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Preparation of steel substrates before application of paints and related products — Test methods for metallic blast-cleaning abrasives —

Part 9:
Wear testing and performance

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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 documents 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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This document was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 12, *Preparation of steel substrates before application of paints and related products.*

A list of all parts in the ISO 11125 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.

Introduction

This document is a part of the ISO 11125 series that specifies test methods for metallic blast-cleaning abrasives.

During blast-cleaning, metallic abrasives are subjected to repeated impacts on the substrate to be prepared. These mechanical impacts result in abrasive material fatigue until particles breakdown.

The service life of the metallic blast-cleaning abrasives is influenced by:

— the type of abrasive, in particular, its size and shape, its resilience, its hardness and its internal defects;

— the hardness and the surface conditions of the substrate to be prepared;

— the blasting machine and its settings.

The principle of an abrasive service life testing machine is based on a high number of impacts between a representative sample of the abrasive to be tested and a given target.

Several testing machines exist on the market and depending on their design, the service life obtained under laboratory conditions may or may not be comparable to field operation.

It is important that the user is aware of the different parameters and the respective adjustability. The parameters of the testing machines can vary from one machine to another and therefore can result in different test results.

In general, the effect of wear and consumption are tested. Special arrangements may be required for specific test procedures. The results can be used for comparison purposes (quality inspection) or for monitoring (quality control) of the deliveries for uniformity.

Preparation of steel substrates before application of paints and related products — Test methods for metallic blast-cleaning abrasives —

Part 9: Wear testing and performance

1 Scope

This document specifies three procedures to test the service life of a blast-cleaning abrasive under laboratory conditions.

The performance of an abrasive is also measured by its ability to clean, via transmission of kinetic energy to the substrate in the blasting process. This document also specifies the procedures that can be performed in the same testing machines to help evaluate abrasive performance under laboratory conditions.

This document applies to the testing of virgin metallic blasting media in the delivery state by centrifugal blasting under laboratory conditions.

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 11124-3, *Preparation of steel substrates before application of paints and related products — Specifications for metallic blast-cleaning abrasives — Part 3: High-carbon cast-steel shot and grit*

ISO 11124-4, *Preparation of steel substrates before application of paints and related products — Specifications for metallic blast-cleaning abrasives — Part 4: Low-carbon cast-steel shot*

ISO 11124-5, *Preparation of steel substrates before application of paints and related products — Specifications for metallic blast-cleaning abrasives — Part 5: Cut steel wire*

ISO 11125-1, *Preparation of steel substrates before application of paints and related products — Test methods for metallic blast-cleaning abrasives — Part 1: Sampling*

ISO 11125-2, *Preparation of steel substrates before application of paints and related products — Test methods for metallic blast-cleaning abrasives — Part 2: Determination of particle size distribution*

ISO 11125-3, *Preparation of steel substrates before application of paints and related products — Test methods for metallic blast-cleaning abrasives — Part 3: Determination of hardness*

ISO 11125-4, *Preparation of steel substrates before application of paints and related products — Test methods for metallic blast-cleaning abrasives — Part 4: Determination of apparent density*

ISO 11125-5, *Preparation of steel substrates before application of paints and related products — Test methods for metallic blast-cleaning abrasives — Part 5: Determination of percentage defective particles and of microstructure*

ISO 11125-6, *Preparation of steel substrates before application of paints and related products — Test methods for metallic blast-cleaning abrasives — Part 6: Determination of foreign matter*

ISO 11125-7, *Preparation of steel substrates before application of paints and related products — Test methods for metallic blast-cleaning abrasives — Part 7: Determination of moisture*

ISO 12944-4, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 4: Types of surface and surface preparation*

ISO 565:1990, *Test sieves — Metal wire cloth, perforated metal plate and electroformed sheet — Nominal sizes of openings*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11124-3, ISO 11124-4, ISO 11124-5, ISO 11125-1, ISO 11125-2, ISO 11125-3, ISO 11125-4, ISO 11125-5, ISO 11125-6, ISO 11125-7, ISO 12944-4 and the following 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
blast-cleaning abrasive
solid material intended to be used for abrasive blast-cleaning

3.2
service life
duration of the usability of the *blast-cleaning abrasive* (3.1)

Note 1 to entry: In this field of application the service life is given in the number of cycles in which 100 % of the material wears. In practice, the worn material is removed from the system by ventilation, in the laboratory this is achieved by sieving.

3.3
abrasive consumption
weight of loss of abrasive divided by the weight of thrown abrasive

Note 1 to entry: It is expressed in g/1 000 kg.

