Department of Materials Science and Engineering

Material Selection Guide

MŰEGYETEM 1782

Material Selection Guide

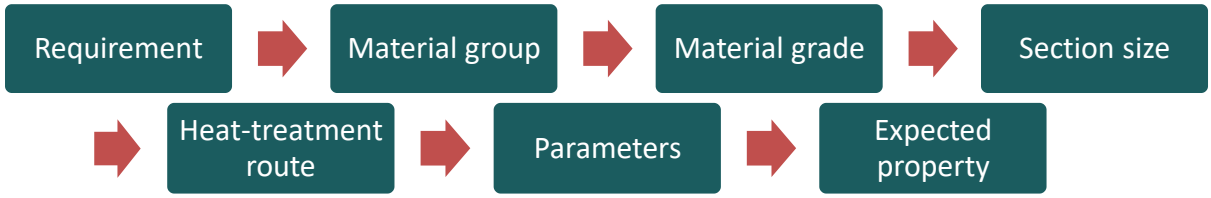
This guide contains tables based on the following standards:

- *ISO 683-1:2016 – Heat-treatable steels. alloy steels and free-cutting steels. Part 1: Non-alloy steels for quenching and tempering*
- *ISO 683-2:2016 – Heat-treatable steels. alloy steels and free-cutting steels. Part 2: Alloy steels for quenching and tempering*
- *ISO 683-3:2022 – Heat-treatable steels. alloy steels and free-cutting steels. Part 3: Case-hardening steels*
- *ISO 4957:2018 – Tool steels*

> The project assignments may also involve other material groups. For example. and without claiming completeness. for corrosion-resistant steels. aluminium alloys. and other light and non-ferrous metals. a reliable manufacturer's datasheet or the applicable standard must be found online.

Using the Guide

1. Select a material group appropriate for the loading of the component or product.
2. Select a specific material grade.
3. Check whether the selected material can achieve the specified mechanical properties at the given section size.
4. Determine the required heat-treatment process.
5. Use the table to select the applicable temperature range and cooling medium.
6. Select the specific temperature based on the required properties. component size. and processing conditions.
7. Specify the holding time and justify its selection.



Brief Summary of Heat Treatment

Heat-treatment operation	Primary purpose
Normalizing	grain refinement and a more homogeneous microstructure
Hardening	martensitic microstructure and high hardness and strength
Tempering	strength–toughness balance
Quenching and tempering	high strength + adequate toughness
Carburizing + hardening	hard case + tough core
Induction hardening	localized wear-resistant martensitic surface

ISO 683-1:2016
Heat-treatable steels. alloy steels and free-cutting steels.
Part 1: Non-alloy steels for quenching and tempering

Chemical composition of non-alloy steels for quenching and tempering

Steel designation	Mass fraction[1] t%									
	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Cr+Mo+Ni
C25	0.22 – 0.29	0.10 – 0.40	0.40 – 0.70	0.045	0.045	0.40	0.10	0.40	0.30	0.63
C30	0.27 – 0.34	0.10 – 0.40	0.50 – 0.80	0.045	0.045	0.40	0.10	0.40	0.30	0.63
C35	0.32 – 0.39	0.10 – 0.40	0.50 – 0.80	0.045	0.045	0.40	0.10	0.40	0.30	0.63
C40	0.37 – 0.44	0.10 – 0.40	0.50 – 0.80	0.045	0.045	0.40	0.10	0.40	0.30	0.63
C45	0.42 – 0.50	0.10 – 0.40	0.50 – 0.80	0.045	0.045	0.40	0.10	0.40	0.30	0.63
C50	0.47 – 0.55	0.10 – 0.40	0.60 – 0.90	0.045	0.045	0.40	0.10	0.40	0.30	0.63
C55	0.52 – 0.60	0.10 – 0.40	0.60 – 0.90	0.045	0.045	0.40	0.10	0.40	0.30	0.63
C60	0.57 – 0.65	0.10 – 0.40	0.60 – 0.90	0.045	0.045	0.40	0.10	0.40	0.30	0.63
Special steels										
C25E	0.22 – 0.29	0.10 – 0.40	0.40 – 0.70	0.025	0.035	0.40	0.10	0.40	0.30	0.63
C25R					0.020 – 0.040					
C30E	0.27 – 0.34	0.10 – 0.40	0.50 – 0.80	0.025	0.035	0.40	0.10	0.40	0.30	0.63
C30R					0.020 – 0.040					
C35E	0.32 – 0.39	0.10 – 0.40	0.50 – 0.80	0.025	0.035	0.40	0.10	0.40	0.30	0.63
C35R					0.020 – 0.040					
C40E	0.37 – 0.44	0.10 – 0.40	0.50 – 0.80	0.025	0.035	0.40	0.10	0.40	0.30	0.63
C40R					0.020 – 0.040					
C45E	0.42 – 0.50	0.10 – 0.40	0.50 – 0.80	0.025	0.035	0.40	0.10	0.40	0.30	0.63
C45R					0.020 – 0.040					
C50E	0.47 – 0.55	0.10 – 0.40	0.60 – 0.90	0.025	0.035	0.40	0.10	0.40	0.30	0.63
C50R					0.020 – 0.040					
C55E	0.52 – 0.60	0.10 – 0.40	0.60 – 0.90	0.025	0.035	0.40	0.10	0.40	0.30	0.63
C55R					0.020 – 0.040					
C60E	0.57 – 0.65	0.10 – 0.40	0.60 – 0.90	0.025	0.035	0.40	0.10	0.40	0.30	0.63
C60R					0.020 – 0.040					
23Mn6	0.19 – 0.26	0.10 – 0.40	1.30 – 1.65	0.025	0.035	0.40	0.10	0.40	0.30	0.63
28Mn6	0.25 – 0.32	0.10 – 0.40	1.30 – 1.65	0.025	0.035	0.40	0.10	0.40	0.30	0.63
36Mn6	0.33 – 0.40	0.10 – 0.40	1.30 – 1.65	0.025	0.035	0.40	0.10	0.40	0.30	0.63
42Mn6	0.39 – 0.46	0.10 – 0.40	1.30 – 1.65	0.025	0.035	0.40	0.10	0.40	0.30	0.63

[1] maximum values unless otherwise indicated

Source: ISO 683-1:2016
Last checked: 2026.08.

+H non-alloy steels for quenching and tempering — hardness after the end-quench test

Steel designation	Designation	Range designation	HRC hardness measured from the quenched end (distance in mm)															
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**13**	**15**	**20**	**25**	**30**
C35E C35R	+H	max.	58	57	55	53	49	41	34	31	28	27	26	25	24	23	20	—
		min.	48	40	33	24	22	20	—	—	—	—	—	—	—	—	—	—
C40E C40R	+H	max.	60	60	59	57	53	47	39	34	31	30	29	28	27	26	25	24
		min.	51	46	35	27	25	24	23	22	21	20	—	—	—	—	—	—
C45E C45R	+H	max.	62	61	61	60	57	51	44	37	34	33	32	31	30	29	28	27
		min.	55	51	37	30	28	27	26	25	24	23	22	21	20	—	—	—
C50E C50R	+H	max.	63	62	61	60	58	55	50	43	36	35	34	33	32	31	29	28
		min.	56	53	44	34	31	30	30	29	28	27	26	25	24	23	20	—
C55E C55R	+H	max.	65	64	63	62	60	57	52	45	37	36	35	34	33	32	30	29
		min.	58	55	47	37	33	32	31	30	29	28	27	26	25	24	22	20
C60E C60R	+H	max.	67	66	65	63	62	59	54	47	39	37	36	35	34	33	31	30
		min.	60	57	50	39	35	33	32	31	30	29	28	27	26	25	23	21
			1.5	**3**	**5**	**7**	**9**	**11**	**13**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**—**
23Mn6	+H	max.	51	48	44	37	33	30	28	26	25	23	—	—	—	—	—	—
		min.	42	38	28	22	—	—	—	—	—	—	—	—	—	—	—	—
28Mn6	+H	max.	54	53	50	48	44	41	38	35	31	29	27	26	25	25	24	—
		min.	45	42	36	27	21	—	—	—	—	—	—	—	—	—	—	—
36Mn6	+H	max.	59	58	57	54	49	45	41	38	35	33	31	30	30	30	30	—
		min.	51	48	42	35	27	23	20	—	—	—	—	—	—	—	—	—
42Mn6	+H	max.	62	61	60	59	57	54	50	45	37	34	32	31	30	29	28	—
		min.	55	53	49	39	33	29	27	26	23	22	20	—	—	—	—	—

Source: ISO 683-1:2016
Last checked: 2026.08.

+HH and +HL non-alloy steels for quenching and tempering — hardness after the end-quench test

Steel designation	Designation	Range designation	HRC hardness measured from the quenched end (distance in mm)														
			1					4					5				
C35E	+HH4		—					34 – 53					—				
	+HH14		51 – 58					34 – 53					—				
C35R	+HL4		—					24 – 43					—				
	+HL14		48 – 55					24 – 43					—				
C40E	+HH4		—					38 – 57					—				
	+HH14		54 – 60					38 – 57					—				
C40R	+HL4		—					27 – 46					—				
	+HL14		51 – 57					27 – 46					—				
C45E	+HH4		—					41 – 60					—				
	+HH14		57 – 62					41 – 60					—				
C45R	+HL4		—					30 – 49					—				
	+HL14		55 – 60					30 – 49					—				
C50E	+HH5		—					—					40 – 58				
	+HH15		58 – 63					—					40 – 58				
C50R	+HL5		—					—					31 – 49				
	+HL15		56 – 61					—					31 – 49				
C55E	+HH5		—					—					42 – 60				
	+HH15		60 – 65					—					42 – 60				
C55R	+HL5		—					—					33 – 51				
	+HL15		58 – 63					—					33 – 51				
C60E	+HH5		—					—					44 – 62				
	+HH15		62 – 67					—					44 – 62				
C60R	+HL5		—					—					35 – 53				
	+HL15		60 – 65					—					35 – 53				
			1.5	**3**	**5**	**7**	**9**	**11**	**13**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
23Mn6	+HH	max.	51	48	44	37	33	30	28	26	25	23	-	—	—	—	—
		min.	45	41	33	27	23	20	—	—	—	—	—	—	—	—	—
	+HL	max.	48	45	39	32	28	25	23	21	20	—	—	—	—	—	—
		min.	42	38	28	22	—	—	—	—	—	—	—	—	—	—	—
28Mn6	+HH	max.	54	53	50	48	44	41	38	35	31	29	27	26	25	25	24
		min.	48	46	41	34	30	27	24	21	—	—	—	—	—	—	—
	+HL	max.	51	49	45	41	35	32	29	26	22	20	—	—	—	—	—
		min.	45	42	36	27	21	—	—	—	—	—	—	—	—	—	—
36Mn6	+HH	max.	59	58	57	54	49	45	41	38	35	33	31	30	30	30	30
		min.	54	51	47	41	34	30	27	24	21	—	—	—	—	—	—
	+HL	max.	56	55	52	48	42	38	34	31	28	26	24	23	23	23	23
		min.	51	48	42	35	27	23	20	—	—	—	—	—	—	—	—
42Mn6	+HH	max.	62	61	60	59	57	54	50	45	37	34	32	31	30	29	28
		min.	57	56	53	46	41	37	35	32	28	26	24	23	22	21	20
	+HL	max.	60	58	56	52	49	46	42	39	32	30	28	27	26	25	24
		min.	55	53	49	39	33	29	27	26	23	22	20	—	—	—	—

Source: ISO 683-1:2016
Last checked: 2026.08.

Heat-treatment data for non-alloy steels for quenching and tempering

Steel designation[a]	Austenitizing temperature[b,c]	Quenching medium[d]	Tempering temperature[e]	Austenitizing temperature for the end-quench test[f]	Normalizing temperature
	°C		°C	°C	°C
C25	860 – 900	Water	550 – 660	—	880 – 920
C30	850 – 890	Water		—	870 – 910
C35	840 – 880	Water or oil		—	860 – 900
C40	830 – 870			—	850 – 890
C45	820 – 860			—	840 – 880
C50	810 – 850	Oil or water		—	830 – 870
C55	805 – 845			—	825 – 865
C60	800 – 840			—	820 – 860
Special steels					
C25E. C25R	860 – 900	Water	550 – 660	—	880 – 920
C30E. C30R	850 – 890	Water		—	870 – 910
C35E. C35R	840 – 880	Water or oil		870 ± 5	860 – 900
C40E. C40R	830 – 870			870 ± 5	850 – 890
C45E. C45R	820 – 860			850 ± 5	840 – 880
C50E. C50R	810 – 850	Oil or water		850 ± 5	830 – 870
C55E. C55R	805 – 845			830 ± 5	825 – 865
C60E. C60R	800 – 840			830 ± 5	820 – 860
23Mn6	840 – 900	Water	550 – 650	880 ± 5	—
28Mn6	830 – 870	Water or oil	540 – 680	850 ± 5	—
36Mn6	820 – 860	Oil or water	540 – 680	840 ± 5	—
42Mn6	830 – 880	Oil	550 – 650	845 ± 5	—

The stated temperatures are provided as guidance. The exact temperature must be selected according to the required properties.
[a] The table also applies to steels designated +H, +HH, and +HL,
[b] Hardening from temperatures at the lower end of the ranges generally uses water cooling, while temperatures at the upper end use oil.
[c] Austenitizing-temperature holding time: at least 30 minutes.
[d] When selecting the quenching medium, its effect on other parameters must also be considered, including shape, size, hardening temperature, and susceptibility to cracking. Other quenching media may also be used.
[e] The tempering time is at least 1 hour.
[f] The specified austenitizing time is 30–35 perc. Applies only to the Jominy test.

