

# **YSS** High Speed Tool Steels



# Chemical compositions of YSS High Speed Tool Steels

(mass%)

		Grade	JIS equivalent	AISI/ASTM W.Nr DIN/ISO	C	Cr	W	Mo	V	Co
Conventional High Speed Tool Steels	Molybdenum HSS	<b>YXM1</b>	SKH51	$\frac{M2}{1.3343}$ HS6-5-2	0.80-0.90	3.80-4.50	6.00-7.00	4.80-5.80	1.80-2.30	–
		<b>YXM4</b>	SKH55	$\frac{-}{1.3243}$ HS6-5-2-5	0.85-0.95	3.80-4.50	6.00-7.00	4.80-5.80	1.80-2.30	4.50-5.50
		<b>YXM27</b>	–	–	1.15-1.25	3.80-4.50	4.80-5.80	5.80-6.80	2.60-2.80	–
		<b>YXM42</b>	SKH59	$\frac{M42}{1.3247}$ HS2-9-1-8	1.00-1.10	3.50-4.25	1.25-2.00	9.00-10.00	1.00-1.50	7.75-8.75
		<b>YXM60</b>	–	–	1.00-1.10	3.80-4.50	5.00-6.00	6.00-7.00	1.50-1.80	7.50-8.50
	Vanadium HSS	<b>XVC5</b>	SKH57	$\frac{-}{1.3207}$ HS10-4-3-10	1.20-1.30	3.80-4.50	9.00-11.00	3.00-4.00	3.20-3.70	9.50-10.50
	Tungsten HSS	<b>YHX2</b>	SKH2	$\frac{T1}{1.3355}$ HS18-0-1	0.73-0.83	3.80-4.50	17.00-18.00	–	0.80-1.20	–
	Matrix HSS	<b>YXR3</b>	Matrix HSS	–	0.6	4.3	–	2.9	1.8	–
		<b>YXR33</b>	Matrix HSS	–	0.5	4.2	1.6	2.0	1.2	1.0 or less
		<b>YXR7</b>	Matrix HSS	–	0.8	4.7	1.3	5.5	1.3	–
P/M High Speed Tool Steels	<b>HAP10</b>	–	–	1.30-1.40	4.50-5.50	2.50-3.50	5.50-6.50	3.60-4.00	–	
	<b>HAP40</b>	SKH40	$\frac{-}{-}$ HS6-5-3-8	1.27-1.37	3.70-4.70	5.60-6.40	4.60-5.40	2.80-3.30	7.50-8.50	
	<b>HAP50</b>	–	–	1.54-1.64	3.70-4.70	7.50-8.50	5.50-6.50	3.80-4.30	7.50-8.50	
	<b>HAP72</b>	–	–	2.02-2.32	3.70-4.70	9.00-10.00	8.00-8.50	4.80-5.10	9.00-10.00	
	<b>HAP5R</b>	–	–	0.9	4.3	2.0	3.0	3.0	–	

HSS: High Speed Tool Steel

## 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.



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## Features of YSS High Speed Tool Steels

