



FCW 400

**Joining/Cladding - Corrosion resisting Alloy
N04400**



SUMMARY

1. General Information
2. Presentation of FCW 400
3. Welding characteristics
4. Applications

1. General Information

- **MONEL® 400 (UNS N04400)**

- Nickel base → %Ni ~ 70%
- Nickel-Copper alloy → %Cu ~ 30%

%Ni	%Cu	%C	%Fe	%Mn	%Si	%S
> 63.0	28.0 34.0	< 0.30	< 2.50	< 2.00	< 0.50	< 0.02

- **MONEL® 400**

- Melting point ~ 1300-1350°C
- Resisting corrosion in a variety of aqueous solutions (notably sea water)

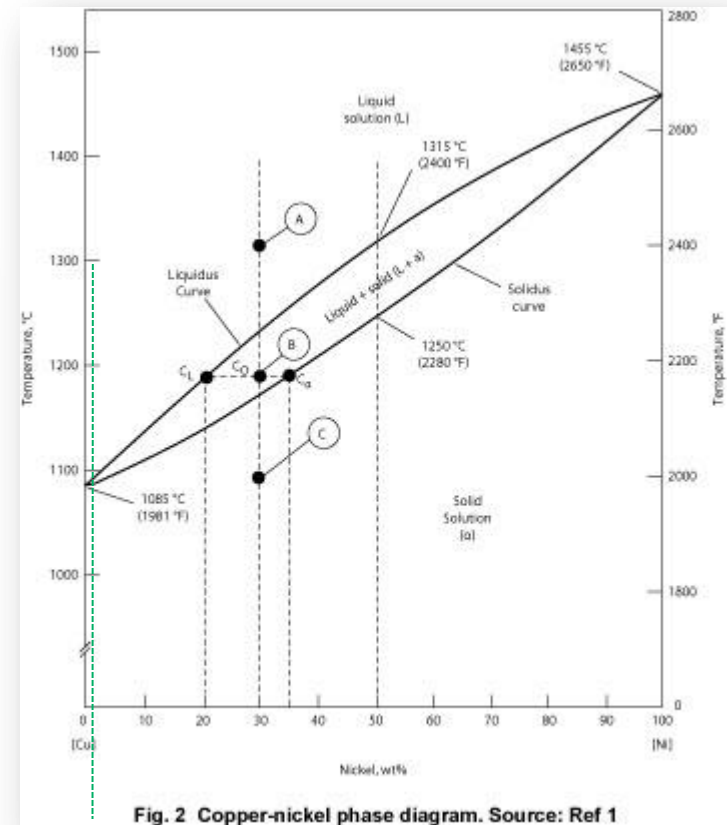
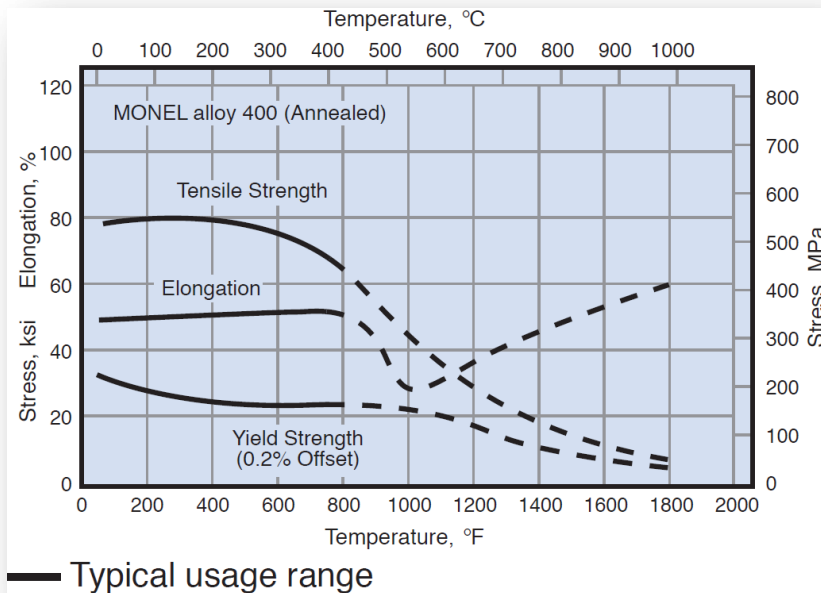


