High-Quality Super Duplex Seamless Tubes for Umbilical Lines
The umbilical cables are the lifelines of deep-sea fields, connecting wells to the mother ship, offshore platform or onshore terminal. Since the early 1990s, seabed-based production systems have become increasingly important. Thus offshore wells are now being built as far as 100 km (62 miles) from the base and up to 3 km (10,000 feet) deep.

Thermoplastic hoses were first used in umbilical service in the mid 1970s, with steel tubes being seriously considered in the late 1990s, when higher mechanical properties and enhanced corrosion resistance were required for service lines carrying methanol, hydraulic and chemical injection fluids at deep and ultra-deep subsea installations.

Seamless tubes are mandatory for deep and ultra-deep water applications, where high pressures require components with enhanced mechanical properties and excellent corrosion resistance.

Mannesmann Stainless Tubes (MST) produces seamless straight tubes up to 30 m (98.4 feet) as well as coiled tubes of super duplex steel for umbilical applications. MST adopts the following processes for umbilical tubing:

- **Hot Extrusion**
- **Cold Pilgering**
- **Solution Annealing**
- **Welding and Reeling (for coiled tubes)**

### Hot Extrusion Process

The extrusion operation begins with a bar with a pilot hole drilled down the centre and a machined nose. This machined bar is heated to a controlled temperature and then expanded to enlarge the pilot hole to the required internal diameter for extrusion. Afterwards, it is extruded to the required size and then water quenched. The extrusion process is used to produce mother tubes (hollows) for further processing by way of cold working. Hot extrusion can be performed either at the MST-Germany mill or SMST-France mill.

### Cold Pilgering

This process has firmly established itself in the production of cold-finished corrosion-resistant steels, owing to the excellent tolerances and low surface roughness values that can be obtained. Pilgering followed by annealing produces a very high-performance product with uniform material microstructure and enhanced mechanical properties. After pilgering, the tubes are degreased and internally and externally cleaned. Cold pilgering is performed at the SMST-Italy mill.

### Solution Annealing

After the tubes have been pilgered, the solution annealing heat treatment is performed to ensure the best material soundness of the delivered product. MST uses a specially designed bright annealing furnace to ensure precise heating and cooling of the tubes and to avoid the formation of intermetallic phases (i.e. sigma phase). The heat treatment is designed to optimise the microstructure and mechanical properties.

### Welding and Reeling

Mannesmann Stainless Tubes (MST) offers GTAW butt-welded tubes coiled on reels for cost-effective umbilical manufacturing. Proper flushing to reach the required level of cleanliness and hydro-pressure testing complete the production of the reel. The welding division is located at the SMST-Italy mill.

Compared to thermoplastic hoses, steel tube umbilicals offer several advantages:

- Higher design working pressure and temperature
- Excellent corrosion resistance in seawater
- Higher mechanical properties
- Excellent fatigue resistance
- No volumetric expansion, without any significant time delay in hydraulic response over long distances
- Higher crush and collapse resistance
- No chemical permeability, thus no risk of methanol diffusion
- Longer and predictable service life

With many years of successful experience in the production of seamless SDSS tubes, Mannesmann Stainless Tubes (MST, formerly DMV) has been active in the umbilical business since its beginning, with its first straight and coiled tubes being produced in 1996 and 2001, respectively.
Quality Control System
The manufacturing process is closely monitored during all steps. Conventional destructive and non-destructive tests (UT, ET, PT, VT) according to international codes and also specially tailored quality tests are performed on finished tubes by on-site laboratories to support high-quality production. In particular, state-of-the-art eddy current equipment is used to continuously confirm the absence of sigma phase along the total length of finished tubes.

When umbilical tubes are delivered on reel, the joints are welded by qualified personnel and surveyed by certified welding coordinators (welding inspector and welding specialists on site). The welding process is properly certified and all butt welds are inspected by x-ray to ensure full compliance with the most stringent requirements. The x-ray machine is equipped with a micro-focus and real-time acquisition system. Reeling operations are monitored in order to prevent accumulation of plastic strain.

All MST plants are equipped with in-house metallurgical and chemical laboratories for conducting certification and product testing during all production stages.

Upon requests for special testing and inspections, MST is supported by its corporate R&D Institute in Germany (Salzgitter Mannesmann Forschung, SZMF).

Full traceability of the products through the whole process, from the incoming raw material bars to the finished tubes, is ensured by the quality control system and the company’s information technology systems, which are integrated in all MST plants. All relevant production data are stored and kept available for the umbilical line’s designed life time.
Standard MST route for umbilical production is depicted below:
- Hollow tubes can be produced at the Montbard plant (SMST-France) and the Remscheid plant (MST-Germany).
- Cold pilgering and finishing, final inspections and controls are performed at the Costa Volpino mill (SMST-Italy).
- Finished tubes move to the welding division at the Costa Volpino mill. Each welding line consists of a GTAW welding machine, x-ray equipment and a coiling system.
Mannesmann Stainless Tubes (MST) offers the DMV 25.7NS (UNS S32750) super duplex grade for steel tube umbilical applications.

