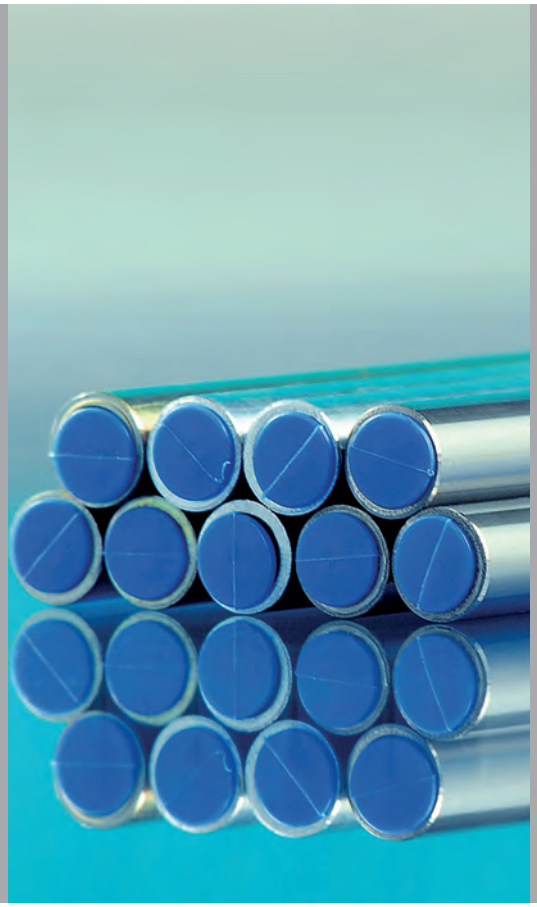




HPL Tubes

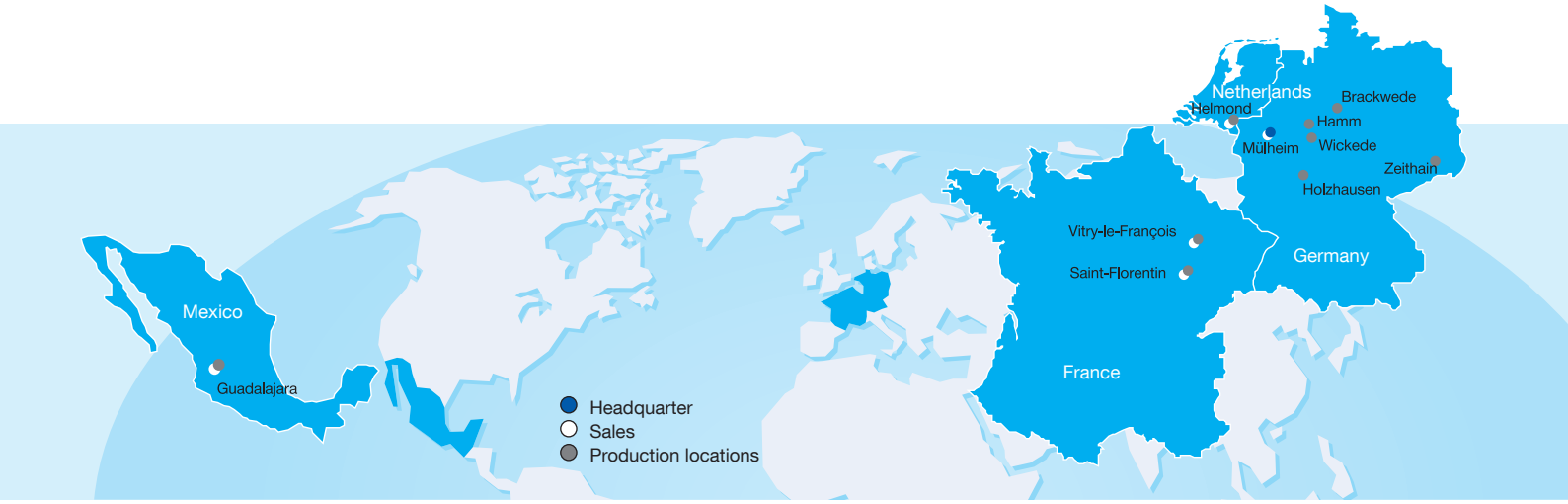
seamless precision steel tubes for hydraulic and pneumatic power systems

