

Pipe Laying





OERLIKON solutions for Pipe Laying

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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 € 13.5 billion in 2010, with 43.000 employees all over the world.

Air Liquide Welding is represented throughout the world by individual ALW companies with a brand portfolio optimised 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. These ALW companies are involved in many different areas of OERLIKON product design, development and application. The research and development centre, AL CTAS, is located in Paris and is the largest privately owned centre for welding R&D. This facilitates the rapid transfer and implementation of important innovations and advances in welding technology throughout the whole of the OERLIKON global network. The utilisation of the strengths and experience of this network enables OERLIKON to maintain its position and international reputation for innovative leadership at the forefront of advanced welding technology in both welding consumables and increasingly equipment and processes.

With this background, OERLIKON has generated a proven history of supplying welding consumables on an ongoing basis 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 has continued to work closely with owners, construction contractors and fabricators to supply customised solutions through performance and innovation by developing and supplying welding products and processes capable of meeting the stringent mechanical property specifications and increasingly the demands for enhanced welding productivity.

The results of this process of ongoing innovation and product development are demonstrated by the range of automated installations, welding consumables and equipment specifically tailored for the high productivity requirements of the onshore and offshore pipelaying industries.



OERLIKON and the Pipe Laying industry



The value of international expertise:

Quality

OERLIKON has a total commitment to quality. The extensive product ranges of automated installations, welding consumables and equipment are manufactured in group production facilities which are ISO certified. Detailed certification is supplied as a matter of routine and customers' special quality requirements, such as increased frequency of batch testing or specialised certification, are also readily accommodated. Large single batches of welding consumables, with specialised testing, are regularly supplied in accordance with customer requirements.

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 performance on site. A team of highly qualified engineers is ready to respond, with the objective of providing technologically relevant and practical solutions, specifically tailored for the pipelaying industry. This applies not only to welding products and equipment but also advanced proven process solutions, to identify the most applicable methods of enhancing deposition rates and productivity. 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.

Please consult OERLIKON Technical service.

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 meeting engineering departments and major manufacturers at the design stage to ensure optimum welding solutions. Specific solutions available from OERLIKON for pipe laying include the DRYBAG moisture resistant packaging system for SAW fluxes, special spooling formats for MIG/MAG wires for orbital systems, protective packaging for welding consumables suitable for high ambient temperature, high humidity climates and designed for use at sea. Batch classification with the possibility to produce very large batches, fully certificated and tested to specified requirements may be agreed to order.

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 and equipment to large industries. A track record of highly successful products combining quality and technology with technical service has been firmly established.

For details of the complete product range, consult www.oerlikon-welding.com

Continually adapting to our customers' needs

The adaptation of welding and cutting solutions to technical changes in materials and manufacturing conditions is carried out continually by the 140 engineers and technicians of CTAS, the largest private research centre in the welding industry.

Market oriented, our metallurgists and engineers work in direct collaboration with steelmakers, pipe manufacturers and pipeline constructors in order to improve the productivity and quality of our products and solutions.

CTAS plays a key role in collaborations and partnerships with various universities and customers and is committed to bring innovation and added-value to the welding & cutting markets.



