Copper Steel: popularly used for high strength and ductility enhancement

Iron-Copper and Copper Steel

P/M Material Properties

Material Designation Code	MINIMUM VALUES (A): Minimum Strength (A) (E) Yield	Ultimate	TYPICAL VALUES (B): TENSILE PROPERTIES: Ultimate Strength	Yield Strength (0.2%)	Elongation (in 1 in.)	ELASTIC CONSTANTS: Young's Modulus	Poisson's Ratio	Unnotched Charpy Impact Energy	Transverse Rupture Strength	Compressive Yield Strength (0.1%)	HARDNESS: Macro (apparent)	Micro-indentation (converted)	Fatigue Limit 90% Survival	Density
	10^3psi	10^3psi	10^3psi	10^3psi	%	10^6psi		ft-lbf	10^3psi	10^3psi	Rockwell	Rockwell	10^3psi	g/cm³
FC-0200-15	15		25	20	1.0	14.0	0.25	4.5	45	18	11 HRB	N/D	10	6.0
-18	18		28	23	1.5	16.5	0.25	5.0	51	21	18		11	6.3
-21	21		31	26	1.5	16.5	0.25	5.5	56	23	26		12	6.6
-24	24		34	29	2.0	19.5	0.27	6.0	63	26	36		13	6.9
FC-0205-30	30		35	35	<1.0	14.0	0.25	<2.0	60	35	37 HRB	N/D	13	6.0
-35	35		40	40	<1.0	16.5	0.25	3.0	75	40	48		15	6.3
-40	40		50	45	<1.0	17.5	0.25	5.0	95	45	60		21	6.7
-45	45		60	50	<1.0	21.5	0.27	8.0	115	50	72		31	7.1
FC-0205-60HT		60	70	(D)	<0.5	16.0	0.25	2.5	95	57	19 HRC	58 HRC	27	6.2
-70HT		70	80		<0.5	15.5	0.25	3.5	110	71	25	58	30	6.5
-80HT		80	90		<0.5	18.5	0.27	4.5	120	86	31	58	34	6.8
-90HT		90	100		<0.5	20.5	0.27	5.5	135	95	36	58	38	7.0
FC-0208-30	30		35	35	<1.0	12.5	0.25	<2.0	60	40	50 HRB	N/D	13	5.8
-40	40		50	45	<1.0	16.5	0.25	2.0	90	45	61		17	6.3
-50	50		60	55	<1.0	17.5	0.25	5.0	125	50	73		23	6.7
-60	60		75	65	<1.0	22.5	0.28	7.0	155	55	84		33	7.2
FC-0208-50HT		50	65	(D)	<0.5	15.0	0.25	2.5	95	58	20 HRC	60 HRC	25	6.1
-65HT		65	75		<0.5	17.5	0.27	3.5	110	72	27	60	30	6.4
-80HT		80	90		<0.5	18.5	0.27	4.5	130	91	35	60	35	6.8
-95HT		95	105		<0.5	21.5	0.27	5.5	150	105	43	60	40	7.1
FC-0505-30	30		44	36	<0.5	12.5	0.25	3.0	77	50	51 HRB	N/D	17	5.8
-40	40		58	47	<0.5	16.5	0.25	4.5	102	54	62		22	6.3
-50	50		71	56	<1.0	17.5	0.25	5.0	124	58	72		27	6.7
FC-0508-40	40		58	50	<0.5	13.0	0.25	3.0	100	58	60 HRB	N/D	22	5.9
-50	50		68	60	<0.5	16.5	0.25	3.5	120	63	68		26	6.3
-60	60		82	70	<1.0	18.5	0.27	4.5	145	68	80		31	6.8
FC-0808-45	45		55	50	<0.5	14.0	0.27	3.0	85	62	65 HRB	N/D	21	6.0
FC-1000-20	20		30	26	<1.0	14.0	0.27	3.5	53	33	15 HRB	N/D	11	6.0

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Iron-Copper and Copper Steel

This subsection covers P/M materials produced from admixtures of elemental iron powder and elemental copper powder with or without graphite powder (carbon). The proportions of each depend on the strength levels required and whether the material is to be used in the as-sintered or heat treated condition.

Material Characteristics

Because graphite diffuses readily into an iron powder matrix during sintering, combined carbon of 0.8% or more is attainable. Copper powder is added to increase strength, hardness and wear resistance. Wear resistance can be enhanced by heat treatment. When the final density is to be 7.0 g/cm^3 or more, these materials may be manufactured by pressing, presintering, repressing and sintering.

