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Flux-cored wire for 1-1.25%Cr-0.5%Mo steels

DW-81B2

KOBE STEEL, LTD.
WELDING COMPANY

KOBELCO
DOC.No.042001-T041

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DW-81B2

Reported by Ken Yamashita
Technical Development Dept., Welding Company, KOBE STEEL, LTD.

1.Introduction

DW-81B2 is a rutile based flux-cored wire for the welding of 1-1.25%Cr-0.5%Mo steels, such as ASTM A387 Gr.11 & Gr.12. DW-81B2 provides many good characteristics, low spatter loss, flat to slightly convex bead configuration, and a moderate volume of slag, which completely covers the weld bead and exhibits self-peeling slag detachability. This document reports some properties of DW-81B2.

2.Applicable code

AWS A5.29 E81T1-B2M & B2, ASME SFA-5.29 E81T1-B2M & B2

3.Product size available

1.2mm dia. x 12.5kg (0.045in. dia. x 25lbs)

4.Recommendable welding condition

Polarity: DC-Electrode Positive (DCEP)
Shielding gas and gas flow rate: 75-80%Ar/bal.CO_2 & 100%CO_2, 20-25l/min. (45-55CFH)
Wire extension from contact tip to work: 20-25mm (3/4-1in.)
Welding position: Flat, Horizontal fillet, Horizontal, Vertical up and Over head position
Preheat and interpass temperature: Preheat and interpass temperature of approximately 150-300℃(300-570°F) is generally necessary to avoid delayed cracking in the weld joints.

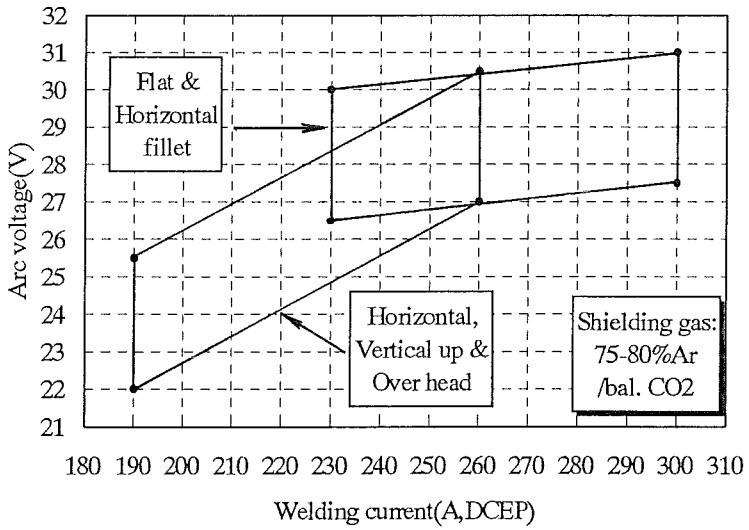

Fig.1 Recommendable welding parameters
※For 100%CO_2 shielding gas use 1-2 voltage higher than shown.

【Note】 Fig.1 shows approximate parameters that will vary with changes in welding conditions. Especially, arc voltage changes by cable length and location of work connection. Please keep the arc length approximately 2.5mm (3/32in.) for regulate arc voltage.

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5.Chemical compositions and mechanical properties of all weld metals

5.1 Effect of shielding gas on chemical compositions and mechanical properties of all weld metals

DW-81B2 can use the several shielding gases, 75-80%Ar/bal.CO_2 gas and 100%CO_2 gas. Also DW-81B2 can meet the requirements of applicable AWS & ASME classifications under the above shielding gases. This section shows the typical chemical compositions and mechanical properties of all weld metals by several shielding gases. Test results are shown in Table 2, Table 3 and Table 4.

