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離岸風電銲接材料簡介

WELDING CONSUMABLES FOR OFFSHORE WIND TURBINES

www.kuangtai.com

Outline

- 離岸風電介紹
- 離岸風電使用母材
- 塔架銲接
- 水下基礎銲接
- 離岸風電廣泰相關銲材

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離岸風電介紹

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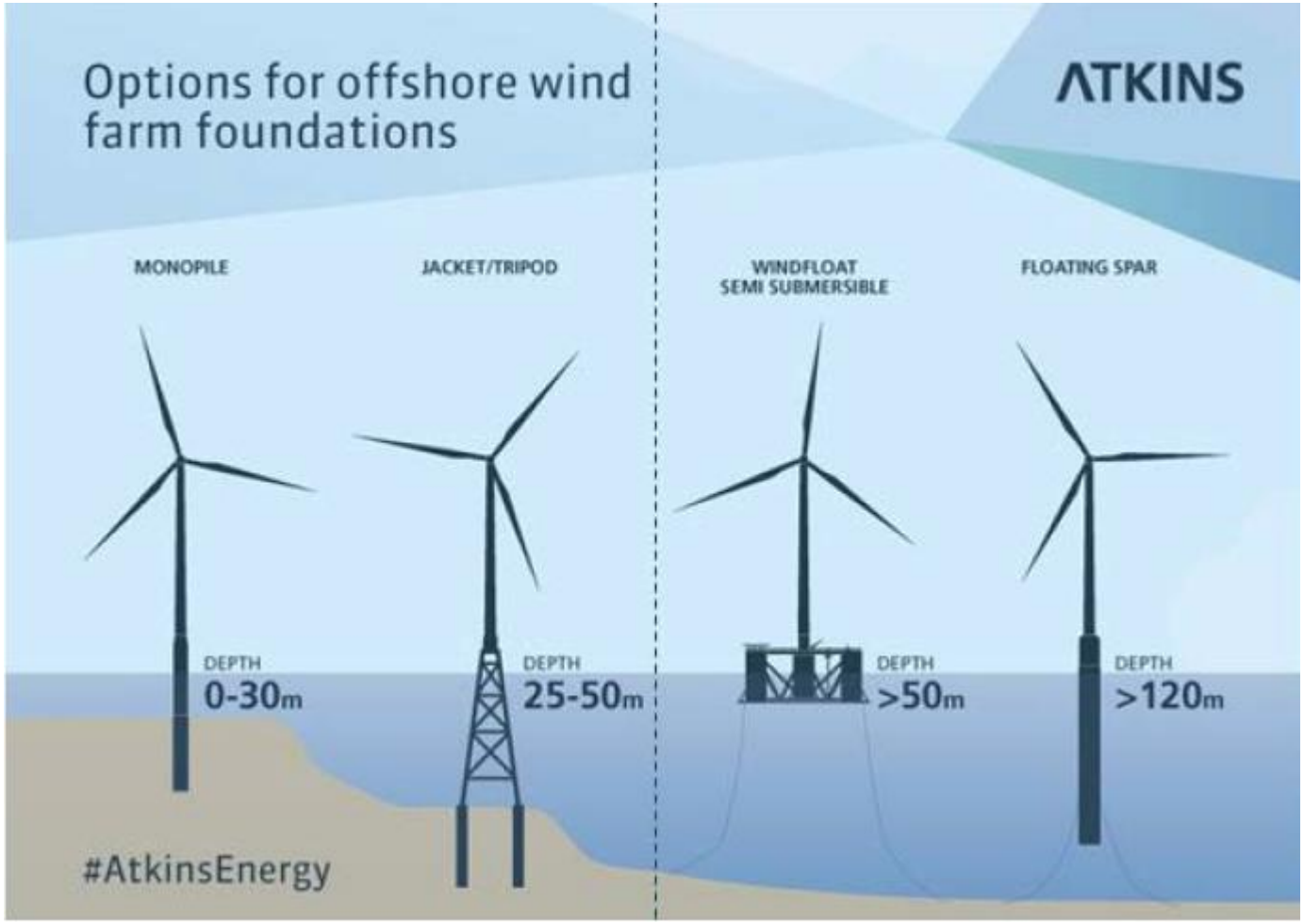
水深與水下基礎型式的關係

固定式 ⟵ 50 m ⟶ 浮體式



Ref: Atkins Energy website

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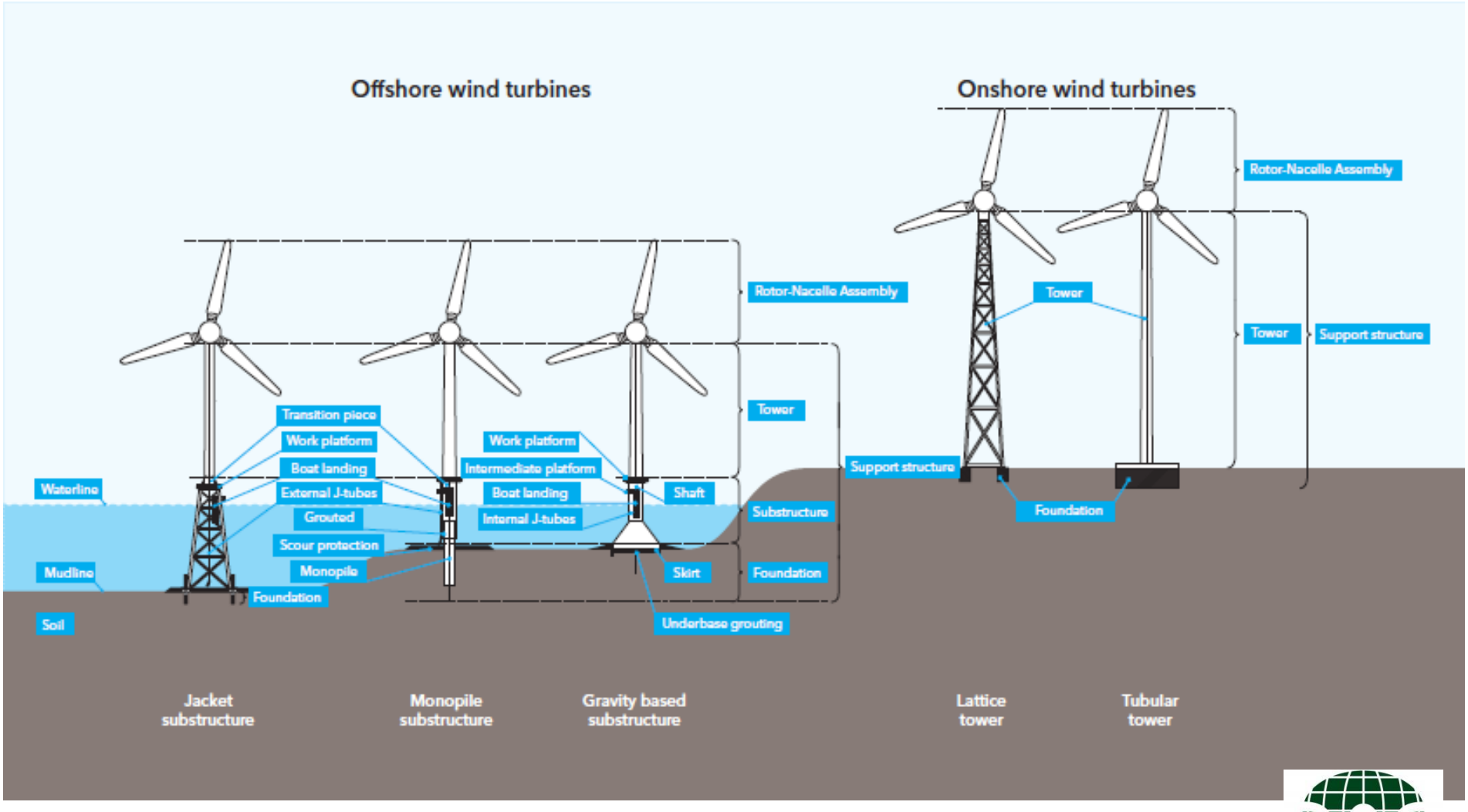
風電種類: Onshore & Offshore



