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FERROUS ALLOYS

1. GENERAL
 This sheet alloy is a precipitation hardening semi-austenitic stainless steel similar to 17-7PH in its general characteristics but having somewhat higher strength and better fracture toughness. The highest toughness and least directionality are obtained by vacuum melting. The alloy possesses good weldability by the GTA or electron beam processes; however, for critical applications welding should be confined to vacuum melted sheet using vacuum melted wire of a special composition. The alloy is unstable at moderately elevated temperatures and for long time exposures above about 500F, this instability can produce significant loss in fracture toughness. Fracture toughness decreases at subzero temperatures and the alloy should not be used at cryogenic temperatures.

1.01 Commercial Designation
 PH14-8Mo precipitation hardening stainless steel.

1.02 Alternate Designations
 None.

1.03 Specifications
 None.

1.04 Composition
 Table 1.04.

TABLE 1.04

Source	ARMCO (1)			
	Fe-14Cr-8Ni-2.5Mo-Al			
	Air Melt		Vacuum Melt	
Element	Percent		Percent	
	Minimum	Maximum	Minimum	Maximum
Aluminum	0.75	1.50	0.90	1.35
Carbon	-	0.05	-	0.05
Chromium	13.75	15.00	14.75	15.50
Manganese	-	1.00	-	0.10
Molybdenum	2.00	3.00	2.00	2.50
Nickel	7.50	8.75	8.00	8.75
Phosphorus	-	0.015	-	0.010
Silicon	-	1.00	-	0.10
Sulfur	-	0.010	-	0.008
Nitrogen	-	-	-	0.01
Iron	Balance		Balance	

1.05 Heat Treatment
 1.051 Anneal to Condition A, 1800 to 1850 F, 30 minutes, air cool (1) (see Figure 3.02141 for effect of solution temperature).
 1.052 Age Condition A to SRH conditions 1685 to 1715 F, 1 hour, air cool to room temperature (Condition A 1700) and within one hour cool to -100 F, 8 hours (Condition SR100) + age 1 hour, air cool. Aging at 940 to 960 F (Condition SRH 950) or 1040 to 1060 F (Condition SRH 1050) is generally used, with the higher temperature giving somewhat lower strength but better toughness (see Figures 3.02142 and 3.02143 for effect of aging temperature).
 1.053 Aging of cold worked alloy (Condition C) 890 to 910 F (Condition CH 900) 940 to 960 F (Condition CH 950) and 1040 to 1060 F (Condition CH 1050) 1 hour, air cool (1).

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

TABLE 1.061

Source	(1, pp. 8, 24)
Alloy	Fe-14Cr-8Ni-2.5Mo-Al
Condition	Rockwell Hardness C
A (a)	88 (c)
SRH950 (a)	49
SRH1050(a)	46
A(b)	88 (c)
SRH950 (b)	48
SRH1050 (b)	45
C (a)	42 (d)
CH950 (a)	52 (d)
CH1050 (a)	51 (d)

(a) Air melted.
 (b) Vacuum induction melted.
 (c) R_b
 (d) Applies to material 0.010 inch and thicker

1.062 Effect of cold rolling and cold rolling plus aging on the hardness of sheet, Figure 1.062.
 1.063 Effect of cold working on tensile properties and hardness for Condition CH 950 (see 3.02144).
 1.07 Forms and Conditions Available
 1.071 Forms. Sheet and strip.
 1.072 Condition. Annealed (Condition A) and cold worked (Condition C).

1.08 Melting and Casting Practice.
 Conventional stainless steel melting and casting practices. Electric arc and vacuum induction melts. Vacuum induction melting allows the full potential of the alloy to be realized because of the close control of quality and composition that is possible (1). For example, vacuum melting results in higher toughness properties and a reduction in the directionality of fracture toughness.

1.09 Special Considerations
 1.091 When PH14-8Mo is fabricated in Condition A, and subsequently heat treated, an allowance should be made for the dimensional change (an overall expansion of approximately 0.004 inches per inch) that occurs during heat treatment (1).
 1.092 Thorough cleaning prior to thermal treatments is recommended in order to avoid carburization and to minimize difficulties when descaling.

1.093 Embrittlement. As might be expected for martensitic stainless steels, this alloy exhibits a metallurgical instability which is manifest as an increase in the tensile yield strength and a decrease in the static crack propagation resistance when cracked or sharply notched specimens are exposed for long periods of time at moderately elevated temperatures and then tested at the exposure temperature or at lower temperatures (e.g. Figures 3.02151 through 3.02156, Figures 3.0313 and 3.03141 and Table 3.02713). These instability effects are not reduced by vacuum melting (see Figures 3.03713 and 3.03714) and appear to be larger the higher the strength level of the material (e.g. Table 3.02712). There is insufficient data to establish the time-temperature relation for the effect of the instability on the mechanical properties; however, it would appear that exposure at temperatures below about 400 F produces negligible embrittlement. In general, the longitudinal direction of sheet has a higher toughness than the transverse direction. However, this directionality is reduced by vacuum melting (see Figure 3.03712). The alloy has poor fracture toughness below about -200 F and should not be used at cryogenic temperatures (see Figure 3.03711).

2. PHYSICAL AND CHEMICAL PROPERTIES

2.01 Thermal Properties
 2.011 Melting range. 2580 to 2640 F.

14	Fe
8	Cr
2.5	Ni
	Mo
	Al

PH14-8Mo

14	Fe
8	Cr
2.5	Ni
	Mo
	Al

PH14-8Mo

- 2.012 Phase changes.
- 2.0121 Phases.
 - Condition A 92 percent austenite
8 percent ferrite
 - Condition SRH 77 percent martensite
15 percent austenite
8 percent ferrite (1).
- 2.013 Time-temperature-transformation diagrams.
- 2.014 Thermal conductivity, comparable to PH15-7Mo (3).
- 2.015 Thermal expansion, Figure 2.015.
- 2.0151 Dimensional changes on heat treating (see 1.091).
- 2.016 Specific heat.
- 2.017 Thermal diffusivity.

- 2.02 Other Physical Properties
- 2.021 Density, Table 2.021.

TABLE 2.021
(1, p. 29)

Source	(1, p. 29)		
Condition	A	SR-100	SRH950
lb per cu in	0.283	0.278	0.278
gr per cu in	7.82	7.69	7.71

- 2.022 Electrical resistivity.
- 2.023 Magnetic properties.
- 2.024 Emissivity.
- 2.025 Damping capacity.
- 2.03 Chemical Properties
- 2.031 General corrosion resistance of the alloy in the hardened condition is comparable or superior to that of 17-7PH and PH15-7Mo (1)(3).
- 2.032 Stress corrosion cracking. Results of stress-cracking exposure tests on air melted sheet in various conditions at Kure Beach, Table 2.032.

TABLE 2.032
(1, p. 32)

Source		(1, p. 32)					
Alloy		Fe-14Cr-8Ni-2.5Mo-Al					
Form		0.050 inch Sheet - Air Melt					
Condition	Direction	Original Properties		Stressed 80 percent F _{ty}		Stressed 50 percent F _{ty}	
		F _{tu} ksi	F _{ty} ksi	Stress ksi	Days to Failure 80 ft lot	Stress ksi	Days to Failure 80 ft lot
SRH 950	L	232	213	171	NF	107	NF
SRH 950 + 1000 hr at 650F	L	250	232	186	449 (1 of 5) (b)	116	NF
SRH 1050	L	213	205	164	NF	103	NF
SRH 1050 + 1000 hr at 650F	L	232	221	176	NF	110	NF
BCHT 1050(a)	L	220	212	170	NF	106	NF
BCHT 1050 + 1000 hr at 650F	L	236	226	181	NF	113	NF
SRH 950	T	241	225	180	NF	112	NF
SRH 950 + 1000 hr at 650F	T	261	236	189	159.2	118	NF
SRH 1050	T	221	213	170	NF	106	NF
SRH 1050 + 1000 hr at 650F	T	242	230	184	292 (3 of 5) (b)	115	NF
BCHT 1050	T	220	211	169	NF	105	NF
BCHT 1050 + 1000 hr at 650F	T	240	226	181	175.6	113	NF
CH 900	L	263	266	212	NF	133	NF
CH 900 + 1000 hr at 650F	L	294	291	233	NF	146	NF
CH 1050	L	238	233	186	NF	116	NF
CH 1050 + 1000 hr at 650F	L	258	254	203	NF	127	NF
CH 900	T	279	275	220	272(4/5)(b)	137	NF
CH 900 + 1000 hr at 650F	T	294	290	232	142.6	145	231.2
CH 1050	T	255	250	200	NF	125	NF
CH 1050 + 1000 hr at 650F	T	266	264	211	NF	132	NF

(a) Braze-cycle heat treatment.
 (b) Indicates number of specimens that failed at average time shown; remainder did not fail in 908 days.
 NF denotes no failure after 908 days.

- 2.04 Nuclear Properties
- 3. MECHANICAL PROPERTIES
- 3.01 Specific Mechanical Properties
Mechanical properties acceptable for material specifications for sheet and strip, Table 3.01.

TABLE 3.01
(1, p. 3)

Source	(1, p. 3)		
Alloy	Fe-14Cr-8Ni-2.5Mo-Al		
Form	Sheet and Strip		
Condition	A	SRH950	SRH1050
F _{tu} maximum - ksi	150	-	-
F _{tu} minimum - ksi	-	220	200
F _{ty} maximum - ksi	65	-	-
F _{ty} minimum - ksi	-	190	180
e(2 in) min-percent			
Thickness - inch			
0.1874-0.020	20	4	4
0.0199-0.010	20	3	3
0.0099-0.005	20	2	2
Hardness, R _c	100*max	45-51	38-45

* R_b
 Properties apply to both air and vacuum induction melts.
 Transverse data.
 All values minimum unless otherwise noted.

- 3.02 Mechanical Properties at Room Temperature
- 3.021 Tension.
- 3.0211 Stress-strain curves for sheet in Condition SRH 1050, Figure 3.0211.
- 3.0212 Producers mechanical properties for sheet and strip for annealed and SRH conditions, Table 3.0212.

TABLE 3.0212
(1, p. 8)

Source		(1, p. 8)				
Alloy		Fe-14Cr-8Ni-2.5Mo-Al				
Form		Sheet and Strip				
Condition	F _{tu} ksi	F _{ty} ksi	e(2 in) percent	Hardness R _c	Toughness W/A(a) in-lb/in ²	
Air Melted						
A	125	55	25	88 (b)	-	
SRH 950	235	220	5	49	850	
SRH 1050	215	205	5	46	1000	
Vacuum Induction Melted						
A	125	55	25	88 (b)	-	
SRH 950	230	215	6	48	1800	
SRH 1050	210	200	6	45	2200	

(a) Precracked sheet Charpy specimen: Same as ASTM E23-64, Figure 4A, except thickness of specimen is sheet thickness and specimen is precracked by fatigue to a depth of 0.030-0.060in
 (b) R_b
 Transverse data.

