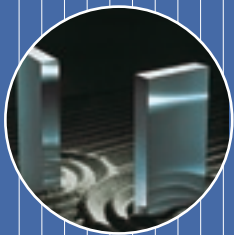
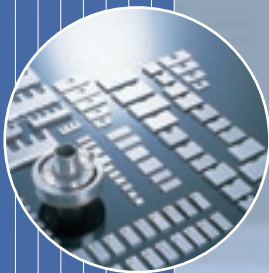
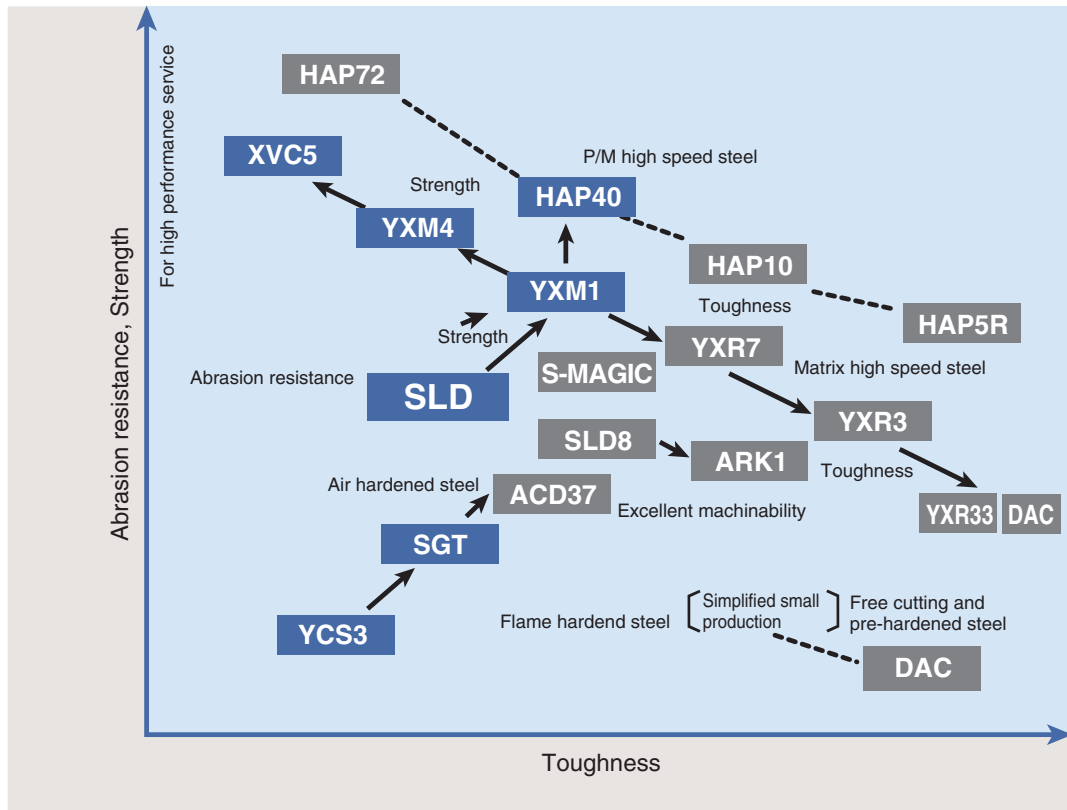


