FOREWORD

The final Technical Engineering Report covering all work performed under Contract AF 33(616)-6346 from 31 March 1959 to 31 March 1962 is divided into four volumes, as follows:

Volume 1 - Summary of mechanical and physical property data collected, including creep and fatigue.

Volume 2a - Details of data collection program. Test techniques and results for tension, compression, bearing, shear, crippling, joints, and physical properties.

Volume 2b - Test techniques and results for creep and fatigue.

Volume 3 - Tables of data collected.

The work was primarily conducted by the Structural Research Department, Engineering Research Laboratory of Lockheed-Georgia Company, a Division of Lockheed Aircraft Corporation. The contract was initiated under Project No. 7381, "Materials Application," Task No. 738103, "Data Collection and Correlation." It was monitored by the Metals and Ceramics Laboratory, Directorate of Materials and Processes, Deputy for Technology, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio. Captain R. G. Henning and Mr. A. W. Brisbane were the project engineers.

Lockheed-Georgia Company supervision was provided by Mr. D. G. Cumro, Structural Research Department Engineer.

ABSTRACT

Mechanical and physical property data, necessary to fulfill the requirements of Phase II of the Department of Defense Titanium Alloy Sheet Rolling Program, were obtained for selected solution treated and aged titanium alloys in sheet form.

Four alloys were investigated: B120VCA (Ti-13V-11Cr-3Al), Ti-6Al-4V, Ti-2.5Al-16V and Ti-4Al-3Mo-1V. They were supplied by the producers in the heat treated condition from three or more heats and three thicknesses of each alloy. Static mechanical property data for tension, compression, bearing, shear and crippling; creep and rupture data for tension, compression, bearing and shear; and axial-load fatigue data were obtained at room and elevated temperatures. Fastener and weld joint data from -320°F to 80°F and physical properties from -420°F to 1200°F were obtained.

Volume 1 summarizes mechanical and physical properties in a form consistent with those given in MIL-HDBK-5. Experimental procedures and test results for static mechanical properties and physical properties are reported in Volume 2a. Volume 2b contains procedures and results for creep and fatigue tests and Volume 3 is a tabular compilation of all data obtained in the program.

This technical documentary report has been reviewed and is approved.

W. J. TRAPP
Chief, Strength and Dynamics Branch
Metals and Ceramics Laboratory
Directorate of Materials and Processes

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

I - INTRODUCTION

In the mid 1950's, the Department of Defense organized an integrated program to accelerate the development of high strength titanium alloy sheet for use in design of advanced aircraft and missile systems. This program, the Titanium Alloy Sheet Rolling Program, was coordinated and administered by the Bureau of Aeronautics, Department of the Navy. The Materials Advisory Board of the National Academy of Sciences was requested to establish a panel to act in an advisory capacity to the Bureau of Aeronautics, and did so with individuals selected from research organizations and academic institutions, from the titanium producing industry and from various aircraft companies. Liaison representatives were provided to the Panel by the various governmental agencies concerned with titanium alloy development. The first meeting of Materials Advisory Board Titanium Alloy Sheet Rolling Panel was held on June 5 and 6, 1956 in Washington, D. C. At this meeting a three phase program was outlined. Phases I and III were concerned with Manufacturing Development and Material Evaluation, respectively. Phase II, with which the present work is concerned, was defined as Design Data Accumulation and was directed toward the development of mechanical property data applicable to design uses for the heat treated titanium alloys. The initiation of work on Phase II was delayed in order for manufacturing development to progress sufficiently to establish consistent processing techniques which would make sheet material, having uniform properties, available for testing. Work commenced on Phase II of the DOD TASRP on 31 March 1959.

General

The program for collection of design data summarized in this report was divided into four basic phases as follows:

1. Phase I, "Static Properties" -room and elevated temperature data for short-time tension, compression, bearing, shear and crippling; effect of long-time temperature exposure on tensile properties.

2. Phase II, "Creep-Rupture Properties" -creep and rupture properties for tension and bearing, creep properties for compression, and rupture properties for shear.

3. Phase III, "Fatigue Properties" -axial-load tension-tension and tension-compression fatigue data at room and elevated temperatures for various stress ratios and stress concentration factors.

4. Phase IV, "Physical and Joint Properties" -measurement of specific heat, thermal coefficient of expansion and thermal conductivity from -420°F to 1200°F; strength data for mechanical and welded joints from -320°F to 80°F.

