



# **HPL Tubes**

**Seamless Precision Steel Tubes  
for Hydraulic and Pneumatic Pressure Lines**

Trading and Industry Division  
November 2006

### What to expect

1. Current Norms and Standards
2. MHP Product Range
3. Production of HPL Tubes
4. Electroplating

Precision steel tubes for hydraulic and pneumatic pressure lines

## Current Norms and Standards



Tube	Superseded	New Standard	Published
seamless, cold drawn	DIN 2391, Part 1+2	DIN EN 10305-1	02/2003
welded, cold drawn	DIN 2393, Part 1+2	DIN EN 10305-2	02/2003
welded, cold sized	DIN 2394, Part 1+2	DIN EN 10305-3	02/2003
seamless HPL tubes	DIN 2391/C, DIN 2445-2	DIN EN 10305-4	10/2003
square & rect. tubes	DIN 2395, Part 1+2	DIN EN 10305-5	08/2003
welded HPL tubes	previously no standard	DIN EN 10305-6	08/2005

## Current Norms and Standards

**DIN 2391**

**Seamless precision steel tubes**

**DIN 1630**

**Seamless circular tubes of non-alloy steels with very high quality requirements**



**DIN EN 10305-4**

**Seamless cold drawn tubes for hydraulic and pneumatic power systems**

**DIN 2445-2**

**Seamless steel tubes for dynamic loads**

for dynamic loads only, 100 to 500 bar

Load case A: peak-to-peak 120 bar (± 60 bar from equilibrium position)

Load case B: peak-to-peak  $p_s+60$  bar (0 to  $p_s + 60$  bar)

delivery condition NBK (+N)

→ used as basis for dimensioning (see catalog)

## Current Norms and Standards

### DIN 2445-2, Load case A: peak-to-peak 120 bar ( $\pm 60$ bar from equilibrium position)

outside diameter [mm]	wall thickness (nominal size as per DIN 2391-1) permissible system pressure $p_s$					
	100 bar	160 bar	250 bar	315 bar	400 bar	500 bar
4	0,8	1,0	-	-	-	-
6	1,0	1,0	1,0	1,0	1,5	1,5
8	1,0	1,0	1,5	1,5	1,5	2,0
10	1,0	1,0	1,5	1,5	2,0	2,5
12	1,0	1,5	2,0	2,0	2,5	2,5
15	1,5	1,5	2,0	-	-	-
16	1,5	1,5	2,0	2,5	3,0	3,5
18	1,5	2,0	2,5	-	-	-
20	1,5	2,0	2,5	3,0	3,5	4,0
22	1,5	2,0	3,0	-	-	-
25	2,0	2,5	3,0	3,5	4,5	6,0
28	2,0	2,5	3,5	-	-	-
30	2,0	3,0	4,0	5,0	5,0	6,0
35	2,0	3,0	-	-	-	-
38	3,0	4,0	5,0	5,5	7,0	8,0
42	3,0	4,0	-	-	-	-
50	4,0	5,0	6,0	8,0	9,0	10,0

## Current Norms and Standards

### DIN 2445-2, Load case B: peak-to-peak $p_s + 60$ bar (0 to $p_s + 60$ bar)

outside diameter [mm]	wall thickness (nominal size as per DIN 2391-1) permissible system pressure $p_s$					
	100 bar	160 bar	250 bar	315 bar	400 bar	500 bar
4	0,8	1,0	-	-	-	-
6	1,0	1,0	1,0	1,0	1,5	2,0
8	1,0	1,0	1,5	1,5	2,0	2,5
10	1,0	1,0	1,5	2,0	2,5	3,0
12	1,0	1,5	2,0	2,0	2,5	3,5
15	1,5	1,5	2,0	-	-	-
16	1,5	1,5	2,5	3,0	3,5	4,5
18	1,5	2,0	2,5	-	-	-
20	1,5	2,0	3,0	3,5	4,5	5,5
22	1,5	2,0	3,0	-	-	-
25	2,0	2,5	3,5	4,5	5,5	7,0
28	2,0	2,5	4,0	-	-	-
30	2,0	3,0	4,0	5,0	7,0	8,0
35	2,5	3,5	-	-	-	-
38	3,0	4,0	5,0	7,0	8,0	10,0
42	3,0	4,0	-	-	-	-
50	4,0	5,0	7,0	9,0	11,0	13,0

