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Construction and installation of ductile iron pipeline system

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 5, *Ferrous metal pipes and metallic fittings*, Subcommittee SC 2, *Cast iron pipes, fittings and their joints*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Construction and installation of ductile iron pipeline system

1 Scope

This document specifies the recommended practices and requirements for the installation of buried and above-ground ductile iron pipeline system conforming to ISO 2531, ISO 7186 and ISO 16631.

The recommended practices in this document are intended to provide the practical advices based on the best methods of construction and installation of ductile iron pipeline system including pipes, fittings, valves and accessories.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2531:2009, *Ductile iron pipes, fittings, accessories and their joints for water applications*

ISO 4179:2005, *Ductile iron pipes and fittings for pressure and non-pressure pipelines — Cement mortar lining*

ISO 8179-1:2017, *Ductile iron pipes, fittings, accessories and their joints — External zinc-based coating — Part 1: Metallic zinc with finishing layer*

ISO 8180, *Ductile iron pipes — polyethylene sleeving for site application*

ISO 10802, *Ductile iron pipelines — Hydrostatic testing after installation*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2531 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
system test pressure
STP
hydrostatic pressure applied to newly laid pipeline in order to ensure its integrity and leak tightness, based on project requirements of working pressure and the surge pressure

Note 1 to entry: The system test pressure (Clause 14) shall never exceed the maximum allowable site test pressure of each component of the pipeline i.e. pipes, *valves* (3.8), fittings and other accessories.

3.2
gravity system
system where flow and/or pressure are caused by the force of gravity.

Note 1 to entry: There are two kinds of such systems:

— pressurized gravity system, where the pipeline operates full;

— non-pressured gravity system, where the pipeline operates partially full.

Note 2 to entry: See 13.1.6.

3.3
local main
water main which connects *principal main(s)* (3.4) with *service pipes* (3.6)

Note 1 to entry: See 13.1.4.

3.4
principal main
water main serving as a principal distributor within the supply area, normally without direct consumer connections

Note 1 to entry: See 13.1.4.

3.5
pumped or gravity system
system where the *gravity system* (3.2) and the pumped system are used, either separately or in combination, to provide the flow and/or pressure

3.6
service pipe
water pipe which supplies water from the *local main* (3.3) to the consumer

3.7
trunk main
water main which interconnects source(s), treatment works, reservoir(s) and/or supply areas, normally without direct consumer connection(s)

Note 1 to entry: See 13.1.4.

3.8
valve
component isolating or controlling flow and pressure

EXAMPLE Isolating valves, control valve, air release valve, non-return valve, hydrant.

Note 1 to entry: See Clause 13.

4 Occupational safety and health requirements

During the execution of the works, it is presupposed that local/national regulations on occupational safety and health are followed.

5 Materials in contact with water intended for human consumption

When used under the conditions for which they are designed, in permanent or in temporary contact with water intended for human consumption, ductile iron pipes, fittings and their joints shall not have detrimental effects on the properties of that water for its intended use.

Ductile iron pipeline systems, including pipes, fittings, accessories and joints, consist of various materials. When used for conveying water intended for human consumption, it is presupposed that the materials in contact with the water meet the relevant requirements of the national standards or regulations in the country of use with respect to effect on water quality.

6 Input control, transport, handling and storage of pipeline components and inspection

6.1 Input control

Immediately after the uploading of the pipes at site, pipeline components, including fittings and accessories, should be checked for the markings, suitability for the use in the defined project and should be inspected for the following:

— deformations or dent;

— cracks;

— damage to the pipe ends;

— damage to the external coating and internal lining.

Items requiring repair should be identified and stored separately.

6.2 Transport, handling and storage and inspection of pipeline components

6.2.1 Transport

The following precautions shall be taken during transport and handling of pipe and pipeline components:

— suitable support for the pipes should be provided, which should be resistant and durable, with timbers under the lower layers of the pipes as well as between the other layers;

— pipes should be secured at the sides and at the ends to prevent any longitudinal movement, to avoid damage in the event of a lorry or truck suddenly braking;

— no part of the pipes should be unsupported with provision of the wooden props;

— pipes should be kept in a balanced condition with two parallel rows of good quality timbers fastened to the floor;

— slings or rubber protected hooks should be used for the loading and unloading of the pipes.

6.2.2 Handling

6.2.2.1 General

Sufficient care shall be taken during handling of the pipe to avoid damage to the pipes, pipe lining and coating. During the loading and unloading operation, no one shall stand below the pipe or pipe bundles or in the area around the crane.

6.2.2.2 and 6.2.2.3 shall be followed for the handling of the pipes.

6.2.2.2 Pipes in bundled condition

Pipes shall be lifted by a suitable method, for example, using slings or by use of forklift (see Figure 1).

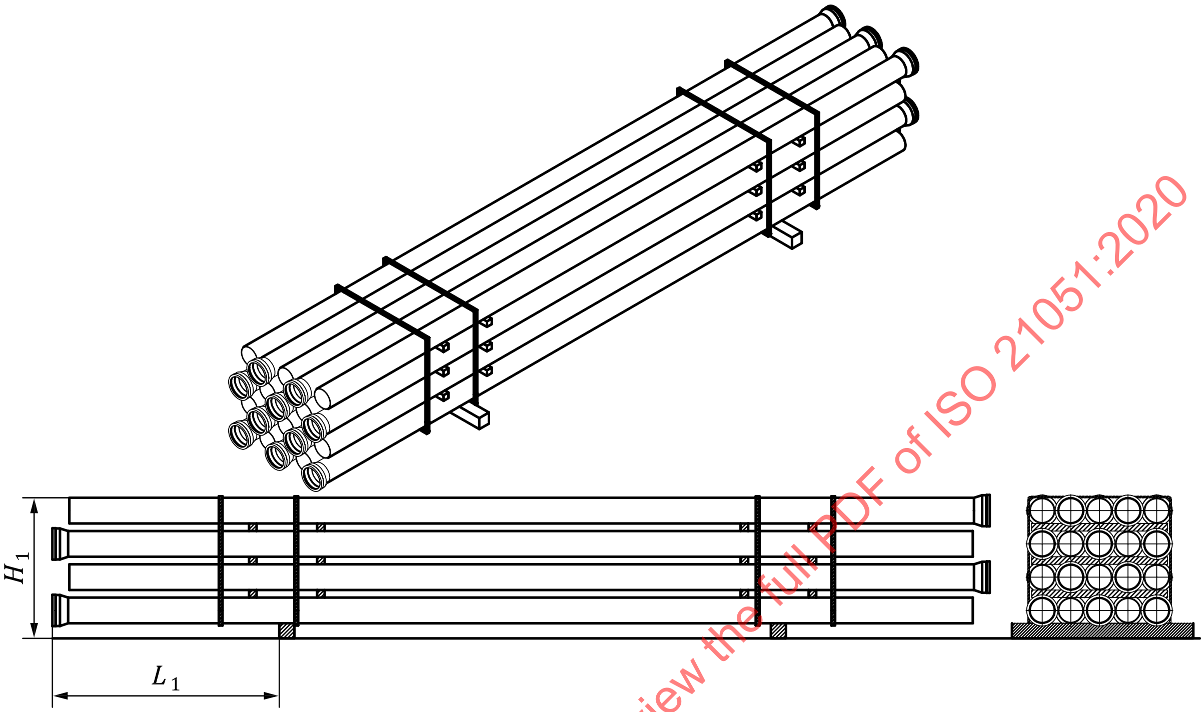
Steel strips are used to bundle the pipes. The straps should only be cut with suitable tools such as tin snips or side cutters. Use of cold chisels, crowbars, pickaxes or the similar material may cause damage to the external coating of the pipes and also means a greater risk of accidents. Before the straps are cut, it shall be ensured that:

a) the bundle of pipes is standing on the non-sloping ground which is levelled to the maximum possible extent and is able to carry the weight of the bundle;

b) the pipes are secured against rolling and slipping;

c) no one is standing beside the bundle of pipes or on the top of it.

After the bundling, the lifting of bundles shall be done from bottom by suitable tolls and not by hooking to the steel strips.



Key

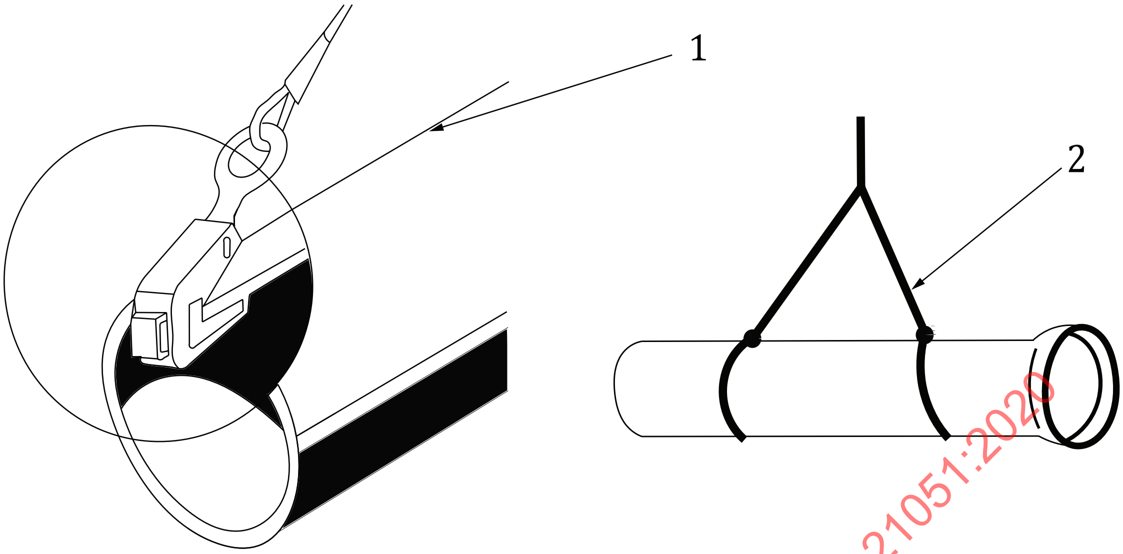
H_1 height ≤3 m

L_1 support location from pipe end ≤1,5 m

Figure 1 — Pipes in bundled condition

6.2.2.3 Pipes in loose condition

For pipe in loose condition, the pipes shall be lifted by use of appropriately shaped hooks or by use of padded slings (see Figure 2) coated with rubber or a similar material to avoid damage to the lining and coating. Sufficient care shall be taken to avoid rolling of the pipes, which may cause damage to the pipe lining and coating.



Key

1 padded slings to be used

2 pipe sling should be protected against sliding

Figure 2 — Lifting of pipes in loose condition

6.2.3 Storage

6.2.3.1 General

Storage of pipes at site should be done considering the local national regulation and all the safety norms.

The following precautions should be taken into account, while storing the ductile iron pipes:

— pipes should be stored so that they do not come in contact with harmful substances like solids, liquids, gases;

— they are therefore also not to be stored directly on the ground, but on appropriate materials;

— pipes should be protected suitably so that they are not internally contaminated with soil, mud, dirt, water or the like by use of suitable method like end caps;

— support and stack heights should be chosen so that damage and permanent deformation or damage to the external protection does not occur.

Manufacturer's recommendations should be followed for the storage of pipes. However, in general the suggested methods of storage are described in 6.2.3.2 to 6.2.3.5.

6.2.3.2 Storage of non-bundled pipes — Parallel stacking

For storage of non-bundled pipes, the parallel stacking method should be used, using wooden battens between rows. The following precautions should be taken for the storage of pipes:

— stacking area should have a foundation so as to have smooth movement of vehicles and easy access to the top layer;

— pipes should be stacked on wooden battens positioned suitably from each end of the pipe;

— the socket of the pipes in each successive layer should be reversed and the battens should be of sufficient thickness to avoid metal to metal contact (Figure 3);

— an adequate number of blocks should be wedged under the outer of pipes of each layer, so as to ensure stability;

— pipes should be protected suitably so that they are not internally contaminated with soil, mud, dirt, water or the like by use of suitable method like end caps.

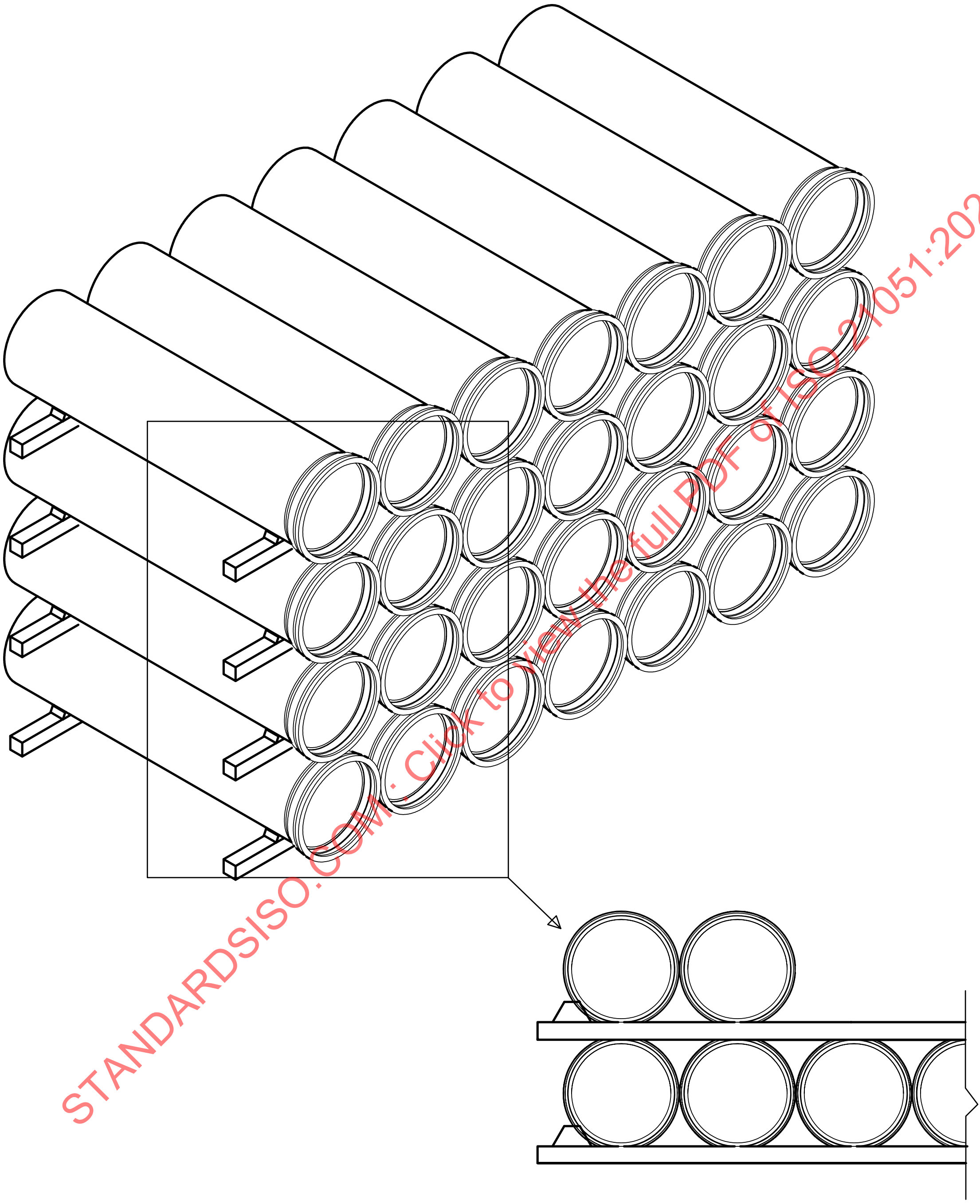
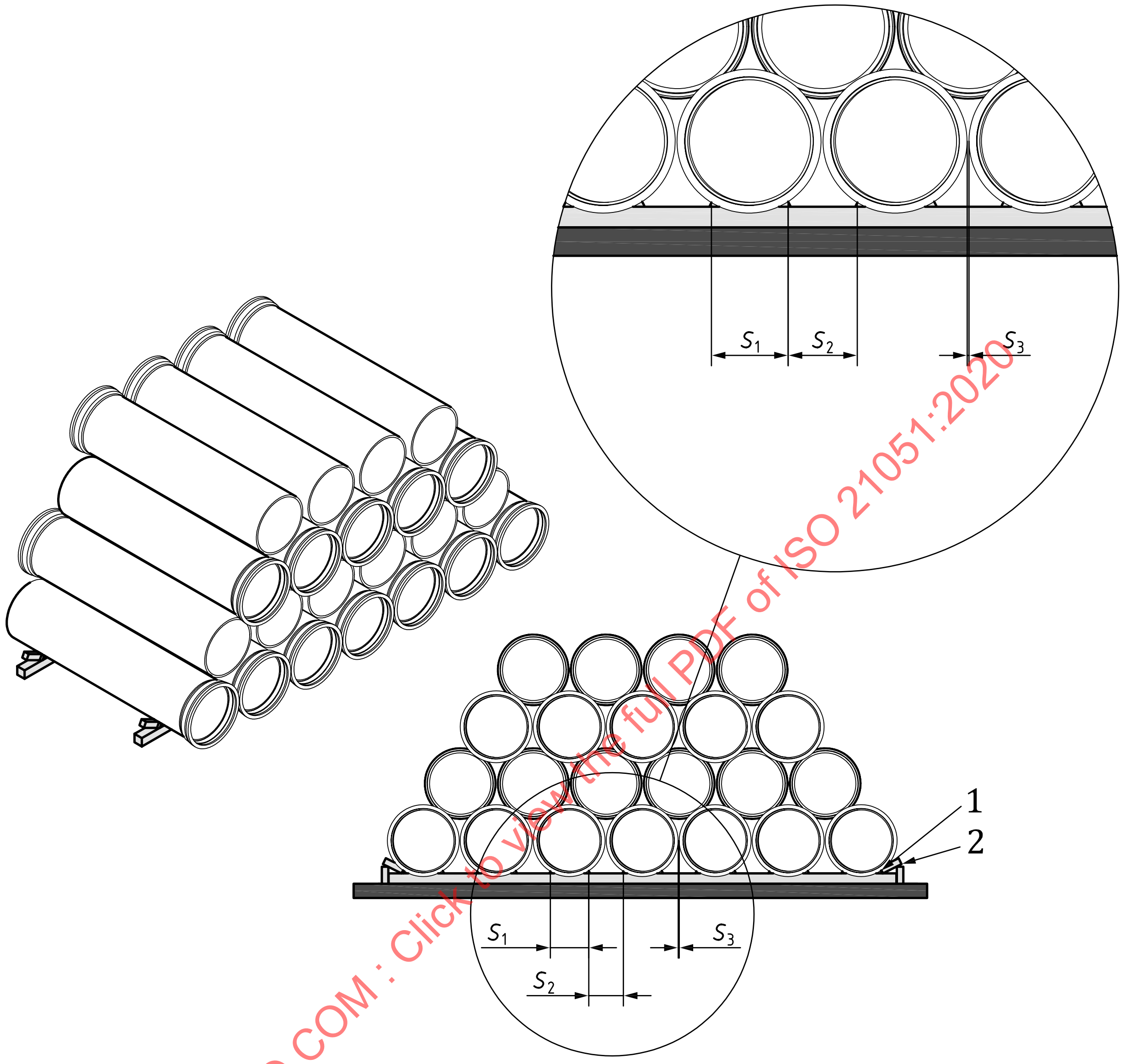


Figure 3 — Parallel stacking of pipes

6.2.3.3 Storage of non-bundled pipes — Pyramid stacking

This method of storing (see Figure 4) is suggested from the safety point of view and cost of materials used for storing. This method of storage requires end lifting of pipes with hooks and a number of pipes can be lifted using multiple hooks.