5.1.1 Test conditions

Table 1 Welding parameters for testing

Welding position	Shielding gas	Welding current	Arc voltage	Preheat & Interpass temp.
1G(Flat)	80%Ar+20%CO_2	230-250A Polarity: DCEP	28-30V	161-191℃ (325-375°F)
	75%Ar+25%CO_2		28-30V	
	100%CO_2		29-31V	

Test method: According to AWS A5.29
Gas flow rate: 25l/min. (55 CFH)
Welding speed: Approximately 20cm/min. (8in. /min.)
Wire extension from contact tip to work: Approximately 20mm (3/4in.)
PWHT condition: 690℃(1275°F)x1hr,FC

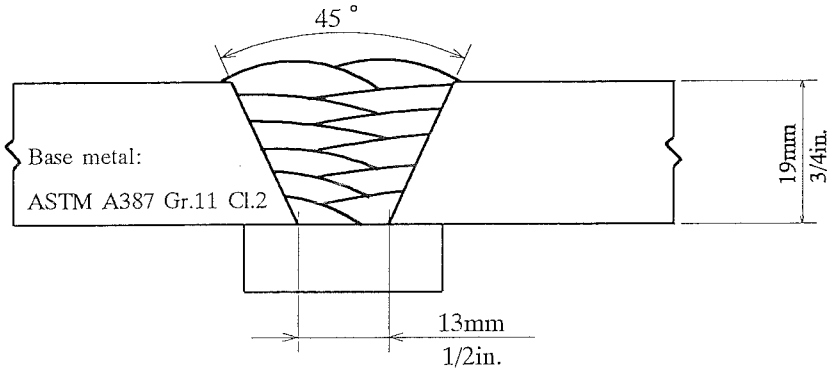

Fig.2 Groove configuration and pass sequence

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5.1.2 Test results

Table 2 Typical chemical compositions of all weld metals (mass%)

Shielding gas	C	Si	Mn	P	S	Ni	Cr	Mo	J-factor ※1	X bar ※1
80%Ar+20%CO_2	0.05	0.61	0.60	0.008	0.013	0.02	1.29	0.51	<121	<10ppm
75%Ar+25%CO_2	0.06	0.62	0.57	0.008	0.010	0.02	1.27	0.50	<119	<10ppm
100%CO_2	0.06	0.46	0.46	0.008	0.009	0.02	1.23	0.48	< 92	<10ppm
Ref. AWS A5.29 E81T1-B2M & B2	0.05 - 0.12	≦ 0.80	≦ 1.25	≦ 0.03	≦ 0.03	---	1.00 - 1.50	0.40 - 0.65	---	---

※1 Supplement data: Sb<0.002mass%, Sn<0.002mass%, As<0.002mass%
J-factor = (Si+Mn) x (P+Sn)x10^4(unit: mass%), X bar = (10P+5Sb+4Sn+As)/100 (unit: ppm)

Table 3 Typical tensile properties of all weld metals at room temperature

Shielding gas	PWHT	0.2% Proof Strength	Tensile Strength	Elongation	Redaction of Area
80%Ar+20%CO_2	690℃x1hr,FC (1275ºFx1hr,FC)	591 MPa (86 ksi)	670 MPa (97 ksi)	24 %	67 %
75%Ar+25%CO_2		578 MPa (84 ksi)	659 MPa (96 ksi)	26 %	65 %
100%CO_2		549 MPa (80 ksi)	633 MPa (92 ksi)	25 %	68 %
Ref. AWS A5.29 E81T1-B2M & B2	690℃x1hr,FC (1275ºFx1hr,FC)	≧470 MPa (≧68 ksi)	550-690 MPa (80-100 ksi)	≧19 %	---

Test method: According to AWS A5.29

Table 4 Typical impact properties of all weld metals

Shielding gas	PWHT	Absorbed energy 2mmvE0℃, J (2mmvE32ºF, ft-lbf)			Avg.
80%Ar+20%CO_2	690℃x1hr,FC (1275ºFx1hr,FC)	28 (21)	34 (25)	49 (36)	37 (27)
75%Ar+25%CO_2		17 (13)	30 (22)	34 (25)	27 (20)
100%CO_2		16 (12)	19 (14)	20 (15)	18 (14)
Ref. AWS A5.29 E81T1-B2M & B2	690℃x1hr,FC (1275ºFx1hr,FC)	Not required			

Test method: According to AWS A5.29

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5.2 Effects of PWHT conditions on mechanical properties of all weld metals

Mechanical property of weld metal changes by Postweld heat treatment (PWHT) condition. This section shows the mechanical properties of all weld metal with DW-81B2 under the several PWHT conditions. Test results are shown in Table 6 and Table 7.

