ISO 6603-1 Determination of Puncture Impact Behaviour of Rigid Plastics Non-Instrumented Impact Testing / Testing Equipment

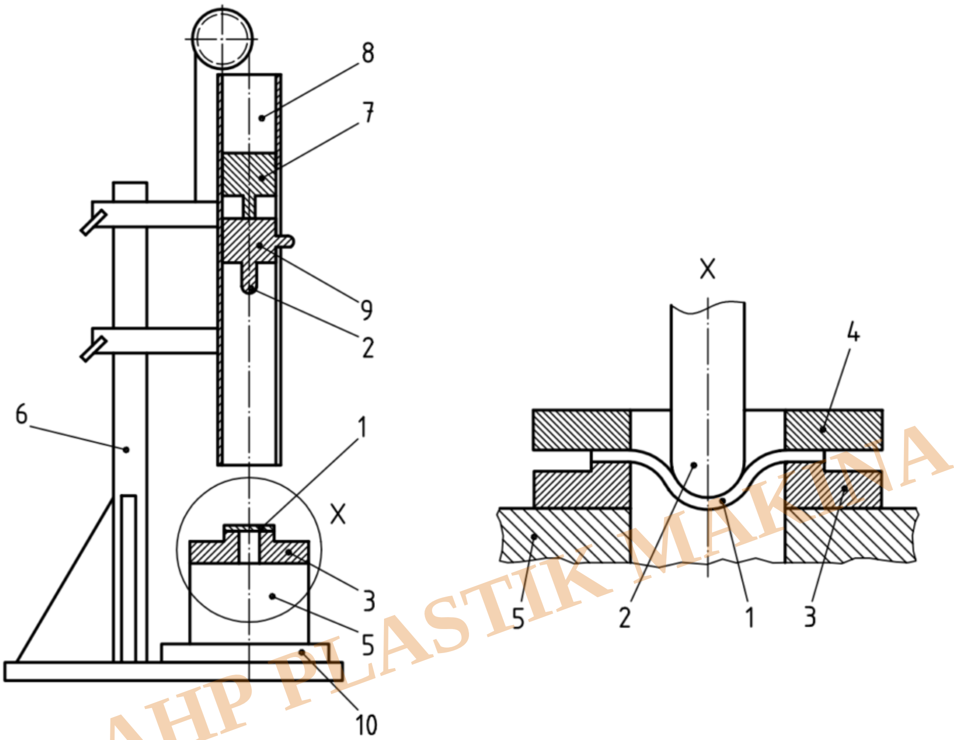
Description

ISO 6603-1 Non Instrumented Impact Tester

4 Principle
The impact strength of suitably sized test specimens is determined by striking them with a lubricated weighted striker dropped vertically from a known height. The test specimen is impacted at its centre by a striker, perpendicular to the surface of the specimen.
Two methods of adjusting the energy at impact are permitted: altering the mass at constant height and altering the height at constant mass.
NOTE The variable-height procedure is velocity-dependent, and differing results may be observed depending upon the material's strain rate.
Two statistical methods of test are given:
Method A: staircase method (individual) (preferred).
Method B: group method (optional).

5 Apparatus
5.1 Test device
5.1.1 Essential components
The essential components of the test device (see Figure 4) are:
– an energy carrier (dart system), of the inertial-mass type, which includes:

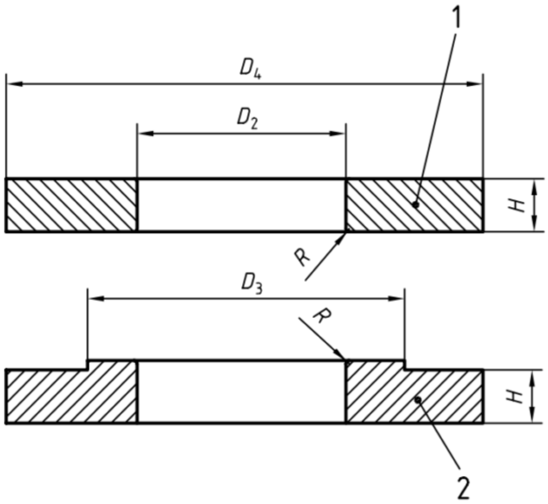
weights,
a striker (lubrication is required);
– a specimen support (see Figure 4), optionally with a clamping device (Figure 5).
The test device shall permit the test specimen to be punctured at its centre, perpendicular to the specimen surface.



