INTERNATIONAL STANDARD ISO 2605/I

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Steel products for pressure purposes — Derivation and verification of elevated temperature properties — Part I : Yield or proof stress of carbon and low alloy steel products

Produits en acier pour récipients à pression — Dérivation et vérification des valeurs à température élevée — Partie I : Limite d'élasticité ou limite conventionnelle d'élasticité des produits en acier au carbone ou faiblement allié

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up 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.

Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 2605/I was drawn up by Technical Committee ISO/TC 17, *Steel*, and was circulated to the Member Bodies in February 1975.

It has been approved by the Member Bodies of the following countries :

Austria	Iran	Spain
Bulgaria	Ireland	Sweden
Czechoslovakia	Mexico	Switzerland
Denmark	Netherlands	Turkey
Finland	Norway	United Kingdom
Germany	Poland	U.S.S.R.
Hungary	Romania	Yugoslavia
India	South Africa, Rep. of	

The Member Bodies of the following countries expressed disapproval of the document on technical grounds :

Australia	Canada	Japan
Belgium	France	U.S.A.

Printed in Switzerland

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0 INTRODUCTION

In the ISO rules for the construction of stationary boilers (ISO/R 831) and the draft rules for the construction of unfired pressure vessels, minimum lower yield or proof stress at elevated temperature is listed as one of the design criteria. Accordingly, International Standards for pressure vessel steels or national standards conforming to the above rules should specify lower yield or proof stress properties at elevated temperature.

NOTE — Where this International Standard subsequently makes reference to proof stress, it should be understood that lower yield stress also applies where appropriate.

International Standards for pressure vessels steels will normally give specified elevated temperature proof stress values which are derived statistically from a body of data. In all such cases the manufacturer may satisfy the customer that the product supplied consistently meets the properties by either

a) hot-testing the product, or

b) producing a body of data on the product.

This International Standard has been prepared in order to implement the alternative procedure using a body of data. It also defines the method by which the minimum elevated temperature yield or proof stress values to be included in International Standards for pressure vessel steels should be derived.

NOTES

1 Whilst the validity of the derivation procedure has been examined in relation to data for a variety of steels, future experience may indicate that modifications are desirable, particularly in relation to the minimum quantity and distribution of data required by the derivation and verification procedures.

2 All tests used to implement this procedure either at room temperature or at elevated temperature shall be carried out in conformity with the appropriate ISO documents (for example ISO 82, ISO 375, at room temperature, and ISO/R 783 at elevated temperatures). However, data previously obtained using other test methods may be used for an interim period.

REFERENCES IN INTRODUCTION

ISO 82, *Steel — Tensile testing.*

ISO 375, *Tensile testing of tubes.*

ISO/R 783, *Mechanical testing of steel at elevated temperatures — Determination of lower yield stress and proof stress and proving test.*

ISO/R 831, *Rules for construction of stationary boilers.*

1 SCOPE AND FIELD OF APPLICATION

This International Standard defines

— a method for deriving minimum elevated temperature lower yield or proof stress values for inclusion in International Standards for steel products for pressure purposes;[1)]

— a verification procedure which may be used by a manufacturer as an alternative to hot-testing for satisfying the purchaser that his product consistently meets the specified minimum elevated temperature proof stress values in such specifications.

2 PROCEDURE FOR DERIVING MINIMUM PROPERTIES

2.1 Basis of method

2.1.1 The elevated temperature proof stress properties are derived from a well-defined body of data on the basis of a linear regression analysis of the elevated temperature proof stress values against the room temperature tensile strengths at each of a number of temperatures.

2.1.2 For the purpose of this International Standard, the specified minimum proof stress value (E_t) at a given temperature is defined as the proof stress derived from the lower 95 % confidence level at a level at a tensile strength 30 N/mm² above the specified minimum tensile strength.

