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FERROUS ALLOYS

1. GENERAL  
 This alloy is a semi-austenite precipitation-hardening stainless steel. It is a modified 17-7PH alloy in which 2 to 3 percent molybdenum is substituted for an equivalent percentage of chromium, thus higher strengths can be obtained both at room and elevated temperatures in the various heat treated conditions (16). The alloy can be considered for utilization at temperatures up to 1000F. PH 15-7Mo is essentially austenitic at room temperature in the annealed or solution-treated condition, but can be transformed to martensite by a series of thermal treatments or by cold working. The alloy can then be further hardened by thermal treatment to strengths in excess of 200 ksi at room temperature (9). The alloy is available in sheet, strip, plate, bar and wire form. It can be formed readily in the annealed condition and is easily welded by various methods. Its heat treatment is identical with that of 17-7PH and much of the information available for the latter alloy also applies to PH 15-7Mo (9).

1.05 Heat Treatment  
 1.051 Solution treat to Condition A.  
 1.0511 Sheet and strip. 1925 to 1975F, 3 minutes per 0.1 inch thickness, air cool (1)(9).  
 1.0512 Bar and forging. 1925 to 1975F, water quench (2)(5)(7); 1875 to 1925, water quench (6).  
 1.052 Age condition A to Condition TH 1050. 1375 to 1425F, 1 1/2 hr (austenite conditioning), air cool to 50 to 60F within 1 hr, hold at 50 to 60F, 1/2 hr (Condition T) + 1040 to 1060F, 1 1/2 hr, air cool (1)(2)(5)(6)(7).  
 1.053 Age Condition A to Condition RH 950. 1735 to 1765F, 10 minutes (austenite conditioning), air cool (Condition A 1750) + -90 to -110F, 8 hr (Condition R-100) + 940 to 960F, 1 hr, air cool (2)(5)(6)(7).  
 1.054 Age Condition C of sheet (cold rolled) or wire (cold drawn) to Condition CH 900. 890 to 910F, 1 hr, air cool (7)(9).  
 1.055 TH and RH conditions are also used with different final age hardening temperatures, e.g., TH 1150, RH 1050, etc. Effect of aging temperature on tensile properties of sheet in various RH conditions, Figures 1.055 and 1.0551.

	Fe
15	Cr
7	Ni
2.5	Mo

PH15-7Mo

1.01 Commercial Designation  
 PH 15-7Mo

1.02 Alternate Designation  
 AISI No. 632

1.03 Specifications  
 Table 1.03

AMS	ASTM	Form	Military
5520A	-	Sheet, Strip, Plate	MIL-A-8955 (ASG)
5657	A461, A564	Bars and Forgings	-
5812B	-	Welding Wire	-
5813A	-	Welding Wire	-

1.04 Composition

1.041 Specification composition, Table 1.041.

Source	AMS (1)(2)		AMS (3)(4)	
	ASTM (5)(6)		MIL (7)	
	MIL (7)		(b)	
Element	Percent		Percent	
	Min	Max	Min	Max
Aluminum	0.75	1.50	0.75	1.25
Carbon	-	0.09	-	0.09
Chromium	14.00	16.00	14.00	15.25
Manganese	-	1.00	-	1.00
Molybdenum	2.00	3.00	2.00	2.75
Nickel	6.50	7.75	6.50	7.75
Phosphorus	-	0.04	-	0.025(c)
Silicon	-	1.00	-	0.50
Sulfur	-	0.03(a)	-	0.025
Iron	Balance		Balance	

(a) 0.040 for ASTM A461(5) and MIL-S-8955 (ASG)(7)  
 (b) Maximum 50 ppm oxygen and 25 ppm hydrogen for AMS 5812B (3)  
 (c) 0.010 for AMS 5812B (3)

1.042 Typical producer composition, Table 1.042.

Source	(8, p. 571)
Alloy	Fe-15Cr-7Ni-2.5Mo
Element	Composition
Aluminum	1.26
Carbon	.07
Chromium	15.05
Manganese	.69
Molybdenum	2.30
Nickel	7.16
Phosphorus	.019
Silicon	.20
Sulfur	.017
Iron	Balance

1.06 Hardness  
 1.061 Typical hardness of sheet for various conditions, Table 1.061.

Source	(9, p. 2, 14)	(11, p. 66)
Alloy	(a)	
Condition	Fe-15Cr-7Ni-2.5Mo	
	Rockwell Hardness C	
A	100(b)(c)	90(b)
T	28	28
TH 1050	40	45
A1750	85(b)	85(b)
R 100	40	40
RH 950	45	48
C	41	45
CH 900	46	50

(a) Applies to material .010 inch and thicker.  
 (b) RB  
 (c) maximum

1.062 Effect of aging temperature on hardness in Condition RH 950 (see 3.0214).  
 1.063 Effect of cold work in Condition A on hardness in Condition TH 1050, Table 1.063.

Source	(9, p. 70)
Alloy	Fe-15Cr-7Ni-2.5Mo
Condition	A + CR + TH 1050
Percent Reduction in Thickness (by rolling)	Hardness, RC
0	44.5
20	43.0
30	42.5

1.0631 Effect of modified TH 1050 heat treatment on cold worked properties (see Special Considerations, section 1.095).  
 1.064 Relationship between hardness and strength for heat treated conditions, Figure 1.064.

1.07 Forms and Conditions Available  
 1.071 Alloy is available in the full commercial range of sizes for sheet, strip, plate, bar, wire and welded tubing (2).  
 1.072 Alloy is available in the Condition A for the full range of products. Strip up to 0.050 inch thick and wire up to 0.050 inch diameter are also available in Condition C (13).

1.08 Melting and Casting Practice  
 Conventional stainless steel melting and casting practices are used. Induction and consumable electrode vacuum melts are also available.

15	Fe
7	Cr
2.5	Ni
	Mo

PH15-7Mo

- 1.09 Special Considerations  
 1.091 Alloy is available in numerous forms (see 1.071), but the primary usage is in the sheet and strip form (13).  
 1.092 In common with the general class of precipitation hardening stainless steels, this alloy is unstable during exposure to temperatures exceeding about 500F. This instability is reflected in an increase in the yield strength and a decrease in fracture toughness. The transverse direction has lower toughness than the longitudinal direction.  
 1.093 Dimensional changes during heat treating to Conditions TH 1050 or RH 950 need consideration and special provisions must be made for machining and tooling.  
 1.094 Thorough cleaning prior to thermal treatments is recommended in order to avoid carburization and to minimize difficulties when descaling.  
 1.095 A modified TH 1050 heat treatment has been developed to compensate for cold working in Condition A when TH 1050 properties are desired (9, p. 70). The treatment is as follows:

Austenite Condition      Air Cool & Refrigerate  
 1550F ± 25F 90 min      0F ± 10F 4 hrs

Precipitation Harden  
 1050F ± 10F 90 min

2. PHYSICAL AND CHEMICAL PROPERTIES

- 2.01 Thermal Properties  
 2.011 Melting range. 2580 to 2640F.  
 2.012 Phase changes. Similar to those in 17-7PH.  
 2.0121 Time-temperature-transformation diagrams.  
 2.013 Thermal conductivity, Figure 2.013.  
 2.014 Thermal expansion, Figure 2.014.  
 2.015 Specific heat, 0.11 Btu per lb F.  
 2.016 Thermal diffusivity  
 2.017- Dilatometer curve indicating dimensional changes during heat treatment from Condition A to Condition RH 950, Figure 2.017.

- 2.02 Other Physical Properties  
 2.021 Density, Table 2.021.

TABLE 2.021  
(9, p. 76)

Source	Fe-15Cr-7Ni-2.5Mo			
Alloy	Fe-15Cr-7Ni-2.5Mo			
Condition	A	TH 1050	RH 950	CH 900
lb per cu in	0.282	0.277	0.277	0.277
gr per cu cm	7.804	7.685	7.680	7.67

- 2.022 Electrical resistivity, Table 2.022.

TABLE 2.022  
(9, p. 76)

Source	Fe-15Cr-7Ni-2.5Mo			
Alloy	Fe-15Cr-7Ni-2.5Mo			
Condition	A	TH 1050	RH 950	CH 900
Microhm - inches	31.5	32.3	32.7	33.1

- 2.023 Magnetic properties. Permeability, Table 2.023.

TABLE 2.023  
(9, p. 76)

Source	Fe-15Cr-7Ni-2.5Mo			
Alloy	Fe-15Cr-7Ni-2.5Mo			
Permeability				
Field Strength Oersted	Condition A	Condition TH 1050	Condition RH 950	Condition CH 900
25	5.1	142	65	-
50	5.2	147	118	-
100	5.1	94	87	70
200	4.7	55	53	44
maximum	5.3	150	119	125

- 2.024 Emissance, Figure 2.024.  
 2.025 Damping capacity.

- 2.03 Chemical Properties  
 2.031 Corrosion resistance (see also 17-7PH).  
 2.0311 General corrosion resistance of PH 15-7Mo in Condition TH1050 and RH 950 is superior to standard hardenable types of stainless steels such as Types 410, 420, and 431, but is not quite as good as Type 304 (9).  
 2.0312 Corrosion rate in several corrosive media, Table 2.0312.

TABLE 2.0312

Source	(9, p. 86)	
Alloy	Fe-15Cr-7Ni-2.5Mo	
Form	0.050 Inch Sheet	
Condition	TH 1050 MPY*	RH 950 MPY*
H <sub>2</sub> SO <sub>4</sub> , 95F		
1 percent	273	0.5
2 percent	78	0.7
5 percent	453	482
H <sub>2</sub> SO <sub>4</sub> , 176F		
1 percent	560(3)	690(2)
2 percent	1300(2)	1440(1)
HCl, 95F		
0.5 percent	31	0.3
1 percent	280	152
HNO <sub>3</sub> , Boil		
25 percent	119	36
50 percent	512	128
65 percent	748	210
Formic Acid, 176F		
5 percent	161	7.3
10 percent	123	74
Acetic Acid, Boil		
33 percent	3.0	7.6
60 percent	33	6.8
H <sub>3</sub> PO <sub>4</sub> , Boil		
20 percent	15.4	22.2
50 percent	97	52
70 percent	600(3)	277
NaOH, 176F		
30 percent	43	3.3
NaOH, Boil		
30 percent	142	139

MPY = Mils Per Year  
 Rates were determined by total immersion for five 48-hour periods. Specimens were activated by brief exposure to DC current for the last three test periods except in the 65 percent nitric acid or where brackets indicate total number of immersion periods.

- 2.0313 Stress corrosion cracking. Results of stress-cracking exposure tests on sheet in various conditions at Kure Beach, Table 2.0313.

TABLE 2.0313

Source	(9, p. 88)						
Alloy	Fe-15Cr-7Ni-2.5Mo						
Form	Sheet						
Condition	Original Properties		Stressed 60 Percent F <sub>ty</sub>			Stressed 40 Percent F <sub>ty</sub>	
	F <sub>tu</sub> ksi	F <sub>ty</sub> ksi	Stress ksi	Days to Failure 80ft lot	Days to Failure 500ft lot	Stress ksi	Days to Failure 800ft lot
TH 1050	222	212	127	182	NF	85	NF
	217	209	125	73(4)	NF	84	NF
	215	206	124	71(2)	NF	82	NF
RH 950	243	218	131	28.2	179(4)	87	92(3)
	243	220	132	22.2	126(4)	88	74(4)
	239	218	131	19	164(4)	87	82(1)
RH 1050	227	219	131	14(4)	NF	88	NF
	222	215	129	21.2(2)	NF	86	NF

NF denotes no failures after 400 days.  
 ( ) Denotes number of specimens failed at average time shown.  
 Remainder of 5 specimens not failed after 400 days.

- 2.03131 Salt coated specimens of this alloy in Condition 1050 exhibit excellent resistance to stress corrosion cracking at 550F for exposure times to 10,000 hours; however, it does show susceptibility to pitting (15).

REVISED: JUNE 1970

FERROUS ALLOYS

- 2.0314 Intergranular corrosion may occur during acid pickling, except in Conditions A and CH 900.
- 2.0315 Hydrogen embrittlement may occur during plating and recommended procedures for preventing same must be followed (12).
- 2.032 Oxidation resistance (see 17-7PH).
- 2.04 Nuclear Properties
- 3. MECHANICAL PROPERTIES
  - 3.01 Specific Mechanical Properties
  - 3.011 AMS and MIL specified mechanical properties for sheet, strip, and plate, Table 3.011.

- 3.013 Producers' guaranteed mechanical properties for sheet, strip, and plate, Table 3.013.

