KOBELCO WELDING TODAY

OCTOBER 2007 VOL.10 [NO.4]

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

Big Changes in the Welding Industry This Decade

Dear readers of KOBELCO WELDING TODAY. I would like to express my hearty thanks for your continuing patronage of the Welding Company of Kobe Steel, Ltd. and for your choosing the welding products of the KOBELCO group companies. Time has passed swiftly as this issue marks the 10th anniversary of this welding magazine. At this occasion I will focus my brief greeting on discussing the current situation of the global welding industry and our policies for the future.

The welding industry in Japan and the rest of the world has, in just these ten years, experienced rapid and revolutionary changes that symbolize the vicissitudes of the industrial landscape as we move forward in the 21st century. Technological innovations exemplify these changes: improved steels with excellent weldability, such as TMCP (thermo-mechanical control process) steel; “high efficiency” welding methods; advanced mechatronics and more prevalent arc welding robots. In addition, there has been a reconsideration of nuclear power in view of global warming, a rise in demand for new energy-related equipment and the development of new welding products that are excellent in ultrahigh-temperature, cryogenic-temperature, and high-strength performance.

With respect to the demand for welding products, it has explosively and globally expanded in association with the rebirth of shipbuilding and construction machinery and the growth of the auto industry in tandem with the rising economies in BRICS countries, such as China in particular. In response to such huge and rapid changes in the welding market, we are always promoting the development of new welding technologies and providing them to the world market. We are also enhancing overseas operations with the upsizing of overseas production and sales bases.

We have been driving forward to intensify our business with customer-oriented KOBELCO welding products and systems, supported by highly reputed technology and quality, and to maintain a stable supply to the world market. In this connection we are looking forward to your kind support of our business activities. We feel pride in our KOBELCO welding products and systems, especially insofar as they have been so highly regarded by our customers, who look upon us with strict but earnest eyes. Based on this viewpoint, I hope that KOBELCO WELDING TODAY will be a useful communication tool between our respected customers and Kobe Steel.

Isao Aida
President of Welding Company
Senior Managing Director of
Kobe Steel, Ltd.

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

My New Position; Hope Your Patronage

I was named as Mr. Tojo's successor as of October 1st. I am now conscious of the high level of responsibility that comes with the new position. As Kobe Steel's global welding business continues to expand, I am determined to do my utmost to supply customers with consistent high-quality products and provide unsurpassed technical services by integrating the capabilities of the worldwide Kobelco Group companies. I sincerely hope to continue having your patronage that you extended to my predecessor.

Thanks to your support, KOBELCO WELDING TODAY celebrates its 10th anniversary with this issue. Fortunately, Kobe Steel's welding business in the overseas market has expanded constantly over these 10 years. Kobelco Welding of Europe (KWE) is now manufacturing flux-cored wires for mild steels with a firm resolution to increase sales and to supply the shipbuilding industry, where demand is quite active.

One of the markets that we are looking at with interest is Russia. The country shows remarkable economic development with its progress in extending petroleum and natural gas pipelines and expanding manufacturing industries. It seems that Russia envisages the end of being just a natural resources exporter and enhancing the manufacturing industries. We should be very happy if we could attract attention to our solution know-how in welding and contribute just a little to Russia's economic progress.

As a final note, this is an era when business enterprises are called upon to bear social responsibility for the environment. We, Kobe Steel, are determined to be conscious of environmental management in the deployment of our global businesses. We should be grateful for your support.

Masakazu Tojo
Senior General Manager
Assistant to President
Welding Company
Kobe Steel, Ltd.

My Post Renewed; My Activities Still Global

In Japan, it is the refreshing autumn now. We can refresh ourselves by looking at trees along the roads and in the mountains with beautiful leaves colored red and yellow. In autumn many trees change from shades of green to dramatic reds and yellows. Every season we issue the quarterly journal, KOBELCO WELDING TODAY, and now we reach the ten-year mark. Due to our readers' solid support, this journal is now enjoying the 10th anniversary of the first issue. I hope your continuous support for this journal will continue for the days to come.

