

Seamless precision steel tubes

for hydraulic and pneumatic applications



MANNESMANN
PRECISION TUBES

A Member of the Salzgitter Group



The Company Group

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 from the starting material to the finished precision steel tube ready for shipment.

Mannesmann offers specially optimized precision steel tubes with outside diameters of 30 to 380 mm and wall thicknesses up to 25 mm for a wide range of applications.

The typical features of cold finished precision steel tubes are:

- free choice in a continuous size range
- high dimensional accuracy
- fine surface quality
- definable mechanical properties

This makes cold finished precision steel tubes particularly suitable for use in hydraulic and pneumatic systems.

Particularly high requirements are placed on the design and workmanship of the working cylinder in such systems. Besides reliable static and dynamic load behavior,

a decisive precondition for its functional efficiency is the interaction of dimensional accuracy and outstanding quality of the inside surface and the piston seal.

Our ongoing development of the manufacturing processes and steel grades we use, including modified materials, enables us to produce tubes with the mechanical and technological properties required specifically for hydraulic and pneumatic systems and tailored to our customers' individual requirements.

The modified steel grades, in particular, have been developed for use in low temperature applications, to prevent brittle fracture or multiple component failure, thus raising the level of reliability of component parts.

Table 1: Tube types in this brochure

Application	Cylinder barrels			Piston tubes	
Standard	EN 10305-1		EN 10216-1/-3	EN 10305-1	
Mannesmann designation	HPZ-tubes	tubes for cylinder construction		HPK-tubes	tubes for cylinder construction
	HP tubes				
Delivery condition	+SR		+N/+QT	+SR	+N/+QT
Page	5	8	7	10	

Dimensional accuracy

As a result of the cold forming process, the diameter and wall thickness tolerances are substantially reduced compared to hot rolled tubes. A shift of tolerances for machining purposes is possible without any problem.

Delivery conditions

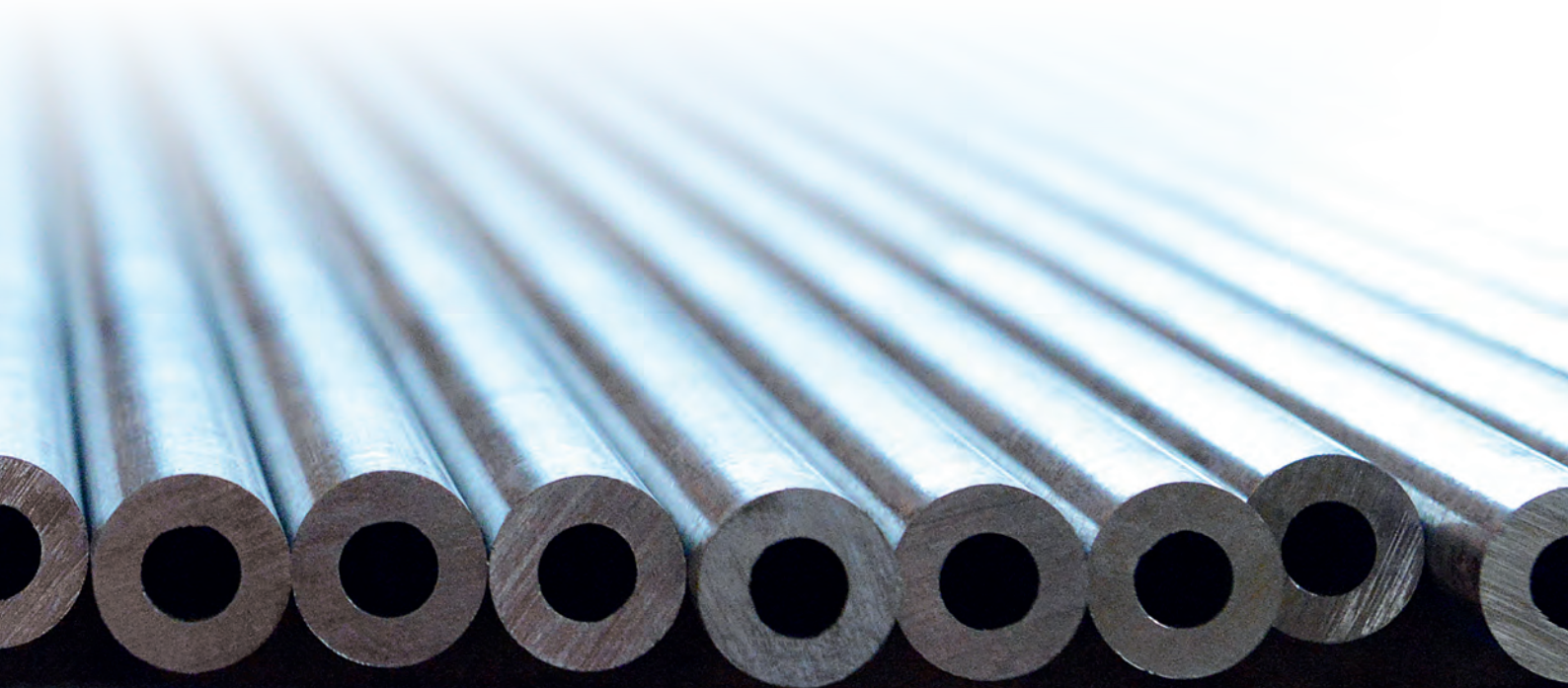
Precision steel tubes are available in a variety of delivery conditions to suit customer and application requirements. An overview of available delivery conditions is shown in Table 2.

