OERLIKON

Pipe Mills

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www.oerlikon-welding.com

AIR LIQUIDE WELDING

OERLIKON solutions for Pipe Mills

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Introduction

Air Liquide SA, with its headquarters in Paris, France, is one of Europe's larger multinational companies. It had a consolidated turnover of € 16.4 billion in 2015, with 50 000 employees all over the world.

Air Liquide Welding is represented throughout the world with a brand portfolio optimized locally to the needs of all types of customers. OERLIKON brand is an important part of this portfolio and has a long and distinguished history of innovation in welding products.

Air Liquide Welding have 3 research and development centers located in Pont-Sainte-Maxence *(France)* for equipment & automation, in Due Carrare *(Italy)* and Eisenberg *(Germany)* for consumables.

This facilitates the rapid transfer and implementation of important innovations throughout the whole OERLIKON network, enableling to maintain the brand position and international reputation of innovative leadership in advanced welding technology.

OERLIKON has generated a proven history of supplying welding consumables for the most demanding and critical applications, particularly in the energy sector to industries such as offshore oil and gas and nuclear power generation. OERLIKON supplies customized solutions through performance and innovation, by developing and providing welding products and processes meeting the stringent mechanical property specifications and the increasing demands for enhanced welding productivity.

The results of this process are demonstrated by the range of automated installations, welding consumables and equipment specifically tailored for the high productivity requirements of wind turbine tower and foundation fabrication.

OERLIKON and pipe mills

A commitment to technical excellence supported by a dedication to quality is regarded as fundamental to OERLIKON's success in high productivity fabrication.

Quality

OERLIKON has a total commitment to quality. The product ranges are manufactured in group production facilities, all of which are ISO certified. Detailed certification for welding consumables is supplied as a matter of routine and customers' special quality requirements for increased frequency of batch testing or specialised certification are also readily accommodated. This ensures the reliability and reproducibility fabricators need in the pipe fabrication industry.

Technical Service

OERLIKON's involvement with its products does not stop at manufacture. OERLIKON provides a close and detailed participation with the application of products, right from the initial selection to welding characteristics on site.

A team of highly qualified engineers is ready to respond in collaboration with the pipe mill, with the objective of providing technologically relevant and practical solutions.

A large information base is at the service of every customer to ensure the most cost effective selection of process and welding procedure to meet the needs of any application.

Flexibility

The OERLIKON product range is continuously developing in response to changing technological requirements. As new steel types are developed and used, as new more demanding applications are developed, so OERLIKON reacts to provide the right products, regularly meets engineering departments and major manufacturers at the design stage to ensure optimum welding solutions.

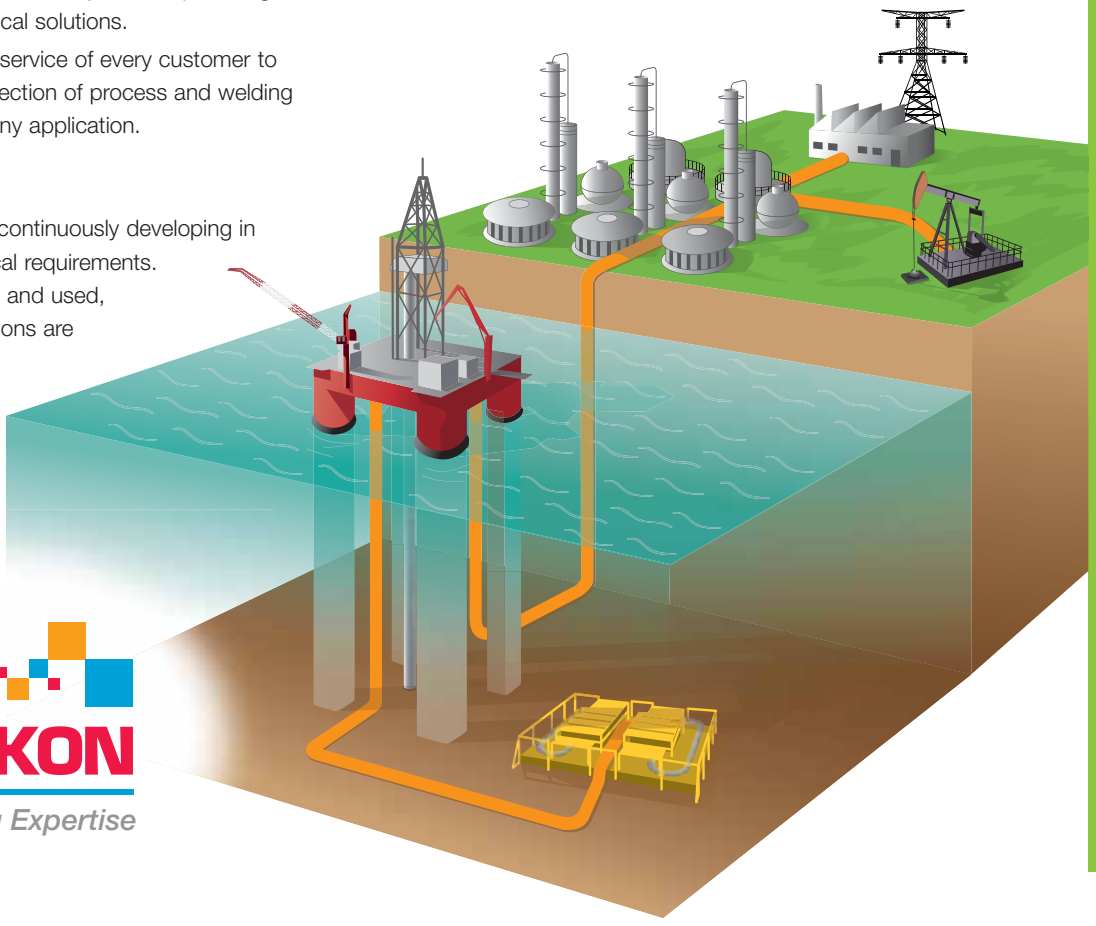
Information

All OERLIKON products are backed by a full technical information package, which is available in printed or electronic format, on the OERLIKON web sites. Product information is written to enable the professional welding engineer to select the correct OERLIKON product for the application.

In order to elaborate the technology of the product range in more detail, technical articles are available in the journal of OERLIKON's welding and cutting expertise, "Competence".

Track Record

OERLIKON is a technological innovator and major supplier of welding products to the pipe fabrication industry for significant projects. A track record of highly successful products combining quality and technology with technical service has been firmly established.



OERLIKON

Demand the Welding Expertise

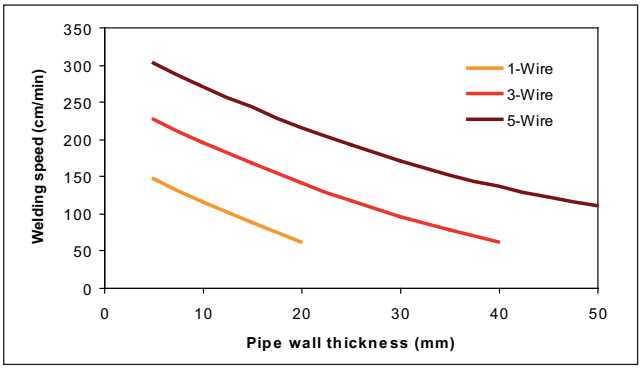
High Productivity Welding of Line Pipe

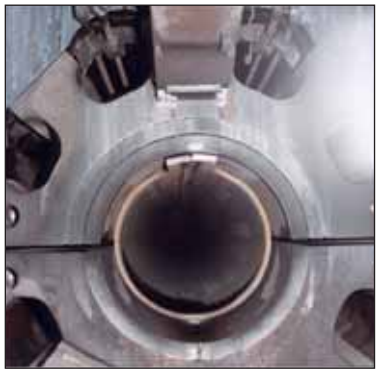
The drive for high productivity multiple wire submerged arc welding began in the late 1960s with the commercial industrialisation of tandem wire submerged arc welding. The deposition rate of the SAW process was increased to approximately 15 kg/hr. The advantages of adding additional wires in a pipe mill, highlighted the process difficulties in developing a sufficiently reactive method of controlling the current supply to each wire. This posed further challenges for consumable design in order to give effective slag characteristics and bead shape control at these higher welding speeds and heat inputs. By the late 1970s, 3 wire welding in pipe mills was commonplace and deposition rates of up to approximately 25 kg/hr were being achieved in pipe thicknesses up to 30 mm. By the mid 1980's, 5 wire welding was being introduced with full electronic control, achieving deposition rates of approximately 45 kg/hr for pipe ODs, for wall thicknesses in excess of 20 mm.

When OD longitudinal seam welding with 5 wires, the welding current is increased towards 5,000 A. To gain maximum productivity, welding speed must be as fast as possible (in excess of 2 m/min) consistent with reliable high speed wire feeding and the characteristics of the SAW flux. These are key factors in determining the balance of heat input, penetration and bead shape.

