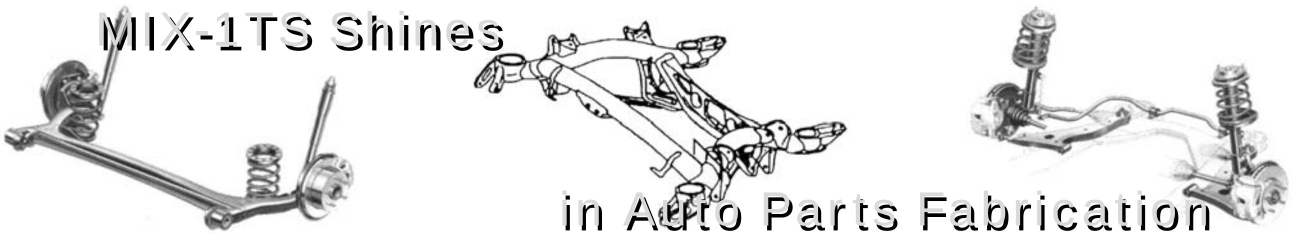
KOBELCO WELDING TODAY

APRIL 2007 VOL.10 [NO.2]

Boost your Quality and Productivity.
Count on KOBELCO Solid and Flux-Cored Wires!

MIX-1TS Shines in Auto Parts Fabrication



MIX-1TS is an innovative solid wire tailored to improve welding workability and to reduce postweld repair work particularly in welding galvanized steel sheets (mild steel and high tensile strength steel) in the auto parts fabrication field. MIX-1TS is classified as AWS A5.18 ER70S-G but has a unique chemical composition to achieve unsurpassed performance in high speed welding of galvanized steel sheets.

(1) EXTREMELY LOW SPATTER results from a stable arc and pulsed current, eliminating the adverse effects of zinc vapor that is generated from galvanized steel sheets during welding (Fig. 1).

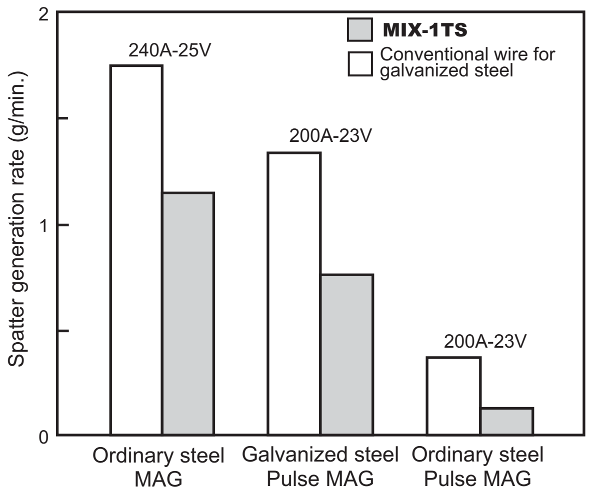


Figure 1: Comparison of spatter generation rates between MIX-1TS (1.2mmØ) and conventional wire for galvanized steel in lap fillet welding in the horizontal position (Wire-feed speed: 6.8m/min.; Plate thickness: 2.6mm; Zinc coating: 45g/m^2; Wire extension: 15mm; Welding speed: 80cm/min.; Shielding gas: 80%Ar-20%CO_2).

(2) HIGH POROSITY RESISTANCE is obtained with the sophisticated chemical composition of the wire and pulsed current, eradicating the adverse effect of zinc vapor (Fig. 2).

(3) HIGH GAP RESISTANCE is the result of the elaborate chemical composition of the wire which provides higher deposition rates at lower welding currents due to the higher electric resistance of the wire, thereby resulting in better gap-bridging ability and higher resistance to burn through (Fig. 3).

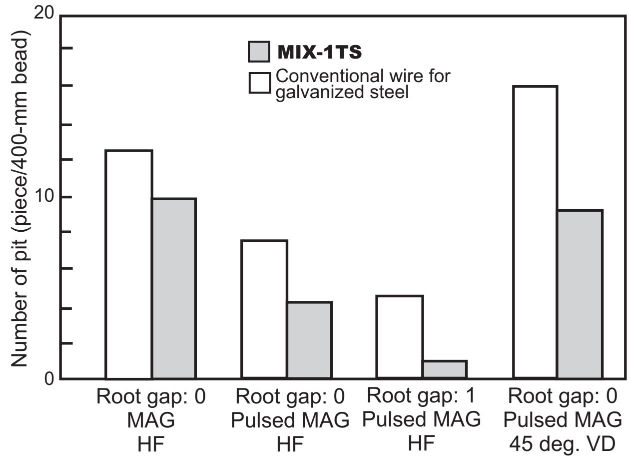


Figure 2: Comparison of MIX-1TS (1.2mmØ) to conventional wire for galvanized steel in terms of weld metal porosity in lap fillet welding in the horizontal and 45-deg vertical down positions (Wire-feed speed: 7.4m/min.; Plate thickness: 2.3mm; Zinc coating: 45g/m^2; Root gap: 0-1mm: Wire extension: 15mm; Welding speed: 100cm/min.; Shielding gas: 80%Ar-20%CO_2).

