



Performance requirements for plastics pipes and fittings for use in underground drainage and sewage

Aptitude à l'emploi des tubes et raccords en matière plastique utilisés pour l'assainissement enterré

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ISO/TR 7074 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 section 1.

SECTION 1 - HISTORICAL BACKGROUND

1. DISCUSSIONS IN ISO

Work within ISO/TC 5/SC 6 (now ISO/TC 138) on a specification for plastics pipes and fittings made of UPVC for use in underground sewage was approved at the sub-committee meeting in Stockholm in 1969 when Working Group A was established and the responsibility for drafting the specification allocated later on to a Task Group (now ISO/TC 138/SC 1/AGH-1 - Buried drain and sewer pipes).

At the WG 1 meeting in Berlin in 1972 the U.K. proposed that TG 1 should give consideration to the so-called Box Loading Test (BLT) as described in BS 4660. This was accepted.

The "Specification for pipes and fittings of unplasticized polyvinyl chloride (UPVC) for buried drain and sewer pipes" (doc. 138/1 N 161) was forwarded to TC 138 level by resolution in Madrid in 1972 without any functional test requirements for pipes or fittings and at the same time it was decided that TG 1 should continue its specification work on the quality testing of fittings.

The above mentioned specification, now ISO/DIS 4435, was accepted with 24 approvals, 2 disapprovals and no abstentions (see doc 138 N 153).

After having finalized the leakproofness tests for fittings, TG 1 was, by resolution of WG 1 in Bremen in 1974, to continue under the leadership of Finland developing suitable tests for pipes and fittings.

Since then, in the period 1974-1978, nine further Task Group meetings were held keeping in mind the following terms of reference:

- To prepare a functional performance test (type test by nature), considering the long term durability of fittings, which simulates, as far as possible, practical conditions.
- To develop a simple production quality control test, especially for injection moulded drainage fittings, which examines the strength of the weld line, which may be weaker than the the fitting in general.

The main task, being derived from the actual initiative, was to study the testing of UPVC assemblies but the AHG has also studied the applicability of the methods established to other plastics materials: no final conclusions have been drawn however.

During the work of TG 1 it became evident that no unanimous proposal could be reached within the TG upon the methods to be used and therefore TG 1 agreed that all prepared descriptions of test methods should be circulated to the WG 1 meeting in Tel Aviv for wider consideration. At the meetings in November 1977 it was agreed that documents 138/1 N 369, N 370 and N 371 should be compiled into a Technical Report.

SECTION 2 - BASIC TECHNICAL PROBLEMS

2. INTRODUCTION

When flexible plastic pipe is used for underground drainage and sewage, a so-called pipe structure is formed by the interaction of the mechanical properties of the pipe and the surrounding soil. The behaviour of the pipe structure over a long period depends on the ageing properties of both components, i.e. changes in the pipe or fitting material and variations in the earth pressure distribution cause diminishing pipe strength.

The main loading factors, which should be taken into account when dimensioning the pipe structure are:

- a) static and dynamic loads which cause bending stresses and fatigue phenomena in the pipe and fitting wall;
- b) thermal loads which cause accelerated ageing and possible softening in the material and bending stresses in the pipe and fitting wall;
- c) chemical influence of waste water.

These factors cause changes of differing degrees in pipe and fitting materials depending on:

- dimensions and geometry;
- elasticity and stiffness;
- creep and relaxation properties;
- frozen-in-stresses;
- tensile, compressive and fatigue properties;
- softening temperature;
- molecular weight and its distribution.

3. QUALITY CONTROL PROBLEMS

With manufactured products, quality is mainly determined by quality of design and quality of manufacture:

- Quality of design is defined as the excellence of the design in relation to ease of manufacture and to the customer's requirements
- Quality of manufacture is defined as the fidelity with which the product conforms to the design.

When discussing the quality control, which is defined according to the European Organization For Quality Control (EOQC) as a system for programming and coordinating the efforts of the various groups in an organization to maintain or improve quality, at an economical level, we see that the document ISO/TC 138/WG 1 N 299 gives a definition for Quality

Control Test that should preferably be called a Production Control Test. The Type Tests and Performance Tests fall under the heading Quality of design:

- The definition of Performance Tests states that they are carried out in order to assess the ability of a product or assembly of components to fulfill its function
- The definition of Type Tests states that they are carried out in order to prove the general suitability of materials and components.

The question is to which definition should be added the words "over the required time", which is defined as the period of time (for pipes and fittings normally 50 years) during which the user expects the item to be in a condition to perform its required function. Does the testing of wear-out or degradation failures belong to both groups? It is clear that in order to get reliable results from a test which simulates functional and environmental stresses the test shall include an accelerating factor. What accelerating means should be chosen is dependent on the parameters to be investigated. The Task Group has studied the effects of temperature, which is known from previous experience to be a reliable factor, increment of induced stress and dynamic loading.

An accelerated test is defined as a test in which the applied stress (loading) level is chosen to exceed that stated in the reference conditions in order to shorten the time required to observe the stress response of the item, or magnify the response in a given time. To be valid, an accelerated test must not alter the basic modes and/or mechanisms of failure, or their relative prevalence.

In order to be able to state the reference conditions one should carry out Field Reliability Tests, which are defined as a reliability compliance or determination tests made under stated and controlled conditions of use and recorded conditions of environment in the field.

Because results over a 50 years period are not yet available, field data and results from Endurance Tests have been studied by the Task Group.

The idealized target of the TG could be crystallized as follows: To establish a simple, easy and quick test, which by simulation takes account of the performance requirements set by the environment and the function stresses, reveals inadequate design strength in view of long term durability, which could be used as a reliability test, as a production control test and as a screening test. A screening test is intended to remove unsatisfactory items or those likely to exhibit early failures.

Not surprisingly this proved to be unreasonable and therefore the task Group split the programme into smaller individual Tasks.

