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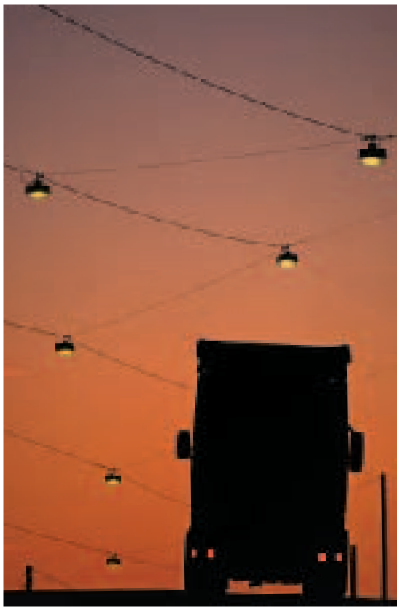

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Welding LPG tankers the ESAB way

by Ben Altemühl, editor of Svetsaren, interviewing Stocznia Gdynia production management

ESAB is supplying the Gdynia Yard with a complete consumables package for welding gas tanks in NV 2-4 low-temperature steel.

Acknowledgement

We would like to thank the Gdynia production management for allowing us to visit the yard and for providing us with the information on which to base this article. We would especially like to thank Mr. Zenon Szymanski (EWE*) and Mr. Marek Piechulski (EWE), the welding engineers, for their co-operation and support. We also compliment our colleagues at ESAB Poland on the marketing success achieved at the Gdynia yard. (*European Welding Engineer)

Stocznia Gdynia

Visiting this immense shipyard, located in the Baltic port of Gdynia, and witnessing the enormous activity, the title of the national anthem automatically springs to mind, “Jeszcze Polska nie zginę≥a” – “Still Poland is not lost”.

The history of the Gdynia shipyard, founded in 1922, is associated in many ways with the 20th century misery and uprising of the Polish nation as a whole. It was establsihed in the roaring twenties with ship repairs and was as hard hit as Poland itself by the Great Depression that was soon to follow, smothering any attempt to transform itself into a fully-fledged new building yard. It would take a series of bankruptcies and re-starts under new ownership before, at the end of the thirties, the first Gdynia-designed ships slid off the slipway.

The rapid growth of the Gdynia shipyard was dramatically hampered by the outbreak of World War II. Stocznia Gdynia was placed under the management of Deutsche Werke Kiel AG and was once again transformed into a busy repair yard and submarine building centre.

In 1943 and 1944, allied bombing destroyed the shipyard almost completely. After Gdynia’s liberation by the Soviet and Polish Armies in 1945, the yard rendered all kinds of services, before it reached its present form. Its portfolio of orders included chimney pipes for a portable stove and the repair of cars (among them those powered by wood gas).

The shipyard went on to become the largest repair base for the Polish fleet when merchant and naval vessels started coming back to Poland from their war-time wandering, along with the German ships given to Poland as war reparation and the English and American

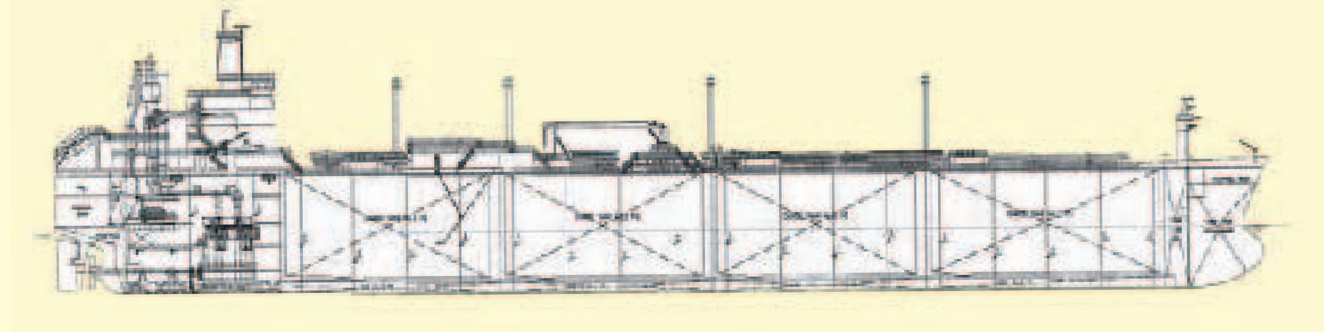


Figure 1. Blueprint of a DNV class 1A1 LPG tanker.

ships received from military stores. In the fifties and sixties, the majority of the ships that were built were delivered to USSR owners. Soon after, a new era dawned when the series production of B-523 type cargo ships was started, fulfilling the special requirements of Norwegian owners. From that time, Stocznia Gdynia had access to its own design department and more and more orders were also received from western countries. From the mid-sixties, Gdynia has broken records designing and delivering up to 117,000 tonne deadweight OBO carriers, liquid gas carriers with prismatic tanks, bulk carriers and bulk tankers. In 1970, shipyard workers in Gdynia, just like their colleagues in Gdansk, undertook, on behalf of the whole nation, a rebellion against the government. A monument still serves as a reminder of the victims who were killed and injured.

In 1980, the powerful Solidarity movement was born in the neighbouring Lenin Shipyard in Gdansk, triggering martial law in 1981 but also political and social changes, which led to today's market economy.

Stocznia Gdynia is now one of the largest and most profitable European yards, exporting close to 100% of its products to clients from all over the world. It is capable of building ships up to 400,000 dwt and consumes around 150,000 tonnes of steel a year. It builds fishing trawlers, general cargo and multi-purpose container vessels, crude and chemical tankers, OBO carriers, car carriers and large passenger ferries. The yard is ISO 9001 certified and has access to modern design and analysis tools such as CAD/CAM, NAPA, Tribon and Foran systems.

LPG carriers

At the time of our visit, the construction of the first of two 50,000 tonne deadweight DNV class 1A1 LPG tankers was nearing completion. These ships have four tank sections with a total capacity of 78,500 m^3, each of which consists of two independent prismatic tanks (see Figures 1 and 2). The tanks have a double hull and are surrounded by a safety barrier. The red lines in Figure 2 indicate the use of DNV class NV 2-4 low-temperature steel for the tanks and the safety barrier, whereas the green lines represent standard shipbuilding grades according to the Polish Bureau of Shipping (A32 and D32). The tanks are designed for a service temperature of –50ºC at an overpressure of 0.275 bar. The CVN requirement for the steel and the welds is 27J at –55ºC.

Table 1 shows the chemical and mechanical requirements for DNV NV 2-4. Plates according to NV 2-4 specification are purchased from the Polish steel manufacturer Huta Czestochowa in three thickness categories; 12, 20 and 28 mm.

As can be seen from Figure 3, the carriers are constructed in sections according to modern shipbuilding practice involving panel fabrication, the construction of sub-sections, the assembly of grand sections and the final connection of grand sections in the dock. Plates coloured red represent DNV NV2-4 steel and the green ones indicate standard shipbuilding steel. The hull sections are welded together in the dock to form the hull of the ship. The tanks are completed at the yard before being lowered into the hull. After this, the prefabricated top side including the deck is attached, together with the processing installations (Figure 4).

The welding of DNV NV 2-4 low-temperature steel

Although steels according to DNV class NV2-4 are developed for low-temperature service, they contain only a small amount of alloying elements and have a relatively low carbon equivalent. In the thickness range used by the Gdynia Yard (12, 20 and 28 mm) to construct the tanks, no preheating is required. However, to avoid the loss of HAZ impact toughness, there are limitations to the heat input and the interpass temperature.

From the point of view of the weld metal, extra care is required to avoid the loss of low-temperature impact toughness. The consumables used by the Gdynia Yard

Figure 2. Cross-section of an LPG tank consisting of two independent compartments. The red lines are DNV NV 2-4 class steel and the green lines are standard shipbuilding quality.

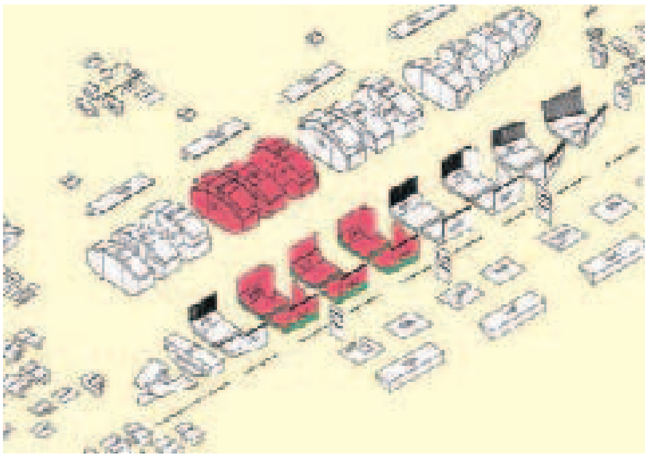


Figure 3. Exploded view of the tanker, showing construction stages.

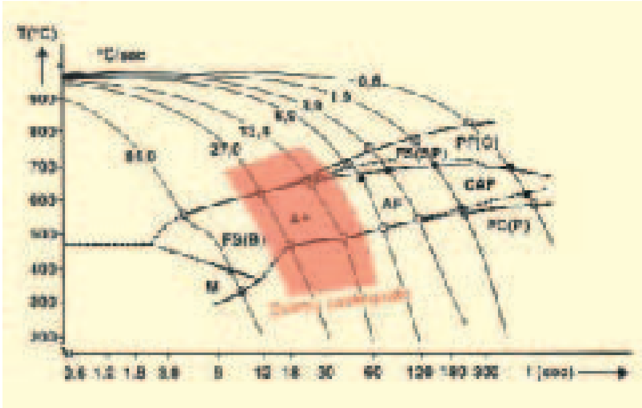


Figure 5. CCT diagram of CMn-Ti-B weld metal.

for welding DNV NV 2-4 steel fall into two categories; basic for SAW and MMA and rutile Ti-B micro-alloyed for FCAW.

Basic consumables produce a low-oxygen ferritic weld metal, consisting mainly of large amounts of somewhat soft grain boundary ferrite and acicular ferrite. The low-temperature toughness depends on the quality of the soft grain boundary ferrite in the microstructure and is further improved by 2.5% Ni-alloying. The microstructure and toughness can be spoilt in two ways. When the heat input is too low, bainite or martensite may appear as a result of the overly rapid cooling of the weld. When it is too high, the ferrite becomes coarse.

For rutile, Ti-B micro-alloyed flux-cored wires, low-temperature toughness is based on the presence of large amounts of fine acicular ferrite. In line with basic consumables, the micro-structure is spoilt when bainite or martensite is introduced when the heat input is too low (see Figure 5). With high heat inputs, however, grain boundary ferrite appears at the expense of acicular ferrite, with an even more detrimental effect on the toughness.

When it comes to the welding of DNV NV 2-4, this means that the heat input has to be within a certain range to be assured of the correct weld microstructure. ESAB recommends a heat input range of 1 to 2.5kJ/mm for the consumables described under the next heading "welding consumables". The welding techniques that are used to build up the joint differ from normal shipbuilding practice and are more in the direction of welding for offshore fabrication. Although preheating is not required for DNV NV 2-4 (as with many offshore steel grades), the interpass temperature must be limited. Full weaving, a very common shipbuilding technique, should be avoided as much as possible because it can take the heat input beyond critical levels. The split-weave or stringer bead technique, both offshore fabrication methods, may be less productive, but it ensures the correct weld microstructure with corresponding good low-temperature impact values.

ESAB has been involved in many LPG projects as a supplier of welding consumables and equipment. In many cases, the company has provided the welder with training and assistance in setting up suitable welding procedures. It has often proved necessary to instruct welders in the right techniques to obtain the desired low-temperature weld metal impact toughness. Special support was given to Gdynia to get it started with the cored-wire welding of the LPG tanks of the carriers currently under construction.

Figure 4. LPG carrier about half way through the production process. On the left-hand side, the top side of the carrier has been attached. On the right, the tanks (covered with insulation material) are still visible.

Welding consumables

To construct the tankers, an innumerable number of panels have to be fabricated, to be connected to sub-sections and grand sections and finally to arrive at the

%C	%Si	%Mn	%S	%P	%N	CE (C+Mn/10)
<0.14	0.15-0.50	0.70-1.60	<0.035	<0.035	<0.009	<0.32

Rm (MPa)	Re (MPa)	A5 (%)	CVN/–55ºC (J)
400-490	255*	>24	>27

Table 1. Chemical composition and mechanical properties for DNV NV 2–4 low-temperature steel.

dock assembly of grand sections. Various welding processes are applied. Wherever possible, mechanised welding is used for increased welding productivity, but manual welding is obviously indispensable for fit-up work and the connection of sub- and grand sections, as well as in dock assembly. Three welding processes prevail; MMA, SAW and FCAW. For the LPG tanks in DNV NV 2-4 steel and the hybrid connections between the tanks and the normal ship quality steel hull, the ESAB consumables listed in Table 2 are used.

OK 73.68 is a basic, 2.5Ni-alloyed LMA electrode with a recovery of 120%. It provides good impact toughness, even in the vertical-up position.

FILARC PZ6116S is a rutile, all-positional cored wire with Ti-B micro-alloying (+1.5%Ni) for use in CO_2 shielding gas.

OK Flux 10.62 is a high basic agglomerated flux (basicity index 3.4), suitable for single and multi-run welding in both butt and fillet welds. It has excellent slag detachability and smooth side-wall blending. In combination with OK Autrod 12.32 (DIN: S3), it produces good CVN impact properties down to –60ºC.

The typical all-weld metal chemical composition and mechanical properties are shown in Table 3.

Figure 9. FCAW under CO_2 gas protection with PZ6116S.

Figure 10. Outdoor FCAW with PZ6116S.

Figure 11. LPG tank under construction.

Fabrication welding

Two main SAW applications can be found in the fabrication of panels. Figure 6 shows the attachment of profiles using double-sided tandem welding with the SAW combination OK Autrod 12.32/OK Flux 10.62. Figure 7 shows the same wire/flux combination used with a tractor for shorter weld lengths.

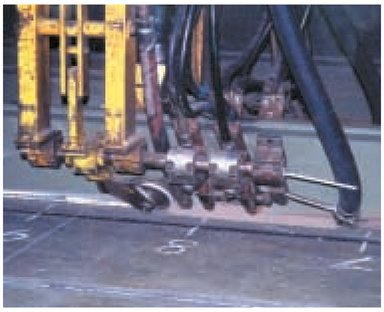


Figure 6. Double-sided SAW welding with OK Autrod 12.32/OK Flux 10.62.

Figure 7. Single-sided SAW welding with OK Autrod 12.32/OK Flux 10.62.

