410 Cb
STAINLESS STEEL

Flange Applications

Knives

Table Flatware

Turbine Blades

TYPE 410 CB is a suitable alternative for Cleveland-Cliffs 409 Ni in some flange applications. In addition, it can be used as a replacement wherever Type 410 is specified in a wide variety of applications, including steam turbine blades, aerospace equipment, mining equipment, knives, table flatware, flat springs, oil and gas and coiled tubing.

Product Description

Type 410 Cb is an improved version of standard Type 410 that provides superior characteristics. By the addition of niobium (Nb), properties are improved without altering any of the desirable characteristics of Type 410.

The alloy offers three major advantages over Type 410:

1) Greater ease in heat treating

2) Higher strength and toughness

3) Improved grain size control

When tempering Type 410, rapid changes in hardness can occur with relatively minor changes in time and temperature. For this reason, it is often difficult to obtain uniform, consistent hardness from part to part, especially when heat-treating large furnace loads where temperature variations are more likely to exist. Type 410 Cb alleviates that problem, because it is not as sensitive to time and temperature variations. Specific hardness ranges can be maintained more consistently.

In the annealed condition, the mechanical properties of Type 410 Cb are about the same as those of Type 410. However, after tempering, the alloy has appreciably higher strength and ductility than Type 410 at both elevated and sub-zero temperatures. Also, the impact strength of Type 410 Cb is significantly higher than Type 410 in most heat-treated conditions.

Composition		(wt %)
Carbon	(C)	0.15 max.
Manganese	(Mn)	0.55 max.
Phosphorus	(P)	0.04 max.
Sulfur	(S)	0.015 max.
Silicon	(Si)	0.60 max.
Chromium	(Cr)	12.5 max.
Niobium	(Nb)	0.30 max.
Molybdenum	(Mo)	0.50 max.

AVAILABLE FORMS

Type 410 Cb is available in 0.0250 – 0.375 in. (0.64 – 9.53 mm), widths up to 33 in. (838 mm) thick strip. For other sizes, contact your Cleveland-Cliffs sales representative.

METRIC PRACTICE

The values shown in this bulletin were established in U.S. customary units. The metric equivalents of U.S. customary units shown may be approximate.

Mechanical Properties

TABLE 1 – ANNEALED MECHANICAL PROPERTIES

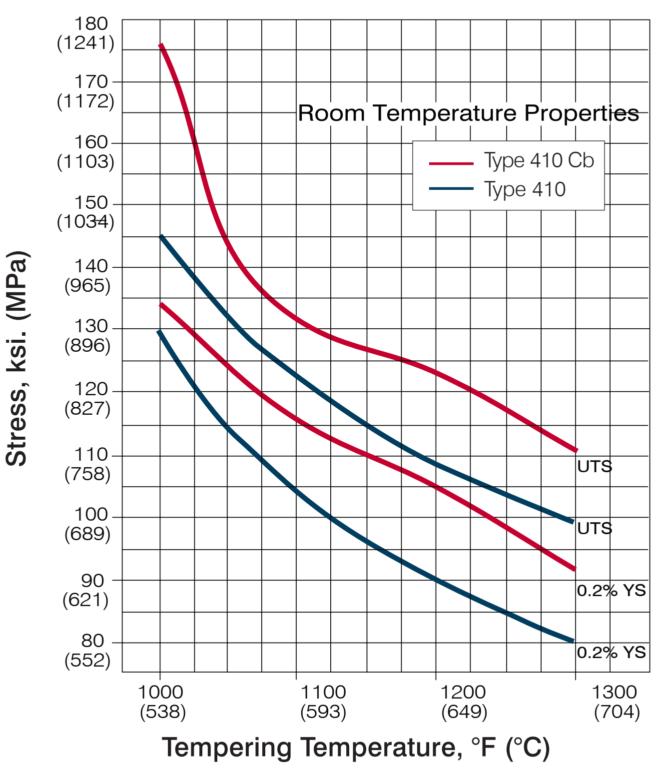
UTS, ksi. (MPa)	0.2% YS, ksi. (MPa)	Elongation % in 2 in. (50.8 mm)	Rockwell Hardness, B
75 min. (517)	60 min. (414)	25 min.	85