Source: ISO 683-1:2016
Last checked: 2026.08.

Mechanical properties of non-alloy steels in the quenched and tempered condition

Steel designation	*d* diameter or *t* thickness workpieces[a]																			
	$d \le 16$ mm $t \le 8$ mm					16 mm < $d \le 40$ mm 8 mm < $t \le 20$ mm					40 mm < $d \le 100$ mm 20 mm < $t \le 60$ mm					100 mm < $d \le 160$ mm 60 mm < $t \le 100$ mm				
	R_{eH}	R_m	A	Z^b	KV_2^d	R_{eH}	R_m	A	Z^b	KV_2^d	R_{eH}	R_m	A	Z^b	KV_2^d	R_{eH}	R_m	A	Z^b	KV_2^d
	min.		min.	min.	min.	min.		min.	min.	min.	min.		min.	min.	min.	min.		min.	min.	min.
	MPa[c]		%	%	J	MPa[c]		%	%	J	MPa[c]		%	%	J	MPa[c]		%	%	J
C25	370	550 – 700	19	—	—	320	500 – 650	21	—	—	—	—	—	—	—	—	—	—	—	—
C30	400	600 – 750	18	—	—	350	550 – 700	20	—	—	300[e]	500 – 650e	21[e]	—	—	—	—	—	—	—
C35	430	630 – 780	17	40	—	380	600 – 750	19	45	—	320	550 – 700	20	50	—	—	—	—	—	—
C40	460	650 – 800	16	35	—	400	630 – 780	18	40	—	350	600 – 750	19	45	—	—	—	—	—	—
C45	490	700 – 850	14	35	—	430	650 – 800	16	40	—	370	630 – 780	17	45	—	—	—	—	—	—
C50	520	750 – 900	13	—	—	460	700 – 850	15	—	—	400	650 – 800	16	—	—	—	—	—	—	—
C55	550	800 – 950	12	30	—	490	750 – 900	14	35	—	420	700 – 850	15	40	—	—	—	—	—	—
C60	580	850 – 1 000	11	25	—	520	800 – 950	13	30	—	450	750 – 900	14	35	—	—	—	—	—	—
Special steels																				
C25E C25R	370	550 – 700	19	—	35	320	500 – 650	21	—	35	—	—	—	—	—	—	—	—	—	—
C30E C30R	400	600 – 750	18	—	30	350	550 – 700	20	—	30	300e	500 – 650e	21 e	—	30e	—	—	—	—	—
C35E C35R	430	630 – 780	17	40	25	380	600 – 750	19	45	25	320	550 – 700	20	50	25	—	—	—	—	—
C40E C40R	460	650 – 800	16	35	20	400	630 – 780	18	40	20	350	600 – 750	19	45	20	—	—	—	—	—
C45E C45R	490	700 – 850	14	35	15	430	650 – 800	16	40	15	370	630 – 780	17	45	15	—	—	—	—	—
C50E C50R	520	750 – 900	13	30	—	460	700 – 850	15	35	—	400	650 – 800	16	40	—	—	—	—	—	—
C55E C55R	550	800 – 950	12	30	—	490	750 – 900	14	35	—	420	700 – 850	15	40	—	—	—	—	—	—
C60E C60R	580	850 – 1 000	11	25	—	520	800 – 950	13	30	—	450	750 – 900	14	35	—	—	—	—	—	—
23Mn6	550	700 – 850	15	—	—	440	650 – 800	18	—	30	400	600 – 750	18	—	30	—	—	—	—	—
28Mn6	590	800 – 950	13	40	25	490	700 – 850	15	45	30	440	650 – 800	16	50	30	—	—	—	—	—
36Mn6	640	850 – 1 000	12	—	20	540	750 – 900	14	—	25	460	700 – 850	15	—	25	410	650 – 800	16	—	20
42Mn6	690	900 – 1 050	12	—	25	590	800 – 950	14	—	30	480	750 – 900	15	—	30	460	700 – 850	16	—	30

[a] R_{eH}: upper yield strength or, if not present, the 0.2% proof strength $R_{p0.2}$; R_m: tensile strength; A: percentage elongation after fracture ($L_0 = 5.65(S_0)^{1/2}$); Z: percentage reduction of area after fracture; KV_2: impact energy of V-notched Charpy test pieces using a 2 mm striker radius; the value is the average of three tests, with no individual value below 70% of the average.

[b] Non-mandatory values.

[c] 1 MPa = 1 N/mm².

[d] If U-notched Charpy test pieces are required, the minimum impact energy is subject to agreement.

[e] For round products up to 63 mm in diameter and flat products up to 35 mm thick.

Source: ISO 683-1:2016

Last checked: 2026.08.

Mechanical properties of non-alloy steels in the normalized condition

Steel designation[b]	*d* diameter or *t* thickness workpieces[a]								
	$d \le 16$ mm $t \le 16$ mm			16 mm < $d \le 100$ mm 16 mm < $t \le 100$ mm			100 mm < $d \le 250$ mm 100 mm < $t \le 250$ mm		
	R_{eH} min.	R_m min.	A min.	R_{eH} min.	R_m min.	A min.	R_{eH} min.	R_m min.	A min.
	MPa		%	MPa		%	MPa		%
C25	260	470	22	230	440	23	—	—	—
C30	280	510	20	250	480	21	230	460	21
C35	300	550	18	270	520	19	245	500	19
C40	320	580	16	290	550	17	260	530	17
C45	340	620	14	305	580	16	275	560	16
C50	355	650	12	320	610	14	290	590	14
C55	370	680	11	330	640	12	300	620	12
C60	380	710	10	340	670	11	310	650	11
Special steels									
C25E C25R	260	470	22	230	440	23	—	—	—
C30E C30R	280	510	20	250	480	21	230	460	21
C35E C35R	300	550	18	270	520	19	245	500	19
C40E C40R	320	580	16	290	550	17	260	530	17
C45E C45R	340	620	14	305	580	16	275	560	16
C50E C50R	355	650	12	320	610	14	290	590	14
C55E C55R	370	680	11	330	640	12	300	620	12
C60E C60R	380	710	10	340	670	11	310	650	11
23Mn6	—	—	—	—	—	—	—	—	—
28Mn6	345	630	17	310	600	18	290	590	18
36Mn6	—	—	—	—	—	—	—	—	—
42Mn6	—	—	—	—	—	—	—	—	—

[a] R_{eH}: upper yield strength or, if not present, the 0.2% proof strength $R_{p0.2}$; R_m: tensile strength; A: percentage elongation after fracture ($L_0 = 5.65(S_0)^{1/2}$)

[b] The table also applies to steels designated +H, +HH, and +HL.

Source: ISO 683-1:2016
Last checked: 2026.08.

Achievable surface hardness of non-alloy steels for quenching and tempering

Steel designation	**Surface hardness**[a] HRC min.
C35E/C35R	48
C45E/C45R	55
C50E/C50R	56
C55E/C55R	58

[a] The table values can be achieved by induction or flame hardening after quenching and tempering, followed by stress-relief heat treatment at 150–180°C for 1 hour. Applicable to sections up to 100 mm in diameter.

Source: ISO 683-1:2016
Last checked: 2026.08.

ISO 683-2:2016
Heat-treatable steels. alloy steels and free-cutting steels.
Part 2: Alloy steels for quenching and tempering

Chemical composition of alloy steels for quenching and tempering

Steel designation	Mass fraction[1] t%									
	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Other
Steels without boron										
34Cr4	0.30 – 0.37	0.10 – 0.40	0.60 – 0.90	0.025	0.035	0.90 – 1.20	—	—	0.40	—
34CrS4					0.020 – 0.040					
37Cr4	0.34 – 0.41	0.10 – 0.40	0.60 – 0.90	0.025	0.035	0.90 – 1.20	—	—	0.40	—
37CrS4					0.020 – 0.040					
41Cr4	0.38 – 0.45	0.10 – 0.40	0.60 – 0.90	0.025	0.035	0.90 – 1.20	—	—	0.40	—
41CrS4					0.020 – 0.040					
25CrMo4	0.22 – 0.29	0.10 – 0.40	0.60 – 0.90	0.025	0.035	0.90 – 1.20	0.15 – 0.30	—	0.40	—
25CrMoS4					0.020 – 0.040					
34CrMo4	0.30 – 0.37	0.10 – 0.40d	0.60 – 0.90	0.025	0.035	0.90 – 1.20	0.15 – 0.30	—	0.40	—
34CrMoS4					0.020 – 0.040					
42CrMo4	0.38 – 0.45	0.10 – 0.40	0.60 – 0.90	0.025	0.035	0.90 – 1.20	0.15 – 0.30	—	0.40	—
42CrMoS4					0.020 – 0.040					
50CrMo4	0.46 – 0.54	0.10 – 0.40	0.50 – 0.80	0.025	0.035	0.90 – 1.20	0.15 – 0.30	—	0.40	—
41CrNiMo2	0.37 – 0.44	0.10 – 0.40	0.70 – 1.00	0.025	0.035	0.40 – 0.60	0.15 – 0.30	0.40 – 0.70	0.40	—
41CrNiMoS2					0.020 – 0.040					
51CrV4	0.47 – 0.55	0.10 – 0.40	0.60 – 1.00	0.025	0.025	0.80 – 1.10	—	—	0.40	V: 0.10 – 0.25
36CrNiMo4	0.32 – 0.40	0.10 – 0.40	0.50 – 0.80	0.025	0.035	0.90 – 1.20	0.15 – 0.30	0.90 – 1.20	0.40	—
34CrNiMo6	0.30 – 0.38	0.10 – 0.40	0.50 – 0.80	0.025	0.035	1.30 – 1.70	0.15 – 0.30	1.30 – 1.70	0.40	—
30CrNiMo8	0.26 – 0.34	0.10 – 0.40	0.50 – 0.80	0.025	0.035	1.80 – 2.20	0.30 – 0.50	1.80 – 2.20	0.40	—
Steels with boron										
20MnB5	0.17 – 0.23	0.40	1.10 – 1.40	0.025	0.035	—	—	—	0.40	B: 0.0008 – 0.0050
30MnB5	0.27 – 0.33	0.40	1.15 – 1.45	0.025	0.035	—	—	—	0.40	B: 0.0008 – 0.0050
39MnB5	0.36 – 0.42	0.40	1.15 – 1.45	0.025	0.035	—	—	—	0.40	B: 0.0008 – 0.0050
27MnCrB5-2	0.24 – 0.30	0.40	1.10 – 1.40	0.025	0.035	0.30 – 0.60	—	—	0.40	B: 0.0008 – 0.0050
33MnCrB5-2	0.30 – 0.36	0.40	1.20 – 1.50	0.025	0.035	0.30 – 0.60	—	—	0.40	B: 0.0008 – 0.0050
39MnCrB6-2	0.36 – 0.42	0.40	1.40 – 1.70	0.025	0.035	0.30 – 0.60	—	—	0.40	B: 0.0008 – 0.0050

[1] maximum values unless otherwise indicated

Source: ISO 683-2:2016
Last checked: 2026.08.

+H alloy steels for quenching and tempering — hardness after the end-quench test

Steel designation	Designation	Range designation	HRC hardness measured from the quenched end (distance in mm)														
			1.5	3	5	7	9	11	13	15	20	25	30	35	40	45	50
Steels without boron																	
34Cr4 34CrS4	+H	max.	57	57	56	54	52	49	46	44	39	37	35	34	33	32	31
		min.	49	48	45	41	35	32	29	27	23	21	20	—	—	—	—
37Cr4 37CrS4	+H	max.	59	59	58	57	55	52	50	48	42	39	37	36	35	34	33
		min.	51	50	48	44	39	36	33	31	26	24	22	20	—	—	—
41Cr4 41CrS4	+H	max.	61	61	60	59	58	56	54	52	46	42	40	38	37	36	35
		min.	53	52	50	47	41	37	34	32	29	26	23	21	—	—	—
25CrMo4 25CrMoS4	+H	max.	52	52	51	50	48	46	43	41	37	35	33	32	31	31	31
		min.	44	43	40	37	34	32	29	27	23	21	20	—	—	—	—
34CrMo4 34CrMoS4	+H	max.	57	57	57	56	55	54	53	52	48	45	43	41	40	40	39
		min.	49	49	48	45	42	39	36	34	30	28	27	26	25	24	24
42CrMo4 42CrMoS4	+H	max.	61	61	61	60	60	59	59	58	56	53	51	48	47	46	45
		min.	53	53	52	51	49	43	40	37	34	32	31	30	30	29	29
50CrMo4	+H	max.	65	65	64	64	63	63	63	62	61	60	58	57	55	54	54
		min.	58	58	57	55	54	53	51	48	45	41	39	38	37	36	36
41CrNiMo2 41CrNiMoS2	+H	max.	60	60	60	59	58	57	55	54	48	42	40	38	37	37	36
		min.	53	53	52	50	47	42	38	35	30	28	26	25	24	24	23
51CrV4	+H	max.	65	65	64	64	63	62	62	61	60	58	57	55	54	53	53
		min.	57	56	55	54	53	52	50	48	44	41	37	35	34	33	32
36CrNiMo4	+H	max.	59	59	58	58	57	57	57	56	55	54	53	52	51	50	49
		min.	51	50	49	49	48	47	46	45	43	41	39	38	36	34	33
34CrNiMo6	+H	max.	58	58	58	58	57	57	57	57	57	57	57	57	57	57	57
		min.	50	50	50	50	49	48	48	48	48	47	47	47	46	45	44
30CrNiMo8	+H	max.	56	56	56	56	55	55	55	55	55	54	54	54	54	54	54
		min.	48	48	48	48	47	47	47	46	46	45	45	44	44	43	43
Steels with boron																	
20MnB5	+H	max.	50	49	49	49	47	45	43	41	33	27	—	—	—	—	—
		min.	42	41	40	37	30	22	—	—	—	—	—	—	—	—	—
30MnB5	+H	max.	56	55	55	54	53	51	50	47	40	37	33	—	—	—	—
		min.	47	46	45	44	42	39	36	31	22	—	—	—	—	—	—
39MnB5	+H	max.	60	60	59	58	57	57	55	53	48	41	37	33	31	—	—
		min.	52	51	50	49	47	44	41	35	28	24	20	—	—	—	—
27MnCrB5-2	+H	max.	55	55	55	54	54	53	52	51	47	44	40	37	—	—	—
		min.	47	46	45	44	43	41	39	36	30	24	20	—	—	—	—
33MnCrB5-2	+H	max.	57	57	57	57	57	56	55	54	53	50	47	45	—	—	—
		min.	48	47	47	46	45	44	43	41	36	31	25	20	—	—	—
39MnCrB6-2	+H	max.	59	59	59	59	58	58	58	58	57	57	56	55	54	—	—
		min.	51	51	51	51	50	50	50	49	47	45	40	35	32	—	—

Source: ISO 683-2:2016
Last checked: 2026.08.