Fe  
 15 Cr  
 7 Ni  
 2.5 Mo  
 PH15-7Mo

TABLE 3.011

Source	AMS (1), MIL (7)				
Alloy	Fe-15Cr-7Ni-2.5Mo				
Form	Sheet, Strip, Plate				
Condition	A	TH 1050	RH 950	C	CH 900
	(1) (7)	(1) (7)	(1) (7)	(7)	(7)
$F_{tu}$ - max - ksi	150	-	-	-	-
min - ksi	-	190	225	200	240
$F_{ty}$ - max - ksi	65	-	-	-	-
min - ksi	-	170	200	175	230
e(2 in) min - percent					
Thickness - inch					
0.0015 - 0.500	25	-	-	1	1
0.0015 - 0.004	-	2(a)	1(a)	-	-
0.005 - 0.009	-	3	2	-	-
0.010 - 0.019	-	4	3	-	-
0.020 - 0.187	-	5	4	-	-
0.188 - 0.500	-	6	5	-	-
Hardness					
RB, max	100(a)	-	-	-	-
RC, min	-	40	40	-	-
		(a)(b)	(a)(b)		

(a) AMS only  
 (b) For thicknesses greater than 0.010

TABLE 3.013

Source	(9, p. 2)						
Alloy	Fe-15Cr-7Ni-2.5Mo						
Form	Sheet, Strip, Plate						
Condition	A	TH 1050	RH 950	C	CH 900		
Thickness - Inch	All	0.0015 to 0.1874	0.1875 to 0.6250	0.0015 to 0.1874	0.1875 to 0.6250	0.0015 to 0.050	0.0015 to 0.050
$F_{tu}$ , minimum ksi	-	190	190	225	225	200	240
maximum ksi	150	-	-	-	-	-	-
$F_{ty}$ , minimum ksi	-	170	170	200	200	175	230
maximum ksi	65	-	-	-	-	-	-
e(2 in), min-percent							
0.0015-0.0049	25	2	-	1	-	1	1
0.005 - 0.0099	25	3	-	2	-	1	1
0.010 - 0.0199	25	4	-	3	-	1	1
0.020 - 0.0369	25	5	-	4	-	1	1
0.036 - 0.1874	25	5	-	4	-	1	1
0.1875 - 0.6250	25	-	4	-	4	-	-
>0.6250	25	-	-	-	-	-	-
RA, min - percent	-	-	20	-	20	-	-
Hardness							
RB, maximum	100	-	-	-	-	-	-
RC, minimum	-	40	40	46	45	41	46
BHN maximum	-	-	372	-	426	-	-

Transverse tensile data

- 3.02 Mechanical Properties at Room Temperature
- 3.021 Tension (see also 1.055)
- 3.0211 Stress-strain diagrams.
- 3.0212 Typical tensile properties for various conditions of sheet, strip, and plate, Table 3.0212.

TABLE 3.0212

Source	(9, p. 14)(16, p. 5)							
Alloy	Fe-15Cr-7Ni-2.5Mo							
Form	Sheet, Strip, Plate							
Condition	A	T	C	TH	A	R	RH	CH
	(9)	(9)	(9)	1050	1750	100	950	900
	(16)	(16)	(16)	(9)(16)	(9)(16)	(9)(16)	(9)(16)	(16)
$F_{tu}$ - ksi	130	145	220	210	150	180	240	265
$F_{ty}$ - ksi	55	90	190	200	55	125	225	260
e(2 in) - percent	35	7	5	7	12	7	6	2

- 3.012 AMS and ASTM specified mechanical properties for bar, Table 3.012.

TABLE 3.012

Source	AMS (2), ASTM (5)			
Alloy	Fe-15Cr-7Ni-2.5Mo			
Form	Bar			
Condition	TH 1050		RH 950	
Thickness-Inches	6 inch diameter and under or distance between parallel sides (2)	0.250 to 0.625 (5)	0.625 to 6 (5)	6 inch diameter and under or distance between parallel sides (2) (5)
$F_{tu}$ , min - ksi	180	185	180	200
$F_{ty}$ , min - ksi	160	160	160	175
e(4D), minimum-percent	8	10	8	7
RA, min-percent	25	30	25	25
Hardness, BHN, minimum	375	371	375	415*

\* ASTM gives 418.

- 3.0213 Effect of solution temperature on tensile properties in Conditions A, TH 1050, and RH 950, Figure 3.0213.
- 3.0214 Effect of aging temperature on tensile properties and hardness in Condition RH 950, Figure 3.0214.
- 3.0215 Effect of exposure to elevated temperatures on tensile properties of sheet in Conditions RH 950 and TH 1050, Figure 3.0215.
- 3.0216 Effect of exposure time to elevated temperatures on strength properties in Condition RH 1075, Figure 3.0216.
- 3.0217 Effect of exposure time, elevated temperatures, and load on tensile properties of sheet in Condition RH 950, Table 3.0217.

TABLE 3.0217

Source	(2)			
Form	0.050 Inch Sheet			
Condition	RH 950			
1000 hours exposure		Properties After Exposure		
Temperature F	Load ksi	Room Temp $F_{tu}$ - ksi	e (2 in) percent, T	
RT	-	248	6.5	
600	90	252	6.5	
	200	283	3.5	
700	40	276.2	4.25	
	190	302.1	2.25	
800	40	282.4	4.5	
	170	308.3	1.75	
900	20	249.8	5.5	
	70	262.4	4.0	

Fe  
15 Cr  
7 Ni  
2.5 Mo

PH15-7Mo

- 3.0218 Effect of thickness on tensile properties of sheet, Figure 3.0218.
- 3.0219 Effect of reduction by shear forming on tensile properties of sheet, Figure 3.0219.
- 3.02111 Effect of reduction by cold working in Condition A on tensile properties in Condition TH 1050, Table 3.02111.

TABLE 3.02111

Source		(9, p. 70)		
Alloy		Fe-15Cr-7Ni-2.5Mo		
Form		0.050 Inch Sheet (Initial Thickness)		
Condition		TH 1050		
Percent Reduction in Thickness (by rolling) Condition A	F <sub>ty</sub> - ksi (0.2 percent)	F <sub>tu</sub> ksi	e(2 in) percent	
0	188	189	9.5	
20	163	191	10.8	
30	150	189	11.4	

(a) Longitudinal data  
(b) Cold working PH15-7Mo in Condition A produces no deleterious effect on mechanical properties in Condition RH 950 (9, p. 71).

- 3.02112 Effect of percent cold reduction and cold reduction temperature on yield strength, Figure 3.02112.
- 3.022 Compression.
- 3.0221 Stress-strain diagrams (see Figure 3.0321).
- 3.023 Impact.
- 3.024 Bending.
- 3.025 Torsion and shear.
- 3.0251 Effect of reduction by shear forming on shear strength of sheet, Figure 3.0251.
- 3.026 Bearing.
- 3.0261 Bearing properties of sheet in Conditions TH 1050 and RH 950, Table 3.0261.

TABLE 3.0261

Source		(9, p. 44)			
Alloy		Fe-15Cr-7Ni-2.5Mo			
Form		Sheet			
Condition	Sheet Thickness inch	Test Direction	e D	F <sub>bry</sub> ksi	F <sub>bru</sub> ksi
TH 1050	0.064	L	1.5	339	402
			2.0	345	497
		T	1.5	325	410
	0.050	L	1.5	316	418
			2.0	342	501
		T	1.5	343	427
RH 950	0.064	L	1.5	350	455
			2.0	390	543
		T	1.5	366	471
	0.050	L	1.5	344	470
			2.0	405	564
		T	1.5	346	476
			2.0	349	487

Each value represents the average of three tests.

- 3.027 Stress concentration.
  - 3.0271 Notch properties.
  - 3.02711 Effect of aging temperature on sharp notch strength of sheet in various RH conditions, Figure 3.02711.
  - 3.02712 The effect of crack length on percent of tensile strength of sheet, Figure 3.02712.
  - 3.0272 Fracture toughness.
- | Condition | K <sub>Q</sub> (plain strain) |
|-----------|-------------------------------|
| TH 1050   | 63 ksi√in                     |
| RH 950    | 52 ksi√in                     |
- Valid plain strain fracture toughness, K<sub>Ic</sub>, data which have been derived from tests that conform in all aspects to the ASTM Recommended Practice appears to be lacking for this material (22). However, data reported by Steigerwald can be presented as K<sub>Q</sub> and used as a qualitative measure of fracture toughness (23). For example, the above data indicates a strong dependence on heat treat condition (this also applies to 17-7PH) (23). Due to the relatively low fracture toughness which exists for PH 15-7Mo and 17-7PH in Condition RH 950, the

PH 14-8Mo alloy should be used when a combination of high strength and high fracture toughness is required (9, p.14).  
Combined properties.

- 3.028
  - 3.03
  - 3.031
  - 3.0311
  - 3.03111
  - 3.03112
  - 3.03113
  - 3.03114
  - 3.0312
  - 3.03121
  - 3.03122
  - 3.0313
  - 3.03131
  - 3.03132
  - 3.03133
  - 3.03134
  - 3.0314
  - 3.03141
  - 3.03142
  - 3.0315
  - 3.03151
  - 3.03152
  - 3.03153
  - 3.03154
  - 3.032
  - 3.0321
  - 3.0322
  - 3.0323
  - 3.033
  - 3.0331
  - 3.034
  - 3.035
  - 3.0351
  - 3.0352
  - 3.036
  - 3.0361
  - 3.0362
  - 3.037
  - 3.0371
  - 3.03711
  - 3.03712
- Mechanical Properties at Various Temperatures  
Tension.  
Stress-strain diagrams.  
Stress-strain curves for sheet in Conditions TH 1050 and RH 950 at elevated temperatures, Figure 3.03111.  
Stress-strain curves at room and low temperature for sheet in Condition RH 950, Figure 3.03112.  
Stress-strain curves in tension for sheet in Condition TH 1050 at elevated temperatures and for various exposure times, Figure 3.03113.  
Stress-strain curves in tension for sheet in Condition RH 950 for various exposure times at elevated temperatures, Figure 3.03114.  
Tension properties for Condition TH.  
Effect of test temperature on tensile properties of sheet in Conditions TH 1050 and RH 950, Figure 3.03121.  
Effect of exposure and test temperature on tensile properties of sheet in Condition TH 1050, Figure 3.03122.  
Tension properties for Condition RH.  
Effect of test temperature on tensile properties of sheet in Condition RH 950 (see 3.03121).  
Effect of test temperature on tensile properties of exposed and unexposed sheet in Condition RH 1050, Figure 3.03132.  
Effect of test temperatures on tensile properties of exposed and unexposed sheet in Condition RH 1100, Figure 3.03133.  
Effect of low test temperature on tensile properties of sheet in Condition RH 950, Figure 3.03134.  
Tension properties for Condition CH.  
Effect of test temperature on tensile properties of exposed and unexposed sheet in Condition CH 900, Figure 3.03141.  
Effect of test temperature on tensile properties of sheet in Condition CH 900, Figure 3.03142.  
Tension properties for various conditions.  
Effect of exposure temperature on tensile properties of sheet in Conditions TH 1050 and RH 950, Figure 3.03151.  
Effect of low test temperature up to 200F on tensile properties of sheet in Conditions RH 950 and CH 1100, Figure 3.03152.  
Effect of test temperature on tensile properties of plate in Condition TH 1050, Figure 3.03153.  
Effect of test temperature on tensile properties of plate in Condition RH 950, Figure 3.03154.  
Compression.  
Stress-strain curves in compression at elevated temperatures for sheet in Conditions TH 1050 and RH 950, Figure 3.0321.  
Effect of test temperature on compressive yield strength of sheet in Conditions TH 1050, RH 950 and CH 900, Figure 3.0322.  
Effect of exposure time and test temperature on compressive yield strength of sheet in Condition TH 1050, Figure 3.0323.  
Impact.  
Effect of low test temperature on impact strength of alloy in Condition TH 1050 and RH 950, Figure 3.0331.  
Bending.  
Torsion and shear.  
Effect of test temperature on shear strength of sheet in Condition TH 1050 and RH 950, Figure 3.0351.  
Effect of exposure time and test temperature on shear strength of sheet in Condition TH 1050, Figure 3.0352.  
Bearing.  
Effect of exposure time and test temperature on bearing properties of sheet in Condition TH 1050, Figure 3.0361.  
Effect of exposure time and test temperature on bearing properties of sheet in Condition TH 1050, Figure 3.0362.  
Stress concentration.  
Notch properties.  
Effect of test temperature on notch and crack strength of sheet in Condition CH 900, Figure 3.03711.  
Effect of test temperature on notch and crack strength

REVISED: JUNE 1970

## FERROUS ALLOYS

- 3.03713 of sheet in Condition RH 1050, Figure 3.03712.  
Effect of test temperature on the sharp notch strength ratio and crack strength ratio for sheet in RH 1050 Condition, Figure 3.03713.
- 3.03714 Effect of test temperature on notch and crack strength of sheet in Condition RH 1100, Figure 3.03714.
- 3.03715 Effect of exposure and test temperature on notch strength of sheet in Condition TH 1050, Figure 3.03715.
- 3.03716 Effect of low test temperature on notch strength of sheet in Condition RH 950, Figure 3.03716.
- 3.03717 Effect of stress concentration factor on notch strength ratio at room temperature and -320F for sheet in Conditions CH 900 and RH 1100, Figure 3.03717.
- 3.0372 Fracture toughness.
- 3.038 Combined properties.
- 3.04 Creep and Creep Rupture Properties
- 3.041 Creep properties for sheet, strip and plate in Condition RH 950 at 600 to 900F, Table 3.041.

