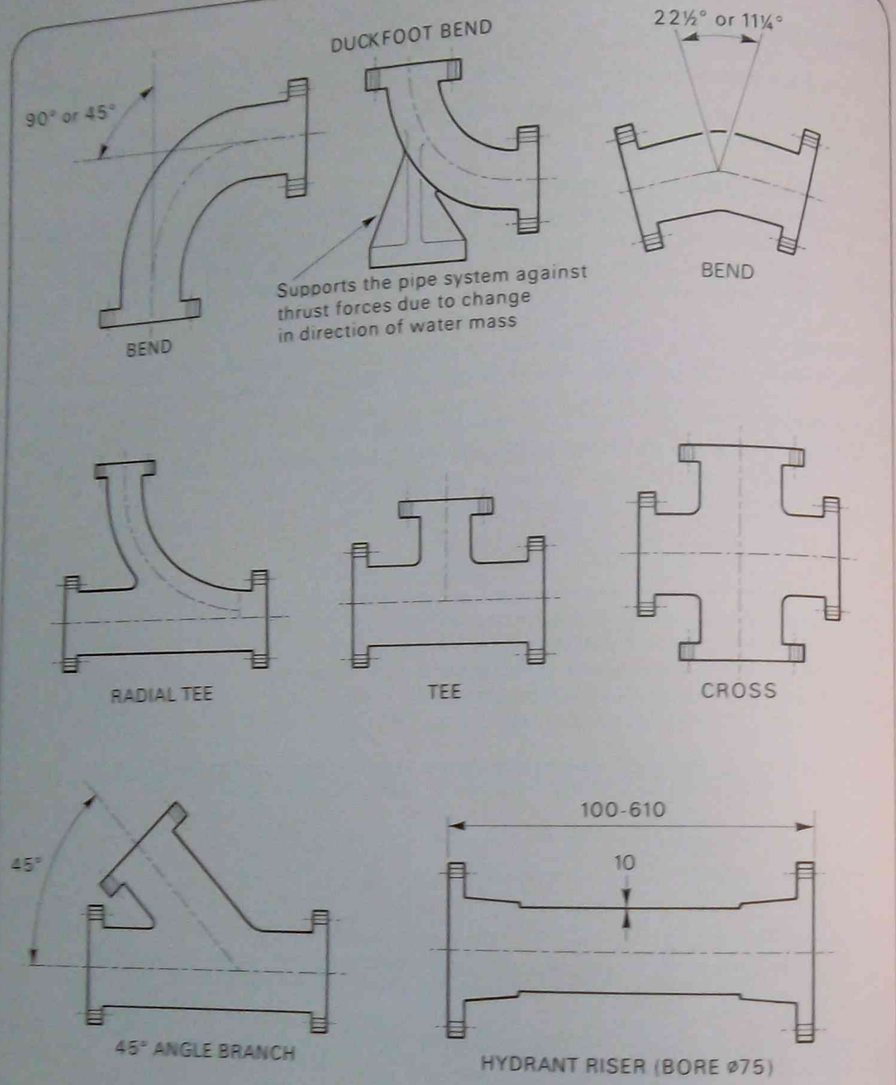


FLANGED CAST IRON FITTINGS

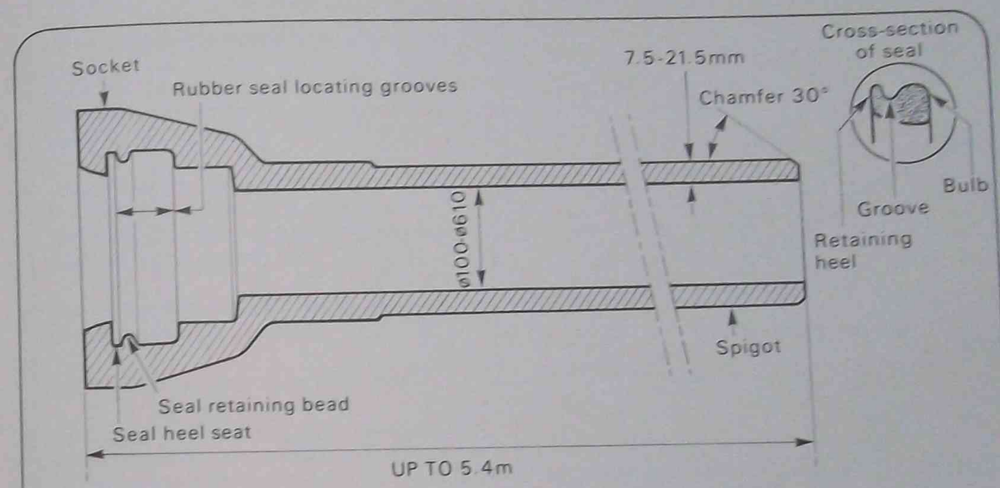
The rubber-sealed type

This type is cast by the same process as the flanged type, but the pipes have an integrally cast socket with specially shaped internal grooves at one end and a 30° chamfered spigot at the other. In classes and wall thickness, they match the flanged-type pipes except that the 75 mm bore one is not made. They are also available with cement mortar linings.

The advantages in using this type of pipe are the speed and ease of assembly which is much like that for RRJVC drain pipes and the flexibility of the pipe system which allows deflection of the rubber seal joints of 3° for large pipes to 5° for the smaller ones whilst remaining watertight at pressures of up to 3445 kPa.

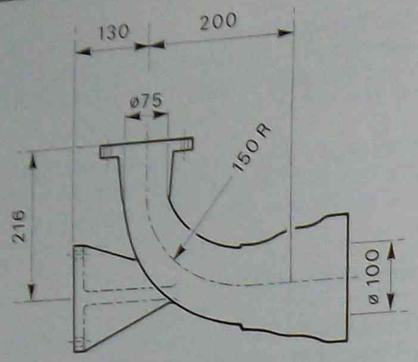
These pipes are also suitable for the making of lead-caulked joints.

The range of fittings, such as bends, tees, tapers, risers and crosses is similar to that for the flanged product, except of course that the flanges have been replaced by sockets.

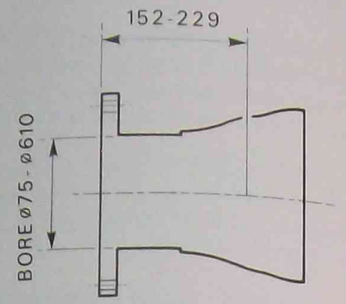


STRAIGHT CAST IRON PIPE FOR RUBBER-SEALED JOINT

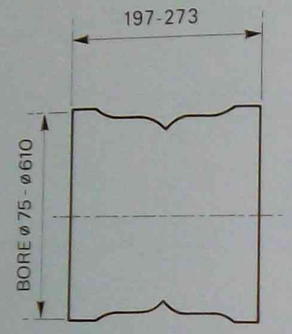
For a range of suitable fittings see page 34.



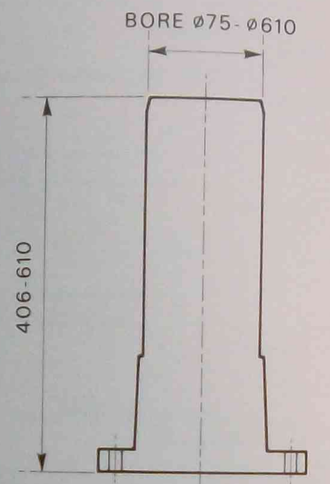
HYDRANT BEND



FLANGED SOCKET

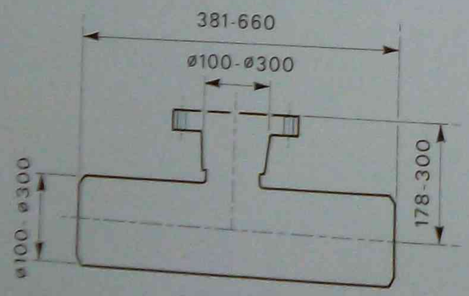


COLLAR

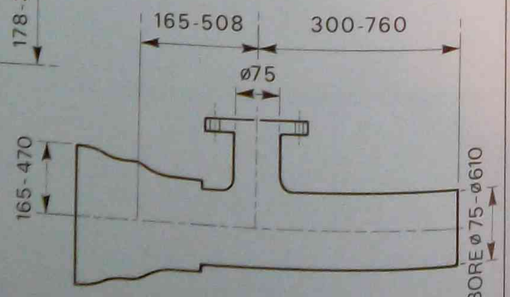


FLANGED SPIGOT

CUT-IN TEE For use with lead joint collars or GIBAULT joints to connect branches to existing pipelines.
The flanged branch can be a rubber ring joint socket.
The bore of the branch can be different to that of the pipe



CUT-IN-TEE



HYDRANT TEE

CAST IRON FITTINGS FOR RUBBER-SEAL JOINTS

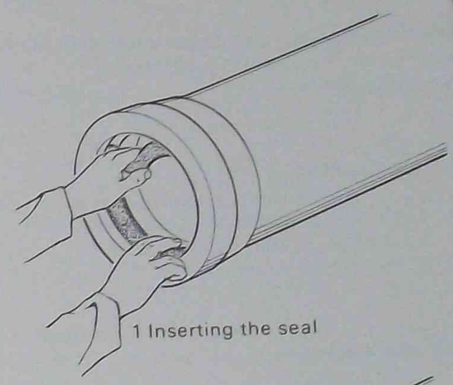
Assembling the rubber joint

Before attempting to join the pipes, it is necessary to inspect the parts to be joined.

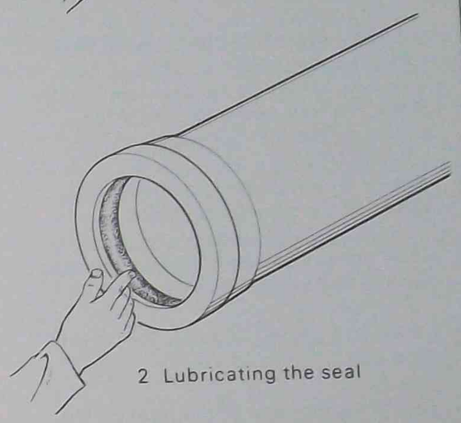
- Both spigot and socket interior should be thoroughly cleaned.
  - — Dirty surfaces may prevent a leak-proof joint.
- The spigot end should have a chamfer (30°) and be free from burrs or nicks which may damage the seal.
- The rubber seal must be clean and not damaged.

To assemble a joint, proceed as follows:

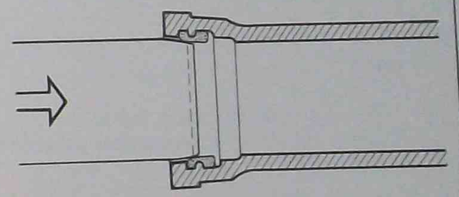
- Flex the seal and insert into the socket, the seal bulb facing towards the spigot end.
- Check that the seal groove is located on the retaining bead of the socket and that the seal retaining heel is firmly bedded in the socked seat.
- Check that the seal is fitted evenly around the circumference.
  - — Smooth out any bulges by hand.
- Apply a thin film of approved lubricant over the surface of the seal that will be in contact with the spigot.
  - — A thin film of the same lubricant can be applied also to the outer surface of the spigot to be fitted (keep it clean!) over a distance of 25 mm from the spigot end.
- Align the spigot squarely to the adjacent socket and carefully enter the spigot into the socket until it makes contact with the seal.
- Complete the assembly for forcing the spigot past the seal until the first reference stripe disappears inside the socket and the second stripe is about flush with the socket face.
  - — The methods of applying the necessary force to do this are explained overleaf.



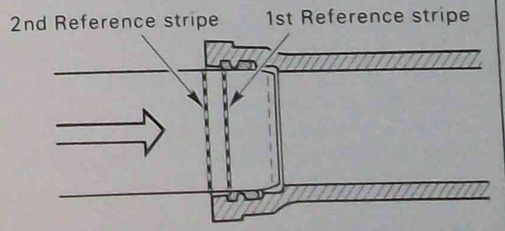
1 Inserting the seal



2 Lubricating the seal



3 Aligning and inserting the spigot



4 Completing the joint

RUBBER-SEAL JOINT ASSEMBLY

Assembly methods

Depending on the size of the pipes and conditions, the following methods of assembly can be used:

Crowbar method

- Apply force against the socket face with a crowbar or other suitable lever to push the pipe home.

Fork tool method

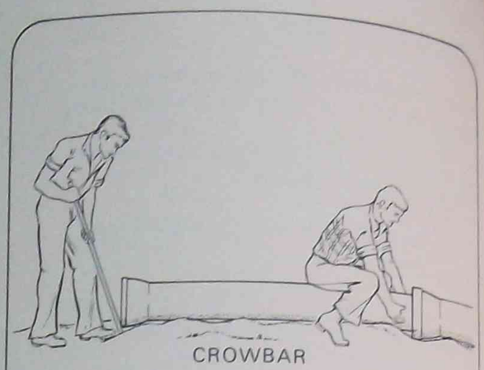
For joints to pipes 100 mm or 200 mm, a fork tool may be used.

- Place the fork over and behind the socket of the last laid pipe.
- Wrap a wire rope sling around the spigot of the pipe to be joined.
- Hook the eye of one of the sling ends into the sliding hook on the rope.
- Locate the sliding hook on the crown of the pipe.
- Hook the other eye of the rope on the hook of the fork lever, making sure that the rope end which is going to take the strain is looped behind the first layer of the rope wrapped around the spigot.
- Pull the fork handle in the direction shown.
  - The pipe should enter the socket easily by using a reasonable amount of force.

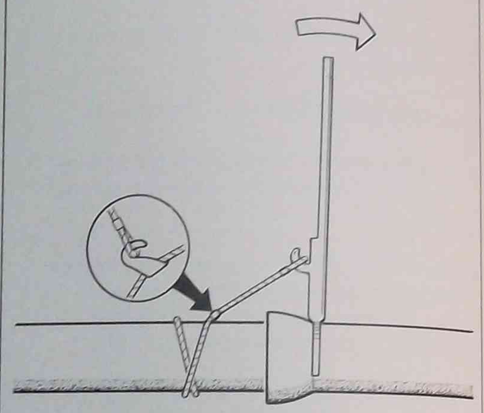
Rack and lever method

(For pipes 200 mm and over)

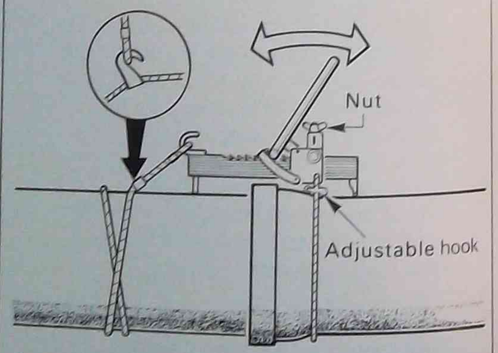
- Place the rack on top of the last laid pipe with the adjustable hooks immediately behind the socket and the rack with its hook resting on the spigot of the other pipe.
- Place the socket sling under the pipe (last laid) and hook its eyes into the adjustable hooks.
- Tighten the nuts to clamp the tackle firmly behind the pipe socket.



CROWBAR



FORK TOOL



RACK AND LEVER

ASSEMBLY METHODS

- The other wire sling is mounted in the same way as for the fork.
- Draw the sling against the pull of the rack hook by sliding it away from the joint area.
- Operate the rack lever to draw the spigot into the socket.

NOTE:

Where a back hoe-type excavator is used for trenching, the machine may be used to push the pipe home.

4.5.4 Mild steel pipes

Very strong and flexible, these can be manufactured to almost any bore size and wall thickness. They can be mortar-cement lined also. For protection against corrosion, the exterior is either painted or wrapped in a variety of corrosion-proof materials. After derusting and cleaning, the exterior of the pipes is usually provided with a layer of glass fibre between the first and second coats of enamel paint that are applied. This is followed up with a wrapping of tar-impregnated asbestos felt and a coating of white wash or PVA as protection against high temperatures during storage.

Because of their greater elasticity and strength, they are well suited to above ground installations and traversing of fairly large gaps with the minimum of support.

The required fittings for a pipeline carried out in mild steel are usually prefabricated to the required size for the installation, the more commonly used being usually in stock.

NOTES

Types of joints

1. Flanged joint

   Suitable for temporary or permanent installations. Requires no special equipment (welding) for installation.

2. Butt joint with collar

   Suitable for permanent installation. Easily lined up. Pipes are joined in the field by welding the strap to the pipe ends which do not require special preparation.

3. Butt joint

   For high-pressure lines. Welded on the outside only on small size pipes. From 762 mm onwards, pipe can be welded both on inner and outer edges. Depending on wall thickness, edge preparation is square, single V or double V or U-form either flame-cut or machined.

4. Ball and socket joint

   Usually for pipes over 730 mm bore. Allows easy change of direction and easy alignment. Suitable for permanent installations where the welding of joints during assembly is possible.

5. Rubber-ring joint

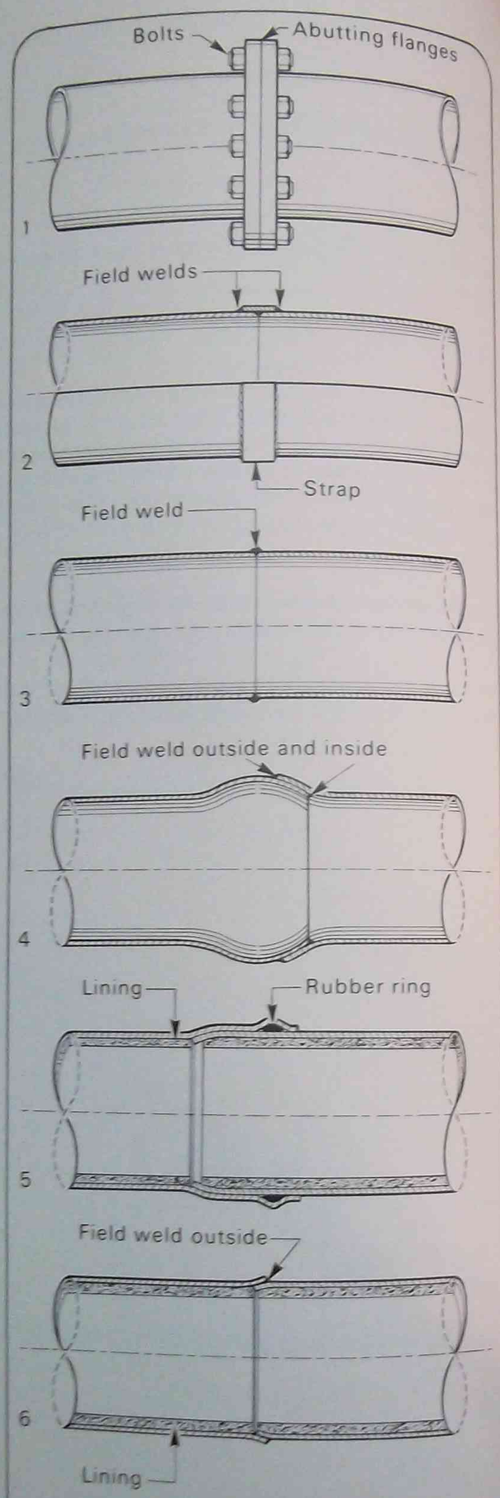
   For use in underground installations. Fast laying rate, requires no special field equipment for jointing (such as welding). The joint is protectively wrapped and acts as a flexible as well as an expansion joint.

NOTE:

The mortar cement lining can be applied to all pipes. Depending on requirements, the mix can vary from 1:2 to 1:3 and the curing may be done with water or steam and the application of the lining carried out by hand or by machine centrifugally.

6. Spherical slip-in joint

   Suitable for permanent installations where the joints can be welded. Usual sizes: 120 mm — 1600 mm. Easily lined up and can take up slight changes in direction. Can be welded internally also on diameters of 914 mm and over; the mortar lining being applied at the joint afterwards to link up the lining of both pipes.



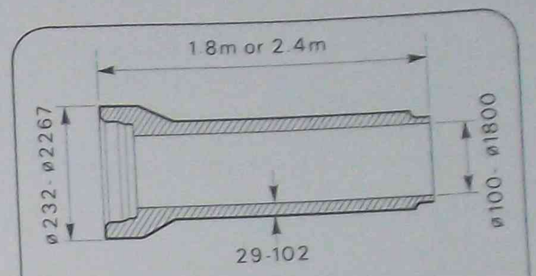
TYPES OF JOINTS
IN MILD STEEL PIPES

4.5.5 Reinforced concrete pipes

Reinforced concrete pipes are usually installed for culverts, for drainage or for water supply. Depending on the purpose of the pipe installation and the pressures to be encountered, various classes of pipes and jointing methods are used.

The pipes themselves are nowadays manufactured by a centrifugal spinning method.

The pipes used for water supply installations are referred to as 'pressure' pipes because they are designed to withstand higher pressures than would normally be experienced in sewerage or in drainage installations.



REINFORCED CONCRETE
PRESSURE PIPE

Like all pipes used in water supply installations, they are made to strict standards and pressure-tested during the manufacturing process. Standard sizes vary from 100 mm to 1800 mm and their lengths are normally 1.8 m for sizes up to 225 mm and 2.4 m for 300 mm pipes and above.

Reinforced concrete pressure pipes are made with a socket at one end and a spigot at the other and both are designed to accommodate a rubber ring (usually of natural rubber for water supply) to make the joint watertight. Assembly is done in a similar way as for all rubber-ring joints. Because of the higher pressures to be handled by the pipe installation, the rubber-ring joint is different from the one used for sewer installations which are designed to cope with pressures of up to 90 kPa only. The test pressures applied to pressure pipes (and depending on wall thickness ordered) vary from between 300 kPa to 1350 kPa.

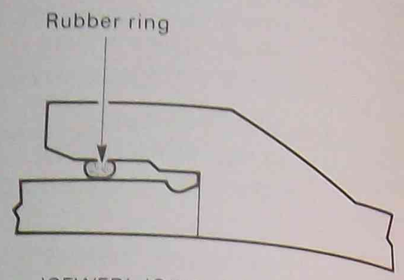
For complete installations, the necessary fittings are available or they can be manufactured as required for any specific installation.

Minor cracks in an installation done in reinforced concrete are sometimes 'self-healing' in the presence of water. Major ones can be repaired by welding the reinforcing rods, should they have broken, and sealing off the cracked portion with epoxy compounds.

The laying of concrete pipes with rubber joints is similar to the ones explained already, except that earth excavating machines should not be used for pushing or homing as this could fracture pipes.

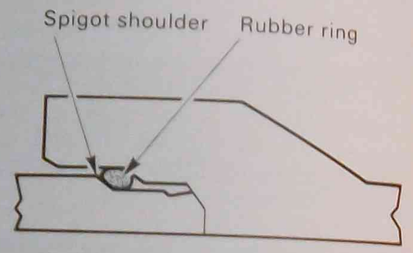
NOTES

The illustrations show the difference between the 'sewer' rolling ring joint and the 'pressure' joints used with reinforced concrete pressure pipes.



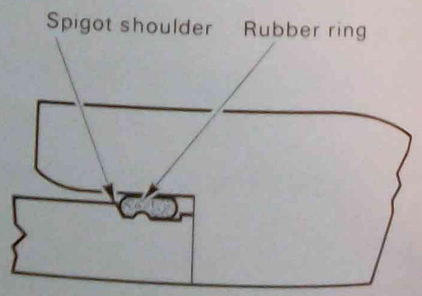
'SEWER' JOINT (ROLLING RING)

In assembling the rolling ring joint, the ring is placed on the locating groove at the end of the spigot and upon entry, the ring rolls over the spigot end until it rests against the spigot shoulder which supports it against dislodgement.



ROLLING RING PRESSURE JOINT

A new development in ring sealing is the 'skid-ring joint'. The ring is placed on the groove provided for it at the end of the spigot where it is supported against dislodgement by a shoulder. During assembly, the ring does not roll but remains in its groove. For easy assembly, and to prevent excessive ring distortion, both ring and socket are lubricated. It is usual to make skid-ring joints on pipes larger than 1800 mm, although some pipes of smaller diameter are available for assembly in this way.



SKID-RING JOINT

RUBBER-RING JOINTS
IN REINFORCED CONCRETE PIPES

4.5.6 Asbestos cement pipes

AC pressure pipes are manufactured from asbestos fibres, cement and silica. The mixture of these three, with water added to make it into a slurry, is fed into a pipe-making machine, the bore being taken up by a mandrel. The slurry is gradually built up in layers on the slowly rotating mandrel while the layers are being compressed by pressure rollers. When the required wall thickness has been obtained, the mandrel is withdrawn and the pipe passed through a hardening chamber. When hard enough, it is passed into an autoclave where it is subjected to high-pressure wet steam of 170°C.

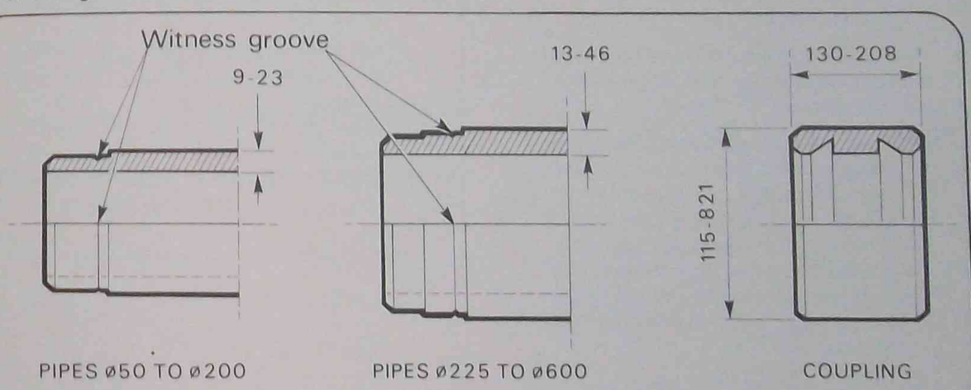
When properly 'cured', the pipe ends are machined to the dimensions required for proper jointing in installations.

AC pressure pipes are manufactured in six classes: A to F. The corresponding working pressures are 300 kPa to 1800 kPa. The pipes and couplings are each tested in the factory to between two and three times the recommended working pressure, i.e. 900 kPa to 5400 kPa, depending on size and class.

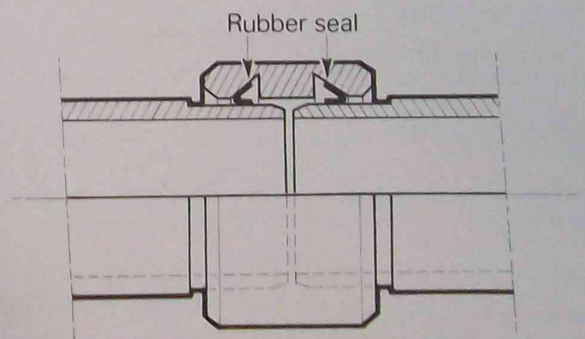
The standard pipe length is 4 m but, up to 10% of any order may be supplied in shorter lengths down to 3.4 m in 150 mm decrements. This practice eliminates wastage at the factory caused by cutting testing samples from pipes as these pipes can be trimmed to the shorter length and used. It is not normal to order lengths shorter than standard. The diameters range from 58 mm through to as large as 600 mm and with special pipe, from 675 mm diameter to 750 mm diameter.

NOTE:

The sizes referred to are nominal only. Internal diameters as well as outside diameters vary depending on the class of pipe. The OD's are usually made so as to match other pipe systems made with different materials so that interchange of fittings is possible between various materials, e.g. spigot-ended valves. Consult manufacturers' catalogues to gain information on the range and type of fittings available.



PIPES ø50 TO ø200 | PIPES ø225 TO ø600 | COUPLING



ASSEMBLED JOINT

AC PIPE SPIGOTS AND COUPLING

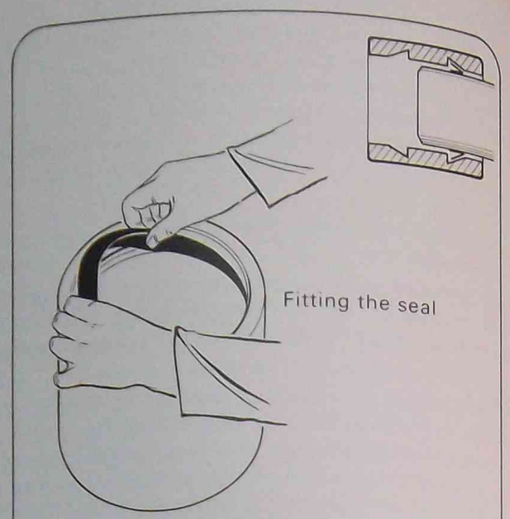
Assembling the pipes

During laying operations, it is more convenient to fit a socket to one end of the pipe before it is lowered into the trench for jointing to the pipe already laid (with the socket in place). To pre-socket a pipe, proceed as follows:

- Check that the coupling is clean and place the special V-shaped rings, as shown (Sharp end of taper outwards).
- Lift the end of the pipe clear of the ground, clean it and support it with a wooden block, if necessary.
- With a brush, apply jointing lubricant to the spigot end as far as the witness groove.
  - — The spigot end must be chamfered after a pipe has been cut with approved cutters to ensure easy entry and to prevent seal damage.
  - — The lubricant is virtually a soft-soap solution. Do not use oil or grease as this will deteriorate the natural rubber rings.
- Push the coupling onto the spigot with a slight twisting motion as far as the witness groove.
  - — For pipes 200 mm and over, support the pipe on a wooden block. After lubricating the spigot and having placed the coupling on the end of the pipe, place a wooden block across the coupling and push the coupling home with the aid of the bar to apply force to the block (see illustration).
- Lower the pipe into the trench and finish the assembly as shown; by hand for pipes under 200 mm and by bar and lifting device for pipes over 200 mm.
  - — The force should not be applied to the coupling in this case. The wooden block is inserted in the open end of the pipe and bears against the pipe end.
- Check that the witness grooves line up with the coupling ends.

NOTE:

Pipes must be in line during assembly of the joints. After jointing, the pipes may be slightly deflected to enable the pipeline to follow curves without affecting the seals. Manufacturers' installation data list the permissible deflections for each size of pipe.

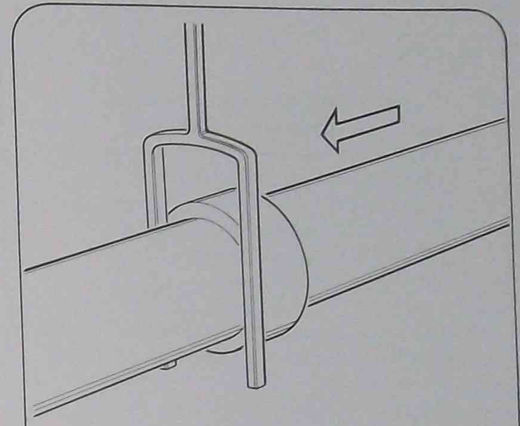


PIPE ASSEMBLY

Where pipes up to 200 mm have not been pre-socketed before laying, coupling retaining forks can be used to secure freshly jointed couplings against backward movement when the next pipe is inserted.

The fork, easily made locally of steel bar or tubing, is held behind the coupling, as shown. The distance between prongs should be 15 mm wider than the outside diameter of the pipe it straddles.

The forks are not needed on pipes over 200 mm because these have been provided with a collar (stop) to prevent coupling movement during assembly.

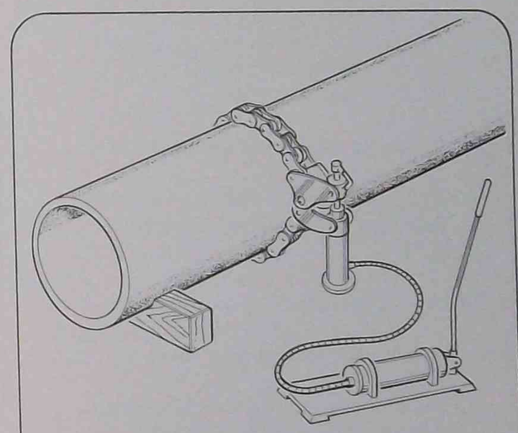


COUPLING RETAINING FORK

Cutting of pipes

AC pipes can be cut to a required length by using:

- a bushman's saw or a power hacksaw blade;
- a manually operated chain-roller cutter, as shown in 'Sanitary Plumbing 2' for pipes of up to 150 mm in size;
- a hydraulically operated version of the chain-roller cutter for larger sizes;
  - — There is no rotation of the wheels or the chain. The pipe cuts around the circumference by the so-called 'snap-pop' principle.
- a high-speed abrasive wheel pipe cutter.
  - — If this wheel is used, all cutting should be done wet to eliminate dust problems.



HYDRAULIC PIPE CUTTER

Pipe ends must be squared and trimmed to ensure proper jointing and a neat job. If pipe ends are to be inserted into couplings, the ends must be chamfered with a rasp (up to 200 mm size).

Larger pipe ends are machined to proper spigot size with a hand-operated field lathe or with one that can be powered electrically or by compressed air.

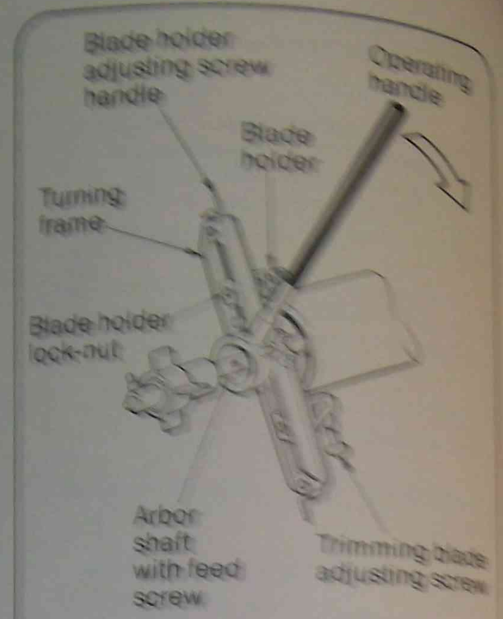
Field lathes

Basically, these consist of the following components:

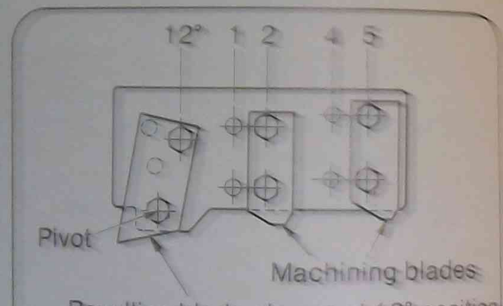
- An arbor:
  - One threaded end supports three feet (or fingers) set at 120 degrees and by turning the arbor, the feet, inserted into the bore of the pipe, expand and firmly locking themselves against the inside wall of the pipe, locate the arbor centrally in the bore.
  - The arbor is also provided with another threaded portion outside of the pipe bore. This accommodates the turning frame hub, which when locked on, provides the automatic feed for external machining of the pipe.
- A turning frame.
  - This accommodates the blade holders and the blades to perform either the trimming or the machining of the pipes.
- An operating handle (or handles).
  - This provides the means to operate these portable manually operated lathes.
- Two blade holders.
  - One holds the trimming blade.
  - The other holds the machining and bevelling blades and is pre-drilled to accommodate the blades for the various lengths of machining required on the different pipe sizes.
  - The holders adjust for diameter size of pipe through the turning of a threaded shaft in the turning frame and are locked in position by means of a locking screw.

Machining operations

The lathes are supplied with manufacturers' instructions for their proper operation. Depending on the size of pipe to be machined, either one of the two types of blade holders must be used with the blades located as shown in the Table and in the illustrations for blade holders.



HAND-OPERATED FIELD LATHE



TOOL HOLDERS

BLADE POSITIONS IN TOOL HOLDERS

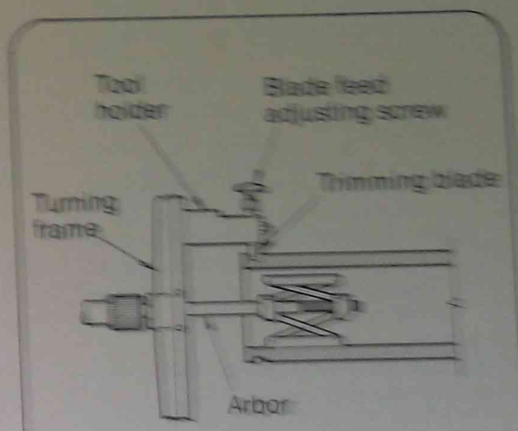
Nominal Pipe Dia	Model B toolholder Tool position	Model C toolholder Tool position
100	1,1	—
150	1,1	—
200	1,1	1,1
225	2,2 & 5,5	2,2 & 5,5
250	2,2 & 5,5	2,2 & 5,5
300	2,2 & 5,5	2,2 & 5,5
375	—	2,2 & 6,6
450	—	2,2 & 6,6
525	—	2,2 & 6,6
600	Use Special Tool Holder	

Preliminaries

- With the proper pipe cutter, cut the pipe approximately 25 mm longer than the finished dimension required.
- Select a pipe which is not out of round by more than 4 mm.
  - Check with calipers.
- Clamp the selected pipe in position on a pipe stand and mark the trim line.
- Install the lathe as per instructions in the manufacturer's manual.

To trim a pipe end:

- Install the lathe so that the face of the knurled bearing of the finger assembly lines up with the line of the proposed trimming.
- Disengage the automatic feed screw.
- Adjust the trimming blade holder by turning the blade holder adjusting screw handle until the holder is about 12 mm from the face of the pipe.
  - Make sure the blade holder lock-nut is loosened when doing this and the trimming blade fully retracted.
- Lock the blade holder against the turning frame by means of the lock-nut (or screw).
- Lower the trimming blade by means of its adjusting screw until it is firmly in contact with the pipe surface.
- Check the alignment of the blade with the trimming line.
- Holding the turning frame against the screw feed assembly on the arbor, rotate the frame to start the groove.

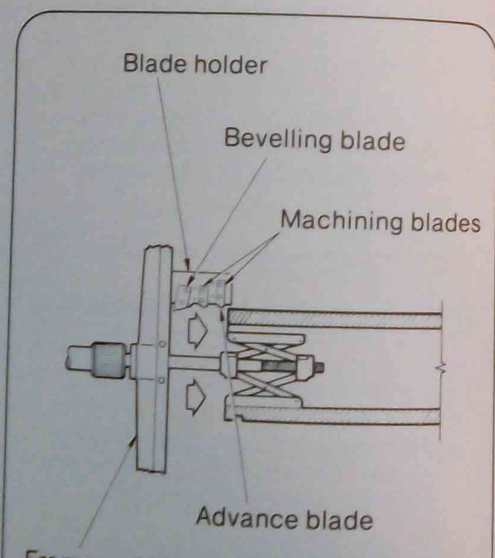


TRIMMING PIPE END

- Adjust the trimming blade feed about 1/8 of a turn per revolution of the frame.
  - — Feed-in the trimming blade only while rotating the frame.
  - — Once a groove is formed, there is no need to hold the turning frame against the screw feed assembly.
  - — If the groove 'loads up', keep rotating the frame, without feeding the blade, until the excess dust has been cleared.
- Continue rotation and trimming blade advance until the cut has been completed.
- Remove the section cut-off, tapping carefully with a hammer if necessary.

To machine the external surface:

- Select the appropriate blade holder for the size of pipe to be machined and fit the blades in their appropriate locations (See Table page 45 and Toolholder illustration).
- Secure the blade holder in the toolholder.
- Check that the screw feed assembly is locked into the arbor shaft.
- Slacken off the collet nut — push clockwise on flanges.
- Slide the turning frame towards the pipe end until the advance blade is level with the trimmed off pipe end.
- Turn the toolholder adjusting screw until this blade is positioned to make a light cut from the pipe surface, then tighten the toolholder lock-nut.
  - — Before adjusting the toolholder, make sure the locking bolt (or nut) is loose.
  - — For manual operation, it may be easier to machine with only the advance blade first, and take a second cut later with the second blade, fitted after the first cut has been made.
- Engage the feed screw by pulling the collet nut flange anticlockwise.
- Rotate frame until about 12 mm have been machined (about 9 revolutions).
- With calipers, check the diameter made and, if necessary, adjust the position of the blade holder.
- Continue turning until the end of the shoulder has been reached.
  - — If only one blade was used, it is necessary to repeat the process with the second blade in position.
  - — To retract the frame, disengage the feed screw and rotate the frame IN THE SAME direction as for the first machining cut while withdrawing the frame.



MACHINING PIPE SPIGOT SURFACE

- Machine a chamfer on the end of the pipe end with the bevelling blade after adjusting the toolholder for this operation.
  - — Chamfers are 9 mm long for pipes 100 to 300 mm and 15 mm for pipes from 375 to 600 mm diameter.
- Disengage the screw feed and retract the turning frame carefully as before.
  - — Before machining the bevel edge, it may be advisable to make one final clean-up machining pass, without altering the blade's setting, to remove the spiral toolmarks that could have been formed on the surface while retracting the turning frame.
- Check the final diameter and size of bevel before finally removing the lathe.

The Gibault joint

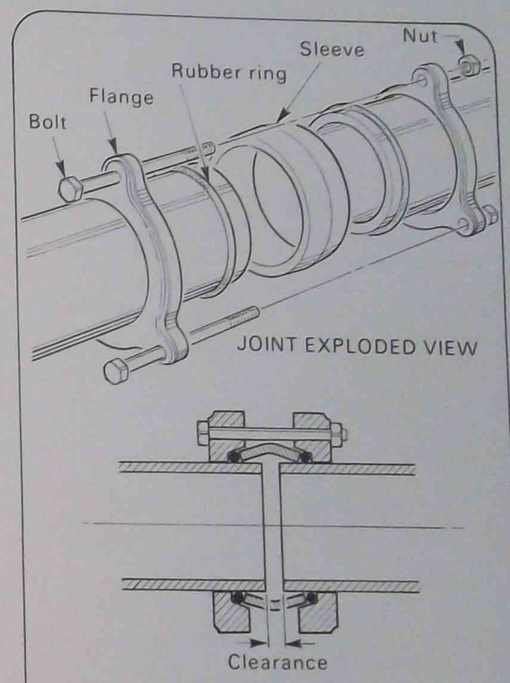
This joint can be used to join two plain pipe ends together, repair longitudinal fractures in pipes or for the installation of plain-ended fittings which may have to be removed for maintenance purposes, such as valves.

The Gibault joint consists of:

- A sleeve (usually cast iron)
- Two flanges (cast iron)
- Two rubber rings
- The necessary nuts and bolts

To make a Gibault joint:

- Place a flange and a rubber ring on each end of the pipes to be joined, as shown.
- Slide the sleeve over the end of one pipe.
- Move the other pipe or fitting into the free sleeve end, leaving about 6 mm clearance between pipe ends for expansion.
- Adjust the sleeve centrally over the pipe ends.
- Draw the flanges and rubber rings up to the sleeve.
- Insert the bolts and nuts, then gradually and evenly tighten the nuts so compressing the rubber rings against the cast iron sleeve and pipe spigot to make a watertight joint.



THE GIBAULT JOINT

Repairing a longitudinal fracture

Where a break is too long to be repaired by a DNR joint (see below for radial fractures), repairs can be carried out as follows:

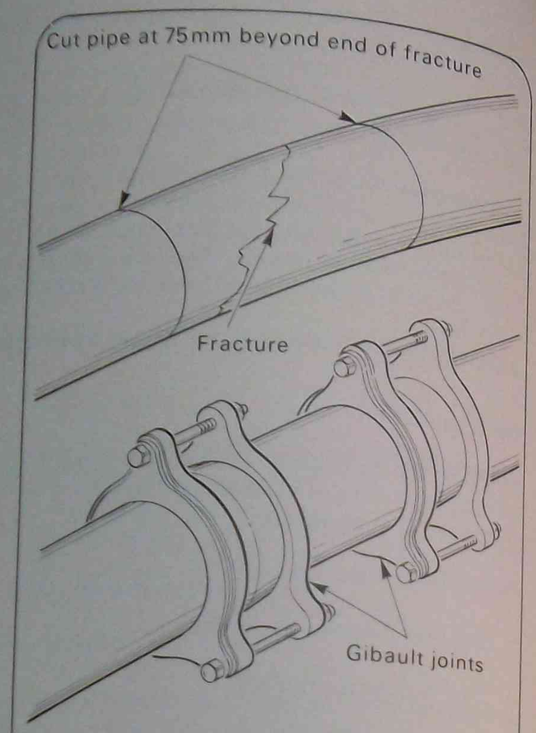
- Using the appropriate cutting tools, cut out the damaged section of pipe at 75 mm beyond the ends of the fracture.
- Cut a suitable length of replacement pipe, making allowances for clearances, and remove sharp edges.
- Assemble the appropriate size Gibault joint over each cut.

Repairing a radial fracture

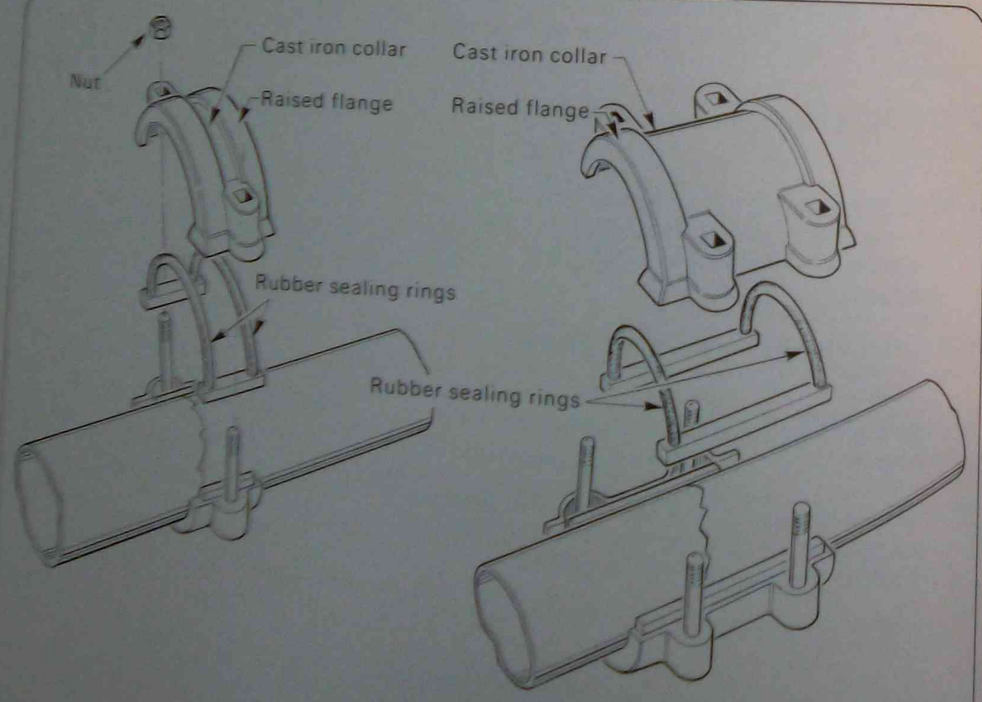
So-called DNR joints can be used for the repair or radial fractures. The joints are supplied in various widths to suit the length of fracture to be repaired. The illustrations are self-explanatory for the sequence of operations required to carry out the repair.

NOTE:

The DNR joint is being phased out in favour of the multi-fit joint (MFJ) which operates safely at higher pressures. Similar in principle to DNR it requires jointing lubricant on the sealing ring-pipe interface.



LONGITUDINAL FRACTURE REPAIR



D N R JOINTS

Multi-fit joints (MFJ)

Multi-fit joints consist of two castings which seal to either asbestos cement or cast iron pipelines by means of two moulded rubber seals which seat into longitudinal and circumferential grooves in each casting. Cup head bolts key into the castings to facilitate clamping of the castings together to form a watertight seal.

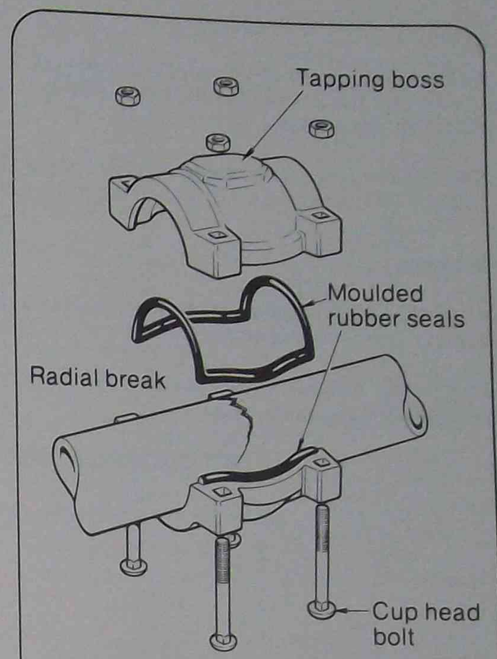
Each casting is provided with a tapping boss for fitting of an off take.

Multi-fit joints with either 80 mm or 100 mm flanged branches to Table 5 of AS 1488-1974 are available in sizes 100 A-F to 200 A-D.

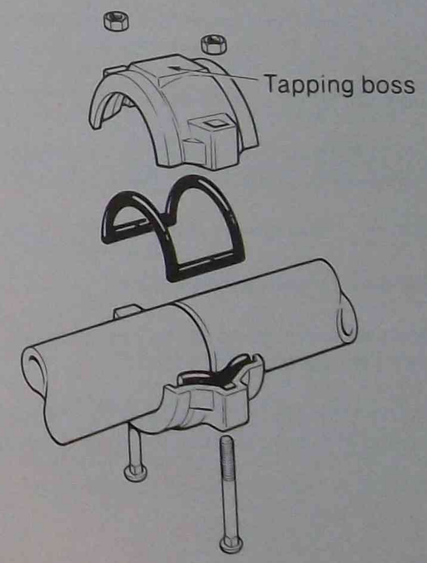
Multi-fit joints have been specifically designed to fit cast iron pipes having outside diameters in accordance with AS 1723-1975, and asbestos cement pipes with outside diameters in accordance with AS 1711-1975.

Types of fittings used with AC water-mains are generaly made from cast iron, e.g. bends, tees, valves, etc, as shown in Section 4.5.3.

NOTES



STANDARD JOINT



SHORT JOINT

MULTI-FIT JOINTS

4.5.7 UPVC Pressure pipe

Rubber-ring jointed UPVC pipes are also used in water supply installations. The pipes are socketed at one end and spigoted at the other. Fittings and seals for use with existing installations in other materials are available.

The sizes of pipes with rubber-ring jointing, range from 50, 65, 80, 90, 100, 125 mm (nominal) right through to 195 mm (see AS 1477-1973 for the full range).

Branding

All UPVC pressure pipes are repetitively branded in accordance with AS 1477-1973 to indicate the nominal diameter and classification.

As a further means of classification, the information is printed in different colours, allocated to classes as in the table below.

PIPE CLASSIFICATION	PRINT COLOUR
4.5	Black
6	Red
9	Blue
12	Green
15	Brown
18	Yellow

The figures in the left-hand column refer to the pipe capacity to withstand at pressure of 10 metres water head for each unit shown. Thus:

Class 6 can stand: 6 x 10 = 60 metres head.
Class 10 can stand: 18 x 10 = 180 metres head.

There are three classes in rubber-ring joints: 6, 9 and 12.

UPVC pressure pipes joined by the solvent-welded process and used for other purposes than for water supply, range in size from 15 to 115 mm.

Of these, there are six classes: 4.5, 6, 9, 12, 15, 18.

Maximum operating temperature

Pressure ratings given in the following table for the various classes of UPVC tube apply only at a service temperature of 20°C.

At service temperature above 20°C, the maximum allowable working pressure is reduced with the increase in temperature. A pressure derating chart is given.

Pipe class	Nominal diameter range (mm)	Recommended max. working pressure @ 20°C (MPa)	Approximate Max. working head (m)
Solvent welded			
4.5	80-195	0.45	45
6	40-195	0.6	60
9	25-195	0.9	90
12	20-195	1.2	120
15	15-115	1.5	150
18	15-195	1.8	180
Rubber-ring joint			
6	50-195	0.6	60
9	50-195	0.9	90
12	50-195	1.2	120

TEMPERATURE DERATING CHART

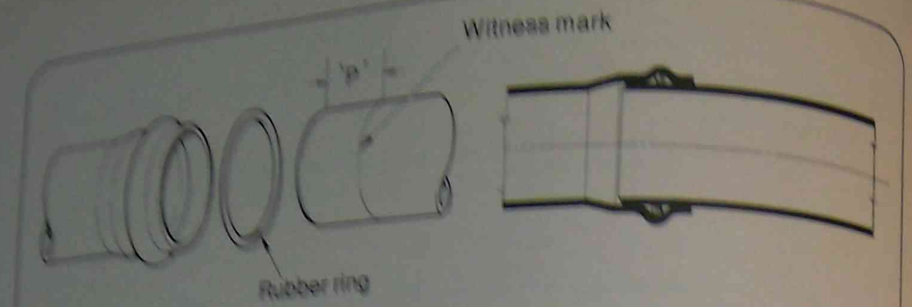
Pipe material temperature (°C)	Maximum allowable pressure (MPa)					
	Class 4.5	Class 6	Class 9	Class 12	Class 15	Class 18
20	0.45	0.60	0.90	1.20	1.50	1.80
30	0.36	0.48	0.72	0.96	1.20	1.40
40	0.27	0.36	0.54	0.72	0.90	1.08
50	0.18	0.24	0.36	0.48	0.60	0.72
60	0.09	0.12	0.18	0.24	0.30	0.36

There are various types of plastic pressure pipe systems available. Each of these systems includes the normal range of fittings. A series of adaptors is also available to enable combination with pipes and fixtures of other materials. Plastic pipes have several important characteristics:

- They are much lighter than other pipes, being only 20% of the weight of a galvanised pipe of equal capacity.
- They do not conduct electricity and are thus not corroded by electrolysis.
- They are easy to handle and to join.
- Smooth internal surfaces reduce friction to a minimum.

Plastic pipes are more affected by exposure to changes in temperature than pipes of other materials. An increase in temperature of the pipe material by 10°C may cause a 30 m pipe to increase in length by 25 mm. If the pipes are subjected to uneven heating, for example being half in shade and half in hot sunlight, they may distort, causing difficulty in forming well-sealed joints. During storage and installation, care should be taken to:

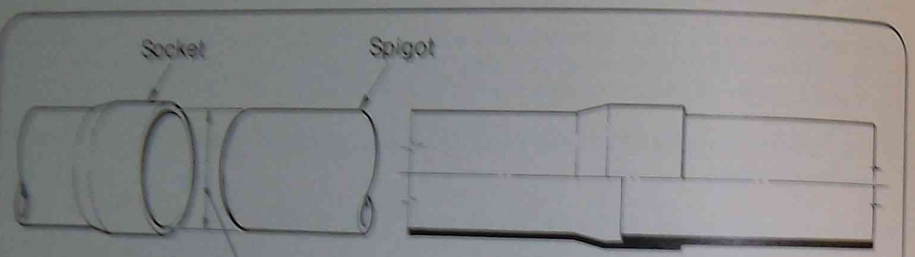
- Stack pipes parallel to each other and in the shade.
- Stack them not more than 7 layers deep.
- Support the pipes at 1 metre centres on bearers about 75 mm wide.