SECTION 3 - TEST METHODS STUDIED

4. MOTIVE

The reason why tests were developed is contained in the sewer pipe specification ISO/DIS 4435. It is stated under the heading "wall thickness" that "Note: The wall thickness of a given fitting may require greater values than given in the table in order to comply with the test requirements of this specification".

Up to now no guidance has been given within ISO for the choice of the class of fittings to be connected to a specific pipe.

5. BOX LOADING TEST (BLT)

Originally the work of TG 1, in its present composition, began with a so-called BLT method, which is a Laboratory Reliability Test by nature. The BLT is meant to be a simulating test which contains thermal shock as an accelerating factor.

5.1 Background

The background to the BLT and the objectives it achieves when pipes and fittings are subjected to it lies in the failures of soil stocks reported during 1966 and 1967 in U.K. A number of

UPVC soil discharge pipes collapsed due to conveyance of hot discharges. Investigations following these failures were carried out by BPF. From this survey two sets of conditions emerged which could have caused the soil systems then in use to fail. These conditions were:

- a) A rapid discharge of the contents of a boiler.
- b) The use of washing machines where the temperature of the water can be as high as 95 °C.

It was subsequently established that plastics soil systems should undergo an elevated temperature cycling test. The idea was that the test would indicate that when a system satisfactorily performed after the test had been completed then for all practical purposes other pipes and fittings identical to those tested would perform satisfactorily in service. This test is now included in relevant ISO Draft International Standards for soil and waste discharge systems inside buildings.

When the U.K. came to examine the question of drainage pipes from the house to sewer it was immediately thought necessary for a similar test to be included to determine the performance of these pipes under the influence of thermal shock. However, because the pipes would be buried in the ground and subjected to external loads, additional criteria would be applied.

Opinions from building authorities, road construction specifiers, transportation authorities and organizations were

examined and certain load criteria emerged. These load criteria can be said to be the maximum possible normal loadings that would pass over or remain on a buried sewer pipe for a length of time. A similar examination with regard to the temperature of the effluent, as carried out for the soil system programme, showed that the effluent conveyed in underground drainage was at a lower and more constant temperature. The practical questions were then raised concerning applying these criteria to a test and it was very quickly seen that to install pipes and fittings in trenches on a continuous basis for test purposes was not practical and an artificial trench had to be designed and specified. Ultimately this artificial trench emerged as the box detailed in the test description which follows this report. It was considered acceptable for all practical purposes that if the physical properties of the box were toleranced, different laboratories could construct boxes and test components in them to a standard method. This method of determining a pass/fail for the products tested by each group would be satisfactory. As for soil systems, the object of the Box Loading Test is to confirm that pipes and fittings which do not deflect by more than a given percentage during the test, and at the test conclusion show no signs of leaks, will give a satisfactory performance when in use. Again, as with the soil systems, it is not intended that systems so tested in the box should be given a numerical value whereby systems from one manufacturer can be directly compared with those of another.

5.2 Objections

The Task Group studied the original U.K. proposal and the corresponding Finnish standard SFS 3143 - 1975. The main arguments against these methods were:

Lack of information concerning

- a) The weld line quality, because of the small number of test pieces
- b) The stiffness, because the temperature is as high as 85° C,
- c) The long term behaviour, because the testing time is short and cannot be sufficiently related to practice
- d) the method is costly, time consuming and complicated
- e) The reproducibility is doubtful.

5.3 Progress

- a) Weld line quality

From the investigations made it can be concluded that "frozen-in-stresses" in injection moulded fittings have a certain effect in relation to the weld line and thus the weld

line can be the weakest part of the fitting. This is evident because when the weld line is placed in the water flow the deformation is often at its maximum and small cracks in the weld line can be found. Because the method was not originally meant for determining the weld line quality by measuring the depth of the crack and because statistically the number of test specimens is too small, it was agreed that in the standard only a reference for further investigations was to be made in the case of crack development.

b) Test temperatures

The water temperature of the hot water cycle was proposed originally as 85 °C. This was enough to raise the mean temperature through 60 °C in the material. This in return can cause acceleration of degradation (ageing) failures and thus select bad material quality from good. When resting and cooling the original test schedule required care to be taken that the crown temperature fell to a maximum of 30 °C. This keeps the total assembly temperature at about a constant level. It is interesting to note the relationship of the wall temperature with the long term pressure test for pipes. Experiments made with water at 70 °C show that the deformations are much smaller.

The Task Group discussed the test temperatures on several occasions and studied many reports in which the conclusions were equal:

Though the temperature from a washing machine can be as high as 95 °C when poured into the soil system, it rapidly decreases and seldom exceeds 60 °C when running in the underground drainage system. There are, however, certain types of housing where hot water is discharged into the underground drainage system at a temperature of at least 85 °C. This was concluded from several field measurements. Thus it can be seen that 85 °C presents a severe, but in some cases relevant figure.

Summary: The hot water temperature was not fixed, because it is dependent on national codes of practice and other mandatory requirements.

c) Long term durability

The Task Group could find only passive and indirect demonstrations of the method's ability to serve as a reliable endurance test.

These are:

- During the 10 years' knowledge of the BLT no failures are known to have occurred in practice to those types of pipes or fittings which have passed the BLT.
- Extensive series of tests made on UPVC show that the long term burst strength is strongly influenced by the combined

effect of the K-value and the Vicat point of fittings material. This is more generally revealed at the elevated pressure test temperature of 60 °C. The results from the BLT tests using the hot water temperature of 85 °C show similar results and this gives the right to suppose that BLT may be used for determining the long term durability.

