Precision surface plates

1. Scope

This Japanese Industrial Standard specifies the rectangular or square precision surface plates (hereafter referred to as surface plates), of which sizes of working surfaces ranging from 160 mm x 100 mm to 2500 mm x 1600 mm.

Remarks 1. The applicable standards to this Standard are given in the following:

JIS G 5501-Grey iron castings

JIS Z 8103-Glossary of terms used in instrumentation

2. The equivalent International Standards to this Standard are the following:

ISO 8512-1-1990 Surface plates - Part 1: Cast iron

ISO 8512-2-1990 Surface plates - Part 2: Granite

2. Definitions

For the purposes of this Standard, the following definitions apply, and others are in accordance with JIS Z 8103.

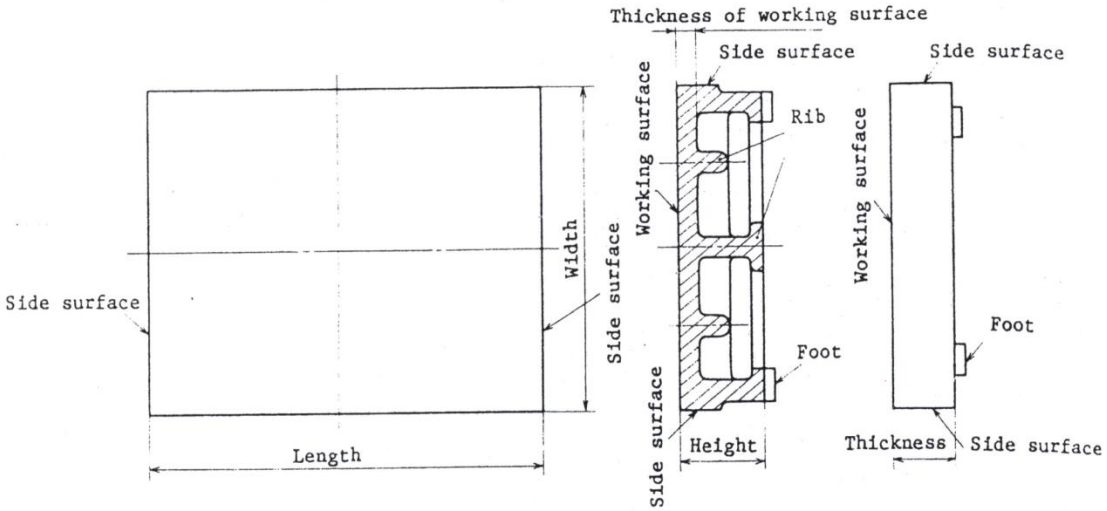
(1) precision surface plates The board shaped structures generally made of cast iron or stone, providing precise flat surfaces or datum flat surfaces for multipurposes on their upper surfaces as the working surfaces.

(2) flatness of working surface The magnitude of the deviation from the working surface of the geometrically true plane. It is expressed by the dimension of the interval where the interval between the two parallel flat planes becomes the minimum, when the working surface has been put between two geometrically true parallel flat planes.

3. Names of respective parts

The names of respective parts of the surface plate to be used in this Standard shall be in accordance with Fig. 1.

Fig. 1. Names of respective parts



Remarks: These Figures are those for simply indicating the names of respective parts, but are not those for specifying the construction and shape.

4. Types and grades

4.1 Types The types of the surface plates shall be classified into made of cast iron and made of stone according to the materials, and the nominal sizes of the working surfaces shall be in accordance with Table 1.

Table 1. Nominal sizes of working surfaces

Unit: mm

Shape	Nominal size
Rectangular shape	160× 100
	250× 160
	400× 250
	630× 400
	1 000× 630
	1 600×1 000
	2 000×1 000
	2 500×1 600
Square shape	250× 250
	400× 400
	630× 630
	1 000×1 000

4.2 Grades The grades of the surface plates shall be the three grades of grade 0, grade 1 and grade 2 according to the flatnesses of working surfaces.

5. Performances

5.1 Flatnesses of working surface To the flatnesses of the working surfaces, two kinds of specifications of the flatness in respect to the overall surface of the working surface and the flatness of local area in respect to a local area of 250 mm x 250 mm at an arbitrary position of the working surface shall apply.