TABLE 3.041

Source	(9, p. 37)		
Alloy	Fe-15Cr-7Ni-2.5Mo		
Form	0.050 Inch Sheet		
Condition	RH 950		
Time - hours	1000		
Creep - percent	0.1	0.2	
Temperature - F	Stress - ksi		
600	132	150	
700	121	142	
800	95	109	
900	36	41	

- 3.042 Creep rupture properties for sheet in Condition TH 1050 and RH 950 at various temperatures, Table 3.042.

TABLE 3.042

Source	(14, F-1-3, F-2-3)					
Alloy	Fe-15Cr-7Ni-2.5Mo					
Form	0.050 Inch Sheet					
Condition	TH 1050			RH 950		
Time - hours	10	100	1000	10	100	1000
Temperature - F	Creep Rupture Strength - ksi					
600	-	179	178	-	202	200
700	177	161	159	200	193	191
800	159	139	137	190	174	171
900	132	108	98	168	125	108

- 3.043 Isochronous stress-strain curves for sheet in Condition RH 950 at 600 to 900F, Figure 3.043.
- 3.044 Creep and creep rupture curves for alloy in Condition RH 950, Figure 3.044.
- 3.045 Creep rupture curves for alloy at 1000F in Condition RH 950, Figure 3.045.
- 3.05 Fatigue properties
- 3.051 S-N curve for sheet in Condition RH 950, Figure 3.051.
- 3.052 S-N curve for notched sheet in Condition RH 950, Figure 3.052.
- 3.053 S-N curves for notched and smooth sheet as a function of temperature in Condition TH 1050, Figure 3.053.
- 3.054 S-N curves for notched and unnotched sheet as a function of temperature in Condition TH 1050, Figure 3.054.

- 3.055 S-N curves for notched and unnotched sheet as a function of temperature in Condition TH 1050, Figure 3.055.
- 3.056 Fatigue-crack propagation rate for two test temperatures for sheet in Condition TH 1050, Figure 3.056.
- 3.057 Fatigue-crack propagation curves as a function of initial net section stress for sheet in Condition TH 1050, Figure 3.057.
- 3.058 Fatigue-crack propagation curves as a function of initial net section stress for sheet in Condition TH 1050 at R = -1, Figure 3.058.
- 3.06 Elastic Properties
- 3.061 Poissons ratio. Condition RH 950, 0.28.
- 3.062 Modulus of elasticity.
- 3.0621 Modulus of elasticity at room and elevated temperatures, Figure 3.0621.
- 3.0622 Modulus of elasticity in compression at room and elevated temperatures, Figure 3.0622.
- 3.0623 Effect of exposure time and test temperature on modulus of elasticity in compression of sheet in Condition TH 1050, Figure 3.0623.
- 3.063 Modulus of rigidity.
- 3.0631 Modulus of rigidity at room and elevated temperatures, Figure 3.0631.
- 3.064 Tangent modulus.
- 3.0641 Tangent modulus curves in compression for sheet in Condition TH 1050 at elevated temperatures and for various exposure time, Figure 3.0641.
- 3.0642 Secant modulus curves in compression at elevated temperatures for sheet in Conditions TH 1050 and RH 950, Figure 3.0642.

	Fe
15	Cr
7	Ni
2.5	Mo

PH15-7Mo

## 4. FABRICATION

- 4.01 Formability  
(see also 17-7PH)
- 4.011 Hydroforming and marforming operations can readily be performed on this alloy and 17-7PH in Condition A. Parts including formers, flanges, hat sections, and frames which have been processed by these methods are used by aircraft manufacturers (9).
- 4.012 Spinning characteristics of this alloy are similar to 17-7PH and Type 301. The strength developed during cold working is primarily dependent upon the amount of cold-work and the temperature at which it is done (see 3.0219, 3.02112, and 3.0251) (9).
- 4.02 Machining and Grinding  
(see also 17-7PH)
- 4.021 Grinding. Material appears to offer no major problems in grinding; however, Conditions TH 1050 and RH 950 are easier to grind than Condition A material (9). Conventional grinding wheels at conventional speeds and feeds appear satisfactory. Grinding characteristics of 17-7PH are comparable to those of this alloy (9).
- 4.03 Welding  
(see also 17-7PH)
- 4.031 Inert gas tungsten arc fusion welding of annealed and subsequently heat treated metal yields a weld efficiency of 80 to 100 percent.
- 4.032 Most welding is performed with the inert gas tungsten arc process or the resistance spot and seam welding processes. Resistance flash butt welding is not recommended for joints to be placed in high strength conditions (11, p. 65).
- 4.033 The molybdenum addition in this alloy causes larger amounts of delta ferrite or free ferrite to form in weld deposits upon solidification. The amounts of ferrite requires some control in order to maintain good ductility in the highest strength conditions. The control is effected through the use of filler metal of appropriate chemical composition or through heat treatment (11, p. 65).

4.034	Fe
15	Cr
7	Ni
2.5	Mo
PH15-7Mo	

To avoid problems with weld metal cracking or lowered ductility a specific composition of hardenable weld wire, designated as W PH 15-7Mo, is recommended for use as electrode or filler rod, Table 4.034.

TABLE 4.034

Source	(9, p. 116)
Alloy	Fe-15Cr-7Ni-2.5Mo
Form	Sheet and Strip
Composition Range, Percent	
Element	Weld Wire WPH15-7Mo
Carbon	0.09 - maximum
Manganese	1.00 - maximum
Phosphorus	0.025 - maximum
Sulfur	0.025 - maximum
Silicon	0.50 - maximum
Chromium	14.00 - 15.25
Nickel	6.50 - 7.75
Aluminum	0.75 - 1.25
Molybdenum	2.00 - 2.75

WPH15-7Mo serves satisfactorily for most welded articles which are heat treated to the lower levels of strength and hardness; that is any treatment involving a final hardening temperature of 1100F or higher.

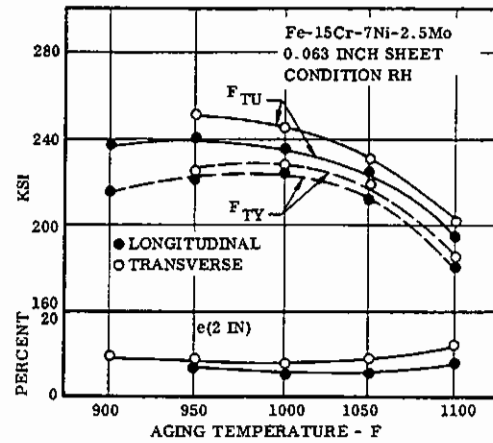


FIG. 1.0551 EFFECT OF AGING TEMPERATURE ON TENSILE PROPERTIES OF SHEET IN VARIOUS RH CONDITIONS. (10, p. 864)

4.035 Strength of spot welded joints, Table 4.035.

TABLE 4.035

Source	(9, p. 119)		
Form	0.049 Inch Sheet		
Condition in which welded	Condition in which tested	Shear Breaking Load lbs/weld (a)	Tension Breaking Load lbs/weld (a)
A	TH 1050	3103	580
T	TH 1050	3438	1648
TH 1050	TH 1050	2896	2015
A	RH 950	2853	520
A 1750	RH 950	3426	-
R 100	RH 950	3335	1232
RH 950	RH 950	2630	2170

(a) Average of twenty (20) tests.

4.04 Heat Treatment (see 17-7PH)

4.05 Surface Treatment (see 17-7PH)

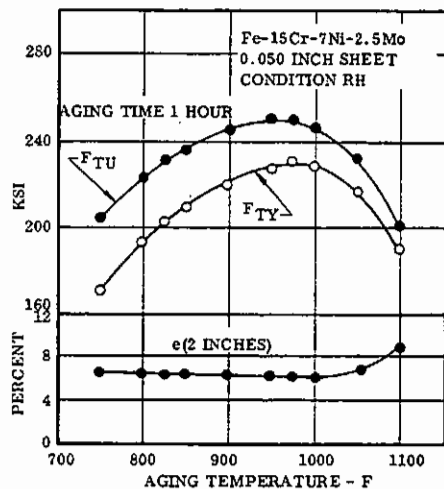


FIG. 1.055 EFFECT OF AGING TEMPERATURE ON TENSILE PROPERTIES OF SHEET IN VARIOUS RH CONDITIONS. (9, p. 68)

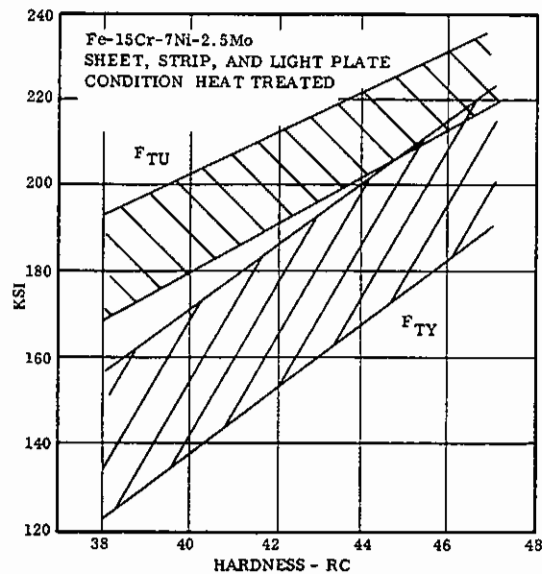


FIG. 1.064 RELATIONSHIP BETWEEN HARDNESS AND STRENGTH FOR HEAT TREATED CONDITIONS (SPREAD IN STRENGTH PROPERTIES DUE PRIMARILY TO VARIATIONS IN CHEMICAL COMPOSITION.) (9, p. 67)

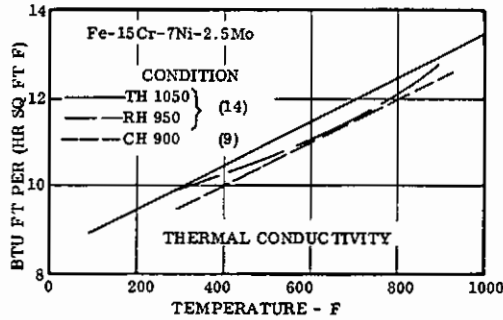


FIG. 2.013 THERMAL CONDUCTIVITY. (9, p. 76)  
(14, p. F-1-1, F-2-1)

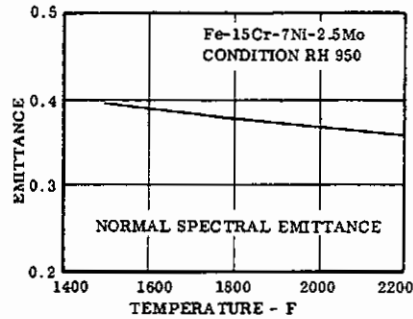


FIG. 2.024 EMITTANCE (9, p. 81; 14, p. F-2-1)

	Fe
15	Cr
7	Ni
2.5	Mo

PH15-7Mo

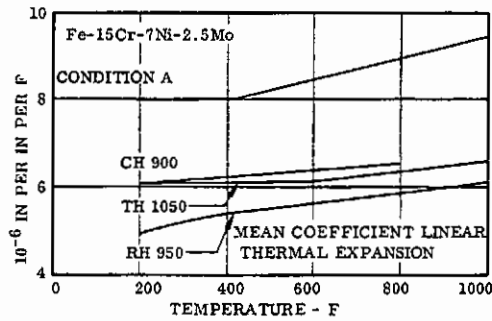


FIG. 2.014 THERMAL EXPANSION. (9, p. 76)

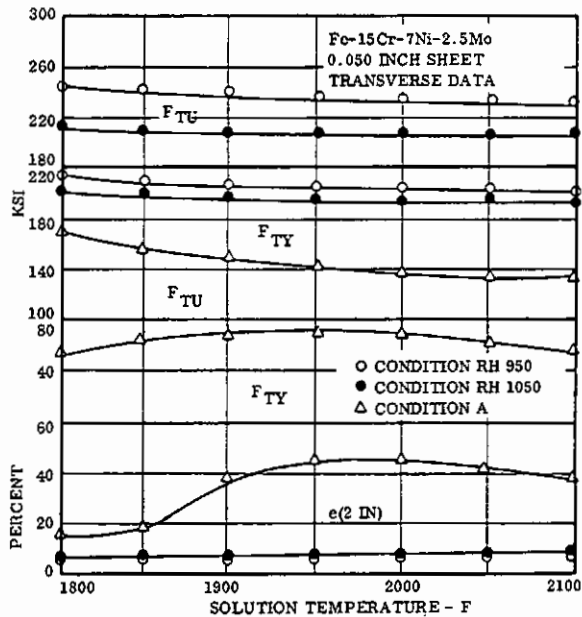


FIG. 3.0213 EFFECT OF SOLUTION TEMPERATURES ON TENSILE PROPERTIES IN CONDITIONS A, TH 1050, AND RH 950. (9, p. 58, 59)