Automatic/mechanised orbital welding of onshore

Stringing

1

Bevelling

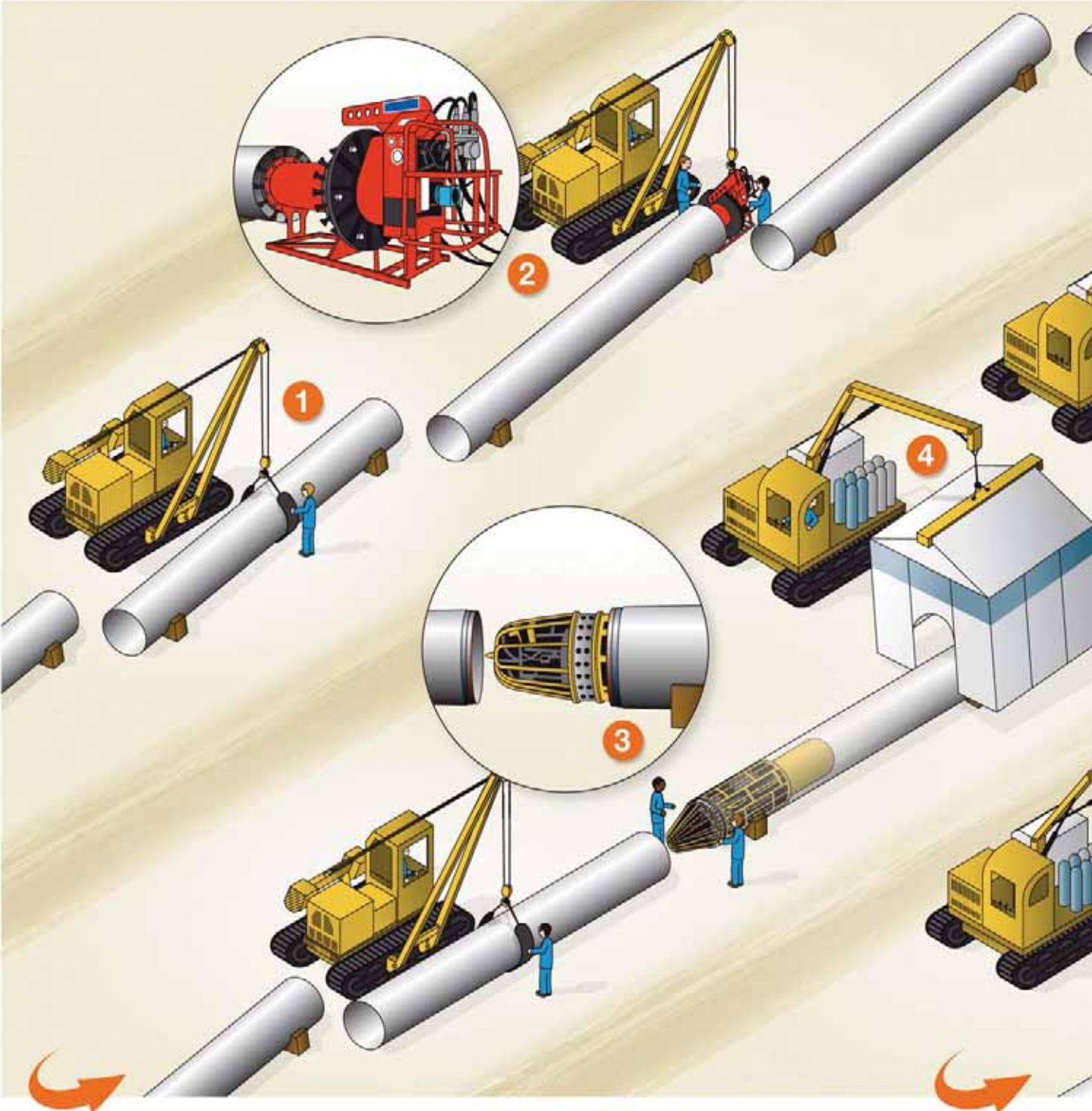
2

Pre-heating
Line up

3

Tent
positioning

4



pipelines

Welding

5

Cleaning

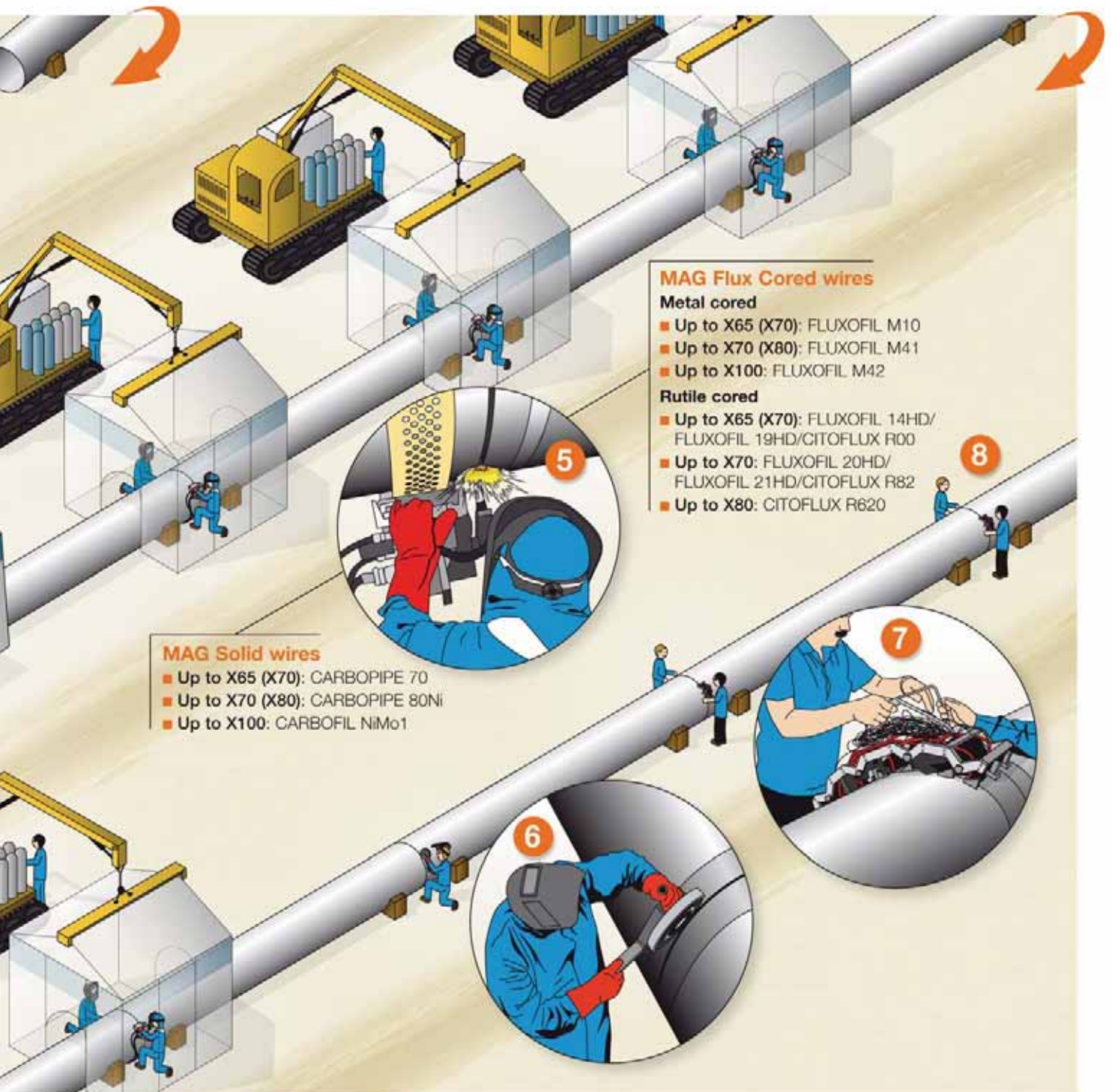
6

NDT

7

Joint coating

8



Welding of off-shore pipelines

Pipe Loading

1

Bevelling

2

Pre-heating
Line-up

3

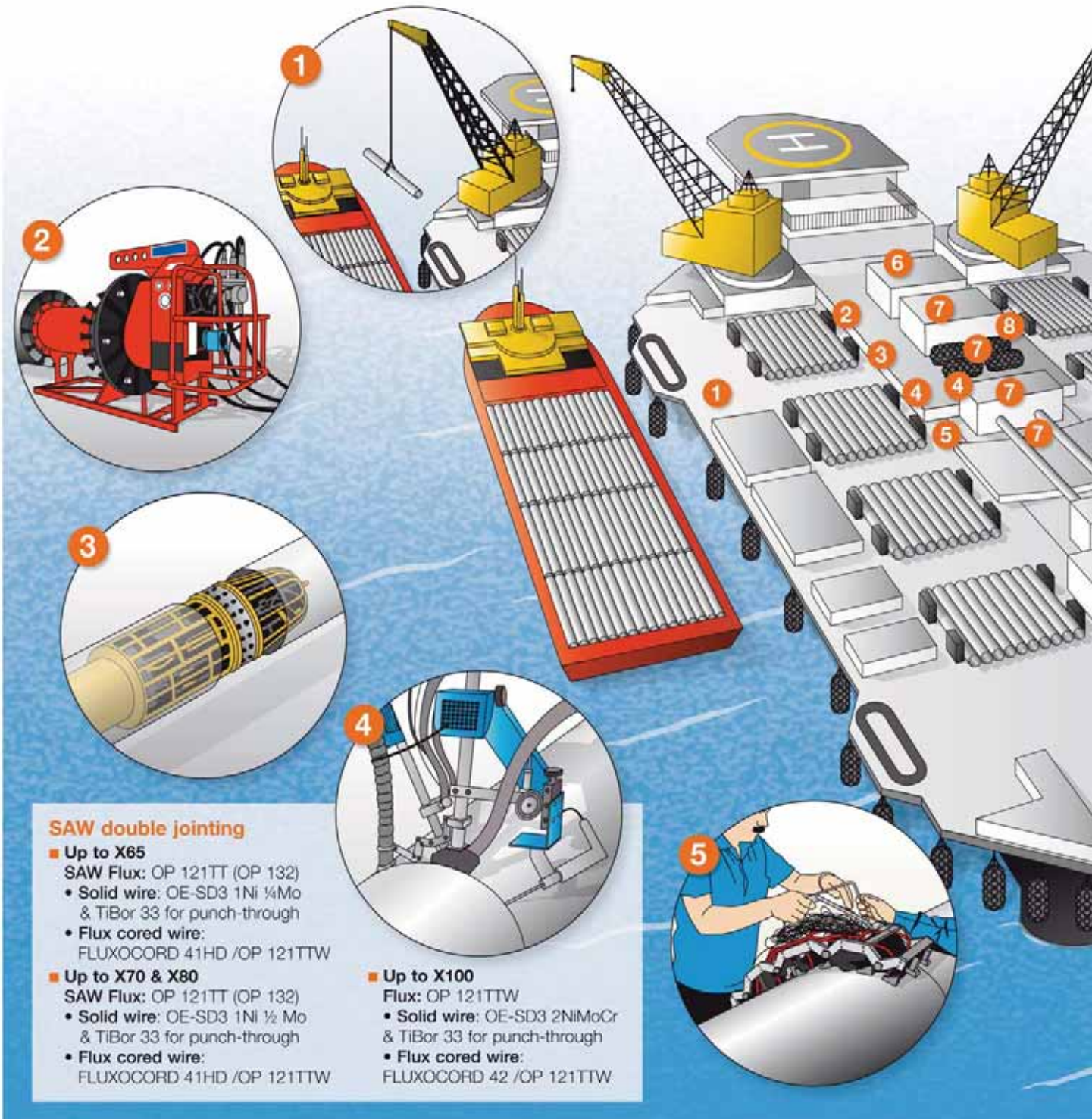
SAW
double
jointing

4

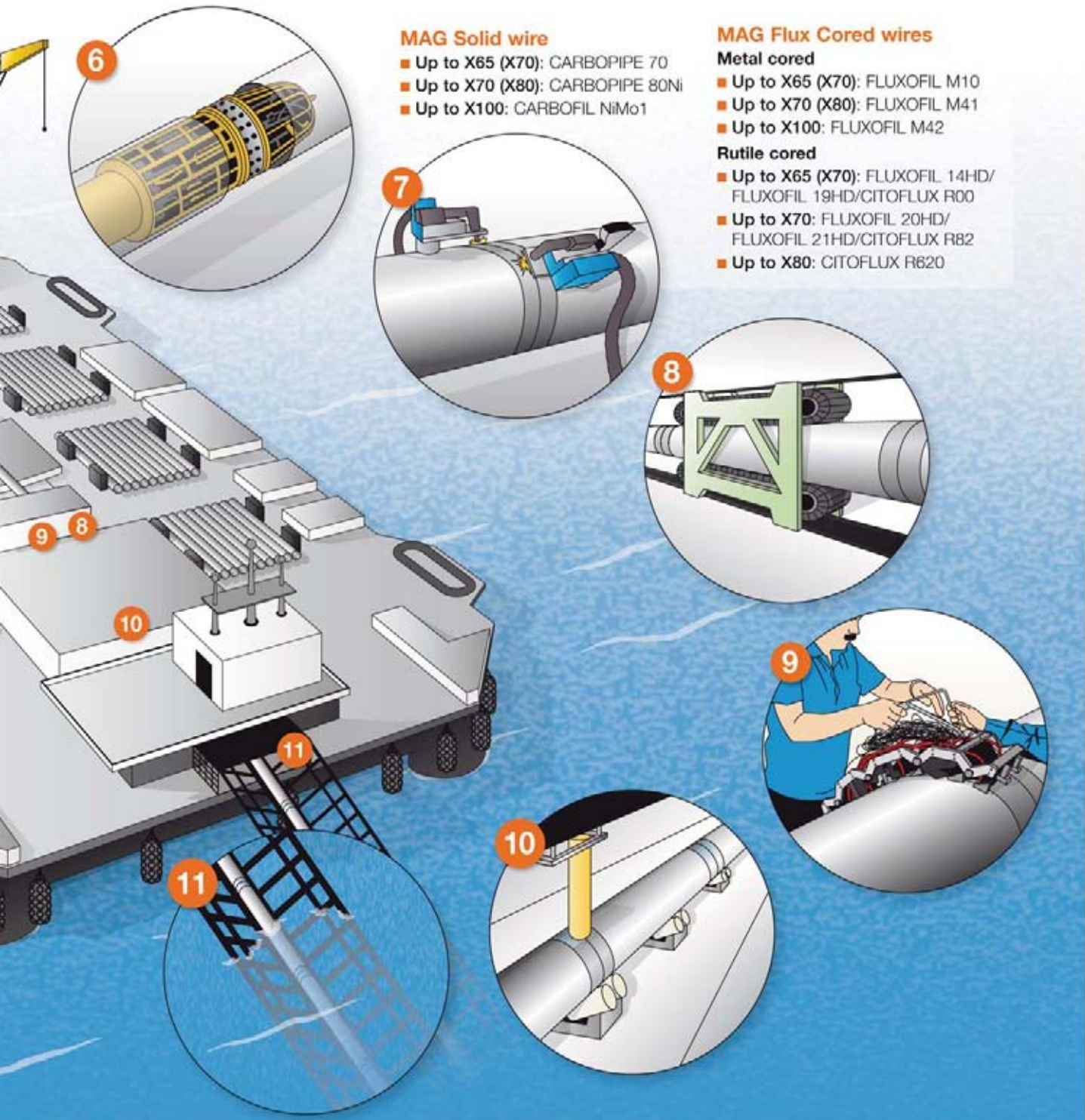
NDT

5

Pre-heating
Line-up



- 6
MIG
Main line
Welding
- 7
Pipe
Feeding
- 8
NDT
- 9
Joint
coating
- 10
Laying
- 11



Selection Guide by process and material grade

Selected OERLIKON welding consumables for joining line pipe

	Line pipe Grade				
API 5L Grade	X42-X52	X60-X65	X70	X80	X100
EN 10208 Classification	L 290 MB - L 360 MB	L 415 MB - L 450 MB	L485 MB	L555 MB	-
MMA WELDING					
MMA PG					
root, cellulosic	FLEXAL 60	FLEXAL 60	FLEXAL 70	FLEXAL 70	FLEXAL 70
fill, cellulosic	FLEXAL 60/70	FLEXAL 70/80	FLEXAL 80	FLEXAL 90	-
fill, basic	-	VERTICORD 80 a)	VERTICORD 80 a)	VERTICORD 90 a)	-
MMA PF					
root, cellulosic	FLEXAL 60	FLEXAL 60	FLEXAL 70	FLEXAL 70	FLEXAL 70
root, basic	TENAX 56S	TENAX 56S	TENAX 56S	TENAX 56S	TENAX 56 S
fill, basic	TENAX 35S	TENAX 56ST	TENAX 88SH R	TENAX 98M TENACITO 65R	TENAX 118M TENACITO 80
TIG WELDING					
TIG PG					
root	CARBOROD 1A	CARBOROD 1A/Ni1	CARBOROD Ni1/1A	CARBOROD Ni1	CARBOROD Ni1
fill	CARBOROD 1A	CARBOROD 1A/Ni1	CARBOROD Ni1	-	-
MIG-MAG solid wire					
GMAW PG					
root	CARBOPIPE 70	CARBOPIPE 70	CARBOPIPE 70 /80Ni b), CARBOFIL MnMo b)	CARBOPIPE 80Ni CARBOFIL NiMo1 b)	CARBOPIPE 80Ni
fill	CARBOPIPE 70	CARBOPIPE 70	CARBOPIPE 70 c) /80Ni b), CARBOFIL MnMo b)	CARBOPIPE 80Ni c) CARBOFIL NiMo1 b)	CARBOFIL NiMo1 CARBOFIL2NiMoCr
Flux cored wire					
FCAW rutile PF					
fill (Ar-CO2)	FLUXOFIL 14HD CITOFILUX R00	FLUXOFIL 14HD CITOFILUX R00	FLUXOFIL 20HD/14HD CITOFILUX R82	CITOFILUX R550 CITOFILUX R620	FLUXOFIL 29HD
fill (CO2-Ar)	FLUXOFIL 19HD	FLUXOFIL 19HD	FLUXOFIL 21HD FLUXOFIL19HD	-	-
FCAW metal cored PG					
root	FLUXOFIL M10/M10 PG	FLUXOFIL M10/M10 PG	FLUXOFIL M10 b) /M41 b) /M41 PG b)	FLUXOFIL M41/M41 PG	FLUXOFIL M42
fill	FLUXOFIL M10/M10 PG	FLUXOFIL M10/M10 PG c)	FLUXOFIL M10 c) /M41 b) /M41 PG b)	FLUXOFIL M41/M41 PG	FLUXOFIL M42
SAW Double jointing					
SAW PA					
SAW fluxes	OP 121TT(W)	OP 121TT(W)	OP 121TT(W)	OP 121TT(W)	OP 121TTW
	OP 132	OP 132	OP 132	OP 132	-
SAW wire - solid					
External welding	OE-SD3	OE-SD3 1Ni1/4Mo	OE-SD3 1Ni1/2Mo	OE-SD3 1Ni1/2Mo OE-SD3 2NiCrMo	OE-SD3 2NiCrMo
Punch-through	TIBOR 33	TIBOR 33	TIBOR 33	TIBOR 33	TIBOR 33
SAW wire - Flux cored					
External welding	FLUXOCORD 31HD	FLUXOCORD 41HD	FLUXOCORD 41HD	FLUXOCORD 42	FLUXOCORD 42
Repair					
MMA					
MMA	TENAX 35S	TENAX 56ST	TENAX 88SH R TENACITO 70	TENAX 98M TENACITO 65R	TENAX 118M TENACITO 80
Flux cored wire	FLUXOFIL 20HD	FLUXOFIL 20HD	CITOFILUX R620	CITOFILUX R620	-

a) basic downhill MMA electrode

b) Formally matching the base material

c) suitable, but formally under-matching

NB: In many cases a multiple choice is available, selection is linked to the project specification, i.e. requirement for overmatching, toughness and chemical analysis.

Selected OERLIKON welding consumables for joining clad pipes and duplex pipes

	Clad pipe			Duplex pipe	
	316L	625	825	Duplex	Super-Duplex
MMA WELDING					
MMA PF					
fill basic	BASINOX 316L	SUPRANEL 625	SUPRANEL 625	BASINOX 22 9 3N	BASINOX EB 25 10 4N
TIG WELDING					
TIG PG					
root	INERTROD 316L	NIROD 625	NIROD 625	INERTROD 22 9 3	INERTROD 25 10 4
fill	INERTROD 316L	NIROD 625	NIROD 625	INERTROD 22 9 3	INERTROD 25 10 4
MIG-MAG solid wire					
GMAW PG					
fill	INERTFIL 316L	NIFIL 625	NIFIL 625	INERTFIL 22 9 3	INERTFIL 25 10 4
root	INERTFIL 316L	NIFIL 625	NIFIL 625	INERTFIL 22 9 3	INERTFIL 25 10 4
Flux cored wire					
FCAW rutile PF					
fill	FLUXINOX 316L PF	FLUXINOX 625	FLUXINOX 625	FLUXINOX 22 9 3 L PF	-
SAW Double jointing					
SAW PA					
SAW fluxes	OP 33	OP 76	OP 76	OP 33	OP 33
SAW wire - solid					
	OE-316L	OE-NIFIL 625	OE-NIFIL 625	OE-S 22 09	OE-S 25 10
Repair					
MMA					
MMA	BASINOX 316L	SUPRANEL 625	SUPRANEL 625	BASINOX 22 9 3 N	BASINOX EB 25 10 4 N
Flux cored wire	FLUXINOX 316L PF	FLUXINOX 625	FLUXINOX 625	FLUXINOX 22 9 3 L PF	FLUXINOX 25 10 4 PF



Selected OERLIKON Welding Consumables for Pipe Lay Applications

All-Weld-Metal Properties, as welded condition

	AWS	EN	Shielding Gas	C	Mn	Si
MIG						
CARBOPIPE 70	A5.18: ER 70S-6	14341-A: G 46 5 M G4Si1	M21	0,08	1,65	0,9
CARBOPIPE 80Ni	A5.28: ER 80S-G	-	M21	0,08	1,7	0,65
CARBOFIL MnMo	A5.28: ER 80S-D2	14341-A: G 50 4 M G4Mo	M21	0,09	1,6	0,6
CARBOFIL NiMo1	A5.28: ER 100S-G	16834-A: G 55 4 C Mn3NiMo	M21	0,07	1,5	0,4
CARBOFIL 2NiMoCr	A5.28: ER 120S-G	16834-A: G 89 4 M Mn4Ni2CrMo	M21	0,08	1,5	0,6
INERTFIL 316L	A5.9: ER 316L	14343-A: G 19 12 3L	M13	0,02	1,4	0,45
INERTFIL 22 9 3	A5.9: ER 22 09	14343-A: G 22 9 3NL	M13	0,02	1,7	0,5
INERTFIL 25 10 4	A5.9: ER 2594	14343-A: G 25 9 4NL	M13	0,01	0,6	0,5
NIFIL 625	A5.14: ER NiCrMo-3	18274: S Ni 6625 (NiCr22Mo9Nb)	I1, I3	0,025	0,4	0,3
TIG						
CARBOROD 1A	A5.18: ER 70S-6	636-A: W 46 5 W4Si1	I	0,08	1,7	0,9
CARBOROD Ni1	A5.18: ER 70S-6	636-A: W 46 5 W4Si1	I	0,08	1,7	0,9
INERTROD 316L	A5.9: ER 316L	14343-A: W 19 12 3L	I	0,02	1,4	0,45
INERTROD 22 9 3	A5.9: ER 22 09	14343-A: W 22 9 3NL	I	0,02	1,7	0,5
INERTROD 25 10 4	A5.9: ER 2594	14343-A: W 25 9 4NL	I	0,01	0,6	0,5
NIROD 625	A5.14: ER NiCrMo-3	18274: S Ni 6625 (NiCr22Mo9Nb)	I	0,025	0,4	0,3
MMA						
FLEXAL 60	A5.1: E6010	2560-A: E 38 3 C 21	-	0,1	0,6	0,2
FLEXAL 70	E 7010-G/E7010-P1	2560-A: E 42 2 Mo C 21	-	0,1	0,7	0,2
FLEXAL 80	A5.5: E8010-G/E8010-P1	2560-A: E 46 3 1NiMo C21	-	0,1	0,8	0,2
FLEXAL 90	A5.5: E9010-G/E9010-P1	2560-A: E 50 2 1Ni C21	-	0,15	0,8	0,2
TENAX 35S	A5.1: E7018-1 H4 (R)	2560-A: E 42 5 B 32 H5	-	0,08	1,35	0,4
TENAX 56S	A5.1: E7016-1 H4	2560-A: E 42 5 B 12 H5	-	0,08	1,2	0,5
TENAX 56ST	A5.5: E8018-G	2560-A: E 46 4 B 32 H5	-	0,06	1,7	0,5
TENAX 88S HR	A5.5: E8018-G H4	2560-A: E 50 6 Mn1Ni B 3 2 H5	-	0,06	1,5	0,3
TENAX 98M	A5.5: E9018-M H4	757: E 55 5 Z B 3 2 H5	-	0,07	1,2	0,4
TENAX 118M	A5.5: E11018-M H4	757: E 69 5 Z B 3 2 H5	-	0,06	1,6	0,3
TENACITO 65R	A5.5: E9018-G H4	757: E 55 6 Mn1NiMo B T 4 2 H5	-	0,05	1,4	0,3
TENACITO 80	A5.5: E11018-G H4	757: E 69 6 Mn2NiCrMo B 4 2 H5	-	0,06	1,8	0,4
VERTICORD 80	A5.5: E8018-G/E8010-P2	2560-A: E 46 4 B 4 5 H5	-	0,07	1,5	0,5
VERTICORD 90	A5.5: E9018-G/E9018-P2	757: E 55 4 Z B 4 5 H5	-	0,06	1,4	0,5
BASINOX 316 L	A5.4: E316L-15	1600: E 19 12 3 L B 42	-	0,025	1	0,3
BASINOX 22 9 3 N	A5.4: E2209-15	1600: E 22 9 3 N L B 42	-	<0,040	1,2	0,4
BASINOX EB 25 10 4 N	A5.4: E2594-15	1600: E 25 9 4 N L B 42	-	0,03	0,8	0,4
SUPRANEL 625	A5.11: E NiCrMo-3	14172: E Ni 6625)	-	0,02	0,9	0,2
Cored Wires						
CITOFILUX R00	A5.20: E71T1-1M-JH4	17632-A: T 42 3 P M 1 H5	M21	0,05	1,4	0,5
CITOFILUX R82	A5.29: E81T1-Ni1M-H4	17632-A: T 46 5 1Ni P M 1 H5	M21	0,05	1,3	0,4
CITOFILUX R550	A5.29: E91T1-GM-H4	18276-A: T 55 5 Mn1,5Ni P M 1 H5	M21	0,05	1,3	0,4
CITOFILUX R620	A5.29: E91T1-G-H4	18276-A: T 62 4 1NiMoP M 1 H5	M21	0,07	1,4	0,4
FLUXOFIL 14HD	A5.20: E71T1-1M-JH4	17632-A: T 46 3 P M 1 H5	M21	0,05	1,4	0,5
FLUXOFIL 19HD	A5.20: E71T1-1C-JH4	17632-A: T 46 3 P C 1 H5	C1	0,05	1,3	0,5
FLUXOFIL 20HD	A5.29: E81T1-Ni1M-JH4	17632-A: T 46 4 P M 1 H5	M21	0,06	1,3	0,4
FLUXOFIL 21HD	A5.29: E81T1-Ni1C-JH4	17632-A: T 46 4 P C 1 H5	C1	0,07	1,4	0,4
FLUXOFIL 29HD	A5.29: E111T1-GM-JH4	18276-A: T 69 4 Z P M H5	M21	0,06	1,4	0,4
FLUXOFIL M10	A5.18: E 70C-6M-H4	17632-A: T 46 4 M M 1 H5	M21	0,08	1,5	0,4
FLUXOFIL M10 PG	A5.18: E 70C-GM-H4	17632-A: T 46 4 M M 1 H5	M21	0,08	1,5	0,4
FLUXOFIL M41	A5.18: E 90C-GM-H4	18276-A: T 55 5 Z M M 1H5	M21	0,08	1,5	0,4
FLUXOFIL M41 PG	A5.28: E 90C-GM-H4	18276-A: T 55 4 Z M M 1H5	M21	0,08	1,5	0,4
FLUXOFIL M42	A5.28: E 110C-GM-H4	18276-A: T 69 4 Mn2NiCrMo M M 1H5	M21	0,05	1,5	0,5
FLUXINOX 316 PF	A5.22: E316LT1-1, E316LT1-4	17633-A: T 19 12 3 L P C 1	M21,C1	<0,04	1,7	0,6
FLUXINOX 22 9 3 L PF	A5.22: E2209T0-1, E2209T0-4	17633-A: T 22 9 3N L R M 3	M21,C1	<0,04	0,8	0,5
FLUXINOX 625	A5.11: -E NiCrMo-3	-	M21,C1	0,03	0,5	0,4
SAW Fluxes & Wires						
OP 121TT/OE-SD3	A5.17: F7A8-EH12K	-	-	0,07	1,6	0,3
OP 121TT/OE-SD3 1Ni¼Mo	A5.23: F8A8-EG-G	-	-	0,07	1,3	0,3
OP 121TT/OE-SD3 1Ni½Mo	A5.23: F9A8-EF3-F3	-	-	0,07	1,5	0,3
OP 121TTW/OE-SD3 2NiMoCr	A5.23: F11A8-F11P5-EG-G	-	-	0,07	1,4	0,4
OP 121TT/OE-TIBOR 33	A5.17: F7A6-EG-G	-	-	0,07	1,2	0,2
OP 132/OE-SD3	A5.17: F7A5-EH12K	-	-	0,07	1,8	0,4
OP 132/OE-SD3 1Ni¼Mo	A5.23: F9A4-EG-G	-	-	0,07	1,6	0,3
OP 132/OE-SD3 1Ni½Mo	A5.23: F10A4-EF3-F3	-	-	0,08	1,8	0,3
OP 132/OE-TIBOR 33	A5.23: F9A4-EG-G	-	-	0,07	1,7	0,4
OP 121TTW/FLUXOCORD 31HD	A5.17: F7AP4-EC-G	-	-	0,06	1,7	0,4
OP 121TTW/FLUXOCORD 41HD	A5.23: F9A8-EC-F3	756: S 50 6 FB T2Ni1Mo	-	0,05	1,3	0,2
OP 121TTW/FLUXOCORD 42	A5.23: F11A8-EC-F5	756: S 69 6 FB TZ	-	0,05	1,4	0,2
OP 33/OE-316L	-	-	-	<0,03	1,6	-
OP 33/OE S 22 09	-	-	-	<0,03	1,8	-
OP 33/OE S 25 10	-	-	-	-	-	-
OP 76/OE-NIFIL 625	-	-	-	0,03	0,3	-

