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Springs — Shot peening —

Part 1: General procedures

Ressorts — Grenaillage de précontrainte —

Partie 1: Modes opératoires généraux

Reference number
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Contents

Page

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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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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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 227, *Springs*.

This second edition cancels and replaces the first edition (ISO 26910-1:2009), of which it constitutes a minor revision. It also incorporates the Amendment ISO 26910-1:2009/Amd. 1:2017.

The changes compared to the previous edition are as follows:

— the Normative reference has been updated to ISO 80000-1;

— "or less" has been deleted from the sentence of 3.5 saturation time;

— "and size" has been added to the sentence of a) of 4.3 Conditions of shot peening;

— "Type A" has been added to the last sentence of 6.2 Selection of the class of Almen strip;

— the statuses of Annexes A and B have been changed to informative.

A list of all parts in the ISO 26910 series can be found on the ISO website.

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.

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Introduction

Shot peening is widely applied to various mechanical and structural elements in a wide range of industrial fields, because of its effective improvement in the strength and life properties at moderate costs. It is also used in some cases for other purposes such as to form thin sheet products, to increase wear resistance, or to assist lubrication effect, deburring and so on. It is, however, especially important for spring industries, as it is indispensable for the achievement of the required fatigue strength and to decrease stress corrosion cracking.

The important effects of shot peening are known to be due mainly to the compressive residual stresses introduced near the shot peened surface, and helped sometimes by the work hardening of the surface layers. Various processing methods have been developed and practised together with diverse materials for shot peening.

This document serves to establish smooth technical communication between the spring manufacturers and industry related to shot peening, including peening machine manufacturers, peening media suppliers and shot peening processors, as well as users of those springs in various industrial sectors.

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Springs — Shot peening —

Part 1: General procedures

1 Scope

This document specifies general requirements for the shot peening process applied to springs in order to improve their resistance to fatigue and stress corrosion cracking, mainly by introducing compressive residual stresses into their surface layers.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 80000-1, *Quantities and units — Part 1: General*

3 Terms and definitions

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

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

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

3.1
shot peening
cold work applied to the surface of a material or a mechanical element, to improve its fatigue strength and stress corrosion cracking resistance, by a stream of near spherical hard particles at a high velocity that generates compressive residual stresses and work hardening in the surface layer

3.2
peening media
generally spherical or near-spherical hard particles, made of metals, glasses or ceramics, used for shot peening

Note 1 to entry: Individual particles can be called shots.

3.3
Almen strip
rectangular metal strip used for evaluating the peening intensity by the magnitude of its bending deformation after shot peening on one surface

3.4
Almen arc height
h
height of the arched deformation of an Almen strip measured on the basis of a fixed span

Note 1 to entry: It is expressed in millimetres.

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3.5
saturation time
t
minimum time for which the successive increase of Almen arc height is 10 % for an additional exposure equal to time *t*, i.e. a total time of 2 *t*

3.6
peening intensity
intensity of shot peening, dependent on the kinetic energy of shots acting on the unit surface area of the workpiece per unit time, and is usually evaluated by the Almen arc height for the saturation time

3.7
saturation curve
trend curve representing the change of Almen arc height with time of shot peening, until the Almen arc height saturates

3.8
coverage
area ratio of the dents formed by shot impacts to the total area of the measuring surface

3.9
residual stress
internal stress of a material remaining after the removal of external forces and heat applied on it

3.10
particle size distribution
size distribution of shots

3.11
ordinary peening
mode of shot peening using one type of peening media nominally larger than 0,2 mm and resulting in an Almen arc height of between 0,15 mm and 0,6 mm (A)

3.12
multi-stage peening
mode of shot peening consisting of a series of peening at different conditions

Note 1 to entry: The name indicates the number of peening conditions combined, for example, “two-stage peening”.

Note 2 to entry: Two-stage peening is the one most practised. It usually consists of a first stage at an intensive peening condition with larger shots at higher speeds, and a second stage at moderate or weak peening condition. The first peening stage generates higher compressive residual stresses deep under the surface of a spring, while the compression is poor near the surface. The second peening generates shallower residual compressive stresses. The sum of the two compressive stresses would give a good distribution pattern of compressive stresses from the surface to the required depth.