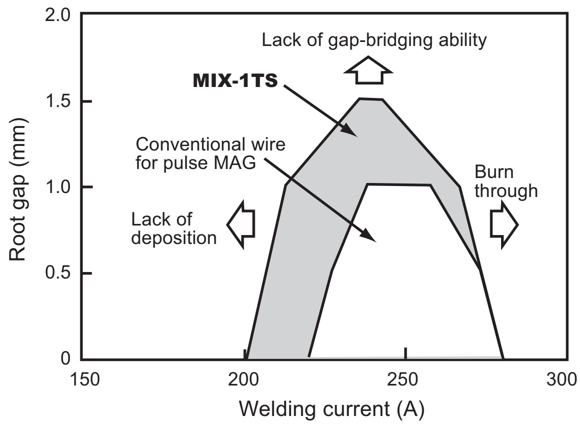


Figure 3: Comparison between MIX-1TS (1.2mmØ) and conventional wire in terms of gap-current parametric envelopes in pulse MAG welding of lap fillet joint in the horizontal position (Steel plate: 2.3-mm ordinary steel; Wire extension: 15mm; Welding speed: 130cm/min.; Shielding gas: 80%Ar-20%CO_2).

In addition, MIX-1TS offers higher hot crack resistance in the welding of corrosion resistant steel that contains higher P and Cu for auto parts applications.

Considerations for the global environment

Masakazu Tojo
General Manager
International Operations Dept.
Welding Company
Kobe Steel, Ltd.

Winter has gone, and spring has come to Japan. Here in Tokyo, it was abnormal that we did not have snow last winter; historically, the phenomenon is unusual; the last time we had no snow was 140 years ago. Many places on our planet have experienced unusual changes in their climates every year recently. I seriously wonder whether the earth is getting sick, or just changing its nature. As scientists link carbon dioxide in the atmosphere with rising temperatures, we should make more effort to prevent the emission of carbon dioxide to improve the global environment.

Several energy sources are being developed as alternatives to oil, coal, and natural gas. Bioenergy is considered to be one of the main sources of an alternative, environment-friendly energy, since the amount of carbon dioxide produced when it is burnt should (at least conceptually) be consumed by the plants grown to replace the biomass fuel. One biomass fuel production process is ethanol fermentation, which produces ethanol, a gasoline substitute. In the construction of the ethanol plants, special types of welding consumables, such as stainless steel flux-cored wires, are indispensable. KOBELCO DW-series stainless FCWs are frequently used in fabrication of ethanol plant tanks. This provides great satisfaction to us from the stand points of business and improving the global environment.

I will continue my business, sharing the viewpoints of our customers, so that I can understand what our customers want to improve and what problems they want to solve. I know that KOBELCO is a customer-oriented company, so you can count on us for improvements and solutions you need to better your welding business.

Boosting our business in the Booming Shipbuilding Industry

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

They say that in Singapore this year a TV drama based on marine engineering is very popular. The subject of the drama is the construction of a large offshore drilling platform. At the climax, the danger of delayed delivery arises because of a change in specifications required by the purchaser. In the end, the danger is overcome by around-the-clock rush work by everybody, and the drama comes to a happy ending. The sponsors of the drama are a group of major Singapore shipbuilding industries and such important maritime organizations as the Association of Singapore Marine Industries, the Maritime and Port Authority of Singapore, and the Singapore Maritime Foundation. It seems that sponsoring the TV drama is an all-out publicity campaign by industries related to marine affairs. Right now, shipbuilders in Singapore are booming due to vigorous demand for offshore structures and their sales continuously increase. At the same time they are suffering from a shortage of manpower. However, they seem to have secured many applicants for job positions thanks to the effect of the drama.

In Japan, too, a TV drama about an integrated steel manufacturer starring a popular personality seems to be making waves across the country now. As in the case of the Singaporean TV drama, I hope that our steel industry will ride the wave of the drama’s popularity and secure good manpower in the employment market. Furthermore, responding to the strong demand for offshore structure construction, we intend to deploy manpower, technical services and product strategies, so that KOBELCO products will be adopted widely. I hope you will support our efforts.

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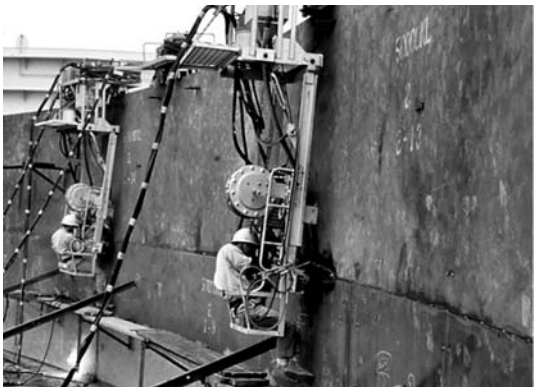


WELDING OF LPG STORAGE TANKS

Part 2: Essential Factors in Controlling Welding Procedures

Following Part 1, How to Select Filler Metals, which appeared in the last issue, Part 2 of this two part series on welding LPG storage tanks discusses the essential factors in controlling welding procedures at the construction site. The welding of LPG storage tanks is typically carried out at site — ideally in good weather but occasionally under such challenging conditions as high winds, rain, sandstorms, high or low temperatures, and high humidity. Also, depending on requirements for weld quality and welding efficiency, a variety of welding processes are used, including shielded metal arc welding (SMAW), submerged arc welding (SAW), gas metal arc welding (GMAW), flux cored arc welding (FCAW), and gas tungsten arc welding (GTAW) — Fig. 1. Hence, more elaborate control of welding procedures is required to ensure the quality of the weld as compared with in-factory welding.