Ni	Cr	Mo	Tensile Strength MPa	Yield Strength MPa	A5d %	ISO-V		
						°C	Joules	
MIG								
-	-	-	>580	>482	>25	-50	>47	CARBOPIPE 70
0,93	-	-	>610	>520	>28	-50	>80	CARBOPIPE 80Ni
-	-	0,5	>680	>520	>22	-40	>70	CARBOFIL MnMo
1	-	0,4	700-890	>620	>18	-40	>60	CARBOFIL NiMo1
2,2	0,4	0,6	>940	>890	>15	-40	>47	CARBOFIL 2NiMoCr
12,5	19	2,6	>510	>350	>30	-120	>32	INERTFIL 316L
9	23	3	>680	>480	>22	-40	>32	INERTFIL 22 9 3
9,5	25	4	>800	>550	>25	-40	>32	INERTFIL 25 10 4
Bal	21	9	>720	>460	>30	-196	>40	NIFIL 625
TIG								
-	-	-	550-680	>460	>24	-50	>60	CARBOROD 1A
-	-	-	550-680	>460	>24	-50	>60	CARBOROD Ni1
12,5	19	2,6	>510	>350	>30	-120	>32	INERTROD 316L
9	23	3	>680	>480	>22	-40	>32	INERTROD 22 9 3
9,5	25	4	>800	>550	>25	-40	>32	INERTROD 25 10 4
Bal	21	9	>720	>460	>30	-196	>40	NIROD 625
MMA								
-	-	-	470-560	>380	>24	-30	>47	FLEXAL 60
-	-	0,5	500-640	>420	>22	-20	>60	FLEXAL 70
0,7	-	0,3	550-680	>460	>22	-30	>47	FLEXAL 80
0,8	-	0,3	580-680	>530	>22	-25	>47	FLEXAL 90
-	-	-	510-640	>420	>22	-50	>100	TENAX 35S
-	-	-	500-640	>420	>22	-50	>110	TENAX 56S
-	-	-	>550	>460	>24	-40	>70	TENAX 56ST
0,8	-	0,2	560-720	>500	>24	-60	>60	TENAX 88S HR
1,6	-	0,3	610-780	>550	>24	-51	>47	TENAX 98M
2	-	0,3	760-960	>690	>20	-60	>70	TENAX 118M
0,95	-	0,4	630-750	>560	>20	-60	>75	TENACITO 65R
2,3	0,4	0,45	850-960	>790	>16	-60	>47	TENACITO 80
-	-	-	560-650	>460	>27	-50	>45	VERTICORD 80
0,9	-	0,3	620-690	>570	>25	-40	>80	VERTICORD 90
11,5	18,5	2,7	>520	>420	>30	-60	>32	BASINOX 316 L
9	23,4	2,8	>690	>550	>25	-50	>50	BASINOX 22 9 3 N
9,5	25	4	>850	>650	>20	-50	>32	BASINOX EB 25 10 4 N
Bal	22	9	>760	>420	>30	-196	>50	SUPRANEL 625
Cored Wires								
-	-	-	500-640	>420	>20	-20	>80	CITOFLEX R00
0,9	-	-	550-690	>460	>22	-50	>80	CITOFLEX R82
0,9	-	-	550-690	>460	>22	-50	>80	CITOFLEX R550
0,9	0,4	-	550-690	>460	>22	-50	>80	CITOFLEX R620
-	-	-	550-650	>460	>24	-20	>80	FLUXOFIL 14HD
-	-	-	550-650	>460	>24	-20	>80	FLUXOFIL 19HD
0,9	-	-	570-680	>480	>24	-40	>80	FLUXOFIL 20HD
0,9	-	-	570-670	>490	>22	-40	>70	FLUXOFIL 21HD
2,9	-	0,35	770-940	>690	>17	-40	>50	FLUXOFIL 29HD
-	-	-	550-680	>460	>24	-40	>80	FLUXOFIL M10
-	-	-	550-680	>460	>24	-40	>60	FLUXOFIL M10 PG
-	-	-	550-680	>460	>24	-50	>47	FLUXOFIL M41
-	-	-	550-680	>460	>24	-40	>47	FLUXOFIL M41 PG
2	0,4	0,4	780-980	>690	>17	-40	>70	FLUXOFIL M42
12	19	2,8	>510	>320	>30	-196	>27	FLUXINOX 316 PF
9	22,5	3	750-900	>550	>24	-30	>40	FLUXINOX 22 9 3 L PF
Bal	21	9	>750	>500	>35	-196	>50	FLUXINOX 625
SAW Fluxes & Wires								
-	-	-	530-630	>450	>25	-60	70	OP 121TT/OE-SD3
0,8	-	0,2	600-650	>530	>24	-40	>120	OP 121TT/OE-SD3 1Ni¼Mo
1	-	0,5	650-750	>540	>20	-40	>70	OP 121TT/OE-SD3 1Ni½Mo
2,2	0,6	0,5	760-900	>720	>18	-40	>47	OP 121TTW/OE-SD3 2NiMoCr
0,4	-	0,4	530-630	>450	>25	-40	>47	OP 121TT/OE-TIBOR 33
-	-	-	530-580	>470	>25	-50	>40	OP 132/OE-SD3
0,8	-	0,2	650-750	>540	>20	-40	>50	OP 132/OE-SD3 1Ni¼Mo
1	-	0,5	690-830	>610	>16	-40	>50	OP 132/OE-SD3 1Ni½Mo
-	-	0,4	650-750	>540	>20	-40	>27	OP 132/OE-TIBOR 33
-	-	-	500-640	>420	>20	-60	>80	OP 121TTW/FLUXOCORD 31HD
0,9	-	0,5	620-720	>550	>18	-60	>60	OP 121TTW/FLUXOCORD 41HD
2,5	0,6	0,4	750-830	>690	>16	-60	>69	OP 121TTW/FLUXOCORD 42
10	18	2,7	>525	>350	>30	-60	60	OP 33/OE-316L
9	23	3	>750	>550	>25	-60	>70	OP 33/OE S 22 09
-	-	-	-	-	-	-	-	OP 33/OE S 25 10
60	23	10	>760	>450	>23	20	>65	OP 76/OE-NIFIL 625

Selected OERLIKON Welding Consumables for Pipe Lay Applications

Classification Society Approvals

	AWS	EN	Shielding Gas	CE	TUV	DB	ABS
MIG							
CARBOPIPE 70	A5.18: ER 70S-6	14341-A: G 46 5 M G4Si1	M21	-	11094.00	-	-
CARBOPIPE 80Ni	A5.28: ER 80S-G	-	M21	-	11887.01	-	-
CARBOFIL MnMo	A5.28: ER 100S-D2	14341-A: G 50 4 M G4Mo	M21	0035-CPD-301	11097.00	42.098.39	-
CARBOFIL NiMo1	A5.28: ER 100S-G	16834-A: G 55 4 C Mn3NiMo	M21	0035-CPD-301	09848	42.098.27	-
CARBOFIL 2NiMoCr	A5.28: ER 120S-G	16834-A: G 89 4 M Mn4Ni2CrMo	M21	-	-	-	-
INERTFIL 316L	A5.9: ER 316L	14343-A: G 19 12 3L	M13	-	02429.08	43.098.07	-
INERTFIL 22 9 3	A5.9: ER 22 09	14343-A: G 22 9 3NL	M13	-	06996.09	-	-
INERTFIL 25 10 4	A5.9: ER 2594	14343-A: G 25 9 4NL	M13	-	-	-	-
NIFIL 625	A5.14: ER NiCrMo-3	18274: S Ni 6625 (NiCr22Mo9Nb)	I1, I3	-	07203.08	-	-
TIG							
CARBOROD 1A	A5.18: ER 70S-6	636-A: W 46 5 W4Si1	I	-	-	-	-
CARBOROD Ni1	A5.18: ER 70S-6	636-A: W 46 5 W4Si1	I	-	-	-	-
INERTROD 316L	A5.9: ER 316L	14343-A: W 19 12 3L	I	-	03286.08	-	AWS A5.28-05
INERTROD 22 9 3	A5.9: ER 22 09	14343-A: W 22 9 3NL	I	-	06995.07	-	-
INERTROD 25 10 4	A5.9: ER 2594	14343-A: W 25 9 4NL	I	-	-	-	-
NIROD 625	A5.14: ER NiCrMo-3	18274: S Ni 6625 (NiCr22Mo9Nb)	I	-	07202.08	-	-
MMA							
FLEXAL 60	A5.1: E6010	2560-A: E 38 3 C 21	-	0035-CPD-C306	10361.	-	3
FLEXAL 70	E 7010-G/E7010-P1	2560-A: E 42 2 Mo C 21	-	0035-CPD-C306	10362.	-	3
FLEXAL 80	A5.5: E8010-G/E8010-P1	2560-A: E 46 3 1NiMo C21	-	0035-CPD-C306	10363.	-	3
FLEXAL 90	A5.5: E9010-G/E9010-P1	2560-A: E 50 2 1Ni C21	-	0035-CPD-C307	-	-	-
TENAX 35S	A5.1: E7018-1 H4 (R)	2560-A: E 42 5 B 32 H5	-	0035-CPD-C303	04468.	10.098.22	4YH5
TENAX 56S	A5.1: E7016-1 H4	2560-A: E 42 5 B 12 H5	-	0035-CPD-C303	04944.	10.098.24	4YH5
TENAX 56ST	A5.5: E8018-G	2560-A: E 46 4 B 32 H5	-	0035-CPD-C303	-	-	4YH5
TENAX 88S HR	A5.5: E8018-G H4	2560-A: E 50 6 Mn1Ni B 3 2 H5	-	-	-	-	-
TENAX 98M	A5.5: E9018-M H4	757: E 55 5 Z B 3 2 H5	-	-	-	-	-
TENAX 118M	A5.5: E11018-M H4	757: E 69 5 Z B 3 2 H5	-	00807.	10.098.21	3YH10	-
TENACITO 65R	A5.5: E9018-G H4	757: E 55 6 Mn1NiMo B T 4 2 H5	-	0035-CPD-C307	TUV	DB	E9018G
TENACITO 80	A5.5: E11018-G H4	757: E 69 6 Mn2NiCrMo B 4 2 H5	-	0035-CPD-C303-307	00812.	-	E 11018-G
VERTICORD 80	A5.5: E8018-G/E8010-P2	2560-A: E 46 4 B 4 5 H5	-	-	04942.	-	-
VERTICORD 90	A5.5: E9018-G/E9018-P2	757: E 55 4 Z B 4 5 H5	-	-	-	-	-
BASINOX 316 L	A5.4: E316L-15	1600: E 19 12 3 L B 42	-	0035-CPD-C303	06339.	30.098.09	-
BASINOX 22 9 3 N	A5.4: E2209-15	1600: E 22 9 3 N L B 42	-	-	-	-	-
BASINOX EB 25 10 4 N	A5.4: E2594-15	1600: E 25 9 4 N L B 42	-	-	-	-	-
SUPRANEL 625	A5.11: E NiCrMo-3	14172: E Ni 6625)	-	-	-	-	-
Cored Wires							
CITOFILUX R00	A5.20: E71T1-1M-JH4	17632-A: T 42 3 P M 1 H5	M21	0035-CPD-C305	11012.04	42.098.43	3YSAH5
CITOFILUX R82	A5.29: E81T1-Ni1M-H4	17632-A: T 46 5 1Ni P M 1 H5	M21	0035-CPD-C307	-	-	4Y400SA H4
CITOFILUX R550	A5.29: E91T1-GM-H4	18276-A: T 55 5 Mn1,5Ni P M 1 H5	M21	-	-	-	-
CITOFILUX R620	A5.29: E91T1-G-H4	18276-A: T 62 4 1NiMoP M 1 H5	M21	-	-	-	-
FLUXOFIL 14HD	A5.20: E71T1-1M-JH4	17632-A: T 46 3 P M 1 H5	M21	0035-CPD-C302	09501.07	42.098.31	3Y40SAH5
FLUXOFIL 19HD	A5.20: E71T1-1C-JH4	17632-A: T 46 3 P C 1 H5	C1	0035-CPD-C302	10389.02	42.098.29	3Y40SAH5
FLUXOFIL 20HD	A5.29: E81T1-Ni1M-JH4	17632-A: T 46 4 P M 1 H5	M21	0035-CPD-C302	09857.05	42.098.20	4Y46SA H5
FLUXOFIL 21HD	A5.29: E81T1-Ni1C-JH4	17632-A: T 46 4 P C 1 H5	C1	0035-CPD-C302	-	-	4Y46SAH5
FLUXOFIL 29HD	A5.29: E111T1-GM-JH4	18276-A: T 69 4 Z P M H5	M21	-	-	-	-
FLUXOFIL M10	A5.18: E 70C-6M-H4	17632-A: T 46 4 M M 1 H5	M21	-	05959.06	42.098.23	4YSA H5
FLUXOFIL M10 PG	A5.18: E 70C-GM-H4	17632-A: T 46 4 M M 1 H5	M21	-	-	42.098.21	4YSA H5
FLUXOFIL M41	A5.18: E 90C-GM-H4	18276-A: T 55 5 Z M M 1H5	M21	-	-	-	-
FLUXOFIL M41 PG	A5.28: E 90C-GM-H4	18276-A: T 55 4 Z M M 1H5	M21	-	-	-	-
FLUXOFIL M42	A5.28: E 110C-GM-H4	18276-A: T 69 4 Mn2NiCrMo M M 1H5	M21	-	05960.04	42.098.24	4Y 690 MS H5
FLUXINOX 316 PF	A5.22: E316LT1-1, E316LT1-4	17633-A: T 19 12 3 L P C 1	M21,C1	-	09844.03	43.098.23	-
FLUXINOX 22 9 3 L PF	A5.22: E2209T0-1, E2209T0-4	17633-A: T 22 9 3N L R M 3	M21,C1	-	09847.02	-	-
FLUXINOX 625	A5.11: -E NiCrMo-3	-	M21,C1	-	-	-	-
SAW Fluxes & Wires							
OP 121TT/OE-SD3	A5.17: F7A8-EH12K	-	-	0035-CPD-C308	03768	51.098.09	3YM (-40 °C)
OP 121TT/OE-SD3 1Ni¼Mo	A5.23: F8A8-EG-G	-	-	0035-CPD-C308	09895	-	4YQ 460M
OP 121TT/OE-SD3 1Ni½Mo	A5.23: F9A8 EF3-F3	-	-	0035-CPD-C308	03969	51.098.09	5YQ 550M
OP 121TTW/OE-SD3 2NiMoCr	A5.23: F11A8-F11P5 EG-G	-	-	0035-CPD-C308	-	-	-
OP 121TT/OE-TIBOR 33	A5.17: F7A6-EG-G	-	-	-	-	-	-
OP 132/OE-SD3	A5.17: F7A5-EH12K	-	-	-	-	-	-
OP 132/OE-SD3 1Ni¼Mo	A5.23: F9A4-EG-G	-	-	-	-	-	-
OP 132/OE-SD3 1Ni½Mo	A5.23: F10A4 EF3-F3	-	-	-	-	-	-
OP 132/OE-TIBOR 33	A5.23: F9A4 EG-G	-	-	-	-	-	-
OP 121TTW/FLUXOCORD 31HD	A5.17: F7AP4-EC-G	-	-	0035-CPD-C302	-	-	-
OP 121TTW/FLUXOCORD 41HD	A5.23: F9A8 EC-F3	756: S 50 6 FB T2Ni1Mo	-	-	-	-	5YQ690M
OP 121TTW/FLUXOCORD 42	A5.23: F11A8-EC-F5	756: S 69 6 FB TZ	-	-	-	-	-
OP 33/OE-316L	-	-	-	0035-CPD-C308	04874	51.098.15	-
OP 33/OE S 22 09	-	-	-	0035-CPD-C308	04725	51.098.15	-
OP 33/OE S 25 10	-	-	-	-	-	-	-
OP 76/OE-NIFIL 625	-	-	-	0035-CPD-C308	03961	-	-

