SVETSAREN

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OASIS OF THE SEAS

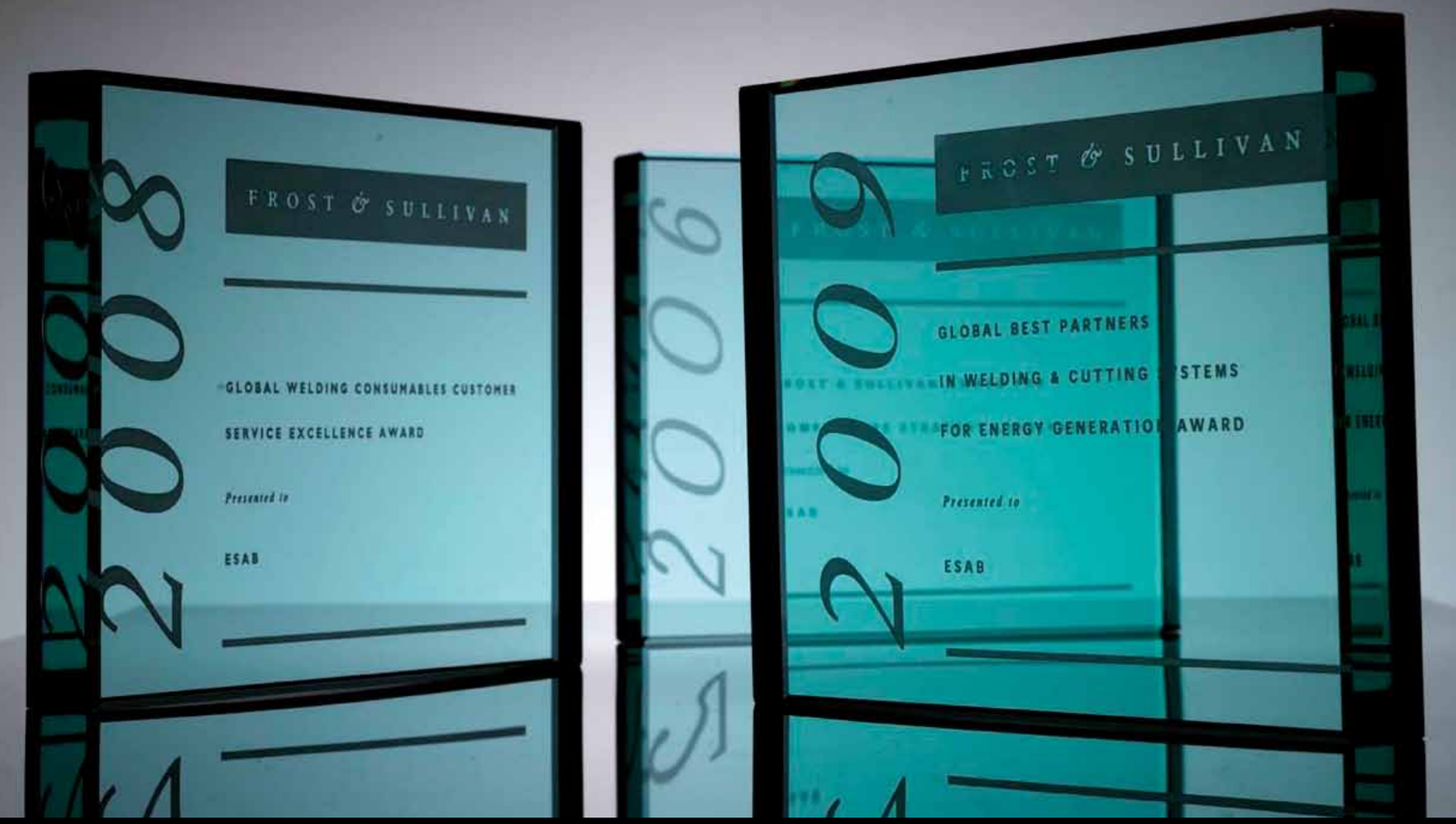
OFFSHORE PIPE LAYING • STAINLESS TANKS • LNG • WIND TOWERS • SHIP PANELS • SKYCOURT • OK ARISTOROD

ESAB®

Frost & Sullivan Energy Generation Award for ESAB

ESAB , recipients of the Frost & Sullivan "2009 Global Best Partners Welding & Cutting Systems for Energy Generation Award", has emerged as the leading manufacturer of welding and cutting systems for energy generation industries including power, LNG tanks, offshore and pipelines industries, in Europe and is also rising strongly to be a leader in the global market. In 2009, it accounted for nearly 18 per cent of the global welding and cutting market for energy generation.

The Frost & Sullivan Best Partners Award is presented each year to the company that has demonstrated unparalleled excellence within its industry and has been a partner who has been nominated by the supply chain participants for their undisputed products and services.



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Svetsaren

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Oasis of the Seas
The world's largest and most expensive luxury cruise ship.

She has some 2,400 kilometres of welds for which more than one million kilos of filler material was used - the overwhelming majority supplied by ESAB.

Contents

ESAB corporate newsflash

American Choppers partners with ESAB. In July 2010, ESAB Welding & Cutting Products in North America, announced a partnership with Orange County Choppers (OCC), the custom motorcycle shop founded by Paul Teutul, Sr. ESAB will be the exclusive welding equipment and cutting provider for OCC, providing all equipment and filler metals used in the workshop and featured on the forthcoming season of American Chopper. The show premiered in the United States on the TLC channel in August. In addition, OCC has designed and built a custom chopper for ESAB.

"ESAB makes the best welding equipment and filler metals on the market today. They have led the industry in innovation for quite some time and have contributed so much to make welding easier, safer and more profitable for welders around the world," says Paul Teutul, Sr. "ESAB cares about the little guys in the shop, whether you're welding for business, art or just to have fun. We love the feel of welding with quality ESAB equipment and filler metals, and we are looking forward to creating some beautiful new bikes with the ESAB advantage."

ESAB filler metals help build new World Trade Center towers. ESAB has partnered with DCM Erectors and the MRP LLC fabrication shop on this project. The companies have worked together for three years on the construction of Tower 1. The main tower of the site, Tower 1 will stand at 107 stories – 562 m tall (1776 ft) – on completion in 2011. Construction is currently underway, and as of May had already reached the 15th floor and consumed more than 45,400 kg of ESAB Coreshield 8 flux-cored wire. The 20th floor will feature all full-penetration welds using Coreshield 8, and it is estimated that this floor alone will require 9080 kg of material. ESAB will provide all the filler metals for Tower 1 and for Tower 4, which will stand at 65 stories. Other ESAB materials to be used in these projects include Coreshield Ni2, Dual Shield 710X, Spoolarc 81, Spoolarc 75, Atom Arc 7018 and OK Flux 10.71. ESAB's complete line of Seismic Certified™ products are ideal for construction of buildings of this nature, and the seismic testing done on these products was instrumental in ESAB securing the bid.

"ESAB is very proud to have been selected to provide materials for this important part of American history," says Jerry Gleisner, Vice President, Sales Eastern USA for ESAB. ESAB is working closely with Airgas of Piscataway, NJ to stock and distribute all the ESAB filler metals required for this job.

ESAB at Beijing Essen 2010. The 15th Beijing Essen Welding & Cutting Fair was held from 27-30 May, 2010, at the new China International Exhibition Centre, in Beijing. Ranking in the top two international welding and cutting shows in the world, Beijing Essen Welding & Cutting Fair is an annual event held, alternately, in Beijing and Shanghai, the two largest economic centres and most popular trade fair cities in China. On a stand covering more than 300 m^2, ESAB brought together all its Chinese subsidiary companies, to demonstrate its rapid growth, strong presence, and commitment to providing satisfactory welding, cutting and automation solutions to the China marketplace.

ESAB Middle East relocates to new, climate-friendly facility. In order to further strengthen the support of the customer base in the Middle East, ESAB ME has invested in a new state of the art facility, merging its operations at a new site in Jafza South, Dubai, UAE.

The new facility has sales and engineering offices, a warehousing and distribution centre, and a custom built demo area featuring key ESAB equipment and processes such as plasma cutting and column and boom welding, together with standard welding applications such as MIG/MAG, TIG, MMA, etc. There is also a training centre with 10 welding stations where customers can be given hands-on introduction to the equipment.

The new facility has a very high environmental profile. The Middle East Centre for Sustainable Development (MECSD) has been engaged as a partner in developing the design and implementation of the new facility. MECSD has guided the project through the US Green Building Council LEED process, targeting the highest possible rating – the Platinum Certificate.

New European welding automation centre in Italy. ESAB's new demo centre for welding automation has been operational for more than a year. It is located in Arluno, near the ESAB headquarters in Mesero, Milan. The demo centre is intended to serve central and southern European markets and markets in the Mediterranean area and the Middle East. ESAB now has two demo centres for welding automation; one in Sweden and one in Italy. The new ESAB Demo Centre is spread over an area of 800 m2 , and is equipped with the latest welding automation systems, including a now highly relevant production system for the conical sections of windmill towers.

New sales offices in Colombia and South Africa. With new sales offices in Bogota, Colombia, and Cape Town, South Africa, ESAB has a greater market presence in both countries through an increased level of local service including technical support, stock, and local personnel. The new office brings the number of countries where ESAB is represented to 122, worldwide.

ESAB goes social. People who use the popular social networking sites Facebook and Twitter, can now interact and communicate with ESAB - a company with more than 100 years of continuous research, development and manufacturing experience and know-how. Keep up with ESAB's latest updates, events and announcements and encourage others to do the same.

http://www.facebook.com/ESAB.Global.Welding.Cutting
http://twitter.com/ESAB_Global
http://www.youtube.com/ESABGlobal

Global sustainable development high on the ESAB agenda. Last June, the 2010 ESAB Global Sustainable Development Conference was held in the Gothenburg area in Sweden. Almost 50 delegates from ESAB units in Asia, Europe, South and North America participated at the conference, making it the biggest event of this type ever held by ESAB. During a full week, there were presentations and training on the progress and challenges facing ESAB, covering environmental, health & safety issues such as chemical/waste management, safety culture, machine guarding, PPE, safety/eco-driving, packaging, purchasing, management of change, energy, RCA, HazCom, ergonomics, BCM and occupational health. At the conference, three global ESAB EHS Awards were presented by ESAB CEO, Mike Foster, to the best performing units in the three areas of Energy, Environment and Safety.

Since 2007, ESAB has held a DNV certification for its ISO14001 group Environmental, Health & Safety management system and a worldwide OHSAS 18001 certification from DNV. Wherever in the world ESAB products are bought, they are produced in accordance with the same global EHS standards.

The new Demobus – ESAB on the move. Touring annually through many countries, the ESAB Demobus has been a highly valued sales tool for ESAB distributors in Europe for many years, enabling them to present to their customers an overview of ESAB's welding solutions and capabilities.

After 20 years on the road, it was time for an update. The new trailer is equipped with the latest welding and cutting equipment, standard

automation, consumables and accessories - including PPE (personal protective equipment). The layout inside the trailer is now more spacious with additional room for customers and demo welders. It has five LCD screens for various multimedia and other presentations.

ASME certification for deliveries to the nuclear industry. Nuclear manufacturing is a type of production where quality and reliability are key factors. Therefore, a code – the ASME code - was developed and put in place in order to regulate all activities within the industry. All manufacturers active in the nuclear industry have to follow this code and be compliant. ASME certification is required for product supply to the nuclear industry. Only a limited number of welding consumable suppliers hold such certificates. Two ESAB companies have obtained certification, ESAB AB, in Sweden, and ESAB Hanover, in the USA. ESAB's range of consumables for the nuclear industry is described in detail on page 65.

A decade of presence in LNG. ESAB continues its traditionally strong position as welding supplier to LNG storage tank projects with an impressive track record during the first decade of the current millennium. All over the world, LNG tank builders select ESAB welding consumables for 9% nickel steels - often used in combination with ESAB power sources and mechanisation equipment such as A2 or A6 welding tractors, Railtrac and Circotech. ESAB's successful LNG consumables range features OK 92.55 (MMA/SMAW), OK Autrod 19.82 (MAG/GMAW) and OK Flux 10.90/ OK Autrod 19.82 (SAW). The worldwide use of LNG is increasing, both in mature economies and developing markets such as China where ESAB holds a strong position. The erection of a 30,000 m^3 tank in Norway by the Swedish company Rodoverken AB, using the unique spiral method, is described in detail on page 29.

Tank location		Year	Customer	Tank size m^3
Cartagena	Spain	2000	Whessoe	160,000
Bilbao	Spain	2000	Technigaz	135,000
Tongyoung	Korea	2001	Daewoo	140,000
Huelva	Spain	2002	Technigaz	160,000
Hazira	India	2002	Technigaz	160,000
Damiette	Egypt	2002	Technigaz	150,000
Damiette	Egypt	2003	Technigaz	150,000
Cartagena	Spain	2003	Technigaz	160,000
Huelva 4	Spain	2004	Technigaz	135,000
Sagunto	Spain	2004	Monesa	150,000
Shenzhen	China	2004	Technigaz	160,000 x 2
Sagunto	Spain	2004	Monesa	150,000
Adriatic	Italy	2004	Whessoe "mock-up"	250,000
Adriatic	Italy	2005	Hyundai Heavy Industry	250,000
Freeport	US	2005	Technip-Zanchry-Saipem	154,000 x 2
Fos-Cavaou	France	2005	Sofregaz-Saipem-Technigaz	110,000 x 3
Zeebrügge	Belgium	2005	Technigaz-Fontech-MBG	140,000
Darwin	Australia	2005	TKK	188,000
Canaport	Canada	2006	SNC-CENMC	160,000 x 2
Shanghai Gas	China	2007	TKK	165,000
Sagunto	Spain	2007	Monesa	150,000
Canaport	Canada	2007	SNC-CENMC	160,000
Adriatic	Italy	2007	Dragados Offshore	125,000 x 2
Fos-Cavaou	France	2007	Technigaz	110,000 x 3
Canaport	Canada	2008	SNC-CENMC	160,000
Stavanger	Norway	2009	Rodoverken AB	30,000
Angola LNG	Angola	2008	TKK	159,000
Angola LNG	Angola	2009	TKK	159,000
Arzew LNG	Algeria	2009	Saipem	160,000 x 2
Dalian	China	2009	HuanQiu	160,000 x 2
Rudong	China	2009	HuanQiu	160,000 x 2
Dongguan	China	2010	Dongguan Jiufeng	80,000 x 2
Dalian	China	2010	HuanQiu	160,000
Rudong	China	2010	HuanQiu	160,000
Sagunto	Spain	2010	Monesa	150,000
Ningbo	China	2010	TGE-CNF	160,000
Ji Munai	China	2010	TGE	30,000
El Musel(Quotation)	Spain	2010	Felguera IHI	150,000 x 3

LNG tanks welded with ESAB consumables, years 2000-2010


Solitaire

If you can dream it, you can do it.

Allseas - top in offshore pipe laying in 25 years.

Ben Altemühl, Editor of Svetsaren

This article looks into the fascinating world of offshore pipe laying, in which welding which is a key technology.

Acknowledgement
We thank Allseas' management for endorsing this article. A special word of thanks goes to Sywert Folkertsma, Unit Head Welding, for his active contribution.

In 1985, Edward Heerema decided to turn a vision into reality and founded Allseas. At that time, the emerging North Sea oil and gas exploration industry was in need of an underwater pipeline infrastructure and his vision, laying pipelines on the seabed using 'dynamic positioning', would prove to be revolutionary. Soon after, the Lorelay was commissioned. Designed in-house and built under the direct supervision of Allseas, she was the first pipelay vessel in the world with dynamic positioning. Now, 25 years later, the company sails the high seas with a fleet of six vessels, has offices in eight countries across the world, and employs around 2500 persons. With the same "can-do" attitude that created this successful company, Allseas is now building the Pieter Schelte – a dynamically positioned platform installation / decommissioning and pipelay vessel. With a length of 382 m and a width of 117 m, it will be the biggest work vessel in the world.

Dynamic positioning
Before Allseas surprised the world with dynamic positioning, pipes were laid by pulling the lay barge towards its anchors while the welded pipe left the ship at its rear. This continuous anchoring was time consuming, especially in deep water. With dynamic positioning, powerful thrusters keep the ship at exactly the coordinates it receives via satellite GPS (Global Positioning System).

Obviously, the ship must lie still relative to the pipeline during welding. This is ensured by

Figure 1. One of three 350 t tensioners onboard Allseas' Solitaire lay barge.

'tensioners'. These are large clamping devices with caterpillar tracks that grip the pipeline, effectively holding the weight of the pipeline between the tensioner and the seabed while the thrusters keep the ship in position (Figure 1).

The tensioners are part of the 'firing line' – a series of welding, non-destructive testing (NDT) and coating stations where 12 m or 24 m pipe segments are connected in stages (root pass, filling and capping) with, in the case of Allseas, the GMAW (MAG) process (Figure 2). When all stations are ready, the pressure on the clamp is decreased and the ship moves forward the length of a pipe segment (12 m or 24 m depending on the vessel) while the tensioner grips the pipe with its caterpillar tracks. The coated and welded pipe leaves the back of the ship via the 'stinger' - a rack that allows the pipe to gradually disappear into the sea, without significant plastic deformation.

Allseas lays pipes by the S-lay technique, where S represents the shape of the pipe between ship and seabed. There is also a J-lay technique,

Figure 2. Firing line onboard Allseas' Audacia lay barge.

where the pipe is welded in PC (2G) position and lowered vertically onto the seabed. S-lay is faster because more welding stations can be used, not just the one or two in the tower of a J-lay barge. The S-lay technique can be applied in water depths from 18 metres to the current record of almost 3 km (Figure 3).

If you can dream It, you can do it

When the entire world is your workplace, nothing is standard and there must be continual improvisation. Allseas, headquartered in Switzerland, is one of the world's major offshore pipeline installation contractors. The company can support its clients in all stages of a project - from design to installation. Projects range from installing pipelines only, to turnkey contracts, from design, engineering, procurement and manufacturing, to installation.

This requires dynamism, inventiveness, and above all, a no-nonsense approach. Allseas relies not only on existing technologies, but develops its own systems and solutions when necessary. Whether it's a tandem welding head for narrow gap GMAW welding, a grit blasting unit, a powder coating machine or a revolutionary design for a multi-purpose vessel such as the Pieter Schelte - everything is designed in-house and adapted to the latest offshore pipe laying requirements. Allseas' company slogan is 'If you can dream it, you can do it'.

This is also reflected in the large number of employees in the engineering and project offices, of which the office in Delft is by far the largest (roughly a fifth of a total 2500 personnel). Of these, almost a quarter have a university degree. Apart from the project engineering and management office in Delft, Allseas has engineering and project offices in Houston for North and South America, and Perth, Australia, serving its customers worldwide and supporting the Allseas fleet.

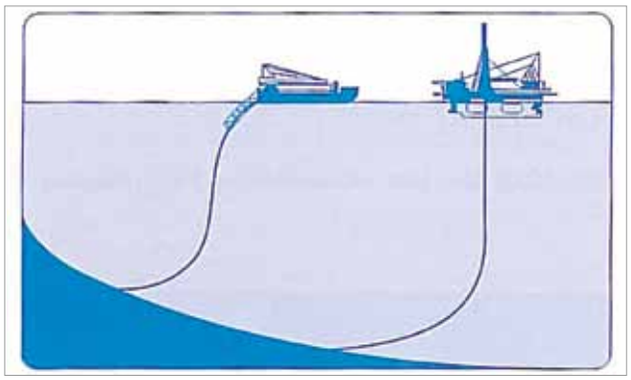
The Allseas fleet

The characteristics of a pipelay vessel are an important factor in the competitiveness of a company active in offshore pipe laying - with time as a central factor. What maximum pipe diameter can be processed? How many kilometres of pipe can be welded and laid per day and what depth can be reached? How quickly can a barge be on-site and how many pipe segments can it carry?

Allseas entered the North Sea offshore industry with a staff of 15 and offices in The Hague and Switzerland. The early years were dedicated to developing the concept of pipe lay with dynamic positioning, and converting a purchased vessel, Natalie Bolten, to the Lorelay - the first lay barge in the world with dynamic positioning. Pipe lay goes hand in hand with the digging and filling of trenches in the seabed so, simultaneously, Digging Donald was developed - an excavator remotely controlled from the (also self-developed) support vessel Trenchsetter.

It was a winning concept. By the end of the eighties, Allseas had taken a 25% market share in the North Sea business. Revolutionary technology enabled the company to compete in a market that was experiencing collapsing oil prices and declining orders.

A rare moment with almost the entire Allseas fleet together. From left to right: Tog Mor, Calamity Jane, Solitaire, Lorelay and Audacia.



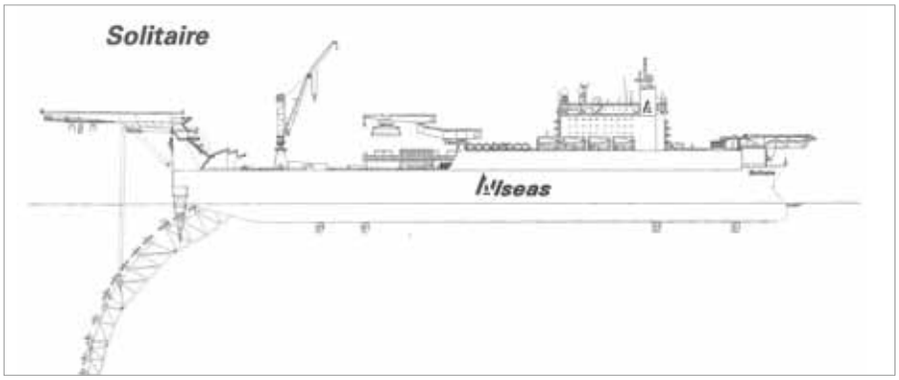


Figure 3. S-lay and J-lay techniques.

The Lorelay is specialised in laying pipelines with small to medium diameters up to 30 inches. Today, she is equipped with the later-developed Phoenix-GMAW welding system (5 stations) in the firing line, and a tensioner capacity of 3 x 55 t, and is able to install up to 7 km of pipeline per day. And, not only in the relatively shallow North Sea, where the first depth record of 300 m was established. The current record for Lorelay is 1960 m, established at the beginning of this century in the Gulf of Mexico.

Interestingly, the concept of the Pieter Schelte, now under construction, was already on the table in the late eighties – an insight into Allseas' vision for the future. But first, in 1998, the Solitaire was to glide from the slipway; an existing ship, the Trentwood, was adapted to meet the requirements of offshore pipe laying. With a length of 300 m, Solitaire by far exceeds Lorelay (182.5 m), also surpassing her sister ship in tensioner capacity (3x 350 t). She can lay pipes with a maximum diameter of 60 inches, can achieve a laying speed of 9 km per day and holds the world record for pipe laying in deep water using the S-lay technique (2775 m, Gulf of Mexico, 2005).

From a welding point of view, it is interesting to note that there are two double-joint welding plants on board, next to a firing line with five GMAW welding stations. First, two 12 m long pipe segments are joined together using the SAW process, before a complete 24 m section enters the firing line. A huge pipe carrying capacity of 22,000 t makes it less dependent on offshore pipe supply.
At the beginning of this century, the fleet was expanded by Tog Mor, a specialised shallow water pipe lay barge, Trenchsetter was replaced by a modern support vessel, Calamity Jane, and Manta was commissioned. Calamity Jane and Manta assist the fleet with underwater reconnaissance, water pressure testing and pigging - the cleaning of the pipe.
The latest addition to the Allseas fleet is the Audacia, also suitable for laying pipes of up to 60 inches diameter. The ship has three 175 t tensioners and seven GMAW welding stations.

Welding as good and as fast as possible
The efficient welding of an offshore pipeline does not really differ much from that of a land line – the deposition rate of the root determines in principle the construction pace. The number of teams or stations for filling, capping and coating is simply adjusted.
The big difference, however, is the influence of welding defects. A weld defect in a land line can be repaired later, without affecting the construction pace. A repair in the firing line of a lay barge,

Figure 4 (left). Macro of narrow gap welding seam for GMAW (production test weld for the Nord Stream project). The opening angle is 3 degrees from the root and zero degrees from the centre.

Figure 5 (right). Macro of a SAW double-joint weld.

however, could mean that the final welding process is halted thereby delaying installation. Therefore, the prevention of welding defects is just as important as a productive welding process - if not more.

This specific industrial requirement is reflected in the complete welding management. Nothing is left to chance. Allseas develops all welding systems and other welding related equipment in-house. The Phoenix welding system, for example, is purchased in parts then self-assembled by Allseas. Components such as welding bugs, welding heads, cable assemblies, clamping devices and control are internally designed, while manufacturing is outsourced. In this way, the company keeps knowledge and innovation of this fundamental technology in-house, and is never dependent on others.

Additionally, under the supervision of welding co-ordinators and welding engineers, Allseas trains its own welding operators, qualifies welding procedures for the various projects and tests new, faster welding methods at its purpose-built welding school in Rotterdam. In terms of equipment, the on-board welding process is replicated exactly at the onshore training school, whereby the same SAW, GMAW and NDT equipment and online systems for monitoring and logging of data are used.

Welding procedure specifications must be successfully tested up to a hundred times before they are accepted for use at sea. Before a welding operator is allowed to work on-board one of the ships, he or she must master a great number of specific procedures outside the usual 5Gu qualification.

And now to sea

The welding process on-board the Solitaire is the most interesting, because it includes SAW double-joint plants where 12 m long pipes are joined into 24 m segments, before entering the firing line. This requires a large ship with huge crane capacity and storage space. The Solitaire is colossal (the length of five Boeing 747s) with six holds to store pipe segments, two double-joint plants, 'ready racks' for interim storage and living accommodation for 420 persons.

Double jointing outside the firing line doubles the ship's laying speed. The process begins with the bevelling of the pipe ends. For SAW this is a U-joint with a land on the outside and a small V-joint on the inside for the sealing run. For GMAW welding on the firing line, it is a narrow gap joint with a small land for the root pass, to reduce the joint volume as much as possible (Figures 4 and 5).

Before double jointing, pipe ends are first thoroughly cleaned, inside and outside, and preheated to 50°C with induction (typically X60 to X70 pipe quality). Then pipes are aligned in the first welding station, using an internal clamp. The root is deposited with a single bead, followed by a number of filling passes, after which the now 24 m long segment moves to the second station. Here the weld is filled until it is ready for capping. In the third and last station, the cap and sealing run are welded simultaneously. A single wire head with 4 mm wire is used for the sealing run – all other layers are performed with a twin wire head with 2.4 mm wire. The welding flux is high basic with good slag detachability and yielding good CVN values at -60°C (EN760: SA FB 1 55 AC H5).

Like all seams, the double joints are 100% ultrasonic tested for welding defects with the same system as used on the firing line - a series of sequentially linked probes, for which water is used as the conducting medium (Figure 6).

The data is projected online and logged, and the system generates an 'accept' or 'non-accept', naturally under human supervision. The pipe then moves on to the 'ready rack' where there must always be sufficient stock to feed the firing line.

The double-joint welding plant is a fine example of welding, but it is in the firing line where "the men are separated from the boys". With up to five GMAW welding stations, a U.S. testing station and four coating stations in operation, up to ten teams work, simultaneously, on different stages of

Figure 6. Automatic ultrasonic testing with pulse echo.

a weld. All of them must try to keep pace with the root pass and release their station when ready. A competitive atmosphere exists between teams that rely on each other's skill and speed (12 hours on, 12 hours off, on average – for five weeks). When the bell rings and green lights show, all stations are ready, all equipment is removed from the pipeline and the ship moves the next 24 m.

In the firing line, the inside and outside of the welding zone are again thoroughly cleaned, followed by preheating to 100°C. Then an internal clamp moves through the 24 m pipe to align the double-joint with the pipeline. A ring of copper blocks provides weld metal support for the root pass. The Phoenix GMAW welding system uses two single torches for the root pass and two tandem torches for the hot pass, filling and capping (Figure 7 and 8). The welding heads are designed by Allseas for narrow gap welding in a seam with an opening angle of 3 degrees or less.

Figure 7. Welding of the root pass on the firing line with two single GMAW torches.

The whole joint is welded vertically down from 12 to 6 'o clock, clockwise and counter clockwise, with one of the torches running ahead of the other; when the second torch is welding the overlap at 6 'o clock, the other is already on its way up. This involves pulsed welding with a high quality welding wire - 1.2 mm diameter ESAB OK Autrod 12.66. The wire has a confined chemical composition for a range of elements and high purity to meet stringent offshore requirements. The shielding gas is 80% Ar/20% CO_2.

All welding stations automatically transmit information to a control room, where screens show, exactly, the stages of the various welds. It is a quick, secure process with very low error rate, aimed at avoiding repairs on the firing line; a repair could result in the vessel sitting idle and losing time and money.

Mechanical requirements

Table 1 shows an example of mechanical requirements imposed by clients on welds to be made and for which WPQ's are to be obtained. The table involves the part of the Nord Stream pipeline from Russia to Western Europe that Allseas started laying in September 2010 in the Baltic Sea. For this project, ESAB OK 12.66 is applied in the firing line.

Figure 8. Welding of filler layers with two tandem SMAW torches.

Overmatching weld metal is a key requirement. Generally, a pipe that leaves the stinger undergoes a strain of up to 0.3%. This is too much to absorb for the small width of weld and heat affected zone; also because weld defects can never be fully avoided. It is safer to distribute the strain over the greater length of the pipe. The degree of overmatch, together with fracture toughness, also plays a part in defect acceptance. Defect acceptance criteria are determined by fracture mechanical calculations according to the ECA method (Engineering Critical Assessment). Defects that do not lead to failure during the design life of the pipe need not be repaired, significantly reducing the cost of offshore pipe laying.

Fracture toughness testing is commonplace in the offshore industry. There are two main methods to determine CTOD (crack tip opening displacement). One is by bending, single edge notch bending (SENB), the other pulling, single edge notch tension (SENT), (Figures 9 and 10). SENT testing generally renders less conservative toughness results because there is a (mostly) two-axis stress condition at the crack tip. In SENB, this is a three-axis condition. SENT testing is also more representative for a offshore pipeline. At macro level, the pipe is bent when it leaves the stinger, but at micro level tensile stresses prevail at the crack tip of welding defects.

This is not only the case when installing the pipeline, but also during service when changing temperatures cause the pipe to shrink or expand. This can generate considerable stresses in the pipeline. Particularly, in a shutdown or start-up of a pipeline, there will be a considerable stress created by the enormous pressure differences in

Table 1. WPQ mechanical requirements for the Nord Stream project.

• Material:	X70 (485 MPa)
• Preheat:	100°C
• Interpass temperature to be qualified:	250 °C
• All weld tensile – minimum yield strength at 0.5% total strain:	80 MPa greater than SMYS of pipe material, i.e. 565 MPa.
• Transverse weld tensile test:	Fail in the pipe material. Weld metal overmatching actual base material tensile strength.
• Hardness:	300 Hv10 max. (but normally 250 Hv10 is required)
• Charpy-V Impact testing (cap & root) -30 °C:	50 J average / 40 J single min.
• CTOD (SENB) -10 °C:	minimum 0.20mm

the line. In addition, the temperature in the pipe can drop to well below zero.

