DOC.No.042006-T006

Feb.2006

Flux-cored wire for 2.25%Cr-1%Mo steels

DWA-91B3

KOBE STEEL, LTD.
WELDING COMPANY

KOBELCO
DOC.No.042006-T006

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Introduction

DWA-91B3 is a rutile based flux-cored wire for the welding of 2.25%Cr-1%Mo steels, such as ASTM A387 Gr.22. DWA-91B3 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 DWA-91B3.

1.Features of DWA-91B3

・Classification:AWS A5.29 E91T1-B3M, ASME SFA-5.29 E91T1-B3M

2.Product size available

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

3.Recommendable welding condition

・Polarity: DC-Electrode Positive (DCEP)
・Shielding gas and gas flow rate: 75-80%Ar/bal.CO_2 , 20-25l/min. (45-55CFH)
・Wire extension from contact tip to work: 20-25mm (3/4-1in.)
・Welding position: All positions except vertical down position
・Preheat and inter-pass temperature: Preheat and inter-pass temperature of approximately 200-300(390-570ºF) is generally necessary to avoid delayed cracking in the weld joints.

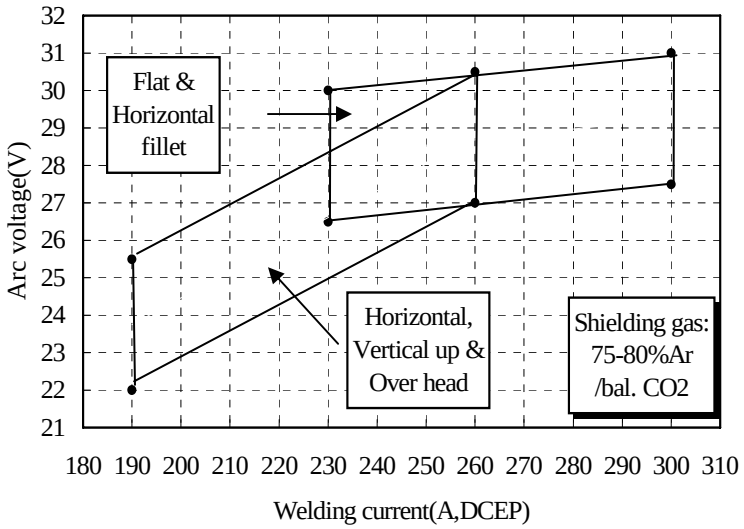


Fig.1 Recommendable welding Conditions(parameter box)

【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.

4.Chemical compositions and mechanical properties of all weld metal

DWA-91B3 can meet the requirements of applicable AWS & ASME classifications under shielding gas 75-80%Ar and bal.CO_2. This section shows the typical chemical compositions and mechanical properties of all weld metals. Test results under the welding conditions of Table 1 are shown in Tables 2 to 6.

4.1 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	240-260A	27-30V	161-191℃ (325-375ºF)

