



**TECHNICAL DELIVERY CONDITIONS  
PJSC DNEPROSPETSSTAL**

**Metal products of high-speed and  
alloy tool steel manufactured by  
powder metallurgy methods**

**Registered document number:**

TU DSS 005-2013

(Supersedes TU DSS 005-2003)

**Reasons for revision:**

Expanding of the product range and the need to clarify the requirements for products.

**List of revised supplements:**

- Section 1 – Added with a new range of hot-rolled bars and rods, which are processed on the Landgraf automatic line
- Section 3 – Updated with new steel grades, updated a number of the chemical composition of used steel, delete the reference to DIN 17350.
- Section 4 – Clarified the requirements for deviations from diameter of hot-rolled bars, added with the new dimensions of bars with ground and polished surface, extended size range of rectangular forgings.
- Section 5 – Added with standards for the new steel grades, specified technical requirements for previously mastered metal products
- Sections 6, 7, 10 – Clarified the requirements in connection with the expanding of the size range of steel products and the introduction of references to EN 10308, EN 10228-3.

including amendment letters № 112-1137 dd. 17.05.2013, № 112-1256 dd. 31.05.2013

**APPROVED:**

Deputy Technical Director  
(for Technology)



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The present technical delivery conditions are harmonized with the requirements specified in DIN EN ISO 4957, ASTM A 600, ASTM A 681 and cover technical requirements for metal products of high-speed and alloy tool steel manufactured by powder metallurgy methods and exported by PJSC "Dneprospestal".

The present technical delivery conditions are an integral part of the PJSC "Dneprospestal" contract with customers abroad.

## 1. SCOPE

The present technical delivery conditions cover the following products:

1. Hot-rolled round bars 12-40 mm in diameter with turned or ground surface and bars over 40-89 mm in diameter with turned surface.
2. Forged round bars 74-410 mm in diameter with turned surface.
3. Round bars 3-50 mm in diameter with ground and polished surface.
4. Hot-rolled round bars 20-130 mm in diameter with ground and polished surface processed on the Landgraf automatic line.
5. Forged bars 80-350 mm in square side.
6. Rectangular forgings 30-350x80-610 mm.
7. Extrusion billets 450 mm in diameter.
8. Forged disks 415-750 mm in diameter with turned surface.
9. Powder in capsules 500 mm in diameter.

## 2. MANUFACTURE

Steel shall be produced by powder metallurgy method. Subsequently, the billets are subject to hot deformation on the rolling mills, radial forging machines, presses and rolling mills.

Powder atomising is accomplished by nitrogen blowing. Then capsules filled with powder are subjected to hot gas-pressure extrusion in order to get extrusion billets.

Bars 3-50 mm in diameter are ground and polished by any method of surface layer removal at the manufacturer's option.

Hot-rolled bars 20-130 mm in diameter are ground and polished on the Landgraf automatic line.

## 3. STEEL GRADES

Steel grades and chemical composition conforming to DIN EN ISO, ASTM, and other specifications are shown in Tables 1, 2, 3.

For steel grades shown in Tables 1 and 3 variations in chemical composition in finished product shall not exceed the values specified in Table 4.

In Table 2 permissible deviations from chemical composition of finished product are considered.

**Table 1. Steel grades and chemical composition according to EN и DIN EN ISO 4957**

№	Steel grade			Weight percent by element, %									
	Grade designation	Specification	GOST	C	Mn	Si	P	S	Cr	W	Mo	V	Co
							max						
<b>High-speed steel</b>													
1	HS12-1-4-5-PM (1.3202-PM)	—	P12MΦ4K5-МП	1,30 1,45	max 0,40	max 0,45	0,030	0,030	3,80 4,50	11,50 12,50	0,70 1,00	3,50 4,00	4,50 5,00
2	HS10-4-3-10-PM (1.3207-PM)	DIN EN ISO 4957	P10M4Φ3K10-МП	1,20 1,35	max 0,40	max 0,45	0,030	0,030	3,80 4,50	9,00 10,00	3,20 3,90	3,00 3,50	9,50 10,50
3	S 6-5-2-8-PM (1.3222-PM)	—	P6M5Φ3K8-МП	1,40 1,50	0,20 0,40	0,20 0,40	0,030	0,030	4,00 4,50	6,00 6,70	4,70 5,20	2,20 2,60	7,50 8,50
4	HS6-5-2-5-PM (1.3243-PM)	DIN EN ISO 4957	P6M5K5-МП	0,87 0,95	max 0,40 <sup>1)</sup>	max 0,45	0,030	0,030 <sup>1)</sup>	3,80 4,50	5,90 6,70	4,70 5,20	1,70 2,10	4,50 5,00
5	HS2-9-1-8-PM (1.3247-PM)	DIN EN ISO 4957	P1M10K8-МП	1,05 1,15	max 0,40	max 0,70	0,030	0,030	3,50 4,50	1,20 1,30	9,00 10,00	0,90 1,30	7,50 8,50
6	HS 18-1-2-5-PM (1.3255-PM)	—	P18MΦ2K5-МП	0,75 0,83	max 0,40	max 0,45	0,030	0,030	3,80 4,50	17,50 18,50	0,50 0,80	1,40 1,70	4,50 5,00
7	HS 12-1-4-PM (1.3302-PM)	—	P12MΦ4-МП	1,20 1,35	max 0,40	max 0,45	0,030	0,030	3,80 4,50	11,50 12,50	0,70 1,00	3,50 4,00	max 0,50
8	HS 12-1-2-PM (1.3318-PM)	—	P12MΦ2-МП	0,90 1,00	max 0,40	max 0,45	0,030	0,030	3,80 4,50	11,50 12,50	0,70 1,00	2,30 2,60	max 0,50
9	HS6-5-2C-PM (1.3343-PM)	DIN EN ISO 4957	P6M5-МП	0,86 0,94	max 0,40 <sup>1)</sup>	max 0,45	0,030	0,030 <sup>1)</sup>	3,80 4,50	5,90 6,70	4,70 5,20	1,70 2,10	max 0,50
10	HS6-5-3-PM (1.3344-PM)	DIN EN ISO 4957	P6M5Φ3-МП	1,15 1,25	max 0,40	max 0,45	0,030	0,030	3,80 4,50	5,90 6,70	4,70 5,20	2,70 3,20	max 0,50
11	HS 2-9-1-PM (1.3346-PM)	—	P2M9Φ-МП	0,78 0,86	max 0,40	max 0,45	0,030	0,030	3,50 4,20	1,50 2,00	8,00 9,20	1,00 1,30	max 0,50
12	HS 18-0-1-PM (1.3355-PM)	DIN EN ISO 4957	P18-МП	0,73 0,83	max 0,40	max 0,45	0,030	0,030	3,80 4,50	17,20 18,70	max 1,00	1,00 1,20	max 0,50
<b>Alloy tool steel</b>													
13	X210Cr12-PM (1.2080-PM)	DIN EN ISO 4957	X12-МП	1,90 2,20	0,20 0,60	0,10 0,60	0,030	0,030	11,00 13,00	max 0,20	max 0,30	max 0,15	max 0,50
14	X153CrMoV12-PM (1.2379-PM)	DIN EN ISO 4957	X12MΦ-МП	1,45 1,60	0,20 0,60	0,10 0,60	0,030	0,030	11,00 13,00	max 0,20	0,70 1,00	0,70 1,00	max 0,50

Table 1 (continued)

№	Steel grade			Weight percent by element, %									
	Grade designation	Specification	GOST	C	Mn	Si	P	S	Cr	W	Mo	V	Co
							max						
15	X220CrVMo13-4-PM (1.2380-PM)	—	X12MΦ4-МП	2,10 2,30	0,25 0,40	0,15 0,30	0,030	0,020	12,50 13,50	max 0,20	0,80 1,10	3,70 4,00	max 0,50
16	X60WCrMoV9-4-PM (1.2622-PM)	—	6X4B9MΦ-МП	0,55 0,65	0,20 0,40	0,20 0,40	0,030	0,030	3,70 4,20	8,50 9,50	0,80 1,00	0,60 0,80	max 0,50

**Notes:**

1. For these steel grades weight percent S=0.060-0.150% and Mn ≤0.80% can be stated in the order. In this case the letter “Y” is to be added in hyphen in the end of GOST grade designation.

2. Oxygen content shall be evaluated in the powder.

3. For all steel grades Argon content shall not exceed 0.05 ppm (0.000005%), Titanium— 0,03%, Aluminium— 0,035%, Nickel— 0,40%, Copper—0,30%.

