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Agricultural irrigation equipment — Emitters and emitting pipe — Specification and test methods

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 9261 was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 18, *Irrigation and drainage equipment and systems*.

This second edition of ISO 9261 cancels and replaces ISO 9261:1991 and ISO 9260:1991, of which it constitutes a technical revision.

Agricultural irrigation equipment — Emitters and emitting pipe — Specification and test methods

1 Scope

This International Standard gives mechanical and functional requirements for agricultural irrigation emitters and emitting pipes, and, where applicable, their fittings, and provides methods for testing conformity with such requirements. It also specifies the data to be supplied by the manufacturer to permit correct information, installation and operation in the field.

It is applicable to emitters, emitting and dripping (trickling) pipes, hoses, including collapsible hoses ("tapes") and tubing of which the emitting units form an integral part, to emitters and emitting units with or without pressure regulation and with flow rates not exceeding 24 l/h per outlet (except during flushing), and to fittings dedicated to the connection of emitting pipes, hoses and tubing. It is not applicable to porous pipe (pipe that is porous along its entire length), nor does it cover the performance of pipes as regards clogging.

2 Normative references

The following referenced documents are indispensable for the application 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 3501, *Assembled joints between fittings and polyethylene (PE) pressure pipes — Test of resistance to pull out*[1)]

ISO 8796:—[2)], *Polyethylene PE 32 and PE 40 pipes for irrigation laterals — Susceptibility to environmental stress cracking induced by insert-type fittings — Test method and specification*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
emitter
dripper
device fitted to an irrigation lateral and intended to discharge water in the form of drops or continuous flow at flow rates not exceeding 24 l/h except during flushing

3.2
in-line emitter
emitter intended for installation between two lengths of pipe in an irrigation lateral

1) Requirements for connections of insert-type fittings are to be included in a future edition.

2) To be published. (Revision of ISO 8796:1989)

3.3
on-line emitter
emitter intended for installation in the wall of an irrigation lateral, either directly or indirectly by means such as tubing

3.4
multiple-outlet emitter
emitter in which the output flow is divided and directed to several distinctly different locations

3.5
multiple emitter
multiple-outlet emitter in which every outlet is a secondary emitter with its own flow rate

NOTE The pressure relationship ($q = kp^m$), and the flow rate of each outlet is not generally dependent on the flow rate of other emitters.

3.6
emitting pipe
continuous pipe, hose or tubing, including collapsible hose ("tape") with perforations or other hydraulic devices formed or integrated in the pipe, hose or tubing during production and intended to discharge water in the form of drops or continuous flow, at flow rates not exceeding 24 l/h except during flushing

3.7
regulated emitter/emitting pipe
pressure compensating emitter/emitting pipe
emitter/emitting pipe which maintains a relatively constant flow rate at varying water pressures at the emitter/emitting pipe inlet within the limits specified by the manufacturer

3.8
regular emitter/emitting pipe
emitter/emitting pipe whose flow rate is different from zero when the inlet pressure is different from zero

3.9
non-leakage emitter/emitting pipe
emitter/emitting pipe whose flow is zero whenever the pressure at the inlet of the emitter/emitting pipe is lower than a value (other than zero) declared by the manufacturer

3.10
unregulated emitter/emitting pipe
non-pressure compensating emitter/emitting pipe
emitter/emitting pipe whose flow rate varies with inlet water pressure

3.11
flow rate
emission rate of an emitter or an emitting pipe

3.12
minimum working pressure
lowest working pressure at the inlet to an emitter/emitting pipe recommended by the manufacturer to ensure proper operation of the emitter/emitting pipe

3.13
maximum working pressure
highest water pressure at the inlet to an emitter/emitting pipe recommended by the manufacturer to ensure proper operation of the emitter/emitting pipe

3.14
non-reusable emitting pipe
emitting pipe not intended for removal from the field and reinstallation

3.15
reusable emitting pipe
emitting pipe designed for removal from the field and reinstallation with proper handling from one season to another or under other circumstances

3.16
emitting unit
section of an emitting pipe, including all its hydraulic devices formed or integrated in the pipe during production and all of the emitter inlets, repeated at intervals, from which water is discharged to one clearly distinguishable location

3.17
unit emitting pipe
length of emitting pipe containing one emitting unit

3.18
clamping band
ring-like or band-like device used for obtaining a watertight joint between an emitting pipe and a fitting

