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HYUNDAI WELDING

WELDING SOLUTIONS FOR THE PIPELINE INDUSTRY

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HYUNDAI WELDING AT THE CORE OF PIPELINES

Pipelines are an efficient, safe, and low-emission means of transport of oil, natural gas, water, and other gases & liquids over long distances and, as such, extremely important for the global economy and its future development. Pipelines are the primary mode of transportation for crude oil and petroleum products. Approximately 70% of all crude oil and petroleum products are moved by pipeline.

There are essentially three major types of pipelines; gathering , transmission and distribution pipelines. Gathering pipelines collect raw materials, such as oil and natural gas from production wells, for further processing. Transmission pipelines are used to transport liquids and gas over extremely long distances - between plants or even between countries – and distribution pipelines bring products to end-users. In terms of length, transmission pipelines cover by far the largest distance. Worldwide over two billion km of transmission pipelines are in operation. Product wise, natural gas features the longest pipeline length.

The construction of cross country and offshore pipelines is a major, worldwide business with many specialised contractors and suppliers involved. In the field of welding, HYUNDAI WELDING is an innovative supplier of high quality filler materials for the productive welding of pipelines. The offer to the industry comprises welding consumables for manual, mechanised and automated operation. A good example are the electro-chemically copper-coated E-Line solid wires for vertical-down narrow gap welding with orbital (multi-head) equipment, providing prolonged, trouble-free GMAW with reduced maintenance of liners and torches.

PIPELINES TO REMAIN IMPORTANT INTO THE FUTURE

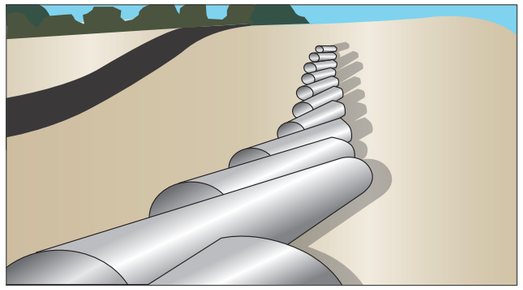
The Covid-19 pandemic, as well as recent geopolitical conflicts, have made energy security dominate international policy agendas. It has undoubtedly accelerated the ongoing transition to clean energy technologies to counteract global warming to a point where today investments in renewable energy are exceeding those in fossil fuels. Nevertheless, renewable energy is still in the beginning of its life cycle in many parts of the world and most power is still derived from conventional fuels. For their transport over long distances, pipelines remain the most cost-efficient solution and currently many projects are planned or executed. The global pipeline construction market size was valued at $45.7 billion in 2021, and is projected to reach some $73 billion by 2030.

Conscious of the need to reduce carbon emissions and the impossibility to derive energy entirely from renewable resources, many industrial states consider natural gas an intermediate step in the transition from fossil fuel to a fully green energy future. This has given rise in the demand for adequate gas distribution pipelines, resulting in major projects in North America, Latin America, the Middle East & Africa and Asia, with China accounting for the largest market in the latter region. In addition, a growing world population and migration to cities - in combination with global warming -increasingly leads to a shortage of fresh water. The need to transport it to living areas from richer areas and from desalination plants causes a surge in (waste)water pipeline projects.

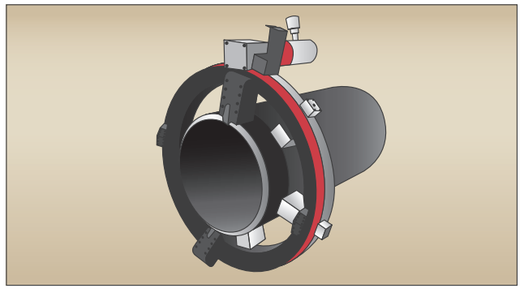
Green hydrogen is another form of energy that is claiming its place in the global energy landscape. The first hydrogen factories driven by wind and solar energy are being built and inevitably pipelines will be needed to bring it to households and industry. Innovations in automation and robotics applied in areas such as pipeline construction, operation, inspection, maintenance and management are transforming the industry. Aided by artificial intelligence, they offer improved quality, safety and (cost) efficiency and help overcome labour shortage, environmental regulations, and complex site conditions.

STEPS IN PIPELINE FABRICATION

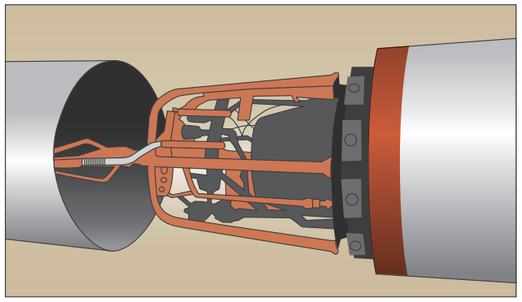
1. Stringing
Laying out of pipeline sections along the planned route



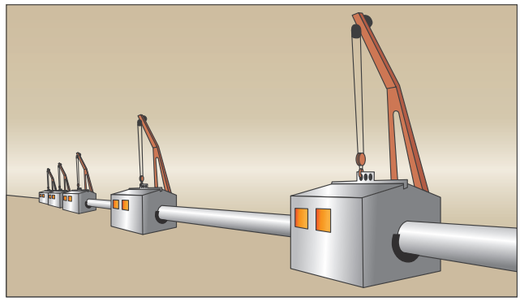
2. Bevelling
Machining of the correct joint preparation for the welding process to be used



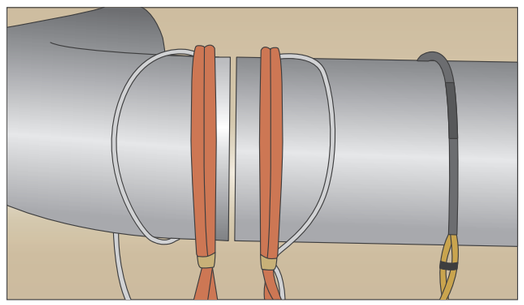
3. Line up
Positioning and fixation of the pipe-ends to be welded



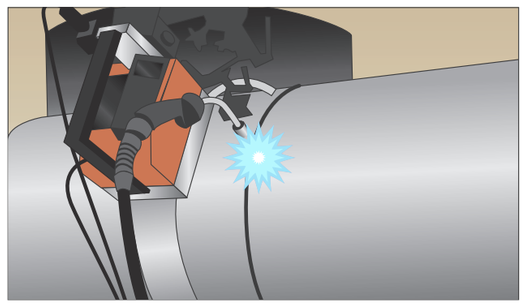
4. Tent placement
A welding tent protects against outdoor weather conditions