3.13
stress peening
mode of shot peening applied under a static force corresponding to the working force of the spring during use

Note 1 to entry: Stress peening ensures that a spring will keep its intended compressive residual stresses under the applied tensile stresses at its working state. This is one of the frequently used techniques for laminated leaf springs, for example.

3.14
hot peening
mode of shot peening applied at elevated temperatures ranging from 150 °C to 350 °C for steel springs

Note 1 to entry: Hot peening is based on the ageing effect of steels. It is generally advantageous for achieving enhanced compressive residual stresses especially in hard steel springs.

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3.15
heavy peening
mode of shot peening resulting in an Almen arc height larger than 0,6 mm (A) using a peening media larger than 0,2 mm

3.16
fine peening
mode of shot peening resulting in an Almen arc height smaller than 0,15 mm (A) using a peening media not exceeding 0,2 mm

3.17
X-ray stress measurement
method for measuring internal stresses near the surface of polycrystalline materials based on X-ray diffraction techniques

4 Strategies for conducting shot peening

4.1 General

The mode, condition, category of peening machine, protection of non-peening surface and pre- and post-peening treatment should be determined based upon past experience and anticipated results prior to carrying out the process.

4.2 Mode of shot peening

The mode of shot peening shall be one of the following:

a) ordinary peening;

b) multi-stage peening;

c) stress peening;

d) hot peening;

e) heavy peening;

f) fine peening.

4.3 Conditions of shot peening

The conditions of shot peening shall be defined for the following items:

a) type of peening media and size;

b) desired Almen arc height, h, in combination with the class of Almen strip;

c) coverage, indicating the location and area of measurement;

d) processing time of shot peening, when this applies. A multiplication factor to the saturation time, t, could be indicated, instead of the Almen arc height, h, if this is agreed upon by the purchaser and supplier.

For multi-stage peening, the conditions of shot peening shall be indicated for individual stages.

NOTE Mechanical properties of peened material do not always directly correspond to the Almen arc height, since the effect varies depending on the size and shape of shots and the hardness of the material treated.

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4.4 Category of shot peening machine

There are two main categories of machines for springs, centrifugal and air-blasting, according to the projection method of shots. The former is suitable for projecting larger amounts of shots on wider areas treating several springs together, and the latter for smaller amounts, but at higher intensities on more focused areas.

The machine category shall be selected considering the design concepts of springs. Other specific details of the machine should be clarified, with its identification code, if necessary.

4.5 Protection of non-peening surface

Areas that do not require shot peening shall be clearly defined. Selected areas where the peening must not affect the springs surface shall be protected as required by appropriate means, such as shields, masks or adhesive tapes.

4.6 Pre- and post-peening treatments

Requirements shall be indicated for:

a) pre-peening treatment (e.g. cleaning and degreasing);

b) post-peening treatment (e.g. rust protection, coating and wrapping).

Care should be taken to prevent rusting, as it is generally easy for shot peened materials to start rusting, especially in moist air.

5 Peening media

The type of media used shall be as given in Table 1.

Table 1 — Types of peening media

Type Name	Code	Material	Apparent density 10^3 kg/m^3	Shape	Nominal diameter mm	Hardness HV
Conditioned cut wire shot	CCW	Steel	7,65 to 7,95	Near spherical	0,2 to 3	350 to 850
Cast steel shot	SS	Cast steel	7,45 min.	Spherical	4 max.	200 to 850
Glass beads	GB	Glass	2,30 min.	Spherical	1 max.	450 to 550
Ceramic beads	CB	Ceramic	3,60 to 3,95	Spherical	1 max.	500 to 800
NOTE 1 Cut wire shot can be used if conditioned in-house before shot peening springs to prevent unacceptable surface damage. NOTE 2 If cut wire shot is used, the characteristic of CCW in Table 1 is applied to cut wire shot.						

Any other type of spherical or near spherical media can be used upon agreement between the purchaser and supplier, if it can be demonstrated that no adverse damage is done.

6 Almen strip

6.1 Class of Almen strip

Almen strips shall be one of the three classes defined in Table 2, all having the same shape and size as shown in Figure 1.