Figure 8. MMA welding with OK 73.68.

Another important SAW application is the connection of plates to panel walls with butt welds using double-sided welding. Figure 12 gives a characteristic welding procedure specification. Note the maximum interpass temperature of 150ºC, which is stipulated for all welding of DNV NV 2-4.

MMA is applied to a limited extent only, mainly for fit-up work in the construction of the sub- and grand sections of the LPG tanks. Figure 8 shows MMA welding with OK 73.68, a very versatile consumable for this kind of work.

FCAW is being used increasingly to replace MMA in order to produce increased welding productivity, especially in positional welding. It provides a fine spray arc at all applicable welding currents, making it easy to control the heat input in vertical-up welding and the welding of root passes on ceramic backing strips, for example. It is used indoors for manual fit-up work (Figure 9), as well as outside in the fabrication of sub-sections (Figure 10) and the connection of tank segments to complete tanks, where it is used for the main vertical assembly welds. The use of CO_2 shielding gas makes the wire more suitable for work outside in windy conditions than types using Ar-based mixed gas. Figure 13 shows a

For MMA	OK 73.68	EN 499: E 46 6 2Ni B 32 H5	AWS A5.5: E8018-C1
For FCAW	PZ6116S	EN 785: T 46 6 1.5Ni P C 1 H5	AWS A5.29: E81T1-K2 J
For SAW			
	OK Flux 10.62/ OK Autrod 12.32	EN 756: S 46 6 FB S3Si	

Table 2. ESAB welding consumables for DNV NV 2-4.

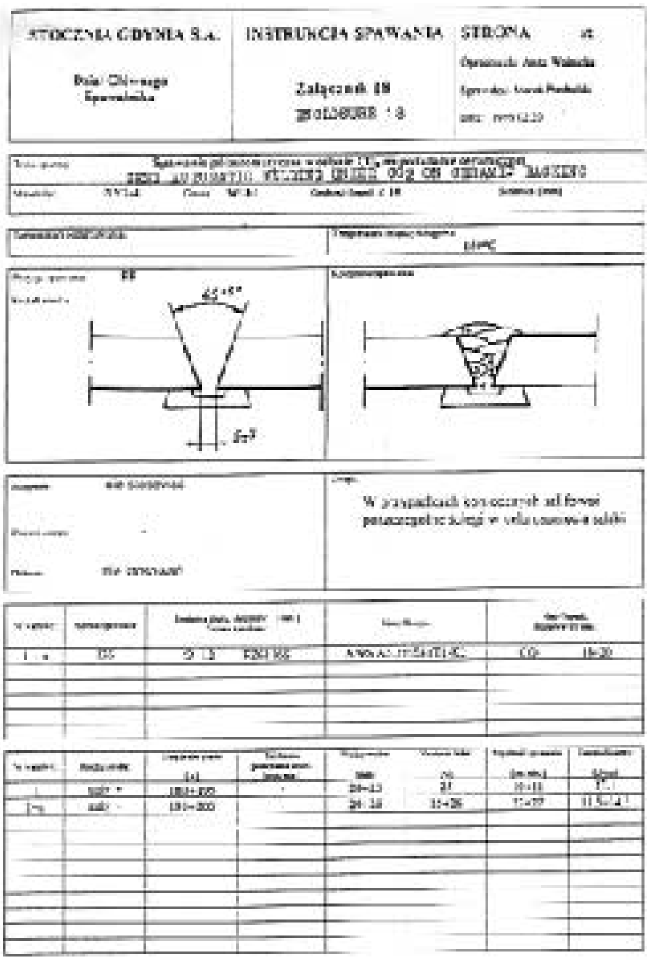
	%C	%Mn	%Si	%Ni	Rm (MPa)	Re (MPa)	A5 (%)	CVN/–60ºC (J)
OK 73.68	0.05	1.0	0.35	2.4	610	520	26	105
PZ6116S	0.05	1.3	0.4	1.5	615	550	25	75
OK Autrod 12.32/ OK Flux 10.62	0.07	1.4	0.3	–	580	475	28	90

Table 3. All-weld metal chemical composition and mechanical properties of ESAB consumables for DNV NV 2-4.

welding procedure specification for welding DNV NV 2-4 in the PF position.

Conclusion

ESAB is supplying the Gdynia Yard with a complete package of consumables for welding LPG tanks in DNV NV 2-4 low-temperature steel. The package includes consumables for MMA, SAW and FCAW. ESAB's assistance with educating the welders and the establishment of welding procedures, in particular for FCAW, has contributed to the successful fabrication of the tanks.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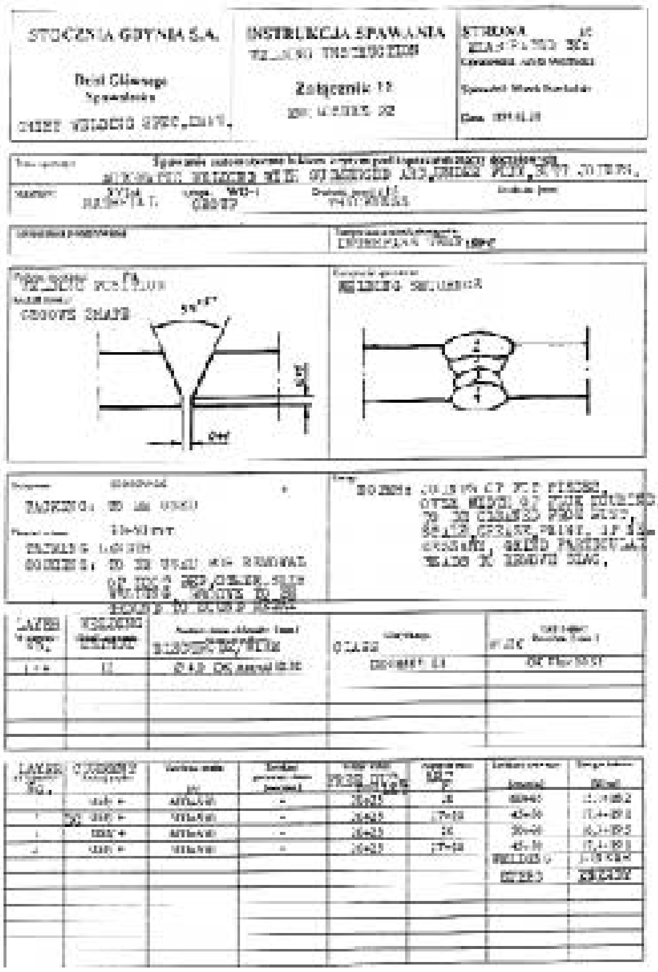
Załącznik 18

Figure 12.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Załącznik 11

Figure 13.

FILARC PZ6105R The robot-friendly cored wire

by Tapio Huhtala, ESAB B.V., the Netherlands

In Svetsaren 98/3 and 00/1, we introduced PZ6105R, ESAB's metal-cored wire for robotic welding, and described its use for the fabrication of excavator frames in medium to thick steel, as well as the fabrication of thin-plate automotive components.
This article focuses on ESAB's aim to work closely with clients on different projects involving mechanisation in our desire to sharpen their competitive edge. Some additional applications will be presented in the field of thin-plate welding, including new applications from the automotive industry.

The markets nowadays are becoming increasingly large and transparent. This tendency offers commercial potential to individual fabricators, but at the same time it can entail a threat. Established companies are experiencing increasing competition from newcomers in their branch of industry operating at international level. In order to remain competitive, they have to re-assess their business and change their market approach. They frequently conclude that a new growth strategy is impeded by what are known as limiting factors which affect the way they run their company.

These limiting factors may be encountered in the supply of raw materials, the availability of labour, production capacity, warehouse capacity, financing, market demand and the delivery of finished products to end users. A bottleneck in one or more of these links in the production and marketing chain may account for the difference between success and failure for the whole company.

A shortage of skilled labour, for example, is a problem many fabricators are coping with in today's booming economy. Being successful calls for a creative approach when it comes to recruiting new staff, re-educating one's own personnel, mechanisation, or even outsourcing work to specialist firms.

The same goes for stocks. The market demand may justify a higher stock level, but at the same time companies are trying to minimise the amount of money invested in stocks. Creative solutions are found in modern stock management systems such as EOQ (Economic Order Quantity), JIT (Just In Time) and MRP (Materials Requirement Planning).

In the area of financing, renting or leasing can be considered when traditional financing instruments represent a limiting factor.

Welding, a necessary production step for many fabricators, can also constitute a bottleneck in the production chain. This bottleneck can be concentrated at the welding station itself, but it is very often a combination of fabrication steps associated with welding, such as high repair and scrap rates.

Co-operation with fabricators

ESAB makes its knowledge of welded fabrication available to the automotive industry by participating in projects that aim to increase the competitiveness of individual fabricators in this field. In the assessment of the welding situation and the implementation of more productive solutions, always in close co-operation with the fabricator, different types of problem emerge.

One that is more or less standard is the lack of time on the part of the fabricator who is often caught up in a very tight production schedule. Further down the line, there may be preoccupations about running tests on production lines at the risk of causing unacceptable downtime. Very often, the availability of a skilled robot programmer is a problem that stands in the way of effective testing on the customer's site.

ESAB has recognised these problems and has developed its own test facilities to minimise on-site testing as far as possible and thereby the impact on the fabricator's normal production set-up. When on-site testing becomes necessary, the type that has the least effect is chosen, for example, by utilising the weekends or other times when regular production is stopped.

This working process is explained in more detail below.

Working process

Phase 1

In every case, the projects begin with a thorough evaluation of the production situation by skilled people from ESAB working together with the fabricator. Subjects such as needs, requirements, determination of bottlenecks, limitations related to welding equipment and torch positions, discussions about present problems and so on are covered.

When there is agreement that there are significant benefits to be gained, the project proceeds into phase two. This consists of welding trials at one of our welding application laboratories on samples supplied by the clients.

Phase 2

At the present time, ESAB has two locations (Utrecht in the Netherlands and Göteborg in Sweden) where more advanced tests including robot welding can be carried out. During the tests, the fabricator's situation is copied as closely as possible. If, for example, the freedom is given to test other gases, this is done to see whether any additional benefits can be obtained. Quite frequently, clients have a central gas network supplying a specific shielding gas, so a change of shielding gas is then out of the question. After the welding trials, the results are carefully evaluated and reported back to the clients. Assistance with cost calculations can also be provided in cases where sufficient information has been received.

When the results of the welding trials show for some reason that no additional benefits will be gained by implementing the findings, the project is terminated. When the outcome is positive, it is up to the fabricator to decide if and when he wants to move into phase three, on-site testing. The major benefit provided by ESAB by working in this way is, quite naturally, a minimum impact on the company's own production. The only risk the fabricator takes is the cost of the samples sent to the welding application laboratories.

Phase 3

During phase three, welding trials are performed on site under ESAB's guidance using the company's own equipment and new evaluations, based on the values obtained, are made. The time span of the on-site testing varies. Sometimes a short on-site test is followed by a long-term one. After a careful evaluation of the data that are obtained, it is up to the company to decide whether or not to transfer its process.

Some examples are given below of projects carried out using this approach. As many fabricators, especially in the automotive industry, are not keen on publishing information about their production, we refrain from mentioning the names of the companies involved. Moreover, all the data presented here are values obtained after phase two in the different projects, i.e. after tests at our welding application laboratory in Utrecht.

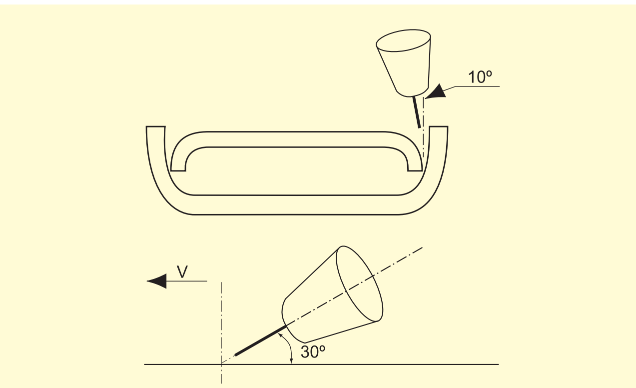


Figure 1. Safety component

Application 1
Welding a safety component for trucks

The problem definition:

- Lack of fusion caused by the torch being directed more towards the inner ring. The reason for this torch position is to avoid melting the outside edge of the sample
- The spatter level is too high, resulting in an undesirable amount of post-weld grinding
- The productivity of the welding station is too low, i.e. it is a bottleneck in the production process

Figure 1 shows a cross-section of a safety component for trucks. The parent material is equal to St 37.2 with an outer diameter of 100mm and a thickness of 4.5mm. These parts have been welded with SG2-type solid wire, diameter 1.2mm, using the pulse technique and a welding speed of 14.5 mm/s.

Like all the other tests described below, the application research was performed with an ABB IRB 1400 welding robot and an ESAB Aristorob 500 power source. Suitable parameters for welding the circular weld were found at 398A/6V/10m/min. at 25mm stick-out length. The travel speed obtained was 1.3m/min. A gas mixture of $90Ar/10CO_2$ was used as gas protection.

Figure 2. Safety component welded with PZ6105R

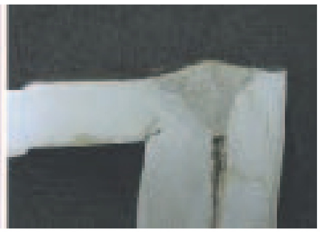


Figure 3. Etched cross-section

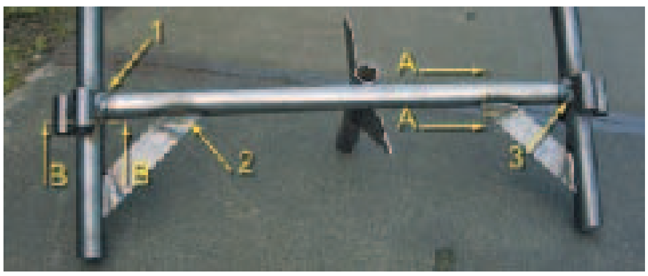
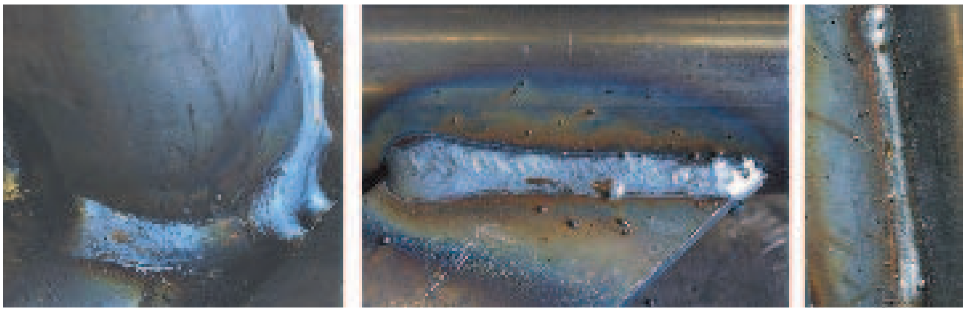


Figure 4. Scaffolding component



Figures 5,6,7. Solid wire welds 1,2,3

Figures 8,9,10. Welds 1,2,3 made with PZ6105R.