Four titanium alloys; B120VCA (Ti-13V-11Cr-3Al), Ti-6Al-4V, Ti-2.5Al-16V, and Ti-4Al-3Mo-1V, supplied by the producers in solution treated and aged condition from DOD stock were evaluated. The material was from three nominal thicknesses and several

Manuscript released by the authors on May 30, 1962 for publication as an ASD Technical Documentary Report.

Four titanium alloys; B120VCA(Ti-13V-11Cr-3Al), Ti-6Al-4V, Ti-2.5Al-16V and Ti-4Al-3Mo-1V, supplied by the producers in solution treated and aged condition from DOD stock were evaluated. The material was from three nominal thicknesses and several heats of each alloy and was specified to meet the requirements of quality, interstitial limits and strength established by the Materials Advisory Board. However, some of the required material was unavailable from producer's current supplies and it was necessary to substitute early DOD sheet, commercial sheet and reheat treated sheet. For certain test conditions requiring forming and welding, the material was received in the solution treated condition and was subsequently aged by Lockheed. The testing procedures employed in this program followed the recommendations of the MAB Subpanel on Uniform Procedures for Structural Design Data Collection. Members of this subpanel acted in a consulting capacity during the course of data collection.

Volume 2b

The final engineering report is presented in four volumes. This volume describes in detail the equipment and techniques involved in performing the creep-rupture and axial-load fatigue tests and presents in summary form the property data resulting from these tests. The summary creep curves and the fatigue S-N curves, which constitute a major portion of the data presented in this volume, were determined by constructing a "best-fit" line through the creep test data and a smooth curve through the lower part of the fatigue data scatterband.

Compressive-creep, bearing creep-rupture, single shear stress-rupture and double shear stress-rupture tests were performed by Southern Research Institute, Birmingham, Alabama. A description of the equipment and procedures used and the data obtained by SRI are presented herein and in Reference 1.

Since the purpose of this program was primarily for collection of design data, no comment, observation or analysis was made as to the merits of one alloy with respect to another. Such an analysis of merit has been left for the users of these data as dictated by their particular applications.

II - SUMMARY

Creep-rupture and axial-load fatigue data were collected for Ti-6Al-4V, Ti-2.5Al-16V and Ti-4Al-3Mo-1V, only. The beta alloy, B120VCA, was not included in these two phases of the program.

Details of specimen design and preparation, equipment and experimental techniques, and methods of data analysis are discussed for creep and fatigue tests.

Graphical presentations are made of tensile, compressive, bearing, single shear and double shear creep properties. Also presented are room and elevated temperature axial-load fatigue S-N curves obtained for stress concentrations of 1.0 and 2.82 at four stress ratios.

The following summary table details the variables included in the program, indicating types of information obtained and volumes in which the data are reported.

TABLE I SUMMARY OF TESTS CONDUCTED AND DATA REPORTED

(a) PHASE I

Alloys: B120VCA, 6Al-4V, 2.5Al-16V, 4Al-3Mo-1V Heats/Alloy - 3(1) Grain Direction - Longitudinal and Transverse	Thickness, In.			Temperature, °F							Reported in Volume
	0.020	0.063	0.125	80	200	400	600	800	900	1000	
TENSION											
1. Ultimate and yield strengths	x	x	x	x	x	x	x	x	x	x	1, 2a and 3
2. Elastic moduli	x	x	x	x	x	x	x	x	x	x	1, 2a and 3
3. Elongations	x	x	x	x	x	x	x	x	x	x	1, 2a and 3
4. Poisson's Ratio		x		x	x	x	x	x	x	x	2a
5. Tangent moduli	x	x	x	x	x	x	x	x	x	x	1
6. Stress-strain curves	x	x	x	x	x	x	x	x	x	x	1
COMPRESSION											
1. Yield strengths		x	x	x	x	x	x	x	x	x	1, 2a and 3
2. Elastic moduli		x	x	x	x	x	x	x	x	x	1, 2a and 3
3. Secant and tangent moduli		x	x	x	x	x	x	x	x	x	1
4. Stress-strain curves		x	x	x	x	x	x	x	x	x	1
5. Ramberg-Osgood parameters		x	x	x	x	x	x	x	x	x	3
BEARING (e/D = 1.5 and e/D = 2.0, D = 1/8 inch)											
1. Ultimate and yield strengths	x			x	x	x	x	x	x	x	2a and 3
BEARING (e/D = 1.5 and e/D = 2.0, D = 3/16 inch)											
1. Ultimate and yield strengths	x			x	x	x	x	x	x	x	2a and 3
BEARING (e/D = 1.5 and e/D = 2.0, D = 5/16 inch)											
1. Ultimate and yield strengths	x	x	x	x	x	x	x	x	x	x	1, 2a and 3
SINGLE SHEAR											
1. Ultimate strengths	x	x	x	x	x	x	x	x	x	x	1, 2a and 3
DOUBLE SHEAR											
1. Ultimate strengths			x	x	x	x	x	x	x	x	2a and 3
CRIPPLING											
1. Critical crippling stresses		x		x	x	x	x	x	x	x	2a
2. Compressive yield stresses		x		x	x	x	x	x	x	x	2a
3. Compressive elastic moduli		x		x	x	x	x	x	x	x	2a
4. Ramberg-Osgood parameters		x		x	x	x	x	x	x	x	2a