Key

1 triangle wedge

2 stopper

S_1 spacing of triangular wedges of each individual pipe

S_2 spacing between triangular wedges of adjacent pipe at bottom

S_3 spacing between two adjacent pipes at socket face position (to ensure proper socket segregation)

Figure 4 — Pyramid stacking of pipes

The bottom layer is laid on two timbers, arranged in parallel, one being 1 m from the socket end and the other 1 m from the spigot end. The pipes are also parallel with one another. The pipes at the two ends are secured at the sockets and spigots with large wooden wedges nailed to the timbers. Strong stopper shall be used at both ends of the bottom layer to avoid stock collapse. Dimensions of S_1, S_2 and S_3 shall be decided to ensure proper socket segregation of pipes in the same tier.

The upper layers consist of pipes laid alternatively, socket to spigot, with the sockets in one tier overhanging the spigots of the pipes in the tier below. All the sockets of one tier overhang the spigots of the tier below by approximately 10 cm, thus avoiding the deformation of the spigots.

6.2.3.4 Storage of non–bundled pipes — Square stacking

In this method, in the bottom layer, the tier of first layer is similar to pyramid stacking, but the sockets should be alternatively turned to one side and then to the other side. In addition, the sockets should overhang the spigots of adjacent pipes by the whole socket length, plus 5 cm. In the upper layers, each tier consists of parallel pipes, alternating as in the bottom layer. The pipes in one tier are placed perpendicular to the pipes in the tier below. Further, the spigots of the pipes are naturally wedged in by the sockets of the pipes in the tier immediately below. This method keeps packing material to be minimum, but due to the stack formation, implies individual lifting of pipes by their ends.

The maximum number of layers for each size and type of pipes shall be decided based on the consideration of no deformation in the spigot due to the load above. It is suggested to follow manufacturer's recommendations. However, suggested number of layers for stacking in different methods of stacking is given in Table 1:

Table 1 — Stacking of pipes – Suggested maximum number of layers

Serial No.	Nominal pipe size (DN)	Class of pipe	Number of layers in parallel stacking	Number of layers in pyramid stacking	Number of layers in square stacking
1	80	C40	30	50	30
2	100	C40	27	38	27
3	125	C40	22	30	22
4	150	C40	22	26	22
5	200	C40	18	20	18
6	250	C40	16	16	16
7	300	C40	14	13	14
8	350	C30	12	12	12
9	400	C30	11	11	11
10	450	C30	9	10	9
11	500	C30	8	9	8
12	600	C30	7	8	7
13	700	C25	5	7	5
14	800	C25	4	6	4
15	900	C25	4	5	4
16	1 000	C25	3	4	3
17	1 100	C25	3	3	3
18	1 200	C25	2	3	2
19	1 400	C25	2	3	2
20	1 500	C25	2	2	2
21	1 600	C25	1	2	1
22	1 800	C25	1	2	1
23	2 000 to 2 600	C25	1	2	1

NOTE For other classes, a separate calculation is necessary to arrive at the safe number of layers for stacking.

6.2.3.5 Storage of gaskets

Gaskets shall be stored in cool, dry place without being subjected to any deformation. Gaskets should be protected from the direct sunlight. Care shall be taken to ensure that they are not damaged and do not get dirty. The shelf life of the gaskets should be as per the manufacturer's recommendations. The expired gaskets should not be used in the pipe installation.

6.2.4 Inspection

Mishandling of ductile iron pipes may cause damage to linings, coatings and may create ovality in pipes.

Before lowering the pipes into trenches, the following checks should be made:

— ovality in pipe;

— condition of cement mortar lining;

— loss of external coating;

— surface condition of spigot area and socket area, which should be clean and any extra paint build up should be removed.

Any damaged pipes should be stored separately and repairs should be carried as per the guidelines provided in Clauses 7 and 8.

7 Coating and lining repairs

7.1 General

As a general principle, ductile iron pipes, fittings and valves are supplied with works applied coatings. Special added coatings are provided at site, if necessary. It is important to select the type of the coating considering the corrosion so as to ensure the durability of the pipeline.

Linings are protective coatings on the internal surfaces of the pipelines. Their purpose is to protect the material of the pipes against chemical reactions with the medium flowing through pipes. These linings are considered to be an integral part of pipe.

The external coating and lining of the pipeline components can become damaged during transportation, handling and storage, which require repair at site.

7.2 Repair external coating

7.2.1 General

Damages like scratches, not affecting the outer coating, don't need to be repaired. Other damages affecting the outer coating should be repaired by applying the outer coating material, as per the recommendations of the manufacturer by brush, roller or spray after cleaning the surface of the coating.

7.2.2 Repair procedure

Areas left uncoated, e.g. under the test and coating damaged in excess of 5 cm^2 per square meter of coating, shall be repaired in accordance with the requirements of ISO 8179-1:2017, 5.5, b).

In case of low temperatures and humidity, the pipe surface should be heated to an adequate temperature as per manufacturer's recommendations before applying the coating in criss-cross passes.

The manufacturer's recommendations should be followed for special coatings.

NOTE In case of loss of gloss or fading of colour of the external finishing layer, which can be due to exposure to sunlight and other strong rays, without affecting the thickness of the coating, no repair is necessary.

7.3 Repair cement mortar lining

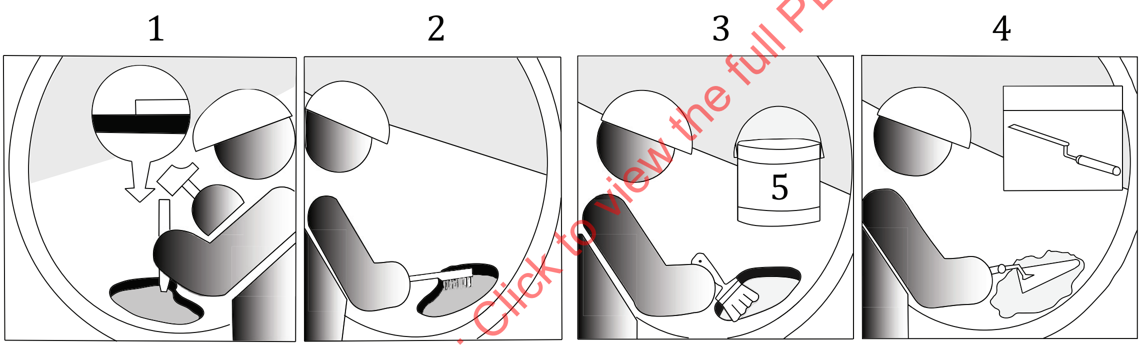
7.3.1 General

The hairline cracks and shrinkage cracks are associated with the cement mortar lining and commonly appear when the lining gets dried. The disbondment and shrinkage of the cement mortar occur due to the storage of the pipe and fittings in a hot and dry environment particularly directly under the sun. The heat in the environment causes the expansion of the metal and at the same time shrinkage in the cement mortar, resulting in disbondment. When such pipes and fittings come in contact with water, due to absorption of moisture, the lining will swell; the cracks will close; and ultimately the cement mortar lining will heal due to autogenous process.

In such cases the crack width and the radial displacement should not exceed the permissible values mentioned in ISO 4179:2005, Table 1. If the crack width and radial displacement value exceeds the permissible limits, it shall be repaired as per the procedure prescribed by the manufacturer. The repair material is cement mortar of a similar type as the one used to line the pipe, or a dedicated repair material made of mineral and organic finders.

7.3.2 Repair procedure cement mortar lining

The cement mortar lining should be repaired for the damage, which is visible and affects the minimum thickness requirement of the lining as per ISO 4179. The brief procedure is described in Figure 5 below:



Key

1 step 1 : Cut the damaged portion.

2 step 2 : Clean the cut out portion.

3 step 3 : Wet the surface.

4 step 4 : Apply smooth cement mortar and finish with towel.

5 water + emulsion

Figure 5 — Repair of cement mortar lining

8 Cutting of pipes and ovality correction

8.1 Cutting of pipes

8.1.1 General

If site demands the cutting of pipe to any length, the same can be done if the external diameter (DE) of the pipe is checked and found within the tolerance limit. Small diameter pipes up to DN 300 can be cut up to 2/3 of the length of the pipe from the spigot end, so as to ensure that the external diameter of the pipe is within the tolerance limit for DE. For pipes above DN 300, the manufacturer can supply at the request of the purchaser a certain percentage of the total quantity of pipes (duly marked), which has the DE within the tolerance limit such that the pipes can be cut at any point. For the balance quantity of pipes, pipes can be cut at site allowing the assembly of joint over at least 2/3 of the pipe length from the spigot after checking the ovality of pipe and the external diameter within the tolerance limits.

8.1.2 Pipe cutting tools

Pipe can be cut using electric high-speed disc cutter or conventional hack-saw depending upon the pipe diameter. For large diameter pipes (above DN 1 000), the automated chain cutter can be used.

8.1.3 Chamfering of cut edge

After cutting of the pipe, the cut edge should be chamfered with a grinder for mechanical joint pipes or should be chamfered using a grinder for the push-in joints to avoid damage to the gasket. For mechanical joint pipes, the edges may only be rounded. Also, in case of any damage to the lining and coating, the same shall be repaired before the use of cut length pipes. The chamfer dimension should be followed as per the manufacturer's recommendations.

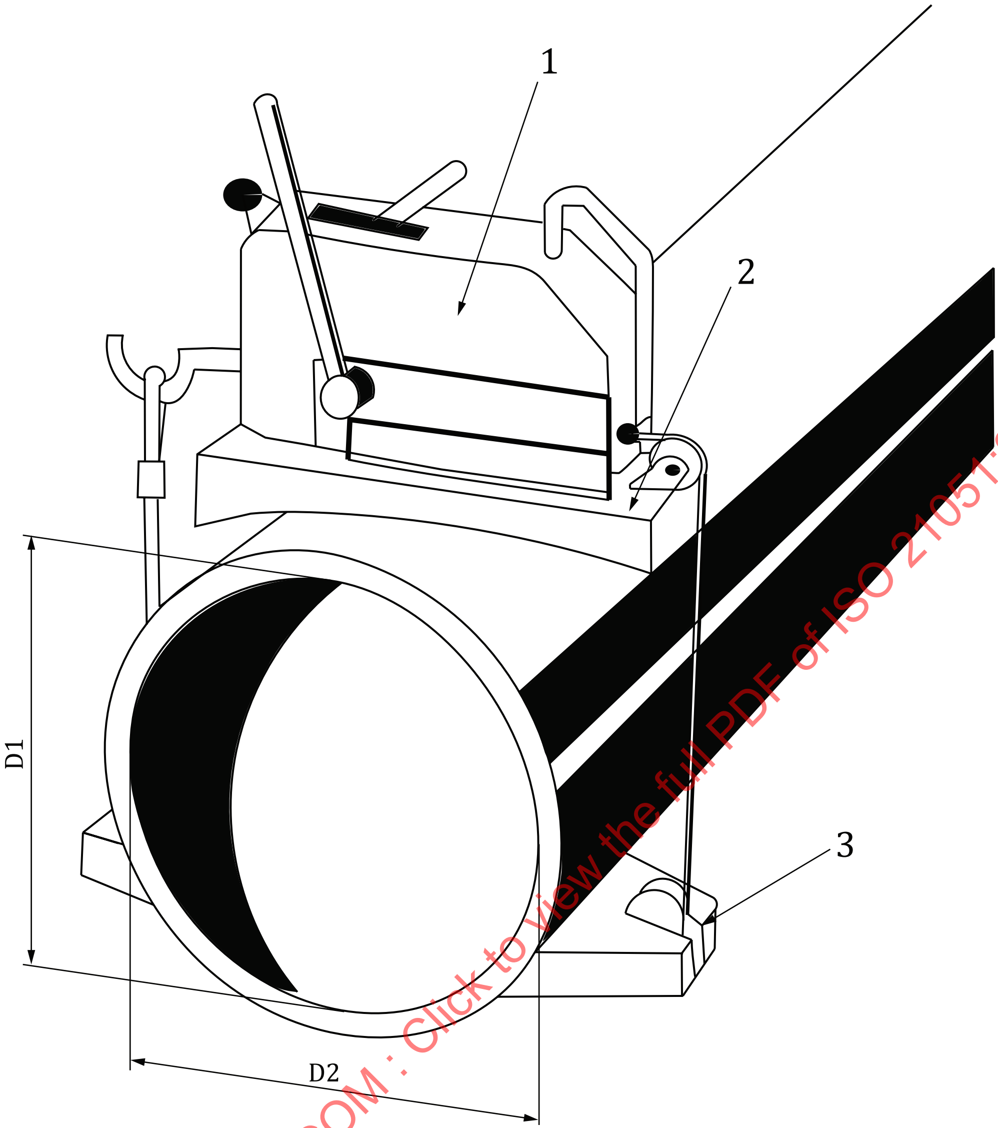
8.1.4 Repair of damaged lining and coating

In case of any damage to the lining and coating due to cutting, the same shall be repaired before the use of cut length pipes. Further, the cut surface of the pipe shall be coated with suitable coating material as per the manufacturer’s recommendations before use.

8.2 Ovality correction

Transport, handling and storage can bring sufficient pipe ovality to affect the assembly of pipe components. If the ovality of the pipe is not in accordance with the requirement of ISO 2531:2009, 4.2.2, re-rounding of the pipes shall be done at site as per the manufacturer's recommendations for ovality correction.

For the pipes up to DN 600 (see Figure 6), the suitable equipment can be used to bring down the ovality within the prescribed limit. Whereas, for the pipes above DN 600 (see Figure 7), hydraulic jack can be used to correct the ovality of the pipes.



