Doc.No. 28-02-2011-AA-2594

April.2010

Flux Cored Wire for Super Duplex Stainless Steel

Ceweld® AA-2594

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Flux Cored Wire for Super Duplex Stainless Steel; AA-*2594*

AA-2594 is a flux cored wire designed for welding 25Cr type duplex stainless steels especially for Super Duplex grade, PRE (Pitting Resistance Equivalent) is over 40. Ar-CO_2 mixture gas or 100%CO_2 is recommended shielding gas for excellent weldability.

1. General instruction

1-1. Applicable code

AWS A5.22/A5.22M:2010 E2594T1-4, E2594T1-1

1-2. Applicable base metals

Examples of base metal to which AA-2594 is applied are presented in Table1. AA-2594 can be applied to 22Cr type duplex stainless steel (S31803, S32205) as well.

Table 1 25Cr type duplex stainless steel

ASTM (UNS)	EN	JIS	Chemical composition	Commercial grade
S32750	1.4410	-	25Cr-7Ni-4Mo-0.28N	*SAF2507, NAS74N*
S32760	1.4501	-	25Cr-7Ni-3.8Mo-0.7Cu-0.7W-0.25N	*Zeron100*
S32506	-	SUS329J4L	25Cr-7Ni-3Mo-0.15N-0.2W	*NAS64*

1-3. Recommended welding conditions

AA-2594 is applicable not only at flat or horizontal fillet but horizontal or vertical up position. While either of Ar-20 to 25% CO_2 and 100%CO_2 can be used for shielding gas, Ar-20 to 25% CO_2 is most recommended for best practice. Holding relatively shorter stick-out, 15-20mm helps easy operate. No preheat or post-weld heat treatment is recommended to prevent the formation of metallic compound e.g. sigma phase. For same reason, inter-pass temperature should be controlled less than 150℃.

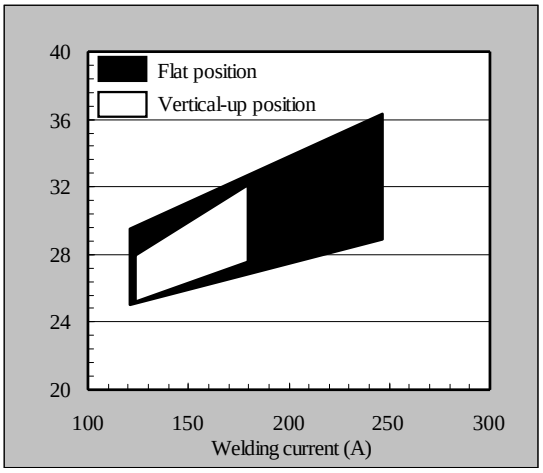


Fig.1 Recommended welding conditions (Ar-20 to 25%CO_2)

2. Properties of all-weld metal

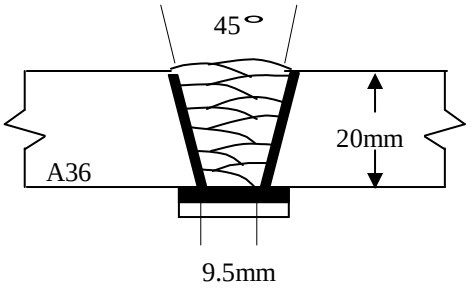
An all-weld metal was produced per AWS A5.22/A5.22M:2010 *"Specification for Stainless Steel Flux Cored and Metal Cored Welding Electrodes and Rods"* and its chemical composition, mechanical properties and corrosion properties were evaluated.

2-1. Welding conditions

Welding conditions in producing all-weld metal are shown in Table2.

Table 2 Welding conditions for all-weld metal

Welding wire	**AA-2594, 1.2mm** Mfg.No. J9H35113369
Polarity	DC-EP
Welding position	Flat
Shielding gas	Ar-20%CO2
Welding current	200A
Arc voltage	30V
Inter-Pass temperature	<150℃
Pass sequence	6 layers-12 passes



Beveled surface is buttered by AA-2594.

2-2. Chemical composition of all-weld metal

Chemical compositions of all-weld metal are presented in Table3. Requirement for E2594TX-X in AWS A5.22/A5.22M:2010 is shown for reference.

Table 3 Chemical composition (%), PRE and ferrite content of all-weld metal

	C	Si	Mn	P	S	Cu	Ni	Cr
AA-2594	0.026	0.50	1.18	0.02	0.005	0.031	9.6	25.7
A5.22/A5.22M E2594TX-X	*-0.04*	*-1.00*	*0.5-2.5*	*-0.04*	*-0.03*	*-1.5*	*8.0-10.5*	*24.0-27.0*

	Mo	Nb	W	N	PRE	FNW	FF
AA-2594	3.79	0.016	<0.1	0.24	42.0	49	36
A5.22/A5.22M E2594TX-X	*2.5-4.5*	-	*-1.0*	*0.20-0.30*	-	-	-

PRE: Cr+3.3Mo+16N

FNW: Ferrite Number (FN) by WRC1992 Diagram

FF: Ferrite Number (FN) by Ferrite Scope (*Fischer Ferite Scope MP-30*)

2-3. Tensile properties of all-weld metal

Tensile test result conducted at ambient temperature 20℃ is presented in Table4.

Table 4 Tensile properties of all-weld metal

	0.2% P.S. (N/mm^2)	T.S. (N/mm^2)	EL (%)
AA-2594	712	905	27
A5.22/A5.22M E2594TX-X	-	*760 min.*	*15min.*

2-4. Charpy impact properties of all-weld metal

Charpy impact tests(10 x 10mm, 2mm V notch) were conducted at several temperatures from -50℃ to 20℃. Absorbed energy and lateral expansion are presented in Table5.

Table 5 Absorbed Energy and lateral expansion at Charpy impact test

	@-85℃	@-70℃	@-50℃	@-40℃	@-20℃	@0℃	@20℃
CVN (J)	23, 23, 23 Avg. 23J	27, 25, 26 Avg. 26J	35. 32, 33 Avg. 33J	39, 37, 42 Avg. 39J	53, 48, 42 Avg. 48J	56, 57, 51 Avg. 55J	61, 58,61 Avg. 60J
L.E. (mm)	0.16,0.0.28,0.20 Avg. 0.21mm	0.27,0.25,0.21 Avg. 0.24mm	0.34,0.0.37,0.31 Avg. 0.34mm	0.40,0.28,0.42 Avg. 0.37mm	0.62,0.55,0.56 Avg. 0.58mm	0.79,0.59,0.61 Avg. 0.66mm	0.83,0.79,0.77 Avg.0.80mm

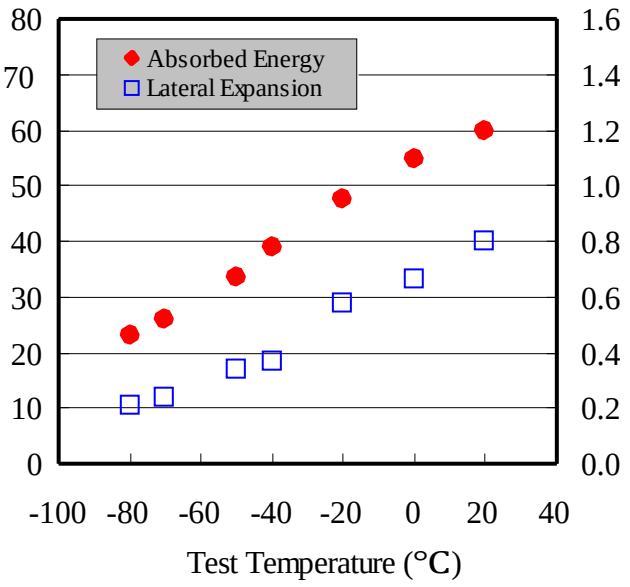


Fig.2 Charpy impact test results of all-weld metal

2-5. Copper-Copper Sulfate-Sulfuric Acid Test *(ASTM A262, Practice E)*

Copper-Copper Sulfate-Sulfuric Acid Test (Strauss test) based on ASTM A262 Practice E was carried out on a specimen taken from all-weld metal. The bent specimen was examined by optical microscope to determine the presence of fissures or cracks due to intergranular attack.

