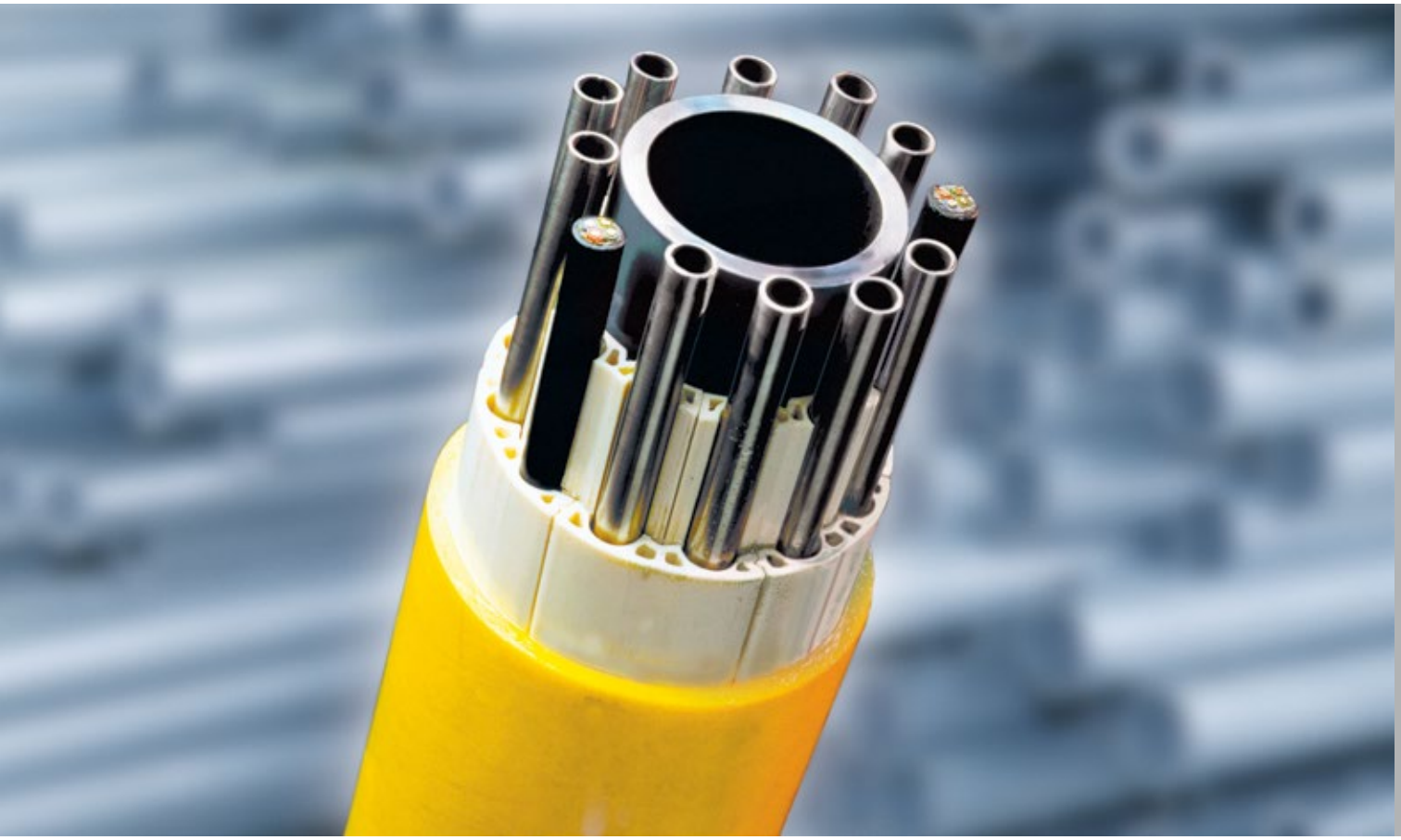


High-Quality Super Duplex Seamless Tubes for Umbilical Lines

SALZGITTER
MANNESMANN
STAINLESS TUBES

A Member of the Salzgitter Group

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.