UPVC RUBBER RING JOINT

TABLE OF RUBBER-RING JOINTING PIPES DETAILS

Nominal Diameter of Pipe (mm)	IP Metric (mm)	Mean Outside Diameter (mm)	Class 6 60 m head (0.6 MPa) Mean Inside Diameter (mm)	Class 6 60 m head (0.6 MPa) Mean Wall Thickness (mm)	Class 6 60 m head (0.6 MPa) Approx. Mass (kg/100 m)	Class 9 90 m head (0.9 MPa) Mean Inside Diameter (mm)	Class 9 90 m head (0.9 MPa) Mean Wall Thickness (mm)	Class 9 90 m head (0.9 MPa) Approx. Mass (kg/100 m)	Class 12 120 m head (1.2 MPa) Mean Inside Diameter (mm)	Class 12 120 m head (1.2 MPa) Mean Wall Thickness (mm)	Class 12 120 m head (1.2 MPa) Approx. Mass (kg/100 m)
50	50	60.3	56.7	1.8	49	55.1	2.6	70	53.7	3.3	89
80	101	88.9	83.7	2.6	105	81.3	3.8	151	79.1	4.9	195
100	132	114.3	107.9	3.2	170	104.7	4.8	250	101.7	6.3	321
150	125	160.3	151.3	4.5	333	146.9	6.7	489	142.7	8.8	633
200	166	219.1	206.7	6.2	626	200.9	9.1	905	195.3	11.9	1192



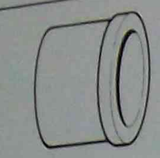
UPVC SOLVENT-WELDED JOINT

TABLES OF SOLVENT-WELDED PIPES DETAILS

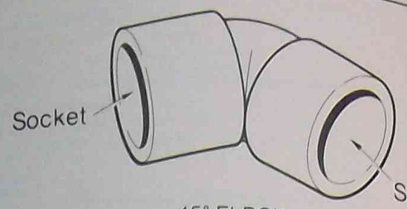
Nominal Diameter of Pipe (mm)	Mean Outside Diameter (mm)	Class 4.5 45 m head (0.45 MPa) Mean Inside Diameter (mm)	Class 4.5 45 m head (0.45 MPa) Mean Wall Thickness (mm)	Class 4.5 45 m head (0.45 MPa) Approx. Mass (kg/100 m)	Class 6 60 m head (0.6 MPa) Mean Inside Diameter (mm)	Class 6 60 m head (0.6 MPa) Mean Wall Thickness (mm)	Class 6 60 m head (0.6 MPa) Approx. Mass (kg/100 m)	Class 9 90 m head (0.9 MPa) Mean Inside Diameter (mm)	Class 9 90 m head (0.9 MPa) Mean Wall Thickness (mm)	Class 9 90 m head (0.9 MPa) Approx. Mass (kg/100 m)
15	21.3	—	—	—	—	—	—	—	—	—
20	26.7	—	—	—	—	—	—	—	—	—
25	33.5	—	—	—	—	—	—	—	—	—
32	42.2	—	—	—	—	—	—	30.5	1.5	23
40	48.2	—	—	—	45.2	1.5	33	38.4	1.9	35
50	60.3	—	—	—	56.7	1.8	49	44.0	2.1	45
80	88.9	84.9	2.0	81	83.7	2.6	104	55.1	2.6	69
100	114.3	109.3	2.5	130	107.9	3.2	168	81.3	3.8	150
150	160.3	153.4	3.4	253	151.3	4.5	328	104.7	4.8	247
175	200.3	191.7	4.3	396	189.0	5.6	517	146.9	6.7	482
195	219.1	209.7	4.7	474	206.7	6.2	621	183.5	8.8	758
225	250.4	239.8	5.3	613	236.4	7.0	803	200.9	9.1	904

Nominal Diameter of Pipe (mm)	Mean Outside Diameter (mm)	Class 12 120 m head (1.2 MPa) Mean Inside Diameter (mm)	Class 12 120 m head (1.2 MPa) Mean Wall Thickness (mm)	Class 12 120 m head (1.2 MPa) Approx. Mass (kg/100 m)	Class 15 150 m head (1.5 MPa) Mean Inside Diameter (mm)	Class 15 150 m head (1.5 MPa) Mean Wall Thickness (mm)	Class 15 150 m head (1.5 MPa) Approx. Mass (kg/100 m)	Class 18 180 m head (1.8 MPa) Mean Inside Diameter (mm)	Class 18 180 m head (1.8 MPa) Mean Wall Thickness (mm)	Class 18 180 m head (1.8 MPa) Approx. Mass (kg/100 m)
15	21.3	—	—	—	18.3	1.5	14	17.7	1.8	16
20	26.7	23.7	1.5	18	22.9	1.9	22	22.3	2.2	25
25	33.5	29.7	1.9	28	28.9	2.3	33	28.1	2.7	39
32	42.2	37.4	2.4	44	36.4	2.9	53	35.4	3.4	62
40	48.2	42.8	2.7	57	41.6	3.3	69	40.4	3.9	80
50	60.3	53.7	3.3	88	52.1	4.1	107	50.5	4.9	127
80	88.9	79.1	4.9	193	76.7	6.1	234	74.7	7.1	271
100	114.3	101.7	6.3	317	98.9	7.7	385	96.1	9.1	449
150	160.3	142.7	8.8	624	138.7	10.8	756	134.7	12.8	875
175	200.3	178.3	10.9	971	173.4	13.5	1178	168.4	15.9	1369
195	219.1	195.3	11.9	1136	189.5	14.8	1412	184.3	17.4	1644

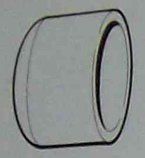
NOTES



REDUCING BUSH



45° ELBOW



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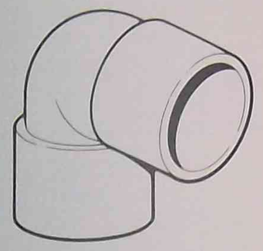
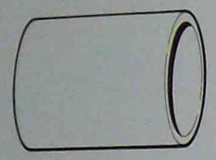
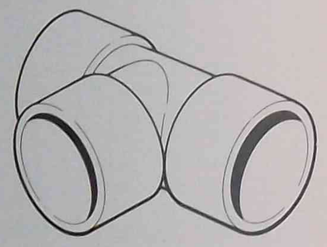


90° ELBOW



COUPLING



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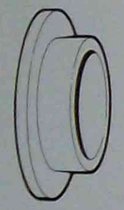
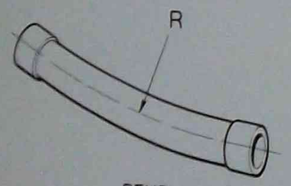


FLANGE



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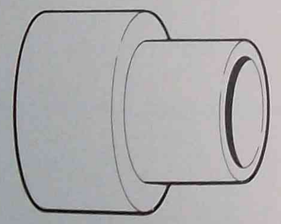
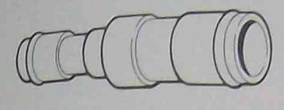
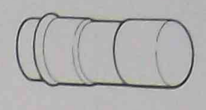


REDUCING COUPLING

FITTINGS USED ON UPVC SOLVENT-WELDED MAINS



REDUCER



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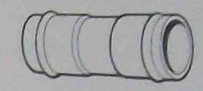
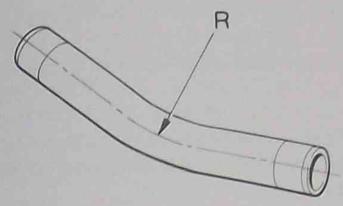


STANDARD COUPLING



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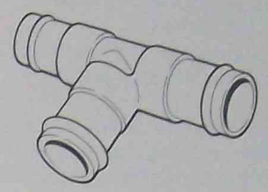
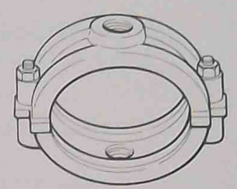
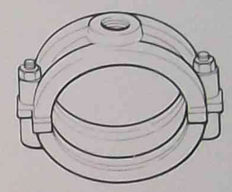


TEE

FITTINGS USED ON RUBBER RING JOINTED UPVC WATER MAINS



DOUBLE TAP



SINGLE TAP

DNR TAPPING BANDS FOR UPVC PRESSURE PIPES

4.5.8 Securing the mains

When the mains are under pressure, considerable thrust is set up, especially where there are directional changes or fittings, such as valves, in the installation. Thrust blocks, usually of concrete (mix: 1:2:5), are installed at critical locations and elsewhere as required to prevent movement of the pipework.

Location of thrust blocks is required:

- at all bends or junctions;
- at the termination of pipework;
- at valves installed in the pipework;
- at a change in diameter of the main;
- in areas of unstable soil conditions.

The thrust blocks transfer the load from the fittings to a wider load-bearing area on the undisturbed faces of the trench walls.

It is generally the practice to install these blocks after the line has been partly back-filled and consolidated. This ensures that the pipes in the vicinity of the fittings are adequately restrained and that neither pipes nor fittings can move away from the thrust blocks.

Installation

Thrust blocks should bear firmly against the side of the trench. It may therefore be necessary to trim the side of the trench or to excavate a recess into the trench wall by hand. Should it be necessary to install the thrust blocks as construction progresses, soil should be tamped down around and over the pipe up to the crown surface for at least one pipe length away from the fitting.

NOTES

The thrust acts through the centre line of the fitting and therefore the thrust block should be constructed symmetrically about this centre line.

Thrust blocks should be constructed of a 1:2:5 concrete mix and 7 days allowed for the concrete to set before testing.

The concrete is mixed, placed fairly dry and carefully tamped around the fitting, making it easy to shape the block to a wedge shape with its widest part against the solid undisturbed trench wall. Blocks usually require some concrete forming construction at the sides to achieve the proper bearing area with a minimum of concrete.

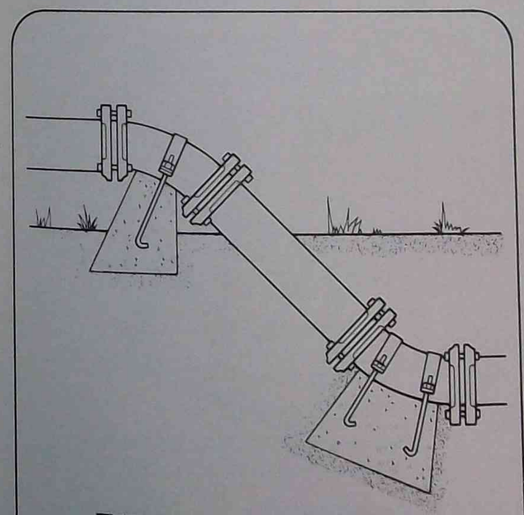
When a cast iron fitting is used to change the direction of the pipeline in the vertical plane, the concrete thrust block should be designed so that its weight is greater than the thrust in the fitting. The fitting should be anchored to the block, using steel straps or rods.

NOTE:

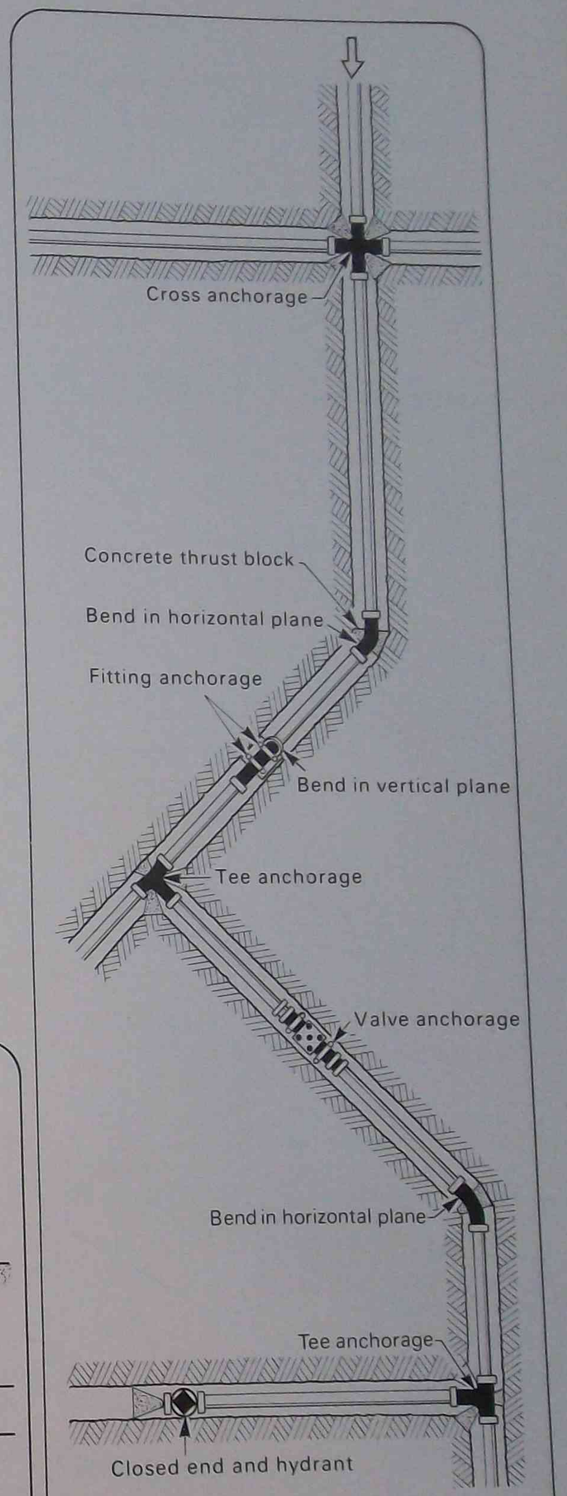
On some fittings, the thrust-absorbing means are part of the fitting, e.g. duck-foot bend.

4.5.9 Typical irrigation set-out

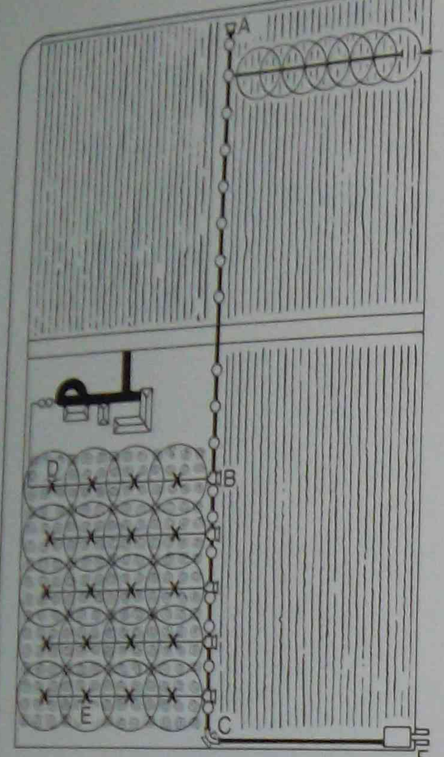
Even on irrigation lines, which are normally classed as private mains in a non-public situation, e.g. market garden, nursery, etc., thrust blocks to prevent movement must be installed.

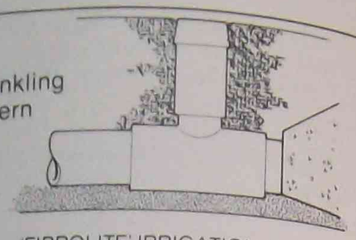


TYPICAL ANCHORAGE OF A VERTICAL BEND

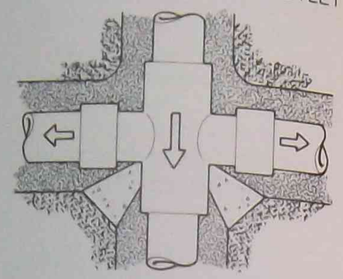


TYPICAL THRUST BLOCK INSTALLATION

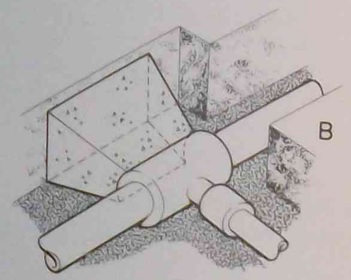




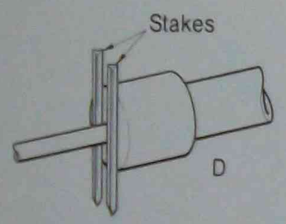
'FIBROLITE' IRRIGATION OUTLET



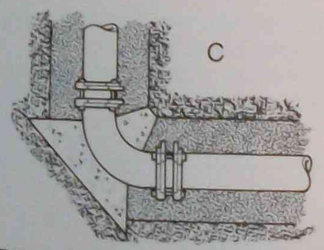
'FIBROLITE' CROSS



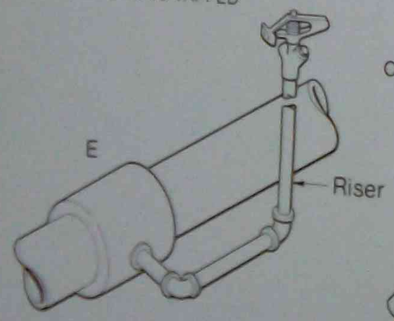
'FIBROLITE' TEE



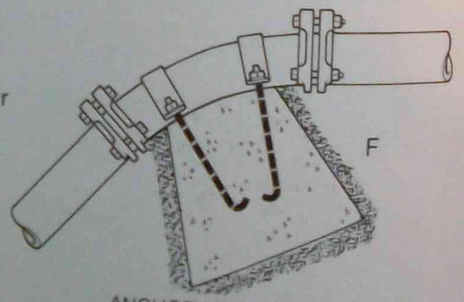
'FIBROLITE' CLOSED COUPLING TAPPED



CAST IRON BEND IN HORIZONTAL PLANE



'FIBROLITE' TAPPED COUPLING SHOWING A TYPICAL IRRIGATION RISER



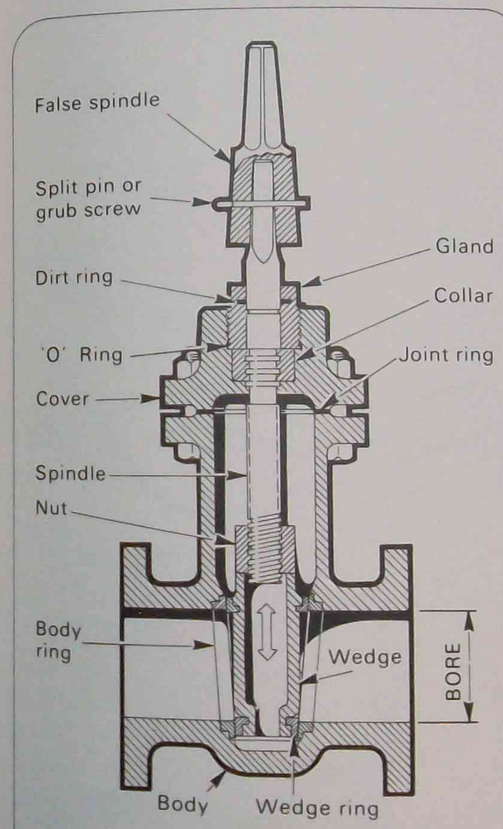
ANCHORAGE OF CAST IRON BEND IN VERTICAL PLANE

TYPICAL IRRIGATION INSTALLATION SHOWING LOCATION AND DETAILS OF ANCHOR BLOCKS

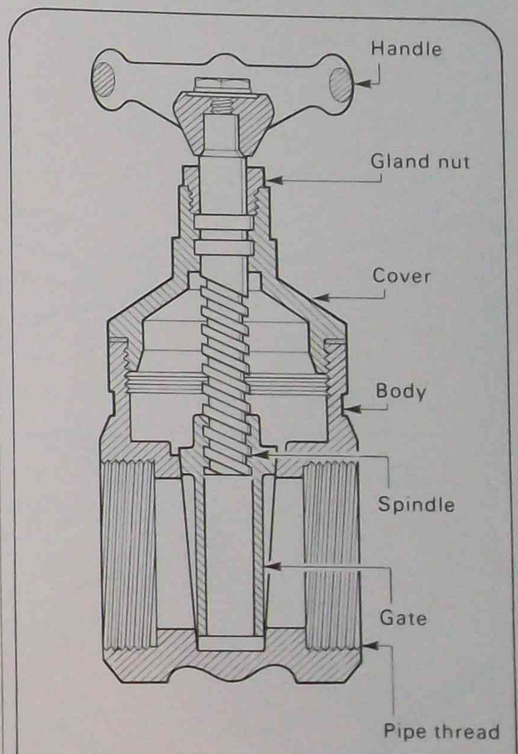
4.5.10 The sluice and the gate valve

These are installed in the pipeline to control the flow of water. They are not meant to act as throttling devices to regulate the volume of water flowing through the pipes. They are either fully open, their straight bore allowing unrestricted water flow, or fully closed, cutting off the water supply to the downstream portion of the pipeline.

Gate valves are produced in many sizes suitable for insertion into the pipeline system. They are either flanged, socket or spigot-ended to match the features of the mains jointing system used. Smaller valves, as illustrated, have screwed ends to match smaller size pressure installations. The larger valves do not usually feature a handwheel when placed underground, but the spindle end is squared off to accommodate a long T-shaped key. This spindle end is housed in a cast iron cover and accessible by lifting the cover lid. By turning the spindle by handwheel or key, the gate fitted to the threaded part is moved upwards to open the valve or downwards to close it, depending on which way the spindle is rotated. Directions for closing or opening the valve are usually cast on the handwheel. Large, key-operated valves usually require an anticlockwise rotation of the spindle for closing and a clockwise one for opening, but this depends on the pattern or design preferred or approved for installation by the Supply Authorities.



SLUICE VALVE (CLOSED)



GATE VALVE

NOTE:

All British valve standards call for clockwise closing unless specifically ordered to the contrary.

5 WATER SERVICES

A separate service pipe which taps into the Water Supply Authority's mains is usually provided for each property to be supplied.

The diameter of the service pipe is in relation to the requirements of the user.

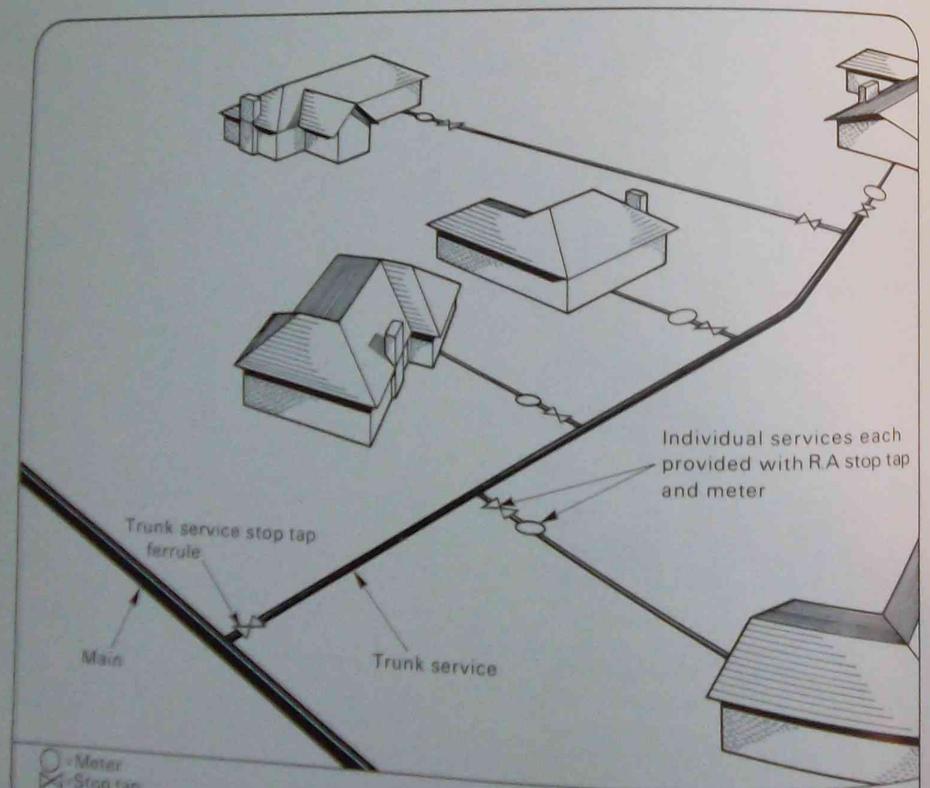
The supply authorities normally supply tables which indicate:

- Maximum number of pipes that may be tapped into the local mains and trunk services.
- The maximum size of such service pipes for each type of property.

5.1 TRUNK SERVICES

Circumstances, particularly in outlying areas, may make it necessary to connect a pipe of larger diameter than the usual service pipe size to accommodate local requirements. Such lines tapped into the mains to service an area are called: 'Trunk service lines' or 'Trunk service' or 'Joint service'.

The service pipes for each individual property are then tapped into this in the same way as the service pipe is tapped into a main.



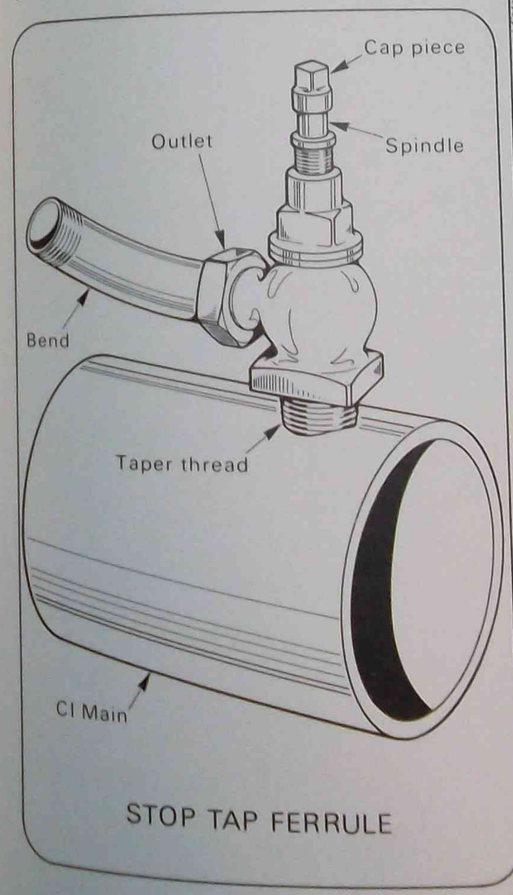
TRUNK SERVICE

5.2 CONNECTION OF SERVICES TO THE MAIN

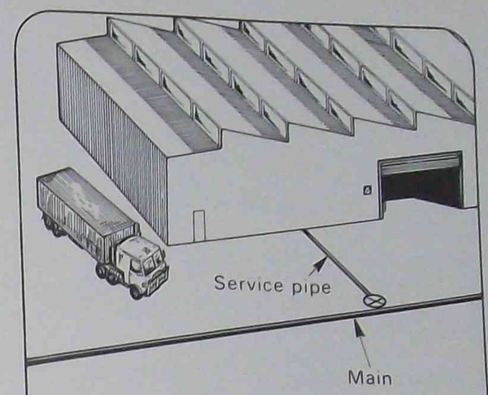
The connection between the main and the service pipe is made by fitting a stop tap assembly (called a ferrule) into the main. The service pipe is then fitted to the outlet of the ferrule. The ferrule contains a screw-down stop valve and has a male tapered BSP thread at its lower end for connecting it to the main. At the top of the spindle is a square cap piece which enables the valve to be opened or closed with a wrench or a key. The outlet at the side of the ferrule is provided with a union nut for attachment of the service pipe. The ferrule is usually fitted on the main, directly in front of the property to be serviced.

Ferrules may be fixed to cast iron mains by:

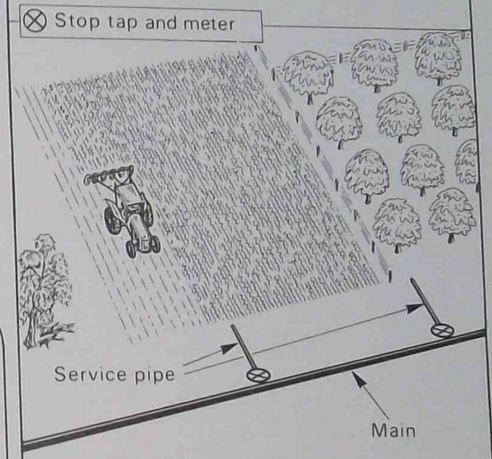
- Screwing directly into a BSP threaded hole in the main.
- Screwing into a wrought iron clip fixed around the main.
- A breeching connection.



STOP TAP FERRULE

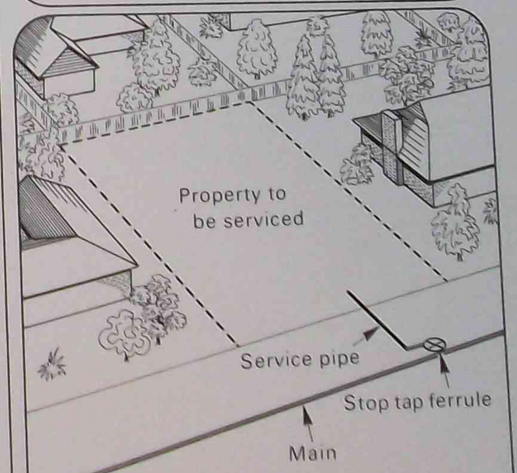


INDUSTRIAL USE



AGRICULTURAL/IRRIGATION USE

USE OF LARGE SERVICE PIPE



LOCATION OF FERRULE

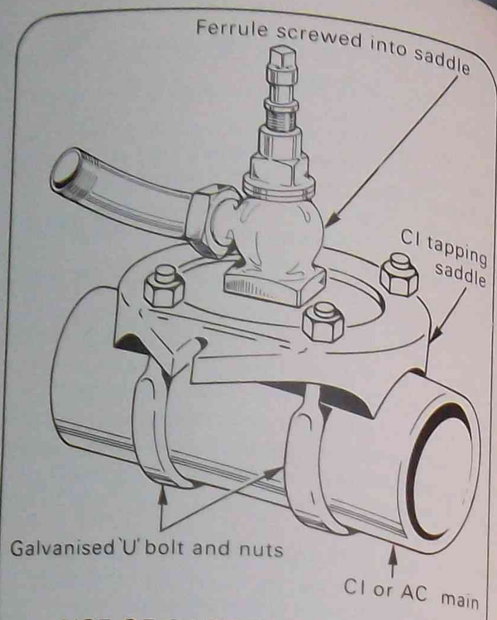
5.2.1 Use of the cast iron saddle

A cast iron saddle may be used when the size of the hole required would weaken the main or produce a weak joint if the ferrule were screwed directly into the main.

The saddle is placed so that the ferrule is directly over a hole drilled in the main and the top half of the saddle is bedded on the main with a rubber sealing washer.

Most Water Supply Authorities have tables detailing the maximum size of hole which may be used without the saddle support.

The recommended maximum diameter tapping that is permitted for each diameter of water-mains is as per table below:

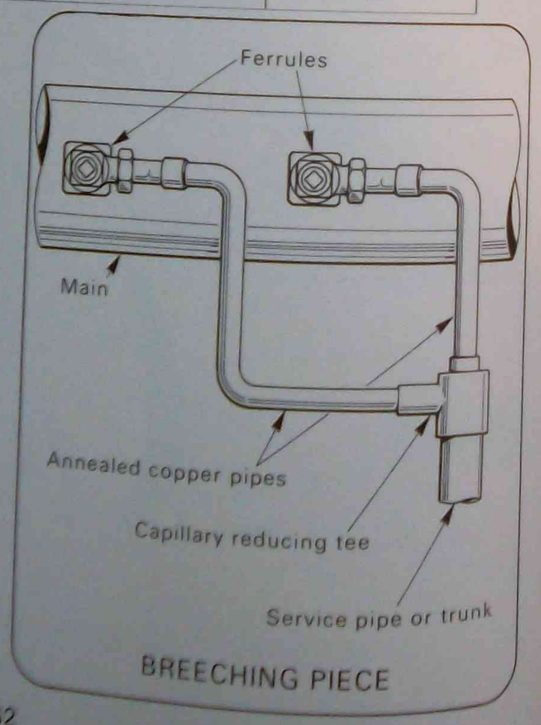


USE OF CAST IRON SADDLE

DIAMETER OF WATER-MAIN (mm)	WITHOUT TAPPING SADDLE. CAST IRON WATER-MAINS ONLY (mm)	WITH TAPPING SADDLE (mm)
80	20	40
100	20	40
125	25	40
150	25	65
175	25	65
200	32	65
225	40	65
Over 225	50	—

5.2.2 Breeching connection

A breeching connection is sometimes used to connect a large diameter service pipe or trunk to a main. Two ferrules are used. The ferrules are connected to the service pipe by annealed copper pipes, as a Y-piece or a Tee-piece. The use of two ferrules allows a greater volume of water into the service pipe.



BREECHING PIECE

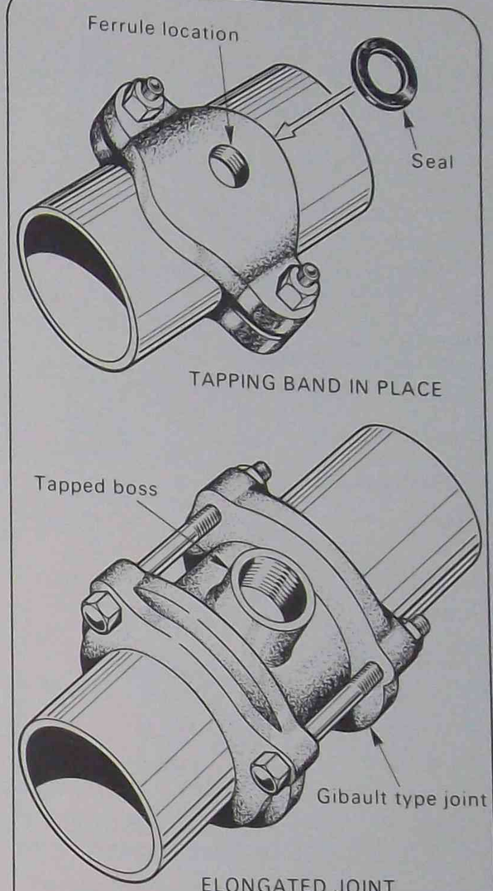
5.2.3 Fixing ferrules into AC, concrete or plastic mains

Ferrules may be fitted to AC, concrete or plastic mains by tapping saddles. A tapping saddle or band is drilled and threaded to accept a ferrule. It is clamped to the main so that the ferrule is directly over a hole drilled in the main. Sealing material is placed between the saddle and the main. Concrete mains pipes sometimes have brass ferrules cast in situ during manufacture.

The tapping band, used for connection of the ferrule, consists of two sections of cast iron curved to fit snugly to the outside diameter of the main. The two sections are clamped together by galvanised iron bolts and nuts. The top section is drilled and tapped to accept the threaded ferrule end. The seal, between band and drilled hole in the main, is made by compressing a rubber ring between main and tapping band.

Tapping bands should not be located closer than 150 mm from the end of a closed-off AC pipe. The maximum allowable tapping sizes for each normal size of AC pipe are tabulated below.

NOMINAL PIPE DIAMETER (mm)	MAXIMUM TAPPING SIZE (inch BSP)
50 & 58	1 (25 mm)
80	1 (25 mm)
100	1½ (38 mm)
150	1½ (38 mm)
200	2 (50 mm)



TYPES OF TAPPING BANDS FOR AC PIPES

NOTE:

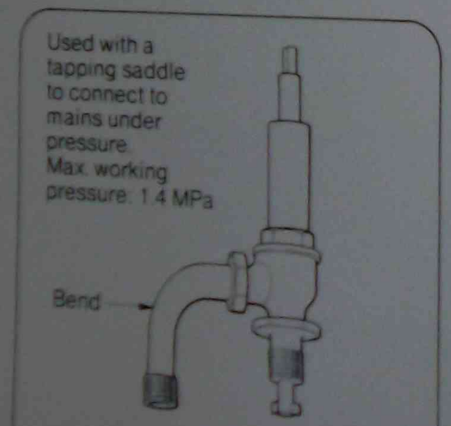
Tapping bands should not be used where the water head in the line may at any time exceed 140 metres (equivalent pressure = 1400 kPa).

In lines where the pressure exceeds 1400 kPa and a larger delivery through the service pipe is required compared to what would normally be available by fitting a tapping band, elongated joints may be installed.

The elongated joint, as shown, is somewhat similar to a Gibault joint, except that its sleeve has been elongated to allow space for the tapped BSP boss.

WITH JUMPER VALVE

BARBER HAYS FERRULE

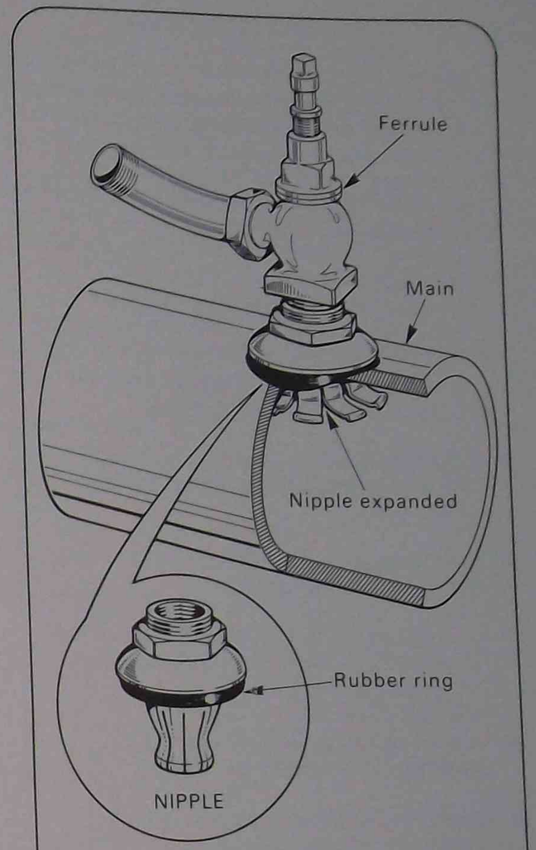


SELF-INSERTING MAINS FERRULE

STANDARD
(WITHOUT JUMPER VALVE)

BARBER HAYS FERRULE

Ferrules are also available with an expanding brass nipple formed on the lower end. A special key is used to expand the lower portion which grips a hole drilled in the wall of the main.



NIPPLE-MOUNTED FERRULE

5.3 TAPPING THE MAIN

The action of drilling and tapping a hole in a main to fit a ferrule is called: 'tapping the main'. This may be carried out by a plumber or by an employee of the water authority. Before commencing the work, permission must be obtained from the Water Supply Authority to tap the main and from the local Council to open the road.

Two techniques may be used for tapping the main:

- With the water in the main shut off.
- Without shutting off the water in the main.

5.3.1 Tapping with the water shut off

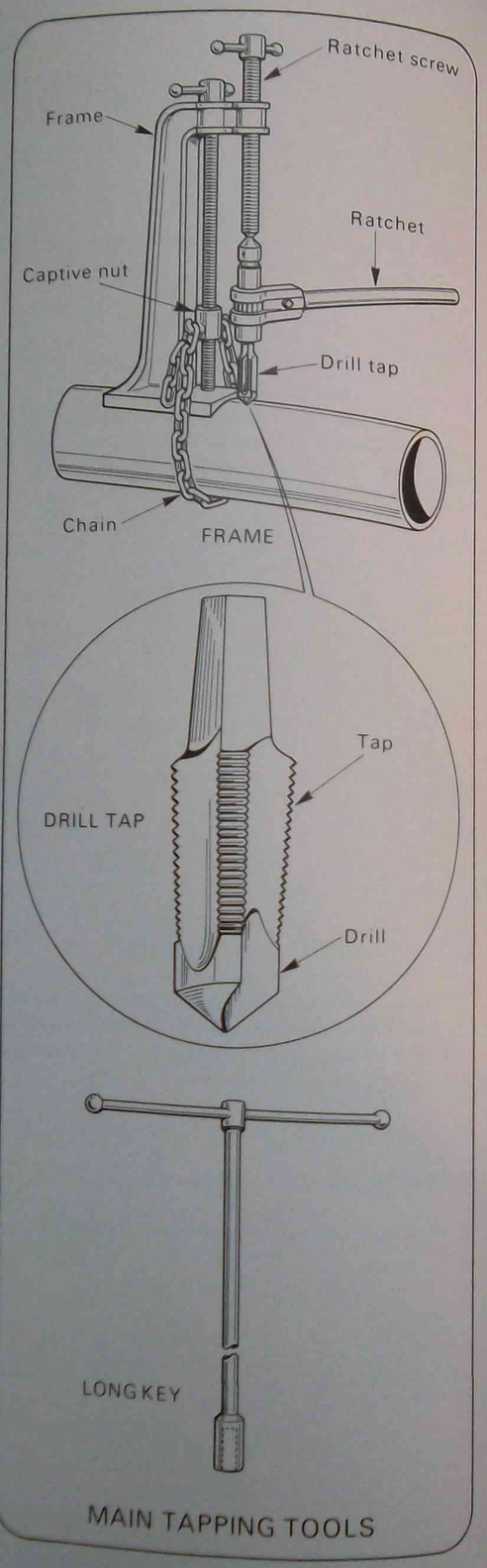
The ground around the main is opened and the tools for tapping are assembled on the main. They consist of a frame, secured by a chain passed around the main and held by a captive nut on a clamping screw. The tapping procedure is as follows:

- Assemble a drill tap into the lever-operated ratchet mounted within the frame.
  - The drill tap is held against the main by a ratchet tightening screw.
- Adjust the tapping tools to position the drill tap vertically above the centre line of the main.
- Start tapping by turning the ratchet lever to rotate the tap.
  - The drill tap is held firmly to the main by continuously tightening the ratchet screw.
- Continue tapping until the main is pierced and the thread well started.
- Dismantle the frame from the main, leaving the drill tap in position.
- Engage a long key with the drill tap and continue tapping until the correct depth of thread has been reached.

NOTE:

With small diameter mains, care must be taken to ensure that the tap does not cut into the opposite side of the main.

- When the thread has been cut to a sufficient depth, remove the tap.
- Prepare the thread of a ferrule with hemp or thread-sealing tape.
- Screw the ferrule tightly into the main until the outlet faces in the right direction.
- Turn on the water in the main and examine the ferrule connection for water leaks.



MAIN TAPPING TOOLS

5.3.2 Tapping under pressure

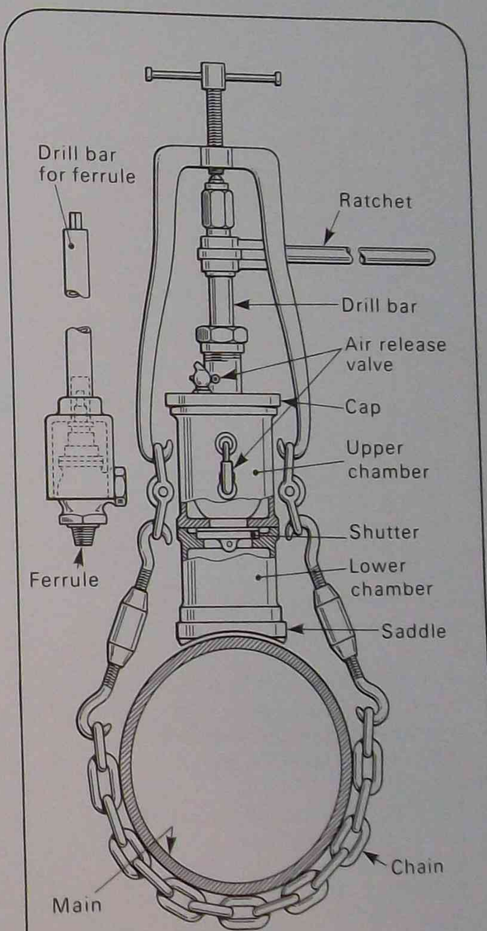
Tapping under pressure is usually done by employees of the supply authority. A special pressure tapping machine is used for this. It consists of a saddle, secured to the main by chains which are tightened by means of turnbuckles. The saddle supports a cylinder divided into an upper and a lower chamber by a shutter.

When closed, this shutter keeps the lower chamber watertight. The top of the upper chamber is closed off by a cap secured to it by nuts and bolts. The cap itself is bored to allow a drill bar to pass while the upper chamber is large enough to house the ferrule to be inserted after drilling and tapping has been completed.

The drill frame attaches to shackles of the chains, supports the drill bar and ratchet and accommodates the clamping screw which secures the drill bar and provides the required drilling and tapping pressure.

Air and water release valves are provided to the upper chamber.

- A centre mark is made on the main where the ferrule is to be installed.
  - The centre mark is made to provide proper drill location.
- The machine is installed to the main and directly over the centre mark.
- The drill bar is passed through the cap, the drill tap attached and the cap secured to the upper chamber.
- The release valve is opened.
- The clamping screw is tightened down and drilling/tapping started by clockwise rotation of the ratchet, maintaining the necessary pressure by gradually screwing down the clamping screw.
- When the drill breaks through the mains wall, air and water escape from the release valves.
- The release valves are closed and tapping continued until sufficient thread depth has been obtained.
  - This is indicated by the depth that the drill bar has been lowered during the tapping operation.



TAPPING UNDER PRESSURE MACHINE

- When sufficient thread depth has been obtained, the clamp screw is released and the drill tap is screwed out of the main and raised into the upper chamber by the drill bar.

- The shutter is closed and the cap removed.
- The water pressure is confined to the lower chamber.
- The drill bar for the ferrule is inserted in the cap, the ferrule attached and the cap replaced.
- The shutter is opened, allowing drill bar to be lowered and the attached ferrule to be installed in the tapped thread, using the ratchet mechanism, as before.
- When the ferrule is secured, the machine is dismantled and the ferrule further tightened and adjusted to its required alignment.

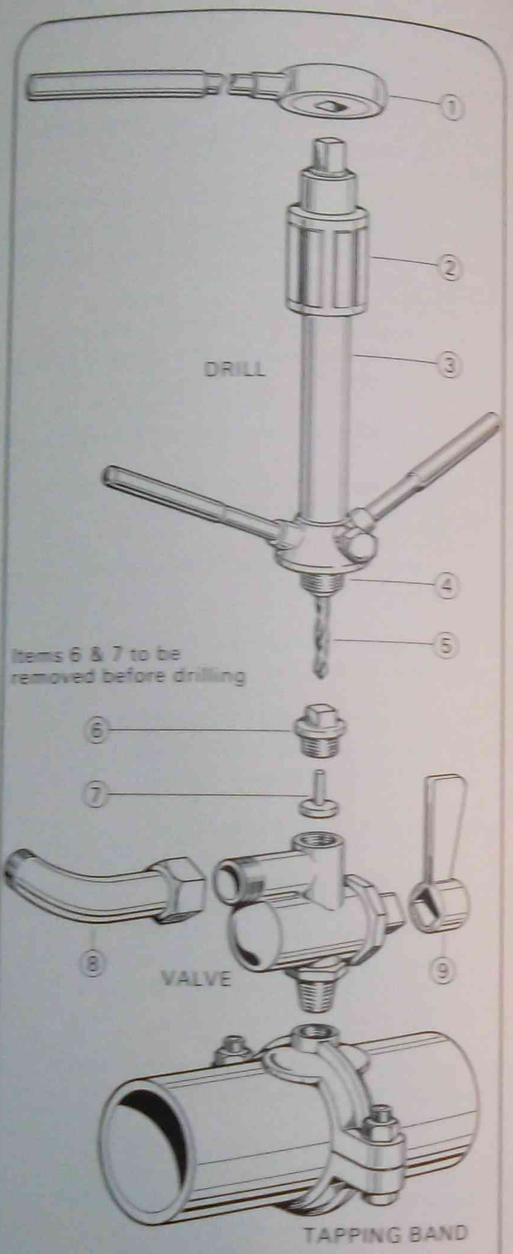
NOTE:

When AC mains are tapped under pressure, the machine is attached to a tapping band which already has the tapped hole; the main being drilled only.

An alternative means of tapping under pressure is by using a special ferrule, tapping band and drill tool adaptor. The procedure is as follows:

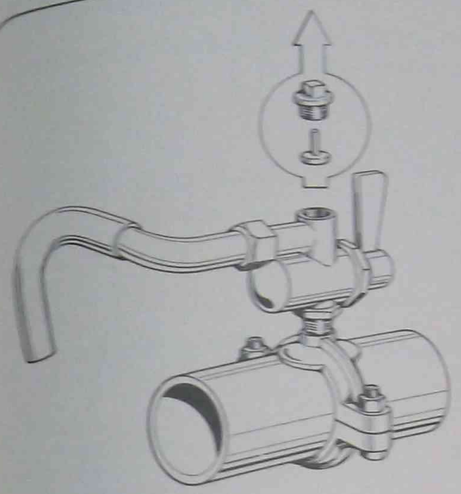
- The tapping band, with its inbuilt seal, is bolted to the main.
- The ferrule, which has a threaded plug screwed into the top, is screwed into the tapping band.
- The valve of the ferrule is opened, the plug removed and a short length of hose connected to the bend.
- The drill tool, with the appropriate drill fitted to it, is screwed into the ferrule and the feed handle rotated until the drill is hard against the main.
- Drilling is commenced by rotating the ratchet and is continued until the main is fully pierced and water flows from the hose.
- The feed handle is unscrewed and withdrawn from the body and the valve turned off.
- The drill tool body is then unscrewed from the ferrule and the plug replaced.

The ferrule is now ready for connection of the service pipe.

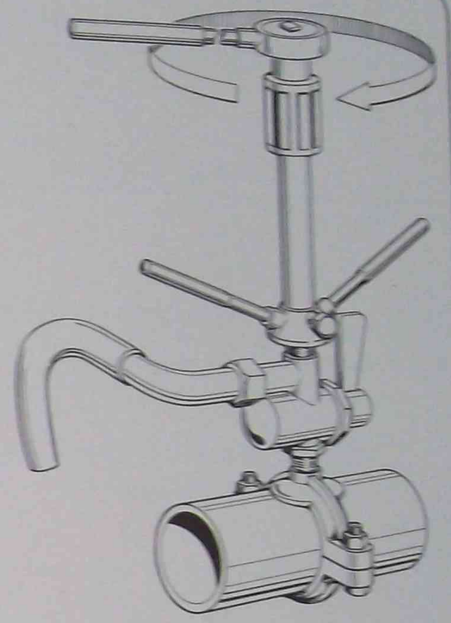


1. Ratchet	4. Adaptor	7. Reflux valve
2. Feed handle	5. Drill	8. Bend
3. Drill body	6. Plug	9. Valve handle

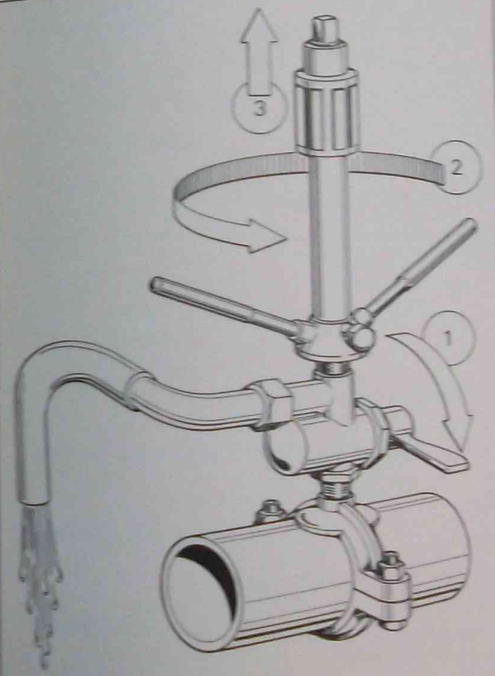
TAPPING BAND AND DRILL TOOL



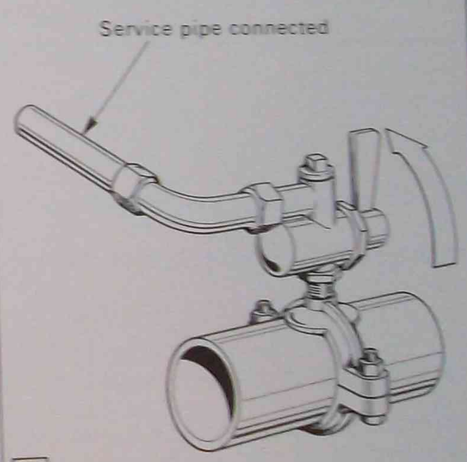
1 Plug and Reflux valve removed-Valve opened



2 Drilling starts



3 When water flows from hose –
1 Close valve
2-3 Stop drilling and remove Drill tool



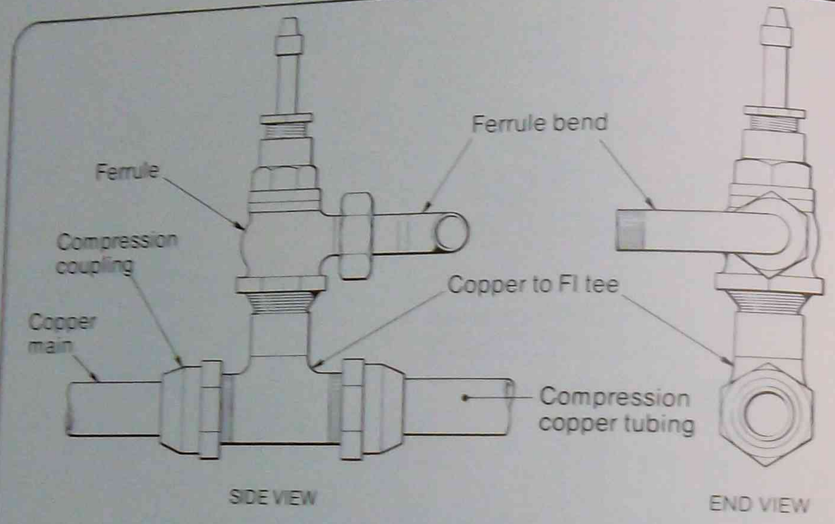
4 Operation completed-Connection made-Valve opened

SEQUENCE OF OPERATION
(TAPPING BAND AND DRILL TOOL ADAPTOR)

5.3.3 Tapping small diameter copper mains

Tappings to small copper mains should be made by inserting a copper to FI (female iron) tee in the main using compression couplings or a copper to FI capillary tee type S with silver brazed joints.

The FI outlet and the ferrule should be kept in a vertical position. The illustration shows the arrangement of copper to FI tee and ferrule using compression fittings.



TAPPING INTO SMALL COPPER MAINS

Under no circumstances is a triple union copper or soft-solder capillary tee to be used.

The Approved Authority will ensure that tappings are carried out only in the approved manner.

NOTE:

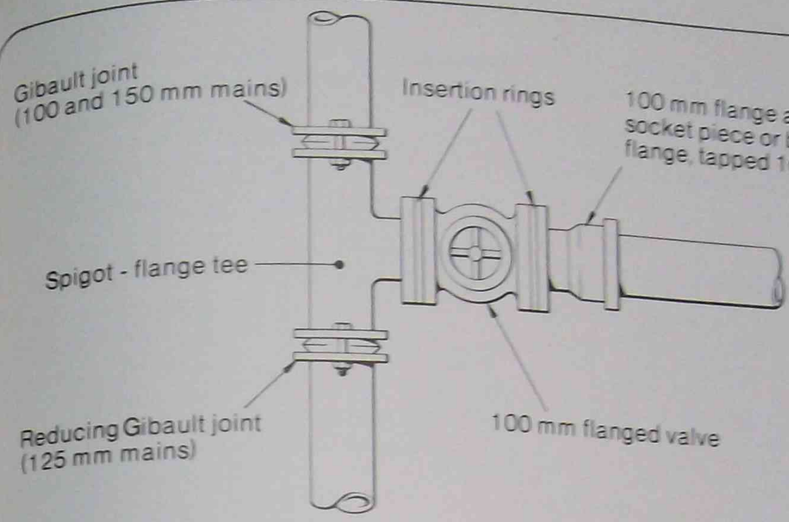
This is normally the method used for copper trunk service or court services.

Similar methods, where permitted, are used where the material is galvanised pipe. The fitting (tee) is a galvanised tee with the ferrule remaining the same.