Ref: DNVGL-ST-0126 Support structures for wind turbines

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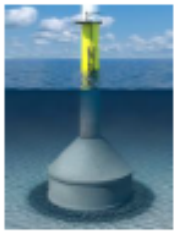
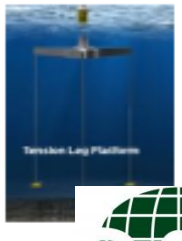
離岸風電常見基礎

基礎型式	重力式 (Gravity)	單樁式 (Monopile)	沉吸式 (Suction)	三桿式 (Tripod)	三樁式 (Tripile)	套筒式 (Jacket)	浮筏式 (Floating)
適用水深	0-10 m	5-35 m	20-30m	20-50 m	20-70 m	30-70 m	>50 m
土層承載條件	土層須具一定程度承載力，並進行整地	不適用於過於堅實之土層	需要土質鬆軟均勻之土層	縮短三支基樁個別長度，但仍須驗證	類似單樁條件，但無法沿用三支單樁設計條件	基樁斷面小，掏刷效應低，承受彎矩較小	不需要基樁，只需要少數錨定
典型重量	1000-3000 噸	600-700 噸	1000-1200 噸	900-1000 噸	1200-1600 噸	700-900 噸	700-1200 噸
國際案例*	頗多 (10%)	極多 (>75%)	少 (<1%)	中等 (4%)	少 (<2%)	中等 (<5%)	極少 (0.1%)
概念圖例							

*註：參考 EWEA (2015), The European offshore wind industry - key trends and statistics 2014, Report.統計資料。

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主流的水下基礎

- Monopile-為歐洲主流的水下基礎低成本方案。惟台灣地處亞太地震帶，於潛力風場場址地質鑽探結果分析，普遍認為以苗栗為分界，苗栗以北有岩層且地震影響較輕微可適用其作為離岸風機之水下基礎。

- Jacket-擁有較複雜的truss結構，故其製造較費工，成本亦相對較高，但其擁有較佳的穩定度，適合在苗栗以南的軟弱泥土質地盤及較活躍的地震帶使用。

- 已有開發商評估彰化外海風場若使用Monopile其重量將達Jacket的2倍，故Monopile在台灣並非絕對的低成本方案。

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政府獎勵示範風場

福海風場

彰化縣芳苑鄉外海
離岸: 8~12 公里
水深: 20~45 公尺
容量: 108 MW
數量: 30架

FOWI 海洋風場

苗栗縣竹南鎮外海
離岸: 1~5公里
水深: 15~30公尺
容量: 130MW
數量: 36架

台電

彰化縣芳苑鄉西側海域
離岸: 6~8 公里
水深: 15~ 26 公尺
容量: 108MW
數量: 30架

Ref: 離岸風電知識網

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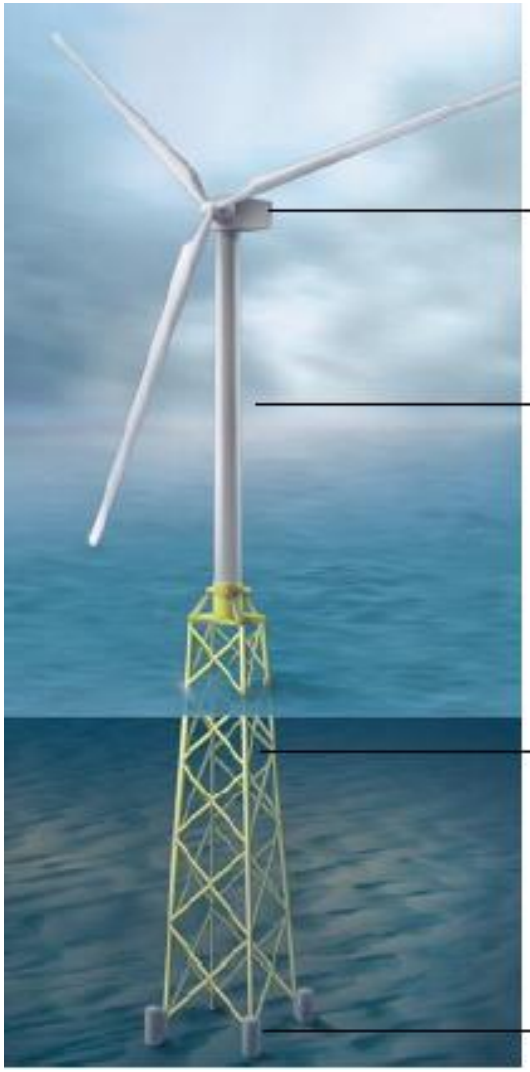
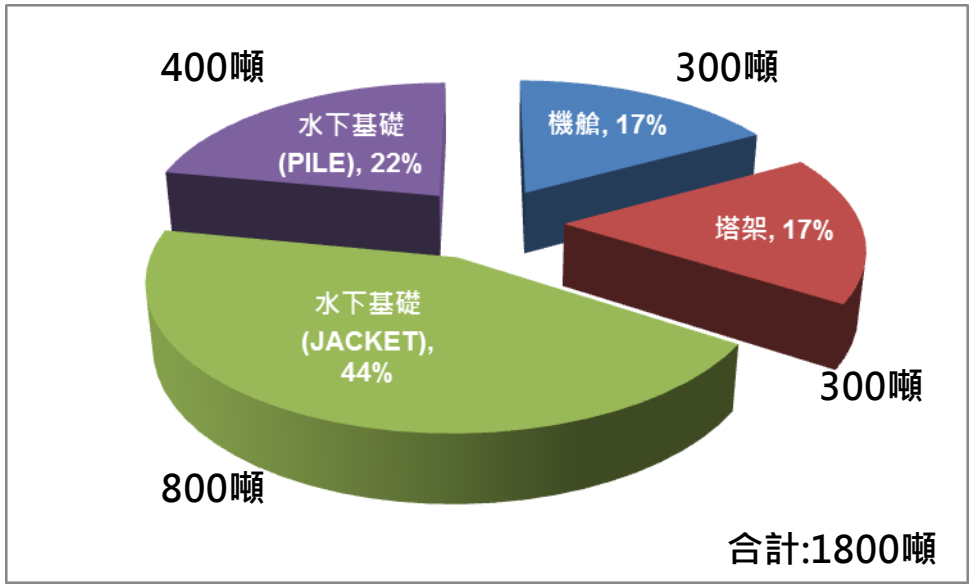
離岸風電結構與鋼材用量