INITIALS	AWS	EN	CE	TÜV	DB	ABS	BV	DNV	GL	LRS	PRS	RMRS	RINA	ANR
DESCRIPTION	American Welding Society	European Normalization	European Conformity	Technischer Überwachungs Verein	Die Bahn	American Bureau of Shipping	Bureau Veritas	Det Norske Veritas	Germanischer Lloyd	Lloyds Register of Shipping	Polski Rejestr Statkow	Russian Maritime Register of Shipping	Registro Italiano Navale	Romanian Naval Authority

Classification Society									
BV	DNV	GL	LRS	PRS	RMRS	RINA	ANR		
									MIG
-	-	-	-	-	-	-	-	-	CARBOPIPE 70
-	-	-	-	-	-	-	-	-	CARBOPIPE 80Ni
-	-	-	-	-	-	-	-	-	CARBOFIL MnMo
-	-	-	-	-	-	-	-	-	CARBOFIL NiMo1
-	-	-	-	-	-	-	-	-	CARBOFIL 2NiMoCr
-	-	-	-	-	-	-	-	-	INERTFIL 316L
-	-	-	-	-	-	-	-	-	INERTFIL 22 9 3
-	-	-	-	-	-	-	-	-	INERTFIL 25 10 4
-	-	-	-	-	-	-	-	-	NIFIL 625
									TIG
-	-	-	-	-	-	-	-	-	CARBOROD 1A
-	-	-	-	-	-	-	-	-	CARBOROD Ni1
-	-	-	-	-	-	-	-	-	INERTROD 316L
-	-	-	-	-	-	-	-	-	INERTROD 22 9 3
-	-	-	-	-	-	-	-	-	INERTROD 25 10 4
-	-	-	-	-	-	-	-	-	NIROD 625
									MMA
-	3	-	3m	-	-	-	-	-	FLEXAL 60
-	3	-	3Ym	-	-	-	-	-	FLEXAL 70
-	3	-	3Ym	-	-	-	-	-	FLEXAL 80
-	-	-	-	-	-	-	-	-	FLEXAL 90
3YHHH	4YH5	4Y40H5	3YmH5	-	-	4D/4YDH5	-	-	TENAX 35S
3YHHH	4YH5	3YH10	4YmH5	-	-	4YH5	-	-	TENAX 56S
-	-	-	-	-	-	-	-	-	TENAX 56ST
-	-	-	-	-	-	-	-	-	TENAX 88S HR
-	-	-	-	-	-	-	-	-	TENAX 98M
4Y50H5	3YH5	5Y42mH10	-	5Y50HHH	-	-	-	-	TENAX 118M
-	-	-	-	-	5Y50HHH	-	-	-	TENACITO 65R
-	None/4Y69H5	3Y69H5	-	-	3Y69HHH	-	-	-	TENACITO 80
-	-	-	-	-	-	-	-	-	VERTICORD 80
-	-	-	-	-	-	-	-	-	VERTICORD 90
-	-	-	-	-	-	-	-	-	BASINOX 316 L
-	-	-	-	-	-	-	-	-	BASINOX 22 9 3 N
-	-	-	-	-	-	-	-	-	BASINOX EB 25 10 4 N
-	-	-	-	-	-	-	-	-	SUPRANEL 625
									Cored Wires
SA3YMH5	III Y40MS(H5)	3YH5S	3Y40 H5 (+TA3)	-	3Y40S HHH	3YS H5	3Y HHH	-	CITOFILUX R00
-	V Y46MS (H5)	-	4Y40 H5	-	-	-	-	-	CITOFILUX R82
-	IVY55MS H5	-	4Y62S H5	-	-	-	-	-	CITOFILUX R550
-	-	-	-	-	-	-	-	-	CITOFILUX R620
SA-3Y40MHHH	IIIIY40MSH5	3Y40H5S	3Y40SH5	3S/3Y40SH5	3Y/3Y40SH3	-	-	-	FLUXOFIL 14HD
SA-3Y40MHHH	IIIIY40MSH5	3Y40H5S	3Y40SH5	3S/3Y40SH5	3Y/3Y40SH5	3Y40SH5	-	-	FLUXOFIL 19HD
SA4Y46MHHH (UPKV-40)	4Y46MSH5	4Y46H5S	4Y46SH5	-	4Y46SH5	-	-	-	FLUXOFIL 20HD
SA4Y46HHH (UPKV-40)	4Y46MSH5	4Y46H5S	4Y46SH5	-	-	-	-	-	FLUXOFIL 21HD
-	-	-	-	-	-	-	-	-	FLUXOFIL 29HD
SA4YMHHH	IV Y40MS H5	4YH5S	4Y40 SH5	-	-	-	-	-	FLUXOFIL M10
SA4YMHHH	IV Y40MS H5	4YH5S	4Y40 SH5	-	-	-	-	-	FLUXOFIL M10 PG
-	-	-	-	-	-	-	-	-	FLUXOFIL M41
-	-	-	-	-	-	-	-	-	FLUXOFIL M41 PG
4Y 69 MS H5	4Y 69 MS H5	-	4Y 690 MS H5	-	-	-	-	-	FLUXOFIL M42
-	316L	-	316LS	-	-	316 L S	-	-	FLUXINOX 316 PF
UP	DUPLEX	4462	S31803S	-	-	-	-	-	FLUXINOX 22 9 3 L PF
-	-	-	-	-	-	-	-	-	FLUXINOX 625
									SAW Fluxes & Wires
A3YM	IVY42M H5	5Y40M	4Y40M H5	-	5Y40M HHH	-	-	-	OP 121TT/OE-SD3
-	-	-	-	-	-	-	-	-	OP 121TT/OE-SD3 1Ni¼Mo
-	-	-	3Y50M H5	-	-	-	-	-	OP 121TT/OE-SD3 1Ni½Mo
-	-	-	5Y69M H5	-	-	-	-	-	OP 121TTW/OE-SD3 2NiMoCr
-	-	-	-	-	-	-	-	-	OP 121TT/OE-TIBOR 33
-	-	-	-	-	-	-	-	-	OP 132/OE-SD3
-	-	-	-	-	-	-	-	-	OP 132/OE-SD3 1Ni¼Mo
-	-	-	-	-	-	-	-	-	OP 132/OE-SD3 1Ni½Mo
-	-	-	-	-	-	-	-	-	OP 132/OE-TIBOR 33
-	-	-	4Y42M H5	-	-	-	-	-	OP 121TTW/FLUXOCORD 31HD
-	VY69M	6Y69M	-	-	-	-	-	-	OP 121TTW/FLUXOCORD 41HD
-	-	-	-	-	-	-	-	-	OP 121TTW/FLUXOCORD 42
-	-	-	-	-	-	-	-	-	OP 33/OE-316L
-	-	-	-	-	-	2209 M	-	-	OP 33/OE S 22 09
-	-	-	-	-	-	-	-	-	OP 33/OE S 25 10
-	-	-	-	-	-	-	-	-	OP 76/OE-NIFIL 625

Guide to OERLIKON consumable designations for Pipe Laying Applications



2010-927

A selection of key OERLIKON welding consumables for Pipe Laying Applications.

For further details of the complete range consult www.oerlikon-welding.com.

Product Range	Key Features	Main applications
MMA		
TENAX	Low hydrogen (-18) coated C-Mn and low alloy compositions	High toughness joints in structural and low alloy steels
TENACITO	Basic (18) coated, C-Mn and low alloy compositions, low hydrogen, good low temperature toughness. 2.5 and 3.2 mm are double coated giving optimum control for root runs and positional welding	High toughness joints in structural and low alloy steels
FLEXAL	Cellulosic coated, for welding pipes in the vertically down position. Root runs are welded DC-	High toughness joints in pipe steels X42 - X100. Used for root and hot passes as well as filling and capping
VERTICORD	Basic coated, for welding pipes in the vertically down position. Very low hydrogen potential, used DC+, X ray quality deposit	High toughness joints in pipe steels X42 - X80. ISO-V to -40°C
VPM DRY Packaging	Vacuum packaging systems for MMA electrodes, eliminating the need for re-conditioning prior to use	Contains ≈ 3 kg, higher strength alloys, site applications
MAG		
CARBOPIPE	C-Mn & low alloy ferritic steel wires, copper coated, all formats	Specially developed for high toughness pipe welding
TIG		
CARBOROD	C-Mn & low alloy ferritic steel rods, copper coated	Wide range of compositions including higher strength steels
Cored wires		
FLUXOFIL	Flux cored wires, used with mixed shielding gases & CO ₂ . Seamless, coppered, very low hydrogen characteristic. Precision layer wound on baskets	Wide range of compositions including higher strength steels. Excellent for higher hardenability steels. Semi and fully automatic applications
FLUXOFIL M	FLUXOFIL system, metal cored wires	Wide range of compositions including higher strength steels. Excellent for higher hardenability steels. Semi and fully automatic applications
CITOFILUX	Flux cored wires, used with mixed shielding gases & CO ₂	Wide range of compositions including higher strength steels
FLUXOCORD	Flux cored wires for submerged arc welding with OP 121TTW. Seamless, coppered, very low hydrogen characteristic	High productivity joints in structural and low alloy steels. Wide range of higher hardenability steels
SAW Fluxes		
OP 121TT	Agglomerated fluoride basic flux. B.I.3.1. Low hydrogen controlled. Multi-wire, AC/DC. SAW wires: all OERLIKON C-Mn & low alloy grades	High toughness joints in structural and higher strength steels. ISO-V & CTOD tested. High productivity
OP 121TTW	Agglomerated fluoride basic flux. B.I.3.1. Multi-wire, AC/DC. Very low hydrogen controlled, very low impurity / residual elements. SAW wires: all OERLIKON C-Mn & low alloy grades and FLUXOCORD SAW cored wires	Used with higher hardenability OE solid SAW wires and FLUXOCORD wires for high deposition rate welding. High toughness, ISO-V & CTOD tested. High productivity
OP 132	Agglomerated aluminate basic flux, B.I. 1.5. Low hydrogen controlled. Multi-wire, AC/DC. Excellent slag detachability, very stable arc characteristic. SAW wires: all OERLIKON C-Mn & low alloy grades	High productivity joint filling. Reduced joint angles. ISO-V to -40°C & CTOD tested.
DRYBAG /BIGBAG	Vacuum packaging system for OERLIKON SAW fluxes. Variety of formats: 25, 500 & 800 kg	Eliminates flux re-conditioning prior to use even following extended transport or use in high humidity ambient conditions

Note: For full details of the OERLIKON range of welding consumables, consult www.oerlikon-welding.com or the Product Data handbook.

Focus on MMA electrodes



MMA electrodes for Pipeline Laying.

MMA electrodes

The OERLIKON range of MMA electrodes for pipeline welding is comprehensive, covering all pipe grades from the lowest up to API 5L X100.

Cellulosic coated MMA electrodes are used for both downhill and uphill joint filling, with cellulosic MMA for the root pass followed by basic coated MMA electrodes for the fill-cap and, in case of special requirements in terms of joint toughness, and low hydrogen potential fully basic MMA electrodes may be used.

OERLIKON provides a full solution of both cellulosic and basic coated MMA electrodes for all pipeline requirements.

A selection of key products is shown below. A more complete view of the product range is shown on pages 10 & 11 or consult the OERLIKON Consumables product data handbook.

MMA Cellulosic coated range

FLEXAL 60 / FLEXAL 70 / FLEXAL 80

Product Features:

- Good penetration
- Easy arc striking
- Excellent slag removal
- Very good control in all positions
- Designed for root pass welding using DC- polarity and DC+ for the hot, filling and capping passes

MMA Basic coated range

TENAX and TENACITO

Widely used by the pipeline welding industry, typically for the uphill process.

Product Features:

- Low hydrogen content
- High joint toughness and CTOD values
- Excellent all position weldability
- Easy slag removal even from narrow joints

The TENAX range is single coated, while the 2.5 & 3.2mm diameters of the TENACITO range are double coated for maximum arc stability and weld pool control, particularly when welding positional joints.

TENAX 35S

AWS A5.1, E-7018-1H4 conforming to NACE requirements (E-7018-1H4R in DRY packaging).

TENAX 56S

AWS A5.1, E7016-1 H4 which is a basic coated E7016 type specifically designed for root passes, difficult positional welding and repair welding.

TENAX 56ST

Low hydrogen deposit, depositing high toughness weld metal even in high heat input welding procedures, suitable to API X65.

TENAX 88S HR

AWS A5.5, E8018-GH4

Ni and Mo alloyed, to deposit a higher strength level with good joint toughness.

TENACITO 65R

AWS A5.5, E9018 GH4

Suitable to API 5L X80 pipe grades, and API 5L X70 with over-matching requirements, typically a yield stress overmatching 80 MPa is regularly stipulated for offshore pipelines.

TENAX 118M

Suitable for X100 pipe grades, the weld metal attains the required strength while retaining very good levels of toughness. A low heat input procedure is recommended using 3.2mm electrodes with exact control of the interpass temperature.

VERTICORD 80 & 90

Basic coated low hydrogen electrodes for downhill welding, which deliver both high productivity and very good mechanical properties.

Focus on pipe welding applications



Typical Welding Conditions for the Automatic and Mechanised Welding of Pipelines

General information on the process

Welding is carried out using MIG welding heads (bugs) which move around the circumference of the pipe guided by belts, with each bug carrying one or more torch. Systems with torches linked to an external welding clamp are also used in the offshore field. The welding process may be either GMAW or FCAW. A summary of the main features of the mechanised pipeline welding technologies is given below.

