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JFE Steel's Abrasion-Resistant Steel Plates EVERHARD™†

1. Introduction

Abrasion-resistant steel plates reduce wear loss by stones, earth, and sand in comparison with ordinary steel materials, and are used in a wide range of fields, including construction machinery and industrial machinery, which are indispensable for development of social infrastructure, and mining machinery which is actively used at resource extraction sites. In response to the need for improved efficiency in construction work and heightened demand for resources, demand for abrasion-resistant steels is increasing, and higher performance is also required. Since JFE Steel began the manufacture and sale of its EVERHARD™ abrasion-resistant steel plate in 1955, the company has realized technical development responding to the diverse needs of customers as Japan's representative maker and supplier of abrasion-resistant steel plates[1]. Today, EVERHARD™ is used not only in Japan, but in countries around the world. JFE Steel produces more than 100 000 tons of EVERHARD™ products each year.

This report introduces the product lineup of JFE Steel's EVERHARD™ abrasion-resistant steel plates, together with the features of these products.

2. Features of EVERHARD™

2.1 EVERHARD™ Product Lineup

The product lineup and features of the EVERHARD™ Series are shown in **Table 1**. In general, abrasion resistance increases with the surface hardness of steel plates. In addition to the surface hardness grade, JFE Steel is responding to a wide range of applications by developing diverse products with various special features.

In the "Standard Series," surface hardness is guaranteed by the alloy design and special heat treatment. In addition to surface hardness, the "LE Series" guarantees low temperature toughness at −40°C, enabling use in arctic climates, and also realizes improved safety against external impact and cold bending forming. Here, the numbers showing hardness (400, 450, etc.) mean the median value of the surface hardness range. In addition, extra-heavy gauge products exceeding 101.6 mm and thin products with a plate thickness of 5 mm have also been developed. The "SP Series" was developed based on the concept of abrasion resistance exceeding that of the HB500 class.

Table 1 EVERHARD™ Series and features

Series	Features	Products	Grade	Surface hardness (HB)	Thickness (mm)	Low temperature toughness of longitudinal direction
Standard	Basic EVERHARD Basic alloy-design for economical and easy-welding fabrication	EVERHARD C340 EVERHARD C400 EVERHARD C450 EVERHARD C500 EVERHARD C550	HB340 HB400 HB450 HB500 HB550	340±30 400±30 450±25 500±40 550±40	38–160 6–101.6 6–101.6 6–101.6 6– 32	—
LE	Low temperature service Sufficient toughness at −40°C Lined up to HB500 class	EVERHARD C400LE EVERHARD C450LE EVERHARD C500LE	HB400 HB450 HB500	400±30 450±25 500±40	6–60 6–50.8 6–32	$vE_{-40°C} \geqq 27$ J ($t \geqq 12$) $vE_{-40°C} \geqq 27$ J ($t \geqq 12$) $vE_{-40°C} \geqq 21$ J ($t \geqq 12$)
SP	"Beyond" EVERHARD Super abrasion-resistance beyond HB500 class	EVERHARD SP	HB450	≧401	6–65	—

vE: Charpy absorbed energy HB: Brinell hardness

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2.2 Abrasion Resistance

The relationship between the surface hardness and abrasion resistance of EVERHARD™ is shown in **Fig. 1**. Abrasion resistance is expressed by the ratio with 400 MPa class mild steel in the rubber wheel abrasion test in accordance with ASTM G65. The abrasion resistance of EVERHARD™ increases with the hardness grade. The abrasion resistance of the HB400 class is approximately 3 times that of 400 MPa class steel, and HB450 and HB500 class steels have outstanding abrasion resistance approximately 4 and 5 times higher than the 400 MPa class, respectively. EVERHARD SP has even higher abrasion resistance, exceeding even JFE Steel's HB500 class steel. This performance is achieved by a combination of EVERHARD™ microstructure control technology and a proprietary JFE Steel's hard precipitate dispersion technology[2].

2.3 Low Temperature Toughness (LE Series)

In the EVERHARD "LE Series," Charpy absorbed energy at −40°C is guaranteed through refinement of the microstructure by a proprietary microalloying technology and heat treatment process[3, 4]. Because low temperature toughness tends to decrease as plate thickness increases, there was a limit to plate thickness with the conventional technology. However, in response to requests for heavier gauges accompanying the larger scale of dump trucks and shovels, the maximum thickness of EVERHARD C400LE was increased from the conventional 32 mm to 60 mm, and a new product, EVERHARD C450LE (Maximum thickness: 50.8 mm) was also developed. This further expanded the range of applications of the "LE Series" and is expected to contribute to improved safety and longer life of construction and industrial machinery.

