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NONFERROUS ALLOYS

1. GENERAL  
 Ti-6Al-2Cb-1Ta-0.8Mo (Ti-621/0.8) is a modification of the Ti-7Al-2Cb-1Ta (Ti-721) composition, itself a modification of the original Ti-8Al-2Cb-1Ta (Ti-821) alloy. The Ti-721 alloy was introduced specifically to avoid weld-cracking problems encountered in thick plate with the Ti-821 composition. The Ti-621/0.8 alloy was developed as a saltwater stress-corrosion resistant modification of Ti-721.  
 Ti-6Al-2Cb-1Ta-0.8Mo is of medium strength and, on the basis of fracture appearance, is considered seawater stress-corrosion resistant. Sustained-load tests on precracked specimens, however, indicate the load-carrying capability of the alloy is reduced in seawater although no evidence of stress-corrosion cracking has been observed on the fracture surfaces of failed specimens.  
 The alloy is forgeable and weldable and is intended for use as a structural alloy for marine application. It is normally processed in the beta phase region. On request, however, the alloy may be processed in the alpha-beta field with an improvement in strength at some sacrifice in toughness. All data presented in this chapter are for beta processed material, with the exception of the producer's guaranteed properties for alpha-beta processed material presented in Table 3.014.

- 1.01 Commercial Designation  
 Ti-6Al-2Cb-1Ta-0.8Mo  
 Ti-6Al-2Cb-1Ta-1Mo
- 1.02 Alternate Designations  
 RMI-6Al-2Cb-1Ta-0.8Mo  
 RMI-6Al-2Cb-1Ta-1Mo  
 Ti-621/0.8  
 Ti-621/1.0
- 1.03 Specifications  
 MIL-T-9046F (April 3, 1967), Amendment 1 (March 15, 1968).
- 1.04 Composition
- 1.041 Producer's specified composition, Table 1.041.

TABLE 1.041

Source	RMI(1)	
	Weight Percent	
	Minimum	Maximum
Aluminum	5.50	6.50
Columbium	1.50	2.50
Tantalum	0.50	1.50
Molybdenum	0.50	1.50
Iron		0.25
Carbon		0.05
Nitrogen		0.03
Oxygen		0.10
Hydrogen		0.0125*
Other Elements (each)		0.10
Other Elements (combined)		0.40
Titanium	Balance	

\*Bar and billet 0.0125 maximum; sheet and plate 0.0150 maximum.

1.042 Military's specified composition, Table 1.042.

TABLE 1.042

Source	Military (?)	
	Weight Percent	
	Minimum	Maximum
Aluminum	5.5	6.5
Columbium	1.5	2.5
Tantalum	0.5	1.5
Molybdenum	0.5	1.0
Iron		0.20
Carbon		0.05
Nitrogen		0.03
Oxygen		0.10
Hydrogen		0.0125*
Other Elements (total)		0.40
Titanium	Balance	

\* Shall be determined on each lot of the product as shipped.

	Ti
6	Al
2	Cb
1	Ta
0.8	Mo

Ti-6Al-2Cb-1Ta-0.8Mo

- 1.05 Heat Treatment
- 1.051 Stress relief anneal; 1100F, 2 hours, AC (9).
- 1.0511 Stress relaxation of plate at 900 and 1000F, Figure 1.0511.
- 1.052 Full anneal; 1650F, 1 hour, AC (9).
- 1.053 Solution treat and age; 1650F, 1 hour, WQ + 1100F, 2 hours, AC (9).
- 1.054 This alloy is generally used in the as-fabricated or fabricated-plus-annealed conditions. A small increase in strength can be obtained by solution treating and aging, but at a considerable sacrifice in ductility and toughness (compare as-rolled plate with plate solution treated and aged in Tables 3.0217 and 3.0338). Studies are continuing to establish heat treating schedules for optimum combinations of strength, toughness, weldability, and seawater stress-corrosion resistance (9).
- 1.055 A quench delay from the solution treating furnace to the quenching medium may be encountered in some production heat treating processes. Figure 1.0551 gives cooling curves for 1 inch x 6 inch x 6 inch sections cooled in air from various initial temperatures. These data may be used to determine the furnace temperature required to give a desired quenching temperature. It should be noted, however, that the effect of quench delay on strength and toughness of this alloy is small for delay times up to 1 1/2 minutes (see Figures 3.0213 and 3.0333).
- 1.0551 Cooling rate curves for 1 inch plate cooled in air, Figure 1.0551.
- 1.06 Hardness  
 Annealed condition, RC-30 (10).
- 1.07 Forms and Conditions Available
- 1.071 Alloy is available as billet, bar, plate, sheet, and wire. Billet and plate size limitations are generally controlled by the size and weight of the ingot and size of the processing equipment. Bar and plate are available in the annealed, as-rolled, or as-hot worked condition. Billet, sheet, and wire are available in the annealed condition.
- 1.072 All products are normally beta processed (rolled, forged, etc.). On request, however, the alloy may be processed in the alpha-beta region with an improvement in strength at some sacrifice in toughness (9).
- 1.08 Melting and Casting Practice
- 1.081 Alloy is multiple melted by the consumable electrode process, using controlled atmosphere and pressure. Ingot sizes produced to date are 30 inch diameter by approximately 10,000 pounds, and 36 inch diameter by approximately 15,000 pounds.

	Ti
6	Al
2	Cb
1	Ta
0.8	Mo

Ti-6Al-2Cb  
-1Ta-0.8Mo

1.09  
1.091

#### Special Considerations

Alloy modification. This alloy, Ti-6Al-2Cb-1Ta-0.8Mo, is being modified to have slightly higher molybdenum (1.2 percent) content to compete with ELI grade Ti-6Al-4V (11). The modified alloy has improved strength over Ti-621/0.8 and is both weldable and seawater stress-corrosion resistant. No information is available, however, regarding its fracture toughness.

RMI has recently announced that it will market Ti-6Al-2Cb-1Ta-0.8Mo and Ti-6Al-2Cb-1Ta-1.2Mo under the single designation Ti-6Al-2Cb-1Ta-1Mo. Variations in molybdenum content will be made to suit the requirements of the customer (11)(9).

1.092

Oxygen and interstitial element contents. Oxygen content influences the strength and toughness of this alloy. Table 3.02113 shows a modest but consistent elevation in smooth tensile strength associated with an increase in oxygen level from 0.058 to 0.122 weight percent. While the comparison is made for materials given slightly different high temperature treatments (1900F vs 1950F), this difference in heat treatments would not be expected to produce the observed difference in strength. Indeed, for water quenched stock, a lesser strength would be expected for the material treated at the higher temperature (see Figure 3.0212). The same difference in oxygen content (0.058 vs 0.122 weight percent) is shown in Table 3.03313 to produce a significant difference in +32F drop-weight tear energy, the higher oxygen level being responsible for lower values. The -80F standard Charpy V impact energy in the same table does not give a consistent measure of the toughness change with oxygen level.

No data are available to assess the influence of oxygen content on the seawater stress-corrosion susceptibility of this alloy. Results (6) on Ti-6Al-2Sn-1Mo-(1-2)V and Ti-6Al-4Zr-(1-2)V compositions show, however, that heavy concentrations of oxygen lower the aqueous salt solution stress-corrosion resistance of these alloys. In the same study, unalloyed titanium containing a low amount of residual Fe, C, N, and H was made sensitive to seawater stress-corrosion by oxygen contents above approximately 0.250 weight percent. Oxygen may indirectly influence the stress corrosion sensitivity of Ti-Al alloys by affecting the solubility of aluminum in primary alpha and by affecting the kinetics of the  $Ti_3Al$  precipitation reaction; results on Ti-Al compositions (6) have shown that aluminum in solid solution is not responsible for stress-corrosion cracking, but that such is due to the presence of coherent  $Ti_3Al$ .

No results are available to establish the influence of oxygen or other interstitial elements on the fracture toughness of this alloy, nor the possible influence of other interstitial elements on its aqueous salt solution stress-corrosion resistance.

## 2. PHYSICAL AND CHEMICAL PROPERTIES

### 2.01 Thermal Properties

- 2.011 Melting point, approximately 3000F.
- 2.012 Phase changes, beta transus  $1860 \pm 25F$ .
- 2.013 Thermal conductivity, at 70F, 3.7 Btu ft per (hr sq ft F).
- 2.014 Thermal expansion, mean coefficient from 72 to 1200F,  $5 \times 10^{-6}$  in/in/F.
- 2.015 Specific heat.
- 2.016 Thermal diffusivity.

### 2.02 Other Physical Properties

- 2.021 Density, 0.162 lb per cu in, 4.48 gr per cu cm.
- 2.022 Electrical resistivity.
- 2.023 Magnetic properties; alloy is nonmagnetic.
- 2.024 Emittance.
- 2.025 Damping capacity.

2.03  
2.031

### Chemical Properties

Seawater stress-corrosion tests, general. The presence of a sharp notch is a necessary requirement for stress-corrosion cracking of titanium alloys in seawater. The stress level at which seawater stress-corrosion cracking failures take place in susceptible titanium alloys varies with notch acuity (6). In some instances a sharp machined notch is as damaging as a crack, but this depends on the sensitivity of the alloy. This being the case, it is prudent to use cracked specimens in all comparative evaluations of stress-corrosion susceptibility of materials. All results reported in this chapter were obtained using specimens containing fatigue cracks.

2.032

Step load tests. There are two types of tests in common use for the evaluation of seawater stress-corrosion behavior: step load tests and sustained load tests. The step load test seems to be fairly standard from one investigating laboratory to another. All use a precracked bar subjected to cantilever loading. An initial load of about one-half the anticipated failure load is applied and increased in 10 to 15 ksi increments every 5 to 10 minutes until failure. The failure stress is called the nominal bend strength and is calculated for the net section using simple beam theory. The test is performed in both air and salt water (or seawater) and the ratio of the two results is an indication of stress-corrosion resistance.

Results presented in Figure 2.034 and Table 2.035 show seawater-to-air nominal bend strength ratios greater than 0.8 for base plate and GTA and GMA welded plate. No evidence of corrosion cracking was noted on the fracture surfaces of failed specimens, leading the investigator (3)(6)(13) to the conclusion that the alloy is seawater stress-corrosion resistant.

2.033

Sustained load tests. The sustained load test is less standardized than the step load test. Both specimen size and shape may vary. Thus the results in Figure 2.036 were obtained using specimens of 1 inch x 1/2 inch cross section with a fatigue crack about 50 percent deep and side grooved, while the results in Table 2.037 were obtained from specimens of 1 inch x 7/8 inch cross section with a 30 percent deep fatigue crack without side grooves.

Sustained load test results are presented as the stress intensity factor,  $K_I$ , vs time-to-failure. No account was taken of the influence of side grooves for the data reported, as the same calculation for stress intensity factor was used for specimens both with and without side grooves. Nor was any attempt made to assure conditions of plane strain and small scale yielding at the advancing crack tip as the use of  $K_I$  would imply. All the results presented in this chapter fail to satisfy the size requirements for plane strain testing as defined by ASTM Committee E-24 on Plane Strain Fracture Toughness of High Strength Metallic Materials (12). Therefore the symbol  $K_Q$  is used in this chapter rather than  $K_I$ .

Figure 2.036 indicates that a threshold stress intensity factor of about  $82 \text{ ksi}/\sqrt{\text{in}}$  may exist for as-rolled plate on the basis of results to 50 hours holding time at that stress intensity level. Results obtained on conventionally processed Ti-7Al-2Cb-1Ta show that the threshold stress intensity factor determined from short time tests satisfactorily characterizes long time behavior. Specimens of that alloy tested at 5 to 10  $\text{ksi}/\sqrt{\text{in}}$  less than the indicated threshold stress intensity factor did not fail after 500 hours exposure. On this basis, the threshold stress intensity factor for stress corrosion cracking failure in seawater for the present alloy ( $62 \text{ ksi}/\sqrt{\text{in}}$ ) may be valid.

