TECHNICAL REPORT

Plastics piping kits for the underground transport under pressure of water not intended for human consumption, made of glass reinforced filament wound epoxy (GRE)

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Testing procedures for:

A. Determination of the dimensions of the pipe, fitting or joint
B. Determination of the constancy of the composition of the pipe wall
C. Determination of the nominal pressure, the qualified pressure, the qualified stress and the nominal pressure rating of the pipe, pipe plus joint and fitting
D. Determination of the resistance to impact of the pipe

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Foreword

EOTA Technical Reports are developed as supporting reference documents to European Technical Approval Guidelines and can also be applicable to a Common Understanding of Assessment Procedures, an EOTA Comprehension Document or an European Technical Approval, as far as reference is made therein.

EOTA Technical Reports go into detail in some aspects and express the common understanding of existing knowledge and experience of the EOTA bodies at a particular point in time.

Where knowledge and experience is developing, especially through approval work, such reports can be amended and supplemented.
When this happens, the effect of the changes upon the European Technical Approval Guidelines will be laid down in the relevant comprehension documents, unless the European Technical Approval Guideline is revised.

This EOTA Technical Report has been prepared by the approved body Kiwa to define testing and assessment procedures for glass reinforced filament wound epoxy (GRE) pipes, fittings. This in support of the CUAP 07.04/07:2006 "Plastics piping kits for the underground transport under pressure of water not intended for human consumption, made of glass reinforced filament wound epoxy (GRE)".
The test and assessment procedures have been "updated" to the latest "level" (date of the issue of this TR 043).
The main update is reflected in ANNEX C of this TR 043.
In this ANNEX C the latest update of assessment/testing procedures as given in the latest EN standards (developed by CEN/TC155/WG14) has been taken into account.
Furthermore for the reference to the assessment procedures, which refers to the characteristics as given in EN ISO 14692, the on-going work for the revision of this particular standard has been taken into account.
This, to accommodate end-users such as oil/chemical industry companies when drafting their tender documents for e.g. cooling water/fire waterlines to refer directly to the ETA drafted on basis of the CUAP 07.04/07: 2006 and this TR 043.

A. Determination of the dimensions of the pipe, fitting and joint

A.1 General

The determination of the dimensions of the pipe, fitting and joints shall be carried out in accordance with EN ISO 3126.
However due to the nature of the product it is necessary to define additional test procedures.

A.2 Determination of the total wall thickness of the pipe

A.2.1 Test piece

The test piece shall be a pipe with a length of DN in mm with a maximum of 500 mm.

A.2.1 Procedure

A.2.2.1 Mean total wall thickness along the circumference

Measure the wall thickness on 6 places regularly divided along the to be tested cross section.
Calculate from these measurements the mean total wall thickness along the circumference ($e_{c,tot}$).

A.2.2.2 Mean total wall thickness along the generating line

Measure the wall thickness on 10 places regularly divided over an ad random chosen generating line.
Calculate from these measurements the mean total wall thickness along the generating line ($e_{gl,tot}$).

A.2.2.3 Calculation of the total wall thickness of the pipe

The total wall thickness (e_{tot}) is calculated using the formula A.1:

$$e_{tot} = 0{,}5 \times [\, e_{c,tot} + e_{gl,tot} \,] \qquad (A.1)$$

A.3 Determination of the winding angle

A.3.1 Test piece

For the determination of the winding angle (ω) a minimum length of pipe is needed with one thread of winding.

A.3.2 Procedure

Measure in the middle of the test piece the circumference of the pipe in mm;
Measure the thread of one winding in mm;
Calculate the winding angle (ω) using the formula A.2:

$$\tan \omega = a / b \qquad (A.2)$$

whereby:

a is the measured circumference in mm;
b is the thread of one winding in mm.

A.4 Normative references

EN ISO 3126: 2005	Plastics piping components – Measurement and determination of dimensions

B. Determination of the constancy of the composition of the pipe wall

B.1 Principle

The constancy of the composition of the pipe wall is assessed by the determination of the glass and resin content of two samples taken from the pipe wall diametrically opposed to each other. The constancy of the composition is then expressed as a percentage difference between the glass and resin content per surface area.

B.2 Test pieces

Take from the pipe two samples, diametrically opposed to each other.
Each sample with a surface area of 40 mm x 40 mm.
Remove from the samples the top coat and the liner.

B.3 Procedure

Follow the procedure as described in clause 5 of EN 637.
Determine per test piece per surface area A the glass and resin content.
Express for the glass and the resin the values obtained in mass per surface area.

B.4 Expression of results

Compare for the glass and the resin the values from the two samples and express the difference in a percentage.