1) Application to national standards

If a country adopts in its national standard an ISO steel together with the properties specified in International Standards for this steel (or properties derived in accordance with this International Standard from the agreed regression lines), then it is not necessary for the country to separately apply the derivation procedure. If a country specifies non-ISO steels for use in compliance with ISO boiler and pressure vessel design codes, the procedures as given in ISO . . ., *Steel products for pressure purposes — Derivation and verification of elevated temperature properties — Part . . . Derivation of yield at proof stress from limited data,* (in preparation) shall apply.

2.2 Basic requirements

2.2.1 The method shall be applied separately for each product form, thickness range, section size range or heat-treatment condition for which elevated temperature proof stress properties are to be specified in the relevant International Standard, *unless it can be shown that the data being considered belong to the same population.*

2.2.2 The data utilized shall be obtained using test samples which

a) are representative of the thickness or section size range and heat treatment to which the specified properties apply;

b) provide room temperature tensile strength values fairly uniformly distributed over not less than 80 % of the specified tensile strength range(s).

2.2.3 In each case, the test pieces for the room temperature tensile strength and the elevated temperature proof stress determinations shall be taken as close to each other as possible.

2.3 Quantity of data required for derivation of minimum values for International Standards

Test points from at least 50 casts are required at each temperature at which the properties are to be specified (normally at 50 °C intervals). Preferably, five or more countries should contribute to this body of data. It is important to ensure that the test programme as a whole produces data that are representative of the major metallurgical variables allowed for in the specification for the steel concerned.

2.4 Analysis of data

2.4.1 At each temperature, the data shall be plotted in the form of a proof stress/room temperature tensile strength graph as shown in figure 1.

2.4.2 If examination of the data reveals two or more populations, each population shall be treated separately. The quantity of data in each population shall comply with the requirements of 2.3.

NOTE — If two or more populations are treated together, this may result in an abnormally wide scatter band.

2.4.3 The mean regression line, together with the lower 95 % confidence limit, shall then be obtained by standard statistical procedures.

2.5 Derivation of minimum proof stress

2.5.1 At each temperature, 95 % lower confidence level proof stress values shall be read off at five or more discrete tensile strength levels from the graphs prepared in accordance with 2.4. These values shall cover the specified tensile range or ranges for the steel(s) under consideration.

2.5.2 The values so obtained shall then be plotted as a function of temperature and a family of curves for different tensile strength levels constructed. If the values obtained in accordance with 2.5.1 do not produce smooth curves, then conservative curves shall be drawn through the majority of the points at each tensile strength level (see figure 2).

2.5.3 A further tensile strength/proof stress graph shall then be constructed plotting the 95 % lower confidence limit value at each of a number of temperatures, the values being read off the proof stress/temperature curves prepared in accordance with 2.5.2.

A smooth family of 95 % lower confidence limit curves shall be constructed through these points (see figure 3), and the specification minima as defined in 2.1.2 read from these curves.

2.5.4 If, exceptionally, two or more populations have been treated, two or more curves will be obtained for each tensile strength level by the method given in 2.5.2. The specified minima shall be read from the lines derived from the lowest of the curves, providing they do not cross. If the curves cross, as illustrated in figure 2b), the specification minima shall be read from the lowest of the curves at each temperature.

3 VERIFICATION PROCEDURE

3.1 Basis of verification procedure

3.1.1 The basis of the procedure is that data relating to a particular manufacturer's product are compared, at a number of temperatures, with the 95 % confidence limit used to derive the specification minima.

NOTE — Where this International Standard makes reference to a "manufacturer", it should be understood that this may refer to two or more suppliers, provided that

a) they have a common relationship, i.e. are part of the same commercial organization or technical association, and

b) each supplier has contributed to the pool of data.

3.2 Basic requirements

3.2.1 The procedure shall be applied separately for each product form, thickness range, section size range, or heat-treatment condition for which elevated temperature proof stress properties have been derived in accordance with this procedure and are specified in the relevant International Standard and for which verification is sought.

