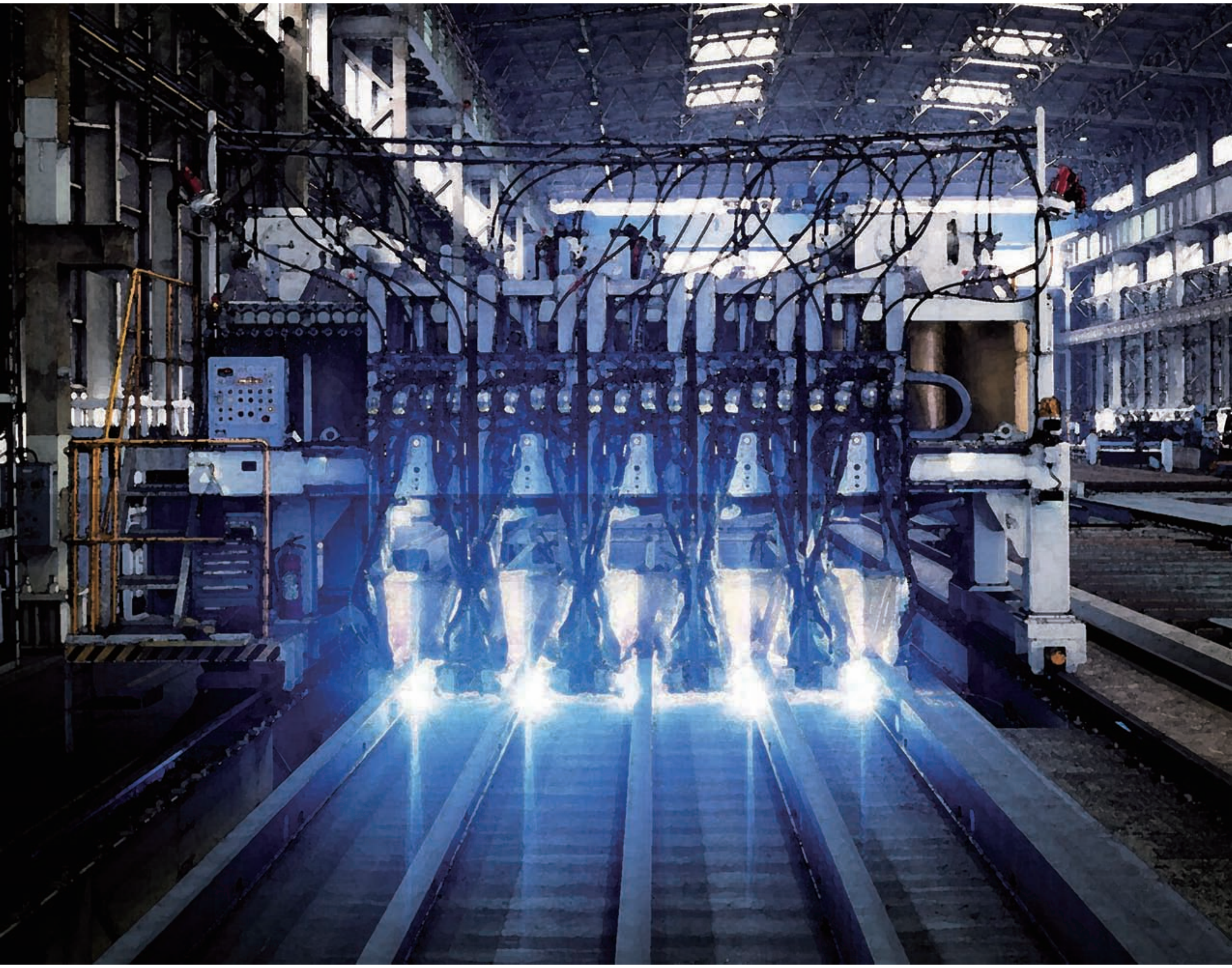
KOBELCO WELDING TODAY

APRIL 2008 VOL.11 [NO.2]



The KOBELCO Arc: Energy that Strengthens the World

FAMILIARC™ DW-100E
FAMILIARC™ MX-200E
Unsurpassed Flux-Cored Wires in E- and EH-Grade Steel Hulls

Grade E mild steel and Grade EH high strength steel are engineered to possess low-temperature notch toughness (27-41 Joules min. at –40°C) for specific applications in ship hulls in accordance with the rules of the ship classification societies (AB, LR, NV, BV, and NK). In the unlikely event that a brittle crack occurs in a ship hull during a rough voyage, the grade-E and grade-EH steel components are expected to arrest the crack, thereby preventing the hull from fracturing. Therefore, these special steels are required to be welded with Grade-3 welding consumables including DW-100E and MX-200E that are introduced here.

DW-100E for positional welding

DW-100E, a rutile type flux-cored wire (FCW), is classified as E71T-9C in accordance with AWS A5.20. In addition, this wire can fulfill the ship class impact toughness requirements: 34 Joules min. at –20°C in vertical-up welding and 47 Joules min. at –20°C in other welding positions. The Charpy impact absorbed energy of the weld metal varies depending on the welding position and the location from which the impact test specimen is taken; nevertheless, any of the impact test results satisfies the ship class requirements for Grade-3 wires in all position welding (Figure 1). DW-100E (1.2 mmØ) can be used in all positions (flat, horizontal, vertical up, vertical down, and overhead) with a welding current in the 200-250A range without the need of readjusting the welding current as the welding position changes.

