Total Steel

TECHNICAL BULLETIN 7

JFE

EH500LE

Abrasion Resistant Steel Plate

Manufacturer's Testing

total quality total service **Total Steel**

CONTENTS

I SPECIFICATION

1. Manufacturing Process and Available Thicknesses

Grade	Thickness	Heat Treatment
JFE-EH500LE	6 ~ 32 mm	Controlled heat treatment

2. Chemical Composition

Thickness	Chemical composition (wt.%)									
	C	Si	Mn	P	S	Cr	Mo	Ti	B	Ceq (LR)
~19 mm	0.29 max	0.55 max	1.60 max	0.020 max	0.010 max	0.40 max	0.35 max	0.02 max	0.004 max	0.55 max
19.1 ~ 32 mm										0.58 max

Ceq(LR)=C+Mn/6+Cu/15+Ni/15+Cr/5+Mo/5+V/5

3. Mechanical Properties

Brinell hardness (3000 kgf)	Charpy impact properties Absorbed energy at -40°C(J) (Average of 3 tests)
477 ~ 556	21 min

Impact properties are guaranteed for the plate of the thickness not less than 12 mm in longitudinal direction unless otherwise specified.

II TEST RESULTS

1. Steel Plates Tested

1-1 Chemical Composition

Table 1: Ladle Analysis (wt.%)

C	Si	Mn	P	S	Cr	Mo	Ti	B	Ceq (LR)	P_{CM}
0.26	0.31	1.33	0.007	0.002	0.10	0.13	0.01	0.0011	0.53	0.36

Small amount of other microalloying elements are added

Ceq(LR)=C+Mn/6+Cu/15+Ni/15+Cr/5+Mo/5+V/5

P_{CM}=C+Si/30+Mn/20+Cu/20+Ni/60+Cr/20+Mo/15+V/10+5B

Table 2: Product Analysis (wt.%)

Thickness (mm)	C	Si	Mn	P	S	Cr	Mo	Ti	B	Ceq (LR)	P_{CM}
12	0.26	0.31	1.32	0.006	0.002	0.10	0.13	0.01	0.0012	0.52	0.35
20	0.26	0.32	1.34	0.006	0.002	0.10	0.13	0.01	0.0012	0.53	0.36
25	0.26	0.32	1.34	0.006	0.002	0.10	0.13	0.01	0.0012	0.53	0.36
32	0.27	0.32	1.38	0.008	0.002	0.10	0.14	0.01	0.0012	0.54	0.36

Small amount of other microalloying elements are added

Ceq(LR)=C+Mn/6+Cu/15+Ni/15+Cr/5+Mo/5+V/5

P_{CM}=C+Si/30+Mn/20+Cu/20+Ni/60+Cr/20+Mo/15+V/10+5B

2. Properties of base plates

2-1 Microstructure

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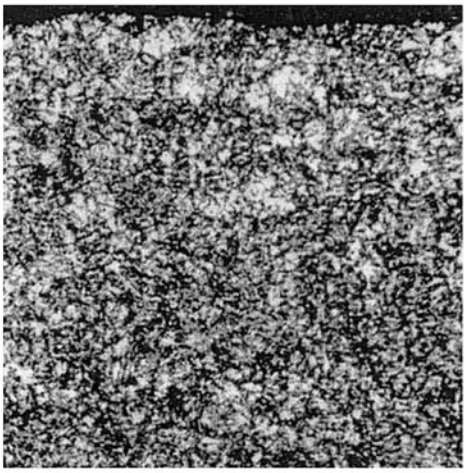
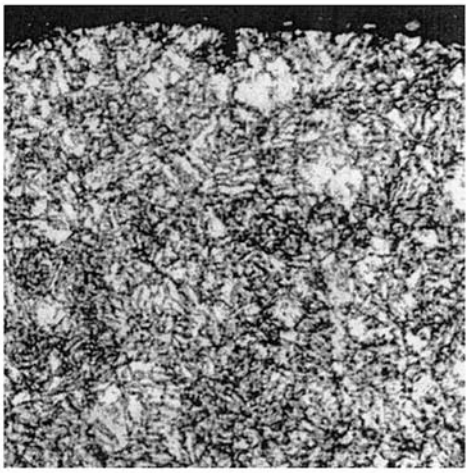
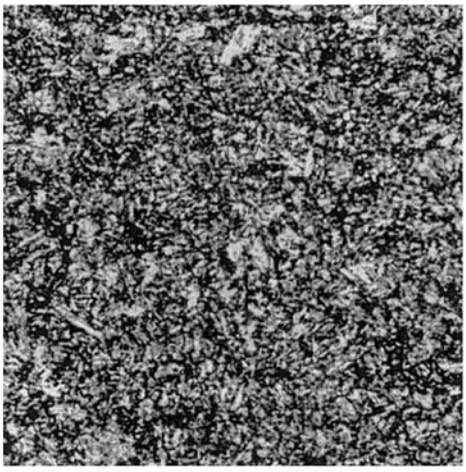
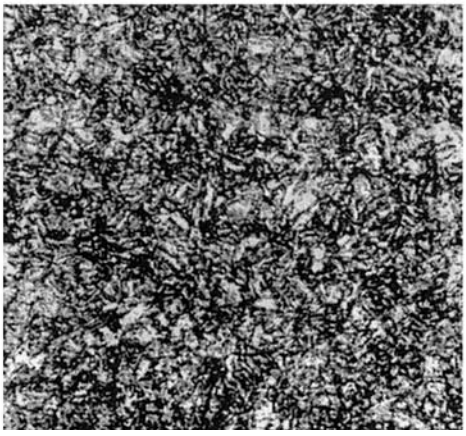
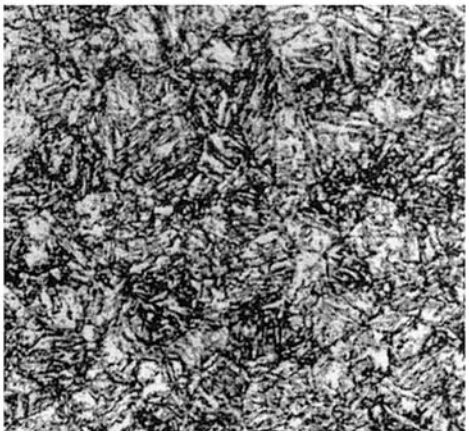
Surface		
1/4 t		
1/2 t		