Surface condition

The surfaces of cold finished precision steel tubes in the delivery conditions +SR and +N are free from scale and exhibit the smoothness typical of cold drawn products. Tubes in the delivery condition +QT show the typical quenched and tempered surface condition both internally and externally.

Table 2: Delivery conditions

Example	+SR	cold drawn and stress relieved
100 ± 0.50 or	+N	normalised
100 -1.00/+0 or	+QT	quenched and tempered
100 -0/+1.00 mm		



HPZ-tubes are seamless cold finished precision steel tubes for the manufacture of cylinder barrels. They are supplied in the delivery condition +SR.

Piston seals require high surface quality which, in the case of tubes for cylinder barrels, is achieved by finish-machining. The tolerances are designed to allow machining by either honing or skiving and roller-burnishing.

Cylinder barrels are dimensioned by their inside diameter and wall thickness, which between them determine the dimension of the outside diameter.

The inside diameters and permissible eccentricity are listed in the adjacent tables. In the case of intermediate sizes, the permissible tolerances for the next nominal size up are applicable. The tolerances for the outside diameter are as per EN 10305-1. Tubes can also be ordered by the outside and inside diameters or by the outside diameter and the wall thickness.

A shift or change of the tolerances may be agreed upon; for telescopic cylinders, a machining allowance can be applied to the outside diameter.

Table 3: Supply range, dimensions and tolerances of HPZ-tubes in delivery condition +SR

Inside diameter, nominal size	Machining allowance, nominal wall thickness/permissible deviation									
	5	7.5	10	12.5	15	17.5	20	22.5	25	> 25 – 28.5
25										
30										
35										
40										
45	-0.20/-0.35									
50		-0.20/-0.40								
55										
60										
63										
65		-0.20/-0.45								
70										
75										
80										
85										
90			-0.40/-0.70							
95										
100										
105										
110										
115										
120				-0.50/-0.90						-0.80/ -1.30
125										
130										
135										
140		-0.50/-1.20								
145	///									
150	///									
155		///								
160										-1.00/ -1.50
165										
170					-0.50/-1.00					
175										
180										
185										
190										
195										
200										
205			///							-1.20/ -1.90
210										
215										
220			///							
225										
230										
235										-1.40/-2.10
240										
245						-0.70/-1.40				
250			///							
255										
260										
265										-1.60/ -2.40
270				///		-1.00/-2.55				
280										
290				///						
300										
310						-1.00/-2.70				-1.60/ -2.60
320				///						
330										
340						-1.00/-2.80				-1.60/ -2.80
350										

Eccentricity 5.0 %
 Eccentricity 7.5%
 Eccentricity 10.0 %
 Dimensions on request
 Tolerances on request

Tubes for cylinder construction are seamless cold finished precision steel tubes in the delivery conditions +N or +QT, or tubes in the delivery condition +SR outside the specified size or tolerance ranges for the manufacture of cylinder barrels.

Unlike EN 10305-1, the EN 10216 series of standards belongs to the material standards harmonized as per PED Directive 2014/68/EU, according to which Mannesmann Precision Tubes

as a registered materials manufacturer supplies seamless cold-finished precision steel tubes in a broad spectrum of dimensions. Thanks to their continuous size range as well as optimized tolerances and surfaces compared to hot-finished tubes, precision steel tubes are increasingly used as semi-finished products.

For hydraulic systems subject to the Pressure Equipment Directive, Parts 1 and 3 of EN 10216 are primarily taken

into account, as the design temperature limits lie within the range of -50 °C to +100 °C. Generally, carbon steels and fine-grain structural steels are used in this temperature range. For Parts 2 and 4 of EN 10216, please consult our brochure „Seamless cold-drawn heat exchanger tubes for process industries“.

The tolerances and machining allowances for delivery condition +QT are subject to special agreement.

