# RWANDA STANDARD

# DRS

# 532

First edition

2023-mm-dd

## Natural stone test methods — Determination of abrasion resistance

**ICS 73.020; 91.100.15**

Reference number

DRS 532: 2023

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# Contents

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# Foreword

Rwanda Standardsarepreparedby Technical Committees and approved by Rwanda Standards Board (RSB) Board of Directors in accordance with the procedures of RSB, in compliance with Annex 3 of the WTO/TBT agreement on the preparation, adoption and application of standards.

The main task of technical committees is to prepare national standards. Final Draft Rwanda Standards adopted by technical committees are ratified by members of RSB Board of Directors for publication and gazettment as Rwanda Standards.

DRS532was prepared by Technical Committee RSB/TC 9, *Civil engineering and building materials.*

In the preparation of this standard, reference was made to the following standard:

BS EN 14157:2004, Natural stone test method — Determination of abrasion resistance

The assistance derived from the above source is hereby acknowledged with thanks.

## Committee membership

The following organizations were represented on the Technical Committee on *Civil engineering and building materials*(RSB/TC 9) in the preparation of this standard.

A+Construction Group Ltd

Africeramics Ltd

Consultants Engineers Group (CEG) Ltd

D&D Resources Ltd

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# Natural stone test methods — Determination of resistance of marble to thermal and moisture cycles

## 1   Scope

This Draft Rwanda standards specifies three test methods to determine the abrasion resistance of natural stones used for flooring in buildings. One of the methods – the 'wide wheel abrasion method' is defined as the reference method.

## 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 editioncited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

RS ISO 630-2,*Hot rolled products of structural steels - Technical delivery conditions*

DRS 530, *Natural stone test methods: Determination of geometric characteristics on units*

ISO 4288, *Geometrical Product Specifications (GPS) -- Surface texture: Profile method -- Rules and procedures for the assessment of surface texture*

RS ISO 6506-1, *Metallic materials -- Brinell hardness test -- Part 1: Test method*

## 3   Terms and definitions

For the purposes of this standard,the following terms and definitions given in RSISO 630-2 , DRS 530,  ISO 4288,  RS ISO 6506-1 apply.

## 4   Method A – Wide Wheel Abrasion Test

### 4.1   Principle

The test is carried out by abrading the face of a specimen which will be exposed in use with an abrasive materialunder standard conditions.

### 4.2   Abrasive material

The abrasive required for this test shall be a corundum (white fused alumina) with grit size of 80. It shall not be used for more than three times.

## 4.3 Apparatus

### 4.3.1 The 'wearing' machine

The wearing machine (see Figure 1) is essentially made of a wide abrasion wheel, a storage hopper with one or two control valves to regulate the output of the abrasive material, a flow guidance hopper, a clamping trolley and a counterweight.

When two valves are used, one shall be used to regulate the rate of flow and can be permanently set while the other is used to turn the flow on and off.
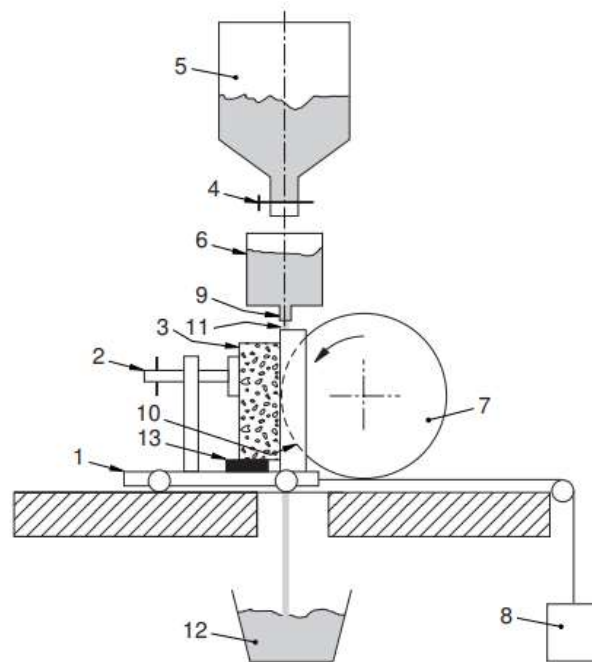


**Key**

1 Clamping trolley
2 Fixing screw
3 Specimen
4 Control valve
5 Storage hopper
6 Flow guidance hopper
7 Wide abrasion wheel
8 Counterweight
9 Slot
10 Groove
11 Abrasive material flow
12 Abrasive collector
13 Wedge

**Figure 1 — Principle of the wearing machine**

The wide abrasion wheel shall be made of steel Fe 690 according to ISO 630-2. The hardness of the steel shall be between 203 HB and 245 HB. Its diameter shall be (200 ± 1) mm and its width shall be (70 ± 1) mm. It shall be driven to rotate 75 revolutions in (60 ± 3) seconds.