MANNESMANN
PRECISION TUBES
A Member of the Salzgitter Group



Mannesmann Precision Tubes

As a leading European manufacturer of cold-drawn seamless and welded precision steel tubes, the Mannesmann Precision Tubes Group offers a wide range of products as well as comprehensive technical advice and consultation, sales and services with ample scope for intelligent solutions. Synergistic effects within the Salzgitter Group provide for outstanding efficiency and performance. An integrated quality management system according to ISO 9001, IATF 16949 and ISO 14001 ensures consistent, high quality standards along the process chain from the starting material to the finished precision steel tube ready for shipment.



General Information

HPL tubes are seamless cold-drawn precision steel tubes predominantly used as pressure lines in hydraulically or pneumatically operated systems. For installation purposes, both permanent and non-permanent joints are available. In hydraulic systems the velocity and pressure of the flow are subject to variations. The resulting pressure surges are superimposed on the internal pressure. Pulsating stresses are prevalent in pressure lines. When designing the tubes for such systems, the actual stress profile under service conditions must be taken into account. Measurements and requirements in this brochure are harmonized with EN 10305-4 „Seamless cold-drawn tubes for hydraulic and pneumatic power systems“, which defines the technical delivery conditions.

Dimensions

The selection of dimensions shown in Table 1 is in accordance with EN 10305-4 „Steel tubes for precision applications – Technical delivery conditions – Part 4: Seamless cold drawn tubes for hydraulic and pneumatic power systems“ and DIN 2445-2, „Seamless steel tubes for dynamic loads; Steel tubes for precision application in fluid systems, 100 bar to 500 bar“ and also takes into account established dimensions in hydraulic and pneumatic engineering practice. For new designs we recommend using the standardized dimensions (DIN 2445) highlighted in grey in Table 1.

Deviation Limits

- Outside diameter and inside diameter as shown in Table 1.
- Straightness in accordance with EN 10305-4.
- For tubes ordered by their outside diameter and inside diameter, the maximum permissible eccentricity is 7.5 %.
- The tubes are supplied in lengths of 6,000 mm -0/+10 mm. Shorter lengths down to 4,000 mm are bundled separately.

Steel grades

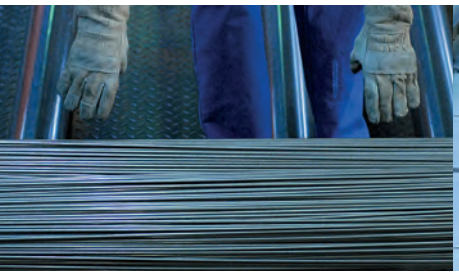
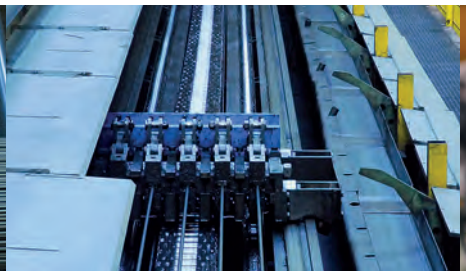
HPL tubes in accordance with EN 10305-4 are supplied in steel grades E 235 or E 355.

Technical delivery conditions

The tubes are normalized (+N) in a controlled atmosphere in accordance with EN 10305-4.