- The functional stresses in practice consist of among others those caused by thermal shocks. This kind of fatigue loading on the construction is repeated in the BLT for a reasonable number of cycles which correlates to practice.

d) Costs

The BLT apparatus is not a cheap test device for plastic pipes and fittings, however, the test is intended to be carried out only when a new material or construction is introduced.

e) Reproducibility

The main reasons postulated for the poor reproducibility of the original test where:

- the filling method was not described clearly enough
- the filling material and its compactness varied too much from one test station to another
- the possible deformation of the box was not restricted

The Task Group studied these points and on the ground of separate investigations these factors were eliminated or restricted to a reasonable level when considering the practical nature of the test.

f) Other objections

2500 cycles are recommended. This is based on the fact that it corresponds in practice to approximately one thermal attack per week during 50 years. The fact that the deformation is continuously rising towards the end of the test brings up for discussion the possibility of increasing the test to 2700 cycles which simulates full 50 years service life. This is contrary to the proposed reduction of the test to 1500 cycles.

The Task Group has also discussed the magnitude of the superimposed load which originally was 36 kN for 110 mm pipe. This relates to a backfill height of about 3 m where as the proposed 50 kN relates to a backfill height of 4 m. According to the tests made with 36 kN and 50 kN there is no marked difference between the deformations produced. Therefore in order to obtain more reproducible results the Task Group suggests a load of 50 kN for all underground drain pipes and fittings up to 160 mm.

5.4 The advantages of the BLT

The main advantages of the BLT are:

- a) It can be used for studying of the long term behaviour of pipes, fittings and assemblies in respect of stability of construction and tightness.
- b) The method has proved to give good simulation of the pipe structure in real field conditions. That is, the deformation caused by the soil load is of the same magnitude.
- c) The method gives information of the material's general suitability, of the soundness of construction and of possible weak points caused by manufacture.
- d) The method is applicable to all flexible pipe and fitting materials.

5.5. Work still to be undertaken

5.5.1

The original method used in North European countries consists of two parts:

- a) for drain pipes and fittings up to and including DN 160 mm using cycling thermal-shocks with water temperature 85/10 °C
- b) for sewer pipes and fittings of 200 mm and above using continuous water flow with a temperature of 50 °C and a load as per table 1.

Table 1 Test conditions

Nominal outside diameter DN	Width of the box a mm	Length of the box b _{min} mm	Height of the box h mm	Load F kN	Hot water temp. T ₁ °C
100	700	1200	810	50 ± 2	85 ± 2
125	700	1200	825	50 ± 2	85 ± 2
160	700	1200	860	50 ± 2	85 ± 2
200	800	1500	900	50 ± 2	50 ± 2
250	900	1500	950	50 ± 2	50 ± 2
315	1000	1500	1015	55 ± 2	50 ± 2
400	1300	1500	1100	55 ± 2	50 ± 2
500	1800	1500	1200	60 ± 2	50 ± 2

The latter application is deleted from the present ISO test method, however, the need for such a test should be evaluated.

5.5.2

The hot water temperature and the permitted end deformation are left to be fixed by the national member bodies. However, it is recommended that the water temperatures used should be the same for all materials. The final end deformation value may vary from material to material depending on proven practical field experience.

6. WATER CYCLING TEST (WCT)

6.1. Background

By testing several kinds of fittings in the BLT it can be shown that for certain types the weld line has a tendency to open. It was therefore suggested that this phenomena could be investigated using a cheaper method than the BLT.

The Task Group studied a few different methods and came to the conclusion that the "Elevated temperature cycling test on fittings" as described in BS 4660 serves as a relatively easy method for determining the weld line strength. The cycling of hot and cold water is made in the same manner as in the BLT but the fittings are mechanically unloaded. Comparative tests have shown that the same tendency of cracking is achieved, when the test is made with the test piece surrounded by air, as in the WCT, compared to the results from the BLT. During the test the weld line is of course placed in the water flow. The cycling test is primarily a kind of a functional type test for fittings exposed to hot water, i.e. for diameters 110, 125 and 160 mm. Test work has shown that the method is not suitable for testing polyethylene fittings.

6.2 Summary

The Task Group prefers the WCT to the BLT in terms of weld line strength testing. For production quality control purposes the method is not particularly suitable since it is time consuming. Its usefulness is evident for repeated type testing made by the manufacturer or control inspector.

7. FATIGUE BENDING TEST (FBT)

7.1 Background

In order to find a suitable quick test on weld lines, the Task Group started to examine the so-called Fatigue Bending Test (FBT). When comparing the newest version to the original

proposal from from the Netherlands, the test description has changed a lot. The Task Group has studied the influence of

- frequency
- amplitude
- type of loading
- test sample size
- positions from where the sample should be taken
- temperature

7.2 Objections

During the work the following objections to the proposed method were made:

- As it now stands the method is unsuitable for its originally expected end use: quick quality control
- The method is of such a nature that it is necessary to use quite large numbers of test pieces in order to obtain statistically significant results.
- The method is not suitable for fittings made of polyolefins.

7.3 Advantages

- The method is shown to give information of the weld line quality
- The method can be used to measure the material's fatigue properties. Thus it simulates in one way or other the dynamic loading characteristics of the fittings more accurately than the BLT.

7.4 Work still to be undertaken

In further investigations stress should be laid on following features:

- the criteria for pass/fail should be established
- the statistical parameters should be clarified
- tests in a cooled liquid bath should be carried out in order to try to prevent this possible source of unreliable results: i.e. the warming up of the material.

7.5. Summary

The method is still under development. Promising results have been obtained especially when considering the possibilities which the method may serve for product development and processing technology.

8. IMPACT RESISTANCE TESTS (IRT)

8.1 Background

The need for a quick quality test for weld lines was the motive of the Netherlands when beginning the work with the IRT. The method has been developed from the common method ISO R 179 which has been used for the testing of fitting quality for example in specifications for ABS and PP soil and waste discharge systems in buildings.

When comparing the latest edition to the original proposal it can be seen that the test description has been changed notably only in one detail, that is, the striking edge hits the specimen on the outer surface, which the Task Group regards as an improvement.

