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Plastics piping systems for pressure and non-pressure drainage and sewerage — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin

Systèmes de canalisation en matières plastiques pour les branchements et les collecteurs d'assainissement avec ou sans pression — Systèmes en plastiques thermodurcissables renforcés de verre (PRV) à base de résine de polyester non saturé (UP)

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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 10467 was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 6, *Reinforced plastics pipes and fittings for all applications*.

Plastics piping systems for pressure and non-pressure drainage and sewerage — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin

1 Scope

This International Standard specifies the properties of piping system components made from glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP) for drainage or sewerage with or without pressure, as well as the properties of the system itself.

This International Standard is applicable to GRP-UP piping systems, with flexible or rigid joints with or without end thrust load-bearing capability, primarily intended for use in buried installations.

NOTE Piping systems conforming to this International Standard can also be used for non-buried applications provided the influence of the environment and the supports are considered in the design of the pipes, fittings and joints.

This International Standard is applicable to pipes, fittings and their joints of nominal sizes from DN 50 to DN 4000 which are intended to be used for the conveyance of drainage or sewerage at temperatures up to 50 °C, with or without pressure. In a pipework system, pipes and fittings of different nominal pressure and stiffness ratings may be used together.

Clause 4 specifies the general aspects of GRP-UP piping systems intended to be used in the field of drainage or sewerage with or without pressure.

Clause 5 specifies the characteristics of pipes made from GRP-UP with or without aggregates and/or fillers. The pipes may have a thermoplastics or thermosetting resin liner. Clause 5 also specifies the test parameters for the test methods referred to in this International Standard.

Clause 6 specifies the characteristics of fittings made from GRP-UP, with or without a thermoplastics or thermosetting resin liner, intended to be used in the field of drainage or sewerage. Clause 6 specifies the dimensional and performance requirements for bends, branches, reducers, saddles and flanged adaptors. Clause 6 is applicable to fittings made using any of the following techniques:

a) fabrication from straight pipes;

b) moulding by

  1) filament winding,

  2) tape winding,

  3) contact moulding,

  4) hot or cold compression moulding.

Clause 7 is applicable to the joints to be used in GRP-UP piping systems to be used for the conveyance of surface water or sewerage, both buried and non-buried. It covers requirements to prove the design of the joint. Clause 7 specifies type test performance requirements for the following joints as a function of the declared nominal pressure rating of the pipeline or system:

a) socket-and-spigot (including double-socket) joints or mechanical joints;

b) locked socket-and-spigot joints;

c) cemented or wrapped joints;

d) bolted flange joints.

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 75-2:2003, *Plastics — Determination of temperature of deflection under load — Part 2: Plastics and ebonite*

ISO 161-1, *Thermoplastics pipes for the conveyance of fluids — Nominal outside diameters and nominal pressures — Part 1: Metric series*

ISO 527-4, *Plastics — Determination of tensile properties — Part 4: Test conditions for isotropic and orthotropic fibre-reinforced plastic composites*

ISO 527-5, *Plastics — Determination of tensile properties — Part 5: Test conditions for unidirectional fibre-reinforced plastic composites*

ISO 2078, *Textile glass — Yarns — Designation*

ISO 2531, *Ductile iron pipes, fittings, accessories and their joints for water or gas applications*

ISO 3126, *Plastics piping systems — Plastics components — Determination of dimensions*

ISO 4200, *Plain end steel tubes, welded and seamless — General tables of dimensions and masses per unit length*

ISO 7432:2002, *Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Test methods to prove the design of locked socket-and-spigot joints, including double-socket joints, with elastomeric seals*

ISO 7509, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of time to failure under sustained internal pressure*

ISO 7511:1999, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Test methods to prove the leaktightness of the wall under short-term internal pressure*

ISO 7685, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of initial specific ring stiffness*

ISO 8483:2003, *Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Test methods to prove the design of bolted flange joints*

ISO 8513:2000, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of longitudinal tensile properties*

ISO 8521:1998, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of the apparent initial circumferential tensile strength*

ISO 8533:2003, *Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Test methods to prove the design of cemented or wrapped joints*

ISO 8639:2000, *Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Test methods for leaktightness of flexible joints*

ISO/TR 10465-3, *Underground installation of flexible glass-reinforced thermosetting resin (GRP) pipes — Part 3: Installation parameters and application limits*