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

### Outstanding Features;

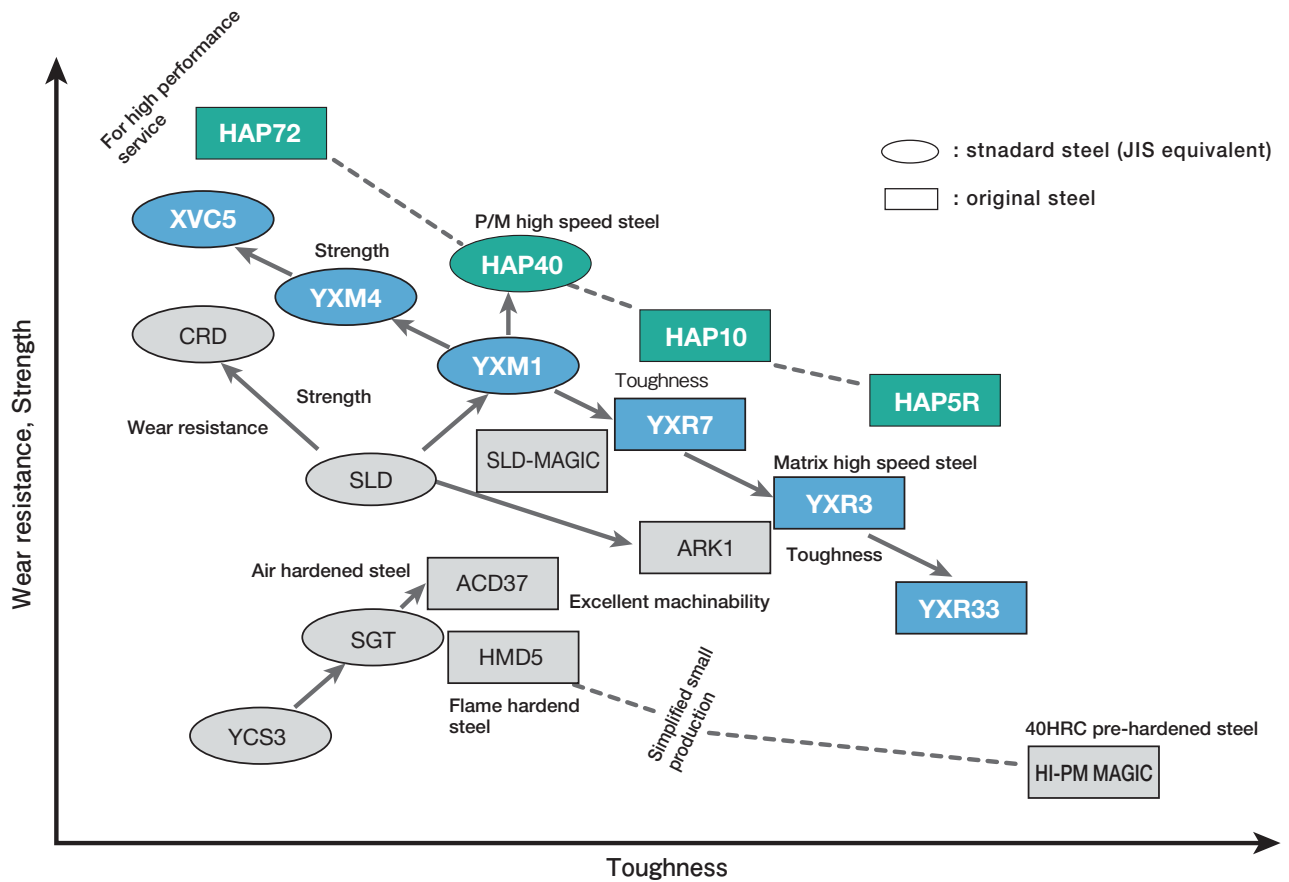
- High toughness
- High wear resistance
- Stabilized heat treatment property
- Stable performance due to uniform and fine carbide distribution
- Good mechanical properties coming from fine and uniform grain size
- High purity with least inclusions and gases



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# 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"



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# Characteristics of YSS High Speed Tool Steels

## Wear resistance (Ogoshi method)

Grade	Hardness (HRC)	Specific wear ( $\text{mm}^3/(\text{mm}^2 \cdot \text{mm}) \times 10^{-7}$ )	
		0.5	1.0
YXM1	65.5	~0.5	~0.5
YXM4	66.0	~0.5	~0.5
YXM27	66.0	~0.5	~0.5
XVC5	67.0	~0.5	~0.5
YXR33	58.0	~0.5	~0.5
YXR3	59.0	~0.5	~0.5
YXR7	65.0	~0.5	~0.5
HAP5R	60.7	~0.5	~0.5
HAP10	64.0	~0.5	~0.5
HAP40	67.2	~0.5	~0.5
HAP72	70.0	~0.5	~0.5
SKD11	60.5	~0.5	~0.5
SKD61	55.5	~0.5	~1.85