B.5 Normative references

EN 637: 1994/AC: 1995	Plastics piping systems – Glass-reinforced plastics components – Determination of the amount of constituents using the gravimetric method

C. Determination of the nominal pressure, the qualified pressure, the qualified stress and the nominal pressure rating of the pipe, pipe plus joint and fitting

C.1 General

The assessment procedures for the characteristics related to pressure as detailed in this Technical Report are **not only** based on the approach taken in EN 1796, but also on the approach taken in the EN ISO 14692 series.
This type of piping system – glass-reinforced filament wound epoxy – is also used for the applications as given in the EN ISO 14692 series. Therefore in order to accommodate the end-user for these piping systems the additional characteristics are covered in this Technical Report.
In the EN ISO 14692 for the assessment procedures reference is made to ASTM testing standards. While this EOTA Technical Report is to be used in the European context for CE marking the test procedures are amended for referring to EN and ISO test methods.
The amendments to these procedures are detailed in the respective clauses.

NOTE 1: *There is **no** relation between the "nominal pressure (PN)" (as defined in EN 1796) and a "System Design Procedure" as defined in EN ISO 14692-3.*

NOTE 2: *There is a relation between the ""qualified pressure ($q_{p,T,x}$)" (as defined in EN ISO 14962-2) and a "System Design Procedure" as defined in EN ISO 14692-3.*

NOTE 3: *This Technical Report does not aim to define a relation between the "nominal pressure (PN)" (as defined in EN 1796) and the "qualified pressure ($q_{p,T,x}$)" (as defined in EN ISO 14962-2).*

C.2 Definitions

For the purpose of this Technical Report the following definitions (taken from respectively EN 1796 and EN ISO 14692) apply.

C.2.1 Definitions according EN 1796

C.2.1.1 Nominal pressure (PN):

A numerical designation of a component (pipe, fitting or joint) of a piping system related to the mechanical characteristics of that component used for reference purposes.

For glass reinforced epoxy piping systems the nominal pressure (PN) is calculated from the mean long-term hydrostatic pressure (LTHP) in bars at 23 ºC for a 50 years service life and a factor F and rounded to the next lower value of the R 10 series in the preferred numbers given in ISO 497 (with the addition of 6).

The nominal pressure (PN) is expressed in:

- PN_R when the mean long-term hydrostatic pressure (LHTP) is obtained by testing under static biaxial loading (with end-thrust)
- PN_U when the mean long-term hydrostatic pressure (LHTP) is obtained by testing under static uniaxial loading (without end-thrust)

C.2.1.2 The mean long-term hydrostatic pressure at a temperature T in °C and a service life x in years ($LTHP_{T,x}$):

The mean long-term hydrostatic pressure ($LTHP_{T,x}$) at *T* in °C and a service life *x* in years, expressed in megapascals (MPa), is the extrapolated mean long term failure pressure at a temperature T in °C and a service life of x in years.
The extrapolated value is obtained from long-term failure pressure data from pressure testing according EN 1447 under respectively static biaxial loading (with end-thrust) or static uniaxial loading (without end-thrust) and the extrapolation procedure as detailed in ISO 10928 Method A (covariance method).

C.2.1.3 Factor (F):

The factor F to be applied for the determination of the nominal pressure (PN) shall be declared by the manufacturer and shall take into account a combined loading (pressure and bending).

NOTE: *The definition of factor F differs from the statements made in table 15 of EN 1796.*

C.2.2 Definitions according EN ISO 14692 series

C.2.2.1 Qualified pressure at a temperature T in °C and a service life x in years ($p_{q,T,x}$):

The qualified pressure ($p_{q\,T,\,x}$) at a temperature *T* in °C and a service life *x* in years, expressed in megapascals (MPa), is as defined in clause 2.2.105 of EN ISO 14692-1, with following amendments:

- Procedure ASTM D2992 replaced by EN 1447 and ISO 10928 Method A. The extrapolated value is obtained from long-term failure data from pressure testing according EN 1447 under static biaxial loading (free ends) and the extrapolation procedure as described in ISO 10928 Method A (covariance method).
- Subscripts added to the qualified pressure ($p_{q,T,x}$):
  - Index (T) to indicate temperature (65 °C or design temperature if higher).
  - Index (x) to indicate service life (20yr or design life if longer).

C.2.2.2 Qualified stress at a temperature T in °C and a service life x in years ($\sigma_{qs,\,T,\,x}$):

The qualified stress ($\sigma_{qs,\,T,\,x}$) at a temperature *T* in °C and a service life *x* in years, expressed in megapascals (MPa), is as defined in clause 2.2.105 of EN ISO 14692-1, with following amendments:

- The qualified pressure (p_q) is replaced by the qualified pressure ($p_{q\,T,\,x}$) according C.1.2.1.
- Subscripts added to the qualified stress ($\sigma_{qs,\,T,\,x}$):
  - Index (T) to indicate temperature (65 °C or design temperature if higher).
  - Index (x) to indicate service life (20yr or design life if longer).

C.2.2.3 Gradient (G)

C.2.2.3.1 Measured gradient at temperature T (G_T)

The gradient (G_T), at a temperature *T* in °C is the gradient of the extrapolated mean long term failure at temperature T, as described in the clauses 6.2.3.1, 6.2.3.2.1 and 6.2.3.3.1 of EN ISO 14692-2, with following amendments:

- The procedure ASTM D 2992 is replaced by EN 1447 and ISO 10928 Method A. The extrapolated value is obtained from long-term failure pressure data from pressure testing according EN 1447 under static biaxial loading (free ends) and the extrapolation procedure as detailed in "Method A" of ISO 10928 (covariance method).
- Subscripts added to gradient (G_T):
  Index (T) to indicate temperature (65 °C or design temperature if higher).

