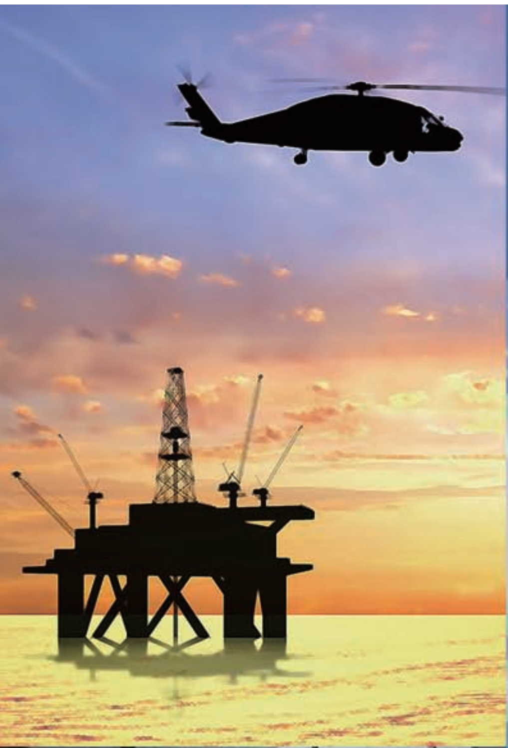
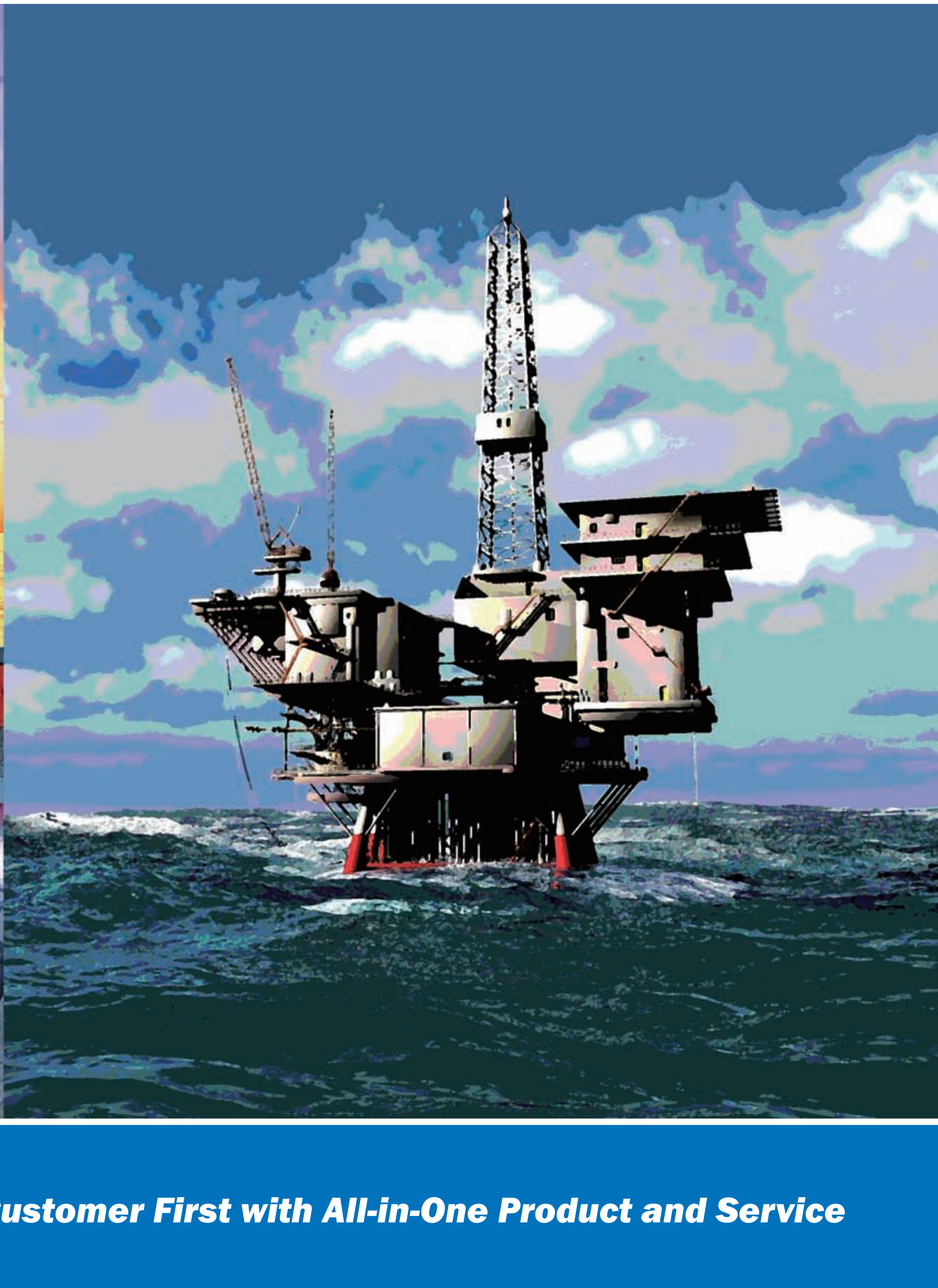
KOBELCO WELDING TODAY

Vol.14 No.2 2011





KOBELCO Puts the Customer First with All-in-One Product and Service

TRUSTARC™ LB-67LJ

(AWS A5.5 E9016-G)

meeting the requirements of 610 MPa high tensile strength steel and low temperature service

With oil explorations increasingly moving into colder and deeper seas, oil rig construction requires higher tensile strength steels to minimize weight and to improve the notch toughness of the welded joints at the low temperatures. Table 1 shows the recommended Kobe Steel's covered electrodes for 550 MPa or higher tensile strength steels and low temperature service with DC application. Table 2 shows an example of the recent requirements for offshore oil drilling rigs.

