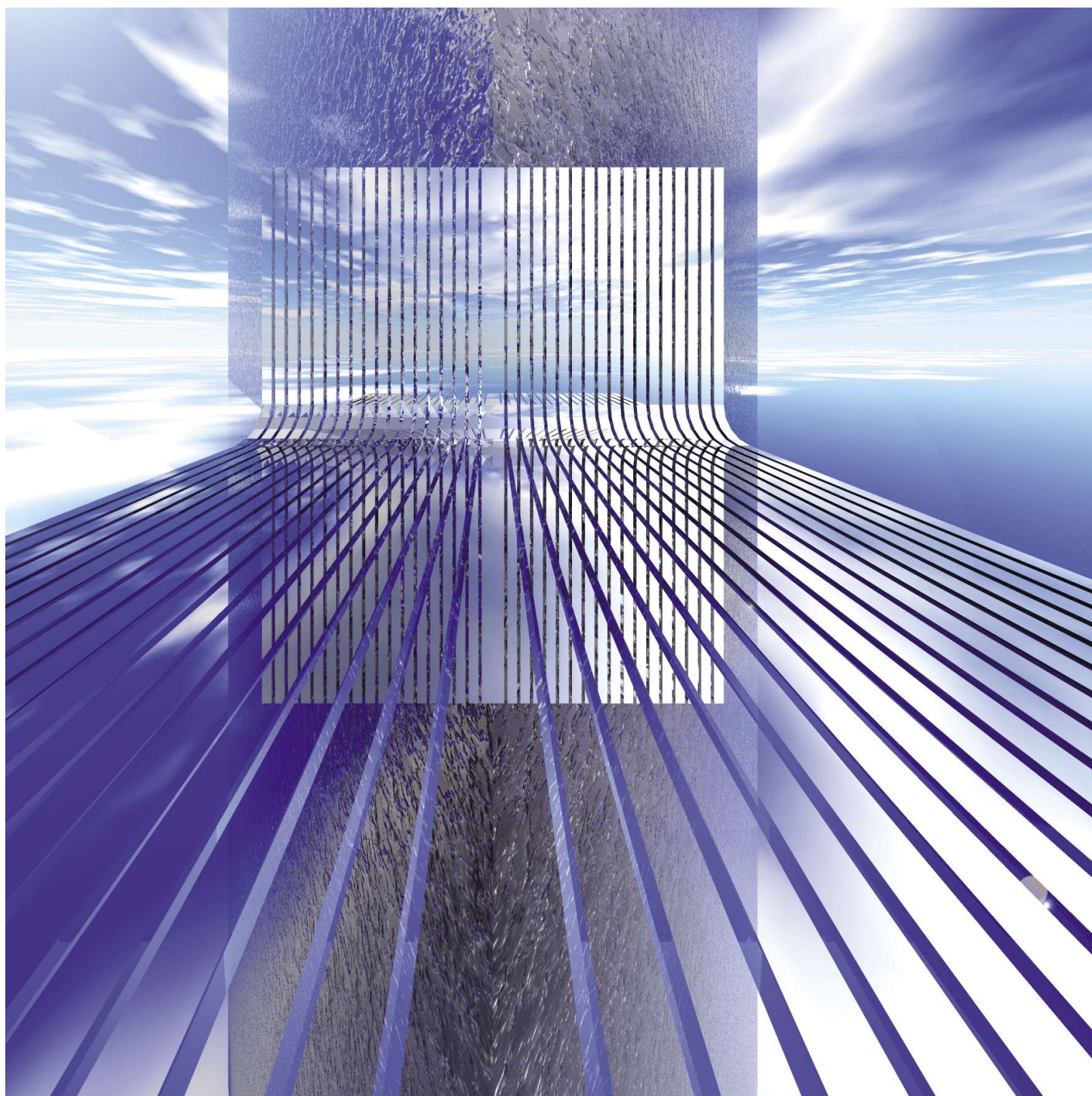




SPECIAL STEEL SHEET



JFE Steel Corporation



West Japan Works (Fukuyama)

JFE Steel Corporation produces various types of special steel sheets under an integrated quality control system at modern facilities in East Japan Works and West Japan Works. JFE's special steel products support technical innovation and improved productivity at customers, and have won an excellent reputation for high dimensional accuracy, quenchability, and formability.

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Characteristics

1. Uniform quality

Integrated operation control and highly computerized production processes ensure a high level of uniformity in product quality.

2. High dimensional accuracy and excellent surface quality

JFE's production plants boast some of the world's most advanced steelmaking, hot rolling, and cold rolling equipment, ensuring high dimensional accuracy and outstanding surface quality.

3. Wide product line

A wide range of steel grades and product dimensions are available to meet diverse customer requirements.

4. Strict quality control and inspection system

All products can be used with confidence thanks to scientific quality control and strict testing and inspection.

(JFE's steel sheet production system is certified under ISO 9001.)



East Japan Works (Chiba)

