2023-10-25

ISO/FDIS 10928:2023(E)

ISO-<u>/</u>TC-<u>138/SC-<del>06/WG 01</del> <u>6</u></u>

Secretariat:-\_ASI

Date: 2023-12-11

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

Systèmes de <u>canalisationcanalisations</u> en matières plastiques—— Tubes et raccords plastiques thermodurcissables renforcés de verre (PRV) — Méthodes pour une analyse de régression et leurs utilisations

(https://standards.iteh.ai)
Document Preview

SO/FDIS 10928

ttps://standards.iteh.ai/catalog/standards/sist/29a14c6a-2abd-40a6-b526-4ec60b415630/iso-fdis-1092

## FDIS stage

### © ISO 2023

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office CP 401 • Ch. de Blandonnet 8 CH-1214 Vernier, Geneva Phone: +41 22 749 01 11

Email E-mail: copyright@iso.org
Website: www.iso.org

Published in Switzerland

### iTeh Standards (https://standards.iteh.ai) Document Preview

ISO/FDIS 10928

https://standards.iteh.ai/catalog/standards/sist/29a14c6a-2abd-40a6-b526-4ec60b415630/iso-fdis-10928

### **Contents**

<u>Forev</u>	vord	vi
Introd	duction	<u></u> vii
1	Scope	1
2	Normative references	1
3	Terms and definitions	1
4	Principle	1
5	Procedures for determining the linear relationships — Methods A and B	1
5.1	Procedures common to methods A and B	1
5.2	Method A — Covariance method	2
5.2.1	General	2
5.2.2	Suitability of data	<u></u> 3
5.2.3	Functional relationships	
5.2.4	Calculation of variances	<u></u> 4
5.2.5	Check for the suitability of data for extrapolation	<u></u> 5
5.2.6	Validation of statistical procedures by an example calculation	<u></u> 6
5.3	Method B — Regression with time as the independent variable	<u></u> 10
5.3.1	General	10
5.3.2	Suitability of data	<u></u> 11
5.3.3	Functional relationships	
5.3.4	Check for the suitability of data for extrapolation	12
5.3.5	Validation of statistical procedures by an example calculation	12
tps://	Application of methods to product design and testing	lis-1092 13
6.1	General	
6.2	Product design	14
6.3	Comparison to a specified value	14
6.4	Declaration of a long-term value	14
Annex	x A (informative) Second-order polynomial relationships	<u></u> 15
A.1	General	<u></u> 15
A.2	Variables	<u></u> 15
A.3	Solution system	<u></u> 16
A.4	Suitability of data	<u></u> 16
A.5	Check for the suitability of data for extrapolation	<u></u> 17
A.6	Validation of statistical procedures by an example calculation	17
Annex	x B (normative) Calculation of lower confidence and prediction limits for method A	21
B.1	General	
B.2	Calculation of quantities and variances	21
B.3	Calculation of confidence intervals	22

B.4 Validation of procedures by a sample calculation
Bibliography25
Foreword iv
Introduction v
1 Scope 6
2 Normative references 6
3 Terms and definitions 6
4——Principle——6
5 Procedures for determining the linear relationships — Methods A and B 7
5.1 Procedures common to methods A and B 7
5.2 Method A — Covariance method 7
<del>5.2.1 General 7</del>
5.2.2 Suitability of data 8
5.2.3 Functional relationships 8
5.2.4 Calculation of variances 9
5.2.5 Check for the suitability of data for extrapolation 9
5.2.6 Validation of statistical procedures by an example calculation 11
5.3 Method B — Regression with time as the independent variable 14
5.3.1 General 14 Document Preview
5.3.2 Suitability of data 15
5.3.3 Functional relationships 15 ISO/FDIS 10928
5.3.4 Check for the suitability of data for extrapolation 2ab 15 a6-b526-4ec60b415630/iso-fdis-10928
5.3.5 Validation of statistical procedures by an example calculation 16
6——Application of methods to product design and testing 17
6.1 General 17
6.2 Product design 17
6.3 Comparison to a specified value 18
6.4 Declaration of a long-term value 18
Annex A (informative) Second-order polynomial relationships 19
A.1 General 19
A.2 Variables 19
A.3—Solution system 20
A.4 Suitability of data 20
A.5 Check for the suitability of data for extrapolation 21
A.6—Validation of statistical procedures by an example calculation 21
Annex B (normative) Calculation of lower confidence and prediction limits for method A 24
B.1 General 24

B.2	Calculation of quantities and variances 24	
B.3	Calculation of confidence intervals 25	
B.4	Validation of procedures by a sample calculation	25
Bibliog	<del>graphy 27</del>	

### iTeh Standards (https://standards.iteh.ai) Document Preview

**ISO/FDIS 10928** 

https://standards.iteh.ai/catalog/standards/sist/29a14c6a-2abd-40a6-b526-4ec60b415630/iso-fdis-10928

© ISO-2023-\_- All rights reserved——————

#### **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.

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 <a href="https://www.iso.org/directives">www.iso.org/directives</a>).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <a href="www.iso.org/patents.www.iso.org/patents.">www.iso.org/patents.www.iso.org/patents.</a> ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see <a href="https://www.iso.org/iso/foreword.html">www.iso.org/iso/foreword.html</a>.