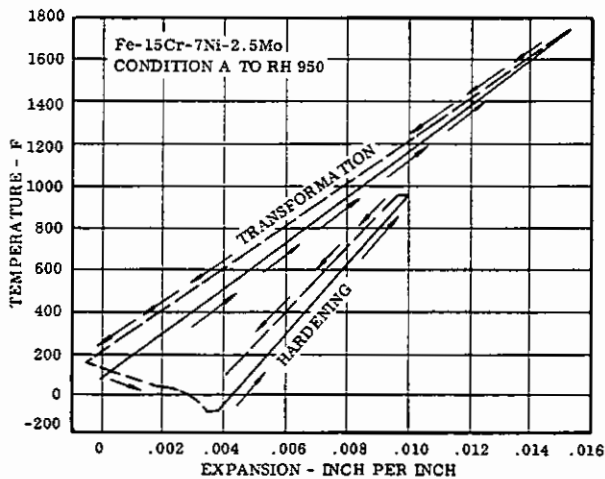


FIG. 2.017 DILATOMETER CURVE INDICATING DIMENSIONAL CHANGES DURING HEAT TREATMENT FROM CONDITION A TO CONDITION RH 950. (9, p. 78)

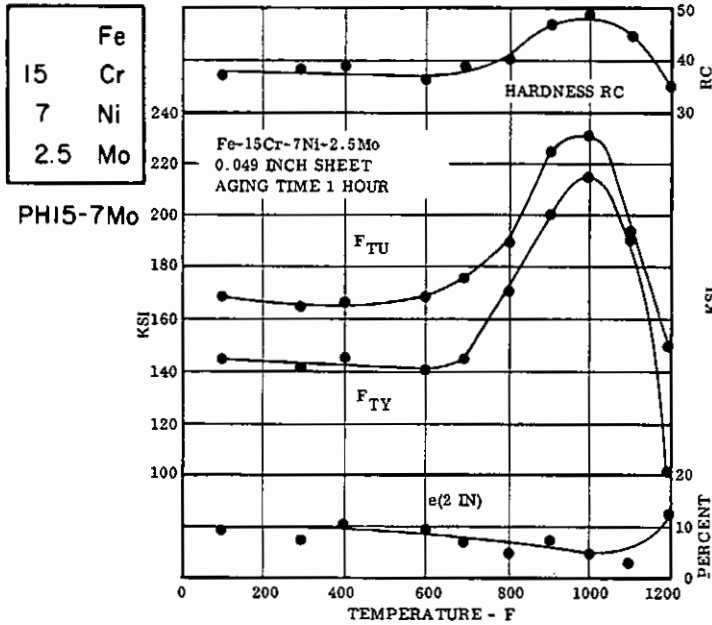


FIG. 3.0214 EFFECT OF AGING TEMPERATURE ON TENSILE PROPERTIES AND HARDNESS IN CONDITION RH 950. (17, p. 113)

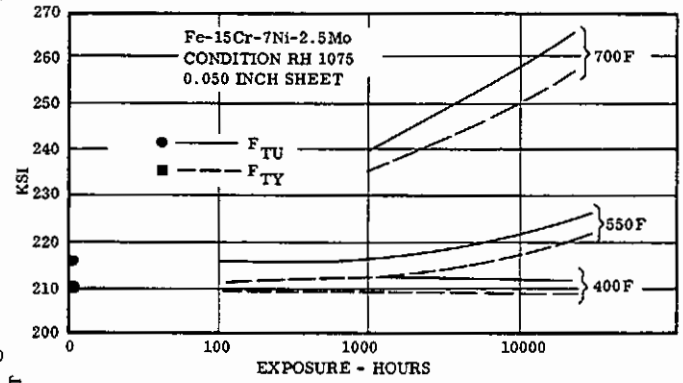


FIG. 3.0216 EFFECT OF EXPOSURE TIME TO ELEVATED TEMPERATURES ON STRENGTH PROPERTIES IN CONDITION RH 1075. (9, p. 57)

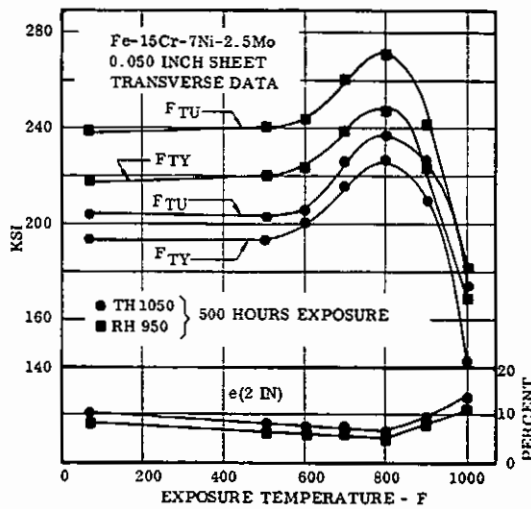


FIG. 3.0215 EFFECT OF EXPOSURE TO ELEVATED TEMPERATURES ON TENSILE PROPERTIES OF SHEET IN CONDITIONS RH 950 AND TH 1050. (9, p. 55)

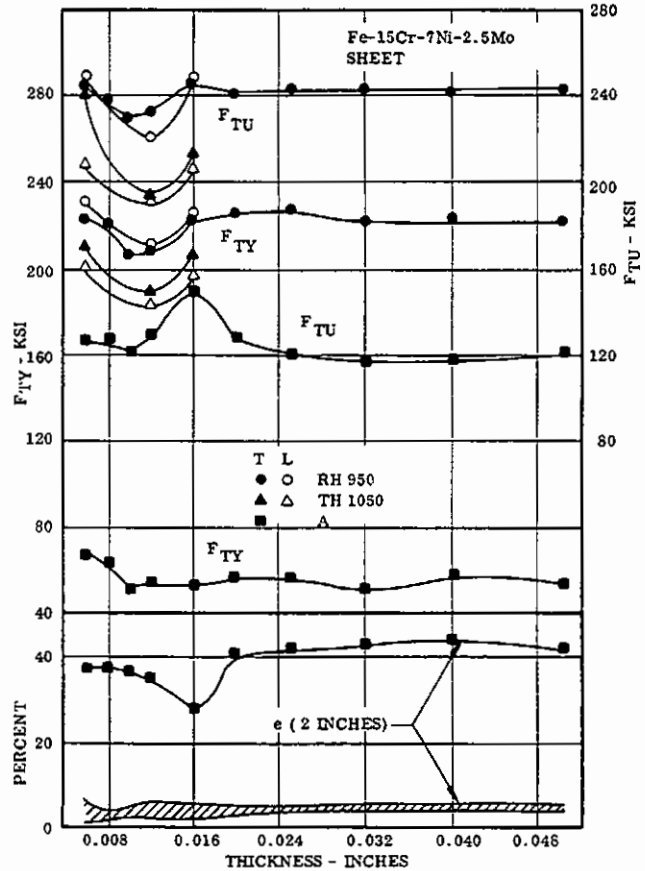


FIG. 3.0218 EFFECT OF THICKNESS ON TENSILE PROPERTIES OF SHEET. (18, p. 164, 167-169)

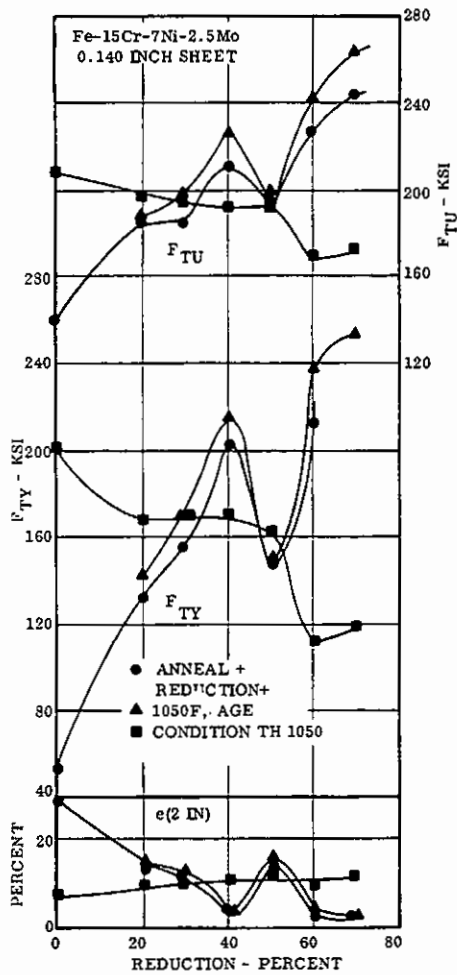


FIG. 3.0219 EFFECT OF REDUCTION BY SHEAR FORMING ON TENSILE PROPERTIES OF SHEET. (19, p. 188-192)

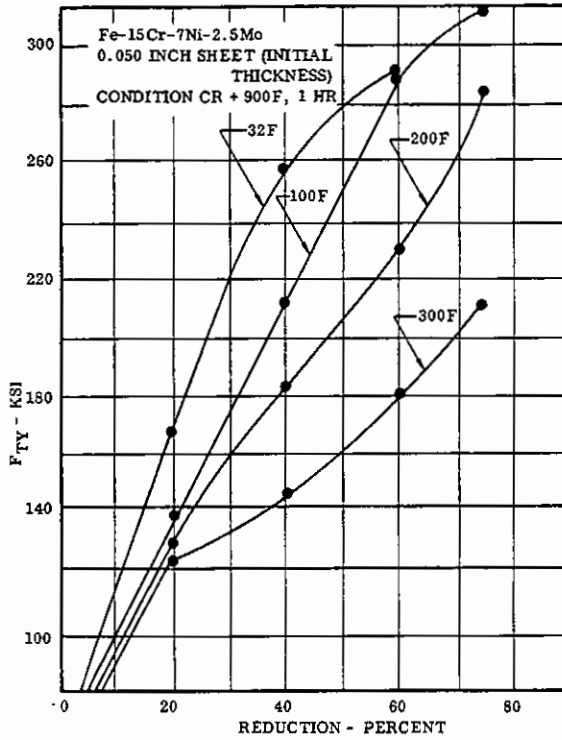


FIG. 3.02112 EFFECT OF PERCENT COLD REDUCTION AND COLD REDUCTION TEMPERATURE ON YIELD STRENGTH. (9, p. 103)

Fe
15 Cr
7 Ni
2.5 Mo
PH15-7Mo.

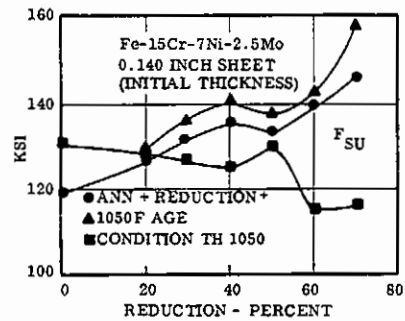


FIG. 3.0251 EFFECT OF REDUCTION BY SHEAR FORMING ON SHEAR STRENGTH OF SHEET. (19, p. 274-277)

Fe
15 Cr
7 Ni
2.5 Mo

PH15-7Mo

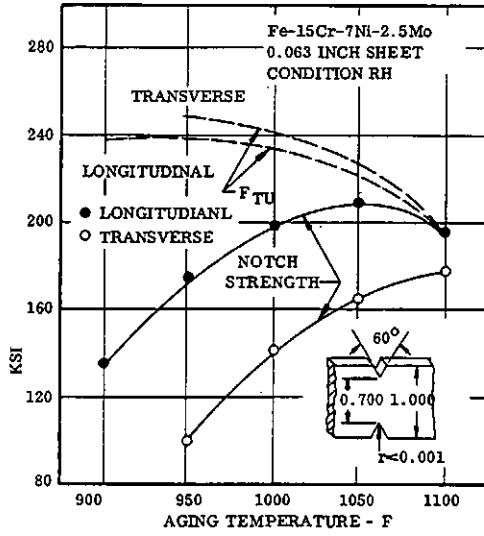


FIG. 3.02711 EFFECT OF AGING TEMPERATURE ON SHARP NOTCH STRENGTH OF SHEET IN VARIOUS RH CONDITIONS. (20, p. 854)

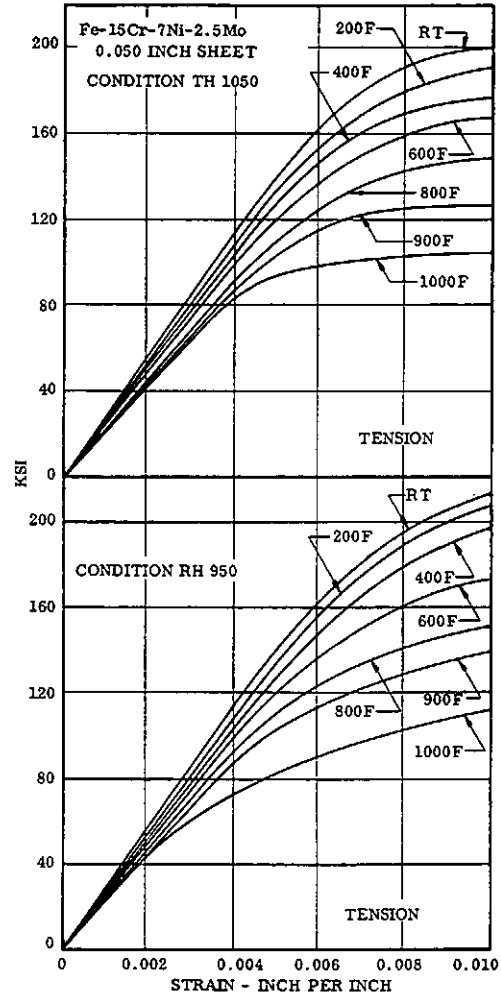


FIG. 3.03111 STRESS-STRAIN CURVES FOR SHEET IN CONDITIONS TH 1050 AND RH 950 AT ELEVATED TEMPERATURES. (12)