3.4
Almen strip
UNS G10700 carbon steel specimen that is used to calibrate the energy of an abrasive stream

3.5
Almen strip holding fixture
device used to fasten *Almen strips* (3.4) in suitable locations that represent the position and angular orientation of the surfaces of a part where the intensity is to be determined and verified

3.6
arc height
flat *Almen strip* (3.4) that, when subjected to a stream of shot moving at an adequate velocity, bends in an arc corresponding to the amount of energy transmitted by the shot stream

Note 1 to entry: The height of the curved arc measured in millimetre is the arc height, measured by an Almen gauge.

3.7
Almen intensity
Almen strip *arc height* (3.6) at saturation

Note 1 to entry: This term comes into effect only when saturation is achieved.

Note 2 to entry: Surface preparation is not solely a question of Almen intensity. Size and hardness of the blasting media are important to achieve a good surface cleaning or a good surface roughness.

3.8
saturation
minimum number of cycles necessary to achieve the desired *Almen intensity* (3.7) which, when doubled does not increase the Almen strip *arc height* (3.6) by more than 10 %

3.9
saturation curve
curve that plots Almen strip *arc height* (3.6) (ordinate) with the number of cycles (abscissa)

Note 1 to entry: See Figure 2.

3.10
transmitted energy
ability of the abrasive to transmit its kinetic energy to the substrate to perform useful work in cleaning or preparing the surface

4 Principle

The service life of metallic blast-cleaning abrasive is determined by various factors. It is dependent on the substrate itself, on the blasting system and its operating parameters, as well as on the blasting media. Therefore, laboratory testing can only give an indication of the consumption or wear of the metallic blast-cleaning abrasive.

5 Samples

Sampling for either preliminary testing or testing by centrifugal blasting under laboratory conditions, or both, shall be carried out in accordance with ISO 11125-1. The sample taken should be about 1 kg to 2 kg. This is sufficient material to complete the full suite of tests.

6 Preliminary testing

All abrasive samples should be tested for particle size distribution, hardness, density, defects, microstructure and foreign matter according to ISO 11125-2, ISO 11125-3, ISO 11125-4, ISO 11125-5 and ISO 11125-6, respectively. Samples which fail preliminary testing shall not be subject to centrifugal blasting machine tests.

7 Apparatus

7.1 Abrasive service life testing machine, whose principle is based on a high number of impacts between a representative sample of the abrasive to be tested and a given target.

The design and operation of the testing machine are specified in the operating instructions.

Depending on the design of the testing machines, the force of the impact between the abrasive and the target is controlled by the speed of the abrasive or by the speed of the target. The setting of these speeds shall be done as recommended by the manufacturer.

The test machine is equipped with a device allowing the recirculation of the abrasive after each cycle, the test media remaining in the machine for a predetermined number of cycles, or test interval.

Calibration of the testing machine shall be done as recommended by the manufacturer, using a representative sample of an abrasive of known service life.

NOTE Different testing machines produce different results.

7.2 Balance, capable of weighing to an accuracy of 0,1 g.

7.3 Test sieves, circular, with a height of 25 mm to 50 mm and a sieving area approximately 200 mm diameter, made of woven metal wire cloth. The frame of the test sieves shall be of metal. The range of nominal mesh apertures depends on the nominal size of the product to be tested and the cut point according to the application (see Table 2) and shall comply with the requirements of ISO 565:1990, Table 2. The sieves shall have square openings. A lid and a residue pan shall also be provided.

7.4 Sieve shaker.

7.5 Sample divider.

8 Blast-cleaning abrasive testing under laboratory conditions

8.1 Testing machines

The design and operation of a test machine is specified in the operating instructions.

Calibration of a test machine shall be done as recommended by the manufacturer.

NOTE Different testing machines produce different results.

8.2 Test method procedures

8.2.1 100 % breakdown method

8.2.1.1 Test procedure average life measurement

The breakdown curve typical of the abrasive particle is obtained by running a representative sample through a set of cycles dependant on the hardness of the abrasive as defined in Table 1. After each set of cycles, the material is sieved to remove undersized material using an appropriately sized cut point sieve (see Table 2). The percentage of undersize shall be recorded and set aside as a control. The material above the cut point is then reintroduced into the machine and the test is repeated for another set of cycles. This is repeated until the percentage of retained material is equal to or less than 3 %. The percentage retained is then plotted against the number of cycles. The percentage retained is extrapolated to 0 for the next test cycle interval. The service life of the material is determined by measuring the area under the histogram. The abrasive removed by sieving is then weighed to determine the loss in the machine. The loss in the machine should be less than 1 %.