C.2.2.3.2 Default gradient ($G_{default}$)

The default gradient ($G_{default}$), in megapascals per hour (MPa/h), is the gradient as defined in clause 6.2.3.2.1 and following the conditions as tabled in Table 2 of EN ISO 14692-2.
Whereby:

- The default gradient ($G_{default}$) shall only be used for design temperatures up to 65 ºC.

NOTE: *The term "gradient G" is not defined in EN ISO 14692-1 clause 2 "Terms and definitions". Therefore no reference can be made to EN ISO 14692-1.*

C.2.2.4 Product family:

The product family is as defined in EN ISO 14692-1 clause 2.2.100.

C.2.2.5 Product family representative:

The product family representative is as defined in EN ISO 14692-1 clause 2.2.101.

C.2.2.6 Product sector:

The product sector is as defined in EN ISO 14692-1 clause 2.2.102.

C.2.2.7 Product sector representative:

The product sector representative is as defined in EN ISO 14692-1 clause 2.2.103.

C.2.2.8 Component variant:

The component variant is as defined in EN ISO 14692-1 clause 2.2.9.

C.2.2.9 Joint

The joint is as defined in EN ISO 14692-1 clause 2.2.63.

C.2.2.10 Fitting

The fitting is as described in EN ISO 14692-2 clause 6.2.39.
NOTE: *fittings can be produced by various production processes, e.g. filament winding on a mold or filament winding on pipe segments that are fitted in the shape of a fitting*

C.2.2.11 Fabrication process

The fabrication process is as described in clause 3.1 of EN ISO 14692-4.

C.2.2.12 Survival test:

The survival test is as described in clause 6.2.3.2.2 of EN ISO 14692-2, with the following amendment:

- The procedure ASTM D 1598 is replaced by the procedure according EN 1447.

C.3 Principle

C.3.1 Nominal pressure (PN)

- A sufficient number of cut lengths of a representative pipe sample are pressure tested at a temperature of 23 ºC to obtain at least 18 points
  - Under static biaxial loading (with end-thrust); failure
  - Under static uniaxial loading (without end-thrust).

  The obtained failure points shall be distributed between 0,1h and 10 000 h, whereby at least one failure point shall exceed 10 000 h.

- From these failure points, using standard extrapolation procedures, the mean long-term hydrostatic pressure at a temperature of 23 ºC and 50 years ($LTHP_{23,50}$) under respectively static biaxial loading (with end-thrust) or under uniaxial loading (without end-trust) shall be determined.

- From the mean long-term hydrostatic pressure at a temperature of 23 ºC and 50 years ($LTHP_{23,50}$) and the factor (F) the nominal pressure (PN) shall be calculated, rounded to the next lower value of the R 10 series of the preferred numbers given in ISO 497 (with the addition of the value 6 bar).

The nominal pressure is expressed as:

- PN_R ,when the mean long-term hydrostatic pressure (LHTP) is obtained by testing under static biaxial loading (with end-thrust);
- PN_U ,when the mean long-term hydrostatic pressure (LHTP) is obtained by testing under static uniaxial loading (without end-thrust).

C.3.2 Qualified pressure ($p_{q,T,x}$)

- For the determination of the qualified pressure ($p_{q,T,x}$) the test methodology according clause 6.2.2 of EN 14692-2 shall be followed, taking into account the following modifications/amendments.
  - The definitions for the “Plain Pipe Product Sector Representative” and the “Component Variant” is added;
  - The value of the minimum Gradient is for all Product Families set at the value 0,03. This is irrespective of the value of the measured gradient.

- To determine the qualified pressure ($p_{q,T,x}$), all components shall be divided into the following two groups.
  - Product Family;
  - Product Sector.

- A **Product Family** is a group of components that have the same function and are produced by a comparable production process (e.g. plain pipe, pipe plus joint, elbows, tees, reducers and flanges from distinctive product families).

- A **Product Sector** is a subdivision of Product Family, limited by the diameter (DN) and the qualified pressure ($p_{q,T,x}$).

- Within these two Groups the following components are defined.
  - Product Family Representative;
  - Product Sector Representative;
  - Component Variant.

  Whereby,
  a. A **Product Family Representative** is a component that is taken to be representative for a given Product Family.
  The regression gradient of the Product Family Representative is used to define the test pressure for a Survival Test on a Product Sector Representative.
  b. A **Product Sector Representative** is a component that is taken to be representative of a given Product Sector.
  c. A **Component Variant** is an individual component, forming part of a Product Sector.

- A sufficient number of a Product Family Representative" are pressure tested under static biaxial loading (free ends) at a temperature of 65 ºC or higher to obtain at least 18 failure points per temperature.
  These failure points shall be distributed between 0,1h and 10 000 h, whereby at least one failure point shall exceed 10 000 h.