Type of weld

- Pipeline circumferential butt welds

Process

- GMAW or FCAW orbital system using 2 or more welding bugs (single torch or double torch)

Positions

- 5G, downhill or uphill
- 2G for offshore J lay

Base materials

- Pipe steels are C-Mn, micro-alloyed types API 5L from X42 to X100 or EN 10208 from L235 MB to L555 MB
- Outer Diameter: 6" to 64" + (150 mm to 1 630 mm+)
- Wall Thickness: 6 mm to 40 mm

Shielding gases

- Root-Hot pass
 - 100% CO₂ (also Ar-CO₂ 50-50)
- Filling passes
 - CO₂-Ar (70-30, 60-40, 50-50) - 20-80 for FCW uphill or for pulsed arc
- Cap
 - CO₂-Ar (60-40, 50-50, 20-80) - 20-80 for FCW uphill or for pulsed arc

Arc characteristic

- CV mode or pulsed arc

Selection of the process is mainly related to the following factors:

1 - Joint preparation

The first selection is the joint preparation, illustrated in the table below.

To maximise productivity and reduce consumable consumption, a narrow joint may be selected for the pipe-end. In order to carry out this machining on site, a special bevelling machine is used. If the pipe end is the narrow type (see 1a/1b) line-up will be done using an internal clamp, without a root gap, in order to make the operation as rapid as possible.

Some typical joint dimensions are shown below. A small reverse 'V' bevel, where the dimensions are labelled as h, β can also be used.

The joint preparation is selected on the basis of the welding process/parameters and shielding gas.

Typical values	
H	1.5 – 2.8 mm
h	0.5 – 1.5 mm
R	1.6 – 6.0 mm
α	1 – 10 for full downhill process, >12 for uphill process
β	30 – 45°
γ	30 – 45°
Width	depending on thickness and other factors



2 - Depositing the Root Pass

The type of weld preparation selected depends mainly on the method chosen for depositing the root pass.

If the root pass is welded from the outside, then the bevel used is a J type (1a). When copper backing is allowed, an internal clamp is used, carrying copper shoes to support the root bead during solidification. When a copper backing is not used for metallurgical reasons, the root pass can be deposited without any support, but at a lower welding speed and using a special root process. The welding position is downhill in both cases.

If the root pass is deposited from the inside, the bevel type selected is a compound 'V' (1b.) and an internal clamp is used with a special device carrying the MIG torches. Finally, if pipe bevelling is not performed on site, i.e. the bevel is the original 'V' type (see 2); line-up is made using a 3-4 mm gap. In this case, the root pass is deposited manually or semi-automatically, generally using either MMA electrodes or solid wire MIG, also metal cored wires or GTAW may be used.

Root technologies

Copper backing allowed

- GMAW
 - Downhill automatic-mechanised 'U' Type Bevel (1a.)

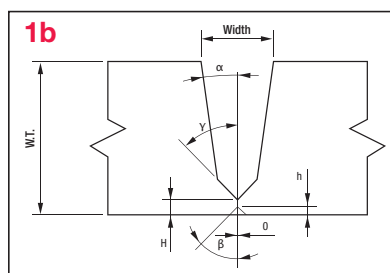
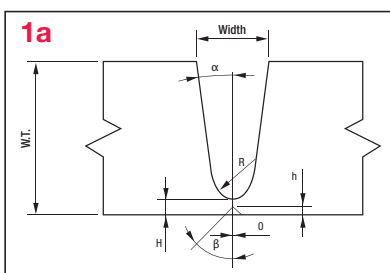
Copper backing not allowed

- GMAW
 - Automatic downhill 'U' Type Bevel
 - Internal welding clamp Compound 'V' Type Bevel (1b.)

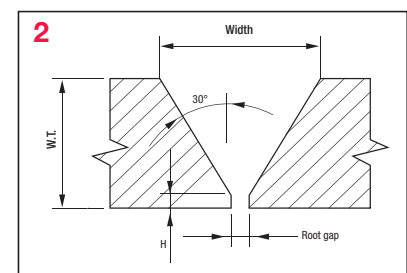
Manual

- SMAW
- GTAW
- GMAW not automatic

Site bevel preparation 'U' type / compound 'V' type



In shop bevel preparation 'V' type



3 - Depositing the Filling and Cap passes

Uphill welding is possible with both bevel types 1 and 2.

The flux cored wire welding process is generally selected using a rutile wire as the fast-freezing rutile slag allows the welding travel speed to be increased resulting in an increased deposition rate for each pass. In the case of a narrow bevel (see 1a/1b) the angle must be sufficient to avoid slag entrapment inside the bevel. Downhill welding is usually selected when using solid or metal cored wires. When downhill welding in the CV Mode, for both root and filling passes, shielding gas mixtures with a high content of CO₂ are generally used. This technical solution results in reduced NDT indications, reduced porosity and eliminates lack of fusion defects.

Filling-cap technologies

uphill - auto/mechanised

- FCAW
 - Rutile Wire (FLUXOFIL and CITOFILUX R types)

downhill - auto/mechanised

- GMAW
 - CARBOPIPE 70 & 80Ni
- FCAW
 - Metal Cored Wire (FLUXOFIL M types)

4 - The OERLIKON range of welding consumables

OERLIKON can supply tailored specialist solutions for any of the processes described. The CARBOPIPE range of solid MIG wires was specially developed for these automatic and mechanised downhill orbital welding applications and the FLUXOFIL range of tubular flux cored wires and rutile and metal cored wires are widely used for on site applications.

Consumables for Automatic/Mechanised Welding



The CARBOPIPE range of solid MIG/MAG WELDING wires for pipelines

General

To fully satisfy the requirements of orbital automatic/mechanised pipe welding, mainly in the downhill position, OERLIKON has introduced a dedicated range of MIG/MAG welding wires - **CARBOPIPE**.

This range of MIG/MAG wires was developed by the Air Liquide Welding centre of excellence CTAS following a comprehensive programme to fully define the current and future requirements of these specialised applications. Comprehensive testing of welding characteristics, mechanical and chemical properties, resulted in this new range of all position wires, specially developed for 5G downhill automatic welding.

Features of the CARBOPIPE range

Raw materials

These wires are produced using selected primary steel from qualified European suppliers with chemical composition controlled within a narrowly defined range. The result is excellent mechanical properties due to the low controlled levels of residual and impurity elements. Microalloyed to meet the special requirements of this industrial segment.

Production

Carbopipe wires are specially produced by ALW using a dedicated dry drawing process and a high adherence coating of constant thickness which reduces the glide force through the liner and the contact tip.

This state of the art controlled drawing process is combined with an exacting tolerance of the wire diameter.

Quality control

In addition to the QMS system, each production batch is tested for:

- Arc stability and feedability

- Raw material chemical analysis
- Weld metal mechanical and chemical properties
- Helix
- Cast is set in the optimal range
- Wire diameter (very low tolerance)

Enhanced Welding Performance in Practise

The combination of raw material selection, production process and quality control for the CARBOPIPE range results in reliably delivering the top performance level required when pipeline welding:

- Excellent arc stability
- Low spatter
- Uniform feeding
- Reduction in peeling and clogged liners
- Reduction in contact tip wear
- Straight wire feeding from the torch giving improved control of the centre-line in narrow joint gaps.
- Reproducible and reliable properties spool by spool

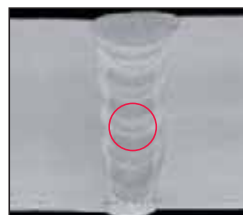
CARBOPIPE 70 and CARBOPIPE 80Ni

CARBOPIPE 70

Chemical composition (typical values, with minimum and maximum values)

Product		Wire composition %											
		C	Si	Mn	P	S	Ni	Cr	Mo	V	Cu*	Al	Ti+Zr
CARBOPIPE 70	Typical	0.080	0.90	1.65	0.008	0.008	-	-	-	-	-	-	-
EN ISO 14341-A: G4Si1		0.06 - 0.14	0.80 - 1.20	1.60 - 1.90	≤ 0.025	≤ 0.025	≤ 0.15	-	≤ 0.15	-	-	≤ 0.02	≤ 0.15
AWS 5.18: ER 70 S-6		0.06 - 0.15	0.80 - 1.15	1.40 - 1.85	≤ 0.025	≤ 0.035	≤ 0.15	≤ 0.15	≤ 0.15	≤ 0.03	≤ 0.5	-	-

When welding downhill in a narrow gap joint, CARBOPIPE 70 is suitable for pipe steel grades up to API 5L X70 even if it is formally undermatching. Strength values in this joint configuration will satisfy those required, while the ductility and toughness of the weld metal remain excellent. The yield stress and UTS are higher than would be anticipated from the all-weld-metal data because of the different welding parameters and conditions in this specialised application.



Macro of welded joint with hardness HV₁₀ indentations and position of the all weld metal tensile specimen.



Typical mechanical testing results for CARBOPIPE 70 in API 5L X70

- Weld Metal Hardness: **max 250 HV₁₀**
- Weld Metal c/l Impact test (-30°C) ~ **100 J**
- Weld Metal CTOD (-10°C) **0.4 - 0.6 mm**

- Longitudinal Tensile test (specimen d. 6.0 mm at the weld metal c/l):
 - Yield strength: **550 - 640 MPa**
 - Tensile strength: **640 - 710 MPa**
 - Elongation: **>22%**

CARBOPIPE 80Ni

Chemical composition (typical values, with minimum and maximum values)

Product		Wire composition %											
		C	Si	Mn	P	S	Ni	Cr	Mo	V	Cu ⁺	Al	Ti+Zr
CARBOPIPE 80Ni	Typical	0.080	0.65	1.70	-	-	0.93	-	-	-	0.16	-	-
AWS 5.18: ER 80 S-G		The composition shall be reported, the requirements are those agreed to by the purchaser and supplier											

CARBOPIPE 80Ni is the best solution in the following cases:

1. When improved toughness at low temperatures is required, to -60°C
2. When a formal overmatching with API 5L X70 is required
3. For API 5L X70 very high productivity and/or when a low cooling rate process are used (multi-welding heads and multi torch or J-Lay 2G position)
4. For API 5L X80 welding in 5G narrow gap.

Typical mechanical testing results for CARBOPIPE 80Ni in API 5L X70

- Weld Metal Hardness: **max 250 HV₁₀**
- Weld Metal c/l Impact test (-40°C) ~ **180 J**
- Longitudinal Tensile test (specimen d. 6.0 mm at the weld metal c/l)
 - Yield strength: **590 - 670 MPa**
 - Tensile strength: **690 - 740 MPa**
 - Elongation: **>22%**
- Weld Metal CTOD (-10°C) **0.4 - 0.6 mm**

OERLIKON solid MIG/MAG wires for pipelines		
Steel grades	CARBOPIPE 70	CARBOPIPE 80Ni
API	ER 70S-6	ER 80S-G
X 42	X	-
X 46	X	-
X 52	X	-
X 56	X	-
X 60	X	-
X 65	X	X
X 70	(X) Not 2G ! 5G 'formal' undermatching	X
X 80	-	(X) 5G only

Packaging

CARBOPIPE wires can be delivered to order with a wide range of spools and packaging, as follows:

Diameter mm	Spool	Surface	Technology	Weight (net) kg
0.90	S 117	Copper	PLW	2.5*
1.00	S 117	Copper	PLW	2.5*
1.20	S 117	Copper	PLW	2.5*
0.90	S 200	Copper	Random	5
1.00	S 200	Copper	Random	5
1.20	S 200	Copper	Random	5
0.90	SD 300 K	Copper	Random	15*
1.00	SD 300 K	Copper	Random	15*
1.20	SD 300 K	Copper	Random	15*
1.00	B 300	Copper	PLW	16
1.00	B 300	Copper	PLW	16

* Maximum value, by special request the weight per spool can be reduced, e.g. 1,5kg for S 117 or 12kg for S 300

Focus on flux and metal cored wires



The OERLIKON range of flux cored wires for pipeline welding is comprehensive and covers all applications, while providing a wide variety of options via both the FLUXOFIL and CITOFILUX product ranges .

OERLIKON cored wires are characterised by very good slag removal and a smooth weld bead surface which is deposited without undercut into the base metal. These wires are particularly suitable for fully mechanised orbital welding and can be welded in all positions with a single set of welding parameters.

FLUXOFIL cored wires are manufactured using a process similar to the production of a solid wire and results in a seamless flux-cored wire with a number of product advantages:

Low Hydrogen Potential

FLUXOFIL wires have a hydrogen potential of ~4 ml H₂ per 100 g deposited weld metal when used straight from the carton or store with no re-conditioning. This is very low and can be considered by the welding engineer to be an excellent safety factor. A reduction in pre-heat may also be possible meaning more cost effective fabrication.

Feeding Characteristics

The solid sheath provides uniform mechanical properties around the wire circumference and hence the wire feeding is smooth without kinking or spiralling. The production annealing ensures close control of the wire hardness and this in turn reduces wear of the wire feeder and cable hose assembly.

Stability in Welding

FLUXOFIL wires are coppered in exactly the same way as solid wire. Current transfer from the torch contact tube to the wire is thus improved.

CITOFILUX cored wires were recently introduced to the OERLIKON product range, manufactured using a folded strip technique. This range of wires includes, rutile, basic and metal cored wires, bringing another balance of operating characteristics, mechanical properties and deposition rate to the OERLIKON range of cored wires, to meet all fabrication requirements.

Deposition rate

CITOFILUX rutile cored wires feature enhanced filling of the flux core, which results in increased current carrying capacity, thus increasing welding speed and hence deposition rate.

Key products

A selection of key products is shown below. A more complete view of the product range is shown on pages 10-11 or consult the OERLIKON Welding Consumables Product Data handbook for full details.

■ FLUXOFIL 20HD

A rutile flux cored electrode filler wire for gas shielded welding with mixed gases, e.g.80%Ar/20%CO₂. The higher core filling ratio results in increased welding speeds and deposition rate. Used in all positions including vertically up and vertically down. FLUXOFIL 20HD deposits C-1.2%Mn-0.9%Ni steel weld metal with optimised operating characteristics and deposit toughness down to -40 °C, in both the as welded and stress relieved conditions and in conformance with NACE requirements.

■ FLUXOFIL 21HD

Rutile flux cored electrode filler wire, similar in all respects to FLUXOFIL 20HD, but used with CO₂ shielding gas.

■ CITOFILUX R82

Rutile flux cored electrode filler wire for gas shielded welding in all positions with mixed gases, e.g.80%Ar/20%CO₂. CITOFILUX R82 deposits C-1.4%Mn-0.8%Ni steel weld metal with optimised operating characteristics and deposit toughness in the range -40 °C to -50 °C, in both the as welded and stress relieved conditions and in conformance with NACE requirements.

■ CITOFILUX R550

Rutile flux cored electrode filler wire for gas shielded welding in all positions with mixed gases, e.g.80%Ar/20%CO₂. CITOFILUX R550 deposits C-1.0%Mn-1,5%Ni steel weld metal with deposit toughness down to -50 °C, in both the as welded and stress relieved conditions.

■ CITOFILUX R620

Rutile flux cored electrode filler wire for gas shielded welding in all positions with mixed gases, e.g.80%Ar/20%CO₂. CITOFILUX R620 deposits C-1.3%Mn-0.4%Ni steel weld metal with deposit toughness in the range -50 °C to -60 °C, in both the as welded and stress relieved conditions.

Consumables for clad and duplex pipeline welding



STAINLESS STEEL CLAD PIPES

■ MMA

The BASINOX range of basic coated manual metal arc welding electrodes is designed to enable the diversity of stainless steels – plates, pipes, tubes, castings and forgings – to be welded both to themselves and to each other. Smooth operation in all positions with minimal spatter and near self-releasing slag for excellent weld bead appearance and profile. The BASINOX range also has a proven resistance to both weld start and weld bead porosity giving high radiographic integrity. This makes these electrodes particularly suitable for the most critical applications.

The BASINOX range of MMA welding electrodes is as follows: 308L, 308LP, RS308L, RS308H, 347, RS347, 316L, 316LP, RS316L, 317, 318, 309L, RS309L, 309MoL, RS309Mo, 310, RS310 & 904L.

The range of applications is as diverse as the comprehensive range of electrodes.

■ MIG/TIG

A comprehensive range of OERLIKON INERTFIL and INERTROD wires for all applications, e.g. 308L, 347, 316L, 309L & 312.