Supply Range

Dimensions, tolerances and flow cross sections of HPL tubes

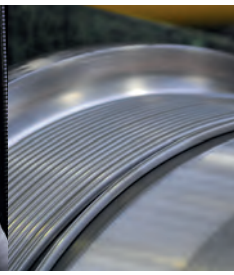


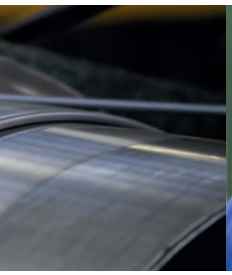
Table 1: Supply range, dimensions, tolerances, and flow cross sections

Outside diameter	Tolerances	Inside diameter	Tolerances	Wall thickness	Flow cross-section
mm	mm	mm	mm	mm	mm
4	+/-0.08	2.4	+/-0.15	0.80	0.045
4	+/-0.08	2.0	+/-0.15	1.00	0.031
5	+/-0.08	3.5	+/-0.15	0.75	0.096
5	+/-0.08	3.0	+/-0.15	1.00	0.071
6	+/-0.08	4.0	+/-0.12	1.00	0.126
6	+/-0.08	3.0	+/-0.15	1.50	0.071
6	+/-0.08	2.0	+/-0.15	2.00	0.031
8	+/-0.08	6.0	+/-0.10	1.00	0.283
8	+/-0.08	5.0	+/-0.10	1.50	0.196
8	+/-0.08	4.0	+/-0.15	2.00	0.126
8	+/-0.08	3.0	+/-0.15	2.50	0.071
10	+/-0.08	8.0	+/-0.08	1.00	0.503
10	+/-0.08	7.0	+/-0.12	1.50	0.385
10	+/-0.08	6.0	+/-0.15	2.00	0.283
10	+/-0.08	5.0	+/-0.15	2.50	0.196
12	+/-0.08	10.0	+/-0.08	1.00	0.785
12	+/-0.08	9.0	+/-0.10	1.50	0.636
12	+/-0.08	8.0	+/-0.12	2.00	0.503
12	+/-0.08	7.0	+/-0.15	2.50	0.385
14	+/-0.08	12.0	+/-0.08	1.00	1.131
14	+/-0.08	11.0	+/-0.08	1.50	0.950
14	+/-0.08	10.0	+/-0.10	2.00	0.785
14	+/-0.08	9.0	+/-0.12	2.50	0.636
15	+/-0.08	13.0	+/-0.08	1.00	1.327
15	+/-0.08	12.0	+/-0.08	1.50	1.131
15	+/-0.08	11.0	+/-0.10	2.00	0.950
15	+/-0.08	10.0	+/-0.12	2.50	0.785
15	+/-0.08	9.0	+/-0.15	3.00	0.636
16	+/-0.08	14.0	+/-0.08	1.00	1.539
16	+/-0.08	13.0	+/-0.08	1.50	1.327
16	+/-0.08	12.0	+/-0.15	2.00	1.131
16	+/-0.08	11.0	+/-0.15	2.50	0.950
16	+/-0.08	10.0	+/-0.15	3.00	0.785
16	+/-0.08	9.0	+/-0.15	3.50	0.636
18	+/-0.08	16.0	+/-0.08	1.00	2.011
18	+/-0.08	15.0	+/-0.08	1.50	1.767
18	+/-0.08	14.0	+/-0.08	2.00	1.539
18	+/-0.08	13.0	+/-0.15	2.50	1.327
18	+/-0.08	12.0	+/-0.15	3.00	1.131
20	+/-0.08	17.0	+/-0.08	1.50	2.270
20	+/-0.08	16.0	+/-0.08	2.00	2.011
20	+/-0.08	15.0	+/-0.15	2.50	1.767
20	+/-0.08	14.0	+/-0.15	3.00	1.539
20	+/-0.08	13.0	+/-0.15	3.50	1.327
20	+/-0.08	12.0	+/-0.15	4.00	1.131
20	+/-0.08	11.0	+/-0.15	4.50	0.950
22	+/-0.08	20.0	+/-0.08	1.00	3.142
22	+/-0.08	19.0	+/-0.08	1.50	2.835
22	+/-0.08	18.0	+/-0.08	2.00	2.545
22	+/-0.08	17.0	+/-0.08	2.50	2.270
22	+/-0.08	16.0	+/-0.15	3.00	2.011
22	+/-0.08	15.0	+/-0.15	3.50	1.767
22	+/-0.08	14.0	+/-0.15	4.00	1.539
25	+/-0.08	22.0	+/-0.08	1.50	3.801
25	+/-0.08	21.0	+/-0.08	2.00	3.464
25	+/-0.08	20.0	+/-0.08	2.50	3.112
25	+/-0.08	19.0	+/-0.15	3.00	2.835
25	+/-0.08	18.0	+/-0.15	3.50	2.545
25	+/-0.08	17.0	+/-0.15	4.00	2.270
25	+/-0.08	16.0	+/-0.15	4.50	2.011