5.2.1 Test conditions

Table 5 Welding parameters for testing

Welding position	Shielding gas	Welding current	Arc voltage	Preheat & Interpass temp.
1G(Flat)	80%Ar+20%CO_2	230-250A Polarity: DCEP	28-30V	161-191℃ (325-375°F)

Test method: According to AWS A5.29
Gas flow rate: 25l/min. (55 CFH)
Welding speed: Approximately 20cm/min. (8in. /min.)
Wire extension from contact tip to work: Approximately 20mm (3/4in.)
Groove configuration and pass sequence: The same condition in Fig.2.
PWHT conditions: 690℃(1275°F)x1hr,FC and 690℃(1275°F)x12hr,FC

5.2.2 Test results

Table 6 Typical tensile properties of all weld metals under the several PWHT conditions

PWHT	L.M.P.※2	Test temp.	0.2% P.S.	T.S.	El.	R.A.
As welded	---	R.T.	666 MPa (97 ksi)	752 MPa (109 ksi)	17 %	65 %
690℃x1hr,FC (1275°Fx1hr,FC)	$19.26x10^3$		591 MPa (86 ksi)	670 MPa (97 ksi)	24 %	67 %
690℃x12hr,FC (1275°Fx12hr,FC)	$20.30x10^3$		549 MPa (80 ksi)	636 MPa (92 ksi)	25 %	71 %
Ref. AWS A5.29 E81T1-B2M & B2 690℃x1hr,FC (1275°Fx1hr,FC)	$19.26x10^3$	R.T.	≧470MPa (≧68ksi)	550-690MPa (80-100ksi)	≧19%	---

Test method: According to AWS A5.29
※2 L.M.P.(Larson-Miller temper parameter)=(273+T)x(20+logt), T=PWHT temperature(℃), t=PWHT time(hr)

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Table 7 Typical impact properties of all weld metals under the several PWHT conditions

PWHT	L.M.P.	Absorbed energy 2mmvE0℃, J (2mmvE32°F, ft-lbf)			Avg.
As welded	---	26 (19)	28 (21)	45 (33)	33 (24)
690℃x1hr,FC (1275°Fx1hr,FC)	19.26x10³	28 (21)	34 (25)	49 (36)	37 (27)
690℃x12hr,FC (1275°Fx12hr,FC)	20.30x10³	32 (24)	36 (27)	58 (43)	42 (31)
Ref. AWS A5.29 E81T1-B2M & B2 690℃x1hr,FC (1275°Fx1hr,FC)	19.26x10³	Not required			

Test method: According to AWS A5.29

5.3 Mechanical Properties of all weld metals at elevated temperatures and creep rupture properties

DW-81B2 has sufficient mechanical property of all weld metal at elevated temperature and creep rupture property for practical uses. Test results are shown in Table 8 and Table 9.

5.3.1 Test conditions

Test conditions, groove configuration and pass sequence are the same conditions in Table 5 and Fig.2.

5.3.2 Test results

Table 8 Typical tensile properties of all weld metals at elevated temperatures

PWHT	Test temp.	0.2% P.S.	T.S.	El.	R.A.
690℃x1hr,FC (1275°Fx1hr,FC)	R.T.	591 MPa (86 ksi)	670 MPa (97 ksi)	24 % ※3	67 %
	250℃ (480°F)	488 MPa (71 ksi)	573 MPa (83 ksi)	17 % ※4	64 %
	450℃ (840°F)	446 MPa (65 ksi)	510 MPa (74 ksi)	16 % ※4	66 %
	500℃ (930°F)	439 MPa (64 ksi)	490 MPa (71 ksi)	16 % ※4	68 %
	600℃ (1110°F)	375 MPa (54 ksi)	406 MPa (59 ksi)	15 % ※4	74 %

※3 Test method: According to AWS A5.29
※4 Tensile specimen size: 6.0mm (15/64in.) dia., G.L.=5D

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7. Window type restraint cracking test

7.1 Test conditions

Table 13 Welding parameters for testing

Welding Position	Shielding gas	Welding Current	Arc voltage	Welding Speed	Preheat & Interpass temp.
1G(Flat)	80%Ar+20%CO_2	250A Polarity: DCEP	28V	30cm/min. (12in. /min.)	Preheat: None Interpass temp: ≦150℃(≦300°F)

Gas flow rate: 25l/min. (55 CFH), Wire extension from contact tip to work: 20mm (3/4in.)

