“Try not to become a man of SUCCESS, but rather try to become a man of VALUE”

BASIC OF PIPING MATERIAL

By:
Miduk Aritonang
1. MATERIAL

MATERIAL

METAL

NON METAL:
- Plastic : Fibre Reinforced Plastic (FRP), etc
- Polymer : PE, PVC, PTFE/Teflon, etc

FERRO:
- Carbon Steel (CS)
- Low Temperature Carbon Steel (LT-CS)
- Stainless Steel (SS)
- Alloy Steel

NON FERRO:
- Aluminium, Magnesium, Titanium, etc
- Incoloy
- Inconel
2. CRYSTAL STRUCTURE OF IRONS:

**Face Centred Cubic (FCC)**
- Stable structure above about 900 °C
- Atom volume is about 74 %
- Coordination num. is 12
- Known as **Austenite**
- Low Strength, Ductile, High Toughness
- Non Magnetic
- Aluminium, Nickel, etc

**Body Centred Cubic (BCC)**
- Stable structure below about 700 °C
- Atom volume is about 68 %
- Coordination num. is 8
- Known as **Ferrite**
- High Strength, Brittle, Low Toughness
- Magnetic
- Iron, Chromium, Vanadium, Molybdenum, Tungsten, etc

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3. TESTING OF MATERIAL

- Hardness Test → Hardness measurement of material toward a deformation (plastic deformation or permanent deformation)

Type of Hardness Test:
- Scratch Hardness
- Identification Hardness
- Dynamic Hardness

Type of Identification Hardness Test:
- Brinell Hardness → by J.A. Brinell (1900), using steel ball.
- Vickers Hardness → using diamond pyramid
- Rockwell Hardness → using cone pyramid
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- Tensile Test
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- Impact Test
- Non Destructive Test
  - To detect a defect or crack/fracture at inside or surface material without damage a material.

- Visual Method
- Liquid Penetrant Method
- Magnetic Particle Method
- Ultrasonic Method
- Radiographic Method
- Eddy Current Method
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- **Visual Method**
  - Visual monitoring or using optic device (fiberscope, boroscope, etc) with min. of enlargement is 5x
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- Liquid Penetrant Method
  - Using Fluorescent Penetrant

Crack
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- **Magnetic Particle Method**
  - These particles are attracted to magnetic flux leakage fields and will cluster to form an indication directly over the discontinuity. This indication can be visually detected under proper lighting conditions.
  - Can be detect surface defect and also inside defect

To appear new pole (North & South Pole)
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- **Ultrasonic Method**
  - Using Piezo Electric that can be convert the electric energy (current) to mechanical energy (wave) & the other hand, and called as Probe.
  - Function of Probe device are as Transmitter and also Receiver

![Diagram of Ultrasonic Method](image)

- Oscilloscope or Flaw Detector Screen
- Initial pulse
- Crack echo
- Back surface echo
- Plate
- Crack

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Radiography Method

- Defect
- Specimen
- Film
- Film (Top View)
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- **Eddy Current Method**

![Diagram of Eddy Current Method]

- **Coil**
- **Coil's magnetic field**
- **Eddy current's magnetic field**
- **Conductive material**
- **Eddy currents**
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NDT Inspection Level

ASNT – SNT – TC – Level I:

- Technicians qualified to perform only specific calibrations and tests under close supervision and direction by higher level personnel
- Can only report test results
- Normally they work following specific work instructions for testing procedures and rejection criteria.

ASNT – SNT – TC – Level II:

- Engineers or experienced technicians who are able to set up and calibrate testing equipment, conduct the inspection according to codes and standards (instead of following work instructions) and compile work instructions for Level 1 technicians
- Have authorize to report, interpret, evaluate and document testing results
- Must be familiar with applicable codes and standards and have some knowledge of the manufacture and service of tested products

ASNT – SNT – TC – Level III:

- Specialized engineers or very experienced technicians. They can establish NDT techniques and procedures and interpret codes and standards
- Conducts directly NDT laboratories and have central role in personnel certification
- Have wider knowledge covering materials, fabrication and product technology.
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➤ Others Inspection