5.3.4 Large tappings (tee-insertions)

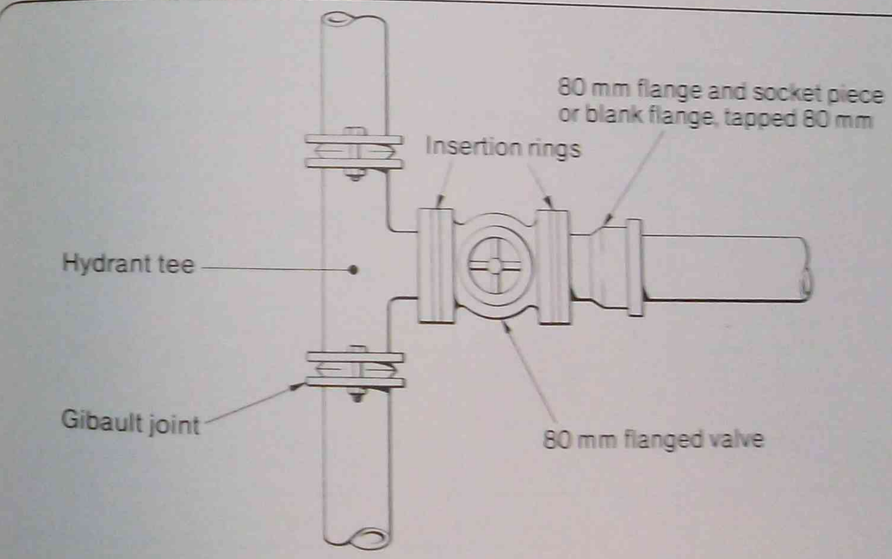
These are made to cater for the following:

- Fire services
- Domestic services
- Sprinkler services

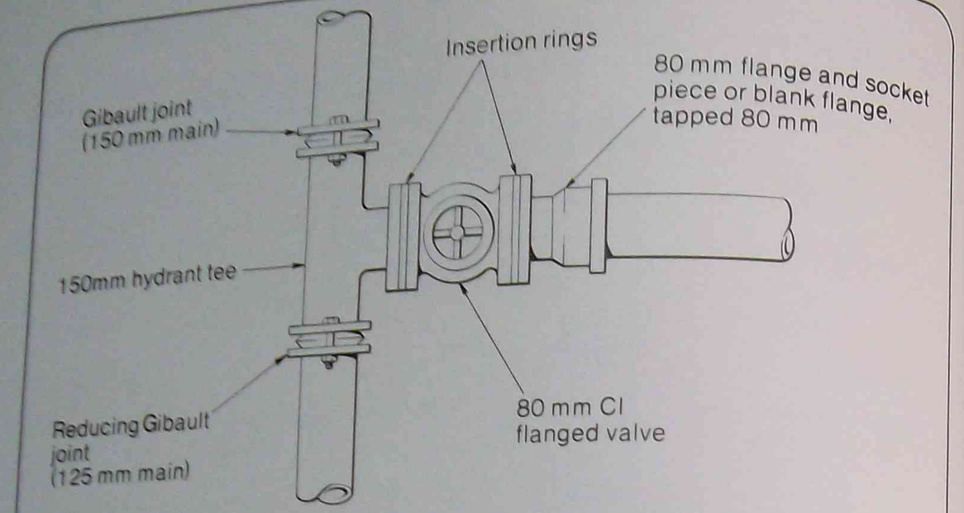


100 mmSERVICES FROM 100, 125 AND 150 mm MAINS

Flanged fittings must be used when available and their installation should be as shown in the illustrations following.



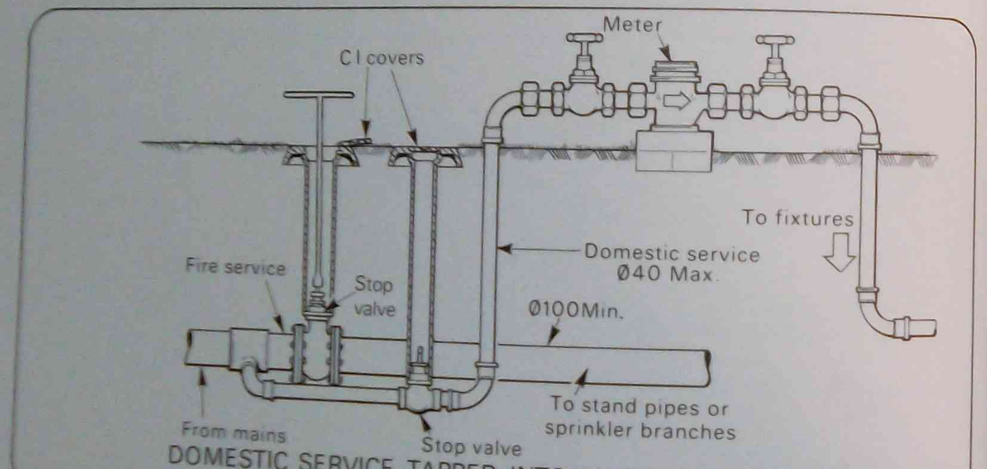
80 mm SERVICE FROM 80 OR 100 mm MAIN



80 mm SERVICE FROM 125 OR 150 mm MAIN

5.3.5 Combined fire and domestic water services

The general layout is shown in the illustration below.



DOMESTIC SERVICE TAPPED INTO FIRE SERVICE

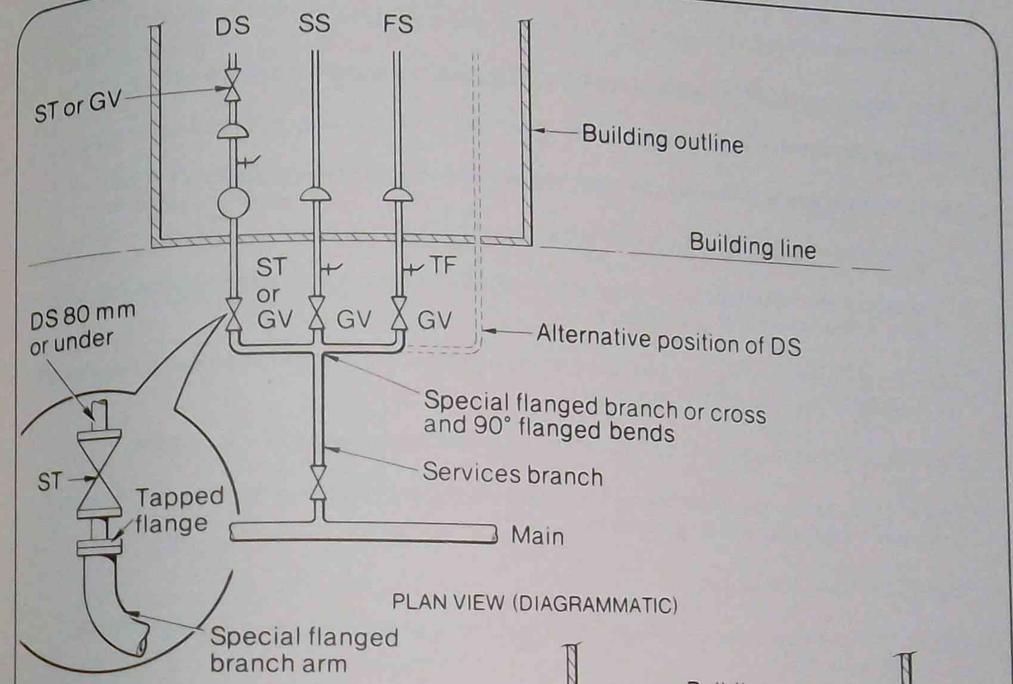
At tenements which are unfenced on the building line and have a permanent open area in front of the building, it is permissible to locate the controlling stop taps on the fire and general services as well as the meter connections just inside the building line. The stop taps and meter connections should then be fixed above ground or all may be housed below ground level in a properly constructed and drained brick or concrete pit.

NOTE:

For further information on fire and sprinkler services, refer to Water Supply Manual 11-3.

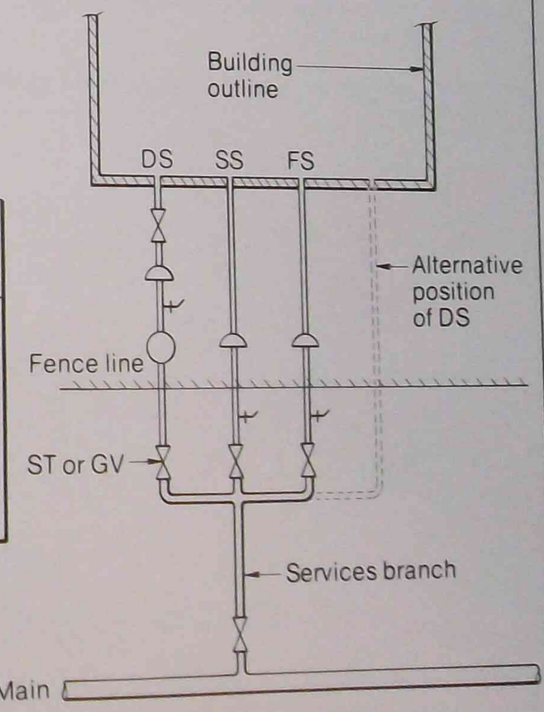
5.3.6 Trident service

This type of service saves two or three tappings (tee insertions) where three different types of services are required. The illustrations below show the diagrammatic layout of such a system.



PLAN VIEW (DIAGRAMMATIC)

Abbreviation or symbol	Meaning
DS	Domestic service
SS	Sprinkler service
FS	Fire hydrant service
ST ⋈	Stop tap
GV ⋈	Gate valve
RV ▷	Reflux valve
TF +	Testing ferrule
	Meter



PLAN VIEW

TYPICAL TRIDENT SERVICE INSTALLATIONS

REVISION QUESTIONS

1. What requirements must be satisfied for connecting the water supply to fixtures?
2. What is meant by 'cross connection'?
3. a What is the chemical symbol for water?
   b What does it mean and in which states does water occur?
4. What determines whether water is 'soft' or 'hard' and how does it come about?
5. What are the various ways in which water is purified? Discuss fully how this occurs.
6. What are the general names of the pipes used in the reticulation system?
7. a What materials are used in the construction of mains?
   b What are the advantages of rubber-sealed joints and describe an assembly sequence for a joint in the material of your choice.
8. Apart from a flanged joint in a mild steel mains pipeline construction, name and describe the other types of joints and their application.
9. Describe the Gibault joint and the operational sequence for making one in a main.
10. Why is it necessary to secure the mains installation against movement? Describe how this is done and where. Illustrate by preference.
11. Explain the trunk service.
12. Explain in detail how a domestic water-main tapping is completed under pressure by the Approved Authority.
13. Explain, with the aid of neat drawings, how a trident service is set out complete with all valves and fittings.

6 MATERIALS USED FOR WATER SERVICES (PIPES & FITTINGS)

The materials used for water services include a range of pipes, fittings, valves, taps and seals for carrying and controlling the flow of water from the mains to the various outlets required in an installation.

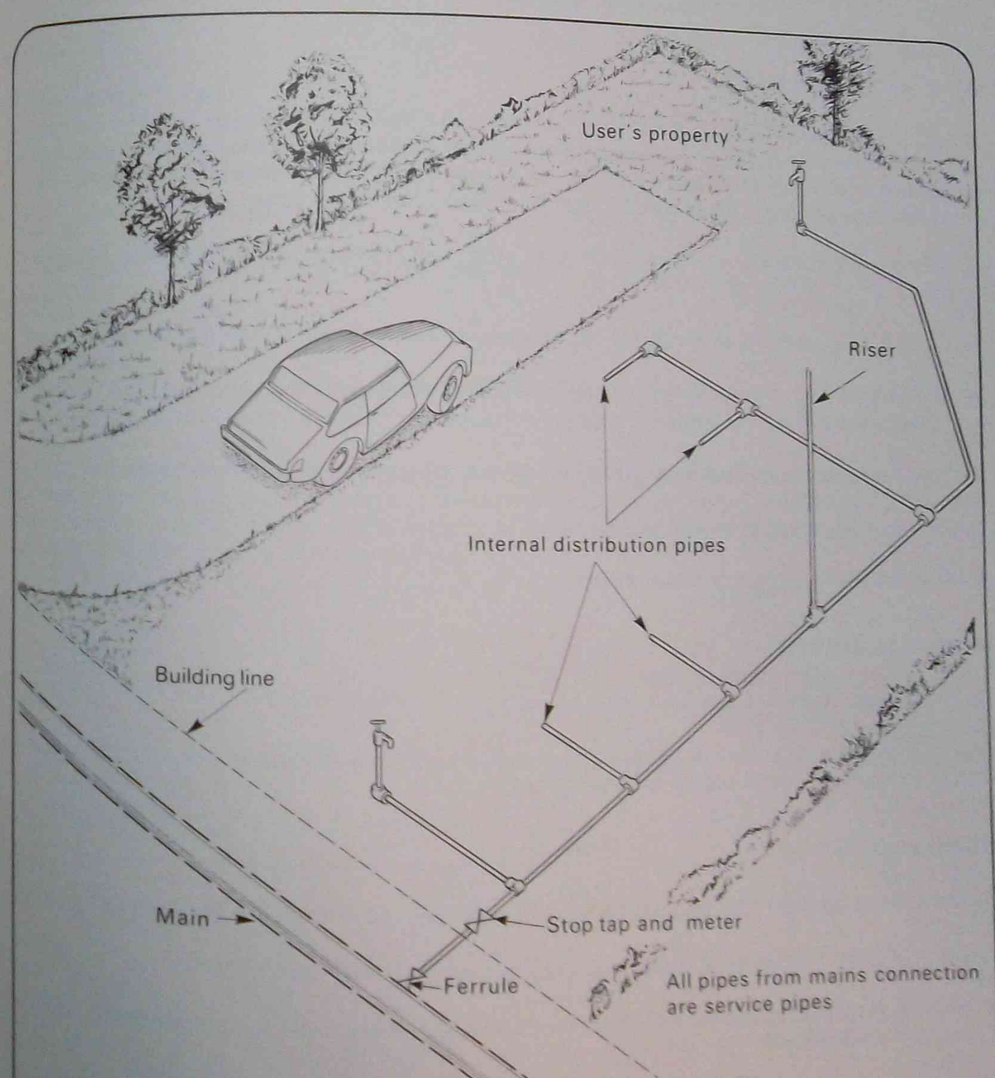
6.1 SERVICE PIPES

The term 'service pipe' includes all pipes installed to serve the needs of a consumer. Some of these pipes are also known as:

- Distribution pipes
  - These service pipes carry the water within a user's property to discharging points, e.g. fixtures.
- Risers
  - These are service or distribution pipes which carry the water to storage tanks or to elevated property positions.

NOTE:

Service pipes start at the mains.



DISTRIBUTION AND SERVICE PIPES

6.1.1 Types of pipes

Service pipes are manufactured from the following materials:

- Copper
- Galvanised steel (GS)
- Plastic (UPVC and Polyethylene)
- Stainless steel
- Brass
- Cast iron
- Asbestos cement

Each type is available in various sizes.

6.1.2 Copper pipes

Drawn copper pipes are measured at their outside diameters. They are widely used for connecting various fixtures and appliances to service pipes. These pipes are specified by some water supply authorities as the only permissible type for use in connecting users' service to the mains. The characteristics of copper pipes which make them durable for this purpose are:

- Smooth internal surface, ensuring minimum friction and promoting a high volume of water flow.
- Wall of great strength, enabling the use of pipes with thinner walls than galvanised pipe.
- The external and internal surfaces quickly develop a protective oxide coating which prevents further corrosion.
- They are easy to anneal and bend and they are not affected by vibration stresses.
- They may be brazed or bronze welded.
- They are easily chrome or nickel plated.

Material specifications

Copper pipes must be in accordance with AS 1432.

Copper alloy pipes must be type 259D, 70/30 arsenical brass in accordance with AS 1567 and must comply dimensionally with copper tube to AS 1432.

Fittings specifications

Copper and copper alloy fittings must comply with AS 1585, AS 1590 or AS 1645 where applicable.

Copper fabricated fittings must comply with the following:

- Sockets fabricated in copper tube must be made with the approved tools specifically designed for such purpose.
- Fabricated junctions and fittings must be made from types A, B, or C tube, with the approved tools designed for such purpose.

- All fabricated socket junctions and other fitting joints must be silver brazed or bronze welded.
- All fabricated sections or installations may be required to be hydrostatically tested to 200 m head pressure (= 2 MPa).

Restrictions on use

Type 'D' tubes

- Type 'D' tubes must only be used in the 'as drawn' condition, except that local annealing is permissible where necessary for making joints.
- Type 'D' tubes must not be bent.
  Type 'D' tubes must not be used in the meter assembly.

Unsuitable locations

Copper and copper alloy pipes and fittings should not be used, unless suitably protected against external corrosion where they might come in contact with material such as:

- Ash
- Sodium chloride (salt)
- Any compound containing magnesium oxychloride (magnesite).

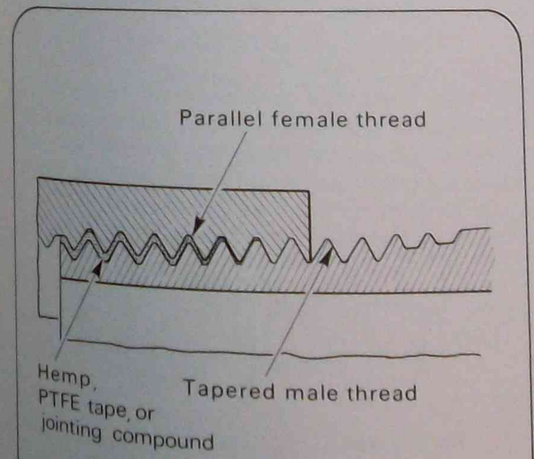
6.1.3 Methods of jointing

The various approved methods of jointing tubes depend on the material used and the type of installation.

Screwed joints

These must be used between heavy thickness screwing quality copper or copper alloy tubes.

The most widely used thread combination is the parallel female and taper male threads. Complete matching of the threads always occurs at some point on the taper. Further tightening beyond this point ensures a watertight joint. Hemp packing or thread sealing tape is used between the threads to assist in the making of a watertight joint.



BSP THREAD ON GS PIPES

BSP THREAD DIMENSIONS

NOMINAL METRIC SIZE (mm)	THREADS PER 25 mm
7	19
15	14
20	14
25	11
32	11
40	11
50	11
DIAMETER TAPERS AT 1 IN 16 FOR ALL TAPERED THREADS	

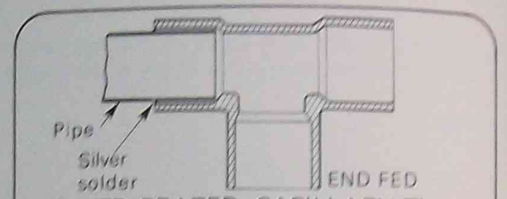
In making such joints, the following must be observed:

- All tube threads must be in accordance with AS 1722.
- All fitting threads must be in accordance with the appropriate Australian Standard for the fitting.
- Where a sealing thread and a fastening thread are joined, a seal must be formed by using polytetrafluoroethylene (PTFE) tape, hemp or approved pipe jointing compound on metal threads, but only PTFE tape on UPVC threads.
- Where two fastening threads are joined, a seal must be formed as described above, or, where applicable, an appropriate gasket or grummet must be used.

Silver-brazed joints (capillary type)

These joints are held together by silver brazing alloy which is caused to flow, when hot, into the joint by capillary action. The fittings used in capillary type silver brazed joints are made from brass or copper and are so designed that the pipe ends may be pushed into the sockets of the fittings.

Silver brazing alloys for jointing copper and copper alloy must be in accordance with AS 1167 tables 1 or 2 only, and must contain not less than 1.8% silver.



SILVER BRAZED CAPILLARY TYPE

Bronze-welded joints

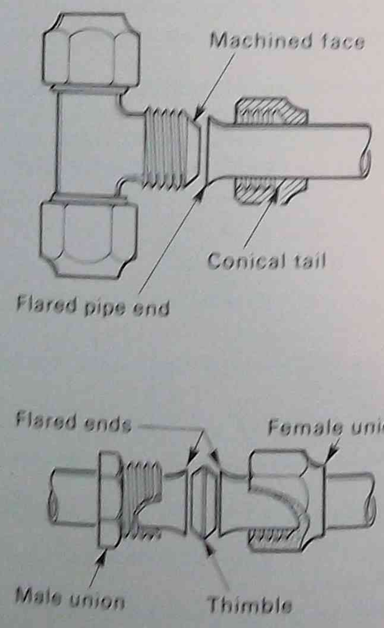
The bronze welding filler rods used for these joints must be in accordance with AS 1588 and their copper content must not be less than 57%.

The joints in bronze welding must be formed by belling or other methods used for fusion-welded joints, so as to permit satisfactory deposition of weld material.

Types A, B, C and D copper tubes.

The joints between types A, B, C and D copper tubes must be:

- silver brazed; or
- bronze welded;
  - — Not permitted on type D tubes.
- made with compression fittings to AS 1645, except for D tubes where this method is not permissible.
  - — Expanded compression joints have flared or expanded pipe ends. The flared end is gripped between the machined face of a fitting and the cone-shaped tail of a union nut as illustrated. Alternatively, the joint may be made by inserting a loose thimble (sometimes called an olive) between the two flared ends of the pipes to be joined. The joint is then made by a set of matching male and female union connections which, when tightened, compress the flared ends of the pipes tightly against the machined thimble.

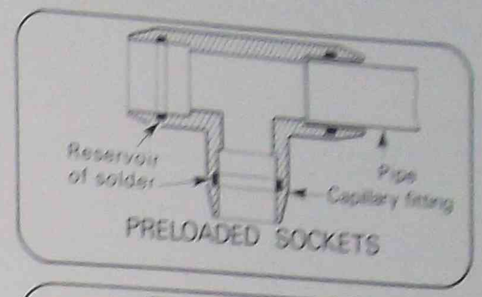


EXPANDED COMPRESSION JOINTS COPPER PIPES

- made with capillary fittings to AS 1585, table 1B and silver brazed;
- made with capillary fittings to AS 1585 table 1A and soft soldered.
  - — Soft solder composition must be nominally: one part of lead to one part of tin (50/50), and must comply with AS H1.

Preloaded sockets

The sockets are made with an annular ring filled with solder during manufacture. The joint is made by applying heat after the pipe end has been inserted. For the fitting shown, it is obviously necessary to have all three pipe ends inserted before heat is applied to the joint.



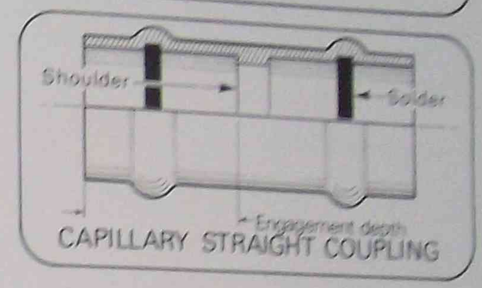
PRELOADED SOCKETS

The engagement depth is important, because there are two different lengths.

'L' = long
'S' = short.

'L' may be used for 'soft' (50/50) solder as well as for 'hard' silver solder.

'S' can only be used for 'hard' silver solder.



CAPILLARY STRAIGHT COUPLING

Copper pipes to flanged valves and fittings

Joints between copper water service pipes larger than 65 mm and flanged valves or fittings must be made using cast brass or gunmetal flanges into which the copper or copper alloy pipes must be:

- silver brazed for tube types A, B, C, D and for the screwing class; or
- bronze welded for tube types A, B, C and screwing class only.

The flanges must be secured to the flanges of valves and fittings by gunmetal or extruded brass bolts and nuts; the joint to be made watertight with a gasket of approved material.

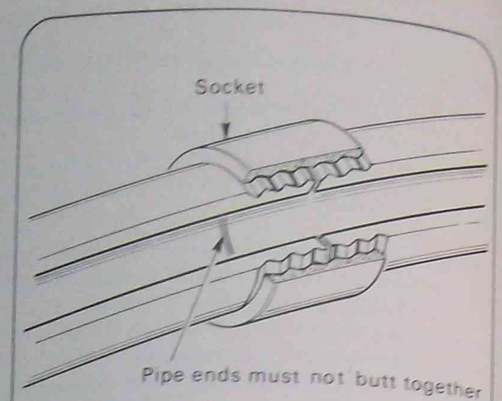
8.1.4 Galvanised steel pipes

These pipes are made from mild steel. Both surfaces are coated with zinc to prevent corrosion. They are cheap, strong and easy to install. The size is specified by the nominal inside diameter of the pipe, expressed in millimetres. Galvanised pipes are subject to corrosion when used for soft water and this corrosion causes discolouration of the water and restrictions in the pipe bore. Also the outer coating can be affected when in contact with certain types of soil which, after eating away the coating, leave the unprotected base material open to corrosive attack.

Galvanised steel pipe joints

The pipes are joined together with internally threaded sockets using hemp or plastic tape as a sealant. The thread on the ends of pipes is cut with a thread cutter (stock and die) in the manner described in Manual '1-9 Handtapping and Thread Cutting', Section 4.

To ensure a good joint is made, the pipe ends and the thread must be cut square to the pipe centre line. This way, there is proper pipe alignment and a good fit with the socket. The two pipe ends must not abut against each other inside the socket, because in tightening one of the ends, the fitting or the threads could be damaged; a leaking and useless joint will have to be remade.



GALVANISED PIPE JOINT

Material specifications

Galvanised steel tube must be in accordance with AS 1074.

For pipe sizes less than 100 mm, 'heavy' wall thickness tubing must be used, and for pipe sizes 100 mm or larger, 'medium' or 'heavy' wall thickness tubing must be used.

Screwed fittings must comply with AS 1590, BS 143 and BS 1256, as applicable.

Welded fabricated fittings must be hot-dipped galvanised after fabrication and tested hydrostatically to 200 m head pressure or by other approved means.

Restrictions on use

Galvanised steel tubing and fittings must not be concealed within walls (including ducts), floors or ceiling spaces of buildings.

Galvanised steel tubing must not be bent.

Unsuitable locations

Galvanised steel pipes and fittings may suffer rapid corrosion in certain types of acidic soils, unless suitable protective coatings or wrappings are applied.

British standard pipe thread

This type of screw thread is used for pipe connections and the attachment of pipe fittings. It is usually referred to as BSP thread. It may be tapered or parallel. All water supply fittings for galvanised pipe are threaded to this standard. Most female outlets have parallel threads. The tapered and parallel types of BSP thread may be used in the combination of parallel female and parallel male threads. This combination is often used when attaching a pipe to a fitting by means of a plain nipple, or when joining two pieces with a long screw.

6.1.5 UPVC pipes

The pressure pipe version is becoming popular for internal installation in some localities. The assembly of a system of water distribution is simplified because of the ease with which this can be done. A large range of fittings is available. A variety of adaptors exists for combining UPVC pipework with systems of other materials. The joining of pipes is usually done by solvent welding as previously described.

However, there are a few restrictions that have to be observed when using these pipes.

UPVC pipes and fittings must be in accordance with AS 1477 class 18, or as approved. (See Tables section 4.5.7).

Restrictions on use

UPVC pipes and fittings must not be concealed within walls (including ducts) floor or ceiling spaces of buildings, or used above ground where they are exposed to direct sunlight.

Method of jointing

The jointing of UPVC pipes can be done by means of:

- solvent-welded joints;
- rubber-ring joints; or
- other methods as approved by the Authority.

Special installation requirements

- Earthing electrical installations.
  - Being a non-conductive material, UPVC cannot be used as a means of earthing electrical installations, or for dissipating static charges.
  - Metallic water pipes must not be replaced with UPVC pipes until the earthing system of the electrical installation has been checked and modified, if necessary, by a licensed electrical contractor.
  - Prior to using UPVC pipes in a new water service, the Statutory Electrical Supply Authority must be notified.
- Hot water cylinder supply.
  - Where UPVC pipe is used for cold water supply to a directly connected HW cylinder, it must not be used for the last 1 m or such a connection and must not be taken beyond the check valve.
- Stand-pipes
  - All stand-pipes, except where fixed to a building wall, must be of approved metallic material and firmly clipped to a suitable support to prevent stress being imparted to the underground pipe in the event of strain being imposed on the riser pipe.

- Installation below ground.

  — Care should be taken to ensure that pipes installed in trenches are clear of sharp objects such as rocks, brickbats, etc. Preferaby the pipes should be surrounded with fine spoil or sand.

- Repairs to service.

  — Approved thimble-type fittings should be used if the service is to be put into immediate use. Repairs with solvent cement are not suitable unless the service can be left for 24 hours before water pressure is applied.

- Connections to pipes of other materials.

  — Fittings with screwed end connections for accommodating pipes of other materials may be used, provided both threads are of the fastening type.

  — Screw threads must not be cut on UPVC pipe.

NOTE:

All other precautions must comply with AS 2032.

6.1.6 Polyethylene pipes

The material from which these pipes are made is sometimes also referred to as 'Polythene' and abbreviated to 'PE'. The material for pressure pipes used in water supply, and other installations, is a high-density type of PE. The pipes are made by an extrusion process to various bore sizes and pressure ratings.

PE pipes are light, flexible, tough and easy to install by using the specially adapted compression fittings. Because the material from which the pipes are made contains a certain amount of carbon black, sunlight has no effect on it; it is also resistant to chemical and electrolytic corrosion.

The smooth bore of the pipes ensures a minimum of restriction to waterflow.

The pipes are supplied in long-length coils, making the need for joints relatively small.

The material has a rather high coefficient of thermal expansion, but this can be counteracted by 'snaking' the pipes in some cases instead of fixing them rigidly in the one plane or in a straight line at their ends or at intermediate supporting points.

WARNING:

Plastic pipes (UPVC and PE) do not conduct electricity and they cannot be used for earthing electrical wiring installations as is done with metallic pipework.

Where alterations to metallic water supply pipes become necessary and replacements are to be made in plastic piping, the plumber should bring to the notice of the property owner that he must arrange with a qualified electrician to have a proper main earthing conductor connected up before the plastic water supply work can be installed. (This may not be required in new buildings in which specifications call for a plastic water supply installation.)

Installation requirements

The installation of PE pipework for water supply is restricted to:

- Cold water installations.
- The property boundaries.
- The outlet side of the meter.

  — The PE (or other plastic pipe) must end at the vertical riser to the meter, and the connecting pipe from there to the PE fitting must be of approved metal in the case of meter installations above ground.

  — For installations of the meter below ground, the plastic pipe may be connected directly to the meter, provided the water meter assembly is properly supported.

- Underground installations, but is not permitted under building slabs.
- Above ground installations.

  — But not within walls, ducts, floor or ceiling spaces.

- The use of compression type fittings of the approved standard and of the correct size.

  — The fittings to be used have identifying marks or labels for proper matching with the standard of pipe for which they are designed.

- Connection to the inlet side of a directly connected hot water cylinder.

  — Here also, the PE pipe must end not closer than 1 metre from the HW cylinder inlet connection and not be taken past the non-return valve. (HW installations are dealt with in 'Water Supply — 4').

Handling and protection

Tough and resilient as they are, PE pipes should not be dropped, dragged along or roughly treated. When laid in trenches, they should be at least 300 mm below ground surface level and properly covered by back-fill to protect them against mechanical damage. There should be no sharp objects, rocks or brickbats resting against them. When placed in rocky ground, the pipes should be protected from damage by placing soil, sand or light screenings around them.

6.1.7 Making PE pipe joints

Use only approved brands of pipe for the installation. These may bear the manufacturer's name, but must show the mark: 'Type 50 Polyethylene — Class 15. Instead of 'Polyethylene' they may show: 'Polythene or PE' and in addition, the Australian Standard may be shown (AS K 119 for imperial sizes or AS 1159 for metric sizes).

The procedure for joining PE pipes together, applies also to the making of connections to the range of fittings that must be used with them. Consult manufacturers' catalogues for the full range of fittings available for PE pressure pipework installations.

To make a PE pipe joint, proceed as follows:

- Cut the proper lengths of pipe, using a hacksaw or a fine-toothed woodsaw.

— Cut the pipe squarely, using a mitre box if necessary.

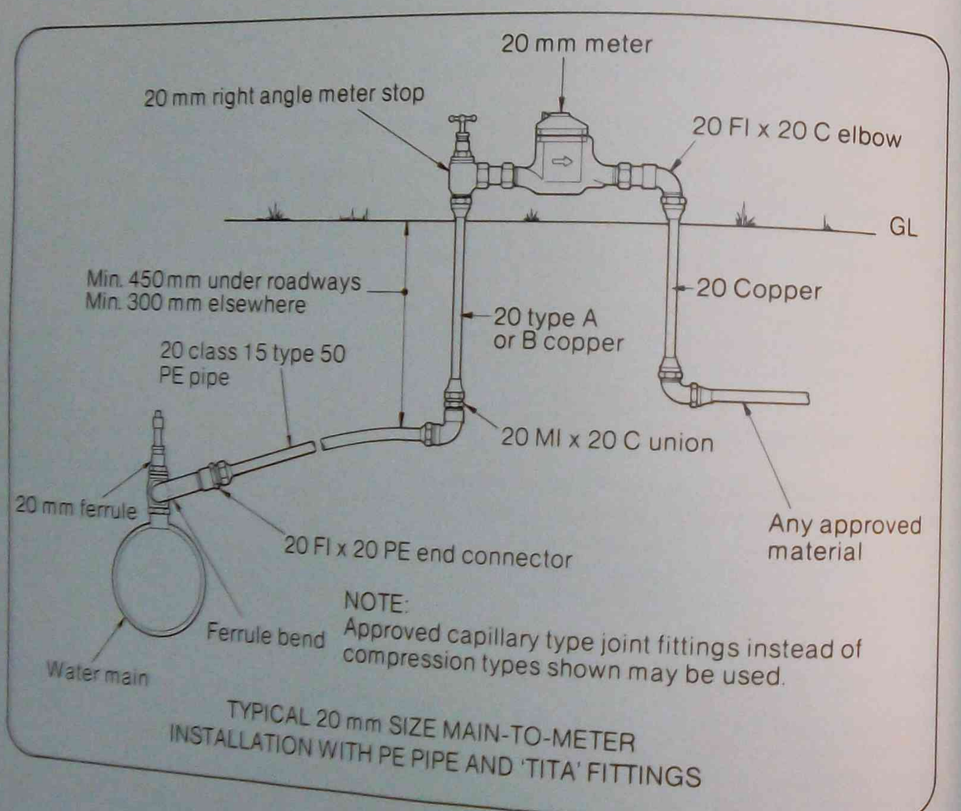
- Remove burrs and swarf from the pipe ends with sand paper or a fine cut file, making sure no material remains in the pipe bore.

- Select the proper pipe joining fittings for the size of pipe being used.

  — The pipe joining fitting consists of a body (compression nut) with threaded ends, two lugged nuts, two wedging rings (blue) and two tapered thimbles. (The thimbles are colour-coded for correct matching with the service line pressure.

NOTE:

Colour coding of items and the details given on pages 86 and 87 refer to one particular brand of fittings that are available. Consult manufacturers' catalogues for alternatives, or ask your instructor to show you the range available.



NOTE:
Approved capillary type joint fittings instead of compression types shown may be used.

TYPICAL 20 mm SIZE MAIN-TO-METER
INSTALLATION WITH PE PIPE AND 'TITA' FITTINGS

To make a joint:

- Unscrew the lugged nuts from the pipe fitting and slip one over each end of the pipes to be joined, as shown in (1).

- Slip a wedging ring over each end of the pipes (1).

- Insert the appropriate tapered thimble into each pipe end and drive it carefully home with a square-faced mallet (2) and (3).

- Insert one pipe end into the body of the compression nut and screw the lugged nut to the compression nut, making sure the pipe end is not pushed out (4).

- Hold the lugged nut, by hand or with a suitable wrench, and tighten the body to the lugged nut by using a close-fitting spanner on the flats of the body.

  — No great force is necessary for tightening, because the joint tightens up under line pressure.

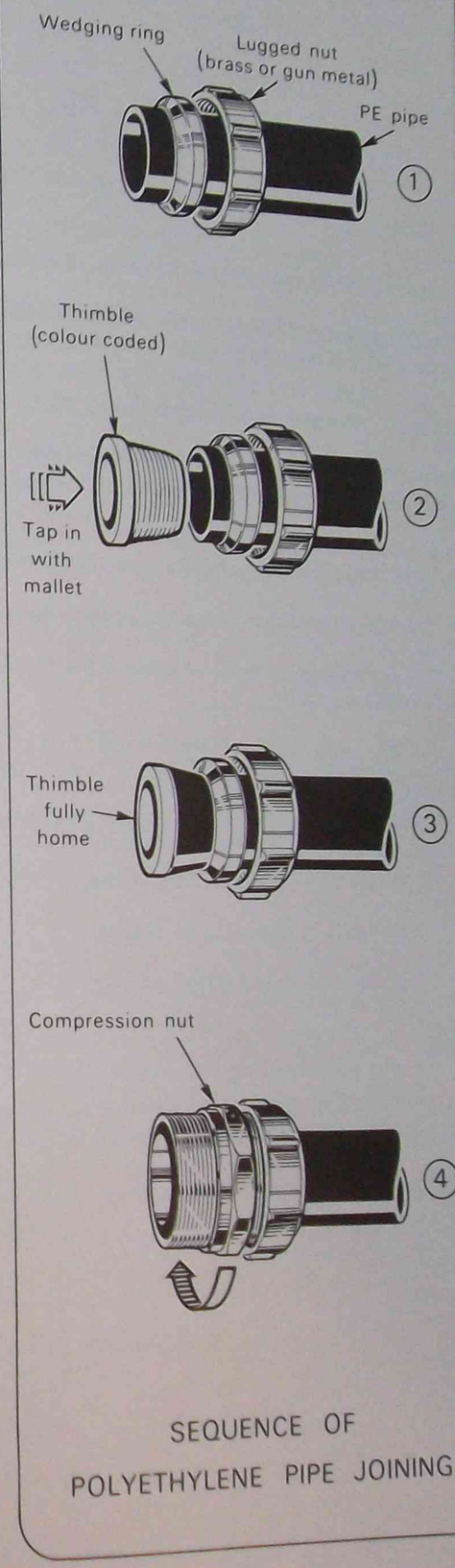
- Repeat the process with the other pipe end.

  — When tightening up the other pipe end, make sure the first joint is not loosened.

The procedure remains the same for connecting the pipes to any of the fittings used, except of course that the various fittings take the place of the compression nut.

NOTE:

Check with the manufacturers for other methods of jointing or ask your instructor to show you examples.



SEQUENCE OF
POLYETHYLENE PIPE JOINING

CLASS	PRESSURE RATING (Metres head)	THIMBLE COLOUR CODE	PIPE SIZES (mm)
12	120	RED	OD: 16 25 32 40 50 63
9	90	WHITE	OD: 32 40 50 63
6	60	BLACK	OD: 25 32 40 50 63

Classes 6 and 9 used only on low pressure installations and only with Supply Authority's approval.

The OD remains the same for the comparable bore sizes, regardless of class. That means, the same wedging rings and lugged nuts can be used between classes, but the thimbles will vary.

6.1.8 Conversion of imperial to metric

Before 1974, some installations in PE were made using 'inch' size pipes and fittings. In some cases, it may be required to branch into 'inch' size installations with metric size piping.

This is possible without much difficulty, but first it is necessary to be able to recognise the 'imperial' installation which differs from the metric in the following items:

- There is an octagonal brass nut instead of a lugged nut on the fittings.
- The nominal bores between classes are the same, but the OD for each nominal bore varies. That means that:
  - The same coded thimble (usually brass or yellow glass resin) can be used for similar bores of different classes, e.g. 16 mm thimble for 16 mm pipe, classes B, C and D.
  - Different wedging rings must be used for the various classes of similar bore pipes:
    - Black — Class B (60 m head).
    - White — Class C (90 m head).
    - Red — Class C (120 m head).

NOTE:

Classes B and C correspond roughly to classes 6 and 9 respectively.
Class D corresponds to Class 12.

In most cases, converting or extending the imperial pipe system to the metric system can be done by using the existing imperial body size fitting and changing the wedging rings and the thimbles to the required sizes and pressure codes for the metric pipe.

Exceptions to this are tabulated below.

CONVERSION/EXTENSION OF IMPERIAL TO METRIC

IMPERIAL	METRIC	USE
Classes B & C Sizes 1¼", 1½", 2"	Classes 6 & 9 Sizes: 32, 40 50 mm	1. Metric conversion adaptor of proper size. 2. Proper metric thimble (black or white) according to pressure class on metric side. 3. Correct metric wedging ring on metric side.
Class D Sizes: 1¼", 1½"	Class 12 Sizes: 32, 40 mm	1. Appropriate metric thimble (red) on metric side. 2. Imperial wedging rings (red) can be used here.
Class D Size: 2"	Class 12 Size: 50 mm	1. Appropriate conversion adaptor. 2. Correct size thimble (red) on metric side. 3. Correct metric wedging ring on metric side.

6.1.9 Brass pipes 70/30 (copper alloy)

Solid drawn brass pipes are sometimes used as small diameter delivery pipes to and within fixtures. Brass pipes are specified by outside diameters and the size of wall thickness. Brass pipes are not suitable for use with compression joints, because they cannot be annealed (softened) to form the necessary flared ends. The joints used with brass pipes are screwed joints and the fittings used with brass pipes are also made of brass to avoid electrolytic corrosion that may occur between dissimilar materials in the presence of moisture. They may also be joined with capillary fittings or silver soldered.

6.1.10 Stainless steel pipes

Pipes

Stainless stell tubes must be in accordance with AS 1769 and AS G31 material grade 304.

Fittings

Fittings for use with stainless steel must be copper or copper alloy (70/30 brass) in accordance with AS 1585 or AS 1645 or other approved fittings.

Restrictions on use

Stainless steel may be used below ground only where approved.

Unsuitable locations

Stainless steel should not be used unless suitably protected against external corrosion, where it might be in contact with materials such as:

- Ash;
- Sodium chloride (salt); or
- Any compound containing magnesium oxychloride (magnesite).

Jointing methods

For pipework up to 25 mm:

- Compression-type joints using copper or copper alloy fittings in accordance with 1645.
- Capillary-type joints using copper or copper alloy fittings in accordance with AS 1585.
- Capillary-type joints using expanded sockets made in the stainless steel tube.
- Croxed-type joints using approved fittings.

For pipework larger than 25 mm:

- Butt welded using a tungsten inert gas (TIG) argon arc method; or
- Flanged joints equivalent at least to table F rating of AS 2129.

Jointing practice

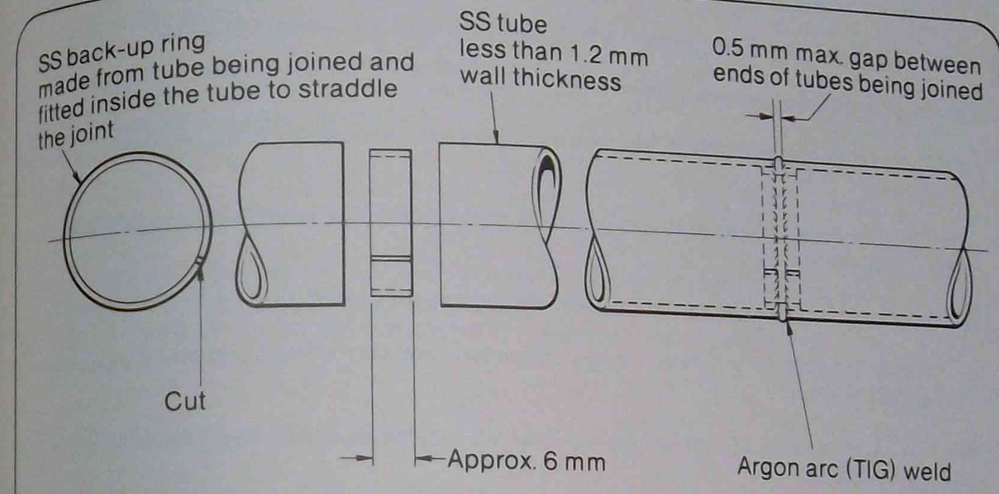
The jointing methods used for stainless steel are:

- Soft-soldering.
  - Soft-soldered joints must be made using a phosphoric acid based paste flux. Chloride fluxes must NOT be used.
- Brazing.
  - Brazing alloy must be in accordance with AS 1167, Table 1, alloy A8.
- A fluoborate paste must be used for flux, and must be washed from the installation on completion of the joints.
- Croxed joints.

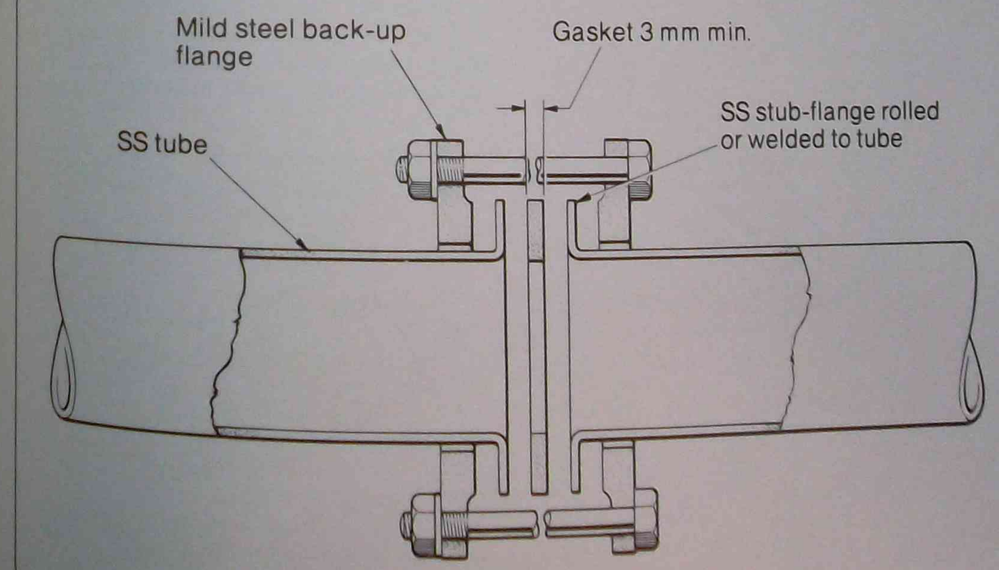
These joints must be made with an approved 'croxing' tool and using crox nuts in accordance with AS 1645.

- Argon arc (TIG) welding.
  - The gaps between abutting tube ends to be joined should not be greater than 0.5 mm.
  - For tubes of wall thickness less than 1.2 mm, a stainless steel back-up ring, approximately 6 mm long, made from the tube being joined, must be fitted inside the tube to straddle the joint.
  - The filler rod used must be stainless steel of the low carbon type and should not be more than 2 mm in diameter to ensure minimal heat input.
  - The ends to be joined should be butted and held firmly together and tack-welded in at least four spots around the circumference prior to welding the entire joint.

- Flanged joints.
  - Flanged joints must be made up by forming a stub flange of the same thickness as the tube, having a diameter conforming to dimensions 'F' in AS 2129.
  - The stub flange may be either rolled or welded to the tube.
  - A mild steel back-up flange must be used in accordance with AS 2129.
  - The gasket thickness must not be less than 3 mm.



ARGON ARC (TIG) WELDING OF SS TUBING LESS THAN 1.2 mm WALL THICKNESS



FLANGED JOINT IN SS TUBING

NOTE:

The various ways of jointing pipes are explained separately in greater detail in section 7.

REVISION QUESTIONS

1. a What is the difference between hydrostatics and hydraulics?

   b In what units can hydrostatic pressure be expressed?

   c A manometer fitted to a water container gives a reading of 85 cm. Calculate in kPa the pressure exerted on the bottom of the tank (1 cm $H_2O = 0.098$ kPa) (8.33 kPa).

   d A Bourdon type of pressure gauge gives a reading of 196 kPa. Determine the head of water corresponding to this pressure in metres. (Take 10 cm $H_2O = 0.98$ kPa) (20 m).

2. List the conditions in a pipe system which affect the flow and volume of water.

3. a What is meant by service pipes?

   b Some pipes are called distribution pipes, others are risers. What is the distinction between the two?

4. What is the most widely used thread combination for joining galvanised steel pipes. Are any other combinations used?

5. a What types of joint fittings are used for joining copper pipes?

   b What is the difference between long engagement capillary fittings and short engagement capillary fittings?

6. What types of capillary fittings are there? What are they made of and describe how they are used to join pipes.

7. How are brass pipes specified and how are they joined?

NOTES

7 FITTINGS FOR SERVICE PIPES

Various fittings are available for use in installing a new water service or when altering existing services. Fittings are used for:

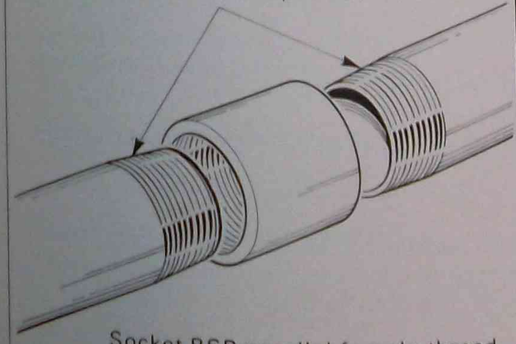
- Joining pipes together or to appliances.
- Joining pipes of different diameters together.
- Changing pipeline direction.
- Sealing pipe ends.
- Teeing a new pipe into an existing service.
- Joining pipes of different materials.

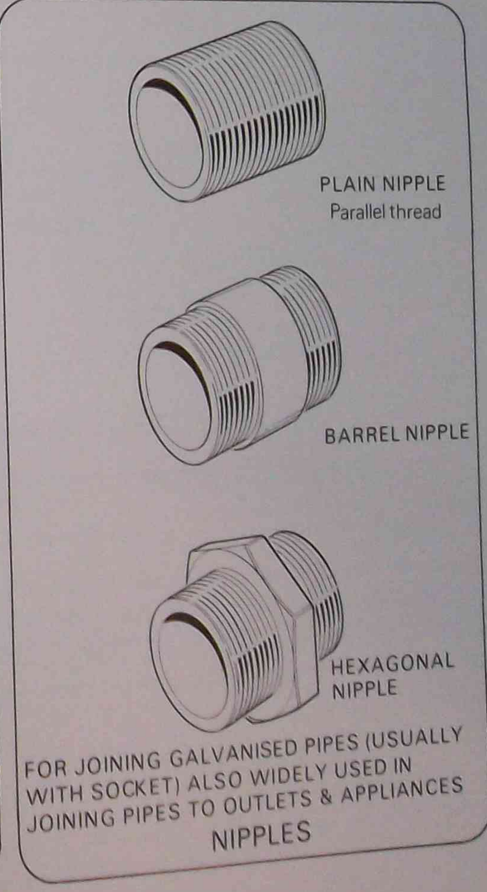
7.1 FITTINGS FOR JOINING PIPES

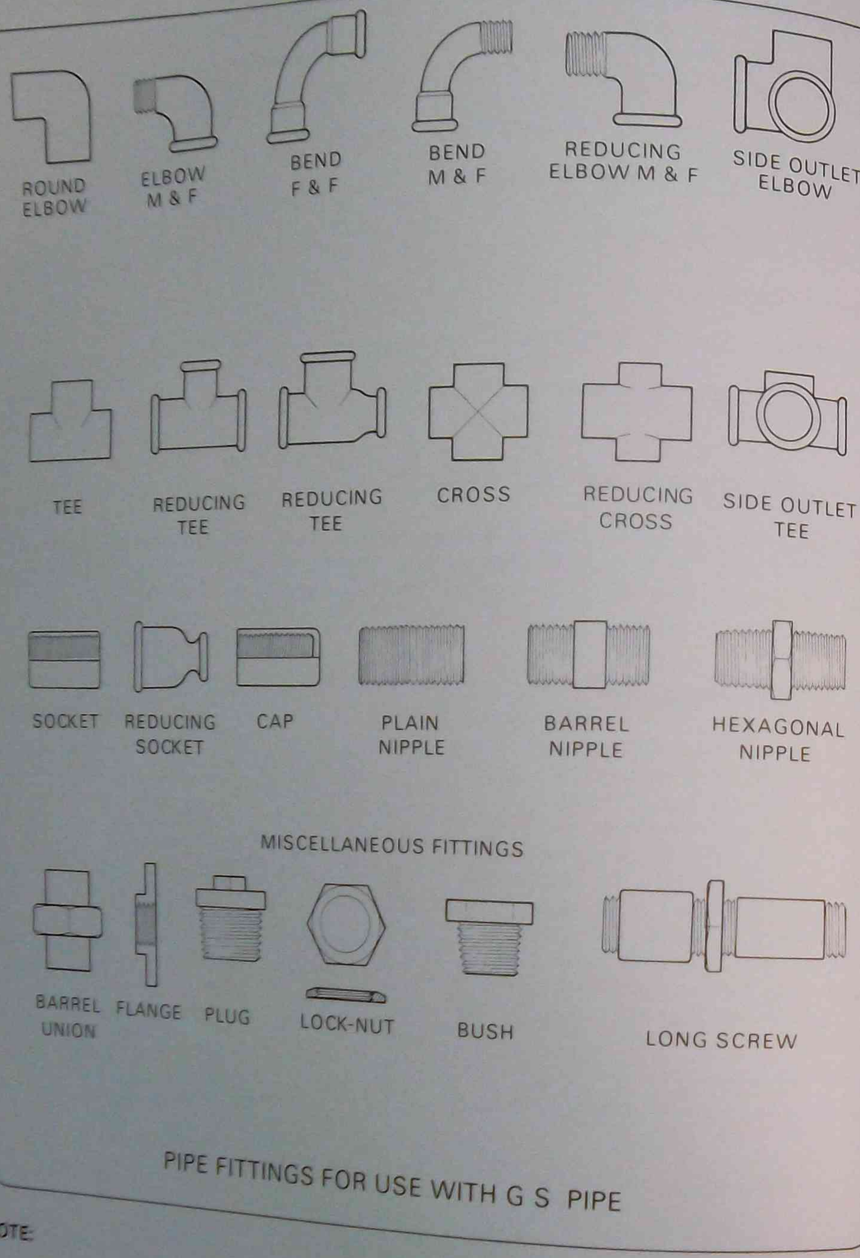
For any pipe material used for distribution pipes, a great many fittings are available. In designing an installation, it is well to consult manufacturers' catalogues to gain an idea as to which fittings can be best used for overall economy, ease of installation and to save labour.

7.1.1 Galvanised steel pipes

Bends made too sharp in these tough pipes may result in the zinc coating cracking or separating from the parent metal, so destroying the anti-corrosive characteristics. Designing an installation with these pipes, requires the use of many fittings such as elbows, bends, tees, crosses, sockets, nipples, etc. The most satisfactory joining of pipework in this material is by the use of taper male threads in conjunction with parallel female threads and hemp.







PIPE FITTINGS FOR USE WITH G S PIPE

NOTE:

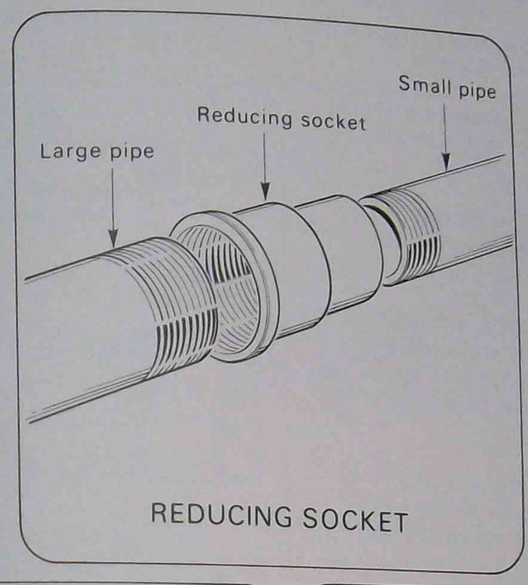
The barrel union is often used in pipe repairs or where disconnections for maintenance purposes are required. Low-pressure unions, using gaskets or sealing rings and high-pressure unions with ground internal mating surfaces are available. Ask your instructor to show you these fittings.

Joining pipes of same diameter

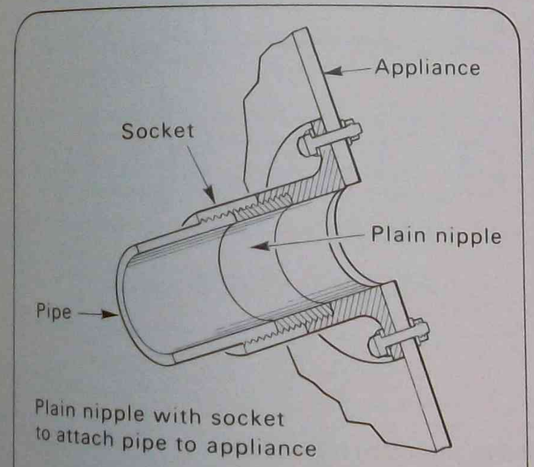
This is usually done by using sockets and nipples in combination with sockets.

Joining pipes of different diameter

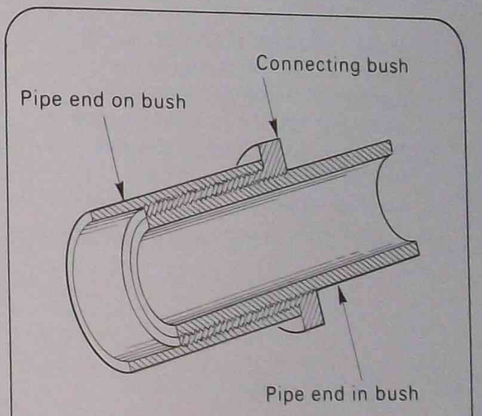
For this, bushes and reducing sockets are used.