- From these failure points, using standard extrapolation procedures, the following parameters are determined.
  - The 97,5 % lower confidence limit ($LCL_{T,,x}$) at a temperature *T* in °C and a service life *x* in years;
  - The gradient (G_T) at a temperature *T* in °C.

NOTE: *The minimum value of the gradient (G) for all Product Families Representatives is set at 0,03, irrespective of the measured gradient.*

- The qualified pressure ($p_{q,T,x}$), at a temperature *T* in °C and a service life *x* in years, of the **Product Family Representative** is set equal to the 97,5 % lower confidence limit ($LCL_{T,x}$) at the temperature *T* and the service life *x*.

NOTE: *The qualified pressure to be declared shall be less than or equal to the 97,5 % lower confidence limit ($LCL_{T,x}$) at the temperature T and the service life x.*

- The qualified pressure ($p_{q,T,x}$), at a temperature *T* in °C and a service life *x* in years, of the **Product Sector Representative** is verified by a 1000 h survival test at the temperature *T,* which is 65 ° C or higher.
  The test pressure is calculated from the following parameters.
  - The qualified pressure ($p_{q,T,x}$) of the Product Sector Representative;
  - The service life *x* of the Product Sector Representative;

- The gradient (G_T) of the Product Family Representative.

NOTE: *A default gradient ($G_{default}$) according table 2 of EN ISO 14692-2 may be used for given Product Sector Representatives.*

- The qualified pressure ($p_{q,T,x}$), at a temperature *T* in °C and a service life *x* in years, of the **Component Variant** is verified by either one of the following methods.
  - The 1 000 h survival test as described for the Product Sector Representative;
  - Or, by scaling from the Product Sector Representative in accordance with the procedure as detailed in clause 6.2.3.2.2 of EN ISO 14692-2.

C.4 Apparatus

Apparatus according EN 1447 with the following specifications:

- End sealing device:
  - Type 1 for testing with end-thrust (biaxial loading)
  - Type 2 for testing without end-thrust (uniaxial loading)
- Testing in air environment;
- Oven or container, with a forced air circulation, capable of keeping the required temperature at ± 2 ° C;
- Time and pressure tolerance. When added together, the tolerance for the timing device and the tolerance for the pressure gauge shall not exceed ± 2 %.

C.5 Procedure for the determination of the mean long-term hydrostatic pressure at a temperature T and a service life x ($LTHP_{T,x}$), the nominal pressure (PN), the qualified pressure and the qualified stress at a temperature T and the service life x ($p_{q,T,x}$ and $\sigma_{qs,T,x}$) of a family pipe representative

C.5.1 Pressure testing

- Select a representative pipe for the performance of the long term pressure test;
- Select the temperature for testing that include at least the temperature of 23 ° C;
- The long-term failure pressure shall be determined in accordance with EN 1447, using end sealing device Type 1 (biaxial loading) or Type 2 (uniaxial loading);
- Prepare a sufficient number of test pieces, so that at least 18 failure points are obtained to carry out the analysis according ISO 10928 Method A (covariance method);
- The length L in mm of the test pieces between the end sealing devices shall conform to table C.1 or according to the formula (C.1).

$$L = (2 \times e_{reinf} \times DN)^{0,5} \qquad (C.1)$$

Whereby, e_{reinf} is the thickness of the reinforced wall in mm.

The value for L shall be whichever is the smallest.

Table C.1 – Length of test piece between end sealing devices.

Nominal size DN	Minimum length L [a] mm
≤ 250	3 x [DN] + 250
> 250	[DN] + 1000
[a] It is permissible to use lengths less than those shown providing the end restraints do not have any effect on the result	

- The times to failure of the 18 or more test pieces shall be between 0,1 h and over 10^4 h and the distribution of these results shall be conform to the limits given in table C.2.

Table C.2 – Failure time distribution

Failure time - t_u h	Minimum number of failure values
$10 \leq t_u \leq 1000$	4
$1000 < t_u \leq 6000$	3
$6000 < t_u$	3 [a]
[a] At least one of these shall exceed 10000 h.	

NOTE 1: *When test pieces have not failed after more than 10000 h they may include as failures following the procedure as detailed in clause 9.3.2 of ASTM D2992-12*

NOTE 2: *When failure points occur below 10 h they may include as failures following the procedure as detailed clause 9.3.3 of ASTM D2992-12.*

NOTE 3: *It is allowed to test a pipe at other defined temperatures in access of 23 ºC and up to 95 ºC, since the gradient and the long term hydrostatic pressure or qualified pressure is likely to be more conservative than at 23 ºC.*

C.5.2 Calculation of the mean long-term hydrostatic pressure at a temperature T and a service life x ($LTHP_{T,x}$) and the nominal pressure (PN)

- Calculate from the minimum of 18 determined failure points from the pressure testing of the representative pipe sample at a temperature T in ºC and the service life x the mean long-term hydrostatic pressure ($LTHP_{T,x}$) in megapascals (MPa), using the extrapolation procedure as detailed in "Method A" of ISO 10928 (covariance method).