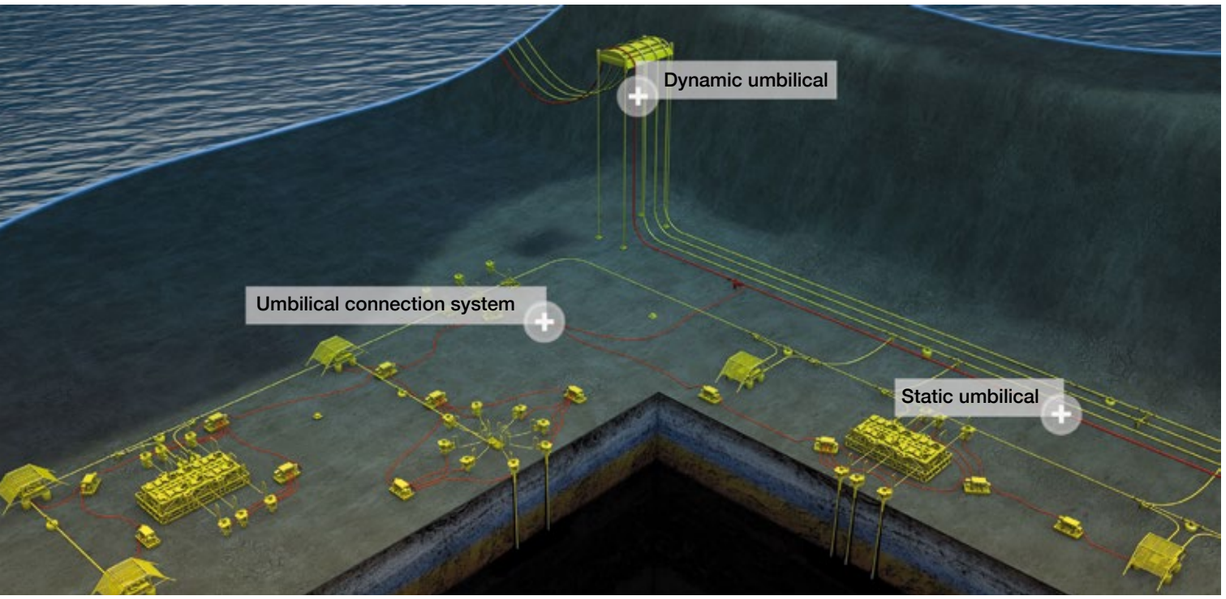
Thermoplastic hoses were first used in umbilical service in the mid 1970s, with steel tubes being seriously considered in the late 1990s, when higher mechanical properties and enhanced corrosion resistance were required for service lines carrying methanol, hydraulic and chemical injection fluids at deep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

Super duplex stainless steels (SDSS) are used in steel tube umbilicals for deep water installations.

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, Salzgitter Mannesmann Stainless Tubes (SMST, 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.

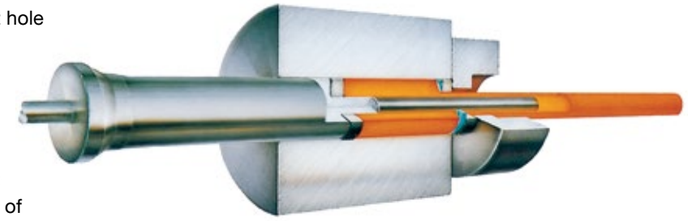


SMST Manufacturing Process for Seamless Umbilical Tubes

Salzgitter Mannesmann Stainless Tubes (SMST) produces seamless straight tubes up to 30 m (98.4 feet) as well as coiled tubes of super duplex steel for umbilical applications.

SMST 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 SMST-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.
SMST 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.

Bright annealing furnace at the mill in Costa Volpino, Italy

Welding and Reeling
Salzgitter Mannesmann Stainless Tubes (SMST) 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.

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.