3.2.2 The data utilized shall be obtained using test samples which

a) are representative of the thickness or section size range and heat treatment to which the specified properties apply;

b) provide room temperature tensile strength values reasonably uniformly distributed over not less then 60 % of the specified tensile strength range(s).

3.2.3 In each case, the test pieces for the room temperature tensile strength and the elevated temperature proof stress determination shall be taken as close to each other as possible.

3.3 Quantity of data required

3.3.1 For a given specification, grade, product form and given heat-treatment condition, data shall be obtained by each individual manufacturer from a minimum of 15 casts selected at random (subject to 3.2.2 above).

3.3.2 To obtain verification over the whole temperature range, data in accordance with 3.3.1 shall be obtained in accordance with the following conditions :

a) Carbon steels : at each of at least three temperatures for which ISO scatter bands are available. The minimum temperature shall be 100 °C or 150 °C, the highest temperature not less than 350 °C and the maximum temperature interval more than 100 °C.

b) Low alloy steels : at each of at least three temperatures for which ISO scatter bands are available. The minimum temperature shall be 150 °C or 200 °C, the highest temperature not less than 450 °C and the maximum temperature interval not more than 150 °C.

3.3.3 To obtain verification at a single temperature, data at the temperature for which verification is required shall be obtained in accordance with 3.3.1.

3.3.4 The temperatures selected shall be those for which values are specified in the relevant International Standard (i.e. multiples of 50 °C).

3.4 Presentation of data

For each temperature, the manufacturer's data shall be presented in the form of a graph in which the elevated temperature yield or proof stress values are plotted as a function of room temperature tensile strength and on which the lower 95 % confidence limit from which the specification value was derived is also plotted (see 2.5 and figure 4).

3.5 Verification requirement

3.5.1 Provided that not more than one, or 2,5 %, of the test results, whichever is the greater number, obtained from the minimum of 15 casts tested at a specific temperature falls below the appropriate 95 % confidence limit for that temperature then the data presented shall be regarded as establishing that the manufacturer's product meets the specified minimum value at that temperature.

3.5.2 Provided that this condition is met at the temperatures stipulated in 3.3.2, then the complete data presented shall be regarded as establishing that the manufacturer's product meets the specified values over the whole temperature range to which the specification applies.

3.6 Applicability of the verification procedure

If the tensile strength used for deriving the minimum elevated temperature proof stress values in the International Standard in accordance with clause 2 is that specified in 2.1.2 (i.e. the minimum specified tensile strength plus 30 N/mm²), then the manufacturer may supply his product without making elevated temperature proof stress tests provided that he has met the requirements of this verification procedure.

3.7 Check testing after verification

3.7.1 When quality control check tests are carried out subsequent to verification, such additional data which become available as a result of these tests shall be added to the records. In any event, where production permits, the results of at least two casts shall be added to the records every 2 years.

3.7.2 In cases where a lapse in production of more than 2 years has occurred since verification, the manufacturer shall hot-test the first two casts on re-start of production at temperatures in accordance with the requirements of 3.3.2 or 3.3.3. Provided that none of the results obtained falls below the appropriate 95 % confidence limit, then the manufacturer may continue to supply his products without making hot-tests.

3.8 Delivery conditions

The manufacturer may supply his product as satisfying the minimum elevated temperature proof stress value or values of a particular specification provided that he certifies that

a) he has carried out all the necessary tests as required by this International Standard and has proved that his product satisfies the verification procedure

1) over the whole temperature range, or

2) at a single temperature, which shall be stated;

b) the manufacturing process and heat treatment employed have not been changed compared with those used when providing the data for the verification procedure.