+HH and +HL alloy steels for quenching and tempering — hardness after the end-quench test

Steel designation	esignation	Range designation	HRC hardness measured from the quenched end (distance in mm)														
			1.5	3	5	7	9	11	13	15	20	25	30	35	40	45	50
34Cr4 34CrS4	+HH	max.	57	57	56	54	52	49	46	44	39	37	35	34	33	32	31
		min.	52	51	49	45	41	38	35	33	28	26	25	24	23	22	21
	+HL	max.	54	54	52	50	46	43	40	38	34	32	30	29	28	27	26
		min.	49	48	45	41	35	32	29	27	23	21	20	—	—	—	—
37Cr4 37CrS4	+HH	max.	59	59	58	57	55	52	50	48	42	39	37	36	35	34	33
		min.	54	53	51	48	44	41	39	37	31	29	27	25	24	23	22
	+HL	max.	56	56	55	53	50	47	44	42	37	34	32	31	30	29	28
		min.	51	50	48	44	39	36	33	31	26	24	22	20	—	—	—
41Cr4 41CrS4	+HH	max.	61	61	60	59	58	56	54	52	46	42	40	38	37	36	35
		min.	56	55	53	51	47	43	41	39	35	31	29	27	26	25	24
	+HL	max.	58	58	57	55	52	50	47	45	40	37	34	32	31	30	29
		min.	53	52	50	47	41	37	34	32	29	26	23	21	—	—	—
25CrMo4 25CrMoS4	+HH	max.	52	52	51	50	48	46	43	41	37	35	33	32	31	31	31
		min.	47	46	44	41	39	37	34	32	28	26	24	23	22	22	22
	+HL	max.	49	49	47	46	43	41	38	36	32	30	29	28	27	27	27
		min.	44	43	40	37	34	32	29	27	23	21	20	—	—	—	—
34CrMo4 34CrMoS4	+HH	max.	57	57	57	56	55	54	53	52	48	45	43	41	40	40	39
		min.	52	52	51	49	46	44	42	40	36	34	32	31	30	29	29
	+HL	max.	54	54	54	52	51	49	47	46	42	39	38	36	35	35	34
		min.	49	49	48	45	42	39	36	34	30	28	27	26	25	24	24
42CrMo4 42CrMoS4	+HH	max.	61	61	61	60	60	59	59	58	56	53	51	48	47	46	45
		min.	56	56	55	54	52	48	46	44	41	39	38	36	36	35	34
	+HL	max.	58	58	58	57	56	54	53	51	49	46	44	42	41	40	40
		min.	53	53	52	51	49	43	40	37	34	32	31	30	30	29	29
50CrMo4	+HH	max.	65	65	64	64	63	63	63	62	61	60	58	57	55	54	54
		min.	60	60	59	58	57	56	55	53	50	47	45	44	43	42	42
	+HL	max.	63	63	62	61	60	60	59	57	56	54	52	51	49	48	48
		min.	58	58	57	55	54	53	51	48	45	41	39	38	37	36	36
41CrNiMo2 41CrNiMoS2	+HH	max.	60	60	60	59	58	57	55	54	48	42	40	38	37	37	36
		min.	55	55	55	53	51	47	44	41	36	33	31	29	28	28	27
	+HL	max.	58	58	57	56	54	52	49	48	42	37	35	34	33	33	32
		min.	53	53	52	50	47	42	38	35	30	28	26	25	24	24	23
51CrV4	+HH	max.	65	65	64	64	63	62	62	61	60	58	57	55	54	53	53
		min.	60	59	58	57	56	55	54	52	49	47	44	42	41	40	39
	+HL	max.	62	62	61	61	60	59	58	57	55	52	50	48	47	46	46
		min.	57	56	55	54	53	52	50	48	44	41	37	35	34	33	32
36CrNiMo4	+HH	max.	59	59	58	58	57	57	57	56	55	54	53	52	51	50	49
		min.	54	53	52	52	51	50	50	49	47	45	44	43	41	39	38
	+HL	max.	56	56	55	55	54	54	53	52	51	50	48	47	46	45	44
		min.	51	50	49	49	48	47	46	45	43	41	39	38	36	34	33
34CrNiMo6	+HH	max.	58	58	58	58	57	57	57	57	57	57	57	57	57	57	57
		min.	53	53	53	53	52	51	51	51	51	50	50	50	50	49	48
	+HL	max.	55	55	55	55	54	54	54	54	54	54	54	54	53	53	53
		min.	50	50	50	50	49	48	48	48	48	47	47	47	46	45	44
30CrNiMo8	+HH	max.	56	56	56	56	55	55	55	55	55	54	54	54	54	54	54
		min.	51	51	51	51	50	50	50	49	49	48	48	47	47	47	47
	+HL	max.	53	53	53	53	52	52	52	52	52	51	51	51	51	50	50
		min.	48	48	48	48	47	47	47	46	46	45	45	44	44	43	43

Source: ISO 683-2:2016
Last checked: 2026.08.

Heat-treatment data for alloy steels for quenching and tempering

Steel designation[a]	Austenitizing temperature[b,c]	Quenching medium[d]	Tempering temperature[e]	Austenitizing temperature for the end-quench test[f]
	°C	°C	°C	°C
34Cr4. 34CrS4	830 – 870	Water or oil	540 – 680	850 ± 5
37Cr4. 37CrS4	825 – 865	Oil or water	540 – 680	845 ± 5
41Cr4. 41CrS4	820 – 860	Oil or water	540 – 680	840 ± 5
25CrMo4 25CrMoS4	840 – 880	Water or oil	540 – 680	860 ± 5
34CrMo4 34CrMoS4	830 – 870	Oil or water	540 – 680	850 ± 5
42CrMo4 42CrMoS4	820 – 860	Oil or water	540 – 680	840 ± 5
50CrMo4	820 – 860	Oil	540 – 680	850 ± 5
41CrNiMo2 41CrNiMoS2	830 – 860	Oil or water	540 – 660	845 ± 5
51CrV4	820 – 860	Oil	540 – 680	850 ± 5
36CrNiMo4	820 – 850	Oil or water	540 – 680	850 ± 5
34CrNiMo6	830 – 860	Oil	540 – 660	845 ± 5
30CrNiMo8	830 – 860	Oil	540 – 660	845 ± 5
20MnB5	880 – 920	Water	400 – 600	900 ± 5
30MnB5	860 – 900	Water	400 – 600	880 ± 5
39MnB5	840 – 880	Water or oil	400 – 600	850 ± 5
27MnCrB5–2	880 – 920	Water or oil	400 – 600	900 ± 5
33MnCrB5–2	860 – 900	Oil	400 – 600	880 ± 5
39MnCrB6–2	840 – 880	Oil	400 – 600	850 ± 5

The stated temperatures are provided as guidance. The exact temperature must be selected according to the required properties.

[a] The table also applies to steels designated +H. +HH. and +HL.

[b] Hardening from temperatures at the lower end of the ranges generally uses water cooling, while temperatures at the upper end use oil.

[c] Austenitizing-temperature holding time: at least 30 minutes.

[d] When selecting the quenching medium, its effect on other parameters must also be considered, including shape, size, hardening temperature, and susceptibility to cracking. Other quenching media may also be used.

[e] The tempering time is at least 1 hour.

[f] The specified austenitizing time is 30–35 perc. Applies only to the Jominy test.

Source: ISO 683-2:2016
Last checked: 2026.08.

Mechanical properties of alloy steels in the quenched and tempered condition

Steel designation	d diameter or t thickness workpieces[a]																								
	$d \le 16$ mm $t \le 8$ mm					16 mm < $d \le 40$ mm 8 mm < $t \le 20$ mm					40 mm < $d \le 100$ mm 20 mm < $t \le 60$ mm					100 mm < $d \le 160$ mm 60 mm < $t \le 100$ mm					160 mm < $d \le 250$ mm 100 mm < $t \le 160$ mm				
	$R_{p0.2}$	R_m	A	Z[b]	KV_2[d]	$R_{p0.2}$	R_m	A	Z[b]	KV_2[d]	$R_{p0.2}$	R_m	A	Z[b]	KV_2[d]	$R_{p0.2}$	R_m	A	Z[b]	KV_2[d]	$R_{p0.2}$	R_m	A	Z[b]	KV_2[d]
	min.		min.	min.	min.	min.		min.	min.	min.	min.		min.	min.	min.	min.		min.	min.	min.	min.		min.	min.	min.
	MPa[c]		%	%	J	MPa[c]		%	%	J	MPa[c]		%	%	J	MPa[c]		%	%	J	MPa[c]		%	%	J
34Cr4 34CrS4	700	900 – 1100	12	35	—	590	800 – 950	14	40	40	460	700 – 850	15	45	40	—	—	—	—	—	—	—	—	—	—
37Cr4 37CrS4	750	950 – 1150	11	35	—	630	850 – 1000	13	40	35	510	750 – 900	14	40	35	—	—	—	—	—	—	—	—	—	—
41Cr4 41CrS4	800	1000 – 1200	11	30	—	660	900 – 1100	12	35	35	560	800 – 950	14	40	35	—	—	—	—	—	—	—	—	—	—
25CrMo4 25CrMoS4	700	900 – 1100	12	50	—	600	800 – 950	14	55	50	450	700 – 850	15	60	50	400	650 – 800	16	60	45	—	—	—	—	—
34CrMo4 34CrMoS4	800	1000 – 1200	11	45	—	650	900 – 1100	12	50	40	550	800 – 950	14	55	45	500	750 – 900	15	55	45	450	700 – 850	15	60	45
42CrMo4 42CrMoS4	900	1100 – 1300	10	40	—	750	1000 – 1200	11	45	35	650	900 – 1100	12	50	35	550	800 – 950	13	50	35	500	750 – 900	14	55	35
50CrMo4	900	1100 – 1300	9	40	—	780	1000 – 1200	10	45	30	700	900 – 1100	12	50	30	650	850 – 1000	13	50	30	550	800 – 950	13	50	30
41CrNiMo2 41CrNiMoS2	840	1000 – 1200	10	—	—	740	900 – 1100	11	—	—	640	800 – 950	12	—	—	540	750 – 900	13	—	—	—	—	—	—	—
51CrV4	900	1100 – 1300	9	40	—	800	1000 – 1200	10	45	30	700	900 – 1100	12	50	30	650	850 – 1000	13	50	30	600	800 – 950	13	50	30
36CrNiMo4	900	1100 – 1300	10	—	—	800	1000 – 1200	11	—	—	700	900 – 1100	12	—	—	600	800 – 950	13	—	—	550	750 – 900	14	—	—
34CrNiMo6	1 000	1200 – 1400	9	40	—	900	1100 – 1300	10	45	45	800	1000 – 1200	11	50	45	700	900 – 1100	12	55	45	600	800 – 950	13	55	45
30CrNiMo8	850	1030 – 1230	12	40	—	850	1030 – 1230	12	40	30	800	980 – 1180	12	45	35	800	980 – 1180	12	50	45	750	930 – 1130	12	50	45
20MnB5	700	900 – 1050	14	55	—	600	750 – 900	15	55	60	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
30MnB5	800	950 – 1150	13	50	—	650	800 – 950	13	50	60	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
39MnB5	900	1050 – 1250	12	50	—	700	850 – 1050	12	50	60	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
27MnCrB5-2	800	1000 – 1250	14	55	—	750	900 – 1150	14	55	60	700e	800 – 1000e	15e	55e	65e	—	—	—	—	—	—	—	—	—	—
33MnCrB5-2	850	1050 – 1300	13	50	—	800	950 – 1200	13	50	50	750e	900 – 1100e	13e	50e	50e	—	—	—	—	—	—	—	—	—	—
39MnCrB6-2	900	1100 – 1350	12	50	—	850	1050 – 1250	12	50	40	800e	1000 – 1200e	12e	50e	40e	—	—	—	—	—	—	—	—	—	—

[a] $R_{p0.2}$: 0.2% proof strength; R_m: tensile strength; A: percentage elongation after fracture ($L_0 = 5.65(S_0)^{1/2}$); Z: percentage reduction of area after fracture. KV_2: impact energy of V-notched Charpy test pieces using a 2 mm striker radius; the value is the average of three tests, with no individual value below 70% of the average.