Figure 11. Etched cross-section A-A of a scaffolding component welded with PZ6105R.

The results showed a 38% increase in welding speed and the samples were free from spatter. The burn-in profile and bead profile were good without any melting of outer edges, suggesting significant potential for a productivity increase as a result of a reduced scrap and repair rate.

Figure 2 shows the component after being welded with PZ6105R using the above-mentioned parameters. Figure 3 shows a cross-section of the weld. It can be seen that the weld is relatively flat with good penetration, without melting the outer edge, in a series of tests repeatedly meeting all the quality objectives set by the client.

Application 2
Welding scaffolding

The problem definition:

- Excessive spatter level necessitating post-weld cleaning
- The productivity of the welding station is too low, i.e. it is a bottleneck in production

A non-automotive, yet interesting, application, involving the welding of 2.2mm thick tubes to produce scaffolding. The client uses robot welding together with 1.0mm diameter solid wire under 80/20 Ar/CO_2 gas protection, using conventional MIG power sources.

Figure 4 shows a reference sample taken from the client's production. The numbers indicate the different types of weld, whereas the letters show the locations from which transverse cross-sections were taken from samples produced with PZ6105R. Figures 5 to 7 show the solid-wire welds corresponding to the numbers 1 to 3 in Figure 4.

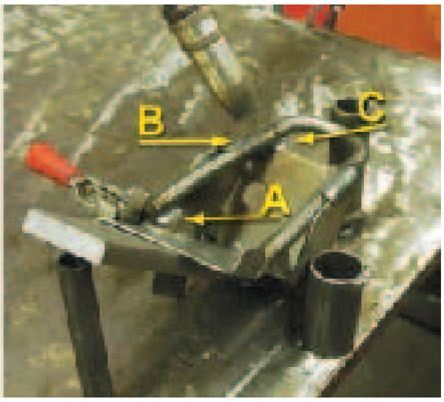
The same welds, now performed with PZ6105R using the same shielding gas, are shown in Figures 8 to 10. The welds are flatter and spatter is virtually absent. A transverse cross-section taken from location A and representative of the type of penetration obtained is shown in Figure 11.

The results showed that the spatter could be almost eliminated. There is potential for increasing productivity by more than 40% and a corresponding cost reduction/ sample of more than 20%.

Figures 12a, b and c show the results of tests performed on another scaffolding component from the same customer. The problem definition is the same as for the previously mentioned component.

Equally good results were obtained in terms of spatter. The productivity increase and reduction in production costs were even larger than the above-mentioned figures.

Figures 12a,12b,12c. Another component (12a) welded with solid wire (12b) and with PZ6105R (12c).



Figures 13,14. Tow eyelet welded with solid wire and special fixture (14) for robotic tests with PZ6105R.

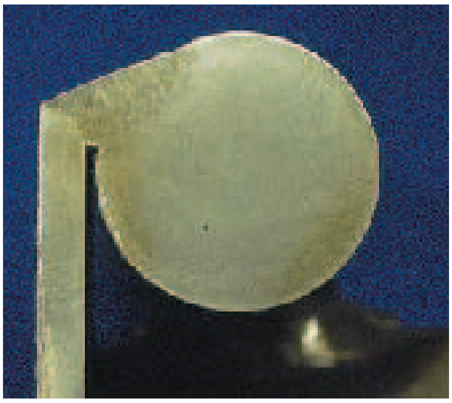


Figure 15. Cross section of weld B in figure 14.

Figure 16. Exhaust pipe hook

Application 3

Welding tow eyelets and hooks for exhaust pipes

Problem definition:

- Productivity at the welding station is too low
- The welding station is a bottleneck in the production process

The third example deals with the welding of tow eyelets with a plate thickness of 2mm (Figure 13). The steel bar which has to be attached has a diameter of 12mm. Oil residue is frequently present on the 2mm plate. This work is currently done at a robot station with 1.2mm diameter solid wire under $90Ar/7.5CO_2/2.5O_2$, using conventional MIG power sources. The welding is done in the PB position at a travel speed of 0.8–1.0 m/min.

To perform the tests, a fixture was constructed for the components (Figure 14). The letters indicate the locations of the different welds. Figure 15 shows a transverse cross-section of weld B. It is clear that the weld quality is good. Suitable parameters were found around 290A/23V/8 m/min. at a travel speed of approximately 1.62 m/min. for welds A to C (20mm stickout), accounting for an increase in travel speed of around 70%.

In combination with the above-mentioned application, another welding trial was conducted on hooks for exhaust pipe systems (Figure 16). This component is produced at another robot station. It was not as urgent for the customer to increase productivity at this station as it was in the previous application. These tests were conducted for future needs. The welding was done in the PB and PG positions. Currently, solid wire ∅ 1.2mm is used under $90Ar/7.5CO_2/2.5O_2$ shielding gas. The welding speed for the major long weld deposited in the PG position is 1.2 m/min.

Welding speeds in the range of 1.4–2.0.m/min were achieved. The higher welding speed is valid for the long weld deposited in the PG position.

Summary

The competition within industry is increasing, forcing companies to re-assess their business situation. Identifying limiting factors has become increasingly important. There are some problems that companies have to deal with when working with process improvements. They include lack of time, limited access to robots and programmers and the risk of lost production associated with running on-site tests during normal production time. ESAB has recognised these problems and works together with a number of clients in a flexible manner, offering minimised risk levels and increasing the probability of success for clients.

For more information, please contact your local ESAB organisation.

About the author

Tapio Huhtala is a product manager for unalloyed cored wires at ESAB B.V. in Utrecht in the Netherlands. He joined ESAB in 1993 and worked as a research metallurgist in Goteborg until 1998.

ESAB's submerged arc solution for efficient trailer beam fabrication

by Shaun Studholme and Derek Harvey – ESAB UK Ltd.

Metal Design and Fabrication, MDF, a trailer beam fabricator located in Antrim, Northern Ireland has obtained a major increase in manufacturing output by installing a custom made ESAB twin wire submerged arc welding system using OK Tubrod 14.00S metal cored wire with OK 10.71 agglomerated flux.

MDF

MDF is a successful fabricator of trailer beams supplying frames to the major truck manufacturers in the UK as well as several countries on the European mainland and are expanding rapidly.

To enable them to meet the increasing demand for their products, they decided to invest in a new submerged arc welding system for the fabrication of their mainstream beams (figure 1), replacing their old double headed single wire SAW installation using solid wire.

ESAB were awarded the contract after having presented a solution that provided increased welding productivity as well as flexibility for the various designs of beams that MDF produce. Along with the installation of the new system, MDF reorganised their workshop layout to optimise the efficient supply of beam components to the welding station. Having used the new welding unit for over a year, MDF claim that it is 3 to 4 times more productive than before, depending on the type of trailer beam.

Figure 1. MDF's custom made ESAB twin wire submerged arc welding system. At the request of MDF, part of the photograph has been blurred.

Double headed twin-arc SAW installation

The manipulator type MBVA 550 is mounted on a compact track, which requires a minimum amount of floor space. It is sited so that the unit can travel along the length of two side-by-side welding fixtures, welding one assembly while the second unit jig is being unloaded and re-loaded. The column is fitted with 180 degree rotation to allow for positioning the boom over the fixtures. The carriage carries a special OPC flux recovery unit, and a TPC 75 pressure tank for delivering flux to the two A6 welding heads, which deliver twin wires via bent D20 contact tubes. The arrangement allows for welding web widths from 70mm to 800mm. A VEC motor giving a tacho feedback into a PEG 1 control unit provides accurate carriage travel along the track that is long enough to cover the fixture and parking areas.

The welding heads are positioned and guided along the length of the beam by GMD guidance units, which control the vertical slides, and complete horizontal carriage allowing for motorised movement along the full length of the boom.

Welding voltage and current are pre-set and continually monitored by two PEG 1 control units, giving constant stable conditions.

For safety and optimum use of space, the welding and control cables are housed in a cable chain that is fitted within the rail assembly. The cables run the full

OK Tubrod 14.00S (with OK Flux 10.71)	AWS A5.17-89: F7A2-EC1
OK Flux 10.71	EN 765: S A AB 1 67 AC H5

Table 1. Wire and flux classifications.

length of the track, between the carriage and floor sited LAE welding power sources.

Apart from the welding parameters, all controls are fitted on a remote control unit, which can be hand-held by the operator while positioning and welding the beams.

Welding consumables

Included in ESAB's proposal was the use of the cored wire/flux combination OK Tubrod 14.00S-Ø2.4mm/ OK Flux 10.71, equipping MDF's SAW installation with this proven consumable package for high speed fillet welding.

OK Tubrod 14.00S is a metal cored wire providing a deposition rate that is up to 20% higher than a solid wire of the same diameter, depending on the welding application. It has been designed for use with OK Flux 10.71, an agglomerated, aluminate-basic flux that is slightly Si and Mn alloying. Table. 1 gives the wire and flux classifications.

The combination is used when high integrity welded joints are required in mild and medium tensile steels, providing an excellent bead appearance in single and multi-layer butt and fillet welds with good impact toughness down to –20ºC. It is suited for both single wire and twin wire applications. The slag detachability is good, also in narrow joints.

The MDF application consists of the simultaneous welding of two fillet welds with twin arc heads in the PB position (see photo). The flat strip varies in thickness from 4–8mm, whereas the vertical plates have a thickness between 8–20mm.

One advantage reported by MDF is that the wire/flux combination gives a round, but relatively flat bead penetration. Even when welding 8mm sheet, no burn-through problems occur, as encountered regularly with the old station using solid wire.

A second benefit is that the various beams, regardless the material thickness, can be welded at the same parameter setting of 580A/29V and 130cm/min. travel speed. This avoids the time consuming resetting of parameters which adversely effects the production efficiency.

A third advantage reported is the better slag detachability, saving time in the manual removal of slag.

Further, MDF are very satisfied with the appearance of the welds especially the blending of the toes. The latter is crucial for trucks, since the dynamic load they are subjected to can lead to the formation of fatigue cracks when welds do not smoothly blend with the plate material.

Coupled with the greatly increased productivity these benefits have helped to ensure that MDF remains at the leading edge of trailer beam manufacture.

Figure 2. SAW with OK Tubrod 14.00S/OK Flux 10.71. Note that the slag is self releasing.

Figure 3. The self-released slag is easily removed.

Figure 4. Bead appearance. The standing fillet weld is flat with a smooth blending of the toes.

About the authors

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Derek Harvey joined ESAB in 1983 as a Service Engineer, and became a member of the arc-equipment technical department, based at Waltham Cross some years later. In 1993 he was appointed Sales Manager for Welding automation Equipment and has responsibility for the sale of automatic SAW, MIG/MAG, and mechanised TIG equipment.

Newly-developed consumable makes thin-plate welding more effective

by Lars-Erik Stridh, ESAB AB, Göteborg

As a result of increasingly fierce competition from low-cost countries, rapid changes are taking place within the welding industry in Europe. A large part of the heavy welding industry is moving its production eastwards, to countries with low labour costs, leaving behind it industries with skilled and mechanised welding. Europe has a number of major automotive producers with many suppliers, most of whom have introduced robotic welding into their production process.

The consumables these robots use for welding are generally solid wire with a diameter of 1.0mm. The shielding gas is often a mixed gas with a third component to minimise spatter. Continuous developments are taking place within automotive production when it comes to systems for joining sheet metal. These systems include bonding, resistance welding, MIG soldering, laser welding and closing-head rivets. Arc welding still maintains a powerful position in present-day automotive production and, depending on the brand, there are between one and two kilograms of weld metal in every vehicle.

Robotic welding increases at a relatively constant rate every year. The number of arc welding robots rises by around 10% every year in Europe. In the automotive industry, these robots are usually included in advanced cells containing several robots that work together in a production chain. In the fiercely competitive situation that currently exists, it is vital for the automotive industry and its suppliers to make this production process as efficient as it can possibly be.

Interior from the robot cell in Göteborg where a front suspension part is test welded with OK Tubrod 14.11 Ø 1.4 mm.

Background

The requirements that are set for welding for different components for the automotive industry are naturally rigorous. After all, the vehicles that are involved are going to transport people and attempts are constantly being made to find lighter materials to reduce the weight. This is done to economise on natural resources and cut fuel consumption, but, at the same time, the safety standards for passengers are being constantly stepped up. The plate thicknesses are small and homogeneous wire is generally used. One of the problem areas is penetration. The measurement precision of the sheet-metal components which are going to be welded together varies. This means that the joints are slightly different and their position varies somewhat. This is a problem, as the arc from a ∅ 1mm homogeneous wire has a small diameter, making the penetration profile narrow and thereby sensitive to joint tolerances. In practice, this means that welding defects such as incomplete penetration or perforation easily occur.

It is also important that the transition between the parent metal and the weld run is uniform and smooth. In other words, the fatigue strength must be high. This characteristic is becoming increasingly important as more and more high strength steel is being used in structures to save weight by reducing plate thickness

Productivity and cycle times in the robot cell are very important when it comes to keeping costs down. As a result, attempts are made to increase the welding speed whenever possible. This leads to another important factor – the hardness of the weld metal and the HAZ (heat affected zone). The heat that develops in the arc from a homogeneous wire is relatively low and this results in rapid cooling and the risk that the hardness will be too high and the weld joint will therefore be brittle.

Example of the very good penetration also at high welding speeds, in this case 27 mm/sec.

New approach

ESAB's process know-how and collaboration with different suppliers to the automotive industry and with the automotive industry directly, in combination with these customers' production expertise, has resulted in a new concept for welding thin plate, which can now be used successfully within the automotive industry.

When it comes to welding thin plate, most people assume that they should use solid wire with a small diameter. Few of them consider using a metal-cored wire with a larger diameter. However, this is exactly where developments have led – namely to robot welding using a metal-cored wire with a diameter of 1.4mm.

The product is called OK Tubrod 14.11. It is a welding wire that has been developed to suit robot welding. It is therefore easy to feed, as it must not cause feed disruptions. The arc is stable and produces a minimum of spatter and one very important characteristic is that it is possible to weld with high currents and relatively low arc voltage with no reduction in arc stability. This has been made possible by target-oriented development work.