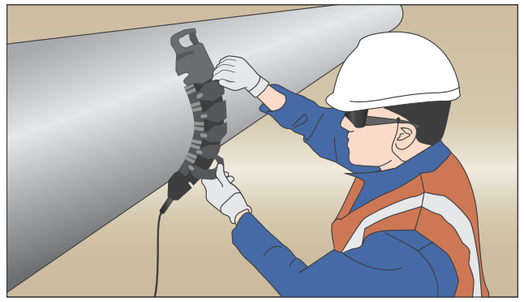
5. Preheating
Preheating removes moisture from the welding zone and limits the weld cooling rate



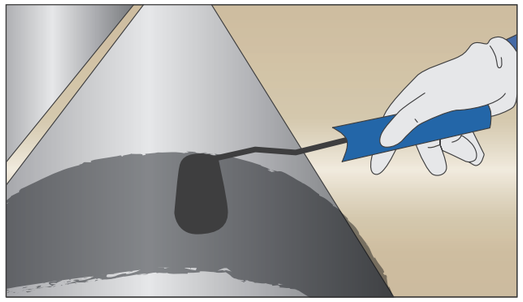
6. Welding
Welding can be manual or mechanised/automatic with orbital systems



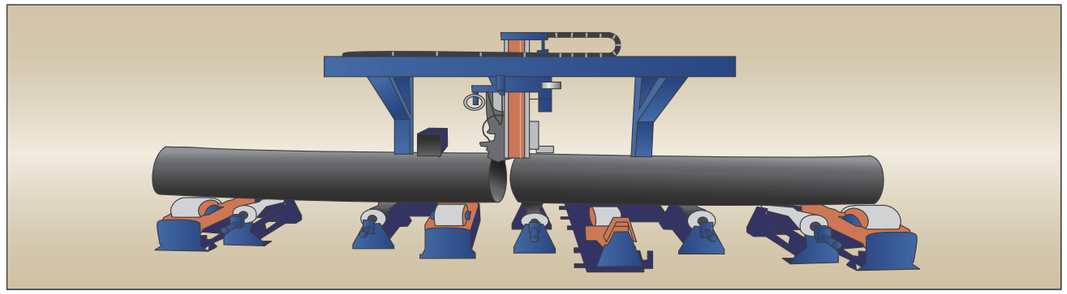
7. NDT
Non destructive testing to check for possible welding defects and repairs



8. Coating
Sealing the weld area



9. Double jointing
The double jointing of pipes can be a good choice for accelerating the progress of pipe laying. It takes place at double joint stations, off the mainline, to create a stock of pre-joined pipeline sections and reduce the number of welds needed on the mainline.



WELDING PROCESSES

MAW/MMA - MANUAL
Vertical-down, cellulosic electrodes : S-6010.D, S-7010.P1, S-8010.P1
Vertical-up, basic electrodes: S-76LTH, S-7018.1H, S-8018.G, S-9018.M, S-11018.M

FCAW - MECHANISED
Vertical-up with orbital equipment or manually with all-positional rutile cored wires:
SF-71MC, SC-71SR, SC-71MSR, Supercored 81, Supercored 81MAG, SC-91LP
Vertical down with orbital equipment or manually with self-shielded cored wires: Pipecored 71, Pipecored 81

GMAW/MIG – MECHANISED/AUTOMATIC
Vertical down narrow gap welding with orbital equipment using solid wire:
SM-70EN, SM-1N, SM-100 from E-Line range of electrically coated solid wires

SAW
Double jointing on roller beds with internal/external submerged arc welding equipment:
Superflux 787/H-12K, Superflux 787/Ni-5, Superflux 787/F-3

PIPELINE STEEL PRODUCTION METHODS

The use of modern high strength steel with a good field weldability enables transportation of higher volumes at higher pressures and has aided the cost efficiency of pipelaying. A revolution in steel manufacturing that started in the seventies - thermo-mechanically controlled processing (TMCP) – enables the production of low-carbon line pipe with elevated strength, good toughness and excellent weldability.

High strength steel derives its strength from its micro structure. The elevated yield strength is obtained by grain size refinement achieved through recrystallization during several steps in the rolling process and through micro-structural changes obtained by micro-alloying and accelerated cooling. At the same time, lower levels of carbon reduce the hardenability of the steels and thereby improve the weldability under field conditions.

Thermo-mechanically processing is today the dominant production method for line pipe, while traditionally hot rolled and normalised steels are still widely available for lower strength grades and quenched & tempered types for higher strength grades. Most steel mills supply longitudinally welded pipes, because they offer the most economic solution and highest safety.

Line pipe is classified in international and local standards, of which most important are API 5L, EN ISO 3183 and DNV OS-F101. High strength pipe grades X70 and X80 are commonly used nowadays in the construction of long distance pipelines, while the first pipeline projects in X90 and X100 are underway.

API grade	Production method	Carbon content/micro-alloying	Microstructure
X52 – X60	Hot rolled and normalised	0.20%C / V	Banded ferrite & perlite, coarse grain size
X70	TMCP	0.12%C / Nb, V	Uniform ferrite & perlite, finer grain size
X80	TMCP & Accelerated cooling	0.08%C / Nb, Ti	Ferrite & bainite, extremely fine grain size
X100	TMCP & Accelerated cooling	0.08%C / Nb, Ti, Mo	Ferrite & bainite, extremely fine grain size

PIPELINE STEEL GRADES

PSL	Delivery Condition	API 5L - Pipe grade/Steel grade
PSL 1	As-rolled, normalizing rolled, normalized or normalizing formed	L175 or A25 / L175P or A25P / L210 or A
	As-rolled, normalizing rolled, thermomechanical rolled, thermomechanical formed, normalizing formed, normalized, normalized and tempered; or if agreed, quenched and tempered for SMLS pipe only	L245 or B
	As-rolled, normalizing rolled, thermomechanical rolled, thermomechanical formed, normalizing formed, normalized, normalized and tempered or quenched and tempered	L290 or X42 / L320 or X46 / X360 or X52 / X390 or X56 / L415 or X60 / X450 or X65 / L485 or X70
PSL 2	As-rolled	L245R or BR / L290R or X41R
	Normalizing rolled, normalizing formed, normalized or normalized and tempered	L245N or BN / L290N or X42N / L320N or X46N / L360N or X52N / L390N or X56N / L415N or X60N
	Quenched and tempered	L245Q or BQ / L290Q or X42Q / L320Q or X46Q / L360Q or X52Q / L390Q or X56Q / L415Q or X60Q / L450Q or X65Q / L485Q or X70Q / L555Q or X80Q / L625Q or X90Q / L690Q or X100Q
	Thermomechanical rolled or thermomechanical formed	L245M or BM / L290M or X42M / L320M or X46M / L360M or X52M / L390M or X56M / L415M or X60M / L450M or X65M / L485M or X70M / L555M or X80M
	Thermomechanical rolled	L625M or X90M / L690M or X100M / L830M or X120M