[b] Non-mandatory values.

[c] 1 MPa = 1 N/mm².

[d] If U-notched Charpy test pieces are required, the minimum impact energy is subject to agreement.

[e] For round products up to 63 mm in diameter and flat products up to 35 mm thick.

Source: ISO 683-2:2016
Last checked: 2026.08.

Achievable surface hardness of alloy steels for quenching and tempering

Steel designation	**Surface hardness**[a] HRC min.
37Cr4/37CrS4	51
41Cr4/41CrS4	53
42CrMo4/42CrMoS4	53
50CrMo4	58

[a] The table values can be achieved by induction or flame hardening after quenching and tempering, followed by stress-relief heat treatment at 150–180°C for 1 hour. For grades 37Cr4/37CrS4 and 41Cr4/41CrS4, the values apply to sections up to 100 mm in diameter; for 42CrMo4/42CrMoS4 and 50CrMo4, they apply up to 250 mm.

Source: ISO 683-2:2016
Last checked: 2026.08.

ISO 683-3:2022
Heat-treatable steels. alloy steels and free-cutting steels.
Part 3: Case-hardening steels

Chemical composition of case-hardening steels

Steel designation	Mass fraction[1] t%									
	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	B
Non-alloy case-hardening steels										
C10E	0.07 – 0.13	0.40	0.30 – 0.60	0.025	0.035	0.40	0.10	0.40	0.30	—
C10R					0.020 – 0.040					
C15E	0.12 – 0.18	0.40	0.30 – 0.60	0.025	0.035	0.40	0.10	0.40	0.30	—
C15R					0.020 – 0.040					
C16E	0.12 – 0.18	0.40	0.60 – 0.90	0.025	0.035	0.40	0.10	0.40	0.30	—
C16R					0.020 – 0.040					
22Mn6	0.18 – 0.25	0.40	1.30 – 1.65	0.025	0.035	0.40	0.10	0.40	0.30	—
Alloy case-hardening steels										
17Cr3	0.12 – 0.20	0.40	0.60 – 0.90	0.025	0.035	0.70 – 1.25	—	—	0.40	—
17CrS3					0.020 – 0.040					
20Cr4	0.17 – 0.23	0.40	0.60 – 0.90	0.025	0.035	0.90 – 1.20	—	—	0.40	—
20CrS4					0.020 – 0.040					
28Cr4	0.24 – 0.31	0.40	0.60 – 0.90	0.025	0.035	0.90 – 1.20	—	—	0.40	—
28CrS4					0.020 – 0.040					
16MnCr5	0.14 – 0.19	0.40	1.00 – 1.30	0.025	0.035	0.80 – 1.10	—	—	0.40	—
16MnCrS5					0.020 – 0.040					
16MnCrB5	0.14 – 0.19	0.40	1.00 – 1.30	0.025	0.035	0.80 – 1.10	—	—	0.40	0.0008 – 0.0050
20MnCr5	0.17 – 0.22	0.40	1.10 – 1.40	0.025	0.035	1.00 – 1.30	—	—	0.40	—
20MnCrS5					0.020 – 0.040					
18CrMo4	0.15 – 0.21	0.40	0.60 – 0.90	0.025	0.035	0.90 – 1.20	0.15 – 0.25	—	0.40	—
18CrMoS4					0.020 – 0.040					
24CrMo4	0.20 – 0.27	0.40	0.60 – 0.90	0.025	0.035	0.90 – 1.20	0.15 – 0.30	—	0.40	—
24CrMoS4					0.020 – 0.040					
22CrMoS3–5	0.19 – 0.24	0.40	0.70 – 1.00	0.025	0.020 – 0.040	0.70 – 1.00	0.40 – 0.50	—	0.40	—
20MoCr4	0.17 – 0.23	0.40	0.70 – 1.00	0.025	0.035	0.30 – 0.60	0.40 – 0.50	—	0.40	—
20MoCrS4					0.020 – 0.040					
16NiCr4	0.13 – 0.19	0.40	0.70 – 1.00	0.025	0.035	0.60 – 1.00	—	0.80 – 1.10	0.40	—
16NiCrS4					0.020 – 0.040					
18NiCr5–4	0.16 – 0.21	0.40	0.60 – 0.90	0.025	0.035	0.90 – 1.20	—	1.20 – 1.50	0.40	—
17CrNi6–6	0.14 – 0.20	0.40	0.50 – 0.90	0.025	0.035	1.40 – 1.70	—	1.40 – 1.70	0.40	—
15NiCr13	0.12 – 0.18	0.40	0.35 – 0.65	0.025	0.035	0.60 – 0.90	—	3.00 – 3.50	0.40	—
20NiCrMo2–2	0.17 – 0.23	0.40	0.65 – 0.95	0.025	0.035	0.35 – 0.70	0.15 – 0.25	0.40 – 0.70	0.40	—
20NiCrMoS2–2					0.020 – 0.040					
17NiCrMo6–4	0.14 – 0.20	0.40	0.60 – 0.90	0.025	0.035	0.80 – 1.10	0.15 – 0.25	1.20 – 1.60	0.40	—
17NiCrMoS6–4					0.020 – 0.040					
23MnCrMo5–5–4	0.20 – 0.25	0.40	1.10 – 1.40	0.025	0.035	1.10 – 1.40	0.20 – 0.50	0.60	0.40	—
18CrNiMo7–6	0.15 – 0.21	0.40	0.50 – 0.90	0.025	0.035	1.50 – 1.80	0.25 – 0.35	1.40 – 1.70	0.40	—

[1] maximum values unless otherwise indicated

Source: ISO 683-3:2022
Last checked: 2026.08.

+H case-hardening steels — hardness after the end-quench test

Steel designation	Desig nation	Range designation	HRC hardness measured from the quenched end (distance in mm)												
			1.5	3	5	7	9	11	13	15	20	25	30	35	40
17Cr3 17CrS3	+H	max.	47	44	40	33	29	27	25	24	23	21	—	—	—
		min.	39	35	25	20	—	—	—	—	—	—	—	—	—
20Cr4 20CrS4	+H	max.	49	48	46	42	38	36	34	32	29	27	26	24	23
		min.	41	38	31	26	23	21	—	—	—	—	—	—	—
28Cr4 28CrS4	+H	max.	53	52	51	49	45	42	39	36	33	30	29	28	27
		min.	45	43	39	29	25	22	20	—	—	—	—	—	—
16MnCr5 16MnCrS5 16MnCrB5	+H	max.	47	46	44	41	39	37	35	33	31	30	29	28	27
		min.	39	36	31	28	24	21	—	—	—	—	—	—	—
20MnCr5 20MnCrS5	+H	max.	49	49	48	46	43	42	41	39	37	35	34	33	32
		min.	41	39	36	33	30	28	26	25	23	21	—	—	—
18CrMo4 18CrMoS4	+H	max.	47	46	45	42	39	37	35	34	31	29	28	27	26
		min.	39	37	34	30	27	24	22	21	—	—	—	—	—
24CrMo4 24CrMoS4	+H	max.	52	52	51	50	48	46	43	41	37	35	33	32	31
		min.	44	43	40	37	34	32	29	27	23	21	20	—	—
22CrMoS3–5	+H	max.	50	49	48	47	45	43	41	40	37	35	34	33	32
		min.	42	41	37	33	31	28	26	25	23	22	21	20	—
20MoCr4 20MoCrS4	+H	max.	49	47	44	41	38	35	33	31	28	26	25	24	24
		min.	41	37	31	27	24	22	—	—	—	—	—	—	—
16NiCr4 16NiCrS4	+H	max.	47	46	44	42	40	38	36	34	32	30	29	28	28
		min.	39	36	33	29	27	25	23	22	20	—	—	—	—
18NiCr5–4	+H	max.	49	48	46	44	42	39	37	36	34	32	31	31	30
		min.	41	39	35	32	29	27	25	24	21	20	—	—	—
17CrNi6–6	+H	max.	47	47	46	45	43	42	41	39	37	35	34	34	33
		min.	39	38	36	35	32	30	28	26	24	22	21	20	20
15NiCr13	+H	max.	46	46	46	46	45	44	43	41	38	35	34	34	33
		min.	38	37	36	34	31	29	27	26	24	22	22	21	21
20NiCrMo2–2 20NiCrMoS2–2	+H	max.	49	48	45	42	36	33	31	30	27	25	24	24	23
		min.	41	37	31	25	22	20	—	—	—	—	—	—	—
17NiCrMo6–4 17NiCrMoS6–4	+H	max.	48	48	47	46	45	44	42	41	38	36	35	34	33
		min.	40	39	37	34	30	28	27	26	24	23	22	21	—
23MnCr-Mo5–5–4	+H	max.	48	48	48	48	47	47	46	46	44	43	42	41	41
		min.	40	40	39	38	37	36	35	34	32	31	30	29	29
18CrNiMo7–6	+H	max.	48	48	48	48	47	47	46	46	44	43	42	41	41
		min.	40	40	39	38	37	36	35	34	32	31	30	29	29

Source: ISO 683-3:2022
Last checked: 2026.08.

+HH and +HL case-hardening steels — hardness after the end-quench test

Steel designation	Designation	Range designation	HRC hardness measured from the quenched end (distance in mm)												
			1.5	3	5	7	9	11	13	15	20	25	30	35	40
17Cr3 17CrS3	+HH	max.	47	44	40	33	29	27	25	24	23	21	—	—	—
		min.	42	38	30	24	20	—	—	—	—	—	—	—	—
	+HL	max.	44	41	35	29	25	23	21	20	—	—	—	—	—
		min.	39	35	25	20	—	—	—	—	—	—	—	—	—
20Cr4 20CrS4	+HH	max.	49	48	46	42	38	36	34	32	29	27	26	24	23
		min.	44	41	36	31	28	26	24	22	—	—	—	—	—
	+HL	max.	46	45	41	37	33	31	29	27	24	22	21	—	—
		min.	41	38	31	26	23	21	—	—	—	—	—	—	—
28Cr4 28CrS4	+HH	max.	53	52	51	49	45	42	39	38	33	30	29	28	27
		min.	48	46	43	36	32	29	26	23	20	—	—	—	—
	+HL	max.	50	49	47	42	38	35	33	30	27	24	23	22	21
		min.	45	43	39	29	25	22	20	—	—	—	—	—	—
16MnCr5 16MnCrS5 16MnCrB5	+HH	max.	47	46	44	41	39	37	35	33	31	30	29	28	27
		min.	42	39	35	32	29	26	24	22	20	—	—	—	—
	+HL	max.	44	43	40	37	34	32	30	28	26	25	24	23	22
		min.	39	36	31	28	24	21	—	—	—	—	—	—	—
20MnCr5 20MnCrS5	+HH	max.	49	49	48	46	43	42	41	39	37	35	34	33	32
		min.	44	42	40	37	34	33	31	30	28	26	25	24	23
	+HL	max.	46	46	44	42	39	37	36	34	32	30	29	28	27
		min.	41	39	36	33	30	28	26	25	23	21	—	—	—
18CrMo4 18CrMoS4	+HH	max.	47	46	45	42	39	37	35	34	31	29	28	27	26
		min.	42	40	38	34	31	28	26	25	22	20	—	—	—
	+HL	max.	44	43	41	38	35	33	31	30	27	25	24	23	22
		min.	39	37	34	30	27	24	22	21	—	—	—	—	—
24CrMo4 24CrMoS4	+HH	max.	52	52	51	50	48	46	43	41	37	35	33	32	31
		min.	47	46	44	41	39	37	34	32	28	26	24	23	22
	+HL	max.	49	49	47	46	43	41	38	36	32	30	29	28	27
		min.	44	43	40	37	34	32	29	27	23	21	20	—	—
22CrMoS3–5	+HH	max.	50	49	48	47	45	43	41	40	37	35	34	33	32
		min.	45	44	41	38	36	33	31	30	28	26	25	24	23
	+HL	max.	47	46	44	42	40	38	36	35	32	31	30	29	28
		min.	42	41	37	33	31	28	26	25	23	22	21	20	—
20MoCr4 20MoCrS4	+HH	max.	49	47	44	41	38	35	33	31	28	26	25	24	24
		min.	44	40	35	32	29	26	24	22	—	—	—	—	—
	+HL	max.	46	44	40	36	33	31	29	27	24	22	21	20	20
		min.	41	37	31	27	24	22	—	—	—	—	—	—	—
16NiCr4 16NiCrS4	+HH	max.	47	46	44	42	40	38	36	34	32	30	29	28	28
		min.	42	39	37	33	31	29	27	26	24	22	21	20	20
	+HL	max.	44	43	40	38	36	34	32	30	28	26	25	24	24
		min.	39	36	33	29	27	25	23	22	20	—	—	—	—
18NiCr5–4	+HH	max.	49	48	46	44	42	39	37	36	34	32	31	31	30
		min.	44	42	39	36	33	31	29	28	25	24	23	23	22
	+HL	max.	46	45	42	40	38	35	33	32	30	28	27	27	26
		min.	41	39	35	32	29	27	25	24	21	20	—	—	—
17CrNi6–6	+HH	max.	47	47	46	45	43	42	41	39	37	35	34	34	33
		min.	42	41	39	38	36	34	32	30	28	26	25	25	24
	+HL	max.	44	44	43	42	39	38	37	35	33	31	30	29	29
		min.	39	38	36	35	32	30	28	26	24	22	21	20	20

