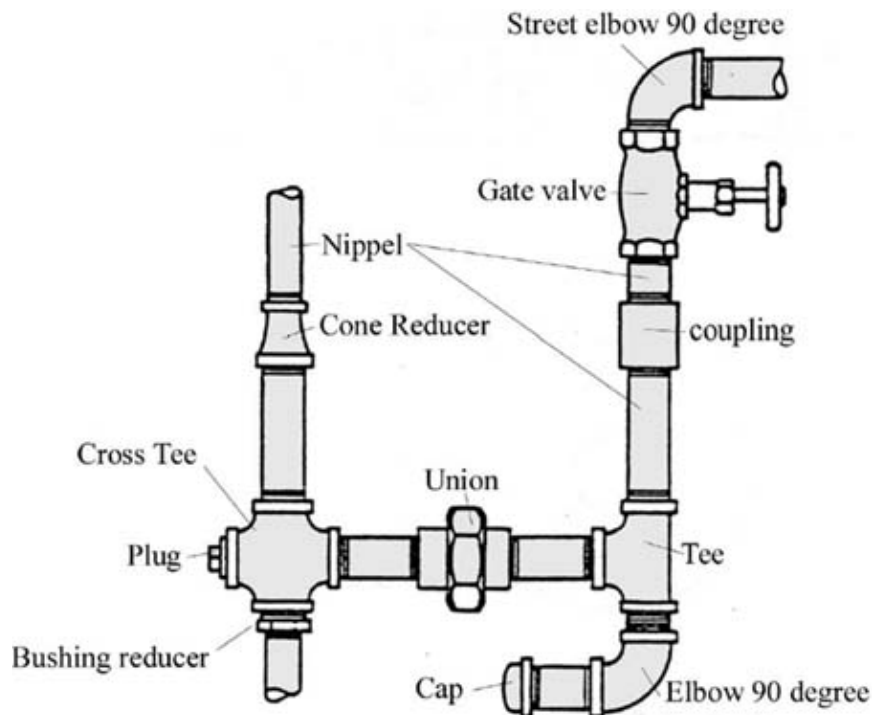
**Rigid type:** Polyvinyl chloride (PVC); Chlorinated Polyvinyl Chloride (cPVC); Unplasticized Polyvinyl Chloride (uPVC)

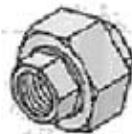
To prevent accidents by stumbling, the pipes should be stored properly in a pipe rack. To avoid mistakes in selecting the needed pipe, each sort of pipe should have its own subdivision within the rack. Each subdivision should be labeled with the material of the pipe, the size of the pipe and the purchase number. For example: **G.I. ½" # 40 – 1473358.**



### 3.2 Common Galvanized Fittings

Most pipe installations change somewhere direction and the size of the pipe are also often changing and not to forget it is necessary to control the whole system. This means that different pipe-fittings, valves and controls are necessary.

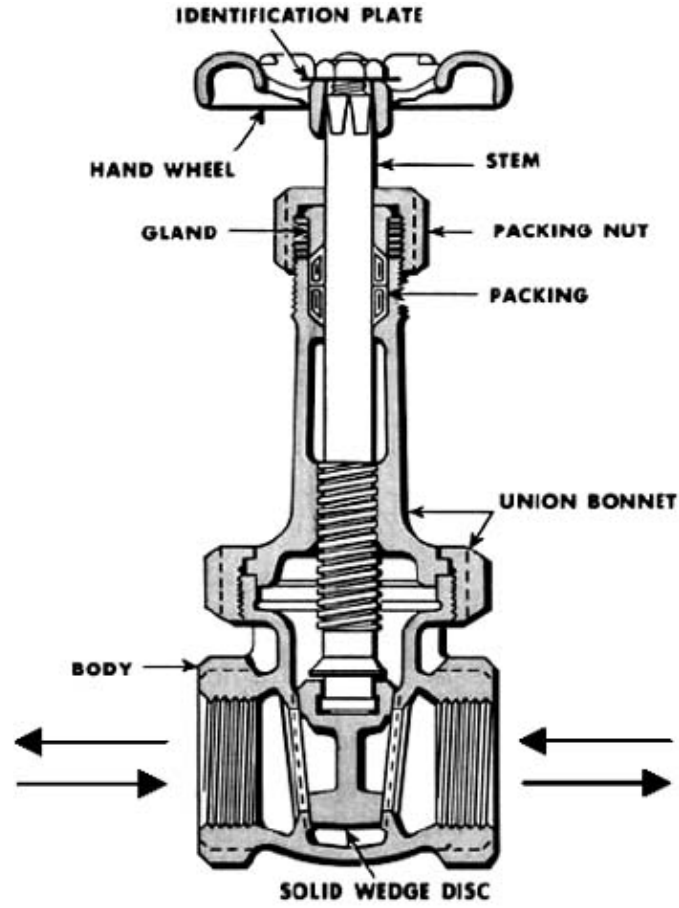




Other Fittings

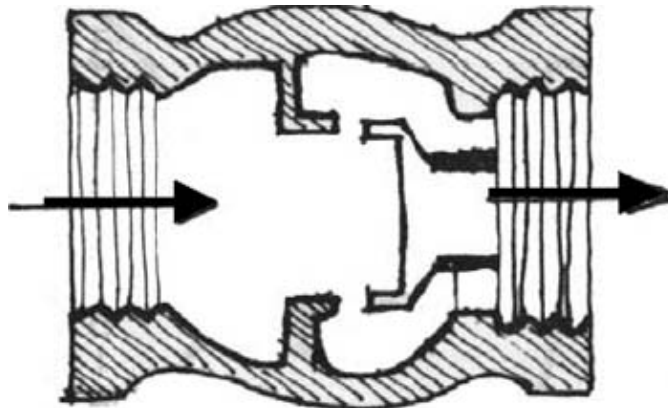
- .....
- .....
- .....
- .....

3.3 Common Valves



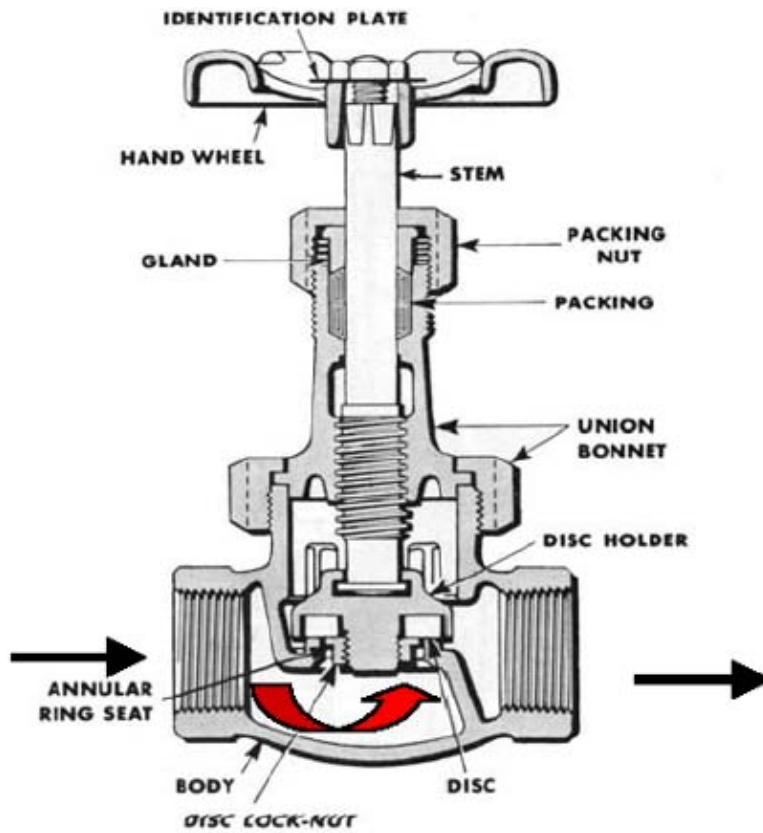
Gate Valve – Rising Stem Type

Gate valves, sometimes called full-way valves, are the most commonly used valves. They should be all the time either wide open or completely closed. They are usually not installed in piping systems where they will be opened or closed frequently. The wedge disk operates like a gate and fits in closed position against machined surfaces. They are available in different constructions e.g. with rising stem or the non-rising stem. Can be installed in both directions.



Check Valve

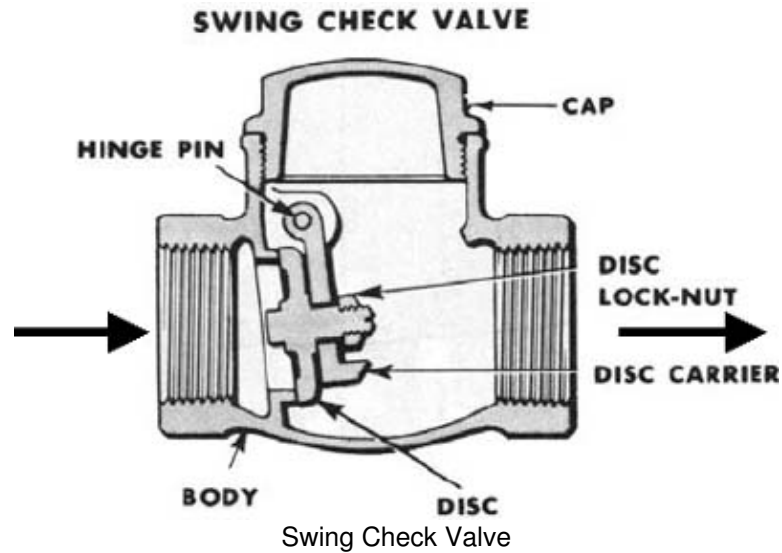
Check valves are used when it is necessary that the flow through a pipe should be always in one direction and there is a possibility of a flow, taking place in the opposite direction. **Check valves can be installed only in one direction.**



Globe Valve

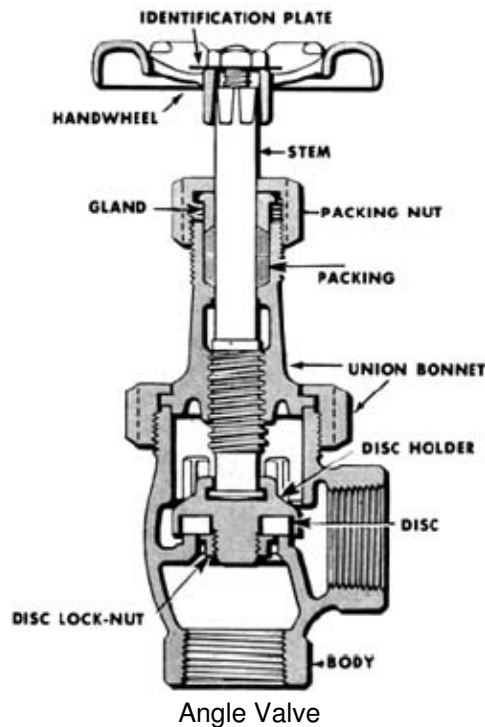
A globe valve is a compression type valve. The construction of a globe valve requires water flowing through it to change direction several times, causing turbulence, resistance to the flow of water, and a considerable pressure drop. The composition disk is replaceable made of different materials for use with water, hot water, chemicals etc.

**Globe valves can be installed only in one direction.**

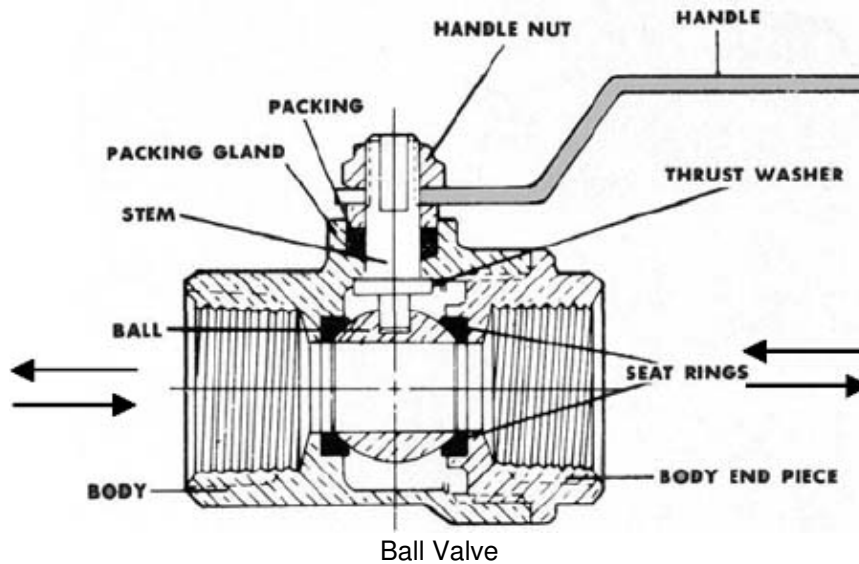


A swing check valve is a valve that permits the flow of water within the pipe in only one direction and closes automatically to prevent backflow. They offer quick, automatic reactions to changes in the direction of the flowing water.

**Swing valves can be installed only in one direction.**



Angle valves are globe valves in which the inlet and outlet openings are at a 90 ° angle to one another. It offers less resistance to the flow of water through it than a globe valve and a following 90 ° elbow. The use of an angle valve also reduces the number of joints and thus saves installation time. Globe valves and angle valves are recommended on installations that require frequent operation, throttling and/or positive shutoff when closed.



A ball valve is a valve in which the flow of fluid is controlled by a rotating drilled ball that fits tightly against a flexible seat in the valve body. It requires only a 90° rotation of the handle to open or close the valve. Ball valves are full-way valve that can be used for throttling.

### 3.4 Tools for laying out, fitting and installing pipes

#### Laying out

- Tape measure
- Plumb-bob
- Nylon cord
- Mechanical level
- Scriber
- Soapstone or pencil

#### Installation

- Teflon tape & pipe seal
- Pipe wrench
- Chain wrench
- Adjustable wrench
- Vise grip
- Hammer
- Cold chisel

#### Pipe Cutting & Threading

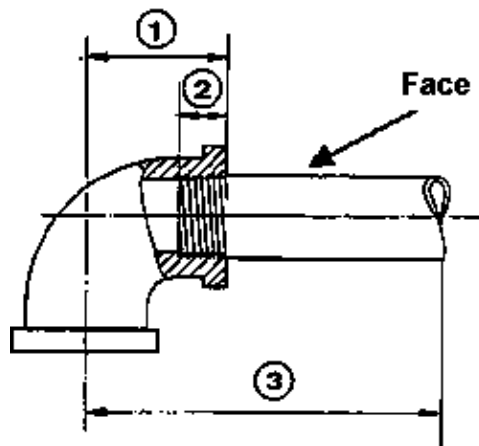
- Pipe vise
- Hacksaw
- Pipe cutter
- File half-round
- Deburrer
- Pipe threader manual
- Pipe threader machine type
- Cutting Oil
- Set of screw driver
- Set of combination wrench
- Universal pliers
- Electric drill machine
- Set of masonry drill bits
- Set of wall plug (TOX)
- Set of pipe clamps, fixtures
- Test gauge for final pressure test

## 4. Pipe Fitting Process for Galvanized Pipes

### 4.1 Measurement of Galvanized Steel Pipes

Like in other occupational areas measuring is one of the most important parts of pipe installation. Before you cut any pipe, exact measurements must be taken. Most likely for measuring pipes the tape rule is to be used. For marking out the use of scribe, pencil or soap stone is common.

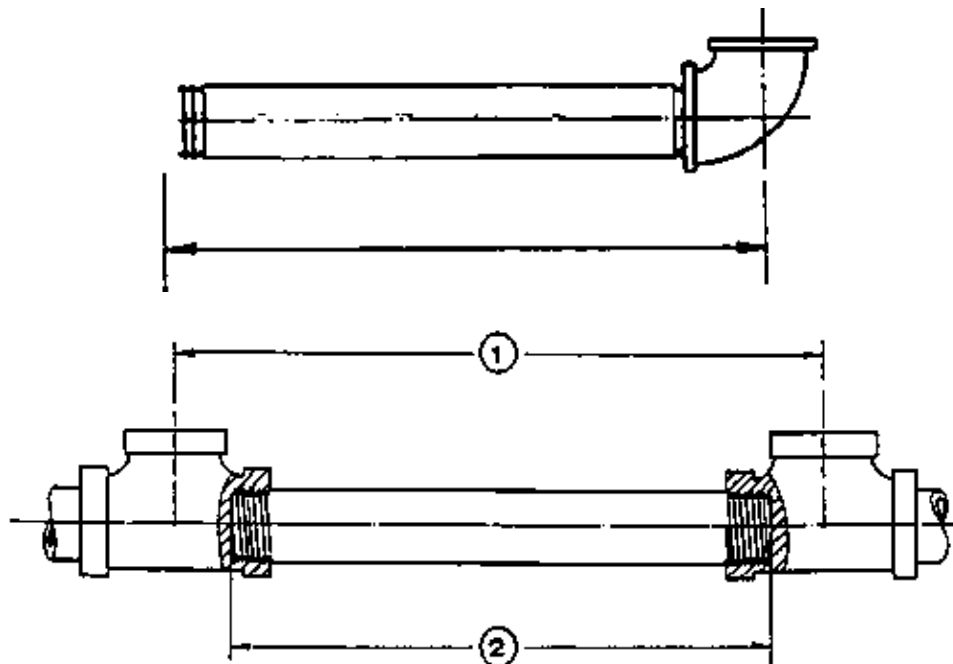
An accepted overall tolerance for pipe installations is 2 mm plus and 2 mm minus the demanded size. Below you can find some methods on how to measure properly.