3.19
fitting
connecting device suitable for attachment to an emitting pipe with or without a clamping band

3.20
inlet fitting
fitting having one end suitable for connection to a standard irrigation pipe or appliance and the other end or ends suitable for connection to an emitting pipe

3.21
in-line fitting
fitting having both ends suitable for connection to an emitting pipe

3.22
nominal diameter
numerical designation used to refer to the size of an emitting pipe, approximately equal to the outside diameter of the emitting pipe

3.23
nominal size
numerical designation used to refer to the size of an in-line emitter, approximately equal to the inside diameter of an irrigation lateral pipe to which it is intended to be connected

3.24
nominal test pressure
p_n
reference pressure, to be used for test purposes, of 100 kPa at the inlet of an unregulated emitter/emitting unit, or any other pressure as designated in manufacturer's publications

3.25
nominal flow rate
q_n
⟨unregulated emitter/emitting pipe⟩ flow rate, expressed in litres per hour, of an emitter/emitting unit operating at the nominal test pressure and at a water temperature of 23 ± 3 °C, as specified by the manufacturer

3.26
nominal flow rate
q_n
⟨regulated emitter/emitting pipe⟩ flow rate, expressed in litres per hour, of an emitter/emitting unit operating in the range of regulation and at a water temperature of 23 ± 3 °C, as specified by the manufacturer

3.27
nominal flow rate
q_n
⟨multiple outlet emitter⟩ flow rate of each outlet, as specified in 3.25 and 3.26, accordingly

3.28
range of working pressures
all water pressures at the emitter/emitting unit inlet between and including the minimum working pressure, p_{min}, and the maximum working pressure, p_{max}, recommended by the manufacturer to ensure proper operation

3.29
range of regulation
⟨regulated emitter/emitting pipe⟩ all water pressures at the emitter/emitting unit inlet in which each emitter/emitting unit is expected to discharge the nominal flow rate

3.30
emitter/emitting unit exponent
m
numerical value that defines the exponential relationship between emission rate and pressure

NOTE $q \approx kp^m$: for an exponent (m) of 0, the emission rate does not vary with pressure; for an exponent of 1, the emission rate varies linearly with pressure.

3.31
collapsible hose
"tape"
emitting pipe whose structure causes its cross-section (which is generally round or rounded when the pressure at the inlet of the emitting pipe is within the range of working pressures recommended by the manufacturer) to alter itself when the pressure is zero, generally because of a small wall thickness or because of the flexible nature of the material from which the emitting pipe is made

3.32
spacing [of emitting units]
distance between two successive emitting units along an emitting pipe

4 Classification

Emitters/emitting pipes are classified according to the following criteria (see 4.1 to 4.5).

4.1 Reusability (emitting pipes)

Two categories of duration of use are classified:

4.1.1 non-reusable emitting pipes;

4.1.2 reusable emitting pipes.

4.2 Type of pressure regulation

Two categories of operation are classified:

4.2.1 unregulated emitters/emitting pipes;

4.2.2 regulated emitters/emitting pipes.

4.3 Type of operation at low pressure

Two categories of operation at low pressure are classified:

4.3.1 regular

4.3.2 non-leakage

4.4 Type of emitter connection to the pipe

Three types of emitter connection are classified:

4.4.1 on-line (emitter)

4.4.2 in-line (emitter)

4.4.3 formed or integrated in the pipe (emitting pipe)

4.5 Type of multiple-outlet emitter

4.5.1 multiple emitter

4.5.2 regular multiple-outlet emitter.

5 Designation (emitting pipes)

Emitting pipes shall be designated by

a) the words “emitting pipe”,

b) reference to this International Standard,

c) the nominal diameter, in millimetres,

d) nominal flow rate, in litres per hour,

e) maximum working pressure, in multiples of 100 kPa units.

EXAMPLE An emitting pipe complying with this International Standard, of 16-mm nominal diameter, 2 l/h nominal flow rate, intended for operation at working pressures up to a maximum of 120 kPa is designated as follows:

Emitting pipe ISO 9261 16 - 2 - 1,2

6 Marking

6.1 Emitting pipe

Each emitting pipe shall bear clear and permanent markings including the following details:

a) name of manufacturer or registered trademark;

b) mark for identification of year of manufacture;

c) designation according to Clause 5;

d) arrow indicating direction of flow (if it affects operation of the emitting pipe);

e) spacing of emitting units, in centimetres.