Figure 2.037 indicates that the threshold stress intensity may be as low as  $70 \text{ ksi}/\sqrt{\text{in}}$  for plate in various heat treated conditions. The same threshold appears to characterize welds of this alloy (see Figure 2.038).

Although these sustained load test results indicate a time-dependent reduction in load carrying capability

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of cracked specimens in salt water, the investigators (2)(5)(14) conclude that this alloy is completely stress-corrosion resistant in salt water environment, based on their interpretation that stress-corrosion features are absent on the fracture surfaces of failed specimens. This, of course, suggests that the same reduction in load carrying capacity would be expected for companion tests in air (14).

Fatigue. Figure 2.039 shows no difference in high or low cycle fatigue strength for smooth or mildly-notched specimens as a function of environment (i. e., air vs seawater).

- 2.034 Seawater stress-corrosion behavior of plate, Figure 2.034
- 2.035 Seawater stress-corrosion behavior of welded plate, Table 2.035.

- 2.036 Sustained load seawater stress-corrosion behavior of as-rolled plate, Figure 2.036.
- 2.037 Sustained load seawater stress-corrosion behavior of plate in several heat treated conditions, Figure 2.037.
- 2.038 Sustained load salt water stress-corrosion behavior of welded plate, Figure 2.038.
- 2.039 Effect of seawater environment on low and high cycle fatigue strength of smooth and mild notch specimens, Figure 2.039.
- 2.04 Nuclear Properties

	Ti
6	Al
2	Cb
1	Ta
0.8	Mo

Ti-6Al-2Cb  
-1Ta-0.8Mo

TABLE 2.035

Source		(3, p. 15)					
Alloy		Ti-6Al-2Cb-1Ta-0.8Mo					
Form		1 inch rolled plate, welded (1)					
Filler Metal				F <sub>ty</sub> (2)	Sea Water Stress-Corrosion (3)(4) Heat Affected Zone		
Welding Process	Nominal Composition	Wire Diameter Inch	Condition of Weldment	(0.2 Percent Offset) ksi	S <sub>nair</sub> ksi	S <sub>nsw</sub> ksi	S <sub>nsw</sub> / S <sub>nair</sub>
GTA	Ti-621/0.8	1/8 Flat Strip	As-Welded	115	236	252	1.07
	Ti-621/0.8	1/8 Flat Strip	900F, 2 hrs, AC	115	235	232	1.01
	Ti-621/0.5	0.062	As-Welded	105	230	224	1.02
	Ti-621/0.5	0.062	900F, 2 hrs, AC	109	211	228	1.08
GMA	Ti-621-0.5	0.062	As-Welded	108(5)	222	216	0.97
	Ti-621/0.5	0.062	900F, 2 hrs, AC	113(5)	226	211	0.94
	Ti-621/0.5	0.062	As-Welded	113(6)	---	---	---
	Ti-621/0.5	0.062	900F, 3 hrs, AC	116(6)	---	---	---

(1) See Table 4.031 for weld joint configuration  
 (2) Remainder of smooth properties corresponding to these stress-corrosion data appear in Table 4.031  
 (3) See Figure 2.034 for specimen configuration and definition of S<sub>nair</sub> and S<sub>nsw</sub>.  
 (4) Properties of weld metal are:

	S <sub>nair</sub>	S <sub>nsw</sub>	S <sub>nsw</sub> /S <sub>nair</sub>
As-Welded	222	217	0.98
900F, 2 hrs, AC	217	250	1.15

(5) Determined using SR-4 strain gauges mounted on weld metal of specimen  
 (6) Determined from "all-weld" specimen

Ti  
6 Al  
2 Cb  
1 Ta  
0.8 Mo

Ti-6Al-2Cb  
-1Ta-0.8Mo

3. MECHANICAL PROPERTIES  
3.01 Specified Mechanical Properties  
3.011 Producer's guaranteed properties for plate, Table 3.011.

Table 3.011

Source	(1)	
Alloy	Ti-6Al-2Cb-1Ta-1Mo	
Form	Plate	
Condition	As-Rolled*	
Thickness, inch	≤ 1	>1 to 3
F <sub>tu</sub> , minimum - ksi	120.0	115.0
F <sub>ty</sub> , minimum - ksi	110.0	100.0
F <sub>cy</sub> , minimum - ksi	118.0	108.0
e(l inch), minimum - percent	10	10
RA, minimum - percent	20	20
Standard Charpy V, minimum - ft-lbs		
+32F	25	25
-80F	21	21

\*Rolled from above the beta transus temperature

- 3.013 Military's specified properties, Table 3.013.

TABLE 3.013

Source	(7)
Alloy	Ti-6Al-2Cb-1Ta-0.8Mo
Form	Plate up to 2.750 inches *
Condition	Mill Annealed
F <sub>tu</sub> , minimum - ksi	103
F <sub>ty</sub> , minimum - ksi	95
e(2 inches minimum or 4D) - percent	10.0

\*Rolled from above the beta transus temperature

- 3.014 Producer's guaranteed properties for alpha-beta processed sheet and plate, Table 3.014.

TABLE 3.014

Source	(9)				
Alloy	Ti-6Al-2Cb-1Ta-0.8Mo				
Form	Sheet and Plate				
Condition	Alpha-Beta Processed + Full Annealed 1650F, 1 hr, AC				
Thickness Inch	≤ 0.125	>0.125 to 0.500	>0.500 to 1.00	>1.00 to 2.50	>2.50 to 4.00
F <sub>tu</sub> , minimum - ksi	130	125	125	120	115
F <sub>ty</sub> , minimum - ksi	120	115	115	110	105
F <sub>cy</sub> , minimum - ksi			120	115	110
e(2 inches), minimum - percent	10	10	10	10	10
RA, minimum - percent			20	20	20
Standard Charpy V IE @ 32F - ft-lbs			21	23	25

No fracture toughness or sea water stress-corrosion data are available for Alpha-Beta processed material

- 3.012 Producer's guaranteed properties for billet products, Table 3.012.

TABLE 3.012

Source	(1)	
Alloy	Ti-6Al-2Cb-1Ta-1Mo	
Form	Billet Products*	
Test Condition	Full Section ** ≤10 inch rd	Test Forged*** >4 inch rd to 12 inch rd
F <sub>tu</sub> , minimum - ksi	115.0	125.0
F <sub>ty</sub> , minimum - ksi	100.0	110.0
F <sub>cy</sub> , minimum - ksi	105.0	115.0
e(l inch), minimum - percent	10	10
RA, minimum - percent	20	25
Standard Charpy V, minimum - ft-lbs, +32F	23	25

\*Processed from above the beta transus temperature  
\*\*As-forged or forged and full annealed 1650F, 1 hr, AC  
\*\*\*Test forge procedure: 3:1 upset to maximum 7/8 inch thick from above beta transus and full annealed 1650F, 1 hr, AC

- 3.02 Mechanical Properties at Room Temperature  
3.021 Tension (see 3.031)  
3.0211 Solution treated tensile properties of plate specimens air cooled or furnace cooled from various solution temperatures, Figure 3.0211.  
3.0212 Solution treated tensile properties of plate specimens water quenched from various solution temperatures, Figure 3.0212.  
3.0213 Effect of quench delay on solution treated tensile properties of plate, Figure 3.0213.  
3.0214 Effect of aging temperature on tensile properties of plate, Figure 3.0214.  
3.0215 Effect of aging time on tensile properties of plate, Figure 3.0215.

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3.0216 Alpha-beta versus beta solution treatment regarding tensile properties of as-quenched or quenched and aged plate, Table 3.0216.

TABLE 3.0216

Source		(4, p. 10)(5, p. 26)				
Alloy		Ti-6Al-2Cb-1Ta-0.8Mo				
Form		1 inch rolled plate				
Condition	Test Direction	F <sub>tu</sub> ksi	F <sub>ty</sub> ksi	e(1 in) %	RA %	
As-rolled	L	119.6	101.8	10.8	23.1	
	T	123.0	105.0	12.5	33.6	
Alpha annealed (1600F, 1 hr, AC)	L	118.2	99.2	12.5	28.0	
	T	122.4	107.4	12.5	31.9	
Alpha-beta annealed, air-cooled (1815F, 1 hr, AC)	L	118.2	97.7	12.5	31.3	
	T	122.2	104.0	13.0	33.0	
Alpha-beta solution treated, quenched (1815F, 1 hr, WQ)	L	126.0	101.2	13.0	29.0	
	T	129.0	108.4	11.8	30.7	
Alpha-beta solution treated, aged (1815F, 1 hr, WQ+1100F, 2 hrs, AC)	L	127.0	108.9	10.5	20.8	
	T	135.5	118.9	10.5	22.1	
Beta annealed, air-cooled (1900F, 1 hr, AC)	L	123.2	101.4	11.8	24.6	
	T	123.2	103.4	12.2	27.7	
Beta solution treated, quenched (1900F, 1 hr, WQ)	L	131.1	110.2	12.8	31.0	
	T	128.1	108.0	8.8	23.8	
Beta solution treated, aged (1900F, 1 hr, WQ+1100F, 2 hrs, AC)	L	135.3	117.1	9.5	24.8	
	T	135.4	116.2	9.5	21.2	

Each value average of two tests.

	Ti
6	Al
2	Cb
1	Ta
0.8	Mo

Ti-6Al-2Cb-1Ta-0.8Mo

3.0217 Tensile and compressive properties of 1 inch and 2.5 inch plate from two heats and in several heat treated conditions. Table 3.0217.

TABLE 3.0217

Source		(2, pp. 21, 22, 23, 26)						
Alloy		Ti-6Al-2Cb-1Ta-0.8Mo						
Form		Rolled Plate						
Heat	Plate Thickness Inches	Test Direction	F <sub>cy</sub> ksi	F <sub>tu</sub> ksi	F <sub>ty</sub> ksi	e(1 in) %	RA %	
As Rolled								
A	1	L		120.7	99.9	17.0	30.4	
		T		123.5	105.8	17.0	28.4	
B	1	L	103.6	118.6	95.6	17.0	35.4	
		T	109.8	121.6	102.4	11.0	30.6	
B	2.5(1)	L		101.2	117.6	96.9	12.5	32.0
		T		99.8	117.4	98.6	12.0	32.8
1650F, 1 Hour, AC								
A	1	L		120.1	102.2	14.0	30.7	
		T		120.6	101.0	12.8	26.0	
B	1	L	107.6	118.6	94.7	15.5	34.4	
		T	115.1	118.5	96.9	14.5	35.2	
1875, 1 Hour, WQ								
B	1	L	112.2	127.8	108.6	10.2	18.6	
		T	114.0					
B	2.5(1)(2)	L	114.8	125.9	107.0	10.0	23.0	
		T	117.8	122.2	106.5	10.0	28.0	
1875F, 1 Hour, WQ + 1100F, 2 Hours, AC								
B	1	L	118.0	130.2	111.5	11.2	20.8	
		T	121.6	130.8	112.2	9.2	16.2	
		L	123.6	129.3	115.4	10.0	13.4	
		T	120.8	128.9	115.8	8.8	14.4	
1875F, 1 Hour, WQ + 1100F, 8 Hours, AC								
B	1	L	121.4	127.8	109.7	9.5	20.6	
		T	123.6	131.7	114.6	9.8	18.0	
2000F, 1 Hour, 70 Seconds Delay (in air), WQ								
A	1	L		126.2	105.8	11.0	24.2	
		T		127.5	107.6	9.8	26.8	
B	1	L	112.0	124.4	98.8	12.0	26.1	
		T	120.4	126.6	102.1	10.2	19.4	
2000F, 1 Hour, 70 Seconds Delay (in air), WQ + 1000F, 4 Hrs, AC								
B	1	L	123.4	128.1	105.4	7.5	11.2	
		T	122.4	129.6	108.4	9.5	14.7	
2000F, 1 Hour, 70 Seconds Delay (in air), WQ + 1100F, 8 Hrs, AC								
A	1	L		126.8	109.8	10.8	20.3	
		T		131.6	114.7	10.0	16.2	
B	1	L	119.2	128.0	109.1	6.2	10.8	
		T	122.0	130.0	111.0	8.8	14.9	

Each value average of two tests.  
 (1) Specimens taken from mid-thickness.  
 (2) 1.5 hours at solution temperature.