Remarks: The peripheral rim portion of the working surface corresponding to 2 % of the size of the surface plate width (however, it shall be 20 mm in maximum.) may be excluded from the application of the prescription of flatness, if its portion is in the condition where it does not cause any inconvenience in use.

5.1.1 Flatness of overall surface The tolerance values for the flatness of the overall surface of the working surface shall be in accordance with Table 2.

Informative reference: In the case where the size of the working surface is 2500 mm x 1600 mm or under and is different in size from the nominal size, the tolerance values for the flatness shall be calculated in accordance with Informative Reference 1.

Table 2. tolerance values for flatnesses of overall surfaces

Nominal size of working surface mm	Tolerance values for flatness of overall surface(1)(2) μm			Excluding width of peripheral portion mm	Length of diagonal line mm (Informative reference)
	Grade 0	Grade 1	Grade 2		
160× 100	3	6	12	2	188
250× 160	3.5	7	14	3	296
400× 250	4	8	16	5	471
630× 400	5	10	20	8	745
1 000× 630	6	12	24	13	1 180
1 600×1 000	8	16	33	20	1 880
2 000×1 000	9.5	19	38	20	2 236
2 500×1 600	11.5	23	46	20	2 960
250× 250	3.5	7	15	5	354
400× 400	4.5	9	17	8	566
630× 630	5	10	21	13	891
1 000×1 000	7	14	28	20	1 414

Notes ([1]) These shall be of at 20°C in temperature and 58 % in humidity.

([2]) The calculation formula shall be given in Informative Reference 1.

Furthermore, values have been rounded off to the nearer values of 0.5 μm for grade 0 and 1 μm for grades 1 and 2.

5.1.2 Flatness of local area The tolerance values for flatnesses of local area 250 mm x 250 mm at an arbitrary position shall be in accordance with Table 3.

Remarks: As the surface plate of which the length of the diagonal line is smaller than 354 mm has no measuring area of 250 mm x 250 mm, the prescription of the flatness of local area shall not be applicable.

Table 3. Tolerance values of flatness for local area

Unit: μm

Grade	Tolerance values of flatness for local area([1])
0	3.5
1	7
2	15

5.2 Rigidity of surface plate The surface plate of 400 mm x 250 mm or over in the size of working surface, when it has been subjected to a load on the center of its working surface, shall be that of having such a rigidity as not exceeding 1 μm per 200 N in the flexure at the loaded portion.

6. Shapes and dimensions

The tolerance values for respective sizes of the working surfaces of the surface plates shall be ±5 % of its nominal sizes.

Furthermore, the heights, thicknesses and masses for the general surface plates shall be as given in Informative Reference Table 1.

Informative Reference Table 1.
Heights, thicknesses and masses for surface plates

Nominal size of working surface mm	Made of cast iron		Made of stone	
	Height mm (Informative reference)	Mass kg (Informative reference)	Minimum thickness mm (Informative reference)	Mass kg (Informative reference)
160× 100	–	–	–	–
250× 160	–	–	–	–
400× 250	100	25	50	15
630× 400	150	90	70	50
1 000× 630	200	300	100	180
1 600×1 000	250	900	160	720
2 000×1 000	280	1 350	200	1 120
2 500×1 600	320	2 800	250	2 800
250× 250	80	20	50	10
400× 400	100	40	70	30
630× 630	150	150	70	80
1 000×1 000	200	500	100	280

7. Construction and appearance

The construction and appearance of the surface plates shall be in accordance with the following:

(1) The surface plates shall be provided with three feet.

(2) The ribs of the cast iron surface plates shall be so constructed as to lessen the deformations of surface plates as far as possible.

(3) The side surfaces of the cast iron surface plates shall be so constructed as to facilitate handling and transportation by providing such as grips or holes.

(4) The working surfaces of the grade 0 and grade 1 cast iron surface plates shall be finished to good quality scraping or to the finish equal to or superior to this, and of the grade 2 may be by the same method or by machine finish.

