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Global Steel Grade Encyclopedia



涵盖的行业或国家与地区类别



美国材料与试验协会

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动力机械工程师协会

EU

前欧洲标准化

AISI

美国钢铁学会



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国际标准

JASO

日本汽车标准组织

EN

欧洲标准

JB

中国机械行业标准

UNS

统一编号系统

UNI

意大利标准



美国机械工程师协会

SS

瑞典标准



国家标准



日本工业标准

Types of YSS cold work tool steels

Grade					Chemical composition (%)								
YSS	Color	JIS equivalent	AISI	DIN WNr.	C	Si	Mn	Cr	W	Mo	V	Co	Others
Cold work tool steels	SLD-MAGIC	Original steel			High-performance cold work tool steel								Free-cutting elements added
	SLD	SKD11	D2	1.2379	1.5	0.3	0.4	12.0	—	0.9	0.3	—	
	SLD10	8% Cr steel			1.0	1.0	0.4	7.5	—	2.8	0.4	—	
	ARK1	Original steel			0.7	0.3	0.4	7.5	—	1.0	0.3	—	S : 0.05
	SGT	SKS3	O1	1.2510	1.0	0.3	1.0	0.7	0.7	—	—	—	
	YCS3	SKS93	W5		1.0	0.4	0.9	0.4	—	—	—	—	
	ACD37	Original steel	A4		0.9	0.3	2.0	1.1	—	1.3	—	—	
	HMD5	Original steel			0.7	1.0	1.0	1.2	—	0.2	—	—	
	HI-PM MAGIC	Original steel			40HRC pre-hardened steel								
High speed tool steels	YXM1	SKH51	M2	1.3343	0.9	0.3	0.4	4.2	6.5	5.0	2.0	—	
	YXM4	SKH55		1.3243	0.9	0.3	0.3	4.2	6.5	5.3	1.9	5.0	
	YXR7				0.8	0.8	0.3	4.7	1.3	5.5	1.3	—	
	YXR3	Matrix high speed steel			0.6	1.5	0.4	4.3	—	2.9	1.8	—	
	YXR33				0.5	0.2	0.5	4.2	1.6	2.0	1.2	—	
P/M High speed tool steels	HAP5R	P/M high speed steel			0.9	0.8	0.3	4.3	2.0	3.0	3.0	—	
	HAP10		M3 : 2		1.4	0.6	0.3	5.0	3.0	6.0	3.8	—	
	HAP40	SKH40		1.3244	1.3	0.3	0.4	4.2	6.0	5.0	3.1	8.0	
	HAP72	P/M high speed steel			2.1	0.4	0.3	4.2	9.5	8.3	5.0	9.5	

Applications in cold work dies

Application		Standard hardness (HRC)	Recommended YSS steel			
			For general use	For mass production use		
				For abrasion resistance	For impact resistance	
Cold press die	Blanking dies (small, progressive)	58-62	SLD, SLD-MAGIC, ARK1	HAP10, HAP40	YXM1, YXR7, HAP5R	
	Blanking dies	For general sheet use	55-60	HMD5	SLD, SLD-MAGIC	ARK1
		For general heavy plate use	58-62	SLD, SLD-MAGIC, ARK1	HAP10, HAP40	YXM1, YXR7, HAP5R
	Bending and Swaging dies	For general sheet use	58-62	SLD	SLD-MAGIC	ARK1
For general heavy plate use		58-62	SLD, SLD-MAGIC	HAP40	YXM1	
Cold forging dies	Forging dies	Male die	58-63	SLD, SLD-MAGIC	YXM1, HAP40, YXM4	YXR7, YXR3, HAP10
		Female die	55-60	SLD, SLD-MAGIC, ARK1	YXM1, HAP10	YXR7, YXR3, HAP5R
	Heading dies	Male die	58-62	SLD, SLD-MAGIC	HAP40, YXM4	YXM1, YXR7, YXR3
		Female die	55-60	YSM	SLD, SLD-MAGIC	YXM1, YXR7, YXR3
Thread forming dies		58-64	SLD	YXR7, YXM1, SLD10		
Cold working rolls		≥80HS	SLD, SLD-MAGIC	YXM1, HAP40		



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Types of YSS cold work tool steels

Grade	Characteristics	Main Application	
YSS			
Cold work tool steels	SLD-MAGIC	High-performance cold work tool steel attaining both extended die life and easy die fabrication.	Cold work dies for high-tensile steels, SUS, mass production, and general use.
	SLD	Cold work die steel with high abrasion resistance for general use, excellent harden-ability and minimal quench stress.	Cold work dies for general use, forming roll, shear blade.
	SLD10	Extremely high hardness with excellent toughness in die steels, 62-64HRC.	Rolling dies.
	ARK1	Cold work die steel with high toughness and improved machinability.	Dies for printed circuit board, die plates, stripper plates.
	SGT	Cold work die steel with superior machinability for general use; Special care is required for quenching large-size dies or wire electric discharge machining.	Dies for deep drawing, gauges.
	YCS3	Carbon tool steel for small production to be quenched in oil. Improved SK105 grade for its hardenability.	Press forming dies, jigs and tools, gauges.
	ACD37	Vacuum quenched and air quenched steel. Improved SGT grade for its hardenability and wire electric discharge machining.	Dies for deep drawing, gauges.
	HMD5	Steel for flame hardening, resulting in high hardness and small strain even with air quenched; good weldability.	Dies for deep drawing.
	HI-PM MAGIC	40HRC pre-hardened steel.	Press forming dies for small production, jigs and tools.
High speed tool steels	YXM1	High speed steel with high abrasion resistance and toughness for general use.	Cold forging dies, cold heading dies, slitter.
	YXM4	High speed steel to prevent from abrasion, seizure and deformation under high pressure	Cold forging dies, drawing dies.
	YXR7	Matrix high speed steel, extremely highest toughness in 62-65HRC. Available for vacuum quenching.	Rolling dies, cold forging dies, roll, cold forging punches, blanking punches.
	YXR3	Matrix high speed steel for general use, extremely highest toughness in 58-61HRC.	Dies to be used for cracking or chipping resistance.
	YXR33	Matrix high speed steel highest toughness in high speed steels. Standard hardness 54-58HRC.	Cold forging dies, warm forging dies.
P/M High speed tool steels	HAP5R	Extremely tough Powder Metallurgy process high speed steel.	Cold forging dies, fine blanking dies.
	HAP10	Extremely tough Powder Metallurgy process high speed steel.	Cold forging dies, fine blanking dies.
	HAP40	P/M high speed steel with high abrasion resistance and toughness for general use.	Press forming dies for mass production, roll.
	HAP72	P/M high speed steel with high hardness and highest abrasion resistance.	Cold plastic working dies of long life, high performed IC molds.

