TMCP STEEL PLATE

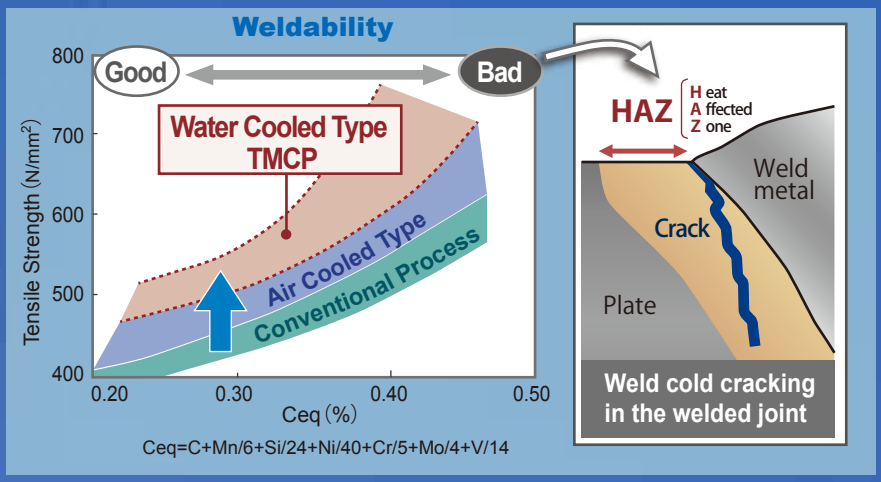
STRUCTURAL STEEL FOR BUILDINGS

JFE Steel Corporation

Advantage of TMCP Steel Plates

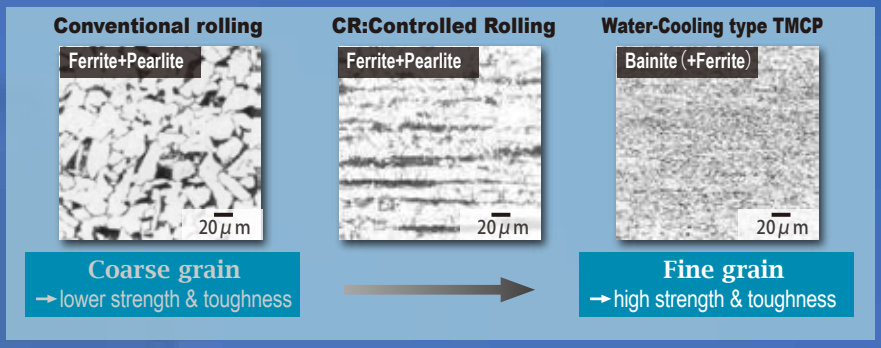
1. Improvement in Efficiency of Fabrication and Its Reliability

It is able to suppress the weld cracking and decrease the preheating temperature because of its low carbon equivalent value, and also improve the toughness of welded joint.

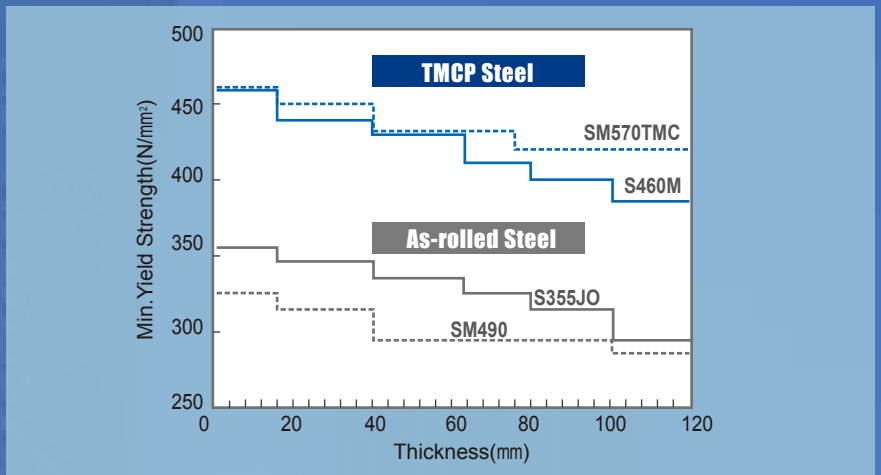


2. Superior Strength and Toughness

After rolling process, the plate is treated by water cooling device, Super-**OLAC**(Online Accelerated Cooling), and gains finer grain in microstructure than the conventional steel.



