



# DMV 22.5

## 1. Applications

DMV 22.5 is a duplex (austenitic – ferritic) Cr-Ni-Mo-steel with nitrogen addition. The combination of high mechanical properties and good corrosion resistance, especially pitting and crevice, presents a good basis for diverse pipe and tube applications such as:

- Oil & Gas production and processing: OCTG (Oil Country Tubular Goods). Subsea, process and utility services.
- Chemical, Petrochemical, Urea and Food industries especially in the presence of high stress and high chloride content bearing environments.
- Maritime applications ship building; desalination plants; seawater systems.

|                                |                               |                                 |
|--------------------------------|-------------------------------|---------------------------------|
| Carbon<br><b>C</b><br>≤0.02    | Chromium<br><b>Cr</b><br>22.0 | Nickel<br><b>Ni</b><br>5.3      |
| Molybdenum<br><b>Mo</b><br>3.2 | Nitrogen<br><b>N</b><br>0.17  |                                 |
| Manganese<br><b>Mn</b><br><1.7 | Silicon<br><b>Si</b><br><0.4  | Phosphorus<br><b>P</b><br>≤0.02 |
|                                |                               | Sulphur<br><b>S</b><br>≤0.002   |

Chemical composition nominal %

## 2. Main Features

DMV 22.5 is characterised by:

- Balanced austenitic - ferritic microstructure
- High mechanical properties: yield strength is about twice that of austenitic stainless steel grade AISI 316L
- Resistance to general corrosion, pitting, crevice is superior to that of stainless steel grade AISI 316L
- High resistance to stress corrosion cracking and hydrogen sulphide attack
- Typical range of service temperature: -50°C up to +280°C (-58°F up to +540°F)
- Good weldability

## 3. Description

### 3.1 Reference Standards

- UNS S31803 / S32205 acc. to ASTM A 789 / A 790; ASME SA 789 / SA 790; NACE MR0175 / ISO 15156
- 1.4462 acc. to EN 10216-5; EN 10297-2; VdTÜV data sheet 418
- ISO 13680
- API 5LC / DNV OS F101

## 3.2 Chemical Composition

DMV 22.5 typical values

|           | weight % |
|-----------|----------|
| <b>C</b>  | ≤0.02    |
| <b>Si</b> | ≤0.4     |
| <b>Mn</b> | 1.7      |
| <b>P</b>  | ≤0.02    |
| <b>S</b>  | ≤0.002   |
| <b>Cr</b> | 22.0     |
| <b>Ni</b> | 5.3      |
| <b>Mo</b> | 3.2      |
| <b>N</b>  | 0.17     |
| <b>Fe</b> | Balance  |

PREN ≥ 35

(PREN = %Cr + 3.3 x %Mo + 16 x %N)

### 3.3 Mechanical Properties

Following values are guaranteed in the solution annealed condition:

#### 3.3.1 Tensile Properties at 20°C (68°F)

|                      | MPa     | ksi    |
|----------------------|---------|--------|
| <b>0.2% Y.S. min</b> | 485     | 70     |
| <b>U.T.S.</b>        | 640-920 | 93-133 |

### 3.3.2 Tensile Properties at Elevated Temperatures

| Temperature<br>°C | (°F)         | 0.2 % Y.S. min. |     |
|-------------------|--------------|-----------------|-----|
|                   |              | MPa             | ksi |
| <b>50</b>         | <b>(122)</b> | 415             | 60  |
| <b>100</b>        | <b>(212)</b> | 360             | 52  |
| <b>150</b>        | <b>(302)</b> | 335             | 48  |
| <b>200</b>        | <b>(392)</b> | 310             | 45  |
| <b>250</b>        | <b>(482)</b> | 295             | 42  |

1 MPa=1 N/mm<sup>2</sup>; 1 ksi=6.9 MPa  
( ) = calculated values

#### 3.3.3 Hardness

DMV 22.5 has max. 26 HRC / max. 260 HB conformity with NACE MR0175.

N.B. Higher mechanical values can be achieved in the cold hardened condition.

#### 3.3.4 Impact Resistance

The V-notch impact energy at 20°C (68°F) is min. 90 J (67 ft lb) and at -46°C (-51°F) is min. 45 J (34 ft lb).