Furthermore, the distribution of the touching faces of the scraper shall be uniform.

(5) The working surfaces of the grade 0 stone surface plates shall be finished by good quality lapping, and of the grade 1 and grade 2 may be by the same method or by the polishing finish.

(6) The peripheral rims and each corner of the working surfaces of the surface plates shall be processed with roundings of 2 mm or over in radius or the chamfers of 45° as above.

Materials

The materials of the surface plates shall be in accordance with the llowing:

(1) The material of the cast iron surface plates shall be FC 250 specified in JIS G 5501 or the cast iron of equal to or superior to this in mechanical properties, and of which structure shall be homogeneous and shall be free from harmful defects such as blowholes, pinholes and cracks. However, for the grade 2 surface plates, very small defects of the working surface may be repaired by filler metal of the same material in composition.

Furthermore, for the purposes of removing internal stresses, necessary heat treatment or natural seasoning shall be used.

(2) The material of the stone surface plates shall be granite or that equal to or superior to this in physical properties([3]), and of which structure shall be homogeneous and shall be free from defects such as cracks and the like.

Note ([3]) The physical properties of the stone material to be used for the surface plates are given in Informative Reference 2.

Measuring methods

9.1 Measuring methods of flatness The measuring method of the flatness all be in accordance with the following:

9.1.1 Measuring methods for flatness of overall surface The measure-nts for flatness of working surface of the surface plate shall be carried t under the no load condition, supporting the working surface nearly rizontally. The measuring method shall be in accordance with one of the llowing:

(1) Method by using a level

(2) Method by using an autocollimeter

(3) Method by comparison with a reference surface

The measurements shall be carried out after the surface plate has been lapted sufficiently to the ambient temperature and humidity.

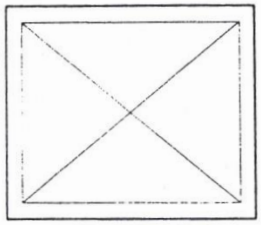
In addition, in order to avoid the influences of working patterns nerated by scraping, cutting and the like, it should be preferable to easure by placing the block gauge of 30 mm x 9 mm in sectional dimensions the measuring points on the working surface.

The flatness shall be obtained by calculation based on the heights of respective measuring points from each other measured along the measuring lines on the working surface.

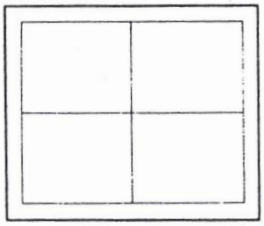
The method to determine the measuring lines shall be in accordance with either one of the two methods given in Fig. 2.

Fig. 2. Measuring lines (1)

Diagonal lines method



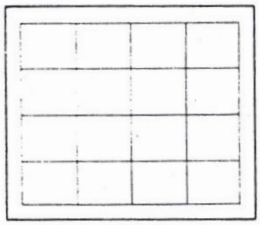
Parallel crosses method



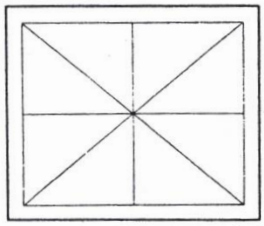
The measuring lines may be increased by the number of lines (Example 1 of Fig. 3) according to the sizes of the surface plates, or by the combined method of the diagonal lines method and parallel crosses method (Example 2 of Fig. 3).

Fig. 3. Measuring lines (2)

Example 1



Example 2



In order to simplify the calculation for obtaining flatness, the number of measuring points on respective measuring lines parallel to the sides of the working surface shall be taken as an odd number, and the intervals thereof shall generally be in accordance with Table 4.

Table 4. Intervals between measuring points and number of measuring points

Length or width of working surface mm	Interval between measuring points mm	Number of measuring points
250	110	3
400	90	5
630	140	5
1 000	155	7
1 600	190	9
2 000	190	11
2 500	240	11

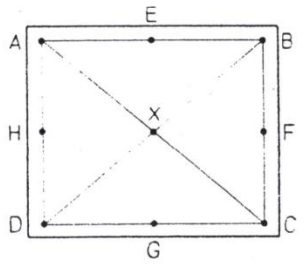
Remarks: The interval between measuring points of the working surface less than 250 mm in length or width are taken optionally.