Having the finer grain micro-structure, TMCP steel plate achieves higher strength and toughness than the conventional steel. Especially, the higher yield strength generally means the higher design strength, which is highly useful and effective in various design aspects.



3. Short Lead Times

Lead time is short because TMCP process consists of a series of rolling processes and online accelerated cooling process which does not involves off-line procedure.

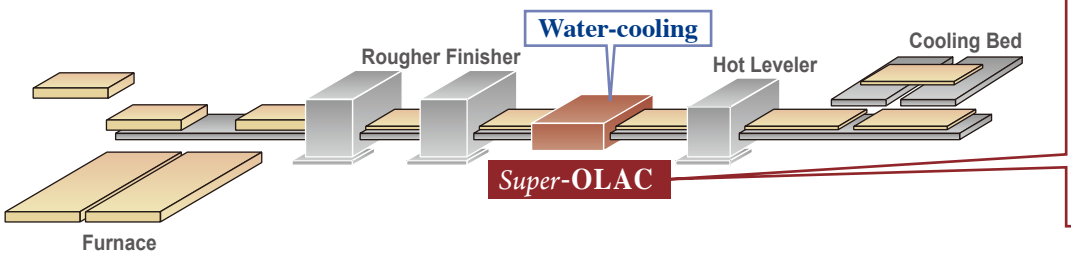
4. TMCP Steel is online-heat treated and low-alloyed metal

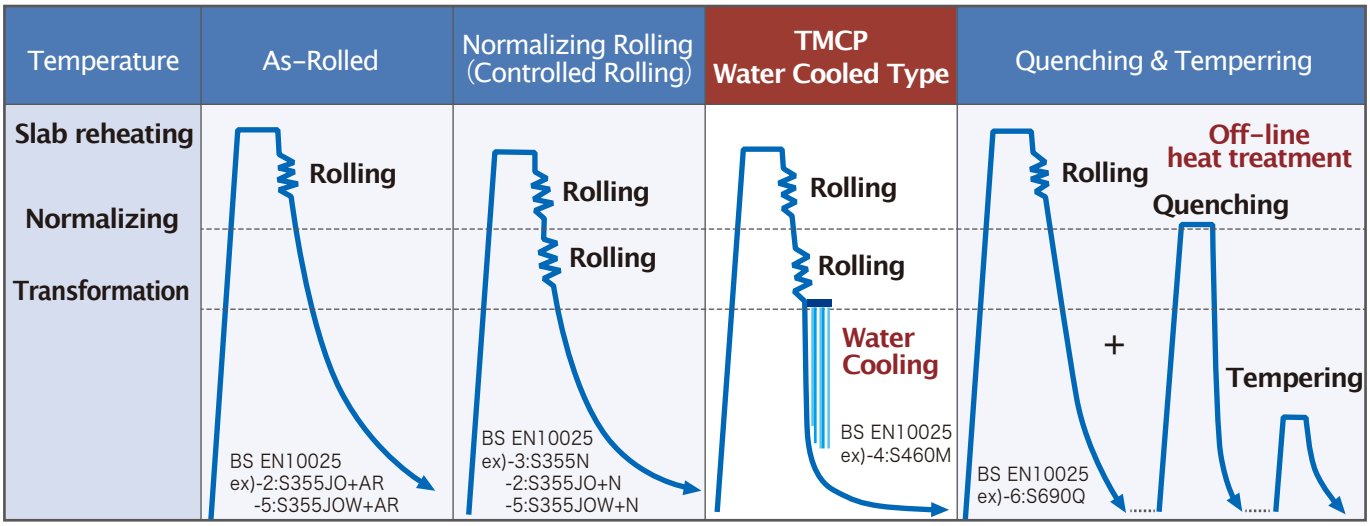
Besides, in case of TMCP, alloy content is quite low because it achieves higher strength by means of online accelerated cooling method.