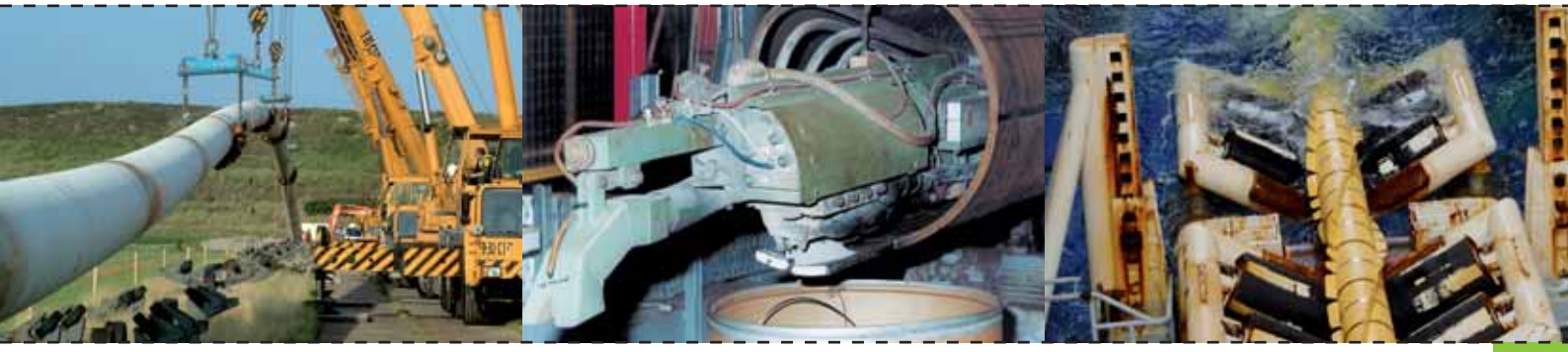
OERLIKON submerged arc flux developments have been an important factor in achieving these increases in productivity as multi-wire systems were developed.

The current challenge is utilising these high levels of welding productivity to produce high toughness joints in higher strength grades of line pipe, X80 and X100, for high pressure gas transport.





Micro-Alloying with Titanium and Boron - the development of OERLIKON TIBOR solid SAW wires

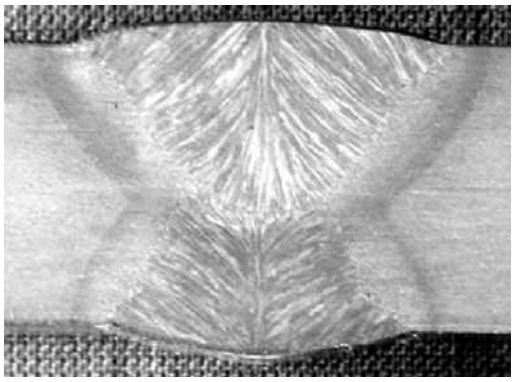


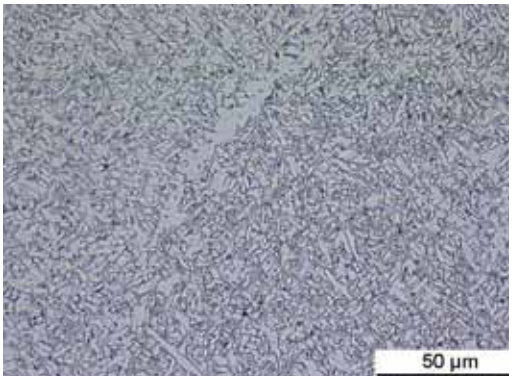
There are two principal approaches to achieving high toughness weld metal at low temperatures with modern pipe plate compositions, The first approach is to use the Mn-Mo alloying system and the second is to use the Mo-Ti-B system. The aim of both approaches is to achieve high levels of weld metal toughness through microstructural control. Correctly designed, these alloying systems delay transformation at the austenite grain boundaries during cooling of the weld metal, discouraging nucleation and growth of grain boundary ferrite allotromorphs and encouraging the nucleation and growth of acicular ferrite on inclusions in the intragranular regions. Both alloy systems require the use of semi- basic SAW fluxes, such as OERLIKON OP132, to control the oxygen content of the weld metal and hence the inclusion volume fraction and size distribution.

Improvements in weld toughness through welding consumable design are dependent on the variations in weld metal composition and inclusion characteristics as a result of dilution from the pipe plate, notably with the alloying elements nitrogen, aluminium, niobium and calcium. High productivity pipe welding is a high dilution process, where for example two pass welded joints can have 70% dilution of the weld bead from the pipe plate. Thus the steelmaking route and alloying regime of the pipe steel have a strong effect on the final weld metal chemistry and mechanical properties.

OERLIKON has pioneered the development of Ti/B type submerged arc welding consumables for demanding multi-wire, high speed, high arc energy longitudinal pipe welding applications. This led to the development of solid SAW wires based on the Mn-Mo-Ti-B system, firstly OE-TIBOR 22 and subsequently OE-TIBOR 33.

OERLIKON OE-TIBOR 33/OP 132 was specifically developed for the multi-wire, two pass, longitudinal seam welding of X65 pipe steels. High levels of CVN at -30 ºC are achieved in the weld metal, while meeting X65 weld strength and requirements for hydrogen induced cracking (HIC) and sulphide stress corrosion cracking (SSCC).





Submerged arc wires and fluxes for pipe mill applications

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OERLIKON's agglomerated submerged arc welding fluxes, in combination with the OERLIKON range of solid and Fluxocord wires, have achieved worldwide recognition as the first choice for quality submerged arc welding for a variety of reasons.

Technology

OERLIKON submerged arc wire specifications are designed to incorporate the state of the art technology and in combination with OERLIKON SAW fluxes, high levels of weld metal toughness are generated for specific alloy types. In addition, as new steels and applications are developed new OERLIKON wires are designed and introduced to the range.

Operating Characteristics

OERLIKON fluxes for pipe mill applications have stable high speed, multi- wire operation at high currents, together with excellent slag detachability.

Low Hydrogen Potential

OERLIKON SAW fluxes are designed and manufactured to give a low hydrogen potential in use. This minimises the risks of weld metal hydrogen (chevron) cracking in the welding of more hardenable pipe steels, even after recirculation. These flux characteristics are now enhanced by the OERLIKON DRYBAG packaging system, meaning that flux can be used with confidence, without reconditioning, in higher humidity conditions.

Toughness

Consistent CVN and CTOD at sub-zero temperatures in thicker wall pipe for fully sour service applications, through the right combination of wire and flux.

Reproducibility

Supporting the metallurgical rationale for OERLIKON agglomerated fluxes, the grain size distribution and agglomerate strength ensure reliable recirculation characteristics and consistent chemistry. This is most important when submerged arc welding.

Quality

All OERLIKON agglomerated fluxes and welding wires are produced in ISO certified group manufacturing plants, under the most stringent quality control systems.

Submerged arc wires and fluxes for pipe welding - Principal products

A selection of the most important welding consumable products for both longitudinal seam and spiral seam pipe welding are shown below, based on industry custom and practise. An overview of this product range selection is shown on page 12 or consult the OERLIKON Welding Consumables Product Data handbook or www.oerlikon-welding.com for full details.

OERLIKON SAW Wires

Product features

- Conformance to OERLIKON specifications and national standards where specified
- Optimised chemical alloying to maximise joint toughness
- Low levels of residual and impurity elements
- Closely controlled copper coating
- Consistent performance through control of:
  • Wire hardness • Cast • Helix
- High productivity bulk packaging options
- Full range of diameters available, 2.4 - 5.0mm

For details of the full range of FLUXOCORD wires, see "OERLIKON Welding Consumables Product Data" or www.oerlikon-welding.com

Solid wires

Type	AWS	EN	C	Mn	Si	S	P	Cr	Ni	Mo	
OE-S1	EL12	S1	0.1	0.5	0.1	<0.020	<0.020	--	--	--	
OE-S2	EM12K	S2	0.1	1	0.1	<0.020	<0.020	--	--	--	
OE-S2Mo	EA2	S2Mo	0.1	1	0.2	<0.020	<0.020	--	--	0.5	
OE-TIBOR 33	EA2TiB	SZ	0.07	1.2	0.3	<0.015	<0.015	--	--	0.5	+Ti,B
OE-SD3	EH12K	S3Si	0.1	1.7	0.3	<0.020	<0.020	--	--	--	
OE-SD3Mo	EA4	S3Mo	0.1	1.6	0.1	<0.020	<0.020	--	--	0.5	
OE-SD3 1Ni¼Mo	EG	SZ	0.1	1.5	0.25	<0.020	<0.020	--	1	0.3	
OE-SD3 1Ni½Mo	EF3	S3NiMo1	0.1	1.8	0.2	<0.020	<0.020	--	0.9	0.6	
OE-SD3 2NiCrMo	EG	S3Ni2.5CrMo	0.1	1.5	0.2	<0.020	<0.020	0.7	2.4	0.5	

Flux cored wires

Type	AWS A5.17	AWS A5.23	EN 756	C	Mn	Si	S	P	Cr	Ni	Mo
FLUXOCORD 31HD / OP 121TT(W)	F7AP8-EC1	-	S 35 6 FB T3	0.06	1.70	0.40	<0.020	<0.020	-	-	-
FLUXOCORD 41HD / OP 121TT(W)		F9AP8-EC-F3	S 50 6 FB T2Ni1Mo	0.05	1.30	0.20	<0.020	<0.020	-	0.90	0.50
FLUXOCORD 43.1 / OP 121TT(W)	-		-	0.05	1.40	0.10	<0.020	<0.020	-	1.80	0.35
FLUXOCORD 42 / OP 121TT(W)	-	F11A4-EC-F5	-	0.05	1.40	0.20	<0.020	<0.020	0.60	2.50	0.40
FLUXOCORD 83 / OP 121TT(W)	-	-	-	0.06	1.70	0.50	<0.020	<0.020	0.30	2.70	0.50

OERLIKON SAW Fluxes

The OERLIKON submerged arc fluxes most used in pipe mill applications are:

- **OP 119, OP 192P & OP 132.**
  OP 119 is widely used for spiral seam welding
- **OP 192P & OP 132**
  are used for both two pass longitudinal seam and spiral seam welding applications. These fluxes are optimised for high productivity performance in multi-wire, AC/DC, high welding speed pipe welding applications.
- **OP 121TT & OP121TTW**
  are used in multi pass and special applications, particularly when maximum joint toughness at higher strength levels is required.