Ti
6 Al
2 Cb
1 Ta
0.8 Mo

3.0218 Tensile and compressive properties as a function of specimen location and direction for as-rolled 1 inch and 2.5 inch plate from two heats, Table 3.0218.

Ti-6Al-2Cb  
-1Ta-0.8Mo

TABLE 3.0218

Source					(3, p.9)				
Alloy					Ti-6Al-2Cb-1Ta-0.8Mo				
Form					Rolled Plate				
Condition					As-Rolled				
Heat	Plate Thickness Inches	Specimen in Plane of Plate (area)	Location in Plate Thickness-Direction	Specimen Direction	F <sub>cy</sub> ksi	F <sub>tu</sub> ksi	F <sub>ty</sub> ksi	e(1 inch) percent	RA percent
A	1	1	Mid-Thickness	L	110	120	102	12	32
				T	111	121	101	12	23
A	1	2	Mid-Thickness	L	---	120	102	14	35
				T	---	121	101	12	25
B	1	1	Mid-Thickness	L	---	119	98	14	38
				T	---	120	101	12	27
B	2.5	1	Surface	L	106	117	97	12	28
				T	107	120	100	11	30
			Mid-Thickness	L	107	117	96	13	30
				T	105	117	99	11	32
B	2.5	2	Surface	L	---	118	97	12	29
				T	---	120	100	12	23
			Mid-Thickness	L	---	118	97	14	32
				T	---	119	99	14	35
B	2.5	2	-----	ST	103	117	96	11	38

0.505 inch diameter tensile specimens; each value average of two tests.

Specimen locations in plane of plate

3.0219 Variation in room temperature tensile properties and -80F and +32F standard Charpy V impact energy as a function of specimen location for as-rolled and heat treated 2.5 inch plate, Table 3.0219.

TABLE 3.0219

Source		(3, p.8)					
Alloy		Ta-6Al-2Cb-1Ta-0.8Mo					
Form		2.5 inch Rolled Plate					
Condition	Specimen Location	Room Temperature Tensile Properties				Standard Charpy V Impact Energy	
		F <sub>tu</sub> ksi	F <sub>ty</sub> ksi	e(1 in) %	RA %	@ -80F	@ +32F
As-Rolled	Surface	117	97	12	28	27	33
	Mid-Thick	117	96	13	31	26	34
2300F, 1 hr, WQ	Surface	127	108	9	19	29	40
	Mid-Thick	122	104	8	17	29	36
2300F, 1hr, WQ+1100F, 2hrs, AC	Surface	130	114	7	14	26	32
	Mid-Thick	125	108	8	16	25	30

All longitudinal properties.  
Heat treatments performed on 5x4x2.5 inch sections, specimens removed from the center of these sections at either the surface or mid-thickness locations.

NONFERROUS ALLOYS

3.02110 Room temperature tensile and compressive strengths and -80F and +32F impact energies for as-rolled plate of various sizes, Table 3.02110.

	Ti
6	Al
2	Cb
1	Ta
0.8	Mo

Ti-6Al-2Cb  
-1Ta-0.8Mo

TABLE 3.02110

Source	(1)							
Alloy	Ti-6Al-2Cb-1Ta-1Mo							
Form	Rolled Plate							
Condition	As-Rolled							
Size - Inches	Test Direction	Room Temperature Properties					Standard Charpy V Impact Energy	
		F <sub>cy</sub> ksi	F <sub>tu</sub> ksi	F <sub>ty</sub> ksi	ε(1 inch) percent	RA percent	ft-lbs	
							+32F	-80F
1/2x24x60	L		135.5	124.2	10.0	34.0	28.0	26.0
	T		138.0	127.4	11.0	36.0	28.0	22.5
1x24x96	L	113.0	121.0	106.0	13.0	41.0	29.0	26.0
	T	126.0	126.0	114.0	12.0	28.0	30.0	22.5
1 3/4x65 diameter	L		120.0	104.0	11.0	35.0		27.0
	T		123.0	108.0	11.0	31.0		27.0
2x40x50	L	124.0	122.5	111.5	12.0	34.0	24.0	27.0
	T	114.0	122.0	110.0	14.0	39.0	27.0	25.0
2 3/8x36x48	L	114.0	122.0	107.0	14.0	25.0	45.5	26.5
	T	126.0	124.0	110.0	13.0	22.0	31.0	25.5
2 3/8x19 1/2x112	L	122.9	121.0	108.5	13.5	33.0	35.0	36.0
	T	116.6	121.0	107.0	15.0	33.5	41.0	34.0
2 3/8x 20x75	L	112.0	120.5	106.5	12.5	29.0	36.0	34.0
	T	119.5	121.5	107.0	13.5	25.0	37.0	34.0
3x46x46	L	111.3	117.4	100.3	13.5	29.5		28.0
	T	113.7	121.5	102.8	14.0	26.0		27.5
4x24x96	L		115.0	97.0	13.0	24.0		29.0
	T		117.7	95.0	14.0	25.0		28.0

Not all from same heat. Center properties. Single Tests.

## NONFERROUS ALLOYS

RELEASED: JUNE 1969

	Ti
6	Al
2	Cb
1	Ta
0.8	Mo

3.02111 Room temperature tensile and compressive properties and -80F and +32 impact energies of as-forged pressure vessel cover, Table 3.02111.

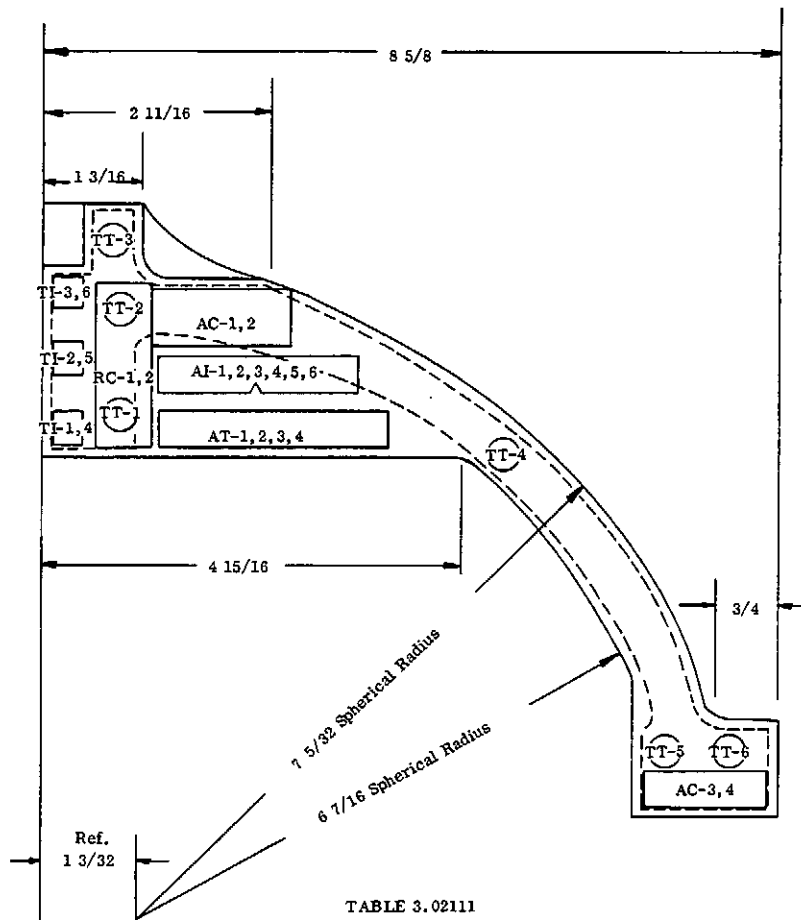
Ti-6Al-2Cb  
-1Ta-0.8Mo

TABLE 3.02111

Source		(1)					
Alloy		Ti-6Al-2Cb-1Ta-0.8Mo					
Form		Pressure Vessel Cover					
Condition		As-Forged					
Specimen Location	Room Temperature Properties					Standard Charpy V Impact Energy	
	F <sub>cy</sub> ksi	F <sub>tu</sub> ksi	F <sub>ty</sub> ksi	e(1 in) %	RA %	+32F ft-lbs	-80F ft-lbs
TT-1		126.3	105.9	13	37.2		
TT-2		125.5	110.1	15	39.6		
TT-3		125.6	109.0	13	36.9		
TT-4		127.6	116.8	15	38.6		
TT-5		126.9	111.8	13	22.7		
TT-6		128.3	117.3	15	38.8		
AT-1		126.2	113.3	14	28.6		
AT-2		126.0	113.3	14	36.7		
AT-3		126.3	112.8	14	37.2		
AT-4		126.1	112.9	14	38.6		
RC-1	122.1						
RC-2	118.9						
AC-1	119.5						
AC-2	121.8						
AC-3	123.2						
AC-4	119.6						
TI-1						39.0	
TI-2						44.0	
TI-3						39.0	
TI-4							33.0
TI-5							28.0
TI-6							27.5
AI-1						38.0	
AI-2						43.0	
AI-3						41.0	
AI-4							29.0
AI-5							28.0
AI-6							29.0

	Ti
6	Al
2	Cb
1	Ta
0.8	Mo

Ti-6Al-2Cb  
-1Ta-0.8Mo



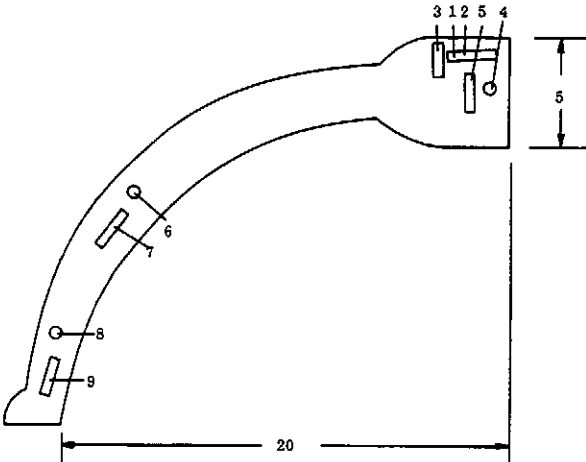
Ti  
6 Al  
2 Cb  
1 Ta  
0.8 Mo

Ti-6Al-2Cb  
-1Ta-0.8Mo

3.02112 Room temperature tensile properties and +32F impact energy of forged dome, Table 3.02112.

TABLE 3.02112

Source		(1)				
Alloy		Ti-6Al-2Cb-1Ta-0.8Mo				
Form		Forged Dome				
Condition		As-Forged				
Specimen Location	Room Temperature Properties				Standard Charpy V Impact Energy @32F ft-lbs	
	F <sub>tu</sub> ksi	F <sub>ty</sub> ksi	e(1 in) %	RA %		
1	122.1	107.4	10.5	27.2	21.0	
2	122.6	108.2	12.5	29.9		
3	122.6	108.4	12.0	30.5		
4	124.8	113.6	17.0	30.5		
5	130.0	114.0	9.5	22.3		22.0
6	129.4	118.0	17.5	38.8		23.5
7	130.2	118.6	17.5	37.2		23.5
8	135.6	123.8	15.0	37.5		27.0
9	133.4	122.2	15.0	37.2		22.0



3.02113 Effect of oxygen content on tensile properties of plate in various heat treated conditions, Table 3.02113.

- 3.02114 True-stress/true-strain curves for 1 inch and 2.5 inch as-rolled plate, Figure 3.02114.
- 3.022 Compression (see also 3.032 and Tables 3.0217, 3.0218, 3.02110, and 3.02111).
- 3.0221 Effect of tensile prestrain on compressive yield strength of plate (Bauschinger Effect) with and without stress relief treatment, Table 3.0221.