A very common joint; overlap. Plate thickness is 1.5mm and welding speed in this case 32 mm/sec.

Customer applications

The following example illustrates the advantages. A supplier to the automotive industry welds many different small components. The company uses ∅ 1.0mm solid wire and, to obtain the widest possible penetration, it uses pure carbon dioxide as the shielding gas. Six robots work together in a robot cell. A centrally-located welding table is filled with six identical components and it then rotates one-sixth of a revolution after each welding operation. The six robots weld different parts of the component simultaneously, which means that the welding times are different and some robots have to wait a few seconds while the others finish welding. The waiting times are not that long – anything from four to ten seconds – but, in view of the fact that there are six welding operations in the total cycle, the total waiting time can be a minute or two. The refilling time in the cell is short and the cell welds continuously, so there can be as much as an hour of non-productive time during the course of a day. Over a month, this makes 20 hours. The production cost in an uncomplicated robot cell with one robot, one positioner and one operator is around SEK 1,000 an hour. The production cost in a complicated robot cell with six robots is naturally much higher. So the cost of this ”waiting time” is very high.

As this company is currently operating at maximum capacity when it comes to what solid wire can achieve while maintaining approved quality levels, tests were conducted using OK Tubrod 14.11, ∅ 1.4mm. In the tests that were conducted using a robot at the ESAB Welding Centre in Göteborg, it was found that the welding speed could be increased from 18 mm/sec for solid wire to 30 mm/sec for flux-cored wire. This means that the whole of the waiting time described above could be eliminated for some robots and that the total cycle time could also be reduced by synchronising the welding speed of the robots.

The photographs show examples of the surface appearance and penetration during these welding tests.

Another example from another supplier who also welds components for the automotive industry is shown

Part from car industry Weld length: 31 cm.	Solid wire	OK 14.11	Difference
Cycle time (s)	58.6	40	–31%
Welding speed (m/min)	0.6	1.5	+150%
Welding time (s)	31	12.4	–60%
Robot motion time (s)	27.6	27.6	
Cycle time/unit (s)	58.6	40	–31%
Reloading time (s)	10	10	
Number of units/h	52	72	+38%
	OK 14.11	**Solid wire**	
Wire consumed/unit (kg/unit)	0.014	0.014	
Wire price (£/kg)	4:36	0:77	
Wire cost (£/unit)	0:0612	0:0106	
Shielding gas consumed (m^3/unit)	0.014	0.018	
Shielding gas price (£/m^3)	2:83	2:47	
Shielding gas cost (£/unit)	0:0400	0:0400	
Energy cost (£/unit)	0:0047	0:0047	
Robot + operator cost (£/h)	103:06	103:06	
Robot + operatos cost (£/unit)	1:43	1:68	
Total cost (£/unit)	**1:55**	**1:73**	

in the table. In this table, the cost is presented for the previous method of welding with 1.0mm solid wire and is compared with the results for the same component using OK Tubrod 14.11, Ø1.4mm cored wire.

Advantages

The reason why the use of this relatively thick, metal-cored wire, OK Tubrod 14.11, has been given such a good reception is quite naturally largely due to the opportunity to reduce the total cost by cutting the cycle times as a result of the improvement in productivity. In addition, the welding quality is also enhanced. The run geometry produces a smooth, fine transition to the parent metal. As penetration is wider and more reliable, welding is now also more tolerant as far as gap variations are concerned, thereby reducing the number of welding defects and the number of rejects. This represents savings that directly affect the profit margin. What is more, the amount of spatter from the wire is also lower, thereby reducing the number of stoppages to clean fixtures. Furthermore, the cleaning of gas hoods which the robot performs at the cleaning station is reduced by 50%, with the result that the cycle time is even further reduced.

Summary

There is excellent potential for streamlining the robot welding of thin plate This applies particularly to the automotive industry and its suppliers who demand high productivity and high and reproducible quality. It is, however, important, when introducing a new consumable for welding which can cut cycle times, that the whole production chain is taken into account, in order to avoid creating a bottleneck further down the chain and thereby losing the savings that are made in the welding cell. By planning the welding operation carefully and adapting the remainder of the production chain, a great deal of money can be saved and the automotive industry in Europe can maintain its competitive edge and keep jobs in Europe.

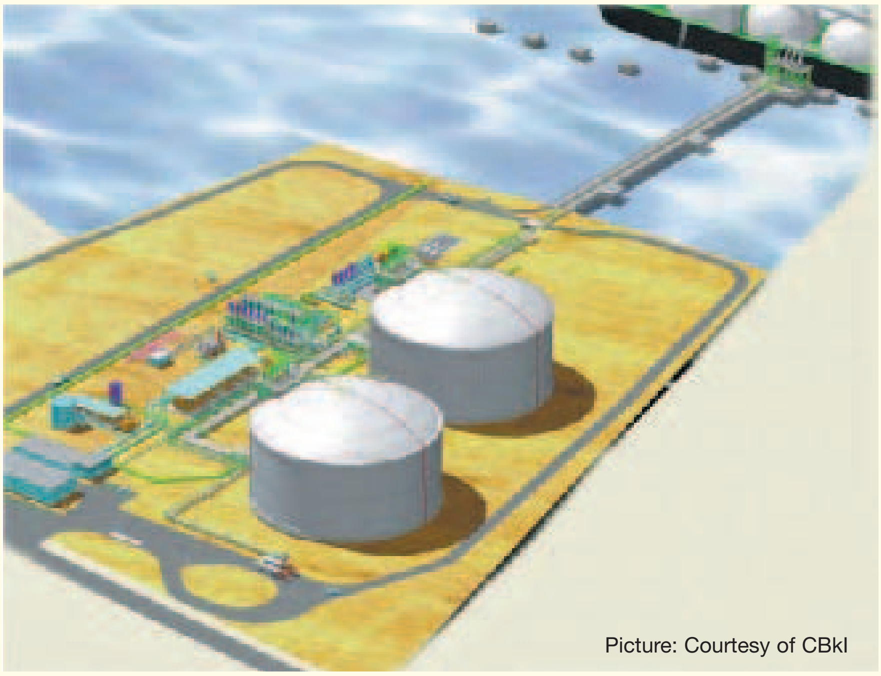
About the authors

Lars-Erik Stridh, EWE, graduated from Bergsskolan in 1982. He worked three years as a welding engineer at a repair and maintenance company in Göteborg and after that 13 years as product manager for flux cored wires at a competitive company. Lars-Erik Stridh joined ESAB in 1999, is based in Göteborg but works on ESAB's total market.

Stub-ends & Spatter

PEH Process Controller.

ESAB supplies consumables and equipment for yet another LNG storage tank project



Picture: Courtesy of CBkl

There is a growing interest in the use of natural gas as a source of energy. Much of the gas resources in the world are, however, generally located far from the main consumption areas. For this reason the need for transportation and storage of gas is increasing in many parts of the world.

ESAB has an impressing track reference in supplying welding consumables and equipment for large LNG tank constructions. The majority of the large land based tanks are constructed in 9%Ni steel and the gas is stored in a liquefied condition at temperatures below –105°C.

In May 2000 ESAB received an order for consumables and welding equipment for the welding of land based LNG tanks (140.000 m^3 each) for a gas terminal in Izmir, Turkey. (The contractor is EgeGaz and the project management is made by CB&I.)

The consumables including the electrode OK 92.45 (AWS 5.9 ENiCrMo-3) as well as the flux and solid wire combination OK Flux 10.16/OK Autrod 19.82 (AWS 5.9 ER NiCrMo-3) have been supplied and a customer designed SAW equipment, Circotech, for the 2G SAW welding inside the tank.

Would you like more information on these products, please contact ESAB at e-mail consumables@esab.se or fax + 46 31 509 170.

Great success with the new Process Control system from ESAB

The new PEH Process Controller has been well received by the welding market. So far, more then 1000 units have been delivered.

The PEH Process Controller is not only taking care of the welding parameters such as current, voltage and travel speed but optimises the best welding performance for the welding parameters, wire diameter, start, stop and the material to be welded. The unit has a user-friendly micro processor and a big display on which all the parameters are showed. The unit can also calculate the heat input and show it on its display before and during welding. It is possible to pre-set all parameters before welding and store ten different welding parameter set.

The PEH Process Controller has several menus; two for the welder and two for set-up and installation. This process controller is successfully used for stationary welding heads, tractors, column & booms and special customised solutions.

ESAB and GEISMAR co-operate successfully around Flash Butt Welding of rail profiles and rail frogs

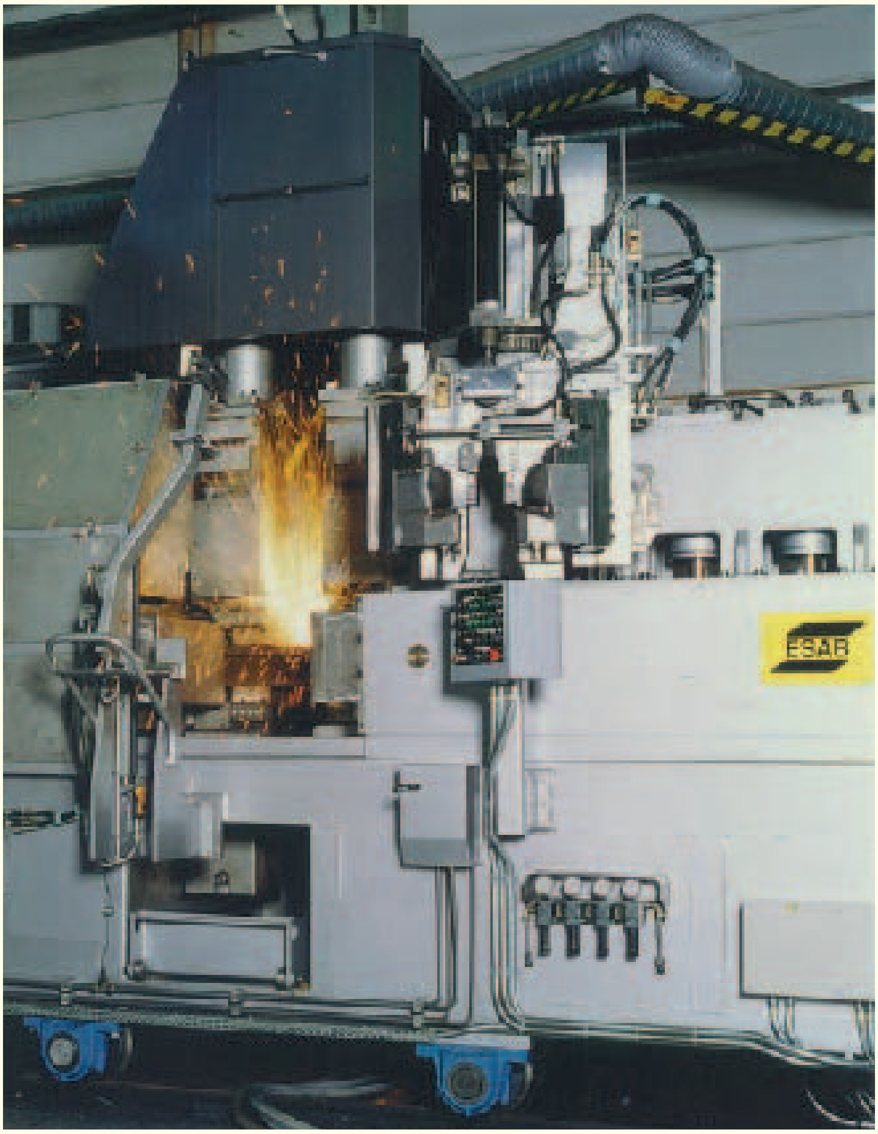
ESAB Welding Equipment AB, Automation & Engineering, has established a partnership agreement with GEISMAR Société des Anciens Établissements in France, relating to the delivery of flash butt welding machines for welding rail profiles and rail frogs.

GEISMAR has the know-how, resources and products in the field of joining of rails and frogs including equipment and processes needed to complete this process. With the ESAB welding equipment their special market organisation can now support and supply the customers with complete lines for rail joining.

ESAB and GEISMAR received their first order as a result of this co-operation in 1998. The welding machine was delivered to JR-West in Osaka, Japan in November of 1999 and is now in full production.

Another two new contracts for delivery year 2000 have been signed. The first one for Bulgarian State Railways with delivery at the end of June and the second to Latvian State Railways with delivery in November.

The parties are working closely together on new projects and there are a number of even more promising projects coming up within the near future.

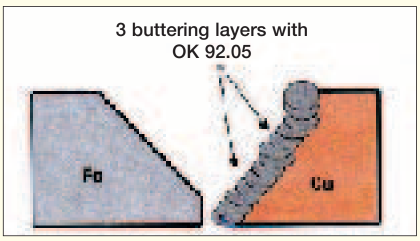


OK 92 05 improved SMAW electrode for welding pure nickel

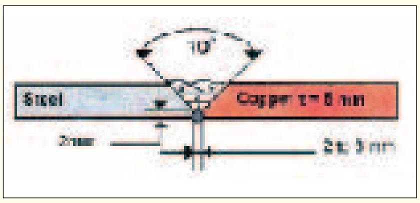
OK 92.05 is a basic type electrode for joining pure nickel in wrought and cast forms. It can be used to join dissimilar metals such as nickel to steel, nickel to copper, copper to steel and to surface steel.

OK 92.05 produces an austenitic weld metal and fulfils AWS/ SFA 5.: ENi-1. A lab application was carried out at the ESAB Process Centre in Gothenburg where copper was joined to steel. In this case, the copper was not pre-heated because of its thickness, but, in cases where thicker or larger pieces are to be welded, pre-heating in excess of 300°C is normal for copper.

A three-layer buffer area was welded onto the copper. The buffer layer was ground to obtain a total 70° wide angle and the root run was then performed with OK 92.05 ∅ 2.5 mm. The joint was filled in four passes using 3.25 mm ∅ electrodes. The interpass temperature was kept at 150°C and the object

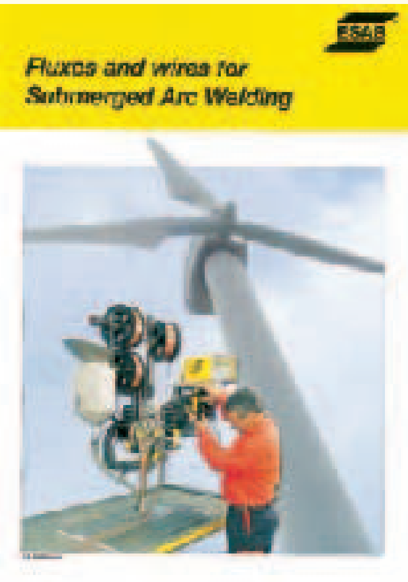


was allowed to air-cool to room temperature.