ISO 10466, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Test method to prove the resistance to initial ring deflection*

ISO 10468, *Glass-reinforced thermosetting plastics (GRP) pipes — Determination of the long-term specific ring creep stiffness under wet conditions and calculation of the wet creep factor*

ISO 10471, *Glass-reinforced thermosetting plastics (GRP) pipes — Determination of the long-term ultimate bending strain and the long-term ultimate relative ring deflection under wet conditions*

ISO 10928:1997, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Methods for regression analysis and their use*

ISO 10952, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Determination of the resistance to chemical attack from the inside of a section in a deflected condition*

ISO 11922-1, *Thermoplastics pipes for the conveyance of fluids — Dimensions and tolerances — Part 1: Metric series*

ISO 14828, *Glass-reinforced thermosetting plastics (GRP) pipes — Determination of the long-term specific ring relaxation stiffness under wet conditions and calculation of the wet relaxation factor*

ISO 15306, *Glass-reinforced thermosetting plastics (GRP) pipes — Determination of the resistance to cyclic internal pressure*

EN 681-1, *Elastomeric seals — Materials requirements for pipe joint seals used in water and drainage applications — Part 1: Vulcanized rubber*

EN 681-2, *Elastomeric seals — Materials requirements for pipe joint seals used in water and drainage applications — Part 2: Thermoplastic elastomers*

JIS A 5350, *Fibreglass reinforced plastic mortar pipes*

3 Terms and definitions

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

3.1
nominal size
DN
alphanumerical designation of size, which is common to all components in a piping system, which is a convenient round number for reference purposes and is related to the internal diameter in millimetres

NOTE The designation for reference or marking purposes consists of the letters DN plus a number.

3.2
declared diameter
diameter which a manufacturer states to be the mean internal or external diameter produced in respect of a particular nominal size (DN)

3.3
nominal stiffness
SN
alphanumerical designation of stiffness classification purposes, which has the same numerical value as the minimum initial value required, when expressed in newtons per square metre (N/m^2) (see 4.1.3)

NOTE The designation for reference or marking purposes consists of the letters SN plus a number.

3.4
specific ring stiffness
S
measure of the resistance, in newtons per square metre, of a pipe to ring deflection per metre length under external load as defined by Equation (1):

$$S = \frac{E \times I}{{d_m}^3} \qquad (1)$$

where

E is the apparent modulus of elasticity as determined in a ring stiffness test, in newtons per square metre (N/m^2);

I is the second moment of area in the longitudinal direction per metre length, in metres to the fourth power per metre (m^4/m), i.e.

$$I = \frac{e^3}{12} \qquad (2)$$

e being the wall thickness, in metres (m);

d_m is the mean diameter of the pipe, in metres (m) (see 3.5)

3.5
mean diameter
d_m
diameter of the circle corresponding to the middle of the pipe wall cross-section and given, in metres (m), by either Equation (3) or (4)

$$d_m = d_i + e \qquad (3)$$

$$d_m = d_e - e \qquad (4)$$

where

d_i is the internal diameter, in metres (m);

d_e is the external diameter, in metres (m);

e is the wall thickness of the pipe, in metres (m)

3.6
initial specific ring stiffness
S_0
value of S obtained when determined in accordance with ISO 7685, in newtons per square metre (N/m^2)

3.7
wet creep factor
$\alpha_{x,\ \mathrm{wet,\ creep}}$
ratio of the long-term specific ring stiffness, $S_{x,\ \mathrm{wet}}$, at x years (see 4.6), determined under sustained loading in wet conditions in accordance with ISO 10468, to the initial specific ring stiffness, S_0, both measured at the same position referred to as reference position 1

NOTE It is given by Equation (5):

$$\alpha_{x,\ \mathrm{wet,\ creep}} = \frac{S_{x,\ 1,\ \mathrm{wet}}}{S_{0,\ 1}} \quad (5)$$

3.8
wet relaxation factor
$\alpha_{x,\ \mathrm{wet,\ relax}}$
ratio of the long-term specific ring stiffness, $S_{x,\ \mathrm{wet}}$, at x years (see 4.6), determined under sustained deflection in wet conditions in accordance with ISO 14828, to the initial specific ring stiffness, S_0, both measured at the same position, referred to as reference position 1