4. For high-speed steel (items 1-12) nitrogen content shall not exceed 0.08% and for alloy tool steel (items 13-16) nitrogen content shall not exceed 0.15%.

5. For high-speed steel (items 1-12) oxygen content shall not exceed 0.015% and for alloy tool steel (items 16-20) oxygen content shall not exceed 0.020%. In controversial cases (when there are disagreements between manufacturer and buyer) oxygen content shall be evaluated in the finished product at a distance 1/6 of diameter or thickness counting from the bar surface.

**Table 2. Steel grades and chemical composition according to ASTM**

№	Steel grade			Weight percent by element, %									
	Grade designation	Specification	GOST	C	Mn	Si	P	S <sup>1)</sup>	Cr	W	Mo	V	Co
							max						
<b>High-speed steel</b>													
1	M2-PM regular C	ASTM A 600	P6M5-МП1	0,78 0,88	0,15 0,40	0,20 0,45	0,030	0,030	3,75 4,50	5,50 6,75	4,50 5,50	1,75 2,20	max 0,50
2	M2-PM high C	ASTM A 600	P6M5-МП2	0,95 1,05	0,15 0,40	0,20 0,45	0,030	0,030	3,75 4,50	5,50 6,75	4,50 5,50	1,75 2,20	max 0,50
3	M3-PM class 1	ASTM A 600	P6M5Φ3-МП1	1,00 1,10	0,15 0,40	0,20 0,45	0,030	0,030	3,75 4,50	5,00 6,75	4,75 6,50	2,25 2,75	max 0,50
4	M3-PM class 2	ASTM A 600	P6M5Φ3-МП2	1,15 1,25	0,15 0,40	0,20 0,45	0,030	0,030	3,75 4,50	5,00 6,75	4,75 6,50	2,75 3,25	max 0,50
5	M4-PM	ASTM A 600	P6M5Φ4-МП	1,25 1,40	0,15 0,40	0,20 0,45	0,030	0,030	3,75 4,75	5,25 6,50	4,25 5,50	3,75 4,50	max 0,50
6	M7-PM	ASTM A 600	P2M9Φ2-МП	0,97 1,05	0,15 0,40	0,20 0,55	0,030	0,030	3,50 4,00	1,40 2,10	8,20 9,20	1,75 2,25	max 0,50

Table 2 (continued)

№	Steel grade			Weight percent by element, %									
	Grade designation	Specification	GOST	C	Mn	Si	P	S <sup>1)</sup>	Cr	W	Mo	V	Co
							max						
7	M42-PM	ASTM A 600	P2M10ΦK8-МП	1,05 1,15	0,15 0,40	0,15 0,65	0,030	0,030	3,50 4,25	1,15 1,85	9,00 10,00	0,95 1,35	7,75 8,75
8	M48-PM	ASTM A 600	P10M5Φ3K9-МП	1,42 1,52	0,15 0,40	0,15 0,40	0,030	0,030	3,50 4,00	9,50 10,50	4,75 5,50	2,75 3,25	8,00 10,00
9	M50-PM	ASTM A 600	P0M4ΦC-МП	0,78 0,88	0,15 0,45	0,20 0,60	0,030	0,030	3,75 4,50	max 0,30	3,90 4,75	0,80 1,25	max 0,50
10	M61-PM	AISI	P12M6Φ5-МП	1,75 1,85	0,25 0,50	0,20 0,45	0,030	0,050 0,090	3,50 4,25	12,00 13,00	6,00 6,75	4,50 5,25	max 1,00
11	T15-PM	ASTM A 600	P12MΦ5K5-МП	1,50 1,60	0,15 0,40	0,15 0,40	0,030	0,030	3,75 5,00	11,75 13,00	max 1,00	4,50 5,25	4,75 5,25
<b>Alloy tool steel</b>													
12	A11-PM	AISI	P0M1CΦ10-МП	2,40 2,50	0,35 0,60	0,75 1,10	0,030	0,050 0,090	4,75 5,50	max 0,50	1,10 1,50	9,25 10,25	max 0,50
13	D2-PM	ASTM A 681	X12MΦ-МП	1,40 1,60	0,10 0,60	0,10 0,60	0,030	0,030	11,00 13,00	max 0,20	0,70 1,20	0,50 1,10	max 0,50
14	D3-PM	ASTM A 681	X12-МП	2,00 2,35	0,10 0,60	0,10 0,60	0,030	0,030	11,00 13,50	max 1,00	max 0,30	max 1,00	max 0,50
15	D7-PM	ASTM A 681	X12MΦ4-МП	2,15 2,50	0,10 0,60	0,10 0,60	0,030	0,030	11,50 13,50	max 0,20	0,70 1,20	3,80 4,40	max 0,50
16	H43-PM	ASTM A 681	6X4M8Φ2-МП	0,50 0,65	0,15 0,40	0,20 0,45	0,030	0,030	3,75 4,50	max 0,30	7,75 8,50	1,80 2,20	max 0,50

**Notes:**

1. On agreement between sides stated in the specification, all steel grades can be produced with sulphur content 0,060-0,150%. In this case the letter «Y» is to be added in hyphen in the end of GOST grade designation.0
2. Oxygen content shall be evaluated in the powder.
3. For all steel grades argon content shall not exceed 0,05 ppm (0,000005%), titanium content shall be max 0,03%, aluminium content shall not exceed 0,035%, total amount of nickel and copper shall be max 0,75%.
4. For high-speed steel (items 1-11) weight percent by nitrogen shall not exceed 0,08%, and for alloy tool steel (items 12-16) — 0,15%.
5. For high-speed steel (items 1-11) weight percent by oxygen shall not exceed 0,015%, and for alloy tool steel (items 12-16) — max 0,020%. In controversial cases (when there are disagreements between manufacturer and buyer) oxygen content shall be evaluated in the finished product at a distance 1/6 of diameter or thickness counting from the bar surface.

**Table 3. Steel grade and chemical composition according to innovator's standards**

№	Steel grade			Weight percent by element, %									
	Grade designation	innovator <sup>1)</sup>	GOST	C	Mn	Si	P	S	Cr	W	Mo	V	Co
							max						
<b>High-speed steel</b>													
1	S390-PM	Böhler	P10M2Φ5K8-МП	1,55 1,65	0,20 0,40	0,20 0,40	0,030	0,030	4,50 5,10	10,00 10,80	1,80 2,20	4,60 5,00	7,70 8,30
2	S590-PM	Böhler	P6M5Φ3K8-МП	1,25 1,35	0,20 0,40	0,50 0,70	0,030	0,030	3,90 4,50	5,90 6,70	4,75 5,25	2,75 3,25	8,10 8,70
3	S690-PM	Böhler	P6M5Φ4-МП	1,30 1,40	0,20 0,40	0,20 0,40	0,030	0,030	3,80 4,40	5,50 6,30	4,70 5,30	3,90 4,30	max 0,50
4	S790-PM	Böhler	P6M5Φ3-МП	1,25 1,35	0,20 0,40	0,30 0,70	0,030	0,030	3,90 4,50	5,90 6,70	4,70 5,30	2,75 3,25	max 0,50
5	CPM REX45	Crucible	P6M5Φ3K8-МП	1,25 1,35	0,20 0,40	0,45 0,65	0,030	0,050 0,070	3,75 4,35	6,00 6,50	4,75 5,25	2,80 3,30	7,70 8,30
6	ASP 2005	Erasteel	P3M3Φ4-МП	1,45 1,55	max 0,40	max 0,45	0,030	0,030	3,80 4,20	2,35 2,65	2,35 2,65	3,80 4,20	max 0,50
7	ASP 2023	Erasteel	P6M5Φ3-МП	1,20 1,35	max 0,40	max 0,45	0,030	0,030	3,80 4,40	6,00 6,80	4,75 5,25	2,85 3,30	max 0,50
8	ASP 2030	Erasteel	P6M5Φ3K8-МП	1,20 1,35	max 0,40	max 0,45	0,030	0,030	3,80 4,40	6,00 6,80	4,75 5,25	2,85 3,30	8,20 8,80
9	ASP 2053	Erasteel	P4M3Φ8-МП	2,35 2,65	max 0,40	max 0,45	0,030	0,030	4,00 4,40	4,00 4,40	2,90 3,30	7,70 8,30	max 0,50
10	ASP 2060	Erasteel	P6M7Φ6K10-МП	2,15 2,45	max 0,40	max 0,45	0,030	0,030	4,00 4,40	6,20 6,80	6,70 7,30	6,20 6,80	10,20 10,80
<b>Alloy tool steel</b>													
11	K190-PM	Böhler	X12MΦ4-МП	2,20 2,40	0,20 0,40	0,50 0,70	0,030	0,020	12,00 13,00	max 0,50	0,95 1,20	3,80 4,20	max 0,50
12	K340-PM	Böhler	110X8M2ΦC-МП	1,00 1,20	0,30 0,50	0,70 1,10	0,030	0,030	8,00 8,60	max 0,50	1,90 2,30	0,35 0,65	max 0,50
13	VANADIS 4-PM	Böhler	150X8M2Φ4C-МП	1,45 1,55	0,30 0,50	0,90 1,10	0,030	0,030	7,50 8,50	max 0,50	1,40 1,60	3,80 4,20	max 0,50
14	CRU-WEAR	Crucible	110X8BM2Φ2C-МП	1,00 1,20	0,25 0,45	1,00 1,20	0,030	0,030	7,30 7,70	1,00 1,30	1,45 1,75	2,20 2,60	max 0,50
15	CPM 3V	Crucible	8X8MΦ3-МП	0,75 0,85	0,30 0,60	0,30 0,60	0,030	0,030	7,25 7,75	max 0,50	1,20 1,40	2,50 3,00	max 0,50

