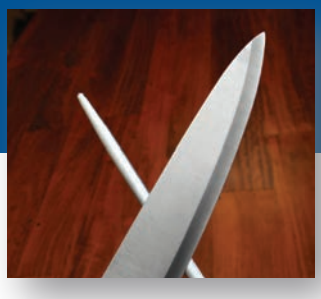
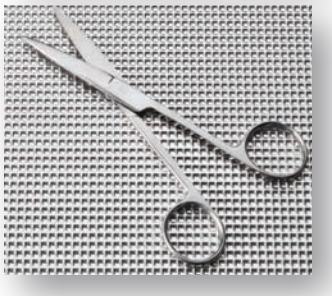
CLIFFS

MARTENSITIC STAINLESS STEEL

COMPARATOR





- **Pliers**
- **Screwdrivers**
- **Springs**
- **Staple Guns**
- **Vehicle Stampings**

MARTENSITIC STAINLESS STEELS are characterized by high strength and hardness in the heat-treated condition. Cleveland-Cliffs offers a range of martensitic stainless alloys which contain 11 – 17% chromium (Cr) with 0.15 – 0.63% carbon (C). Martensitic grades are magnetic in both the annealed and hardened (heat treated) condition. Cleveland-Cliffs martensitic stainless steels are supplied in the as-annealed condition, ready for blanking, bending and forming followed by heat treatment to obtain customer specific properties.

Applications for the martensitic stainless steels include: cutlery, cookware, surgical and dental instruments, springs, scissors, industrial blades, vehicle stampings, screwdrivers, pliers and staple guns.

Product Description

The balance of the strength, hardness, toughness and corrosion resistance of martensitic grades can be varied by altering the heat treatment. The higher carbon martensitic stainless steels should not be used in the as-hardened condition (without stress relief) as the toughness may not be sufficient for most applications. In addition, most martensitic stainless steels should not be used above 800 °F (425 °C) due to loss of strength and corrosion resistance.

Cleveland-Cliffs produces eight martensitic grades tailored for a variety of property requirements and applications.

Applications for the martensitic stainless steels include: cutlery, cook wear, surgical and dental instruments, springs, scissors, industrial blades, vehicle stampings, screwdrivers, pliers and staple guns.

TABLE 1 – TYPICAL CHEMICAL COMPOSITION TABLE

	Alloy	C	Mn	P Max.	S Max.	Si	Cr	Ni Max.	Others
Type 410	410	0.14	0.40	0.04	0.010	0.30	11.80	0.50	–
	410HC	0.18	0.50	0.04	0.010	0.50	11.80	0.50	–
Type 420	420 mod	0.20	0.50	0.04	0.010	0.45	12.70	0.50	–
	420LC	0.24	0.50	0.04	0.010	0.45	13.00	0.50	–
	420	0.38	0.40	0.04	0.010	0.40	12.80	0.50	–
	420HC	0.42	0.40	0.04	0.010	0.50	12.80	0.50	–
	420 ULTRA HONE®	0.42	0.40	0.04	0.010	0.50	14.20	0.50	0.05 N, 0.85 Mo, 0.10 V, 0.10 Co
Type 440	440A	0.62	0.40	0.04	0.010	0.40	16.60	0.50	–

**The values listed are typical values and are not suitable as minimum or maximum limits for specification.*

Product Description

TABLE 2 – AVAILABLE FORMS

Cleveland-Cliffs martensitic alloys are produced in coils and cut lengths.

Alloy	Gauge in., (mm)	Width in., (mm)
Type 410	0.010 – 0.125 (0.25 – 3.20)	36 (914)
Type 420	0.015 – 0.250 (0.38 – 6.35)	26 (660)
Type 440	0.010 – 0.145 (0.25 – 3.68)	26 (660)

For other widths and thicknesses, inquire.

TABLE 3 – TYPE 410 FATIGUE STRENGTH*

Tempering Temperature, °F (°C)		Endurance Limit, ksi. (MPa) – 10^7 cycles
70	(21)	58.0 (400)
700	(371)	49.0 (338)
850	(454)	43.5 (296)
1000	(538)	27.0 (186)

**Heat treated to 110 ksi. (758 MPa) YS.*

TABLE 4 – TYPICAL MECHANICAL PROPERTIES

Alloy	Annealed				Heat Treated
	YS, (ksi.)	TS, (ksi.)	EL % in 2"	Hardness[1, 2], (HRB)	Hardness[3], (HRC)
Type 410	42	75	31	77	42
410HC	43	78	31	83	43
420 mod	47	81	30	82	51
420LC	48	84	29	82	53
Type 420	46	89	28	87	54
420HC	50	92	27	89	56
420 ULTRA HONE	57	100	25	93	57
440A	58	100	22	93	58

[1]#1 finish hardness, for #2B finish add 2 pts. RB +/-1 standard deviation.

