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The characteristics of the weldable ferritic stainless steel, RIVER LITE 434 LN-2, produced by SS-VOD process, are reviewed. In order to improve its toughness. C and N contents of the steel have been reduced to extremely low levels and Nb and Al added. The weld joint made under the suitable welding conditions also is superior in toughness. Therefore, the steel plate up to about 12 mm in thickness for structural use above a temperature 0℃ can be manufactured. Being excellent in pitting corrosion resistance and free of stress corrosion cracking, the plates are suitable for the use as vessels in wet corrosive environment and have mainly been applied to hot water reservoirs.

The body can be viewed from the next page.

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1 Introduction

SUS444 (18Cr-2Mo)is a low carbon, low nitrogen ferritic stainless steel superior in pitting corrosion and crevice corrosion resistance, and especially in resistance to the stress corrosion cracking which is a serious problem in austenitic stainless steels such as SUS304 and SUS316. Superior in ductility in sheet weldments because of its low C and N contents, this steel is mainly used in solar energy collectors and thin welded tubes for hot water environments.

However, thicker ferritic stainless steel sheet generally has lower toughness, especially in the heat affected zone (HAZ) of welded joints due to grain coarsening caused by welding heat input. It is well known that the reduction of C and N contents is effective in improving toughness.[1] Simple reduction of C and N contents, however, is not sufficient in weldable plate for structural use, and, consequently, SUS444 has been used only in sheet thinner than 3 mm.

An investigation was made on the effect of chemical composition on the toughness and corrosion resistance of low C, low N 18Cr-2Mo steel produced using the SS-VOD (Strongly Stirred-Vacuum Oxygen Decarburization) process[2] developed by Kawasaki Steel. On the basis of these studies, **RIVER LITE 434LN-2** (below, R434LN-2) with excellent weld toughness and corrosion resistance characteristics was developed.

This report describes experimental results in which the effect of chemical composition on the toughness of ferritic stainless steels was investigated. A review will then be made of the characteristics of the weldable ferritic stainless steel R434LN-2 for structural use developed on the basis of these investigations.

* Originally published in *Kawasaki Steel Giho*, 17(1985)3, pp. 249–257

2 Investigation of Chemical Composition

Binder, et al.[1] have reported that reduction of C and N contents is effective in improving the toughness and ductility of high Cr ferritic stainless steel. Accordingly, the effect of C and N contents on the toughness of Cr ferritic stainless steel was studied first in this investigation. **Figure 1** shows the effect of C and N contents on the toughness of weld metal in a TIG weld in 3 mm thick 16Cr ferritic stainless steel.[2] Toughness increases greatly as C and N decrease.

With the SS-VOD process, it is possible to reduce the C and N contents of 16–20%Cr steels to extremely low levels, 20 and 40 ppm respectively. Therefore. the toughness of 18Cr-2Mo steels with extremely low levels of C and N was investigated. **Figure 2** shows the effect of heat treatment temperature on the 2 mm V-notch Charpy impact properties of 4 mm thick 18Cr-2Mo steel which was held at 1 000–1 200°C for 10 min, and then water-quenched.[3] Toughness decreases as heating temperature increases, due to grain coarsening. Degradation of toughness is a serious problem with structural ferritic stainless steels, since the weld HAZ is heated to 1 200–1 300°C.

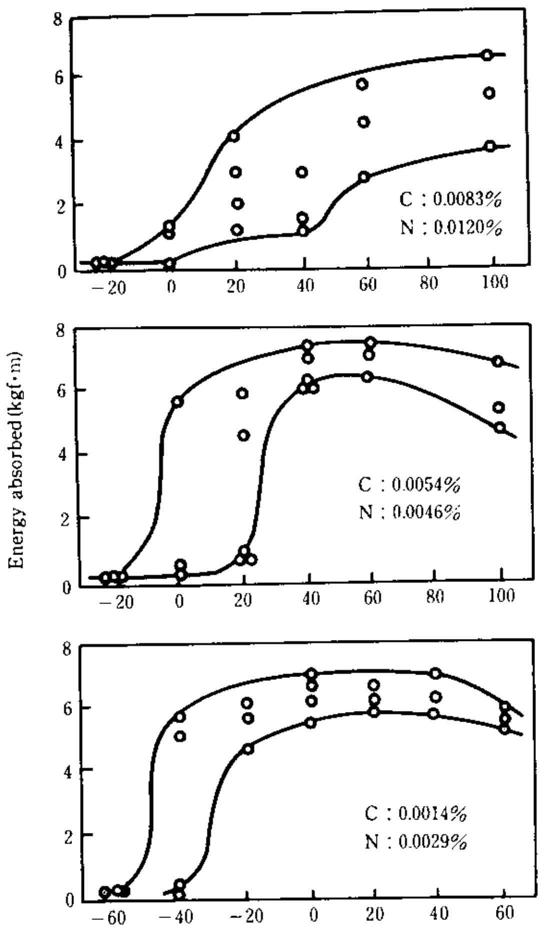


Fig. 1 Charpy energy vs. temperature curves for TIG weld metals of 3 mm thick 16% Cr steels

