410 Cb STAINLESS STEEL

AK Steel

- Greater Ease in Heat Treating Over Type 410
- Higher Strength and Toughness Than Type 410
- Improved Grain Size Control Over Type 410

Applications Potential

AK Steel 410 Cb can replace 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 that could include steam turbine blades, aerospace equipment, mining equipment, knives and table flatware and flat springs.

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PRODUCT DESCRIPTION

AK Steel 410 Cb is an improved version of standard Type 410 that provides superior characteristics, yet costs no more. By the addition of columbium, 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. AK Steel 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 AK Steel 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 AK Steel 410 Cb is significantly higher than Type 410 in most heat-treated conditions.

Typical Composition

	%
Carbon	0.12 max
Manganese	0.19 max
Phosphorus	0.021 max
Sulfur	0.004 max
Silicon	0.24 max
Chromium	11.9
Columbium	0.15 max
Molybdenum	0.027 max

Available Forms

AK Steel 410 Cb is available in 0.0250" to 0.375" thick strip. For other sizes, inquire.

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. Conversion to the metric system, known as the International Systems of Units (SI) has been accomplished in accordance with ASTM E380.

The newton (N) has been adopted by the SI as the metric standard unit of force. The term for force per unit of area (stress) is the newton per square meter (N/m^2). Since this can be a large number, the prefix mega is used to indicate 1,000,000 units and the term meganewton per square meter (MN/m^2) is used. The unit (N/m^2) has been designated a pascal (Pa). The relationship between the U.S. and the SI units for stress is: 1000 pounds/in^2 = 1 kip/in^2 (ksi) = 6.8948 meganewtons/m^2 (MN/m^2) = 6.8948 megapascals (MPa).

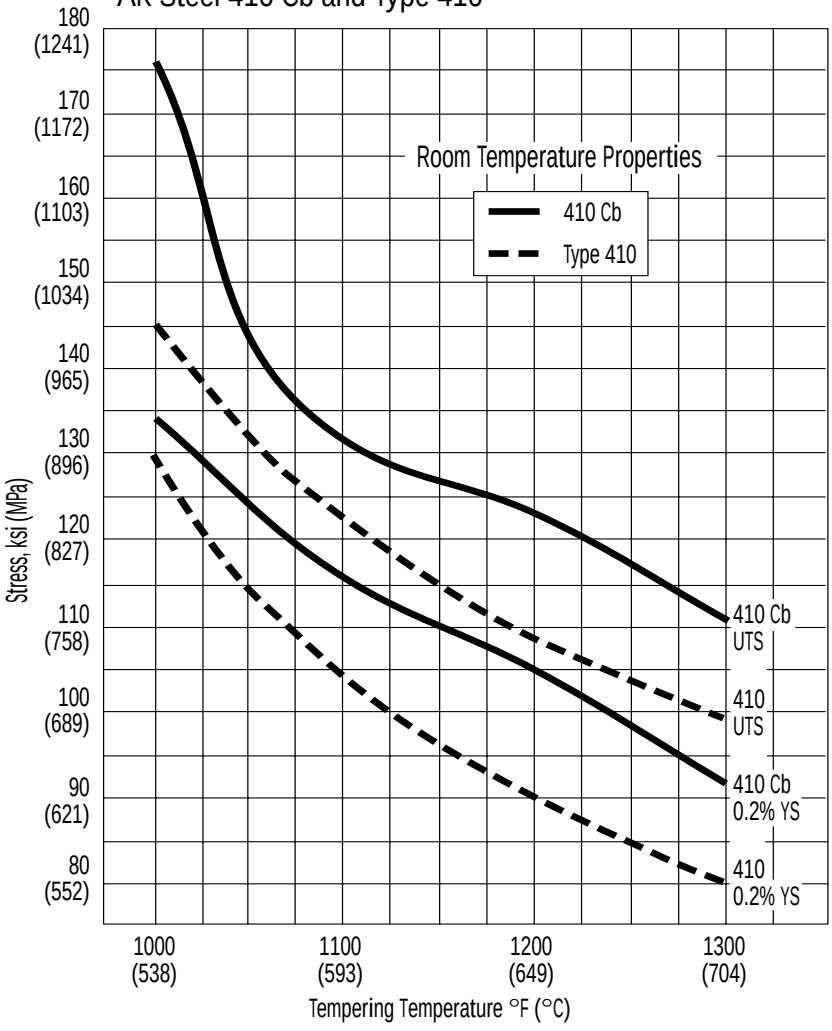
Table 1
Typical Mechanical Properties*

Tempering Temperature °F (°C)	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation 5 in 2" (50.8 mm)	Hardness Rockwell	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 minutes, oil quenched plus tempered for 4 hours at temperature shown.

Data is a product of one plant-processed heat, 3/8" (9.5 mm) plate, transverse direction.