- 1 = Center to face
- 2 = Engagement of thread
- 3 = Center of fitting to end of pipe measurement

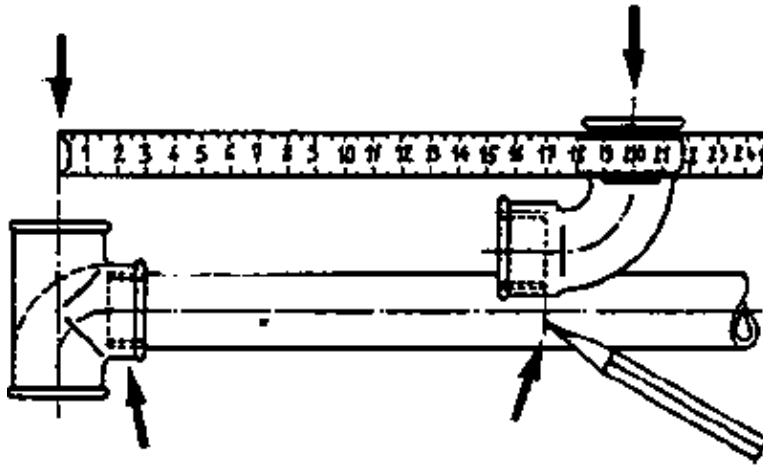
**Pipe length are generally measured by one of the following methods:**

End of pipe thread to center of fitting



- 1 = Center of fitting to center of fitting
- 2 = End of pipe to end of pipe

An "end of pipe to center of fitting" measurement is made by tightening the first fitting on the threaded end of a pipe. Then place the end of the rule exactly in the center of the next fitting, measure along the pipe and mark out the proper length, as shown in the illustration beside.



#### 4.2 Clamping Pipes

To cut pipes they must be fixed to prevent them from rotating. The pictures below show you some common holding devices.



Portable Tristand Chain Vice





Portable Tristand Yoke Vise



Bench Yoke Vise



Top Screw Post Chain Vise



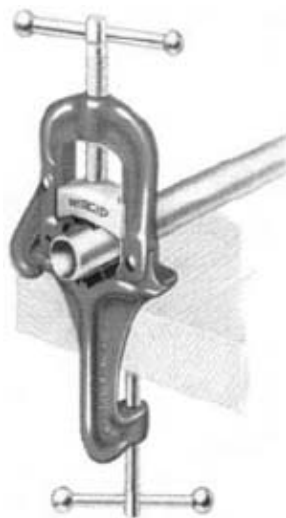
Top Screw Stand Chain Vise



Top Screw Bench Chain Vise



Bottom Screw Bench Chain Vise



Portable Kit Yoke Vise (Fits 4" Plank)



(Fits 4" Post)

### 4.3 Cutting Galvanized Pipes

Actually there are two common manual ways to cut galvanized steel pipes.

- Using a hacksaw
- Using a pipe cutter.

#### 4.3.1 Hacksaw

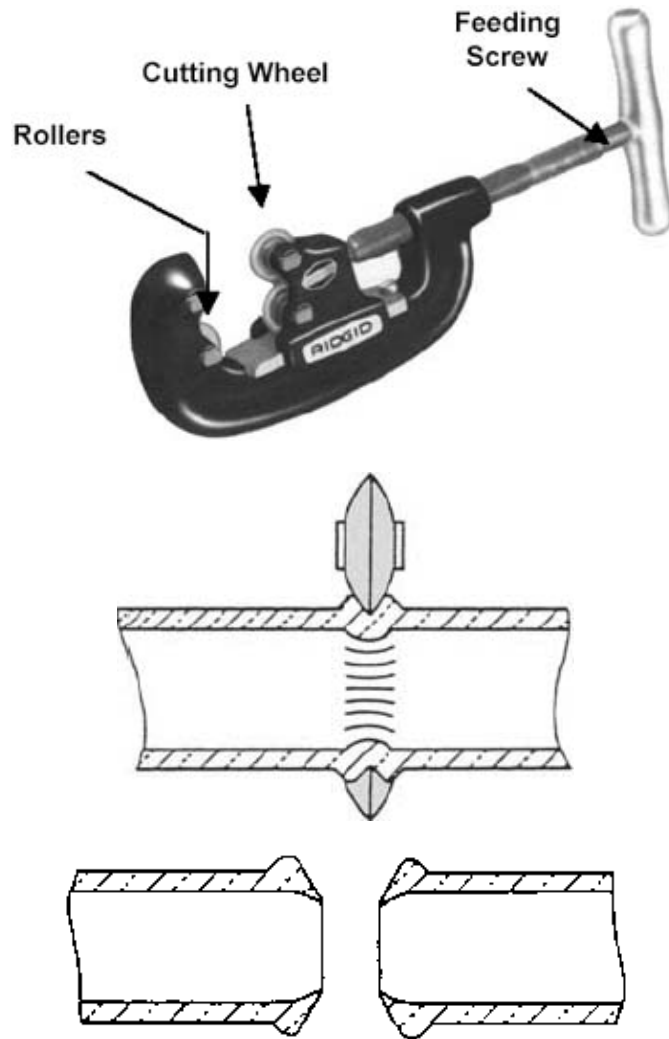
The hacksaw is the most important cutting tool for sawing metal to the required size. The following procedure is recommended:

- Before you start sawing, make sure you have measured and marked the correct length.
- Clamp the pipe as short as possible to prevent rotating during cutting and to prevent unnecessary vibration
- Use the edge of a file to make a notch at the marked position. This notch will make it easy to start with sawing.
- Saw with steady, even strokes, keeping the blade upright and square in the cut. Use the full length of the blade.
- Before finishing the cutting operation, the pipe must be supported with one hand. This will prevent the fall of the cut pipe and prevent the blade of the hacksaw being damaged.



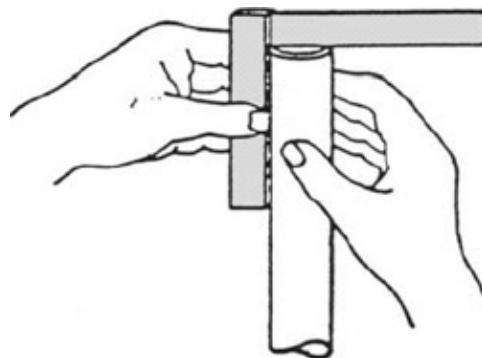
#### 4.3.2 Pipe Cutter

Actually this type of cutter does not remove any metal. The wheel squeezes the metal and forces it ahead of the cutter until the pipe is cut through. The operation is very easy. After mounting the pipe cutter to the pipe, tighten the feeding screw so that the cutting wheel is touching the pipe. Rotate the pipe cutter around the pipe. After the first or second turn, check that the cutting wheel is hitting exactly the scribed line. Keep rotating and every two or three turn's use the feeding screw to put some more pressure on the cutting wheel. Before the cut is completed support the pipe with your left hand so that it does not fall. Since cutting the pipe in this manner leaves a large ridge on the inside of the pipe, which would obstruct the flow, the pipe must be de-burred or reamed with a file or a pipe reamer.

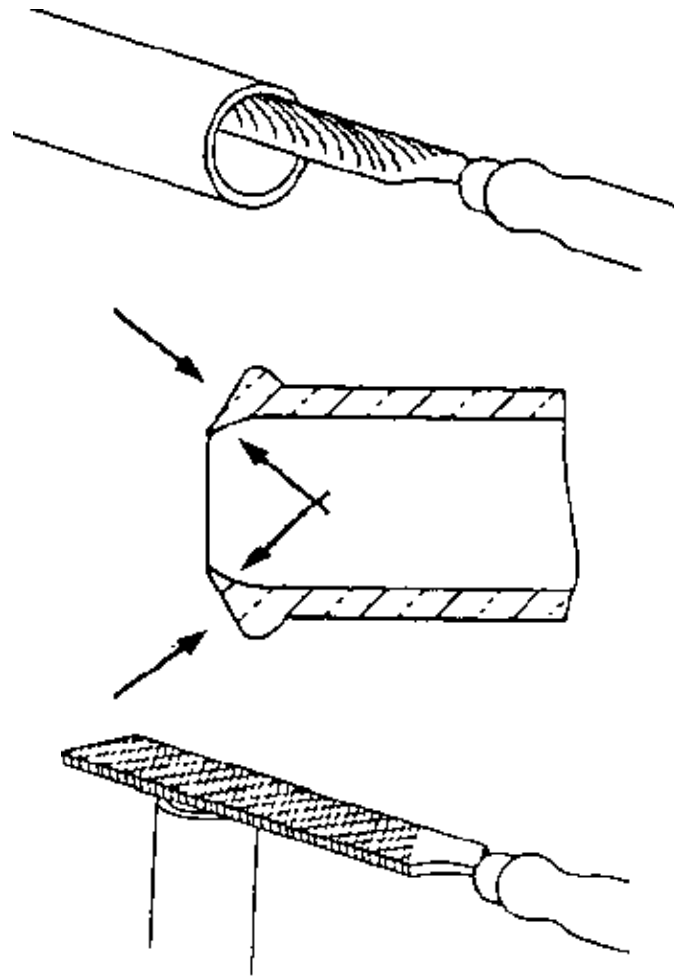


#### 4.3.3 Filing and De-burring the Pipe

After cutting the pipe check the square ness of the pipe end. If it is necessary file it to the right angle.



Remember, the installation of a pipe system should be done accurately. This means, that the pipes should be free from any burr inside or outside.

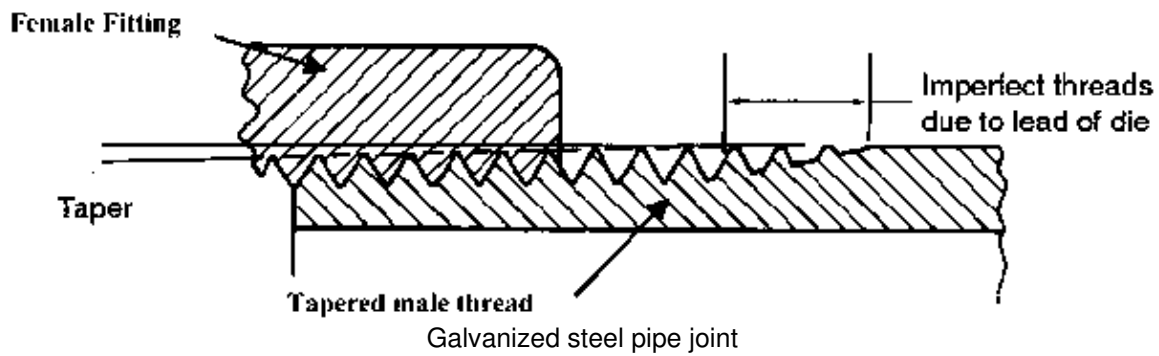


#### 4.4 Manual Pipe Threading

When using galvanized pipes for installations most likely both ends of the pipe will have a thread. Since all pipefittings are tapered with the internal (female) pipe thread during manufacturing, the pipe fitter has to cut only the external thread.

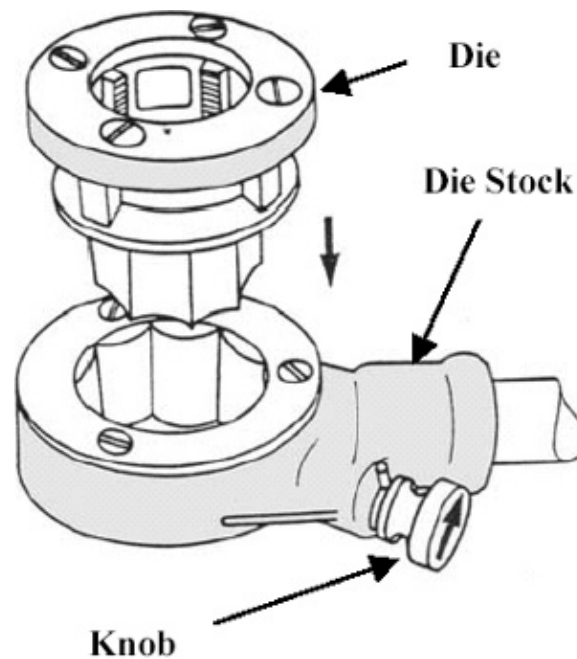
#### Characteristics of Tapered Pipe Threads according to the ANSI and ISO Standard

Nominal Pipe Size	Threads per Inch	Appr. Length of threads	Appr. Number of threads to be cut
1/8	27	3/8	10
1/4	18	5/8	11
3/8	18	5/8	11
1/2	14	3/4	10
3/4	14	3/4	10
1	11 1/2	1	11
1 1/4	11 1/2	1	11
1 1/2	11 1/2	1	11
2	11 1/2	1	11

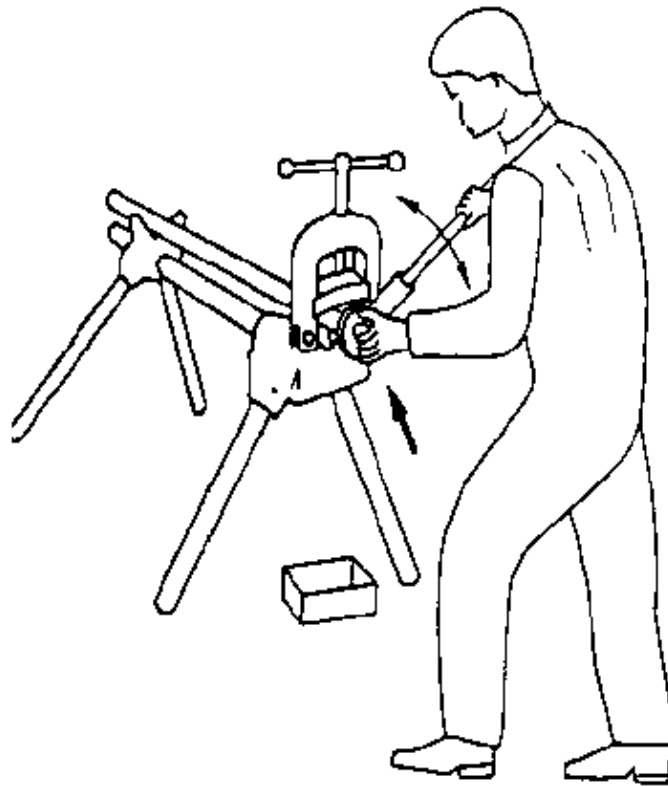


#### 4.4.1 Thread Cutting Procedure

- Select the correct die head
- Put the die head in the ratchet socket using the knob to open and close the socket
- Check the correct position of die head
- Fix the pipe in a suitable vice (pipe extension within 150 mm to 250 mm)
- Apply a cutting lubricant to the part, which is to be threaded. During threading apply from time to time some new lubricant. Catch the dropping down lubricant and the chips in a box. Otherwise it will contaminate the floor and make it slippery.



- Bring the die-stock to the pipe and apply a little pressure to the stock. Keep the handle at right angles to the pipe axis. Rotate the handle clockwise with slight pressure towards the pipe, at right angles to the pipe axis.
- When the dies "bite" into the pipe, stop pushing and simply continue the rotation, by moving the handle up and down.

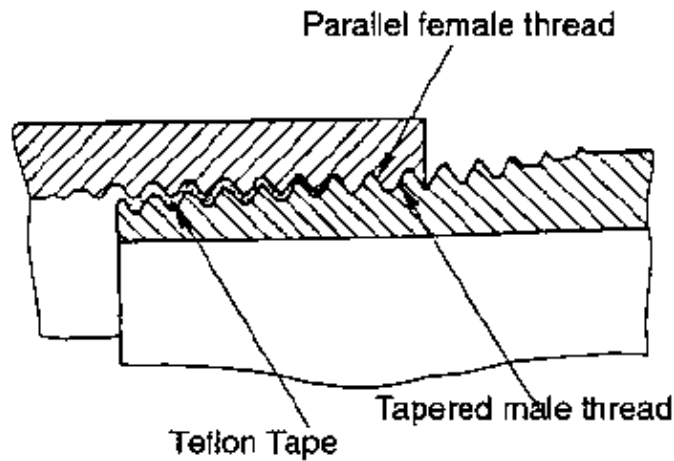


- If the die sticks there are probably some metal chips in the way. To break the metal chips reverse the knob and move the die anti-clockwise for half a round. Then proceed with cutting.
- After cutting the full length of thread reverse the knob and move the die anti-clockwise until you can take it off.
- Finally, clean off the threads with a wire brush and some cleaning rag.
- Test the thread with a fitting (elbow or tee). If it is too tight, adjust the dies again and repeat the threading operation.
- Finally clean the stock and die and store them properly.

#### **4.5 Assembling Galvanized Steel Pipes**

A pipe fitter's basic skill is to assemble, join and install pipe systems. He must know what kind of joint to use for different kind of piping materials, and must be able to make this joint absolutely watertight. Joints should not leak.

When you start to join or assemble galvanized pipes and fittings, you must know that the parallel female thread and the taper male are, without doubt, the most common type of connection.