Marine & chemical
environments



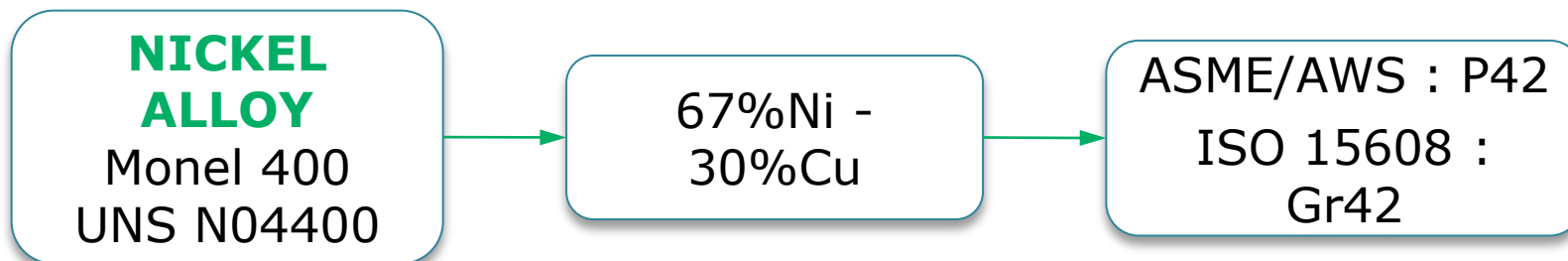
1. General Information

- Typical mechanical properties of **MONEL® 400**
 - Yield Strength → 240 MPa
 - Tensile strength → 550 MPa
 - Elongation → 40%



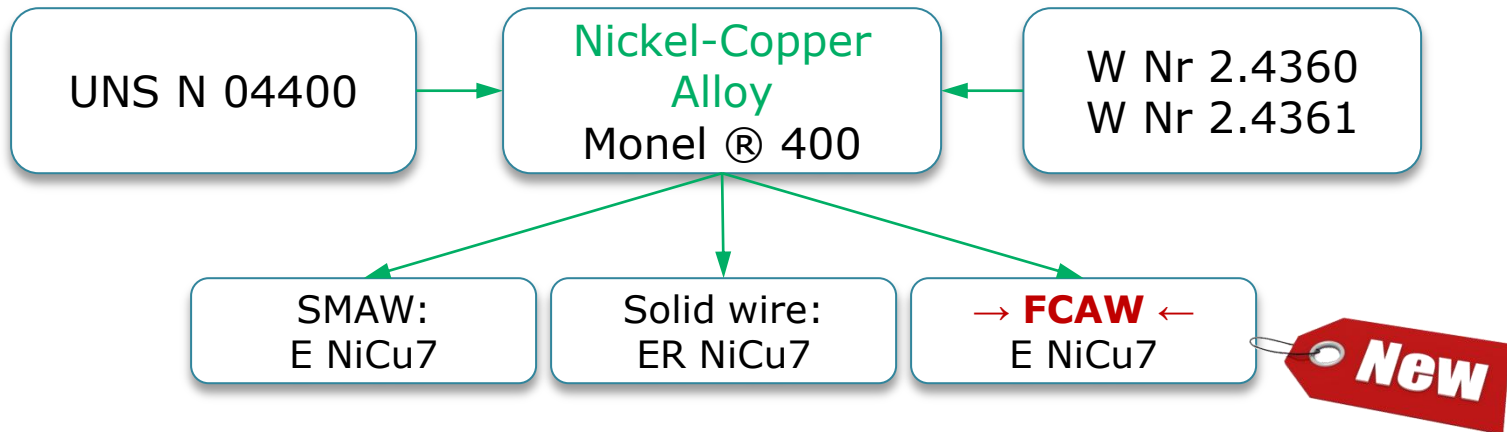
1. General Information

- **MONEL® 400 (UNS N04400)**
 - Nickel-Copper alloy



2. Presentation of FCW 400

- **FCW 400** is a Nickel-Copper alloy
 - Good mechanical properties
 - Excellent resistance to corrosion