YSS COLD WORKING TOOL STEELS



Characteristics of YSS Cold Work Tool Steels



● Comparison of characteristics

YSS grade	Abrasion resistance	Pressure resistance	Strength at elevated temperature	Toughness	Hardenability	Distortion by heat treatment	Machinability	Weldability	Standard hardness (HRC)
S-MAGIC	A	A	B	A ⁻	A ⁺	A ⁺	A ⁻	B	58~62
SLD	A	A	B	B	A ⁺	A ⁺	B	C	57~63
ARK1	B ⁺	A	B	A	A ⁺	A ⁺	A	B	58~60
SLD8	A ⁻	A	B ⁺	A ⁻	A ⁺	A	B ⁺	C	58~63
SLD10	A ⁻	A ⁺	A ⁻	A ⁻	A ⁺	A	B ⁻	C	59~65
CRD	A ⁺	A	C	C	B ⁻	B	C	D	57~63
YCS3	D	C	D	C	D	D	A ⁺	B	57~63
SGT	C	B ⁺	D	B	C	D	A	B	57~63
ACD37	B	A ⁻	C	B	A ⁺	A	A	B	55~60
HMD5 HMD1	C	B	D	B	—	—	A	A	55~60
HPM1 HPM2T	D ⁻	D	D	A ⁻	—	—	A ⁻	A	40
YXM1	A	A ⁺	A	A ⁻	B	B	B	C	58~64
YXM4	A ⁺⁺	A ⁺	A ⁺	B	B	B	B ⁻	C	62~66
XVC5	A ⁺⁺⁺	A ⁺⁺	A ⁺⁺	C	B	B ⁻	C	D	63~67
YXR7	A	A ⁺	A	A	A	B	B	C	61~65
YXR3	A ⁻	A	A	A ⁺	B	B	B ⁺	C ⁺	58~61
YXR33	B	B	A ⁺	A ⁺⁺	A	B	B ⁺	C ⁺	54~58
HAP5R	A	A ⁺	A	A ⁺	A	A	B	C	58~62
HAP10	A ⁺	A ⁺	A	A	A	A	B ⁻	C	62~65
HAP40	A ⁺⁺	A ⁺⁺	A ⁺⁺	A ⁻	B	A	C ⁺	C	64~67
HAP72	A ⁺⁺⁺	A ⁺⁺⁺	A ⁺⁺⁺	C	A ⁻	A	C ⁻	D	68~71

(A is the uppermost level and + indicates higher performance)

Applications and YSS grade Features

YSS grade	Main applications	Features
S-MAGIC (NEW)	Cold work dies for high-tensile steels, SUS, mass production, and general use.	High performance cold work tool steel attaining both extended mold lifespan and outstandingly easy mold fabrication. 60~62 HRC with high temperature tempering. Excellent wear & galling resistance.
SLD	Cold work dies for general use, forming roll, shear.	Cold work die steel with high abrasion resistance for general use, excellent harden-ability and minimal quench stress.
ARK1	Dies for printed circuit board, die plates, stripper plates.	Cold work die steel with high toughness and improved machinability. The same heat treatment conditions as SKD11.
SLD8	Rolling dies, cold forging dies.	62HRC or more with high temperature tempering, superior machinability and toughness.
SLD10	Rolling dies.	Extremely highest hardness in die steels. 62-64HRC, with excellent toughness.
CRD	Drawing dies, blanking dies for mass production, brick liner.	Cold work die steel with highest abrasion resistance.
YCS3	Press forming dies, jigs and tools.	Carbon tool steel for small production to be quenched in oil, easy to heat-treat.
SGT	Dies for deep drawing, gauges.	Cold work die steel with superior machinability for general use; Be careful with quenching large dies and wire electric discharge machining.
ACD37	Dies for deep drawing, gauges.	Vacuum quenched and air quenched steel, improved for SGT as to hardenability and wire electric discharge machining.
HMD5 HMD1	Dies for deep drawing.	Steel for flame hardening, resulting in high hardness and small strain even with air quenched; good weldability.
HPM1	Press forming dies for small production, jigs and tools.	Free cutting and fully hardened steel, good nitriding characteristics.
YXM1	Cold forging dies, cold heading dies, slitter.	High speed steel with high abrasion resistance and toughness for general use.
YXM4 XVC5	Cold forging dies, drawing dies.	High speed steel to prevent from abrasion, seizure and deformation under high pressure.
YXR7	Rolling dies, cold forging dies, roll, cold forging punches, blanking punches.	Matrix high speed steel, extremely highest toughness in 62-65HRC. available to vacuum quenching.
YXR3	Dies to be used for cracking or chip breaking resistance.	Matrix high speed steel for general use, extremely highest toughness in 58-61HRC.
YXR33	Cold forging dies, warm forging dies.	Matrix high speed steel extremely highest toughness in high speed steels.
HAP5R	Cold forging dies, fine blanking dies.	Standard hardness 56-58HRC. Extremely tough Powder Metallurgy process high speed steel.
HAP10	Fine blanking dies.	Extremely tough Powder Metallurgy process high speed steel.
HAP40	Press forming dies for mass production, roll.	P/M high speed steel with high abrasion resistance and toughness for general use.
HAP72	Cold plastic working dies of long life, high performance IC molds.	P/M high speed steel with high hardness and highest abrasion resistance.