Applications in cold work dies

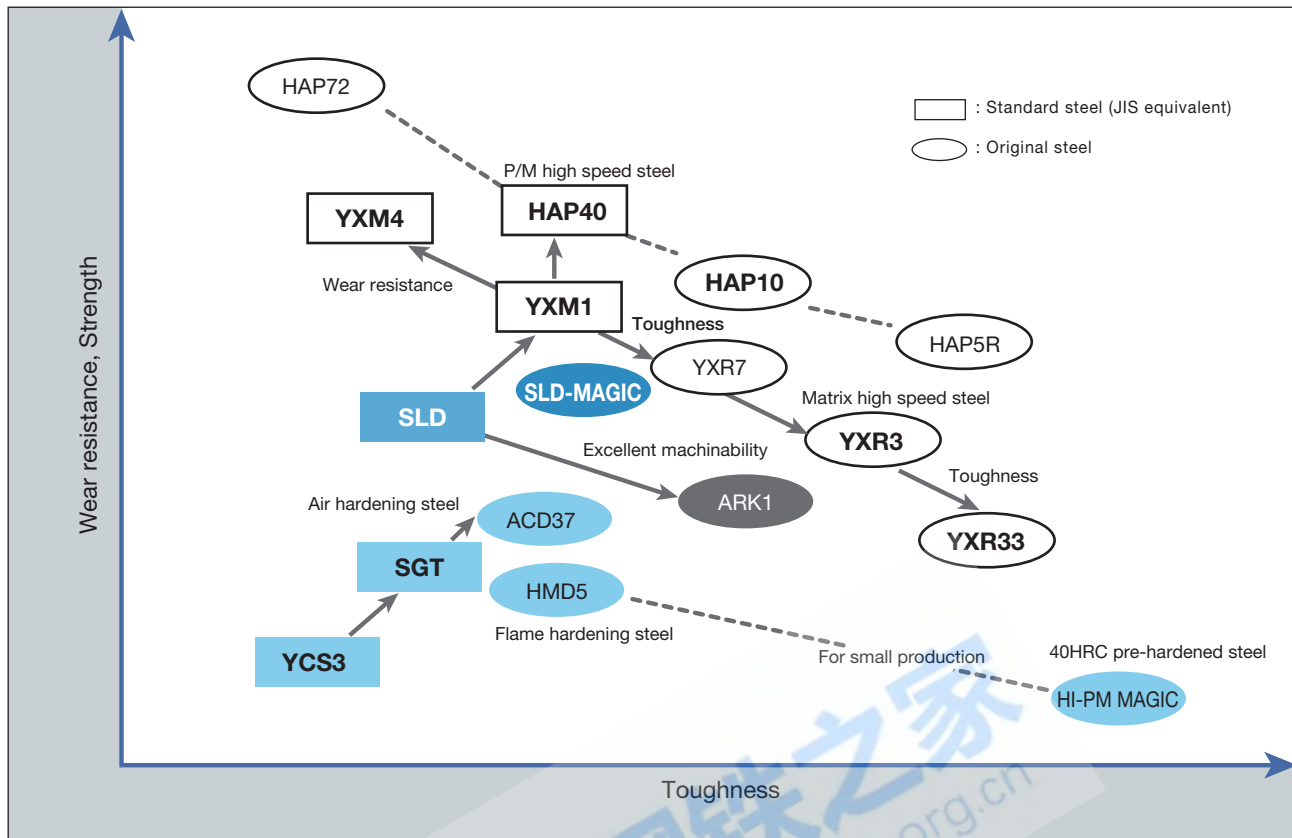
Application			Standard hardness (HRC)	For general use	Recommended YSS steel	
					For mass production use	
					For abrasion resistance	For impact resistance
For plastic forming	Trimming dies	For sheet use	55-60	SLD, SLD-MAGIC, ARK1	YXM1, HAP40	YXR3, YXR7
		For heavy plate use	50-55	DAC, DM		
	Cold hobbing dies	55-60	SLD, SLD-MAGIC	YXM1		
	Drawing dies	57-62	SLD, YXM1	HAP40		
Machine cutter	Shearing blade (straight tooth)	For sheet service	55-60	SLD, SLD-MAGIC, ARK1	YXM1, YXR7	YXR3
		For medium plate	53-58	SLD, SLD-MAGIC, ARK1, ACD8		YXR33
		For heavy plate	48-53	DM, ACD8		
	Rotary shear slitters	54-60	SLD, SLD-MAGIC, ARK1	YXM1, HAP40		
	Billet shear	Thicknesses 50mm and under	50-55	DM, ACD8		
Thicknesses over 50mm		48-53	DAC, DM, ACD8			
Gauges			60-64	SGT, ACD37, YCS3		



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Characteristics of YSS cold work tool steels