Table 1: **TRUSTARC™** covered electrodes for high tensile strength steels and low temperature service with DC

YS (MPa)	TS (MPa)	IV (J)	Service temperature (°C) *1 −20	−40	−60
≥420	≥550	≥42	**LB-62UL** (AC/DCEP) [AW/SR]	**LB-62L** (AC/DCEP) [AW/SR]	
≥500	≥610	≥50	**LB-62** (AC/DCEP) [AW/SR] **LB-62U** (AC/DCEP) [AW/SR]	**LB-67LJ** (DCEP) [AW] **LB-67L** (DCEP) [AW/SR]	
≥550	≥670	≥55	**LB-106** (AC/DCEP) [AW]	**LB-70L** (DCEP) [AW]	—
≥690	≥770	≥69	**LB-116** (AC/DCEP) [AW]	**LB-80L** (DCEP) [AW]	

*1: (AC/DCEP) indicate applicable current and polarity. [AW/SR] indicate postweld conditions: [AW] for as-welded; [SR] for PWHT.

Table 2: Recent requirements for offshore structures

Yield strength	Tensile strength	Impact value	CTOD *1
≥500 MPa	≥610 MPa	≥50 J at −60°C	≥0.10 mm at −40°C

*1: Crack-Tip Opening Displacement.

The **TRUSTARC™** LB-67LJ covered electrode, classified as AWS A5.5 E9016-G, meets all of the requirements shown in Table 2. It features low oxygen and no molybdenum content in the deposited metal. Table 3 shows the typical chemistries and diffusible hydrogen content of the deposited metal, which can guarantee the H4 hydrogen level as per the AWS standard.

Table 3: Typical chemistries and diffusible hydrogen content of **TRUSTARC™** LB67LJ deposited metal

Chemical composition (%)								
C	Si	Mn	P	S	Ni	Ti	B	O
0.07	0.39	1.10	0.005	0.002	2.60	0.02	0.002	0.016
Diffusible hydrogen content (ml/100g)								
2.3	2.0	1.6	2.1	(Av. 2.0)				

A test of welding butt joints was carried out using 610 MPa class steel with a thickness of 60 mm and with a double-V groove (50° each) in the 1G, 2G and 3G welding positions. The welding conditions are shown in Table 4; the cross sectional macrostructures of 1G, 2G and 3G weld joints, in Figure 1; the results of tensile, impact and CTOD tests, in Table 5.

Table 4: Butt joint test welding conditions

Welding position	Welding current (A)	Arc voltage (V)	Welding speed (mm/sec)	Heat input (kJ/mm)	Cooling rate (°C/sec)
1G	160	24-25	1.5-1.9	Av. 2.0	21.1
2G	150	24-25	2.6-3.5	Av. 1.5	28.2
3G	140	24-25	0.7-0.9	Av. 4.0	10.6

Note (1) Electrode size and polarity: 4.0mmØ and DCEP.
(2) Preheating and interpass temperature: 90-110°C.
(3) Cooling rate, calculated by Rosenthal's equation at 540°C.

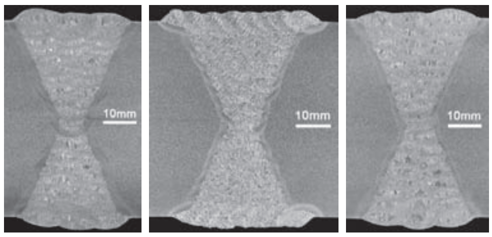


Figure 1: Macrostructures of **TRUSTARC™** LB-67LJ weld joints (1G, 2G and 3G positions from the left)

Table 5: Mechanical properties of **TRUSTARC™** LB-67LJ weld joints in 1G, 2G and 3G positions

Welding position	Specimen location	YS (MPa)	TS (MPa)	El (%)	IV at -60°C Av. (J)	CTOD at −40°C (mm)
1G	Final side	550	650	28	152	0.98, 0.50 [δu]
	Center	637	703	24	131	
	Back side	578	669	27	146	
2G	Final side	640	708	25	186	0.74, 0.98 [δm]
	Center	719	767	21	131	
	Back side	627	687	22	189	
3G	Final side	573	696	26	149	0.78, 0.27 [δu]
	Center	617	700	19	158	
	Back side	576	668	23	141	

In the window-restrained cracking tests with 60-mm thick plate, no cold cracking occurred when using a 50°C preheating and interpass temperature. These laboratory test results suggest the following to prevent cold cracking in on-site welding: preheating and interpass temperatures of a minimum 50°C for plates up to 50 mm thick, and minimum 75°C for plates more than 50 mm thick; plus immediate post weld heating of 150-200°C × 1 hr.

Direct communication with customers requires finding out real needs

My heartfelt greetings to KWT readers! I am Fusaki Koshiishi, General Manager of the Technical Development Department (TDD). I would like to express my warmest gratitude for your continuous patronage of Kobelco's welding products.

Before I was assigned to the TDD seven years ago, I used to work in the former International Operations Department (IOD) (currently International Sales and Marketing Section) and had many chances to visit various countries on business. What I learned from these trips is the importance of understanding each country's culture and communicating directly with customers in order to grasp their true needs; after all, needs vary in different country and even among individual customers.

I am quite confident that the strength of Kobelco products lies in the stability of their quality. It is obvious that stable product quality originates in the product design and production technology; however, more fundamental, I believe, is a quality-oriented spirit among the fellow workers, for they are the ultimate source of reliable products for our customers.

In the last year in the Welding Business, just as the domestic marketing department and the overseas marketing department were unified into one Marketing Department in order to better facilitate the global business, the two research and development (R & D) departments, one for welding consumables and another for welding equipment and robotic systems have been united into one TDD in order to efficiently provide the customers with a total welding solution of products, processes and services.

It is my opinion that welding is the key technology that supports a wide variety of industries such as energy, shipbuilding, and construction. We would like to contribute to all industries in the world by continuing to improve welding efficiency, weld quality, workplace safety and the environment.

Lastly, my pleasure during an overseas trip comes from trying the unique and special foods and drinks in each country and chatting with as many people as possible. I am looking forward to seeing you in somewhere and listening to your opinions and desires — of course while drinking and eating together!

Thank you again and wishing all of you good health and prosperity.

Fusaki Koshiishi
General Manager
Technical Development Department
Welding Business
Kobe Steel, Ltd.

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KOBELCO WELDING TODAY
is published by
Marketing Department
Welding Business, Kobe Steel, Ltd.
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Kobelco's Welding Consumables for LNG Storage Tanks Made of 9% Ni Steel

LNG is Liquefied Natural Gas, in which the main ingredient, methane, is liquefied at the extremely low temperature of minus 161.5 °C. Liquefied natural gas takes up 1/600th the volume of natural gas in a gaseous state, making possible the mass transportation and storage by LNG ships and tanks. Additionally, as natural gas emits 20-40 % less CO_2 than other fossil fuels such as petroleum and coal, it is widely considered a form of clean energy. As a result, LNG consumption is forecast to steadily increase as seen in Figure 1, which shows the recent growth of worldwide LNG imports.