Key

1 Test specimen
2 Hemispherical striker tip
3 Test specimen support
4 Clamping ring (optional)
5 Base
6 Stand for falling-dart system
7 Holding and release system for weighted striker
8 Guide shaft for weighted striker
9 Weighted striker
10 Acoustic isolation (optional)

Figure 4 — Falling-dart system (example)



Key

1 Clamping ring (optional)

2 Specimen support

Dimensions in millimetres

	Specimen type	
	Square of side 60	Disc of diam. 140
D_2	40 ± 2	100 ± 5
D_3	60	140
D_4	min. 90	min. 200
H	12	12
R	1	1

Figure 5 — Schematic drawing of clamping device (optional)

5.1.2 Falling-dart system

The falling-dart system shall be capable of holding and releasing a weighted striker such that it will fall constrained by one or more guides. The fall shall be nominally without friction and losses through windage, or the amount of friction has to be taken into account in the calculations.

5.1.3 Weights (masses)

Appropriate weights are required that can be firmly attached to the striker. The combined mass of the attached weights, and the mass of the striker, shall be known to within 1 %.

5.1.4 Striker

The preferred striker has a polished hemispherical striking surface with a diameter 20 mm +- 0,2 mm. Alternatively, a 10 mm +- 0,1 mm diameter striking surface may be used.

NOTE: The size, dimensions and condition of the surface of the striker will affect the results.

The preferred striker is one made of any material with sufficient resistance to wear and of sufficiently high strength to prevent plastic deformation. In practice, hardened tool steel or similar material with a hardness of 54 HRC has been found acceptable. Harder materials or materials with a lower density (for example titanium) with equivalent hardness are also acceptable. The hemispherical surface of the striker shall be lubricated to reduce any friction between the striker and the test specimen (see annex B of ISO 6603-2:—).

5.1.5 Support ring

The support ring (see Figures 4 and 5) shall be rigidly fixed on a rigid base and shall be designed such that air cannot be trapped under the test specimen, possibly causing a spring effect. Below the support ring, there shall be enough distance for the striker to travel after total penetration of the test specimen. The support ring shall have an inside diameter of either 40 mm+-2 mm or 100 mm+-5 mm and a minimum height of 12 mm.

5.1.6 Striker/support combinations

The following striker/support combinations are permissible:

Striker	Support	
20 mm	40 mm	Default combination
10 mm	100 mm	Optional

5.1.7 Base for test device

The test device shall be firmly mounted on a rigid structure of sufficient stiffness to minimize deflection of the specimen support. The mass of the base shall be at least 180 kg.

The test device is generally susceptible to mechanical vibration. The design of the foundation on which the base is mounted shall be such as to minimize the effect of any mechanical vibration in the system. The centre of gravity of the base shall be in line with the trajectory of the impacting striker.

5.1.8 Clamping device (optional)

When it is utilized, a two-piece annular specimen clamp consisting of the support ring and a clamping ring shall be used (see Figure 5).

The clamping device shall have an inside diameter equal to 40 mm+-2 mm or 100 mm+-5 mm. The clamp may work by the application of force on the specimen. A clamping force of >3 kN is recommended.

NOTE: Pneumatically and screw operated clamps have been successfully employed. The results obtained for clamped and unclamped specimens are likely to be different because the edges of an unclamped specimen are free to move under test and specimen vibrations with higher amplitudes may occur (see annex C of ISO 6603-2:—).

5.1.9 Device for catching the dart after impact

This device is designed to prevent multiple impacts on the specimen and damage to the striker.

5.2 Thickness gauge

This device shall enable the thickness of the test specimens to be measured to an accuracy of +-0,01 mm.

6 Test specimens

6.1 Shape and dimensions

The preferred test specimen is 60 mm+-2 mm square or 60 mm+-2 mm in diameter, with a thickness of 2,0 mm+-0,1 mm, and is used with the 40 mm diameter support ring.

For testing brittle fibre-reinforced plastic composites and low failure strain plastics, a test specimen 140+- mm 2 mm square or 140 mm+-2 mm in diameter with a recommended thickness of 4,0 mm+-0,2 mm may be used with the 100 mm diameter support ring.