TABLE 3.0221

Source		(3, p.13)		
Alloy		Ti-6Al-2Cb-1Ta-0.8Mo		
Form		1 Inch Plate		
Condition		As-Rolled		
Tensile Prestrain Percent	Stress Relief Treatment		F <sub>cy</sub> ksi	
	Temp-F	Hours	(0.01% Offset)	(0.2% Offset)
0.0	RT	--	87	110
1.28	RT	--	45	89
1.28	600	1	63	96
1.28	600	3	65	99
1.28	900	1	75	104

- 3.023 Impact (see 3.033)
- 3.024 Bending.
- 3.025 Torsion and shear.
- 3.026 Bearing.
- 3.027 Stress concentration (see 2.03 for influence of sea-water on cracked specimens).
- 3.0271 Notch properties.

TABLE 3.02113

Source		(4, p.10)							
Alloy		Ti-6Al-2Cb-1Ta-0.8Mo							
Form		1 inch Rolled Plate							
Condition	Test Direction	F <sub>tu</sub> ksi		F <sub>ty</sub> ksi		e(1 inch) percent		RA percent	
		Al	Cb	Ta	Mo	Fe	C	N	O
Weight Percent		6.2	2.40	1.00	0.74	0.06	0.02	0.006	0.058
1900F, 1 Hour, AC	L	123.2				101.4		11.8	24.6
	T	123.2				103.4		12.2	27.7
1900F, 1 Hour, WQ	L	131.1				110.2		12.8	31.0
	T	128.1				108.0		8.8	23.8
1900F, 1 Hour, WQ + 1100F, 2 Hours, AC	L	135.3				117.1		9.5	24.8
	T	135.4				116.2		9.5	21.2
Weight Percent		6.0	1.98	0.92	0.80	0.05	0.03	0.006	0.122
1950F, 1 Hour, AC	L	127.6				105.5		12.2	27.6
	T	128.5				106.3		12.5	26.5
1950F, 1 Hour, WQ	L	135.2				115.0		11.5	27.3
	T	136.6				116.6		10.8	19.4
1950F, 1 Hour, WQ + 1100F, 2 Hours, AC	L	137.1				119.8		12.5	25.4
	T	139.0				121.1		9.2	16.0

All values average of two tests.

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- 3.0272 Fracture toughness. There exists no information on the plane strain fracture toughness of this alloy, even though the alloy is intended for structural applications in deep diving submersibles where heavy sections may operate under conditions of plane strain. In addition, temperature lower than ambient will be encountered in marine applications, increasing the possibility of plane strain failures.  
Judging from the scatter in Charpy V energies (see Figure 3.0331) it might be expected that considerable scatter in fracture toughness values would be encountered.
- 3.028 Combined properties.
- 3.03 Mechanical Properties at Various Temperatures
- 3.031 Tension (see 3.021)
- 3.0311 Effect of test temperature on tensile properties of stress relieved pancake forging, Figure 3.0311.
- 3.0312 Effect of test temperature on tensile properties of full annealed pancake forging, Figure 3.0312.
- 3.0313 Effect of test temperature on tensile properties of solution treated and aged pancake forging, Figure 3.0313.
- 3.032 Compression.
- 3.033 Impact (see Tables 3.0219 through 3.02112)
- 3.0331 Effect of test temperature on standard Charpy V impact energy of 1 inch and 2.5 inch as-rolled plate from two heats, Figure 3.0331.

- 3.0332 Room temperature yield strength and -80F standard Charpy V impact energy of plate specimens air cooled or water quenched from various solution temperatures, Figure 3.0332.
- 3.0333 Effect of quench delay on room temperature yield strength and -80F impact energy of solution treated plate, Figure 3.0333.
- 3.0334 Effect of aging temperature on room temperature yield strength and -80F impact energy of plate, Figure 3.0334.
- 3.0335 Effect of aging time on room temperature yield strength and -80F impact energy of plate, Figure 3.0335.
- 3.0336 Room temperature yield strength and +32F standard Charpy V impact energy of plate air cooled from various solution temperatures, with and without subsequent aging, Figure 3.0336.
- 3.0337 Alpha-beta versus beta solution treatment regarding -80F standard Charpy V and +32F drop weight tear energies of as-quenched or quenched and aged plate, Table 3.0337.

	Ti
6	Al
2	Cb
1	Ta
0.8	Mo

Ti-6Al-2Cb  
-1Ta-0.8Mo

TABLE 3.0337

Source	(4, p.10)(5, p.26)			
Alloy	Ti-6Al-2Cb-1Ta-0.8Mo			
Form	1 Inch Rolled Plate			
Condition	Test Direction	F <sub>ty</sub> @RT ksi	Standard Charpy V Impact Energy @ -80F ft-lbs	Drop Weight Tear Energy @ +32F ft-lbs
As-Rolled	L	101.8	23.5	2266*
	T	105.0	23.0	2146*
Alpha annealed (1600F, 1 Hour, AC)	L	99.2	29.2	2443
	T	107.4	32.2	2846
Alpha-beta annealed, air-cooled (1815F, 1 Hour, AC)	L	97.7	32.5	2560
	T	104.0	28.2	2266
Alpha-beta solution treated, quenched (1815F, 1 Hour, WQ)	L	101.2	27.8	2560
	T	108.4	32.2	2443
Alpha-beta solution treated, aged (1815F, 1 Hour, WQ + 1100F, 2 Hours, AC)	L	108.0	25.5	2086
	T	118.9	29.0	1905
Beta annealed, air-cooled (1900F, 1 Hour, AC)	L	101.4	33.0	2618
	T	103.4	28.2	1966
Beta solution treated, quenched (1900F, 1 Hour, WQ)	L	110.2	30.5	2266
	T	108.0	26.8	2266
Beta solution treated, aged (1900F, 1 Hour, WQ + 1100F, 2 Hours, AC)	L	117.1	24.0	1723
	T	116.2	23.2	2146

All values average of two tests except DWT values which are individual results.  
Smooth tensile properties presented in Table 3.0216 correspond to these impact data.  
Same DWT specimen as in Table 3.0338 except 18 inches long by 4.5 inches deep.  
\*In a separate study on this same heat, the following results were obtained:  
2384 ft-lbs(L) and 1784 ft-lbs(T) (5, p.25)

	Ti
6	Al
2	Cb
1	Ta
0.8	Mo

3.0338 Room temperature yield strength, -80F standard Charpy V and +32F drop weight tear energies of 1 inch plate in several heat treated conditions, Table 3.0338.

Ti-6Al-2Cb  
-1Ta-0.8Mo

TABLE 3.0338

Source		(2, p.23)	
Alloy		Ti-6Al-2Cb-1Ta-0.8Mo	
Form		1 Inch Rolled Plate	
Test Direction	F <sub>ty</sub> @RT ksi	Standard Charpy V Impact Energy @ -80F ft-lbs	Drop Weight Tear Energy @ +32F ft-lbs
As-Rolled			
L	95.6	32.3	2325*
T	102.4	27.0	1662*
1650F, 1 Hour, AC			
L	94.7	30.5	1966
T	96.9	29.0	1966 1966**
1875F, 1 Hour, WQ + 1100F, 2 Hours, AC			
L	111.5	25.0	1662
T	112.2	21.5	1630
1875F, 1 Hour, WQ + 1100F, 8 Hours, AC			
L	109.7	24.2	1784
T	114.6	22.8	1478
2000F, 1 Hour, 70 Seconds Delay (in air), WQ			
L	98.8	18.8	1228
T	102.1	19.5	1296
2000F, 1 Hour, 70 Seconds Delay (in air), WQ + 1000F, 4 Hours, AC			
L	105.4	18.5	1296
T	108.4	22.2	1478 1113**
2000F, 1 Hour, 70 Seconds Delay (in air), WQ + 1100F, 8 Hours, AC			
L	109.1	18.0	1478
T	111.0	18.5	1418
Each value average of two tests. Smooth tensile and compressive properties for heat B in Table 3.0217 correspond to these impact tests. *In a preliminary study on this same heat, the following results were obtained: 2206 ft-lbs(L) and 1966 ft-lbs(T). (5, p.25) **0.025 inch removed from each surface by machining prior to test.			
Drop-Weight Tear Test Specimen (brittle weld initiates crack)			

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3.0339 Effect of oxygen content on room temperature yield strength and -80F standard Charpy V impact and +32F drop weight tear energies of plate in various heat treated conditions, Table 3.0339.

	Ti
6	Al
2	Cb
1	Ta
0.8	Mo

Ti-6Al-2Cb  
-1Ta-0.8Mo

TABLE 3.0339

Source	(4, p. 10)									
Alloy	Ti-6Al-2Cb-1Ta-0.8Mo									
Form	1 Inch Rolled Plate									
Condition	Test Direction	F <sub>ty</sub> @RT ksi				Standard Charpy V Impact Energy @ -80F ft-lbs				Drop Weight Tear Energy @ +32F ft-lbs
		Al	Cb	Ta	Mo	Fe	C	N	O	
Weight Percent		6.2	2.40	1.00	0.74	0.06	0.02	0.006	0.058	
1900F, 1 Hour, AC	L		101.4			33.0			2618	
	T		103.4			28.2			1966	
1900F, 1 Hour, WQ	L		110.2			30.5			2266	
	T		108.0			26.8			2266	
1900F, 1 Hour, WQ + 1100F, 2 Hours, AC	L		117.1			24.0			1723	
	T		116.2			23.2			2146	
Weight Percent		Al	Cb	Ta	Mo	Fe	C	N	O	
		6.0	1.98	0.92	0.80	0.05	0.03	0.006	0.122	
1950F, 1 Hour, AC	L		105.5			24.8			1784	
	T		106.3			25.5			----	
1950F, 1 Hour, WQ	L		115.0			22.5			----	
	T		118.6			24.0			----	
1950F, 1 Hour, WQ + 1100F, 2 Hours, AC	L		119.8			22.0			1173	
	T		121.1			23.2			----	

All values average of two tests, except DWT values, which are individual results.  
Smooth tensile properties presented in Table 3.02113 correspond to these impact data.  
Same DWT specimen as in Table 3.0338 except 18 inches long by 4.5 inches deep.

- 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
- 3.05 Fatigue Properties (See also Figure 2.039)
- 3.051 Low cycle fatigue crack growth rate for mildly-notched plate specimens, Figure 3.051.
- 3.06 Elastic properties.
- 3.061 Poisson's ratio : elastic, 0.31; plastic, 0.42.
- 3.062 Modulus of elasticity: E<sub>t</sub>=17.0 x 10<sup>6</sup> psi;  
E<sub>c</sub>=18.3 x 10<sup>6</sup> psi.
- 3.063 Modulus of rigidity.
- 3.064 Tangent modulus: 3.10 x 10<sup>6</sup> psi (0.2 percent offset yield strength).
- 3.065 Secant modulus: 12.5 x 10<sup>6</sup> psi (0.2 percent offset yield strength).
- 4. FABRICATION
- 4.01 Formability
- 4.011 Recommended forging temperatures: blocking, 1850-1950F; finishing, 1900-1850F.
- 4.02 Machining  
See other titanium alloy chapters and Air Force Machinability Data Center, Metcut Research Assoc., Cincinnati, Ohio 45209.
- 4.03 Welding  
Alloy is weldable (see also Table 2.035 and Figure 2.058).