5MW離岸風電鋼材用量



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Ref: 離岸風機 國產水下基礎 推動規劃，中國鋼鐵

離岸風電使用母材

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	EN 10025-2	*EN 10025-3*	*EN 10025-4*	*NV grade*	*Test temperature NV grade (°C)*
Normal strength steel (NS)	S235JR	–	–	NV A	+20
	S235J0	–	–	NV B	0
	S235J2	–	–	NV D	-20
	–	–	–	NV E	-40
High strength steel (HS)	S275J0	S275N	S275M	NV A27S	0
	S275J2	S275N	S275M	NV D27S	-20
	–	S275NL	S275ML	NV E27S	-40
	–	–	–	NV F27S	-60
	(S355J0)	S355N	S355M	NV A36	0
	S355K2, (S355J2)	S355N	S355M	NV D36	-20
	–	(S355NL)	S355ML	NV E36	-40
	–	–	–	NV F36	-60
Extra high strength steel (EHS)	–	S420N	S420M	NV A420	0
	–	S420NL	S420ML	NV D420	-20
	–	(S420NL)	(S420ML)	NV E420	-40
	–	–	–	NV F420	-60
	–	S460NL	S460ML, (S460M)	NV A460	0
	–	(S460NL)	S460ML	NV D460	-20
	–	(S460NL)	(S460ML)	NV E460	-40
	–	–	–	NV F460	-60

Note:
[1] Grades in parentheses compare reasonably well with corresponding NV grades with respect to Charpy V-notch impact r

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母材化學成份要求

Designation		C % max.	Si % max.	Mn % max.	P % max. [a]	S % max. [a b]	Nb % max.	V % max.	Al_{total} % min. [c]	Ti % max.	Cr % max.	Ni % max.	Mo % max.	Cu % max. [d]	N % max.
According EN 10027-1 and CR 10260	According EN 10027-2														
S275M	1.8818	0,15 [e]	0,55	1,60	0,035	0,030	0,06	0,10	0,015	0,06	0,35	0,35	0,13	0,60	0,017
S275ML	1.8819				0,030	0,025									
S355M	1.8823	0,16 [e]	0,55	1,70	0,035	0,030	0,06	0,12	0,015	0,06	0,35	0,55	0,13	0,60	0,017
S355ML	1.8834				0,030	0,025									
S420M	1.8825	0,18 [f]	0,55	1,80	0,035	0,030	0,06	0,14	0,015	0,06	0,35	0,85	0,23	0,60	0,027
S420ML	1.8836				0,030	0,025									
S460M	1.8827	0,18 [f]	0,65	1,80	0,035	0,030	0,06	0,14	0,015	0,06	0,35	0,85	0,23	0,60	0,027
S460ML	1.8838				0,030	0,025									

[a] For long products the P and S content can be 0,005 % higher.

[b] For railway applications a maximum S content of 0,012 % may be agreed at the time of enquiry and order.

See option 32.

[c] If sufficient other N-binding elements are present the minimum total Al content does not apply.

[d] Cu content above 0,45 % may cause hot shortness during hot forming.

[e] For long products a maximum C content of 0,17 % for grade S275 and a maximum C content of 0,18 % for grade S355 applies.

[f] For long products of the grades S420 and S460 a maximum C content of 0,20 % applies.

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母材強度要求

Designation		Minimum yield strength R_{eH} [a] MPa[b] Nominal thickness mm						Tensile strength R_m [a] MPa[b] Nominal thickness mm					Minimum percentage elongation after fracture[c] % $L_0 = 5{,}65\sqrt{S_o}$
According EN 10027-1 and CR 10260	According EN 10027-2	≤ 16	> 16 ≤ 40	> 40 ≤ 63	> 63 ≤ 80	> 80 ≤ 100	> 100 ≤ 120 [d]	≤ 40	> 40 ≤ 63	> 63 ≤ 80	> 80 ≤ 100	> 100 ≤ 120 [d]	
S275M S275ML	1.8818 1.8819	275	265	255	245	245	240	370 to 530	360 to 520	350 to 510	350 to 510	350 to 510	24
S355M S355ML	1.8823 1.8834	355	345	335	325	325	320	470 to 630	450 to 610	440 to 600	440 to 600	430 to 590	22
S420M S420ML	1.8825 1.8836	420	400	390	380	370	365	520 to 680	500 to 660	480 to 640	470 to 630	460 to 620	19
S460M S460ML	1.8827 1.8838	460	440	430	410	400	385	540 to 720	530 to 710	510 to 690	500 to 680	490 to 660	17

[a] For plate, strip and wide flats with widths ≥ 600 mm the direction transverse (t) to the rolling direction applies. For all other products the values apply for the direction parallel (l) to the rolling direction.