N.B. This grade is liable to metallographic modification after prolonged exposure in the range 600 - 900°C (1112 - 1652°F) leading to reduced impact properties. Prolonged service above 280°C (540°F) can also lead to a reduction in impact resistance and increase in hardness.

### 3.4 Physical Properties

| Density at 20°C (68°F) |                     |
|------------------------|---------------------|
| g/cm <sup>3</sup>      | lbs/in <sup>3</sup> |
| 7.92                   | 0.285               |

| Coefficient of Thermal Expansion between 20°C (68°F) and... |       |                     |                      |
|---|-------|---------------------|----------------------|
| °C  | (°F)  | 10 <sup>-6</sup> /K | 10 <sup>-6</sup> /°F |
| 100   | (212) | 13.1                | 7.1                  |
| 200   | (392) | 13.6                | 7.6                  |
| 300   | (572) | 14.1                | 8.1                  |
| 400   | (752) | 14.6                | 8.2                  |

| Thermal Conductivity |       |         |                |
|----------------------|-------|---------|----------------|
| °C                   | (°F)  | W/(m K) | Btu/(hr ft °F) |
| 20                   | (68)  | 13.9    | 8              |
| 100                  | (212) | 15.8    | 9              |
| 200                  | (392) | 16.8    | 10             |
| 300                  | (572) | 19.2    | 11             |
| 400                  | (752) | 20.2    | 12             |

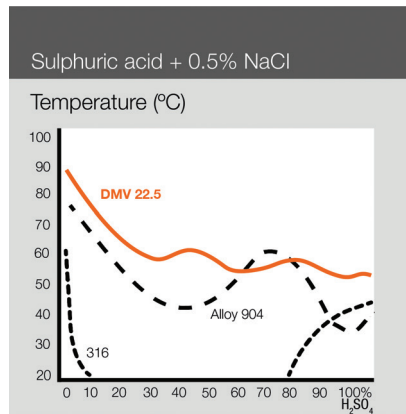
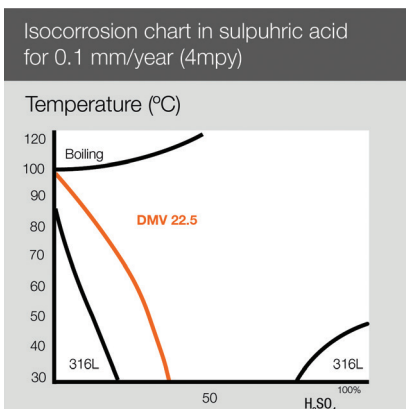
| Modulus of Elasticity |       |                     |                     |
|-----------------------|-------|---------------------|---------------------|
| Temperature           |       | 10 <sup>3</sup> MPa | 10 <sup>3</sup> ksi |
| °C                    | (°F)  |                     |                     |
| 20                    | (68)  | 200                 | 29.0                |
| 100                   | (212) | 195                 | 28.3                |
| 200                   | (392) | 187                 | 27.1                |
| 300                   | (572) | 179                 | 25.9                |

### 3.5 Corrosion Properties

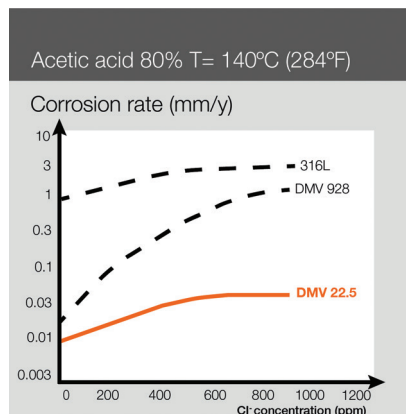
#### 3.5.1 General Corrosion

The chemical composition of DMV 22.5 makes it more resistant to corrosion than AISI 316L stainless steel in many corrosive environments like:

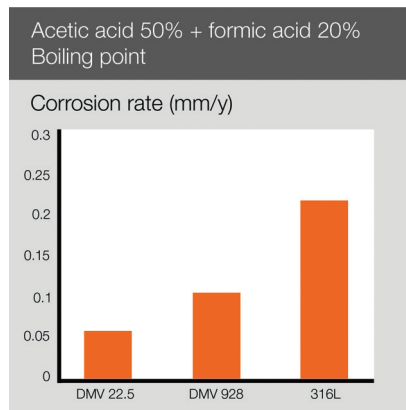
- Sulphuric acid



- Acetic acid



- Mixture of acetic and formic acids



- Hydrochloric acid
- Organic acids

#### 3.5.2 Intergranular Corrosion

In the annealed condition, without any sensitization treatment, corrosion rates in boiling nitric acid to ASTM A 262-C, remain below 1.1 mm/y (6.1 µm / 48h) which is equal to 3.7 mils / month. After sensitization, DMV 22.5 meets the requirements of copper - coppersulfate - sulfuric acid intercrystalline tests such as ASTM A 262-E (Strauss test) or ISO 3651-B.