(b) PHASE II

Alloys: 6Al-4V, 2.5Al-16V, 4Al-3Mo-1V Grain Direction - Longitudinal (2)	Heats per Alloy	Thickness, In.	Temperature, °F					Reported in Volume
			500	600	700	800	900	
TENSILE CREEP-RUPTURE								
1. Strain-time curves	3	0.063	x	x	x	x	x	2b
2. Stress and time to rupture and to various strains	3	0.063	x	x	x	x	x	1, 2b and 3
3. Larson-Miller plots	3	0.063		x	x	x		2b
COMPRESSIVE CREEP								
1. Strain-time curves	1	0.063		x	x	x		2b
2. Stress and time to various strains	1	0.063		x	x	x		2b and 3
BEARING CREEP-RUPTURE								
1. Strain-time curves	1	0.063		x	x	x		2b
2. Stress and time to rupture and to various strains	1	0.063		x	x	x		2b and 3
SHEAR STRESS-RUPTURE								
1. Stress and time to rupture	3	0.063 0.125		x	x	x		2b and 3

(c) PHASE III

Alloys: 6Al-4V, 2.5Al-16, 4Al-3Mo-1V Heats/Alloy - 3 to 5 Grain Direction - Longitudinal Thickness, In. - 0.020, 0.063, 0.125	Stress Concentration		Temperature, °F					Reported in Volume
	1.0	2.82	80	400	600	800	900	
AXIAL-LOAD FATIGUE								
1. Cycles to failure at								
a. Stress Ratio = ∞	x	x	x	x	x	x	x	3
b. Stress Ratio = 1.0	x	x	x	x	x	x	x	3
c. Stress Ratio = 0.3	x	x	x	x	x	x	x	3
d. Stress Ratio = 0	x	x				x	x	2b
2. S-N Curves	x	x	x	x	x	x	x	2b
3. Alternating to mean stress diagrams	x	x	x	x	x	x	x	1

(d) PHASE IV

Alloys: B120VCA, 6Al-4V, 2.5Al-16V, 4Al-3Mo-1V Heats per alloy: 1 Grain Direction-Longitudinal and Transverse(3)	Thickness, In.		Temperature, °F					Reported in Volume
	0.063	0.125	-320	-200	-100	-65	80	
FASTENER JOINTS IN TENSION								
1. Ultimate and yield strengths	x		x	x	x	x	x	2a and 3
WELDED JOINTS IN TENSION								
1. Ultimate and yield strengths	x		x	x	x	x	x	2a and 3
2. Elastic moduli	x		x	x	x	x	x	2a and 3
3. Elongations	x		x	x	x	x	x	2a and 3
4. Joint efficiencies	x		x	x	x	x	x	3
TENSION								
1. Ultimate and yield strengths	x		x	x	x	x	x	2a and 3
2. Elastic moduli	x		x	x	x	x	x	2a and 3
3. Elongations	x		x	x	x	x	x	2a and 3
4. Stress-strain curves	x		x	x	x	x	x	2a
THERMAL EXPANSION		x	-453°F to 1200°F					2a and 3
THERMAL CONDUCTIVITY		x	-423°F to 1200°F					2a and 3
SPECIFIC HEAT		x	-423°F to 1200°F					2a

(1) Only one heat was tested for 0.020 inch Ti-6Al-4V.
(2) Tensile creep-rupture was conducted on one heat of each alloy in the transverse direction at 600, 700 and 800°F.
(3) Thermal expansion and thermal conductivity specimens were in the longitudinal direction only.