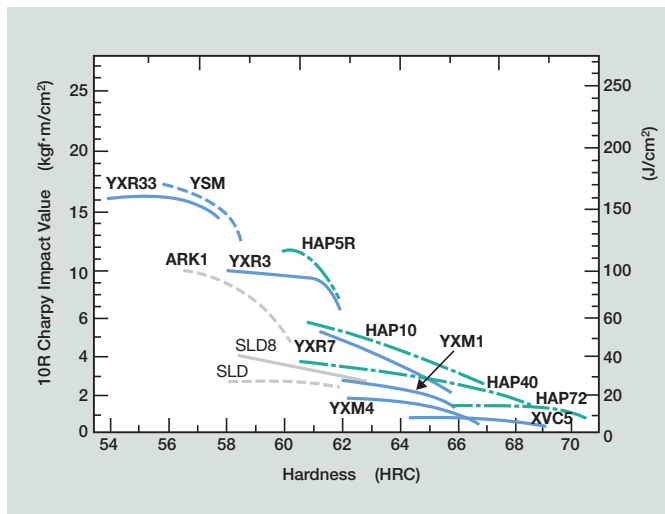
**Test condition**  
 Co-friction material: SCM415      Friction length: 400m  
 Load: 67N (6.8kgf)                  Friction speed: 0.78m/sec

## Wear resistance (Abrasive Wear)

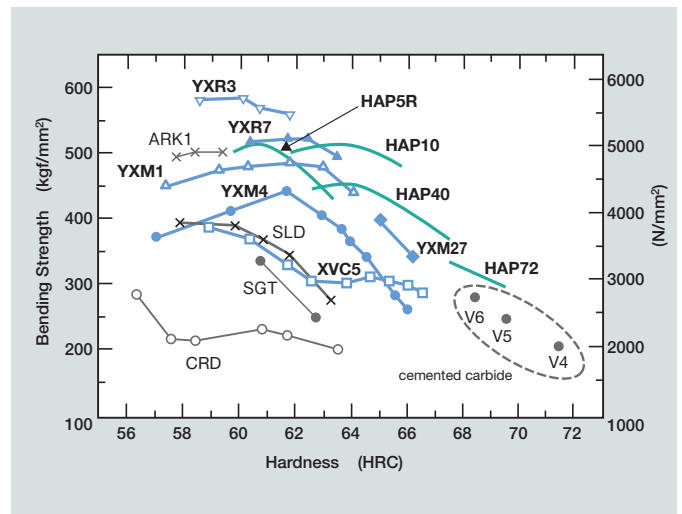
Grade	Hardness (HRC)	Wear (Volume loss; YXM1=1)		
		1.0	2.0	3.0
YXM1	65	1.0	1.0	1.0
YXM4	65	~1.0	~1.0	~1.0
XVC5	67	~1.0	~1.0	~1.0
YXR3	61	~1.0	~1.0	~1.0
YXR33	58	~1.0	~1.0	~1.0
HAP10	65	~1.0	~1.0	~1.0
HAP72	70	~1.0	~1.0	~1.0
SKD11	59	~1.0	~1.0	~1.0

**Test condition**  
 Sandpaper: Al<sub>2</sub>O<sub>3</sub> # 500      Revolution: 980rpm      Friction length: 1000mm  
 Lubricant: dry                  Load: 49N (5kgf)