Standards

The laying of pipelines at sea is bound by very strict procedures, which are laid down in standards. In projects in European waters this usually involves:

OFFSHORE STANDARD
Det Norske Veritas
DNV-OS-F101
SUBMARINE PIPELINE SYSTEMS

Here, all steps in the construction of an offshore pipeline are described in great detail, from the drawing board to underwater inspection of the pipeline. Also welding in all its facets is described with a great number of requirements for organisation, qualification and documentation. Table 2 gives an indication of the large number of mechanical tests required for a WPQ of longitudinal and girth butt welds.

Repair Welding

Repair welding is also laid down in this standard. This involves separate WPQ's that are obtained by performing the repair procedure on a gouged part of a girth weld welded with an approved WPS. Subsequently, samples for mechanical testing are taken from the repaired part. Individual repair procedures are required for different clock positions. In addition, DNV requires a preheat temperature which is 50 degrees higher than used in production welding.

A repair costs time and money, so everything is aimed at avoiding this. When a defect is too large, however, the firing line is halted and a repair is made as quickly as possible.

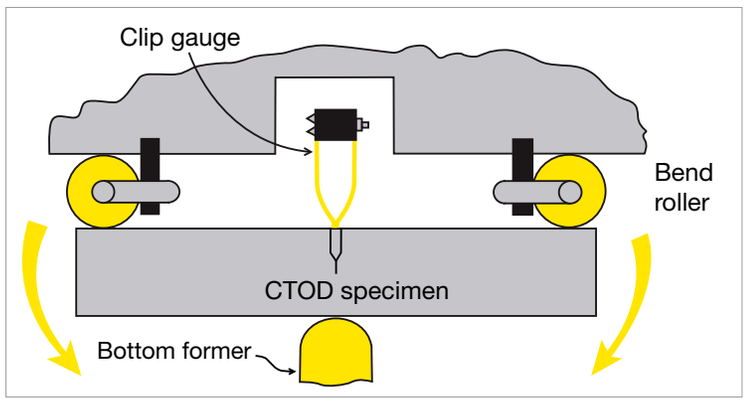


Figure 9. SENB test method.

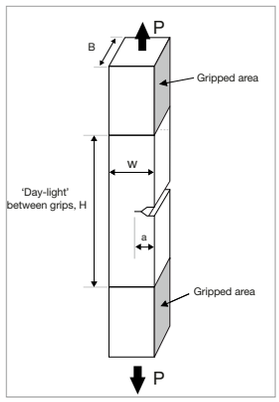


Figure 10. SENT test method.

For the Nord Stream project (X70), Allseas qualified a new repair procedure that uses a cored wire specially developed for this application - ESAB Pipeweld 101-T1. This is a rutile flux cored wire with excellent weldability (spray arc) in all positions. A rapidly solidifying slag supports the weld pool, enabling high deposition rates – ideal for quick manual repairs. The chemical composition, based on TiB micro-alloying, meets the max 1% Ni NACE offshore requirement (H_2S stress corrosion). It is also a consumable with a diffusible hydrogen content below EN H5 for the entire envelope of welding parameters. The wire is used in combination with the coated electrode FILARC 76S (ESAB) for the root pass.

ESAB Pipeweld 101-T1 is alloyed to give a good microstructure at relatively high heat input and prolonged cooling time during the weld repair with a minimum of grain boundary ferrite and maximum acicular ferrite, Figure 11. This results in good mechanical properties with overmatching tensile and yield strength, good CVN impact toughness at -40 ºC and hardnesses well below maximum allowed levels.

Pieter Schelte

With Pieter Schelte, Allseas is taking another innovative step. More than 25 years after the rise of the North Sea oil and gas industry, existing resources are becoming depleted and rigs must be removed - a worldwide trend that will continue. From 2013, Pieter Schelte will be the world's largest pipe lay barge, with a tensioner capacity twice that of the Solitaire and with sufficient crane capacity to lift platform topsides up to 48,000 t and jackets up to 25,000 t. Naturally, the vessel utilises dynamic positioning.

About the author:

Ben Altemuhl EWE, is Editor of Svetsaren and Marketing Communication Manager for ESAB's consumables division. He joined ESAB in 1991.

Table 2. Mechanical tests required for longitudinal and circumferential joints in DNV-OS-F101.

Table C-3 Qualification of welding procedures for longitudinal and girth butt welds

TEST JOINT		*MINIMUM NUMBER OF EACH SPECIFIED TEST*									
Wall thickness (mm)	D *(mm)*	*Transverse weld Tensile*	*Transver-seall-weld Tensile* 1)	*All-weld tensile* 2)	*Root bend* 10)	*Face bend* 10)	*Side-bend* 10)	*Charpy V-notch sets* 4,5,6,7)	*Macro and hardness* 11)	*Other tests* 12)	*Fracture toughness*
≤ 25	≤ 300	2	2	2	2 3)	2 3)	0	4 8)	2	13)	13)
	> 300	2	2	2	4 3)	4 3)	0	4 8)	2	13)	13)
> 25	≤ 300	2	2	2	0	0	4	6 8,9)	2	13)	13,14)
	> 300	2	2	2	0	0	4	6 8,9)	2	13)	13,14)

Notes:

1) Transverse all weld tensile are required if an ECA is performed.
2) All weld tensile tests are not required for OD ≤ 200 mm and not if transverse all-weld tests are performed.
3) For welding processes GMAW and FCAW, side bend tests shall be performed instead of root and face bend tests.
4) Impact testing is not required for t < 6 mm.
5) Each Charpy V-notch set consists of 3 specimens.
6) The notch shall be located in the weld metal, the fusion line (FL) sampling 50% of HAZ, FL+2 mm and FL+5 mm, see Appendix B, Figure 3 through Figure 5.
7) For double sided welds on C-Mn and low alloy steels, four additional sets of Charpy V-notch test specimens shall be sampled from the weld metal, FL (sampling 50% of HAZ), FL+2 mm and FL+5 mm in the root area, see Appendix B Figure 5.
8) If several welding processes or welding consumables are used, impact testing shall be carried out in the corresponding weld regions, if the region tested cannot be considered representative for the complete weld.
9) When the wall thickness exceeds 25 mm for single sided welds, two additional sets of Charpy V-notch test specimens shall be sampled from the weld metal root and FL in the root area.
10) Bend tests on clad/lined pipes shall be performed as side bend tests.
11) For girth welds in welded pipe, one macro and hardness shall include an intersection between a longitudinal/girth weld.
12) Requirements for corrosion tests, chemical analysis and microstructure examination are specified in F.
13) Fracture toughness testing is only required when a generic or full ECA is performed for pipeline girth butt welds. Extent of testing shall be in accordance with Appendix A.
14) For nominal wall thickness above 50 mm in C-Mn and low alloy steels fracture toughness testing is required unless PWHT is performed.

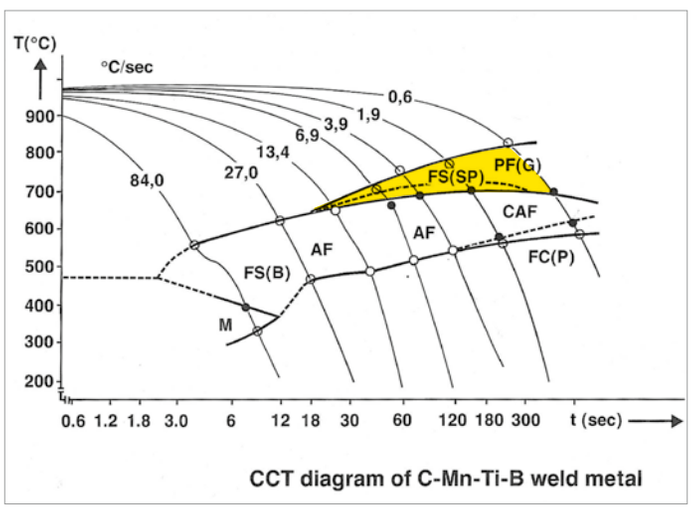


Figure 11. CCT diagram of C-Mn-Ti-B weld metal. AF (acicular ferrite) and CAF (course acicular ferrite) are components in the microstructure that increase weld metal toughness. PF(G) (primary grain boundary ferrite) and FS(P) (ferrite second side plate) are components that deteriorate toughness. By micro-alloying B, the yellow area has been moved to the right, while addition of Ti has expanded the area with AC and CAF towards longer cooling times.

Figure 12. Graphical impression of the Pieter Schelte, a combined vessel for pipe lay and installing and dismantling rigs. It will be the biggest of its kind in the world - and uses dynamic positioning.

Finnish structures for Stockmann gas field in the Barents Sea

Extreme low temperature toughness requirements

Juha Lukkari ESAB OY, Helsinki, Finland

Over the last decades, offshore oil and gas exploration has expanded to deeper and colder waters. Accordingly, mechanical requirements for steels and weld metal have increased, especially low-temperature toughness demands. The article reviews the manufacturing of offshore structures for use in the Barents Sea.

Oy SteelDone Group Ltd, a metalworking project management and marketing company based in northern Finland, has delivered large-scale steel structures and piping for two semi-submersible oil platforms for the Stockmann gas field in the Barents Sea. The value of the contract was some 10 million euro and took almost 100 man-years. The last steel structures were delivered to the Vyborg shipyard in, in Russia, October 2009. The combined steel weight for the whole project was around 2500 tonnes. ESAB supplied the flux/cored wire combination for submerged arc (SAW) welding; a productive solution that satisfied impact toughness demands at –60°C and CTOD demands at –30°C.

Figure 1. The hull of the drilling platform at sea.

The world's largest gas field

Once completed, the Stockmann field, owned by Russian Gazprom, will be the world's largest gas field. It is located in the Barents Sea about 600km off the coast of Kuola, between Murmansk and Novaya Zemlya. The estimated cost of the construction project is €15bn. The gas is located beneath the sea bed at a depth of over 300 m. The size of the field is estimated at 3,800bn cubic metres of natural gas (at normal pressure). The total area of the field is approximately 1400 km^2

Within the current timetable, the first phase of construction for the drilling platforms is scheduled to end in 2015 and to be operational in 2016. Based on current data, the field will require a staggering 20 to 30 platforms. Gazprom estimates that it will be fully operational around 2030.

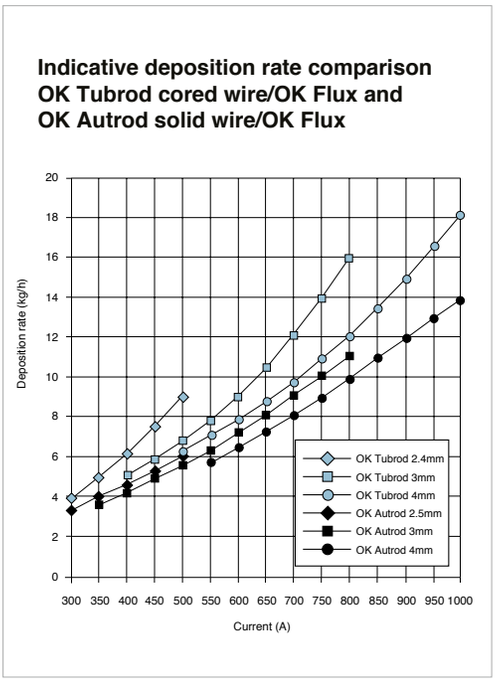


Figure 2. The deposition rate of cored wire and solid wire in SAW welding.

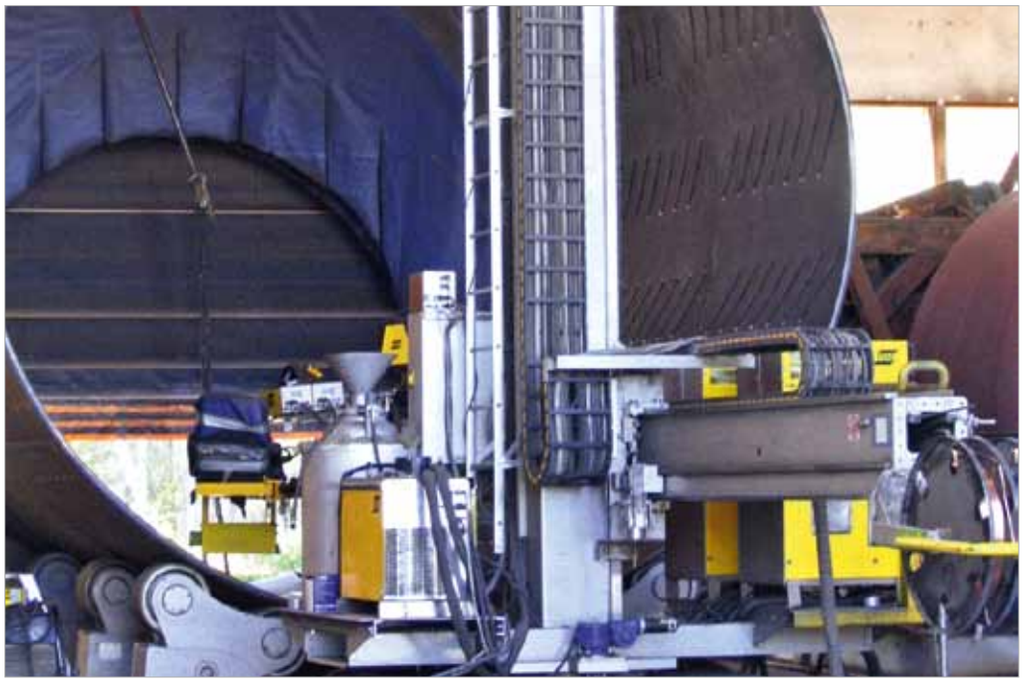


Figure 3. SAW column and boom is fitted for tandem welding, used extensively in the welding of peeling drums and other heavy-duty products.

Table 1. CTOD tests for OK Tubrod 15.25S + OK Flux 10.62 and OK Autrod 13.24 + OK Flux 10.62
15.25S+10.62: steel: Grade 50D, thickness: 40 mm, gap in 60-V weld.
13.24+10.62: steel: Weldox 500 D, thickness: 50 mm, gap in half-V weld
NOTE: AW: as welded and PWHT: post weld heat treated

Combination	Charpy at -60ºC (J) Weld metal: surface	Charpy at -60ºC (J) Weld metal: root	CTOD (mm) at -40ºC Weld metal
15.25S+10.62: AW	144, 126, 147	208, 152, 159	>0.862, >0.836, >0.857

Combination	Charpy at -46ºC (J) Weld metal: surface	Charpy at -46ºC (J) Weld metal: centre	CTOD at -46ºC (mm) Weld metal
13.24+10.62: AW	155, 146, 147, 86, 160 / 139	146, 138, 105, 133, 154, / 135	0.345, 0.191, 0.328
13.24+10.62: PWHT: 2 h @ 620ºC	108, 101, 106, 98, 120, / 107	127, 120, 130, 150, 124 / 130	0.082, 0.158, 0.954

Table 2. Product information for combination OK Tubrod 15.25S + OK Flux 10.62

Classification: AWS A5.23	F7A8-EC-Ni2
All weld metal: typical chemical composition	0.06 % C 0.3 % Si 1.3 % Mn 2.2 % Ni
All weld metal: typical mechanical properties	Yield strength: 492 MPa Tensile strength: 581 MPa Elongation: 29% Impact toughness: 96 J @ -60ºC

Based on preliminary data, two platforms need to be built each year. Nevertheless, as a result of the current global economic downturn, the project has been put on hold after completion of the first two platforms.

The hulls for the two first platforms were built at the Vyborg shipyard, the support structures for the main support legs in Finnish yards, and the drilling unit, at the Samsung yard in Japan. The platform, designed by the Norwegian firm MOSS, is a semi-submersible fitted with two pontoons, and will be used as either a drilling platform or floating production platform, as required. The dimensions of each support leg are 118m x 70m x 40m and each weighs 15,000t. A football pitch would fit inside the platform.

The Finnish-produced components are highly challenging (from both a geometrical and welding perspective) transitional pieces [cones], which connect the support tubes to the main legs, K-connectors and flange pipes. The main welding process for these components was SAW welding. MAG welding with cored wire was little used; almost exclusively for tack welds and root passes.

SteelDone Group Oy
This metalworking project management and marketing company represents five metalworking businesses located in northern Finland, all with extensive experience in manufacturing large-scale, challenging steel structures for the Norwegian and Russian oil and gas industries: Iin konepaja Oy, Rannikon Konetekniikka Oy, Miilukangas Ky, Raahen Tevo Oy, and Raahen Insinöörisuunnittelu Oy. Four of the companies participated in the Stockmann project.

Demanding requirements for steel and welds
The requirements set for the welding work within this project were exceptionally demanding, as the structures will be exposed to extreme conditions in the Arctic Ocean. The temperature can drop to -50°C. The requirements were set by the client and conform to the rules of the Russian Maritime Register of Shipping.

The steel used was PC F 36 TMCP (MRS XIII), as required by the Shipping Register, and the plate thicknesses were between 20 and 60mm. The steel was supplied by the nearby Rautaruukki steel mill. The steel was manufactured using modern thermo-mechanical rolling, which gives high strength in spite of low alloying content.

The typical CE in the plates was 0.35, which is particularly low considering plate thickness. As a result, the weldability of the steel is very good and preheating is only needed for thick plates. The minimum plate thickness for preheating was 50mm at a temperature of 75°C.

The Shipping Register's requirements for F36 steel are:
- Yield strength: 355 MPa
- Tensile strength: 490-620 MPa
- Ultimate elongation: at least 21%
- Impact strength:
  < 50 mm: min 24J/transversal and min 34J/longitudinal at -60°C
  > 50 < 70 mm: min 27J/transversal and min 41J/longitudinal at -60°C

The same requirements apply to welded joints and each company made its own procedure tests. In addition to the normal Charpy impact toughness requirements, the more stringent CTOD (Crack Tip Opening Displacement) requirements were set for the steel and filler metals. The CTOD test also measures the material's toughness and is often used in the offshore oil and gas industry for evaluating tensile strength.

CTOD test at -30°C: The requirement was min. 0.25 mm (most demanding case in this project) This project's structural class was the most demanding required by the register's rules: special structures exposed to ice, wind and cyclical wave motion as well as seismic stress. Additionally, the plate thickness class was 50-70 mm and the steel's yield strength 355 MPa. Based on this, the CTOD requirement was 0.25 mm, minimum.

Filler metal testing
From these requirements, ESAB sought suitable filler metals for SAW welding - the main process. Generally, the testing temperature in CTOD is 'only' -10°C so results for -30°C or lower are rarely available. When the projects are moved to colder conditions, temperatures will be in the range of -30 and -50°C. The client was satisfied for CTOD testing to be carried out by the filler metal supplier.

Two combinations for SAW welding with values that satisfied test results were considered:
- OK Autrod 13.24 (1%Ni-0.2%Mo) + OK Flux 10.62: CTOD tested at -46°C


Fig. 4. A large transitional piece.

- OK Tubrod 15.25S (2.3%Ni)+ OK Flux 10.62: CTOD tested at -40°C

OK Tubrod 15.25S cored wire was selected for the project as its CTOD values satisfied the broader margins of the requirements and were clearly superior to the 13.24 + 10.62 combination (Table 1). Furthermore it is higher alloyed, which was expected to be an advantage in the area of the strongly diluted root, from which impact specimens in thick plates also had to be taken. In comparing price between cored wire and solid wire, cored wire also proved to be cheaper. On the other hand, more attention had to be paid to the storage of cored wire. Naturally, the companies were also in contact with other filler metal suppliers. The ESAB combination produced the best CTOD values.


Figure 5. SAW column and boom.

Table 3. An example of results of SAW welding procedure test (OK Tubrod 15.25S + OK Flux 10.62).

Tensile tests	Result
1	554 MPa (BM)
2	554 MPa (BM)
Bend tests	
4 side bend specimens	180°, no defects
Impact tests	Surface (J @ -60°C)
WM	81, 75, 94/83
FL	209, 120, 253/194
FL+2	243, 249, 215/236
FL+5	247, 275, 297/273
	Root (J @ -60°C)
WM	127, 112, 121!120
FL	209, 239, 14/154
FL+2	230, 37, 210/159
FL+5	243, 245, 244/244
Hardness tests	
BM	173-187 HV, 160-186 HV
HAZ	188-212 HV, 189-225 HV
WM	203-245 HV

Other data for the combination is given in Table 2. The companies also wanted to take advantage of the greater productivity offered by using cored wire. The deposition curves for cored and solid wires in SAW welding are given in Figure 2. Welding work began in December with welding procedure tests. SAW welding tests, conformant to standard EN ISO 15614-1, were on 50 mm plate, with X groove. The tests included normal tensile, bending, hardness and impact tests. Impact tests were done on both the surface of the first side welded and in the area of the root which is known to be more critical.

Without exception, the results of the tensile, bending and hardness tests easily met all the set requirements. In impact tests, the results of some individual specimens from the heat-affected zone of the joint in the root area did not meet requirements, and the impact tests had to be repeated, Table 3. The new test used a lower interpass temperature and heat input, achieving acceptable results.
Almost 15 tonnes of OK Tubrod 15.25S cored wire was used in the four companies, and almost the same amount of OK Flux 10.62 flux. The consumption of MAG cored wire was only about one ton. For each delivery lot (batch) of the cored wire, mechanical tests of the all weld metal had to be done, Table 4.

Iin Konepaja manufactured transitional pieces, K-connectors and pipes for the Stockmann project, and also bent semi-finished components for other companies in the group, Figure 4. One end of the transitional piece is round and the other, connected to the foot, is square.

The company specialises in machinery and steel construction and in the manufacture of pressure vessels and thick plate-metal structures. Core products include pressure vessels, lime sludge reburning kilns and peeling drums, and components for the offshore industry.

SAW welding is the main process used. The company has several ESAB A2 submerged arc tractors and two welding column and booms, the newest of which is fitted for twin tandem process and for the use of cold wire, Figure 3.

Rannikon Konetekniikka Oy is both an engineering company and a provider of installation services. Products include welded beams and beam structures, machines, equipment, machinery frames, production lines, plate-metal and steel structures, all of which set high standards for welding work. For the Stockmann project, the company produced 16 transition pieces using SAW welding and MAG with flux cored wire.
"We have been using cored wire in submerged arc welding for several years, so it's not something new for us", said Quality Assurance Manager, Antero Tanska. "Not a single defect was found in the SAW welds under NDT inspection. The cored wire seemed more productive than the solid wire, perhaps by 20-30%. This is significant, particularly in the welding of thick plates of more than about 30 mm, where the use of cored wire should be considered."

Figure 6. Submerged arc welding in progress.

Fig. 7. Tandem SAW column and boom.

Figure 8. A finished part leaving for the port for onward shipment to Vyborg.

Miilukangas Ky's produces equipment and components for the offshore, steel, paper and forestry industries, lifting and moving equipment, and large welded steel structures.
The company uses two SAW column and booms, one equipped with a tandem system, Figure 7. In normal production the SAW combination is OK Autrod 12.22 + OK Flux 10.71 and, for high impact toughness, OK Autrod 13.27 + OK Flux 10.62.

In this project, cored wire was used for the first time in submerged arc welding. Adaptor pieces were made, and only single-wire welding was used, even though the company uses the tandem process in the welding of large, heavy-duty tubular pieces.

Table 4. An example of lot-specific testing for the OK Tubrod 15.25S + OK Flux 10.62 SAW welding combination.

All weld metal chemical composition	0.052% C 0.37% Si 1.34% Mn 2.21% Ni 0.017% P and 0.007% S
All weld metal mechanical properties	Yield strength: 477 MPa Tensile strength: 584 MPa Elongation: 29.3% Impact toughness @ -50°C (J): 162, 165, 174

"Welders were always asking why the tandem process was not being used, as they really wanted to use it", said Production Manager, Juha Seppälä. "To be safe, we decided to begin with single-wire welding, because we had no previous experience of cored wire.

We were, of course, a little reluctant to use cored wire in production, at first, even though procedure tests had gone well. Everything was successful. However, for the next Vyborg projects, we will also carry out tests in tandem and buy wire in 100 kg reels."

Raahen Tevo Oy specialises in demanding machining and welding of equipment for the steel, paper, chemical, shipbuilding and offshore industries - as well as manufacture of marine propellers up to 7 m diameter. The company produced 3 m diameter pipes for the Stockmann project, bent from sheet metal into cowling cylinders which were then welded into pipes using an OK Tubrod 14.04 and OK Autrod 13.27 + OK Flux 10.62 wire/flux combination. Throughput time was shortened by making an SAW welding portal, used to weld the cowling cylinder butt joints at both ends. The degree of precision required for the welding joints was UT-100%+20% (measured by two different devices and inspectors). Weld error was minimal.

"Of all the company's products (machined, welded, surface-treated and cast), more than half are delivered to the offshore industry, so the inspection reports of the different classification societies have become very familiar", said Managing Director, Teuvo Joensuu.

The classifications for the OK Autrod 13.27 + OK Flux 10.62 wire/flux combination are EN 756: S 46 7 FB S2Ni2 and AWS A5.23: F8A10-ENi2-Ni2/ F8P10-ENi2-Ni2. Traditionally, this is the most common combination in Finland for structures for the offshore, shipbuilding, pressure vessel and bridge building industries when, for example, impact strength requirements are between -40°C and -60°C.

About the author:

Juha Lukkari is Regional Product Engineer at ESAB Oy, Helsinki, Finland.

High productivity for stainless tanks

ESAB Shield-Bright cored wires pave the way to speedy quality welding

Tamás Sándor, ESAB Kft, Budapest, Hungary

Patent Kft. is a Hungarian company that successfully survived the political and economic transformation by combining quality traditions with an easy acceptance of new, productive technologies. ESAB is their preferred welding partner, appreciated for its customer orientated practical support. In 2009, ESAB assisted in the implementation of a productive process solution for the welding of stainless steel tanks – using Shield-Bright cored wires.

Patent Kft

Patent Kft started in 1989 with the production of stainless barrels and devices for breweries. Since then, their portfolio has expanded with tanks for the food (milk), chemical and pharmaceutical industries, pressure vessels, containers, silos and smaller vessels for power plants. From the beginning, the company aimed at the demanding Western European market, adopting high quality standards which formed the basis for current success. They are the dominant Hungarian company in their field of fabrication and enjoy an excellent reputation outside the country. A tight deadline for a new project - the construction of four 1500 m^3 tanks for Hungary's largest chemical company – resulted in a management decision to invest in the future by re-assessing the welding of stainless steel tanks, the objective being to drastically increase productivity.

A change in welding culture

It was clear from the moment Patent Kft received the order that their traditionally applied welding technology, manual and mechanised TIG welding, was far too slow to meet the requested delivery time and that it was the right moment to change

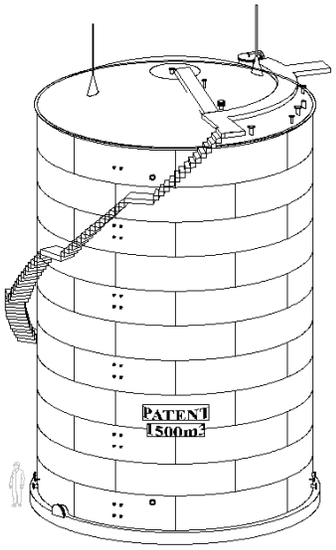


Figure 1. 3-D view of the container tanks.

Figure 2. ESAB style demonstration.

Figure 3. Butt welding application with ESAB Miggytrac 2000X-tra.

to a more economical technology. With assistance and support from ESAB, management embarked on a revolution in welding culture. After two decades of tradition in high quality TIG welding, a company like Patent Kft is steeped in TIG and abandoning it might be compared to quitting smoking. It was a massive challenge – as much for the management as for the employees.

ESAB's stainless steel tank welding solution needed to cover the complete welding process - power sources, consumables, mechanisation and welding procedures. In addition, ESAB was asked to provide practical demonstrations and welder training.

Scope of welding tasks

The tanks, each with a diameter of 11m and a height of 16m, are made of 304L type austenitic stainless steel in 5, 6, 8, 10 and 12mm thickness. They have 11 rings constructed from 1500 x 6000 mm sheets. First the roof is constructed, and lifted, after which the rings are fitted, one by one, from top to bottom, to form the shell. The welding of the shell involves 380 m of joints in the PC (2G) position and 100m in PF (3G) position, plus the joints in the roof and bottom plate.
The tank welding tasks involved three areas: the bottom; the shell; and the roof.

Tank bottom

The bottom of the tank is constructed from 5mm thick, 6000 x 1500mm sheets. The sheets are bevelled to 60° butt joints and the root is welded onto 5 mm thick stainless steel strips. This bottom plate is welded onto a 12mm thick base ring by means of overlap joints, whereas the first tank ring is joined to the same base ring with two-sided fillet welds. These downhand butt, overlap and fillets welds are suitable for light mechanisation - ESAB's Miggytrac 2000 welding tractor being a logical choice.

Less obvious was the selection of ESAB's top-end digital power source, the AristoMig 5000iw with AristoPendant U8 control pendant and AristoFeed 3004w wire feed unit - where a less advanced power source would also have fulfilled the requirements for the complete tank. Patent Kft management opted for the AristoMig 5000iw, because its SuperPulse function in the U8 control unit could be applied to other projects. Very thin plate applications - a substantial part of the Patent Kft portfolio which was formerly covered by mechanised TIG -can now be welded with the faster MAG process making it possible to combine arc types and fully control the heat input. In this way, the company has a 'work horse' for heavy welds and, at the same time, a machine for precision welds.
ESAB advised Patent Kft to extensively test 1.2mm Shield-Bright 308L X-tra rutile cored wire for the downhand butt, overlap and fillet welds, convincing them that this consumable best met their high quality and productivity demands. This wire has been specially developed for applications in the PA and PB position, yielding high integrity welds at deposition rates as high as 10kg/h (Ar/2.5% CO_2 shielding gas). It allows Patent Kft to weld the butt and fillet welds in the tank bottom in one pass at a travel speed of 50-55 cm/min and a deposition rate of around 10kg/h (butt welds on stainless steel backing strip)

Tibor Patonai, Technical Manager: "Previously, we welded thicker plates in three runs, using synchronic TIG for the root (two welders welding the same joint, simultaneously), and the solid wire MAG process for the filler layers. With ESAB's Shield-Bright on ceramic backing, we complete joints in one run; even when welding manually. Another advantage is reduced deformation as a result of the high travel speed and low heat input. In addition, we enjoy an extremely low defect rate with hardly any porosity, cold laps or slag inclusions. The Shield-Bright products became so popular in our workshop that even the proudest TIG welders volunteered to use the wire, in spite of their long time antipathy for the MAG process."

Tank shell

The tank shell represents the majority of the welding work. During the planning stage, it was divided into two welding areas; the top segments (5 to 5mm, 5 to 6 mm, 6 to 6mm joints) and the lower segments (8 to 8mm, 8 to 10mm, 10 to 10mm and 10 to 12mm). All involve butt joints in the PC (2G) and PF (3G) positions.
For the top segment, welds in PC position were carried out with solid wire MAG welding with 1.0mm OK Autrod 308LSi welding wire. Welds were performed in one run on FILARC PZ1500/87 ceramic backing with concave groove. Bevelling was not necessary and welds were absolutely

free of defects - together bringing substantial time and cost savings. The PF welds were still welded with synchronised TIG, because there was not enough time to train the welders in the use of MAG welding with ESAB SuperPulse.