・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℃(1275ºF)x1hr,FC

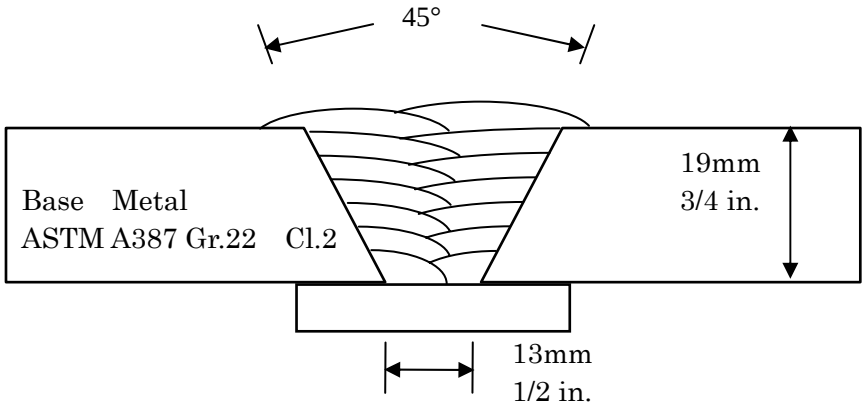


Fig.2 Groove configuration and pass sequence

4.2 Test results

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

	C	Si	Mn	P	S	Ni	Cr	Mo	J-factor ※	X bar ※
80%Ar+20%CO_2	0.06	0.34	0.81	0.008	0.012	0.02	2.24	0.96	115	<10ppm
AWS A5.29 E91T1-B3M	0.05 - 0.12	≦ 0.80	≦ 1.25	≦ 0.03	≦ 0.03	---	2.00 - 2.50	0.90 - 1.20	---	---

※ Supplement data: Sn=0.002mass%, Sb<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 metal at room temperature

	PWHT	0.2% Proof Strength	Tensile Strength	Elongation	Redaction of Area
80%Ar+20%CO_2	690℃x1hr,FC (1275ºFx1hr,FC)	608 MPa (88 ksi)	706MPa (102 ksi)	24 %	70 %
AWS A5.29 E91T1-B3M	690℃x1hr,FC (1275ºFx1hr,FC)	≧540 MPa (≧78 ksi)	620-760 MPa (90-110 ksi)	≧17 %	---

Test method: According to AWS A5.29

Table 4 Typical impact properties of all weld metal

	PWHT	Absorbed energy 2mm vE, J (2mm vE, ft-lbf)				Avg.
80%Ar+20%CO_2	690℃x1hr,FC (1275ºFx1hr,FC)	10℃ (50ºF)	126 (93)	128 (94)	132 (97)	129 (95)
		0℃ (32ºF)	45 (33)	36 (27)	42 (31)	41 (30)
		-18℃ (-0.4ºF)	22 (16)	27 (20)	35 (26)	28 (21)
AWS A5.29 E91T1-B3M	Not required					

Test method: According to AWS A5.29

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

Mechanical property of weld metal changes by postweld heat treatment (PWHT) conditions. This section shows the mechanical properties of all weld metal with DWA-91B3 under the several PWHT conditions. Test results are shown in Tables 5 & 6 and Fig.3.
Moreover, the microstructure of weld metals under some PWHT conditions are shown in Table 7.

4.3.1 Test results under several PWHT conditions

Table 5 Typical tensile properties of all weld metal under several PWHT conditions

PWHT	L.M.P. ※	Test temp.	0.2% P.S.	T.S.	El.	R.A.
690℃x1hr,FC (1275ºFx1hr,FC)	$19.3x10^3$	R.T.	608 MPa (ksi)	706 MPa (ksi)	24 %	70 %
690℃x12hr,FC (1275ºFx12hr,FC)	$20.3x10^3$		561 MPa (ksi)	659 MPa (ksi)	25 %	73 %
710℃x24hr,FC (1310ºFx24hr,FC)	$21.0x10^3$		528 MPa (ksi)	630 MPa (ksi)	26 %	71 %
AWS A5.29 E91T1-B3M 690℃x1hr,FC (1275ºFx1hr,FC)	$19.3x10^3$	R.T.	≧540MPa (≧78ksi)	620-760MPa (90-110ksi)	≧17%	---

Test method: According to AWS A5.29

※ L.M.P.(Larson-Miller temper parameter)=(273+T)x(20+logt)
T=PWHT temperature(℃), t=PWHT time(hr)