A mobile clamping trolley is mounted on bearings and forced to move forwards to the wheel by a counterweight having a mass of (14 ± 0,01) kg.

The storage hopper containing the abrasive material feeds a flow guidance hopper.

The flow guidance hopper may have a cylindrical or rectangular cross-section and shall have a slotted outlet. The length of the slot shall be (45 ± 1) mm and the width shall be (4 ± 1) mm. The body of the flow guidance hopper shall be at least 10 mm bigger than the slot in all directions. In the case of a hopper with a rectangular crosssection and at least one of the sides inclined down to the length of the slot, these dimensional limitations are not necessary (see Figure 2)
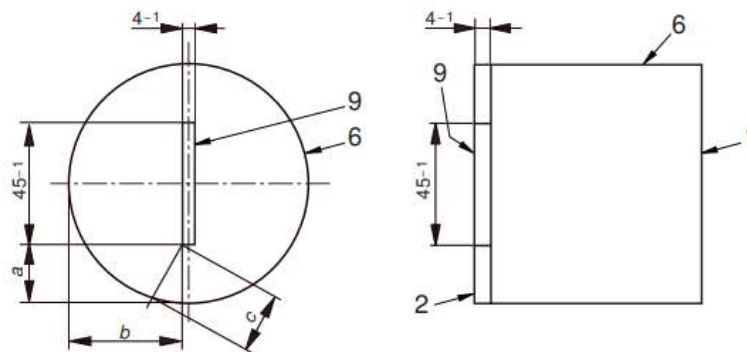


For key see Figure 1

1 Inclined side

2 Vertical side

a,b,c > 10

Figure 2 — Position of the slot at the base of the flow guidance hopper in case of cylindrical cross section (left) and of rectangular cross section (right)
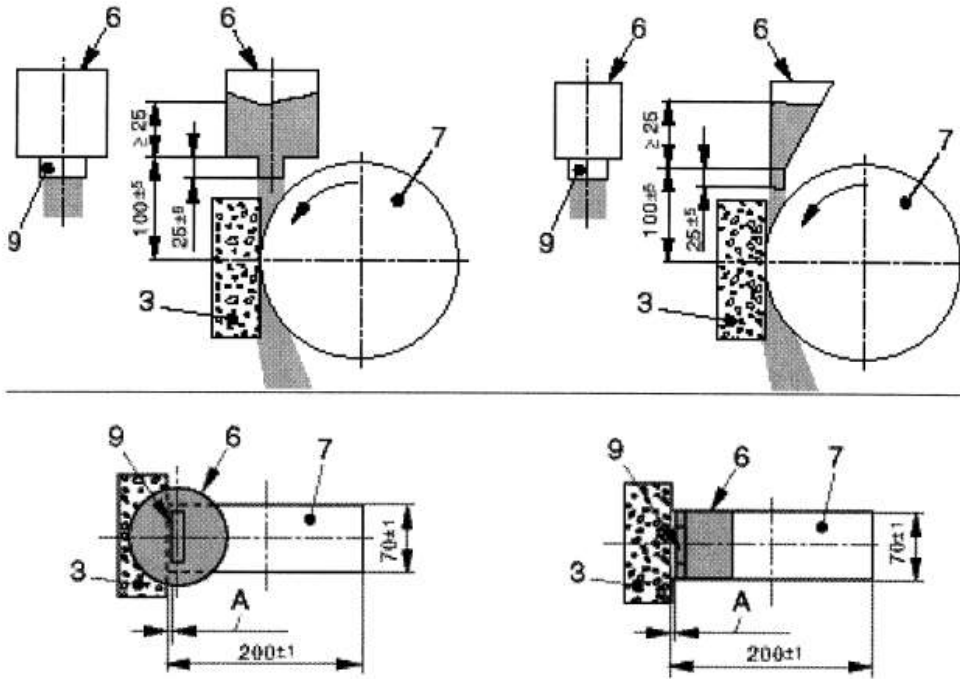
Top front view, bottom plan view

For key see Figure 1

A      distance of the flow of abrasive from the leading edge of the wheel (from 1 to 5).

**Figure 3 — Position of the slot relative to the wide abrasion wheel for a cylindrical cross section of the flow guidance hopper (left) and for a rectangular cross section of the flow guidance hopper (right)**

The flow of the abrasive material from the flow guidance hopper shall be at a minimum rate of 2.5 litres per minute onto the wide abrasion wheel. The flow of abrasive shall be constant and the minimum level of the abrasive in the flow guidance hopper shall be 25 mm (see Figure 3).

**4.3.2  Magnifying glass**

A magnifying glass having at least 2 x magnification and preferably equipped with a light.

**4.3.3  Ruler**

A steel ruler.

**4.3.4  Calliper**

A digital calliper, having an accuracy of at least 0,05 mm

## 4.4  Calibration

The apparatus shall be calibrated after grinding 400 grooves or every two months whichever is sooner and every time there is a new operator, a new batch of abrasive, or a new abrasion wheel.