The test can be performed with less striker energy than described at the moment in the draft standard.

8.2 Objections

The main arguments against the method are:

- Due to the weld line there is often a small notch in the test bar. This causes much variation in the test results.
- The method does not give an indication of the fitting's overall performance ability; only giving results from various points of the fittings.
- The original intention was to substitute the FBT by the IRT but there is doubt that the IRT tests the same parameters.
- The machining of the test bars can easily affect the results.
- The method is not suitable for PE at the test temperature of 23 °C.
- The number of test pieces must be quite large in order to obtain statistically significant results.

8.3 Advantages

- The method may give information of the weld line quality more easily than the FBT.
- The method gives information of the material's impact resistance properties which the BLT is unable to do.

8.4 Further work to be undertaken

In further investigations stress should be laid on following features:

- The impact energy should be fixed for different fitting materials.
- The notch effect problem is still to be solved.

9. OTHER TESTS METHODS STUDIED

9.1 Pulsating Load Test

The CSTB have been studying the behaviour of empty plastics pipes under pulsating load induced on the top of the pipe in a jig, which facilitates suspension in the horizontal direction. The aim is to obtain a correlation between this laboratory test and a site test program with a "carousel" traffic load simulator. Thus the test is analogous with the FBT and it would be interesting to find out if there is any correlation between these methods.

9.2 Line Load tests

In Sweden and in the Netherlands many Line Load tests have been carried out. The method has been analogous to the WCT with the exception that the fittings were compressed to a certain degree. The method has been later deleted because comparative experiments have shown that the WCT brings out the tendency to cracking at least as clearly.

9.3 Plate Test

In Sweden a compression test for fittings is included in the manufacturer's specifications on drain and sewage pipes and fittings. The method consists of a simple determination of the rigidity or stiffness of the fittings when compressed to 5 % deflection. This test is used for quality control purposes by the way that in quality control tests the results shall show at least 90 % of the stiffness which was accepted in a type test. The Task Group has not studied the test method any further.

9.4 N.O.L.-test

The U.K. has studied the possibilities of using a straight-forward tensile testing method according to the A.S.T.M procedure, for the testing of weld line quality. The results were not promising.

10. COMPARABILITY OF THE DIFFERENT TESTS

Much work has been done in the Task Group 1 in order to establish correlations between the test methods described. It has been shown that:

- The results from BLT and FBT seem to show some correlation.
- The BLT and the WCT give similar results when testing the tendency to weld line cracking.
- The WCT seems to have no correlation to the IRT when testing the weld line quality
- There is correlation between the results from IRT and FBT in terms of weld line strength.

11. SUMMARY

As a result from the comprehensive test programme carried out by the members of the Task Group it can be stated that:

1. All the test methods are useful but it is to be noted that they seem to test different parameters.
2. The Box Loading Test seems to be the most useful when considering materials and the geometric design of the fitting.
3. The FBT and IRT tests seem to be most useful when considering the moulding technique and the quality assurance of the fittings.

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SECTION 4 - PREVAILING TEST METHODS

12. BOX LOADING TEST (BLT)

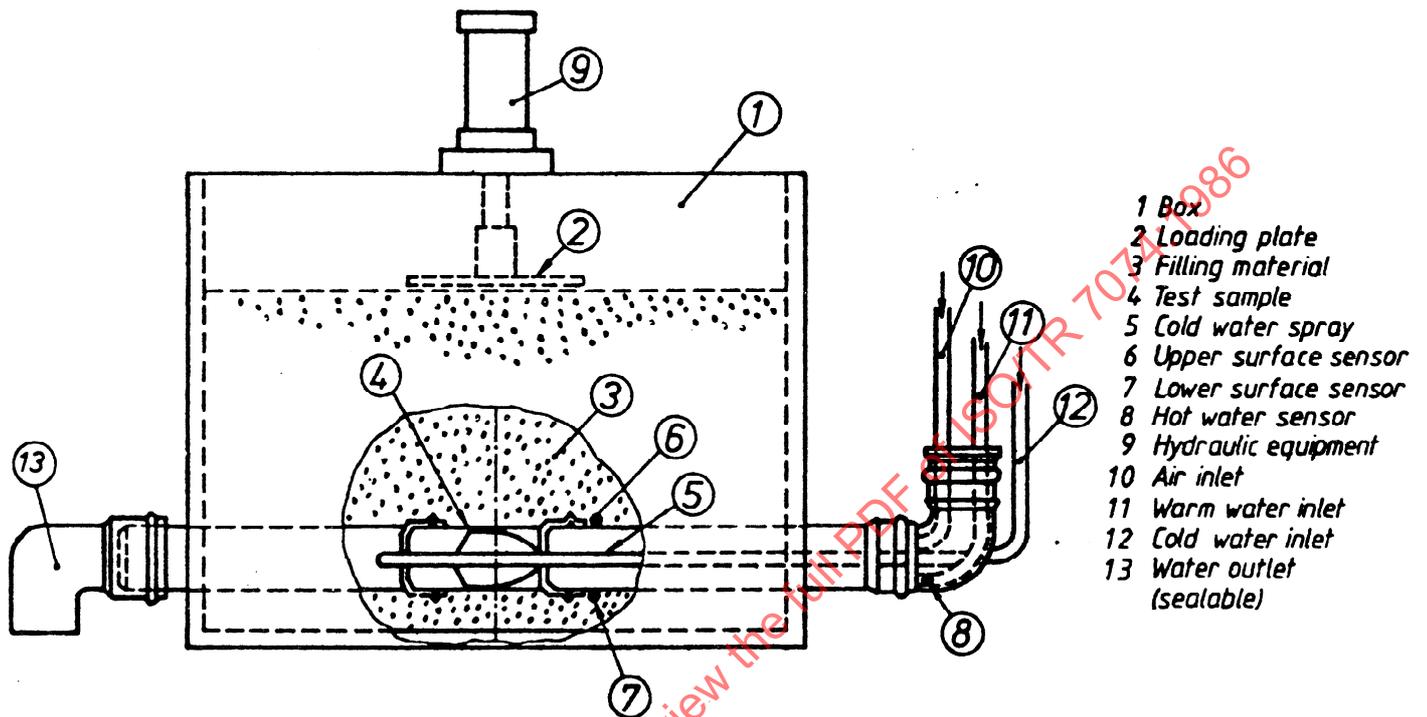


Figure 1. The BLT apparatus

12.1 Scope and field of application

This present document specifies a method for testing the long term durability of pipes and fittings intended for use in underground drainage systems up to and including 160 mm.