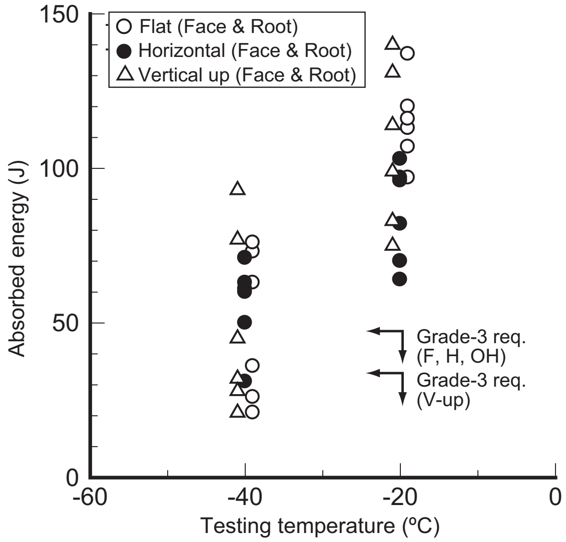


Figure 1: Absorbed energy obtained in Charpy impact testing of weld joints (Wire: DW-100E, 1.2mmØ; Base metal: SM490A, 25mm thick., single-V groove; Welding current: 180-280A; Arc voltage: 24-30V; Shielding gas: 100%CO_2; Welding position: flat, horizontal, vertical up; Backing: FB-B3).

MX-200E for fillet welding

MX-200E, a metal type FCW, is classified as E70T-9C in conformity with AWS A5.20. In addition, this wire can meet the ship class impact toughness requirement for Grade-3 wires: 47 Joules min. at –20°C. Furthermore, MX-200E excels in the resistance to porosity on primer-painted steel plates and produces high-quality fillet weld beads with regular ripples, even fillet legs, and smooth surfaces in flat and horizontal fillet welding as shown in Figure 2.

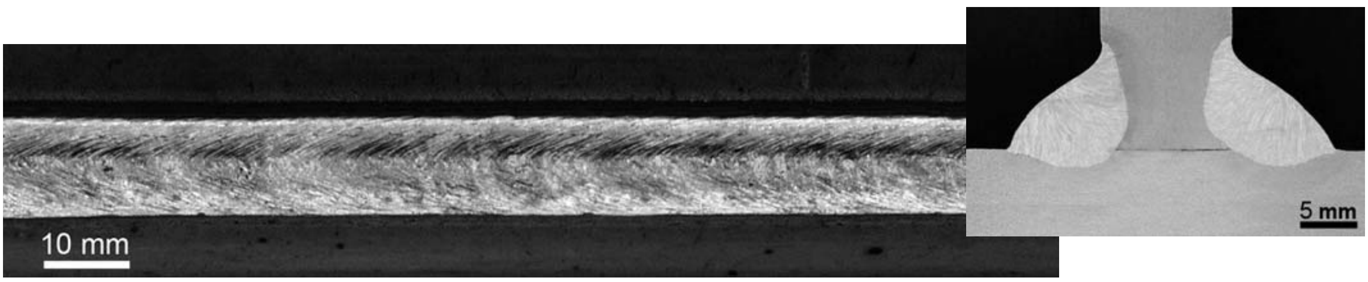


Figure 2: Bead appearance and macrostructure of MX-200E fillet weld made on inorganic-zinc-primer-coated steel fillet joint.

Persistent Challenges in Research and Development

Half a year has elapsed since the year 2008 started. During this period, such events as the sub-prime loan problem that I referred to in the last issue, the skyrocketing prices and tight supply of iron ore, crude oil and other raw materials, and the big fluctuations in currency rates worldwide brought about by the depreciation of the US dollar, have put the industrial world onto a knife-edge.

Though demand for steel products continues to rise in such industries as shipbuilding, machinery construction, and energy exploitation, new management problems are popping up such as price hikes and difficulties in procuring raw materials. Rising prices and tightening supplies of iron ore and metallurgical coal are global, and the limits to high prices can neither be predicted nor countered by ever-continuing efforts of cost reduction. Such being the situation, we are once again reluctantly compelled to revise prices of our products in order to continue stable supply to our precious customers. I really hope that you will understand and extend your cooperation to us.

Besides fulfilling our responsibility of ensuring stable supply, we are engaged in research and development day in day out to live up to the expectation of our customers and to contribute to development of the industrial world by working out solutions to welding tasks to improve the production processes of customers. We have participated in both the Japan International Welding Show in Osaka in April and the Beijing-Essen Welding Fair in China in May, this year. Next year, a quadrennial international trade fair, the Essen Welding Fair, will be held, which will provide the best opportunities for us to exhibit our newest developments in welding processes, machines, and materials. Please do visit our booth in the next big chance to acquaint yourself with our newest technologies and enhance your confidence in KOBELCO and your own business. We look forward to being honored with your continued patronage.