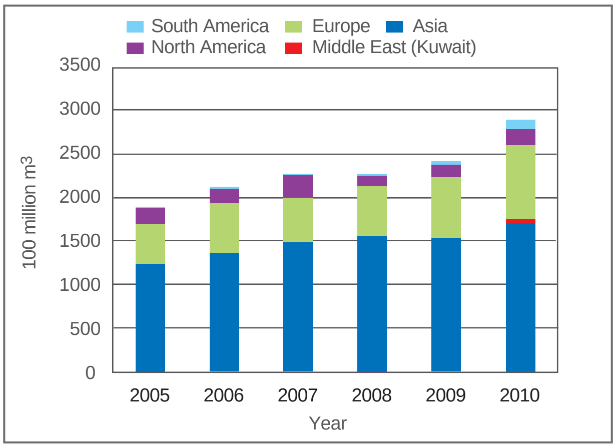

Figure 1: Worldwide LNG imports [1]

9%Ni steel is commonly used for aboveground LNG tanks

There are two types of LNG tanks, one for ocean-going LNG ships and the other for onshore storage. As for LNG storage tanks, they can be built either above or below ground. Aboveground tanks usually take the form of a dual shell structure that is cylindrical in shape with a flat bottom, while underground tanks are of the membrane type. Because the inner tank is directly exposed to LNG at minus 161.5 °C, it must have a high level of notch toughness. The inner tanks of aboveground storage tanks are therefore commonly made of 9% Ni steel or aluminum alloy, while those of underground tanks are made of 304 and/or 304L austenitic stainless steels. The choice of material depends on the boiling point of the relevant gas (Refer to Figure 2) because the liquefaction of the gas requires such a particular low temperature.

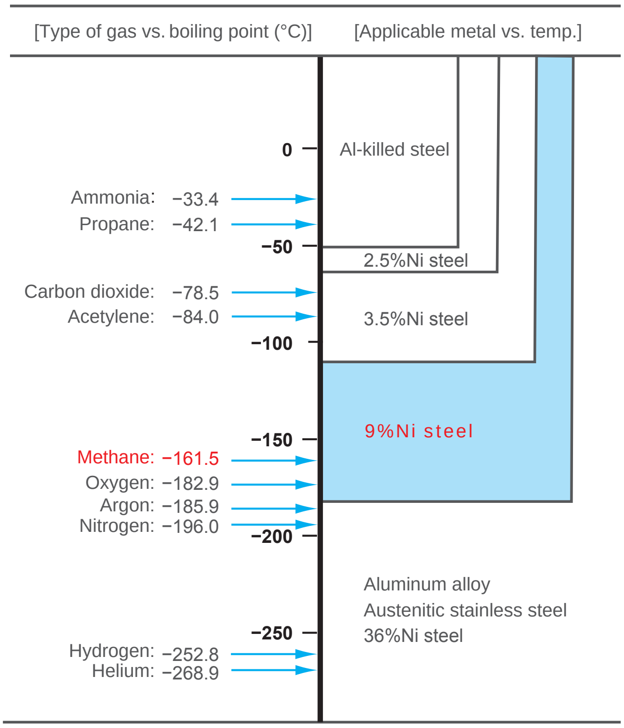

Figure 2: The boiling points of various liquefied gases and applicable metals for storage tanks.

The rest of this article will introduce aboveground LNG tanks with inner tanks made of 9% Ni steel and discuss related welding consumables and procedures.

Figure 3 shows an aboveground, flat-bottomed, cylindrical LNG storage tank known as a PCLNG. This structure, widely adopted in overseas countries, has a surrounding wall made of pre-stressed concrete (PC), an outer shell and roof made of low temperature service carbon steel, an inner shell made of 9% Ni steel, and an inner aluminum deck that is suspended from the carbon steel dome roof on the 9% Ni cylindrical shell.

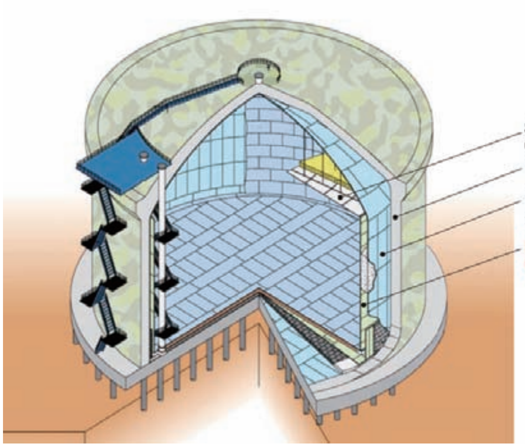

Figure 3: A cross sectional view of PCLNG storage tank [2].

Regulations and standards for LNG tanks

A wide range of regulations and standards define the design, construction, inspection and maintenance of LNG tanks made of 9% Ni steel. Some of the relevant ASME, API, BS EN, and JIS standards are provided below.

(1) ASME Sec. VIII, Div. 1: Design and fabrication of pressure vessels; Div. 2: Alternative rules.

(2) API Standard 620: Design and construction of large, welded, low-pressure storage tanks; Appendix Q: Low-pressure storage tanks for liquefied hydrocarbon gases at temperature not lower than −270°F (−168°C).

(3) BS EN 14620-1(2006): Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0°C and −165°C, Part 1: General.

(4) JIS B8265(2010): Construction of pressure vessel — General principles; JIS B8267(2008): Construction of pressure vessel.

The most commonly applied regulations and standards worldwide are ASME Sec. VIII and API 620. Table 1 provides a comparison of allowable stresses on aboveground LNG tanks made of 9% Ni steel. Depending on what standard is applied, the allowable stress varies and thus the plate thickness of the shell differs accordingly. As seen in Table 1, ASME and JIS calculate the allowable stress by the strength of the welded butt joint, whereas API uses the strength of the weld metal.