Table 4: Standard specifications for order information, steel grades, delivery conditions, scope of testing and marking

	EN 10216-1		EN 10216-3	
Seamless steel tubes for pressure purposes – Technical delivery conditions				
	Tubes in carbon steels with defined properties at room temperature		Tubes in fine-grain structural steels	
Order information	Quantity – Dimensions – Number of this standard – Steel grade designation		Quantity – Dimensions – Number of this standard – Steel grade designation – Test category	
Delivery condition	+N		+N, +QT	
Grades	P195TR1, -TR2 P235TR1, -TR2 P265TR1, -TR2		P275NL1, -NL2 P355N, -NL1, -NL2, -NH P460N, -NL1, -NL2, NH P620Q, -QH, -QL P690Q, -QH, -QL1, QL2	
Scope of testing Mandatory tests	For grade TR1 <ul style="list-style-type: none"> Heat analysis Tensile test (RT) Leakage test Dimensional check Visual inspection 	For grade TR2 <ul style="list-style-type: none"> Heat analysis Tensile test (RT) Charpy impact test Leakage test Dimensional check Visual inspection 	TC1 <ul style="list-style-type: none"> Heat analysis Tensile test (RT) Tensile test (H grades) Ring flattening/drift expanding test Charpy impact test Leakage test Dimensional check Visual inspection Material identity check 	TC2 <ul style="list-style-type: none"> Heat analysis Tensile test (RT) Tensile test (H grades) Ring flattening/drift expanding test Charpy impact test Leakage test Dimensional check Visual inspection Non-destructive longitudinal defect detection Material identity check
Tube marking	Indelible at D > 51mm <ul style="list-style-type: none"> Manufacturer's mark Number of this standard Steel grade Heat number Inspector's mark or seal Production order number Country of origin 		Indelible at D > 51mm <ul style="list-style-type: none"> Manufacturer's mark Number of this standard Steel grade Test category Heat number Inspector's mark or seal Production order number Country of origin 	

Please do not hesitate to contact us if you have other or additional requirements.

Table 5: Product range, dimensions and tolerances of HPZ-tubes in delivery condition +N

Inside diameter, nominal size	Machining allowance, nominal wall thickness/permissible deviation									
	5	7.5	10	12.5	15	17.5	20	22.5	25	> 25 – 28.5
25										
30	-0.45									
35										
40	-0.55									
45										
50	-0.60									
55										
60										
63	-0.65									
65										
70		-0.70				-0.75				
75	-0.80									
80										
85	-0.85									
90										
95		-0.90								
100							-1.10		-1.20	
105	-1.00									-0.80 / -1.60
110										
115		-1.20								
120										-1.00 / -1.90
125						-1.30				
130										
135										
140										
145					-1.40					-1.00 / -2.00
150										
155										
160	-0.50					-1.50				
165										-1.00 / -2.10
170										
175										
180					-1.60					
185										
190										-1.00 / -2.20
195										
200						-1.70				
205										-1.20 / -2.50
210										
215								-1.80		-1.20 / -2.60
220										
225										-1.40 / -2.80
230					-2.00					
235										
240						-2.10				-1.40 / -2.90
245	-0.70									
250										
255							-2.20			
260										
265										-1.60 / -3.20
270										
280						-2.60				-1.60 / -3.30
290										
300						-2.70				-1.60 / -3.40
310	-1.00									
320						-2.80				-1.60 / -3.50
330										
340						-2.90				
350										

Eccentricity 5.0 %
 Eccentricity 7.5 %
 Eccentricity 10.0 %
 Dimensions on request
 Tolerances on request

HP tubes



HP-tubes is a collective term used for cylinder barrel tubes that have been internally machined to a defined ISO tolerance, mainly by skiving and roller burnishing, or by honing.

Their special features are:

- top-quality micro-finished inside surface
- low roughness values
- high profile bearing ratio
- favorable sliding properties

Besides HPZ-tubes according to Table 3, cylinder tubes in the delivery conditions +N or +QT may be used as starting tubes for HP-tubes.

The tolerance class for the machined inside diameter is H8 or, for limit dimensions, H9.

Surface condition

The following roughness values according to ISO 4287 and ISO 4288 are specified for the inside surface:

$$R_a < 0.3 \mu\text{m}$$

$$R_z < 2.0 \mu\text{m}$$

Other parameters can be determined on request.