ABRACOR is the first company
to propose a flux cored wire for **Alloy 400**



2. Presentation of FCW 400

- **FCW 400** description:

- Nickel-copper alloy wire for gas shielded flux cored arc welding
- Produced from a fully matching strip composition
- Deoxidation system designed to eliminate porosity and hot cracking
- Good slag release leaving a clean weld surface
- Good wetting with the base metal
- DC+ current
- Pulling technique
- Excellent resistance to hot cracking

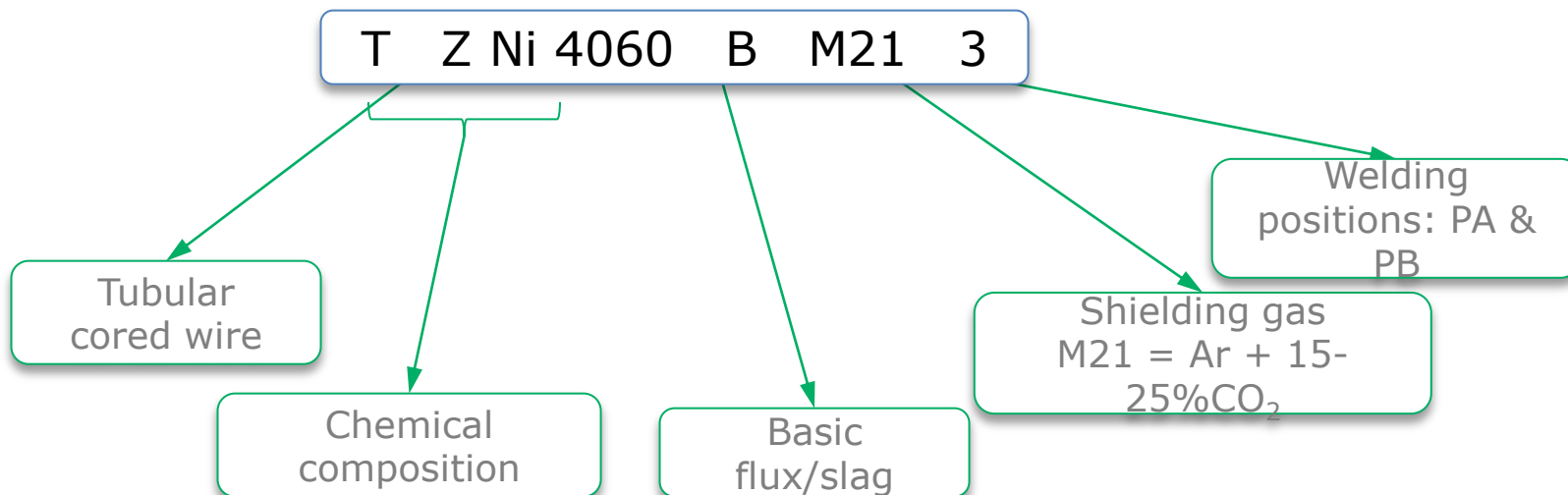
- **Classification:**

- EN ISO 12153 → T Z Ni 4060 (NiCu30Mn3Ti) B M21 3
- ASME II C → ENiCu7T0-4 → AWS A 5.34 /A5.34M



2. Presentation of FCW 400

- **Classification** according to the EN ISO 12153:



- **Typical all-weld metal analysis** of the **FCW 400**:

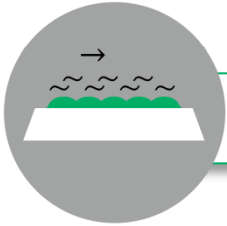
%C	%Mn (*)	%Si	%Ni	%Cu	%Ti (**)	%Fe	%Al	%S	%P
0.05	3.5	0.4	63	30	2.0	1.0	0.07	0.005	0.001

(*) : Manganese has a beneficial effect on ductility and resistance to hot cracking

(**) : Titanium percentage is increased to suppress porosity

3. Welding characteristics

- **FCW 400** is used for JOINING and CLADDING



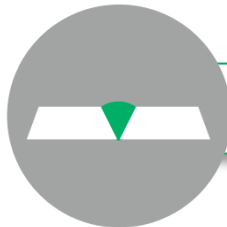
Cladding

Weld-overlay

A full NiCu7 composition is achieved in two layers on carbon steel

Excellent protection of the weld pool → Slag + Shielding gas

Low dilution compare to solid wire



Joining

Homogeneous welds of Nickel-Copper alloy

Heterogeneous welds

3. Welding characteristics

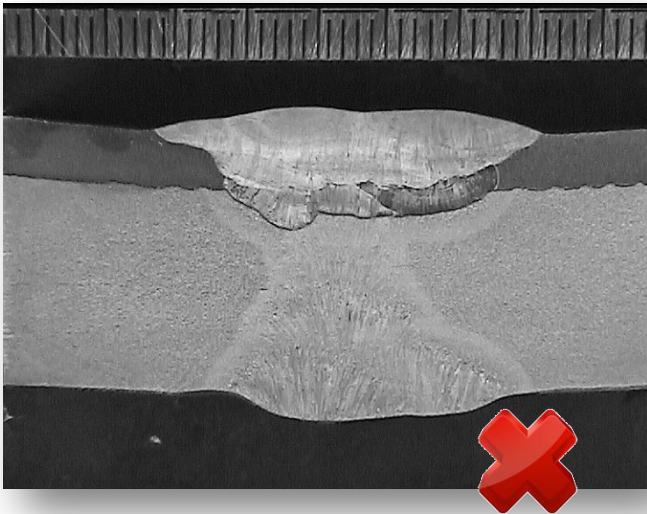
- **JOINING** with **FCW 400**
 - No preheating
 - Interpass temperature $\sim 150^{\circ}\text{C}$
- Heterogeneous weld possibilities

	Fe	Cr Ni	Fe Cu	Cu	Cu Al	Cu Sn Al	Cu Sn	Cu Ni	Ni Cu
Ni Cu	$\gamma 400$	$\gamma 400$	$\gamma 400$	$\gamma 400$	$\gamma 400$	$\gamma 400$	$\gamma 400$	$\gamma 400$	$\gamma 400$
Cu Ni	$\gamma 400$	$\gamma 400$	$\gamma 400$	$\gamma 400$	$\gamma 400$	$\gamma 400$	-	-	-



3. Welding characteristics

- **CLADDING** with **FCW 400**
 - Keep preheat to a minimum or according to base metal
 - String or weave bead
 - No trailing shield needed (Slag protection)
 - No specific buffer layer needed
 - Low dilution



Solid wire : ERNi1 + ERNiCu7



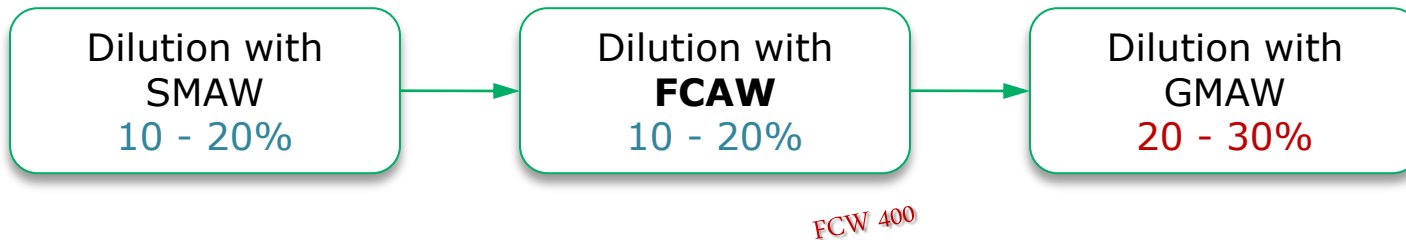
FCW 400 : ENiCu7

3. Welding characteristics

▪ Effect of dilution on **MONEL® 400**

The dilution rate depends on several factors :