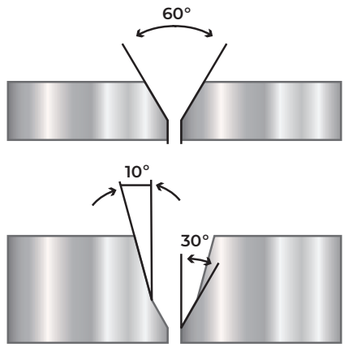
Letter R: As rolled
Letter N: Normalizing rolled, Normalized formed, Normalized
Letter Q: Tempered and quenched
Letter M: Thermomechanical rolled or thermomechanical formed
Letter S: Sour Services, comes with PSL2 pipe for NS, QS, and MS, eg API 5L X65QS

SHIELDED METAL ARC WELDING

SMAW (MMA) has traditionally been a very popular choice for pipe welding applications across the world, due to its simplicity and the ample availability of trained welders. Even today, it remains a very practical choice for the welding of land pipelines in countries where mechanised welding systems and skilled operators are not available. Fabricators may even prefer SMAW for mainline welding when field conditions are challenging (accidented terrain, many crossings) and root gap and pipe dimensions vary. Another advantage is that the standard API V60 bevels provided by the steel mill can be used.

Vertical down welding with cellulosic electrodes is still very common for steel grades up to X70. These electrodes produce a fast freezing slag that supports the weld metal in pipe welding positions (12 to 6 o' clock), enabling welders to produce defect-free welds. The laying speed of a pipeline is the most important economic factor and it is in turn determined by the time needed to produce the root pass. When this stage is completed, the internal clamp can be released and move on to the next weld, together with a team of specialised root pass welders. Immediately, hot pass welders take over, followed by teams specialised in filling and capping.

Cellulosic electrodes contain a substantial amount of moisture in their coating, needed for their specific welding properties and for the metallurgy of the weld. The weld metal hydrogen content is relatively high and may lead to hydrogen induced cracking. For this reason, their use is not recommended for steels with a strength level above X70. Although a lot slower, basic low-hydrogen electrodes for vertical-up welding are the safer option for hydrogen critical applications.



Typical joint preparations for SMAW and FCAW

FLUX CORED ARC WELDING WITH ORBITAL EQUIPMENT

In their search for higher productivity in the laying of land pipelines, many contractors have adopted mechanised flux-cored arc welding to replace the slower SMAW processes described above. It involves relatively simple and lightweight orbital equipment with two or more tractors holding a welding gun with optional torch weaving, walking over a rail attached to the circumference of the pipe. Flux-cored wires used are almost exclusively low-hydrogen rutile types with a fast freezing slag and good all-positional weldability. They are welded vertical-up from 6 to 12 'o clock, on two sides simultaneously. Each side may have two tractors in tandem, depending on the pipe diameter. Mechanised flux-cored arc welding brings many advantages:

- It is highly productive for filling and capping
- It uses a standard API V60 pipe mill bevel
- It requires less welders and is less strenuous
- Sturdy, conventional power sources can be used for field welding
- Welding parameters for each pass and clock position can be stored in the power source controllers and re-used, leading to a predictable weld quality
- Low-hydrogen cored wires are available for all strength levels.

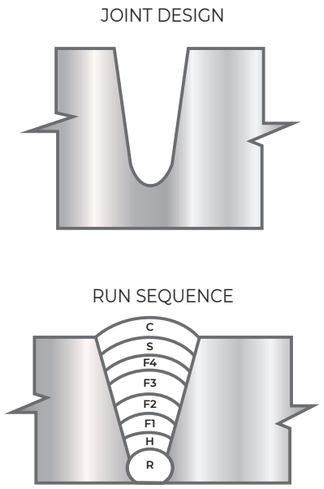
Despite their excellent characteristics for pipeline welding, these flux-cored wires cannot be used for welding a root pass in an open joint, needing a support in the bottom to accommodate the high energy and penetration. To provide this support, pipeline fabricators rely on traditional cellulosic or basic stick electrodes or utilise modern inverter type GMAW power sources with weld metal transfer control for one-sided welding of high quality root passes without backing material. These power sources adjust the welding current at the short circuit to obtain a stable, low-heat input metal transfer with little or no spatter. Wire electrodes used for GMAW are almost exclusively solid types.

MECHANISED GAS METAL ARC NARROW GAP WELDING

Systems for vertical-down gas metal arc welding have been in use since the sixties and are nowadays highly efficient and available from various welding equipment manufacturers. It uses a narrow gap joint preparation with a relatively small opening angle to save on weld volume and welding time - mostly prepared, at the job site, just before welding to obtain a clean and accurate bevel. A small land at the bottom of the joint provides the support for an externally welded root pass; with or without the use of internal water-cooled copper backing shoes. An alternative system requires an adapted bevel to allow an internally welded sealing run.

These systems use high quality solid wire electrodes under CO^2 or Ar/CO^2 gas shielding and apply weaving to obtain good side-wall wetting. Tractors move simultaneously from 12 to 6 o' clock on both sides of the pipe. Depending on required productivity, torches can be single wire or twin-wire; the latter feeding two wires into a single weld pool at increased welding speed. Two torches can also be used in tandem on a single tractor to further reduce welding time and even systems are in use with two individual tractors in operation on each side. The modern systems have inverter type power sources enabling full control of arc behaviour, use of synergic lines and storage and re-use of parameter settings for layer sequences and different clock positions. They can be equipped with varying types of joint tracking devices and with systems for weld monitoring and data logging and can reach a high degree of automation.

Mechanised/automatic vertical-down GMAW using a narrow gap provides the highest productivity available today for pipeline welding. It requires less weld metal to fill a joint and enables high welding currents, saving welding time and costs. It takes time to test these systems under field conditions and obtain a stable process, but once established they provide high productivity pipeline welding with low repair rates. This explains the widespread use for not only land pipelines, but also for offshore pipe laying from specialised vessels (S & J-lay).



