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Unplasticized polyvinyl chloride (PVC-U) pipes for water supply — Recommended practice for laying

*Canalisations en polychlorure de vinyle non plastifié (PVC-U) pour l'adduction d'eau
— Pratique recommandée pour la pose*



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Contents

	Page
Foreword	iii
0 Introduction	1
1 Scope	1
2 Field of application	1
3 References	1
4 Parameters influencing design	2
5 Hydraulic properties	2
6 Assembly methods	3
7 Bends	7
8 Storage, handling and transport	7
9 Inspection	9
10 Laying	9
11 Test pressure procedure	11
12 Corrosion protection	13
13 Water hammer	13
14 Repairs	13
Annex 1	15
Annex 2	17

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The main task of ISO technical committees is to prepare International Standards. In exceptional circumstances a technical committee may propose the publication of a technical report of one of the following types:

- type 1, when the necessary support within the technical committee cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development requiring wider exposure;
- type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical reports are accepted for publication directly by ISO Council. Technical reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 4191, which is a technical report of type 3, was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*.

The reasons which led to the decision to publish this document in the form of a Technical Report type 3 are explained in the Introduction.

This Technical Report gives advice for avoiding errors in the installation of plastics pipes. Certain other requirements could be put forward to cover special safety or installation conditions.

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Unplasticized polyvinyl chloride (PVC-U) pipes for water supply — Recommended practice for laying

0 INTRODUCTION

This subject was studied by working group 2 (WG 2), now sub-committee 2 (SC 2) of ISO/TC 138 and resulted in the production in 1979 of draft proposal DP 4191.2. WG 2 has examined the comments received on this draft proposal and decided to convert it into a type 3 Technical Report, so as not to oppose certain national regulations already in existence, which are not always taken into account by this document (national regulations still take precedence over an ISO Technical Report). In particular, national safety regulations shall be followed during the laying of buried PVC pipes for water supply.

1 SCOPE

This Technical Report gives instructions for the correct use and installation of unplasticized PVC pipes for water supply. The geometrical, mechanical and physical properties of the pipes and fittings, covered by this Technical Report, are given in DIS 4422.

2 FIELD OF APPLICATION

This Technical Report is applicable to PVC pipes for :

- buried pipelines and branches for water supply
- overhead pipes for water distribution to the interior and exterior of buildings
- the transport of water under pressure up to a temperature of 45°C for general use, and likewise for potable water supply

NOTE - Only companies with competent staff should be awarded contacts for the laying of pipes. The appropriate safety regulations of the country should be complied with.

3 REFERENCES

DIS 4422 - Unplasticized polyvinyl chloride pipes and fittings for water supply - Specifications.

TR 10501 - Thermoplastics pipes for the transport of liquids under pressure - Calculation of head losses.

4 PARAMETERS INFLUENCING DESIGN

4.1 Nominal pressure and service pressure

- 4.1.1 The nominal pressure and permissible service pressures for water at temperatures up to 45°C are given in DIS 4422, table 1.
- 4.1.2 The maximum permissible service pressures have been calculated on the basis of well established data, taking a service life of at least 50 years of continuous service, with a safety coefficient in excess of 2.

4.2 Precautions

- 4.2.1 Where a pipe is likely to operate under abnormal mechanical or physical conditions, it may be beneficial to use a stronger design than for normal conditions.
- 4.2.2 The pipe elements shall not be exposed to flames or to radiant heat which is likely to raise their surface temperature to more than 60°C.
- 4.2.3 Where national regulations authorise the use of metal pipes for the earthing of electrical installations, care should be taken to maintain electrical continuity of the pipes, or to provide a new earth.
- 4.2.4 Unplasticized PVC does not conduct electricity and thus cannot be used for earthing; neither can these tubes be thawed by electrical means using the pipe as a conductor.
- 4.2.5 On account of the high electrical resistance of unplasticized PVC pipes, precautions shall be taken where hazards exist due to static electricity.
- 4.2.6 Unplasticized PVC is susceptible to splitting; screw cutting or tapping on site is therefore not recommended.
- 4.2.7 The forming of joints and bends on site is not recommended.
- 4.2.8 The handling and laying of unplasticized PVC pipes require the taking of reasonable precautions. Despite their robustness which is usually more than adequate for withstanding normal laying, it should be known that their constituent material becomes less robust at low temperatures encountered in winter.
- 4.2.9 The pipes shall not be covered with solvents or aggressive paints.
- 4.2.10 For drinking water networks, refer to sub-clause 7.1.4 of DIS 4422.