Refer to the machine manufacturers' manual for the size of sample to be used in the test.

Table 1 — Recommended test cycles

Hardness of the unused grain [HV 1]	Test cycle interval *n*
< 550	500
550 – 700	300
> 700	100

Table 2 — Dimension of the cut point sieve according to the abrasive blasting application and the nominal dimension of the blasting media

Application	Cut point sieve
Surface preparation and descaling	1/4 nominal dimension
Desanding	1/3 nominal dimension
Shot peening	1/2 nominal dimension

NOTE The nominal dimension is defined for each type of metallic abrasive in the relevant part of the ISO 11124 series.

8.2.1.2 Test evaluation

The service life is defined as the area under the curve of the % retained plotted against the number of cycles.

The area can be calculated as the sum of the areas of the trapezoids that can be drawn after each set of cycles.

The area of one trapezoid a_i (see dark grey in Figure 1) can be calculated as:

$$a_i = n \cdot \left(r_{i+1} + \frac{r_i - r_{i+1}}{2} \right)$$

The area, A, under the curve (see light grey in Figure 1) can be expressed as:

$$A = \sum_{i=0}^{N} a_i = n \left(\frac{r_0}{2} + \sum_{i=1}^{N} r_i \right) = n \left(50 + \sum_{i=1}^{N} r_i \right)$$

where

n is the number of cycles per test interval;

r_i is the % retained after the i sets of n cycles;

N is the number of sets of n cycles necessary to end the test.

NOTE r_0 = 100 % and r_{N+1} = 0.

The area A is expressed in % cycle.

The service life of the sample expressed in cycle is equal to A/100.

Considering that one cycle matches one throw, the consumption of the abrasive expressed in g/1 000 kg can be calculated as the inverse of the average life expressed in cycle multiplied by 10^6.

8.2.1.3 Example

Tested abrasive: ISO 11124 M/HCS/S118/430 HV (ISO 11124-3)

Test cycle interval: n = 500 cycles

Application: desanding (to determine cut point)

Rejection size sieve 0,425 mm

The service life of the abrasive has been tested following the 100 % breakdown method. For this abrasive, the number N of set of cycles is 13.

The % retained values r_i recorded during testing are reported in Table 3 and plotted in Figure 1.

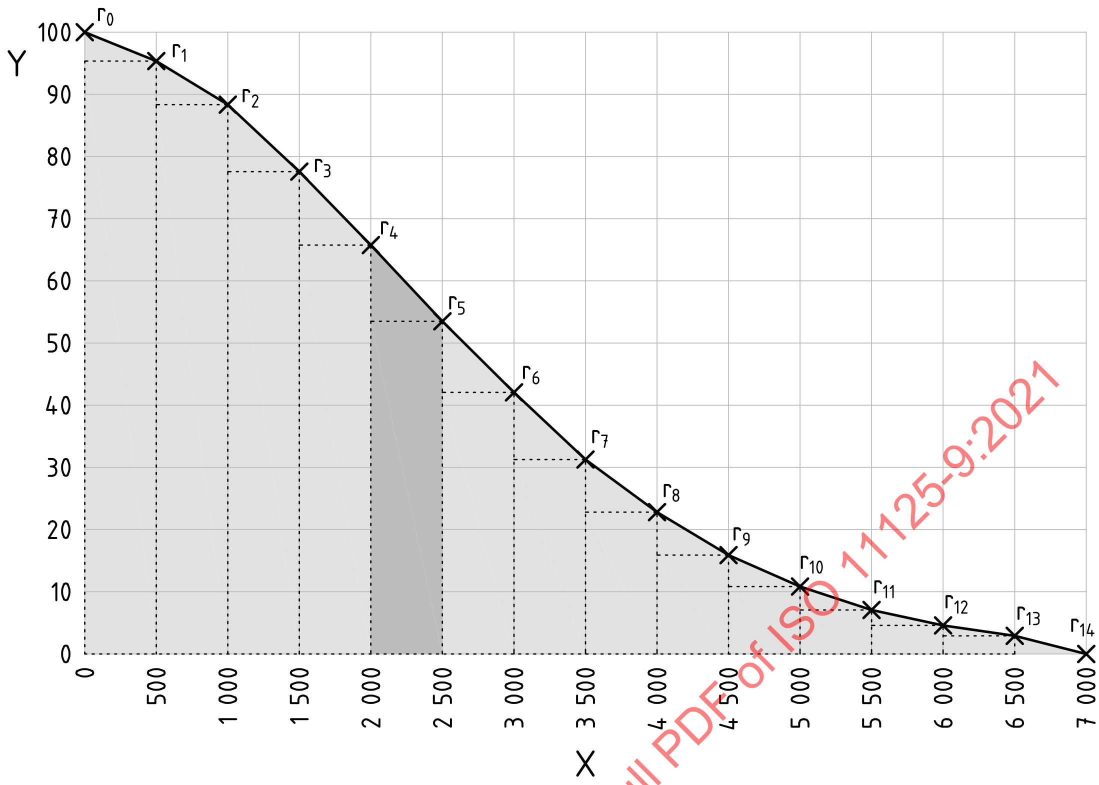
Table 3 — Percentage retained recorded during testing