Characteristics of steels



Comparison of characteristics

Grade	Wear resistance	Pressure resistance	Toughness	Hardenability	Distortion by heat treatment	Machinability	Weldability	Standard hardness (HRC)
SLD-MAGIC	A	A	A ⁻	A ⁺	A ⁺	A ⁻	B	58-62
SLD	A	A	B	A ⁺	A ⁺	B	C	57-63
SLD10	A ⁻	A	A ⁻	A ⁺	A	B ⁻	C	59-65
ARK1	B ⁺	A	A	A ⁺	A	A ⁻	B	58-60
SGT	C	B ⁺	B	C	D	A	B	57-63
YCS3	D	C	C	D	D	A ⁺	B	57-63
ACD37	B	A ⁻	B	A ⁺	A	A	B	55-60
HMD5	C	B	B	—	—	A	A	55-60
HI-PM MAGIC	D ⁻	D	A ⁺⁺	—	—	A ⁻	A ⁺	40
YXM1	A	A ⁺	A ⁻	B	B	B	C	58-64
YXM4	A ⁺⁺	A ⁺	B	B	B	B ⁻	C	62-66
YXR7	A	A ⁺	A	A	B	B	C	61-65
YXR3	A ⁻	A	A ⁺	B	B	B ⁺	C ⁺	58-61
YXR33	B	B ⁺	A ⁺⁺	A	B	B ⁺	C ⁺	54-58
HAP5R	A	A	A ⁺	A	A	B	C	58-62
HAP10	A ⁺	A ⁺	A	A	A	B ⁻	C	62-65
HAP40	A ⁺⁺	A ⁺⁺	A ⁻	B	A	C ⁺	C	64-67
HAP72	A ⁺⁺⁺	A ⁺⁺⁺	C	A ⁻	A	C ⁻	D	68-71

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



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Characteristics of YSS cold work tool steels

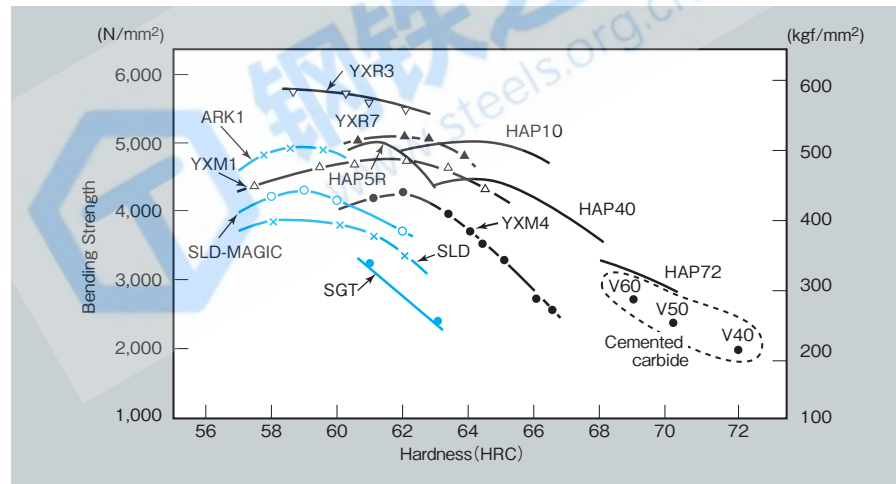
Wear resistance

Grade	Hardness (HRC)	Specific abrasion volume (mm ³ /mm ² · mm) × 10 ⁻⁷			
		0.5	1.0	1.5	2.0
SLD-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
SGT	60.0	~0.7	~0.8	~0.9	~1.0
YCS3	60.0	~0.8	~0.9	~1.0	~1.1
ACD37	60.0	~0.9	~1.0	~1.1	~1.2
YXM1	65.5	~0.4	~0.5	~0.6	~0.7
YXM4	66.0	~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

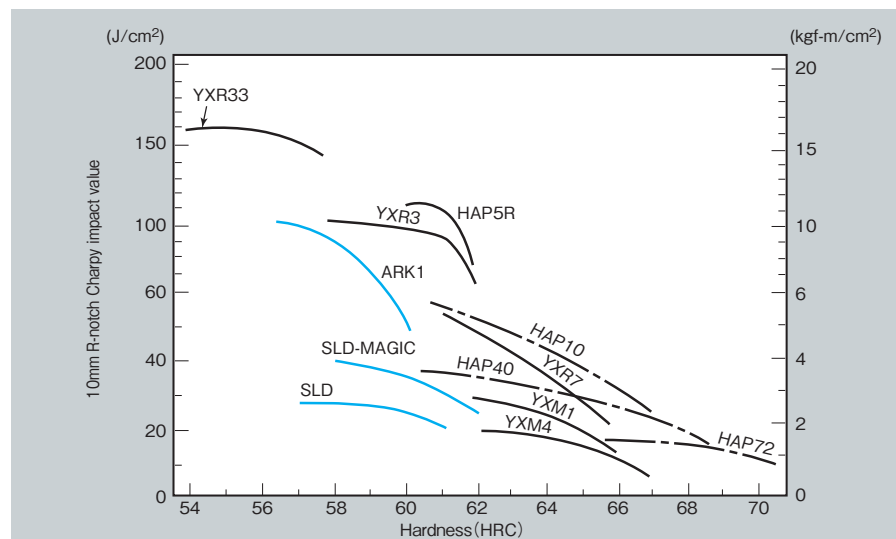
Ongoshi-method wear test
 Work material : SCM415
 Friction distance : 400m
 Friction speed : 0.76m/s
 Load : 67N