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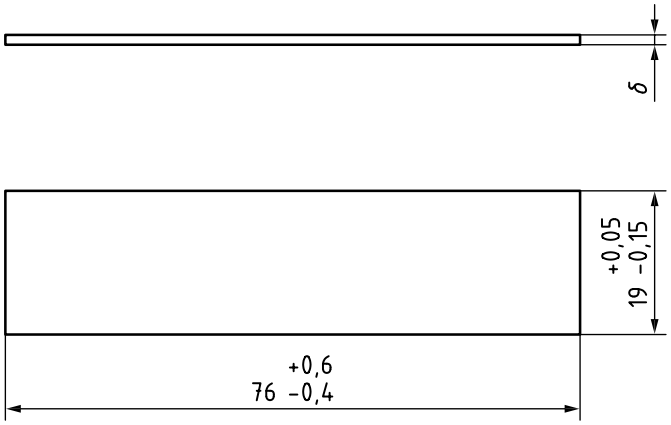
Table 2 — Classes of Almen strip

Class	Thickness, δ mm		Hardness [a]	Flatness tolerance [b] mm	Material
	Nominal	Tolerance			
N	0,8	+0,01 −0,04	72,5 – 76 HRA	0,025	Carbon steel, with 0,60 % to 0,80 % of carbon
A	1,3	+0,02 −0,03	44 – 50 HRC	0,025	
C	2,4	+0,01 −0,04	44 – 50 HRC	0,038	

[a] ISO 6508-1.

[b] ISO 1101.

Dimensions in millimetres



Key

δ thickness

Figure 1 — Shape and size of test strip

6.2 Selection of the class of Almen strip

An appropriate class of Almen strip shall be selected, taking into consideration the intensity of shot peening. Various classes of Almen strips give generally different Almen arc heights, h, according to their thickness, δ, even under the same peening condition.

Strip A is for general use in the middle range of peening intensities, and strips N and C are for lower and higher ranges, respectively. Type A Almen strips shall be used for Almen arc heights not greater than 0,6 mm.

6.3 Almen strip holder

An Almen strip shall be fixed on a thick steel holder as defined in Figure 2. The holder shall have a flat mounting surface with fastening screws that keep the Almen strip flat in contact with the surface during peening. Care is required so that the screw heads do not affect Almen arc height. The hardness of the holder should be at least 57 HRC to avoid early wear.

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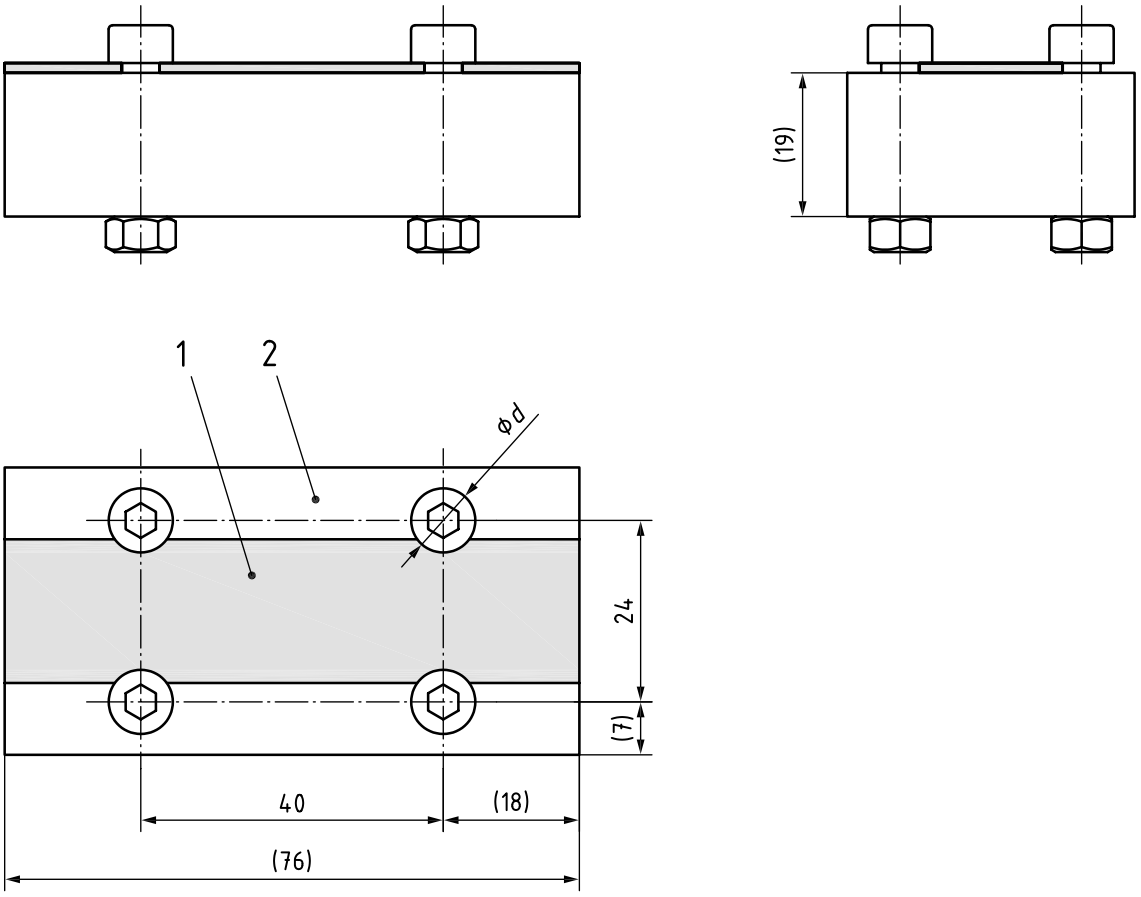
Dimensions in millimetres