## **DIN EN 10305 Part 4**

1. mandatory information / options
2. delivery condition
3. steel grade: chemical composition, mechanical properties
4. roughness / surface quality und internal soundness
5. length / dimensions and tolerances
6. frequency of testing / inspection documents
7. sampling
8. test methods
9. marking
10. protection and packaging

## **DIN 2413 Part 1**

### **Design of steel pressure pipes**

Design of wall thickness depends on the service conditions the pipes is subjected to;  
It is calculated according to DIN 2413 Part 1 and is divided into three load cases.

- |                |   |
|----------------|---|
| Load case I:   | predominantly static loading for a temperature up to 120 °C |
| Load case II:  | predominantly static loading for a temperature over 120 °C  |
| Load case III: | fatigue loading for a temperature up to 120 °C              |

## HPL Tubes (seamless)

Seamless cold-finished tubes for hydraulic and pneumatic pressure lines.

### General Information

outside diameter:	4 - 80 mm (further dimensions on request)
wall thickness:	0,75 - 12,5 mm
technical standards:	EN 10305-4 (previously DIN 2391 and DIN 1630)
tolerances:	according to table HPL tubes
steel grades:	E235 (St 37.4), E355 (St 52.4)
delivery condition:	+N (NBK)
design of wall thickness:	DIN 2413-1 Load case I, II or III

## Chemical composition

Steel grade	C [%]	Si [%]	Mn [%]	P [%]	S [%]
E235 (St 37.4)	max. 0,17	max. 0,35	0,7	max. 0,025	max. 0,015
E355 (St 52.4 <sup>1)</sup> )	max. 0,22	max. 0,55	1,6	max. 0,025	max. 0,015

<sup>1)</sup> Additions of Nb, Ti and V are permitted at the discretion of the manufacturer.

## Mechanical properties

Steel grade	Delivery condition	R <sub>m</sub> [N/mm <sup>2</sup> ]	R <sub>p0,2</sub> [N/mm <sup>2</sup> ]	A <sub>5</sub> [%]
E235 (St 37.4)	+N (NBK)	340 – 480	min. 235	min. 25
E355 (St 52.4)	+N (NBK)	490 – 630	min. 355	min. 22

## Technical features

### tolerances

outside diameter:	see catalog
wall thickness:	EN 10305-4 (DIN 2391-1)
straightness:	EN 10305-4 (DIN 2391-2)

### surface

Inside surface: EN 10305-4 (DIN 2391)

