KUANG TAI

# 高強度高韌性低溫用低合金鋼銲接材料

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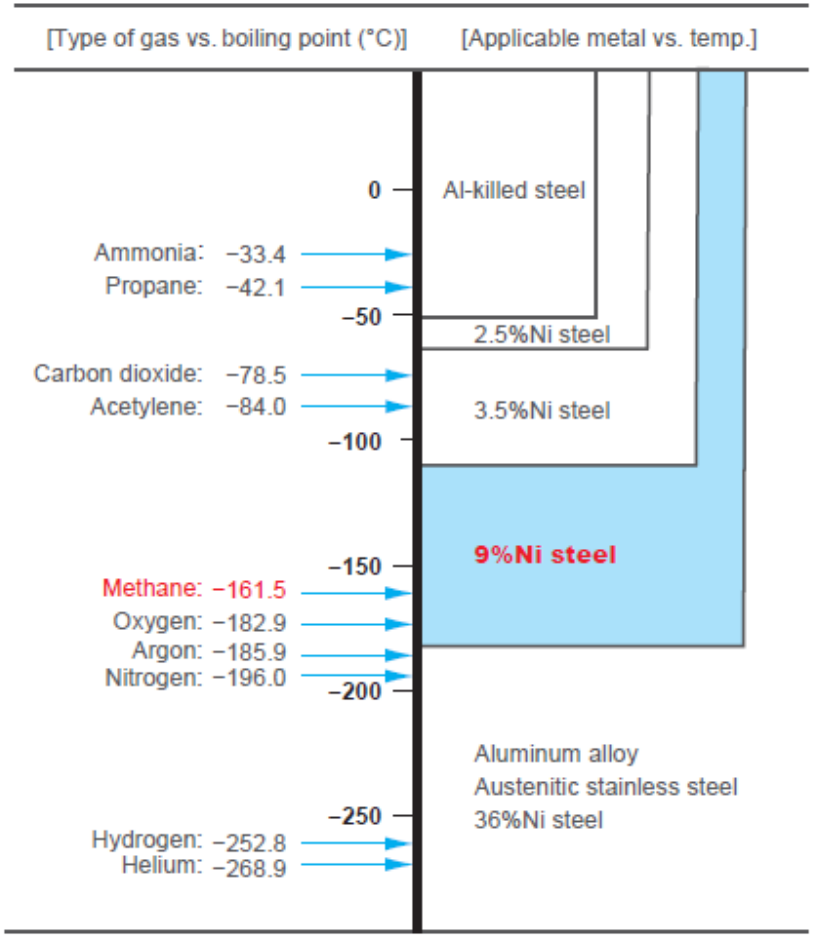
www.kuangtai.com

# 低合金鋼種類

- 耐熱鋼
  - 含0.5%~9% Cr 及0.5~1% Mo
- **低溫鋼**
  - **含1.5%~3.5% Ni**
- 耐候鋼
  - 含少量Cu、Cr、Ni使鋼材表面形成緻密氧化層保護，防止再向內腐蝕
- 高強鋼
  - 控制Mn、Cr、Ni、Mo達到高抗拉強度與降伏強度

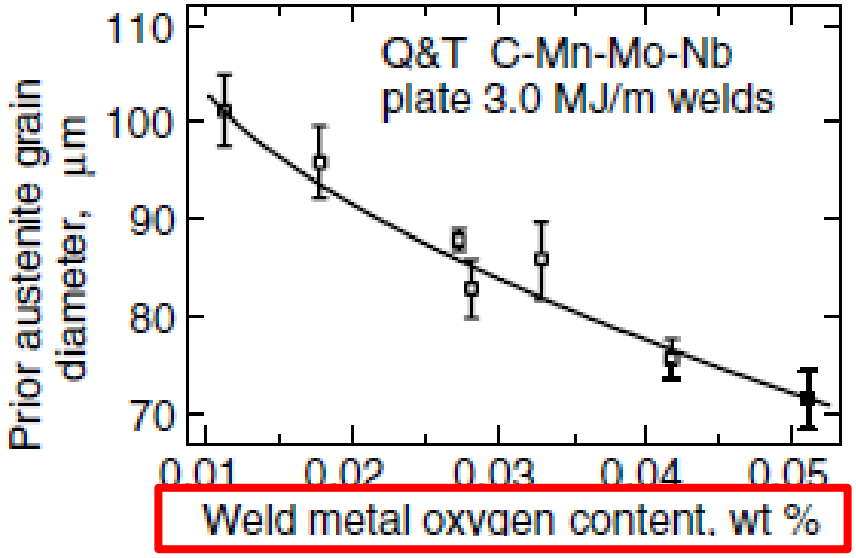
# 低溫鋼定義

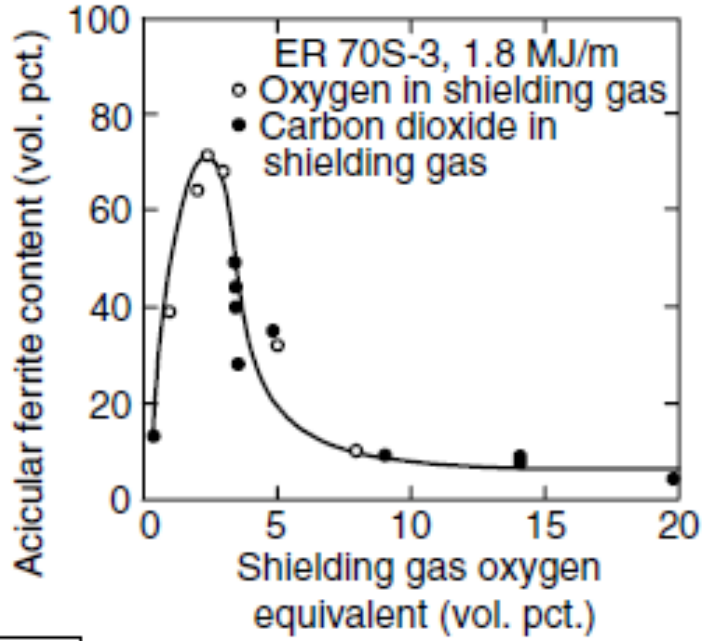
- 低溫鋼的工作溫度介於-20~-296ºC之間的工程結構用鋼
  - 肥粒鐵型
    - 1.5%Ni鋼 (工作溫度: -20~-50ºC)
    - 2.5%Ni鋼 (工作溫度: -50~-70ºC)
    - 3.5%Ni鋼 (工作溫度: -70~-100ºC)
  - 低碳麻田散鐵型
    - 9%Ni 鋼 (工作溫度: -100~-196ºC)