Table 3 (continued)

№	Steel grade			Weight percent by element, %									
	Grade designation	innovator <sup>1)</sup>	GOST	C	Mn	Si	P	S	Cr	W	Mo	V	Co
							max						
16	CPM 9V	Crucible	P0M2CΦ9-МП	1,75	0,35	0,75	0,030	0,030	5,00	max	1,10	8,70	max
				1,85	0,65	1,10			5,50	0,50	1,50	9,30	0,50
17	CPM 10V	Crucible	P0M2CΦ10-МП	2,35	0,35	0,75	0,030	0,050	5,00	max	1,10	9,25	max
				2,55	0,65	1,10			5,50	0,50	1,50	10,25	0,50
18	PMD 440	—	X18MΦ6-МП	2,10	0,30	0,30	0,030	0,030	17,00	max	0,40	5,50	max
				2,30	0,60	0,60			18,00	0,30	0,60	6,00	0,50
19	PMD 550	—	X17M2Φ3K2-МП	2,50	0,30	0,30	0,030	0,030	16,50	max	1,70	3,10	1,70
				2,70	0,60	0,60			17,50	0,30	2,00	3,50	2,40

**Notes:**

1. Producing of these steel grades is possible only with written permission of an innovator and a know-how owner.
2. Oxygen content shall be evaluated in the powder.
3. Argon content shall not exceed 0.05 ppm (0.000005%), titanium - 0.03%, aluminium - 0.035%, total amount of nickel and copper shall be max 0.75%.
4. For high-speed steel (items 1-10) oxygen content shall not exceed 0.015% and for alloy tool steel (item 11-19) oxygen content shall not exceed 0.020%. In controversial cases (when there are disagreements between manufacturer and buyer) oxygen content shall be evaluated in the finished product at a distance 1/6 of diameter or thickness counting from the bar surface.
5. For high-speed steel (items 1-10) nitrogen content shall not exceed 0.08% and alloy tool steel (items 11-19) nitrogen content shall not exceed 0.15%.

**Table 4. Maximum permissible deviations from chemical composition in finished products for steel with chemical composition acc. to tables 1, 3**

Element	Weight percent by element, % (heat analysis)	Permissible deviation from chemical composition, %
C	≤ 1,25	± 0,03
	> 1,25 ≤ 1,60	± 0,04
	> 1,60	± 0,05
Mn	≤ 0,65	± 0,04
Si	≤ 1,20	± 0,03
P	≤ 0,030	+ 0,005
S	≤ 0,030	+ 0,005
	0,050-0,150	± 0,005
Cr	≤ 10,00	± 0,10
	> 10,00	± 0,15
W	≤ 2,00	± 0,07
	> 2,00 ≤ 10,00	± 0,10
	> 10,00 ≤ 18,70	± 0,20
Mo	≤ 1,10	± 0,05
	> 1,10	± 0,10
V	≤ 1,00	± 0,04
	> 1,00 ≤ 1,40	± 0,05
	> 1,40 ≤ 2,10	± 0,07
	> 2,10	± 0,10
Co	≤ 8,80	± 0,10
	> 8,80	± 0,15

#### 4. Product range

##### 4.1 Hot-rolled round bars 12-40 mm in diameter with turned or ground surface and bars over 40-89 mm in diameter with turned surface.

Bar diameter, utmost deviations from diameter shall conform to the requirements stated in Table 5.

**Table 5. Diameter and utmost deviations from diameter for hot-rolled**

Diameter, mm	Utmost deviations from diameter, mm	
	lot 1	lot 2
12,00 - 15,24	±0,18	+0,36/-0,00
over 15,24 to 20,00	±0,20	+0,40/-0,00
over 20,00 to 49,00	±0,30	+0,60/-0,00
over 49,00 to 59,00	±0,40	+0,80/-0,00
over 59,00 to 80,00	±0,50	+1,00/-0,00
over 80,00 to 89,00	±0,65	+1,30/-0,00

**Notes:**

1. Lot number shall be stated in the specification.

Out-of-round shall not exceed 50% of the total deviations from diameter.

Straightness deviations shall not exceed 2.5 mm per 1 m of bar length. Overall bow shall be max 0.2% of the length.

Bar ends shall be straight cut without burrs and centre holes.

Inclination from the straight cut is to be max 0.1 of bar diameter.

Bars shall be 3000-4000 mm in length with utmost deviations from the length ± 100 mm. Other lengths can be agreed in the specification.



#### 4.2 Forged round bars 74-410 mm in diameter with turned surface

Bar diameter, utmost deviations from diameter shall conform to the requirements stated in Table 6.

**Table 6. Bar diameter and utmost deviations from diameter for forged bars**

Diameter, mm	Utmost deviations from diameter, mm	
	lot 1	lot 2
74,00 - 79,00	±0,50	+1,00/-0,00
over 79,00 to 97,00	±0,60	+1,20/-0,00
over 97,00 to 115,00	±0,70	+1,40/-0,00
over 115,00 to 155,00	±0,90	+1,80/-0,00
over 155,00 to 200,00	±1,00	+2,00/-0,00
over 200,00 to 300,00	±1,50	+3,00/-0,00
over 300,00 to 350,00	±1,75	+3,50/-0,00
over 350,00 to 410,00	±2,00	+4,00/-0,00

**Notes:**

1. Lot number is to be stated in the specification.
2. Actual lengths are allowed to agree in the specification.

Out-of-round shall not exceed the total utmost deviations from diameter.

Straightness deviations of the bars shall be 2,0 mm per 1 m of length. The overall bow shall not exceed 0,2% of length.

Bar ends shall be straight cut. Burrs and center holes are not allowed.

Inclination from the straight cut shall not exceed 0,1 of bar diameter.

Bars shall be 1100-4000 mm in length with utmost deviations from the length ±100 mm. Other lengths can be agreed in the specification.

#### 4.3 Round bars 3-50 mm in diameter with ground and polished surface

Bar diameter, utmost deviations from diameter as well as bar length and utmost deviations from length shall conform to the requirements stated in Table 7.

**Table 7. Sizes of bars with ground and polished surface and its utmost deviations**

Diameter, mm	Utmost deviations from diameter, mm				Length, mm	Utmost deviations from length, mm
	h9	h10	h11	h12		
3,00	-0,025	-0,040	-0,060	—	1500-2000	+50/-0
over 3,00 to 5,00	-0,030	-0,048	-0,075	-0,120	1500-2500	+50/-0
over 5,00 to 6,00	-0,030	-0,048	-0,075	-0,120	2000-3200	+50/-0
over 6,00 to 7,50	-0,036	-0,058	-0,090	-0,150	2000-3200	+50/-0
over 7,50 to 10,00	-0,036	-0,058	-0,090	-0,150	2000-4000	+50/-0
over 10,00 to 13,00	-0,043	-0,070	-0,110	-0,180	2000-4000	+50/-0
over 13,00 to 15,00	-0,043	-0,070	-0,110	-0,180	2500-6000	+50/-0
over 15,00 to 18,00	—	-0,070	-0,110	-0,180	2500-6000	+50/-0
over 18,00 to 30,00	—	-0,084	-0,130	-0,210	2500-6000	+50/-0
over 30,00 to 34,00	—	-0,100	-0,160	-0,250	2500-6000	+50/-0
over 34,00 to 50,00	—	—	-0,160	-0,250	2500-6000	+50/-0

**Notes:**

1. On agreement between sides stated in the specification, bars shall be produced with plus tolerances on diameter equal in modulus to minus tolerances shown in Table 7. In this case, size tolerances h9, h10, h11, h12 are given instead of k9, k10, k11, k12.
2. Actual lengths can be negotiated in the specification.