Toughness

Bending strength



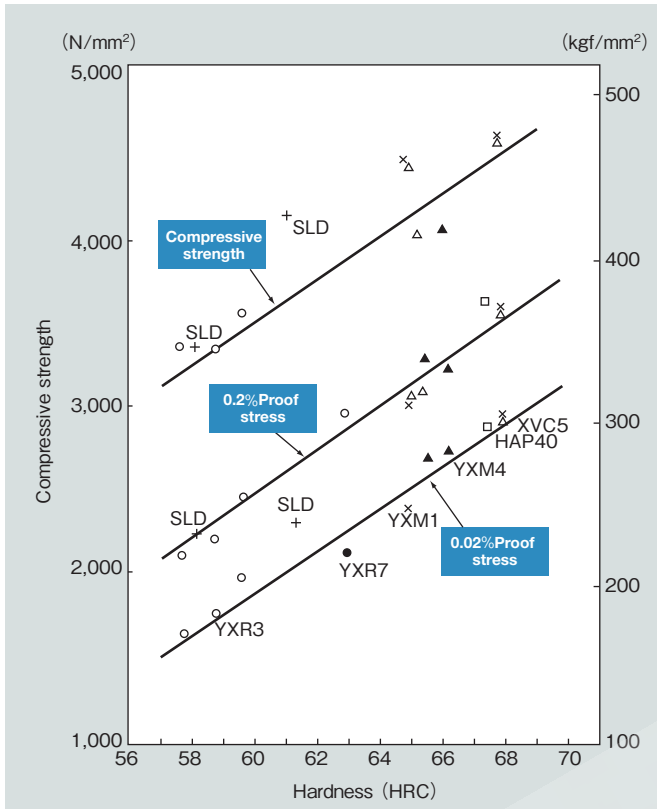
Charpy impact value



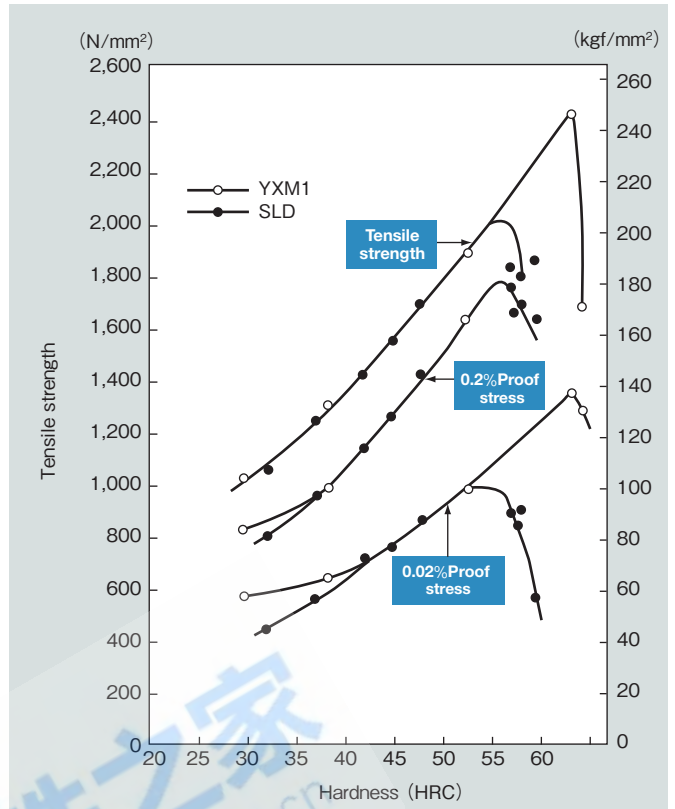
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Characteristics of YSS cold work tool steels

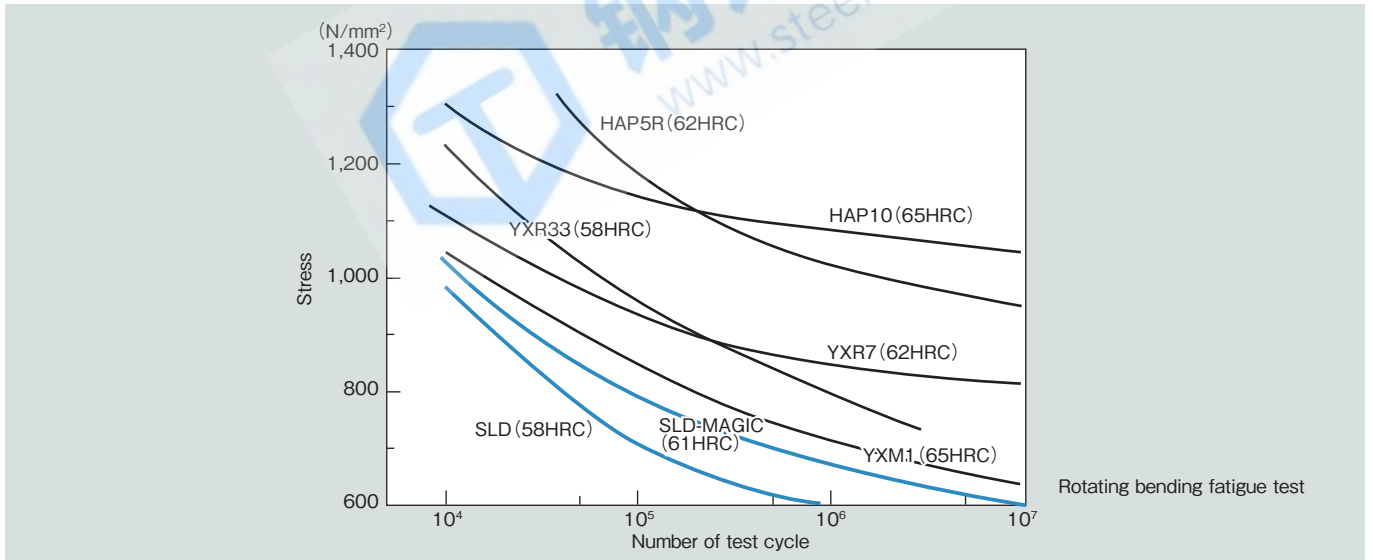
Compressive strength



Tensile strength



Fatigue strength



Physical properties

Grade	Thermal expansion coefficient ×10 ⁻⁶ /°C 20-200°C	Thermal conductivity W/(m·K) 20°C	Young's modulus GPa
SLD-MAGIC	12.2	16.5	209
SLD	11.2	20.6	211
SGT	13.6	23.3	201
YCS3	14.3	25.9	207
YXM1	11.2	21.0	216
YXR3	11.3	18.7	212
HAP40	10.3	19.3	227



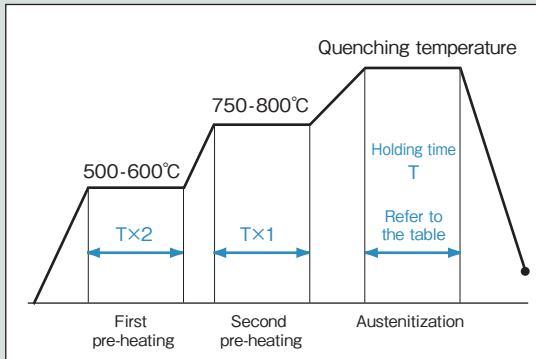
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Heat treatment of YSS cold work tool steels

Hardening

* Please refer to the standard heat-treatment condition of each grade for hardening and quenching condition.