Thermo-Mechanical Control Process

"TMCP" stands for "Thermo-Mechanical Control Process"

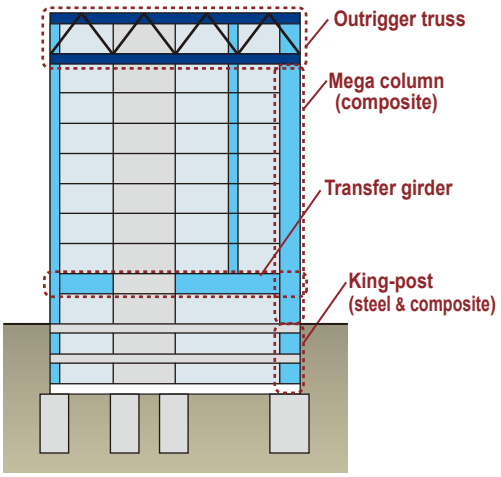
Layout of Manufacturing Line



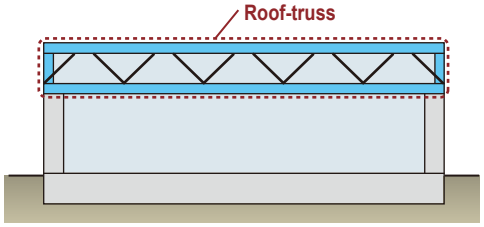


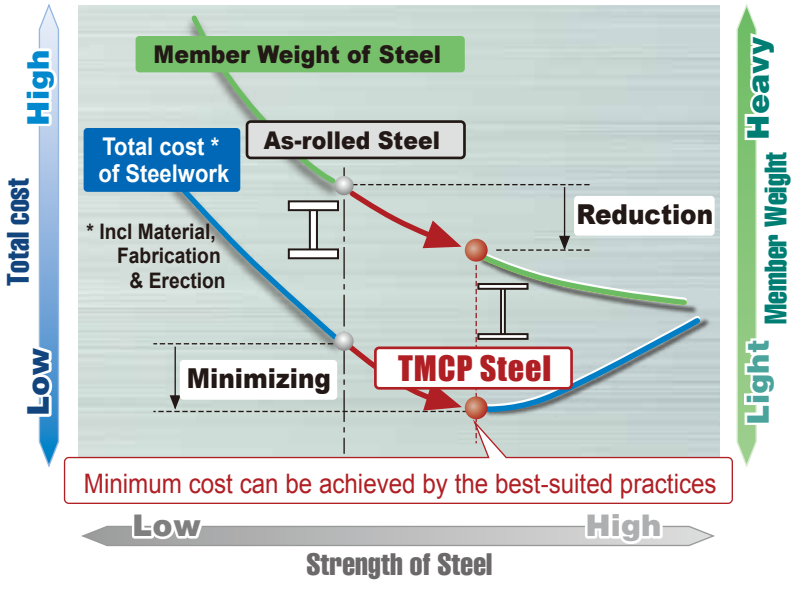
Practical Application

High-rise building



Large spanning structure





PRODUCT SPECIFICATION

Chemical Composition

EN10025-4:2004

Designation	t (mm)	Chemical composition of the ladle analysis (%)															CEV (%) max.			
		C max.	Si max.	Mn max.	P max.	S max.	Nb max.	V max.	Al_{total} min.	Ti max.	Cr max.	Ni max.	Mo max.	Cu max.	B max.	N max.	≦16	16< ≦40	40< ≦63	63< ≦120
S355M	≦120	0.14	0.50	1.60	0.030	0.025	0.05	0.10	0.02	0.05	0.30	0.50	0.10	0.55	—	0.015	0.39	0.39	0.40	0.45
S355ML					0.025	0.020														
S420M	≦120	0.16	0.50	1.70	0.030	0.025	0.05	0.12	0.02	0.05	0.30	0.80	0.20	0.55	—	0.025	0.43	0.45	0.46	0.47
S420ML					0.025	0.020														
S460M	≦120	0.16	0.60	1.70	0.030	0.025	0.05	0.12	0.02	0.05	0.30	0.80	0.20	0.55	—	0.025	0.45*	0.46*	0.47*	0.48*
S460ML					0.025	0.020														

Carbon equivalent value CEV(%)=C+Mn/6+(Cr+Mo+V)/5+(Ni+Cu)/15

* S460M can be delivered with Low CEV option(LCE) upon request, which is specially-designed by JFE Steel Corp so that max. CEV is maintained equal or lower than 0.43; refer page-5 for the further details.