The current was 55 amps for the root run and 115 amps DC+ for the fill.
Root face 2 mm.
Root opening 2 to 3 mm.
Thickness of workpiece 5 mm.
Joint geometry 70°.

New catalogue about SAW from ESAB



ESAB has put together a 44-page catalogue about submerged arc welding. In addition to product information, it also contains useful information about the properties of different types of flux and the way these properties affect welding results. A Quick Selection Guide shows which flux and wire combinations correspond to different EN and AWS classifications, together with an explanation of the way these classifications should be interpreted. There is a special section dealing with ESAB's different packaging types, such as Big Barrel and Big Bag, which offer bulk users rational flux handling. The advantages of the new Eurospool and the Marathon Pac™ bulk pack are presented in another chapter in the catalogue.

Other valuable information provided in this new catalogue includes the way productivity and welding results are affected by the polarity of the welding current and whether one, two or three wires should be used or the addition of metal powder or cold wire. The catalogue also explains how to perform a welding cost estimate, using a calculation template.

The new SAW catalogue, which is available in English, is recommended for everyone involved with submerged arc welding. It can be ordered from ESAB's European sales companies.

World's largest cutting machine to Meyerwerft in Germany

ESAB-Hancock has received a major order from the Jos. L. Meyerwerft shipyard in Germany. To combat the competition from Asiatic yards, Meyerwerft is expanding its production capacity by investing somewhere in the order of DEM 200 million. Among other things, these investments include a totally new panel line with the most modern cutting technology.

Meyerwerft selected ESAB-Hancock for this order which is worth several million DEM. It comprises a 28 m wide TELEREX TXB 25000 panel machine, a NUMOREX 6500 trimming machine and the associated environmental equipment.

The automation level of the cutting unit and the specified precision are the highest that are technically feasible at the present time. The decisive factors when it came to capturing this order were ESAB-Hancock's technical system, combined with the high level of reliability demonstrated by previous cutting equipment which ESAB-Hancock has supplied to this shipyard.

Storage and handling of consumables

Welding defects and the subsequent repair and warranty costs can be due to negligence or a lack of knowledge when it comes to the storage and handling of consumables. ESAB is now publishing a revised version of its brochure entitled "Recommendations for the storage, redrying and handling of ESAB welding consumables".

This brochure provides instructions on the way stick electrodes and wires should be stored and how they can be reconditioned after incorrect storage. Suitable equipment for storing and drying, as well as different types of packaging which reduce the risk of moisture absorption, are also described.

A special section is devoted to the handling of flux for submerged arc welding, together with the special requirements imposed on the storage and handling of aluminium wires and flux-cored wire. This new version of "Recommendations for the storage, redrying and handling of ESAB welding consumables" is currently only available in English and can be ordered from your nearest ESAB office.

ESAB pulsed gas-shielded metal arc brazing of surface-coated sheets

by Dipl.-Ing. Hendrik Rohde, Jochen Katic and Dipl.-Ing. Rolf Paschold, ESAB GmbH, Solingen

1. Gas-shielded metal arc brazing

Brazing is a process for joining metallic materials with the aid of a melted filler (solder), the melting temperature of which lies below that of the parent metal. The parent metal is wetted, without being melted.

In Gas-shielded Metal Arc (GMA) Brazing, copper-based alloys are often used as the filler, the melting temperature of which is below that of the steel to be joined. In an ideal situation, the parent metal is not melted at the edges. Although the arc, which burns under a shielding gas atmosphere, is used to warm the parent metal and melt the filler, the process is much more like soldering. Suitable shielding gases for GMA-Brazing are inert gases like Argon but gas mixtures consisting of Argon and small amounts of active gases like Oxygen are more common. Because of that the process is called GMA-Brazing including MIG- and MAG-Brazing.

2. Area of application

Sheet steel and steel sections are more and more frequently provided with protection from corrosion in the form of an aluminium coating or layers of zinc, applied either electrolytically or by hot-galvanising. Typical areas of application are vehicle bodywork, components used in ventilation, cooling and air-conditioning equipment, household equipment, fire-resistant doors, roof and facade components in the building industry etc. Of course, many of these components have to be joined.

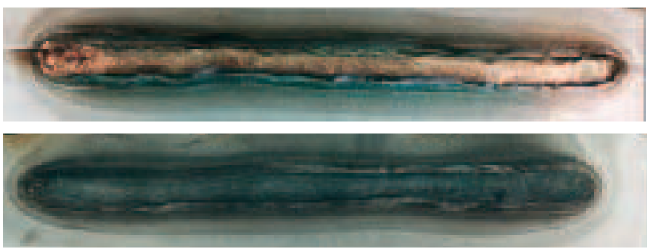


Figure 1. Front and back of a GMA brazing seam on vehicle body panels. A residual zinc coating is retained adjacent to the seam and on the back.

3. GMA-brazing is given corrosion-protection

When welding galvanised structures, the evaporation of the zinc close to the seam causes a zone which is prone to corrosion because of the lack of a protective layer. Wires of the type EN 440 – G2Sil are also used to reduce the tendency to produce pores, the weld metal from which offers no rust protection whatsoever. In this case the destroyed corrosion protection has to be restored subsequently at considerable expense, e.g. by re-galvanising. In contrast, copper wires are used in GMA-Brazing, which produce a corrosion-resistant solder. Copper is characterised by high solubility for zinc. An example of this is provided by the various brass alloys. The melting range of the CuSi3-alloy OK Autrod 19.30 is approximately 910–1025°C, the melting point of zinc is 419°C. During brazing, the liquid zinc remaining on the surface of the sheet metal is included in the solder alloy, as a consequence of which a brass solder is produced. This applies particularly to the transition between the solder and zinc top layer adjacent to the seam. In the transverse micro-section illustrated (figure 2) the bronze solder can be seen on the right side. The light yellow colouring indicates the low proportion of

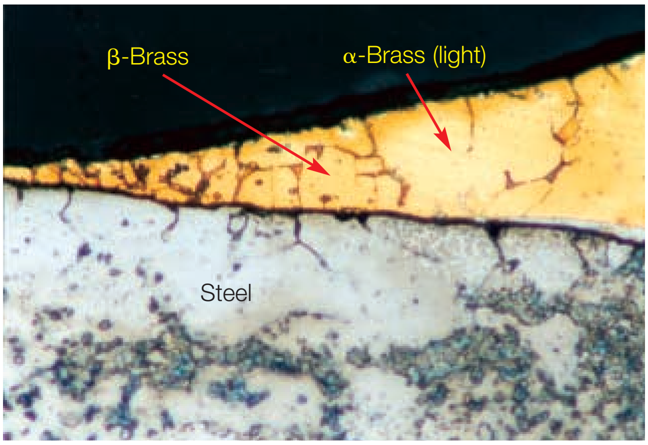


Figure 2. Transition from copper braze to galvanized base material. The braze and the zinc coating mix to form brass.

zinc. This mainly involves α-brass. As the transition from the solder to the remaining zinc layer is approached, the proportion of dark coloured areas increases. The concentration of zinc in the solder is higher here, ß-brass is present. The fluid transition from the CuSi-solder via a mixed layer consisting of brass to the zinc produces a sealed corrosion protection layer. This also applies to the back of the weld on which a residual layer of zinc is retained, even with thin sheet. The ESAB pulsed GMA-Brazing process makes subsequent corrosion protection superfluous, digital regulation of the parameters reduces the evaporation of zinc next to the seam and from the back of the sheet.

4. Heat input and Zinc vapour

The boiling point of pure zinc is 907°C. Zinc begins to evaporate from this temperature onwards. As the amount of heat input into the galvanised sheet increases, a larger quantity of zinc evaporates. The zinc vapour counteracts the transfer of droplets and deflects the droplets. Targeted transfer of droplets into the molten pool becomes impossible; the result is considerable formation of spatter and at the very least a seam with an unattractive appearance. Therefore, when GMA-Brazing the rule is: Only as much heat as necessary!

5. Pulsed GMA-brazing using the ESAB Aristo 2000-System

A few users of the GMA-Brazing process have been working to date without a pulsed arc, which is only advantageous in the PG-Position. In these cases, the process takes place within the short arc mode. The short circuits associated with this between the wire electrode and the parent metal lead to considerable spatter formation if the power source is not sufficiently well regulated. The heat input can only be controlled to an unsatisfactory extent. In addition, the welder or "brazer" must adhere to a very constant contact tube distance as even slight deviations lead immediately to considerable changes in the parameters and consequently impair the process and the result. Handling is difficult and the welder has the result "in his hands" in a very real sense.

The pulsed GMA-Brazing process with the ESAB Aristo 2000-System offers the best possible preconditions for a successful bond. As a consequence of the process, the flow of zinc vapour counteracts the arc pressure. This must be countered by using a slightly forehand torch action and especially an extremely short arc. This requirement makes very high demands on the equipment.

The digital Aristo 2000 achieves very high current rise rates with very steep pulse signal edges in order to enable small droplets to be transferred to the molten pool in a targeted way with short pulse current times. The digital regulation system has to work extremely quickly and precisely to achieve this – a requirement which the ESAB Aristo 2000-System fulfils exceptionally well.

Successful pulsed GMA-Brazing also makes high demands on the wire feed unit because the process does not tolerate even slight changes in the rate at which the wire is fed. The regulated ESAB wire feed system keeps the speed required at a constant level regardless of external disruptions.

With the ESAB Aristo 2000-System, handling pulsed GMA-Brazing is less "the driving force for the weld" because the tolerance is much greater in sofar as the distance away of the contact tube is concerned. The application of heat is reduced; where very thin bodywork sheet is concerned, there is less risk of the seam collapsing. Taken as a whole, the ESAB technology provides a better result in sofar as quality assurance, corrosion protection and the appearance of the seam are concerned.

The digital Aristo 2000 system used offers both the convenience of a synergy setting and the possibility of optimising all the parameters relevant to the process individually. The values produced can be filed on a PC-

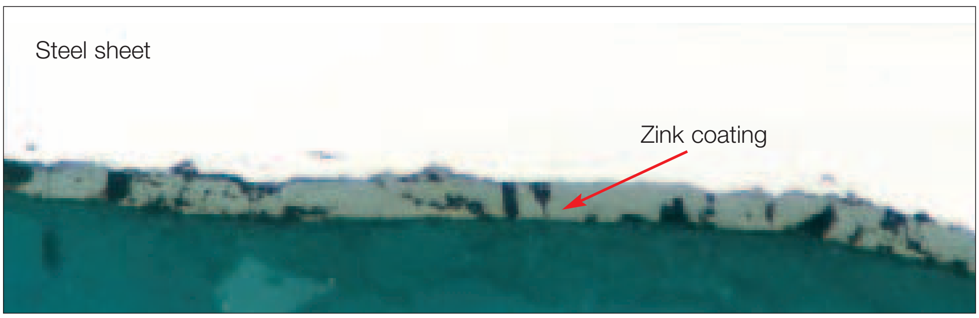


Figure 3. Transverse section through GMA -brazing seam on a body panel (s = 0.8 mm). Location of section: underside of panel. A residual zinc coating is retained.

Figure 4. ESAB Aristo 2000 – LUD 320.

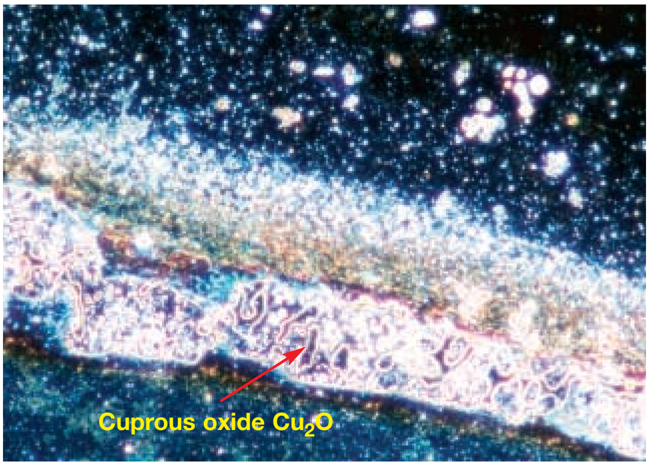


Figure 6. Dark-field image of the CuSi3 braze when using an M13 protective gas. The few eutectic precipitations contain only small fractions of Cu_2O.

memory card and loaded into the system again when required. If the arc power is to be adjustable continuously over a certain range, the user can program his own characteristic curves for synergy without entering into the system. In this way, he can combine the individuality of his optimised setting with the convenience of a synergy. Using this PC-memory card, we can also find parameters for you at our premises, optimise and store them. Then you simply load these data into your LUD and start.

6. Wire for GMA-brazing

A number of different copper wires can be used for GMA-Brazing. Normally, the 3% Si-alloy OK Autrod 19.30 (DIN 1733: SG-CuSi3) is used:

Wire	Cu	Si	Mn	Melting range °C
OK Autrod 19.30	Basis	3.0	1.0	910-1025

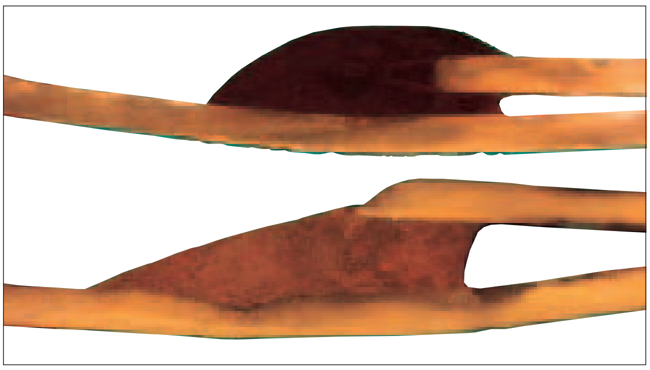


Figure 5. Transverse section through ESBA GMA-brazed joints on vehicle body panels (s = 0.8 mm) with different gap widths. The braze flows deep into the gap.

The wire diameter 1.0 mm is the main one used. Delivery is usually on 15 kg basket spools. For mechanized and fully automated systems OK Autrod 19.30 Ø1.0 mm is also available in the ESAB MARATHON PAC™ Octagonal.