5 HYDRAULIC PROPERTIES

PVC pipes have a smooth polished internal surface which considerably delays the formation of scale.

5.1 Loss of head

The universal table given in annex to ISO/TR 10501 ¹⁾ gives the loss of head to be allowed for thermoplastics pipes with a smooth internal surface.

5.2 Internal diameter

As it is the external diameter of an unplasticized PVC pipe which is specified, the internal diameter varies according to its pressure series S (see DIS 4422, table 1), and this should be taken into account when calculating the hydraulic properties.

Note - The nominal size DN cannot be subject to measurement and shall not be used for purposes of calculation, as DN is only loosely related to manufacturing dimensions

6 ASSEMBLY METHODS

6.1 General

- 6.1.1 Unplasticized PVC pipes complying with DIS 4422 are manufactured by continuous extrusion, but they are normally supplied in standard lengths. Some have smooth ends and are assembled by means of separate sleeves, while others are provided with a prefabricated socket at one end.
- 6.1.2 The joints and fittings to be used with unplasticized PVC pipes are specified in DIS 4422. They are designed so as to have a service life at least as long as that of the pipes themselves. As a result, they can withstand the test pressures applicable to the series of pipes concerned. (see DIS 4422, § 6.1.1.)
- 6.1.3 The types of joints can be divided into three categories,
- (1) cemented joints, where adhesive is applied both to the spigot end of the pipe and in the socket (see § 6.2). These joints withstand "end thrust"
 - (2) automatic joints, where an elastic seal is automatically compressed and forms a sealed joint when the spigot end is inserted into the socket (see § 6.3)
 - (3) mechanical joints, in which a sealing washer is compressed by any external means of tightening (see § 6.4)
- 6.1.4 These three categories of joint may form an integral part of sockets already provided on the pipe itself : in this case they are termed "preformed joints". As an alternative, two joints may be combined in a double socket for joining pipes with smooth ends : in this case they are termed "sleeves".

1) to be published

6.1.5 The pipe joints described in annex 2, § 2 and 3, in which water tightness under pressure relies on the compression of an elastic sealing element, offer little resistance to end thrust which occurs at bends, flanges, valves, etc; consequently, the pipe should be adequately anchored if such joints are used. Pipes shall in any case be suitably anchored. There are also special sleeves with high tensile strength capable of holding where there is thrust (see annex 2, figure 2c).

6.1.6 If it will be necessary at some time to dismantle the piping, mechanical joints should preferably be used.

6.2 Cemented joints

6.2.1 The dimensions of the sockets and spigot ends shall meet the requirements of DIS 4422 if successful cemented joints are to be obtained. A typical joint is shown in figure 1b of annex 2.

6.2.2 The adhesives shall meet the functional requirements of DP 9311 and the identification characteristics (as in DIS 7387/1) specified by the manufacturer.

6.2.3 The adhesives shall not contain any substance which is likely to affect the taste or odour of the water, or to have a toxic effect, or to encourage the growth of bacteria.

NOTE - It is however necessary to rinse recently laid pipes.

6.2.4 Jointing operation

According to the nature of the adhesive and the clearance tolerances between the spigot end and the socket (§ 5.2.1 of DIS 4422), there are different methods of cementing. The manufacturer's instructions shall be followed. There are however some points common to all cemented joints :

- (1) Adhesive can be inflammable : do not smoke in the area in which it is being used. The adhesive shall be applied in a well ventilated space.
- (2) The adhesive shall have the required viscosity, it shall not be diluted.
- (3) The pipe shall be :
 - cut square to its axis
 - chamfered at the end to prevent the over-spill of adhesive (see figure 1a, annex 2)
- (4) The surfaces to be joined shall be clean, dry and free from grease
- (5) Special precautions shall be taken when cementing is performed at temperatures close to freezing.
- (6) Apply the adhesive in an even layer in a longitudinal direction, but with a thicker coating on the spigot end.