The abrasive flow rate shall be verified by pouring the material from a height of approximately 100 mm into a pre-weighed rigid container with a smooth rim, of height (90 ± 10) mm and of known volume when filled to the top, this shall be approximately 1 litre. As the container fills, the pourer shall be raised to approximately maintain the 100 mm fall. When the container is filled, the top shall be struck off level and weighed to determine the mass of abrasive for a known volume, i.e. the density. The abrasive shall be run through the wearing machine for (60± 1 ) s and collected below the abrasion wheel in a pre-weighed container of at least 3 litres capacity. The filled container shall be weighed and from the density determined above, the rate of abrasive flow can be verified as not less than 2,5 litres per minute.

The apparatus shall be calibrated against a reference sample of "Boulonnaise Marble" using the procedure in 3.6.1 and the counterweight adjusted so that after 75 revolutions of the wheel in (60 ± 3) seconds the length of the groove produced is (20,0 ± 0,5) mm. The counterweight shall be increased or decreased to increase or decrease the groove length respectively. The clamping trolley/counterweight assembly shall be checked for undue friction.

NOTE The "Boulonnaise Marble" reference is: Lunel demi-clair, thickness: 5 cm, c/passe 2 faces ground with a diamond grit size 100/120, with a rugosity class Ra = (1,6 ± 0,4) µm in accordance with  ISO 4288.

The groove shall be measured using the procedure in 3.6.2 to the nearest 0,1 mm and the three results averaged to give the calibration value.

An alternative material may be used for the reference sample if a good correlation (that is where the $r^2$ is greater than 0,8 has established with the reference material "Boulonnaise Marble".

At every calibration of the apparatus the squareness of the sample supports shall be checked.

The groove on the reference sample shall be rectangular with a difference between the measured length of the groove at either side not exceeding 0,5 mm. If necessary, check that:

The sample has been held square to the wheel.

The clamping trolley and the slot from the flow guidance hopper are parallel to the wheel axle.

The flow of abrasive is even across the slot.

The friction in the trolley/counterweight assembly is not undue.

## 4.5  Preparation of test specimens

The test specimen shall be a whole product or a cut piece measuring at least (100 x 70) mm incorporating the upper face of the unit. At least six specimens shall selected from an homogenous batch. The sampling is not the responsibility of the test laboratory except where especially requested. The orientation of the test face with respect to anisotropy planes (e.g. bedding, foliation) shall be noted.

The test specimens shall be clean and dried at (70 ± 5) °C to a constant mass. Constant mass is reached when the difference between two successive weighings at an interval of (24 ± 2) h is not greater than 0,1 % of the mass of the specimen.

The upper face, which shall be tested, shall be flat within a tolerance of ± 1 mm measured in accordance with DRS 530 in two perpendicular directions, but over 100 mm.

If the upper face has a rough texture or is outside this tolerance it shall be lightly ground to produce a smooth flat surface within tolerance.

Immediately before testing, the surface to be tested shall be cleaned with a stiff brush and covered with a surface dye to facilitate measuring the groove (e.g. painting with a permanent marker pen).

## 4.6    Test procedure

### 4.6.1    Test Method

Fill the storage hopper with dry abrasive material, (maximum moisture content 1,0%). Move the clamping trolley away from the wide abrasion wheel. Position the specimen on it so that the groove produced shall be at least 15 mm from any edge of the specimen and fix the specimen on a wedge to let the abrasive flow pass under it. Place the abrasive collector beneath the abrasion wheel.

Bring the specimen into contact with the wide abrasion wheel. Open the control valve and simultaneously start the motor so that the wide abrasion wheel achieves 75 revolutions in (60 ± 3) s. Visually check the regularity of the flow of the abrasive material during the test. After 75 revolutions of the wheel, the abrasive flow and the wheel are stopped. Whenever possible, two tests shall be performed on each specimen. These shall be on adjacent faces if there is any doubt on the orientation of the stone in use.

### 4.6.2    Measuring the groove

Put the specimen under a magnifying glass to facilitate the measuring of the groove.

With a pencil with a lead diameter 0.5 mm and hardness 6H or 7H, draw the external longitudinal limits (l1 and l2) of the groove using a ruler (see Figure 4).

Then draw a line (A B) in the middle of the groove perpendicular to the centreline of the groove. Position a digital calliper square tips on the points A and B to the inside edge of the longitudinal limits (l1 and l2) of the groove and measure and record the dimension to the nearest ± 0.1 mm.

For calibration purposes, repeat the measurement (10 ± 1) mm from the ends of the groove (C D) to give 3 readings.

