

CHROMESHIELD® 22

STAINLESS STEEL



Appliances
Architectural
Cookware
Food Service Equipment
Tubing



CLEVELAND-CLIFFS CHROMESHIELD® 22 STAINLESS STEEL combines the exceptional corrosion performance of a high chromium ferritic alloy with the enhanced ductility of Cleveland-Cliffs' ULTRA FORM® technology. This product is dual stabilized with both titanium and niobium to improve weld corrosion performance. Small additions of copper and molybdenum further enhance corrosion resistance. CHROMESHIELD 22 Stainless Steel is more corrosion resistant than Type 430, Type 441 and even Type 304 in some environments. It is acceptable for the food contact zone of restaurant equipment under NSF International Standard 51. CHROMESHIELD 22 Stainless Steel meets the requirement for UNS S44330, but has a different stability requirement.

CHROMESHIELD® 22 STAINLESS STEEL

Product Description

CHROMESHIELD® 22 Stainless Steel is a high chromium ferritic stainless steel with small copper and molybdenum additions that further enhance the corrosion resistance. The grade is dual stabilized with both titanium and niobium (Ti + Nb) to improve weld corrosion performance.

CHROMESHIELD 22 Stainless Steel is more corrosion resistant than Type 430, Type 441 and even Type 304 in some environments.

Composition		(wt %)
Carbon	(C)	0.02 max.
Manganese	(Mn)	1.00 max.
Phosphorus	(P)	0.03 max.
Sulfur	(S)	0.01 max.
Silicon	(Si)	1.00 max.
Chromium	(Cr)	21.0 – 22.5
Nickel	(Ni)	0.40 max.
Molybdenum	(Mo)	0.30 – 0.50
Copper	(Cu)	0.45 – 0.75
Titanium + Niobium	(Ti + Nb)	0.20 + 4(C+N) min.

AVAILABLE FORMS

CHROMESHIELD 22 is available in most gauges, in widths up to and including 48 in. and in 2D, 2B, and directional polished finishes.

TABLE 1 – TYPICAL ROOM TEMPERATURE MECHANICAL PROPERTIES

UTS, ksi. (MPa)	0.2% YS, ksi. (MPa)	Elongation % in 2 in. (50.8 mm)	Rockwell Hardness
76 (524)	56 (386)	31	B84

TABLE 2 – FORMABILITY

Plastic Strain Ratio*			Ridge Rating**	Olson Cup Height in. (mm)
r_m	Δr_1	Δr_2		
1.50	0.32	0.86	1.5	0.438 (11.2)

* $\Delta r_1 = (r_0 + r_0^2 - 2r_{45})/2$; $\Delta r_2 = r_{max} - r_{min}$.
 **Rating scale of 1 – 5 with 5 the heaviest.

MICROSTRUCTURE

CHROMESHIELD 22 Stainless Steel features a uniform equiaxed grain structure that enhances material formability.



Typical microstructure at 100X original magnification as etched with Vilella's etchant.

CHROMESHIELD® 22 STAINLESS STEEL

Physical Properties

TABLE 3 – SPECIFIC HEAT AND THERMAL CONDUCTIVITY

Temperature, °F (°C)	Specific Heat, J/g/K	Thermal Conductivity	
		W/m/K	(BTU/hr./°F)
23 (73.4)	0.461	15.7	9.1
50 (122)	0.471	16.1	9.3
100 (212)	0.490	17.0	9.8
200 (392)	0.532	18.6	10.8
300 (572)	0.577	20.1	11.6
400 (752)	0.627	21.4	12.4
500 (932)	0.692	22.6	13.1
600 (1112)	0.918	23.8	13.8
700 (1292)	0.762	13.7	7.9
800 (1472)	0.684	14.9	8.6
900 (1652)	0.659	16.6	9.6
1000 (1832)	0.658	18.2	10.5

FIGURE 1 – MEAN COEFFICIENT OF THERMAL EXPANSION

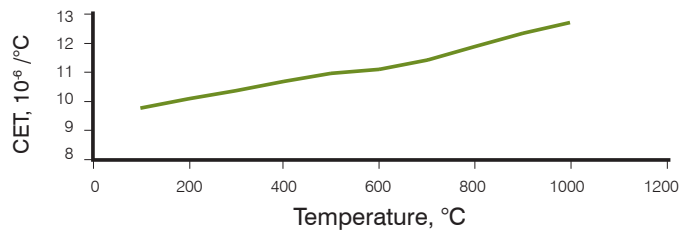


TABLE 4 – THERMAL RESISTIVITY

Temperature, °F (°C)	Heating, μm•cm	Cooling, μm•cm
23 (73.4)	66.9	65.7
50 (122)	69.2	67.7
100 (212)	73.6	71.9
200 (392)	81.9	80.1
300 (572)	89.2	87.9
400 (752)	95.8	95.1
500 (932)	102.4	102.3
600 (1112)	109.4	110.2
700 (1292)	114.7	115.1
800 (1472)	117.6	117.8
900 (1652)	119.7	119.8
1000 (1832)	121.5	121.5

