Product description

Mannesmann Line Pipe has developed an advanced bainitic steel for the transportation of gaseous or liquid media at ultra-low temperatures.

Starting material production at Salzgitter Flachstahl GmbH is based on the ASTM A553 Standard Specification for Alloy Steel, Quenched and Tempered, 8 and 9 % Nickel. This material, known from its use in heavy plate for LNG tanks, has been adapted to the requirements of strip rolling for the production of LNG line pipe at the HFI pipe mills in Hamm and Siegen.

This was accomplished by a quench-and-temper treatment in which the pipe body is heated to austenitizing temperature, followed by hardening and tempering. As hardening leads to a dramatic increase in brittleness, subsequent tempering at approximately 620 °C is essential to ensure transformation of the martensitic to a tempered martensitic/bainitic microstructure with the required mechanical properties.

The material used is a so-called air-hardening material which requires no accelerated water quenching. Cooling in air is beneficial because it helps to avoid the generation of internal stresses or negative geometrical effects. Pipes heat treated in this way possess high toughness in the weld and base material as shown in Figure 1.

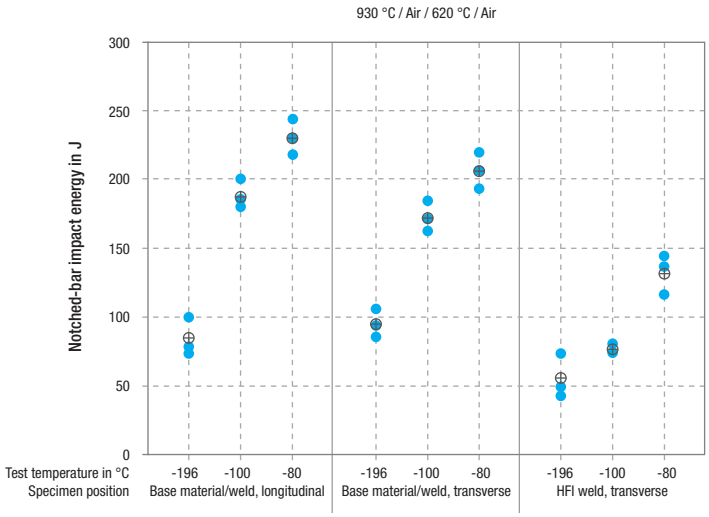

Figure 1: Charpy-V test results (full-size specimen after Q & T) as a function of test temperature and specimen position

Application

FW Fernwärme-Technik in Celle, Germany, developed a special multi-pipe system in MLP Type 1 steel for the transportation of liquefied natural gas (LNG) at a temperature of M 162 °C (Figures 2 and 3). In a 3-year test period with liquid nitrogen it was proved that the pipe system fulfills all requirements of LNG transportation. Moreover it offers potential to replace expensive and less available austenitic steels for applications at temperatures down to M 196 °C.

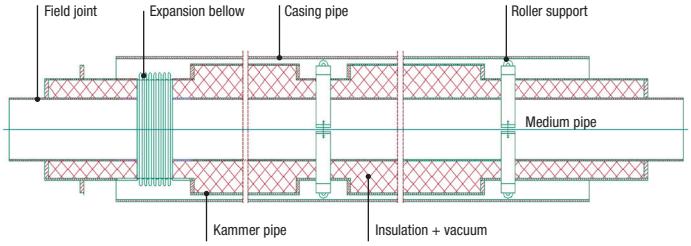

Figure 2: Schematic illustration of FW-Kammer-Pipe

The system concerned is a triple pipe system with a chamber for the transportation of fluids at cryogenic temperatures and meets the following requirements:

- avoidance of thermal bridges and very low heat transfer to the fluid
- possible natural compensation of cold induced contraction
- passive protection of the outer pipe against corrosion in soil
- in the event of an inner or outer pipe leak, pipeline operation will continue until repair
- permanent vacuum (over 30 years) in the chamber
- cost savings through the use of fine-grain steel for the outer pipe

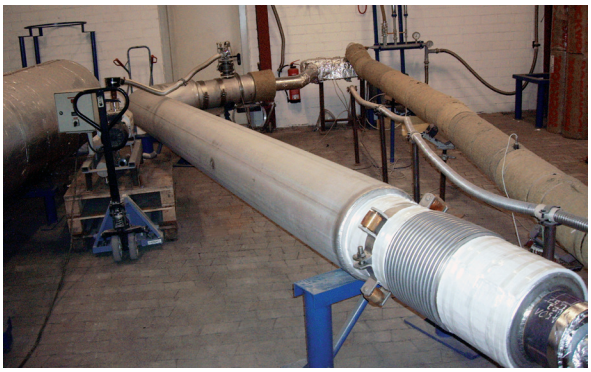

Figure 3: FW-Kammer-Pipe during assembly

Material Datasheet 202 | Mill Standard: SMLP Type 1

Scope

This Material Specification applies to welded nickel-alloyed low-temperature steels, whose properties in the delivery condition are specified below. Pipes in these steels are produced to the technical delivery standard ASTM A 553.

The HFI welding technology used is essential for the reliability of the products. The manufacturers ensure that their calculation, design and processing methods are appropriate for the material, correspond to state of the art technology, and are suitable for the intended use.

Chemical composition

C %	Si %	Mn %	P %	S %	Al %	Cu %	Cr %	Ni %	Mo %	N %
max. 0.08	max. 0.32	0.40–0.70	max. 0.015	max. 0.005	0.015–0.060	max. 0.40	max. 0.30	8.5–9.5	max. 0.10	max. 0.012

Other elements: Nb max. 0,02 %; V max. 0,02 %; Ti max. 0,02 %

Mechanical properties at room temperature

Mill standard	Yield strength $R_{t0.5}$ min. in N/mm² for wall thicknesses < 16 mm	Tensile strength R_m in N/mm² for wall thicknesses < 16 mm	Elongation A2" min. in %
SMLP Type 1	585	690–825	22

The test is carried out on longitudinal specimens

Charpy V-notch testing

Mill standard	Charpy test results in [J] Average[1] of 3 Charpy-V specimens at test temperature in °C	
	-196 transverse	-196 longitudinal
SMLP Type 1	40	70

The lateral expansion results of the impact test specimens are available on request.
[1] Minimum average values, only one individual value may be 30 % below the average value.