Type and Chemical Compositions

Grade		Chemical Composition (%)										
YSS	JIS equivalent	C	Si	Mn	P	S	Ni	Cr	W	Mo	V	Co
S-MAGIC	Patent pending	High performance cold work tool steel										
SLD	SKD11	1.50	0.25	0.45	≤ 0.025	≤ 0.010	–	12.00	–	1.00	0.35	–
ARK1	Patented steel	High toughness cold work tool steel										
SLD8	Patented steel	High strength cold work tool steel										
CRD	SKD1	2.10	0.25	0.45	≤ 0.025	≤ 0.010	–	13.50	–	–	–	–
YCS3	SKS93	1.05	0.35	0.80	≤ 0.030	≤ 0.030	–	0.40	–	–	–	–
SGT	SKS3	0.95	0.25	1.05	≤ 0.025	≤ 0.010	–	0.75	0.75	–	–	–
ACD37		0.85	0.25	2.10	≤ 0.025	≤ 0.010	–	1.20	–	1.50	–	–
HMD5 HMD1	Original steel	Flame hardened tool steel										
HPM1	Patented steel	0.12	0.30	0.90	≤ 0.025	≤ 0.10	3.00	–	–	0.30	Cu2.2	Al1.0
YXM1	SKH51	0.85	0.25	0.35	≤ 0.025	≤ 0.010	–	4.15	6.50	5.30	2.05	–
YXM4	SKH55	0.85	0.25	0.35	≤ 0.025	≤ 0.010	–	4.15	6.50	5.30	2.05	5.00
XVC5	SKH57	1.25	0.25	0.35	≤ 0.025	≤ 0.010	–	4.15	10.00	3.50	3.45	10.00
YXR7 YXR3	Original steel	Matrix high speed steel										
YXR33	Patented steel	Extremely tough matrix high speed steel										
HAP5R HAP10	P/M high speed steels	Extremely tough P/M high speed steel										
HAP40	SKH40	1.3	–	–	–	–	–	5.0	3.0	6.0	4.0	–
HAP72	Patented steel	2.1	–	–	–	–	–	4.0	9.5	8.2	5.0	9.5

Heat Treatment

(1) Annealing

- All material is delivered as spheroidized annealed condition.
- When used after reforging, spheroidized annealing is to be done before hardening.
- Stress relief annealing is to be done in order to remove stress occurred by cold working such as cold drawing, cold rolling or cutting and machining.
 - Heating temperature: 650-700°C
 - Holding time: 1h/25mm thickness

(2) Holding time at hardening temperature

- High speed tool steel

- Preheating time 1st stage: 30 minutes for every 25 mm of the tool at 500-550°C
 2nd stage: (holding time X 2) at 850°C
 3rd stage: (holding time X 2) at 1,050°C
 Preheating is (holding time X 2) at 900°C for small thickness (50 mm max.) and simple shape tools, and wherever facilities are limited. The first stage can be omitted for small tools.

2. Holding time at hardening temperature (holding time)

Furnace type	Time	Thickness (mm)									
		5	10	20	30	40	50	60	70	80	90
Salt bath	Holding time (sec)	60	90	160	240	280	350	390	420	440	495
	Thickness X multiple	X12	X9	X8	X8	X7	X7	X6.5	X6	X5.5	X5.5

Note: Use the holding time in the salt bath as the immersion time.

● Cold die steels, alloy tool steels and carbon tool steels

- Preheating time 1st stage: (holding time X 2) at 500-550°C
 2nd stage: (holding time X 1) at 750-800°C

(Unnecessary for SK, SKS)

Except that preheating can be omitted wherever an electric furnace is used or for small tools (50mm or less thickness) and simple shape tools.