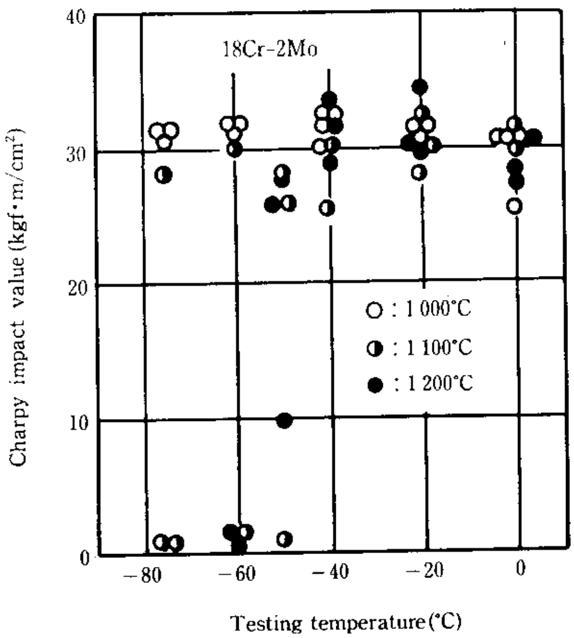


Fig. 2 Charpy absorbed energy vs. test temperature of solution-treated specimens followed by water quenching (4 mm thick, 2 mm V-notch)

Generally, carbide- and nitride-forming elements such as Ti and Nb are added to ferritic stainless steels to prevent intergranular corrosion of the HAZ. The effect on toughness of these stabilizing elements, as well as that of Al, a nitride or oxide forming element was therefore studied. **Figure 3** shows the effect of Ti, Nb, and Al levels on the Charpy impact properties of 18Cr-2Mo steels which were held for 5 min at 1 200°C, then water-quenched, air-cooled, or furnace-cooled. The toughness of 18Cr-2Mo-0.2Nb steel decreases as the rate of cooling from 1 200°C is reduced. When cooling rates are relatively high, as with water-quenching or air-cooling, the addition of about 0.2% Al is extremely effective in improving toughness. With 18Cr-2Mo-0.2Nb steel containing 0.5% or more Ti, however, the energy transition temperature is between 100 and 200°C regardless of the cooling rate and, further, the improvement in toughness brought about by addition of Al, mentioned above, is lost.

Figure 4 shows Charpy test results for test pieces of differing chemical composition held for 5 min at 1 200°C, then cooled at various rates. As shown in **Figure 5**, electron beam welding was applied to the central area of test pieces on which thin Ti and mild steel strips had been set.[3] As a result, brittle cracking

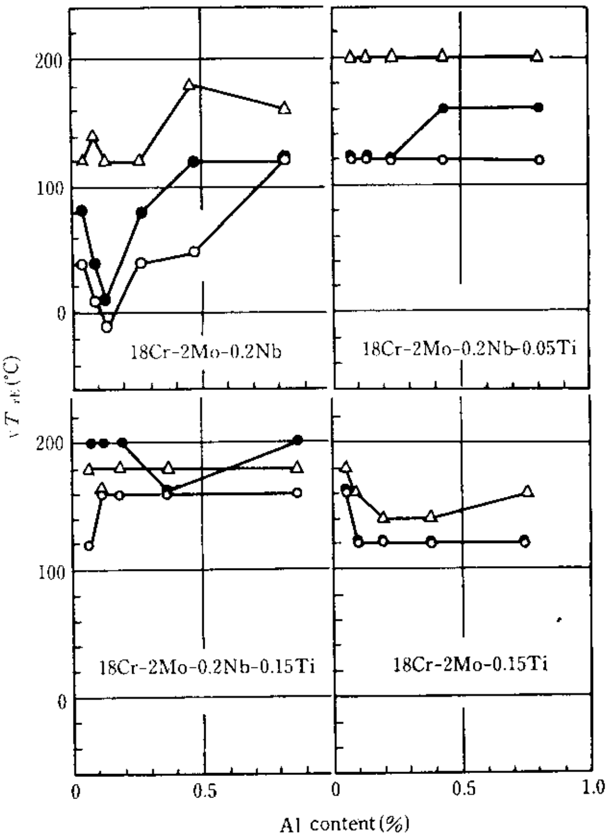


Fig. 3 Influence of chemistry (Nb, Ti, Al) and cooling rate after heat-treatment at 1200°C for 5 min on Charpy V-notch toughness of 18Cr-2Mo steels (full size)

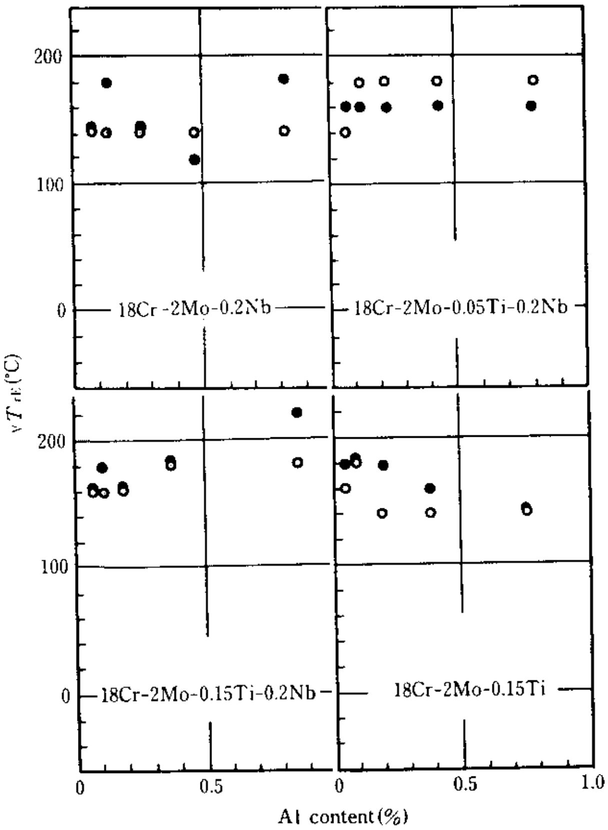


Fig. 4 Influence of chemistry (Nb, Ti, Al) and cooling rate after heat-treatment at 1200°C for 5 min on the toughness of Charpy specimens (full size) having weld crack

