

1. GENERAL

This is a heat treatable alpha-beta titanium alloy capable of developing strengths over 200 ksi ultimate. In the heat treated condition it develops shear strengths in excess of 115 ksi, higher than that of other presently available commercial titanium alloys, and is used in the aerospace industry primarily for fasteners. Unfortunately, no information is available on the fracture toughness of this alloy. However, based on experience with other high-strength titanium alloys and on the high sensitivity of this alloy to even mild stress concentrations, special attention should be given to crack propagation resistance when using this alloy in critical applications. In order to avoid segregation of beta-stabilizing elements, special precautions must be used when melting. Use of this alloy above 350 F is not recommended. Welding of this alloy is also not recommended.

- 1.01 Commercial Designation  
Ti-1Al-8V-5Fe
- 1.02 Alternate Designation  
RMI-1Al-8V-5Fe
- 1.03 Specifications  
Standard Press Steel Company Specification  
SPS-M-174
- 1.04 Composition  
1.041 Producer's guaranteed composition and users specified composition, Table 1.041.

TABLE 1.041

Source	R.M.I. (1), S.P.S. (7)	
	Weight Percent	
	Min	Max
Aluminum	0.8	1.8
Vanadium	7.5	8.5
Iron	4.0	6.0
Carbon		0.05
Hydrogen		0.0125
Oxygen	0.25	0.50
Nitrogen		0.07
Titanium		Balance

- 1.05 Heat Treatment
- 1.051 Stress-relief anneal, 1000 to 1100F, 1-hour, air cool.
- 1.052 Anneal, 1250 F, 1 hour, furnace cool to 900 F, air cool.
- 1.0521 Producer notes that alternate production anneal of 1250 - 1350 F, 1 - 2 Hours, air cool, may be used.
- 1.053 Solution treat, 1400F, 1-hour, water quench. Material's response to heat treatment is sometimes variable, requiring alternate solution treatment generally within the range 1350 to 1450F, to develop guaranteed properties.
- 1.054 Age, 900 - 1000 F, 2 hours, air cool.
- 1.06 Hardness
- 1.07 Forms and Conditions Available
- 1.071 Alloy is available in annealed condition as billet and bar.
- 1.08 Melting and Casting Practice
- 1.081 Melting. Multiple consumable electrode melting with at least one stage under vacuum.
- 1.09 Special Considerations
- 1.091 Alloy segregation. In common with other titanium alloys containing high percentages of the beta-stabilizing elements, special precautions must be used when melting this alloy to avoid segregation of these elements. Segregation of iron has been reported as a problem; however, the producer claims presently used melting methods minimize this problem. See Table 1.0911.

- 1.0911 Billet analysis survey of current heat where modified processing was employed, Table 1.0911.

TABLE 1.0911

Source	R.M.I. (1)								
Alloy	Ti-1Al-8V-5Fe								
Form	6 Inch Round Corner Square Billet								
	Weight Percent								
	Top (1)			Middle (1)			Bottom (1)		
	E(2)	MR(2)	C(2)	E	MR	C	E	MR	C
Al	1.7	1.7	1.8	1.6	1.7	1.7	1.7	1.8	1.8
V	8.2	8.3	8.2	8.2	8.2	8.3	8.1	8.2	8.2
Fe	4.8	4.9	5.7	4.8	4.9	5.4	4.8	4.9	4.6
O <sub>2</sub>	0.373	0.384	0.377	0.408	0.437	0.428	0.427	0.394	0.384

(1) Billet location in ingot.  
 (2) E = Edge  
 MR = Mid-Radius  
 C = Center } Location in billet face

	Ti
1	Al
8	V
5	Fe

- 1.092 Toughness. The notch strength of this alloy is affected by both notch sharpness and strength level. Tests on small notched rounds, (Figure 3.02712) show a notch strength to yield strength ratio of unity for annealed material, ( $F_{ty} = 167$  ksi) at  $K_t = 8$  and for solution treated and aged material, ( $F_{ty} = 228$  ksi) at  $K_t = 3$ . Care must be exercised in the use of this alloy in either heat treated condition for applications involving high stress levels and even moderate stress concentrations.
- 1.093 Stress corrosion. See section 2.031.
- 1.094 Stability. The only data available on the elevated temperature stability of this alloy are presented in Table 3.0216. They indicate only small changes in smooth properties for the exposure conditions investigated. One is to be cautioned, however, that a more discriminatory test using cracked specimens may not give the same result.

