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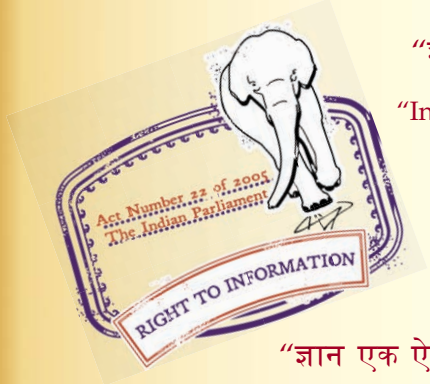
IS 12288 (1987): Code of Practice for Use and Laying of Ductile Iron Pipes [CED 24: Public Health Engineering.]



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"Knowledge is such a treasure which cannot be stolen"

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Indian Standard

CODE OF PRACTICE FOR USE AND LAYING OF DUCTILE IRON PIPES

UDC 628·1/·2 : 621·643·2 (669·131·7) : 006·76

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 6

October 1988

Indian Standard

CODE OF PRACTICE FOR USE AND LAYING OF DUCTILE IRON PIPES

0. FOREWORD

0.1 This Indian Standard was adopted by the Bureau of Indian Standards on 30 December 1987, after the draft finalized by the Water Supply and Sanitation in Buildings Sectional Committee had beed approved by the Civil Engineering Division Council.

0.2 The laying of pipelines for water supply and drainage has been generally governed by the guidelines laid down by various municipalities and local authorities. However, at present there are no guidelines for laying of ductile iron pipes which have been used in India recently at some places. This code is intended to give guidelines for proper laying of ductile iron pipes.

0.3 For the purpose of deciding whether a particular requirment of this standard is complied with, the final values, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This code covers the methods of laying centrifugally cast (spun) ductile iron pressure pipes of diameters 80 mm and above, laid either above ground or below ground for water supply and drainage. It also includes handling and jointing of pipes, hydrostatic testing, commissioning of laid pipes, back filling, restoration and maintenance of surfaces.

1.2 For the purpose of this code, ductile iron pressure pipes and the fittings shall conform to IS : 8329-1977*.

2. ROUTING

2.1 General — The choice of route for a pipeline is governed by economic considerations and other factors such as overhead and underground cables, existing pipelines and traffic flow.

2.2 For cross country terrain before carrying out final field survey, the pipe alignment shall be marked on Survey of India maps and reconnaisance should be undertaken along the pipe route selected. Any change called for should be made before the final survey is undertaken.

2.3 Final Field Survey Plans — Field surveys for strip width representing about 500 m along the proposed alignments should be carried out. Any vertical section or profile along the pipeline route should be shown to a scale appropriate to the variations in ground elevation. Special crossings which require permission from authority should be detailed on separate drawings and cross referenced to the appropriate strip plan; the scale should be between 1 : 100 and 1 : 125 depending on the complexity of the work. In built up areas, consideration should be given to the use of plans of 1 : 1250 scale. In urban areas, trail trenches at suitable intervals will be necessary to locate the utilities which may affect the laying of pipes.

*Specification for centrifugally cast (spun) ductile iron pressure pipes for water, gas and sewage.

3. SITE PREPARATION

3.1 Preliminary work required to be done before laying of pipelines includes pegging out, clearing and disposal of all shrubs, grasses, large and small bushes, trees, hedges, fences, gates, portions of old masonry, boulders, and debris from the route.

3.2 Where trees have been felled, the resulting timber shall be stacked properly and disposed of as directed by the authority. Tree roots within a distance of about 0·5 metre from either side of the pipeline should be completely removed before laying pipelines.

3.3 All other serviceable materials, such as wood, bricks and stones, recovered during the operation of clearing the site, shall be separately stacked and disposed of as directed by the authority.

4. FORMATION

4.1 General — Before pipeline is laid, proper formation shall be prepared for pipeline.

4.2 Excavation and Preparation of Trenches for Laying Underground Pipeline

4.2.1 The width of the trench at bottom between the faces of sheeting shall be such as to provide not less than 200 mm clearance on either side of the pipe except where rock excavation is involved. Trenches shall be of such extra width, when required, as will permit the convenient placing of timber supports, strutting and planking, and handling of specials.

4.2.2 Special consideration should be given to the depth of the trench. In agricultural land, the depth should be sufficient to provide a cover of not less than 900 mm so that the pipeline will not interfere with the cultivation of the land. In rocky ground, rough grazing or swamps, the cover may be reduced provided the water in the pipeline is not likely to freeze due to frost.

4.2.3 It may be necessary to increase the depth of pipeline to avoid land drains or in the vicinity of roads, railways or other crossings.

4.2.4 Care should be taken to avoid the spoil bank causing an accumulation of rainwater.

4.2.5 Where pipes are to be bedded directly on the bottom of the trench (*See* Fig. 1A), it should be trimmed and levelled to permit even bedding of the pipeline and should be free from all extraneous matter which may damage the pipe or the pipe coating. Additional excavation should be made at the joints of the pipes so that the water main is supported along its entire length.

4.2.6 Where excavation is through rocks or boulders, the pipeline should be bedded on concrete bedding (*see* Fig. 1B) or on at least 150 mm of fine grained material (*see* Fig. 1C), or other means are used to protect the pipe and its coating. Material harmful to the pipeline should not be used.

4.2.7 Temporary underpining, supports and other protective measures for building structures or apparatus in or adjacent to the trench should be of proper design and sound construction.

4.3 Rock Excavation — The term 'rock' wherever used in this standard, shall have the same meaning as given in terminology in IS : 1200 (Part 1)-1974*.