The interval between the measuring points on a diagonal line shall be so determined as to coincide at the center, considering the relation given in Table 4 also.

An example of the method to obtain flatness from the measured values of heights of respective measuring points from each other shall be given in the following (the unit in this example shall all be as μm).

The symbols of respective points shall be in accordance with Fig. 4.

Fig. 4. Symbols of measuring points



(a) The heights of measuring points from each other measured along respective measuring lines

A X C	0	−0.3	+0.8
B X D	0	−7.0	+1.0
A E B	0	+15.5	+7.0
C G D	0	+6.4	+6.0
B F C	0	−7.5	−7.0
D H A	0	−9.0	−7.4

(b) Obtain the value of the center intersecting point (X), when the heights of both ends of diagonal lines AC and BD have been made the same value.

A X C	0	-0.7	0
B X D	0	-7.5	0

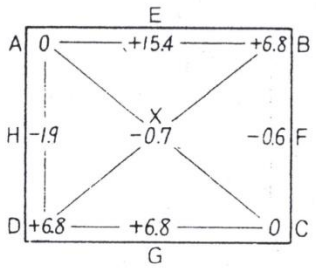
(c) Obtain the values at both ends by adding or subtracting the values of either of the measuring lines so that the values of above point (X) become the same value.

When, the value of B X D line is added by (-0.7) - (-7.5) = + 6.8

B X D +6.8 -0.7 +6.8 are obtained.

(d) Then the values of the both ends of the measuring lines of periphery other than the diagonal lines agree with the values of 4 points determined in (C), and the values of the middle points thereof are obtained as given in Fig. 5.

Fig. 5. Values of measuring points (1)

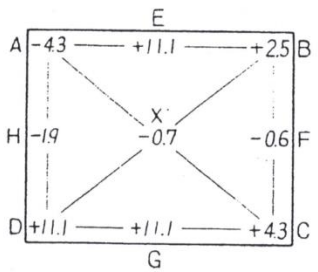


The difference between the highest point and the lowest point in this case is as follows:

Highest point	+15.4
Lowest point	-1.9
Difference	17.3

(e) In Fig. 5, when A E B line is lowered by 4.3 (15.4-1/2 x 6.8) taking the H X F line as an axis, the values of respective points become as given in Fig. 6.

Fig. 6. Values of measuring points (2)

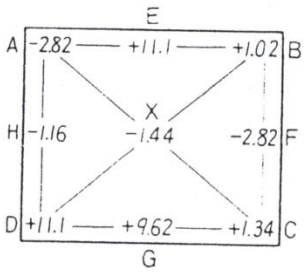


The difference between the highest point and the lowest point in this case is as follows:

Highest point	+11.1
Lowest point	-4.3
Difference	15.4

(f) Further, when point A is raised by 1.48 (2/5 the difference between the point A and the point F), taking the D E line as an axis, the values of respective points become as given in Fig. 7.

Fig. 7. Values of measuring points (3)



The difference between the highest point and the lowest point in this case is as follows:

Highest point	+11.1
Lowest point	-2.82
Difference	13.92
	≒ 13.9

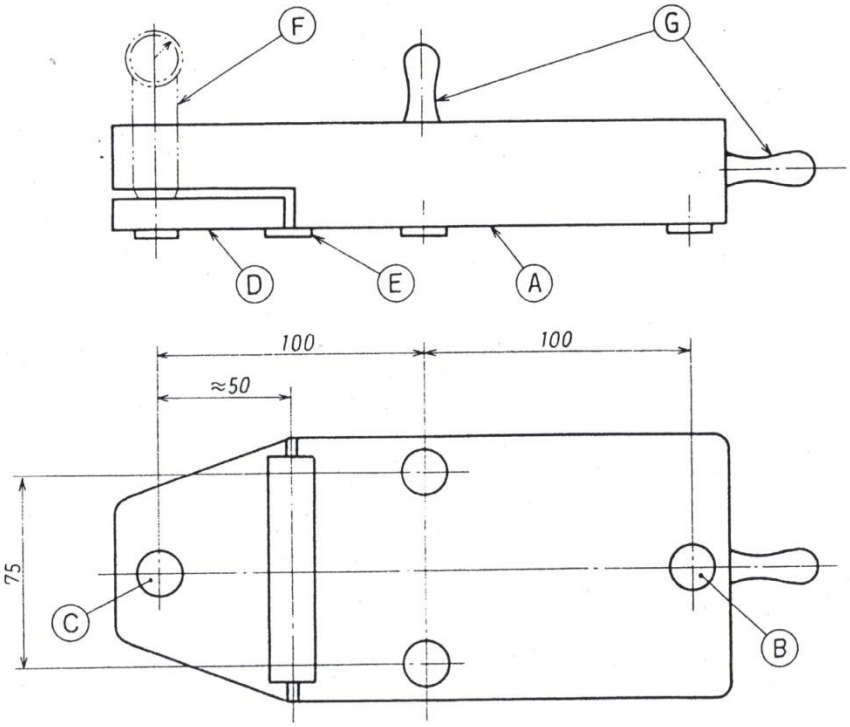
The differences between the highest points and the lowest points in , (e) and (f) are (d) > (e) > (f), and the value in (f) is the smallest. efore, the flatness of this surface plate shall be 13.9 μm.

9.1.2 Measuring method of flatness on local area The measuring method he flatness on the local area shall be to find the portion where the cator indicates the variation of readings exceeding the tolerance values he flatness of the local area, scanning completely the surface of the ing surface of the surface plate by the datum gauge exemplified in 8.

As regards this portion, measure the flatness using the method given in .1.

Fig. 8. Datum gauge (Example)

Unit: mm



Ⓐ Base block Ⓓ Block Ⓕ Indicator

Ⓑ, Ⓒ Pads Ⓔ Plate spring Ⓖ Insulating handle

Remarks: Four pieces are in the same plane, and each 280 mm^2 in area.

9.2 Measuring method of rigidity

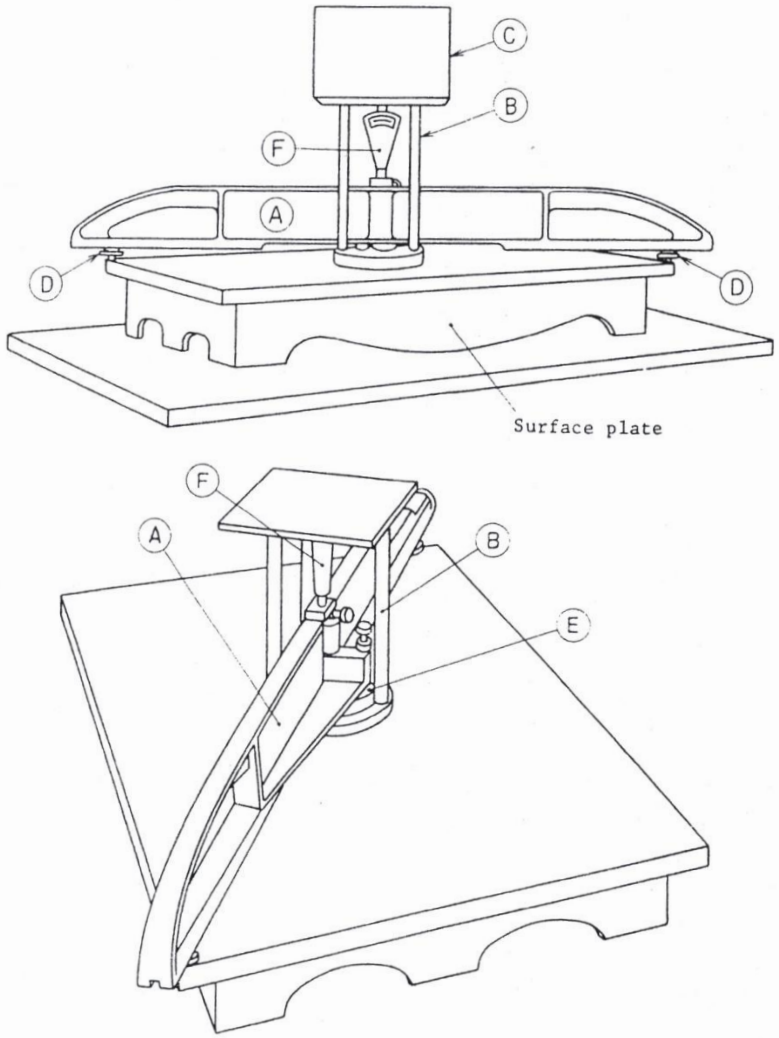
9.2.1 Measuring apparatus of rigidity An example of the apparatus shall be given in Fig. 9. Fundamentally the apparatus shall be constituted of the following members.