Table 6 Test condition and result in Copper-Copper Sulfate-Sulfuric Acid Test

Size of Specimen	Test Solution	Time of exposure	Evaluation
5 x 25 x 75 mm	6%$CuSO_4$ + 16%H_2SO_4 solution aq.	15 hrs	Satisfactory (No crack)

2-6. Nitric Acid Test *(ASTM A262, Practice C)*

Nitric Acid Test (Huey Test) based on ASTM A262 Practice C was carried out on a specimen taken from all-weld metal. For consistent result, test was carried out five times repeatedly for 48 hours with a fresh test solution.

Table 7 Test condition in Nitric Acid Test

Size of Specimen	Initial weight	Test Solution	Boiling period
3 x 20 x 30mm ($15cm^2$)	13.91 g	Boiling 65%HNO_3 solution aq.	48 hrs

Table 8 Loss of weight

No.	1st	2nd	3rd	4th	5th	Average
(g/m^2 hr)	0.13	0.15	0.20	0.26	0.29	0.21
(ipm)	0.00046	0.00054	0.00073	0.00092	0.00104	0.00074

2-7. Ferric Chloride Test

2-7-1. ASTM G48 Practice E *"Critical pitting temperature test for stainless steels"*

Critical Pitting Temperature (CPT) was determined as 40°C by ASTM G48 Practice E *"Critical pitting temperature test for stainless steels"*.

Table 9 Pitting Corrosion Test result by G48

Size of Specimen	Test Solution	Time of exposure	CPT (°C)
3 x 20 x 30mm	6%$FeCl_3$ + 1%HCl solution aq.	24 hrs	40

2-7-2. ASTM A923 Practice C *"Ferric Chloride Corrosion Test for Classification of structures of Duplex Stainless Steels"*

No corrosion loss took place at the specimen exposed in 6%FeCl3 solution aqua which pH is controlled at 1.3 at 40°C for 24 hours.

Table10 Test condition and corrosion rate per A923

Size of Specimen	Test Solution	Time of exposure	Test temperature (°C)	Corrosion rate (mdd)
5 x 25 x 50mm	6%$FeCl_3$ + HCl solution aq. (pH = 1.3)	24 hrs	40	0.00

2-8. Microstructure of all-weld metal

Mirror polished specimen of all-weld metal was electrically etched in chromium acid. Its microstructure is shown in Fig.3.

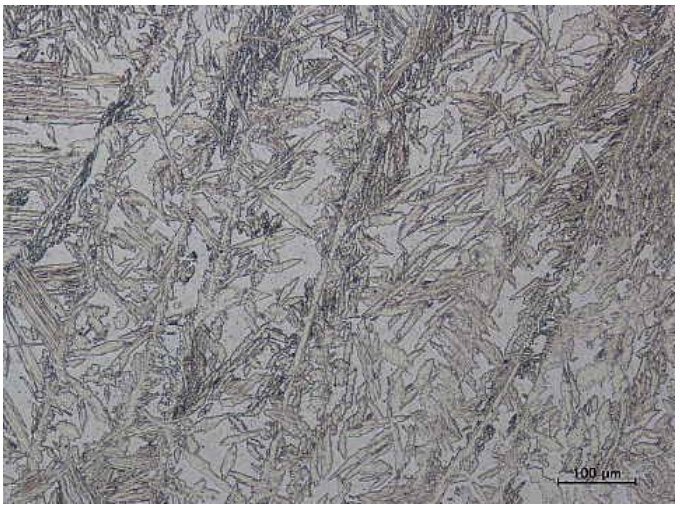


Fig.3 Microstructure of all-weld metal
AA-2594

3. ***Properties of butt joint***

V-groove butt weld joints of super duplex stainless steels were produced by A-2594 at different positions; flat, horizontal and vertical-up. Ar-20%CO_2 was applied as shielding gas.

3-1. Base metals

Two different kinds of grade of super duplex stainless steel were prepared. One is 13mm thick S32750 grade, and the other is 20mm thick S32760 grade.

Table11 Chemical compositions of base metals (%)

Grade	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	W	N	PRE	PREW
S32750	0.019	0.38	0.70	0.021	0.001	0.09	7.0	25.6	3.8	0.09	0.28	42.6	42.8
S32760	0.025	0.32	0.71	0.022	0.001	0.60	7.0	25.4	3.5	0.6	0.21	40.3	41.3

* PRE: Cr+3.3Mo+16N, **PREW: Cr+3.3(Mo+1/2W) +16N

3-2. Welding conditions

Table12 Welding condition (Base metal S32750)

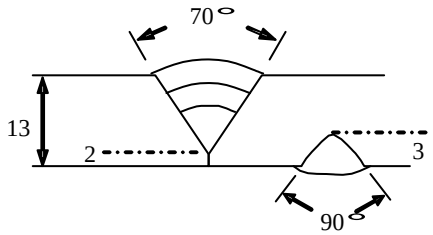
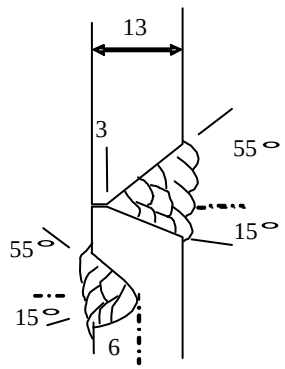
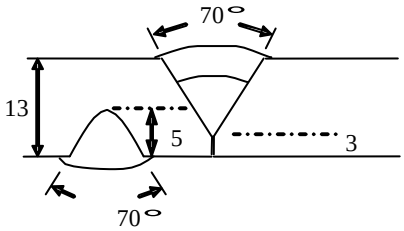
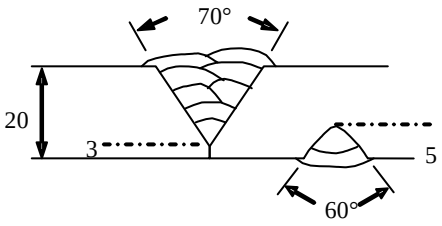
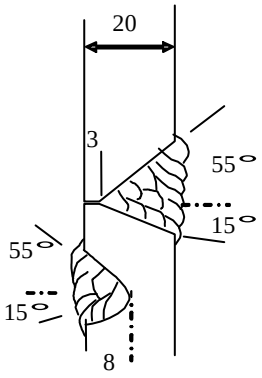
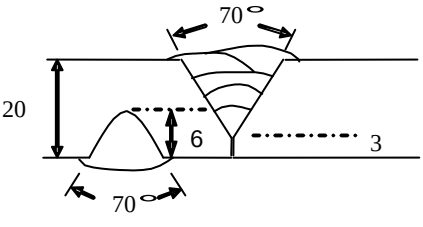
Groove preparation	Position	Side	Layers and passes	Welding current (A)	Arc voltage (V)	Inter-pass temp. (℃)
	Flat	Face	3 layers -3 passes	200	30	<150
		Back	1 layer -1 pass	200	30	<150
	Horizontal	Face	4 layers -10 passes	1st-9th:200 10th:160	28 26	<150
		Back	3 layers -7 passes	1st-6th:200 7th:160	28 26	<150
	Vertical-up	Face	2 layers -2 passes	160	26	<150
		Back	1 layer -1 pass	160	26	<150

Table13 Welding condition (Base metal S32760)

Groove preparation	Position	Side	Layers and passes	Welding current (A)	Arc voltage (V)	Inter-pass temp. (℃)
	Flat	Face	5 layers -8 passes	200	30	<150
		Back	2 layers -2 passes	200	30	<150
	Horizontal	Face	4 layers -12 passes	1st-11th:200 12th:160	28 26	<150
		Back	3 layers -8 passes	1st-7th:200 8th:160	28 26	<150
	Vertical-up	Face	4 layers -5 passes	160	26	<150
		Back	1 layer -1 pass	160	26	<150

3-3. Appearance and cross sectional view of weld joint

Weld bead appearances and macro structures of cross sections of welding joints are presented in Table14-1 and Table14-3 respectively. Ferrite number (FN) measured by Ferrite Scope at the surface of final weld bead on face side was also shown in Table14-2 and Table14-4. Average value among 10 measurements is reported.