Key

1 winch

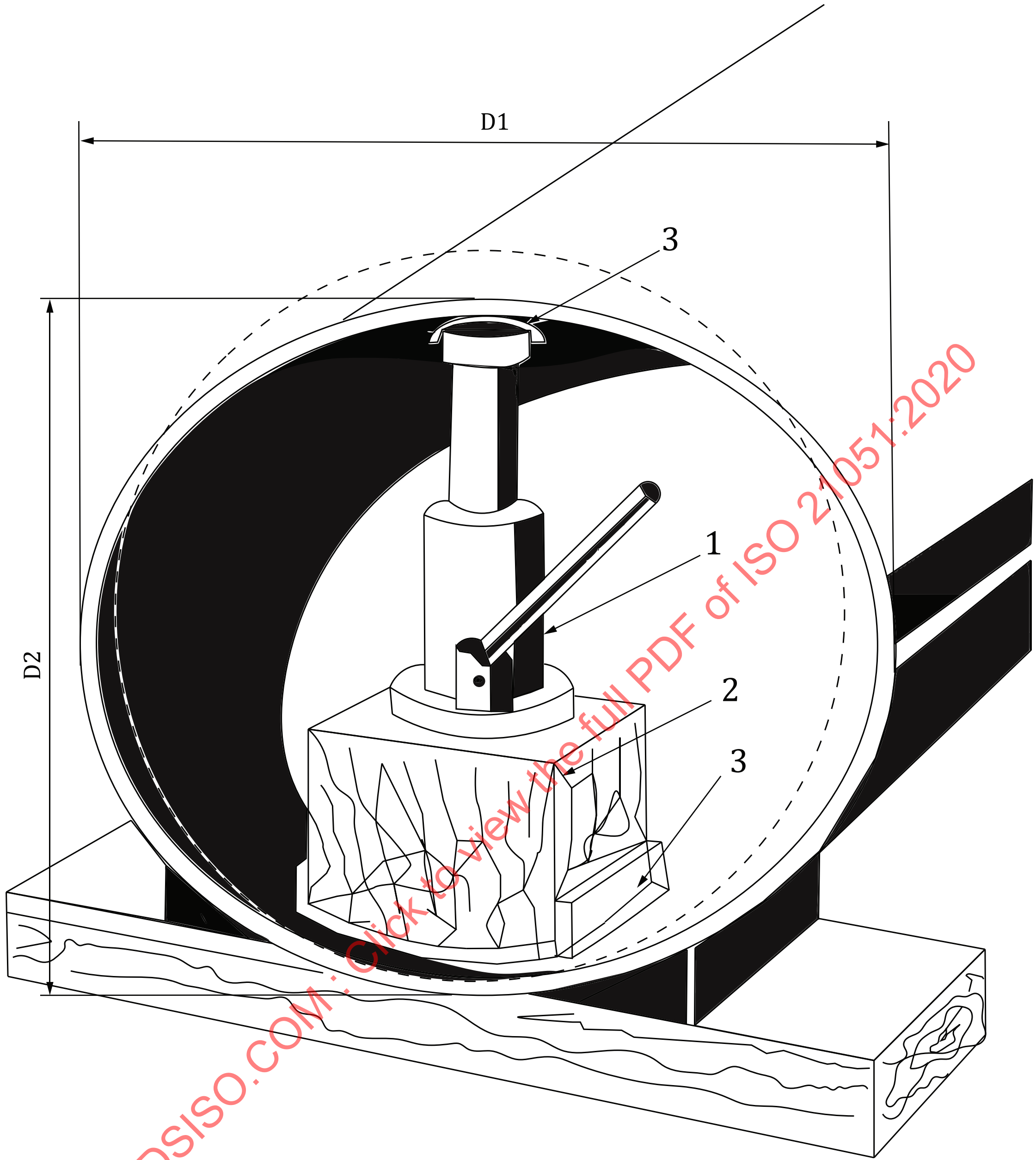
2 winch support with cable guide roller

3 base plate with 2 cable guide roller

D1 major axis

D2 minor axis

Figure 6 — Ovality correction up to DN 600



Key

1 hydraulic jack
2 block
3 two sufficiently large rubber-coated protective pads
D1 major axis
D2 minor axis

Figure 7 — Ovality correction by hydraulic jack for pipes above DN 600

Sufficient care should be taken to avoid the damage to the lining and coating of the pipes during ovality correction; however, in case of any damage, the same shall be repaired before the use of the pipe.

9 Site preparation and pipe trenches

9.1 Trench width

The trench width should be decided considering the type of soil, backfilling and the compaction equipment. Wherever mechanical compaction is required, the trench should be wide enough to accommodate the mechanical equipment and workman for the installation of the pipeline.

The following considerations shall be given for deciding the trench width:

a) recommended minimum clearance between the pipe outer diameter and the trench wall as DN 300;

b) accommodation of mechanical equipment and workmen;

c) depth of trench;

d) soil characteristics;

e) extra space where timber support, strutting/planking and handling of fittings and valves are required;

f) safety of the personnel;

g) any other site considerations as required.

In case the pipes are to be laid in narrow trenches, special precautions shall be taken to ensure the laying of pipes is done in a safe manner.

9.2 Trench excavation and minimum depth of cover

9.2.1 General

For trench excavation, trench depth and the type of soil will govern the type of trench and the shoring requirements. Some of the soils require heavy shoring, which should be given extra care. The type of trench and the related compaction parameters are given in 11.2.3.

Trench bottom should be true and even to give the barrel of the pipe soil support for its full length. In case of soft subgrade, trench bottom should be improved by adding crushed stone with due compaction or any other suitable method.

9.2.2 Minimum depth of cover

The minimum depth of cover should be decided considering the following aspects:

a) site conditions and customer's requirements;

b) allowable depth of cover based on external loads meeting requirements of ISO 10803;

c) frost free depth;

The minimum depth of the cover also depends upon the class of pipe, traffic loading and the type of trench and the soil. For each combination, it is important to check the minimum and maximum depth of the cover as per the procedures and guidelines provided in ISO 10803.

9.2.3 Regulations

The following shall be taken into consideration:

a) In case of rock excavation, blasting, if required, shall take the regulations of the local authority into consideration.

b) Public safety should be considered at all times. Suitable barricades, adequate construction signs, guards, flashing warning lights should be available to protect the pipe.

c) Open-cut trenches should be sheeted and braced as may be necessary to protect life, property and work.

10 Pipeline protection

10.1 General

Ductile iron pipes require different types of protections for outside coating, depending upon aggressiveness of external operating environments.

Soil examination is recommended in order to determine the soil aggressivity by determining the values of above parameters, along the alignment of the pipe.

Depending upon the aggressivity of the soil, the suitable outer coating should be applied on the pipes, depending on the levels of the above parameters, which are mostly factory applied. The use of a particular type of coating is suggested in ISO 2531:2009, Annex A. Further, in case of factory applied coatings, the suitable method of protection for jointing areas at site shall be done using manufacturer's recommendations.

For certain types of aggressive environment, the encasement of polyethylene sleeving may be recommended, for which the application requirements are given below.

For the type of internal protection required based on the parameters of the fluid to be transported, selection of the protection should be made based on the criteria defined in ISO 2531:2009, Annex B.

10.2 Site applied polyethyelene sleeving

In case the polyehtyelene sleeving is selected as site, applied coating as per the requirement of Clause 10 and the requirements as given in Annex A shall be used for such application; the requirements of materials shall be as per ISO 8180.

11 Laying of pipes

11.1 Precautions at site before laying

11.1.1 General

Pipes shall not be dragged along the alignment. Pipes also shall not be dropped into the trenches, which can cause damage to the pipes. Trenches shall also be checked for sharp objects, which should be cleaned to avoid damage to the coating or wrapping.

Pipes shall only be lowered into/lifted from trenches using webbing slings or padded hooks or any other suitable method and care should be taken when removing these to avoid damage to the outer coating.

Pipes shall not be rolled in from the side of the trenches to prevent damage to the coatings. Also rolling of the pipes along the ground is not permitted.

All pipes and fittings shall be laid along the trench on the opposite side from the excavated earth.

11.1.2 Preparation before pipe laying and jointing

All construction debris should be removed from the inside of the pipe before the joint is made. No end protective at the end of the pipe should be removed permanently until the pipe or fitting is about to be jointed.

11.2 Construction of pipe trenches

11.2.1 General

Before the pipes are laid, the trench should be checked for correct depth, gradient, width and condition of trench bottom.

11.2.2 Bedding

11.2.2.1 General

Joint holes should be formed in bedding material or excavated final surface for each socket to ensure that each pipe is uniformly supported throughout the length of the barrel and to enable the joint to be made. Wherever the pipes are required to be bedded directly on the trench bottom, the surface should be levelled to provide even bedding of the pipeline and shall be free from all extraneous matter, which may damage the pipe or the pipe coating. When the pipes are laid on hard bed, suitable depression in the bedding is to be provided to accommodate the socket.

If the trench bottom is not suitable as bedding for the pipes (e.g. stones, rock, non-load bearing or loosened soil), the trench should be excavated to a greater depth, depending on the material of the pipe and its external protection. The extra soil removed should be replaced by a suitable selected material considering the following:

a) it should be sufficiently stable, when laid, to support the pipeline in the correct position both during and after laying and to enable the installed pipeline to accommodate internal and external loads;

b) it shall not cause corrosion, damage or degradation of the pipes, coatings and components with which it is in contact;

c) it shall be chemically stable and does not react adversely with the soil or groundwater;

d) it shall be capable of being compacted to the required density;

e) it shall not include debris, organic materials, frozen soil, large stones, rocks, tree roots and similar large objects.

Such a material should be a suitable granular material compacted over the full width of the pipe trench in layers not exceeding 150 mm before compaction, to a finished thickness of specified value above the crown of the pipe.

11.2.2.2 Suggested bedding materials

a) Case 1: where the native ground is fine grained such as clay, silt, sand and if the embedment is partially or totally below the water table, all materials selected for the embedment should be such that the fines will not migrate from the adjacent soil of the trench bottom or walls. Conversely, the possibility of migration of fines from the embedment into the native soil should be minimized by specifying materials with a suitable grading.

b) Case 2: when the native soil is suitable for bedding, the native soil is the sole lower bedding (see Figure 8). When the native soil is not suitable for the bedding, the lower bedding shall confirm to the grain specification in Table 2:

Table 2 — Grain size for bedding and sidefill material

Type of pipe and coating	Grain size for the crushed material	Grain size for the natural granular material
Ductile iron pipes coated in accordance with ISO 8179-1	0 mm to 16 mm with single particle up to 32 mm	0 mm to 32 mm with single particle size up to 63 mm
Ductile iron pipes with polyurethane Coating	0 mm to 5 mm with single particle up to 10 mm	0 mm to 6,3 mm with single particle size up to 12 mm

NOTE In specific cases, the manufacturer's recommendations can be used for the bedding.

c) Case 3 : When the pipe is to be laid in the rocky strata, a minimum flat layer of lower bedding of 100 mm should be used for the pipes up to DN 250 and 150 mm for the pipes above DN 250. The bedding material can be a bed of sand, crushed stone or earth free from stones and properly levelled.

11.2.2.3 Backfilling and compaction

After the pipe laying, the upper bedding, later fill and the cover zone should be filled with backfill material by suitable compaction in layers.

In all cases, the execution of the embedment i.e. lower bedding, upper bedding, cover zone and main backfill, should be carried out by placing layers of suitable material as specified and the degree of compaction of the embedment shall provide the minimum support required by the structural design calculations, in relation to the nature of the native soil and the allowable settlement. If the designer specifies a degree of compaction, preliminary tests should be carried out prior to the installation of the pipeline to verify that the required degree of compaction is obtainable. This depends upon the method of compaction, the soil nature, the equipment, the number of passes per layer and the thickness of layers. Till the hydro testing is completed, backfill of the material may not be done to the full compaction level, as the inspection of the joints may be required. Consideration shall be given to protect the pipe coatings and sleeving from being damaged during pipe laying. In particular, the use of angular granular material 5 mm or greater in size for bedding and sidefill should not be used.

In all cases, the silt and clay content shall not be more than 6 % by weight to avoid excessive settlement.

In case of pipes being laid for sewerage application, the following additional precautions should be taken:

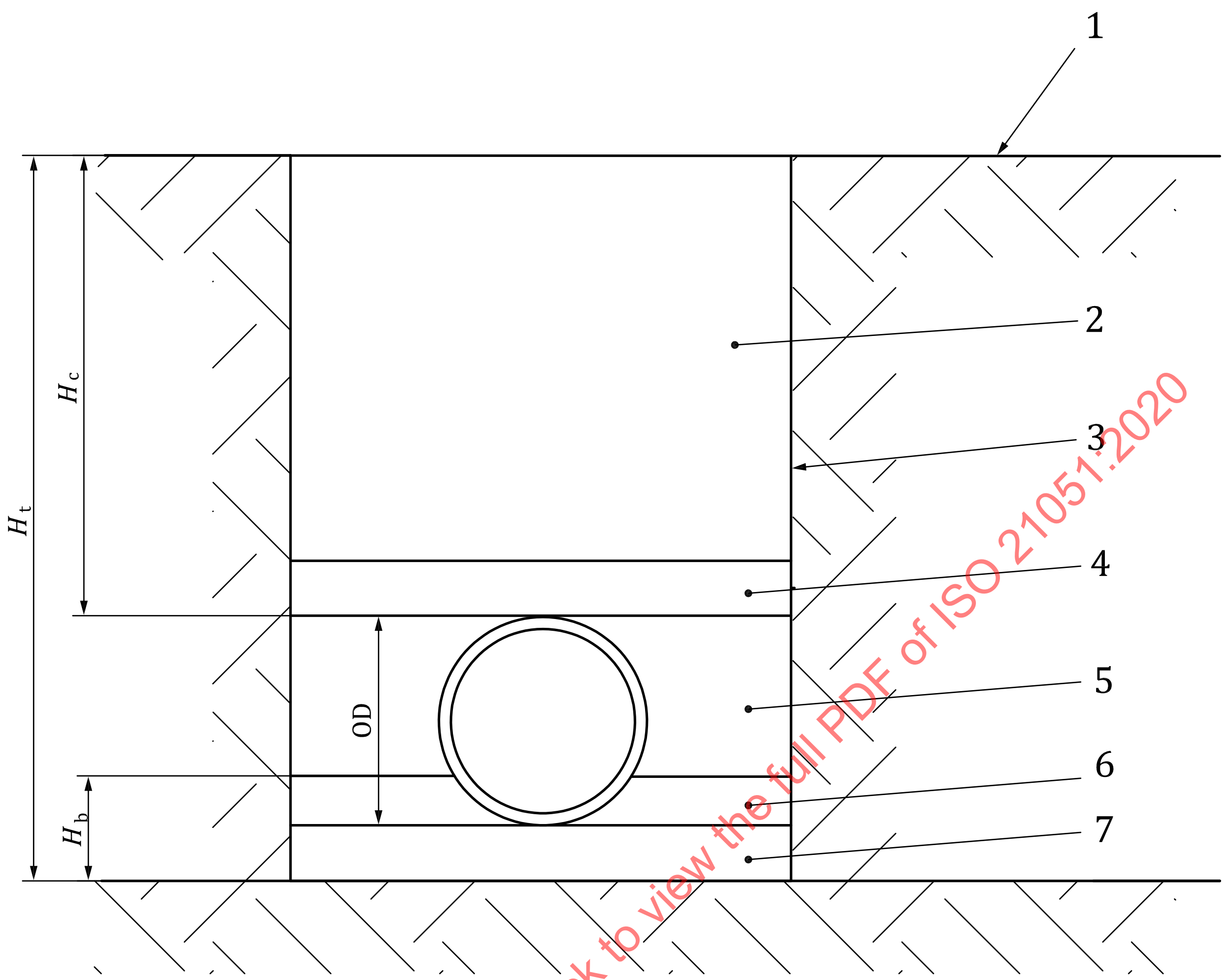
a) wherever the flow of groundwater is likely to transport the fine soil particles, water stops of puddle clay extending up through the bedding and sidefill shall be placed across the trench and immediately downstream of any temporary works;

b) in bad ground conditions, where the migration of the pipe granular into the ground may occur or fines may be moved from the surround material into the bedding material causing a lack of support of the bedding, the surrounding shall be protected by a suitable method as per the manufacturer's recommendations (e.g. geotextiles membrane etc).

In special site conditions, the manufacturer's recommendations should be followed for the bedding, considering continuous developments.

11.2.3 Trench types

National regulations shall be taken into consideration when deciding the trench types; however in case of no national regulation, the following guidelines should be used for types of trench depending upon the site conditions and bedding (see Figures 8 and 9).



Key

1 surface
2 main fill
3 wall of trench
4 direct cover zone
5 lateral fill
6 upper bedding layer
7 lower bedding layer
H_t depth of trench
H_c height of cover
H_b height of bedding
OD outside diameter of pipe

Figure 8 — Typical pipe bedding

a) Trench type 1

Embedment (pipeline zone) dumped.

b) Trench type 2

Embedment (pipeline zone) with very light compaction, greater than 75 % standard proctor density.

c) Trench type 3

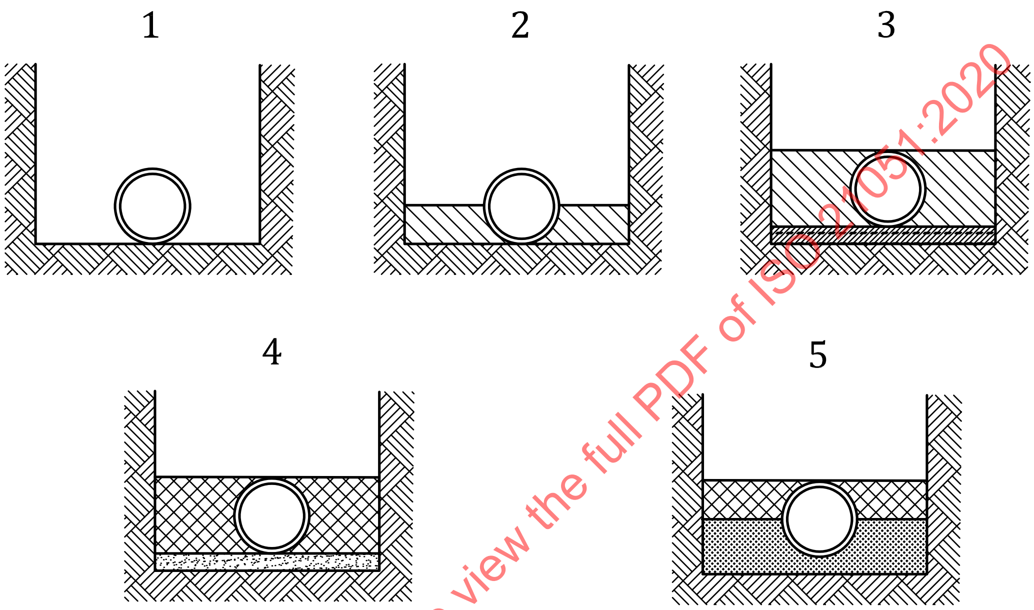
Embedment (pipeline zone) with light compaction, greater than 80 % standard proctor density.

d) Trench type 4

Embedment (pipeline zone) with medium compaction, greater than 85 % standard proctor density.

e) Trench type 5

Embedment (pipeline zone) with high compaction, greater than 90 % standard proctor density.