1. PMI (Positive Material Identification)
   - PMI requirement is aimed to verify the grade of the material and not the exact chemical composition on the material certificate
   - PMI requirements usually for Low Alloy (1¼Cr - ½ Mo, 2¼Cr - 1Mo steels), Stainless Steel and Duplex Stainless Steel.
   - Equip.: Portable Alloy Analizers, etc

2. Ferrite Test
   - Ferrite test requirement to determine delta ferrite of Austenitic Stainless Steel and Duplex Stainless Steel
   - Ferrite test applied prior to any PWHT
   - Equip.: Ferritscope (Fischer) or equivalent, and calibrated in accordance with AWS A 4.2.
4. ANSI/ASME RELATED TO PIPING MATERIAL

**ANSI/ASME B31**

<table>
<thead>
<tr>
<th>Description</th>
<th>Code</th>
</tr>
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<tbody>
<tr>
<td>Power Piping</td>
<td>B31.1</td>
</tr>
<tr>
<td>Fuel Gas Piping</td>
<td>B31.2</td>
</tr>
<tr>
<td>Process Piping</td>
<td>B31.3</td>
</tr>
<tr>
<td>Pipeline Liquid Petro. Transportation Piping System</td>
<td>B31.4</td>
</tr>
<tr>
<td>Refrigeration Piping</td>
<td>B31.5</td>
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<td>Nuclear Power Piping</td>
<td>B31.7</td>
</tr>
<tr>
<td>Gas Transmission &amp; Distribution piping</td>
<td>B31.8</td>
</tr>
<tr>
<td>Building Services Piping</td>
<td>B31.9</td>
</tr>
</tbody>
</table>
“Try not to become a man of SUCCESS, but rather try to become a man of VALUE”

ANSI/ASME B36
• Welded and Seamless Wrought Steel Pipe \ B36.10
• Stainless Steel Pipe \ B36.19

ANSI/ASME B16
• Pipe Flanges and Flanged Flange (up to 24”) \ B16.5
• Large Diameter Steel Flanges (26” to 60”) \ B16.47
• Forged Flange, Socket Welding and Threaded \ B16.11
• Factory-Made Wrought Buttwelding Flange \ B16.9
• Metallic Gaskets for Pipe Flanges Ring-Joint, Spiral Wound and Jacketed \ B16.20
5. PIPES MATERIAL

- Seamless
- Welded
  - Welded Joint
  - Threaded Joint
  - Flanged Joint
    - Plan End (PE)
    - Bevel End (BE)
    - Threaded End (TE)

- Schedule: - ASME B36.10 → Carbon Steel (CS) Pipe
  - ASME B36.19 → Stainless Steel (SS) Pipe

Example:
CS Pipe SMLS Sch. 80 PE A106 Gr. B ASME 36.10 SRL
CS Pipe ERW Sch. 20 BE A53 Gr. A ASME 36.10 SRL
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SEAMLESS
- Seamless Pipe Manufacture

WELDED
- Longitudinal Welded Pipe
- Spiral Welded Pipe

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ELECTRIC RESISTANCE WELDED (ERW) PIPE

- Lowest Cost
- ERW type only that still be produced by domestic pipe manufacture
- ERW type mostly produced for small diameter pipe, up to Ø 30"
- ERW type for small wall thickness & Seamless type for heavy wall thickness
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6. FITTINGS MATERIAL

Elbow:
- 45 deg. Elbow
- 90 deg. Elbow
  - Seamless
  - Welded
- Short Radius (SR) Elbow
- Long Radius (LR) Elbow
  - Welded joint
  - Threaded joint
  - Flange joint

Tee:
- Straight Tee
- Reducer Tee
  - Seamless
  - Welded
- Welded joint
- Threaded joint
- Flange joint
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Reducer:
- Concentric Reducer
- Eccentric Reducer

Nipple:
- Concentric Nipple
- Eccentric Nipple

Outlet Fitting (Olet):
- Nipolet
- Weldolet
- Threadolet
- Sockolet

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Cap:

Plug:

Union:

Coupling:
7. FLANGES MATERIAL

Flanges Rating:
- ANSI/ASME
  - 150#, 300#, 400#, 600#, 900#, 1500#, 2500#
- API
  - 2000#, 3000#, 5000#, 10,000#, 15,000#, 20,000#, 30,000#

Flanges Dimensional:
- ANSI/ASME 16.5
  - 24 “ & below
- ANSI/ASME 16.47
  - 26” & above

