

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

1. Introduction

With the larger scale of global mineral resource, infrastructure and agricultural food development of recent years, various requirements have been imposed to abrasion-resistant steel plates used in mining, construction and agricultural machinery. Since the first commercialization of abrasion-resistant steel plates in 1955, JFE Steel has consistently promoted the development of new products in response to the requirements of the times¹⁾, and has also published "Guidelines for Fabrication" covering welding, thermal cutting and mechanical processing so that customers can use these abrasion-resistant steel plates with even greater confidence. As a result, more than 50 000 tons of JFE abrasion-resistant steel plates are now newly used each year in countries around the world.

This article introduces the features of JFE Steel's product lineup of EVERHARD™ abrasion-resistant steel plates and the related Guidelines for Fabrication.

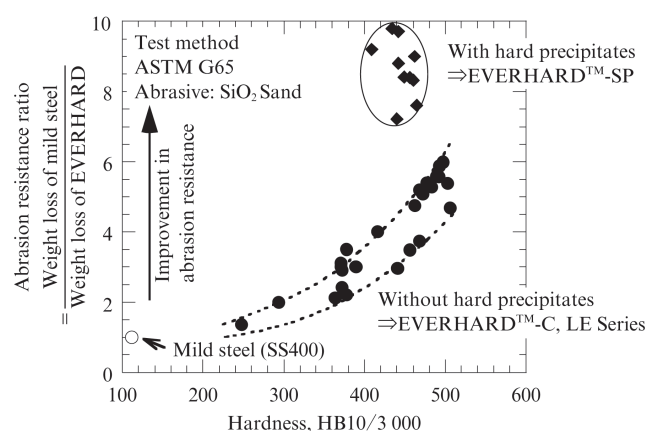


Fig. 1 Relationship between hardness and slip abrasion resistance

2. Features of EVERHARD™

2.1 Abrasion Resistance Properties

Figure 1 shows the relationship between hardness and slip abrasion resistance. Slip abrasion resistance is

Table 1 EVERHARD™ series and features

Series	Features	Brand name	Thickness (mm)	Surface hardness (HB)	Low temperature toughness of longitudinal direction
C	Basic EVERHARD Basic alloy-design for economical, easy-welding and fabrication	EVERHARD-C340	38-160	340 ± 30	—
		EVERHARD-C400	5-101.6	400 ± 30	
		EVERHARD-C450	5-101.6	450 ± 25	
		EVERHARD-C500	5-101.6	500 ± 40	
		EVERHARD-C550	6-32	550 ± 40	
		EVERHARD-C600	6-25.4	600 ± 30	
LE*	Low temperature service Sufficient toughness at -40°C Available up to HB500 class	EVERHARD-C400LE	5-12	400 ± 30	—
			12.1-101.6		vE-40°C ≥ 27 J (Ave.)
		EVERHARD-C450LE	5-12	450 ± 25	—
			12.1-50.8		vE-40°C ≥ 27 J (Ave.)
			50.9-80		
		EVERHARD-C500LE	5-12	500 ± 40	vE-40°C ≥ 21 J (Ave.)
			12.1-50.8		
			50.9-80		
SP	"Beyond" EVERHARD Superior abrasion-resistance beyond HB500 class	EVERHARD-SP	6-65	≥ 401	—

vE: Charpy absorbed energy, HB: Brinell hardness

* Core hardness guaranteed upon customer's request

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evaluated by the rubber wheel abrasion test conforming to ASTM G65, and is compared with the amount of abrasion weight loss of mild steel. Abrasion resistance increases with hardness, and in the case of HB500 class steel, abrasion resistance approximately 5 times higher than that of mild steel can be obtained. Moreover, abrasion-resistant property greatly exceeding that of the conventional HB500 class can be obtained by fine dispersion of hard precipitates. The next section describes JFE's lineup of abrasion-resistant steels which were developed based on this knowledge.

2.2 EVERHARD™ Product Lineup

Table 1 shows the EVERHARD product lineup and its features. The C Series consists of steel plates in which surface hardness is guaranteed by alloy design and special heat treatment, and guarantees a range of surface hardness, considering workability (easy welding and fabrication) when manufacturing equipment in which EVERHARD is used. It is possible to produce EVERHARD-C340 with plate thicknesses up to 160 mm and EVERHARD-C400, C450 and C500 with thicknesses up to 101.6 mm. EVERHARD-C550 and C600 have also been commercialized for environments in which abrasion resistance properties are a particularly high priority, such as liners with simple shapes.

In addition to the features of the C Series, the LE Series consists of abrasion-resistant steel plates which guarantee low temperature toughness at -40°C . This low temperature toughness, which is not possible in conventional abrasion-resistant steel plates, was achieved in the LE Series by applying microalloying technology and heat treatment technology²⁻⁴⁾. The LE Series has been commercialized up to HB500 grade, and is the optimum line of products for environments where high toughness is required, particularly for use in cold climates and under conditions that involve impact environments. The LE Series can also be used in applications in which it is necessary to secure internal hardness. EVERHARD-C400LE has been commercialized in plate thicknesses up to 101.6 mm, and EVERHARD-C450LE and EVERHARD-C500LE are available in thicknesses up to 80 mm.