- (7) Cementing shall be performed quickly. For diameters ≥ 90 mm, two persons are required to apply the adhesive to the spigot end and to the socket simultaneously.
- (8) Smudges of adhesive shall be removed as soon as the joint has been made. Once the joint is made, leave to dry without disturbing for at least 5 minutes.
- (9) The joint becomes resistant to pressure only after an additional period. This period depends upon :
 - the type of adhesive (see manufacturer's instructions)
 - the play between the socket and spigot end
 - the ambient temperature (see table 4 of annex 1)
 - the test pressure
- (10) Special bonding techniques shall be used for diameters of 200 mm and above.

6.3 Joints using an elastic sealing ring (automatic joints)

- 6.3.1 An automatic joint comprises an elastic sealing element which is automatically compressed and which forms a seal when the spigot end is inserted into the socket. The elastic sealing ring is located in the socket; the profiles of the ring and of the socket depend on the manufacturer's design. The rings to be used shall be those supplied by the manufacturer for his own assembly system. If the elastic sealing ring is not in place at the time of delivery, clean the groove, remove any foreign bodies and then locate the ring correctly in the groove.
- 6.3.2 Manufacturers generally suggest sealing rings of natural or synthetic rubber, or a mixture of the two (see DIS 4422, § 9).
- 6.3.3 Automatic joints are not intended to withstand end thrust. Particular attention shall be paid to the correct anchorage of the elements. The anchorage blocks shall be designed to withstand the thrust due to the maximum pressure which the pipe may be subjected to, i.e. normally the test pressure. It is recommended that direct contact between the unplasticized PVC pipe and the anchorage block be avoided, by interposing an appropriate flexible polyethylene film. Figures 7a, b and c of annex 2 give examples of arrangements.
- 6.3.4 Correct assembly by means of an automatic joint requires that the spigot end be chamfered and correctly lubricated prior to insertion into the socket. Where the pipe manufacturer does not supply a lubricant, use one which does not have any harmful effect on the pipe, fitting, or elastic sealing ring; if the pipe is to carry potable water, the lubricant shall not be toxic, shall not impart any taste or odour to the water, and shall not encourage the growth of bacteria.

As soon as the spigot end has been lubricated, it should be introduced into the neighbouring socket, after it has been correctly aligned, so as to avoid any risk of soiling or pollution. The spigot end shall be inserted into the socket up to the

reference mark made by the manufacturer. The penetration of the tube into the sealing element of the socket guarantees good holding under pressure. Where there is no mark, insert the spigot end fully if laying takes place in cold weather. If laying takes place in warm weather, it is recommended that the pipes be cooled before assembly, for example by placing at the bottom of the trench.

NOTE - The pipes may be recut on site but the cut shall be square and the end shall be chamfered. Sealing rings which have slipped out of place and dirt under the sealing rings are the most frequent causes of leaks : both problems can be avoided by correct operation.

6.4 Mechanical joints

6.4.1 Compression joints (see figure 3, annex 2)

These are similar to automatic joints, the only difference being that the elastic ring is compressed by means of an external tightening system. An example of this is given in figure 3, where the joint is bolted or screwed onto the socket. Mechanical compression joints are useful for joints to pipes of other materials, such as asbestos cement or cast iron, where necessary using adapters.

Care should be taken not to overtighten the elastic ring which is in contact with the PVC-U pipe, otherwise there is a risk of the pipe deforming under the thrust exerted by the ring and the tightness of the joint can be impaired. Because of the smooth surface of an PVC-U pipe, sealing is obtained with a light compression. For the lightest pipes, an internal sleeve may be used to increase their rigidity.

6.4.2 Threaded joints

There is a range of threaded joints for assembly to metallic pipes :

- Unplasticized PVC adapter fittings (see figure 4a, annex 2) as in DIS 4422, § 5.2.3.
- PVC and metal adapter fittings (see figure 4b, annex 2) as in DIS 4422, § 5.2.3.

In general unplasticized PVC does not thread well on account of its susceptibility to splitting.