- 3.0213 Producers typical mechanical properties for sheet and strip for cold rolled conditions, Table 3.0213.

TABLE 3.0213
(1, p. 24)

Source		(1, p. 24)		
Alloy		Fe-14Cr-8Ni-2.5Mo-Al		
Form		Sheet and Strip		
Condition	C (a)	CH900	CH950	
F _{tu} - ksi	210	280	270	
F _{ty} - ksi	180	270	260	
e(2 in) - percent	5	1.5	1.5	
Hardness RC (b)	42	52	51	

(a) Condition C represents 60 percent cold reduction.
 (b) Applies to material 0.010 inch and thicker.
 Transverse data.

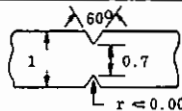
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- 3.0214 Effect of heat treatment and cold work on mechanical properties.
- 3.02141 Effect of solution temperature on the tensile properties of air melt sheet in Conditions A and SRH 950, Figure 3.02141.
- 3.02142 Effect of aging temperature on the tensile properties of high purity air melt sheet (SRH conditions), Figure 3.02142.
- 3.02143 Effect of aging temperature and time on the tensile and precracked Charpy impact properties of sheet (SRH conditions), Figure 3.02143.
- 3.02144 Effect of cold work on mechanical properties of air and vacuum melted sheet in Condition CH 950, Table 3.02144

TABLE 3.02144

Source		(1, p. 25)							
Alloy		Fe-14Cr-8Ni-2.5Mo-Al							
Form		0.025 inch Sheet							
Condition		CH 950							
Cold Reduction percent	Air Melted				Vacuum Induction Melted				
	40		60		40		60		
Direction	L	T	L	T	L	T	L	T	
F _{tu} - ksi	259	270	278	298	240	261	264	279	
F _{ty} - ksi	254	260	273	289	235	256	258	269	
e(2 in) percent	2.0	1.5	2.0	1.5	1.5	1.5	1.5	1.5	
NTS - ksi*	253	206	237	154	241	241	249	237	
Sharp notch to yield strength ratio	1.0	0.79	0.86	0.53	1.03	0.94	0.97	0.88	
Hardness, R _c	51	51	52	52	50	50	50	50	



- 3.02145 Effect of cold rolling on the tensile properties of as rolled and rolled and aged air melted sheet, Figure 3.02145.
- 3.0215 Effect of exposure on tensile properties.
- 3.02151 Effect of exposure temperature and time on the tensile properties of air melted sheet in SRH 950 Condition, Figure 3.02151.
- 3.02152 Effect of exposure temperature and time on the tensile properties of air melted sheet in SRH 1050 condition, Figure 3.02152.
- 3.02153 Effect of exposure temperature and time on the tensile and precracked Charpy impact properties of vacuum melted sheet in SRH 950 condition, Figure 3.02153.
- 3.02154 Effect of exposure temperature and time on the tensile and precracked Charpy impact properties of vacuum melted sheet in SRH 1050 condition, Figure 3.02154.
- 3.02155 Effect of exposure temperature and time on the tensile properties of air melted sheet in CH 900 condition, Figure 3.02155.
- 3.02156 Effect of exposure temperature and time on the tensile properties of air melted sheet in CH 1050 condition, Figure 3.02156.

- 3.02157 Effect of high temperature exposure temperature on the tensile properties of air melt sheet (SRH conditions), Figure 3.02157.
- 3.022 Compression. Compressive yield strength (0.2 percent) data indicate higher values in the transverse direction. Typical longitudinal and transverse values (average of 3 tests) are 214.5 and 220.1 ksi, respectively (4).
- 3.0221 Stress-strain diagrams.
- 3.023 Impact.
- 3.0231 General. Due to thickness limitations, impact values measured by the standard techniques (Charpy notch or Keyhole, Izod, tension impact, or drop weight tests) are not available. However, a limited amount of precracked Charpy impact data does exist for sheet material. Typical values are shown in Figures 3.02143, 3.02153, and 3.02154 which indicate the impact energy for Condition SRH 1050 is superior to that for Condition SRH 950. The precracked Charpy values are improved by vacuum melting (see Table 3.0212).
- 3.024 Bending. Comparable in bend quality to 17-7PH.
- 3.025 Torsion and shear. Ultimate shear strength data indicates slightly higher values in the longitudinal direction. Typical longitudinal and transverse values (average of 3 tests) are 133.3 and 131.4 ksi, respectively (4).
- 3.026 Bearing.
- 3.0261 Bearing properties of sheet in Condition SRH 1050, Table 3.0261.

	Fe
14	Cr
8	Ni
2.5	Mo
	Al

PH14-8Mo

TABLE 3.0261

Source		(4)		
Alloy		Fe-14Cr-8Ni-2.5Mo-Al		
Form		0.050 inch Sheet		
Condition		SRH1050		
Test Direction	e/D	F _{bry} - ksi	F _{bru} - ksi	
L	1.5	289.3	330.9	
T	1.5	290.9	332.2	
L	2.0	350.9	441.0	
T	2.0	353.5	441.3	

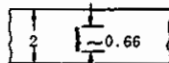
Each value represents the average of three tests.

- 3.027 Stress concentration.
- 3.0271 Notch properties.
- 3.02711 Effect of aging temperature on the sharp notch properties of high purity air melt sheet in SRH condition, Figure 3.02711.
- 3.02712 Tensile yield strength and crack strength for SRH 950, SRH 1050 and BCHT conditions before and after elevated temperature exposure, Table 3.02712.

TABLE 3.02712

Source		(3, p. 8)																	
Alloy		Fe-14Cr-8Ni-2.5Mo-Al																	
Form		0.050 inch Sheet, Air Melt																	
Condition	SRH 950						SRH 1050						BCHT 1050*						
	None		500F 1000 hr		650F 1000 hr		None		500F 1000 hr		650F 1000 hr		None		500F 1000 hr		650F 1000 hr		
Direction	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	
F _y - ksi	215	216	223	221	240	232	207	204	210	211	221	220	206	206	211	207	230	225	
Crack strength ksi	202	163	205	169	197	147	202	175	206	182	209	175	189	167	199	171	200	155	
Crack to yield strength ratio	0.94	0.75	0.92	0.76	0.82	0.63	0.98	0.86	0.98	0.86	0.94	0.79	0.92	0.81	0.94	0.82	0.87	0.69	

* Simulated braze cycle: 1675F, 15 min → 1000F in 30 min, AC + -100F, 8 hr + 1050F, 8 hr, AC.



Center fatigue crack, aged before cracking.

Fe
14 Cr
8 Ni
2.5 Mo
Al

PH14-8Mo

3.02713 Tensile yield strength and crack strength for CH 900 and CH 1050 conditions before and after elevated temperature exposure, Table 3.02713.

TABLE 3.02713

Source		(1, p. 28)															
Alloy		Fe-14Cr-8Ni-2.5Mo-Al															
Form		0.050 inch Sheet, Air Melt															
Condition		CH 900								CH 1050							
Exposure	Direction	None		500 F 1000 hr		650 F 1000 hr		500 F 10,000 hr		None		500 F 1000 hr		650 F 1000 hr		500 F 10,000 hr	
		L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
F _y - ksi		267	271	270	273	290	294	278	286	249	254	251	258	284	270	247	264
Crack strength ksi		233	142	243	135	227	119	192	111	223	159	229	169	236	153	190	119
Crack to yield strength ratio		0.86	0.52	0.90	0.50	0.78	0.41	0.69	0.39	0.89	0.62	0.91	0.65	0.83	0.57	0.77	0.45

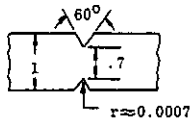
See Table 3.02712 for specimen design.

3.02714 Sharp notch properties for air and vacuum melted sheets as a function of cold working in the CH 950 condition (see Table 3.02144).

3.03142 Effect of test temperature on tensile and sharp notch properties of air melt sheet (SRH 950 condition) before and after elevated temperature stress exposure, Table 3.03142.

TABLE 3.03142

Source		(6, p. 38)															
Alloy		Fe-14Cr-8Ni-2.5Mo-Al															
Form		0.050 inch Sheet Air Melt															
Condition		SRH 950															
Exposure	Test Temp - F	None				550 F, 2,400 hr				550 F, 7,000 hr				550 F, 10,000 hr			
		80		-110		80		-110		80		-110		80		-110	
Direction	F _y - ksi	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
		F _y - ksi		183	184	210	206	186	186	203	197	191	201	214	222	193	189
F _{tu} - ksi		225	227	261	256	227	235	266	267	231	233	270	280	229	226	268	270
e(2 in) - percent		12	10	14	-	13	8	11	11	12	7	14	11	11	10	15	-
NTS - ksi		211	189	227	185	204	-	232	-	207	185	229	198	213	171	220	191
Sharp notch to yield strength ratio		1.2	1.0	1.1	.90	1.1	-	1.1	-	1.1	.92	1.1	.89	1.1	.90	1.1	.86



Notched before exposure

3.0272 Fracture toughness.
3.02721 General. Valid plane strain fracture toughness values (K_{Ic}) are not available for this alloy and probably could not be obtained in sheet gages except at cryogenic temperatures. However, a measure of the mixed mode fracture toughness can be obtained from tests on sharply notched or cracked specimens. Tests of these types indicate the toughness decreases with an increase in the yield strength. Thus, the SRH 1050 condition is slightly tougher than the SRH 950 condition (e.g. Figure 3.03711) and the CH 900 and CH 1050 conditions are considerably less tough than the corresponding SRH conditions (compare Table 3.02712 and Table 3.02713). As discussed in 1.09, long time exposure at moderately elevated temperatures can reduce the fracture toughness of this alloy in all commercial conditions of temper. The toughness is generally lower in the transverse than in the longitudinal direction although this directionality is reduced by vacuum melting (see Figure 3.03712). Fracture toughness at cryogenic temperatures is very poor (see Figure 3.03711).

3.03 Mechanical Properties at Various Temperatures

3.031 Tension.
3.0311 Stress-strain diagrams.
3.0312 Effect of test temperature on the tensile properties of normal and high purity air melt sheet (SRH 950 condition), Figure 3.0312.
3.0313 Effect of test temperature on the tensile properties of high purity air melt sheet (SRH 1050 condition), Figure 3.0313.
3.0314 Effect of exposure on tensile properties at elevated temperatures.
3.03141 Effect of test temperature on tensile properties of air melt sheet (SRH 950 condition) before and after elevated temperature stress exposure, Figure 3.03141.