This method is particularly intended for the use as a functional type test.

12.2 Test principle

Whilst subjected to a static load, acting through a gravel-filled box, alternate discharges of hot and cold water are passed through the test assembly.

Deformation of the specimen under test is measured. There shall be no leakage of the test specimen either during or after the test.

12.3. Apparatus

12.3.1

The apparatus, consisting essentially of an assembly of pipe and fitting placed in a gravel-filled box, shall be generally as shown in figure 1.

The box shall have internal dimensions of 700 mm x 1200 mm and shall be about 1000 mm deep.

The inside walls of the box shall be lined with film faced shuttering plywood for external use.

The box shall be constructed and reinforced such that, when under load, at no point shall it deflect by more than 3 mm. The pipe-line shall run into and out of the box through apertures suitably sealed so as to impose no restraint upon the assembly.

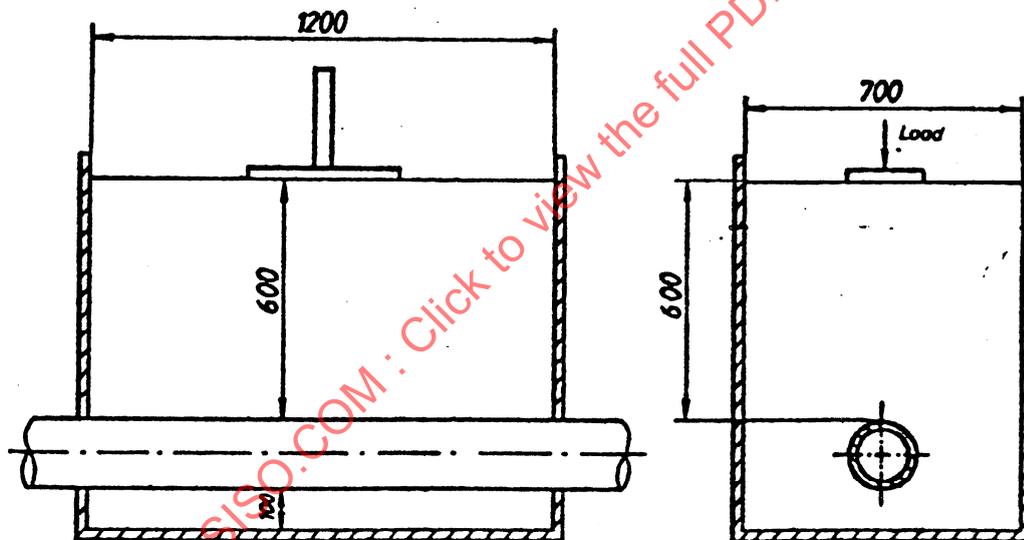


Figure 2. The dimensions of the box

12.3.2

During testing the box is filled to the specified height with gravel having a granular composition within the range shown in figure 3.

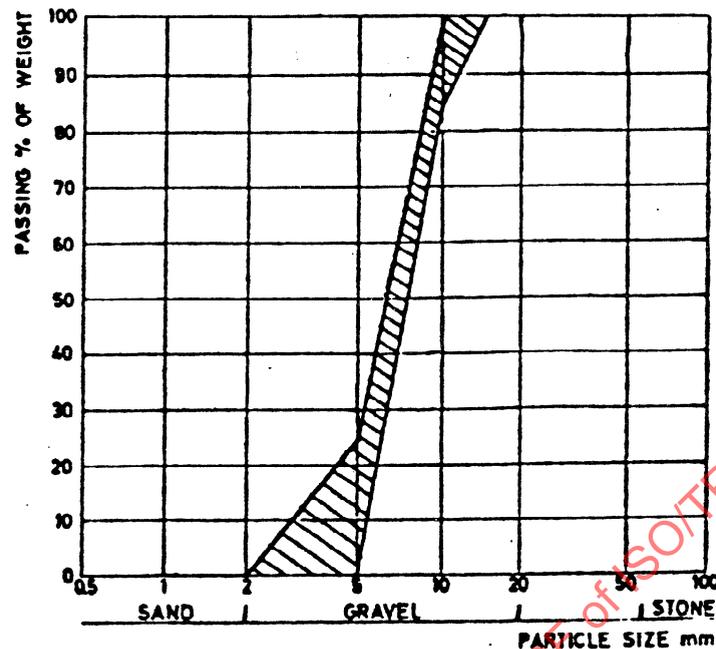


Figure 3. Gradation range of the filling material for BLT-test

The gravel shall be washed natural material comprising hard, durable and clean particles.

Table 2 Particle shape

Classification	Description
Rounded	Fully water-worn or completely shaped by attrition
Irregular	Naturally irregular or partly shaped by attrition and having rounded edges
Angular	Possessing well defined edges formed at the intersection of roughly planar faces
Flaky	Material of which the thickness is small relative to the other two dimensions
Elongated	Material, usually angular, in which the length is considerably larger than the other two dimensions
Flaky and elongated	Material having the length considerably larger than the width, and the width considerably larger than the thickness

Table 3. Surface texture

Surface texture	Characteristics
Glassy	Conchoidal fracture
Smooth	Water-worn, or smooth due to fracture of laminated or fine-grained rock
Granular	Fracture showing more or less uniform rounded grains
Rough	Rough fracture of fine or medium-grained rock containing no easily visible crystalline constituents
Crystalline	Containing easily visible crystalline constituents
Honeycombed	With visible pores and cavities

The particles shall be rounded or irregular as defined in table 2 and their surface texture shall be glassy or smooth as defined in table 3. A certain amount, maximum 10 per cent by weight of angular particles with granular, rough or crystalline surface texture is allowed in the filling material.