OK Autrod 19.30 is particularly suitable for GMA-Brazing. Hardly any spatter is produced when combined with the ESAB Aristo 2000-System. No pores or cracking of the solder was found in the brazing specimens investigated. No scales are formed and there is only a very thin layer of slag on the surface. The ESAB OK Autrod 19.30 provides very good wetting and gap bridging (figure 5). As a consequence of capillary action, the solder flows into the air gap of overlap joints well. The relatively soft solder makes it easy to remove the weld reinforcement, in so far as this is at all necessary to produce a flat seam. When removing it, the zinc layer alongside the seam is damaged far less than is the case with hard weld metal.

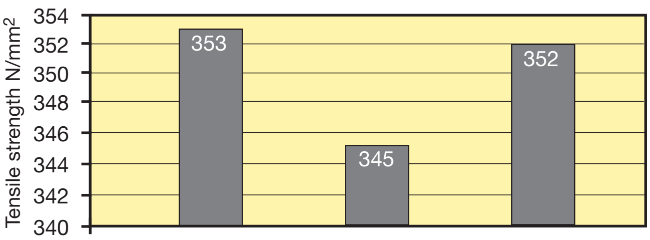
7. Shielding gases for GMA-brazing

Pure argon is frequently used in practice for GMA-Brazing. However, gases with a proportion of active gas are also suitable for GMA-Brazing, e.g. gases EN 439-M12 with CO_2-proportions of 1–3%. More recent investigations at ESAB have shown that the use of an M13 shielding gas complying with EN 439 (Ar+1% O_2) is advantageous. The surface tension of the molten pool is reduced, as a consequence of which the flow and wetting characteristics are improved significantly. At the same time the stability of the arc improves. No scales are formed in the seam and it has an excellent appearance. However, the use of shielding gases containing proportions of active gas raises a number of questions. Copper forms copper oxide (Cu_2O) when combined with dissolved oxygen. Cu_2O is deposited at the particle boundaries which can tear open during cold forming. In general, a very brittle microstructure is produced. As a consequence of the embrittling effect of the copper oxide, only well de-oxidised types of copper are deemed suitable for welding. More precise investigations were undertaken at ESAB to establish whether using shielding gases with an active gas content has a disadvantageous effect on brazed seams. It became apparent during the latte that only extremely small proportions of copper oxide can be detected in the solder and that these are only present in a small number of zones containing eutectic separations. The silicon present in OK Autrod 19.30 has a deoxidising effect and keeps the Cu_2O-proportions very low.

As small proportions of Cu_2O are only present in restricted areas and no marked particle boundary films were found anywhere, no embrittling effect is to be expected. Consequently, there are no objections to small proportions of active gas in the shielding gas. This was also supported by the investigations undertaken on strength.

8. Strength of the brazed joints

Pulsed GMA-brazed joints were produced on an overlap joint in electro-galvanised sheet metal bodywork 0.8 mm thick. OK Autrod 19.30 Δ1.0 under shielding gas M13 with 1% O_2 and the ESAB Aristo 2000-System were used. Then flat tensile test specimens were taken and tested:



The position of the fracture in the tensile test specimen was always in the unaffected parent metal! Therefore the ESAB GMA-brazed joints fulfil the demands made of the joint completely.

9. Suggestions for practical use

The optimum parameters are more difficult to set for GMA-Brazing than for MIG/MAG-welding. The thickness and position of the zinc layer, in particular, play a very large part. Setting all the pulse parameters individually is indispensable for the best possible result.

Torch position

In GMA-Brazing, the torch position can have a considerable influence on the formation of the seam and the introduction of heat into the parent metal, as in MIG/MAG-welding. Less heat is brought into the galvanised parent material if the torch is in a forehand position. It causes a smaller quantity of zinc to evaporate and the degree to which droplet transfer impaired is significantly lower. With the torch held in a forehand position, the brazed seam is flatter and somewhat wider, but more importantly, there is less spatter. The unavoidable amounts of spatter, which occur at the start of the process because the evaporation of the zinc is stronger, land before the torch and are reliably melted again.

Molten pool

GMA-Brazing can be done with the molten pool running slightly ahead. This is a little strange to the MIG/MAG-welder at first because he usually has to ensure the avoidance of bonding errors and reliable penetration. However, deep penetration is undesirable in GMA-Brazing; it is only necessary to ensure good wetting.

10. Conclusion

ESAB provides all the pre-conditions for successful pulsed GMA-Brazing. The Aristo 2000-System makes digitally regulated power sources and wire feed devices available which fulfil the high demands of the pulsed GMA-Brazing process in the best possible way. Combined with the wire electrode OK Autrod 19.30, brazed joints are produced which demonstrate the best quality and excellent mechanical quality values.

About the authors

Hendrik Rohde graduated in 1991 as a mechanical and welding engineer from the Technical University of Magdeburg and joined ESAB Germany in the same year. In 1995, he became a European Welding Engineer. He is now product manager for arc welding products with GMAW as the main field and he also specialises in modifications for the use of welding machines with mechanised equipment.

Jochen Katic is an EWS and works as a demo-welder for mechanised welding processes. He joined ESAB GmbH Solingen in 1990. Mr. Katic is also a specialist in welding with flux-cored wires and he is often involved in research and development projects for customer applications in automatic and robotic welding.

Rolf Paschold, product manager at ESAB GmbH Solingen (Germany), graduated in 1990 as a mechanical and welding engineer. He joined ESAB in 1991 and is the sales support manager for welding consumables. Mr Paschold has always shown a special interest in tailor-made process applications developed together with the customer.

The use of rutile cored wires for welding high strength steel in crane fabrication

by Ben Altemühl, ESAB B.V., Utrecht, The Netherlands

High strength steels are increasingly applied in crane fabrication, with the aim to obtain weight savings or a higher lifting capacity. Simultaneously, cored wire welding is becoming more popular. This has to do with the high quality demands cranes are subjected to for security reasons, but also with the higher welding productivity cored wires offer.

On the European welding consumable market, the availability of cored wires for high strength steel has been limited to mainly metal-cored and basic types. Recently, however, ESAB has introduced two rutile types with a minimum yield strength of 620 and 700 MPa under the product names OK Tubrod 15.07 and OK Tubrod 15.09 respectively.

The wires are characterised by high welding productivity, good mechanical properties, a very low weld metal hydrogen content, and above all, excellent weldability.

ESAB developed these wires at the request of several European crane fabricators, among which the Dutch company Huisman-Itrec. They tested the OK Tubrod 15.09 for welding Weldox 700 and have gained production experience in a number of projects.

OK Tubrod 15.07 is still in its testing stage. At this moment, it is being tested for the mechanised welding of pipelines in X80.

This article will introduce the new rutile cored wires for high strength steel, while describing the experiences of Huisman-Itrec with the OK Tubrod 15.09.

Huisman-Itrec

Huisman-Itrec B.V. in Rotterdam, is the result of a merger in 1981 between the crane fabricator Huisman and the engineering bureau Itrec. Their most important activity is the construction of cranes and other lifting equipment for the offshore industry, the dock industry, civil works and shipbuilding. With design facilities for engineering, hydraulic and electric propulsion systems,

and for software, the company delivers client specified installations. Huisman-Itrec specialise in systems that are not available on the market as standard products. Examples are cranes for deep-water applications, and ship motion compensation systems. Other products built by Huisman-Itrec are floating sheerlegs, self propelled heavy transporters, equipment for installing pipelines on the seabed, drilling equipment, and even amusement park attractions. These products are delivered to clients all over the world.

The company constructs according to the requirements of the leading approval societies in this branch of industry (e.g. Lloyds), and execute a high quality standard. When not building on site, products are tested with in-house facilities, before delivery.

	AWS A5.29-98	EN 12535-00	Approvals
OK Tubrod 15.07	E101T1-K7M H4	T 62 4 Mn2Ni P M 2 H5	–
OK Tubrod 15.09	E111T1-GMH4	T 69 4 Z P M 2 H5	ABS*, LR*

*Table 1. AWS and EN classifications and approvals. *= limited approval.*

Figure 1. Vertically-up welding of a crane beam in Weldox 700.

Figure 2. Vertically-up welding of a crane beam in Weldox 700.

OK Tubrod 15.07 and 15.09

Both types are all-positional rutile cored wires with AWS and EN classifications according to table 1. The strength properties are tuned for high strength steel with a minimum yield strength of 620 and 700 MPa, with good CVN toughness at –40ºC. Table 2 gives the all-weld metal chemical composition and mechanical properties.

The wires are developed for all-positional welding under 80%Ar/20%CO_2 shielding gas, falling within EN 439 class M21. Vertical down welding, however, is not recommended because of the high risk of cracking in the first thin layer; especially in fabrications with a high restraint.

It concerns butt-closed cored wires with a filling degree of approximately 18%. The slag is fast freezing to support the weld pool during positional welding. The arc action is spray-arc at all welding currents, and the weldability is excellent. Another advantage is that, with the same wire size, a uniform parameter setting can be used when components have to be welded in several positions.

The high productivity, compared to solid wires and basic cored wires, becomes apparent in positional welding (PC, PF and PE). Vertically-up welding with a deposition rate of 3kg/h, for instance, is attainable.

The weld metal hydrogen content falls within Class H5 of EN785 for the operating envelope of parameters and corresponding stick-out lengths, which is exceptional for rutile consumables. This is of great importance for the welding of high strength steels. Normally, the weld metal has a higher Carbon Equivalent than the high strength parent metal, and therefore it will undergo the austenite-ferrite transition later. For this reason, hydrogen in the weld metal will not be able to diffuse to the heat affected zone and remain in the weld metal. Add this to the limited heat input, needed to give the weld metal sufficient strength properties, and all ingredients are present to cause hydrogen induced cracking. Low-hydrogen weld metal is therefore crucial for successful crack-free welding. This is also reflected by the preheating recommendations for Weldox 700, which are based on H5 class filler materials (Table 3).

The wires are not recommended for constructions that are submitted to a stress relief treatment, which would result in partial loss of toughness properties. In these cases, the use of a basic cored wire is advised.

Experiences with OK Tubrod 15.09 in crane fabrication

The introduction of OK Tubrod 15.09 at Huisman-Itrec is part of a general transition from solid to cored wire welding, carried through over the past years by the welding department with the aim to improve the allover welding productivity. An additional advantage, especially with rutile cored wires, is that also temporary welders master the required skills relatively quickly, which enhances the flexibility required by production.

At this moment, over 85% of all weld metal is deposited with metal cored or rutile cored wires, which brought along a substantial increase in productivity. It concerns mainly manual welding, but the welding department is investigating the possibilities of light mechanisation. All welders are certified up to H-L045 (6G).

	%C	%Si	%Mn	%Ni	%Mo	%P	%S
OK 15.07	0.04-0.07	0.30-0.50	1.45-1.75	2.30-2.70	–	<0.020	<0.020
OK 15.09	0.04-0.09	0.30-0.50	0.95-1.35	2.50-3.10	0.25-0.35	<0.015	<0.015
	Rp0.2 (MPa)	**Rm (MPa)**	**A5d (%)**	**ISO-V (J at –40ºC)**			
OK 15.07	>620	700-830	>18	>47 (>27 at –50ºC)			
OK 15.09	>690	770-900	>16	>41			

Table 2. All weld metal chemical composition and mechanical properties.

Combined thickness (mm) t1+t2+t3=	10	20	30	40	50	60	70	80	90	100	110	120	130
WELDOX 700								75ºC		100ºC		150ºC	

Table 3. Preheating recommendations for Weldox 700 based on a maximum heat input of 1.7kJ/mm and low-hydrogen weld metal (EN 785 class H5).

Correct heat input	**1.2-1.4KJ/mm/Tp 80ºC/Ti 170ºC**						
Tensile test	Rm (MPa)		Re (MPa)		A (%)		
	848		825		15.6		
CVN at –40ºC (Av.3)	WF	FL	FL+2mm	FL+5mm	WR	FR	FR+2mm
	54	54	161	161	33	39	122
Hardness HV10 (Av.3)	Weldox 700	WBZ		Las	WBZ		Weldox 700
Root	273	434		297	417		279
Center weld	276	343		259	331		286
Bend test	Magnaflux		Ultrasonic				
OK	no indications		no indications				

High heat input	**1.7-2.0 KJ/mm/Tp 80ºC/Ti 190ºC**						
Tensile test	Rm (MPa)		Re (MPa)		A (%)		
			841		780 15		
CVN at –40ºC (Av.3)	WF	FL	FL+2mm	FL+5mm	WR	FR	FR+2mm
	54	102	168	123	31	30	135
Hardness HV10 (Av.3)	Weldox 700	WBZ		Las	WBZ		Weldox 700
Root	266	397		290	395		282
Center weld	266	343		289	346		861
Bend test	Magnaflux		Ultrasonic				
OK	no indications		no indications				

Table 4. Mechanical weld metal properties at a correct heat input and a too high heat input. V-joint/ plate thickness 30mm, combined thickness 60mm/ Weldox 700 Heat no. 366631/ position PF. WF = Weld Face, FL = Fusion Line, WR = Weld Root, FR = Fusion Line Root.

Figure 3. Crane pedestal part.

Figure 4. Vertically-up welding of a pedestal part.

Huisman-Itrec increasingly applies Weldox 700 high strength steel for the construction of lifting equipment. The components to be welded, such as crane beams, masts and pedestal parts, are too large to be turned, making positional welding unavoidable. Until recently, the Weldox 700 was welded with a combination of coated electrodes and solid wire, but also here the company wanted to change over to 100% cored wire welding. That is why they requested ESAB to develop such a wire, which received a positive reply, also motivated from an international context.

After the development of the wire, Huisman-Itrec submitted the first test spools to a rough test to verify the suitability for welding Weldox 700. It concerned a V-joint in thick plate, welded in PF position without preheating and without controlling the interpass temperature. The strength properties of the joint were measured by tensile tests with transverse and longitudinal test bars. Cross weld, a tensile strength of 769MPa was obtained, with the rupture in the parent metal. In the longitudinal direction, the yield strength was too low (668MPa) whereas a tensile strength of 754MPa was satisfactory.