	Head diameter, *d*	
	Nominal	**Tolerance**
Round head screw	9	0 -0,6
Hexagon socket head cap screw	8,5	0 -0,36



Key

1 Almen strip
2 holder
d head diameter

NOTE Values in parentheses are for information only.

Figure 2 — Shape and dimensions of Almen strip holder

7 Method of measurement

7.1 Measurement of Almen arc height

Almen arc height, *h*, shall be measured, on the unpeened surface of an Almen strip, as the height of the midpoint e from a reference plane defined by the points a, b, c and d, as shown in Figure 3. Almen

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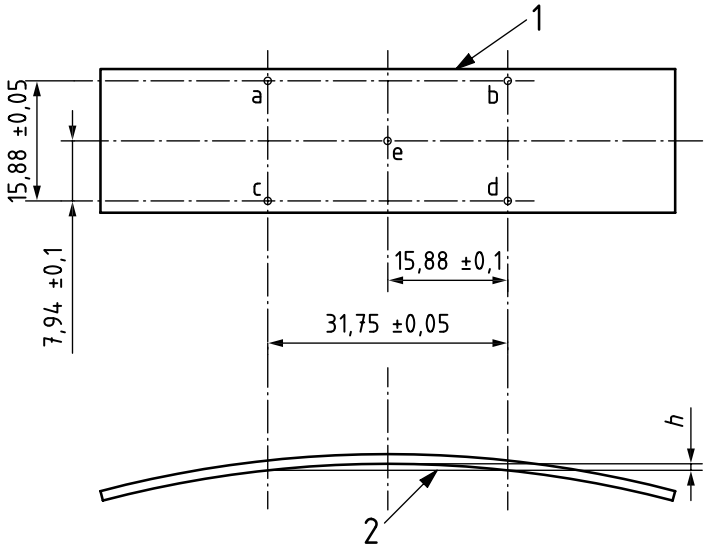
arc height shall be determined to a resolution of 0,01 mm by appropriate means. Annex C supplies information about a commonly used device, known as the Almen gauge.

Almen arc height, *h*, shall be expressed with the class of test strip in parentheses, as in the following examples.

EXAMPLE 1 0,35 mm (A): Almen arc height of 0,35 mm by Almen strip A.

EXAMPLE 2 0,20 mm (C): Almen arc height of 0,20 mm by Almen strip C.

Dimensions in millimetres



Key

1 Almen strip
2 reference plane
h Almen arc height

Figure 3 — Definition of Almen arc height

7.2 Evaluation of coverage

Coverage shall be evaluated either on a spring surface or a suitable reference surface as agreed upon by the purchaser and supplier. The numerical value shall be rounded to the nearest of 5 % step in accordance with ISO 80000-1.

Coverage may be determined by comparing the magnified photographs of peened surface with the standard photographs given in Annex A.

A supplemental strip or coupon may be used to evaluate the coverage by agreement between the purchaser and supplier. It should have an equivalent hardness to the spring to treat and be fixed on a solid holder similar to the test strip holder. Its surface is preferably polished with a buff for easy observation.