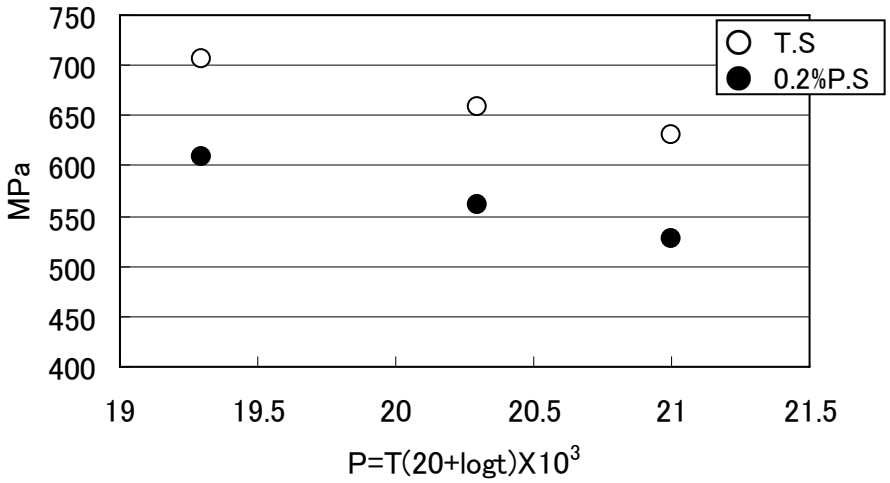


Fig.3 Effect of PWHT Conditions

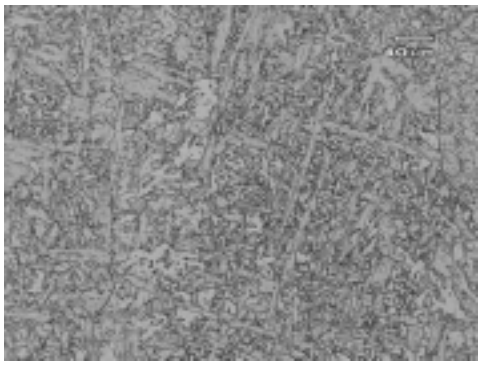
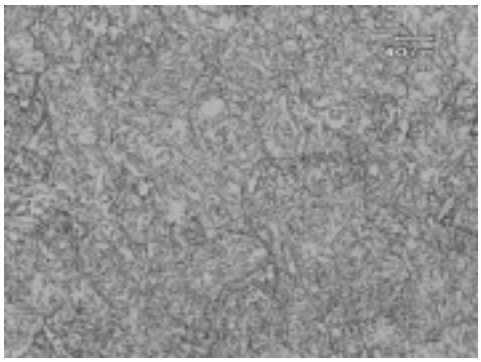
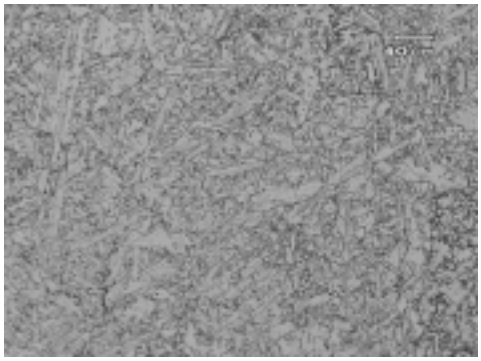
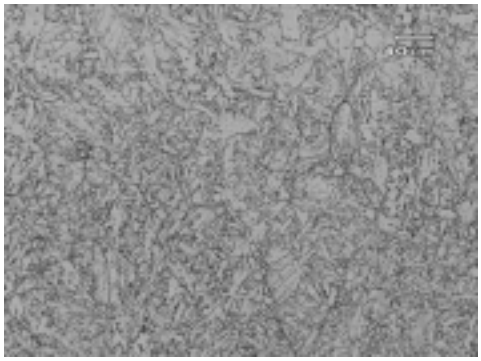
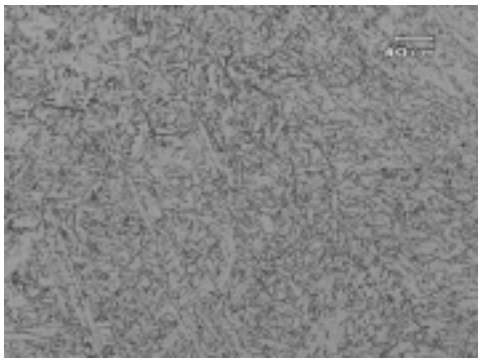
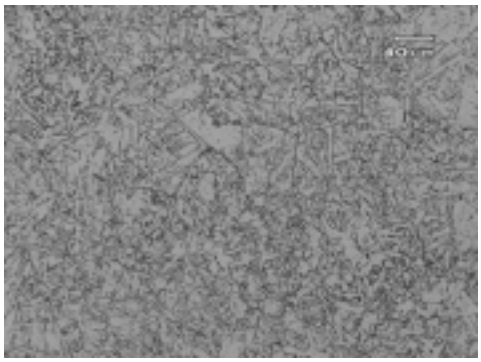
Table 6 Typical impact properties of all weld metals under the several PWHT conditions