	Rm (MPa)	Re (MPa)	A5 (%)	CVN –40ºC (J)
Weldox 700	780-930	>700	>14	>27
Heat nr. 366631	826	759	15	158(Av.3)

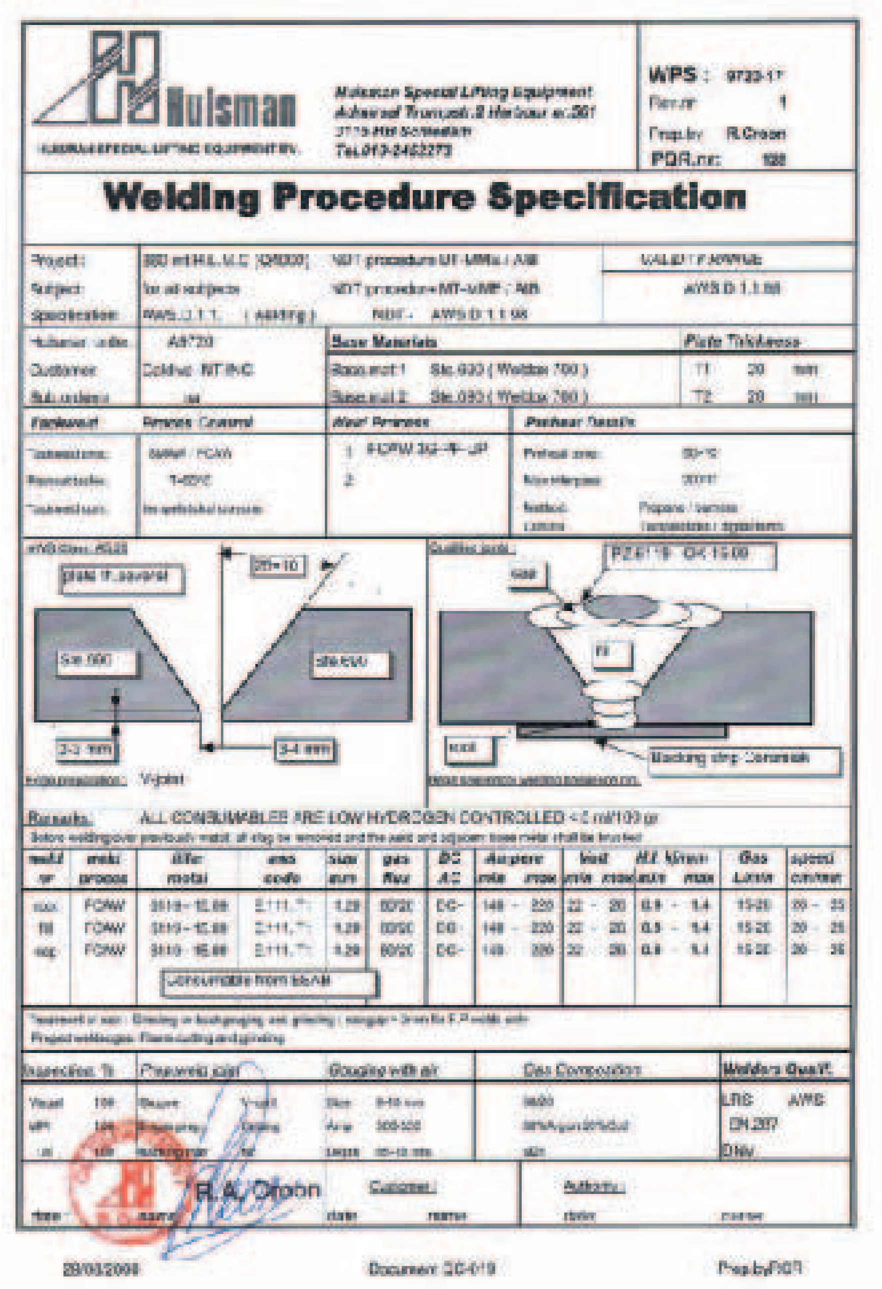
The CVN toughness (Av. 3) was 53J at –40ºC for the weld and 42J for the root (welded on ceramic strip). The results of the side bend tests were good. Subsequent ultrasone and magnaflux testing proved that the weld was free of defects and, more importantly, cracks.

WPS'es

On the basis of these results, the welding department of Huisman-Itrec decided to continue the investigation, aiming at the establishing of suitable welding procedure specifications (WPS) for Weldox 700. In addition, the company wanted to obtain a Lloyds yard approval for a project with a CVN requirement of 27J at –40ºC, awaiting the general Lloyds approval ESAB had requested.

Table 3 gives the preheat recommendations for Weldox 700, based on a weld metal hydrogen content of max. 5ml/100g deposited weld metal and a maximum heat input of 1.7kJ/mm. To understand the effect of the heat input on the mechanical properties, test plates were welded (800×30×30mm) at a correct heat input (1.2-1.4kJ/mm) and at higher heat input (1.7–2.0 kJ/mm). Table 4 summarises the results.

The strength requirements of Weldox 700 (Table 5) were met, as well as the maximum hardness requirement of 425HV10. The same is valid for the CVN toughness of the weld; even for the root.


Huisman
WPS: 9733-17
PQR.nr: 188
Welding Procedure Specification
Remarks: ALL CONSUMABLES ARE LOW HYDROGEN CONTROLLED
Consumable from ESAB
R. A. Croon
28/03/2000
Document 30-019

On the basis of these results, Huisman-Itrec was granted the local approval they needed for OK Tubrod 15.09, valid for one specific product and one batch. Figure 5 shows a WPS for the position PF that Huisman-Itrec developed subsequently.

In a later stage, ESAB obtained the general Lloyds approval; be it with a limitation. For this class of consumables, Lloyds has a CVN demand of 69J at –40ºC. For rutile consumables, this is too high, however. That is why the approval is limited to projects with CVN requirements of 42J at –40ºC or lower, which is sufficient for many applications.

Fabrication experience

Huisman-Itrec applies OK Tubrod 15.09 for welding in PF position. For downhand work, they kept on using a metal-cored type. After successful use on a smaller project, OK Tubrod 15.09 was utilised for a bigger project, the fabrication of a series of cranes for Mammoet B.V. The figures 1 to 4 show the application of the wire.

It is applied successfully for the vertically-up welding of crane beams, pedestal parts and other crane components. The welders are very pleased with the new consumable and also temporary workers learn to use it within an acceptable period of time. Essential for welding Weldox 700 is that the low heat input, needed to obtain sufficient strength and toughness, can be maintained well, also in PF position. This is more difficult with solid wire, basic, or metal-cored wires, because these are welded close to the short arc mode. The success also becomes apparent from the 100% ultrasonic and magnaflux NDT that was performed. The defect rate was below 0.5%.

About the author

Ben Altemühl, BSc, welding engineer, joined ESAB in 1990 as sales promotion manager for FILARC Welding Industries in the Netherlands. Since 1999, he has been responsible for the sales promotion of all cored-wire products within ESAB Europe's Business Area Consumables.

The new ESAB EcoMig welding wire adopted by Fai Komatsu Industries for welding its earth-moving equipment.

by Ferruccio Mariani, ESAB Italy

High performance, reliable quality and product ecology are the main reasons for the choice of ESAB OK Autrod 12.50 Eco Mig wire. At FKI, Fai Komatsu Industries, highly-developed welding systems and processes are used for welding specialized products which are aimed primarily at demanding markets in industrialized countries.

Robotic cells with fully-automated loading and unloading systems, combined with the latest generation of high-speed welding processes, all complying with environmental requirements.

In just the same way that a formula 1 engine has to be filled with a sophisticated fuel in order fully to develop its power, FKI has adopted a welding wire which complies with the demanding requirements imposed by its welding equipment and processes to provide outstanding performance.

ESAB OK Autrod 12.50 EcoMig in the octagonal Marathon Pac not only comes up to all the company's expectations, it also produces other additional advantages, as we will see in the following interview.

FKI

FKI S.p.A. in Este (Padua, Italy) is one of the four production units of the Komatsu Group in Europe and specializes in the so-called "utility range".

The company was set up in 1963 with the name FAI, Fabbrica Attrezzature Industriali (Industrial Equipment Factory).

Its initial operations focused on equipping tractors with some added components in order to make them more versatile and suitable for many different operations. This is how the so-called "terna" was born, a name which recalls its three functions: the tractor itself, the front shovel and the rear excavator. During the development of the building trade, changes in market de-

mand led the “terna” to become fully independent equipment, retaining only the functions of digging and loading but keeping its name at the same time.

Over the years, other products were added to the “terna” and FAI continued to expand until about 12 years ago, when it came in contact with Japanese Komatsu and set up a joint venture for the production of a range of mini-excavators, a product which had not yet been introduced in Europe. The relationship developed and was consolidated about four years ago with the birth of FKI, FAI KOMATSU INDUSTRIES S.p.A., in which 100% of the shares are owned by Komatsu. Nowadays, FKI has almost 900 employees.

“Turnover in 1999 was USD 260 million, this year it will be about 325. During the last three years, we have more than doubled our turnover,” says Claudio Gallana, production manager, with justifiable pride in his voice *“This is thanks to synergies with the Komatsu Group and particularly to favourable trends on the market.”*

FKI’s market operations focus on five product lines: firstly excavators, secondly the stiff “terna” series that is expanding rapidly thanks to new markets, like the USA, thirdly the line of articulated “ternas”, similar to the previous one but with central articulation that allows the machine to operate in narrow environments and more uncomfortable situations. They are followed by the line of so-called “skid steer loaders”, small loading machines. This is an important product for FKI and it is experiencing a particular period of market growth. Last but not least comes the line of compact excavators, also called midi-excavators.

FKI constitutes the focal point of the utility division which is experiencing powerful expansion in the Komatsu Group, as it is the only manufacturer of this

range of products for the European market. Utility is the series of relatively small machines which are used in the building trades for repair and maintenance work, like roads, pavements and so on. The market is experiencing very favourable trends, mainly in industrialized countries where the major infrastructure, such as roads, bridges and viaducts, has already been constructed but where there is a great deal of work to be done in cities, or historical centres, or constructing new apartment blocks, where machines of this kind play a key role. In spite of the relatively high investment cost, they are a more efficient alternative in all the above-mentioned countries where the labour costs are really high.

We asked Mr. Gallana for some information about market position, objectives and strategies.

"On a worldwide scale," he replies, *"when it comes to the global market and product dimensions, it would be true to say that Komatsu and Caterpillar are always competing for first place. Afterwards," he continues smiling and looking at the ground "there are some others... Anyway, not all the players are comparable in terms of product range and type. As far as our Italian production is concerned, it has to be said that we have an important presence on the Italian market; in fact, for some products it accounts for more than 30–35%. For instance, the mini-excavator made its appearance on the Italian market together with us. We are now also supplying the American market, mainly with two product lines: "ternas" and skid steer loaders.*

"At this very moment, one extremely important objective is to keep our market shares at a high level and this isn't so easy because the market is growing at a really fast rate, even faster when we add the further positive feedback from group synergies.

"One of the main difficulties in our area is finding skilled workers. I want to give you an example; it is still easy enough to find young technicians if you offer them the chance to operate a welding robot, but, when you look for a welder who is able to handle a welding torch, that's much harder. That's why we have pushed the accelerator on robotic welding, also taking account of the higher productivity and the profit produced by the lower cost of robotic technology nowadays. We definitely need to stay on the road to productivity. At the same time, we must take care of the balance between our growth, which is forecast to remain good over the next few years, and the related costs, because the favourable trend on the market cannot last for ever."

Importance of welding

As far as production is concerned, the five product lines are produced on three assembly lines, so there is a product mix on some lines. The majority of components are welded inside the factory – this particularly involves the main structures of the machine, while small or minor components and sub-assemblies with less rigorous requirements are supplied by outside subcontractors.

Basically the production cycle is as follows: the components are pre-assembled using special equipment, which is very flexible, the result of Italo-Japanese joint design. They are then taken to the robotic cells where the welding operation is performed. Robotic welding accounts for 80–90% of the total weld, but some welding still has to be done manually for many reasons, such as difficult access to the welding position and so on. So there is a final phase in which the small percentage of welding that is left is completed manually.

The welding operation employs about 10–15% of the total work force directly or indirectly. In terms of welding time in the production cycle, the situation is not homogeneous, it varies because, for some machines, all the components are welded inside the factory. In this case, welding takes 30–35% of the total cycle time. For other types of machine, only the main components are welded inside, while minor components are subcontracted to outside suppliers. Taking account of this variability, it would be true to say that an average of 60% of the structures are welded inside.

Anyone used to visiting welding departments at mechanical industries would expect to find the well-known "atmosphere" at FKI as well: arcs crackling and flashing, the emission of fumes in the environment, piles of welded and unwelded components close to welding stations, noise... well you could not possibly be more mistaken! With the maximum respect for sacred things, when you enter the welding hall at FKI, you feel as though you are entering a cathedral. This is the perfect definition: space and airiness, a sober atmosphere, cleanliness, a lack of noise and arcs flashing. What impresses the visitor instead is the sight, inside the hall, of two rows of cubic constructions, each about ten metres wide, surrounded by rail tracks: they are the robotic cells. Inside, there are the welding robots with the related positioning devices. Every cell is equipped with a very effective system of electrostatic filters which trap the last molecule of particles and fumes developed by welding. Electric arcs, radiation, heat, fumes and noise are therefore restricted inside the cells. This is a 93-metre line made up of six - it will be eight by the end of the year – robotic cells, supplied by a trolley system for loading and unloading the components in a fully automated and randomized manner.

Each robot is programmed in such a way that it can recognize every component and carry out the related welding programme. In other words, the first assembly on the waiting list goes to the first cell where the previous welding programme has been completed. This system allows maximum flexibility in the production cycle and high efficiency, cutting all the waiting times from the different preparation times for the different components.

The welding process is the high-speed T.I.M.E. process, which offers very high productivity in welding. Obviously, the requirements imposed on the welding wire are really demanding: over 400 amp current (the diameter size which is used everywhere is 1.20mm), over 20 m/min wire speed, a 20-metre liner guiding the wire through the chain system of the three-axis cartesian robot gantry up to the welding head. Last but not least, after such a long journey, the wire ends up with a very long stick-out that has to be absolutely straight!

"High quality together with consumable reliability are basic requirements," Mr. Gallana stresses. *"Welding is a complex problem, especially robotic welding, because it is affected by plant-related phenomena as well as by the consistency of the consumables – the shielding gas and wire, particularly in such a complicated process as we have. The first and most important requirement for us is the consistency. Another basic requirement is the service; this involves a continuous search for improvements, as well as the solution to specific problems. In other words, the ability to conduct new tests, find fast solutions and react quickly – to be innovative. As far as I'm concerned, ESAB fulfils these requirements."*

From OK Autrod 12.51 Marathon to OK Autrod 12.50 EcoMig in the octagonal Marathon Pac

We contacted Giampaolo Bellucco, the person responsible for auxiliary materials. *"Since we introduced robotization, the need to use large wire packaging has arisen,"* he explains.

"As a first step, we conducted some trials with 90 kg bobbins, but the real solution came when ESAB supplied us with its OK Autrod 12.51 wire in the Marathon drums. Since the beginning, it has come off best compared with all its competitors. We started using it and we then continued for years, but...good, better, best, never let it rest! Recently, we performed a number of rigorous large-scale tests on products and suppliers and this took us a further step forward."