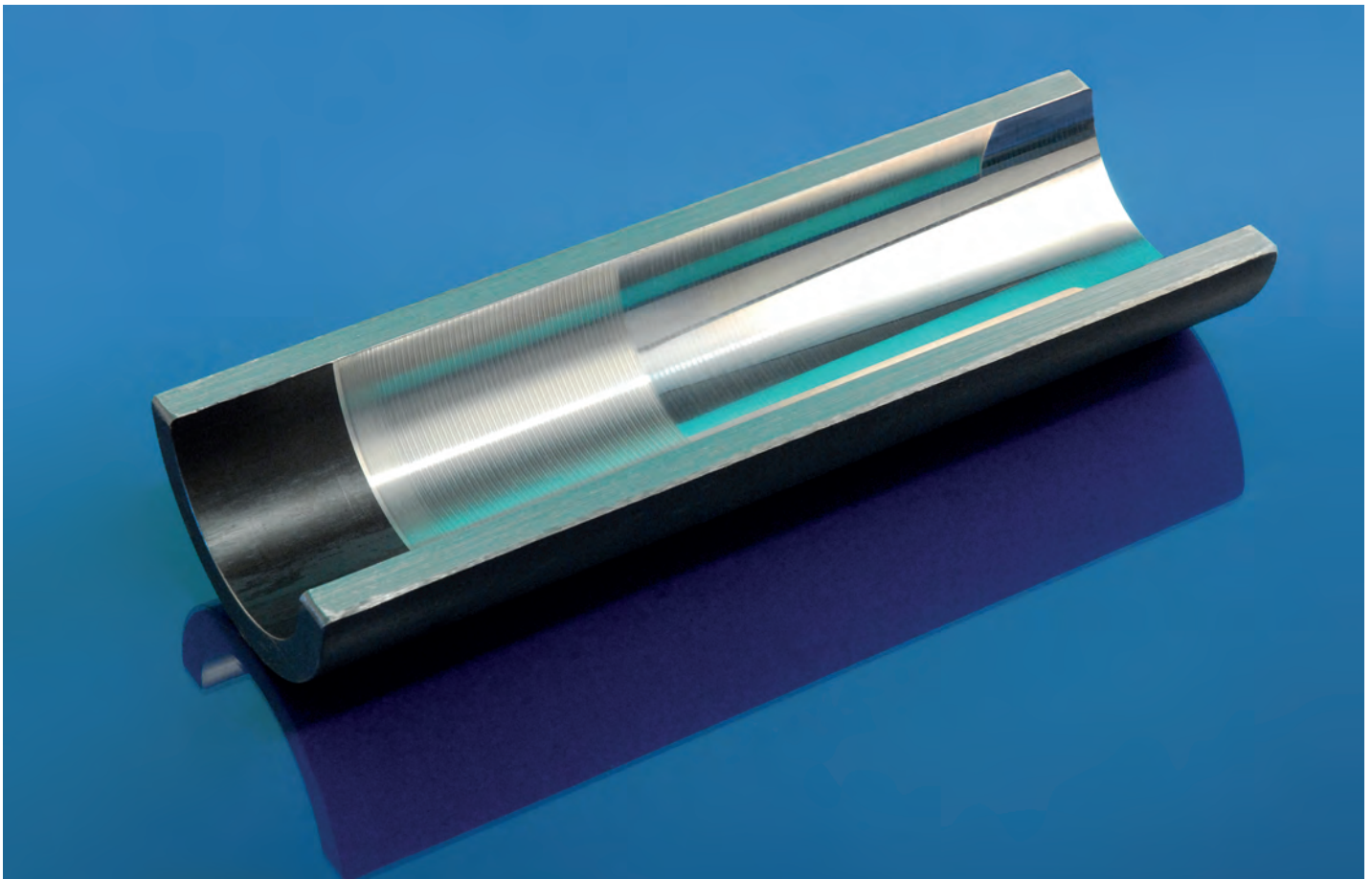
The outside surface meets the requirements of the relevant technical delivery condition or it exhibits the condition typical of the quenched-and-tempered condition, as applicable.

Custom-machining

Besides internal machining, other machining steps can be carried out to customer requirements, including:

- cutting to fixed lengths
- tube end machining, e.g. welding bevels
- transverse holes
- circumferential grooves
- threads

Please contact us if you require special custom-machining operations or machining according to drawings.





HPK-tubes are seamless cold finished precision steel tubes in the +SR delivery condition for the manufacture of pistons, telescopic cylinders and linear guide elements.

Tubes for cylinder construction are seamless cold finished precision steel tubes in the +N or +QT delivery condition or tubes in the +SR delivery condition outside of the specified range of dimensions or tolerances.

The high surface quality of HPK-tubes is achieved by subsequent machining. The tolerances in Table 5 apply to the production of a surface suitable for chrome plating.

Tubes for cylinder pistons are specified by their outside diameter and wall thickness which determine the inside diameter. Outside diameters and eccentricity are listed in Table 5. The applicable standard for inside diameters is EN 10305-1. The specified outside diameter tolerances apply to centerless grinding or skiving with subsequent fine grinding.