Toshiyuki Okuzumi
General Manager
International Operations Dept.
Welding Company
Kobe Steel, Ltd.

CONTENTS

Shipbuilding Increasingly Demands High-Efficient Welding Processes

Welding innovation driven by the boom in shipbuilding

The global shipbuilding industry has experienced both peaks and troughs in ship orders and completions over the last five decades. The first peak in ship completions (approx. 34 million tons) was seen in about 1975. However, the second oil crisis of 1979 triggered the inflation of oil prices that caused the sagging of the worldwide economy and led to a rapid drop (40% of the peak) in ship completions. Since then, production remained low from 1979 to 1988. After hitting bottom in 1988, the industry has seen ever-increasing demand for container ships, bulkers, and oil tankers, driven by economic globalization and the consequent increase in marine freight, with dramatic completion records of over 52 and 56 million tons in 2006 and 2007, respectively [Ref. 1].

With the high speed growth in ship demands, shipyards worldwide, but particularly in Japan, Korea and China, have enhanced their shipbuilding capacities. In support of this trend, the rationalization of welding processes, which represent approximately 25-28% of all operations [Ref. 2], has been a key factor. The shipyards have improved welding efficiency by employing welding processes that enable quicker work flows, faster travel speeds, and less labor. Figure 1 shows how consumption ratios of welding consumables have changed in a number of welding processes used in Japanese shipyards. This diagram demonstrates that innovation in the welding process has featured “semiautomatic processes,” “mechanized processes,” and “robotic processes,” as substitute for traditional shielded metal arc welding to improve the competitiveness of the shipyards.

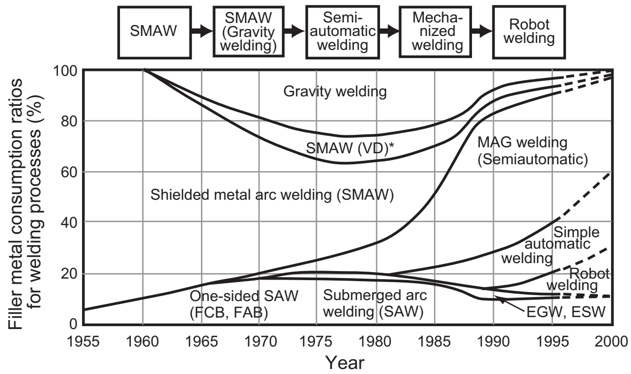


Figure 1: Changes in filler metal consumption ratios for individual welding processes used by the shipyards of Japan (VD: vertical downward position) [Ref. 3].

One-sided SAW: reducing downtime in the panel line

Automated welding for shipbuilding in Japan began with the submerged arc welding (SAW) process in 1950, which has remained vital in long welding joints of thick plates ever since. For instance, one-sided SAW practiced by the leading shipyards in 1963 eliminated the downtime associated with turning over the work for welding the backside after welding the face. To meet the demand for more reliable one-sided SAW, Kobe Steel developed the FCB (Flux Copper Backing) and RF (Resin Flux) processes in 1964.

Figure 2 shows the principles of FCB and RF processes. In FCB welding, an air hose is used to put pressure on a solid copper backing plate so that the reverse side of the joint can maintain contact with the backing flux to form a consistent penetration bead. The RF process also employs an air hose to put pressure on the reverse side of the joint, but it uses a special backing flux (**RF-1**) with thermosetting resin that is supported by the underlaying flux put on the flux bag to form the penetration bead.

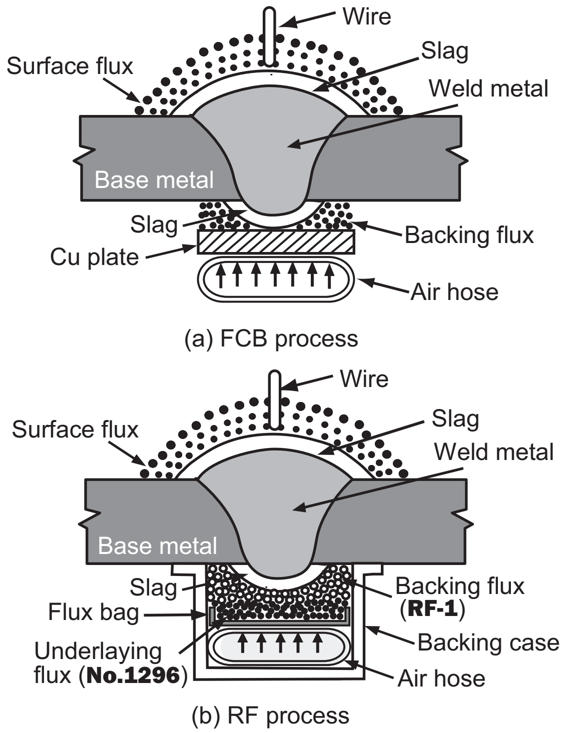


Figure 2: Principles of FCB and RF processes for plate-to-plate one-sided SAW.