REDUCING SOCKET



NIPPLE & SOCKET COMBINATION



CONNECTING BUSHES

Directional changes and distribution

Changing the direction of flow is done using a range of bends, elbows and springs. Distribution to various areas of an installation can be done by inserting tees, crosses and such like fittings. Their use, as said earlier, avoids the need to make sharp bends in the galvanised pipes, but bends of up to 15° can be made without undue damage.

Closing off pipe ends

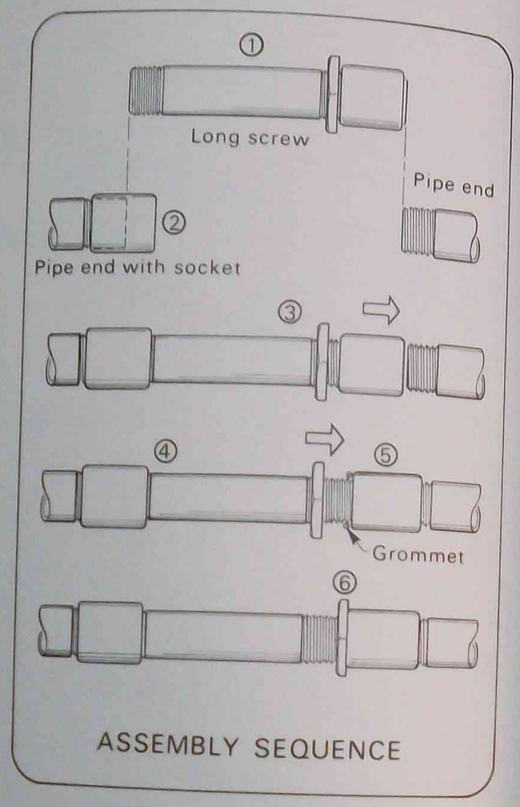
Plugs or caps may be used for this. Where a pipe ends on a socket, a plug will be used. On the other hand, if no socket is used, a cap may be fitted to close off the pipe end.

Use of the long screw

The long screw is a piece of pipe (of suitable diameter for the job) with an ordinary length of thread on one end and a thread long enough to take a socket plus a lock-nut on the other. The long screw is used to fill the space between two pipes that end in right hand threads.

To assemble a joint with a long screw, proceed as follows:

- 1 Ensure that the long screw length is a neat fit between the fixed pipe ends to be joined and that it is the correct size pipe.
- 2 If not fitted already, install a socket, using hemp or tape to one threaded pipe end, as shown.
- 3 Install the short threaded end of the long screw into the socket of the fixed pipe end.
- 4 Tighten the long screw end securely into the pipe socket with a suitable pipe wrench, using hemp or tape if necessary, to make a watertight joint.
- 5 Using hemp or tape on the other fixed pipe end, engage the long screw socket with the pipe end and tighten it.
- 6 Make a small grommet with hemp, wrap it around the thread at the junction of socket and long screw pipe, then turn the lock-nut towards the socket and tighten it securely against hemp and socket for a watertight joint.

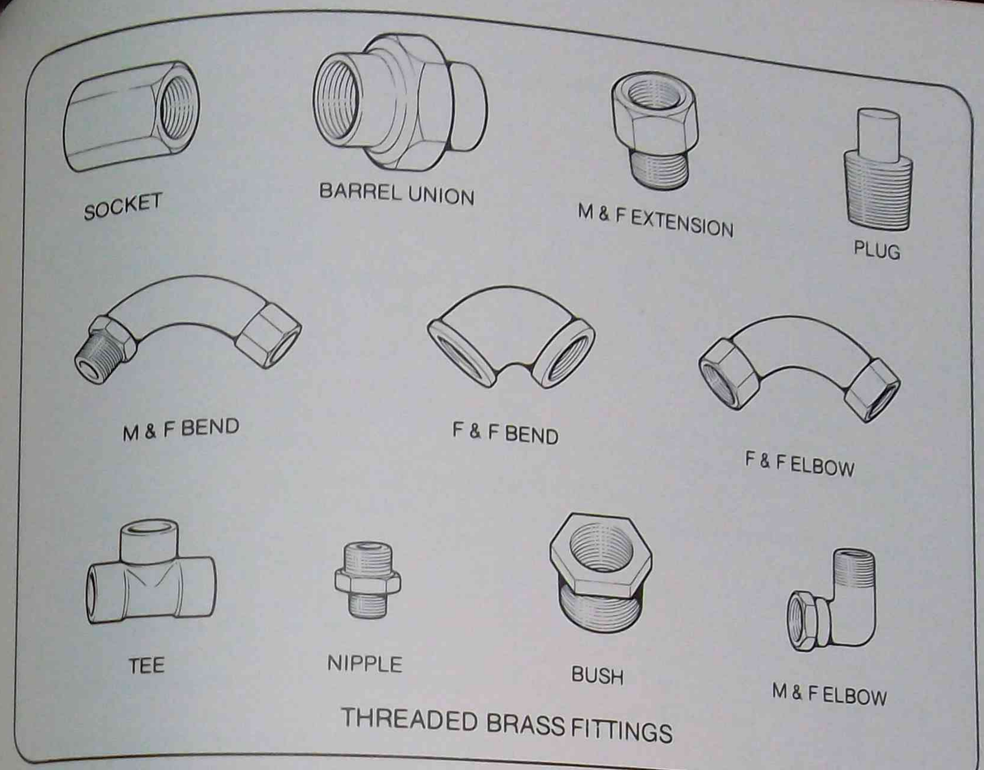


ASSEMBLY SEQUENCE

7.1.2 Copper pipes

Copper pipes made of screwing copper can be joined by means of threaded brass sockets or brass barrel unions as shown in the illustration.

These threaded fittings are sealed in the same way as galvanised pipe threads with either hemp, PTFE tape or an approved jointing compound. Brass elbows, tees or other similar brass fittings as illustrated may be used in the installation of copper pipelines.



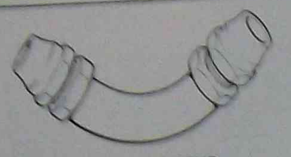
THREADED BRASS FITTINGS

7.1.3 Copper tubes

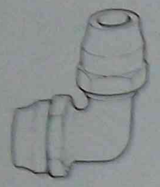
Copper tubes can be joined in a number of ways.

- With compression copper-to-copper unions.

Compression-type fittings made of brass and used with copper tube are shown in the illustration page 96.


C x C METER BEND

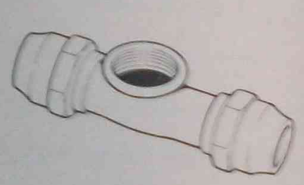

I.F x C METER BEND


C x C ELBOW


I.M x C ELBOW


I.F x C ELBOW


I.F x C LUGGED ELBOW


I.F CENTRE x C TEE

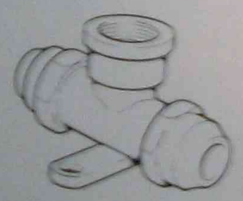

THREE-WAY TEE


I.F x C CENTRE TEE

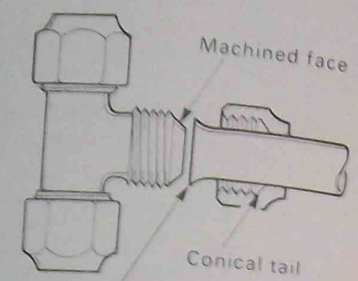

I.M x C UNION

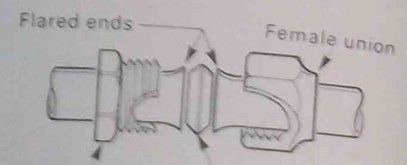

C x C UNION


I.F x C UNION


I.F CENTRE x C LUGGED TEE

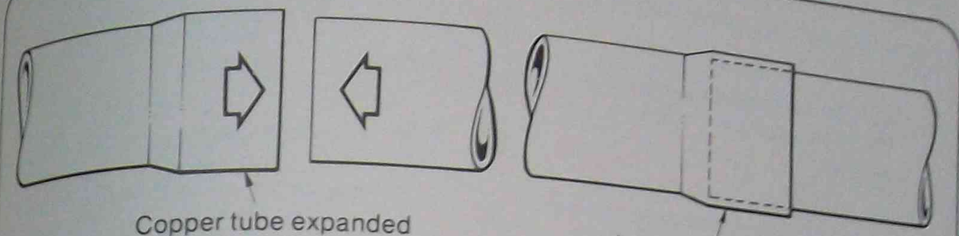
SOME TYPICAL COMPRESSION FITTINGS





EXPANDED COMPRESSION JOINTS
COPPER PIPES

- With expanded capillary joints.
  - Normally made in the copper tube with a rast tube expander. (Tube must be annealed prior to expanding).



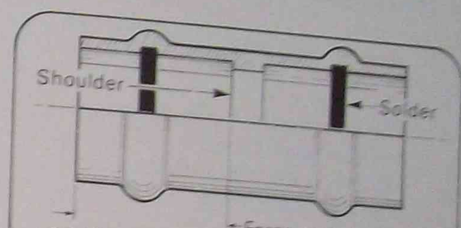
MAKING AN EXPANDED CAPILLARY JOINT

- Capillary joints.

These joints are the same as the expanded joints, but they are made to a size to accept the tube without any expanding of the tube.

Straight joints can be made by means of capillary straight couplings either soft soldered (preloaded) or silver brazed in either copper or in brass.

The range of such fittings is very large. Consult manufacturers' catalogues to gain an insight of the possible application of such fittings in an installation.



CAPILLARY STRAIGHT COUPLING

NOTES

Making a capillary joint

- Cut the tube end square, then ream, deburr and size it.
- Clean the capillary bores and the tube surfaces which will be inserted in the fitting.
  - No solder will adhere to a surface that is oily, dusty, or otherwise unclean.
- Apply flux to the outside of the tube and inside the cup of the fitting, making sure that the surfaces to be joined are completely covered.
  - Apply the flux carefully and sparingly.
- Bend the soldering wire over about the same length as the size of the fitting.
  - A 12 mm bend for a 12 mm diameter fitting.
  - For fittings over 50 mm diameter, the bent piece should be approximately three times the diameter of the fitting.
- Apply a flame to the fitting, heating tube and cup, until the solder melts when placed on the joint.
- Move the flame towards the centre of the fitting until the solder is absorbed and the joint completed.
- Remove excess solder while still plastic with the aid of a small brush or a piece of cloth.
  - Leave a fillet around the ends of the fitting while it cools.

NOTE:

The use of soldering wire is not required with preloaded fittings.

MAKING A CAPILLARY JOINT WITH SOLDER

- Bronze-welded joints.

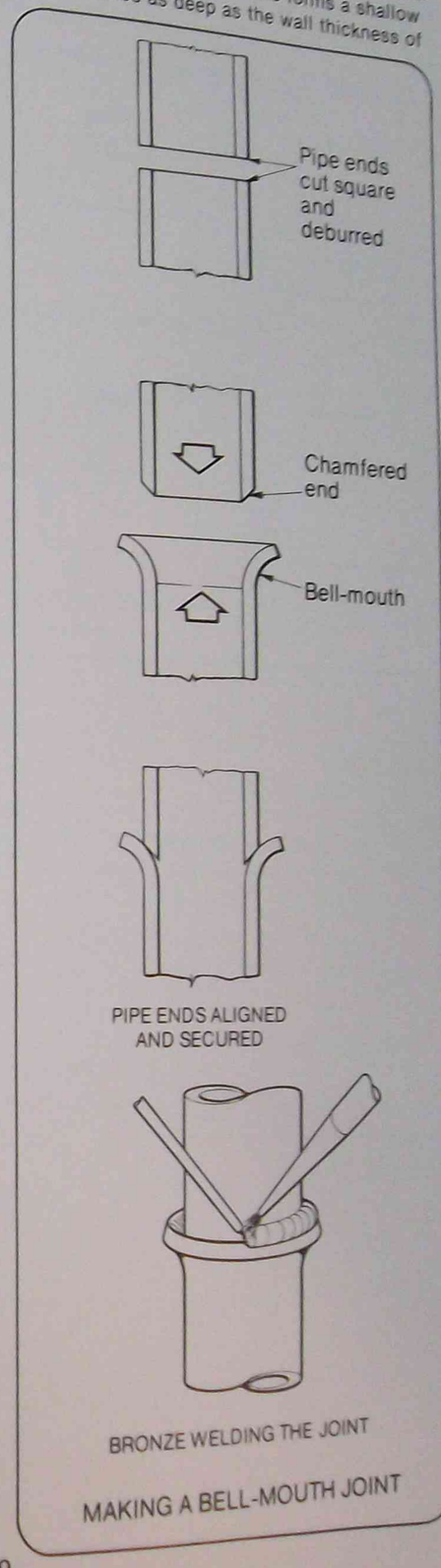
Bronze-welding is another method of jointing copper tube. The type of joint to use on straight tube is the 'bell-mouth' joint, as shown. One end of the tube is flared by means of a block and pin to form a bell-mouth into which the end of the next tube is inserted. This forms a shallow cup for receiving the filler rod and should be about 1.5 times as deep as the wall thickness of the tube. The end of the inserted tube should be chamfered to obtain a good fit and the inside of the cup and the end of the inserted tube should be thoroughly cleaned.

To make a bell-mouth joint:

- Prepare the ends of the tubes as explained.
- Secure the ends in position, ensuring proper line-up.
- With the blowpipe flame set to 'neutral', pre-heat both adjacent tube areas to dull red heat.
  - Keep the inner tip of the flame away a little distance from the joint to obtain spread and uniformity of heat.
  - At the same time, warm the end of the filler rod and dip it into the flux, if dry flux is used.
- When dull red heat is obtained on the tube ends, change the flame to slightly 'oxidising' and moving the tip closer in, deposit a bead of bronze into the bell space around the joint.
  - Avoid overheating the copper or the bronze by taking care to lift the flame momentarily as the bronze deposit 'takes' to the copper, otherwise a poor joint (porous weld) could result if the bronze is allowed to 'burn'.

To make branch joints, the procedure remains the same except that the preparation for the joints is different:

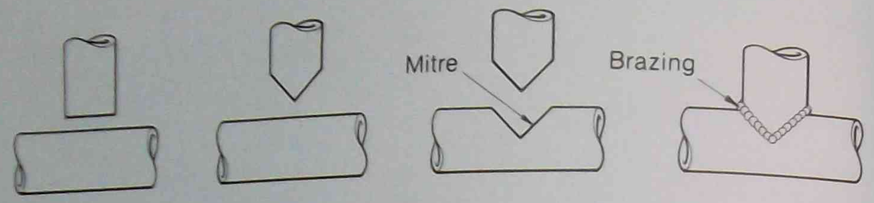
- For a branch using tubes of the same diameter, the tube joints are mitred with a hacksaw, as shown.
- For a branch with tubes of different diameters, the main tube is bored to the same diameter as the smaller tube and the end of this one is filed to fit snugly to the main one, as shown.



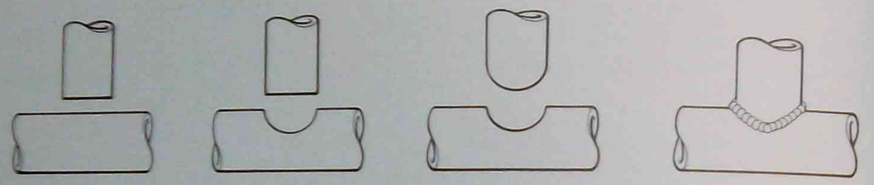
MAKING A BELL-MOUTH JOINT

Branch joints

Branch joints may be prepared either by mitering the tubes by cutting with a hacksaw, as shown or by boring a hole in the main tube having the same diameter as the bore of the branch tube, as shown below and filing the end of the branch tube to fit snugly to it.



MITRED BRANCH FOR TUBES OF EQUAL DIAMETER



BRANCH IN TUBES OF DIFFERENT DIAMETERS

MAKING BRANCHES

NOTES

- *Crox joints.*

  – Such joints are approved for making joints between copper tubes and male threads of fixtures or fittings.

A special Crox tool is used for fabricating the end of the tube to suit the type of joint to be made.

To make a Crox joint:

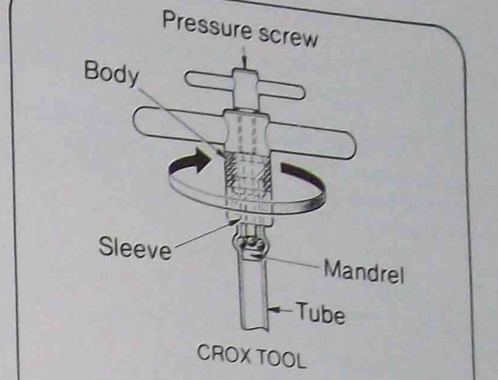
- Cut the end of the tube square and deburr both inside and outside of the tube end.
- Anneal the tube end.
- Slip on the flat-seat nut, as shown.
- Place the annealed end of the tube over the tool mandrel and force the sleeve into the body.
- Screw down the pressure screw while rotating the body of the tool.

  – The pressure screw pushes the centre steel ball down, forcing the side balls sideways into the inside wall of the tube so forming a concave ridge into the internal surface of the tube, while at the same time forming a bulge around the outer surface.

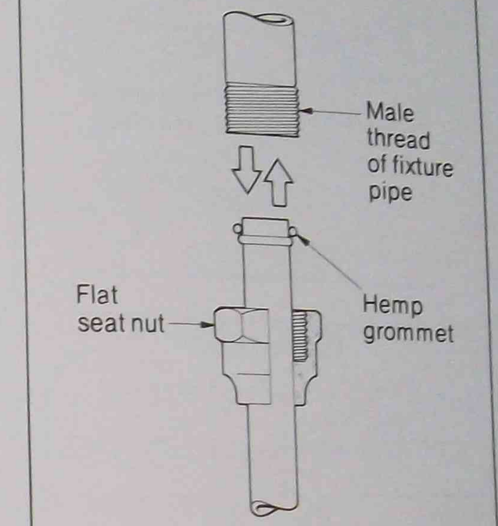
- When the Crox is completed, slacken off the pressure screw, then remove the tube from the mandrel.

  – The spring-loaded sleeve will return to its original position and retain the outer steel balls inside the mandrel.

- Make a hemp grommet on the end of the tube, as shown, and complete the joint by screwing the flat-seat nut to the end of the other pipe.



CROX TOOL



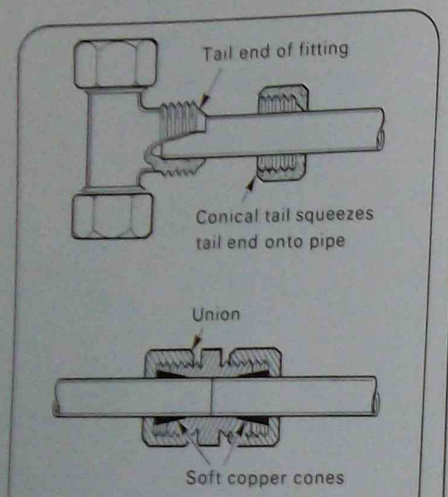
THE CROX JOINT

NOTES

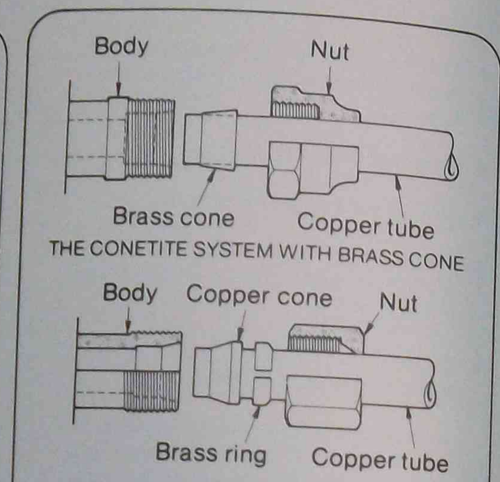
- Friction joints.

  — This type of joint is more suited for use with stainless steel tube. However, it is used in conjunction with copper tube in some States.

These joints are made by slightly squeezing the end of the pipe in the socket of a fitting or against conical-shaped soft copper rings which are compressed into the annular recesses of the fitting by unions on each side when tightened up. These friction joints are only suitable when no strain will be placed on the joint.



FRICTION JOINTS-COPPER PIPES



OTHER FRICTION JOINT SYSTEMS

NOTE:

Similar types of fittings, as shown for making compression joints, are available for these types of joints.

8 ASSEMBLING PIPES

After the type of pipe to be used in an installation has been selected, the pipes must be assembled to provide the desired facilities. This involves:

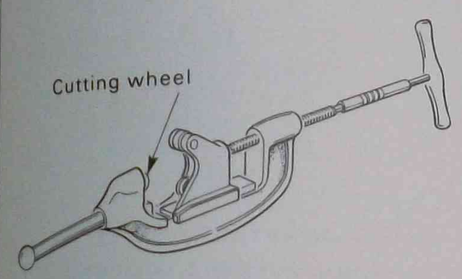
- Measuring the pipes.
- Cutting the pipes.
- Joining the pipes and fittings.

8.1 MEASURING THE WORK

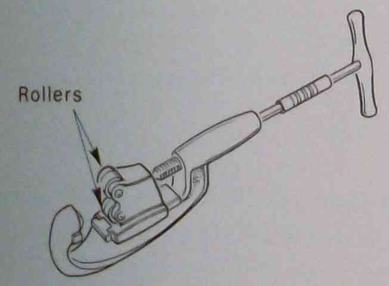
When measuring the work, the plumber rarely has a detailed drawing of the pipe layout to use as a basis for his planning. If he has a drawing, it may for example, only show the layout of the kitchen, laundry and bathroom appliances. The plumber must design his own pipework to service these appliances.

Pipe measurements may be made from several points of reference. (See illustration.)

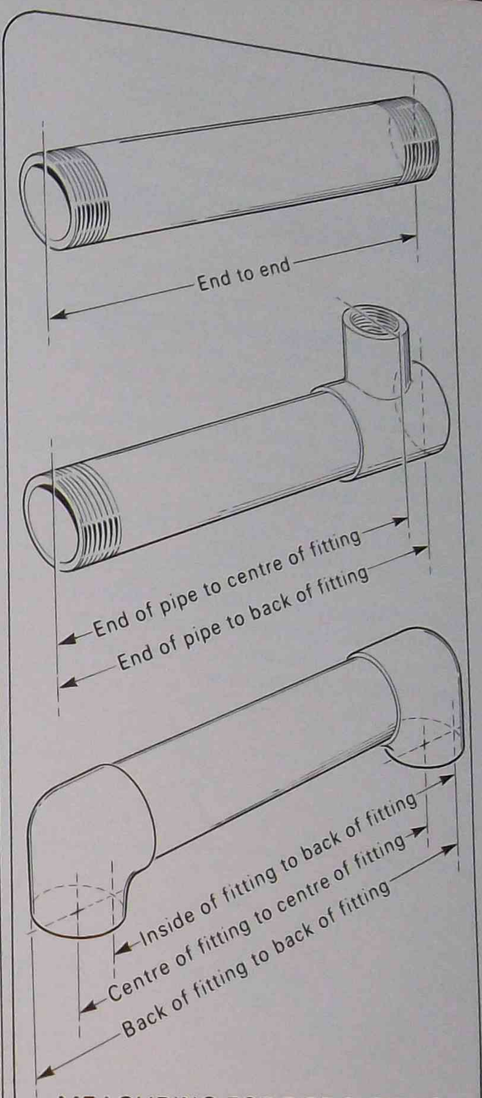
Whatever points of reference are used, accurate allowances must be made for the depth to which pipe ends are to be inserted into the fittings.



HEAVY-DUTY PIPE CUTTERS



WIDE-ROLL PIPE CUTTERS



MEASURING FOR PIPE CUTTING

8.2 CUTTING THE PIPES

Pipes may be cut with a hacksaw or pipe cutter. A hacksaw is preferable for small diameter pipes, as it cuts quickly and cleanly.

Some pipe cutters are provided with special wide rollers which reduce external burring of the cut pipe.

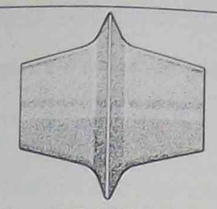
The cutting wheels fitted in pipe cutters vary in design. There are basically three designs, as shown in the illustration.

Plastic pipes may be cut with a fine-tooth saw, but to ensure a square cut, a mitre box should be used. Burrs must be removed by filing or sand papering.

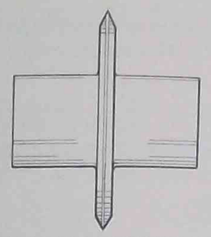
VC, asbestos cement and CI pipes may be cut with a chain pipe cutter or an abrasive disc saw. In an emergency, these may be cut with a cold chisel. In this case, the location of the cut is marked and a groove is gradually cut with a cold chisel, using relatively light hammer blows while turning the pipe. The process is continued until the pipe finally breaks cleanly.

8.2.1 Tubing cutters

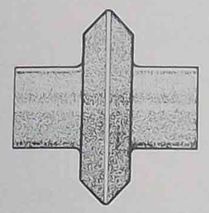
Various types of tube cutters are available. They have been specially designed for the cutting of tubes and should not be used on galvanised or black iron pipe.



WHEEL FOR CAST IRON PIPE

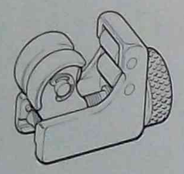


STANDARD THIN WHEEL FOR COPPER AND PLASTIC

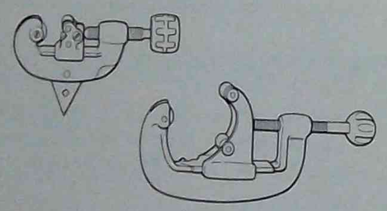


HEAVY DUTY WHEEL

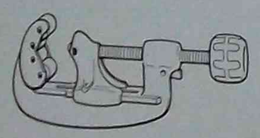
PIPE CUTTER WHEELS



MIDGET CUTTERS



CUTTERS FOR COPPER, BRASS AND ALUMINIUM

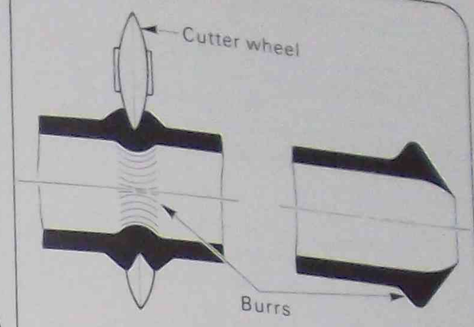


QUICK-ACTING CUTTERS

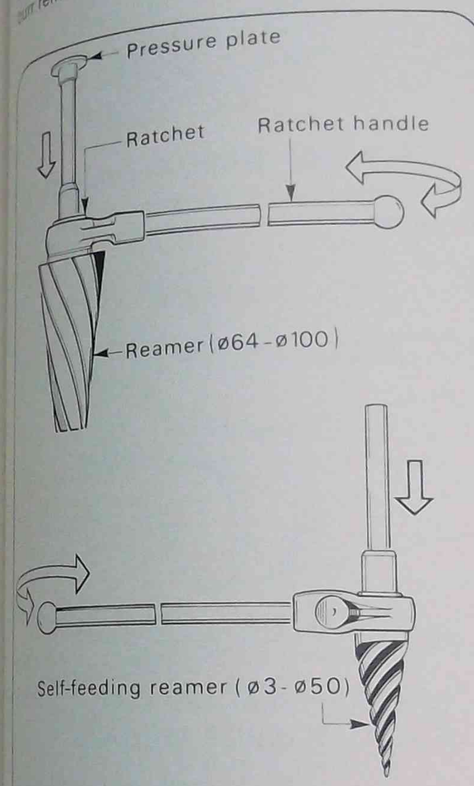
TUBING CUTTER TYPES

8.2.2 Deburring the pipes

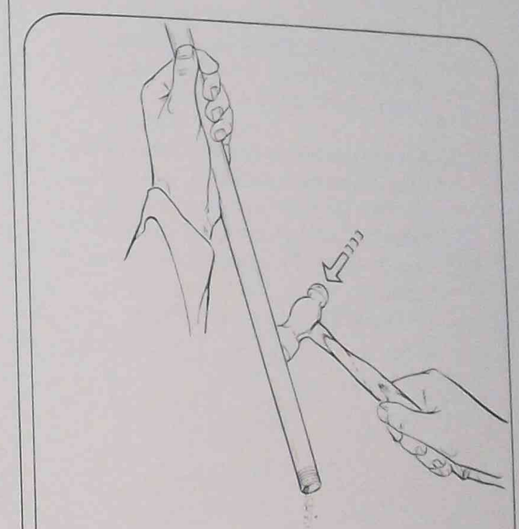
When the pipes have been cut, the burrs must be removed from both edges of the cut. A burr left on the outside of any pipe may foul the mating socket of the next piece of pipe or fitting. A burr left on the inside causes friction when water passes through the pipe. Outside burrs are removed with a file. Inside burrs are removed with a reamer, rat-tail file or rotary burr remover.



PIPE ENDS BURRED BY CUTTERS



SPIRAL RATCHET PIPE REAMERS FOR INTERNAL DEBURRING



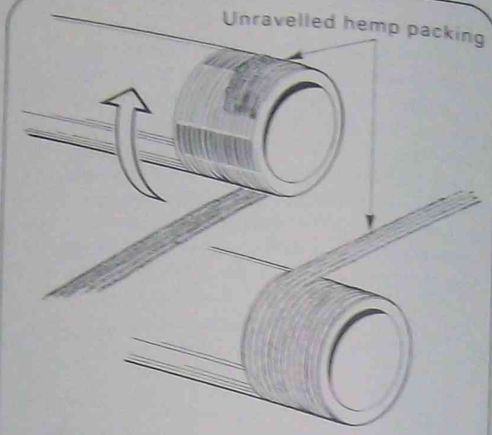
CLEARING BORE AND THREAD

8.3 JOINING GALVANISED PIPES

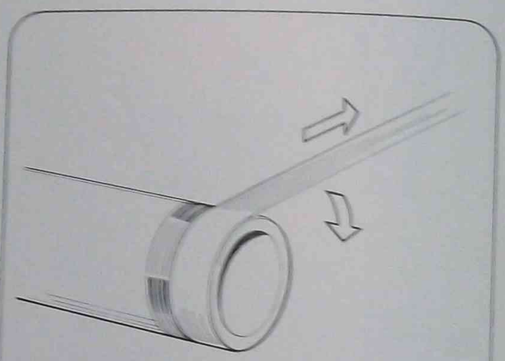
The following procedure is used to join galvanised pipes together or to fittings:

- Support the pipe in a proper pipe vice and tighten it securely.
- With a thread cutter (stocks and dies), cut male threads on the ends of each pipe to be joined as explained in the manual for 'Hand Tapping and Thread Cutting'.
- Raise each length of pipe and tap it lightly with a hammer or a wrench to clear any foreign matter from the interior.
  - Check that the pipe interior is clean.
- Clean any metal cuttings from the threads.

- Wind sealing material on to the male thread of the pipe end.
  - If hemp is used as a sealing material, unravel it and wrap it around the thread, commencing at the cut end and following the thread in a clockwise direction when facing the pipe end.
  - If sealing tape is used, wind it on in the direction of the thread and stretch it slightly as it is wound.
- Engage the male and female threads and make the first few turns by hand.
- Use pipe wrenches to tighten the threads gradually and evenly.
  - Hold the wrenches close to the joint for maximum torque.
  - Should the pipe thread suddenly tighten before many threads are engaged, the thread has probably crossed. Unscrew the joint and restart the threads correctly.
  - If the thread slips or turns easily for a few turns then suddenly jams, unscrew the joint and examine the threads. If undamaged, carefully re-engage them. If damaged, recut the thread or replace the fitting, then complete the joint in the proper way.

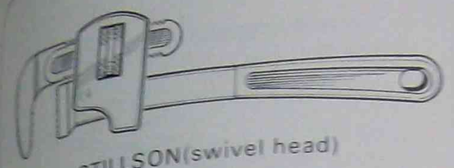


PLACING HEMP ON THREADS

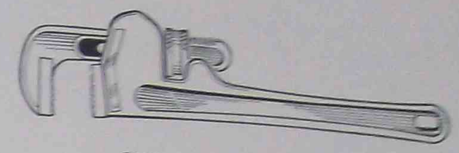


STRETCH SEALING TAPE SLIGHTLY WHILE WINDING

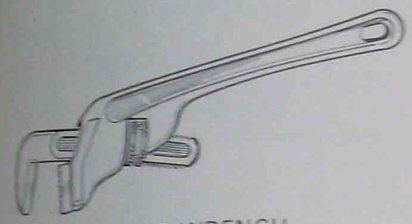
NOTES



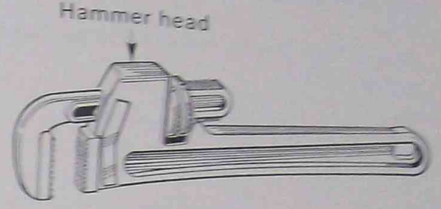
STILLSON(swivel head)



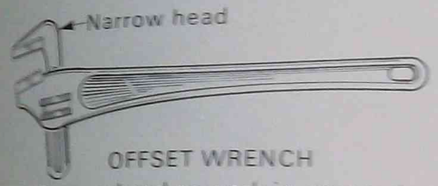
STRAIGHT WRENCH



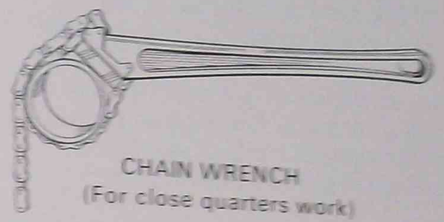
END WRENCH
(For work close to wall or on closely spaced pipes)



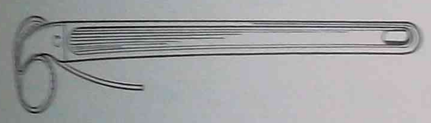
HAMMER WRENCH
(For occasional use as a hammer Has broad jaws)



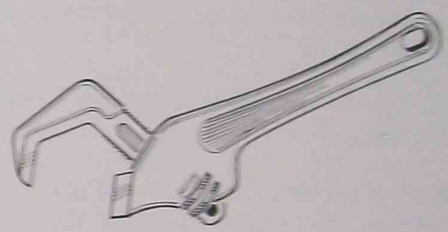
OFFSET WRENCH
(For overhead or work in corners)



CHAIN WRENCH
(For close quarters work)



STRAP WRENCH
(Nylon strap for use on thin or plated pipes. Polyurethane-coated strap for UPVC pipes)



OFFSET HEX WRENCH
(For large nuts in tight corners)

TYPES OF WRENCHES

8.4 JOINING COPPER AND STAINLESS STEEL TUBES

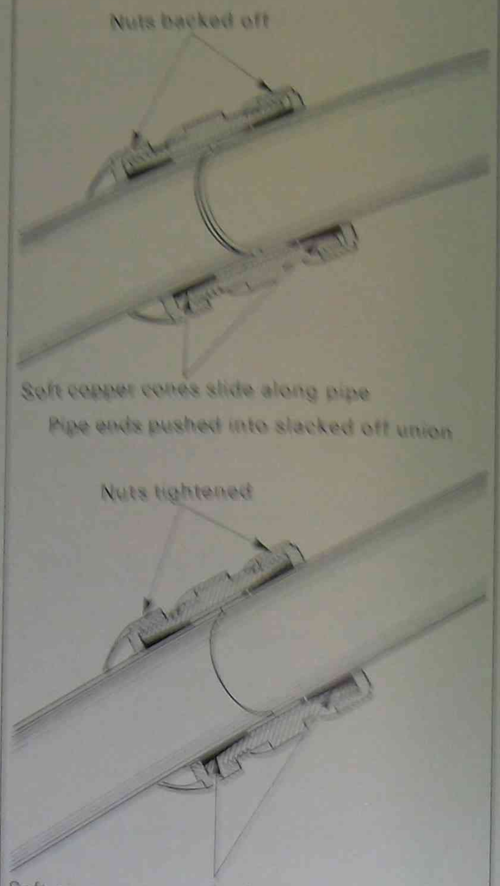
8.4.1 Compression joints (Friction)

Joining copper pipes with a friction joint is done as follows:

- Cut the pipes to the required length and the ends square to the pipe centre line.
- Deburr both inside and outside surfaces at the cut.
- Clean out the inside of the pipes to ensure no foreign matter remains.
- Take a straight union of the correct size for the pipe, remove the nuts and check that each end of the union is provided with a soft copper cone.
- Check that the cones are properly located and replace the nuts loosely.
- Insert the end of one pipe half-way into the union body, then tighten the nut sufficiently by hand or spanner to prevent the union from slipping.
- Insert the other pipe end into the free union end until it abuts against the pipe already fitted.
- Tighten the nut on that side in the same way as the first.
- Holding the union body nut with one spanner, tighten each union cap nut with another spanner in turn until the pipe ends are firmly gripped by the copper cones.

NOTE:

This type of joint is only suitable where no strain is to be put on it. It is used in some States only.



COPPER PIPES JOINED BY FRICTION COMPRESSION JOINT

8.4.2 Compression joints (Flared)

These joints require the use of a flaring tool which is available in a variety of versions. The most commonly used are illustrated.

To join copper pipes with expanded compression joints, proceed as follows:

- Cut the pipes to the required length, ensuring that the cuts are square to the pipe centre line.
- Deburr the pipe ends inside and out.

- Select the correct size union fitting, unscrew the two nuts and slip one on each end of the pipes to be connected.

– Make sure the threaded parts of each nut will face one another when the pipes are brought together.

- Clamp one of the pipe ends to be flared into the correct size hole of the flaring tool, allowing sufficient pipe material to protrude to cover the bevel of the flaring block.

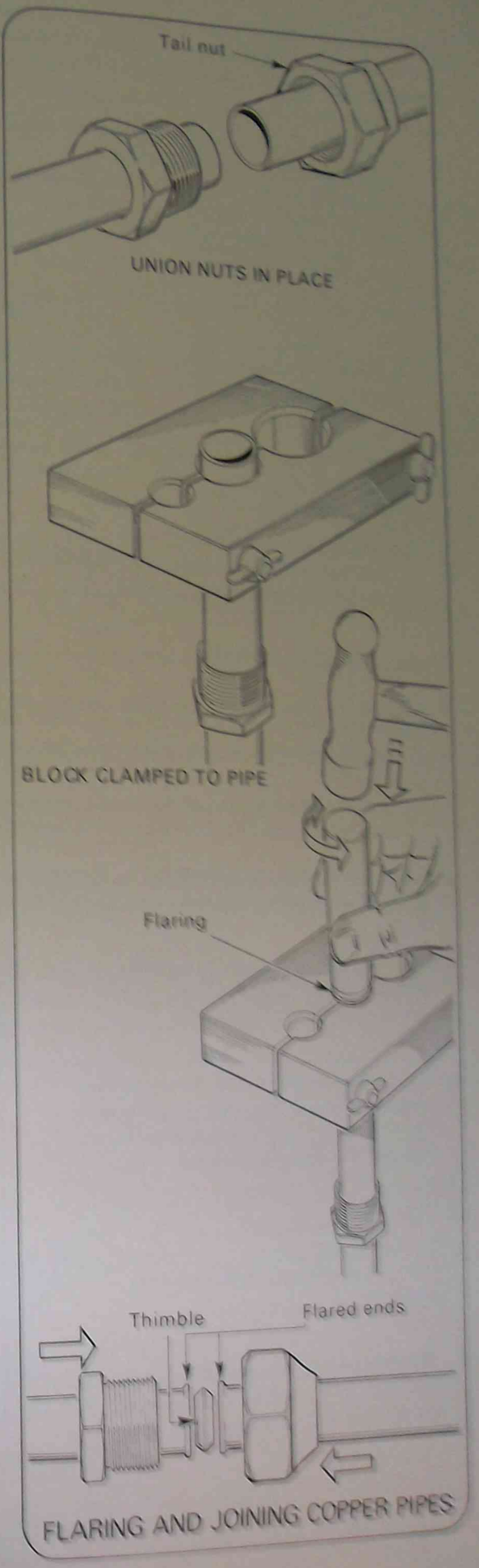
– Should the pipe material appear to be 'workhardened' during preliminary operations, it is a good precaution to anneal the pipe ends prior to flaring the avoid splitting of the flare.

– To have both hands free for flaring when the pipe end to be flared is unsupported, clamp the flaring block or yoke in a vice.

- If a block and drift is used, engage the narrow end of the drift into the pipe end.
- Tap the thick end of the drift with a series of light hammer blows, while turning the drift, until the pipe end is flared into the proper bell shape.
- Repeat this process for the second pipe end.
- Bring the two pipe ends together with the union nuts against the flared edges.
- Insert the copper or brass thimble (olive) provided with the union into the flared edges, line up the threads of the nuts, engage them by hand.
- Using two spanners, tighten the union nuts securely.

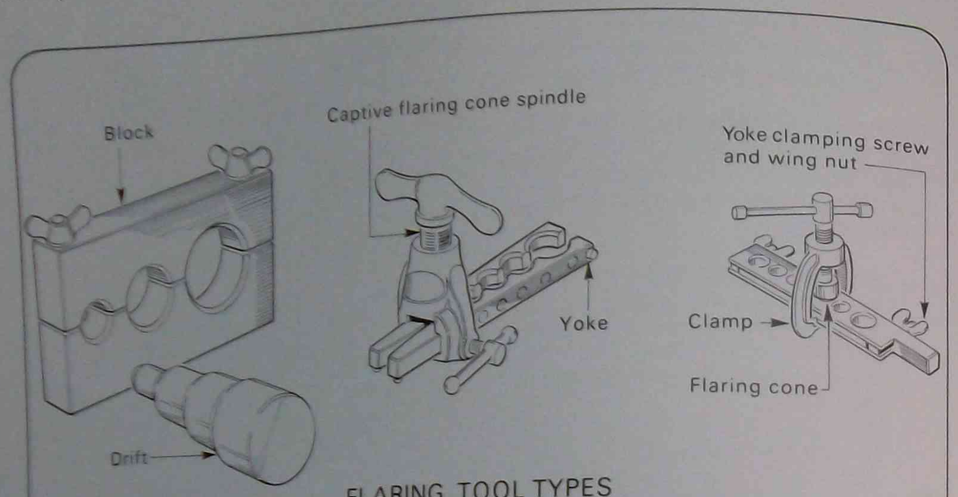
NOTE:

Jointing compounds are also used to help seal the joint. The compound is applied between the faces of the joint.



FLARING AND JOINING COPPER PIPES

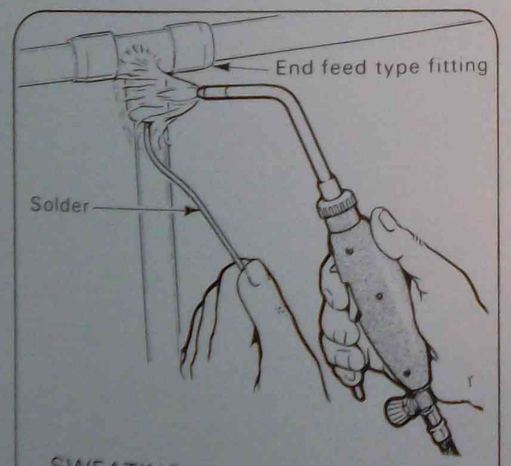
With the other flaring tools shown in the illustration, the flaring is done by screwing the flaring cone (fitted at the end of the threaded spindle) into the pipe end until the flare is completed.



FLARING TOOL TYPES

8.4.3 Capillary joints

- Prepare the pipe ends as for other operations (deburr).
- Clean the external surfaces of the pipe ends with steel wool or sand paper.
  - Do not use emery paper because hard particles could lodge into the soft copper material and reduce the effectiveness of the seal and the strength of the joint.
- Clean the sockets of the fittings to be used with steel wool or sand paper if the grease-proof protective wrapping has been damaged or is missing.
- Apply soldering flux to the outside surfaces of the pipe ends and to the inside of the fitting sockets.
- Insert the pipe ends into the respective sockets of the fitting, then slightly twist the pipes to spread the flux evenly between the mating surfaces.
- Heat the assembled joint with a blowlamp or gas torch until rings of solder appear at the mouths of the sockets.
- Remove the heat source, allow the assembly to cool, then wipe off any excess flux with a damp cloth.



SWEATING A CAPILLARY JOINT

9 LAYING SERVICE PIPES

The service pipe connected to the main ferrule must be of the material specified by the local water authority. Most authorities in Australia specify copper pipes.

Conditions of the soil may need to be considered when choosing the type of service pipe to be installed in the user's property. For example, soil of an acid nature and areas containing ashes have a corrosive effect on metal piping. When subjected to these conditions, metal pipes must be protected against them. This may be done by surrounding them with sand or tarred screenings. Pipes should be laid in the most direct route and with minimum use of fittings to avoid flow friction.

In areas where below-freezing temperatures may occur, pipes must be buried deep enough to prevent the water in them from freezing.

Pipes must also be buried deep enough to protect them from the weight of vehicles. Municipal authorities specify the depths at which pipes must be laid under roads and footpaths and this often dictates the depth at which pipes must be laid in private property.

Under concrete roads, or in areas where future access to the pipe might be difficult, it is good practice to lay the service pipe inside another pipe of larger diameter. The service pipe can then be readily disconnected and withdrawn for repair.

The most usual method of laying the service pipe is to open a trench from the main to the point of entry to the user's property. The pipes are then cut to length, threaded and assembled. The assembled pipes are then laid in the prepared trench, taking care to ensure that no dirt enters the open pipe ends.

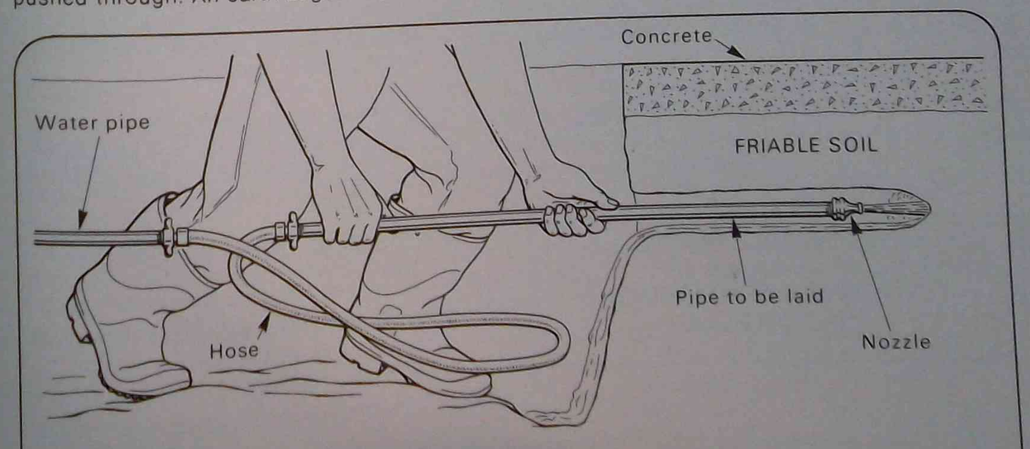
When opening the trench, the excavated road metal should be placed clear of excavated topsoil, so that it can eventually be replaced on top of the back-fill.

When opening a trench through a grassed area, the top few centimetres of grassed earth should be cut into sods, stacked on one side of the trench and later relaid on top of the back-fill.

9.1 THE WATER DRILL

In soft or friable soil, it may be possible to use a water drill to cut a hole for pipe laying. A water drill consists of a length of hose with one end attached to a water tap. The other end of the hose is connected to one end of the pipe to be laid.

A brass nozzle is fitted to the other end of the pipe. When the water is turned on, it flows out through the nozzle under pressure, washes away the soil and forms a tunnel for the pipe to be pushed through. An earth auger may also be used to cut a tunnel under narrow paths.

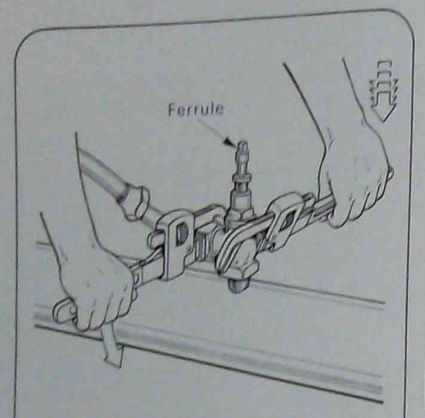


WATER DRILL USED IN FRIABLE SOIL

9.2 CONNECTING THE SERVICE PIPE TO THE MAIN

After the pipes have been laid and connected to the water meter or stop tap at the point of entry into the user's property, the service pipe is connected to the ferrule.

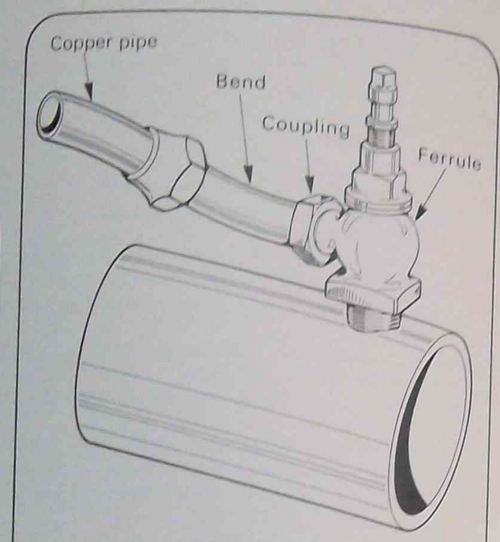
Care must be taken when tightening the coupling to the ferrule as excessive strain may cause a leak around the joint of the ferrule or force the ferrule out of the main. Take the following precautions:



USING TWO WRENCHES

USING ONE WRENCH

TIGHTENING MAIN-SERVICE PIPE COUPLING



PIPE CONNECTED TO FERRULE

- Use two wrenches, one to tighten the coupling, the other to hold the ferrule and so counteract the torque caused by the tightening operation.

  — If you cannot use two wrenches, use your foot to steady the ferrule, as shown.

- Before turning on the water at the ferrule, open the stop tap at the point of entry to the user's property to allow air in the pipes to escape.

  — If this is not done, air will be compressed in the pipe and cause water hammer which may burst the pipe at one of the joints.

- Turn on the water at the ferrule very slowly.

- When the water has passed through the service pipe and is flowing steadily, shut the stop tap.

The pipe trench should not be filled in immediately because it is necessary to inspect the pipe and joints for leaks after remaining under full pressure for a period. Most Water Supply Authorities will insist on inspecting the installation before the trench is back-filled.

When filling-in the trench, the pipe should be well supported by soft earth, rather than by stones. The filling should be consolidated by tamping.

9.3 WATER METERS

Water meters, which are owned, supplied and maintained by the Water Supply Authority, may be fixed on properties to register the quantity of water consumed. Some authorities require a meter to be fixed on every property supplied.

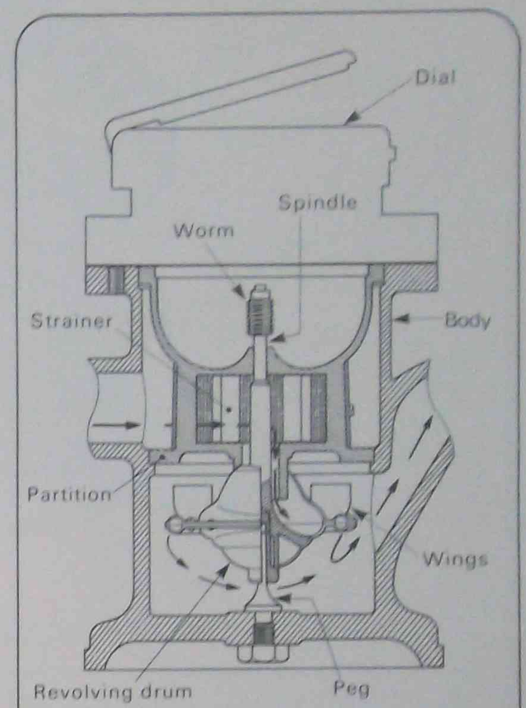
Others require meters to be fixed only when water is to be used for purposes other than normal domestic use. There are two types of meter:

- Inferential meters
- Positive displacement meters

9.3.1 Inferential meters

Inferential meters are used to measure large volumes of water such as for industrial purposes.

A typical inferential water meter has a brass or gunmetal body, partitioned to form an upper and a lower chamber.



SECTION OF INFERENTIAL WATER METER

Water enters the upper chamber through the inlet, passes through a copper strainer and is then directed through a tube into the interior of a revolving drum in the lower chamber. This tube is formed around the spindle on which the drum is mounted.

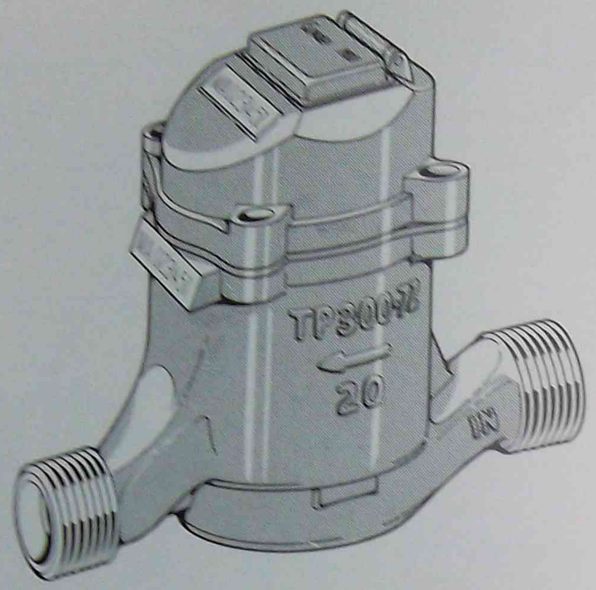
The drum is formed of sheet bronze in two pieces, stamped to shape and fastened together to form curved channels which convey water from within the drum to its outside through a series of ports.

The drum turns on a peg at its base. A worm gear is fitted at the top of the spindle which forms the upper part of the drum. The worm gear actuates a series of gear wheels which register, on the dial above, the quantity of water which has passed through the meter.

When water escapes through the series of ports around the drum, the drum is made to revolve. The velocity of the water varies as it passes through the drum. Wings are attached to the outside of the drum to act as stabilisers to ensure that the rotation of the drum is related to the volume of water passing through the meter and is not affected by variations in pressure.

9.3.2 Positive displacement meters

Positive displacement water meters measure the quantity of water passing through them by recording the number of times a container of water of known capacity is filled and emptied. These meters are widely used on domestic water installations.



TYPICAL POSITIVE DISPLACEMENT METER

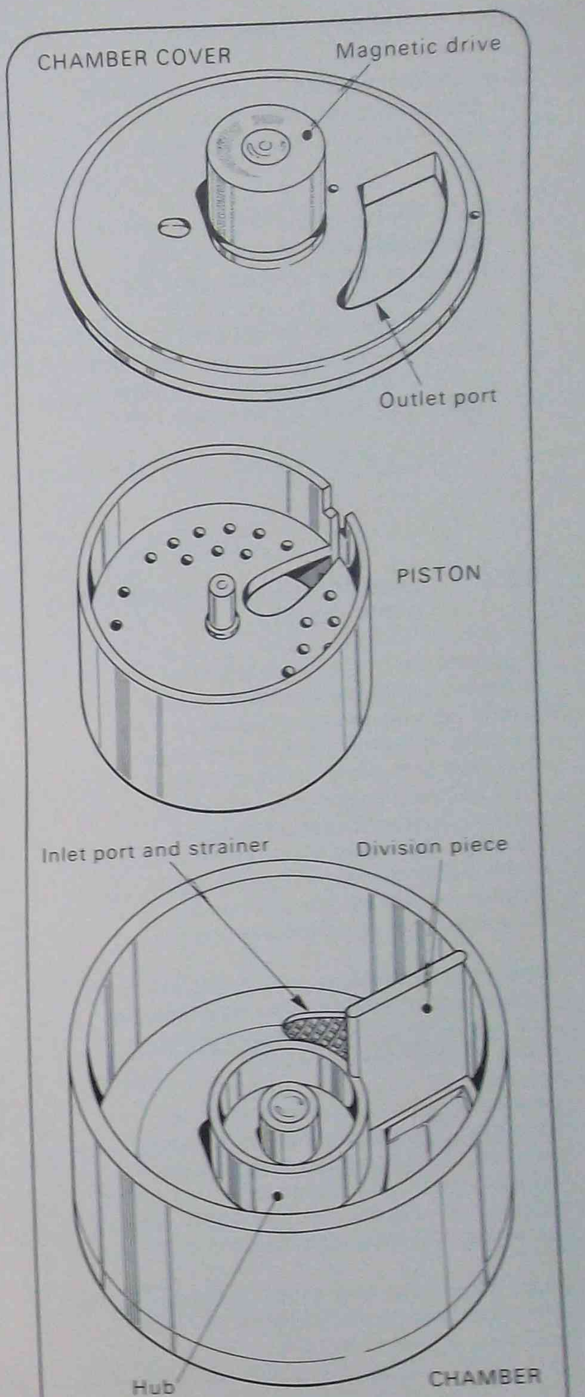
Its internal details and operation are illustrated on next page.