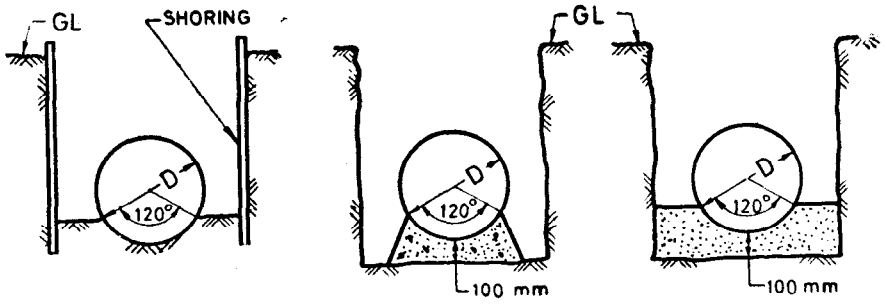
4.3.1 Blasting — Blasting for excavation shall be permitted only after securing the approval of the authority and only when proper precautions are taken for the protection of persons and property. The hours of blasting shall be fixed by the authority. The procedure of blasting shall conform to the requirements of the authority.

4.4 Braced and Sheeted Trenches — Open-cut trenches shall be sheeted and braced as required by any governing state laws and municipal regulations and as may be necessary to protect life, property and the work. When close sheeting is required, it shall be so driven as to prevent adjacent soil from entering the trench either below or through such sheeting.

4.4.1 The authority shall have the right to order the sheeting to be driven to the full depth of the trench or to such additional depths as may be required. Where the soil in the lower reaches of a trench has the necessary stability, the authority at its discretion may permit stopping of the driving of sheeting at some designated elevation above the trench bottom.

4.4.2 Sheeting and bracing which is to be left in place should be removed for a depth of 900 mm below the established street level or the existing surface of the street, whichever is lower. Sheeting except that which has been left in place, may be removed after the backfilling has been completed or has been brought up to such an elevation as to permit its safe removal. Sheeting and bracing may be removed before filling the trench, but only in such a manner as will ensure the adequate protection of the complete work and adjacent structures.

*Method of measurement of building and civil engineering works : Part 1 Earth work (*third revision*).



1A Trench in Earth or Murum

1B Trench in Hard Rock with Cement Concrete Bedding.

1C Trench in Hard Rock with Sand Bedding.

FIG. 1 TRENCHING OF DUCTILE IRON PIPES

4.5 Surface Material for Re-use — All surface materials which, in the opinion of the authority, are suitable for re-use in restoring the surface shall be kept separate from the general excavated material as directed by the authority.

4.6 Stacking Excavated Material — All excavated material shall be stacked in such a manner that it will not endanger the work or workmen and it will avoid obstructing footpaths, roads and driveways. Hydrants under pressure, surface boxes, fire or other utility controls shall be left unobstructed and accessible during the construction work. Gutters shall be kept clear or other satisfactory provisions made for street drainage, and natural water-courses shall not be obstructed.

4.7 Barricades, Guards and Safety Provisions — To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, torches, red lanterns and guards, as required, shall be placed and maintained during the progress of the construction work and until it is safe for traffic to use the roadways. All materials, piles equipment and pipes which may serve as obstruction to traffic shall be enclosed by fences or barricades and shall be protected by illuminating proper lights when the visibility is poor. The rules and regulations of the local authorities regarding safety provisions shall be observed.

4.8 Maintenance of Traffic and Closing of Streets — The work shall be carried including closing of road/street in such a manner which will cause the least interruption to traffic. Where it is necessary for traffic to cross the open trenches, suitable bridges shall be provided.

4.8.1 Suitable signs indicating that a street is closed shall be placed and necessary detour signs for the proper maintenance of traffic shall be provided.

4.9 Protection of Property and Structures — Trees, shrubbery, fences, poles, and all other property and surface structures shall be protected unless their removal is shown on the drawings or authorized by the authority. When it is necessary to cut roots and tree branches, cutting shall be done under the supervision and direction of the authority.

Temporary support, adequate protection and maintenance of all underground and surface structures, drains, sewers and other obstructions encountered in the progress of the work, shall be provided under the direction of the authority. The structures, which may have been disturbed, shall be restored after completion of the work.

4.10 Protection of the Existing Service — As far as possible, the pipeline shall be laid below existing services, like water and gas pipes, cables, cable ducts and drains but not below sewers which are usually laid at greater depth. Where it is unavoidable, pipeline should be suitably protected. A minimum clearance of 150 mm shall be provided between the pipeline and such other services. Where thrust or auger boring is used for laying pipeline across roads, railways or other existing utilities, large clearance as required by the authority shall be provided. Adequate arrangements shall be made to protect and support the existing services during the laying operations. The pipeline shall be so laid as not to obstruct access to other services for inspection, repair and replacement. When such utilities are met with during excavation, the authority concerned shall be intimated and arrangements should be made to support and protect the utilities in consultation with them.

4.11 Back-Filling — For the purpose of back-filling, the depth of the trench shall be considered as divided into the following three zones from the bottom of the trench to its top:

a) *Zone A* : From the bottom of the trench to the level of the centre line of the pipe,

b) *Zone B* : From the level of the centre line of the pipe to a level 300 mm above the top of the pipe, and

c) *Zone C* : From a level 300 mm above the top of the pipe to the top of the trench.

4.11.1 *Back-Fill Material* — All back-fill material shall be free from cinders, ashes, slag, refuse, rubbish, vegetable or organic material, lumpy or frozen material, boulders, rocks or stone or other material, which in the opinion of the authority, is unsuitable or deleterious. However, material containing stones up to 200 mm as their greatest dimension may be used in Zone C, unless specified otherwise herein.