100µm 50µm

Photo 1: Microstructure (t = 12 mm)

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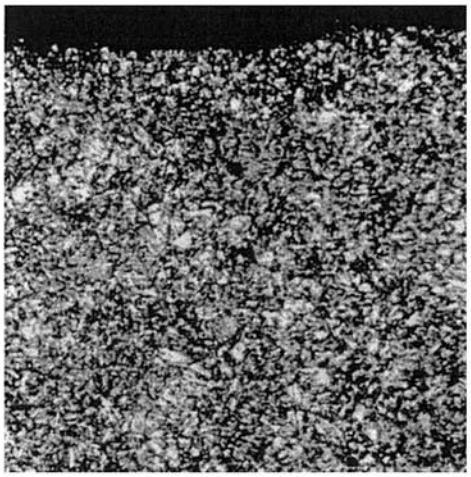
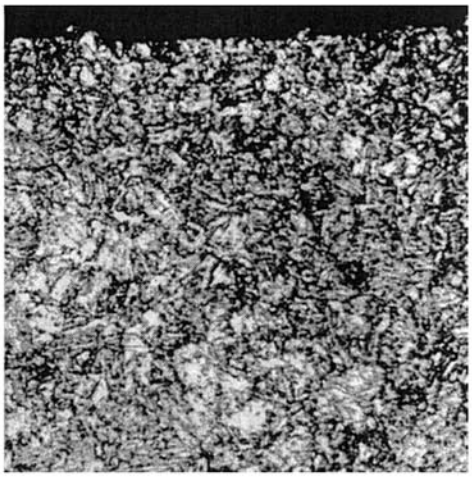
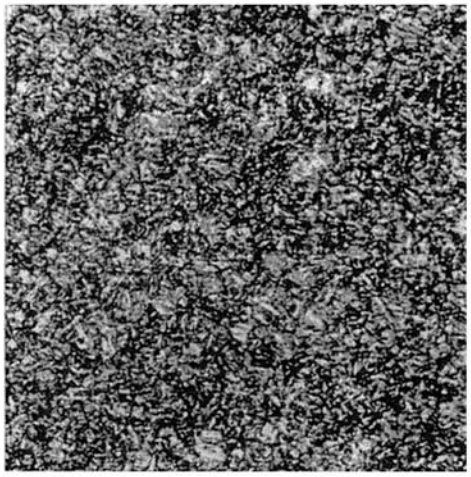
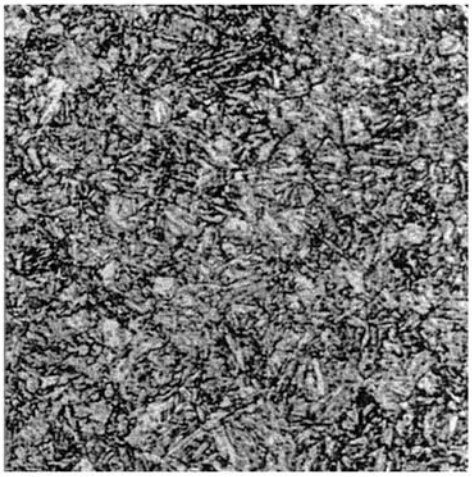
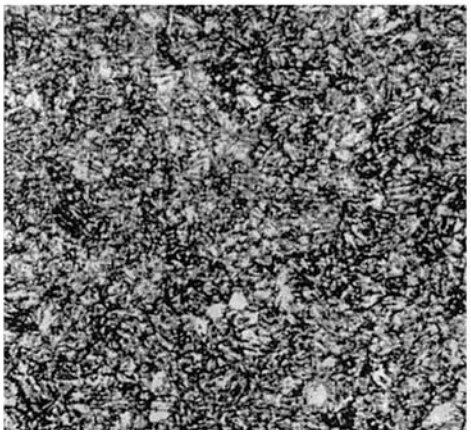
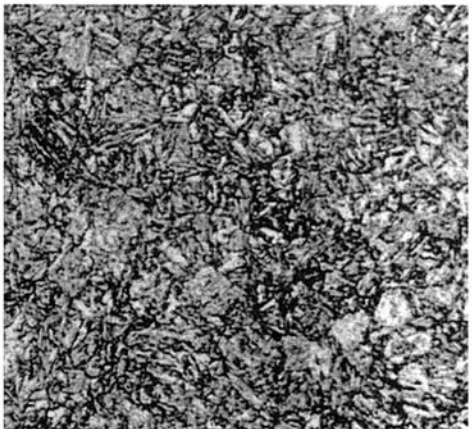
Surface		
1/4 t		
1/2 t		

100µm 50µm

Photo 2: Microstructure (t = 20 mm)