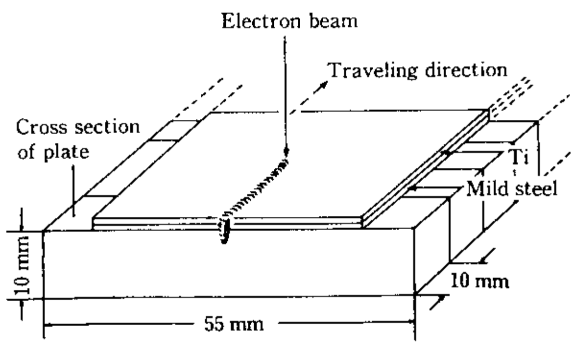


Fig. 5 Preparation of the specimen having brittle weld crack

occurred, as expected. The energy transition temperature was high at 100–200°C, regardless of cooling rate or stabilizing elements, and toughness was low.

The following two conclusions with regard to toughness in ferritic stainless steels can be made on the basis of the results shown in Figs. 3 and 4:

(1) With specimens such as blunt-notch type Charpy V-notch pieces, toughness is very effectively improved by reduction of C and N, addition of Nb and suitable amounts of Al as stabilizing elements, and control of cooling rate.

(2) The measures described in (1) have no effect on sharp cracks in Ti-embrittled beads. In brittle fractures, most of the energy absorbed by a Charpy V-notch specimen is known to be the energy necessary for crack initiation. Moreover, according to results obtained with Ti-embrittled bead specimens, it can be thought that the chemical composition and cooling rate do not prevent crack propagation.

With Charpy V-notch specimens, toughness decreases with decreases in cooling rate. This can be explained as follows: carbide and nitride of Cr or of stabilizing elements precipitate at grain boundaries in much greater amounts with lower cooling rates, and their presence renders the grain boundaries more susceptible to

Photo 1 Microstructures after heat-treatment at 1 200°C for 5 min, followed by air-cooling

cracking. With Ti-added steels, the Charpy V-notch impact property is markedly degraded, although neither coarsening nor refining of grain is observable on addition of Nb or Ti, as can be seen from the microstructures of the specimens shown in **Photo 1**, which were held at 1 200°C for 5 min, then air cooled. However, in the Ti-added steel, coarse TiN precipitates can be observed. Consequently, it can' be concluded that the cause of degradation of toughness on addition of Ti is that, because TiN does not dissolve even at high temperatures, existing as a coarse precipitate, cracking is easily initiated in the region of grain boundary precipitates, regardless of cooling rate.

The addition of a suitable amount of Al is effective in improving the Charpy V-notch impact property. The reason for this has not yet been clarified, but may be related to a reduction of inclusions owing to the decrease in O content and to the change of inclusions to a fine C-type by addition of Al. On the other hand, excessive addition of Al causes a reduction in toughness; this seems related to the degradation of mechanical properties due to an increase in solute Al.

Table 1 shows the pitting potentials of 18Cr-2Mo steels. Pitting corrosion resistance is not affected by stabilizing elements (Ti, Nb) or by Al content.

Thus, as a result of investigation of the effect of chemical composition and thermal history on the toughness of 18Cr-2Mo steel plate, it can be concluded, in summary, that extreme reduction of C and N contents and addition of Nb and Al as stabilizing elements are effective measures for improvement of toughness, and that pitting corrosion resistance is also superior.

Table 1 Effect of chemistry (Nb, Ti, Al) on pitting potential (Vc'_{10}) at 80°C in 100 ppm Cl^- solution

	Al (%)	Vc'_{10} (mV vs. SCE)
18Cr-2Mo-0.2Nb	0.057	455, 400
	0.13	473, 460
	0.26	500, 443
	0.47	453, 463
	0.82	435, 450
18Cr-2Mo-0.15Ti	0.048	403, 433
	0.093	445, 433
	0.38	440, 413

3 R434LN-2 Steel Plate

3.1 Chemical Composition and Manufacturing Process

Table 2 shows the range of chemical compositions and a typical example of R434LN-2 plate. From the point of view of improving toughness, C and N contents are reduced to about 20 and 50 ppm, respectively, using the SS-VOD process, and Nb and Al are added as stabilizing elements.

Figure 6 shows the manufacturing process for R434LN-2 plate. Hot rolling facilities used differ according to plate thickness and width; i.e., thin, narrow plate is produced at the hot strip mill, and thick, wide plate at the plate mill. Both products are then subjected to heat-treatment and pickling.