3.03143 Effect of test temperature on tensile properties of vacuum melt sheet (SRH 950 condition) before and after elevated temperature stressed exposure, Figure 3.03143.
3.03144 Effect of test temperature on tensile properties of vacuum melt sheet (SRH 1050 condition) before and after elevated temperature stressed exposure, Figure 3.03144.
3.032 Compression.
3.033 Impact(see also 3.0231). Limited data available indicates a large difference in (W/A) values for the SRH conditions. Typical values obtained at -300 F for vacuum melted SRH 950 and SRH 1050 conditions are 800 and 1676 in-lbs/in², respectively (1, p. 13). Air melted data for Condition SRH 1050 is much lower - 814 in-lbs/in² (1, p. 13).
3.034 Bending.
3.035 Torsion and shear.
3.036 Bearing.
3.037 Stress concentration.
3.0371 Notch properties.
3.03711 Effect of test temperature on the sharp notch properties of high purity air melt sheet in SRH 950 and SRH 1050 conditions, Figure 3.03711.
3.03712 Effect of test temperature on longitudinal and transverse sharp notch properties of air and vacuum melted sheet (SRH 950 condition), Figure 3.03712.
3.03713 Effect of test temperature on the longitudinal and transverse sharp notch properties of air and vacuum melted sheet (SRH 950 condition) after elevated temperature stress exposure, Figure 3.03713.
3.03714 Effect of test temperature on the transverse sharp notch properties of air and vacuum melted sheet (SRH 950 condition) before and after elevated temperature stressed exposure, Figure 3.03714.

- 3.03715 Effect of test temperature on tensile and sharp notch properties of air melt sheet (SRH 950 condition) before and after elevated temperature stress exposure (see Table 3.03142).
- 3.03716 Effect of test temperature on the crack strength of sheet (SRH 1050 condition) before and after elevated temperature creep exposure (cracked after exposure), Table 3.03716.

- 3.053 Fatigue-crack propagation curves as a function of test temperature and alternating stress amplitude for sheet in Condition SRH 950, Figure 3.053.
- 3.054 Fatigue-crack propagation rate at three temperatures for sheet in Condition SRH 950, Figure 3.054.

	Fe
14	Cr
8	Ni
2.5	Mo
	Al

PH14-8Mo

TABLE 3.03716

Source		(7, pp. 179, 195)											
Alloy		Fe-14Cr-8Ni-2.5Mo-Al											
Form		0.025 inch Sheet											
Condition		SRH 1050											
Exposure		None		550 F 754 hr		550 F 1000 hr		550 F 6000 hr		550 F 25,060 hr		550 F 25,800 hr	
Test Temp		RT	-65 F	RT	-65 F	RT	-65 F	RT	-65 F	RT	-65 F	RT	-65 F
Crack Strength ksi		199	243	227	255	229	249	235	253	232	244	237	252
Crack to Yield Strength Ratio		0.91	1.08	1.03	1.11	1.02	1.05	1.08	1.12	1.04	1.05	1.06	1.08

Fatigue Crack — 1/4 Elox Notch

Specimen Cracked After Exposure

Longitudinal data, average of 4 or more tests.

- 3.0372 Fracture toughness, (see 3.0272).
- 3.038 Combined properties.
- 3.04 Creep and Creep Rupture Properties
- 3.041 Effect of stress level on smooth creep properties for sheet in Condition SRH 1050, Figure 3.041.
- 3.042 Effect of exposure (time and temperature) and creep stress on room temperature and elevated temperature tensile properties for sheet in Condition SRH 1050, Table 3.042.

- 3.06 Elastic Properties
- 3.061 Poisson's ratio.
- 3.062 Modulus of elasticity.
- 3.0621 Young's modulus, E. Static E:

Condition	Temperature - F	Direction	E - 10 ⁶ psi
SRH 950	550	L	23.3
		T	-
	RT	L	28.3
		T	29.4
	-109	L	29.4
		T	-

TABLE 3.042

Source		(7, pp. 155-157)						
Alloy		Fe-14Cr-8Ni-2.5Mo-Al						
Form		0.025 inch Sheet						
Condition		SRH 1050						
Creep Stress Level - ksi	Exposure Temp - F	Exposure Time - hr	Static Test Temp - F	F _{ty} (a) ksi	F _{tu} (a) ksi			
-	-	-	RT	199(b)	216(b)			
-	-	-	550	174(b)	190(b)			
Heat soaked only	550	754	RT	209	220			
			550	178	192			
		1,000	RT	209	222			
			550	177	194			
		6,000	RT	200	218			
			550	180	194			
25,060	RT	210	221					
	550	175	195					
103	550(c)	754	RT	194	219			
			550	189	202			
1,000		RT	195	224				
		550	189	200				
6,000		RT	192	224				
		550	180	196				
25,060	RT	205	221					
	550	175	195					
Heat soaked only	550(d)	25,800	RT	209	223			
			550	181	195			
RT			203	220				
550			176	197				

(a) Average of 3 or more tests.
 (b) Data supplied by Armco Steel Corporation.
 (c) Intermittent heating and loading.
 (d) Creep applied during steady state heating.

- 3.063 Modulus of rigidity.
- 4. FABRICATION
- 4.01 Formability
(see 17-7PH and PH15-7Mo)
- 4.02 Machining and Grinding
(see 17-7PH)
- 4.03 Welding
- 4.031 General. The general welding characteristics of this alloy are similar to those of 17-7PH and PH15-7Mo. GTA or electron beam welds in the annealed sheet followed by SRH treatment possess essentially 100 percent tensile strength joint efficiency (see Tables 4.035, 4.036 4.038, and 4.039). Welding wire composition may be similar to that of the parent metal. However, where good weld toughness is required a special vacuum melted wire composition should be used (Table 4.032). Based on precracked Charpy test specimen results, welds in air melted material are likely to have low toughness even when the special wire is used (see Table 4.033). However, welds in vacuum melted sheet using the special filler have W/A values somewhat higher than those obtained for the parent metal (compare Table 4.034 and Table 3.0212). Heat treatment may be adapted to either high or low temperature brazing cycles. However, brazing temperatures higher than 1975 F may cause grain growth and intergranular penetration which will adversely effect the final heat treated properties. The alloy is readily brazed in Condition A, then transformed and aged. However, variations in brazing cycle and heat treating sequence are possible. A series of brazing cycle heat treatments is shown in Table 4.0311. Care should be taken to see that parts are not under tension while the brazing alloy is liquid or intergranular cracking may occur. Parts should be thoroughly cleaned before and after brazing in order to obtain best brazing results.

- 3.05 Fatigue Properties
- 3.051 S-N curves for smooth sheet as a function of stress ratio in Condition SRH 1050, Figure 3.051.
- 3.052 S-N curves for notched sheet as a function of stress ratio in Condition SRH 1050, Figure 3.052.

Fe
14 Cr
8 Ni
2.5 Mo
Al
PH14-8Mo

4.032 Composition of precipitation-hardening weld wire available for use as filler wire, Table 4.032.

TABLE 4.032
(1, p. 41)

Source	Fe-14Cr-8Ni-2.5Mo-Al	
Alloy	Fe-14Cr-8Ni-2.5Mo-Al	
Form	Sheet and Strip	
Composition Range - Percent		
Element	Weld Wire WPH14-8Mo(a)	Weld Wire WPH13-8Mo(b)
C	0.02-0.05	0.05 max
Mn	1.00 max	1.00 max
P	0.015 max	0.015 max
S	0.010 max	0.010 max
Si	1.00 max	1.00 max
Cr	13.50-15.50	12.00-14.00
Ni	7.50-9.50	7.00-9.00
Mo	2.00-3.00	2.00-3.00
Al	0.75-1.50	0.75-1.50

(a) Air melted, similar in composition to PH14-8Mo base material and is satisfactory filler in many applications.
(b) Vacuum melted, recommended for joining vacuum melted materials or where maximum strength, ductility, and toughness are required.

4.035 Tensile properties of air and vacuum melted electron beam welded sheet in the SRH conditions, Table 4.035.

TABLE 4.035
(1, p. 45)

Source	Fe-14Cr-8Ni-2.5Mo-Al			
Alloy	Fe-14Cr-8Ni-2.5Mo-Al			
Form	0.050 inch Sheet			
Condition	Vacuum Melted		Air Melted	
	EB + SRH950	EB + SRH1050	EB + SRH950	EB + SRH1050
F _{ty} - ksi	218	208	214	203
F _{tu} - ksi	229(a)	209(a)	224(b)	206(c)
e(2 in) percent	3.5	2	3.5	3

(a) Fracture in heat affected zone.
(b) Fracture in fusion line.
(c) Fracture at junction of fusion line and base metal.

4.033 Mechanical properties of GTA welded joints for air melted sheet in SRH conditions, Table 4.033.

TABLE 4.033
(1, p. 43)

Source	Fe-14Cr-8Ni-2.5Mo-Al			
Alloy	Fe-14Cr-8Ni-2.5Mo-Al			
Form	0.050 inch Sheet, Air Melted			
Condition	Annealed + Welded + SRH 950		Annealed + Welded + SRH 1050	
Filler	Heat A	Heat B	Heat A	Heat B
(a) F _{ty} - ksi	204	195	196	191
(b) F _{ty} - ksi	216	208	199	194
(a) F _{tu} - ksi	217(c)	211(c)	201(d)	195(c)
(b) F _{tu} - ksi	227(c)	224(c)	207(d)	204(c)
(a) e(2 in) - percent	1.2	3.0	2.7	2.0
(b) e(2 in) - percent	2.3	2.3	4.3	4.6
(a) W/A - in lbs/in ²	227	97	168	142
(b) W/A - in lbs/in ²	253	370	-	550

(a) WPH14-8Mo
(b) WPH13-8Mo
(c) Fracture in weld metal
(d) Fracture in base metal
(e) See Table 3.0212.

4.036 Effect of test temperature on the tensile properties of air melted, GTA welded sheet in the SRH 950 condition, Table 4.036.

TABLE 4.036
(1, p. 45)

Source	Fe-14Cr-8Ni-2.5Mo-Al		
Alloy	Fe-14Cr-8Ni-2.5Mo-Al		
Form	0.025 in Sheet, Air Melted		
Condition	GTA Welded + SRH 950		
Test Temperature	650F	RT	-100F
F _{ty} - ksi	176	189	-
F _{tu} - ksi (a)	198	224	246
e(2 in) - percent	2.8	2.3	0.5

(a) All fractures in weld metal.

4.034 Mechanical properties of GTA welded joints for vacuum melted sheet in SRH conditions, Table 4.034.

TABLE 4.034
(1, p. 44)

Source	Fe-14Cr-8Ni-2.5Mo-Al	
Alloy	Fe-14Cr-8Ni-2.5Mo-Al	
Form	0.050 inch Sheet, Vacuum Melted	
Condition	Annealed + Welded + SRH950	Annealed + Welded + SRH 1050
(a) F _{ty} - ksi	209	199
(b) F _{ty} - ksi	216	206
(a) F _{tu} - ksi	215	200
(b) F _{tu} - ksi	230	210
(a) e(2 in) - percent	1.5	1.7
(b) e(2 in) - percent	2.5	2.8
(a) W/A - in lbs/in ²	2217	2667
(b) W/A - in lbs/in ²	2443	2760

(a) Nonc.
(b) WPH 13-8Mo
(c) See Table 3.0212.
All Tensile fractures occurred in weld metal.