2.4 Bending Formability

Cold bending forming of EVERHARD™ is possible by the press method and roll bending method, and the recommended minimum bending radius is shown. However, since care is necessary for processing, users should refer to the product catalog, etc. for detailed information. EVERHARD "Standard and LE Series" are product series which achieves easy adjustment of conditions during forming and improved forming accuracy by strict control of surface hardness within a narrow range.

2.5 Weldability

High hardness, high strength steel plates generally display high sensitivity to welding low temperature cracking. In contrast, crack-free welding is possible with EVERHARD™ provided welding is performed properly. Low temperature cracks occur in weld metal or the heat affected zone (HAZ) when these regions are embrittled by penetration of hydrogen into the steel as a result of welding. However, this type of crack can be prevented by selection and control of welding consumables, etc., together with proper preheating. For example, the recommended preheating temperatures of the "Standard Series" are shown in **Table 2**. These are based on the results of y-groove weld cracking test (JIS Z 3158, JIS: Japanese Industrial Standards) of shielded metal arc welding using an ultra-low hydrogen welding electrode and gas metal arc welding using a solid wire. As these are examples in which restraint is comparatively large, it is also possible to simplify welding work, for example, by relaxing the preheating temperature corresponding to the restraint intensity in actual welding.

2.6 Overall Surface Marking

In response to users'requests, "overall surface mark-

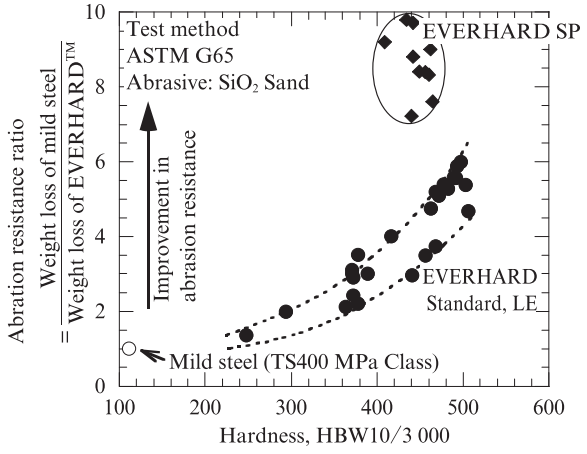

Fig. 1 Relationship between hardness and abrasion resistance

Table 2 Preheating temperature guideline of EVERHARD™

Production	Welding method	Thickness (mm)					
		10	20	30	40	50	60–100
EVERHARD C400	SMAW	50°C	75°C	100°C		>125°C	
	GMAW	R. T.		50°C		>50°C	
EVERHARD C450	SMAW	50°C	75°C	100°C		>125°C	
	GMAW	R. T.		50°C		>75°C	
EVERHARD C400LE	SMAW	75°C	100°C	125°C			
	GMAW	R. T.		50°C			
EVERHARD C450LE	SMAW	75°C	100°C	125°C			
	GMAW	R. T.	50°C	75°C			

SMAW: Shielded metal arc welding
GMAW: Gas metal arc welding R. T. : Room temperature

Photo 1 Example appearance of EVERHARD C500 (JFE-EH-C500)

ing" is applied to EVERHARD™ to enable easy identification of steel plates even after cutting. In this marking method, the product standard and other information are printed over the entire plate surface. Primer painted product can also be provided. An example of application is shown in **Photo 1**.

3. Conclusion

The features of JFE Steel's EVERHARD™ abrasion-resistant steel plate series were introduced. In the future, JFE Steel will work to improve quality and develop new products for various applications and use environments, and will continue to manufacture and sell EVERHARD™ products that customers can use with confidence.

References

1) For example, Abrasion-Resistant Steel Plates of JFE Steel. JFE Technical Report. 2008, no. 11, p. 26–28.
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For Further Information, Please Contact:

Plate Business Planning Dept., JFE Steel
Phone: (81) 3-3597-3371 Fax: (81) 3-3597-3533
Website: http://www.jfe-steel.co.jp/en/products/plate/index.html