The coverage value can be used in practice to indicate the treatment time of shot peening. In such a case, the length of time taken to reach 100 % coverage is regarded as a unit. The treatment time would then be expressed as 200 % coverage time for twice the unit time length, and 300 % coverage time for three times the unit time length, for example.

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7.3 Determination of saturation time

The corresponding Almen arc height, *h*, is expected to be obtained by doing shot peening until saturation time, *t*, as long as the operating condition of the device is kept constant. The method for determining saturation time, *t*, is given in Annex B.

8 Shot peening machine

Machines for shot peening shall be able to generate a stream of shots, preferably continuous and uniform, to hit perpendicularly against the spring surface to treat. The stream of shot should be preferably unidirectional and at a constant speed, so that the desired peening intensity can be obtained by adjusting the exposure time to the shot flow. Shot peening machines shall have the following functions:

a) regulation of the flow rate of peening media by means of an orifice or gate valve;

b) adjustment of the ejecting speed of the media by variation of the rotational speed of the wheel, in the case of centrifugal machines;

c) adjustment of the ejecting speed of the media by variation of the air pressure and/or the flow rate, in case of air blasting machines.

See 4.4 for details of the types of peening machine.

9 Control of shot peening

9.1 Almen arc height

Initial peening verification requires generation of a full saturation curve with a minimum of four Almen strips to establish the process parameters, then routine repeat production may use a simplified peening intensity measurement with only one Almen strip to verify that the peening intensity is within tolerance. The verification procedure shall be agreed upon by the purchaser and supplier.

9.2 Coverage

Coverage assessment should be made at suitable intervals.

10 Measurement of residual stress

Residual stresses may be measured to evaluate the actual improvement brought by the shot peening process, when this is agreed upon by the purchaser and supplier. It is recommended that the measurement be made according to the X-ray stress measurement method.

11 Report

The following items shall be recorded and reported upon request by the purchaser:

a) the mode of peening;

b) the type of shot;

c) the Almen arc height, *h* (target range and actual value obtained);

d) the coverage or processing time;

e) the category of peening machine;

f) the residual stress when measured.

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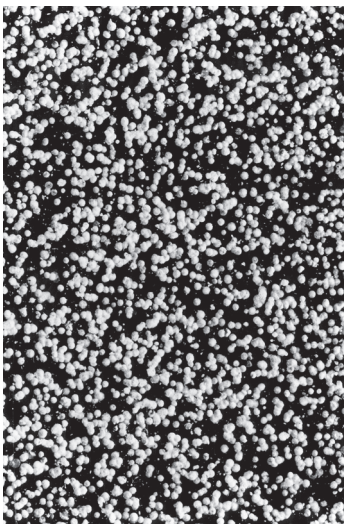
Annex A
(informative)

Standard photographs of coverage

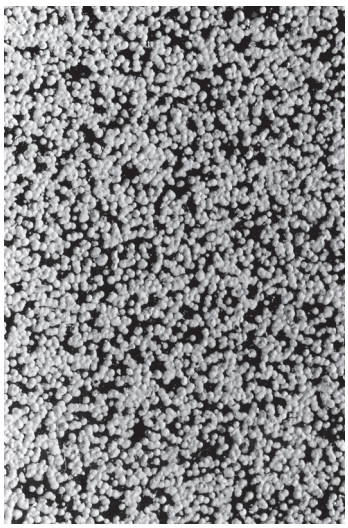
A.1 General

This annex specifies the standard photographs of coverage by shot peening.