4.037 Sharp notch properties at low and elevated temperatures for welded sheet in the SRH 1050 condition, Table 4.037.

TABLE 4.037
(1)

Source	Fe-14Cr-8Ni-2.5Mo-Al			
Alloy	Fe-14Cr-8Ni-2.5Mo-Al			
Form	0.050 in Sheet, Air Melted			
Condition	GTA Weld + SRH 1050			
Crack Location	Parent Metal		Weld	HAZ
Direction	L	T		
Notch Strength ksi (a)				
-100F	-	-	96	217
RT	202	175	170	193
650F	-	-	142	146

(a) For specimen see Table 3.02712.

4.038 Effect of exposure time and temperature on the tensile properties of air melted welded sheet in SRH conditions, Table 4.038.

TABLE 4.038

Source		(1, p. 46)			
Alloy		Fe-14Cr-8Ni-2.5Mo-Al			
Form		0.050 inch Sheet, Air Melted			
Condition	Exposure	F _{ty} ksi	F _{tu} ksi	e(2 in) percent	Fracture Location
SRH950	None	216	227	8	-
EB + SRH950		214	224	3.5	FL
SRH950	1270 hrs -650F	230	243	9	-
EB + SRH950		227	239	4	FL/BM
SRH950	1060 hrs -750F	246	258	6	-
EB + SRH950		245	253	2.5	WM/FL
SRH1050	None	202	207	6.5	-
EB + SRH1050		203	206	3	FL/BM
SRH1050	1270 hrs -650F	217	223	5.5	-
EB + SRH1050		213	217	3.5	WM/FL
SRH1050	1060 hrs -750F	235	236	5	-
EB + SRH1050		230	234	2	FL

FL - Fusion Line
BM - Base Metal
WM - Weld Metal

4.039 Effect of exposure time and temperature on the tensile properties of vacuum melted welded sheet in SRH conditions, Table 4.039.

TABLE 4.039

Source		(1, p. 47)			
Alloy		Fe-14Cr-8Ni-2.5Mo-Al			
Form		0.050 inch Sheet, Vacuum Melted			
Condition	Exposure	F _{ty} ksi	F _{tu} ksi	e(2 in) percent	Fracture Location
SRH950	None	221	235	6	-
EB + SRH950		218	230	3.5	HAZ
GTA + SRH950		224	235	2	WM
SRH950	1270 hrs -650F	236	251	6	-
EB + SRH950		233	247	3	HAZ/BM
GTA + SRH950		242	245	2	WM
SRH950	1060 hrs -750F	247	266	3.5	-
EB + SRH950		247	262	3.5	HAZ/BM
GTA + SRH950		235	260	1	WM
SRH1050	None	209	212	4	-
EB + SRH1050		208	209	2	HAZ
GTA + SRH1050		210	210	1.5	WM
SRH1050	1270 hrs -650F	224	228	4	-
EB + SRH1050		224	227	2.5	HAZ/W
GTA + SRH1050		224	224	1.5	WM
SRH1050	1060 hrs -750F	239	245	4.5	-
EB + SRH1050		240	244	2.5	WM
GTA + SRH1050		244	245	2.5	WM

HAZ - Heat Affected Zone
WM - Weld Metal
BM - Base Metal

Fe
14 Cr
8 Ni
2.5 Mo
Al

PH14-8Mo

4.0310 Tensile and hardness properties of sheet produced by various brazing cycle heat treatments, Table 4.0310.

TABLE 4.0310

Source		(1, p. 40)			
Alloy		Fe-14Cr-8Ni-2.5Mo-Al			
Form		Sheet			
Brazing Cycle		F _{ty} ksi	F _{tu} ksi	e(2 in) percent	Hardness R _c
A	Air Melted	201	221	7	48.5
B		208	223	5.5	49
C		221	238	8	49.5
D		217	234	8	49
E		212	228	5	48
F		217	226	4	46.5
G		211	219	4	46
H		210	217	4	45.5
J		208	215	4.5	45.5
K		209	217	4.5	45.5
L		212	227	4.5	47.5
F		Vacuum Melted	212	-	5
G	208		-	6	44
H	205		-	6	44
J	200		-	7	43
K	198		-	7	44
L	209		-	5.5	46

A - 1950F, 10 min; Cool to 1700F in 5/10 min, Hold 30 min; Cool to 100F in 20 min; Cool to 75F; Cool to -100F, hold 8 hrs; 950F, 30 hrs.
B - 1950F, 10 min; Cool to 1000F in 20 min; Cool to 75F; 1700F 30 min; Cool to 1000F in 20 min; Cool to 75F; Cool to -100F, hold 8 hrs; 950F, 3 hrs.
C - 1740F, 15 min; Cool to 1000F in 17 min; Cool to 75F; Cool to -100F, hold for 8 hrs; 950F, 1 hr.
D - Same as cycle C except cooling time to 1000F was 120 min.
E - Same as cycle C except cooling time to 1000F was 165 min.
F - Heat to 1600F in 8 hrs; heat to 1685F in 30 min; hold 15 min; Cool to 1525F in 30 min; hold 2 hrs; cool to 1000F in 1 hr; Cool to 300F in 4 hrs; air cool to 75F; Cool to -160F in 5 hrs, hold 8 hrs; Warm to 30F in 10 hrs; Air warm to 75F; Harden at 1050F, 1 hr.
G - Same as cycle F except cool to -100F in 3 hrs, hold 8 hrs; warm to 30F in 9 hrs.
H - Same as cycle F except cool to -100F in 5 hrs; hold 4 hrs; warm to 30F in 11 hrs.
J - Same as cycle F except cool to -50F in 2 hrs, hold 8 hrs; warm to 30F in 7 hrs.
K - Same as cycle F except cool to -50F in 2 hrs, hold 8 hrs; warm to 30F in 7 hrs.
L - Heat to 1600F in 8 hrs; Heat to 1685F in 45 min; Hold 15 min; Cool to 1000F in 50 min; Cool to 300F in 4 hrs; air cool to 75F; Cool to -140F in 4 hrs, hold 8 hrs; warm to 30F in 10 hrs; Air warm to 75F; Harden at 1050F, 1 hr; air cool.

Fe	4.0311
14 Cr	4.0312
8 Ni	4.0313
2.5 Mo	
Al	

PH14-8Mo

4.0311 Effect of test temperature on tensile properties of vacuum melt sheet given simulated braze cycle and tested before and after elevated temperature stressed exposure, Figure 4.0311.

4.0312 Effect of test temperature on the sharp notch properties of vacuum melted sheet given simulated braze cycle and tested before and after elevated temperature exposure, Figure 4.0312.

4.0313 Effect of exposure time and temperature on the tensile properties of vacuum melted sheet in various simulated braze cycle conditions, Table 4.0313.

TABLE 4.0313

Source	(1, p. 47)				
Alloy	Fe-14Cr-8Ni-2.5Mo-Al				
Form	0.050 inch Sheet, Vacuum Melted				
Condition	Exposure	F _{ty} ksi	F _{tu} ksi	e(2 in) percent	Fracture Location
BCHT 950	None	222	233	4.5	-
EB + BCHT 950		228	237	3	WM/BM
TIG + BCHT950		216	216	2	WM
BCHT 950 + EB		157	157	1.5	FL/WM
BCHT 950	1270 hr -650 F	242	256	4	-
EB + BCHT 950		243	249	2	WM/HAZ
TIG + BCHT950		240	239	1.5	WM
BCHT 950 + EB		173	190	1	FL/W
BCHT 950	1060hr -750 F	261	272	3	-
EB + BCHT950		257	268	2	WM
TIG + BCHT950		251	251	1	WM
BCHT 950 + EB		200	209	1	WM
BCHT 1050	None	211	215	6	-
EB + BCHT1050		210	213	2.5	WM
TIG+BCHT1050		206	206	4	WM
BCHT 1050	1270 hr -650 F	224	227	3.5	-
EB+BCHT 1050		232	226	2	HAZ
TIG+BCHT1050		207	207	1.5	WM
BCHT 1050	1060 hr -750 F	240	246	3.5	-
EB + BCHT1050		243	247	1.5	WM
TIG + BCHT1050		231	231	1.5	WM

See Tables 4.038 and 4.039 for definition of fracture locations.

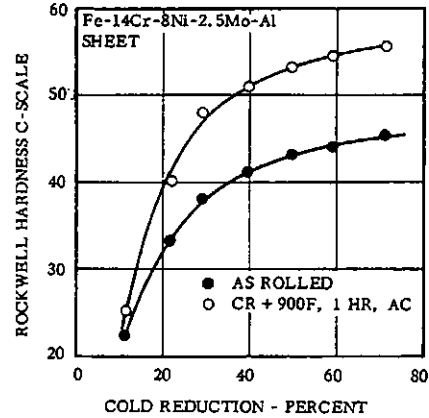


FIG. 1.062 EFFECT OF COLD ROLLING AND COLD ROLLING PLUS AGING ON THE HARDNESS OF SHEET (1)

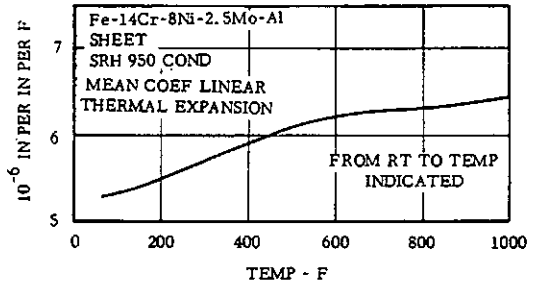


FIG. 2.015 THERMAL EXPANSION (1)

4.04 **Heat Treatment**
(see also 17-7PH, 4.043 and 4.044)

4.041 Air is a satisfactory furnace atmosphere for annealing or heat treating. Electric furnaces or full-muffle fuel-fired furnaces to protect the material from combustion products and flame impingement are best suited for heat treatment. Dry hydrogen, argon, helium, or vacuum atmospheres may be used for annealing if quench rates approaching air cooling can be attained. Controlled atmospheres such as dissociated ammonia are not recommended because of the hazard of nitriding. Molten salts should not be used because of the danger of carburization or intergranular attack (3). For complete freedom from scale or heat discoloration, a vacuum furnace is required.

4.05 **Surface Treating**
(see also 17-7PH, 4.051 and 4.052)

4.051 Some degree of intergranular penetration usually occurs during any pickling operation. However, in Conditions A and CH 900, the penetration resulting from acid pickling is usually slight (1).