Table 1: Allowable stresses of aboveground LNG tanks made of 9% Ni steel

Code or standard		Formula to calculate allowable stress	Standard strength (MPa)	Allowable stress (MPa)
API 620 Appendix Q		Smaller value between 1/3 σBM^{*1} and 2/3 σYM^{*2}	$\sigma BM^{*1} \geq 660$ $\sigma YM^{*2} \geq 360$	220
ASME Sec. VIII	Div. 1	1/3.5 σB^{*3}	$\sigma B^{*3} \geq 660$	190
	Div. 2	1/2.4 σB^{*3}	$\sigma B^{*3} \geq 660$	280
JIS	B 8265	1/4 σB^{*3}	$\sigma B^{*3} \geq 660$	160
	B 8267	1/3.5 σB^{*3}		190

*1: Tensile strength of weld metal.
*2: Proof strength of weld metal.
*3: Tensile strength of welded butt joint.

When calculating the allowable stress of 9% Ni steel as per API 620 Appendix Q, the lower value of the strength between the plate (e.g. quenched-and-tempered ASTM A553 Type I: $\sigma B \geq 690$ MPa; $\sigma Y \geq 585$ MPa) and the weld metal (e.g. JIS Z 3225 D9Ni-1: $\sigma B \geq 660$ MPa; $\sigma Y \geq 360$ MPa), namely the strength of the weld metal, is adopted as the standard strength in general. In addition, The Appendix Q allows to use the tensile strength of 690 MPa and the proof strength of 400 MPa as the maximum permitted values for determining the allowable stress, though they must be tested and proven. Thus, API allows adopting the higher strength design, which makes the reduction of plate thickness possible.

In 1960, a destructive test involving a large-sized pressure vessel made of 9% Ni steel was carried out in the USA that proved that 9% Ni steel could be used safely without postweld heat treatment for stress relief. Since then, large capacity tanks made of 9% Ni steel have been constructed widely.

Over time, as tank capacities have been getting larger, the applied plate thickness has also been increasing. While tanks with a capacity of 80,000 kilo liters (kl) would have a 9% Ni steel inner shell with a maximum plate thickness of 30 mm, 140,000 kl tanks require plate that is 40 mm thick. Currently, the design of 200,000 kl tanks is under investigation; these would require plates with thickness of 50 mm, reaching the maximum tank capacity.

Specifications and features of 9% Ni steel

9% Ni steel is ferritic, possessing excellent mechanical properties at the cryogenic temperatures as well as good cutting, bending and welding characteristics. Table 2 shows the ASTM and JIS specifications for 9% Ni steel.

Table 2: ASTM and JIS specifications for 9% Ni steel

Standard	ASTM		JIS G 3127	
	A353	A553 Type I	SL9N 520	SL9N 590
Max. plate thick. (mm)	50	50	50	100
Heat treatment	NNT	QT	NNT	QT
C (%)	≤ 0.13		≤ 0.12	
Si (%)	0.15-0.40		≤ 0.30	
Mn (%)	≤ 0.90		≤ 0.90	
P (%)	≤ 0.035		≤ 0.025	
S (%)	≤ 0.035		≤ 0.025	
Ni (%)	8.50-9.50		8.50-9.50	
0.2%PS (MPa)	≥ 515	≥ 585	≥ 520	≥ 590
TS (MPa)	690-825		690-830	
El (%), *t*: Thick.(mm)	≥ 20.0		≥ 21 ($6 \leq t \leq 16$) *1 ≥ 25 ($t > 16$) *1 ≥ 21 ($t > 20$) *2	
IV (J) at −196°C	≥ 34		≥ 34	≥ 41
LE*3 (mm) at −196°C	≥ 0.38		-	

*1: With a plate-type specimen as per JIS Z 2201 No. 5 (GL: 50 mm).
*2: With a round specimen as per JIS Z 2201 No. 4 (GL: 50 mm).
*3: Lateral expansion.

The steels applied in LNG tank construction are mainly ASTM A353 and A553 Type I, and JIS G3127 SL9N520 and SL9N590. A353 and G3127 SL9N520 are stated as double-normalized and tempered material (NNT), while A553 Type I and G3127 SL9N590, are listed as quenched and tempered material (QT). Compared with NNT, the QT material has the higher 0.2% proof strength as well as higher impact toughness on thicker plate. Because of these factors, QT material is mainly used, particularly for the heavy duty parts such as the shell and the bottom.

There are two important precautions to be considered when handling 9% Ni steel before it is provided for welding.

(1) When the processing strain of 9% Ni steel in the cold working process exceeds 3%, the impact property sharply drops in proportion to the strain rate, and in this case, post heat treatment is recommended as specified in API 620 Appendix Q.

(2) 9% Ni steel has the disadvantage of being easily magnetized. Attention is necessary to prevent it from becoming magnetic during manufacturing, transport and processing such as cutting and bending. During transportation, it is especially advisable to avoid the use of magnetic cranes for lifting and to keep the 9% Ni steel plate away from high voltage power cables.

The residual magnetism in 9% Ni steel will cause magnetic arc blow, making for an unstable arc during welding. Some fabricators prefer to specify their own limit of 50 Gauss or less when accepting 9% Ni steel from plate suppliers. Another solution for magnetic arc blow is to apply AC welding for SMAW, already widely accepted by fabricators.

Specifications and features of welding consumables

The welding consumables that are generally used for welding 9% Ni steel are high Ni alloy such as the Inconel type (Ni-Cr alloy), and the Hastelloy type (Ni-Mo alloy) though their chemical compositions are quite different from those of 9% Ni steel. Although the strength of high Ni alloy is lower than that of 9% Ni steel, it does not cause brittle fractures, even at cryogenic temperatures, because of its full austenitic microstructure.

The first application of 9% Ni steel in Japan occurred in 1966 for a liquefied oxygen tank, on which Inconel type electrodes were used. Since then, with continual improvements in welding automation, crack resistance and strength of weld metal, Hastelloy type welding consumables (Ni-Mo alloy) have increasingly been put into practice. Molybdenum (Mo) in Hastelloy type welding consumables has been found effective in preventing hot cracks.

AWS specifies the welding consumables for 9% Ni steel in A5.11, A5.14 and A5.34 as part of the specifications for nickel and nickel alloy welding consumables. By contrast, JIS sets forth specific regulations for welding consumables to be used with 9% Ni steel in Z 3225, Z 3332 and Z 3333 as shown in Table 3. Only in regards to FCAW does JIS not directly specify the consumables to be used with 9% Ni steel.