Welding operation at umbilical line

Reeling system at umbilical line

SMST Manufacturing Process for Seamless Umbilical Tubes

Umbilical joint inspected by x-ray system

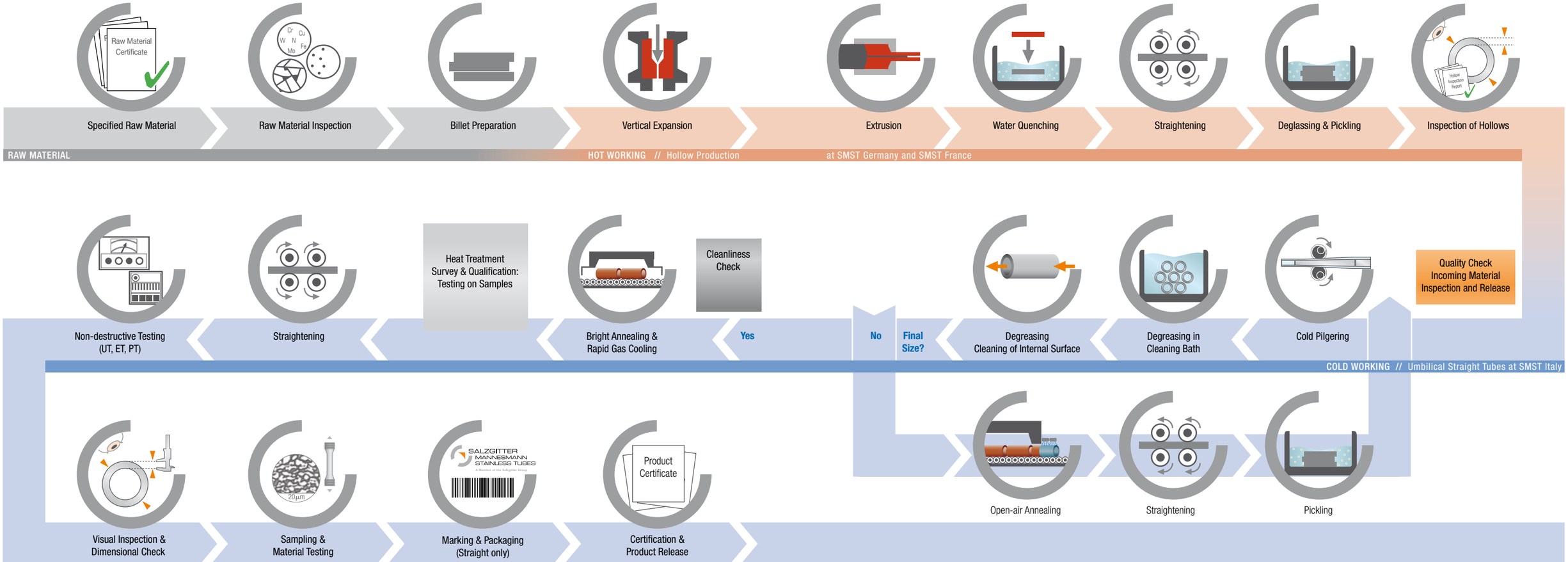
All SMST plants are equipped with in-house metallurgical and chemical laboratories for conducting certification and product testing during all production stages.

Upon requests for special testing and inspections, SMST 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 SMST plants.
All relevant production data are stored and kept available for the umbilical line's designed life time.

Quality control at production site

Standard SMST route for umbilical production is depicted below.
· Hollow tubes can be produced at the Montbard plant (SMST-France) and the Remscheid plant (SMST-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.



SMST Manufacturing Process for Seamless Umbilical Tubes

ISO 9100
ISO 14001
CERTIFIED

ASME NCA 3800
welding not covered
CERTIFIED

NORSOK M-650 ed. 4
DNV-OS-B101
QUALIFIED

SMST's wide -ranging production experience and its broad knowledge of super duplex grades ensures fulfilment of the strictest requirements for mechanical and corrosion resistance of umbilical tubes as part of tailored project solutions.

SMST has been active in the global market for stainless steel umbilicals since the 1990s and over 3 million metres of umbilical tubes have been delivered to major umbilical producers over the last 15 years.