Key

1 trench type 1
2 trench type 2
3 trench type 3
4 trench type 4
5 trench type 5

Figure 9 — Trench types

Bedding for pipes should be laid by spreading and compacting a suitable granular bedding material over the full width of the pipe trench. After the pipes have been laid, an additional material should, if required, be placed and compacted equally on each side of the pipes under the pipe haunches, and where applicable, this should be done in sequence with the removal of the trench supports to prevent the formation of voids.

11.2.4 Soil types

Different types of soils, as defined in ISO 10803, are given below:

a) Soil group A: angular graded stone (6 mm to 40 mm), also including a number of fill materials which have regional significance, such as crushed stone, crushed gravel, pea gravel and crushed shells.

b) Soil group B: coarse; grained soils with little or no fines. No particles larger than 40 mm.

c) Soil group C: coarse; grained soils with fines and fine grained soils with medium to no plasticity, with more than 25 % coarse particles, liquid limit less than 50 %.

d) Soil group D: fine; grained soils with medium to no plasticity, with less than 25 % coarse particles, liquid limit less than 50 %.

e) Soil group E: fine; grained soils with medium to high plasticity, liquid limit greater than 50 %.

f) Soil group F: organic soils.

11.3 Safety, protection of property and structures

a) Prior to the commencement of operations, a check shall be made that the appropriate safety measures have been taken. Trees, shrubbery, fences, poles, and all other property and surface structures should 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 should be done.

b) 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.

c) As far as possible, the water pipeline should be laid below existing services, like water and gas pipes, cables, cable ducts and drains but not below sewers which are usually laid at a greater depth. Where it is unavoidable, the pipeline should be suitably protected. A minimum clearance of 150 mm should be provided between the pipeline and such other services. The relevant national regulations, if exist, shall be taken into consideration. Where thrust or auger boring is used for laying pipeline across roads, railways or other existing utilities, large clearance should be provided. Adequate arrangement should be made to protect and support the existing services during the laying operations. The pipeline should be so laid as not to obstruct access to other services for inspection, repair and replacement. When such utilities are encountered during excavation, arrangements should be made to support and protect utilities in consultation with them.

12 Push-in joints, jointing and anchoring

12.1 Preparations before jointing

The following preparations shall be done before the jointing:

a) cleaning of all the parts including spigot surface and socket seating area;

b) chamfering on the spigot;

c) appropriate lubrication of the jointing components;

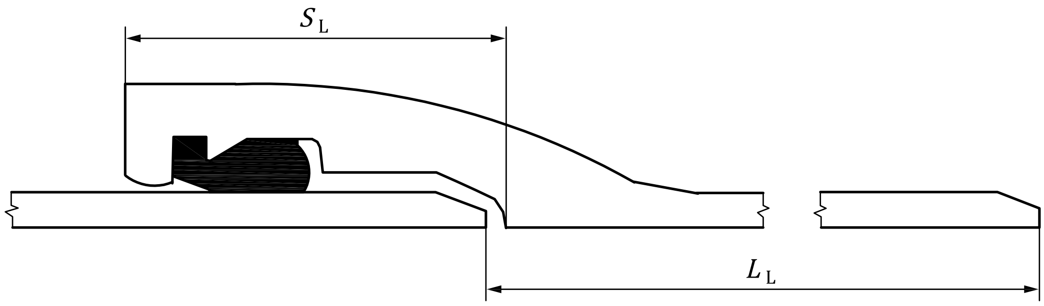
d) alignment of the spigot within the socket;

e) checking ovality of the spigot of the pipe.

12.2 Push-in joints

12.2.1 General

A typical push-in joint is given in Figure 10:



Key

S_L socket length

L_L laying length

Figure 10 — A typical push-in joint

12.2.2 Push-in joint assembly for the pipes

12.2.2.1 Steps for jointing

Push-in joint assembly for the pipes shall be made in the following steps:

a) all foreign matter in the socket shall be removed i.e. mud, sand, cinders, gravel, pebbles, trash, frozen material etc. The gasket seat shall be thoroughly inspected to be cleaned.

b) the gasket of proper design as per the manufacturer's design, shall be wiped with a clean cloth, flexed and then placed into the socket with the rounded bulb end entering first. Looping the gasket in the initial insertion will facilitate seating the gasket heel evenly around the retainer seat. Smaller sizes require only one loop. For pipes of diameters above DN 500, it may be necessary to make two or more loops in the gaskets as shown in Figure 11.

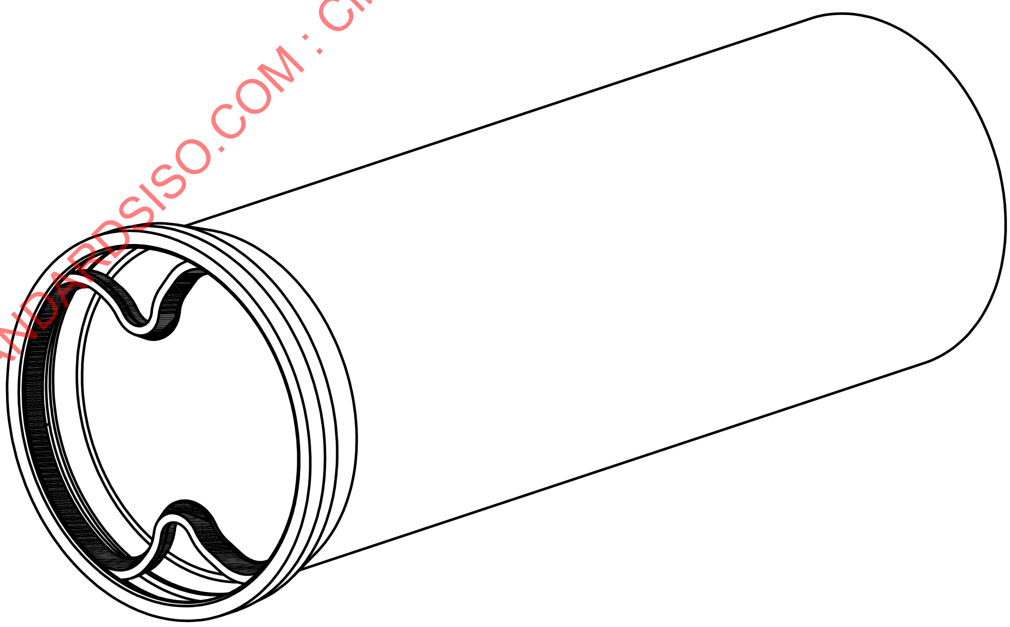
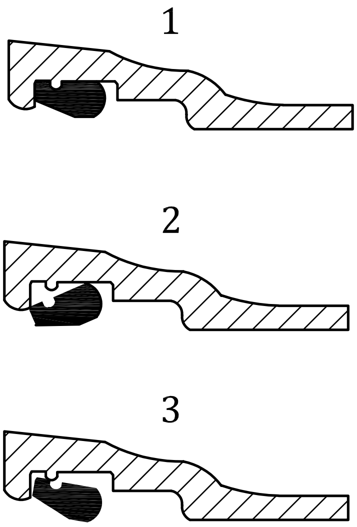


Figure 11 — Placement of gasket for push on joint

c) When installing the pipe in subfreezing weather, the gaskets, prior to their use, shall be kept warm by suitable means.

d) The inner edge of the retaining heel shall not protrude from the retaining beed of the socket, as shown in Figure 12:



Key

1 correct position

2 incorrect position

3 incorrect position

Figure 12 — Correct position of gasket inside the socket

e) Apply lubricant to the exposed surface of the gasket and spigot end of the pipe, as shown in Figure 13. Also refer to the manufacturer's recommendations for the use of lubricant.

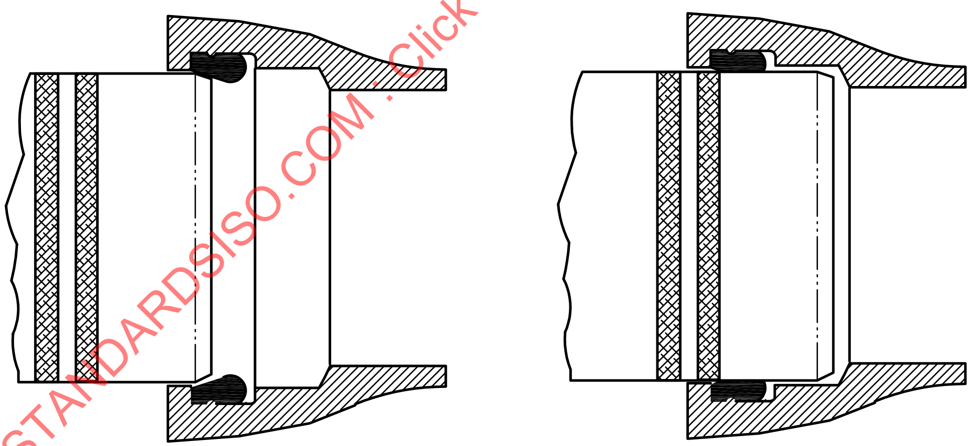


Figure 13 — Initial entry of plain end in socket and completely assembled joint

f) Ensure that the plain end of the pipe is chamfered. The plain end of the pipe shall be cleaned of all foreign materials on the outside from the end to the insertion marks on the pipe for the joint. Further, the plain end of the pipe should be in reasonably straight alignment and carefully entered into the socket until it just makes a contact with gasket (see Figure 13).

g) The spigot end of the pipe shall be pushed into the socket of the other pipe and not the other way. Pipes with small diameters can be pushed with a long bar. For pipes with large diameters, use of other equipment like jack, lever puller or backhoe is necessary. Pipe manufacturers normally give insertion marks on the spigot end of the pipe. Insertion of the spigot end into the socket is recommended till the socket is positioned between the insertion marks. It is recommended that first the spigot end is inserted into the socket so that the socket face remains within the insertion marks on the spigot. After the joint is made, the pipe is deflected as per the allowable angle of deflection.

h) During the jointing of the pipes on the ground, it is important to keep the major axis of the pipe on the spigot side always vertical.

NOTE The direction of laying (arrangement of socket and spigot) has no relevance to the direction of flow of water.

12.2.2.2 Jointing methods

The jointing can be done by various methods as given below:

a) Trench excavator method

This method (see Figure 14) can be used for the pipes from DN 80 to DN 2 000. Wherever the trench is being prepared by using a backhoe type excavator, this machine may be used to push the spigot into the socket. A timber should be placed between the pipe and the backhoe bucket to avoid damage to the pipe.

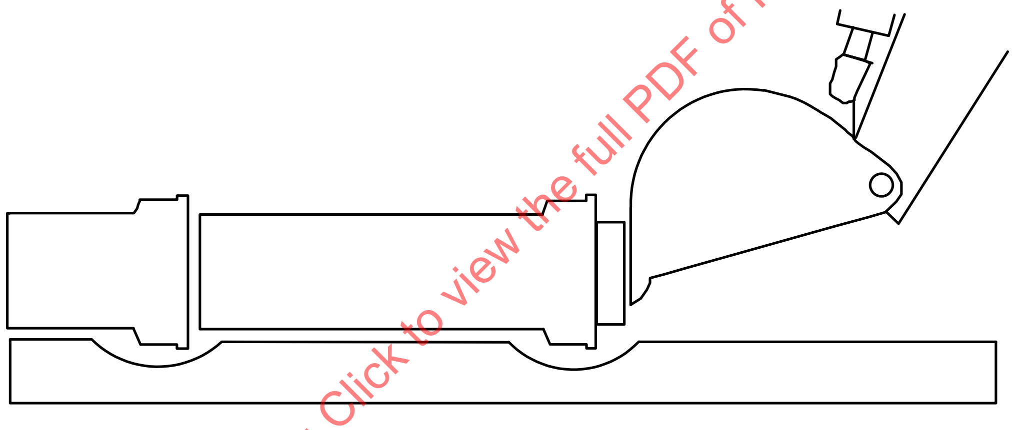


Figure 14 — Trench excavator method

b) Crowbar method

For pipes with small diameters up to DN 150, the jointing of pipes can be achieved by pushing the pipe with a crowbar against a timber (see Figure 15) held against the face of the socket of the entering pipe.

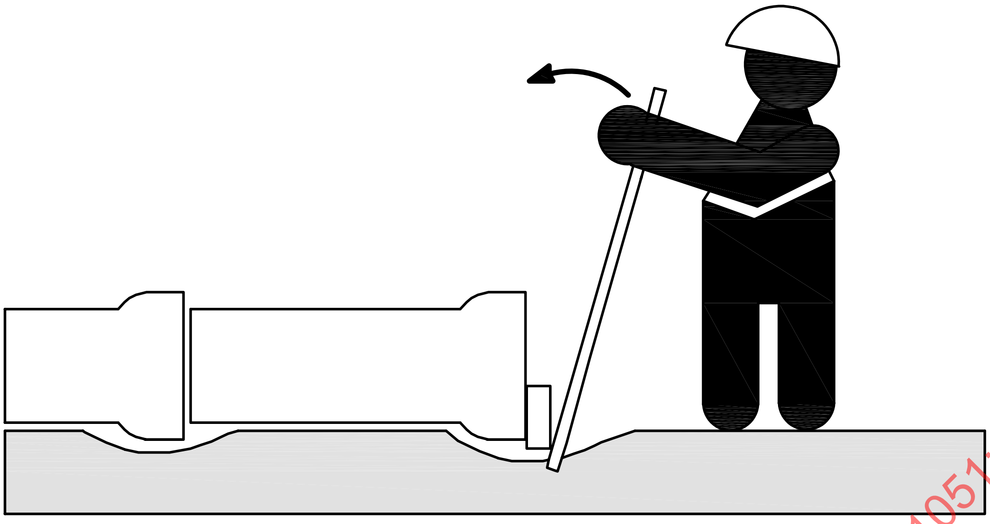


Figure 15 — Crowbar method

c) Rack and lever method

This method of jointing is normally used for pipe sizes from DN 80 to DN 450. The rack and lever jointing set comprises of a rack with hook bolt, two long ropes, a short rope, an extension tube and socket hook (see Figure 16).