Table14-1Weld bead appearance and macrostructure (Base metal: S32750)

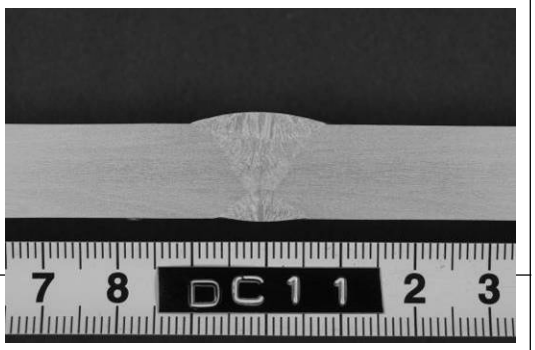
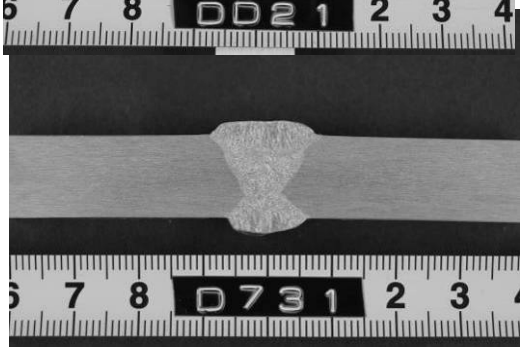
Position	Weld bead (face side)	Cross sectional macro structure
Flat		
Horizontal		
Vertical-up		

Table14-2 Ferrite Number (FN)

Position	Flat	Horizontal	Vertical-up
FN	37	36	33

Table14-3 Weld bead appearance and macrostructure (Base metal: S32760)

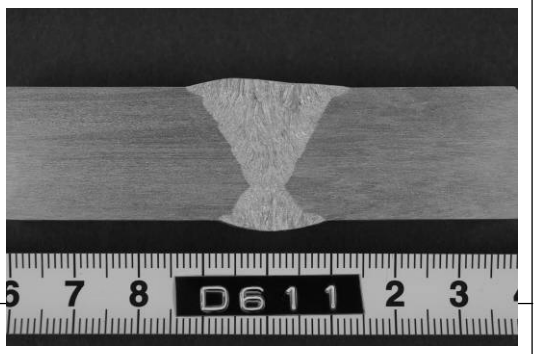
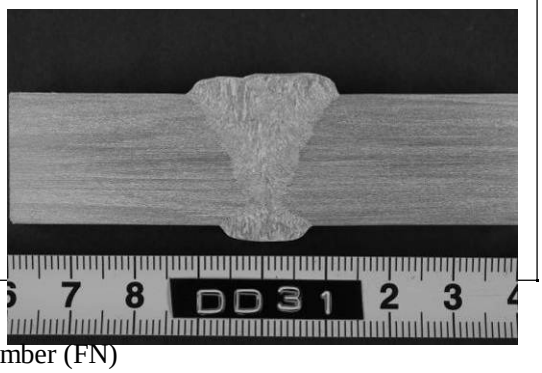
Position	Weld bead (face side)	Cross sectional macro structure
Flat		
Horizontal		
Vertical-up		

Table14-4 Ferrite Number (FN)

Position	Flat	Horizontal	Vertical-up
FN	36	39	35

3-4. Radiographic test of weld joint

Weld joint was subject to radiographic test to evaluate the soundness of the weld metal. Both ends were exempt and 200mm length of the center of the weld bead was evaluated.

Table15 Radiographic test

Position	S32750 by AA-2594		S32760 by AA-2594	
	Liner indication	Round indication	Liner indication	Round indication
Flat	None	<1mm x 1	None	<1mm x 1
Horizontal	None	<1mm x 3	None	<1mm x 5
Vertical-up	None	None	None	None

3-5. Side-bend test of weld joint

Side-bend test was conducted in accordance with AWS B4.0/4.0M with the test piece thickness, t=10mm (2/5in.) as bending radius is equal to 3t. Test piece was bended 180 degrees. Bended surfaces in 3 pieces from each welding position were examined and results are shown in Table16-1 and 16-2.

Table16-1 Side bend test result (S32750/ AA-2594)

No.	Test piece	Bended specimen	Defect	Result
Flat	1st		None	Satisfactory
	2nd		0.5mm x 1	Satisfactory
	3rd		0.5mm x 1	Satisfactory
Horizontal	1st		0.5mm x 1	Satisfactory
	2nd		None	Satisfactory
	3rd		0.5mm x 1	Satisfactory
Vertical-up	1st		0.5mm x 1	Satisfactory
	2nd		None	Satisfactory
	3rd		None	Satisfactory

Table16-2 Side bend test result (S32760/ AA-2594)

No.	Test piece	Bended specimen	Defect	Result
Flat	1st		0.5mm x 1	Satisfactory
	2nd		0.5mm x 1	Satisfactory
	3rd		None	Satisfactory
Horizontal	1st		0.5mm x 2	Satisfactory
	2nd		0.5mm x 1	Satisfactory
	3rd			
Vertical-up	1st		None	Satisfactory
	2nd		None	Satisfactory
	3rd		0.5mm x 2	Satisfactory

3-6. Charpy impact test

Charpy impact test was conducted in accordance with AWS B4.0/4.0M. Test piece was taken from the center of the plate so that the notch locates in the center of the weld metal.

Table17-1 Charpy impact test result (S32750/ AA-2594)