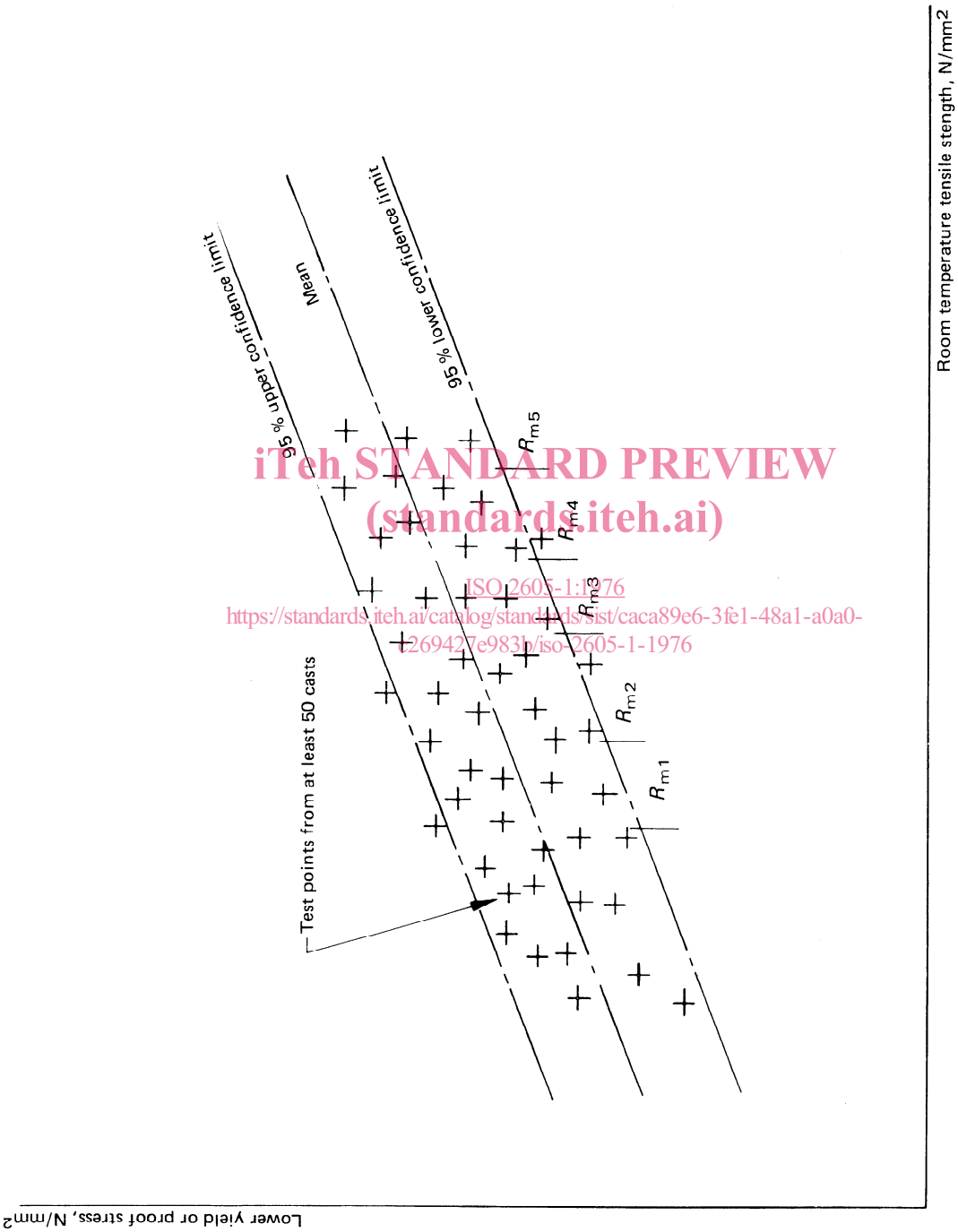

FIGURE 1 – Typical regression plot for derivation of minimum proof stress at t °C