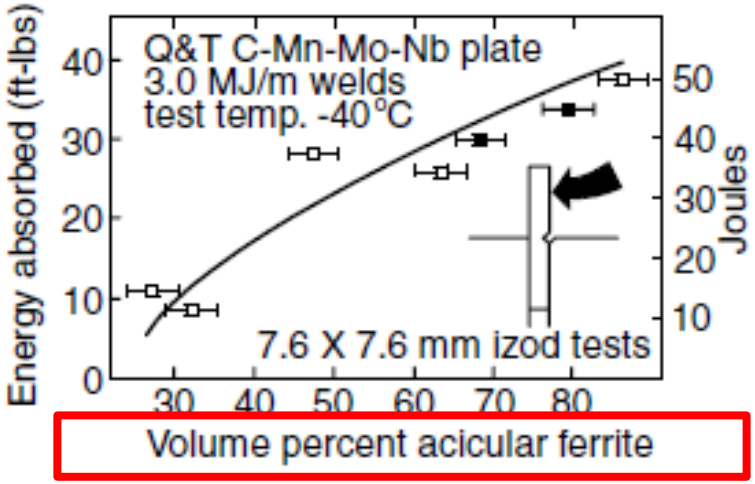



*Ref: Kobe Welding Today, 2011 No.2*

# 低溫衝擊韌性



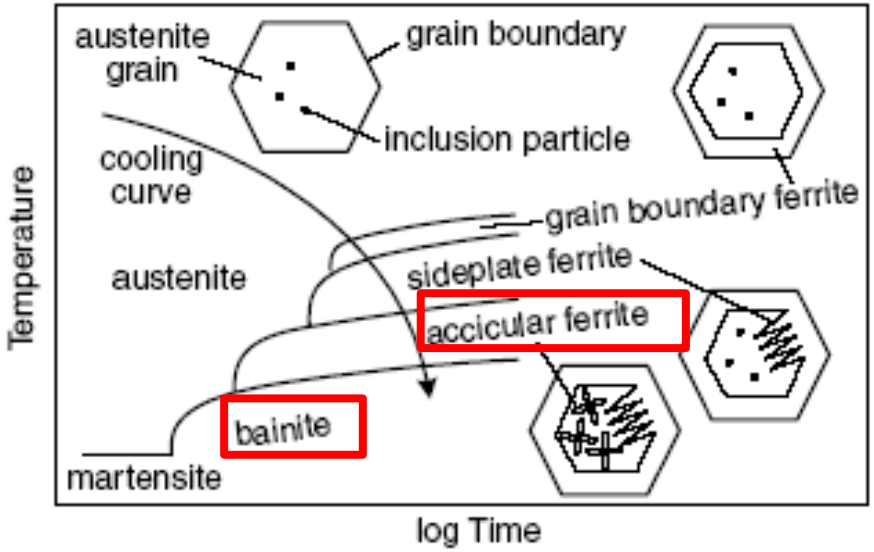



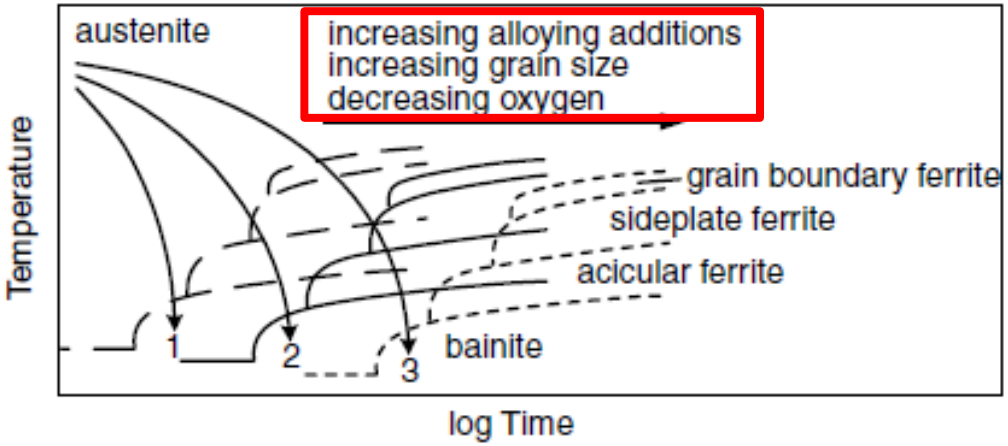



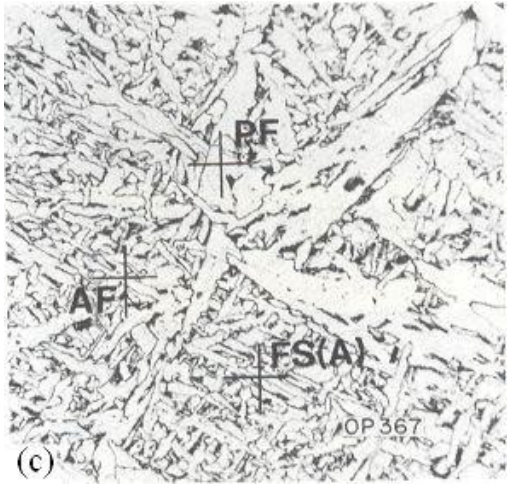


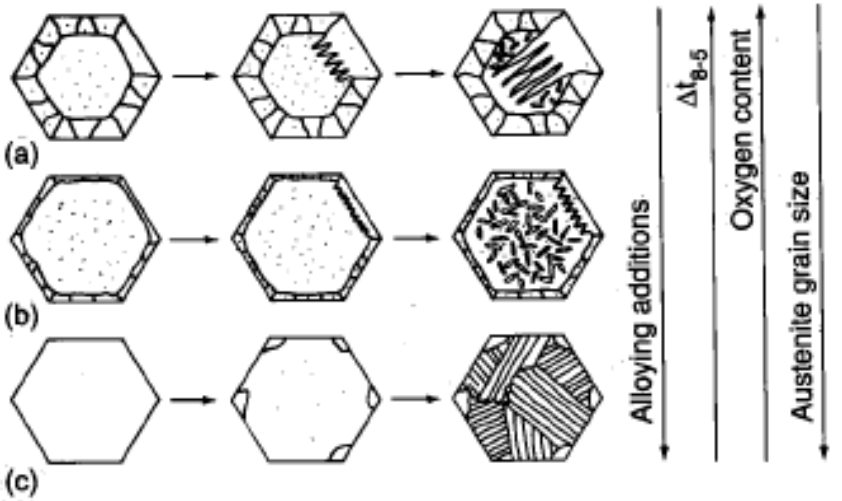

Ref: S. Kou, Welding Metallurgy

# 低溫鋼組織細化






Ref: S. Kou, Welding Metallurgy

# 民生用低合金高強度鋼

- 日本
  - HT-50 (C-Mn)
  - HT-60 (Ni-Cr-Mo)
  - HT-80 (Ni-Cr-Mo)
  - HT-100 (Ni-Cr-Mo)

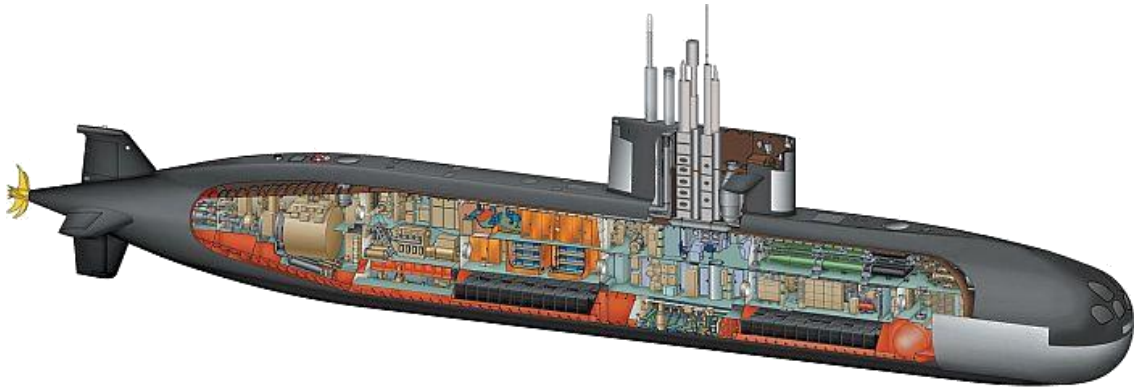
製程: 1.軋制
2.正火
3.調質
4.TMCP
5.淬火+時效
6.淬火+低溫回火

- 歐美高強度管線用鋼
  - X70 (C-Mn or Cu)
  - X80 (Ni-Cr-Mo or Ti-B)
  - X100 (Mo)