Expansion coefficient

Average value, for information only.

T - Temperature in °C	$a_{20,T}$ in 10^{-6}/K
-195	8.6
-100	10.0
0	10.6
100	11.4
200	11.8
300	12.3
400	12.4
480	12.6

Delivery condition

- Quenched & Tempered (Q&T)
- Pipe heating is performed by electromagnetic induction.

Technical delivery condition

- Pipe testing according to ASTM A 553. Test results are according to this MDS, tolerances to ASTM A 553.

Certification

Pipes made from this material are supplied with 3.1 inspection certificates (confirmed by the manufacturer's independent inspector) or 3.2 (confirmed by an inspector authorized by the customer and the manufacturer's independent inspector) according to EN 10204. In the certificates it will be stated that the pipes supplied meet the purchase order requirements, including specific test requirements.

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MANNESMANN. Das Rohr.

HFI-welded steel pipes for waste water, salt water, brines and similar media

Corrosion protection by linings

MANNESMANN LINE PIPE
A Member of the Salzgitter Group

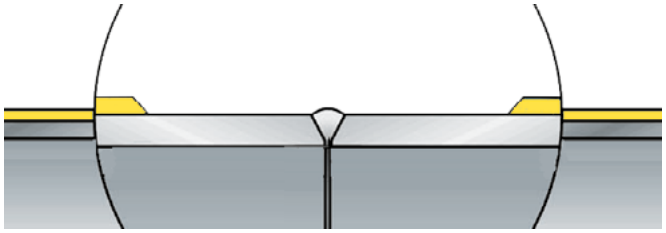
Product description

Depending on the composition of the medium, steel pipe for the transportation of wastewater, salt water, brines and similar should be protected by an anti-corrosion lining, especially when the media do not promote passivation of the steel surface. For this purpose, special linings are available whose chemical resistance has been verified in additional type tests.

Steel pipe for sewer systems is standardized in DIN 2460 (Steel water pipes and fittings). This standard also provides information about the static design of steel pipes. Pipe deliveries are usually made in accordance with the technical delivery conditions of DIN EN 10224.

Application area

Steel pipes with and without cement mortar lining are chiefly used for pressure pipelines with welded joints for the transportation of wastewater, salt water, brines and similar media. If the medium promotes the passivation of steel by the formation of a surface layer, the pipes are joined by butt-welding, a method typically employed in gas and drinking water supply systems. For pipelines with a special cement-mortar lining, slip welding joints are used, which are sealed by applying an optionally available flexible, thermosetting sealant to the socket base before welding. The advantage of this joint is that it provides axial conductivity which – as in the case of pipelines carrying media that are hazardous to groundwater – allows cathodic corrosion protection as a supplementary measure to the pipe coating, thus enabling continuous monitoring of the pipeline.



Butt-weld joint

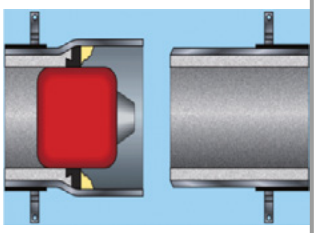
Slip-welding joint

Product properties

The lining's chemical resistance is verified in a six-month type test according to DIN EN 598 in a sour (pH 3) and in an alkaline environment (pH 13). In a second test, the solid components typically encountered in sewer pipes are measured. For this purpose, a 1-meter-long pipe section filled with a gravel sand-water mix is fixed in place in a test stand and inclined in alternating directions through 100,000 cycles. In both tests, the abraded material must not exceed the values specified in the standard.

Application example: pipes with slip-welding joint

Welding procedure



Before inserting the spigot end, a thermosetting sealant is applied to the socket base. When the spigot end is inserted, this material is pressed against the pipe wall in the joint area. After tack welding, any excess material can be removed with the aid of a foam pig. Only then can the pipes be joined by a fillet weld. The sealant is cured under the effect of the welding heat.

Pipe-laying

Directional changes, irrespective of whether or not the steel pipes are lined with cement mortar, are made with the aid of prefabricated pipe/segment bends or within the limits of the permissible elastic bending radius. Based on standing agreements with manufacturers of such fittings we can offer you a suitable solution or bring you in touch with a manufacturer. The maximum permissible elastic bend is 500 x OD. The pipes – including pipes with slip-welding joints – are welded together in a straight line before being subjected to elastic bending. Inserting the spigot at an angle before welding is not recommended.

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LINE PIPE
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Corrosion protection by linings

Typical product properties and data

Pipe [1]		
Size range	DN 100 to DN 600	
Wall thickness	3.2 to 10 mm [1]	
Yield strength (steel)	235 to 480 N/mm² (depending on steel grade) [1] [2]	
Fracture resistance (steel)	415 to 570 N/mm² (depending on steel grade) [1] [2]	
Elongation after fracture	20 to 25 % (depending on steel grade) [1]	
Elastic modulus	210 000 N/mm²	
Coefficient of thermal expansion	11.2 x 10^{-6} 1/K (cement mortar, depending on moisture content between 6 and 14 x 10^{-6})	
External corrosion protection	Pain coats, protective coatings	
Internal corrosion protection	with	I without cement mortar lining
Permissible crack width	–	I 0.6 mm (after immersion in water, if appropriate)
Surface roughness	–	I k_s = 0.1 mm [3]
Service temperature	400 °C	I 50 °C [4]
Typical range of pH	≥ pH 5 [5]	
Permissible flow rate	Cement mortar lining: up to 10 m/s (without cavitation!)	

[1] Other wall thicknesses and steel grades on request.

[2] Depending on pipe size

[3] Hydraulic calculations are usually based on the pipeline conditions. With drinking water pipelines, the integral roughness R_i is 0.1 mm for straight routes, and >0.4 mm to 1.0 mm for systems with multiple bends and branches. In sewer systems, the surface roughness parameter R_a under service conditions ranges from 0.25 mm to 0.5 mm and from 0.7 mm to 1.5 mm.