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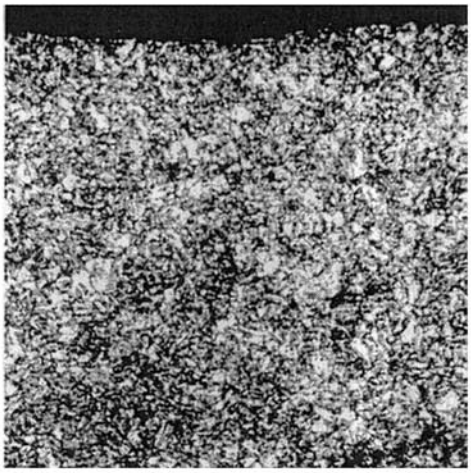
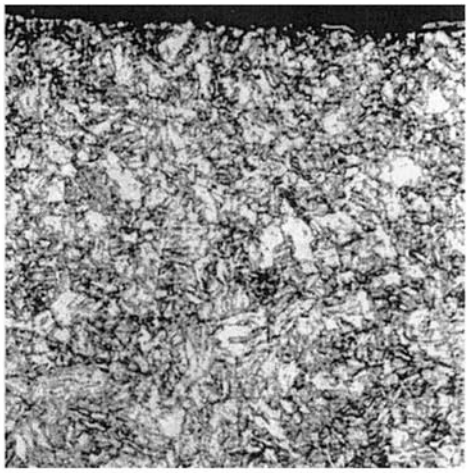
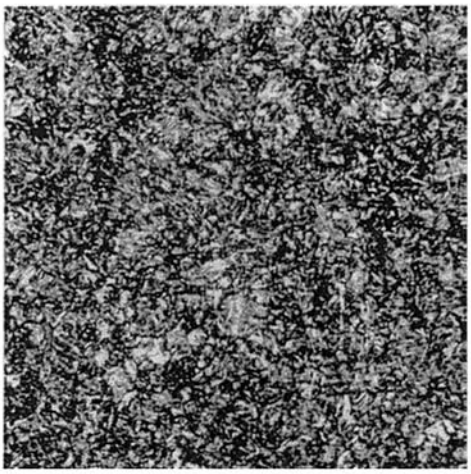
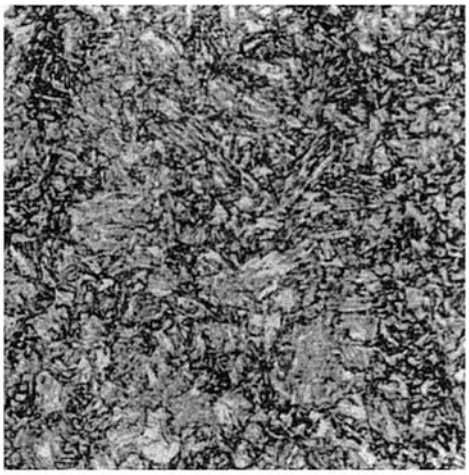
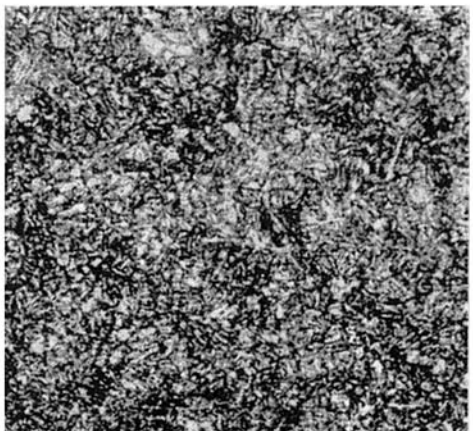
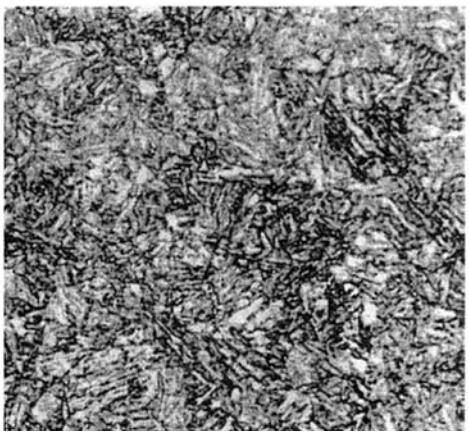
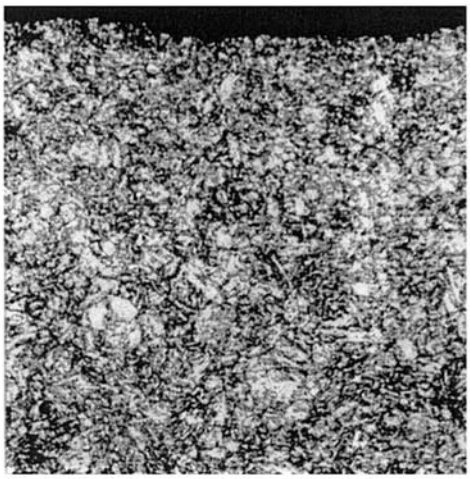
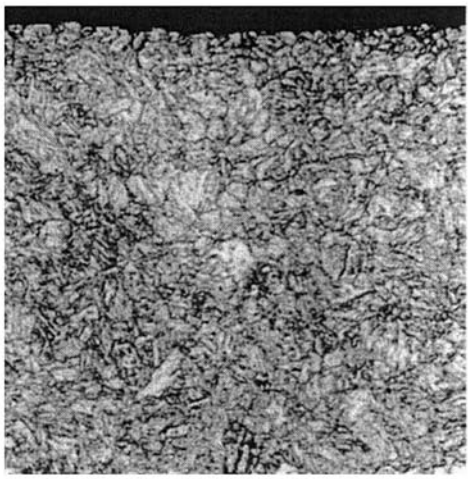
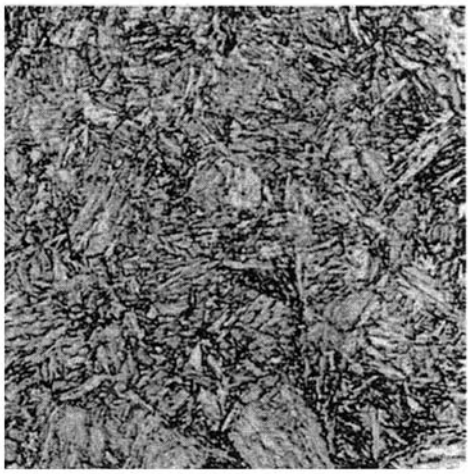
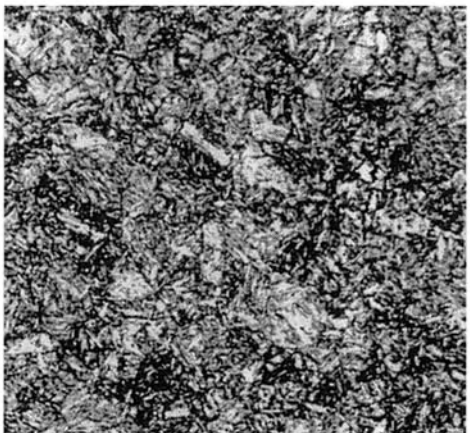
Surface		
1/4 t		
1/2 t		

100µm 50µm

Photo 3: Microstructure (t = 25 mm)

	x 200	x 400
Surface		
1/4 t		
1/2 t		

100µm 50µm

Photo 4: Microstructure (t = 32 mm)