CHROMESHIELD® 22 STAINLESS STEEL

Mechanical Properties

HIGH TEMPERATURE CREEP RESISTANCE

Sag resistance testing is a simple, common measure of a materials' resistance to creep. In testing, the sag resistance of CHROMESHIELD 22 Stainless Steel was found to be superior to Type 439 and equivalent to Type 444.

TABLE 5 – DEFLECTION AFTER 100 HOUR TEST DURATION 1600° F (871° C) TEST TEMPERATURE

Alloy	Deflection* in. x 10 ⁻³ (mm)
CHROMESHIELD 22 SS	101 (2.57)
Type 439	241 (6.12)
Type 444	100 (2.54)
18 Cr-Cb™ SS	89 (2.26)

*Average of triplicate tests.

TABLE 6 – CHARPY V-NOTCH IMPACT TOUGHNESS

Temperature, °F (°C)	Hot Rolled,* in. •lbs./in. ² (J/cm ²)	Cold Rolled & Annealed,** in. •lbs./in. ² (J/cm ²)	Welded** (Autogenous GTAW), in. •lbs./in. ² (J/cm ²)
72 (22)	4151 (72.69)	8378 (146.7)	11781 (206.3)
32 (0)	4655 (81.52)	8317 (145.6)	12036 (210.7)
0 (-17)	2385 (41.76)	7975 (139.6)	8993 (157.5)
-20 (-28)	2308 (40.41)	—	—
-30 (-34)	—	6868 (120.2)	6568 (115.0)
-40 (-40)	1480 (25.91)	—	—
-60 (-51)	—	7057 (123.5)	507 (8.87)

*Gauge = 0.180 in. (4.57 mm) **Gauge = 0.075 in. (1.91 mm)

FIGURE 2 – EFFECT OF COLD REDUCTION ON MECHANICAL PROPERTIES

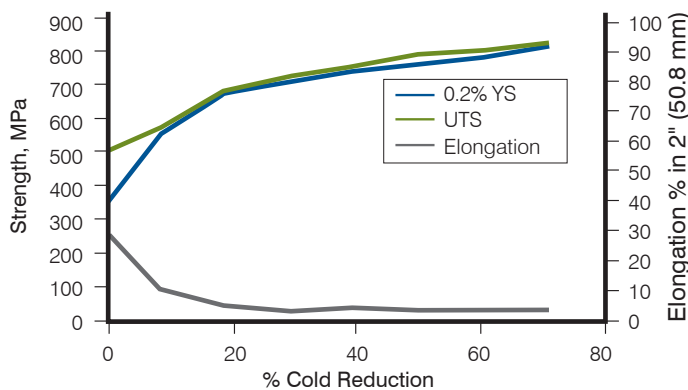
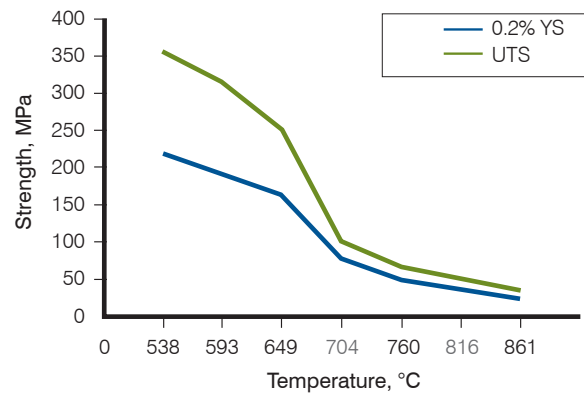