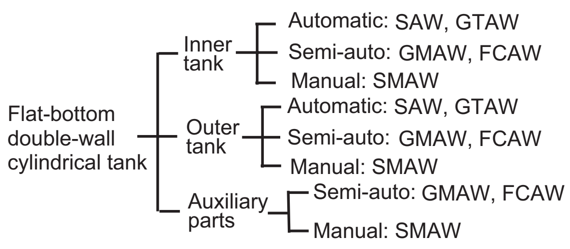


Figure 1: Typical welding processes used for constructing flat-bottom double-wall cylindrical tanks.

Moisture pick up and drying of welding consumables

SAW granular flux as well as the fluxes used in covered electrodes and flux-core wires pick up moisture during storage and usage at a low or high rate depending on ambient temperature and relative humidity. Figure 2 compares the effects of ambient temperature and relative humidity, or the water vapor pressure, on the moisture absorption rate of a moisture-resistant low-hydrogen electrode (such as LB-62UL, LB-62L, LB-80UL, and LB-116) and a conventional low-hydrogen electrode. Clearly, higher ambient temperature and relative humidity results in higher rates of moisture absorption for both types of low hydrogen electrodes, although they do differ in degree.

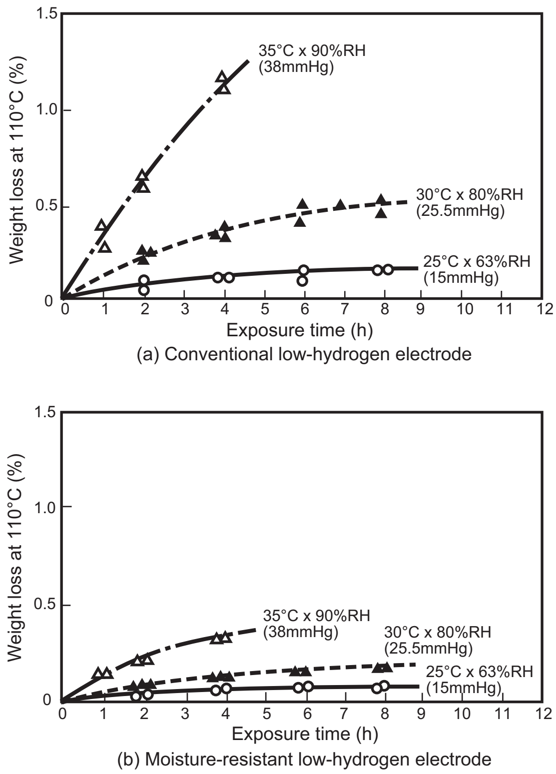


Figure 2: Moisture absorption curves of a moisture-resistant low-hydrogen electrode and a conventional low-hydrogen electrode as related to ambient temperature and relative humidity (The water vapor pressure given in the parentheses was calculated by using the relevant temperature and relative humidity).

The absorbed moisture in an electrode can be a source of diffusible hydrogen in the weld metal. Figure 3 shows how the absorbed moisture increases the diffusible hydrogen in the weld metal as related to the water vapor pressure of the welding atmosphere. For instance, the use of an ultra-low hydrogen electrode with absorbed moisture of 0.2% results in a weld metal containing 1.5 times the amount of diffusible hydrogen of the same electrode but dried immediately before use. In addition, the hydrogen content of the weld metals linearly increases in tandem with the rise in the water vapor pressure of the welding atmosphere for any of the electrodes tested regardless of the moisture content. Because diffusible hydrogen in weld metals can cause cold cracks and porosity, covered electrodes should be dried according to specified temperatures and time periods and, after drying, put in a holding oven before use to prevent moisture pick up.

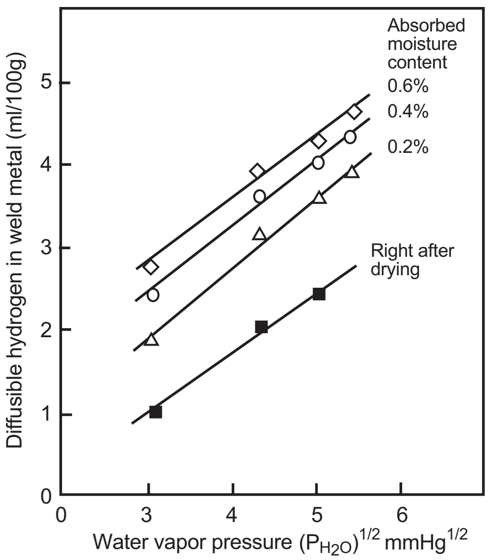


Figure 3: Relationship between absorbed moisture content and diffusible hydrogen in weld metals as a function of water vapor pressure of the welding atmosphere (Testing electrode: an ultra-low hydrogen type).