6.4.3 Flanged joints

Flanges can be used (see figure 5, annex 2) for joining together unplasticized PVC pipes, and for joining them to metal flanges, valves and flanged fittings. The joint is obtained by compression of a gasket or ring placed against the flange. Gaskets or rings of plasticized PVC, or containing aggressive substances shall be avoided. The flanges may be assembled

- a) by cementing (onto a pipe spigot) of a flat joint PVC fitting for a mating flange (figure 5b, annex 2) as in DIS 4422, § 5.3).
- b) by cementing (to a pipe spigot) of a PVC fitting with a groove and O-ring for a mating flange (figure 5c, annex 2) as in DIS 4422, § 5.3.
- c) by using a threaded joint in combination with a metal flange (figure 5c, annex 2), as in DIS 4422, § 5.2.

7 BENDS

7.1 Cold bending

Unplasticized PVC pipes with external diameter up to 200 mm have a degree of flexibility and can bend to follow the windings of the ground and upward turns; however, the radius of curvature (R) shall not be less than about 300 times the external diameter of the pipe. Figure 6, annex 2, shows a method of cold bending and adjusting, for pipes in standard lengths of 6 m and 12 m. With certain types of joint, there may be limits to the possible range of bending radii.

7.2 Hot bending

Bends can be made with a minimum bending radius of 2.5 to 5 times the diameter of the pipe, utilizing the thermoplastic properties of the material. However, this is a delicate operation as it depends on the external diameter and the thickness of the pipe and it is not recommended that it be carried out on site.

8 STORAGE, HANDLING AND TRANSPORT

8.1 Storage

- 8.1.1 Unplasticized PVC pipes are durable despite their lightness. Consequently handling is very easy and they are more likely to be mistreated than their metal counterparts. This tendency should be eliminated and reasonable precautions taken during handling and storage to ensure that the pipes are not damaged.
- 8.1.2 Unplasticized PVC pipes shall be stacked on a reasonably flat surface, free from sharp objects, stones or projections likely to deform or damage them.
- 8.1.3 Lateral supports shall be installed at maximum intervals of 1.5 metre and these supports shall preferably consist of posts at least 50 mm wide. If the tubes are in bundles of approximately 1 x 1 m, the lateral supports shall be spaced at greater distances up to 2.5 to 3 metres.
- 8.1.4 The pipes shall be supported evenly over their whole length. If this is not possible, they should be carried on wooden supports of at least 50 mm usable width, the axes of which are at most 2 metres apart. If the tubes are in bundles of approximately 1 x 1 m, the supports may be spaced up to 3 m

apart. Pipes of different diameters and different thicknesses shall be stacked separately, or, if this is not possible, the largest and thickest shall be placed at the bottom.

- 8.1.5 When stacking socket-end and spigot-end pipes, the sockets shall be alternated within the pile and shall project sufficiently for the pipes to be correctly supported along their whole length.
- 8.1.6 Place the piles of pipes in a location where it is not possible for dirt to get into the pipes. Do not place in contact with pipes for fuels, solvents or paints.
- 8.1.7 Do not construct piles of such a height that the pipes would be deformed.
- 8.1.8 The storage of pipes in direct sunlight shall be restricted to a period of 18 months from their manufacture.
- 8.1.9 In hot countries or tropical climates, reduce the height of the piles and do not store the pipes in direct sunlight.

8.2 Handling

- 8.2.1 When handling the pipes, care should be taken not to damage the surface. This is especially important if the ends have been treated, for example for spigot and socket joints, or if they have been chamfered.
- 8.2.2 Do not drag the pipes along the ground.
- 8.2.3 Load and unload the pipes by hand and do not let them slip. If handling equipment is used, choose techniques which are not likely to damage the pipes. Direct contact with metal pipes, slings, hooks or chains is forbidden.
- 8.2.4 Do not throw the pipes onto a hard surface.
- 8.2.5 If the pipes have been telescoped for transporting, always remove the inner pipes first and stack them separately.
- 8.2.6 The impact resistance of unplasticized PVC is reduced in cold weather and more care needs to be taken in handling during winter. If the temperature falls below -15°C , special laying instructions should be requested from the manufacturer.