By the way, I personally have to say good-bye to all of our dearest readers of KOBELCO WELDING TODAY, since I have transferred out from the position of General Manager of the International Operations Department (IOD) as of this October 1st. At a new post commissioned by the president of Welding Company, I am responsible for developing global strategies for international operations. I would like to express my sincere gratitude to all of you for your hearty support extended to me and the IOD for the last six and a half years, during which I was very happy to execute my business with you. Mr. Toshiyuki Okuzumi whom you may know very well, is my successor. I would like to ask you to support him in the same way as you have done.

We are increasing our production capacity of flux-cored wires for stainless and carbon steels in order to improve the shortage problem. The world economy continues to boom and is growing higher than we had expected. In response to this brisk economy, our strategy is to reinforce overseas production and sales to catch up with the increasing global demand for both general-purpose as well as value-added welding. In this connection, we sincerely hope your consistent patronage for KOBELCO products in the future.

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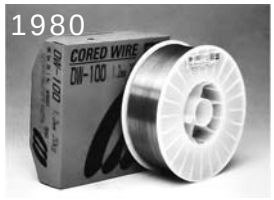

The start of domestic covered electrode production (1932-1945)

Until around 1930, most covered electrodes used in Japan were imported, though leading shipbuilders and machinery fabricators were able to produce them for their own uses. Similarly, Kobe Steel also produced its own covered electrodes in-house. Around 1932, Kobe Steel began to pursue full-scale research and development of covered electrodes, acknowledging the importance of welding technology, and responding to the increased demand for domestically-produced covered electrodes.

In 1939, Kobe Steel was charged by the naval force at the time to develop a covered electrode for naval applications comparable to Arcos Stabilend, an imported product from Belgium. The purpose was to establish a self-supporting production framework to overcome the difficulties at that time of importing industrial goods from overseas on account of deteriorating international trade. Kobe Steel executed in-depth research and development to solve the problems of high sulfur content in domestic core rod and to explore domestic ores suitable for the covering flux of the electrodes.

Consequently, in 1942, Kobe Steel developed a high quality ilmenite electrode comparable to or better than the imported electrode, and the new electrode was given the name **B-17**. Almost immediately, B-17 was adopted full swing for ships and other heavy-duty naval structures. The monthly production of the electrodes reached 540 metric tons in the high season, which accounted for the bulk of total domestic demand in wartime. B-17, which is now classified as AWS A5.1 E6019, continues to be produced with consistent quality and is supplied domestic and overseas markets.

Production and supply for civilian demand in the postwar era (1945-1959)

After World War II, Kobe Steel's main electrode factory, the Hidaka Plant, restarted production of covered electrodes for civilian uses in 1946 and was first in Japan to acquire the certificate of Lloyd's Resister of Shipping (UK) for B-17 in 1948. Hence, the credibility of the quality of Kobe Steel electrodes was heightened, and, as a result, most of the electrodes used for building ships for export as well as for domestic use carried the Kobe Steel brand. In 1949, production of a new ilmenite electrode, the **B-10** (E6019), started, and this electrode then became very popular for general applications.

In response to the sharp postwar increase in demand for welding electrodes, Kobe Steel built a state-of-the-art mass production factory, the Yamate Plant, in Kobe City in 1951. The new plant allowed Kobe Steel to achieve a monthly electrode production capacity of 1500 metric tons. That year, two new types of electrodes were developed for the first time in Japan: a titania electrode, called **RB-26** (E6013) for thin steel work and a low hydrogen electrode, **LB-26** (E7016), for thick steel work (Figure 1).

Figure 1: **RB-26** and **LB-26** joined **B-17** and **B-10** for diversified applications in the early postwar era.

In 1952, the Welding Department took on a more integrated framework by organizing the research and development section at the Yamate Plant. The scope of products was expanded with special covered electrodes for high tensile strength steel, low alloy steel, stainless steel, and hardfacing to respond to the diversified needs of the market. That year, in order to expand sales of welding electrodes particularly to small-scale domestic customers and users, a sales network for Kobe Steel welding consumables, the "Shin Yo Kai," was set up (Figure 2). The sales network has been expanded and strengthened ever since to cover the entire Japanese market.

Figure 2: The "Shin Yo Kai" sales network was established in 1952 to promote sales in the Japanese domestic market.