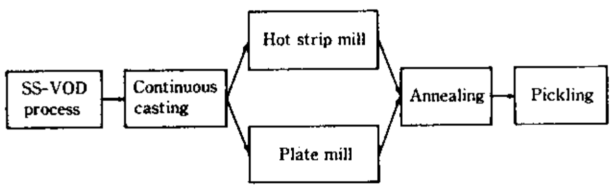


Fig. 6 Manufacturing process of R434LN-2 plate

3.2 Mechanical Properties

Table 3 shows the mechanical properties of R434LN-2 plate, including its superior ductility due to reduction of C and N. **Figure 7** shows the energy transition curves of

Table 2 Typical examples of chemical composition of R434LN-2 (wt%)

	C	Si	Mn	P	S	Ni	Cr	Mo	N	Al	Nb	Nb/C+N
Specification	≤0.020	≤1.0	≤1.0	≤0.040	≤0.030	≤0.60	17.50~19.50	1.75~2.25	—	0.1~0.4	—	≥10
An enample of plates	0.002	0.15	0.15	0.025	0.005	0.10	18.10	2.00	0.0050	0.22	0.24	34

Table 3 Mechanical properties of 6 mm thick R434LN-2 plate

	Tensile test			Bend test	Impact test
	0.2% proof strength (kgf/mm²)	Tensile stength (kgf/mm²)	Elongation in G.L. of 50 mm (%)	180°, r=1 t	2 mm V-notch Charpy absorbed energy at 0°C (kgf·m)
Specification*1)	>25	>42	≥20	Good	Min. ave. 4.8 (10×10 mm) 3.6 (10×7.5 mm) 2.5 (10×5 mm)
An example*2)	32	52	39	Good	14.5

*1 Transverse direction
*2 Transverse direction, 6 mm thick

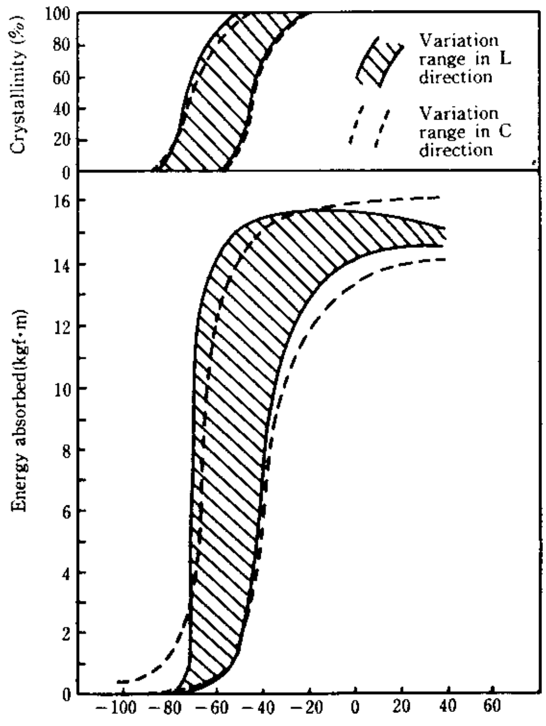


Fig. 7 Charpy absorbed energy vs. temperature plots of 6 mm thick R434LN-2 plate (2 mm V-notch half sized specimen)

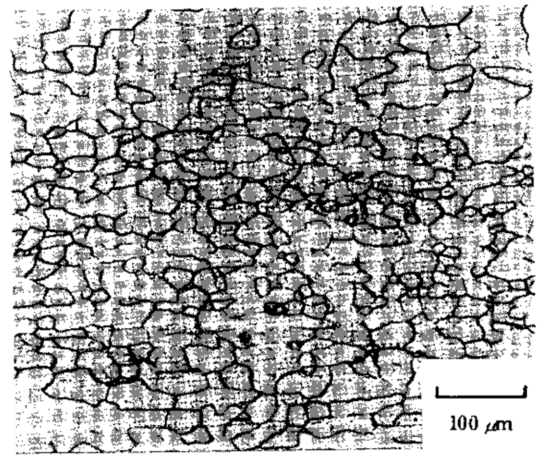


Photo 2 Microstructure of 6 mm thick R434LN-2 plate (L-cross section)

half-sized 2 mm V-notch specimens of the plate. The energy transition temperature is as low as −50°C, meaning toughness is excellent. **Photo 2** shows plate microstructure.

Table 4 shows mechanical properties of a cold-pressed head plate of R434LN-2 (SD 1 000 mm dia., 6 mm thickness). **Figure 8** shows results of a Charpy V-notch impact test on the head plate. Even at the flange portion, which is subjected to the most severe cold working, the reduction in ductility is small, and toughness is almost equal to that of the base plate (see Figs. 7 and 8).