- Calculate from the mean long-term hydrostatic pressure at 50 years and a temperature of 23 ºC ($LTHP_{23,50}$) in bars and the factor F the nominal pressure PN_R (biaxial loading) or PN_U (uniaxial loading) expressed in bars using the formula (C.2).

  PN_R or PN_U (expressed in bars) = $LTHP_{23,50}$ / F (C.2)

  Whereby the value for F is set at 2,0.

  NOTE: *The value 2,0 for F is conservative in regard to the values for F as given in table 15 of EN 1796.*

- The calculated value of PN_R or PN_U shall be rounded to the next lower value of the R 10 series of the preferred numbers given in ISO 497, with the addition of the value 6.

C.5.3 Procedure for the determination of the qualified pressure at a temperature T and the service life x ($p_{q, T, x}$), the qualified stress at a temperature T and the service life x ($\sigma_{qs, T, x}$) and the gradient at a temperature T (G_T) of a plain pipe Product Family Representative.

- Select the applicable plain pipe Product Family Representative as described in clause 6.2.1.3 of EN ISO 14692-2.
- Select the temperature for testing (65 °C or design temperature if higher) and the service life (20 years or design service life if more).
- Determine the qualified pressure and the qualified stress at a temperature T and the service life x ($p_{q, T, x}$ and $\sigma_{qs, T, x}$) and the gradient at temperature T (G_T), all as defined in the clauses 6.2.1.2 and 6.2.3.1 of EN ISO 14692-2, with following amendments:
  - The procedure according ASTM D2992 and annex K of EN ISO 14692-2 is replaced by EN 1447 and ISO 10928 “Method A”. The extrapolated value is obtained from long-term failure pressure data from pressure testing according EN 1447 under static biaxial loading (free ends) and the extrapolation procedure as detailed in “Method A” of ISO 10928 (covariance method).
  - Failure time distribution shall be as defined in table C.2.
  - Subscripts added to the qualified pressure (p_q) and qualified stress (σ_{qs}):
    - Index (T) to indicate temperature (65 °C or design temperature if higher).
    - Index (x) to indicate service life (20 yr or design service life if more).
  - Subscript added to the gradient (G):
    Index (T) to indicate temperature (65 °C or design temperature if higher).

NOTE 1: *When test pieces have not failed after more than 10000 h they may include as failures following the procedure as detailed in clause 9.3.2 of ASTM D2992-12.*

NOTE 2: *When failure points occur below 10 h they may include as failures following the procedure as detailed in clause 9.3.3 of ASTM D2992-12.*

NOTE 3: *It is allowed to test a component at temperatures in access of the design temperature, since the gradient and the qualified pressure is likely to be more conservative for higher temperatures.*

NOTE 4: *It is allowed to determine the gradient and the qualified pressure at design temperature (G_T and $\sigma_{qs,\,T,\,x}$) by interpolation, since the gradient change is likely to increase with increasing temperatures.*

NOTE 5: *It is permissible to test a pipe that includes a joint, as described in clause 6.2.3.1 of EN ISO 14692-2.*

NOTE 6: *The minimum gradient for all Product Families is set at 0.03, irrespective of the measured gradient.*

C.5.4 Procedure for the determination of the qualified pressure and the qualified stress at a temperature T and the service life x ($p_{q,\,T,\,x}$ and $\sigma_{qs,\,T,\,x}$) of a plain pipe Product Sector Representative.

As an amendment on clause 6.2.2 of EN ISO 14692-2:

- Select the applicable plain pipe Product Sector Representative as described in clause 6.2.1.3 of EN ISO 14692-2 with following amendment:
  - The Product Sector Representative can be of any pressure and diameter combination. The limitations of the represented Product Sector in terms of pressure and diameter are as described in C.5.12.
- Select the temperature for testing (65 °C or design temperature if higher) and the service life (20 yrs or design service life if higher).
- Verify the qualified pressure at a temperature T and the service life x ($p_{q,\,T,\,x}$), in megapascals (MPa), of the plain pipe Product Sector Representative as described in C.5.5, using the gradient (G_T) as determined in C.5.3.
- Determine the qualified stress at a temperature T and the service life x ($\sigma_{qs,\,T,\,x}$) as described in clause 6.2.3.1 equation (7) of EN ISO 14692-2.

NOTE: *It is permissible to test a pipe that includes a joint, as described in clause 6.2.3.1 of EN ISO 14692-2.*

C.5.5 Procedure for the determination of the qualified pressure and the qualified stress at a temperature T and the service life x ($p_{q,\,T,\,x}$ and $\sigma_{qs,\,T,\,x}$) of a plain pipe Component Variant

As an amendment on clause 6.2.2 of EN ISO 14692-2:

- Determine the qualified pressure at a temperature T and the service life x ($p_{q,\,T,\,x}$), in megapascals (MPa), of a plain pipe Component Variant by either of following methods:
  - A 1000 hr survival test as described for Product Sector Representative in C.5.4.
  - Scaling from the applicable Product Sector Representative, as described in clause 6.2.3.2.3 of EN ISO 14692-2.
- Determine the qualified stress at temperature T and service life x ($\sigma_{qs,\,T,\,x}$) of a plain pipe Component Variant by either of following methods:
  - Following the procedure as described in clause 6.2.3.1 “equation 7” of EN ISO 14692-2 (in case that the qualified pressure of the plain pipe Component Variant is verified by 1000 hr test).