For the lower segment in thicker plate, multi-layer welds were performed with 1.2mm Shield-Bright 308L all positional rutile cored wire with fast freezing slag. It was applied in both manual (root runs in PF position) and mechanised welding (filler and cap layers). The root procedure, however, differed for the PC and PF welding positions. Initially, economic root pass welds with Shield-Bright 308L in PC position on ceramic backing at a travel speed of 28 cm/min proved unsuccessful, because the necessary heavy tack welds could not be remelted completely. Also big fit-up and root gap variations played a role in insufficient root penetration. This was avoided by welding the root pass in PC position with solid wire on PZ1500/87 backing, but at a lower travel speed of 13-15 cm/min. For the filling and cap layers, Shield-Bright 308L yielded high integrity welds at travel speeds of 40 and 60 cm/min, respectively.

In PF position, there were similar conditions for the root pass, but insufficient root penetration was not an issue because of the larger weld pool. The full joint was welded with ShieldBright 308L. The root pass was done manually on FILARC PZ1500/71 ceramic backing with a rectangular groove. The fit-up tolerances did not allow for mechanisation in the filling and cap layer.

Tank roof

The roof grid (called the star by the welders), was pre-fabricated in the workshop and transported in one piece to the tank construction site. Most of the welding work could be brought in the downhand position to optimise benefit from the high deposition rate of ESAB's ShieldBright 308L X-tra. The remaining positional welds were performed with ShieldBright 308L. After on-site connection of the star to the tank's top segment, stiffener beams, cover plates and piping were all welded with the all positional ShieldBright 308L.

Shield-Bright benefits:

- **Downhand and all-positional rutile wires for austenitic stainless steel**
- **Productive**
- **Welder-friendly**
- **Superb weld appearance**
- **No pulse equipment needed**
- **Ar/CO_2 mixed gas and CO_2**
- **Vacuum packed**

Figure 4. Butt joint with Shield-Bright 308L X-tra.

Figure 5. One run PC joint with OK Autrod 308LSi.

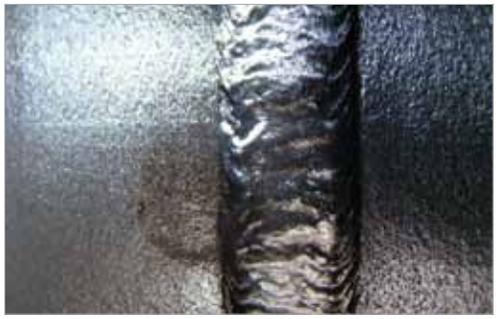


Figure 6. Shield-Bright 308L cover-layer after pickling.

Partnership

The Patent Kft partnership with ESAB is based on practical, result-orientated advice and support. Prior to the project, this took the form of local demonstrations, the joint evaluation of different solutions, the selection of the most suitable and effective welding technology and the establishment of welding procedures. This co-operation continued into the construction stage, where active support solved occasional problems. The co-operation was the basis for the successful construction of the four 1500 m^3 tanks within a period of five months – well within the the deadline required by the customer.

Figure 7. The roof grid (star).

Mr. Tibor Patonai concluded, "ESAB's approach is the most sympathetic in the marketplace. They do not press us to apply any standard technology, but actively help us to realise the solution that best meets our quality and productivity needs. Their flexible and helpful attitude was key to reaching our targets with this project."

Figure 8. Shield-Bright 308L X-tra joint in pre-fabrication of the 'star'.

About the author:

Tamás Sándor
Mechanical engineer, IWE is Product Manager Consumables at ESAB Hungary. He joined ESAB in 2005

Oasis of the Seas – some facts	
Length:	361 metres
Breadth:	66 metres
Draught:	9.2 metres
Height:	64 metres (from water level)
Service speed:	22 knots
Gross tonnage:	225,000 tons
Passenger capacity:	5,400 passengers
Crew capacity:	2,100

Oasis of the Seas

The world's largest and most expensive luxury cruise ship.

Juha Lukkari ESAB Oy, Helsinki, Finland

Oasis of the Seas is colossal. The ship compares to a small town - carrying up to 7500 passengers. She has some 2,400 kilometres of welds for which more than one million kilos of filler material was used - the overwhelming majority supplied by ESAB - selected to ensure secure welds at a high productivity.

Acknowledgement
We thank the STX Finland shipyard management for their permission to write this article. We especially thank Pasi Hiltunen, who kindly answered our questions and provided information about the ship welding processes.

Born in Finland
Oasis of the Seas is a masterpiece of Finnish expertise and workmanship. She inherited the title of the world's largest cruise liner from sister ship, Freedom of the Seas, which was completed in 2006. Both ships were built at STX Finland's Turku shipyard. Gross tonnage (GT) of is 225,000 tons while that of Freedom of the Seas is a comparatively modest 158,000 tons. *Oasis of the Seas* is 23 metres longer than her sister ship. STX Europe is the world's leading builder of cruise ships. The Group has 15 shipyards, located in Finland, France, Norway, Romania, Brazil and Vietnam, and some 16,000 employees. STX Finland operates three shipyards in Finland - in Turku, Rauma and Helsinki.

The ship was ordered by the Royal Caribbean Cruises Ltd, a Norwegian-U.S. enterprise and the second largest cruise ship company in the world. Construction started on 1 March 2007 and the ship sailed for its home port in Miami, Florida, on 27 November 2009. The ship cost around one billion euro!

Oasis of the Seas received vast media coverage when it arrived in the United States, and was then reported to be the most popular Google search term in the world. More than six million people had visited the *Oasis of the Seas* website by the end of 2009.

Luxurious Central Park.

Sister ship, Allure of the Seas, is currently under construction in Turku and will be handed over to the customer later this year.

Outstanding features

Central Park, at the heart of the ship, is about 100 metres long and 30 metres wide and features 12,000 real trees and plants. Cabin compartments are situated on both sides of Central Park. A 500-seat stern amphitheatre has fine views to the sea. There are many large swimming pools (containing 2,300,000 litres of water), a tennis court, minigolf course, basketball course, climbing wall, day nursery, treatment studios and numerous restaurants, as well as operating theatre, marriage chapel and a unique 700-metre running track.

Enormous welding project

The construction of the ship's hull was a vast plating and welding effort. The hull comprises some 500,000 parts, welded to each other to form small blocks, which are then welded together to create grand blocks. The hull consists of 181 grand blocks weighing 200-600 tons each, typically measuring 22 m long by 32 m wide by 13 m high. The steel plate weight of the hull is around 45,000 tons.

Complete, partly finished grand blocks are painted and transported to the construction area for assembly. This is followed by furnishing and decoration work and mounting of the staterooms. The ship has some 2,400 kilometres of welds for which more than 1000 tons (over one million kilograms) of filler material was used, divided in the following proportions:

- Flux cored arc welding 75 %
- Submerged arc welding: 15 %
- Manual metal arc welding: 9 %
- Other processes: 1 %

Steels used

The thickness of the ship's bottom plates is 20 mm and that of the side plates between 15 mm and 32 mm. There are 17 decks. In the hotel area, deck plate thickness is usually 5.5 mm. The steels are ordinary ship construction steels with grades from 235 to 355 MPa. High-strength NVA 40 ship construction steel was used for some hull parts.

ESAB - the main supplier of filler metals

ESAB supplied an overwhelming majority of filler metals, selected with the aim of obtaining secure welds at a high productivity :

- PZ6113 all positional rutile flux-cored wire
- OK Tubrod 14.12 metal-cored wire
- OK 48.00 (and OK 46.00) covered electrode
- OK Autrod 12.22 (and OK Tubrod 15.00 S) submerged arc wire
- OK Flux 10.71 submerged arc flux

FCAW dominates

Flux cored arc welding is the most common welding method, used in as many jobs as possible. All cored wires are welded using shielding gas. M21 mixed gas is used with metal-cored wires and mixed gas or carbon dioxide with rutile flux-cored wires. Metal-cored wires are mainly used for fillet welding in different positions. The special feature of the OK Tubrod 14.12 metal-cored wire used is excellent weldability in vertical down fillet welding (PG). Rutile flux-cored wires are used in different types of butt welds in blocks, often combined with ceramic backing. Welding processes jobs are manual, mechanised by means of small tractors and carriages on rails, and robotic.

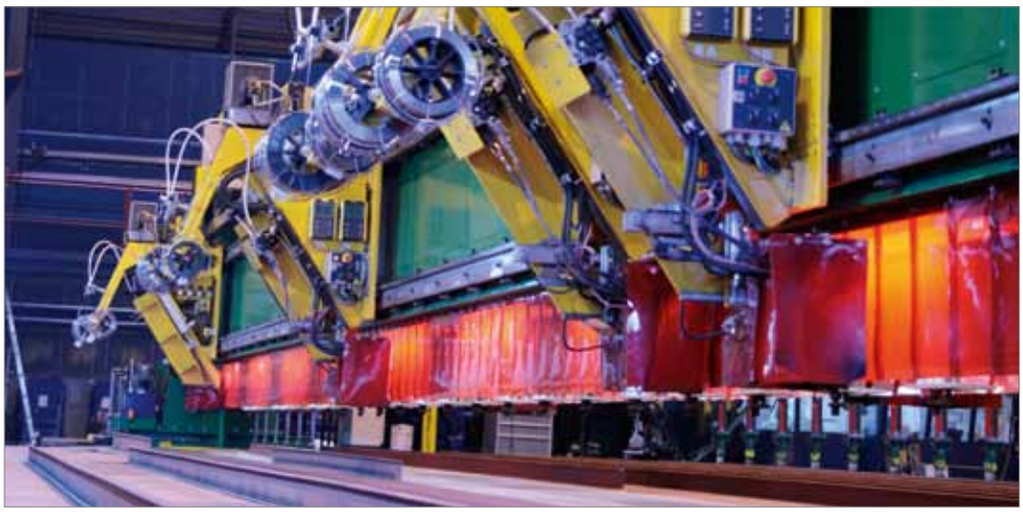
Large-scale tandem MAG welding equipment was used during construction of the ship for fillet welding of stiffeners. It consisted of 8 tandem welding heads in which the first wire is solid wire and the second is metal-cored.

Submerged arc welding is performed in several welding stations and lines, including one-sided welding stations, a stiffener fillet welding station and a Tee profile manufacturing station, and welding tractors. The main filler material is solid wire, but flux-cored wire is also used. The submerged arc welding processes use 1, 2 or 3 wires, twin wire welding and serial arc welding.

Mechanised horizontal MAG welding with flux-cored wire in the hull.

Robotic welding in the bulkhead axis.

MAG welding with flux-cored wire.



Tandem MAG portal for panel line beam welding.

Laser hybrid welding station and a complete hybrid weld.

Manual metal arc welding was used for tack welding and the outfitting welding.
Laser hybrid MAG welding was also adopted during the construction of *Oasis of the Seas.* A 6 kW fibre laser was used on a 12 metre line on which one-sided butt joint welds are made on 5.0 to 6.5 mm plates. Laser hybrid welding is a powerful process when compared with traditional submerged arc welding. Above all the method is accurate with few and very small welding deformations.

"We have many other welding processes and approved WPS'es in reserve" says Pasi Hiltunen, Head of the Welding and Quality Department. " They include electroslag welding (ESW), electrogas welding (EGW) and plasma welding, and we can also use friction-stir welding (FSW) through our subcontractors".

The construction introduced new challenges to welding technology. New laser hybrid welding and a large-scale tandem MAG filler welding stations were adopted during the manufacturing process. High-strength NVA 40 steel was introduced, which required attention to welding metallurgy. The use of fast welding processes of this kind may result in very hard welds, and controlling this requires a lot of work. In addition, duplex stainless steel was used in some spherical parts, which made them difficult to process, plate and weld.
The quality requirements for the welds were very strict. The hull is dynamically loaded, which must be taken into consideration in planning and manufacture.

Extensive training for welding personnel
STX Finland's shipyards have assigned major resources to training and qualifying welding personnel at all levels:

- IWE (International Welding Engineer)
- IWT (International Welding Technologist)
- IWS (International Welding Engineer)
- IWI (International Welding Inspector)
- Visual inspector

Training continues. Competence requirements for welders are strict. All welders must pass the competence tests required by EN 287 or EN

1415. A vocational college is established in the shipyard.

Cooperation

Pasi Hiltunen stresses the importance of cooperation between the supplier and the shipyard.

"We utilise ESAB's good products and skilled personnel in a variety of ways, which is important to the shipyard. In addition, ESAB's instructors regularly visit the shipyard to arrange short courses or briefings for welders and other personal specialising for example in cored wire and submerged arc welding".

Future

Concluding the interview, Pasi Hiltunen said,"In global terms the shipyard industry is undergoing the most severe crisis of all time. However, we believe that ships will continue to be built in Finland. The shipyard closely monitors trends in welding technology and chooses new solutions and methods that suit its needs".

Products used

FILARC PZ6113 represents the latest generation of all position rutile, low-hydrogen flux-cored wires. This multipurpose wire is the most productive consumable available for manual and mechanised positional welding and, at the same time, is extremely welder firendly. It can be used in pure CO_2 as well as Ar/CO_2 shielding gas. Deposition rates in vertical up welding can reach 4 kg/h (100% duty cycle).

Classification

SFA/AWS A5.20	EN ISO 17632-A
E71T-1C H4	T 42 2 P C 1 H5
E71T-1M H8	T 46 2 P M 1 H10

OK Tubrod 14.12 (1.2 mm) – is a unique metal cored wire with great versatility for manual welding in shipbuilding. It is a truly all-positional consumable, since its use includes the very productive vertical down welding of fillet welds in thinner plate. It can be welded in $C0_2$ and Ar/CO_2 (M21) mixed gas and has a high tolerance to primer. Vertical down fillet welding with OK Tubrod 14.12 provides a productive, high-quality solution for 5 to 10 mm plate thickness where vertical up welding with, for instance, MMA or FCAW would result in too much deformation, due to the higher heat input. Travel speeds in this position can reach 50- to 70 cm/min.

Classification

AWS A /SFA 5.18	EN 758
E70C-6M	T 42 2 M M 1 H10
E70C-6C	T 42 2 M C 1 H10

OK Flux 10.71 is an agglomerated, basic flux for submerged arc welding. It is used for single and multi-run welding of all plate thicknesses. It can be combined with a wide range of solid wires and cored wires and is suitable for all kinds of steels. OK Flux 10.71 combines good toughness with excellent weldability. It is used for single and multiwire procedures such as tandem, twin-arc, tandem-twin welding, and more, for butt, overlap and fillet welds. It works equally well on DC and AC current. High welding speeds can be achieved producing a finely rippled weld metal - all in combination with good impact values.

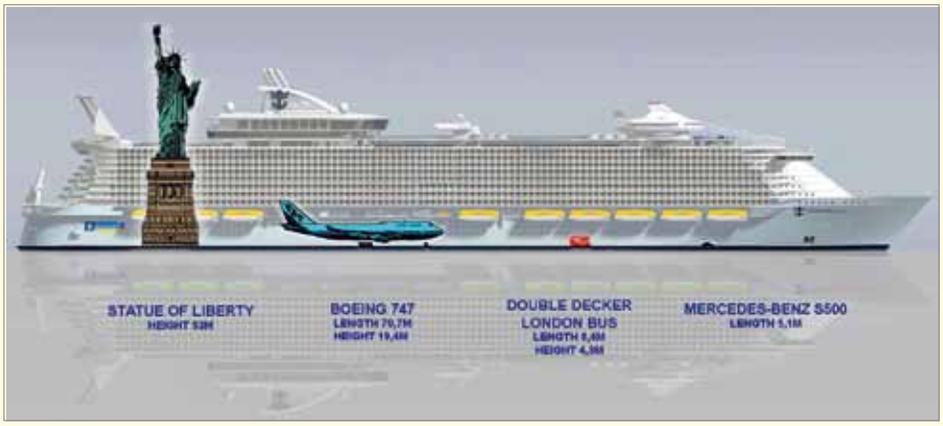
Classification

Flux:	EN 760: SA AB 1 67 AC H5

OK 48.00 is a reliable general purpose LMA electrode for non- and low-alloyed steels, depositing a tough crack resistant weld metal. The electrode can be used for welding structures where difficult stress conditions cannot be avoided.

Classifications:

AWS A/SFA 5.1:	E7018
EN 499:	E 42 4 B 42 H5



About the author:

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LNG tank erection using the spiral method

A unique procedure applied by Midroc Rodoverken AB.

Ben Altemühl, Svetsaren Editor

Nordic LNG, a small-scale LNG project developer, invested 145 million Euro in the construction of a 300,000 tpy gas liquefaction plant near Stavanger, Norway – to become operational in autumn 2010. Swedish construction company, Rodoverken AB, will erect the 30,000 m^3 LNG storage tank – the only tank builder in the world using the renowned spiral method.

Norway plans small-scale LNG plant near Stavanger

Nordic LNG, a joint venture between Norwegian utility, Lyse Energi, Stavanger, and the maritime transportation service company, IM Skaugen, Oslo, develops small-scale LNG (liquefied natural gas) projects to provide gas supply to customers in Northern Europe. The Nordic LNG concept includes active development and involvement in the whole energy supply chain, including liquefaction, transport and the sale of LNG direct to end-users.

The Stavanger liquefaction plant, designed by Linde, Wiesbaden, Germany, will receive 200 million cubic metres of Norwegian natural gas - extracted by Royal Dutch Shell - transported to the processing plant via a Lyse owned high-pressure pipeline. Lyse and its partners build, own and operate the LNG plant, while IM Skaugen owns and operates the multi-gas carriers needed for sea transportation. The Nordic LNG joint venture is responsible for the marketing and sales of LNG to industrial customers – mainly in the pulp and paper, chemicals and minerals industries – and for logistics including terminals, land based transport and end-user local storage. Supplies will cover the Greater Oslo region and the Swedish west coast. Storage of gas near main users is in a number of small LNG tanks spread across the region.

Rodoverken AB

Rodoverken AB, in Ödsmål, Sweden, designs, supplies and installs atmospheric tanks and pressure vessels - mainly in Northern Europe. It is also a significant piping and mechanical contractor in the petrochemical, paper and pulp and energy industries. The company has around 150 employees and a turnover of approximately 300 MSEK. It is part of Midroc Europe -a consortium of companies owned by the Saudi Midroc Group - with three divisions: Contracting & Consulting; Property Investments; and New Technologies.

As part of a strong business group, Rodoverken has access to extensive support. Midroc Europe can provide many of the trades required for large plant construction. Services can be delivered

individually by each of the subsidiaries or can be integrated as multi-discipline packages with a single point of contact.

The spiral method – ingenious, safe tank construction

Rodoverken AB has successfully used the spiral method for tank shell erection for more than 35 years. It is applied on tanks, silos and other cylindrical shells with self-supported roofs and floating roof tanks. In terms of welding, it has many advantages over traditional methods of tank construction, where the shell is erected ring by ring with the placement of the roof as a last step. For example:

- All welding takes place at ground level in a relatively small work area. This is convenient for the workers and enhances the safety.
- Welding takes place under comfortable, weather protected conditions.
- Each joint is welded at the same location and under similar conditions
- Welding equipment is small and easily handled.
- Easy supervision, eg, X-ray proofing.

The technique is based on rotating the upper part of the shell of the tank along an inclined plane formed by the base of the shell. Rotation is accomplished by means of hydraulic jacks that nudge the upper part step by step.

Construction starts with the bottom, where plates are laid out and welded in the normal manner. Next, the lower shell part is welded to the bottom, the upper edge of which forms the spiral (Figure 2). Subsequently, hydraulic jacks are placed along the spiral upper edge.

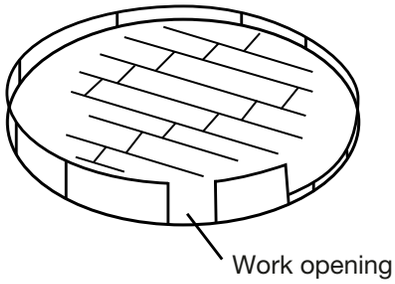


Figure 2. Lower shell part with spiral form upper edge.

The next step is the construction of the roof structure, which takes place at ground level. First the top course with a counter spiral is prepared in exactly the same way as the bottom course, by placing plates step by step onto the jacks, while welding the vertical joints. Together they form a low tank wall with a horizontal top edge. At this low height, the roof structure is erected, followed by the roof plating (Figure 3). In this way, a rigid construction is formed from the outset, avoiding any risk of collapse of the tank during a storm.

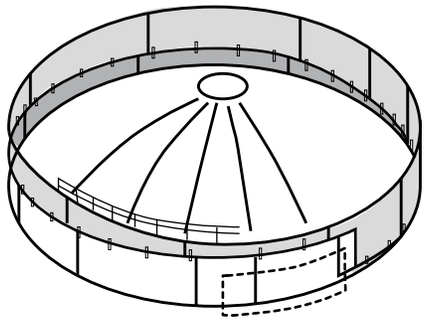


Figure 3. Roof and top part of shell erected. Hydraulic jacks are in place.

The third stage involves the welding of the fill-in plates (Figure 4). They are connected to their predecessors by one-sided vertical welds, in welding cabins outside the tank, and pulled into the tank by the jacks in steps of 100 mm. Once inside the tank, at the work opening, the reverse side of the vertical joint is welded, after which it is pulled-in again over the full plate length. Now the horizontal joint is tacked and welded over the full plate length, from both the inside and outside of the tank.

Three welding steps are carried out, simultaneously, by three teams: first side of vertical weld; second side of vertical weld; and tacking and welding of horizontal weld.

Once each new plate is connected, this procedure is repeated. When the last shell plate has been processed and the tank is fully erected, the jacks are removed and wedges are placed to give the correct root gap. Then the last joint, the spiral, is welded.

This unique tank construction method is especially convenient when space around the

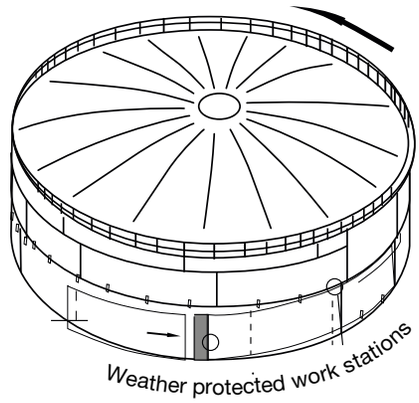


Figure 4. Erection of the shells.

tank foundation is limited, a tank has to be erected among existing tanks or close to a class A storage tank, unfavourable climate exists, or tanks are erected at remote sites with difficult access for cranes and other heavy equipment.

Steel and welding consumables for LNG tanks

Methane liquefies at –163°C to become LNG, decreasing its volume by a factor of more than 600. The materials used in tanks which keep the gas at liquefaction temperature need to remain ductile and crack resistant with a high level of safety. The material also needs to have high strength, in order to reduce the wall thickness of the container and must permit welding without any risk of brittle fracture.

In the case of land-based tanks, 9% nickel steels provide the required combination of properties at a reasonable price. The excellent impact properties at cryogenic temperatures are the result of a fine-grained structure of tough nickel-ferrite. Small amounts of stable austenite, formed due to a quenched and tempering treatment in a very narrow band, further improve impact resistance.

Weldability is good with 9% nickel steels. Unless the constructions are heavily restrained, there is no need for preheating or a post weld heat treatment and the material is not prone to excessive hardening. The interpass temperature should be kept below 150°C. The peak hardness in the HAZ will reach 250-320 Hv10 at heat inputs between 1-3 KJ/mm.

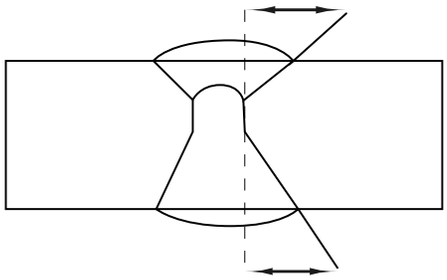


Figure 5. Unsymmetrical X-joint. Joint openings angle: 35°/40°. Root gap: 2-4 mm. Nose: 2-3 mm. The wall thickness ranges between 10 and 13 mm. The material grade is EN 10028-4: X7Ni9 / 1.5663.

The magnetic properties of 9% nickel steel mean that arc blow will occur and that counter measures need to be taken such as AC welding when possible, the placement of split earth clamps and plate demagnetisation.

For cryogenic temperature applications, nickel-based, austenitic weld metals should be used to comply with ductility and strength requirements. They also have a thermal expansion coefficient of the weld metal which closely matches that of 9% nickel steel itself.

Table 1 gives an overview of ESAB consumables for 9% nickel steel. They have been successfully applied worldwide in a vast number of LNG projects and have an enviable reputation for weldability and mechanical properties - as documented in many welding procedure qualification records.

Step by step spiral tank welding

The first step in Rodoverken's unique spiral tank welding method is the joining of the plates to be fed into the concrete outer structure to form the tank. This involves mechanised MIG welding, in PF position, of the first side of an unsymmetrical X-joint, Figure 5. This takes place in two welding cabins placed outside the concrete wall. Root pass welding is done in the first cabin, the filling in the second cabin.

The welding consumable used is 1.2 mm OK Autrod 19.82, used under Ar/30% helium shielding gas. The process is mechanised, using ESAB Railtrac welding tractors with control unit and remote control. Power sources are AristoMig

Figure 7. Welding of the first side of the vertical welds, taking place outside the concrete wall in a welding cabin.

Figure 6. Joining of plates in PF position before they are fed into the tank's concrete outer wall. Welding process: mechanised MIG.

Figure 8. MIG welding of the reverse side of the vertical joint, in the work opening inside the concrete tank wall, using OK Autrod 19.82, AristoMig 500 power sources and Railtrac equipment for mechanised welding.

500 with U8 control unit. It involves double pulse welding using synergic lines stored in the memory of the U8 control unit. Minimal weaving is applied for the root pass, whereas for the filling passes up to 15 mm weaving width is applied.
When the first side of the vertical joint is finished, having passed the two welding cabins, the added plate is pulled into the work opening in the concrete wall. Step two in the process now takes place: the second side of the vertical weld is completed, following the same welding procedure, after grinding the root area (Figure 8).
The third step is the tacking and welding of the horizontal joints. This involves double-sided submerged arc welding in PC position (horizontal vertical) over two or three plate lengths using ESAB A6 welding tractors travelling over a rigid rail fixed to the bottom ring. Here, a technology is applied which is typical for tank building: submerged arc welding (SAW) in PC position (horizontal-vertical), Figures 9, 10 and 11. The flux, needed to protect the weld pool, is kept in place by a belt with a rotation speed that equals the travel speed of the tractor. The flux used here – agglomerated fluoride basic OK Flux 10.90 – has been especially developed for this purpose. It

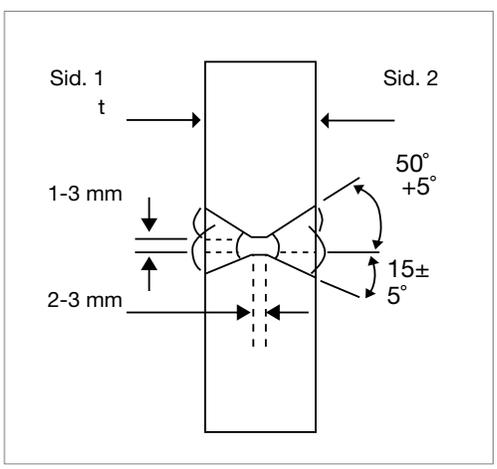


Figure 9. Symmetrical X-joint to be SAW welded in PC position using ESAB's OK Flux 10.90/OK Autrod 19.82 flux/wire combination. The root gap is only a few mms wide to avoid lack of fusion. The root is ground back before welding the second side. The first filler layer on each side always has a certain amount of undercut at the upper edge, but this is taken away by the second filler layer.

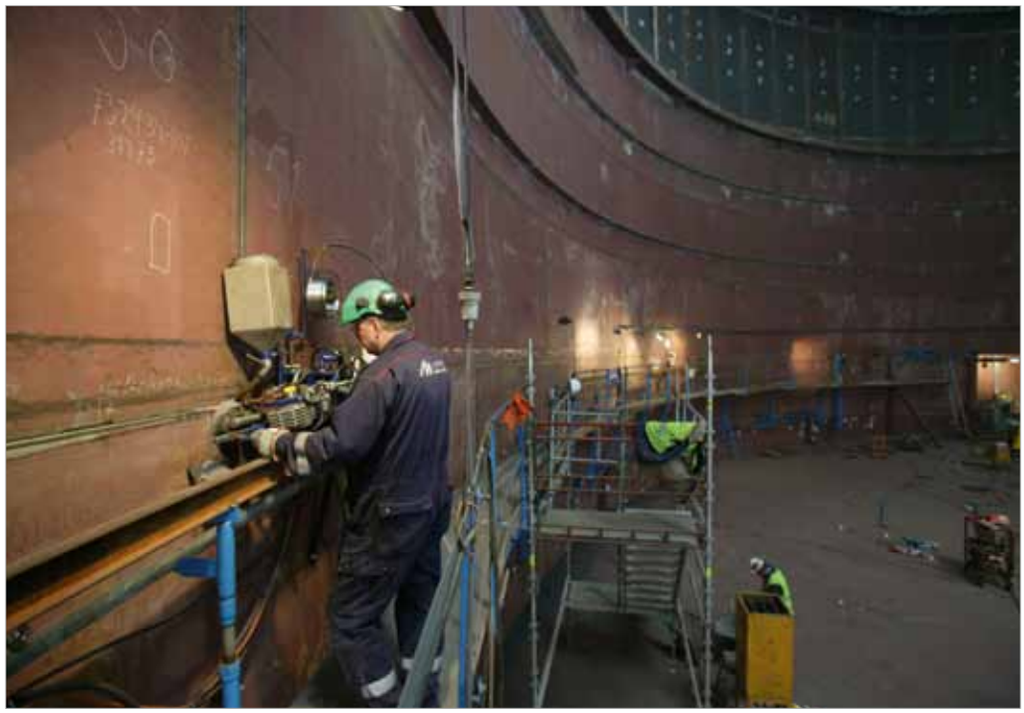


Figure 10. Overview of the area where SAW welding of horizontal joints takes place. Visible is scaffolding near ground level, the rail for the subarc tractor which is fixed to the bottom plate and – in the background – the work opening.

Figure 11. Close-up of the SAW welding in PC position. A rotating belt keeps the weld pool protected by flux. The same procedure is first executed on the outside of the tank, after which the root area is ground to prepare for the inside weld.

Table 1. Overview of ESAB welding consumables for 9% nickel steel.