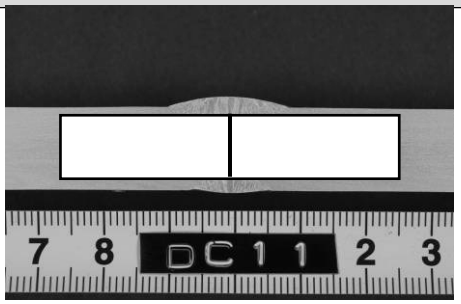
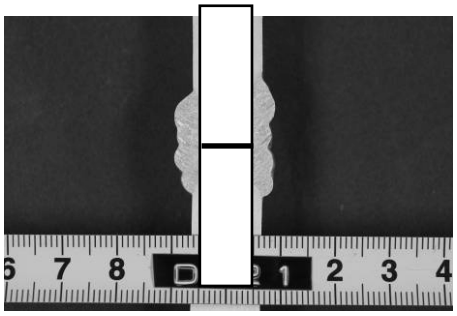
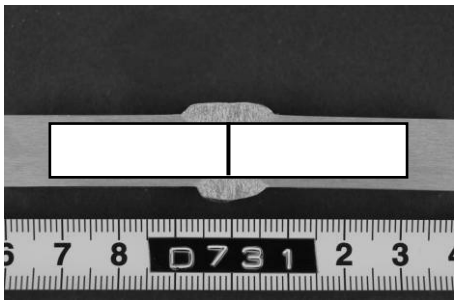
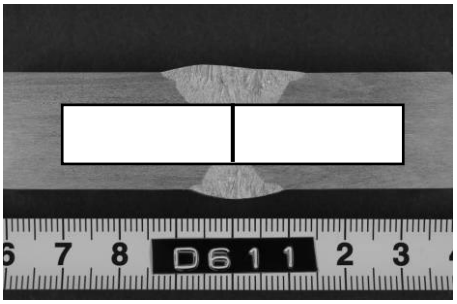
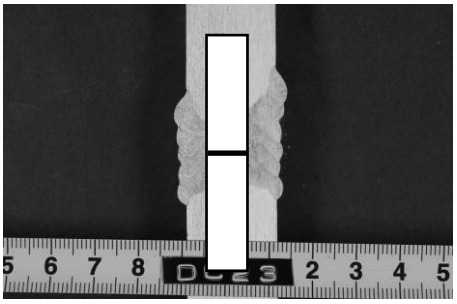
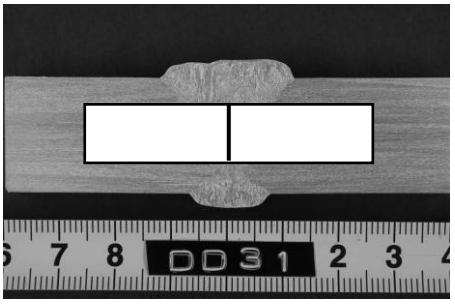
Position	Test piece location in the weld metal	Test temp. (°C)	Absorbed Energy (J)	Lateral Expansion (mm)
Flat		20°C	62, 69, 70 Avg. 67 J	0.72, 0.84, 0.80 Avg. 0.79mm
		-40°C	51, 48, 57 Avg. 52 J	0.57, 0.54, 0.59 Avg. 0.57mm
Horizontal		20°C	58, 60, 63 Avg. 45 J	0.60, 0.60, 0.53 Avg. 0.58mm
		-40°C	37, 40, 41 Avg. 39 J	0.31, 0.33, 0.24 Avg. 0.29mm
Vertical-up		20°C	81, 84, 75 Avg. 80 J	0.96, 0.94, 0.94 Avg. 0.95mm
		-40°C	56, 52, 52 Avg. 53 J	0.43, 0.47, 0.58 Avg. 0.49mm

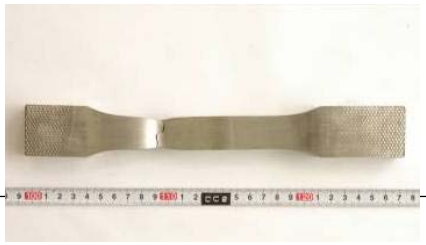
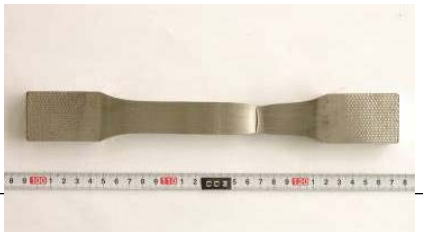
Table17-2 Charpy impact test result (S32760/ AA-2594)

Position	Test piece location in the weld metal	Test temp. (°C)	Absorbed Energy (J)	Lateral Expansion (mm)
Flat		20°C	56, 56, 48 Avg. 53 J	0.50, 0.65, 0.42 Avg. 0.49mm
		-40°C	38, 41, 36 Avg. 38 J	0.27, 0.33, 0.37 Avg. 0.32mm
Horizontal		20°C	63, 68, 66 Avg. 66 J	0.64, 0.62, 0.69 Avg. 0.65mm
		-40°C	54, 46, 49 Avg. 50 J	0.47, 0.39, 0.45 Avg. 0.44mm
Vertical-up		20°C	74, 76, 83 Avg. 78 J	0.87, 0.91, 0.93 Avg. 0.90mm
		-40°C	46, 49, 44 Avg. 37 J	0.39, 0.46, 0.41 Avg. 0.42mm

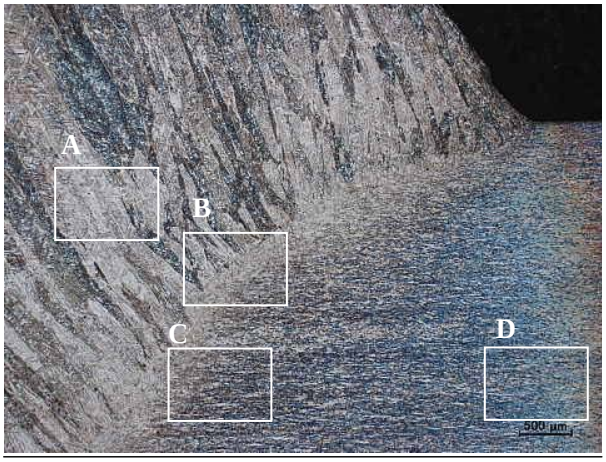
3-7. Transversal tensile test

Transverse tensile test was conducted in accordance with AWS B4.0/4.0M.

Table18 Transverse tensile test result

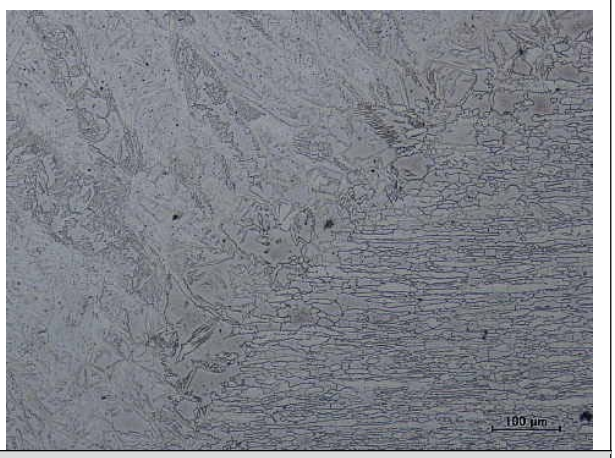
No.	Size	Tensile stress (N/mm^2/psi)	Fractured location	Appearance of test specimen
S32750 Flat	13 x 25mm (t x w)	873	Base metal	
S32750 Horizontal	13 x 25mm (t x w)	866	Base metal	
S32750 Vertical-up	13 x 25mm (t x w)	862	Base metal	
S32760 Flat	20 x 25mm (t x w)	799	Base metal	
S32760 Horizontal	20 x 25mm (t x w)	788	Base metal	
S32760 Vertical-up	20 x 25mm (t x w)	785	Base metal	

3.8. Microstructure



Location of observation

Weld metal

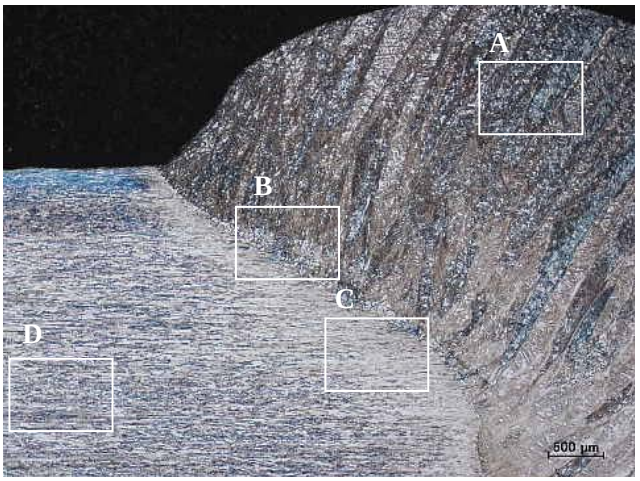


Fusion line

Heat affected zone

Base metal

Fig.4-1 Microstructure of weld joint (S32750, Horizontal position)