Fluxes used in SAW include MF-38 and MF-33H, which are fused fluxes, and PF-100H and PFH-80AK, which are bonded fluxes. Typical fused fluxes are made up of glassy particles, so they absorb little moisture, but moisture can be deposited on the particles. In contrast to fused fluxes, bonded fluxes absorb moisture because they contain water glass (the main moisture absorbing substance) for binding the flux particles. Figure 4 shows an example of a moisture absorption curve for PF-100H.

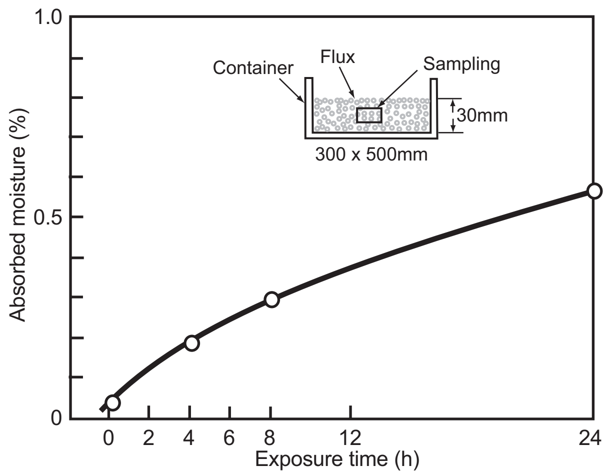


Figure 5: A moisture absorption curve for PF-100H bonded flux tested in the atmospheric condition of 30°C x 80%RH.

As the moisture content increases in SAW fluxes, either fused flux or bonded type, the diffusible hydrogen in the weld metal increases as in the case of covered electrodes, causing poor bead appearance, porosity, and cold cracks in the weld metal. To overcome this problem, SAW fluxes, should be dried and kept in a holding oven before use. Table 1 shows the proper drying and holding procedures for covered electrodes and SAW fluxes. Note the maximum total hours for drying and holding in order to prevent deterioration of the electrodes and fluxes from excessive exposure to heat. The maximum number of times electrodes and fluxes can be dried is similarly listed to prevent damage.

The cored flux in flux-cored wires can also pick up moisture, though at a lower rate since the flux does not contain water glass — unlike SAW bonded fluxes or electrode coverings. The absorbed moisture in flux-cored wires can cause pits, worm-tracking porosity, and cold cracks in the weld metal; however, moisture in flux-cored wires cannot be removed through drying as heat can damage the wire. To avoid moisture absorption, once a spool of flux-cored wire has been unpacked, all of the wire should be consumed in one day. To avoid the hazards of moisture, dust and dew, any remaining wire should be kept in a plastic bag, placed in its original cardboard box and stored in a low humidity room.

The solid wires used in GMAW and GTAW do not absorb moisture, but moisture can form on the wire surface and cause rust. Solid wire that has been affected by moisture cannot be dried by heating

Table 1: Recommended drying and holding procedures for covered electrodes and SAW fluxes

Product name	LB-52NS NB-1SJ LB-62L	LB-62UL	LB-116	LB-80UL	MF-38 MF-33H	PF-100H	PFH-80AK
Type of welding consumable	Low hydrogen	Low hydrogen	Low hydrogen	Low hydrogen	Fused flux	Bonded flux	Bonded flux
Max. allowable moisture content (%)(1)	0.4	0.4	0.3	0.3	0.05	0.5	0.5
Drying temperature (°C)	350-400	350-430	350-400	350-430	150-350	200-300	250-300
Optimum drying time (h)	1	1	1	1	1	1	1
Max. total drying time (h)	12	12	12	12	24	24	24
Max. number of drying times	3	3	2	2	5	5	5
Holding temperature (°C)	100-150	100-150	100-150	100-150	100-150	100-150	100-150
Max. total holding time (h)	72	72	24	24	72	72	72
Drying cycle time (h)(2)	4	4	2	2	8	8	8

1. Drying is needed when the moisture content exceeds the value (the weight loss of the covering and flux at 110°C) specified for each electrode and flux to limit the diffusible hydrogen in the weld metal and to recover the original welding usability.
2. Drying is needed after every specified number of hours to limit the moisture in electrodes and fluxes, provided the ambient temperature and relative humidity are 30°C x 80%RH.

because the heat can damage the wire. Excessive rust can cause irregular wire feeding and porosity in the weld metal. Therefore, any remaining wire should be handled in the same way as flux-cored wires.

Preheating and postheating

Welding joints often require preheating, which results in slowing the postweld cooling rate and decreasing the hardness of the weld, thereby preventing cold cracks. The necessity and exact temperature of preheat may depend on many factors, such as:
(1) Steel grade and chemical composition
(2) Plate thickness
(3) Welding heat input
(4) Ambient temperature
(5) Degree of joint restraint
(6) Characteristics of welding consumables
(7) Welding process

The exact preheat temperature can only be determined by taking into account the factors surrounding the actual job as well as the regulations that apply to the LPG tank under construction. For instance, in Japan, LPG installations must follow the Guidance to Installation of Spherical Gas Holders of The Japan Gas Association and the Standards for Usage of High Tensile Strength Steels of The High Pressure Gas Safety Institute of Japan [Ref. 1].

