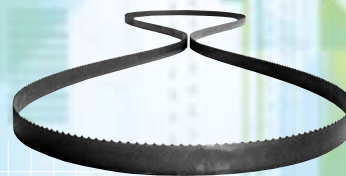
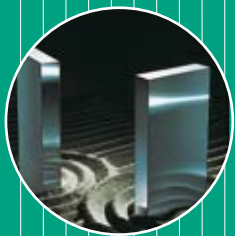


YSS HIGH SPEED TOOL STEELS



Chemical compositions of YSS High Speed Tool Steels

(mass%)

		Grade	JIS equivalent	AISI equivalent	C	Si	Mn	Cr	W	Mo	V	Co
Conventional High Speed Tool Steels	Molybdenum HSS	YXM1	SKH51	M2	0.9	0.3	0.4	4.2	6.5	5.0	2.0	–
		YXM4	SKH55	M35	0.9	0.3	0.3	4.2	6.5	5.3	1.9	5.0
		YXM27	–	–	1.2	0.5	0.3	4.2	5.3	6.3	2.7	–
		YXM42	SKH59	M42	1.1	0.3	0.3	3.9	1.5	9.5	1.2	8.0
		YXM60	–	–	1.1	0.3	0.3	4.2	5.5	6.5	1.7	8.0
	Vanadium HSS	XVC5	SKH57	–	1.3	0.3	0.3	4.2	10.0	3.5	3.5	10.0
	Tungsten HSS	YHX2	SKH2	T1	0.8	0.3	0.3	4.2	18.0	–	1.0	–
	Matrix HSS	YXR3	Matrix HSS	–	0.6	1.5	0.4	4.3	–	2.9	1.8	–
		YXR33	Matrix HSS	–	0.5	0.2	0.5	4.2	1.6	2.0	1.2	–
		YXR7	Matrix HSS	–	0.8	0.8	0.3	4.7	1.3	5.5	1.3	–
P/M High Speed Tool Steels	HAP10	–	–	1.4	0.6	0.3	5.0	3.0	6.0	3.8	–	
	HAP40	SKH40	–	1.3	0.3	0.4	4.2	6.0	5.0	3.1	8.0	
	HAP50	–	–	1.6	0.4	0.3	4.0	8.0	6.0	4.0	7.9	
	HAP72	–	–	2.1	0.4	0.3	4.2	9.5	8.3	5.0	9.5	
	HAP5R	–	–	0.9	0.8	0.3	4.3	2.0	3.0	3.0	–	

HIGH SPEED TOOL STEELS

Isotropy



Yasugi (Kaigan) Works

YSS High Speed Tool Steels are used not only for cutting tools but also various forming tools which require higher wear resistance and toughness. Along with conventional type steels, there are some grades made by powder metallurgy process (HAP series) that has superb wear resistance and toughness because of higher alloy content and uniform fine microstructure.

YSS High Speed Tool Steels are made of strictly chosen raw material, and made with advanced refining and casting (powder metallurgy) technologies.