8.3 Transport

- 8.3.1 When transporting pipes, use flat bed vehicles. The bed shall be free from nails and other protuberances. The pipes shall rest uniformly on the vehicle over their whole length.
- 8.3.2 The vehicles shall have side supports appropriately spaced approximately 2 metres apart, and the pipes shall be secured effectively during transport. All posts shall be flat with no sharp edges. For pipes in bundles of approximately $1 \times 1 \text{ m}$, the space of the side supports may be increased to 2,5 to 3 metres.

- 8.3.3 When loading socket-end and spigot-end pipes, stack the pipes so that the sockets do not take any load.
- 8.3.4 Load the pipes onto the vehicle with an overhang not exceeding 1 m.
- 8.3.5 Load the thicker pipes before the thinner ones.

9 INSPECTION

- 9.1 The pipes shall be inspected by the purchaser or his representative at the place of delivery.
- 9.2 Check the markings of the pipes to ensure that they correspond to the specifications of the order.

10 LAYING

10.1 General

- 10.1.1 Reasonable care shall be taken in the handling and laying of unplasticized PVC pipes. Despite their robustness which enables them to withstand most stresses encountered in normal use, the constituent material does become more fragile at low temperatures such as are encountered in winter.
- 10.1.2 Attention should be paid to precautions preventing the freezing of water pipes.

10.2 Laying of buried pipes

- 10.2.1 Follow carefully the instructions in § 8.1.1 and 8.2.1
- 10.2.2 Do not dig the trench too far in advance and backfill as soon as possible. At the level of the top of the pipes the trench shall be as narrow as possible, but not less than the external diameter of the pipe plus 300 mm, so that the sides of the pipes can be correctly compacted.
- 10.2.3 Do not use clay or peat in direct contact with the pipe, either for the bottom or sides of the trench or for backfilling at the top, unless specified in national regulations. If other materials have been extracted from the trench which can be compacted sufficiently to fix the pipes properly in place, these may be used; this applies to sand, gravel, top soil and light soils. If none of the material extracted from the trench can be used in contact with the pipes, because it cannot be compacted or is too compact, sand, or fine earth of particle size less than 20 mm, brought from elsewhere, should be used.
Do not encase the pipes in concrete, which would transform the flexible pipe into a rigid bar with no flexural strength which would be likely to break during any movements of the earth.

The thinner the pipes and the greater the loads applied, the more important it is to follow the recommendations for coating the pipes. Following the recommendations of this Technical Report it is generally ensured that Series S pipes are reliable if they are buried at a depth of at least 1 metre under a road; laying at greater depth may prove necessary on account of the climatic conditions (risk of freezing).

- 10.2.4 The base of the trench shall be carefully levelled and cleared of any sharp edges and stones. If this is not possible, apply a suitable material (see 10.2.3) over a thickness of at least 10 cm.
- 10.2.5 Lay the pipes on the prepared bed making allowances for thermal expansion, particularly if laying takes place in very hot weather. Leave the pipes to cool at the bottom of the trench before completing assembly and backfilling.
- 10.2.6 Anchoring blocks shall be placed against the pipes at each change of direction and at each fixed point. They shall be designed in such a way as to withstand the maximum thrust produced by testing of the pipe. These blocks shall be carefully designed in view of the flexibility of the material; for guidance, see figure 7, annex 2.
- 10.2.7 Secure the pipes along the side with suitable backfill material (see 10.2.3) compacted into successive layers of 100 mm maximum. The same material shall then be placed over the pipe to a height equal to two thirds the diameter but at least 100 mm and not more than 300 mm, and thoroughly compacted.

NOTE - Certain national regulations require that the joints are not covered before the final pressure testing of the pipe.

10.3 Laying of overhead pipes

- 10.3.1 It is essential to note that unplasticized PVC pipes cannot withstand the freezing of fluids which they contain; consequently measures shall be taken to drain and/or isolate sections which are likely to freeze.
- 10.3.2 The coefficient of linear expansion of unplasticized PVC is approximately 6 to 7 times that of steel; steps shall therefore be taken to offset the effects of the difference.