+HH and +HL case-hardening steels — hardness after the end-quench test

Steel designation	Designation	Range designation	HRC hardness measured from the quenched end (distance in mm)												
			1.5	3	5	7	9	11	13	15	20	25	30	35	40
15NiCr13	+HH	max.	46	46	46	46	45	44	43	41	38	35	34	34	33
		min.	41	40	39	38	36	34	32	31	29	26	26	25	25
	+HL	max.	43	43	43	42	40	39	38	36	33	31	30	30	29
		min.	38	37	36	34	31	29	27	26	24	22	22	21	21
20NiCrMo2–2 20NiCrMoS2–2	+HH	max.	49	48	45	42	36	33	31	30	27	25	24	24	23
		min.	44	41	36	31	27	24	22	21	—	—	—	—	—
	+HL	max.	46	44	40	36	31	29	27	26	23	21	20	20	—
		min.	41	37	31	25	22	20	—	—	—	—	—	—	—
17NiCrMo6–4 17NiCrMoS6–4	+HH	max.	48	48	47	46	45	44	42	41	38	36	35	34	33
		min.	43	42	40	38	35	33	32	31	29	27	26	25	24
	+HL	max.	45	45	44	42	40	39	37	36	33	32	31	30	29
		min	40	39	37	34	30	28	27	26	24	23	22	21	—
23MnCrMo5–5–4	+HH	max.	48	48	48	48	47	47	46	46	44	43	42	41	41
		min.	43	43	42	41	40	40	39	38	36	35	34	33	33
	+HL	max.	45	45	45	45	44	43	42	42	40	39	38	37	37
		min.	40	40	39	38	37	36	35	34	32	31	30	29	29
18CrNiMo7–6	+HH	max.	48	48	48	48	47	47	46	46	44	43	42	41	41
		min.	43	43	42	41	40	40	39	38	36	35	34	33	33
	+HL	max.	45	45	45	45	44	43	42	42	40	39	38	37	37
		min.	40	40	39	38	37	36	35	34	32	31	30	29	29

Source: ISO 683-3:2022
Last checked: 2026.08.

Heat-treatment data for case-hardening steels

Steel designation	Austenitizing temperature for the end-quench test[a]	Carburizing temperature[b]	Direct-hardening temperature[c,d]	Double hardening		Tempering temperature[e]
				Core-hardening temperature[d]	Case-hardening temperature[d]	
	°C	°C	°C	°C	°C	°C
Non-alloy case-hardening steels						
C10E C10R	—	880 – 980	830 – 870	880 – 920	780 – 820	150 – 200
C15E C15R	—	880 – 980	830 – 870	880 – 920	780 – 820	150 – 200
C16E C16R	—	880 – 980	830 – 870	880 – 920	780 – 820	150 – 200
22Mn6	—	880 – 980	830 – 870	880 – 920	780 – 820	150 – 200
Alloy case-hardening steels						
17Cr3 17CrS3	880 ± 5	880 – 980	820 – 860	860 – 900	780 – 820	150 – 200
20Cr4 20CrS4	900 ± 5	880 – 980	820 – 860	860 – 900	780 – 820	150 – 200
28Cr4 28CrS4	850 ± 5	880 – 980	820 – 860	860 – 900	780 – 820	150 – 200
16MnCr5 16MnCrS5 16MnCrB5	900 ± 5	880 – 980	820 – 860	860 – 900	780 – 820	150 – 200
20MnCr5 20MnCrS5	900 ± 5	880 – 980	820 – 860	860 – 900	780 – 820	150 – 200
18CrMo4 18CrMoS4	900 ± 5	880 – 980	820 – 860	860 – 900	780 – 820	150 – 200
24CrMo4 24CrMoS4	900 ± 5	880 – 980	820 – 860	860 – 900	780 – 820	150 – 200
22CrMoS3–5	900 ± 5	880 – 980	820 – 860	860 – 900	780 – 820	150 – 200
20MoCr4 20MoCrS4	910 ± 5	880 – 980	820 – 860	860 – 900	780 – 820	150 – 200
16NiCr4 16NiCrS4	880 ± 5	880 – 980	820 – 860	850 – 890	780 – 820	150 – 200
18NiCr5–4	880 ± 5	880 – 980	820 – 860	840 – 880	780 – 820	150 – 200
17CrNi6–6	870 ± 5	880 – 980	820 – 860	830 – 870	780 – 820	150 – 200
15NiCr13	850 ± 5	880 – 980	810 – 850	840 – 880	780 – 820	150 – 200
20NiCrMo2–2 20NiCrMoS2–2	900 ± 5	880 – 980	820 – 860	860 – 900	780 – 820	150 – 200
17NiCrMo4–6 17NiCrMoS4–6	900 ± 5	880 – 980	810 – 850	830 – 870	780 – 820	150 – 200
23MnCrMo5–5–4	860 ± 5	880 – 1050	860 – 900	890 – 920	780 – 820	150 – 200
18CrNiMo7–6	860 ± 5	880 – 980	810 – 850	830 – 870	780 – 820	150 – 200

The stated temperatures are provided as guidance. The exact temperature must be selected according to the required properties.

[a] Austenitizing-temperature holding time: at least 30 minutes.

[b] The carburizing temperature depends on the steel composition, workpiece mass, and carburizing medium. If direct hardening follows, the carburizing temperature generally does not exceed 950°C. For special processes, such as vacuum carburizing, higher temperatures (1020–1050°C) are uncommon.

[c] The quenching medium depends, for example, on workpiece shape, cooling characteristics, and furnace load.

[d] Direct hardening may cause distortion; select a temperature between the core-hardening and case-hardening temperatures.

[e] The tempering time is at least 1 hour.

Source: ISO 683-3:2022
Last checked: 2026.08.

Achievable tensile strength of case-hardening steels after tempering at 200°C

R_m MPa min.	$d \leq 16$ mm	16 mm < $d \leq 40$ mm	40 mm < $d \leq 100$ mm
1 200	20MnCr5. 20MnCrS5. 17NiCrMo6–4. 17NiCrMoS6–4. 18NiCr5–4. 17CrNi6–6. 23MnCrMo5–5–418CrNiMo7–6		
1 100	22CrMoS3–5. 18CrMo4. 18CrMoS4. 20NiCrMo2–2. 20NiCrMoS2–2	18NiCr5–4. 17CrNi6–6. 23MnCrMo5–5–4. 18CrNiMo7–6	
1 000	15NiCr13. 16MnCr5. 16MnCrS5. 16MnCrB5. 16NiCr4. 16NiCrS4	17NiCrMo6–4. 17NiCrMoS6–4	
900	20MoCr4. 20MoCrS4. 28Cr4. 28CrS4	20MnCr5. 20MnCrS5. 22CrMoS3–5	
800	C16E. C16R. 17Cr3. 17CrS3. C15E. C15R	18CrMo4. 18CrMoS4. 15NiCr13. 16MnCr5. 16MnCrS5. 16MnCrB5. 16NiCr4. 16NiCrS4 20NiCrMo2–2. 20NiCrMoS2–2. 20MoCr4. 20MoCrS4	18NiCr5–4. 17CrNi6–6. 18CrNiMo7–6. 22CrMoS3–5. 23MnCrMo5–5–4. 17NiCrMo6–4. 17NiCrMoS6–4
700		28Cr4. 28CrS4	15NiCr13. 20MnCr5. 20MnCrS5
600		17Cr3. 17CrS3. C16E. C16R. C15E. C15R	18CrMo4. 18CrMoS4. 20NiCrMo2–2. 20NiCrMoS2–2. 28Cr4. 28CrS4. 16MnCr5. 16MnCrS5. 16MnCrB5
500	C10E. C10R		
400		C10E. C10R	

Source: ISO 683-3:2022
Last checked: 2026.08.

ISO 4957:2018
Tool steels

Composition, heat treatment, and hardness of non-alloy cold-work tool steels

Steel designation	Mass fraction. t%					Hardness (annealed)[a] +A HBW max.	Hardening			
	C	Si	Mn	P max.	S max.		Austenitizing temperature °C (±10 °C)	Quenching medium	Tempering temperature °C (±10 °C)	Hardness HRC min.
C45U	0.42 – 0.50	0.15 – 0.40	0.60 – 0.80	0.030	0.030	207	810	Water	180	54
C70U[b]	0.65 – 0.75	0.10 – 0.30	0.10 – 0.40	0.030	0.030	183	800	Water	180	57
C80U[b]	0.75 – 0.85	0.10 – 0.30	0.10 – 0.40	0.030	0.030	192	790	Water	180	58
C90U[b]	0.85 – 0.95	0.10 – 0.30	0.10 – 0.40	0.030	0.030	207	780	Water	180	60
C105U[b]	1.00 – 1.10	0.10 – 0.30	0.10 – 0.40	0.030	0.030	212	780	Water	180	61
C120U[b]	1.15 – 1.25	0.10 – 0.30	0.10 – 0.40	0.030	0.030	217	770	Water	180	62

Elements not specified in the table must not be intentionally added without agreement with the purchaser, except in quantities required to complete the heat treatment.

[a] In the cold-drawn condition (+A+C), hardness may be 20 HBWhigher than in the annealed condition (+A).

[b] Steel grades C70U to C120U are shallow-hardening steels. On 30 mm diameter specimens, hardness must be measured at a depth of approximately 3 mm. The maximum through-hardening diameter is 10 mm.

Source: ISO 4957:2018
Last checked: 2026.08.

Composition, heat treatment, and hardness of alloy cold-work tool steels

Steel designation	Mass fraction[a]. t%								Hardness (annealed)[b] +A HBW max.	Hardening			
	C	Si	Mn	Cr	Mo	Ni	V	W		Austenitizing temperature °C (±10 °C)	Quenching medium	Tempering temperature °C (±10 °C)	Hardness HRC min.
105V	1.00 – 1.10	0.10 – 0.30	0.10 – 0.40	—	—	—	0.10 – 0.20	—	212	790	Water	180	61
50WCrV8	0.45 – 0.55	0.70 – 1.00	0.15 – 0.45	0.90 – 1.20	—	—	0.10 – 0.20	1.70 – 2.20	229	920	Oil	180	56
60WCrV8	0.55 – 0.65	0.70 – 1.00	0.15 – 0.45	0.90 – 1.20	—	—	0.10 – 0.20	1.70 – 2.20	229	910	Oil	180	58
102Cr6	0.95 – 1.10	0.15 – 0.35	0.25 – 0.45	1.35 – 1.65	—	—	—	—	223	840	Oil	180	60
21MnCr5	0.18 – 0.24	0.15 – 0.35	1.10 – 1.40	1.00 – 1.30	—	—	—	—	217	—[c]	—[c]	—[c]	—[c]
70MnMoCr8	0.65 – 0.75	0.10 – 0.50	1.80 – 2.50	0.90 – 1.20	0.90 – 1.40	—	—	—	248	835	Air	180	58
90MnCrV8	0.85 – 0.95	0.10 – 0.40	1.80 – 2.20	0.20 – 0.50	—	—	0.05 – 0.20	—	229	790	Oil	180	60
95MnWCr5	0.90 – 1.00	0.10 – 0.40	1.05 – 1.35	0.40 – 0.65	—	—	0.05 – 0.20	0.40 – 0.70	229	800	Oil	180	60
X100CrMoV5	0.95 – 1.05	0.10 – 0.40	0.40 – 0.80	4.80 – 5.50	0.90 – 1.20	—	0.15 – 0.35	—	241	970	Air	180	60
X153CrMoV12	1.45 – 1.60	0.10 – 0.60	0.20 – 0.60	11.0 – 13.0	0.70 – 1.00	—	0.70 – 1.00	—	255	1 020	Air	180	61
X210Cr12	1.90 – 2.20	0.10 – 0.60	0.20 – 0.60	11.0 – 13.0	—	—	—	—	248	970	Oil	180	62
X210CrW12	2.00 – 2.30	0.10 – 0.40	0.30 – 0.60	11.0 – 13.0	—	—	—	0.60 – 0.80	255	970	Oil	180	62
35CrMo7[d]	0.30 – 0.40	0.30 – 0.70	0.60 – 1.00	1.50 – 2.00	0.35 – 0.55	—	—	—	—[d]	—	—	—	—[d]
40CrMnNiMo8-6-4[d,e]	0.35 – 0.45	0.20 – 0.40	1.30 – 1.60	1.80 – 2.10	0.15 – 0.25	0.90 – 1.20f	—	—	—[d]	—	—	—	—[d]
45NiCrMo16	0.40 – 0.50	0.10 – 0.40	0.20 – 0.50	1.20 – 1.50	0.15 – 0.35	3.80 – 4.30	—	—	285	850	Oil	180	52
X40Cr14[f]	0.36 – 0.42	≤ 1.00	≤ 1.00	12.5 – 14.5	—	—	—	—	241	1 010	Oil	180	52
X38CrMo16[d,e]	0.33 – 0.45	≤ 1.00	≤ 1.50	15.5 – 17.5	0.80 – 1.30	≤ 1.00	—	—	—[d]	—	—	—	—[d]

[a] For all steels, phosphorus and sulfur contents are ≤ 0.030 mass%.
[b] In the cold-drawn condition (+A+C), hardness may be 20 HBWhigher than in the annealed condition (+A).
[c] After carburizing, hardening, and tempering, this material reaches 60 HRC.
[d] This steel is generally supplied quenched and tempered to approximately 300 HBW.
[e] By agreement, the sulfur content may be increased to 0.050–0.100 mass%. and Ni may be omitted.
[f] This steel may also be supplied pre-heat-treated to approximately 300 HBW.