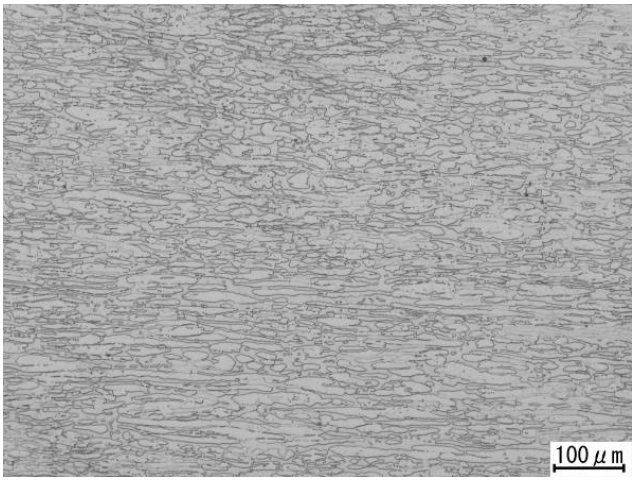


Location of observation

(A) Weld metal

(B) Fusion line

(C) Heat affected zone

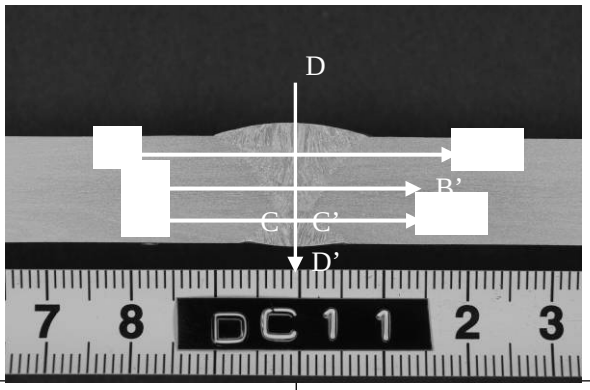


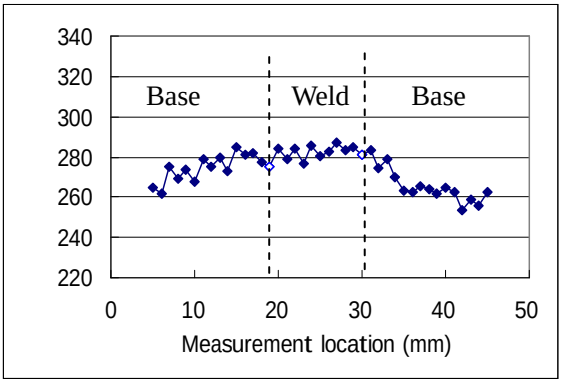
(D) Base metal

Fig.4-2 Microstructure of weld joint (S32760, Horizontal position)

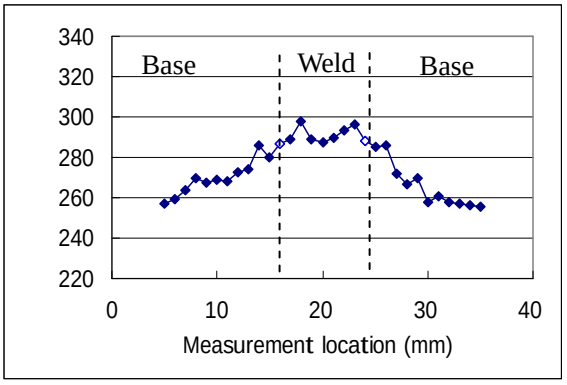
3-9. Hardness test

Vickers hardness test was conducted every 1mm along the lines shown in Fig.5-1 to 5-6. 10kgf was loaded for 15sec in the test.

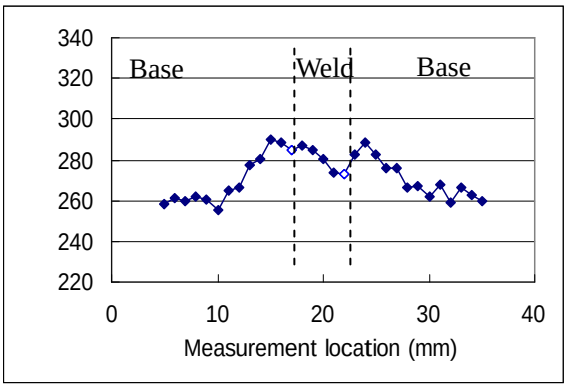




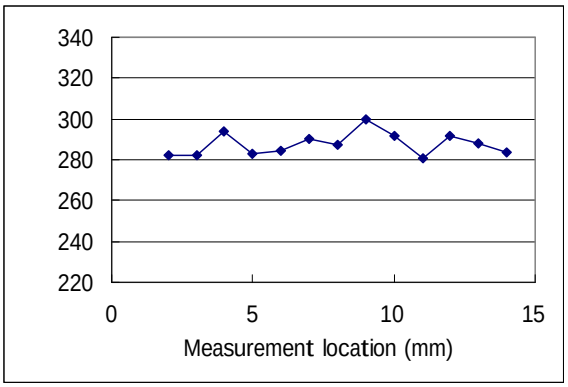
Line A-A'



Line B-B'

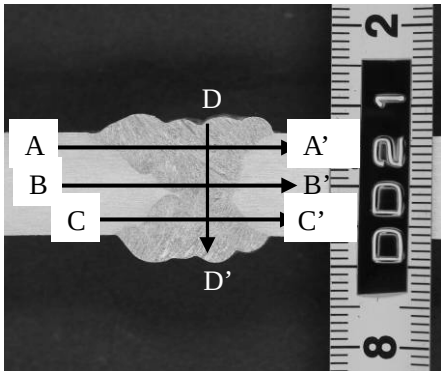


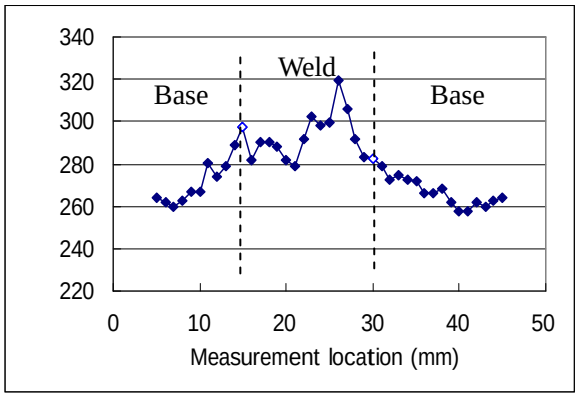
Line C-C'



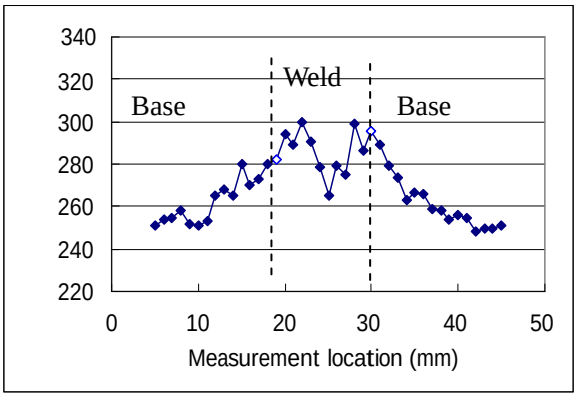
Line D-D'

Fig.5-1 Vickers hardness distribution across the weld (S32750, Flat position)