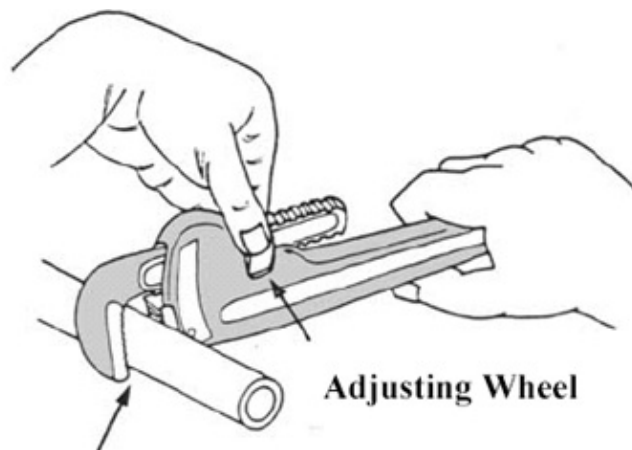
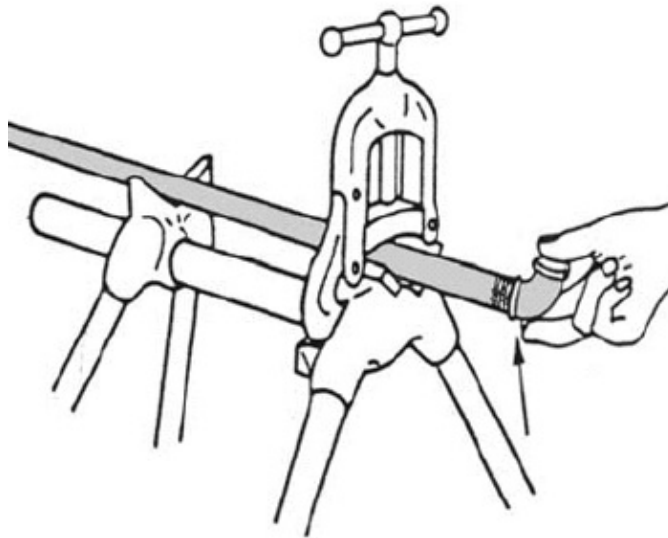
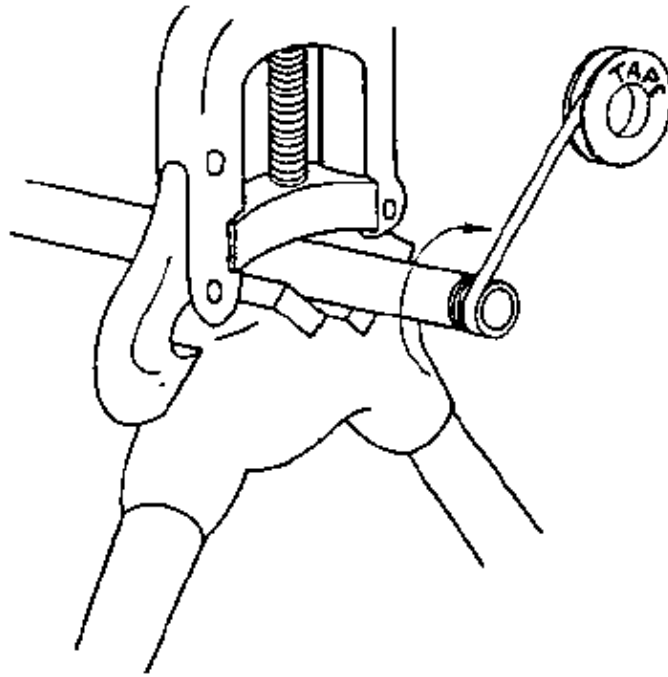
**Procedure of Assembling:**

- Fix the pipe in an applicable pipe vice
- If necessary clean the pipe with a steel brush or a cleaning rag
- Make sure that the pipe is also clean inside. Remove any burr and other materials
- To make a sound screw joint, threads must engage freely and it should be possible to turn the fitting for the first few turns by hand without any difficulty
- Wrap "Teflon" tape round the male thread in the same direction as the male thread. **Do not apply sealing compound.**

Screw the pipe fitting onto the end of the galvanized pipe by hand as far as it will go

- Now use a pipe wrench. Adjust the wrench to the right size while using the adjustment wheel.
- Continue the screwing process, using gradual, even increase in force to tighten the threads together. Do not over-tighten the fitting. This can cause a pipe fitting to split.
- If you assemble two pipe joints (a fitting in between) then use two pipe wrenches.
- To assemble pipes with a diameter bigger than 2", the use of a chain wrench is sometimes recommended. But do not use it for diameters below 2". Otherwise the pipe might be flattened or damaged.



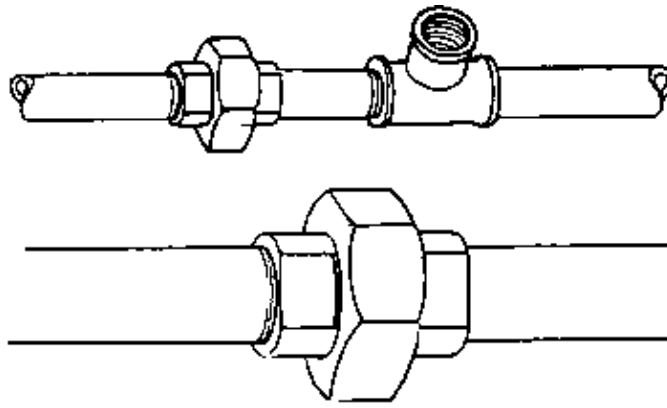


**Adjustable Jaw**

**Adjusting Wheel**

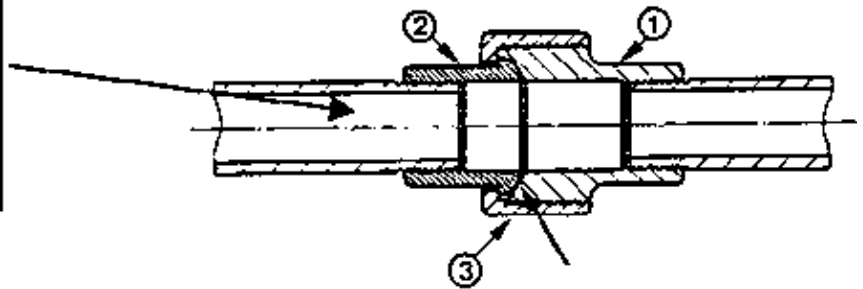
**Union:**

When the threaded ends of two pipes meet, the best way to assemble them, or connect them, is to use a union. This makes it easy to take the pipe system apart for repairs.



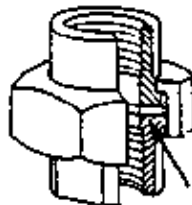
A union is a device used to connect pipes. It usually consists of three pieces:

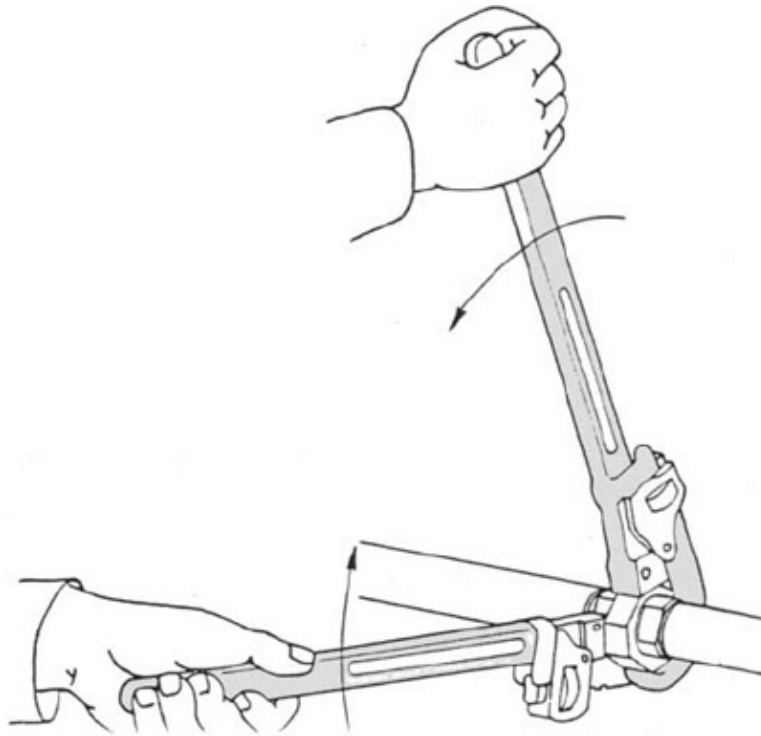
- 1** - The "thread end" fitted with female and male threads
- 2** - The "bottom end" fitted with female threads
- 3** - The ring, which has an end inside flange at one end



Actually there are two different types of unions available:

- One with a ground joint, which does not acquire a sealing to make the connection watertight.
- One, which requires a soft rubber, leather or "Teflon" washer to make the connection watertight.





**Note:**

A little grease on the union joint ensures easy disconnection.

Use two pipe wrenches to assemble or tighten the union. Hold one side of the union in one pipe wrench and the ring of the union in the other.

Turn the two pipe wrenches gently in opposite directions until it is tighten.

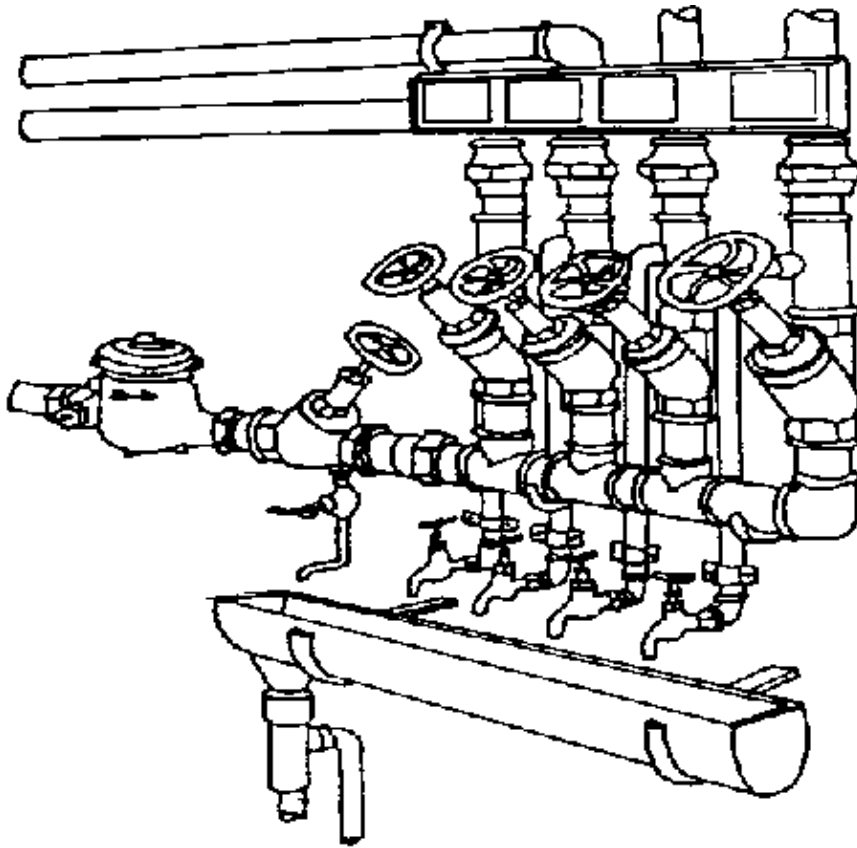
#### **4.6 Installation of Valves**

A valve is a fitting installed in a piping system to control the flow of fluid within that system in one or more of the following reasons:

- To turn the water on
- To turn the water off
- To control the direction of the water flow
- To regulate pressure or to relieve excess pressure

To accomplish these methods of control over the fluids within the piping system, pipe fitters install the following types of valves.

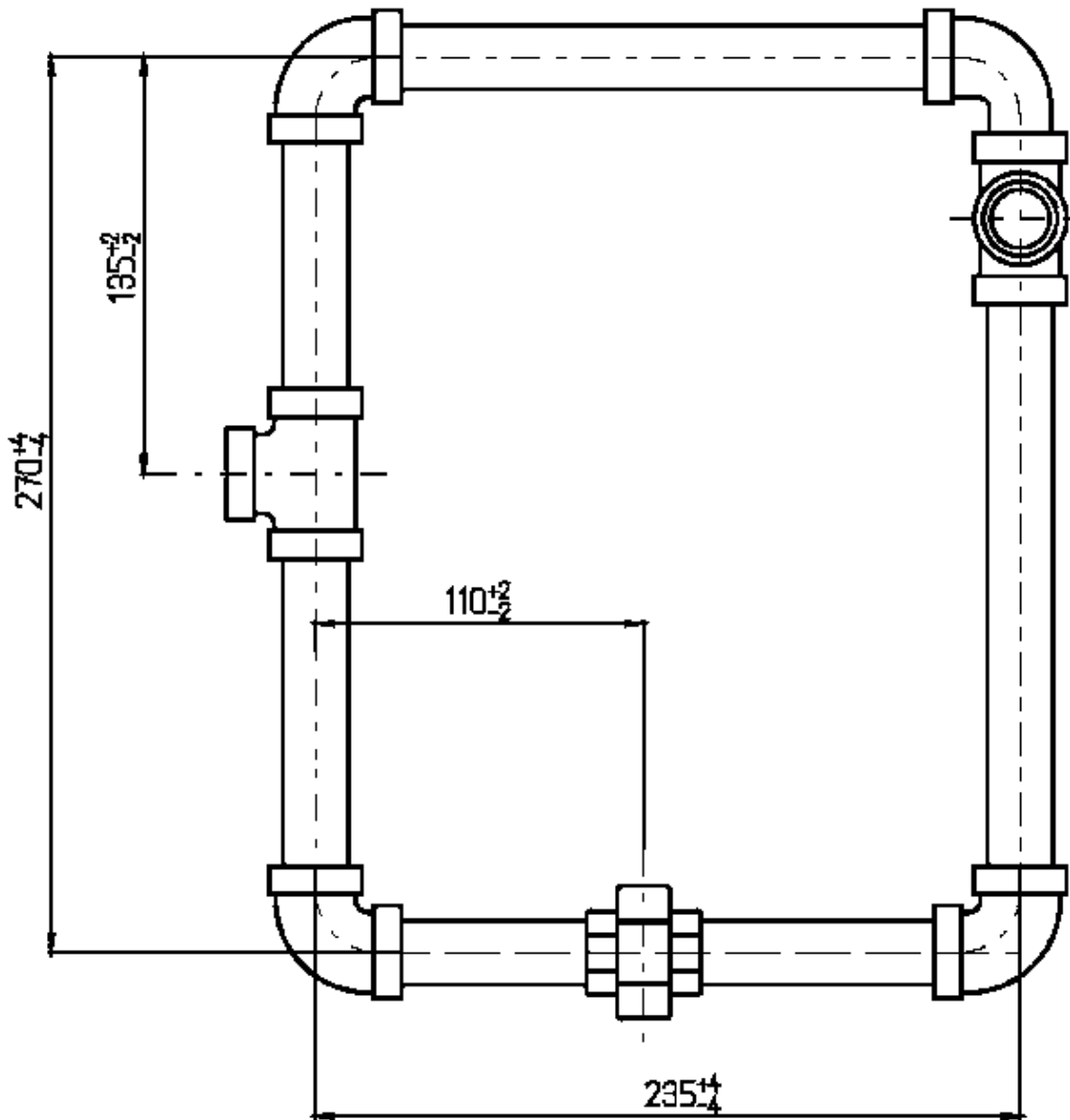
- Gate valve
- Globe valve
- Ball valve
- Check valves
- Angle valve



**Sample of a water distribution system:**

Each of the four (4) lines can be closed separately. The access water of each line can be emptied separately.