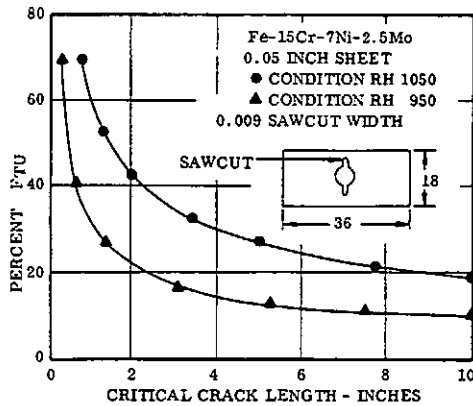


FIG. 3.02712 EFFECT OF CRACK LENGTH ON PERCENT OF TENSILE STRENGTH OF SHEET. (21, p. 325)

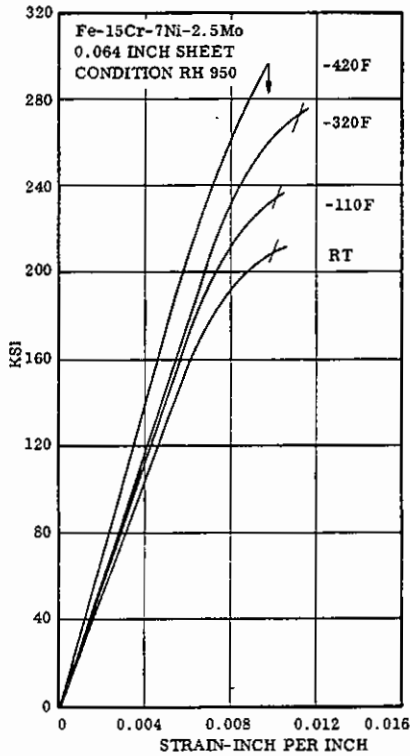


FIG. 3.03112 STRESS-STRAIN CURVES AT ROOM AND LOW TEMPERATURES FOR SHEET IN CONDITION RH 950. (24, p. 40)

	Fe
15	Cr
7	Ni
2.5	Mo

PH15-7Mo

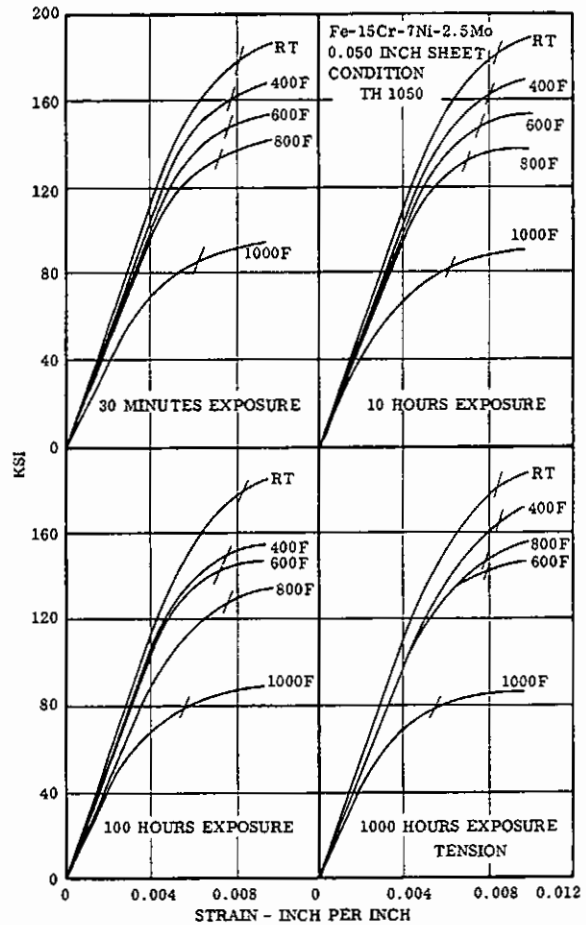


FIG. 3.03113 STRESS-STRAIN CURVES IN TENSION FOR SHEET IN CONDITION TH 1050 AT ELEVATED TEMPERATURES AND FOR VARIOUS EXPOSURE TIMES. (25, p. 194-197)

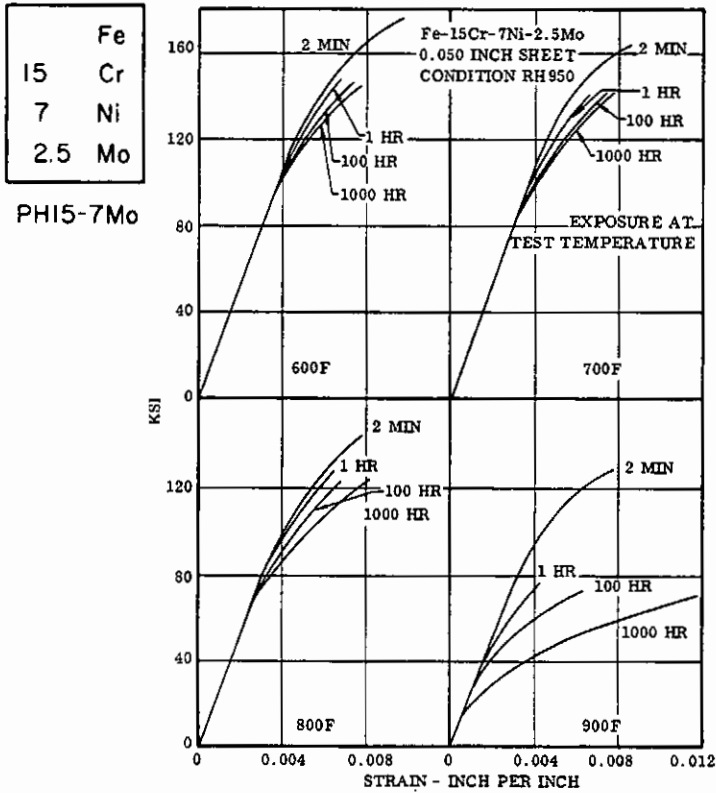


FIG. 3.03114 STRESS-STRAIN CURVES IN TENSION FOR SHEET IN CONDITION RH 950 FOR VARIOUS EXPOSURE TIMES AT ELEVATED TEMPERATURES. (9, p. 37)

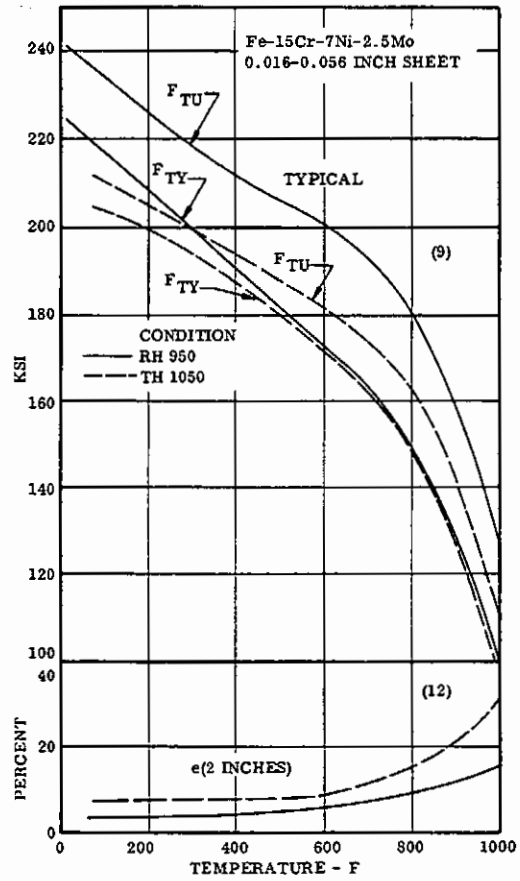


FIG. 3.03121 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF SHEET IN CONDITIONS TH 1050 AND RH 950. (9, p. 17, 12)

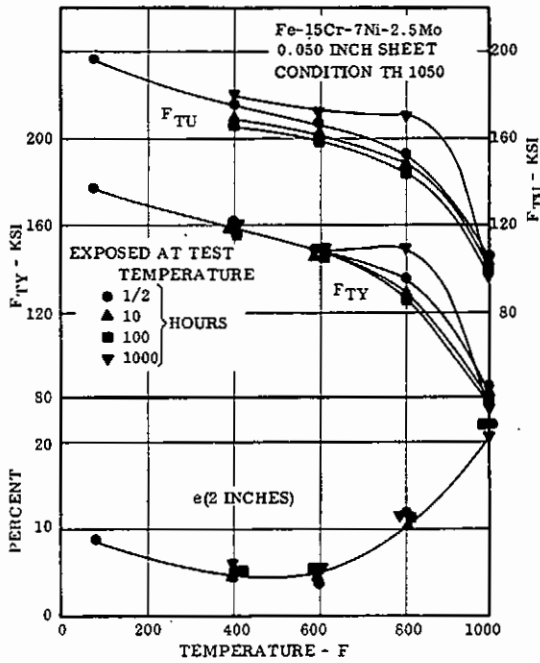


FIG. 3.03122 EFFECT OF EXPOSURE AND TEST TEMPERATURE ON TENSILE PROPERTIES OF SHEET IN CONDITION TH 1050. (25, p. 41-44)

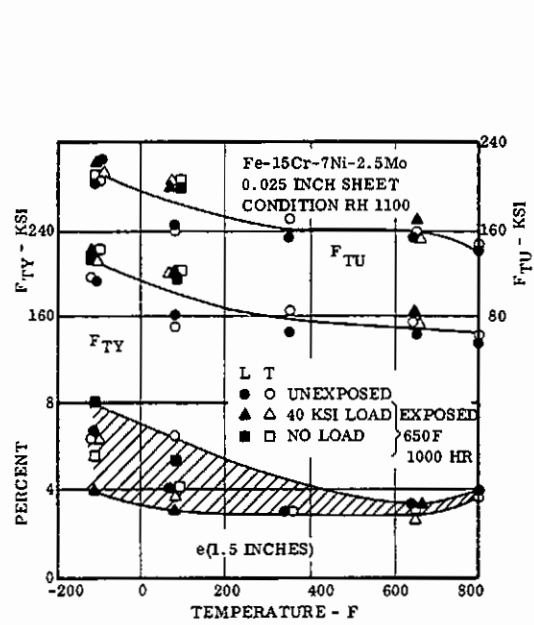


FIG. 3.03133 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF EXPOSED AND UNEXPOSED SHEET IN CONDITION RH 1100. (20)

Fe
15 Cr
7 Ni
2.5 Mo
PH15-7Mo

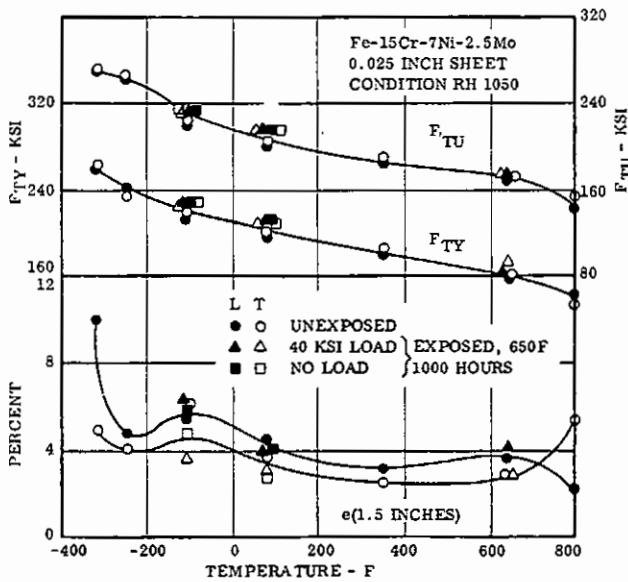


FIG. 3.03132 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF EXPOSED AND UNEXPOSED SHEET IN CONDITION RH 1050. (20)

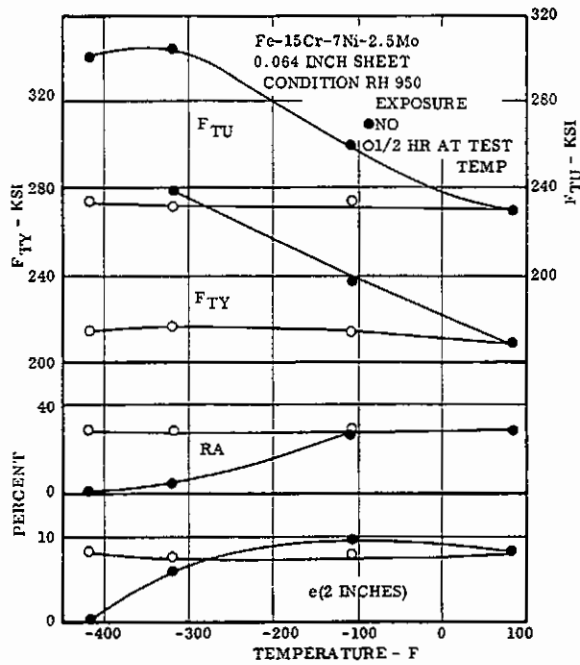


FIG. 3.03134 EFFECT OF LOW TEST TEMPERATURE ON TENSILE PROPERTIES OF SHEET IN CONDITION RH 950. (24, p. 22)