2. PHYSICAL AND CHEMICAL PROPERTIES

- 2.01 Thermal Properties
- 2.011 Melting temperature.
- 2.012 Phase changes. Alloy transforms on cooling from beta to alpha + beta at 1525 F  $\pm$  25 F.
- 2.0121 Isothermal T-T-T Diagram, Figure 2.0121
- 2.013 Thermal conductivity.
- 2.014 Thermal expansion.
- 2.015 Specific heat.
- 2.02 Other Physical Properties
- 2.021 Density. 0.168 lb per cu in. 4.65 gr per cu cm.
- 2.022 Electrical resistivity.
- 2.023 Magnetic properties. Alloy is nonmagnetic.
- 2.024 Emissivity.
- 2.025 Damping capacity.
- 2.03 Chemical Properties
- 2.031 Corrosion resistance. Susceptibility to solid salt stress corrosion at elevated temperatures and delayed failure of cracked specimens at room temperature in aggressive aqueous environments have become critical problems in the application of titanium alloys to engineering structures. Unfortunately, no pertinent data of this sort are available to characterize the corrosion resistance of this alloy. The inadvertent stress corrosion crack developed in air during creep exposure for a single specimen in Table 3.0217 suggests that the corrosion susceptibility of this alloy in aggressive environments be studied before it is used in critical applications.

2.04 Nuclear Properties

- 3. MECHANICAL PROPERTIES
- 3.01 Specified Mechanical Properties

1	Ti
8	Al
5	V
	Fe

- 3.011 Producer's guaranteed minimum properties at room temperature for heat treated bar, Table 3.011.

TABLE 3.011

Source		R. M. I. (1)	
Alloy		Ti-1Al-8V-5Fe	
Form		Up to 1 1/16 - in Diameter Bar	
Condition		Heat Treated	
Guaranteed RT Properties			
F <sub>tu</sub>	min-ksi	210	
F <sub>ty</sub>	min-ksi	200	
e	min-percent	6.0	
RA	min-percent	12.0	
F <sub>su</sub>	min-ksi	115	

- 3.012 Typical room temperature tensile properties of as-shipped, mill annealed bar of various sizes, Table 3.012.

TABLE 3.012

Source		R. M. I. (1)			
Alloy		Ti-1Al-8V-5Fe			
Form		Bar			
Condition		Mill Annealed			
Typical RT Properties*					
Bar Diameter Inch	F <sub>tu</sub> ksi	F <sub>ty</sub> ksi	e(4D) percent	RA percent	
3/8	175.2	169.1	13.0	37.6	
1/2	175.7	168.7	14.0	49.0	
3/4	168.3	162.3	18.0	37.1	
1 1/16	178.0	166.0	17.0	43.0	

\* 1/4 - inch diameter specimens

- 3.02 Mechanical Properties at Room Temperature  
 3.021 Tension.  
 3.0211 Effect of annealing treatment on room temperature tensile properties of bar, Table 3.0211.

TABLE 3.0211

Source		R. M. I. (1)			
Alloy		Ti-1Al-8V-5Fe			
Form		3/8 - in Diameter Bar			
Condition		Annealed			
Room Temperature Tensile Properties*					
Annealing Treatment	F <sub>tu</sub> ksi	F <sub>ty</sub> ksi	e(4D) percent	RA percent	
1250 F, 1/2Hr, AC	183.0	178.7	15.0	47.5	
1325 F, 1/2Hr, AC	175.3	169.5	16.0	47.7	
1400 F, 1/2Hr, AC	170.9	166.8	13.5	43.0	
1250 F, 1/2Hr, FC to 900F, AC	179.1	175.9	20.5	52.9	

\* 1/4 - inch diameter specimens

- 3.0212 Effect of solution temperature on room temperature tensile properties of heat treated bar, Figure 3.0212.  
 3.0213 Effect of solution treat and aging temperature on room temperature tensile properties of bar, Figure 3.0213.