For bars 3,00-15,00 mm in diameter (size tolerance h9 (k9)) with ground and polished surface, bars over 15,00-34,00 mm in diameter (size tolerance h10 (k10)) and bars over 34,00-50,00 mm in diameter (size tolerance h11 (k11)) it is permitted to deliver 10% of each item with size tolerance h10 (k10), h11 (k11) и h12 (k12) correspondingly separately bundled. Bundle tags shall contain additional marking in a form of a round 4-5 mm in diameter in the right top corner.

Out-of round shall not exceed one half of the utmost deviations from diameter.

Straightness deviations of the bars up to 30 mm (incl.) in diameter shall not exceed 0,5 mm per 1 m of length; for bars over 30 mm in diameter straightness deviation shall be 1,0 mm per 1 meter of length.

Bar ends shall be straight cut. Burrs and center holes are not allowed. Inclination from the straight cut shall not exceed 0,1 of bar diameter.

#### 4.4 Hot-rolled round and forged bars with ground and polished surface 20-130 mm in diameter, processed on the "Landgraf" automatic line

Bar diameter and its utmost deviations shall conform to the requirements stated in Tables 8, 8A.

**Table 8. Diameter and its utmost deviations for bars 20-70 mm in diameter, processed on the "Landgraf" automatic line**

Diameter, mm	Utmost deviations from diameter for size tolerances, mm					
	h9	k9	h10	k10	h11	k11
20,00 - 30,00	-0,052	+0,052	-0,084	+0,084	-0,130	+0,130
over 30,00 to 50,00	-0,062	+0,062	-0,100	+0,100	-0,160	+0,160
over 50,00 to 70,00	-0,074	+0,074	-0,120	+0,120	-0,190	+0,190

**Notes:**

1. Required size tolerances shall be stated in the specification.
2. For bars with size tolerance h9 (k9) и h10 (k10) it is permitted to deliver 10% of each item with size tolerance h10 (k10) и h11 (k11) correspondingly, separately bundled. In this case, bundle tags shall contain additional marking in form of a round 4-5 mm in the right top corner.

Out-of -round shall not exceed one half of the utmost deviations from diameter.

**Таблица 8А. Diameter and its utmost deviations for bars over 70 mm to 130 mm with ground and polished surface, processed on the "Landgraf" automatic line**

Diameter, mm	Utmost deviations from diameter for size tolerances, mm					
	h11	k11	h12	k12	h13	k13
over 70,00 to 80,00	-0,190	+0,190	-0,300	+0,300	-0,460	+0,460
over 80,00 to 120,00	-0,220	+0,220	-0,350	+0,350	-0,540	+0,540
over 120,00 to 130,00	-0,250	+0,250	-0,400	+0,400	-0,630	+0,630

**Notes:**

1. Required size tolerances shall be stated in the specification.
2. On agreement between sides stated in the specification, for bars with size tolerance h11 (k11) it is permitted to deliver 10% of each item with size tolerance h12 (k12) correspondingly, separately bundled. In this case, bundle tags shall contain additional marking in form of a round 4-5 mm in the right top corner.

Straightness deviations of the bars up to 30 mm (incl.) in diameter shall not exceed 0,5 mm per 1 m of length; for bars over 30 mm to 70 mm in diameter straightness deviation shall be 1,0 mm per 1 meter of length, for bars over 70 mm in diameter straightness deviation shall be 1,5 mm per 1 meter of length.

Bar ends shall be straight cut or turned. Inclination from the straight cut shall not exceed 0,1 of bar diameter.

One end of the bars up to 70 mm in diameter shall be chamfered 2-4 mm in width. Both bar ends chamfered 2-4 mm in width are allowed.

Bars shall be 3000-6000 mm with utmost deviations from the length  $+50 / -0$  mm. Actual lengths are to be stated in the specification.

#### 4.5 Forged bars 80-350 mm in square side

Square bar sizes and their utmost deviations shall conform to the requirements shown in Table 9.

**Table 9. Forged square bar sizes and utmost deviations from its sizes**

Square side, mm	Utmost deviations from square side, mm
80,0-85,0	+3,0/-0,0 (+3,0/-0,0)
over 85,0 to 105,0	+3,5/-0,0 (+3,5/-0,0)
over 105,0 to 115,0	+4,0/-0,0 (+4,0/-0,0)
over 115,0 to 145,0	+4,5/-0,0 (+4,0/-0,0)
over 145,0 to 150,0	+5,0/-0,0 (+5,0/-0,0)
over 150,0 to 180,0	+7,0/-0,0 (+5,0/-0,0)
over 180,0 to 200,0	+8,0/-0,0 (+5,0/-0,0)
over 200,0 to 350,0	+10,0/-0,0 (+5,0/-0,0)

**Notes:**

1. For planed or milled bars utmost deviations are indicated in brackets; for bars with grinding of the surface utmost deviations are indicated without brackets.

The difference between the diagonals at the same section shall not exceed 5% of the square side.

Bars are delivered with sharp edges. Edge chamfering not exceeding 3% of square side is allowed.

For planed or milled bars straightness deviations shall not exceed 2,5 mm per 1 m of length; for bars with complete or spot grinding of surface straightness deviations shall not exceed 5,0 mm per 1 m of length. Overall bow shall not exceed the permissible straightness deviation value multiplied by total length value in meters.

On agreement between sides stated in the specification, chamfering of longitudinal edges for bars up to 200 mm in square side is to be 8-15 mm in width; for bars over 200 mm in square side it shall be 10-20 mm in width.

Bar ends shall be straight cut. Inclination from the cut shall not exceed 0.1 of square side. Burrs and bent ends are not allowed.

Bars shall be 1100-4000 mm with utmost deviations from the length  $\pm 100$  mm. Actual lengths are to be stated in the specification.

#### 4.6 Rectangular forgings 30-350x80-610mm

Sizes of rectangular forgings and utmost deviations from its sizes shall conform to the values shown in Table 10.

The difference between the diagonals at the same section shall not exceed the sum of utmost deviations from the width.

Convexity or concavity of narrow sides is permitted. Convexity shall not exceed utmost deviations from the width and concavity shall not reduce section under the limits of nominal size. Forgings are delivered with sharp edges. Edge chamfering not exceeding 0.030 of the thickness is permitted.

**Table 10. Sizes of rectangular forgings and utmost deviations from its sizes**

Thickness, mm	Width, mm	Utmost deviations, mm		
		From thickness	From width	
a) for forgings delivered after spot grinding				
30-50 51-79 80-150	80-200 80-300 80-350	+3,0/-0,0 +4,5/-0,0 +5,0/-0,0	Width, mm	Utmost deviations, mm
			80-119	+4,0/-0,0
			120-179	+5,0/-0,0
			180-214	+7,0/-0,0
			215-249	+8,0/-0,0
			250-284	+9,0/-0,0
			285-344	+10,0/-0,0
			345-350	+12,0/-0,0
б) for planed or milled forgings delivered after complete surface conditioning				
80-100	300	+5,0/-0,0 (+5,0/-0,0)	+10,0/-0,0 (+5,0/-0,0)	
over 100 to 250	over 300 to 500	+7,0/-0,0 (+5,0/-0,0)	+15,0/-0,0 (+10,0/-0,0)	
over 250 to 350	over 500 to 610	+10,0/-0,0 (+5,0/-0,0)	+15,0/-0,0 (+10,0/-0,0)	

**Notes:**

1. Maximal cross section area of delivered forgings shall be 1520 cm<sup>2</sup>.
2. For planed or milled forgings utmost deviations are indicated in brackets, for forgings after complete grinding of surface imperfections, utmost deviations are given without brackets.

On agreement between sides stated in the specification, chamfering of longitudinal edges for bars up to 200 mm in square side is to be 8-15 mm in width; for bars over 200 mm in square side it shall be 10-20 mm in width.