NOTE It is given by Equation (6):

$$\alpha_{x,\ \mathrm{wet,\ relax}} = \frac{S_{x,\ 1,\ \mathrm{wet}}}{S_{0,\ 1}} \quad (6)$$

3.9
calculated long-term specific ring stiffness
$S_{x,\ \mathrm{wet}}$
calculated value of S (see 4.6) at x years, obtained by Equation (7):

$$S_{x,\ \mathrm{wet}} = S_0 \times \alpha_{x,\ \mathrm{wet}} \quad (7)$$

where

x is the elapsed time, in years, specified in this International Standard (see 4.6);

$\alpha_{x,\ \mathrm{wet}}$ is either the wet creep factor (see 3.7) or the wet relaxation factor (see 3.8);

S_0 is the initial specific ring stiffness, in newtons per square metre (N/m^2) (see 3.6).

3.10
rerating factor
R_{RF}
multiplication factor that quantifies the relation between a mechanical, physical or chemical property under the service conditions compared to the respective value at 23 °C and 50 % relative humidity (R.H.)

3.11
nominal pressure
PN
alphanumeric designation for pressure classification purposes which is numerically equal to the resistance of a component of a piping system to internal pressure, expressed in bars[1)]

NOTE The designation for reference or marking purposes consists of the letters PN plus a number.

3.12
type test
test carried out in order to assess the fitness for purpose of a product or assembly of components to fulfil its or their function(s) in accordance with the product specification

3.13
nominal length
numerical designation of pipe length which is equal to the laying length (see 3.15), expressed in metres (m), rounded to the nearest whole number

3.14
total length
distance between two planes normal to the pipe axis and passing through the extreme end points of the pipe, expressed in metres (m)

3.15
laying length
total length of a pipe minus, where applicable, the manufacturer's recommended insertion depth of the spigot(s) in the socket

3.16
normal service conditions
conveyance of surface water or sewage in the temperature range 2 °C to 50 °C, with or without pressure, for 50 years

NOTE At temperatures above 35 °C, it may be necessary to rerate the pipe.

3.17
working pressure
p_W
internal pressure, excluding surge, at which a system is to be continuously operated, expressed in bars

3.18
maximum working pressure
maximum internal pressure, excluding surge, at which a system can be continuously operated, expressed in bars

3.19
surge
rapid change in internal pressure, either positive or negative, caused by a change in the flow velocity

NOTE It is expressed in bars.

3.20
surge allowance
value, expressed in bars or as a percentage of the maximum working pressure of a pipe, that can be added to the maximum working pressure to allow for occasional fluctuations in pressure

NOTE The value may vary depending upon the anticipated frequency of the surge conditions.

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1) 1 bar = 10^5 N/m^2 = 100 kPa (or = 0,1 MPa)

3.21
static design pressure
maximum working pressure of a system, taking into account current and future use, fixed by the designer

NOTE It is expressed in bars.

3.22
maximum design pressure
maximum working pressure, including surge, that the designer anticipates in a system

NOTE It is expressed in bars.

3.23
non-pressure pipe or fitting
pipe or fitting subjected to an internal pressure not greater than 1 bar

3.24
pressure pipe or fitting
pipe or fitting having a nominal pressure classification, expressed in bars, greater than 1 bar and which is intended to be used at internal pressures up to its nominal pressure in bars

3.25
buried pipeline
pipeline which is subjected to the external pressure transmitted from soil loading, including traffic and superimposed loads and possibly the pressure of a head of water

3.26
non-buried pipeline
pipeline which is subjected to negative and positive pressure, forces resulting from its supports, environmental conditions, e.g. snow and wind, and possibly the pressure of a head of water

3.27
sub-aqueous pipeline
pipeline which is subjected to an external pressure arising from a head of water and conditions such as drag and lift caused by current and wave action

3.28
design service temperature
maximum sustained temperature at which a system is expected to operate, expressed in degrees Celsius (°C)

3.29
variance
measure of dispersion based on the mean square deviation from the arithmetic mean

3.30
standard deviation
σ
positive square root of the variance

3.31
coefficient of variation
Y
ratio of the standard deviation to the absolute value of the arithmetic mean [see Equation (8)]:

$$Y = \frac{\text{Standard deviation of the population}}{\text{Mean of the population}} \quad (8)$$

NOTE In this International Standard, it is expressed as a percentage.