- 3.0214 Effect of quench rate from solution treat temperature on room temperature tensile properties of heat treated bar, Table 3.0214.

TABLE 3.0214

Source		R. M. I. (1)			
Alloy		Ti-1Al-8V-5Fe			
Form		9/16 - inch Diameter Bar			
Condition		Solution Treat + 1000F, 2 Hr, AC			
Room Temperature Tensile Properties*					
Solution Treatment	F <sub>tu</sub> ksi	F <sub>ty</sub> ksi	e(4D) percent	RA percent	
1375F, 1-Hr, WQ	206	194	15	39	
1375F, 1-Hr, AC	205	194	16	41	
1400F, 1-Hr, WQ	217	204	12	30	
1400F, 1-Hr, AC	211	198	13	33	

\* 1/4 - inch diameter specimens

- 3.0215 Effect of aging temperature and time on room temperature tensile properties of bar, Figure 3.0215.

- 3.0216 Effect of exposure to elevated temperature with load on room temperature tensile properties of annealed and heat treated bar, Table 3.0216.

TABLE 3.0216

Source		R. M. I. (1)					
Alloy		Ti-1Al-8V-5Fe					
Form		3/8 Inch Diameter Bar					
Creep Exposure			Subsequent RT Tensile Properties*				
Temp F	Stress ksi	Time Hr	Perm- anent deform- ation percent	F <sub>tu</sub> ksi	F <sub>ty</sub> ksi	e(4D) percent	RA percent
Annealed Bar							
None			—	178	171	18.3	44.8
800	20	10	0.155	177	172	23.5	52.3
800	50	10	0.83	177	174	23.5	52.5
800	20	313.3	1.29	177	171	7.5**	10.2**
800	30	310.5	2.79	177	170	23.0	54.0
600	110	310.5	0.78	177	167	22.5	51.1
Heat Treated Specimen							
None			—	208	198	12.0	37.5
800	45	212.5	—	211	202	15.0	38.9

\* 1/4 - inch diameter specimens  
 \*\* Stress corrosion crack

- 3.022 Compression.  
 3.023 Impact.  
 3.024 Bending.  
 3.025 Torsion and shear.  
 3.026 Bearing.  
 3.027 Stress concentration.  
 3.0271 Notch properties.

3.02711 Room temperature smooth and mild-notch tensile properties of annealed and heat treated bar, Table 3.02711.

TABLE 3.02711

Source	R.M.I. (1)				
Alloy	Ti-1Al-8V-5Fe				
Form	5/8 Inch Diameter Bar				
Heat Treatment	Room Temperature Tensile Properties				
	F <sub>tu</sub> ksi	F <sub>ty</sub> ksi	e(4D) percent	RA percent	NTS ksi
1250 F, 1-Hr, FC to 900 F, AC	181	170	18	50.5	244
1375 F, 1-Hr, WQ + 1000 F, 2-Hr, AC	203	197	15	39.7	250
1425 F, 1-Hr, WQ + 1000 F, 2-Hr, AC	212	200	10.5	27.9	254

Ti
1 Al
8 V
5 Fe

- 3.02712 Effect of stress concentration factor on the notch strength of annealed and heat treated bar, Figure 3.02712.
- 3.028 Combined properties.
- 3.03 Mechanical Properties at Various Temperatures
- 3.031 Tension.
- 3.0311 Effect of test temperature on smooth tensile properties of annealed and heat treated bar, Figure 3.0311.
- 3.032 Compression.
- 3.033 Impact.
- 3.034 Bending.
- 3.035 Torsion and shear.
- 3.036 Bearing.
- 3.037 Stress concentration.
- 3.038 Combined properties.
- 3.04 Creep and Creep Rupture Properties
- 3.041 Creep deformation in 300-hours for annealed bar at 600F and 800F, Figure 3.041.
- 3.042 Minimum creep rate curves at 600F and 800F for annealed bar, Figure 3.042.
- 3.043 Effect of stress concentration factor on room temperature notch stress rupture strength for annealed and heat treated bar, Figure 3.043.
- 3.05 Fatigue Properties
- 3.051 Room temperature axial load fatigue properties of 3/8 - 24 bolts, Figure 3.051.
- 3.06 Elastic Properties
- 3.061 Modulus of elasticity at room temperature and 600 F for annealed and heat treated conditions, Table 3.061.