Tensile Creep-Rupture Tests

Test Specimen

Tensile creep specimens were machined to the configuration shown in Figure 1, as specified in Reference 2. The machined edges of each specimen test section were polished with No. 400 emery paper and microscopically examined to verify the absence of edge cracks and notches. Specimen dimensions were determined by a minimum of five micrometer measurements each of width and thickness.

Test Details

Tensile creep-rupture tests were performed in Arcweld or Baldwin lever arm type creep machines having a combined range of maximum load capacities from 6,000 pounds to 30,000 pounds. Load was applied through the lever system by calibrated weights, and the system was accurate to within ± 0.5 percent as determined by calibration with National Bureau of Standards certified proving rings. Each machine was equipped with an automatic beam leveler, a time totalizer and a power cutoff system actuated by specimen failure. Some of these machines are shown in Figure 2.

Specimen length was such that a pinned clevis was attached at each end just outside a cylindrical furnace. Spherically seated loading rods, attached to the clevises, insured uniaxial loading. Loads were applied automatically by motor-driven elevators within a time span of one to three minutes.

Creep strains were measured over a two inch gage length using two general types of systems. The first system employed an Arcweld telescoping extensometer with a Daytronic differential transformer sensing element as shown in Figure 3. The differential transformer signal, which was proportional to strain, was recorded versus time by a Brown ElectroniK millivolt strip chart recorder, or in some cases, intermediate amplification was provided by a Model 300A Daytronic Differential Transformer Indicator. The sensitivity of this system was preselected in the range of five microinches per inch to 75 microinches per inch, depending upon the maximum creep strain to be measured for the particular test. Sensitivity was defined as the least reading on the recorder chart paper which was approximately 0.05 inch.

With the other creep strain measuring system, the output from a Baldwin-Lima-Hamilton two inch gage length, direct contact, follow-up type creep extensometer was recorded versus time by a Baldwin-Lima-Hamilton Multipoint Creep Recording System with a sensitivity of 50 microinches per inch.

Calibration of all creep strain measuring systems was performed in accordance with the method of Reference 3 to an accuracy of ASTM Class B or better using a Baldwin-Lima-Hamilton Portable Extensometer Comparator and precision gage blocks.

Creep-rupture specimens were heated and tested in either zone controlled cylindrical Arcweld or Marshall testing furnaces controlled, respectively, by Wheelco saturable core reactor type controllers and Brown ElectroniK Electr-O-Pulse Relay and Control System. The control thermocouple was located in the furnace windings with exception of two furnaces where it was located in the furnace atmosphere.

Specimen temperature was measured by three 28-gage Chromel-Alumel thermocouples made from selected, checked and calibrated wire. The thermocouples were mechanically attached at each end and at the center of the test section with the center thermocouple on the opposite side of the specimen from the other two. Thermocouple beads were in contact with the test specimen, but were insulated from the thermocouple clamps and the furnace atmosphere by an asbestos pad. After each test, the portions of the thermocouples that had been inside the furnace were cut off and the wires were rebeaded for the next test. Outputs from the thermocouples were measured with a Brown Type 153 ElectroniK Recorder.

In order for a temperature equilibrium to be reached, each specimen was soaked at the test temperature for approximately four hours before loading. Test temperatures were maintained within the limits of $\pm$ 3°F as indicated on the recorder.

Data Analysis

A time versus strain curve, which included initial loading strain plus creep strain, was autographically recorded for each creep-rupture test performed. In some instances, particularly when loading above the yield strength of the material, the initial loading strain was so great that a reset of the strain follower was necessary; and an accurate determination of the initial loading strain could not always be made.

For low stress level tests, the point defining the end of loading strain and initiation of creep strain was considered to be when the loading beam of the creep machine leveled; however, it was necessary to assume the start of creep strain measurements for the high stress level tests when the weights cleared the elevator, since considerable primary creep occurred while the beam was leveling.