[b] 1 MPa = 1 N/mm^2

[c] For product thickness < 3 mm for which test pieces with a gauge length of L_o = 80 mm shall be tested, the values shall be agreed at the time of the enquiry a

[d] For long products a thickness ≤ 150 mm applies.

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母材低溫韌性要求

longitudinal

Designation		Minimum values of impact energy in J at test temperatures, in °C						
According EN 10027-1 and CR 10260	According EN 10027-2	+ 20	0	- 10	- 20	- 30	- 40	- 50
S275M S355M S420M S460M	1.8818 1.8823 1.8825 1.8827	55	47	43	40 [a]	-	-	-
S275ML S355ML S420ML S460ML	1.8819 1.8834 1.8836 1.8838	63	55	51	47	40	31	27

[a] This value corresponds with 27J at - 30 °C (see Eurocode 3).

transverse

Designation		Minimum values of impact energy in J at test temperatures, in °C						
According EN 10027-1 and CR 10260	According EN 10027-2	+ 20	0	- 10	- 20	- 30	- 40	- 50
S275M S355M S420M S460M	1.8818 1.8823 1.8825 1.8827	31	27	24	20	-	-	-
S275ML S355ML S420ML S460ML	1.8819 1.8834 1.8836 1.8838	40	34	30	27	23	20	16

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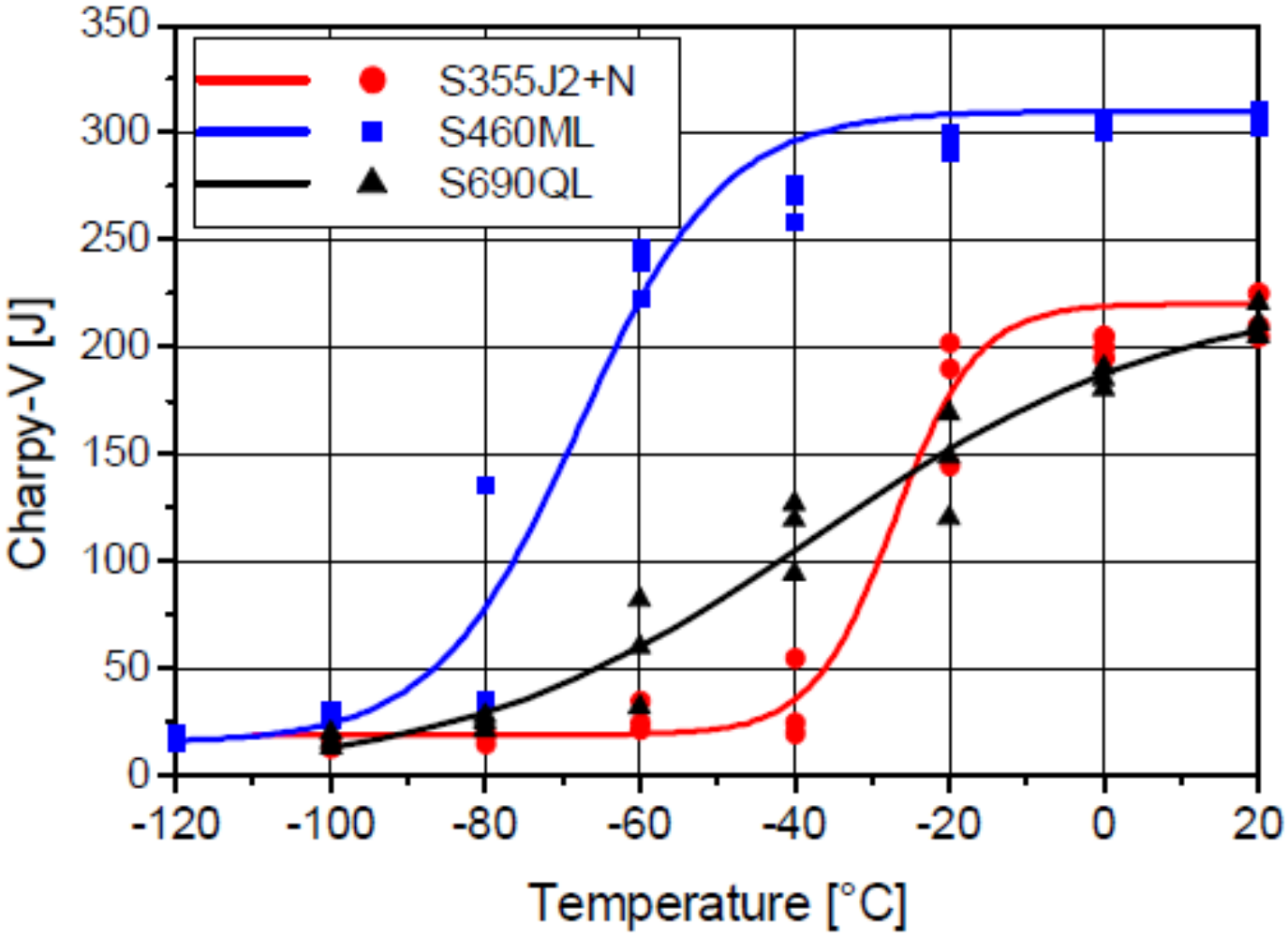
不同母材的韌脆轉換溫度



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塔架銲接

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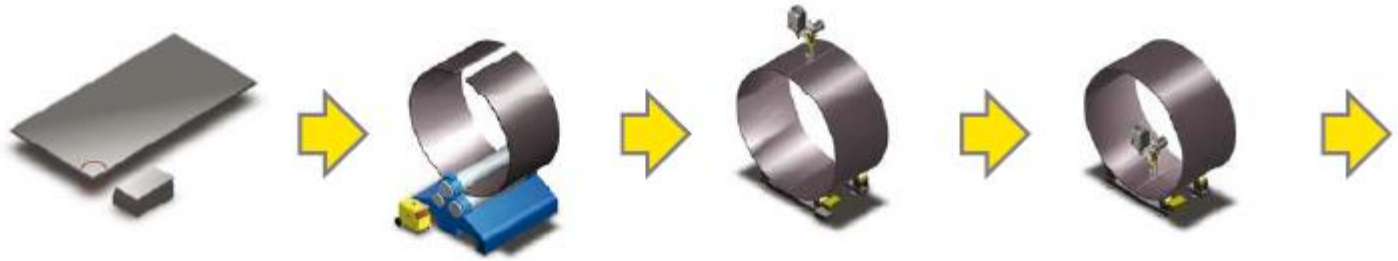
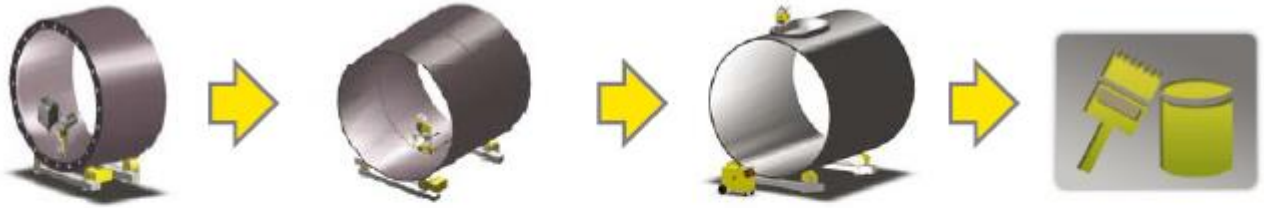
塔架製作流程