Application



Saws



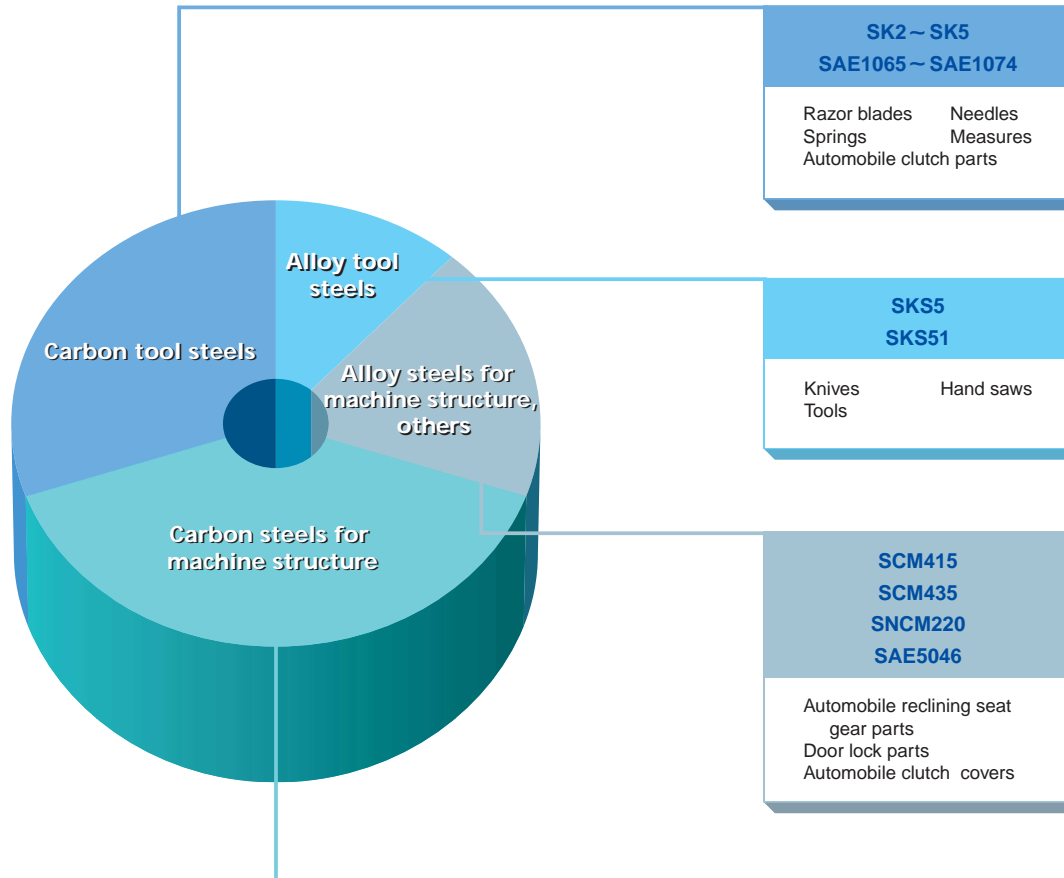
Needles, knives



Knives



Automobile seat belt buckles



Safety shoes protectors



Chains



Sprocket gears



Gears

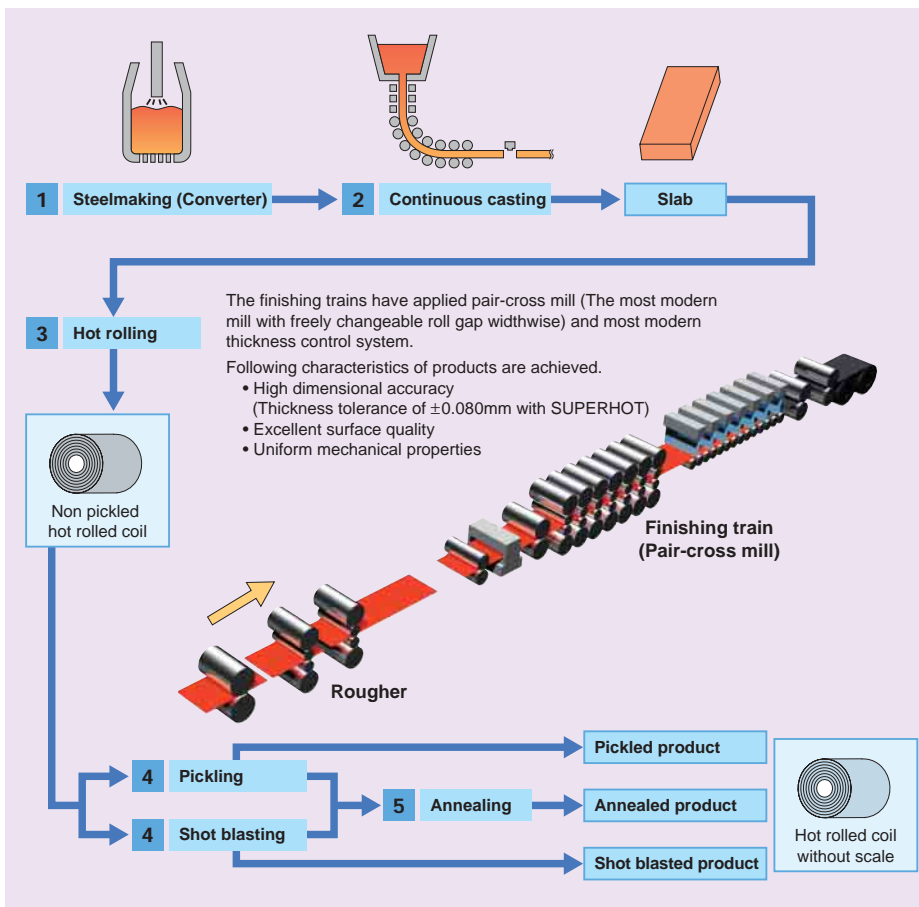


Hose bands, sheet springs

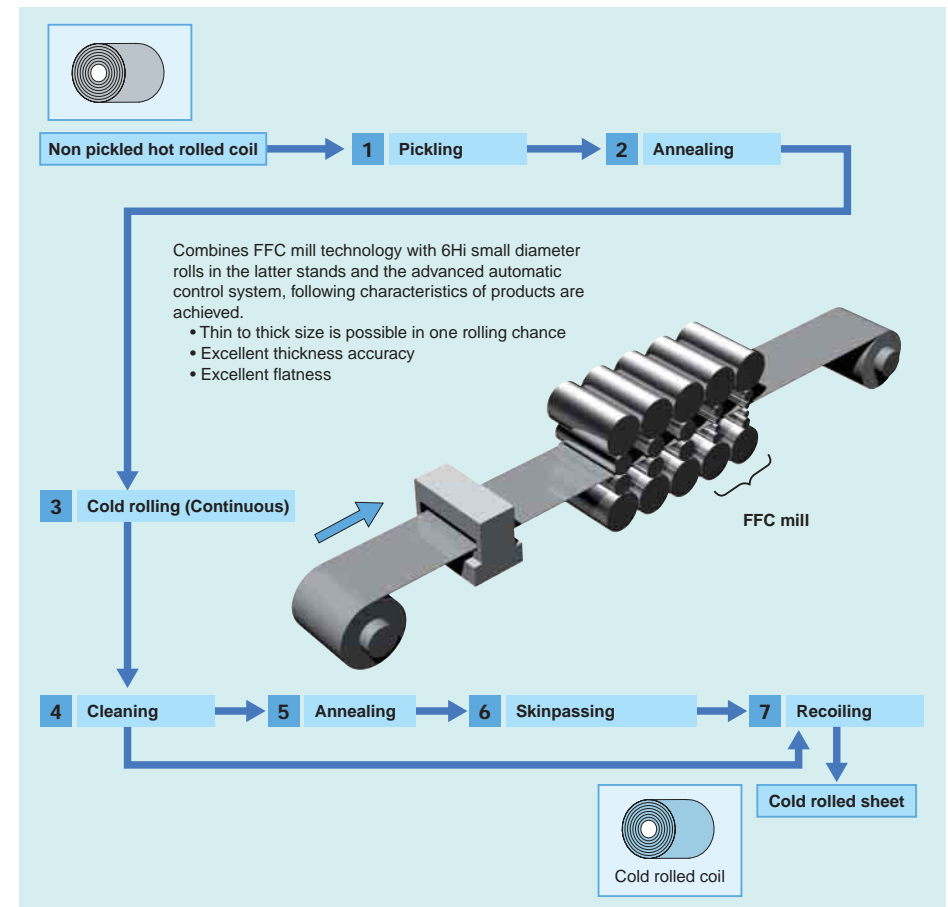
Manufacturing process



Hot rolled sheet



Cold rolled sheet



Applicable standard

Classification	Standard			Designation
Hot rolled steel sheet	JIS	JIS G 4051	Carbon steels for machine structural use	S-C, S-CK
		JIS G 4103	Nickel chromium molybdenum steels	SNCM
		JIS G 4104	Chromium steels	SCr
		JIS G 4105	Chromium molybdenum steels	SCM
		JIS G 4106	Manganese steels and manganese chromium steels for machine structural use	SMn SMnC
		JIS G 4401	Carbon tool steels	SK
		JIS G 4404	Alloy tool steels	SKS
		JIS G 4801	Spring steels	SUP
		JIS G 4805	High carbon chromium bearing steels	SUJ
	SAE			
Cold rolled steel sheet	JIS	JIS G 3311	Cold rolled special steel strip	S-CM, SK-M
	JIS*	JIS G 4051	Carbon steels for machine structural use	S-C, S-CK
		JIS G 4401	Carbon tool steels	SK
		JIS G 4404	Alloy tool steels	SKS
	SAE			

* : Cold rolled steel sheets with the corresponding chemical compositions.

Surface finish and heat treatment

Hot rolled steel sheet

Surface	Annealing	Remarks
Non pickled	Yes	Hot rolled coils are annealed with scale. Decarburized layer is generated at surface. Suitable for applications which needs grinding.
	No	As hot rolled with scale. Hardness because not annealed. Availability of working is subject to negotiation.
Pickled	Yes	Hot rolled and annealed after descaling at pickling line. Attractive surface and very little decarburized layer.
	No	Descaled at pickling line. Comparatively soft material suitable to applications which require no working or will be annealed by customers.
Shot blasted	Yes	Hot rolled and annealed after descaling by shot blasting. Suitable for applications which require rough surface finish and for thicker gauge which can not be pickled.
	No	Mechanically descaled by shot blasting. Rough finish surface and hardened surface. Suitable for punch working.
Ground	Yes	Reductive scale is removed by brush after annealing. Useful for removing surface scale from very thick materials. Details are subject to negotiation.

Cold rolled steel sheet

Surface	Annealing	Remarks
Bright finish	Yes	Carbon is spheroidized by annealing after cold rolling. Bright finish at skinpass after annealing with bright finish rolls.
	No	As cold rolled. Suitable for applications which require annealing by customer. Bright finish at cold rolling.
Dull finish	Yes	Spheroidized by annealing after cold rolling. Dull finish by skinpass rolling after annealing.
	No	As cold rolled with dull finish at cold rolling. Has advantage of less risk of defects than in bright finish.