Features of YSS High Speed Tool Steels

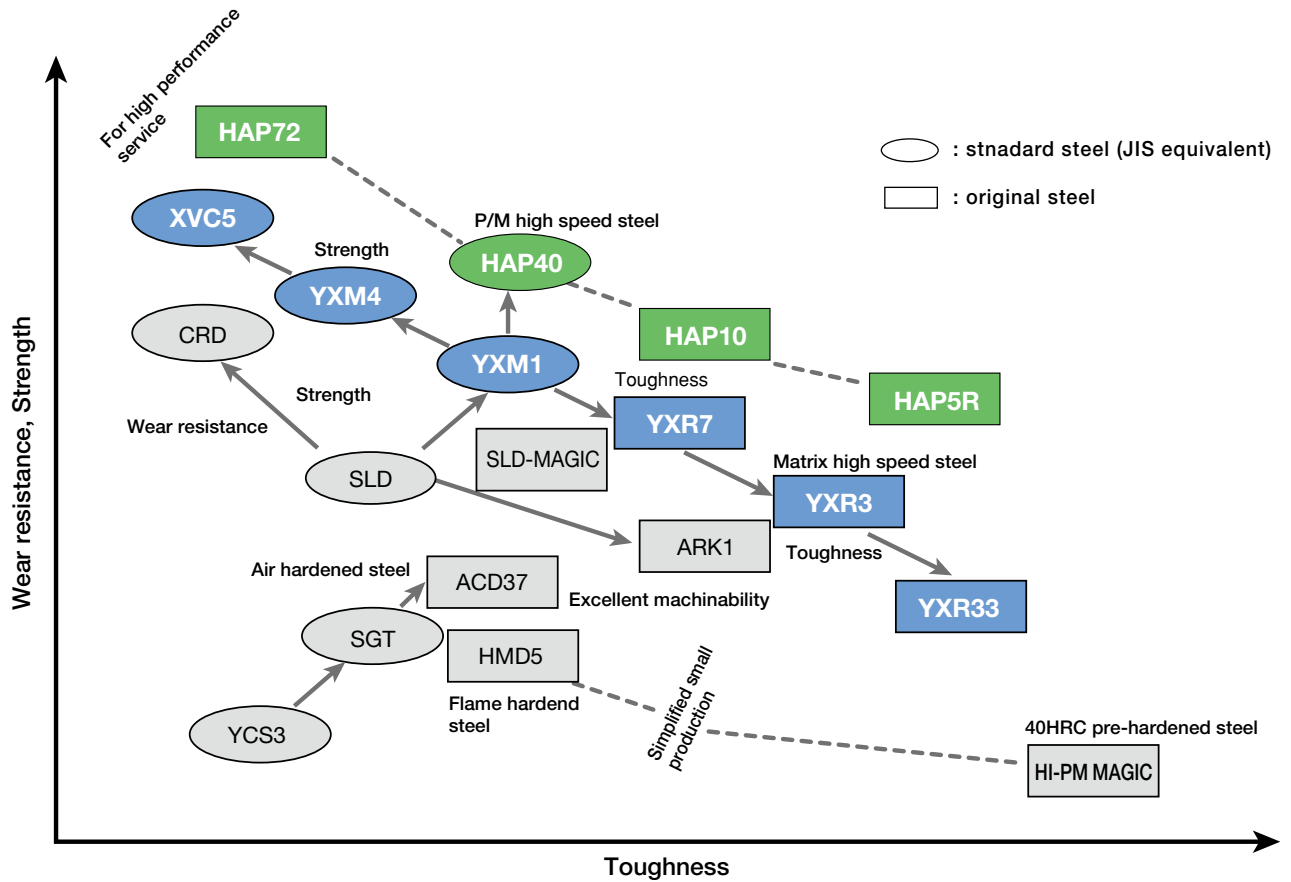
		Grade	Features
Conventional High Speed Tool Steels	Molybdenum HSS	YXM1	Standard Molybdenum high speed steel with superior toughness
		YXM4	Standard Cobalt alloyed Molybdenum high speed steel with superior heat resistance
		YXM27	High Vanadium high speed steel with good wear resistance and grindability and grindability
		YXM42	Super-hard high speed steel suitable for cutting for hard materials
		YXM60	High-performance high speed steel with superior durability, toughness and grindability
	Vanadium HSS	XVC5	High-performance Cobalt alloyed Vanadium high speed steel with wear/heat resistance
	Tungsten HSS	YHX2	Standard Tungsten high speed steel
	Matrix HSS	YXR3	Matrix high speed steel for forging tools with superior toughness
		YXR33	Matrix high speed steel for forging tools with most superior toughness
YXR7		Matrix high speed steel for forging tools with superior strength/toughness	
P/M High Speed Tool Steels	HAP10	Superior toughness effective to avoid chipping	
	HAP40	Most standard grade with good balance of hardness, toughness and wear resistance	
	HAP50	Higher hardness, good heat and wear resistance	
	HAP72	Good heat wear resistance and highest obtainable hardness of 70HRC	
	HAP5R	Toughest P/M high speed steel	