Figure 5 shows results of the y-groove weld cracking test (as per JIS Z 3158) for LB-80UL and LB-116. The results are plotted along the coordinates of the crack sensitivity parameter (Pc) and preheat temperature. The Pc consists of the chemical composition of the base metal, plate thickness (t), and diffusible hydrogen in the weld metals (H). The trend lines of critical preheat temperature in the figure reveal that the higher the Pc, the higher the critical preheat temperature; in addition, the critical preheat temperature of LB-80UL is shown to be lower than that of LB-116.

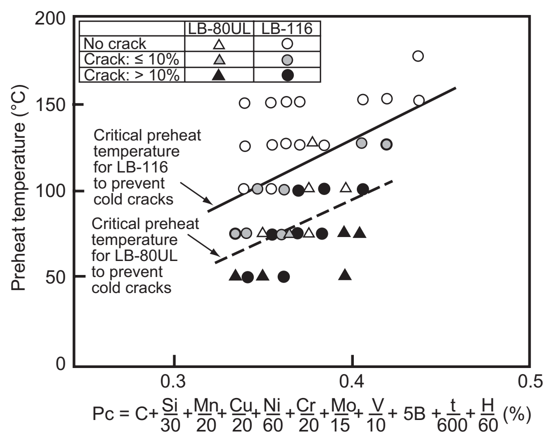


Figure 5: y-groove weld cracking test results of LB-80UL and LB-116 in terms of the root crack sensitivity of the welds.

Figure 5 also suggests that preheat temperature must be determined taking the chemical composition of the base metal, plate thickness, the diffusible hydrogen content of the weld metal into consideration.

As a rule of thumb, Table 2 shows Kobe Steel's recommendations for preheat and interpass temperatures for individual welding consumables, although exact temperatures should be determined by taking into account the various factors discussed above. Interpass temperature must be equal to or higher than the minimum preheat temperature but lower than the specified maximum temperature. With excessively high interpass temperatures, the tensile strength and impact strength of the weld metal can be reduced due to coarse crystal grains caused by excessively slow cooling rates.

Table 2: Recommended preheat and interpass temperatures for individual welding consumables

Welding process	Product name	Min. preheat temp. (°C)(1)	Min. and max. interpass temp. (°C)(2)
SMAW	LB-52NS, NB-1SJ LB-62L	50-100	50-150
	LB-62UL	25-75	25-150
	LB-80UL	75-150	75-200
	LB-116	120-180	120-200
SAW	MF-38/US-36 MF-38/US-49A MF-38/US-40 MF-33H/US-49A PF-100H/US-36LT	50-100	50-150
	PFH-80AK/US-80BN	75-150	75-200
FCAW	DW-55LSR DWA-55LSR	50-100	50-150
	DW-60	50-150	50-150
GMAW	MGS-50LT MGS-63B	25-75	25-150
	MG-60	50-100	50-150
	MG-80 MGS-80	75-150	75-200
GTAW	TGS-1MT TGS-60A	25-75	25-150
	TGS-80AM	75-150	75-200

1. The minimum preheat temperature can vary depending on plate thickness, ambient temperature, and the degree of restraint.
2. The minimum interpass temperature is the same as the minimum preheat temperature and the maximum interpass temperature is to prevent deterioration of the strength and toughness of the weld metal.

Table 3 shows how the minimum preheat and interpass temperature depend on plate thickness and heat input in the use of DW-55LSR for instance. This is because the cooling rate of the weld increases — thus becoming more susceptible to cold cracking — as the plate thickness of the base metal increases; conversely, the cooling rate decreases as the heat input increases.

Table 3: Recommended minimum preheat and interpass temperatures for DW-55LSR to be used in the as-welded condition

Heat input (kJ/mm)	Min. preheat and interpass temperature (°C)(1)		
	t < 25 mm	25 ≤ t < 38 mm	38 ≤ t ≤ 50 mm
Approx. 1.0	Room temp.	75	100
Approx. 1.5	Room temp.	50	100
Approx. 2.3	Room temp.	Room temp.	75

1. When ambient temperature is lower than 5°C, the minimum preheat and interpass temperature should be 40°C regardless of plate thickness and heat input to prevent cold cracks.

If extra-thick high-strength steel construction that is highly restrained is cooled down after welding and left at room temperature for long periods, the remaining diffusible hydrogen in the weld and the residual stresses may cause cold cracks (also known as delayed cracks), even when proper preheat is applied. To avoid these effects, postheat treatment is applied to the weldment to encourage the diffusion of remaining hydrogen from the weld. This benefits of postheat can be increased with higher postheat temperature and longer soaking time — typically, 150-250°C x 20-60min. The exact temperature and time depend on the steel grade and the location of weld seam in a LPG tank. The weld seams that require postheat treatment as per the Guidance to Installation of Spherical Gas Holders are, for instance, the transverse and longitudinal weld seams, nozzle neck, and reinforcement ring of a high-pressure spherical tank [Ref. 1].