Chemical composition

Classification	Designation		C	Si	Mn	P	S	Cu	Ni	Cr	Ni+Cr	Mo	V
	JIS	SAE											
Carbon steel	S20C		0.18-0.23	0.15-0.35	0.30-0.60	≤ 0.030	≤ 0.035	≤ 0.30	≤ 0.20	≤ 0.20	≤ 0.35		
	S30C(M)		0.27-0.33	0.15-0.35	0.60-0.90	≤ 0.030	≤ 0.035	≤ 0.30	≤ 0.20	≤ 0.20	≤ 0.35		
	S35C(M)		0.32-0.38	0.15-0.35	0.60-0.90	≤ 0.030	≤ 0.035	≤ 0.30	≤ 0.20	≤ 0.20	≤ 0.35		
	S45C(M)		0.42-0.48	0.15-0.35	0.60-0.90	≤ 0.030	≤ 0.035	≤ 0.30	≤ 0.20	≤ 0.20	≤ 0.35		
	S50C(M)		0.47-0.53	0.15-0.35	0.60-0.90	≤ 0.030	≤ 0.035	≤ 0.30	≤ 0.20	≤ 0.20	≤ 0.35		
		SAE1050	0.47-0.55	0.15-0.35	0.60-0.90	≤ 0.030	≤ 0.035						
	S55C(M)		0.52-0.58	0.15-0.35	0.60-0.90	≤ 0.030	≤ 0.035	≤ 0.30	≤ 0.20	≤ 0.20	≤ 0.35		
		SAE1055	0.52-0.60	0.15-0.35	0.60-0.90	≤ 0.030	≤ 0.035						
	S60CM		0.55-0.65	0.15-0.35	0.60-0.90	≤ 0.030	≤ 0.035	≤ 0.30	≤ 0.20	≤ 0.20			
		SAE1060	0.55-0.66	0.15-0.35	0.60-0.90	≤ 0.030	≤ 0.035						
	S65CM		0.60-0.70	0.15-0.35	0.60-0.90	≤ 0.030	≤ 0.035	≤ 0.30	≤ 0.20	≤ 0.20			
		SAE1065	0.59-0.70	0.15-0.35	0.60-0.90	≤ 0.030	≤ 0.035						
	S70CM		0.65-0.75	0.15-0.35	0.60-0.90	≤ 0.030	≤ 0.035	≤ 0.30	≤ 0.20	≤ 0.20			
		SAE1070	0.65-0.76	0.15-0.35	0.60-0.90	≤ 0.030	≤ 0.035						
		SAE1074	0.69-0.80	0.15-0.35	0.50-0.80	≤ 0.030	≤ 0.035						
	S75CM		0.70-0.80	0.15-0.35	0.60-0.90	≤ 0.030	≤ 0.035	≤ 0.30	≤ 0.20	≤ 0.20			
		SAE1075	0.69-0.80	0.15-0.35	0.40-0.70	≤ 0.030	≤ 0.035						
Ni-Cr-Mo steel	SNCM220		0.17-0.23	0.15-0.35	0.60-0.90	≤ 0.030	≤ 0.030	≤ 0.30	0.40-0.70	0.40-0.65		0.15-0.30	
		SAE8620	0.17-0.23	0.15-0.35	0.60-0.90	≤ 0.035	≤ 0.040	≤ 0.35	0.40-0.70	0.35-0.60		0.15-0.25	
Cr steel	SCr420		0.18-0.23	0.15-0.35	0.60-0.85	≤ 0.030	≤ 0.030	≤ 0.30	≤ 0.25	0.90-1.20			
		SAE5046	0.43-0.48	0.15-0.35	0.75-1.00	≤ 0.035	≤ 0.040	≤ 0.35	≤ 0.25	0.20-0.35			
Cr-Mo steel	SCM415		0.13-0.18	0.15-0.35	0.60-0.85	≤ 0.030	≤ 0.030	≤ 0.30	≤ 0.25	0.90-1.20		0.15-0.30	
	SCM420		0.18-0.23	0.15-0.35	0.60-0.85	≤ 0.030	≤ 0.030	≤ 0.30	≤ 0.25	0.90-1.20		0.15-0.30	
		SAE4130	0.27-0.34	0.15-0.35	0.35-0.60	≤ 0.035	≤ 0.040	≤ 0.35	≤ 0.25	0.80-1.15		0.15-0.25	
	SCM435		0.33-0.38	0.15-0.35	0.60-0.85	≤ 0.030	≤ 0.030	≤ 0.30	≤ 0.25	0.90-1.20		0.15-0.30	
Mn steel		SAE1541	0.36-0.45	0.15-0.35	1.30-1.65	≤ 0.030	≤ 0.035						
Mn-Cr steel	SMnC443		0.40-0.46	0.15-0.35	1.35-1.65	≤ 0.030	≤ 0.030	≤ 0.30	≤ 0.25	0.35-0.70			
Carbon tool steel	SK85 [SK5(M)]		0.80-0.90	0.10-0.35	0.10-0.50	≤ 0.030	≤ 0.030	≤ 0.25	≤ 0.25	≤ 0.30			
	SK95 [SK4(M)]		0.90-1.00	0.10-0.35	0.10-0.50	≤ 0.030	≤ 0.030	≤ 0.25	≤ 0.25	≤ 0.30			
	SK120 [SK2(M)]		1.15-1.25	0.10-0.35	0.10-0.50	≤ 0.030	≤ 0.030	≤ 0.25	≤ 0.25	≤ 0.30			
Alloy tool steel	SKS5		0.75-0.85	≤ 0.35	≤ 0.50	≤ 0.030	≤ 0.030	≤ 0.25	0.70-1.30	0.20-0.50			
	SKS51		0.75-0.85	≤ 0.35	≤ 0.50	≤ 0.030	≤ 0.030	≤ 0.25	1.30-2.00	0.20-0.50			
Spring steel	SUP10		0.47-0.55	0.15-0.35	0.65-0.95	≤ 0.035	≤ 0.035	≤ 0.30		0.80-1.10			0.15-0.25
		SAE6150	0.46-0.54	0.15-0.35	0.60-0.90	≤ 0.035	≤ 0.040	≤ 0.35	≤ 0.25	0.80-1.15			≥ 0.15
Cr-Bearing steel	SUJ2		0.95-1.10	0.15-0.35	≤ 0.50	≤ 0.025	≤ 0.025	≤ 0.25	≤ 0.25	1.30-1.60			

— Reference —

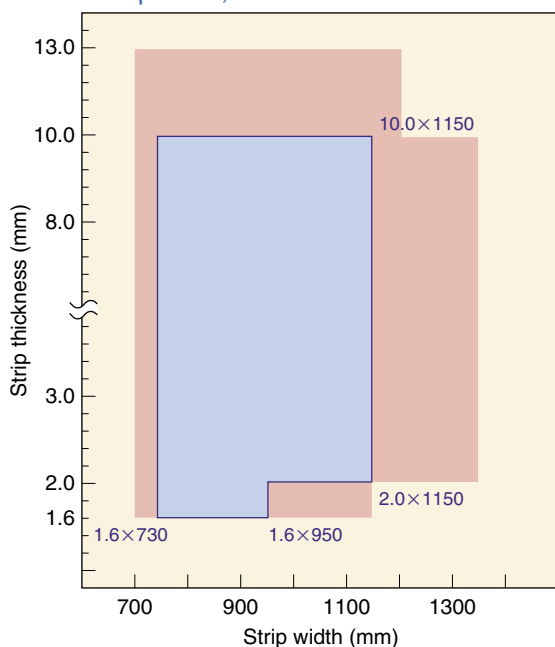
- [] means the former standards of the tool steels.
- (M) means the order as cold rolled special steel strip is possible.
- Si in SAE standard is 0.15%- 0.35% if not specified.
- The standards not specified above, or special chemical compositions freely come to negotiation.