Flux/wire combination	Classification flux	Classification wire	Chemical composition weld metal (%)								Mechanical properties weld metal			
OK Flux 10.90/ OK Autrod 19.82											Rel (MPa)	Rm (MPa)	A4/A5 (%)	CVN (J)
	EN 760: SA AF 2 CrNi DC	EN S Ni6625 (NiCr22Mo9Nb)	C	Si	Mn	Cr	Ni	Mo	Fe	Nb + Ta	440	720	33	90 at -196°C
		AWS ERNiCrMo-3	0.01	0.2	2	21	Bal.	8,5	2	3				
MIG wire														
OK Autrod 19.82		EN 18274: S Ni 6625	0.01	0.1	0.1	22	Bal.	9	<2	3.65	500	780	45	110 at -196°C
		AWS/SFA 5.14: ERNiCrMo-3												
MMA electrode		Classification												
OK 92.55		EN ISO 14 172: E Ni 6620 (NiCr14Mo7Fe)												
		AWS/SFA 5.11: EnNiCrMo-6	0.05	0.3	3	12.9	69.4	6.2	5	1.3	460	720	40	100 at -196 °C

Figure 12. Welding of the tank's reinforcement rings, when all principal welds are NDT tested and approved. The same versatile OK Flux 10.90/OK Autrod 19.82 flux/wire combination is used.

is suitable for single and multi-layer welding of butt and fillet welds in unlimited plate thickness 9% nickel steel. A major benefit is excellent weldability – particularly in PC position – and superb slag release. It is used in combination with nickel-base 1.6 mm diameter OK Autrod 19.82 SAW wire. The same flux/wire combination is used for the stiffener rings, which are attached when all principal welds are visually inspected and 100% X-rayed (Figure 12).

When all welding is finished, the completed tank above the bottom ring is lifted and transported by the jacks in steps of 100 mm over a full plate length. It is an amazing experience to hear and see several hundreds of tonnes of steel being lifted and moved. Particularly, when it is realised that this project concerns a relatively small 30,000 m^3 tank - and that tanks triple this size are often lifted!

About the author:

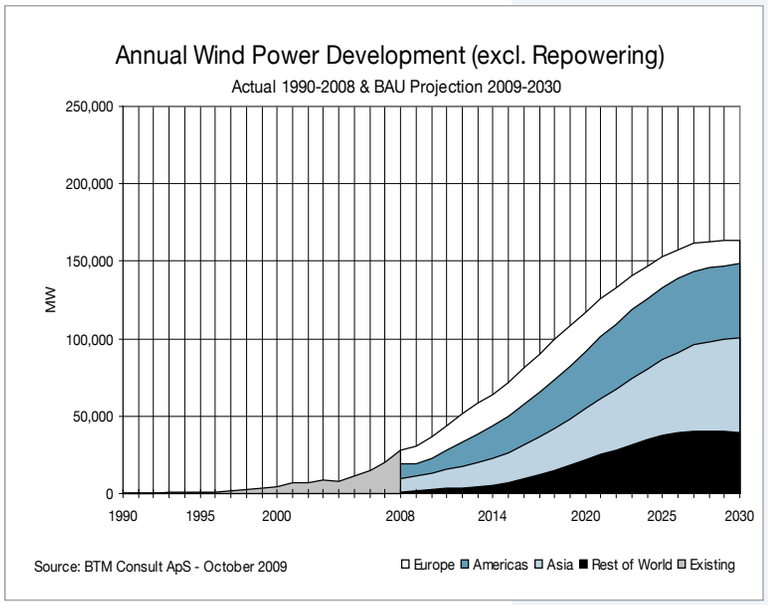
Ben Altemühl EWE is Editor of Svetsaren and Marketing Communication Manager for ESAB's consumables division. He joined ESAB in 1991.

Profitable wind tower production through optimised welding and cutting solutions

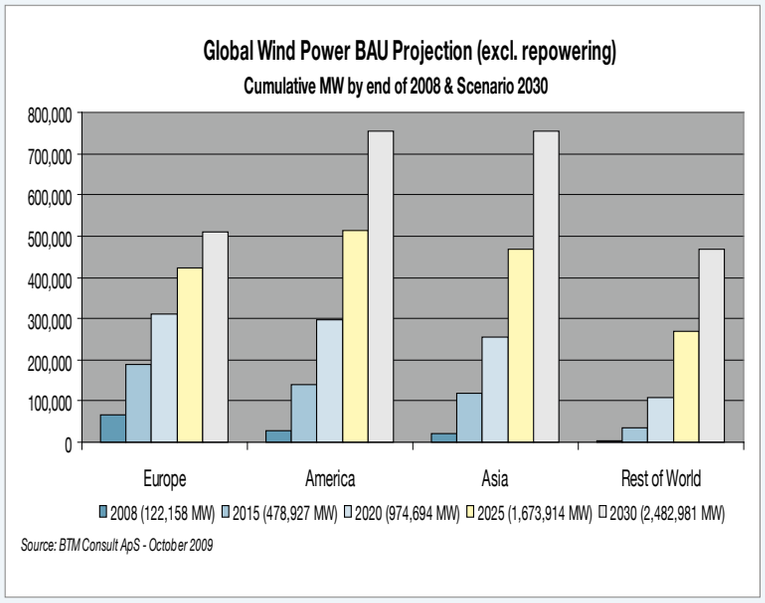
Tobias Finndin, ESAB AB, Gothenburg, Sweden.

Siemens press picture

Welding and cutting processes are, probably, the most time consuming elements in wind tower production. As the demand for wind towers grows, manufacturers must consider the best methods for achieving increased productivity through training, by working with existing machinery, and growing with a strong partner, such as ESAB.



Courtesy of BTM Consults ApS.



Courtesy of BTM Consults ApS.

Considering the current and expected future demands for renewable wind energy, and taking into account the relatively simple base structure and principle of an industrial wind turbine, it might be expected that many companies would be making good profits producing wind towers. However, looking more carefully at the details of wind tower production, it is clear that this is a complex environment where rigorous demands on quality and strength need to be carefully balanced against tough productivity levels in order to reach even modest revenue margins. This article focuses on the production of one of the three major sections of a wind turbine – the wind tower – and explains the production methods (the various steps from steel plates to finished towers) with a special focus on welding and cutting. The article further examines how various alternative production steps can be optimised and made more effective in order to contribute to overall production and profitability by higher throughput and/or cost savings.
We look at the challenges involved – strength requirements, materials choices, flow layout variations, and more. We also consider welding requirements - bead shape, speed limitations, heat-input, consumables requirements and solutions, and high productivity welding processes - and look at duty-cycle [arc factor], set-up times, high-productivity big bulk consumable solutions, logging and quality systems, etc.

The wind turbine market
The current global demand for wind energy [and wind towers] is at an all time high with even greater demand forecast for the future. The greatest demands for wind turbines come from North America, Europe and Asia [China], followed by a lesser demand from South America, the APAC, Russia and the Middle East.

The driving forces behind these demands vary across nations, however the most common are political pressure and profits to be made through high demand for' green', low-cost electricity. [1] The EU's so called '2020-agreement' is a good example of how a political agenda drives the wind turbine industry. By the year 2020, combined electricity capacity in the European Union must include 20% energy from renewable sources. Each member state has a set goal for its increased green energy ratio and, for most countries, wind energy is the most attractive option [2]. (A similar target is set by the U.S Department of energy [3]). These politically driven demands, in turn, create a slightly artificial market where wind tower investment will be profitable not just through common market dynamics. Governments will make the creation of wind energy profitable through subsidies, tax-incentives, etc, in order to drive developments. Combining the need for electricity, and the political agendas, current and future demand for wind towers cannot be questioned. For those that can set up and run high productivity wind tower production, there will be a profitable marketplace.
With the ever-increasing demand for wind towers, there is still a shortage in production capacity in many areas of the world. Where under-capacities exist, a second market approach can often be found – wind towers exported from low- labour countries. When contractors struggle to meet deadlines, a wind tower shipped from across the globe will be less costly than missing the wind park delivery time.

The challenges in production
To fully understand the production challenges, we must first look at wind tower construction. A wind turbine consists of three main sections: the foundation at ground level; the nacelle with generator and blades; and the tower which has to guide all forces to the ground and sustain the weight at the top. A modern on-shore wind tower

varies between 90 and 140 metres in height and is, in most cases, slightly conical. Most towers are of steel construction with a typical diameter of 4.5 metres and weight of 250 tons. Plate thickness varies from 16 mm to 60 mm throughout the tower wall. For off-shore towers, the wall thickness can reach 100 mm or even 140 mm in a monopile foundation. As on-shore wind towers are transported by road to the erection site, the infrastructure sets the limitations for the design. Thus, towers are made in segments of between 27-30 metres that are screwed together on-site to create the entire tower. The segments are made from a number of circular 'cans' usually 3 to 3.5 metres long, a segment thus made from 8-10 cans. The cans in turn are rolled steel plates that again are subject to infrastructure and transport limitations - hence the length of the cans.

Steps in wind tower segment production

With only minor variations, most wind tower segments are produced in the same way across the globe:

- Plates are cut to form the conical segment and edges are prepared for welding.
- Plates are rolled to a circular shape [cans] and tack-welded.
- Cans are welded longitudinally in order to become a (mechanically performing) homogenous piece.
- When needed, the cans are re-rolled to become circular.
- Segment end-pieces are fitted with a flange, which is tack welded and then fully welded circumferentially.
- Circular cans are circumferentially welded to form a longer[cigar-shaped] piece.
- When all cans have been welded together, the segment is ready for blasting and painting. (The bottom segment will also have a door frame attached.)

Demands

The basic demand on a wind tower is to support the weight of the nacelle and the forces that are transferred in the strongest winds. Dependant on the climate where the wind turbine is to be built, materials must be able to withstand these forces in cold temperatures and tough conditions - especially in off-shore environments. The tower supplier will adhere to specific demands, usually set by local regulatory bodies [geographic area], depending on the choice of society rules from bodies such as GL (Germanischer Lloyd) or DNV (Det Norske Veritas). The rules vary between societies but are all in the same area; 27 J at -40°C or in some cases even 27 J at -50°C. For off-shore towers, the demands are often 47 J at -60°C. [4],[5]. Plate qualities for on-shore wind towers are usually S355J2G3 and S355N. For off-shore wind towers, thermo- mechanically rolled low temperature qualities such as S355G7+M and S355G9+M are used. Because of the geometrical shape of the wind tower (symmetric and round over the horizontal plane) there are no benefits in using a higher strength steel in the construction. [6]

The flow layout in production

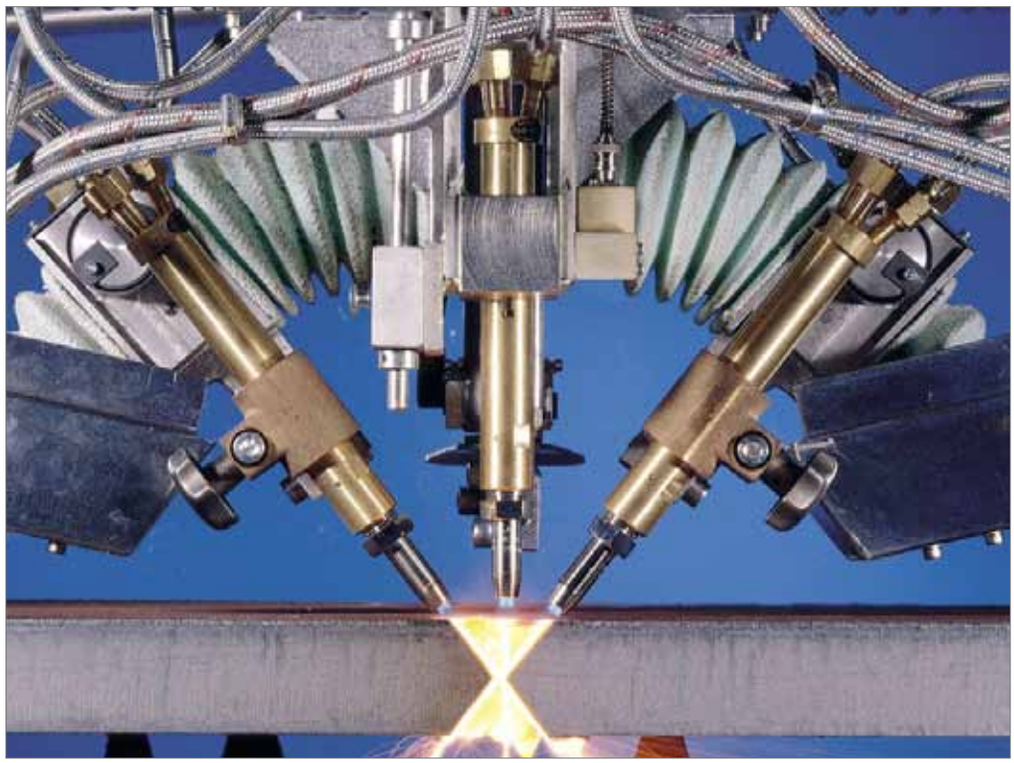
When assembling the cans into the wind tower segments a few variants exist: the growing line principle, where one can at a time is added to the growing segment; the added line principle where cans are added two-by-two, then four-by-four and, finally, eight-by-eight; and also a mixed layout. There are also variants when flanges are added to the cans or segment (pre-assembly or to the finished can-segment-shape). The choice of variant is more dependent on shop floor limitations and other preferences, and are not subject to any universal logic.

Major production challenges

It is evident that welding and cutting are the major elements in wind tower segment production in terms of time and value-added processes. The costs for welding and cutting account for only a small part of the tower cost (1-2%) but, at the same time, take up most of the production time. When striving to improve productivity in wind tower production, welding and cutting are good areas on which to focus.

Cutting

Plates that are to be rolled and welded into the circular, slightly conical shapes must be cut from the rectangular shape into a more curved form. In order to achieve quality welding, all plate edges

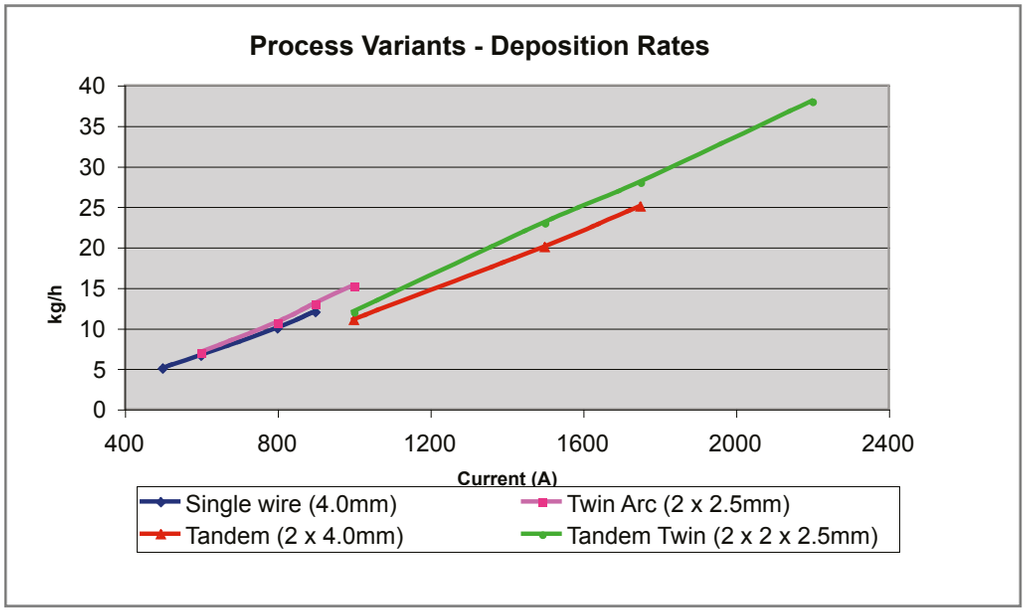


Cutting with an ESAB VBA triple torch for an x-joint preparation

must also be pre-prepared. For most of the plates (the thicker ones) this can require a number of cutting and grinding operations – but it can also be done in one smooth cutting run when utilising a high-accuracy cutting method. An ESAB VBA triple-torch can cut at three accurate angles all the way around a wind tower plate in one single cutting run. This is done using oxy-fuel cutting, a slower method than plasma cutting, but offering the necessary accuracy.

Welding

The welding involved in wind tower production is dependent on the society rules that set the toughness levels. Based on these, bead shape, tensile strength, etc, can be determined.
With demands set, the welding joint geometry and welding process can be considered – in the majority of cases submerged arc welding (SAW) is the preferred choice. SAW offers the highest rate of deposited weld metal compared with other suitable welding methods.
With the process and joint types identified, the details of the joint geometry can be settled. To achieve high productivity, welding of joints should be in as short a time as possible. Actual welding time can be adjusted by varying two factors - the deposition rate and the total joint volume.

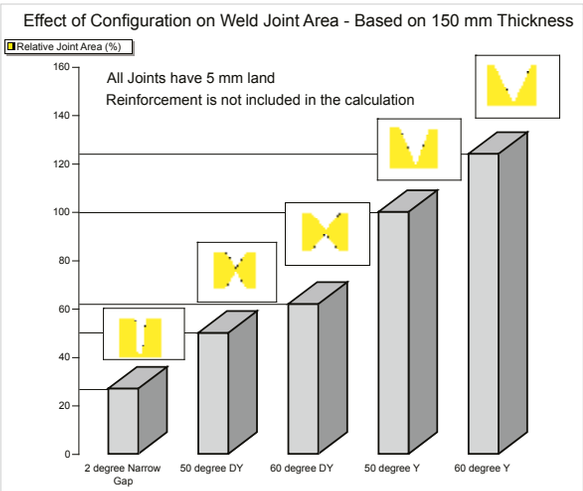


Comparison table of SAW variants [8

SAW Variant	Single Wire	Twin Wire	Tandem	Tandem Twin	Multi Wire
Number of Wires	1	2	2	4	3 – 6
Max. total deposition rate solid wire (kg/h)	up to 12	up to 15	up to 25	up to 38	up to 90

Joint volume

Joint volume can be varied by using different joint types, however double sided x-joints (or single sided v-joints) are the most common. In thicker plates, often in off-shore monopiles, other joint shapes can be found, such as a grinded u-groove. By changing the joint opening angle, joint volume can be changed. However, with a narrower joint opening (smaller angle) tougher demands are placed on the welding consumables' performance e.g. slag detachability.
The most common joint angle is 60°. OK Flux 10.72 (EN 760 – SA AB 1 57 AC H5) allows the reduction of included angle of the weld joint from the typical 60° to 50° due to its superior slag detachability. In addition to high deposition rates, this further increases productivity due to reduced weld joint volume. OK Flux 10.72 is designed for good toughness values down to -50°C when used with OK Autrod 12.22 (EN 756 – S2Si) non-alloyed wire.. The wire has tighter chemical tolerances against EN 756 and low impurities to further increase toughness values [7].



Joint types and joint volumes.

Deposition rate – welding speed

Although the smallest possible joint volume and joint opening angle might appear the most appealing, the choice of SAW must be taken into account. By choosing a variant with higher deposition rate, overall welding time can be lowered, even when the welding process demands a slightly larger joint opening than a lower deposition rate alternative. By increasing the number of welding wires and optimising wire diameters, deposition rate can be dramatically changed.

Heat input and strength

When calibrating the welding process and joint shape for optimised welding, there is also a contrasting force to be considered – strength requirements. With increased deposition rate, heat input increases, heating up the weld object. Too

Loading and positioning can be done easily with ESAB's self-aligning or manually adjusted roller beds.

much heat and the mechanical properties will not match the requirements. If the work piece gets too hot, the process must be adapted or the work piece be allowed to cool between runs – both adjustments again increasing the total production operation time. If the welding travel speed is increased, heat input per millimeter is lowered.

Welding travel speed

With increased deposition rate and increased heat input the solution is to increase the travel speed. Especially when welding the longer circumferential joints, an increased travel speed allows the work piece to cool down before one whole rotation has been made and a new layer is to be welded. When welding with high deposition rates, e.g. 30-40 kg/hour, a travel speed of 100-120 cm per minute is often ideal.

For quality results, an automated system is needed with an automatic joint tracking system to make sure the welding takes place at the ideal spot. Although the aim is perfectly round welding cans, wind tower segments often have small deviancies from the ideal shape which can cause the cans to slide horizontally when rotated. As the welding equipment is often held stable by a welding crane, any movement of the work piece must be measured by the seam tracking equipment and the welding automatically adjusted. ESAB has developed several joint tracking solutions, varying from mechanical seam trackers to more advanced optical systems. These solutions ensure stable, controlled welding at high speeds, with easy supervision for the operator.

Example calculation

A tower has a total joint length of 480 metres, with mean joint angle opening of 60°. The total welding volume is 0.063 m^3 (with a mean plate thickness of 25 mm, corresponding to 490 kg of weld metal to be used. Using a single wire process with a deposition rate of 8 kg/hour, total welding time is 490/8 = 61 hours. If the joint opening is reduced to 55°, the new total welding volume is 0.056 m^3 which, welded by the same process, reduces total welding time to 441/8 = 55 hours, a change of 9%.

If the welding process is changed from single wire to tandem wire, with a deposition rate of 20 kg/h, welding time will be further reduced to 441/20 = 22 hours, or 59% of the starting time. With an even higher deposition rate, say, 38 kg/hour, total time will be 12 hours.

Arc Factor

Optimising the welding process and joint volume is only a part of attaining high productivity. The entire work station duty-cycles need to be improved in order to reap the benefits of higher deposition. There are many components that make up the so called 'Arc Factor' – the percentage of time in a duty cycle that is actually spent welding.

The higher the arc factor, the greater the effects of a high deposition welding process, the higher the value added time of production.

Typical work cycle at a wind tower welding station:-

- Load work piece at roller beds
- Adjust work piece alignment
- Attach start and stop plates (longitudinal joints only)
- Check and replenish welding consumables when needed
- Move welding head to joint and start position
- Adjust electrode stick-out
- Set joint tracking systems (when needed)
- Check/set parameters
- Get into welding position

When looking at the station work cycle it is clear that the arc factor will always be low. However, there are a number of welding related components in the factor that can easily be adjusted and lowered (timewise).

Loading and positioning

Using ESAB easy-to-use and accurate self-aligning or manually adjusted roller beds, loading and positioning of the work piece can be done quickly. By integrating all station controls - positioning and welding - in the same control units, further time can be saved and work environment improved.

Bulk size welding consumables

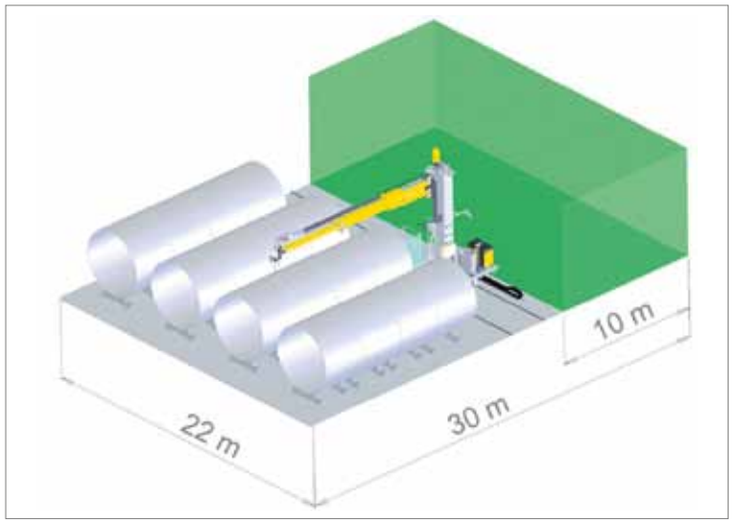
The changeover time for setting up a new 100 kg

wire spool can be 20 – 40 minutes depending on set-up and experience. By using larger 1000 kg EcoCoil wire packages on turntables, these costly changeover times (and frequency) are reduced. A 1000 kg EcoCoil will often last an entire shift, or more.
The continuous supply of welding flux is equally important. Various systems exist to ensure a constant flux supply whilst keeping it dry and in good condition. To get the most out of the flux consumable it is advisable to circulate and re-use leftover slag - requiring good re-circulation systems with quality filters to ensure good weld results. Flux is often used in 25 kg bags which require frequent refilling of the flux container. By using a bulk solution, such as the ESAB 1000 kg BigBag, the time spent refilling can be kept to a minimum, and flux handling kept very simple and effective.

Seam tracking, checking and monitoring
With a good joint tracking system, set-up time is very low (a few seconds only) and assistance and monitoring is easy, being integrated in the welding control system. This way, the operator can control the entire welding process from one easily set-up system. With the integration of a logging system - such as ESAB Weldlog – welding data can be logged in real-time from several welding stations, and data can be stored for future control and reference purposes.

ESAB Weldlog system
With the integration of a logging system and control system, where parameters for all joint variants can be stored for easy access, set-up time and post-welding time can be reduced further.
The combination of effective consumables packages and systems, integrated control, log and joint tracking systems all help increase the arc factor. In combination with a high deposition process, this opens up opportunities for high profitability.

Further improvements
In the quest for high margins and good profits, there are further considerations. By increasing the arc factor and flow throughput time, a factory can reduce the number of necessary workstations, or simply harvest the profit from increased volume. However, to be fully optimised, factory floor space must be used in the best way - floor space is often a limiting factor in production that poses challenges for flow layout and in-house logistics. Space required for welding equipment should, therefore, be kept to a minimum. One example to achieve this is ESAB's new three-section telescopic boom - the Telbo™. This telescopic boom requires less space than traditional, fixed-length booms, thereby increasing production area.



Sketch of a Telbo™ telescopic boom in wind tower production, (green area indicates increased available factory space).

Wind tower fabricators often face challenges in operator knowledge and competence. To weld with a new process requires training and support. As a supplier to the welding industry for more than 100 years, ESAB provides such help and support by training, through experts visiting the customer, or in one of the company's dedicated training and education centres.

Conclusion
Looking at the market potential for wind towers there are plenty of opportunities for fabricators to make good profits, now and in the future. Considering the production steps involved - cutting, rolling, welding and painting the tower segments – it is clear that cutting and welding are the most important areas. By optimising weld geometry and joint volume, matched with a high deposition submerged arc welding process, productivity can be increased dramatically. However, only looking at the welding details is not enough to become fully profitable - the arc factor (part of duty cycle spent welding) must also be at a high enough level.
The arc factor can be increased by using the right equipment and consumables, such as ESAB's 1000 kg BigBag flux and 1000 kg EcoCoil wire. By reducing set-up and preparation time at welding stations, through the use of fully integrated equipment and control systems, while also using advanced seam tracking and logging systems, the arc factor can reach levels for high productivity and production with high profitability.

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[8] - Technical Handbook SAW, ESAB AB Göteborg (2008), p. 69.

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Complete solutions for the fabrication of wind towers

ESAB has been involved in the wind tower industry from the early days, and has steadily responded to increasing requirements to the point where, today, a majority of wind towers in service, worldwide, have been manufactured using our technology. All over the world, we partner with manufacturers of towers, foundation piles and transition pieces, for land-based, offshore or arctic service.

The PLC control unit

The space saving ESAB telescopic column and boom - Telbo™.

Our services range from retrofitting of existing production facilities to turnkey equipment for greenfield installations. In this issue of Svetsaren, we present a complete station for welding circumferential joints in wind tower sections – with many recent innovations – designed to deliver all-round productivity. This is valuable not only for the wind tower industry, but for fabrication of any large circular object with circumferential and longitudinal welds. The installation features innovations that lead to higher welding productivity:

- The revolutionary, space saving ESAB telescopic column and boom - Telbo™
- The 1000kg EcoCoil™ bulk wire spools
- The new moisture protected 1000kg BigBag for welding flux

Telbo ™

Telbo™ - ESAB´s unique telescopic column and boom - requires significantly less rear clearance because of the unique 3-section telescope-like retraction of the boom. All three sections are synchronised to ensure even, stable motion throughout the entire reach-out. Offering flexibility for plant design, Telbo™ can save valuable workshop space and can considerably reduce investment costs for buildings, heating, lighting, etc. Two standard sizes are available: Telbo™

6500 with a travel range of 6.5m and 8m max reach-out; or Telbo™ 9500 with 9.5m travel range and an outstanding 12m reach-out. The latter has a boom end loading capacity of 500 kg! Using Telbo™, production will be more flexible, even when mixed sized workpieces are to be welded. Consequently, dwell times are dramatically cut.

When it comes to stability, there is an obvious advantage in being able to use a tandem welding head with front mounted 100kg wire reels, still ensuring consistent quality of welds! The operator, with easy access to the fully integrated PLC control system, can safely control the welding operations at the work platform. It includes a modem for all –function external communication - including the weld process - and for fast, accurate on-line support from ESAB.
Joint tracking can be accurately controlled using a supervision welding head camera, reproducing the joint on a monitor at the platform.

EcoCoil™ bulk wire spools
In many welding set-ups, conventional 30kg spools can be replaced with EcoCoil™ bulk wire spools - reducing the number of spool changes by a factor of 33. Moreover, packaging material is reduced to a minimum whilst still giving full protection from moisture and dust during transport. All materials are fully recyclable. Since it is a one-way-package, there is no need for return logistics.
The costs for the required decoiling stand/ turntable are soon compensated by time savings on spool changes, after which the big savings begin. Advantages over heavy spools are achieved because the wire is not spooled tightly around the cardboard core. In the start and stop phases, the spool can slowly accelerate and stop whilst the wire is fed to the welding head at constant speed, thereby reducing welding defects.

New to the market is our environmentally friendly 350kg Octagonal BigDrum™ for 2.5mm to 5 mm wire diameters. This is for customers who require frequent wire changes, prefer to have a lower weight per package, or need to have the full wire package protected against dirt or moisture during pay-off. The ESAB Octagonal BigDrum™ is based on the Marathon Pac™ outer shell - but with an inner tube. The packaging is made of cardboard and thus disposed of as recyclable paper. The Octagonal BigDrum™ needs to be placed on a rotating table during decoiling which, of course, can be obtained from your full solution provider or ESAB.

ESAB BigDrum

BigBag.

The new moisture protected BigBags have a very well defined discharge spout which can be closed during the flux flow. In order that customers can use fluxes without prior redrying, ESAB has equipped the BigBags with an aluminium liner, reliably protecting the flux from moisture, even in tough climates such as around the equator. The complete BigBag is fully recyclable.

The world renowned OK Flux 10.72 wind tower submerged arc flux
OK Flux 10.72 is an agglomerated, basic flux, designed for the production of wind towers. It combines the high demands for multi-layer thick section welding, using high deposition rates with respectable toughness values down to -50°C when combined with a standard non-alloyed SAW wire. It is used for single and multiwire procedures such as tandem, twin-arc, and tandem-twin welding and works equally well on DC and AC current. The excellent slag removal in narrow V-joints allows the included angle of the joint to be reduced. OK Flux 10.72 can be applied for unlimited plate thicknesses.

KÉSZ Ltd. welds Budapest's new SkyCourt terminal with ESAB super trio

OK AristoRod 12.50 & QSet™ and OK Tubrod 15.14 provide productive high quality welding.

Tamás Sándor, ESAB Kft, Budapest, Hungary.

Future SkyCourt

BUD SkyCourt, a spacious, sophisticated terminal building, is to be constructed at Budapest Airport. Operational in 2012, SkyCourt will make the whole flying experience more comfortable – and Hungary will have another landmark building of which to be proud. A giant steel structure, fabricated by KÉSZ Ltd., will support the roof that covers an area of almost 8000 m^2. Sophisticated ESAB power source technology and innovative welding consumables ensure structure quality and directly assist in meeting deadlines.