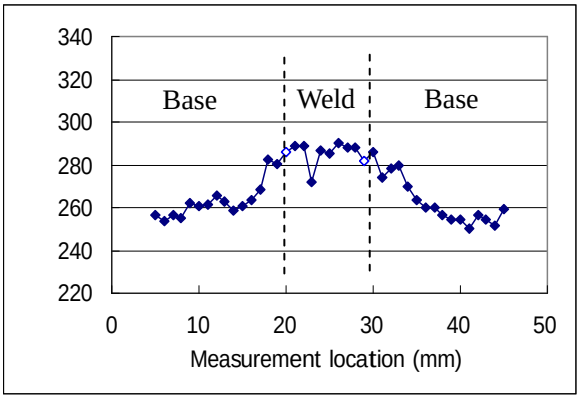




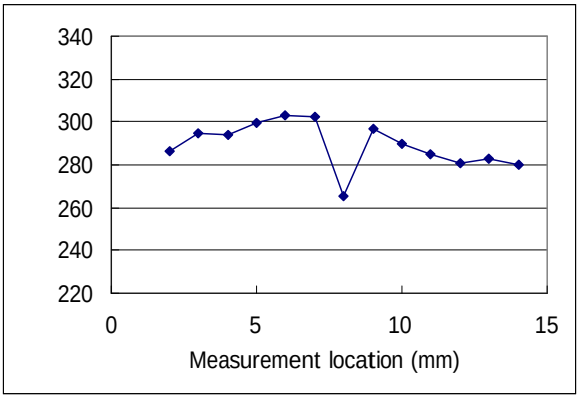
Line A-A'



Line B-B'

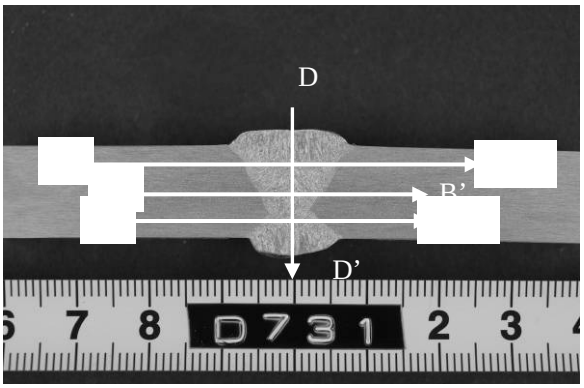


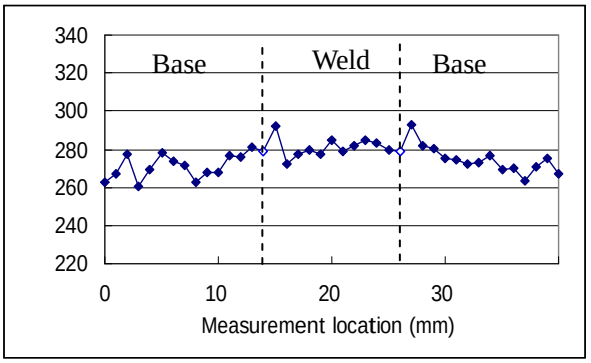
Line C-C'



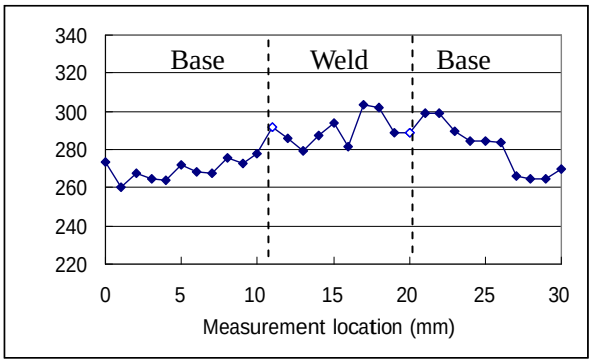
Line D-D'

Fig.5-2 Vickers hardness distribution across the weld (S32750, Horizontal position)

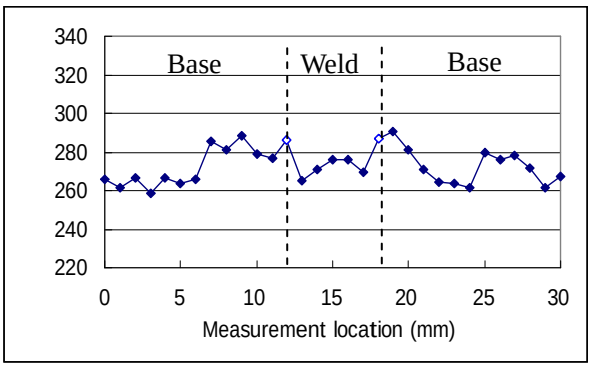




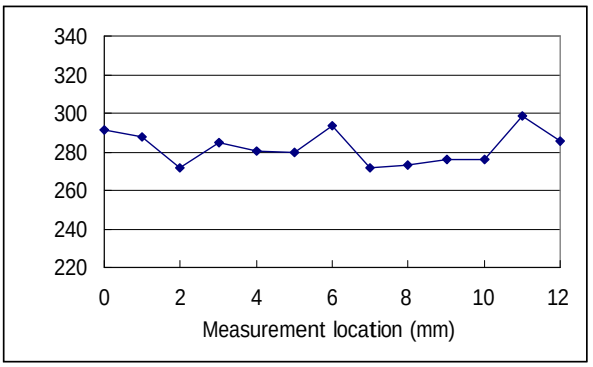
Line A-A'



Line B-B'

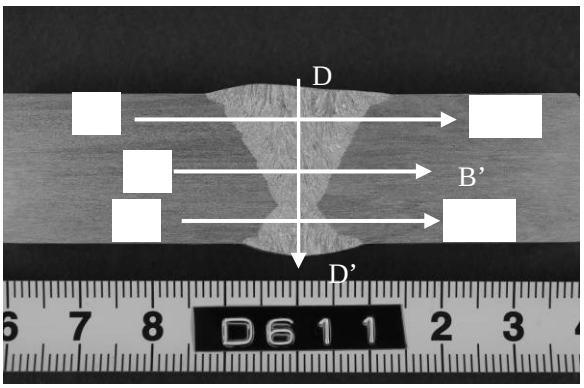


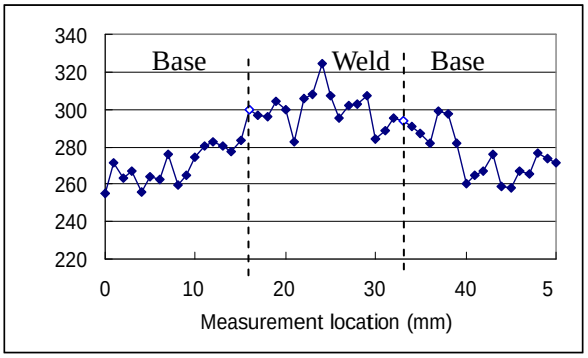
Line C-C'



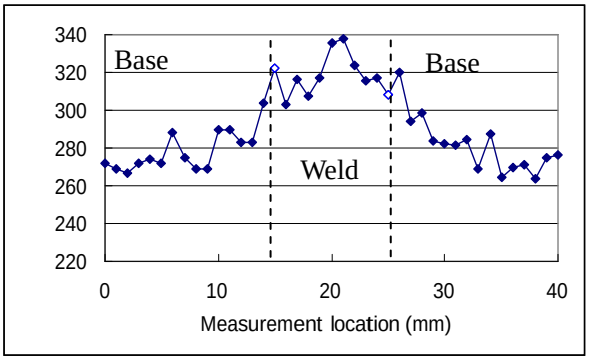
Line D-D'

Fig.5-3 Vickers hardness distribution across the weld (S32750, Vertical-up position)

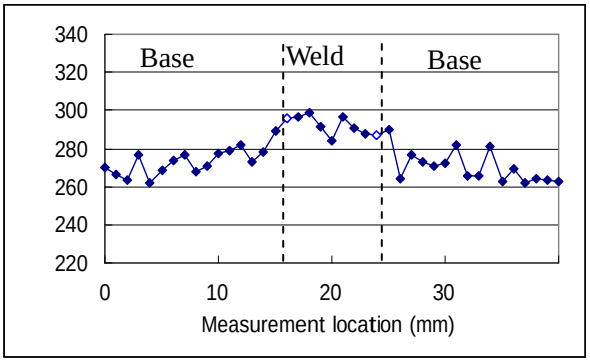




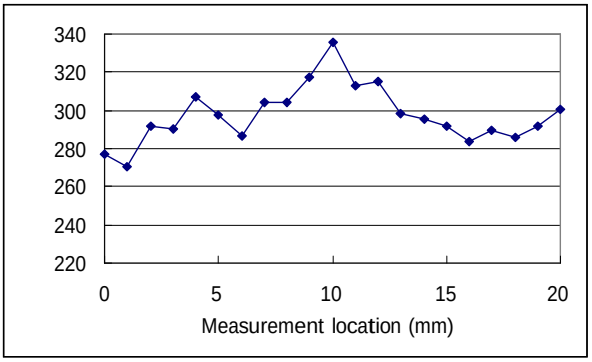
Line A-A'