Common Size Ranges for Umbilical Tubes

Coiled Tubes			
Inner Diameter		Wall Thickness	
Inch	mm	from [mm]	to [mm]
3/8	9.53	1.0	2.0
1/2	12.70	1.0	2.6
5/8	15.88	1.0	2.6
3/4	19.05	1.1	3.0
1	25.40	1.2	3.0
1 1/4	31.75	1.5	3.0
1 1/2	38.10	2.0	3.0

Other dimensions available on request

Straight Tubes			
Inner Diameter		Wall Thickness	
Inch	mm	from [mm]	to [mm]
3/8	9.53	1.0	2.0
½	12.70	1.0	2.6
⅝	15.88	1.0	2.6
¾	19.05	1.1	3.0
1	25.40	1.2	3.0
1¼	31.75	1.5	3.0
1½	38.10	2.0	3.0
1¾	44.45	2.5	5.5
2	50.80	2.7	6.0
2¼	57.15	2.9	5.5
2¾	69.85	3.2	6.0
3	76.20	3.0	10.5
3¼	82.55	3.5	10.5
3½	88.90	4.0	12.5

Other dimensions available on request

Salzgitter Mannesmann Stainless Tubes (SMST) 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:

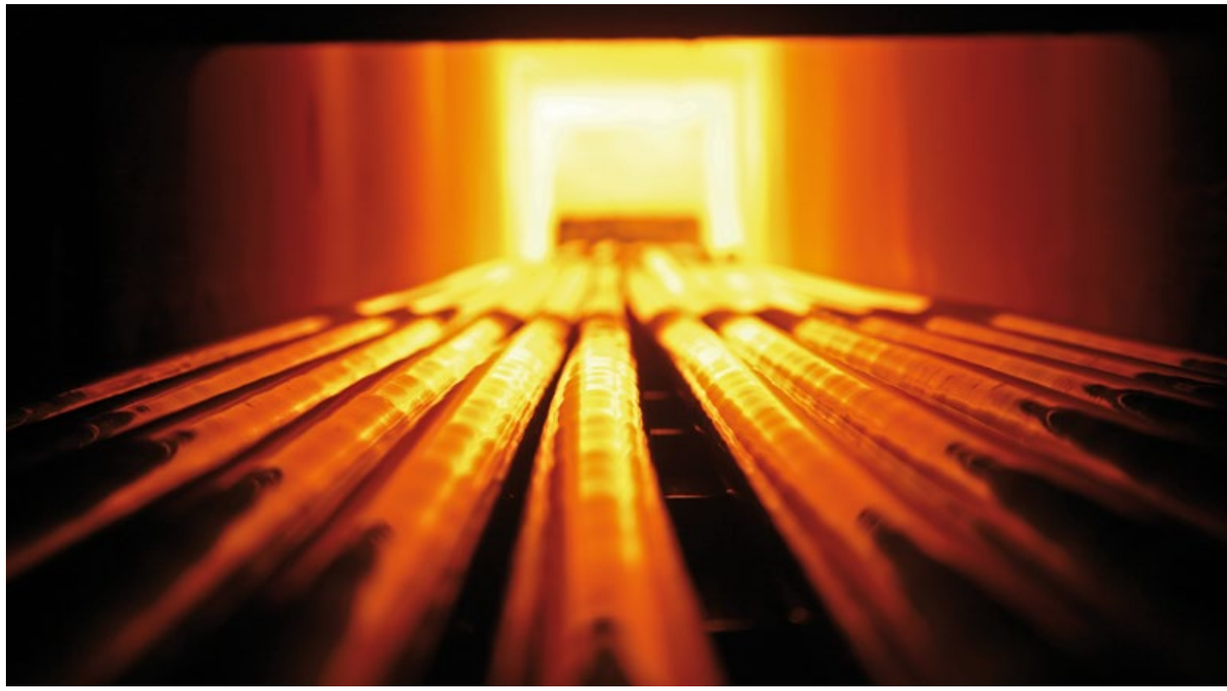
PREN = %Cr + 3.3%Mo + 16%N weight%

To ensure a high resistance to pitting and crevice corrosion, all SMST super duplex grades have a PREN value between 42.5 and 43.5.
Microstructure phase balance ensures a ferrite content in the range of 40% to 55% in the final tube.

Resistance of super duplex grades against localised corrosion in several environments typical for umbilical applications has been evaluated over the years, on straight tubes and welded samples, with and without strain by reeling:

- Critical Pitting Temperature (CPT) and Critical Crevice Temperature (CCT) measurements in iron chlorite solution ($FeCl_3$) in accordance with the ASTM G-48 method
- CPT and CCT measurements in seawater
- Corrosion tests in Yellow Death and Green Death solutions
- Corrosion tests in sulphuric acid solution (H_2SO_4), in phosphoric acid solution (H_3PO_4) and in dilute hydrochloric acid solution (HCl)
- Slow Strain Rate (SSR) tests in inert and aggressive environments

Isocorrosion charts (0.1 mm/year, 4 mils/year) in selected environments are available.