6.2 Preparation of test specimens

The test specimens shall be prepared in accordance with the relevant material specification. Where none exists, or when not otherwise specified, test specimens shall be prepared in accordance with ISO 293, ISO 294-3, ISO 295 or ISO 1268 as appropriate or machined from plates in accordance with ISO

2818 (see note). The test specimens may also be prepared with a cutting or punching device, since there are no special requirements for the cut edges.
NOTE:The preparation of test specimens 140 mm square or 140 mm in diameter by injection moulding is not yet covered by any International Standard.
Because the larger specimen is used primarily for fibre-reinforced plastic composites, it is recommended that they be made by machining from sheet material.
Test specimens taken from larger sheets or sections of sheet shall be taken from locations that are as uniformly distributed over the surface as possible. Non-homogeneous edge zones shall not be used.
The thickness of these test specimens shall be the thickness of the sheet up to a thickness of 4 mm. If the sheet is more than 4 mm thick, the specimens shall be machined to 4 mm.

6.3 Non-homogeneous test specimens

In general, the test is conducted on either side of the specimen, selected at random. However, if there is a reason to believe that the results are dependent on which side of the specimen faces the striker, each side shall be tested separately. This especially holds for test specimens with textured surfaces, specimens lacquered on one side and specimens which are UV-aged. When assessing the influence of a one-sided treatment, the test specimen shall be impacted on the opposite side.

6.4 Checking the specimens

The specimens shall be free of twist and warpage. Both surfaces shall be smooth and free of scratches, pits and sink marks to avoid notching effects.
The specimens shall be checked for conformity with these requirements by visual observation or by measuring with a thickness gauge. Specimens showing any observable departure from one or more of these requirements shall be rejected.

6.5 Number of test specimens

For tests conducted under constant conditions:
Method A: staircase method (individual) (preferred)
At least 30 test specimens shall be used (10 for pretesting to determine the starting energy).

Method B: group method (optional)
At least 40 test specimens shall be used (10 for pretesting and 30 for the main test).
If a large number of test specimens is required, for example to determine the temperature dependence of the parameters measured, the test specimens shall be selected in accordance with statistical principles.
6.6 Conditioning of test specimens
The test specimens shall be conditioned as required by the relevant material specification or as agreed upon by the interested parties. Otherwise, the most appropriate conditions from ISO 291 shall be selected.

7 Procedure

7.1 Test atmosphere

7.1.1 General
Conduct the test in one of the standard atmospheres specified in ISO 291.
7.1.2 Room-temperature testing
If a standard atmosphere from ISO 291 was used for conditioning, conduct the test in the same atmosphere. If not, ensure that the transit time tT (see note) is short enough (i.e. less than 5 s) to prevent changes in the mechanical behaviour (state of material) of the test specimen caused by

changes in the temperature of the specimen. For dry polyamides, for instance, a transit time of up to 30 min has been found not to markedly affect the impact behaviour when testing in an atmosphere of 23 °C and 50 % R.H.

NOTE The transit time tT is the total time from the removal of the specimen from the conditioning environment until the specimen is impacted.

7.1.3 Low-temperature testing

When test specimens are conditioned at low temperature and the test equipment is at room temperature, a transit time tT (see note to 7.1.2) short enough to prevent significant changes in the temperature of the test specimen prior to impact is required (i.e. less than 5s). Differences in humidity between the test specimen conditioning atmosphere and the test atmosphere are critical.

7.2 Measurement of thickness

For each test specimen, measure the thickness to the nearest 0,02 mm at three points which are equidistant to one another on a circle with a radius of 10 mm centred on the centre of the specimen. Record the average value of the measured thickness (see note). If the thickness of any specimen differs by more than 5 % from the average thickness of the specimens from that sample, discard that specimen and replace it with another specimen.

NOTE When using injection-moulded specimens, it is not necessary to measure the dimensions of each specimen. It is sufficient to measure one specimen from each set.

When using multiple-cavity moulds, measure the thickness of the specimens from each cavity. If the difference in specimen thickness between mould cavities is greater than 5 %, the specimens from each cavity shall be treated as different batches.

7.3 Clamping the test specimen (optional)

The default condition for this test is that the specimen is unclamped.

If the specimen is clamped, however, take care to ensure that the clamping force does not induce bending or torsional forces in the specimen.

7.4 Lubrication

Lubricate the tip of the striker with oil or grease before each test. The viscosity of the lubricant shall be in the range 10 cP < Viscosity< 10000 cP (see annex B of ISO 6603-2:—)

7.5 Puncture test procedure

7.5.1 General

Place the test specimen on the support ring (5.1.5) and clamp in place, if appropriate. When testing machined specimens, impact the specimen on the machined surface. Firmly secure the necessary weights (5.1.3) to the striker (5.1.4). Put the dart (5.1.2) into position at the specified height, according to the method used, and release the dart. If the dart rebounds from the surface of the test specimen, catch the dart after it bounces to prevent

–multiple impacts with the surface of the test specimen;

–any damage to the hemispherical surface of the dart if it impacts with metal parts of the apparatus.