■ FCW

A comprehensive range of FLUXINOX stainless cored wires for applications e.g. FLUXINOX positional e.g. FLUXINOX 316L-PF applications. Including alloys 308L, 308H, 347, 307, 316L, 318, 309L, 309MoL, 22.9.3L, 310, and 625.

■ SAW

OP 33 is a special semi-basic agglomerated flux with a basicity index of 1.8. It is used for the welding of stainless and heat-resisting steels. In respect to the carbon content of the weld metal, OP 33 is neutral. Typically used with AWS A5.9 grade 300 series wires, e.g. OE-316L, OE-308L, OE-309LMo.

DUPLEX AND SUPER DUPLEX STAINLESS STEELS

Duplex stainless steel (e.g. W.No. 1.4462) is used for pipe lines and matching consumables are available:

■ MMA

BASINOX 22.9.3N and EB 25.10.4 are MMA electrodes depositing Cr-Ni-Mo-N duplex stainless steel weld metal, highly resistant to intergranular pitting and stress corrosion in the presence of hydrogen-containing aqueous solution or wet gases.

■ MIG/TIG

INERTFIL/INERTROD 22.9.3 and 25.10.4 are solid wires depositing duplex stainless steel weld metal.

■ FCW

FLUXINOX 22.9.3L, 25.10.4 and 22.9.3L-PF for positional welding of duplex stainless steels.

■ SAW

OE-S22 09/OP 33 is used for the high deposition rate welding of duplex stainless steels.

NI ALLOY CLAD PIPES (625 AND 825)

■ MMA

SUPRANEL 625 is used for the manual welding of alloys 625 and 825.

■ MIG/TIG

NIFIL/NIROD 625, MIG and TIG wires.

■ SAW

Combination OP 76/OE-NIFIL 625.

Submerged arc wires and fluxes for double and triple jointing



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

Toughness

Consistent CVN and CTOD even at deep sub-zero temperatures through the right combination of wire and flux.

Weldability

As well as the consistent ability to deliver the highest levels of mechanical properties, OERLIKON fluxes have stable arc running characteristics together with excellent slag detachability.

Technology

OERLIKON submerged arc wire specifications are designed to incorporate the state of the art technology and hence the highest levels of weld metal toughness are generated for the alloy type. In addition, as new steels and applications are developed so special wires are designed and introduced to the range.

Low Hydrogen Potential

OERLIKON fully basic fluxes and semi basic SAW fluxes are designed and manufactured to give a low hydrogen potential under the most demanding conditions. This minimises the risks

of weld metal hydrogen cracking. These flux characteristics are supported by the OERLIKON DryBag packaging system, which is particularly relevant for use in high humidity climates.

Reproducibility

Consolidating 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.

Productivity

OERLIKON can input into the optimum choices of the number of wires, head geometry and wire size for a given application, in order to optimise productivity in a given application. Improved deposition rates can be attained without sacrificing weld metal toughness, operability or bead profile.

Quality

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

Key products

A selection of key products is shown below.

A more complete view of the product range is shown on pages 10-11 or consult the OERLIKON Welding Consumables Product Data handbook for full details.

Submerged Arc Fluxes

■ OP 121TT

OP 121TT has achieved worldwide recognition by the offshore oil and gas industry. It is an agglomerated flux with high basicity, (basicity index = 3) FB type, and is used for joints of high structural integrity where excellent sub-zero Crack Tip Opening Displacement (CTOD) fracture toughness is required. OP 121TT is capable of generating such properties at high deposition rates using multi-wire welding, giving the potential for high levels of welding productivity. OP 121TT has a low hydrogen potential, HDM < 5 ml H₂ per 100 g deposited weld metal, with excellent recirculation characteristics in automatic systems, where low hydrogen levels are readily achieved.

■ OP 121TTW

OP 121TTW is an agglomerated flux with high basicity, (basicity index = 3), FB type, with a very low diffusible

hydrogen potential, of < 4 HDM. It is used for welding thicker sections of more hardenable steels. OP 121TTW is particularly suitable in combination with the OE FLUXOCORD range of cored wires for submerged arc welding.

■ OP 132

OP 132 is an aluminate-basic type flux characterised by its excellent current carrying capacity, even at very high local currents the welding process remains stable. The weld seam shows good wetting, a regular flow and a broad, flat profile with excellent slag detachability even in narrow joint preparations.

Submerged Arc Wires

The OERLIKON range of submerged arc wires contain low levels of impurity and residual elements and are optimised for joint toughness at the full range of strength levels.

■ **Solid wires:** OE-SD3, OE-SD3 1Ni ¼Mo, OE-SD3 1Ni ½Mo, OE-TIBOR 33 for "punch through" joint completion.

■ **Flux cored wires** for SAW welding (FLUXOCORD range) to maximise productivity in combination with OP 121TTW flux : FLUXOCORD 31HD, 41HD & 42.

Focus on Productivity: Double and Triple Jointing



There are a number of routes to enhance the deposition rate of the submerged arc welding (SAW) process and increase overall fabrication productivity. These range from methods requiring low investment, such as a reduction in wire diameter, the use of flux cored wires up to process modifications involving capital investment in multi-wire and narrower gap welding.

This overview of methods for enhancing the deposition rate of the submerged arc process when welding pipe steels is intended to act as a guide to the main choices available in different fabrication scenarios.

Air Liquide Welding has a detailed knowledge of the product and process variants and there are OERLIKON submerged arc wires, fluxes and equipment with proven track records in gaining full benefit from high deposition process routes.

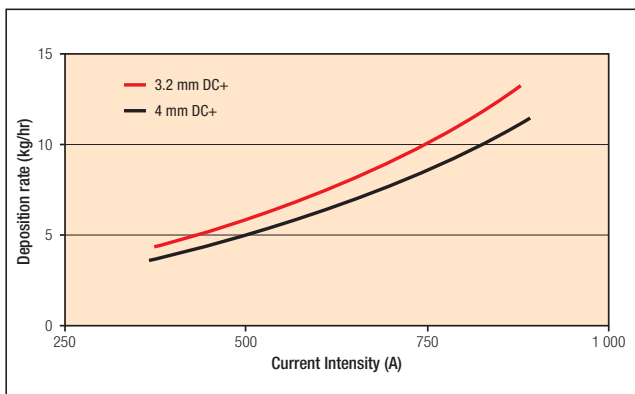
The number of combinations of process and welding consumables, polarity of welding current and weld preparation is extensive and the examples chosen are illustrative of proven techniques. Contact OERLIKON for further details.

1 - Submerged arc welding with Solid Wire

The Effect of Single Solid Wire Diameter

By decreasing the wire diameter used, at constant current, the current density is increased and hence the deposition rate is increased. At 450 A, current densities for SAW wires in the size range 2.0 - 4.0 mm are as follows:

SAW Wire Diameter mm	Current Density at 450 A A/mm ²
2.0	143
2.4	99
3.0	64
3.2	56
4.0	36

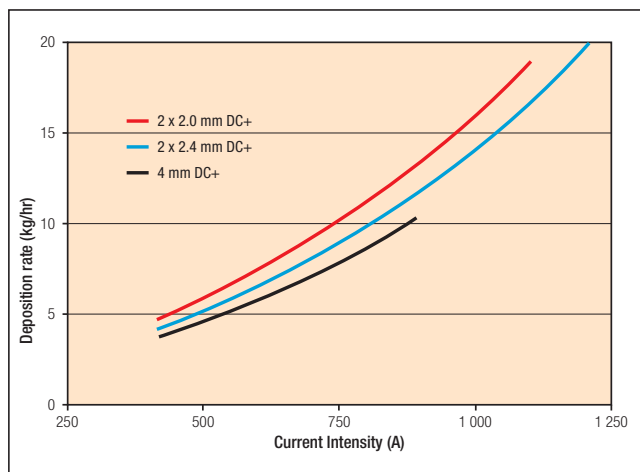


By decreasing the SAW solid wire diameter from 4.0 mm to 3.2 mm and welding at 700 A, the deposition rate is increased from 8 kg/hr to 9 kg/hr with very low capital expenditure and operator training.

Single Head: Single Wire & Twin Wire Welding

The effects of welding current on deposition rate are shown below. When SAW welding with a single solid 4 mm SAW wire at 700 A the deposition rate is 8 kg/hr of weld metal.

Twin wire welding uses two smaller diameter submerged arc welding wires, generally 2.0 mm or 2.4 mm diameters, which are fed through the same contact tube using a single control panel and a single power source. Using twin 2.4 mm wires at the same current increases the deposition rate to 9 kg/hr of weld metal and using 2.0 mm wires at the same current further increases the deposition rate to 10 kg/hr of weld metal.





The process advantages of twin wire welding are as follows:

- Higher currents of ~900 A can be used combined with increased welding speeds
- Mechanical properties are retained, no overall change in arc energy
- Excellent weld bead shape and appearance
- Very low capital investment
- Can be used in hybrid-twin and twin-tandem configurations

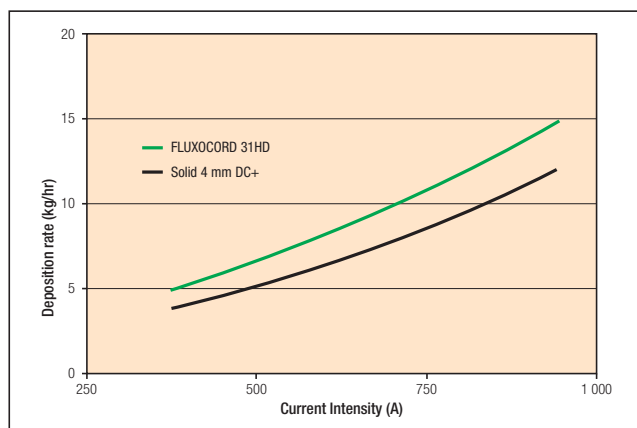
Against the reference of a single solid 4 mm SAW wire, deposition rate improvements can be achieved by using twin 2.4 mm or twin 2.0 mm SAW wires. At 900 A, the deposition rate of the 2.4 mm twin arrangement is 12 kg/hr and for the 2.0 mm twin arrangement is 13 kg/hr.

2 - FLUXOCORD flux cored welding wires for SAW

OERLIKON FLUXOCORD is a range of flux cored wires specifically designed for use with the SAW process. These seamless wires are manufactured using the OERLIKON FLUXOFIL process and are supplied copper coated in either standard reel or bulk packaging formats. The deposition rate of the SAW process can be improved considerably using these flux cored wires with no capital expenditure required for new equipment.

- Increased deposition rate by ~25% when used with OERLIKON OP SAW fluxes
- Excellent mechanical properties, at least as good as the equivalent solid wire

- Flexibility of alloying regime, wide range of compositions available
- Very limited operator training required, uses standard SAW equipment
- Flexible: used single, tandem and twin wire
- Seamless, with reduced sensitivity to atmospheric conditions

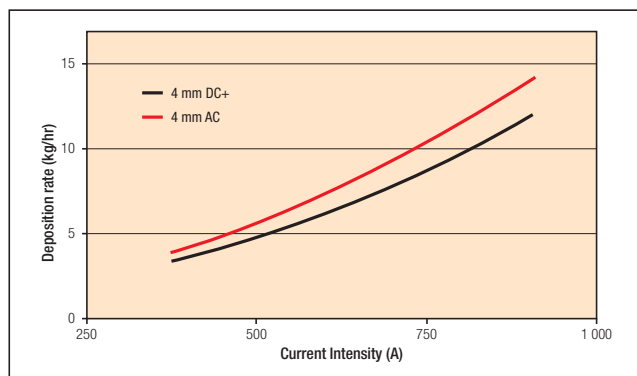


When SAW welding single wire welding with 4 mm diameter wire at 700 A, replacing a solid OE-SD3 wire with FLUXOCORD 31HD will increase the deposition rate from 8 kg/hr to 10 kg/hr.

3 - The Effects of Polarity

An increase in deposition rate of nominally 25% is obtained by using AC polarity rather than DC+ polarity, regardless of wire diameter.

Tandem wire SAW welding with a DC+ lead wire, AC trail wire configuration with a deposition rate of ~15 kg/hr of weld metal more than doubles the 7 kg/hr deposition rate of single wire DC+ SAW welding.



Product Packaging Welding Consumables



MIG/MAG wires (solid and FCW)



B 300

Spools

- S 117 (2.5 or 1.0 kg) - PLW
- S 200 (5.0 kg)
- SD 300K 15 kg - reinforced
- B 300 (16 kg) - PLW



SD 300K



S 117



S 200

TIG

Rods

- 1.6, 2.0 & 2.4 mm diameter in 1 m length
- Full range of compositions
- Alloy grades are coin stamped
- Bright finished
- Fully certificated



2006-940



2006-943

SAW Fluxes

Sacks

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

MMA

Standard Packaging

- Reliable protective packaging for most applications
- 3 packets per outer carton
- Packet weight ~5 kg



2006-937

Vacuum Packaging

- No re-conditioning required before use
- No quivers or holding ovens are required
- Ideal for on site applications
- Simplified QA procedures

VPMD

- Pack contents ~3 kg
- Supplied in outer cartons ~15 kg



2009-012

Metal Can

For FLEXAL and VERTICORD electrodes



2008-643

SAW Wires

Spools

- B 450 (25 kg)
- B 570 (90 kg)
- 100% recyclable



2006-936



2010-269

Drums

- 300 kg
- 700 kg



Dedicated Offshore Packaging

SAW flux in DRYBAG and SAW wire in foil, supplied in polymer lined wooden crates containing corrosion inhibitors.

Variants of packing solutions are available on request to suit specific requirements.

DRYBAG



Absolute watertight control for submerged arc fluxes. DRYBAG an innovative packaging system from OERLIKON reduces costs, time and energy.

DRYBAG delivers SAW flux to the fabrication site with the same low moisture level as during packing in the production plant. The SAW flux is ready for use on site in the low hydrogen condition, straight from the DRYBAG with no re-conditioning.

DRYBAG : **a packaging solution from our R&D teams**

The research and development and the production departments of the Air Liquide Welding group, have developed an innovative new packaging system for OERLIKON submerged arc welding fluxes: DRYBAG a fully moisture proof packaging system making any requirement for flux conditioning unnecessary, resulting in high-quality welds even in the most hostile ambient conditions.

DRYBAG is made of an advanced composite foil, specially developed for vacuum packaging applications. For enhanced security, a partial vacuum is produced in the DRYBAG during the packaging of the welding flux. The low-pressure serves as an indicator for the security of the packaging. Oerlikon DRYBAG offers similar levels of security as packaging in metal drums, but is more cost effective. DRYBAG is available in 25 kg or larger, 500 or 800 kg formats. The 25 kg-DRYBAG can be stored, transported and palletised in the same way as regular 25 kg bags and the larger formats have an integral pallet.

Advantages

- No risk of moisture ingress, even during transcontinental or maritime transport and following long-term storage in adverse conditions
- No risk from ambient humidity, even in extreme climatic conditions
- No need to re-condition the flux before use
- This new packaging solution enables fabricators to reduce the risk of hydrogen induced cracking
- No requirement for detailed control of temperature or humidity during storage, thereby saving time and energy costs
- Improved, simplified handling and storage compared to existing solutions using metal drums, again reducing costs

OERLIKON : Satisfied customers are our primary objective

Main off-shore pipeline contractors choose OERLIKON DRYBAG OP 121TT and OP 132 submerged arc fluxes



For storage of the submerged arc flux at sea DRYBAG packaging is the chosen solution to avoid moisture pick up. Also for SAW-wire, special packing in aluminium foil has been developed to avoid corrosion. Using these solutions low hydrogen welding consumables during welding are assured.

Arc equipment

MMA electrode power sources



2570-07

MMA electrode power sources

OERLIKON propose a wide range of equipment for MMA welding. This is a selection of units for on site applications in all conditions.