In 1954, a low hydrogen electrode, **LB-52** (E7016), for high tensile strength steel was developed. Low hydrogen electrodes have greatly contributed to the rapid development of heavy-duty welded structures and machinery made of high tensile strength steel in Japan. Since around 1955, Kobe Steel began paying attention to the hazards of the welding fumes emitted from low hydrogen electrodes and may have been the first in the world to begin medical research into the effects of fumes on the health of welders. This research contributed to development of "harmless-fume" and "low-fume" covered electrodes such as **LBM-52** (E7016) and **ZERODE-44** (E6013) in later years.

In 1957, a new ilmenite electrode, **B-14** (E6019), was developed to improve the vertical-up usability of B-10. In that year, in order to produce electrodes with more consistent quality, a flux-processing factory was established at the Yamate Plant; since then flux raw materials have been processed in a controlled sequence from acceptance, preliminary treatment, to automatic dosing. In 1959, in response to the rapid growth of the welding industry, the Welding Department was made independent of the Iron and Steel Division and reestablished as the Welding Electrode Division. Ever since, development, production, and sales of welding products have been carried out in a coherent corporate system, though later the name of the division was changed to the Welding Division and, more recently to the Welding Company.

Expansion and advancement in the era of the booming economy (1960-1974)

As economic growth soared in Japan, so did demand for welding consumables; as a result, the annual production of Kobe Steel electrodes reached 44,300 metric tons, straining the maximum capacity of both the Hidaka and Yamate Plants. In order to increase production capacity, upgrade and expand technical research and development, and respond to rising demand for welding consumables in the Tokyo metropolitan district, Kobe Steel established the state-of-the-art Fujisawa Plant in Fujisawa City in 1961. In the next year, the flux-processing factory and the research and development section were transferred to the Fujisawa Plant from the Yamate Plant. In the meantime, in order to respond to the increasing demand for welding consumables in western Japan, the Ibaraki Plant in Ibaraki City was established with the most advanced facilities including those transferred from the Yamate Plant in 1961. In particular, the Ibaraki Plant was outfitted with equipment for production of solid wires, taking into account the trends towards greater automatization in the welding industry.

In 1963, the Shinkannsen Super-Express Line was under construction so as to make ready for the Tokyo Olympic Games of 1964. For joining the long rails in the field, thermit welding was a standard method at the time. However, in order to speed up welding in the field, arc welding was also considered. At the request of the Japan National Railroad, Kobe Steel executed research and developed the enclosed arc welding process that used a rail-fit welding jig, high tensile strength steel covered electrodes of **LB-116** (E11016-G) and **LB-80EM**, and special postweld heat treatment. This enclosed arc welding process succeeded at joining long rails on site (Figure 3).

Figure 3: The long rails of the Shinkansen Super-Express Line were successfully welded by the enclosed arc welding process developed by Kobe Steel.

In the early 1960s, the Japanese shipbuilding industry began to expand to meet increasing demand for new ships: from 1,500,000 GT (12% of the world total) in 1962, Japanese ship production increased yearly up to 17,000,000 GT (50% of the world total) in 1975. To cope with such strong demand from the shipbuilding industry, Kobe Steel promoted research and development of submerged arc welding consumables. Fused fluxes, such as **G-50** and **G-80**, were produced and supplied by Hanshinn Yosetsu Kizai Co., Ltd., a joint venture between Kobe Steel, Ltd. and Osaka Transformer Co., Ltd. (currently Daihen Corp.) under technical collaboration (1959-1969) with Union Carbide Corp. In order to improve high-current usability and notch toughness of fused fluxes, the bonded flux, **PFH-45**, was developed in 1961 and first applied in a 64,000 DWT tanker in 1963; since then, the use of this flux has widened in shipyards throughout Japan.

Starting around 1963, tankers began to be designed with longer hulls. For more efficient fabrication of long ship hull blocks, shipbuilders desired a welding procedure that dispensed with the need to weld both sides of the steel plates. In response, Kobe Steel developed two different one-sided submerged arc welding processes along with the required fluxes in 1964: the **RF** (resin flux) process for 25-mm or thinner plates and the **FCB** (flux copper backing) process for 40-mm or thinner plates (Figure 4). These processes were employed for 10 years by successive Japanese shipbuilders eventually reaching over 40 shipyards. In addition, starting in 1970, the FCB process spread among shipbuilders overseas in former Yugoslavia, Italy, Spain, USA, and Korea.