Standard dimensions according to DIN 2445-2.

Other dimensions on request.

Dimensions, tolerances and flow cross sections of HPL tubes






Outside diameter	Tolerances	Inside diameter	Tolerances	Wall thickness	Flow cross-section
mm	mm	mm	mm	mm	mm
25	+/-0.08	14.0	+/-0.15	5.50	1.539
25	+/-0.08	13.0	+/-0.15	6.00	1.327
28	+/-0.08	25.0	+/-0.08	1.50	4.909
28	+/-0.08	24.0	+/-0.08	2.00	4.524
28	+/-0.08	23.0	+/-0.08	2.50	4.155
28	+/-0.08	22.0	+/-0.15	3.00	3.801
28	+/-0.08	21.0	+/-0.15	3.50	3.464
28	+/-0.08	20.0	+/-0.15	4.00	3.112
28	+/-0.08	18.0	+/-0.15	5.00	2.545
30	+/-0.08	26.0	+/-0.08	2.00	5.309
30	+/-0.08	25.0	+/-0.08	2.50	4.909
30	+/-0.08	24.0	+/-0.15	3.00	4.524
30	+/-0.08	22.0	+/-0.15	4.00	3.801
30	+/-0.08	20.0	+/-0.15	5.00	3.112
30	+/-0.08	18.0	+/-0.15	6.00	2.545
35	+/-0.15	31.0	+/-0.15	2.00	7.548
35	+/-0.15	30.0	+/-0.15	2.50	7.069
35	+/-0.15	29.0	+/-0.15	3.00	6.605
35	+/-0.15	28.0	+/-0.15	3.50	6.158
35	+/-0.15	27.0	+/-0.15	4.00	5.726
35	+/-0.15	25.0	+/-0.15	5.00	4.909
35	+/-0.15	23.0	+/-0.15	6.00	4.155
38	+/-0.15	33.0	+/-0.15	2.50	8.553
38	+/-0.15	32.0	+/-0.15	3.00	8.042
38	+/-0.15	30.0	+/-0.15	4.00	7.069
38	+/-0.15	28.0	+/-0.15	5.00	6.158
38	+/-0.15	27.0	+/-0.15	5.50	5.726
38	+/-0.15	26.0	+/-0.15	6.00	5.309
38	+/-0.15	24.0	+/-0.15	7.00	4.524
38	+/-0.15	22.0	+/-0.15	8.00	3.801
38	+/-0.15	18.0	+/-0.15	10.00	2.545