2. Holding time at hardening temperature (holding time)

Furnace type	Time	Thickness (mm)								
		≤ 15	25	50	75	100	125	150	200	300
Salt bath or electric furnace	Holding time (min)	15	25	40	50	60	65	70	80	100

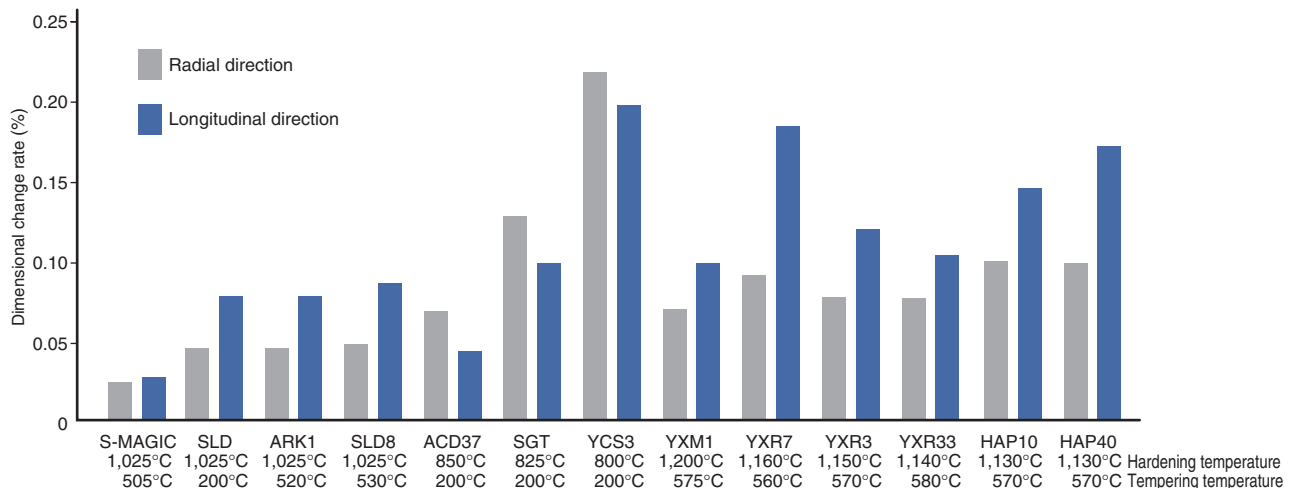
Note: Using salt bath needs preheating and the holding time used as the immersion time.

(3) Holding time at tempering temperature

Thickness (mm)	≤ 25	26~35	36~64	65~84	85~124	125~174	175~249	250~349	350~499
Holding time for tempering (h)	1	1.5	2	3	4	5	6	7	8

Note: Apply this standard to tempering at 500°C or more, and increase elongate tempering time to tempering temperature X 1.5 for 250-500°C and holding time X 2 for tempering temperature less than 250°C

