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Plastics — Determination of Izod impact strength

Plastiques — Détermination de la résistance au choc Izod



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Contents

Page

| | |
|--|----|
| Foreword..... | iv |
| 1 Scope | 1 |
| 2 Normative references | 2 |
| 3 Terms and definitions | 2 |
| 4 Principle..... | 3 |
| 5 Apparatus | 3 |
| 6 Test specimens | 3 |
| 7 Procedure | 7 |
| 8 Calculation and expression of results..... | 7 |
| 9 Precision..... | 8 |
| 10 Test report | 8 |

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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 180 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 2, *Mechanical properties*.

This third edition cancels and replaces the second edition (ISO 180:1993), which has been technically revised.

Plastics — Determination of Izod impact strength

1 Scope

1.1 This International Standard specifies a method for determining the Izod impact strength of plastics under defined conditions. A number of different types of specimen and test configurations are defined. Different test parameters are specified according to the type of material, the type of test specimen and the type of notch.

1.2 The method is used to investigate the behaviour of specified types of specimen under the impact conditions defined and for estimating the brittleness or toughness of specimens within the limitations inherent in the test conditions.

1.3 The method is suitable for use with the following range of materials:

- rigid thermoplastic moulding and extrusion materials, including filled and reinforced compounds in addition to unfilled types; rigid thermoplastics sheets;
- rigid thermosetting moulding materials, including filled and reinforced compounds; rigid thermosetting sheets, including laminates;
- fibre-reinforced thermosetting and thermoplastic composites incorporating unidirectional or non-unidirectional reinforcements such as mat, woven fabrics, woven rovings, chopped strands, combination and hybrid reinforcements, rovings and milled fibres and sheet made from pre-impregnated materials (prepregs);
- thermotropic liquid-crystal polymers.

1.4 The method is not normally suitable for use with rigid cellular materials and sandwich structures containing cellular material. Also, notched specimens are not normally used for long-fibre-reinforced composites or thermotropic liquid-crystal polymers.

1.5 The method is suited to the use of specimens which may be either moulded to the chosen dimensions, machined from the central portion of a standard multipurpose test specimen (see ISO 3167) or machined from finished or semifinished products such as mouldings, laminates and extruded or cast sheet.

1.6 The method specifies preferred dimensions for the test specimen. Tests which are carried out on specimens of different dimensions or with different notches, or specimens which are prepared under different conditions, may produce results which are not comparable. Other factors, such as the energy capacity of the apparatus, its impact velocity and the conditioning of the specimens can also influence the results. Consequently, when comparative data are required, these factors must be carefully controlled and recorded.

1.7 The method should not be used as a source of data for design calculations. Information on the typical behaviour of a material can be obtained, however, by testing at different temperatures, by varying the notch radius and/or the thickness and by testing specimens prepared under different conditions.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 291:1997, *Plastics — Standard atmospheres for conditioning and testing.*

ISO 293:1986, *Plastics — Compression moulding test specimens of thermoplastic materials.*

ISO 294-1:1996, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 1: General principles, and moulding of multipurpose and bar test specimens.*

ISO 295:1991, *Plastics — Compression moulding of test specimens of thermosetting materials.*

ISO 1268:1974¹⁾, *Plastics — Preparation of glass fibre reinforced, resin bonded, low pressure laminated plates or panels for test purposes.*

ISO 2602:1980, *Statistical interpretation of test results — Estimation of the mean — Confidence interval.*

ISO 2818:1994, *Plastics — Preparation of test specimens by machining.*

ISO 3167:—²⁾, *Plastics — Multipurpose test specimens.*

ISO 10724-1:1998, *Plastics — Injection moulding of test specimens of thermosetting powder moulding compounds (PMCs) — Part 1: General principles and moulding of multipurpose test specimens.*

ISO 13802:1999, *Plastics — Verification of pendulum impact-testing machines — Charpy, Izod and tensile impact-testing.*

3 Terms and definitions

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

3.1

Izod unnotched impact strength

a_{iU}
impact energy absorbed in breaking an unnotched specimen, referred to the original cross-sectional area of the specimen

NOTE It is expressed in kilojoules per square metre (kJ/m²).

3.2

Izod notched impact strength

a_{iN}
impact energy absorbed in breaking a notched specimen, referred to the original cross-sectional area of the specimen at the notch, with the pendulum striking the face containing the notch

NOTE It is expressed in kilojoules per square metre (kJ/m²).

1) Under revision as a series of 11 parts.

