

RELEASED: MARCH 1971  
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FERROUS ALLOYS

1. GENERAL  
 This is an austenitic, sulfur-containing, free-machining chromium-nickel-manganese-copper stainless steel, which was developed as an alternate material for Type 303 applications. It is a low nickel substitute for Type 303 and 303Se with equivalent mechanical and physical properties and comparable corrosion resistance, but with superior machining characteristics. This alloy is available as hot rolled and cold finished bars, rod, and wire; extruded hollow bars; billets; and forgings. It is non-magnetic in the annealed condition.

1.01 Commercial Designation  
 203 EZ

1.02 Alternate Designations  
 XM-1

1.03 Specifications  
 Table 1.03.

TABLE 1.03

AMS	Form	Military	Federal	ASTM
-	Wire, annealed or cold worked	MIL-W-52263B(MR)	QQ-S-764a	A581-67
-	Wire, cold finished			
-	Bar, annealed or cold worked			
-	Bar, hot finished or cold finished			A582-67

1.04 Composition  
 Table 1.04.

TABLE 1.04

Source	Military(1), Federal(2), ASTM (3, 4)		(5)	
	Percent		Percent	
	Minimum	Maximum	Minimum	Maximum
Carbon	-	.08	-	.08
Manganese	5.00	6.50	5.50	6.50
Silicon	-	1.00	-	1.00
Phosphorus	-	.04	-	.04
Sulfur	.15	.35	.15	-
Chromium	16.00	18.00	16.00	17.00
Nickel	5.00	6.50	5.00	6.00
Molybdenum	-	.50	-	-
Copper	1.75	2.25	1.75	2.15
Iron	Balance		Balance	

1.05 Heat Treatment  
 1.051 Anneal at 1900-2050F followed by water quenching to obtain maximum corrosion resistance and ductility(6).  
 1.06 Hardness  
 Alloy can be hardened only by cold work which increases both the strength and hardness. A typical annealed hardness range of 81-98 Rockwell B can be increased by cold drawing to 24-45 Rockwell C (6).

1.07 Forms and Conditions Available  
 1.071 The steel is available in a wide commercial range of sizes for bars, rod, wire, billets, forgings, and extruded hollows (6).  
 1.072 All wrought products are available in the annealed condition. Smaller size bars, rod, and wire are also available cold drawn to various strength and hardness levels (5).

1.08 Melting and Casting Practice  
 Electric furnace air melt.

1.09 Special Considerations  
 1.091 Alloy must be annealed after hot working. Annealing should be followed by rapid cooling to prevent harmful carbide precipitation, and thereby obtain maximum corrosion resistance. For the same reason, heating within the 800-1600F range should be avoided unless the material can be subsequently annealed.

1.092 Because the free machining austenitic grades have a slightly reduced corrosion resistance in comparison with the non sulfur-bearing types of stainless steel, bright machined parts may be susceptible to surface dulling or etching by final treatment with nitric acid solutions. Several alternate solutions with milder pickling actions are recommended (5).

2. PHYSICAL AND CHEMICAL PROPERTIES

2.01 Thermal Properties  
 2.011 Melting range. 2550-2630F (7).  
 2.012 Phase changes.  
 2.0121 The steel is subject to carbide precipitation at 800 to 1600F.  
 2.0122 Cold work may transform a small amount of austenite to ferrite (martensite).  
 2.013 Thermal conductivity. 212F, 9.5 Btu ft per (hr sq ft F) (5).  
 2.014 Thermal expansion, Figure 2.014.  
 2.015 Specific heat.  
 2.016 Thermal diffusivity.  
 2.02 Other Physical Properties  
 2.021 Density. 0.284 lb per cu in, 7.87 gr per cu cm (6).  
 2.022 Electrical properties, resistivity, Figure 2.022.  
 2.023 Magnetic properties. This steel is non-magnetic in the annealed condition. Permeability of annealed material is less than 1.02 (5, p. 3). It becomes slightly magnetic when severely cold worked.  
 2.024 Emissance.  
 2.025 Damping capacity.

2.03 Chemical Properties  
 2.031 Corrosion resistance.  
 2.0311 The corrosion resistance of austenitic, free-machining stainless steels, in general, has been sacrificed somewhat in order to enhance machinability. They are comparable to Type 302 in many of the milder corrodants, and are satisfactory for atmosphere service, for most foodstuffs, and for most organic chemicals. However, the sulfur-containing grades are inferior to their non free-machining counterparts in severe corrodants, such as reducing acids and chlorides (8, p. 53)(9, p. 116). The corrosion resistance of 203 EZ is equivalent to that of Type 303 (10, p. 3)(5, p. 2).  
 2.032 This steel, like Type 303, is susceptible to stress cracking if cold worked.  
 2.033 203 EZ has good resistance to oxidation at temperatures up to 1700F. In extreme oxidizing atmospheres, irregular scaling may be encountered, particularly above 1400F (5, p. 2).