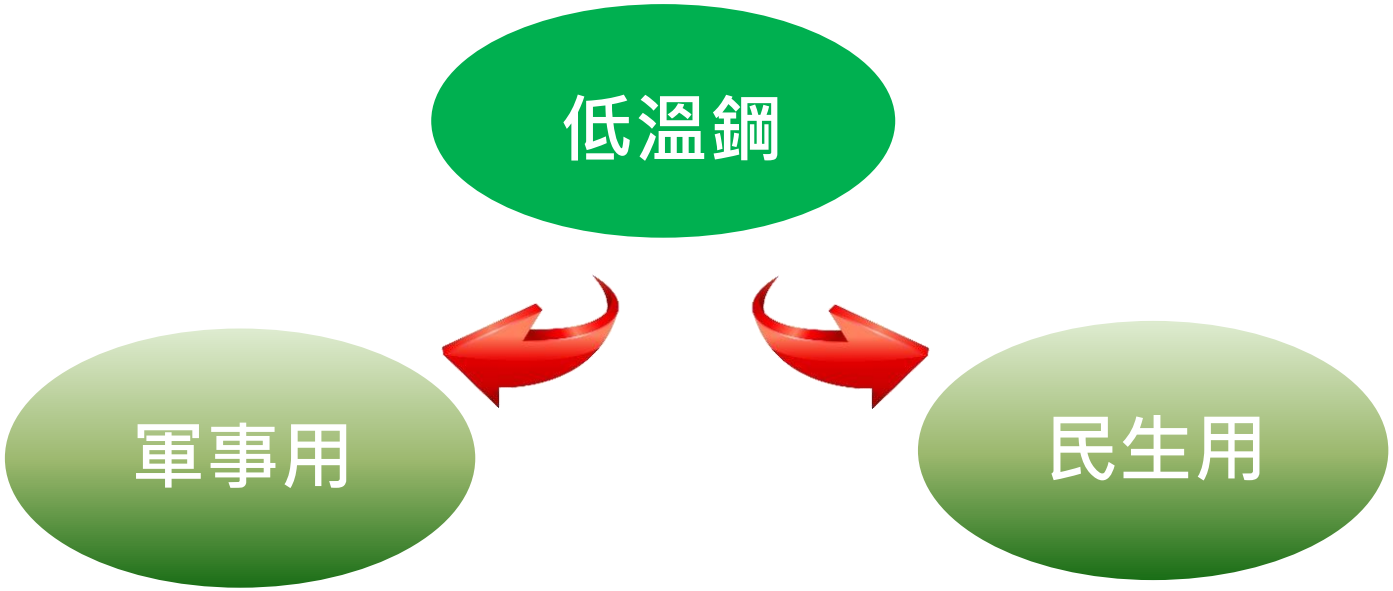
製程: 1.TMCP
2.CR+時效
3.調質

# 潛艦用低合金高強度高韌性鋼

- 美國
  - HY-80 & HSLA-80
  - HY-100 & HSLA-100
  - HY-130
- 日本
  - NS 46
  - NS 63
  - NS 80
  - NS 90
  - NS 110



# 低溫鋼應用




- 軍艦
- 潛艦

- 低溫壓力容器
- 輸油管線&海底管線
- 海洋結構物

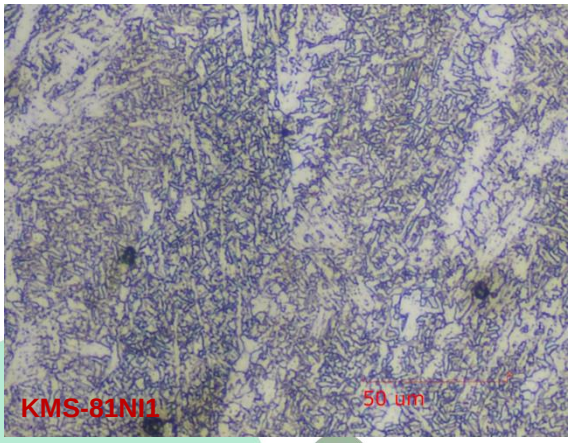
# 民生應用-
# 低溫壓力容器、輸送管線及設備

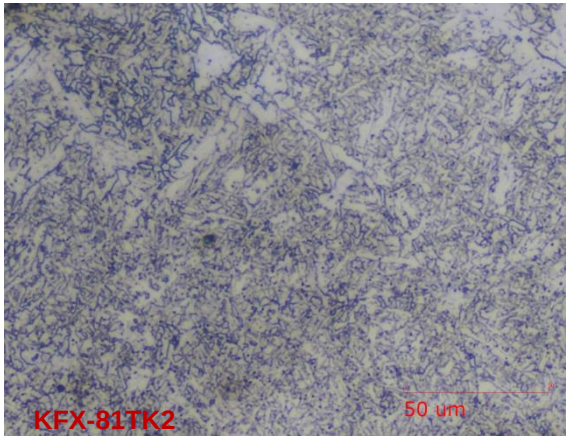
- LNG
- LPG
- 液態氧(-183ºC)
- 液態氮(-196ºC)
- 液態氫(-253ºC)
- 液態氦(-269ºC)

