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Plastics piping systems- — Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Methods for regression analysis and their use

Systèmes de ~~canalisation~~canalisations en matières plastiques- — Tubes et raccords plastiques thermodurcissables renforcés de verre (PRV) — Méthodes pour une analyse de régression et leurs utilisations

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Contents

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document 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.*

This fourth edition cancels and replaces the third edition (ISO 10928:2016), which has been technically revised.

The main ~~change is~~changes are as follows:

— ~~Informative~~ Annex B, “Non-linear relationships~~” in the third edition”~~, has been removed~~,~~ due to its complexity and highly ~~specialised~~specialized and limited application~~.[1]~~;

— ~~Formula B.3 (C.3 in the third edition)~~

— Formula (B.3) [Formula (C.3) in ISO 10928:2016] has been corrected to include a factor 2 before Bx_L.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

~~[1] It is planned to publish the Annex B “Non-linear relationships” in a separate document.~~

Introduction

This document describes the procedures intended for analysing the regression of test data, usually with respect to time, and the use of the results in the design and assessment of conformity with performance requirements. Its applicability is limited to use with data obtained from tests carried out on samples. Referring standards require estimates to be made of the long-term properties of the pipe for such parameters as circumferential tensile strength, long-term ring deflection, strain corrosion and creep or relaxation stiffness.

A range of statistical techniques that ~~could~~can be used to analyse the test data produced by destructive tests ~~was~~were investigated in the preparation of this document. Many of these simple techniques require the logarithms of the data to:

a) ~~a)~~ be normally distributed~~,~~;

b) ~~b)~~ produce a regression line having a negative slope~~,~~; and

c) ~~c)~~ have a sufficiently high regression correlation (see ~~Table 1).~~Table 1).

~~While~~Analysis of data from several tests showed that in the ~~last two~~destructive test context, while conditions ~~(~~b~~,~~) and c) can be satisfied, ~~analysis of several destructive test data shows that~~ there is often a skew to the distribution and hence ~~this primary~~ condition ~~(~~a) is not satisfied. ~~Therefore, further~~Further investigation into techniques that can handle skewed distributions resulted in the adoption of the covariance method (~~Method~~method A, see ~~5.2) of~~5.2) for the analysis of such data ~~for~~within this document.

~~However, the~~The results from non-destructive tests, such as long-term creep or relaxation stiffness, often satisfy all three conditions. Therefore, a simpler procedure, using time as the independent variable (~~Method~~method B, see ~~5.3),~~5.3), can also be used in accordance with this document.

These two analysis procedures (~~Method~~method A~~, Method~~ and method B) are limited to analysis methods specified in ISO product standards or test methods. ~~However, other~~Other analysis procedures can be useful for the extrapolation and prediction of long-term behaviour of some properties of glass-reinforced thermosetting plastics (GRP) piping products. For example, a second-order polynomial analysis is sometimes useful in the extrapolation of creep and relaxation data. This is particularly the case for analysing shorter term data, where the shape of the creep or relaxation curve can deviate considerably from linear. A second-order polynomial analysis is included in ~~Annex A.~~Annex A.

Plastics piping systems - — Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Methods for regression analysis and their use

1 Scope

This document specifies procedures suitable for the analysis of data which, when converted into logarithms of the values, have either a normal or a skewed distribution. It is intended for use with ~~the~~ test methods and referring standards for glass-reinforced thermosetting plastics (GRP) pipes or fittings for the analysis of properties as a function of time. However, it can also be used for the analysis of other data.

~~Depending upon~~Two methods are specified, which are used depending on the nature of the data~~, two methods are specified~~. Extrapolation using these techniques typically extends a trend from data gathered over a period of approximately 10 000 h to a prediction of the property at 50 years, which is the typical maximum extrapolation time.

This document only addresses the analysis of data. The test procedures for collecting the data, the number of samples required and the time period over which data are collected are covered by the referring standards and/or test methods. ~~Clause 6~~Clause 6 discusses how the data analysis methods are applied to product testing and design.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ~~—~~ISO Online browsing platform: available at ~~https://www.iso.org/obp~~https://www.iso.org/obp

— ~~—~~IEC Electropedia: available at ~~https://www.electropedia.org/~~https://www.electropedia.org/

4 Principle

Data are analysed for regression using methods based on least squares analysis which can accommodate the incidence of a skew ~~and/~~or a normal distribution or both. The two methods of analysis used are the following:

— ~~—~~method A: covariance using a first-order relationship;

— ~~—~~method B: least squares, with time as the independent variable using a first-order relationship.