Typical narrow gap joint preparations for GMAW

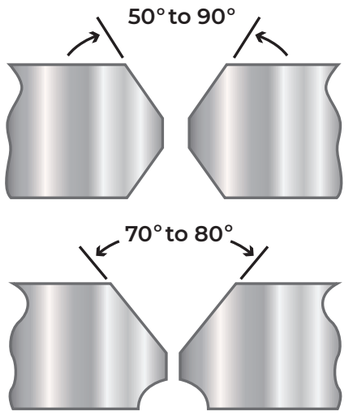
DOUBLE JOINTING WITH SUBMERGED ARC WELDING

The double jointing of pipes can be a good choice for accelerating the progress of pipe laying. It takes place at double joint stations, off the mainline, to create a stock of pre-joined pipeline sections and reduce the number of welds needed on the mainline. Double jointing involves the joining of two standard length (e.g. 12m) pipes end-to-end to create 24m sections, which may again be joined to form 48m sections (quadruple jointing). The stations can be shop-based or move with the mainline, depending on terrain conditions and transportation possibilities. A variety of fabricators worldwide offer double jointing systems with the following facilities:

- Pipe edge beveling
- Pipe line-up clamp
- Pipe fit-up system
- Preheating equipment
- External SAW welding station
- Internal SAW welding station
- NDT inspection equipment
- Pipe conveyors

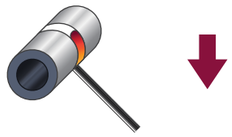
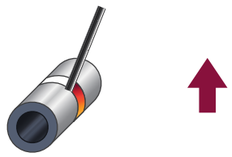
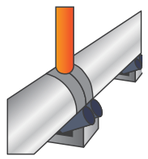
The submerged arc process is very suited for this application, because it is productive and yields high quality welds with the required strength and toughness. To further increase productivity, systems may be equipped with twin wire torches and with welding heads placed in tandem.

Any pipeline project inevitably has a number of locations where mechanised welding cannot be applied, such as bends, crossings, elevations and T-joints with other lines. Due to their geometry, they have to be welded without internal backing for the root pass. This also applies to repairs of weld defects on the mainline. This work is often done manually with stick electrodes or cored wires.



Typical joint preparations for submerged arc welding

CONSUMABLE LIST FOR THE PIPELINE INDUSTRY

ISO 3183	L320	L360	L390		L415	L450	L485	L555	L625	L690
API 5L grade	X46	X52	X56		X60	X65	X70	X80	X90	X100
SMAW / MMA										
 Root cellulosic - vertical down	S-6010.D	S-6010.D	S-6010.D		S-7010.P1	S-7010.P1	S-7010.P1	-	-	-
Fill cellulosic - vertical down	S-6010.D S-7010.P1	S-6010.D S-7010.P1	S-6010.D S-7010.P1		S-8010.P1	S-8010.P1	S-8010.P1	-	-	-
 Root cellulosic - vertical up	S-6010.D	S-6010.D	S-6010.D		S-6010.D S-7010.P1	S-6010.D S-7010.P1	-	-	-	-
Root basic - vertical up	S-76LTH	S-76LTH	S-76LTH		S-76LTH	S-76LTH	S-76LTH	-	-	-
Fill basic - vertical up	S-7018.1H	S-7018.1H	S-7018.1H		S-8018.G	S-8018.G	S-9018.M	S-9018.M	S-11018.M	S-11018.M
GMAW / MIG										
 E-line (electrically copper-coated) solid wires for dependable vertical-down narrow gap welding with mechanised/ automated orbital equipment. Used for mainline welding of land pipelines and for welding offshore pipelines on board of pipelaying vessels, S-lay and J-lay.	SM-70EN	SM-70EN	SM-70EN SM-1N		SM-70EN SM-1N	SM-1N	SM-1N	SM-1N SM-100	SM-100 SM-100	SM-100
FCAW Rutile										
 Rutile flux-cored wires for highly productive vertical-up welding with orbital equipment and for manual welding. Suited for hot pass, filling and capping. Root pass: SMAW, GTAW or GMAW. Used for mainline welding of land pipelines, tie-ins and crossings.	SF-71MC SC-71SR SC-71MSR	SF-71MC SC-71SR SC-71MSR	SF-71MC SC-71SR SC-71MSR		SF-71MC SC-71SR SC-71MSR	SF-71MC SC-71SR SC-71MSR	Supercored 81 Supercored 81MAG	SC-91LP	SC-91LP	-
FCAW Self-shielded										
 Self-shielded cored wires for productive vertical-down welding with manual operatiion. Root pass: SMAW, GTAW or GMAW.	Pipecored 71	Pipecored 71	Pipecored 71		Pipecored 71	Pipecored 81	Pipecored 81	-	-	-
SAW – Double Jointing										
 Superflux 787 -Versatile production flux for double jointing with good welding characteristics for single wire, twin, tandem, tandem-twin. Good slag detachability and good recyclability.	Superflux 787 / H-12K	Superflux 787 / H-12K	Superflux 787 / H-12K		Superflux787 / Ni-5	Superflux787 / Ni-5	Superflux787 / Ni-5	Superflux787 / F-3	Superflux 787 / F-3	-