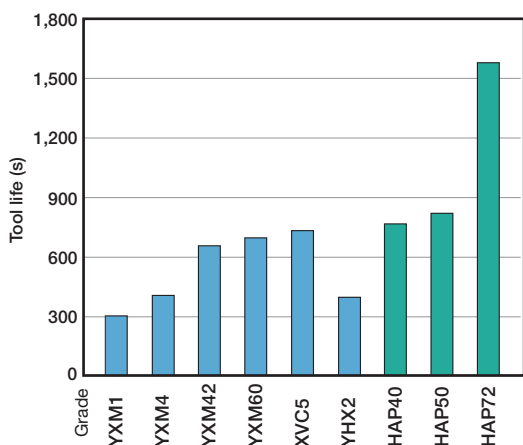
## Charpy impact value



## Bending strength

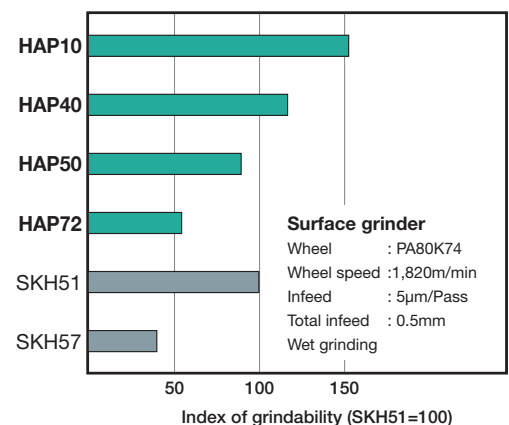


## Continuous Cutting test by turning tool



**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



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# Recommended grade by application of YSS High Speed Tool Steels

## Cutting tools

( ) shows standard employed hardness/HRC.

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



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# Recommended grade by application of YSS High Speed Tool Steels

## Cold working tools

( ) shows standard employed hardness/HRC.

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 dies	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	



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# 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	<b>YXM1</b>	800-880 Slow cooling	(1)1,220-1,240 (2)1,200-1,220 Oil(hot bath)	550-570 Air cooling	255 Max	63 Min
	<b>YXM4</b>	800-880 Slow cooling	(1)1,230-1,250 (2)1,210-1,230 Oil(hot bath)	560-580 Air cooling	277 Max	64 Min
	<b>YXM27</b>	800-880 Slow cooling	1,180-1,210 Oil(hot bath)	550-580 Air cooling	255 Max	64 Min
	<b>YXM42</b>	820-880 Slow cooling	(1)1,190-1,210 (2)1,170-1,190 Oil(hot bath)	520-590 Air cooling	285 Max	66 Min
	<b>YXM60</b>	820-880 Slow cooling	(1)1,190-1,210 (2)1,170-1,190 Oil(hot bath)	560-590 Air cooling	285 Max	66 Min
	<b>XVC5</b>	820-880 Slow cooling	(1)1,230-1,250 (2)1,210-1,230 Oil(hot bath)	550-580 Air cooling	285 Max	64 Min
	<b>YHX2</b>	820-880 Slow cooling	(1)1,270-1,290 (2)1,250-1,270 Oil(hot bath)	560-580 Air cooling	248 Max	62 Min
	<b>YXR3</b>	800-880 Slow cooling	(1)1,150-1,170 (2)1,130-1,150 Oil(hot bath)	560-590 Air cooling	241 Max	57 Min
	<b>YXR33</b>	800-880 Slow cooling	1,080-1,140 Oil(hot bath)	550-600 Air cooling	241 Max	56 Min
	<b>YXR7</b>	800-880 Slow cooling	(1)1,160-1,180 (2)1,130-1,150 Oil(hot bath)	540-580 Air cooling	241 Max	62 Min
P/M High Speed Tool Steels	<b>HAP10</b>	820-880 Slow cooling	(1)1,170-1,190 (2)1,050-1,170 Oil(hot bath)	550-580 Air cooling	269 Max	(1) 65-66 (2) 58-65
	<b>HAP40</b>	820-880 Slow cooling	(1)1,180-1,210 (2)1,120-1,190 Oil(hot bath)	560-580 Air cooling	277 Max	(1) 66-68 (2) 64-66
	<b>HAP50</b>	820-880 Slow cooling	(1)1,200-1,220 (2)1,180-1,200 Oil(hot bath)	560-580 Air cooling	293 Max	(1) 67-69 (2) 66-67
	<b>HAP72</b>	820-880 Slow cooling	1,180-1,210 Oil(hot bath)	560-580 Air cooling	352 Max	68-70
	<b>HAP5R</b>	820-880 Slow cooling	1,120-1,160 Oil(hot bath)	530-580 Air cooling	269 Max	58-62