TABLE 2 – EFFECT OF TEMPERING TEMPERATURE ON HARDENED* MECHANICAL PROPERTIES

Tempering Temperature, °F (°C)	UTS, ksi. (MPa)	0.2% YS, ksi. (MPa)	Elongation % in 2 in. (50.8 mm)	Rockwell Hardness	Charpy Impact V-Notch, ft.•lbs. (J)
500 (260)	181 (1248)	150 (1034)	15	C32	27 (38)
700 (371)	177 (1220)	149 (1027)	14.5	C36	24 (34)
900 (482)	187 (1289)	144 (993)	17	C35	18 (25)
1000 (538)	176 (1213)	134 (924)	14	C33	8 (11)
1100 (593)	132 (910)	116 (800)	17	C26	19 (27)
1200 (649)	123 (848)	105 (724)	18	C24	33 (47)
1300 (704)	111 (765)	92 (634)	20	B89	41 (58)
1400 (760)	95 (655)	73 (503)	26	B92	78 (110)

*Hardened at 1850°F (1010 °C) for 30 min., oil quenched plus tempered for 4 hr. at temperature shown.

FIGURE 1 – COMPARISON OF PROPERTIES TYPE 410 CB AND TYPE 410*

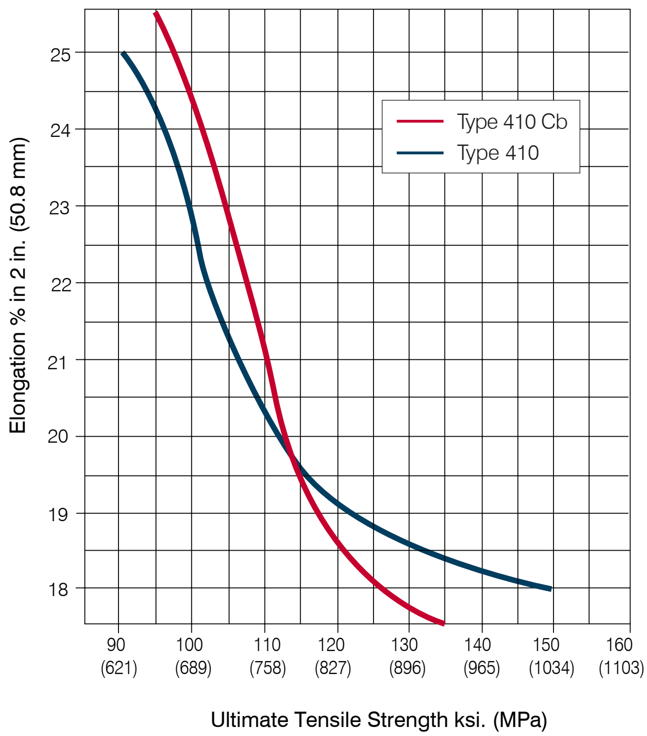


Type 410 Cb exhibits better ductility at given strength levels up to 115 ksi. (793 MPa) UTS than Type 410. This results from the higher tempering temperatures required for Type 410 Cb to produce the same strength.

*Type 410 properties are derived from bar data.

Mechanical Properties

FIGURE 2 – ELONGATION VS. ULTIMATE TENSILE STRENGTH TYPE 410 CB AND TYPE 410*



**Type 410 properties are derived from bar data. Type 410 Cb data based on 0.375 in. (9.5 mm) strip, transverse direction.*

Figure 2 shows the comparative typical elongation obtained in Type 410 and Type 410 Cb hardened and tempered to various strengths.

TABLE 3 – FATIGUE STRENGTH (R.R. MOORE ROTATING BEAM TEST) R = -1

Tempering Temperature,* °F (°C)	Type 410 Cb		Type 410	
	UTS, ksi. (MPa)	Fatigue Strength at 10^7 cycles, ksi. (MPa)	UTS, ksi. (MPa)	Fatigue Strength at 10^7 cycles, ksi. (MPa)
1050 (566)	147 (1014)	79 (545)	134 (324)	69 (476)
1125 (607)	135 (931)	70 (483)	120 (827)	62 (427)
1200 (649)	129 (889)	68 (469)	109 (752)	56 (386)

**From pre-existing bar data. Hardened at 1850 °F (1010 °C), 30 min., oil quench, then tempered for 4 hrs. as indicated.*