3.32
acceptable quality level
AQL
quality level which, for the purposes of sampling inspection of a continuous series of lots, is the limit of a satisfactory process-average percent nonconforming

3.33
projected failure pressure at 6 min
p_6
value at 6 min derived from the pressure regression line obtained from long-term pressure tests performed in accordance with ISO 7509 and analysed in accordance with ISO 10928

3.34
projected failure pressure at 50 years
p_{50}
value at 50 years derived from the pressure regression line obtained from long-term pressure tests performed in accordance with ISO 7509 and analysed in accordance with ISO 10928

3.35
pressure regression ratio
$R_{\mathrm{R},\,p}$
ratio of the projected failure pressure at 50 years, p_{50}, to the projected failure pressure at 6 min, p_6, obtained from long-term pressure tests performed in accordance with ISO 7509 [see Equation (9)] and analysed in accordance with ISO 10928

$$R_{\mathrm{R},\,p} = \frac{p_{50}}{p_6} \tag{9}$$

3.36
initial failure pressure
p_0
pressure at which failure occurs with specimens subjected to short-term tests performed in accordance with ISO 8521

3.37
minimum failure pressure at 50 years
$p_{50,\,97{,}5\,\%\,\mathrm{LCL,\,min}}$
failure pressure at 50 years which 97,5 % of products are required to exceed [see Equation (10)]:

$$p_{50,\,97{,}5\,\%\,\mathrm{LCL,\,min}} = \mathrm{PN} \times \eta_{\mathrm{t,\,PN},\,97{,}5\,\%\,\mathrm{LCL,\,min}} \tag{10}$$

3.38
minimum failure pressure at 6 min
$p_{6,\,\mathrm{min}}$
failure pressure at 6 min which 97,5 % of products are required to exceed [see Equation (11)]:

$$p_{6,\,\mathrm{min}} = \frac{p_{50,\,97{,}5\,\%\,\mathrm{LCL,\,min}}}{R_{\mathrm{R},\,p}} \tag{11}$$

3.39
correction factor for initial failure pressure
C
factor used to convert projected 6-min values, p_6, to initial failure pressure values, p_0 [see Equation (12)]:

$$C = \frac{p_0}{p_6} \tag{12}$$

3.40
minimum initial failure pressure
$p_{0,\text{ min}}$
initial failure pressure, determined in accordance with ISO 8521, which 97,5 % of products are required to exceed [see Equation (13)]:

$$P_{0,\text{ min}} = P_{6,\text{ min}} \times C \qquad (13)$$

3.41
minimum design pressure
$p_{0,\text{ d}}$
design initial failure pressure to ensure 97,5 % of products will exceed $p_{0,\text{ min}}$ [see Equation (14)]:

$$p_{0,\text{ d}} = p_{0,\text{ min}} \times \frac{1}{(1 - Y \times 0{,}01 \times 1{,}96)} \qquad (14)$$

3.42
minimum mean failure pressure at 50 years
$p_{50,\text{ mean, min}}$
failure pressure at 50 years which 50 % of products are required to exceed [see Equation (15)]:

$$p_{50,\text{ mean, min}} = \text{PN} \times \eta_{\text{t, PN, mean}} \qquad (15)$$

where PN is expressed in bars

3.43
AQL multiplier
MPL_{test}
multiplier, whose value is dependent upon the specified AQL (see 3.32), that is used with the coefficient of variation (see 3.31)

EXAMPLES If the AQL = 6,5 %, then MPL_{test} = 1,51. If the AQL = 2,5 %, then MPL_{test} = 1,96.

3.44
tensile safety factor
η_{t}
safety factor which is applied to the tensile strength of a product

3.45
tensile safety factor related to $p_{50,\text{ 97,5 \% LCL, min}}$
$\eta_{\text{t, PN, 97,5 \%, min}}$
safety factor which is applied to the nominal pressure (PN) to ensure that 97,5 % of products when installed in the ground can operate at a working pressure, p_{w} (see 3.17), equal to PN without failure for at least 50 years

NOTE For further information, see ISO/TR 10465-3.