12.3.3

The load shall be applied by means of suitable hydraulic equipment acting through a 450 mm x 300 mm x 20 mm rigid steel plate - the 450 mm dimension being parallel to the assembly - and shall be maintained within ± 2 kN. The plate shall be sufficiently rigid not to deflect during the test.

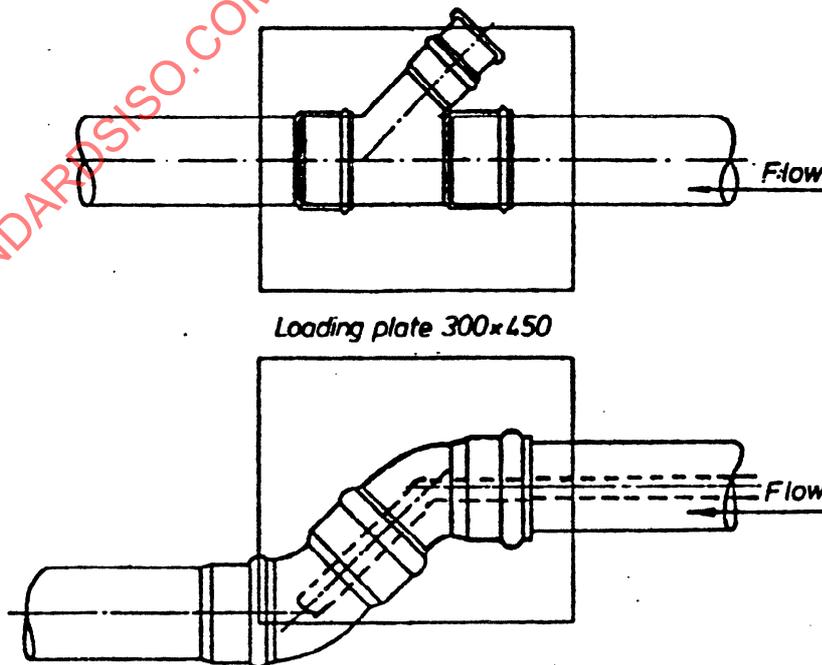


Figure 4. Example of positioning of a fitting under the pressure plate

12.3.4

Hot water is conducted along the invert of the specimen under test. Cold water is sprayed on to the uppermost third part of the inside surface of the specimen throughout its entire length.

12.3.5

External surface temperatures and water temperature are recorded using an automatic continuous recording device. The test requires three temperature sensors capable of measuring to an accuracy of ± 1 °C.

12.3.6

Changes of the internal vertical diameter of the test specimen shall be measured to within $\pm 0,1$ mm.

12.4. Test specimens

The test specimen consists either of a fitting assembled with two or more pieces of pipe, of size and quality for which the fitting is designed, or of a full length of pipe having no joints. For pipe with integral sockets, the socket where jointed to a plain pipe is placed directly under the loading plate.

12.5. Conditioning

Specimens shall not be tested within a period of 24 hours after production.

The temperature of the assembly shall be at room temperature when beginning the test.

12.6. Test procedure

12.6.1

A gravel bed, 100 mm thick, is levelled so that a fall of about 1/50 is achieved in the direction of flow.

Place the assembly flat on the gravel bed directly under the loading plate generally as indicated in fig. 4. The weld line of fittings, if any, is subjected to the flow of water, where this is possible.

When testing a branch, the side limb shall be in the horizontal position and any socket not being used shall be sealed with short length of pipe with a plug attached.

If necessary gravel may be added so that the assembly rests on an even base.

12.6.2

Attach two sensors to the outer surface of the pipe in accordance with fig. 1. Place a third temperature sensor in the hot water stream.

12.6.3

Pour gravel into the box from a funnel having an opening of 50 mm diameter, until a depth of 600 mm above the crown of the specimen has been achieved. Pouring shall be carried out over the whole area of the box and from a constant height of 750 mm, taking care of uniform filling without compacting on both sides of the test specimen.

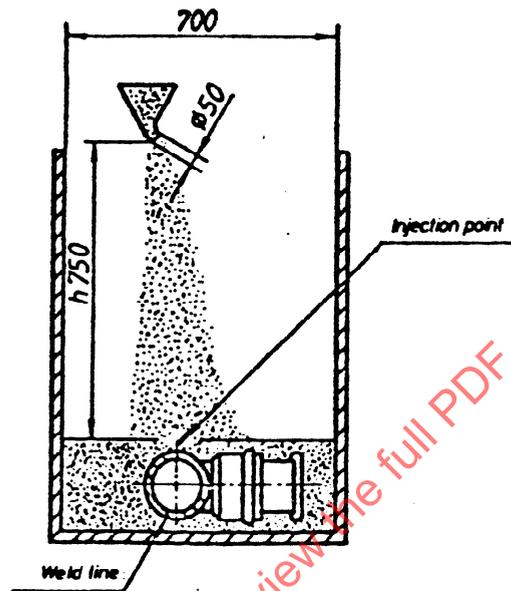


Figure 5. Example of the filling procedure

12.6.4

The specified load of 50 kN shall be applied through the loading plate to the gravel surface vertically above the test assembly and shall be maintained throughout the test even if the water flow is interrupted from time to time.

If, when the load is applied, the plate penetrates more than 25 mm into the gravel the load shall be removed and gravel added until, with the load re-applied, penetration does not exceed 25 mm.