ASTM A1066/A1066M-11(2015)

Designation	t (mm)	Chemical composition of the heat analysis (%)															CEV (%) max.
		C max.	Si max.	Mn max.	P max.	S max.	Nb max.	V max.	Al_{total} min.	Ti max.	Cr max.	Ni max.	Mo max.	Cu max.	B max.	N max.	
Grade 50	≦100	0.14	0.15 -0.50	0.70 -1.60	0.030	0.020	0.05	0.08	0.02	—	0.30	0.30	0.10	0.35	0.002	—	0.40
Grade 60	≦100	0.16	0.15 -0.50	0.80 -1.70	0.030	0.020	0.05	0.08	0.02	—	0.30	0.70	0.20	0.35	0.002	—	0.43
Grade 65	≦75	0.16	0.15 -0.50	0.80 -1.70	0.030	0.020	0.05	0.08	0.02	—	0.30	0.70	0.25	0.35	0.002	—	0.45

Carbon equivalent value CEV(%)=C+Mn/6+(Cr+Mo+V)/5+(Ni+Cu)/15

JIS G3106:2015

Designation	t (mm)	Chemical composition of the ladle analysis (%)															Ceq (%) max.	PCM (%) max.
		C max.	Si max.	Mn max.	P max.	S max.	Nb max.	V max.	Al_{total} min.	Ti max.	Cr max.	Ni max.	Mo max.	Cu max.	B max.	N max.		
JIS G3106	t≦50	0.18	0.55	1.70	0.035	0.035	Other elements can be added as required.										0.44	0.28
SM570TMC	50<t≦100																0.47	0.30

Carbon equivalent value: Ceq (%)=C+Mn/6+Si/24+Ni/40+Cr/5+Mo/4+V/14
Weld Cracking Parameter: Pcm (%)=C+Si/30+Mn/20+Cu/20+Ni/60+Cr/20+Mo/15+V/10+5B

JFE Brand of TMCP Steel Plates (HBL™ series products)

Designation	t (mm)	Chemical composition of the ladle analysis (%)															Ceq (%) max.	PCM (%) max.
		C max.	Si max.	Mn max.	P max.	S max.	Nb max.	V max.	Al_{total} min.	Ti max.	Cr max.	Ni max.	Mo max.	Cu max.	B max.	N max.		
HBL325B	40<t≦50	0.18	0.55	1.60	0.030	0.015	Other elements can be added as required.										0.38	0.24
HBL325C	50<t≦100	0.20			0.020*	0.008*											0.40	0.26
HBL355B	40<t≦50	0.20	0.55	1.60	0.030	0.015	Other elements can be added as required.										0.40	0.26
HBL355C	50<t≦100				0.020*	0.008*											0.42	0.27
HBL385B-L	12<t≦19	0.20	0.55	1.60	0.030	0.015	Other elements can be added as required.										0.44	0.29
HBL385B	19<t≦50				0.020*	0.008*											0.40	0.26
HBL385C	50<t≦100																0.42	0.27
HBL440B	19<t≦40	0.12	0.55	1.60	0.030	0.008	Other elements can be added as required.										0.44	0.22
HBL440C	40<t≦100				0.020*												0.47	
HBL630B-L	12<t≦40	0.12	0.55	2.50	0.030	0.015	Other elements can be added as required.										0.60	0.30
HBL630C-L					0.015*	0.008*												

*: Max. values of P and S content in the case of HBL###C
Carbon equivalent value: Ceq (%)=C+Mn/6+Si/24+Ni/40+Cr/5+Mo/4+V/14
Weld Cracking Parameter: Pcm (%)=C+Si/30+Mn/20+Cu/20+Ni/60+Cr/20+Mo/15+V/10+5B
HBL™ series products are approved and certified by Ministry of Land, Infrastructure, Transportation and Tourism.