Face Type (ASME B16.5 and ASME B16.47):
1. Raised Face (RF) → Rating: 150# to 600#
2. Flat Face (FF) → usually used for Ductile Iron or Cast Iron
3. Ring Type Joint (RTJ) → Rating: 900# & above

Type End Connection:
1. Weld Neck (WN) → 2” & above
2. Socked Weld (SW) → 1½” & below
3. Slip On (SO)
4. Threaded

Others:
1. Blind Flange
2. Orifice Flange
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BASIC OF PIPING MATERIAL

- Weld Neck
- Socked Weld
- Slip On
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8. GASKET & RING MATERIAL
"Try not to become a man of SUCCESS, but rather try to become a man of VALUE"

9. BOLT & NUT MATERIAL

- Stud Bolt
- Mechanical Bolt
10. VALVES MATERIAL

Basic Type:
1. Gate Valve  → Isolation valve usually for liquid
               → Open or Close
               → On-Off
2. Ball Valve  → Isolation valve usually for gas
               → Open or Close
               → Manual On-Off
3. Globe Valve → Good throttling for control
4. Check Valve → One direction of flow
5. Butterfly Valve → Isolation for water line
               → Not suitable as primary block valves for vessels, tanks, etc
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11. SPECIAL ITEMS MATERIAL

Strainer

Barred Tee

Flame Arrestor

Chemical Injection
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12. WELDING

Single sided butt weld

Double sided butt weld with defects in root and on surface
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Mostly International Standard for Welding:

- Structure Welding  → AWS
- Pressure Parts Welding  → ASME Section IX
- Pipeline Welding  → API 1104
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**AWS Specifications:**

<table>
<thead>
<tr>
<th>Group</th>
<th>AWS Specification</th>
<th>Electrode</th>
<th>Flux</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A5.1</td>
<td>E6010, E6011</td>
<td></td>
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<tr>
<td></td>
<td>A5.5</td>
<td>E7010, E7011</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>A5.5</td>
<td>E6010, E6011</td>
<td>E9010</td>
</tr>
<tr>
<td>3</td>
<td>A5.1 or A5.5</td>
<td>E7015, E7016, E7018</td>
<td></td>
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<tr>
<td></td>
<td>A5.5</td>
<td>E8015, E8016, E8018</td>
<td>E9018</td>
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<td>4</td>
<td>A5.17</td>
<td>EL8, EL12, EM5K, EM12K, EM13K, EM15K</td>
<td>P6XZ, F6X0, F6X2, F7XZ, F7X0, F7X2</td>
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<tr>
<td>5</td>
<td>A5.18</td>
<td>ER70S-2, ER70S-6, ER80S-D2, ER90S-G</td>
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<tr>
<td>6</td>
<td>A5.2</td>
<td>RG60, RG65</td>
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<tr>
<td>7</td>
<td>A5.20</td>
<td>E61T-GS4, E71T-GS4</td>
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<td>8</td>
<td>A5.29</td>
<td>E71T8-K6</td>
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<td>9</td>
<td>A5.29</td>
<td>E91T8-G</td>
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</table>

*Note: Other electrodes, filler metals, and fluxes may be used but require separate procedure qualification.*

*Any combination of flux and electrode in Group 4 may be used to qualify a procedure. The combination shall be identified by its complete AWS classification number, such as F7A0-EL12 or F6A2-EM12K. Only substitutions that result in the same AWS classification number are permitted without requalification.*

*A shielding gas (see 5.4.2.10) shall be used with the electrodes in Group 5.*

*In the flux designation, the X can be either an A or P for As Welded or Post-Weld Heat-Treated.*

*For root-pass welding only.*
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13. Design Temperature vs. Material