Line B-B'

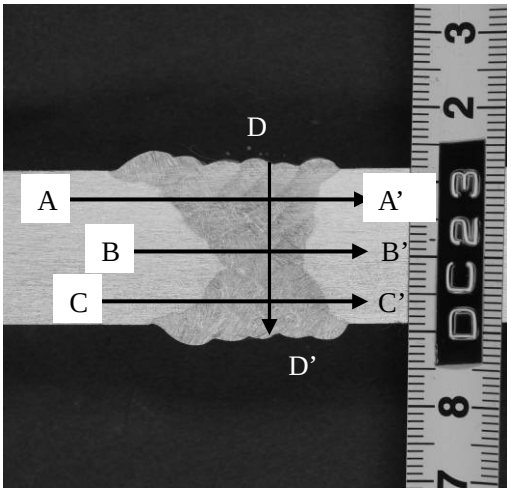


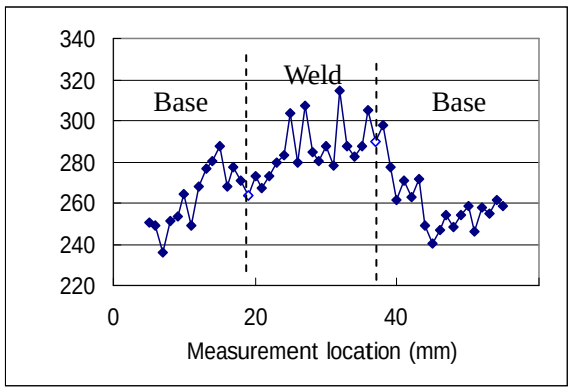
Line C-C'



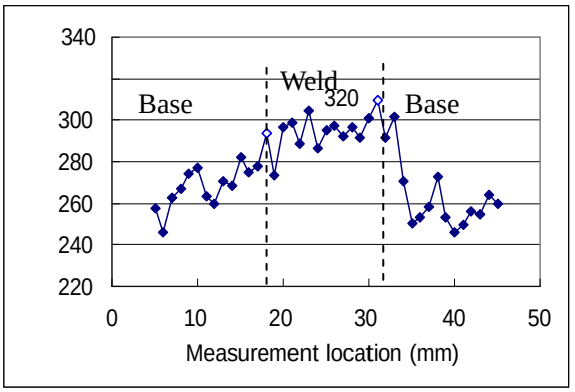
Line D-D'

Fig.5-4 Vickers hardness distribution across the weld (S32760, Flat position)

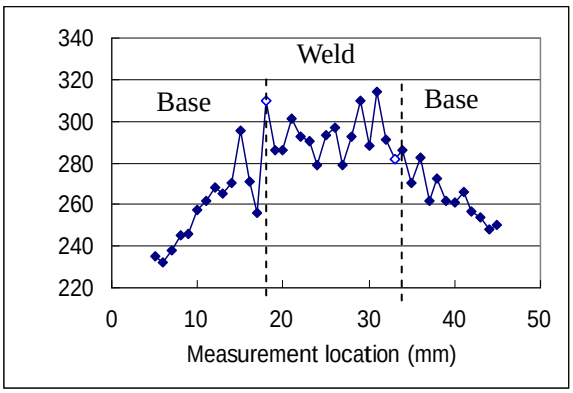




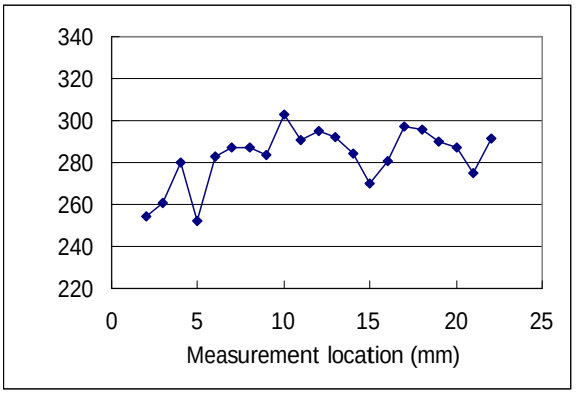
Line A-A'



Line B-B'

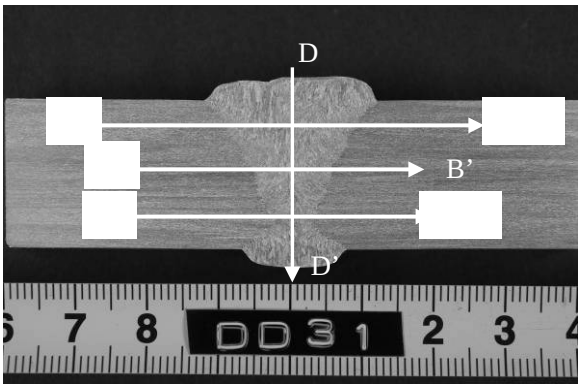


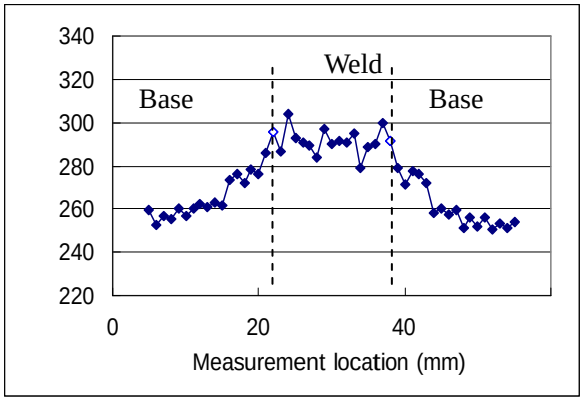
Line C-C'



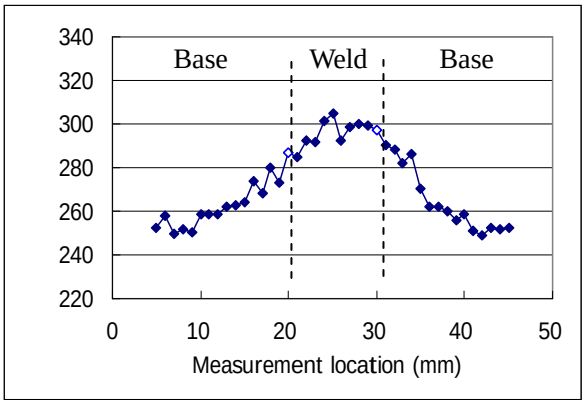
Line D-D'

Fig.5-5 Vickers hardness distribution across the weld (S32760, Horizontal position)