Dimensions in millimetres
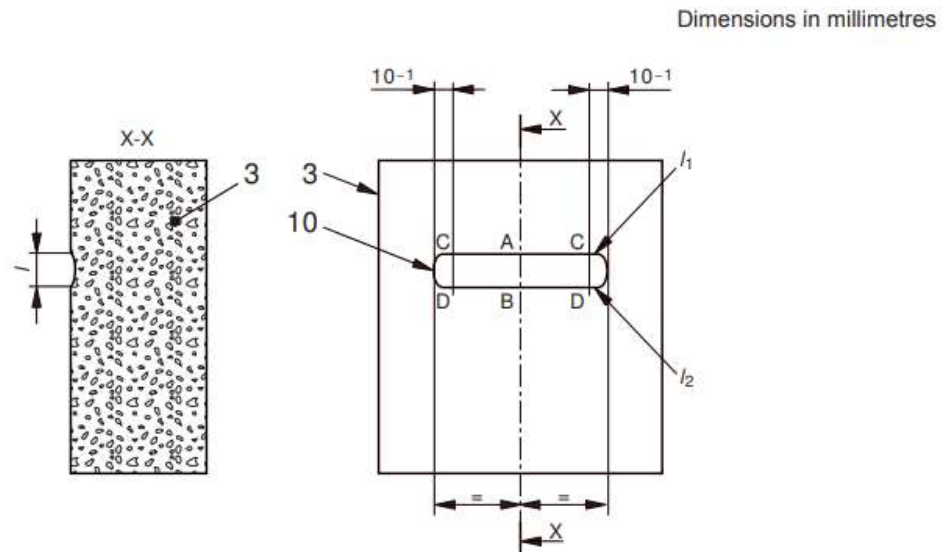


For key see Figure 1

Figure 4 — Example of a tested specimen showing a groove

Some surface dyes may be removed above the groove by the action of the abrasive. This shall be ignored in producing lines l1 and l2 which shall be drawn where the specimen surface is abraded.

## 4.7   3.7 Test results

The result of each specimen is the dimension corrected by a calibration factor and then rounded to the nearest 0,5 mm. The calibration factor is the arithmetic difference between 20.0mm and the recorded calibration value. For example, if the calibration value is 19.6 mm and the dimension is 22.5 mm, the result is 22.5 mm + (20.0 – 19.6) mm = 22.9 mm rounded to 23.0 mm. If two grooves have been cut in a specimen the larger value is taken as the result.

## 5   Method B – Böhme Abrasion Test

### 5.1   Principle

The test specimen is placed on the test track of the Böhme disc abrader on which standard abrasive is strewn, the disc being rotated and the specimens subjected to an abrasive load of (294 + 3) N for a given number of cycles (see 4.5).

The abrasive wear is determined as the loss in specimen volume.

### 5.2   Abrasive material

The standard abrasive used shall be an artificial corundum[1) ] designed to produce an abrasive wear of 1.10 mm to 1.30 mm when testing standard granite specimens and of 4.20 mm to 5.10 mm when testing standard

limestone specimens. Compliance with these requirements, the homogeneity of the material and the uniformity of bulk density and grading of the abrasive shall be checked.

## 5.3 Apparatus

### 5.3.1 Thickness measuring device.

A dial gauge, with the plunger having a spherical bearing and an annular contact face of 8 mm outside and 5 mm inside diameter, and a measuring table, shall be used to establish the reduction in thickness,

### 5.3.2 Disc abrader

The Böhme disc abrader as shown in Figure 5 consists essentially of a rotating disc with a defined test track to receive the abrasive, a specimen holder and a loading device.

The rotating disc shall have a diameter of approximately 750 mm and be flat and positioned horizontally. When loaded, its speed shall be (30 ± 1) revolutions per minute.

The disc shall be provided with a revolution counter and a device that switches off the disc automatically after 22 revolutions.

### 5.3.3 Test Track

The test track shall be annular, with an inside radius of 120 mm and an outside radius of 320 mm (i.e be 200 mm wide), and be replaceable. The track shall be made of cast iron with a perlitic structure, a phosphorus content not exceeding 0.35 % and a carbon content of more than 3 %. The track shall have a Brinell hardness of 190 to 220 HB 2.5/187.5 (as defined in ISO 6506-1), determined as the mean of measurements taken at not less than ten points along the edge of the track.

The track surface is subject to wear in service; the resulting reduction in thickness shall not exceed 0.3 mm and any grooves not be deeper than 0.2 mm. If these values are exceeded, the track shall be replaced or refinished. When the track has been refinished three times, its hardness shall be determined anew.

### 5.3.4 Specimen holder

The specimen holder shall consist of a U-frame approximately 40 mm high, with a clear distance of (5 ± 1) mm from the test track. The frame shall be positioned so that the centreline distance between specimen and disc is 220 mm and the angle bead of the specimen holder, which supports the specimen, is located at a distance of (4 ± 1) mm above the disc.

The mounting of the specimen holder shall ensure that, during testing, no vibration occurs.

### 5.3.5 Loading device

The loading device shall consist of a lever of two arms of different length, a loading weight and a counterweight, the lever being pivoted with as little friction as possible and positioned almost horizontally during the test. The system shall be designed to ensure that the load is transferred vertically via the plunger to the centre of the specimen. The self-weight of the lever and the support for the loading weight is balanced by the counter-weight. The force acting on the specimen results from the loading weight multiplied by the

leverage ratio, the mass of the weight being selected to produce a test force of (294 ± 3) N (corresponding to about 0.06 N/mm²), which shall be verified by calculation.