Features;

- High toughness
- High wear resistance
- Stabilized heat treatment property
- Stable performance due to uniform and fine carbide distribution
- Good mechanical properties coming from fine and uniform grain size
- High purity with least inclusions and gases

Characteristics of YSS High Speed Tool Steels

● Characteristics of steels



● Properties Comparison Table

Grade	Strength at elevated temperature	Quench and tempered hardness	Wear resistance	Machinability	Toughness
YXM1	A	C	C	C	B
YXM4	A	C	B	C	B
YXM27	B	C	B	C	B
YXM42	A	B	A	B	C
YXM60	A	B	A	B	C
XVC5	A	C	A	D	D
YHX2	A	C	C	B	C
YXR3	D	D	D	A	A
YXR33	C	D	D	A	A
YXR7	D	C	C	C	B
HAP10	D	C	A	B	B
HAP40	B	B	A	C	B
HAP50	B	B	A	B	B
HAP72	B	A	A	D	D
HAP5R	D	D	C	B	A

Excellent "A" → Ordinary "C" → Poor "E"

Characteristics of YSS High Speed Tool Steels

● Wear resistance (Ogoshi method)

Grade	Hardness (HRC)	Specific wear (mm ³ /(mm ² · mm) × 10 ⁻⁷)	
		0.5	1.0
YXM1	65.5	~1.5	~1.5
YXM4	66.0	~1.5	~1.5
XVC5	67.0	~1.5	~1.5
YXR33	58.0	~1.5	~1.5
YXR3	59.0	~1.5	~1.5
YXR7	65.0	~1.5	~1.5
HAP5R	60.7	~1.5	~1.5
HAP10	64.0	~1.5	~1.5
HAP40	67.2	~1.5	~1.5
HAP72	70.0	~1.5	~1.5
SKD11	60.5	~1.5	~1.5
SKD61	55.5	~1.5	~1.85

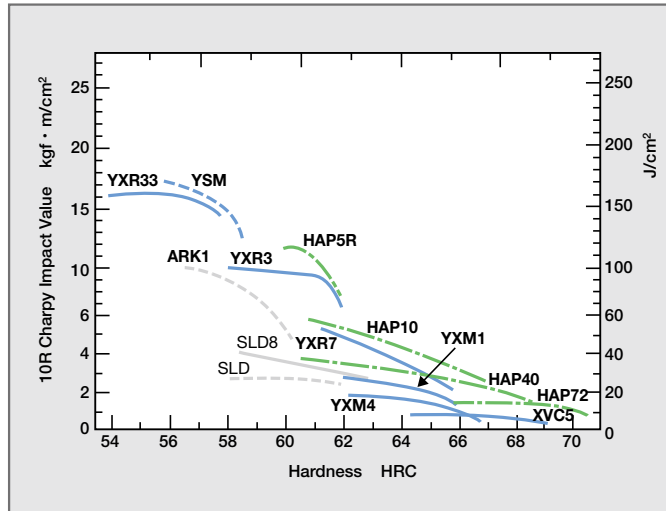
Test condition
 Co-friction material : SCM415 Friction length : 400m
 Load : 67N (6.8kgf) Friction speed : 0.78m/sec

● Wear resistance (Abrasive Wear)