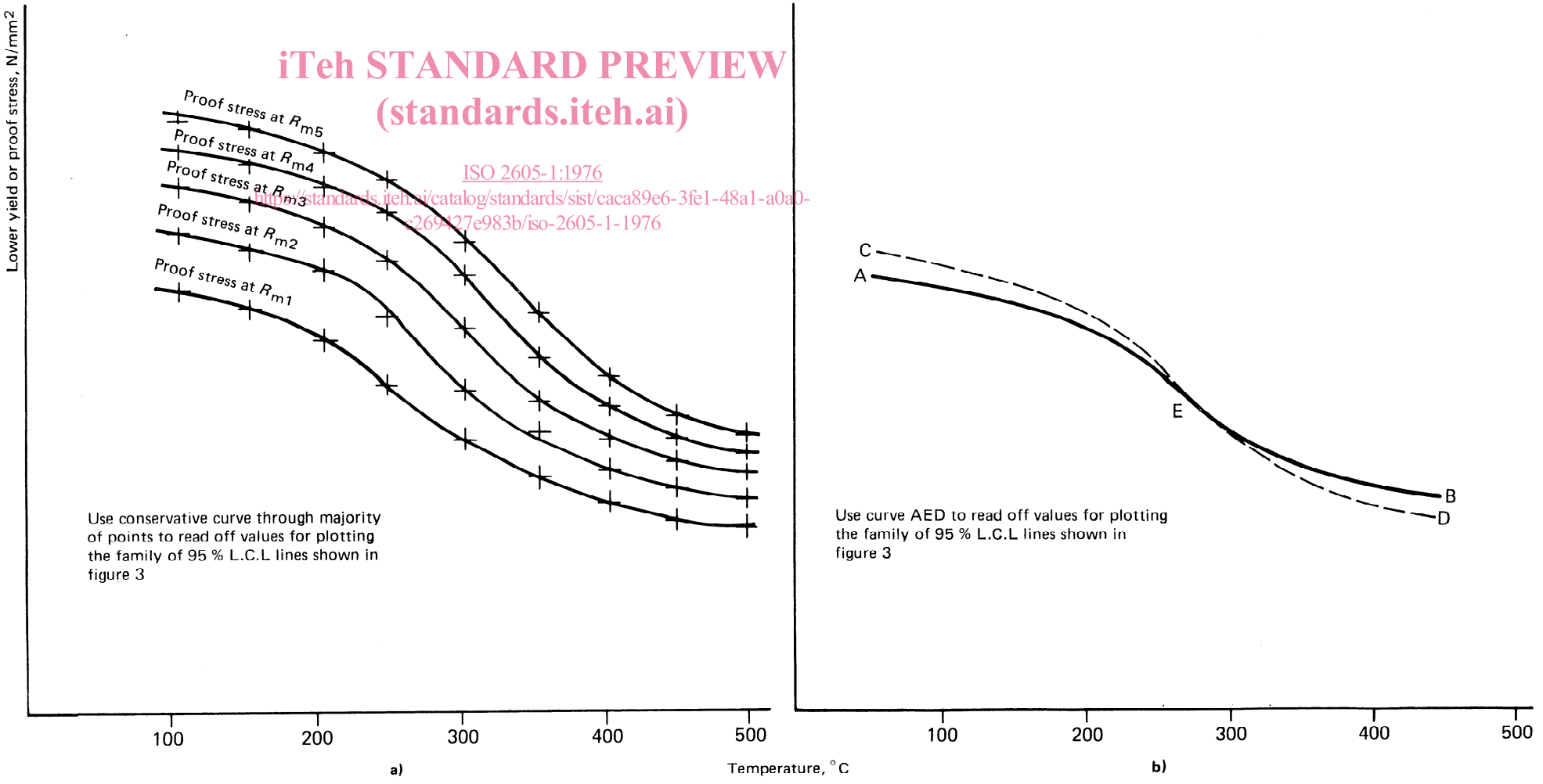

FIGURE 2 – **Proof stress/temperature plots** (see 2.5.2 and 2.5.4)