Application

P/M iron-copper and copper steel materials find wide usage in medium strength structural applications. Copper contents of 2% are typical. When secondary machining is required, combined carbon contents of less than 0.5% should be specified. Material in this category also can be heat treated to increase strength and wear resistance. Higher copper content materials (in the range of 5%) are recommended when maximum wear resistance is required and when heat treating is not practical. Low density parts can be oil-impregnated for self-lubrication in use.

Microstructure

Admixed copper powder melts at approximately 1980 °F (1082 °C), flows between the iron particles and into small pores, and thus helps the sintering of the steel. Normally sintered alloys with 2% copper show little or no undissolved copper. At higher percentages, the copper will be seen as a separate phase. The copper dissolves in the iron but does not penetrate to the center of the larger iron particles. When copper melts, it diffuses or migrates leaving behind fairly large pores. These pores remain and can easily be seen in the microstructure.

Chemical Composition, % – Iron-Copper and Copper Steel

Material Designation	Fe	Cu	C	Element
FC-0200	Bal.	1.5	0.0	Minimum
	Bal.	3.9	0.3	Maximum
FC-0205	Bal.	1.5	0.3	Minimum
	Bal.	3.9	0.6	Maximum
FC-0208	Bal.	1.5	0.6	Minimum
	Bal.	3.9	0.9	Maximum
FC-0505	Bal.	4.0	0.3	Minimum
	Bal.	6.0	0.6	Maximum
FC-0508	Bal.	4.0	0.6	Minimum
	Bal.	6.0	0.9	Maximum
FC-0808	Bal.	7.0	0.6	Minimum
	Bal.	9.0	0.9	Maximum
FC-1000	Bal.	9.0	0.0	Minimum
	Bal.	11.0	0.3	Maximum

Other Elements: 2.0% maximum may include other minor elements added for specific purposes.

NOTES:

(A) Suffix numbers represent *minimum* strength values in 10^3 psi (see page 2); yield in the as-sintered condition and ultimate in the heat treated condition.

(B) Mechanical property data derived from laboratory prepared test specimens sintered under commercial manufacturing conditions.

(C) Additional data in preparation will appear in subsequent editions of this standard.

(D) Yield and ultimate tensile strength are approximately the same for heat treated materials (see page 3).

(E) Tempering temperature for heat treated (HT) materials: 350 °F (177 °C).

N/D Not determined for the purposes of this standard.

To select a material optimum in both properties and cost-effectiveness, it is essential that the part application be discussed with the P/M parts manufacturer. (See **Explanatory Notes: Minimum Value Concept** *page 2.) Both the purchaser and the manufacturer should, in order to avoid possible misconceptions or misunderstandings, agree on the following conditions prior to the manufacturer of a P/M part: minimum strength value, grade selection, chemical composition, proof testing, typical property values and processes that may affect the part application.*

MPIF Designation	Nominal Composition, %	Density, g/cc	Hardness Rockwell	Transverse Rupture Strength, psi	Ultimate Tensile Strength, psi	Yield Strength, psi	Elongation %
SS-303N1	18Cr;11Ni;1Mn; Fe: Bal	6.40	62B	86,000	39,000	32,000	0.50
SS-304N1	19Cr;10Ni;1Mn; Fe:Bal.	6.40	61B	112,000	43,000	38,100	0.50
SS-316L	17Cr;13Ni;2.2Mo;0.9Si; Fe:Bal	6.50	65B	94,000	45,000	30,000	6.00
SS-410	13Cr;0.8Si;0.8Mn Fe:Bal	6.20	15C	85,000	66,700	56,900	0.00

Typical Raw Material (metal powder) for Stainless Steel

Grade	Recommendations	Equivalent Specifications
SS-303	Austenitic machining grade, preferred for parts requiring extensive machining, non-magnetic high strength and hardness. Good corrosion resistance	MPIF: SS-303N2-35 ASTM: B 783-90
SS-304	General purpose austenitic grade, has good strength and corrosion resistance. Non-magnetic and non-machinable. Weak magnetic property.	MPIF: SS-304N2-33 ASTM: B 783-90
SS-316	Corrosion resistance is better than SS-303. First choice for general purpose applications. Non-magnetic.	MPIF: SS-316N2-33 ASTM: B 783-90 DIN: SINT-C40
SS-410	Used in applications requiring hardness and wear resistance. Carbon is added for increased heat-treatment response. It has fair corrosion resistance and poor machinability.	MPIF: SS-410-90HT ASTM: B 783-90 DIN: SINT-C43