TYPICAL MECHANICAL PROPERTIES AND CHEMICAL COMPOSITION (%) OF ALL-WELD METAL

Process	Product Name	AWS	EN	Typical Chemical Composition of All-Weld Metal(%)														Typical Mechanical Properties of All-Weld Metal					
				C	Si	Mn	P	S	Ni		Cr	Mo	Ti	V	B	Cu	Al	As Welded / PWHT	YS	TS	EL	Impact ISO-V	
																			MPa (lbs/in²)	MPa (lbs/in²)	(%)	°C (°F)	J (ft·lbs)
SMAW	S-6010.D	A5.1 E6010	ISO 2560-A E 38 0 C 2 1	0.1	0.17	0.42	0.015	0.017	-		-	-	-	-	-	-	-	As Welded	447 (64,900)	517 (75,000)	32.3	-30 (-22)	62 (46)
	S-7010.P1	A5.5 E7010-P1	-	0.127	0.24	0.45	0.017	0.006	0.023		0.017	0.162	-	-	-	-	-	As Welded	480 (69,600	565 (82,000)	28.8	-45 (-49)	47 (35)
	S-8010.P1	AWS A5.5 E8010-P1	-	0.16	0.25	0.8	0.016	0.004	0.62		0.04	0.001	-	0.01	-	-	-	As Welded	499 (72,400)	613 (88,900)	28.4	-30 (-22)	47 (35)
	S-76LTH	A5.5 E7016-G	ISO 2560-A E 42 6 Z B 1 2 H5	0.08	0.35	1.35	0.013	0.004	0.45		-	-	0.018	-	0.0015	-	-	As Welded	540 (78,400)	590 (85,600)	30	-60 (-76)	100 (72)
	S-7018.1H	A5.5 E7018-1 H4R	ISO 2560-A E 42 4 B 3 2 H5	0.06	0.25	1.35	0.014	0.005	-		-	-	-	-	-	-	-	As Welded	493 (71,500)	566 (82,100)	30.8	-45 (-49)	152 (112)
	S-8018.G	A5.5 E8018-G	ISO 2560-A E 46 2 1Ni B 3 2	0.07	0.061	1.29	0.016	0.012	0.83		-	-	-	-	-	-	-	As Welded	542 (78,700)	622 (90,300)	30.2	-20 (-4)	103 (76)
	S-9018.M	A5.5 E9018-M	ISO 2560-A E 50 4 B 4 2	0.05	0.46	1.21	0.017	0.011	1.47		-	0.22	-	-	-	-	-	As Welded	585 (85,000)	646 (93,800)	27.6	-50 (-58)	89 (66)
	S-11018.M	A5.5 E11018-M	ISO 2560-A E 62 4 B 4 2	0.07	0.48	1.62	0.023	0.012	2.04		0.21	0.35	-	-	-	-	-	As Welded	722 (104,900)	796 (115,600)	21.6	-50 (-58)	50 (37)
GMAW	SM-70EN ** / *	A5.18 ER70S-6	ISO 14341-A G 42 2 C1 4Si1	0.09	0.56	1.06	0.015	0.012	-		-	-	-	-	-	-	-	As Welded	461 (66,862)	560 (81,221)	29	-20 (-4)	95 (70)
			ISO 14341-A G 46 5 M21 4Si1	0.09	0.68	1.26	0.015	0.012	-		-	-	-	-	-	-	-	As Welded	524 (76,000)	617 (89,488)	27	-50 (-58)	61 (45)
	SM-1N	A5.28 ER80S-Ni1	-	0.088	0.62	1.15	0.011	0.01	-		-	-	-	-	-	-	-	As Welded	594 (86,000)	671 (97,300)	32.3	-45 (-49)	59 (43)
	SM-100	A5.28 ER100S-G	-	0.072	0.36	1.32	0.008	0.008	1.61		0.25	0.21	-	-	-	-	-	As Welded	717 (103,992)	785 (113,854)	18.4	-40 (-40)	38 (28)
FCAW-G	SF-71MC** / *	A5.20 E71T-1C/-9C/-12C	ISO 17632-A T46 2 P C1 1 H10	0.04	0.40	1.2	0.01	0.012	-		-	-	-	-	-	-	-	As Welded	510 (74,000)	550 (80,000)	28	-29 (-20)	75 (55)
		A5.20 E71T-1M/-9M/-12M	ISO 17632-A T46 3 P M21 1 H10	0.04	0.50	1.41	0.01	0.014	-		-	-	-	-	-	-	-	As Welded	540 (78,000)	605 (88,000)	28	-29 (-20)	90 (66)
	SC-71SR**	A5.20 E71T-1C/-9C-J/-12C-J H4	ISO 17632-A T 42 4 P C1 1 H5	0.05	0.40	1.2	0.011	0.01	0.38		-	-	-	-	-	-	-	PWHT 620 x 2hr	540 (78,400)	560 (81,300)	30	-40(-40)	60 (44)
	SC-71MSR*	A5.20 E71T-12M-J	ISO 17632-A-T 46 4 P M21 1 H5	0.06	0.35	1.24	0.012	0.012	0.45		-	-	-	-	-	-	-	PWHT 620 x 2hr	523 (75,700)	552 (80,000)	33	-40(-40)	57 (42)
	Supercored 81**	A5.29 E81T1-Ni1C	ISO 17632-A-T 46 2 1Ni P C 1	0.03	0.35	1.25	0.011	0.012	0.95				-	-	-	-	-	As Welded	570 (82,700)	640 (92,900)	25	-30 (-22)	90 (66)
	Supercored 81MAG*	A5.29 E81T1-Ni1M H4	ISO 17632-A T 50 6 1Ni P M21 2 H5	0.05	0.28	1.2	0.008	0.012	0.93		-	-	-	-	-	-	-	As Welded	550 (79,900)	590 (85,700)	26	-60 (-76)	60 (44)
	SC-91LP*	A5.29 E91T1-GM	ISO 17632-A-T 50 4 1Ni P M21 1 H5	0.05	0.40	1.4	0.013	0.006	0.9		-	-	-	-	-	-	-	As Welded	650 (94,300)	690 (100,000)	24.5	-40 (-40)	60 (44)
FCAW-S	Pipecored 71	AWS A5.29 E71T8-K6	ISO 17632-A T 42 6 1Ni Y NO 5	0.04	0.14	1.37	0.009	0.001	0.85		0.026	0.004	-	0.009	-	0.022	0.93	As Welded	450 (65,300)	540 (78,300)	29	-60°C (-76)	70 (52)
	Pipecored 81	AWS A5.29 E81T8-Ni2-J	ISO 17632-A T 46 5 2Ni Y NO 5	0.04	0.12	1.35	0.008	0.002	1.98		0.025	0.005	-	0.009	-	0.020	0.95	As Welded	520 (75,400)	595 (86,300)	28	-50°C (-58)	95 (70)
SAW	Superflux787 / H-12K	A5.17 F7A(P)8-EH12K	ISO 14171 S 42 6 FB S3Si	0.07	0.36	1.57	0.015	0.004	-		-	-	-	-	-	-	-	As Welded	491 (71,000)	575 (83,000)	32	-62 (-80)	120 (89)
	Superflux787 / Ni-5	A5.23 F8A(P)8-ENi5-Ni1	ISO 14171 S 46 6 FB S3Ni1Mo0.2	0.06	0.34	1.38	0.015	0.003	0.83		-	0.22	-	-	-	-	-	As Welded	592 (86,000)	614 (89,000)	31	-62 (-80)	83 (61)
	Superflux787 / F-3	A5.23 F9A(P)8-EF3-F3	ISO 14171 S A FB 1 / S3Ni1Mo	0.07	0.35	1.69	0.019	0.003	0.84		-	0.47	-	-	-	-	-	As Welded	675 (98,000)	729 (106,000)	26	-62 (-80)	98 (72)