2) To be published. (Revision of ISO 3167:1993)

3.3 parallel impact p

(laminar-reinforced plastics) impact with the direction of blow parallel to the plane of reinforcement

NOTE The direction of the blow in the Izod test is usually "edgewise parallel" (ep) (see Figure 1).

3.4 normal impact n

(laminar-reinforced plastics) impact with the direction of blow normal to the plane of reinforcement

NOTE This kind of impact is not usually used with the Izod test, but is indicated for the sake of completion (see also Figure 1).

4 Principle

The test specimen, supported as a vertical cantilever beam, is broken by a single impact of a striker, with the line of impact a fixed distance from the specimen clamp and, in the case of notched specimens, from the centreline of the notch (see Figure 2).

5 Apparatus

5.1 Test machine

5.1.1 The principles, characteristics and verification of suitable test machines are detailed in ISO 13802.

5.1.2 Some plastics are sensitive to clamping pressure. When testing such materials, a means of standardizing the clamping force shall be used and the clamping force shall be recorded in the test report. The clamping force can be controlled by using a calibrated torque wrench or a pneumatic or hydraulic device on the vice clamping screw.

5.2 Micrometers and gauges

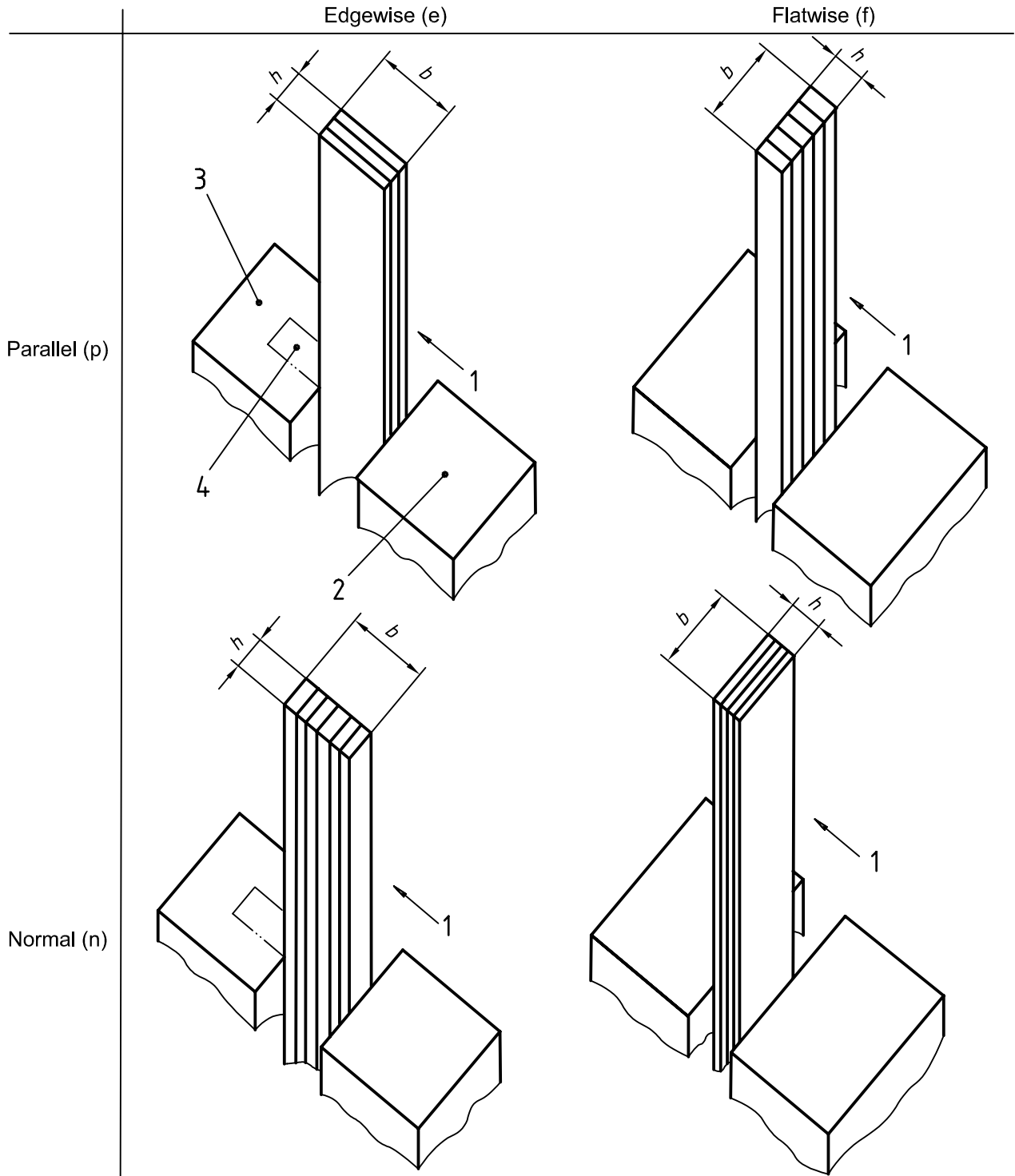
Micrometers and gauges capable of measuring the essential dimensions of test specimens to an accuracy of 0,02 mm are required. For measuring the dimension b_N of notched specimens, the micrometer shall be fitted with an anvil of width 2 mm to 3 mm and of suitable profile to fit the shape of the notch.