(4) Dimensional changes after heat treatment



Heat Treatment

(5) Standard heat treatment conditions

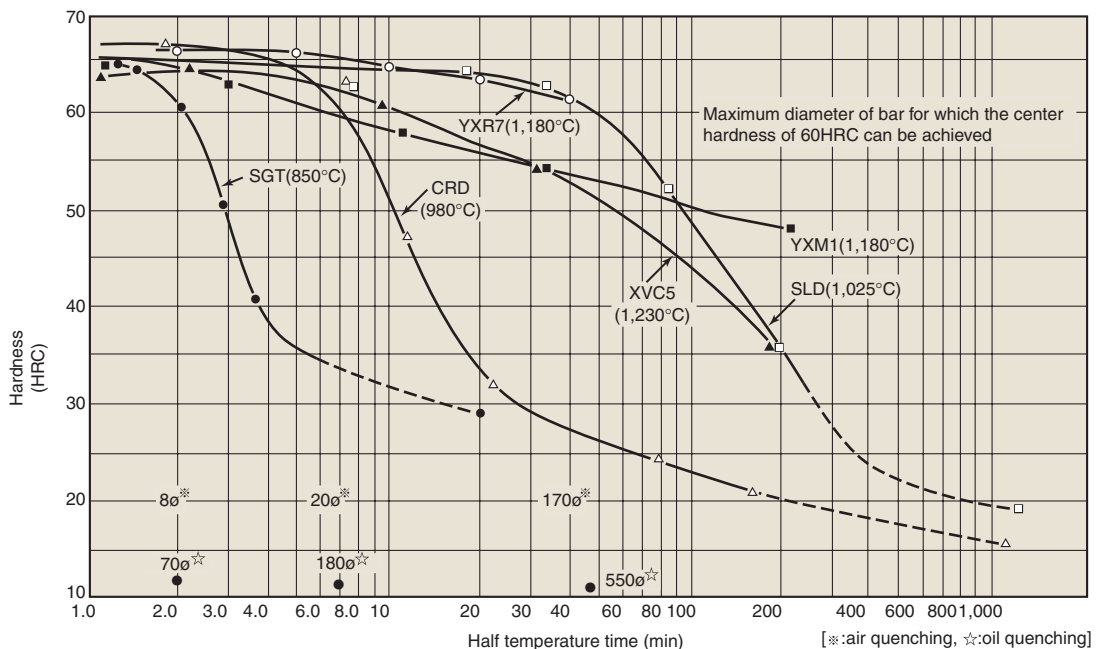
YSS grade	Annealing		Hardening		Tempering	
	Temperature (°C)	Hardness (HBW)	Temperature (°C)		Temperature (°C)	Hardness (HRC)
S-MAGIC	830-880 Slow cooling	≤ 255	1010-1040 Air quenching		480~530 Air cooling	≥ 60
SLD	830-880 Slow cooling	≤ 248	1000-1050 (980-1030) Air quenching (Oil quenching)		150~200 Air cooling	≥ 58
ARK1	830-880 Slow cooling	≤ 248	1010-1040 Air quenching		480~530 Air cooling	≥ 58
SLD8	830-880 Slow cooling	≤ 248	1020-1040 Air quenching		520~550 Air cooling	≥ 60
CRD	830-880 Slow cooling	≤ 248	930-980 (950-1000) Oil quenching (Air quenching)		150~200 Air cooling	≥ 61
YCS3	750-780 Slow cooling	≤ 212	790-850 Oil quenching		150~200 Air cooling	≥ 63
SGT	750-780 Slow cooling	≤ 217	800-850 Oil quenching		150~200 Air cooling	≥ 60
ACD37	750-800 Slow cooling	≤ 235	830-870 Air quenching		150~200 Air cooling	≥ 58
HMD5/HMD1	825-875 Slow cooling	≤ 235	Flame hardening			
YXM1	800-880 Slow cooling	≤ 255	(1)1220-1240 (2)1200-1220 Oil quenching		550~570 Air cooling	≥ 63
YXM4	800-880 Slow cooling	≤ 277	(1)1230-1250 (2)1210-1230 Oil quenching		560~580 Air cooling	≥ 64
XVC5	820-880 Slow cooling	≤ 285	(1)1230-1250 (2)1210-1230 Oil quenching		550~580 Air cooling	≥ 64
YXR7	800-880 Slow cooling	≤ 241	(1)1160-1180 (2)1120-1160 Oil quenching		550~580 Air cooling	≥ 61
YXR3	800-880 Slow cooling	≤ 241	(1)1150-1170 (2)1130-1150 Oil quenching		560~590 Air cooling	≥ 58
YXR33	800-880 Slow cooling	≤ 241	1080-1160 Oil quenching		550~600 Air cooling	≥ 55
HAP5R	820-870 Slow cooling	≤ 269	1120-1160 Oil quenching		530~580 Air cooling	≤ 58
HAP10	820-870 Slow cooling	≤ 269	(1)1170-1190 (2)1120-1170 Oil quenching		530~580 Air cooling	≥ 61
HAP40	820-870 Slow cooling	≤ 277	(1)1190-1210 (2)1120-1190 Oil quenching		560~580 Air cooling	≥ 64
HAP72	820-870 Slow cooling	≤ 352	1180-1210 Oil quenching		560~580 Air cooling	≥ 68

(1) Simple shape tools

(2) The others, especially needs toughness

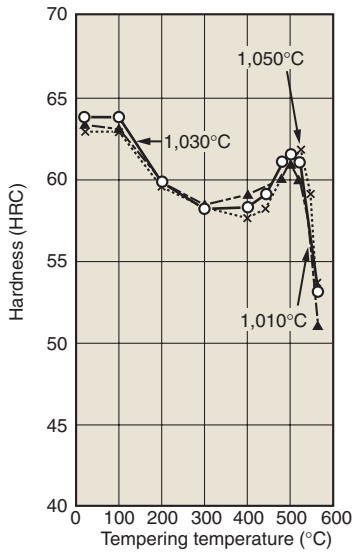
*Sample size is 15mm square or round and 20mm length based on the JIS Standard hardness test.