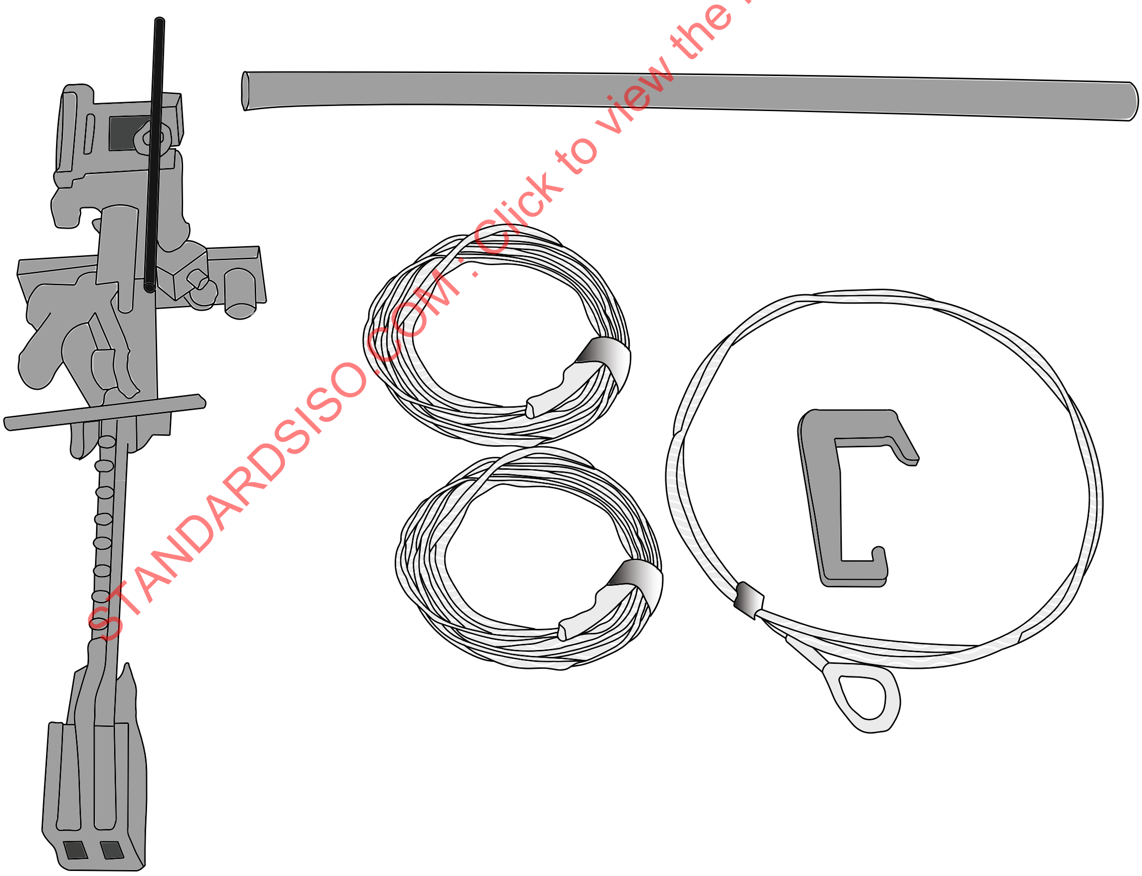
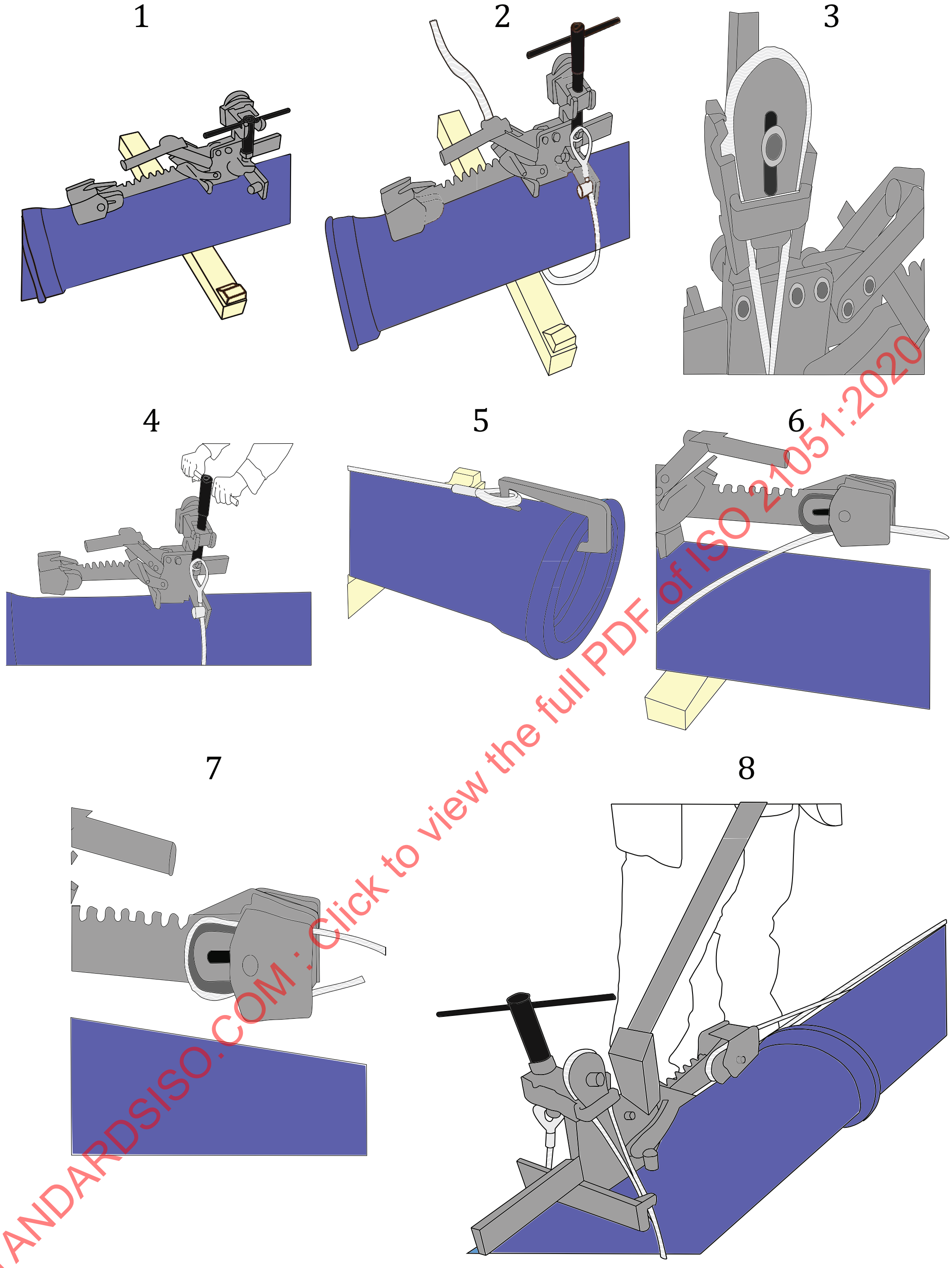


Figure 16 — Rack and Lever jointing set

Steps for jointing for rack and lever method are as follows (see Figure 17):



Key

1 step 1
2 step 2
3 step 3
4 step 4
5 step 5
6 step 6
7 step 7
8 step 8

Figure 17 — Rack and Lever method

Step 1: Enter the spigot of the pipe into socket until contact with gasket is made. Place the rack assembly on the socket of the installed pipe and fully extend the rack.

Step 2: Screw the hook bolt to its lowest position and attach the eye of the short rope.

Step 3: Pass the rope under the pipe making sure it is positioned behind the guide lugs and thread the plain end up through one side of the rope grip and pass the rope over the top of the rope grip and down the other side.

Step 4: Take up the slack and secure in the rope grip. Tighten the nut on the hook bolt until the rack assembly is secure.

Step 5: Attach the eye of one long rope to the socket hook and place the socket hook over the end of the pipe.

Step 6: Thread the plain end of the rope through the rope grip on the rack;

Step 7: Take up the slack in the rope and pass the rope round the rope grip and back through the taper to secure the rope grip.

Step 8: Fit the extension tube to the lower on the rack assembly and operate to compete the joint.

d) Chain pulley block method

Generally for bigger diameter pipes, the following are two constraints in the case of excavator bucket pushing:

— less control over the insertion and in some cases over insertion of the spigot in the socket;

— alignment of pipe is also one major concern.

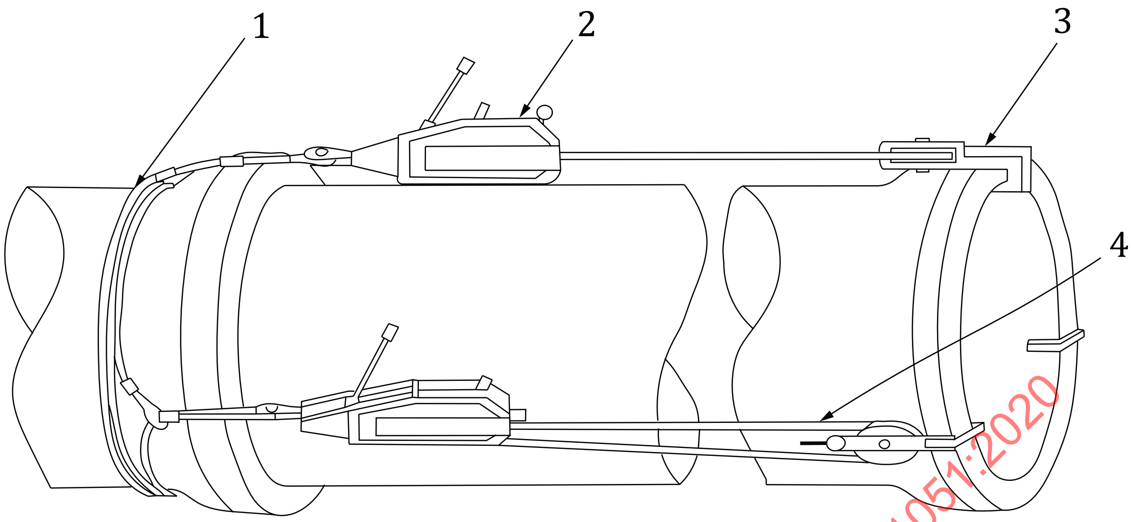
To overcome the above two constraints in the case of the excavator bucket pushing method, chain pulley block method (see Figure 18) can be adopted, as per the details given below:

The rope should be looped and positioned behind the socket, the free end should then be attached to the pulley block. The second rope can then be threaded through the winch and, using a hook, the joint is now made by operating the winch. Larger pipe diameters require more than one chain pulley block. For capacity of the chain pulley block, the manufacturer's recommendations shall be followed (see Table 3).

Table 3 — Recommended number of chain pulley blocks

Serial no.	Pipe diameter	Numbers of chain pulley blocks (minimum)
1	Up to DN 600	1
2	DN 700 to DN 1 200	2
3	DN 1 400 to DN 2 600	3

Depending on the field situation, additional rope/chain pulley blocks may be used.



Key

1 looping of rope behind the socket

2 winch

3 hook

4 second rope (made of textile fibre)

Figure 18 — Chain Pulley method (Pipe Jointing)

12.2.3 Jointing of push-on fittings

Jointing of push-on fittings should be done by use of rack and lever equipment as explained below.

a) Form loops in two long ropes by passing plain ends through the eyes.

b) Position the loops behind the socket of the fitting with the eyes diametrically opposite and on the horizontal centre line.

c) Thread the plain ends of the ropes through the gripping arrangement on the rack of the rack and lever equipment.

d) Operate the extension tube of the rack and lever equipment to complete the joint.

e) To dismantle the equipment, release tension on ropes by moving handle and ratchet back and release the ropes by hammering the rope grip.

f) In case of components externally coated with polymeric coatings, such as epoxy, polyurethane, it is strictly forbidden to use metallic rope in direct contact with the coating.

12.2.4 Jointing of fittings by jointing tackle (assembler)

The jointing of the fitting with the pipe can also be done by using a suitable jointing tackle (see Figure 19).

a) Enter the plain end of the pipe into the socket of fitting, until the contact with the gasket is made.

b) Place the jointing clamp on the spigot of the pipe.

c) Operate the tackle to make the joint.

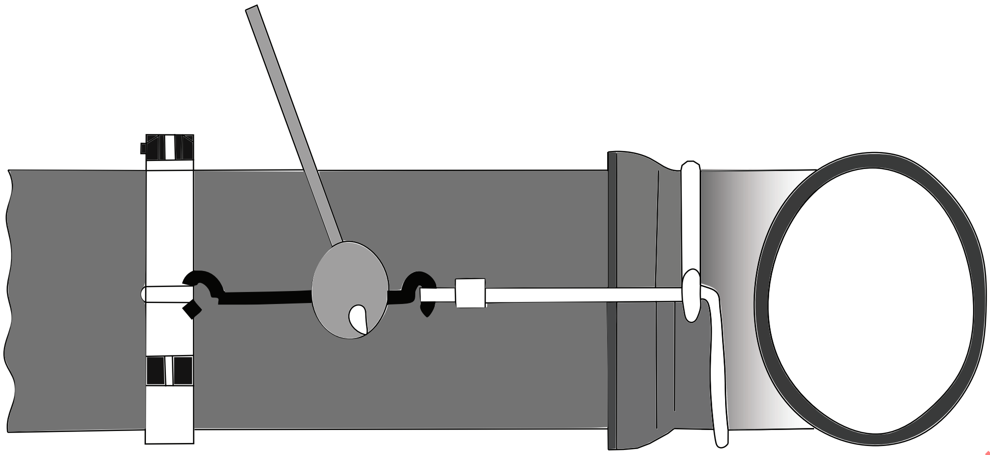


Figure 19 — Jointing of fittings by jointing tackle (assembler)

NOTE Any other method of jointing as recommended by the manufacturer can be used.

12.2.5 Jointing of fittings by winch method

Like pipe jointing, the wire rope should be looped and positioned behind the socket, the free end should then be attached to the winch. The second wire rope should be looped and positioned behind the socket of the fitting. The joint is now made by operating the winch (see Figure 20).

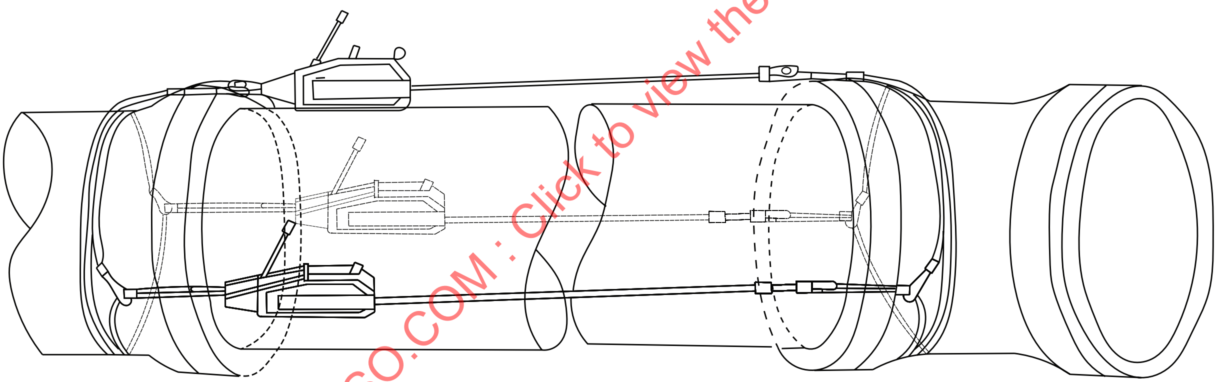
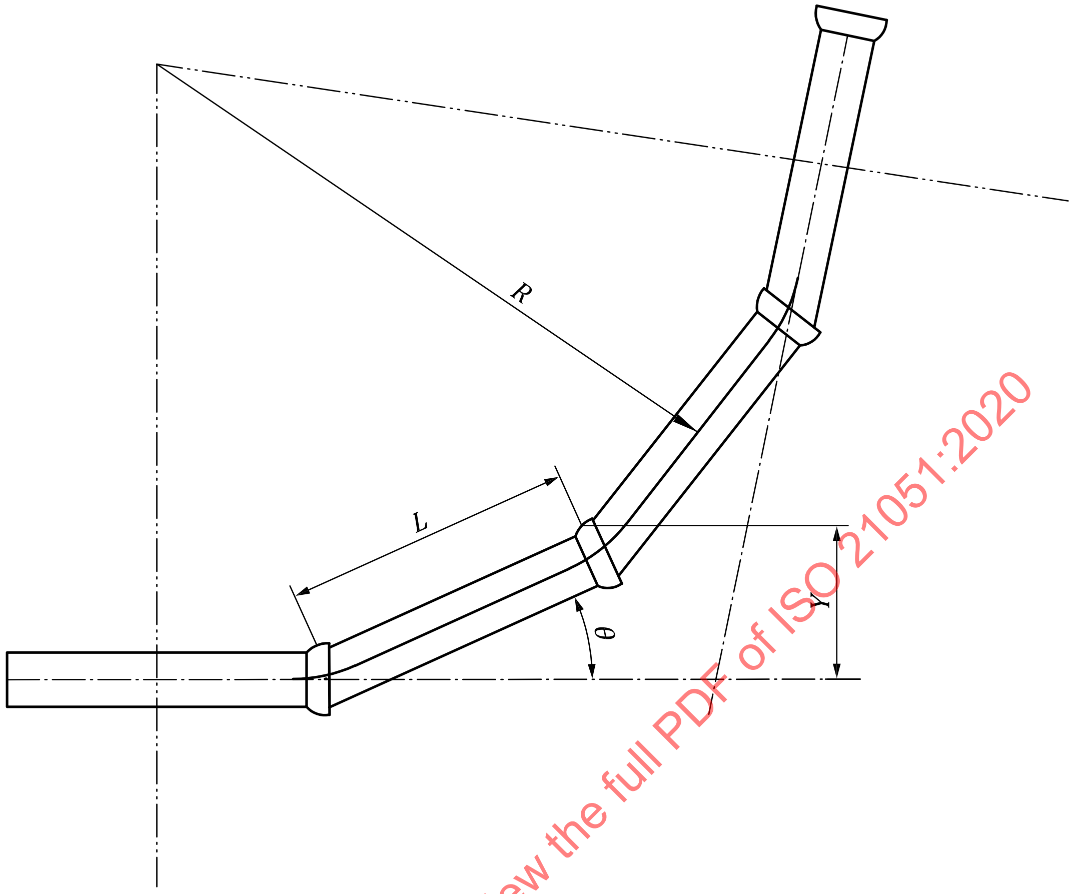


Figure 20 — Winch method (fitting jointing)

12.2.6 Maximum joint deflection and laying length

The joints for the ductile iron pipes have an inbuilt permissible deflection. Long radius curves may be negotiated by deflecting the joints (see Figure 21). The details of offset dimension and the radius of curvature for the given permissible deflection by the manufacturer are given in Figure 21. The permissible deflection allowed shall be as per the manufacturer's recommendations.