2-2 Tensile Test

Table 3: Results of Tensile Test

Thickness (mm)	Specimen	Position	Direction	YS or 0.2%PS (N/mm^2)	TS (N/mm^2)	El (%)
12	JIS No. 5	Full Thickness	C	1317	1715	15
20	JIS No. 5	Full Thickness	C	1203	1681	17
	JIS No. 4	1/2 t	C	1280	1653	12
25	JIS No. 5	Full Thickness	C	1240	1672	18
	JIS No. 4	1/2 t	C	1193	1632	11
32	JIS No. 5	Full Thickness	C	1314	1556	22
	JIS No. 4	1/4 t	C	1320	1516	12
	JIS No. 4	1/2 t	C	1298	1465	12

JIS No. 5: 25 mm width x 50 mm GL
JIS No. 4: 14 mm diameter x 50 mm GL

2-3 Charpy Impact Test

Table 4: Results of Charpy Impact Test

Thickness (mm)	Specimen	Direction	Absorbed energy at -40°C (J)			
			Each.			Ave.
12	2 mm V-Notched	L	43	43	33	40
20	2 mm V-Notched	L	45	36	46	42
25	2 mm V-Notched	L	42	35	43	40
32	2 mm V-Notched	L	34	30	31	32
Spec.		L	–			≥ 21

2-4 Hardness Distribution in Thickness Direction

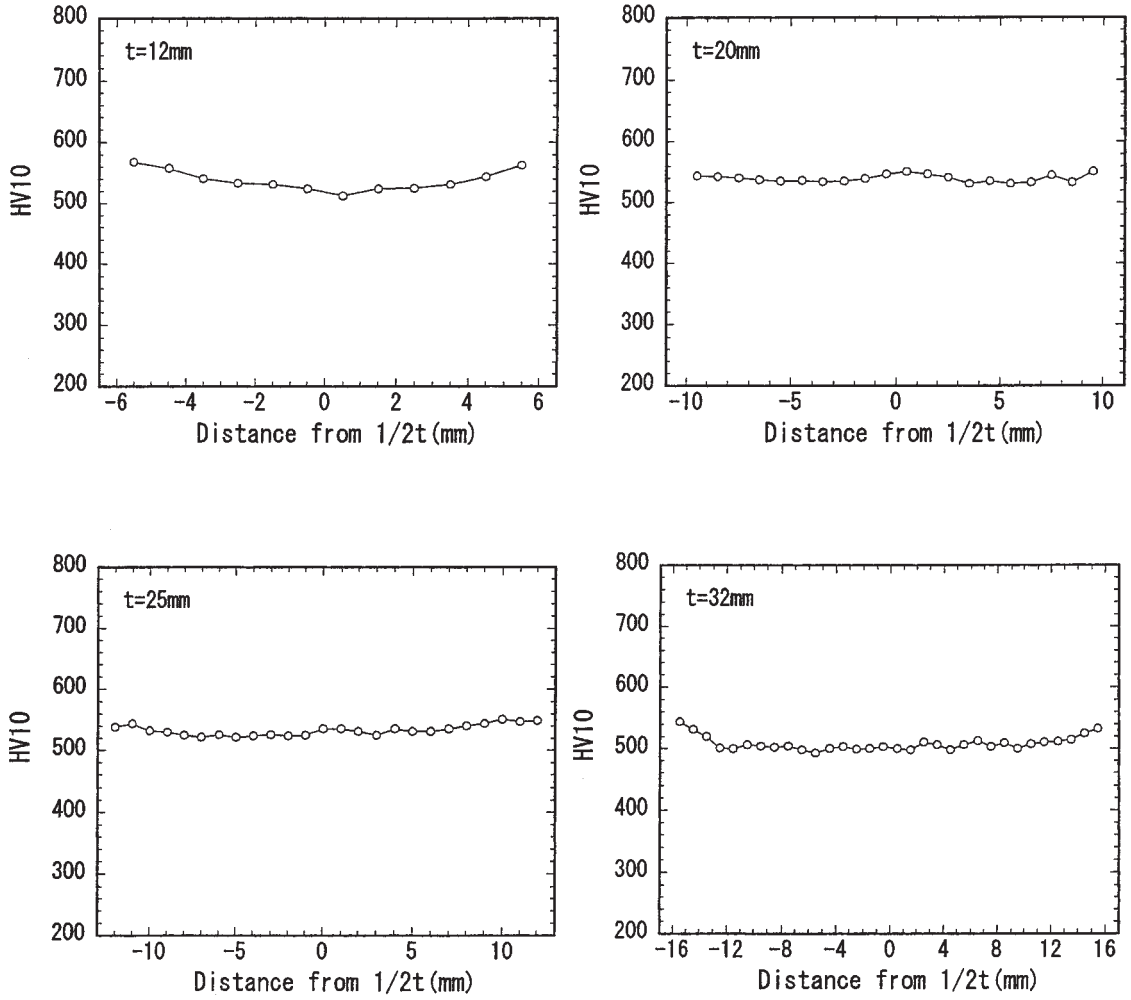


Figure 1: Hardness Distribution in Thickness Direction

2-5 Brinell Hardness Test

Table 5: Results of Brinell Hardness Test

Thickness (mm)	Each	Ave.
12	504, 507, 504, 501, 498	503
20	501, 495, 501, 507, 504	502
25	507, 492, 495, 501, 510	501
32	492, 488, 510, 513, 511	503
Spec.	–	477 ~ 556

2-6 Bending Test

Table 6: Results of Bending Test

Thickness (mm)	Direction	Specimen*		Bending radius (t : thickness of specimen)			
		No.	Width (mm)	2.5 t	2.0 t	1.5 t	1.0 t
12	L	JIS No. 1	50	❍	❍	×	–
	C			❍	×	×	–
20	L			❍	❍	×	–
	C			❍	❍	×	–
25	L			❍	❍	×	–
	C			❍	❍	×	–
32	L			❍	❍	❍	×
	C			❍	❍	❍	×