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



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# 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 is required)
  - Holding time :1h/25mm thickness

## Holding time of austenitizing

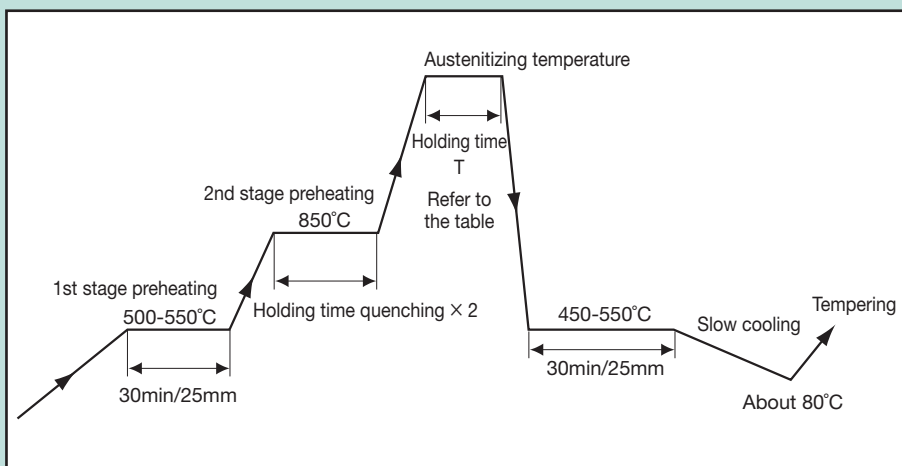
Preheating time 1st stage : 30 minutes for every 25 mm of the tool at 500-550°C

2nd stage: (Ta × 2) at 850°C

3rd stage: (Ta × 2) at 1,050°C

} Preheating is (Ta × 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 furnace	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)	×12	×9	×8	×8	×7	×7	×6.5	×6	×5.5	×5.5