Figure 4: The **FCB** process achieved ultimate welding efficiency in one-sided submerged arc welding of hull plates.

In Thailand, in the 1960s, a high degree of economic development was seen in the private sector; as a result, the real GDP growth rate in this period reached a high of 8.0%. In such a climate of economic expansion, a great number of foreign companies invested and established joint-venture companies in Thailand. In 1968, Kobe Steel invested, for its first overseas investment, in the establishment of Thai-Kobe Welding (TKW) (Figure 5) in cooperation with Watana Intertrade Co., Ltd. and Kim Chong Hin Import Export Co., Ltd. to produce and supply RB-26 for the Thai market.

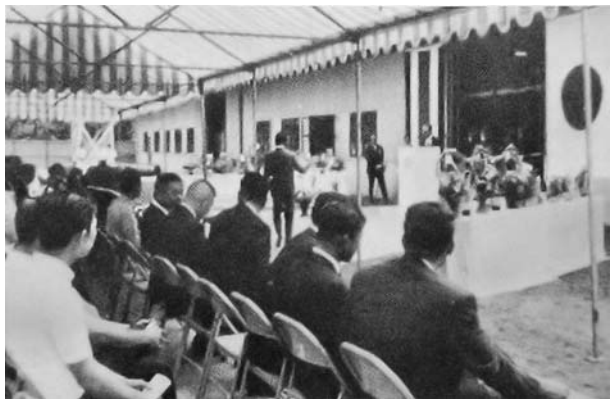

Figure 5: Opening ceremony of Thai-Kobe Welding in 1969.

In 1968, Kobe Steel began production and supply of MG solid wires, such as **MG-50** (ER70S-G), under sublicense from Matsushita Electric Industrial Co. Ltd. After that, Kobe Steel was able to establish a framework for supplying solid wires to the semi-automatic welding markets such as rolling stock, autos, and industrial machinery.
To satisfy increased demand for covered electrodes from shipbuilders in western Japan, the Saijo Plant was established in Hiroshima prefecture in 1970. This plant features superior productivity and decreased labor costs.

In 1974, a highly-efficient, potable electrogas arc welding process named **SEGARC** was developed. Utilizing specific flux-cored wires, **DWS-43G** (EG70T-2), **DWS-1LG**, and **DWS-60G**, it offered high deposition rates. Since then SEGARC has been used for vertical welding joints in ship hulls, bridges, storage tanks, and large diameter pipes (Figure 6).

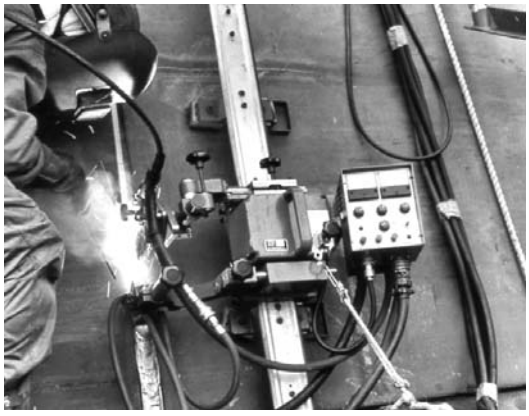

Figure 6: The **SEGARC** electrogas arc welding process was used for ship hull vertical joints.

Highly efficient welding consumables in the era of production rationalization (1975-1986)

In order to recover after the first global energy crisis hit in 1973, every industry promoted production rationalization. As a result, in the welding industry, every fabricator began to increase their use of the highly-efficient and cost-effective CO_2 arc welding process to improve welding efficiency and thereby decrease production costs. To respond to these new circumstances, production of solid wires at the Ibaraki Plant was increased; in addition, Kobe Steel built the Fukuchiyama Plant in 1975, equipping it with cutting-edge production facilities for solid wires, and thereby realizing production cost savings and quality improvement.