SkyCourt is a giant passenger hall located between Terminals 2A and 2B of Budapest's Ferihegy airport. Project investment may reach 200 million Euro. The base area of the construction will be almost 8000 m^2 – the size of ten football pitches. SkyCourt will increase the airport's capacity and serve passengers in a more relaxed atmosphere. It will have a shopping area at departure level and bars and restaurants at mezzanine level.

The 70 x 114 m base area will be covered by a 770 ton roof constructed from 14 sections of 68 m truss-girders. Each truss-girder will be welded from 20 - 22 m girder-segments, Figure 1. This roof structure will be held in its final 16 m high location by 40 pillars.

With huge windows, contemporary architectural design, and breathtaking views, SkyCourt will offer a uniquely attractive waiting area for passengers. Visitors' first and last impressions of Hungary are formed at Ferihegy. All parties involved are, therefore, resolved to ensure that Terminal 2 is as acclaimed as Terminal 1- which won the Europa Nostra architectural award.

The eye-catching, custom-made girders will make a lasting impression on visitors. Just to design such a roof structure is difficult. But, to manufacture it from 5 - 10 m pipes with 4 - 25 mm wall thickness and 88.9 - 508 mm outer diameter - while maintaining all angles and tolerances - is extremely challenging.

The two essential elements, for the accurate and productive completion of such a complicated project, are precise edge bevelling and productive welding technology that eliminates the possibility of weld defects.

Pipe end preparation

The preparatory phase is often the bottleneck in production. It was clear, from the beginning, that for the SkyCourt project, every single piece of pipe must be cut exactly to the correct length and bevelled accordingly (Figure 2). Accordingly, KÉSZ Ipari és Gyártó Ltd. set a CNC controlled and computer-aided pipe-end cutter and edge beveller machine to work. This machine tailors the pipe end's geometry according to the oxyfuel cutting process, creates the bevelling and finally draws the number, location and orientation of the pipe in the structure (Figure 3).

Welding technology

The most important aspects of the project - tight deadline and the very high quality demands - required the welding solution to be fast and reliable. Welding defects and associated re-work had to be avoided, demanding the use of a reliable defect-safe welding technology.

The construction involves butt and fillet welds, Figure 1, and positional welding. Three types of welding are required:

- Root runs in fillet welds
- Root runs in butt welds
- Filler and cap layers in butt welds

When using the traditional MAG process with solid wires, *root runs in fillet welds* can only be performed with satisfactory penetration in the position PF (vertically-up). In vertical down welding (PG), the weld pool runs ahead of the arc, forcing the welder to follow. This usually results in lack of root fusion, irrespective of the applied welding current (Figure 4A). Upward welding is slow, however, and therefore ESAB advised the use of OK Tubrod 14.12 - a metal-cored wire specially developed for fast vertical down welding in the shipbuilding industry. It is used with DC- polarity in PC position and provides good weld penetration (Figure 4B). For this critical application, KÉSZ welding management nevertheless decided to rely on the security of vertical-up welding with solid wire, where welders can pay more attention to weld pool control.

Root runs in butt welds are completely different. The local volume of the weld edges is significantly smaller than with fillet welds, so less heat input is needed to melt them (Figure 5). In practice, this means that root runs in butt welds can be performed in position PG (vertical down) with solid welding wire used in the short arc mode. It is precision work: any misdirection of the torch could lead to arcinstability, lack of fusion defects and porosity.

ESAB's solution for this application, approved and successfully applied by KÉSZ Ltd., was a combination of ESAB QSet™ power sources and

Figure 1. Truss-girder segment.

Figure 2. Efficient edge preparation was prerequisite for easy production flow.

Benefits of the OK Aristorod™ wire range of non–copper coated MAG wires:

- Consistent welding performance
- Stable arc with low feeding force
- Excellent arc ignition
- High current application
- Extremely low overall spatter
- Trouble-free feedability, even at high wire feed speed and long feed distances
- Low fume emission

Figure 3. Pipe ends prepared for butt welding. Note the graphics instructions for joining pipes (number, location and orientation).

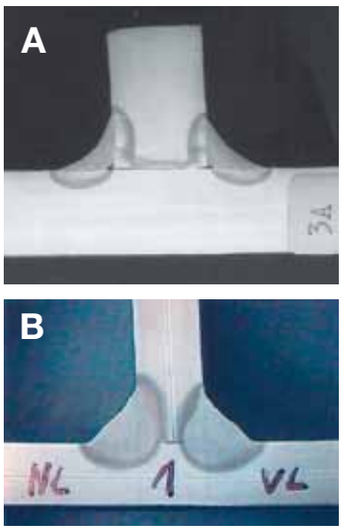


Figure 4. Fillet joints welded in position PG (vertical down).
A. with solid wire (DC+; I=220 A; U=25 V);
B. with metal- cored wire OK Tubrod 14.12-1.2mm (DC- ; I=230 A; U=26 V)

OK AristoRod™ 12.50 non-copper coated MAG wire. Keystones for the success of this application are the superior feeding properties of the wire and the stable short arc welding characteristics of the power source. These features are necessary to suppress spatter to a minimal level, while the welder can easier avoid problems such as lack of fusion and porosity.

KÉSZ Ipari és Gyártó Ltd., has long been a user of OK AristoRod 12.50. The excellent feeding behaviour and the resulting exceptionally stable arc (and parameters) proved to be of vital importance for welding root passes of butt joints in thick-walled pipes. Scientific evidence of the superior characteristics of OK AristoRod wires is given in the article on page 54 of this issue of Svetsaren.

Unique features of the QSet™ technology

- No synergic lines
- Applicable with all wire + shielding gas combinations
- Reduced spatter level in short circuit arc transfer
- Single button setting – maximal welder-friendly setting

ESAB's QSet™ technology is a key element for faultless welding of root runs. Several technologies stabilise the short arc and the complete root welding process, all using current modulation. ESAB's QSet™ is a technology with special adaptive regulation, using the important arc time/ short circuit time ratio to control the process. This provides a number of unique features. Most importantly, it automatically finds the optimal short arc parameters without having to select any settings or synergic lines. All the welder needs to do is set the wire feed speed with the single control and make a test start of a few seconds - after which he can start welding. This is an extremely valuable feature in workshops. QSet™ is described in detail on page 35 of Svetsaren 1/2006, see esab.com.
The accurately prepared root passes of the heavy walled pipes were not only defect-free, but were also welded at a 30% increased welding speed with the QSet™ + OK Aristorod™ machine/ welding wire combination combination, compared to their former root welding solution. Post-welding cleaning was eliminated due to the low spatter.

Traditional MAG welding with solid wire has its limitations in *filling butt joints*, when it involves positional welding and relatively high wall thickness. With increasing wall thickness, the welding current in PF position can only be increased to a level of 140 -150 A for skilled welders and 120 -130 A for less skilled welders, before the weld pool becomes too large to control. At these current levels, it is difficult to avoid lack of fusion defects, slag inclusions and insufficient penetration. Moreover, productivity is low.

For this project, a safer and far more productive solution was found in the use of OK Tubrod 15.14 all-positional rutile cored wire with a fast freezing slag system. In this application, it can be welded at 200 – 240 A with a spatter free arc which ensures a proper penetration and eliminates the risk of welding defects. Weld repairs were almost zero.

Moreover, low spatter level and self-releasing slag reduce post weld cleaning and associated costs.

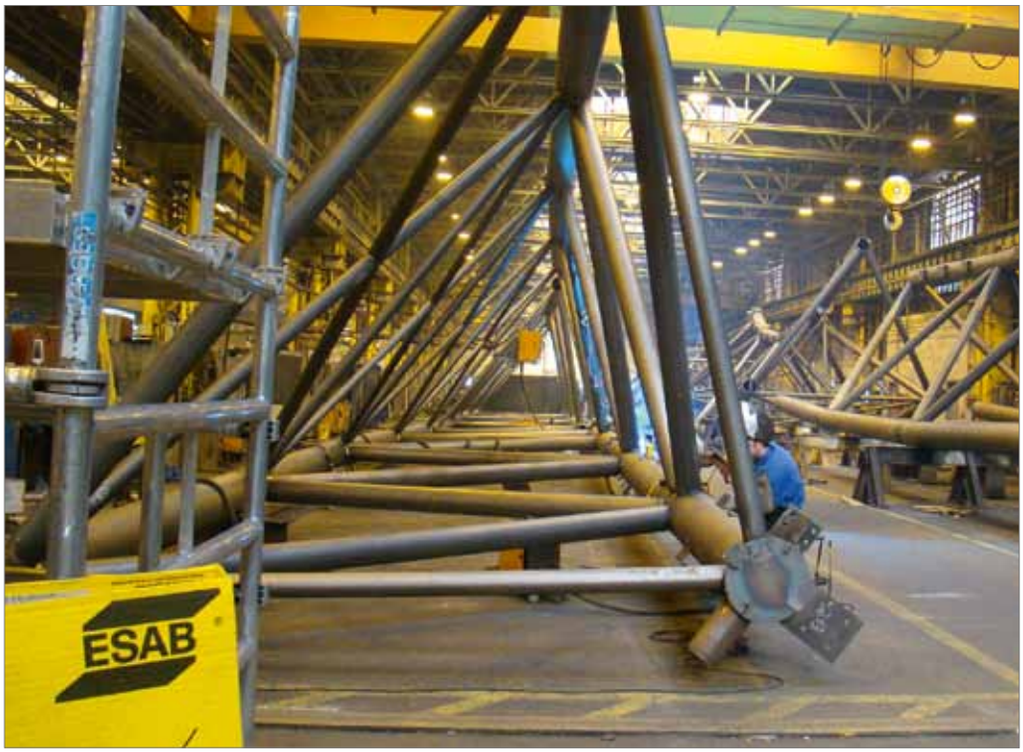
Most importantly, the use of OK Tubrod 15.14 resulted in a dramatic increase in productivity without the necessity to rotate the long, heavy pipes to bring them to best position. The welding speed was about 2.5 times higher than with the traditionally used MAG solid wire process. This means, in practice, that a butt weld in a pipe with 350 mm outer diameter can be welded in about the same time as a 150 mm pipe with the former method.

The next award

Careful selection of productive welding solutions for the various welding tasks enabled KÉSZ Ipari és Gyártó Ltd. to satisfy the high quality requirements of the SkyCourt project and complete the roof structure within the deadline. We congratulate the company and, as with the reconstruction of Ferihegy airport Terminal, in 2006, trust that SkyCourt will be granted similar architectural awards.

Figure 5. Bevelled pipes prepared for butt welding.

Figure 6. Joint welded with OK Tubrod 15.14 all-positional rutile cored wire. Note the spatter free area adjacent to the joint and the completely self-released slag.



"Full steam ahead" –segments of the SkyCourt roof structure during manufacturing.

OK Tubrod 15.14 benefits:

- High deposition rate: lower welding times, saves welding costs
- All positions: one wire for several applications, lower cost for welder training
- Welder friendly: easy to use, lower risk of defects
- Excellent weld quality: lower repair rate, higher production output, lower welding costs
- Low hydrogen: less risk of cracks, lower repair rates, lower welding costs

About the author:

Tamás Sándor
Mechanical engineer, IWE is Product Manager Consumables at ESAB Hungary. He joined ESAB in 2005.

Figure 1. Classical steam boiler header.

ESAB narrow gap welding technology

boosts production for Slovakian boiler fabricator

Ing. Daniel Stano, SES a.s. Tlmace, Slovakia & **Ing. Juraj Matejec,** PhD, ESAB Slovakia s.r.o. Bratislava, Slovakia.

SES a.s., Slovakia's largest boiler fabricator, has automated the fabrication of thick-walled boilers using ESAB narrow gap welding technology, gaining reproducible high weld quality at much increased productivity. The ESAB solution consists of ESAB's new HNG-S single wire narrow gap head mounted on an ESAB CaB 460 4x4 column and boom installation, PEH control system and ESAB Romar CDI/CD-100 roller beds with 200t capacity produced in ESAB's Singapore plant. The solution includes the use of OK Flux 10.62 - a flux for critical applications, especially suitable for narrow gap welding - and OK Autrod 12.24 (0.5% Mo).

Narrow gap welding – a logical choice

Welding is one of the most important manufacturing technologies in the production of equipment for the power industry, determining not only the quality of the finished product, but also influencing the economy of the manufacturing process. For SES, the introduction of narrow gap submerged arc welding for thick-walled components is another milestone in a continuous process of welding methods innovation.

The collection and distribution of media in the tube systems of classical steam boilers is performed in pressure vessels, called headers, and connection boxes. These are thick-walled components, because of the high internal pressure. The same type of heavy joint appears in other heat exchangers produced by SES.

At SES, circumferential welds in the main body of the header and those connecting the dished end plates, were previously welded by a combination of MMA and TIG. Performed by highly skilled welders, this procedure has traditionally satisfied extremely high quality demands - but it cannot meet today's productivity requirements in highly competitive markets.

Narrow gap welding is a logical choice for this type of joint in repetitive fabrication. It can be fully automated and, with qualified welding procedures in place, yields reproducible weld quality and very high productivity due to the high deposition rate of the SAW process and the greatly reduced joint volume. Also, the one-sided butt arrangement makes it easier to avoid linear misalignments as opposed to two-sided joint (X-prep). Welding parameter sets for different joints can be stored in the control unit and retrieved for welding identical products and welding statistics can be logged for quality assurance records.

The main feature of narrow gap welding is its high degree of mechanisation enabling multi-layer welds, automatically. Repetitive high weld quality is produced by the machine itself and does not depend on the intervention of an operator. This is extremely important for high quality welding of thick sections because repairs are extremely costly.

However, account must be taken of the process's large initial investment, and the more expensive machining of narrow gap joint preparations. These need to be fully justified by cost analyses, with which, ESAB can assist.

Narrow gap welding offers the following advantages:

- High productivity, reduced cycle time.
- Reduced welding consumables consumption.
- Reduced energy consumption.
- Lower energy costs for preheating, due to shorter cycle times.
- Less deformation, due to a lower heat input and reduced shrinkage.

Narrow gap joint preparation

The narrow gap joint is normally U-shaped with an included angle of 2 to 10° (Figure 2).

It is more expensive to machine, but melting the root area becomes easier and more secure, while slag detachability is enhanced. In this thickness, the volume of a narrow gap preparation is about 2.5 times lower than in a standard groove with 50° opening (Figure 3).

SES applies a root with a land of 8 mm. The joint is MMA tack welded from the inside and, subsequently, the joint is filled by narrow gap

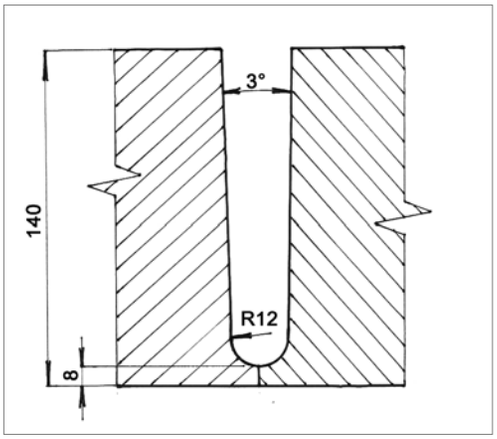


Figure 2. Standard narrow gap joint preparation.

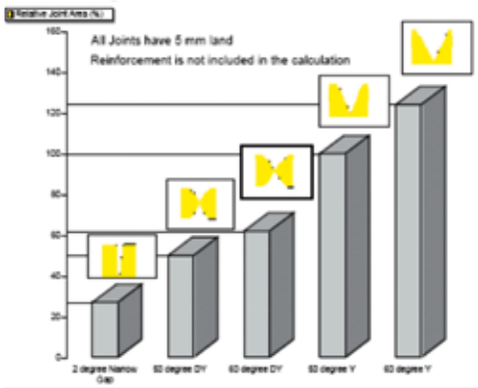


Figure 3. Effect of joint type on joint volume.

welding from the outside. Then the root area is ground away from the inside and is finished by SAW.

ESAB narrow gap welding equipment

For welding thick walled sections, ESAB developed two types of advanced welding heads, designated HNG-S (single wire) and HNG-T (tandem wire). They are designed for use in a 20-25mm wide gap, with individual weld passes being laid alternatively on the left and right side. All heads (swords), including types with contact jaws, flux supply, flux recovery or tactical sensors, are insulated. This avoids unwanted arcing, when the equipment moves accidentally against the joint edges.

HNG is a basic narrow-gap welding system, primarily designed for single-wire welding of pressure vessels with wall thickness up to 350 mm (Figure 4). The tandem version, which carries the same basic features, is discussed in detail in the Product News section on page 76.

The head needs to be mounted on a carrier – normally a column and boom (CaB) installation - which ensures its correct positioning relative to the weld piece. ESAB builds and supplies a range of standard CaB's, but can also deliver custom-made equipment. The same applies to the roller beds that carry and rotate the weld piece (see the Product News section on page x for detailed information).

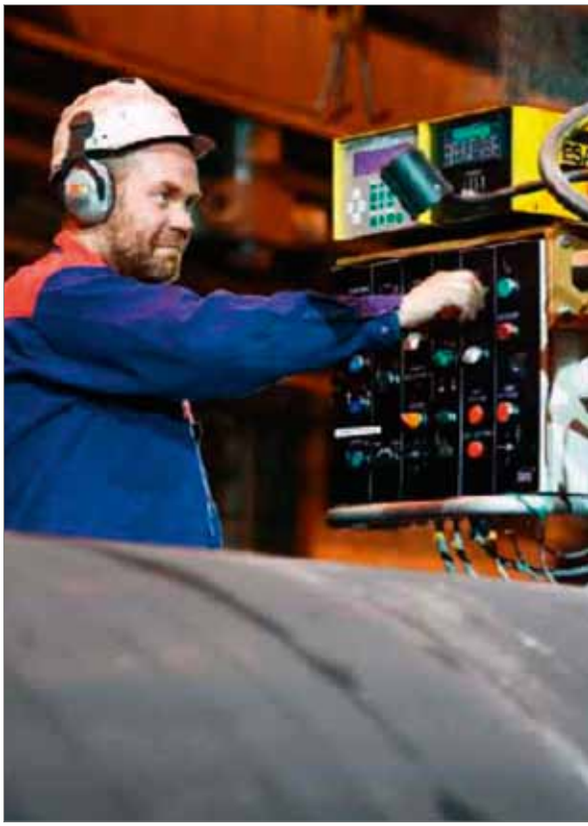


Figure 4. ESAB HNG single wire welding head.

The PEH control unit is the 'brains' of the narrow gap equipment. It controls the power source, the welding head, the flux supply, the column and boom and the roller bed.

PEH main features include:

- Control of several parameters depending on weld progress. For example, angular speed, and thus welding speed, is controlled depending on the

Table 1. Mechanical requirements WPQ for type I and II steels.

	CVN		CTOD	
Steel type	minimum average	minimum single	thickness	minimum
I	34J/-40ºC	27J/-40ºC	<76mm (3")	0.25mm/-10ºC
			>76mm (3")	0.38mm/-10ºC
II	34J/-18ºC	27J/-18ºC	<76mm (3")	0.25mm/-10ºC
			>76mm (3")	0.38mm/-10ºC

Table 2. Typical chemical composition and mechanical properties in AW and SR condition for OK Autrod 12.24/OK Flux 10.62 wire/flux combination.

Content (%)	C	Si	Mn	Mo
OK 12.24 + 10.62	0.07	0.22	1.0	0.5

OK 12.24 + 10.62	Testing temp. (°C)	Rm (MPa)	Re (MPa)	A5 (%)	KV (J)/°C +20	0	-20	-40	-50
As welded	20	580	500	25	140	115	80	60	45
Stress relieved 580°C/1h	20	530	470	26	140	100	75	55	40

Table 3: Mechanical properties from the welding procedure qualification.

R_m (joint)		582 – 605 MPa (required >420MPa),
R_m (weld metal)		624 MPa (required >580MPa),
R_e		545 MPa (required >500 MPa),
A_5		25.4% (required >25%).
CVN notch toughness		145 – 195J at 20°C.
Hardness	WM	207 – 243 HV10,
	HAZ	245 – 273 HV10.
Side bending		180° – satisfactory.

remaining joint depth since the peripheral speed would increase with the progressing buildup sequence. The overlap length of each pass is controlled, accordingly.

- Programming of warning signals and delays.
- Real parameters displayed during welding process.
- Control of the function of automatic electrode shifting after each part revolution enables automatic multi-layer narrow gap welding without interruptions.
- Automatic tactile seam tracking in two axes – vertical with respect to the joint bottom and horizontal, with respect to the both walls of a narrow gap.

Welding of a header

Figure 5 shows a schematic illustration of a header with the main circumferential joints indicated as well as the joint preparations used for the various joints.

The external diameter of the header is 2197 mm and the wall thickness is 140 mm. It is made from low-alloyed creep resistant steel containing 0.5%Mo (16Mo3), ASME designation SA 302. The interpass temperature is 350°C, maximum. The preheating temperature is 150 - 200°C.

The wire/flux combination selected for welding the

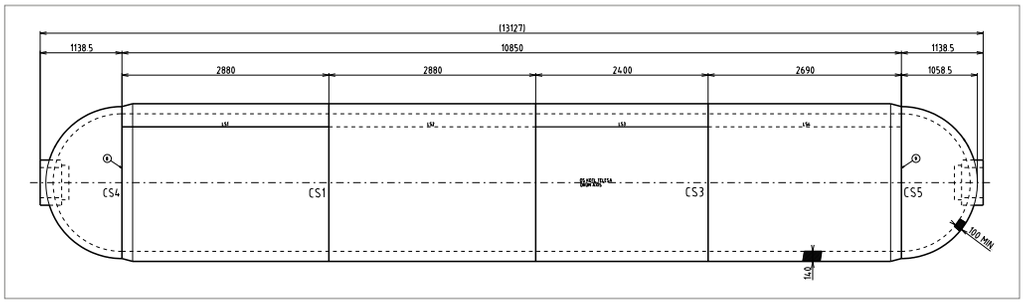
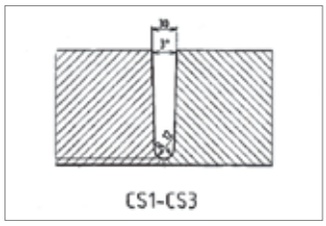
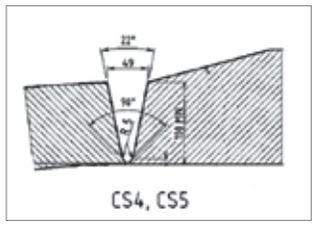


Figure 5.





header was OK Autrod 12.24/OK Flux 10.62. OK Autrod 12.24 (EN ISO 24598 S Mo) is a solid 4 mm SAW wire alloyed with 0.5%Mo.

ESAB OK Flux 10.62 (EN 760: SA FB 1 55 AC H5 is a high basic agglomerated flux for multi-layer welding of applications with low-temperature toughness demands, both as welded and stress relieved, see Table 1.

The wire/flux combination is CTOD tested. It ensures a high purity weld metal with a low oxygen content (~300 ppm) and also a low diffusion hydrogen content (less than 5ml/100 g weld metal). The flux is frequently used in the manufacturing of thermal power and nuclear energy equipment.

In narrow gap welding, it is essential that the process operates free from inconsistencies. The side-wall wetting must be perfect in order to avoid lack of fusion in the following layer. Slag is required to be self-releasing, even on preheated high strength steels. OK Flux 10.62 meets all these narrow gap welding criteria. With the correct welding position and parameters, the slag releases spontaneously and falls down due to rotation of the welded part.

Figure 6 shows the SES welding station used for the circumferential welds of the header. It consists of an ESAB CaB 460 4x4 column and boom with ESAB HNG narrow gap welding head, two pairs of synchronised roller beds ESAB CI-100 and CDI-100 with a total capacity 200t and an ESAB LAF

Figure 6. Overview of the submerged arc welding station for circumferential welds.

Figure 7. A view into the gap of the assembled joint before the start of the process.

Figure 8. A view at the joint during welding.

Figure 9. Exhaustion of unconsumed flux from the surface of the joint.

Figure 10. Spontaneous slag detachment.

Figure 11. Automatic overlapping and bead shift after each revolution.

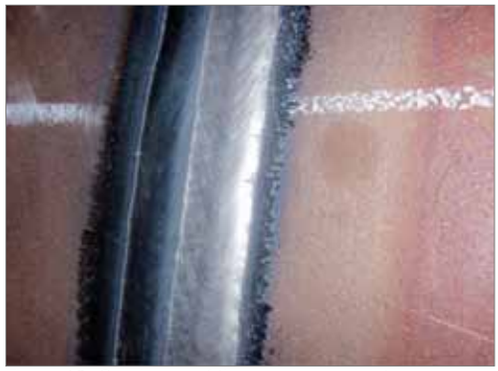


Figure 12. Cap layers of the narrow gap joint.

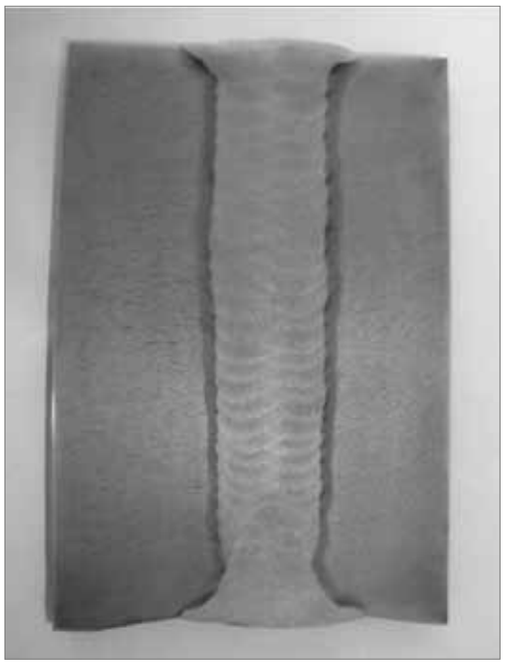


Figure 13. Macro section of the finished joint.

1000 DC power source with PEH control system. Figure 7 shows the joint preparation with the narrow gap welding head before welding and Figure 8 gives a view of the joint during the welding. Unconsumed flux is exhausted rather close to the point where the arc is burning under the flux layer. In total 57 (left and right deposited) layers are needed to fill the complete external side of the joint – an operation that takes 17 hours of uninterrupted welding.

Figure 9 shows a close-up of the joint during welding, with the flux layer behind the welding head, the flux recovery tube and the slag after removal of the flux.

During continuous cooling, slag spontaneously detaches from the weld bead (Figure10) and falls down, away from the gap. On the weld bead surface, the next layer can be deposited immediately, without any cleaning being necessary. After each revolution, the head automatically shifts to the other side of narrow gap, as shown in Figure 11.

After filling and capping the narrow gap joint gap (Figure 12), the root area is ground back and another 12 layers are deposited from the inner side. Total consumables consumption for one circumferential joint is 200 kg of welding wire and the same volume of flux.

Quality and productivity

Figure 13 shows a perfect macro from the welding procedure qualification test and Table 2 gives the obtained mechanical properties, which fully satisfied customer requirements. Circumferential joints were 100% X-ray tested.

The implementation of ESAB narrow gap welding for circumferential joints in thick-walled headers provided SES a.s. with a technology that yields drastically reduced cycle times, but also satisfies the company's tradition for high quality. The system offers defect-free welding in continuous automatic operation At the same time, the welding department has gained leading edge welding technology.

Daniel Stano

Juraj Matejec

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Kranendonk Production Systems BV supplies robotic panel welding line to Fincantieri Monfalcone

ESAB $U8_2$ robot package delivers latest digital welding technology.

Kevin Jongkind, Kranendonk Production Systems B.V, Tiel, The Netherlands.

Dutch robot integrator Kranendonk has delivered a robotic panel welding line to the Italian shipyard, Fincantieri Monfalcone, a world leader in cruise shipbuilding. The panel welding line is a autonomous production system consisting of two gantries, each with four suspended robots equipped with the latest ESAB digital welding technology.

Robotic welding cuts cost

Over the years, shipbuilding has been gradually transformed from labour intensive into a technology driven industry. High quality demands in the world marketplace pushed the shipyards to mechanise and automate their production processes. Shorter delivery times generate the need for pre-outfitting of hull segments and pushes for 3D designs.

The first part of the steel production process (marking, cutting, 2D blocks etc) is already quite well automated. The 3D panel and grand-block assembly are very difficult to automate or robotise.The nature of these operations, which are one-of-a-kind and often performed in inaccessible places, makes efficient, cost-effective automation difficult. To overcome these problems and increase production efficiency, Kranendonk has developed robotic welding systems with special programming software to obtain the highest possible up-time. With a direct interface between the CAD-system and the production automation system an even profitable situation is created. This interface makes one-piece production possible and very profitable.

Fincantieri Monfalcone

Fincantieri Monfalcone is a world leader in cruise shipbuilding. In autumn 2010, the *Queen Elizabeth* was launched - one of the most advanced ships sailing the oceans. Following the

Figure 1. Four robots welding simultaneously with no possibility of collisio. Two gantries over a 35 x 16.5 m wide panel.

Figure 2. High quality equipment reduces downtime.

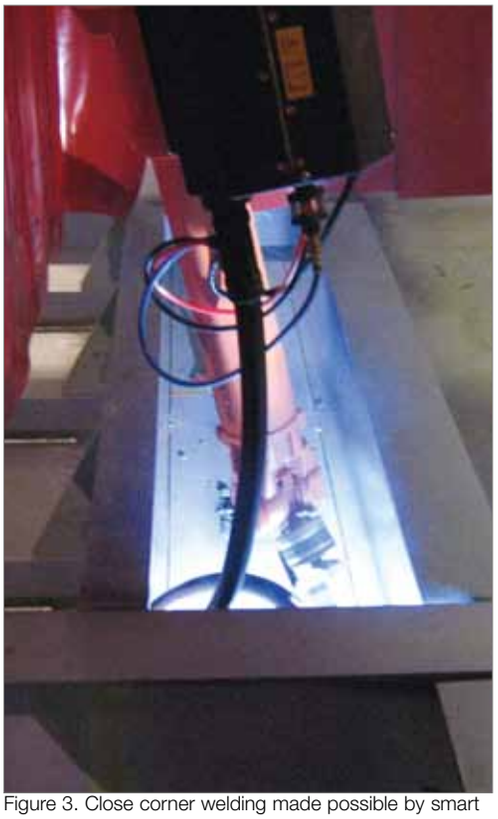

Figure 3. Close corner welding made possible by smart sensors and programming software.

'Q*ueen Victoria*', delivered in Marghera in 2007, the '*Queen Elizabeth*' - called by many 'the ship of the year' – is the first cruise ship built by the Monfalcone shipyard for Cunard Line, and the second '*Queen*' to be delivered by Fincantieri to the iconic British brand.

Fincantieri has built 51 cruise ships since 1990, of which 47 were for the six main brands in the Carnival Group. A further 12 ships will be built in Fincantieri's shipyards up to 2012.

The purchase and supply of a profile cutting line, in 2000, subsequently led Fincantieri Monfalcone to invite Kranendonk to become its automation partner. The Profile plasma cutting equipment increased productivity and efficiency. The production system completes the entire cycle in one operation with consistent quality. By integrating various applications such as transportation or buffering of profiles, the profile cutting line becomes faster and more flexible.