Available product size range

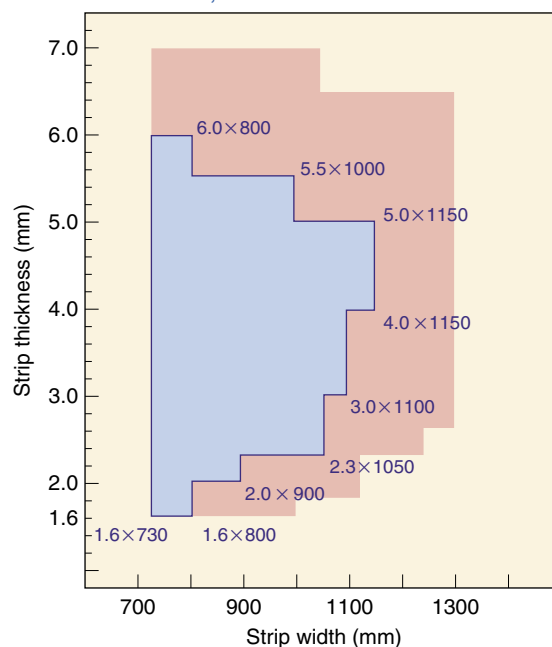
Hot rolled sheet

Available Discussion

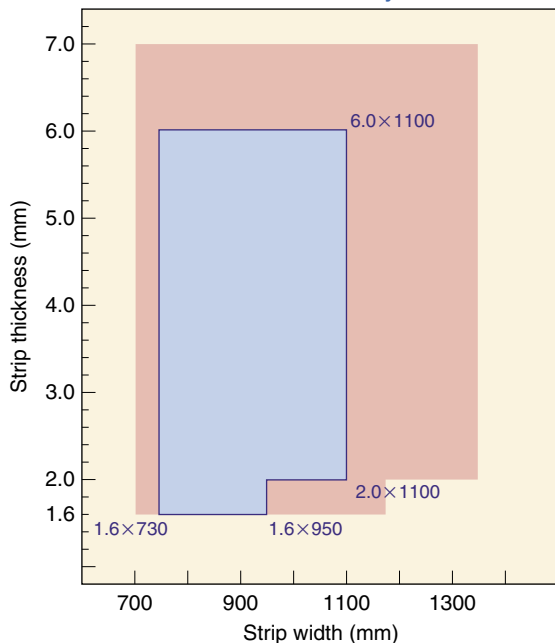
Non pickled, all standards



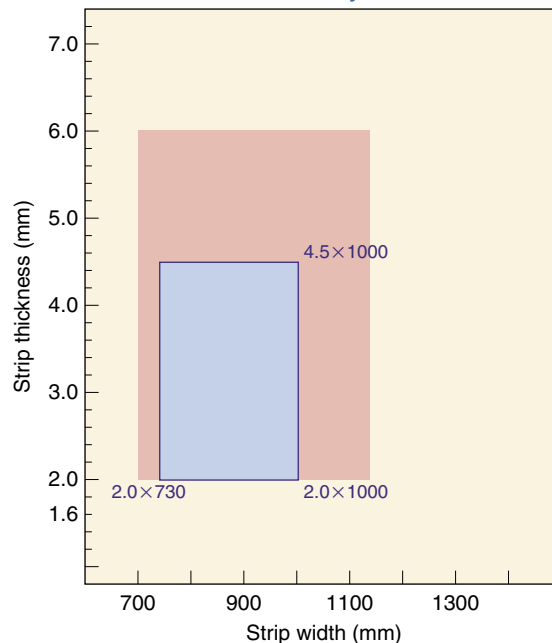
Shot finish, all standards



Pickled, carbon steel, alloy steel



Pickled, tool steel, alloy tool steel



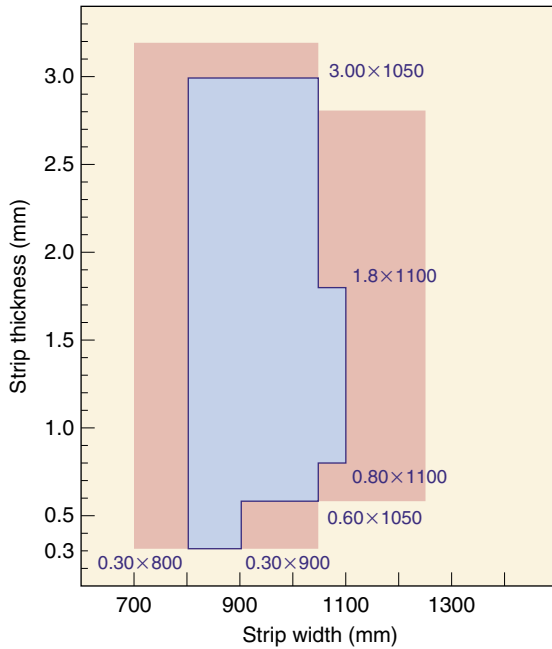
— Reference —

1. The standards not specified above and sizes outside the available area are subject to negotiation.
2. Slit width is also available and is subject to negotiation.