Table 4 Mechanical properties of the cold-pressed head plate (SD 1000 mm dia, 6 mm thick) of R434LN-2

Portion of head	Direction	0.2% proof strength (kgf/mm²)	Tensile strength (kgf/mm²)	Elongation (%)
Frange	L	68	73	15
	T	70	74	15
Knuckle	L	54	57	22
	T	55	58	26
Crown	L	43	52	33
	T	45	52	36

3.3 Corrosion Resistance

Figure 9 shows the corrosion rate for R434LN-2 in a 4 hours test in 10%$FeCl\cdot 6H_2O$ solution. The pitting corrosion resistance of R434LN-2 is superior to those of

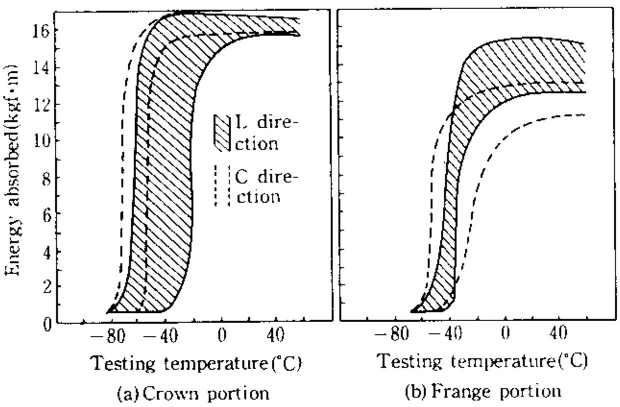


Fig. 8 Charpy impact test results of the cold-pressed head plate (SD 1000 mm dia, 6 mm thick) of R434LN-2 by using half sized specimen

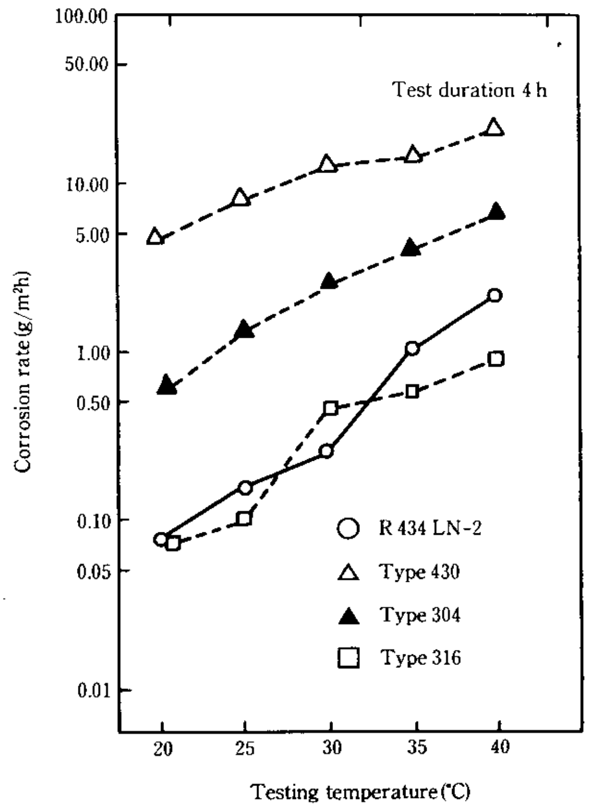


Fig. 9 Corrosion rate of R434LN-2 in 10% $FeCl_3 \cdot 6H_2O$ solution in comparison with those of commercial grade stainless steels

SUS430 and SUS304, and comparable to that of SUS316.

Table 5 shows results of Strauß tests and stress corrosion cracking tests of R434LN-2 and austenitic stainless steels in boiling 42% $MgCl_2$ aqua solution, with constant stress applied to TIG welded joints. No intergranular corrosion sensitivity was shown in R434LN-2, SUS304, or SUS316 welded joints. R434LN-2 also showed no stress corrosion cracking, but such cracking did occur with SUS304 and SUS316.

Table 5 Corrosion test results of TIG welded joints of R434LN-2 and austenitic stainless steels

Steel	Strauβ test	Rupture time in the boiling solution of 42% $MgCl_2$	
		Stress (kgf/mm^2)	Rupture time (h)
R 434 LN-2	Passed	30	>500
Type 304	Passed	20	1
Type 316	Passed	20	4

Table 6 Corrosion rates of R434LN-2 and austenitic stainless steels after immersion in boiling solutions for 24 h

($g/m^2 \cdot h$)

	5% H_2SO_4	1% HCl	80% CH_3CO_2H	50% HCO_2H	50% NaOH
R 434 LN-2	474	320	<0.01	2.02	6.90
Type 304	183	12.2	0.29	0.46	2.03
Type 316L	4.96	16.2	0.19	0.45	3.12

Table 6 shows corrosion resistance in boiling acids. R434LN-2 was superior in acetic corrosion resistance to SUS304 or SUS316L, but inferior in resistance to hydrochloric and sulfuric acids and alkali. In using R434LN-2, therefore, it is necessary to give consideration to corrosive environment factors, including corrosive medium, concentration, and temperature.

4 Welding

Generally, TIG or MIG arc welding is used with stainless steel plates. This section describes the properties of welds with R434LN-2 and a few important points to be considered in using these arc welding methods.

4.1 Mechanical Properties

Table 7 shows typical examples of TIG and MIG arc welding conditions with 6-mm thick R434LN-2 plate. **Table 8** shows the chemical composition of matching consumables. To compensate for the loss of Cr and Mo during welding, the contents of these elements in the consumable are somewhat higher than that of the base metal. **Photo 3** shows macrostructure of an MIG arc welded joint produced under the conditions shown in Table 7. **Photo 4** shows macrostructure with TIG welding. In MIG arc welding, use of Y-316L wire results in a