Key

θ	angle of allowable deflection
Y	displacement/offset dimension in meters, $Y = L \times \sin(\theta)$
L	length of each pipe in meters
R	radius of curvature, $R = L / (2 \times \tan \theta/2)$

Figure 21 — Pipeline curve geometry

EXAMPLE

Diameter of pipe = 300 mm

Length of pipe = 5,5 m

Allowable deflection angle $\theta = 3^0\ 30'$

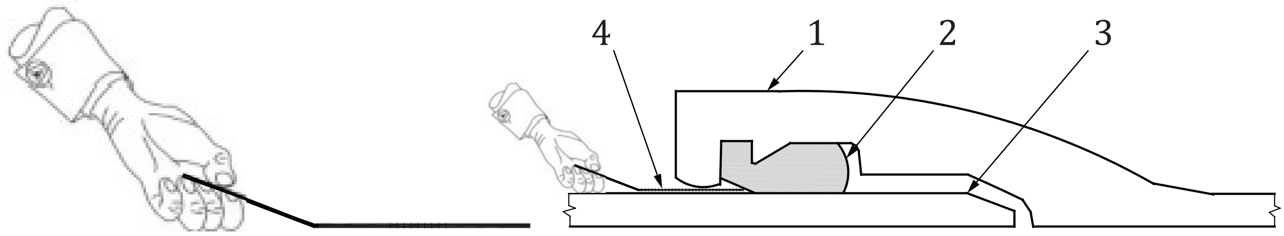
Joint deflection offset $S = L \times \sin \theta = 5{,}5 \times \sin(3^0\ 30') = 336$ mm;

Radius of curvature $R = L / (2 \times \tan \theta/2) = 5{,}5/\ (2 \times \tan(3^0\ 30'/2)) = 90$ m

It is to be ensured that any deflection in the joint should be given after jointing of the pipes.

12.2.7 Inspection of the joint

After the joint has been made by insertion of the spigot into the socket, the joint should be checked if the gasket is correctly inserted or not. A metal rule shall be inserted into the socket gap (see Figure 22). The depth of insertion (provide by the manufacturer and indicated on each pipe), should be equal around the whole circumference. If a difference is found, the gasket may have been displaced and the joint should be dismantled and re-made.



Key

1 socket

2 gasket

3 spigot

4 feeler gage/metal rule

Figure 22 — Inspection of joint

12.2.8 Dismantling of Joint

Push-in joints are normally dismantled with the same equipment which was used for the jointing. In this case, the equipment is fixed on the spigot end and is operated against the socket, so that the socket is pushed out till the joint is opened. One of the arrangement is shown below in Figure 23.

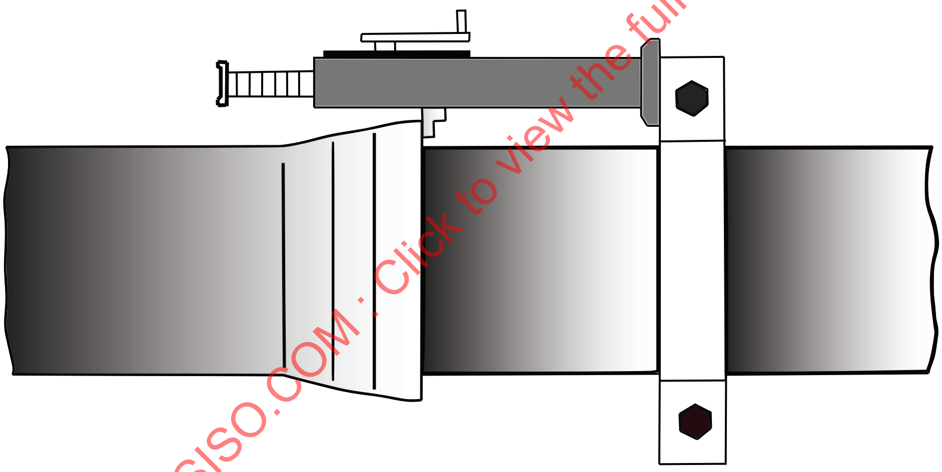
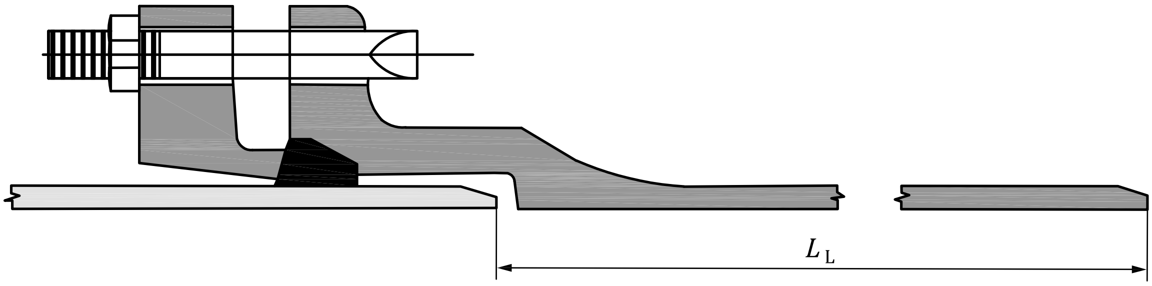


Figure 23 — Dismantling of joint

12.3 Mechanical joints

12.3.1 General

A typical mechanical joint is shown in Figure 24.



Key

L_L laying length

Figure 24 — A typical mechanical joint

12.3.2 Mechanical joint assembly for pipes

Mechanical joint assembly for pipes shall be made in the following steps:

a) Place the gland on the plain end (spigot end) with the lip extension toward the plain end, followed by the gasket with the narrow edge of the gasket toward the plain end (see Figure 25).

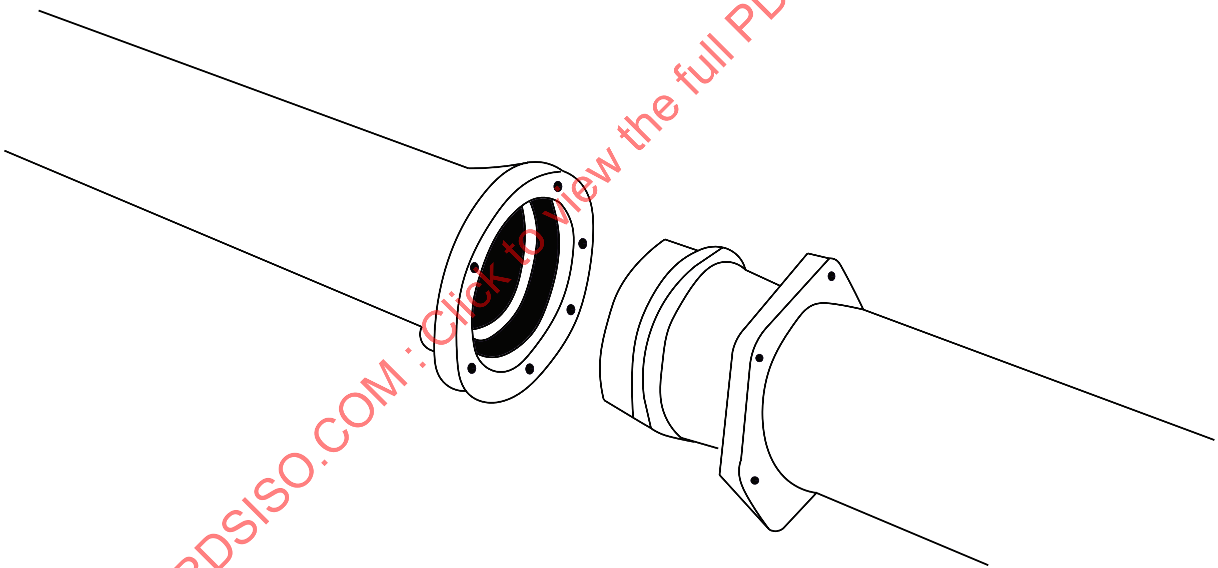


Figure 25 — Jointing of mechanical joint

b) Insert the plain end into the socket and press the gasket firmly and evenly into the gasket recess. Keep the joint straight during the assembly (see Figure 26).

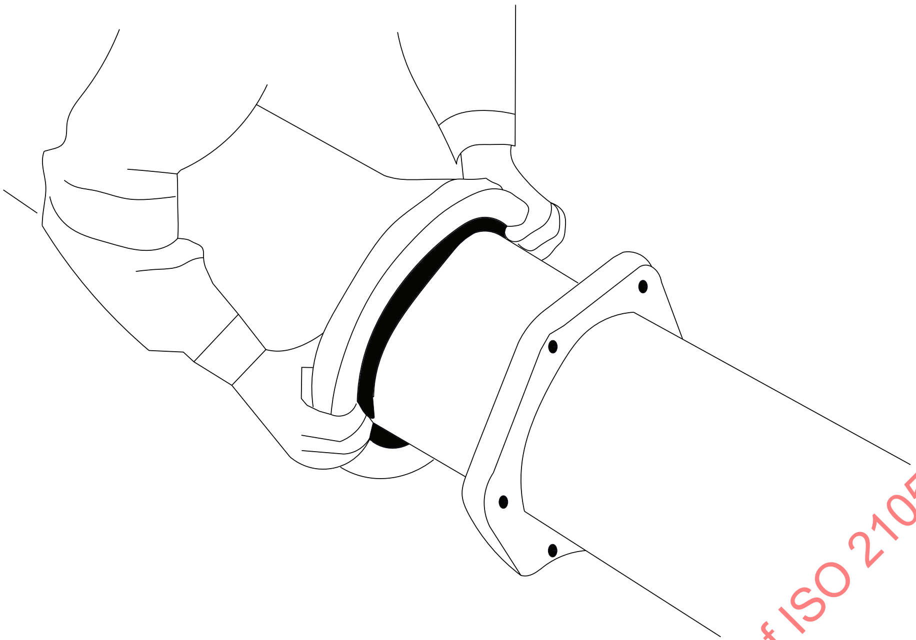


Figure 26 — Jointing of mechanical joint — Placement of gasket

c) Push the gland toward the socket and centre it around the plain end with the gland lip against the gasket. Insert bolts and hand tighten nuts. Make deflection after joint assembly but before tightening the bolts.

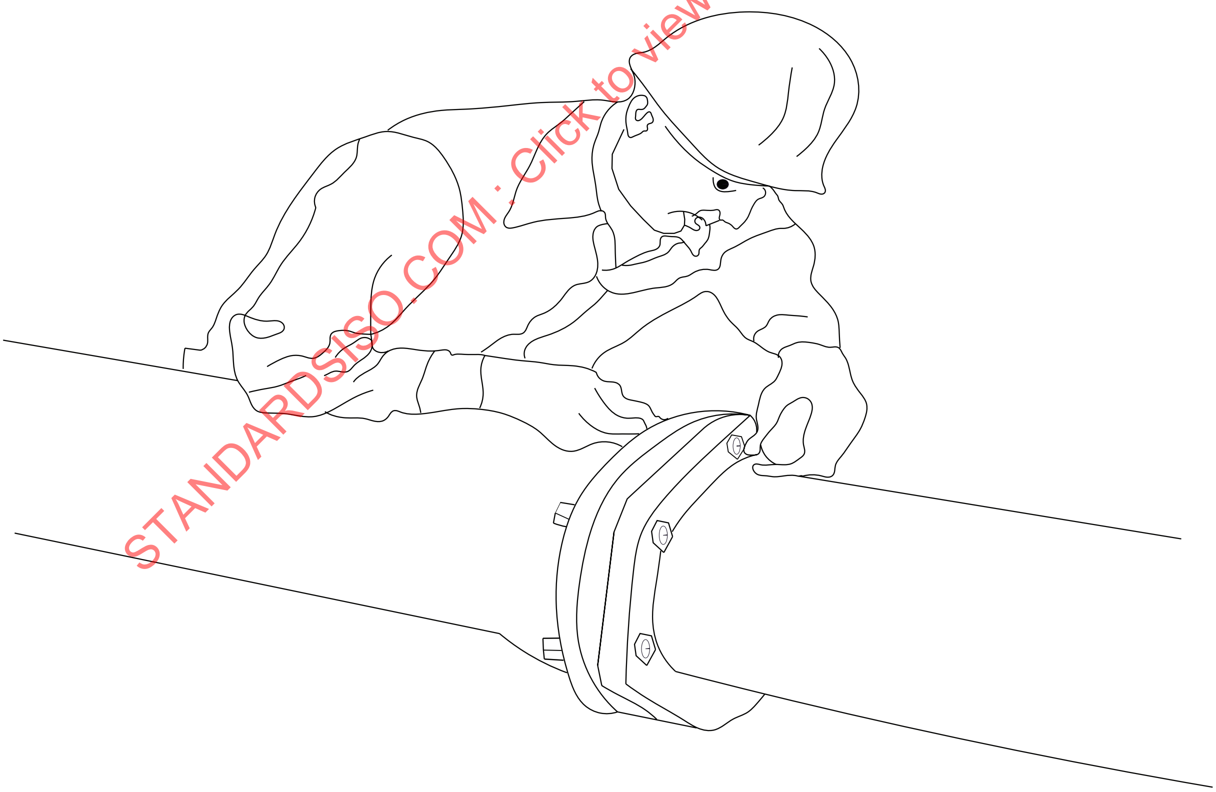


Figure 27 — Jointing of mechanical joint — Jointing of bolts

d) Tighten the bolts to the normal range if bolt torque while constantly maintaining approximately the same distance between the gland and the face of the flange at all points around the socket. This consistency can be achieved by partially tightening the bottom bolt first, then the top bolt, then the bolts at either side, and finally the remaining bolts (see Figure 27).

For other types of special joints, use the manufacturer recommendations for the preparation and jointing procedures.

12.4 Flanged Joints

12.4.1 General

Flanged joints are made on pipes having machined flanges 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. Gaskets of other materials, both metallic and non-metallic, are used for special applications.

The following precautions are necessary for a flanged joint.

a) Flanged pipes are mainly for over-ground installation. Buried installation of flanged pipe is not recommended.

b) Flanged joint being a rigid joint, perfect alignment of the flange faces during jointing and bolt tightening is absolutely vital.

c) Use of duck-foot bend at bottom of vertical flange pipe line is necessary.

d) For high pressure application, even flanged pipeline (both horizontal and vertical) needs thrust block/support at bends/tees.

e) Flange pipe laying is preferred from one side; if it is done from both sides, then it is necessary to put flexible coupling or mechanical joint collar in between to avoid pulling the flanged pipes flanges from both ends.

12.4.2 Flange bolting tightening sequence

It is important to follow a flange bolting tightening sequence in order to maintain the proper seating of the flange bolts and equal distribution of force on all the bolts.

After flange assembly and all nuts have been run down by hand, start wrench tightening following the sequence of the numbers indicated (marking the number on the flange with a crayon aids in keeping track of the tightening process), as shown in the Figure 28.

During all of the following steps, keep any gap between flanges even all around the circumference, and nuts made up approximately the same amount on each end of the bolt.

a) Before staring the bolt tightening, first of all it shall be ensured that the faces of the flanges are flat, clean and free from dirt or particles of foreign matter.

b) First time around just snug all the nuts with a hand wrench.

c) Second time around tighten the diagonally opposite nuts firmly with the same wrench.

d) Third time around apply approximately 25 % of the recommended torque.

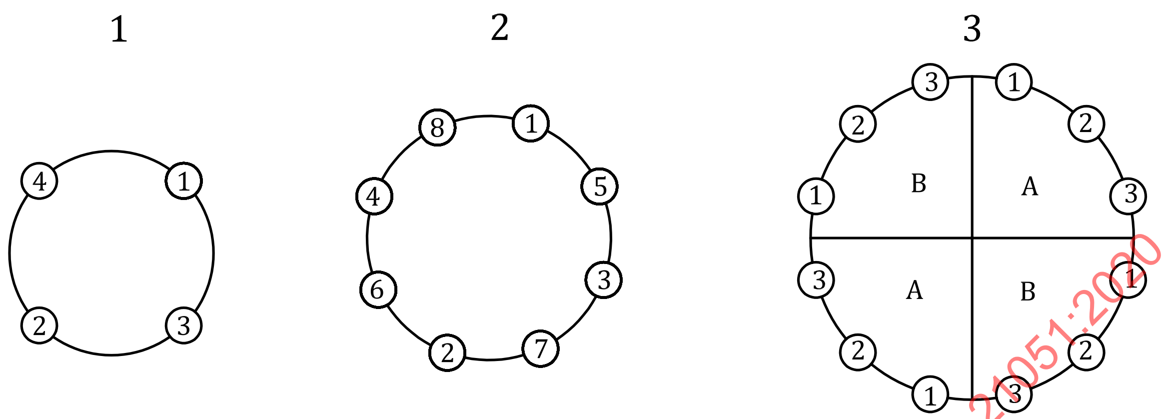
e) Fourth time apply approximately 75 % of the recommended torque.

f) Fifth time around, apply 100 % of the recommended torque.

g) Repeat this process until nuts do not move under 100 % of the recommended torque.

h) If possible, re-torque after 24 h. Most of any bolt preload loss occurs within 24 h.

For sizes having 12 bolts or more it is advisable that two jointers work simultaneously on diametrically opposite bolts. Each jointer tightens the first nut in the first quadrant, then the first nut in the first quadrant, then the first nut in the second quadrant, returns to the second nut in the first quadrant and so on as shown in Figure 28.



Key

1 4 bolts tightening sequence

2 8 bolts tightening sequence

3 12 bolts tightening sequence

A 1st

B 2nd

Figure 28 — Bolt tightening sequence for flanges

12.4.3 Maximum bolt tightening torque

The torque to be applied for the joint sealing will depend on various factors including the gasket material, surface conditions and site test pressure. Maximum torque for bolt tightening should be according to gasket manufacturer specification. In case, no instruction from manufacturer is available, maximum torque for bolt tightening is calculated using the following formula:

$$T = K \times D \times F$$

where

T is the target torque, in N.mm;

K is the nut factor, for zinc plated coating the K value varies from 0,17 to 0,22;

D is the nominal bolt diameter, in mm;

F is the target bolt load, in N.

$$F = A \times S_y \times 0{,}60$$

A is the tensile stress area, in m^2;

S_y is the bolt yield strength, N/m^2.