Tables

TABLE 4 – TYPICAL SHORT-TIME ELEVATED TEMPERATURE PROPERTIES

Property	Tempering Temperature,* °F (°C)	Test Temperature, °F (°C)				
		Room	500	700	900	1100
UTS, ksi. (MPa)	1100 (593)	135 (931)	117 (807)	110 (758)	97 (669)	74 (510)
	1200 (659)	121 (834)	105 (724)	101 (695)	92 (634)	69 (476)
	1300 (704)	114 (786)	91 (627)	85 (524)	76 (547)	55 (379)
0.2% YS, ksi. (MPa)	1100 (593)	122 (841)	107 (738)	101 (696)	92 (634)	71 (490)
	1200 (649)	107 (738)	97 (669)	90 (621)	81 (558)	62 (427)
	1300 (704)	94 (648)	79 (545)	75 (517)	68 (469)	51 (352)
Elongation % in 2 in. (50.8 mm)	1100 (593)	19 (-7)	17 (-8)	15 (-9)	18 (-8)	21 (-6)
	1200 (649)	21 (-6)	20 (-6)	28 (-2)	19 (-7)	22 (-6)
	1300 (704)	21 (-6)	19 (-7)	18 (-8)	20 (-7)	25 (-4)

**From pre-existing bar data. Hardened at 1850 °F (1010 °C), 30 min., oil quench, then tempered for 4 hrs. as indicated.*

TABLE 5 – STRESS-RUPTURE STRENGTH

Time to Rupture, Hrs.	Tempering Temperature,* °F (°C)	Type 410 Cb				Type 410	
		Hardened at 1850 °F		Hardened at 2000 °F			
		Stress to Rupture,* ksi. (MPa)	Elongation at Rupture, %	Stress to Rupture,** ksi. (MPa)	Elongation at Rupture, %	Stress to Rupture,* ksi. (MPa)	Elongation at Rupture, %
100	900 (482)	63 (436)	14	73 (503)	10	46 (317)	16
	1000 (538)	48 (331)	15	60 (417)	10	32 (221)	21
	1100 (593)	32 (221)	15	43 (276)	12	18 (124)	25
1000	900 (482)	58 (440)	13	68 (469)	10	40 (276)	20
	1000 (538)	42 (290)	14	52 (359)	11	25 (172)	23
	1100 (593)	22 (152)	16	25 (172)	20	12 (83)	32

From pre-existing bar data.
**Test samples hardened at 1850 °F (1010 °C), 30 min., oil quench plus 1200 °F (649 °C), 4 hr., air cool.*
***Test samples hardened at 2000 °F (1093 °C), 30 min., oil quench plus 1200 °F (649 °C), 4 hr., air cool.*

Tables

TABLE 6 – TYPICAL V-NOTCH IMPACT ENERGY*, ft.•lbs. (J)

Test Temperature, °F (°C)	Testing Temperature, °F (°C)					
	Type 410 Cb			Type 410		
	1200 (649) (RC 25)	1250 (678) (RC 23)	1300 (704) (RC 22)	1100 (593) (RC 25)	1200 (649) (RB 100)	1250 (678) (RB 97)
75 (24)	87 (96)	104 (115)	110 (122)	38 (42)	89 (99)	105 (117)
32 (0)	65 (72)	83 (92)	105 (117)	26 (29)	55* (61)	79 (88)
0 (-18)	46 (51)	77 (85)	87 (97)	15 (17)	27 (30)	42 (47)
-50 (-46)	27 (30)	48 (53)	65 (72)	10 (11)	17 (19)	24 (27)
-100 (-73)	21 (23)	43 (48)	49 (54)	5 (6)	11* (12)	15 (17)

**From pre-existing bar data.*

CORROSION RESISTANCE

The corrosion resistance of Type 410 Cb is similar to Type 410. However, the tempering characteristics of Type 410 Cb offer an advantage over Type 410 with stress corrosion cracking resistance. In order to achieve similar tensile strengths, a higher tempering temperature is used with Type 410 Cb. The higher temperature results in more effective relief of residual stresses that are known to promote stress cracking in some environments. Like Type 410, Type 410 Cb should not be used in the as annealed condition. Corrosion resistance is poor when used in this condition.

FORMABILTY

Type 410 Cb can be fabricated using the same procedures for Type 410 of similar hardness or strength.

WELDABILTY

The martensitic class of stainless steels has limited weldability due to its hardenability. It is usually not necessary to preheat this alloy to avoid cold cracking. Postweld heat treatment could be considered to achieve optimum properties. This particular alloy is generally considered to have equivalent weldability to the most common alloy of this stainless class, Type 410. A major difference is the niobium addition for this alloy, which improves properties without affecting the weldability. When a weld filler is needed, AWS E/ER 410, Cleveland-Cliffs 410 NiMo, and Cleveland-Cliffs 309L are most often specified. AWS E/ER 409 is often used for attachment welds in automotive exhaust systems. Type 410 is well known in reference literature and more information can be obtained in the following ways:

1. ANSI/AWS A5.9, A5.22, and A5.4 (Stainless welding electrode specifications).
2. "Welding of Stainless Steels and Other Joining Methods," SSINA, (www.ssina.com).