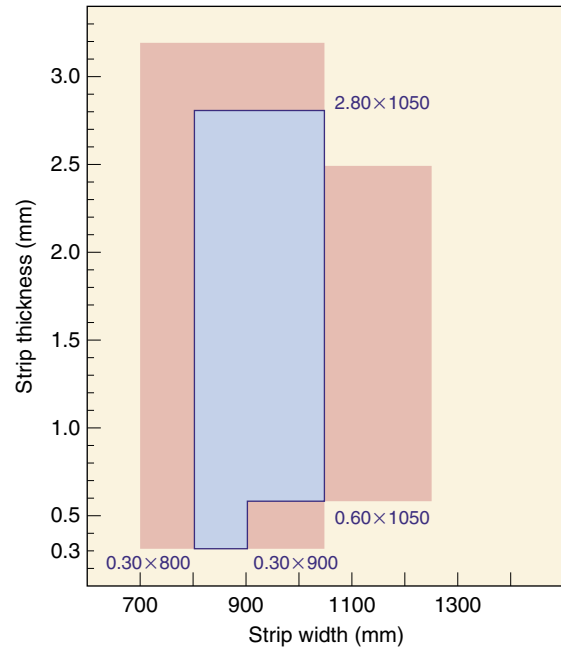
Cold rolled sheet

Available Discussion

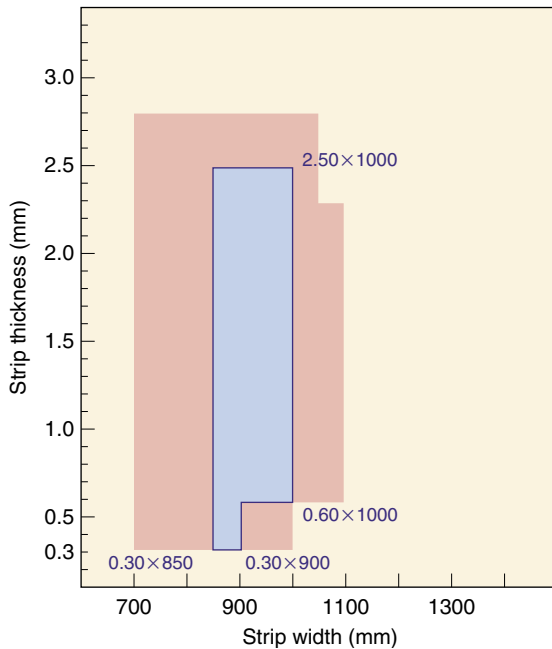
S20C ~ S55C, SCM415, SCr420



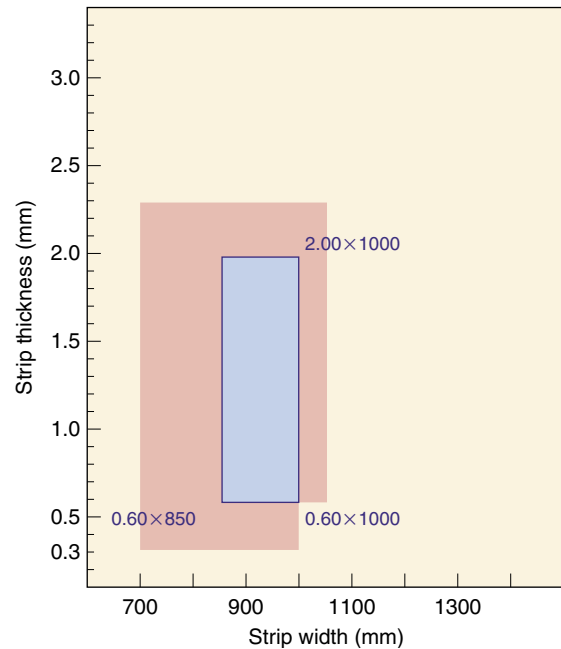
SAE1060 ~ 1075, SCM430•435



SK5



SK4, SKS5, SKS51



— Reference —

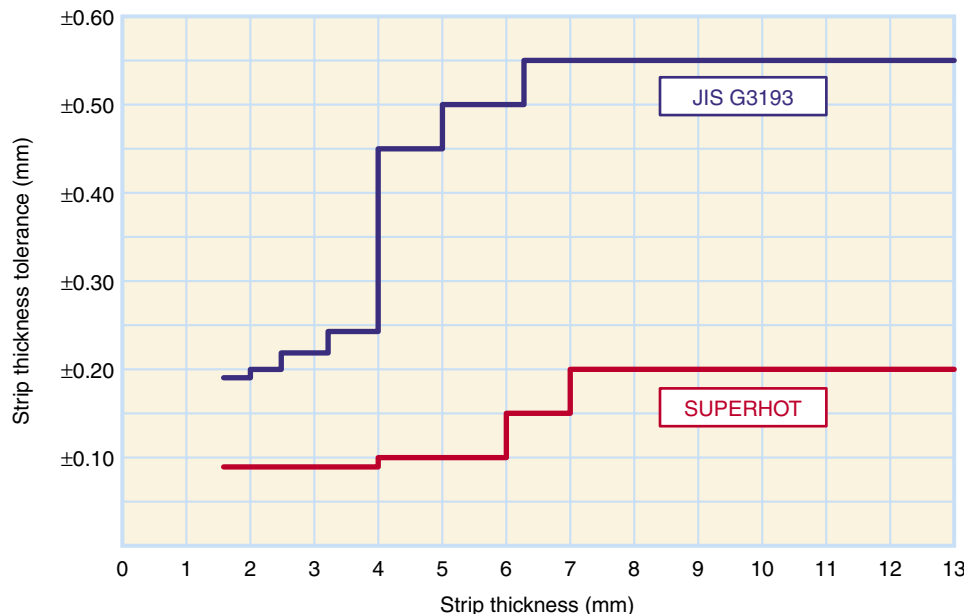
1. The standards not specified above and sizes outside the available area are subject to negotiation.
2. Slit width is also available and is subject to negotiation.
3. Hard materials (As cold rolled) is also available. It is subject to negotiation.

Available product size range

Dimensional tolerance

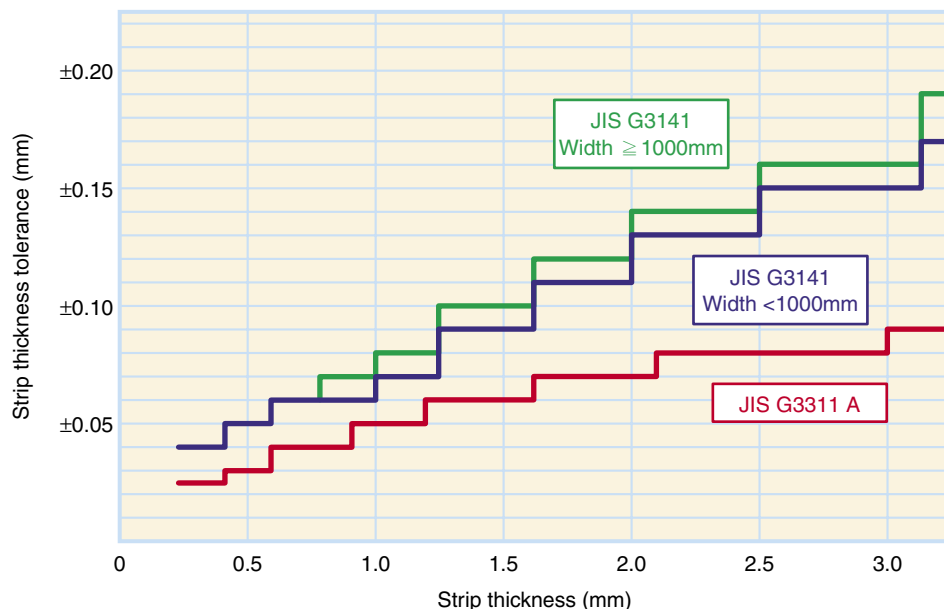
Hot rolled steel sheet

Basic standard is JIS G 3193 (Dimension, mass and permissible variation of hot rolled steel plates, sheets and strip). For SAE, ASTM is generally applied outside of Japan and JIS 3193 in Japan. For high thickness accuracy, SUPERHOT tolerance can be applied (see figure).



Cold rolled steel sheet

Basic standard is JIS G 3141 (Cold rolled steel coils and strips). For high thickness accuracy, JIS G 3311 (Cold rolled special steel strip) can be applied.

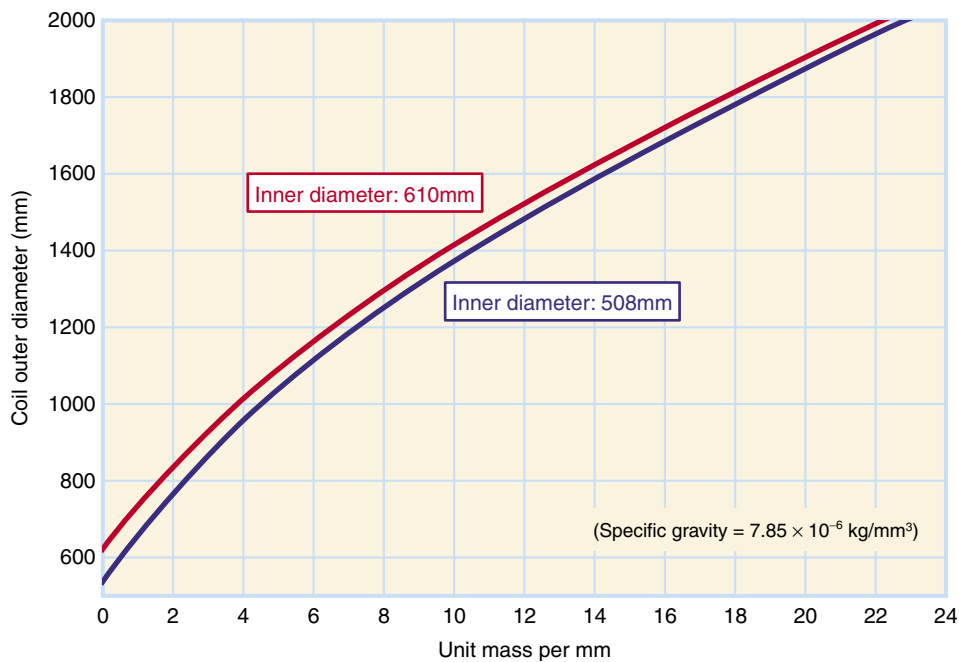


Hardness conversion table

(SAE J 417)