CITOARC 1800 HPF

2009-092



- Very light and portable unit for maintenance
- Ultra flexible for light duty and flexible finishing applications
- Possibility to weld with very long primary cable (up to 70 m)

CITOARC 2200i VRD

2009-055



- Portable 3 phase unit for heavy applications and maintenance operations
- Generator compatible
- Built-in Voltage Reduction Device for higher security, for welding all types of MMA electrodes, including cellulosic
- Inverter technology

CITOARC 1900 EXPERT

- CITOARC 1900 EXPERT offers top welding performance with the possibility to adjust both the Arc Force and Hot Start parameters.
- Maximum safety is ensured with the Voltage Reduction Device (VRD) making this equipment suitable for demanding site environments.
- This unit is designed for heavy duty use, for welding all types of MMA electrodes, including cellulosic.
- Microprocessor controlled, the CITOARC 1900 EXPERT offers excellent arc stability, even with fluctuating input voltage.
- The built-in Power Factor Correction (PFC) module enables welding with 160 Amps at 50% duty cycle at 40 °C ambient temperature with a primary consumption of only 16A.
- The CITOARC 1900 EXPERT features a digital parameter display.
- Generator compatible, may be used with long length cables, up to 70m in 2.5 mm² section).
- CITOARC 1900 EXPERT is very versatile and when TIG welding, the slope up and slope down times can be set by the control panel.



2010-066

CITOARC 3500i

- Multi-process (MMA, Gouging, TIG DC, MIG) inverter unit
- Welding MMA electrodes up to Ø 6.3 mm
- MIG welding with the DV 4004 wire feeder option
- CC/CV 3phase unit
- Weighing only 29 kg



2006-782



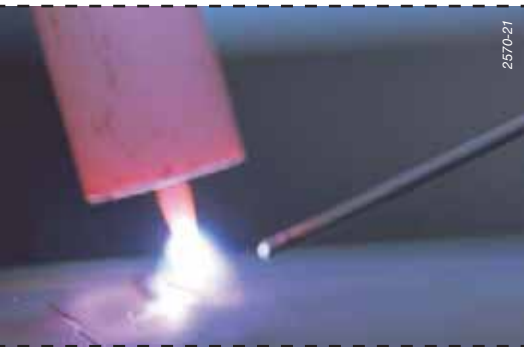
2009-500

CITOROD 6500 XT

- For the heaviest duty applications including arc air gouging
- Thyristor technology
- Multiprocess (MMA, Gouging, TIG DC, MIG) - 3 phase unit
- Possibility of MIG/MAG welding using DEVIDARC an autonomous wire-feeder

Technical specifications:	CITOARC 1800 HPF	CITOARC 1900 EXPERT	CITOARC 2200i VRD	CITOARC 3500i	CITOROD 6500 XT
Primary					
Power supply	230 V single-phase	230 V +/-20 % single-phase	400 V three-phase	400 V three-phase	230 - 400 V three-phase
Effective consumption	15 A	16 A	9 A	28.5 A	102 - 60 A
Secondary					
Open circuit voltage	44 V	67 V (14 V rest voltage)	105 V (14 V rest voltage)	91 V	75 V
Welding current	10 - 180 A	5- 160 A	5 - 220 A	5 - 350 A	10 - 630 A
Duty cycle 10 min. cycle (at 40 °C)	180 A at 20%	160 A at 40% 150 A at 60% 130 A at 100%	220 A at 35%	350 A at 35%	630 A at 35%
Diam. Electrode	MMA	1.6 to 4.0 mm	1.6 to 4.0 mm	1.6 to 6.0 mm	1.6 to 6.3 mm
	Gouging	-	-	Up to 6.3 mm	Up to 10 mm
Dimensions (L x W x H)	170 x 320 x 395 mm	205 x 345 x 450 mm	250 x 470 x 450 mm	525 x 300 x 390 mm	1000 x 600 x 600 mm
Net weight	6.6 kg	9 kg	19 kg	29 kg	176 kg

TIG installations



2570-21

OERLIKON high-performance TIG machines are designed for on-site durability and premium quality results. This inverter range equips welders for a wide diversity of activities in both regular and high-tech applications.



CITOTIG

Optimised performance and advanced functionality:

- CITOSTEP double current level function, allows the power input to be changed without interruption when welding
- Synergic pulse function, for ease of setting the pulsed current parameters
- Storage facility for welding parameters
- Reliability designed in with an efficient isolated cooling system which prevents dust and small metal particles from penetrating the machine interior
- Optional low voltage OCV with Voltage Reduction Device available
- Generator compatible

The DC sets are used for TIG welding stainless and structural steels and have the flexibility to weld with all types of MMA welding electrodes, with excellent arc characteristics.



2011-101



2011-103



2011-131

Technical specifications:	DC welding		
	CITOTIG II 200 DC	CITOTIG II 300 DC (W)	CITOTIG II 400 DC W
Primary			
Power supply	230 V single-phase	400 V three-phase	
Consumption	15 A	6.6 A	11 A
Secondary			
Open circuit voltage	80 V	80 V	80 V
Welding current	5 - 200 A	5 - 300 A	5 - 400 A
Duty cycle 10 min. cycle (at 40°C)	200 A at 30%	230 A at 60%	285 A at 60%
Diam. Electrode	1.6 to 4.0 mm	1.6 to 5.0 mm	1.6 to 6.0 mm
Other			
Dimensions (L x W x H)	410 x 180 x 390 mm	500 x 180 x 390 mm 500 x 180 x 650 mm in W version	500 x 180 x 650 mm
Net weight	15 kg	22 kg / 32 kg in W version	33 kg
Cooling unit	No	Yes in W version	Yes

The CITOSTEP function in the CITOTIG range

With the CITOSTEP function, two current levels can be chosen, the welding current and the basic current. This facilitates the change from one to the other by rapidly pressing the torch trigger. The CITOSTEP function can be used to adjust heat input momentarily, to change welding positions or to replenish the filler metal supply without having to stop welding.

Accessories

This very high-tech range of TIG equipment has all the product features required by the most skilled welders for the widest range of demanding applications. For maximum functionality, there is a full range of accessories, such as hand- or foot-operated remote control units and trolleys.

MIG/MAG installations

1877-48



2006-788

CITOMIG 500 XP

Optimised performance and advanced functionality:

With the CITOMIG range OERLIKON welding sets utilise highly developed and carefully applied technology.

This robust and reliable range will always meet the challenge, even under heavy duty conditions.

CITOMIG sets are available in air or water, compact or separate versions, meeting every need and offering the following advantages.

Product features and advantages:

- Three-phase, dual-voltage power supply allowing connection to any type of three-phase power supply
- Digital parameter display (plate thickness / current / wire speed)
- 4 feed-rollers unit with speed regulation system providing constant wire feed
- "Assisted adjustment" mode taking into account the thickness to be welded
- "Spatter reduction" system based on coil saturation after the striking phase
- 2T/4T/spot/intermittent welding modes for an optimised operating procedure
- Ventilation automatically operates when required
- 2 coil positions
- Plug-in harnesses on generator side
- Fully sheathed and shielded harness for greater robustness
- Ultra-compact wire-feed unit designed for restricted access
- Wire-feed unit delivered with the possibility of wire speed adjustment and equipped with gas purge

CITOPULS II

Digital technology for advanced welding installations

CITOPULS II is the only product on the MIG/MAG welding market offering superior quality welding and advanced welding processes with a simple interface. Moreover DIGIPULS II is designed in a modular system for a better fit with the users' requirements.

- Superior quality welding and advanced processes and features
- Fully digitally controlled inverter: for process repeatability and consequently higher welding quality and simpler regulation
- In Synergic mode, more than 100 synergies are available
- Soft switching inverter (increased efficiency of the power source)
- Full range of processes
 - Standard MIG/MAG
 - Pulsed MIG/MAG
 - Speed Short Arc™ (for high quality thin sheet welding & root pass)
 - Spray Modal™ (special for high quality welding of aluminium)
 - Cold Double Pulse (producing very high quality welds on thin material)
 - MIG brazing
 - MMA coated electrodes
- Powerful installation up to 420 A at 60%
- Storage of 100 welding programs (with expert wire feeder DVU P500 or advanced remote control RC JOB)
- Parameter locking with a digit code (with expert wire feeder DVU P500 or advanced remote control RC JOB). When this function is activated, the welder can still fine-tune the parameters in a +/- 20% range
- A user interface (Power source and wire feeder) designed for a really easy to use front panel
- A modular concept for a better fit with the users' requirements

Specify and build your installation:

- Power sources
- Wire feeders
- Cooling unit
- Harnesses (up to 50 m for on site applications)
- Trolleys for the installation and the wire-feeder
- Remote control
- Torches (standard, with potentiometer, push-pull, automatic...)
- More benefits for the user
- Small machine for easier access
- Light installation (37 kg for the power source)
- Compatible with motor generators
- A powerful 4-wheel feeder unit with drive rollers as standard



2010-901_net



Product Features for Pipe Laying Applications

- Suitable to be driven by a diesel engine
- Readily interfaced with the orbital system control panel
- Able to work with orbital system welding head
- Separate cooler for torches is optional

MIG/MAG installations



CITOWAVE MXW

Product features and advantages:

Same as the CITOPULS range with in addition:

- Advanced torch "DIGITAL": a range of ergonomic torches with the possibility on the handle to - select the program number - adjust the wire feed speed - adjust the arc length
- More processes: Soft current, Pulsed, SSA, SSP, SM, CDP, MIG brazing, MMA, and PR Spray
- More memory: 153 welding programs on CITOWAVE MXW for all welding applications. The power sources also allow memorisation of 100 programs, selectable from the wire feeder, remote control and CITORCH M E family
- Control of aluminium welding (Spray Modal™): special welding transfer which provides reduced porosity and increases the penetration

- More controls: parameters monitoring, indication of defects, parameter blocking on several levels, printing, 99 programs, calibration...
- More cycles: 2T / 4T / Spot weld / Cold Double Pulse current (CDP)

Technical specifications:	CITOMIG 500 XP	CITOPULS II 420	CITOWAVE 400	CITOWAVE 500
Technology	Thyristor	Inverter		
Primary power supply (3 phase)	230/240/380/400 V	400 V		
Primary consumption @ I max	50 A (400 V)	35 A	35 A	45 A
Welding current	16 A - 480 A	20 A - 420 A	20 A - 400 A	20 A - 500 A
Duty cycle 10 min. cycle (at 40°C)	480 A @ 50%	400 A @ 60%	400 A @ 60%	500 A @ 60%
Suitable wire diameter	0.8 to 1.6 mm			

Process advantages for a perfect assembly:

This new generation of power sources provides new welding methods able to meet quality and productivity levels in response to the needs of the pipe laying industry.

Process	Definition	Customer advantages	Power source
Speed Short Arc™ (SSA)	The Speed Short Arc™ allows a high travel speed due to a rigid arc and a cold regime. It is very effective for welding thin steel plates, working in position and in closed angle and filling bevels. The SSA™ is used for short circuit welding though the normal globular regime travel speed domain.	<ul style="list-style-type: none"> ■ Increase in travel speed ■ Reduced distortion (thin steel sheets) ■ Suited to welding in position ■ Tolerance and usability 	CITOWAVE CITOPULS II
Soft Silence Pulse™ (SSP)	The Soft Silence Pulse™ is a quieter pulsed mode mainly intended for stainless steel welding applications. The SSP™ produces a softer but very stable arc with good wetting of the weld bead. This waveform significantly reduces spatter and gives a very fine appearance to the weld bead.	<ul style="list-style-type: none"> ■ Reduction of noise ■ Good wetting of the weld bead ■ Reduction of spatter ■ Good weld bead appearance 	CITOWAVE
Cold Double Pulse™ (CDP)	The Cold Double Pulse™ produces very high quality welds on thin material while avoiding distortion. CDP™ gives a TIG appearance to the weld and is very effective on very thin aluminium or stainless steel sheet (< 2 mm). The operating technique is made easier due to good control of the weld pool even on badly-prepared sheets. This sequencer mode automatically chains hot arc and cold arc regimes together.	<ul style="list-style-type: none"> ■ Effective on thin sheets ■ Reduces distortion ■ Easy operating technique ■ TIG appearance weld bead 	CITOPULS II CITOWAVE

SAW power sources and welding heads



STARMATIC power sources

- 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.



Welding head

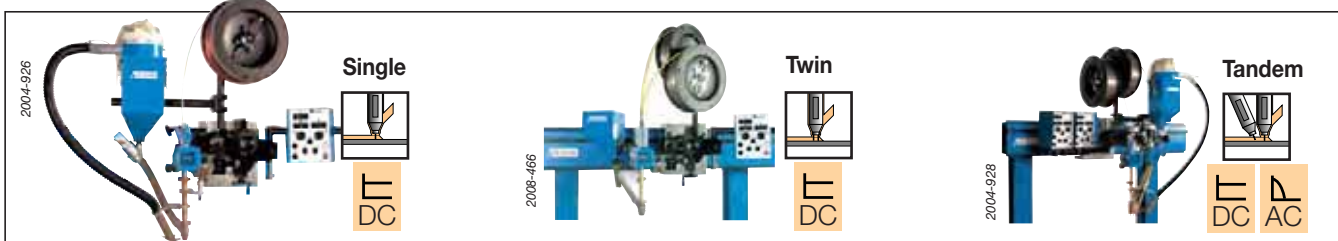
Standard applications SUBARC 5

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



Special applications

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



SAW equipment & 3A welding system



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



3A WELDING SYSTEM a new generation of mobile console control device

The 3A Welding System plug & play Mobile Console gives the operator complete mobility and permits the management of both machine and process. This new generation interface is easy to use and operators are rapidly able to program the machine efficiently. The multipurpose 3A welding system concept is designed for all arc welding processes, and the equipment remains upgradable with the open architecture.



Advanced mobile console

- Centralised console
- Mobile plug & play system
- User friendly-interface

Automatic machine management

- Process management
- Machine cycle control
- Integrated peripherals

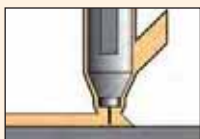
Architecture based on new concept

- Modular and flexible solutions
- Full digital control
- Ready for networking and communication

Mobile console: browsing on the screens with a graphic representation of the machine.