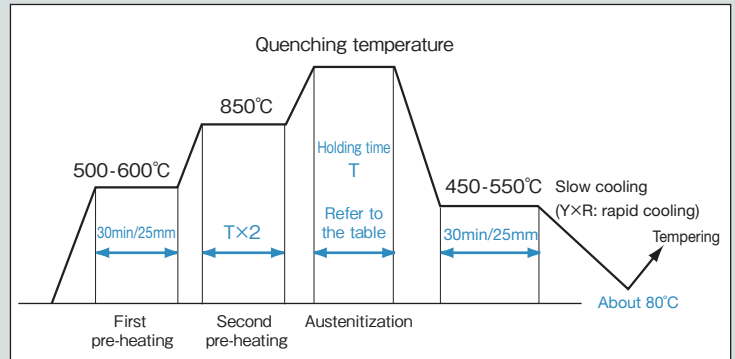
Alloy tool steels, Carbon tool steels



Holding time at austenitizing temperature

Thickness (mm)	≤15	25	50	75	100	125	150	200	300
Holding time (min)	15	25	40	50	60	65	70	80	100

High speed tool steels

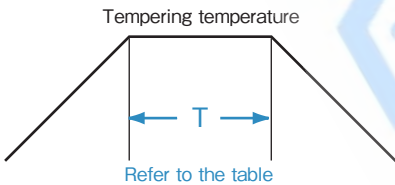


Holding time at austenitizing temperature

Heating furnace	Thickness (mm)	Time									
		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

Note: If you take preheating time, dipping time can be regarded as holding time.

Tempering



Note1: This standard is applicable to tempering at 500°C or more. When tempering at 250-500°C, holding time must be increased to 1.5 times longer and at lower than 250°C, 2 times longer than the standard.

Note2: Tempering is required no less than two times for grades containing no cobalt and at least three times for grades containing cobalt to improve toughness when high temperature tempering is done.

Note3: Because toughness deteriorates, tempering higher than 600°C must avoid for high-speed tool steels.

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

Annealing

- All material is delivered as spheroidized annealed condition.
- After reforging, spheroidizing is to be done before hardening. Please refer to the standard heat treatment conditions.
- Stress relief annealing is to be done to remove stress caused by cold working such as drawing and rolling and to soften or reduce distortion caused by subsequent hardening.
 - Heating temperature : 650-700°C
 - Holding time : 1h/25mm thickness



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Heat treatment of YSS cold work tool steels

Standard heat treatment conditions

	Grade	Hardness as delivering	Heating temperature		Tempered hardness (HRC)	Annealing
			Hardening	Tempering		
Cold work tool steels	SLD-MAGIC	≤255	1,010-1,040 Air cool	480-530 or 150-250 Air cool	≥60	830-880 Slow cooling
	SLD	≤248	1,000-1,050 Air cool	480-530 or 150-200 Air cool	≥58	830-880 Slow cooling
	SLD10	≤248	1,020-1,070 Air cool	520-550 Air cool	≥62	830-880 Slow cooling
	ARK1	≤248	1,010-1,040 Air cool	480-530 or 150-250 Air cool	≥58	830-880 Slow cooling
	SGT	≤217	800-850 Oil quench	150-200 Air cool	≥60	750-780 Slow cooling
	YCS3	≤212	790-850 Oil quench	150-200 Air cool	≥63	750-780 Slow cooling
	ACD37	≤235	830-870 Air cool	150-200 Air cool	≥58	750-800 Slow cooling
	HMD5	≤235	Flame hardening 940-1100°C		—	825-875 Slow cooling
High speed tool steels	YXM1	≤255	(1) 1,200-1,240 Oil quench (2) 1,160-1,200	550-570 Air cool	≥63	800-880 Slow cooling
	YXM4	≤277	(1) 1,230-1,250 Oil quench (2) 1,210-1,230	560-580 Air cool	≥64	800-880 Slow cooling
	YXR7	≤241	(1) 1,160-1,180 Oil quench (2) 1,120-1,160	540-580 Air cool	≥62	800-880 Slow cooling
	YXR3	≤241	(1) 1,150-1,170 Oil quench (2) 1,130-1,150	560-590 Air cool	≥57	800-880 Slow cooling
	YXR33	≤241	1,080-1,140 Oil quench	550-600 Air cool	≥54	800-880 Slow cooling
P/M High speed tool steels	HAP5R	≤269	1,120-1,160 Oil quench	530-580 Air cool	≥58	820-870 Slow cooling
	HAP10	≤269	(1) 1,170-1,190 Oil quench (2) 1,120-1,170	550-580 Air cool	≥63	820-870 Slow cooling
	HAP40	≤277	(1) 1,190-1,210 Oil quench (2) 1,120-1,190	560-580 Air cool	≥66	820-870 Slow cooling
	HAP72	≤352	1,180-1,210 Oil quench	560-580 Air cool	≥68	820-870 Slow cooling