Ti
6 Al
2 Cb
1 Ta
0.8 Mo

Ti-6Al-2Cb  
-1Ta-0.8Mo

4.031 Room temperature tensile properties of welded 1 inch plate in as-welded and in stress relieved conditions, Table 4.031.

Table 4.031

Source		(3, p.15)							
Alloy		Ti-6Al-2Cb-1Ta-0.8Mo							
Form		1 Inch Rolled Plate, Welded							
Welding Process	Filler Metal		Condition of Weldment	Room Temperature Tensile Properties					Location of Fracture
	Nominal Composition	Wire Diameter Inches		F <sub>tu</sub> ksi	F <sub>y</sub> (0.2% Offset) ksi	ε(1 inch) percent	RA percent		
GTA	Ti-621/0.8	1/8 Flat Strip	As-Welded	127	115	9	26	Base Metal	
	Ti-621/0.8	1/8 Flat Strip	900F, 2 Hrs, AC	129	115	10	25	Base Metal	
	Ti-621/0.5	0.062	As-Welded	123	105	11	33	Base Metal	
	Ti-621/0.5	0.062	900F, 2 Hrs, AC	124	109	11	31	Base Metal	
GMA	Ti-621/0.5	0.062	As-Welded	120	108(1)	10	31	Base Metal	
	Ti-621/0.5	0.062	900F, 2 Hrs, AC	127	113(1)	9	26	Base Metal	
	Ti-621/0.5	0.062	As-Welded	125	113(2)	12	23	Weld	
	Ti-621/0.5	0.062	900F, 3 Hrs, AC	127	116(2)	11	25	Weld	

(1) Determined using SR-4 strain gauges mounted on weld zone of specimen.  
 (2) Determined from "all weld" specimen.

4.032 Stress-strain curve for weld zone of GMA welded plate, Figure 4.032.

4.033 Room temperature yield strength and +32F standard Charpy V impact energy of welded 1 inch plate, Table 4.033.

TABLE 4.033

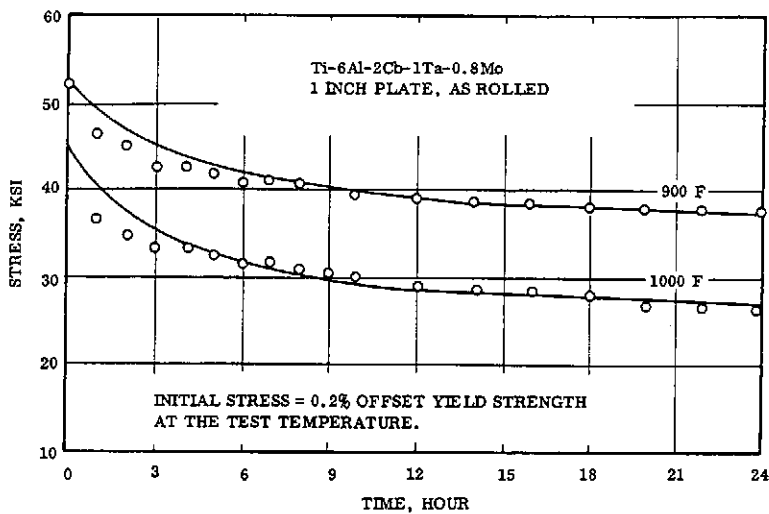
Source		(3, p.15)				
Alloy		Ti-6Al-2Cb-1Ta-0.8Mo				
Form		1 Inch Rolled Plate, Welded(6)				
Welding Process	Filler Metal		Condition of Weldment	F <sub>y</sub> (5) (0.2 percent Offset) ksi	Standard Charpy V Impact Energy(1) @+32F - ft-lbs	
	Nominal Composition	Wire Diameter Inches			Weld Zone	HAZ
GTA	Ti-621/0.8	1/8 Flat Strip	As-Welded	115	--	49
	Ti-621/0.8	1/8 Flat Strip	900F, 2 Hrs, AC	115	32	41
	Ti-621/0.5	0.062	As-Welded	105	--	43
	Ti-621/0.5	0.062	900F, 2 Hrs, AC	109	--	40
GMA	Ti-621/0.5	0.062	As-Welded	108(2)	39	41
	Ti-621/0.5	0.062	900F, 2 Hrs, AC	113(2)	35	39
	Ti-621/0.5	0.062	As-Welded	113(3)	40(4)	--
	Ti-621/0.5	0.062	900F, 3 Hrs, AC	116(3)	38(4)	--

(1) Drop-weight tear energy for GMA weld using Ti-621/0.8 filler is (5, p.25):  
 As-welded, 2026 ft-lbs  
 As-welded + 1900F, 1 Hr, Helium Cool, 2560 ft-lbs  
 (Same DWT specimen as in Table 3.0338 except 18 inches long x 4.5 inches deep)  
 (2) Determined using SR-4 strain gauges mounted on weld metal.  
 (3) Determined from "all weld" specimen.  
 (4) At -80F, 35 ft-lbs for as-welded and for 900F, 3 hrs, AC conditions.  
 (5) Remainder of smooth tensile properties corresponding to these impact data appear in Table 4.031.  
 (6) Weld joint configuration is shown in Table 4.031.

4.04 Heat Treatment

4.05 Surface Treatment

NONFERROUS ALLOYS



Ti
6 Al
2 Cb
1 Ta
0.8 Mo

Ti-6Al-2Cb  
-1Ta-0.8Mo

FIG. 1.0511 STRESS RELAXATION OF PLATE AT 900 AND 1000 F

(3, FIG. 8)

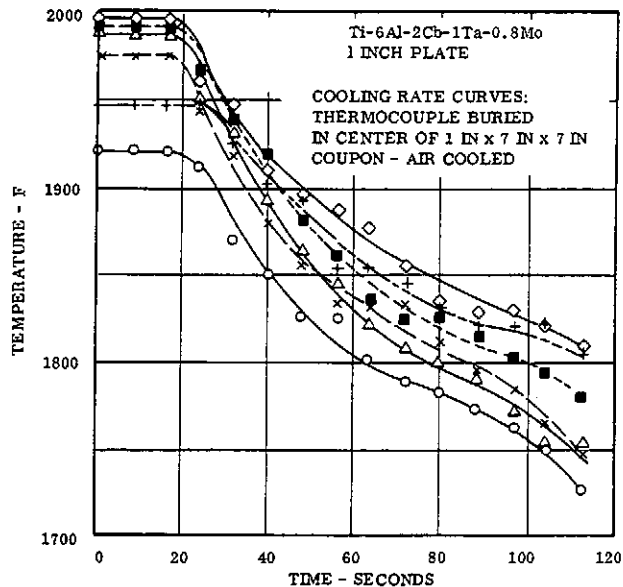


FIG. 1.0551 COOLING RATE CURVES FOR 1 INCH PLATE COOLED IN AIR.

(2, p. 20)

	Ti
6	Al
2	Cb
1	Ta
0.8	Mo

Ti-6Al-2Cb  
-1Ta-0.8Mo

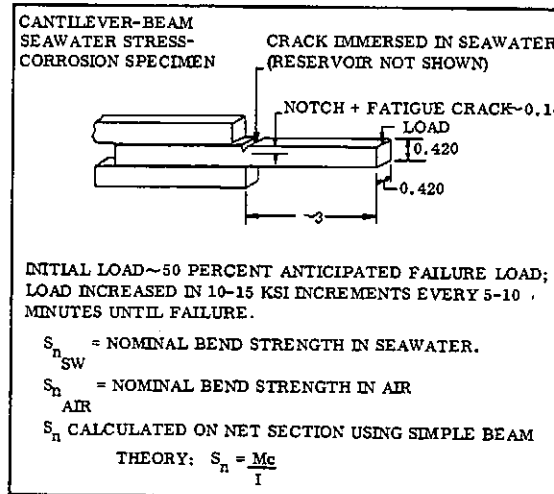
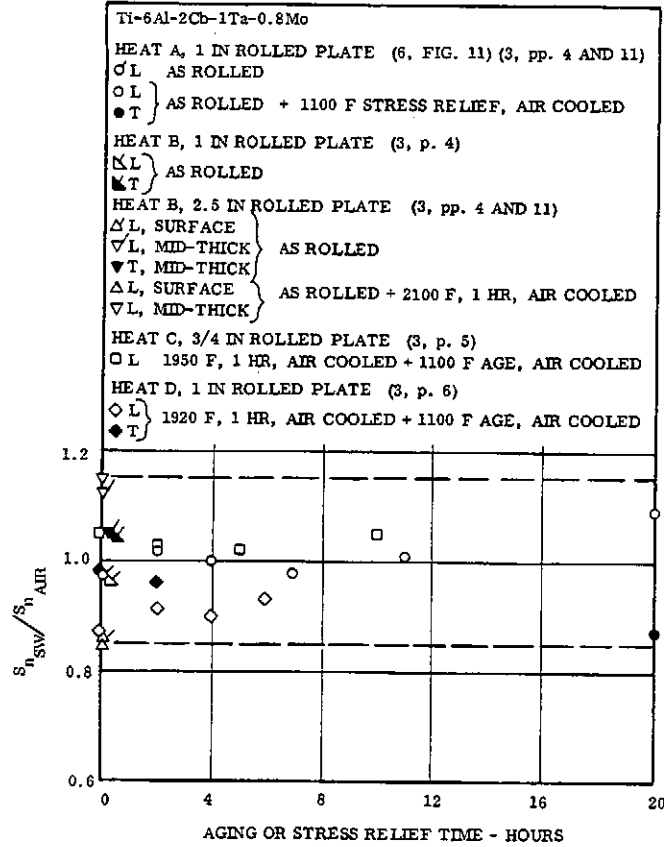


FIG. 2.034 SEAWATER STRESS CORROSION BEHAVIOR OF PLATE.

NONFERROUS ALLOYS

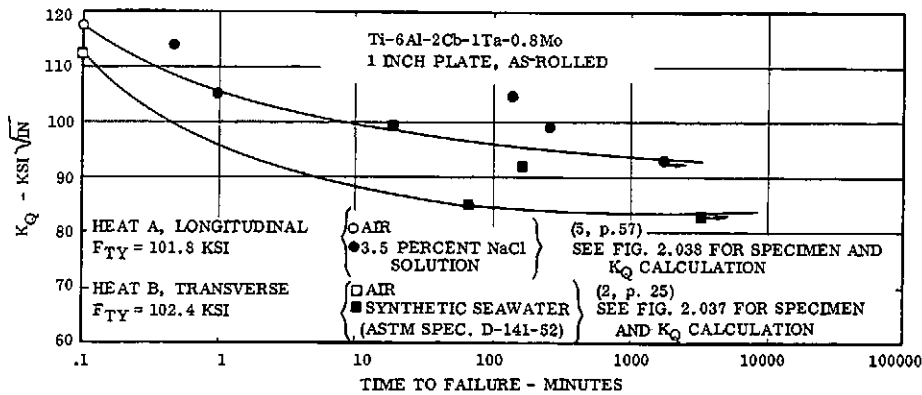


FIG. 2.036 SUSTAINED LOAD SALT WATER STRESS-CORROSION BEHAVIOR OF AS ROLLED PLATE.