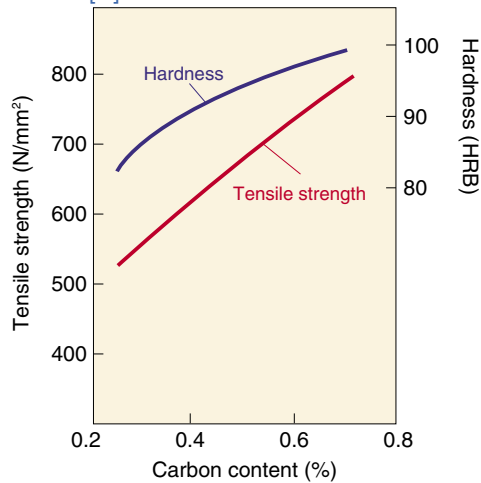
Vickers Hardness HV	Rockwell Hardness		Tensile Strength N/mm ² (kgf/mm ²)	Vickers Hardness HV	Rockwell Hardness		Tensile Strength N/mm ² (kgf/mm ²)	Vickers Hardness HV	Rockwell Hardness		Tensile Strength N/mm ² (kgf/mm ²)
	B Scale HRB	C Scale HRC			B Scale HRB	C Scale HRC			B Scale HRB	C Scale HRC	
940	–	68.0	–	540	–	51.7	1860 (190)	280	(103.5)	27.1	890 (91)
920	–	67.5	–	530	–	51.1	1825 (186)	275	–	26.4	875 (89)
900	–	67.0	–	520	–	50.5	1795 (183)	270	(102.0)	25.6	855 (87)
880	–	66.4	–	510	–	49.8	1750 (179)	265	–	24.8	840 (86)
860	–	65.9	–	500	–	49.1	1705 (174)	260	(101.0)	24.0	825 (84)
840	–	65.3	–	490	–	48.4	1660 (169)	255	–	23.1	805 (82)
820	–	64.7	–	480	–	47.7	1620 (165)	250	99.5	22.2	795 (81)
800	–	64.0	–	470	–	46.9	1570 (160)	245	–	21.3	780 (79)
780	–	63.3	–	460	–	46.1	1530 (156)	240	98.1	20.3	765 (78)
760	–	62.5	–	450	–	45.3	1495 (153)	230	96.7	(18.0)	730 (75)
740	–	61.8	–	440	–	44.5	1460 (149)	220	95.0	(15.7)	695 (71)
720	–	61.0	–	430	–	43.6	1410 (144)	210	93.4	(13.4)	670 (68)
700	–	60.1	–	420	–	42.7	1370 (140)	200	91.5	(11.0)	635 (65)
690	–	59.7	–	410	–	41.8	1330 (136)	190	89.5	(8.5)	605 (62)
680	–	59.2	–	400	–	40.8	1290 (131)	180	87.1	(6.0)	580 (59)
670	–	58.8	–	390	–	39.8	1240 (127)	170	85.0	(3.0)	545 (56)
660	–	58.3	–	380	(110.0)	38.8	1205 (123)	160	81.7	(0.0)	510 (53)
650	–	57.8	–	370	–	37.7	1170 (120)	150	78.7	–	490 (50)
640	–	57.3	–	360	(109.0)	36.6	1130 (115)	140	75.0	–	455 (46)
630	–	56.8	–	350	–	35.5	1095 (112)	130	71.2	–	425 (44)
620	–	56.3	–	340	(108.0)	34.4	1070 (109)	120	66.7	–	390 (40)
610	–	55.7	–	330	–	33.3	1035 (105)	110	62.3	–	–
600	–	55.2	–	320	(107.0)	32.2	1005 (103)	100	56.2	–	–
590	–	54.7	2055 (210)	310	–	31.0	980 (100)	95	52.0	–	–
580	–	54.1	2020 (206)	300	(105.5)	29.8	950 (97)	90	48.0	–	–
570	–	53.6	1985 (202)	295	–	29.2	935 (96)	85	41.0	–	–
560	–	53.0	1950 (199)	290	(104.5)	28.5	915 (94)				
550	–	52.3	1905 (194)	285	–	27.8	905 (92)				

Unit mass per mm

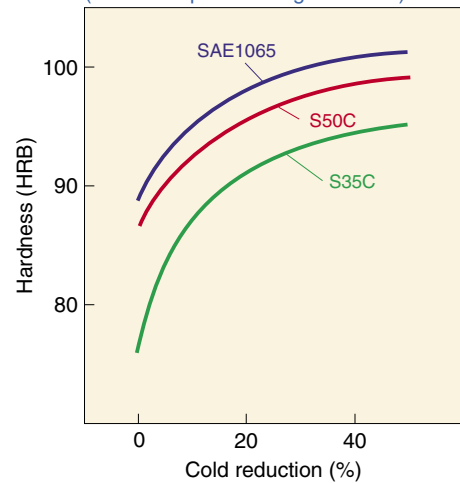


Mechanical properties by heat treatment

Relation between strength and [C] contents of hot rolled steel

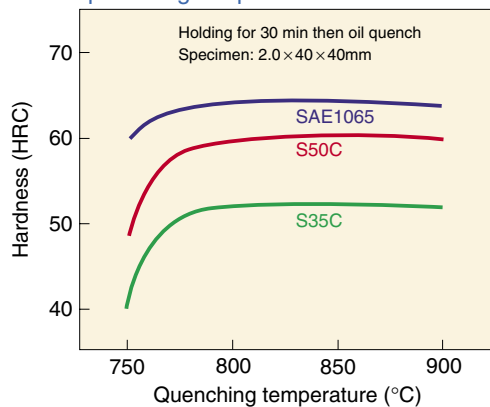


Relation between hardness and cold reduction
(Material: spheroidizing annealed)

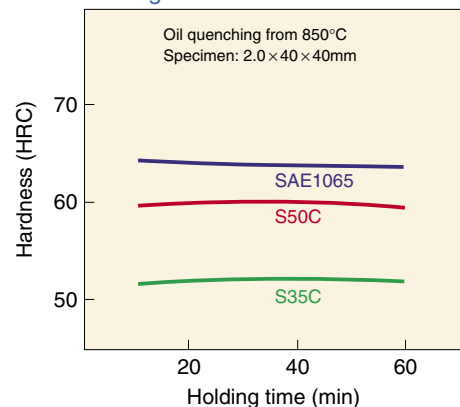


Relation between hardness and quenching condition (As-hot rolled)

Relation between hardness and quenching temperature

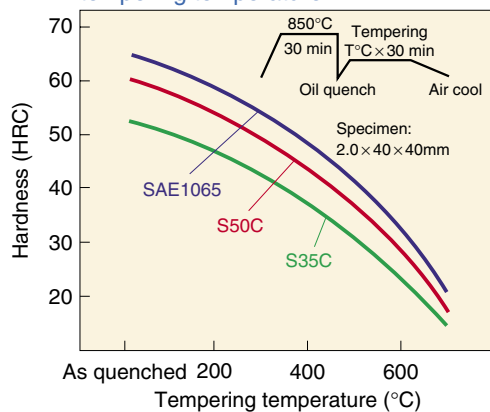


Relation between hardness and holding time

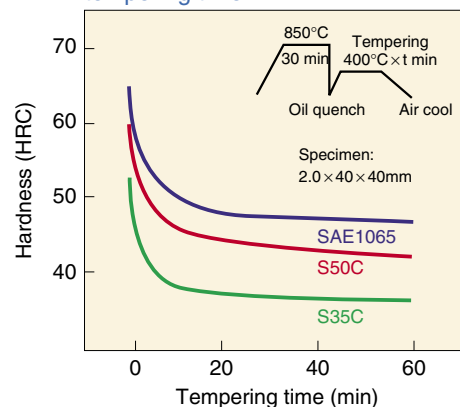


Relation between hardness and tempering condition (As-hot rolled)

Relation between hardness and tempering temperature

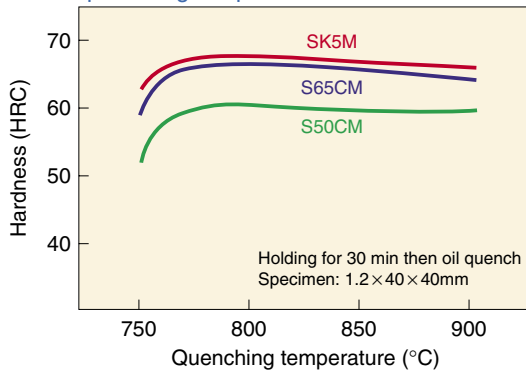


Relation between hardness and tempering time

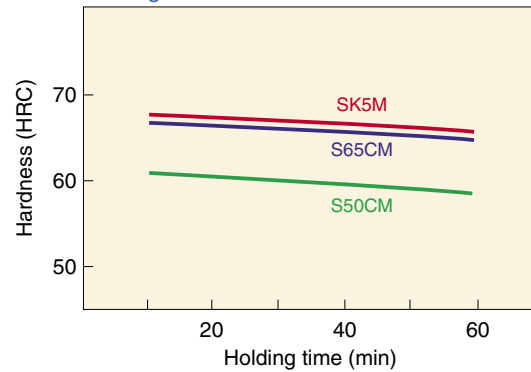


Relation between hardness and quenching condition (Cold rolled steel)

