13CR & SUPER 13CR GRADES

RELIABLE, COST-EFFECTIVE SOLUTIONS FOR SWEET CO₂ ENVIRONMENTS

BEST CORROSION RESISTANCE  HIGHEST PROVEN PERFORMANCE  COST EFFECTIVE
A FULL PORTFOLIO
OF CORROSION
RESISTANT GRADES

Our extended portfolio covers operational scenarios from conventional to very challenging and extreme well conditions, supporting you on selecting the right material for your well environment. Our portfolio, available in the full range of outside diameter up to 10 ¾”, includes:

- **13% Chromium (13CR),** strictly compliant with the latest edition of API 5CT and ISO 11960 standards, offering enhanced corrosion resistance thanks to a more controlled chemistry than standard API L80 13Cr. Suitable for temperatures up to 150°C.

- **13% Chromium Modified (13CRM),** in accordance with group 1 material category 13-5-2 of API 5CRA and ISO 13680. Its enhanced chemistry (containing 13% Cr, 4% Ni and 1% Mo) provides enhanced usage temperature (up to 180°C) and mechanical resistance.

- **Super 13% Chromium (13CRSS),** in accordance with group 1 material category 13-5-2 of API 5CRA and ISO 13680, and S41426. This richer alloy provides enhanced resistance at low temperature with H₂S, and at temperatures up to 180°C.

- **Enhanced Super 13% Chromium (13ECRSS),** strictly compliant with group 1 material category 13-5-2 of API 5CRA and ISO 13680, allows for resistance up to 190°C, and enhanced corrosion performance at very low pH levels with H₂S.

```
<table>
<thead>
<tr>
<th>SMYS (ksi)</th>
<th>VM</th>
<th>XX</th>
<th>YY</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>110</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>125</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

- **3% Chromium:**

  Thanks to its Chromium content, this grade presents a reduced corrosion rate in sweet environments with temperatures up to 90°C, thus extending the lifetime of the string and reducing workover frequency of carbon steel completions.

- **Operational efficiency:**

  All Chromium grades are available with dope-free technology CLEANWELL® developed VAM®. This environmentally friendly coating contributes to reducing galling sensitivity, thus presenting significantly lower back-out rates, near zero rejects and overall running time reduction of 50%.
Corrosion on flow-wetted tubulars is becoming increasingly challenging with the exploitation of O&G fields with high acidic content combined with high temperature levels.

Under such conditions and in presence of CO₂, carbon steel is known to suffer from mass loss corrosion, leading to high cost of material replacement and workover operations.

Thanks to their Chromium contents above 12%, Martensitic (MSS) and Super Martensitic Stainless Steels (SMSS) develop a passive layer of Chromium oxide that protects the material from the corrosive environment.

As a result, these grades remain passive and unharmed under conditions when carbon steel are subjected to severe general and localized corrosion, allowing the use of one single string for the whole well life and thus providing the most cost-effective solution.

Vallourec has a long track record of developing and delivering the highest performance proprietary MSS and SMSS grades in the market as a competitive and highly effective response to sweet corrosion, reducing costs and extending the lifespan of the well.

### MATERIAL SELECTION

<table>
<thead>
<tr>
<th>CO₂ ≥ 2 psi and Flow-wet pipes</th>
<th>H₂S ≥ 6 psi</th>
<th>T ≤ 232°C</th>
<th>Enhanced Super 13Cr</th>
<th>VM 13ECRSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂S ≥ 6 psi</td>
<td>T ≤ 232°C</td>
<td></td>
<td>Super 13Cr</td>
<td>VM 13CRM</td>
</tr>
<tr>
<td>T ≤ 190°C</td>
<td></td>
<td></td>
<td>13Cr</td>
<td>VM 13CR</td>
</tr>
<tr>
<td>H₂S ≤ 1.5 psi</td>
<td>T ≤ 190°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₂S ≤ 6 psi</td>
<td>T ≤ 190°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limited S°</td>
<td>T ≤ 232°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₂S ≤ 6 psi</td>
<td>T ≤ 232°C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### CONVENTIONAL ONSHORE AND OFFSHORE WELLS:

All types of corrosive environments with a maximum service temperature of 150°C

**Your challenges**
- Reduce total cost of ownership
- Fit-for-purpose material selection
- Large developments

**Our solution**
- 3CR: onshore and shallow water
- 13CR: adapted to most onshore and offshore environments
- 13CRM: increase SMYS of 110ksi for higher internal pressures demands

### HP/HT WELLS:

High mechanical requirements and high temperature exposure

**Your challenges**
- Material normative qualification
- Well integrity
- Temperature and pressure

**Our solution**
- 13CRM: a cost-effective alternative to Super 13CR for non-sour environments
- 13CRSS: Increased mechanical resistance and higher corrosion resistance during shut-in phase at low temperatures when in presence of H₂S
- 13ECRSS: increased corrosion resistance at low and high temperature
LOW TEMPERATURE CORROSION RISK:
During shut-in phase, the top of the well is subjected to low temperature levels.
Under such conditions and when in the presence of \( \text{H}_2\text{S} \), Sulphide Stress Cracking (SSC) phenomenon is considered to be catastrophic and represents a major concern for operators during well design and material selection, since it can lead to tubular string failure within days or even hours. \( \text{H}_2\text{S} \) resistant material therefore becomes a must.

HIGH TEMPERATURE CORROSION RISK:
During production, the tubing string is in contact with formation fluid at high temperatures. Under such conditions, the two main corrosion mechanisms to be assessed are:
- \( \text{CO}_2 \) corrosion: \( \text{CO}_2 \) drives the acidity and corrosive levels of the environment, since the formation of carbonic acid leads to the occurrence of general mass loss and localized attacks.
- Stress Corrosion Cracking (SCC): cracking of metal that occurs under the unfavorable combination of corrosive environments, high temperature and mechanical loads.

INNOVATION AND KNOW-HOW TO GUARANTEE YOUR WELL INTEGRITY

Corrosive environments affect a material’s performance and string integrity. Sweet environments, when in presence of \( \text{CO}_2 \) and \( \text{H}_2\text{S} \) corrosive gases, lead to different corrosion risks that need to be assessed during material selection of flow-wetted tubulars:

MATERIAL SELECTION EXPERTISE: SELECTING THE RIGHT MATERIAL FOR YOUR APPLICATION

Many different parameters impact on a material’s corrosion performance, such as temperature, presence of corrosive gases, chloride content, pH level, among others.

Since materials performance mappings are not able to take all these parameters into consideration, Vallourec puts at your disposal a team of experts to support you in your Material Selection process.

Our testing expertise allow us to evaluate our material performance in your well conditions, according to NACE standard test, or following the latest, most state-of-the-art testing techniques.
“Vallourec’s material qualification for specific well environments allowed us to improve our material selection, replacing CRA duplex material with the more cost-effective S13Cr solution, a highly advantageous move for the business.”

Badr El Din Petroleum Company (BAPETCO) Egypt