Outside diameter	Tolerances	Inside diameter	Tolerances	Wall thickness	Flow cross-section
mm	mm	mm	mm	mm	mm
42	+/-0.20	38.0	+/-0.20	2.00	11.341
42	+/-0.20	36.0	+/-0.20	3.00	10.179
42	+/-0.20	34.0	+/-0.20	4.00	9.079
42	+/-0.20	32.0	+/-0.20	5.00	8.042
42	+/-0.20	30.0	+/-0.20	6.00	7.069
42	+/-0.20	26.0	+/-0.20	8.00	5.309
50	+/-0.20	42.0	+/-0.20	4.00	13.854
50	+/-0.20	40.0	+/-0.20	5.00	12.566
50	+/-0.20	38.0	+/-0.20	6.00	11.341
50	+/-0.20	36.0	+/-0.20	7.00	10.179
50	+/-0.20	34.0	+/-0.20	8.00	9.079
50	+/-0.20	32.0	+/-0.20	9.00	8.042
50	+/-0.20	30.0	+/-0.20	10.00	7.069
50	+/-0.20	28.0	+/-0.20	11.00	6.158
50	+/-0.20	24.0	+/-0.20	13.00	4.524
55	+/-0.25	47.0	+/-0.25	4.00	17.349
55	+/-0.25	43.0	+/-0.25	6.00	14.522
55	+/-0.25	39.0	+/-0.25	8.00	11.946
55	+/-0.25	35.0	+/-0.25	10.00	9.621
60	+/-0.25	50.0	+/-0.25	5.00	19.635
60	+/-0.25	44.0	+/-0.25	8.00	15.205
60	+/-0.25	40.0	+/-0.25	10.00	12.566
60	+/-0.25	35.0	+/-0.25	12.50	9.621
70	+/-0.30	60.0	+/-0.30	5.00	28.274
70	+/-0.30	54.0	+/-0.30	8.00	22.902
70	+/-0.30	50.0	+/-0.30	10.00	19.635
70	+/-0.30	45.0	+/-0.30	12.50	15.904
80	+/-0.35	68.0	+/-0.35	6.00	36.317
80	+/-0.35	64.0	+/-0.35	8.00	32.170
80	+/-0.35	60.0	+/-0.35	10.00	28.274
80	+/-0.35	55.0	+/-0.35	12.50	23.758

Standard dimensions according to DIN 2445-2.

Other dimensions on request.

Wall thickness

calculations



Dimensioning of wall thickness

Wall thickness calculations for steel tubes under internal pressure are carried out in accordance with DIN 2413 Part 1. Material data for seamless tubes under cyclic loading can be taken from DIN 2413 Part 1, paragraph 4.2.3. A selection of tube dimensions for design pressure p_s of 100 to 500 bar

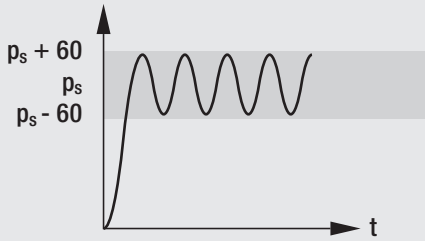


Table 2: Dimensions, load case A for pressure range p_s ±60 bar

Tube outside diameter	Resulting wall thickness at a given operating pressure p_s					
	100 bar	160 bar	250 bar	315 bar	400 bar	500 bar
mm	mm	mm	mm	mm	mm	mm
4	0.8	1.00	-	-	-	-
6	1.0	1.00	1.00	1.00	1.50	1.50
8	1.0	1.00	1.50	1.50	1.50	2.00
10	1.0	1.00	1.50	1.50	2.00	2.50
12	1.0	1.50	2.00	2.00	2.50	2.50
15	1.5	1.50	2.00	-	-	-
16	1.5	1.50	2.00	3.00	3.00	3.50
18	1.5	2.00	2.50	-	-	-
20	1.5	2.00	2.50	3.00	3.50	4.00
22	1.5	2.00	3.00	-	-	-
25	2.0	2.50	3.00	3.50	4.50	6.00
28	2.0	2.50	3.50	-	-	-
30	2.0	3.00	4.00	5.00	5.00	6.00
35	2.0	3.00	-	-	-	-
38	3.0	4.00	5.00	5.50	7.00	8.00
42	3.0	4.00	-	-	-	-
50	4.0	5.00	6.00	8.00	9.00	10.00

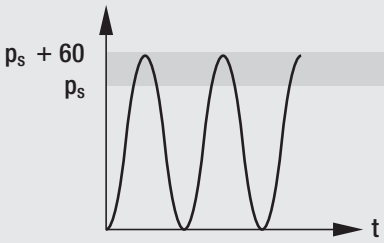
The values above refer to the calculation of straight tubes. For tube bends, a calculation in accordance with DIN 2413:2011-06, Part 2 must be carried out if necessary.



is contained in DIN 2445 Sheet 2. As pressure surges must be expected in hydraulic systems, creep rupture and fatigue rupture stresses must be duly considered in design calculations. DIN 2413 Part 1 and supplement 1 to DIN 2445 contain the relevant instructions for wall thickness calculations.