(6) Hardenability (Half temperature time: time required to cool from the austenitizing temperature to half that temperature) $\{(austenitizing\ temperature + room\ temperature) / 2\}$

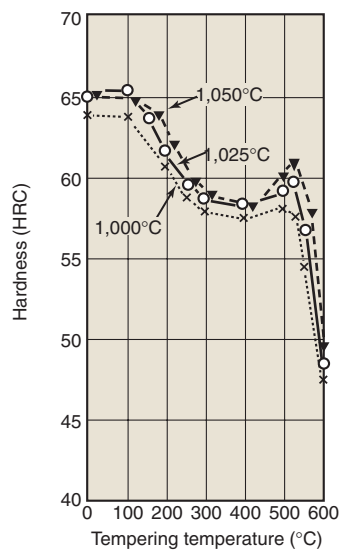


YSS Quenched and tempered hardness curve

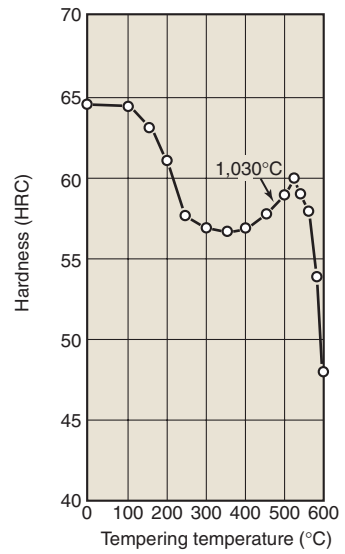
S-MAGIC



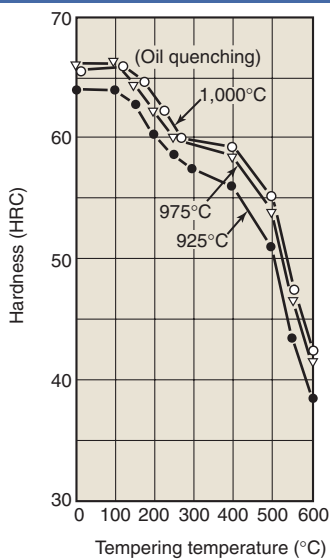
SLD



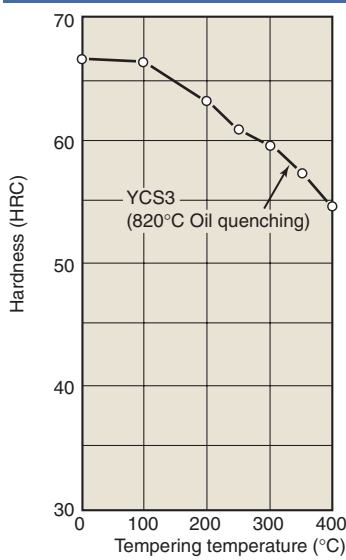
ARK1



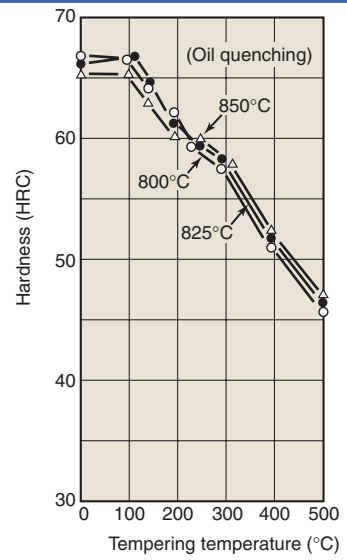
CRD



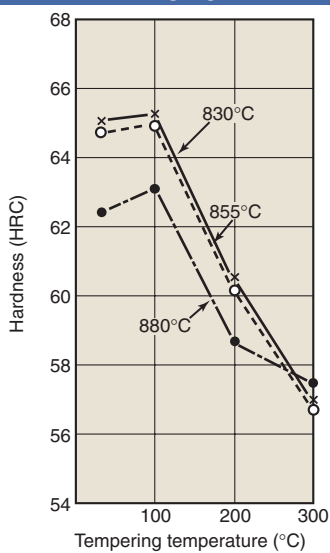
YCS3



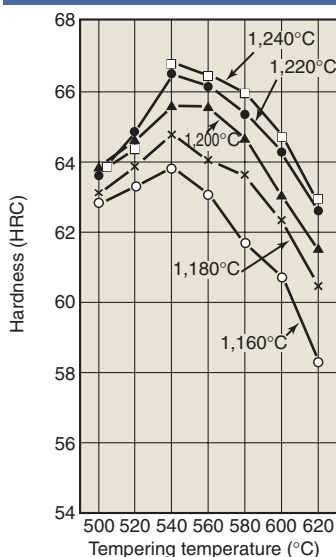
SGT



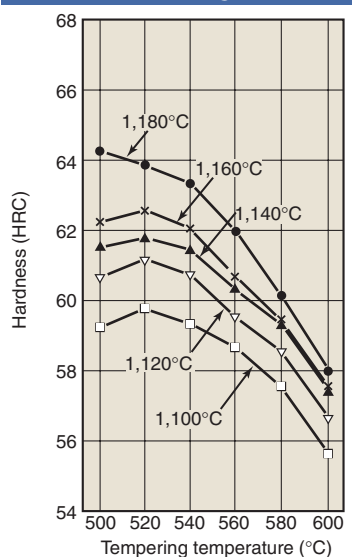
ACD37



YXM1

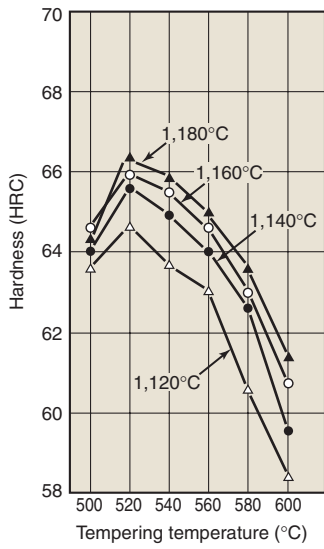