The **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 (1080°F-2060°F), with rapid gas cooling.

DMV 25.7NS Reference Standards

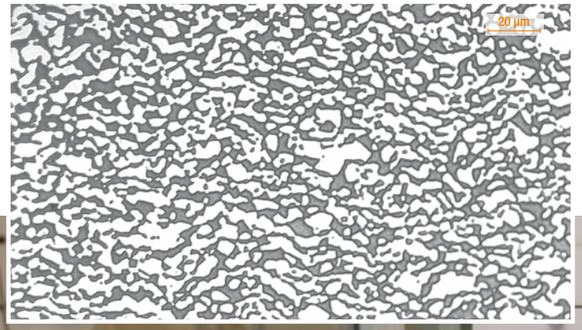
UNS S32750 acc. to:
- ASTM A789 / A790
- ASME SA789 / SA790
- NACE MR0175
- ISO 15156

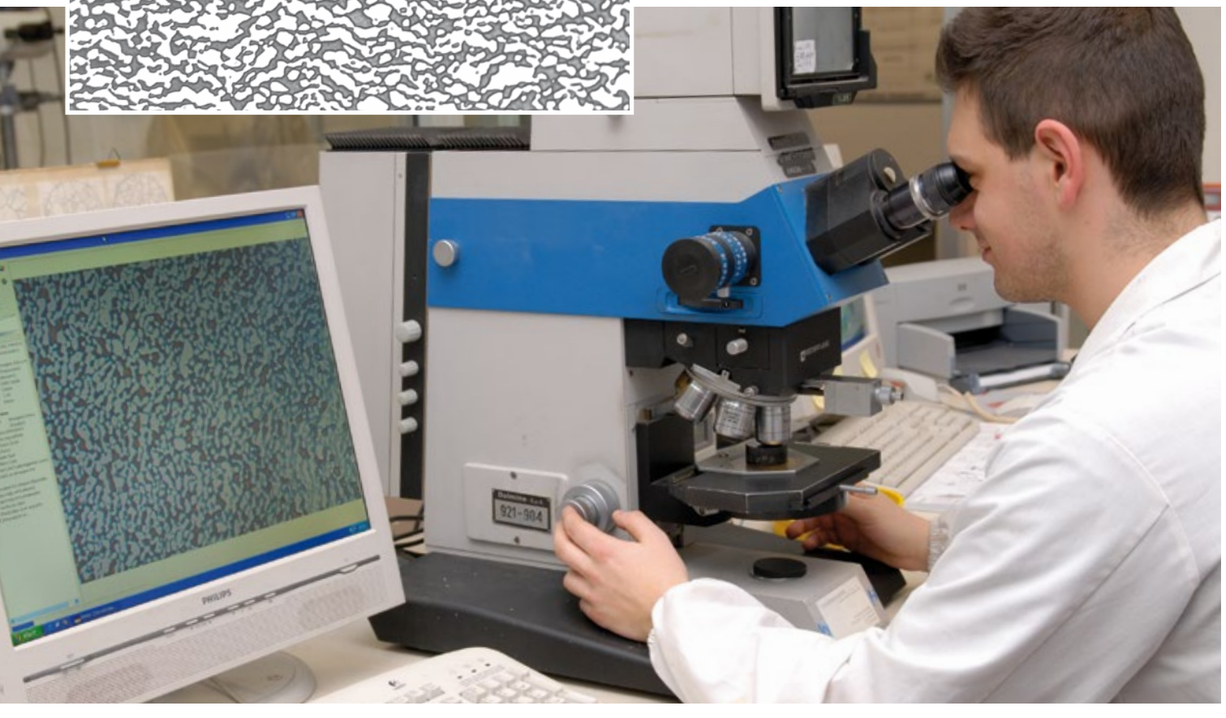
1.4410 acc. to:
- EN 10216-5
- EN 10297-2
- ISO 13680

DMV 25.7NS Nominal Composition (WT%)										
C	Si	Mn	P	S	Cr	Ni	Mo	N	Cu	Fe
0.02	0.6	0.6	0.02	<0.002	25.5	7.0	4.0	0.3	0.25	Bal.