No tests were continued after 1.0 percent creep strain was reached if failure was not anticipated within 500 hours. Also, when it became evident that the desired creep strain value would not be reached within 500 hours, the test was ordinarily discontinued. Those tests that were allowed to continue longer, and still did not fail or reach the desired magnitude of strain are, for convenience, listed in the tables in Volume 3 as having been discontinued after 500 hours.

From the creep strain curves, initial loading strains and times to reach creep strains of 0.05 percent, 0.1 percent, 0.2 percent, 0.5 percent and 1.0 percent were determined and tabulated along with the times to rupture. These tabulations were then used to plot log stress versus log time summary curves. Those summary curves which extend to the ordinate or 0.10 hour are based upon test data obtained for times less than 0.10 hour.

Master curves were plotted for the longitudinal rupture and creep data using the Larson-Miller parameter (Reference 4). Use of this parameter is beneficial in presenting rupture and creep data for design purposes and for predicting long-time rupture and creep properties from short-time data. This parameter allows most rupture and creep data, regardless of the temperature at which the tests were conducted, to be represented by a smooth curve when presented as F versus T(C + log t), F being on a logarithmic scale and T(C + log t) on a linear scale.

F = Stress

T = Absolute temperature, (°F + 460)

C = Constant, dependent upon activation energy

t = time in hours

A plot of this nature is called a master creep or rupture curve since it is actually a superposition of rupture or creep curves at different temperatures.

In preparing master plots for rupture and creep data, several values for C must be evaluated before an optimum value is obtained which suitably fits the data.

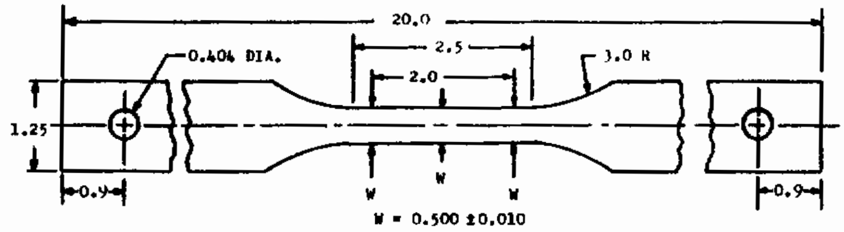
Since the operation for determining optimum C values is quite laborious and time consuming if done by hand, a program was set up for processing these data on the IBM 7090 computer. The optimum C was obtained from the input data using the following cubic equation.

$$T(\log t + C) = a + a_1(\log F) + a_2(\log F)^2 + a_3(\log F)^3$$

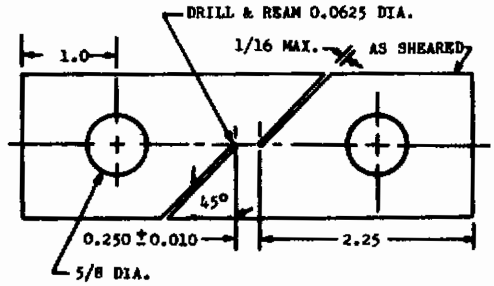
or

$$\log t = C + a\left(\frac{1}{T}\right) + a_1\left(\frac{1}{T}\right)(\log F) + a_2\left(\frac{1}{T}\right)(\log F)^2 + a_3\left(\frac{1}{T}\right)(\log F)^3$$

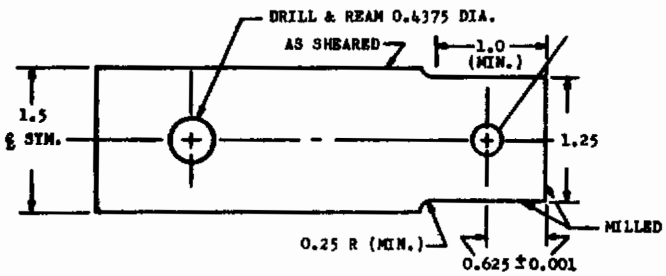
This was done by minimizing the expression for the sum of the squares of the deviations and solving the resulting equations for C. This method has been used by NASA with acceptable results, as reported in Reference 5. Using the C value obtained, T(C + log t) was computed and plotted as a function of stress.