(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

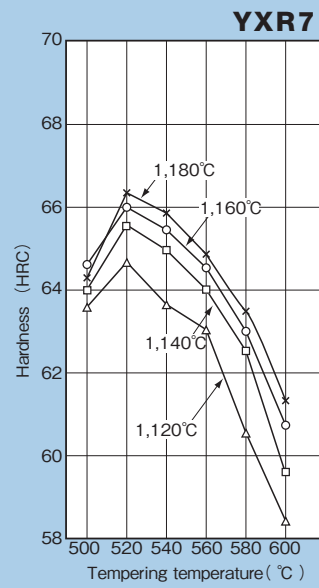
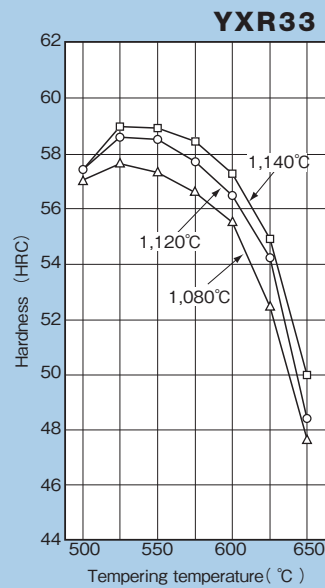
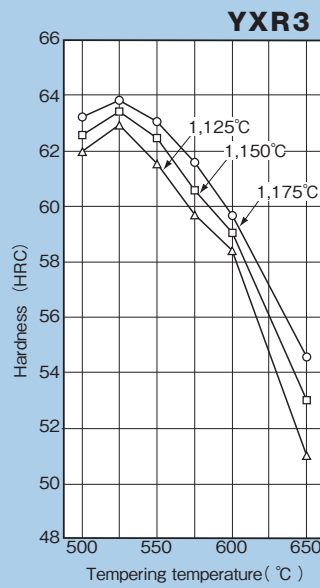
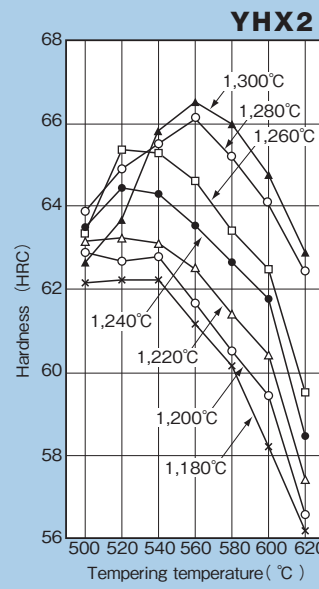
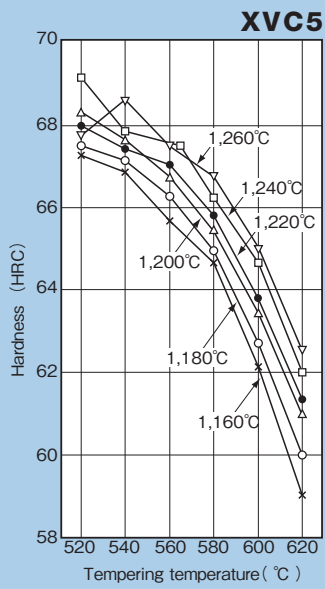
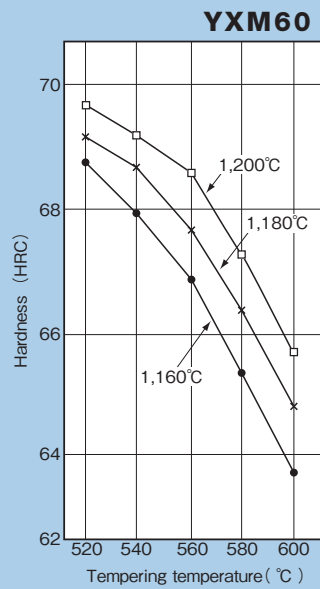
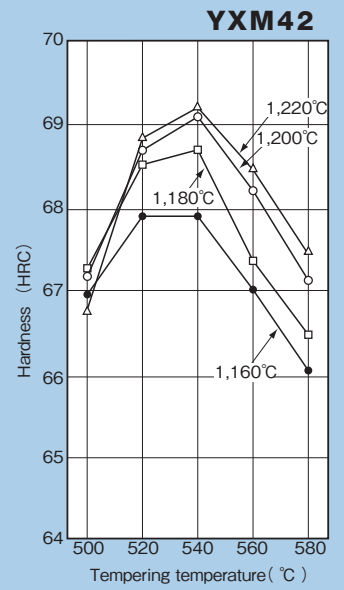
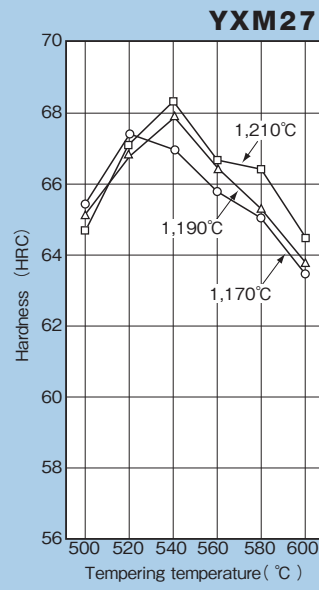
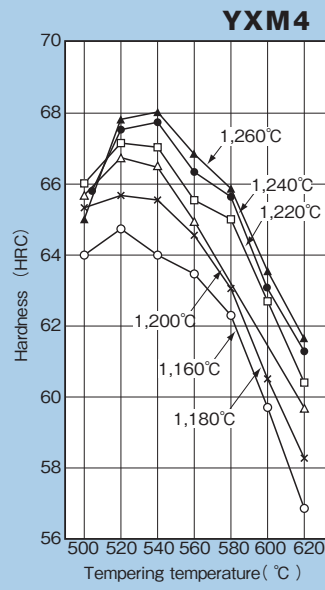
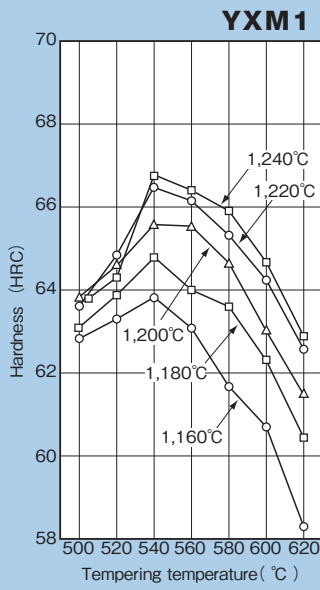
(Remarks) Tempering is needed more than 2 times for grades containing no cobalt and needed more than 3 times for grades cobalt alloyed in order to make it tough enough.