(a) A beam integrated with an indicator

(b) A mass support which is independent of the beam in construction

(c) A mass for loading

Fig. 9. Measuring apparatus of rigidity (Example)



(A)	Beam	(D)	Supporting legs (two pieces)
(B)	Center mass support	(E)	The third foot (offset)
(C)	Mass (for loading)	(F)	Precision indicator

The beam (A) is of rigid construction being supported by two legs (D), these legs can be positioned at an arbitrary interval along the beam. he center of the beam, the third foot (E), being offset from the center of the two feet, is provided, and further the indicator (F) being htly offset towards the center in the same manner is installed so that a e head contacts on to the surface plate.

Therefore, the foot (E) being offset can accomplish to stabilize the beam and the duty as the microadjustment device of the indication of the indicator. This amount of offset, in order to minimize the measuring error, shall be made extremely small compared to the amount of the offset of the foot (E).

The center mass support (B), being independent of the beam, can be moved up and down on the surface plate with respect to the beam within a limit. The central area on the surface plate to which a load is applied shall be 120 mm in diameter for the surface plate of less than 1000 mm x 1000 mm in the size of working surface, and be 300 mm in diameter for the larger surface plate than that.

The load to be used in the measurement shall generally be not made to such an amount as to deform the surface plate to 1/2 or over the permissible value of the flatness of overall surface. The masses of the maximum concentrated loads applicable to the surface plates of respective sizes and grades shall be given in Table 5.

Table 5. Masses for maximum concentrated load of surface plates

Dimensions of working surface of surface plate	Masses of the maximum concentrated loads liable to generate deformation of 1/2 the tolerance value for flatness of overall surface of surface plates with respect to respective grades kg		
	Grade 0	Grade 1	Grade 2
400× 250	40	80	160
630× 400	50	100	200
1 000× 630	60	120	240
1 600×1 000	80	160	330
2 000×1 000	95	190	380
2 500×1 600	115	230	460
400× 400	45	90	170
630× 630	50	100	210
1 000×1 000	70	140	280

9.2.2 Measuring procedures The measuring procedures for rigidities of rface plates shall be in accordance with the following:

(1) The leg interval of both ends of beam shall be installed on its diagonal line adjusting to the length of the diagonal line of the surface plate to be measured.

(2) Set the indicator on the surface plate, and take the reading of its value.

(3) Put the specified mass on the mass support, and take the reading of the value of the indicator.

(4) Remove the mass to ascertain the value of the indicator under the no load condition.

(5) Convert the difference of readings of the indicator of (2) and (3) in proportion to per 200 N, and obtain the deformation amount of the surface plate.

Inspection

The inspection of the surface plates shall be carried out on the permances, shapes and dimensions, construction and appearance, and material, the results shall satisfy the requirements of 5., 6., 7. and 8.

Designations

The surface plate shall be designated by the title of the Standard or ber of the Standard, type, grade and size of working surface.

Example 1. Precision surface plate, made of cast iron, grade 1, 1000 x 630

Example 2. JIS B 7513, made of stone, grade 0, 1600 x 1000

Marking

The surface plate shall be marked with the following information.

1) Manufacturer's name or its abbreviation

2) Serial number

3) Grade

4) Nominal size of working surface

5) Mass

Informative Reference 1. Bases of tolerances on flatness

Preface

This Informative Reference describes tolerances on flatness based on ISO 8512, and it does not constitute a part of this Standard.

