

FREE CUTTING STEEL

Kinds of Free Cutting Steel		Material Codes (Note 1)	Addition, or Change, To Chemical Composition (%)							Heat Treatment (For Ref.)	Main Uses		Remarks
			Addition of Mn				Elements used To Improve Machinability						
			To Base Steels										
			with lower limit of Mn content less than 0.40%		with lower limit of Mn content of 0.40% or more		S	Pb	Ca				
Lower Limit	Upper Limit	Lower Limit	Upper Limit										
Lead Free-cutting Steel	Type 0	L0	—	—	—	—	0.015 ~0.030	0.02 ~0.05	—	See Standards for base steels ("Carbon steel for machine structure" and "Alloy steels for structural uses").	SCM318HL0 S45CVL0	Gears, Yokes	Parts requiring high machinability, used as strength members
	Type 1	L1	—	—	—	—	—	0.04 ~0.08	—		SMnCV525 S1L1	High-strength connecting rods	
	Type 2	L2	—	—	—	—	—	0.10 ~0.30	—		SMnCV525 S1L2		
Sulfur Free-cutting Steel	Type 1	S1	+0.20	+0.30	+0.10	+0.20	0.04 ~0.07	—	—		ASB43S1 S50CVS1	Frt. axle balancers	
	Type 2	S2	+0.30	+0.40	+0.20	+0.30	0.08 ~0.12	—	—				
Ca Free-cutting Steel	Type 1	US1	+0.20	+0.30	+0.10	+0.20	0.04 ~0.07	—	0.001 ~0.010		S53CUS1	Connectin g rods	Strength parts of which high machinability is required
	Type 3	SMn451US	—	—	—	—	0.030 ~0.045	—	0.001 ~0.010		SMn451US	Frt axles	To be replaced with ASB43S1 in new-design parts

Note 1. To create the code for a free-cutting steel, the symbol " " in Material Codes column shall be replaced with the code for applicable base steel, except for SMn451US.

Remarks 1. Applicable base steels are the carbon steels for machine structure and alloy steels for structural uses specified in ISC standards.

2. To modify a base steel into the corresponding free-cutting steel, the upper and lower limits of Mn content (specification value) of the base steel is changed by addition of Mn in amount shown in the above table.

(Example)

	Base Steel		Free-cutting steel	
	Material Codes	Mn Content (%) in Spec.	Material Codes	Mn Content (%) in Spec.
Base Steel (S20C)	S20C	0.30~0.60	S20CS1	0.50~0.90
Base Steel (S50C)	S50C	0.60~0.90	S50CS1	0.70~1.10

3. To modify a base steel into the corresponding free-cutting steel, sulfur content (spec. value) in the base steel shall be changed to the content shown in the above table and Pb and Ca shall be dosed to the base steel to achieve their contents shown in the above table.

4. To use free-cutting steels, consult Materials Development Sec. No. 1, Veh. & Exp. Dept. and PT Manuf. Engineering No. 1 and 2.

5. Standard dimensions and tolerances for free-cutting steels shall be as shown in Tables 2 and 3 of Standard Dimensions and Tolerances (A140)

6. Chemical composition of the base steel of SMn451US is as shown below :

Chemical Composition (%)					
Material Code	C	Si	Mn	P	S
SMn451	0.47~0.55	0.15~ 0.35	1.20~ 1.50	0.030 (max)	0.030 (max)

Impurities shall not exceed 0.35 % (Cr), 0.25 % (Ni) and 3.0 % (Cu)

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Kinds of Free-cutting Steel		Lead Free-cutting Steel Type 0 (L 0)	Lead Free-cutting Steel Type 1 (L 1)	Lead Free-cutting Steel Type 2 (L 2)	Sulfur Free Cutting Steel Type 1 (S 1)	Sulfur Free Cutting Steel Type 2 (S 2)	Calcium Free-cutting Steel Type 1 (U S 1)
Elements Added To Improve Machinability		Pb(0.02~0.05%)	Pb(0.04~0.08%)	Pb(0.10~0.30%)	S(0.04~0.07%)	S(0.08~0.12%)	Ca + S (0.04~0.07%)
Mechanical Properties	Tensile Strength	Equal to base steel	Equal to base steel	Equal to base steel. (However, at 300°C or higher, elongation, reduction in area and impact value will drop.)	Equal to base steel. (However, impact value will drop slightly)	Slightly Lower than that of base steel. (Impact value will drop in particular.)	Equal to base steel. (However, impact value will drop slightly)
	Elongation/Reduction in Area						
	Impact Value						
	Fatigue Strength			Slightly drops in high-load area	Equal to base steel.	Lower than base steel	Roughly equal to base steel.
	Rolling Contact Fatigue Life	Slightly drops under high bearing pressure.	Slightly drops under high bearing pressure.	Drops under high bearing pressure.	—	—	Equal to base steel.
Workability	Hot Forging	Equal to base steel.	Equal to base steel.	Lower than base steel	Equal to base steel.	Lower (high-temp embrittlement)	Roughly equal to base steel.
	Cold Forging			Equal to base steel.	Lower than base steel	Significantly lower	Lower than base steel
	Weldability	Roughly equal to base steel.	Equal to base steel.	Slightly lower than base steel	Roughly equal to base steel.	Lower than base steel	Roughly equal to base steel.
Heat Treatment incl. Refining		Equal to base steel.	Equal to base steel.	Equal to base steel.	Equal to base steel.	—	Equal to base steel.
Machinability	Tool Life	Superior to base steel	Superior to base steel	Superior to base steel	Superior to base steel	Superior to base steel	Superior to base steel
	Chip Crushability	Excellent	Excellent	Excellent	Moderately superior to base steel	Superior	Moderately superior to base steel
	Roughness of Finished Surface	Superior to base steel	Superior to base steel	Superior to base steel	Moderately superior to base steel	Superior to base steel	Moderately superior to base steel
Uses	Recommended Uses	For carburized / refined parts	For carburized / refined parts	For refined / small-size parts	For refined / small-size parts	For small-size parts (subjected to machining only)	For refined parts
	Remarks	Available for gears if degassed. Suitable for cutting with high-speed steel tool.	Available for gears if degassed. Suitable for cutting with high-speed steel tool.	In application to parts used under high bearing pressures, attention should be paid to rolling fatigue life and offsetting material cost by improvement in cutting operation.	Suitable particularly to drilling with drill of high-speed tool steel at relatively slow feed speed	Use for parts requiring high strength should be avoided. Suitable particularly to drilling with drill of high-speed tool steel at relatively slow feed speed	Suitable for cutting with high-speed steel tool and also carbide tools. Service life of carbide tools will be several to 10 times the life of base steel tools.

Remark : Prior to use for parts, consult Materials Development Sec. No. 1, Veh. R & Exp. Dept. and PT Manuf. Engineering No. 1 and No. 2.