Dimensions in millimetres
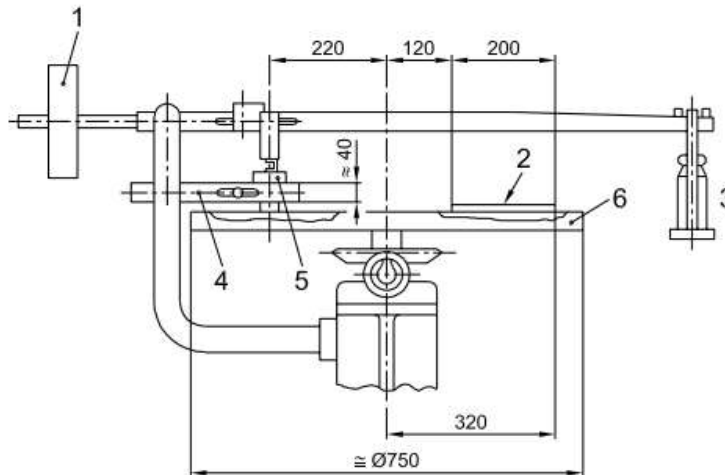


**Key**

1 counterweight

2 test track

3 loading weight

4 specimen holder

5 specimen

6 rotating disc

**Figure 5 — Principle of Böhme disc abrader**

## 5.4   Preparation of test specimens

The test specimens shall be cubes with an edge length of (71 ± 1.5) mm or parallelepipeds with a square base of (71 ± 1.5) mm side.

At least six specimens shall selected from an homogenous batch. The sampling is not the responsibility of the test laboratory except where especially requested. The orientation of the test face with respect to anisotropy planes (e.g. bedding, foliation) shall be noted.

The contact face and the opposite face of the specimen shall be parallel and flat.

The test specimen shall be clean and dried at $(70 \pm 5)°C$ to a constant mass, pre-grinding of the contact face by four cycles (see 5.5) being usually required.

For the exceptional case of testing specimens in the wet or water-saturated condition (see 4.5), the specimens shall be immersed in water for not less than seven days and wiped with a damp artificial sponge prior to each weighing so that all specimens appear equally damp.

Each specimen shall be taken from no less than three different samples or work pieces of the same type.

Prior to testing, determine the apparent density of the specimen, $\rho b$, by measurements of the sides, to the nearest 0,1 mm, and by weighing, to the nearest 0.1 g also to determine the initial mass ($m_i$).

## 5.5   Test Procedure

Prior to the abrasion test and after every four cycles (see below) weigh the specimen to an accuracy of 0.1 g.

Pour 20 g of standard abrasive on the test track. Clamp the specimen into the holder and, with the test contact face facing the track, load centrically with $(294 \pm 3)$ N.

Start the disc taking care that the abrasive on the track remains evenly distributed over an area defined by the width of the specimen.

Test the specimen for 16 cycles, each consisting of 22 revolutions.

After each cycle, clean both disk and contact face, turn the specimen progressively through 90° and pour again 20 g of standard abrasive on the track.

When testing damp or water-saturated specimens, prior to each cycle, the track shall be wiped with a lightly damp artificial sponge and moistened before being strewn with abrasive. From the start of the test, water shall be caused to drip, at a rate of approximately 13 ml of water (corresponding to 180 to 200 drops) per minute onto the track from a container with an adjustable pivoting nozzle. The drops must fall through a distance of approximately 100 mm on the middle of the track at a point 30 mm in front of the specimen. When testing in accordance with this method, care shall be taken to ensure that the abrasive is continuously returned to the effective area of the track (i.e the area defined by the width of the specimen). After the test the specimen is dried to constant mass and weighed to the nearest 0.1 g (mf)

## 5.6   Test results

Calculate the abrasive wear after 16 cycles as the mean loss in specimen volume ΔV, from the equation:

$$\Delta H = \frac{\Delta m}{\rho_b}$$

Where:

$\Delta V$ is the loss in volume after 16 cycles, in cubic millimeters to the nearest cubic millimetre;

$\Delta m$ (mi - mf) is the loss in mass after 16 cycles in grams, to the nearest 0.1 g;

$\rho b$ is the apparent density of the specimen or, in the case of multi-layer specimens, the apparent density of the wearing layer in grams per cubic millimeters.

## 6  Method C – Amsler Abrasion Test

### 6.1  Principle

Specimens are placed on the Amsler disc on which standard abrasive is strewn, the disc being rotated and the specimens subjected to an abrasive load for a given number of cycles.

### 6.2  Abrasive material

Medium silica sand (sand whose particles have dimensions between 0.2mm and 0.6mm).