(1) Simple shape tools

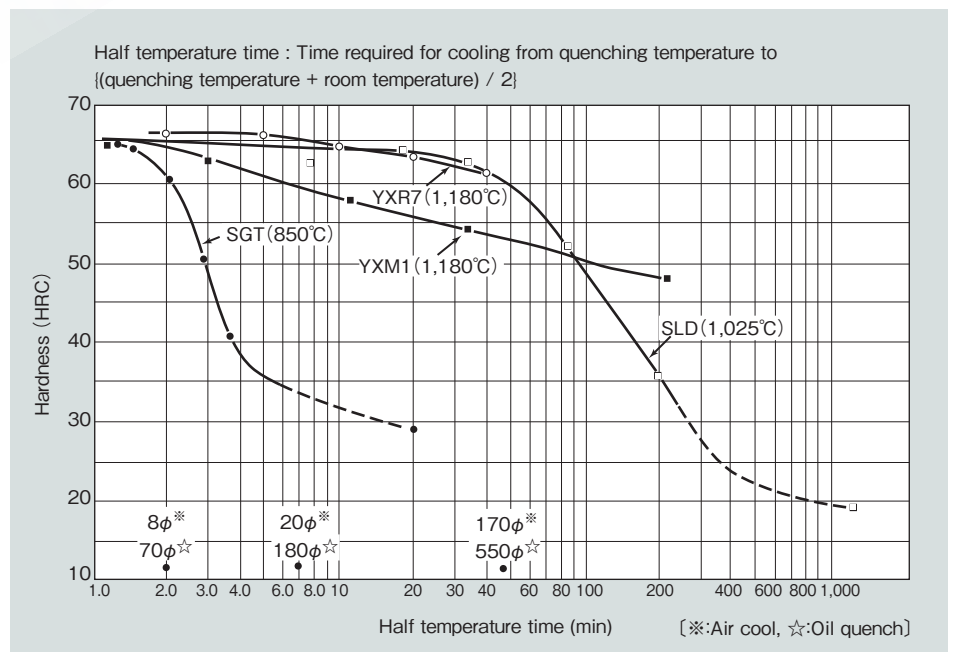
(2) Tools of complicated shape, requiring toughness in particular

* Specimen size is 15mm square or round by 20 mm long in accordance with JIS standard hardness test.

Hardenability

The maximum diameter of a round bar stock that obtains 60 HRC hardness at its center by quenching.

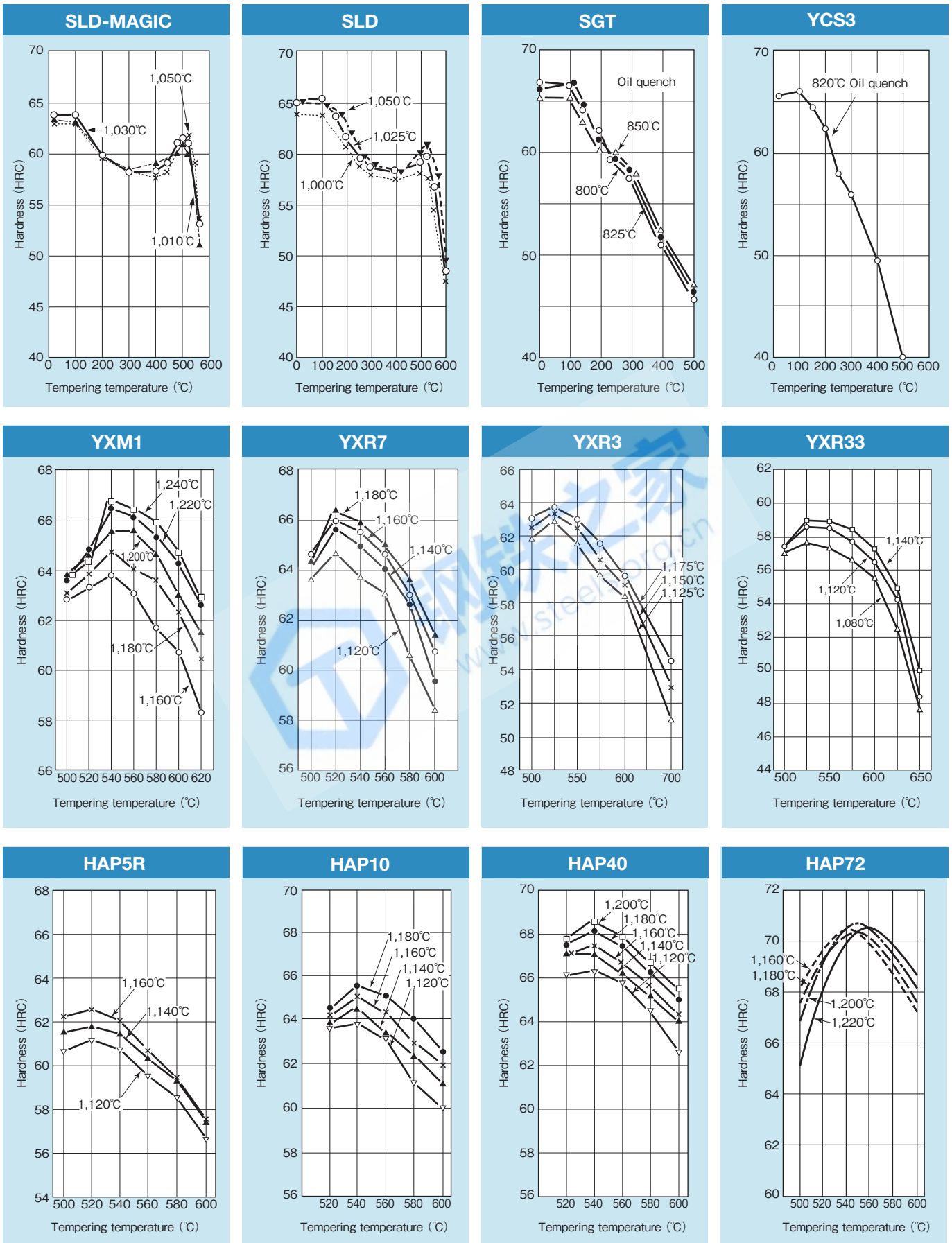
Grade	Cooling	
	Air cool	Oil quench
SLD-MAGIC	φ170	φ550
SLD	φ170	φ550
ACD37	φ120	—
SGT	φ8	φ70
YXM1	φ20	φ180
YXR7	φ170	φ550
HAP10	—	φ180