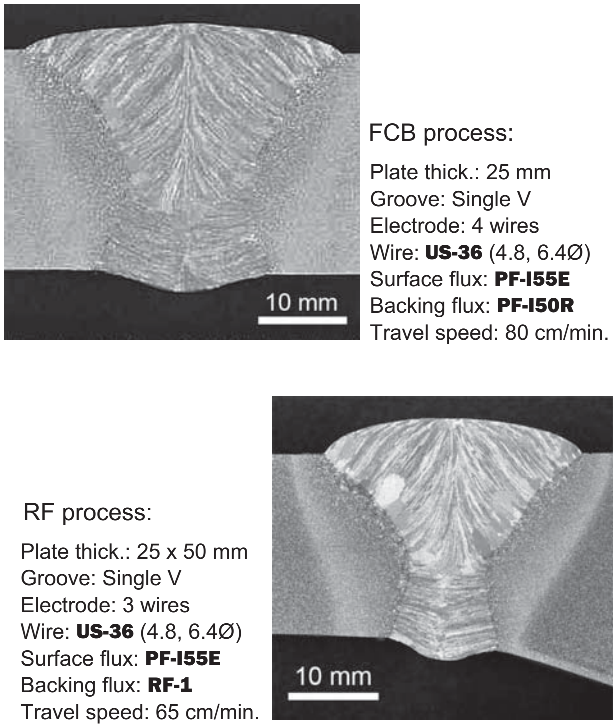


Figure 3: Macrostructures of weld joints made by one-sided SAW (top: FCB process; bottom: RF process)

With these processes, mild steel and 490-MPa high tensile strength steel plates of 10-40 mm thickness can be joined with single-pass melt-through welds on the face side of the joint with dedicated surface and backing fluxes together with one, two, three, or four wire electrodes depending on the plate thickness and desired travel speed. Figure 3 shows typical macrostructures of weld joints made by FCB and RF processes. Specifically, the FCB process is suitable for joining plates of similar thickness with high currents at high speeds, while the RF process is suitable for thinner plates and tapered transition joints and can accommodate larger joint misalignment.

In 1965 a few shipyards applied these processes in the panel line for welding plate-to-plate butt joints. Within ten years FCB and RF processes were employed by more than 40 shipyards in Japan. Since then these processes have become standard for joining plates in the panel line of shipyards in Japan. Following the first export of a FCB process system to a shipyard in Yugoslavia in 1970, the process has been employed by many shipyards in such countries as Italy, Spain, USA, Korea, and China. Figure 4 shows the FCB and RF processes in operation.

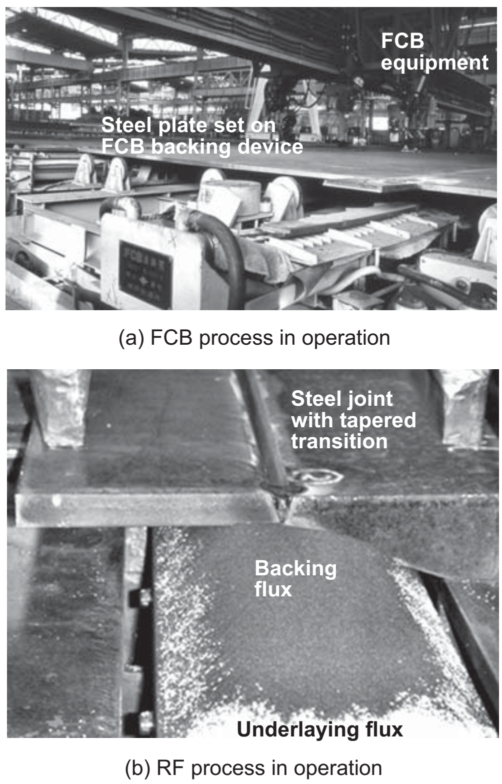


Figure 4: FCB (top) and RF (bottom) processes in operation in shipyards.

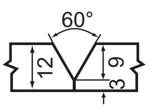
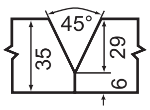
Table 1 is a quick guide to the appropriate welding fluxes and wires for the FCB and RF processes. Table 2 shows typical welding conditions for FCB one-sided SAW, and Table 3 shows the typical chemical and mechanical properties of the FCB weld metal.

Table 1: Appropriate fluxes and wires for FCB and RF processes for mild steel and 490-MPa high tensile strength steel

Process	FCB		RF
Steel type	General	TMCP	General
Surface flux	**PF-I50**	**PF-I55E**	**PF-H55E**
Wire	**US-43**	**US-36**	**US-36**
Backing flux	**PF-I50R** (**MF-1R**)[1]	**PF-I50R** (**MF-1R**)[1]	**RF-1**

1. MF-1R is more suitable for 20 or less thick plates.

Table 2: Typical welding conditions for FCB one-sided SAW with one pass weld (flux/wire: **PF-I55E/US-36**)[1]

Joint configuration	Wire size (mmØ)	Welding current (A)	Arc voltage (V)	Travel speed (cm/min.)
	L: 4.8 T: 4.8	L: 950 T: 780	L: 35 T: 42	67
	L: 4.8 T_1: 4.8 T_2: 4.8	L: 1400 T_1: 1200 T_2: 1250	L: 33 T_1: 40 T_2: 50	40