Precautions shall be taken to avoid application of very high torque, which can damage the gasket of the joint.

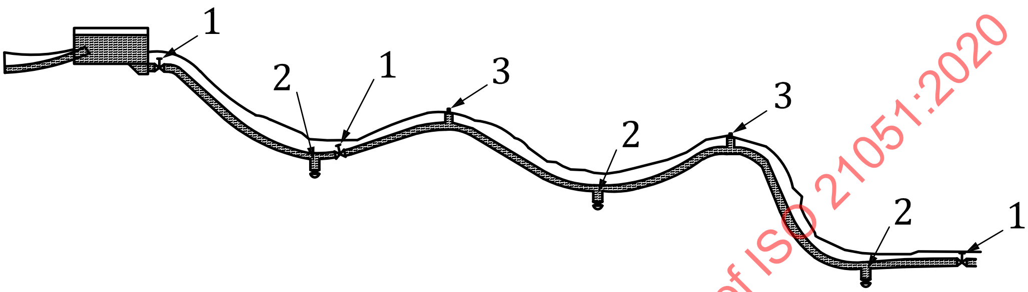
NOTE The maximum torque value are applicable on lubricated threads.

13 Functional features and installation of valves

13.1 Installation of valves

13.1.1 General

Valves are components in piping systems (see Figure 29) which, in addition to the function of "conducting the medium", also have the functions of blocking or regulating the rate of flow and the pressure. Valves are also necessary for the isolating segments of the pipeline and for draining the liquids and venting of air pockets.



Key

1 isolation valve

2 drain valve

3 air valve

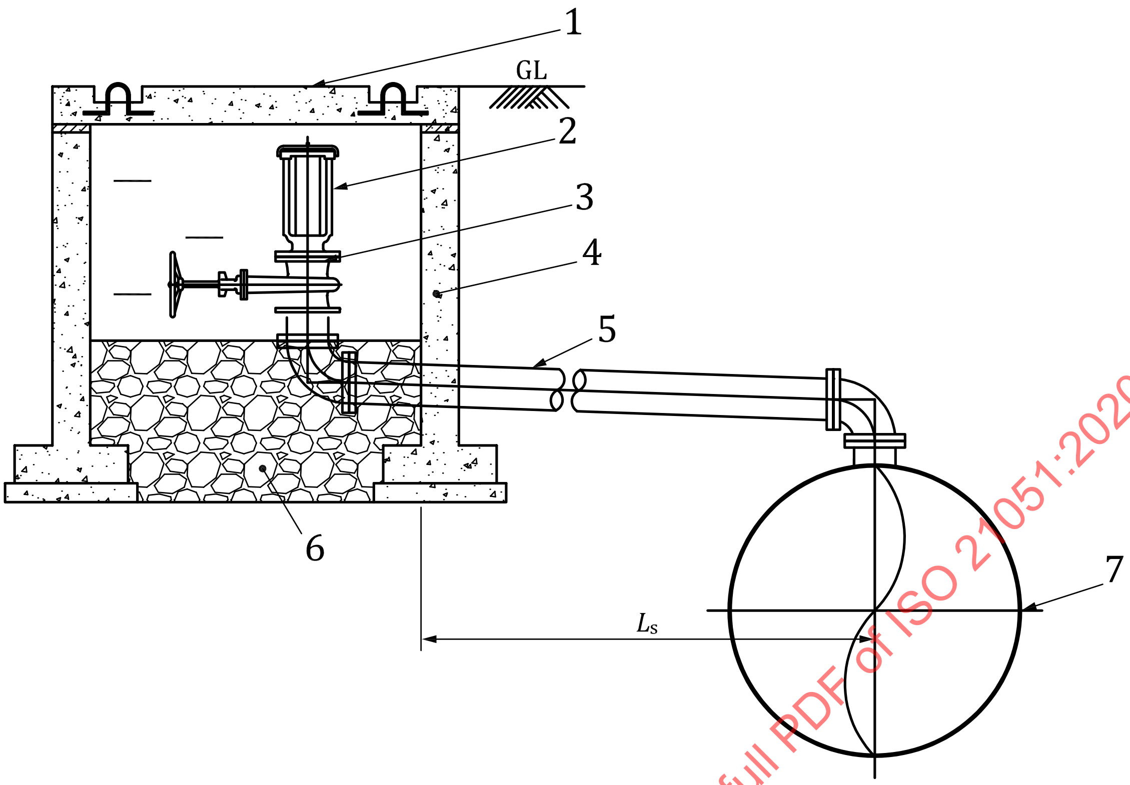
Figure 29 — Placement of valves along the pipeline alignment

All valves should be provided with necessary support. Valves installed above ground or in plant piping systems should be supported to prevent bending of the valve and connections as a result of the pipe loading. Valves should preferably be placed in concrete or masonry chambers to allow the access and the operation. Access manholes should be large enough to allow removal of valve for future replacement. In case the valve is installed below the ground level, necessary access and operating arrangement shall be provided for the operation of the valve. Thrust resulting from the valve closure should be carefully considered in the design of the piping system and valve chambers.

Various types of valves should be provided as per 13.1.2 to 13.1.6.

13.1.2 Air valves

An air valve is required to facilitate the release of air at high flow rates, when the pipeline is being filled and to permit the entry of air at higher flow rates during the draining. Air valves should be provided at every peak point in case of undulating terrain and at every 1 km in a flat terrain. The size and type of air valve should be determined. Even in case of no space available for the installation of air valve directly on the pipe, the air valve should be installed with a tapped connection and the location of air valve may be slightly away (see Figure 30), wherever the space is available. Air valve should always be exposed to air for the flow of air in and out of air valve and if necessary the air valve chamber may be connected with a pipe leading to the atmosphere.



Key

1 precast slab with lifting leg
2 air valve
3 sluice valve
4 reinforced concrete
5 branch pipe
6 gravels and murum to allow drainage
7 main pipe
L_s length to suit site
GL ground level

Figure 30 — Typical air valve chamber installation (in case of space constraint)

13.1.3 Scour valves or drain valves

Scour valves or drain valves should be provided at every low point for draining and flushing.

The size of the valve will depend upon the volume of water to be drained, the time available and the capacity of the receiving water course or area.

13.1.4 Isolation valves

The location of isolating valves shall be planned to facilitate shut-off in an emergency. Consideration should be given to the number of properties likely to be affected in relation to the required level of service. Local circumstances involving housing density and the location of hospitals, schools, apartment buildings and industrial premises should be taken into account.

Isolation valves should be installed on all branches as close as possible to the through main. Valve location and metering installation should facilitate leak detection procedures. Between two line valves it may be useful to install facilities for releasing pressure, for venting and draining. For principal and local mains, hydrants may fulfil this purpose.

The distance and location of shut off valves should be fixed according to the local conditions. In general, the intervals between shut-off valves should not exceed:

— in trunk mains: 5 km;

— in principal mains: 2 km;

— in local mains (rural): 1 km;

— in local mains (urban): 0,5 km.

In case of a gate valve for large diameter pipeline (>DN 600) and having relatively high pressure (>10 bar), a bypass arrangement should be provided for the ease of operation.

13.1.5 Hydrants

Hydrants are required for fire-fighting. They may also be used for the operational purposes, e.g. filling, draining, venting and flushing of the main. Wherever, hydrants are installed on trunk mains or principal mains, an isolating valve should be provided. Consideration should be given to avoiding stagnation at hydrants.

13.1.6 Surge limiting equipment

Proper installation of non-return valve with pressure release valve as a bypass arrangement may reduce the surge pressure to a great extent.

Surges can be generated following power failures, pump starting or stopping and valve operation. Consideration should be given to the need for the surge limiting equipment as part of the pumped or gravity system.

14 Restrained joints and thrust blocks

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.

Anchorage to resist the thrust should be designed taking into account the system test pressure (STP).

The best way to resist the thrust in case of buried pipelines is to use the restrained joint pipes (self-anchored joints). In such a case, the restraint is achieved by transferring the thrust forces generated to the surrounding soil structure.

The other method of resisting thrust forces is the use of thrust blocks, wherever allowed by ground conditions, access and space.

For the design of restrained joint pipes, ISO 10804 shall be followed.

15 Cleaning, hydraulic testing and commissioning of pipeline and pipeline components

15.1 Cleaning

Before testing, the pipeline should be cleaned internally as thoroughly as possible to ensure that no foreign matter remains inside the pipe.

15.2 Hydraulic testing

Newly installed pipelines shall be tested in accordance to ISO 10802.

16 Flushing and disinfection

All efforts should be made to keep lines clean during installation. However, thorough flushing is recommended prior to the pressure testing. Flushing should be accomplished by partially opening and closing the valves and hydrants several times under expected operating pressure with adequate flow velocities to flush foreign materials out of the valves and hydrants.

Disinfected water should be used for disinfection of the pipeline to an acceptable level before discharge to water source.

If chlorinated products are used after chemical cleaning, it is necessary to ensure, by appropriate control, that there is no residual cleaning agent before proceeding to the disinfection step. If residual is present, it is imperative to repeat the rinsing operation.

The cleaning and disinfection procedure is considered satisfactory when the results comply with the criteria for the potable water as per the national standard. In case no requirements are given in the national standard, the criteria presented in Table 4 (see below) may be used as a guideline.

Table 4 — Criteria for quality of potable water

Parameters to be controlled	Acceptance criteria
Free chlorine (in situ)	≤ 0,5 mg/l
pH (in situ)	6,5 < pH < 9
Turbidity increase (in situ)	+0,5 FNU (check FNU or NTU) <0,5 FNU
Turbidity (in situ)	2 FNU
Test aspect / colour / odour / savour (in situ)	No anomalies
Conductivity	180 µs/cm to 1 000 µs/cm
Ammonium concentration (NH_4)	<0,1 mg/l
Nitrites concentration (NO_2)	<0,1 mg/l
Iron concentration (Fe)	<200 µg/l
Coliform bacteria (total coliforms), E. coli and faecal enterococcidans in 100 ml	Absence

Key
FNU formazin nephelometric unit
NTU nephelometric turbidity unit

NOTE In a newly commissioned pipeline (without seal coat), the pH value can increase in the initial few days which normally comes down to the normal limits within 2 to 3 weeks of commissioning.

17 Service connections

17.1 General

After the pipe has been hydro tested, flushed and disinfected, the service connections can be made. There are various types of service connections available and reference should be made to the applicable national standard.

However, normally two types of service connections, i.e. conventional type and external seal type, are used as described in 17.2 and 17.3.

17.2 Conventional type service connection

The inlet of the conventional type connections has taper screw threads. The angle of taper and type of screw threads may vary on the connections of different types of manufacturers (see Figures 31).

When fully tightened, the threaded inlet of the connection provides both anchorage and a leak tight seal. The minimum thickness of pipe should be 6 mm for direct tapping service connection.

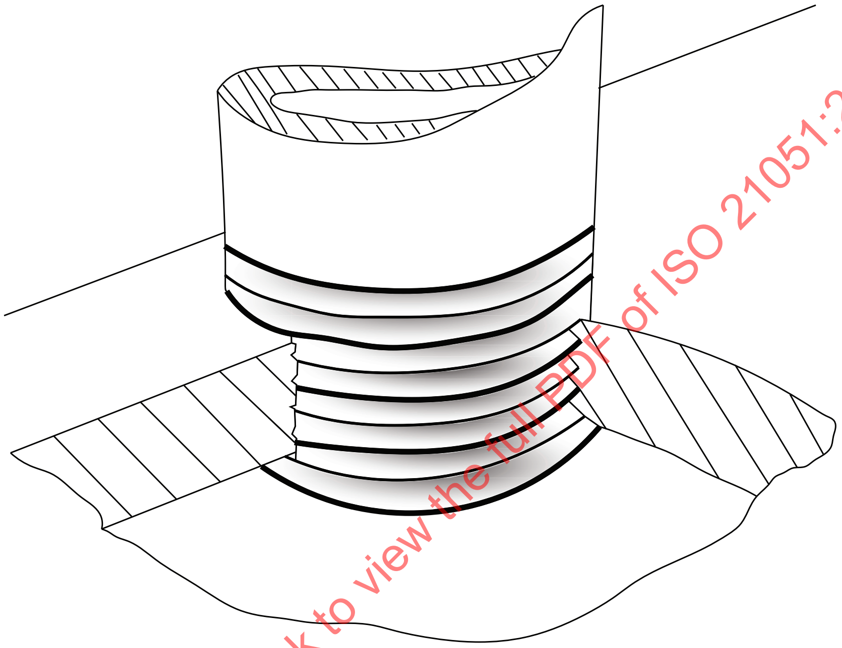


Figure 31 — Direct service connection (convention type) for ductile iron pipes

17.3 External seal type connection

In the external seal type connections, the pressure seal is achieved by compressing a gasket of elastomeric material onto the pipe body and the inlet stem of the connections. The required compressive load is applied by tightening a backing nut onto a suitable shaped saddle.

A suitable saddle should be used in case of factory applied wrapping on ductile iron pipes (see Figure 32).

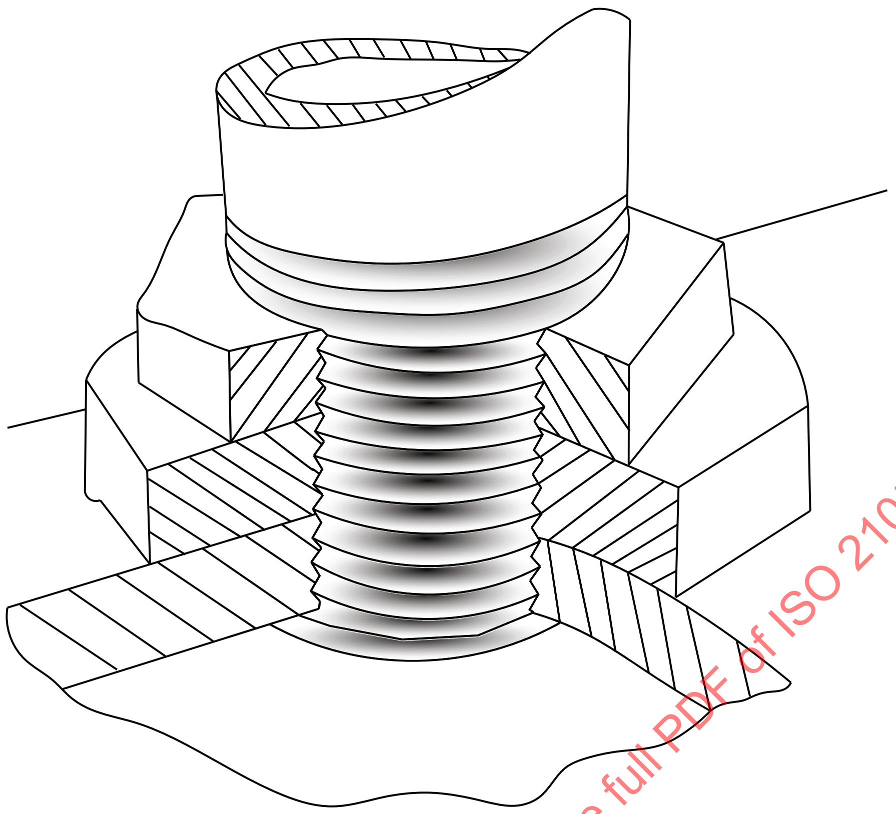
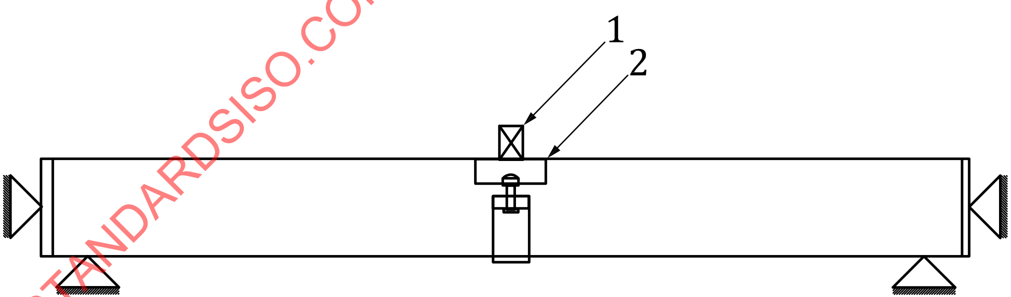


Figure 32 — External seal type connections for ductile iron pipes

17.4 Saddle for ductile iron pipes for distribution network

Since the wall thickness of the ductile iron pipes to be used in the distribution system have thickness lower than 5 mm, direct service connections (see Figure 33) are not possible and therefore a saddle should be used for the service connection. The saddle can be of ductile iron or high-density polyethylene (HDPE).