TABLE 3.061

Source	(8)	
Alloy	Ti-1Al-8V-5Fe	
Temp-F	Anneal	ST + Age
RT	16.5	16.5
600 F	14.7	14.5

- 4. FABRICATION
- 4.01 Formability
- 4.011 This alloy has a low beta transus, 1525 F ± 25 F, and to obtain optimum tensile ductility the material should receive final reductions of 50 percent or more below 1500 F.

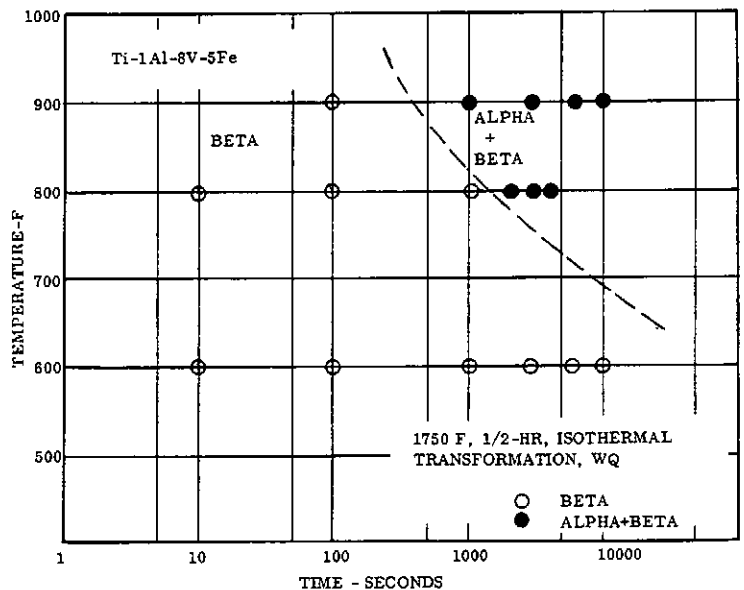


FIG. 2.0121 ISOTHERMAL T-T-T DIAGRAM (5,p.5)

	Ti
1	Al
8	V
5	Fe

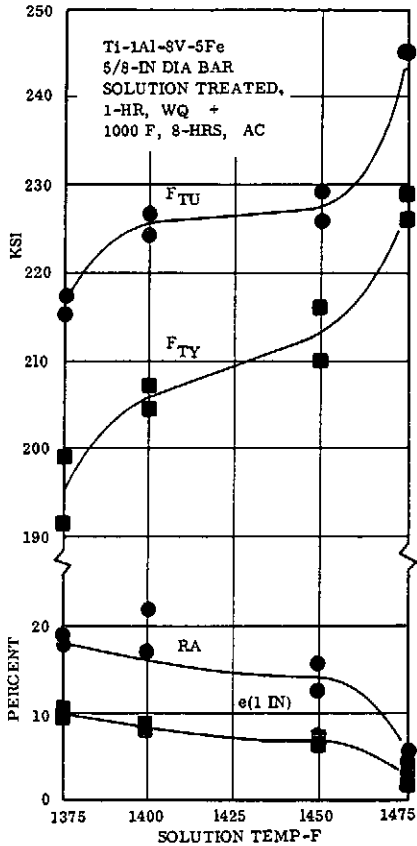


FIG. 3.0212 EFFECT OF SOLUTION TEMPERATURE ON ROOM TEMPERATURE TENSILE PROPERTIES OF HEAT TREATED BAR (3, p. 7)

