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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of International Trade and Industry through deliberations at Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law. Consequently JIS G 0552:1977 is replaced with JIS G 0552:1998.

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Methods of ferrite grain determination test for steel

Introduction This Japanese Industrial Standard was partially revised in 1977 since establishment in 1957, and has come to present. Though nearly 20 years have elapsed from the last revision, since there is a necessity for achieving conformance to International Standard **ISO 643:1983**, *Steels — Micrographic determination of the ferritic or austenitic grain size* conjointly with technical progress during that time, the revision is executed.

Main revised points are as follows.

- a) The application range is conformed to 0.25 % or under carbon content.
- b) The use symbol and the relation formula are conformed to International Standard. Further, the item of report is newly established.
- c) As the judging method, a counting method and a judging method by intersected segment (grain size) are added as Annexes.

1 Scope This Japanese Industrial Standard specifies the testing method of measuring ferrite grain size (hereafter referred to as "grain size") of steel mainly with a carbon content not more than 0.25 %.

Remarks: The corresponding International Standard to this Standard is shown as follows.

ISO 643 *Steels — Micrographic determination of the ferritic or austenitic grain size*

2 Definitions For the purpose of this Standard, the following definitions apply:

- a) **grain size** Grain size means the size of ferrite crystal grain of steel, and its marking is expressed in grain size number.
- b) **grain size number** The grain size number means the number expressed in accordance with either the method 1) or 2) undermentioned after the grain size has been measured by the specified method.
 - 1) Table 1 shall apply to the expression of grain size number when the measurement is made by comparison method.

Table 1 Grain size number

Grain size No. <i>G</i>	Number of crystal grain per mm ² of sectional area <i>m</i>	Mean sectional area of crystal grain mm ²	Mean number of crystal grain in 25 mm ² at 100 magnifications <i>n</i>
-3	1	1	0.062 5
-2	2	0.5	0.125
-1	4	0.25	0.25
0	8	0.125	0.5
1	16	0.062 5	1
2	32	0.031 2	2
3	64	0.015 6	4
4	128	0.007 81	8
5	256	0.003 90	16
6	512	0.001 95	32
7	1 024	0.000 98	64
8	2 048	0.000 49	128
9	4 096	0.000 244	256
10	8 192	0.000 122	512

Remarks: In Table 1, the following relation formula is concluded.

$$m=8 \times 2^G$$

- 2) In measurements made by intercept method, the following formula shall apply to the expression of grain size number. The grain size number shall be rounded off to the first decimal place.

$$n=500(M/100)^2(I_1 \times I_2)/(L_1 \times L_2)$$

$$G=(\log n)/(0.301)+1 \dots\dots\dots (1)$$

where, *G* : grain size No.

n : number of grain size in 25 mm² under a microscope of 100 magnification

M : microscope magnification

*L*₁(or *L*₂) : total length (unit: mm) of one linear length of the segments orthogonally crossing each other

*I*₁ (or *I*₂) : total number of crystal grain intercepted by *L*₁ (or *L*₂)

Remarks: Attached Fig. 3 shows a relationship included within formula (1) in a graphic chart.

- c) **mixed grain** Mixed grain shall mean the presence of 20 percent or more of crystal grain different, approximately 3 or more in grain size number within one visual field.
- d) **elongation rate** This is the ferrite crystal grain elongated due to the working, which shall be calculated from the following formula:

$$e = n_1/n_2$$

where, e : elongation rate

n_1 : number of crystal grain intercepted by a certain length of a segment orthogonal to the direction in which the grains have been elongated

n_2 : number of crystal grain intercepted by a segment identical in length to the n_1 segment parallel to the direction in which the grains have been elongated

3 Classification of testing methods Testing methods shall be classified into following two categories:

- a) Comparison method
- b) Intercept method

The test shall be made, usually, by comparison method, but, where ferrite crystal grains are markedly elongated or required to be accurate, intercept method should be rather used.

Further, the counting method may be used as agreed upon between the purchaser and supplier. In this case Annex 1 applies. Also, the intersected segment method may be used as agreed upon between the purchaser and supplier. In this case, Annex 2 applies.

4 Treatment of test piece Steel with the section parallel to or at a right angle to the working direction shall be etched after being finished by polishing. For this etching, a solution, preferably of about 5 percent nitric acid alcohol should be applied for 15 s. If necessary, the surface, as it is, of the test piece may be subjected to the testing.

Remarks: As the etching solution nitryl (ethanol nitrate), picryl (ethanol picrate) or an appropriate reagent may be used excepting this.