1. L: leading wire; T: trailing wire; T_1: 1st T; T_2: 2nd T

Table 3: Chemical and mechanical properties of FCW one-sided SAW weld metal (flux/wire: **PF-I55E/US-36**)[1]

C%	0.12	0.11
Si%	0.24	0.31
Mn%	1.10	1.38
P%	0.012	0.012
S%	0.004	0.004
Mo%	0.10	0.13
0.2%OS (MPa)	470	450
TS (MPa)	580	610
El (%)	29	24
vE0°C (J)	146	140
vE-20°C (J)	130	114
Base metal[2]	K32D, 12-mm thick	K40D, 35-mm thick

1. Refer to Table 2 for the welding conditions.
2. High strength steel for hulls—Min. YP: 315MPa for K32D, 390MPa for K40D

FAB one-sided SAW: able to join curved shells and hull unit blocks

The FAB process developed by Kobe Steel uses a portable flexible backing material, called **FA-B1**, which has a unique structure as shown in Figure 5. With this process, one-sided SAW can be applied to curved joints in the assembly stage and block-to-block joints in the erection stage. Because FA-B1 can be attached with close contacts on the backside surface of the work, one-sided melt-through welds of consistent quality can easily be facilitated. FA-B1 can accommodate misaligned joints, dissimilar thicknesses, tapered transition, and distortion; it features light weight and moisture resistance. This process can use a number of SAW flux/wire combinations and filler metal powder (**RR-2**) in addition to FA-B1: **MF-38/US-36** or **PF-I52E/US-36** for mild steel and **MF-38/US-49** or PF-I52E/US-36 for 490-MPa high tensile strength steel. Figure 6 shows the FAB process being used on a curved assembly.

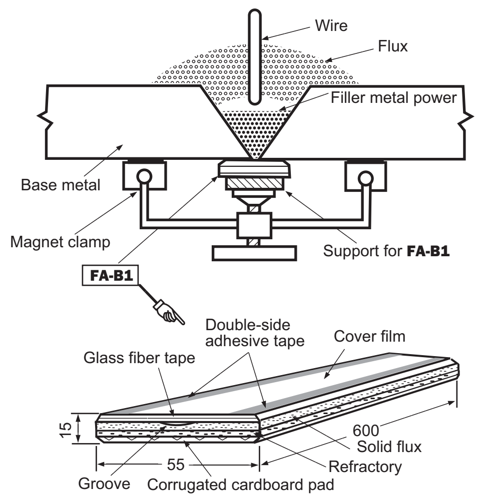


Figure 5: Principles of FAB process with **FA-B1** backing material for one-sided SAW of curved shells and unit blocks.

Figure 6: FAB process being used on a curved work with **FA-B1** attached on the reverse side of the work.

GMAW line welders: innovating fillet welding on the assembly line

After unit panels have been butt-joined by one-sided SAW, they are transferred to the assembly line for the fitting and welding of stiffening members (longitudinals and transverse bulkheads) onto the panel by fillet welding. Panel-to-stiffener fillet welding has become more efficient with automatic gas metal arc welding carried out with portable self-propelled tractors, line welders, and robots. Accounting for 70% or more of total welding in general hull construction in terms of man-hours, fillet welding must be efficient and of high quality for hull productivity to improve. Many leading shipyards now carry out panel-to-stiffener fillet welding with GMAW line welders (an automatic gas metal arc welding system with flux-cored wires), which can weld up to five longitudinals simultaneously onto a panel.

The Twin-Tandem One-Pool (TOP) process is a unique GMAW line welding process developed by Kobe Steel. Figure 7 illustrates the principles of the TOP process, in which two wire electrodes are arranged in tandem to form one weld pool on each side of the tee joint. The TOP process uses the dedicated metal-type flux-cored wire **MX-200H** to obtain a consistent quality finish at high speeds of 130-150 cm/min. in horizontal fillet welding—Figure 8.

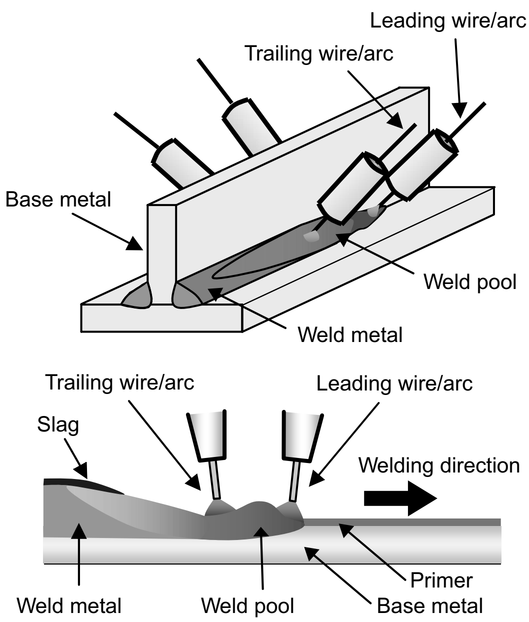


Figure 7: Principles of the Twin-Tandem One-Pool process

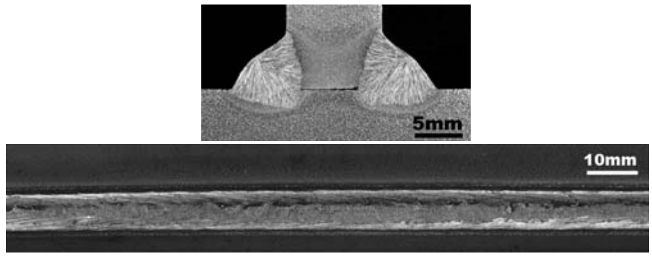


Figure 8: Typical bead appearance and macrostructure of **MX-200H** (1.6 mmØ) fillet weld made by the TOP process on a primer coated steel plate (CO_2 shielding; inorganic zinc primer of approx. 20 µm thick.; travel speed of 150 cm/min.)