【Note】 The wire for this testing was exposed in air, at 30℃(86°F), 80%R.H. for three (3) days after unpacking.

Table 14 Chemical composition of test plate, ASTM A387 Gr.11 Cl.2 (mass%)

C	Si	Mn	P	S	Ni	Cr	Mo
0.15	0.61	0.54	0.007	0.010	0.04	1.30	0.53

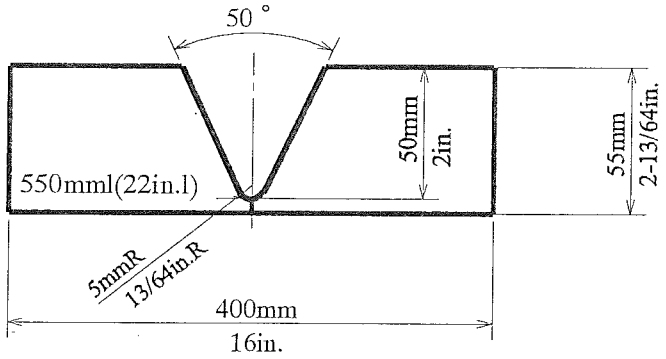

Fig.3 Groove configuration of test plate

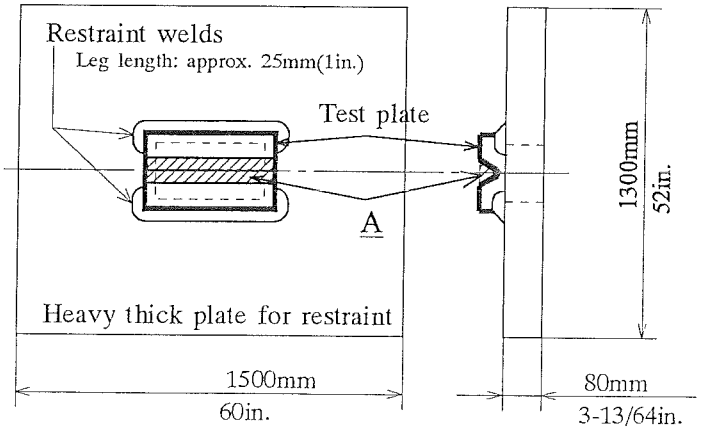

Fig.4 Restraint condition of test plate

【Note】 Test plate was kept one(1) week under restraint condition, after welded of area A with DW-81B2.

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Table 9 Typical creep rupture properties of all weld metals

PWHT	Test temp.	Stress	Rupture time
690°Cx1hr,FC (1275°Fx1hr,FC)	550°C (1022°F)	177 MPa (26 ksi)	1248 hr
		157 MPa (23 ksi)	1933 hr
		137 MPa (20 ksi)	3731 hr

【Specimen size】6.0mm dia. (15/64in.dia.), G.L.=5D

6.Diffusible hydrogen content of weld metal

Diffusible hydrogen content of weld metal changes by wire extension from contact tip to work and shielding gas. This section shows the diffusible hydrogen content of weld metal with DW-81B2 under the several conditions. Test results are shown in Table 12.

6.1 Test conditions

Table 10 Welding parameters for testing

Welding Position	Shielding Gas	Welding Current	Arc Voltage	Welding Speed	Preheat Temp.	Welding Environment
1G(Flat)	80%Ar+20%CO_2	240A Polarity: DCEP	29V	30cm/min. (12in. /min.)	None	26°Cx69%R.H. (79°Fx69%R.H.)
	100%CO_2		30V			

Gas flow rate: 25l/min. (55 CFH)

【Note】The wire for this testing was exposed in air, at 30°C(86°F), 80%R.H. for three (3) days after unpacking.