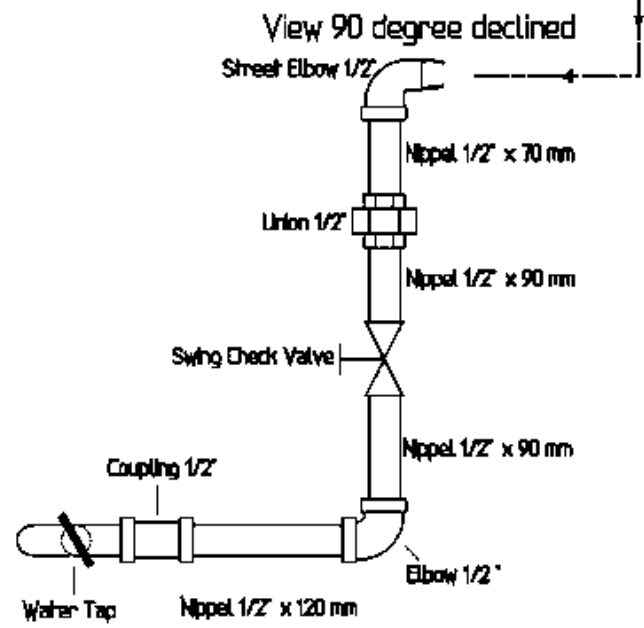
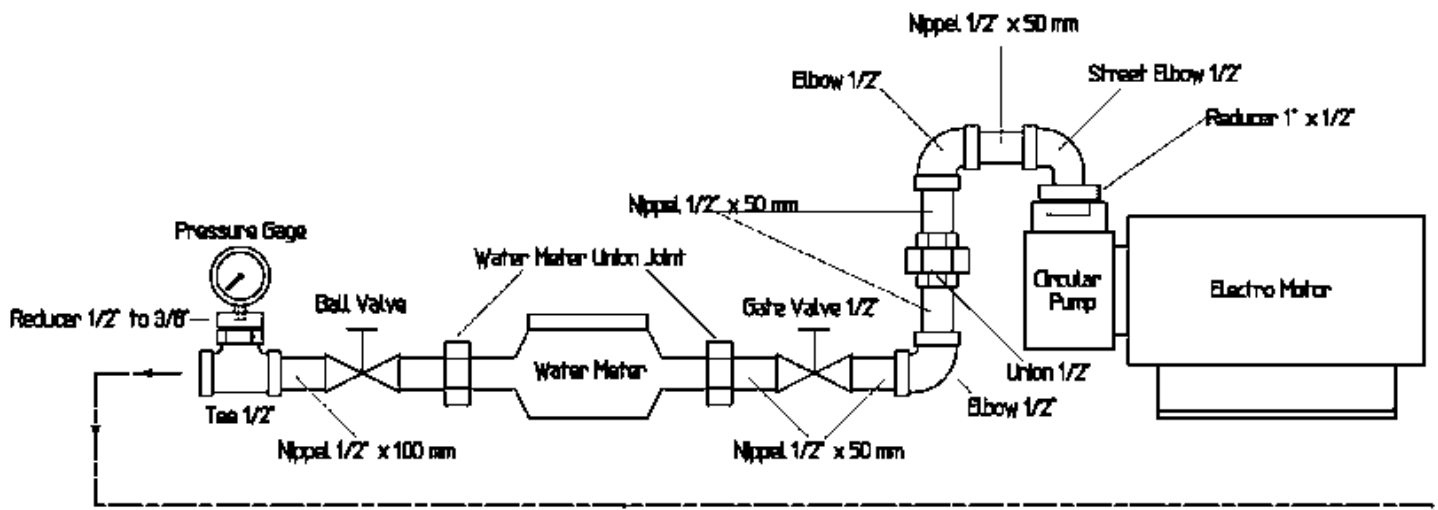
**Practical Exercise No. 1 – Assembling 1/2 " Galvanized Steel Pipe System**



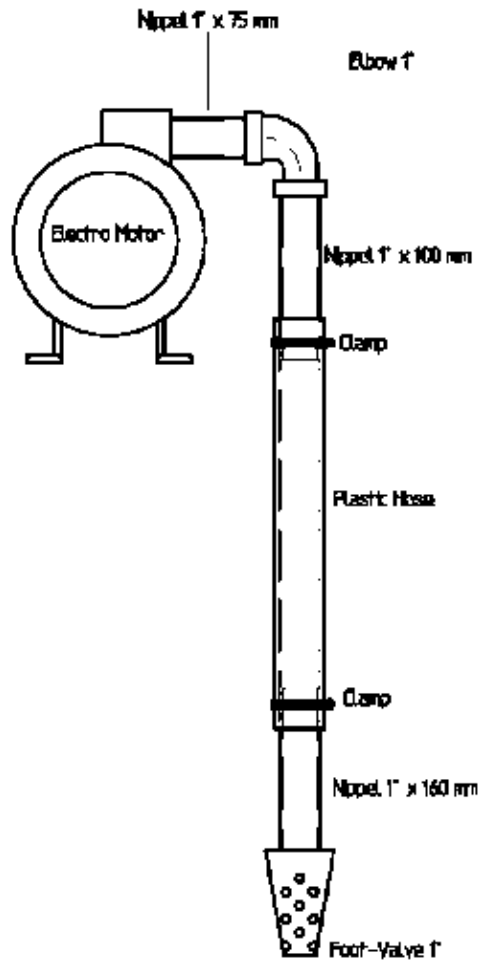
**Instructions:**

1. Study the technical drawing and identify the different fittings
2. Calculate the length of nippel according to the overall measurements given in the technical drawing.
3. After laying-out use a hacksaw to cut the pipes to the necessary length. Do not forget to remove the burr.
4. Use a pipe vise and a 1/2 " die set and cut the threads. Do not forget to apply sufficient cutting fluid.
5. Assemble the pipes and fittings according to the technical drawing. Use Teflon tape for sealing.
6. Test the piping system against leakage.
7. Ask your supervisor for a final evaluation of the project.
8. Dismantle and store all parts properly.

**Practical Exercise No. 2 – Water System Installation**



### Side View



### Practical Exercise No. 2 – Water System Installation

After installing the water system:

1. Measure the time (in seconds) it will take to fill a water pale. Check the pressure in the pipe system reading the pressure gage.

Time t = ..... Seconds  
Pressure P= ..... PSI

After connecting the water hose to the water tap:

2. Measure the time (in seconds) it will take to fill a water pale. Check the pressure in the pipe system reading the pressure gage.

Time t = ..... Seconds  
Pressure P = ..... PSI

After changing the pipe system from 1/2" to 1" diameter:

3. Measure the time (in seconds) it will take to fill a water pale. Check the pressure in the pipe system reading the pressure gage.

Time t = ..... Seconds  
Pressure P = ..... PSI

Conclusions:

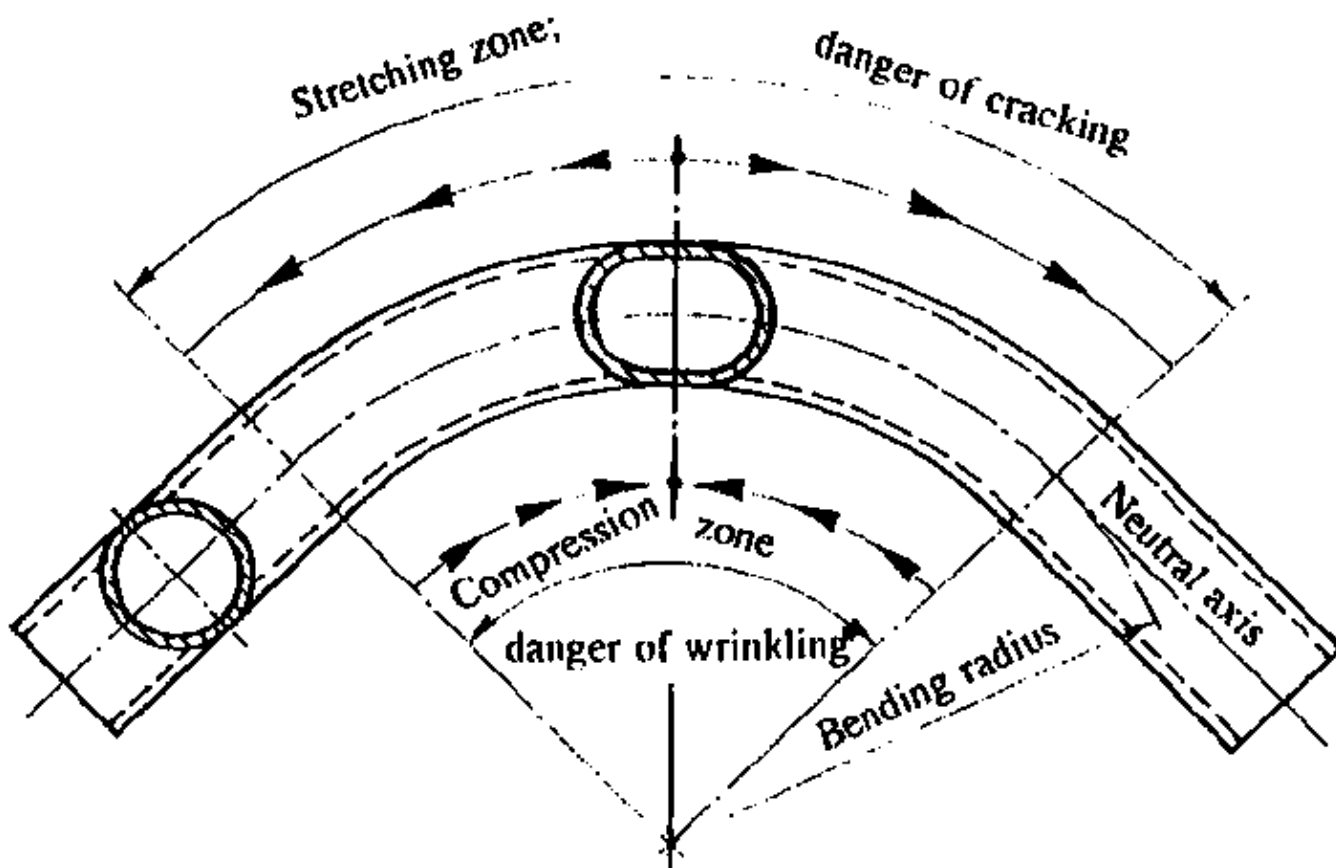
When the pipe diameter is smaller in diameter the pressure (p) will be ..... and the Volume (Q) of water delivered per minute will be .....

When the pipe diameter is bigger in diameter the pressure (p) will be ..... and the Volume (Q) of water delivered per minute will be .....

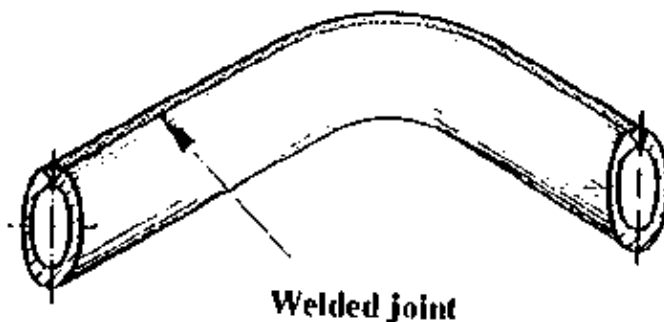
## 5. Bending Principles

### 5.1 Cross-Sectional Deformation

When bending, the outer portion of the workpiece is stretched and its inner portion is compressed. This means that the outer portion is subjected to tension while the inner portion is subjected to compression. The neutral axis of the workpiece should not be affected by tension or compression.



Cross-sectional deformation during bending



The welding seam should be the neutral axis during bending



## 5.2 Minimum Bending Radius

If the tension is too great the farthest distance from the neutral axis becomes the **danger zone**, particularly if the tensile strength of the material is exceeded when it is being pressed. Through the stretching on the outer radius, a crack will develop, or in the inner radius, a wrinkle will be formed on the pipe. In order to eliminate cracks and wrinkles, the bending radius must be calculated accurately.

**The bigger the bending radius, the smaller the possibility for cracks or wrinkles to occur.**

For all pipes, there is a minimum-bending radius. The bending radius depends on the material, so with the pipe diameter, wall thickness and heating temperature.

**The minimum-bending radius for steel pipe is calculated as follows:**

Cold bending:

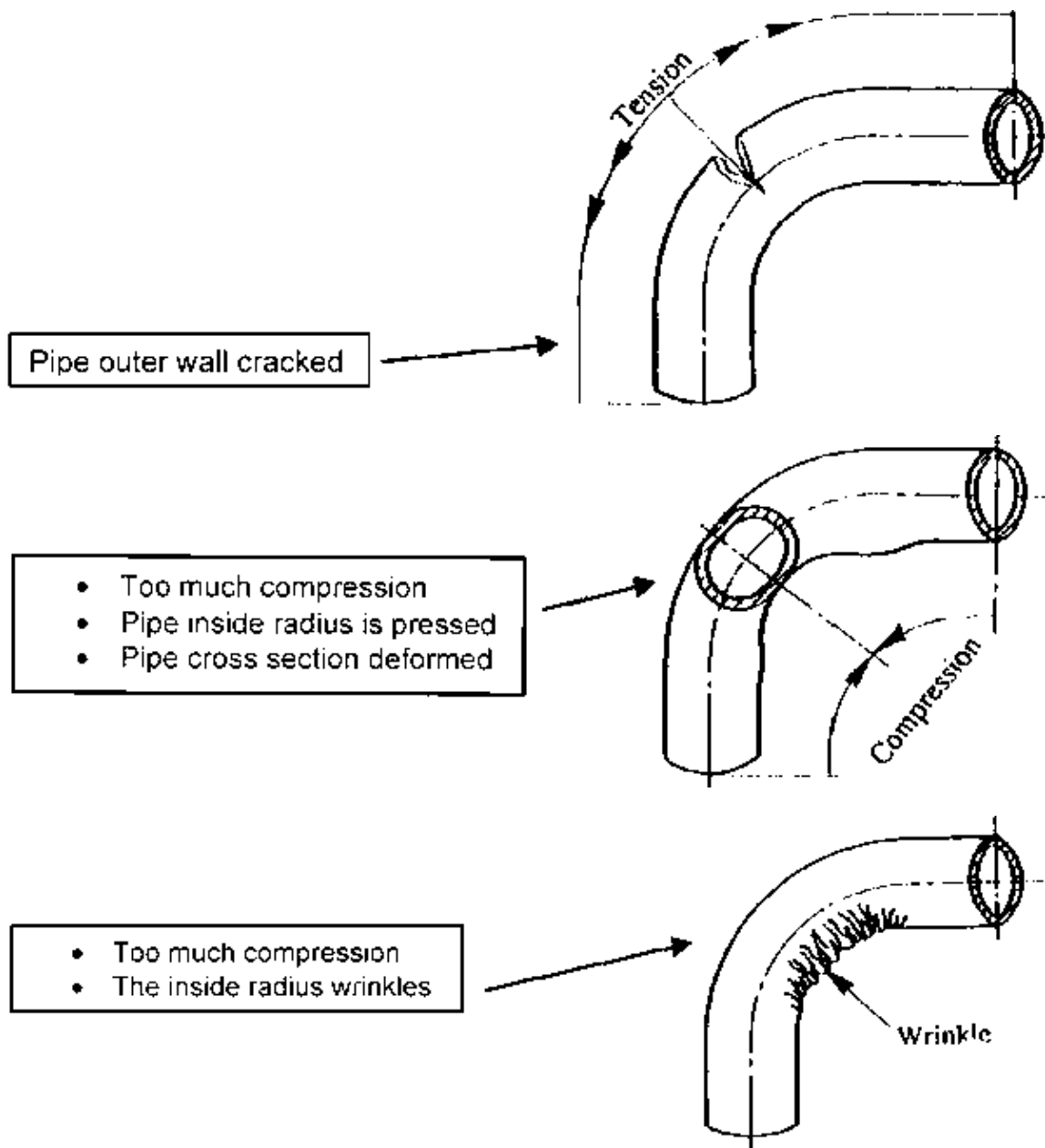
Radius = appr. 10 x outside diameter

Hot bending:

Radius = appr. 4 x outside diameter

With other bending machines and devices:

Radius = appr. 2 x outer diameter

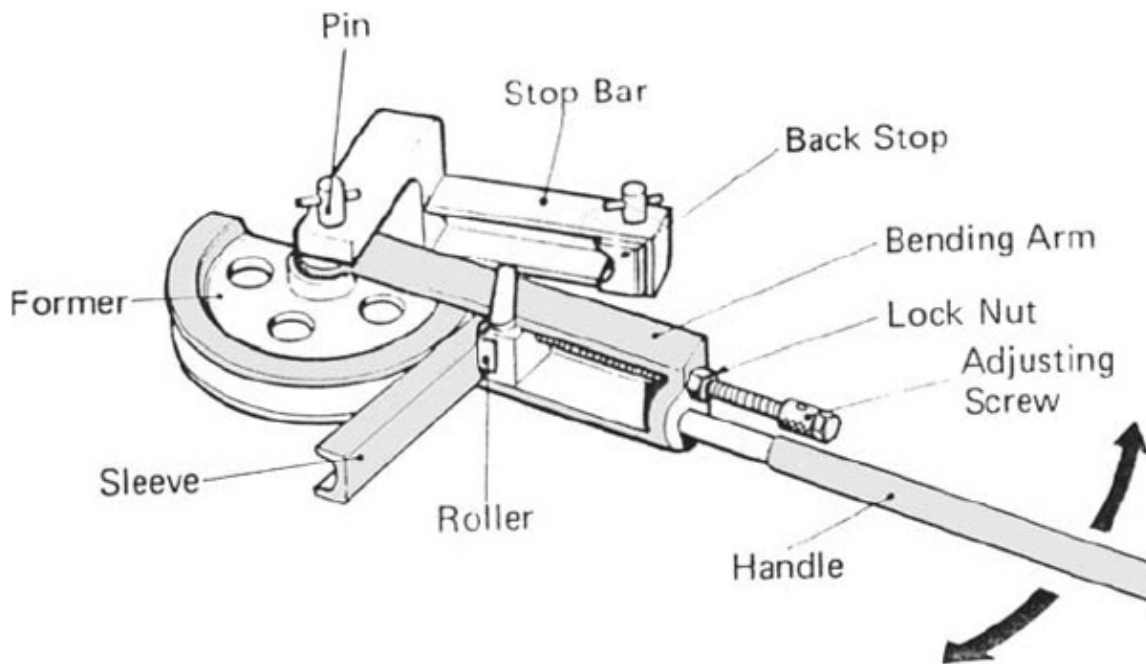


## 6. Cold bending of Pipes

Pipes are cold bent to minimize the need for expensive connectors and to reduce the cost of installing pipe systems. Bending may be done by hand or machine. The machines may be hand or power operated. There are two common bending machines. During this seminar only the Hydraulic Pipe Bending Machine will be discussed.