#### 3.5.3 Stress Corrosion Cracking

The austenitic-ferritic structure of this stainless steel confers a high level of resistance to Stress Corrosion Cracking (SCC) in most industrial diluted chloride media when stress level is below the yield strength.

- In chloride environments: (Chloride Stress Cracking - CSC)

The table below gives the results of stress corrosion cracking tests after 500 hours in three different boiling chloride solutions and with three kinds of test pieces: U bent, 4 point bent-beam and C ring:

|   | Test piece          | DMV 22.5 | 316L |
|---|---------------------|----------|------|
| <b>MgCl<sub>2</sub> 45% boiling 155°C (310°F)</b> | <b>U bent (1)</b>   | F        | F    |
|   | <b>4 points (2)</b> | 100%     | 50%  |
|   | <b>C ring (3)</b>   | 25%      | 5%   |
| <b>CaCl<sub>2</sub> 50% boiling 150°C (302°F)</b> | <b>U bent (1)</b>   | F        | F    |
|   | <b>4 points (2)</b> | 100%     | 50%  |
|   | <b>C ring (3)</b>   | 100%     | 50%  |
| <b>NaCl<sub>2</sub> 25% boiling 110°C (230°F)</b> | <b>U bent (1)</b>   | NF       | F    |
|   | <b>4 points (2)</b> | 100%     | 50%  |
|   | <b>C ring (3)</b>   | 100%     | 50%  |

1. F = failure NF = no failure
2. 4 points bent-beam test - stress before rupture (percentage of Y.S.)
3. C ring test - stress before rupture (percentage of Y.S.)

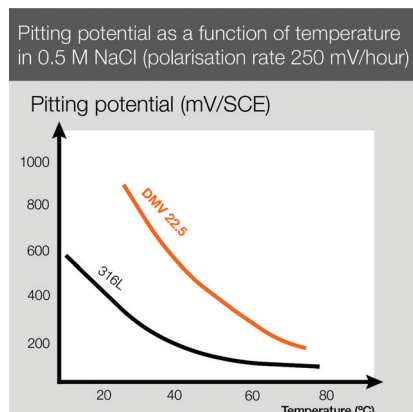
- In H<sub>2</sub>S - Cl environments: (Sulphide Stress Cracking - SSC)

DMV 22.5 is an austenitic-ferritic stainless steel approved by NACE MR0175 / ISO 15156-3 for use in sour environment. DMV 22.5 shows good resistance to sulphide stress cracking corrosion test at 24°C (75.2°F) and 90°C (194°F) over 720 hours period (NACE TM0177) in CO<sub>2</sub>-H<sub>2</sub>S - Cl media as indicated in the table below:

| Test solution           | NACE TM0177           | NACE TM0177           |
|-------------------------|-----------------------|-----------------------|
| <b>pH<sub>2</sub>S</b>  | 1 bar                 | 16 bars               |
| <b>NaCl</b>             | 50 g/l                | 50 g/l                |
| <b>Test temperature</b> | 24°C (75.2°F)         | 90°C (194°F)          |
| <b>Stress value</b>     | 350 N/mm <sup>2</sup> | 325 N/mm <sup>2</sup> |
| <b>Test results</b>     | no failure after 720h | no failure after 720h |

### 3.5.4 Pitting and Crevice Corrosion

The resistance to pitting and crevice corrosion increases with the content of chromium, molybdenum and nitrogen in the steel. Due to the relatively high level of these three elements, DMV 22.5 has noticeably better resistance to this type of corrosion than AISI 316L, as shown on the graph below.