[4] Temperatures up to the boiling range are possible. Cavitation must be avoided.

[5] The application range may be further expanded after successful additional field studies.

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MANNESMANN. Das Rohr.

MAPUR®
Field coating system

Corrosion protection and mechanical protection all in one

MANNESMANN LINE PIPE
A Member of the Salzgitter Group

Product description

In addition to multi-layer systems that combine polyethylene and polypropylene coatings or polyethylene and polyamide, other systems based on GFRP or cement mortar are used in trenchless projects. The common feature of all these coating systems is the well-established corrosion protection coating of polyethylene with an additional top coat for averting mechanical damage. With all these systems, the pipe joint areas can be sealed with MAPUR®, a polyurethane-based casting resin system.

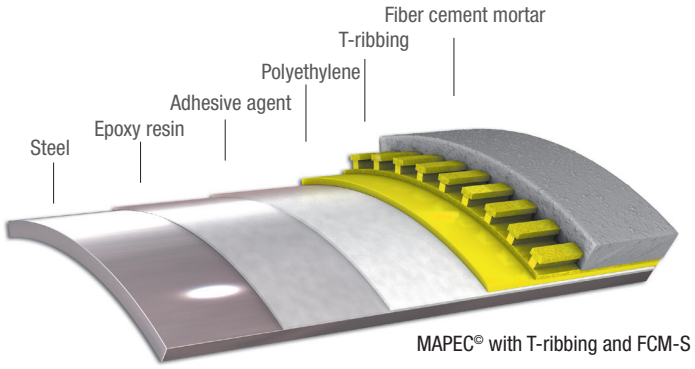
Application

There are two types of casting systems for field coating. In the case of cement mortar or GFRP coating, a sand-filled polyurethane system is used (MAPUR®). The casting mix for field coating steel pipes with a multi-layer coating has no sand filling (MAPUR® 2012).

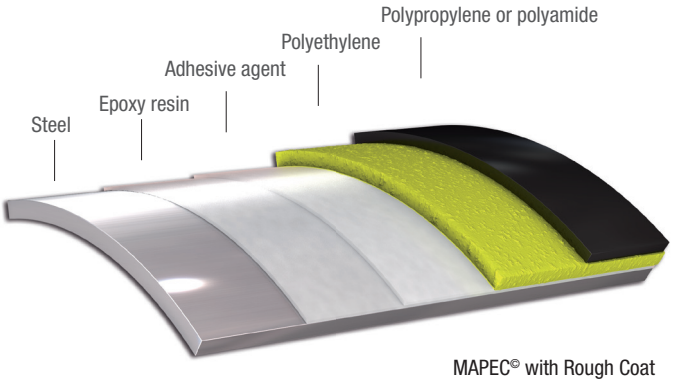
The pipe end structure provides for high shear bond strength in the transition area. With cement mortar coatings (FCM-S), this is ensured by the PE-coating's T-ribbing, while multi-layer coating systems use a "rough coat" for this purpose. This is produced by spraying coarse PE granules onto the freshly extruded polyethylene coating while the pipe string is still hot.

Product properties

The distinctive feature of a cast field coating is that it does not overlap with the mill-applied coating. This design has proven particularly advantageous in trenchless projects where the pipe string is pulled through the drilled bore. A corresponding reference to the high tensile shearing loads involved here is included in the current draft version of DIN 30675-1.



MAPEC© with T-ribbing and FCM-S



MAPEC© with Rough Coat

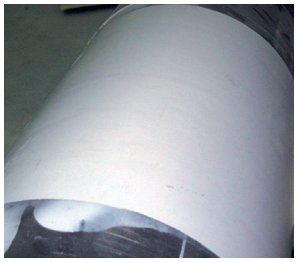
Practical testing

Practical tests have verified the material's suitability in terms of both its flexibility during pipe bending and its impact resistance.

Polyurethane (PUR) field coating before and after bending

Impact test

Cast field coating of cement mortar coated pipe joints



Cast field coating of pipes with multi-layer coating systems

MAPUR®
Field coating system

MANNESMANN LINE PIPE
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Corrosion protection and mechanical protection all in one

FCM field coating systems (T-ribbing and 10 mm FCM)

Joints/Steel pipe	Cardboard molds [1]		Casting mortar	MAPUR® casting resin [2]
outside diameter [mm]	Length [mm]	Width [mm]	Bucket (A = 7.9 kg / B = 12.1 kg) Value in brackets = Number of joints	Mass/joint [kg]
114.3	41	61	A (2)	5.3
139.7	49	61	B (2)	6.3
168.3	58	61	B (2)	7.4
219.1	74	61	A (1)	9.4
273	91	61	B (1)	11.5
323.9	107	61	B (1)	13.6
355.6	117	61	B (1)	14.8
406.4	133	61	2 A (1)	16.8
508	165	61	2 A (1)	20.8
610	297	61	A + B (1)	24.9

Field coating system for multi-layer coatings (2 + 2 mm)[3]

Joints/Steel pipe	Cardboard molds [1]		MAPUR® 2012 casting resin [2]
outside diameter [mm]	Length [mm]	Width [mm]	Mass/joint [kg]
114.3	36	51	1
139.7	44	51	1.2
168.3	53	51	1.5
219.1	69	51	2.1
273	86	51	2.7
323.9	102	51	3.2
355.6	112	51	3.5
406.4	128	51	4
508	160	51	5
610	191	51	6

[1] The data apply to pipe whose cement mortar coating has been cut back approx. 25 mm, and the PP or PA top coat (in the case of multi-layer systems) by approx. 20 cm.

[2] The data are reference values and may vary with the care applied in fitting the mold.

[3] Field coating system on request.

Application examples

Cement mortar coating

In the case of FCM-coated pipes, the joint area is initially field coated using one of the customary corrosion protection systems to DIN 30672 or DIN EN 12068. This is then complemented with a sand-filled polyurethane resin system (MAPUR®), until the thickness of the anti-corrosion coating (min. 7 mm) is reached. The resin is cast into a re-usable, rigid mold of polypropylene or aluminum sheet lined with foil.