Non-flatness and convexity of forgings after spot grinding of surface imperfections or forgings after complete surface conditioning shall be max 0,4% of the length; and for planed or milled flats it shall be max 0,2% of the length.

Bar ends shall be straight cut and deburred. Inclination from the cut shall not exceed 0.1 of thickness.

Rectangular forgings shall be 1000-4000 mm in length with utmost deviations from the length  $\pm 100$  mm. Actual lengths shall be stated in the specification.

**4.7 Round extrusion billets 450 mm in diameter**

Extrusion billets 450 mm in diameter and 1500 mm in length.

Utmost deviations from the diameter shall not exceed  $\pm 20,0$  mm; utmost deviations from the length shall not exceed  $\pm 100$  mm. Extrusion billet weight shall be (1900 $\pm$ 200) kg.

Out-of-round is not checked on extrusion billets.

Ends are not cut before the delivery of extrusion billets.

**4.8 Forged disks 415-745 mm in diameter with turned surface**

Disks sizes and its utmost deviations shall conform to the requirements stated in Table 11.

**Table 11. Forged disks sizes and its utmost deviations**

Diameter, mm	Utmost deviations from diameter, mm	Disk length, mm	Utmost deviations from the length, mm
415-745	+6,0/-0,0	$\geq 400$	$\pm 10$

**Notes:**

1. Forgings are considered to be disks when the following relationship is true  $\frac{D}{L} \geq 1,0$ , where  
D — diameter (mm), L — length (mm).
2. Actual lengths and diameters are stated in the specification.
3. Other sizes for disks can be additionally negotiated in the specification.

Out-of-round shall not exceed the sum of utmost deviations from diameter.

Disk edges shall be processed on lathe or cut on cutting machine at the customer's option. Inclination from the cut shall not exceed 10 mm.

#### 4.9 Powder in capsules 500 mm in diameter

Powder particles shall be spherical. Maximal particle size shall be 800 mkm.

Powder shall be in metal capsules with welded covers.

Capsules are (500±10) mm in diameter, (1710±20) mm in length, (1900±200) kg in weight.

### 5 TECHNICAL REQUIREMENTS

5.1 Products shall be delivered in annealed condition. Hardness of finished product shall conform to the requirements stated in Table 12.

**Table 12. Hardness of products in annealed condition**

№ 1)	Steel grade			Brinell hardness in delivery condition
	Grade designation	specification	GOST	
<b>High-speed steel with chemical composition according to Table 1</b>				
1	HS12-1-4-5-PM (1.3202-PM)	—	P12MΦ4K5-MΠ	240-300
2	HS10-4-3-10-PM (1.3207-PM)	DIN EN ISO 4957	P10M4Φ3K10-MΠ	≤ 302
3	S 6-5-2-8-PM (1.3222-PM)	—	P6M5Φ3K8-MΠ	≤ 285
4	HS6-5-2-5-PM (1.3243-PM)	DIN EN ISO 4957	P6M5K5-MΠ	≤ 269
5	HS2-9-1-8-PM (1.3247-PM)	DIN EN ISO 4957	P1M10K8-MΠ	≤ 277
6	HS 18-1-2-5-PM (1.3255-PM)	—	P18MΦ2K5-MΠ	240-300
7	HS 12-1-4-PM (1.3302-PM)	—	P12MΦ4-MΠ	240-300
8	HS 12-1-2-PM (1.3318-PM)	—	P12MΦ2-MΠ	225-280
9	HS6-5-2C-PM (1.3343-PM)	DIN EN ISO 4957	P6M5-MΠ	≤ 269
10	HS6-5-3-PM (1.3344-PM)	DIN EN ISO 4957	P6M5Φ3-MΠ	≤ 269
11	HS 2-9-1-PM (1.3346-PM)	—	P2M9Φ-MΠ	225-280
12	HS 18-0-1-PM (1.3355-PM)	DIN EN ISO 4957	P18-MΠ	≤ 269
<b>Alloy tool steel with chemical composition according to Table 1</b>				
13	X210Cr12-PM (1.2080-PM)	DIN EN ISO 4957	X12-MΠ	≤ 248
14	X153CrMoV12-PM (1.2379-PM)	DIN EN ISO 4957	X12MΦ-MΠ	≤ 255
15	X220CrVMo13-4-PM (1.2380-PM)	—	X12MΦ4-MΠ	≤ 270
16	X60WCrMoV9-4-PM (1.2622-PM)	—	6X4B9MΦ-MΠ	≤ 270
<b>High-speed steel with chemical composition according to Table 2</b>				
1	M2-PM regular C	ASTM A 600	P6M5-MΠ1	≤ 248
2	M2-PM high C	ASTM A 600	P6M5-MΠ2	≤ 255
3	M3-PM class 1	ASTM A 600	P6M5Φ3-MΠ1	≤ 255
4	M3-PM class 2	ASTM A 600	P6M5Φ3-MΠ2	≤ 255
5	M4-PM	ASTM A 600	P6M5Φ4-MΠ	≤ 255
6	M7-PM	ASTM A 600	P2M9Φ2-MΠ	≤ 255
7	M42-PM	ASTM A 600	P2M10ΦK8-MΠ	≤ 269
8	M48-PM	ASTM A 600	P10M5Φ3K9-MΠ	≤ 311
9	M50-PM	ASTM A 600	P0M4ΦC-MΠ	≤ 248
10	M61-PM	AISI	P12M6Φ5-MΠ	≤ 255
11	T15-PM	ASTM A 600	P12MΦ5K5-MΠ	≤ 277
<b>Alloy tool steel with chemical composition according to Table 2</b>				
12	A11-PM	AISI	P0M1CΦ10-MΠ	≤ 277
13	D2-PM	ASTM A 681	X12MΦ-MΠ	≤ 255
14	D3-PM	ASTM A 681	X12-MΠ	≤ 255
15	D7-PM	ASTM A 681	X12MΦ4-MΠ	≤ 262
16	H43-PM	ASTM A 681	6X4M8Φ2-MΠ	≤ 235

**Table 12 (continued)**

Steel grade				Brinell hardness in delivery condition
No <sup>1)</sup>	Grade designation	specification	GOST	
<b>High-speed steel with chemical composition according to Table 3</b>				
1	S390-PM	Böhler	P10M2Φ5K8-МП	≤ 300
2	S590-PM	Böhler	P6M5Φ3K8-МП	≤ 300
3	S690-PM	Böhler	P6M5Φ4-МП	≤ 280
4	S790-PM	Böhler	P6M5Φ3-МП	≤ 280
5	CPM REX45	Crucible	P6M5Φ3K8-МП	≤ 285
6	ASP 2005	Erasteel	P3M3Φ4-МП	≤ 260
7	ASP 2023	Erasteel	P6M5Φ3-МП	≤ 260
8	ASP 2030	Erasteel	P6M5Φ3K8-МП	≤ 300
9	ASP 2053	Erasteel	P4M3Φ8-МП	≤ 300
10	ASP 2060	Erasteel	P6M7Φ6K10-МП	≤ 340
<b>Alloy tool steel with chemical composition according to Table 3</b>				
11	K190-PM	Böhler	X12MΦ4-МП	≤ 260
12	K340-PM	Böhler	110X8M2ΦC-МП	≤ 235
13	VANADIS 4-PM	Böhler	150X8M2Φ4C-МП	≤ 255
14	CRU-WEAR	Crucible	110X8BM2Φ2C-МП	≤ 255
15	CPM 3V	Crucible	8X8MΦ3-МП	≤ 255
16	CPM 9V	Crucible	P0M2CΦ9-МП	≤ 277
17	CPM 10V	Crucible	P0M2CΦ10-МП	≤ 277
18	PMD 440	—	X18MΦ6-МП	≤ 321
19	PMD 550	—	X17M2Φ3K2-МП	≤ 321

**Notes:**

- Numbers are in accordance with ones given in Tables 1, 2, 3.

Extrusion billets are delivered in annealed condition without hardness testing of finished product.

**5.2** Surface performance of round, square bars, rectangular forgings and disks shall conform to the following:

**5.2.1 Round bars**

5.2.1.1. Round bars 12-40 mm in diameter are delivered in turned or ground condition, round bars over 40 mm to 410 mm are delivered in turned condition with following surface roughness:

- $R_z \leq 60$  mkm — for bars up to 180 mm (incl.);
- $R_z \leq 80$  mkm — for bars over 180 mm.