The DMV 25.7NS grade offers:
- High corrosion resistance in marine environments
- High mechanical properties
- High resistance to fatigue
- Excellent corrosion resistance to fluids commonly transmitted through umbilicals
- Good weldability
- Cost-effectiveness

The typical chemical composition of DMV 25.7NS super duplex steel – chromium, nickel, molybdenum, nitrogen – guarantees an excellent resistance against localised corrosion, such as pitting and crevice corrosion.

The resistance to localised corrosion is generally assessed by using the Pitting Resistance Equivalent Number (PREN) as follows:

PREN = %Cr + 3.3%Mo + 16%N weight%
The Grade DMV 25.7NS (UNS S32750) grade is a super duplex ferritic-austenitic Cr-Ni-Mo steel with nitrogen addition. The finished tubes are delivered following bright solution annealing in the temperature range 1025°C-1125°C (1857°F-2067°F), with rapid gas cooling.

DMV 25.7NS Reference Standards

- UNS S32750 acc. to:
  - ASTM A789 / A790
  - ASME SA789 / SA790
  - NACE MR0175
  - ISO 15156

- 1.4410 acc. to:
  - EN 10216-5
  - EN 10297-2
  - ISO 13680

Trace elements are always monitored (i.e. oxygen, boron).

DMV 25.7NS Nominal Composition (WT%)

<table>
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<tr>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Cr</th>
<th>Ni</th>
<th>Mo</th>
<th>N</th>
<th>Cu</th>
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<tr>
<td>0.02</td>
<td>0.6</td>
<td>0.6</td>
<td>0.02</td>
<td>&lt;0.002</td>
<td>25.5</td>
<td>7.0</td>
<td>4.0</td>
<td>0.3</td>
<td>0.25</td>
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Microstructure (ferrite ~ 50%)

Optimisation of DMV 25.7NS Heat Treatment

- Temps°C Cooling Rate Time-Temperature-Precipitation (TTP) Curve
- 20°C/s
- 1°C/s

Mechanical Properties at 20°C

According to ASTM A789

- Yield Strength (0.2% offset) Min. 550 MPa (80 ksi) 750 MPa (109 ksi)
- Ultimate Tensile Strength Min. 900 MPa (130 ksi) 950 MPa (138 ksi)
- Elongation in 2” or 50 mm Min. 15% 35%
- Hardness Max. 22 HRC (max. 300 HBW) 27 HRC

Corrosion Resistance

Critical Pitting & Critical Crevice Temperatures

| CPT | 85°C (187°F) |
| COT | 55°C (131°F) |

Magnification at 20X, max. weight loss 1.0 g/m².

Critical Pitting Temperatures in Green and Yellow Death Solutions

- Green Death Solution 90°C (194°F)
- Yellow Death Solution 75°C (167°F)

Tensile Properties at Elevated Temperatures

<table>
<thead>
<tr>
<th>Temperature</th>
<th>0.2% Yield Strength (Average)</th>
<th>Ultimate Tensile Strength (Average)</th>
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<tbody>
<tr>
<td>°C</td>
<td>°F</td>
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<tr>
<td>398</td>
<td>750</td>
<td>510</td>
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</table>

Magnification at 20X, max. weight loss 1.0 g/m².

CPT and CCT values according to ASTM G48 methods E and method F, respectively. Test surfaces dry ground to 120 mesh. Corrosion results vary with product form and surface finish.
Mannesmann Stainless Tubes GmbH
Wiesenstrasse 36
45473 Mülheim an der Ruhr
Germany
Tel.: +49 208 458 - 01
Fax: +49 208 458 - 2640

info@mst.mannesmann.com
www.mannesmann-stainless-tubes.com

Salzgitter Mannesmann Stainless Tubes Deutschland GmbH
Sales:
Wiesenstrasse 36
45473 Mülheim an der Ruhr
Germany
Tel.: +49 208 458 2611
Fax: +49 208 458 2641

Production:
Bahnstrasse 61
42859 Remscheid
Germany

Salzgitter Mannesmann Stainless Tubes France SAS
Route de Semur
21500 Montbard
France
Tel.: +33 3 80 89 52 00
Fax: +33 3 80 89 52 26

Mannesmann SOTEP Stainless Tubes
Les Midors Chouday
36100 Issoudun
France
Tel.: +33 2 54 21 25 39
Fax: +33 2 54 21 77 93

Salzgitter Mannesmann Stainless Tubes Italia S.r.l.
Via Piò 30
24062 Costa Volpino (BG)
Italy
Tel.: +39 35 975 744
Fax: +39 35 975 803

Salzgitter Mannesmann Stainless Tubes USA, Inc.
12050 West Little York
Houston Texas 77041
USA
Tel.: +1 713 466 7278
Fax: +1 713 466 3769

MANNESMANN. Das Rohr.
www.mannesmann.com