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%

<table>
<thead>
<tr>
<th>%Ni</th>
<th>%Cu</th>
<th>%C</th>
<th>%Fe</th>
<th>%Mn</th>
<th>%Si</th>
<th>%S</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 63.0</td>
<td>28.0</td>
<td>&lt; 0.30</td>
<td>&lt; 2.50</td>
<td>&lt; 2.00</td>
<td>&lt; 0.50</td>
<td>&lt; 0.02</td>
</tr>
<tr>
<td></td>
<td>34.0</td>
<td></td>
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</tr>
</tbody>
</table>

- **MONEL® 400**
  - Melting point ~ 1300-1350°C

- Resisting corrosion in a variety of aqueous solutions (notably seawater)
1. General Information

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

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![Typical usage range](image1.png)

*Fig. 2 Copper-nickel phase diagram. Source: Ref 1*
1. General Information

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

**NICKEL ALLOY**
Monel 400
UNS N04400

67%Ni - 30%Cu

ASME/AWS : P42
ISO 15608 : Gr42
2. Presentation of FCW 400

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

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**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:

```
T  Z  Ni 4060  B  M21  3
```

- Tubular cored wire
- Chemical composition
- Basic flux/slag
- Shielding gas: M21 = Ar + 15-25%CO₂
- Welding positions: PA & PB

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

<table>
<thead>
<tr>
<th>%C</th>
<th>%Mn (*)</th>
<th>%Si</th>
<th>%Ni</th>
<th>%Cu</th>
<th>%Ti (**)</th>
<th>%Fe</th>
<th>%Al</th>
<th>%S</th>
<th>%P</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>3.5</td>
<td>0.4</td>
<td>63</td>
<td>30</td>
<td>2.0</td>
<td>1.0</td>
<td>0.07</td>
<td>0.005</td>
<td>0.001</td>
</tr>
</tbody>
</table>

(*) : 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 ~150°C

- Heterogeneous weld possibilities

<table>
<thead>
<tr>
<th></th>
<th>Fe</th>
<th>Cr Ni</th>
<th>Fe Cu</th>
<th>Cu</th>
<th>Cu Al</th>
<th>Cu Sn Al</th>
<th>Cu Sn</th>
<th>Cu Ni</th>
<th>Ni Cu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ni Cu</td>
<td>γ400</td>
<td>γ400</td>
<td>γ400</td>
<td>γ400</td>
<td>γ400</td>
<td>γ400</td>
<td>γ400</td>
<td>γ400</td>
<td>γ400</td>
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<tr>
<td>Cu Ni</td>
<td>γ400</td>
<td>γ400</td>
<td>γ400</td>
<td>γ400</td>
<td>γ400</td>
<td>γ400</td>
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</tbody>
</table>
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

- Oscillation of 20mm large
  - FCW 400
    - DC+
    - 215A - 25V
    - 29cm/min
  - SOLID WIRE PULSED
    - 215A - 26V
    - 29cm/min

→ Dilution 13%
3. Welding characteristics

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

**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

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

- 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

- **Alkylation plant**
  - Sulphuric & Hydrofluoric acid

- **Salt plant**
  - Evaporator bodies

- **Refining**
  - Crude oil distillation

- **Offshore structure**
  - Splash-zone

- **Valve ball**
  - Cladding
4. Application of FCW 400

**CLADDING on Carbon-Steel**

One Layer deposit

<table>
<thead>
<tr>
<th>Lot</th>
<th>132832</th>
<th>Sample: Gamma 400 1.2 1 couche</th>
<th>WF03312V003400GAMMAG</th>
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<tbody>
<tr>
<td>C</td>
<td>0.0257</td>
<td>Si</td>
<td>0.273</td>
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<tr>
<td></td>
<td></td>
<td>P</td>
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<tr>
<td></td>
<td></td>
<td>Cr</td>
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<tr>
<td></td>
<td></td>
<td>Ni</td>
<td>&lt; 0.05</td>
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</tr>
<tr>
<td>Nb</td>
<td>0.0192</td>
<td>Ti</td>
<td>1.59</td>
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<td></td>
<td></td>
<td>V</td>
<td>&lt; 0.01</td>
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Two Layers deposit

<table>
<thead>
<tr>
<th>Lot</th>
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<th>Sample: Gamma 400 1.2 2 couches</th>
<th>WF03312V003400GAMMAG</th>
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<tbody>
<tr>
<td>C</td>
<td>0.0273</td>
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<td>Cr</td>
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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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