The OERLIKON range of submerged arc fluxes is very comprehensive and for specific pipe welding applications other SAW fluxes may be proposed by OERLIKON technical service, for example OP 122 and OP 178.

For details of the complete product range, consult "OERLIKON Welding Consumables Product Data" or www.oerlikon-welding.com

SAW Flux-wire data sheets

SAW Rutile-Acid Flux
Line Pipe Applications

OP 119

OP 119 is an agglomerated calcium-silicate type flux with stable operating characteristics over a wide range of welding parameters, used extensively for the spiral seam welding of line pipe. The high current carrying capacity enables high levels of productivity to be attained using multi wire systems, for use with both AC and DC+. The slag is self releasing, to leave a smooth bead profile without undercut. OP 119 donates manganese and silicon and is a cost effective choice with both OE-S1 & S2 wires. The slag freezes quickly and smaller diameter pipes and girth seams can be welded without run off. Damp flux should be re-dried at 300-350 °C for 1 hour.

Classification

EN 760 SA CS 1 77 AC H5

Applications

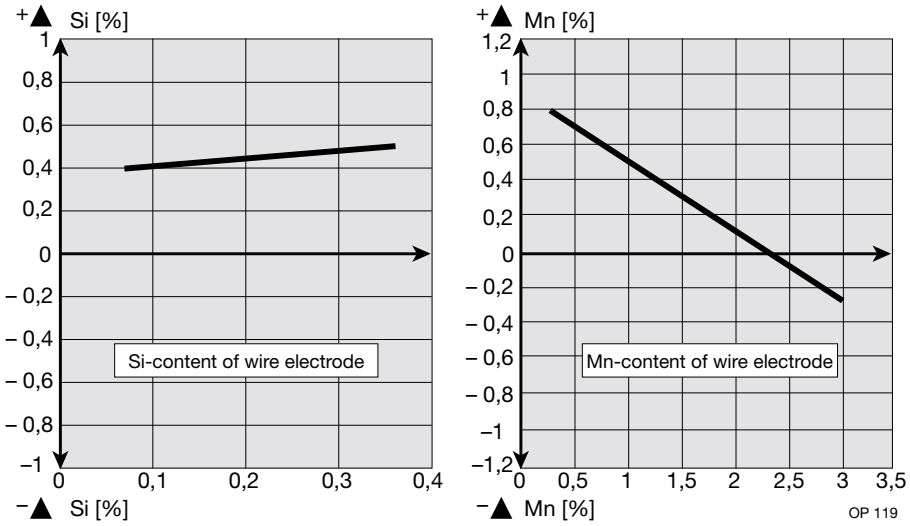
EN 10208-2	L240	L290	L360	L415	L450	L485	L555
API-5L / 5LS	B	X42 X46	X52	X56 X60	X65	X70	X80

Main Constituents & Basicity index

CaO+MgO	CaF_2	Al_2O_3+MnO	SiO_2 + TiO_2
20%	10%	25%	40%
Boniszewski Basicity index: ~1.0			

Metallurgical Behaviour

Pick up and Burn out of the alloying elements Si & Mn = f (alloy content of the wire electrode)
DVS Merkblatt 0907 Part 1.



Main characteristics

Two-run technique

Chemical composition and mechanical properties (typical values) in the as welded condition on API 5L X70 pipe steel*

Wire Grade	AWS-A5.17 & A5.23	C	Mn	Si	Mo	Hardness HV 10	Yield strength MPa	Tensile strength MPa	Impact Energy - ISO-V (J)	
									0 °C	-20 °C
OE-S1	F7TA0G-EL12	0.07	1.2	0.4	--	190	450	530	60	35
OE-S2	F8TA0G-EM12K	0.07	1.4	0.4	--	200	500	590	70	35
OE-S2 Mo	F9TA0G-EA2	0.07	1.4	0.4	0.2	220	560	630	100	50

** the chemical composition and mechanical properties of the weld metal are strongly dependant on the chemistry of the pipe steel.*

Multi-run technique

Classification of all-weld-metal wire-flux combinations - All weld metal analysis and mechanical properties, as welded condition

Wire Grade	AWS-A5.17 & A5.23	C	Mn	Si	Mo	Yield strength MPa	Tensile strength MPa	A5 %	Impact Energy - ISO-V (J)	
									0 °C	-20 °C
OE-S1	F7A0 EL 12	0.05	1.1	0.5	--	>360	420-520	>24	>60	>30
OE-S2	F7A2 EM 12K	0.05	1.4	0.5	--	>400	520-620	>24	>80	>50
OE-S2 Mo	F8A0 EA2 A2	0.05	1.3	0.5	0.5	>480	600-700	>20	>50	>35

SAW Flux-wire data sheets

SAW Semi Basic Flux
Line Pipe Applications

OP 192P

OP 192P is an agglomerated aluminate-basic flux with stable operating characteristics over a wide range of welding parameters, Used extensively for both the longitudinal and spiral seam welding of line pipe in single or multi pass applications. The high current carrying capacity enables high levels of productivity to be attained using multi wire systems, for use with both AC and DC+. The slag is self releasing, to leave a smooth bead profile without undercut. High deposit toughness to -40 °C can be attained at a variety of strength levels depending on wire selection and welding technique.

Additional feature: Excellent weldability in thin plate applications. Damp flux should be re-dried at 300-350 °C for 1 hour.

Classification

EN 760 SA AB 1 67 AC H5

Applications

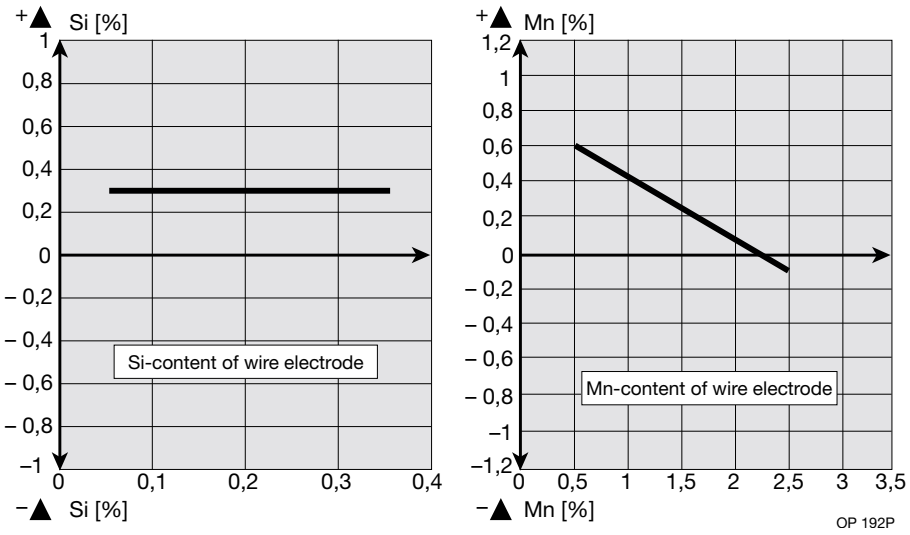
EN 10208-2	L240	L290	L360	L415	L450	L485	L555
API-5L / 5LS	B	X42 X46	X52	X56 X60	X65	X70	X80

Main Constituents & Basicity index

MnO+FeO	$CaO+CaF_2+MgO$	$Al_2O_3+T_2+ZrO_2$	SiO_2
8%	43%	28%	19%
Boniszewski Basicity index: ~1.3			

Metallurgical Behaviour

Pick up and Burn out of the alloying elements Si & Mn = f (alloy content of the wire electrode)
DVS Merkblatt 0907 Part 1.