Number of set of cycles	Cumulative number of cycles	% retained r_i	Trapezoid area a_i expressed in %. cycle
0	0	100	48 750
1	500	95	45 750
2	1 000	88	41 500
3	1 500	78	36 000
4	2 000	66	30 000
5	2 500	54	24 000
6	3 000	42	18 250
7	3 500	31	13 500
8	4 000	23	9 750
9	4 500	16	6 750
10	5 000	11	4 500
11	5 500	7	3 000
12	6 000	5	2 000
13	6 500	3	750
14	7 000	0	0

For the example given, the area under the curve is equal to:

$$A = 284\ 500\ \%.\text{cycle}$$

The service life expressed in cycles is $A/100$, that is 2 845 cycles for the data reported in the example and the consumption is 351 g per 1 000 kg of thrown abrasive.



Key

X number of cycles

Y % retained

Figure 1 — Percentage retained plotted against the number of cycles

8.2.2 Full wear test (100 % replacement method)

8.2.2.1 Test procedure

The number of passes per test interval is set on the test machine according to Table 1 and a representative sample is fed into the testing machine. After each test interval, the blasting abrasive shall be removed from the test machine and sieved to remove undersized material using an appropriately sized cut point sieve (see Table 2). The mass loss shall be recorded, and the retained sample is made up to the original sample weight with abrasive from the original sample and returned to the test machine. This process shall be repeated until the cumulative mass loss is at least 100 % of the initial charge.

8.2.2.2 Test evaluation

The 100 %-durability, N_{100}, in number of cycles, is calculated from:

$$N_{100} = N_{\Sigma} - \frac{n}{v_{\mathrm{I}}} \cdot (V_{\Sigma} - 100)$$

where

N_Σ is the cumulative number of passes over all test cycles;

n is the test cycle interval, in number of cycles;

v_l is the loss at the last test cycle, in percent;

V_Σ is the cumulative loss over all test cycles, in percent.

The 100 % replacement method determines the number of cycles required to breakdown a quantity of abrasive equal to the initial quantity loaded in the test machine.

8.2.2.3 Example

Tested abrasive: ISO 11124 M/HCS/S140/480 HV (ISO 11124-3)

Test cycle interval: n = 500 cycles

Application: desanding (to determine cut point)

Cut point 0,425 mm

The percentage retained values recorded during testing are reported in Table 4.

Table 4 — Percentage retained recorded during testing

Cumulative number of cycles	Percentage retained	Percentage loss	Percentage cumulative loss
0	100		
500	93,0	7,0	7,0
1 000	85,6	14,4	21,4
1 500	82,4	17,6	39,0
2 000	80,0	20,0	59,0
2 500	80,7	19,3	78,3
3 000	81,7	18,3	96,6
3 500	83,7	16,3	112,9

For the example given, the cumulative number of passes N is 3 500, the loss at the last test cycle interval is 16,3 %, and the cumulative loss over all test is 112,9 %.

The service life of this abrasive measured according to the 100 % replacement method is then

$$N_{100} = 3\ 500 - \frac{500}{16,3}(112,9 - 100) = 3\ 104 \text{ cycles}$$

8.2.3 Stabilized consumption test

8.2.3.1 Test procedure

The number of passes per test interval is set on the test machine according to Table 1 and a representative sample is fed into the testing machine. After each test interval, the blast-cleaning abrasive shall be removed from the test machine and sieved to remove undersized material using an appropriately sized cut point sieve (see Table 2). The mass loss shall be recorded, and the retained sample is made up to the original sample weight with abrasive from the original sample and returned to the test machine. This process shall be repeated until, for three consecutive test cycles, the difference between the largest and the smallest values of the mass loss is less than 3 % of the mean value of these three consecutive mass losses.