- Welding process
- Welding parameters (Heat input)
- Welding position



▪ Dilution with base metal

- If “%Fe > 15-20%” → Ductility problems can occur
- If “%C > 0.4%” → Ductility problems can occur
- If “%Si > 1.5%” → Ductility problems can occur



3. Welding characteristics

- Effect of dilution on **MONEL® 400**

- If “%Fe > 15-20%” → Ductility problems can occur

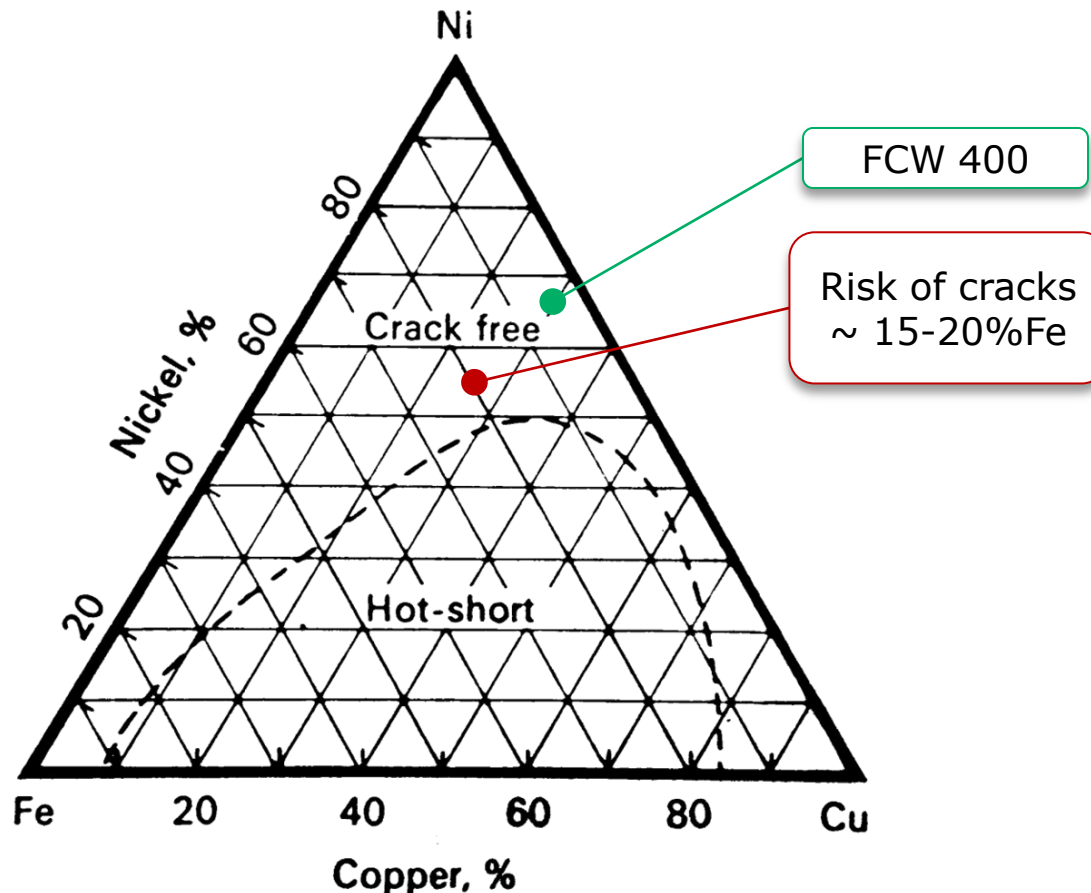


Diagram for hot-cracking susceptibility of iron-diluted nickel-copper alloys

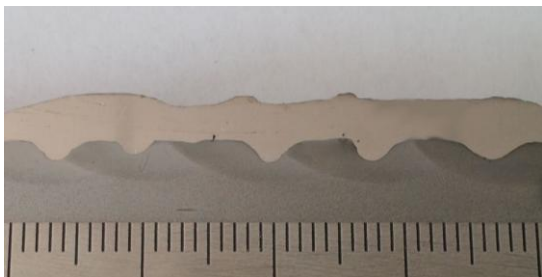
3. Welding characteristics

- Cladding on Carbon Steel (Gr1.1 / P1G1)
 - Flux cored wire compared to Solid wire

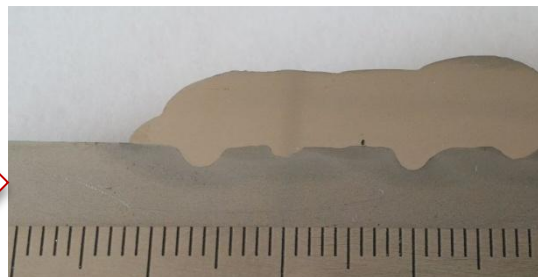