OP 192P

Main characteristics

Two-run technique

Chemical composition and mechanical properties (typical values), as welded condition on API 5 L X80 pipe steel *

Wire Grade	AWS A5.23	C	Mn	Si	Mo	Others	Hardness HV 10	Yield strength MPa	Tensile strength MPa	Impact Energy - ISO-V (J)		
										-20 °C	-30 °C	-40 °C
OE-S2	F8TA0G-EM12K	0.07	1.4	0.35	--	--	200	500	590	80	--	--
OE-S2 Mo	F9TA2G-EA2	0.07	1.4	0.35	0.2	--	220	560	630	100	50	--
TIBOR 33	F9TA4G-EA2TiB	0.07	1.45	0.35	0.2	Ti, B	230	600	670	140	100	50

** the chemical composition and mechanical properties of the weld metal are strongly dependant on the chemistry of the pipe steel.*

Multi-run technique

Classification of all-weld-metal wire-flux combinations - All weld metal analysis and mechanical properties, as welded condition

Wire Grade	AWS A 5.17 & A5.23	C	Mn	Si	Mo	Yield strength MPa	Tensile strength MPa	A5 %	Impact Energy - ISO-V (J)		
									-20 °C	-30 °C	-40 °C
OE-S2	F7AP4-EM12K	0.05	1.4	0.45	--	>400	480-580	>25	>100	>70	>27
OE-S2 Mo	F8AP2-EA2-A2	0.06	1.4	0.50	0.5	>470	570-680	>22	>60	>47	--
OE-SD3 Mo	F9AP2-EA4-A4	0.06	1.7	0.60	0.5	>550	630-720	>20	>50	>27	--

SAW Flux-wire data sheets

SAW Semi- Basic Flux
Line Pipe Applications

OP 132

OP 132 is an agglomerated aluminate-basic flux with stable operating characteristics over a wide range of welding parameters. A global choice for both the longitudinal and spiral seam welding of line pipe in single or multi pass applications in combination with both solid and OE FLUXOCORD wires. The high current carrying capacity enables high levels of productivity to be attained using multi wire systems, for use with both AC and DC+.

The slag is self releasing, to leave a smooth bead profile without undercut. OP 132 donates manganese and excellent sub zero CVN and CTOD deposit toughness can be attained at higher strength levels, depending on wire selection and welding technique. The weld deposit is highly resistant to copper induced cracking. Damp flux should be re-dried at 300-350 °C for 1 hour.

Classification

EN 760 SA AB 1 67 AC H5

Applications

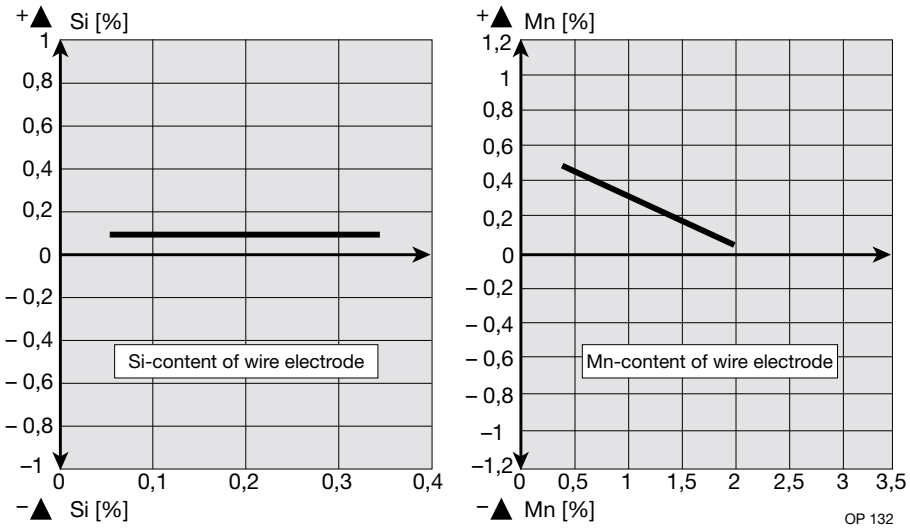
EN 10208-2	L290	L360	L415	L450	L485	L555	
API-5L / 5LS	X42 X46	X52	X56 X60	X65	X70	X80	X100

Main Constituents & Basicity index

CaO+MgO	CaF_2	Al_2O_3+MnO	SiO_2 + TiO_2
25%	15%	35%	20%
Boniszewski Basicity index: ~1.5			

Metallurgical Behaviour

Pick up and Burn out of the alloying elements Si & Mn = f (alloy content of the wire electrode)
DVS Merkblatt 0907 Part 1.



Main characteristics

Two-run technique

Chemical composition and mechanical properties (typical values) in as welded condition on API 5L pipe steel*

Wire Grade	API 5L steel	AWS-A5.23	C	Mn	Si	Mo	Others	Hardness HV 10	Yield strength MPa	Tensile strength MPa	Impact Energy - ISO-V (J)			
											-20 °C	-30 °C	-40 °C	-50 °C
OE-S2	X70	F8TA2G-EM12K	0.07	1.4	0.25	--	--	200	500	590	80	--	--	--
OE-S2 Mo	X80	F9TA4G-EA2	0.07	1.4	0.25	0.2	--	220	560	630	100	70	--	--
TIBOR 33	X80	F9TA6G-EA2TiB	0.07	1.45	0.25	0.2	Ti, B	230	600	670	150	120	100	80
FC X100T	X100	F11TA4G-ECG	0.07	1.8	0.3	0.4	--	280	700	850	50	40	30	--

** the chemical composition and mechanical properties of the weld metal are strongly dependant on the chemistry of the pipe steel.*

Multi-run technique

Classification of all-weld-metal wire-flux combinations - All weld metal analysis and mechanical properties, as welded condition

Wire Grade	AWS A 5.17 & A5.23	C	Mn	Si	Mo	Yield strength MPa	Tensile strength MPa	A5 %	Impact Energy - ISO-V (J)		
									-20 °C	-40 °C	-50 °C
OE-S2	F7A5-EM 12K	0.06	1.3	0.2	--	>400	480-510	>27	>140	>40	--
OE-S2 Mo	F8A5-EA2-A2	0.06	1.3	0.2	0.5	>470	550-620	>23	>110	>80	--
OE SD3 Mo	F9A5-EA4-A4	0.06	1.7	0.4	0.5	>540	620-660	>21	>100	>60	>50

SAW Flux-wire data sheets

SAW Basic Flux
Pipe & Tubular Applications

OP 121TT

OP 121TT is a fully basic agglomerated flux with stable operating characteristics over a wide range of welding parameters. Used extensively for the welding of tubular sections, construction pipe and line pipe with both solid and OE FLUXOCORD wires in multi pass applications for as welded, stress relieved and fully heat treated applications. OP 121TT has a low hydrogen content of <5 ml H_2 per 100 g deposited weld metal in the as manufactured condition with a high resistance to moisture pick up during exposure under workshop conditions. The current carrying capacity of ~1000 A per wire enables high levels of productivity to be attained using single, twin, tandem and other multi wire systems, with both AC and DC+. The slag is easily removed, to leave a smooth bead profile and well blended toes. OP 121TT has a neutral flux characteristic for manganese and silicon and can be used with a wide range of wires to achieve the highest strength levels while retaining excellent CVN and CTOD weld metal toughness. The slag freezes quickly and smaller diameter pipes and girth seams can be welded without run off.

Damp flux should be re-dried at 300-350 °C for 1 hour.

OP 121TTW is an agglomerated flux with high basicity, B.I. ~3.1, with a very low diffusible hydrogen content of <4 ml H_2 per 100 g deposited weld metal. It is used for welding steels with high hardenability such as X100 or thicker sections of higher strength steels. OP 121TTW is particularly suitable in combination with the OE FLUXOCORD range of cored wires for submerged arc welding.

Classification

EN 760 SA FB 55 AC H5

Applications

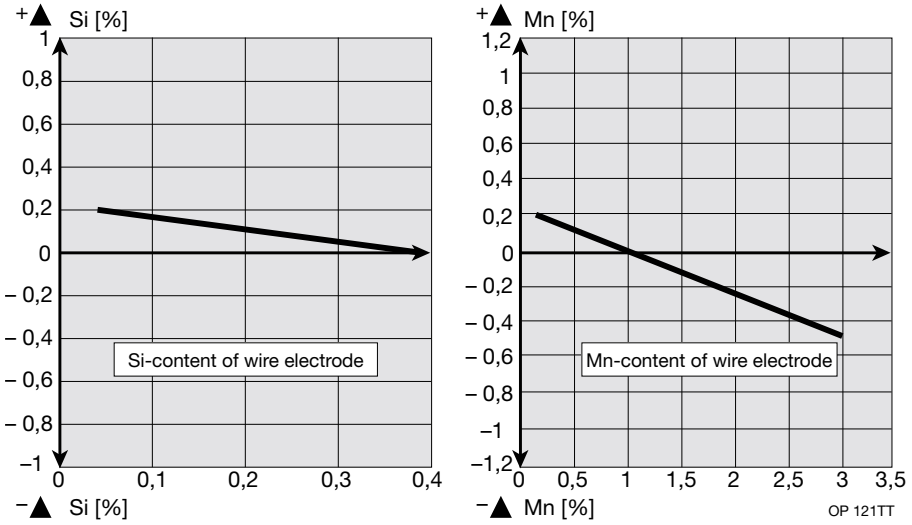
EN 10208-2	L290	L360	L415	L450	L485	L555	
API-5L / 5LS	X42 X46	X52	X56 X60	X65	X70	X80	X100

Main Constituents & Basicity index

CaO+MgO	CaF_2	Al_2O_3+MnO	SiO_2 + TiO_2
40%	25%	20%	15%
Boniszewski Basicity index: ~3.1			

Metallurgical Behaviour

Pick up and Burn out of the alloying elements Si & Mn = f (alloy content of the wire electrode)
DVS Merkblatt 0907 Part 1.