In 6 weight%  $\text{FeCl}_3$  solution (ASTM G 48) the Critical Pitting Temperature (CPT) and Critical Crevice corrosion Temperature (CCT) are, respectively:

|     |      |        |
|-----|------|--------|
| CPT | 30°C | (86°F) |
| CCT | 20°C | (68°F) |

### 3.5.5 Galvanic Corrosion

Galvanic corrosion can occur when two dissimilar metals are connected. The position of DMV 22.5 on the electropotential scale is very similar to that of austenitic stainless steels. This enables it to be coupled with austenitic stainless steels within its passivity range.

## 4. Supply

### 4.1 Dimensional Range

Outside diameter: up to 250 mm (9.84 inches).

Wall thickness: up to 50 mm (1.97 inches).

## 4.2 Delivery Condition

Pipes and tubes are delivered in cold or hot finished condition depending on size and specification. Normally they will be supplied in annealed condition.

### 4.3 U-bent

Also available upon request.

## 5. Fabrication

### 5.1 Heat treatment

Pipes and tubes are delivered in the annealed condition. In case a subsequent processing requires an additional heat treatment, this has to be performed at 1020 - 1100°C (1870 - 2010°F) followed by rapid cooling in air or water. This is especially recommended when the steel has been exposed in temperature ranges 350 - 525°C (662 - 977°F) or 600 - 950°C (1112 - 1742°F) for a long duration causing embrittlement and reduced corrosion resistance.

### 5.2 Expanding

DMV 22.5 tubes and pipes can be expanded similarly to austenitic stainless steels, bearing in mind, however, their greater strength. "Close fit" clearance per TEMA is recommended.

### 5.3 Bending

#### Cold

Despite their greater strength, during bending DMV 22.5 tubes behaves similarly to austenitic steels. When plastic deformation exceeds 25%, subsequent heat treatment is necessary. In case of special applications where VdTÜV data-sheet 418 is specified, heat treatment is mandatory if deformation exceeds 10%.

#### Hot

Bending is possible in the range 1000 - 950°C (2010 - 1742°F) and must be followed by rapid cooling. It should, however, be noticed that the strength of DMV 22.5 is low at high temperatures which can have a negative influence on the final shape.

## 5.4 Cutting and Machining

A higher wear rate of the tools than that of austenitic steels can be noticed when cutting and machining of DMV 22.5 due to the higher hardness.

## 5.5 Welding

DMV 22.5 has a good weldability. Welding is possible with all processes usual for stainless steels. Preheating and heat treatment after welding is normally not necessary. Butt welding or welding to tube plate is carried out using the gas tungsten arc welding process (TIG / GTAW) with a filler metal having a similar composition (PREN > 35) enriched with elements to favour austenite formation. Use moderate heat input in the range of 10 to 25 kJ / cm. In all cases it is imperative to remove all traces of superficial oxidation which might initiate localised attack.

## 6. Standards and References

DMV 22.5 is delivered in accordance with European, American and other international standards.

Mannesmann Stainless Tubes has delivered DMV 22.5 tubes and pipes to a wide range of different applications world-wide. You can get more detailed information for the special fields of OCTG and other oil & gas applications in separate annexes, which are available on request.

For obtaining material samples or specific queries, please contact our sales offices.

## OUR DUPLEX FAMILY

| Austenitic Ferritic |                    |               |     |                              |      |     |     |       |                              |                   |                    |                             |     |                   |     |
|---------------------|--------------------|---------------|-----|------------------------------|------|-----|-----|-------|------------------------------|-------------------|--------------------|-----------------------------|-----|-------------------|-----|
| DMV Designation     | Nearest equivalent |               |     | Typical Chemical composition |      |     |     |       |                              | Density           |                    | Min. Mechanical Prop. at RT |     |                   |     |
|                     | UNS                | EN            | JIS | Cmax                         | Cr   | Ni  | Mo  | Cu    | Others                       | g/cm <sup>3</sup> | lb/in <sup>3</sup> | Yield St. $R_{p0.2}$        |     | Tensile St. $R_m$ |     |
| DMV 22.5            | S31803             | 1.4462.1.4501 |     | 0.03                         | 22.0 | 5.5 | 3.0 |       | N 0.17 <sup>(2)</sup>        | 7.8               | 0.28               | 450                         | 65  | 620               | 90  |
| DMV 25.7 N          | S32760             | 1.4410.1.4477 |     | 0.03                         | 25.0 | 7.0 | 4.0 | 0.8   | N 0.25; W 0.5 <sup>(2)</sup> | 7.8               | 0.28               | 550                         | 80  | 750               | 109 |
| DMV 25.7 NS         | S32750             |               |     | 0.03                         | 25.5 | 7.0 | 4.0 |       | N 0.3 <sup>(2)</sup>         | 7.8               | 0.28               | 550                         | 80  | 750               | 109 |
| DMV 29.7            | S32906             |               |     | 0.03                         | 29   | 7   | 2.3 | <0.80 | N 0.35 <sup>(2)</sup>        | 7.8               | 0.28               | 650                         | 394 | 800               | 116 |