Multi-layer systems

The joint areas in pipe with a multi-layer coating system are field coated with pure casting resin (MAPUR® 2012). Here, too, a re-usable, rigid mold of polypropylene or aluminum sheet lined with foil is used.

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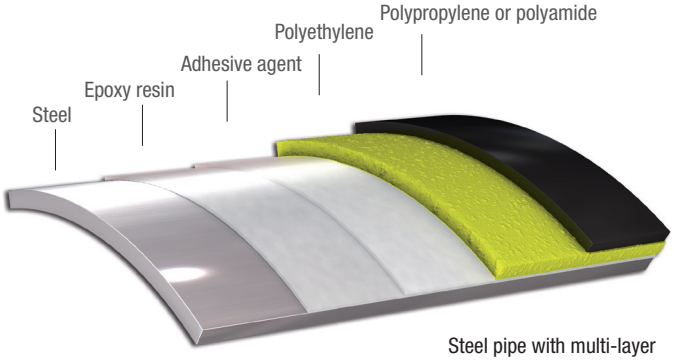
Multi-layer coating systems for steel pipe

MANNESMANN LINE PIPE
A Member of the Salzgitter Group

Separate functionalities of corrosion protection and mechanical protection

Product description

Multi-layer systems consist of a combination of a three-layer polyethylene coating (PE) and a mechanical protection layer of polypropylene (PP) or polyamide (PA 12). Coarse PE granules, which are sprayed and fused onto the freshly extruded polyethylene coating while the pipe string is still hot, give the coating a rough surface. The “rough coat” produced in this way provides for frictional resistance, which prevents separation of the subsequently applied top coat of PP or PA 12 during pipe string pulling in trenchless pipe-laying projects.



Steel pipe with multi-layer coating system

What is PA 12?

The PA 12 used here is marketed under the tradename Vestamid® and is a modified polyamide. The best known synthetic polyamides are Nylon (PA 6.6) and Perlon (PA 6), which are used in the textile sector.

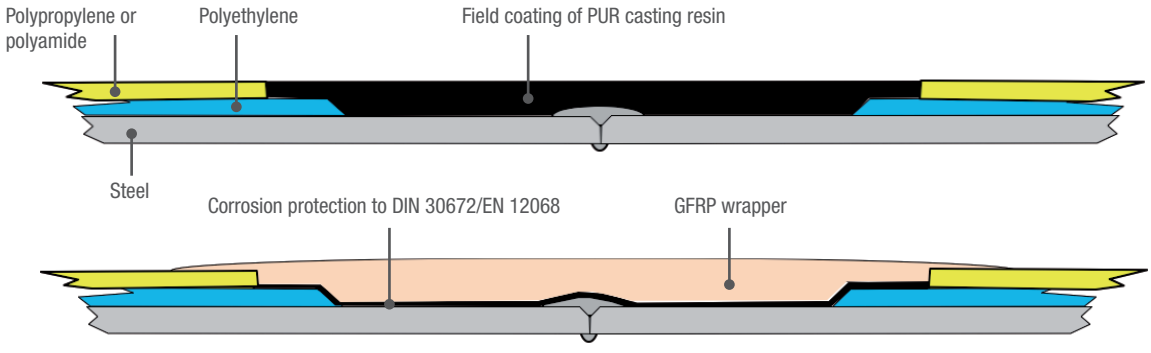
Application

As a rule, multi-layer coating systems are used for non-conventional pipe-laying techniques; they replace PE- or PP-based thick-layer systems. Field coating materials for pipe with multi-layer coating systems include polyurethane (PUR) casting resin and GFRP-based coating systems. The pipe ends are appropriately prepared at the pipe mill, i.e. the polyamide layer is cut back on the polyethylene coating over a length of at least 50 mm. This is long enough to ensure that the overlap of the mill-applied corrosion protection and the field coating meets standard specifications.

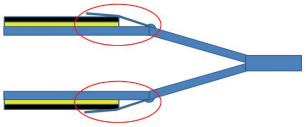
If short pipes are required, a circumferential cut should be made into the polyamide layer using a specially prepared cutting tool, whose blade only protrudes far enough to penetrate the outer coating to a maximum depth of 2 mm. For a precise circumferential cut, a clamp can be provisionally fitted around the pipe as a guide for the cutter. For trenchless projects where the pipe string is pulled through the drilled bore, a weld-on collar is available for protection of the pipe end coating.

Product properties

Multi-layer coating systems possess excellent shearing resistance. The combination of PE and PA 12 or of PE and PP provides for a functional separation of corrosion protection and mechanical protection. Initial cracks in the outer mechanical protection layer are stopped at the interface between the corrosion protection and mechanical protection. This is a property that cannot be achieved in PE- or PP-based thick-layer systems.



Field coating options for multi-layer coating systems



Welded ion collar for pipe end protection

MANNESMANN LINE PIPE
A Member of the Salzgitter Group

Separate functionalities of corrosion protection and mechanical protection

Typical product properties and data

Pipe	
Size range	DN 100 to DN 600
Wall thickness	3.2 to 25.4 mm
Yield strength (steel)	235 to 480 N/mm² (depending on steel grade)
Fracture resistance (steel)	415 to 570 N/mm² (depending on steel grade)
Elongation after fracture	20 to 25 % (depending on steel grade)
Modulus of elasticity	210 000 N/mm²

Top coat [1)]

Property	Polypropylene PP	Polyamide PA12
Shore hardness D (RT)	60	65
Impact resistance (J/mm layer thickness)	10 (0 °C)	20 (-40 °C)
Penetration depth (RT mm)	0.1	0.075
Shear resistance (N/cm²)	100	100
Temperature resistance	max. 85 °C (depending on PE type used)	

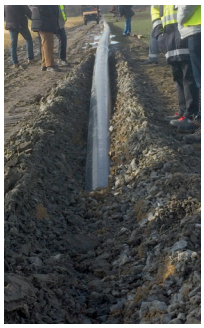
[1)] Independent of the top coat, a polyethylene base layer is provided.