4.11.1.1 *Back-fill sand* — Sand used for back-fill shall be a natural sand complying with **4.11.1**, graded from fine to coarse. The total weight of loam and clay in it shall not exceed 10 percent. All material shall pass through a sieve or aperture size 2·00 mm [*see* IS : 2405 (Part 2)-1980*] and not more than 5 percent shall remain on IS Sieve or aperture size 0·63 mm.

4.11.1.2 *Back-filling gravel* — Gravel used for back-fill shall be natural gravel, complying with **4.11.1** and having durable particles graded from fine to coarse in a reasonably uniform combination with no boulders or stones larger than 50 mm in size. It shall not contain excessive amount of loam and clay and not more than 15 percent shall remain on a sieve of aperture size 75 micron.

*Specification for industrial sieves: Part 2 Perforated plates (*first revision*).

4.11.2 *Back-Filling in Freezing Weather* — Back-filling shall not be done in freezing weather except by permission of the authority, and it shall not be made with frozen material. No fill shall be made where the material already in the trench is frozen.

4.11.3 Back-filling in Zone A shall be done by hand with sand, fine gravel or other approved material placed in layers of 150 mm and compacted by tamping. The back-filling material shall be deposited in the trench for its full width of each side of the pipe, fitting and appurtenances simultaneously.

4.11.4 Back-filling in Zone B shall be done by hand or approved mechanical methods in layers of 150 mm, special care being taken to avoid injuring or moving the pipe. The type of back-fill material to be used and the method of placing and consolidating shall be prescribed by the authority to suit individual locations.

4.11.5 Back-filling in Zone C shall be done by hand or approved mechanical methods. The types of back-fill material and method of filling shall be as prescribed by the authority.

4.11.6 *Back-Fill Under Permanent Pavement* — Where the excavation is made through permament pavements, curbs, paved footpaths, or where such structures are undercut by the excavation, the entire back-fill to the subgrade of the structures shall be made with sand in accordance with **4.11.1.1**. Paved footpaths and pavements consisting of stone, gravel, slag or cinders shall not be considered as being of a permanent construction. Method of placing and consolidating the back-fill material shall be prescribed by the authority.

4.11.7 *Back-Fill With Excavated Material* — The excavated material may be used for back-fill in the following cases, provided it complies with **4.11.1** :

a) In Zone C, in cases where settlement is unimportant and when shown on the drawings or specified, the back-fill shall be neatly rounded over the trench to a sufficient height to allow for settlement to the required level.

b) In any zone, when the type of back-fill material is not indicated or specified, provided that such material consists of loam, clay, sand, fine gravel or other materials which are suitable for back-filling in the opinion of the authority.

4.11.8 *Concrete Slabs Over Pipes* — When pipes are laid under roads and pavement subjected to heavy traffic loads, the trenches may be covered with reinforced concrete slabs of suitable dimensions.

4.12 Preparation of Formation for Pipeline Above Ground — Formation should be prepared by cutting high grounds and filling in low areas. Care should be taken while fixing the alignment and gradient of the pipeline, to balance the cutting and filling quantities, as far as possible, with minimum of load. Care should also be taken to ensure that the pipe rests fully either on cutting or on bank.

4.12.1 *Cutting High Grounds* — Excavation for the formation in cutting should be done in such a manner as to obtain sufficient width at the bottom to accommodate the pipeline, its supports, a service passage and side drains. The sides of the cuttings should generally have the following slopes:

a) Earth *MURUM* and boulders	1 : 1
b) Hard *MURUM* and soft rocks	½ : 1
c) Hard rock	¼ : 1

All excavated material shall be the property of the authority and shall be stacked or disposed of as directed under **4.6** above.

4.12.2 *Preparation of Embankment* — Material used for embankment shall be spread in horizontal layers not exceeding 300 mm thick. Each layer shall be consolidated by watering, ramming and rolling before the next layer is laid. Mechanical consolidation is recommended. The consolidation obtained shall not be less than 90 percent of the proctor density [*see* IS : 2720 (Part 7) 1980*]. Any wash-outs during the rains shall be replaced with suitable material. The embankment shall be finished to the correct dimensions and gradient prescribed by the authority. If banking is to be done on the sloping ground or on embankment, it shall be cut in steps of not less than 300 mm deep and 450 mm wide to give a proper bond. Side slopes of the embankment shall not be steeper than 1½ horizontal to 1 vertical. The slopes of embankment should be protected by pitching or any other method, if so required by the authority.

4.12.3 *Width of Embankment* — The width of the embankment at top shall be such as to accommodate the pipe line and the service passage.

4.12.4 *Materials for Embankment* — Materials used for embankment shall be such that it does not harm the pipeline. It shall not swell when moisture laden, or shrink and crack when dry, and shall have self-draining properties. Mud, clay, slush and decaying vegetable matter shall not be used. The materials shall also be free from cinders, ashes, refuse, rubbish, organic material, frozen material or material which, in the opinion of the authority, is unsuitable or deleterious. All lumps

*Methods of test for soils: Part 7 Determination of water content dry density relation using light compaction (*second revision*).

and clods shall be broken to allow uniform subsidence of the earth work throughout the embankment.

5. LAYING OF PIPES

5.1 Laying Underground — Pipes should be lowered into the trench with tackle suitable for the weight of pipes. For smaller sizes, up to 250 mm nominal bore, the pipe may be lowered by the use of ropes but for heavier pipes, either a well designed set of shear legs or mobile crane should be used. When lifting gear is used, the positioning of the sling to ensure a proper balance, should be checked when the pipe is just clear of the ground. If sheathed pipes are being laid, suitable wide slings or scissor dogs should be used.