A typical positive displacement water meter comprises a piston rotating with a displacement chamber in the meter body. Water enters the meter and passes through a strainer and inlet port into the chamber, where it fills and drives the piston around a central hub until the piston reaches the outlet port in the top of the working chamber.

Water is delivered from the meter in a series of small rapid impulses. The meter chamber has a division piece which guides the piston in its rotation so that the only connection between the inlet and outlet ports is through the piston. The water is admitted to the piston through a number of small holes in the bottom and recesses on its sides.

The piston oscillates around the centre hub. While the chamber is filling on one side, the piston is delivering water on the other.

The piston rotations are recorded on a dial through mechanical gearing or through a magnetic drive as shown in the illustration.

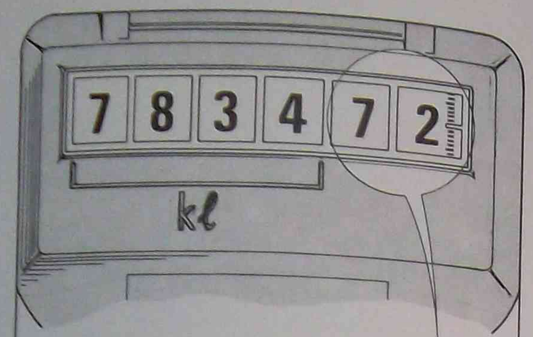


WORKING PARTS OF POSITIVE DISPLACEMENT WATER METER

9.3.3 Reading water meters

Water meters register the amount of water that passes through them in kilolitres (kl). The dial of the water meter is read as follows:

- Black figures on the left of the arrow marked below the dial, show the amount of water consumed in kilolitres.
- Red numbers on the right of the arrow marked below the dial, show decimals of a kilolitre and are used only when testing the meter for accuracy.



READING : 7834.72 KILOLITRES

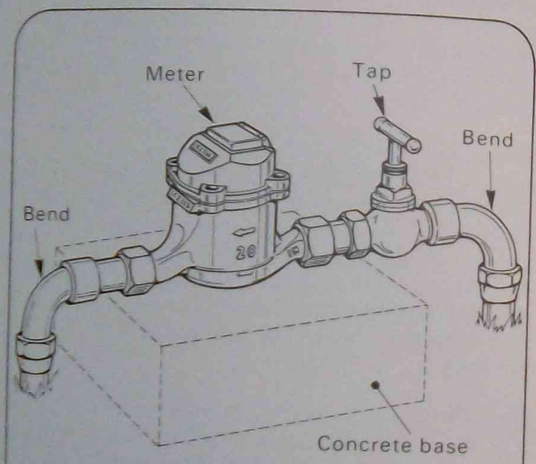
9.3.4 Location and installation of water meters

In general, the meter should be in a protected but easily accessible place. It should be mounted on a firm base if the diameter of the bends is 15 mm or more, level, and preferably, above ground. If it must be fitted below ground level, a properly drained meter pit must be installed. The meter must be installed close to the building line and the precise location, as well as the manner of installation, are usually specified.

Most local authorities specify the use of copper pipe connections to water meters and that all joints must be compression joints for easy disconnecting.

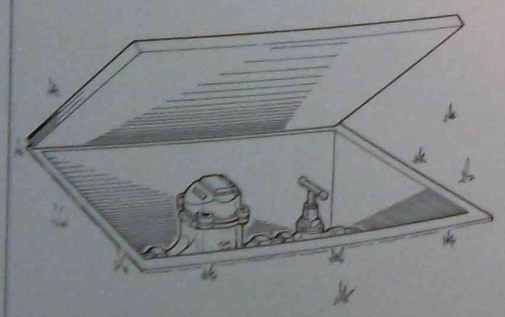
When the use of galvanised pipes is permitted, four long radius bends are required. Upright sections of pipe are placed between the upper and lower bends so that they may be sprung slightly apart, if necessary, to disconnect the meter.

Large meters are connected by flanged joints and feature a strainer or 'dirt box' upstream of the meter.

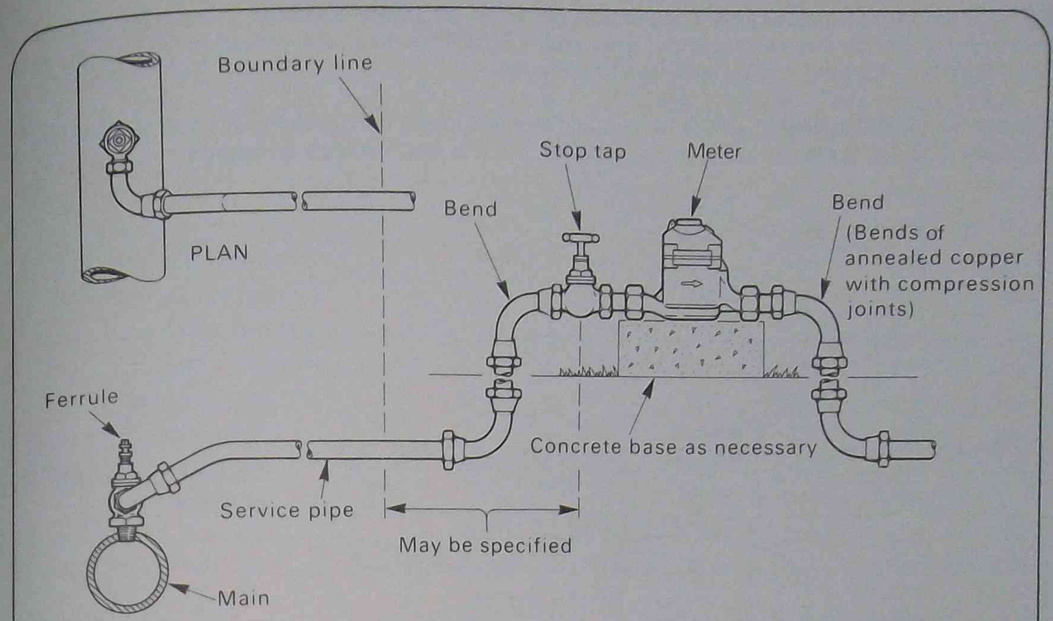


Meter must be mounted level-Base usually required for pipes of 75mm or more-Stop tap may be next to meter or further upstream

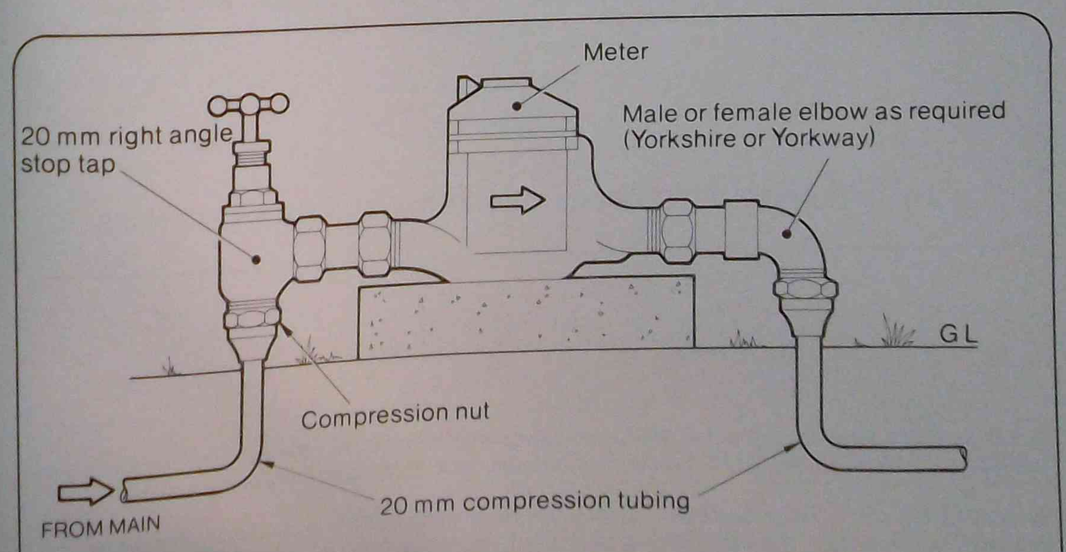
Well-drained pit if below ground-Stop tap may be in box



METER MOUNTING



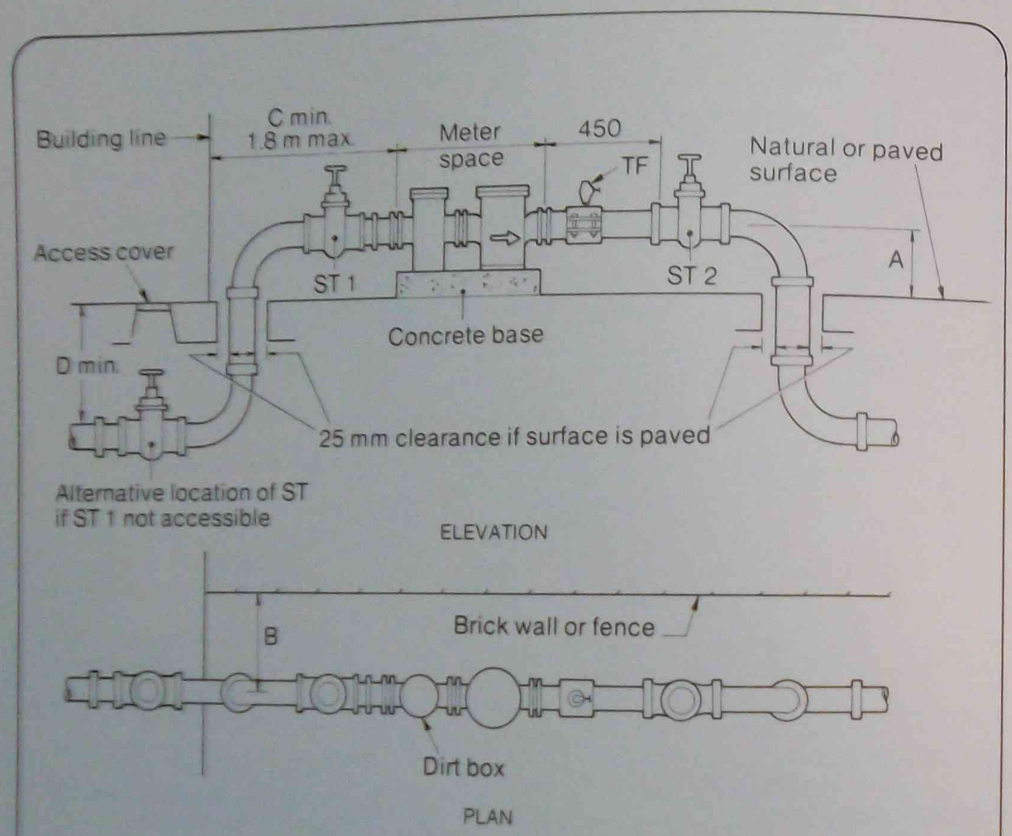
TYPICAL SERVICE CONNECTION



APPROVED METHOD OF FIXING A 20 mm RIGHT ANGLE STOP TAP

Water supply authorities usually specify that, for pipes of 50 mm diameter or more, provision must be made for testing the meter without disconnecting it. This may be achieved by installing a stop cock ferrule and a gate valve upstream of the meter.

To test the meter, the gate valve is closed and a check meter connected to the top cock ferrule. A quantity of water is passed through both meters and the dial readings compared.



TYPICAL LARGE METER INSTALLATION FOR 80 AND 100 mm SERVICES

If 100 mm stop taps are not obtainable, gate valves may be used, but the connections must then include a reflux valve similar to the connections for 150 mm meters to prevent backflow.

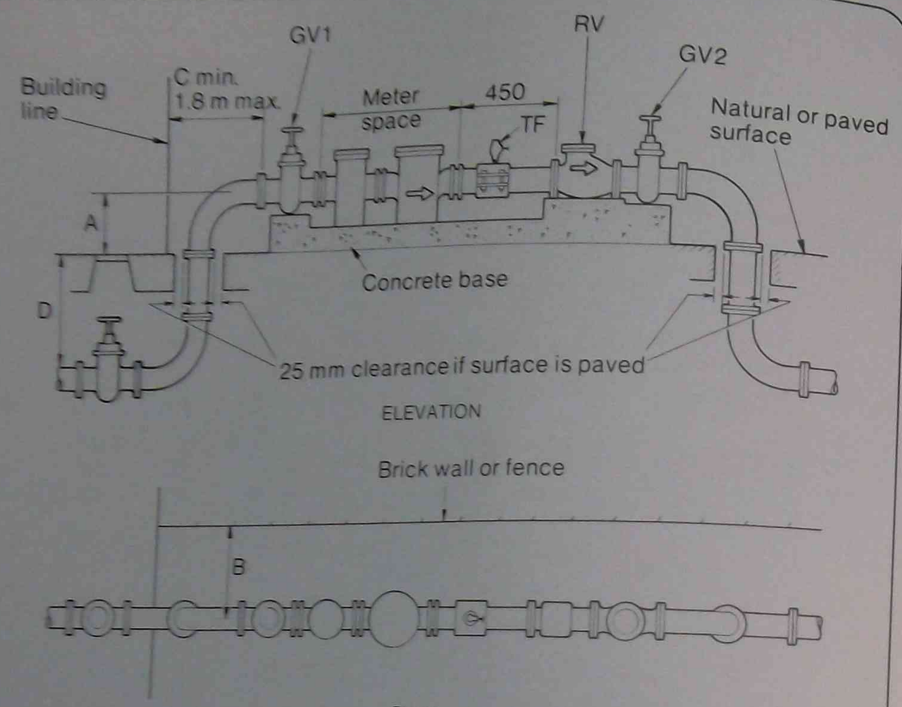
Where the 80 mm or 100 mm meter connections are installed below ground level in a pit as provided in the by-law, the connections must conform to the illustration including the inlet and outlet bends and risers.

For dimensions A, B, C and D, refer to next Table.

TABLE FOR METER SPACES AND CONNECTION DIMENSIONS FOR 50, 80 AND 100 mm METERS

SIZE (mm)	TYPE		DAVIES SHEPHARD MANUFACTURE				
			METER SPACE (mm)	A (mm)	B (mm)	C (mm)	D (mm)
50	Full-way inferential	E-F	533	254	381	686	762
80	Full-way inferential	F-F	692	330	381	686	762
100	Full-way inferential	G-F	787	356	457	838	838
80	Ordinary inferential	F	578	254	381	686	762
100	Ordinary inferential	G	673	279	457	838	838
50	Trade positive	D-FP	572	178	381	686	762
80	Trade positive	F-FP	800	229	381	686	762
100	Trade positive	G-FP	940	229	457	838	838
			EMAIL MANUFACTURE				
50	Trade positive	E-FP	575	178	381	686	762
80	Trade positive	F-FP	787	229	381	686	762

NOTES



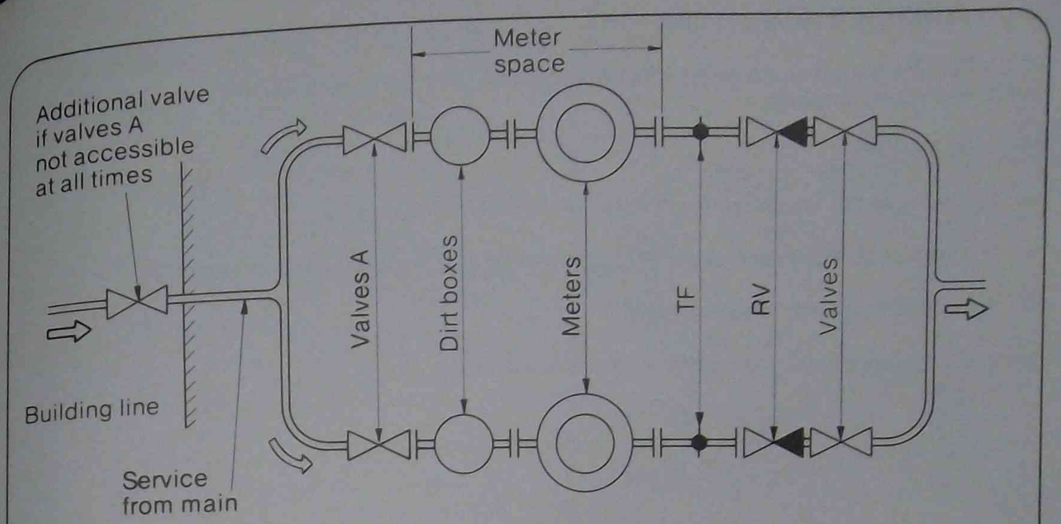
LARGE METER INSTALLATION FOR 150 mm SERVICE

Where 150 mm meter connections are installed below ground level in a pit, as provided in the by-law, the connections must conform to the illustration below, including the inlet and outlet bends and riser.

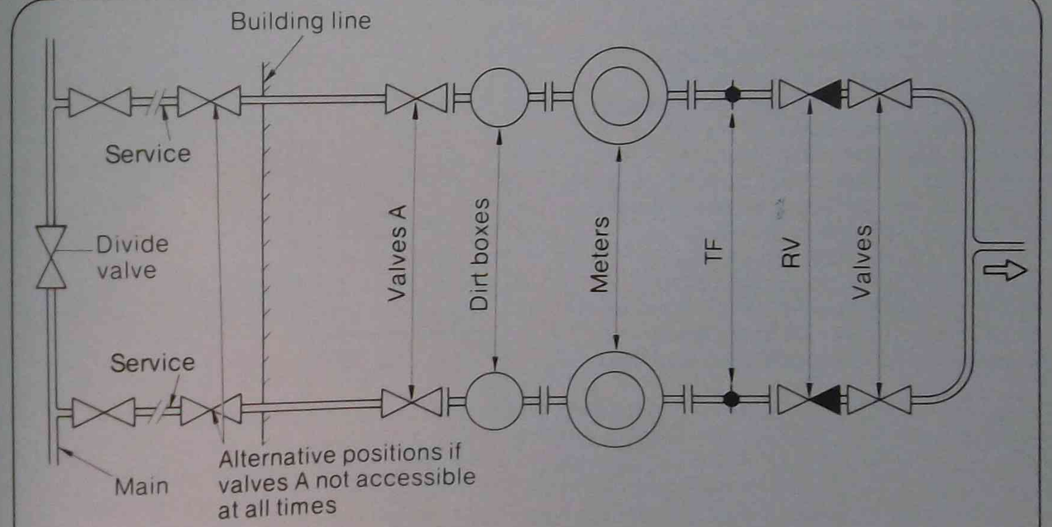
The next Table refers to dimensions A, B, C and D related to 150 mm meter set-up.

TABLE FOR METER SPACES AND CONNECTION DIMENSIONS FOR 150 mm METERS

SIZE (mm)	TYPE		MADE BY DAVIES SHEPHARD METER SPACE (mm)	A (mm)	B (mm)	C (mm)	D (mm)
150	Full-way inferential	H-F	1100	483	600	1200	900
150	Ordinary inferential	H	845	356	600	1200	900



TWIN METERS — SINGLE SERVICE INSTALLATION



TWIN METERS — DUAL SERVICES INSTALLATION

The meter connections shown may be fixed above ground as detailed in previous illustrations or may be housed below ground level in a properly constructed and drained brick or concrete pit.

10 DISTRIBUTION PIPES

When distribution pipes are being laid, care must be taken to ensure the minimum water friction is obtained inside the pipes.

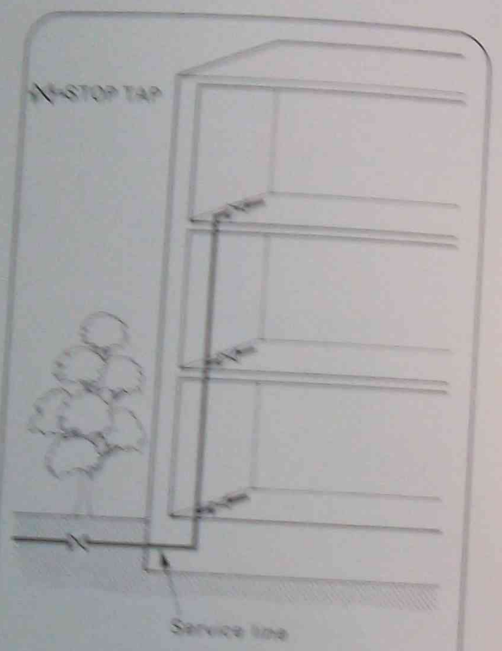
This involves:

- Careful reaming and deburring of internal surfaces of pipe ends.
- The use of fittings which cause the least friction, e.g. bends rather than elbows.
- A minimum of directional changes.
- Selection of the shortest possible route for the pipes.

10.1 PLANNING FOR FUTURE WORK

Stop taps should be placed in easily accessible locations so that sections of the distribution pipe installation can be isolated by shutting off the supply to such sections needing repairs, or for the installation of additional piping for extensions. In multi-storey buildings a stop tap is required at each floor where the riser is tapped for service to that floor.

Plugs should also be installed at such locations where future extensions are likely to be made. This avoids unnecessary cutting of pipes and additional work later.



STOP TAP ON EACH FLOOR IN MULTI-STOREY BUILDINGS

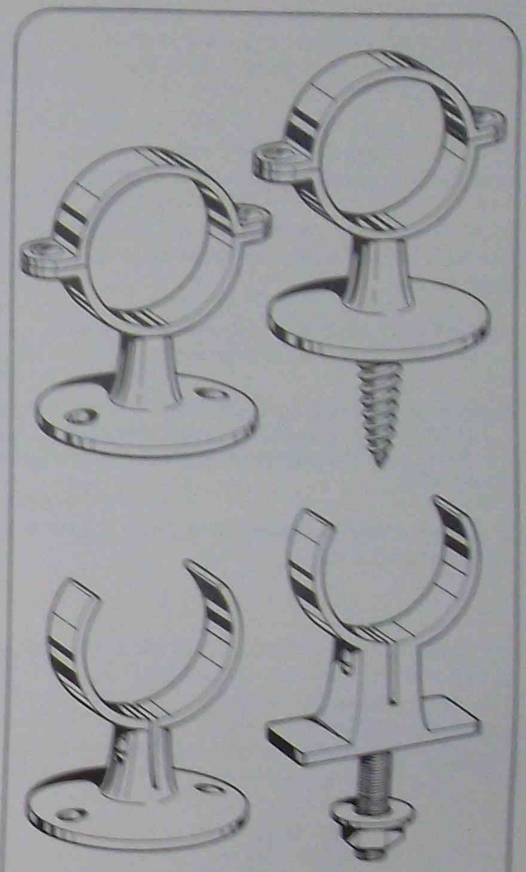
10.2 TESTING THE INSTALLATION

Small installations are usually tested as a whole, after connection to the main. Large installations are installed and tested in sections. Pipe ends are closed off by plugs or blind flanges and the section or sections laid, are tested for leaks under full water pressure. At the completion of the test, any leaks are rectified and the test repeated until the installation is satisfactory for the section under construction. At the completion of the test, the water is turned off, the water drained from the pipes by removal of plugs or flanges and the next section is laid when the testing process is repeated once more until the whole installation has been subjected to the necessary testing and approved by the appropriate authority.

10.3 LAYING THE DISTRIBUTION PIPES

Pipes that are laid outdoors are buried for their protection against physical damage. Within buildings, pipes are laid above ground level for easy access when repairs or alterations to the piping become necessary. In some types of buildings, pipes may be installed in recesses or ducts. Such installations must be in accordance with local regulations. Certain regulations also exist for conditions when pipes must traverse walls or floors (See: 'Sanitary Plumbing 4' Section 6). External walls, pierced to allow the passage of pipes, must be plugged with mortar around the pipes and internal wall holes in wall cladding around pipes, masked by suitable cover plates or flanges.

Pipes laid externally underground are sufficiently secured by the earth tamped around them, but pipes installed above ground must be firmly secured to walls or structures. A wide range of clips is available for this purpose, chrome plated clips of various shapes and designs being available for securing plated pipes installed exposed to internal walls. (For masonry type of clips, see 'Sanitary Plumbing 3'.



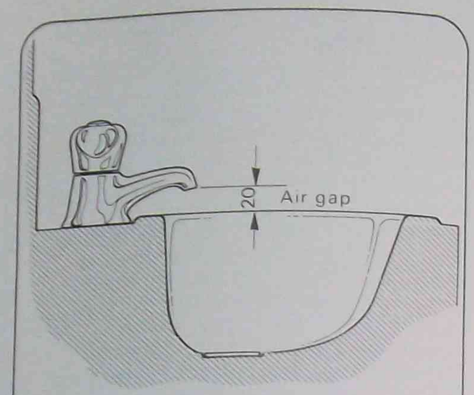
PIPE SUPPORTING CLIPS FOR EXPOSED PLATED PIPES

10.4 CONNECTING THE SUPPLY TO FIXTURES

General

The supply of water to fixtures must be carried out according to strict regulations. These apply whether such fixtures are connected directly to the supply or indirectly through storage tanks or flushing of any fixture, storage tank or flushing device cannot flow back into the supply pipes. If backflow was possible through a pipe installation, a 'cross connection' would exist and this must always be prevented. No connection may be made to fixtures, or service pipes laid, unless the Authority's permission is given.

This is done by providing an air gap of at least 20 mm between the lowest level of water inlet and the highest part of the overflow pipe or rim of a fixture.

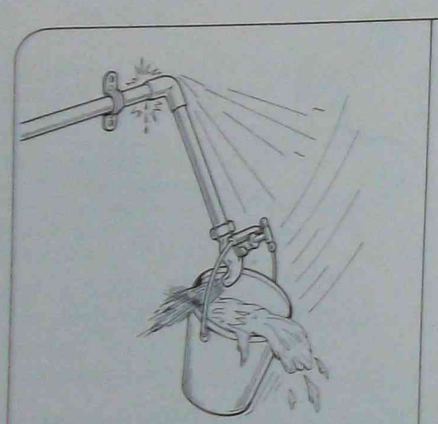


AIR GAP OVER SINKS AND BASINS

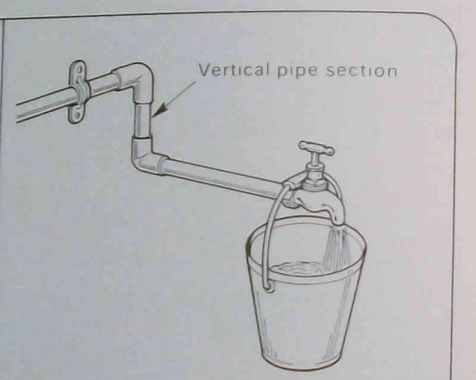
10.4.1 Requirements for tap installation

Apart from the air gap requirement between tap outlet and fixture overflow level, a tap must be:

- Easily accessible by a person to operate it, whatever fixture it may serve.
- So installed that it can be used conveniently, e.g. high enough over sink bowls, to allow adequate space for working.
- Installed over disconnector gullies or yard gullies in such a way that pipe joints cannot be loosened by loads.


Unsupported tap swings down under weight - Screw joint leaks

INCORRECT



Tap braced by vertical pipe section, joints will not loosen

CORRECT

NOTE:

Final connection from service pipe to fixture is by means of a length of annealed copper pipe (usually plated) and with compression joints, e.g. to cistern, HWS, basins, etc.

10.4.2 Requirements for fixtures

The pipework to supply water to any fixture or flushing device must be of a size allowing the delivery of at least 5-10 litres per minute. (Usually specified by Water Supply Authorities.)

10.4.3 Storage tanks

Storage tanks are used to serve the following purposes:

- To provide a supply of water that is physically disconnected from the mains supply.
- To store and distribute water in buildings at a level higher than that which the supply authority provides through its mains.
- To provide a reserve of water.

Physically disconnected supply from tanks

This system must be installed to supply water to flush valves, the storage tank supplying no other fixtures than those. If it is desired to supply water to other fixtures or services, a second tank or a cistern supplied from the first one must be installed, the supply to flush valves remaining disconnected from the service pipe supply.

High-level tanks

There are cases where the pressure of supply water is not sufficient to reach beyond a height that would ensure satisfactory operation of fixtures that may be installed in upper storeys of buildings. In such cases, the supply authority may approve the installation of booster pumps to ensure adequate supplies to outlets located above the 15 metre level. Where no approval for the use of such pumps has been given, outlets at the 15 metre or higher levels are to be supplied from a high-level storage tank of sufficient capacity to serve the number of outlets required.

Construction

Storage tanks may be constructed from a variety of approved materials, but the most widely used are:—

- Copper sheet, not less than 0.55 mm thick.
- Copper alloy sheet, not less than 0.55 mm thick.
- Galvanised steel sheet not less than 0.79 mm thick.
  - — As galvanised tanks may need replacing, provision must be made for such an event during construction of building structures.

Every storage tank must have:

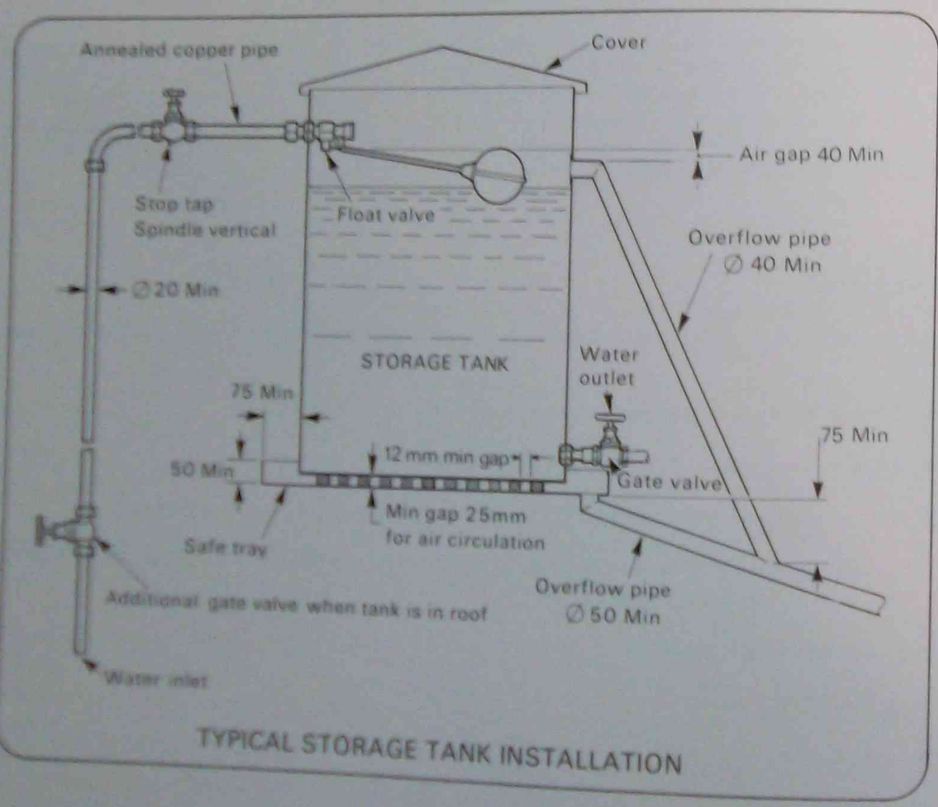
- a close-fitting cover;
- an overflow;
- a safe tray;
- watertight joints.

The overflow is constructed in such a way that when the control valve discharges into the tank at full capacity under a pressure of 686 kPa (70 metres of head) and all outlets serviced by that tank are closed, the air gaps listed in the Table page 126 are maintained between the static water level in the tank and the outlet of the control valve.

ORIFICE OF FLOAT VALVE (mm)	MINIMUM AIR GAP (mm)
10	20
15	40
20	60
25	75
More than 25	3 times outlet size (Max: 150 mm)

Unless special arrangements have been made for drainage, a safe tray must be provided which complies with the following:

- it must extend 75 mm (minimum) beyond any part of the storage tank;
- it must have a turned-up edge of at least 50 mm;
- it must be made of 0.60 mm commercial grade galvanised steel sheet or better;
- it must have an overflow pipe of at least 40 mm diameter, supported close to the heater or tank, then at every 2 m. Its seams must be uppermost and its watertight joints lapped in the direction of flow.



TYPICAL STORAGE TANK INSTALLATION

Tank installation

The following requirements apply for the installation of storage tanks:

- A supporting platform of hardwood, at least 25 mm thick, or other durable material with its planks not more than 25 mm apart, supported by adequate bearers, not more than 450 mm centre to centre or closer.
- The base of the tank must not rest on the safe tray, but be supported at least 25 mm above its surface for allowing air to circulate between the two.
- Storage tank and safe tray overflows must discharge to where they cannot cause damage or nuisance.
- The vertical distance from a storage tank outlet to any flush valve or cistern outlet, must be at least 3 metres.
- Tank capacity must be not less than 50 litres for each flush valve served when measured above the invert of the outlet pipe to 20 mm below the overflow level.
- The supply pipe to a storage tank must be 20 mm or larger to maintain an adequate supply to all fixtures served by the tank.
- If the storage tank capacity is more than 50 litres, a control valve must be installed to the outlet, close to the tank, and in an accessible position.
- The installation must usually be approved by the Supply Authority.

10.4.4 Supply from tanks to cisterns and flush valves

In general, the requirements listed below apply, with possible variations between localities.

Storage tanks to cisterns

Water supply to cisterns is controlled by float valves as follows:

- Where the vertical distance between the tank's full water-level and the cistern inlet is below 6 metres, a low pressure float valve delivering at least 7 litres per minute at 30 kPa is used (30 kPa = 3 m head).
- In all other cases, a high-pressure float valve or a universal control valve must be fitted. The valve so installed, must have the capacity to deliver 12 litres per minute at a pressure of 550 kPa (about 55 m head).

Regulations also lay down the size of the pipes to be installed between tank and cistern. Where only cisterns are to be served, the size of pipes to be installed is determined by the number of cisterns served, according to the table page 128.

The use of galvanised steel pipes is not permitted for this.

When other fixtures, apart from cisterns, have to be supplied through the same pipes, a plan of the proposed installation has to be submitted to the Supply Authority for approval.

TABLE OF SERVICE PIPE SIZES TANKS & CISTERNS

SERVICE PIPE DIAMETER (mm)	MAXIMUM NUMBER OF CISTERNS
20	3
25	10
32	30
40	50
50	100

Storage tanks to flush valves

Regulations also determine the permissible water heads under which flush valves are to operate and this is usually between 3-30 metres (30-294 kPa). Special arrangements for pressure regulations are required when higher pressures in the pipe system would be likely to occur, e.g. breaker tank or pressure ratio valves.

As for the supply of water to cisterns, the pipe sizes to be used are laid down for the number of flush valves to be supplied; the use of galvanised steel pipes is banned here too. The size of delivery pipes is reduced when a change in size is necessary and then progressing downwards from the storage tank level.

HEAD AVAILABLE (m) OR PRESSURE (kPa) MINIMUM	SERVICE PIPE DIAMETER (mm)	FLUSH VALVES ON SAME FLOOR AND LOWER
3(30)*	40	2
	50	15
	65	50
	80	150
6(60)	40	3
	50	30
	65	150
	80	200
9(90)	40	4
	50	50
	65	200
12(120)	40	6
	50	100
	65	250

*Figures in brackets represent pressures in kPa.

Detailed installation plans must be supplied to the authority for water supply if the number of flush valves to be served exceeds that listed in the table.

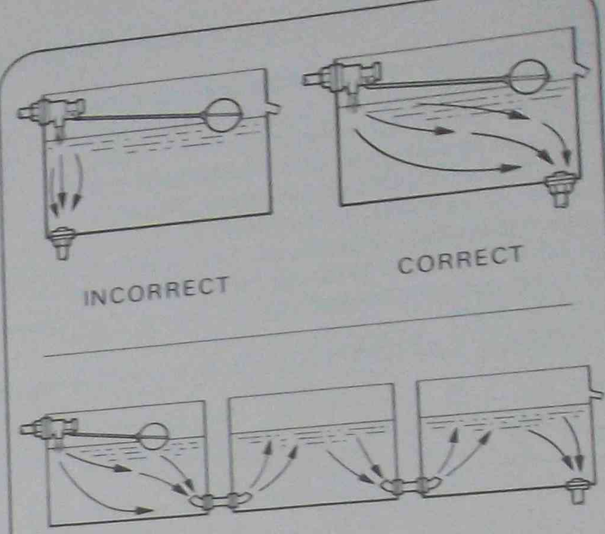
10.4.5 Sedimentation and stagnation in tanks

Sedimentation is the settling of particles of dirt and foreign matter to the bottom of storage tanks. Dirt should be allowed to settle in the tank instead of being released into the delivery pipe. The inlet level of the outlet pipe should be mounted a little higher than the tank bottom surface to allow for this.

Also, the supply valve outlet and the outlet pipe inlet should not be in line or close together because such an arrangement would allow:

- direct flow from supply to outlet, allowing the bulk of water stored to remain stagnant;
- stagnant water to be supplied to fixtures in cases when the normal supply would fail, or be interrupted for a while.

In some cases, it is necessary to interconnect several tanks in series. The same principles apply here to overcome those problems. The water is made to traverse the tanks before discharging through the outlet, as shown.



WATER TRAVERSING TANKS

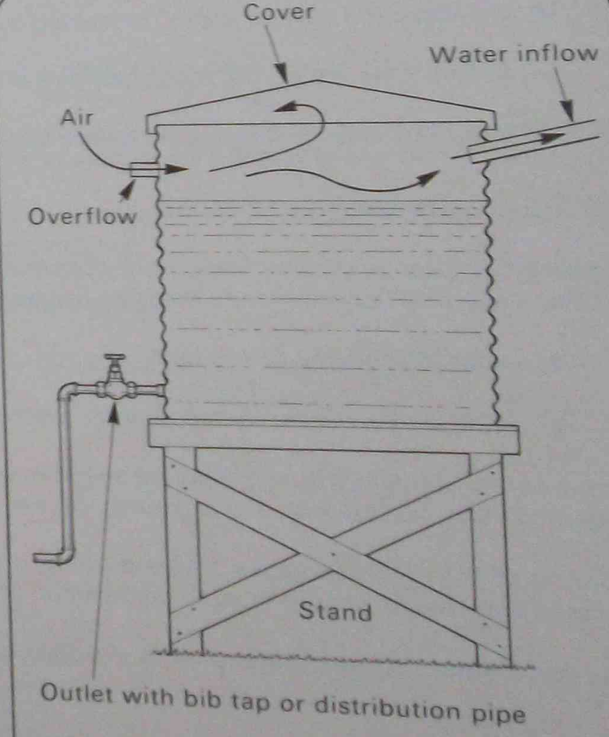
POSITION OF OUTLETS FROM STORAGE TANKS

11 COLLECTION OF ROOF-WATER

In rural districts, many households depend upon the rain-water collected from the house roof and stored in tanks. As the roof and its gutters are frequently fouled with dust and other impurities, rain will wash these into the tank. To overcome this, a filter can be fitted between the roof and the inlet to the tank. The roof catchment area should not be made of lead, or painted with lead-based paints, because 'soft' water dissolves lead which could then find its way into the water supply.

11.1 STORAGE OF RAIN-WATER

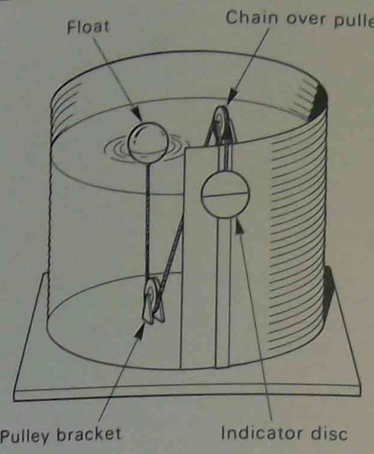
Rain-water tanks may be located above or below ground level. Where the only source of water supply is water collected from the roof, the tank capacity should be equal to about 90 days normal usage. For calculation for the size of tank required, allow 90-100 litres per day per person for all domestic purposes.



TYPICAL RAIN-WATER TANK INSTALLATION

11.1.1 Above ground tanks

Above ground tanks may be made from a variety of materials. Corrugated galvanised steel tanks are the most commonly used. They are usually placed on a stand in the coolest place that can be found. Water, kept cool, remains palatable and evaporation loss is reduced. The tank should have a close-fitting lid to keep out dirt and airborne impurities.



WATER LEVEL INDICATOR ON TANK

To prevent pollution, the storage tank overflow should not be connected directly with a closed drain. Water is drawn from the tank either:

- directly from a bib tap fitted a short distance above the bottom of the tank; or
- by a distribution pipe or pipes connected to outlets throughout the house.
  - — In this case a stop tap must be fitted at the tank outlet.

A level indicator may be fitted to a storage tank, as shown.

11.1.2 Underground tanks

Underground tanks may be made from concrete, stone or brickwork. The inner and outer surfaces of the walls and floors of tanks must be sealed against the passage of water to prevent both:

- water leaking out of the tank;
- pollution by contaminated subsoil water entering the tank.

The internal walls of the floor may be waterproofed by cement rendering or by suitable plastic sheeting. The outside wall and base may be set in puddled clay.

The top of the tank must have a strong cover, fitted with an inspection opening, and must be located well above ground level to prevent run off water entry.

The water from the tank is pumped to elevated tanks and delivery to the outlets is then by gravity.

NOTE:

For further information on these types of tanks, refer to Basic Training Manual '12-5 Roof Plumbing'.

REVISION QUESTIONS

1. a Why is it not possible to make sharp bends in galvanised steel pipes?
   b What is a long screw and where is it used?
   c Describe its installation sequence.
2. What is 'annealing' of copper? Describe how this is done.
3. a List some of the advantages of using PE pipes.
   b What should a plumber do before modifying an existing metallic water supply pipework with polyethylene?
   c What are the restrictions on the use of PE pressure pipe in water supply installations?
   d What are the main differences between the imperial and metric PE pipework?
4. a What kind of tools are used to cut pipes?
   b Why is it necessary to deburr pipes before joining and how can this be done?
5. a Describe the procedure for joining copper pipes with:
   - Friction joints
   - Expanded joints
   - Capillary joints.
6. Why is cutting with a hacksaw preferable to cutting with pipe cutters?
7. What reasons could there be for insisting that a mitre box be used when cutting UPVC pipes with a saw?
8. Explain with the aid of a fully labelled neat drawing, how a domestic meter assembly is installed from water main to garden hose tap.
9. Show by means of a fully labelled drawing, a typical storage tank installation.
10. Explain with the aid of a fully labelled diagram, how the Authority would tap a water main under pressure and the operation of the tapping machine.
11. Explain what is a combined fire and domestic water service.
12. Explain with the aid of a neatly drawn and labelled drawing, what a trident service is.

NOTES FOR THE INSTRUCTOR

In these Training Manuals the term 'instructor' refers to any person who may train or be directly responsible for training individuals.

For example, the task of instructing may be the sole or shared responsibility of:

—skilled tradespeople

—leading hands

—supervisors

—instructors

—apprentice trainers

—managers.

INITIAL PLANNING

A Analyse:

- The training requirements of a newcomer, considering that the person:

  —may have no previous experience in the subject;

  —will need to do productive work as soon as possible.

- What the trainee must learn about:

  —the tools used for the subject;

  —the terminology involved in the subject;

  —basic working methods.

- What will be the first productive work you will be able to give the trainee.

B Decide:

- Whether your trainees need information to supplement that given in this manual.
- Whether or when additional training material or exercises will be required to improve on the skill gained.
- Which other Basic Training Manuals the trainee should use during training.

C Plan:

The explanations, demonstrations and the practice required by the trainee, preferably on an individual basis, if numbers allow.

USING THE MANUAL

It may be of assistance to the trainee to arrange for short periods of learning followed by short periods of practice in applying the knowledge gained.

To keep interest alive, it will be useful to relate, as much as possible, the material treated in this manual with actual practical applications in the field.

PRACTICAL EXERCISES AND PROJECTS

There may be areas and tasks in actual situations where the developing skills of the trainee can be put to effective productive use at any stage during the period he or she is learning the subject. Such possibility should be carefully considered and used to the full for the trainee's benefit as well as that of the firm.

Give the trainee as many opportunities as possible to use the whole range of hand tools on suitable small jobs to enable him or her to acquire quickly the manual dexterity required.

Small projects and exercises to suit particular work situations may be devised, but they must take into consideration the limits of skill and knowledge of the trainee.

Whatever form of exercise is used to develop practical skill, it must be carefully planned. A suggested course of instruction is:

- Prepare the working area, the materials and the hand tools to be used.
- Make the aim of the project clear to the trainee.
- State how you intend to assess the proficiency of the trainee.
- Stress key points in the project, paying particular attention to safety precautions.
- Explain clearly and thoroughly any new steps in the project.
- Check that the trainee can use the hand tools correctly.
- Assess the finished project, record the results and discuss with the trainee your appraisal of his or her performance.
- If you are satisfied with the performance, direct the trainee to the next exercise or project.

TRAINING RECORDS

Simple training records will help in planning systematic training.

Record:

- the parts of the manual learnt by the trainee;
- your assessment of the general skills developed;
- the practical exercises undertaken and completed.

Use your record to measure the trainee's performance and to assess his or her readiness for undertaking actual operations.

Draw up a simple record card to suit your needs.

Using records helps to pinpoint the trainee's strengths and weaknesses. They ensure that training in essential skills is not missed. Training records can be used to help co-ordinate on-the-job training and technical school learning. Where trainees have to serve a probationary period, records assist when the trainee's progress is being assessed.

PUBLICATIONS IN BASIC TRAINING MANUALS — WATER SUPPLY

Title	
11.1	WATER SUPPLY — 1
11.2	WATER SUPPLY — 2
11.3	WATER SUPPLY — 3
11.4	HOT-WATER SYSTEMS

OTHER PUBLICATIONS IN BASIC TRAINING MANUALS
(Available at date of printing)

FITTING SERIES	10 MANUALS
WORKSHOP SAFETY	1 MANUAL
PRACTICAL GEOMETRY	3 MANUALS
LATHE WORK	7 MANUALS
SHAPING AND SLOTTING	3 MANUALS
GRINDING	3 MANUALS
MILLING	4 MANUALS
ARC WELDING	4 MANUALS
SOLDERING	1 MANUAL
SANITARY PLUMBING	4 MANUALS
ROOF PLUMBING	6 MANUALS
BRICKLAYING	2 MANUALS
CARPENTRY AND JOINERY	14 MANUALS (MORE IN PREPARATION)
PAINTING & DECORATING	10 MANUALS
ELECTRICAL	13 MANUALS
MOTOR VEHICLES	10 MANUALS (MORE IN PREPARATION)
PANEL BEATING	3 MANUALS (MORE IN PREPARATION)
VEHICLE PAINTING	1 MANUAL (MORE IN PREPARATION)
FURNITURE REMOVALS	4 MANUALS
TIMBER TECHNOLOGY	1 MANUAL
SHEETMETAL	(MANUALS IN PREPARATION)

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Manuals may be purchased from Commonwealth Government Bookshops.

Mail orders to: Mail Order Sales,
Australian Government Publishing Service,
P.O. Box 84,
CANBERRA. A.C.T. 2601.

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USAGE

QUALITY AND CONTENT

Yes / Modifications

Easy to understand ☐ Yes ☐ No
Technically accurate ☐ Yes ☐ No
Value in training ☐ Yes ☐ No
Up to date ☐ Yes ☐ No

TRAINING AIDS

Did you use the manual to produce any of the following aids?

☐ Charts
☐ Overhead transparencies
☐ Video/Films
☐ Models
☐ Cutaways
☐ Slides/Audio tapes

NEW MANUALS

What subject area would you like the Basic Training Manuals to cover in the future?

PERSONAL DETAILS

Name: Position:
Address: Organisation:
Telephone No:
Postcode Date:

Inclusion of your name and telephone number would enable contact to be made to discuss your comments, if necessary.

Please enclose additional information as you think necessary

ALL INFORMATION PROVIDED WILL BE TREATED IN STRICT CONFIDENCE

BASIC TRAINING MANUAL

15-4

PAINTING & DECORATING

Colour

NATIONAL BUILDING AND CONSTRUCTION
INDUSTRY TRAINING COUNCIL

DEPARTMENT OF EMPLOYMENT, EDUCATION AND TRAINING

BASIC TRAINING MANUAL

15-4
PAINTING & DECORATING
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CONTENTS

Preface v
Instructions to trainee vi

1 Objectives of this manual 1

2 Colour and light 2
2.1 The spectrum 2
2.2 Colour perception 3

3 Colour spectrum 4
3.1 Primary colours 4
3.1.1 Light primaries 4
3.1.2 Pigment primaries 4
3.2 Secondary colours 5
3.3 Tertiary colours 5
3.4 Neutrals 6
3.5 Dimensions of colour 7

4 Revision questions 7

5 Colour mixing and matching 8
5.1 Basic pigment colour wheel 8
5.2 Extended basic colour wheel 9
5.3 Tones 10
5.4 Cast of colours 11
5.5 Tints and shades of tertiary colours 12
5.6 Colour reduction 12
5.7 Discords 13

6 Colour schemes 14
6.1 Basic colour psychology 15
6.1.1 Warm and cool colours 16
6.1.2 Advancing and receding colours 16
6.2 Colour harmonies 17
6.2.1 Monochromatic 18
6.2.2 Complementary 18
6.2.3 Analogous 18
6.2.4 Triadic 19
6.2.5 Split complementary 19
6.2.6 Achromatic 19
6.3 Juxtaposition 20
6.3.1 Simultaneous tone contrast 20
6.3.2 Simultaneous chromatic contrast 22
6.4 After-image 23
6.5 Effect of surface texture on colour 25
6.6 Effect of artificial light on colour 26

7	**Colour systems**	27
7.1	Ostwald system	27
7.2	CIE system	28
7.2.1	CIE colour map	28
7.3	Munsell system	29
8	**Revision questions**	30
9	**Colour standards and codes**	31
9.1	Colour standards	31
9.2	Identification colours for portable fire extinguishers	31
9.3	Identification of piping, conduits and ducts	32
9.4	Industrial safety colour code	33
10	**Glossary of terms**	34
	Notes for the instructor	40
	Other publications	42
	User comment sheet	

USER COMMENT SHEET

Please use the sheet on page 43 to let the Training Publications Unit know your assessment of the quality of the material contained in the manual and what future training material should be produced.

PREFACE

This manual is one of a series that has been developed to progressively increase the practical skills of a trainee in painting, decorating and signwriting.

Other manuals in this series cover:

- Paints: types, reasons for coating, surfaces coated, health and cleanliness, glossary of terms.
- Surface preparation: removal of existing coatings.
- The systematic procedure for the painting of interior and exterior surfaces.
- Glazing: removal of broken glass, cutting glass, reglazing.
- Staining: filling, clear finishing, opaque and semi-opaque finishes.
- Paper-hanging: drop and set patterns, preparation, adhesives.
- Signwriting: tools and equipment, use and control of the sign pencil, layout of alphabet, design and simple signs.
- French polishing: preparation, materials, sequential procedures.

Each manual is self-contained and is intended as an instructional guide in on-the-job training situations. It may be used by instructors or for self-teaching purposes.

The aim of the manual is to help the trainee to develop a particular skill to the stage where it can be applied productively on the job. Ideally, the manual should be used as part of a course of instruction involving:

- demonstrations of practical skills by instructors or experienced tradespeople;
- planned and supervised practice in handling the equipment involved;
- instruction in safe working procedures.

The manuals may be used in any order convenient to the learning needs of the trainee and may be obtained individually or in sets to cover the range of skills in the trade area.

It may be advisable to use part of this manual with sections of other manuals in this series to follow an operation right through.

INSTRUCTIONS TO TRAINEE

This manual is a teaching aid to your skill development. It is best used on the job where you can handle and use the equipment shown.

You should follow the directions given by the person training you. To reach the required standard of skill, you must pay particular attention to your instructors' explanations and demonstrations. Supervised and individual practice is essential.

Practice means making repeated efforts to improve your level of skill. Study is making an effort to learn. Every advance in skill depends on study and practice. Progress is obtained by co-operating actively in the training arranged for you.

When you study all or part of this manual, try to use a definite plan of study. The following plan is effective.

SURVEY: Read quickly through the headings as you turn the pages. Glance at the illustrations. Get an overall view before you read.

QUESTION: Ask yourself: What do I know? What do I need to know? How will this manual help me to learn?

READ: Read right through each section carefully. Be thorough, but do not dawdle. Reading quickly will help you to concentrate.

DO: Use all your senses in learning. Getting the 'feel' of any subject is essential in learning it. Follow the directions given to you; they are meant to assist you in the gaining of the skills you need.

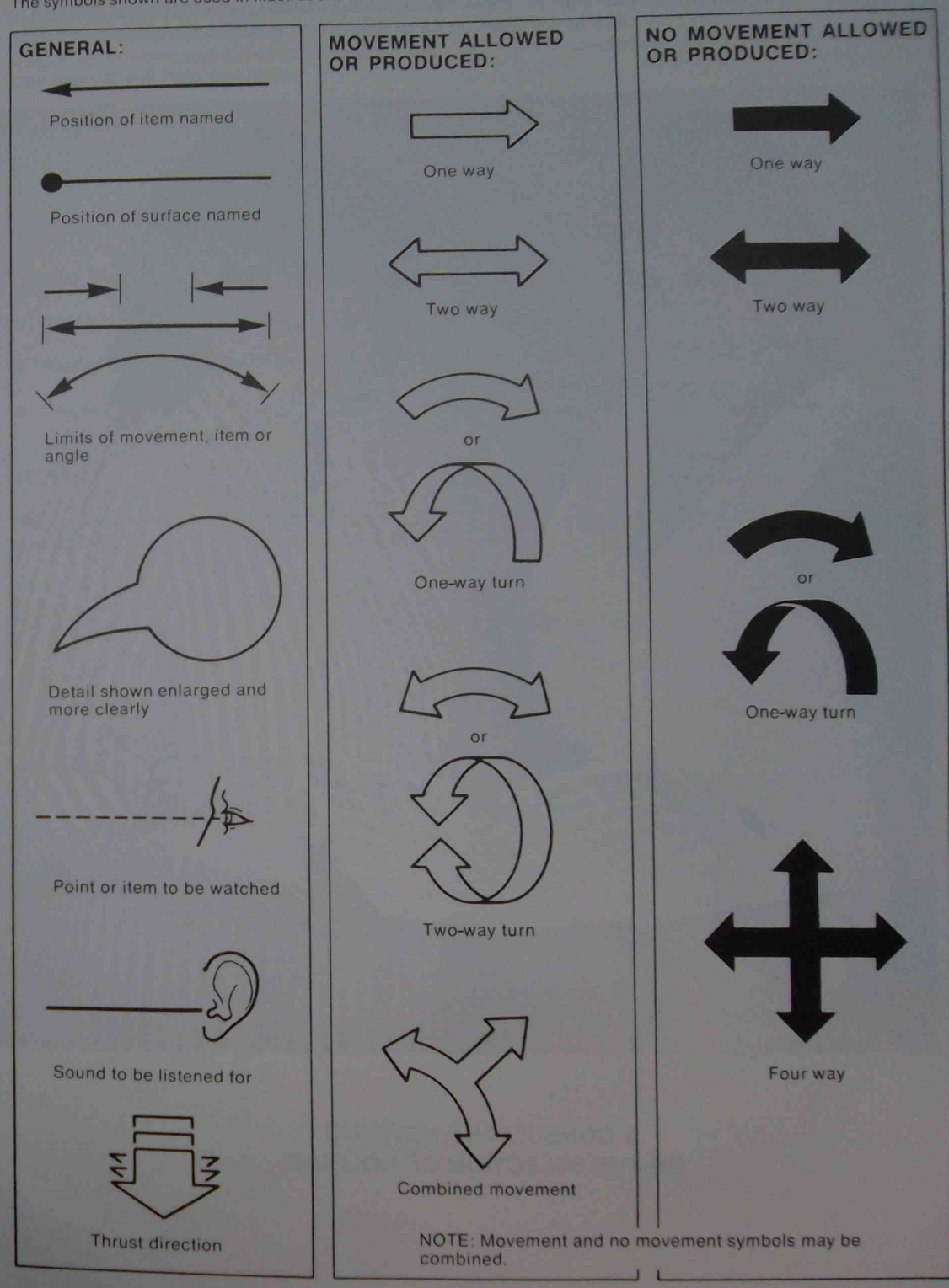
REVIEW: Shut the manual. Try to remember the main points of the section. Check to see that you are right. Revise points on which you are doubtful.