Application examples



Installation of a gas pipeline with multi-layer coating system using the flush-drilling technique

Stadtwerke Düsseldorf



Installation of a high-pressure gas pipeline using the plowing technique

Stadtwerke Mönchengladbach

Note

Multi-layer coating systems for trenchless pipe-laying projects are included in the current draft version of DIN 30675-1. Tests and requirements are specified in Mill Standard T10.00.002 of Mannesmann Line Pipe GmbH.

Title: "Multi-layer coating system for circular steel hollow sections, comprising a three-layer polyethylene coating and a polyamide-based top coat – Requirements and tests"

The works standard can be downloaded as a PDF file from the link "Mill standards" on our website:
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MANNESMANN. Das Rohr.

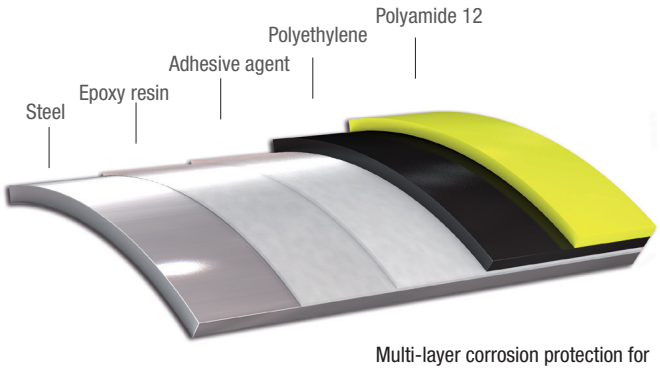
Polyamide 12 – a high-strength material for steel pipe coatings

Corrosion protection for offshore installations

MANNESMANN LINE PIPE
A Member of the Salzgitter Group

Product description

In a project sponsored by the German Federal Ministry of Education and Research, a weather-resistant, extrudable corrosion protection coating was developed for use on hollow steel sections in offshore installations. It is a multi-layer system comprising a three-layer polyethylene coating (PE) with an epoxy resin primer (approx. 100 µm), an adhesive agent (approx. 200 µm), and a PE-layer (min. thickness 1.8 mm) as well as a weather-resistant top layer for mechanical protection. The material of this top layer (min. thickness 2.0 mm) is based on Polyamide 12 and has been specially adapted and optimized for the intended offshore application.



Multi-layer corrosion protection for offshore installations

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

This coating was developed in a research project (sponsored by the German Federal Ministry of Education and Research) for the foundation structures of offshore wind turbines.[1)]

Application

Corrosion is a major threat to materials used in offshore installations. Salt water, mechanical loads due to drifting ice floes, swell, and – above all – exposure to ultra-violet radiation are factors that can severely affect the efficiency of corrosion protection.

To counter this threat, a corrosion protection system was developed that combines the well-established 3-layer polyethylene coating with a top layer of polyamide 12. However, the service properties of this coating system extend well beyond the application profile of a coating for offshore installations and are relevant to above-ground pipelines in every context, e.g.:

- Bridges
- Onshore installations
- Hydraulic steel structures
- Platforms for the oil & gas industry
- Piping systems for industrial plants

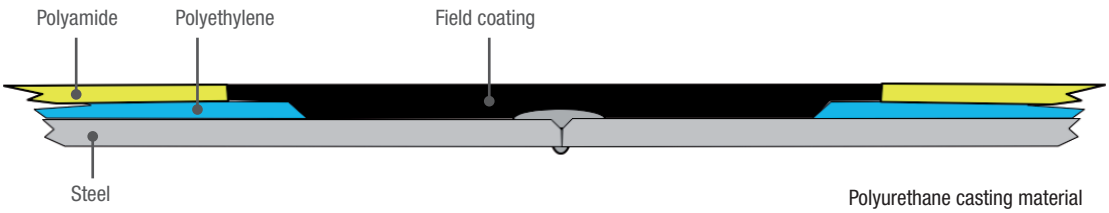
Product properties

What is PA 12?

The PA 12 used here is marketed under the tradename Vestamid® and is a modified polyamide. The best-known synthetic polyamides are Nylon (PA 6.6) and Perlon (PA 6), which are used in the textile sector.

The polyethylene-based corrosion protection coating is a long-lived system which has proved its efficiency on buried pipelines for decades. The additional extruded top layer of polyamide is responsible for mechanical protection and also possesses excellent resistance to ultra-violet radiation.

For the joint area between pipes or pipes and fittings, a field coating system based on polyurethane (PUR) is available. This has also been developed as part of the sponsored research project.



Polyurethane casting material for field coating

[1)] The responsibility for the contents of this publication rests with the authors.

Polyamide 12 – a high-strength material for steel pipe coatings

Corrosion protection for offshore installations

MANNESMANN LINE PIPE
A Member of the Salzgitter Group

Typical product properties and data

Pipe dimensions	
Outside diameter	114.3 – 610 mm
Wall thickness (dependent on diameter)	3.2 – 25.4 mm
Length	max. 18 mm

Polyamide top layer	
Thickness	min. 2 mm
Color	RAL1023, traffic yellow [1]
Shore hardness D	65
Impact resistance (-40°C)	20 J/mm layer thickness
Elongation at rupture (RT)	min. 200 %

[1] Other colors on request

Note

Tests and requirements for the multi-layer coating system on structural steel hollow sections are specified in Mill Standard T10.00.001 of Mannesmann Line Pipe GmbH.

Title: "Multi-layer coating system for circular steel hollow sections, comprising a three-layer polyethylene coating and a polyamide-based top coat – Requirements and tests"

The works standard can be downloaded as a PDF file from the link "Mill standards" on our website:
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MANNESMANN. Das Rohr.

MANNESMANN
LINE PIPE
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Mannesmann Premium Line Pipe

Line pipe for the toughest requirements

Fast & secure

The supply security provided by line pipe that can be delivered at short notice is becoming increasingly important for many customers in the oil & gas and chemical industries. The right steel pipe also has to be available on site in small quantities and at short notice. Mannesmann Premium Line Pipe is a product tailored to the respective requirements.

At a glance

Grade: L360NE to ISO 3183 and X52NE to API 5L
Coating conforming to DIN 30670 S-v (HDPE, reinforced)
Coating color: black
Production lengths: 12,000 mm +/-500 mm *

* Other lengths available on request

In stock

So that we can respond quickly and flexibly to our customers' wishes, we keep a selection of Mannesmann Premium Line Pipe in stock (no minimum order quantity). This saves our customers the cost of their own storage and logistics.