- The qualified stress ($\sigma_{qs, T, x}$) of the plain pipe Component Variant is set equal to the qualified stress ($\sigma_{qs, T, x}$) of the applicable plain pipe Product Representative (in case the qualified pressure of the plain pipe Component Variant is determined by scaling)

C.5.6 Procedure for the determination of the gradient at temperature T (G_T) of a pipe plus joint Product Family Representative.

- Select the applicable pipe plus joint Product Family Representative as described in clause 6.2.3.2.1 of EN ISO 14692-2.
- Select the temperature for testing (65 °C or design temperature if higher).
- Determine the gradient of the pipe plus joint at temperature T (G_T) as defined in clause 6.2.3.2.1 of EN ISO 14692-2, with the amendments described in C.5.3.

C.5.7 Procedure for the determination of the qualified pressure at a temperature T and the service life x ($p_{q, T, x}$) of a pipe plus joint Product Sector Representative

- Select the applicable pipe plus joint Product Sector Representative as defined in clause 6.2.3.2.2 of EN ISO 14692-2, with following amendment:
  - The Product Sector Representative can be of any pressure and diameter combination. The limitations of the represented Product Sector in terms of pressure and diameter are as described in C.5.12.
- Select the temperature for testing (65 °C or design temperature if higher) and the service life (20 years or design service life if more).
- Verify the qualified pressure at a temperature T and the service life x ($p_{q, T, x}$), in megapascals (MPa), of the pipe plus joint Product Sector Representative as described in the clauses 6.2.3.2.2 and 6.2.7 of EN ISO 14692-2, using the gradient (G_T or $G_{default}$) as determined in clause C.5.6, with following amendment:
  - The procedure in ASTM D1598 is replaced by EN 1447 (free ends).

C.5.8 Procedure for the determination of the qualified pressure at a temperature T and the service life x ($p_{q, T, x}$) of a pipe plus joint Component Variant

- Determine the qualified pressure at a temperature T and the service life x ($p_{q, T, x}$), in megapascals (MPa), of a pipe plus joint Component Variant by either of following methods:
  - A 1000 hr survival test as described for Product Sector Representative in C.5.7.
  - Scaling from the applicable Product Sector Representative, as described in clause 6.2.3.2.3 of EN ISO 14692-2.

C.5.9 Procedure for the determination of the gradient at temperature T (G_T) of a Product Family Representative of a fitting or fabrication method.

- Select the applicable Product Family Representative of the fitting or fabrication method, as described in clause 6.2.3.3.1 of EN ISO 14692-2.
- Select the temperature for testing (65 °C or design temperature if higher).
- Determine the gradient of the pipe plus joint at temperature T (G_T) as defined in clause 6.2.3.3.1 of EN ISO 14692-2, with the amendments described in C.5.3.

C.5.10 Procedure for the determination of the qualified pressure at a temperature T and the service life x (pq, T, x) of a Product Sector Representative of a fitting or fabrication method.

- Select the applicable Product Sector Representative of the fitting or fabrication method, as defined in clause 6.2.3.3.2 of EN ISO 14692-2, with the following amendment:
  - The Product Sector Representative can be of any pressure and diameter combination. The limitations of the represented Product Sector in terms of pressure and diameter are as described in C.5.12.
- Select the temperature for testing (65 °C or design temperature if higher) and the service life (20 yrs or design service life if more).
- Verify the qualified pressure at a temperature T and the service life x ($p_{q, T, x}$), in megapascals (MPa), of the Product Sector Representative of the fitting or fabrication method, as described in the clauses 6.2.3.3.2 and 6.2.7 of EN ISO 14692-2, using the gradient (G_T or $G_{default}$) as determined in clause C.5.9, with following amendment:
  - The procedure in ASTM D1598 is replaced by EN 1447 (free ends).

C.5.11 Procedure for the determination of the qualified pressure at a temperature T and the service life x (pq, T, x) of a Component Variant of a fitting or fabrication method.

- Determine the qualified pressure at a temperature T and the service life x ($p_{q, T, x}$), in megapascals (MPa), of a Component Variant of a fitting or fabrication method, by either of following methods:
  - A 1000 hr survival test as described for Product Sector Representative in C.5.10.
  - Scaling from the applicable Product Sector Representative, as described in clause 6.2.3.3.3 of EN ISO 14692-2.

C.5.12 Grouping of the product sector pipe plus joint

All individual components (Components Variants) within a given Product Sector may be considered as represented by the Product Sector Representative of that product Sector.