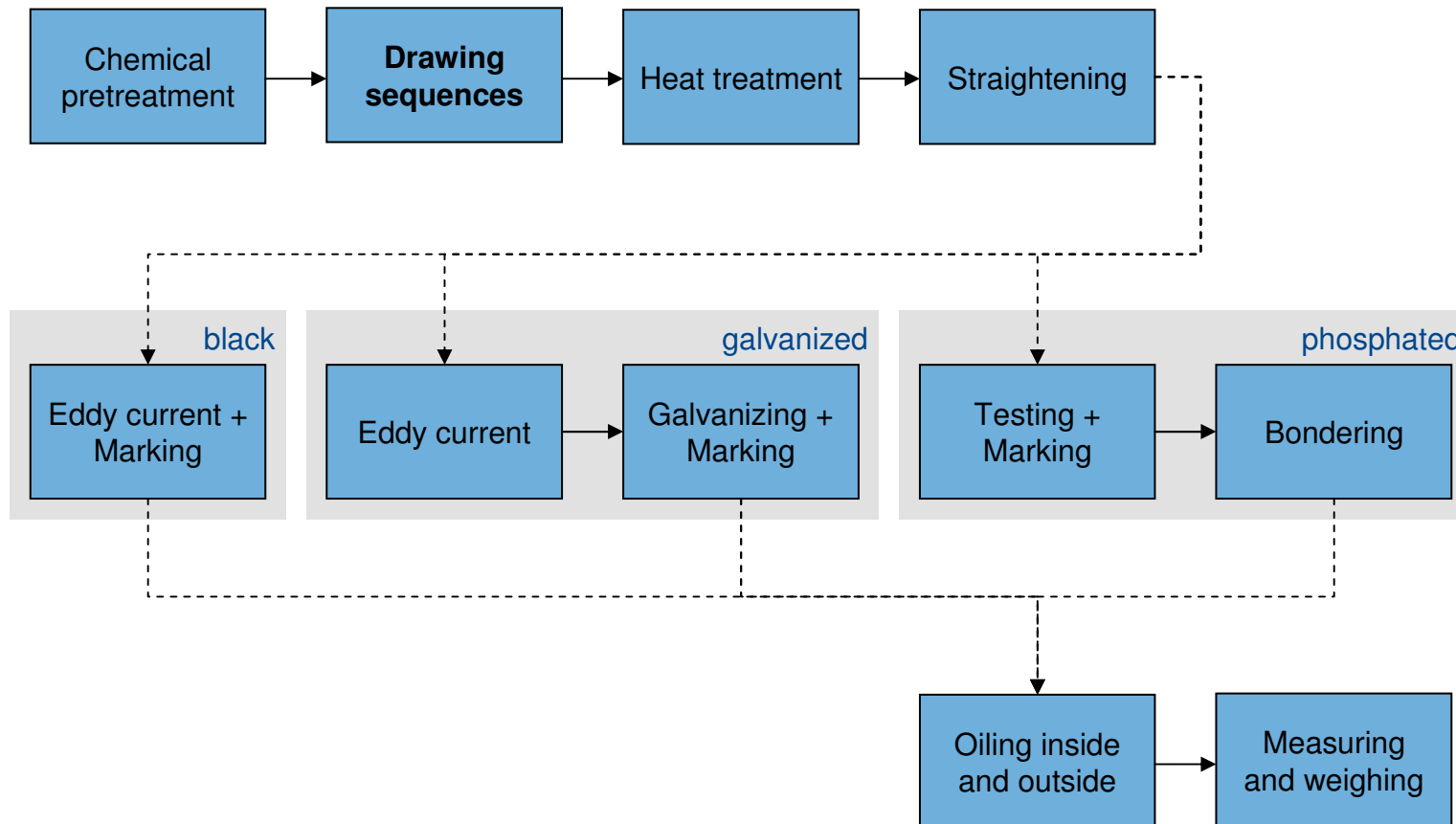
### corrosion protection

inside diameter:	2 mm ≤ 6 mm	group O
	≥ 6 mm	phosphated and oiled
outside diameter:	4 mm - 42 mm	<i>(further dimensions (&gt; 42 mm) on request)</i>
		zinc-plated + blue passivation (Cr-6 free)
		zinc-plated + high-performance passivation (Cr-6 free)
		zinc-plated + yellow chromating
		zinc-plated + olive chromating

### marking

along the entire length of the tube, e.g.: MHP-BR-St37.4-12x1-3148876  
(MHP-BR-EN10305-4-E235-12x1)

## Production of HPL Tubes



## **Electroplating**

**Initially** electroplating was understood as deposit of metals or diluted solutions with direct current (electrolytic metal deposition).

**Today** electroplating contains all electrolytic and chemical procedures to coat metals and/or inorganic and/or organic coatings, including the corresponding processes for the previous and subsequent treatment (cleaning, passivating).