Heat input control

With higher heat input, the crystal grains of the heat-affected zone of aluminum-killed steels and high tensile strength steels (typical steel grades for LPG tanks) tend to become coarser, and the matching weld metal exhibits the same tendency. Figure 6 shows the effect of heat input on the impact strength of LB-62UL weld metal. It reveals that the absorbed energy is apt to decrease as the heat input increases. This is why the heat input should be kept lower than the critical value. Table 4 shows Kobe Steel's recommendation in terms of the maximum heat input for the welding consumables for flat-bottom double-wall cylindrical tanks of 490MPa tensile strength steel. Conversely, excessively low heat input increases the hardness of the weld metal and the heat-affected zone of the base metal, thereby causing cold cracks in the weld. Hence, the heat input should be maintained within an appropriate range, taking into account the characteristics of the welding consumable and base metal to be used. Table 5 shows the appropriate ranges of heat input for DW-55LSR.

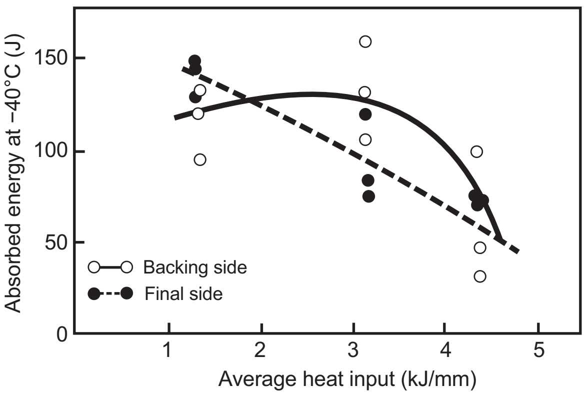


Figure 6: Absorbed energy of LB-62UL weld metal as a function of average heat input in double-sided butt welding.

Table 4: Maximum heat input for welding consumables for flat-bottom double-wall cylindrical tanks of 490-MPa high tensile strength steel

Welding process	Product name	Max. heat input (kJ/mm)
SMAW	NB-1SJ	4.5 (Thick plate) 3.0 (Plate thick.: 15mm max.)
	LB-52NS	4.0 (Thick plate) 2.5 (Plate thick.: 15mm max.)
SAW	PF-100H/US-36LT MF-38/US-36 MF-38/US-49A	3.0
FCAW	DW-55LSR	2.5
GMAW	MGS-50LT	3.0
GTAW	TGS-1MT	(1)

1. In GTAW, wire-feed speed should be controlled instead of heat input: 30g/min. max. (Plate thick.: 25mm min.); 20g/min. max. (Plate thick.: less than 25mm).

Table 5: Ranges of appropriate heat input in relation to welding position and plate thickness for DW-55LSR to be used in the as-welded condition

Welding position	Plate thickness range (mm)	Heat input range (kJ/mm)
Flat and horizontal	20 ≤ t < 70	1.0-2.5
Vertical up	20 ≤ t < 70	1.5-2.5

Countermeasures to high winds

High winds at the construction site can disturb the shielding effects of SMAW, FCAW, GMAW and GTAW, degrading the performance of welding consumables and increasing the nitrogen and hydrogen content of the weld metals. Usability, impact strength, and porosity resistance can all deteriorate as a result. The use of wind shields can protect the arc and weld pool from high wind where wind velocity is 5m/sec. or higher with a low hydrogen electrode, 2m/sec. or higher with a solid wire and a flux-cored wire, and 1m/sec. or higher with a GTAW filler wire.

Examples of welding procedures

Typical welding procedures for shell-to-shell horizontal joint and shell-to-annular plate joint of a flat-bottom double-wall cylindrical tank are shown in Tables 6 and 7.

Table 6: Shell-to-shell horizontal SAW procedures with PF-100H/US-36LT (3.2mmØ)

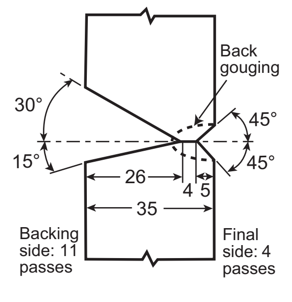
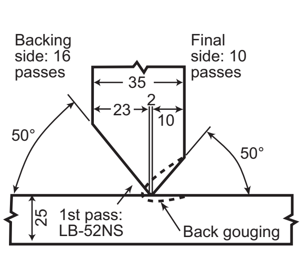
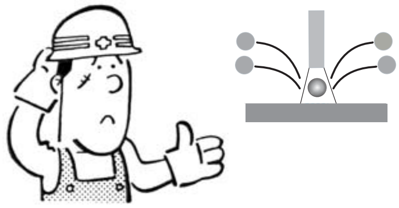
Base metal	SLA 360 (Si-Mn, TS: 490-610MPa)	Groove prep and pass Nos. 
Welding current	400-450A (DCEP)	
Arc voltage	23-26V	
Welding speed	30-60cm/min	
Heat input	1.0-1.9kJ/mm	
Preheat temp.	50-100°C	
Interpass temp.	50-125°C	

Table 7: Shell-to-annular plate horizontal and horizontal fillet SAW procedures with PF-100H/US-36LT (2.4mmØ)