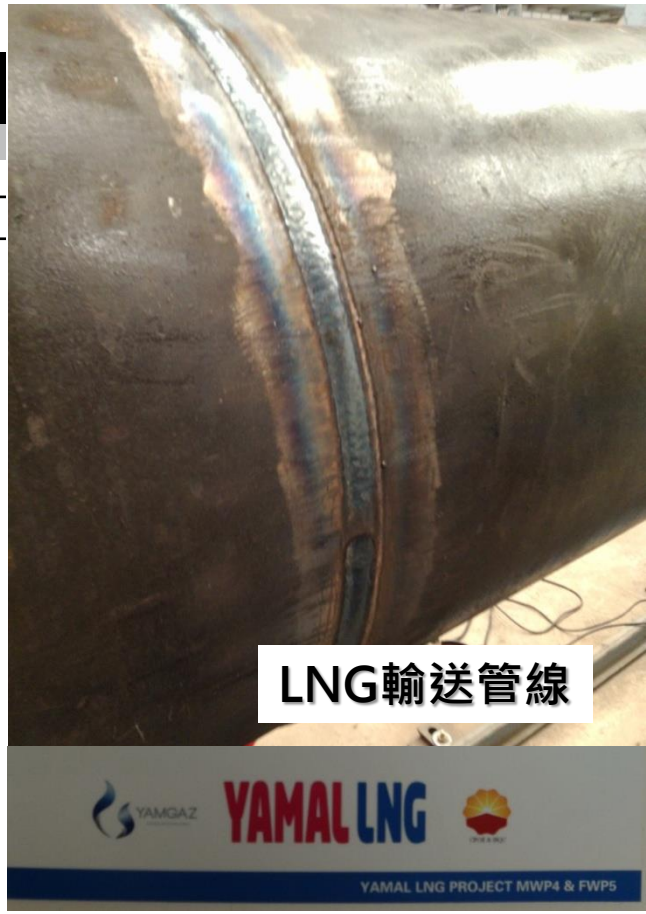
# 民生應用-LNG輸送管線

| 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 | - | - |



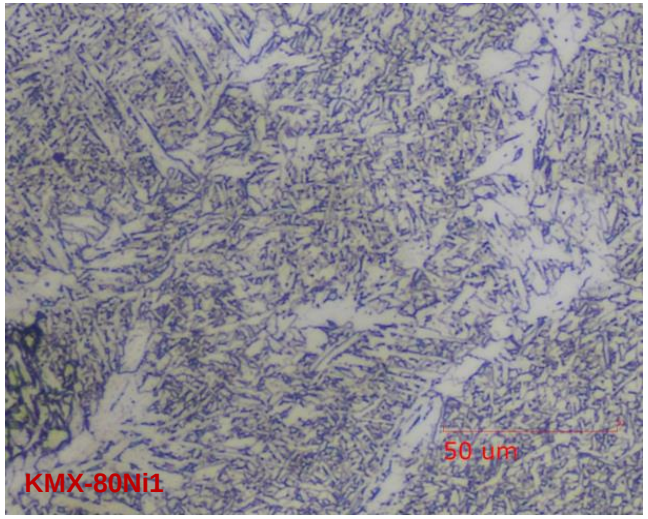



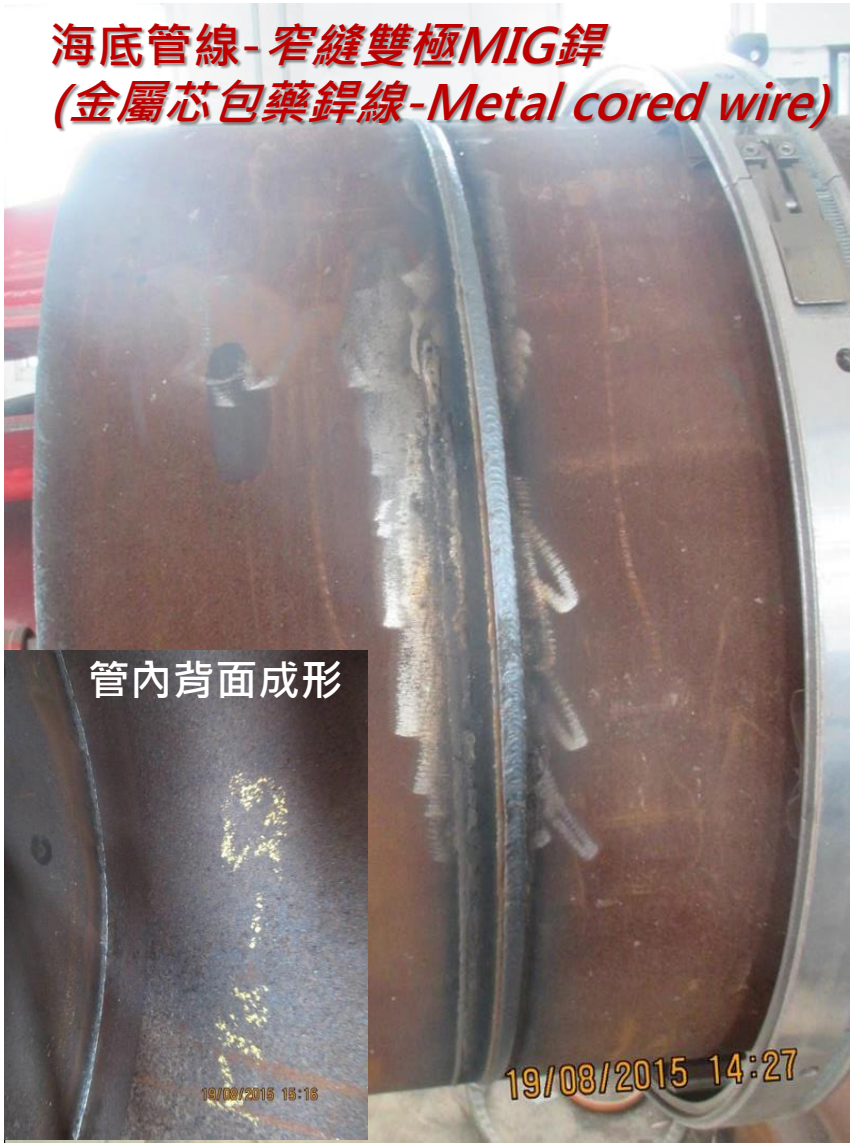

**Root pass: *KM-80Ni1* (ER80S-Ni1)**
**Hot/Cap pass: *KFX-81TK2* (E81T1-K2C)**

# 民生應用-海底管線

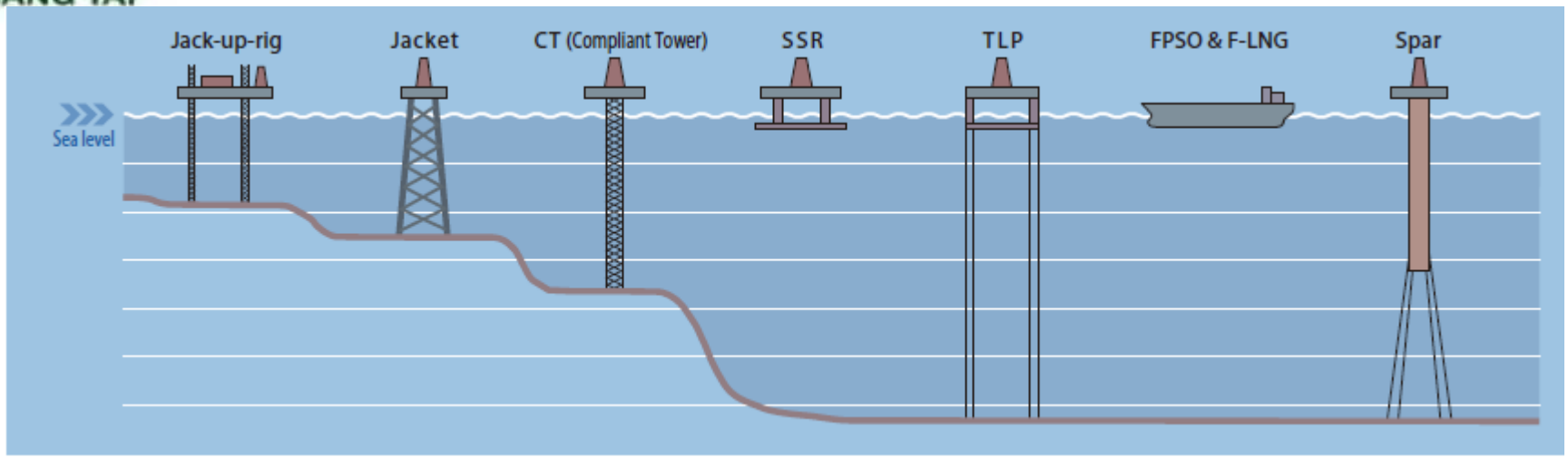
**Root pass: *KMX-80Ni1* (E80C-Ni1)**
**Hot pass: *KMX-80Ni1* (E80C-Ni1)**
**Cap pass: *KMX-80Ni1* (E80C-Ni1)**