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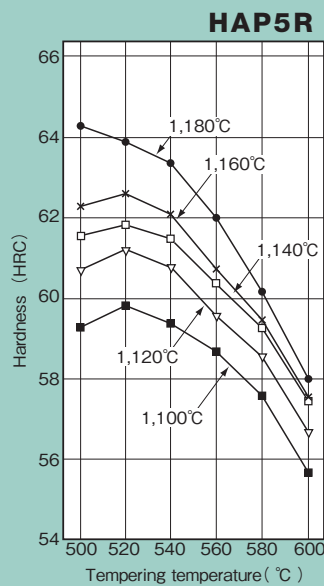
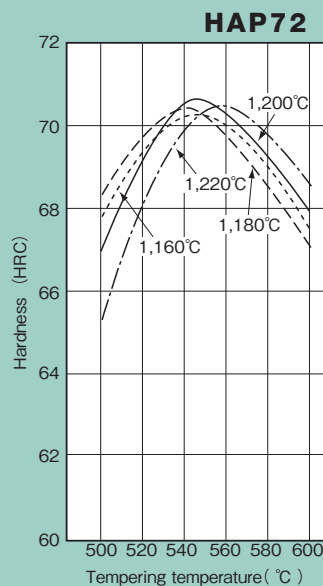
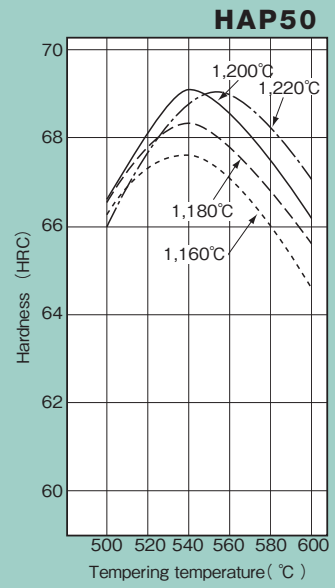
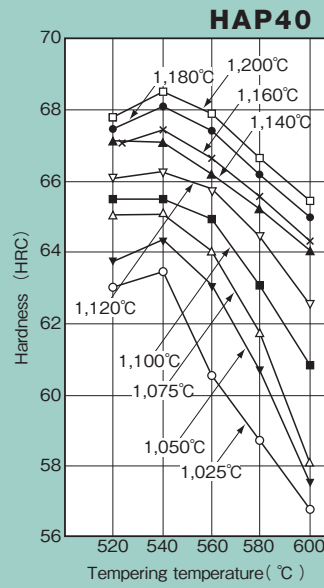
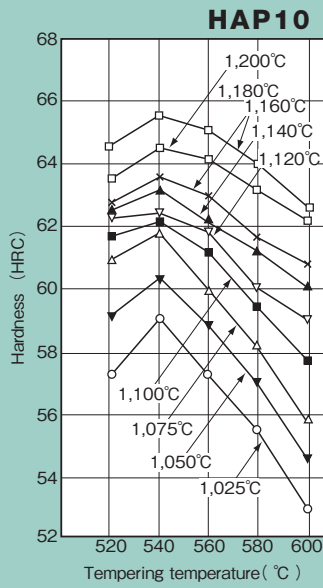
## Conventional High Speed Tool Steels



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# Standard heat treatment conditions of YSS High Speed Tool Steels

## P/M High Speed Tool Steels



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