8.2.3.2 Test evaluation

The abrasive consumption, expressed in g/1 000 kg, can be calculated as

$$\frac{10^6}{n}\frac{v_m}{100-\frac{v_m}{2}}$$

where

v_m is the mean value of the last three measured mass losses, in percent;

n is the test cycle interval, in number of cycles.

8.2.3.3 Example

Tested abrasive: ISO 11124 M/CW/C200/410 HV (ISO 11124-5)

Tested cycle interval: 500

Application: surface preparation (to determine cut point)

Rejection size sieve: 0,5 mm

The consumption of the abrasive has been tested following the stabilized consumption method. The percentage loss recorded during testing is reported in Table 5. For this abrasive, the number N of set of cycles is 18.

Table 5 — Percentage loss recorded during t testing

Number of set of cycles	Cumulative number of cycles	% retained	% loss	Average of three consecutive losses	Stabilization criteria[a] %
0	0	100,00	—	—	—
1	500	80,20	19,80	—	—
2	1 000	80,20	19,80	—	—
3	1 500	81,77	18,23	19,28	8,1
4	2 000	84,16	15,84	17,96	22,1
5	2 500	85,71	14,29	16,12	24,4
6	3 000	85,78	14,22	14,78	11,0
7	3 500	86,76	13,24	13,92	7,5
8	4 000	87,19	12,81	13,42	10,5
9	4 500	87,68	12,32	12,79	7,2
10	5 000	87,32	12,68	12,60	3,9
11	5 500	86,27	13,73	12,91	10,9
12	6 000	84,80	15,20	13,87	18,2
13	6 500	85,22	14,78	14,57	10,1
14	7 000	85,85	14,15	14,71	7,1
15	7 500	85,29	14,71	14,55	4,3
16	8 000	84,80	15,20	14,69	7,1
17	8 500	84,80	15,20	15,04	3,3
18	9 000	84,73	15,27	15,22	0,5

[a] The stabilization criteria is calculated as the difference between the largest and the smallest values of the mass loss for three consecutive test cycles divided by the mean value of these three consecutive mass losses.

The consumption measured according to the stabilized consumption test is 329 g per 1 000 kg of thrown abrasive.

9 Transmitted energy tests

9.1 Transmitted energy test (100 % replacement)

9.1.1 General

To fully assess the performance of an abrasive, a transmitted energy test can be performed on the used material resulting from the full wear test (100 % replacement method, see 8.2.2). If the design of the testing machine allows, a standard test strip is placed in the blast stream. The curvature of the strip after impact by the abrasive indicates the level of energy transmitted by the particles to the strip.

9.1.2 Test method

After the full wear test, a representative 50 g sample of the used abrasive is taken. A standard test strip is selected, checked that it is flat, and then inserted into the test machine, fastening to a standard test strip holder. Load the sample into the machine. Expose the test strip to the blast stream for 40 cycles, then remove the strip and measure arc height (curvature). The difference in curvature between the strip before and after the test indicates the transmitted energy for the given exposure time.

9.2 Transmitted energy test (at full saturation)

9.2.1 General

The Almen arc rise is very dependent on the number of cycles, 40 cycles may not represent standard strip saturation for all sizes. It may be necessary to develop a full saturation curve to fully understand the performance of the shot under test.

9.2.2 Test method

Calibration of the Almen gauge shall be checked as recommended by the manufacturer.

An Almen strip is placed in the test machine fastened to the Almen strip holding fixture and a 50 g representative sample of the resulting mix obtained using the 100 % replacement or stabilized consumption method is fed into the testing machine. After a given number of cycles, the test strip is removed to measure the corresponding arc height with the Almen gauge.

The test is repeated at least four times by fastening an unused test strip in the testing machine and by doubling the number of cycles between each test.

NOTE The first arc height measure is usually done by fixing the number of cycles between two and five.

9.2.3 Test evaluation

The Almen intensity is determined by interpreting the saturation curve.

It is recommended to use a saturation curve solver application to determine the Almen intensity (see NF L06-832:2008, Annex D[5]).

9.2.4 Example

Tested abrasive: ISO 11124 M/HCS/S118/480 HV (ISO 11124-3)

The resulting mix has been obtained with the stabilized consumption method and cut point of 0,590 mm. The arc heights recorded during testing are reported in Table 6 and plotted in Figure 2.