These details shall be marked at intervals not exceeding 5 m.

Notwithstanding the above, the marking on non-reusable emitting pipes (Class 4.1.1) does not have to be permanent but shall appear on the package in accordance with the marking requirements of 6.4.

6.2 Emitter

Each emitter shall bear clear and permanent markings including the following details:

a) name of the manufacturer or registered trademark;

b) nominal flow rate, in litres per hour;

c) nominal size (in-line emitters), in millimetres;

d) arrow indicating direction of flow (if important for proper operation).

Nominal flow rate [see b) of this subclause] may be indicated by the colour of any part of the emitter, or by any other method described in the manufacturer's literature.

6.3 Fittings

Each emitting pipe fitting shall bear a clear and permanent marking of the name of the manufacturer or registered trademark.

6.4 Packaging of emitting pipes

When emitting pipes are supplied in coils, each coil shall carry an attached tag bearing the following clear, legible and permanent information:

a) name of manufacturer or registered trademark;

b) designation according to Clause 5;

c) nominal diameter of emitting pipe, in millimetres;

d) catalogue number of emitting pipe, or other catalogue identification;

e) classification according to 4.1, 4.2 and 4.3;

f) length of emitting pipe in coil, in metres;

g) year of production and manufacturing lot;

h) nominal flow rate of unit emitting pipe, in litres per hour, and nominal test pressure (unregulated emitting pipe), p_n;

i) spacing of emitting units, in metres.

6.5 Packaging of fittings

Fittings shall be supplied in package form, each bearing the following clear, legible and permanent information:

a) name of manufacturer;

b) catalogue number;

c) nominal diameter of emitting pipe and, if applicable, nominal diameter of the irrigation lateral or the nominal size of the thread for which the fittings are intended;

d) year of manufacture and manufacturing lot.

7 Construction and materials

7.1 General

The emitter/emitting pipe, its parts and fittings shall have no manufacturing defects that could impair performance.

The construction of the emitter/emitting pipe and its fittings shall permit their easy connection, with or without clamping bands, whether the connection is made manually or by means of suitable tools supplied by the manufacturer.

7.2 Dimensions (emitting pipe)

7.2.1 The manufacturer shall specify the outside diameter, inside diameter and wall thickness of the product, in millimetres, and the actual dimensions of the product shall comply with those declared by the manufacturer in accordance with 9.4.2.

7.2.2 The dimensions of the connecting fittings shall fit the dimensions of the emitting pipe, to ensure easy and reliable connection.

7.3 Materials

The material used in the manufacture of emitters/emitting pipes and their fittings shall be resistant to fertilizers and other chemicals commonly employed in agricultural irrigation and shall be suitable for use with water at temperatures up to 60 °C and at operating pressures designated by the manufacturer.

The materials shall, insofar as possible, not support the growth of algae and bacteria. The parts that are exposed to light shall be opaque and protected against UV degradation.

7.4 Fittings (emitting pipe)

The manufacturer shall be able to supply, for each type and size of emitting pipe, fittings suitable in size and shape to make secure connections to the emitting pipe.

The jointing, made with or without the use of clamping bands, shall be of sufficient strength to withstand the full range of working pressures.

Clamping components, such as bands and screws, shall be of non-corroding materials or of materials protected against corrosion.

7.5 Connection to irrigation lateral (in-line emitter)

When polyethylene (PE) lateral is used, in-line emitter ends shall not increase the diameter of the polyethylene pipe by more than 20 %.

NOTE Dimensions of the polyethylene pipe laterals are specified in ISO 8779.

8 Test specimens and conditions

8.1 Test specimens

The sample shall include 25 specimens taken at random from a lot of at least 500 emitters/emitting units. A specimen is composed of either one emitter or one non-truncated emitting unit from the emitting pipe. The number of test specimens (emitters/emitting units) required for each test is indicated in Clause 9 for the relevant tests. For emitting pipes, ensure that the test specimen is not taken from adjacent sections of the pipe and does not contain either the first or last emitting unit of the lot. For multiple outlet emitters, the sample shall include at least 10 emitters or 25 outlets.