Examine the test specimen to determine whether it has or has not failed in accordance with any of the definitions given in 3.2. The failure criteria defined in 3.2 describe definite alterations of the test specimen caused by the falling mass, a failure being defined as any break in the surface of the specimen which is visible to the naked eye. These failure criteria shall be either as specified in the relevant material specification or agreed upon by the interested parties. If other failure criteria (e.g. crazing, indentation, stress whitening, etc.) are deemed to be of importance, these criteria shall be defined by agreement between the interested parties and included in the test report. Each test specimen shall be impacted only once.

7.5.2 Constant height of fall (preferred)

A height of fall of 1 m should preferably be chosen for a variable falling mass. If the specimen cannot be broken by this method, then the alternative constant falling mass approach is recommended.

7.5.3 Constant falling mass (optional)

If a variable height is used, it should be chosen over any range between 0,3 m and 2,0 m, but preferably around 1,0 m.

7.6 Method A: staircase method (preferred)

7.6.1 General

In this method, a uniform energy increment is employed during testing and the energy is adjusted after striking each test specimen. The energy at impact is adjusted either by altering the mass at constant height or altering the height at constant mass (see, however, the note to clause 4).

7.6.2 Pretesting

Use 10 test specimens to estimate the 50 % impact-failure energy E50.

NOTE It is suggested that, during pretesting, the increments used are not uniform. Begin with relatively large increments to find the energies which will cause, with certainty, failure (or no failure). Finish the pretesting with smaller energy increments in order to estimate roughly the energy that causes 50 % of the test specimens to fail.

7.6.3 Test procedure As a starting point, select an energy near the expected impact-failure energy, based on the pretesting.

Select an energy increment ΔE appropriate to the impact strength of the sample. The value chosen fo preferably be such that three to six energy steps will be employed in the determination. A ΔE va approximately 5 % of the expected impact-failure energy E, based on the pretesting, is usually appropri

After striking the first specimen, examine it to determine whether it has or has not failed and record t the form shown in Figure 6 or 7, using an “o” to denote non-failure and an “x” to denote failure.

If the first specimen fails, decrease the energy by ΔE. If the first specimen does not fail, increase the e Continue testing successive specimens, decreasing or increasing the energy by ΔE between drops upon whether the preceding specimen did or did not fail.

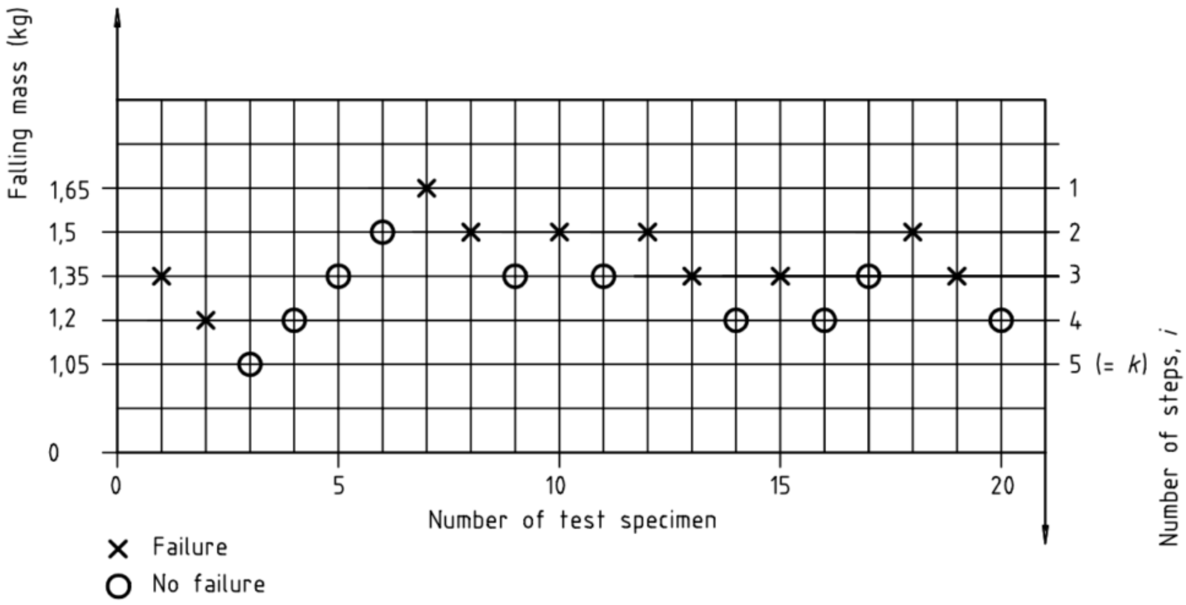


Figure 6 — Example of method A (staircase) test results with constant height of fall (0,66 m)