The system

The robotic panel welding line is an autonomous production system for the fabrication of panels. By combining the best hardware and software, Kranendonk commissioned a system consisting of two individual gantries which can be programmed by a single operator.

Automatic welding of superstructures demands the highest quality from both hardware and software, and the supplier's ability to integrate the system into the customer's production environment. Most important is the integration and control of robot gantry motion and positioning. A standard robot carrier facilitates robotic welding of extreme product sizes such as panel sections for cruise ships (for example: 35*16.5 metres). All external and internal robot axes are integrated into one unit, the system thus operating as one coordinated robot. The stability and motion performance of the gantry ensures the system's full control over all weld positions.

The two welding gantries are each equipped with four suspended robots using the latest ESAB welding equipment based on the AristoMig 5000iw power source. This digital water-cooled power source with up to 500 A/39 V at 60% duty cycle, is specially designed for heavy duty production welding. The computer controlled inverter technology gives an almost spatter free short arc, even at high welding speeds, and a very stable pulsed arc.

ESAB's RoboFeed wire feeder is used to ensure that the attachment of the wire feed system does not limit the wide working envelope, and that robot movements do not disturb the welding process. To allow the full working range for the first and second axis all cables are concealed in a cable carrier system and the wire feed unit is mounted on the robot. This ensures a very short distance between wire unit and welding torch - an essential parameter for constant wire feed. ESAB Marathon Pac bulk drums provide a continuous supply of welding wire for minimal wire renewal downtime.

Kranendonk and ESAB have a history of close cooperation dating from 1988 when they supplied their first mutually produced robotic production system. Kranendonk specifies ESAB products because of consistently high quality and the company's worldwide support network.

The ABB IRB 2400L robots used are dedicated to efficient arc welding, having a 1.8 m reach and 7 kg load capacity. To overcome the inaccuracy of tack welding, several sensors systems are used. The start of a weld is located by touch sensing with the cup. Weld tracking is achieved by through-the-arc-sensing, whereby product and robot system tolerances are compensated. The result is increased production rates, reduced lead times, high stability, integration of external axes and long intervals between maintenance.

Depending on application, automation level and number of welding robots various programming methods can be used to control the system. Two methods developed by Kranendonk are ARAC and RINAS.

RinasWeld work preparation software system

The latest development in offline programming is model based programming. RinasWeld is such a system which automatically generates robot programs for automatic welding of ship panels or block sections.

The main objective of this package is to create and maintain a combined model with full control over the 3D workspace and the objects within this space. In practice, this means that RinasWeld software creates a collision-free robot program from the customer's CAD data with virtually no programming time - which means that no human programmer is required.

The system automatically recognises the correct predefined weld situation and calculates the correct robot path. The software automatically selects the predefined process information for each desired situation. It is also possible to accumulate the user's experience of the specific welding process. Since panel deformation due to heat input is a critical issue, the way the weld sequence is built up needs to be designed carefully to determine the correct weld strategy. RinasWeld is ideal in this situation.

Integration of model based software is independent of specific CAD systems; it can import many different types and levels of CAD data.

Online operator interface

Kranendonk production systems are delivered with a full graphical operator interface. The menu structure and push buttons on the ARAC operator interface automatically guide the operator to the correct command to perform a certain task. Actions such as manual robot control for service, adjusting parameters or real-time control of the process are clearly shown by Kranendonk-developed pictures and icons. The graphical operator interface is easily understood so that new operators are familiar with the production system within days – with no language barriers. The operator interface can be adjusted at any time if special customer needs occur.

Kranendonk

Kranendonk Production Systems BV is a supplier of turnkey automated production systems including installation, production start-up, customer training and services. Kranendonk has developed special production systems for robotic welding and thermal cutting at shipyards. The highly skilled staff consists of specialists in mechanical engineering, electrical engineering, control systems, robot applications, project management and software for CAD/CAM process and logistics. This skilled and highly motivated team of engineers have enabled Kranendonk to become a leader in the field of one-piece production using industrial robots.

Kranendonk has designed, built and commissioned over 200 systems, worldwide, for one-piece production in various industry segments. Projects include complete systems for the welding of ship panels for Newport News, Nordic Yards, Meyer Werft, STX, DCNS, Aker and Fincantieri.

E-mail: sales@kranendonk.com
www.kranendonk.com

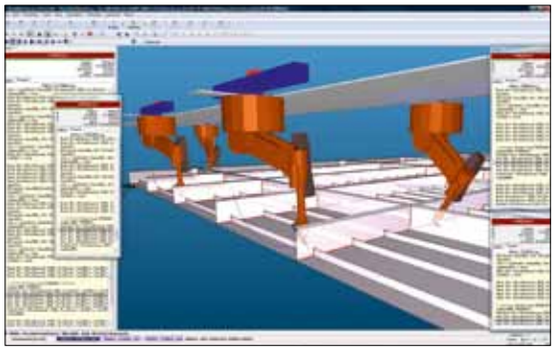

Figure 4. RinasWeld automatic programming software for Fincantieri.

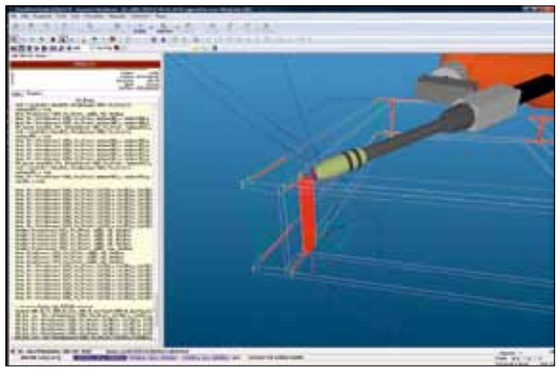

Figure 5. Automatic selection of weld parameters for predefined weld situations recognised in CAD-model.

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OK AristoRod™ - simply the best!

ESAB non-copper coated MAG wire - the benchmark in Europe and now conquering the world.

Maria Bergenstråhle and **Mats Linde**, ESAB AB, Gothenburg, Sweden.

A decade after ESAB launched OK AristoRod™ non-copper coated MAG wire with Advanced Surface Characteristics (ASC), its success stands undisputed in the European welding industry where the most demanding of fabricators have embraced the wire for its superior welding characteristics.

OK AristoRod™ brings process stability, prolonged trouble-free feeding, reduced maintenance downtime and less post-weld labour, all adding up to increased productivity and lower welding costs. It has become the benchmark product in developed European welding markets such as Scandinavia, Germany and France and its use is quickly spreading into North America and developing markets such as South America and China. In addition to the plant in Vamberk, Czech Republic, ESAB has established production facilities in Argentina and China - all producing AristoRod™ wires to the same stringent quality standard. Now, cost-conscious fabricators across the world are switching from copper coated MAG wire to non-copper coated OK AristoRod™.

Copper coating not the Holy Grail

Copper coated wires are widely used because of their good welding performance. They dominate the MAG welding wire market and are still an excellent solution for many fabricators. This does not mean, however, that there are no drawbacks to a copper coating. For many years, there was simply nothing better available.

Copper was originally applied to improve a MAG wire's feeding properties through improved cur-

rent transfer between wire and tip and not – as often claimed – to reduce tip wear or to protect against rust. Since current transfer determines a large part of the actual feeding force needed, the copper coating, primarily, enhances wire feedability. Reduced tip wear should be regarded as a favourable side effect or, in the case of rust on the wire surface, even as not correct.

The weakness of a copper coated wire lies in the fact that copper is a soft alloy, sensitive to mechanical damage during feeding. Copper particles chip off and contaminate the feeding system. They gradually clog the liner and gun and melt into the contact tip (arcing), increasing feed resistance and, eventually, leading to burnback of the wire to the contact tip - halting the MAG process. The severity and speed of contamination depends on a number of factors:

- Wire quality.
- Type of roller and roller pressure.
- Type of liner.
- Liner length.
- Wire feed speed.
- Curves in the cable assembly.

Wire quality is one of the main influences. Creating an optimal copper coating is a complicated process with a number of critical production steps. Cleanliness and degree of roughness before coppering, for example, are extremely important. They determine how well the copper coating adheres to the wire surface and resists being rubbed off during feeding. Equally important is the thickness of the layer – thick enough to provide the necessary benefits, but thin enough not to chip off during feeding.

This explains why there are so many MAG wire qualities on the market - from superior to inferior and everything in between. Creating a high quality copper coated wire requires knowledge and experience and excellent quality control which, in practice, is available to only a limited number of producers.

The fact that contamination also depends on the conditions of feeding and the welding parameters, makes the picture even more complicated. A poor quality wire may present few problems when welded under 'favourable feeding conditions', whereas even a high quality copper coated wire may fail when feeding conditions are extremely demanding.

Demanding feeding conditions can be present in manual welding, but are more likely to occur in mechanised and robotic welding due to the often higher wire feed speeds and duty cycles, many starts and stops and longer liners. It is in European industries with this type of welding where OK AristoRod™ wires have built an excellent reputation. Good examples are the production of car components, such as car seats and cross beams, truck axles, earth moving equipment and forklift truck frames and crane beams. Some of these have been described in detail in previous issues of Svetsaren.

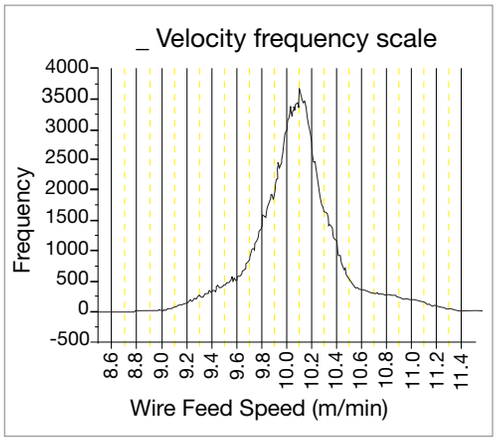


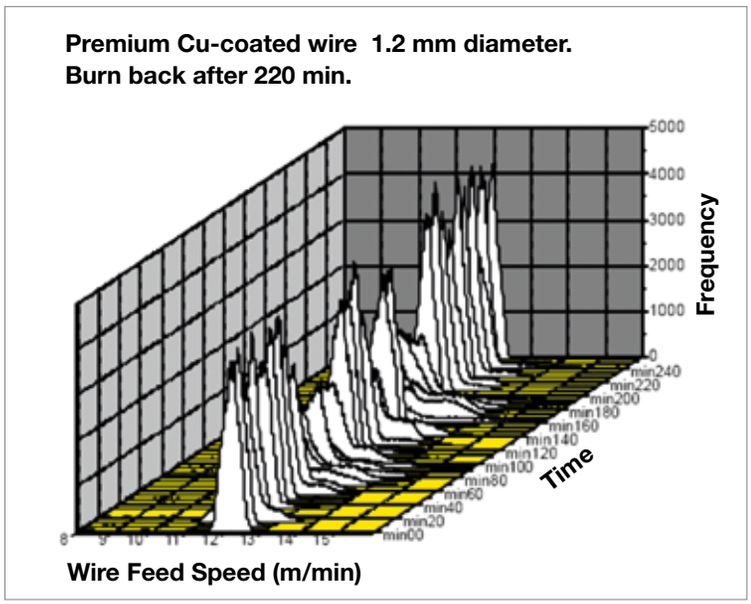
Figure 2. Wire feed stability measured at the torch set value 10.1 m/min.

Advanced Surface Characteristics

Knowledge – originally gained by ESAB in the production of cored wires in the 1990's - was further developed and refined and applied in solid wire production to result in the OK AristoRod™ range of non-copper coated wires with Advanced Surface Characteristics - products with unique properties compared with copper coated MAG wires. Table 1 surveys unique ASC features and the resulting benefits for users.

Table 1. ESAB AristoRod™ with Advanced Surface Characteristics has a number of unique features with advantages for manual, mechanised and robotic welding. These translate into clear benefits that, together, add up to increased productivity and lower welding costs.

Feature	Benefit
Consistent welding performance,	Consistent weld results
Stable arc with low feeding force	High weld quality. Reduced rework or post weld cleaning
Excellent arc ignition	Reduced post weld cleaning
High current operability	Higher productivity
Extremely low spatter level	Reduced post weld cleaning
Trouble-free feedability, even at high wire feed speeds and long feed distances	Higher productivity, reduced equipment downtime
Low fume emission	Cleaner working environment



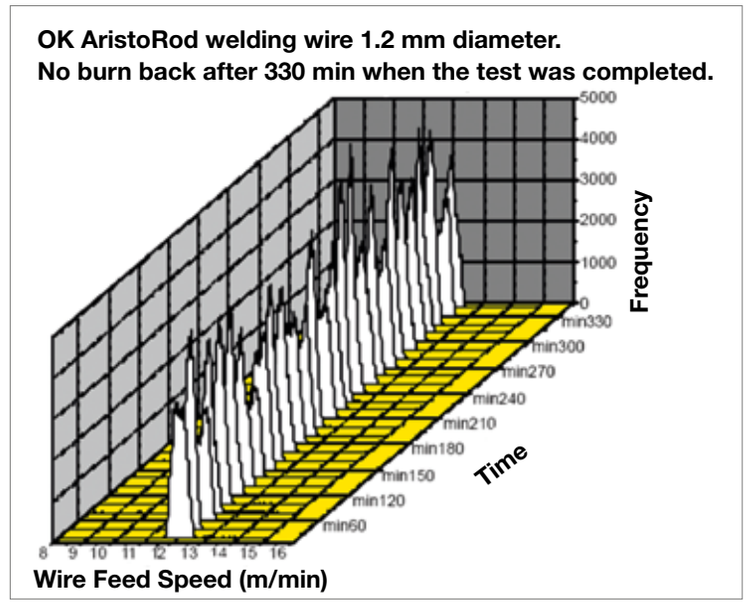


Figure 3. Wire feed speeds variations for a nominal speed of 12.5 m/min. The vertical axis shows the number of measurements. Wire diameter is 1.2 mm for both wires. Parameters used in the test are 350 A, 32 V, 20 mm stick out. Shielding gas: 80%Ar/20% CO_2. Source: ISF, Aachen.

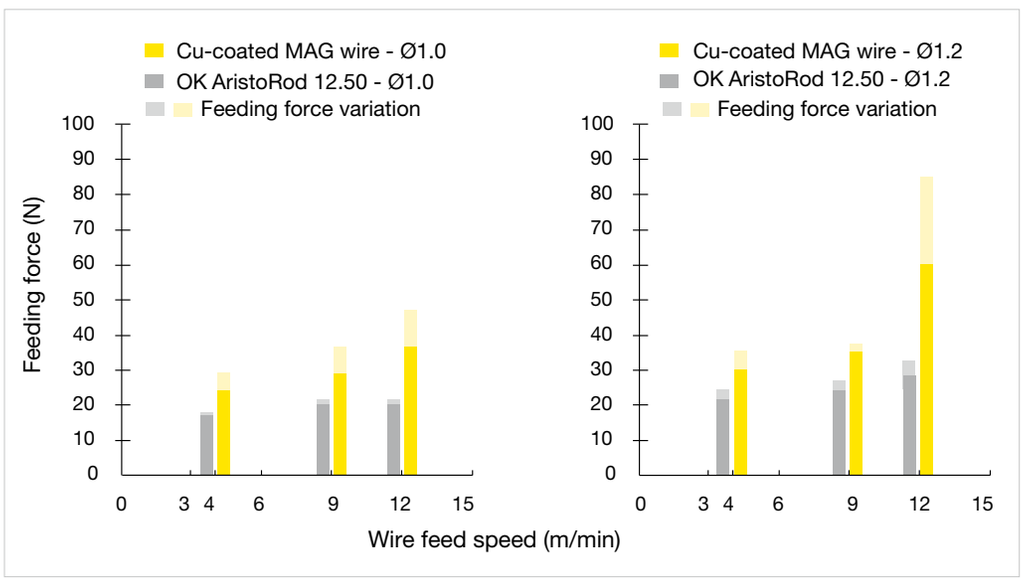


Figure 4. Feeding force for OK AristoRod™ and copper coated wire at various wire feed speeds. Ar/CO_2 shielding gas. Source: ESAB.

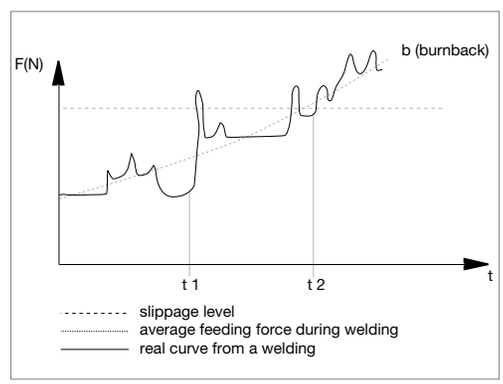


Figure 5. Increasing feeding force due to copper particle contamination of the feeding system leading to burn-back. Source: ESAB.

Scientific evidence

This article presents a summary of a benchmark investigation carried out by ISF Aachen, the German welding research authority. In this project, OK AristoRod™ was compared with a wide selection of copper coated MAG wires from the world's most important suppliers. Unless stated otherwise, the results are shown for OK AristoRod™ and a high quality copper coated wire. The information is completed by data from ESAB's own research. The data source is given in diagram captions.

Wire feed stability

Wire feed stability is important for arc stability. Unstable feeding results in an unstable arc with more spatter and less straight weld beads. Figure 2 shows the velocity frequency scale measured during 20 minutes of welding. Actual wire feed speed is measured at the welding torch. Between the feeding rolls and torch, the wire, together with

the liner, acts as a spring. This is why wire speed is lower than set value when feeding force suddenly increases, and higher when feed force suddenly decreases. If slip occurs between feeding rolls and wire, the actual wire feed speed is more severely affected. A wide, low curve represents unstable feeding, while a small, high curve shows stable feeding.

Figure 3 shows a series of these diagrams, obtained by measuring up to 330 minutes of welding, for OK AristoRod™ and copper-coated MAG wire. Clearly, feeding is much more stable for OK AristoRod™ and there is substantial speed variation with the copper-coated wire. With OK AristoRod™, the test was completed over the full period of 330 minutes, while the test with the copper coated wire was abandoned after 220 minutes due to burnback of the wire at the contact tip.

Feeding force- the force needed to push a wire through a liner and torch – is related to feeding stability. This force depends on many factors, such as type and length of the liner, curves in the cable assembly and curves in the welding torch, and also on the surface of the wire. Figure 4 shows the feeding force measured in a standardised set-up for OK AristoRod™ and copper coated wire for two wire diameters. It can be seen that the feeding force is not only lower for AristoRod™, but also that variation is substantially smaller, indicating more stable feeding conditions.

Figure 5 shows what happens when copper coating particle contamination clogs the wire feed system. The feeding force increases gradually beyond the level where the wire will continually slip. The arc will become very unstable and finally the wire burns back to the contact tip. Not a single copper coated wire lasted the full 330 minutes of welding. Tests had to be abandoned because of burnback, some after just 8 minutes.

Arc Stability

Arc stability is determined in high current welding tests in two ways: by measuring the vibration, welding current and voltage; and by recording the brightness variations of the arc. The test set-up used for measuring the arc stability is shown in Figure 6.

Vibration is measured by a sensor placed on the

Figure 6. Set-up used for high current welding tests

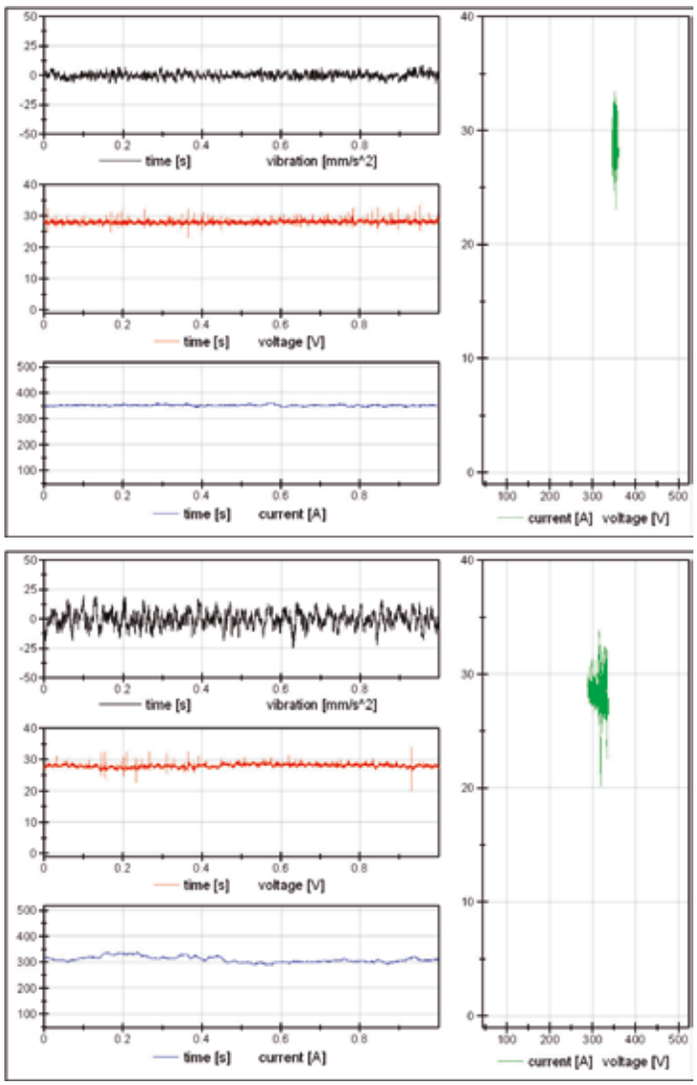


Figure 7. Results of high current welding tests for OK AristoRod™ (top) and copper coated wire reveal that the arc stability is substantially better with OK AristoRod™ . Source: ISF Aachen.

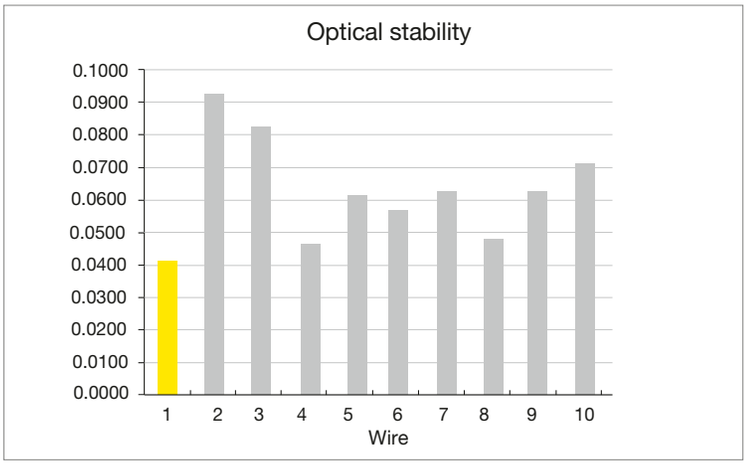


Figure 8. Light intensity variations of the arc during one second, recorded by high speed camera (3000 frames/s). Number 1 shows OK AristoRod™. Numbers 2 to 10 are various copper coated wires available to the global marketplace. Source: ISF Aachen.

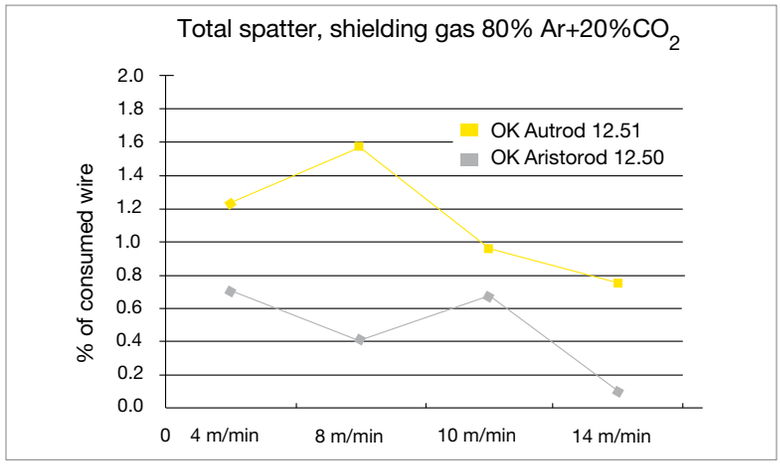


Figure 9. Total of small and large spatter - mixed gas (M21). Source: ESAB. OK Autrod 12.51 is ESAB's premium quality copper-coated wire (EN G3Si1/AWS ER70S-6).

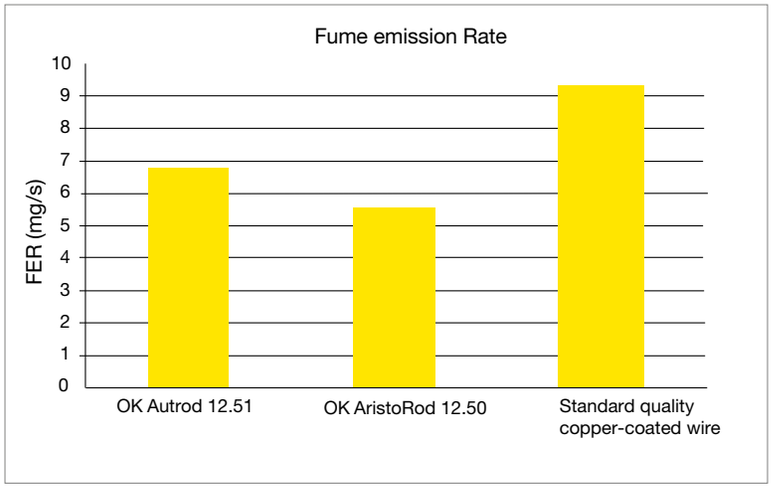


Figure 10. Fume emission rate measured using the Swedish fume box method. Source: ESAB.

torch while, simultaneously, current and voltage are recorded in ms by the power source control unit. Variations in the brightness of the arc are extracted from high speed videos recording actual arc behaviour.

Figure 7 shows typical results for OK AristoRod™ and copper coated wire. The vibration, measured in m/s^2, is substantially higher for the copper coated wire, while voltage and welding current vary within a larger scatterband. The green area shows the voltage and current window. Voltage variations are, of course, unavoidable, because of the droplet split-off. However, voltage variance is higher with copper-coated wire. Current variance is even more pronounced, due to the less stable arc.

This is confirmed by the brightness variations (grey scale variation) recorded by the high speed camera, Figure 8. From all wires tested, OK AristoRod clearly gave the highest arc stability. High speed videos reveal a more stable arc with less spatter for OK AristoRod™.

Spatter

Arc stability and spatter are related in the sense that a less stable arc leads to more spatter. Small spatter is not so harmful, because it solidifies without sticking to the surface of the plate. Large spatter, however, solidifies onto the plate and needs to be removed, which is time consuming and costly. Figure 9 compares spatter behaviour of OK AristoRod™ and high quality copper coated wire, revealing a striking difference in the amount of spatter. Spatter is measured by welding between copper collector boxes and weighing the collected spatter.

Fume

The absence of a copper coating leads to a reduced fume emission rate. In Figure 10, OK AristoRod™ fume emission is compared with a high quality copper coated wire with an optimal coating thickness, and a copper coated wire with a thicker copper layer.

Corrosion

It is a myth that the copper coating protects the wire from corrosion during storage or use. On the contrary, under the influence of humidity, the difference in electro-chemical potential between wire and copper layer can promote the formation of rust at micro defects in the copper coating. Figure 11 shows the wire surface after 6 days of unprotected exposure at 80% relative humidity and 26.6ºC. No corrosion spots are visible on the OK AristoRod™ wire surface, while the first small corrosion spots appear on the copper coated wire surface. Figure 12 shows the result after 14 days. The first spots now also appear on the OK AristoRod surface, while the copper coated wire shows advanced pitting corrosion.

A complete range

The research data presented in this article explains how and why OK AristoRod™ non-copper coated MAG wire became Europe's benchmark - and is now conquering the world. It is the

ideal MAG wire for demanding welding conditions in manual, mechanised and robotic applications. OK AristoRod™ is available in a variety of non and low alloyed types, Table 2.

Together with ESAB's Marathon Pac™ bulk drum system it forms an unbeatable combination for continuous trouble-free welding.

Figure 11. Wire surface after 6 days of unprotected exposure at 80% relative humidity and 26.6ºC. Left OK AristoRod™, right copper coated wire. Source: ISF Aachen.

Figure 12. Wire surface after 14 days of unprotected exposure at 80% relative humidity and 26.6ºC. Left OK AristoRod™, right copper coated wire. Source: ISF, Aachen.

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Table 2. The AristoRod™ range of non-copper coated wires.

Product	Classification wire		Classification wire and weld metal			Shielding gas		Steel type
	AWS		EN-ISO			EN-ISO 14175		
OK AristoRod™	A5.18	A5.28	14341-A	16834-A	21952-A /-B	M21	C1	
12.50	ER70S-6		G3Si1			G 42 4	G 38 2	Normal strength
12.57	ER70S-3		G2Si			G 38 3	G 35 2	Normal strength
12.62	ER70S-2		G2Ti			G 46 4	G 42 3	Normal strength
12.63	ER70S-6		G4Si1			G 46 4	G 42 2	Normal strength
12.65	ER70S-6		G4Si1			G 46 4	G 42 2	Normal strength
13.08		ER80S-D2	G4Mo		G 4Mo / G 1M3	G 50 4	G 46 0	Creep resistant
13.09		ER80S-G	G2Mo		G MoSi /G 1M3	G 46 2	G 38 0	Creep resistant
13.12		ER80S-G			G CrMo1Si / G 1CM3			Creep resistant
13.16		ER80S-B2			G 55A 1CM			Creep resistant
13.22		ER90S-G			G CrMo2Si			Creep resistant
13.26		ER80S-G	G0			G 46 4	G 42 0	Weather resistant
55 (13.13)		ER100S-G		G Mn3NiCrMo		G 55 4		High strength
69 (13.29)		ER110S-G		G Mn3Ni1CrMo		G 69 4		High strength
79 (13.31)		ER120S-G		G Mn4Ni2CrMo		G 79 4		High strength
89 (1B96)		ER120S-G		G Mn4Ni2CrMo		G 89 4		High strength


F3-FA

Record plate thickness weld with PZ6138 cored wire

Heerema Fabrication Group completes unique gas platform with 135 mm welds

Eric de Man, ESAB bv, Amersfoort, The Netherlands.

A weld thickness world record has been set by Heerema Fabrication Group (HFG), Vlissingen, The Netherlands while constructing the state-of-the-art F3-FA mobile production platform for Centrica Energy on the Dutch continental shelf. Using ESAB's 1.2 mm diameter PZ6138 all-positional rutile cored wire, a weld thickness of no less than 135 mm needed to be covered in the difficult PC (2G) position.

This unique platform is the largest of its kind ever built at the Vlissingen yard and has been fabricated in record-time of less than one year. It created approximately 1,000,000 man hours of work for Heerema Vlissingen and its direct subcontractors. The platform has a total height of 133 metres of which the legs are 75 metres long and weigh 1,200t each. The topsides have a weight of 4,000 tonnes and are 50 metres wide, 30 metres long and 30 metres in height. Four huge, five-storey high suction buckets, each able to hold more than 2.5 million litres of water, anchor it in position. The total weight of the platform is 8,800 tonnes.