2.04 Nuclear Properties

3. MECHANICAL PROPERTIES

3.01 Specified Mechanical Properties  
 3.011 Mechanical properties as specified by military and ASTM specifications, Table 3.011.

TABLE 3.011

Source	Military (1)		ASTM (3)		ASTM(4)
	Wire		Wire		Bar
Condition	Ann	CD	Ann	CD	Ann
Thickness - in	-	-	-	< .500	≥ .250
F <sub>u</sub> , min - ksi	-	-	85	115	-
max - ksi	115	130	125	145	-
Hardness					
BHN - min	-	-	-	-	-
- max	-	-	-	-	262

	Fe
17	Cr
6	Ni
6	Mn
2	Cu
+	S

203 EZ

17	Cr
6	Ni
6	Mn
2	Cu
+	S

203 EZ

3.02 Mechanical Properties at Room Temperature  
 3.021 Typical and minimum properties for bars, Table 3.021.

TABLE 3.021

Source	(11)(6)		(5)				(6)
	Annealed		CD				CD
Condition							Full Hard
Diameter - inches	3	1	≥ 3.00	≅ 1.50 to 3.00	≅ 1.25 to 1.50	≅ 1.00 to 1.25	≅ .75 to 1.00
F <sub>tu</sub> , typical - ksi	80	87	-	-	-	-	130-210
minimum - ksi	-	-	80	95	100	105	115
F <sub>ty</sub> , typical - ksi	37	45	-	-	-	-	100-185
minimum - ksi	-	-	35	45	50	65	80
e(2 in), typical - percent	60	53	-	-	-	-	10-25
minimum - percent	-	-	28	28	28	20	15
RA, typical - percent	65	63	-	-	-	-	40-55
minimum - percent	-	-	45	45	45	35	35
Hardness - typical							
BHN	141-158	158-171	-	-	-	-	248-430
Rockwell B	77-83	84-87	-	-	-	-	-
Rockwell C	-	-	-	-	-	-	24-45
Impact strength - typical							
Izod ft-lb	-	85	-	-	-	-	-

3.03 Mechanical Properties at Various Temperatures  
 3.031 Effect of test temperature on tensile properties, Figure 3.031.  
 3.0311 Stress-strain diagrams, Figure 3.0311.  
 3.033 Effect of test temperature on impact properties, Table 3.033.

4.02 Machining and Grinding  
 4.021 The machinability of 203 EZ is superior to that of Type 303, and it can be machined at higher speeds with equal or better tool life(5)it is recommended that speeds be increased on the order of 20-50 percent over those used for Type 303, approaching the speeds used for Type 416, while maintaining the same feed. An improvement in surface finish is also obtained at the higher cutting speeds (5, pp. 1, 5, 6)(12, p. 3). As with other austenitic steels, very sharp tools, low feeds, deep cuts and heavy equipment are required. Machining speeds between 75 and 85 percent of those used for mild carbon steels are suitable.(14).

TABLE 3.033

Source	(11)							
	Bar							
Condition	Annealed							
Diameter - in	1				3			
Test Temp - F	-100	-65	RT	212	-100	-65	RT	212
Impact strength, Charpy V-notch ft-lb								
long - avg	(207)	(197)	(184)	(198)	67	65	75	75
trans - avg	-	-	-	-	14	13	16	15

( ) Tests indicated by parentheses did not fracture completely through. Other tests showed normal fractures.

4.03 Welding  
 4.031 Welding of these steels is not generally recommended. Fusion welding with Type 310 electrodes is possible to a very limited extent, and post weld annealing is necessary  
 4.032 203 EZ can be successfully brazed using proprietary techniques. (14)

4.04 Surface Treatment  
 4.041 Machined parts should be thoroughly cleaned prior to service. Passivation is recommended for certain applications in which case precautions may have to be taken as given under 1.092 Special Considerations.

3.04 Creep and Creep Rupture Properties  
 3.05 Fatigue Properties  
 3.051 Fatigue strength in annealed condition is approximately 50 percent of tensile strength (5, p. 4).  
 3.06 Elastic Properties  
 3.062 Modulus of elasticity in tension, 29.0 x 10<sup>3</sup> ksi (5, p. 4).