Surface of round bars shall be free of cracks, laps (forging folds), scabs and capsule remains.

Local imperfections shall be removed by flat grinding. The width of grind-outs shall be min 5 times the depth.

The depth of spot grinding shall not reduce the bar size under the nominal one.

Single marks, scratches, indentations and other surface defects of mechanical origin with depth max  $\frac{1}{2}$  of the total utmost deviations from diameter counting from the actual size are allowed without grinding.

Welding or weld repair of surface defects is not permitted.

5.2.1.2. Defects of mechanical origin with depth max  $\frac{1}{2}$  of the total utmost deviations from diameter are allowed on the surface of ground and polished bars 3-50 mm in diameter after surface layer removing accomplished at the manufacturer's option.

Surface roughness  $R_a$  shall be max 2,5 mkm.

5.2.1.3. Defects of mechanical origin with depth shown below are allowed on the surface of ground and polished hot-rolled and forged bars 20-130 mm in diameter processed on the Landgraf automatic line:

- Defect depth shall be max 0,040 mm — for bars with size tolerance h9 (k9);



— Defect depth shall not exceed  $\frac{1}{2}$  of utmost deviations from diameter for bars of all diameters with size tolerance h10 (k10) - h13 (k13).

Surface roughness Ra shall be max 2,5 mkm for bars 20 - 70 mm in diameter and max 5,0 mkm for bars over 70 mm in diameter.

### 5.2.2 Round bars and rectangular forgings

Round bars and rectangular forgings are delivered after spot grinding of surface defects as well as after complete surface conditioning. Product surface shall be planed or milled that shall be stated in the specification.

For square bars and rectangular forgings after complete surface conditioning as well as for products with planed or milled surface roughness Rz shall not exceed 100 mkm.

Cracks, laps, scabs and capsule remains are not permitted on the surface of square bars and rectangular forgings.

Local imperfections shall be removed by flat grinding. The width of grind-outs shall be min 5 times the depth. The depth of grind-outs shall not reduce product size under the minimally permitted limits.

Single marks, scratches and other defects of mechanical origin are permitted without flat grinding if their depth:

- max 1,0 mm - for metal products up to 100 mm in square side or thickness
- max 2,0 mm – for metal products 100-180 mm in square side or thickness
- max 2,5 mm – for metal products over 180 mm in square side or thickness.

Welding repair of surface imperfections or flash welding is not permitted.

### 5.2.3 Disks

Disks are delivered with turned surface.

Surface roughness Rz shall be max 100 mkm.

Disk surface shall be free of cracks, laps, scabs and capsule remains.

Local imperfections shall be removed by flat grinding. The width of grind-outs shall be min 5 times the depth.

The depth of grind-outs shall not reduce product size under the minimally permitted limits.

Defects of mechanical origin are permitted without grinding if their depth does not exceed 2,5 mm.

Welding repair of surface imperfections or flash welding is not permitted.

Requirements stated in items 5.3, 5.4, 5.5, 5.6, 5.8, 5.9 are not applied for this type of metal products.

**5.3** Laminations, inclusions, cracks, sulphuric segregation as a ring pattern (severity 3) are not allowed in steel macrostructure tested according to GOST 28393-89. Sulphuric segregation consisting of etched dots and non-ring pattern lines (severity 1, 2) are permitted.

**5.4** Microstructure tested according to GOST 28393-89 shall be free from:

- microporosity exceeding severity 3;
- oxides precipitated on boundaries of powder particles (oxygen segregation) that exceed severity 2;
- foreign powder particles if there is more than one in a section.

**5.5** Carbide inhomogeneity of high-speed steel shall be tested as per SEP 1615 and shall conform to the standard photograph 1, row A.

Carbide inhomogeneity of alloy tool steel X210Cr12-PM (1.2080-PM), X153CrMoV12-PM (1.2379-PM), X220CrVMo13-4-PM (1.2380-PM), D2-PM, D3-PM, D7-PM, K190-PM shall be not higher than in standard photographs 11, 12, 13, 21, 31, 41 of BÖHLER scales AL011 DE-10.91-300 Ke. Carbide inhomogeneity of other alloy tool steel grades according to Tables 1, 2, 3 is not tested.

5.6 Hardness of specimen after quenching and tempering for steel grades with chemical composition shown in Tables. 1, 2, 3 shall meet the requirements of Table 13.

**Table 13. Hardness of specimen after quenching and tempering**

№ 1)	Steel grade			Hardness, HRC	Temperature of, °C		quenchant
	Grade designation	Specification	GOST		quenching	tempering	
<b>High-speed steel with chemical composition according to Table 1</b>							
1	HS12-1-4-5-PM (1.3202-PM)	—	P12MΦ4K5-МП	≥ 65	1230±20	560±10	oil
2	HS10-4-3-10-PM (1.3207-PM)	DIN EN ISO 4957	P10M4Φ3K10-МП	≥ 66	1230±10	560±10	oil
3	S 6-5-2-8-PM (1.3222-PM)	—	P6M5Φ3K8-МП	≥ 66	1220±10	560±10	oil
4	HS6-5-2-5-PM (1.3243-PM)	DIN EN ISO 4957	P6M5K5-МП	≥ 64	1210±10	560±10	oil
5	HS2-9-1-8-PM (1.3247-PM)	DIN EN ISO 4957	P1M10K8-МП	≥ 66	1190±10	550±10	oil
6	HS 18-1-2-5-PM (1.3255-PM)	—	P18MΦ2K5-МП	≥ 64	1280±20	560±10	oil
7	HS 12-1-4-PM (1.3302-PM)	—	P12MΦ4-МП	≥ 65	1240±20	570±10	oil
8	HS 12-1-2-PM (1.3318-PM)	—	P12MΦ2-МП	≥ 64	1250±20	560±10	oil
9	HS6-5-2C-PM (1.3343-PM)	DIN EN ISO 4957	P6M5-МП	≥ 64	1210±10	560±10	oil
10	HS6-5-3-PM (1.3344-PM)	DIN EN ISO 4957	P6M5Φ3-МП	≥ 64	1200±10	560±10	oil
11	HS 2-9-1-PM (1.3346-PM)	—	P2M9Φ-МП	≥ 64	1200±20	540±10	oil
12	HS 18-0-1-PM (1.3355-PM)	DIN EN ISO 4957	P18-МП	≥ 63	1260±10	560±10	oil
<b>Alloy tool steel with chemical composition according to Table 1</b>							
13	X210Cr12-PM (1.2080-PM)	DIN EN ISO 4957	X12-МП	≥ 62	970±10	180±10	oil
14	X153CrMoV12-PM (1.2379-PM)	DIN EN ISO 4957	X12MΦ-МП	≥ 61	1020±10	180±10	air
15	X220CrVMo13-4-PM (1.2380-PM)	—	X12MΦ4-МП	≥ 60	1050-1130	500-550	oil, air
16	X60WCrMoV9-4-PM (1.2622-PM)	—	6X4B9MΦ-МП	≥ 56	1275±25	520±10	oil, air
<b>High-speed steel with chemical composition according to Table 2</b>							
1	M2-PM regular C	ASTM A 600	P6M5-МП1	≥ 64	1225±10	550±10	oil
2	M2-PM high C	ASTM A 600	P6M5-МП2	≥ 65	1215±10	550±10	oil
3	M3-PM class 1	ASTM A 600	P6M5Φ3-МП1	≥ 64	1215±10	550±10	oil
4	M3-PM class 2	ASTM A 600	P6M5Φ3-МП2	≥ 64	1215±10	550±10	oil
5	M4-PM	ASTM A 600	P6M5Φ4-МП	≥ 64	1215±10	550±10	oil
6	M7-PM	ASTM A 600	P2M9Φ2-МП	≥ 65	1215±10	550±10	oil
7	M42-PM	ASTM A 600	P2M10ΦK8-МП	≥ 66	1190±10	540±10	oil
8	M48-PM	ASTM A 600	P10M5Φ3K9-МП	≥ 66	1200±10	540±10	oil
9	M50-PM	ASTM A 600	P0M4ΦC-МП	≥ 59	1115±10	540±10	oil
10	M61-PM	AISI	P12M6Φ5-МП	See note 3)			
11	T15-PM	ASTM A 600	P12MΦ5K5-МП	≥ 65	1240±10	540±10	oil