The coefficient of linear expansion is approximately 60×10^{-6} , or 0.06 millimetres per metre and per degree Centigrade. The following formula may be used for calculating dimensional variation :

$$\Delta L = 0.06 \times L \times \Delta t$$

with : ΔL = variation in length (in mm)
 L = initial length (in m)
 Δt = difference in temperature (in °C)

example : for a temperature difference of 20°C, an unplasticized PVC pipe 10 m long will have a variation in length of : $0,06 \times 10 \times 20 = 12 \text{ mm}$.

Table 1 of annex 1 gives the expansions or contractions for temperature differences of 10 to 50°C and pipe lengths of 1 to 20 metres.

Table 2 of annex 1 determines the length (a) of pipe which compensates for thermal expansion.

- 10.3.3 The pipe shall be laid for maximum reduction in stress. The best solution is to locate bends between fixed points. Examples of correct and incorrect arrangements are shown in figure 9, annex 2.
- 10.3.4 Use continuous self-supporting props. Self-supporting props may be made of concrete, steel or wood, without special arrangement, provided that they are sufficiently robust and comprise a saddle or V-shaped cut for holding the pipe. An example of a continuous support is given in figure 8 of annex 2. The pipe is fixed onto the support by means of clips but these clips shall not press against the pipe and shall allow it to slide freely. The supports shall have smooth surfaces for preventing wear to the pipe and shall not be located too near to a bend.
- 10.3.5 Along walls and in cable ducts, hooks, clamps, belts or slings may be used (see figure 10 a, b, and c of annex 2).
- 10.3.6 Unplastificized PVC pipes shall be laid at a suitable distance from hot objects or pipes to prevent the material being damaged by radiant heat.
- 10.3.7 All manual control devices (such as valves) shall be correctly supported so that the pipe is not subjected to any torsional strain (see figure 11, annex 2).
- 10.3.8 The subsequent addition of a valve or T-piece to an existing pipeline may be done as shown in figures 12a and b of annex 2, or by using a supporting stool or connecting block.
- 10.3.9 Do not lay the pipes in areas exposed to direct sunlight.
- 10.4 Spacing of supports
The recommended horizontal and vertical spacing is shown in table 3 of annex 1.

11 TEST PRESSURE PROCEDURE

The tests shall be carried out in accordance with current national procedure, particularly with regard to the duration of the test and the pressure to be applied. In the absence of any national regulations, the procedure described in this Technical Report shall be applied.

11.1 Hydrostatic test pressures

- 11.1.1 The hydrostatic testing of a pipe shall be carried out at ambient temperature.
- 11.1.2 The test pressure shall not exceed 1.5 times the rated pressure for the weakest part of the pipeline.
- 11.1.3 The test pressure shall be applied for at least one hour, but under no circumstances for more than 24 hours.

11.2 Execution of the hydrostatic test

- 11.2.1 After completion of the laying operations, all the elements of the pipeline shall be inspected and tested to ensure the safety and reliability of the network. For large scale networks, the tests are done on sections of maximum length 500 m.
- 11.2.2 Networks with cemented joints shall not be tested until a certain period has elapsed after the completion of the final joint (see details in table 4 of annex 1).
- 11.2.3 Before testing, the anchorage blocks shall be allowed sufficient time to acquire their strength, e.g. for the concrete to set.
- 11.2.4 Partial backfilling is generally sufficient for holding the pipes in place while leaving the joints exposed for inspection. Temporary end plugs shall be secured.
- 11.2.5 Overhead pipelines shall be correctly propped and supported wherever necessary, according to the service and environmental conditions.
- 11.2.6 All intermediate control valves shall be open throughout the duration of the test. If a network is to be tested by sections, the ends shall be temporarily closed by means of suitable joints.
- 11.2.7 Manometers shall be calibrated according to the level at which they are placed. Air vents at high points shall be open during the filling of the network.
- 11.2.8 Slowly fill the pipes with water starting from the lowest point, thus avoiding water hammer and removing all air.
- 11.2.9 Once it has been completely filled with water, leave the pipeline to rest for 24 hours. Close the air vents and carry out an initial inspection to check that all the joints are leaktight.
- 11.2.10 Slowly increase the pressure, preferably using a hand-pump, until the required pressure is obtained. A preliminary application of pressure for 15 minutes may be made before the test proper, so that the elements in the pipeline can settle, for example against the anchorage blocks. For pipelines with large diameters, motor pumps may be used.