- $\mathbf{DN_1}$ and $\mathbf{p_{q,1}}$ refer to the size and pressure rating (p_q) of the Product Sector Representative that has been tested.
- $\mathbf{DN_2}$ and $\mathbf{p_{q,2}}$ refer to the limits of the Product Sector that is represented by $\mathbf{DN_1}$ and $\mathbf{p_{q,1}}$ of the tested Product Sector Representative.

In table C.4 the equations (C.4) to (C.8) are summarized.
Refer to Figure C.1 and Figure C.2 for examples.

DN:

- When $DN_1 \leq 300$

$$0 \leq DN2 \leq 1{,}6 \times DN_1 \qquad \text{(C.4)}$$

- When $DN_1 > 300$

$$0{,}5 \times DN_1 \leq DN_2 \leq 1{,}6 \times DN_1 \qquad \text{(C.5)}$$

p_q:

- When $p_{q,1} \leq$ 100 bar

$0 \leq p_{q,2} \leq 1{,}6 \times p_{q,1}$ (C.6)

- When $p_{q,1} >$ 100 bar

$0{,}5 \times p_{q,1} \leq p_{q,2} \leq 1{,}6 \times p_{q,1}$ (C.7)

DN x p_q:

$DN_2 \times p_{q,2} \leq DN_1 \times p_{q,1}$ (C.8)

Table C.4 – Qualification ranges

Product that has been tested	**Products that are considered represented by DN_1 and $p_{q,1}$**
$DN_1 > 300$ $p_{q,1} > 100$ bar	$0{,}5 \times DN_1 \leq DN_2 \leq 1{,}6 \times DN_1$ and $0{,}5 \times p_{q,1} \leq p_{q,2} \leq 1{,}6 \times p_{q,1}$ and $DN_2 \times p_{q,2} \leq DN_1 \times p_{q,1}$
$DN_1 \leq 300$	Same as above except no limit on minimum DN
$p_{q,1} \leq 100$ bar	Same as above except no limit on minimum p_q

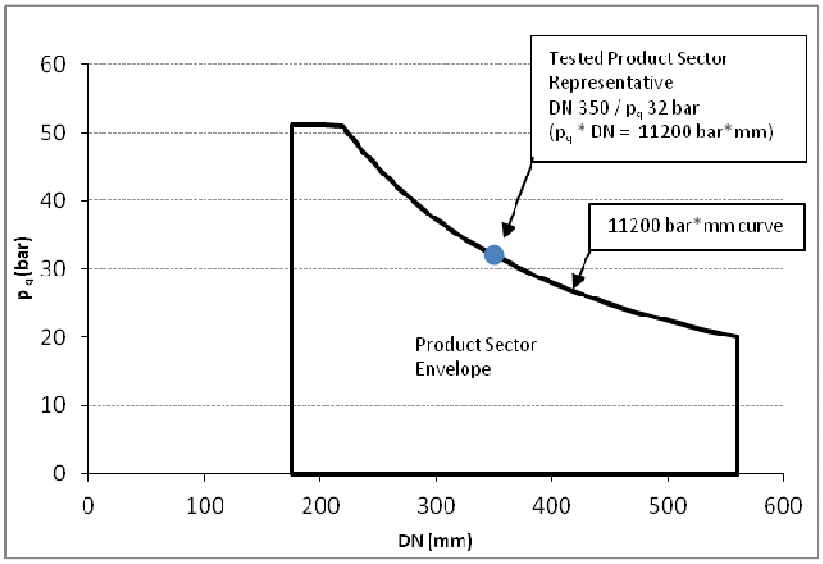

Figure C.1 – Example where DN_1 = 350 mm and $p_{q,1}$ = 32 bar

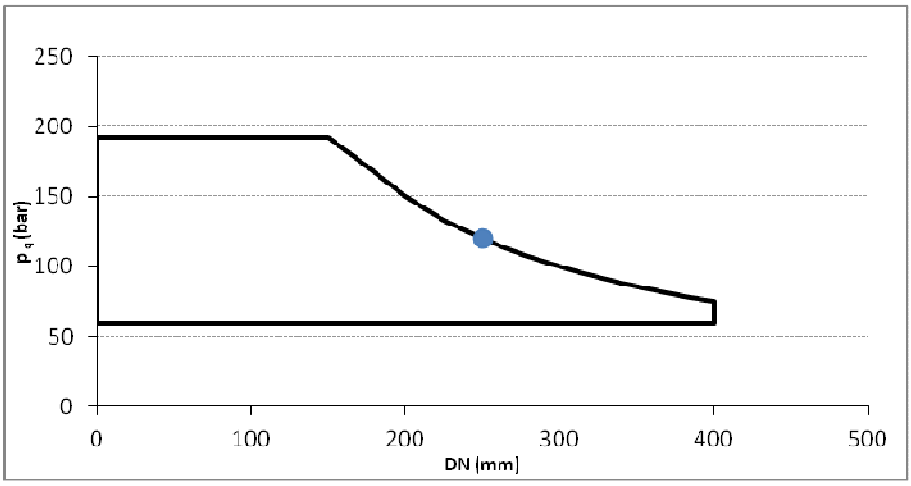

Figure C.2 – Example where DN_1 = 250 mm and $p_{q,1}$ = 120 bar

NOTE: *For the purpose of this EOTA Technical Report the grouping on "representative products" is based on the "Floating Product Sector" approach as has been developed for the revision of ISO 14692-2.*
This "Floating Product Sector" approach gives more flexibility in the testing of specific sizes and pressure classes, while maintaining the rigour of a robust qualification program.
This "Floating Product Sector" approach is far more stringent than the rules given in CEN/TS 14362 e.g. for a "pipe test group ", which leaves all options open!