Source: ISO 4957:2018
Last checked: 2026.08.

Composition, heat treatment, and hardness of hot-work tool steels

Steel designaetion	Mass fraction[a]. t%								Hardness (annealed)[b] +A HBW max.	Hardening			
	C	Si	Mn	Cr	Mo	V	W	Other		Ausztenitizing temperature °C (±10 °C)	Quenching medium	Tempering temperature °C (±10 °C)	Hardness HRC min.
55NiCrMoV7[c,d]	0.50 – 0.60	0.10 – 0.40	0.60 – 0.90	0.80 – 1.20	0.35 – 0.55	0.05 – 0.15	—	Ni: 1.50 – 1.80	248[d]	850	Oil	500	42[e]
32CrMoV12-28	0.28 – 0.35	0.10 – 0.40	0.15 – 0.45	2.70 – 3.2	2.50 – 3.00	0.40 – 0.70	—	—	229	1 040	Oil	550	46
X37CrMoV5-1	0.33 – 0.41	0.80 – 1.20	0.25 – 0.50	4.8 – 5.5	1.10 – 1.50	0.30 – 0.50	—	—	229	1 020	Oil	550	48
X38CrMoV5-3	0.35 – 0.40	0.30 – 0.50	0.30 – 0.50	4.8 – 5.2	2.70 – 3.2	0.40 – 0.60	—	—	229	1 040	Oil	550	50
X40CrMoV5-1	0.35 – 0.42	0.80 – 1.20	0.25 – 0.50	4.8 – 5.5	1.20 – 1.50	0.85 – 1.15	—	—	229	1 020	Oil	550	50
50CrMoV13-15	0.45 – 0.55	0.20 – 0.80	0.50 – 0.90	3.0 – 3.5	1.30 – 1.70	0.15 – 0.35	—	—	248	1 010	Oil	510	56
X30WCrV9-3	0.25 – 0.35	0.10 – 0.40	0.15 – 0.45	2.5 – 3.2	—	0.30 – 0.50	8.5 – 9.5	—	241	1 150	Oil	600	48
X35CrWMoV5	0.32 – 0.40	0.80 – 1.20	0.20 – 0.50	4.75 – 5.5	1.25 – 1.60	0.20 – 0.50	1.10 – 1.60	—	229	1 020	Oil	550	48
38CrCoWV18-17-17	0.35 – 0.45	0.15 – 0.50	0.20 – 0.50	4.0 – 4.7	0.30 – 0.50	1.70 – 2.10	3.8 – 4.5	Co: 4.0 – 4.5	260	1 120	Oil	600	48

Elements not specified in the table must not be intentionally added without agreement with the purchaser, except in quantities required to complete the heat treatment.

[a] For all steels. phosphorus content is ≤ 0.030 mass% and sulfur content is ≤ 0.020 mass%.

[b] In the cold-drawn condition (+A+C), hardness may be 20 HBWhigher than in the annealed condition (+A).

[c] The sulfur content of this material is ≤ 0.030 mass%.

[d] In larger sizes, it is supplied quenched and tempered to approximately 380 HBW.

[e] This value applies only to smaller sizes.

Source: ISO 4957:2018
Last checked: 2026.08.

Composition, heat treatment, and hardness of high-speed steels

Steel designaetion	Mass fraction[a,b]. t%							Hardness (annealed)[c] +A HBW max.	Hardening			
	C	Si max.	Co	Cr	Mo	V	W		Austenitizing temperature °C (±10 °C)	Quenching medium[d]	Tempering temperature °C (±10 °C)	Hardness HRC min.
HS0-4-1	0.77 – 0.85	0.65	—	3.9 – 4.4	4.0 – 4.5	0.90 – 1.10	—	262	1 120	—	560	60
HS1-4-2	0.85 – 0.95	0.65	—	3.6 – 4.3	4.1 – 4.8	1.70 – 2.20	0.80 – 1.40	262	1 180	—	560	63
HS18-0-1	0.73 – 0.83	0.45	—	3.8 – 4.5	—	1.00 – 1.20	17.2 – 18.7	269	1 260	—	560	63
HS2-9-2	0.95 – 1.05	0.70	—	3.5 – 4.5	8.2 – 9.2	1.70 – 2.20	1.50 – 2.10	269	1 200	—	560	64
HS1-8-1	0.77 – 0.87	0.70	—	3.5 – 4.5	8.0 – 9.0	1.00 – 1.40	1.40 – 2.00	262	1 190	—	560	63
HS3-3-2	0.95 – 1.03	0.45	—	3.8 – 4.5	2.50 – 2.90	2.20 – 2.50	2.70 – 3.00	255	1 190	—	560	62
HS6-5-2	0.80 – 0.88	0.45	—	3.8 – 4.5	4.7 – 5.2	1.70 – 2.10	5.90 – 6.70	262	1 220	—	560	64
HS6-5-2C[e]	0.86 – 0.94	0.45	—	3.8 – 4.5	4.7 – 5.2	1.70 – 2.10	5.90 – 6.70	269	1 210	—	560	64
HS6-5-3	1.15 – 1.25	0.45	—	3.8 – 4.5	4.7 – 5.2	2.70 – 3.20	5.90 – 6.70	269	1 200	—	560	64
HS6-5-3C	1.25 – 1.32	0.70	—	3.8 – 4.5	4.7 – 5.2	2.70 – 3.20	5.90 – 6.70	269	1 180	—	560	64
HS6-6-2	1.00 – 1.10	0.45	—	3.8 – 4.5	5.5 – 6.5	2.30 – 2.60	5.90 – 6.70	262	1 200	—	560	64
HS6-5-4	1.25 – 1.40	0.45	—	3.8 – 4.5	4.2 – 5.0	3.70 – 4.20	5.20 – 6.00	269	1 210	—	560	64
HS6-5-2-5[e]	0.87 – 0.95	0.45	4.5 – 5.0	3.8 – 4.5	4.7 – 5.2	1.70 – 2.10	5.90 – 6.70	269	1 210	—	560	64
HS6-5-3-8	1.23 – 1.33	0.70	8.0 – 8.8	3.8 – 4.5	4.7 – 5.3	2.70 – 3.20	5.90 – 6.70	302	1 180	—	560	65
HS10·4-3-10	1.20 – 1.35	0.45	9.5 – 10.5	3.8 – 4.5	3.2 – 3.9	3.00 – 3.50	9.00 – 10.0	302	1 230	—	560	66
HS2-9-1-8	1.05 – 1.15	0.70	7.5 – 8.5	3.5 – 4.5	9.0 – 10.0	0.90 – 1.30	1.20 – 1.90	277	1 190	—	550	66

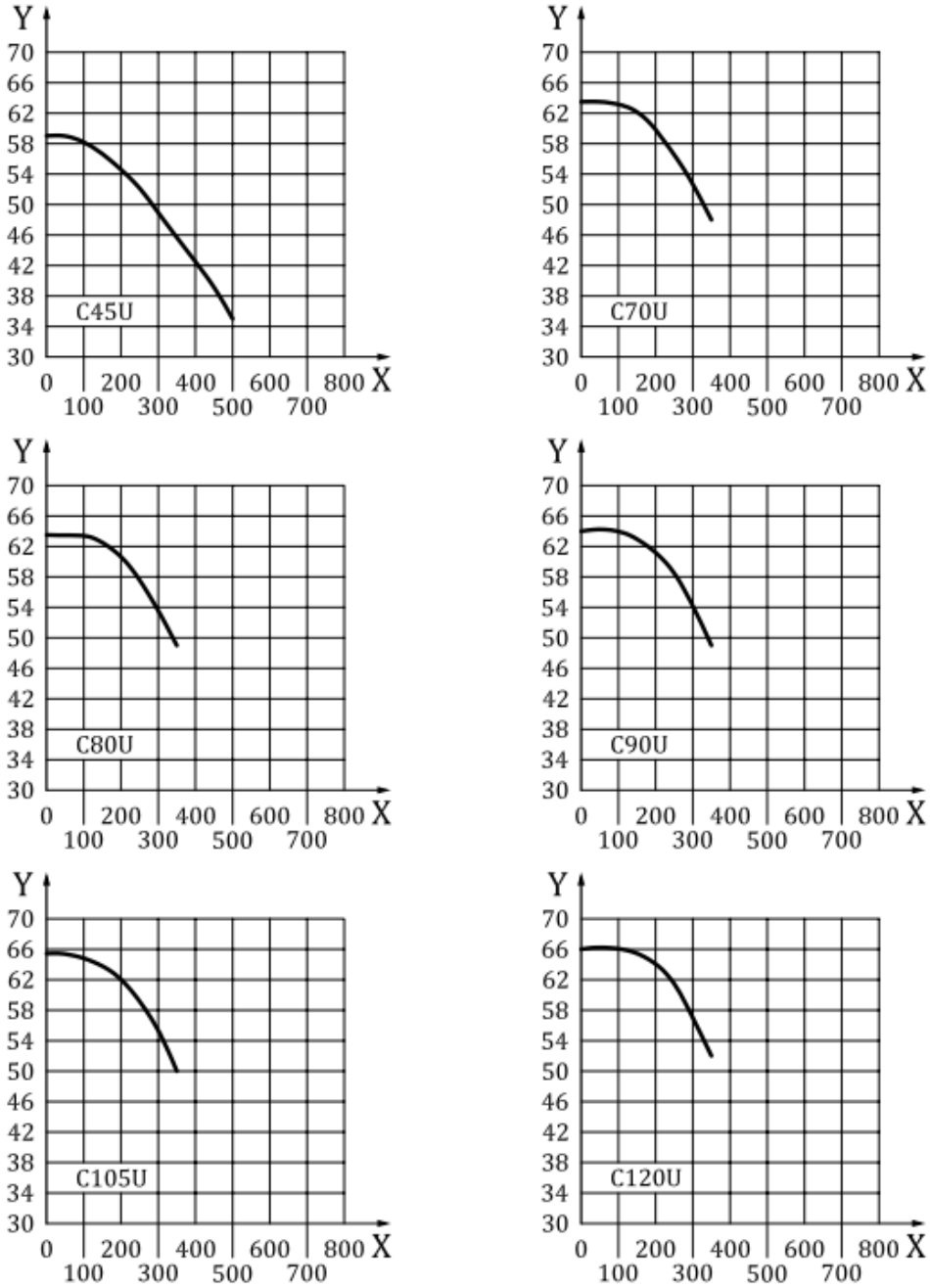
Elements not specified in the table must not be intentionally added without agreement with the purchaser, except in quantities required to complete the heat treatment.
[a] Mn content is 0.40 mass% maximum unless otherwise specified.
[b] For all steels, phosphorus and sulfur contents are ≤ 0.030 mass%.
[c] In the cold-drawn condition (+A+C), hardness may be 50 HBW higher, and in the cold-rolled condition (+A+CR) 70 HBW higher, than in the annealed condition (+A).
[d] In practice. the quenching medium is air, gas, or a salt bath.
[e] The sulfur content may be increased to 0.060–0.150 mass%. In this case, the Mn content is 0.80 mass% maximum.

Source: ISO 4957:2018
Last checked: 2026.08.

Effect of tempering temperature on tool-steel hardness according to ISO 4957:2018

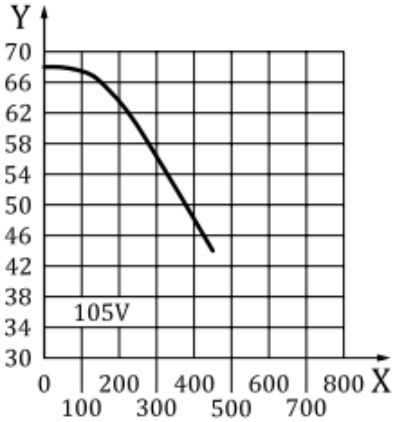
X: tempering temperature, °C
Y: hardness, HRC
Hardening:

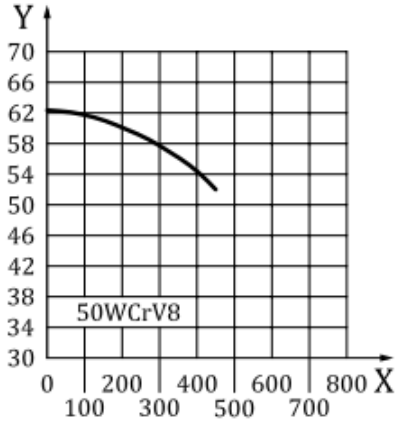
- C45U: 810°C, water
- C70U: 800°C, water
- C80U: 790°C, water
- C90U: 780°C, water
- C105U: 780°C, water
- C120U: 770°C, water