<table>
<thead>
<tr>
<th>Design Temperature °F</th>
<th>Material</th>
<th>Plate</th>
<th>Pipe</th>
<th>Forgings</th>
<th>Fittings</th>
<th>Bolting</th>
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<tbody>
<tr>
<td>Low Temperature</td>
<td>31% Nickel</td>
<td>A-203</td>
<td>Gr. D</td>
<td>Gr. 3</td>
<td>A-360</td>
<td>A-420</td>
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<tr>
<td>-150 to -76</td>
<td>21% Nickel</td>
<td>A-203</td>
<td>Gr. A</td>
<td>A-518</td>
<td>A-333</td>
<td>Gr. 6</td>
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<td>-75 to -51</td>
<td>21% Nickel</td>
<td>A-518</td>
<td>Gr. 55, 60</td>
<td>Gr. 360</td>
<td>A-420</td>
<td>A-193</td>
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<tr>
<td>-50 to -21</td>
<td>21% Nickel</td>
<td>A-518</td>
<td>Gr. All</td>
<td>Gr. 360</td>
<td>A-420</td>
<td>A-193</td>
</tr>
<tr>
<td>-20 to 4</td>
<td>5 to 32</td>
<td>A-518</td>
<td>Gr. 1 or 6</td>
<td>Gr. 360</td>
<td>A-420</td>
<td>A-193</td>
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<tr>
<td>Intermediate</td>
<td>Carbon Steel</td>
<td>A-516</td>
<td>Gr. B, 105.</td>
<td>A-181</td>
<td>Gr. 60, 70</td>
<td>Gr. WPL8</td>
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<tr>
<td>33 to 60</td>
<td>Carbon Steel</td>
<td>A-516</td>
<td>Gr. 106</td>
<td>A-181</td>
<td>Gr. 60, 70</td>
<td>Gr. WPL8</td>
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<tr>
<td>61 to 775</td>
<td>Carbon Steel</td>
<td>A-516</td>
<td>Gr. 106</td>
<td>A-181</td>
<td>Gr. 60, 70</td>
<td>Gr. WPL8</td>
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<tr>
<td>Elevated Temperature</td>
<td>C - 1%Mo</td>
<td>A-204</td>
<td>A-335</td>
<td>Gr. P1</td>
<td>A-182</td>
<td>A-234</td>
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<tr>
<td>776 to 875</td>
<td>1% C - 1%Mo</td>
<td>A-204</td>
<td>A-335</td>
<td>Gr. P1</td>
<td>A-182</td>
<td>A-234</td>
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<tr>
<td>976 to 1000</td>
<td>1% C - 1%Mo</td>
<td>A-387</td>
<td>A-335</td>
<td>Gr. P12</td>
<td>A-182</td>
<td>A-234</td>
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<tr>
<td>11% C - 1% Mo</td>
<td>A-387</td>
<td>A-335</td>
<td>Gr. P11</td>
<td>A-182</td>
<td>A-234</td>
<td>Gr. WP1</td>
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<tr>
<td>1001 to 1100</td>
<td>21% C - 1% Mo</td>
<td>A-387</td>
<td>A-335</td>
<td>Gr. F22</td>
<td>A-182</td>
<td>A-234</td>
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<tr>
<td>High Temperature</td>
<td>Stainless Steel</td>
<td>A-240</td>
<td>Gr. 347H</td>
<td>A-312</td>
<td>Gr. 347H</td>
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<td>Incoloy</td>
<td>B-424</td>
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"Try not to become a man of SUCCESS, but rather try to become a man of VALUE"