Cutting　Rolling　Tack welding　Longitudinal seams



Flanges　Circumferential seams　Door frame　Blasting & painting

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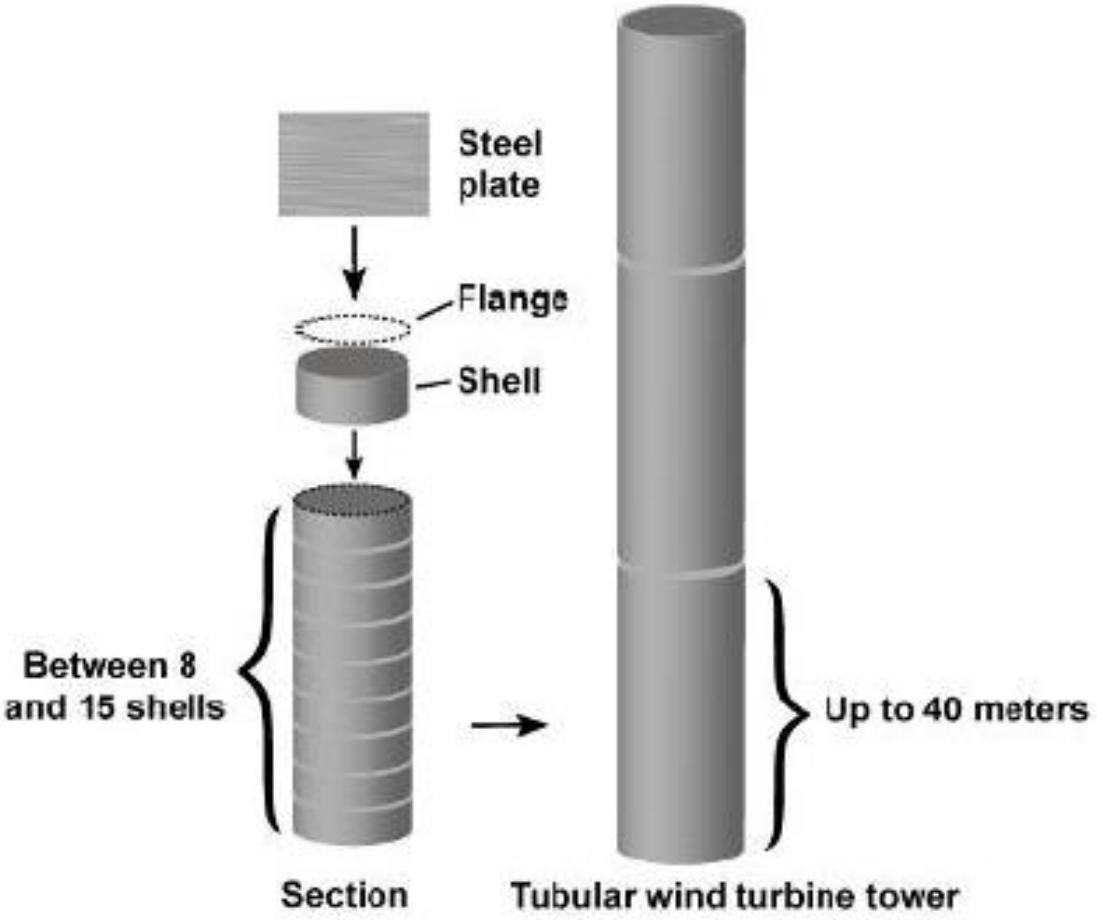
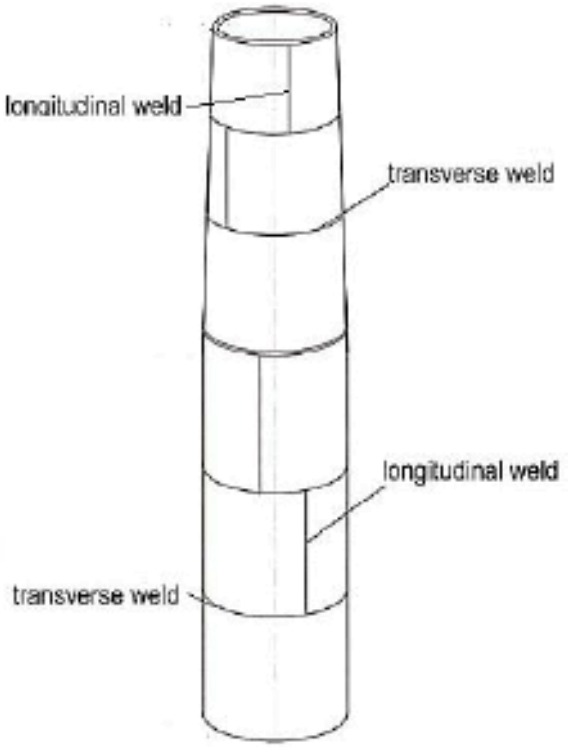
塔架組裝





Ref :Welding Procedures Specification for FCAW of Wind Towers,

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塔架製作

銲線: KW-3　4.8mm
銲藥: KF-550
F7A2-EM12K

Ref: Maximising Quality and Productivity in Offshore Fabrication, TWI Technology Centre