"Once more, ESAB emerged as the winner with its new ecological wire OK Autrod 12.50 EcoMig, which we have now definitively adopted. All the other competitors failed miserably because the actual results did not come up to the promises."

Silvano Crescente, the person responsible for FMS plant, joins in. *"Since I started using this new wire, I have encountered far fewer problems on this plant. This is very sophisticated equipment, the wire mustn't create problems, we use the T.I.M.E process, the programming is fairly complicated and it does not forgive mistakes with the welding wire. Constant, regular feed is an essential factor. We have six robots, since the first test we started with all of them, I'm talking about 35–37 pieces a day, two hours of arc time per piece on average, you can really see if the wire can take the punishment. As a matter of*

fact, the evaluation comes out completely in favour of ESAB OK Autrod 12.50 EcoMig compared with all the wires tested.

"Every stoppage costs money," continues Mr Crescente "because a package of unreliable wire results in a one-hour stop, including checks and replacement. A reliable wire like this generates nice savings!"

"We haven't yet quantified the accuracy," Mr. Bellucco adds, "but we have noted a number of additional advantages: lower torch and liner cleaning frequency, less spatter, longer service life for contact tips, generally speaking I have noted a sharp reduction in all the components that are subject to wear, which means that less time needs to be spent on maintenance as well. Now I must say something about fume reduction, that's real evidence!"

Environmental considerations

At this point, we allow ourselves the luxury – metaphorically speaking – of interrupting Mr. Bellucco for just a short digression. FKI's industrial complex is located in Este, at the foot of the Euganei Hills, a well-known area which has become rich and famous thanks to its thermal springs and waters, a place where the environment creates well-being and health. It could be a coincidence, but it is noticeable that, as far as we know, FKI is the first company, or at least one of the first, in the metal-mechanical field in Italy to have applied for environmental certification according to ISO 14.000 and the company will shortly be receiving it.

"ISO 14.000," explains Mr. Bellucco " *is the norm that governs the environmental impact of operations from every angle. We have made a clear-cut, intentional, evaluated and planned choice in this area, even if I have to admit that complying with this standard is far more demanding compared with what we needed to do years ago to obtain the quality certificate according to ISO 9000. How to get rid of waste, how to control air pollution, the products and their handling, the contact of different products with the employees and the impact of our products on the environment and so on...it's a really demanding task.*

"For many years, we developed our control system and managed our purification systems, but another step forward now has to be made. It relates first and foremost to people's cultural side. The working environment is part of our life, I mean "our" in the widest sense of the word on a world scale. Everybody must be prepared to respect the standards that eventually generate common welfare. In this respect, our personnel are very positive and co-operative. Last but not least, we must remember that a comfortable working environment is an incentive for higher efficiency.

"An excellent illustration was recently given here by ESAB's Autrod OK 12.50 EcoMig wire, when the welders realized that it developed far fewer fumes. We are naturally taking advantage of this in robotic welding because it reduces the frequency with which the electrostatic filters need to be cleaned, which has an obvious advantage when it comes to productivity, but robotic welding is done inside the cells while the operators are outside so that they are not in direct contact with the arc and fumes. However, we also have semi-automatic welding sites. There are about 30 of them at which minor components or sub-assemblies are welded. Even if there is a fume extraction system, the fumes developed by welding are still immediately visible and in direct contact with the welder's environment."

"In the past, in order to obtain higher productivity by means of higher duty cycles, we made many attempts to move from 15 kg reels to higher weight packages like OK Autrod 12.51 Marathon, in order to reduce the stoppages caused by changing the reel every 15 kg. Of course, everybody knows that this kind of stoppage is welcomed by welders as it often gives them an opportunity to have a short break during work."

"Well, as soon as we asked the welders to test the new ecological non-copper-coated OK Autrod 12.50 wire in the octaconal Marathon Pac we were surprised to find that they fell in love with it. They have not only accepted it, they have even approved it through their trade union representatives. Nowadays, it is the only wire they want. They have realized that being at the forefront when an innovation is introduced is useful for them and not just for the company. All of this is mainly due to the sharp reduction in fumes."

"An ecological product like this makes our life easier, even when it comes to the acquisition of ISO 14.000.

"By the way, the new octagonal Marathon Pac is also an advantage. When it is empty, the cardboard can be easily squashed and stacked on pallets, you can pile up many of them in a very small space and, finally, managing rejects is less demanding from a logistical point of view."

ESAB's role

We ask Mr. Bellucco to formulate a final opinion of ESAB. *"When it comes to the product itself, I think I've already said everything. When it comes to supplier quality, I would put it this way.*

"Each company's name is associated with an image, but, when you analyse the facts in depth, the 'real' image does not always correspond to the 'virtual' one. In ESAB's case, I must say that the image associated with its name is synonymous with the actual, verified truth – reliability. At least as far as we are concerned."

"Not because there has never been a problem, but because, whenever problems have occurred, ESAB has always been able to accept and resolve them, giving us the necessary support. I have had the chance to verify the service, reliability and consistency. I find that ESAB is a problem-solving supplier which is available and ready to work together. It makes me feel secure. It's more than enough!"

Mr. Bellucco's conclusion is very gratifying for a company like ESAB that has always wanted to work together as a partner alongside its customers and to pursue objectives of common interest.

Welding hydraulic cylinders using OK Tubrod 14.11 and the MAG and MAG-tandem process

by Dipl. Ing. Klaus Blome, ESAB GmbH, Solingen, Germany

Hydraulic cylinders are a vital part of modern industrial machinery. All the operating movements of large equipment such as earth-movers and road-building machines can be performed with a very high level of accuracy and dynamics, especially when combined with electronic controls.

An hydraulic excavator (Figure 1) performs its operational movements via hydraulically-activated cylinders. The boom is lifted by two hydraulic cylinders (Figure 2), while the jib and the bucket are each moved by one hydraulic cylinder (Figure 3). Depending on the size of the machine, the design pressure of the cylinders is between 160 and 320 bar. Pressure peaks which are several times the design pressure may occur during operation when the static load (load in the bucket, intrinsic weight) and the dynamic forces (moving the excavator, loading or unloading process) are superimposed. The design and in particular the production and quality assurance of these components is therefore extremely important.

Connecting the cylinder head and base to the guide tube (Figure 6) imposes rigorous demands on the quality and reliability of the welding process that is used.

In most cases, the circumferential welds take the form of U-welds. The centring, which is machine turned so that it can be assembled as a perfect fit, serves as backing for the root pass (Figure 7).

As the tube is machine turned to a preset fit dimension (e.g. H8) after welding to guide the piston, minimum penetration is specified for the root pass (depending on the design, approx. 1.5/3 mm). During this process, the centring lip must be melted so that a defect-free surface is produced when it has been machine turned.

A number of different welding methods are used to meet these quality requirements, while increasing productivity at the same time. They include:

- MAG or MAG pulse with solid wire and various shielding gas mixtures to improve penetration characteristics, especially in the root
- Friction welding and flash butt welding
- MAG double-wire or MAG tandem welding

If reliable, deep penetration and increased productivity are required as a result of higher welding speeds and/or process reliability, it is possible to utilise the specific characteristics of OK Tubrod 14.11, metal-cored wire. The stable, wide arc guarantees reliable penetration and uniform seam quality. The special striking and feeding characteristics of this flux-cored wire, which has been optimised for automated processes, make an almost defect-free process cycle possible, even in conjunction with high welding parameters and when used for long periods.

Figure 1. Hydraulic excavator.

Figure 2. Lifting hydraulics for the boom.

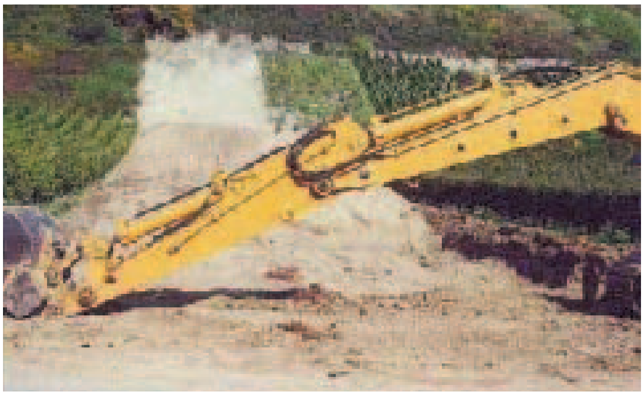


Figure 3. Hydraulic cylinder for moving the bucket and jib.

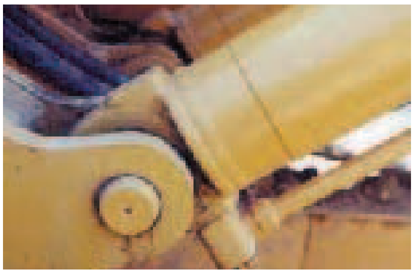


Figure 4. Cylinder base.

Figure 5. Cylinder head.

OK Tubrod 14.11 has already shown itself to be extremely effective when manufacturing hydraulic cylinders for excavators and other road-construction machinery. U-welds, as illustrated in Figure 7, are welded in four passes using OK Tubrod 14.11 ∅ 1.4 mm. This involves the use of either conventional MAG techniques (Table 1) or the MAG tandem method (Table 2).

In comparison with the MAG tandem method, which was used in the past with 2×1.0 mm solid wire, the welding speeds achieved in this case in production conditions with OK Tubrod 14.11 ∅ 1.4 mm were almost able to match those of classical MAG welding with a wire electrode. It was even possible to increase productivity because the quality of the welded joints was significantly better and more reliable.

To obtain a further increase in production, it is possible to weld the intermediate layer of relatively large hydraulic cylinders using the MAG tandem method and 2×OK Tubrod 14.11 ∅ 1.4 mm. The reliability of the process is so high, as a result of the high stability of the arc and the fine feeding characteristics of the flux-cored wire, that the second flux-cored wire (slave) can be applied without interrupting the welding process. At the same time, the welding speed is naturally increased in order to prevent the formation of an uncontrollably large molten pool. The top pass again reverts to welding with just one electrode which oscillates to produce the best possible seam surface. The second flux-cored wire is switched off again during the process. No process disruptions or disadvantageous effects on the quality of the seam have so far been observed.

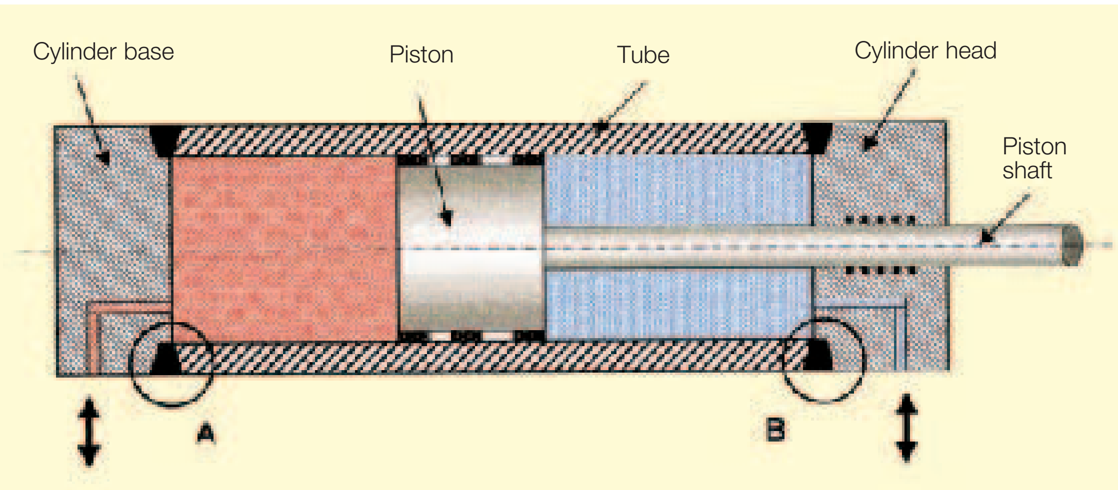


Figure 6.

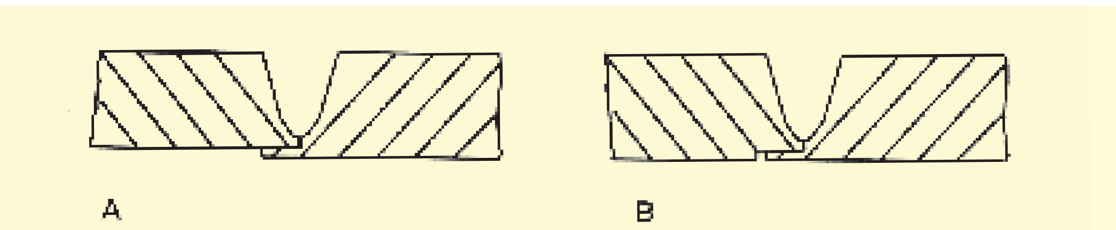


Figure 7.

As a matter of principle, the MAG tandem method offers an opportunity to improve the productivity of MAG welding. However, if this process is used with solid wire, a few typical weak points can be observed, such as a tendency towards undercutting, high contact tip wear, the need to reset the process parameters frequently, high thermal loads on the torch and so on.

Experience to date indicates that at least the directly process-related defects can be significantly reduced by using OK Tubrod 14.11.

About the author

Klaus Blome obtained an MSc from the Technical University RWTH of Aachen. He joined ESAB Germany in 1990 as a product manager for welding consumables. Between 1992 and 1997, he was international product manager for cored wires at Filarc Welding Industries in Utrecht. He returned to ESAB Germany in 1997. Klaus Blome was recently appointed regional sales manager west and key account manager as from January 2001.

OK Tubrod 14.11 1.4 mm / 82/18 Ar/CO_2	Welding current (A)	Voltage (V)	Welding speed (cm/min)
Root	350 / 360	30 / 31	60 / 62
2 intermediate passes	390 / 400	35 / 36	58 / 60
Top layer (oscillating)	410 / 420	36 / 37	40 / 42

Table 1. U-seam on hydraulic cylinders (D = 210 mm, b = 20 mm). Conventional MAG welding with OK Tubrod 14.11 Ø 1.4 mm.

OK Tubrod 14.11 1.4 mm / 82/18 Ar/CO_2	Welding current (A)	Voltage (V)	Welding speed (cm/min)
Root (single wire)	350 / 360	30 / 31	45 / 50
Intermediate pass	Master 400 / 410	35 / 36	80 / 85
(Tandem)	Slave 310 / 320	33 / 34	
Top pass (oscillating)	410 / 420	36 / 37	60 / 62

Table 2. U-seam on hydraulic cylinders (D = 210 mm, b = 20 mm). MAG tandem welding with 2×OK Tubrod 14.11 Ø 1.4 mm.

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