In 1976, Intan Pertiwi Industry (INTIWI) was established as a technical collaboration in Indonesia (Figure 7) and began to produce and supply covered electrodes under the license from Kobe Steel in 1977. Since then INTIWI has been producing a wide range of covered electrodes, including those for mild steel, high tensile strength steel, stainless steel, cast iron, and hardfacing. The company's production and sales have increased, achieving 50% market share due to a high reputation among users.

Figure 7: INTIWI's factory started production of **RB-26** in 1977 under license from Kobe Steel.

In response to the market demand for improving efficiency and usability in stainless steel welding, the DW series of stainless flux-cored wires, **DW-308L** (E308LT0-1/-4), **DW-316L** (E316LT0-1/-4), **DW-309L** (E309LT0-1/-4), and **DW-309MoL** (E309LMoT0-1/-4), was developed in 1978 (Figure 8). Well-suited to CO_2 arc welding, the DW series of stainless flux-cored wires have grown in use year after year due to their excellent performance over covered electrodes. Adding to their popularity have been high performance variations such as **DW-308LP** (E308LT1-1/-4), **DW-309LP** (E309LT1-1/-4), and **DW-316LP** (E316LT1-1/-4 for out-of-position welding that were added to this series in later years.

Figure 8: DW stainless flux-cored wires contributed to high efficiency in stainless steel welding.

1978 saw the development of **PICOMAX**, equipment for multiple-use automatic welding that offered compact size, light weight, and easy operation. With this equipment, automatic gas shielded arc welding could be conducted with solid wires or flux-cored wires in one semi-automatic welding machine. Since then this equipment has been used for various applications such as steel structures, pipes, and storage tanks (Figure 9).

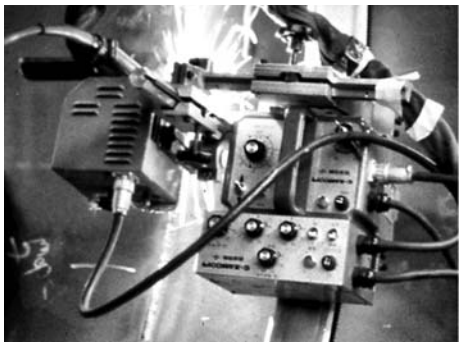

Figure 9: **PICOMAX** has contributed to production rationalization with its multiple functions.

In 1979, Kobe Steel expanded its overseas production base by establishing Kobe Welding (Singapore), KWS (Figure 10), to cover not only the Singaporean domestic market but also markets in neighboring countries. KWS began with production of covered electrodes for mild steel and high tensile strength steel. In KWS, the ASEAN Marketing Dept. (AMD) was organized to provide market-oriented technical services in the South East Asian markets. The AMD personnel covered technical services not only in Singapore but also in Malaysia, Thailand, Indonesia, and Philippines.

Figure 10: The position of KWS has been strengthened by increasing the production and sales of welding consumables.

1980 saw the development of **DW-100** (E71T-1C), a rutile flux-cored wire for mild steel and 490MPa high tensile strength steel (Figure 11). This flux-cored wire was highly reputed for solid ultimate performance and provided the momentum for shipbuilders to employ automatic and semi-automatic welding with DW-100 instead of shielded metal arc welding with covered electrodes. Consequently, the consumption of DW-100 began to climb rapidly year after year. In 1981, Ni-bearing rutile flux-cored wires, **DW-55E** (E71T-9C-J) and **DW-55L** (E81T1-K2C), were developed for low temperature applications such as offshore structures in response to demand from the shipbuilding industry.

Figure 11: **DW-100** was an epoch-making flux-cored wire that provided a core technology for developing other flux-cored wires.

In 1982, **LB-52U** (E7016), which had been developed in 1959 for “uranami” or root-pass melt-through welding with penetration beads, was evaluated highly in a welding test of natural gas pipelines in the then Soviet Union (Figure 12). Kobe Steel successfully received a series of large purchase orders for LB-52U together with **LB-62D** (E9018-G) for filling passes. Since then LB-52U has remained highly reputed due to its unsurpassed performance in the root pass welding and used continuously in such pipeline welding applications.