水下基礎(JACKET)銲接

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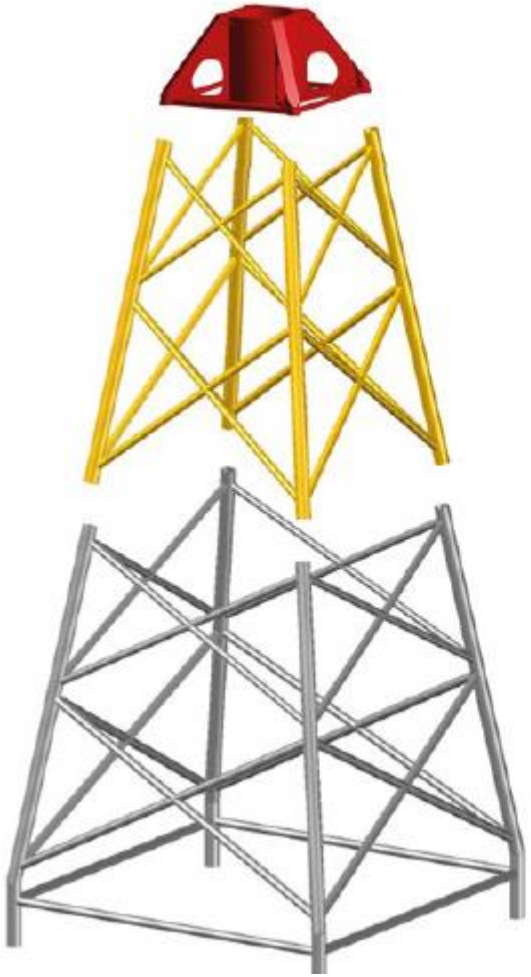
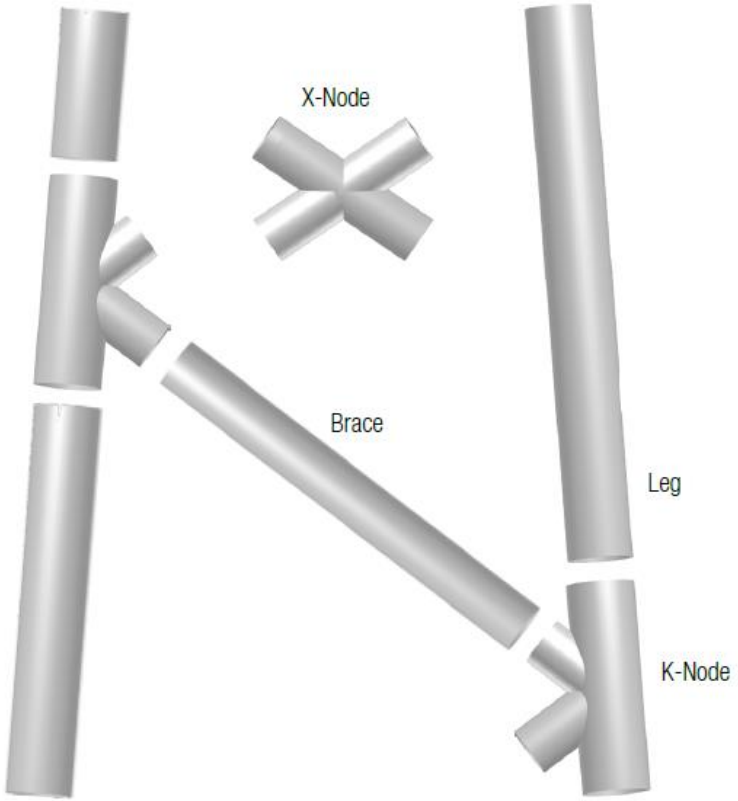
套筒式(JACKET)水下基礎



Top section:
Flexible –Turbines 5-8 MW

Middle section:
Fix

Bottom section:
Adoption on the ground



Ref: Jacket beats Monopile, ST3 OFFSHORE

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套筒式銲接

- **FCAW : KFX series**
- **MCAW : KMX series**
- **GMAW : KM series**

Ref: Jacket beats Monopile, ST3 OFFSHORE

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離岸風電相關銲接材料

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離岸風電銲接材料建議

Base metal 母材	GMAW (Root pass) 實心銲線 (打底用)	MCAW (Root pass) 金屬芯包藥銲線 (打底用)	FCAW (Fill & Cap) 包藥銲線 (填充&蓋面用)	SAW (Fill & Cap) 潛弧銲材 (填充&蓋面用)
S355J0 S355J2	KM-56Z (ER70S-6)	KMX-70M (E70C-6M)	KFX-71T (E71T-1C)	KF-550+KW-3 (F7A2-EM12K)
S355ML	KM-56Z (ER70S-6)	KMX-70M (E70C-6M)	KFX-719J (E71T-9C-J)	KF-880+KW1 (F7A4-EH14)
S420ML S460ML	KM-80SNi1 (ER80S-Ni1)	KMX-80N1 (E80C-Ni1)	KFX-81TK2 (E81T-K2C)	KF-880+KW-80SNi1 (F8A6-ENi1K-Ni1)

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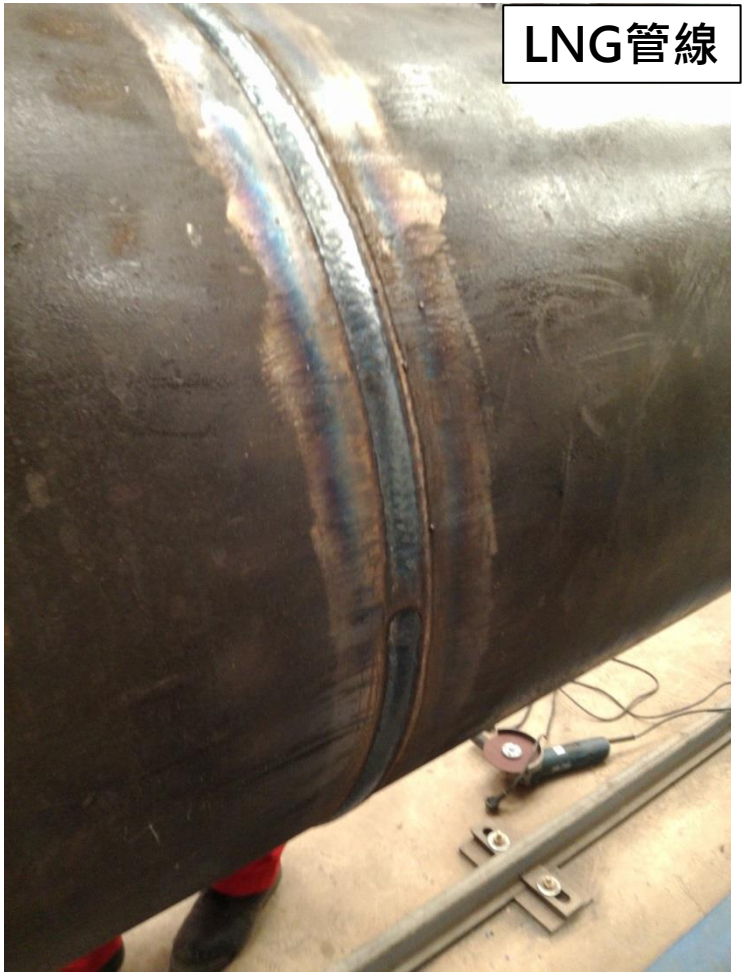
KM-80SNi1&KFX-81TK2 海工方面應用