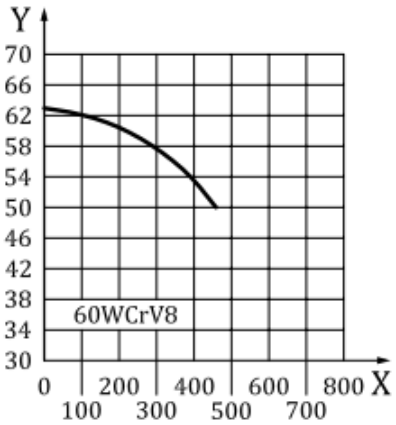


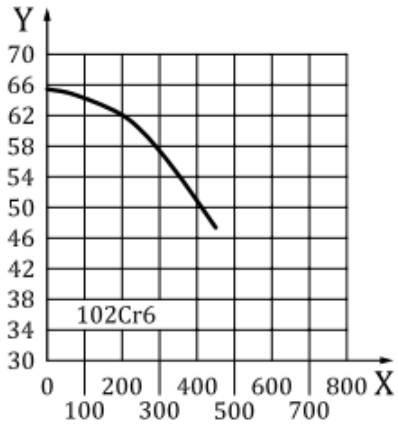
X: tempering temperature, °C
Y: hardness, HRC
1: hardness of the case-hardened surface
Hardening:

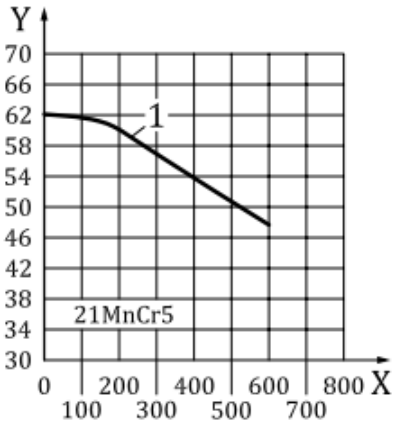
- 105V: 790°C, water
- 50WCrV8: 920°C, oil
- 60WCrV8: 910°C, oil
- 102Cr6: 840°C, oil
- 21MnCr5: 820°C, oil
- 70MnMoCr8: 835°C, oil

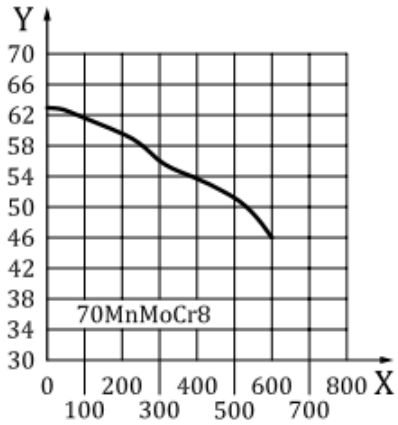






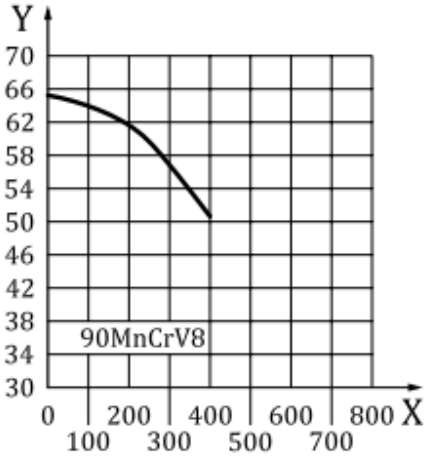


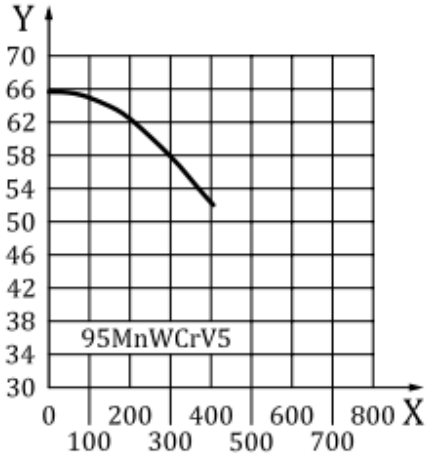


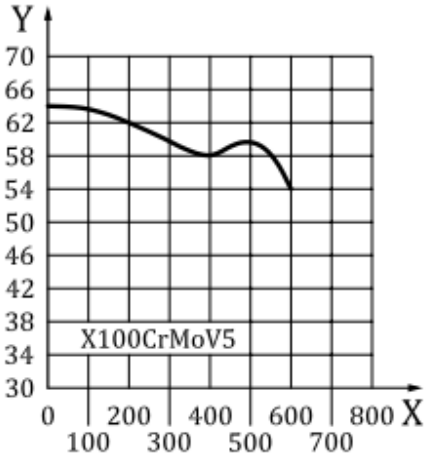


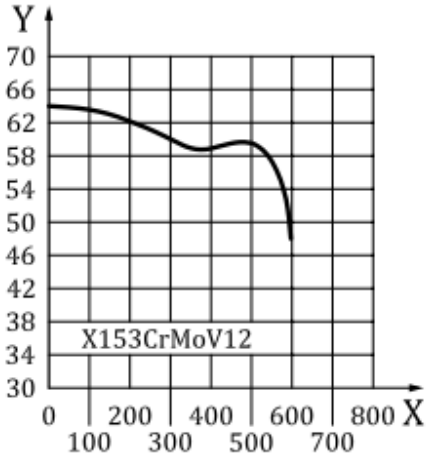
X: tempering temperature, °C
Y: hardness, HRC
Hardening:

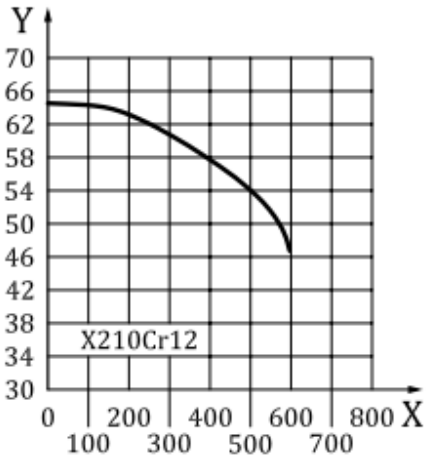
- 90MnCrV8: 790°C, oil
- 95MnWCrV5: 800°C, oil
- X100CrMoV5: 970°C, air/water
- X153CrMoV12: 1020°C, air
- X210Cr12: 970°C, oil
- X210CrW12: 970°C, oil

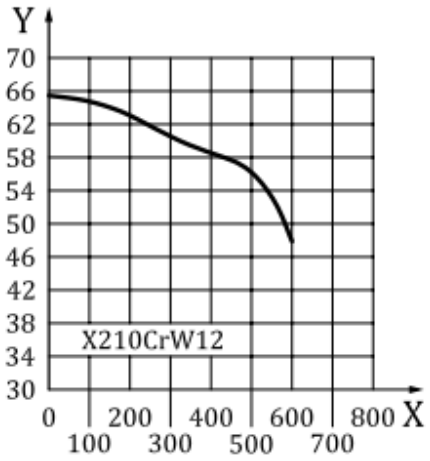






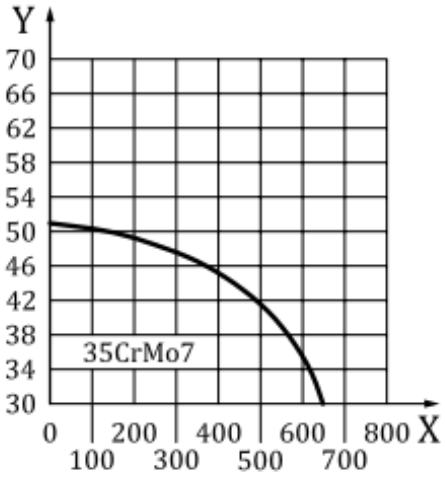


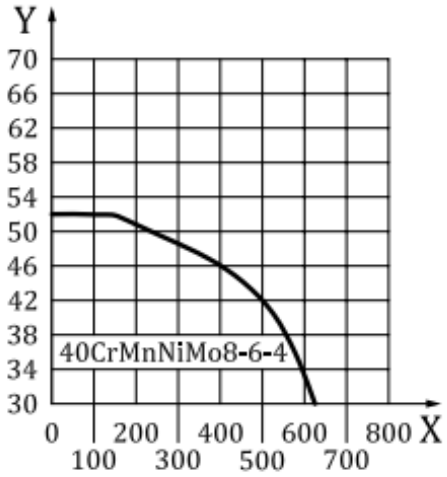


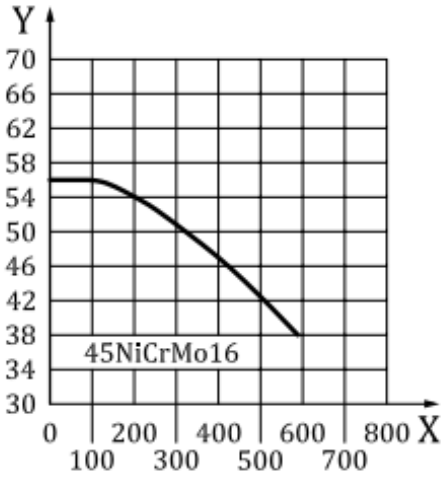


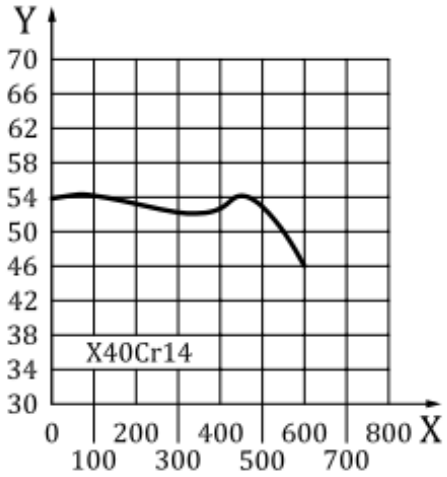
X: tempering temperature, °C
Y: hardness, HRC
Hardening:

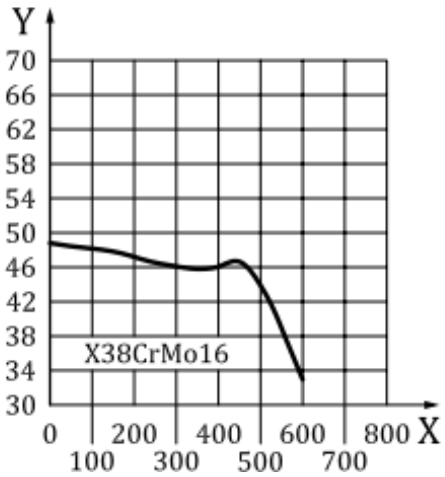
- 35CrMo7
- 40CrMnNiMo8-6
- 45NiCrMo16: 850°C, water
- X40Cr14: 1010°C, water
- X38CrMo16





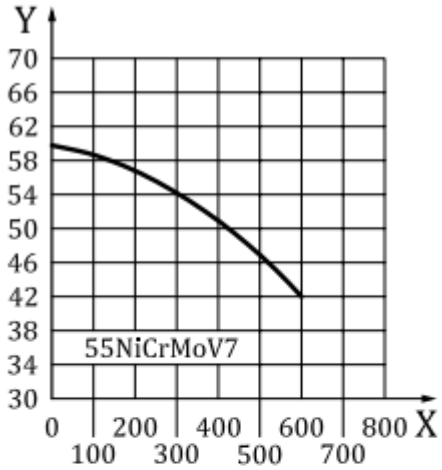


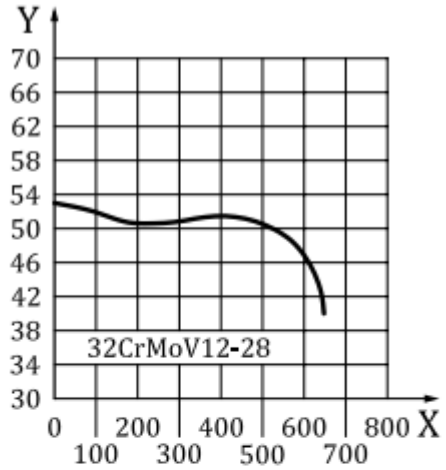


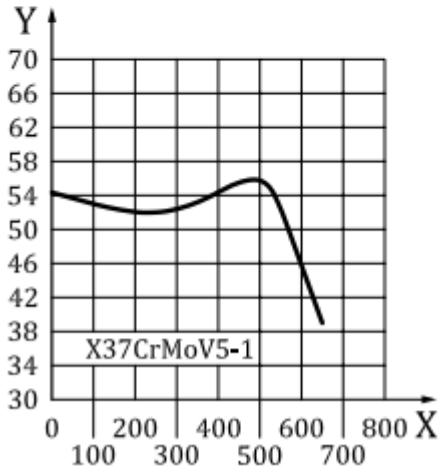


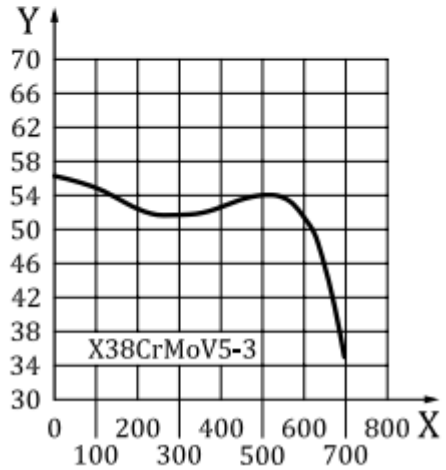
X: tempering temperature, °C
Y: hardness, HRC
Hardening:

- 55NiCrMoV7: 850°C, oil
- 32CrMoV12-28: 1040°C, oil
- X37CrMoV5-1: 1020°C, oil
- X38CrMoV5-3: 1040°C, oil