Außendurchmesser Outer diameter	Wanddicke Wall thickness	Werkstoff Grade	MAPEC® PE Schichtdick Layer thickness
mm (inch)	mm (inch)		mm
168.3 (6 5/8)	4.50 (0.177)	L360NE/X52NE	2.7
219.1 (8 5/8)	6.35 (0.250)	L360NE/X52NE	2.7
273.0 (10 3/4)	6.35 (0.250)	L360NE/X52NE	2.7
323.9 (12 3/4)	7.1 (0.280)	L360NE/X52NE	2.9
406.4 (16)	7.1 (0.280)	L360NE/X52NE	2.9
508.0 (20)	8.74 (0.344)	L360NE/X52NE	3.2

Mannesmann Premium Line Pipe

Line pipe for the toughest requirements

MANNESMANN LINE PIPE
A Member of the Salzgitter Group

For the toughest requirements

- High-grade starting material conforming to the familiar specifications / starting material certificate, acceptance test certificate (APZ) 3.1
- Extremely tight production tolerances in terms of length, roundness, diameter, straightness and wall thickness
- Extensive testing using the non-destructive and destructive tests listed opposite

Non-destructive testing

- US testing of strip, weld seam and pipe ends
- Pressure test for each pipe
- Metallographic inspection of the microstructure and hardness test

Destructive testing

- Notched bar impact test at -20°C
- Ring folding test
- Guided bend test
- Hot tensile test (80°C & 150°C)
- Tensile tests inclusive of kxS values

! Certified by an independent test institute with acceptance test certificate (APZ) 3.2

Dependable coating

The pipes are given a black MAPEC® PE (HDPE) coating as standard. This reliably protects the pipes from corrosion and mechanical damage and enables them to withstand even the toughest conditions.
We can also provide other coating systems for our steel pipes with delivery times and to suit individual customer requirements..

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MANNESMANN. Das Rohr.

HFI-welded steel pipes for abrasive media

Material solutions taking account of the corrosive effect of the transported medium

MANNESMANN LINE PIPE
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Product description

Solids such as ores, tar sands or fly ashes are transported in slurry pipelines over many kilometers. These are solid media with a small grain size that are either dry or mixed with liquids, mostly water. Depending on their corrosive effect, a variety of pipe designs are suitable for transporting these abrasive media:
- pipes with an abrasion-resistant lining
- pipes made from abrasion-resistant steels

The abrasion-resistant lining is made from polyurethane resin. Pipes with this lining are offered in cooperation with Roplast GmbH, a subsidiary of Rosen GmbH based in Lingen, Germany. An application example can be viewed at the following link: www.rosen-group.com/global/solutions/industry-case-studies/mining/kouribgas-slurry-pipe.html

The lining can be adapted to the medium and operating conditions involved. For media with slight or no corrosive effect, steels with appropriate abrasion resistance are available. The overleaf material datasheet provides information about the abrasion-resistant material Dura L.

Applications

Abrasion-resistant pipes can be found in a wide variety of applications:
- Tar sand production
- Ore transportation
- Fly ash transportation

The pipe connections used are predominantly mechanical, such as flange or coupling joints. Given the abrasive medium and corrosive environment, gaps should be avoided. Specifications concerning the tolerances at the pipe ends can be taken into account. The design of the connections allows the pipe to be rotated. In addition, pipe routing can be easily modified.

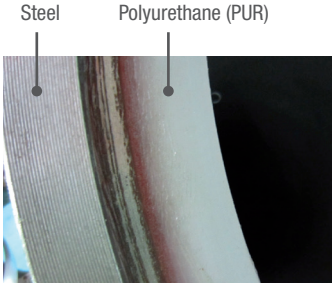
Coupling for grooved pipe

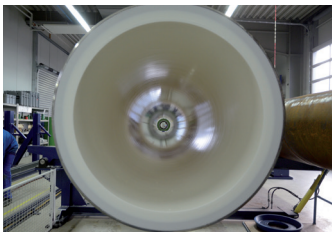
Flange connection for a T-piece

Product properties

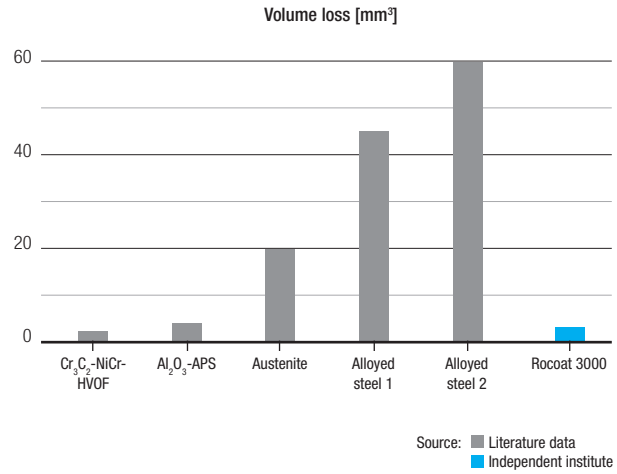
The measures for increasing abrasion resistance ensure a longer service life compared to standard pipe designs. Smooth surfaces provide for increased production as well as reducing pump output and the associated energy consumption. Lined pipe can be cold bent, the permissible bending radius being about 40 times the outside diameter.

Composite structure: Steel pipe with polyurethane lining (Rocoat 3000)





The results of the abrasion test to ASTM G75 confirm the outstanding properties of polyurethane linings. For example, Rocoat proves extremely resistant compared to alloyed steels. In terms of resistance, Rocoat 3000 is comparable to the aluminum oxide layers (Al_2O_3-APS) applied using a plasma process, or the chromium-carbide-based ceramic layers (Cr_3C_2-NiCr-HVOF) applied by high-speed flame spraying.



MANNESMANN LINE PIPE
A Member of the Salzgitter Group

Material solutions taking account of the corrosive effect of the transported medium

Dura L material

Scope of application

This datasheet covers welded steel pipe which features the properties described below in the delivery condition. All the pipes used have been subjected to induction annealing of the weld.