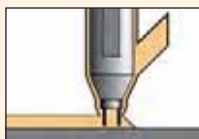


SAW head configurations for 3A welding system



Single wire

1 300 A* 100% DC+



Twin arc

1 300 A* 100% DC+



Tandem arcs

1 300 A* 100% DC+
1 000 A 100% AC



Tandem hybrid

1 300 A* 100% DC+
1 000 A 100% AC



Tandem twin

1 300 A* 100% DC+
1 000 A 100% AC

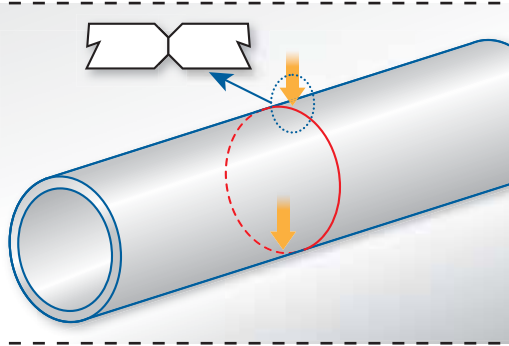


Tandem powder

1 300 A* 100% DC+
1 000 A 100% AC

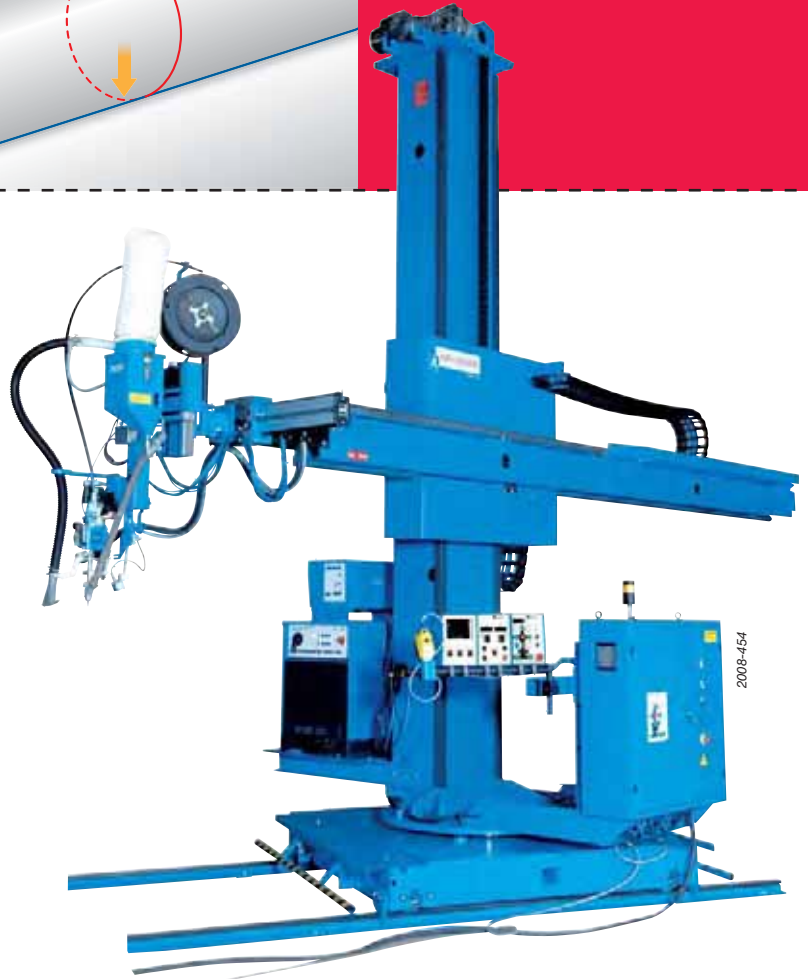
* Maximum current with single power source, possibility to connect power sources in parallel

SAW Double jointing Column and Boom Solutions



Column & Boom for longitudinal or circumferential welding

- Fixed or Mobile Based Column & Boom depending on the number and arrangement of the workstations
- Height depending on maximum pipe diameter
- Wire spools located on the other end of the boom
- Cable chain on arm and column
- Boom movement range up to 4.3 m
- Column travel adapted for internal and external welding
- Programmable welding length
- Optional rotator block for circumferential welding
- Combined with LP or LP-2R rotator set



Internal boom for pipe jointing

Outstanding features

- Programmable current downslope (Crater control)
- 450mm Internal DX7 welding head (mono and tandem wire)
- Pressurised & recycling flux device
- Video camera

Components

Platform

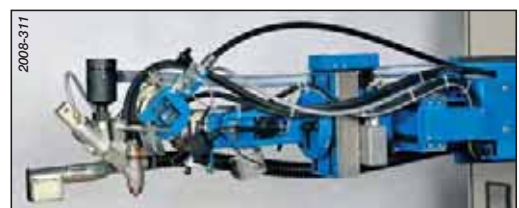
- STARMATIC 1003 DC Power source
- Pressurised recycling SAW flux device
- Hydraulic generator
- Operator control boxes :
 - Current downslope control box
 - Subarc 5 control box
 - Video + Monitor
 - Movement control box (movement of the boom, welding head...)

13.5 m welding boom

- External harnesses to facilitate maintenance operations
- Bolted & dismantled boom
- 2 Hydraulic retractable wheels (Longitudinal movement)
- 4 Hydraulic retractable wheels (Rotation)

Welding Head

- Electrical vertical slide
- Electrical horizontal slide
- DX7 welding head
- Video camera
- Curved wire feeds
- Automatic flux valve



Rotators



LP series of heavy-duty rotators for 42 t to 200 t

- Special frame conception with built-in roll supports reduces welding height from the ground
- Machined bed on the idler and drive roll for perfect alignment
- Remote pendant kit auto and display is standard on all versions
- Thick polyurethane layer on the roller
- Screw adjusting working diameter
- Manual remote / 3 A system compliant
- Possible options:
 - Lorry and railway
 - Self aligning version



TR series of fit-up rotators TR associated with LP range

This is a low cost solution for handling the assembly of pipe sections. It also does not require other equipment such as a crane when extending the section length.



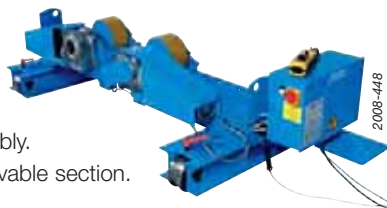
TR Rotators



The operator adjusts the position of the can for tack welding via the remote control of the fit up rotators

Motorised lorry, railways

This option allows moving the section for fit up assembly. One motorised unit per movable section.



Anti drift device

This anti drift system allows the pipe to turn without twisting. The system is commonly fixed on the idle rotator and is very useful for multi-turn applications.



	LMC/LFC 30	LMC/LFC 55	LMC/LFC 100	LMC/LFC 200
ASSOCIATED ROTATORS	TR 30/ ST 30	TR 42/ LP 42 TR 55/ LP 55	TR70/ TR 100 LP70/ LP100	TR 160/ TR 200 LP160/ LP 200



	MAD 30	MAD 55	MAD 100	MAD 200
ASSOCIATED ROTATORS	TR 30/ ST 30	TR 42/ LP 42 TR 55/ LP 55	TR70/ TR 100 LP70/ LP100	TR 160/ TR 200 LP160/ LP 200

Accessories and PPE (Personal Protective Equipment)



Air Liquide Welding through WELDLINE offers a wide range of tools and accessories dedicated for welding applications (cables, earth clamps, torches, brushes and hammers, sprays...) as well as personal protective equipment for the welder (gloves, clothing, goggles, mask...) and for the workshop (strips, curtains etc.).

Tungsten electrodes

For TIG welding, a full range of non consumable tungsten electrodes.

The range includes pure tungsten electrodes and several types of alloyed electrodes.

Pure Tungsten for AC welding of aluminum

Tungsten + thorium for DC welding

Tungsten + cerium for DC welding

Tungsten + lanthanum for both DC and AC welding

Tungsten + rare earths for both DC and AC welding



Welder Protection

A complete range of helmets, leather and cotton clothing, glasses, gloves and shoes. The ZEPHYR helmet ensures comfort and protection with a new high performance liquid crystal cell, extra-wide vision and extreme reliability. The ZEPHYR is equipped with a forced air flow system preventing welding fume from infiltrating into the welder's helmet. The filter and protection screen are easy to extract, with pressure on the push button. Adjustable head gear (4 positions) with an optimised design to ensure good protection of the head, and light weight for comfort.



Cables and connectors

Primary and secondary cables, solid copper meeting the international standards requirements.



Sprays

Anti-splatter (SPRAYMIG), crack detection products (SKINCRIC), leak detection (BUBBLE).



Stainless steel treatment

WELDLINE propose a complete range of products for stainless steel surface treatment:

- CLEANOX (Degreasing, product in liquid)
- PICKLINOX (Pickling, product in gel, paste or liquid)
- RESTORINOX (Passivation, product in gel)



Ovens



A full range of portable quivers, holding and re-baking ovens for MMA electrodes and hopper ovens for SAW fluxes.

Temperature Conversion Table

°C	°F	°C	°F	°C	°F	°C	°F	
-156.6	-250	-418	-36.6	-34	-29.2	-25.5	-14	6.8
-128.8	-200	-328	-36.1	-33	-27.4	-25.0	-13	8.6
-101.1	-150	-238	-35.5	-32	-25.6	-24.4	-12	10.4
-73.3	-100	-148	-35.0	-31	-23.8	-23.8	-11	12.2
-45.5	-50	-58	-34.4	-30	-22.0	-23.3	-10	14.0
-45.0	-49	-56.2	-33.8	-29	-20.2	-22.7	-9	15.8
-44.4	-48	-54.4	-33.3	-28	-18.4	-22.2	-8	17.6
-43.8	-47	-52.6	-32.7	-27	-16.6	-21.6	-7	19.4
-43.3	-46	-50.8	-32.2	-26	-14.8	-21.1	-6	21.2
-42.7	-45	-49	-31.6	-25	-13.0	-20.5	-5	23.0
-42.2	-44	-47.2	-31.1	-24	-11.2	-20.0	-4	24.8
-41.6	-43	-45.4	-30.5	-23	-9.4	-19.4	-3	26.6
-41.1	-42	-43.6	-30.0	-22	-7.6	-18.8	-2	28.4
-40.5	-41	-41.8	-29.4	-21	-5.8	-18.3	-1	30.2
-40.0	-40	-40.0	-28.8	-20	-4.0	-17.8	0	32.0
-39.4	-39	-38.2	-28.3	-19	-2.2	-17.2	1	33.8
-38.8	-38	-36.4	-27.7	-18	-0.4	-16.7	2	35.6
-38.3	-37	-34.6	-27.2	-17	1.4	-16.1	3	37.4
-37.7	-36	-32.8	-26.6	-16	3.2	-15.6	4	39.2
-37.2	-35	-31	-26.1	-15	5.0	-15.0	5	41.0

°C	°F	°C	°F	°C	°F	°C	°F	
-33.3	26	78.8	7.78	46	114.8	18.9	66	150.8
-2.78	27	80.6	8.33	47	116.6	19.4	67	152.6
-2.22	28	82.4	8.89	48	118.4	20.2	68	154.4
-1.67	29	84.2	9.44	49	120.2	20.6	69	156.2
-1.11	30	86.0	10.0	50	122.0	21.1	70	158.0
-0.56	31	87.8	10.6	51	123.8	21.7	71	159.8
0.00	32	89.6	11.1	52	125.6	22.2	72	161.6
0.56	33	91.4	11.7	53	127.4	22.8	73	163.4
1.11	34	93.2	12.2	54	129.2	23.3	74	165.2
1.67	35	95.0	12.8	55	131.0	23.9	75	167.0
2.22	36	96.8	13.3	56	132.8	24.4	76	168.8
2.78	37	98.6	13.9	57	134.6	25.0	77	170.6
3.33	38	100.4	14.4	58	136.4	25.6	78	172.4
3.89	39	102.2	15.0	59	138.2	26.1	79	174.2
4.44	40	104.0	15.6	60	140.0	26.7	80	176.0
5.00	41	105.8	16.1	61	141.8	27.2	81	177.8
5.56	42	107.6	16.7	62	143.6	27.8	82	179.6
6.11	43	109.4	17.2	63	145.4	28.3	83	181.4
6.67	44	111.2	17.8	64	147.2	28.9	84	183.2
7.22	45	113.0	18.3	65	149.0	29.4	85	185.0

°C	°F	°C	°F	°C	°F	°C	°F	
71	160	320	177	350	662	621	1150	2102
77	170	338	182	360	680	649	1200	2192
82	180	356	188	370	698	677	1250	2282
88	190	374	193	380	716	704	1300	2372
93	200	392	199	390	734	732	1350	2462
99	210	410	204	400	752	760	1400	2552
100	212	413	232	450	842	788	1450	2642
104	220	428	260	500	932	816	1500	2732
110	230	446	288	550	1022	843	1550	2822
116	240	464	316	600	1112	871	1600	2912
121	250	482	343	650	1202	899	1650	3002
127	260	500	371	700	1292	927	1700	3092
132	270	518	399	750	1382	954	1750	3182
138	280	536	427	800	1472	982	1800	3272
143	290	554	454	850	1562	1010	1850	3362
149	300	572	482	900	1652	1038	1900	3452
154	310	590	510	950	1742	1066	1950	3542
160	320	608	538	1000	1832	1093	2000	3632
166	330	626	566	1050	1922	1121	2050	3722
171	340	644	593	1100	2012	1149	2100	3812

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 Celsius 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/mm ²	ksi	psi	MPa	N/mm ²	ksi	psi	MPa	N/mm ²	ksi	psi	MPa
150	21.8	21800	150	350	50.8	50800	350	550	79.8	79800	550
160	23.2	23200	160	360	52.2	52200	360	560	81.2	81200	560
170	24.7	24700	170	370	53.7	53700	370	570	82.7	82700	570
180	26.1	26100	180	380	55.1	55100	380	580	84.1	84100	580
190	27.6	27600	190	390	56.6	56600	390	590	85.6	85600	590
200	29.0	29000	200	400	58.0	58000	400	600	87.0	87000	600
210	30.5	30500	210	410	59.5	59500	410	610	88.5	88500	610
220	31.9	31900	220	420	60.9	60900	420	620	89.9	89900	620
230	33.4	33400	230	430	62.4	62400	430	630	91.4	91400	630
240	34.8	34800	240	440	63.8	63800	440	640	92.8	92800	640
250	36.3	36300	250	450	65.3	65300	450	650	94.3	94300	650
260	37.7	37700	260	460	66.7	66700	460	660	95.7	95700	660
270	39.2	39200	270	470	68.2	68200	470	670	97.2	97200	670
280	40.6	40600	280	480	69.6	69600	480	680	98.6	98600	680
290	42.1	42100	290	490	71.1	71100	490	690	100.1	100100	690
300	43.5	43500	300	500	72.5	72500	500	700	101.5	101500	700
310	45.0	45000	310	510	74.0	74000	510	710	103.0	103000	710
320	46.4	46400	320	520	75.4	75400	520	720	104.4	104400	720
330	47.9	47900	330	530	76.9	76900	530	730	105.9	105900	730
340	49.3	49300	340	540	78.3	78300	540	740	107.3	107300	740

N/mm ²	ksi	psi	MPa	N/mm ²	ksi	psi	MPa	N/mm ²	ksi	psi	MPa
750	108.8	108800	750	950	137.8	137800	950	1150	166.8	166800	1150
760	110.2	110200	760	960	139.2	139200	960	1160	168.2	168200	1160
770	111.7	111700	770	970	140.7	140700	970	1170	169.7	169700	1170
780	113.1	113100	780	980	142.1	142100	980	1180	171.1	171100	1180
790	114.6	114600	790	990	143.6	143600	990	1190	172.6	172600	1190
800	116.0	116000	800	1000	145.0	145000	1000	1200	174.0	174000	1200
810	117.5	117500	810	1010	146.5	146500	1010				
820	118.9	118900	820	1020	147.9	147900	1020				
830	120.4	120400	830	1030	149.4	149400	1030				
840	121.8	121800	840	1040	150.8	150800	1040				
850	123.3	123300	850	1050	152.3	152300	1050				
860	124.7	124700	860	1060	153.7	153700	1060				
870	126.2	126200	870	1070	155.2	155200	1070				
880	127.8	127800	880	1080	156.6	156600	1080				
890	129.1	129100	890	1090	158.1	158100	1090				
900	130.5	130500	900	1100	159.5	159500	1100				
910	132.0	132000	910	1110	161.0	161000	1110				
920	133.4	133400	920	1120	162.4	162400	1120				
930	134.9	134900	930	1130	163.9	163900	1130				
940	136.3	136300	940	1140	165.3	165300	1140				

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

Welding positions according to DIN EN ISO 6947:1997-05

Butt welds



PA Horizontal
1G flat position



PC Transverse
2G position



PE Overhead
4G position



PG Vertical down
3Gd position



PF Vertical up
3Gu position

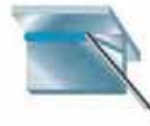
Fillet welds



PA Horizontal
1F flat position



PB Horizontal
2F downhand position



PD Horizontal
4F overhead position



PG Vertical down
3F position



PF Vertical up
3Fu position

Pipe welds



PA Pipe: rotated
1G Axis: horizontal
ASME: 1G



PG Pipe: fixed
5Gd Axis: horizontal
ASME: 5Gd



PF Pipe: fixed
5Gu Axis: horizontal
ASME: 5Gu



PC Pipe: fixed
2G Axis: vertical
ASME: 2G



H-LO45 Pipe: fixed
6G Axis: e.g. 45°
ASME: 6G

Pipe welds



PB Pipe: rotated
2F Axis: horizontal
ASME: 2F



PG Pipe: fixed
5Fd Axis: horizontal
ASME: 5Fd



PF Pipe: fixed
5Fu Axis: horizontal
ASME: 5Fu



PB Pipe: fixed
2F Axis: vertical
ASME: 2F



PD Pipe: fixed
4F Axis: vertical
ASME: 4F



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