HAP5R

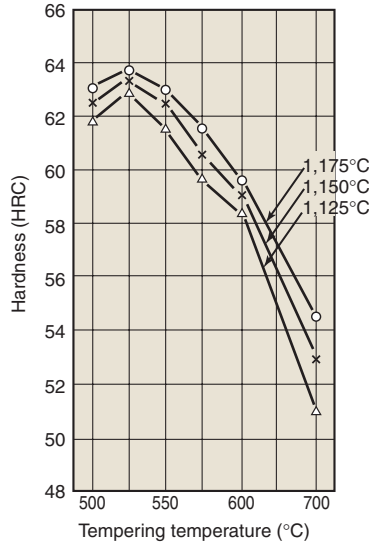


YSS Quenched and tempered hardness curve

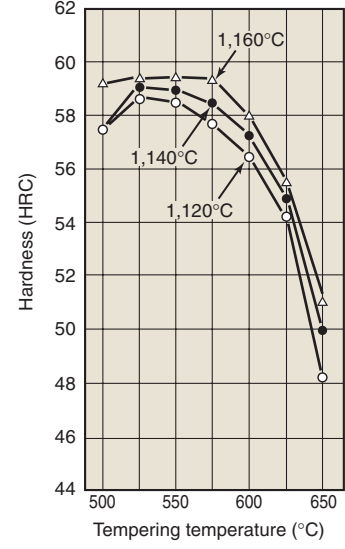
YXR7



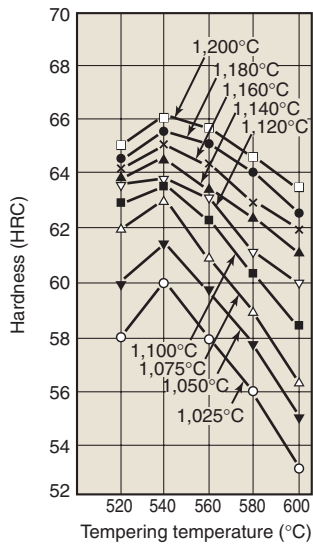
YXR3



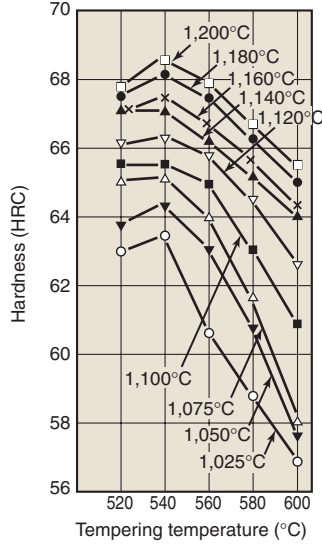
YXR33



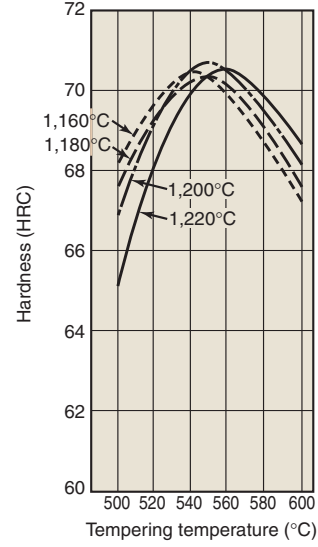
HAP10



HAP40



HAP72



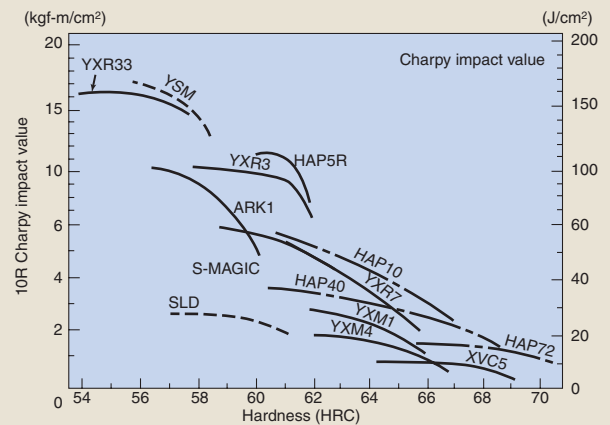
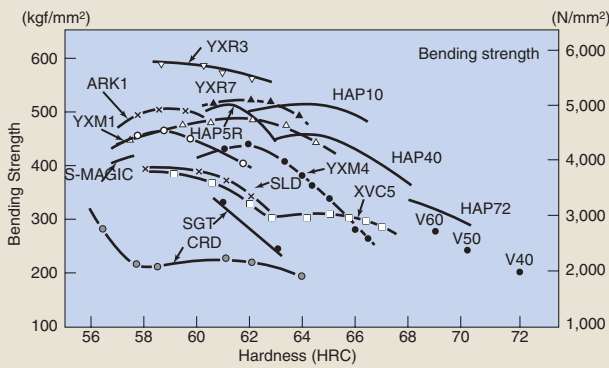
YSS Properties

●Abrasion resistance

YSS grade	Hardness (HRC)	Specific abrasion volume(mm ³ /mm ² ·mm)X10 ⁻⁷			
		0.5	1.0	1.5	2.0
S-MAGIC	62.0	~0.4	~0.5	~0.6	~0.7
SLD	60.0	~0.5	~0.6	~0.7	~0.8
ARK1	59.0	~0.6	~0.7	~0.8	~0.9
SLD8	62.5	~0.5	~0.6	~0.7	~0.8
YCS3	60.0	~0.8	~1.0	~1.2	~1.4
SGT	60.0	~0.7	~0.8	~0.9	~1.0
ACD37	60.0	~0.6	~0.7	~0.8	~0.9
YXM1	65.5	~0.5	~0.6	~0.7	~0.8
XVC5	67.0	~0.4	~0.5	~0.6	~0.7
YXR7	65.0	~0.5	~0.6	~0.7	~0.8
YXR3	59.0	~0.6	~0.7	~0.8	~0.9
YXR33	58.0	~0.7	~0.8	~0.9	~1.0
HAP5R	60.0	~0.5	~0.6	~0.7	~0.8
HAP10	64.0	~0.4	~0.5	~0.6	~0.7
HAP40	67.0	~0.4	~0.5	~0.6	~0.7
HAP72	70.0	~0.4	~0.5	~0.6	~0.7

The Ogoshi type abrasion tester was used to determine abrasion resistance of matched SCM415 samples, tested under the following conditions: abrasion length of 400 mm, load of 67N, and friction speed of 0.78 m/sec.

●Toughness




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