PHYSICAL PROPERTIES

Density, lbs/in³. (g/cm³)	0.28 (7.73)
Electrical Resistivity, μΩ•in. (μΩ•cm)	22.5 (57)
Thermal Conductivity, BTU/hr./ft./°F (W/m•K) 212 °F (100 °C) 932 °F (500 °C)	 14.4 (24.8) 16.6 (28.6)
Coefficient of Thermal Expansion, in./in./°F (μm/m•K) 32 – 212 °F (0 – 100 °C) 32 – 1200 °F (0 – 649 °C)	 5.5 X 10^{-6} (9.9) 6.5 10^{-6}(11.6)
Modulus of Elasticity, ksi. (MPa)	29 x 10^3 (200 x 10^3)

410 Cb STAINLESS STEEL

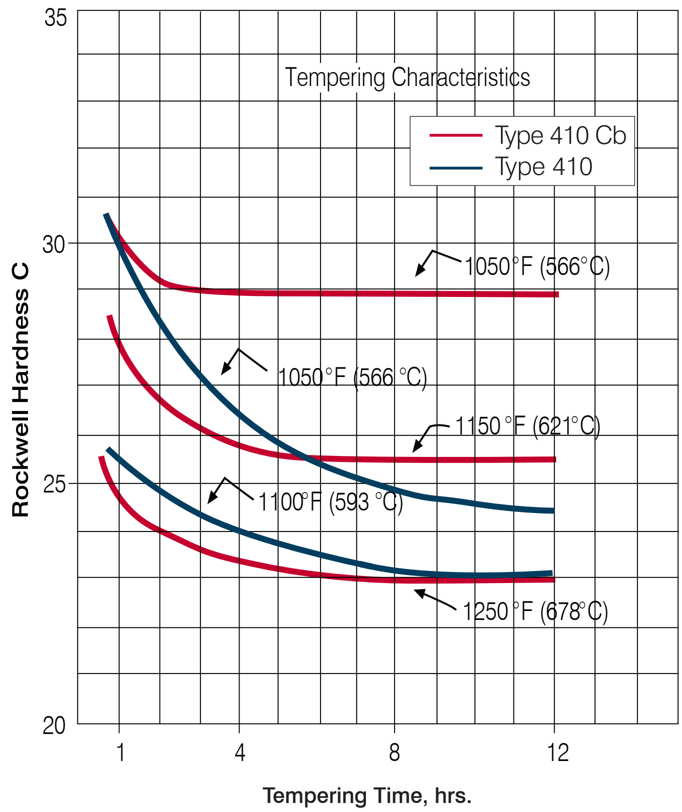
HEAT TREATMENT

Hardening temperatures for Type 410 Cb are in the same general range as those used for Type 410. However, higher tempering temperatures are required to obtain the same hardness in Type 410 Cb. Due to the higher tempering temperatures, more internal stresses are removed, resulting in better ductility.

When tempering Type 410, temperatures must be held within a narrow range to achieve a specific hardness. Variations in either temperature or time cause the hardness to vary, resulting in costly re-treatments or rejects. Also, parts must be racked carefully in the furnace to assure uniform heating throughout the charge.

With Type 410 Cb, the allowable temperature range for tempering to achieve a specific hardness is almost twice that for Type 410. Because temperature variation and time are much less critical than for Type 410, re-treatments are virtually eliminated. In addition, parts made of Type 410 Cb can be batched or stacked instead of racked in the furnace. This procedure not only permits larger furnace loads, but also reduces costly hand labor needed for racking. Figure 3 shows the effect of tempering time on Type 410 Cb and Type 410, and further shows why time at temperature is not as critical with Type 410 Cb.

FIGURE 3 – COMPARISON OF TEMPERING CHARACTERISTICS TYPE 410 AND TYPE 410



About Cleveland-Cliffs Inc.

Cleveland-Cliffs is the largest flat-rolled steel producer in North America. Founded in 1847 as a mine operator, Cliffs also is the largest manufacturer of iron ore pellets in North America. The Company is vertically integrated from mined raw materials and direct reduced iron to primary steelmaking and downstream finishing, stamping, tooling, and tubing. The Company serves a diverse range of markets due to its comprehensive offering of flat-rolled steel products and is the largest steel supplier to the automotive industry in North America. Headquartered in Cleveland, Ohio, Cleveland-Cliffs employs approximately 25,000 people across its mining, steel and downstream manufacturing operations in the United States and Canada.

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