8.2 Order of tests

The tests shall be conducted in the order given in Clause 9. All tests, beginning with that of 9.2, shall be conducted on specimens tested according to 9.1.

8.3 Test conditions

Unless otherwise specified, carry out all tests at ambient air temperature and at a water temperature of 23 °C ± 3 °C. Ensure that the water used is clear water filtered through a filter with nominal aperture of 75 µm to 100 µm, or as recommended by the manufacturer, with a total load of contaminants not exceeding 25 mg/l.

8.4 Accuracy of measuring devices

The water pressure shall be measured with measuring devices capable of measuring with an error not exceeding 1 % of the actual values.

During the test, the pressure shall not vary by more than 2 %.

The flow rate shall be measured with measuring devices capable of measuring with an error not exceeding ± 0,5 % of the nominal flow rate.

9 Test methods and requirements

9.1 Uniformity of flow rate

9.1.1 General

This test applies to regulated and unregulated emitters/emitting pipes. The test sample shall include 25 emitters/emitting units in accordance with the requirement in 8.1. When multiple emitters are tested, each outlet shall be considered as a single emitter.

9.1.2 Unregulated emitters/emitting pipes

Measure the flow rates of the emitters/emitting units when the water pressure at the inlets of the emitters/emitting units equals the nominal test pressure. Record separately the measured flow rate of each emitter/emitting unit.

Calculate the coefficient of variation, C_v, from the following formula:

$$C_v = \frac{s_q}{\bar{q}} \times 100$$

where:

s_q is the standard deviation of the flow rates for the sample, in litres per hour;

$\bar{q}$ is the mean flow rate of the sample, in litres per hour.

The mean flow rate of the test sample shall not deviate from the nominal flow rate, q_n, by more than ± 7 %.

The coefficient of variation, C_v, of the flow rate of the test sample shall not exceed 7 %.

9.1.3 Regulated emitters/emitting pipes

Condition the emitters/emitting units in the test sample by operating them for a total of 1 h. The conditioning procedure shall consist of the following steps.

a) Set the minimum working pressure and maintain it for 3 min.

b) Set the maximum working pressure and maintain it for 3 min.

c) Set the minimum working pressure and maintain it for 3 min.

d) Set the maximum working pressure and maintain it for 3 min.

e) Set the minimum working pressure and maintain it for 3 min.

f) Set the maximum working pressure and maintain it for 3 min.

g) Set the pressure at the midpoint of the range of regulation and maintain it until the total time of the conditioning procedure (1 h) is completed.

h) Immediately after conditioning and while maintaining the inlet pressure at the midpoint of the range of regulation, test the emitters/emitting units according to 9.1.2.

The emitters/emitting units shall comply with the requirements of 9.1.2.

9.2 Flow rate as a function of inlet pressure

Perform the tests for determining flow rate as a function of inlet pressure as a continuation of the tests performed in accordance with 9.1. When multiple emitters are tested, each outlet shall be considered as a single emitter.

9.2.1 Test method

Test each emitter/emitting unit in steps not greater than 50 kPa, from zero pressure up to 1,2 p_{max}, such that at least four values of flow rates at four different pressures are obtained. Measure the flow rates at least 3 min after reaching the test pressure.

Test non-leakage emitters/emitting pipes in steps not greater than 10 kPa from zero pressure up to 0,5 p_{max}. Starting from 0,5 p_{max}, continue raising the pressure in steps not exceeding 50 kPa.

Continue the tests of the regulated emitters/emitting units decreasing the pressure from 1,2 p_{max} to 0 in the same pressure values shall be used as when testing at rising pressures.

If the actual inlet pressure exceeds the desired inlet pressure by more than 10 kPa during its rise and fall, return to zero pressure and repeat the test.

9.2.2 Unregulated emitters/emitting pipes

Calculate, for each pressure level, the average emission rate, $\bar{q}$, in litres per hour, obtained by measuring the flow rates of the emitters/emitting units at rising pressure.

Plot the curve $\bar{q}$ as a function of inlet pressure. The curve of $\bar{q}$ shall conform to the curve presented in manufacturers' publications within an allowable deviation of not more than ± 7 %.