Table 11 Extract conditions

Method	Atmosphere	Temperature	Time
According to AWS A4.3 Gas chromatograph	Ar	45°C (113°F)	72 hr

6.2 Test results

Table 12 Typical diffusible hydrogen content in weld metal with DW-81B2

Wire extension from contact tip to work	Shielding gas	
	80%Ar+20%CO_2	100%CO_2
15mm (19/32in.)	7.0, 7.6, 6.8, 6.8 Avg. 7.1ml/100g	4.5, 4.7, 5.4, 4.2 Avg. 4.7ml/100g
20mm (3/4in.)	5.7, 5.6, 6.0, 5.6 Avg. 5.7ml/100g	2.6, 2.8, 2.9, 2.8 Avg. 2.8ml/100g

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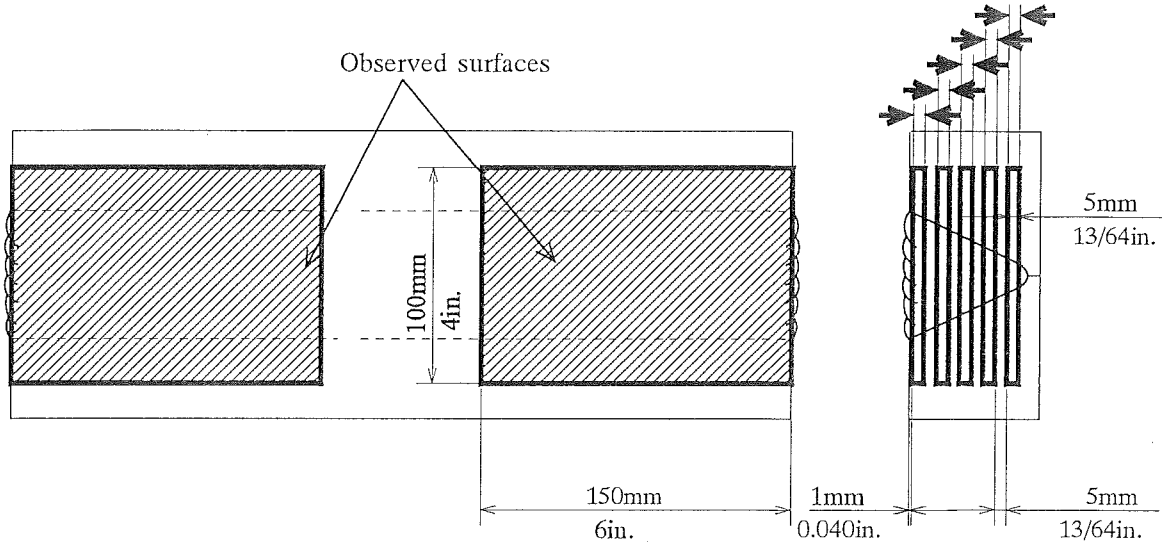

Fig.5 Location of observed surface

7.1.2 Test results

Table 15 Results of window type restraint cracking test

Observed surface from top of the test plate	Test results
1mm (0.040in.)	No crack
6mm (15/64in.)	No crack
11mm (7/16in.)	No crack
16mm (5/8in.)	No crack
21mm (53/64in.)	No crack
26mm (1-3/64in.)	No crack
31mm (1-15/64in.)	No crack
36mm (1-7/16in.)	No crack
41mm (1-41/64in.)	No crack
46mm (1-27/32in.)	No crack

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8.Chemical composition and mechanical property of weld joint

8.1 Welding conditions and location of each specimen

Tested weld joint was the same as window type restraint cracking test. Fig.6 shows the location and dimension of each specimen.