4. FABRICATION

4.01 Formability  
 4.011 Forging. Normal practice consists of preheating at 1500-1600F then raising the temperature rapidly to within the range of 2050-2300F. The finishing temperature should be maintained above 1700F. After forging, annealing at 1900-2050F followed by rapid cooling is recommended (6).  
 4.012 Cold forming is possible to a limited extent and 203 EZ behaves similarly to Type 303 in operations such as upsetting, coining, staking, etc. (12). Material with sulfur on the low side of the chemistry range (.18-.25) exhibits better cold formability and is equivalent to that of Type 303Se (14). The 203 EZ material should be annealed after severe forming to prevent stress cracking

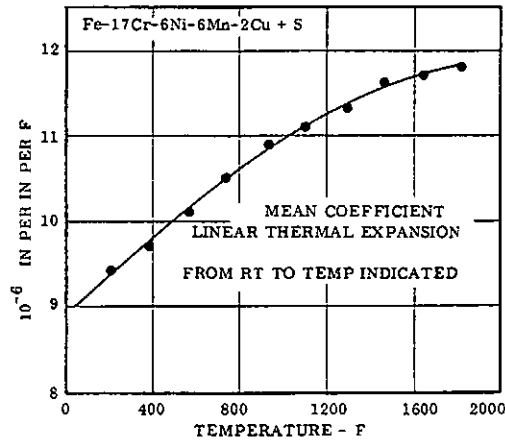


FIG. 2.014 THERMAL EXPANSION. (6, p. 5)

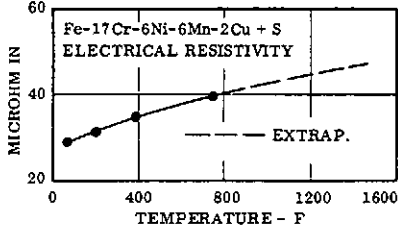


FIG. 2.022 ELECTRICAL RESISTIVITY.. (5, p. 3)

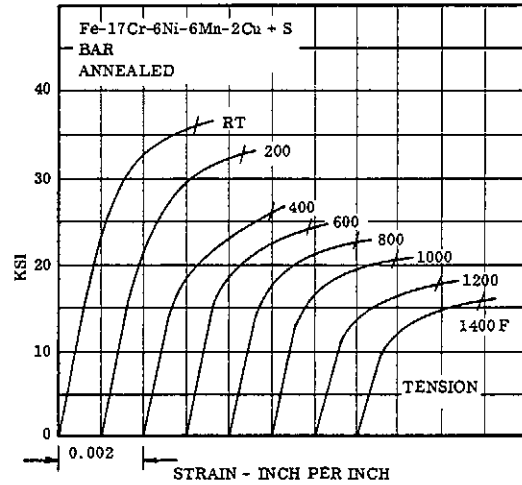


FIG. 3.0311 STRESS-STRAIN CURVES AT ROOM AND ELEVATED TEMPERATURES FOR BAR. (13)

Fe
17 Cr
6 Ni
6 Mn
2 Cu
+ S

203 EZ

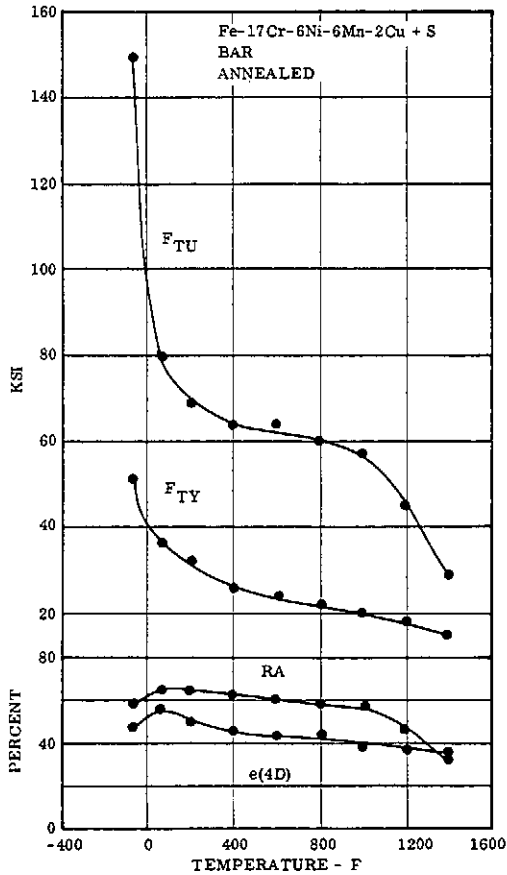


FIG. 3.031 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES. (5, p. 4)(11)(13)

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