Figure 12: Welding test of covered electrodes on pipeline segments in the then Soviet Union in 1982.

In 1985, a metal flux-cored wire, **MX-100** (E70T-1C) (Figure 13) was developed for steel structures, industrial machinery, and construction machinery. It offered high deposition rates together with the soft arc and low spatter associated with DW-100 as well as the reduction in slag covering one finds with solid wires. To respond to the continuously increasing consumption of flux-cored wires, the production framework of the Fujisawa Plant was strengthened, and a new production line for flux-cored wires was employed at the Ibaraki Plant.

Figure 13: **MX-100** was an epoch-making metal flux-cored wire suitable for steel structures, industrial machinery, and construction machinery.

The year 1980 has been called "the first year of the robot," because robotization started in earnest in the welding industry. Kobe Steel also began comprehensive research and development of arc welding robots, particularly for steel structures and construction machinery. In 1982, an intelligent electrically-powered robot, ARCMAN-S, was developed and marketing began in full. Since then Kobe Steel has expanded the arc welding robot business by developing not only articulated robots, but also gantry type NC robots, welding power sources, positioners, and shuttles (Figure 14). The **ARCMAN** series of articulated robots and systems have seen continual improvement in welding performance to meet the needs of diverse applications, including shipbuilding and bridge construction. Two-Joint Synchronized Arc Welding System was developed for assembling steel columns in 2003.

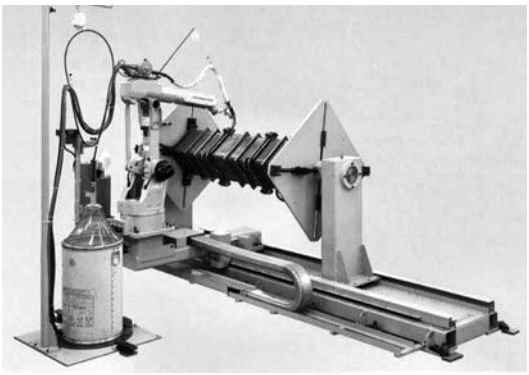

Figure 14: An **ARCMAN** welding robot system consists of an intelligent articulated robot, power source, positioner, and shuttle.

High-value added welding consumables and expanded globalization (1987-present)

In 1988, Kobe MIG Wire (Thailand), KMWT (Figure 15), was incorporated at the Bangpoo Industrial Estate in Samutprakarn, Thailand. Focusing production mainly on **MG-51T** (ER70S-6), KMWT has become a production base for exports to markets in the ASEAN countries, Oceania, and North America. That year, TKW moved to the same area in order to meet increased demands for various covered electrodes for mild steel, high tensile strength steel, and stainless steel.

Figure 15: KMWT and TKW have been located at the same yard since 1988 for more efficient plant management.

In 1988, a special tandem submerged arc welding process with a flux-wire combination of **PFI-53ES**/**US-36L** began to be employed for the corner joints of box columns made of mild steel or 520MPa high tensile strength steel in high-rise buildings. By using high currents (2100A for the leading wire, 1700A for the trailing wire), 60-mm thick plates could be joined with a single pass (Figure 16).

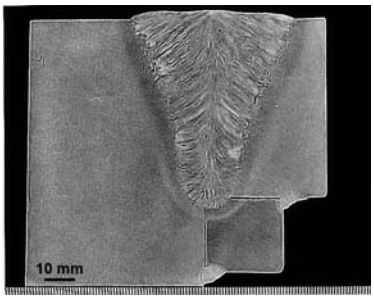

Figure 16: Cross sectional macrostructure of a corner joint weld of a box column tandem-submerged-arc welded with a flux-wire combination of **PFI-53ES**/**US-36L**.

In 1989, marketing began of a porosity resistant metal flux-cored wire, **MX-200** (E70T-1C), for horizontal and flat fillet welding of primer-coated steel plates (Figure 17). At that time, shipbuilders and bridge fabricators were employing automatic welding systems for fillet welding joints in ship hulls and bridge assemblies, and hence they needed a primer-resistant welding wire. MX-200 was highly reputed for many reasons: excellent porosity resistance; high speed welding (30-80 cm/

min) capability; regular-shaped weld bead with glossy appearance; and low spatter on primer-coated, varnish-coated, and rusted plates of mild steel and 490MPa high tensile strength steel.