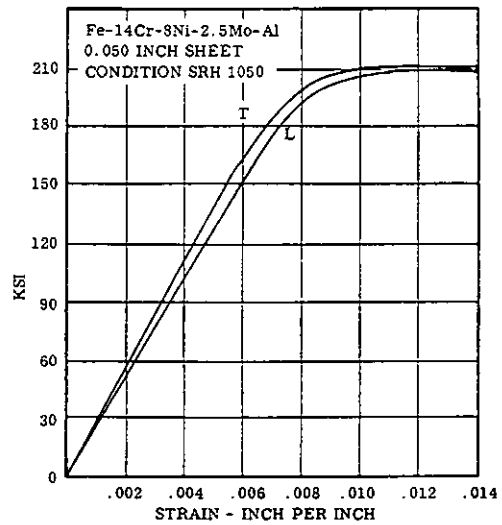


FIG. 3.0211 STRESS-STRAIN CURVES FOR SHEET IN CONDITION SRH 1050. (4)

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FERROUS ALLOYS

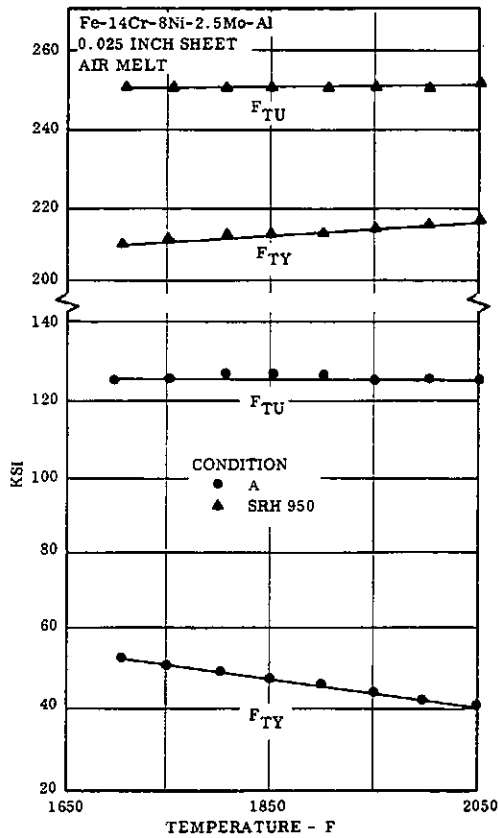


FIG. 3.02141 EFFECT OF SOLUTION TEMPERATURE ON THE TENSILE PROPERTIES OF AIR MELTED SHEET IN CONDITIONS A AND SRH 950. (1, p. 21)

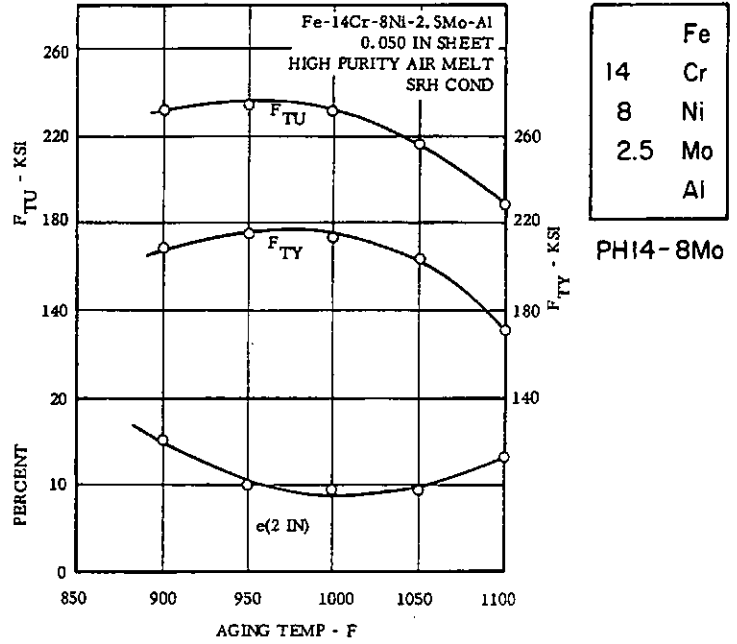


FIG. 3.02142 EFFECT OF AGING TEMPERATURE ON THE TENSILE PROPERTIES OF HIGH PURITY AIR MELT SHEET (SRH CONDITIONS) (5)

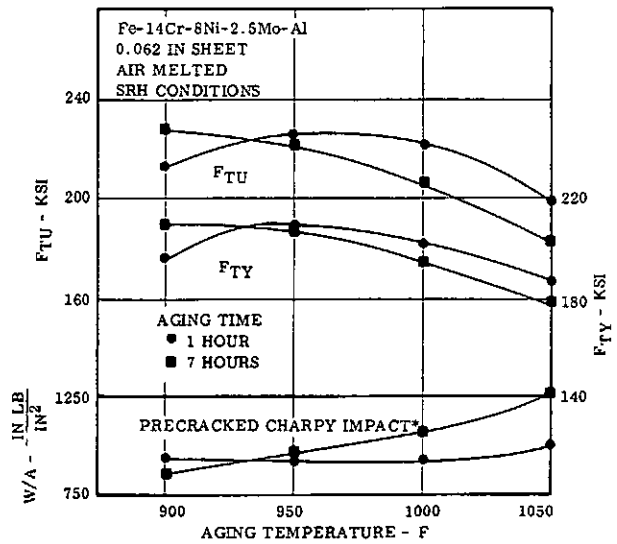


FIG. 3.02143 EFFECT OF AGING TEMPERATURE ON THE TENSILE AND PRECRACKED CHARPY IMPACT PROPERTIES OF SHEET (SRH CONDITIONS). (1, p. 23)

* see Table 3.0212

	Fe
14	Cr
8	Ni
2.5	Mo
	Al

PH14-8Mo

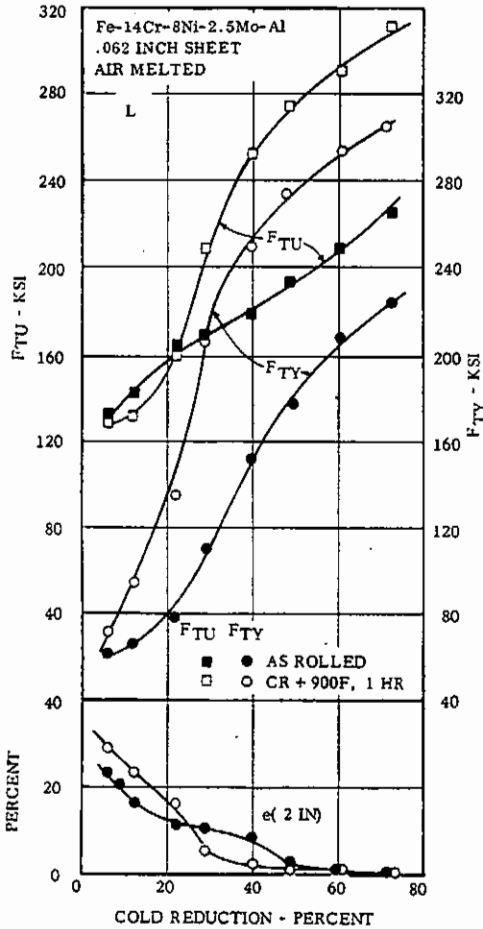


FIG. 3.02145 EFFECT OF COLD ROLLING ON THE TENSILE PROPERTIES OF AS ROLLED AND ROLLED AND AGED AIR MELTED SHEET. (1, p. 24)

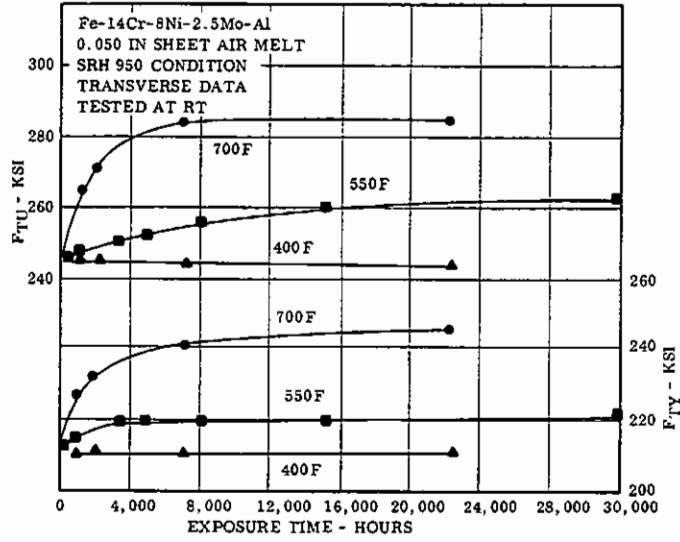


FIG. 3.02151 EFFECT OF EXPOSURE TEMPERATURE AND TIME ON THE TENSILE PROPERTIES OF AIR MELTED SHEET IN SRH 950 CONDITION. (1, p. 14)

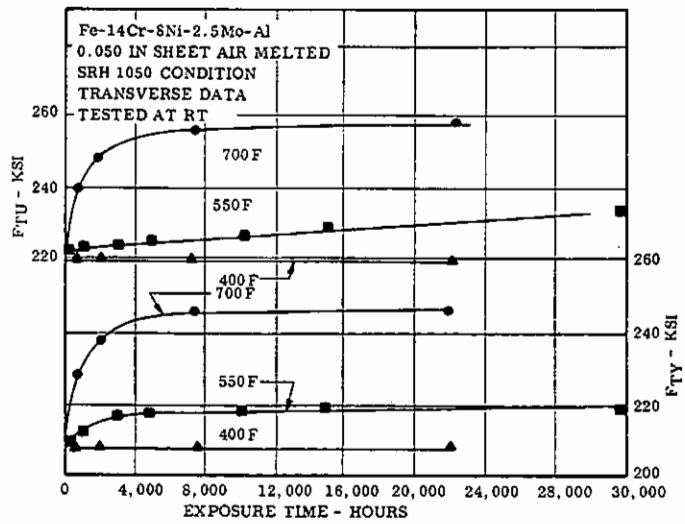


FIG. 3.02152 EFFECT OF EXPOSURE TEMPERATURE AND TIME ON THE TENSILE PROPERTIES OF AIR MELTED SHEET IN SRH 1050 CONDITION. (1, p. 14)

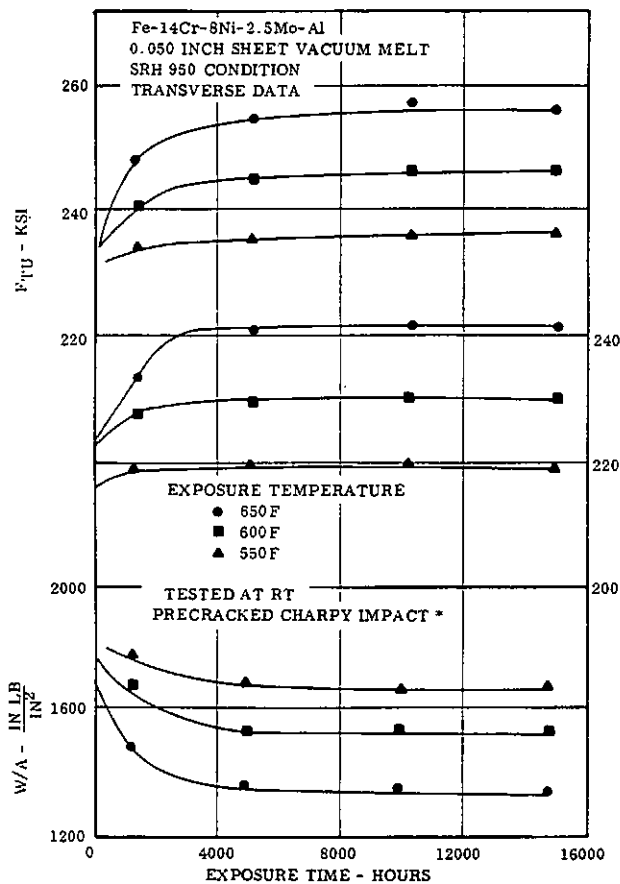


FIG. 3.02153 EFFECT OF EXPOSURE TEMPERATURE ON TIME ON THE TENSILE AND PRECRACKED CHARPY IMPACT PROPERTIES OF VACUUM MELTED SHEET IN SRH 950 CONDITION. (1, p. 19)

* See Table 3.0212.