***海底管線-窄縫雙極MIG銲***
***(金屬芯包藥銲線-Metal cored wire)***

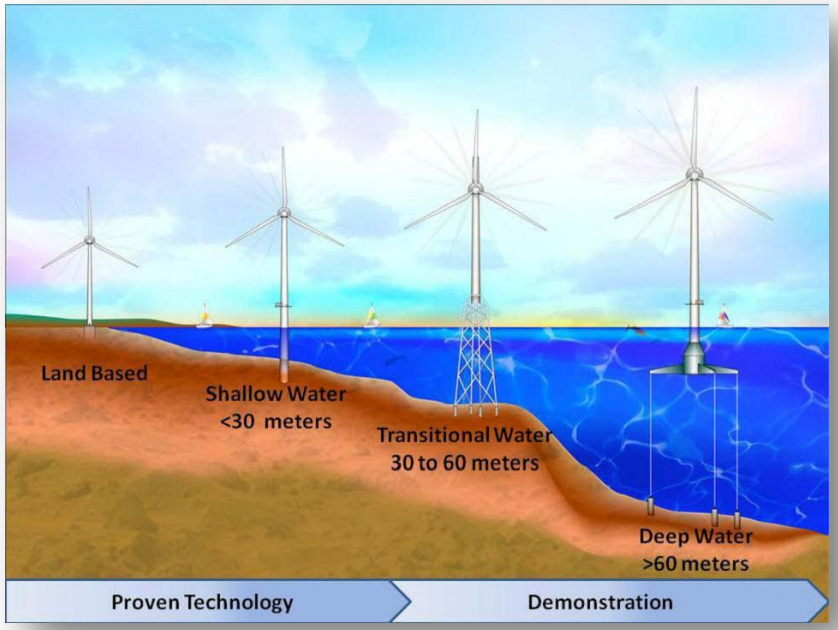


# 民生應用-海洋平台

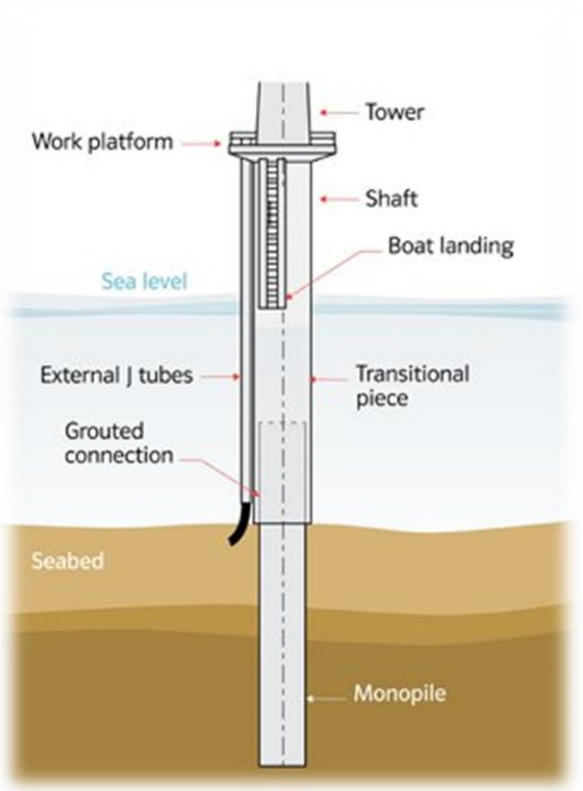



***Basic requirement:***
***-40ºC or -60ºC  impact toughness***

# 民生應用-離岸風力發電




水下支撐結構

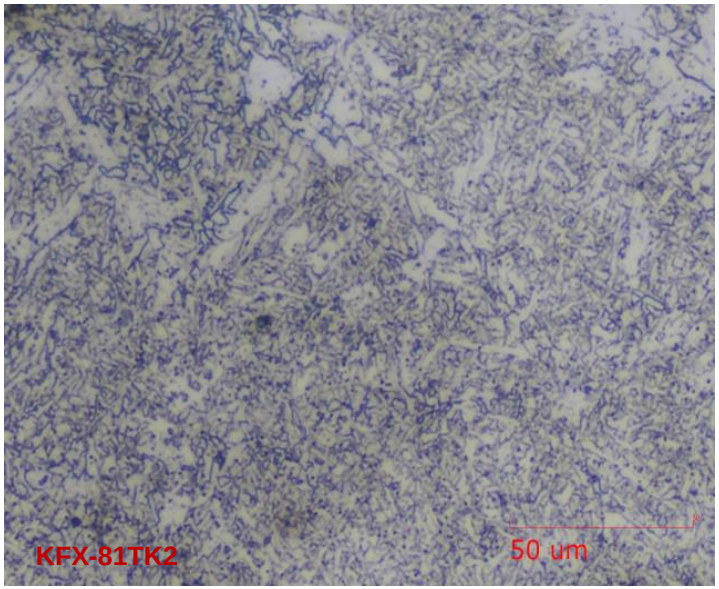



**EN 10025-3/4 S355NL & S460ML**
**中鋼: S690Q**

***Basic requirement:***
***-40°C or -60°C impact toughness***

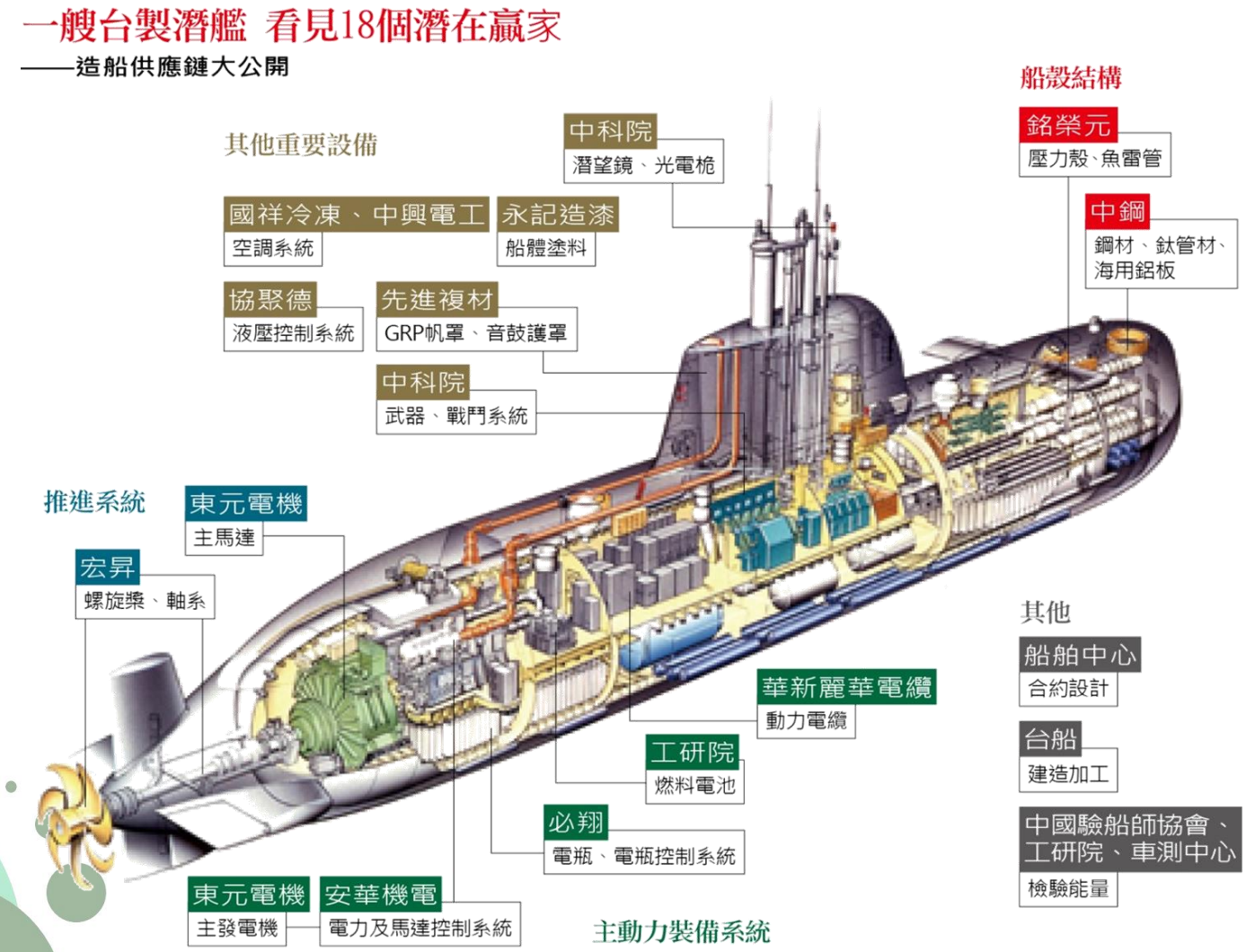
# 民生應用-海洋平台


***KFX-81TK2* (E81T1-K2C)**




| Brand Name | Tensile Test Results | | | Charpy V-Notch Impact Value (Joules) | | | Diffusible hydrogen (ml/100g) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Y.S. (MPa) | T.S. (MPa) | EL. (%) | -30℃ | -40℃ | -60℃ | 1 | 2 | 3 |
| KFX-81TK2 | 592 | 635 | 24 | 140 | 100 | 80 | 4.1 | 4.2 | 3.9 |
| E81T1-K2C | 470 min. | 550–690 | 19min | 27 min | - | - | 5 max | | |

# 軍事用-潛艦


一艘台製潛艦 看見18個潛在贏家
——造船供應鏈大公開
船殼結構
銘榮元
壓力殼、魚雷管
中鋼
鋼材、鈦管材、海用鋁板
其他重要設備
中科院
潛望鏡、光電桅
國祥冷凍、中興電工
空調系統
永記造漆
船體塗料
協聚德
液壓控制系統
先進複材
GRP帆罩、音鼓護罩
中科院
武器、戰鬥系統
推進系統
東元電機
主馬達
宏昇
螺旋槳、軸系
其他
船舶中心
合約設計
台船
建造加工
中國驗船師協會、工研院、車測中心
檢驗能量
華新麗華電纜
動力電纜
工研院
燃料電池
必翔
電瓶、電瓶控制系統
東元電機
主發電機
安華機電
電力及馬達控制系統
主動力裝備系統

# HY & HSLA比較

| | C | Si | Mn | Ni | Cr | Mo | Cu |
|---|---|---|---|---|---|---|---|
| HY-80 | 0.18 | 0.15-0.35 | 0.1-0.4 | 2.0-3.25 | 1.0-1.8 | 0.2-0.6 | - |
| HSLA-80 | 0.06 | 0.4 | 0.4~0.7 | 0.7~1.0 | 0.6~0.9 | 0.15~0.25 | 1.0~1.3 |

