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**Steel — Macroscopic examination by
etching**

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Foreword

This Japanese Industrial Standard has been revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by The Japan Iron and Steel Federation (JISF) with a draft being attached, based on the provision of Article 12, paragraph (1) of the Industrial Standardization Act applied *mutatis mutandis* pursuant to the provision of Article 16 of the said Act. This edition replaces the previous edition (**JIS G 0553**: 2012), which has been technically revised.

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NOTE Based on Article 9 of the Supplementary Provisions to the Unfair Competition Prevention Act etc., any submission of proposal, or employment of procedures such as deliberation by the Japanese Industrial Standards Committee under the previous Industrial Standardization Act shall be deemed to have been conducted pursuant to the provision of Article 12, paragraph (1) of the revised Industrial Standardization Act.

Steel — Macroscopic examination by etching

Introduction

This Japanese Industrial Standard has been prepared based on **ISO 4969**: 2015, Edition 2, with some modifications of the technical contents.

The vertical lines on both sides and dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JB.

1 Scope

This Standard establishes guidelines for the macroscopic examination on the surface of steel products ¹⁾ by hot etching, room temperature etching and electrolytic etching.

The method has very wide application. The following selections make it possible to achieve the required aim.

- Type, concentration and temperature of etchant
- Etching apparatus
- Conditions of surface preparation of test piece

NOTE 1 It might be difficult to see fine voids and cracks and discriminate between them, and determine their nature by macroetching.

NOTE 2 The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 4969 : 2015 *Steel — Etching method for macroscopic examination* (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

Note ¹⁾ Steel products include semi-finished products.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this Standard. The most recent edition of the standard (including amendments) indicated below shall be applied.

JIS B 0601 *Geometrical Product Specifications (GPS) — Surface texture : Profile method — Terms, definitions and surface texture parameters*

3 Terms and definitions

For the purpose of this Standard, the following terms and definitions apply. The

terms and their designations shown in parentheses indicate the irregularity of structure and not necessarily mean defects.

Figure 1 shows examples of macrostructure of steel products manufactured from killed steel ingots. Figure 2 shows an example of macrostructure of steel products manufactured from semi-finished products produced by continuous casting.

Terms **3.3** and **3.6** shall apply to steel products manufactured from ingots; **3.16** to steel products manufactured from semi-finished products produced by continuous casting. Other terms shall apply to ingots, and steel products manufactured from semi-finished products produced by continuous casting.

3.1

looseness (L or Lc)

spongy pattern appeared on the entire cross-section (L) or only at the centre (Lc) of steel product caused by quick progression of etching

3.2

forging crack (F)

crack generated at the centre of steel product due to improper operation of forging or rolling

3.3

splash (SP)

irregular (unusual) etching pattern such as splash, in which etching contrast differs from that in surrounding

3.4

crack beneath surface (Cb, Cd or Cs)

crack generally parallel to the surface of steel product generated under the mould surface of ingot (Cb); crack on the diagonal portion close to the surface of semi-finished product produced by continuous casting (Cd); crack parallel to the chill layer lying immediately beneath the chill layer (Cs)

NOTE The diagonal portion means the crossing position of columnar crystal growths or dendrite crystal growths.

3.5

dendrite (D)

tree-like trace of crystals formed during solidification and remained inside the steel product

3.6

ingot pattern (I)

black, white or other contour line revealed according to the etching concentration difference due to the change in crystalline state or the segregation of components during

solidification process of steel

3.7

centre segregation (Sc)

etching concentration difference revealed at the centre of steel product, due to segregation of components during the solidification process of steel

3.8

equiaxed structure (E)

crystal structure not having particular directivity revealed by etching at the centre of cross-section, which is different from chill crystal or columnar crystal on outer surface of cross-section of steel product

3.9

pit (T or Tc)

spotty cavities of visible size generated by etching on the entire cross-section of steel (T) or those generated at the centre of cross-section of steel product (Tc)

3.10

blow hole (B)

splash-like trace remained on the cross-section of steel product due to incomplete pressure bonding of blowholes or pinholes

3.11

non-metallic inclusion (N)

inclusion of visible size composed of non-metals

Etchant used for revealing the macrostructure may dissolve inclusions and make blow holes. It exists on the surface or immediately beneath the surface of steel product, or sometimes inside.