	Fe
15	Cr
7	Ni
2.5	Mo

PH15-7Mo

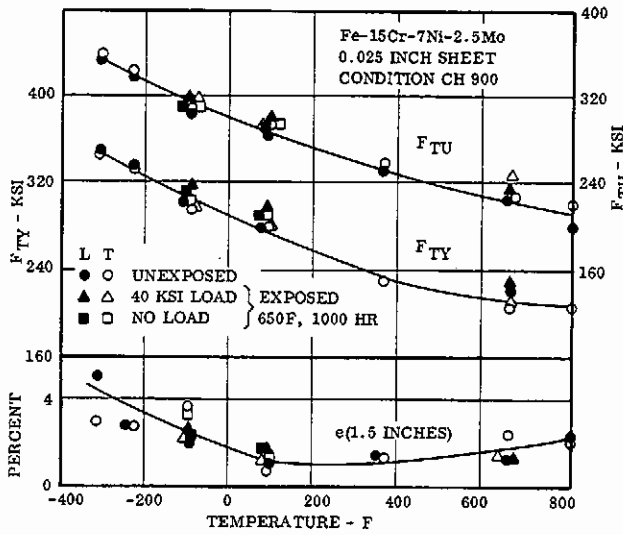


FIG. 3.03141 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF EXPOSED AND UNEXPOSED SHEET IN CONDITION CH 900. (20)

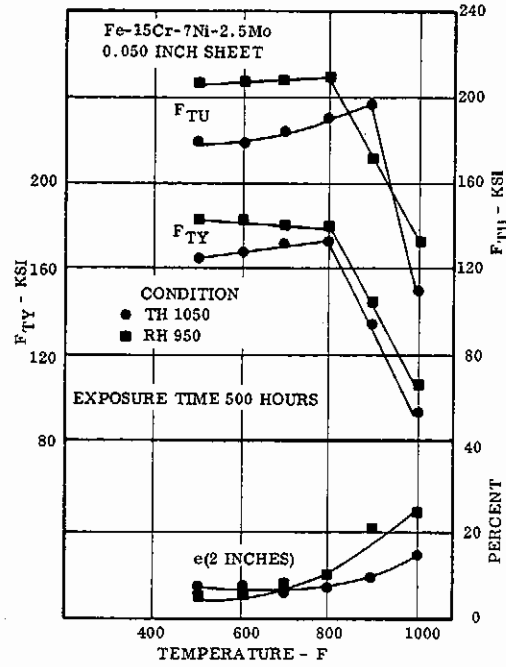


FIG. 3.03151 EFFECT OF EXPOSURE TEMPERATURE ON TENSILE PROPERTIES OF SHEET IN CONDITIONS TH 1050 AND RH 950. (9, p. 55)

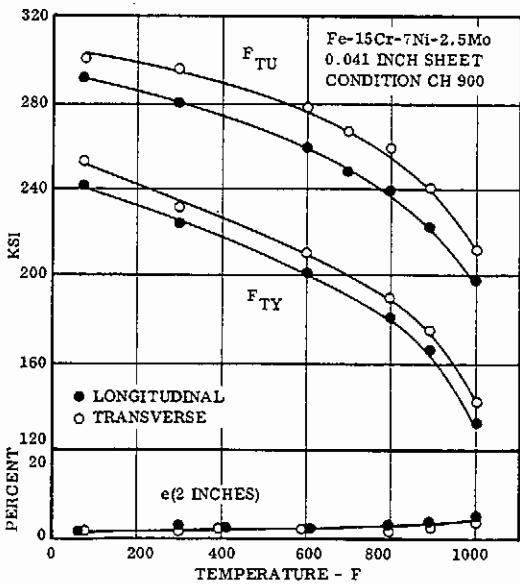


FIG. 3.03142 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF SHEET IN CONDITION CH 900. (26, p. 4)

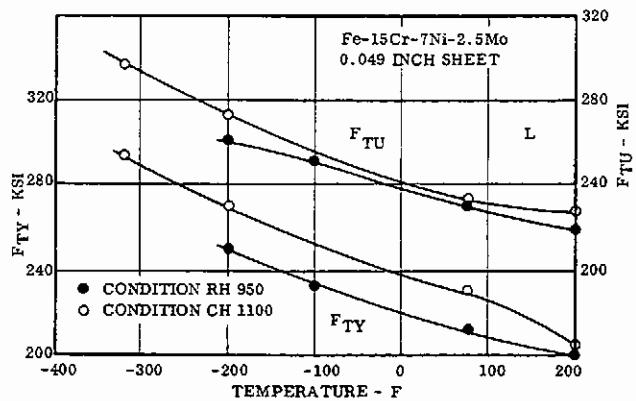


FIG. 3.03152 EFFECT OF LOW TEST TEMPERATURE ON TENSILE PROPERTIES OF SHEET IN CONDITION RH 950 AND CH 1100. (27, p. 57)

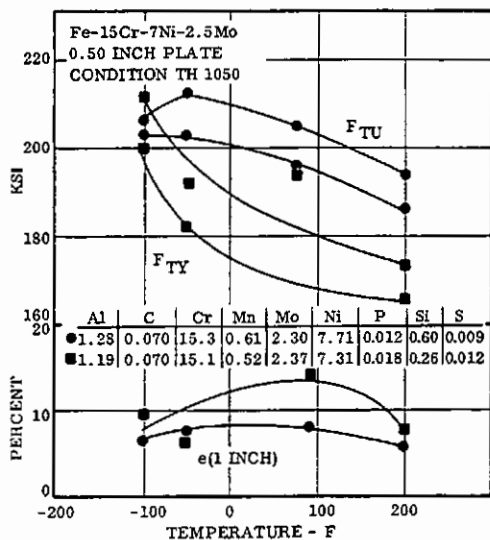


FIG. 3.03153 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF PLATE IN CONDITION TH 1050. (23, p. 73)

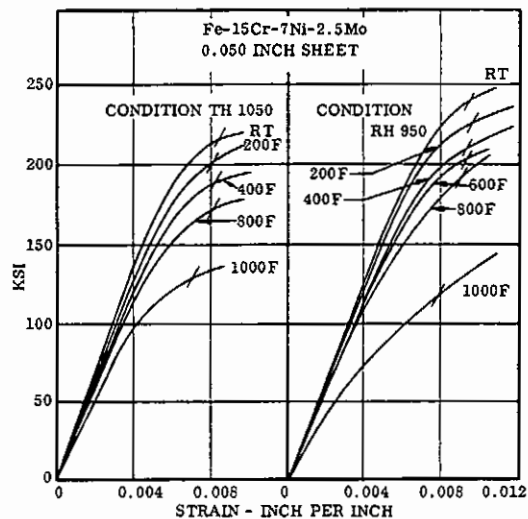


FIG. 3.0321 STRESS-STRAIN CURVES IN COMPRESSION AT ELEVATED TEMPERATURES FOR SHEET IN CONDITIONS TH 1050 AND RH 950. (9, p. 29)

Fe
15 Cr
7 Ni
2.5 Mo
PH15-7Mo

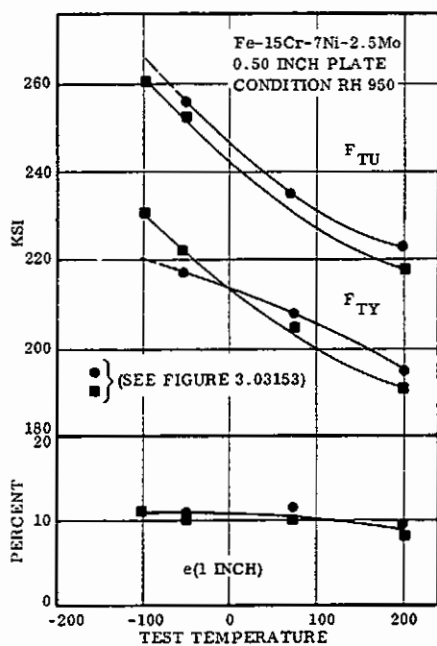


FIG. 3.03154 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF PLATE IN CONDITION RH 950. (23, p. 75)

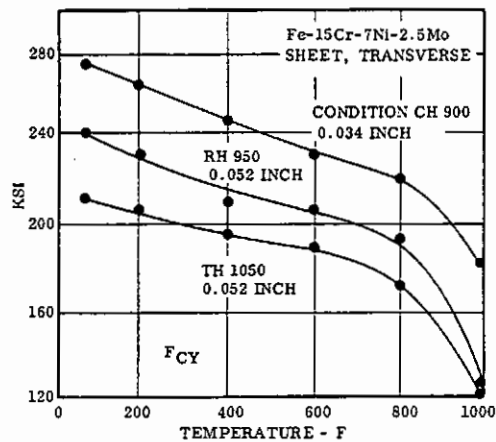


FIG. 3.0322 EFFECT OF TEST TEMPERATURE ON COMPRESSIVE YIELD STRENGTH OF SHEET IN CONDITIONS TH 1050, RH 950, AND CH 900. (12)

Fe
15 Cr
7 Ni
2.5 Mo

PH15-7Mo

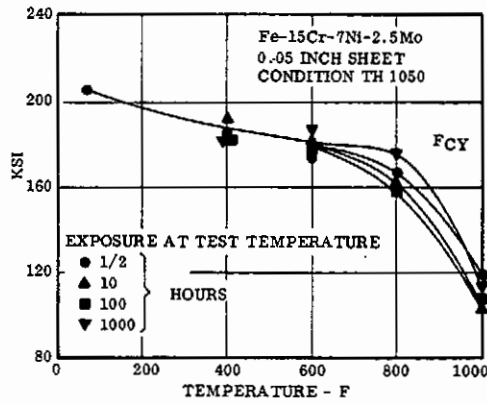


FIG. 3.0323 EFFECT OF EXPOSURE TIME AND TEST TEMPERATURE ON COMPRESSIVE YIELD STRESS OF SHEET IN CONDITION TH 1050. (25, p. 51-53)

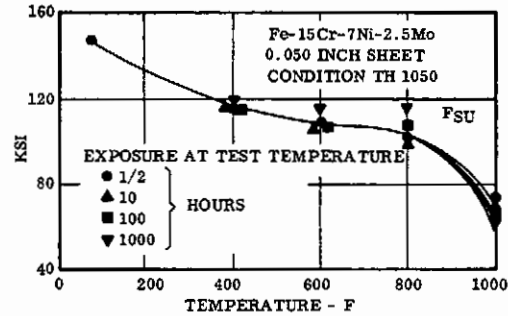


FIG. 3.0352 EFFECT OF EXPOSURE TIME AND TEST TEMPERATURE ON SHEAR STRENGTH OF SHEET IN CONDITION TH 1050. (25, p. 60-62)

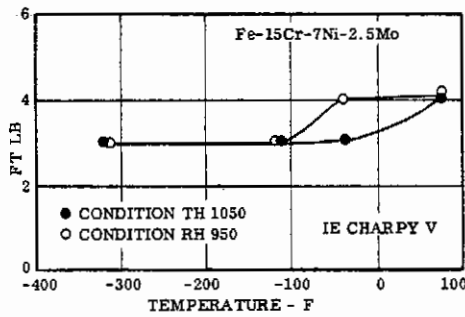


FIG. 3.0331 EFFECT OF LOW TEST TEMPERATURE ON IMPACT STRENGTH OF ALLOY IN CONDITION TH 1050 AND RH 950. (14, p. F-1-3, F-2-4)

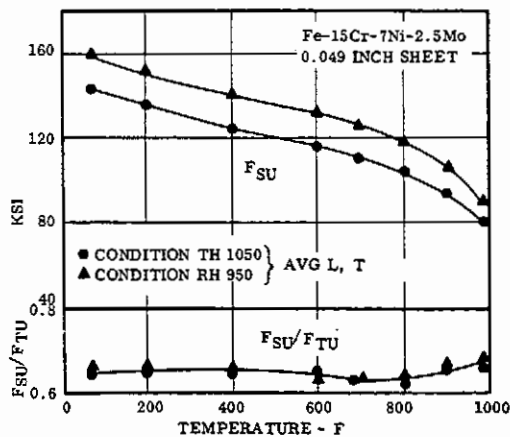


FIG. 3.0351 EFFECT OF TEST TEMPERATURE ON SHEAR STRENGTH OF SHEET IN CONDITIONS TH 1050 AND RH 950. (12, 2A-9-1)