FIGURE 3 – TYPICAL ELEVATED TEMPERATURE STRENGTH PROPERTIES



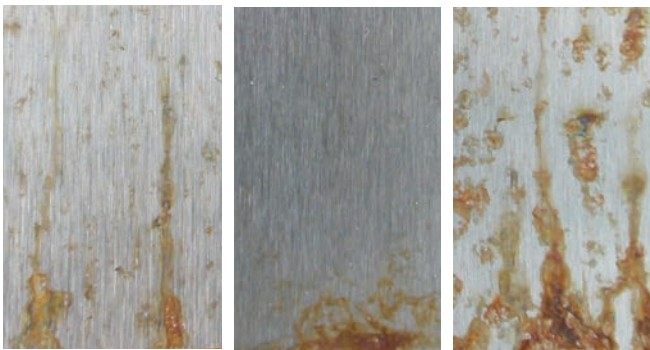
CHROMESHIELD® 22 STAINLESS STEEL

Corrosion Resistance

Cleveland-Cliffs CHROMESHIELD® 22 Stainless Steel exhibits superior chloride pitting resistance when compared to Type 430 and Type 441 stainless steels. The nickel-free 22% chromium (Cr) plus copper, low molybdenum alloy has an overall chloride resistance that is the same, if not better, than that shown by Type 304 stainless steel. The dual stabilized ferritic shows excellent intergranular corrosion resistance when welded and is not prone to the chloride stress corrosion cracking that austenitic grades tend to suffer. CHROMESHIELD 22 Stainless Steel resists staining from common food products and has comparable resistance to various cleaners and bleaching agents as Type 304.

CCT 1 CORROSION TEST

Cyclic corrosion testing per CCT 1 test procedure after 50 cycles of exposure.



Type 304

CHROMESHIELD
22 SS

Type 430

CCT 1 CYCLE CORROSION TEST

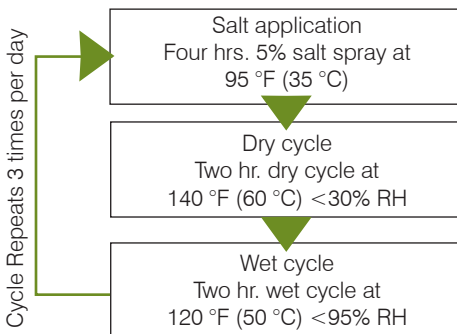
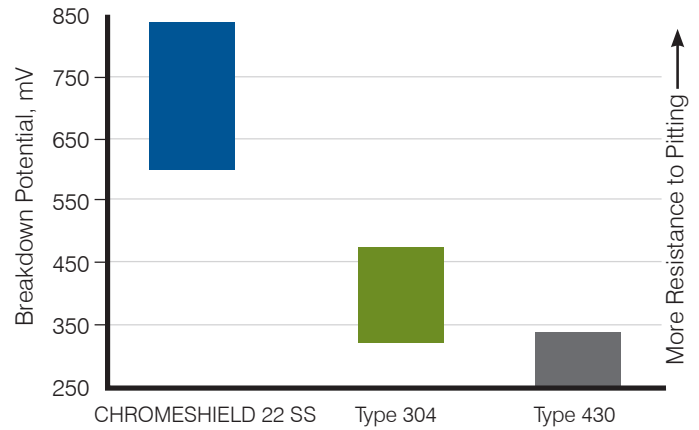


FIGURE 4 – CHLORIDE PITTING RESISTANCE

Electrochemical Breakdown Potential in 3.5% sodium chloride solution at room temperature



CHROMESHIELD® 22 STAINLESS STEEL

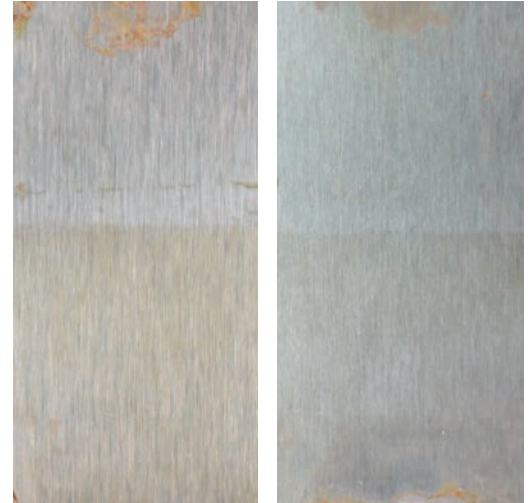
Corrosion Resistance

TABLE 7 – STAINING RESISTANCE

Product	Type 430	Type 304	CHROMESHIELD 22 SS
Ketchup	U*	U	No Attack
Mustard	P	P	No Attack
Hot Sauce	P	P	No Attack
Lemon Juice	U	P	No Attack
Tomato Sauce	U	U	U
Horseradish Sauce	P	P	P