YAMAL LNG

打底: KM-80SNi1　填充&蓋面: KFX-81TK2

青島中油海 中国石油

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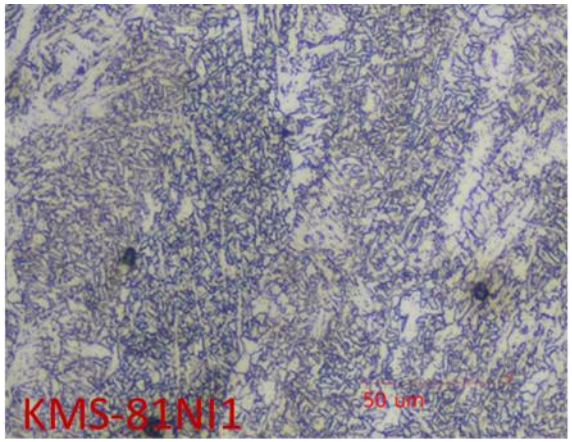
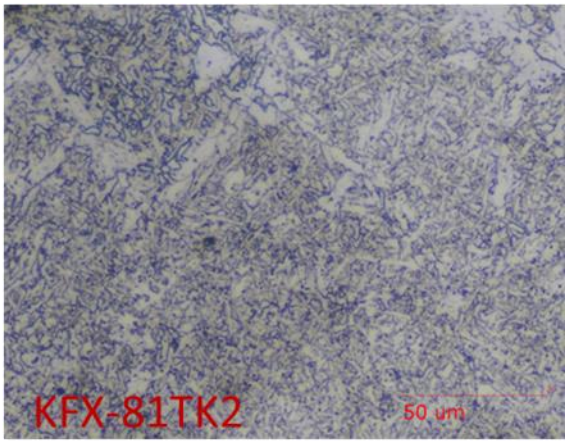
KM-80SNi1&KFX-81TK2 數據

Brand Name	Tensile Test Results			Charpy V-Notch Impact Value (Joules)		
	Y.S. (MPa)	T.S. (MPa)	EL. (%)	-29℃	-45℃	-60℃
KMS-80SNi1	509	598	29	87	69	42
ER80S-Ni1	470 min	550 min.	24 min	-	27 min	-

Brand Name	Tensile Test Results			Charpy V-Notch Impact Value (Joules)		
	Y.S. (MPa)	T.S. (MPa)	EL. (%)	-30℃	-40℃	-60℃
KFX-81TK2	592	635	24	140	100	80
E81T1-K2C	470 min.	550–690	19min	27 min	-	-





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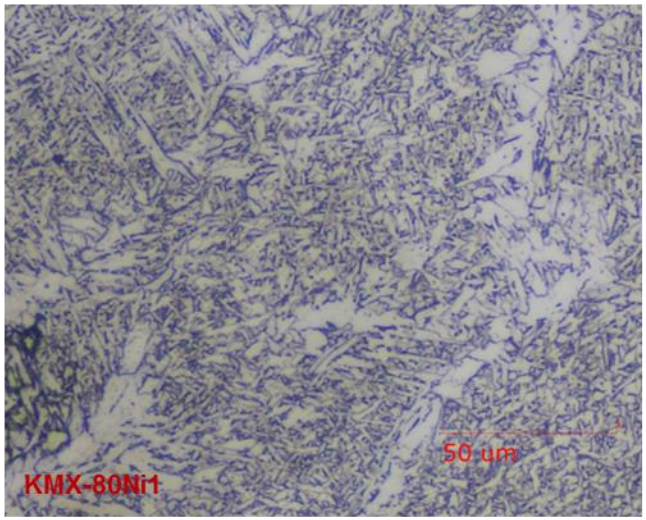
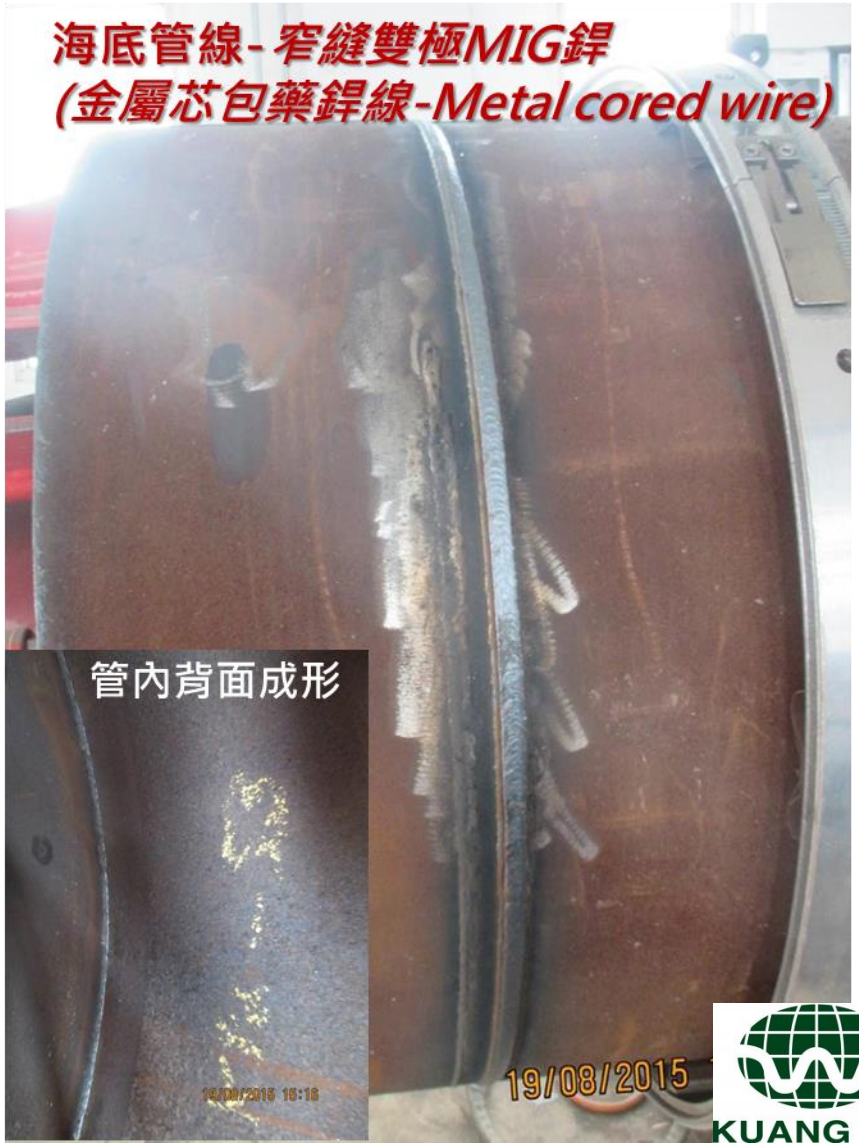
KMX-80Ni1 海底管線應用