Main characteristics

Multi-run technique

Classification of all-weld-metal wire-flux combinations - All weld metal analysis and mechanical properties, as welded condition

Wire Grade	AWS A5.17 & A5.23	C	Mn	Si	Ni	Mo	Cr	Yield Strength MPa	Tensile Strength MPa	A5 %	Impact Energy - ISO-V (J)		
											-20 °C	-40 °C	-60 °C
OE-S2 Mo	F8A4 EA2-A2	0.07	0.9	0.2	--	0.5	--	>470	550-680	>24	>100	>50	--
OE-SD3	F7A8 EH12K	0.07	1.6	0.3	--	--	--	>450	530-630	>25	>140	>100	>70
OE-SD3 Mo	F8A6 EG-A4	0.07	1.3	0.3	--	0.5	--	>520	600-700	>24	>120	>80	--
OE-SD3 1Ni ¼Mo	F8A8-EG-G	0.07	1.3	0.3	0.8	0.2	--	>530	600-650	>24	>140	>120	>80
OE-SD3 1Ni ½Mo	F9A8 EF3-F3	0.07	1.5	0.3	1.0	0.5	--	>540	650-750	>20	>90	>70	>50
OE-SD3 2NiCrMo	F11A6 EG-G	0.07	1.4	0.4	2.2	0.5	0.6	>720	850-1000	>14	>90	>70	>50
FLUXOCORD 31 HD	F7A8 –EC1	0.05	1.6	0.3	--	--	--	>450	500-600	>25	>140	>100	>60
FLUXOCORD 41 HD	F9A8 –EC-F3	0.05	1.4	0.2	1.2	0.4	--	>550	620-760	>20	>120	>100	>60
FLUXOCORD 42	F11A8 –EC-F5	0.08	1.4	0.25	2.35	0.5	0.5	>690	760-830	>16	>90	>70	>50
FLUXOCORD 83	F13A4 –EC-F5	0.06	1.5	0.4	2.8	0.5	0.2	>830	890-1000	>12	>50	>40	--

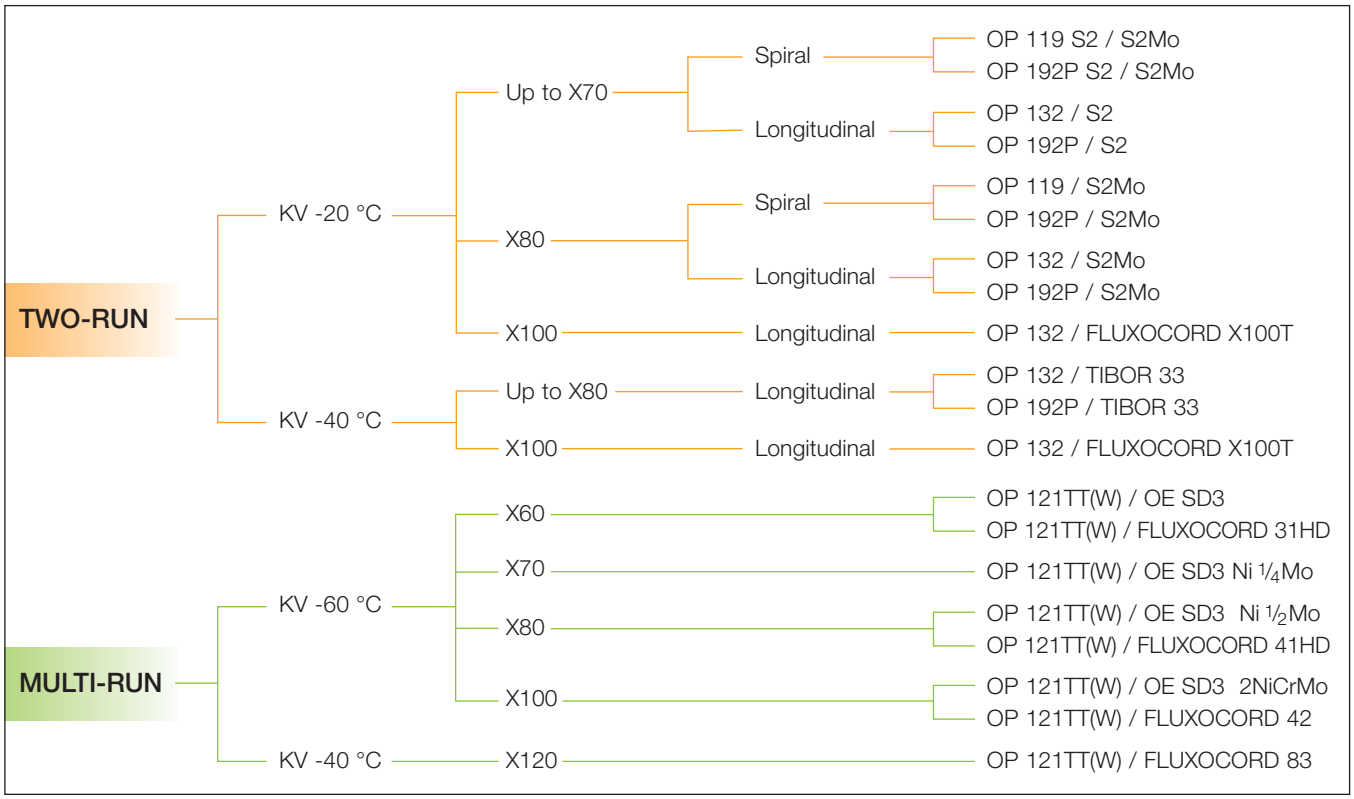
SAW Flux/Wire Selection Guide for Pipe steels



Selection guide

	OP 119	OP 192P	OP 132	OP 121 TT
Technology	**TWO-RUN**			**MULTI-RUN**
Spiral	●●●	●●●	●●	●
Thickness > 1”	●●	●●	●●●	●●●
High speed	●●●	●●●	●●	●
Low temp. KV	●	●●	●●●	●●●
Slag removal	●●●	●●●	●●●	●●●
Weldability	●●●	●●	●●	●●

● Not recommended
●● Good
●●● Very good
●●● Excellent



** the chemical composition and mechanical properties of the weld metal are strongly dependant on the chemistry of the pipe steel.*

Note:

Two pass welds when pipe welding are high dilution and the pipe steel chemistry will therefore have a strong effect on the chemistry and mechanical properties of the final joint. When two pass pipe welding it is therefore possible for a range of wire chemistries to meet the joint strength requirements for a given chemistry of pipe steel. Joint toughness, and service requirements, e.g. sour service, must also be carefully considered in combination with the pipe chemistry during the selection of an OERLIKON wire/flux combination - please consult OERLIKON technical service and experienced engineers will recommend the most appropriate choice of SAW wire/flux combination and welding procedural guidelines for the application.

Classification Society Approvals

Type	AWS	TÜV	DB	ABS	BV	DNV	GL	LRS	RMRS
SAW									
OP 119 / OE-S1	F7A0 EL12	06699	51.098.18	-	-	-	-	-	-
OP 119 / OE-S2	F7A2 EM12K	06700	51.098.18	-	-	-	-	-	-
OP 119 / OE-S2Mo	F8A0 EA2 A2	06702	51.098.18	-	-	-	-	-	-
OP 192 / OE-S2	F7AP4 EM12K	TÜV	DB	-	-	-	-	-	-
OP 132 / OE-S2	F7A5 EM12K	09860	51.098.22	-	-	-	-	-	-
OP 132 / OE-S2Mo	F8A5 EA2-A2	09861	51.098.22	-	-	-	-	-	-
OP 121TT / OE-SD3	F7P8 EH12K	03768	51.098.09	3YM (-40 °C)	3YM	IVY42M H5	5Y40M	4Y40M	5Y40M HHH
OP 121TT / OE-SD3 1Ni ¼Mo	F8A8-EG-G	09895	-	-		-	-	-	-
OP 121TT / OE-SD3 1Ni ½Mo	F9A8 EF3-F3	-	-	-	-	-	-	3Y50M	-
OP 121TT / SD3 2NiCrMo	F11A6 EG-G	10356	51.098.09	-	-	-	-	-	-

INITIALS	AWS	EN	TÜV	DB	ABS	BV	DNV	GL	LRS	PRS	RMRS
DESCRIPTION	American Welding Society	European Normalization	Technischer Überwachungs Verein	Deutsche Bahn	American Bureau of Shipping	Bureau Veritas	Det Norske Veritas	Germanischer Lloyd	Lloyd's Register of Shipping	Polski Rejestr Statkow	Russian Maritime Register of Shipping

Product packaging - welding consumables

In the demanding environment of a pipe mill, the packaging of SAW wires and fluxes can make a significant contribution to productivity and technical performance.
OERLIKON bulk SAW wire systems are designed for fast reliable pay off, to minimise wire change overs and optimise productivity.
OERLIKON SAW BIGBAG flux packaging system efficiently delivers flux in bulk quantities into central flux hoppers, now combined with the DRYBAG system for very low flux moisture content, eliminating the need to re-condition flux before use.