Relation between hardness and quenching temperature

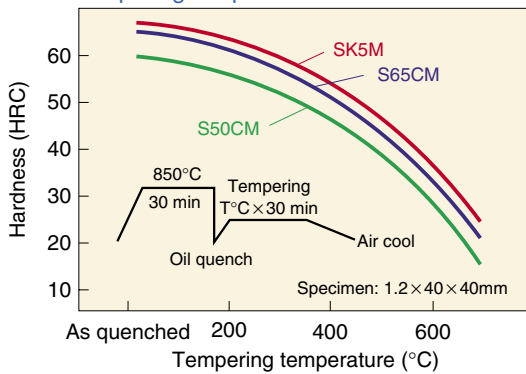


Relation between hardness and holding time

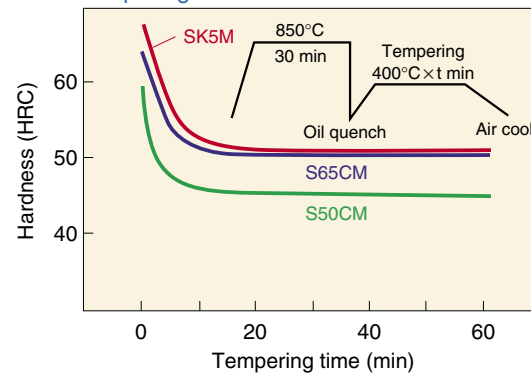


Relation between hardness and tempering condition (Cold rolled steel)

Relation between hardness and tempering temperature



Relation between hardness and tempering time



Effect of chemical elements

- | | | | |
|-----------|--|-----------|---|
| C | Forms semi-stable Fe_3C (Cementite) carbide. Stable phase is graphite. Improves quenchability, strength and anti-abrasion properties. C content of 0.77% is eutectoid, 0.02% - 0.77% is hypo-eutectoid and over 0.77% is hyper-eutectoid. The strength of carbon steel is increased by transformation of pearlite, bainite to martensite in cooling from high temperature. | Cu | Improves quenchability. Dissolves cementite and promotes graphitization. Increases strength by generating precipitates at high temperature. Improves corrosion resistance. |
| Si | Increases strength as a solid solution strengthening element. Promotes spheroidization of cementite and graphitization. Improves impact values in the low temperature temper-brittleness range below 300°C in the same manner of Cr, Mo and V. | Ni | Forms stable austenite and lowers the transformation temperature. Multiple addition with Cr and Mo strengthens ferrite and extremely improves low temperature embrittlement. Promotes graphitization by dissolving cementite. |
| Mn | Stabilizes austenite and lowers the transformation temperature, improving quenchability. Increases strength without reducing toughness. Stabilizes cementite and suppresses graphitization. Fixes S as MnS and thereby prevents red brittleness. | Cr | Improves quenchability and prevents softening during temper by forming secondary carbides. Extremely suppresses graphitization by refining carbide particles. Improves corrosion resistance and anti-abrasion resistance. |
| P | Generally contained as an impurity. Segregates at grain boundaries reducing impact properties. Increases temper brittleness, but also increases strength, grindability and corrosion resistance. | Mo | Forms carbides, increasing resistance to temper softening. Promotes secondary hardening. Improves brittleness by preventing temper embrittlement. |
| S | Generally contained as an impurity. Lowers ductility during hot rolling. Red brittleness is caused by FeS . Red brittleness is prevented by adding Mn to form MnS , also resulting in improved grindability. | Al | Used as deoxidizer in steelmaking. Combines with N to form AlN and improves toughness by suppressing abnormally enlarged austenitic grains. |
| | | N | Combines with nitride creators. Improve toughness by refining grains and preventing abnormal coarsening of austenite. |

Introduction of functional products

In addition to products specified in JIS and other public standards, JFE Steel has developed various new functional products. Examples are introduced below.

SUPERHOT

JFE produces high quality hot rolled special steel SUPERHOT, which is characterized by excellent thickness accuracy, surface quality, and workability in comparison with conventional hot rolled special steels, by applying an advanced hot rolling mill, proprietary technologies, and strict controls. SUPERHOT is widely used in items which cannot be substituted with cold rolled products, such as chain plates, seat belt tongues, recliner gears, and pole parking.

Characteristics

1. Excellent accuracy of thickness

Longitudinal thickness deviation is extremely small and the crown is also flat. Actual measured data of thickness deviation and profile is shown.

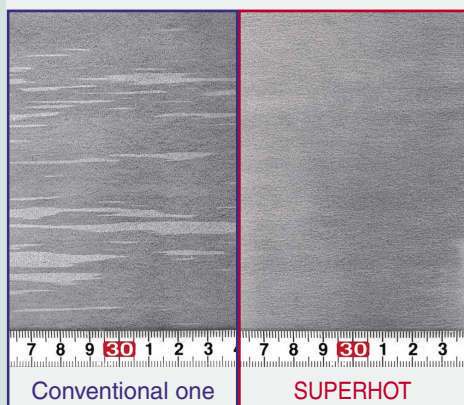
2. Excellent quality thick sheet

Descaling at the coil form of the strip more than 9mm is possible.

3. Excellent surface quality

Red scale is controlled in minimum. The example is shown below.

Comparison of surface between SUPERHOT and Conventional one



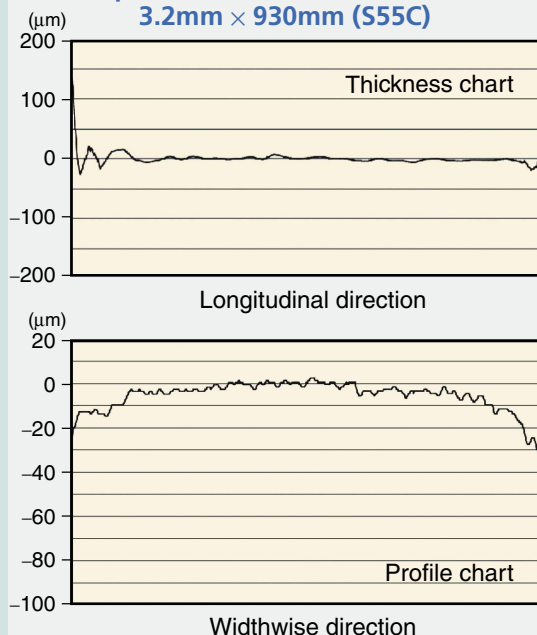
4. Excellent workability

It is suitable to fine blanking, tough standing and slight curvature bending.

Standard

Excellent thickness accuracy product and excellent surface quality products are applicable to all standards. Excellent quality thick sheet and excellent workability products are mainly applicable to SC, SCM and SCr.

Example of thickness measurement of 3.2mm × 930mm (S55C)



Application

Parts of reclining seat



Gear plate



Lock gear

Hyper-Burring High Carbon Hot Rolled Steel Sheet

Hyper-Burring is a high carbon steel for machine structural use with uniformly dispersed fine carbides. This new product was developed by applying JFE's *Super* OLAC H technology, and provides extremely high performance in burring (hole expansion), press forming, and heat treatment in comparison with conventional high carbon hot rolled steels.

(*Super* OLAC H: *Super* On-Line *A*ccelerated *C*ooling for *H*ot strip mill)

Characteristics

1. Hole expanding ratio is two times larger with conventional products.
2. Softer steel sheet can be produced.

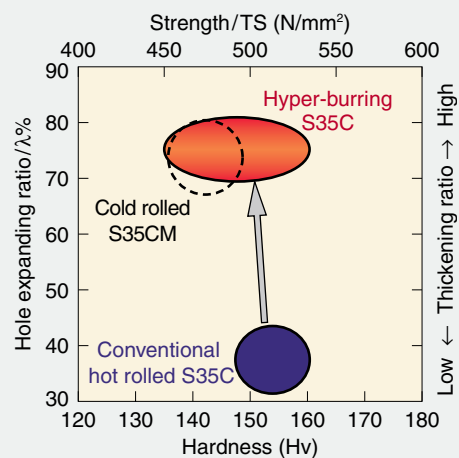
Standard and dimension

Standards S30C-S45C are applicable with spheroidizing annealed steel in thickness of 2.3-6.5mm.
(Details are subject to negotiation.)