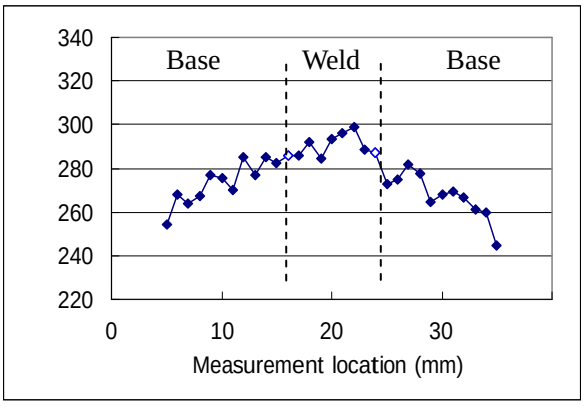




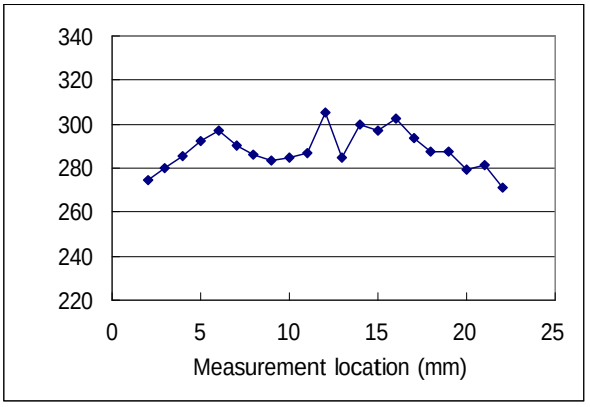
Line A-A'



Line B-B'



Line C-C'



Line D-D'

Fig.5-6 Vickers hardness distribution across the weld (S32760, Vertical-up position)

4. Summary

AA-2594 is a flux cored wire for welding 25Cr type duplex stainless steel, especially for super duplex grade.

25Cr-9Ni-3.7Mo-0.25N type chemical composition of all-weld metal ensures PRE>40 and its well-balanced ferrite and austenite in microstructure contribute to excellent corrosion resistance and sound mechanical properties.

AA-2594 can be applied at all positions by selecting proper welding condition. It is suggested that heat input is controlled within moderate range, generally guided as 5-25KJ/cm, to obtain optimized microstructure or prevent the formation of metallic compound detrimentally affecting toughness and corrosion resistance in weld metal and heat affected zone.

(Complete)

Appendix; Welding Parameters

Table 19-1 Base: S32750, Position: Flat

Position	Side	Pass	Current (A)	Voltage (V)	Speed (cm/min)	Heat input (KJ/cm)
Flat (1G)	Face	1	200	30	39	9.2
		2			29	12.4
		3			23	15.7
	Back	1			23	15.7

Table 19-2 Base: S32750, Position: Horizontal

Position	Side	Pass	Current (A)	Voltage (V)	Speed (cm/min)	Heat input (KJ/cm)
Horizontal (2G)	Face	1	200	28	29	11.6
		2			60	5.6
		3			52	6.5
		4			67	5.0
		5			55	6.1
		6			41	8.2
		7			52	6.5
		8			48	7.0
		9			48	7.0
		10			35	9.6
		11	160	26	40	6.2
	Back	1	200	28	56	6.0
		2			52	6.5
		3			68	4.9
		4			65	5.2
		5			54	6.2
		6			50	6.7
		7	160	26	65	3.8

Table 19-3 Base: S32750, Position: Vertical up

Position	Side	Pass	Current (A)	Voltage (V)	Speed (cm/min)	Heat input (KJ/cm)
Vertical up (3G)	Face	1	160	26	11	22.7
		2			12	20.8
	Back	1	140	24	17	11.9

Table 19-4 Base: S32760, Position: Flat

Position	Side	Pass	Current (A)	Voltage (V)	Speed (cm/min)	Heat input (KJ/cm)
Flat (1G)	Face	1	200	30	37	9.7
		2			26	13.8
		3			35	10.3
		4			40	9.0
		5			37	9.7
		6			33	10.9
		7			29	12.4
		8			31	11.6
	Back	1			26	13.8
		2			32	11.3

Table 19-5 Base: S32760, Position: Horizontal

Position	Side	Pass	Current (A)	Voltage (V)	Speed (cm/min)	Heat input (KJ/cm)
Horizontal (2G)	Face	1	200	28	28	12.0
		2			40	8.4
		3			27	12.4
		4			44	7.6
		5			39	8.6
		6			29	11.6
		7			47	7.1
		8			43	7.8
		9			43	7.8
		10			28	12.0
		11			45	7.5
		12	160	26	58	4.3
	Back	1	200	28	58	5.8
		2			71	4.7
		3			50	6.7
		4			54	6.2
		5			47	7.1
		6			43	7.8
		7			44	7.6
		8	160	26	63	4.0

Table 19-6 Base: S32760, Position: Vertical up

Position	Side	Pass	Current (A)	Voltage (V)	Speed (cm/min)	Heat input (KJ/cm)
Vertical up (3G)	Face	1	160	26	13	19.2
		2			14	17.8
		3			11	22.7
		4			15	16.6
		5			15	16.6
	Back	1			16	15.6
		2			15	16.6
		3			15	16.6

Appendix2

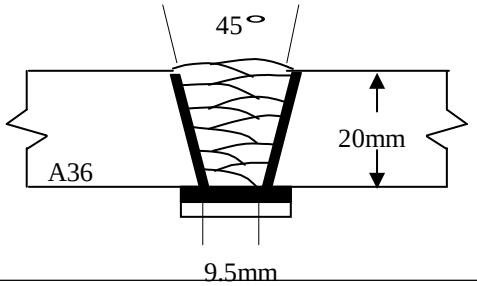
Properties of all-weld metal with 100%CO_2 shielding gas

1. Welding conditions

Welding conditions in producing all-weld metal with 100%CO_2 are shown in Table20.

Table20 Welding conditions for all-weld metal

Welding wire	**AA-2594, 1.2mm** Mfg.No. J9H35113369
Polarity	DC-EP
Welding position	Flat
Shielding gas	100%CO_2
Welding current	200A
Arc voltage	32V
Inter-Pass temperature	<150℃
Pass sequence	6 layers-12 passes



Beveled surface is buttered by AA-2594.

2. Chemical composition of all-weld metal

Table21 Chemical composition (%), PRE and ferrite content of all-weld metal

	C	Si	Mn	P	S	Cu	Ni	Cr
AA-2594	0.027	0.40	1.06	0.019	0.004	0.030	9.6	25.0
A5.22/A5.22M E2594TX-X	*-0.04*	*-1.00*	*0.5-2.5*	*-0.04*	*-0.03*	*-1.5*	*8.0-10.5*	*24.0-27.0*

	Mo	Nb	W	N	PRE	FNW	FF
AA-2594	3.75	0.016	<0.1	0.23	41.1	45	34
A5.22/A5.22M E2594TX-X	*2.5-4.5*	-	*-1.0*	*0.20-0.30*	-	-	-

PRE: Cr+3.3Mo+16N

FNW: Ferrite Number (FN) by WRC1992 Diagram

FF: Ferrite Number (FN) by Ferrite Scope (*Fischer Ferite Scope MP-30*)

3. Tensile properties of all-weld metal

Tensile test result conducted at ambient temperature 20℃ is presented in Table22.

Table 22 Tensile properties of all-weld metal

	0.2% P.S. (N/mm^2)	T.S. (N/mm^2)	EL (%)
AA-2594	690	886	20
A5.22/A5.22M E2594TX-X	-	*760 min.*	*15min.*

4. Charpy impact properties of all-weld metal

Charpy impact tests (10 x 10mm, 2mm V notch) were conducted at several temperatures at -40℃. Absorbed energy and lateral expansion are presented in Table23.

Table23 Absorbed Energy and lateral expansion at Charpy impact test

	@-40℃
CVN (J)	50, 50, 43, Avg. 47J
L.E. (mm)	0.43, 0.54, 0.34, Avg. 0.44mm

5. Ferric Chloride Test of all-weld metal by ASTM G48 Practice E

Critical Pitting Temperature (CPT) was determined as 40℃ by ASTM G48 Practice E *"Critical pitting temperature test for stainless steels"*.

Table24 Pitting Corrosion Test result by G48

Size of Specimen	Test Solution	Time of exposure	CPT (℃)
3 x 20 x 30mm	6%$FeCl_3$ + 1%HCl solution aq.	24 hrs	40