- 11.2.11 Isolate the pipeline from the test pump for at least 1 hour. The test is considered satisfactory if the quantity of water required for re-establishing the required pressure does not exceed the quantity calculated by the following formula :
- 3 litres per kilometre of pipe, per 25 mm of internal diameter, per 0,3 MPa (3 bars) of test pressure, and per 24 hours. For pipes not exceeding 30 metres in length and 63 mm in diameter, the pressure loss after the test period of 1 hour shall not exceed 0,05 MPa (0,5 bars).
- 11.2.12 An additional inspection of the complete system may be carried out at normal service pressure, during which manoeuvrability of the valves and their correct operation can be checked.
- 11.2.13 All defects revealed by the test shall be rectified and a new test carried out until a satisfactory result is obtained.

12 CORROSION PROTECTION

- 12.1 Unplasticized PVC pipes are resistant to soil components and do not require any corrosion protection.
- 12.2 Care should be taken, especially near houses, to ensure that the backfill materials are not polluted by tar, paint, solvents, fuels, etc.
- 12.3 Where adjacent metallic parts are protected, no hot- or cold-applied coatings, or varnishes containing solvents shall come into contact with PVC.
- 12.4 Anti-corrosion tape applied to metal connecting pieces shall be of a type which does not damage the pipes or fittings if they come into contact with the pipeline.

13 WATER HAMMER

If suitable precautions are not taken, water hammer may result in the failure of the pipeline. Where there is a risk of water hammer (starting up or stopping of pumping units, possibility of sudden cutoff, etc.), protection against water hammer should be provided in the most suitable form (surge tank, water hammer suppression chamber, discharge valve, etc.).

14 REPAIRS

Various methods can be used for repairing leaks or damage to sections of unplasticized PVC piping. In general, the best method is to cut and replace the damaged section using a pre-fabricated element or fitting. Where leakage occurs in a cemented joint, it is recommended that re-cementing should not be attempted with the old elements.

Sliding sleeves are available, without a central stop, which are specially made for repair work. These slide onto the spigot ends and are reset so that the required position is obtained for a leaktight joint.