PWHT	L.M.P.	Absorbed energy 2mmvE0℃, J (2mmvE32ºF, ft-lbf)			Avg.
690℃x1hr,FC (1275ºFx1hr,FC)	$19.3x10^3$	45 (33)	36 (27)	42 (31)	41 (30)
690℃x12hr,FC (1275ºFx12hr,FC)	$20.3x10^3$	99 (73)	121 (89)	116 (86)	112 (83)
710℃x24hr,FC (1310ºFx24hr,FC)	$21.0x10^3$	64 (47)	102 (75)	31 (23)	66 (49)
AWS A5.29 E91T1-B3M 690℃x1hr,FC (1275ºFx1hr,FC)	$19.3x10^3$	Not required			

Test method: According to AWS A5.29

4.3.2.Microstructure of weld metal under PWHT conditions

Table 7 Microstructure of weld metal

PWHT	Microstructure	
	Non reheated zone	Reheated zone
690℃x1hr,FC (1275ºFx1hr)		
690℃x12hr,FC (1275ºFx12hr)		
710℃x24hr,FC (1310ºFx1hr)		

5.Diffusible hydrogen content of weld metal

Diffusible hydrogen content of weld metal changes by wire extension from contact tip to works. This section shows the diffusible hydrogen content of weld metal with DWA-91B3 under two wire extension conditions. Test condition and result are shown in Tables 8 and 9, respectively.

5.1 Test conditions

Table 8 Welding parameters for testing

	Shielding Gas	Welding Current	Arc Voltage	Welding Speed	Preheat Temp.	Welding Environment
1G(Flat)	80%Ar+20%CO_2	250A DCEP	28V	30cm/min. (12in. /min.)	None	11℃x42%R.H. (52ºFx42%R.H.)

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

5.2 Test results

Table 9 Typical diffusible hydrogen content in weld metal with DWA-91B3

Wire extension from contact tip to work	Unit: ml/100g
15mm (19/32in.)	6.2, 5.8, 6.2, 5.5 Avg. 5.9
20mm (3/4in.)	4.5, 4.3, 4.2, 4.2 Avg. 4.3

6. Window type restraint cracking test

6.1 Test conditions

Table 10 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℃(≦302ºF)

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

Table 11 Chemical composition of test plate, ASTM A387 Gr.22 Cl.2 (mass%)