| Dimensional Range | Instrumentation |       | Heat Exchangers U-bent tubes |       | Heat Exchangers Straight tubes |       | Process Pipe |        |
|-------------------|-----------------|-------|------------------------------|-------|--------------------------------|-------|--------------|--------|
|                   | mm              | inch  | mm                           | inch  | mm                             | inch  | mm           | inch   |
| Outside Diameter  |                 |       |                              |       |                                |       |              |        |
| min               | 6.0             | 0.236 | 12.7                         | 0.5   | 9.5                            | 0.374 | 6.0          | 0.236  |
| max               | 25.0            | 0.984 | 38.1                         | 1.5   | 50.8                           | 2.0   | 280.0        | 11.024 |
| wall thickness    |                 |       |                              |       |                                |       |              |        |
| min               | 0.5             | 0.02  | 0.89                         | 0.035 | 0.89                           | 0.035 | 0.5          | 0.02   |
| max               | 2.5             | 0.098 | 4.5                          | 0.177 | 4.5                            | 0.177 | 50.0         | 1.969  |

## TOLERANCES

According to typical manufacturing Norms or individual customer requirements.

| Outside Diameter            | Hot Extruded                         |  | Cold Finished Tubes                  |  |                                       |  |                                      |  |
|-----------------------------|--------------------------------------|--|--------------------------------------|--|---------------------------------------|--|--------------------------------------|--|
|                             |                                      |  | D2                                   |  | D3                                    |  | D4                                   |  |
| EN ISO 1127 tolerance class | D2                                   |  | D2                                   |  | D3                                    |  | D4                                   |  |
| Permissible deviation       | ± 1.0%<br>(min. ± 0.5 mm (±0.0197")) |  | ± 1.0%<br>(min. ± 0.5 mm (±0.0197")) |  | ± 0.75%<br>(min. ± 0.3 mm (±0.0012")) |  | ± 0.5%<br>(min. ± 0.1 mm (±0.0039")) |  |

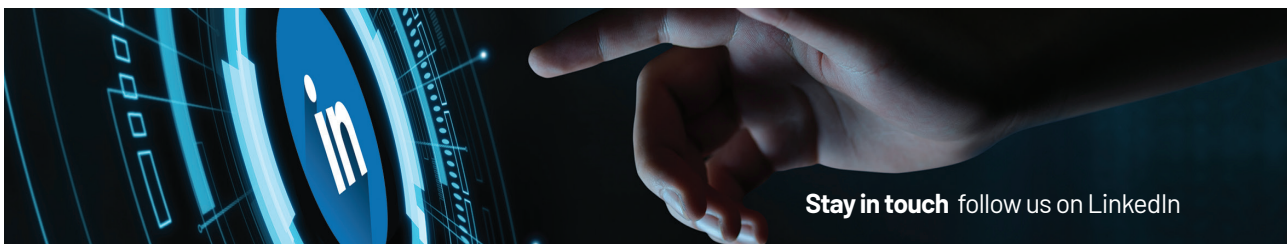
| Wall Thickness              | Hot Extruded                          |                                       | Cold Finished                       |  |
|-----------------------------|---------------------------------------|---------------------------------------|-------------------------------------|--|
|                             | ≤ 5 mm (0.1969")                      | > 5 mm (0.1969")                      | T3                                  |  |
| EN ISO 1127 tolerance class | T1                                    | T2                                    | T3                                  |  |
| Permissible deviation       | ± 15.0%<br>(min. ± 0.6 mm (±0.0236")) | ± 12.5%<br>(min. ± 0.4 mm (±0.0157")) | ± 10%<br>(min. ± 0.2 mm (±0.0074")) |  |



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