The tubes can also be ordered by their outside diameter and inside diameter or by their inside diameter and wall thickness.

The first figure in the table below indicates the minimum machining allowance (MA_{min}) and the second the maximum machining allowance (MA_{max}). The minimum machining allowance (MA_{min}) is identical for delivery conditions +SR and +N. The maximum

allowance can be found in the column for the relevant delivery condition. In the case of intermediate sizes, the tolerances for the next nominal size up are applicable. A shift or change in the upper or lower machining allowance may be agreed upon; similarly, a

machining allowance can be specified for the inside diameter of telescopic cylinders. Tolerances and machining allowances for the delivery condition +QT are subject to special agreement.

Table 6: Product range, dimensions and tolerances of piston tubes in delivery conditions +SR and +N

Outside diameter, nominal size				Nominal wall thickness/permissible deviation											
mm	MA_{min} +SR/+N	MA_{max} +SR	MA_{max} +N	4	5	6	7.5	10	12.5	15	17.5	20	22.5	25	> 25 – 28.5
25															
30															
35	+0.20	+0.35	+0.35												
40															
45	+0.25	+0.45	+0.50												
50															
55			+0.55												
60															
63		+0.55	+0.60												
65															
70	+0.30		+0.65												
75															
80			+0.65												
85		+0.60	+0.70												
90															
95			+0.85												
100															
105		+0.80													
110			+0.90												
115	+0.40														
120															
125															
130		+0.90	+1.10												
135															
140															
145															
150			+1.50												
155															
160	+0.70	+1.30													
165															
170			+1.60												
175															
180															
185															
190			+1.80												
195															
200	+0.80	+1.50													
205															
210			+1.90												
215															
220															
225															
230			+2.10												
235	+0.90	+1.70													
240															
245			+2.20												
250															
255			+2.30												
260															
265	+1.10	+2.00	+2.40												
270															
280			+2.50												
290	+1.20	+2.30	+2.60												
300			+2.70												

Eccentricity 5.0 %
 Eccentricity 7.5%
 Eccentricity 10.0 %
 Dimensions on request

Mechanical and technological properties

Table 7: Tube steel grades in various delivery conditions

Steel grade	Previous designation	Delivery condition	Mean wall thickness ¹⁾	Tensile strength	Yield strength	Elongation	Impact energy ²⁾			
				R_m (RT) MPa	$R_{p0.2}$ (RT) MPa	A (RT) %	KV Joule			
							-20°C, long.	-20°C, transv.	-40°C, long.	-40°C, transv.
MW-Grade 550 ⁴⁾	E355	+SR	$5 \leq s \leq 25$	620	550	15	–	–	–	–
MW-Grade 660	StE 460	+SR	$5 \leq s \leq 25$	700	660	15	–	–	–	–
MW-Grade 520		+SR	$5.5 \leq s \leq 25$	580	520	15	27	–	–	–
MW-Grade 620 _{SWB}	(new)	+SR	$5.5 \leq s \leq 20$	700	620	18	27	–	–	–
MW-Grade 540 _{SWB}	E355 _{SWB}	+SR	$5.5 \leq s \leq 25$	620	540	18	40	–	–	–
			$25 < s \leq 28.5$	600	540	18	40	–	–	–
MW-Grade 620 _{MOD}	(new)	+SR	$5.5 \leq s \leq 20$	700	620	18	35	27	–	–
			$20 < s \leq 25$	670	600	18	35	27	–	–
MW-Grade 600 _{MOD} ³⁾	P550 _{MOD}	+SR	$5.5 \leq s \leq 20$	650	600	18	100	80	27	27
			$20 < s \leq 25$	630	550	18	80	60	27	27
MW-Grade 650 _{MOD} ³⁾	P650 _{MOD}	+SR	$5.5 \leq s \leq 20$	700	650	18	100	80	40	27
			$20 < s \leq 25$	640	590	17	80	60	40	27
MW-Grade 700 _{MOD} ³⁾	P700 _{MOD}	+SR	$5.5 \leq s \leq 20$	750	700	18	100	80	40	27
			$20 < s \leq 25$	680	640	17	80	60	40	27
MW-Grade 355	P355N	+N	$5.5 \leq s \leq 20$	490	355	22	40	27	27	27
			$20 < s \leq 25$	490	345	22	40	27	27	27
MW-Grade 460	P460N	+N	$5.5 \leq s \leq 12$	560	460	19	40	27	27	27
			$12 < s \leq 20$	560	450	19	40	27	27	27
			$20 < s \leq 25$	560	440	19	40	27	27	27

C35
C45E
C60
28Mn6
25CrMo4
34CrMo4
42CrMo4
E410 (20MnV6)