9.2.3 Regulated emitters/emitting pipes

Calculate, for each inlet pressure level, p, the average flow rate, $\bar{q}$, obtained by measuring the flow rates of the emitters/emitting units at rising and falling pressure (the average of eight flow rate measurements).

The values of $\bar{q}$ shall not deviate from the nominal flow rate by more than ± 7 %.

For non-leakage emitters/emitting units, the pressure at which flow begins and the pressure at which the flow stops shall not vary by more than 20 % from the manufacturer's declared pressure.

9.3 Determination of emitter/emitting unit exponent

The relation between the flow rate, q, in litres per hour, and the inlet pressure in an emitter/emitting unit, p, in kilopascals, is given by the formula:

$$q \cong k \times p^m$$

where

k is a constant;

m is the emitting exponent.

Using all the q and p values obtained in 9.2.3, calculate the exponent, m, from the following formula:

$$m = \frac{\sum(\lg p_i)(\lg \bar{q}_i) - \frac{1}{n}\left(\sum \lg p_i\right)\left(\sum \lg \bar{q}_i\right)}{\sum(\lg p_i)^2 - \frac{1}{n}(\sum \lg p_i)^2}$$

where

i is 1,2,3... n;

n is the number of pressure values used in 9.2.2 or 9.2.3;

$\bar{q}$ is the mean flow rate, in litres per hour;

p is the inlet pressure, in kilopascals.

For regulated emitters/emitting pipes, the value of the emitting exponent, m, shall not exceed 0,2.

The calculated exponent shall not deviate from the manufacturer's declaration by more than ± 5 %.

NOTE The emitter/emitting unit "constant", k, can also be calculated by the following formula:

$$k = \exp\left[\left(\frac{\sum \ln q_i}{n}\right) - \frac{m \times \left(\sum \ln p_i\right)}{n}\right]$$

where

i is 1,2,3... n;

n is the number of pressure values used in 9.2.3;

q_1 is the mean flow rate, in litres per hour;

p_1 is the inlet pressure, in kilopascals;

m is the emitter/emitting unit.

9.4 Dimensions

9.4.1 Wall thickness of emitting pipe

Measure the wall thickness using a measuring instrument having an accuracy of 0,01 mm. The measurement may be rounded to the nearest 0,05 mm.

Measure the wall thickness of the emitting pipe at four points equally spaced on the periphery of the pipe. Repeat the test at two cross-sections. In the event of a part of the pipe wall being thicker by design (for example, a flap in the emitting pipe), disregard such increased thickness.

The wall thickness of the emitting pipe, when measured individually at each of the four points, shall not be less than 90 % of the declared wall thickness.

9.4.2 Inside diameter of emitting pipe

Measure the inside diameter using a measuring instrument having an accuracy of 0,05 mm. The measurement may be rounded to the nearest 0,1 mm.

To measure the inside diameter of the emitting pipe, insert a conical part (apex angle not greater than 10°) into the end of the emitting pipe, taking care not to enlarge the pipe diameter. Mark on the cone the circle made by the end of the pipe and measure its diameter.

Alternative measuring methods, such as calculation of the diameter by measuring the pipe circumference, may be used.

The measured inside diameter shall not deviate by more than ± 0,3 mm from the declared diameter.

9.4.3 Spacing of emitting units

Measure three spacings of emitting units accurately to the nearest 1,0 mm.

The spacings of the emitting units shall not deviate by more than 5 % from the spacings declared by the manufacturer.

9.5 Resistance to hydraulic pressure

9.5.1 Resistance to hydraulic pressure at ambient temperature, 23° ± 3 °C

Carry out the test on a length of pipe consisting of five emitters or five emitting units joined by means of in-line fittings.

Carry out the test in two stages (see 9.5.1.1 and 9.5.1.2).

9.5.1.1 Connect the assembly to a source of water (connecting the emitting pipe by means of an inlet fitting) and close its outlet end. Fill the assembly with water and check that no air remains trapped in the pipe. Increase the water pressure gradually (10 s minimum) to 1,2 p_{max} for non-reusable emitting pipes or to 1,8 p_{max} for reusable emitting pipes and for emitters, and maintain the test pressure for 1 h.

The assembly shall withstand the test pressure without showing signs of damage to the emitters/emitting pipes, the emitting units or the connecting fittings. The assembly shall not pull apart, and no leakage shall occur at the inlet fitting. Leakages not exceeding the emission rate of one emitting unit are permissible at in-line fittings.