3.12

pipe (P)

internal trace of shrinkage hole generated in the solidification and shrinkage process or crack formed in the hot forming process due to incomplete pressure bonding

3.13

hair crack (H)

hair-like crack generally revealed between the centre of cross-section and the surface of steel product

3.14

circumference flaw (K, Kb or Kr)

flaw due to circumference blow hole (Kb); flaw due to rolling or forging (Kr); other flaw

generated in the circumference of steel product (K)

3.15

mid-radius crack (CM)

crack or crack pattern revealed near the centre of cross-section of steel product, generated in the direction from inside to surface of steel product

3.16

white band (W)

band-like white pattern generally revealed between the centre and the surface of steel product as the trace of electromagnetic stirring during continuous casting

4 Principle

4.1 Macroscopic etching reveals the macrostructure of a metal test piece and any gross physical or chemical irregularities present.

4.2 The reagent acts by dissolving different parts of the metal surface at unequal rates, and thus, produces differences in level which makes observation possible.

The use of the test and the conditions for interpreting the results observed depend on the particular case, details are presented in product standards or shall be as agreed between the purchaser and the manufacturer.

4.3 Macroscopic examination after etching reveals lack of chemical uniformity (segregation of elements), lack of physical uniformity (cracks or porosity), and any intentional or accidental structural variations such as those caused, for instance, by hardening, decarburization or case hardening.

4.4 In addition, enhanced sensitivity can be achieved by altering the conditions of test piece preparation and/or attack. For instance, it is possible to reveal the dendritic structure of a metal or the presence of inclusions or very small defects.

5 Sampling

5.1 The position and number of sampling shall be determined according to the requirements of the product standard, specification, contract or order. In the absence of any special requirements, sampling is required to be planned according to the details of the manufacturing process and the grade being evaluated.

5.2 The macroetching test, as applied to the inspection of steel products of this method, is carried out on test pieces, usually 13 mm to 25 mm in thickness. Test pieces are usually cut to reveal a transverse surface, but the requirements of the specification, contract, or order can include the preparation and examination of a longitudinal surface. In most cases, a longitudinally-oriented test piece is taken with the plane to be etched along the centreline of the wrought product and it includes both outside surfaces with a length in the longitudinal direction, usually 1.5 times greater than the product thickness or diameter.

5.3 Test pieces may be cold cut from the source by any convenient fashion; saws and abrasive cut-off wheels are particularly effective. The use of torch cutting or hot cutting should be used only when necessary to cut a test piece from a large specimen. It is advisable to locate the test surfaces well, away from the hot-cut surface avoiding sampling defects, such as deformations, heat affected zone and cracks.

5.4 Large specimens can be cut into smaller pieces to facilitate handling and to comply with safety requirements. The sectioning of large specimen should be done so as not to disturb the central portion of the section.

6 Preparation of test piece

6.1 The degree of surface preparation necessary depends on the precision required for macroscopic examination by acid etching. Surface of the test piece to be examined should be, as a rule, finished with R_a of between 30 μm and 3.5 μm in an arithmetical mean roughness as specified in JIS B 0601.

6.2 While rough machining, resulting in relatively coarse surfaces, can be sufficient in certain cases [routine inspection to reveal a pipe (see 3.12), for example], more careful machining is generally required.

6.3 The criteria to be observed when machining are as follows :

- a) cutting-tool marking should not be pronounced, for example, as the result of incorrect adjustment, excessively deep cuts or heavy feeds on the lathe or the shaping machine; good results are generally obtained with a feed of approximately 0.1 mm;
- b) there should be as little cold working of the surface as possible, due for instance
 - 1) to a type of tool which is not suitable for the metal, or which is badly sharpened, and
 - 2) to the use of unsuitable grinding wheels (e.g., less than F100 specified in JIS R 6001-1).

6.4 The main types of machining generally used are the following :

- a) grinding (with or without preliminary machining);
- b) shaping or turning, provided that the lathe is fitted with a speed adjuster.

6.5 Where acid etching is used to reveal very fine defects or structural irregularities (different welding zones for instance), careful polishing is recommended; the finer the polishing, the better the definition.

6.6 After surface preparation, the test piece is cleaned carefully with suitable solvents. Any grease, oil, or other residue will produce uneven attack. Once cleaned, care should be taken not to touch the surface of test piece or contaminate it in any way.

7 Solutions

7.1 The solutions used for etching are as given in 8.1.9 and Annex JA depending on each test method. In most cases, a good grade of reagent should be used but need not