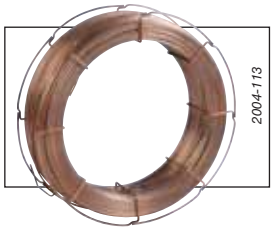
OERLIKON "OE" Submerged Arc Welding Wires

OERLIKON High Productivity Delivery System

- Designed for high consumption pipe-mill environments
- Wire is free spooled, 1,000-3,000 kg
- Pay off system adaptable for floor or gantry
- Reliable rapid pay off at high wire feed speeds
- Double HDPE layer protection from atmosphere during storage
- Integral pallet

OERLIKON Round Pac

- Heavy duty cardboard drums
- 320 kg & 600 kg formats
- 100% recyclable
- Reliable rapid pay off at high wire feed speeds
- Fitted sling points for handling safety



Spool

- B450
- 100% recyclable
- Supply: 1 tonne/ 40 x 25 kg coils per pallet

OERLIKON "OP" Submerged Arc Welding Fluxes

OERLIKON DRYBAG

This new packaging solution has been developed by the Air Liquide research teams for OERLIKON submerged arc welding fluxes.

OERLIKON DRYBAG packaging system features:

- Triple layer composite technology system
- Fully moisture proof
- Low vacuum
- Protection from atmospheric humidity
- Designed for the most hostile ambient conditions
- Protection during extended transport and storage
- Supply: 1 tonne / 40 x 25 kg

OERLIKON PE Sack

- Weld sealed
- 100% recyclable ("4")
- Easy to handle
- Effective flux protection from the environment
- Supply: 1 tonne / 40 x 25 kg sacks per pallet

OERLIKON BIGBAG

A specially designed packaging system for high consumption pipe-mill environments. Combining the BIGBAG bulk flux packaging system with the low vacuum, composite technology DRYBAG system, delivering these additional benefits:

- 500, 800 and 1000 kg formats
- Mounted on an integral pallet
- Ready slung for crane lifting safety
- Very fast flux discharge

Arc equipment for pipe mills and large fabrication sites

MIG/MAG welding equipment

OERLIKON CITOMIG and CITOPULS ranges of heavy-duty MIG/MAG machines have a comprehensive array of features focused on the requirements of major fabricators. Durable design is combined with easy-to-use control panels and a variety of synergic programmes, combining improved productivity with high quality results.

WARRANTY 3 YEARS

Conventional switch based MIG-MAG installations

CITOMIG

Two power sources for intensive industrial applications in workshop conditions. These machines are easy to use via an intuitive parameter adjustment system which provides optimised welding parameters for the highest quality results.

Product features:

- Digital parameter display
- 4 rollers feeder with speed regulation
- Assistant adjustment mode
- Complete welding cycle
- Compact wirer feeder
- Protected harness (5 m or 10 m)
- 30 step adjustment
- 220/400 V three phase

CITOMIG 400W XP 380 A at 40%

CITOMIG 500W XP 480 A at 50%

Digital technology for advanced welding installations

CITOSTEEL 420

CITOSTEEL 420 is the best technical choice for conventional welding applications. The technology used, inverter and digital control results in better welds with increased welding productivity. The continuous welding adjustment combined with synergic curves and the possibility to memorise the parameters brings both welding comfort and efficiency.

Product features and benefits:

- Fully digital controlled inverter,
  - More than 80 synergies are available in flat current,
  - Front panels are easy to understand and use,
  - Small machine for easier access,
  - Light installation (37 kg for the power source),
  - Compatible with motor generator,
  - Full range of processes:
    - Standard MIG/MAG
    - Speed Short Arc
    - Mig brazing
    - Gouging (up to 6.3 mm diameter electrode)
    - MMA coated electrode,
  - Powerful installation up to 420 A at 60%,
  - Storage of 100 welding programs,
  - Parameters locking with a digit code,
  - The parameters will be limited from 0 to +/- 20% range,
  - Harnesses (up to 50 m).

Product features:

- Digital parameter display
- Harness 5 m to 50 m
- 400 V three-phase
- MMA welding
- Gouging

CITOSTEEL 420 420 A at 60%

Arc equipment for pipe mills and large fabrication sites

Plasma cutting installations

OERLIKON has a complete Manual Plasma cutting range for all applications,

WARRANTY 3 YEARS

MMA elctrode power sources

OERLIKON has a wide range of equipment for MMA welding on site in all conditions.

From the CITOCUT K, a single phase unit with integrated compressor, a highly portable unit that cuts up to 6 mm, to the NERTAJET 50, a high performance chopper, multi gas machine that cuts up to 50 mm of steel.

CITOCUT 40i

Heavy duty portable cutting unit inverter technology.

- 400 V 50/60 Hz three phase.
- Heavy duty cycle, 120 A at 60% at 40 °C.
- Quality cut, up to 40 mm.
- Contact cut, distance cut, plasma gouging.
- Blow back start, no HF interference.
- Grid cutting capability.

CITOCUT 40

Product features.

- High cutting capcity: 40 mm with 120 A.
- High duty cycle: 50% at 40 °C.
- 4 steps for setting the current according to the thickness to cut.
- IP 23 for indoor and outdoor applications.
- High quality cut with drag cutting nozzles.
- Delivered ready to use with 6 m torch, air hose, primary cable, earth cable, starting set of wear parts.
- Input voltage three phases : 220/230/380/400 V - 50/60 Hz

From small, portable, high performance machines which can be carried by the welder to the location, such as the CITOARC 1900i, to rugged thyristor controlled units, such as the CITOROD 6500TH designed for heavy duty site applications, with rack fitting, remote parameter control and use with very long cables

CITOARC 1900i

Single phase inverter, portable machine.

- MMA / TIG Lift / MMA Cellulosic.
- 230 V 50/60 Hz single phase.
- Motor generator compatible.
- Duty cycle 160 A at 60%.
- Light and portable 40 x 18 x 30 cm - 11kg.
- Digital display.
- Remote control.
- 2 years warranty

CITOROD 6500 XT

Thyristor controlled multiprocess power source.

Product features.

- For the heaviest duty applications including gouging,
- Thyristor technology,
- Multiprocess (MMA, Gouging, TIG DC, MIG)
  - 230/400/440 V • 50/60 Hz • 3 phase unit,
- Possibility of MIG/MAG welding using DEVIDARC an autonomous wire-feeder
  - Heavy duty cycle, 630 A at 35%
  - Hot start and arc force adjustment
  - Remote control
  - Hoisting ring standard, suitable for rack fitting

Equipment for submerged arc welding

Power sources

STARMATIC

- Rugged, reliable, suitable for aggressive industrial surroundings.
- Fan-cooled, fitted with thermal cut-out, easy to move using crane or forklift.
- Quick connection to the core of the installation by simple and accessible connectors.
- Remote control system.
- Function type:
  1 - SAW direct current (DC).
  2 - SAW alternative current (AC).
  3 - SAW gouging arc.

	STARMATIC 1303 DC	STARMATIC 1003 AC/DC	
Duty cycle at 100%	1 300 A - 44 V	1 000 A - 44 V	
Welding range	2 DC	1 AC - 1 DC	
Primary power supply	400-440 V 50/60 Hz* three-phase	380/400/415 V 50/60 Hz* three-phase	
Technology	Thyristors	Thyristors	
Power at 100% duty cycle	99 kVA	64.6 kVA	
External-static characteristics		AC	DC
- flat	■	■	■
- drooping	■	■	■
Net weight	483 kg	540 kg	

***** *For other primary power supply three-phase, consult Air Liquide Welding.*

Equipment for submerged arc welding

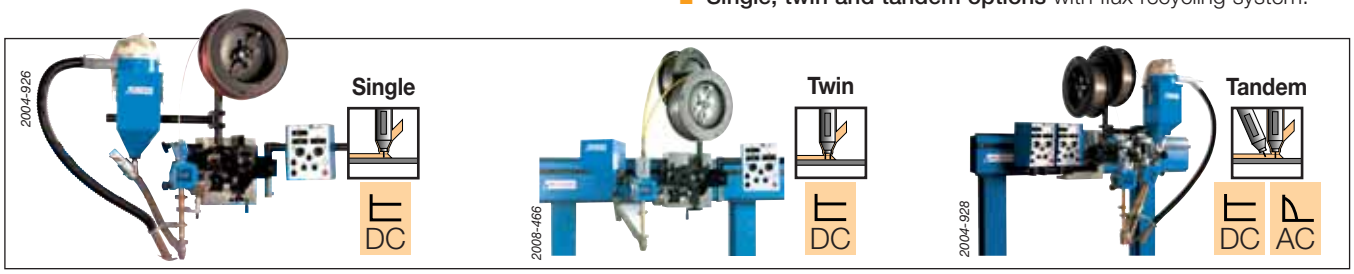
Welding heads

SUBARC 5 standard welding heads

A complete range of high-performance equipment using microprocessor technology to combine performance, flexibility of use and guaranteed high reliability in welding cycle management.

For the most demanding applications, SUBARC 5 is a compact welding and hard surfacing installation. It allows accurate pre-setting and pre-selection of the actual welding current and voltage parameters for excellent arc striking every time:

- **Submerged arc welding:**
  - direct current: flat or drooping power source characteristics.
  - alternating current: drooping power source characteristic.
- **MIG/MAG** (spray-arc transfer).
- **Single, twin and tandem options** with flux recycling system.



Submerged arc special welding heads.

Single or tandem narrow-gap torch.

- Narrow-gap torch/holding device up to 250 mm wall thicknesses.
- Changeable head (standard heads up to 180 mm available).
- Self-centring head on floating bearing.
- Ceramic coating.

Single or twin heavy duty torch.