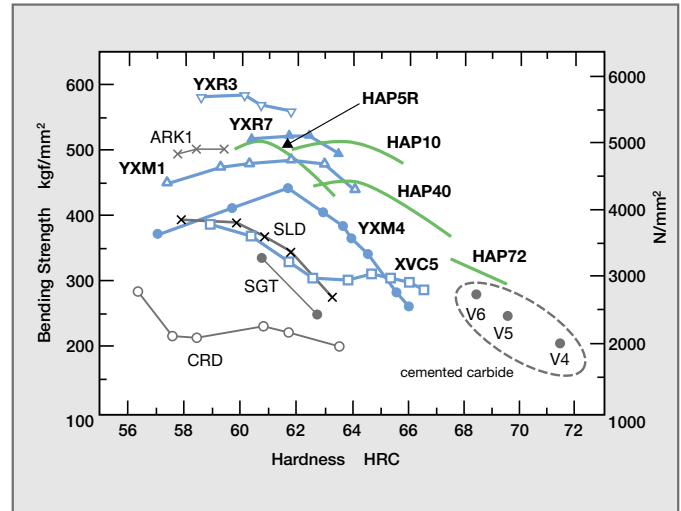
Grade	Hardness (HRC)	Wear (Volume loss; YXM1=1)		
		1.0	2.0	3.0
YXM1	65	1.0	1.0	1.0
YXM4	65	~1.0	~1.0	~1.0
XVC5	67	~1.0	~1.0	~1.0
YXR3	61	~1.0	~1.0	~1.0
YXR33	58	~1.0	~1.0	~1.0
HAP10	65	~1.0	~1.0	~1.0
HAP72	70	~1.0	~1.0	~1.0
SKD11	59	~1.0	~1.0	~1.0

Test condition
 Sandpaper : Al₂O₃ #500 Revolution : 980rpm Friction length : 1000mm
 Lubricant : dry Load : 49N (5kgf)

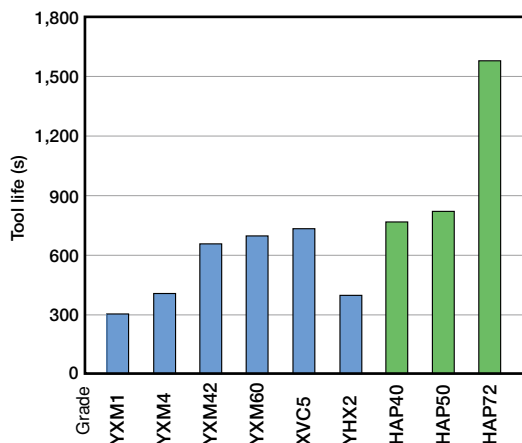
● Charpy impact value



● Bending strength

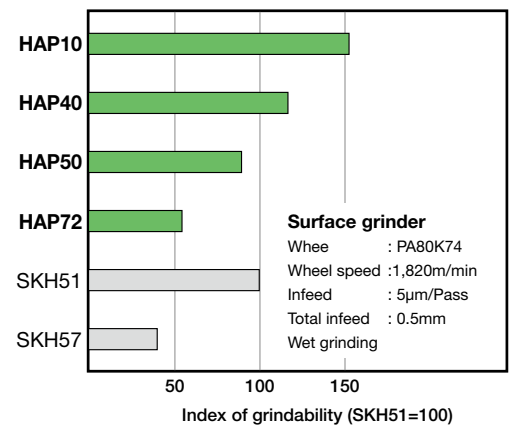


● Continuous Cutting test by turning tool



Cutting condition
 Work : SKT4(357HB)
 Machine : Automatic lathe
 Tool tip shape : 8-15-6-6-20-15-0.5R
 Cutting speed : 25m/min
 Depth of cut : 1mm
 Feed : 0.3mm/rev
 Dry cutting

● Grindability



Surface grinder
 Wheel : PA80K74
 Wheel speed : 1,820m/min
 Infeed : 5µm/Pass
 Total infeed : 0.5mm
 Wet grinding