The methods include statistical tests for the correlation of the data and the suitability for extrapolation.

5 Procedures for determining the linear relationships — Methods A and B

5.1 Procedures common to methods A and B

Use method A (see ~~5.2)~~5.2) or method B (see ~~5.3)~~5.3) to fit a straight line of the form given in ~~Formula (1):~~Formula (1):

~~$y = a + b \times x$~~ $y = a + b \times x$ (1)

where

y is the logarithm, lg, of the property being investigated;

a is the intercept on the y-axis;

b is the slope;

x is the logarithm, lg, of the time, in hours.

5.2 Method A — Covariance method

5.2.1 General

For method A, calculate the following variables in accordance with ~~5.2.2 to 5.2.5, using Formulae (2), (3) and (4):~~5.2.2 to 5.2.5, using Formulae (2), (3) and (4):

~~$Q_y = \frac{\sum (y_i - Y)^2}{n}$~~ (2)

~~$Q_x = \frac{\sum (x_i - X)^2}{n}$~~ $Q_y = \frac{\sum (y_i - Y)^2}{n}$ (2)

$Q_x = \frac{\sum (x_i - X)^2}{n}$ (3)

~~$Q_{xy} = \frac{\sum [(x_i - X) \times (y_i - Y)]}{n}$~~ (4)

$Q_{xy} = \frac{\sum [(x_i - X) \times (y_i - Y)]}{n}$ (4)

where

Q_y is the sum of the squared residuals parallel to the y-axis, divided by n;

Q_x is the sum of the squared residuals parallel to the x-axis, divided by n;

Q_{xy} is the sum of the squared residuals perpendicular to the line, divided by n;

Y is the arithmetic mean of the y data, i.e. given as ~~Formula (5):~~Formula (5):

~~$Y = \frac{\sum y_i}{n}$~~ (5)

$Y = \frac{\sum y_i}{n}$ (5)

X is the arithmetic mean of the x data, i.e. given as ~~Formula (6):~~Formula (6):

~~$X = \frac{\sum x_i}{n}$~~ (6)

$$X = \frac{\Sigma x_i}{n} \quad (6)$$

x_i, y_i are individual values;

n is the total number of results (pairs of readings for x_i, y_i).

NOTE If the value of Q_{xy} is greater than zero, the slope of the line is positive and if the value of Q_{xy} is less than zero, then the slope is negative.

5.2.2 Suitability of data

Calculate the linear coefficient of correlation, r, using ~~Formulae (7) and (8):~~Formulae (7) and (8):

~~$r^2 = \frac{Q_{xy}^2}{Q_x \times Q_y}$~~ $r^2 = \frac{Q_{xy}^2}{Q_x \times Q_y}$ (7)

~~$r = \left| \left(r^2 \right)^{0,5} \right|$~~ $r = |(r^2)^{0,5}|$ (8)

~~Table 1~~Table 1 gives the minimum acceptable values of the correlation coefficient, r, as a function of the number of variables, n, and Student´s t-distribution ~~t,~~t_ν, where ~~t,~~t_ν is based on a two-sided 0,01 level of significance.

Table 1 — Minimum values of the correlation coefficient, r, for acceptable data from n pairs of data

Number of variables n	Degrees of freedom $n-2$	Student's t-distribution ~~t,~~t_ν (0,01)	Minimum r	Number of variables n	Degrees of freedom $n-2$	Student's t-distribution ~~t,~~t_ν (0,01)	Minimum r
13	11	3,106	0,683 5	26	24	2,797	0,495 8
14	12	3,055	0,661 4	27	25	2,787	0,486 9
15	13	3,012	0,641 1	32	30	2,750	0,448 7
16	14	2,977	0,622 6	37	35	2,724	0,418 2
17	15	2,947	0,605 5	42	40	2,704	0,393 2
18	16	2,921	0,589 7	47	45	2,690	0,372 1
19	17	2,898	0,575 1	52	50	2,678	0,354 2
20	18	2,878	0,561 4	62	60	2,660	0,324 8
21	19	2,861	0,548 7	72	70	2,648	0,301 7
22	20	2,845	0,536 8	82	80	2,639	0,283 0
23	21	2,831	0,525 6	92	90	2,632	0,267 3
24	22	2,819	0,515 1	102	100	2,626	0,254 0
25	23	2,807	0,505 2				