

# A a -Re a See P a e JFE S ee †

## 1. Overview

Over the years since the production launch the “Ever Hard” (EH) abrasion-resistant steel plates from JFE Steel in the 1960’s, EH plates have been used for wide-ranging applications in industries such as mining, civil engineering, and construction machinery. Ever Hard plates have also been steadily improved to satisfy more exacting customer demands for abrasion resistance, low-temperature toughness, weldability, and deep-hardened thick plates. JFE Steel’s efforts to deliver these improvements have culminated in the following products<sup>1)</sup>:

- (1) Standard and alloy type series in 1985
- (2) Special grade JFE-EH-SP in 1993
- (3) LE Type series in 2003 (The Japan Institute of Metals Award 2003)

With rising global demand, the production of EH plates has reached an annual tonnage of about 70 000.

This report introduces the specifications and charac-

teristics of the Ever Hard steel plates from JFE Steel.

## 2. Specifications and Characteristics

### 2.1 Specifications for EH Plates

**Table 1** shows JFE Steel standards for abrasion-resistant steel plates (EH) categorized into three groups (standard, alloy, and LE types) and one special grade (EH-SP). The diverse grades available accommodate the needs and demands of various users.

The three-digit notation for the grades in Arabic numerals is the classification for minimum Brinell hardness. A classification of ‘360’ means that the hardness of plate surface is over 360 (average 400); ‘400’ means over 400 (average 450); ‘500’ means not less than 477 (average 500).

The letter ‘A’ next to the Arabic numerals denotes the alloy type, and ‘LE’ stands for leading edge.

The properties of each type are as follows<sup>1)</sup>:

Table 1 JFE steel standards for abrasion resistant steel plates

Grade	Thickness (mm)	Tensile strength (MPa)	Yield strength (MPa)	Elongation at break (%)	Impact energy (J)	Hardness (HRC)	Surface roughness (Ra)	Notes
A360	3	475	375	22	27	36	0.1	
	6	475	375	22	27	36	0.1	
A400	3	500	400	22	27	36	0.1	
	6	500	400	22	27	36	0.1	
A500	3	550	450	22	27	36	0.1	
	6	550	450	22	27	36	0.1	
EH-SP	3	550	450	22	27	36	0.1	
	6	550	450	22	27	36	0.1	

<sup>1)</sup>C<sub>eq</sub>=C+Mn/6+(Cu+Ni)/15+(Cr+Mo+V)/5

† Originally published in *JFE GIHO* No. 18 (Nov. 2008), p. 72–74

- (1) The standard type has three grades, JFE-EH360, JFE-EH400, and JFE-EH500, ranging in thickness from 6 to 50.8 mm. A minimum surface hardness is guaranteed.
- (2) The alloy type has two grades, JFE-EH360A and JFE-EH500A, ranging in thickness from 6 to 100 mm. The thicker plates have a higher guaranteed minimum surface hardness than the standard type.
- (3) The LE type guarantees low-temperature toughness at  $-40^{\circ}\text{C}$  and a low carbon equivalent to maintain the surface hardness. The LE type is available in two grades, JFE-EH360LE and JFE-EH500LE, ranging in thickness from 6 to 32 mm. Both have excellent weldability and cold-formability.
- (4) JFE-EH-SP has the same hardness as JFE-EH400, but even better abrasion resistance. Its thickness ranges from 6 to 65 mm.

## 2.2 Characteristics of EH Plates

### 2.2.1 Abrasion resistance

**Figure 1** shows the relationship between hardness and the abrasion resistance ratio. The abrasion resistance was evaluated according to ASTM G65 (ASTM: American Society for Testing and Materials).  $\text{SiO}_2$  was used for abrasive. The abrasion resistance was calculated as the ratio of the weight loss of TS 400  $\text{N}/\text{mm}^2$  steel to the weight loss of abrasion-resistance steel.

Abrasion resistance generally increases with hardness. The abrasion resistance ratio of the EH360, EH400 and EH500 grades are about three, four and five times that of TS 400  $\text{N}/\text{mm}^2$  steel, respectively. JFE-EH-SP has a very high abrasion resistance in spite its relatively lower hardness<sup>1)</sup>. This property can be attributed to the

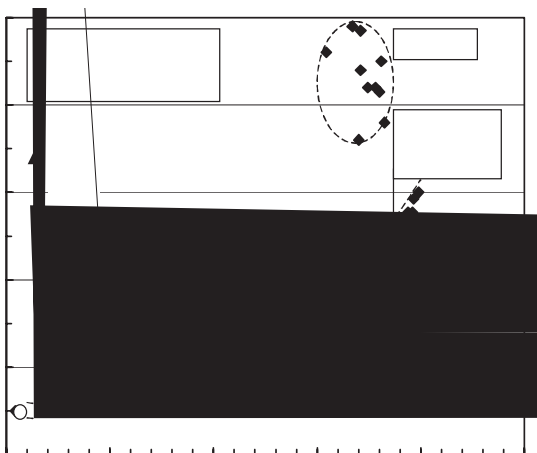


Fig. 1 Relation between hardness and abrasion resistance ratio

hard precipitates in JFE-EH-SP. Engineers must note, however, that the abrasion resistance of a steel will vary with the abrasion environment. If you are planning to use abrasion-resistant steel for a particular application, please consult with JFE Steel beforehand.

### 2.2.2 Low-temperature toughness and weldability

**Figure 2** compares the absorbed energy of the Standard and LE types. The LE type has lower carbon equivalent than the standard type and double the absorbed energy. The LE type is suitable for the use in cold areas, where its superior resistance to impacts can be expected to extend its lifetime.

Shield metal arc welding and gas shielded welding are generally available for EH plates. **Figure 3** shows y-groove cold cracking test results for each grade. Delayed cracking must be prevented in EH plates, as well as high-strength steel. To accomplish this, it is important to keep the welding material dry and remove all oil and rust from the plate surfaces. Delayed cracking is much easier to prevent in the LE type than in the Standard Type, though the same preheating temperature

Fig. 2 Comparison of absorbed energy of Standard and LE type

Fig. 3 Recommendation on preheating temperature