Base metal	SLA 360 (Si-Mn, TS: 490-610MPa) SLA 325 (Si-Mn, TS: 440-560MPa)	Groove prep and pass Nos. 
Welding current	350-420A (DCEP)	
Arc voltage	22-26V	
Welding speed	30-45cm/min	
Heat input	1.1-2.2kJ/mm	
Preheat temp.	100°C	
Interpass temp.	100-150°C	

» Reference «
[1] Welding of LPG/LNG tanks, Kobe Steel Ltd., 1990



Welding of Galvanized Steel Sheets

Question:

We weld a variety of galvanized steel sheets by semi-automatic CO_2 welding. However we have a hard time with postweld treatment and repair, because pits occur often and a lot of spatter is generated. Could you please explain how porosity and spatter generate with galvanized steel sheets and recommend a good welding wire to solve these problems?

Answer:

Galvanized steel sheets are widely used in many steel structures like cars, steel towers, bridges and buildings because of their cost-effectiveness due to excellent corrosion resistance and rust prevention. They include hot-dip galvanized steels, 5%Al-alloyed hot-dip galvanized steels, 55%Al-alloyed hot-dip galvanized steels, electrogalvanized steels, and other galvanized steels.

The weldability of these steels is related to the amount of zinc coating (g/m^2). The thicker the zinc coating, the more the porosity (pits and blowholes) and spatter that result in arc welding. Porosity can be understood by noting that the zinc coating decomposes in the arc heat and that the zinc vaporizes at around 900°C to become a gas, causing bubbles in the weld pool and porosity in the weld metal. As to the increase of spatter, The force of the zinc vapor jet against the arc likely causes the metal droplet transfer to become unstable, thereby expelling the metal droplets outside the arc as spatter.

A variety of porosity-resistant low-spatter welding wires for galvanized steel sheets have been developed. These wires have sophisticated chemical compositions that suppress the growth of gas bubbles trapped in the weld pool and stabilize metal droplet transfer.

Cars, electric machinery, office equipment, and vending machines typically adopt electro-galvanized steel sheets with $50g/m^2$ or less of coating and alloyed hot-dip galvanized steel sheets with $40\text{-}100g/m^2$ of coating. For these thin-coated steel sheets, solid wires, such as MG-1Z (for CO_2 gas shielding), MIX-1Z (for Ar-CO_2 mixed gas shielding), and MIX-1TS (for Ar-CO_2 mixed gas shielding and pulsed current) are recommended.

Table 1 shows the applications for and characteristics of the above-mentioned welding wires. If you take into account the shielding gas composition and the power source output characteristics when selecting a wire, you will be able to perform highly efficient welding resulting in high quality welds, less porosity, and low spatter.

Table 1: Solid wires for gas metal arc welding of galvanized steel sheets

Name of Wire	Diameter (mm)	AWS Standard	Application	Characteristics
MG-1Z	1.0, 1.2	A5.18 ER70S-G	Parts for cars, rolling stock, housings, electric machinery	For CO_2 gas shielding. Suitable for sheets with a zinc coating of up to about $60g/m^2$.
MIX-1Z	1.0, 1.2	A5.18 ER70S-G		For Ar+CO_2 mixed gas shielding. Pulsed current brings about less porosity.
MIX-1TS	1.2	A5.18 ER70S-G		For Ar+CO_2 mixed gas shielding with pulsed current. Extremely less porosity and spatter.

Revisions in AWS A5.20 & A5.29

AWS A5.20-2005 (Specification for Carbon Steel Electrodes for Flux Cored Arc Welding) and A5.29-2005 (Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding) have been adopted, superseding A5.20-1995 and A5.29-1998 respectively. The revisions relate to classification designations, chemical compositions and mechanical properties of weld metals. In response to these revisions, the 2006 addenda of the ASME Code has employed the new AWS specifications as SFA-5.20-2005 and SFA-5.29-2005 respectively.

Kobe Steel has revised the classifications of relevant flux-cored wires in accordance with the new AWS specifications as shown in Tables 1 and 2.

Table 1: New and old classifications of carbon steel flux-cored wires (AWS A5.20)

Product name	Old (1995)	New (2005)
DW-100, DW-100V	E71T-1	E71T-1C
DW-100E	E71T-9	E71T-9C
DW-50	E71T-1/-1M	E71T-1C/-1M E71T-9C/-9M
DWA-51B	E71T-5MJ	E71T-5M-J
MX-200, DW-200 MX-100, MX-200H	E70T-1	E70T-1C
DW-55E	E71T-9J	E71T-9C-J
MX-55LF	E70T-9J	E70T-9C-J
DWA-55E	E71T-9MJ	E71T-9M-J
DWA-55ESR	E71T-12MJ	E71T-12M-J

Table 2: New and old classifications of low-alloy flux-cored wires (AWS A5.29)

Product name	Old (1998)	New (2005)
DW-588	E81T1-W2	E81T1-W2C
DW-55L DW-55LSR	E81T1-K2	E81T1-K2C
DWA-65L	E91T1-K2MJ	E91T1-K2M-J
DWA-81Ni1	E81T1-Ni1MJ	E81T1-Ni1M-J
DW-62L	E91T1-Ni2J	E91T1-Ni2C-J
DW-81B2	E81T1-B2/-B2M	E81T1-B2C/-B2M
DW-91B3	E91T1-B3/-B3M	E91T1-B3C/-B3M

As regards chemical composition, the requirements of maximum carbon content (A5.20) and phosphorous and sulfur content (A5.29) have been changed. As to mechanical properties, tensile strength requirements have become stricter. In accordance with these changes, Kobe Steel has changed the guarantee values related to these requirements as shown in Tables 3 and 4.