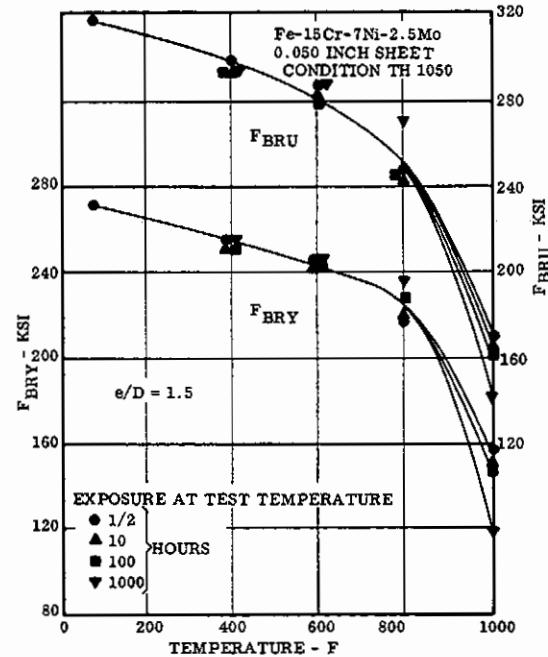


FIG. 3.0361 EFFECT OF EXPOSURE TIME AND TEST TEMPERATURE ON BEARING PROPERTIES OF SHEET IN CONDITION TH 1050. (25, p. 54-56)

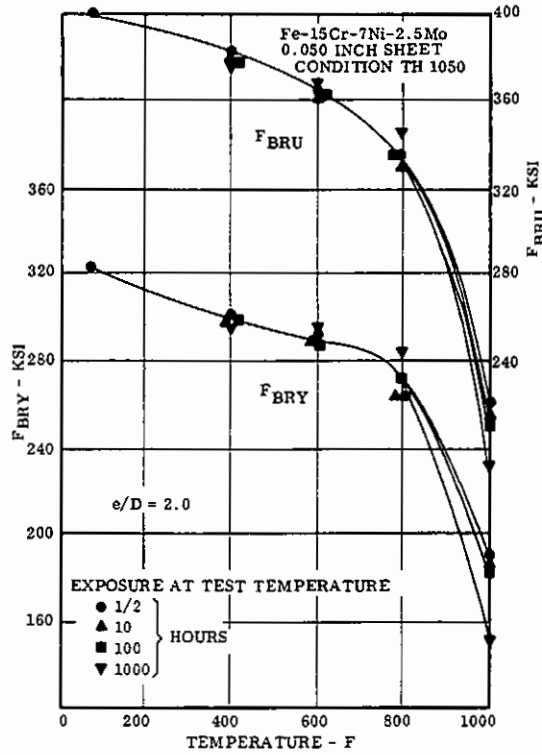


FIG. 3.0362 EFFECT OF EXPOSURE AND TEST TEMPERATURE ON BEARING PROPERTIES OF SHEET IN CONDITION TH 1050.  
(25, p. 57-59)

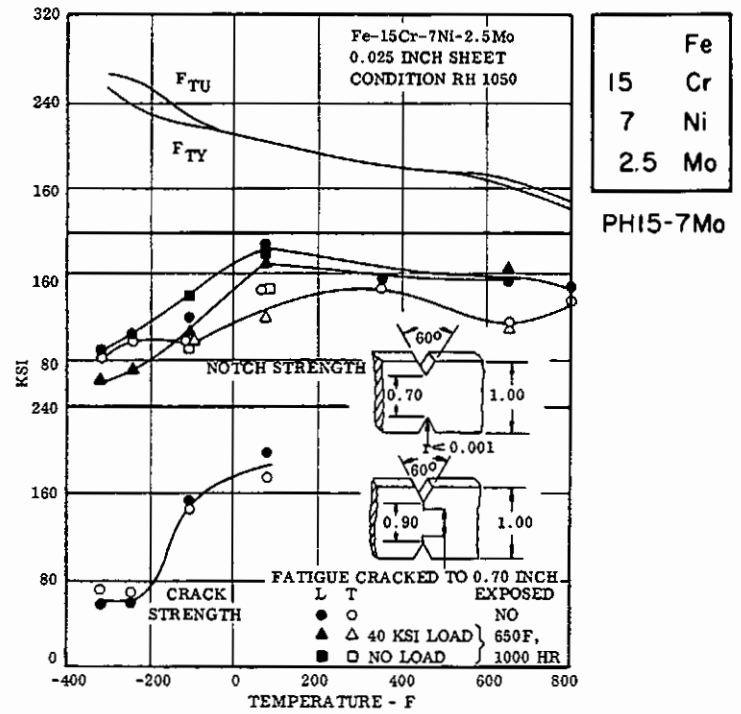


FIG. 3.03712 EFFECT OF TEST TEMPERATURE ON NOTCH AND CRACK STRENGTH OF SHEET IN CONDITION RH 1050.  
(20)

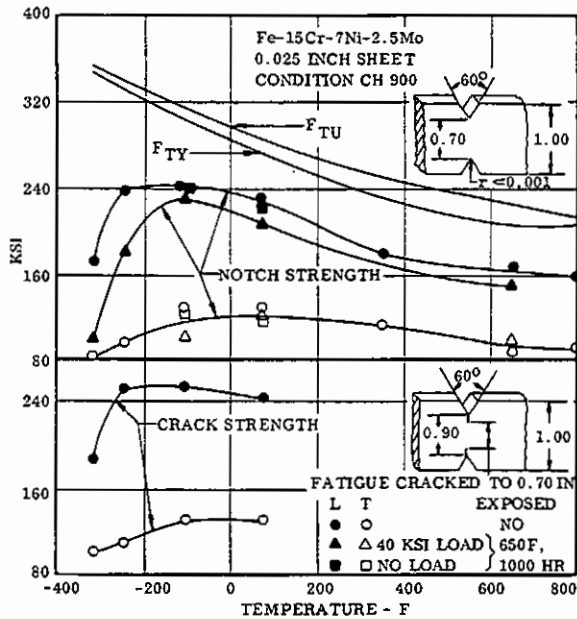


FIG. 3.03711 EFFECT OF TEST TEMPERATURE ON NOTCH AND CRACK STRENGTH OF SHEET IN CONDITION CH 900  
(20)

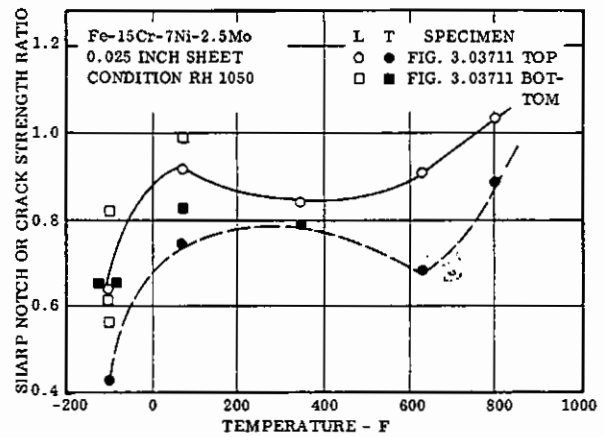


FIG. 3.03713 EFFECT OF TEST TEMPERATURE ON THE SHARP NOTCH TENSILE STRENGTH RATIO AND CRACK STRENGTH RATIO FOR SHEET IN CONDITION RH 1050.  
(28, p. 867)



REVISED: JUNE 1970

FERROUS ALLOYS

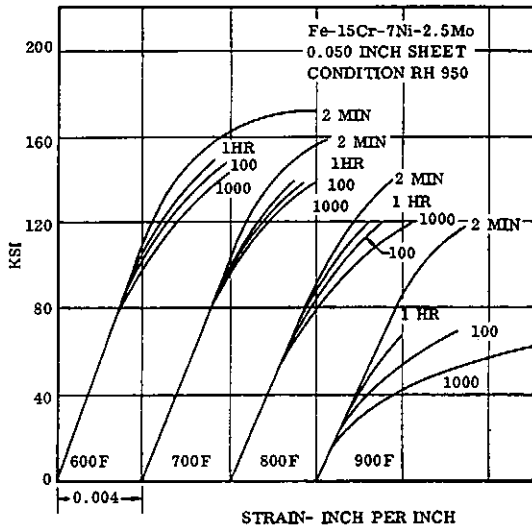
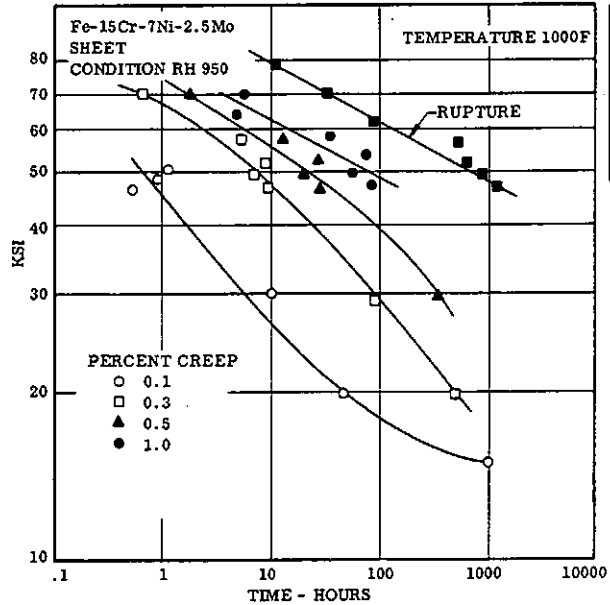


FIG. 3.043 ISOCHRONOUS STRESS-STRAIN CURVES FOR SHEET IN CONDITION RH 950 AT 600 TO 900F. (9, p. 37)



Fe
15 Cr
7 Ni
2.5 Mo
PH15-7Mo

FIG. 3.045 CREEP RUPTURE CURVES FOR ALLOY AT 1000 F IN CONDITION RH 950. (8, p. 663)

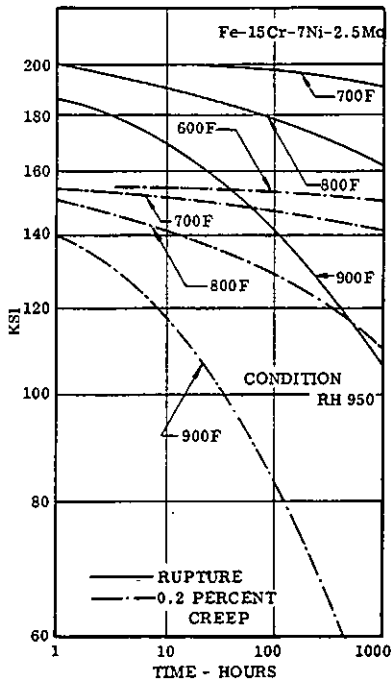


FIG. 3.044 CREEP AND CREEP RUPTURE CURVES FOR ALLOY IN CONDITION RH 950. (29, p. 345)

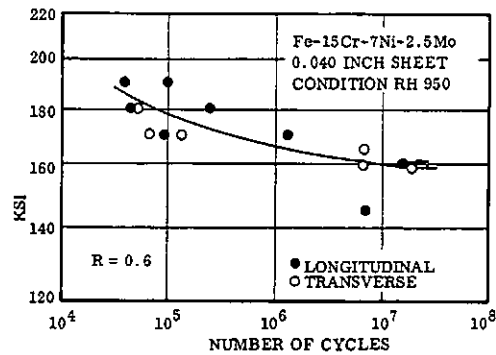


FIG. 3.051 S-N CURVE FOR SHEET IN CONDITION RH 950. (14, p. F-2-4)

Fe
15 Cr
7 Ni
2.5 Mo

PH15-7Mo

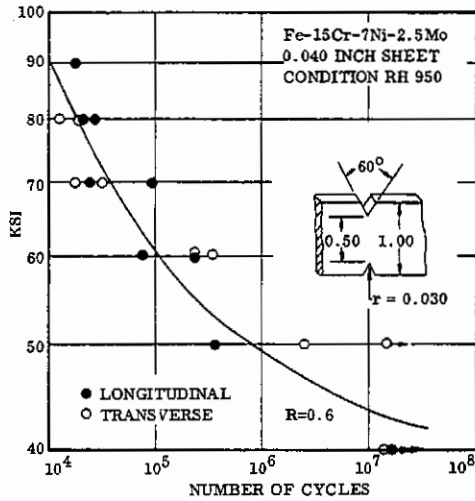


FIG. 3.052 S-N CURVE FOR NOTCHED SHEET IN CONDITION RH 950. (30, p. 12)

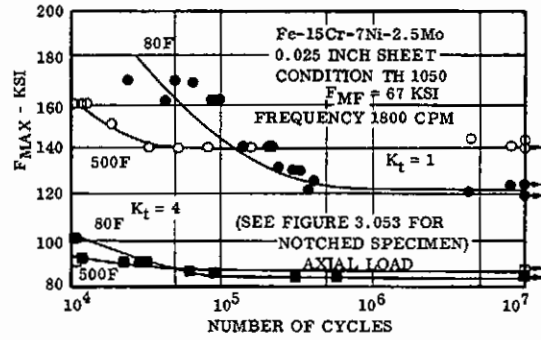


FIG. 3.055 S-N CURVES FOR NOTCHED AND SMOOTH SHEET AS A FUNCTION OF TEMPERATURE IN CONDITION TH 1050. (31, p. 21-23)