Connections are made to hot and cold water inlets. The assembly shall be subjected to the alternate passage of hot and cold water according to the following schedule for 2500 cycles:

1. Hot water at a rate of 23 ± 1 litres per minute at a temperature of $T \pm 2$ °C measured at the entry during a period of 90 ± 1 s.
2. Rest and drain for 60 ... 70 s, removal of steam with air blast (around $10 \text{ m}^3/\text{h}$)

3. Cold water flow at a rate of 23 ± 1 litres per min at a temperature of 5 to 20 °C during a minimum period of 90 s supplemented if desired, by a cold air blast of duration sufficient to reduce the temperature recorded at sensor 6 to 30 °C.

4. Rest and drain for 60 ... 70 s, air blast if required.

12.7. Calculation and expression of results

12.7.1

Deformation of the test sample shall be measured as a change in vertical internal diameter, usually at the centre of the specimen, since this point is directly under the centre of the loading plate during the test.

12.7.2

The vertical diameter shall be measured:

- (i) immediately after placing the test piece on the gravel bed
- (ii) after 2500 cycles with the load still applied

12.7.3

Deformation is calculated as follows:

$$\text{deformation } \lambda = 100 \cdot \frac{d_1 - d_2}{d_1} = \frac{\delta}{d_1} \cdot 100 \%$$

where d_1 = internal diameter (mm) obtained according to the first measurement (i)

d_2 = internal diameter (mm) in the following measurements

12.7.4

After the 2500 cycles and with the load still applied, the test assembly shall be capable of accepting the passage of a steel ball with a diameter determined as follows:

$$\text{Ball diameter} = d_1 - \delta \text{ max allowed}$$

12.7.5

After cycling the pipe ends shall be sealed and the assembly filled with water at a temperature of 5 to 20 °C.

After the assembly has been conditioned for 15 minutes with the load still applied, a hydrostatic pressure of e.g. 35 kPa shall be withstood for 15 minutes without leakage.

13 IMPACT RESISTANCE TEST (IRT)

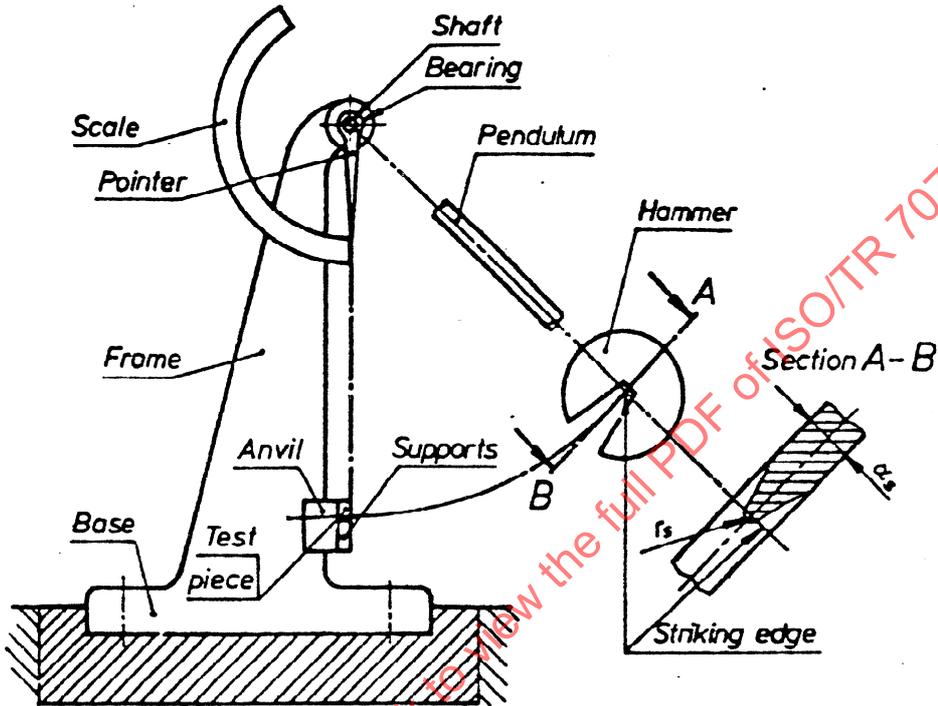


Figure 6. Pendulum impact apparatus

13.1 Scope and field of application

This present document specifies a method for testing the weld line strength of injection moulded fittings for use in underground drainage and sewage up to and including 160 mm.

The method is particularly intended for use as a quick quality control test.

13.2 Test principle

The curved testpieces are struck once on the outside surface at the point of weld line with a standard pendulum hammer. The impact energy consumed by the specimen is measured and/or the test specimen is registered to be broken or not.

13.3 Apparatus

Testing of the impact resistance of unnotched curved bars shall be carried out with a standard pendulum impact apparatus according to ISO/R 179, as seen in fig. 6. The dimensions of the striking edge of the pendulum and of the supports are indicated in fig. 7.

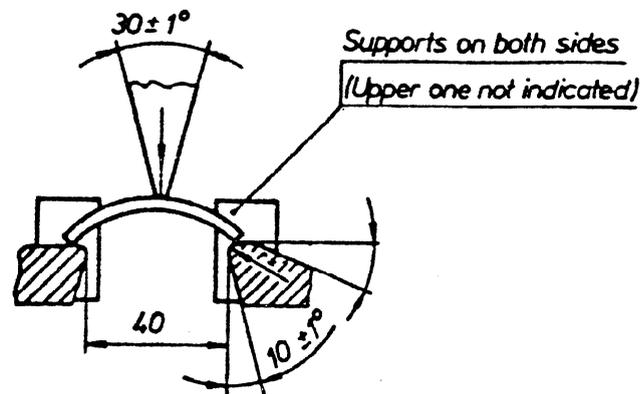


Figure 7. Positioning of a sample

The energy content of the hammer should be 15,03 Nm when hitting the centre of the specimen with a velocity of 3,8 m/s.