Table 3: New and old guarantee values for carbon steel flux-cored wires (AWS A5.20)

Product name	Old (1995)		New (2005)	
	C	TS(1)	C	TS(1)
DW-100, DW-100V DW-100E DW-50, DWA-51B MX-200, DW-200 MX-100, MX-200H DW-55E, MX-55LF DWA-55E	0.18% max.	70 ksi min. (480 MPa min.)	0.12% max.	70-95 ksi min. (480-660 MPa min.)
DWA-55ESR	0.15% max.	70-90 ksi (480-620 MPa)(2)	0.12% max.	70-90 ksi (480-620 MPa)

1. The MPa values are equivalent to the ksi values but are rounded.
2. Not changed.

Table 4: New and old guarantee values for low-alloy flux-cored wires (AWS A5.29)

Product name	Old (1998)		New (2005)	
	P	S	P	S
DW-588, DW-55L DW-55LSR, DWA-65L, DWA-81Ni1 DW-62L, DW-81B2 DW-91B3	0.03%	0.03%	0.030%	0.030%

Based on the new AWS specifications, the classification system is described as follows.

A5.20: E(1)(2)T-(3)(4)-JXHX, e.g. E71T-1M-JDH8
A5.29: E(1)(2)T(3)-(5)(4)-JHX, e.g. E81T1-Ni1M-JH8

where,
E: indicates electrodes.
T: indicates flux-cored electrodes.
(1) thru (5): indicate the performance described in the following tables.

JX and J (Optional): The letter J indicates that the electrode meets the requirements for improved toughness and will deposit weld metal with Charpy V-Notch properties of at least 27J at –40°C (A5.20) or at a test temperature of 10°C lower than the specified temperature (A5.29). The letter D or Q when present in the X position (A5.20) indicates that the weld metal will meet supplemental mechanical property requirements with welding done using low heat input and fast cooling rate procedures, as well as using high heat input and slow cooling rate procedures.
HX (Optional): indicates the maximum level of diffusible hydrogen in the weld metal; i.e. H16 for 16ml/100g, H8 for 8ml/100g, and H4 for 4ml/100g.

(1) All-weld metal tensile strength and impact value(1)

Code(2)	Tensile strength		Impact value ft-lb (J)
	ksi	MPa(3)	
6	60 min.(4)	410 min.	Average: 20 (27) Each: 15 (20) at a specific temperature depending on classification
7	70 min.(4)	480 min.	
8	80-100	550-690	
9	90-110	620-760	
10	100-120	690-830	
11	110-120	760-900	
12	120-140	830-970	

1. PWHT is required depending on classification.
2. A5.20 specifies 6 and 7 only.
3. The MPa values are equivalent to the ksi values but are rounded.
4. Maximum tensile strength is required depending on classification.

(2) Welding position

Code	Designation
0	Flat, Horizontal fillet
1	All positions

(3) Usability(1)

Code	Shielding gas	Polarity	Application
1	CO_2 or Ar+CO_2	DCEP	Single or Multiple pass
2	CO_2 or Ar+CO_2	DCEP	Single pass
3	None	DCEP	Single pass
4	None	DCEP	Single or Multiple pass
5	CO_2 or Ar+CO_2	DCEP or DCEN(2)	Single or Multiple pass
6	None	DCEP	Single or Multiple pass
7	None	DCEN	Single or Multiple pass
8	None	DCEN	Single or Multiple pass
9	CO_2 or Ar+CO_2	DCEP	Single or Multiple pass
10	None	DCEN	Single pass
11	None	DCEN	Single or Multiple pass
12	CO_2 or Ar+CO_2	DCEP	Single or Multiple pass
13	None	DCEN	Single pass
14	None	DCEN	Single pass
G	None, CO_2, Ar+CO_2, or Not specified(2)	DCEP, DCEN, or Not specified(2)	Single pass, Single or Multiple pass(2)

1. A5.29 specifies 1, 4, 5, 6, 7, 8, 11, and G only.
2. Depends on classification.

(4) Shielding gas

Code	Designation
M	75-80%Ar / Bal. CO_2
C	CO_2
None	Self-shielded

(5) Chemical composition of all-weld metal (A5.29)

Code	Type	Code	Type	Code	Type	Code	Type
A1	C-Mo	B3H	Cr-Mo	D1	Mn-Mo	K6	Other low-alloy
B1	Cr-Mo	B6		D2		K7	
B1L		B6L		D3		K8	
B2		B8		K1	Other low-alloy	K9	
B2L		B8L		K2		W2	
B2H		Ni1	Ni	K3		G	
B3		Ni2		K4			
B3L		Ni3		K5			

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