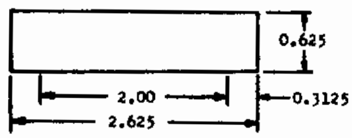
TENSILE CREEP-RUPTURE SPECIMEN



SINGLE SHEAR STRESS-RUPTURE SPECIMEN



BEARING CREEP-RUPTURE SPECIMEN



COMPRESSIVE CREEP SPECIMEN

DOUBLE SHEAR STRESS-RUPTURE SPECIMEN

FIGURE 1 - CREEP-RUPTURE SPECIMENS
(All Dimensions in Inches)

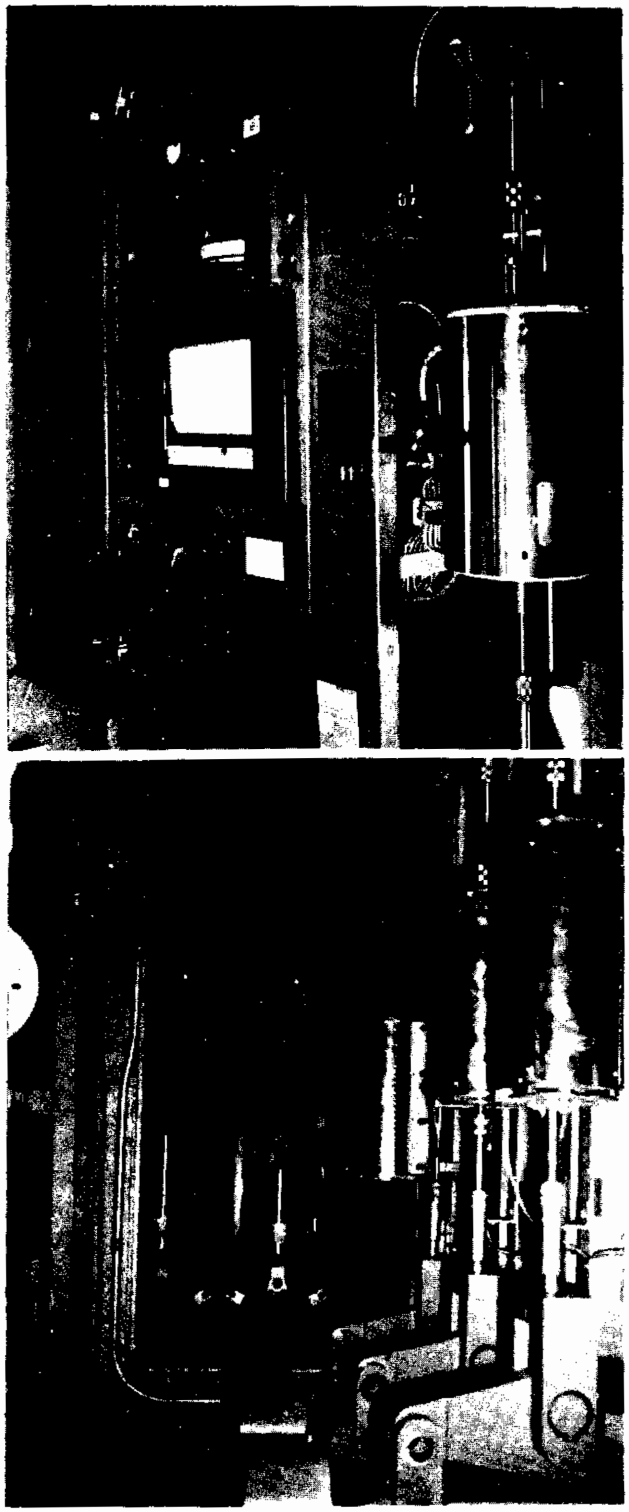


FIGURE 2 - CREEP-RUPTURE MACHINES

FIGURE 3 - CREEP EXTENSOMETER

Compressive Creep Tests

Test Specimens

The test specimens for compressive creep evaluations were machined to the configuration shown in Figure 1. This design differed somewhat from that of the static test specimens but still conformed to the requirements set forth in Reference 2. The preparation, inspection and measurement of these specimens were similar to those described for the tensile creep specimens.

Test Details

Compressive creep tests were conducted by Southern Research Institute in dead-weight testing machines designed and fabricated by that organization. The machines employed a counter balanced lever arm, with a magnification ratio of 20 to 1, located below the specimen. Load was applied by hand crank in approximately two minutes through a ram and subpress arrangement. Five machines of this type were available, and their overall load accuracy was within ± 1 percent. A photograph of one of the machines is shown in Figure 4.