On request – chemical and mechanical properties in delivery conditions +C, +SR, +N and +QT according to customer specification

- 1) When ordering by inside and outside diameter the resultant mean wall thickness must be taken into account. Wall thicknesses not included in the table are available on request.
 - 2) The values for the given notched bar impact energy (KV) are valid for full-size Charpy V-notch specimens (test cross-section 80 mm²). The impact energy values achieved for smaller wall thicknesses are based on the actual wall thickness of the specimen.
 - 3) Outside diameter > 80 mm only
 - 4) Option 2 on request
- All figures are minimum values. RT: Room temperature

Alternative materials and standards (ASTM/ASME, BS, NF, GOST, JIS, etc.) on request.

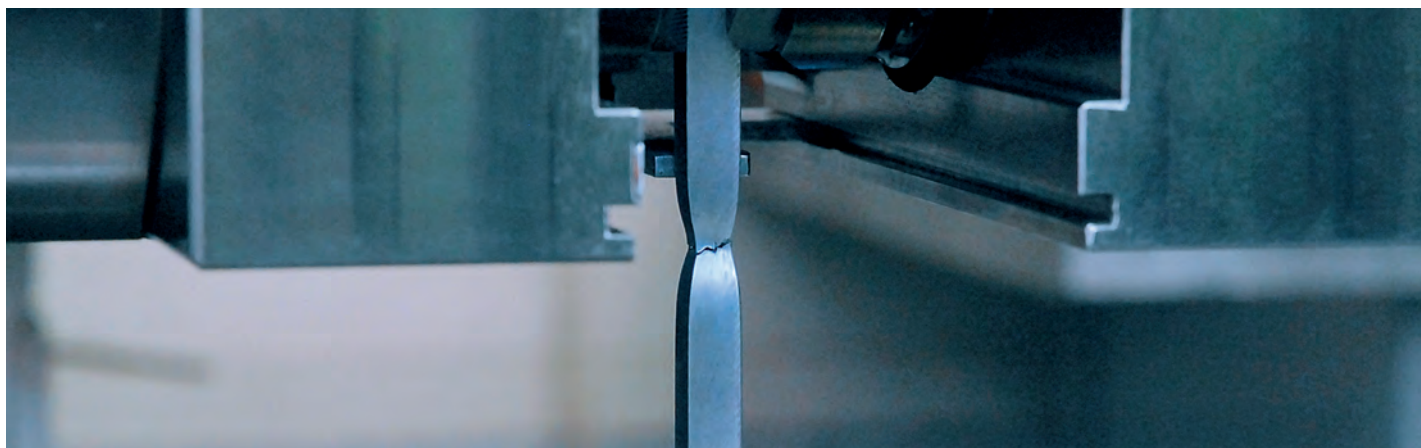


Table 8: Tube steel grades for use in cylinder construction

Steel grade	Chemical composition ^{1) 2)}															
	C	Si	Mn	P	S	Al	Cu	Cr	Ni	Mo	V	Ti	W	N	Nb	Nb+Ti+V
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
MW-Grade 355/550	0.22	0.55	1.60	0.025	0.025	≥ 0.02	–	–	–	–	–	–	–	–	–	–
MW-Grade 460/660	0.22	0.60	1.00 – 1.70	0.025	0.025	≥ 0.02	0.70	0.30	0.80	0.10	0.20	0.04	–	0.02	0.05	0.22
MW-Grade 520	0.22	0.55	1.60	0.025	0.025	≥ 0.02	–	–	–	–	–	–	–	–	–	–
MW-Grade 620 _{SWB}	0.22	0.60	1.00 – 1.70	0.025	0.025	≥ 0.02	0.30	0.30	0.70	0.10	0.20	0.02	–	0.02	0.05	0.22
MW-Grade 540 _{SWB} ³⁾	0.22	0.55	1.60	0.025	0.025	≥ 0.02	–	–	–	–	–	–	–	–	–	0.22
MW-Grade 620 _{MOD}	0.20	0.60	1.00 – 1.70	0.025	0.025	≥ 0.02	0.30	0.50	0.70	0.30	0.20	0.02	–	0.02	0.05	0.22
MW-Grade 600 _{MOD}	0.22	0.55	1.60	0.025	0.025	≥ 0.02	–	–	–	–	–	–	–	–	–	0.22
MW-Grade 650 _{MOD}	0.20	0.60	1.00 – 1.70	0.025	0.025	≥ 0.02	0.30	0.80	0.70	0.40	0.15	0.02	–	–	–	–
MW-Grade 700 _{MOD}	0.20	0.60	1.40 – 1.90	0.025	0.025	0.07	0.40	0.80	0.80	0.50	0.15	–	0.80	–	–	–

1) The addition of micro-alloying elements is permissible at the manufacturer's discretion.
 2) If nitrogen is bound by niobium, titanium or vanadium, then the definition of aluminum content is not required.
 3) SWB = special heat treatment.
 Unless otherwise indicated, all figures are maximum values.