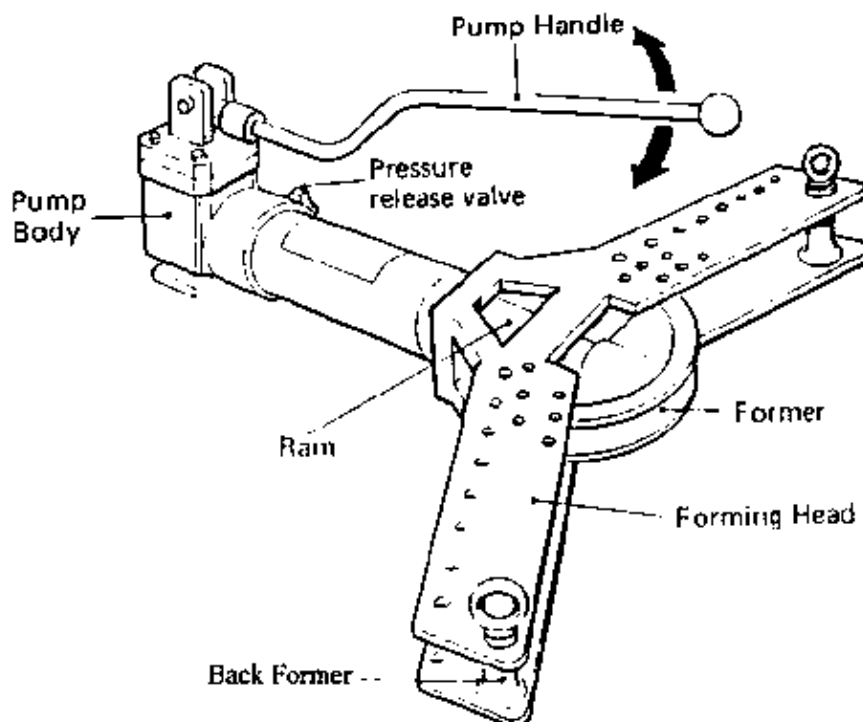
### Hand Compression Pipe Bending Machine

This type is used to bend carbon steel pipes up to 1/2 " steel pipes and copper pipes up to 1 " diameter.



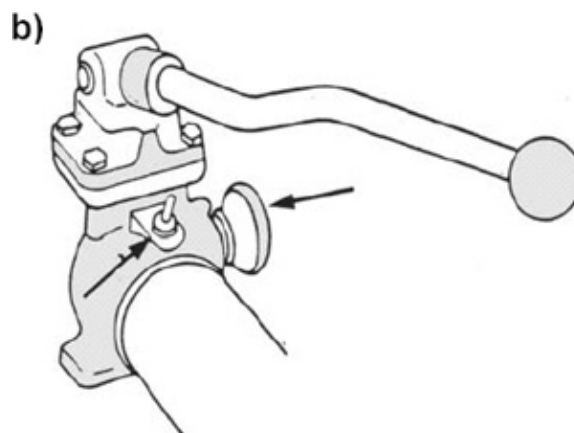
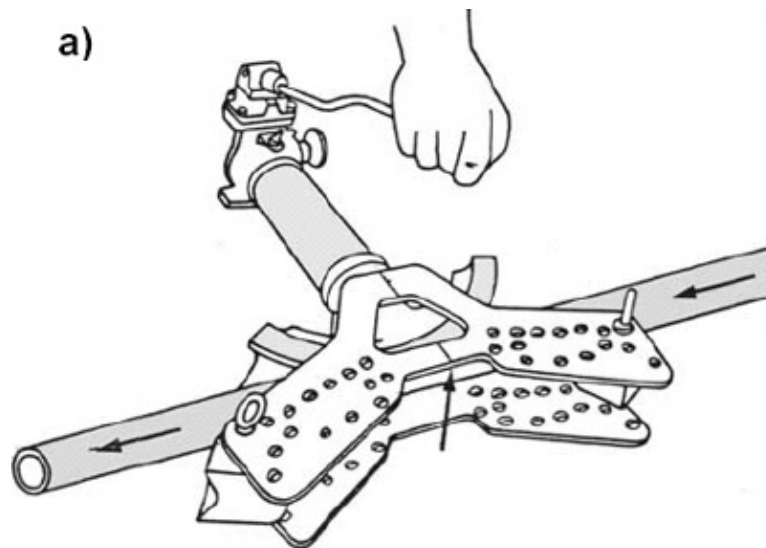
### Manually operated Hydraulic bending Machine

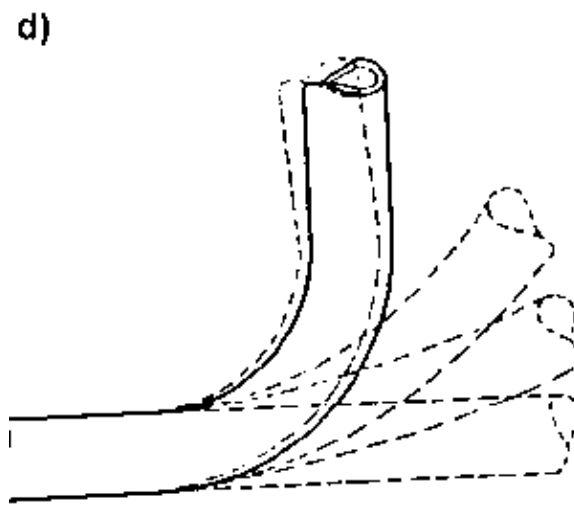
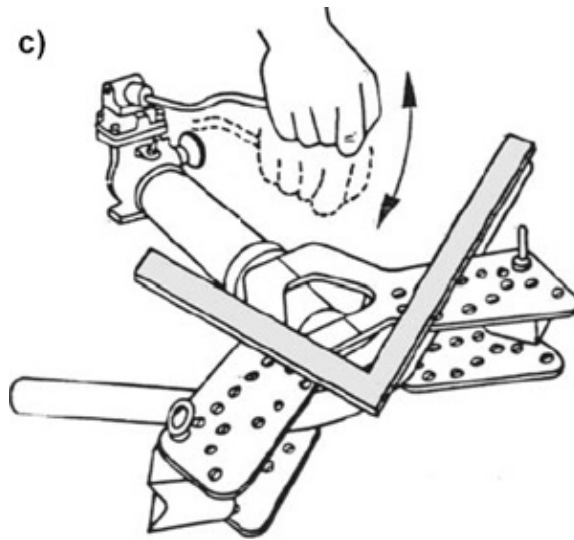
This machine uses hydraulic pressure to bend steel pipes of 1/2 " to 2 " diameter.



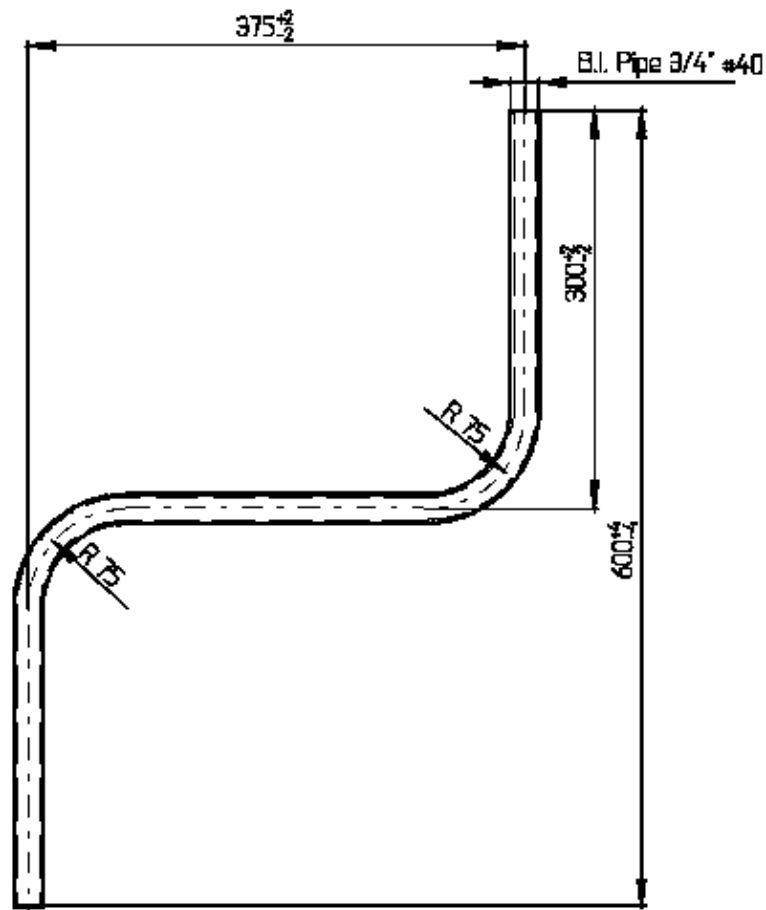
## Hydraulic Pipe Bending Procedure

- a) When using a hydraulic pipe bender, it is necessary to use suitable pipe length. Calculate and measure the pipe before you start to bend. See at chapter 1, Technical Mathematic.
- b) Mark out the center of the bend. This mark will be placed aligned to the center of the former.
- c) Before you start to use the hydraulic bender ensure that the correct size of the former is attached to the hydraulic ram (e.g. 2" former for 2" pipe)
- d) Place the two back formers in the correct holes in the base plate (depending on the pipe diameter).
- e) Feed the pipe in between the former and the two back formers. Check the center marking line of the pipe with the marking of the machine – picture **a**).
- f) Close the pressure release valve and the bleed screw before start to bend – picture **b**).
- g) Start pumping the hydraulic ram forward. Check once again the right position of the pipe in the former. Keep pumping the handle until the correct angle is obtained. Check the angle with a template or a long (adjustable) square – picture **c**).
- h) Be aware that there is because of the flexibility of the metal a so-called "**spring back**" effect. The pipe will not hold the reached bend angle completely after finishing with pumping. Because of this effect bend the pipe a few degrees more – picture **d**).





**Practical Exercise No. 3 – Cold Bending with Hydraulic Pipe Bender**



#### Instructions:

1. Study the technical drawing and calculate the cutting length.
2. Cut the calculated length of pipe and deburr it properly.
3. Mark the center for the two bends.
4. Bend the first bow following the instruction given in the "**Hydraulic Pipe Bending Procedure**".
5. To bend the second bow, clamp the pipe in the hydraulic pipe bender and level the pipe using a spirit level. Bend the second bow.
6. Control all measurements and angles. If necessary try to correct them.

## 7. Hot Bending of Pipes

The use of bends in a pipe work system **minimizes** the number of expensive angle fittings, reduces resistance at the bend to the flow of liquids or gases, and allows pipe runs to be installed around obstructions.

Hot bending methods are used where the required bend radius cannot be formed by machine or the pipe wall is too thick, or too thin to be bent cold.

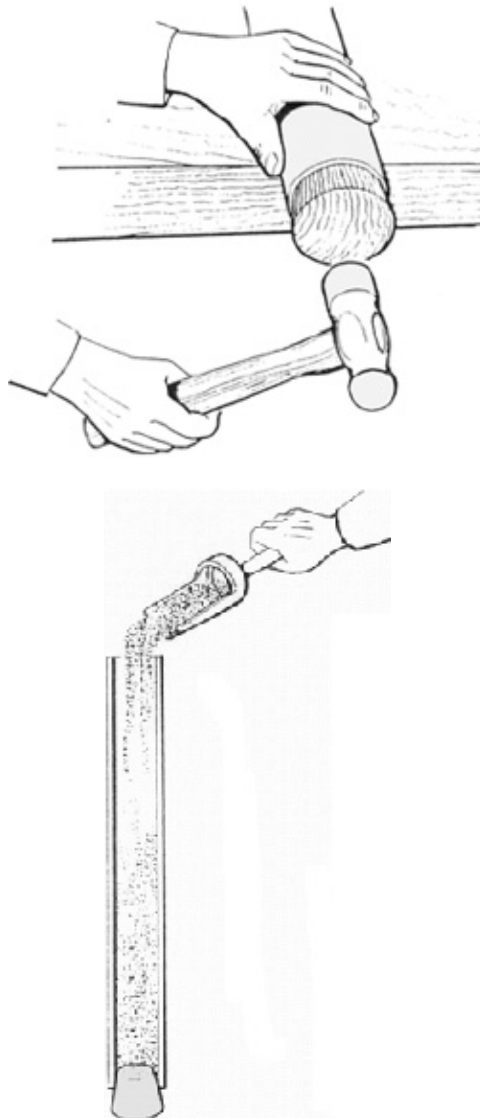
### 7.1 Bending Pipes using Sand Filling

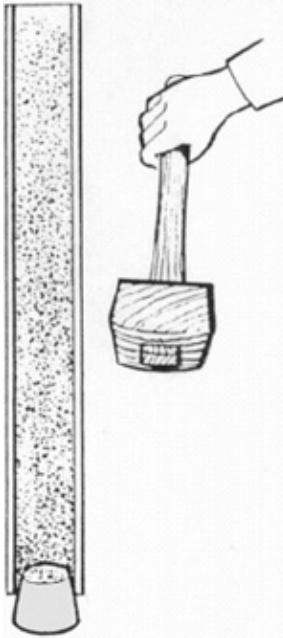
Carbon pipes over 25 mm bore should be filled with **dry sand** so that the pipe wall does not collapse or wrinkle during the hot bending operation. When bending smaller bore pipes, the collapse or wrinkling of the

wall is less likely to occur. This is due to relationship between the bore and wall thickness. Sand filling in these instances is unnecessary.

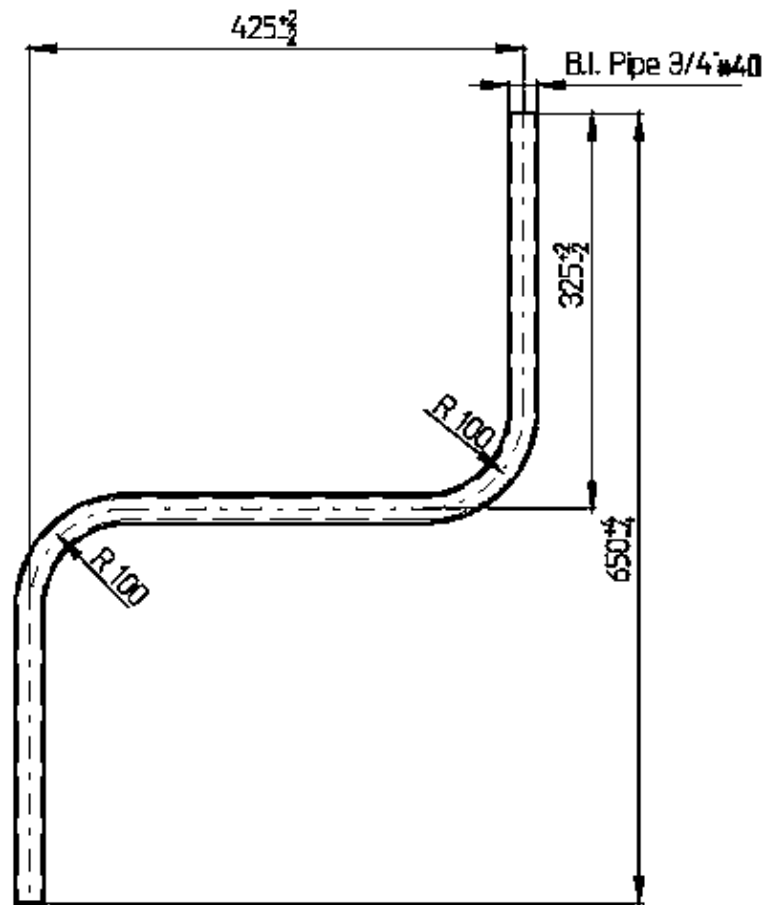
**Procedure:**

- a. Check that the material, bore and schedule of the pipe are as specified as on the drawing.
- b. Seal one end of the pipe with a **wooden plug**. Avoid driving the plug with too much force, as this will widen the pipe diameter.
- c. Fill the tube with **dry sand**, tapping the pipe slightly along its length with a wooden mallet or a piece of wood to ensure that the sand is tightly compacted. As the sand becomes compacted and its level falls, top up with dry sand and continue to tap the pipe with the mallet until filled.
- d. Seal the open end of the pipe with a second plug. When the pipe is filled with compacted sand. The pipe is now ready for heating and bending.