All construction debris should be cleared from the inside of the pipe either before or just after a joint is made. This is done by passing a pull-through in the pipe, or by hand, depending on the size of the pipe. When laying is not in progress, a temporary end closure should be securely fitted to the open end of the pipeline. This may make the pipe buoyant in the event of the trench becoming flooded, in which case the pipes should be held down either by partial re-filling of the trench or by temporary strutting. All persons should vacate any section of trench into which the pipe is being lowered.

5.1.1 On gradients of 1 : 15 or steeper, precautions should be taken to ensure that the spigot of the pipe being laid does not move into or out of the socket of the laid pipe during the jointing operations. As soon as the joint assembly has been completed, the pipe should be held firmly in position while the trench is backfilled over the barrel of the pipe. The backfill should be well compacted.

5.2 Laying Above Ground — The ground should be dressed to match the curvature of the pipe shell for an arch length subtending an angle of 120° at the centre of the pipes. Alternatively, the pipeline should be laid either on saddle, roller or rocker supports as specified by authority. The pipes may be allowed to rest on ground if the soil is non-aggressive.

5.3 Supporting Pipes above Ground — The following recommendations assume that no additional bending moments above those due to the self weight of the pipe and its contents are present.

5.3.1 *With Spigot and Socket Pipes* — It is recommended that above ground installations of spigot and socket pipes be provided with one support per pipe, the supports being positioned behind the socket of each pipe.

This results in a normal distance between supports of 4 m as shown in Fig. 2A.

Pipes should be fixed to the supports with mild steel straps so that axial movement due to expansion or contraction resulting from temperature fluctuation, is taken up at individual joints in the pipeline. In addition, joints should be assembled with the spigot end withdrawn 5 to 10 mm from the bottom of the socket to accommodate these thermal movements.

Pipes supported in this way are capable of free deflection and axial movement at the joints which accommodate small movements of the pipe supports.

The designed anchorage shall be provided to resist the thrusts developed by internal pressure at bends, tees, etc.

Where a pipeline crosses a watercourse, the design and method of construction should take into account the characteristics of the watercourse. The concerned authorities may be consulted to ascertain the nature of bed, scour levels, maximum velocities, high flood levels, seasonal variation, etc, which affect the design and laying of pipeline. Early consultation with river authorities will assist in evaluating the effect of river characteristics (for example, nature of bed, scour levels, maximum velocities, high flood levels, seasonal variations, etc), on design and construction.

If necessary, unsupported spans between 4 and 6 m may be obtained by positioning the pipe supports relative to the pipe joints as shown in Fig. 2B

5.3.2 *With Flanged Pipes* — The recommended maximum unsupported span is 8 m. The supports shall be located at the centre of every second pipe as shown in Fig. 3A.

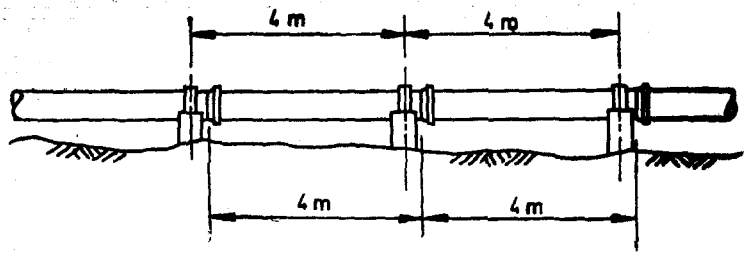
The recommended maximum unsupported span at water course is 8 m. The relative positions of pipe joints and pipe supports should be as shown in Fig. 3B.

The supports of all flanged pipework spans should be stable and unyielding due to movements in the pipeline.

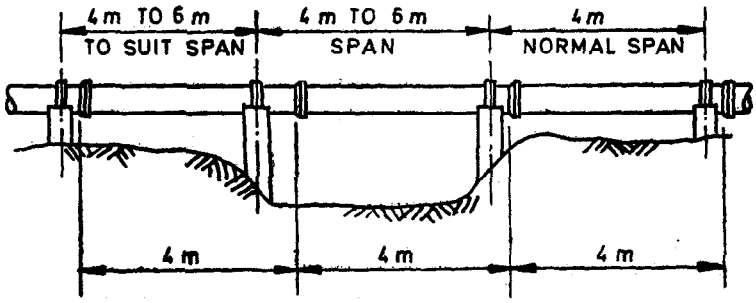
The straps should prevent any lateral movement or lifting of the pipelines but not restrict expansions and constructions caused by temperature fluctuations.

5.4 Cutting of Pipes — The cutting of pipe for inserting valves, fittings, etc, shall be done in a neat and workman like manner without damage to the pipe or lining so as to leave a smooth end at right angles to the axis of the pipe. Methods of cutting ductile iron pipes are given in **5.4.1** to **5.4.3**.

5.4.1 *By Hacksaw* — Hand or power operated hacksaw should be used with blades having teeth at a pitch of 1 mm.