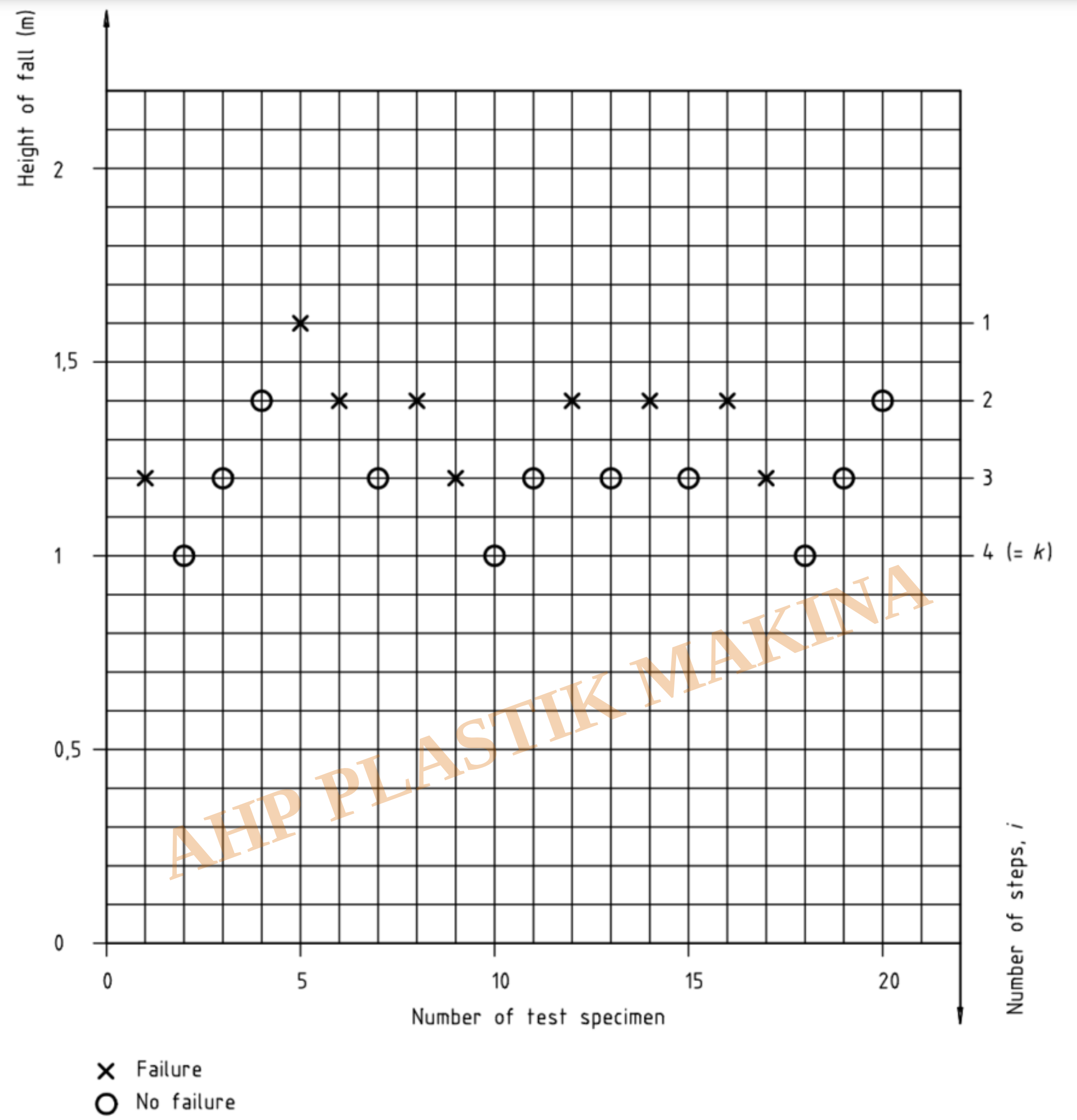


Figure 7 — Example of method A (staircase) test results with constant mass (1 kg)

7.6.4 Expression of results

7.6.4.1 Calculation

Calculate the 50 % impact-failure energy E50, in joules, as follows:

$E_{50} = H \times g \times m_{50}$ in the case of constant height

$E_{50} = m \times g \times H_{50}$ in the case of constant mass

where

H is the constant height of fall, in metres;

m is the constant falling mass, in kilograms;

g is the acceleration due to gravity (9,81 m/s^2);

$$m_{50} = m_a + \Delta m\left(\frac{A}{N} \pm 0{,}5\right)$$

$$H_{50} = H_a + \Delta H\left(\frac{A}{N} \pm 0{,}5\right)$$

[the plus sign is taken if the no-failure ($N = N_o$) blows are considered and the minus sign if the failure ($N = N_x$) blows are considered]

m_a being the smallest mass among the k mass steps m_i (i = 1 to k) from the main test, in kilograms,

Δm being the mass increment, in kilograms,

H_a being the smallest height among the k height steps H_i (i = 1 to k) from the main test, in metres,

ΔH being the height increment, in metres;

$$N = \sum_{i=1}^{k} n_i$$

[total number of failed (N_x) or not failed (N_o) specimens, depending which number is smaller]

n_i being the number of specimens that have failed or not failed, respectively, at each height H_i or mass m_i;

$$A = \sum_{i=1}^{k} n_i z_i$$

z_i being the number of mass increments from m_a or the number of height increments from H_a, given by

$$z_i = \frac{m_i - m_a}{\Delta m}$$

or

$$z_i = \frac{H_i - H_a}{\Delta H}$$

7.6.4.2 Standard deviation

Calculate the standard deviation s, in joules, as follows:

$$s = 1{,}62\ \Delta E \left(\frac{NB - A^2}{N^2} + 0{,}029 \right)$$

where

$$B = \sum_{i=1}^{k} n_i z_i^{\,2}$$

This formula is valid only if $\dfrac{NB - A^2}{N^2} > 0{,}3$.

Examples of the calculations are given in annex A.

NOTE If the condition $0{,}5s \leqslant \Delta E \leqslant 2s$ is not fulfilled, it is strongly recommended that the test be repeated with anoth

7.7 Method B: group method

7.7.1 General

In this method, successive groups of at least 10 test specimens each are tested. For each group, one impact energy is employed and from group to group the energy is varied in increments. The energy at impact is adjusted either by altering the mass at constant height or altering the height at constant mass (see, however, the note to clause 4)

Testing is carried to a point where there are at least five percentage-failure results: one 0 % failure result, one 100 % failure result and at least three results between the 0 % and 100 % results. The three results between the 0 % and 100 % limits shall not all be lower or higher than 50 %.

7.7.2 Pretesting

Test a minimum of 10 test specimens to estimate the approximate limits at which 0 % and 100 % failure occurs.

7.7.3 Test procedure

Select the mass (or height) increments such that, between the “0 %” and “100 %” limits, based on the pretesting, a minimum of three points is determined, at each of which at least 10 test specimens are tested.

Record the failure mass (or height) and the percentage of failures for each point.

At this stage, if the minimum five results described in 7.7.1 have been obtained, testing is complete.

7.7.4 Expression of results

7.7.4.1 Calculation

Plot the data on linear probability graph paper (see Figure 8) with mass (or height) along the linear axis and percent failure along the probability axis, omitting the 0 % and 100 % failure points.

Fit the best straight line through the points and read M50 (or H50) from the graph at the falling mass (or height of fall) corresponding to the intersection of the straight line with the 50 % probability line.

7.7.4.2 Standard deviation

To determine the standard deviation s, determine in the same way E_{16} and E_{84} as shown in Figure 8 and c
as follows:

$$s = \frac{E_{84} - E_{16}}{2}$$

NOTE The best-fitting straight line may be obtained by a suitable technique such as the least-squares
regression analysis.

An example of the calculation is given in annex A.