Figure 9 shows a multiple-electrode line welder system used on a shipyard assembly line to weld stiffeners onto panels, incorporating the TOP process with MX-200H. This machine with five welding heads with 20 wire electrodes each can weld on both sides of five longitudinal stiffeners simultaneously onto a panel.

Figure 9: Twin tandem welding of five longitudinals onto one panel by using **MX-200H** flux-cored wires.

MX-200H is characterized by less slag to help the release of the sources of porosity (H_2, CO_2, and zinc vapor) from the weld pool and higher molten metal viscosity to suppress the generation and growth of porosity in the weld metal. This sophisticated design enables high speed welding of fillet joints coated with inorganic zinc primer. Table 4 shows the typical chemical and mechanical properties of MX-200H deposited metal.

Table 4: Typical chemical and mechanical properties of **MX-200H** (AWS E70T-1C) deposited metal (CO_2 shielding)

C%	Si%	Mn%	P%	S%
0.06	0.55	1.55	0.015	0.008
0.2% OS (MPa)	TS (MPa)	El (%)	vE–18°C (J)	
500	600	27	90	

EGW systems: improving weld productivity on vertical joints

In the erection stage of shipbuilding, vertical joints of side shells, bulkheads, bulker hoppers, and hatch coamings are typically joined by electrogas arc welding (EGW) with flux-cored wires. Among various EGW processes, the SEGARC process developed by Kobe Steel offers high deposition rates (e.g. 180 g/min. with a current of 380 amp.) and uses lightweight compact-sized equipment (**SEGARC-2Z**). It is suitable for one-pass welding of 9-25 mm thick plates (50 mm max. with oscillation) with a single electrode. As shown in Figure 10, SEGARC is a one-sided welding process that employs one water-cooled copper shoe on the front side and one stationary backing (molded refractory flux or water-cooled copper plate) set on the backside. It progresses with a flux-cored wire of 1.6 mmØ fed into the weld pool from the front side. Figure 11 shows the SEGARC process being operated on a vertical hull joint.

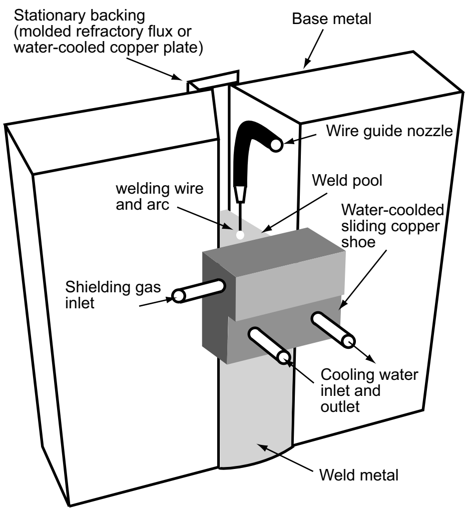


Figure 10: Principles of the SEGARC process for EGW of vertical joints of 9-25 mm in thickness and 2-6 m in length.

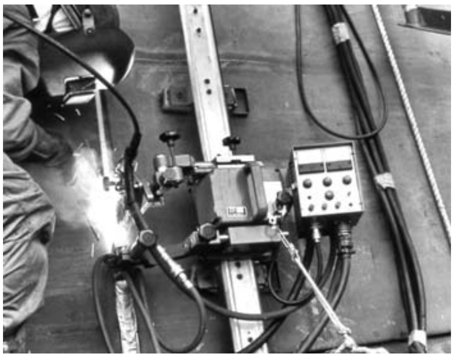
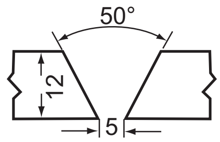
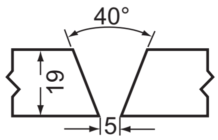
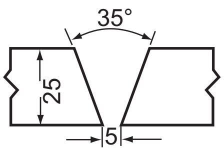


Figure 11: The SEGARC process being used for EGW of a vertical hull joint.

Table 5 shows the typical welding procedures for the SEGARC process with **DW-S43G** (AWS EG70T-2) flux-cored wire for mild steel and 490-MPa high tensile strength steel. The typical chemical and mechanical properties of the weld metal are shown in Table 6. Figure 12 shows the typical macrostructure of an EGW weld joint.

Table 5: Welding procedures for SEGARC process with **DW-S43G** flux-cored wire (1.6 mmØ)[1]

Plate thickness (mm)	Groove preparation (mm)	Welding current (A)	Arc voltage (V)	Travel speed (cm/min.)
12		350	34	12
19		380	35	8
25		380	37	6

1. Wire extension: 35 mm; Shielding gas: CO_2; Gas flow rate: 30 liter/min.; Backing: water-cooled copper plate or **KL-4**.