Mechanical Properties

EN10025-4:2004

Designation	Yield strength (MPa) min.						Tensile strength (MPa) min./max					YR (%) max.	Minimum value of impact energy at test temperature
	≦16	16< ≦40	40< ≦63	63< ≦80	80< ≦100	100< ≦120	≦40	40< ≦63	63< ≦80	80< ≦100	100< ≦120		
S355M	355	345	335	325	325	320	470 /630	450 /610	440 /600	440 /600	430 /590	—	40J@-20℃
S355M													27J@-40℃
S420M	420	400	390	380	370	365	520 /680	500 /660	480 /640	470 /630	460 /620	—	40J@-20℃
S420ML													27J@-40℃
S460M	460	440	430	410	400	385	540 /720	530 /710	510 /690	500 /680	490 /660	—	40J@-20℃
S460ML													27J@-40℃

Minimum values of impact energy are values for impact tests on longitudinal V-notch test pieces.

ASTM A1066/A1066M-11(2015)

Designation	Yield strength (MPa) min.		Tensile strength (MPa) min.		YR (%) max.	Minimum value of impact energy at test temperature
	≦75	75< ≦100	≦75	75< ≦100		
Grade 50	345		450		—	48J@-23℃
Grade 60	415		520		—	
Grade 65	450	—	550	—	—	

In addition, the following special supplementary requirements are also suitable for use with this specification.
S75. Maximum Yield Point to Tensile Strength Ratio: The max. yield to tensile ratio shall be 0.87 for grade 50 and 0.90 for grade 60. In this case the max. carbon content on the heat analysis can be raised to 0.16% for grade 50.
S76.Maximum Tensile Strength: The max. tensile strength shall be 630MPa for grade 50, 680MPa for grade 60, 720MPa for grade 65.

JIS G3106:2015

Designation	Yield strength (MPa) min./max				Tensile strength (MPa) min./max				YR (%) max.	Minimum value of impact energy at test temperature
	≦16	16< ≦40	40< ≦75	75< ≦100	≦16	16< ≦40	40< ≦75	75< ≦100		
JIS G3106 SM570TMC	460	450	430	420	570/720				—	47J@-5℃

JFE Brand of TMCP Steel Plates (HBL™ series products)

Designation	Yield strength (MPa) min./max			Tensile strength (MPa) min./max			YR (%) max.	Minimum value of impact energy at test temperature
	12≦ ≦19	19≦ ≦40	40< ≦100	12≦ ≦19	19≦ ≦40	40< ≦100		
HBL325B HBL325C	—		325/445	—		490/610	≦80	27J@0℃
HBL355B HBL355C	—		355/475	—		520/640	≦80	27J@0℃
HBL385B-L	385/505	—		550/670	—		≦80	70J@0℃
HBL385B HBL385C	—	385/505		—	550/670			
HBL440B HBL440C	—	440/540		—	590/740		≦80	70J@0℃
HBL630B-L HBL630C-L	630/750		—	780/930		—	≦85	47J@0℃

*: Max. values of P and S content in the case of HBL###C
Carbon equivalent value: Ceq (%)=C+Mn/6+Si/24+Ni/40+Cr/5+Mo/4+V/14
Weld Cracking Parameter: Pcm (%)=C+Si/30+Mn/20+Cu/20+Ni/60+Cr/20+Mo/15+V/10+5B
HBL™ series products are approved and certified by Ministry of Land, Infrastructure, Transportation and Tourism.