Key

1 valve

2 saddle

Figure 33 — Saddle for service connection for ductile iron pipes

18 Supporting pipes

18.1 General

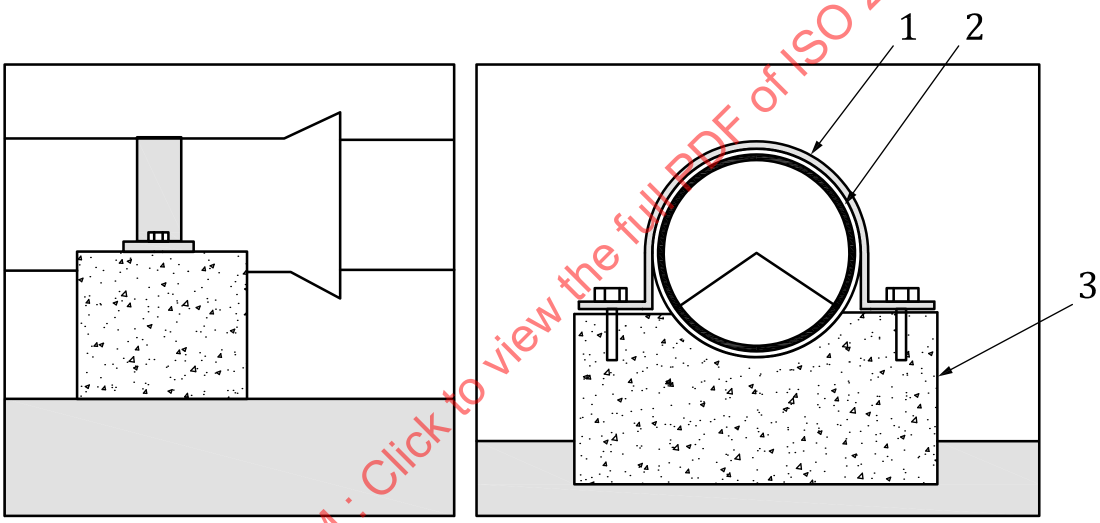
Whenever the pipes are required to be laid above ground on supports, the recommendations given in 18.2 to 18.4 should be followed.

18.2 Support for above ground installation

Above ground installations of socket and spigot pipe shall be provided with at least one support per pipe, the support should be positioned behind the socket of each pipe (see Figure 34).

Pipes should be fixed to the supports with steel straps, so that axial movement due to expansion, or contraction resulting from temperature fluctuations, is taken up at individual joints in the pipeline.

Properly designed anchorage in the form of thrust blocks should be provided to resist the thrusts developed by internal pressure at bends, tees etc.



Key

1 fixing clamp

2 rubber lining

3 concrete support

Figure 34 — Pipe on supports

18.3 Maximum span for river crossing

Where a support cannot be provided at every pipe e.g. at river crossings etc., spans up to 11 m for the pipes of length 5,5 m and 12 m for the pipes of length 6 m, can be installed by positioning supports relative to the joints as indicated in the Figure 35 below.

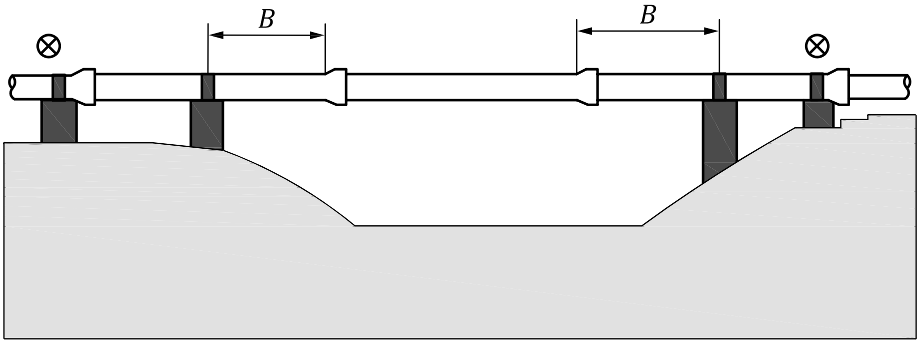


Figure 35 — Maximum span for ductile iron pipes on supports

The length of the dimension *B* should not exceed the one quarter of the total span. Cut pipes, fittings, valves etc., which are adjacent to the span, should be positioned outside the joints marked X and the length between the joints X – X should be equal to the 3 full length pipes.

To prevent excessive stresses in the pipe, the joints at each end of the centre suspended pipe should not be deflected.

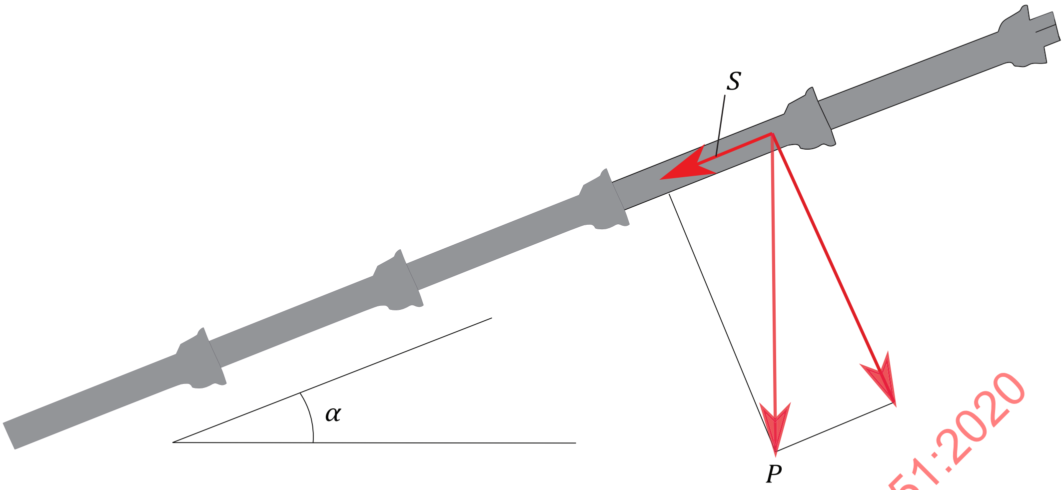
18.4 Laying of ductile iron (DI) pipes in hilly terrain

18.4.1 General

The laying of push-in joint DI pipes in a hilly terrain requires certain precautions and certain specific directives as per the details given below.

18.4.2 Pipe line anchoring on slope

Beyond a certain angle the friction between the pipes and ground is insufficient to hold the pipeline. In such cases, it is advisable to counteract the axial gravity component of the force generated due to the pressure, weight of pipe and weight of water with structurally designed anchor blocks/vertical anchor walls/self-anchored joints (i.e. restrained joint) or combination of vertical supports and restrained joint (see Figure 36).



Key

S slip

P gravity force

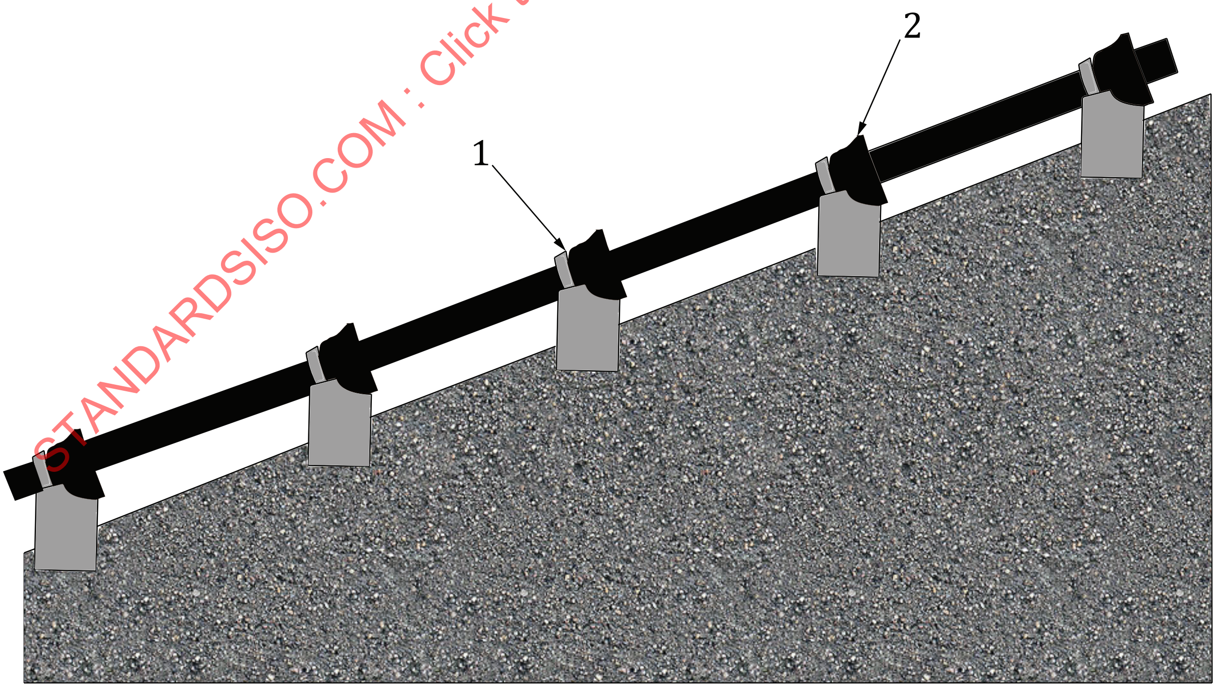
α slope angle

Figure 36 — Force diagram on DI pipes on slope

For restrained joint pipes, the reference shall be made to ISO 10804.

Laying of ductile iron pipes on steep inclines can be performed in two ways:

a) By the installation of concrete thrust blocks cum supports on every pipe. The anchor shall be suitably placed near the socket of the DI pipe. The typical arrangement is shown in Figure 37.



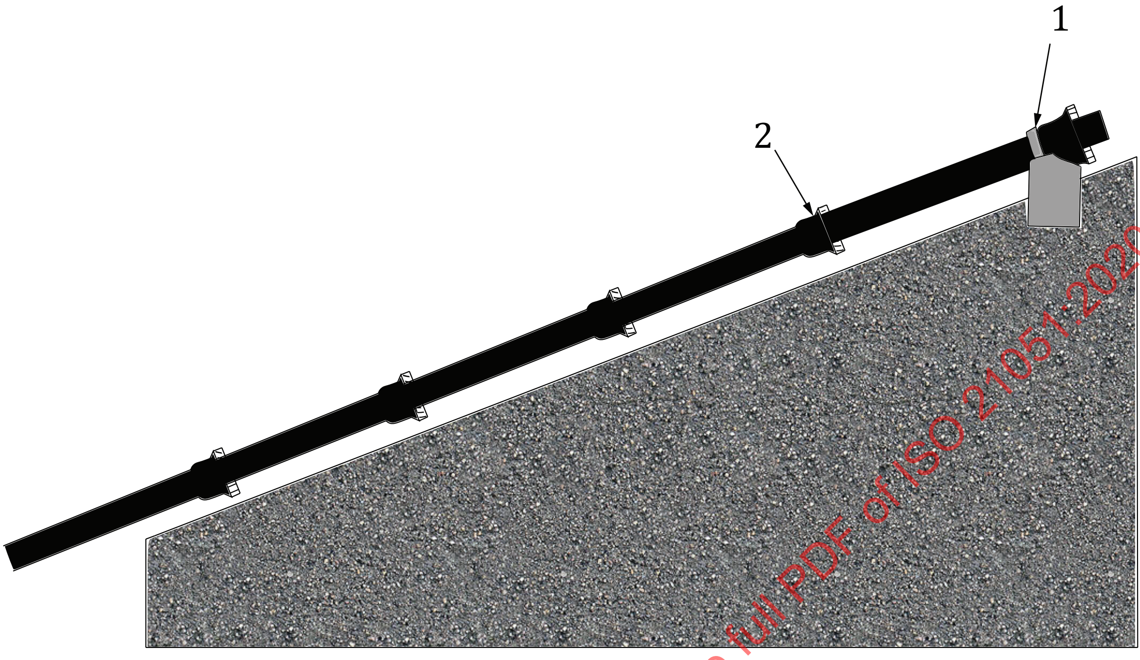
Key

1 anchoring collar

2 unrestrained joints

Figure 37 — Concrete supports arrangement in DI pipes at slope

b) By the installation of a concrete thrust block at the head of a self-anchored pipe section. Normally in such a case, the self-anchored restrained joints pipe is used for jointing the pipes. The concrete vertical supports shall be provided at the top of the slope and in between the slopes at certain points only for the purpose of holding the pipes. The typical arrangement is shown in Figure 38.



Key

1 anchoring collar

2 self-anchored joints

Figure 38 — Self-anchored/restrained joint DI pipes at slope

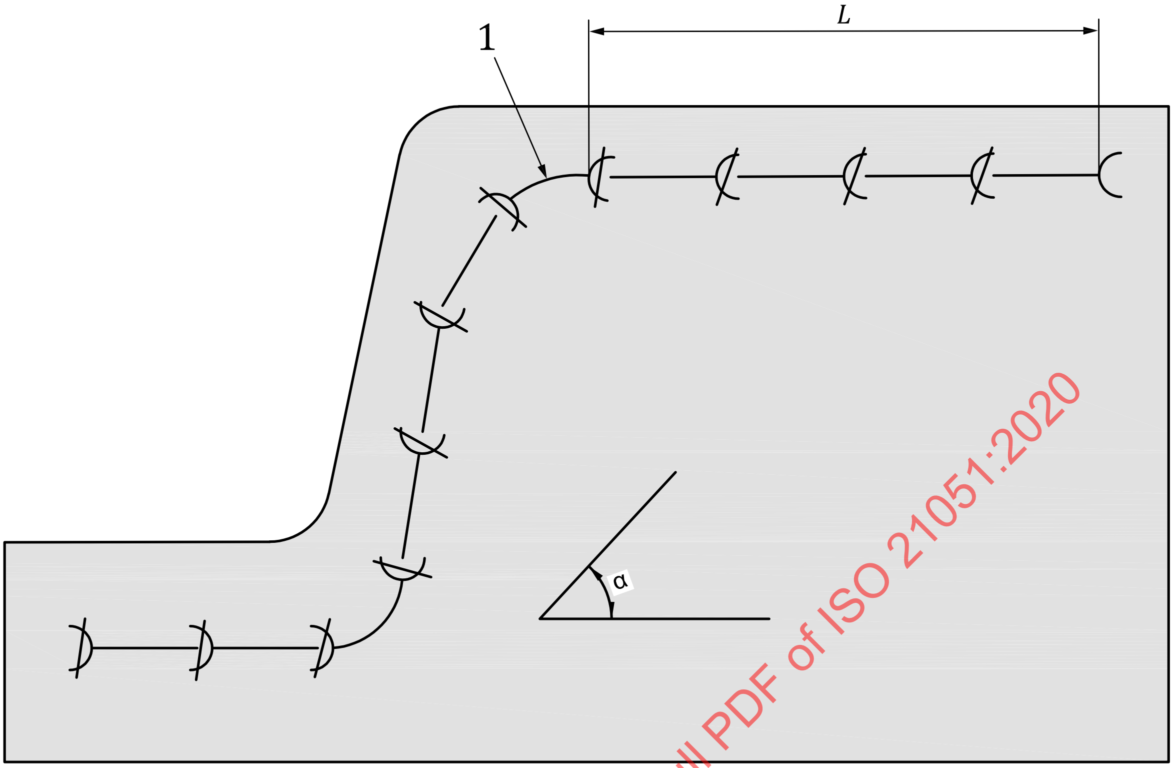
18.4.3 Basic precaution during trenching and bed preparation for pipes on slope

The following precautions shall be taken during the bed preparation for the pipes to be laid in a hilly terrain:

a) In rocky ground which is common in hilly areas, all stones/hard rock with sharp edges shall be removed from the trench bed. Ensure trench bottom is trimmed and levelled to provide an even bed of soft soil or sand of minimum 100 mm depth;

b) Avoid the use of angular granular material 5 mm or greater in size for bedding or sidefill.

c) If the gradient is 1:2 or steeper, even in the case of underground installation, the pipes neck should be anchored by concreting/brick or boulder masonry. If ground is loose and has low bearing capacity, concrete packing shall be provided behind the socket to avoid down-sliding/snaking of pipes and subsequent joint separation (see Figure 39). For very steep gradients, restrained joints/flanged joints or providing concrete anchor blocks behind each socket are recommended, even when laid underground.



Key

1 uppermost self-anchored bend

L length of self-anchored pipe in one direction of bend

α slope angle

Figure 39 — Anchoring for pipes on slope

18.4.4 Additional precautions during laying in a hilly and rocky terrain

a) It is common practice to lay the pipes with socket facing the direction in which the work is progressing, however it is not mandatory.

b) For example, when the pipes are being laid downhill, the pipes are occasionally laid with the sockets facing uphill, for the ease of installation, however the direction of socket is not functionally related to the direction of flow within the main. The specific method of laying depends upon the slope of the hill, soil conditions and structural design of the pipeline system with suitable anchoring system to avoid pipe movement.

c) All fittings should be suitably anchored against displacement as recommended in the laying specification. External anchorage should be provided at blank ends, bends, tees, tapers and valves also to resist the thrust arising from internal pressure and dynamic loading. Concrete anchor blocks should be of such a shape as to leave the joint area clear.

d) Where the soil/pipe friction is low, care should be taken to ensure that no excessive spigot entry or withdrawal occurs. All spigots should be marked with the depth of socket before laying and care should be taken to see that all joints are completely assembled up to the required mark.

e) Hilly areas often get heavy rainfall in short duration and have heavy run-off. In such cases, an alternative arrangement is required to protect the DI pipe and laying should be done as shown in Figure 40, where most of water is diverted through a higher drain, the pipe covered with soft soil and the cover lined with boulders which protects the pipe from heavy run off.