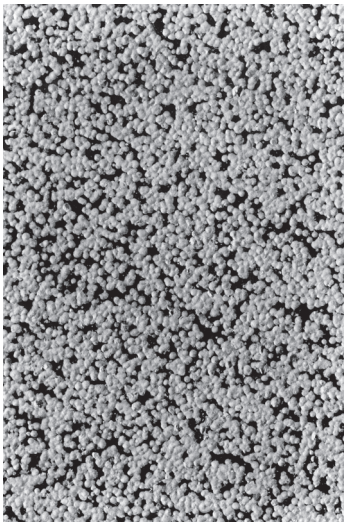
A.2 Standard photographs



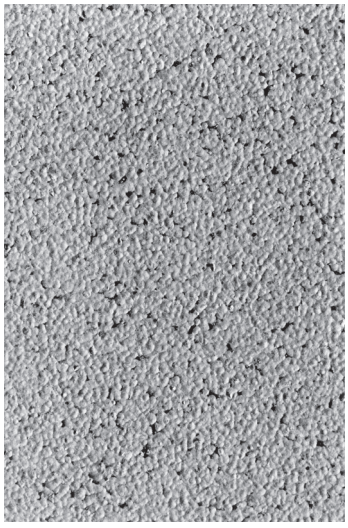
a) Coverage of 50 %



b) Coverage of 70 %



c) Coverage of 85 %



d) Coverage of 100 %

NOTE Actual values for a), b), c) and d) before rounding are: 50,0, 69,8, 85,2 and 97,7, respectively.

Figure A.1 — Standard photographs of coverage

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Annex B
(informative)

Saturation time

B.1 General

This annex describes the method for determination of the saturation time, *t*, from a saturation curve.

B.2 Saturation time

Determine saturation time, *t*, according to the following procedure.

a) Conduct shot peening with four or more Almen strips under a planned condition (peening media, flow rate and machine type), and trace an average trend curve, as shown in Figure B.1, which represents a saturation curve.

b) Draw lines parallel to the vertical axis from an arbitrary time *t* and the time 2 *t*, and define intersections of the parallel lines with the saturation curve as B_1 and B_2, respectively.

c) Draw lines parallel to the horizontal axis from B_1 and B_2 and define intersections of the parallel lines with the vertical axis as C_1 and C_2, respectively.

d) The saturation time, *t*, is the minimum time for which the increase of Almen arc height, *h*, from *t* to 2 *t* does not exceed 10 % of the value at *t*.

e) Verification of the peening intensity is made for one Almen strip, when required, by checking the resultant Almen arc height by indicated process. Details for verification procedure shall be agreed upon by the purchaser and supplier.

f) Items a) to d) describe the procedure for initial verification and item e) is the procedure used for routine monitoring.

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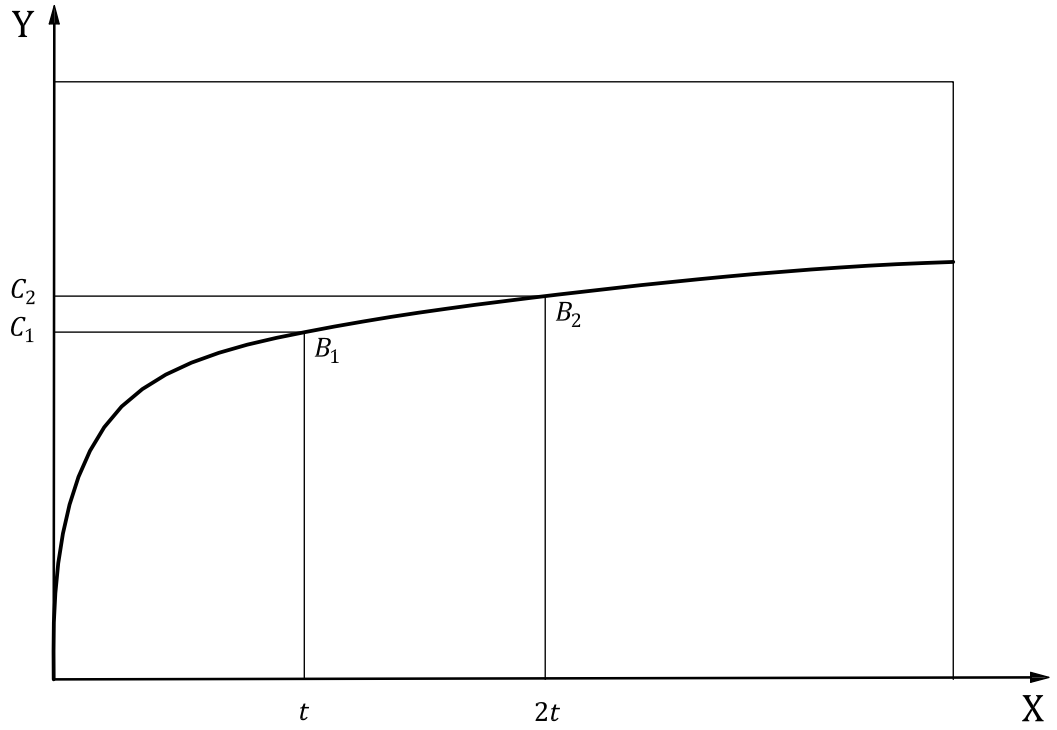

Key

X time, t

Y Almen arc height, h

Figure B.1 — Saturation curve

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Annex C
(informative)

Almen gauge

C.1 General

This annex describes the Almen gauge used for the measurement of the Almen arc height, *h*.