**Table 13 (continued)**

№ 1)	Steel grade			Hardness, HRC	Temperature, °C		quenchant
	Grade designation	Specification	GOST		quenching	tempering	
<b>Alloy tool steel with chemical composition according to Table 2</b>							
12	A11-PM	AISI	P0M1CΦ10-МП	≥ 60	1120±10	540±10	air
13	D2-PM	ASTM A 681	X12MΦ-МП	≥ 59	1010±10	205±10	air
14	D3-PM	ASTM A 681	X12-МП	≥ 61	970±10	205±10	oil
15	D7-PM	ASTM A 681	X12MΦ4-МП	≥ 63	1065±10	205±10	air
16	H43-PM	ASTM A 681	6X4M8Φ2-МП	≥ 58	1190±10	550±10	air
<b>High-speed steel with chemical composition according to Table 3</b>							
1	S390-PM	Böhler	P10M2Φ5K8-МП	65-69	1150-1230	520-550	oil, air
2	S590-PM	Böhler	P6M5Φ3K8-МП	65-67	1075-1180	520-550	oil, air
3	S690-PM	Böhler	P6M5Φ4-МП	64-66	1150-1200	540-570	oil, air
4	S790-PM	Böhler	P6M5Φ3-МП	64-66	1050-1180	540-570	oil, air
5	CPM REX45	Crucible	P6M5Φ3K8-МП	≥ 66	1190±10	550±10	oil, air
6	ASP 2005	Erasteel	P3M3Φ4-МП	≥ 64	1180±10	540±10	oil, air
7	ASP 2023	Erasteel	P6M5Φ3-МП	≥ 65	1180±10	540±10	oil, air
8	ASP 2030	Erasteel	P6M5Φ3K8-МП	≥ 66	1180±10	540±10	oil, air
9	ASP 2053	Erasteel	P4M3Φ8-МП	≥ 65	1180±10	540±10	oil, air
10	ASP 2060	Erasteel	P6M7Φ6K10-МП	≥ 68	1180±10	540±10	oil, air
<b>Alloy tool steel with chemical composition according to Table 3</b>							
11	K190-PM	Böhler	X12MΦ4-МП	≥ 62	1050-1150	530±10	oil
12	K340-PM	Böhler	110X8M2ΦC-МП	≥ 60	1040-1080	560±10	oil
13	VANADIS 4-PM	Böhler	150X8M2Φ4C-МП	≥ 60	1020±10	500±10	air
14	CRU-WEAR	Crucible	110X8BM2Φ2C-МП	61-63	1120±10	550±10	oil
15	CPM 3V	Crucible	8X8MΦ3-МП	≥ 58	1025±10	540±10	air
16	CPM 9V	Crucible	P0M2CΦ9-МП	≥ 56	1120±10	540±10	oil
17	CPM 10V	Crucible	P0M2CΦ10-МП	≥ 60	1120±10	540±10	air
18	PMD 440	—	X18MΦ6-МП	≥ 54	1010±10	210±10	oil
19	PMD 550	—	X17M2Φ3K2-МП	≥ 63	1100±10	200±10	oil

**Notes:**

- Numbers are in accordance with ones given in Tables 1, 2, 3.
- Tempering of high-speed steel and alloy tool steel at 500°C and over is carried out 2-3 times, soaking 2 hours.
- For steel grade M61-PM (P12M6Φ5-МП) hardness of specimens, temperature of quenching and tempering and quenchant shall be stated in the specification.

**5.7** Metal products 20 mm and over in diameter or thickness are to be US-tested according to EN 10308 (for rolled stock) and according to EN 10228-3 (for forged stock) inspection chart for type 1a (metal products of round section), type 1b (metal products of square and rectangular sections) and type 2 (discs).

The results of test shall conform to the norms of Table 14.

**Table14. US-testing norms**

Diameter or thickness of metal products, mm	Product type				
	rolled stock		forged stock		
	Quality class acc. to EN 10308		Quality class acc. to EN 10228-3		
	Inspection chart				
	type 1a (for metal products of round section)	type 1b (for metal products of square and rectangular sections)	type 1a (for metal products of round section)	type 1b (for metal products of square and rectangular sections)	Type 2 (discs)
20 - 89	4		4		-
over 89 to 410	-		4		-
over 410 to 745 (discs)	-		-		3

**Notes:**

1. The other norms and methods of US-testing shall be stated in the specification.

For bars with ground and polished surface manufacturer's technology shall provide conformity with US-testing norms when semi-product is tested.

**5.8** Non-metallic inclusion content is tested in accordance with DIN 50602 (method K) or ASTM E 45 (method A). The testing method shall be stated in the specification.

Non-metallic inclusion content according to DIN 50602 (method K) shall not exceed (oxides + sulfides)  $K0 \leq 10$ .

Average non-metallic inclusion ratio according to ASTM E 45 (Method A) shall conform to the requirements shown in Table 15.

**Table15. Average non-metallic inclusion ratio according to ASTM E 45**

Inclusion series	Inclusion type			
	A	B	C	D
thin	2,0	2,0	2,0	2,0
heavy	1,5	1,5	1,5	1,5

**5.9** Average number of crossed grains (austenitic grain size) after quenching determined by Snyder-Graff method should not be worse than 13.

**5.10** For turned round bars, forged square bars and rectangular forgings with planed or milled surface or after complete surface conditioning, bars with ground and polished surface as well as disks decarburizing (ferrite + transition zone) is not permitted that shall be guaranteed by the manufacturer's technology.

For forgings delivered after spot grinding of surface defects in a case of forgings up to 100 mm in thickness decarburization depth shall not exceed 2% of the thickness; for forgings over 100 mm in thickness decarburization depth shall not exceed 1% of the thickness

**5.11** For metal products up to 200 mm in diameter and for square and rectangular products with equivalent cross section area reduction ratio shall be min 4. For such metal products reduction ratio is provided by the manufacturer's technology and shall not be stated in the certificate.

For metal products over 200 mm in diameter and for square and rectangular products with equivalent cross section area reduction ratio shall be min 2,5 and shall be stated in the specification. For these metal products it is permitted to discuss other reduction ratio values in the specification.

**5.12** Extrusion billets and capsules with the powder are delivered in accordance with manufacturer's standards. Extrusion billets are delivered without checking of surface defect depth, macro- and microstructure, decarburizing depth, grain size, finished product hardness and hardness of specimens after quenching and tempering, as well as non-metallic inclusion content and foreign powder particle content, carbide inhomogeneity and without US-testing also.

Powder particles in capsules shall be spherical. Particle size shall be max 800 mkm.

**5.13** Metal products shall be radiation and mercury free that shall be provided by manufacturer's technology.

**5.14** Mixing tests shall be provided by spark method or by other acceptable non-destructive test methods.

## **6 Acceptance rules and testing methods**

Acceptance rules and testing methods shall be in accordance with GOST 28393-89 including the following details:

— macrostructure requirements according to paragraph 5.3 of the present technical delivery conditions (excepting sulfur segregation) are allowed to provide by US-testing when diameter of reference reflector (KSR) or diameter of flat bottom hole (FBH) max. 1,0 mm. For metal products over 200 mm in diameter or thickness sulfur segregation requirements are provided by the manufacturer's technology;

— Ultrasonic testing is performed according to EN 10308 (for rolled stock) and according to EN 10228-3 (for forged stock) min 10% of bars up to 60 mm incl. in diameter or thickness are to be US-tested, and 100% of bars over 60 mm in diameter or thickness are to be tested;

— If it is required by customer and stated in the specification, non-metallic inclusion content is determined according to DIN 50602 (Method K) or ASTM E 45 (Method A) ;

— Argon content requirements are guaranteed by micro-porosity testing according to paragraph 5.4 of the present technical delivery conditions;

— Carbide inhomogeneity is to be tested in accordance with SEP 1615 for high-speed steel and for alloy tool steel of steel grades X210Cr12-PM (1.2080-PM), X153CrMoV12-PM (1.2379-PM), X220CrVMo13-4-PM (1.2380-PM), D2-PM, D3-PM, D7-PM, K190-PM it shall be tested in accordance with Böhler scale AL011 DE-10.91-300 Ke;

— Samples for carbide inhomogeneity testing are taken at  $\frac{1}{2}$  of radius counting from the surface of a round bar or at  $\frac{1}{4}$  of thickness counting from the surface of square or rectangular bars;

— For bars with ground and polished surface diameter, out-of-round and surface roughness shall be evaluated at a distance min 25 mm from a bar end for bars up to 50 mm in diameter and min 50 mm from a bar end for bars over 50 mm in diameter;

— Acceptance rules and testing methods for powder in capsules shall be in accordance with manufacturer's standards.