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Heat treatment of YSS cold work tool steels

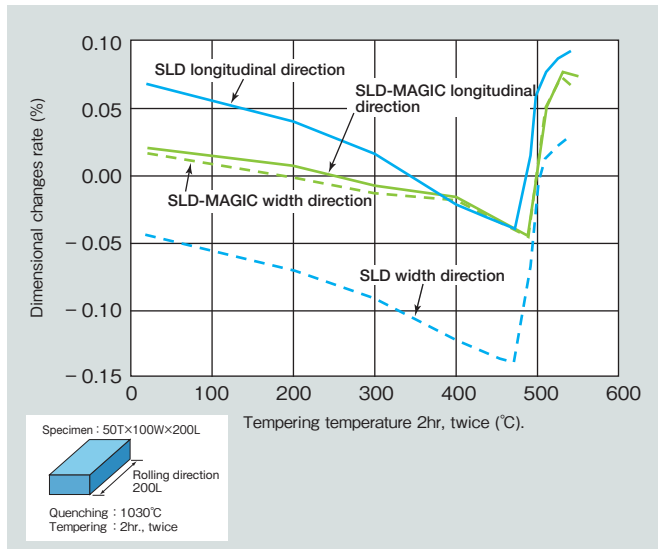
Quenched and tempered hardness curves



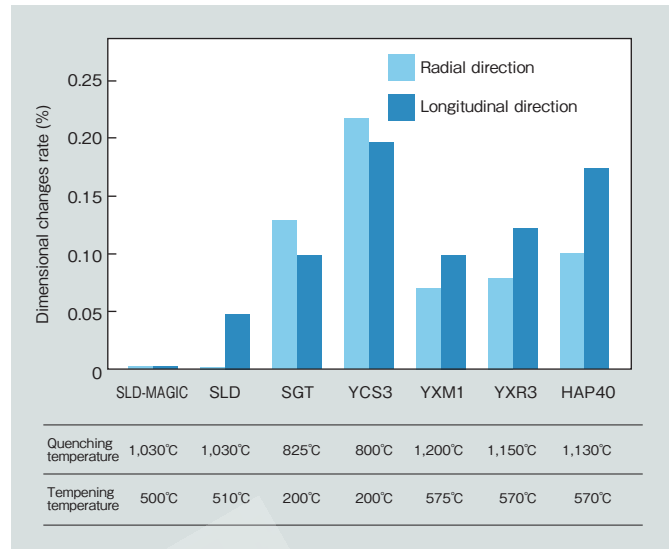
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Heat treatment of YSS cold work tool steels

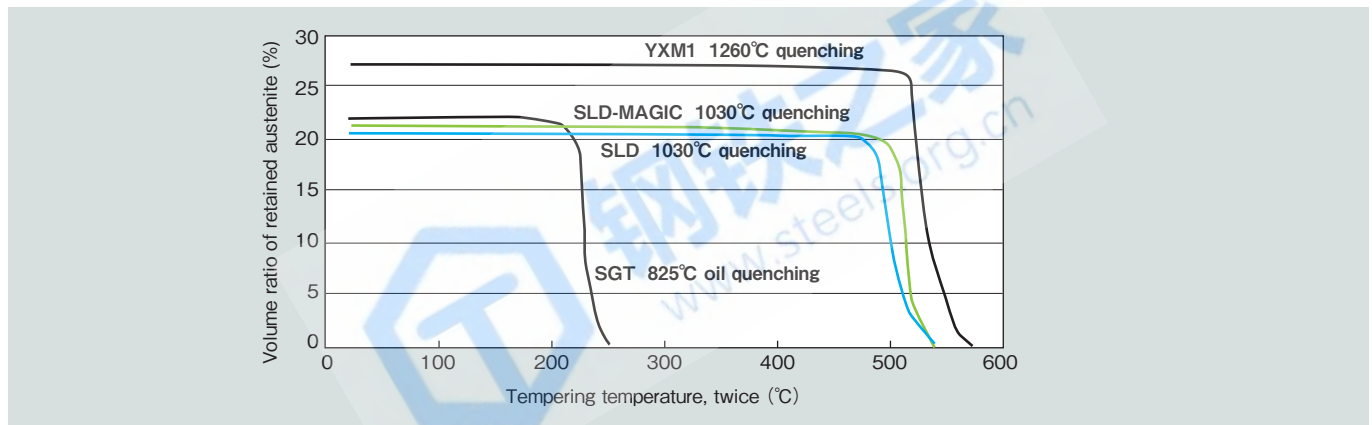
Dimensional change after heat treatment of cold dies steel



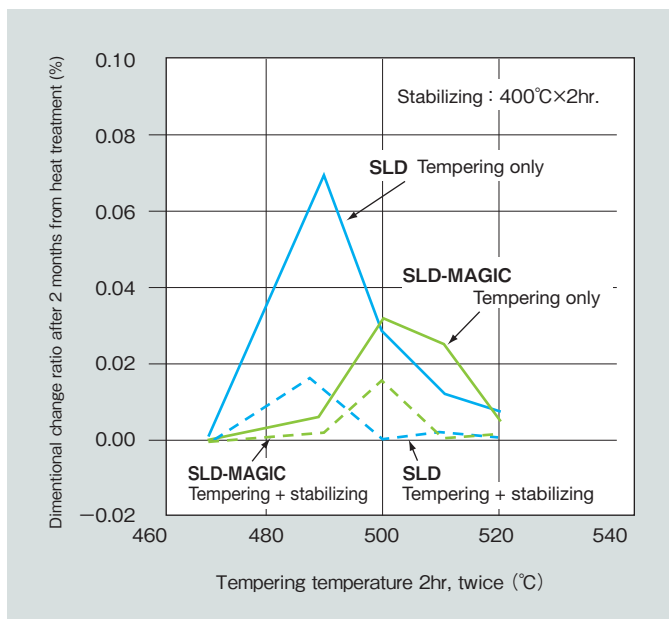
Dimensional changes after heat treatment