C.2 Almen gauge

The Almen gauge is a special device for measuring the deformation of test strip, as illustrated in Figure C.1.

Four steel balls create a reference plane for the measurement.

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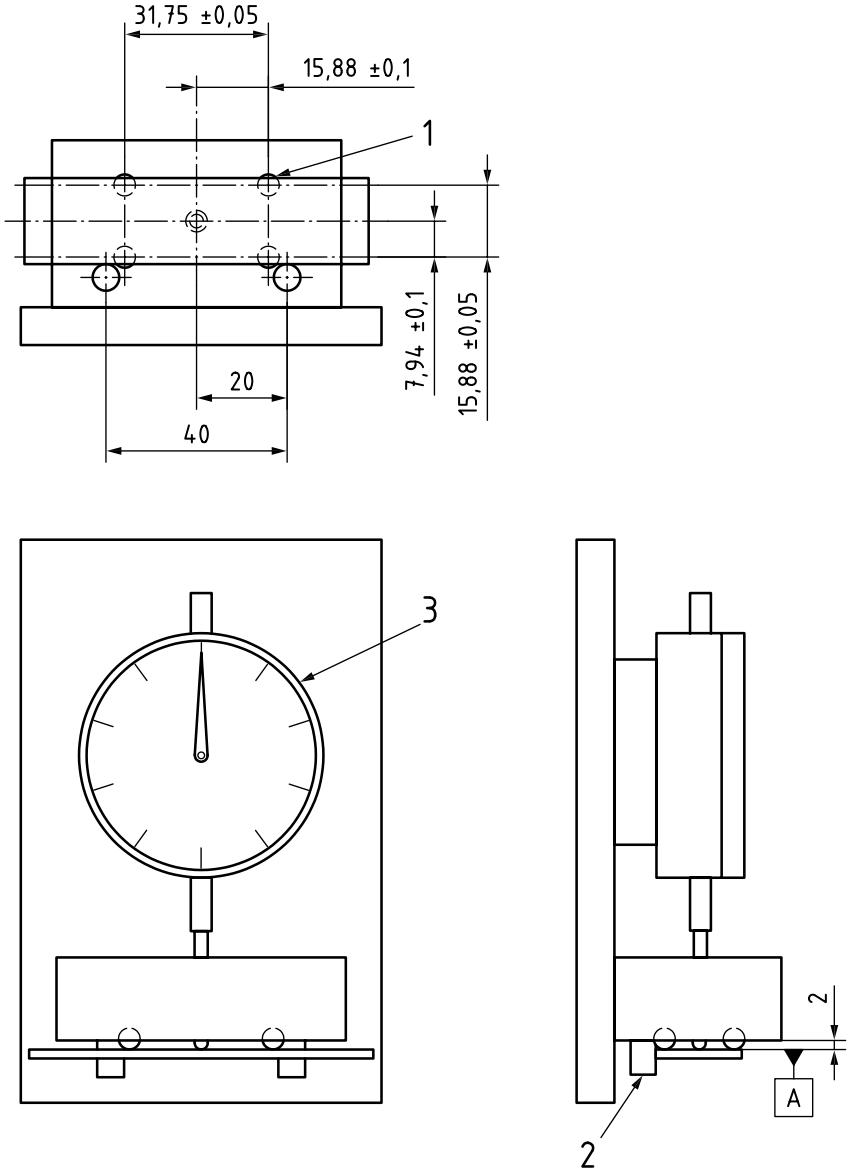
Dimensions in millimetres



Key

1 ⌀4,76 steel ball
2 guide pin
3 measuring device (dial gauge, etc.)

Figure C.1 — Almen gauge

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[1] ISO 1101, *Geometrical product specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out*

[2] ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method*

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