1. Bases of tolerances on flatness of overall surface

The tolerances on flatness of the overall surface are based on the following formula:

$$t=c_1 l+c_2 \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (1)$$

where, t : the tolerance on flatness of overall surface (μm)

l : the nominal length of the diagonal line of a surface plate being rounded off to the nearest above 100 mm (mm)

c_1, c_2 : constants for the grades of the surface plate, and are given in Informative Reference 1 Table 1.

Informative reference 1 Table 1. Values of c_1 and c_2

Grade of surface plate	c_1	c_2
0	0.003	2.5
1	0.006	5
2	0.012	10

2. Surface plates of other than nominal sizes

In the case of the surface plates of other than the nominal sizes given in Table 1 of the text, the tolerance values for flatness of their overall surfaces are calculated using the formula (1).

3. Tolerance values on flatness of local area

The tolerance value on the flatness of local area is the value calculated from the formula (1), taking the size of working surface as 250 mm x 250 mm.

Informative Reference 2. Physical properties of stones

Face

This Informative Reference describes the physical properties of stones ed on ISO 8512-2, and it does not constitute a part of this Standard.

Physical properties

The stones used for surface plates should preferably have the physical perties given in the following:

1) Density: 2.5×10^3 to 3×10^3 kg/m^3

2) Tensile breaking stress: 7 to 35 N/mm^2

3) Compressive breaking stress: 100 to 300 N/mm^2

4) Porosity coefficient: 1.5 % or under

5) Imbibition coefficient: 3 % or under

6) Coefficient of linear thermal expansion: 2 to 8 x 10^{-6}k^{-1}

Informative Reference 3. Matters to be attended to in handling of surface plates

Preface

This Informative Reference describes the matters to be attended to in handling of the surface plates based on ISO 8512, and it does not constitute a part of this Standard.

1. Matters to be attended in handling

Matters to be attended in handling of the surface plates are in accordance with the following:

(1) A surface plate should preferably be installed in an atmosphere of controlled temperature and humidity. Direct sunlight and abrupt ventilation must be avoided.

In addition, it is also important so as not cause a temperature gradient of upper side and under side such that the working surface and its underside are at different temperatures.

Informative Reference: If there is a persistent difference of 1°C between the upper surface and the back surface, in the surface plate of 1000 mm x 630 mm in working surface and 250 mm in thickness, there can be a distortion of about 5 μm in a cast iron surface plate and about 1 μm in a granite surface plate. These values are equivalent to 80 % and 15 % of the permissible values of flatness of grade 0 respectively.

(2) The surface plate is to be installed on a firm stable foundation being sufficiently levelled.

(3) In general, after the surface plate has been levelled by the feet of the three horizontal adjusting screws, adjust the remaining auxiliary feet so as not to impair levelness and giving the minimum deviation from flatness.

(4) Referring to the text 9.2, pay attention so that the surface plate is not overloaded and disperse the load as much as possible.

(5) Since there are local unevennesses on the working surface of the scraper or machine finished surface plate, the use of point contact must be avoided. Contact should be made through the block gauge of 10 mm or under in height (see JIS B 7506) or a similar precision distance piece.

(6) The working surface must be used widely and effectively, and concentrated use always on a certain point must be avoided.

7) The working surface is of a datum and must be protected from damage as much as possible. It must always be kept clean, and a tool and measuring instrument must not be placed directly on the working surface.

3) The flaws on the working surface of a cast iron surface plate generates burrs. Since these burrs accelerate the wear of the working surface, the method of elimination is to use a grindstone, and then polishing agents shall be completely wiped off.

9) When the surface plate is left unused, a cover is always to be put on the upper face. When it is not used for a long period, the working surface of a cast iron surface plate is coated with a corrosion inhibitor.

)) Since the working surface of a surface plate gets wear by use, the flatness of the working surface is to be inspected periodically according to the frequencies of uses, and it is necessary to know the degree of wear. The inspection method of flatness is to be in accordance with 9.1 of the text.

L) Specialist services of surface plate manufacturers should be utilized to repair or recondition surface plates.