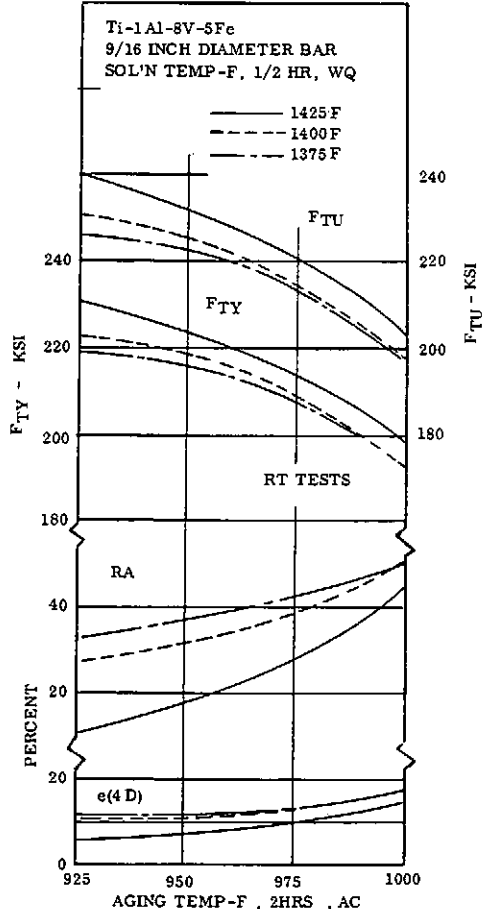


FIG. 3.0213 EFFECT OF SOLUTION TREAT AND AGING TEMPERATURES ON ROOM TEMPERATURE TENSILE PROPERTIES OF BAR (1)

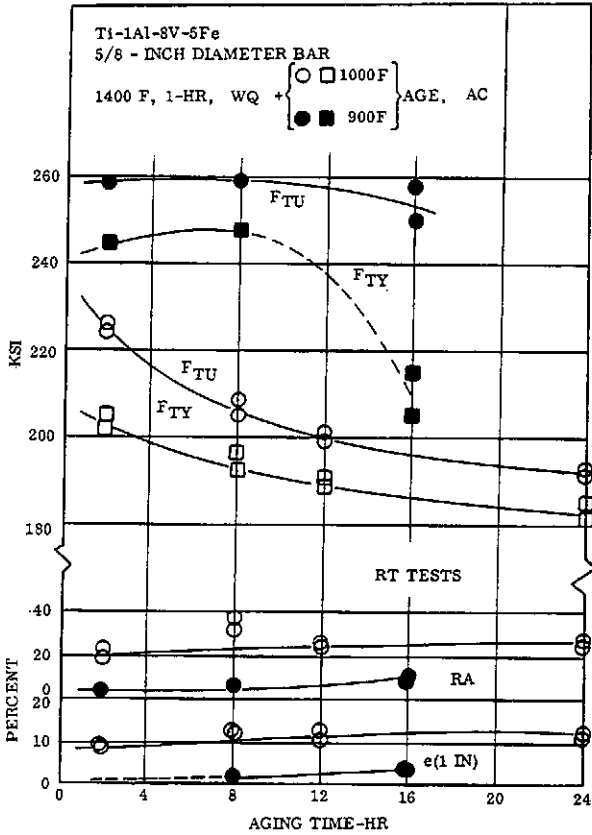


FIG. 3.0215 EFFECT OF AGING TEMPERATURE AND TIME ON ROOM TEMPERATURE TENSILE PROPERTIES OF BAR

(3, p.6)

Ti
1 Al
8 V
5 Fe

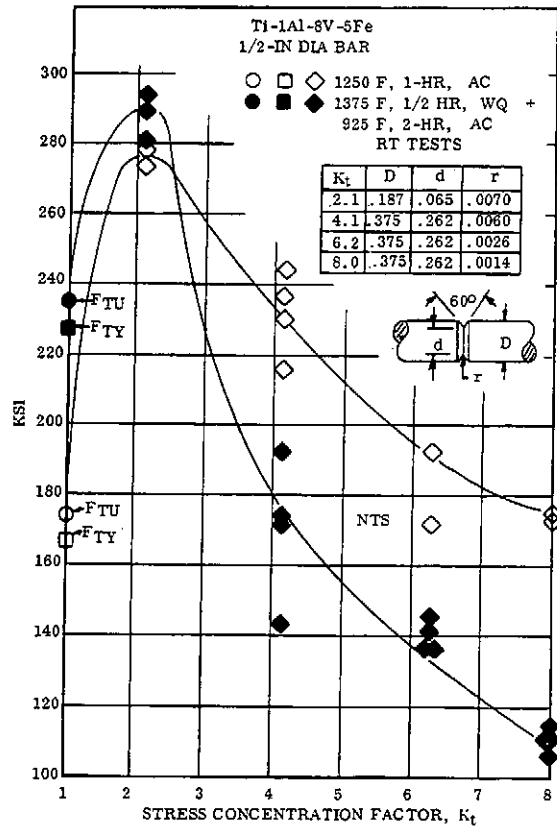


FIG. 3.02712 EFFECT OF STRESS CONCENTRATION FACTOR ON THE NOTCH STRENGTH OF ANNEALED AND HEAT TREATED BAR

(2, pp. 5-7)