銲接性提升

製造成本下降

銅析出硬化提高強度

HY-80 需預熱90~150度
HSLA-80不需預熱

中鋼開發
HSLA-80

| 鋼板 | 厚度 (mm) | 機性表現 | | | |
|---|---|---|---|---|---|
| | | YS (MPa) | TS (MPa) | EL (%) | $CVN_{-84℃}$ (J) |
| HSLA-80 | 13 | 606 | 681 | 28 | 194.2 |
| | 15 | 581 | 628 | 30 | 310.0 |
| | 20 | 559 | 617 | 26 | 245.3 |
| | 32 | 594 | 666 | 26 | 217.0 |
| 美軍規格 | -- | 552-690 | -- | ≧20 | ≧142 |

# HY & HSLA-銲接性比較

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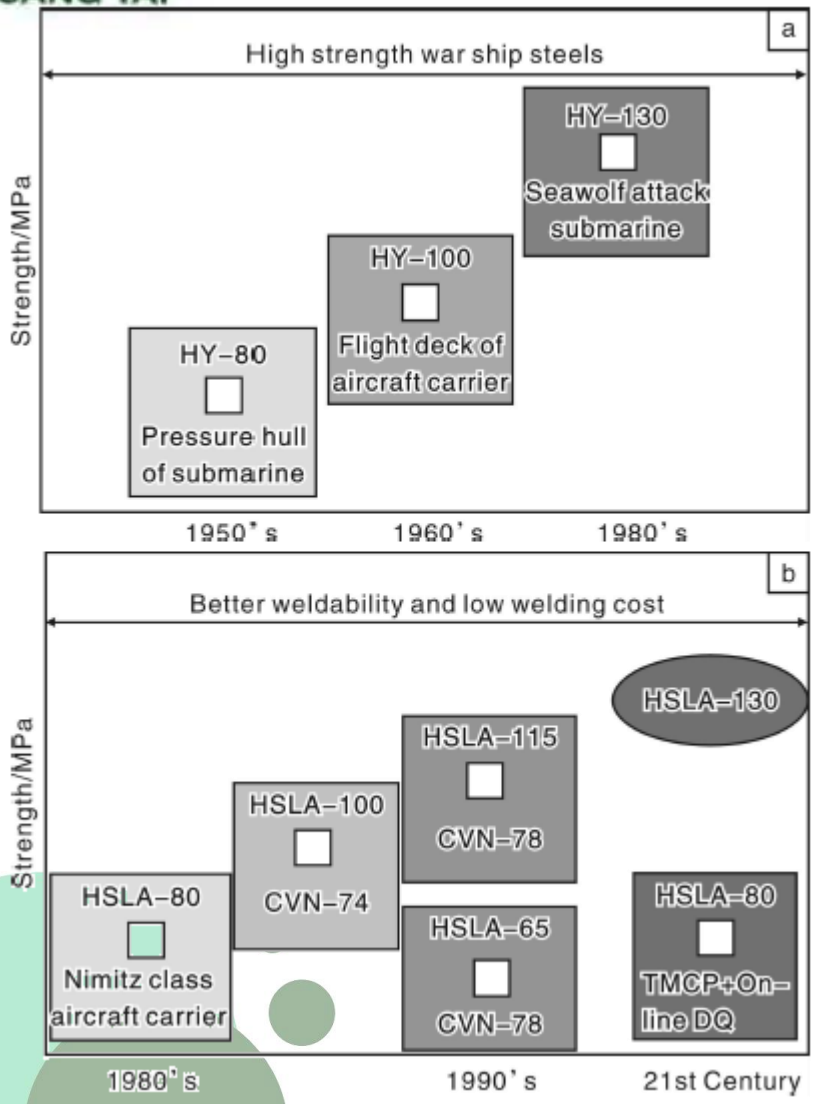
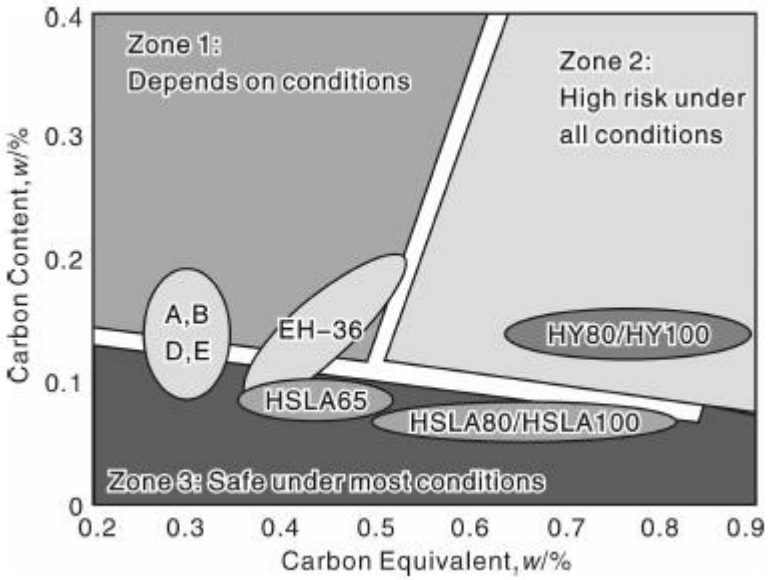
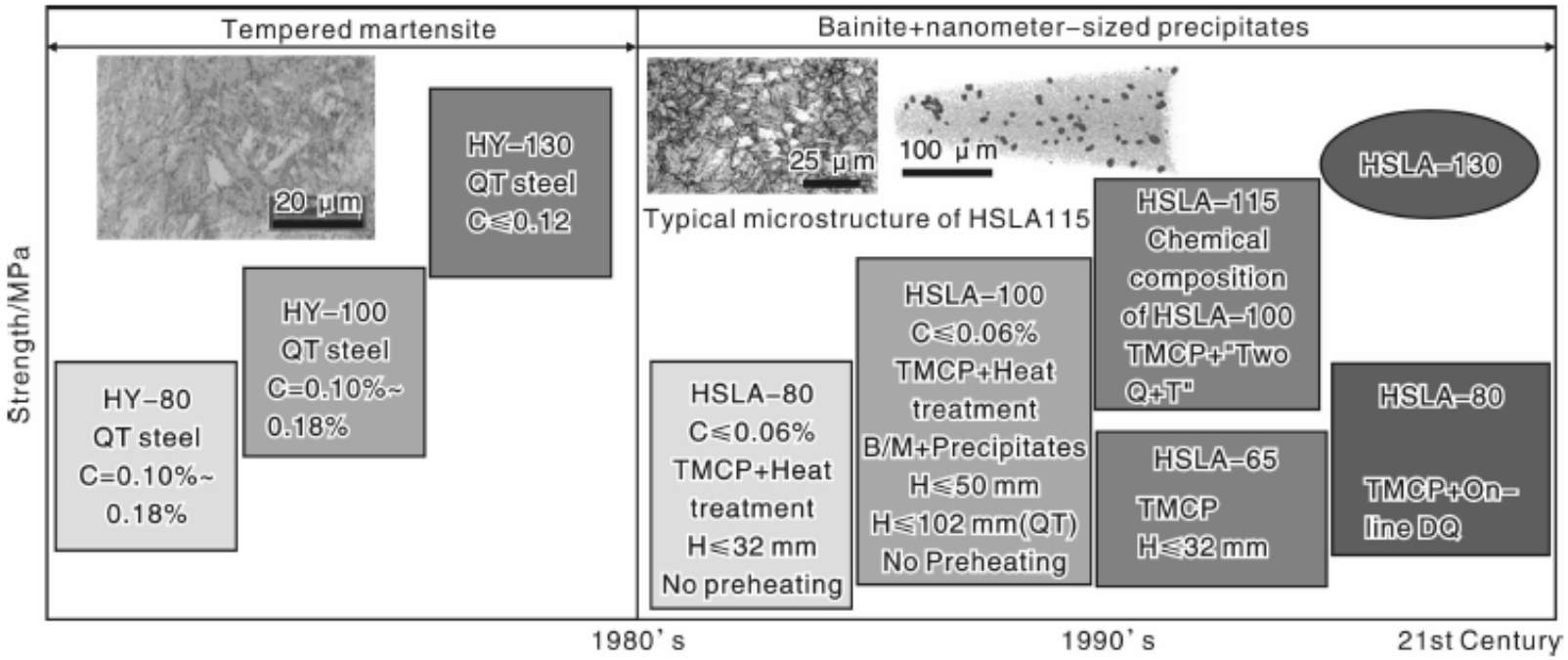