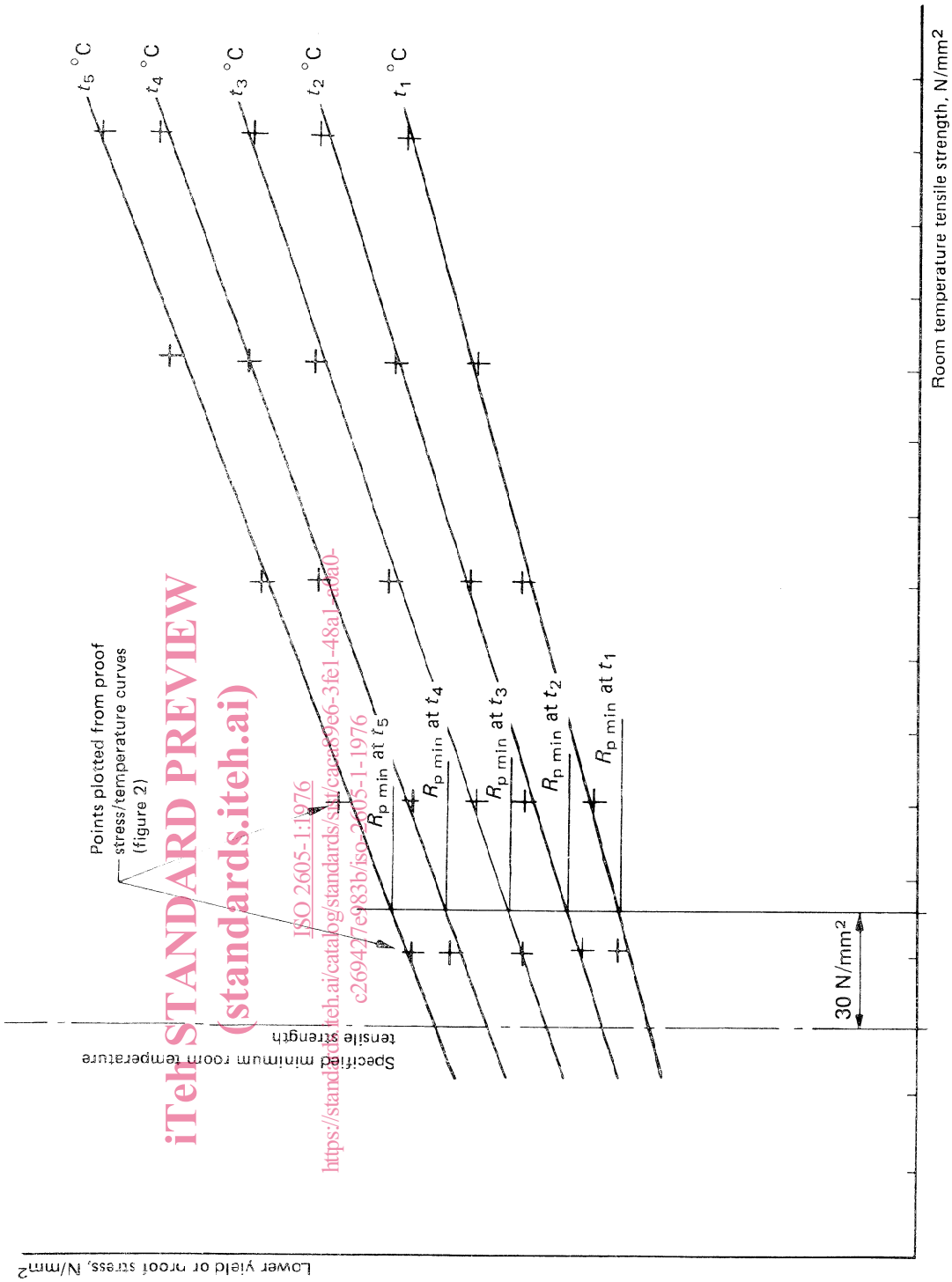

FIGURE 3 – Final family of 95 % lower confidance limit lines, from which the specification minima are read and which are used for verification in accordance with clause 3