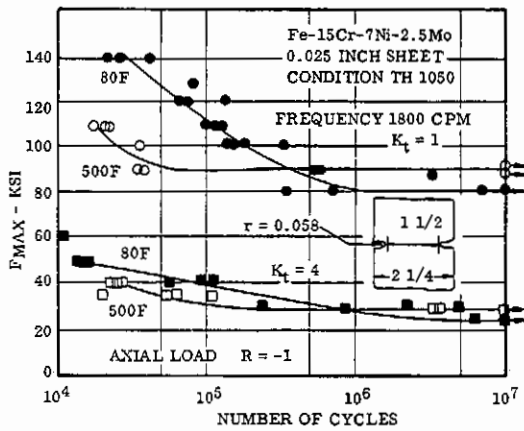


FIG. 3.053 S-N CURVES FOR NOTCHED AND SMOOTH SHEET AS A FUNCTION OF TEMPERATURE IN CONDITION TH 1050. (31, p. 21-23)

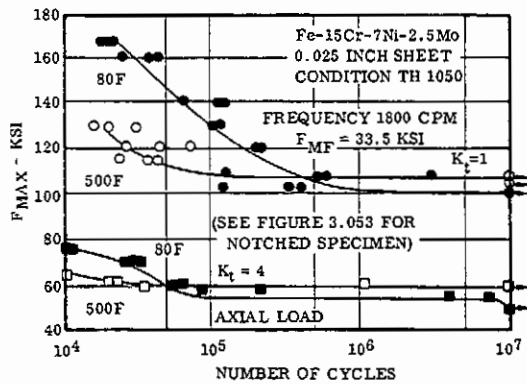


FIG. 3.054 S-N CURVES FOR NOTCHED AND SMOOTH SHEET AS A FUNCTION OF TEMPERATURE IN CONDITION TH 1050. (31, p. 21-23)

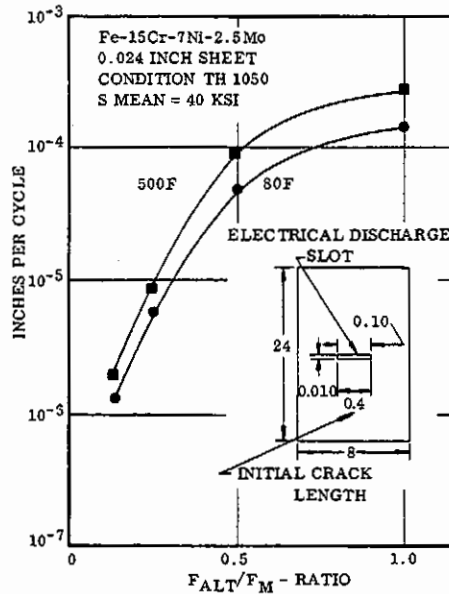
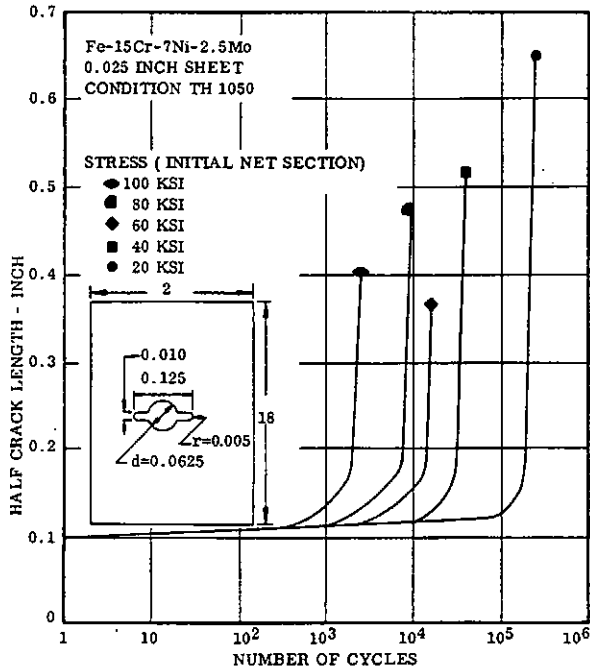


FIG. 3.056 FATIGUE-CRACK PROPAGATION RATE FOR TWO TEST TEMPERATURES FOR SHEET IN CONDITION TH 1050. (32, p. 18, 19)



	Fe
15	Cr
7	Ni
2.5	Mo

PH15-7Mo

FIG. 3.057 FATIGUE-CRACK PROPAGATION CURVES AS A FUNCTION OF INITIAL NET SECTION STRESS FOR SHEET IN CONDITION TH 1050. (33, p. 21)

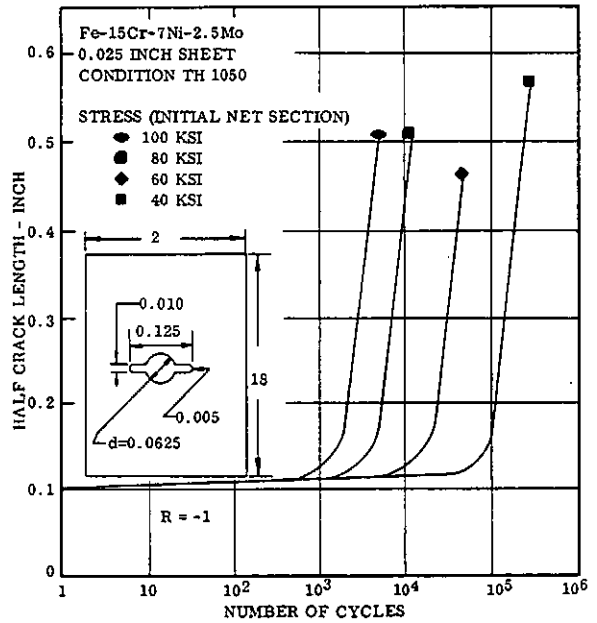


FIG. 3.058 FATIGUE-CRACK PROPAGATION CURVES AS A FUNCTION OF INITIAL NET SECTION STRESS FOR SHEET IN CONDITION TH 1050. (33, p. 22)

Fe  
15 Cr  
7 Ni  
2.5 Mo  
PH15-7Mo

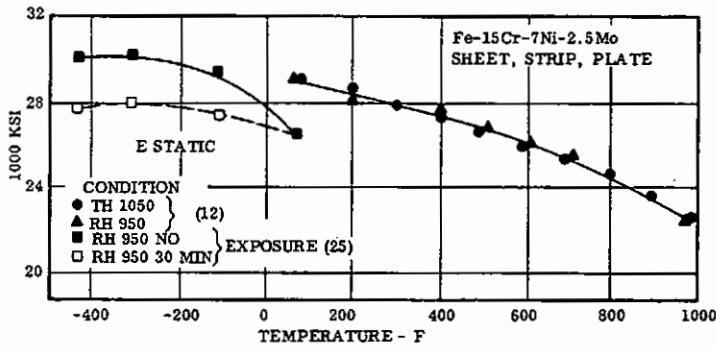


FIG. 3.0621 MODULUS OF ELASTICITY AT ROOM AND ELEVATED TEMPERATURES. (12, p. 2B-4-1)(25, p. 22)

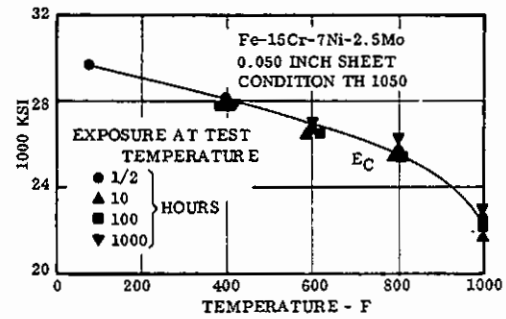


FIG. 3.0623 EFFECT OF EXPOSURE AND TEST TEMPERATURE ON MODULUS OF ELASTICITY IN COMPRESSION OF SHEET IN CONDITION TH 1050. (25, p. 51-53)

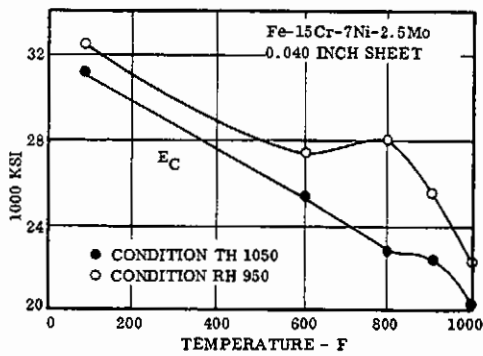


FIG. 3.0622 MODULUS OF ELASTICITY IN COMPRESSION AT ROOM AND ELEVATED TEMPERATURES. (34, p. 31, 46, 47)

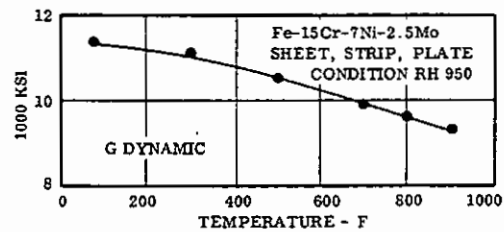


FIG. 3.0631 MODULUS OF RIGIDITY AT ROOM AND ELEVATED TEMPERATURES. (12, p. 2A-4-1)

	Fe
15	Cr
7	Ni
2.5	Mo

PH15-7Mo

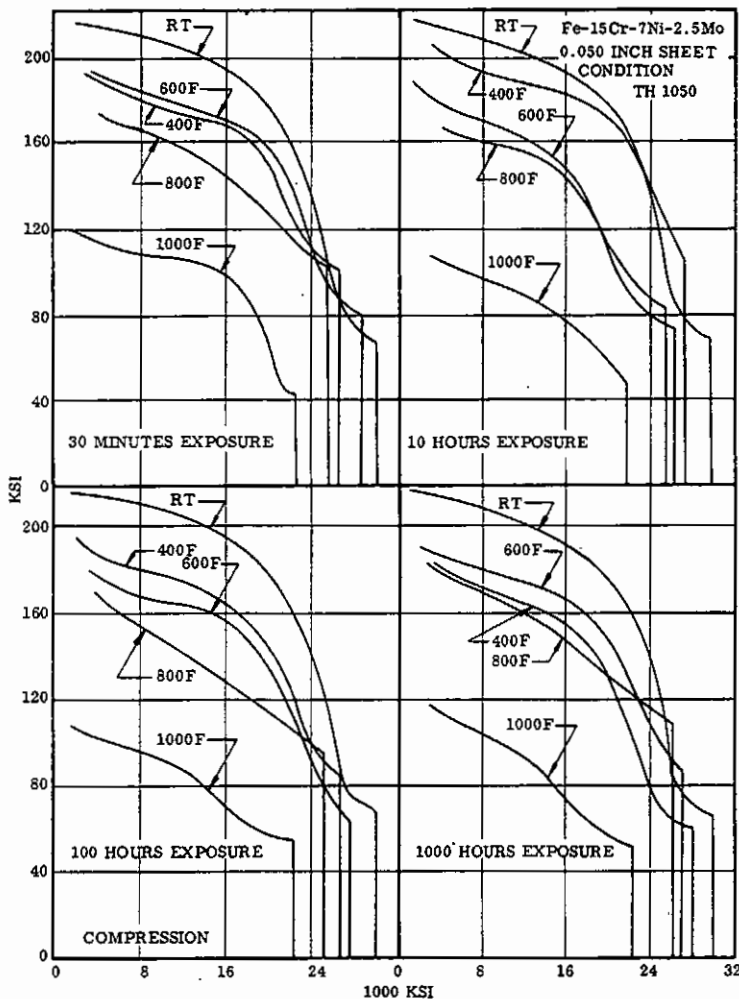


FIG. 3.0641 TANGENT MODULUS CURVES IN COMPRESSION FOR SHEET IN CONDITION TH 1050 AT ELEVATED TEMPERATURES AND FOR VARIOUS EXPOSURE TIMES. (25, p. 202-205)

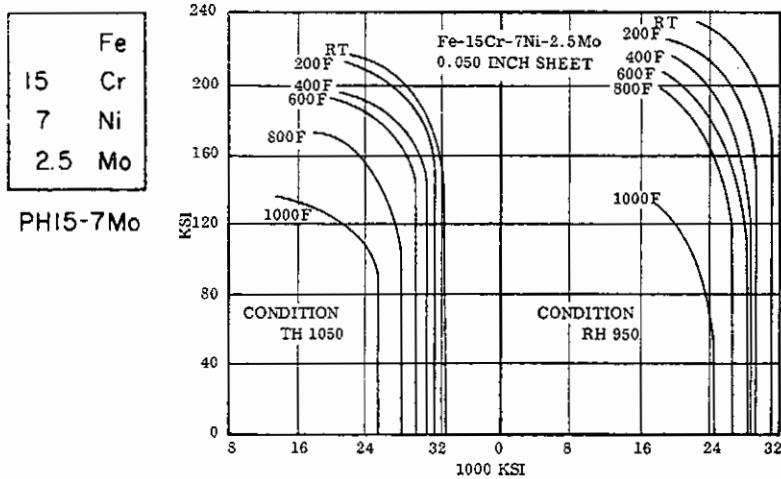


FIG. 3.0642 SECANT MODULUS CURVES IN COMPRESSION AT ELEVATED TEMPERATURES FOR SHEET IN CONDITIONS TH 1050 AND RH 950. (9, p. 30)

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