It is also allowed the use the default gradient, $G_{default}$, as detailed in table 2 of EN ISO 14692-2.

C.6 Normative references

EN 1447: 2009 + A.1: 2010	Plastics piping systems – Glass-reinforced thermosetting plastics(GRP) pipes and fittings – Determination of the long-term resistance to internal pressure
EN 1796: 2012	Plastics piping systems for water supply with or without pressure – Glass-reinforced thermosetting plastics (GRP)) based on unsaturated polyester resin (UP) – Specifications for pipes, fittings and joints
CEN/TS 14632: 2012	Plastics piping systems for drainage, sewerage and water supply, pressure and non-pressure – Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP) – Guidance for the assessment of conformity

EN ISO 14692-1: 2003	Petroleum and natural gas industries – Glass-reinforced plastics (GRP) piping – Part 1: Vocabulary, symbols, applications and materials
EN ISO 14692-2: 2003	Petroleum and natural gas industries – Glass-reinforced plastics (GRP) piping – Part 2: Qualification and manufacture
EN ISO 14692-3: 2003	Petroleum and natural gas industries – Glass-reinforced plastics (GRP) piping – Part 3: System Design
EN ISO 14692-4: 2003	Petroleum and natural gas industries – Glass-reinforced plastics (GRP) piping – Part 4: Fabrication, installation and operation
ISO 497: 1973	Guide to the choice of preferred numbers and of series containing more rounded values of preferred numbers
ISO 10928: 2009	Plastics piping systems – Glass-reinforced thermosetting plastics (GRP) pipes and fittings – Methods for regression analysis and their use
ASTM D 1598-02: 2009	Standard Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure
ASTM D 2992-12: 2012	Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for " Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings

D. Determination of the resistance to impact of the pipe

D.1 Principle

A length of pipe is filled with water and 4 times subjected to a blow from a falling striker at places equally divided over one pitch, with a specified load and from a specified height.
After the impact the pipe is subjected to a biaxial loaded internal pressure of 1,5 times PN_R.
The pipe under pressure is then again 4 times subjected to a blow from a falling striker at places equally divided over one thread, with the same specified load and height.
The pressure of 1,5 times PN_R is then kept for 168 h.
After this time the test piece is examined for defects.

D.2 Test piece

The test piece shall be a length of pipe with a free length (see clause 6.1 of EN 1447), comprising with the length of one pitch plus two times the length of the failure zone as defined in clause 9.1 of EN 1447.
The minimum length of the test piece shall be 1,5 meters.

D.3 Apparatus

D.3.1 Falling Weight Testing Machine

The "Falling Weight Testing Machine" shall be in principle in accordance with clause 4.1 of ISO 3127 with the following specifications/amendments.

- Striker.

The striker shall be type **d25.** The mass of the striker shall be **500 g.**

- Rigid test support.

The rigid test support shall be a flat rigid sheet.

D.3.2 Apparatus for internal pressure test

The apparatus shall be in accordance with clause 5 of EN 1447 with the following specifications.

- End sealing device.

The end sealing device shall be Type 1, according Figure 1 of EN 1447.

- Container for water.

A container is not required. The test is performed in air.

D.4 Conditioning and test temperature

The temperature for conditioning and test shall be (23 ± 2) °C. The time of conditioning shall be at least 24 h.

D.5 Procedure

- Attach the end-sealing devices to the test piece and fill the assembly with water.
- Attach the test piece to the pressurising system, avoiding entrapment of air.
- Adjust the test piece in the falling weight testing machine on the rigid test support.
- Perform 4 times an impact test on the test piece at places equally divided over on pitch from a height according table D.1.
- Raise the test pressure inside the test piece to 1,5 times PN_R.
- Perform again an impact as described above, but at 4 different places.
- Maintain the water pressure inside the test piece for a period of 168 h.
- Control during this period of time the test piece on defects as defined in clause 9 of EN 1447.
- After this period of time let the pressure down and disconnect the test piece from the end-sealing device and control visually the test piece in and outside for defects.

Table D.1 – Falling height

Nominal size DN	Falling height in mm
≤ 750	500
> 750	1000

D.6 Expression of results

NOTE – if present – the failure mode at the pressure testing and results of the visual examination of the test piece after the testing.

D.7 Normative references

EN 1447: 2009 + A.1: 2010	Plastics piping systems – Glass-reinforced thermosetting plastics(GRP) pipes and fittings – Determination of the long-term resistance to internal pressure
ISO 3127 : 1994	Thermoplastics pipes – Determination of resistance to external blows – Round the clock method