* Total thickness ❍ : No cracking × : Cracks

3. Weldability

3-1 Maximum Hardness Test

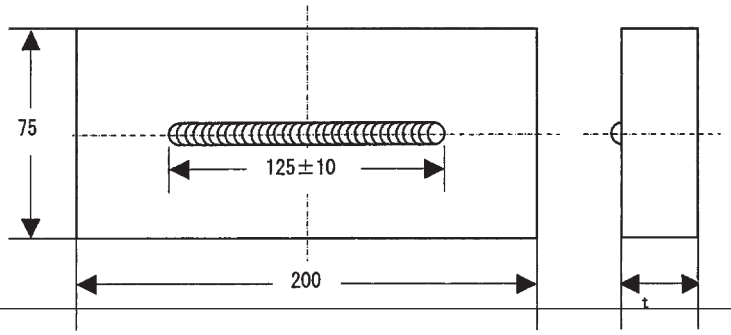
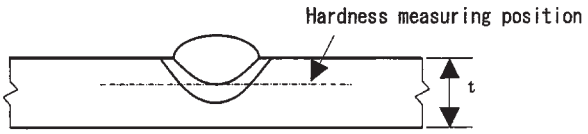
Specimen	
Hardness measuring position	

Figure 2: Test Conditions

Table 7: Welding Conditions

Welding method	SMAW
Thickness	20 mm
Welding material	LB-62 4.0 mm Ø (KOBELCO)
Welding conditions	170A–25V–15 cm/min
Welding heat input	17 kJ/cm
Preheating temperature	25°C, 50°C, 100°C

Table 8: Results of Maximum Hardness Test

Preheat temperature	25°C	50°C	100°C
Maximum hardness (HV10)	487	478	457

3-2 y-Groove Cracking Test

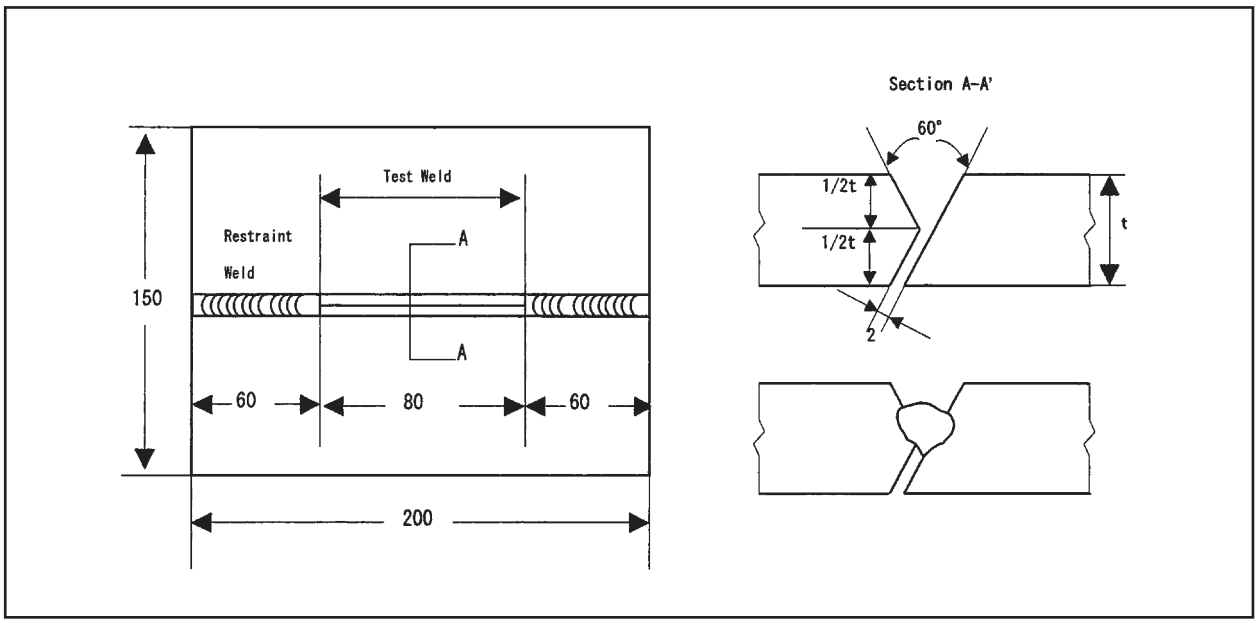


Figure 3: Specimen Configuration

Table 10: Welding Conditions

Welding method	SMAW	GMAW CO_2 100%)
Thickness	20 mm	20 mm
Welding material	LB-62 4.0 mm Ø (KOBELCO)	MG-50 1.2 mm Ø (KOBELCO)
Welding conditions	170A–25V–15 cm/min	240A–30V–25 cm/min
Welding heat input	17 kJ/cm	17 kJ/cm
Preheating temperature	100°C, 125°C, 150°C	50°C, 75°C, 100°C

