

REVISED: MARCH 1963

FERROUS ALLOYS

- 1. **GENERAL**  
HNM is a precipitation hardening austenitic steel, specifically developed for high stress rupture and creep properties in the range of 1000 to 1400 F and is not prone to over-aging in this temperature range. It has very low magnetic permeability, and is normally supplied in the solution treated condition, to a hardness of Brinell 201 maximum. Typical applications include, transformer parts, nonmagnetic balls, aircraft structural and engine components, shafts and gears, (1, p.1, 2).
- 1.01 **Commercial Designation.** Crucible HNM.
- 1.02 **Alternate Designation.** None.
- 1.03 **Specifications.** MIL-S-17759-D (ships).
- 1.04 **Composition.** Table 1.04.

TABLE 1.04

Source	Crucible (1, p.1)	
	Percent Nominal	
Carbon	0.30	
Chromium	18.5	
Manganese	3.5	
Nickel	9.5	
Phosphorus	0.25	
Silicon	0.50	
Sulfur	0.025	
Iron	Balance	

- 1.05 **Heat Treatment**
- 1.051 **Anneal.** 2000 to 2150 F, 30 min, water quench. Sections < 5/8 in thick may be air cooled. The optimum solution treatment for best properties after aging is approximately 2050 F. (1, p.1).
- 1.052 **A<sub>2</sub>e.** 1300 F, 16 hr, air cool.
- 1.06 **Hardenability**
- 1.061 The alloy is hardenable by precipitation treatment, see 1.052, (1, p.2).
- 1.07 **Forms and Conditions Available**
- 1.071 The alloy is available in the form of bar, sheet and strip in the solution treated condition (BHN 201 maximum), (1, p.1).
- 1.08 **Melting and Casting Practice**
- 1.09 **Special Considerations**
- 2. **PHYSICAL AND CHEMICAL PROPERTIES**
- 2.01 **Thermal Properties**
- 2.011 Melting range
- 2.012 Phase changes. None.
- 2.013 Thermal conductivity
- 2.014 Thermal expansion, Fig. 2.014.
- 2.015 Specific heat
- 2.02 **Other Physical Properties**
- 2.021 Density. 0.284 lb per cu in. 7.85 gr per cu cm.
- 2.022 Electrical resistivity, Fig. 2.022. (1, p.1).
- 2.023 Magnetic properties
- 2.0231 Magnetic permeability, Table 2.0231.

TABLE 2.0231

Source	(1, p.3)	
	Fe-(0.3C)-18.5Cr-9.5Ni-3.5Mn	
Alloy	ST + age	
Condition	ST + age	
Induction, oersteds	H = 290	H = 500
Maximum permeability	1.003	1.003

- 2.03 **Chemical Properties**
- 2.031 **Corrosion resistance.** This alloy satisfactorily resists rusting and pitting under normal atmospheric conditions. It is, however, inferior to the regular 18Cr-8Ni stainless steel types, but superior to the straight chromium stainless steel types, (1, p.3).
- 2.032 Oxidation resistance. See 2.031.
- 2.04 **Nuclear Properties**
- 3. **MECHANICAL PROPERTIES**
- 3.01 **Specified Mechanical Properties**
- 3.02 **Mechanical Properties at Room Temperature.** See 1.05.
- 3.021 **Producer's typical mechanical properties for bar and sheet.** Table 3.021.

	Fe
0.3	C
18.5	Cr
9.5	Ni
3.5	Mn

HNM

TABLE 3.021

Source	(1, p.4)			
	Fe-(0.3C)-18.5Cr-9.5Ni-3.5Mn			
Alloy	Bar		Sheet	
Form	Bar		Sheet	
Condition	ST 2050 F, 30 MIN OQ	ST 2050 F, WQ + age 1300 F, 16 hr	ST 2050 F, 15 MIN AC	ST 2050 F, AC + age 1300 F, 16 hr
F <sub>tu</sub> ' - ksi	116	145	106	133.5
F <sub>ty</sub> ' - ksi	56	92	55	90.4
e (2 in)- percent	57.5	23	48	11
RA. - percent	60	38	-	-
Hardness,				
BHN	192	302	-	-
RB	-	-	87.5	-
RC	-	-	-	33