### 6.3  Apparatus

#### 6.3.1  Amsler machine

Amsler-Laffon machine consisting essentially of the following elements:

a)  Horizontal disk of casting iron that rotates around their vertical axle;

b)  Device that, during the test, keeps the test specimens supported on the upper face of the disk, under a

share force of 335 N each, and compels them to rotate around its vertical axle with an angular speed of 0.75 of revolution per minute;

c) Device that drops water, drop to drop, and sand (see 5.2) on the disk, next to each test specimen, at a rate of about 150 g/min. The position of the test specimen in relation to the centre of the disk and the angular speed of this are regulated in such a way that the paths described on the disk by the centres of the faces of the test specimen are performed with the speed of 1.25 m/s.

#### 6.3.2  Calliper

A digital calliper, having an accuracy of at least 0,05 mm

## 6.4 Preparation of test specimens

The test specimens are obtained by sawing entire pieces, one from each piece, and have the plane dimensions of 60 mm x 60 mm. The edges are rounded off with a radius of approximately 2 mm. The upper surface of the test specimens is regularized by the application of a plaster layer that gives them the total thickness of 25 mm.

At least six specimens shall be selected from an homogenous batch. The sampling is not the responsibility of the test laboratory except where especially requested. The orientation of the test face with respect to anisotropy planes (e.g. bedding, foliation) shall be noted.

## 6.5 Test procedure

The thickness of each specimen is measured at the middle of the four lateral faces (smaller faces). The test specimens are assembled in the machine and this is put in motion. The machine is stopped when the centre of the abraded face of each test specimen completes a 200m travel on the disk.

The test specimens are removed from the machine, washed with tap water and cleaned with a cloth.

The final thickness is measured as it was previously (at the middle of the four lateral faces of each specimen).

## 6.6 Test results

The abrasion wear of each specimen is calculated by the equation:

$l_1 - l_2$

where:

I1 - is the average thickness of each specimen before the test, in millimetres;

l2 - is the average thickness of each specimen after the test, in millimetres;

The abrasion wear of each specimen is rounded to the nearest 0.1 mm. The average thickness of the abrasion layer is then calculated and the result is expressed in millimetres to the nearest millimetre.

## 7 Test report

The test report shall contain the following information:

c)    a) unique identification number of this report;

d)   b) number, title and date of issue of this document; name and address of the test laboratory and the address where the test was carried out if this is different from the address of the laboratory; name and the address of the client;

e)   It is the responsibility of the client to give the following information:

— petrographic name of the stone

— commercial name of the stone

— country and region of extraction

— name of the supplier

— direction of any existing plane of anisotropy (if relevant to the test), to be clearly indicated on the sample or on each specimen by means of two parallel lines;

— name of the person or organisation which carried out the sampling;

— surface finish of the specimen (if relevant to the test)

f)   date of delivery of the sample or of the specimens;

g)   date when the specimens were prepared (if relevant) and the date of testing;

h)   number and dimensions of the specimens

i)   surface finish of the specimens;

j)   orientation of the test face with respect to the anisotropy planes;

k)   test method used – (Method A – Wide wheel Abrasion, Method C - Amsler or Method B – Böhme);

l)   calibration value;

m)   For each specimen:

a)   When using Method A, the length of the groove in millimeters to the nearest 0.5 mm;

b)   When using Method B, the loss in volume in cubic millimetres to the nearest cubic millimetre.

c)   When using Method C, the thickness of the abraded layer in millimetres to the nearest millimetre.

n)   appropriate mean value for the method used

o)   All deviations from the document and their justification

The test report shall contain the signatures and roles of those responsible for the testing and the date of issue of the report.

It shall also state that the report should not be partially reproduced without written consent of the test laboratory.

# Annex A
## (normative)

# Correlation between the reference method and the other two methods

## A.1  Introduction

There are limited data available to provide correlations between Method B – Bohme and the reference method and Method C Amsler and the reference method. The available data are summarised below.