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 <del>change is</del><u>changes are</u> 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. <sup>1</sup> :

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<sub>1</sub>.

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 <a href="https://www.iso.org/members.html">www.iso.org/members.html</a>.

© ISO-2023-- All rights reserved

<sup>\*</sup>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 <u>the</u> 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 <u>couldcan</u> be used to analyse the test data produced by destructive tests <u>waswere</u> 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) produce a regression line having a negative slope, and
- c) have a sufficiently high regression correlation (see Table 1). Table 1).

WhileAnalysis of data from several tests showed that in the last two destructive test context, while conditions (b<sub>7</sub>) 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 (Methodmethod 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 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.

© ISO-\_2023-\_- All rights reserved———

### iTeh Standards (https://standards.iteh.ai) Document Preview

ISO/FDIS 10928

https://standards.iteh.ai/catalog/standards/sist/29a14c6a-2abd-40a6-b526-4ec60b415630/iso-fdis-10928

## 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 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:

- IEC Electropedia: available at <a href="https://www.electropedia.org/">https://www.electropedia.org/</a>

### 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  $\frac{5.2}{5.2}$ ) or method B (see  $\frac{5.3}{5.3}$ ) to fit a straight line of the form given in Formula (1):

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

where

- is the logarithm, lg, of the property being investigated; y
- is the intercept on the y-axis; а
- b is the slope;
- is the logarithm, lg, of the time, in hours. Χ

### 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):

$$Q_{y} = \frac{\sum (y_{i} - Y)^{2}}{n}$$

$$\frac{Q_{x} = \frac{\sum (x_{i} - X)^{2}}{n}}{n} Q_{y} = \frac{\sum (y_{i} - Y)^{2}}{n} \frac{\text{Teh Standards}}{n}$$

$$Q_{x} = \frac{\sum (x_{i} - X)^{2}}{n} \text{ (https://standards.iteh.ai)}$$

$$\frac{Q_{xy} = \frac{\sum (x_{i} - X)^{2}}{n}}{n} \text{ (3)}$$

$$Q_x = \frac{\sum (x_i - X)^2}{n}$$
 (https://standards.iteh.al)

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

https://standards.iteh.ai/catalog/standards/sist/29a14c6a-2abd-40a6-b526-4ec60b415630/iso-fdis-10928
$$Q_{xy} = \frac{\sum [(x_i - X) \times (y_i - Y)]}{n}$$
(4)

where

- $Q_{\rm v}$ is the sum of the squared residuals parallel to the y-axis, divided by *n*;
- $Q_{\rm x}$ is the sum of the squared residuals parallel to the x-axis, divided by *n*;
- is the sum of the squared residuals perpendicular to the line, divided by *n*;  $Q_{xy}$
- is the arithmetic mean of the y data, i.e. given as Formula (5):

$$Y = \frac{\sum y_i}{n} \tag{5}$$

$$Y = \frac{\sum y_i}{n} \tag{5}$$

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

$$\underline{X} = \frac{\sum x_i}{n} \tag{6}$$

-© ISO-\_2023-\_- All rights reserved

$$X = \frac{\sum x_i}{n} \tag{6}$$

 $x_i, y_i$  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):

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

$$r = \left| \binom{r^2}{0.5} \right|_{r = \left| (r^2)^{0.5} \right|}$$
 (8)

<u>Table 1 Table 1</u> gives the minimum acceptable values of the correlation coefficient, r, as a function of the number of variables, n, and Student's t-distribution  $t_{v_1}t_{v_2}$  where  $t_{v_1}t_{v_2}$  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 of data

Number of variables	Degrees of freedom	Student's	Minimum -	nt	Number of variables	Degrees of freedom	Student's t	Minimu m
n	n – 2	- distribut	r ICO/EI	) I C	n	n – 2	- distributi	-
nttps://standar	ds.iteh.ai/cat	ion <u>t,t</u> (0,01)	<u>ISO/FI</u> rds/sist/29a	)15 (4c)	10928 5a-2abd-40a6	5-b526-4ec6(	on <u>t₁tν</u> (0,01)	r )-fdis-1092
13	11	3,106	0,683 5	_	26	24	2,797	0,4958
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	0,3248
21	19	2,861	0,548 7	-	72	70	2,648	0,3017
22	20	2,845	0,5368	_	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	_	-	-	-	-