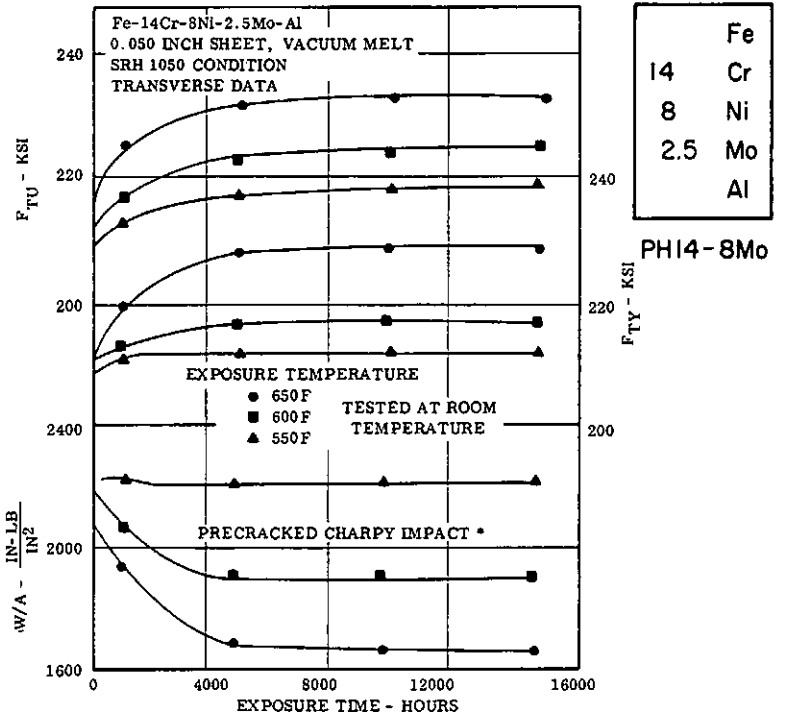


FIG. 3.02154 EFFECT OF EXPOSURE TEMPERATURE AND TIME ON THE TENSILE AND PRECRACKED CHARPY IMPACT PROPERTIES OF VACUUM MELTED SHEET IN SRH 1050 CONDITION. (1, p. 20)

*See Table 3.0212.

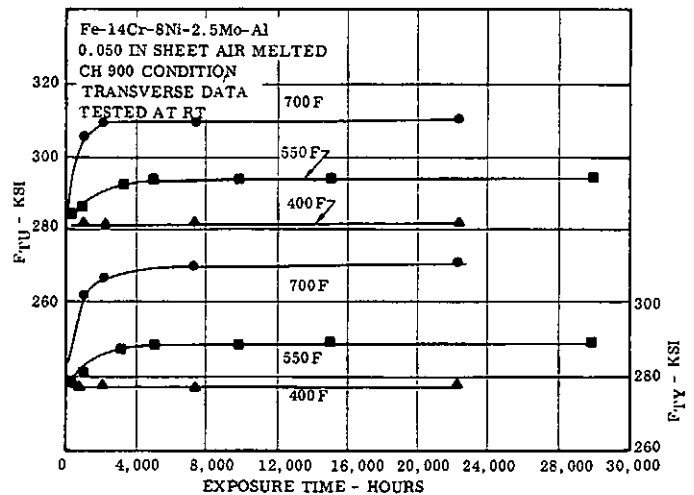


FIG. 3.02155 EFFECT OF EXPOSURE TEMPERATURE AND TIME ON THE TENSILE PROPERTIES OF AIR MELTED SHEET IN CH 900 CONDITION. (1, p. 26)

Fe
14 Cr
8 Ni
2.5 Mo
Al

PH14-8Mo

	Fe
14	Cr
8	Ni
2.5	Mo
	Al

PH14-8Mo

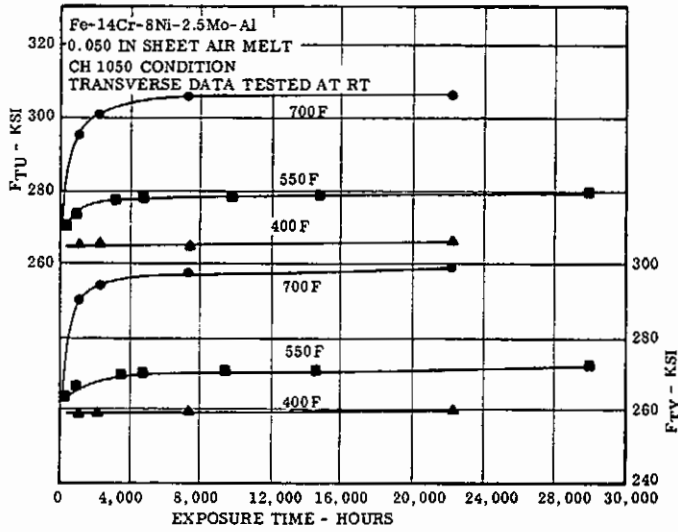


FIG. 3.02156 EFFECT OF EXPOSURE TEMPERATURE AND TIME ON THE TENSILE PROPERTIES OF AIR MELTED SHEET IN CONDITION CH 1050. (1, p. 27)

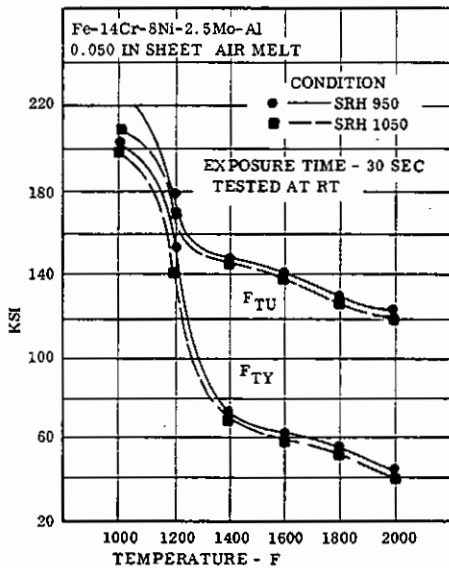


FIG. 3.02157 EFFECT OF HIGH TEMPERATURE EXPOSURE TEMPERATURE ON THE TENSILE PROPERTIES OF AIR MELT SHEET (SRH CONDITIONS). (1, p. 11)

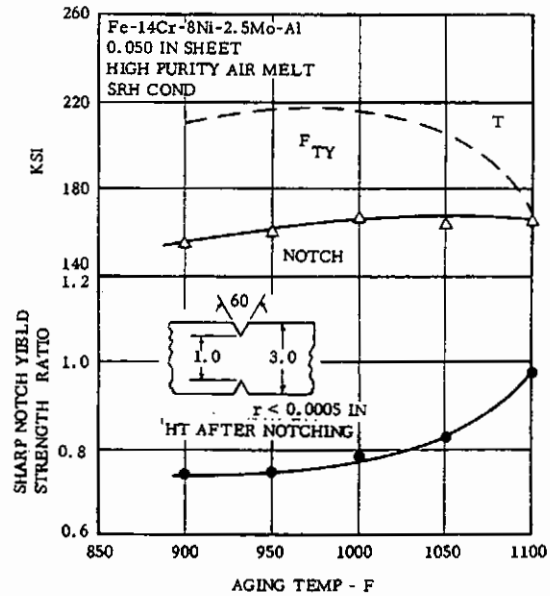


FIG. 3.02711 EFFECT OF AGING TEMPERATURE ON THE SHARP NOTCH PROPERTIES OF HIGH PURITY AIR MELT SHEET IN SRH CONDITION (5)

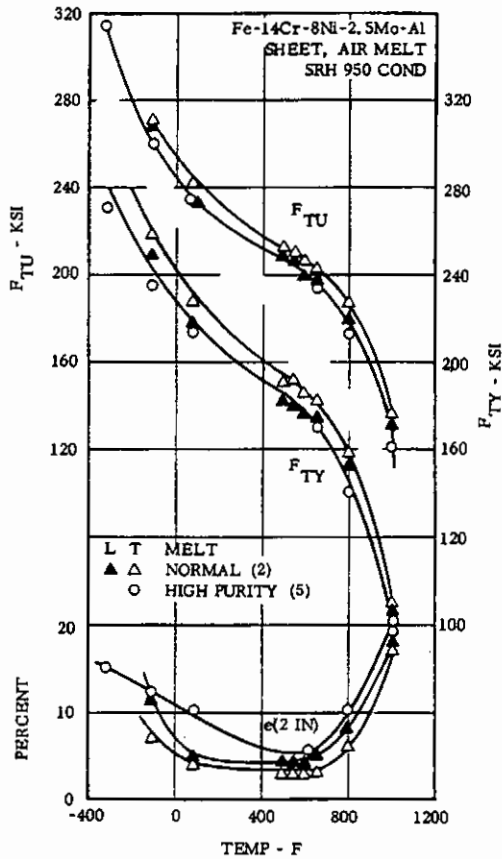


FIG. 3.0312 EFFECT OF TEST TEMPERATURE ON THE TENSILE PROPERTIES OF NORMAL AND HIGH PURITY AIR MELT SHEET (SRH 950) (2)(5)