One way of fixing important instructions in your mind is to repeat them over and over.

Practical exercises are given in this manual. Do not be satisfied by doing them once. Repeat the exercises as often as possible as this will enable you to develop your skills.

SYMBOLS

The symbols shown are used in illustrations in these manuals.



A CONSULTANT ADVISING
ON THE SELECTION OF COLOURS

1 OBJECTIVES OF THIS MANUAL

In painting and decorating, colour is encountered every day and understanding the nature of colour is important if colour is to be used to its greatest advantage.

This manual will help you learn:

- the nature and composition of colour;
- the terminology used to describe different characteristics of colour and other factors that influence the perception of colour;
- colour standards and their application in Australia.

The aim of this manual is to teach you to:

- Identify primary, secondary, tertiary colours and their tones.
- Recognise the relationships between hues and organise them into harmonies.
- Prepare colour schemes taking into account basic colour psychology, after-image, juxtaposition and effects of texture and artificial lighting.

NOTE:

If you come across any term you are unfamiliar with or for which you want a detailed description, refer to the Glossary of Terms on pages 34 to 39.

2 COLOUR AND LIGHT

The source of all colour is light. Without light, colour does not exist. Colour may be described as an impression of visible radiant energy of certain wavelengths. The form of an object may be recognised because of the contrast between the colour or colours of the object and the background.

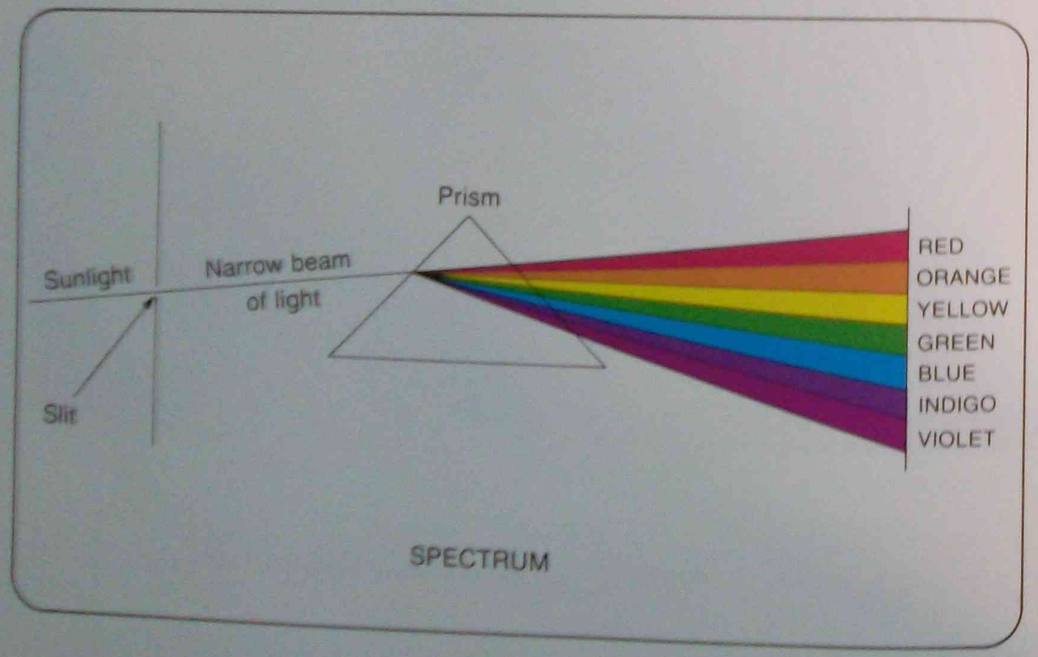
Ultraviolet rays, infra-red rays, light rays, X-rays and cosmic rays are all forms of radiant energy. These electro-magnetic energy rays are identical except for their wavelength, the distance between adjacent wave-crests and the frequency of pulsation.

The human eye receives and responds only to the radiant waves known as light waves, or spectral band, lying between the ultraviolet band and the infra-red band.

When light strikes a surface, waves of certain lengths are absorbed and others are reflected. It is the reflected waves which are picked up by our eyes and registered by the brain as colours.

2.1 THE SPECTRUM

When light is directed through a transparent material, such as glass, its speed is slowed down. If at the same time the light rays can be bent, for example through a glass prism, when the light emerges from the other side it will have been divided into individual colour waves. This can easily be seen if rays are projected onto a white screen. This coloured reflection will show a distinct range of colours, always in the same order: red, orange, yellow, green, blue, indigo and violet, known as the spectrum. A similar effect is produced in nature when sunlight is broken up by raindrops and a rainbow is produced.



SPECTRUM

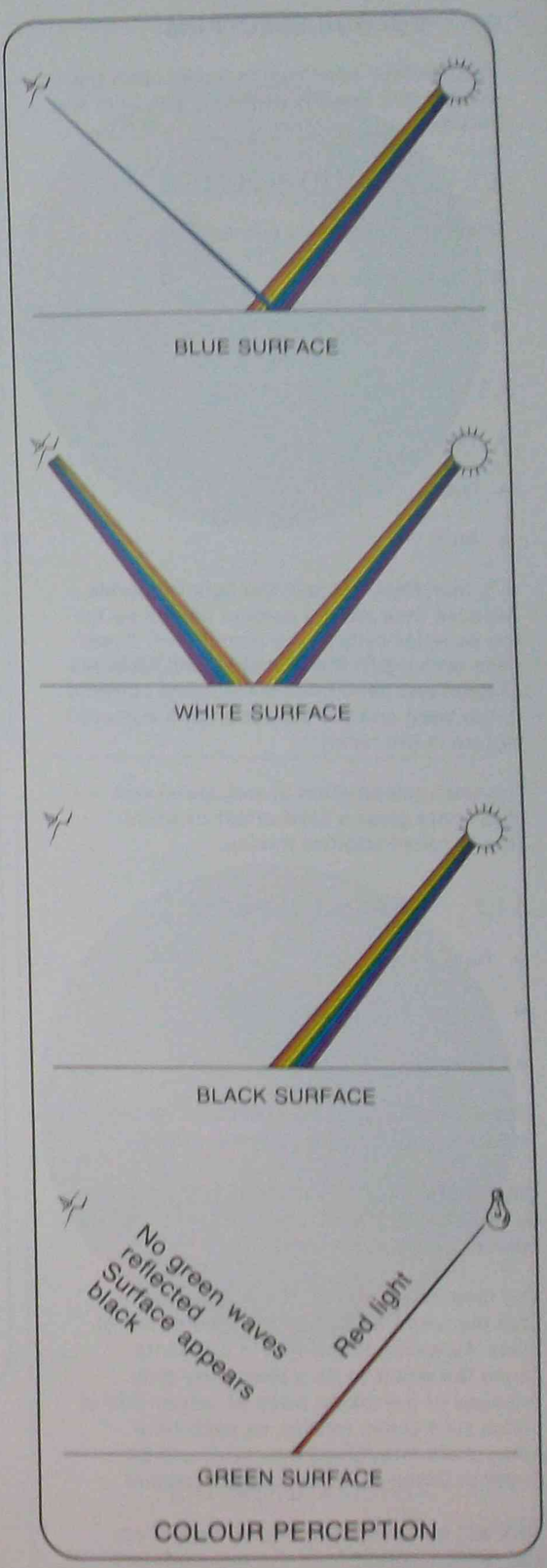
2.2 COLOUR PERCEPTION

An object which is seen by a person with normal vision as blue is absorbing all the light of other wavelengths and reflecting only the waves of blue length. The sensation caused by these waves meeting the eye is registered as blue by the brain.

- A white surface reflects all waves.

- A black surface absorbs all, reflecting none.

- If the light source is not white the surface will appear a different colour, e.g. if a red light is directed onto a green surface the surface will appear to be dark grey or black. This occurs because the light source does not contain any of the green wavelengths necessary to be reflected for the surface to appear green. This will happen whenever a light source other than white is directed onto a coloured surface.



COLOUR PERCEPTION

3 COLOUR SPECTRUM

The painters' spectrum is based upon the colours red, orange, yellow, green, blue and purple.

3.1 PRIMARY COLOURS

There are two sets of primary colours:

- Light primaries.
- Pigment primaries.

3.1.1 Light primaries

- Red.
- Green.
- Blue.

It is important to know the light primaries because they are the colours picked up by the receptor cells in the human eye. These cells respond to the primaries and mixtures of them and send minute electrical currents to the brain and the sensation of a coloured picture is the result.

The total combination of red, green and blue lights gives a total effect of white. This is called additive mixing.

3.1.2 Pigment primaries

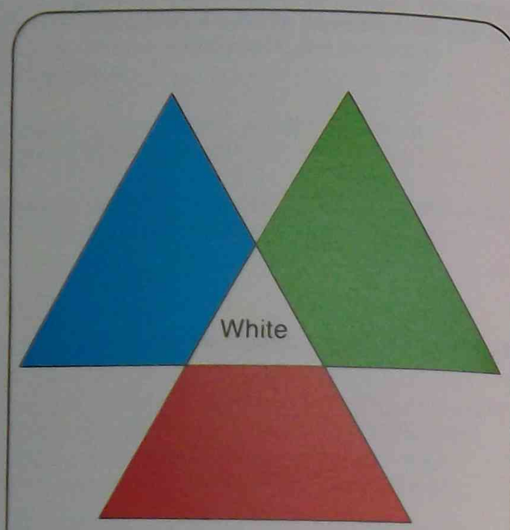
- Red.
- Yellow.
- Blue.

These colours cannot be obtained by the intermixing of any two or more colours.

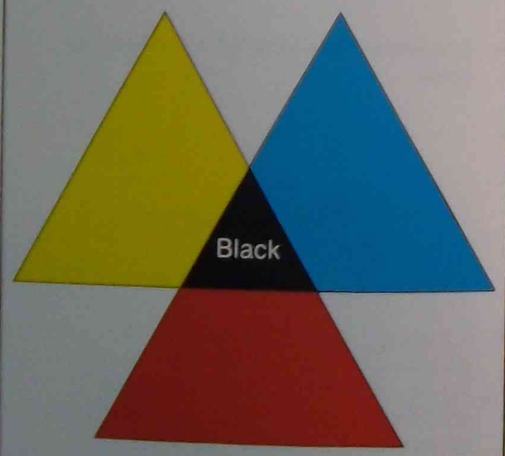
When they are of full chroma, it is possible by intermixing them to obtain the remaining colours of the spectrum.

The total combination of red, yellow and blue pigments should give a total effect of black. However, impurities in pigments cause the result to be a deep dirty grey. Because of the taking away of colour this is called subtractive mixing, as each time colours are intermixed the result will be duller or dirtier than the original colours.

This will be seen when mixing secondary and tertiary colour from the three primary colours.



LIGHT PRIMARIES



PIGMENT PRIMARIES

PRIMARY COLOURS

3.2 SECONDARY COLOURS

- Green.
- Purple.
- Orange.

When the three primary pigment colours are mixed together in pairs, secondary colours are obtained.

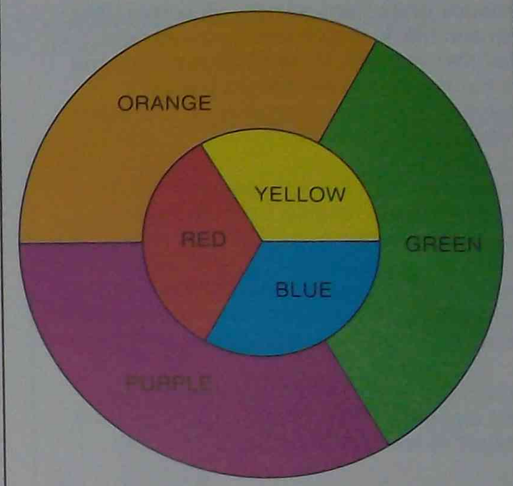
yellow + blue = green

blue + red = purple

yellow + red = orange

In theory, secondary colours are two primary colours mixed together in equal proportions. However, as the tinting strength of the primary pigment colours are not equal, this does not occur and allowances must be made when mixing secondary colours.

In general use, the secondary colours are obtained as separate pigments rather than as admixtures of the primaries.



SECONDARY COLOURS

3.3 TERTIARY COLOURS

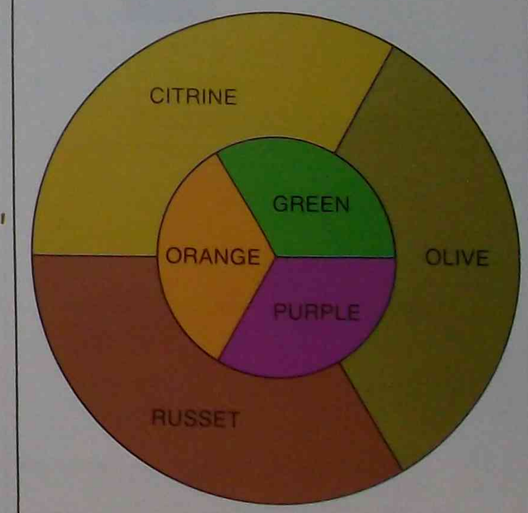
- Olive.
- Citrine.
- Russet.

When the three secondary colours are mixed together in pairs, tertiary colours are obtained.

purple + green = olive

orange + green = citrine

orange + purple = russet



TERTIARY COLOURS

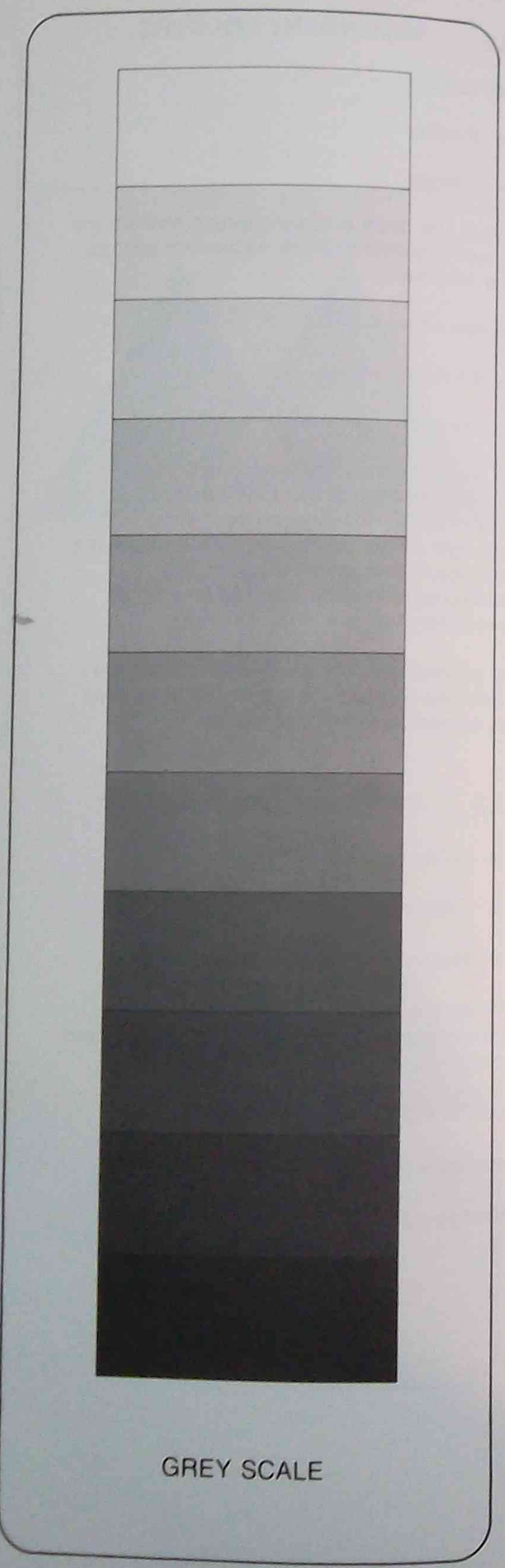
3.4 NEUTRALS

Because white light reflects all colour light rays and black absorbs all coloured light rays, they are said to be without colour and are not referred to as colours but as neutrals. Grey being a mixture of black and white is also a neutral.

When nine greys are arranged in a graduated scale ranging from white to black, it is referred to as a grey scale.

The grey scale is sometimes referred to as a reflectance scale and is used to describe the amount of light a colour reflects.

Those colours closest to white reflect the most amount of light, those colours closest to black reflect the least amount of light.



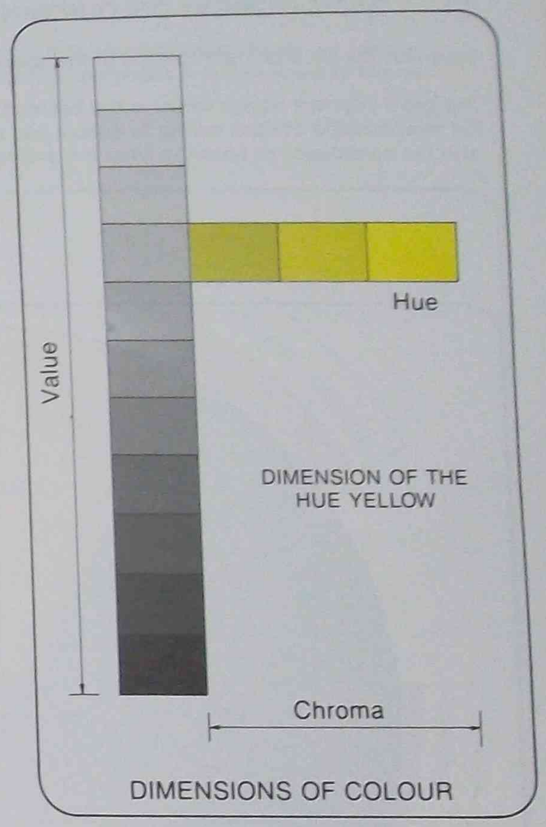
GREY SCALE

3.5 DIMENSIONS OF COLOUR

Colour can be described as having three qualities or characteristics which can be used to describe it accurately and differentiate it from other colours.

The three qualities are:

- Hue, which denotes the basic colour, i.e. red, blue, yellow, green etc.
- Chroma, which means the purity or intensity of a colour.
- Value, which indicates the degree to which a colour reflects light.



DIMENSIONS OF COLOUR

4 REVISION QUESTIONS

- Name the seven colours of the spectrum.
- If a surface reflects all wavelengths of daylight, what colour would the surface appear?
- Name the light primaries.
- Name the pigment primaries.
- If yellow and blue pigments were mixed together, what colour would be obtained?
- What two colours when mixed together give russet?
- What is meant by the term neutral?

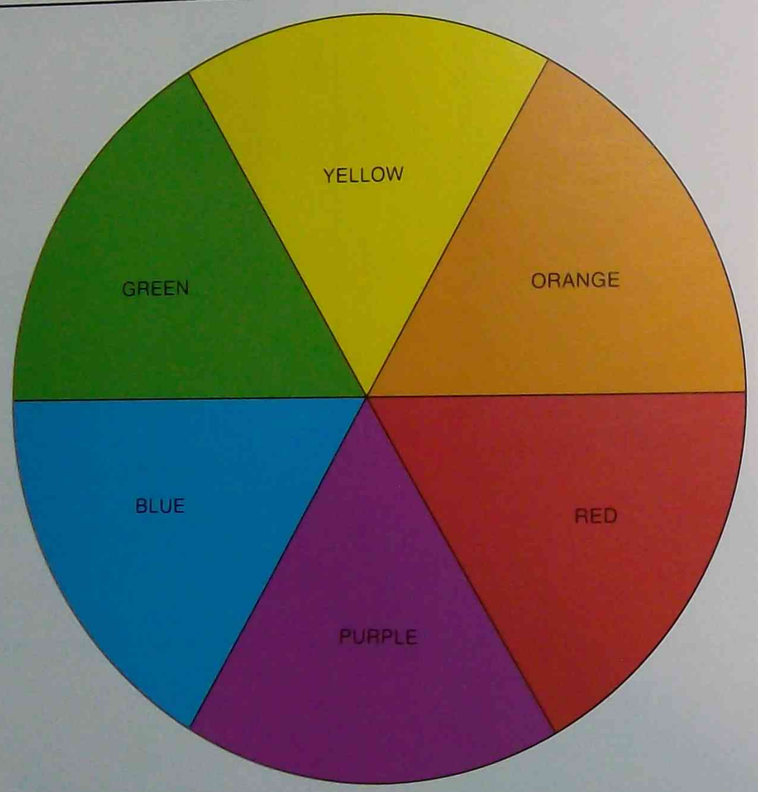
5 COLOUR MIXING AND MATCHING

Very few pigments available to the painter exactly match any one of the spectrum colours, and these undertones, even when slight, have a considerable effect when colours are combined in colour mixing and matching.

5.1 BASIC PIGMENT COLOUR WHEEL

Based on the six dominant colours of the spectrum, the colours are arranged in a circle or wheel.

The basic pigment colour wheel is the basis of colour mixing and colour schemes. Study it and the relationships of each colour to enable you to efficiently mix colours and plan colour schemes with the confidence of knowing what the end result will be.



BASIC PIGMENT COLOUR WHEEL

NOTE:

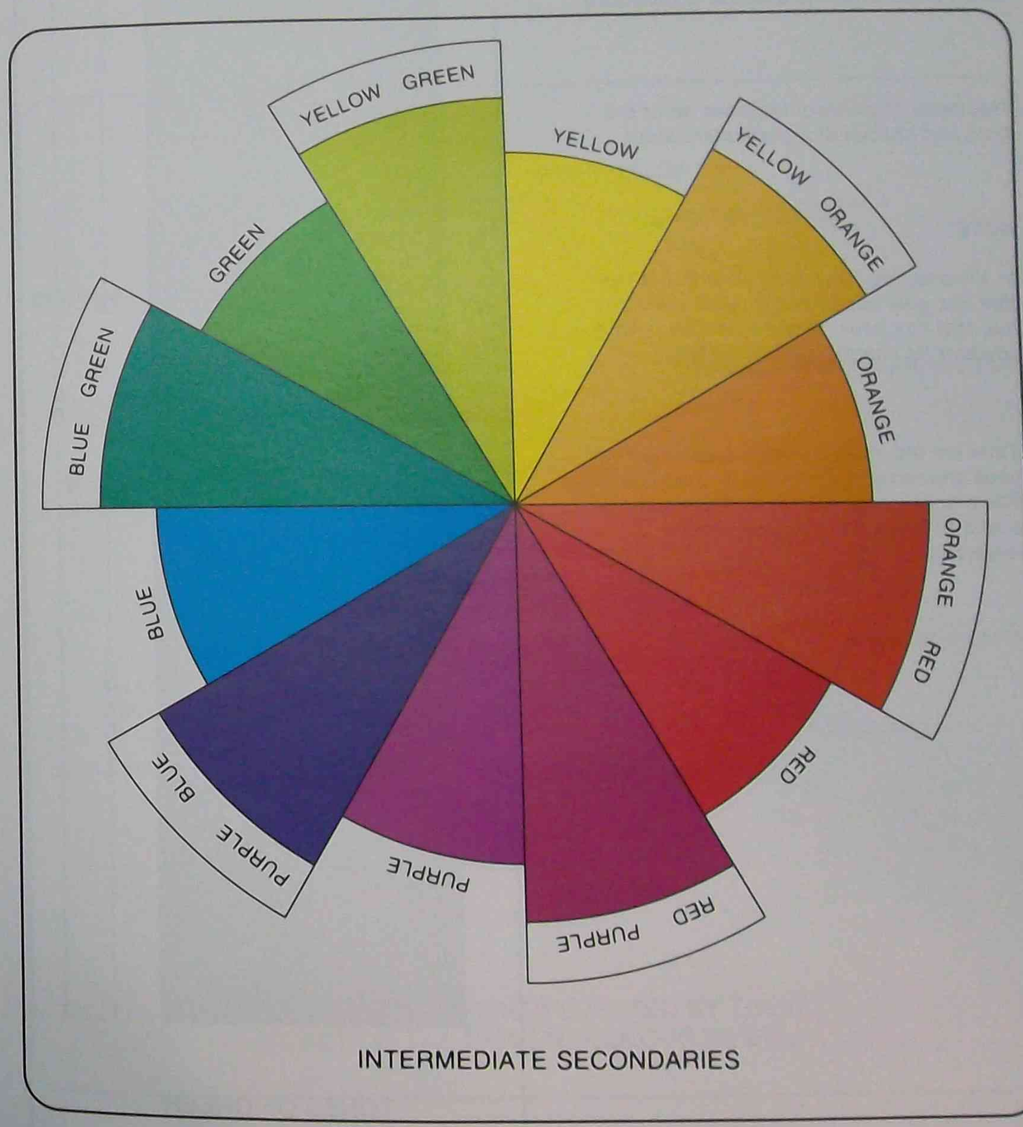
The violet light rays of the spectrum are generally referred to in pigments as the colour purple.

5.2 EXTENDED BASIC COLOUR WHEEL

To allow a wider selection of colours, the basic colour wheel is extended by the inclusion of six additional colours that are located between each of the secondary colours and their neighbouring primary colours.

These colours are called **intermediate secondaries**.

By varying the proportion of the colours used to obtain intermediate secondaries, an infinite number of colours can be obtained. However, for practical purposes it is restricted to twelve.



INTERMEDIATE SECONDARIES

5.3 TONES

The range of colours available on the pigment colour wheel can be further extended by the addition of varying amounts of white or black to any of the colours.

When white is added a tint is produced.

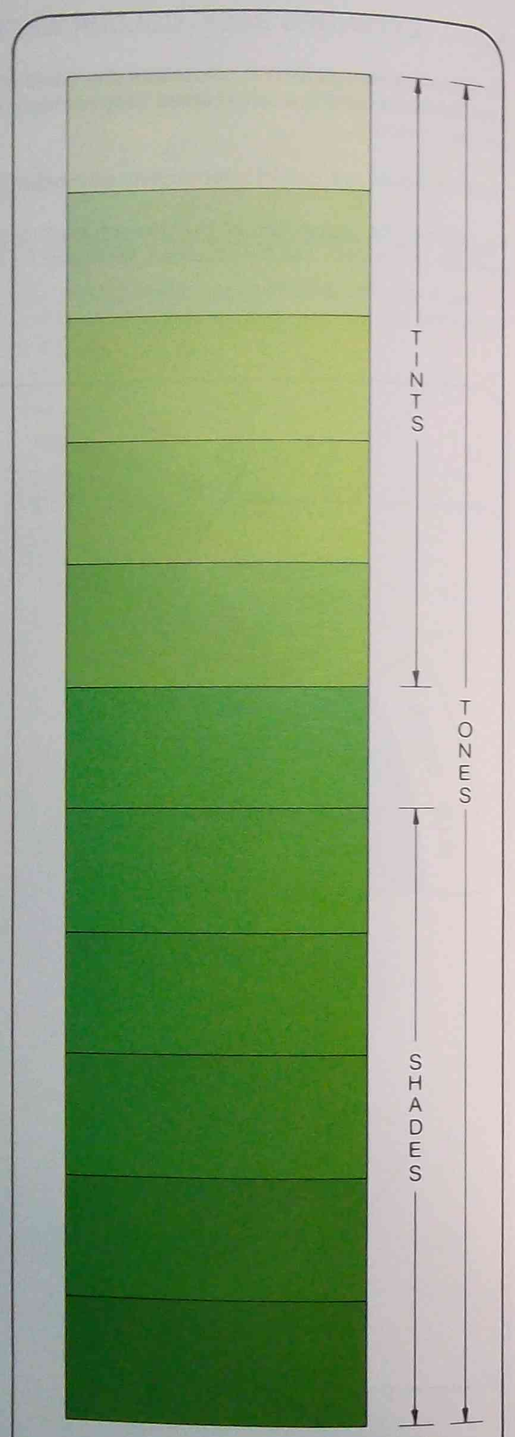
When black is added a shade is produced.

The tones of a colour includes all of the tints and shades of a particular colour.

NOTE:

In Victoria, the term 'tone' refers to a hue that has grey added and this includes any hue that has been 'toned down' by having some of its complementary added.

Tints are the most common type of colour used and mixed by painters and decorators. The process is in reverse in that colour is added to white paint to produce the required tint.



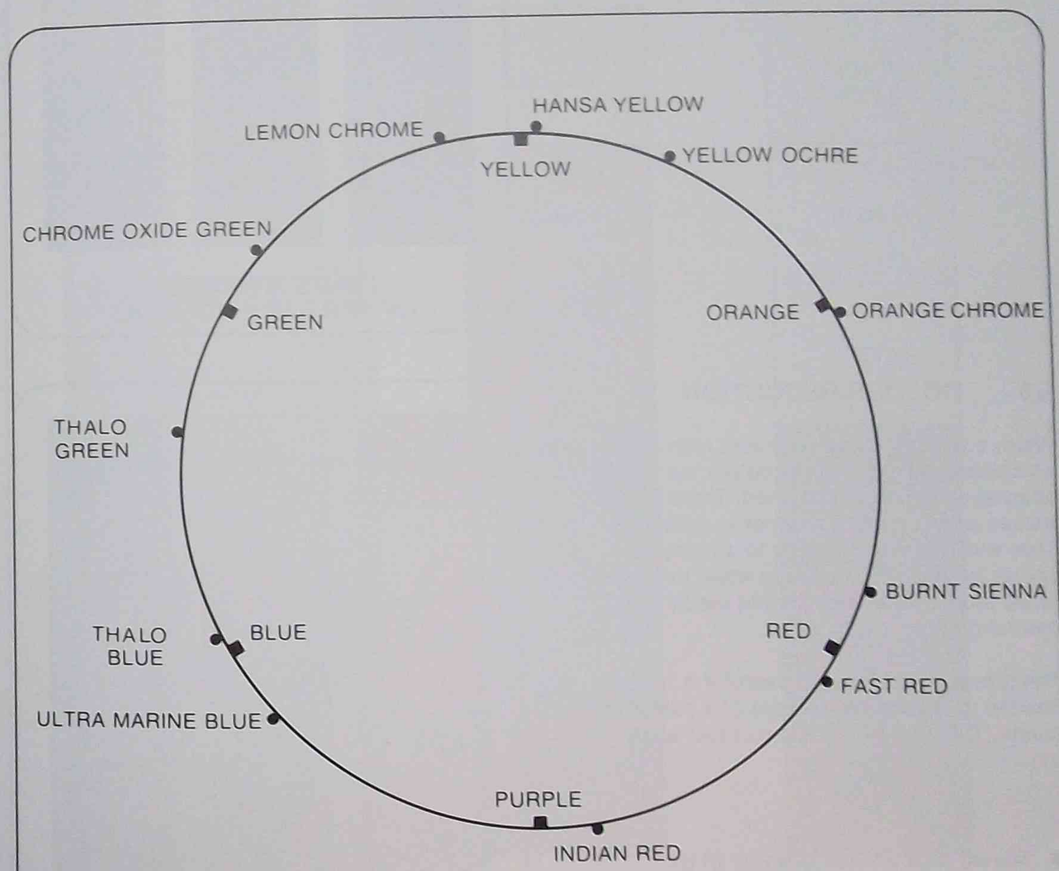
TONES OF GREEN

5.4 CAST OF COLOURS

The pigment colour wheel allows the characteristics of common paint tinters or stainers used by painters and decorators to be studied.

Pigment colours are rarely pure colours. They are generally undertoned to varying degrees with some other colour and are described by the visual undertone that they have, i.e. yellow-lemon chrome is described as a greenish-yellow meaning that visually, although it is yellow, it appears to be undertoned with green. This tendency to be undertoned is referred to as a colour cast.

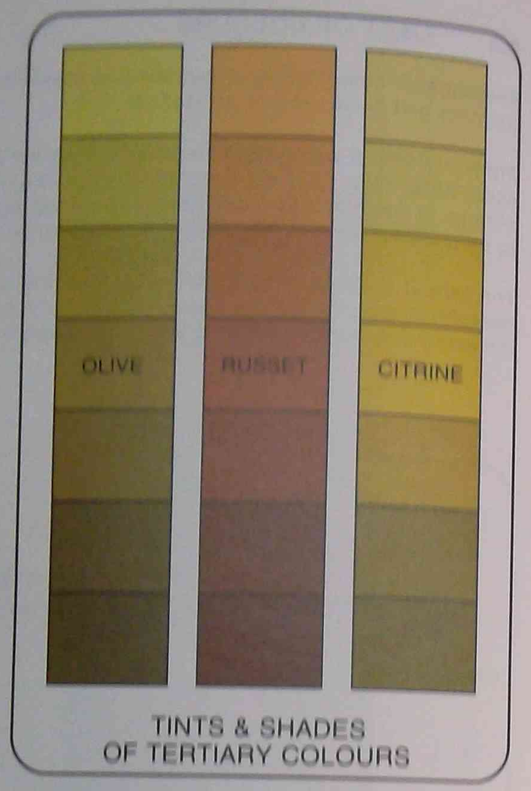
The cast of a colour is important when selecting colours for mixing and matching purposes because irrespective of the quantities used, if the cast of those being used is different to that of the sample, accurate matching will be impossible.



COLOURED PIGMENTS LOCATED BY THEIR CAST ON THE PIGMENT COLOUR WHEEL

5.5 TINTS AND SHADES OF TERTIARY COLOURS

Tertiary colours are generally not included in pigment colour wheels but their value should not be overlooked. When mixing colours, a great proportion of colours on commercial colour cards are either a tint or shade of a tertiary colour.



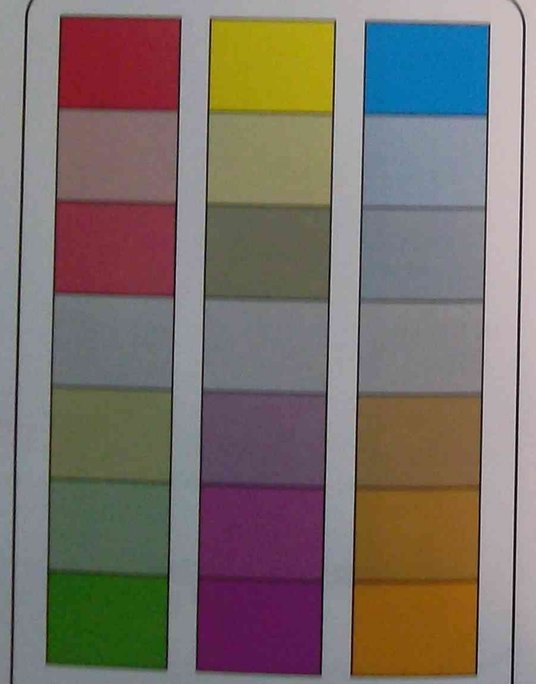
TINTS & SHADES
OF TERTIARY COLOURS

5.6 COLOUR REDUCTION

When a primary colour is mixed with its complementary secondary colour, an alternative tertiary is obtained. There are no names given to these alternative tertiaries. They are, however, referred to as greyed colour because theoretically when mixed in equal proportions, they should result in a neutral grey.

The greying of colours is useful if it is desired to reduce the chroma of a particular colour. This can be achieved in two ways by:

- Mixing with a small quantity of its complementary colour.
- Mixing with a small quantity of mid-grey.



COLOUR REDUCTION WITH GREY

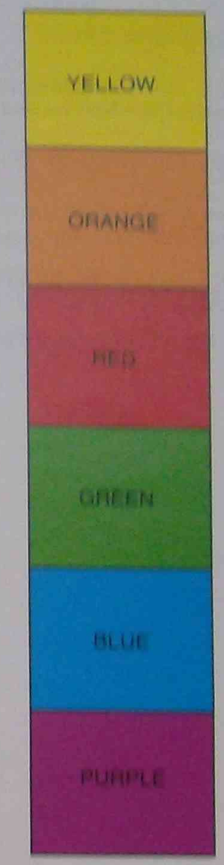
5.7 DISCORDS

When the six basic colours are located on a grey scale in accordance with their reflective value, they are said to be in the natural tonal order of colour.

Yellow, being the most reflective, is located near the top of the grey scale while purple, being the least reflective, is located near the bottom of the grey scale.

If colours are used out of the natural tonal order, i.e. pale blue with deep yellow, then the pale blue becomes discordant with the deep yellow because the tonal value of the colours has been reversed.

GREY TONES



NATURAL TONAL
ORDER OF COLOURS

DISCORD COLOURS

6 COLOUR SCHEMES

The use of colours purposely selected to create a specific mood, effect or character is called a colour scheme.

The successful planning of colour schemes depends on a number of factors. If these factors are fully considered, it would result in a colour scheme that will suit the job needs and bring out the intended mood or character.

The factors to be considered are:

- Preferences for certain colours. These could include traditional, ethnic, religious or personal preferences.
- Fixed colours such as carpets, furniture, tiles and the like which are part of the overall colour scheme. These include colours used for safety and identification purposes.
- The effects of juxtaposition on the chosen colours.
- The type of lighting and any effects that it will have on the chosen colours. Colours viewed in daylight conditions can vary dramatically when viewed in artificial lighting conditions.
- Tonal value and the amount of light you anticipate will be reflected by the colours used.
- The optical effects caused by advancing or receding colours. Dark tones tend to give an impression of closing in areas while light tones give an impression of enlarging areas.
- The aspect of the job which may require the choice of warm or cool colours.
- Architectural features which may require either highlighting or playing down.

NOTES

6.1 BASIC COLOUR PSYCHOLOGY

The main psychological aspects of colour often seem more emotional and personal than scientific and therefore determining reactions to colour is sometimes difficult.

Tradition, religion and superstition play a large part in how people respond to certain colours.

Common psychological associations of colours are:

COLOUR	POSITIVE	NEGATIVE
Yellow	Sun, happiness, splendour	Cowardice
Blue	Truth, aristocracy	Depression
Red	Warmth, passion	Anger, danger
Green	Safety, tranquility, hope	Envy, inexperience
Purple	Pomp, royalty	Mystery, martyrdom
Orange	Attention, cheerfulness	Caution, overbearing
White	Integrity, purity	Coldness
Black	Elegance	Death, terror, sorrow
Grey	Compromise	Resignation, humility

When choosing colour schemes, you should be conscious of the psychological associations of colours by people. It should not, however, be the overriding factor in the choice of colour.

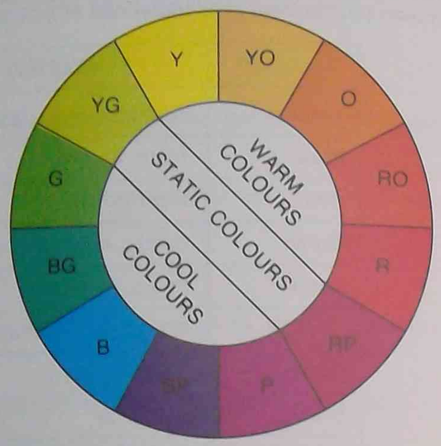
NOTES

6.1.1 Warm and cool colours

The most commonly accepted psychological view to colour is that some colours bring out a warm feeling while others a cool feeling.

The colour wheel is divided into warm and cool colours.

- Warm colours, i.e. red, red-orange, orange, yellow-orange and yellow occupy one half of the wheel.
- Cool colours, i.e. purple, blue-purple, blue, blue-green and green occupy the other half.



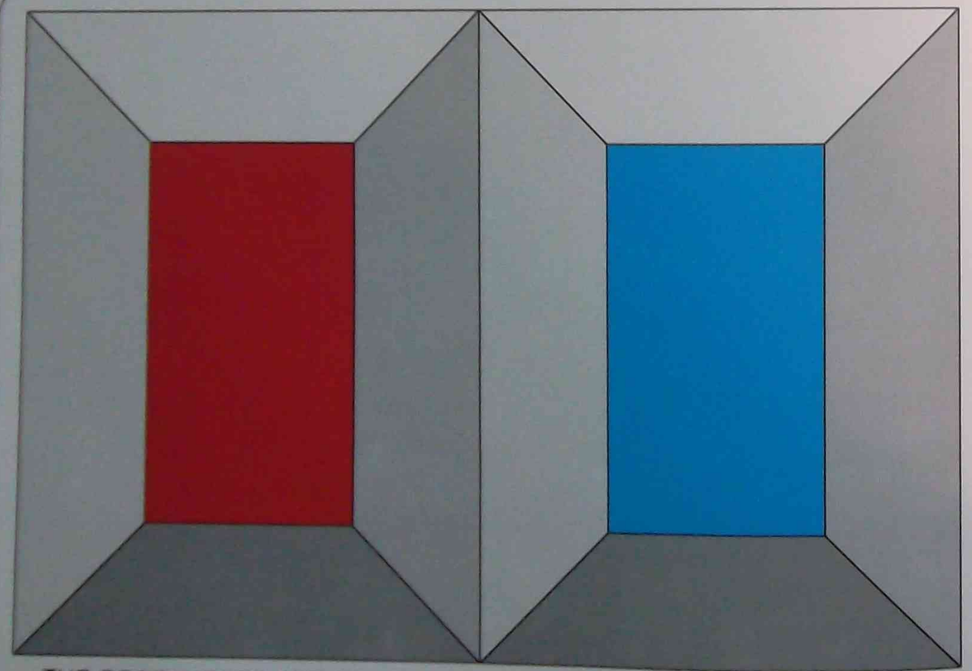
WARM & COOL COLOURS

6.1.2 Advancing and receding colours

Another aspect of warm and cool colours is that warm colours appear to advance and cool colours appear to recede.

Hence, strong warm colours are sometimes referred to as advancing colours and cool colours referred to as receding colours.

The static colours yellow-green and red-purple regardless of their chroma or value will maintain an optically fixed position and will neither appear to advance nor recede.


THE RECTANGLES ARE EQUIDISTANT HOWEVER THE RED (ADVANCING) APPEARS TO BE CLOSER THAN THE BLUE (RECEDING)

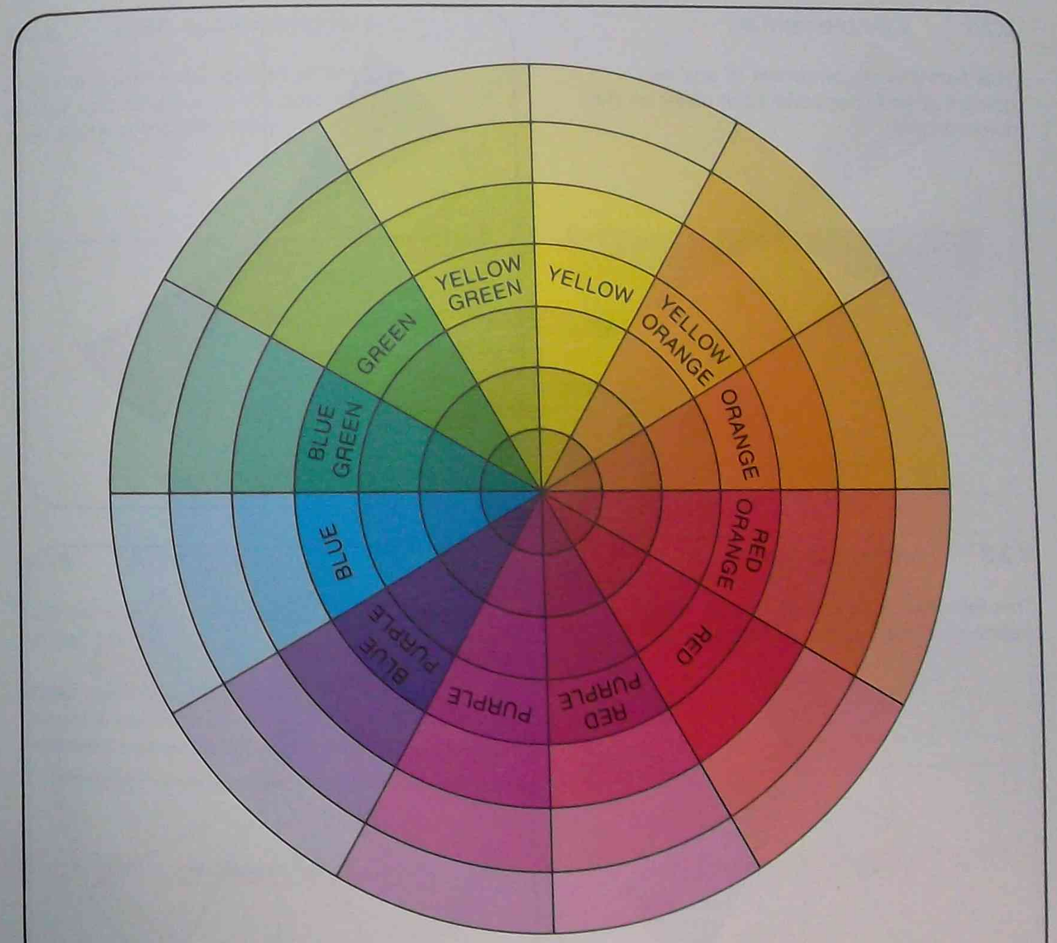
6.2 COLOUR HARMONIES

Colour harmonies are theoretical guides and should only be used as a fundamental method of planning colour schemes. The basis of colour harmony theory is the pigment colour wheel and the various relationships that can be formed between the colours.

Colours represented on the pigment colour wheel are usually in their spectral order and at full chroma.

When applying colour harmony theory, it should be remembered that the colour wheel presents only the location of the hues and that each hue should be viewed as including all of the tones available for that hue, e.g. red is represented only once but its position is representative of the tones of red from pale pink through to deep blood red. The same applies to all of the other hues represented on the wheel.

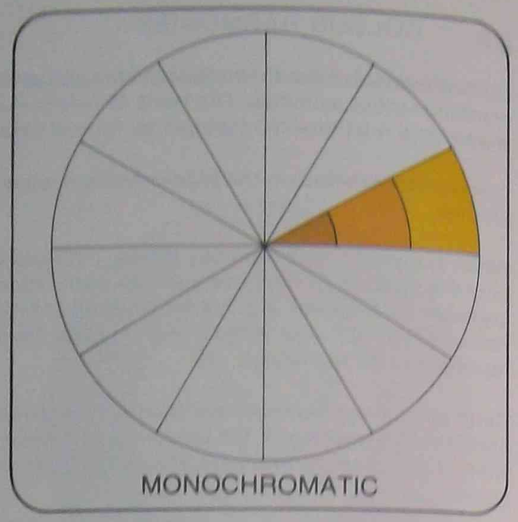
Generally, colour schemes are chosen from commercial colour cards and you will have to envisage the position of the colours on the pigment colour wheel when selecting the colours you wish to use. Special attention should be given to the selection of the correct tone of each chosen colour.



COLOUR HARMONIES

6.2.1 Monochromatic

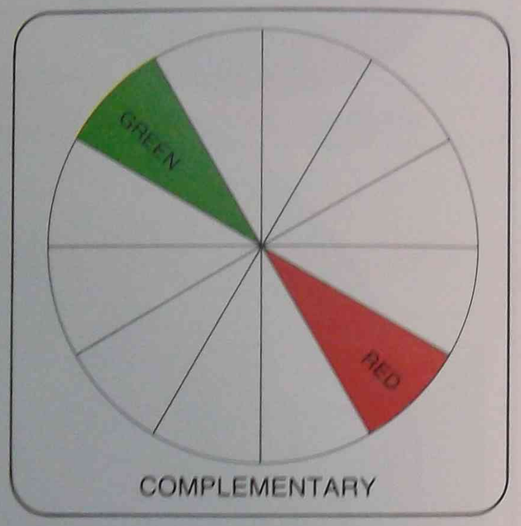
This harmony is comprised of a number of tints and/or shades of any one colour only.



MONOCHROMATIC

6.2.2 Complementary

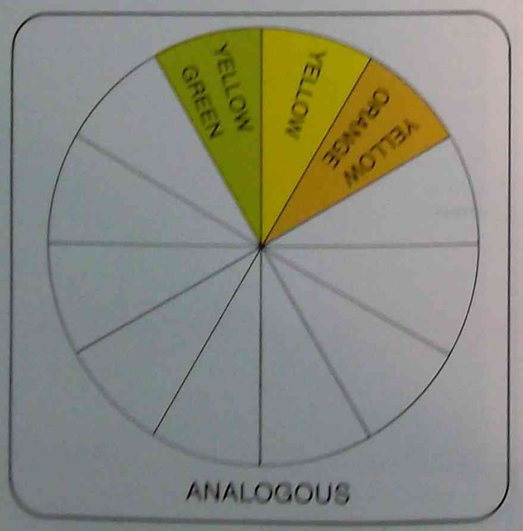
This harmony is comprised of any two colours directly opposite each other on the colour wheel.



COMPLEMENTARY

6.2.3 Analogous

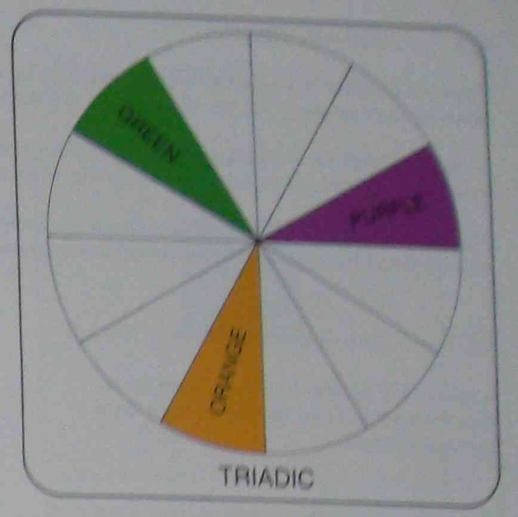
This harmony is comprised of any three adjacent colours on the colour wheel.



ANALOGOUS

6.2.4 Triadic

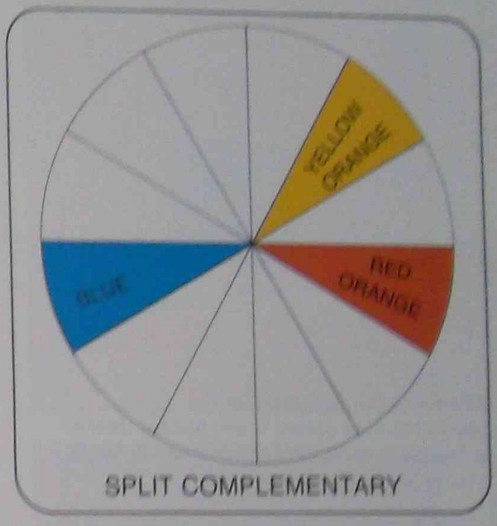
This harmony is comprised of any three colours spaced equi-distant on the colour wheel.



TRIADIC

6.2.5 Split complementary

This harmony is comprised of any one colour combined with the colours either side of its complementary.

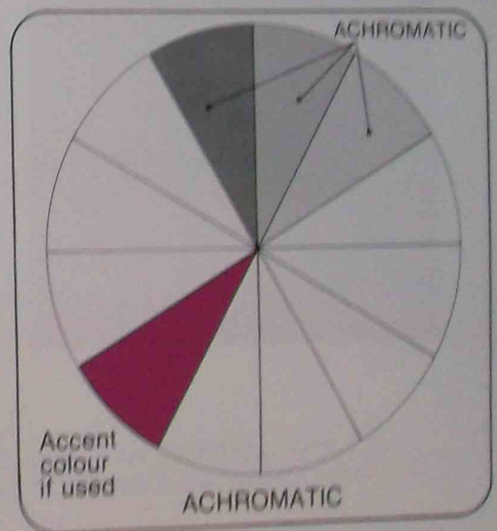


SPLIT COMPLEMENTARY

6.2.6 Achromatic

This harmony is comprised of a number of neutral tones.

When used in conjunction with one tone only of a colour, achromatic harmonies are referred to as accent harmonies.



ACHROMATIC

6.3 JUXTAPOSITION

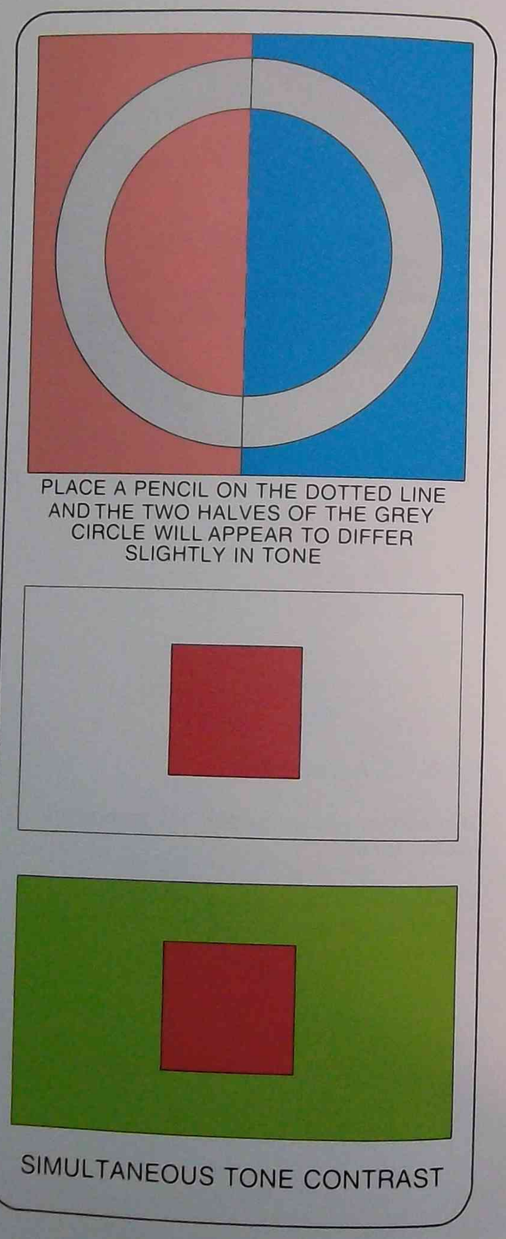
When one colour is placed alongside another, or when one colour in a small area is placed over a larger area of another colour, the colours are said to be in juxtaposition.

Unless isolated for some specific purpose, no colour is ever seen alone but is affected by other colours in juxtaposition with it and coming within the field of vision of the observer.

When colours are placed in juxtaposition they can influence each other in one of two ways — simultaneous tone contrast and simultaneous chromatic contrast.