3. Welding characteristics

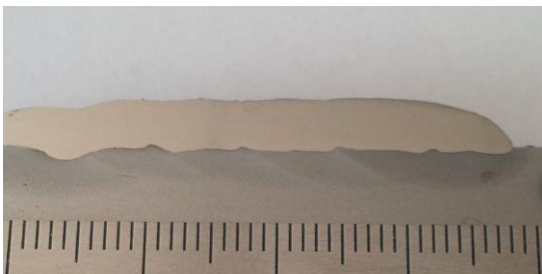
- Cladding on Carbon Steel (Gr1.1 / P1G1)
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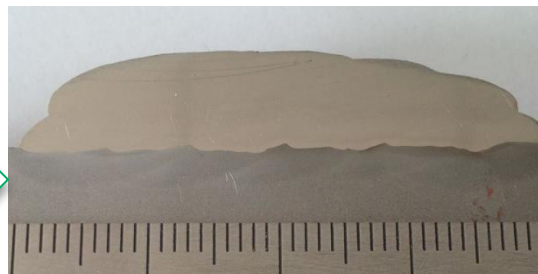
SOLID WIRE – 1st layer
Pulsed ; 215A - 26V - 29cm/min



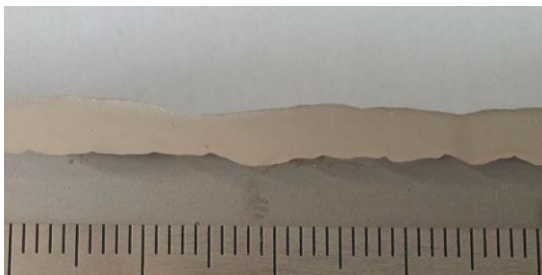
SOLID WIRE – 2nd layer
Pulsed ; 215A - 26V - 29cm/min



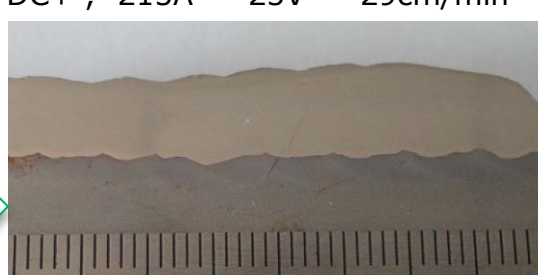
FCW 400 – 1st layer
DC+ ; 215A - 25V - 29cm/min



FCW 400 – 2nd layer
DC+ ; 215A - 25V - 29cm/min



FCW 400 – 1st layer
DC+ ; 170A - 26V - 29cm/min



FCW 400 – 2nd layer
DC+ ; 170A - 26V - 29cm/min

3. Welding characteristics

- Cladding on Carbon Steel (Gr1.1 / P1G1)
 - Flux cored wire compared to Solid wire