Table 6: Typical chemical and mechanical properties of **DW-S43G** weld metal by SEGARC process (CO_2 shielding)

C%	Si%	Mn%	P%	S%	Mo%	Ni%	Ti%
0.08	0.35	1.63	0.014	0.010	0.17	0.02	0.02

0.2% OS (MPa)	TS (MPa)	El (%)	vE–20°C (J)
470	600	27	62

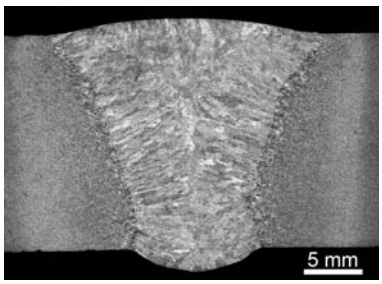


Figure 12: Typical macrostructure of EGW weld joint by SEGARC process

» References «
[1] Shipbuilders' Association of Japan. Shipbuilding Stat, Mar. 2008.
[2] D. W. Miller. Welding Automation in Japanese Shipbuilding. Welding & Metal Fabrication, Mar. 2000.
[3] Takeuchi and Suga. Robot Welding of Large Structures. Seizado.

Did you know why FCWs are used in large quantities in shipbuilding ?

Since the early 1980s, the production of flux-cored wires (FCWs) in Japan has been increasing year by year, reaching over 125,000 metric tons in 2007 [Ref. 1]. This figure accounts for about 35% of the total annual production of all welding consumables in Japan. FCWs are mainly used by shipbuilders; 60% of all welding consumables used in Japanese shipyards are FCWs [Ref. 2].

The high consumption of FCWs in shipyards can be attributed to their superior characteristics: a high deposition rate and excellent usability (low spatter, self-peeling slag removal, and less undercut) in positional semiautomatic, mechanized, and robotic welding of thin and thick wall work. With a higher deposition rate, welding speeds can be increased and thus welding efficiency can be improved; additionally, the consumption of shielding gas can be reduced due to shorter welding times. Figure 1 compares the deposition rates of FCWs (rutile and metal types), solid wires, and covered electrodes.

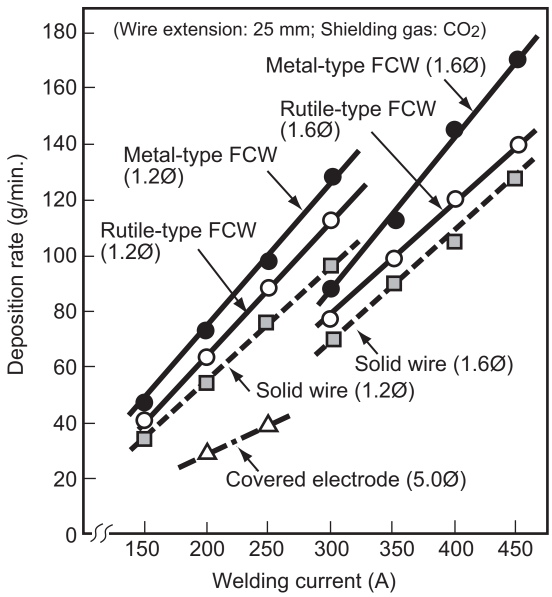


Figure 1: Deposition rates of covered electrodes, solid wires, rutile-type FCWs, and metal-type FCWs as a function of welding currents.

As shown in the figure, the deposition rate of FCWs is approximately 10% higher than that of solid wires and is far higher than that of covered electrodes. The deposition rate of metal-type FCWs is also about 15% higher than that of rutile-type FCWs. It should be noted, though, that deposition rate increases as welding current increases for any welding consumable.

The effect of welding current on deposition rates is vital, particularly for FCWs, because they can use higher welding currents in all-position welding as compared with sold wires and covered electrodes. Most FCWs are designed to use high currents in the globular transfer mode. The globular arc with an FCW generates very low spatter and less undercut with a stable arc due to the effect of the cored flux. The viscous molten slag of all-position-type FCWs keeps the weld pool in suitable shape to produce excellent bead appearance in positional welding. Therefore, as shown in Figure 2, high welding currents can be used in any welding position, thereby facilitating high deposition rates and thus high welding efficiency as such.

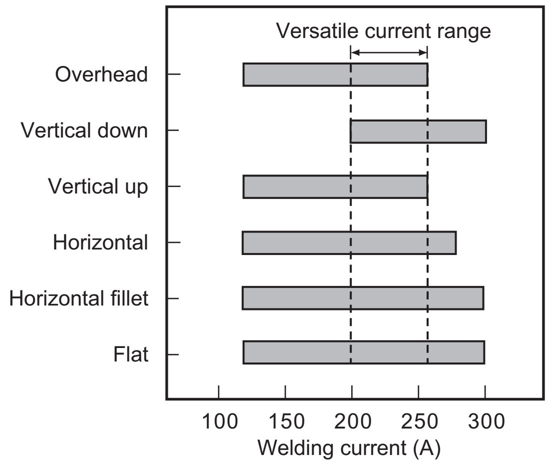


Figure 2: Proper welding current ranges for individual welding positions and versatile current range for positional welding (DW-100, 1.2Ø, CO_2 shielding).