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Annex 1

1 THERMAL EXPANSION OR CONTRACTION

TABLE 1 - Maximum expansion or contraction of unplasticized PVC pipe

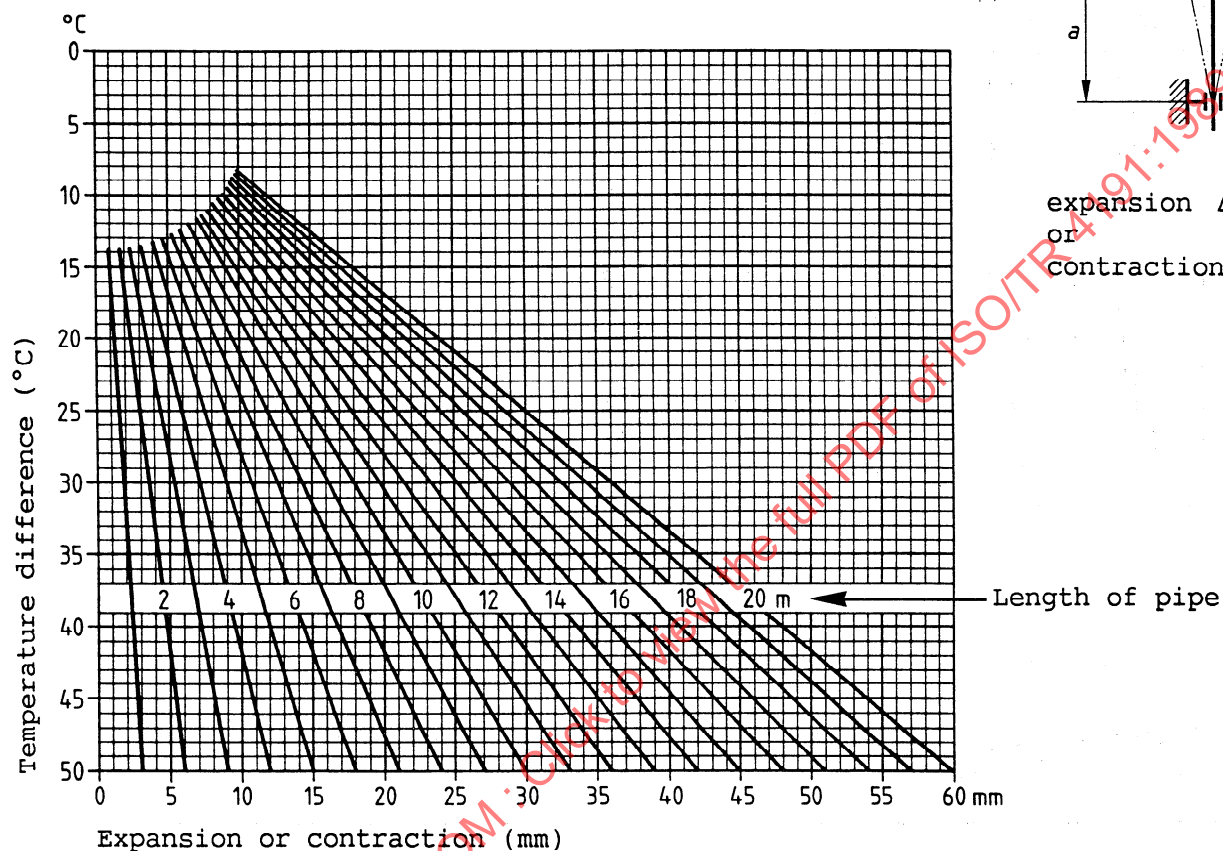
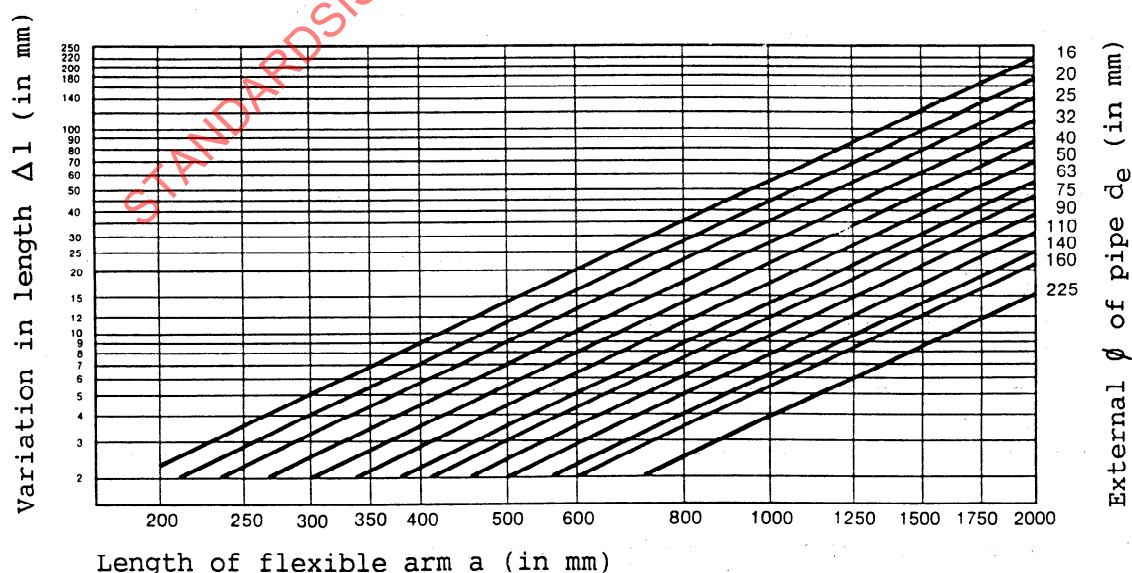


TABLE 2 - Determination of the length of the flexible arm



Example: For a pipe with expansion of 10 mm and an external diameter (d_e) of 50 mm, the length of the arm (a) shall be at least 750 mm.