- Thicknesses up to 70 mm.
- Kit to retrofit on SUBARC installations.
- Adjustable nozzle.
- 2.4 mm to 5.0 mm single wire diameter.
- 2 x 1.6 mm - 2 x 2.4 mm twin wire diameter.

Submerged arc welding heads for pipe mills.

- Customised installations.
- Multi-wire welding heads 5 wire.

Equipment for submerged arc welding

SAW self propelled tractor.

A practical, efficient and cost effective solution.

MEGATRAC 6 SUBARC 3C

- Modular S.A. carriage which can be adapted to various applications.
- Flat and angle assembly of plates in all grades and thicknesses.
- Wheel diameter: 150 mm.
- Crabbing arms

Positioning equipment

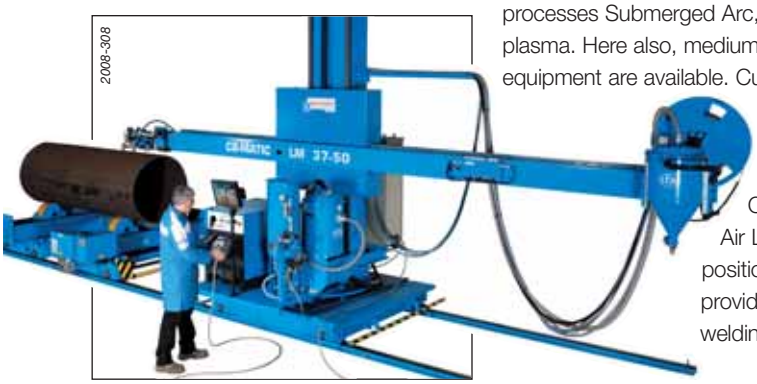
Air Liquide Welding provides a large range of positioning equipment such as rotators and column and booms.

Rotators

The ROTAMATIC range from 2 tons to 600 tons allows the rotation of vessels or tube for manual or automatic welding. Medium duty and heavy duty ranges are available to fit the needs of every customer.

Column and booms

CB-MATIC, the Air Liquide Welding column and boom range is the professional answer to your needs. Ideal for perfect positioning of the welding head in every welding processes Submerged Arc, MAG, TIG and plasma. Here also, medium and heavy duty equipment are available. Customised solutions are often created to fit the customers' requirements. Combined together, Air Liquide Welding positioning equipment provides a wide range of welding solutions.



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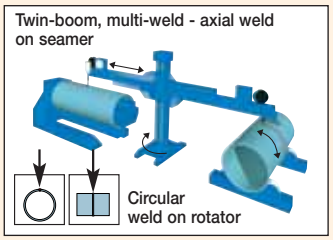

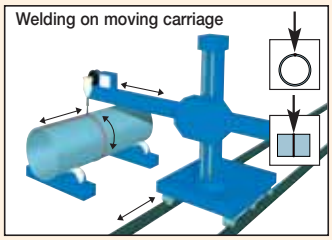

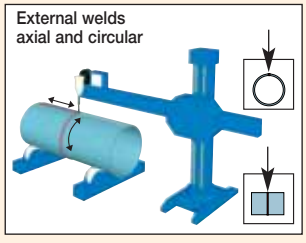

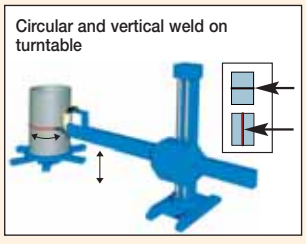

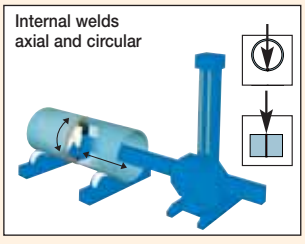

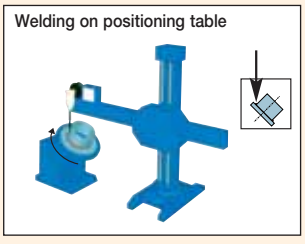

Temperature Conversion Table

°C		°F
- 156.6	**- 250**	- 418
- 128.8	**- 200**	- 328
- 101.1	**- 150**	- 238
- 73.3	**- 100**	- 148
- 45.5	**- 50**	- 58
- 45.0	**- 49**	- 56.2
- 44.4	**- 48**	- 54.4
- 43.8	**- 47**	- 52.6
- 43.3	**- 46**	- 50.8
- 42.7	**- 45**	- 49
- 42.2	**- 44**	- 47.2
- 41.6	**- 43**	- 45.4
- 41.1	**- 42**	- 43.6
- 40.5	**- 41**	- 41.8
- 40.0	**- 40**	- 40.0
- 39.4	**- 39**	- 38.2
- 38.8	**- 38**	- 36.4
- 38.3	**- 37**	- 34.6
- 37.7	**- 36**	- 32.8
- 37.2	**- 35**	- 31

°C		°F
- 36.6	**- 34**	- 29.2
- 36.1	**- 33**	- 27.4
- 35.5	**- 32**	- 25.6
- 35.0	**- 31**	- 23.8
- 34.4	**- 30**	- 22.0
- 33.8	**- 29**	- 20.2
- 33.3	**- 28**	- 18.4
- 32.7	**- 27**	- 16.6
- 32.2	**- 26**	- 14.8
- 31.6	**- 25**	- 13.0
- 31.1	**- 24**	- 11.2
- 30.5	**- 23**	- 9.4
- 30.0	**- 22**	- 7.6
- 29.4	**- 21**	- 5.8
- 28.8	**- 20**	- 4.0
- 28.3	**- 19**	- 2.2
- 27.7	**- 18**	- 0.4
- 27.2	**- 17**	1.4
- 26.6	**- 16**	3.2
- 26.1	**- 15**	5.0

°C		°F
- 25.5	**- 14**	6.8
- 25.0	**- 13**	8.6
- 24.4	**- 12**	10.4
- 23.8	**- 11**	12.2
- 23.3	**- 10**	14.0
- 22.7	**- 9**	15.8
- 22.2	**- 8**	17.6
- 21.6	**- 7**	19.4
- 21.1	**- 6**	21.2
- 20.5	**- 5**	23.0
- 20.0	**- 4**	24.8
- 19.4	**- 3**	26.6
- 18.8	**- 2**	28.4
- 18.3	**- 1**	30.2
- 17.8	**0**	32.0
- 17.2	**1**	33.8
- 16.7	**2**	35.6
- 16.1	**3**	37.4
- 15.6	**4**	39.2
- 15.0	**5**	41.0

°C		°F
- 14.4	**6**	42.8
- 13.9	**7**	44.6
- 13.3	**8**	46.4
- 12.8	**9**	48.2
- 12.2	**10**	50.0
- 11.7	**11**	51.8
- 11.1	**12**	53.6
- 10.6	**13**	55.4
- 10.0	**14**	57.2
- 9.44	**15**	59.0
- 8.89	**16**	61.8
- 8.33	**17**	63.6
- 7.78	**18**	65.4
- 7.22	**19**	67.2
- 6.67	**20**	68.0
- 6.11	**21**	69.8
- 5.56	**22**	71.6
- 5.0	**23**	73.4
- 4.44	**24**	75.2
- 3.89	**25**	77.0

°C		°F
- 33.3	**26**	78.8
- 2.78	**27**	80.6
- 2.22	**28**	82.4
- 1.67	**29**	84.2
- 1.11	**30**	86.0
- 0.56	**31**	87.8
0.00	**32**	89.6
0.56	**33**	91.4
1.11	**34**	93.2
1.67	**35**	95.0
2.22	**36**	96.8
2.78	**37**	98.6
3.33	**38**	100.4
3.89	**39**	102.2
4.44	**40**	104.0
5.00	**41**	105.8
5.56	**42**	107.6
6.11	**43**	109.4
6.67	**44**	111.2
7.22	**45**	113.0

°C		°F
7.78	**46**	114.8
8.33	**47**	116.6
8.89	**48**	118.4
9.44	**49**	120.2
10.0	**50**	122.0
10.6	**51**	123.8
11.1	**52**	125.6
11.7	**53**	127.4
12.2	**54**	129.2
12.8	**55**	131.0
13.3	**56**	132.8
13.9	**57**	134.6
14.4	**58**	136.4
15.0	**59**	138.2
15.6	**60**	140.0
16.1	**61**	141.8
16.7	**62**	143.6
17.2	**63**	145.4
17.8	**64**	147.2
18.3	**65**	149.0

°C		°F
18.9	**66**	150.8
19.4	**67**	152.6
20.2	**68**	154.4
20.6	**69**	156.2
21.1	**70**	158.0
21.7	**71**	159.8
22.2	**72**	161.6
22.8	**73**	163.4
23.3	**74**	165.2
23.9	**75**	167.0
24.4	**76**	168.8
25.0	**77**	170.6
25.6	**78**	172.4
26.1	**79**	174.2
26.7	**80**	176.0
27.2	**81**	177.8
27.8	**82**	179.6
28.3	**83**	181.4
28.9	**84**	183.2
29.4	**85**	185.0

°C		°F
30.0	**86**	186.8
30.6	**87**	188.6
31.1	**88**	190.4
31.7	**89**	192.2
32.2	**90**	194.0
32.8	**91**	195.8
33.3	**92**	197.6
33.9	**93**	199.4
34.4	**94**	201.2
35.0	**95**	203.0
35.6	**96**	204.8
36.1	**97**	206.6
36.7	**98**	208.4
37.2	**99**	210.2
38	**100**	212.0
43	**110**	230
49	**120**	248
54	**130**	266
60	**140**	284
66	**150**	302