13.4. Test specimens

From each fitting five testpieces are cut in the circumferential direction with their centre on a weld line. The specimen shall be smooth and free from cracking initiators.

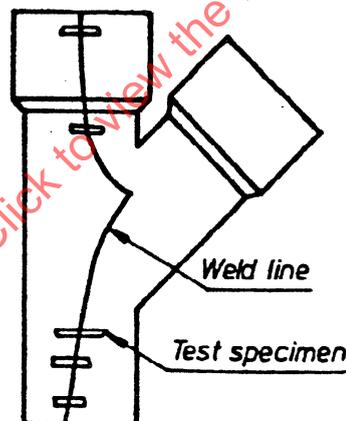


Figure 8. Example on points of sampling when testing the impact resistance of the weld line

The dimensions of the testbar are given in fig. 9.

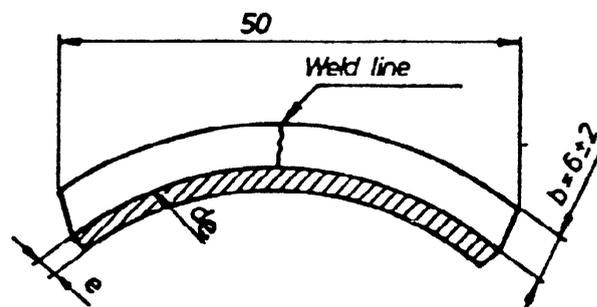


Figure 9. Dimensions of standard curved small testbars.

13.5 Conditioning

When the IRT is used for production control purposes conditioning of test specimens for 2 hours at 23 ± 2 °C is sufficient.

For more precise investigations the test samples should not be selected until at least 24 hours have elapsed after production and the specimens should be kept for at least 16 h at 23 ± 2 °C and a relative humidity of 50 ± 5 %.

13.6. Test procedure

13.6.1

Measure, to an accuracy of 0,1 mm, the length across the chord and the breadth and thickness of the specimen in the centre (at the point of weld line).

13.6.2

Rigidly fasten the pendulum impact apparatus to a rigid base and adjust it so that the striking edge hits the specimen over its entire width.

13.6.3

Place the curved test specimen on the supports in such a manner that the striking edge hits the centre of the test specimen on the outside surface.

13.6.4

Adjust the pointer of the pendulum impact apparatus so that it touches the driving pin when the pendulum is hanging vertically. Carry out blank tests to ensure that the total friction loss, including the friction of the pointer, does not exceed 0,5 per cent of the maximum impact energy when the pendulum is swinging up to the maximum amplitude.

13.6.5

The pendulum is lifted and arrested, the specimen is arranged according to the instructions given in clause 13.6.3 and the pendulum released carefully.

13.7. Calculation and expression of results

13.7.1 Calculation of impact energy.

If needed the impact energy is calculated as follows:

13.7.1.1

The impact energy consumed by the specimen is read on the scale to accuracy of $\pm 0,05$ Nm.

13.7.1.2

If the arithmetic mean of all absolutely calculated deviations of the individual results exceeds 10 per cent from the mean value, another five specimens should be tested to ensure a reliable mean value. The above is valid if specimens are taken at the exactly same place.

13.7.1.3

The impact resistance a_c (in kJ/m²) of the curved specimen is given by:

$$a_c = \frac{A_n}{b \cdot e}$$

where

A_n = impact energy in kJ
 b = width of the test piece in m
 e = thickness of the test piece in m

13.7.2 Results for production control

For production control purposes the results are expressed as the number of fractures/number of strikes.

14. FATIGUE BENDING TEST (FBT)

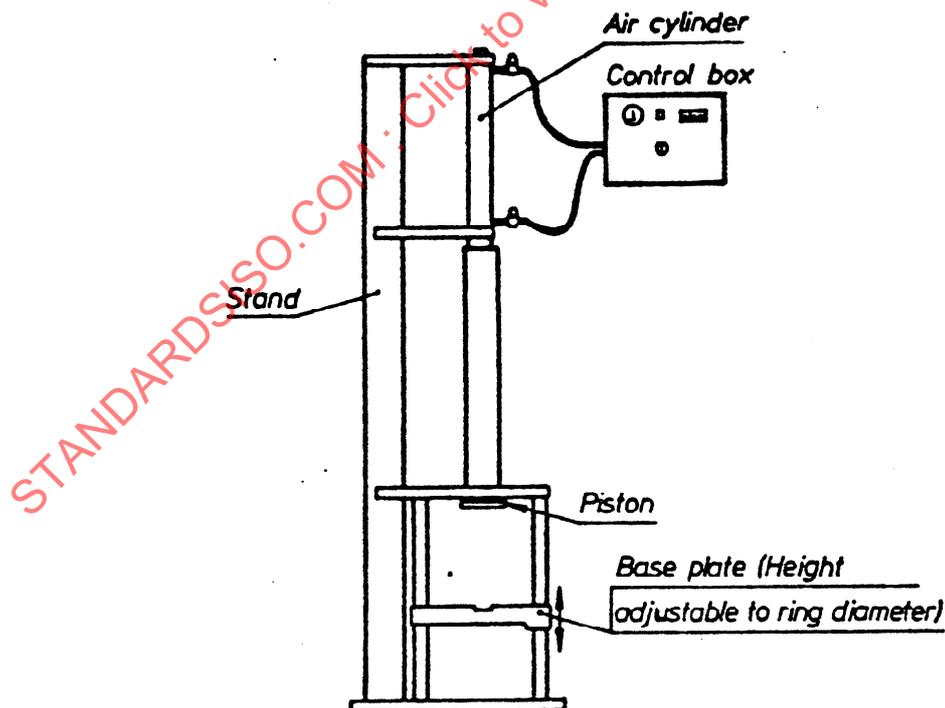


Figure 10. Example of a FBT apparatus