The processor or fabricator must make sure that their calculation, design and working processes match the material and application besides being state-of-the-art. Processing must be performed in accordance with SEW 088.

Chemical composition

C %	Si %	Mn %	P %	S %	Al %	Cu %	Cr %	Ni %	Mo %	N %	B %
0.30 - 0.37	0.15 - 0.55	1.45 - 1.80	max. 0.025	max. 0.010	0.010 - 0.060	max. 0.15	max. 0.15	max. 0.15	max. 0.05	max. 0.010	max. 0.0005

Mechanical properties at room temperature

Yield strength $R_{t0,5}$ min. in N/mm² for wall thicknesses < 12.7 mm	Tensile strength R_m in N/mm² for wall thicknesses < 20 mm	Elongation at rupture A in %
min. 413	min. 620	min. 22

- The test is carried out on longitudinal specimens
- Hardness measurement, min. individual value 210 HB
- Vickers small-load test HV1 according to ISO 6507 on the first pipe of each coil

Micro-hardness is measured in high-carbon areas at four selected points across the wall thickness.
HV to HB conversion: 1:1.

Hydrostatic test

- Scope of testing: each pipe
- Holding time: min. 5 seconds
- Test pressure level: calculated on the basis of the minimum wall thickness and a guaranteed yield strength utilization of 90 %.

Geometrical properties

- Wall thickness tolerance: - 0.5 mm / + 15 %
- Diameter tolerance: ± 0.5 % of outside diameter (measured with tape measure)
- Ovality: 1.5 % of outside diameter (measured with slide gauge)
- Pipe ends: cut off vertical to the pipe axis
- Geometry of the scraping area:
  - · External scraping: smooth
  - · Internal scraping: + 1.52 mm / - within the wall thickness tolerance
- Out-of-straightness: max. 2 mm/m
- Lengths: according to order specifications

Nondestructive testing

Weld: 100 % ultrasonic defect detection, incident angle of acoustic wave: 45°. Calibration with N10 groove.

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MANNESMANN. Das Rohr.

HFI-welded steel pipes

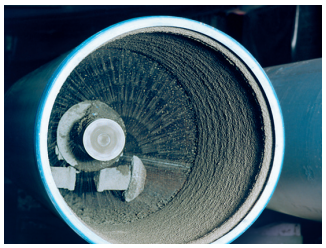
for oil-gathering systems in water-flooded oilfields

MANNESMANN LINE PIPE
A Member of the Salzgitter Group

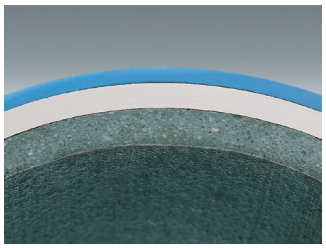
Product description

For the transportation of oil-water mixtures Mannesmann Line Pipe offers steel pipe with slip-welding joints and a modified cement mortar lining as internal corrosion protection. The method of applying the lining with the aid of a rotor head and the subsequent controlled rotation of the pipe together ensure maximum compaction and smoothing of the lining without demixing the cement mortar.

Steel pipes with modified cement mortar lining (mCML) and slip welding joints are a technically mature and cost-effective solution, which has proved its reliability in numerous laboratory tests as well as in many years‘ successful service in an experimental pipeline.



Spray lining



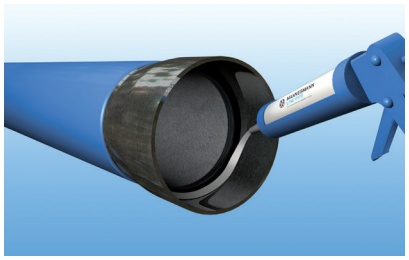
Smoothing of the lining by pipe rotation

Caulking tool

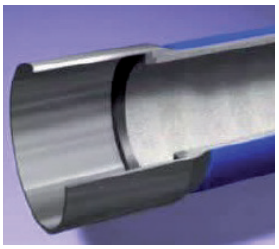
The use of slip-welding joints provides for sealing of the pipe joint areas. For completion of the pipe lining before welding, a thermosetting sealant is applied to the socket base.

Steel pipes for buried and above-ground pipelines are protected by proven PE or PP coatings. For above-ground pipelines, both mill-applied and field coating systems are available for corrosion protection.

Pipe-laying is facilitated through the use of a caulking tool perfectly adapted to the design of the slip-welding joint. Before lining, an oil-resistant rubber stop ring is placed into the socket base. Firmly anchored in the cement mortar, it prevents lining damage and spalling during the installation of the pipe joint.



Sealant application



Slip welding joint with stop ring in socket base

Application area

The pipe described here is primarily intended for use in enhanced oil recovery. This frequently involves water flooding or re-injection. Although the recovery rates are almost doubled, over time water flooding changes the properties of the medium being produced and hence calls for stronger corrosion protection on the pipe inside surface.

Product properties

Depending on their size, the pipes can be used at high operating pressures (up to 100 bar) and temperatures (up to 130 °C). The lining is suitable for liquid media containing dissolved salts, gases and solids and is resistant to basic, neutral and weakly acidic (pH>6) environments.

The application range may be further expanded after successful additional field studies.

for oil-gathering systems in water-flooded oilfields

MANNESMANN LINE PIPE
A Member of the Salzgitter Group

Typical product properties and data

Parameter	Properties (standard value)
Diameter	DN 100 to DN 600
Wall thickness	3.2 - 13 mm
Pipe length	up to 16 m
Yield strength	235 - 360 N/mm²
Tensile strength	360 - 460 N/mm²
Elongation at break	20 to 25 %

Typical values of the cement mortar lining based on modified blast furnace cement

(Report MA 39 – VFA 2011-1353.01 Inspection and Certification Board, Vienna, Austria, 2013)

Property	Requirements acc. to EN 598	Verified
Variation of the cement mortar lining thickness: pH 3 pH 13	 0.2 / -0.2 mm 0.2 / -0.2 mm	 0.05 mm -0.09 mm
Abrasion resistance	≤ 0.6 mm	0.21 mm
Compressive strength	50 MPa	59.06 MPa
Axial bending strength	19 kNm	Free of damage under loads of 19 kNm
Ring stiffness	Free of damage	Free of damage