## A.2  Correlation between Method A 'Wide Wheel Abrasion' and Method C 'Amsler' Abrasion test

Two main sets of data were available for inclusion. The results are presented below as Figures A.1, A.2 and A.3.
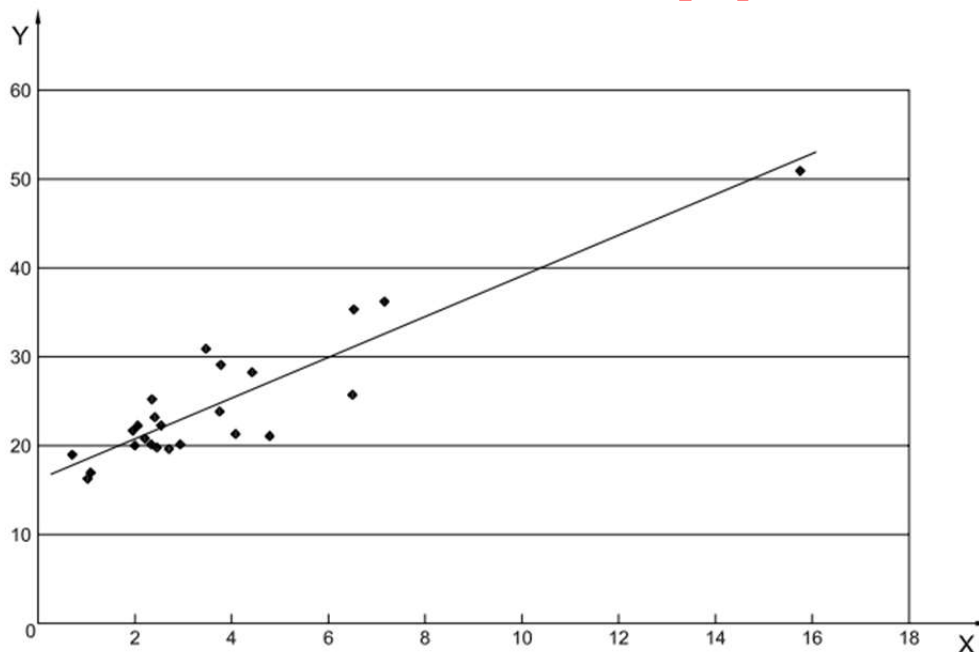


Key

X    Thickness of abraded layer in Amsler method in millimetres

Y    Dimension of the groove of Capon method in millimetres

♦    Series 1

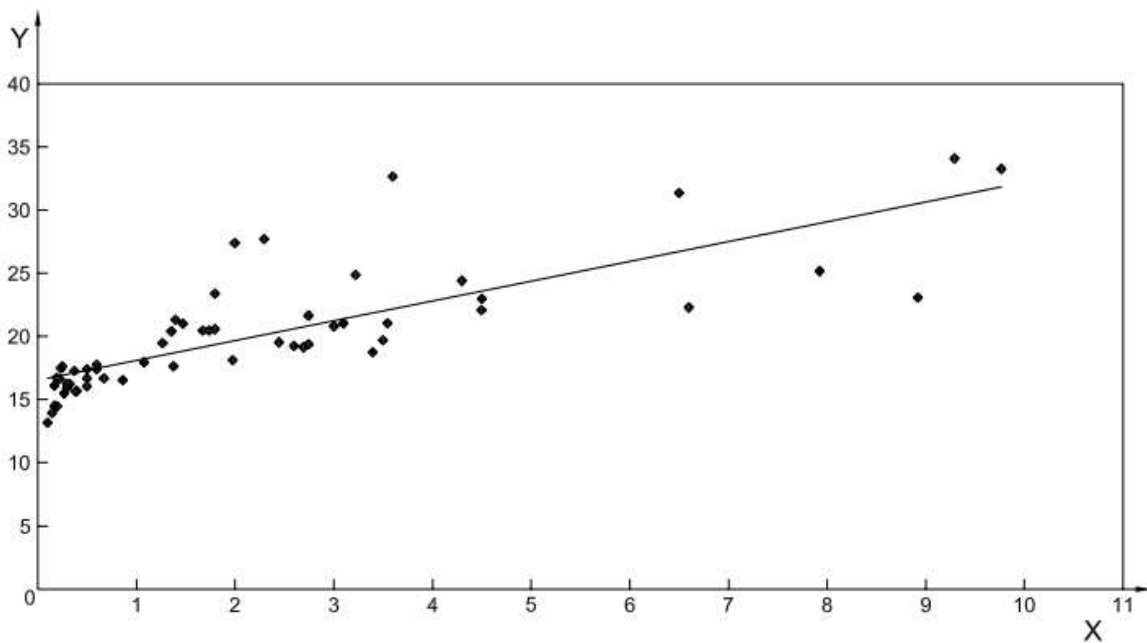**Figure A.1 — Correlation of Wide Wheel Abrasion (Capon) and Amsler based on Belgian data**

Fitting a linear correlation through this first set of data (24 stone – mostly limestones) - gives:

**Wide Wheel = 16.3 + 2.25 (Amsler)** $r^2$ = 0.83.

This is based on data from Belgium determined using the test method of a Portuguese document (Figure A.1).

Fitting a linear correlation through this second set of data (Portuguese data for all stone type) – gives (Figure A.2):