## Electroplating

### Technical terms

#### Galvanizing

Surface coating of steel as a protection against corrosion.

Zinc layers protect the metal (tubes) against red rust.

#### Chromating and Passivation

Conditioning of metal surfaces to generate a protective layer for zinc layer.

The rate of corrosion in this coating is extremely low. Another type of passive corrosion protection is the application of surface coatings that prevent the corrosive medium to penetrate to the subjacent material (zinc layer).

Chromate and passivation layers protect the metal against white rust.

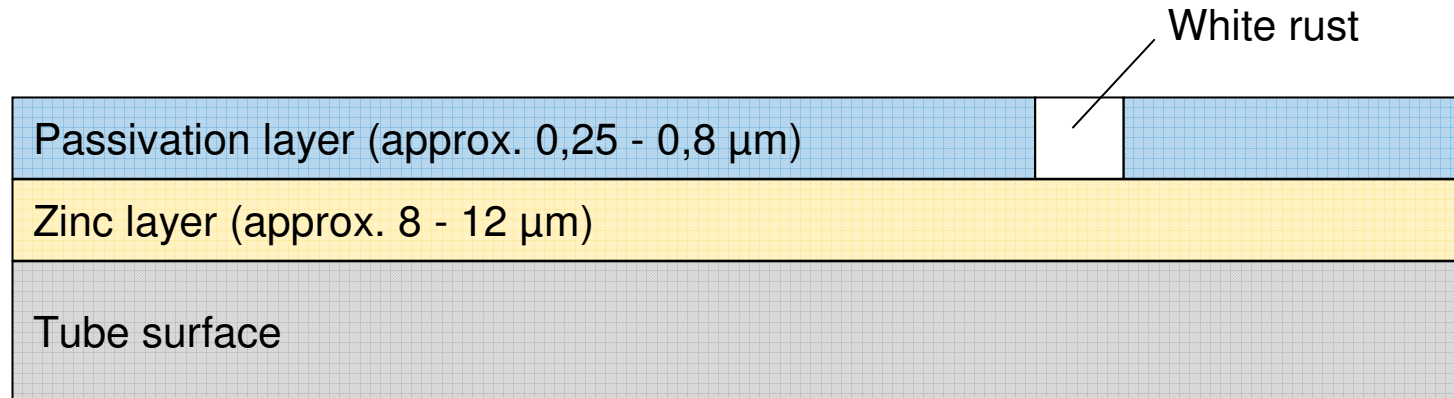
Passivation layers contain trivalent Chrome (Cr-3), whereas chromate layers contain hexavalent Chrome (Cr-6). Passivations are not affected by the End of Life Vehicles Directive (ELV) coming into effect in 2007, and will therefore still be permitted in the future.