REF:新一代舰船用钢制备技术的现状与发展展望

# HY&HSLA比較-*組織比較*

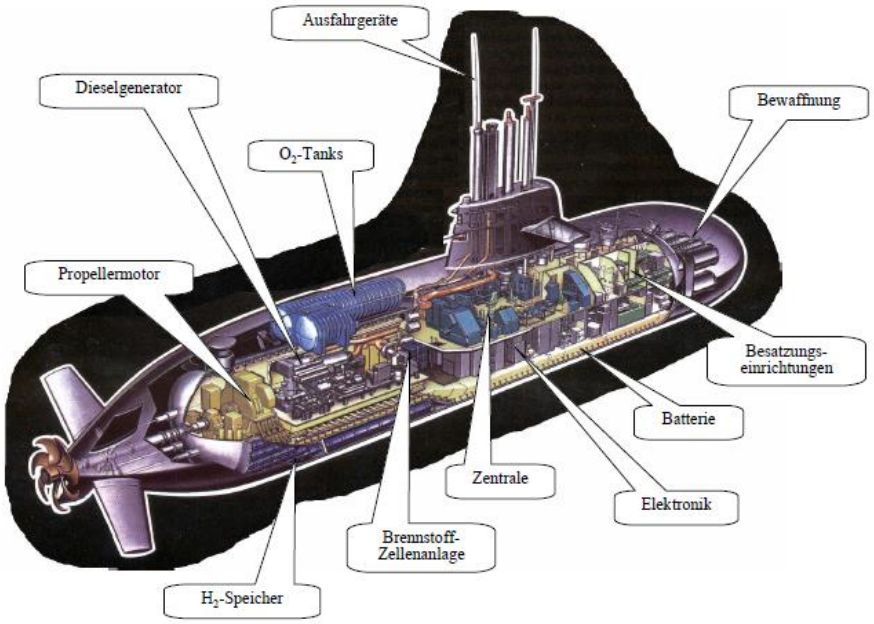


# 軍事用-潛艦用銲材

***Welding Consumable specification:***

**T9074-BC-GIB-010/0200**

**FILLER MATERIALS FOR CRITICAL APPLICATIONS: REQUIREMENTS FOR FLUX-CORED WELDING ELECTRODES, BARE WELDING ELECTRODES AND FLUXES, AND COVERED WELDING ELECTRODES FOR LOW-ALLOY STEEL APPLICATIONS**



# 潛艦用銲材

- *SMAW-Chemical Composition*

| Element | MIL-10018-M1 | MIL-10718-M | MIL-12018-M2 |
|---|---|---|---|
| Carbon | 0.06 | 0.07 | 0.07 |
| Manganese | 0.80 - 1.85 | 0.80 - 1.85 | 0.80 - 1.85 |
| Silicon | 0.65 | 0.60 | 0.65 |
| Phosphorus | 0.025 | 0.025 | 0.025 |
| Sulfur | 0.017 | 0.017 | 0.012 |
| Chromium | 0.40 4/ | 0.40 4/ | 0.65 |
| Nickel | 1.25 - 3.00 | 1.25 - 2.50 | 1.50 - 4.00 |
| Molybdenum | 0.50 | 0.25 - 0.50 | 0.90 |
| Vanadium | 0.05 | 0.05 | 0.05 |
| Copper | 2/ | 2/, 3/ | 2/, 3/ |
| Boron | --- | 3/ | 3/ |

***KL-108M*** ***KL-118M***

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# 潛艦用銲材

- *SMAW-Mechanical Properties*

| Property | Condition | MIL-10018-M1 | MIL-10718-M | MIL-12018-M2 |
|---|---|---|---|---|
| Yield strength (ksi) | As-welded | 82 - 110 2/ | 88 - 122 2/, 12/ | 102 - 123 2/, 3/ |
| | Stress relieved | 80 | 86 | ---- |
| Ultimate tensile strength (ksi) | | 4/ | 4/ | 4/ |
| Elongation in 2 inches (percent) | As-welded | 20 5/ | 20 5/ | 18 5/ |
| | Stress relieved | 20 | 20 | ---- |
| Transverse side bend | | 6/ | 6/ | 6/ |
| Charpy V-notch 8/ Energy ft-lb average @ Temperature (F) | As-welded | 35@(-60F) 60@(0F) | 35@(-60F) 60@(0F) | 45@(-60F) 8/ 60@(0F) |
| | Stress relieved | 20@(-60F) 50@(0F) | 20@(-60F) 50@(0F) | ---- |
| Dynamic tear, Energy ft-lb average @ Temperature (F) 9/, 10/ | As-welded | 300@(-20F) 450@(30F) | 300@(-20F) 450@(30F) | 400@(-20F) 575@(30F) |
| Explosion test series | | 11/ | 11/ | 11/ |

# KL-118M-*Data sheet*

## *Mechanic Properties*

| | Tensile Test Results | | | Charpy V-Notch Impact Value (Joules) | | | Diffusible Hydrogen (ml/100g) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Y.S. (MPa) | T.S. (MPa) | EL. (%) | -18℃ | -40℃ | -51℃ | 1 | 2 | 3 |
| KL-118M | 690 | 783 | 22 | 133 | 106 | 85 | 2.7 | 2.9 | 2.5 |
| MIL-11018-M | 616~854 | - | 20 min | 81 min | - | 47 min | 3.2 max for 3.2mm<br>3.5 max for 4.0mm ↑ | | |

## *Chemical Composition*

| | C | Si | Mn | P | S | Ni | Cr | Mo | V |
|---|---|---|---|---|---|---|---|---|---|
| KL-118M | 0.06 | 0.48 | 1.54 | 0.017 | 0.007 | 2.297 | 0.023 | 0.397 | 0.007 |
| MIL-10718-M | ≤0.07 | ≤0.65 | 0.85~1.85 | ≤0.025 | ≤0.017 | 1.25-2.50 | ≤0.40 | 0.25~0.50 | ≤0.05 |

# 潛艦用銲材

- *GMAW & SAW-Chemical Composition*

| Welding process | ALL | GMAW SAW | ALL | GMAW SAW |
|---|---|---|---|---|
| Type 2/ | 100S-1 100S-2 | 100S-1C 100S-2C | 120S-1 120S-2 | 120S-1C 120S-2C |
| Chemical composition (weight percent) 1/ | | | | |
| Carbon | 0.07 3/ | 0.07 3/ | 0.070 3/, 4/ | 0.070 3/, 4/ |
| Manganese | 1.25-1.8 | 1.25-2.5 | 0.90-2.35 | 1.4-3.8 |
| Silicon | 0.20-0.55 | 0.20-0.55 | 0.60 | 0.20-0.55 |
| Phosphorus | 0.012 | 0.012 | 0.012 | 0.012 |
| Sulfur | 0.008 | 0.010 | 0.008 | 0.010 |
| Nickel | 1.40-2.10 | 1.40-2.10 | 1.00-3.0 | 1.00-3.5 |
| Molybdenum | 0.25-0.55 | 0.25-0.55 | 0.30-1.00 | 0.30-1.10 |
| Chromium | 0.30 8/ | 0.30 8/ | 0.80 | 0.60 |
| Vanadium | 0.05 | 0.04 | 0.03 | 0.04 |
| Aluminum | 0.10 | 0.05 | 0.10 | 0.05 |
| Titanium | 0.10 | 0.10 | 0.10 | 0.10 |
| Zirconium | 0.10 | 0.10 | 0.10 | 0.10 |
| Copper | 5/, 6/, 7/ | 5/, 6/, 7/ | 5/, 6/, 7/ | 5/, 6/, 7/ |
| Boron | 7/ | 7/ | 7/ | 7/ |