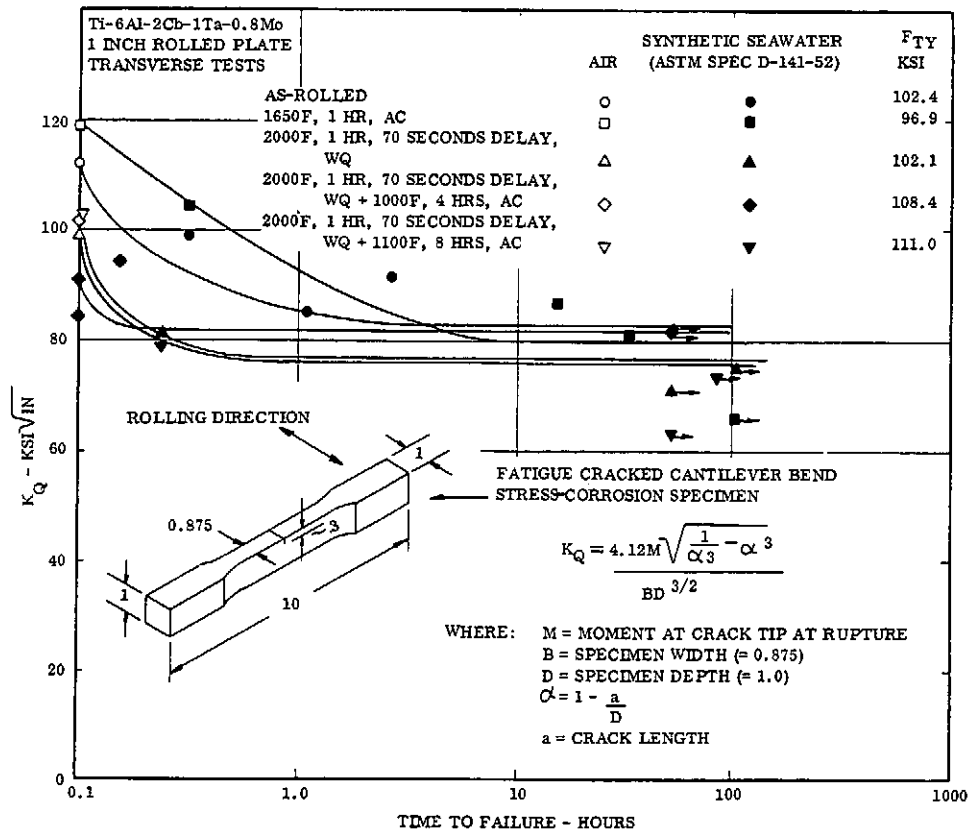


FIG. 2.037 SUSTAINED LOAD SEA WATER STRESS-CORROSION BEHAVIOR OF PLATE IN SEVERAL HEAT TREATED CONDITIONS.

(2, pp. 23 and 25)

	Ti
6	Al
2	Cb
1	Ta
0.8	Mo

Ti-6Al-2Cb  
-1Ta-0.8Mo

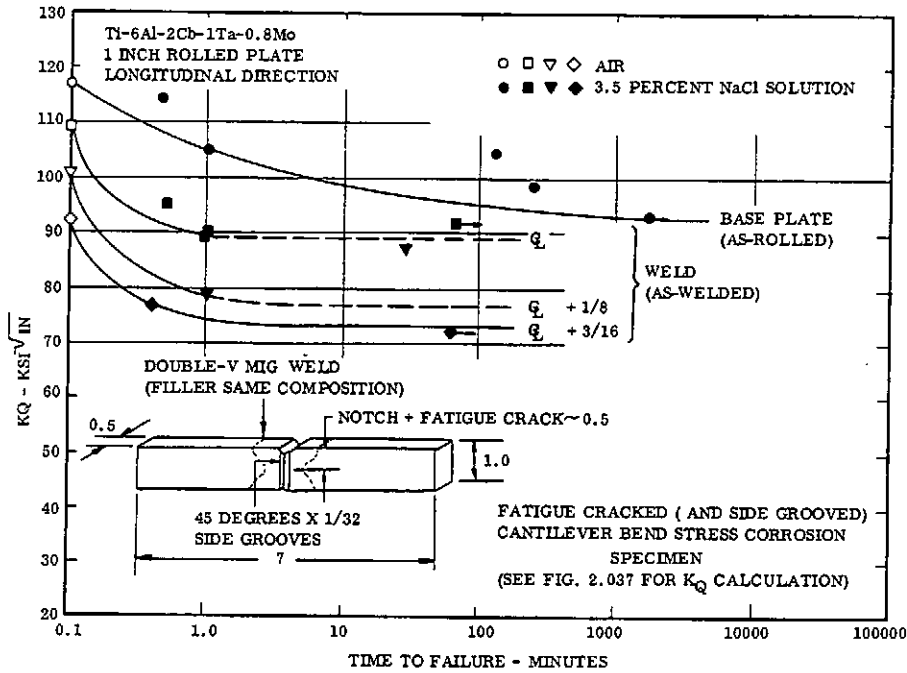


FIG. 2.038 SUSTAINED LOAD SALT WATER STRESS-CORROSION BEHAVIOR OF WELDED PLATE. (5, pp. 57 AND 59)

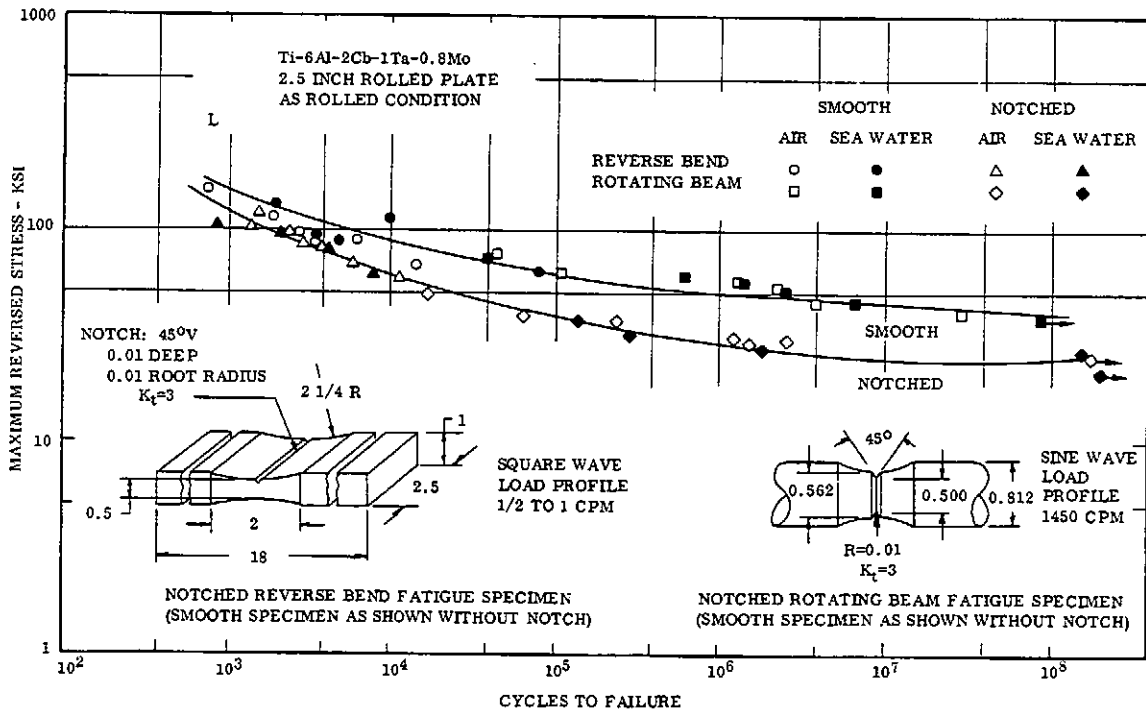
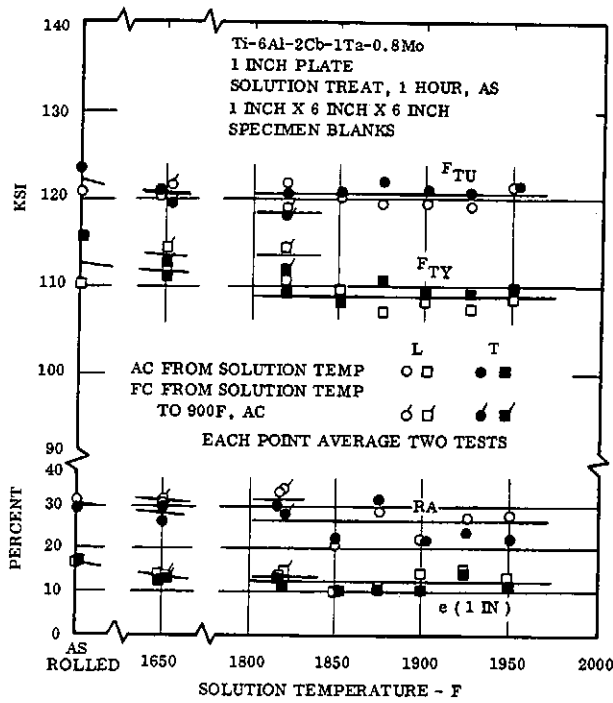


FIG. 2.039 EFFECT OF SEA WATER ENVIRONMENT ON LOW AND HIGH CYCLE FATIGUE STRENGTH OF SMOOTH AND MILD NOTCH SPECIMENS. (3, Fig. 6 and Appendix B)



	Ti
6	Al
2	Cb
1	Ta
0.8	Mo

Ti-6Al-2Cb  
-1Ta-0.8Mo

FIG. 3.0211 SOLUTION TREATED TENSILE PROPERTIES OF PLATE SPECIMENS AIR COOLED OR FURNACE COOLED FROM VARIOUS SOLUTION TEMPERATURES. (2, pp 21-22)

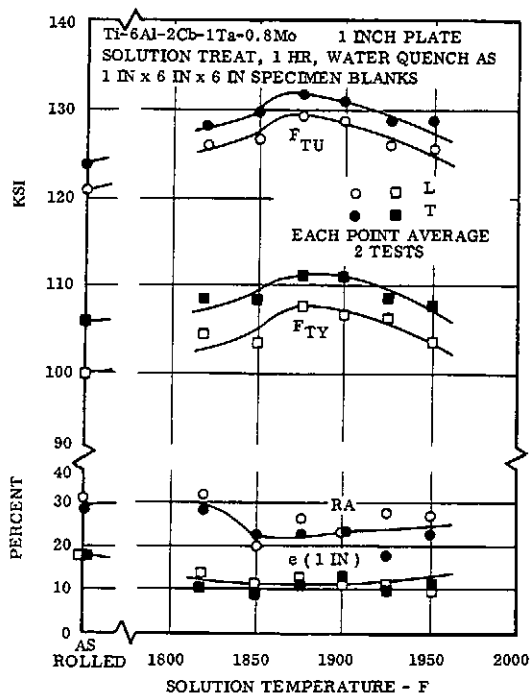


FIG. 3.0212 SOLUTION TREATED TENSILE PROPERTIES OF PLATE SPECIMENS WATER QUENCHED FROM VARIOUS SOLUTION TEMPERATURES. (2, p. 21)