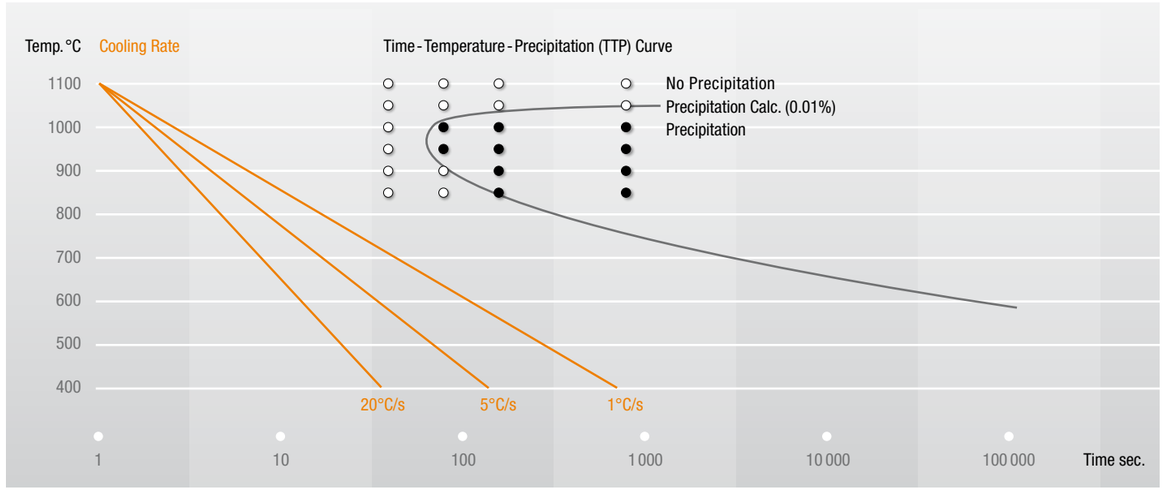
Trace elements are always monitored (i.e. oxygen, boron).

Microstructure (ferrite ~ 50%)





Optimisation of DMV 25.7NS Heat Treatment



Mechanical Properties at 20 °C

	According to ASTM A789	Average Values
Yield Strength (0.2% offset)	Min. 550 MPa (80 ksi)	750 MPa (109 ksi)
Ultimate Tensile Strength	Min. 800 MPa (116 ksi)	950 MPa (138 ksi)
Elongation in 2" or 50 mm	Min. 15%	35%
Hardness	Max. 32 HRC (max. 300 HBW)	27 HRC

Corrosion Resistance

Critical Pitting & Critical Crevice Temperatures	
CPT	85 °C (176 °F)
CCT	55 °C (131 °F)

Magnification at 20X, max. weight loss 1.0 g/m^2

CPT and CCT values according to ASTM G48 method E and method F, respectively. Test surfaces dry ground to 120 mesh. Corrosion results vary with product form and surface finish.

Critical Pitting Temperatures in Green and Yellow Death Solutions	
Green Death Solution	90 °C (167 °F)
Yellow Death Solution	75 °C (194 °F)

Magnification at 20X, max. weight loss 1.0 g/m^2

Green Death solution: 1% $FeCl_3$ + 1% $CuCl_2$ + 11% $H2SO_4$ + 1.2% HCl
Yellow Death solution: 0.1% $Fe_2(SO_4)_3$ + 4% NaCl + 0.01M HCl
Test surfaces dry ground to 120 mesh. Corrosion results vary with product form and surface finish.

Tensile Properties at Elevated Temperatures

Temperature		0.2% Yield Strength (Average)		Ultimate Tensile Strength (Average)	
°C	°F	MPa	ksi	MPa	ksi
20	68	750	109	950	138
65	150	660	96	920	133
93	200	640	93	895	130
121	250	625	91	870	127
149	300	615	89	855	124
204	400	566	82	845	123
260	500	545	79	825	120
315	600	535	77	835	121
343	650	525	76	813	118
371	700	517	75	807	117
398	750	510	74	798	116

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