Root pass: *KMX-80Ni1* (E80C-Ni1)
Hot pass: *KMX-80Ni1* (E80C-Ni1)
Cap pass: *KMX-80Ni1* (E80C-Ni1)





YAMAL LNG

青島中油海 中国石油

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KMX-70M&KMX-80Ni1 數據

Brand Name	Tensile Test Results			Charpy V-Notch Impact Value (Joules)		
	Y.S. (MPa)	T.S. (MPa)	EL. (%)	-30℃	-40℃	-60℃
KMX-70M	450	563	30	71	58	-
E70C-6M	400 min.	480 min.	22 min.	27 min.	-	-

Brand Name	Tensile Test Results			Charpy V-Notch Impact Value (Joules)		
	Y.S. (MPa)	T.S. (MPa)	EL. (%)	-30℃	-45℃	-60℃
KMX-80Ni1	532	611	27	90	72	-
E80C-Ni1	470 min.	550min	24min	-	27 min	-

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YAMAL項目發表論文

International Journal of Oil, Gas and Coal Engineering
2018; 6(4): 44-49
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Application of Automatic TIG Welding for Yamal LNG Process Piping Fabrication

Zhijian Wang[1, *], Yanyan Li[1], Chiaming Chang[2]

[1]China National Petroleum Offshore Engineering Co, Ltd, Qingdao, China
[2]Research and Development Department, Kuanuang Tai Metal Industrial Co., Ltd, Tainan, Taiwan

4.3 Welding parameters

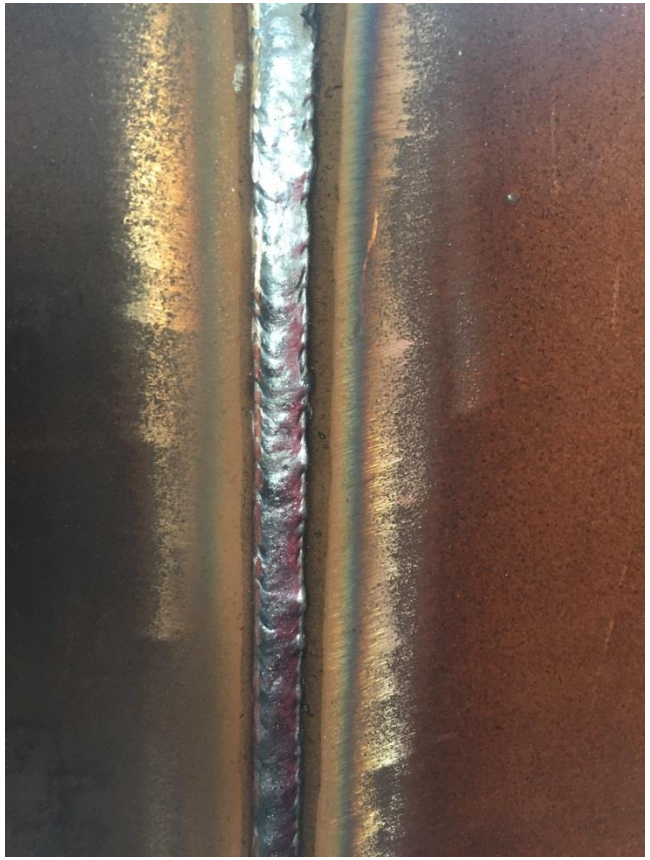
4.3.3 Low temperature carbon steel piping

The temperature design of low temperature carbon steel piping is -50 ℃ depending on the demand of LNG project. The welding consumables of TIG+ FCAW are KM-80Ni1 (ER80S-Ni1)/KFX-81K2 (E81T1-K2). The welding consumables of TIG+SAW are KM-80Ni1 (ER80S-Ni1) and PREMIER WELD Ni1K+PREMOER 8500. Two welding processes meet the toughness requirement of 27J min. at -60 ℃.The design and parameter of welding procedure qualification for low temperature carbon steel is shown in Table 3 and Table 4, respectively.

離岸風電工藝評定

打底: KM-56 (STT打底)

KM-56 背面成形



KFX-719填充

青島中油海 中国石油

KUANG TAI

KM-56Z& KFX-719數據

Brand Name	Tensile Test Results			Charpy V-Notch Impact Value (Joules)		
	Y.S. (MPa)	T.S. (MPa)	EL. (%)	-29℃	-40℃	-50℃
KM-56Z	494	601	27	77	54	-
AWS A5.18 ER70S-6	400 min	480 min	22 min	27	-	-

Brand Name	Tensile Test Results			Charpy V-Notch Impact Value (Joules)		
	Y.S. (MPa)	T.S. (MPa)	EL. (%)	-20℃	-29℃	-40℃
KFX-719	541	585	27	159	139	118
AWS A5.20 E71T-9CJ	390 min	490-670	22 min	-	27 min	-

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離岸風電工藝評定

KW-1+KF-880

青島中油海 中国石油

KUANG TAI

KW-1+KF-880數據

Brand Name	Tensile Test Results			Charpy V-Notch Impact Value (Joules)		
	Y.S. (MPa)	T.S. (MPa)	EL. (%)	-29℃	-40℃	-50℃
KW-1+KF880	516	598	31	110	86	-
AWS A5.17 F7A4-EH14	400 min	4800-660	22 min	-	27min	-

KUANG TAI

海上變電站建造

使用母材: S355ML
使用銲材: KM-56
KFX-719
KW-1+KF-880

水下基礎建造
(JACKET)

海上變電站建造

青島中油海 中国石油

KUANG TAI

KMX-70M打底測試

6G打底

正面銲道

背面銲道

THANK YOU FOR YOUR ATTENTION!

KUANG TAI