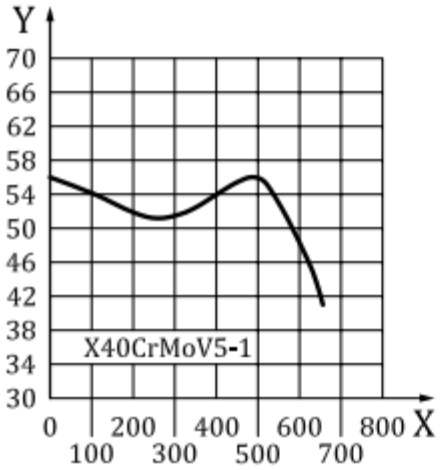


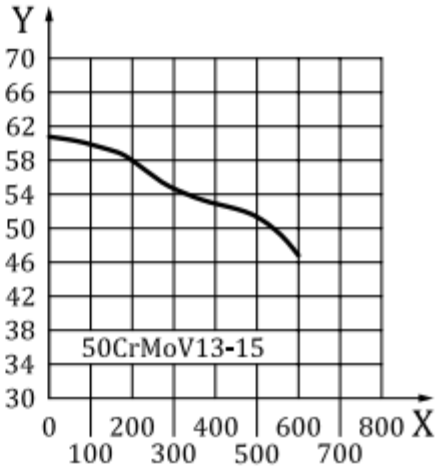


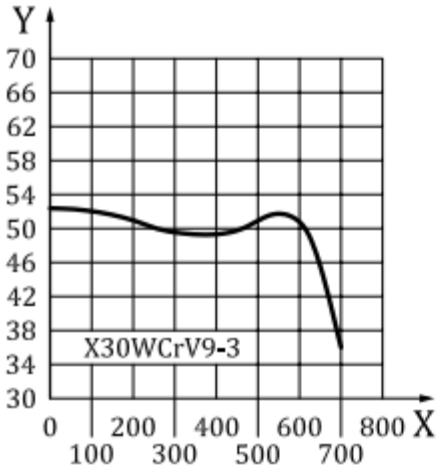


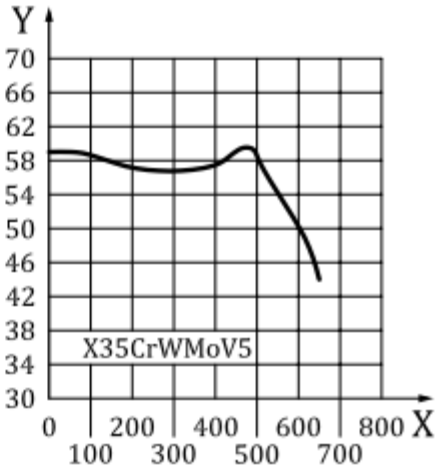
X: tempering temperature, °C
Y: hardness, HRC
Hardening:

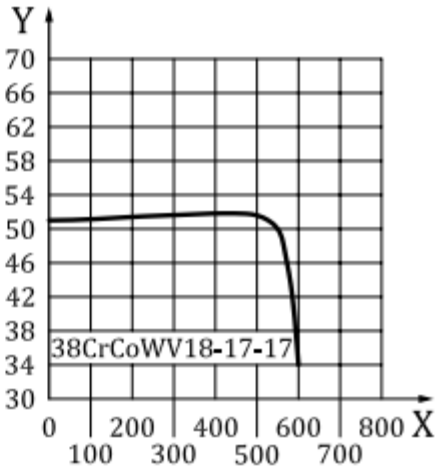
- X40CrMoV5-1: 1020°C, oil
- 50CrMoV13-15: 1010°C, oil
- X30WCrV9-3: 1150°C, oil
- X35CrWMoV5: 1020°C, oil
- 38CrCoWV18-17-17: 1120°C, oil





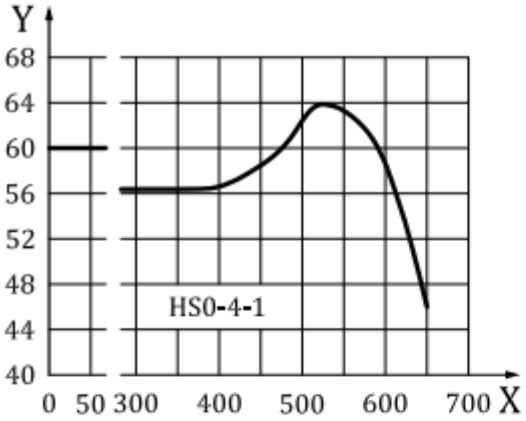


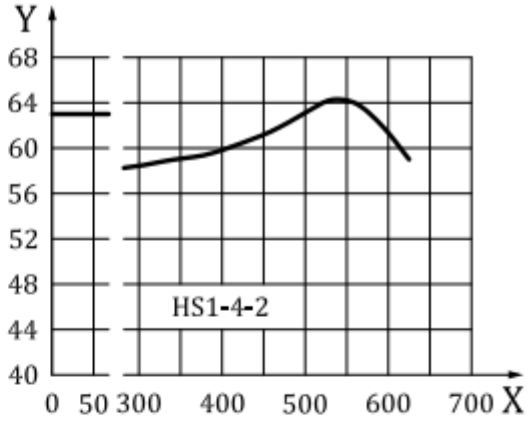


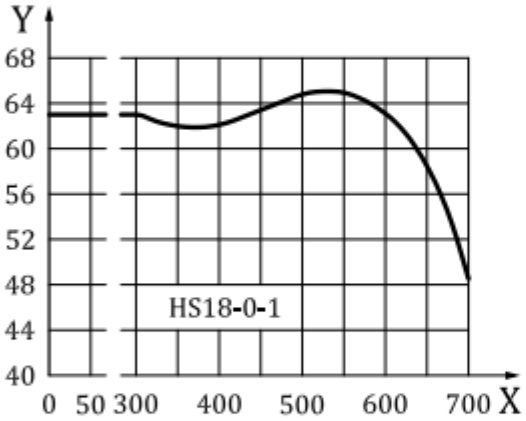


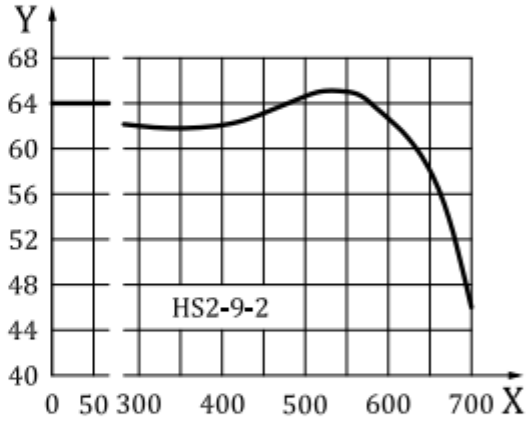
X: tempering temperature, °C
Y: hardness, HRC
Hardening:

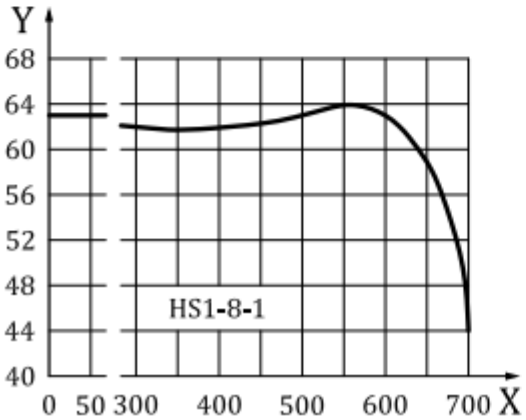
- HS0-4-1: 1120°C, oil
- HS1-4-2: 1180°C, oil
- HS18-0-1: 1260°C, oil
- HS2-9-2: 1200°C, oil
- HS1-8-1: 1190°C, oil
- HS3-3-2: 1190°C, oil

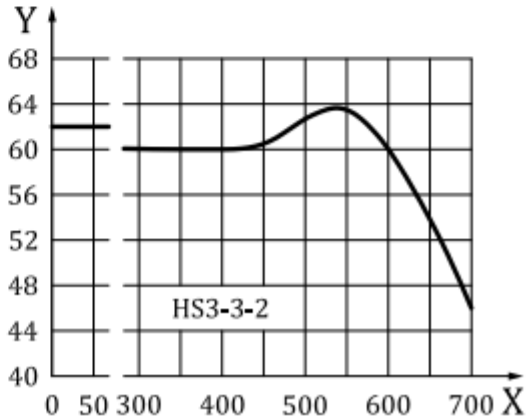






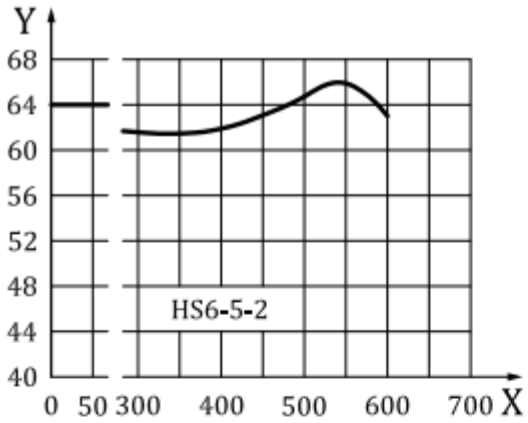


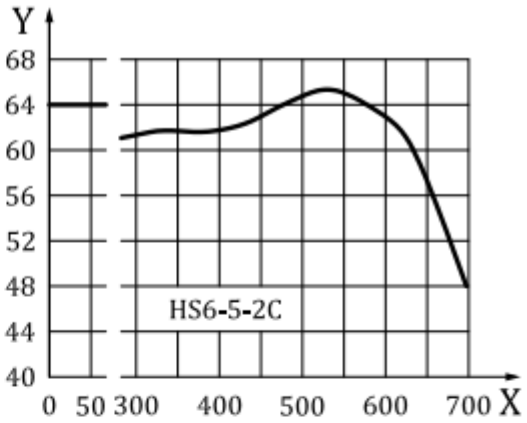


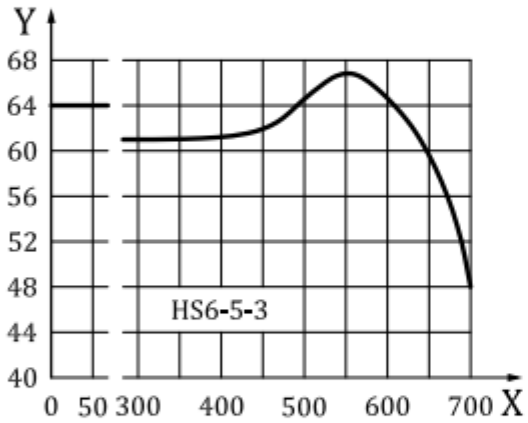


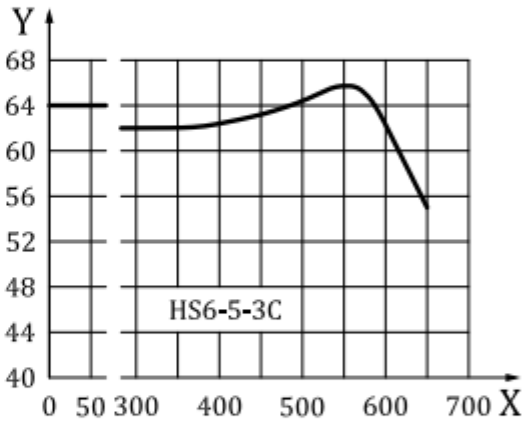
X: tempering temperature, °C
Y: hardness, HRC
Hardening:

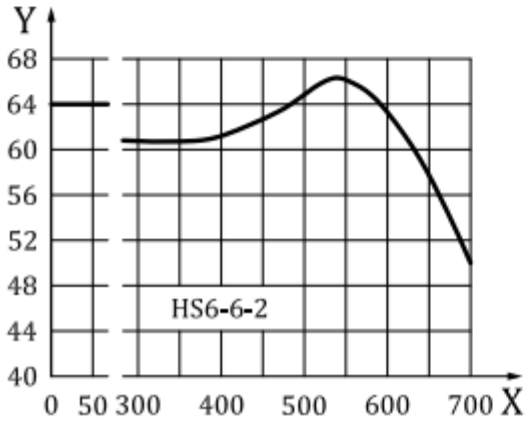
- HS6-5-2: 1220°C, oil
- HS6-5-2C: 1210°C, oil
- HS6-5-3: 1200°C, oil
- HS6-5-3C: 1180°C, oil
- HS6-6-2: 1200°C, oil
- HS6-5-4: 1210°C, oil

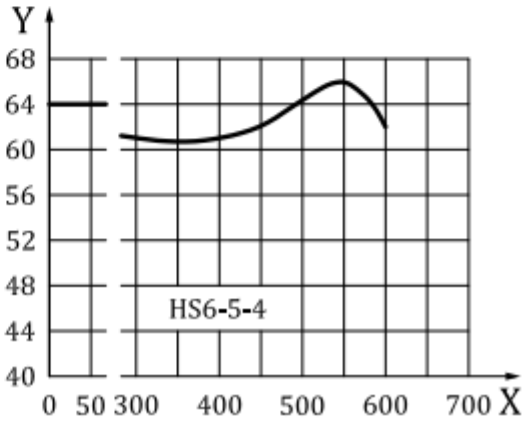












X: tempering temperature, °C
Y: hardness, HRC
Hardening:

- HS6-5-2-5: 1210°C, oil
- HS6-5-3-8: 1180°C, oil
- HS10-4-3-10: 1230°C, oil
- HS2-9-1-8: 1190°C, oil