Table 3: AWS and JIS specifications for welding consumables related to 9% Ni steel

Process	AWS standard	Specifications for
SMAW	A5.11/A5.11M:2005	nickel and nickel alloy welding electrodes for shielded metal arc welding
FCAW	A5.34/A5.34M:2007	nickel-alloy electrodes for flux cored arc welding
GMAW GTAW SAW	A5.14/A5.14M:2005	nickel and nickel alloy bare welding electrodes and rods
Process	**JIS standard**	**Specifications for**
SMAW	Z 3225:1999	covered electrodes for 9% nickel steel
GTAW	Z 3332:1999	filler rods and solid wires for TIG welding of 9% nickel steel
SAW	Z 3333:1999	submerged arc welding solid wires and fluxes for 9% nickel steel

Covered electrodes for 9% Ni steel

Both AWS and JIS specifications for covered electrodes for welding 9% Ni steel are shown in Table 4, and Kobe Steel's recommended covered electrodes, in Table 5.

Table 4: AWS and JIS specifications for covered electrodes for 9% Ni steel

Classification.	AWS A5.11			JIS Z 3225	
	ENiCrFe-9	ENiCrMo-6	ENiMo-8	D9Ni-1	D9Ni-2
C (%)	≤ 0.15	≤ 0.10	≤ 0.10	≤ 0.15	≤ 0.10
Si (%)	≤ 0.75	≤ 1.0	≤ 0.75	≤ 0.75	≤ 0.75
Mn (%)	1.0-4.5	2.0-4.0	≤ 1.5	1.0-4.0	≤ 3.0
Ni (%)	≥ 55.0	≥ 55.0	≥ 60.0	≥ 55.0	≥ 60.0
Cr (%)	12.0-17.0	12.0-17.0	0.5-3.5	10.0-17.0	-
Mo (%)	2.5-5.5	5.0-9.0	17.0-20.0	≤ 9.0	15.0-22.0
W (%)	≤ 1.5	1.0-2.0	2.0-4.0	-	1.5-5.0
Nb+Ta (%)	0.5-3.0	0.5-2.0	-	0.3-3.0	-
Fe (%)	≤ 12.0	≤ 10.0	≤ 10.0	≤ 15.0	≤ 12.0
0.2%PS (MPa)	-	-	-	≥ 360	
TS (MPa)	≥ 650	≥ 620	≥ 650	≥ 660	
El (%)	≥ 25	≥ 35	≥ 25	≥ 25	
IV (J) at -196°C	-	-	-	Av ≥ 34 Each ≥ 27	

Table 5: **PREMIARC™** covered electrodes for 9% Ni steel and their deposited metal properties

Trade desig.	**NI-C70S**	**NI-C70H**	**NI-C1S**
AWS A5.11	ENiCrFe-9	ENiCrMo-6	ENiMo-8
JIS Z 3225	D9Ni-1	-	D9Ni-2
Feature	Inconel type	Inconel type	Hastelloy type
Polarity	AC	AC	AC
Ship class appro.	NK*1	-	NK*1
C (%)	0.09	0.08	0.03
Si (%)	0.26	0.42	0.49
Mn (%)	2.26	2.85	0.28
Ni (%)	67.6	68.1	68.6
Cr (%)	13.9	12.9	1.9
Mo (%)	3.7	7.1	18.6
W (%)	0.6	1.2	2.9
Nb+Ta (%)	1.7	0.9	-
Fe (%)	9.8	5.5	6.8
0.2%PS (MPa)	430	460	440
TS (MPa)	705	725	730
El (%)	41	42	48
IV (J) at -196°C	62	77	83

*1: NK stands for Nippon Kaiji Kyokai.

PREMIARC™ NI-C70H is a newly-developed covered electrode that shows much higher 0.2% proof strength and tensile strength than other conventional covered electrodes for 9% Ni steel.

Flux-cored wires for 9% Ni steel

A new AWS specification A5.34 was established and made public in 2007 as shown in Table 3. It specifies the chemical compositions and the tension tests in the same manner as A5.11 and A5.14.

The application of flux-cored wires (FCWs) for LNG tanks made of 9% Ni steel had been limited because tight control of welding conditions in a narrow range was required to prevent hot cracks, and the all-position welding was difficult. However, as shown in Table 6, Kobe Steel has developed two types of the FCWs for welding 9% Ni steel that solve these problems, and recently they have been put into operation. **PREMIARC™ DW-N70S** is designed for down-hand welding and a new FCW, **PREMIARC™ DW-N709SP**, for all position welding as shown in Table 6.

Table 6: **PREMIARC™** FCWs for 9% Ni steel and their deposited metal properties

Trade desig.	**DW-N70S**	**DW-N709SP**
AWS A5.34	-	(ENiMo13-T)*1
Feature	Applicable for downhand welding	▪ Hastelloy type for all position welding. ▪ Excellent hot-crack resistance and CTOD values.
Shielding gas	80%Ar-20%CO_2	80%Ar-20%CO_2
C (%)	0.05	0.02
Si (%)	0.20	0.21
Mn (%)	5.91	2.75
Ni (%)	62.6	62.1
Cr (%)	16.8	6.9
Mo (%)	10.2	17.6
W (%)	-	2.4
Nb+Ta (%)	2.0	-
Fe (%)	1.8	7.7
0.2%PS (MPa)	425	450
TS (MPa)	715	710
El (%)	46	46
IV (J) at −196°C	106	90
LE (mm) at −196°C	-	1.40

*1: The classification of ENiMo13-T is not yet published but will be issued by AWS soon.

DW-N709SP is introduced here as A5.34 (ENiMo13-T), because there is not such a classification in A5.34 yet. According to the latest information, the revised A5.34, which will cover ENiMo13-T, will be issued by AWS soon. For more detailed technical information related to **DW-N709SP**, please see "Kobelco Welding Today, Vol. 13 No. 1 2010."

A butt joint welded on 9% Ni steel by **DW-N709SP** yielded satisfactory results in tensile, impact, CTOD, and bend tests as shown in Table 7. The macrograph of the weld joint and the appearance of the bend test specimens are shown in Figure 4. And Figure 5 shows the FISCO crack test result of **DW-N709SP** weld metal. The crack-free zone has become much wider, even at faster welding speeds, when the susceptibility against hot crack becomes quite critical.