- 3.022 Effect of solution temperature on room temperature tensile properties of aged alloy, Fig. 3.022.
- 3.023 Effect of solution temperature on room temperature impact properties of aged alloy, Fig. 3.023.
- 3.024 Effect of aging temperature and time on room temperature tensile properties, Fig. 3.024.
- 3.03 **Mechanical Properties at Various Temperatures**
- 3.031 Short time tension properties
- 3.0311 Effect of test temperature on tensile properties, Fig. 3.0311.
- 3.032 Short time properties other than tension
- 3.0321 Effect of low and elevated temperatures on impact strength, Fig. 3.0321.
- 3.033 Static stress concentration effects
- 3.04 **Creep and Creep Rupture Properties**
- 3.041 Creep rupture curves at 1000 to 1500 F, Fig. 3.041.
- 3.042 Isochronous stress strain curves at 900 and 1200 F for sheet, Fig. 3.042.
- 3.05 **Fatigue Properties**
- 3.051 S-N curves for bar, Fig. 3.051.
- 3.05 **Elastic Properties**
- 3.061 Modulus of elasticity at room temperature.  $29 \times 10^3$  ksi, (1, p.3).
- 3.062 Modulus of rigidity at room temperature.  $12.3 \times 10^3$  ksi, (1, p.5).
- 4. **FABRICATION**
- 4.01 **Forming and Casting**
- 4.011 Forging. Starting temperature 1850 to 1950 F, finishing temperature 1700 F, minimum, (1, p.1).
- 4.012 Since the alloy is very susceptible to work hardening re-solution treatment should precede and follow each drastic forming operation, (1, p.1).
- 4.02 **Machining**
- 4.021 Similar to the 18-8 types of austenitic steel requiring, heavy positive feed, rigid equipment and sharp tools, (1, p.2).

Fe	4.03
0.3 C	4.031
18.5 Cr	
9.5 Ni	4.032
3.5 Mn	

HNM

- 4.03 Welding  
 General. The alloy is difficult to weld and is not recommended where welding is required. Heats with lower phosphorus content are slightly more weldable and the use of ferritic weld metal reduces the extent of weld cracking, (1, p.2).  
 Brazing. HNM can be successfully brazed by oxyacetylene torch and furnace methods using an alloy conforming to AMS-Specification 4775. Furnace brazing and solution treating can be performed simultaneously at 2150 F, 30 min in argon gas. The tensile strength of the brazed joint is 74 ksi at 1300 F, (1, p.3).
- 4.04 Heating and Heat Treating
- 4.05 Surface Treating

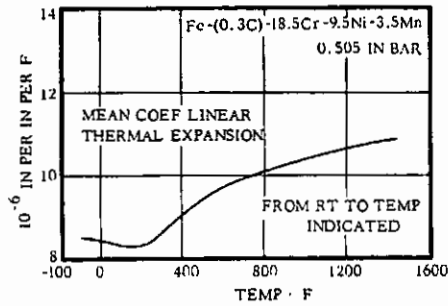


FIG. 2.014 THERMAL EXPANSION (1, p.3)

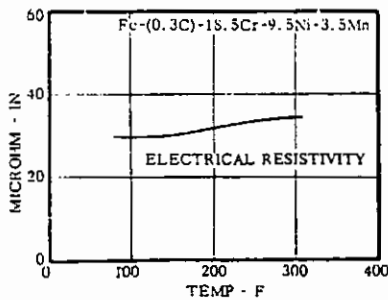


FIG. 2.022 ELECTRICAL RESISTIVITY (1, p.3)

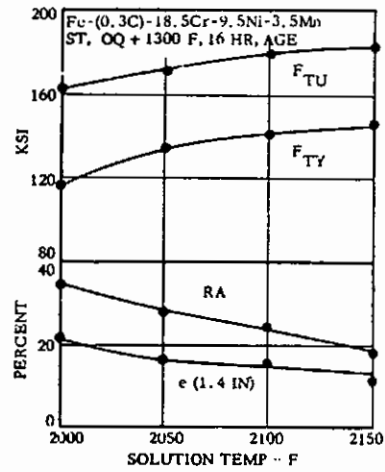


FIG. 3.022 EFFECT OF SOLUTION TEMPERATURE ON ROOM TEMPERATURE TENSILE PROPERTIES OF AGED ALLOY (2, p.3)

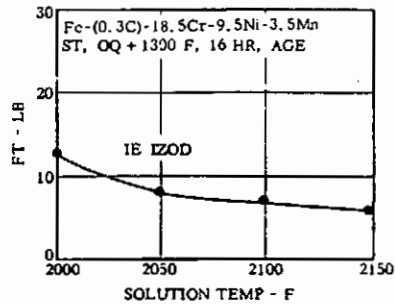


FIG. 3.023 EFFECT OF SOLUTION TEMPERATURE ON ROOM TEMPERATURE IMPACT PROPERTIES OF AGED ALLOY (2, p.3)

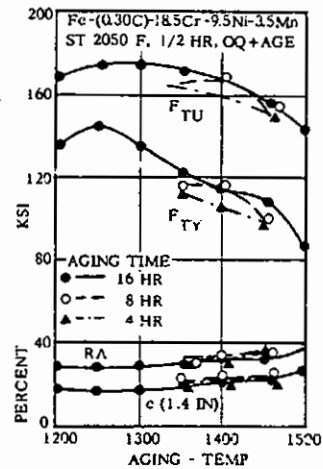


FIG. 3.024 EFFECT OF AGING TEMPERATURE AND TIME ON ROOM TEMPERATURE TENSILE PROPERTIES (2, p.4)