6 Test specimens

6.1 Preparation

6.1.1 Moulding and extrusion compounds

Specimens shall be prepared in accordance with the relevant material specification. When none exists, and unless otherwise specified, specimens shall be either directly compression moulded or injection moulded from the material in accordance with ISO 293, ISO 294-1, ISO 295 or ISO 10724-1 as appropriate, or machined in accordance with ISO 2818 from sheet that has been compression or injection moulded from the compound. Specimens may also be cut from multipurpose test specimens complying with ISO 3167, type A.



Key

- | | | | |
|---|-------------------|---|-----------------|
| 1 | Direction of blow | 3 | Fixed vice jaw |
| 2 | Movable vice jaw | 4 | Optional groove |

Edgewise (e) and flatwise (f) indicate the direction of the blow with respect to the specimen thickness h and specimen width b . Normal (n) and parallel (p) indicate the direction of the blow with respect to the laminate plane.

The usual Izod test is "edgewise parallel". When $h = b$, parallel as well as normal impact testing is possible.

Figure 1 — Scheme of designations describing the direction of blow

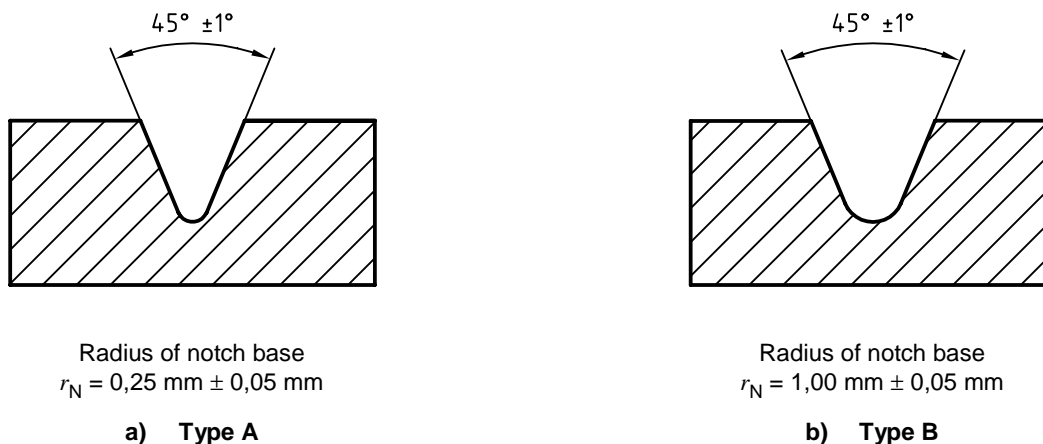


Figure 2 — Notch types

6.1.2 Sheets

Specimens shall be machined from sheets in accordance with ISO 2818. Whenever possible, specimens with notch A shall be used. The machined surface of unnotched specimens shall not be tested under tension.

6.1.3 Long-fibre-reinforced materials

A panel shall be prepared in accordance with ISO 1268 or another specified or agreed upon preparation procedure. Specimens shall be machined in accordance with ISO 2818.

6.1.4 Checking

The specimens shall be free of twist and shall have mutually perpendicular parallel surfaces. The surfaces and edges shall be free from scratches, pits, sink marks and flash.

The specimens shall be checked for conformity with these requirements by visual observation against straightedges, squares and flat plates, and by measuring with micrometer callipers.

Specimens showing measurable or observable departure from one or more of these requirements shall be rejected or machined to proper size and shape before testing.

6.1.5 Notching

6.1.5.1 Machined notches shall be prepared in accordance with ISO 2818. The profile of the cutting tooth shall be such as to produce in the specimen a notch of the contour and depth shown in Figure 2, at right angles to its principal axes. The notch profile shall be checked at regular intervals.