3.46
relative ring deflection
y/d_{m}
ratio of the change in diameter of a pipe, y, in metres, to its mean diameter, d_{m} (see 3.5)

NOTE It is derived as a percentage from Equation (16):

$$\text{Relative ring deflection} = \frac{y}{d_{\text{m}}} \times 100 \qquad (16)$$

3.47
projected initial relative ultimate ring deflection
y_2/d_m
projected deflection value at 2 min derived from the ultimate deflection regression line obtained from long-term ultimate deflection tests performed in accordance with ISO 10471 and analysed in accordance with ISO 10928

NOTE It is expressed as a percentage by multiplying by 100.

3.48
minimum initial relative specific ring deflection before bore cracking occurs
$(y_{2,\text{ bore}}/d_m)_{min}$
initial relative deflection at 2 min which a test piece is required to pass without bore cracking when tested in accordance with ISO 10466

NOTE It is expressed as a percentage by multiplying by 100.

3.49
minimum initial relative specific ring deflection before structural failure occurs
$(y_{2,\text{ struct}}/d_m)_{min}$
initial relative deflection at 2 min which a test piece is required to pass without structural failure when tested in accordance with ISO 10466

NOTE It is expressed as a percentage by multiplying by 100.

3.50
extrapolated long-term relative ultimate ring deflection
$y_{u,\text{ wet, }x}/d_m$
deflection value at x years (see 4.6) derived from the ultimate deflection regression line obtained from long-term deflection tests performed under wet conditions in accordance with ISO 10471 and analysed in accordance with ISO 10928

NOTE It is expressed as a percentage by multiplying by 100.

3.51
minimum long-term relative ultimate ring deflection
$(y_{u,\text{ wet, }x}/d_m)_{min}$
required minimum extrapolated value at x years (see 4.6) derived from the ultimate deflection regression line obtained from long-term deflection tests performed under wet conditions in accordance with ISO 10471

NOTE It is expressed as a percentage by multiplying by 100.

3.52
extrapolated long-term relative ring deflection in a corrosive environment
$y_{\text{corr, }x}/d_m$
deflection value at x years (see 4.6) derived from the deflection regression line obtained from long-term deflection tests performed in a corrosive environment in accordance with ISO 10952

NOTE It is expressed as a percentage by multiplying by 100.

3.53
relative ring deflection for a test lasting t hours
$y_{\text{test, }t}/d_m$
relative ring deflection required for test pieces to resist for t h in a test performed in accordance with ISO 10952 in a corrosive environment

NOTE It is expressed as a percentage by multiplying by 100.

3.54
deflection constant
K_t
value used for the calculation of the percentage ring deflection required for test pieces to resist for t h in a test performed in accordance with ISO 10952 in a corrosive environment

NOTE It is expressed as a percentage by multiplying by 100.

3.55
ultimate deflection regression ratio
$R_{R, dv}$
ratio of the extrapolated long-term relative ultimate ring deflection at x years (see 4.6), $y_{u, wet, x}/d_m$ (see 3.50), to the projected initial ultimate ring deflection, y_2/d_m (see 3.47), obtained from long-term ultimate ring deflection tests performed in accordance with ISO 10471 [see Equation (17)] and analysed in accordance with ISO 10928

$$R_{R, dv} = \frac{y_{u, wet, x} / d_m}{y_2 / d_m} \quad (17)$$

3.56
angular deflection
δ
angle between the axes of two consecutive pipes (see Figure 1), expressed in degrees (°)

3.57
draw
D
longitudinal movement of a joint (see Figure 1), expressed in millimetres (mm)

3.58
total draw
T
sum of the draw, D, and the additional longitudinal movement, J, of joint components due to the presence of angular deflection (see Figure 1), expressed in millimetres (mm)

3.59
misalignment
M
amount by which the centrelines of consecutive components fail to coincide (see Figure 1), expressed in millimetres (mm)

3.60
flexible joint
joint which allows relative movement between the components being joined

NOTE Flexible joints which have resistance to axial loading are classified as end-load-bearing.

Examples of this type of joint are:

a) socket-and-spigot joints with an elastomeric sealing element (including double-socket designs);

b) locked socket-and-spigot joints with an elastomeric sealing element (including double-socket designs);

c) mechanically clamped joints, e.g. bolted couplings including components made of materials other than GRP.

3.61
rigid joint
joint which does not allow relative movement between the components being joined