**Practical Exercise No. 4 – Manual Hot Bending**

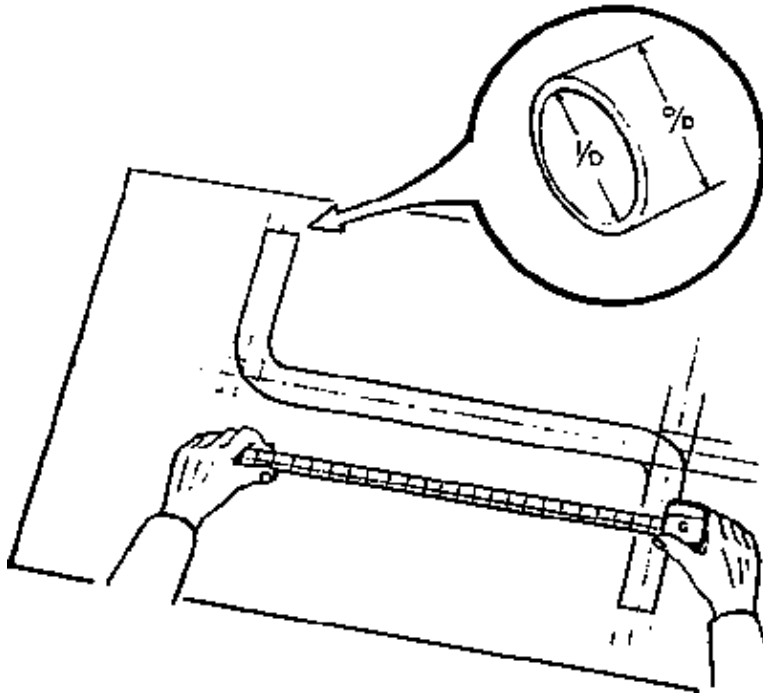


**Instructions:**

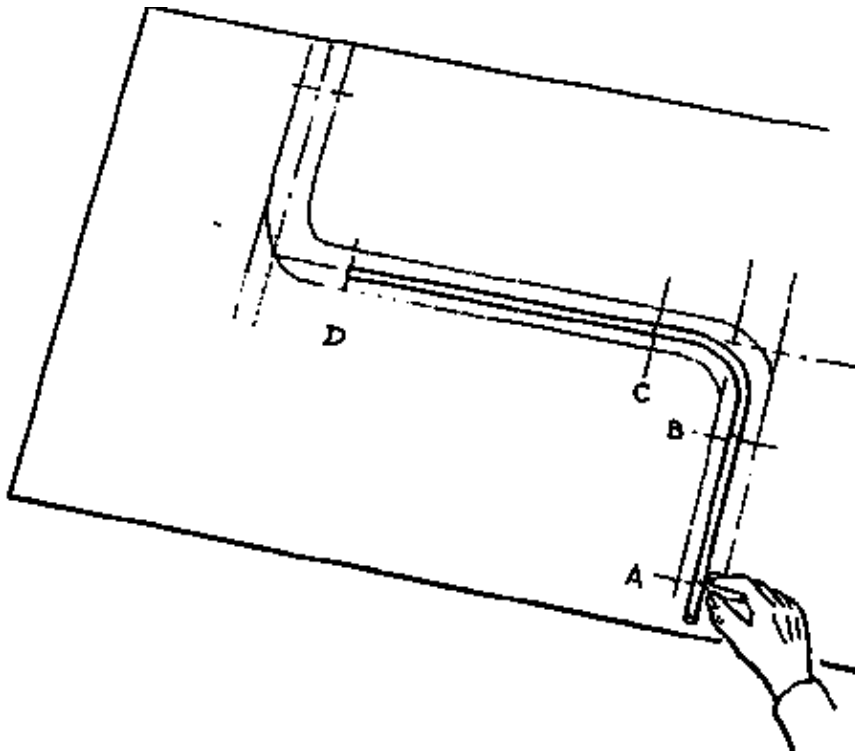
1. Study the technical drawing and calculate the cutting length.
2. Cut the calculated length of pipe and deburr it properly.
3. Mark the center following the "Template Method" or the "Calculation Method"
4. Bend the pipe following the instruction given in next pages.
5. Control all measurements and angles. If necessary try to correct them.

## 7.2 Hot Bending a double 90° bend, using a template wire

Make a full size chalk drawing of the bend, the center line, outlines, radii and leg length on the bench or floor showing Ensure that the correct outside diameter is drawn.

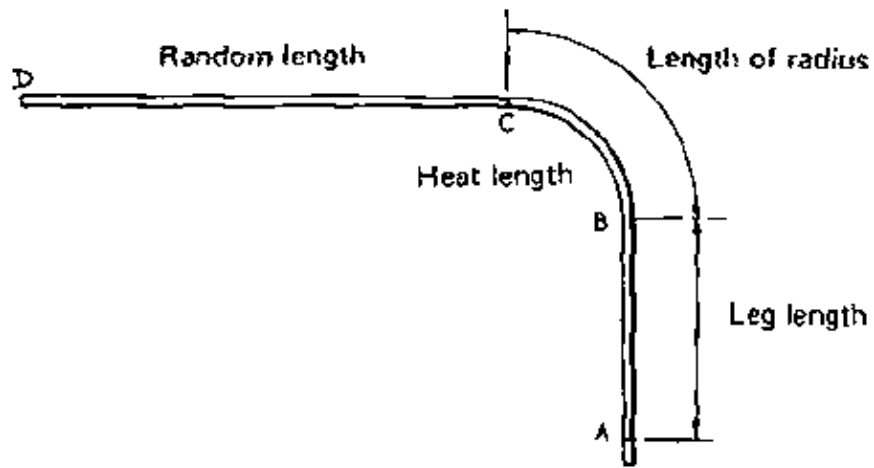


Bend a stiff wire to follow the centerline of the first bend on the bench drawing. This forms a template, which acts as a pattern for bending. Handle it careful to avoid error when the pipe is bent.



Mark the template with length of the radius and the end of the pipe. This length of the radius is the heat length.

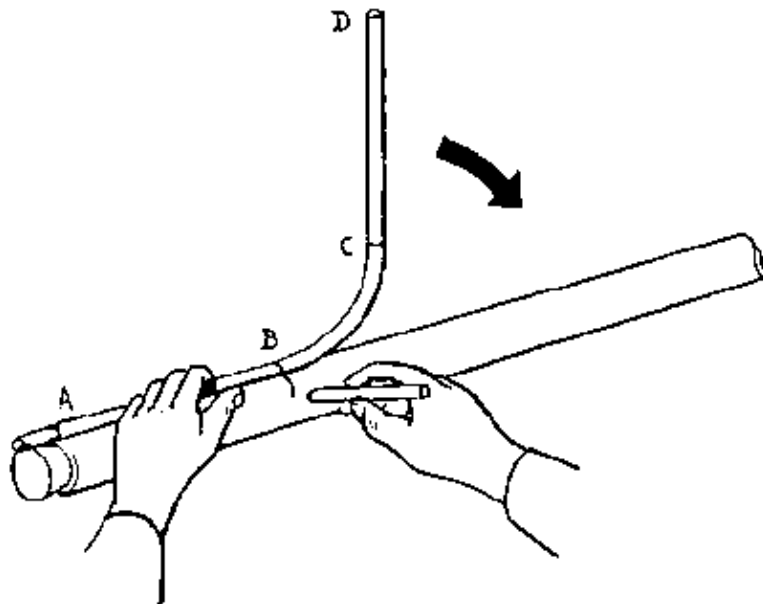




The template wire will then be as shown.

Place the template on the top of the pipe with end A at the end of the pipe and length AB in contact with the pipe as shown.

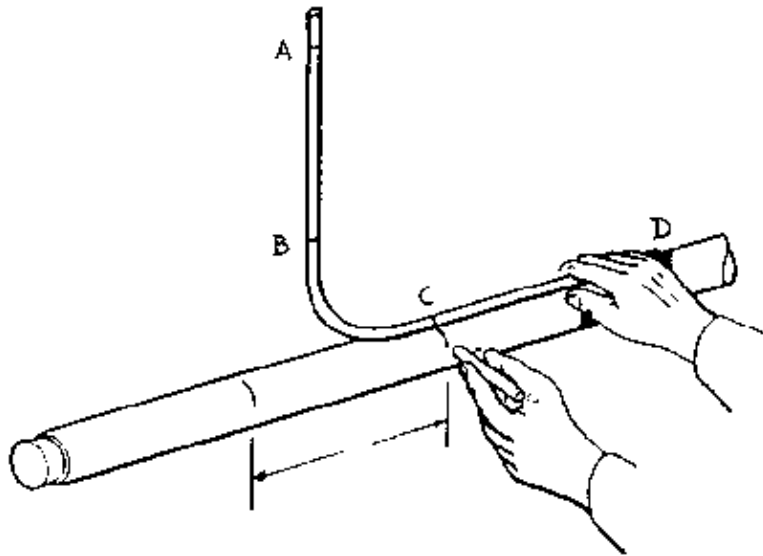
Mark the end of leg length B on to the pipe.



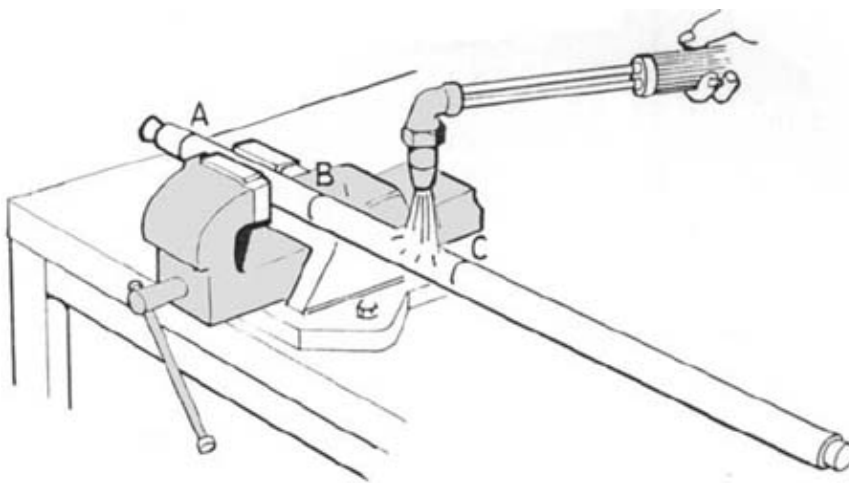
Roll the template through 90° keeping it in contact with the pipe until leg length CD rests on the top of the pipe.

Mark the end of the bend C on to the pipe.

The distance between the two marks on the pipe is the heat length.

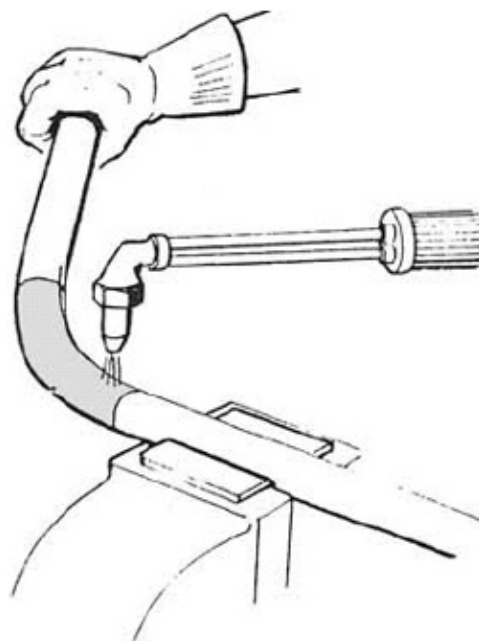


Secure the pipe in a vice. Use copper or aluminum shields to protect the jaws of the bench vice.

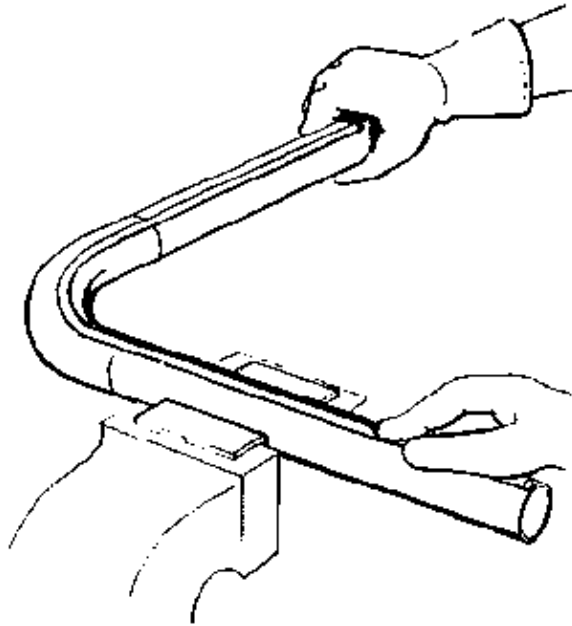


Heat the pipe to a dull red, heating with an oxy-fuel gas-heating torch along the heat length. The pipe must be heated evenly to produce a uniform bend.

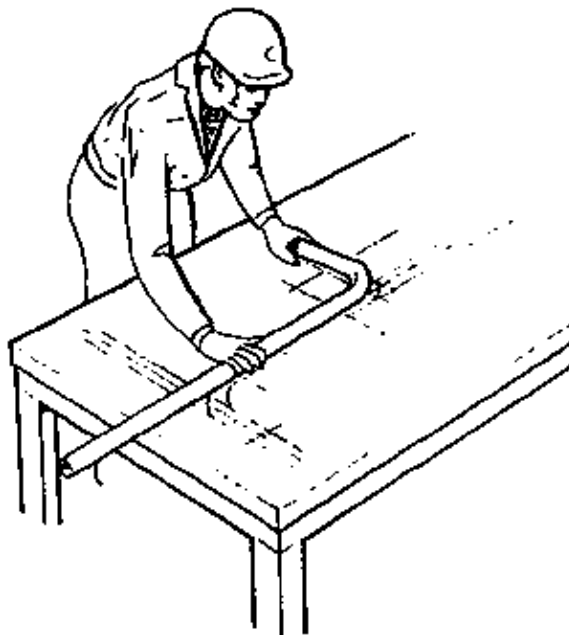
Continue to heat the pipe. Grasp the end of the pipe and pull steadily until a bend of approximately  $45^\circ$  has been formed.



Place the wire template on the pipe and check the bend. Remove the template, re-heat the pipe and continue bending until the pipe conforms to the template.



Remove the pipe from the vice, allow it to cool and then place it on the chalk drawing. Ensure that the outside diameter of the pipe lines up with the chalked outline. Check the first bend for accuracy.



### 7.3 Hot Bending a double 90° bend, using the Calculation Method

This method is used if a workshop drawing is available.

The heat length and centers of bends are determined by calculation.

Calculate the **heat length** of the bent pipe as illustrated.

A 90° circle is required.

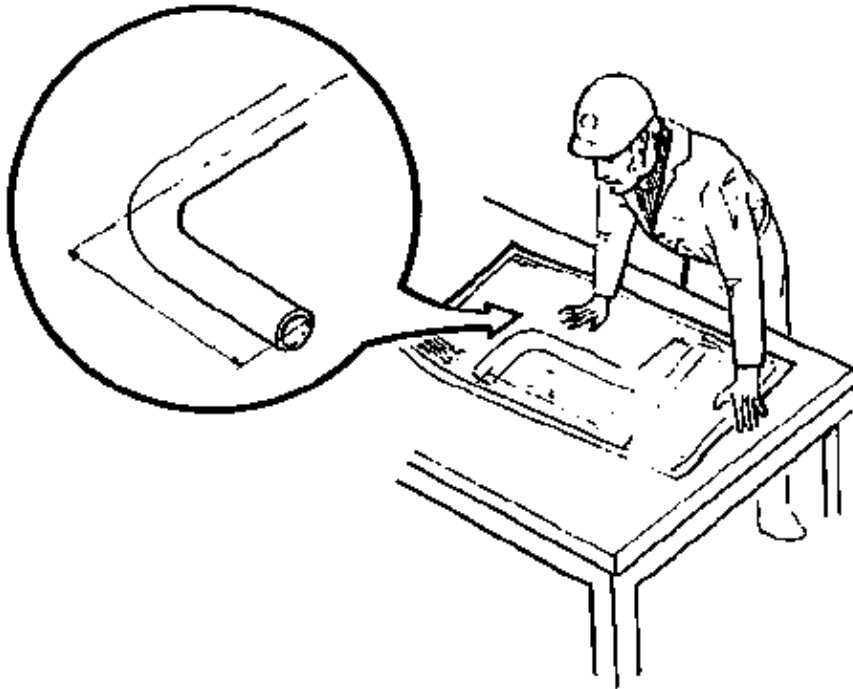
Remember as mentioned in chapter 1 of this course, the complete circle contains 360°. **Therefore 90° is 1/4 of a complete circle.**

$$C = \frac{d \times \text{Pi} \times 90^\circ}{360^\circ}$$

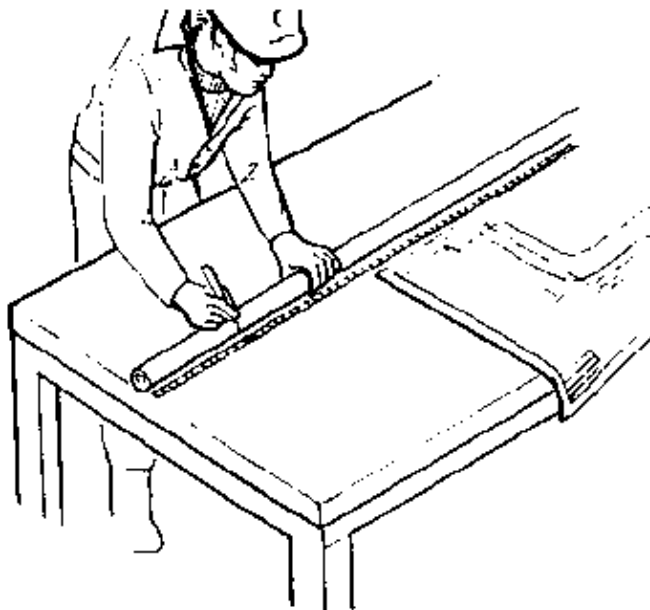
$$C = \frac{200 \text{ mm} \times 3.1416 \times 90^\circ}{360^\circ}$$

**C = 157 mm = Heating Length**

Take from the drawing the length of the first leg of the pipe (**325 mm**) from the end of the pipe to the centerline of the right-angled bend.