Alternative materials and standards (ASTM/ASME, BS, NF, GOST, JIS and others) on request.

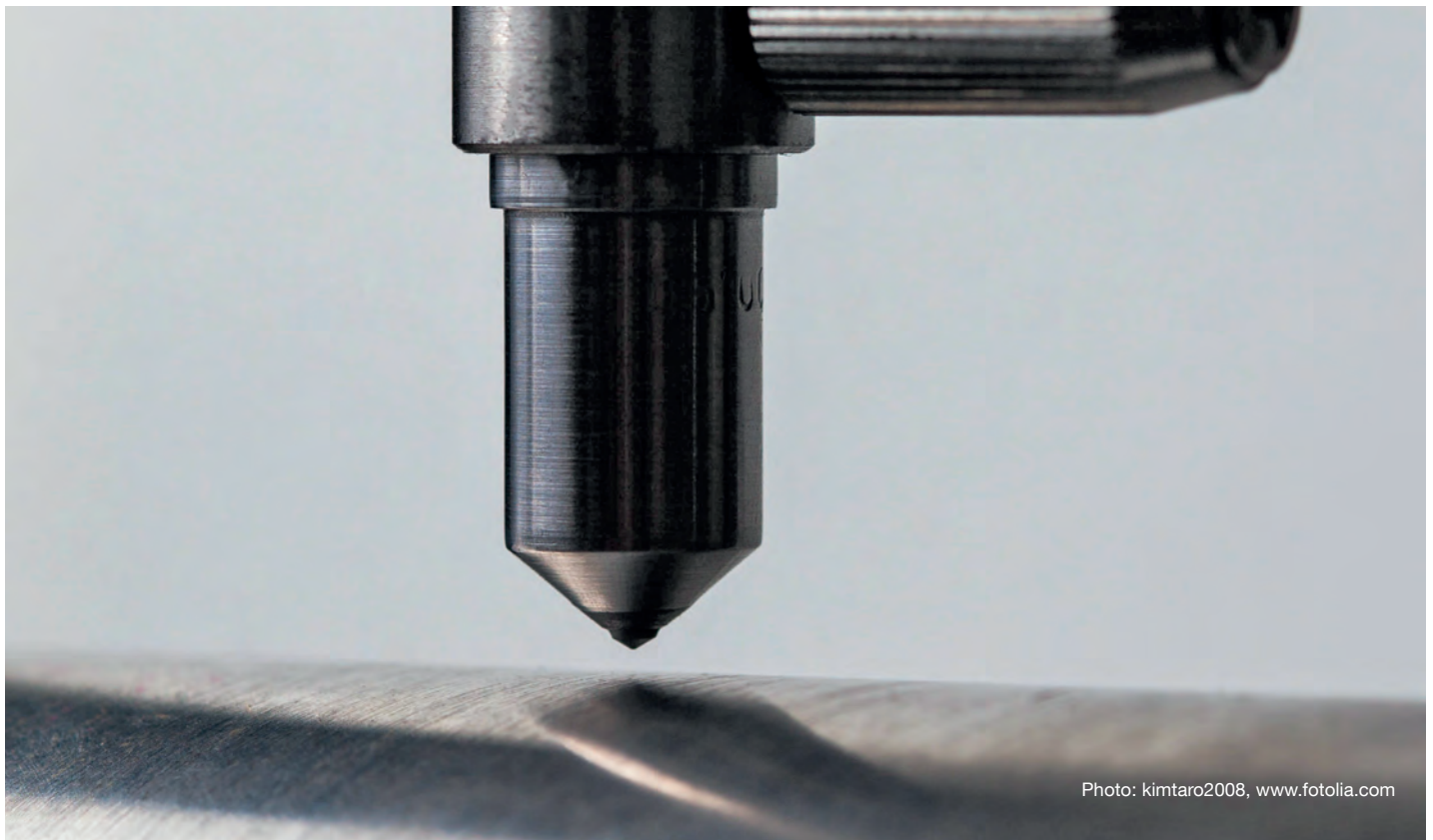
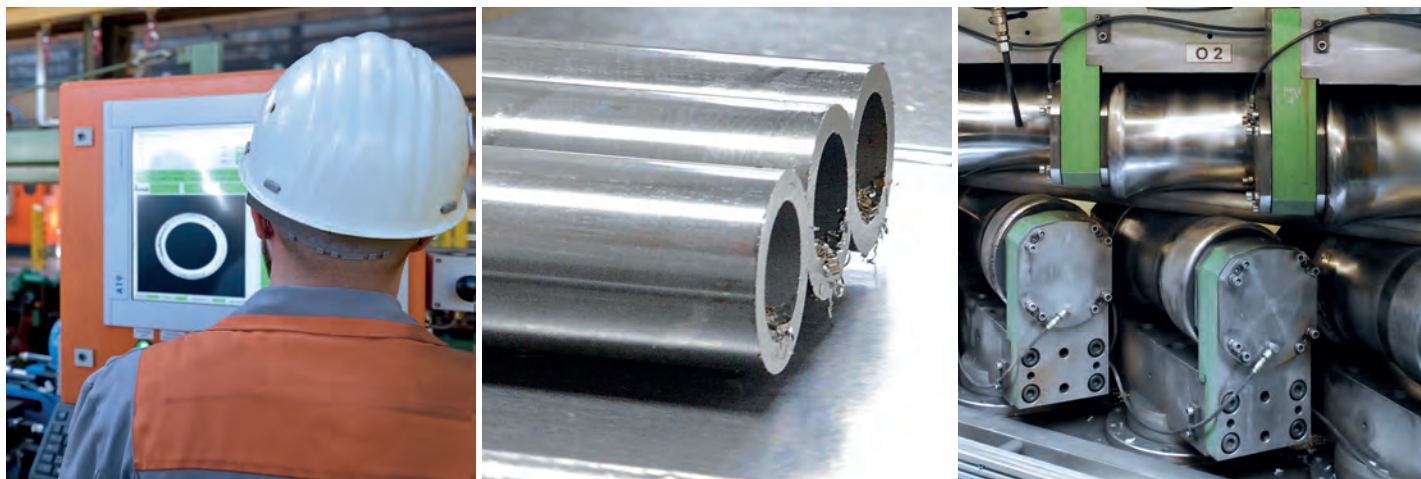