	Fe
14	Cr
8	Ni
2.5	Mo
	Al

PH14-8Mo

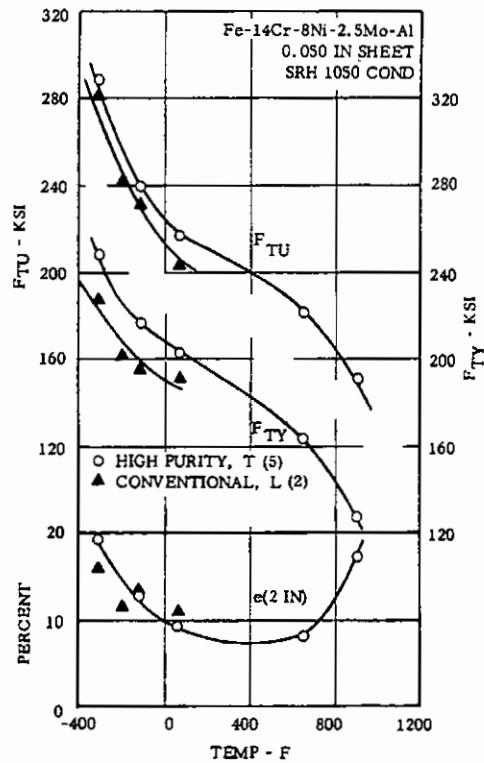


FIG. 3.0313 EFFECT OF TEST TEMPERATURE ON THE TENSILE PROPERTIES OF HIGH PURITY AIR MELT SHEET (SRH 1050) (2)(5)

	Fe
14	Cr
8	Ni
2.5	Mo
	Al

PH14-8Mo

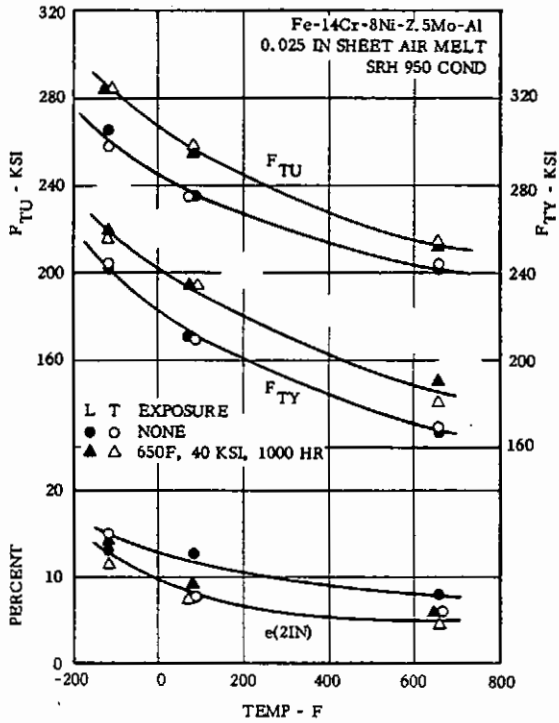


FIG. 3.03141 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF AIR MELT SHEET (SRH 950) BEFORE AND AFTER ELEVATED TEMPERATURE STRESSED EXPOSURE (5)

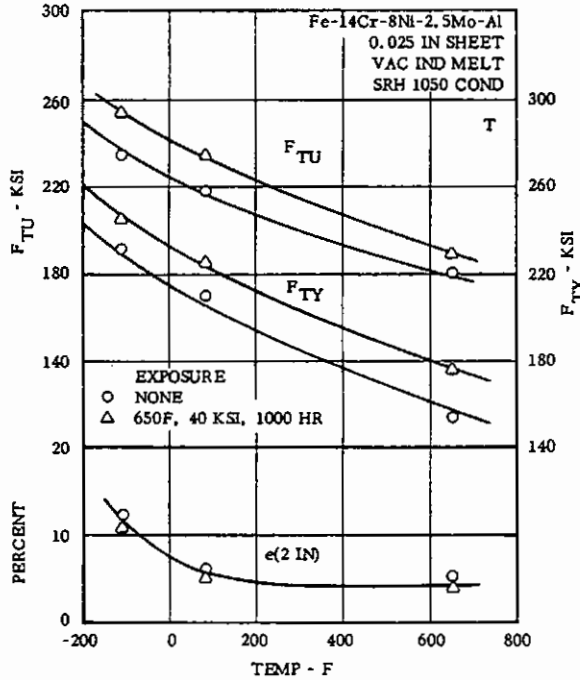


FIG. 3.03144 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF VACUUM MELT SHEET (SRH 1050) BEFORE AND AFTER ELEVATED TEMPERATURE STRESSED EXPOSURE (5)

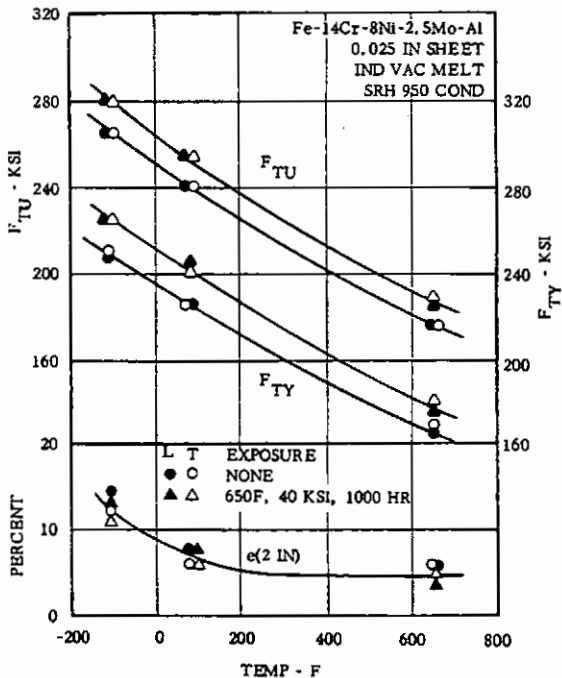


FIG. 3.03143 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF VACUUM MELT SHEET (SRH 950) BEFORE AND AFTER ELEVATED TEMPERATURE STRESSED EXPOSURE (5)

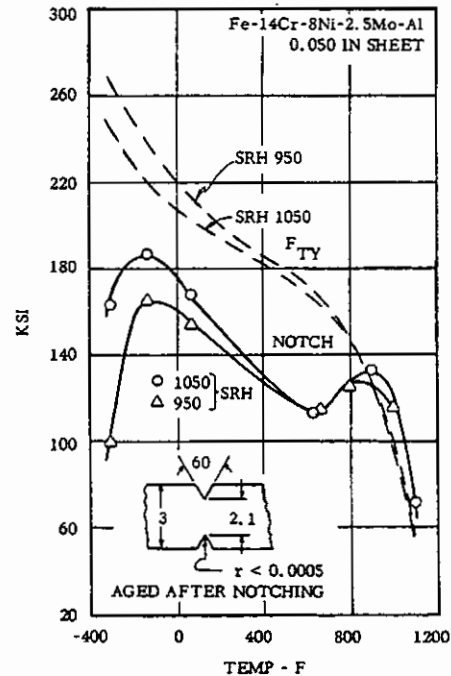


FIG. 3.03711 EFFECT OF TEST TEMPERATURE ON THE SHARP NOTCH PROPERTIES OF HIGH PURITY AIR MELT SHEET IN SRH 950 AND SRH 1050 CONDITIONS (5)

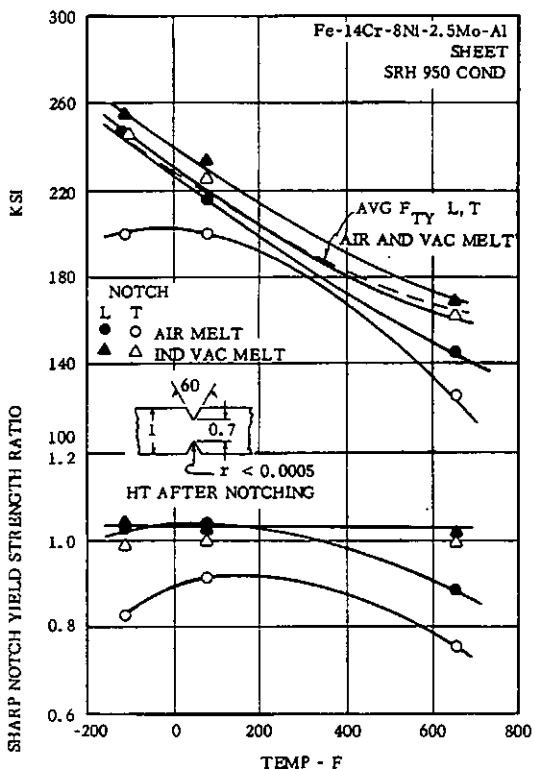


FIG. 3.03712 EFFECT OF TEST TEMPERATURE ON LONGITUDINAL AND TRANSVERSE SHARP NOTCH PROPERTIES OF AIR AND VACUUM MELTED SHEET (SRH 950) (5)

	Fe
14	Cr
8	Ni
2.5	Mo
	Al

PH14-8Mo

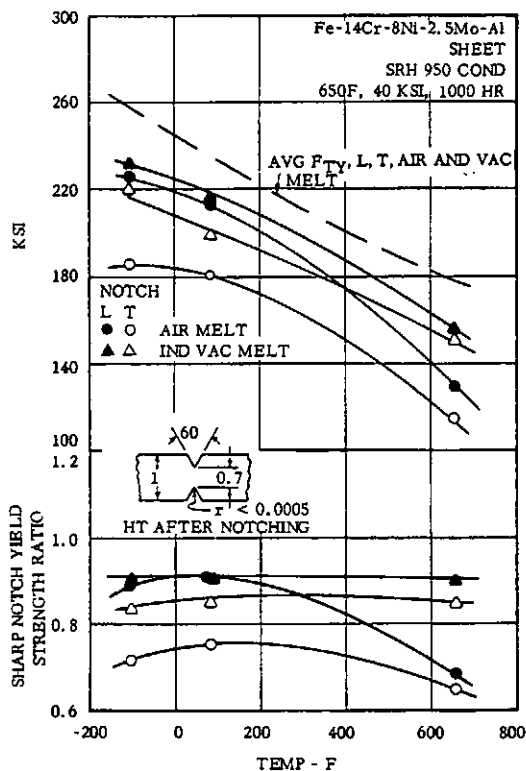


FIG. 3.03713 EFFECT OF TEST TEMPERATURE ON THE LONGITUDINAL AND TRANSVERSE SHARP NOTCH PROPERTIES OF AIR AND VACUUM MELTED SHEET (SRH 950) AFTER ELEVATED TEMPERATURE STRESS EXPOSURE (5)