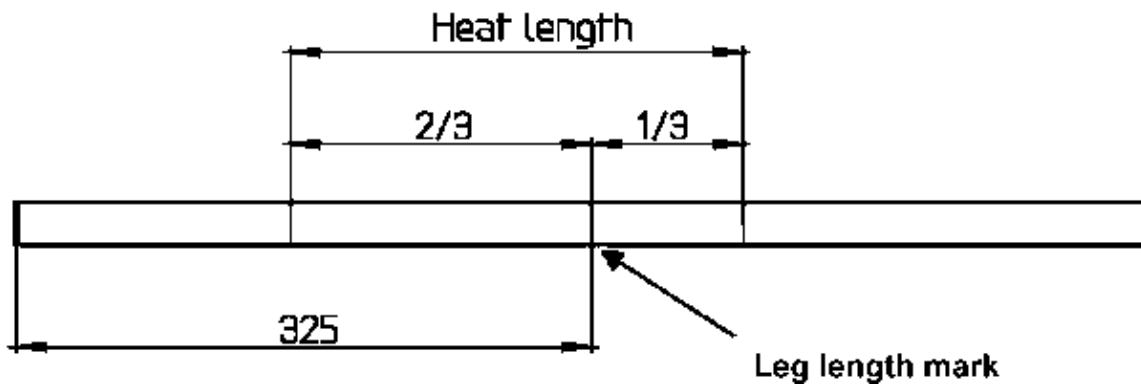
Mark the leg length on the pipe.



**Marking out the heat length**

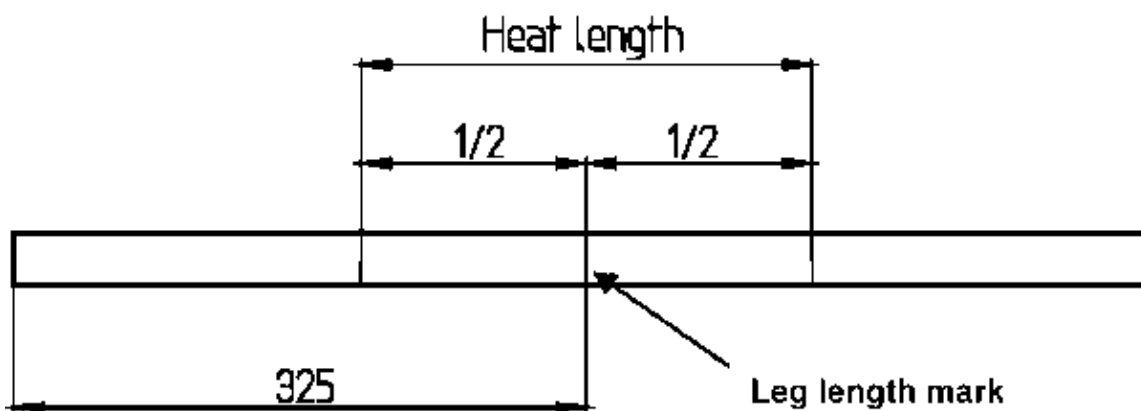
**For bows with 90°:**

Measure distances equal to **two-thirds** of the heat length before and **one-third** of the heat length after the leg length mark.



**For bows with less than 90° :**

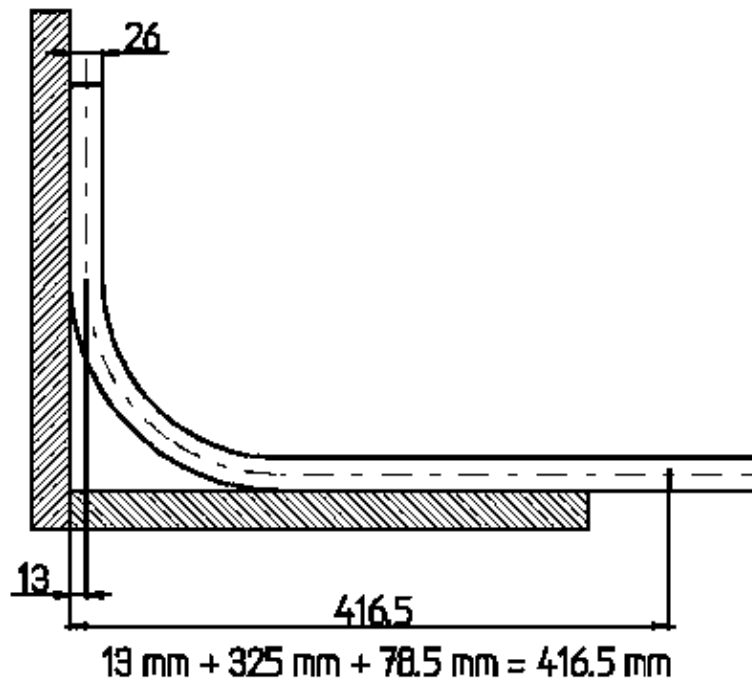
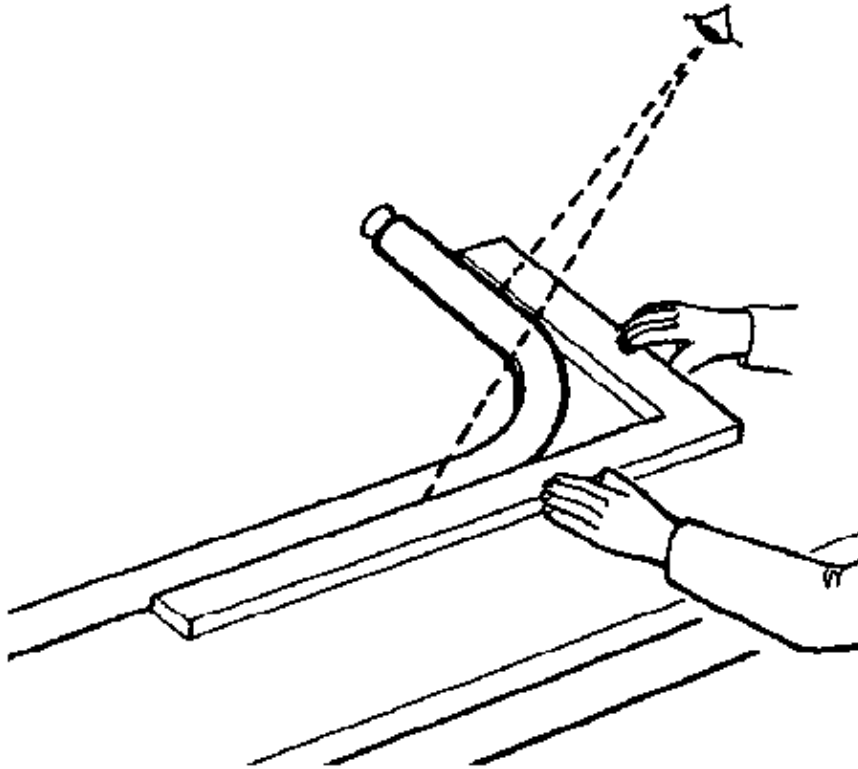
Measure distances equal to one-half of the heat length before and one-half of the heat length after the leg length mark.

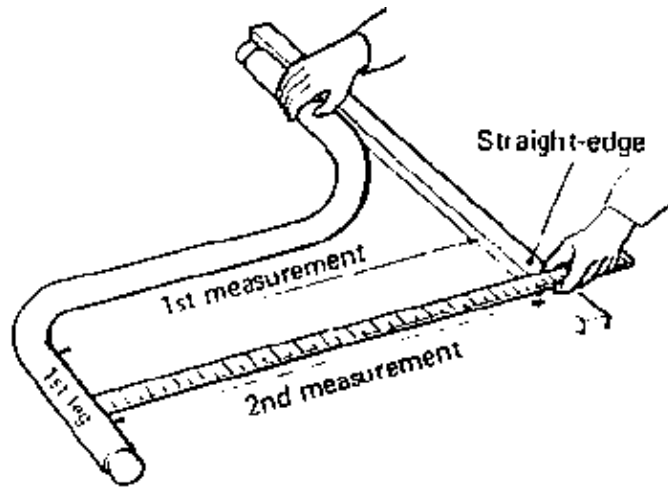
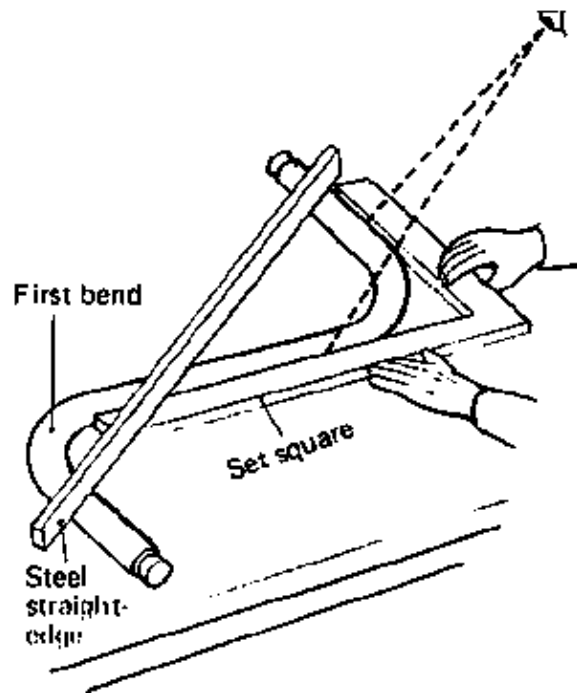


**Procedure:**

- Insert a wooden plug in one end of the pipe:
- Fill the pipe with tightly compacted sand and plug the other end, as previously described.
- Place the pipe in the vice and heat to a red dull red.
- Bend the pipe until a bend of approximately 45° has been formed.
- Re-heat and complete the bend.
- Remove the pipe from the vice and check the accuracy of the bend with a steel square. The back edge of the pipe should be parallel with both legs of the square.
- Locate the position of the second bend by measuring **403.5 mm** plus half the outside diameter of the pipe from the inside face of the square.
- Mark the pipe.
- Measure and mark off the heat length as previously described. I.e. two-thirds of the heat length before and one-third past the leg length mark.
- Heat the pipe and bend as previously described.
- Allow the pipe to cool. Then place a steel square against the outside edge of the pipe to check that the second bend is square.

- Check that the bends are flat by laying a steel ruler across them, as illustrated. The steel ruler should contact the pipe at all three points.
- Remove the square and place the steel ruler against the outside edge of the second leg. Take two measurements at different positions from the inside of the first leg to the inside edge of the steel ruler to check that the two legs are parallel and the dimensional centers of the legs are correct.
- Remove the steel ruler and place the square as shown on the right side. Measure the length of the second leg plus half of the outside pipe diameter and mark the pipe for cutting.

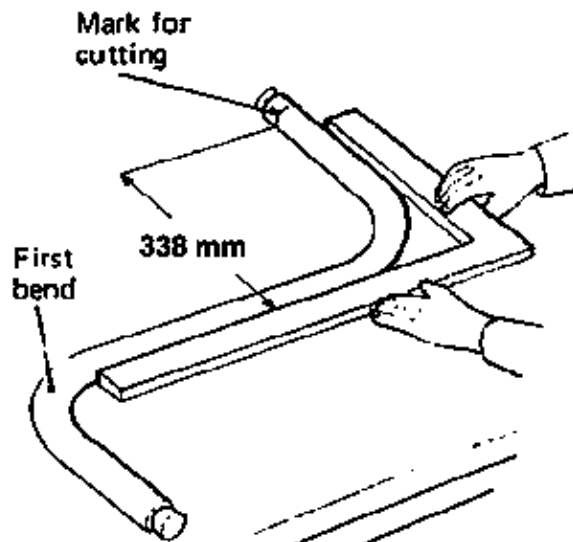




$325 \text{ mm} + 13 \text{ mm} = 338 \text{ mm}$

Remove the wooden plugs and empty out the sand.

Finally cut the pipe to size and remove burr.



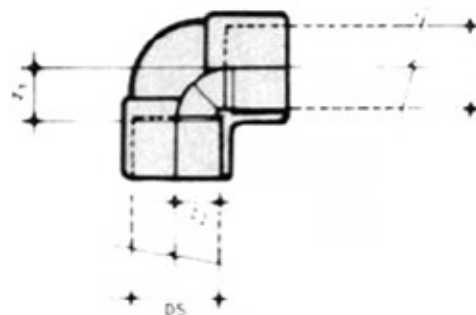
## 8. PVC Pipes

The plastic industry has a variety of compositions of plastic tubing (in coils) and rigid plastic pipe (in lengths) and also fittings used for a wide range of applications. Rigid **polyvinyl chloride pipe** (PVC) pipe is made in three weights for different pressures. The strength of plastic pipe will decrease as temperature increases.

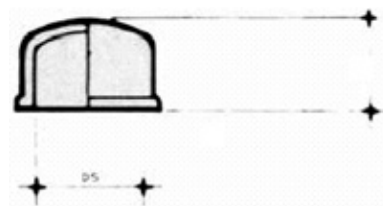
**CPVC** is a rigid **chlorinated polyvinyl chloride pipe** (CPVC) is used for hot water applications. It is industrial thermoplastic piping with an upper working temperature of 100 degrees Centigrade, or about 60 degrees above that of normal rigid vinyl materials. The fittings should always match the specifications of the pipe you are using.



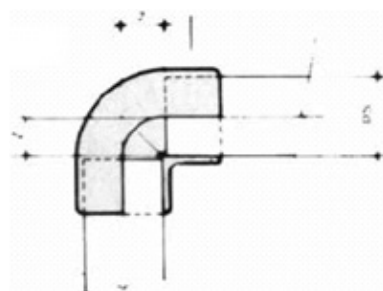
SMALL DIA. PVC PIPE (IN-HOUSE))