°C		°F
71	**160**	320
77	**170**	338
82	**180**	356
88	**190**	374
93	**200**	392
99	**210**	410
100	**212**	413
104	**220**	428
110	**230**	446
116	**240**	464
121	**250**	482
127	**260**	500
132	**270**	518
138	**280**	536
143	**290**	554
149	**300**	572
154	**310**	590
160	**320**	608
166	**330**	626
171	**340**	644

°C		°F
177	**350**	662
182	**360**	680
188	**370**	698
193	**380**	716
199	**390**	734
204	**400**	752
232	**450**	842
260	**500**	932
288	**550**	1022
316	**600**	1112
343	**650**	1202
371	**700**	1292
399	**750**	1382
427	**800**	1472
454	**850**	1562
482	**900**	1652
510	**950**	1742
538	**1000**	1832
566	**1050**	1922
593	**1100**	2012

°C		°F
621	**1150**	2102
649	**1200**	2192
677	**1250**	2282
704	**1300**	2372
732	**1350**	2462
760	**1400**	2552
788	**1450**	2642
816	**1500**	2732
843	**1550**	2822
871	**1600**	2912
899	**1650**	3002
927	**1700**	3092
954	**1750**	3182
982	**1800**	3272
1010	**1850**	3362
1038	**1900**	3452
1066	**1950**	3542
1093	**2000**	3632
1121	**2050**	3722
1149	**2100**	3812

°C		°F
1177	**2150**	3902
1204	**2200**	3992
1232	**2250**	4082
1260	**2300**	4172
1288	**2350**	4262
1316	**2400**	4352
1343	**2450**	4442
1371	**2500**	4532
1399	**2550**	4622
1427	**2600**	4712
1454	**2650**	4802
1482	**2700**	4892
1510	**2750**	4982
1538	**2800**	5072
1566	**2850**	5162
1593	**2900**	5252
1621	**2950**	5342
1649	**3000**	5432

Note: the numbers in bold type refer to the temperature, either in Celsius or Fahrenheit, which is desired to convert into the other scale. If converting from Fahrenheit degrees to Celsius degrees, the equivalent temperature will be found in the left column, while converting from Ceslsius degrees to Fahrenheit degrees the answer will be found in the column on the right.

Impact Toughness Conversion Table

J	ft.lb.	J	ft.lb.	J	ft.lb.	J	ft.lb.
20	14.7	48	35.4	76	56.0	104	76.7
22	16.2	50	36.8	78	57.5	106	78.1
24	17.7	52	38.3	80	59.0	108	79.6
26	19.1	54	39.8	82	60.4	110	81.1
28	20.6	56	41.3	84	61.9	112	82.6
30	22.1	58	42.7	86	63.4	114	84.0
32	23.6	60	44.2	88	64.9	116	85.5
34	25.0	62	45.7	90	66.3	118	87.0
36	26.5	64	47.2	92	67.8	120	88.5
38	28.0	66	48.6	94	69.3	122	89.9
40	29.5	68	50.1	96	70.8	124	91.4
42	30.9	70	51.6	98	72.2	126	92.9
44	32.4	72	53.1	100	73.7	128	94.4
46	33.9	74	54.5	102	75.2	130	95.8

J	ft.lb.	J	ft.lb.	J	ft.lb.
132	97.3	160	118.9	188	138.5
134	98.8	162	119.4	190	140.0
136	100.3	164	120.8	192	141.5
138	101.7	166	122.3	194	142.9
140	103.2	168	123.8	196	144.4
142	104.7	170	125.3	198	145.9
144	106.2	172	126.7	200	147.4
146	107.6	174	128.2		
148	109.1	176	129.7		
150	110.6	178	131.2		
152	112.1	180	132.6		
154	113.5	182	134.1		
156	115.0	184	135.6		
158	116.5	186	137.1		

Conversion factors:
1 Joule = 0.73756 ft.lb.
1 ft.lb. = 1.35582 J

Stress Conversion Table

N/mm²	ksi	psi	MPa
150	21.8	21800	150
160	23.2	23200	160
170	24.7	24700	170
180	26.1	26100	180
190	27.6	27600	190
200	29.0	29000	200
210	30.5	30500	210
220	31.9	31900	220
230	33.4	33400	230
240	34.8	34800	240
250	36.3	36300	250
260	37.7	37700	260
270	39.2	39200	270
280	40.6	40600	280
290	42.1	42100	290
300	43.5	43500	300
310	45.0	45000	310
320	46.4	46400	320
330	47.9	47900	330
340	49.3	49300	340

N/mm²	ksi	psi	MPa
350	50.8	50800	350
360	52.2	52200	360
370	53.7	53700	370
380	55.1	55100	380
390	56.6	56600	390
400	58.0	58000	400
410	59.5	59500	410
420	60.9	60900	420
430	62.4	62400	430
440	63.8	63800	440
450	65.3	65300	450
460	66.7	66700	460
470	68.2	68200	470
480	69.6	69600	480
490	71.1	71100	490
500	72.5	72500	500
510	74.0	74000	510
520	75.4	75400	520
530	76.9	76900	530
540	78.3	78300	540

N/mm²	ksi	psi	MPa
550	79.8	79800	550
560	81.2	81200	560
570	82.7	82700	570
580	84.1	84100	580
590	85.6	85600	590
600	87.0	87000	600
610	88.5	88500	610
620	89.9	89900	620
630	91.4	91400	630
640	92.8	92800	640
650	94.3	94300	650
660	95.7	95700	660
670	97.2	97200	670
680	98.6	98600	680
690	100.1	100100	690
700	101.5	101500	700
710	103.0	103000	710
720	104.4	104400	720
730	105.9	105900	730
740	107.3	107300	740

N/mm²	ksi	psi	MPa
750	108.8	108800	750
760	110.2	110200	760
770	111.7	111700	770
780	113.1	113100	780
790	114.6	114600	790
800	116.0	116000	800
810	117.5	117500	810
820	118.9	118900	820
830	120.4	120400	830
840	121.8	121800	840
850	123.3	123300	850
860	124.7	124700	860
870	126.2	126200	870
880	127.8	127800	880
890	129.1	129100	890
900	130.5	130500	900
910	132.0	132000	910
920	133.4	133400	920
930	134.9	134900	930
940	136.3	136300	940

N/mm²	ksi	psi	MPa
950	137.8	137800	950
960	139.2	139200	960
970	140.7	140700	970
980	142.1	142100	980
990	143.6	143600	990
1000	145.0	145000	1000
1010	146.5	146500	1010
1020	147.9	147900	1020
1030	149.4	149400	1030
1040	150.8	150800	1040
1050	152.3	152300	1050
1060	153.7	153700	1060
1070	155.2	155200	1070
1080	156.6	156600	1080
1090	158.1	158100	1090
1100	159.5	159500	1100
1110	161.0	161000	1110
1120	162.4	162400	1120
1130	163.9	163900	1130
1140	165.3	165300	1140

N/mm²	ksi	psi	MPa
1150	166.8	166800	1150
1160	168.2	168200	1160
1170	169.7	169700	1170
1180	171.1	171100	1180
1190	172.6	172600	1190
1200	174.0	174000	1200

Conversion factors: *1 N/mm² = 145.038 psi*
1 N/mm² = 0.145038 ksi
1 MPa = 145.038 psi
1 MPa = 0.145038 ksi

Note: psi values have been rounded off to the nearest fourth digit.

Welding Units Comparison Tables

Deposition rates

lbs/hr	kg/hr
1	0.45
2	0.9
3	1.36
4	1.81
5	2.26
6	2.72
7	3.17
8	3.68
9	4.08
10	4.53
11	4.98
12	5.44
13	5.89
14	6.35
15	6.80
16	7.25
17	7.71
18	8.16
19	8.61
20	9.07
21	9.52
22	9.97
23	10.43
24	10.88
25	11.33

Wire feed speed

ins/min	m/min
25	0.6
50	1.3
75	1.9
100	2.5
125	3.1
150	3.8
175	4.4
200	5.1
225	5.7
250	6.3
275	6.9
300	7.6
325	8.2
350	8.9
375	9.5
400	10.2
425	10.8
450	11.4
475	12.0
500	12.7
525	13.3
550	14.0
575	14.6
600	15.2
625	15.8
650	16.5
675	17.1
700	17.8

Consumable weight

lbs	kgs
2.2	1
4.4	2
6.6	3
8.8	4
11.0	5
13.2	6
15.4	7
17.6	8
19.8	9
22.0	10
33.0	15
44.0	20
55.0	25
66.0	30
77.0	35
88.0	40
99.0	45
110.0	50

Electrode and wire diameter

inches	mm
0.024	0.6
0.030	0.8
0.035	0.9
0.045	1.0
0.052	1.2
$^{1}/_{16}$	1.6
$^{5}/_{64}$	2.0
$^{3}/_{32}$	2.4
$^{7}/_{64}$	3.0
$^{1}/_{8}$	3.2
$^{5}/_{32}$	4.0
$^{3}/_{16}$	5.0
$^{1}/_{4}$	6.0

Electrode length

inches	mm
10	250
12	300
13	330
14	350
18	450

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