Recommended grade by application of YSS High Speed Tool Steels

● Cutting tools

Application	Recommended Grade		
	For general use	For hard material cutting	For high speed heavy duty cutting
Tool bit	XVC5 (65-68), HAP72 (69-71)		
Drill	YXM1 (63-66)	YXM60, YXM42 (66-68) HAP50 (66-68), HAP72 (68-70)	HAP40, HAP50 (66-68)
Tap	YXM1 (63-66)	YXM27 (65-67), HAP10 HAP40 (65-67), HAP72 (68-70)	YXM27 (65-67), HAP40 (65-67)
Reamer	YXM1 (63-66)	YXM4, YXM60 (65-67)	YXM4 (64-67)
Milling cutter	YXM1 (63-66)	YXM42, YXM60 (65-67) HAP40 (66-68)	YXM4, XVC5 (65-67) HAP40, HAP50 (66-68)
End mill	YXM1, YXM4 (64-66) YXM60 (67-69)	YXM60 (67-69), HAP72 (69-71)	XVC5 (66-68), HAP50 (66-69) HAP72 (69-71)
Broach	YXM1 (63-66), YXM4 (64-67)	YXM60 (66-68), HAP10 HAP40, HAP50 (66-68)	YXM27 (65-67), HAP10 HAP40, HAP50 (66-68)
Hob	YXM4, YXM1 (64-66)	YXM60 (67-69), HAP50 (67-69)	HAP40, HAP50 (66-68)
Pinion cutter	YXM1, YXM4 (63-65)	HAP40 (65-67)	HAP10, HAP40 (64-66)
Shaving cutter	YXM1 (64-66)	YXM27 (65-67) YXM42, YXM60 (66-68)	
Rack cutter	YXR7, YXM1 (63-66)	YXM4 (65-67)	YXM4 (65-67)
Chaser	YXM1 (62-65)	YXM27 (65-67), HAP10 (65-67)	YXM4, YXM27 (65-67)
Metal saw	YXM1 (63-66)		
Hack saw	YXM1 (62-65)	YXM42 (66-68), HAP40 (66-68)	YXM42 (66-68), HAP40 (66-68)
Metal band saw		YXM42 (66-68)	HAP50 (66-68)
Wood cutter	YXR3 (58-61) YXM1, YHX2 (62-65)	YXM42 (66-68)	YXM4 (65-67)

() shows standard employed hardness/HRC.

Recommended grade by application of YSS High Speed Tool Steels

● Cold working tools

Application		Required hardness range (HRC)	Recommended Grade			
			For general use	For mass production use		
				For abrasion resistance	For impact resistance	
Die for cold press	Blanking die		58~62	SLD, SLD-MAGIC, ARK1	HAP10, HAP40	YXM1, YXR7, HAP5R
	Blanking die	Sheet use	55~60	HMD5 (flame hardening type)	SLD, SLD-MAGIC	ARK1
		Heavy plate, high-tensile steel	58~62	SLD, SLD-MAGIC, ARK1	HAP10 · HAP40	YXM1, YXR7, HAP5R
	Bender swaging dies	Sheet use	58~62	SLD	SLD-MAGIC	ARK1
		Heavy plate, high-tensile steel	58~62	SLD, SLD-MAGIC	XVC5	YXM1
Cold working dies	Cold working dies	Male die	58~63	SLD, SLD-MAGIC	YXM1, HAP40	YXR7, YXR3, HAP10
		Female die	55~60	SLD, SLD-MAGIC, ARK1	YXM1, HAP10	YXR3, YXR7, HAP5R
	Cold heading die	Male die	58~62	SLD, SLD-MAGIC	HAP40	YXM1, YXR7, YXR3
		Female die	55~60	YSM	SLD, SLD-MAGIC	YXM1, YXR7, YXR3
Thread rolling dies		58~64	SLD, SLD-MAGIC	YXR7, YXM1, SLD10		
Rolls	Cold rolling mill rolls		80HS Min	SLD, SLD-MAGIC	YXM1, HAP50, HAP40	
Other	Triming dies	Thin material (under 3 mm)	55~60	SLD, SLD-MAGIC, ARK1	YXM1, HAP40	YXR3, YXR7
		Thick material (3 mm or over)	50~55	DAC, DM		
Drawing dies		57~62	YXM1, CRD	XVC5		
Cold hobbing dies		55~60	SLD, SLD-MAGIC	YXM1		
Machine cutlery	Shearing blades (Straight blades)	Thin material plate (under 3mm)	55~60	SLD, SLD-MAGIC, ARK1	YXM1, YXR7	YXR3
		Medium material plate (3mm to 9mm)	53~58	SLD, SLD-MAGIC, ARK1		YXR33
		Heavy material plate (10 mm or over)	48~53	DM		
	Rotary shear, slitters		54~60	SLD, SLD-MAGIC, ARK1	YXM1, HAP40	