9.5.1.2 Reduce the test pressure to the nominal test pressure and maintain it for at least 3 min. Measure the flow rate of each emitter/emitting unit.

For emitters designed to enter a “flush mode” at high pressures to remove clogs, reduce the pressure to zero before measuring flow rate at the nominal pressure.

The flow rate of each emitter/emitting unit shall not deviate by more than ± 10 % from its original flow rate as measured in 9.1.

9.5.2 Resistance to hydraulic pressure at elevated temperature

Carry out the test on an assembly consisting of three emitters connected to a lateral or of three unit emitting pipes joined by means of in-line fittings.

9.5.2.1 Connect the assembly to a source of water by means of an inlet fitting and close its outlet end. Fill the assembly with water and check that no air remains trapped in the pipe. Raise the water pressure gradually (10 s minimum) to the maximum working pressure and maintain the pressure for 1 h while the emitting pipe test assembly is immersed in water at 40 °C ± 3 °C.

The assembly shall withstand the test pressure without showing signs of damage.

9.5.2.2 Remove the test assembly from the water and leave it for 30 min at ambient temperature. Apply a hydrostatic pressure, p_n, for at least 3 min at 23 °C ± 3 °C and measure the flow rate of each emitting unit.

The flow rate of each emitter/emitting unit shall not deviate by more than ± 10 % from its original flow rate, as measured in 9.1.

9.6 Resistance to tension (emitting pipe)

Carry out the test at a temperature of 23 °C ± 3 °C.

If the emitting pipe is reusable, mark two lines, 150 mm apart, on the unit emitting pipe.

Fasten each unit emitting pipe in the grips of a tension-testing machine and uniformly increase (over 20 s to 30 s) the pull on the unit emitting pipe to

a) 160 N for non-reusable emitting pipes (see Clause 4.1.1), or

b) 180 N for reusable emitting pipes (see 4.1.2).

Notwithstanding this, if the manufacturer's publications (see Clause 10) declare that the maximum permitted tension force is less than the abovementioned force, perform the test as specified here with the tension force declared by the manufacturer.

Maintain the tension force for 15 min, then release.

Non-reusable emitting pipes shall withstand the test tension force without breaking or tearing.

Reusable emitting pipes shall withstand the test tension force without breaking or tearing, the nominal flow rate in the test specimen shall not vary by more than ± 10 % from the flow rate measured before testing, and the distance between the two marked lines shall not vary by more than ± 5 % from the distance measured according to this subclause.

9.7 Resistance to pull-out of joints between fittings and polyethylene reusable emitting pipes

The test method and the test equipment used shall be as specified in ISO 3501, except that the test tension force shall be 180 N, applied for 15 min.

Notwithstanding the above, if the manufacturer's publications (see Clause 10) declare that the maximum permitted tension force is less than the abovementioned force, perform the test with the tension force declared by the manufacturer.

The fitting shall not pull out from the emitting pipe.

Where the emitting pipe is not made of polyethylene or the pipe wall is not uniform, this test may be performed in conjunction with the resistance to tension test in 9.6 by connecting between two sections of emitting pipe, each at least 300 mm long.

9.8 Emitter pull-out

Conduct this test at a temperature of 23 °C ± 3 °C, and with a type of pipe suitable for use with the emitter (see Clause 10).

9.8.1 In-line emitters

Perform the test on three lengths of pipe (irrigation lateral), each containing one emitter. Gradually apply an axial tensile force to produce a pull-out force, F, in newtons, on the two lengths of pipe connected to the emitter, where F is calculated from the following formula and is not greater than 500 N:

$$F = 1{,}5\pi\sigma_t\, e(D - e)$$

where

σ_t is the permissible induced stress for pipe material, in newtons per square millimetre (e.g. for polyethylene PE 25: σ_t = 2,5 N/mm^2);

e is the minimum pipe wall thickness, in millimetres;

D is the outside diameter of the pipe, in millimetres.

Apply F for 1 h, with the emitter vertical, by means of a weight or the apparatus specified in ISO 3501.

Notwithstanding the above, if the manufacturer's publications (see Clause 10) declare that the maximum permitted tension force is less than the abovementioned force, perform the test as specified here with the tension force declared by the manufacturer.