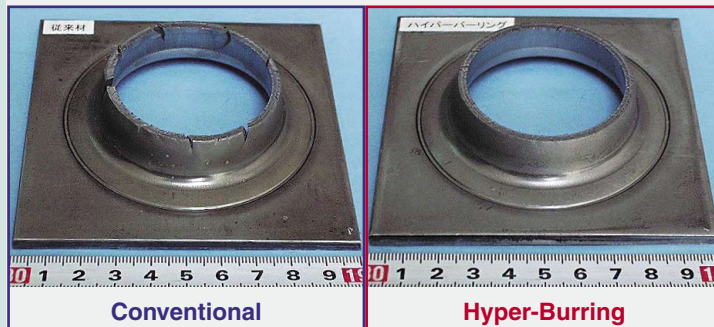
Examples of application

Applicable to parts which require strength, such as automobile drive train, as a substitute for cast and forged parts. Can be used in solid (unitary) parts.

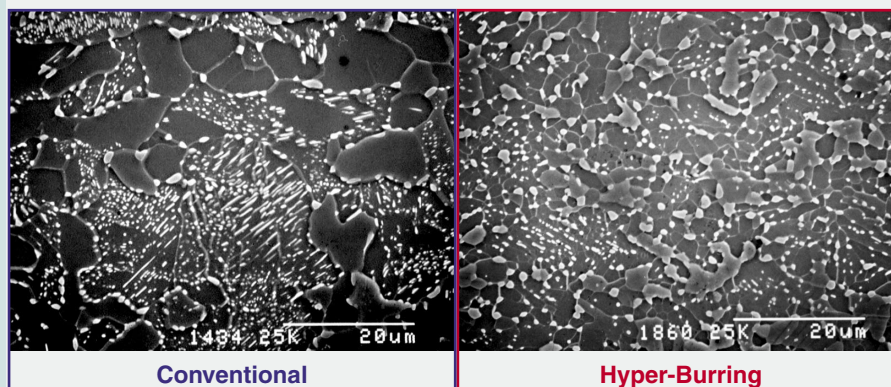
Hole expanding ratio – strength balance



Example of hole expansion (S35C)



Microstructure of Hyper-Burring (S35C)



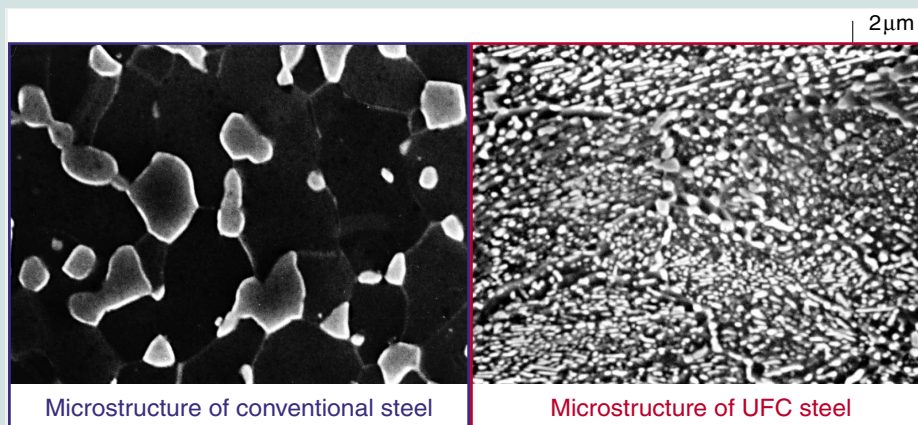
UFC Steel (Ultra Fine Carbide High Carbon Cold Rolled Steel Sheet)

Proper selection of cold rolling and annealing conditions enables uniform dispersion of fine spheroidized carbides 1/10 the size of those in conventional steel. Has won an excellent reputation with customers for improving efficiency in the quenching process and uniform product quality.

(UFC Steel: Ultra Fine Carbide Steel)

Characteristics

- 1) Possible shortening of heat treatment due to easy carbide dissolution.
- 2) Uniform quality after heat treatment.



Standard

Applicable to SK4, SK5.
(Other standards are subject to negotiation.)

Examples for application



Round saw



Handy saw

Non-Oriented High Carbon Cold Rolled Steel Sheet

High carbon steel products with excellent uniformity of mechanical properties in the sheet surface direction. By properly controlling the pearlite structure during hot rolling, the cold reduction ratio, and annealing conditions, and by balancing fine carbide generation and the specified crystal orientation, it is possible to minimize anisotropic characteristics, resulting in improved formability and quenchability.

Characteristics

1. Because anisotropic characteristics of mechanical properties are extremely low, high dimensional accuracy is achieved in the cup cylinder test.
2. Ductility and press formability are excellent.
3. Quenchability is also excellent.

Standard

S35C – S55C. Other standards are subject to negotiation.

Application

Axially symmetrical parts which require high dimensional accuracy, such as transmission parts (Rotating part).

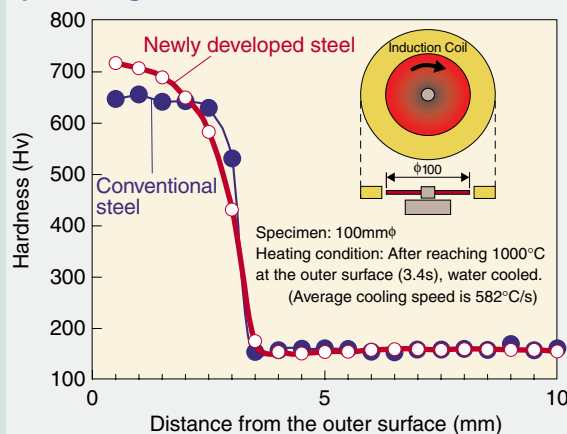
Characteristics of newly developed steel

(Example of S35C cold rolled and spheroidizing annealed)

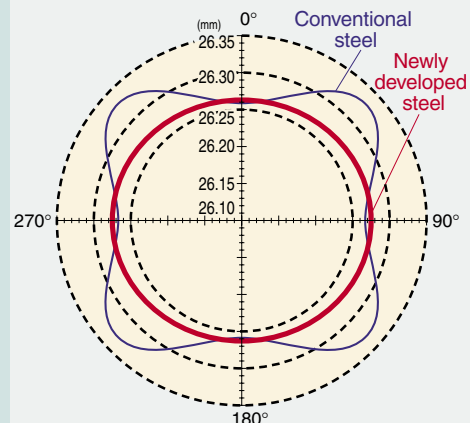
Appearance of cup cylinder tested pieces



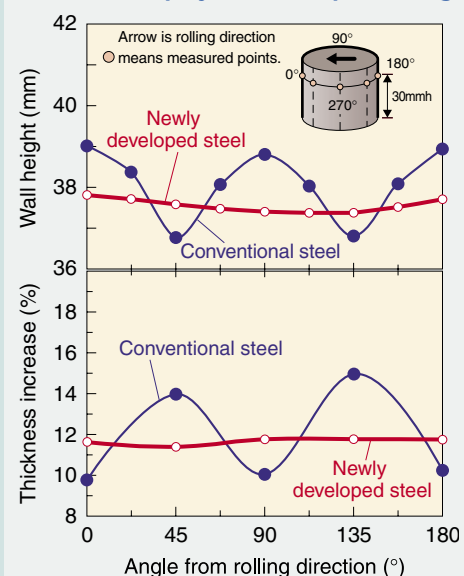
Hardness distribution after high current quenching



Appearance change after cup cylinder tested pieces



Change in wall height and wall thickness after cup cylinder deep drawing



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