Standard heat treatment conditions of YSS High Speed Tool Steels

Grade	Temperature (°C)						Hardness			
	Annealing		Quenching		Tempering		Annealed (HBW)		Quenched and tempered (HRC)	
Conventional High Speed Tool Steels	YXM1	800~880 Slow cooling	1,210	Oil	560	Air cooling	255	Max	63	Min
	YXM4	800~880 Slow cooling	1,220	Oil	560	Air cooling	277	Max	64	Min
	YXM27	800~880 Slow cooling	1,190	Oil	560	Air cooling	255	Max	64	Min
	YXM42	820~880 Slow cooling	1,190	Oil	560	Air cooling	285	Max	66	Min
	YXM60	820~880 Slow cooling	1,200	Oil	550	Air cooling	285	Max	66	Min
	XVC5	820~880 Slow cooling	1,240	Oil	560	Air cooling	285	Max	64	Min
	YHX2	820~880 Slow cooling	1,270	Oil	570	Air cooling	248	Max	62	Min
	YXR3	800~880 Slow cooling	1,150	Oil	560	Air cooling	241	Max	57	Min
	YXR33	800~880 Slow cooling	(1) 1,140 (2) 1,080	Oil	560	Air cooling	241	Max	(1) 56 (2) 54	Min
	YXR7	800~880 Slow cooling	1,150	Oil	560	Air cooling	241	Max	62	Min
P/M High Speed Tool Steels	HAP10	820~880 Slow cooling	1,180	Oil	560	Air cooling	269	Max	63	Min
	HAP40	820~880 Slow cooling	1,200	Oil	560	Air cooling	277	Max	66	Min
	HAP50	820~880 Slow cooling	1,200	Oil	560	Air cooling	293	Max	66	Min
	HAP72	820~880 Slow cooling	1,200	Oil	550	Air cooling	352	Max	68	Min
	HAP5R	820~880 Slow cooling	1,140	Oil	530	Air cooling	269	Max	58	Min

Remarks (1) Tools required for high strength at elevated temperature
(2) Tools required for higher toughness

Standard heat treatment conditions of YSS High Speed Tool Steels

● Annealing

1. All material is delivered as spheroidized annealed condition.
2. When used after reforging, spheroidized annealing is to be done before hardening.
3. 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 : 650~750°C
(to aim higher temperature when softening required)
 - Holding time : 1h/25mm thickness

● Holding time of austenitizing

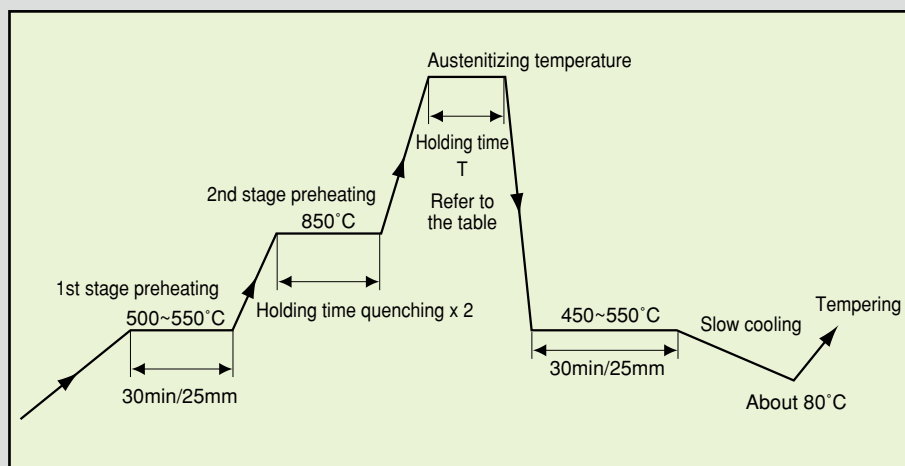
Preheating time 1st stage : 30 minutes for every 25 mm of the tool at 500-550°C

2nd stage: (Ta x 2) at 850°C

3rd stage: (Ta x 2) at 1,050°C

} Preheating is (Ta 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.