6.3.1 Simultaneous tone contrast

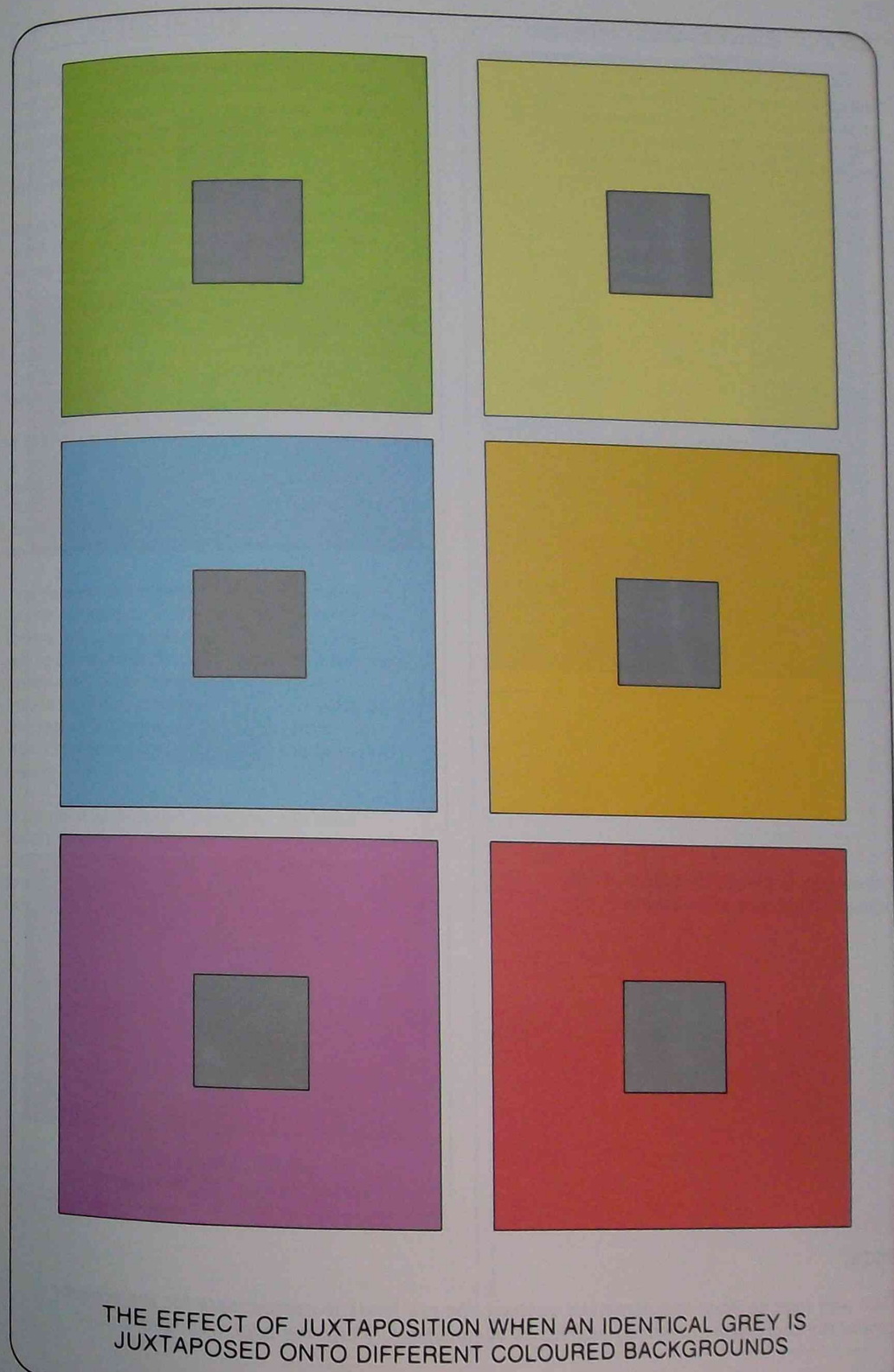
A colour will appear lighter in tone on a dark background and deeper in tone on a light background.



PLACE A PENCIL ON THE DOTTED LINE AND THE TWO HALVES OF THE GREY CIRCLE WILL APPEAR TO DIFFER SLIGHTLY IN TONE

When a colour is placed on its complementary colour it will appear deeper in intensity. A red placed on green appears a more brilliant or intense red.

SIMULTANEOUS TONE CONTRAST

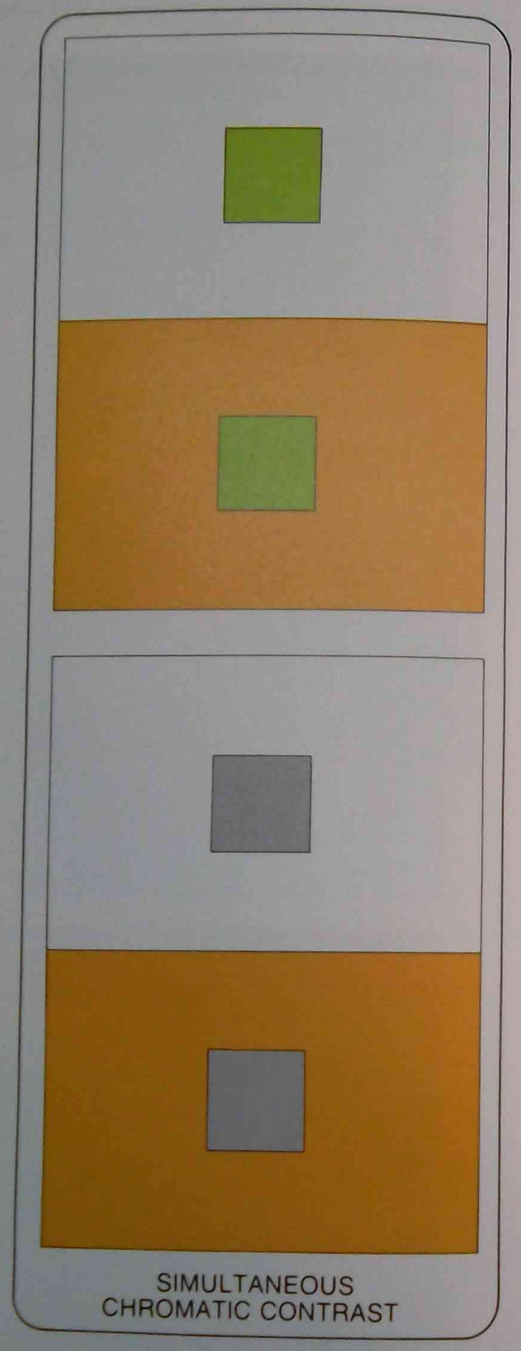


THE EFFECT OF JUXTAPOSITION WHEN AN IDENTICAL GREY IS JUXTAPOSED ONTO DIFFERENT COLOURED BACKGROUNDS

6.3.2 Simultaneous chromatic contrast

When non-complementary colours are placed together, there is a change of hue. When a mid-green is placed on orange it will appear to become a blue-green.

When grey is placed on orange it will appear to become a bluish-grey.



SIMULTANEOUS
CHROMATIC CONTRAST

NOTE:

Both with tone contrast and chromatic contrast, the eye tends to compensate for the broader area of the background colour by pouring its complementary into the superimposed colour.

6.4 AFTER-IMAGE

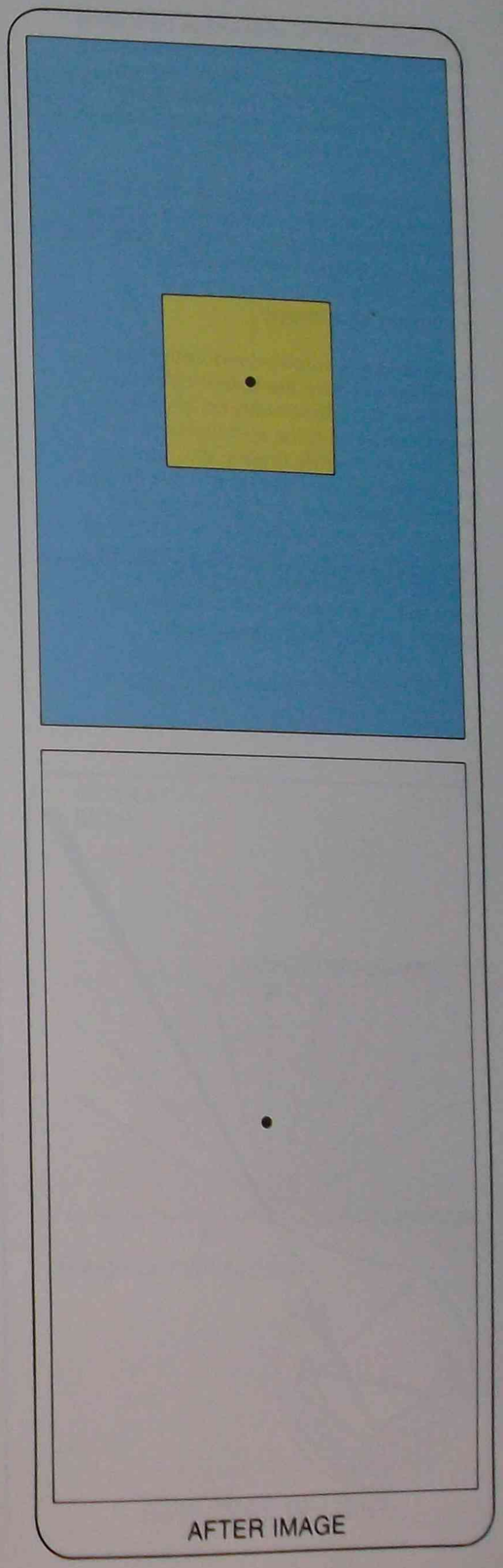
The light-sensitive surface at the back of the eye, the retina, is made up of millions of nerve endings — the receptors — which are of three distinct types, being sensitive to the colours red, green and blue respectively.

When any coloured object is observed, the light that enters the eye stimulates these receptors and a message is sent to the brain. This message, or sensation, is interpreted as a colour and will affect the receiver, either consciously or sub-consciously. The visual receptors are easily tired and quickly lose sensitivity. Hence the phenomenon of the after-image.

If a spot in the centre of a yellow square on a blue background is stared at without blinking for ten seconds and the gaze is then transferred to a black spot on white paper, an after-image of a purple square on an orange background will be seen.

The reason for this is that the blue and green receptors in the affected area of the retina become speedily exhausted. The white background, which produces the red, green and blue sensations of equal intensity, then creates in the tired area of the retina a stronger sensation from the fresh red receptors than from the blue and green.

With normal-sighted persons, the time taken to see an after-image varies. Some see it immediately, while others require a few seconds before it appears. Again, its rate of fading varies with the individual.

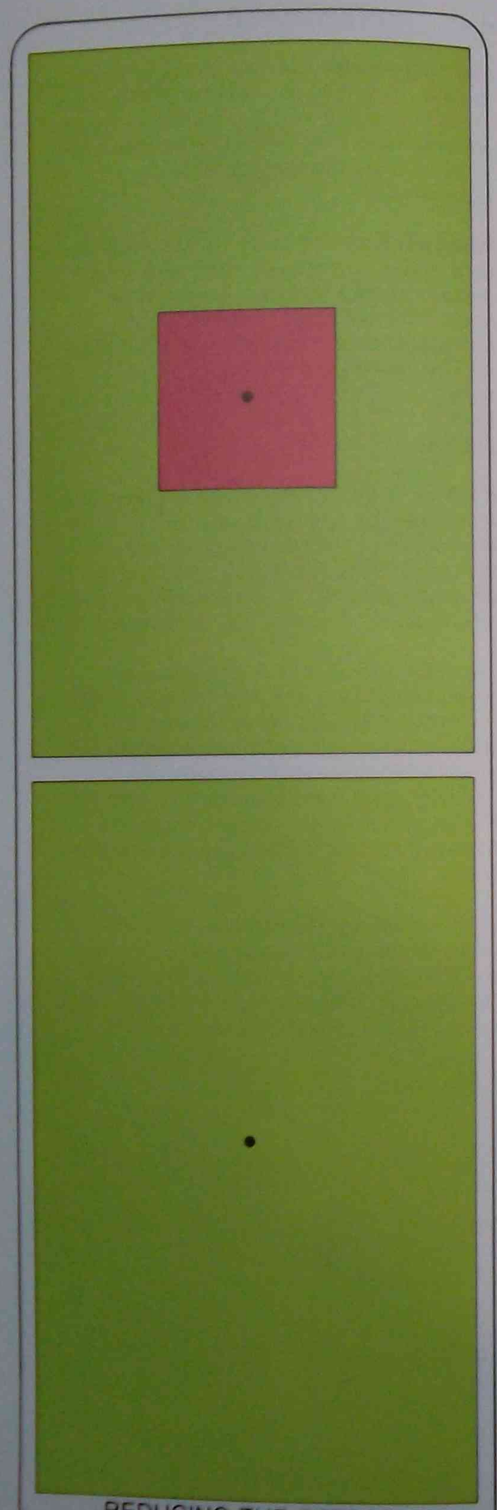


AFTER IMAGE

The colour seen in after-image on a white background is always the complementary colour of the first one viewed, e.g. red, blue, yellow, etc. The complementary colour of a full hue is the hue opposite to it in the pigment colour wheel.

When, therefore, backgrounds are being prepared for known conditions, it is most essential that the colour wheel is taken into account, in order to get the correct complementary colour, which will counteract after-image.

For instance, a surgeon performing an operation will have the colour of blood imprinted sub-consciously on his mind through the eye. If the surroundings — walls of the theatre, towels, etc., are white, on transferring his gaze he will see on this neutral background the hue and tone of green that is the complementary colour of blood. If the surroundings are of that same hue and tone of green, after-image is reduced to a minimum and his eyes will speedily recover their normal sight.



REDUCING THE EFFECT OF AFTER IMAGE

6.5 EFFECT OF SURFACE TEXTURE ON COLOUR

Besides being selectively absorbent to regions of the spectrum, paints and varnishes are generally translucent. They are neither completely transparent nor totally opaque. Even if the surface below the film cannot be seen, some of the light penetrates a part of the film. Not only do the pigments absorb some light but the object does also.

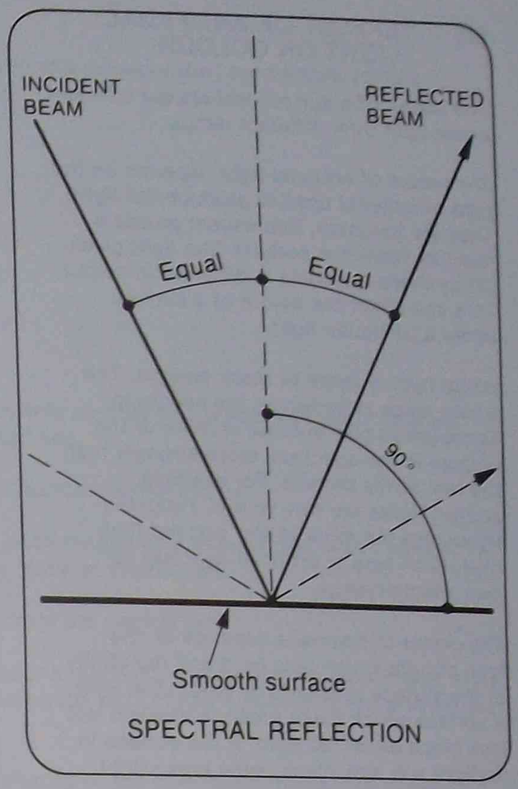
Light is reflected from glossy surfaces just as it is reflected from a mirror. This is called spectral reflection. The approaching light is reflected away at an equal angle on the opposite side of a perpendicular to the surface. When the equal angles are small the percentage of reflection is small, but when the equal angles are large the percentage of reflection is large. This phenomena explains why gloss paints have more purity and brilliance, especially noticeable in deep colours, when seen with the light nearly perpendicular to the surface.

Matt or rough surfaces, on the other hand, are diffusers of light and are seen with a constant 'overlay' of scattered reflection of the light source. This source considered as normal daylight is white, therefore the matt colour is never seen as a pure colour but always as a weakened colour lacking the brilliance of depth of gloss paints.

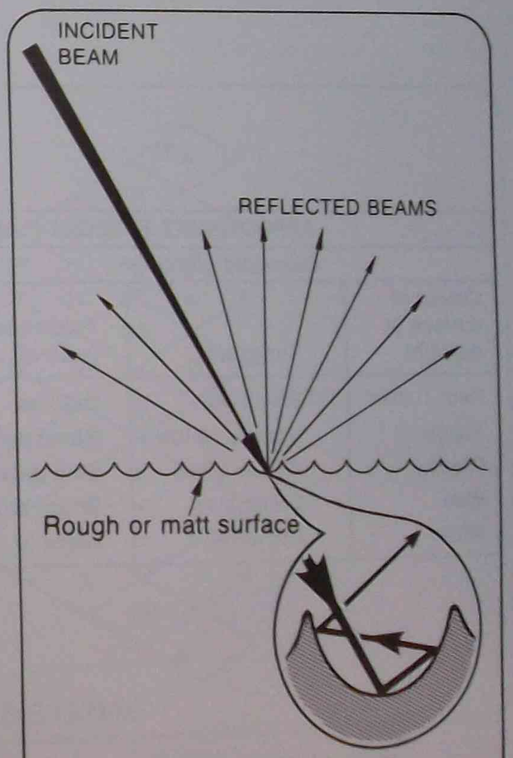
The balance of light not reflected at the surface is absorbed in part by the object, in part by pigment particles or by the surface below, if this penetration is possible. The part not absorbed at these points is reflected back to the surface. And each time the light ray is passed from one medium to another it is refracted or bent in a new direction, hence colours appear darker.

NOTE:

When repairing surfaces, care must be taken to match the texture of the patching compound to that of the original surface. Failure to do so can result in the surface appearing patchy due to differences in the amount of reflected light from the differing textures.



SPECTRAL REFLECTION



DIFFUSERS OF LIGHT

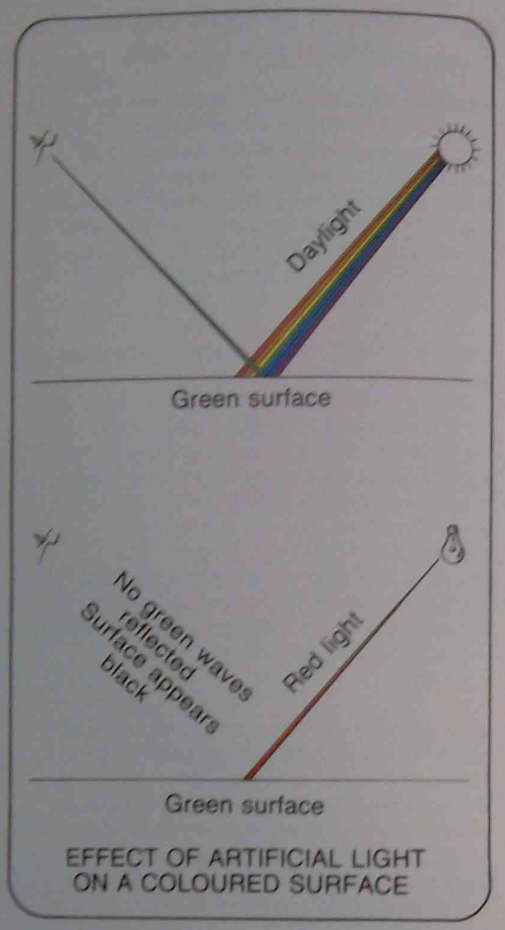
6.6 EFFECT OF ARTIFICIAL LIGHT ON COLOUR

The colour of a surface will appear different under light from different lamps.

The nature of artificial light depends on the type of material used to produce the light. They are tungsten, fluorescent powders, mercury vapour or sodium. The light given off by these materials is different in colour. This can affect the colour of a surface under a particular light.

White light is made of many colours. The whole range is known as the spectrum. Some lamps give out one or more of the colours in the spectrum more strongly than the rest of the colours. For example, sodium lights are very yellow. Tungsten lights give out more yellow and red than blue. Each type of artificial light has its own spectral range.

The colour of a surface depends on the type of light which falls on it and the ability of the surface to absorb or reflect the light. A surface which looks green in daylight will look black under red light. A red surface in daylight will look black under green light.



EFFECT OF ARTIFICIAL LIGHT ON A COLOURED SURFACE

APPROXIMATE EFFECT OF ARTIFICIAL LIGHT ON COLOURS				
	Domestic Lighting		Street Lights	
Colour of surface in daylight	Tungsten	Fluorescent (natural)	Sodium	Mercury
Red	Bright red	Dull red	Brown	Brown or black
Yellow	Intense yellow	Green yellow	Yellow	Green yellow
Green	Yellow green	Blue green	Brown yellow	Dark green
Blue	Green blue	Bright blue	Brown or blue	Deep violet
White	Off white	White	Light yellow	Bluish white

7 COLOUR SYSTEMS

Many systems have been devised to identify, analyse and measure the innumerable colours perceived by the human eye.

Three of the systems used today are:

- Ostwald.
- C.I.E.
- Munsell.

7.1 OSTWALD SYSTEM

This system was developed by F. W. Ostwald early this century and is based on eight colours. These colours are each divided into three separate hues.

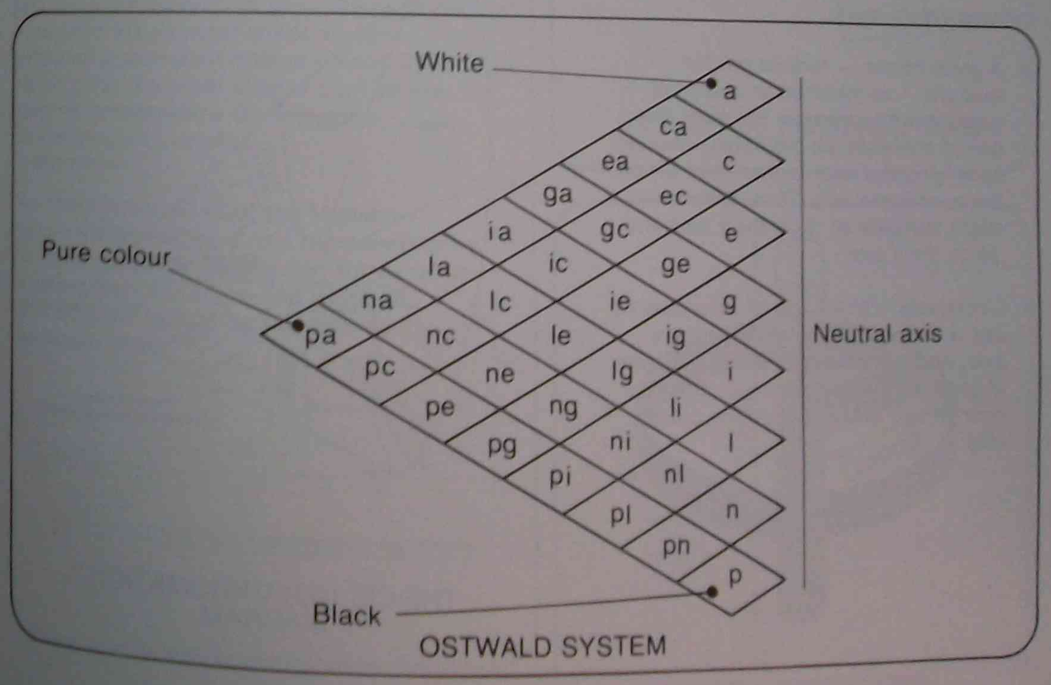
Each hue is allotted a separate page in a colour atlas numbering 1 to 24.

Each page of the atlas is triangular in shape and each hinges on a vertical axis which ranges from white at the top through a series of greys to black at the bottom.

Pure colours are shown at the farthest extremity from the neutral axis.

The upper half of the triangle shows the pure colour mixed with equally varying amounts of white to medium grey. The lower half of the triangle shows the pure colour similarly mixed with equally varying amounts from medium grey to black.

The result is to give 34 distinct tints, tones and shades of the pure colour to each of which is allotted its own reference symbol.



OSTWALD SYSTEM

7.2 C.I.E. SYSTEM

This system was developed in Paris during the Commission Internationale d'Eclairage (International Commission on Illumination) in 1931 and is commonly referred to as the C.I.E. system.

Colour measurements are made with a spectrophotometer which is essentially a light meter for measuring the spectrum. The various readings taken from this instrument are carefully plotted and colour measurements calculated mathematically.

It is a complex system but the most accurate method of specifying colours.

The C.I.E. system is used by The Australian Standards Association to describe colours and is in essence the basis of colour computer systems used by paint manufacturers to match colours.

7.2.1 C.I.E. colour map

The Commission Internationale d'Eclairage chromaticity diagram is a colour map.

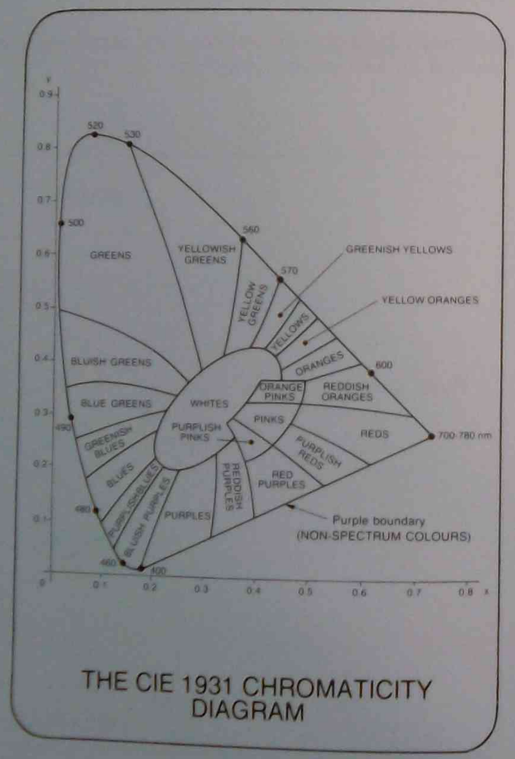
The colours of the spectrum, such as green, blue, red etc., are indicated, together with their wavelenghts, along a horseshoe-shaped curve. The ends of the curve are joined by a straight line representing the purples, which are complementary to the greens. Around the edge of the coloured area are shown the purest colours that a typical set of printing inks can produce.

The dot near the centre of the coloured area represents a 'white' light source composed of equal amounts of the three primary colours whose combination, in various proportions, can be made to match any known colour.

Colours of the same hue increase in purity on a straight line joining the dot to the wavelength of that colour on the curve.

The colour map can be used in two complementary ways:

- A given colour — tomato red for example — is matched as nearly as possible with a spot on the map. The pair of numerals (co-ordinates) uniquely specifying this spot is then read off on the co-ordinate axis. Thus, tomato red might translate as .5 on the x axis and .35 on the y axis.
- Conversely, a given pair of co-ordinates, say .4 on the x axis and .45 on the y axis, would enable the colour — a tone of green — corresponding to those co-ordinates to be located on the colour map.



THE CIE 1931 CHROMATICITY DIAGRAM

7.3 MUNSELL SYSTEM

Developed by A. H. Munsell in 1915 it is the most widely used system of describing colours for painting and decorating purposes.

The system is based on three dimensions: hue, chroma and value; of five principal hues: red, yellow, green, blue and purple; and five intermediate hues: yellow-red, green-yellow, blue-green, purple-blue and red-purple.

The Munsell colour system may be represented by a tree with several branches, each representing one of the principal or intermediate hues.

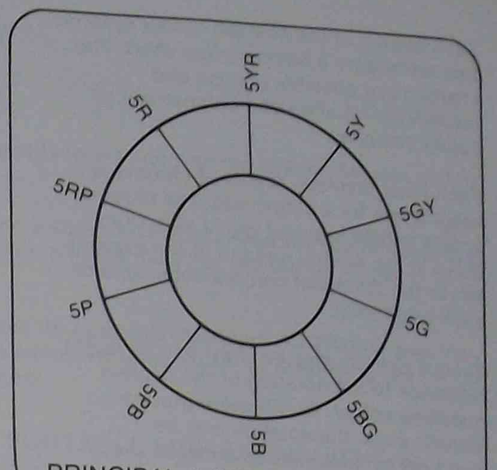
Hue denotes the basic colour — distinguishing yellow from red, blue from green, etc.

Munsell uses ten principal hues:

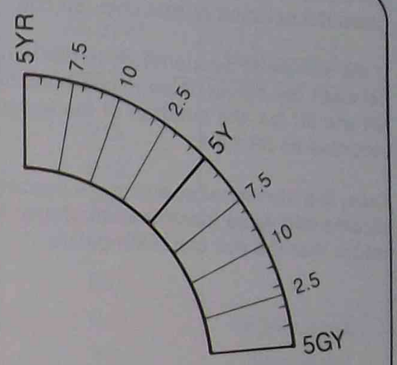
yellow	(Y)	purple-blue	(PB)
yellow-red	(YR)	blue	(B)
red	(R)	blue-green	(BG)
red-purple	(RP)	green	(G)
purple	(P)	green-yellow	(GY)

Each hue is subdivided into ten sections providing a full circle of 100 hues. The true hue is always prefixed by a 5, e.g. 5Y represents pure yellow. 7.5Y is two and a half divisions away from pure yellow in the yellow-red YR (orange) direction and indicates a yellowish orange colour. 2.5Y which is on the other side of pure yellow towards green-yellow GY indicates yellowish green colours.

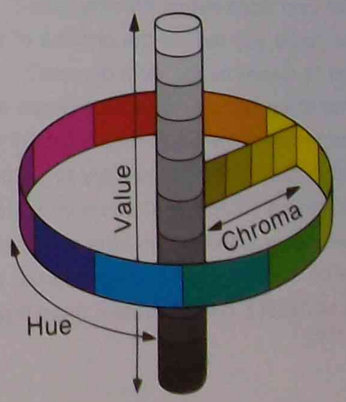
The three dimensions of the Munsell system are shown by a ring representing the ten hues, a central column with a range of values between black and white and a horizontal bar indicating the chroma or saturation levels.



PRINCIPAL & INTERMEDIATE HUES



METHOD OF PREFIXING HUES



MUNSELL DIMENSIONS

Each branch of the Munsell colour systems tree represents a constant-hue chart. The charts make possible precise and meaningful notation and comparison of colour samples.

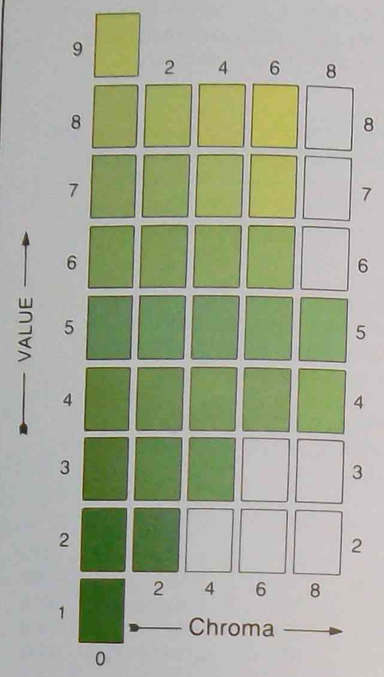
Each chart displays scales of chroma and value levels for a single hue. The chroma scales radiate in equal visual sets from greys at the neutral column at the extreme left to the strongest chroma obtainable on each value level.

Sample colours may be identified by direct reference to the notation of the nearest matching colour. Or, for more precise identification, the notation may be specified by interpolation between the charted colours.

Thus, if a sample of red matches exactly the colour-chip in the position 5R 5/4, it is given the notation of this chip (5R 5/4).

If the sample to be identified is half-way between the colour-chips in positions 5R 4/4 and 5R 5/4, the notation of the sample is recorded as 5R 4.5/4.

Thus, the numerical scales allow precise chroma and value identification of any colour that the eye can distinguish.



GREEN CHART FROM THE MUNSELL COLOUR ATLAS

8 REVISION QUESTIONS

- How would you produce a tint of red?
- What cast does lemon chrome have?
- How could you reduce the chroma of yellow?
- What is meant by the term discord?
- Name three factors to be considered when preparing a colour scheme.
- What is meant by advancing colours?
- What colour is complementary to purple?
- Name three colours that could be used in an analogous colour scheme.
- What colour would be an after-image of blue?
- Why do rough surfaces appear darker than smooth surfaces?
- The MUNSELL colour system uses three factors or dimensions to describe colours — what are they?

9 COLOUR STANDARDS AND CODES

9.1 COLOUR STANDARDS

Probably the most functional use of colour is its ability to provide warning against hazards and to identify items and services.

By allotting specific colours in a consistent manner a conscious association with certain colours in given circumstances is established, i.e. green button starts machine, red button stops machine.

The Standards Association of Australia (S.A.A.) uses its Australian Standard AS 2700 for specific purposes to provide a number of colour standards which includes those for identifying fire extinguishers, pipeline contents and industrial safety.

9.2 IDENTIFICATION COLOURS FOR PORTABLE FIRE EXTINGUISHERS

Australian Standard AS 1849 lays down the colours to be used on portable fire extinguishers to indicate their contents.

Extinguisher Type	Body Colour	AS 2700 Reference No.	Supplementary
Water — soda acid	Red	R13	—
Water — gas containers	Red	R13	—
Water — stored pressure	Red	R13	—
Foam — chemical	Blue	B21	—
Foam — gas container	Blue	B21	—
Foam — stored pressure	Blue	B21	—
Dry chemical	Red	R13	White band
Carbon dioxide	Red	R13	Black band
Halogenated hydrocarbon	Yellow	Y14	—

9.3 IDENTIFICATION OF PIPING, CONDUITS AND DUCTS

Australian Standard AS 1345 is used to identify the contents of pipes, conduits and ducts on ships, in factories or other situations where pipes, conduits and ducts containing various substances or services are used.

SERVICE	COLOUR	AS K185 COLOUR NAME AND REFERENCE NUMBER		AS 2700 COLOUR NAME AND REFERENCE NUMBER
Water		Emerald Green	228	Jade G21
Air		Arctic Blue	112	Aqua B25
Mineral, vegetable and animal oils, combustible liquids		Golden Brown	414	Golden Tan X53
Gases and liquid gases (except air)		Light Beige	366	Sand Y44
Acids and Alkalis		Light Violet	797	Lilac P23
Electrical Services		Light Orange	557	Orange X15
Fire Installations		Signal Red	537	Signal Red R13
Other fluids, including drainage		Black	—	Black —
Steam		Silver-grey	—	—
Communications		White	—	—
Ionizing radiation (liquids, gases)		Golden Yellow	356	Golden Yellow Y14
Other dangerous liquids and gases		Golden Yellow	356	Golden Yellow Y14

NOTE:

Colours shown are representative only of the standard colour.

9.4 INDUSTRIAL SAFETY COLOUR CODE

Industrial Safety Colour Code AS 1318 was formulated in conjunction with the International Organisation of Standardisation (I.S.O.) to provide an international standard range of specific safety colours for use in industry.

ISO NAME	COLOUR	AS 2700 NAME AND REFERENCE NUMBER	TYPICAL APPLICATION
Safety Red		Signal Red R13	Danger, fire-protection equipment and apparatus, stop buttons and emergency stop controls.
Safety Yellow		Sunflower Y15	Places where caution should be exercised. Places where cautionary notices warning of hazards from radioactive sources should be displayed.
Safety Green		Jade G21	Used in conjunction with white denotes safety and indicates the location of safety and first-aid equipment. Green should be in the background or basic colour of starting buttons and similar apparatus.
Auxiliary Blue		Bright Blue B23	Used as a background with white lettering where it is desired to convey general information, i.e. toilets, offices, parking etc.

NOTE:

Colours shown are representative only of the standard colour.

10 GLOSSARY OF TERMS

Achromatic colours — Black, white and the greys — colours devoid of hue.

Additive colour mixing — When light beams of different colours are projected onto a white area, the light reflected is a mixture whose colour derives from the adding together of the colours of the beams. Red, green and blue lights projected at equal intensities add together to produce 'white' light but red and green lights mix additively to produce yellow. By mixing the additive primaries, red, green and blue, in varying proportions a wide range of colours can be produced. The resulting colour is always brighter than that of any of the contributory colours due to the addition of three light beams.

Advancing colours — Warm colours taken from the red, yellow or orange part of the colour wheel. They give the appearance of coming out or advancing towards the eye.

After-image — A colour patch that seems to float in front of the eyes when they are stimulated for a period of time by a colour that strongly differs from that of its background.

Analogous colours — Colours closely related to each other on the colour wheel, e.g. yellow, yellow-green and green.

A.S. — Australian Standard.

Brightness — See Chroma.

B.S. — British Standard.

Cast — A term used to describe the tinge of a colour.

C.I.E. — (Commission Internationale d'Eclairage) International Commission of Illumination 1931.

Chroma — Describes the greyness of a colour. The stronger the chroma or lack of grey in a colour, the purer or brighter the colour appears.

Chromatic circle — See pigment colour wheel.

Clean colour — A vague term generally meaning primary or secondary colours and tints high in chroma and value.

Colorimeter — A device for specifying a colour by matching it with known stimulus that can itself be specified quantitatively.

Colour — The sensation produced by waves of decomposed light upon the optic nerve. Generally, colour is used to describe hues collectively or individually irrespective of their value and chroma. Colour and hue are often used alternatively to imply the same.

Colourant — See Tinters.

Colourfulness — A term coined by the C.I.E. as a synonym for 'saturation' or 'intensity' as descriptive of colour.

Colour reduction — The reduction of a colour chroma by the addition of its complementary colour or grey.

Colour wheel — See pigment colour wheel.

Complementary colours — Any two colours which lie opposite each other on the colour circle and when mixed will produce a neutral grey colour.

Contrasting colours — Colours different in hue, value or chroma when seen together, e.g. the contrast of light colours against dark colours.

Cool colours — Colours from the green and blue part of the colour wheel which give the appearance of coolness.

Darkness — See Value.

Diffraction — The spreading of a wave, especially light, when it meets an obstacle or passes through an aperture.

Dirty colours — A vague term meaning colours having a distinctive deep grey or brown cast.

Discord — A visual sensation caused when various tones of colour are used in a combination that reverses the natural order of colour, i.e. pale green placed against deep yellow.

Dominant hue colour scheme — See Monochromatic.

Earth colours — Those colours that are mixed from naturally occurring clays and oxides, i.e. ochre, sienna, umber. More generally any brown colour.

Electromagnetic spectrum — The entire range of electromagnetic waves from the very short gamma rays found in cosmic radiation through untraviolet light to radar and radiowaves.

Grey — An achromatic colour intermediate in lightness between black and white.

Greyness — See Chroma.

Grey scale — See Value.

Harmonious colours — Three or more colours which appear pleasant when used together in a scheme. Common combinations are: (a) Monochrome; (b) Analogous; (c) Complementary; (d) Split complementary.

Hue — The attribute of a colour by which it is distinguished from another. All colours are judged to be similar to one, or a proportion of two of the spectral hues: red, orange, yellow, green, blue and purple. Thus, crimson, vermillion and pink though different colours are close in hue.

Infra-red radiation	A form of electromagnetic radiation that is continuous with the red end of the visible spectrum but lies beyond it and is of longer wavelength.
Intensity	See Chroma.
Intermediate secondary	A secondary colour that has a visual majority of one of the primary colours used to obtain it. Technically they are secondary colours but because they can readily be described as being closer to one of the primary colours used, the term intermediate secondary is used to distinguish them from pure secondaries, i.e. orange is a pure secondary, red-orange and yellow-orange are intermediate secondaries.
I.S.O.	International Organisation of Standardisation.
Juxtaposition	The effect one colour has on another when viewed side by side. The complementary colour of each will intensify or distort the effect of its neighbour, e.g. when red and yellow are seen together, the red will take on a purplish tinge while the yellow will appear greenish.
Light	Electromagnetic radiation capable of stimulating the eye to produce visual sensations.
Lightness	See Value.
Leaning	See Cast.
Monochromatic	Means one colour. When used to describe a colour harmony, it means a colour used with its tints and/or shades. Neutrals can also be included in monochromatic colour harmonies.
Muddy colours	A vague term generally meaning colours resulting from the mixture of three or more colours or colours having a brownish cast.
Munsell Colour System	A system of defining colours developed by A. H. Munsell of the U.S.A. in 1915.
Natural order of colour	The order which colours of maximum chroma will assume if arranged to progress from the highest value to the lowest value, e.g. yellow, orange, red, green, blue, purple. If white is added to the dark colours and black added to the light colours so that yellow becomes the darkest colour, the natural order is reversed and colours become discordant.
Neutrals	Colours that have no hue or chroma, i.e. black, white and grey.
Neutral grey	A grey devoid of cast.
Newton, Isaac	Proved that visible light was composed of seven coloured rays by passing a narrow beam of light through a glass prism. These colours are known as spectral colours and always occur in the same order — red, orange, yellow, green, blue, indigo and violet.

Non-complementary	Any two colours that are not directly opposite each other on the colour circle.
Optical mixture	The effect of the eye combining differently coloured lights to produce a new colour.
Ostwald Colour System	A system of arranging colours in a colour solid developed by Wilhelm Ostwald.
Pale colours	See Pastel colours.
Pastel colours	Usually refers to colours with a predominance of white or light grey added.
Pigment	An insoluble colouring material, requiring to be applied to a surface in conjunction with a binding material. Pigments coat the colour of the underlying surface rather than combining with it.
Polychromatic	A colour scheme that incorporates many colours.
Primary colours	A set of three colours that can be combined in a colour mixing process to produce a wide range of colours but when mixed together no two will produce the third. Light or additive primaries are red, green and blue. Pigment or subtractive primaries are red, yellow and blue.
Prism	Usually a transparent glass or plastic block of triangular cross-section. Light passing through it is spread out into a spectrum.
Purity	See Chroma.
Receding colours	Generally associated with cool colours. They give the impression that surfaces appear further away than they actually are.
Reflective scale	See Value.
Reflection	The return of lightwaves from a surface. We see non-luminous objects by the light they reflect. Light that is not reflected is either absorbed or transmitted.
Refraction	The bending of light rays as they pass from one medium to another. In general, when light enters a denser medium from a less dense one — water from air for instance — it is bent away from the perpendicular.
Retiring colours	See Receding colours.
S.A.A.	Standards Association of Australia.
Saturation	See Chroma.
Secondary colour	A colour obtained by mixing two primary colours.
Shade	A colour obtained by mixing a colour with black.

Simultaneous contrast	Contrast between areas of different colours that are simultaneously present in the visual field. It can have striking effects on the judgement of colours as when a grey object looks dark against a light background yet light against a dark background or seems to be tinged with the complementary colour of the background. Simultaneous contrast is an optical effect.
Spectral colours	The colours that appear in the spectrum of sunlight ranging from red through orange, yellow, green and blue to violet.
Spectrophotometer	Instrument that measures the wavelengths of colours.
Spectrum	The coloured image formed when light is spread out according to its wavelength by being passed through a prism.
Split complementary	A colour scheme based on one hue contrasted with two hues either side of its complementary colour.
Stainers	See Tinters.
Static colours	Colours that maintain an optically fixed position, neither advancing nor receding.
Subtractive colour mixing	The production of colours by mixing dyes or pigments. The resultant colour is the result of the simultaneous or successive subtraction of various colours from the light passing through the combination.
Surface colour	Colour belonging to (or perceived as belonging to) a surface that sends (or appears to send) light to the eye by reflection.
Tertiary colours	Colours that result from the intermixing of two secondary colours.
Tint	The addition of white to a colour results in a tint of that colour.
Tinters	Coloured pigments in a medium that is soluble in water or oil-based paints and is used by painters and decorators to mix and match colours.
Tonal value	See Value.
Tones	The tints and shades of a given hue are referred to as its tones.
Toners	See Tinters.
Undertone	The perceivable tinge or underlying hue of a colour, i.e. lemon yellow has an undertone of green.
Value	The estimated lightness of a surface colour. A series of greys is imagined to run along a vertical axis with a perfect black (value 0) at the bottom and a perfect white (value 10) at the top. The greys lighten — or increase in value — in steps that are subjectively equal. Colours of the same lightness as a given grey are assigned the same value and arranged on the same horizontal level. Synonyms: greyness, reflectance, tonal value, weight.
Visual mixture or mixing	See Optical mixture.

Warm colours	Colours from the red-yellow-orange part of the colour wheel which give the appearance of warmth.
Wavelength	The distance over which a periodic wave phenomenon repeats itself. The wavelength of light determines its hue.
Weight	See Value.
White light	A mixture of all visible wavelengths of light in the same proportion as they are found in sunlight.

NOTES FOR THE INSTRUCTOR

In these Training Manuals the term 'instructor' refers to any person who may train or be directly responsible for training individuals.

For example, the task of instructing may be the sole or shared responsibility of:

—skilled tradespeople

—leading hands

—supervisors

—instructors

—apprentice trainers

—managers

INITIAL PLANNING

A Analyse:

- The training requirements of a newcomer, considering that the person:

  —may have no previous experience in the subject;

  —will need to do productive work as soon as possible.

- What the trainee must learn about:

  —the materials used for the subject;

  —the terminology involved in the subject;

  —basic working methods.

- What will be the first productive work you will be able to give the trainee.

B Decide:

- Whether your trainees need information to supplement that given in this manual.
- Whether or when additional training material or exercises will be required to improve on the skill gained.
- Which other Basic Training Manuals the trainee should use during training.

C Plan:

The explanations, demonstrations and the practice required by the trainee, preferably on an individual basis, if numbers allow.

USING THE MANUAL

It may be of assistance to the trainee to arrange for short periods of learning followed by short periods of practice in applying the knowledge gained.

To keep interest alive, it will be useful to relate, as much as possible, the material treated in this manual with actual practical applications in the field.

PRACTICAL EXERCISES AND PROJECTS

There may be areas and tasks in actual situations where the developing skills of the trainee can be put to effective productive use at any stage during the period he or she is learning the subject. Such possibility should be carefully considered and used to the full for the trainee's benefit as well as that of the firm.

Give the trainee as many opportunities as possible to use the whole range of reference materials on small jobs to enable him or her to prepare suitable colour schemes taking into account all the factors affecting each situation.

Small projects and exercises to suit particular work situations may be devised, but they must take into consideration the limits of skill and knowledge of the trainee.

Whatever form of exercise is used to develop practical skill, it must be carefully planned. A suggested course of instruction is as follows:

- Prepare the working area, the materials to be used.
- Make the aim of the project clear to the trainee.
- State how you intend to assess the proficiency of the trainee.
- Stress key points in the project, paying particular attention to safety precautions.
- Explain clearly and thoroughly any new steps in the project.
- Check that the trainee can use the reference materials correctly.
- Assess the finished project, record the results and discuss with the trainee your appraisal of the performance.
- If you are satisfied with the performance, direct the trainee to the next exercise or project.

TRAINING RECORDS

Simple training records will help in planning systematic training.

Record:

- the parts of the manual learnt by the trainee;
- your assessment of the general skills developed;
- the practical exercises undertaken and completed.

Use your record to measure the trainee's performance and to assess his or her readiness for undertaking actual operations.

Draw up a simple record card to suit your needs.

Using records helps to pinpoint the trainee's strengths and weaknesses. They ensure that training in essential skills is not missed. Training records can be used to help co-ordinate on-the-job training and technical school learning. Where trainees have to serve a probationary period, records assist when the trainee's progress is being assessed.

PUBLICATIONS IN BASIC TRAINING MANUALS
PAINTING, DECORATING AND SIGNWRITING

15-1 PAINT TYPES AND SURFACE PREPARATION
15-2 PAINTING EQUIPMENT, APPLICATORS AND SCAFFOLDING
15-3 PAINTING TECHNIQUES
15-4 COLOUR
15-5 GLAZING
15-6 STAINING
15-7 PAPER-HANGING
15-8 SIGNWRITING — EQUIPMENT AND USE OF SIGN PENCIL
15-9 SIGNWRITING — DESIGN AND LAYOUT
15-10 FRENCH POLISHING

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(Available at date of printing)

WORKSHOP SAFETY	1 MANUAL
FITTING	10 MANUALS
PRACTICAL GEOMETRY	3 MANUALS
LATHE WORK	7 MANUALS
SHAPING AND SLOTTING	3 MANUALS
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ELECTRICAL	13 MANUALS
ROOF PLUMBING	6 MANUALS
MOTOR VEHICLES	10 MANUALS (MORE IN PREPARATION)
PANEL BEATING	3 MANUALS (MORE IN PREPARATION)
VEHICLE PAINTING	1 MANUAL (MORE IN PREPARATION)
CARPENTRY AND JOINERY	14 MANUALS (MORE IN PREPARATION)
FURNITURE REMOVALS	4 MANUALS
TIMBER TECHNOLOGY	1 MANUAL
SHEETMETAL	(MANUALS IN PREPARATION)

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Manuals are available from Commonwealth Government Bookshops.

Mail orders to: *Mail Order Sales, Australian Government Publishing Service, P.O. Box 84, CANBERRA, A.C.T. 2601.*

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In order to provide you with the most up to date series of Basic Training Manuals it would be helpful if you could complete this short questionnaire and return it to us. No postage is required if posted in Australia.

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In this series: .....
In other series: .....

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How or when have you used the manual (you may tick more than one box)
- ☐ As an apprentice
- ☐ As a trade reference
- ☐ For self learning
- ☐ For upgrading skills
- ☐ As a trainer (please indicate type of trainees, eg apprentices) .....
- ☐ As a student (other than apprentice)
- ☐ For pre-employment training
- ☐ Other (please specify) .....

QUALITY AND CONTENT

	Text		Illustrations	
Easy to understand	☐ Yes	☐ No*	☐ Yes	☐ No*
Technically accurate	☐ Yes	☐ No*	☐ Yes	☐ No*
Value in training	☐ Yes	☐ No*	☐ Yes	☐ No*
Up-to-date	☐ Yes	☐ No*	☐ Yes	☐ No*

*Please explain: .....

TRAINING AIDS

Did you use the manual to produce any of the following aids?
- ☐ Charts
- ☐ Overhead transparencies
- ☐ Slides/Audio tapes
- ☐ Video/Films
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.....

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..... Postcode .....
Position: .....
Organisation: .....
Telephone No: .....
Date: .....

Inclusion of your name and telephone number would enable contact to be made to discuss your comments, if necessary.

Please enclose additional information as you think necessary.

BASIC TRAINING MANUAL

15-3

PAINTING & DECORATING 3

NATIONAL BUILDING AND CONSTRUCTION
INDUSTRY TRAINING COMMITTEE

DEPARTMENT OF EMPLOYMENT AND INDUSTRIAL RELATIONS

BASIC TRAINING MANUAL

15-3
PAINTING & DECORATING 3

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CONTENTS

PREFACE

INSTRUCTIONS TO TRAINEE

SECTION		*PAGE*
	Objectives of this manual	1
1	**Application of pigmented coatings**	2
1.1	Types of pigmented coatings	2
1.1.1	Primers	2
1.1.2	Sealers	2
1.1.3	Intermediate coatings (Undercoats)	3
1.1.4	Finish coatings	3
2	**Method of applying pigmented coatings**	4
2.1	Brushes	5
2.1.1	Types of brushes	5
2.1.2	Sections of a brush	6
2.1.3	Holding a brush	7
2.2	Loading a brush with paint	8
2.3	Applying paint by brush	9
2.3.1	Application	9
2.3.2	Spreading	10
2.3.3	Laying off	10
2.4	Care of brushes	12
2.4.1	Cleaning brushes	12
2.5	Paint roller equipment	14
2.5.1	Paint rollers	14
2.5.2	Roller covers	14
2.5.3	Roller trays	14
2.6	Applying paint by roller	15
2.7	Cleaning rollers	17
3	**Defects caused by poor application**	18
3.1	Shearness	18
3.2	Runs and sagging	18
3.3	Thick edges	19
3.4	Poor opacity	19
3.5	Misses	20
3.6	Ropiness	20
4	**Atmospheric effects on paint coatings**	22
4.1	Weather conditions	22
4.1.1	Wind	22
4.1.2	Sun	23
4.1.3	Humidity	25
4.1.4	Rain	26
4.1.5	Frost and fog	27
4.2	Chemical pollutants	28
5	**General painting procedures**	29
5.1	Health and safety	30
5.2	Setting up a storage area	31

6	**Interior painting procedures**	32
6.1	Preparing the work area	32
6.1.1	Removal of fittings	32
6.1.2	Erecting scaffolding	33
6.2	Washing down surfaces	34
6.3	Sanding surfaces	36
6.4	Repairing surface defects	38
6.4.1	Filling surface imperfections	39
6.4.2	Sanding filled surfaces	40
6.5	Preparing paint for use	41
6.6	Painting the ceiling and cornice	43
6.6.1	Using a roller and extension arm	45
6.7	Painting the walls	46
6.8	Procedure for painting woodwork	47
6.8.1	Painting door frames	47
6.8.2	Painting a panelled door	48
6.8.3	Painting a flush-panel door	49
6.8.4	Painting windows	50
6.8.5	Painting skirting-boards	53
6.9	Preparation for the finish coat	54
	REVISION QUESTIONS	55
7	**Exterior painting guidelines**	57
7.1	Repairing surfaces	58
7.2	Preparing surfaces for painting	58
7.2.1	Priming bare surfaces	60
7.2.2	Caulking open joints and gaps	61
7.3	Procedure for painting exterior surfaces	62
7.4	Applying the final coat	66
	NOTES FOR THE INSTRUCTOR	67
	OTHER PUBLICATIONS	69

PREFACE

This manual is one of a series that has been developed to progressively increase the practical skills of a trainee in painting, decorating and signwriting.

Other manuals in this series cover:

- Paints: types, reasons for coating, surfaces coated, health and cleanliness, glossary of terms.
- Surface preparation: removal of existing coatings, safe use of scaffolding, painters' tools.
- Colour: simple colour wheel, primary, secondary and tertiary colours, tints, shades and tones.
- Glazing: removal of broken glass, cutting glass, reglazing.
- Staining: filling, clear finishing, opaque and semi-opaque finishes.
- Paper-hanging: drop and set patterns, preparation, adhesives.
- Signwriting: tools and equipment, use and control of the sign pencil, layout of alphabet, design of simple signs.

Each manual is self-contained and is intended as an instructional guide in on-the-job training situations. It may be used by instructors or for self-teaching purposes.

The aim of the manual is to help the trainee to develop a particular skill to the stage where it can be applied productively on the job. Ideally, the manual should be used as part of a course of instruction involving:

- demonstrations of practical skills by instructors or experienced tradesmen;
- planned and supervised practice in handling the tools involved;
- instruction in safe working procedures.

The manuals may be used in any order convenient to the learning needs of the trainee and may be obtained individually or in sets to cover the range of skills in the trade area.

It may be advisable to use part of this manual with sections of other manuals in this series to follow an operation right through.

INSTRUCTIONS TO TRAINEE

This manual is a teaching aid to your skill development. It is best used on the job where you can handle the tools and use the equipment shown.

You should follow the general directions given by the person training you. To reach the required standard of skill, you must pay particular attention to your instructors' explanations and demonstrations. Supervised practice is essential.

Practice means making repeated efforts to improve your level of skill. Study is making an effort to learn. Every advance in skill depends on study and practice. You will make most progress by co-operating actively in the training arranged for you.

When you are told to study all or part of this manual, try to use a definite plan of study. The following plan is effective.

SURVEY: Read quickly through the headings as you turn the pages. Glance at the drawings. Get an overall view before you read.

QUESTION: Ask yourself: What do I know? What do I need to know? How will this manual help me to learn?

READ: Read right through each section carefully. Be thorough, but do not dawdle. Reading quickly will help you concentrate.

DO: Use all your senses in learning. Getting the 'feel' of a subject is essential in learning it. Follow the directions given to you; they are meant to assist you in the gaining of the skills you need.

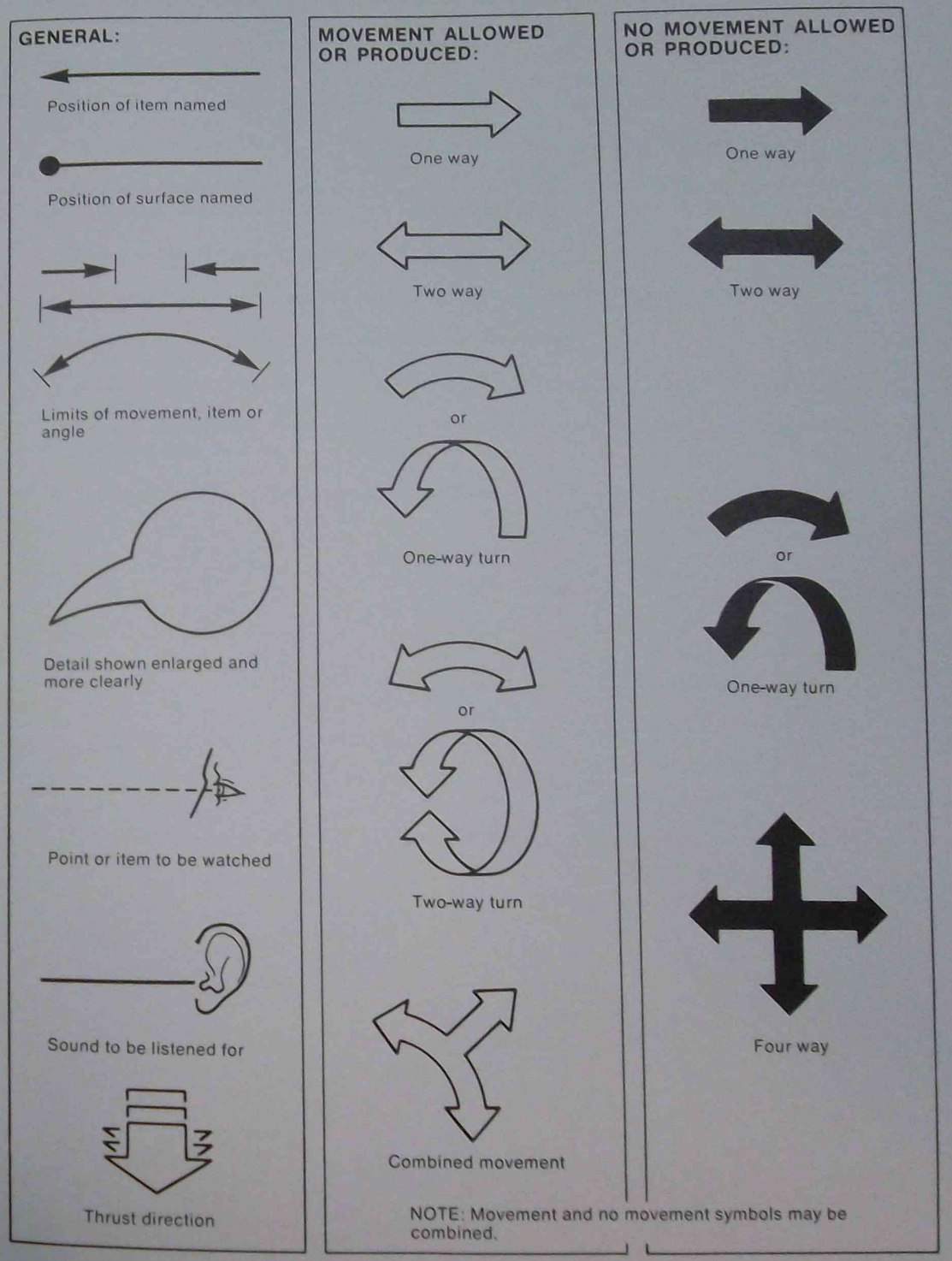
REVIEW: Shut the manual. Try to remember the main points of the section. Check to see that you are right. Revise points on which you are doubtful. Try a few or as many examples as you think you need, without reference to the manual.