**Note:** Cr-6 is 100 times more toxic than Cr-3.

## Electroplating

### White rust

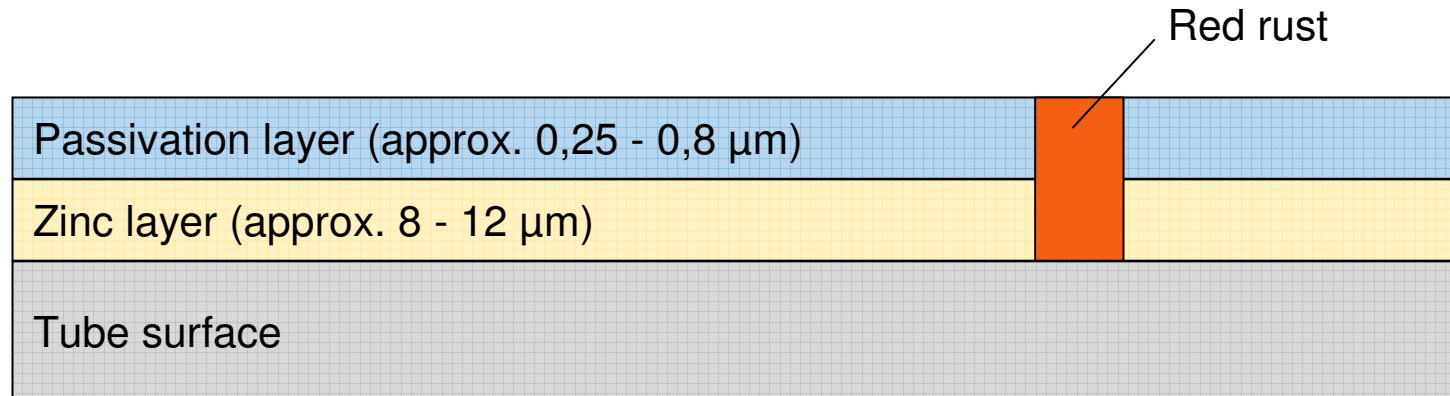
White layer on the zinc surface due to insufficient storing.  
This is no protection against (red) rust.



## Electroplating

### Red rust

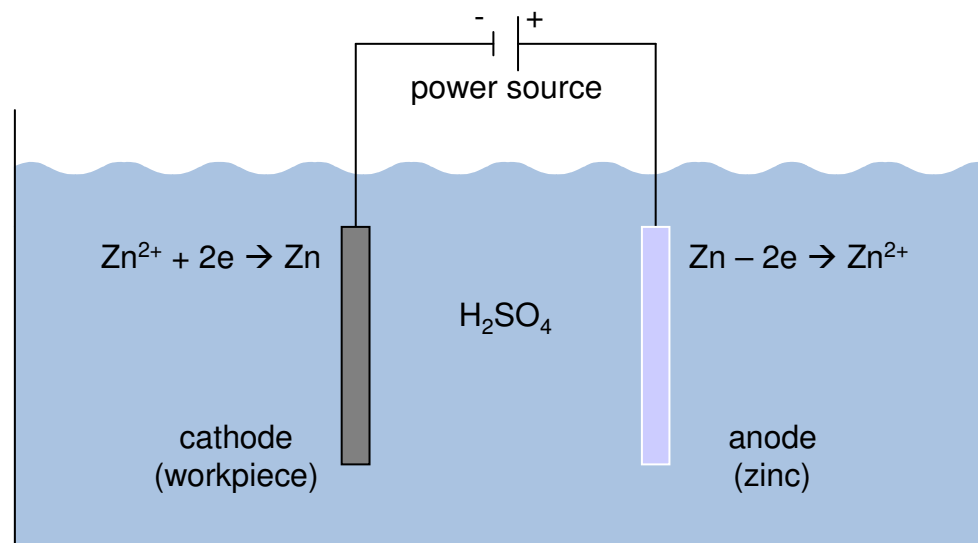
Red rust is caused by atmospheric corrosion and is a product of tube surface and oxygen in the air. Red rust has a brown to red color and a slack appearance.