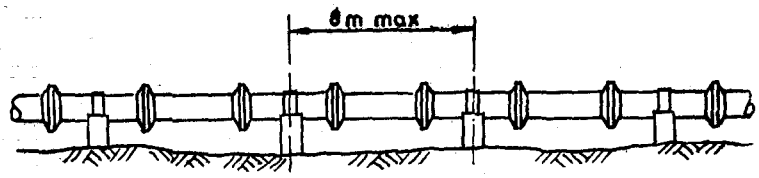


2A. PIPES OVER NORMAL GROUND

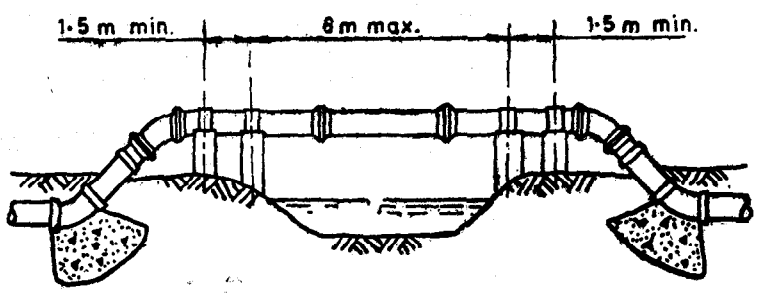


2B. PIPES CROSSING OVER WATER COURSE

FIG. 2 SPIGOT AND SOCKET PIPES LAYING ABOVE GROUND



3A. PIPES ABOVE NORMAL GROUND



3B. PIPES CROSSING WATER COURSE

FIG. 3 FLANGED PIPE LAYING ABOVE GROUND

5.4.2 *By Manually Operated Wheel Cutter* — The type of cutting wheel used for cast iron pipes is not suitable for ductile iron pipe. Special wheels, as used for cutting steel pipes, shall be used and cut ends are trimmed with a file.

5.4.3 *By Pipe Cutting Machine* — Machines with cutter heads or abrasive wheels shall be used. Cutter head should have a front rake angle of 7° as used for steel pipes.

5.5 End Preparation of Cut Pipes for Jointing — The burr left after cutting should be trimmed off by light grinding or by filling.

5.6 Wrapping — When ductile iron pipes are to be laid in aggressive soils, the pipes should be wrapped externally with protective coatings, such as bitumen or coaltar sheathing protective tapes or by loose polythene sleeving, or in certain circumstances, concrete before laying. At joints, bends and valves, precautions should be taken to provide sufficient overlap of the wrapping sleeve so that no pipeline is exposed to the aggressive soil.

5.7 Pipeline Markers — Distinctive markers should be erected at all roads, railways, river and canal crossings, and elsewhere as required to identify the pipeline and to indicate its position. Markers should be placed at field boundaries, preferably in such a way that they are not obscured by vegetation. At all valve installations, plates should be provided to give the same information as on the makers. Markers should not be treated with any substance likely to be harmful to livestock.

5.8 Pipeline Anchorage — All pipelines having unanchored flexible joints require anchorage at changes of direction and at dead ends to resist the static thrusts developed by internal pressure. Dynamic thrusts caused by flowing water act in the same direction as static thrusts. This thrust is of sufficient magnitude at high velocities to warrant safety consideration.

Anchorages to resist the thrust should be designed taking into account the maximum pressure the main is to carry in service or on test, and the safe bearing pressure of the surrounding soil.

Where possible, concrete anchor blocks should be of such a shape as to allow sufficient space for the remaking of the joints. Figure 4 shows typical anchorages using concrete anchor blocks.

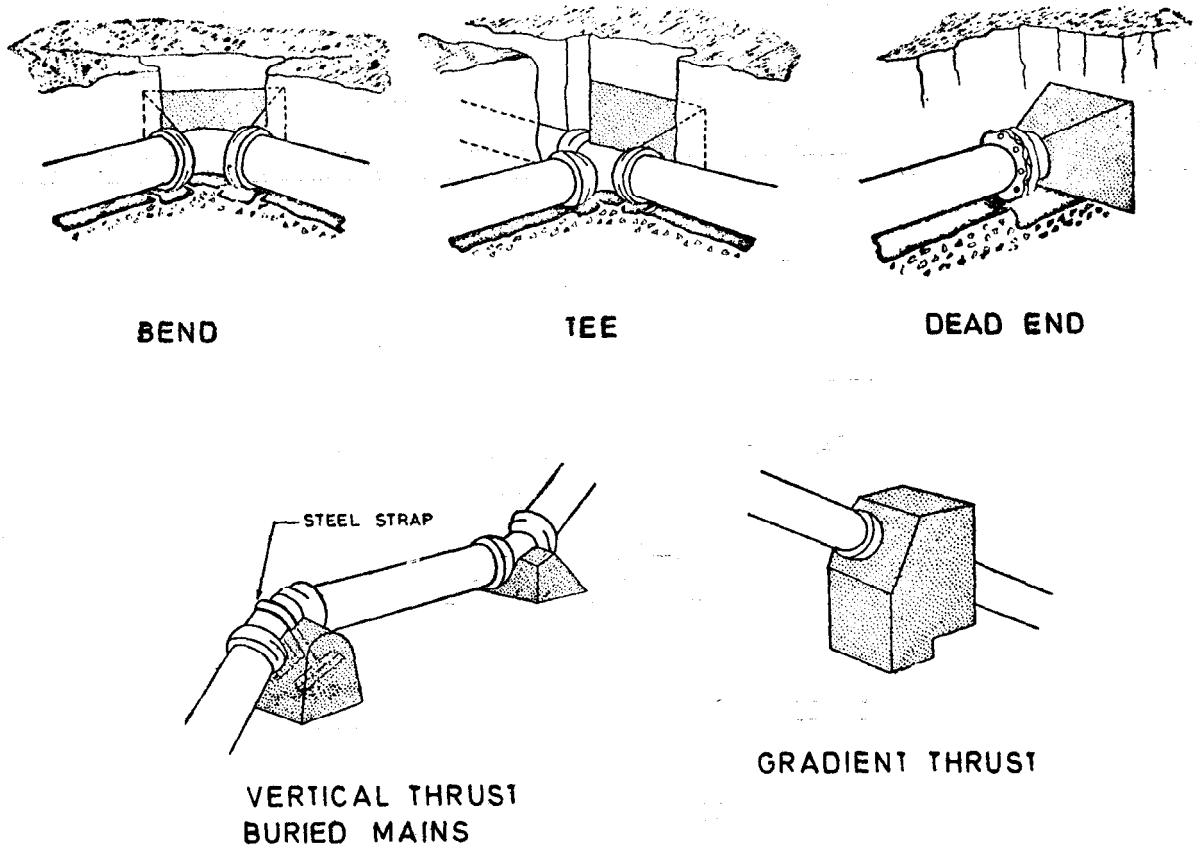


FIG. 4 TYPICAL THRUST BLOCKS

Pipeline should be securely anchored at dead ends, tees, bends, tapers and valves to resist thrust arising from internal pressure. Anchors and thrust blocks should be designed in accordance with IS : 5330–1984*. Steeply inclined pipelines should be secured by transverse anchors spaced as shown below:

Spacing of Transverse Anchors for Steeply Inclined Pipelines

Gradient	*Spacing* m
1 in 2 and steeper	5·5
Below 1 in 2 to 1 in 4	11·0
Below 1 in 4 to 1 in 5	16·5
Below 1 in 5 to 1 in 6	22·0
Flatter than 1 in 6	Not usually required

Typical anchor blocks to resist horizontal thrust, vertical thrust and gradient thrust for buried mains are shown in Fig. 4.

6. JOINTS AND JOINTING

6.0 Two main types of joints are used with ductile iron pipes and fittings:

a) Socket and spigot flexible joints:
   1) Push on joints; and
   2) Mechanical joints;
b) Rigid flanged joint.

6.1 Flexible Joint — The spigot and socket flexible joint should be designed to permit angular deflection in direction and axial movement to compensate for ground movement and thermal expansion and contraction. They incorporate gasket of elastomeric materials and the joints may be of the simple push-on-type or the type where the seal is effected by the compression of a rubber gasket between a seating on the inside of the socket and the external surface of spigot. Joints of the latter type are referred to as mechanical joints. Both push-in (Fig. 5A) and mechanical joints are flexible joints. Flexible joints require to be externally anchored at all changes in direction such as at bends, etc, and at blank end to resist the thrust created by internal pressure and to prevent the withdrawal of spigots.

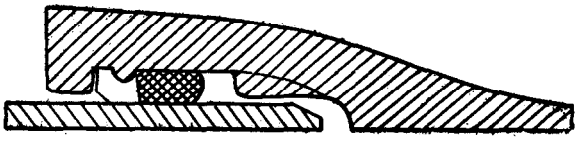
6.2 Flanged Joint — Flanged joints are made on pipes having a machined flange at each end of the pipe. The seal is usually effected by means of a flat rubber gasket compressed between two flanges by means of bolts which also serve to connect the pipe rigidly (*see* Fig. 5B). Gaskets of other materials, both metallic and non-metallic, are used for special applications.

6.3 Jointing Procedure — Procedure for jointing will vary according to the type of joint being used. Basic requirements for all types are:

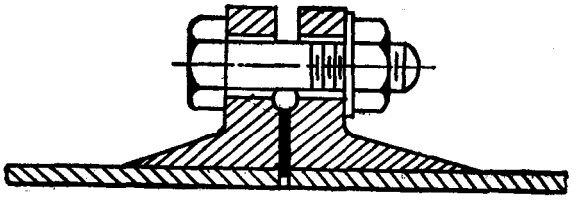
a) Cleanliness of all parts,
b) Correct location of components,
c) Centralization of spigot within socket, and
d) Strict compliance with manufacturer's jointing instructions.

The inside of sockets and the outside of spigots should be cleaned and wirebrushed for a

*Criteria for design of anchor blocks for penstocks with expansion joints (*first revision*).



5A. FLEXIBLE JOINT (PUSH IN TYPE)



5B. FLANGED JOINT

FIG. 5 TYPICAL TYPES OF JOINTS

distance of 150 to 225 mm. Glands and gaskets should be wiped clean and inspected for damage. When lifting gear is used to place the pipe in the trench, it should also be used to assist in centralizing the spigot in the socket.

Where the pipeline is likely to be subjected to movement due to subsidence or temperature variations, the use of flexible joints is recommended. A gap should be left between the end of the spigot and the back of the socket to accommodate such movement.

7. TRANSPORTATION, HANDLING AND INSPECTION

7.1 General — Ductile iron pipes are less susceptible to cracking or breaking on impact but the precautions set out should be taken to prevent damage to the protective coating and brushing or damage of the jointing surfaces.

7.2 Transportation — Pipes should be loaded in such a way that they are secured and that no movement should take place on the vehicle during transit.

The pipes should be loaded on vehicles in pyramid or straight sided formation. In case of pyramid loading, the pipes in the bottom layer should be restrained by the use of broad wooden wedges secured to the vehicle being loaded. The pyramid is to be formed by resting pipes between the pairs of pieces in the preceding layer with the sockets in layers reversed. Straight sided loading may be used with supports along the sides of the vehicles. The use of straight sided loading is advantageous for utilizing full capacity of the vehicle.

7.3 Off-Loading — Cranes should be preferred for off-loading. However, for pipes up to 400 mm nominal bore, skid timbers and ropes may be used.

When using mechanical handling equipment, it is necessary to employ sufficient personnel to carry out the operation efficiently with safety. The pipes should be lifted smoothly without any jerking motion and pipe movement should be controlled by the use of guide ropes in order to prevent damage caused by pipes bumping together or against surrounding objects.

Where the crane operator does not have a clear view, he should be guided by the personnel supervising the operation. When cranes are used, the whole sequence of operation should be carried out smoothly and without snatch. Properly designed hooks and adequate stead ropes are essential. The hooks should be of suitable shape to ensure positive engagement when entered into the ends of the pipes and then should pass over any protective packing fitted around the pipe ends.