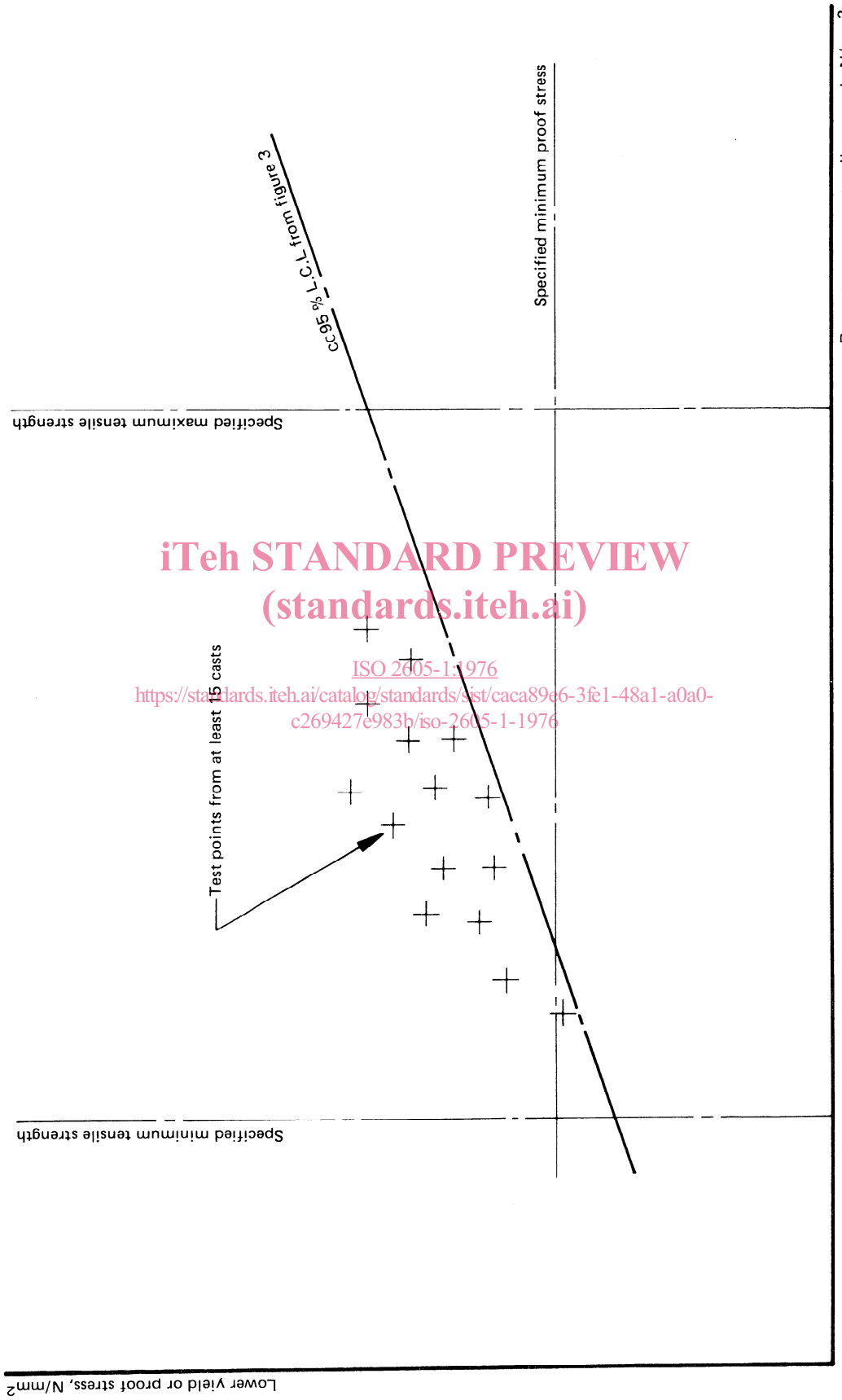

FIGURE 4 — Plot used for verification of a manufacturer's product