One way of fixing important instructions in your mind is to repeat them over and over. Test papers are given in this manual to help you test your understanding of the work. Use them intelligently.

The practical work required of you in this manual will help you to develop the skill to work productively.

SYMBOLS

The symbols shown are used in illustrations in these manuals.



OBJECTIVES OF THIS MANUAL

In painting and decorating, the procedure used to prepare and paint surfaces is important for the successful completion of a particular task.

This manual will help you to learn:

- the order in which the preparation and painting of interior and exterior surfaces is completed;
- the systematic procedure for the painting of individual building components.

This manual is intended for use in conjunction with other manuals in the series dealing with surface preparation, paint removal and basic scaffolding.

The aims of this manual are to teach you how to:

- recognise and identify various interior and exterior building components;
- prepare storage areas, paint and application equipment;
- clear and arrange the work area ready for the commencement of painting;
- complete the preparation and painting of the interior of a room and the exterior of a weatherboard dwelling in a logical sequence;
- use a systematic procedure to paint surfaces.

1 APPLICATION OF PIGMENTED COATINGS

This section explains the techniques of applying pigmented coatings by brush and by paint roller. When used in conjunction with thorough surface preparation, the application techniques will help achieve a finish free of defects.

1.1 TYPES OF PIGMENTED COATINGS

There are many types of pigmented coatings available. However, they can be grouped together and listed as either:

- primers
- sealers
- intermediate coatings
- finish coatings

1.1.1 Primers

A primer is the first coat of paint to be applied to a bare surface. It is the foundation of a paint system and its stability is most important.

The functions of a primer are:

- to help make porous surfaces non-absorbent;
- to provide adhesion to the surface;
- to form a barrier over chemically active surfaces;
- to inhibit the corrosion of metals.

1.1.2 Sealers

A sealer is a coating which is specially formulated to do a specific task. Some examples are:

Acrylic-based sealers

These are formulated to:

- enable same day recoating;
- become the foundation for an acrylic paint system because of their compatibility to acrylic undercoats and finish coats;
- be applied over masonry and plaster surfaces.

Spirit-based sealers

These types of sealers:

- are designed for use over surfaces which have a tendency to soften or stain through following coats of paint;
- act as a barrier coat which prevents soluble inks or dyes from staining following coats of paint.

Oil-based sealers

These sealers have two main purposes:

- to penetrate and bind loose, powdery surfaces;
- to seal highly porous or cement-type surfaces.

1.1.3 Intermediate coatings (undercoats)

These types of coatings are applied between the primer or the sealer and the finishing coat. They are also applied over previously painted surfaces prior to the finishing coat.

The intermediate coat will vary according to the type of system that is used.

The functions of an intermediate coat are to:

- adhere to the primer or sealer and provide a surface to which the finishing coats can adhere;
- provide good opacity to obliterate the primer;
- have good flow and levelling properties;
- provide good sanding properties.

1.1.4 Finish coatings

These coatings are the last or final coats of paint applied to a surface.

Their functions are to:

- protect the surface from the effects of the weather, chemical attack and abrasion;
- decorate the surfaces and appear pleasing to the eye;
- provide texture to a surface;
- provide colour to identify and label surfaces, or to convey a message, e.g. red for danger, orange for caution, green for safety;
- enable the surface to be cleaned easily.

Finish coatings are available in:

- flat (matt)
- semi-gloss
- gloss

Flat, semi-gloss and gloss finishes are available in both water-thinned and solvent-thinned paints.

2 METHODS OF APPLYING PIGMENTED COATINGS

The two most common methods of applying pigmented coatings are by:

- brush
- paint roller

Other methods of applying pigmented coatings are:

Spray-guns

Various types of spray equipment are available for the application of pigmented coatings. The basic principle of spray operation is that the paint is forced, under pressure, through a small opening, causing the paint to atomise into a fine mist which is transferred to the surface to be painted.

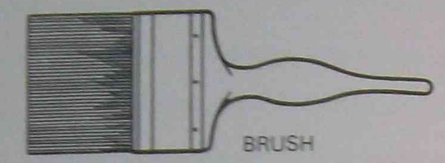
Paint mittens

Paint mittens are designed to fit the hand and are made of sheepskin or a synthetic material similar to that used on paint rollers. They have a waterproof lining to protect the hand and can be washed out and reused.

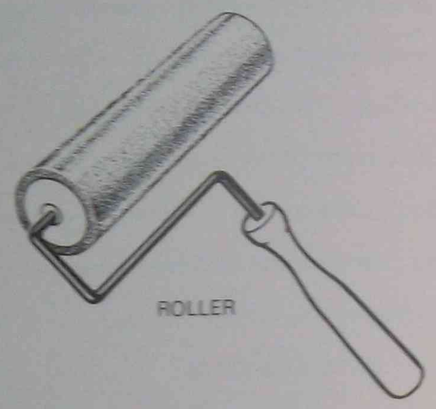
The mitten is loaded by immersing it in the paint, the excess paint is removed by wiping the mitt on the edge of the container. The mitt is then wrapped around the surface to be painted.

Paint pads

A paint pad consists of a foam base covered with a napped fabric similar to a roller cover. The foam base and fabric cover are mounted on a plastic or a metal plate. To hold the pad on the surface with an even pressure, a spring head is attached to the handle. Paint is applied by drawing the loaded pad across the surface.



BRUSH

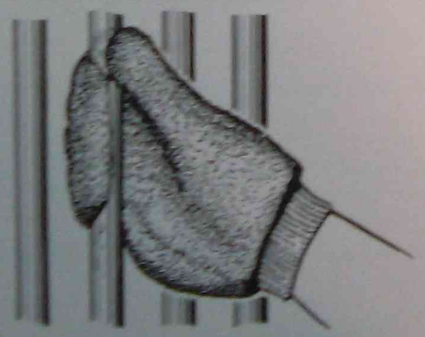


ROLLER

COMMON METHODS OF APPLICATION

SPRAY-GUN

PAINT PAD



PAINT MITTEN

2.1 BRUSHES

2.1.1 Types of brushes

Sash cutters

Used mainly on intricate work for cutting in, e.g. windows, skirting-boards.
Sizes: 12 mm, 25 mm, 75 mm.

Flat paint brush

To apply most types of paint to a wide variety of surfaces, including doors, frames, walls and weatherboards.
Sizes: 25 mm to 100 mm wide.

Flat wall brush

To apply water-thinned paints to large areas.
Sizes: 100 mm to 175 mm wide.

Stroker

Used to apply paint to detailed work and areas of difficult access.
Sizes: 5 mm to 25 mm.

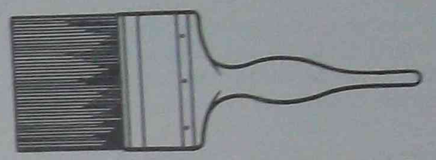
Angle or crevice brush

Used to apply paint to restricted areas, such as behind pipes.

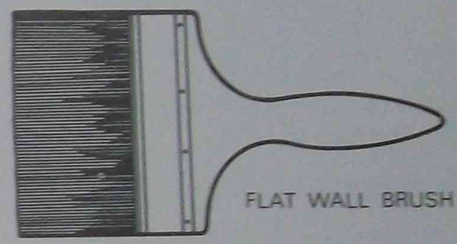
Dusting brush

To remove dust and dirt from surfaces prior to painting. These brushes are available in a wide range of styles and sizes.

SASH CUTTER

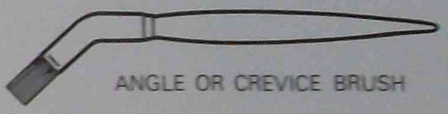


FLAT PAINTBRUSH

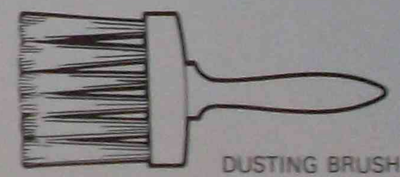


FLAT WALL BRUSH

STROKER



ANGLE OR CREVICE BRUSH



DUSTING BRUSH

TYPES OF BRUSHES

2.1.2 Section of a brush

There are basically four main sections of a paintbrush.

Handle

Usually made of hardwood which is sealed to make handling and cleaning easier.

Stock

The means by which the handle is fixed to the filling. Usually, a ferrule made from copper or nickel-plated steel. The ferrule is riveted or pressed onto the handle.

Setting

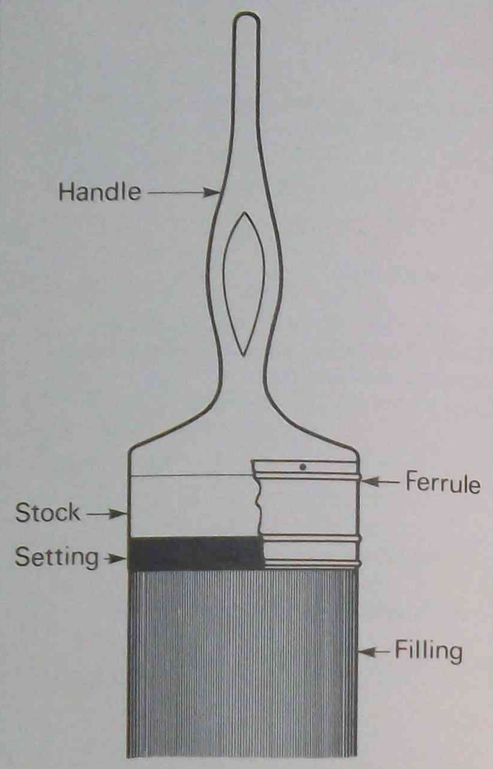
An adhesive which cements the filling together at the root.

Filling

The filling is the section of the brush which holds the paint.

There are four main types:

- pure bristle
- synthetic fibres, such as nylon
- natural fibres obtained from grass and plants
- a mixture of bristles and fibres



SECTIONS OF A BRUSH

2.1.3 Holding a brush

Paint can be applied more evenly, and with less effort, if the brush is held correctly.

Basically, there are three different methods of holding a brush when painting.

Pencil grip

Hold the brush comfortably between your thumb and first finger, as you would a pencil, approx. 30 mm back from the bristles.

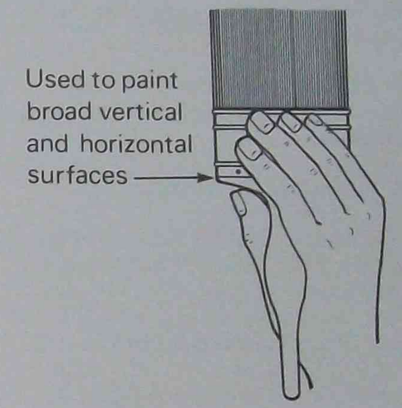
Use this method for holding a sash cutter or a stroker when cutting in, or painting detail work.

PENCIL GRIP

Basic grip

Rest the handle of the brush between your thumb and first finger and apply pressure on the stock with the tips of your other fingers.

This method of holding a brush is the most common. Use it for flat paint and wall brushes. It enables you to control the brush easily when painting broad vertical and horizontal surfaces.



BASIC GRIP

Overhead grip

Hold the brush with all your fingers around the handle and your thumb on top just behind the ferrule.

Use this method when brushing ceilings or overhead work.

OVERHEAD WORK

2.2 LOADING A BRUSH WITH PAINT

The technique used to load a brush with paint must be followed in order to carry out painting cleanly and efficiently.

Failure to follow this technique may cause:

- dripping of paint from the bristles;
- paint to run down the brush onto the handle;
- distortion of the shape of the bristles through misuse;
- paint to run down the sides of the paint pot.

To load the brush:

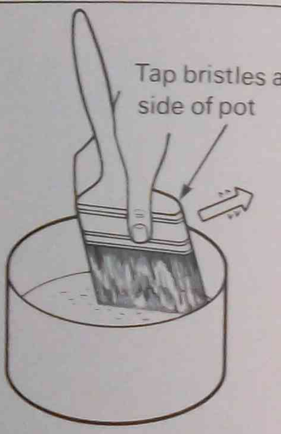
- Hold the brush firmly, using the most suitable grip.
- Dip the bristles into the paint until approximately one-third of the length is submerged.
- Lift the bristles out of the paint.
- Tap both sides of the bristles against one side of the paint pot to remove excess paint.

The brush is now loaded and ready to use.

When repeating this procedure, it may be necessary to remove paint which has built up near the stock. To do this, scrape both sides of the bristles lightly along one side of the paint pot and repeat the loading procedure.

Use only one side of the paint pot at any time to avoid getting paint on your hands and the brush handle when loading the brush.

LOADING THE BRUSH



REMOVING EXCESS

SCRAPE OFF BUILD-UP

2.3 APPLYING PAINT BY BRUSH

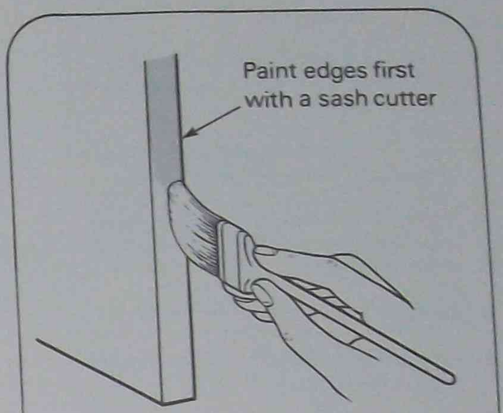
There are three basic steps involved in obtaining an even film of paint with minimum brushmarks on a broad surface.

These are:

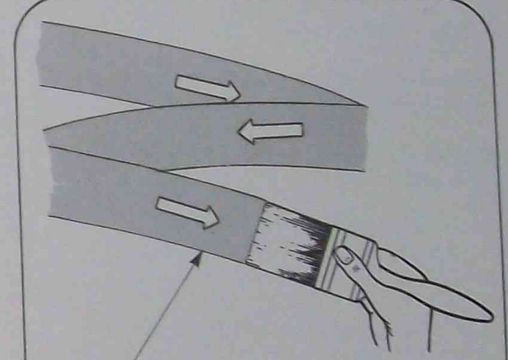
- Applying the paint to the surface.
- Spreading the paint evenly.
- Laying off the paint to eliminate brushmarks.

2.3.1 Application

- Use a sash cutter to paint the edges of the surface.
- On a vertical surface, start in a corner at the highest point.
- On a horizontal surface, start at the furthest point from your body.
- Apply the paint in a criss-cross fashion, using a flat paint brush.
- Use long, steady strokes and do not overbrush the paint.
  - — Do not try to cover too much surface with one brushful, reload the brush at regular intervals.
  - — Do not apply paint to any section larger than half a square metre before proceeding to the next stage of spreading the paint.



PAINT EDGES FIRST



APPLYING THE PAINT

2.3.2 Spreading

After you have applied the paint to the first section, it must be spread out to obtain an even film thickness.

- Place the brush flat onto the surface where you first began application.
- Using the full length of the bristles, draw the brush horizontally across the painted section.
- Apply an even pressure on the brush.
- Repeat this procedure until all applied paint is evenly spread.

SPREADING THE PAINT

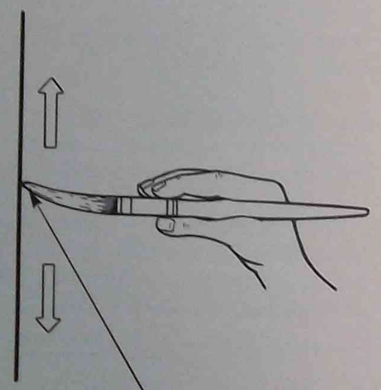
2.3.3 Laying off

The technique of eliminating the brush marks caused by spreading the paint.

Only the tips of the bristles of the brush are used, with a minimum of pressure applied.

This method must be used for semi-gloss and gloss finishes and the intermediate coats beneath them on broad surfaces.

- Remove excess paint from the brush by carefully scraping the bristles on one edge of the paint pot.
- Place the tips of the bristles at the bottom of the painted section.
- Draw the bristles over the paint in an upward motion.
- Cover the full length of the painted section in one motion.
- Repeat this procedure, overlapping each stroke to ensure a uniform finish is obtained.



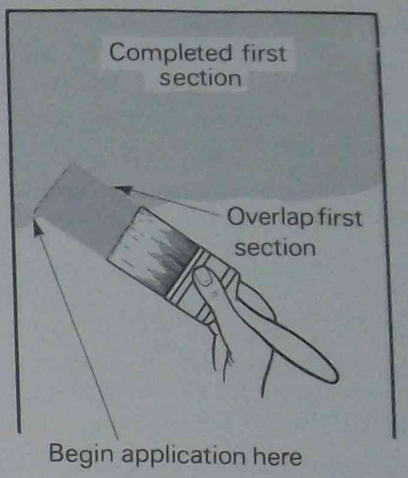
LAYING OFF

Begin application of the next section immediately after laying off.

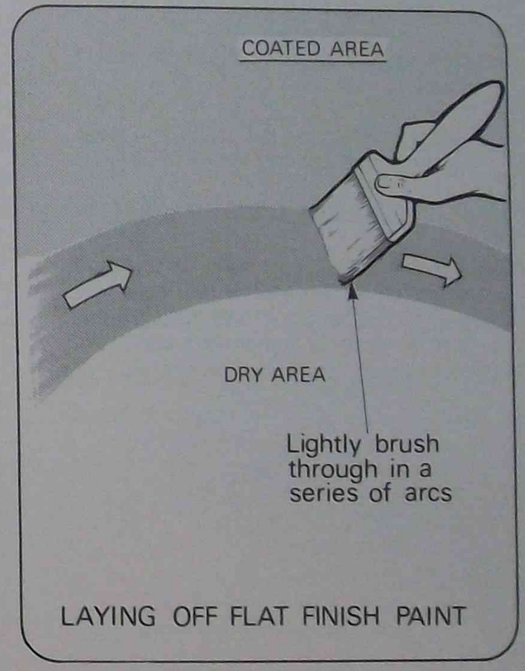
- Load the brush.
- Begin application directly below the finished section.
  - — When applying the paint, slightly overlap the finished section.
- Complete the application, spreading and laying off of the second section before proceeding further.
- Repeat the above steps in sections until the surface is complete.

When brushing paints with a flat finish and thick coatings, such as water-based coatings:

- Load the brush.
- Apply and spread the paint in the one application.
- Finish applying each brushful of paint with sweeping strokes in an arc.
- Avoid brushmarks by applying the tip of the brush to an unpainted section, then brush lightly through the coated area in a series of arcs.
  - — Reduce the pressure applied to the brush at the end of each stroke.



PAINTING NEXT SECTION



LAYING OFF FLAT FINISH PAINT

2.4 CARE OF BRUSHES

More brushes are damaged through improper care and use than are worn out in service.

When using brushes, the life of the brush will be prolonged if you:

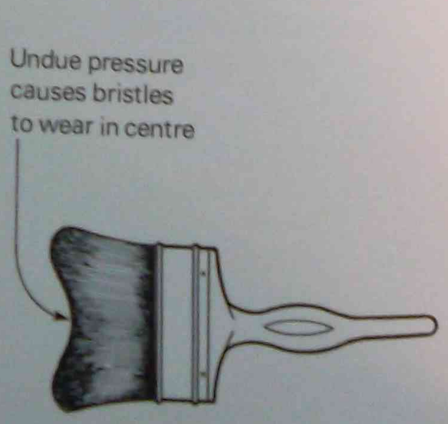
- choose the correct size brush for the job;
  - — Flat large brushes for large areas.
  - — Sash cutters for woodwork.
- do not leave brushes out of paint for any great length of time, causing the paint to dry in the bristles;
- avoid poking the brush at the surface;
  - — The bristles will bend out of shape.
- do not use a large, flat paintbrush edgeways;
  - — This will wear down the corners of the bristles.
- do not apply undue pressure on the brush;
  - — This will cause the bristles to wear out in the centre.

2.4.1 Cleaning brushes

Clean your brushes thoroughly after use to remove all traces of dirt. Pay particular attention to the handle end of the bristles where paint tends to accumulate and harden, causing the bristles to fan out.

FANNED OUT

WORN CORNERS



CENTRE WEAR

Water-based paint

- Remove paint by washing thoroughly in clean water.

NOTE:

Do not wash brushes with the bristles facing upward and the water running down them. This will cause the bristles to tangle and the paint will settle in the bristles near the handle.

- If necessary, remove any hardened paint carefully with a wire brush.
- After washing, spin the brushes to remove traces of dirty water.
  - — Spin in an empty container or bucket to contain the spread of water.
- Wash the brushes in warm, soapy water.
- Rinse thoroughly in clean water.

Oil-based paint

Brushes used for applying oil-based paints can be kept soft overnight by soaking the bristles in water.

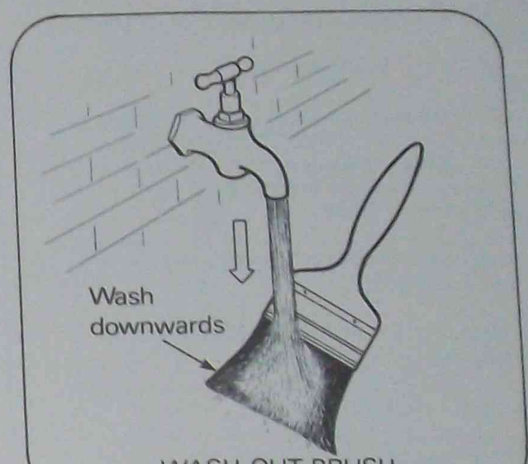
- Suspend the brushes in water so that the bristles are just covered.
- Spin to remove all of the water, before reusing.

If the brushes are to be stored for some time:

- Wash out thoroughly in solvent to remove traces of paint.
- Spin to remove all traces of solvent.
- Wash in soap and water, then rinse clean.
- Straighten and shape the bristles.
- Store the brushes laying down flat.

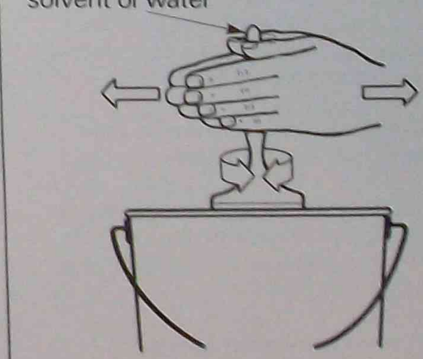
NOTE:

To maintain the shape of the brushes, the bristles can be set in vaseline or neat's-foot oil prior to laying them down.



WASH OUT BRUSH

REMOVING HARDENED PAINT



SPIN TO REMOVE WATER

2.5 PAINT ROLLER EQUIPMENT

2.5.1 Paint rollers

The standard roller consists of a tubular or open-framed cylinder 40 mm diameter by approximately 200 mm long. The cylinder rotates on a spindle attached at right angles to a handle.

Rollers are available in widths from 80 mm up to 460 mm.

Replaceable covers of various fabric materials fit over the roller.

2.5.2 Roller covers

The covers are made to fit firmly over the roller cylinder and are available in widths to suit the various width rollers. The surface is covered with either natural or synthetic fibres or pile, from 6 mm up to 40 mm long, to absorb and hold the paint.

The type and length of the pile is designed to suit the various types of paint to be used and the surface finish over which the paint is applied.

A roller 230 mm wide would be suitable for painting a wall or ceiling approximately 4 metres by 4 metres.

NOTE:

Refer to the manufacturer's specifications and recommendations to select which type of roller would be suitable for the surface to be painted and the type of paint to be used.

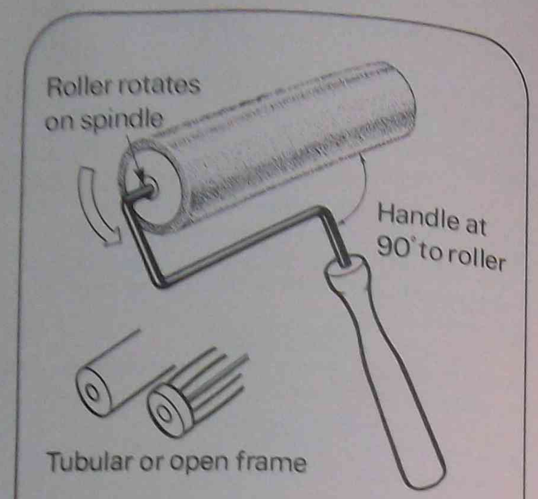
2.5.3 Roller trays

Roller trays and roller buckets are containers designed to hold the paint and are provided with a ribbed, non-skid sloping bottom for loading the roller.

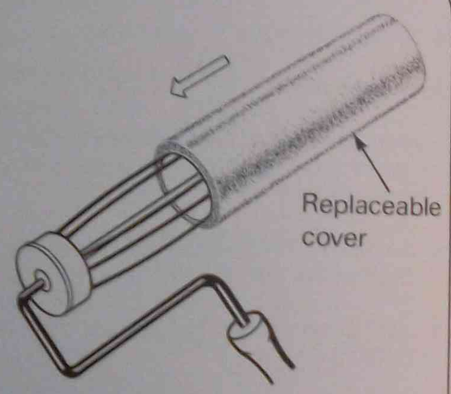
Trays hold approximately 3 litres of paint and buckets hold up to 15 litres.

A roller tray would hold sufficient paint and be safe to use, when working from a scaffolding, to paint a ceiling approximately 4 metres by 4 metres.

For larger areas use a roller bucket.



PAINT ROLLER



ROLLER COVER

ROLLER TRAY

2.6 APPLYING PAINT BY ROLLER

Paint rollers, when used with care, will apply the paint evenly and efficiently.

To obtain a satisfactory finish from paint roller equipment:

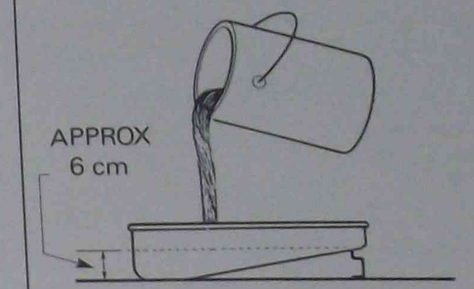
- Select a roller size which you can handle comfortably.
- Choose a roller cover to suit the surface and type of paint.
  - — Refer to the manufacturer's recommendation chart.
- Ensure that all equipment is clean and in good working order.

To load a roller with paint:

- Pour about 6 cm depth of paint into the roller tray or bucket.
- Hold the roller handle firmly and move the roller down the bed of the tray until it is half-covered in paint.
- Draw the roller back up the bed to spread the paint on the cover and to remove excess paint.
- Repeat this procedure until the roller cover is evenly coated with paint.
  - — Do not overload the roller with paint.

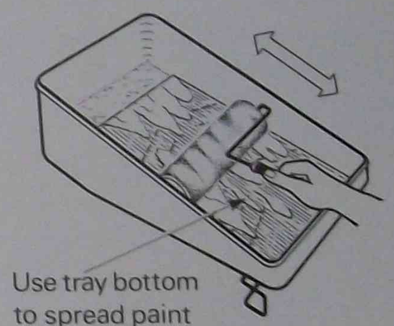
NOTE:

Different roller covers hold varying quantities of paint, depending on the type of pile. Not following the manufacturer's recommendations when choosing a cover could result in poor performance of the roller.



POUR QUANTITY OF PAINT INTO TRAY

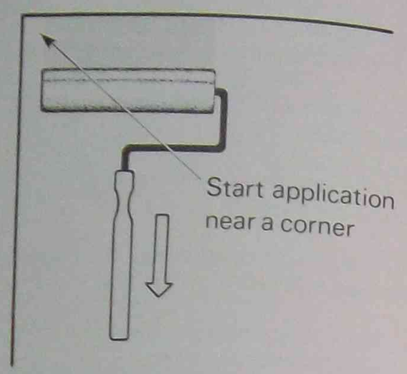
POUR PAINT INTO TRAY



LOADING THE ROLLER

To apply paint by roller:

- Ensure that the roller cover is evenly coated with paint.
- Start application near a corner of the surface.
  - — At the top, if the surface is vertical.

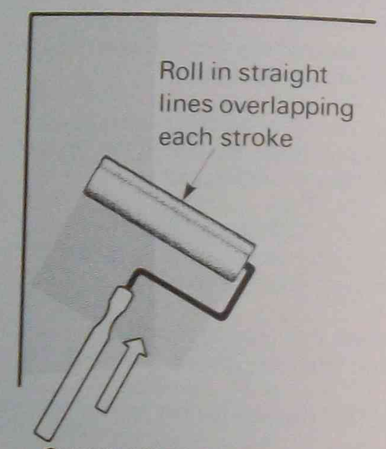


START IN CORNER

- Spread the paint by rolling in straight lines, overlapping with each stroke.
- Work in sections of 1-2 square metres.

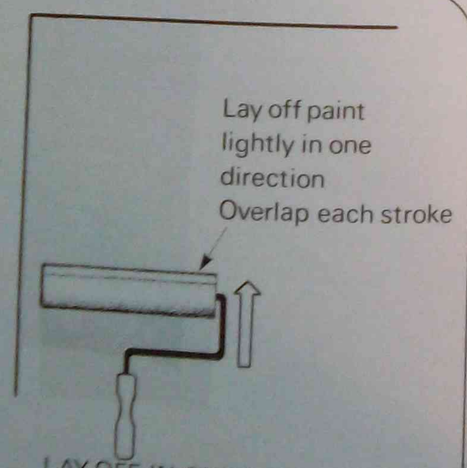
Once the first section of paint is spread evenly:

- Roll out the excess paint from the roller on the bed of the tray.



OVERLAP EACH STROKE

- Lightly roll over the painted section in the one direction to 'lay off' the paint.
  - — Overlap each stroke to ensure that a uniform finish is obtained.
- Repeat the procedure of spreading and laying off in sections until the surface is complete.
  - — Always finish each section by laying off lightly, back into the previously painted area.



LAY OFF IN ONE DIRECTION

2.7 CLEANING ROLLERS

If rollers are to be used again with the same colour and type of paint in the immediate future, immerse them in water. The water covering the rollers prevents the paint from drying.

When a change of colour or paint type is required, or when the roller covers are to be stored for any length of time, carry out the cleaning procedure detailed below.

Water-thinned paints

- Rinse the cover under a running tap or in a bucket of water to remove all traces of paint.
- When reasonably clean, spin out the excess water.
  - — A roller spinner is manufactured for this purpose.

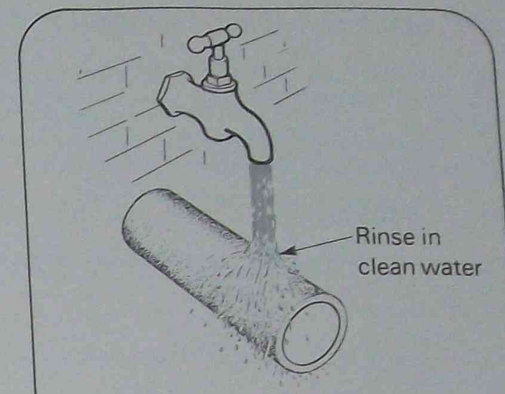
NOTE:

Do not spin out the roller in the area where you have been painting. Spinning spreads the excess paint and water over a wide area.

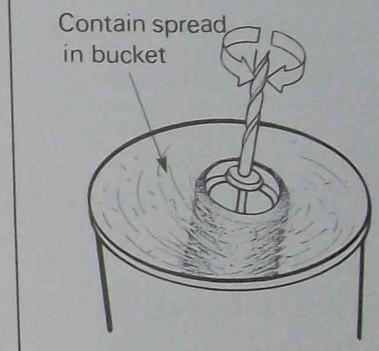
- Clean the roller in an open space. Hold the roller well clear of yourself otherwise you will be spattered, or spin the roller inside a large empty tin or bucket to contain the spread.
- Repeat the rinsing procedure and spin dry.

Solvent-thinned paints

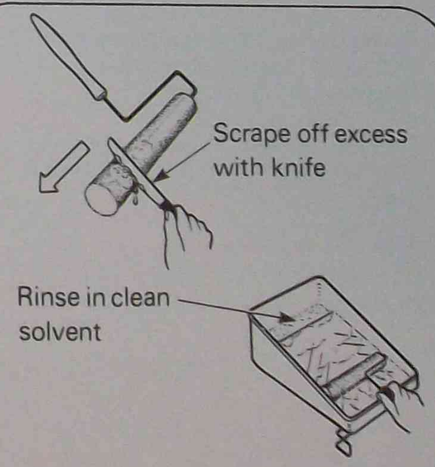
- Carefully scrape off the excess paint from the cover with a knife or scraping blade.
- Pour some clean thinner into a spare roller tray.
- Work the roller into the thinner to remove the remaining paint.
- Spin out the thinner from the roller.
- Replace the thinner in the tray with clean thinner and repeat the procedure.
- Spin the cover dry.
- Wash the cover in soapy water, rinse and spin dry.



WATER-THINNED PAINT



SPIN OUT EXCESS



SOLVENT-THINNED PAINT

3 DEFECTS CAUSED THROUGH POOR APPLICATION TECHNIQUES

Pigmented coatings can be adversely affected by poor application techniques. Some defects become noticeable immediately after application, others may take some time before they appear.

To help you prevent the possibility of defects occurring, examples of defects are defined along with possible causes and means of prevention.

3.1 SHEARNESS

A pigmented coating drying with an uneven gloss or sheen.

Possible causes

- The edge of the paint begins to dry before overlapping of the joints is completed.
- Rapid setting of the paint due to high temperatures, or excessive air movement.
- Application of coatings to a porous surface.
- The intermixing of different paints such as gloss and flat finishes.

Prevention

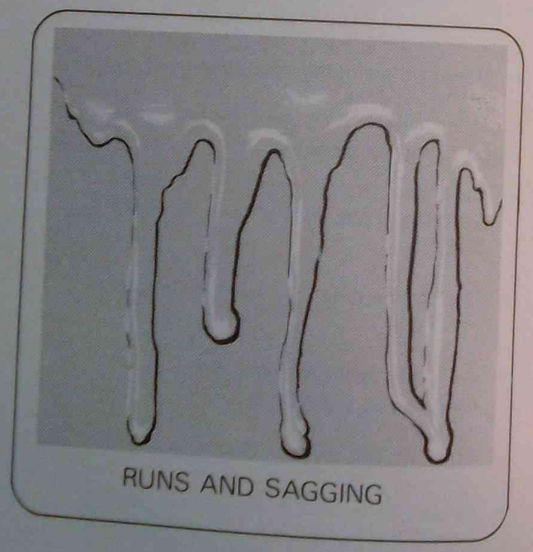
- Do not allow the edges of wet paint to set before commencing the next section.
- If possible, reduce the room temperature when painting inside and avoid excessive air movement.
- Do not paint in direct sunlight.
- Apply finish coatings over well-sealed and undercoated surfaces only.
- Do not intermix different paints.

3.2 RUNS AND SAGGING

Uneven paint film flowing down a vertical surface.

Possible causes

- Failure to 'lay off' or spread the paint thoroughly, causing uneven film thickness.
- Edges of wet paint setting, causing joins in sections to build up paint and sag.
- Paint runs from the corners of mouldings and ornamental work or from projections.



RUNS AND SAGGING

Prevention

- Take care to spread and lay off the paint to ensure even application.
- Do not allow the edges of wet paint to set before overlapping the next section.
- Avoid heavy coats of paint on mouldings, ornamental work and projections.

3.3 THICK EDGES

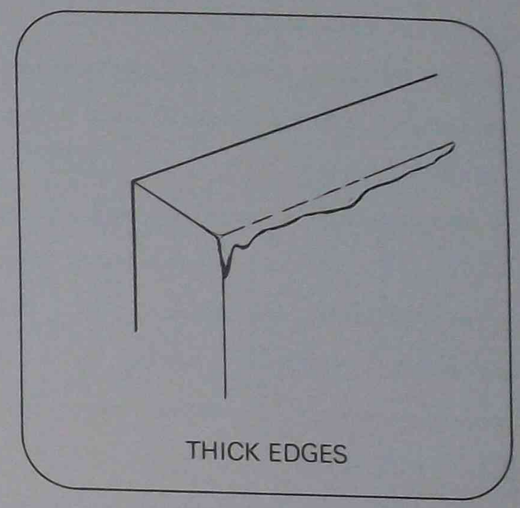
Heavy ridges of paint along the edges of a painted surface.

Possible causes

- Brushing too much paint onto edges.
- Applying too much pressure when rolling a surface near an edge.

Prevention

- Lay off paint near the edges and corners with an almost dry brush.
- Use a roller with care when approaching an edge and do not apply a thick coat or apply undue pressure on the roller.



THICK EDGES

3.4 POOR OPACITY

The failure of a finish coat of paint to obscure completely the surface over which it is applied.

Possible causes

- Uneven paint application causing the finish to appear patchy.
- Spreading the paint out too thinly.
- Overthinning of the paint prior to application.
- Applying light colours over dark.
  - — Some colours are less opaque than others.

Prevention

- Take care to spread and lay off the paint evenly.
- Do not attempt to spread out the paint too thinly.
  - — Refer to the manufacturer's recommended coverage rates listed on the paint can.
- Do not add thinners unless recommended by the manufacturer.
  - — If application is difficult, thinning the paint will reduce its opacity.
- Do not attempt to apply light finish colours over darker undercoats.

3.5 MISSES

Areas which have been left uncoated with paint.

Possible causes

- Careless application.
- Painting under artificial or inadequate lighting conditions.
- Applying paint to textured surfaces using an unsuitable method of application.
- Colour of undercoat too similar to the finish coat.

Prevention

- Apply paint carefully and methodically when spreading and laying off.
- Ensure that painting is carried out under adequate lighting.
- Work away from the light source to help you check completed areas for misses.
- Choose the most efficient method of paint application for textured surfaces.
- Use an undercoat that is slightly lighter in colour than the finish paint.

3.6 ROPINESS

Heavy and thick brushmarks in the surface of the paint film.

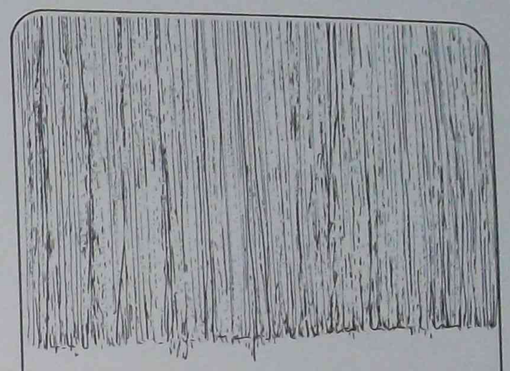
Possible causes

- Uneven or careless application of the paint.
- Brushing too much paint onto the surface.
- Overbrushing the paint until it has begun to set (dry).
- Using paint which is too thick to be brushed easily.
- Applying finish coats to poorly applied undercoats which have brushmarks visible.
- Using a clogged up or dirty brush.
- Applying heavily pigmented coatings (undercoats) onto surfaces that have not been properly sealed.

Prevention

- Use only clean brushes.
- Ensure that surfaces are effectively sealed.
- If an undercoat has brushmarks on its surface, do not apply the finish coat until all brushmarks have been removed by sanding the surface.
- If a paint appears to be too thick to brush, test it on a sample surface and thin if necessary using the manufacturer's recommended thinner.

- Brush paint on in sections, completing each section before proceeding.
- Do not overbrush the paint.
- Do not apply too much paint in one area.
  - The additional thickness will cause brushmarks to stand out.
- Apply paint carefully and methodically when spreading and laying off by brush.



ROPINESS

4 ATMOSPHERIC EFFECTS ON PAINT COATINGS

Paint coatings can be adversely affected by prevailing weather conditions and chemical pollutants. The existing conditions must be considered before applying paint.

Extreme weather conditions and pollutants can affect both wet and dry paint.

Careful pre-planning of exterior work will minimise the possibility of conditions affecting wet paint, e.g. where possible, leave areas protected from the weather for painting during periods of inclement weather.

Careful surface preparation and the choice of finishes will minimise the effect of conditions on dry paint.

The following section details:

- examples of extreme atmospheric conditions and chemical pollutants which may have a detrimental effect on paint coatings;
- the defects these conditions cause to paint;
- the precautions to be taken to avoid these defects;
- the treatment necessary, prior to recoating an affected paint.

4.1 WEATHER CONDITIONS

4.1.1 Wind

A hot wind may cause the paint to dry quickly, making application difficult.

Wind may also blow dust and dirt onto wet paint, resulting in a rough, gritty finish.

Precautions to be taken:

- Avoid painting in extreme windy conditions.
- Clear and sweep away debris and dirt from the surrounding pathways, etc., before painting to minimise the possibility of dirt being blown onto the wet paint.
  - — If possible, dampen down the area by fine spraying with water.

Treatment of affected coatings.

- Do not attempt to treat the surface until the coating is dry, otherwise further damage may result.
- Sand the surface, using an abrasive paper, to remove the dust from the dried paint.
- Recoat the affected area when conditions improve.

4.1.2 Sun

Wrinkling

Direct sunlight onto a wet paint film can cause the coating to dry rapidly. This prevents the film from drying evenly throughout its thickness and may cause the surface of the coating to wrinkle. This defect is most common in oil-based gloss coatings and coatings that have been applied too thickly. Hard drying finishing paints applied over soft (not completely dry) undercoats will often result in wrinkling and cracking.

Precautions

- Avoid painting surfaces in direct sunlight.
- Ensure that the undercoat is thoroughly dry.
- Do not apply too thick a coating.

Treatment

- Allow the coating to dry hard.
- Sand the surface with a coarse-grade silicone carbide paper and water to remove the wrinkles.
  - — Refer to Section 6.3 'sanding surfaces' in the next section of this manual.
- Recoat the affected area when conditions improve.

Cracking and flaking

Sunlight on metal surfaces will cause the metal to heat and expand. If the paint coating is not flexible enough, cracking and flaking of the coating will occur.

Precautions

Refer to the manufacturer's specifications to ensure that the paint coating to be used is suitable for the metal surface to be painted.

Treatment

- Remove the affected coating back to bare metal.
  - — Refer to the manual on surface preparation for details.
- Repaint with a more suitable coating.

Blistering

Painted surfaces with moisture or resin contained within them, when subjected to excessive sun, may cause the coating to blister or bubble when the moisture or resin tries to escape through the coating. Dark colours are more prone to blistering because they absorb more heat.

Precautions

- Ensure that surfaces are thoroughly dry before painting begins.
  - — Brushes that have been stored in water must have all the water removed from the bristles before they are used to apply the paint.
- Use a gas blowtorch to burn out resin from around knots in timber.
  - — Ensure that all moisture and resin have dried out.
- Seal knots with spirit varnish (knotting) to prevent further exudation of resin.
  - — Knotting, a varnish made from shellac and methylated spirits.

Treatment of a blistered coating

- Remove all paint from the surface by burning off.
- Prepare and recoat the surface.

Colour fading

Direct sunlight may cause some colours to fade prematurely.

Precautions

- Use only coatings that are formulated for exterior use.
- Use only light-fast colours on exposed surfaces.

Treatment

- Recoat with a paint recommended for exterior surfaces.
  - — Refer to the manufacturer's specifications when selecting the new paint system.

4.1.3 Humidity

Painting in a humid atmosphere can cause condensation (moisture) to become trapped between the coating and the surface. This may cause flaking and peeling at a later date.

Humidity will cause the drying process of water-thinned coatings to be retarded because evaporation of the water is slowed down.

Condensation caused through humidity promotes the growth of mould and fungus on painted surfaces.

The moisture caused by humidity may cause a milky-white appearance on the surface of gloss finishes. This is called 'blooming'.

Precautions

- Avoid painting in humid conditions.
- Use anti-condensation paints in areas of high condensation.
- Use anti-mould paints on surfaces subject to mould growth.

Treatment of affected coatings

Flaking and peeling

- Remove the affected coating.
- Recoat when the atmosphere is not moisture laden.

Mould and fungus

- Wash the affected coating with a manufactured anti-mould solution.
- Recoat the surface with an anti-mould paint.
- On interior surfaces, improve the ventilation in rooms to reduce condensation.

Blooming

- Mild cases may respond to rubbing with a chamois and warm water.
- Severe cases may need rubbing with a mixture of linseed oil and vinegar.

If removal by the above method is not successful:

- Choose conditions when the atmosphere is not moisture laden.
- Ensure there is adequate ventilation.
- Recoat the surfaces.

4.1.4 Rain

If a paint coating has not dried prior to the commencement of rain, the following defects may occur:

- Pit marks and craters in the surface of an oil-based finish.
- Marks in a water-based coating where the rain has washed the coating off the surface.
- Retarded drying of the coating due to water on its surface.

Precautions

- Do not commence painting if rain is expected before the coating can dry.

Treatment

If the rain has caused pit marks in the coating:

- Allow the coating to dry thoroughly.
- Sand the surface with a medium-grade silicone carbide paper and water to remove the pit marks.
  - — Refer to 'sanding surfaces' in the next section of this manual.
- Recoat the affected area when surfaces will not be affected by rain.

If a water-based coating has been washed off the surface:

- Sand the affected area to a smooth surface and recoat in dry weather conditions.

4.1.5 Frost and fog

If painting is carried out during, or immediately before, a frost or heavy fog, the following defects may occur:

- Retarded drying.
  - — Due to the cold condition slowing down the evaporation of the thinner from the coating.
- Loss of gloss, or blooming.
  - — Due to moisture being taken into the surface.

Precautions

- Do not apply paint in cold, frosty or foggy conditions.
- Do not apply water-based paints when the temperature or surface is below 10 degrees Celsius.
- Do not apply gloss finishes late in the afternoon when the above conditions are expected.

Treatment

If a loss of gloss has occurred:

- Allow the paint to dry thoroughly;
- Follow the precautions outlined above and recoat.

If blooming has occurred:

- Rub with a chamois and warm water; or
- Rub with a mixture of linseed oil and vinegar.

If removal by the above methods is not successful, recoat in dry conditions.

4.2 CHEMICAL POLLUTANTS

Pigmented coatings can be adversely affected by chemical pollutants in the atmosphere and in rain-water which may lay on the painted coatings.

Some pollutants which affect coatings are:

- Hydrogen sulphide
  - — May cause dark stains (sulphide staining) to appear in coatings which contain lead.
- Sulphur dioxide
  - — Can cause crystals to appear on the surface of a coating. These crystals cause an appearance similar to blooming.
- Acids and alkalis
  - — In the atmosphere and in rain-water, may cause the discolouration or bleaching of exposed coatings.

Precautions

- To avoid sulphide staining, use lead-free coatings in industrial areas.
- Where severe chemical attack is likely, use a specialised coating from the vast range available.
- On exterior surfaces, in industrial atmospheres, avoid the use of rich, bright colours which are more likely to discolour and fade.

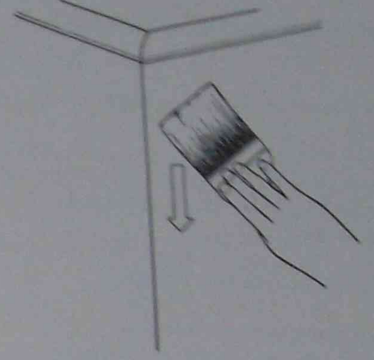
Treatment for affected surfaces

- Wash down the surface with warm water and detergent.
- Follow the above precautions and recoat.

5 GENERAL PAINTING PROCEDURES

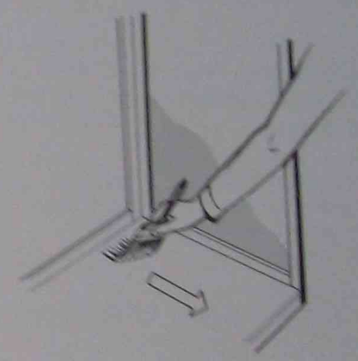
When painting, there are certain guidelines which must be followed in order to complete the task cleanly and efficiently.

- Work down, from top to bottom.
  - — To prevent finished work being damaged by falling dust or paint spots, the ceiling of a room should be finished before the walls.



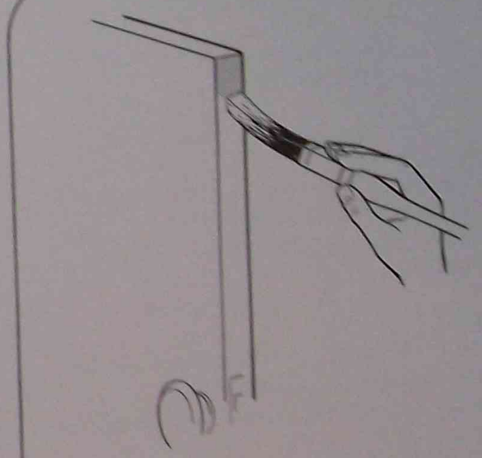
WORK FROM TOP TO BOTTOM

- Work towards yourself.
  - — Always start painting from the furthest point and work towards yourself to prevent you from touching or leaning against finished work.
  - — When painting shelves, bench tops, etc., start painting from the edge furthest from you.



WORK TOWARDS YOURSELF

- Paint the edges first.
  - — A flat surface could be damaged by paint brushed onto the finished face, if its edges are painted last.
  - — Paint the edges of a door before you paint the face.



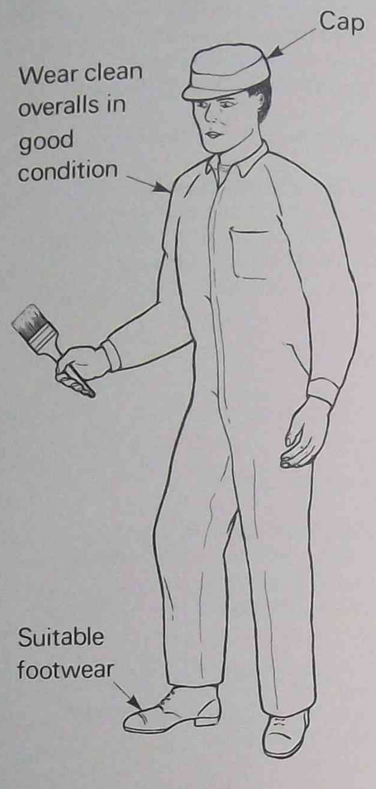
PAINT EDGES FIRST

5.1 HEALTH AND SAFETY

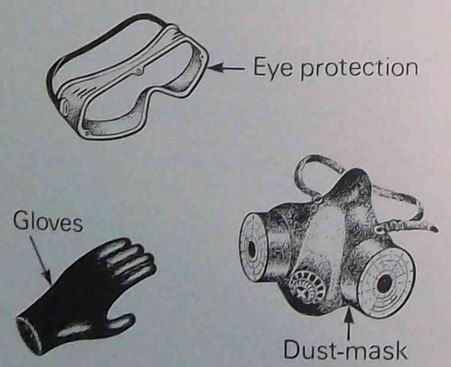
Overalls and protective clothing must be worn.

- Ensure that overalls are in good condition.
  - — Tears in overalls may get caught on scaffolding or surfaces and cause you injury.
- Wear suitable protective footwear.
  - — Reinfored boots, or hard-wearing shoes, will give maximum protection to your feet.
  - — Use only rubber-soled, non-slip footwear.
- Wash overalls at least once a week.
- Do not wear overalls away from the work site.
  - — If worn in public, they spread dirt and subject other people to discomfort.
- Make sure that gloves, eye protection glasses, dust-masks or respirators and ear-muffs are on-site for use when required.
- Wash your hands regularly, especially before eating.
- Use a protective cream on your hands before handling any paint or solvent.
- Do not paint in rooms or enclosed spaces without proper ventilation.
- Do not inhale dust from surfaces being prepared for painting.
  - — Wear a suitable dust-mask.
- Read all instructions on any product if you are in doubt on the health precautions and safe practices to be observed.

NOTE:
Refer to the Health and Cleanliness section of Painting and Decorating Manual Number 1 for further information on safe practices.



DRESS SAFELY – WEAR SUITABLE PROTECTIVE CLOTHING



HAVE THESE ON SITE

5.2 SETTING UP A STORAGE AREA

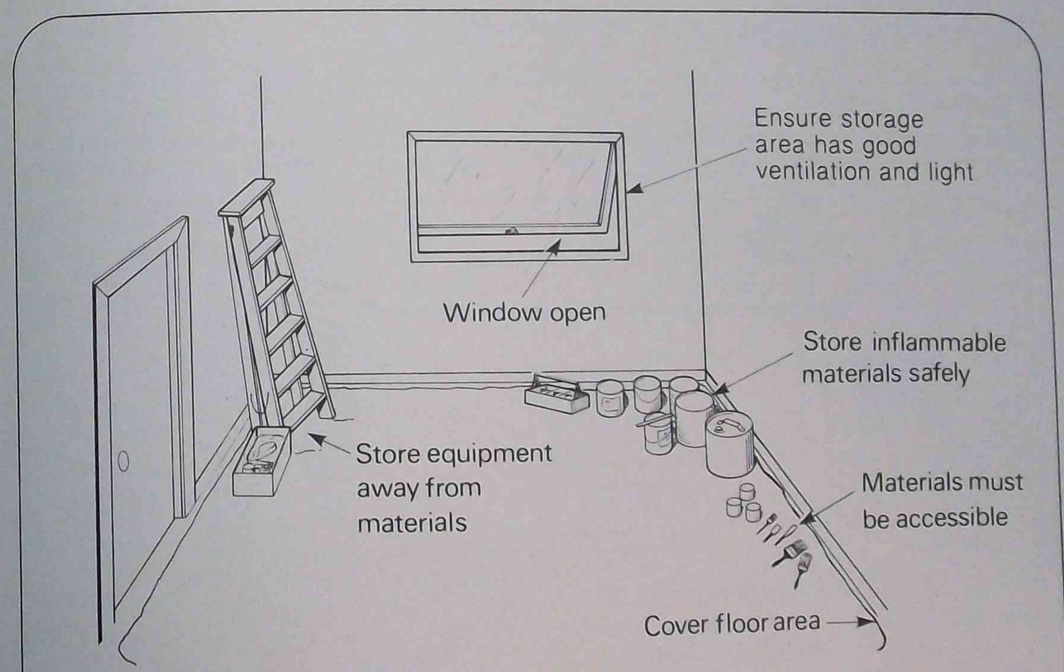
For safety and to allow maximum use of the working area, store all materials and equipment in an area other than the one being painted.

Make sure that the storage area:

- has good ventilation and light;
- is without extremes of temperature;
- is large enough to accommodate easily all materials and equipment;
- is as close as possible to the work area.

When a suitable storage area has been found:

- Cover the floor area to be used with protective drop sheets;
  - — Use double thickness of drop sheet if possible.
- Store materials away from the equipment, to prevent accidents;
- Neatly place all equipment and material so that they are easily accessible;
  - — Keep the area tidy and stay within the covered area.
- Store inflammable materials in an area where the containers cannot easily be tipped over, or damaged, and away from any source of heat or naked flame.



SETTING UP A STORAGE AREA