	Solid Wire ERNiCu7	FCW 400 ENiCu7	FCW 400 ENiCu7
Welding parameters	215A - 26V 29cm/min	215A - 25V 29cm/min	170A - 26V 29cm/min
Polarity	Pulsed	DC+	DC+
Deposition rate	4 kg/h	4.6 kg/h	3.5 kg/h
Dilution rate	23 %	13 %	12 %
%Fe (1st layer)	15.0 %Fe	9.0 %Fe	5.0 %Fe
%Fe (2 nd layer)	3.5 %Fe	2.6 %Fe	2.5 %Fe

- Advantages Flux cored wire compare to Solid wire

Higher
deposition
rate

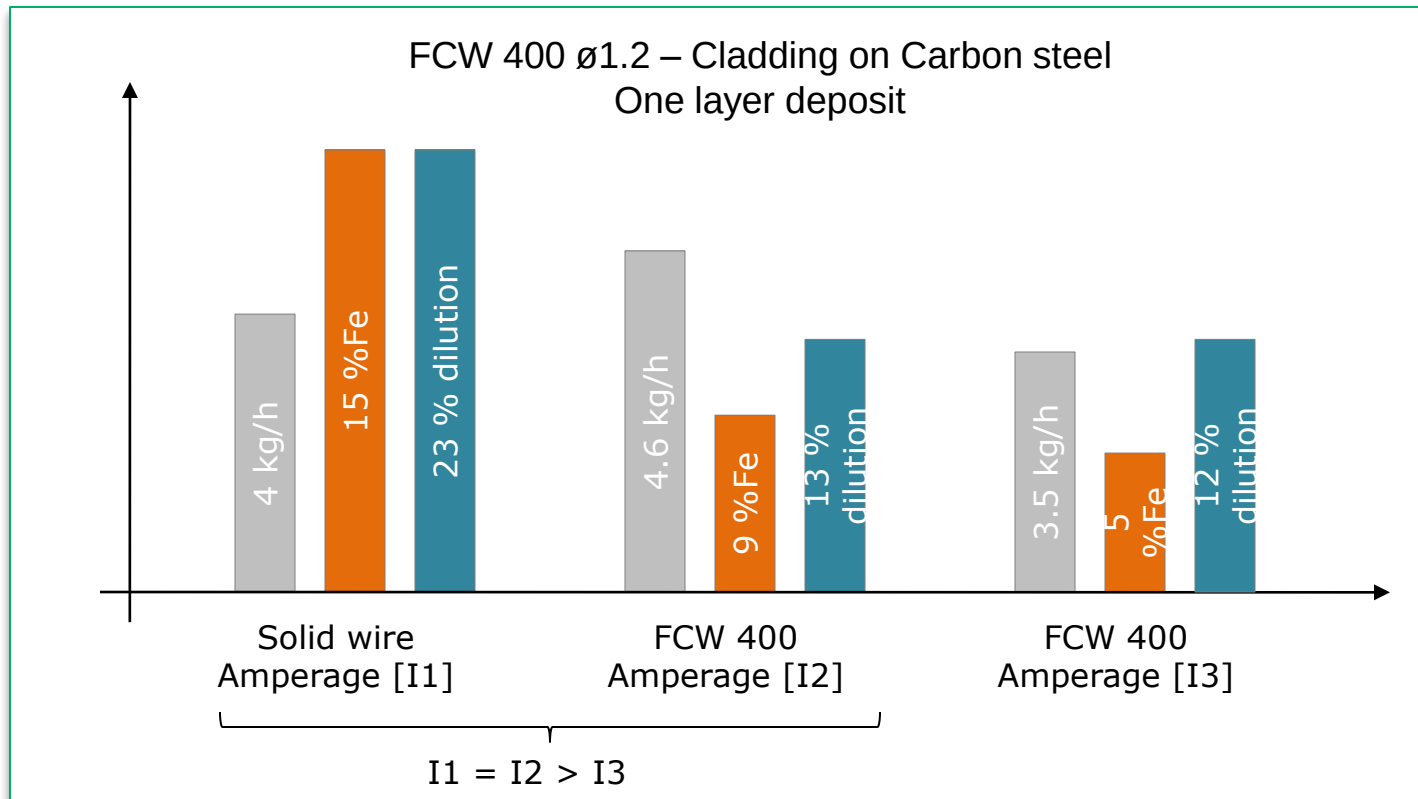
Lower **dilution**
rate

Lower risk of
cracks

Polarity **DC+**

3. Welding characteristics

- Cladding on Carbon Steel (Gr1.1 / P1G1)
 - Flux cored wire compared to Solid wire



- Predilection diagram recommend %Fe < 15-20%
- The lower the dilution is, the lower the %Fe is
- The lower %Fe is, the lower the cracking susceptibility is

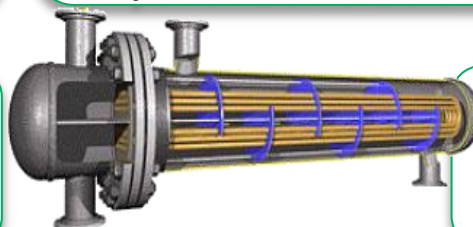
4. Application of FCW 400

- **FCW 400** is used in Marine and Chemical environments

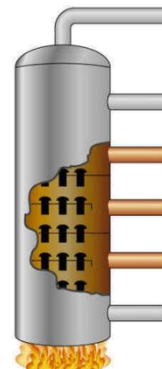
Power Plant
Feed water

Salt plant
Evaporator bodies

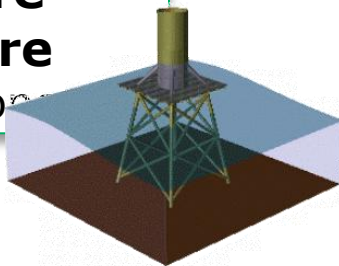
Alkylation plant
Sulphuric &
Hydrofluoric acid



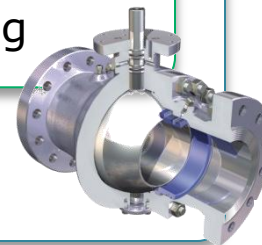
Refining