C	Si	Mn	P	S	Ni	Cr	Mo
0.13	0.21	0.53	0.004	0.010	0.05	2.30	1.01

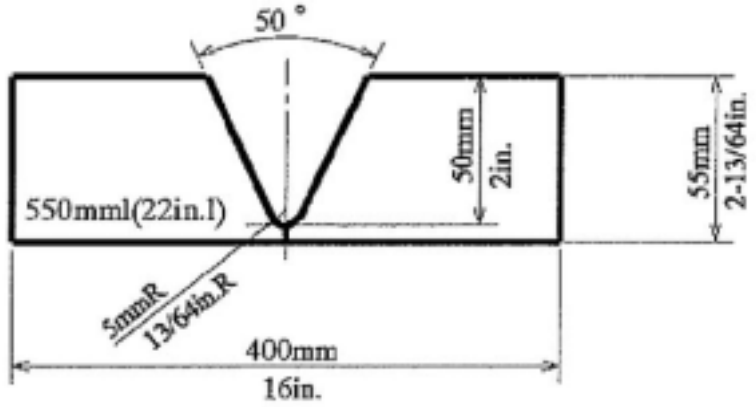


Fig.4 Groove configuration of test plate

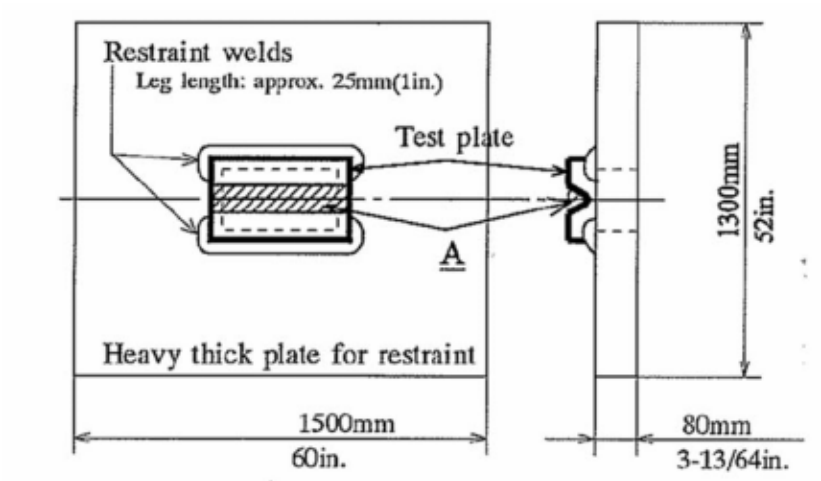


Fig.5 Restraint condition of test plate

【Note】Test plate was kept one week under restraint condition, after welded of area A with DWA-91B3.

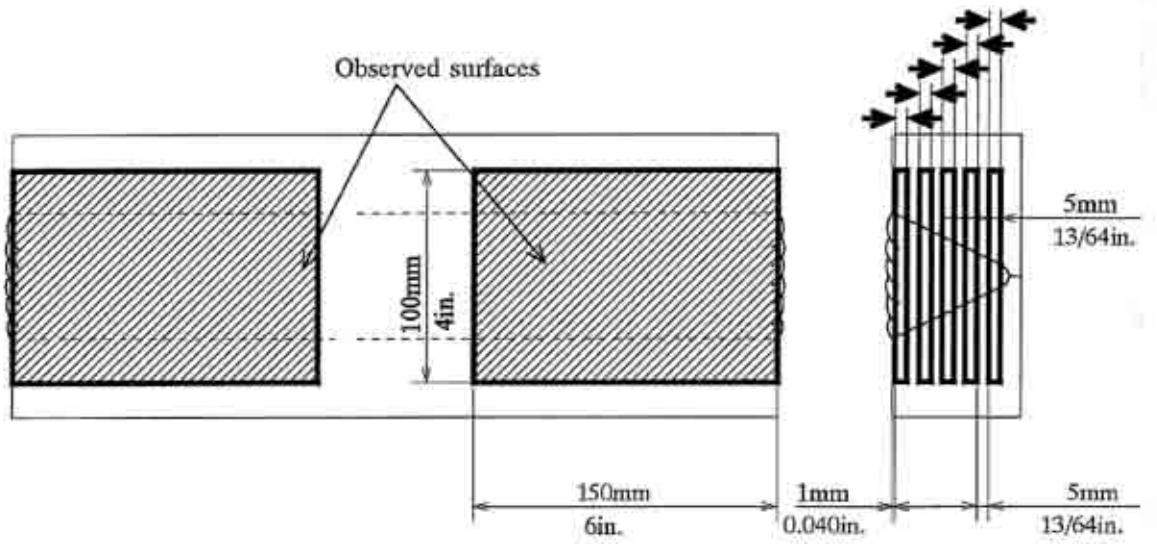


Fig.6 Location of observed surface

6.2 Test result

Table 12 Results of window type restraint cracking test result

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