The use of slings passed around bundles of pipes is not recommended because bundles become unstable as the sling is drawn tight or released. However, when it is necessary to use the central slinging method for lifting single pipe, a broad webbing sling is recommended which minimizes the risk of the pipe slipping. Chain slings may slip and are dangerous.

7.4 Stacking — Pipes being taken to a stock ground for storage and held pending further distribution should be arranged into stacks. The first layer of pipes should be laid on a firm foundation consisting of solid timbers set level on the ground. Subsequent layers should be placed according to the method of stacking adopted. Care should be taken so that the pipes do not rest on their sockets. The height of any stack should not exceed 2 m.

Methods adopted for stacking pipes are described in **7.4.1** to **7.4.5**.

7.4.1 *Square Stacking* — In square stacking method, second and subsequent layers are set at right angles to the previous layer with spigots and sockets alternating in each layer and sockets project beyond spigot end. The pipes rest directly upon those beneath it and care is needed in placing to prevent damage.

7.4.2 *Parallel Stacking with Timbers* — All the pipes are parallel with the sockets of successive layers reversed end-to-end with sockets projecting beyond spigot end. Timber battens, placed about 600 mm from each end at right angles to the pipes, are used to separate the successive layers. Wedges at both ends of each batten prevent pipe movement.

7.4.3 *Nested Stacking (Pyramid Stacking)* — Nested stacking consists of placing each pipe between the two pipes underneath it, with the sockets being all at one end of each layer and being reversed in successive layers. The bottom layer should be firmly anchored to prevent the stack collapse.

7.4.4 *Special Precautions for Bitumen-Sheathed Pipes* — Bitumen-sheathed pipes should be handled with care to avoid any damage to the sheathing. They should not be stacked but laid in a single layer supported on timbers placed under the uncoated portions of the spigots and sockets. Sheathed pipes should be lifted by means of properly designed hooks, fittings into the spigot or socket, or by specially designed slings which will not damage the sheathing. Wire rope, chains or hemp slings should not be used.

7.4.5 *Stringing* — Stringing consists of placing pipes on the ground in line ready for laying. Care should be taken to prevent damage during this operation.

8. HYDRAULIC TESTING

8.1 After a new pipeline is laid and jointed, testing shall be done for :

a) mechanical soundness and leak tightness of pipes and fittings;

b) leak tightness of joints; and

c) soundness of any construction work, in particular that of the anchorages.

8.2 Hydrostatic Testing — The completed pipeline may be tested either in one length or in sections; the length of section depending upon :

1) availability of suitable water,

2) number of joints to be inspected, and

3) difference in elevation between one part of the pipeline and another.

Where the joints are left uncovered until after testing, sufficient material should be backfilled over the centre of each pipe to prevent movement under the test pressure.

It is prudent to begin testing in comparatively short length of test section. Progressively as experience is gained, lengths of about 1·5 km or more, are tested in one section, subject to consideration of length of trench which can be left open in particular circumstances.

Each section should be properly sealed-off, preferably with special stop ends secured by adequate temporary anchors. The thrust on the stop ends should be calculated and the anchors designed to resist it. All permanent anchors (*see* **5.8**) should be in position and, if of concrete, should have developed adequate strength before testing begins. The section under test should be filled with water, taking care that all the air is displaced either through vents at the high points or by using a pig or a sphere.

8.3 The test pressure to be applied should be not less than any of the following:

a) The maximum sustained operating pressure,

b) The maximum static pressure plus 5 N/mm^2, and

c) The sum of the maximum sustained operating pressure (or the maximum static pressure) and the maximum calculated surge pressure.

After filling, the pipeline should be pressurized to the specified operating pressure and left for a period of time to achieve stable conditions.

The length of this period of time depends on many factors such as slight movement of the pipeline under pressure whether air is trapped in the pipeline or whether the pipeline has a concrete lining which absorbs water.

The pipeline is then pressurized up to the full test pressure and the section under test completely closed off. The test should be maintained for a period of not less than 10 minutes to reveal any defects in the pipes, joints or anchorages.

The test pressure should be measured at the lowest point of the section under test or alternatively, an allowance should be made for the static head between the lowest point and the point of measurement, to ensure that the required test pressure is not exceeded at the lowest point.

8.4 In case of extreme temperature conditions, there may be a tendency of hydraulic pressure building up inside the pipeline because of expansion of water during the high day time. This should normally not be of any major concern as the joints and the pipes are manufactured to resist a much high pressure. However, sufficient care should be taken to prevent floating bulging of the pipeline because of building up of such high pressure during the temperature rise.

8.4.1 If the test is not satisfactory, the fault should be found and rectified. Where there is difficulty in locating a fault, the section under test should be sub-divided and each part tested separately.

Methods employed for finding leaks include:

a) Visual inspection of each joint if, not covered by the backfill;

b) Use of a bar probe to detect signs of water in the vicinity of joints, if backfilled;

c) Aural inspection using a stethoscope or listening stick in contact with the pipeline;

d) Use of electronic listening device which detects and amplifies the sound or vibrations due to escaping of water, actual contact between the probe and the pipe is not essential;

e) Injection of a dye into the test water–particularly suitable in water-logged ground; and

f) Introduction of nitrous oxide in solution into the test water and using an infra-red gas concentration indicator to detect the presence of any nitrous oxide that has escaped through the leak.

8.5 After all sections have been joined together on completion of section testing, a test on the complete pipeline should be carried out. This test should be carried out at a pressure not less than the maximum sustained operating pressure or the maximum static pressure of the pipeline and, during the test, inspection made of all work which has not been subject to section tests. During the test, the pressure at the lowest point in the pipeline should not exceed the maximum given in Table 1.