Table 7: Welded joint properties of **PREMIARC™ DW-N709SP** in 3G welding position

Properties	Measurements
Tensile strength at room temp.*1	738 MPa (Fractured at weld metal)
Impact toughness at −196°C	88, 91, 89 (Av. 88) (J)
CTOD at −196°C (δM)	0.39, 0.39, 0.38 (Av. 0.38)
Longitudinal bending, 180°	Good

*1: Base metal is ASTM A553 Type I, 28mm thick, double-V groove.

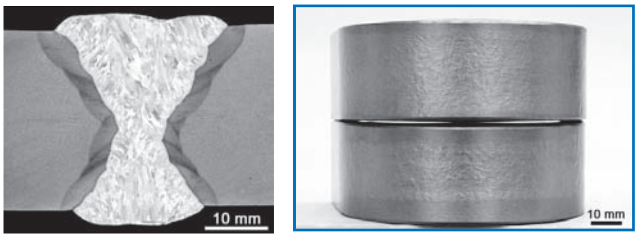

Figure 4: **PREMIARC™ DW-N709SP** exhibits complete fusion in 3G-position butt joint and excellent ductility in bend test.

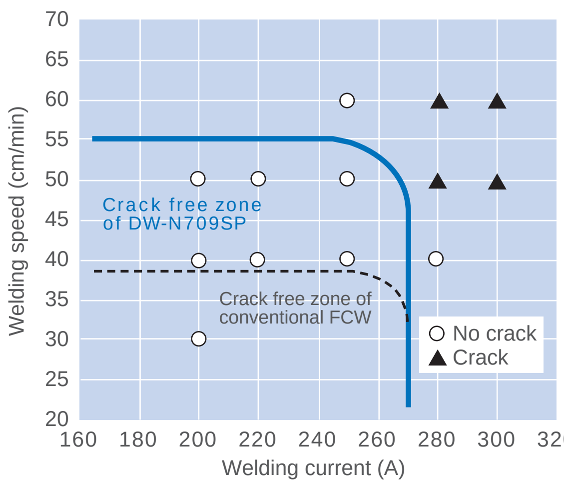

Figure 5: FISCO crack test results of **PREMIARC™ DW-N709SP** weld metal, showing superior hot crack resistance over conventional FCW.

TIG welding wire for 9% Ni steel

Ever since Kobe Steel's MC-TIL process for automatic TIG welding was developed in 1973, it has been applied widely by tank fabricators, particularly in Japan. Overseas, it has been adopted in more than 10 units of LNG tanks made of 9% Ni steel and in about 60 units in the Japanese domestic market.

This efficient automatic TIG welding involves the application of a large welding current and the intentional deflection of arc direction by magnetic force, and it is able to maintain the soundness of weld metal, the principle advantage of GTAW. It is two times more efficient than SMAW and four times more than manual GTAW. Furthermore, the process reduced the defect ratio to almost zero and improved the completion time, total cost and quality of the weld.

AWS and JIS specifications for TIG wires for 9% Ni steel and the properties of the matching filler wire **PREMIARC™ TG-S709S** are shown in Table 8.

Table 8: AWS and JIS specifications for TIG wires for 9% Ni steel and the properties of the matching filler wire **PREMIARC™ TG-S709S**

Properties *1	Classifications		Trade designation
	AWS A5.14 ERNiMo-8	JIS Z 3332 YGT9Ni-2	**TG-S709S**
Features	-	-	▪ Hastelloy type wire and rod. ▪ Suitable for automatic GTAW
Ship class appro.	-	-	NK
C (%)	≤ 0.10	≤ 0.10	0.02
Si (%)	≤ 0.75	≤ 0.75	0.03
Mn (%)	≤ 1.5	≤ 3.0	0.03
Ni (%)	≥ 60.0	≥ 60.0	70.4
Cr (%)	0.5-3.5	-	2.0
Mo (%)	17.0-20.0	15.0-22.0	19.0
W (%)	2.0-4.0	1.5-5.0	3.0
Fe (%)	≤ 10.0	≤ 12.0	5.5
0.2%PS (MPa)	-	≥ 360	460
TS (MPa)	-	≥ 660	730
El (%)	-	≥ 25	47
IV (J) at −196°C	-	Av ≥ 34, Each ≥ 27	160

*1: Chemical compositions are for wire. Mechanical properties are for deposited metal.

SAW wires and fluxes for 9% Ni steel

In its SAW specifications, the AWS regulates wires only in A5.14 whereas JIS specifies the combination of wire and flux, as shown in Table 3 and Table 9. Kobe Steel's SAW wire and flux combinations are shown in Table 10.

Table 9: AWS specifications for SAW wire and JIS specifications for SAW wire and flux combinations for 9% Ni steel

Classification	AWS A5.14	JIS Z 3333	
	ERNiMo-8	FS9Ni-F/YS9Ni	FS9Ni-H/YS9Ni
Applicable to	wire	Weld metal	Weld metal
C (%)	≤ 0.10	≤ 0.10	≤ 0.10
Si (%)	≤ 0.75	≤ 1.5	≤ 1.5
Mn (%)	≤ 1.5	≤ 3.5	≤ 3.5
Ni (%)	≥ 60.0	≥ 60.0	≥ 60.0
Cr (%)	0.5-3.5	-	-
Mo (%)	17.0-20.0	10.0-25.0	10.0-25.0
W (%)	2.0-4.0	-	-
Fe (%)	≤ 10.0	≤ 20.0	≤ 20.0
0.2%PS (MPa)	-	≥ 365	≥ 365
TS (Mpa)	-	≥ 660	≥ 660
El (%)	-	≥ 25	≥ 25
IV (J) at −196°C	-	Av. ≥ 34 Each ≥ 27	Av. ≥ 34 Each ≥ 27

Welding procedures and control

The key factor for the economical and qualitative tank construction is to minimize the amount of on-site fabrication work. This can be achieved by adopting modular design, in which each module is fabricated at a plant and delivered to the site for the connection work afterwards. Even the dome ceiling of an LNG tank is fabricated at a plant and connected to the shell onsite by using the air-raising process.

The welding joints that are typically carried out on 9% Ni steel components on-site is shown in Figure 6. Table 11 shows the welding procedures used on individual joints.