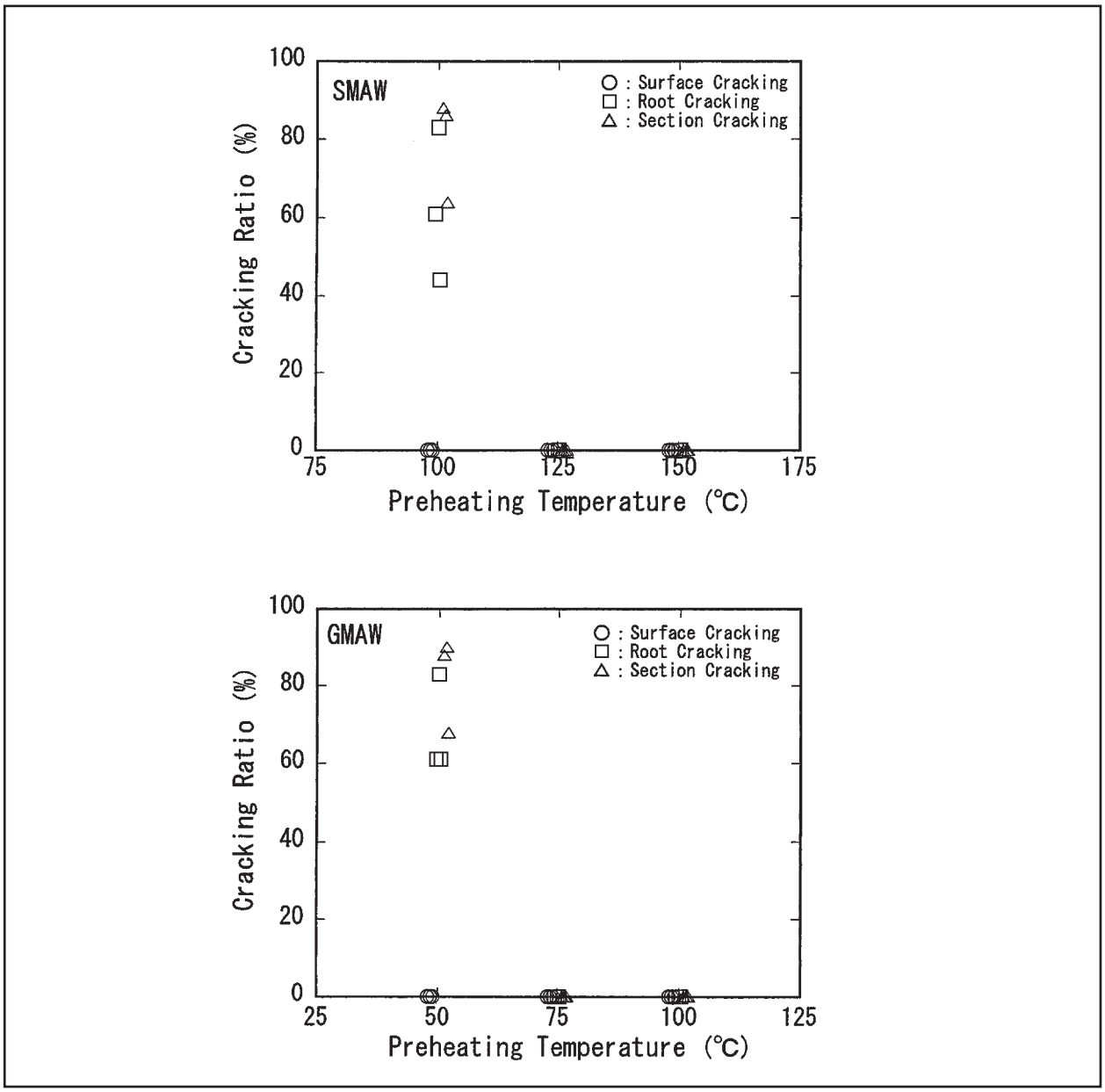


Figure 4: Results of y-Groove Cracking Test

Table 11: Results of y-Groove Cracking Test

Thickness (mm)	Welding method	Preheat Temperature to Prevent from Cracking (°C)
20	SMAW	125
	GMAW	75

4. Mechanical Properties of Welded Joints

4-1 Welding Conditions

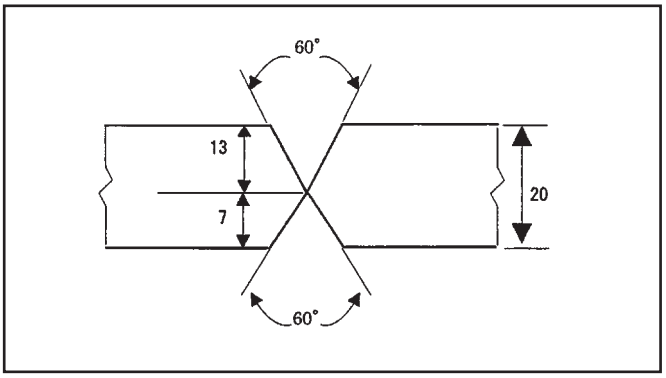


Figure 7: Edge Preparation

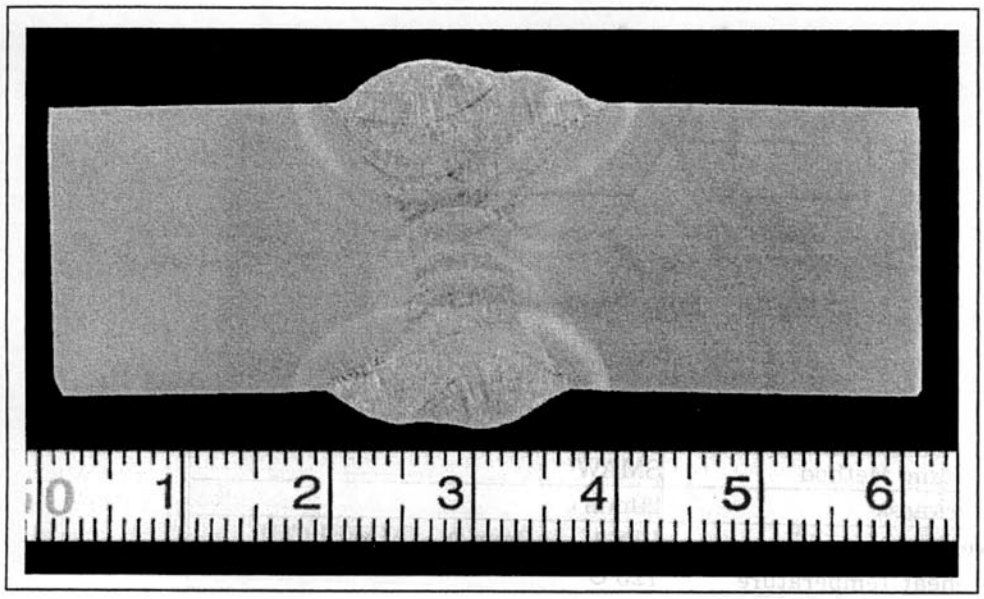
Table 16: Welding Conditions (SMAW)

Welding method	SMAW	
Thickness	20 mm	
Welding materials	LB-62 4.0 mm Ø (KOBELCO)	
Preheat temperature	125°C	
Inter-pass temperature	≤ 250°C	
Pass	1 Pass	Other Pass
Welding current	170A	170A
Arc voltage	25V	25V
Welding speed	15 cm/min	12 cm/min
Heat input	17.0 kJ/cm	21.3 kJ/cm