## **7 Marking and packing**

### **7.1 Marking and packing of hot-rolled or forged bars and rectangular forgings**

One end of each hot-rolled and forged bar over 42 mm in diameter/ square side as well as each rectangular forging shall be stamped with indication of lot number and extrusion billet number, steel grade designation according to a specification applied, manufacturer's logo, and the sign (digital code) of a quality control inspector.

For hot-rolled and forged products up to 42 mm (incl.) in diameter or square side 5-7 product pieces shall be stamped indicating lot number and extrusion billet number, steel grade designation according to a specification applied, manufacturer's logo, and the sign of a quality control inspector. Stamped bar ends shall be colour painted.

For round bars 20-70 mm in diameter processed on the Landgraf automatic line it is permitted to use permanent ink marking instead of die stamping to identify products with lot number, steel grade designation according to specification applied. In bundle of bars over 42 mm in diameter each bar shall be stamped and in the bundle of bars up to 42 mm incl. min 5 bars shall be stamped.

For steel grades according to table 1 while stamping or jet printing it is permitted to indicate identification (digital) number of grade designation instead of full designation.

The ends of hot-rolled or forged bars and rectangular forgings that are opposite to the stamped ones shall be colour painted. Colour shall be stated in the specification

Bundle weight shall not exceed 5000 kg. Other bundle weight shall be stated in the specification.

Before packing hot-rolled and forged round metal products with turned or ground surface, square and rectangular products with planed, milled surface or after complete surface conditioning shall be coated with anticorrosive mineral oil. Then each bundle shall be secured with 2-3 ties 3-4 times with wire 5-7 mm in diameter or with steel band 0,8-1,5 mm in thickness and 30-35 mm in width. Places of tie applying shall be wrapped in polyethylene film or waterproof paper 150-200mm in width with 2 or more coats after that each bundle shall be coated with waterproof paper, polyethylene film and burlap. When band with corrosion preventatives used, places of securement shall not be wrapped with polyethylene film or waterproof paper. To secure packing while handling wooden lagging under strapping up to manufacture's design protects the ties.

Square bars and rectangular forgings after spot grinding of surface defects are not to be coated with mineral oil or corrosion preventatives and shall not be wrapped in waterproof paper and burlap.

On agreement between sides stated in the specification, the following is permitted:

a) hot-rolled and forged metal products with turned surface, with planed or milled surface or products after complete surface conditioning can not be coated with mineral oil, waterproof paper, film and burlap before packing;

b) using of any different corrosion preventative providing corrosion protection of the surface and applying of packing materials other than as indicated above;

c) delivery of products with painted surface.

## **7.2 Marking and packing of bars with ground and polished surface**

Ground and polished bars up to 10.00 mm in diameter shall be rigidly tied in 3 places and wrapped in waterproof paper and then in polyethylene film. Bundle weight shall not exceed 80 kg. Each bundle shall have 2 tags. Bundles of bars should be placed in wooden boxes. Box gross weight shall be max 2000 kg. Faces of each box shall be labeled.

Each bundle of bars over 10.00 mm in diameter shall be secured with 2-3 ties 2-3 times with wire 5-7 mm in diameter or with steel band 0,8-1,5 mm in thickness and 30-35 mm in width. Bundles shall be tightly packed and rigidly tied. Bars with ground and polished surface shall be wrapped in waterproof paper and after that in polyethylene film. To secure packing while handling wooden lagging under strapping up to manufacture's design protects the ties. Each bundle shall have min 2-5 bars that are stamped with lot number and extrusion billet number, steel grade designation according to specification applied. Ends of stamped bars shall be painted with bright colour indicated in the specification. Bundle weight shall not exceed 2500 kg. Other weight can be negotiated in the specification.

For bars processed on the Landgraf automatic line it is permitted to use permanent ink marking instead of die stamping to identify products with lot number, extrusion billet number and steel grade designation according to specification applied.

For steel grades according to table 1 while stamping or jet printing it is permitted to indicate identification (digital) number of grade designation instead of full designation.

Marked bar ends are to be painted with specified colour.

Bars with ground and polished surface shall be coated with anticorrosion lubricant.

On agreement between sides, stated in the specification, it is permitted to use the other types of packing.

### 7.3 Marking and packing of forged disks

One end of each forged disk shall be stamped with lot number and extrusion billet number, steel grade designation according to the specification applied, manufacturer's logo, sign (digital code) of a quality control inspector.

Before packing disks shall be coated with mineral oil, then wrapped in waterproof paper and burlap or, polyethylene film and placed in wooden boxes. It is permitted to use wooden pallets instead of wooden boxes. Fastening security of disks on the wooden pallets is provided by manufacturer. Each box or wooden pallet shall be labeled.

### 7.4 Marking and packing of capsules with powder

Metal plate stamped with steel grade designation according to specification applied and heat number shall be welded to one cover of each capsule with powder.

On agreement between sides stated in the specification, capsule cover that is opposite to the stamped one shall be marked by a dash of colour indicated in the specification.

Type of packing can be best determined by the manufacturer's experience. Bundles shall be tightly packed and rigidly tied. Each bundle shall contain the powder of one heat.

Bundle weight shall not exceed 5000 kg.

### 7.5 Marking and packing of extrusion billets

One end of each extrusion billet shall be stamped with lot number and extrusion billet number, steel grade designation according to specification applied, manufacturer's logo and sign (digital code) of a quality control inspector.

Extrusion billet ends that are opposite to the stamped ones shall be marked with colour indicated in the specification.

Extrusion billets are not to be coated with mineral oil, wrapped in waterproof paper, polyethylene film and burlap.

**7.6** Each bundle shall have 2 tags (one on each side) indicating the following information in Russian and in English (English or German that can be negotiated in the specification):

- contract number
- specification number
- manufacturer
- customer
- steel grade (name and number designation according to specification applied)
- lot number or size tolerance
- lot number and extrusion billet number (heat number for capsules with powder)
- section size, mm
- length, mm
- net/gross weight, kg
- package number and number of packages

## 8 INSPECTION CERTIFICATE

Products shall be accompanied with Inspection certificate according to EN 10204, form 3.1 in English including the following:

- contract number;
- specification number;
- manufacturer;
- customer;
- steel grade (name and number designation according to specification applied);
- lot number or size tolerance;
- lot number and extrusion billet number (heat number for powder in capsules)
- section size, mm;
- bundle weight (net/gross), kg
- forging reduction ratio
- testing results: macrostructure, microstructure, finished product hardness and hardness of specimens after quenching and tempering, decarburization depth grain size, non-metallic inclusions, carbide inhomogeneity, US-testing, forging reduction ratio and mixing test.

The following also should be stated in the certificate:

- "made in Ukraine"
- "radiation free"
- "mercury free"
- "no weld or weld repair"
- "after dimension/surface defect test"

**Note:** when forged disks are delivered, results for finished product hardness testing and US-testing are to be stated in the inspection certificate. "Conforms to the technical delivery conditions" and "satisfactory" shall be stated in the lines "microstructure", "grain size", "carbide inhomogeneity", "non-metallic inclusions", "hardness of specimens after quenching and tempering".

## 9 SUPPLEMENTARY AND SPECIAL REQUIREMENTS

Customer's supplementary and special requirements including extension of product range, changes in chemical composition, technical requirements or testing methods are to be stated separately in the Technical Protocol. The Technical Protocol is an integral part of the contract.

## 10 REFERENCE DOCUMENTS

Designation	name
DIN EN ISO 4957	Tool steels.
ASTM A 600	Standard Specification for Tool Steel High Speed
ASTM A 681	Standard Specification for Tool Steels Alloy
ASTM E 45	Standard Test Methods for Determining the Inclusion Content of steel
DIN 50602	Microscopical examination of the non-metallic inclusion content of high-quality steels using scales.
EN 10204	Metallic products - Types of inspection documents
SEP 1615	Microscopic and macroscopic testing of high-speed steels for their carbide distribution by means of strip mosaics
EN 10308	Ultrasonic testing of steel bars.
EN 10228-3	Non-destructive testing of steel forgings - Part 3: Ultrasonic testing of ferritic or martensitic steel forgings.
GOST 28393-89	Bars and strips of high speed steel by powder metallurgy methods. General technical delivery.