Verified stability in sour gas (H_2S, CO_2) environments

(Report of the Institute for Maintenance and Corrosion Protection, Iserlohn, Germany, 2006)

Test conditions:
Immersion of a steel pipe specimen with mCML in salt water solution (235g / l NaCl), 42 °C, P_{H_2S} = 4 bar, P_{CO_2} = 11 bar, 1000 h

- Mass loss: 0.143 %
- Carbonization rate: 40-50 % (3-4 mm depth)
- pH value on the steel pipe surface: 10-11
- No H_2S induced damage on the steel pipe surface

Thermal stability

(Report SZMF-ED-PB-2009-0219, Salzgitter Mannesmann Forschung, Germany, 2009)

Test conditions:
Immersion of a steel pipe specimen (DN 150, L = 220 mm) with CML into drinking water, 250 °C, P = 43 bar, 60 days

Findings on cement mortar lining:

- no damage

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MANNESMANN. Das Rohr.

HFI-welded Steel Pipes

for the transportation and storage of hydrogen

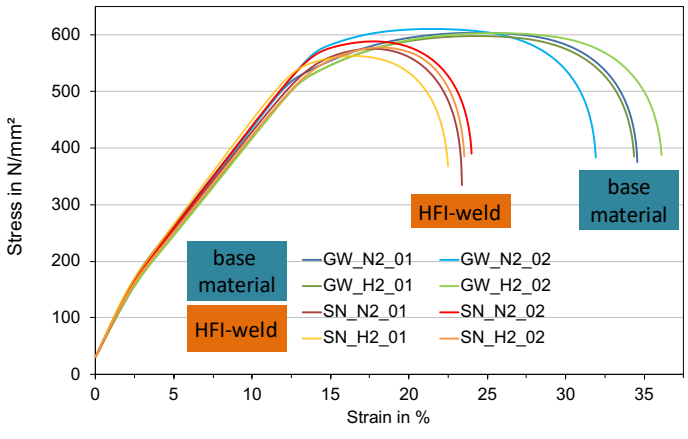
MANNESMANN LINE PIPE
Ein Unternehmen der Salzgitter Gruppe

Product description

"Mannesmann H2ready" steel pipes from Mannesmann Line Pipe offer maximum flexibility and safety for the transport and storage of gaseous hydrogen and of hydrogen admixed to natural gas.

Our pipes feature an optimum service life. Previous tests and existing standards already show that the use of line pipe grades up to API 5L X52 (L360) is non-critical, even if there are restrictions on the alloy content (EIGA Guideline, DVGW tests, EU project NaturalHy). The behavior of higher-strength materials of grade X70 (L485) was tested on exposure to pure compressed hydrogen and hydrogen/natural gas mixtures in slow strain rate tensile tests at 80 bar. Neither the base material, nor the HFI weld or standard girth weld showed signs of increased susceptibility to hydrogen in the structurally relevant area.

We have involved the Group's own research institute, Salzgitter Mannesmann Forschung, in the testing and realization of the highest quality standards.



Stress-strain behavior in slow strain rate tensile test of X70 in 100 % hydrogen (H_2) compared to an inert nitrogen atmosphere (N_2) on base material specimens (GW) and HFI weld specimens (SN).

Application

Besides worldwide increasing energy demand, it is particularly political efforts to reduce greenhouse gas emissions that are generating growing demand for alternative energy sources. This is accompanied by a decline in base-load generation capacity,

which is being accelerated in Germany by the forced phase-out of nuclear power.

Given an energy mix with a strong regenerative focus, the technical compensation of fluctuating electricity production and demand-based long-distance conveyance to the centers of consumption will be of critical importance. Innovations in energy storage and transportation are thus decisive for a successful energy turn-around.

In the power-to-gas sector, hydrogen in particular is proving to be a useful storage and transport medium. New fields of application can be found, for example, in the conversion of electricity, the heat market, automotive industry (fuel cell technology), steel industry, glass industry, chemical industry and food industry.

Especially in Germany, increasing the use of hydrogen makes good sense for several reasons.

- The country has over 100 years' experience of the commercial handling of hydrogen
- It ranks among the group of global leaders in the development of H_2 and fuel cell technologies
- Its chemical industry is searching for hydrogen from increasingly carbon-extensive sources
- There are salt caverns for large-volume H_2 storage in northern Germany (unlike in California or Japan)
- Energy-intensive premium steel production and further processing

for the transportation and storage of hydrogen

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Ein Unternehmen der Salzgitter Gruppe

However, the increased use of hydrogen calls for corresponding infrastructure for the medium's transportation and storage. This creates enormous demand for new gas pipelines suitable for hydrogen conveyance. In the simulation of a hydrogen network

infrastructure with mass-storage facilities, a possible future scenario has been determined: For the complete conversion of mobility to hydrogen as an energy source by the year 2052, with 33.9 million fuel-cell vehicles, 9,450 H_2 filling stations would be required nationwide. Since hydrogen technology is also being seriously promoted in countries with extremely high traffic density, such as the USA, Japan, China and India, there is no question that new pipelines are needed.

High-frequency induction-welded "Mannesmann H2ready" line pipe from Mannesmann Line Pipe, with chemical, mechanical and geometric properties specially adapted to the transport of hydrogen, is ideally suited to the imminent expansion of pipeline capacity. Proven welding technology and the use of modern steel grades resistant to the corrosive effect of hydrogen make our line pipe a cost-effective and environment-friendly solution.

Product properties

Steel as a material is noted for its extremely high toughness, durability and high resistance to external influences. Our supply

range with a broad spectrum of steel pipe dimensions from DN 100 to DN 600 is fully amenable to a wide range of applications and special uses. Thanks to an optimized combination of materials and grades, our "Mannesmann H2ready" pipes are not only clean and safe, but also economical.

Mannesmann Line Pipe GmbH is a member of the „The Fuel Cells and Hydrogen, E-Mobility" EnergyAgency.NRW

EnergieAgentur.NRW

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