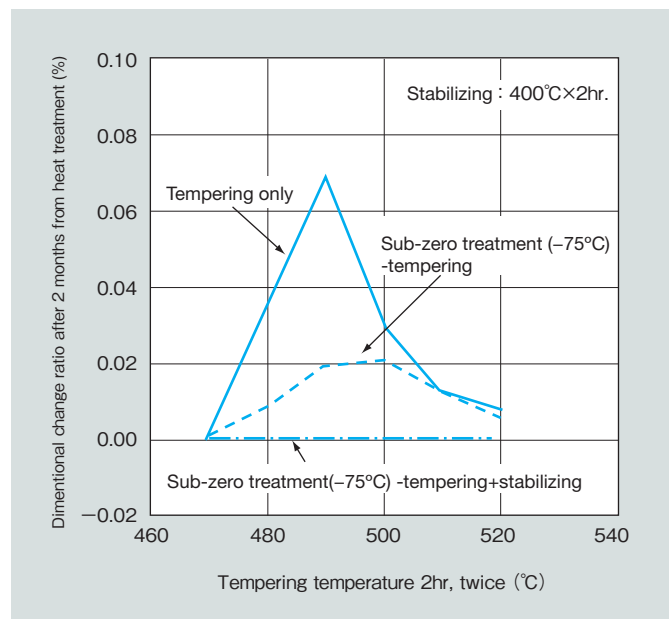
The retained austenite



Secular change and stabilizing treatment on cold work tool steel



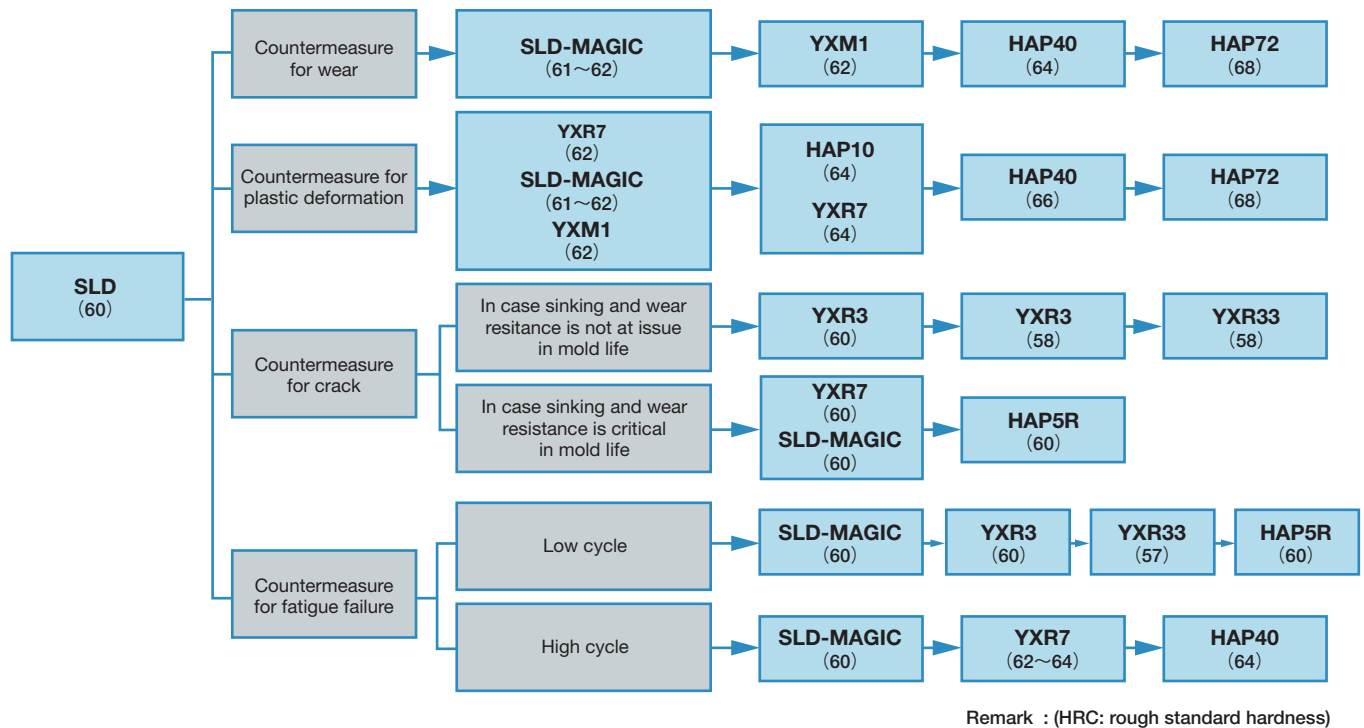
Secular change and sub-zero treatment



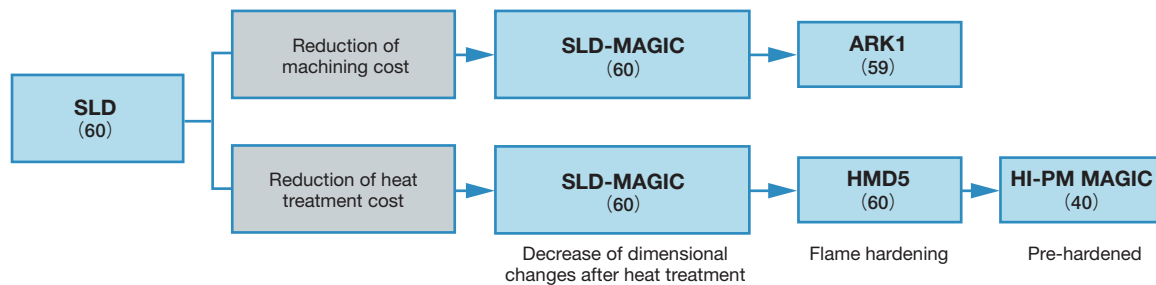
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Improvement processes of YSS cold work tool steels in terms of hardness and dies for various applications

Flowchart to improve die life of cold work tool steels



Flowchart to reduce die cost of cold work tool steels



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