The four 135 mm welds are located in the legs, just above the stiffener frames and suction piles, Figure 1. Each weld has a run around length of about ten metres and the welding time per leg was about two weeks on a two-shift basis. For two good reasons, it involved mechanised welding using a rail track system under 80%Ar/20%CO_2 shielding gas. Obviously, the high weld volume required productive welding but, in addition, limited working height (50 cm above floor level) made manual welding virtually impossible.

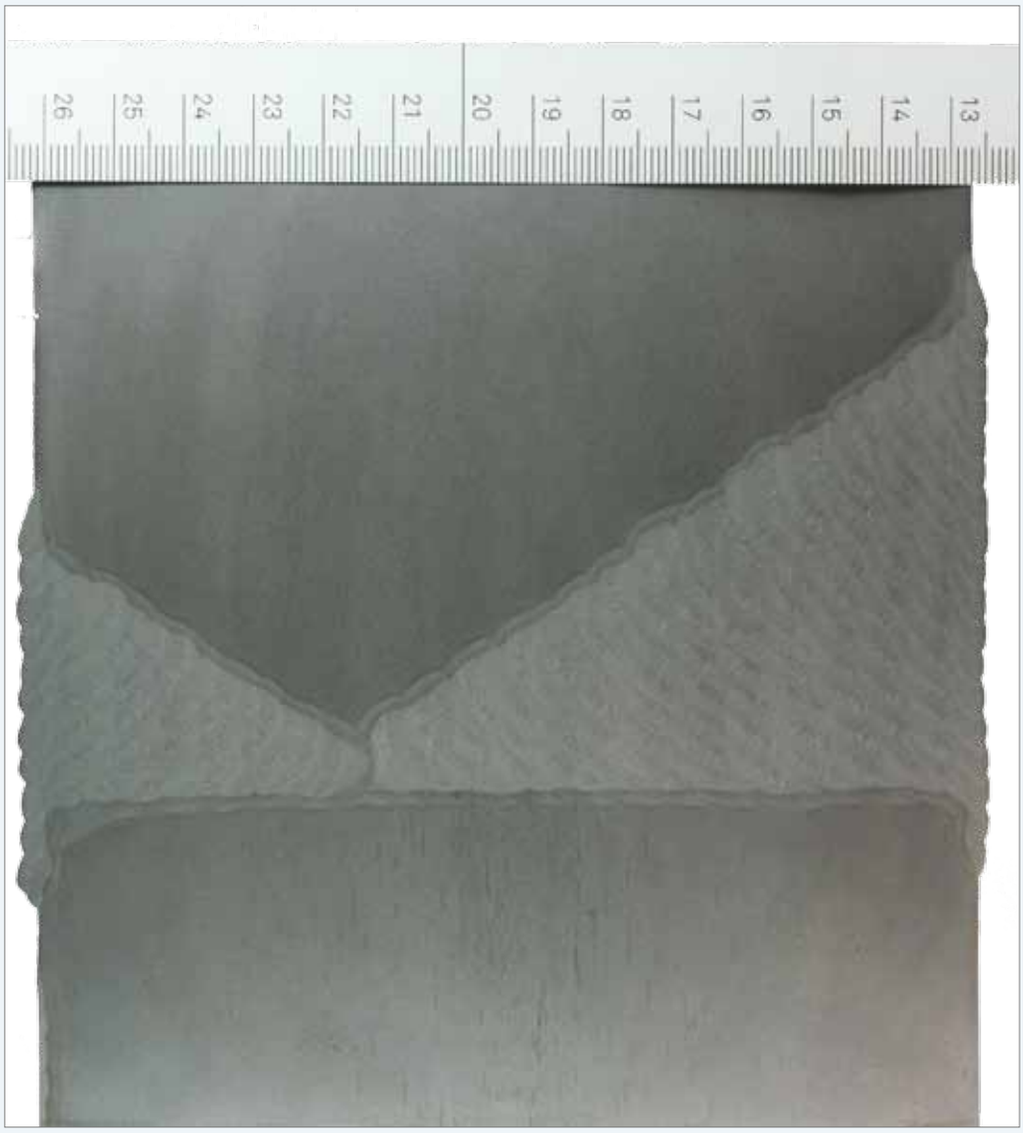

Figure 1. The record weld in PC (2G) position. Plate thickness 135 mm.

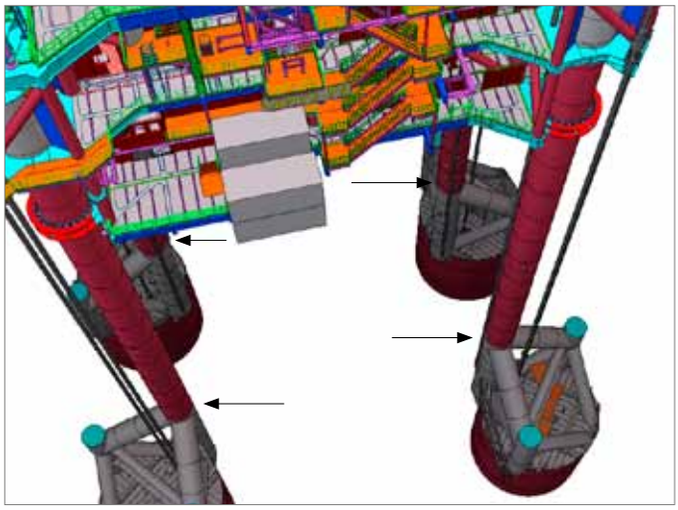

Figure 2. View of Centrica's F3-FA mobile production platform legs. The arrows indicate where the heavy welds in PC (2G) position are located.

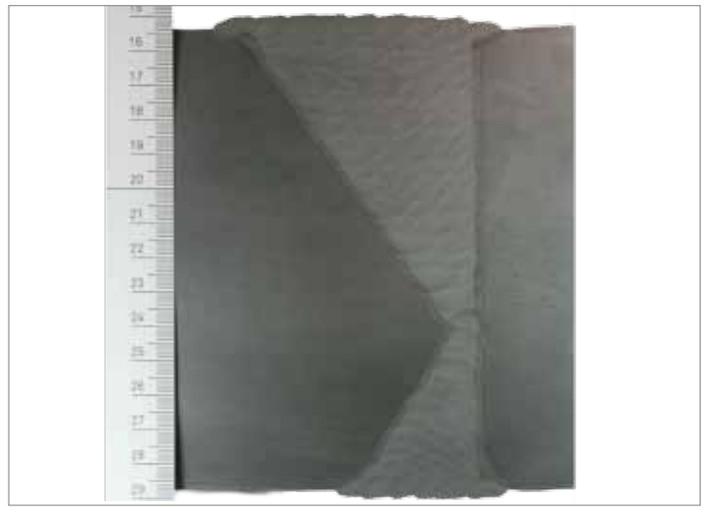

Figure 3. Weld in PF (3G) position. The plate thickness for the WPQ was also 135 mm, but actual welds in the construction were smaller. Weld metal CTOD results at -10°C were 0.87 mm minimum, and 1.12 mm average.

Heerema Welding Engineer, Alfred van Aartsen says: "It was one of the most challenging welds we have made. PC (2G) is a difficult position when it comes to the avoidance of slag inclusions, and working on preheated plates of this size is extremely demanding for welders. Only our very best welders worked on these critical welds. A top quality consumable was used. We have vast experience with PZ6138 and its superb weldability and, again, it stood up to the test."

Apart from this record joint in PC (2G) position, there were a variety of welds in PF (3G) position which were only slightly smaller and equally challenging, Figure 2.
Table 1 surveys the mechanical properties from one of the WPQ's. These included a CTOD value in the heat affected zone of 0.74 mm at 0°C.

Impact tests - Charpy KV -

Notch location	Size [mm]	Test temp. [°C]	Measured values [Joules]	Average value [Joules]
Midweld - cap	10 x 10	- 40	120 - 108 - 108	112
Fusion Line - cap	10 x 10	- 40	90 - 76 - 73	80
Fusion Line + 2 mm - cap	10 x 10	- 40	56 - 45 - 135	79
Fusion Line + 5 mm - cap	10 x 10	- 40	181 - 180 - 164	175
Midweld - root	10 x 10	- 40	114 - 121 - 112	116
Fusion Line - root	10 x 10	- 40	101 - 63 - 66	77
Fusion Line + 2 mm - root	10 x 10	- 40	171 - 162 - 168	167
Fusion Line + 5 mm - root	10 x 10	- 40	191 - 171 - 173	178

Cross weld tensile tests 1)

Dimensions(s) [mm]	Rm [N/mm²]	Fracture location
62.87 x 25.02	516	Base material
62.65 x 24.95	523	Base material
62.91 x 25.17	517	Base material
62.62 x 24.85	520	Base material

Note 1) multiple specimens are used to cover the whole thickness

Technological tests

Type	Former / Bending angle	Result
Side bend	4t / 180°	4 x acceptable

All weld metal tensile test

Dimensions(s) [mm]	Gauge length [mm]	Rp0.2%	Rm [N/mm2]	Elongation	Red.of area
Ø 9.99	50	576	618	22	67

Hardness measurements HV10 (<325 HV10 acc. FEMUA)

Location of indentations	Traverse 1 - 2 mm below outer surface	Traverse root area	Traverse 1 - 2 mm above inner surface
base material	167 - 169 - 166	160 - 165 162	176 - 170 - 177
heat affected zone	187 - 203 - 221 - 251 - 213	215 - 224 - 224 - 240 - 229	174 - 219 - 236 - 247 - 237
weld metal	221 - 228 - 227 - 217 - 221	246 - 251 - 241 - 238 - 228	228 - 230 - 232 - 217 - 210
heat affected zone	209 - 231 - 181 - 180 - 183	219 - 209 - 219 - 204 - 202	213 - 198 - 205 - 182 - 178
base material	167 - 167 - 165	169 - 168 - 163	177 - 179 - 173

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Product News Consumables

New all positional rutile cored wires

ESAB has recently introduced all positional rutile cored wires for low-temperature applications, high strength steels and creep resistant steels.

These wires are extremely "welder friendly" with a soft, spatter-free arc that always operates in the spray arc mode. It is easy to obtain flat welds with a good penetration and smooth wetting onto the plate edges. The brittle slag is easily removed leaving behind a smooth weld appearance. Typical positional welding defects such as lack of fusion and slag inclusions are avoided, due to the spray arc operation. The wires have a good tolerance for fit-up variations. High quality one-sided root runs are made economically on ceramic backing.

The wire formulation provides a fast freezing slag that supports the weld pool well in positional welding, enabling deposition rates which can not be equaled by stick electrodes or solid wires. Deposition rates in vertical up welding can reach up to 4 kg/h (100% duty cycle), making them the most productive consumables available for manual welding in this position. Welding parameters are optimised for each welding position to provide maximum productivity, but one single setting can be selected for all-positions (230A), making it ideal for fit-up work.

Diffusible hydrogen satisfies the EN H5 class tested under the parameters prescribed in the classification standard. Weld metal remains low hydrogen over a wide envelope of welding parameters.

Low-temperature	PZ6138SR and PZ6138S SR
High strength	Dual Shield 55 and Dual Shield 62
Creep resistent	Dual Shield MoL, Dual Shield CrMo1 and Dual Shield CrMo2

PZ6138SR and PZ6138S SR

The PZ6138 family consists of all positional rutile, low hydrogen, flux-cored wires for applications involving the welding of thick steel components with impact toughness requirements down to –60°C. The family is based on FILARC PZ6138 which has been widely applied in offshore fabrication for decades. They are alloyed with 0.9% Ni and micro-alloyed with TiB. PZ6138 and PZ6138 SR are designed for use in Ar/CO_2 mixed gas, whereas PZ6138S SR is used in pure CO_2. Types with the suffix SR provide good low temperature toughness after stress relieving. All types are successfully CTOD tested – the SR types at temperatures as low as –40°C.

Classification

FILARC	EN ISO 17632-A	AWS A5.29
PZ6138	T 50 6 1Ni P M 1 H5	E81T1-Ni1M JH5
PZ6138 SR	T 46 6 1Ni P M 1 H5	E81T1-Ni1M J
PZ6138S SR	T 46 6 1Ni P C 1 H5	E81T1-Ni1CJ

Typical weld metal chemical composition(%)

Chemistry	C	Si	Mn	Ni	P	S
PZ6138	0.051	0.39	1.26	0.86	0.012	0.009
PZ6138SR	0.048	0.37	1.24	0.84	0.010	0.007
PZ6138S SR	0.052	0.32	1.20	0.89	0.011	0.008

Typical weld metal mechanical properties

FILARC PZ	Condition	Rp (MPa)	Rm (MPa)	A5 (%)	CVN (J)/) –60°C
6138	AW	546	614	24	86
6138 SR	PWHT*	544	613	26	91
6138S SR	PWHT*	480	560	25	83

*2h/600°C

FILARC PZ	Condition	CTOD/-10°C	CTOD/-40°C
6138	AW	>0.93, >0.91, >0.96	
6138 SR	AW	0.95, 0.96, 1.05	0.55, 0.52, 0.60
6138 SR	PWHT*	1.52, 1.40, 1.45	0.73, 0.70, 0.86
6138S SR	PWHT*	1.08, 1.17, 1.12	0.17, 0.66, 0.54

Dual Shield 55 and Dual Shield 62

Dual Shield 55 and Dual Shield 62 are all-positional rutile, low hydrogen flux-cored wires for the welding of high strength steels with minimum yield strengths of 550MPa and 620MPa. They have excellent weldability and produce flat beads with good wetting and smooth appearance. Both wires are designed for use in Ar/CO_2 shielding gas.

Classification

Dual Shield	EN 12535	AWS A5.29
55	T 55 4 Z P M 2 H5	E91T1-Ni1M
62	T 62 4 Mn1.5Ni P M 2 H5	E101T1-G

Typical weld metal chemical composition(%), DC

Chemistry	C	Si	Mn	Ni	P	S
Dual Shield 55	0.05	0.41	1.45	0.95	0.008	0.011
Dual Shield 62	0.06	0.41	1.58	1.50	0.010	0.013

Typical weld metal mechanical properties, DC+

	Rp0.2 (MPa)	Rm(MPa)	A5 (%)	CVN (J)
Dual Shield 55	584	660	26	-40°C: 105
Dual Shield 62	670	740	24	-40°C: 95

Dual Shield MoL, Dual Shield CrMo1 and Dual Shield $CrMo_2$

Dual Shield MoL, Dual Shield CrMo1 and Dual Shield CrMo2 are all positional rutile, low hydrogen flux-cored wires for the welding of creep resisting steels with respectively 0.5%Mo, 1.25%/Cr/0.5%Mo and 2.25%Cr/1%Mo. Designed for use in $ArCO_2$ shielding gas, they have excellent weldability and produce flat beads with good wetting and a nice appearance. All wires have good impact toughness down to –20 °C after stress relieving.

Classifications

	EN ISO 17634-A	AWS A5.29
Dual Shield MoL	T MoL P M 2 H5	E81T1-A1M
Dual Shield CrMo1	T CrMo1 P M 2 H5	E81T1-B2M
Dual Shield CrMo2	T CrMo2 P M 2 H5	E91T1-B3M

Typical weld metal chemical composition (%) Ar/CO2, DC+

	C	Si	Mn	Cr	Mo	P	S
Dual Shield MoL	0.053	0.29	0.72	0.04	0.59	0.014	0.010
Dual Shield CrMo1	0.060	0.35	0.90	1.29	0.54	0.012	0.008
Dual Shield CrMo2	0.060	0.33	0.84	2.26	0.94	0.011	0.010

Typical weld metal mechanical properties after PWHT

	PWHT	Rp0.2 (MPa)	Rm (MPa)	A5 (%)	CVN (J)
Dual Shield MoL	615°C / 1hr	505	626	29	145 at -20°C
Dual Shield CrMo1	690°C / 1hr	570	645	23	55 at -20° C
Dual Shield CrMo2	690°C / 1hr	625	710	20	65 at -20°C

- **High deposition rate: reduced welding times leading to overall lower welding costs.**
- **All positional weldability: one wire with the ability to weld several applications**
- **Welder friendly: easy to use with a lower risk of weld defects and reduced welder training costs**
- **High level of weld metal integrity: outstanding CTOD performance to -40°C in both the AW and PWHT conditions**
- **High level of weld quality: consistently low hydrogen (H5) provides assurance against the risk of HAZ hydrogen induced cold cracking**

The ESAB consumables range for nuclear applications

ESAB has renewed and completed its nuclear consumable product range. These consumables are purposely designed for use in primary nuclear circuit components such as reactor pressure vessels (RPV), steam generators (SG), pressurisers and other components of nuclear power plants. This range has been defined to respond to a significant demand for nuclear consumables from manufacturers within the industry located in different parts of the world. It covers the requirements from ASME, RCCM and major nuclear manufacturer specifications.

ESAB Nuclear Welding Consumables Range

AWS class	SMAW	GTAW	GMAW used for mechanised GTAW	SAW	SAW high basicity flux for jointing	SAW, cladding	ESW, cladding
SFA/AWS 5.1							
E7018	OK 48.00 N						
E7018-1	OK 55.00 N						
SFA/AWS A 5.18							
ER70S-3		OK TigrodN 12.60	OK AristoRodN 12.60				
ER70S-6		OK TigrodN 12.65	OK AristoRodN 12.65				
SFA/AWS 5.5							
E8018-G	OK 74.65 N (OK SP 307)						
E9018-G	under development						
SFA/AWS A 5.23							
F10A8-EG-F3/ F9P6-EG-F3				OK Flux 10.62/ OK AutrodN 13.40			
EM2				OK Flux 10.62/ Spoolarc 95			
EF2				OK Flux 10.62/ Spoolarc 44			
SFA/AWS 5.4							
E308L-16	OK 61.30 N						
E308L-15	OK 61.35 N						
E309L-16	OK 76.60N OK 76.61N						
E316L-15	OK 63.25 N						
SFA/AWA A 5.9							
ER308L		OK TigrodN 308L	OK AutrodN 308L	OK Flux 10.93/ OK AutrodN 308L	OK Flux 10.16/ OK AutrodN 308L	OK Flux 10.05/ OK BandN 308L	OK Flux 10.10/ OK BandN 309L ESW
ER309L		OK TigrodN 309L	OK AutrodN 309L	OK Flux 10.93/ OK AutrodN 309L	OK Flux 10.16/ OK AutrodN 309L	OK Flux 10.05/ OK BandN 309L	OK Flux 10.10/ OK BandN 309L ESW
ER316L		OK TigrodN 316L	OK AutrodN 316L	OK Flux 10.93/ OK AutrodN 316L	OK Flux 10.16/ OK AutrodN 316L	OK Flux 10.05/ OK BandN 316L	OK Flux 10.10/ OK BandN 309LMo ESW,
SFA/AWS A 5.11							
ENiCrFe-3	OK 92.96N						
SFA/AWS A 5.14							
ERNiCr-3		OK TigrodN 19.85	OK AutrodN 19.85		OK Flux 10.16/ OK AutrodN 19.85	OK Flux 10.16/ OK BandN NiCr3	OK Flux 10.11/ OK BandN NiCr3

New designations for OK AristoRod™ high strength MAG wire range

ESAB's range of OK AristoRod™ non-copper coated MAG welding wires has new designations – as shown in the Table – with effect from August 2010. The products remain unchanged: welding procedures, or completed welding tests are, therefore, not affected. OK AristoRod™ 89 is a new product. ESAB will issue updated approval certificates and/or affidavit certificates, on request. The transfer period will be kept as short as possible but, during this time, customers may receive labels with either old or new designations.

Table 1. Cost calculation for Hydro Automotive robot station. Weld metal consumption: 4900kg/robot/year

New name	Old name	Item number	A5.28	ISO-EN16834	M21	CE,DB, TûV
OK AristoRod 59	OK AristoRod 13.13	1B13	ER100S-G	G Mn3NiCrMo	G 55 3	
OK AristoRod 69	OK AristoRod 13.29	1B29	ER100S-G	G Mn3Ni1CrMo	G 69 4	x
OK AristoRod 79	OK AristoRod 13.31	1B31	ER110S-G	G Mn4Ni2CrMo	G 79 4	
OK AristoRod 89	-	1B96	ER120S-G	G Mn4Ni2CrMo	G 89 4	x

New in the AristoRodTM family OK AristoRod 89

OK AristoRod 89 is a non copper coated MAG wire for the welding of ultra high strength steels with a yield strength of min. 890MPa. It is low alloyed with 0.4%Cr – 2.2%Ni – 0.55Mo and has a good CVN impact toughness at –40ºC.

OK AristoRod 89 is produced with the unique Advanced Surface Characteristics (ASC) technology. Unlike with copper coated wires, the ASC quality does not deteriorate when applied to a wire surface that has been subjected to annealing, which is necessary to remove the wire reinforcement created in the drawing process. This results in superior feeding properties when compared with copper coated wire. OK AristoRod wires give trouble-free feeding and great arc stability with low spatter, even at high currents and with long feeding distances.

OK AristoRod 89 is available on spools or in the unique ESAB Octagonal Marathon Pac bulk drums, which is extremely economical in mechanised and robotic welding applications.

OK AristoRod 89 is developed for high strength steel grades according to ISO 15608: 2000, such as S890QL, Weldox 900, 1100, 1300, Domex 960, XABO 890,960,1100, NAXTRA 70, OX-700, 800, 1002, Optim 900QC, 960QC, 1100QC and T1 - HY80.

Classification

Wire
EN ISO 16834-A G Mn4Ni2CrMo SFA/AWS A5.28 ER120S-G
Weld Metal (as welded)
EN ISO 16834-A G89 4 M Mn4Ni2CrMo
Approvals
CE, TÜV (PF/3G/3F)

CHEMICAL COMPOSITION (%)

C	Si	Mn	P	S	Cr
0.08-0.12	0.60-0.90	1.60-2.10	<0.015	<0.015	0.25-0.45

Ni	Mo	V	Cu	Al	Ti	Zr
2.10-2.30	0.45-0.65	<0.03	<0.15	<0.03	<0.15	<0.03

MECHANICAL PROPERTIES (all weld metal in M21 shielding gas)

Rp0.2 (MPa)	Rm (MPa)	A4-A5 (%)	CVN at -40°C (J)
890 920	940 1100	>16	>47

New fluxes for SAW and ESW strip cladding

OK Flux 10.18 + OK Band NiCu7
Agglomerated flux for SAW strip cladding with Monel type strips.

OK Flux 10.18 is a neutral, moderately silicon alloying agglomerated flux for SAW strip cladding with Monel type strips. It is specifically designed for use with NiCu7 strip to reach Monel end composition on non-alloyed steel in three layers. Alternatively, it can be used to reach CuNi30 end composition on non-alloyed steel using NiCu7 strip for the buffer layer and CuNi30 strip for the subsequent two layers. The flux/strip combination provides good welding characteristics, smooth weld metal wetting, shiny bead appearance and easy slag removal with 60 mm x 0.5 mm strips. OK Flux 10.18 is used for desalination plants, in the chemical processing and petrochemical industries and for pressure vessels.

Classification

EN760: SA CS 2 DC	
With OK Band NiCu7	EN ISO 18274: B Ni4060 (NiCu30Mn3Ti)
	AWS/SFA 5.14: ERNiCu-7

Cladding with OK Band NiCu7 strip on mild steel plate. DC+, 800A, 29V, 13cm/min.

OK Flux 10.26 + OK Band 316L
New ESW strip cladding flux giving 316L composition in one layer.

OK Flux 10.26 is a high basic, Ni-, Cr- and Mo-alloying agglomerated flux designed for productive electroslag strip cladding. The OK Flux 10.26 with OK Band 316L combination produces a 316L overlay weld metal in one layer, eg, for internal overlay welding of chemical equipment. It can be used with 60mm wide strips. The flux has very good welding characteristics, giving a smooth bead appearance and a self-lifting slag that is easily removed. ESW strip cladding requires a special welding head and a power source with a capacity of at least 1600 A.

Typical applications
- Chemical industry
- Marine applications
- Paper industry digesters, evaporators & handling equipment
- Petroleum refining equipment

Classification

EN 760 : (~SA FB 2 CrNiMo DC)
With OK Band 316L

Full weld bead cladded with OK Flux 10.26/OK Band 316L 60 x 0.5mm. All welds free of surface defects. ESAB A6 head, ESAB 2 x LAF 1600 DC, PEH control unit. 1250 A / 24 V/ 18 cm/min; DC+, s/o 35 mm, FH 45 mm.

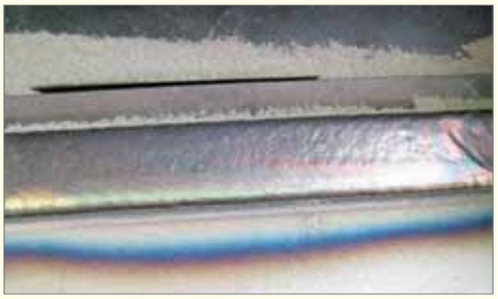
ESAB OK Flux 10.27 + OK Band 309LMoL
New ESW strip cladding flux giving 317L composition in one layer.

OK Flux 10.27 is a high basic, Ni-, Cr- and Mo-alloying agglomerated flux designed for productive electroslag strip cladding. The OK Flux10.27 with OK Band 309LMo combination produces a 317L overlay weld metal in one layer, eg, for the internal overlay welding of paper fibre drums. It is designed for use with 60 mm strips. The flux has very good welding characteristics and a self-lifting slag that is easily removed, leaving a clean, flat overlay.

The weld metal chemical composition does not significantly change within the applicable parameter range and over the cross section of the layer up to 3 mm below the surface. ESW strip cladding requires a special welding head and a power source with a capacity of at least 1600 A. Typical applications are found in gas desulphurisation scrubber systems, chemical and petrochemical processing equipment and pulp and paper plants.

Classification

EN 760: (~SA FB 2 CrNiMo DC)
With OK Band 309LMo ESW



Full weld bead cladded with OK Flux 10.27/OK Band 309LMo ESW). All welds free of surface defects. ESAB A6 head, 2 x ESAB LAF 1600 DC, PEH control unit. 1200 A / 24 V/ 18 cm/min; DC+, s/o 35 mm. Flux not rebaked prior to welding. All welds are free of surface defects.

OK Flux 10.31 + OK Band 7018L
Agglomerated flux for SAW strip cladding with unalloyed CMn strips.

OK Flux 10.31 is a neutral, slightly Mo-alloying agglomerated flux designed for SAW strip cladding with unalloyed CMn strips. It is designed for use with 30, 60 or 90 x 0.5 mm strips, giving very good weldability, excellent slag detachability and weld surface free of residuals. The flux adds, nominally, 0.4% Mo to the first layer. The weld metal chemical composition does not significantly change within the range of applicable welding parameters and over a cross section thickness of three layers.

Hydrogen
Hydrogen content was measured by a unique test procedure, using 10 mm wide strip cut from a 60 mm wide band. A precise cut was made to obtain a 4.5 gram sample of weld metal, according EN ISO 3690. Welding parameters were 350 A, 26 V, 12 cm/min. Results from four welded samples produced between 2.6 and 2.9 ml/100 g of weld metal. Typical applications are the repair and maintenance of shafts and pistons, repair of production defects, buffer layers and the cladding of pressure vessels.

Classification

EN 760: SA CS 3 Mo DC
With OK Band 7018

Full weld bead cladded with OK Flux 10.31/OK Band 7018). ESAB A6 head, 2 x ESAB LAF 1600 DC, PEH control unit. 1000A / 30V / 13 cm/min, DC+. All welds are free of surface defects.

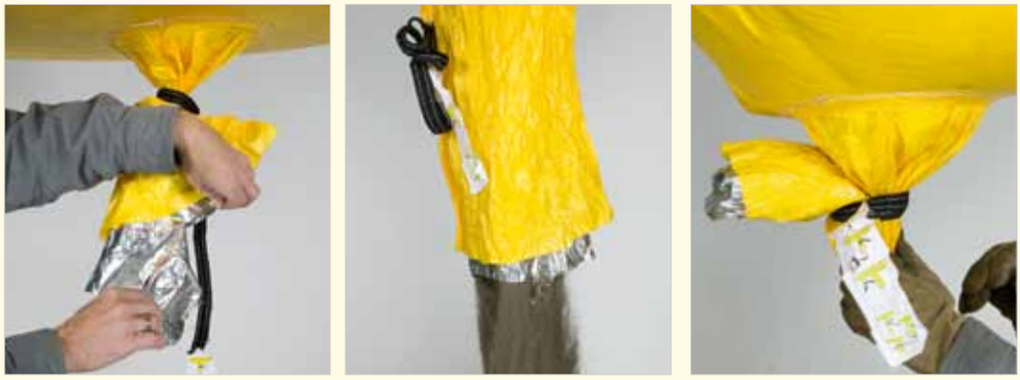
ESAB BigBag with internal aluminium lining

ESAB BigBag is a 1000 kg bulk package for the efficient handling of high quality submerged arc welding fluxes. It can be placed over the flux hopper by crane or in a frame and can be quickly discharged when a refill of the hopper becomes necessary.
In the as-delivered condition, the discharge spout of the BigBag is thermally sealed. It is easy to open without the use of knifes, scissors or other tools. Clear instructions with pictograms are on every bag.

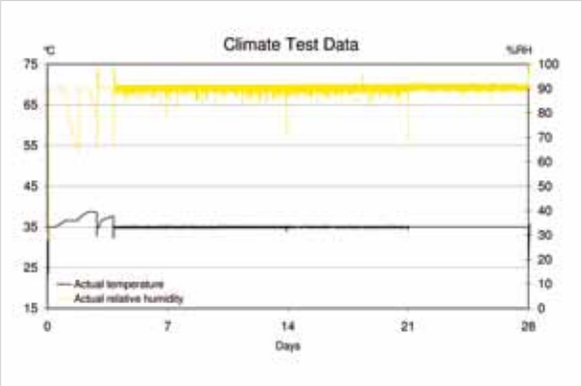
- **No moisture absorption**
- **Possibility to use flux without re-drying**
- **Efficient flux handling**
- **Easy to open and close**
- **Fully recyclable packaging**

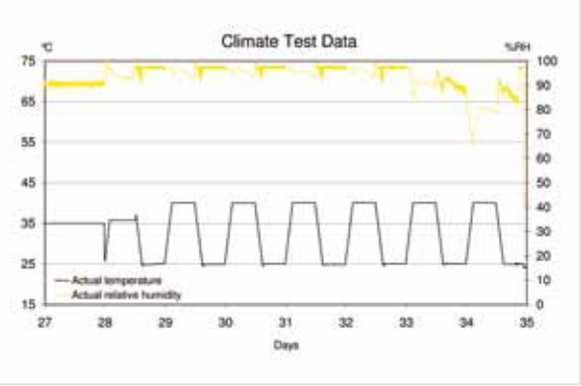
The moisture protection of fully filled BigBags was tested in a climate chamber for 5 weeks. The climate conditions in week 1 to 4 were 35°C / 90% relative humidity, corresponding to average tropical conditions. In week 5, the dew point was artificially reached once a day and droplets appeared on the outer packaging. Two sets of flux samples for moisture testing were taken from the centre of the BigBag and two sets from the side. The diagrams show that no measurable moisture absorption takes place. The diffusible weld metal hydrogen content remains at the as manufactured level.