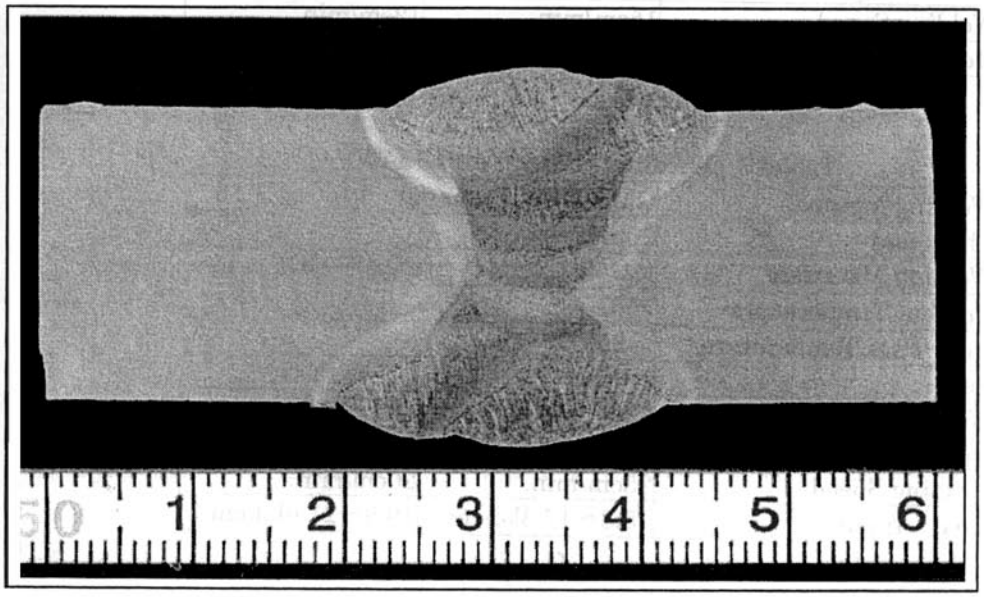
Table 17: Welding Conditions (GMAW)

Welding method	GMAW (CO_2 100%)	
Thickness	20 mm	
Welding materials	MG-50 1.2 mm Ø (KOBELCO)	
Preheat temperature	75°C	
Inter-pass temperature	≤ 250°C	
Pass	1 Pass	Other Pass
Welding current	220 ~ 240A	220 ~ 240A
Arc voltage	30V	30V
Welding speed	25 cm/min	20 cm/min
Heat input	15.8 ~17.3 kJ/cm	19.8 ~21.6 kJ/cm