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# 潛艦用銲材

- *GMAW & SAW-Mechanic Properties*

| Type 2/ | 100S-1<br>100S-1F<br>100S-2<br>100S-2F | 120S-1<br>120S-1F<br>120S-2<br>120S-2F |
|---|---|---|
| Yield Strength (1000 pounds per square inch) (ksi) | 82 to 120 3/, 12/ | 102 to 123 3/, 4/, 12/ |
| Elongation in 2 inches min. (percent) | 16 | 15 |
| Transverse side bend | 5/ | 5/ |
| Charpy V-notch. Energy ft-lb min. average @ Temperature (degrees Fahrenheit) (F) | 35@(-60F) 6/<br>60@(0F) 6/ | 45@(-60F) 6/, 7/<br>60@(0F) 6/ |
| Dynamic tear. Energy ft-lb minimum average @ Temperature (degrees Fahrenheit) (F) | 300@(-20F) 8/, 9/<br>450@(+30F) 9/, 10/ | 400@(-20F) 8/, 9/<br>575@(+30F) 9/, 10/ |
| Explosion test series | 11/ | 11/ |

# KM-100S1-*Data sheet*

## *Mechanic Properties*

| | Tensile Test Results | | | Charpy V-Notch Impact Value (Joules) | | | Diffusible Hydrogen (ml/100g) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Y.S. (MPa) | T.S. (MPa) | EL. (%) | -18℃ | -40℃ | -51℃ | 1 | 2 | 3 |
| KM-100S1 | 651 | 730 | 18 | 155 | 112 | 82 | 2.1 | 2.2 | 2.2 |
| MIL-100S-1 | 575-840 | - | 16 min | 81 min | - | 47 min | | 4.0 max | |

## *Chemical Composition*

| | C | Si | Mn | P | S | Ni | Cr | Mo | V |
|---|---|---|---|---|---|---|---|---|---|
| KM-100S1 | 0.075 | 0.44 | 1.32 | 0.008 | 0.007 | 1.78 | 0.045 | 0.41 | 0.01 |
| MIL-100S-1 | ≤0.07 | 0.2~0.55 | 1.25~1.8 | ≤0.012 | ≤0.008 | 1.2-2.1 | ≤0.30 | 0.25~0.55 | ≤0.05 |

# 潛艦用銲材

- *FCAW-Chemical Composition& Mechanical Properties*

| MIL-type 1/ | Chemical composition (wt. percent) 2/ 3/ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Carbon | Manganese | Silicon | Phosphorus | Sulfur | Nickel | Chromium | Molybdenum | Vanadium | Copper |
| MIL-101TC<br>MIL-101TM | 0.07 | 0.50 to 1.50 | 0.60 | 0.015 | 0.015 | 1.30 to 3.75 | 0.20 | 0.50 | 0.05 | 0.06 |

| MIL-type | 101TC<br>101TM |
|---|---|
| Yield strength (1000 pounds per square inch) (ksi) 2/ | 82 to 110 |
| Elongation in 2 inches min. (percent) | 18 |
| Transverse side bend | 3/ |
| Charpy V-notch. Energy ft-lb minimum average @ Temperature (degrees Fahrenheit) (F) 4/ | 35@(-60F)<br>60@(0F) |
| Dynamic tear. Energy ft-lb minimum average @ Temperature (degrees Fahrenheit) (F) | 300@(-20F) 5/<br>450 @(+30F) 6/ |
| Explosion crack starter test | 7/ |

***KFX-101K3***

# KFX-101K3-*Data sheet*

## *Mechanic Properties*

| | Tensile Test Results | | | Charpy V-Notch Impact Value (Joules) | | | Diffusible Hydrogen (ml/100g) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Y.S. (MPa) | T.S. (MPa) | EL. (%) | -18℃ | -40℃ | -51℃ | 1 | 2 | 3 |
| KFX-101K3 | 674 | 719 | 22 | 112 | 76 | 58 | 3.8 | 3.7 | 3.5 |
| MIL-101TC | 575-770 | - | 18 min | 81 min | - | 47 min | 4.0 max | | |

## *Chemical Composition*

| | C | Si | Mn | P | S | Ni | Cr | Mo | V |
|---|---|---|---|---|---|---|---|---|---|
| KFX-101K3 | 0.04 | 0.28 | 1.278 | 0.013 | 0.006 | 2.14 | 0.04 | 0.30 | 0.015 |
| MIL-101TC | ≤0.07 | ≤0.6 | 0.5~1.5 | ≤0.015 | ≤0.015 | 1.3-3.75 | ≤0.20 | ≤0.5 | ≤0.05 |

# 廣泰全系列低溫鋼用產品

***SMAW***

| Welding consumable | Min. applicable strength (MPa) | | Applicable tmperature(°C) | Chemical compositions of weld metal (mass %) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | YP | TS | vE ≧47J | C | Si | Mn | Ni | Mo | Ti | B |
| KL-718-1 | 400 | 520 | -40 | 0.06 | 0.4 | 1.5 | - | - | 0.03 | 0.004 |
| KN-718G | 400 | 520 | -45 | 0.08 | 0.2 | 1.2 | 1.6 | - | 0.02 | 0.003 |
| KN-818C1 | 460 | 550 | -60 | 0.08 | 0.4 | 1.0 | 2.5 | - | 0.02 | 0.002 |
| KN-916G | 530 | 620 | -60 | 0.07 | 0.3 | 1.3 | 2.6 | - | 0.01 | 0.002 |
| KL-108M | 610 | 690 | -51 | 0.05 | 0.4 | 1.3 | 2.0 | 0.3 | 0.02 | - |
| KL-118M | 680 | 760 | -51 | 0.06 | 0.5 | 1.6 | 2.3 | 0.3 | 0.02 | - |

# 廣泰全系列低溫鋼用產品

***GMAW***

| Welding Consumable | Min. applicable strength (MPa) | | Applicable tmperature(°C) | Chemical compositions of weld metal (mass %) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | YP | TS | vE ≧47J | C | Si | Mn | Ni | Mo | Ti | B |
| KM-80Ni1 | 470 | 550 | -45 | 0.08 | 0.4 | 1.0 | 1.0 | - | - | - |
| KM-80Ni2 | 470 | 550 | -60 | 0.08 | 0.5 | 1.1 | 2.2 | - | - | - |
| KM-90D2 | 540 | 620 | -30 | 0.08 | 0.4 | 1.6 | - | 0.4 | - | - |
| KM-100S1 | 690 | 610 | -51 | 0.07 | 0.4 | 1.3 | 1.8 | 0.4 | - | - |

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# 廣泰全系列低溫鋼用產品

**FCAW**

| Welding Consumable | Min. applicable strength (MPa) | | Applicable tmperature(°C) | Chemical compositions of weld metal (mass %) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | YP | TS | vE ≧47J | C | Si | Mn | Ni | Mo | Ti | B |
| KFX-719 | 400 | 520 | -40 | 0.06 | 0.4 | 1.6 | 0.4 | - | 0.02 | 0.004 |
| KFX-81TNi1 | 470 | 550 | -30 | 0.04 | 0.3 | 1.3 | 0.9 | - | 0.02 | 0.004 |
| KFX-81TNi2 | 470 | 550 | -40 | 0.03 | 0.4 | 1.2 | 1.9 | - | 0.02 | 0.004 |
| KFX-81TK2 | 470 | 550 | -40 | 0.06 | 0.4 | 1.4 | 1.4 | - | 0.02 | 0.004 |
| KFX-91TK2 | 540 | 620 | -50 | 0.05 | 0.4 | 1.6 | 1.6 | - | 0.02 | 0.004 |
| KFX-101K3 | 610 | 690 | -40 | 0.04 | 0.3 | 1.4 | 2.1 | 0.3 | 0.01 | 0.002 |
| KFX-111K3 | 680 | 760 | -40 | 0.06 | 0.4 | 1.8 | 2.3 | 0.3 | 0.02 | 0.004 |

# 廣泰全系列低溫鋼用產品

***MCAW***

| Welding Consumable | Min. applicable strength (MPa) | | Applicable tmperature(°C) | Chemical compositions of weld metal (mass %) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | YP | TS | vE ≧47J | C | Si | Mn | Ni | Mo | Ti | B |
| KMX-70M | 400 | 480 | -30 | 0.05 | 0.4 | 1.5 | - | - | 0.02 | 0.004 |
| KMX-80Ni1 | 470 | 550 | -45 | 0.06 | 0.3 | 1.3 | 0.9 | - | 0.02 | 0.004 |


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# *Thanks for your attention!*

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