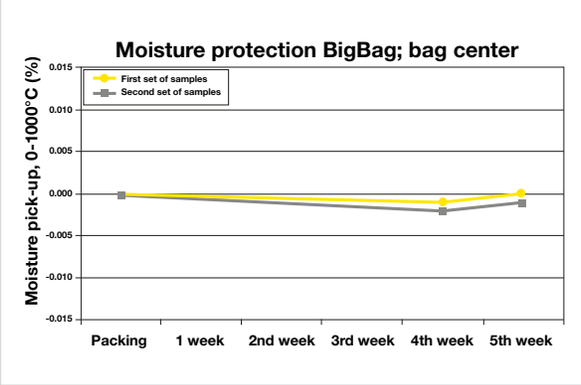
Although it takes only about 1 minute to empty a complete BigBag, small or large volume users can choose to take out any volume of flux at a time by closing the well-defined discharge spout during the flux flow. In this way, valuable time savings can be obtained compared with refilling from 20-30 kg flux bags or buckets.
Another important saving lies in the protection of the flux from moisture absorption. BigBags are made from strong woven polypropylene material that has an internal multi-layered aluminium lining, keeping the flux "factory dry".
Fabricators may decide to use the flux without time consuming and costly re-drying, even in hot and humid environments. In addition, each palet of flux is additionally protected against moisture by wrap or shrink foil.
The complete empty BigBag, including the aluminium liner is disposed as combustible energy recycling material, according to EN 13431.

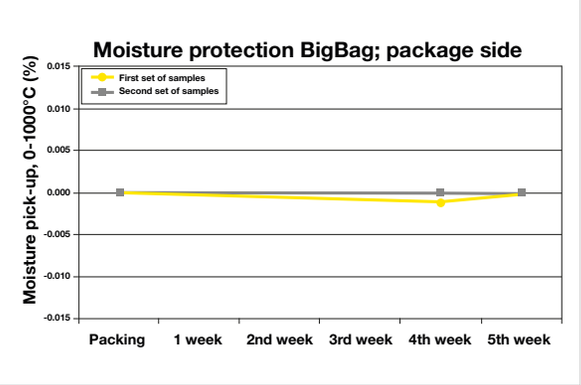


ESAB BigBags are ready prepared to be opened without the use of tools. Any required volume of flux can be taken out using the re-closable discharge spout. Note the internal aluminium lining that protects against moisture absorption.









product news equipment

Caddy® Mig C160i / C200i - The go-anywhere welders

ESAB has introduced two new portable MIG/MAG welding units - Caddy® Mig C160i and Caddy® Mig C200i - each featuring a built-in wire feeder for 200 mm spools.

Compact dimensions and low weight of just 12 kg bring MIG/MAG welding to on-site or assembly applications that formerly had to be MMA or TIG welded. Thinner plates can be welded, there is no slag to be removed, handling is easier than TIG welding and less sensitive to outdoor conditions - especially when using a self-shielded wire such as Coreshield 15. The units feature polarity change terminals for this. Several time-saving, quality-enhancing innovations dramatically reduce workload.

Caddy® Mig C160i is designed for basic MIG/MAG welding of mild steels for repair, maintenance and assembly work on plate thicknesses between 0.5 mm and 4 mm. It delivers 150 A at 35% duty cycle and 40°C ambient temperature.

This easy to use, powerful unit offers excellent welding properties. Operation is simple. One knob adjustment for plate thickness simultaneously sets the appropriate voltage for the 0.8 mm wire and shielding gas. Arc length, or any intended deviation from default arc voltage/wire feed speed, is simply set by another knob that indicates the arc getting hotter or colder. Caddy® C160i combines simple, fool-proof operation with professional welding properties.

Caddy® Mig C200i features an advanced setting and display that extends the range of welding applications to also include aluminium and stainless steels, and brazing.
The machine delivers 180 A @ 25% duty cycle and 40°C ambient temperature. It extends the wire range to 1 mm and plate thickness to 6 mm. The LCD display provides an overview of all adjustable parameters.

Figure 1: Caddy® Mig C160i and Caddy® Mig C200i.

Figure 2: Caddy® Mig C160i panel.

Caddy® Mig C200i can run in manual or QSet™ mode. QSet™ is simply applied artificial intelligence in arc welding. Optimum short arc welding parameters are self-set within a self-learning period of a few seconds. The user can preselect the material type and thickness which the software

translates into an appropriate wire feed speed. Caddy® Mig C200i then automatically sets the optimum voltage - using QSet™ - when the arc is ignited. It learns the process, not just the working point. There is no synergic line. This can be easily tested by, for example, changing shielding gas and watching what happens without touching any knobs or making selections.

Caddy® Mig C200i features some advanced functions. Arc dynamics, ie, the virtual inductance effect, can be adapted to individual needs or application requirements.
Brazing is often used with galvanic zinc coated plates, eg, on car bodies. QSet™ and brazing go hand in hand.

It is a legal requirement to reduce harmonics by using power more efficiently. ESAB uses active PFC (Power Factor Correction) to suppress harmonics, improve the power factor and reduce mains peak current. As result, the machine delivers up to 30% more arc power - whilst running on the same fuse.
The active PFC also improves performance when the unit is powered by a relatively small generator – thus facilitating welding with Caddy® Mig almost anywhere, and in any situation.

A 5.5 kVA 1~ 230V generator with automatic voltage regulation is powerful enough for Caddy® Mig C160i at its full capacity.
Caddy® Mig C160i/200i needs a 6.5 kVA generator. In extreme conditions, both units can be powered from a generator with at least 3.0 kVA on its 1~ 230V output. However, welding output would need to be limited, proportionally.

Both units are supplied fully equipped with a high-quality ESAB torch fitted with wear parts, gas hose and return cable with clamp, and feature tangle-free cable winders, practical shoulder strap and ergonomic handgrip. A trolley - for easier transport of gas cylinder and Caddy® Mig are also available.

An impact-resistant fibreglass-reinforced housing makes it fit for rough conditions and protection to IP 23C, the safety and legal prerequisite for outdoor use.

Typical applications are:
- Repair, maintenance or assembly work
- Agricultural applications
- Auto-repair
- Light metal fabrication
- Transport
- Education
- Household and furniture
- Tack welding
- Use with an automatic voltage regulated generator

Recommended ESAB wires for a complete package, optional diameters in parenthesis:
- 0.8 mm (0.6 mm and 1 mm) OK Autrod 12.51 for welding of mild steel welding.
- 0.8 mm Coreshield 15 for gasless welding of mild steel welding.
- 0.8 mm (1 mm) OK Autrod 19.30 for MIG/MAG brazing.
- 0.8 mm (0.6 mm and 1 mm) OK Autrod 308LSi for 18Cr 8Ni stainless steel welding.
- 0.8 mm (0.6 mm and 1 mm) OK Autrod 316LSi for stainless steel welding.
- 1 mm OK Autrod 5183 for aluminium welding.

Caddy® Mig C160i/200i are designed for both professional workshop and on-site assembly use as well as for demanding semi-professional and DIY applications.

Figure 3: Caddy® Mig C200i panel.

Figure 4: Repairing a broken fence gate with a generator powered Caddy® Mig C200i.

Figure 5: Welding slip-off protection bars to a rack in the workshop.

Product News Equipment

Orbital TIG welding with ESAB
The highest levels of weld reproducibility and quality

The compact, lightweight, Aristo™ MechTig C2002i power source features an integrated Windows-based man-machine interface which, together with the PRH enclosed welding head, makes it ideal for the pharmaceutical and food and beverage industries; shiny welds which require no cleaning. The equipment is robust and user-friendly, allowing one operator to run two welding heads simultaneously for increased productivity. An 'auto generation of parameters' function minimises the equipment start-up period. Basic parameters - material, tube diameter and thickness - are entered by the operator and the control unit automatically calculates a weld programme. This programme, or one refined by the operator, can be stored in the control unit and/or on a USB memory stick for repeated use. The auto generation function is valid for tubes with wall thickness up to 3mm. Alternatively, welding parameters can be manually set using a graphical or spreadsheet interface.

For larger pipes with thicker walls, for instance in the off-shore and power generation industries, the more powerful Aristo™ MechTig 4000i power source with its Aristo™ MechControl 4 control unit is the best choice - using PRC and PRD 160 weld heads. The fully programmable power source maintains precise control of the welding process. Synchronised pulsing minimises the risk of hot cracks, and automatic arc voltage control (AVC) guarantees a constant arc length. Weaving of the electrode holder can give a much quicker filling of the joint and the weave dwell times can be individually programmed to avoid lack of fusion onto the side walls. A small remote control is used to change parameters during welding.

The stationary A 25 modular component system can be used when the weld object can be rotated. The modular components can be put together to suit application requirements, from the basic system with manual slides for positioning of the torch to the more advanced version with weaving and AVC slides.

The Aristo™ MechTig 3000i power source, Aristo™ MechControl 2 control unit and POC weld head, are suitable for tube to tube sheet welding.

New digital controller and power sources for mechanised submerged arc and gas metal arc welding

ESAB's contribution to successful mechanised welding includes the new A2-A6 PEK Process Controller for use with our LAF 631 / 1001 / 1251 / 1601 and TAF 801/ 1251 automatic power sources for automated SAW and GMAW applications. The new controller and power sources use a bus system for internal communication.

Picture 1: A2-A6 PEK Process Controller.

A2-A6 PEK Process Controller

The A2-A6 PEK Process Controller has many features that contribute to high productivity and weld quality. It allows users to adapt settings to individual needs.

A large black on white graphics display provides information about the main parameters - current, voltage, travel speed and heat input. All important settings can be seen on the clear text menu – in any of 16 different languages. Up to 255 complete welding programs can be stored in the memory. A fast mode function covers four parameter sets with just one button, for example root pass, filler and cap layers.

Two control modes are available, CA (Constant Amperage) and CW (Constant Wire feed speed), CA mode being recommended for most applications. It allows presetting of constant welding current, voltage and travel speed and, thus, the WPS specification.
As an important element in digital control, the PEK uses travel motor encoder feedback to automatically control, and maintain constant, travel speed.
External axis, a positioner for example, can be registered in the PEK for correct travel speed control.

Picture 2: A6 tractor with tandem head and two PEK Process Controllers.

The unit supports both user and quality assurance. Process adjustment is supported by an Auto Save function that automaticaly stores all changes in one parameter set - making it quicker to optimise parameters when more than one parameter set is used.
Powerful tools are used to ensure reproducible welds. Limits for weld data can be set to ensure that only approved data is used for welding. Access to the unit can be prohibited by a code lock that prevents unauthorised alteration of setting and welding parameters. Further limits can be set to supervise weld data. This function ensures that parameters have stayed within defined borders and alerts the user if limits are unexpectedly exceeded.
Dynamic control adapts the power source characteristics to the requirements of multi-wire processes.
All setting and welding data can be stored on a USB Stick for backup purposes or off-line transfer to another installation.

Picture 3: LAF power sources.

Each A2-A6 PEK Process Controller handles one process. For tandem applications, two PEK controllers are used in master-slave mode. For multi-wire applications, or the use of different welding heads and processes in one installation, a PLC might be more suitable. ESAB offers separate FAA universal dual motor drive units that can be controlled by means of a PLC.

LAF / TAF power sources

LAF 631 / 1001 / 1251 / 1601 and TAF 801/ 1251 power sources provide maximum currents of 630 / 1000 / 1250 / 1600 A DC and 800 / 1250 A AC at high duty cycles that leave comfortable reserves for uninterrupted welding. The welding current range of all power sources can be extended by connecting two similar units in parallel.

TAF power sources feature voltage fluctuation and voltage drop compensation over long welding

Picture 4: TAF power sources.

cables. Up to 100 metres of cable can be connected.
All power sources are IP23 compliant and can be used for outdoor applications. A dedicated PEI interface is built- in for applications with lower demands on control capabilities.

An optional communication board allows connection to TCP/IP (LAN) and Anybus. Anybus solutions currently cover DeviceNet, CANopen and Profibus. WeldPoint™ can be connected via LAN and the Anybus interface is used for connection to a PLC or robot control.

WeldPoint™
WeldPoint™ can be connected to LAF/TAF power sources that are fitted with an optional communication PCB giving access via LAN or Internet.
WeldPoint™ supports export and import of weld data sets, system settings, setting limits and measure limits as well as export of error log, quality function log and production statistics. It also enables remote setting of current parameters - the perfect backup and restore tool.

GMH joint tracking controller and PAV positioning controller
An installation can be complemented by a GMH joint tracking system or a PAV positioning system.
GMH uses a tactile sensor for tracking, and PAV allows manual positioning adjustments that can be supported by a laser lamp or a camera that shows the joint.
FAA universal dual motor drive can be used instead when a PLC controls the entire installation.

ESAB also offers a budget solution for simple applications.
The analogue A2 PEI Welding Controller can be used with all A2 Automats and A2 motors. Three knobs on the front panel set travel speed, voltage and wire speed. The actual parameters are shown on the digital displays. It can be connected to most analogue DC power supplies.

Picture 5: GMH joint tracking controller with and without remote control.

Picture 6: PAV positioning controller with and without remote control.

Picture 7: PEI welding controller.

The analogue PEI controller can be used with a minimum of training. The A2 Multitrac with PEI controller can be used with the new LAF 631 / 1001 / 1251 / 1601 power sources. In Submerged Arc Welding, 4 mm wire can be used in the single wire version, or 2.5 mm in the twin version.

With the new bus controlled LAF/TAF power sources and the new A2-A6 PEK Process Controller, ESAB offers a system that helps to increase productivity, simplifies reproduction of weld parameters, offers modern data filing and communications options within a company or through the Internet, and many more benefits that make life easier for both operators and supervisors.

Picture 8: A2 Multitrac with PEI controller.

Product News Automation

New HNG Multi head marks 30 years in narrow gap welding

With 30 years experience in submerged arc narrow gap welding, ESAB introduces HNG Multi - the third generation welding head.

Typical SAW narrow gap applications are thick-walled components that demand high quality longitudinal or circumferential welding, for example pressure vessels, rotor shafts, nuclear reactors and turbine shafts. Narrow gap welding offers two major benefits: it is an economical joint configuration with less weld volume to fill compared to other joint configurations; and the automation-friendly joint, welded with moderate parameters limits weld defects and gives a high quality weld.

The ESAB SAW narrow gap welding process is based on a two bead per layer weld procedure in a narrow joint. The standard joint (Figure 3) is machined with a groove angle of 1 to 2 degrees, with 18-24 mm width, and maximum depth of 350 mm.

The HNG Multi welding head is designed for both single (AC or DC) and tandem (DC/AC or AC/AC) wire welding in narrow joints, ranging in width from 18 - 50 mm with depth down to 350 mm. Swords for gap depths of up to 600 mm are available for special applications. Continuous double sided tracking accompanied by continuous joint width measuring makes it possible to weld a wider joint with more beads per layer in the automatic mode if necessary (Figure 4). The bead position is automatically determined by the system.

Narrow gap welding of power plant generator rotor shafts is an excellent example of the capability of this new process. Commonly, rotor shafts are forged in one piece and then machined. Dimensions are limited. It is now possible to forge bigger shafts and weld them using the narrow gap process. The result is shafts of up to 300 tons that, in turn, facilitate the building of giant generators for hydroelectric power plants.
The HNG Multi meets the demands for a fully automatic welding process with accurate control of all parameters for reduced welding times and perfect weld material structure when welding high-tensile material. HNG Multi is suitable for continuous operation under arduous conditions. Several hours of uninterrupted welding is possible. Consistent high precision and wear characteristics are maintained over the entire weld time, even with pre-heated welding objects.

HNG Multi narrow gap welding heads feature several innovations that bring a higher level of functionality. Modular torch design means that both the leading and trailing torch are the same air cooled torch - requiring fewer different parts.

The HNG Multi welding head has been designed around the flat welding nozzle, the so-called sword. Reciprocating nozzle movement is accomplished by means of a pneumatic three-position cylinder and is transferred from cylinder to nozzle through a shaft transmission system Individual lateral offset between wire tips and joint side wall, as well as longitudinal distance between the two wires, can be adjusted as required.
For circumferential applications, the changeover is achieved automatically with an offset to avoid build-up on the same spot. (Figure 5)
Due to the position of the nozzle, the wire enters

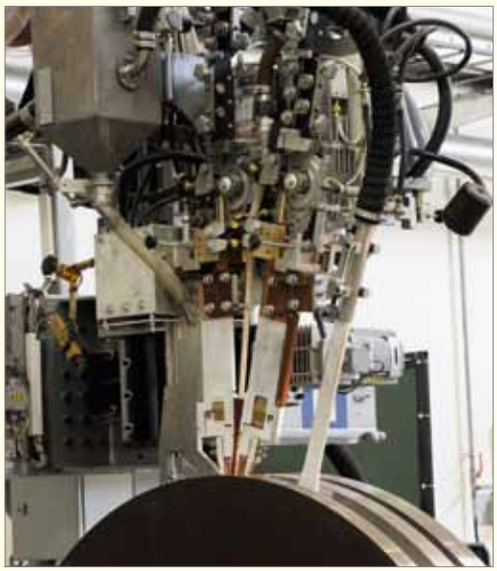


Figure 1: HNG.

Figure 2: HNG close-up.

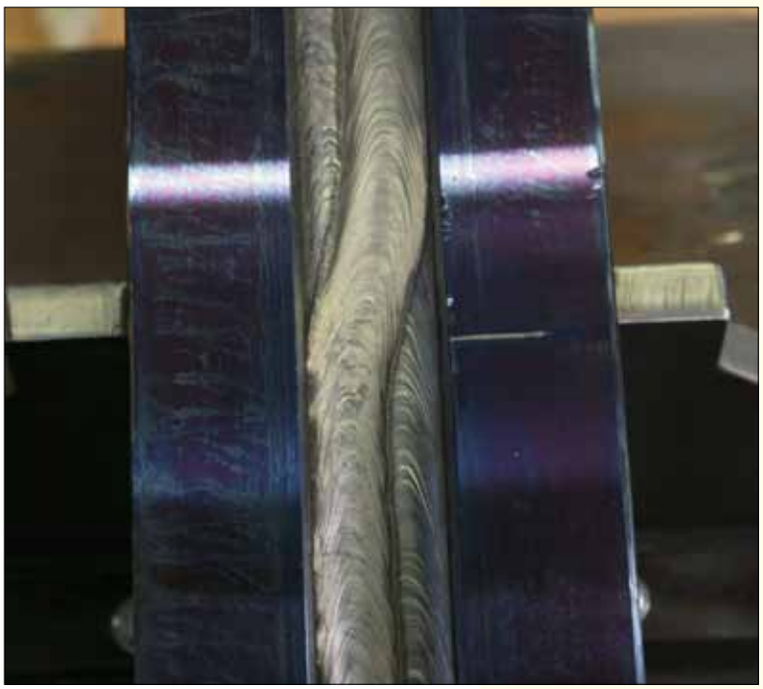


Figure 5: Changeover to the next layer.

Figure 6: PLC and video monitoring.

Figure 3: Standard narrow gap joint weld beads graphics.

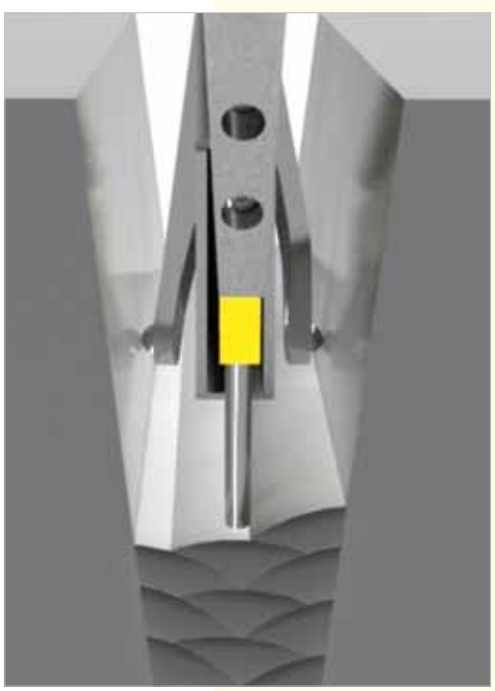


Figure 4: Three weld beads and joint width detection fingers.

the side wall at an angle, giving excellent slag detachability and penetration to prevent weld defects. By joint tracking on the welding side, exact stick-out is achieved and a stable high quality weld process is guaranteed. The narrow gap and the precise bead position are only possible with a reliably straight wire entering the cavern. ESAB's well-known A6-VEC motor is used for wire feeding. The double wire straightening devices for each wire (visible in Figure 1) are fitted to the motor, mounted in two 90° displaced planes.
The narrow gap welding process is controlled by means of a PLC control system that is fully integrated with the welding power supplies and internal and external axis.

As parameter documentation is usually mandatory for the safety critical welds, ESAB's WeldLog weld data logging program can be connected to the narrow gap welding system. It logs and displays, both graphically and numerically, up to 24 channels on up to 8 axes, in real-time. Voltage, current, wire feed speed and travel speed, are logged, simultaneously. Metal deposition rate and heat-input are calculated and displayed. External alarms can be registered to ensure immediate reaction to problems.

Product News Cutting

New VISION™ T5 Control Features 18.5-inch Ergonomic Touch Screen

Simplicity and ease of operation are the guiding principles for ESAB's new touch screen based VISION T5 intelligent user interface. VISION T5 is designed to provide clearly visible important information and feedback to the operator. Operating steps are clear and intuitive, guiding the operator every step of the process. VISION T5 offers a range of features, including:

- New 18.5-inch touch screen that is intuitive, colour-coded, easy to learn and easy to operate. The unique ergonomic wide-screen layout allows easy access with less vertical arm motion than traditional controls, reducing operator stress, and enhancing comfort.
- Complete process integration for every kind of cutting or marking tool, allowing complete process automation, higher productivity, and reliable process setup for consistent cut quality every shift, every operator.
- Integrated process controls that ensure operation is simplified and manual errors are reduced - unlocking all of the productivity potential of your machine.
- New Operating Wizard that simplifies basic operation by guiding the operator through machine start-up and basic steps to cut a part or complete nest. Inexperienced operators can become more productive more quickly with step-by-step guided instructions.
- Dual panel-mounted USB ports that allow easy access to multiple devices and are positioned out of the way to prevent damage.
- New Process Selector yielding increased productivity through faster process setup, with the built-in Process Database, that automatically sets parameters such as cutting speed, kerf offset and timers based on the material thickness, material type, and cut quality desired.
- New EasyShape library of standard shapes facilitates faster setup and cutting of high quality parts.
- Optional Automatic Nesting feature which lets an operator maximise plate utilisation with fully automatic nesting of parts - at the CNC.

SUPRAREX SXE
A self-adapting concept

Freedom is the basic requirement for increased productivity. Flexibility is the key to sustainable process integration. The innovative, modular SUPRAREX SXE gantry machine system gives fabricators have complete freedom to configure the perfect solution for individual applications.

Which metals and what plate size need to be processed? Which cutting technology should be used? How many cutting tools? ESAB answers these and many other questions with the SUPRAREX SXE. Users and their requirements are the measure of all things; the cutting technology adapts itself harmoniously, grows with user demands and is easy to update.

The new SUPRAREX generation machine offers users impressive acceleration and deceleration values, helping to achieve even more productivity and precision. As a high-performance, heavy-duty gantry machine with a rail span of 3,000 up to 8,500 mm, SUPRAREX SXE forms the solid foundation for economical cutting and marking with plasma and oxy-fuel. What's more, with an ESAB VISION numerical control system and COLUMBUS programming software, it is perfectly equipped for integrated, automated production processes.

Every detail of SUPRAREX SXE satisfies even the most stringent quality requirements, whilst low maintenance costs and long service life provide surprisingly favorable cost-benefits.

Flexible and versatile.
With SUPRAREX SXE, the options for combining the diverse range of system modules are almost limitless. From the cutting table to the power supply to the peripheral environmental technology, it is from ESAB, works together and satisfies our internationally recognised quality level.
SUPRAREX SXE is ready to receive a multitude of different tools for cutting, weld preparation and marking with advanced plasma technology or reliable oxy-fuel cutting. Even combinations of these processes, or plasma cutting and marking without tool changes, is easily achieved.

The ease and safety of use of the cutting line, along with loading and unloading, have been considered. The special track concept, for example, allows rapid, trouble-free material feed throughout the cutting area - also an effective way to save valuable time and increase operating efficiency.

With Global SUPRAREX™, oxy-fuel/plasma cutting is brought within financial reach of more fabricators. By standardising the portal width of this normally custom-made system to 4.5 m, 40% of market demand is covered, enabling serial fabrication. This gives the advantage of competitive pricing and short delivery times. The width of the cutting table is adaptable within the 4.5 m span.

SUPRAREX SXE Technical Specifications Summary

Track width	3,000 - 8,500 mm
Cutting processes	Plasma and oxyfuel
Plasma cutting thickness	according to plasma generator
Single-torch plasma cutting equipment	1 - 4 torches
Oxyfuel cutting thickness	up to 200 mm as standard
Single-torch oxyfuel cutting equipment	1 - 12 torches
Machine speed (m/min.)	24 m (40 m optional)
Machine length	2,000 mm
Machine width	3,650 - 9,150 mm
Machine height	2,000 mm (depending on applied tools)
Workpiece support height, table	700 mm

ESAB OXY-FUEL TORCHES

Oxy-fuel cutting is now more economical and precise than ever. ESAB's range of oxy-fuel torches features higher productivity and durability with more cutting options, cutting material thicknesses up to 300 mm.

COOLJET™

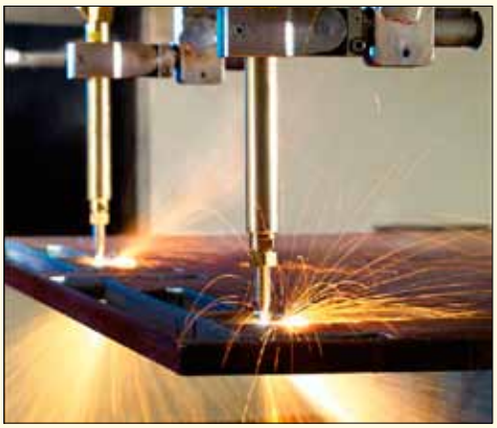
Innovative, fully integrated oxygen cooling guarantees operational safety, highest cutting quality and faster cutting speed.

COOLJET™ greatly reduces the heat generated on the cutting nozzle while preheating to ignition temperature. The innovative valve body ensures efficient heat dissipation and substantially improved cutting gas mixture. The unique cooling of the cutting nozzle makes flame cutting particularly economical. In addition to higher cutting speeds, COOLJET™ offers lower maintenance costs, longer lifetime and greater operational safety.

COOLJET™ is suitable for use on all ESAB flame-cutting machines,even in combination with high-performance nozzles.

COOLJET™ benefits:

- Low maintenance
- Higher cutting speed
- Longer cutting torch lifetime and greater nozzle durability
- Great operational safety due to backfire protection
- Stable flame due to constant flow



Innovative construction of the JETCON™ nozzle holder, allows it to be changed in an instant. The inherent long lifetime of the nozzle holder greatly reduces wear part consumption.

COOLJET PRO™

COOLJET PRO™ has all the benefits and advantages of COOLJET™, plus a quick change system for the cutting nozzles. COOLJET PRO™ is suitable for use on all ESAB flame-cutting machines, even in combination with high-performance nozzles.

COOLJET PRO™ benefits:

- All the advantages of COOLJET™
- Cutting nozzles changed quickly and easily without tools
- Reduced downtime

MULTIJET™

MULTIJET™ revolutionises automated flame cutting. Compact design and the low maintenance internal ignition, protect against impurities.

Multi-torch operation benefits from smaller gaps for higher productivity. In addition, the MULTIJET™ is eminently suitable for use on cutting and heating robots.

MULTIJET™ benefits:

- Basis for automated cut and flame monitoring
- Highly suitable for automated processes since no monitoring is required
- Internal ignition gives greater reliability
- Reduced distances possible in multi-torch operation
- Dirt-resistant and extremely low maintenance

Patented torch with automatic internal ignition, recommended for all automated production processes.

QUATTROJET™

Based on the MULTIJET™ torch, the QUATTROJET™ offers a number of additional advantages that substantially increase productivity and operational safety. Features such as integrated ignition and flame monitoring mean easy operation and enhanced safety. Tool-free nozzle change and integrated height sensing make it particularly cost-effective. Wear parts are kept to a minimum.

QUATTROJET™ benefits:

- Tool-free nozzle change reduces set-up time
- Integrated height sensing allows up to 7% higher material utilisation
- Completely safe internal ignition
- High operational safety due to flame monitoring

TRIPLEJET™

The torch for gas-mixing nozzles - with outstanding features in terms of precision. TRIPLEJET™ allows precise cutting of every conceivable shape and contour. For example, weld preparation can be performed from 16-75 mm up to 45°. Robust, low-maintenance construction from high-grade materials, guarantees maximum reliability and drastically reduces downtime. High temperature resistance saves time-intensive straightening work. TRIPLEJET™ is particularly suitable for use in the 3-torch bevel unit.

TRIPLEJET™ benefits:

- 100% centre running accuracy
- Innovative construction allows cutting of tight contours, flat angles and small radii from 30 mm
- Solid construction with outstanding robustness
- No distortion of the torch under extreme thermal load

Product News Cutting

GRIDJET™

THE UNIQUE NEW DEVELOPMENT FOR CUTTING GRIDS.

From now on, the use of conventional manual procedures is unnecessary. Grid manufacture is automatic, precise, 100% reproducible and cost-effective. The unique technology of the two independently adjustable preheating torches and the centrally rotating main cutting torch allows the individual generation of grid geometries and uninterrupted cutting.
The particular challenge of grid cutting with a "flying start" after a material-free zone is mastered in an inspiring and cost-effective solution. Maximum productivity is achieved in combination with ESAB's COLUMBUS™ programming system, VISION controls and an integrated technology database.

GRIDJET™ benefits:

- Can be used in fully automated production processes
- Uninterrupted cutting of grids
- Any contour
- 100% reproducibility

M3 PLASMA™ - THE THIRD GENERATION PLASMA SYSTEM

ESAB's m3 plasma™ cutting system, presented in Svetsaren 1/2009, enables high-quality precision cutting and marking and high current/thick plate cutting with the same PT-36 plasma torch - replacing up to three single-purpose torches while consuming fewer wear parts. The m3 plasma™ system offers an unsurpassed level of reliability, economy and productivity.

The system has a number of innovations that widen the application scope and enhance cutting quality:

- PT-36 torch, upgradable for very thick stainless steel and aluminium.
- Use of a secondary gas around the plasma arc.
- 'R2' mode for round top edges.
- Suitable for underwater cutting.
- Water injection.

The third generation m3 plasma™ cutting system features a new 360 A power source, priced between the 200 A and 400 A systems. This is the most economic choice in terms of nozzle wear time when cutting with oxygen. The 360 A power source is also available as "stand alone" for retrofit without the need for a new CNC, provided the CNC and the machine are dynamic enough for the plasma process.

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