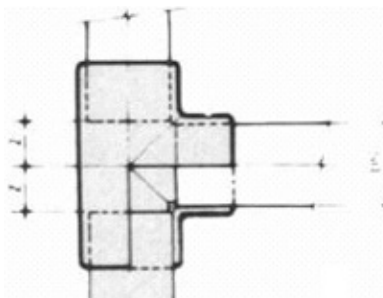
THREADED ELBOW 90°



CAPS

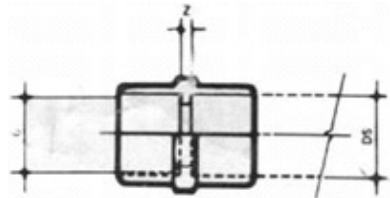


90° ELBOW

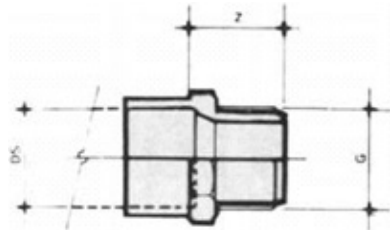


90° TEE

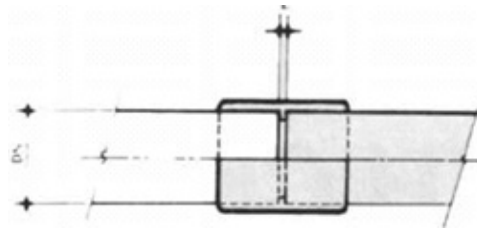




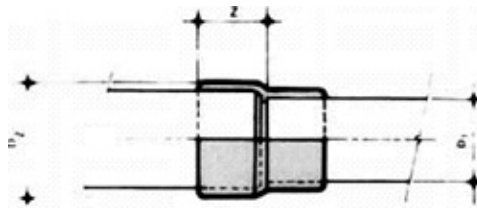
FEMALE THREADED ADAPTOR



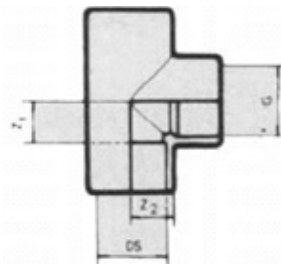
MALE THREADED ADAPTOR



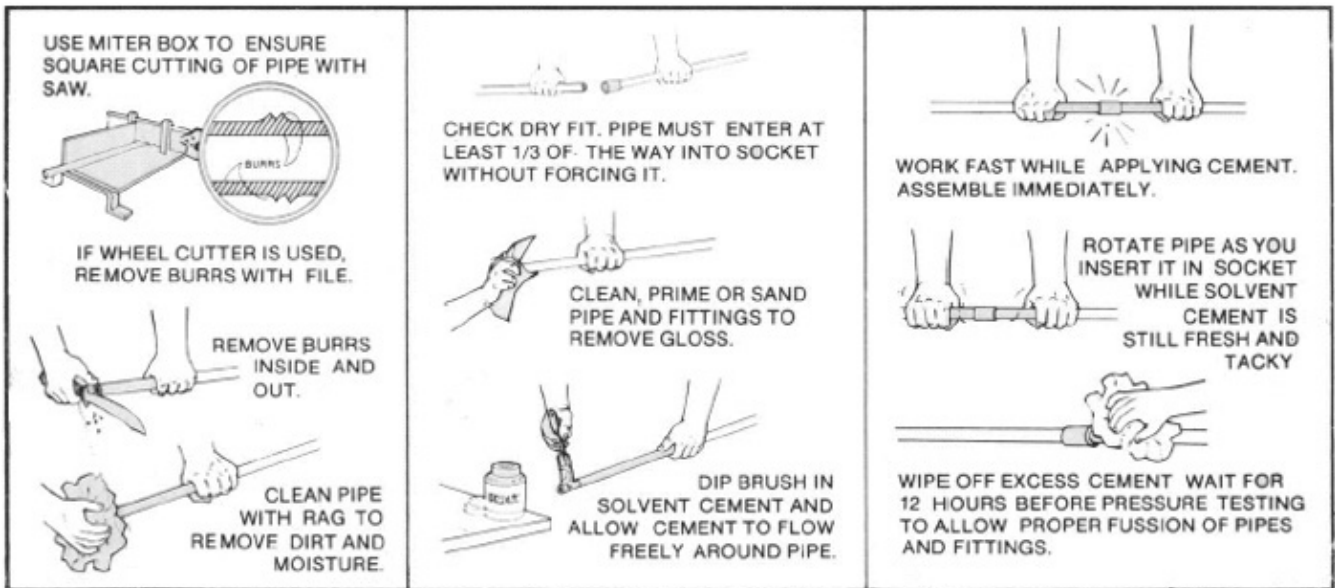
SOCKET/COUPLING



REDUCER

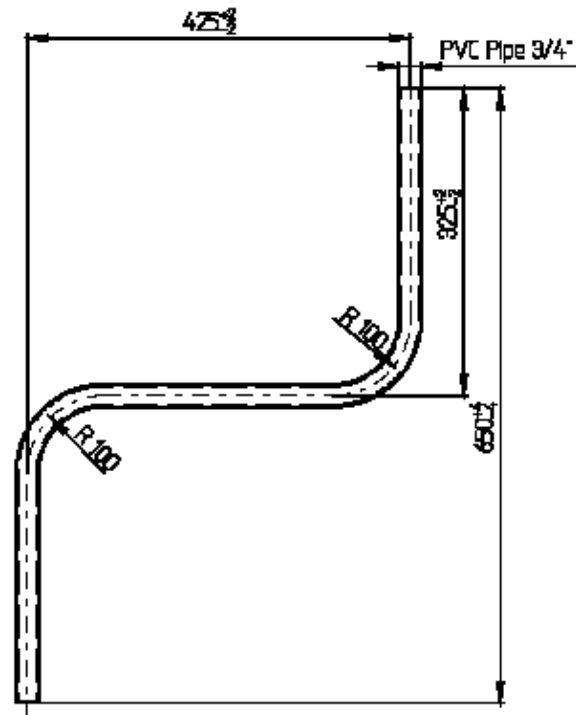


90° THREADED TEE



### PVC – PIPE PROCESSING

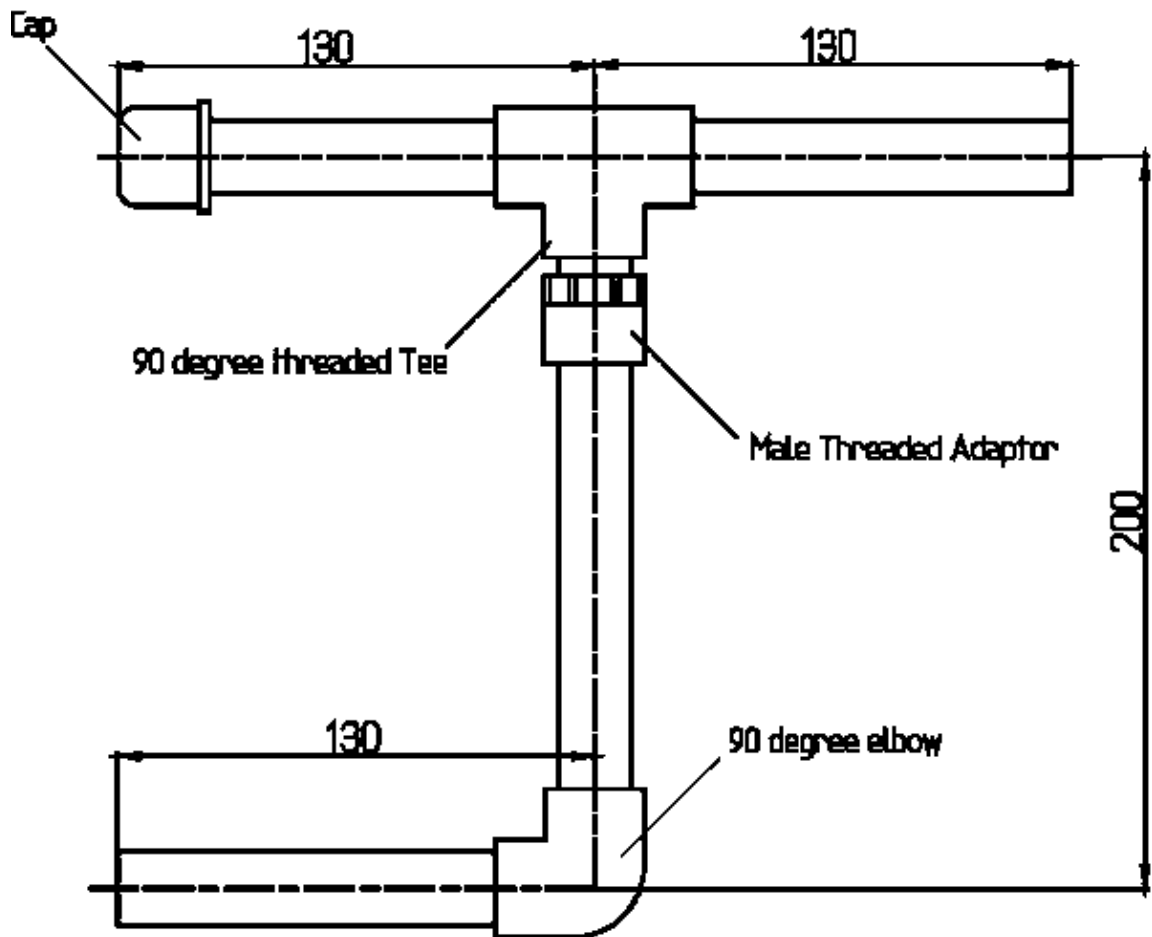
#### Practical Exercise No. 5 – Manual Hot bending of PVC –Pipes



#### Instructions:

1. Study the technical drawing and calculate the cutting length.
2. Cut the calculated length of pipe and deburr it properly.
3. Bend the first leg 90 degrees using the 2/3 and 1/3 method for heating.
4. Control all measurements and check angles with try square or with the drawing pattern.
5. If the bend angles are too less or too much, heat the bended contour again.
6. Continue with step No.3 for the second leg, following the technical drawing.

#### Practical Exercise No. 6 – PVC – Pipe Processing



#### Instructions:

1. Study the technical drawing and calculate the cutting length.
2. Lay out the work on the working bench, following the measurements given in the blue print
3. Secure the necessary fittings for the work and check the diameters of the pipes with the caliper.
4. Cut the calculated length of pipes and deburr it properly.
5. Insert temporarily the pipes together with fittings and compare with the lay out on the workbench.
6. Glue one by one the pipes to the fittings and rasp at least 13 mm on the end of the pipes before applying solvent cement.

## 9. Safety Precautions

### • Personal Protective Equipment (PPE)

Always wear your personal safety equipment. This will protect your body against injury. The most common PPE's are: **Safety goggles** (with side shield), **Safety shoes** (with steel toes), **Long working trousers** (strong material), **Working jacket** (with long sleeves), **Ear plug**, **Safety gloves** and **Safety helmet**.

### • Working Area

Keep your working area, especially the floor, clean and free from any unnecessary items that can cause slipping or stumbling. Pipes should be properly stored in a material rack. Protect the floor against spilled cutting oil. During pipe cutting use always a collecting basin to catch the access oil.

- **Tools**

Never use damaged tools like files without handle, or hammer without wedges. Wipe the handles of tools clean if they are oily or greasy. Slippery tools can glide out of your hand and can cause accidents.

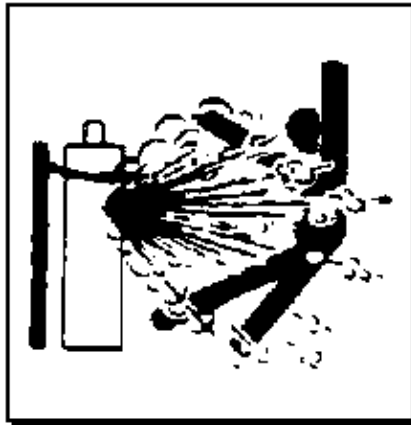
- **Deburr**

Always deburr the end of pipes after cutting to length. Burr can cause cuts during the further processing of pipes.

- **Warm bending**

Always wear leather gloves to handle hot pipes. Use soapstone to write, "**HOT**" on the pipe. This will warn your colleagues before handling the pipe.

- **Handling Gas Cylinders in General**



Pressurized cylinders must be handled with great care. For instant a broken off valve, will release extremely high pressures, which could cause the cylinder to be hurled about at dangerously high speeds. Cylinders should be securely fastened at all times in a vertical position. Chains are usually used to secure a cylinder to a wall or cylinder cart. When moving or storing a cylinder, a threaded protector cap must be fastened to the top of the cylinder. This protects the valve system should it be bumped or the cylinder dropped. It is an accepted procedure to roll a cylinder in the upright position when moving the cylinder. It is also very important to keep excess heat of any kind away from cylinders. When a cylinder is exposed to too much heat, the pressure inside the cylinder will increase. This can lead to an explosion of the cylinder.

**Other Safety Rules for Gas Cylinders:**

- **Never lubricate any oxygen–equipment**

Oil, grease, coal dust, and similar organic materials are easily ignited and burn violently in the presence of oxygen concentrations. Never allow such materials to come in contact with the oxygen or oxygen equipment, including hose.

- **Never use oxygen to clean your working cloth or other equipment**

Serious accidents can result if you use oxygen as a substitute for compressed air. Especially with oxygen saturated working cloth can burn very quick (flash–burning). Even a spark is enough to start the fire.

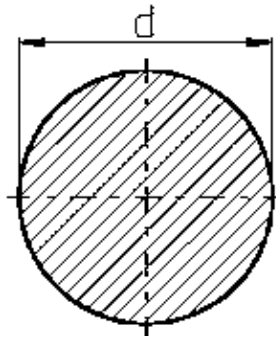
- **Never use very hot water to remove the ice from the outlet of the cylinder**

Inside pressurized cylinders there are normally fusible safety plugs. These plugs can easily melt when using very hot water.

**Calculation of Areas for Round Shapes**

$$\text{Area} = \frac{\text{diameter}^2 \times \pi}{4}$$

$$A = \frac{\text{mm}^2 \times \pi}{4}$$



Calculate the area for a circle with a diameter of 40 mm.

**given:** d = 40 mm

**find:** A

**solution:**

A circular base plate for a water tank has a diameter of 2,000 mm. Calculate the GI-Sheet for the base plate in square meter.

**given:**

**find:**

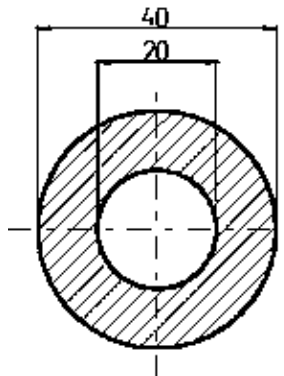
**solution:**

Calculate the area for the given pipe.

**given:**

**find:**

**solution:**



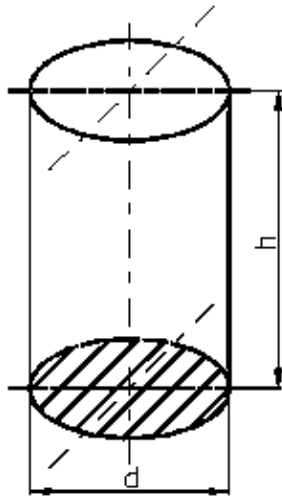
### Calculation of Volumes for Cylindrical Bodies

Volume = base area × height

$$V = \frac{d^2 \times \pi}{4} \times h$$

$$V = A \times h$$

$$V = \text{mm}^2 \times \text{mm} = \text{mm}^3$$



What is the volume of a piece of round bar with a diameter of 200 mm and a length of 1 m.

**given:**

**find:**

**solution:**

Calculate the volume for a round water tank with a diameter of 2 m and a height of 3 m. How many liter of water can you fill if 1 dm<sup>3</sup> is equal to 1 Liter.

**given:**

**find:**

**solution:**

### CONVERSION OF MEASUREMENTS mm, mm<sup>2</sup>, mm<sup>3</sup>

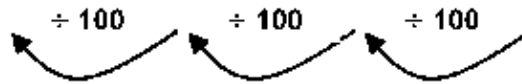
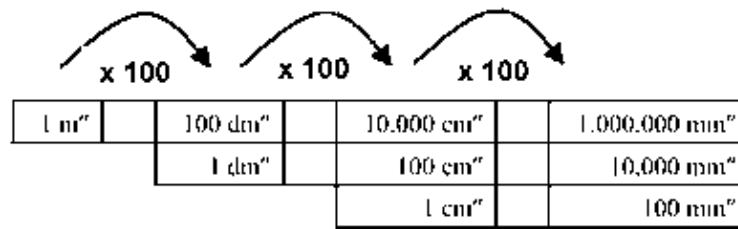
**To convert from a bigger unit to a smaller unit we have to multiply by 10**

1 m	10 dm	100 cm	1.000 mm
	1 dm	10 cm	100 mm
		1 cm	10 mm

**÷ 10      ÷ 10      ÷ 10**

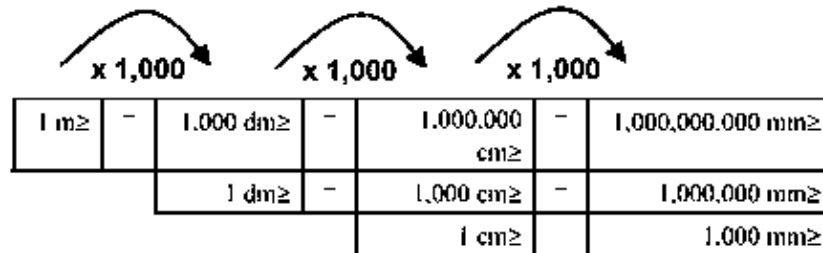
**To convert from a smaller unit to a bigger unit we have to divide by 10**

To convert from a bigger square unit to a smaller square unit we have to multiply by 100



To convert from a smaller square unit to a bigger square unit we have to divide by 100

To convert from a bigger cubic unit to a smaller cubic unit we have to multiply by 1,000



To convert from a smaller cubic unit to a bigger cubic unit we have to divide by 1,000

Resource	Checked	Unit	Qty for 1 Trainee	Qty for 4 Trainees	Need to Order/Replace/Organize			
					Unit	Qty	Unit Price	Amount
<b>Teaching Aids</b>								
Handout		pcs.	1	4				
Overheadfoils		set	1	1				
Overhead projector		pcs.	1	1				
Video tapes – Oxy–Acetylene Safety		pcs.	1	1				
White board		pcs.	1	1				
T.V. – VHS		pcs.	1	1				
<b>Forms</b>								
Bio–Data		pcs.	1	4				
Participant reaction form		pcs.	1	4				
Participant evaluation sheet		pcs.	1	1				
Course evaluation		pcs.	1	1				
Certificate		pcs.	1	4				

<b>Consumables and Parts for Exercises</b>								
<b>Oxygen</b>		Cyl.	1	1				
<b>Acetylene</b>		Cyl.	1	1				
<b>Exercise No. 1</b>								
Elbow ½ "		pcs.	3	12				
Street Elbow ½ "		pcs.	1	4				
Union Tee ½ "		pcs.	1	4				
Cap ½ "		pcs.	1	4				
Teflon Tape		pcs.	1	4				
G.I. Pipe ½ "		length	750 mm	3,000 mm				
<b>Exercise No. 2 (Group Exercise)</b>								
Bushing Reducer ½ " to 3/8 "		pcs.	1	1				
Ball Valve ½ "		pcs.	2	2				
Elbow ½ "		pcs.	5	5				
Street Elbow ½ "		pcs.	2	2				
Reducer 1" X ½"		pcs.	2	2				
Union Tee ½ "		pcs.	2	2				
Swing Valve ½ "		pcs.	1	1				
Coupling ½ "		pcs.	1	1				
Faucet ½ "		pcs.	1	1				
G.I. Pipe ½ "		length	3,000 mm	3,000 mm				
G.I. Pipe 1"		length	1,000 mm	1,000 mm				
Foot Valve 1 "		pcs.	1	1				
<b>Exercise No. 3 and 4.</b>								
B.I. Pipe #40 ¾"		length	3,000 mm	12,000 mm				
PVC Pipe 25 mm		length	1,000 mm	4,000 mm				
<b>Exercise No. 5</b>								
PVC 90 degree threaded Tee –20 mm inside Diameter		pcs.	1	4				
PVC Elbow 20 mm Diameter		pcs.	1	4				



PVC Male threaded adaptor 20 mm inside Diameter		pcs.	1	4				
Teflon Tape		pcs.	1	4				
PVC Cap 20 mm inside Diameter		pcs.	1	4				
PVC Pipe 20 mm outside Diameter		length	1,000 mm	4,000 mm				