Table 3: Dimensions, load case B for pressure ranges of 0 to p_s +60 bar

Tube outside diameter	Resulting wall thickness at a given operating pressure p_s					
	100 bar	160 bar	250 bar	315 bar	400 bar	500 bar
mm	mm	mm	mm	mm	mm	mm
4	0.8	1.00	-	-	-	-
6	1.0	1.00	1.00	1.00	1.50	2.00
8	1.0	1.00	1.50	1.50	2.00	2.50
10	1.0	1.00	1.50	2.00	2.50	3.00
12	1.0	1.50	2.00	2.00	2.50	3.50
15	1.5	1.50	2.00	-	-	-
16	1.5	1.50	2.50	3.00	3.50	4.50
18	1.5	2.00	2.50	-	-	-
20	1.5	2.00	3.00	3.50	4.50	5.50
22	1.5	2.00	3.00	-	-	-
25	2.0	2.50	3.50	4.50	5.50	7.00
28	2.0	2.50	4.00	-	-	-
30	2.0	3.00	4.00	5.00	7.00	8.00
35	2.5	3.50	-	-	-	-
38	3.0	4.00	5.00	7.00	8.00	10.00
42	3.0	4.00	-	-	-	-
50	4.0	5.00	7.00	9.00	11.00	13.00



The values above are related to the calculation of straight tubes. For tube bends, a calculation in accordance with DIN 2413:2011-06, Part 2 must be carried out, if necessary.

Cold workability
HPL tubes are readily cold workable due to their final heat treatment. When bending is performed, the corresponding reduction of the wall thickness and out-of-roundness in the bending area must be considered. The reduction factors for the design of bends and non-circular cross sections are given in DIN 2413 Part 2.

Weldability
The tubes are weldable without preheating and aftertreatment using standard welding techniques.

Surface conditions
In accordance with EN 10305-4 the tubes exhibit smooth inside and outside surfaces with a roughness of $R_a \leq 4$ µm.

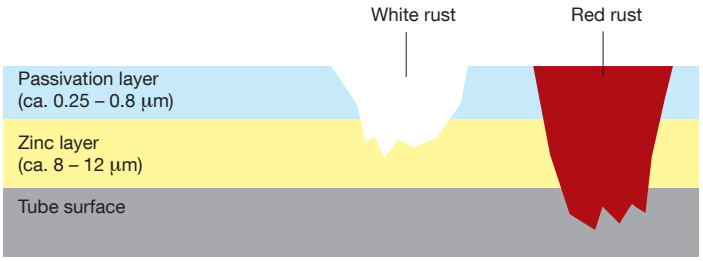
Passivation
Both high-performance and thick-film passivated HPL-tubes are externally galvanized with a zinc coating with a standard thickness of 8 to 12 µm plus a passivation layer. Other coating thicknesses and outside diameters > 42 mm are available on request.

Mannesmann Precision Tubes-high performance passivation provides Cr(VI)-free coatings, in full compliance with the European directive 2000/53/EU of 2007.

Both high-performance and thick-film passivated tubes feature a transparent and colorless appearance. The resistance to white rust (salt spray test to ISO 9227) is ≥ 200 h (this value applies to straight tube sections and decreases after deformation).

White rust is a white deposit that can form on zinc surfaces (galvanized parts) stored in an insufficiently ventilated environment. Loose white rust provides no protection to the surface.

Red rust is a corrosion product that forms during the atmospheric corrosion of iron. It is black or brown to red and has a loose, porous condition.



Unless otherwise specified, the tubes will be coated and tested according to ISO 2081.