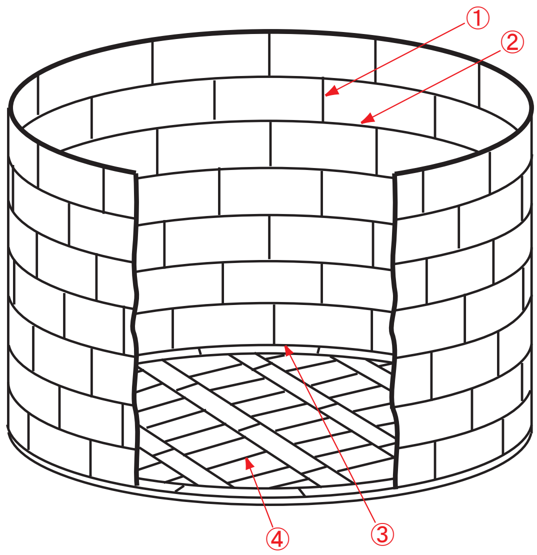

Figure 6: Cross sectional view of typical welding joints in the shell and bottom of a 9% Ni steel tank in on-site fabrication. (Refer to Table 11 for individual welding procedures)

Table 11: Welding procedures for individual joints (Refer to Figure 6 for each joint No.)

Joint No.	①	②	③	④
Component	Side shell	Side shell	Bottom to side shell	Bottom
Type of joint	Double V	Double V	Double bevel	Lap
Welding position*1	3G	2G	2G	2F
Welding process*2	SMAW FCAW Auto-TIG	SAW Auto-TIG	SMAW Auto-TIG	SMAW FCAW Auto-TIG

*1: 3G (Vertical groove); 2G (Horizontal groove); 2F (Horizontal fillet).
*2: Kobelco auto-TIG welding equipment is available only in Japan.

[Note: Inconel is a trademark of Special Metals Corp. Hastelloy is a trademark of Haynes International.]

Table 10: **PREMIARC™** SAW wire and flux combinations for 9% Ni steel and their deposited metal properties

Trade desig. (Flux/wire)	Classification		Features	Pol.	Ship class appro.	Chemical composition (%)								Mechanical properties			
	AWS A5.14	JIS Z 3333				C	Si	Mn	Ni	Cr	Mo	W	Fe	0.2%PS (MPa)	TS (MPa)	El (%)	IV (J) at −196°C
PF-N3/ US-709S	ER NiMo-8 (wire)	FS9Ni-F/YS9Ni	▪ Hastelloy type consumables ▪ Suitable for 1G welding position	AC, DCEP	-	0.03	0.12	1.70	64.1	1.6	16.6	2.5	14.7	400	690	44	80
PF-N4/ US-709S	ER NiMo-8 (wire)	FS9Ni-H/YS9Ni	▪ Hastelloy type consumables ▪ Suitable for 2G welding position	DCEP	NK	0.03	0.74	0.58	64.0	1.7	17.2	2.7	14.9	410	680	43	70

Figure 7 shows examples of groove configurations for SMAW, GTAW, SAW and FCAW in designated welding positions in the figure. Figure 8 shows horizontal fillet welding (2F) on the roof of an LNG tank with **DW-N709SP** flux cored wire. Figure 9 shows overhead butt joint welding (4G) along the bottom plate of an LNG tank with automatic TIG welding equipment using **TG-S709S** TIG wire. These pictures were taken at a construction site in Japan where the major aboveground LNG tanks use the flat-bottom double-shell cylindrical dome-roof structure (Figure 10). The dome roof is also made of 9% Ni steel.

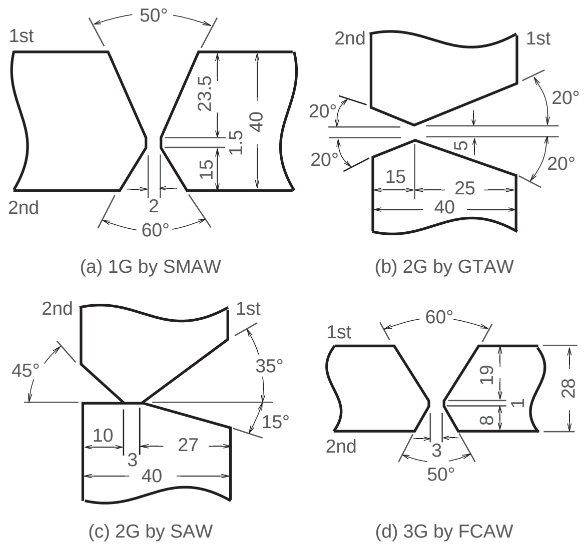

Figure 7: Typical groove configurations for SMAW, GTAW, SAW, and FCAW used for joining 9% Ni steel components in fabrication of an LNG tank.

Figure 8: Horizontal fillet welding (2F) on the roof of an LNG tank is carried out with **PREMIARC™ DW-N709SP** flux cored wire.

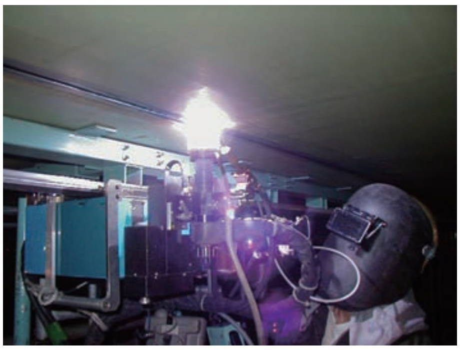

Figure 9: Overhead butt joint welding (4G) along the bottom plate of an LNG tank is conducted with automatic TIG welding equipment using **PREMIARC™ TG-S709S** TIG wire.

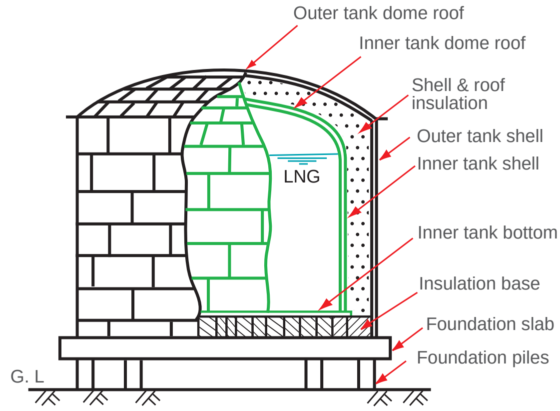

Figure 10: Cross sectional view of the flat-bottom double-shell cylindrical dome-roof LNG tank [3].