6.1.5.2 Specimens with moulded-in notches may be used if specified for the material being tested. Specimens with moulded-in notches do not give results comparable to those obtained from specimens with machined notches. The notch profile shall be checked at regular intervals.

6.2 Anisotropy

Certain types of sheet or panel material may show different impact properties depending on the direction in the plane of the sheet or panel. In such cases, it is customary to cut groups of test specimens with their major axes respectively parallel and perpendicular to the direction of some feature of the sheet or panel which is either visible or inferred from knowledge of the method of manufacture.

6.3 Shape and dimensions

6.3.1 General

For the dimensions of the test specimen, see Table 1.

Where necessary with certain types of apparatus, the length may be shortened symmetrically to 63,5 mm.

The longitudinal direction of the notch is always parallel to the thickness h .

Table 1 — Method designations, specimen types, notch types and notch dimensions

Dimensions in millimetres

| Method designation ^{a,b} | Specimen | Notch type ^a | Notch base radius, r_N | Remaining width, b_N , at notch base |
|---|--|-------------------------|--------------------------|--|
| ISO 180/U | Length $l = 80 \pm 2$ Width $b = 10,0 \pm 0,2$ Thickness $h = 4,0 \pm 0,2$ | Unnotched | — | — |
| ISO 180/A | | A | $0,25 \pm 0,05$ | $8,0 \pm 0,2$ |
| ISO 180/B | | B | $1,00 \pm 0,05$ | |
| ^a If specimens are taken from sheet or products, the thickness h of the sheet or product shall be added to the designation. Unreinforced specimens shall not be tested with their machined surface under tension. ^b If the sheet thickness h equals the width b , the direction of the blow (normal n , or parallel p) shall be added to the designation. | | | | |

6.3.2 Moulding and extrusion compounds

Test specimens with one of two different types of notch shall be used as specified in Table 1 and shown in Figure 2. The notch shall be located at the centre of the specimen.

The preferred type of notch is type A. If information on the notch sensitivity of the material is desired, specimens with notch types A and B shall be tested.

6.3.3 Sheet materials, including long-fibre-reinforced materials

The recommended thickness h is 4 mm. If the specimen is cut from a sheet or a piece taken from a structure, the thickness of the specimen, up to 10,2 mm, shall be the same as the thickness of the sheet or the structure.

Specimens taken from pieces thicker than 10,2 mm shall be machined to $10 \text{ mm} \pm 0,2 \text{ mm}$ from one surface, providing that the sheet is homogeneous in its thickness and contains only one type of reinforcement uniformly distributed. If unnotched specimens are tested, the original surface shall be tested under tension, in order to avoid surface effects.

Specimens shall be tested edgewise parallel, with the exception of specimens with $h = b = 10 \text{ mm}$ which can be tested parallel or normal to the laminate plane (see Figure 1).

6.4 Number of test specimens

6.4.1 Unless otherwise specified in the standard for the material being tested, a set consisting of 10 specimens shall be tested. When the coefficient of variation (see ISO 2602) has a value of less than 5 %, a minimum number of five test specimens is sufficient.

6.4.2 If laminates are tested in the normal and parallel directions, 10 specimens shall be used for each direction.

6.5 Conditioning

Unless otherwise specified in the standard for the material under test, the specimens shall be conditioned for at least 16 h at 23 °C and 50 % relative humidity in accordance with ISO 291, unless other conditions are agreed upon by the interested parties. In the case of notched specimens, the conditioning time is after notching.

7 Procedure

7.1 Conduct the test in the same atmosphere as that used for conditioning, unless otherwise agreed upon by the interested parties, e.g. for testing at high or low temperatures.

7.2 Measure the thickness h and width b of each test specimen, in the centre, to the nearest 0,02 mm. In the case of notched specimens, carefully measure the remaining width b_N to the nearest 0,02 mm.

In the case of injection-moulded specimens, it is not necessary to measure the dimensions of each specimen. It is sufficient to measure one specimen from a set to make sure that the dimensions correspond to those in Table 1. With multiple-cavity moulds, ensure that the dimensions of the specimens are the same for each cavity.

7.3 Check that the impact machine is able to perform the test with the specified velocity of impact and that it is in the correct range of absorbed energy W which shall be between 10 % and 80 % of the available energy at impact, E . If more than one of the pendulums conform to these requirements, the pendulum having the highest energy shall be used.

7.4 Determine the frictional losses and correct the absorbed energy in accordance with ISO 13802.

7.5 Lift the pendulum to the prescribed height and support it. Place the specimen in the vice and clamp it as shown in Figure 1, in accordance with 5.1.2. When determining the notched Izod impact strength, the notch shall be positioned on the side that is to be struck by the striking edge of the pendulum.