The designation according to ISO 2081 should be given as in the following example:

Galvanic Coating ISO 2081-Fe/Zn8/C

This example specifies a galvanic zinc coating on ferrous material (Fe) with a minimum coating thickness of 8 µm (Zn8) and a transparent colorless, iridescent (C).

Temporary Corrosion Protection
All tubes are provided with an inhibitor-containing mineral oil coating as temporary corrosion protection:

HPL tubes, black
2 mm ≤ ID < 6 mm: oil coated internally and externally
ID ≥ 6 mm: oil coated internally and externally or phosphated and oiled internally and externally

HPL tubes, galvanized:
with an OD < 8 mm
or ID ≤ 4 mm: non-greased, unoiled
with an AD > 8 mm
or ID > 4 mm: oiled internally and externally

Table 4: Chemical composition[1)]

Steel grade	C	Si	Mn	P	S
	%	%	%	%	%
E235	≤ 0.17	≤ 0.35	≤ 1.20	≤ 0.025	≤ 0.015
E355	≤ 0.22	≤ 0.55	≤ 1.60	≤ 0.025	≤ 0.015

This requirement is not applicable provided the steel contains a sufficient amount of other nitrogen binding elements, such as Ti, Nb or V. If added, the content of these elements shall be reported in the inspection document.

Table 5: Mechanical properties at room temperature[2)]

Steel grade	Tensile strength	Yield strength	Elongation
	R_m	R_{eH}	A
	MPa	MPa	%
		min	min
E235	340 – 480	235	25
E355	490 – 630	355	22

2) For tubes with outside diameters ≤ 30 mm and wall thicknesses ≤ 3 mm, the R_{eH} minimum values are 10 MPa lower than the values given in this table.



Marking
Continuous full-length marking is applied to all tubes. The marking includes:
- Manufacturer‘s mark
- Tube type
- Dimensions
- Delivery standard
- Steel grade
- Delivery condition
- Batch number
- Additional information: Cr6-free
- Country of Origin

Marking Example:

MPT-BR HPL 10 x 1 EN 10305-4 E235 +N 3484711 Cr6-free Germany

Testing
Unless otherwise specified, HPL tubes will be subjected to specific inspections in accordance with EN 10305-4. This includes mandatory destructive and non-destructive tests. Additional optional or non-specific inspections can be agreed upon.

Inspection certificates
HPL-tubes are supplied with an inspection certificate 3.1 according to EN 10204 as standard. A 3.2 inspection certificates can be agreed upon.

Tube ends
Standard: Smooth, unmachined.
Exception: High-performance passivated tubes with outside diameters < 8 mm or with an inside diameter ≤ 4 mm: „Ends pinched off“, i. e. the ends are sheared off and slightly oval.
End seal (non-pinched-off ends only).
Tubes with inside diameters ≤ 4 mm are closed with plastic end caps.
Tubes with inside diameters > 4 mm are sealed with plastic plugs.
Tubes ≤ 42 mm in outside diameter and lengths other than 6000 +10 / -0 mm are delivered with open ends protected with blue plastic bags.

Packaging
Tubes ≥15 mm outside diameter are packed in hexagonal steel-strapped bundles containing a fixed number of tubes per size. Larger quantities, short lengths and tubes in outside diameters < 15 mm are supplied in round bundles.
Other packaging (e.g. crates, cardboard tubes, bundle ends protected by plastic foil) is available on request.
Packaging in crates is required e.g. for thin-walled tubes or for overseas shipments.

General terms of sale
Please note that our deliveries are made exclusively according to our General Terms and Conditions of Sale and Payment. We will be happy to send you a copy of these on request. Alternatively, you can find them on the internet at www.mannesmann-precision-tubes.com.


MPT-BR HPL 10 x 1 EN 10305-4 E235 +N 3484711 Cr6-frei Germany

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Mannesmann Precision Tubes GmbH, HPL Tubes – seamless precision steel tubes for hydraulic and pneumatic power systems, 003 E 3.19