● Tools of ordinary shape



(Remarks) As for simple figure tools, 1st stage preheating can be skipped and oil quenching can be applied instead of hot salt bath quenching. For complex figure tools, 3rd stage preheat (1,050°C) applying is preferable.

● Holding time at austenitizing temperature (Ta)

Heating surface	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	
	Magnification(Holding time/Thickness)	X12	X9	X8	X8	X7	X7	X6.5	X6	X5.5	X5.5	

(Remarks) Holding time in salt bath = dipping time

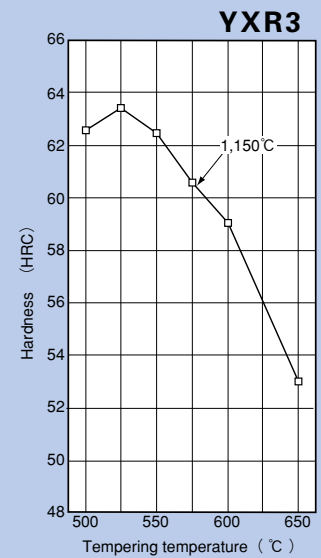
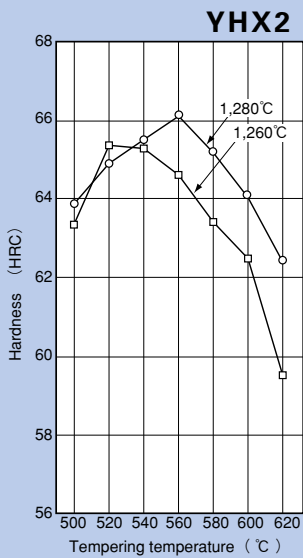
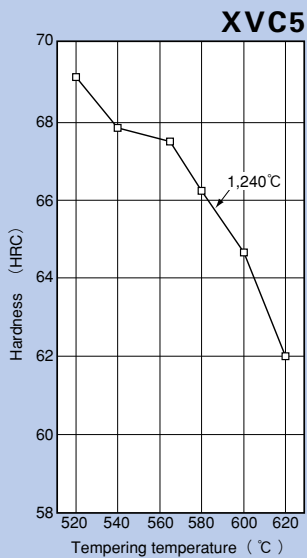
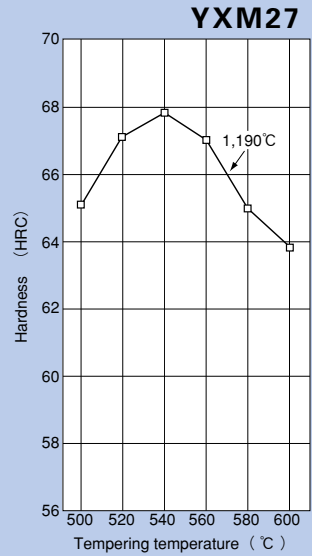
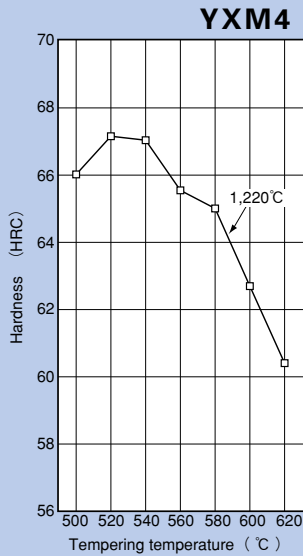
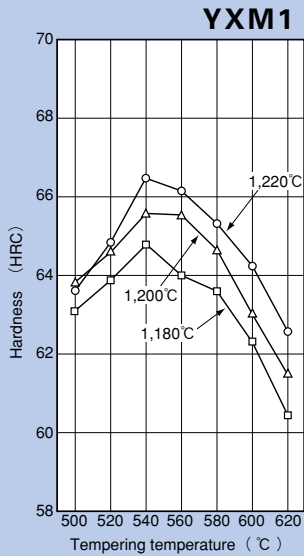
● Holding time at tempering temperature (Tt)