Example of Quality Characteristics

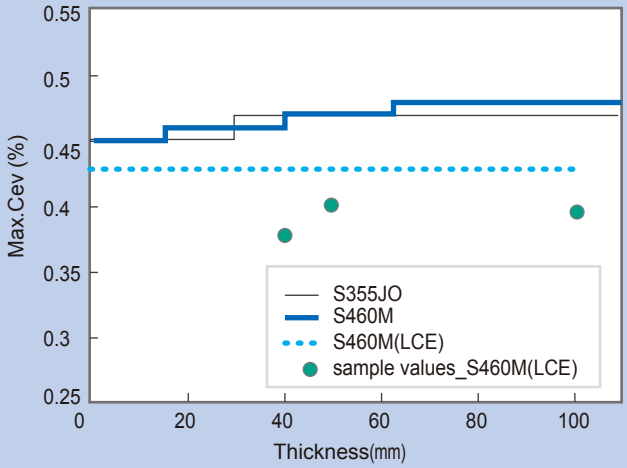
Mechanical Properties

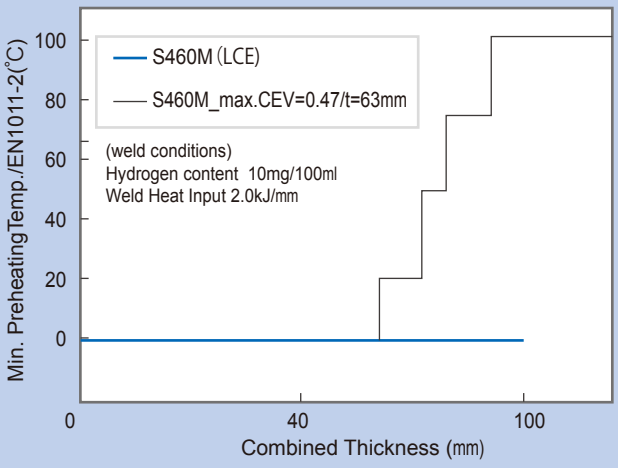
Designation	Thickness (mm)	Tensile test				Charpy impact test	Z-direction property
		YP or YS (N/mm^2)	TS (N/mm^2)	El (%)	YR (%)	Absorbed energy (J)	Reduction of area (%)
S460M	22	560	652	22	—	266 @ -20 ˚C	—
	50	453	600	29	—	261 @ -20 ˚C	—
A1066 Gr.65	50	473	593	31	—	401 @ -23 ˚C	—
HBL325C	50	376	525	36	72	289 @ 0 ˚C	68
	100	359	506	38	71	303 @ 0 ˚C	75
HBL355C	50	388	533	36	73	305 @ 0 ˚C	76
	100	397	532	36	75	306 @ 0 ˚C	73
HBL385C	35	455	596	31	76	269 @ 0 ˚C	73
	100	435	580	31	75	205 @ 0 ˚C	71
HBL440C	19	490	619	18	79	358 @ 0 ˚C	—
	50	484	612	31	79	380 @ 0 ˚C	—

YP: Yield point, YS: Yield strength, TS: Tensile strength, El: Elongation, YR: Yield ratio(=YPorYS/TSx100)

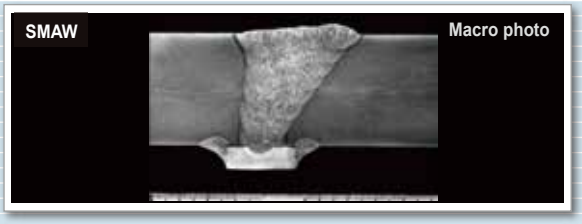
S460M/ Low CEV option (LCE)* specially-designed steel plates for welding without preheating

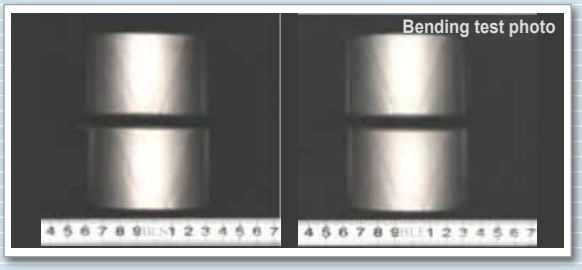
S460M can be delivered with Low Cev option(LCE) upon request, which is specially-designed by JFE Steel Corp., and is avalilable up to 100mm in thickness.
Having the lower contents of CEV than the standard-specified value, S460M(LCE) can be welded with no-preheating while selecting the suitable weld materials and conditions . According to each particular project conditions of steelwork, verification test of JIS Z 3158, y-groove weld cracking test, shall be arranged and executed upon requests.