TABLE 1 MAXIMUM FIELD HYDROSTATIC TEST PRESSURE FOR DUCTILE IRON PIPELINES WITH FLEXIBLE JOINTS

NOMINAL BORE mm	MAXIMUM FIELD HYDROSTATIC TEST PRESSURE N/mm²
Up to 300	4·5
350 to 600	3·0
700 to 1200	2·1

NOTE 1 — The above pressures are 0·5 N/mm² higher than the pressure ratings for ductile iron pipes and fittings with flexible joints. It is not considered necessary to field test ductile iron pipelines to 1½ times the design operating pressure as is often the practice with grey iron pipelines.

NOTE 2 — The field test pressures is applied to ductile iron pipelines only when the pipeline and its fittings are properly anchored.

8.6 It is important to ensure that proper arrangements are made for the disposal of water from the pipeline after completion of hydrostatic testing and that all consents which may be required from authorities have been obtained. In some cases, for example, heavily chlorinated water, some treatment may be necessary before final disposal.

9. FLUSHING AND DISINFECTION OF MAINS BEFORE COMMISSIONING

9.1 The mains intended for potable water supplies should be disinfected before commissioning them for use.

9.1.1 *Distribution System Chlorination of New Mains* — Special care should be taken to ensure disinfection of new mains. Among possible sources of contamination are sewer drainage, contaminated soil in the trench, contamination from workmen and or their equipment and, unavoidable foreign material present in the trench during construction.

9.1.2 Education of crew members for avoiding contamination of the main during construction is fundamental. Contractors and workmen should be thoroughly familiar with all pertinent state and local requirements governing installations of mains. All sewers, water mains and other underground conduits should be located prior to construction and relocated, if necessary, to prevent contamination during construction. Pipe should be strung on high ground. At all times when construction is not actually in progress, watertight plugs should be installed in all pipe openings. Gunny sacks and rags are not adequate. Provision should be made to pump any other water that might have collected in the trench. Special care should be taken to avoid contamination of valves, fittings, and pipe interiors, both before and during construction, each should be inspected and, if necessary, cleaned before installation.

After pressure testing the main, it should be flushed with water of sufficient velocity to remove all dirt and other foreign materials. When this process has been completed, disinfection (using liquid chlorine, sodium or calcium hypochlorite) is proceeded by one of the recommended methods as described in **9.2** and **9.3**.

9.2 Continuous Feed — In this method, water from the distribution system or other approved source and the chlorine from selected source are fed at constant rate into the new main at a concentration of at least 20 to 50 mg/litre. A properly adjusted hypochlorite solution injected into the main with a hypochlorinator, or liquid chlorine injected into the main through a solution feed chlorinator and booster pump may be used. The chlorine residual should be checked at intervals to ensure that the proper level main is filled. All valves, hydrants, etc, along the main should be operated to ensure their proper disinfection. The water should remain in the main for a minimum of 24 hours. Following the 24 hour period, no less than 10 mg/l chlorine residual should remain in the main.

9.3 Slug Method — In this method, a continuous flow of water is fed with a constant dose of chlorine with rates proportioned to give a chlorine concentration of at least 300 mg/l. The chlorine is applied continuously for a period of time to provide a column of chlorinated water that will contact all interior surfaces of the main for a period of at least three hours. As the slug passes, tees, crosses, etc, valves should be operated to ensure their disinfection. This method is used principally for large diameter mains where continous feed is impractical.

9.4 Regardless of the method used, it is necessary to make certain that backflow of the strong chlorine solution into the supplying line does not occur. Following the prescribed contact period, the chlorinated water should be flushed to waste until the remaining water has a chlorine residual approximating that throughout the rest of the system. Bacteriological tests as prescribed by the authorities should be taken, and if the results fail to meet minimum standards, the disinfecting procedure should be repeated and the results again tested before placing the main in service.

10. REMOVAL, RESTORATION AND MAINTENANCE OF PAVED FOOTPATHS, ETC, AFTER LAYING OF PIPE

10.1 Allowable Removal of Pavement — Pavement and road surfaces may be removed as a part of the trench excavation, and the amount removed shall depend upon the width of trench specified for the installation of the pipe and the width and length of the pavement area required to be removed for the installation of gate valves, specials, manholes or other structures. The width of pavement removed along the normal trench for

the installation of the pipe shall not exceed the width of the trench specified by more than 150 mm on each side of trench. The width and the lengths of the area of pavement removed from the installation of gate valves, specials, manholes or other structures should not exceed the maximum linear dimensions of such structures by more than 150 mm on each side. Wherever, in the opinion of the authority, existing conditions make it necessary or advisable to remove additional pavement, it shall be removed as directed by the authority.

10.2 Restoration of Damaged Surface and Property — Where any pavement, shrubbery, fences poles or other property and surface structures have been damaged, removed or disturbed during the course of work, such property and surface structures shall be replaced or repaired after completion of work. All pavements, paved footpaths, curbing, gutters, shrubbery, fences, poles, sod or other property and surface structures removed or disturbed as a part of the work shall be restored to a condition equal to that before the work began, furnishing all labour and materials incidental thereto. In restoring the pavement, sound stone blocks, sound brick or asphalt paving blocks may be re-used. No permanent pavement shall be restored unless and until, in the opinion of the authority, the condition of the back-fill is such as to properly support the pavement.

10.3 Cleaning-up — All surplus materials, and all tools and temporary structures shall be removed from the site as directed by the authority. All dirt, rubbish and excess earth from the excavation shall be hauled to a dump and the construction site left clean to the satisfaction of the authority.