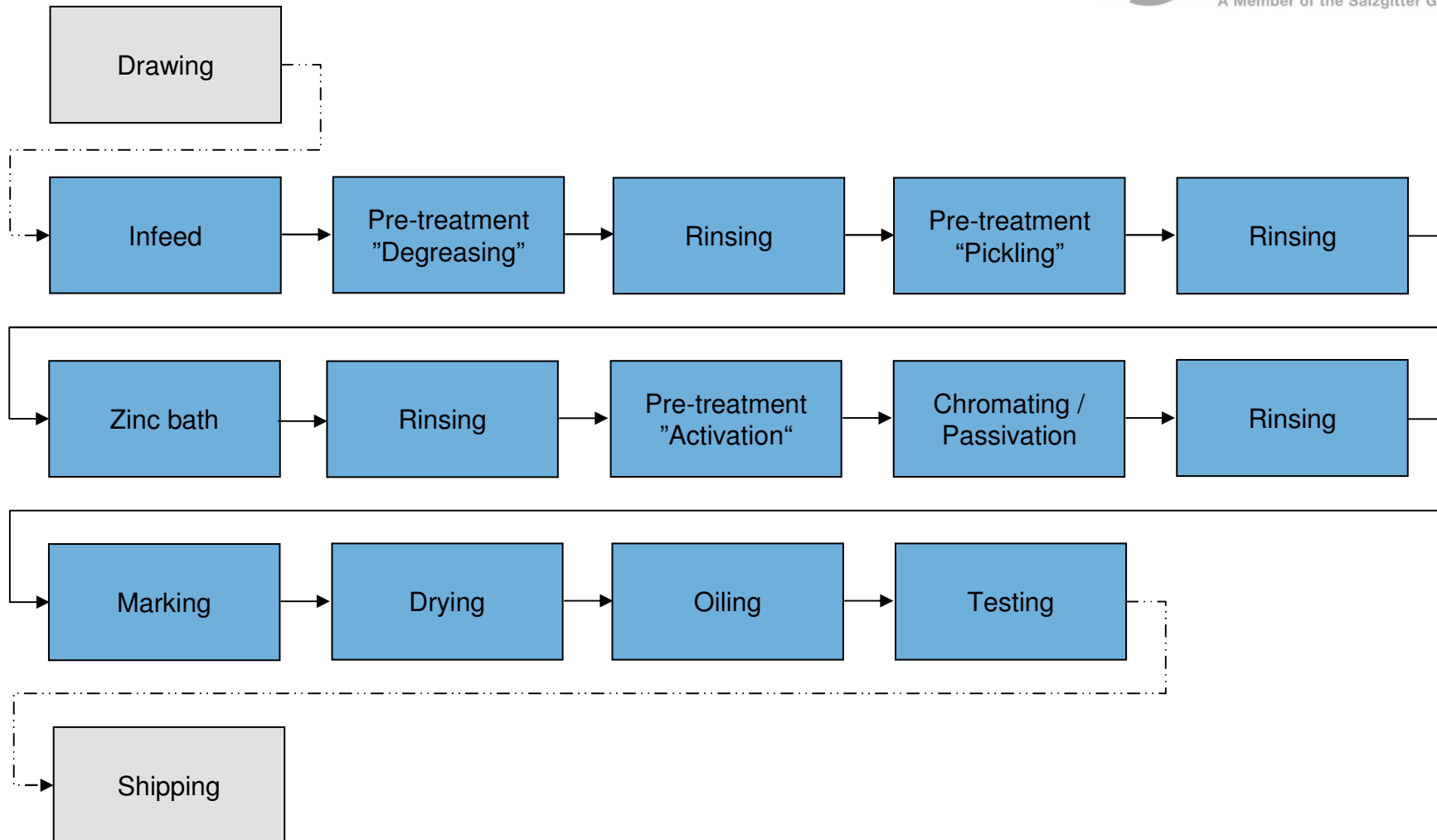
## Electroplating

### Galvanizing

Electroplating for corrosion protection and as an improved surface appearance.



## Process steps of the continuous galvanizing line



## Resistance against white corrosion

### Resistance against white corrosion and Coating thickness

type of chromate / passivation	Cr <sup>6</sup> [µg/cm <sup>2</sup> ]	Salt spray resistance results (MHP)	Minimum resistance (standard) rack / barrel
Blue passivation	< 0,02	> 24h	8h / 16h
High-performance passivation	< 0,02	> 168h	not standardized
Yellow chromating	5 - 20	> 120h	72h / 96h
Olive chromating	10 - 40	> 140h	72h / 120h

Table shows minimum resistance against white rust (comparison between MHP continuous galvanizing line and rack / barrel). Comparison based on DIN 50021 SS Salt spray testing.

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## **Further information**



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