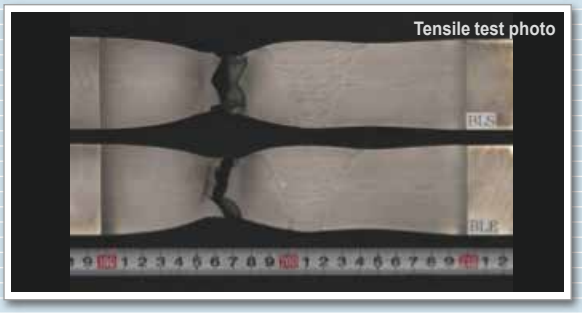




Test Results of Welded Joint





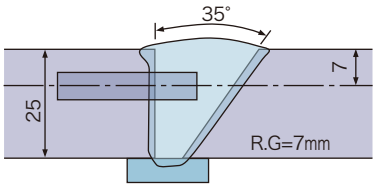
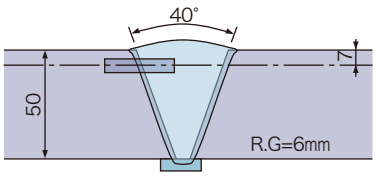
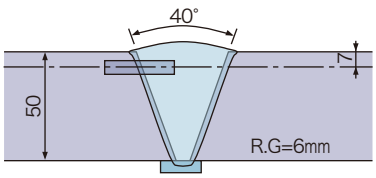


Welding Condition	
Groove	Single V
Parent Metal	S460M – t50mm
Electrode	AWS 5.5 E9016-G
Heat Imp.	20kJ/cm
Int Temp	≦250˚C

Bend Test				
No.	type of test	former diameter	Bend Angle	results
BLS 1	side bend	48mm	180˚	no defects
BLS 2				no defects
BLE 1				no defects
BLE 2				no defects

Test Results		
item	Tested value	Criteria
Tensile Strength (N/mm^2)	636 637	530≦

Toughness of Welded Joint

Welding processes	Groove shape (Sampling position of test pieces)	Designation	Thickness	V-notch position	vE0 (J)
CO_2 gas-shielded metal arc welding Welding consumable: JIS Z 3312 YGW-18 Heat input :30.2 kJ/cm Interpass temp. :≦250˚C		HBL385C	25	W.M F.L HAZ1mm HAZ3mm	156 208 278 280
Shielded Metal arc welding Welding consumable: AWS 5.5 E9016-G Heat input : 20kJ/cm Interpass temp. :≦250˚C		S460M	50	W.M HAZ1mm	207 196 (-20˚C)
Flux cored arc welding Welding consumable: AWS 5.29 E81T1-K2C Heat input : 20kJ/cm Interpass temp. :≦250˚C		S460M	50	W.M HAZ1mm	221 225 (-20˚C)

W.M: Weld metal, F.L: Fusion line, HAZ: Heat affected zone

Cat.No.C1E-015-01

JFE Steel Corporation

http://www.jfe-steel.co.jp/en/

HEAD OFFICE
Hibiya Kokusai Building, 2-3 Uchisaiwaicho 2-chome, Chiyodaku, Tokyo 100-0011, Japan Phone: (81)3-3597-3111 Fax: (81)3-3597-4860

■ASIA PACIFIC

SEOUL
JFE Steel Korea Corporation
16th Floor, 41, Cheonggyecheon-ro, Jongno-gu, Seoul, 03188, Korea
(Youngpung Building, Seorin-dong)
Phone: (82)2-399-6337 Fax: (82)2-399-6347

BEIJING
JFE Steel Corporation Beijing
1009 Beijing Fortune Building No.5, Dongsanhuan North Road, Chaoyang District, Beijing, 100004, P.R.China
Phone: (86)10-6590-9051 Fax: (86)10-6590-9056

SHANGHAI
JFE Consulting (Shanghai) Co., Ltd.
Room 801, Building A, Far East International Plaza, 319 Xianxia Road, Shanghai 200051, P.R.China
Phone: (86)21-6235-1345 Fax: (86)21-6235-1346

GUANGZHOU
JFE Consulting (Guangzhou) Co., Ltd.
Room 3901 Citic Plaza, 233 Tian He North Road, Guangzhou, 510613, P.R.China
Phone: (86)20-3891-2467 Fax: (86)20-3891-2469

MANILA
JFE Steel Corporation, Manila Office
23rd Floor 6788 Ayala Avenue, Oledan Square, Makati City, Metro Manila, Philippines
Phone: (63)2-886-7432 Fax: (63)2-886-7315