# 14. STAINLESS STEEL FAMILY

<table>
<thead>
<tr>
<th>Grade</th>
<th>UNS No.</th>
<th>Family</th>
<th>Cr</th>
<th>Ni</th>
<th>Mo</th>
<th>N</th>
<th>C (max)</th>
<th>Other</th>
<th>PRE No.</th>
<th>Yield Strength</th>
<th>Tensile Strength</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>MPa (min)(^b)</td>
<td>MPa (min)(^b)</td>
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<tr>
<td>420</td>
<td>S42000</td>
<td>Martensitic</td>
<td>13</td>
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<td>0.15 (min)</td>
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<td>430</td>
<td>S43000</td>
<td>Ferritic</td>
<td>17</td>
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<td>0.12</td>
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<td>17.00</td>
<td>205</td>
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<td>304</td>
<td>S30400</td>
<td>Austenitic</td>
<td>18</td>
<td>8 - 9</td>
<td></td>
<td></td>
<td>0.04 - 0.1</td>
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<td>18.00</td>
<td>205</td>
<td>515</td>
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<td>304L</td>
<td>S30403</td>
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<td>18</td>
<td>8 - 9</td>
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<td>&lt; 0.03</td>
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<td>18.00</td>
<td>170</td>
<td>485</td>
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<td>316</td>
<td>S31600</td>
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<td>17</td>
<td>11 - 14</td>
<td>2.1</td>
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<td>0.04 - 0.1</td>
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<td>23.93</td>
<td>205</td>
<td>515</td>
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<td>11 - 14</td>
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<td>&lt; 0.03</td>
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<td>23.93</td>
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<td>485</td>
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<td>904L</td>
<td>N08904</td>
<td>Austenitic</td>
<td>20</td>
<td>25</td>
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<td>0.02</td>
<td>1.5Cu</td>
<td>34.85</td>
<td>220</td>
<td>490</td>
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<td>2205</td>
<td>S31803</td>
<td>Duplex (Ferritic - Austenitic)</td>
<td>22</td>
<td>5</td>
<td>3</td>
<td>0.18</td>
<td>0.03</td>
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<td>34.78</td>
<td>450</td>
<td>620</td>
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<td>17-4PH</td>
<td>S17400</td>
<td>Precipitation Hardening</td>
<td>16</td>
<td>4</td>
<td></td>
<td>0.07</td>
<td>4Cu &amp; 0.5Nb</td>
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<td>16.00</td>
<td>1170</td>
<td>1310</td>
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<tr>
<td>Alloy 254</td>
<td>S31254</td>
<td>Super Austenitic</td>
<td>20</td>
<td>18</td>
<td>6</td>
<td>0.2</td>
<td>0.02</td>
<td>0.75Cu</td>
<td>43.00</td>
<td>300</td>
<td>650</td>
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<tr>
<td>Alloy 2507</td>
<td>S32750</td>
<td>Super Duplex</td>
<td>25</td>
<td>7</td>
<td>4</td>
<td>0.28</td>
<td>0.03</td>
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<td>42.68</td>
<td>550</td>
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</table>

- PREN = Pitting Resistance Equivalent Number
  \[\text{PREN} = \text{Cr} + 3.3 \times \text{Mo} + 16 \times \text{N}\]
- The term “Super” is commonly used when the PRE Number of the alloy is 40 or more
SUPER DUPLEX SS – 25% Cr

• **Composition**
  Typically 25% Cr, 7% Ni, 3.5% Mo

• **Benefits (over 22% Cr – Duplex SS)**
  – 25% higher yield strength
  – Improved localised corrosion resistance
  – Improved chloride SCC resistance
  – Seawater resistant to ~ 20°C

• **Limitations**
  – Higher cost
  – Even greater care required for welding and heat treatments
  – Limited H₂S cracking resistance
  – Limited to -50 ºC impact toughness
15a. ALLOY 825 (INCOLOY 825)

- **Composition**: 42% Ni, 21.5% Cr, 3% Mo, 2% Cu, Fe

- **Benefits**
  - Lower cost “Nickel” alloy
  - Good $\text{H}_2\text{S} / \text{CO}_2$ resistance
  - Welding / fabrication

- **Limitations**
  - Low yield strength
  - Low PREN (~28)
  - Not sea water resistant
15b. ALLOY 625 (INCONEL 625)

- **Composition**  Ni (basis), 22% Cr, 9% Mo, 3.75% Nb, 5% Fe

- **Benefits**
  - Excellent all-round corrosion resistance
  - Welding & fabrication
  - Good mechanical properties

- **Limitations**
  - High cost
### 16. RAW MATERIAL COST GUIDE

<table>
<thead>
<tr>
<th>Material</th>
<th>Cost</th>
</tr>
</thead>
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<tr>
<td>Carbon Steel</td>
<td>1</td>
</tr>
<tr>
<td>Austenitic Stainless Steels (type 304/304L, 316/316 L)</td>
<td>6</td>
</tr>
<tr>
<td>Super Austenitic Stainless Steels</td>
<td>12-20</td>
</tr>
<tr>
<td>22%Cr - Duplex SS</td>
<td>6</td>
</tr>
<tr>
<td>25%Cr - Super Duplex SS</td>
<td>12</td>
</tr>
<tr>
<td>Alloy 825 (Incoloy)</td>
<td>18</td>
</tr>
<tr>
<td>Alloy 625 (Inconel)</td>
<td>35</td>
</tr>
</tbody>
</table>