Table 7 Welding conditions of 6 mm thick R434LN-2

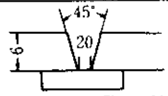
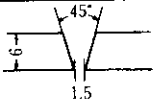
	MIG welding	TIG welding
Groove geometry	 3 mm thick Type 304	
No. of welding pass	1	First side 2 Backing side 1 (No consumable is used)
Welding current	300 A	180 A
Welding voltage	25 V	12 V
Torch gas	(19.8 ℓ Ar + 0.2 ℓ O_2)/min or 20 ℓ Ar/min	15 ℓ Ar/min
Traveling speed	350 mm/min	10 mm/min
Welding consumable	Matching composition consumable Type 316 L	Matching composition consumable Type 316 L Type 309 L

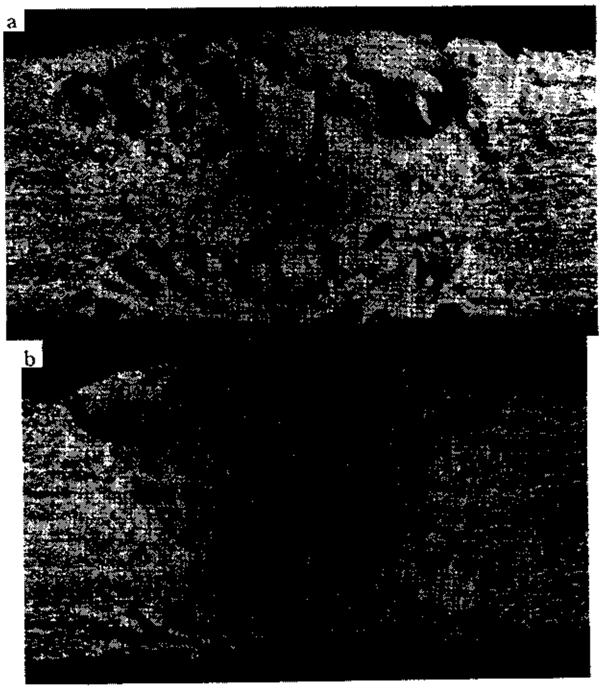
Table 8 Chemical composition of matching compostion consumable (wt %)

C	Si	Mn	P	S	Ni	Cr	Mo	Nb	N
0.009	0.18	0.27	0.024	0.004	0.006	19.04	2.48	0.22	0.011

(a) Matching composition consumable (b) Type 316 L consumable

Photo 3 Macrostructure of MIG welded joint of 6 mm thick R434LN-2

mixed structure composed of about 70% austenite and 30% ferrite, while the matching composition consumable yields a single-phase structure of coarse ferrite. In TIG arc welding, on the other hand, even use of austenitic stainless welding materials Y-309L and Y-316L produces a mixed structure consisting mainly of ferrite with a slight amount of austenite; this results from the high



(a) Matching composition consumable 1 mm
(b) Type 316 L consumable

Photo 4 Macrostructure of TIG welded joint of 6 mm thick R434LN-2

dilution rate of the base metal.

The results of Charpy V-notch impact tests of MIG and TIG welded joints are shown in **Figs. 10** and **11**, respectively. In MIG arc welded joints, there is no energy transition temperature when Y-316L is used, because the microstructure of the weld metal consists mainly of austenite phase. When the matching composition consumable is used, the transition temperature of the weld metal is −20°C, and that of the HAZ is −30°C.

On the other hand, in TIG welding, even when austenitic stainless steel welding materials are used, the energy transition temperature exists because the weld metal microstructure consists mainly of ferrite phase. However, this temperature is as low as −60°C, i.e., toughness is high. When the matching composition consumable is used, the transition temperature of the weld metal is −30°C, lower than with the MIG weld, and shelf energy is also higher. This weld metal therefore is sufficient in toughness for structural use.

As described above, when the matching composition consumable is used, the toughness of MIG weld metal is lower than that of TIG weld metal. This degradation of toughness is thought to be caused by a decrease of cleanliness in weld metal caused by a 1% addition of O_2 to the Ar torch gas to stabilize the arc; O_2 in the weld metal

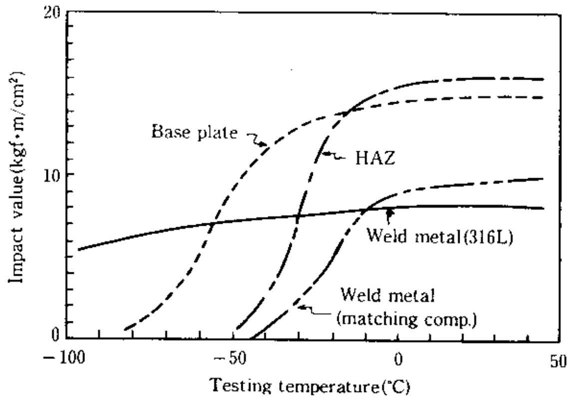


Fig. 10 Results of Charpy impact test for MIG welded joints of 6 mm thick R434LN-2 plate welded by using the matching composition consumable and type 316L consumable (Torch shielding gas of Ar-1% O_2 and 1/2 sized specimen was used)