*U – Uniform Attack, P – Pitting Attack

Partial immersion for 120 hr. in household bleach at 50 °C



Type 304

CHROMESHIELD 22 SS

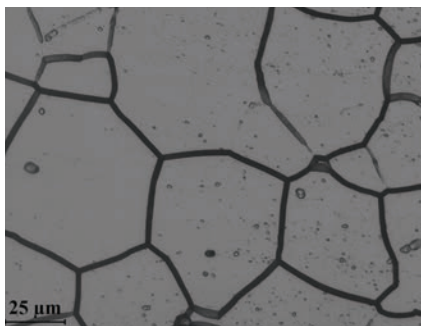
TABLE 8 – CHLORIDE STRESS CORROSION CRACKING RESISTANCE

ASTM G123 Boiling 25% Acidified Sodium Chloride	
Material	Time to Failure
Type 304	336 hrs.
CHROMESHIELD 22 SS	Passed 1000 hrs. with no cracking

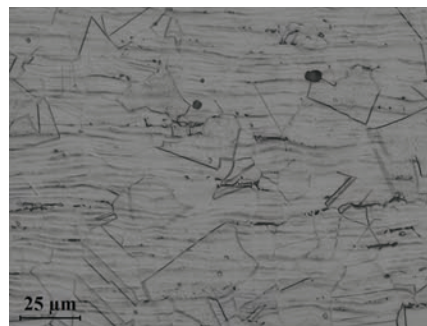
TABLE 9 – INTERGRANULAR CORROSION TEST OF WELDS

ASTM A262/A763		
Material	Copper-Copper Sulfate	Oxalic Etch
Type 430	Fail	Fail – Ditch
Type 304	Pass*	Pass* – Step
CHROMESHIELD 22 SS	Pass*	Pass – Step

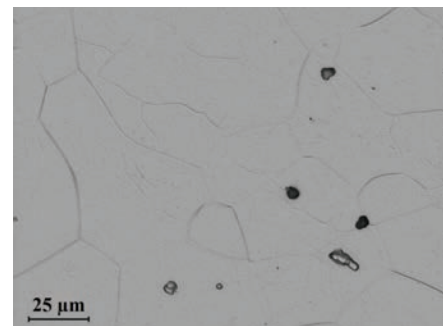
*Low carbon variety only.



Type 430



Type 304



CHROMESHIELD 22 SS

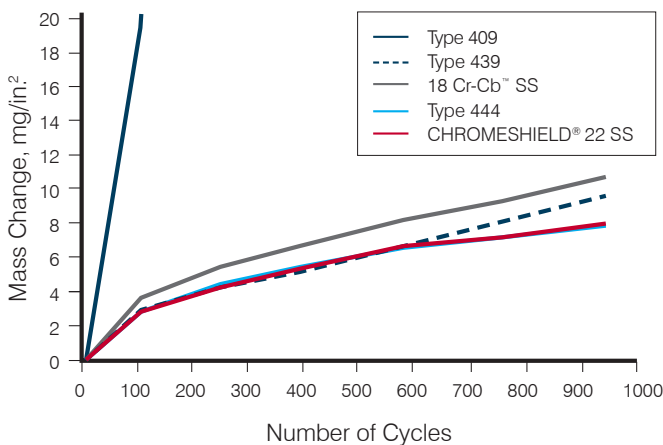
500X photomicrographs after Oxalic Acid screening following ASTM A262/A763

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Oxidation Resistance

CHROMESHIELD 22 has improved resistance to cyclic oxidation than 17 – 18% chromium bearing alloys, and superior performance when compared to Type 409. At 1650° F (899° C), this 22% chromium, low molybdenum ferritic alloy shows to have cyclic oxidation resistance comparable to the 2% molybdenum bearing Type 444.

FIGURE 5 – CYCLE OXIDATION AT 1650° F (900° C)



WELDABILITY

Testing has shown that the CHROMESHIELD 22 Stainless Steel product is readily weldable by the Gas Tungsten Arc Weld (GTAW), Laser Beam Welding (LBW) and Resistance Spot Welding (RSW) processes. Special consideration is required to avoid brittle fractures in the weld zone during fabrication. Maintaining low weld heat input, minimizing discontinuities and occasionally warming the part somewhat before forming may be helpful. This particular alloy is generally considered to have somewhat poor weldability when compared to the most common alloy of the stainless class, Type 409. When a weld filler is required, AWS ER308L or ER2209 may be considered.

UTS, ksi. (MPa)	0.2% YS, ksi. (MPa)	Elongation % in 2 in. (50.8 mm)	Olsen Cup Height, in. (mm)	Minimum 180° Bend Radius
75 (517)	53 (379)	24	0.44 (11.2)	0T

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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