* With M21 Shielding Gas ** With C1 Shielding Gas

APPROVALS

Process	Product Name	AWS	EN	CWB	TÜV	DB	CE	NAKS	KR	ABS	LR	BV	DNV	NK	RS	RINA	CCS	CRS
SMAW	S-6010.D	A5.1 E6010	ISO 2560-A E 38 0 C 2 1	✓	✓	✓	✓	-	2	2, AWS A5.1 E6010	2	2	2	NK KMW2	-	-	-	-
	S-7010.P1	A5.5 E7010-P1	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S-8010.P1	AWS A5.5 E8010-P1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S-76LTH	A5.5 E7016-G	ISO 2560-A E 42 6 Z B 1 2 H5	-	-	-	✓	-	-	5Y, 5Y400 H5	5Y40 H5	-	5Y40 H5 NV 4-4L	-	-	-	-	-
	S-7018.1H	A5.5 E7018-1 H4R	ISO 2560-A E 42 4 B 3 2 H5	✓	-	-	✓	-	-	4Y H5	4YH5	4Y HHH	4YH5	-	-	-	-	-
	S-8018.G	A5.5 E8018-G	ISO 2560-A E 46 2 1Ni B 3 2															
	S-9018.M	A5.5 E9018-M	ISO 2560-A E 50 4 B 4 2	-	-	-	-	-	-	AWS A5.5 E9018-M	-	-	-	-	-	-	-	-
	S-11018.M	A5.5 E11018-M	ISO 2560-A E 62 4 B 4 2	-	-	-	-	-	-	AWS A5.5 E11018-M	-	-	-	-	-	-	-	-
GMAW	SM-70EN	A5.18 ER70S-6	ISO 14341-A G 42 2 C1 4Si1 ISO 14341-A G 46 5 M21 4Si1	-	✓	✓	✓	-	-	-	-	-	IIIY40MS (C1) IVY40MS (M21)	-	-	-	-	-
	SM-1N	A5.28 ER80S-Ni1	-	-	-	-	-	-	-	AWS 5.28 ER80S-Ni1	-	-	-	-	-	-	-	-
	SM-100	A5.28 ER100S-G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FCAW-G	SF-71MC	A5.20 E71T-1C/-9C/-12C A5.20 E71T-1M/-9M/-12M	ISO 17632-A T46 2 P C1 1 H10 ISO 17632-A T46 3 P M21 1 H10	✓	✓	✓	✓	-	-	3YSA H10	3YS H10	SA3YMHH	IIIYMS H10	-	-	-	-	-
	SC-71SR	A5.20 E71T-1C/ -9C-J/-12C-J H4	ISO 17632-A T 42 4 P C1 1 H5	✓	-	-	✓	-	4Y40SG(C)H5	4Y400SA H5	4Y40S H5	SA4Y40 HHH	IV Y40MS (H5)	KSW54Y40G(C)H5	-	-	4Y40SH5	-
	SC-71MSR	A5.20 E71T-12M-J	ISO 17632-A-T 46 4 P M21 1 H5	✓	✓	✓	✓	-	-	4Y400SA H5	4Y40S H5	SA4Y40M HHH	IV Y40MS (H5)	-	-	-	-	-
	Supercored 81	A5.29 E81T1-Ni1C	ISO 17632-A-T 46 2 1Ni P C 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Supercored 81MAG	A5.29 E81T1-Ni1M H4	ISO 17632-A T 50 6 1Ni P M21 2 H5	✓	✓	✓	✓	-	-	5Y400SA H5	5Y40S H5	SA5Y40M HHH	VY40MS H5	-	5Y42SM H5	5Y40S H5	-	-
	SC-91LP	A5.29 E91T1-GM	ISO 17632-A-T 50 4 1Ni P M21 1 H5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FCAW-S	Pipecored 71	AWS A5.29 E71T8-K6	ISO 17632-A T 42 6 1Ni Y NO 5															
	Pipecored 81	AWS A5.29 E81T8-Ni2-J	ISO 17632-A T 46 5 2Ni Y NO 5															
SAW	Superflux787 / H-12K	A5.17 F7A(P)8-EH12K	ISO 14171 S 42 6 FB S3Si	-	-	-	✓	-	-	4YM H5	-	-	VY42M H5	-	-	-	-	-
	Superflux787 / Ni-5	A5.23 F8A(P)8-ENi5-Ni1	ISO 14171 S 46 6 FB S3Ni1Mo0.2	✓	✓		✓	-		A5.23 F8A(P)8-ENi5-Ni1	-	-	VY46M H5	-	-	-	-	
	Superflux787 / F-3	A5.23 F9A(P)8-EF3-F3	ISO 14171 S A FB 1 / S3Ni1Mo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

KR 2 ABS 2, AWS A5.1 E6010 LR 2 BV 2 DNV·GL 2 NK KMW2 TÜV EN ISO 2560-A-E 38 0 C 2 1 DB EN ISO 2560-A-E 38 0 C 2 1 CWB CSA W48 E4310 CE

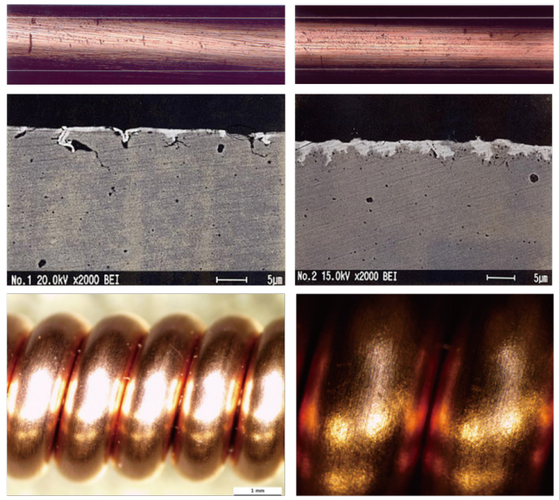
E-LINE SOLID WIRES FOR MECHANISED/AUTOMATED VERTICAL-DOWN WELDING SYSTEMS

HYUNDAI WELDING E-Line range of solid wires is an innovation from the automotive industry made available for pipeline fabrication. Its electrically copper-coated wire surface provides excellent characteristics for narrow gap, vertical-down welding with mechanised or automated systems in mainline welding of land pipelines and for offshore pipelines on board of pipelaying vessels, S-lay and J-lay.

Hyundai E-Line wires feature a thinner, more homogeneous and better adhering coating than with any chemically copper-coated wire available on the market. The presence of less copper with a stronger adhesion results in a reduced risk of liner clogging by copper flaking. This contributes highly to a stable GMAW process for longer periods of time in mechanised and automated welding applications and may lengthen intervals of operation between maintenance of the equipment

The extremely even and smooth wire surface gives improved glide in liner and contact tip with minimal voltage/current fluctuations and thereby a superior arc stability. This brings advantages with all arc types used in pipeline welding in terms of a consistent nice weld appearance with minimal spatter and reduced post weld cleaning. E-Line also features improved start behaviour with reduced arc start time and less start failures.