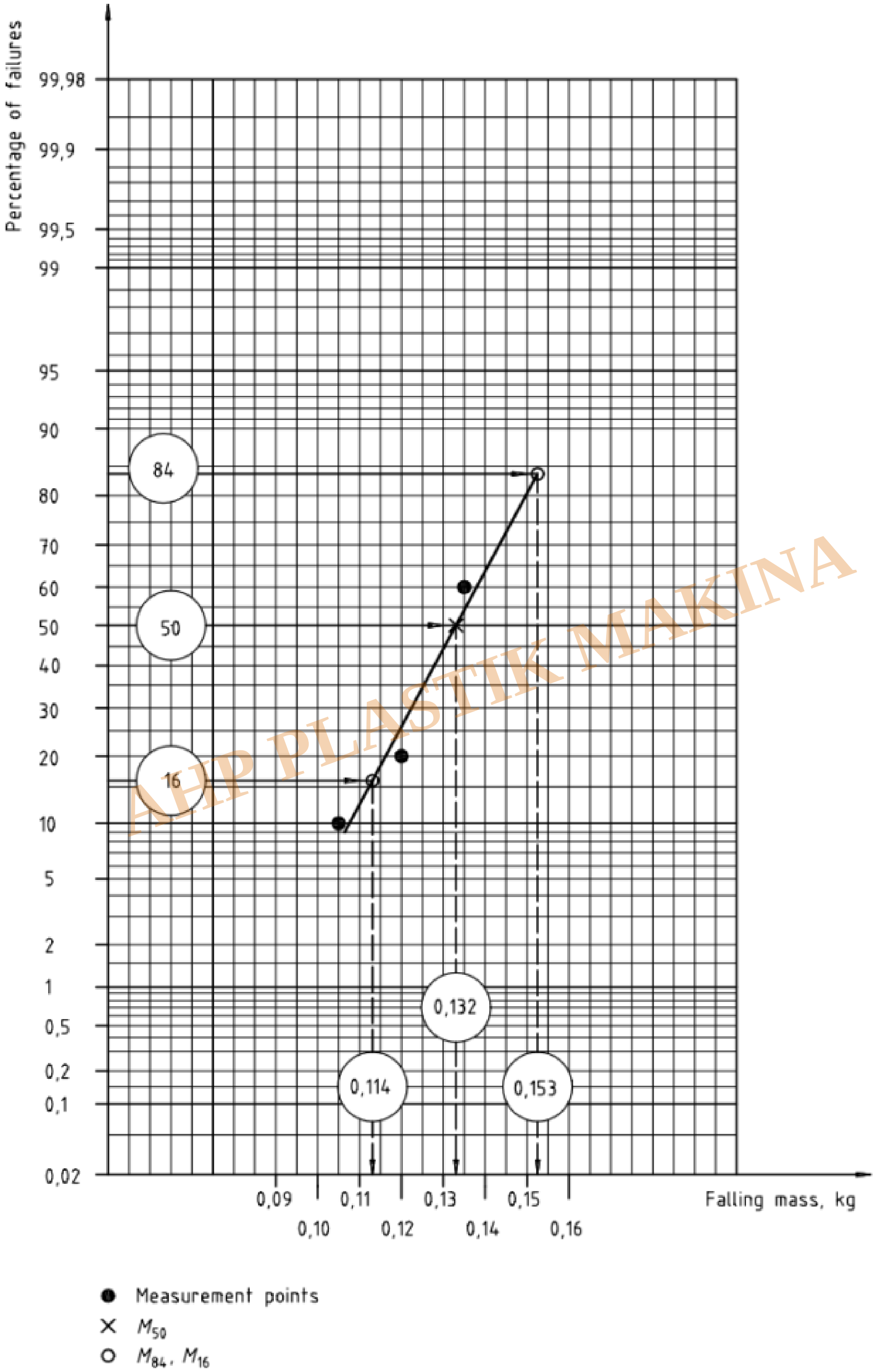


Figure 8 — Example of plot for method B (group) with constant height of fall (1 m)

Annex A
(informative)

Examples of calculations

A.1 Method A: staircase method

EXAMPLE 1: Variable falling mass, constant height of fall (see Figure 6 and Table A.1)

Table A.1

i	**Falling mass** kg	$n_i(\text{o})$	$n_i(\text{x})$	n_i	z_i	$n_i z_i$	$n_i z_i^2$
1	1,65	0	1	1	4	4	16
2	1,50	1	4	4	3	12	36
3	1,35	4	4	4	2	8	16
4	1,20	4	1	1	1	1	1
5 (= k)	1,05	1	0	0	0	0	0
$\sum_{i=1}^{k}$		10 (N_o)	10 (N_x)	10 ($N = N_\text{x}$)		25 (A)	69 (B)

Number of specimens:	20
Height of fall:	0,65 m
Falling mass:	Variable
Mass increment:	0,15 kg
Initial falling mass from pretesting	1,35 kg

The number of failure blows N_x and no-failure blows N_o are the same, so either can be used in the calculation. Otherwise, the smaller number shall be used. In the example in Table A.1 and the following calculation, the failure blows have been used.