Photo: kimtaro2008, www.fotolia.com

General information of hydraulic and pneumatic tubes



Non-destructive testing

It is possible to agree examinations which go beyond the usual requirements of the common standards and meet the specific requirements for cylinder construction:

	Testing for...	Test category
Ultrasonic testing	Longitudinal imperfections	Min. U3B
	Transverse imperfections	
Eddy current testing	Leak-tightness	Min. E3 or E3H
	Longitudinal imperfections	

Other non-destructive examinations on request

Table 9: Permissible deviations for exact lengths

Length mm	Deviations mm
≤ 2,000	+3/0
> 2,000 ≤ 5,000	+5/0
> 5,000 ≤ 8,000	+10/0
> 8,000	Subject to agreement

Lengths

The tubes are available in different types of lengths:

- Mill length: A length of at least 3 m. Standard mill lengths are 5 – 7 m. The difference in length among the individual tubes in a batch must not exceed 2 m.
- Fixed length: A defined length with permissible deviations of ± 500 mm. Up to 10 % of the order volume may be supplied in shorter lengths ≥ 2 m. These must be packaged separately.
- Exact length or combined length: A defined length with permissible deviations as shown in Table 9.

Straightness

Tubes for hydraulic and pneumatic applications are specially straightened with regard to their subsequent machining. The maximum permissible out-of-straightness is 1/1,000 mm for tubes in outside diameters < 270 mm; for outside diameters ≥ 270 mm, it is subject to special agreement. Straightness measurements are carried out on 1-meter tube sections. The deviation is measured between the tube outside surface and a straight line (cord) between the end points. Higher requirements on tube straightness must be specially agreed upon.



Tube ends

The tubes are delivered with square cut ends free from excessive burrs. Special tube end machining can be agreed upon. Tube ends can be protected with plastic plugs or caps.

Marking

(Except for tubes in accordance with EN 10216) Continuous full-length marking is applied to all tubes. The marking includes:

- manufacturer's mark
- tube type
- dimension
- delivery standard
- steel grade
- delivery condition
- batch number
- additional information
- country of origin

Corrosion protection

Internal and external corrosion protection with inhibitor containing mineral oil group O. Alternatively, phosphated or phosphated and oiled.

Packaging

Tubes are delivered in steel-strapped bundles as standard. Packaging in corrugated cardboard, foil or boxes is available on request.

Inspection certificates

Tubes for hydraulic and pneumatic applications are supplied with an inspection certificate 3.1 according to EN 10204 as standard. An inspection certificate 3.2 or a test report 2.2 is available on request.

Marking example:

MPT-BR HPZ 110 x 90 EN 10305-1 E355 +SR 3484711 Made in Germany

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