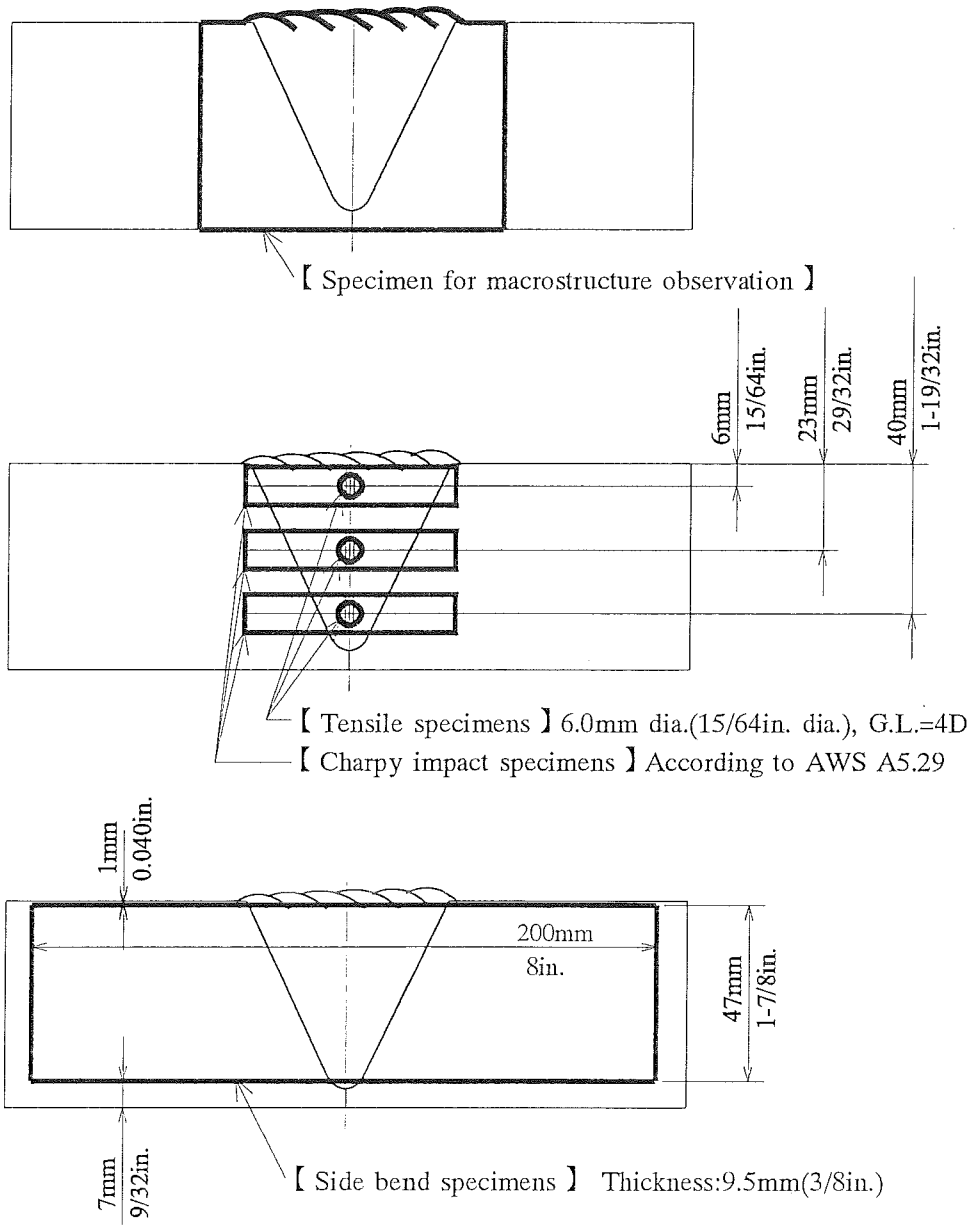

Fig.6 Location and dimension of each specimen

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8.2 Test results

8.2.1 Chemical composition of weld metal

Table 16 Chemical composition of weld metal (mass%)