EVERHARD-SP is a steel plate in which high slip abrasion resistance exceeding that of HB500 grade is obtained without remarkably increasing hardness by dispersing hard precipitate particles in the microstructure, thereby also securing good workability.

2.3 JFE's Guidelines for Fabrication of EVERHARD™

"Guidelines for Welding" summarizes points which require attention when welding EVERHARD. Due to its high hardness, EVERHARD has high weld crack

Brand name	Welding method	Thickness(mm)									
		10	20	30	40	50	60	70	80	90	101.6
EVERHARD-C340	SMAW, FCAW					125°C			>125°C (max. 160mm)		
	GMAW				75°C		>75°C		100°C (max. 160mm)		
EVERHARD-C400	SMAW, FCAW	50°C	75°C		100°C						
	GMAW	Room temperature		50°C				>75°C			
EVERHARD-C450	SMAW, FCAW	75°C			125°C				>125°C		
	GMAW	Room temperature			75°C		100°C		>100°C		
EVERHARD-C500	SMAW, FCAW	125°C		175°C				175-200°C			
	GMAW	Room temperature	75°C	125°C		>125°C		>150°C			
EVERHARD-C550	SMAW, FCAW	200°C									
	GMAW	175°C									
EVERHARD-C600	SMAW, FCAW	200°C									
	GMAW	175°C									
EVERHARD-C400LE	SMAW, FCAW	75°C		100°C		125°C			>125°C		
	GMAW	Room temperature			75°C		>75°C		100°C		
EVERHARD-C450LE	SMAW, FCAW	75°C		125°C		>125°C		200°C			
	GMAW	Room temperature			75°C			175°C			
EVERHARD-C500LE	SMAW, FCAW	125°C		175°C (32mm)		175-200°C			200°C		
	GMAW	Room temperature	75°C (32mm)				175°C (32mm)				
EVERHARD-SP	SMAW, FCAW	100°C		175°C			175-200°C				
	GMAW	75°C				175°C					

SMAW (Shielded metal arc welding) : Welding with a coated electrode.
FCAW (Flux cored arc welding) : Welding with a flux cored wire.
GMAW (Gas metal arc welding) : Welding methods using a welding wire in combination with a shield gas, for example, carbon dioxide gas shielded arc welding, etc.

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Fig. 2 Recommended minimum welding preheating temperature

Brand name	Thickness (mm)										
	10	20	30	40	50	60	70	80	90	100	160
EVERHARD-C340				200				150			
EVERHARD-C400	No Restrictions			200				150			
EVERHARD-C450				200				Preheating			
EVERHARD-C500		250	200	150				Preheating			
EVERHARD-C400LE				200				Preheating			
EVERHARD-C450LE				200				Preheating			
EVERHARD-C500LE		250	200	150				Preheating			
EVERHARD-C550		200									
EVERHARD-C600		200									
EVERHARD-SP		250	200	150	Preheating						

(mm/min)

Fig. 3 Recommended maximum gas-cutting speed

sensitivity in comparison with conventional mild steel plates, but welding is possible without causing cracks by appropriate welding. Cold cracking is delayed cracking which occurs as a result of hydrogen that infiltrates into the steel during welding, but can be prevented by an appropriate selection of welding consumables and welding conditions. As one example, **Fig. 2** shows the recommended welding preheating temperatures for EVERHARD, which were set based on the results of y-groove weld crack tests in accordance with JIS Z 3158. Basically, it is necessary to set a higher preheating temperature in case of high hardness and heavy thickness materials. For this reason, the preheating temperature of LE Series is high in comparison with the C Series.

"Guidelines for Thermal Cutting" summarizes the key points when performing thermal cutting of EVERHARD. As in the case of welding, adequate precautions to prevent delayed cracking are also necessary in thermal cutting of high-hardness EVERHARD. Preheating and post-cutting heat treatment are effective for preventing delayed cracking due to thermal cutting.

However, in cases where preheating and post-cutting heat treatment are difficult, it is also possible to suppress delayed cracking by an appropriate selection of the gas-cutting speed. **Figure 3** shows the recommended gas-cutting speeds without preheating. A slower gas-cutting speed is necessary in case of high hardness and heavy thickness materials. In thermal cutting of small parts, it is necessary to adjust the cutting method so that the temperature of the parts do not exceed 200°C, because an excessive temperature rise may reduce hardness in some cases.

"Guidelines for Bending" and "Guidelines for Machining" summarize the recommended processing conditions for EVERHARD when using various processing methods. In comparison with conventional plates, greater care is required in mechanical forming and machining of high hardness EVERHARD. For details, please refer to the related Guidelines.

3. Conclusion

The features of JFE Steel's EVERHARD Series of abrasion-resistant steel plates and various Guidelines for Fabrication of EVERHARD were introduced. In the future, JFE Steel will continue to work develop new

products and improve product quality corresponding to the application and use environment, and will manufacture and market EVERHARD products that customers can use with satisfaction and confidence.

References

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