Such superior characteristics of FCWs have met the requirements of shipbuilders for improving welding efficiency by employing semiautomatic, mechanized, and robotic welding processes to compete in the highly competitive shipbuilding industry. This is why the consumption of FCWs has been increased in shipbuilding.

» References «
[1] Welding Technology, April 2008. Sanpo Publications Inc.
[2] Takeuchi, Suga. Robot Welding of Large Structures. Seizando Co.

New Product Designation System

FAMILIARC™

TRUSTARC™

PREMIARC™

Here at the Welding Company of Kobe Steel, Ltd., we would like to thank you for your continuous patronage of our products and services. Now we would like to explain the changes in the brand name and product designation system of our welding consumables, effective from April 2008. However, you may rest assured that, except for applying new trademarks and shifting the hyphens, nothing has been changed in the production process, production equipment, raw materials, or high quality design of our products.

New group brand names and the corresponding products

In the new system, all KOBELCO welding consumables will be referred to by a trademarked brand name with trade designation (i.e. product designation). They will be divided into the following three new groups on the basis of the characteristics of the individual products as described below.

FAMILIARC™ (Famili-Arc)

A word that combines "Familiar" and "Arc." Welding consumables belonging to this group are used for general welded structures made of mild steels and high tensile strength steels that have a tensile strength of less than 590 MPa.

TRUSTARC™ (Trust-Arc)

TRUSTARC combines the words "Trust" and "Arc." Welding consumables in this group are used for such high quality steels as high tensile strength steels with a tensile strength of 590 MPa or higher, low temperature steels, and heat-resistant low-alloy steels.

PREMIARC™ (Premi-Arc)

This term combines the words "Premium" and "Arc." Welding consumables in this group are used for stainless steels, 9%Ni steels, Ni-based alloys, hardfacing, and cast irons.

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Table 1: Examples of old and new brand names

Old brand name	New brand name (Trademark + Trade designation)
B-10	FAMILIARC™ **B-10**
MG-50	FAMILIARC™ **MG-50**
TGS-50	FAMILIARC™ **TG-S50**
MGS-50	FAMILIARC™ **MG-S50**
ZERODE-44	FAMILIARC™ **Z-44**
CMA-106N	TRUSTARC™ **CM-A106N**
DW-308	PREMIARC™ **DW-308**

Each new group's brand name (referred to as a "trademark" hereinafter) is put at the head of all individual trade designations. The trade designations are now going to be made by modifying the former brand names in accordance with the new designation system. In the new system the hyphening position of individual product names is also shifted so that no product name begins with more than two alphabetical letters, unless it is a general noun, for the purpose of being denied the right to trademark protection. Therefore, the new brand names consist of a "trademark" plus a "trade designation" as shown in Table 1 above. We are determined to control all the trade designations so that they can be clearly identified

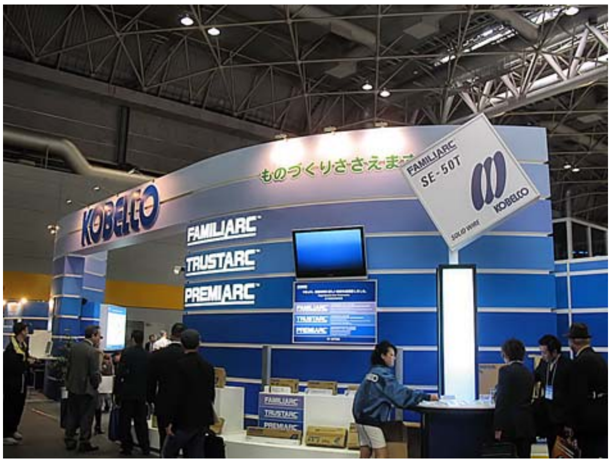
The purpose of changing the product designation system

In recent years, we have found some other companies using our brand names or issuing false certificates that claim to be ours in Japan and some Asian countries.

In order to cope with this problem, we have taken legal actions against verifiable infringers of our brand names and required them to change their product names. However, as long as we continue to use our traditional product designation system it would have been difficult to protect all of our products from imitation. Hence, we have established the new designation system for welding consumables to ensure the integrity of our brand names in the major countries. Our brands will be more clearly identifiable when the particular group brand name or "trademark" is put at the head of an individual "trade designation."

The new designation system is designed not only to prevent the production or import of counterfeit products in Japan and overseas, but also to protect our customers from being deceived by counterfeits in the market.

This modification may require customers and users to modify their relevant purchasing and welding procedure documents. We sincerely hope you will understand the situation and agree with our position. Should you have any questions, please contact the nearest KOBELCO office or sales representative.



KOBELCO welding consumables designated with new brand names were exhibited for customers and users at the Japan International Welding Show 2008 held in April in Osaka.

KOBELCO WELDING TODAY
April 2008 Vol. 11 No. 2

Publisher:
International Operations Dept., Welding Company, Kobe Steel, Ltd.
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