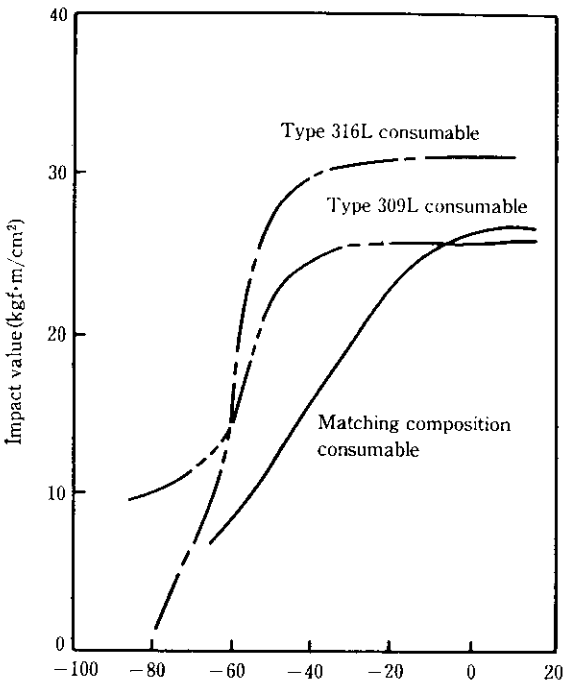


Fig. 11 Results of charpy impact test for TIG weld metals of 6 mm thick R434LN-2 plate welded with the matching composition consumable and austenitic stainless steel consumables (1/2 sized specimen, 3 pass welding)

reaches 130–200 ppm. **Table 9** shows the mechanical properties of welded joints. With both TIG and MIG arc welding, welded joints are superior in ductility, regardless of welding material used, and no cracking is shown in face bend tests. In the root bend test, however, small cracks may occur, originating from such weld defects as pinholes. Accordingly, welding defects must be prevented.

Generally, ferritic stainless steels have higher hydrogen-induced cracking sensitivity than austenitic stainless steels. Consequently, when R434LN-2 plates are welded using the matching composition consumable, strong restraint in welding becomes a problem. **Figure 12** schematically shows a restraint cracking test of a TIG weld with 12-mm thick R434LN-2 plates given single-pass TIG arc welding. The matching composition consumable was used; welding current was 200A, welding voltage 12V, welding speed 10 mm/min, and torch gas 20*l*/min Ar. The results are shown in **Table 10**. Weld cracking occurred when neither preheating nor postheating was performed. On the other hand, no cracking was observed when both preheating and postheating were performed at or above 50°C. Cracking sensitivity changes with weather conditions such as humidity, suggesting that cracking is caused by contamination of the

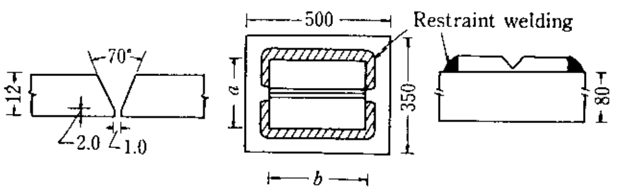


Fig. 12 Outline of restraint cracking test

Table 9 Mechanical properties of MIG and TIG welded joints of 6 mm thick R434LN-2 plate

	Consumable	Tensile strength (kgf/mm²)	Breaking point	Vickers hardness			180° bend ($r=2t$)	
				Weld metal	HAZ	Base metal	Face	Root
MIG	Matching composition consumable	48	Base metal	170	160	160	Good	Small crack
	Type 316L	49	Base metal	200	160	160	Good	Small crack
TIG	Matching composition consumable	49	Base metal	175	170	160	Good	Small crock
	Type 316L	48	Base metal	190	160	160	Good	Small crack
	Type 316L	49	Base metal	210	160	160	Good	Small crack

Table 10 Result of restraint cracking test

Without pre- and post-heating	50°C*)	100°C*)	150°C*)
Crack	No crack	No crack	No crack

* Pre-and post-heating time is 1 h

weld metal by H in the welding atmosphere.

4.2 Corrosion Resistance

Table 11 shows results of Strauß tests and immersion tests in 10%$FeCl_3 \cdot 6H_2O$ aqua solution at 30°C for 4 h on R434LN-2 TIG and MIG arc welded joints. Regardless of the welding process and welding material, no intergranular corrosion was observed. In the MIG arc welded joints, the matching composition consumable showed a lower corrosion rate and better pitting corrosion resistance in the $FeCl_3 \cdot 6H_2O$ solution than Y-316L. **Photo 5** shows the appearance of MIG welds after immersion tests. Pitting is concentrated in the weld metal when Y-316L is used. On the other hand, the corrosion resistance of TIG welds is of about the same level regardless of welding material used, and is superior to that of MIG welds.

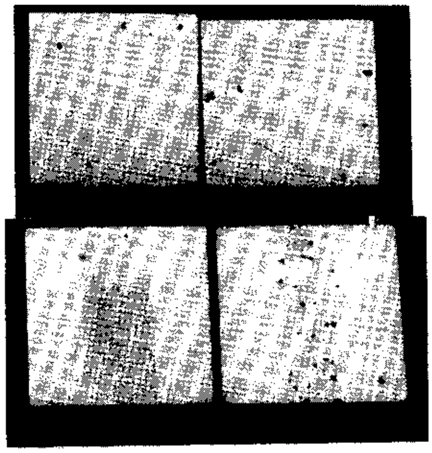
Table 12 shows the pitting potentials of MIG welded joints in 100 ppm Cl^- solution at 80°C. Pitting potential depends on the torch gas used; pitting resistance is lower with Ar-1%O_2 than with Ar, regardless of the welding material. This is related to the fact, as described before, that non-metallic inclusions in weld metal increase when O_2 is added to the Ar torch gas. Thus, the corrosion resistance of TIG arc welds of R434LN-2 is better than that of MIG arc welds, and TIG welding can be expected to provide good corrosion resistance in hot water environments.