HO CHI MINH CITY
JFE Steel Vietnam Co., Ltd.
Unit 1704, 17th Floor, MPlaza, 39 Le Duan Street, Dist 1, HCMC, Vietnam
Phone: (84)28-3825-8576 Fax: (84)28-3825-8562

HANOI
JFE Steel Vietnam Co., Ltd., Hanoi Branch
Unit 1501, 15th Floor, Cornerstone Building, 16 Phan Chu Trinh Street, Hoan Kiem Dist., Hanoi, Vietnam
Phone: (84)24-3855-2266 Fax: (84)24-3533-1166

BANGKOK
JFE Steel (Thailand) Ltd.
22nd Floor, Abdulrahim Place 990, Rama IV Road, Silom, Bangrak, Bangkok 10500, Thailand
Phone: (66)2-636-1886 Fax: (66)2-636-1891

YANGON
JFE Steel (Thailand) Ltd., Yangon Office
Unit 05-01, Union Business Center, Nat Mauk Road, Bocho Quarter, Bahan Tsp, Yangon, 11201, Myanmar
Phone: (95)1-860-3352

SINGAPORE
JFE Steel Asia Pte. Ltd.
16 Raffles Quay, No.15-03, Hong Leong Building, 048581, Singapore
Phone: (65)6220-1174 Fax: (65)6224-8357

JAKARTA
PT. JFE STEEL INDONESIA
6th Floor Summitmas II, JL Jendral Sudirman Kav. 61-62, Jakarta 12190, Indonesia
Phone: (62)21-522-6405 Fax: (62)21-522-6408

NEW DELHI
JFE Steel India Private Limited
806, 8th Floor, Tower-B, Unitech Signature Towers, South City-I, NH-8, Gurgaon-122001, Haryana, India
Phone: (91)124-426-4981 Fax: (91)124-426-4982

MUMBAI
JFE Steel India Private Limited, Mumbai Office
603-604, A Wing, 215 Atrium Building, Andheri-Kurla Road, Andheri (East), Mumbai-400093, Maharashtra, India
Phone: (91)22-3076-2760 Fax: (91)22-3076-2764

CHENNAI
JFE Steel India Private Limited, Chennai Office
No.86, Ground Floor, Polyhose Towers(SPIC Annexe), Mount Road, Guindy, Chennai-600032, Tamil Nadu, India
Phone: (91)44-2230-0285 Fax: (91)44-2230-0287

BRISBANE
JFE Steel Australia Resources Pty Ltd.
Level28, 12 Creek Street, Brisbane QLD 4000 Australia
Phone: (61)7-3229-3855 Fax: (61)7-3229-4377

■ EUROPE and MIDDLE EAST

LONDON
JFE Steel Europe Limited
15th Floor, The Broadgate Tower, 20 Primrose Street, London EC2A 2EW, U.K.
Phone: (44)20-7426-0166 Fax: (44)20-7247-0168

DUBAI
JFE Steel Corporation, Dubai Office
P.O.Box 261791 LOB19-1208, Jebel Ali Free Zone Dubai, U.A.E.
Phone: (971)4-884-1833 Fax: (971)4-884-1472

■ NORTH, CENTRAL and SOUTH AMERICA

NEW YORK
JFE Steel America, Inc.
600 Third Avenue, 12th Floor, New York, NY 10016, U.S.A.
Phone: (1)212-310-9320 Fax: (1)212-308-9292

HOUSTON
JFE Steel America, Inc., Houston Office
750 Town & Country Blvd., Suite 705 Houston, Texas 77024, U.S.A.
Phone: (1)713-532-0052 Fax: (1)713-532-0062

MEXICO CITY
JFE Steel America, Inc., Mexico Office
Ruben Dario #281-1002, Col. Bosque de Chapultepec, C.P. 11580, CDMX. D.F. Mexico
Phone: (52)55-5985-0097 Fax: (52)55-5985-0099

RIO DE JANEIRO
JFE Steel do Brasil LTDA
Praia de Botafogo, 228 Setor B, Salas 508 & 509, Botafogo, CEP 22250-040, Rio de Janeiro-RJ, Brazil
Phone: (55)21-2553-1132 Fax: (55)21-2553-3430

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