C	Si	Mn	P	S	Ni	Cr	Mo
0.05	0.57	0.57	0.008	0.009	0.03	1.28	0.50

8.2.2 Macrostructure of weld joint

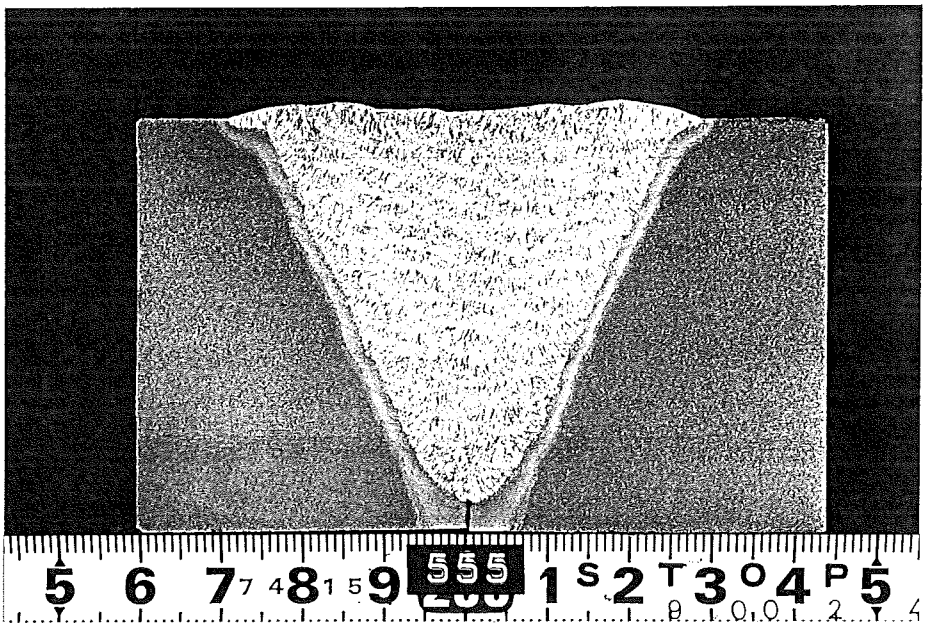

Fig.7 Macrostructure of weld joint with DW-81B2

【Note】There is no defects in observed area. (Pass sequence: 14Layers 49Passes)

8.2.3 Mechanical property of weld joint

Table 17 Tensile property of weld joint at room temperature

Location of specimens	PWHT	0.2% P.S.	T.S.	El.	R.A.
Under 6mm(15/64in.) from base metal surface	690℃x2hr,FC (1275°Fx2hr,FC) L.M.P. =19.55x10^3	579 MPa (84 ksi)	655 MPa (95 ksi)	22 %	66 %
Under 23mm(29/32in.) from base metal surface		569 MPa (83 ksi)	647 MPa (94 ksi)	27 %	70 %
Under 40mm(1-19/32in.) from base metal surface		574 MPa (83 ksi)	652 MPa (95 ksi)	25 %	70 %
Ref. AWS A5.29 E81T1-B2M & B2	690℃x1hr,FC (1275°Fx1hr,FC)	≧470 MPa (≧68 ksi)	550-690 MPa (80-100 ksi)	≧19 %	---

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Table 18 Impact property of weld joint

Location of specimens	PWHT	Absorbed energy 2mmvE20℃, J (2mmvE68°F, ft-lbf)			Avg.
Under 6mm(15/64in.) from base metal surface	690℃x2hr,FC (1275°Fx2hr,FC) L.M.P.=19.55x10^3	29 (21)	30 (22)	45 (33)	35 (25)
Under 23mm(29/32in.) from base metal surface		29 (21)	33 (24)	33 (24)	32 (23)
Under 40mm(1-19/32in.) from base metal surface		30 (22)	35 (26)	37 (27)	34 (25)
Ref. AWS A5.29 E81T1-B2M & B2	690℃x1hr,FC (1275°Fx1hr,FC)	Not required			

8.2.4 Side bend properties of weld joint

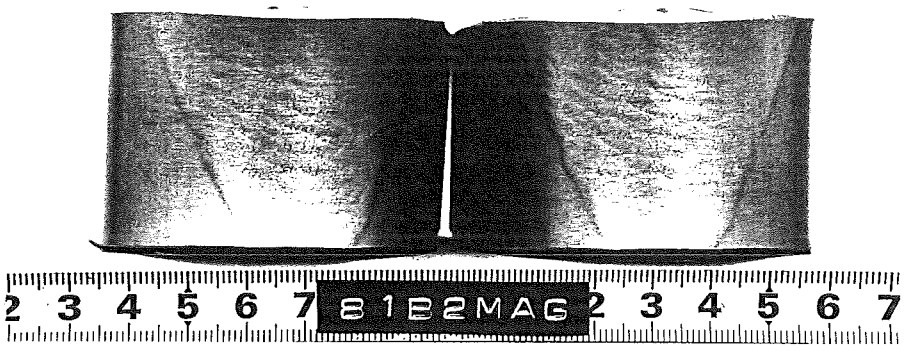

Fig.8 Results of side bend test
Bend radius: 19mm(3/4in.), Bend angle: 180°
【Note】There are no defects on surface of specimens.