7.6 Release the pendulum. Record the impact energy absorbed by the specimen and apply any necessary corrections for frictional losses, etc. (see 7.4).

7.7 Four types of break designated by the following code-letters may occur:

C complete break: a break in which the specimen separates into two or more pieces

H hinge break: an incomplete break such that both parts of the specimen are held together only by a thin peripheral layer in the form of a hinge having low residual stiffness

P partial break: an incomplete break that does not meet the definition for hinge break

N non-break: there is no break, and the specimen is only bent and pushed through the support blocks, possibly combined with stress whitening

8 Calculation and expression of results

8.1 Unnotched specimens

Calculate the Izod impact strength of unnotched specimens, a_{iU} , expressed in kilojoules per square metre, using the following equation:

$$a_{iU} = \frac{E_C}{h \cdot b} \times 10^3 \quad (1)$$

where

E_C is the corrected energy, in joules, absorbed by breaking the test specimen;

ISO 180:2000(E)

h is the thickness, in millimetres, of the test specimen;

b is the width, in millimetres, of the test specimen.

8.2 Notched specimens

Calculate the Izod impact strength of notched specimens, a_{iN} , expressed in kilojoules per square metre, with notches A or B, using the following equation:

$$a_{iN} = \frac{E_c}{h \cdot b_N} \times 10^3 \quad (2)$$

where

E_c is the corrected energy, in joules, absorbed by breaking the test specimen;

h is the thickness, in millimetres, of the test specimen;

b_N is the remaining width, in millimetres, of the test specimen.

8.3 Statistical parameters

Calculate the arithmetic mean of test results and the standard deviation of the mean value, if required, using the procedure given in ISO 2602. For different types of failure within one sample, the relevant numbers of specimens shall be given and mean values shall be calculated.

8.4 Significant figures

Report all calculated mean values to two significant figures.

9 Precision

The precision of this method is not known because interlaboratory data are not available. When interlaboratory data are obtained, a precision statement will be added at the following revision.

10 Test report

The test report shall include the following information:

- a) a reference to this International Standard;
- b) the method used, designated in accordance with Table 1, for example:

Izod impact test ISO 180/A
Type of notch (see Figure 2) _____

- c) all information necessary for identification of the material tested, including type, source, manufacturer's code, grade and history, where these are known;
- d) a description of the nature and form of the material, i.e. whether a product, semifinished product, test plate or specimen, including principal dimensions, shape, method of manufacture, etc., where these are known;
- e) the velocity of impact;

- f) the nominal pendulum energy;
- g) the clamping pressure, if applicable (see 5.1.2);
- h) the method of test specimen preparation;
- i) if the material is in the form of a product or a semifinished product, the orientation of the test specimen in relation to the product or semifinished product from which it was cut;
- j) the number of specimens tested;
- k) the standard atmosphere used for conditioning and testing, plus any special conditioning treatment if required by the standard for the material or product;
- l) the type(s) of failure observed;
- m) the individual test results, presented as follows (see also Table 2):
 - 1) group the results according to the three basic types of failure:
 - C complete break, including hinge break H
 - P partial break
 - N non-break
 - 2) select the most frequent type and record the mean value x of the impact strength for this type of failure, followed by the letter C or P for the type of failure,
 - 3) if the most frequent failure type is N, record the letter N only,
 - 4) add (between brackets) the letter C, P or N for the second most frequent failure type, but only if its frequency is higher than 1/3 (if not relevant, insert an asterisk);
- n) the standard deviations of the mean values, if required;
- o) the date(s) of the test.

Table 2 — Presentation of results

| C | Type of failure | | Designation |
|-----------------|---|-----|---------------|
| | P | N | |
| <i>x</i> | * | * | <i>x</i> C* |
| <i>x</i> | (P) | * | <i>x</i> C(P) |
| <i>x</i> | * | (N) | <i>x</i> C(N) |
| * | <i>x</i> | * | <i>x</i> P* |
| (C) | <i>x</i> | * | <i>x</i> P(C) |
| * | <i>x</i> | (N) | <i>x</i> P(N) |
| * | * | N | N* |
| (C) | * | N | N(C) |
| * | (P) | N | N(P) |
| <i>x</i> | Mean value of impact strength for most frequent failure type, excluding type N. | | |
| C, P or N | Most frequent failure type. | | |
| (C), (P) or (N) | Second most frequent failure type, to be recorded only if its frequency is higher than 1/3. | | |
| * | Not relevant. | | |

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