Crude oil
distillation



Offshore structure
Splash-zone



Valve ball
Cladding



4. Application of FCW 400

■ CLADDING on Carbon-Steel

One Layer deposit

Lot : **132832** Sample : **Gamma 400 1.2 1 couche** WF03312V003400GAMMAG

C	Si	Mn	P	S	Cr	Mo	Ni	Fe	Al
0.0257	0.273	3.52	0.0049	0.0146	0.0356	0.071	< 60.98	1.18	0.123
Nb	Ti	V	W	B	Co	Zr	Cu	Pb	
0.0192	1.59	0.0245	< 0.01	0.0102	0.0219	< 0.05	29.08	0.0078	

Two Layers deposit

Lot : **132832** Sample : **Gamma 400 1.2 2 couches** WF03312V003400GAMMAG

C	Si	Mn	P	S	Cr	Mo	Ni	Fe	Al
0.0273	0.275	3.52	0.0052	0.0161	0.0299	0.07	< 63.17	1.54	0.108
Nb	Ti	V	W	B	Co	Zr	Cu	Pb	
0.075	1.57	0.0238	< 0.01	0.0103	0.0216	< 0.05	29.51	0.0071	

4. Application of FCW 400

- **Heterogeneous** joining

Carbon-Steel to CuNi10 on ceramic backing



Procedure qualification
welding coupon

CONCLUSION – FCW 400



- Cladding & Joining
- Excellent bead appearance (no oxidation)
- No buffer layer needed for cladding application
- High productivity
- Excellent resistance to many corrosive environments



More information about FCW 400:

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