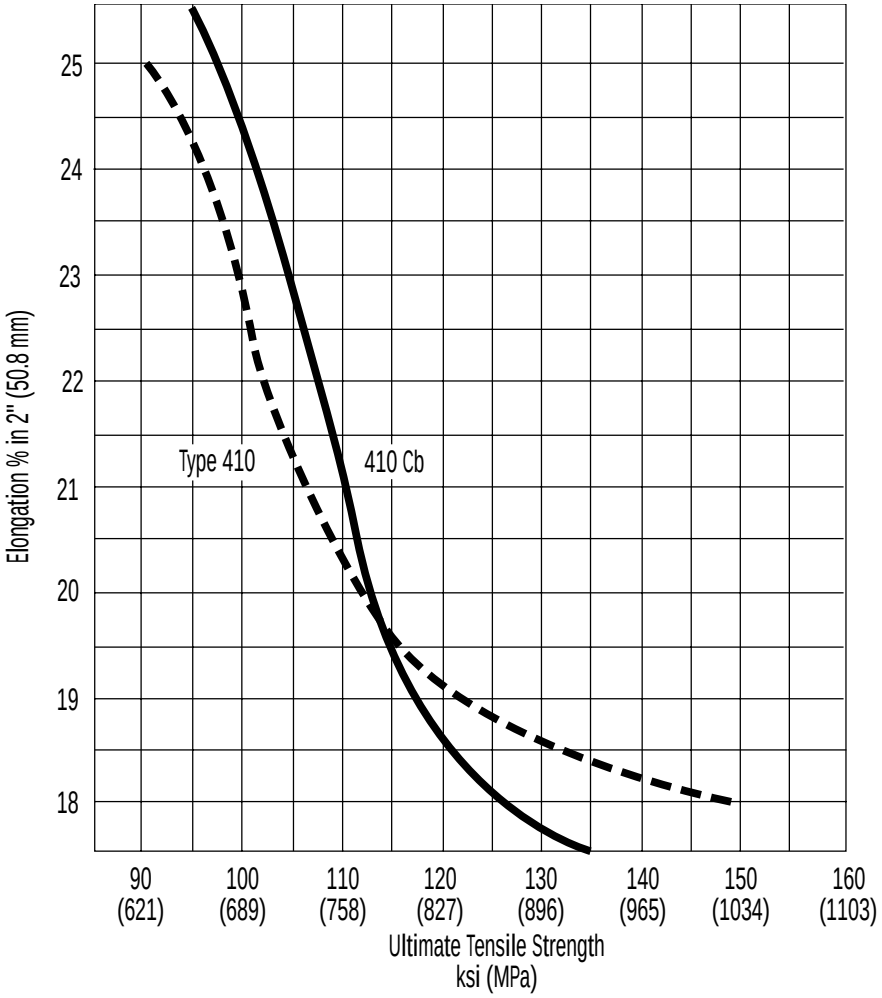
Figure 1
Comparison of Properties
AK Steel 410 Cb and Type 410*



*410 properties are derived from bar data.

AK Steel 410 Cb Stainless Steel exhibits better ductility at given strength levels than Type 410. This results from the higher tempering temperatures required for 410 Cb to produce the same strength. Figure 2 shows the comparative typical elongation obtained in Type 410 and AK Steel 410 Cb stainless steels hardened and tempered to various ultimate strengths.

Figure 2
Elongation Vs. Ultimate Tensile Strength
AK Steel 410 Cb and Type 410*



*410 properties are derived from bar data. 410 Cb data based on 3/8" (9.5 mm) strip, transverse direction.

Table 2
Fatigue Strength
(R. R. Moore Rotating Beam Test)
R = -1

	AK Steel 410 Cb		Type 410	
Tempering Temperature °F (°C)	UTS ksi (MPa)	Fatigue Strength at 10^7 cycles ksi (MPa)	UTS ksi (MPa)	Fatigue Strength at 10^7cycles ksi (MPa)
1050 (566)	147 (1014)	79 (545)	134 (924)	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 minutes, oil quench, then tempered for 4 hours as indicated.

Table 3
Typical Short-Time Elevated Temperature Properties

Property	Tempering Temp.* °F (°C)	Test Temperature, °F 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" (50.8 mm)	1100 (593)	19	17	15	18	21
	1200 (649)	21	20	28	19	22
	1300 (704)	21	19	18	20	25

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

Table 4
Stress-Rupture Strength

		AK Steel 410 Cb				Type 410	
		Hardened at 1850°F		Hardened at 2000°F			
Time to Rupture Hours	Temperature °F (°C)	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	40 (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 minutes, oil quench plus 1200°F (649°C), 4 hours, air cool.