Tips for better welding results on 9% Ni steel

High Ni alloy welding consumables are hot crack sensitive in general, and LNG tanks typically require much dissimilar welding. The following special precautions against hot crack and base metal dilution have to be taken.

Crater crack must be removed: Kobe Steel's welding consumables for 9% Ni steel have been proven to be adequate through the inspection by FISCO crack testing for hot crack susceptibility. However, because crater cracks (one type of hot crack) are common and difficult to avoid, it is strongly recommended for the crater to be ground off each time when the arc stops.

Dilution of base metal affects the mechanical properties of the weld metal: When the base metal is diluted into the weld metal by the arc, the weld metal chemistries can change. These changes can be especially more significant in dissimilar welding, decreasing the tensile strength of the weld metal. It is advised to check the welding conditions and to ensure that the tensile strength and 0.2% proof strength fulfill the requirements in the procedure test in advance.

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Dear KWT readers! I am Naoto Terachi, Manager of Marketing Planning Section.

I was transferred to the International Sales and Marketing Department (ISMD) in July 2010 for 3 months but have recently returned to my previous section due to an organizational change. However, my job now is mostly related to advertising and product planning for overseas markets. So, I still remain in contact with KWT readers, as issuing this KWT magazine is one of my current jobs.

Over the course of my 32 years in the welding business at Kobe Steel, I have worked in the research and development, manufacturing and marketing departments in 10 year intervals respectively. In these 3 different departments, I could experience many facets of Kobelco welding consumables from product design to quality control, quality assurance and marketing planning, which included domestic exhibitions and customer support. However, my experience never reached beyond the Japanese domestic market.

On the other hand, my recent three-month experience in the ISMD, including my visit to FABTECH 2010 and the trip to meet American customers in November 2010 has opened my eyes to the world market.

Current work related to overseas markets includes the issuing of KWT magazine as well as KOBELCO WELDING HANDBOOK and making an easily accessible and useful home page — possibly in several languages.

I wait for your kind accessing of the Kobelco Welding Home Page and look forward to hearing from you in the near future.

I do wish you a good health and good luck.

Naoto Terachi
Manager
Marketing Planning Section
Marketing Department

How do you do! My name is Aya Kuboki and I am currently in charge of the North, Central and South American markets.

Until last summer in 2010, I worked in production process control for flux cored wires (FCWs) for carbon steel at the Ibaraki plant and could be seen wearing a blue working uniform and a safety helmet. But after being transferred to International Sales and Marketing Section (ISMS) in Tokyo, I now wear a suit every day. What a change!

Last November, I had an opportunity to visit the USA and take part in FABTECH 2010 (formerly the AWS Welding Show). My experience and impressions were reported on KWT Vol. 14 No. 1 2011, and I would be pleased if you could take a look at it. Seeing the American market has made me realize how large and how diverse the world market is, and joining ISMS, where the international market challenges you to think creatively, has convinced me that I have to do my best.

In ISMS, we are now attempting to cultivate the Brazilian market, together with Kobelco Welding of America Inc. (KWAI), but there are many incredible tasks that we cannot deal with by ordinary means. We are trying to solve them one by one, getting the advise, support and cooperation from KWAI. Finally we've taken an order from a Brazilian customer. At that moment I felt overwhelmed by the sense of great fulfillment even though my contribution was limited.

There are a lot of issues to be resolved in order to expand our overseas business, and I want to solve those systematically and make steady progress to achieve our final goal: that Kobelco products are used in more structures in many more countries than now.

Thank you very much and with my warmest regards.

Aya Kuboki
in charge of
American continent market
Int'l Sales & Mkt'g Section
Marketing Department

Supporting European Customers with High Quality FCW Products While on Duty and Enjoying European Lifestyle in Personal Life

My dearest KWT readers! My name is Kenichiro Kosaka, and I was assigned to Kobelco Welding of Europe B.V. (KWE) in the Netherlands as Marketing Manager in October 2010 — at the time when KWE celebrated its fifteenth year of manufacturing and supplying flux cored wires (FCWs) to the European market.

KWE was established in 1994. It started manufacturing FCWs for stainless steels right after the Kobe earthquake in Japan in 1995 and producing FCWs for carbon steels in 2007. KWE is now supplying FCWs timely and functioning as Kobelco group's European production and marketing base.

At the 15-year celebration party, I came to recognize the importance of continuously promoting the Welding Business slogan: "QTQ (Quality Products, Technical Support, Quick Delivery)." And in order to achieve the goals, we must visit our customers frequently, understand and respond to their requests, and, in this way, grasp the trends in customer needs. This is how our clients will see that Kobelco is always ready to extend a helping hand. My ultimate goal for marketing at KWE is that all users will recognize that KWE supplies stable, high quality products that can be relied on for all of their jobs.

I am happy to report that I have not been occupied only with business; indeed, I have found that the culture and lifestyle in Europe offer rewards as well. I have been playing piano for 4 years and recently finished the first piano textbook called "BEYER." Now I am practicing "BURGMUELLER" textbook every day by finding some free moments in my busy days.

In Europe, the birthplace of classical music, there are concerts in many large and small venues almost every week. Even in small, elegant churches, you can listen to music played by local musicians who may not be famous but talented nonetheless. It is one of my pleasures in Europe to go and listen to small piano concerts from time to time. It is now my dream that I may one day play piano in a small church and please an audience with the sound of my performance — even though I am still very shy to play piano in front of people.

This winter in the Netherlands was very cold and we had snow that is quite exceptional in this area. It was tough on a new comer like me. By contrast, the European market is becoming more active and busier since the beginning of 2011, and for KWE, our product supply is getting a little tighter. However, this can be easily resolved by raising production to meet the demand, which is still within our full production capacity.

I do hope that more potential users will understand our QTQ, recognize the high quality of Kobelco's FCWs, and start to use them in the very near future.

Thank you and I look forward to seeing you soon in the course of business.

Posing at KWE office is the author of this column, Kenichiro Kosaka, Marketing Manager, KWE.

Enjoying a relaxing moment at home with my hobby of playing piano.

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