	Ti
1	Al
8	V
5	Fe

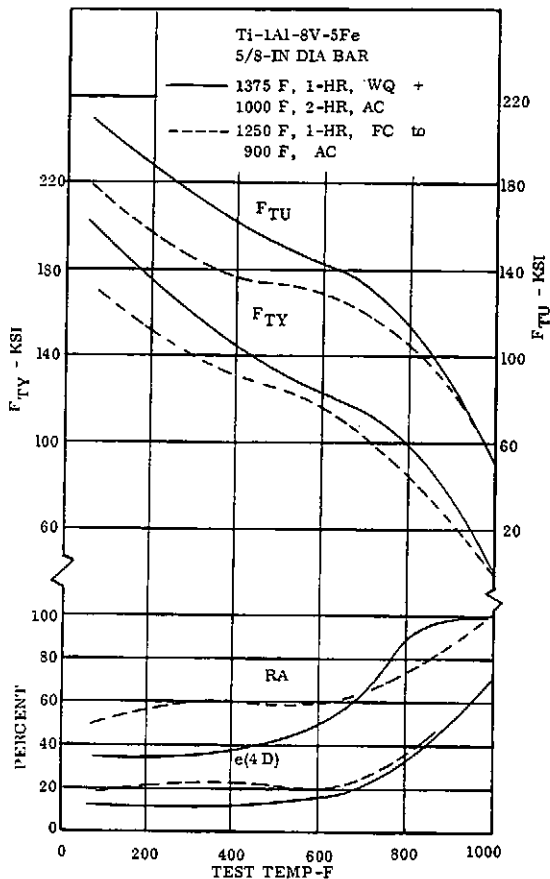


FIG. 3.0311 EFFECT OF TEST TEMPERATURE ON SMOOTH TENSILE PROPERTIES OF ANNEALED AND HEAT TREATED BAR (1)

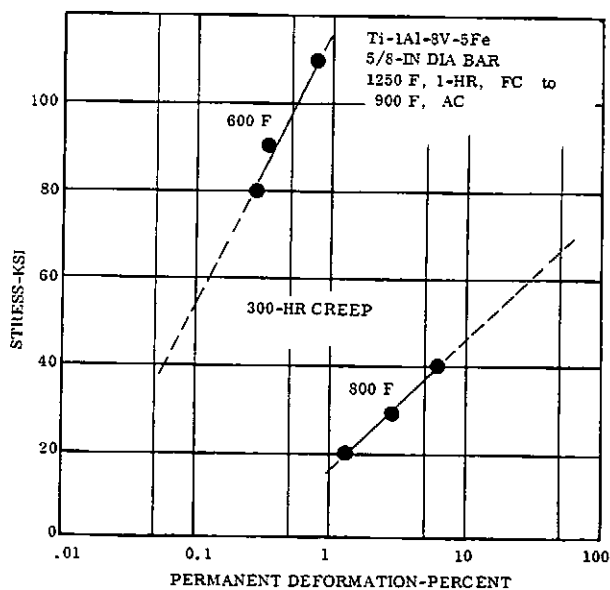


FIG. 3.041 CREEP DEFORMATION IN 300-HOURS FOR ANNEALED BAR AT 600 F AND 800 F

(4,p.6)