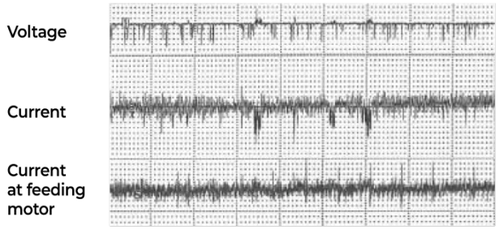
Product name	AWS	EN ISO 14341-A	Shielding gas	CVN
SM-70EN	A5.18 ER70S-6	G 42 2 C1 4Si	CO^2	-20 °C
		G 46 5 M21 4Si	Ar/CO^2	-50 °C
SM-1N	A5.28 ER80S-Ni1		Ar/CO^2	-60 °C
SM-100	A5.28 ER100S-G		Ar/CO^2	-40 °C



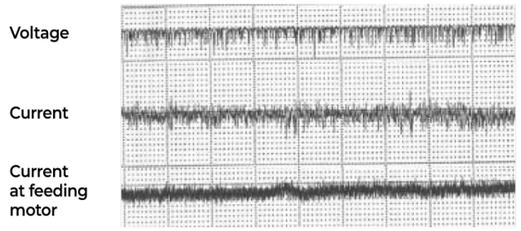
Note: Chemically, with copper sulphate coated wire (left)and electrically coated wire (E-Line). The copper coating of E-Line wires fills up the natural imperfections from the drawing process and adheres better to the wire surface.

Note: Electrically copper-coated wire after extreme deformation showing perfect adhesion of copper on the E-Line surface. It reduces the risk of liner clogging by copper flaking. Visually the colour is brighter than chemically copper coating.

Chemically coated wire



E-Line wire



Note: Surface roughness of chemically coated solid wire (left) and E-Line wire measured over 4 mm wire length.

E-Line characteristics and benefits

1. Low feeding force, superior arc stability	Regular welds with a nice appearance
2. Strong adhesion of copper	Reduced copper flaking, reduced feeding irregularities and less downtime for maintenance
3. Low spatter	Less post weld cleaning
4. Improved start behaviour	Less start failures in robotic welding

RUTILE ALL POSITIONAL CORED WIRES

HYUNDAI WELDING offers a range of all-positional rutile cored wires with fast freezing slag for pipeline applications. They are designed for highly productive vertical-up welding with orbital systems or manually, using a standard API60 bevel. With a soft, spatter-free spray arc at all currents and in any pipe position, they are extremely “welder friendly”, and facilitate the deposition of high quality and defect-free joints.
The fast freezing slag effectively supports the weld pool until solidification which - together with the higher process duty cycle - promotes deposition rates that are several times higher than from any pipeline stick electrode. The slag releases easily, leaving welds with a smooth tie-in and a nice appearance and thereby resistance to crack initiation. Suited for hot pass, filling and capping over root passes deposited with SMAW, GTAW or GMAW. The wires are used for mainline welding of land pipelines, tie-ins and crossings in steel qualities up to X90.

CELLULOSIC ELECTRODES

HYUNDAI WELDING cellulosic electrodes have all-positional capability, but are principally designed for the productive vertical-down welding of pipelines. They are tolerant to poor joint fit-up. They have a high percentage of cellulose in their coating to provide excellent weld penetration and perfect gas shielding. The fast freezing slag enables the use of high welding currents at high deposition rates.

The coating contains moisture needed for the good welding characteristics. This is why they may not be re-baked prior to welding. A consequence is that the weld metal contains a high percentage of diffusible hydrogen and cannot be used for welding steel grades that are sensitive for heat affected zone hardening.
Use of the electrodes is recommended for pipeline steel grades up to X70, while applying a preheat temperature of 100 – 200 ºC. The electrodes are suited for the fast deposition of well-fused root and hot passes and for productive filling and capping. The slag is easily removed after each pass. Use of a remote control is recommended to adapt the current to the clock position during welding.

SELF-SHIELDED CORED WIRES

Pipecored 71 and Pipecored 81 are self-shielded cored wires (FCAW-S) for mechanised and manual downhill welding. Designed for filling and capping, they offer a substantially higher productivity than downhill SMAW, due to the more continuous process and high deposition rate, while eliminating the trouble to supply shielding gas under field conditions. The wires can be used for steels with CVN impact toughness requirements up to -50 ºC (Pipecored 81) and -60 ºC (Pipecored 71). They have excellent characteristics for pipeline welding, easy slag removal and a good welding appearance.

1st pass with slag | 1st and 2nd passes | 1st to 5th passes | 5th pass | 6th pass | 1st to 6th passes | 7th pass | 8th and 9th passes

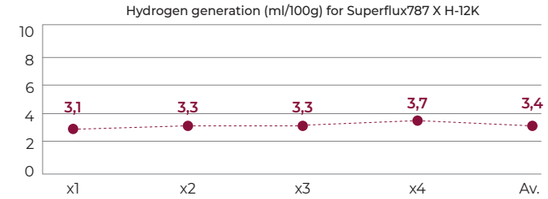
SUPERFLUX 787 FOR DOUBLE JOINTING

Superflux 787 is a versatile submerged arc welding flux designed for the double jointing of pipes. With the same flux and various wires, it covers different yield strength levels and CVN toughness requirements in pipeline fabrication. Grades up to X70 are covered with the combination Superflux 787/H-12K (S3Si). The weld metal meets CVN impact toughness requirements down to -60°C. This combination is also CTOD tested at -10°C (AW) and fulfils the NACE chemical weld metal requirements for offshore pipeline applications in environments where sulphide-induced stress corrosion cracking may be a risk. Higher strength grades are covered with the combinations Superflux 787 / Ni-5 (S3Ni1Mo0.2) and Superflux 787 / F-3 (S3NiMo).

Superflux 787 is a high basic agglomerated flux with a neutral character, promoting a homogeneous chemistry and consistent mechanical properties throughout thick multi-layer welds. It is highly insensitive to rust, scale or primer on the surface to be welded and gives excellent X-ray characteristics. It is an AC/DC+ flux and can be used in single and multi-wire operation. Slag removal is excellent.