**Wide Wheel = 17 + 1,4 (Amsler)**$r^2$ = 0.79



**Key**

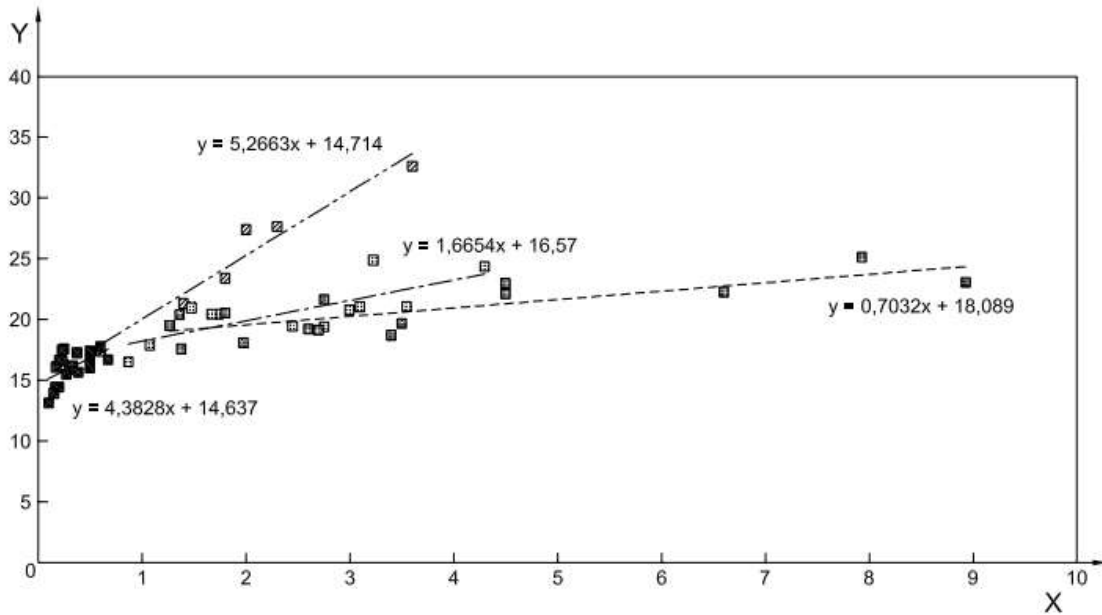X    Thickness of abraded layer in Amsler method in millimetres

Y    Dimension of the groove of Capon method in millimetres

•    Series 1

**Figure A.2 — Correlation of Wide Wheel Abrasion (Capon) and Amsler based on Portuguese data**

However, the data from Portugal shows that the predictability of the equations can be improved by fitting different

equations to different stones types – see Figure A.3.

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**16**

**Key**

X    Thickness of abraded layer in Amsler method in millimetres

Y    Dimension of the groove of Capon method in millimetres

•    Series 1

| | |
|---|---|
| ▨ | Volcanic rocks from Madeira |
| ■ | Granitic rocks |
| ▣ | Marbles |
| ▨ | Limestones |
| —··— | Volcanic rocks from Madeira |
| —·—· | Marbles |
| ----- | Limestones |
| —— | Granitic rocks |

**Figure A.3 — Correlation of Wide Wheel Abrasion (Capon) and Amsler based on Portuguese data arranged according to the petrographic nature of stones**

Overall it is suggested that the following equations are used:

Igneous stones Wide Wheel = 15 + 5 (Amsler)

Sedimentary and Metamorphic stones Wide Wheel = 17 + 1.7 (Amsler)

NOTE These equations need to be agreed and refined as more data becomes available

## A.3  Correlation between Method A 'Wide Wheel Abrasion' and Method B 'Böhme' Abrasion test

Only one dataset is available – this is taken from a series of tests carried out in Germany. The relationship of the results for the Wide Wheel Abrasion test and the Böhme test are show in Figure A.4.
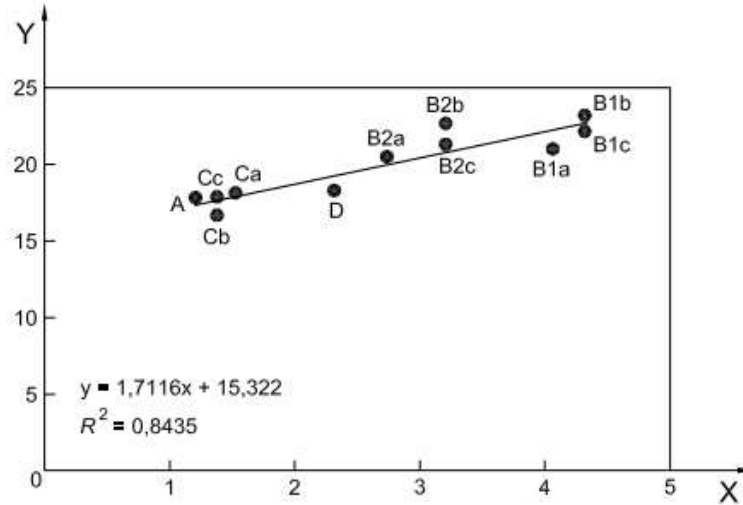


**Key**

X    Loss in volume in Böhme method in cubic millimetres

Y    Dimension of the groove of Capon method in millimetres

**Figure A.4 — Correlation of Wide Wheel Abrasion test (Capon) and Böhme test**

The linear regression produces an equation:

**Wide Wheel = 15.3 + 1.7 (Böhme)** $r^2$ = 0.84

# Bibliography

[1]   FEPA 42F1984, FEPA Fédération des Fabricants de Products Abrasifs. Corundum

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