5 Testing methods

5.1 Comparison method The grain sizes as appearing on the etched surface shall be observed under a microscope and compared with a standard figure.

5.2 Intercept method The number of the ferrite crystal grain intercepted by the 2 segments of a fixed length orthogonally crossing each other shall be determined by observing the grains appearing on the etched plane under a microscope or by means of a microphotograph.

However, the ferrite crystal grain partially intercepted at both ends of a segment shall be counted only one grain and in case there is one partially intercepted grain at one end of a segment, no count shall be taken.

Also, the magnification of the microscope shall be so adjusted that the number of ferrite crystal grain to be intercepted by one segment will be not less than 10 within one visual field and the measurement shall be continued for several visual fields until those grains amount to not less than 50.

Remarks: For the method for observing with a microscope, there are microphotograph and observation on ground glass excepting visual observation.

6 Method of determining grain size in each visual field

6.1 Comparison method

6.1.1 The grain size measured under a microscope shall be compared with the standard figure in Attached Fig. 1 to determine a corresponding grain size number. As a rule, the microscope in this case shall have a magnification of 100, the actual visual field shall be a circle of 0.8 mm diameter, and the size and shape of the projected image or the photographic print shall be a circle of 80 mm diameter.

6.1.2 For grain sizes falling between two consecutive grain size numbers, the smaller grain size number shall be used, but the number of 0.5 shall be added to that number.

6.1.3 When it is difficult to make a determination under a microscope of 100 magnification, 50 or 200 magnification may be used. However, at that time, as given in Table 2, for example, at 50 magnification, the grain size number, thus obtained shall be decreased by 2, and at 200 magnification, the grain size number shall be increased by 2.

Table 2 Relation of grain size number to ordinary magnification

Magni- fication of image	Grain size number related to image to be discriminated with standard drawing number							
	1	2	3	4	5	6	7	8
50	-1	0	1	2	3	4	5	6
100	1	2	3	4	5	6	7	8
200	3	4	5	6	7	8	9	10

6.1.4 For mixed grains, the proportion of the areas of each grain size number shall be determined by eye.

6.1.5 In the case where pearlite and the like are mixed in great numbers so far as the mixed state is banded or granular, the area proportion of the mixed structure and of ferrite crystal grain shall be determined by eye. Subsequently, determination of a corresponding grain size number for only the ferrite crystal grain shall be made by comparison with the standard figure in Attached Fig. 1.

Remarks: Attached Fig. 2 indicates the presence of a pearlite phase in the mixture.

6.2 Intercept method

6.2.1 The grain size number shall be determined by formula (1) or Attached Fig. 3 on the basis of the number of ferrite crystal grain measured under a microscope.

6.2.2 In the case where the pearlite and the like are mixed in great numbers, the area proportion of the mixed structure and of ferrite crystal grain shall be determined by an appropriate method ⁽¹⁾ and then the number of crystal grain in square 25 mm² at 100 magnification shall be measured by intercept method. The results shall be converted into the number of ferrite crystal grain per 25 mm² square to obtain the grain size number determined by formula (1) or by Attached Fig. 3.

Note ⁽¹⁾ For example, point counting method, gravimetric method, photo-tube method, linear analysis method, etc.

6.3 The judging method by a counting method may be used as agreed upon between the purchaser and supplier. In this case, Annex 1 applies.

7 Method for synthetic determination

7.1 In comparison method, the mean grain size number which derives from the method of determining grain size in each visual field in 6.1 by the formula as shown below shall be taken as the grain size of the steel. The mean grain size number shall be rounded off to the first decimal place.

The number of visual fields observed shall be, as a rule, from 5 to 10. Table 3 shows an example.

$$g = \frac{\sum(a \times b)}{\sum b}$$

where, g : mean grain size number
 a : grain size number in each visual field
 b : number of visual fields indicating the identical grain size number

Table 3 Calculation of grain size (example)

Grain size No. in each visual field a	Number of visual fields b	$a \times b$	Mean grain size No. g	Grain size
6	2	12	$\frac{65}{10} = 6.5$	6.5
6.5	6	39		
7	2	14		
Total	10	65		

7.2 In intercept method, the grain size number obtained by the method under 6.2 shall be taken as the grain size of the steel.

7.3 For mixed grain under 6.1.4, the ratio of the mixture shall be determined by the synthetic mean values of the proportion of area of each grain size number.

7.4 The judging method by the intersected segment (grain size) may be used as agreed upon between the purchaser and supplier. In this case, Annex 2 applies.