Figure 17: **MX-200** contributed to the automatization of fillet welding in the shipbuilding and bridge construction fields.

Kobe Steel's advanced welding technology enabled fabrication of high-temperature high-pressure reactor vessels (Figure 18) by using the state-of-the-art high-strength 2.25Cr-1Mo-V steel, which offered high strength and resistance to hydrogen at high operation temperatures. Welding consumables suitable for this steel were developed in 1990: **CMA-106H** for shielded metal arc welding, **PF-500**/**US-521H** for submerged arc welding, and **TGS-2CMH** for gas tungsten arc welding. These welding consumables featured not only high temperature strength but also low susceptibility to temper embrittlement.

Figure 18: Kobe Steel fabricated the world's first state-of-the-art reactor vessel of 2.25Cr-1Mo-V-Cb-Ca steel in 1998 by using the matching welding consumables: **CMA-106H**, **PF-500/US-521H**, and **TGS-2CMH**.

Until 1990, when Kobelco Welding of America (KWAI) was incorporated in Houston, Kobe Steel's welding consumables had been supplied by another U.S. subsidiary of Kobe Steel to the North American market. Currently the flux-cored wires for stainless steel and mild steel and solid wires for mild steel distributed by KWAI are all imported from Thailand, The Netherlands, and Japan. In 2002, KWAI's Houston Head Office was relocated to Stafford, Texas from Houston (Figure 19).

Figure 19: KWAI's functional complex consisting of an office, warehouse, and welding laboratory for demonstrations of products.

In 1993, Kobe Steel established a joint venture, ST Kobe Welding (Malaysia), KWM (Figure 20), with the partner company, Sitt Tatt, to produce and supply RB-26 and some other covered electrodes for the Malaysian domestic market.

Figure 20: A production base established by Kobe Steel and Sitt Tatt in Malaysia.

In 1994, Kobe Steel established Kobelco Welding of Europe (KWE) (Figure 21) in The Netherlands. Its location, virtually at the center of Europe enables customers any place in Europe to receive products within 48 hours. KWE produces DW stainless steel and mild steel flux-cored wires.

Figure 21: KWE's location at the center of Europe enables European customers everywhere to receive services quickly.

In 1995, Kobe Welding of Korea (KWK) (Figure 22) was established in Changwon City. It was the first Kobe Steel affiliated production unit in Korea. KWK has been manufacturing flux-cored wires for mild steel and 490MPa high tensile strength steel and supplies shipbuilders and steel contractors in the domestic market.

Figure 22: KWK has been increasing production and sales due to the booming shipbuilding business in Korea.

In 1996, a revolutionary rutile flux-cored wire for low temperature service, **DW-55LSR** (E81T1-K2C) (Figure 23), was developed. This wire's features include no SR embrittlement, high notch toughness at low temperatures down to –60°C in both as-welded and postweld heat treated conditions, high CTOD value at –20°C, and excellent usability and efficiency in all positions. This wire has been used for butt and fillet welding of offshore structures in cold areas and storage tanks.

Figure 23: **DW-55LSR** is a postweld heat treatable rutile flux-cored wire for low temperature service.

In 2002, Kobe Welding of Tangshan (KWT) was established in Tangshan City, China, as a joint venture among Kobe Steel, Matsushita Industrial Equipment, and Tangshan Kaiyuan Electric. KWT's first step was to produce **MG-51T** (ER70S-6) for domestic and overseas markets (Figure 24).

Figure 24: All the executives of KWT celebrated the inauguration of the factory at the start of production in 2003.

In 2007, the Ibaraki Plant achieved an accumulated production of 3-million metric tons of flux-cored wires, solid wires, and covered electrodes since its inauguration of production in 1961 (Figure 25). Astonishingly, this amount of production matches Japan's domestic total production for about 10 years. The plant continues to march toward new production highs in the future.

Figure 25: The flux-cored wire that got the Ibaraki Plant to achieve the astonishing 3-million MT production figure.

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