Hydrogen Generation Using Gas Chromatograph Method

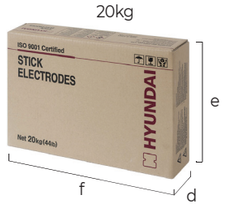
Diameter	4.0mm(5/32in)
Welding Speed	42cm/min(16.53in/min)
Polarity	DC+
Stick-out	38mm(1.5in)
Parameters	575A/27V



Typical mechanical properties, all weld metal, as welded condition

Combination	YS	TS	EL	CVN at -62°C (-80°C)
	MPa (ibs/in²)	MPa (ibs/in²)	(%)	J (ft.lbs)
H-12K	491 (71,000)	575 (83,000)	32	78 (58)
Ni-5	592 (86,000)	614 (89,000)	31	83 (61)
F-3	675 (98,000)	729 (106,000)	26	98 (72)

SMAW Electrodes

Type	Packet	Carton
STANDARD	5kg 	20kg 
	5kg 	
ALUMINUM VACUUM PACK	1.5kg 	15kg 

Carton Size mm (in)	
d	82 (3.2)
e	180-275 (7.1-10.8)
f	312-562 (12.3-22.1)

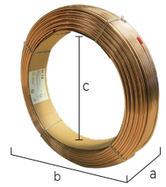
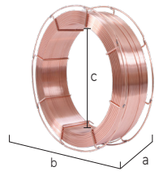
Carton Size mm (in)	
d	96 (3.8)
e	260 (10.2)
f	470-570 (18.5-22.4)

Type	Packet	Carton
PVC BOX (HEXAGONAL)	2.5kg (5.5lbs) 	10-20kg (22-44lbs) 
TIN CAN	4.5kg (9.9lbs) 	
PVC BOX (SQUARE)	5kg (11lbs) 	

Carton Size mm (in)			
Packet	PVC 2.5kg (5.5lbs)	Can 4.5kg (9.9lbs)	PVC 5kg (11lbs)
Carton	10kg (22lbs)	18kg (39.7lbs)	20kg (44.1lbs)
d	80 (3.1)	85 (3.3)	80-85 (3.1-3.3)
e	310-330 (12.2-13)	317 (12.5)	310-345 (12.2-13.6)
f	360-405 (14.2-16)	383-433 (15.1-17)	325-375 (12.8-14.8)

PACKAGING SPECIFICATIONS

Subarc Wire

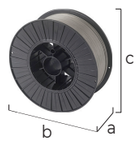
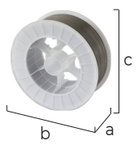
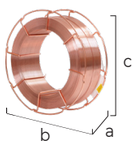
Type	Wire	Size mm (in)			
		Wire	a	b	c
Coil Type		25kg (55lbs)	75/100 (3.0/3.9)	410/420 (16.1/16.5)	305/315 (12.0/12.4)
		30kg (66lbs)	95 (3.7)	400 (15.7)	305 (12.0)
		100kg (220lbs)	90/100 (3.5/3.9)	760 (29.9)	630 (24.8)
Basket Spool		150kg (330lbs)	90 (3.5)	790 (31.1)	630 (24.8)
		25kg (55lbs)	103 (4.1)	413-419 (16.3-16.5)	297-303 (11.7-11.9)

* Other coil sizes available upon request

Subarc Flux

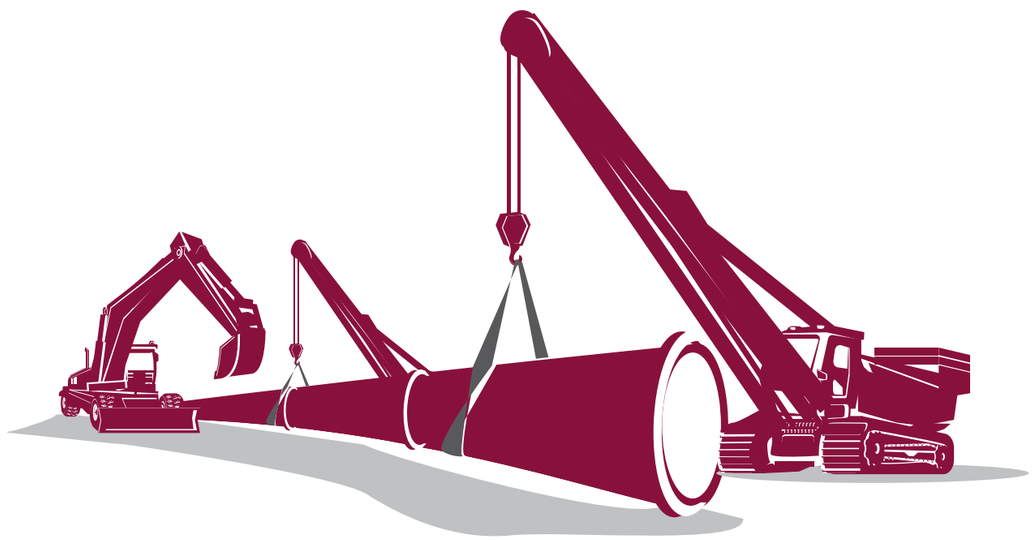
Packaging		
TIN CAN	PE BAG	PAPER BAG
		
15kg, 20kg (33lbs, 44lbs)	20kg, 25kg (44lbs, 55lbs)	20kg, 25kg (44lbs, 55lbs)

GMAW / MIG and Flux Cored Wires

Type	Spool		
	Plastic Spool (GMAW / MIG wires Flux Cored wires)	12.5kg (27.6lbs) / 15kg (33lbs)	Basket Spool (GMAW MIG wires) 15kg (33lbs)
Spool Type			

Spool Size mm (in)		
	Plastic Spool (GMAW / MIG wires Flux Cored wires)	Basket Spool (GMAW MIG wires)
a	110 (4.3)	98 (3.9)
b	270-280 (10.6-11.0)	298 (11.7)
c	270-280 (10.6-11.0)	298 (11.7)

REFERENCES



HYUNDAI WELDING is a global manufacturer of welding consumables and equipment. As the top leading manufacturer of welding consumables in Korea, and with a global network of sales, distribution and manufacturing plants, HYUNDAI WELDING has developed into a key player in the international welding industry.

Our company is fully committed to the ever-changing needs of our customers and has evolved in just under 50 years to provide welding expertise and breakthroughs in welding technology. HYUNDAI WELDING understands customer needs and offers customers world-class products and world-class solutions.

HYUNDAI WELDING's pipeline industry welding solutions meet customer requirements for pipeline projects with a superior customer service and support. By using high quality consumables and equipment portfolio of HYUNDAI WELDING, our customers experience improved productivity and competitiveness in the market.

HYUNDAI WELDING is a world-class manufacturer that specializes in providing optimum welding solutions to its customers, by supplying top-notch welding consumables and equipment. HYUNDAI WELDING has contributed to the development and success of the global welding industry for more than 40 years since its foundation in 1975.

For more information on HYUNDAI WELDING, please visit www.hyundaiwelding.com

E-book

HYUNDAI WELDING

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