** Test samples hardened at 2000°F (1093°C), 30 minutes, oil quench plus 1200°F (649°C), 4 hours, air cool.

Table 5

Typical V-Notch Impact Strength*
ft-lbs (J)

Test Temp. °F (°C)	Tempering Temperature, °F (°C)					
	AK Steel 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.

Physical Properties

Density, 0.28 lb/in^3
7.73 g/cm^3

Electrical Resistivity, microhm-in (microhm-cm) 22.5 (57)

Thermal Conductivity,
BTU/hr/ft^2/ft/°F (W/m•K)
212°F (100°C) 14.4 (24.8)
932°F (500°C) 16.6 (28.6)

Mean Coefficient of Thermal Expansion,
in/in/°F (µm/m•K)
32 - 212°F (0 - 100°C) 5.5 x 10^{-6} (9.9)
32 - 1200°F (0 - 649°C) 6.5 x 10^{-6}(11.6)

Modulus of Elasticity, ksi (MPa)
29 x 10^3 (200 x 10^3)

Corrosion Resistance

The corrosion resistance of AK Steel 410 Cb Stainless Steel is the same as Type 410 as demonstrated in laboratory tests and actual service.

The tempering characteristics of AK Steel 410 Cb offer an advantage over Type 410 in resistance to stress corrosion cracking. To develop similar tensile strengths, a higher tempering temperature is used with AK Steel 410 Cb. The higher temperature results in more effective relief of residual internal stresses that, in some environments, promote stress corrosion cracking.

Fabrication

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

Weldability

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 columbium addition for this alloy, which improves properties without affecting the weldability. When a weld filler is needed, AWS E/ER 410, 410 NiMo, and 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 (filler metals, minimum UTS and elongation).
2. “Welding of Stainless Steels and Other Joining Methods,” SSINA, (800:982-0355).
3. “Welding Stainless Steels,” FDB #SF-71.

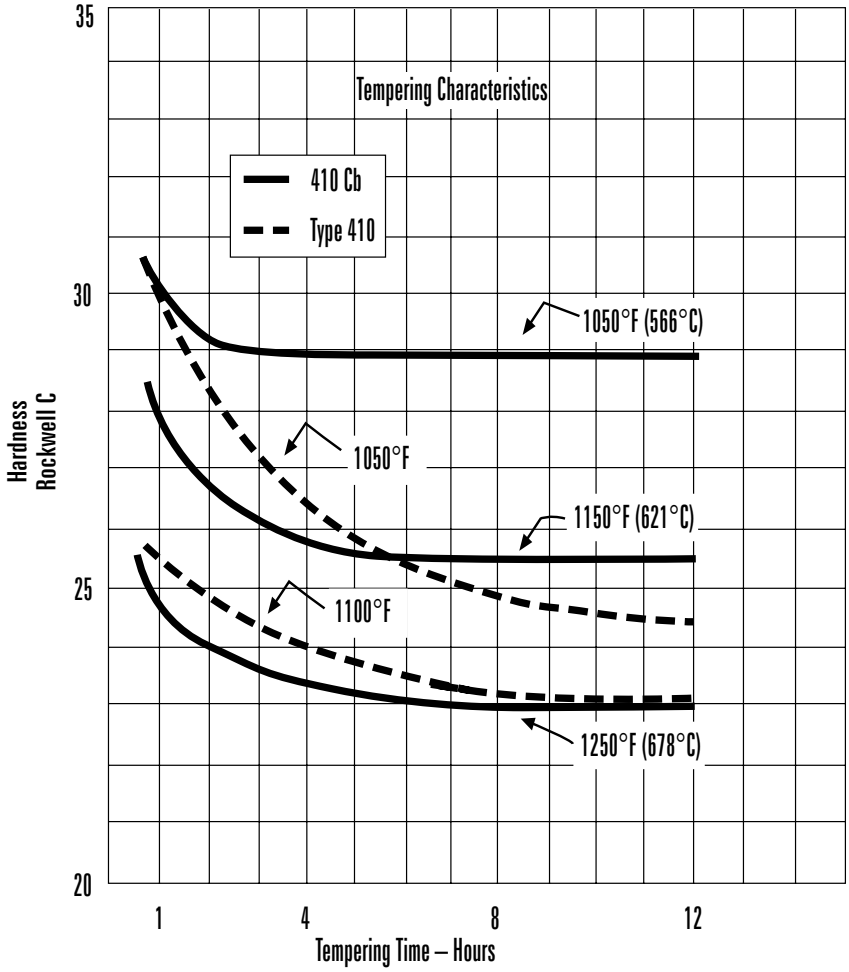
Heat Treatment

Hardening temperatures for AK Steel 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 AK Steel 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 AK Steel 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 AK Steel 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 AK Steel 410 Cb and Type 410, and further shows why time at temperature is not as critical with AK Steel 410 Cb Stainless Steel.

Figure 3
Comparison of Tempering Characteristics
AK Steel 410 Cb and Type 410



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