[2] The annealed hardness will depend on thickness. Material with a thickness less than 0.030 in. (0.762 mm) will tend to have lower as-annealed hardness.

[3] The heat treated hardness are data from internal testing of hardenability to meet various industry specifications or for information. The heat treat parameters used do not necessarily achieve the highest harness achievable for the grade. Actual hardness achievable by the end user will depend on the heat treating process utilized.

Properties

CORROSION RESISTANCE

Heat-treated Type 410 provides good corrosion resistance to air, water and some mild chemicals. It shows satisfactory resistance to nitric acid, concentrated sulfuric acid, dilute acetic acid and naptha. Resistance to food acids is good. In the as-annealed condition this grade will exhibit poor corrosion performance and is not recommended.

Type 420 resists corrosion in both mild industrial and rural atmospheres, in addition to fresh water, some dilute organic acids, crude oil, gasoline, and other comparable corrosive media. Like Type 410, Type 420 should be used in the hardened or hardened and stress-relieved condition in order to maximize its corrosion resistance. In the as-annealed condition this grade will result in poor corrosion performance and is not recommended.

Type 440A provides good corrosion resistance in the hardened and stress-relieved condition. It is resistant to fresh water, steam, crude oil, gasoline, perspiration, alcohol and foodstuffs.

FORMABILITY

Martensitic stainless steels can be moderately cold formed with increasing difficulty as the carbon and chromium increases. These alloys should be in the as-annealed condition for maximum softness and ductility.

WELDABILITY

The martensitic class of stainless steels has limited weldability due to its hardenability. Special consideration is required to avoid cold cracking by preheating to 550 °F (260 °C). Post-weld heat treatment should be considered to achieve required properties. Alloys falling into the Type 420 and Type 440A families are generally considered to have poorer weldability than Type 410. The higher carbon contents of the Type 420 and Type 440A require both preheat and post-weld heat treatment. When a weld filler is needed, AWS E/ER 420, 410 NiMo and 309L are most often specified.

TABLE 5 – PHYSICAL PROPERTIES

	Type 410	Type 420	Type 440A
Density, lbs./in^3 (g/cm^3)	0.28 (7.74)	0.28 (7.74)	0.28 (7.74)
Electrical Resistivity, $\mu\Omega$•in. ($\mu\Omega$•cm) 70 °F (21 °C)	22.50 (57)	21.71 (55)	23.68 (60)
Thermal Conductivity, BTU/hr./ft./°F (W/m/K) 212 °F (100 °C) 932 °F (500 °C)	 14.4 (24.9) 16.6 (28.7)	 – 14.4 (24.9)	 – 14.0 (24.2)
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 x 10^{-6} (11.6)	 5.7 x 10^{-6} (10.2) 6.8 x 10^{-6} (12.1)	 – 5.6 x 10^{-6} (10.06)
Modulus of Elasticity in Tension, ksi. (MPa)	29 x 10^3 (200 x 10^3)	29 x 10^3 (200 x 10^3)	29 x 10^3 (200 x 10^3)
Specific Heat, BTU/lbs./°F (kJ/kg/K) 32 – 212 °F (0 – 100 °C)	 0.11 (0.46)	 0.11 (0.46)	 0.11 (0.46)

Heat Treatment

TABLE 6 – GENERAL HEAT TREATMENT GUIDELINES

	Type 410	Type 420	Type 440A
Annealing	Heat uniformly to 1500 – 1650 °F (816 – 900 °C), slow cool to 1100 °F (593 °C) in furnace, air cool.		
Process annealing	Heat to 1350 – 1450 °F (732 – 788 °C), air cool.		
Preheat (Optional)	Preheat is generally not necessary for Type 410 except where large or complicated sections are involved. Preheat Type 420 and Type 440A are preheated to 1450 °F (788 °C) prior to heating to the desired hardening temperature.		
Hardening	Heat to 1700 – 1850 °F (927 – 1010 °C), air cool or oil quench.	Preheat, then heat to 1800 – 1950 °F (982 – 1066 °C), soak at temperature and air cool or oil quench.	
Sub-zero treatment (Optional)	Not necessary	A subzero treatment of -100 °F (-73 °C) can be performed to obtain maximum hardness.	
Stress relieving	Heat at 300 – 800 °F (149 – 427 °C) for 1-2 hours, air cool.		
Tempering	Heat to 1100 – 1400 °F (593 – 760 °C) for 1-4 hours, air cool.	Not recommended	

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.

CLIFFS

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