	Fe
14	Cr
8	Ni
2.5	Mo
	Al

PH14-8Mo

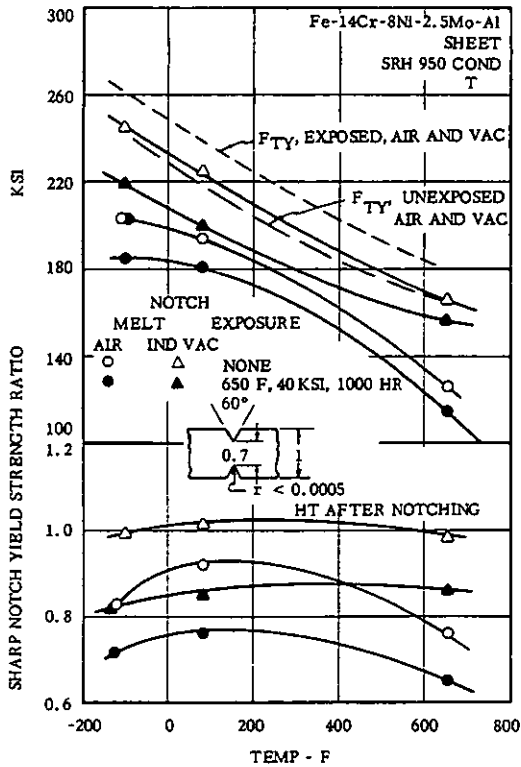


FIG. 3.03714 EFFECT OF TEST TEMPERATURE ON THE TRANSVERSE SHARP NOTCH PROPERTIES OF AIR AND VACUUM MELTED SHEET (SRH 950) BEFORE AND AFTER ELEVATED TEMPERATURE STRESSED EXPOSURE (5)

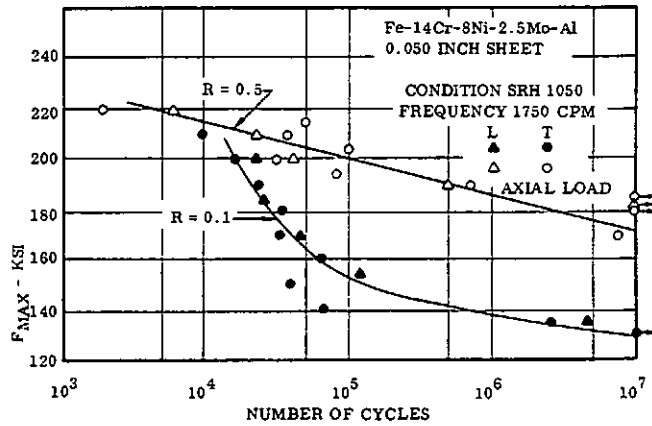


FIG. 3.051 S-N CURVES FOR SMOOTH SHEET AS A FUNCTION OF STRESS RATIO IN CONDITION SRH 1050. (4)

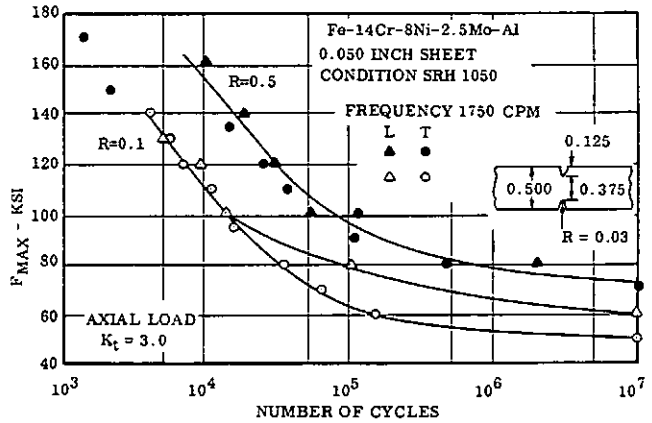


FIG. 3.052 S-N CURVES FOR NOTCHED SHEET AS A FUNCTION OF STRESS RATIO IN CONDITION SRH 1050. (4)

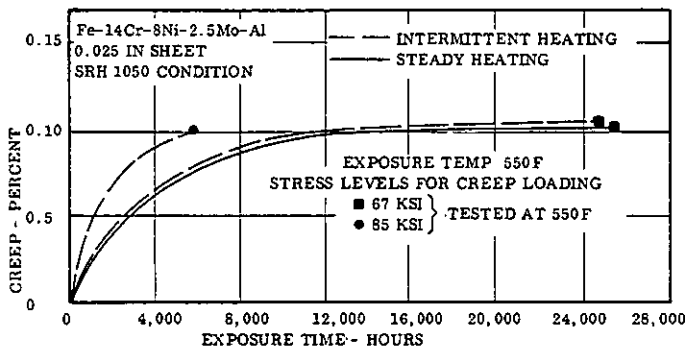
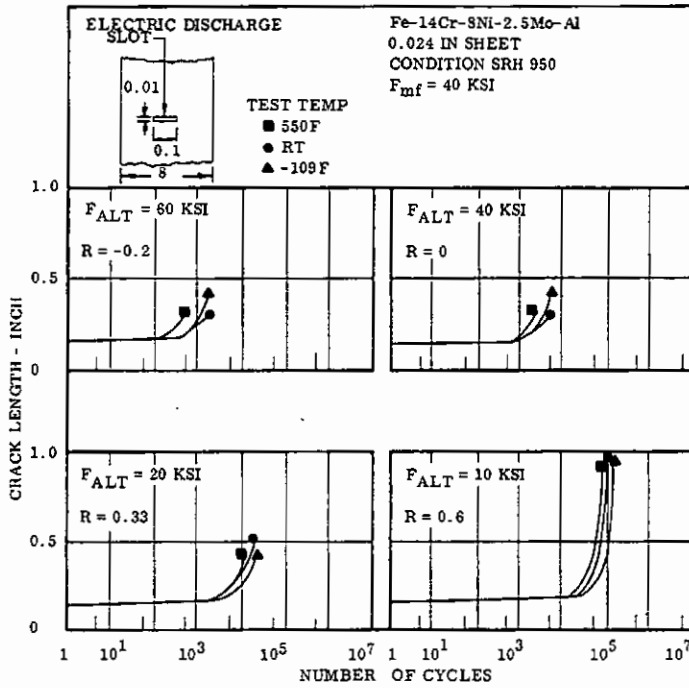


FIG. 3.041 EFFECT OF STRESS LEVEL ON SMOOTH CREEP PROPERTIES FOR SHEET IN CONDITION SRH 1050. (7, p. 47)

NOTE: Data represents total creep, elastic strain not included, and none of the creep is recoverable.



	Fe
14	Cr
8	Ni
2.5	Mo
	Al

PH14-8Mo

FIG. 3.053 FATIGUE CRACK PROPAGATION CURVES AS A FUNCTION OF TEST TEMPERATURE AND ALTERNATING STRESS AMPLITUDE FOR SHEET IN CONDITION SRH 950. (9, p. 13)

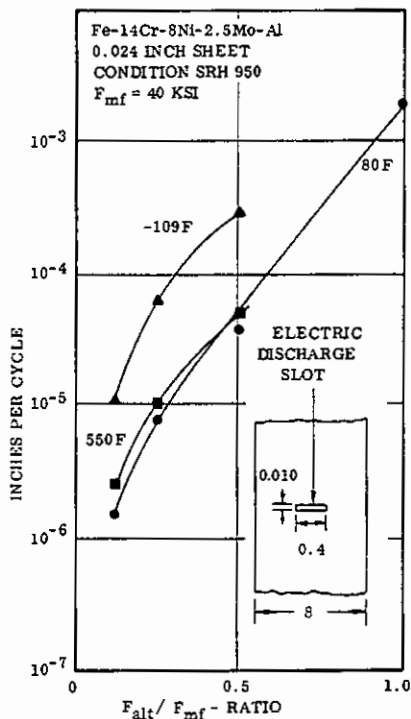


FIG. 3.054 FATIGUE CRACK PROPAGATION RATE AT THREE TEMPERATURES FOR SHEET IN CONDITION SRH 950. (9, pp. 18, 19, 20)

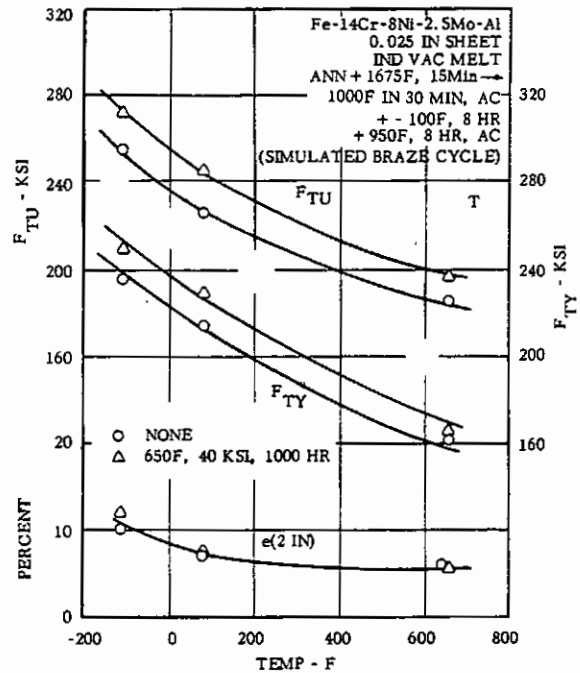


FIG. 4.0311 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF VACUUM MELT SHEET GIVEN SIMULATED BRAZE CYCLE AND TESTED BEFORE AND AFTER ELEVATED TEMPERATURE STRESSED EXPOSURE (5)

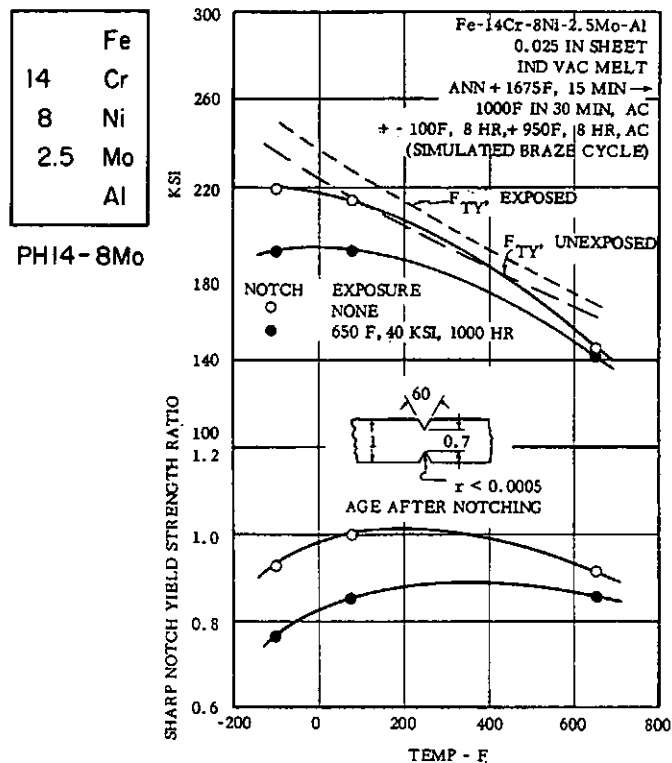


FIG. 4.0312 EFFECT OF TEST TEMPERATURE ON THE SHARP NOTCH PROPERTIES OF VACUUM MELTED SHEET GIVEN SIMULATED BRAZE CYCLE AND TESTED BEFORE AND AFTER ELEVATED TEMPERATURE EXPOSURE. (5)

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