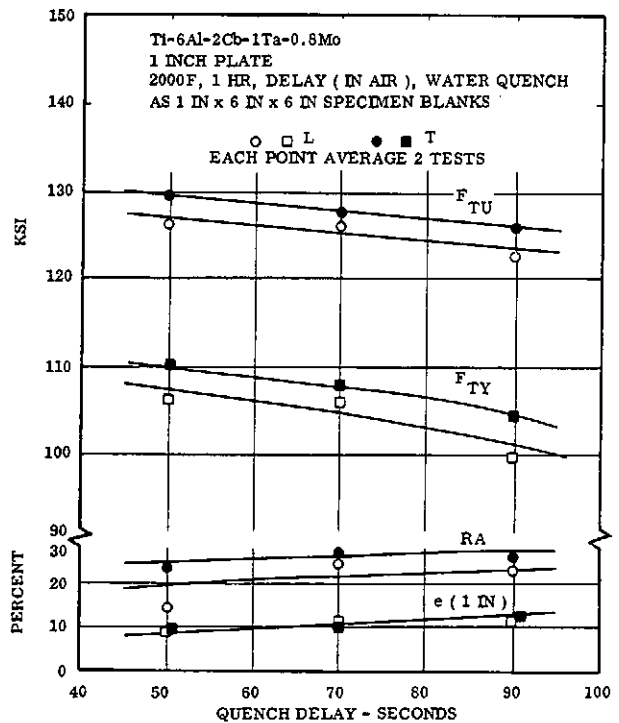


FIG. 3.0213 EFFECT OF QUENCH DELAY ON SOLUTION TREATED TENSILE PROPERTIES OF PLATE. (2, p. 22)

	Ti
6	Al
2	Cb
1	Ta
0.8	Mo

Ti-6Al-2Cb  
-1Ta-0.8Mo

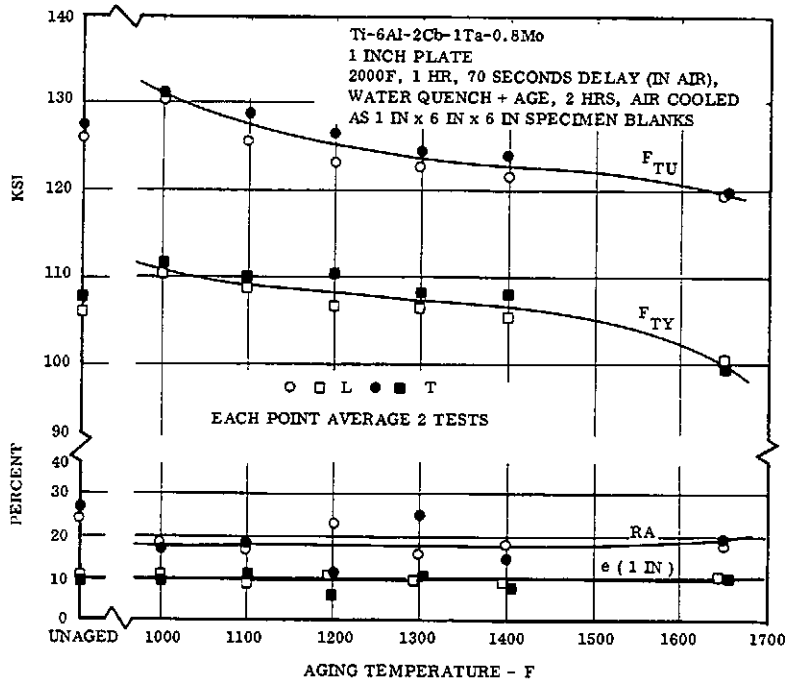


FIG. 3.0214 EFFECT OF AGING TEMPERATURE ON TENSILE PROPERTIES OF PLATE.  
(2, p. 22)

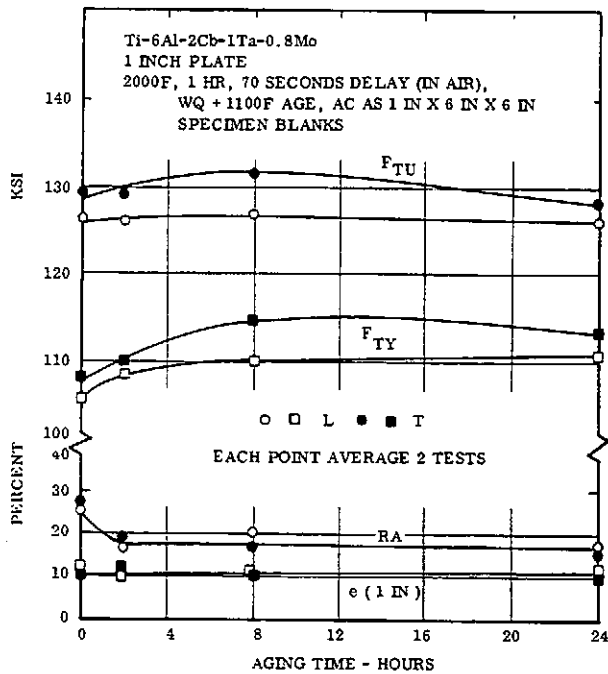


FIG. 3.0215 EFFECT OF AGING TIME ON TENSILE PROPERTIES OF PLATE.

(2, p. 22)

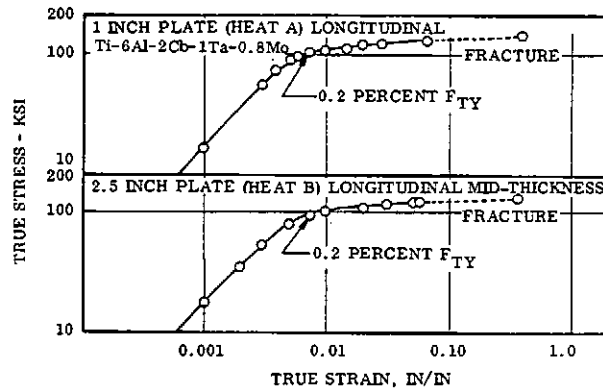
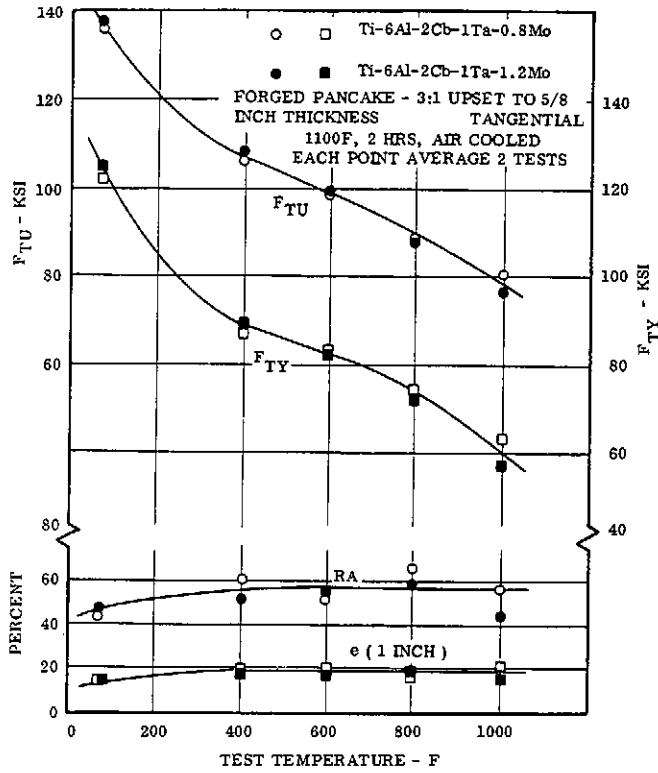


FIG. 3.02114 TRUE STRESS/TRUE STRAIN CURVES FOR 1 INCH AND 2.5 INCH AS-ROLLED PLATE.

(3, FIG. 3)



Ti
6 Al
2 Cb
1 Ta
0.8 Mo

Ti-6Al-2Cb-1Ta-0.8Mo

FIG. 3.0311 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF STRESS RELIEVED PANCAKE FORGING (1)

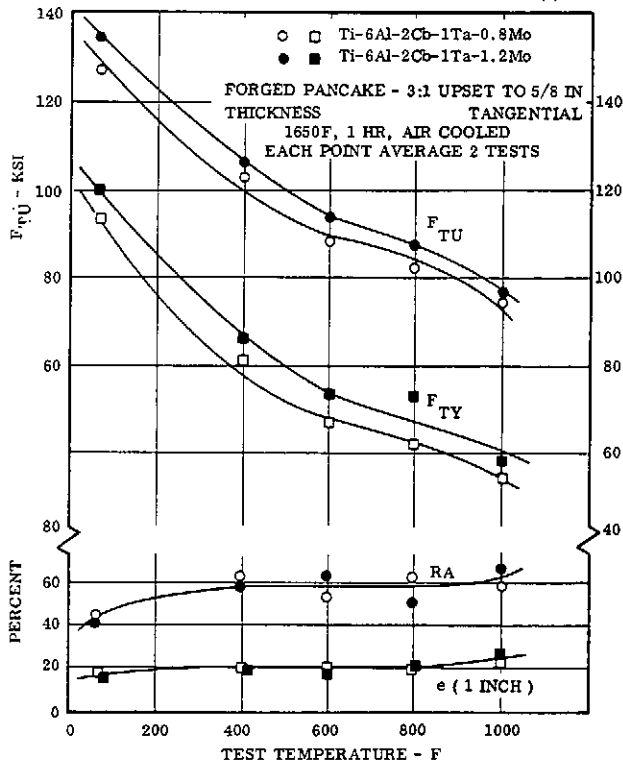


FIG. 3.0312 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF FULL ANNEALED PANCAKE FORGING (1)

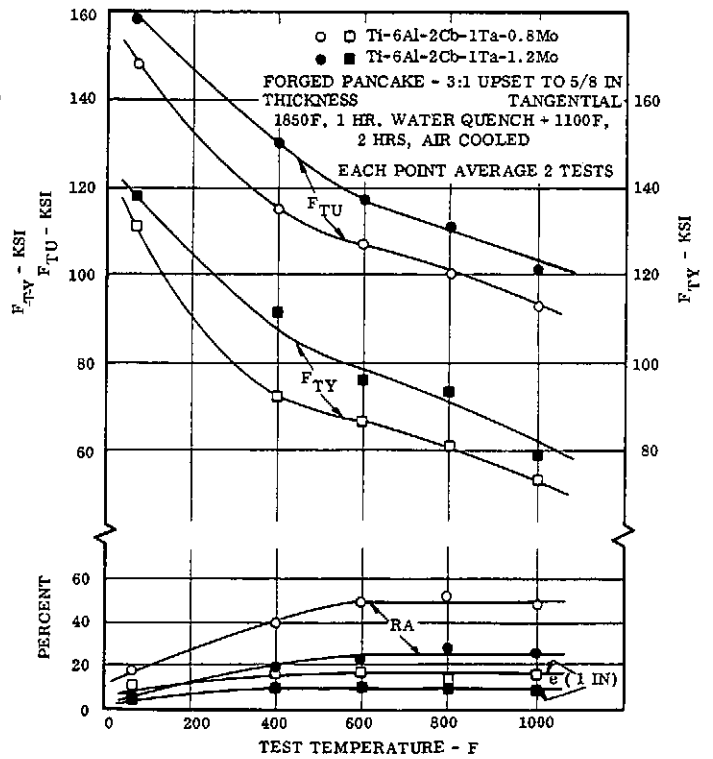


FIG. 3.0313 EFFECT OF TEST TEMPERATURE ON TENSILE PROPERTIES OF SOLUTION TREATED AND AGED PANCAKE FORGING (1)