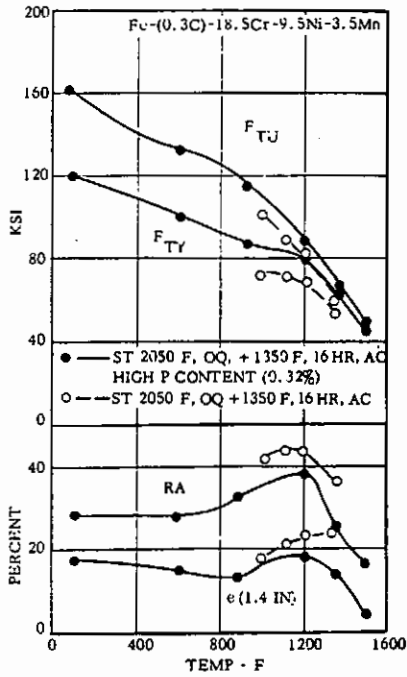


FIG. 3.0311 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES (1, p. 5, 6)

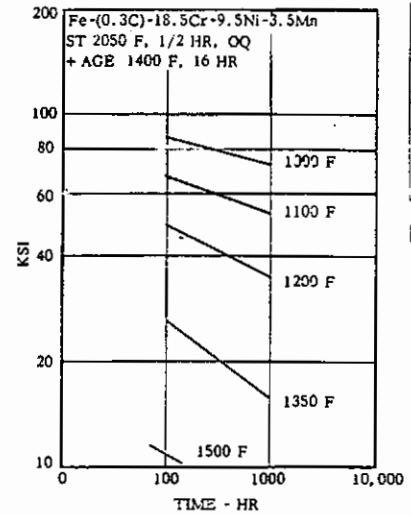


FIG. 3.041 CREEP RUPTURE CURVES AT 1000 TO 1500 F (1, p. 6)

Fe
0.3 C
18.5 Cr
9.5 Ni
3.5 Mn

HNM

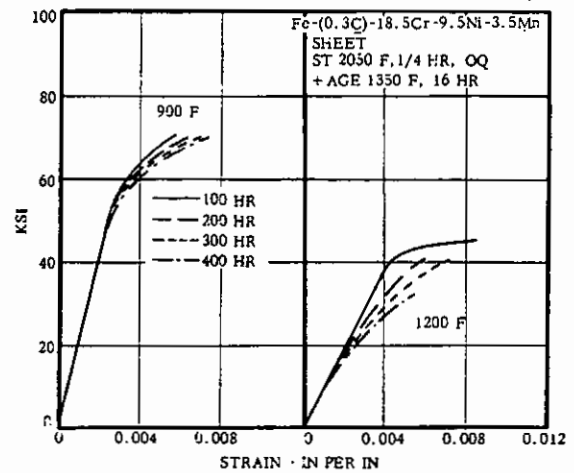


FIG. 3.042 ISOCHRONOUS STRESS STRAIN CURVES AT 900 AND 1200 F FOR SHEET (1, Fig. 3, 4)

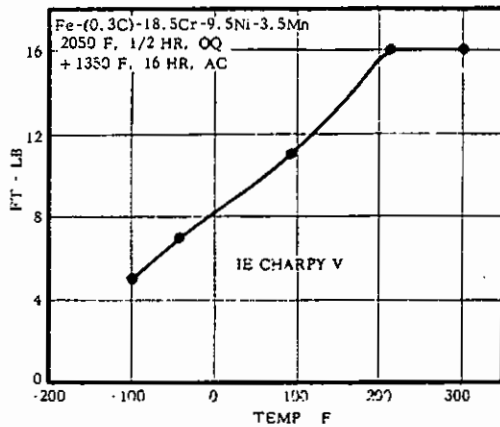


FIG. 3.0321 EFFECT OF LOW AND ELEVATED TEMPERATURES ON IMPACT STRENGTH (2, p. 5)

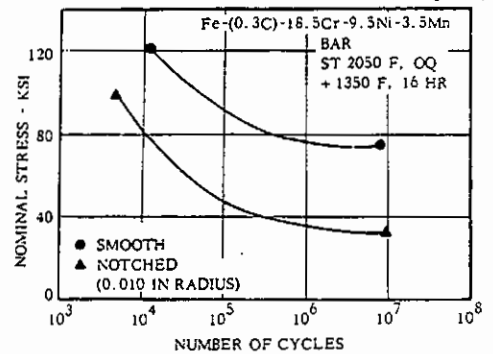


FIG. 3.051 S-N CURVES FOR BAR (1, Fig. 2)

REFERENCES

- 1 "Crucible HNM", Preliminary Data Sheet, Crucible Steel Co., Issue # 2, (June 1960)
- 2 "Crucible HNM (Hardenable Non-Magnetic Steel)", Tentative Data Sheet, Crucible Steel Co., (Aug. 31, 1954)