4-2 Macrostructure



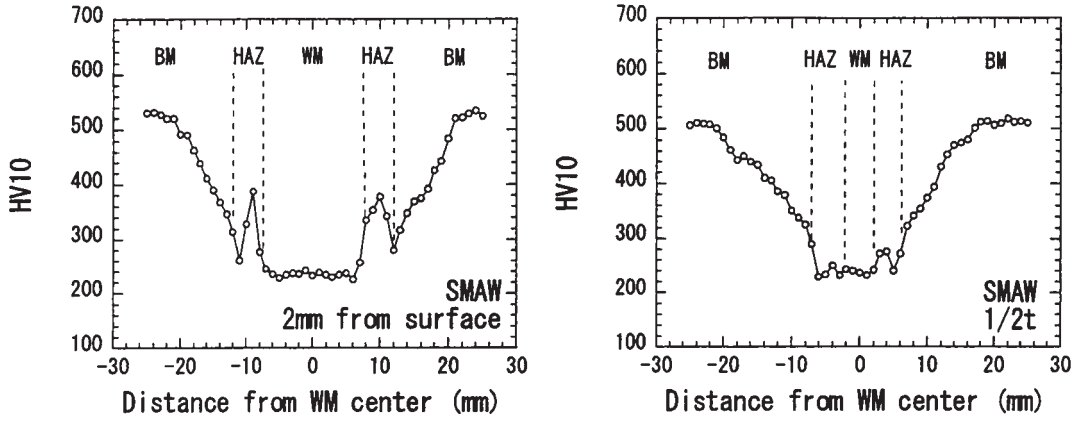
(a) SMAW



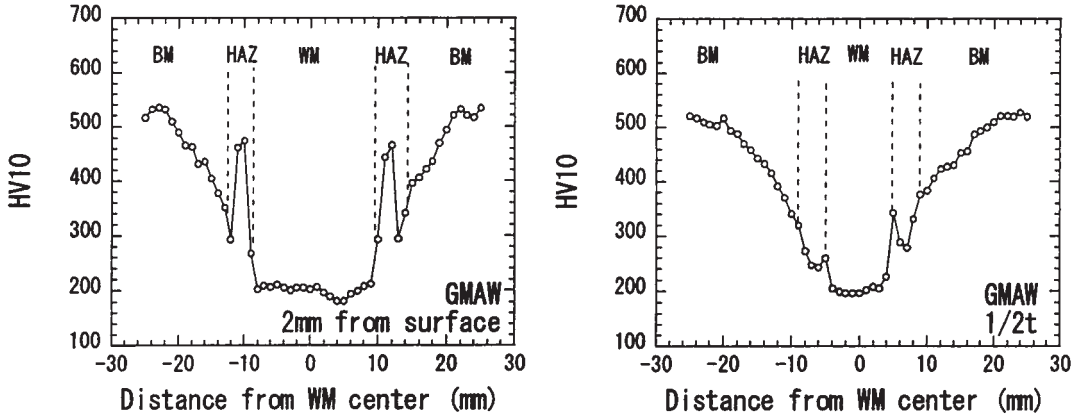
(b) GMAW

Photo 5: Macrostructure

4-3 Hardness Distribution in Welded Joint



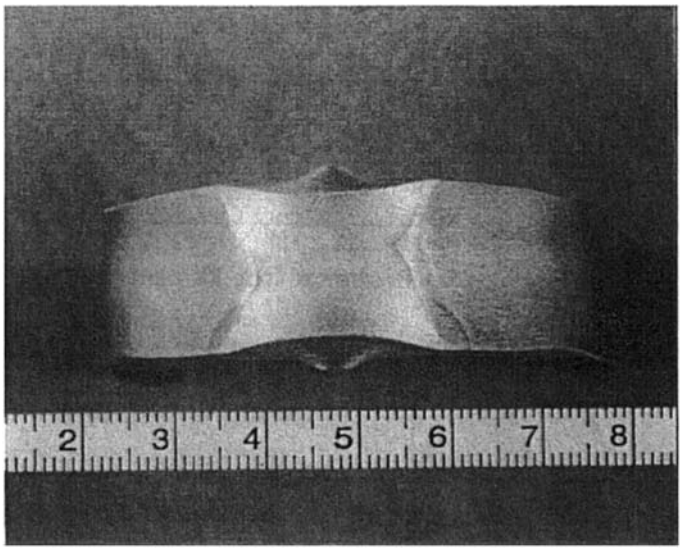
(a) SMAW

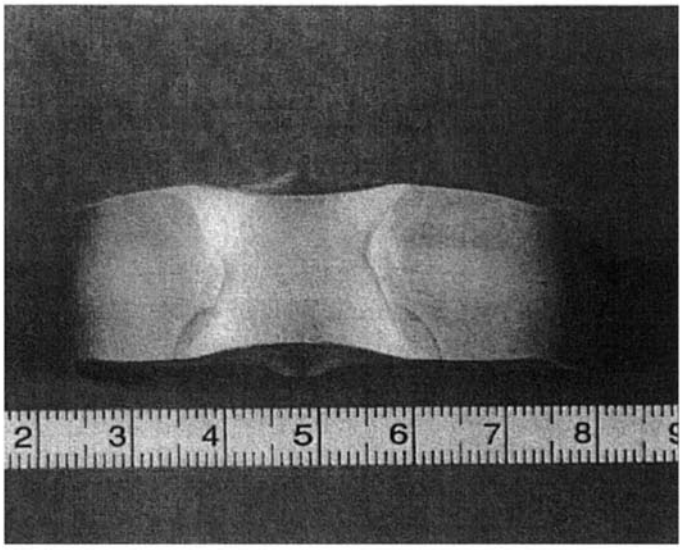


(b) GMAW

Figure 8: Hardness Distribution in Welded Joint

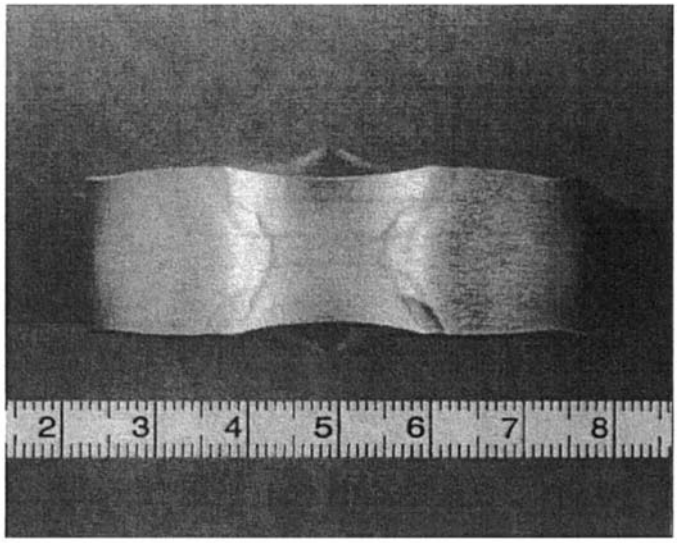
4-4 Side Bend Test of Welded Joint

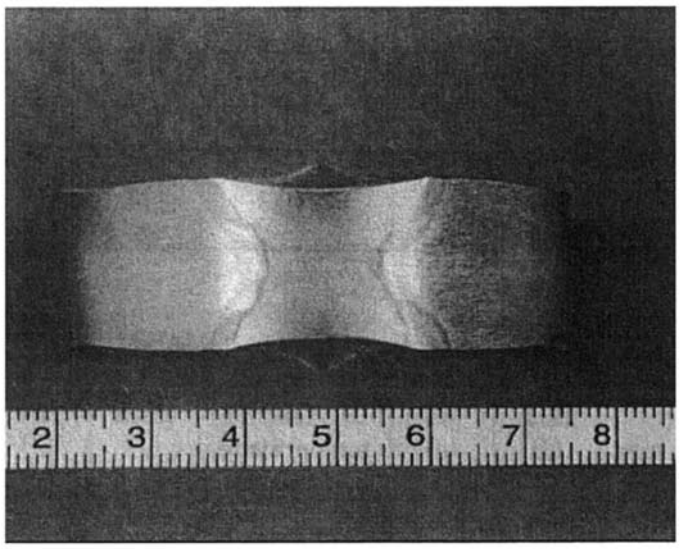




Bending Radius: 20 mm Bending Test Results: **Good**

Photo 6: Results of Side Bend Test (SMAW)





Bending Radius: 20 mm Bending Test Results: **Good**

Photo 7: Results of Side Bend Test (GMAW)

4-5 Charpy Impact Test of Welded Joints

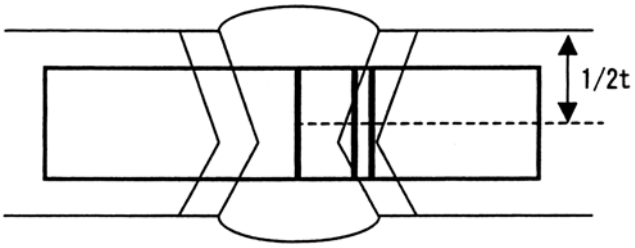


Figure 9: Sampling Position of Test Specimens

Table 18: Results of Charpy Impact Test (SMAW)

Notch position	Absorbed Energy					
	Test temperature (°C)	Each (J)	Ave (J)	Test temperature (°C)	Each (J)	Ave (J)
WM	0	122 121 126	123	-40	42 75 69	62
FL	0	124 162 138	141	-40	84 104 68	85
HAZ	0	167 187 162	172	-40	135 114 89	113

Table 19: Results of Charpy Impact Test (GMAW)

Notch position	Absorbed Energy					
	Test temperature (°C)	Each (J)	Ave (J)	Test temperature (°C)	Each (J)	Ave (J)
WM	0	136 119 121	125	-40	49 62 35	49
FL	0	160 157 143	153	-40	50 40 52	47
HAZ	0	180 181 179	180	-40	179 185 138	167

WM : Weld Metal
FL : Fusion Line
HAZ : Heat Affected Zone

Modified from TEC No. C1E-T033-00
200312 DB

Total Steel

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total quality total service **Total Steel**

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