Thickness (mm)	25	26 - 35	36 - 64	65 - 84	85 - 124	125 - 174	175 - 249	250 - 349	350 - 499
Tempering holding time (hour)	1	1.5	2	3	4	5	6	7	8

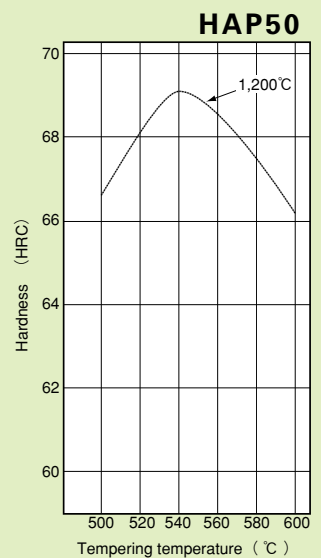
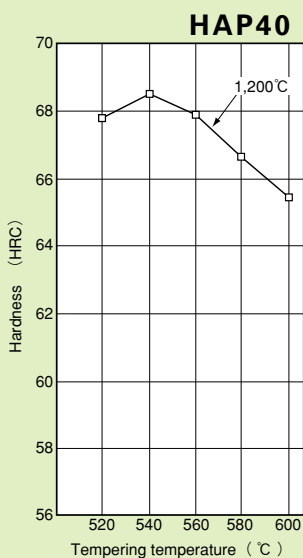
(Remarks) Tempering is needed more than 2 times for grades contain no cobalt and needed more than 3 times for grades cobalt alloyed in order to make it tough enough.

Standard heat treatment conditions of YSS High Speed Tool Steels

● Conventional High Speed Tool Steels

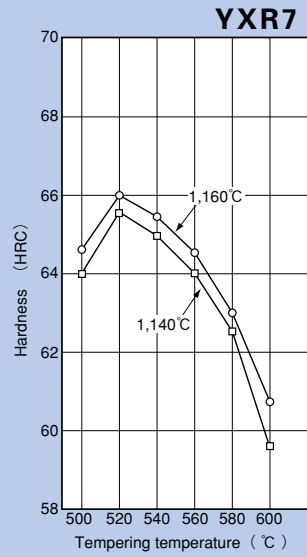
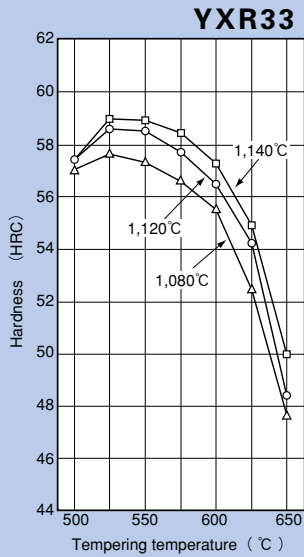
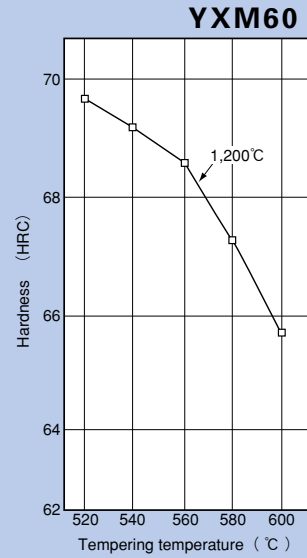
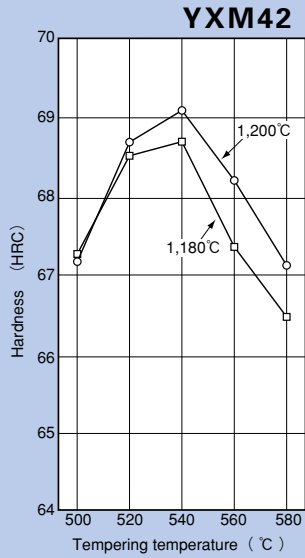


● P/M High Speed Tool Steels



Standard heat treatment conditions of YSS High Speed Tool Steels

Conventional High Speed Tool Steels



P/M High Speed Tool Steels