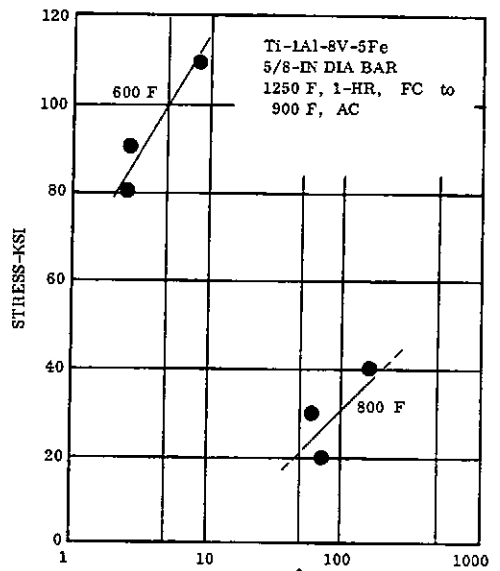


FIG. 3.042 MINIMUM CREEP RATE CURVES AT 600 F AND 800 F FOR ANNEALED BAR (4,p.6)

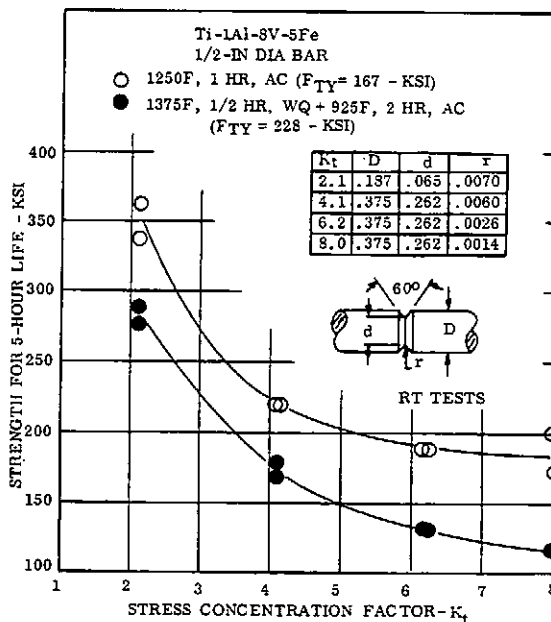
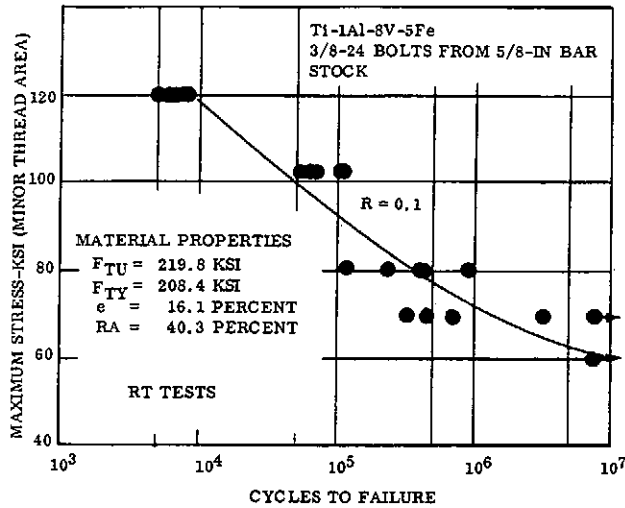


FIG. 3.043 EFFECT OF STRESS CONCENTRATION FACTOR ON ROOM TEMPERATURE NOTCH STRESS RUPTURE STRENGTH FOR ANNEALED AND HEAT TREATED BAR (2,p.8)



	Ti
1	Al
8	V
5	Fe

FIG. 3.051 ROOM TEMPERATURE AXIAL LOAD FATIGUE PROPERTIES OF 3/8-24 BOLTS

(1)

REFERENCES

1. Private communication, Reactive Metals, Inc.
2. L. J. Bartlo, "The Effect of Stress Concentration on Notch Tensile and Static Notch Properties of Ti-1Al-8V-5Fe," Reactive Metals, Inc., Research Report No. 1000R459, M.O. 75003, December 30, 1964.
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8. R. A. Wood, "A Tabulation of Designations, Properties, and Treatments of Titanium and Titanium Alloys, DMIC Memorandum 171, July 15, 1963.
9. J. L. Shannon, Jr. and W. F. Brown Jr., "A Review of Factors Influencing the Crack Tolerance of Titanium Alloys," Applications Related Phenomena in Titanium Alloys, ASTM STP 432, American Society for Testing and Materials, 1967