Table 11 Results of Strauß test and immersion test in 10% $FeCl_3 \cdot 6H_2O$ solution at 30°C for 4 h

	Consumable	Strauβ test	Corrosion rate in 10% $FeCl_3 \cdot 6H_2O$ solution ($g/m^2 \cdot h$)
MIG (Ar-1%O_2)	Matching composition consumable	Good	2.66
	Type 316L	Good	4.12
TIG	Matching composition consumable	Good	0.77
	Type 309L	Good	0.80
	Type 316L	Good	1.15

(a) Welded by matching composition consumable

(b) Welded by Y-316 and Y-316 L



10 mm

Photo 5 Appearance of MIG welded joints after immersion in 10% $FeCl_3 \cdot H_2O$ solution at 30°C for 4 h

Table 12 Pitting potential of MIG welds in 100 ppm Cl^- solution at 80°C

Consumable	Torch gas	Vc'_{10} (mV vs. SCE)	Vc'_{100} (mV vs. SCE)
Matching composition consumable	Ar	502	575
		445	522
	Ar-1%O_2	435	500
		466	510
Type 316L	Ar	530	585
		520	590
	Ar-1%O_2	428	490
		490	485

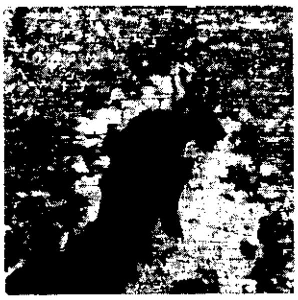
Table 13 shows results of stress corrosion cracking test in boiling 42%$MgCl_2$ aqua solution and in boiling 10%NaCl aqua solution containing 1%$Na_2Cr_2O_7$. Taking the weld zone as a centerline, specimens were U-bent and sealed with silicone resin to leave only the weld metal exposed. Specimens welded with the matching composition consumable exhibited no stress corrosion cracking with either welding process or corrosive solution. Whenever austenitic welding materials were used, however, stress corrosion cracking occurred in the boiling 42%$MgCl_2$ aqua solution. In the immersion test using boiling 10%NaCl aqua solution containing 1%$Na_2Cr_2O_7$, cracks were observed around large pits in the MIG weld metal, as shown in **Photo 6**. No cracking was found with TIG welds, which are less sensitive to stress corrosion cracking. The reason for the lower stress corrosion cracking sensitivity of TIG arc welded joints is considered to be the greater amount of base metal dis-

Table 13 Results of stress corrosion cracking test on welded joints in boiling 42% $MgCl_2$ solution and boiling 10% NaCl solution containing 1% $Na_2Cr_2O_7$ using U-bent Specimen*)

	Consumable	42% $MgCl_2$ boiling solution, for 120 h	(10%NaCl+1%$Na_2Cr_2O_7$) boiling solution for 120 h
MIG (Ar-1%O_2)	Matching composition consumable	No crack	No crack
	Type 316L	Crack	Crack
TIG	Matching composition consumable	No crack	No crack
	Type 309L	Crack	No crack
	Type 316L	Crack	No crack

* Test specimen except weld metal was sealed by silicon resin

(a) Matching composition consumable



(b) Type 316L

Photo 6 Surface observation of U-bent specimen on MIG weld metal after immersion in boiling 10% NaCl solution containing 1% $Na_2Cr_2O_7$ for 120 h

solved into the weld metal than with MIG arc welding.

Thus, austenitic stainless steel welding materials show greater stress corrosion cracking sensitivity than the matching composition consumable. When the corrosive environment changes from severe boiling 42%$MgCl_2$ solution to a more moderate boiling 10%NaCl aqua solution containing 1%$Na_2Cr_2O_7$, stress corrosion cracking sensitivity decreases. This is particularly marked with TIG arc welded joints. Based on this finding, it can be concluded that austenitic stainless steel welding materials will perform well in more moderate environments such as hot water.

4.3 Problems in Welding

Important points to be considered in welding is summarized as follows:

(1) Prevention of carburization of weld metal due to C contamination at the groove face
(2) Prevention of absorption by the weld metal of N and O from the welding atmosphere
(3) Optimization of welding heat input
(4) Prevention of welding defects such as lack of fusion
(5) Application of preheating and postheating in case of severe restraint

If it is impossible to realize (1) and (2), the advantages of improved toughness by extreme reduction of C and N contents are lost. Therefore, necessary measures must include sufficient degreasing of the groove face prior to welding, as well as back-up shielding and after-shielding with Ar, in addition to torch shielding.

5 Conclusions

The chemical composition of weldable structural steel R434LN-2 is characterized by extremely low C and N contents, 20 and 40 ppm respectively, obtained by use of the SS-VOD process developed by Kawasaki Steel, and by the addition of Nb and Al as stabilizing elements. This composition provides extremely excellent toughness. Proper welding conditions ensure high toughness in welded joints, allowing use of steel plate up to approximately 12 mm in thickness in environments above 0°C. Since R434LN-2 has extremely high pitting corrosion resistance and no stress corrosion cracking sensitivity, it is now mainly used in hot water reservoirs. Further, it can be expected that this steel will find increasingly broad application in the future, in view of its outstanding toughness, corrosion resistance, and weldability.

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