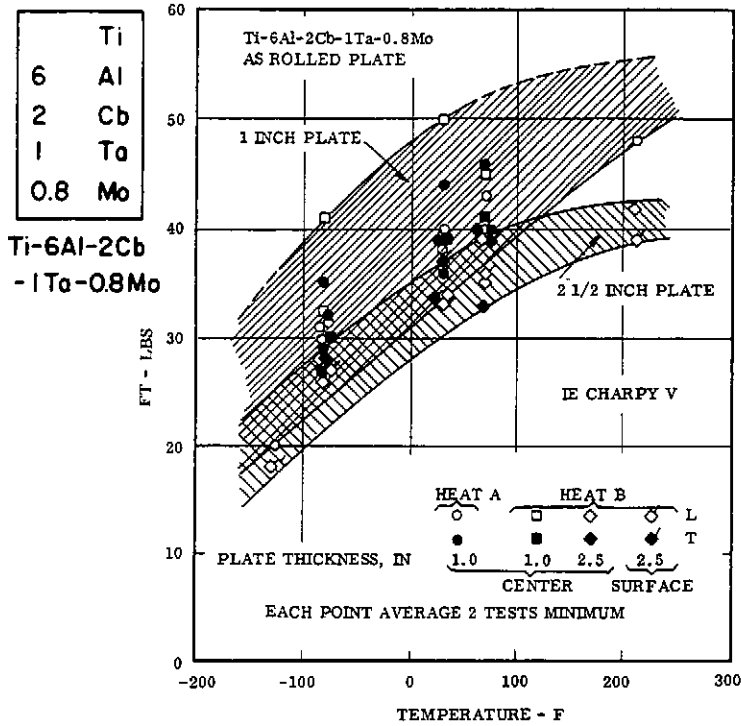


FIG. 3.0331 EFFECT OF TEST TEMPERATURE ON STANDARD CHARPY V IMPACT ENERGY OF 1 AND 2.5 INCH AS-ROLLED PLATE FROM TWO HEATS. (2, pp. 21, 23 and 26)(3, pp. 4, 7 and 11)

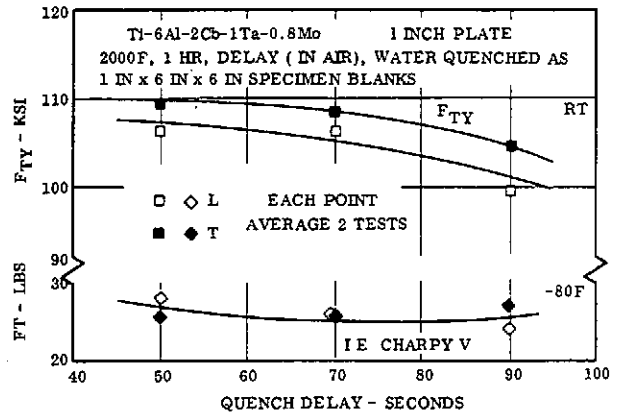


FIG. 3.0333 EFFECT OF QUENCH DELAY ON ROOM TEMPERATURE YIELD STRENGTH AND -80F IMPACT ENERGY OF SOLUTION TREATED PLATE. (2, p. 22)

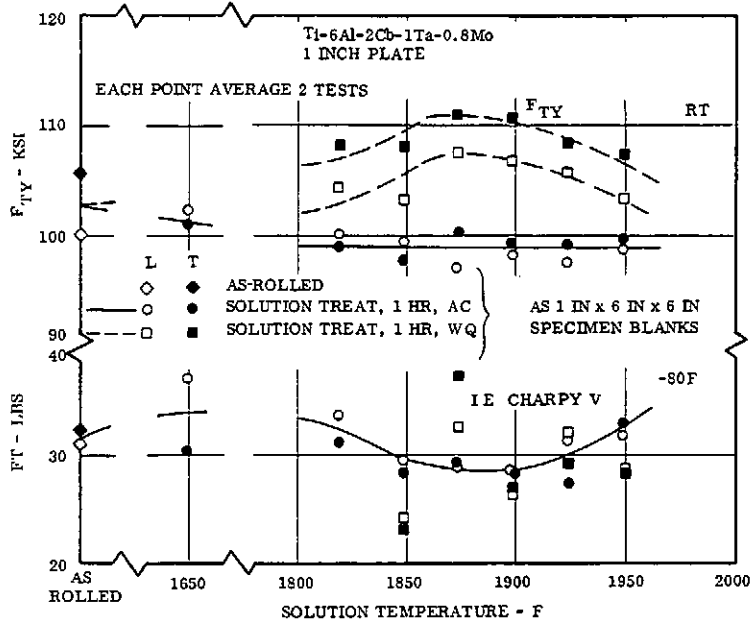
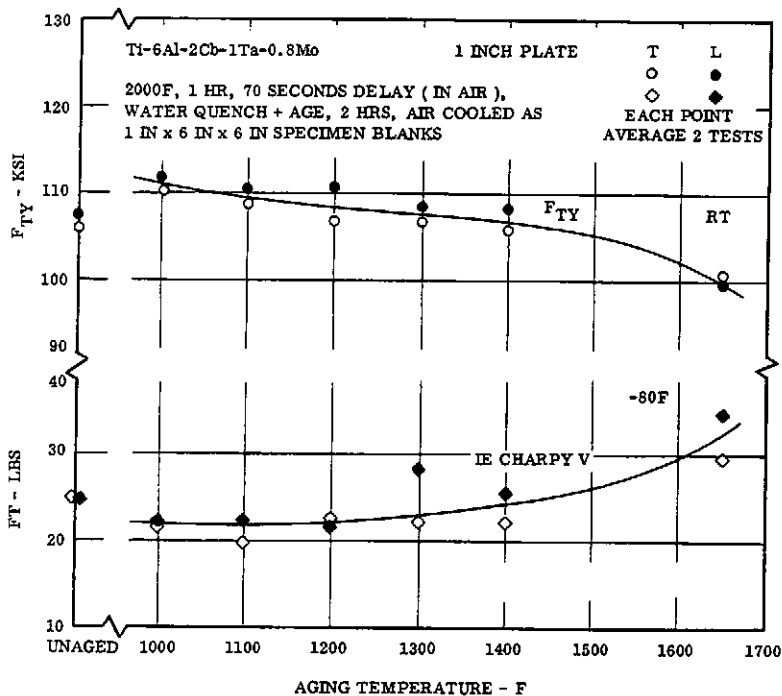


FIG. 3.0332 ROOM TEMPERATURE YIELD STRENGTH AND -80F STANDARD CHARPY V IMPACT ENERGY OF PLATE SPECIMENS AIR COOLED OR WATER QUENCHED FROM VARIOUS SOLUTION TEMPERATURES. (2, pp. 21 - 22)



	Ti
6	Al
2	Cb
1	Ta
0.8	Mo

Ti-6Al-2Cb  
-1Ta-0.8Mo

FIG. 3.0334 EFFECT OF AGING TEMPERATURE ON ROOM TEMPERATURE YIELD STRENGTH AND -80F IMPACT ENERGY OF PLATE.

(2, p. 22)

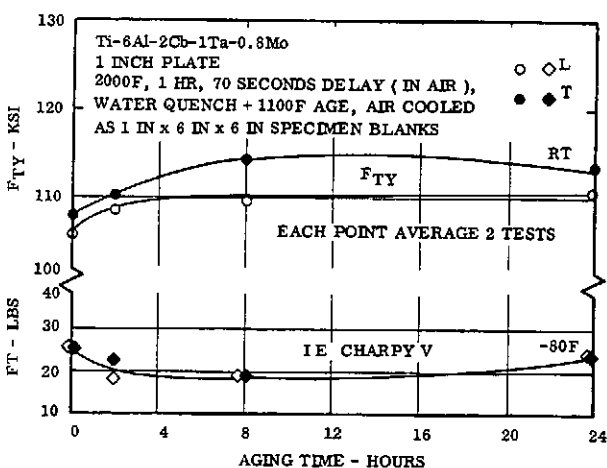


FIG. 3.0335 EFFECT OF AGING TIME ON ROOM TEMPERATURE YIELD STRENGTH AND -80F IMPACT ENERGY OF PLATE.

(2, p. 22)

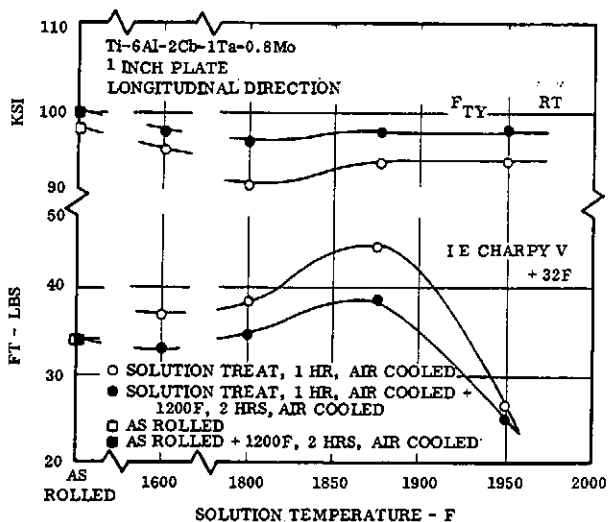


FIG. 3.0336 ROOM TEMPERATURE YIELD STRENGTH AND +32F STANDARD CHARPY V IMPACT ENERGY OF PLATE AIR COOLED FROM VARIOUS SOLUTION TEMPERATURES, WITH AND WITHOUT SUBSEQUENT AGING.

(3, p. 7)

	Ti
6	Al
2	Cb
1	Ta
0.8	Mo

Ti-6Al-2Cb  
-1Ta-0.8Mo

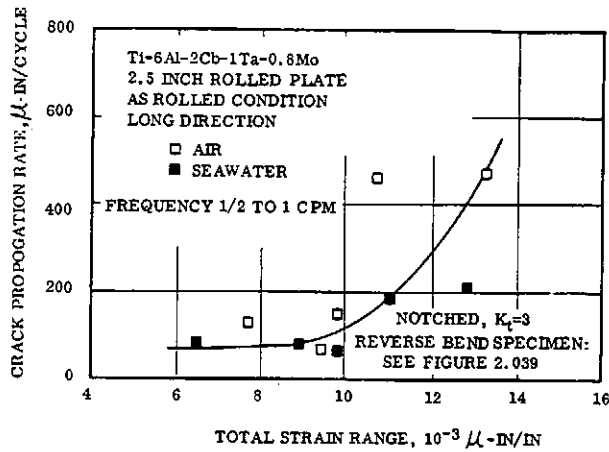


FIG. 3.051 LOW-CYCLE FATIGUE CRACK-GROWTH RATE FOR MILDLY-NOTCHED PLATE SPECIMENS (8, Fig. 7)

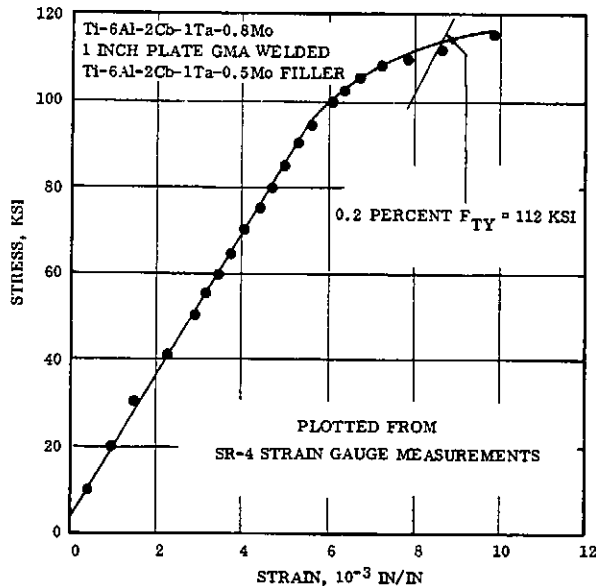


FIG. 4.032 STRESS-STRAIN CURVE FOR WELD ZONE OF GMA WELDED PLATE.

(3, FIG. 9)

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14. Private communication with R.J. Goode, Naval Research Laboratory, Washington, D.C. (January 13, 1969)