M_a = 1,05 kg; ΔM = 0,15 kg; $N = N_\text{x}$ = 10

$$A = \sum_{i=1}^{k=5} n_i z_i = 25$$

$$B = \sum_{i=1}^{k=5} n_i z_i^2 = 69$$

$$E_{50} = HgM_{50} = Hg\left[M_\text{a} + \Delta M\left(\frac{A}{N} - \frac{1}{2}\right)\right]$$

$$E_{50} = 0{,}66 \times 9{,}81\left[1{,}05 + 0{,}15\left(\frac{25}{10} - \frac{1}{2}\right)\right] = 8{,}74 \text{ J}$$

$$s = 1{,}62\ \Delta E \left(\frac{NB - A^2}{N^2} + 0{,}029 \right) = 1{,}62\ (Hg\ \Delta M) \left(\frac{NB - A^2}{N^2} + 0{,}029 \right)$$

$$s = 1{,}62\ (0{,}66 \times 9{,}81 \times 0{,}15) \left(\frac{10 \times 69 - 625}{100} + 0{,}029 \right) = 1{,}07 \text{ J}$$

Thus

E_{50} = 8,74 J

s = 1,07 J

EXAMPLE 2: Variable height of fall, constant mass (see Figure 7 and Table A.2):

Table A.2

i	**Height of fall** m	n_i(o)	n_i(x)	n_i	z_i	$n_i z_i$	$n_i z_i^2$
1	1,6	0	1	1	3	3	9
2	1,4	2	5	5	2	10	20
3	1,2	6	3	3	1	3	3
4 (= k)	1,0	3	0	0	0	0	0
$\sum_{i=1}^{k}$		11 (N_o)	9 (N_x)	9 ($N = N_x$)		16 (A)	32 (B)

Number of specimens:	20
Falling mass:	1 kg
Height of fall:	Variable
Height of fall increment:	0,2 m
Initial height of fall from pretesting	1,2 m

Since $N_x < N_o$, the calculation is conducted on the basis of the $N = N_x$

$$E_{50} = MgH_{50} = Mg\left[H_a + \Delta H \left(\frac{A}{N} - \frac{1}{2} \right) \right]$$

$$E_{50} = 1{,}0 \times 9{,}81 \left[1{,}0 + 0{,}2 \left(\frac{16}{9} - \frac{1}{2} \right) \right] = 12{,}3 \text{ J}$$

$$s = 1{,}62\ \Delta E \left(\frac{NB - A^2}{N^2} + 0{,}029 \right) = 1{,}62\ (Mg\ \Delta H) \left(\frac{NB - A^2}{N^2} + 0{,}029 \right)$$

$$s = 1{,}62\ (1 \times 9{,}81 \times 0{,}2) \left(\frac{9 \times 32 - 256}{81} + 0{,}029 \right) = 1{,}35 \text{ J}$$

Thus

E_{50} = 12,3 J

s = 1,35 J

A.2 Method B: group method

EXAMPLE (see Figure 8)

Height of fall: 1 m

Results of pretesting

0 % failure: 0,090 kg

100 % failure: 0,170 kg

Selected steps for main testing and percentage failures:

Mass (kg)	**Percent failure**
0,105	10
0,120	20
0,135	60

Since $E_{50} = M_{50} \times 9{,}81 \times H$ (M_{50} in kilograms, H in metres, E_{50} in joules)

Figure 8 gives

E_{50} = 0,132 × 9,81 × 1 = 1,29 J

Similarly

E_{16} = 0,114 × 9,81 × 1 = 1,12 J

E_{84} = 0,153 × 9,81 × 1 = 1,50 J

From which

$$s = \frac{1{,}50 - 1{,}12}{2} = 0{,}19 \text{ J}$$

Thus

E_{50} = 1,29 J

s = 0,19 J

ISO 6603-1 Non Instrumented Impact Tester

- Touch display
- Automatic height adjustment
- Anti rebound system for restricting multi-impacts
- Calamp for sample as per ISO6603-1
- Pneumatic clam type
- Sample of square size 60mm, Disk diameter 140mm
- Striker head of hemispherical 20mm diameter (optional 10mm is available)
- Striker hardness more than 54HRC
- support ring of inside diameter 40 and 100 mm
- Base weight is more than 180kg as per standard
- Clamping force is more than 3KN
- Small ample is square 40mm or 40mm diameter disk 2mm thickness
- Bigger sample is 140mm square or 140mm diameter disk with thickness of 4mm
- Striker head can be changed easily
- “Number” & “mass of weights” – “maximum height of impact” are according to customer request

Category

1. Equipment for Standards
2. Standards