Compressive creep specimens were installed in a fixture, shown in Figure 5, that supplied both lateral support and heat. Lateral support was provided by ground and polished nickel blocks mounted in thermal insulation and bearing directly on the specimen faces. The supporting faces of the blocks were lubricated with molybdenum disulfide to minimize friction. Heat was produced by eight 85-watt cartridge heaters inserted into the nickel blocks. Figure 6 shows a cross-sectional view and Figure 7 shows the component parts of the fixture.

For the initial compressive creep evaluations, two adjustable band clamps were used to provide lateral support to the specimens through the nickel support blocks and to hold the parts of the compressive fixture together (see Figure 5). The degree of support was measured in terms of the force required to cause longitudinal slippage of the specimen between the support blocks prior to application of the compressive load. At temperatures of 700°F and 800°F the lateral support necessary to consistently prevent buckling of the specimens was of such magnitude that a force of approximately 50 pounds was required to slip the specimens in the support blocks. Because of the larger stresses required to cause appreciable creep deformation at 600°F, the band-type clamps were inadequate to prevent buckling, consistently, even though they were tightened enough to require a force as high as 150 pounds to slide the specimen between the support blocks. Evidently, the spring constant provided by the band-type clamps was inadequate for this application. A slight modification was made to increase the lateral stiffness of the system by providing direct screw fastening of the two nickel support blocks with one screw adjacent to the center of each edge and perpendicular to the plane of the specimen. After a specimen was inserted in the fixture, the screws were tightened moderately so that the support blocks fitted just snugly against the faces of the specimen. Although the compressive force required to slide the specimen between the blocks was only 10 pounds, very few specimens buckled regardless of the compressive creep load applied.

Compressive creep strain was measured by a compact, two inch gage length, averaging extensometer illustrated in Figure 8. The extensometer was supported by the compressive fixture and attached through holes in the fixture by point contacts fitted into light punch marks in opposite edges of the specimen. Horizontal arms transmitted the deformation between the gage points to the core and coil of two differential transformers. The combined output of these differential transformers was proportional to the average strain occurring over the two inch gage length. Excitation for the transformers in each extensometer was provided by a stable source of voltage at 15,000 cps. The combined output of the two differential transformers was rectified by a phase-sensitive detector and attenuated by a voltage divider. This signal, which was calibrated in terms of specimen deformation, was fed into a strip-chart recorder that provided a curve of creep deformation as a function of time.

Calibration of the compressive creep extensometer was done with a mechanical calibrator. The standard in the calibrator was a sensitive mechanical micrometer driven by a synchronous motor through a set of gears with a fixed ratio. The maximum deviation in indicated deflection in any of the individual calibration curves from the average calibration was ± 750 microinches. This maximum error included non-linearity, mechanical errors, reading errors, electrical errors and non-reproducibility of the deformation measuring system. The majority of the calibration curves, however, showed less than ± 100 microinches deviation in indicated deflection.

Evaluations of the stability of the compressive strain-measuring system showed the drift during 500 hours to be within ± 3 percent of full scale. The available sensitivity of the system was better than 25 microinches.

Temperatures for the compressive creep evaluations were monitored and controlled by a Multipoint Leeds and Northrup Speedomax Potentiometer Recorder with duration-adjusting-type control. Signals to the monitoring and controlling device were supplied by three thermocouples. These thermocouples were inserted through small holes in the compressive fixture, and the junctions were silver-soldered onto a nickel strip inserted between the specimen and the support block on one side. The thermocouple junctions were positioned along the longitudinal axis of the specimen, one at each gage point and one at the center. The center thermocouple was used for controlling the temperature and the others for monitoring.

Two hours were required to heat the compressive specimens to a constant and uniform temperature within ± 3°F of that desired. An additional half hour of soaking time, to further insure stability, was then allowed before the specimens were loaded.

A survey was made prior to initiating testing to determine the temperature distribution on a specimen in the compressive fixture at each test temperature. The thermocouples were in the locations previously described, and their individual EMF outputs at each temperature were measured with a direct reading, portable Leeds and Northrup potentiometer. The results of the survey are tabulated in Table I.

The compressive creep apparatus was qualified in accordance with Part 3 of DMIC Report No. 46D, Reference 6. Briefly, the qualification procedure consisted of compressive modulus of elasticity determinations for specimens at various temperatures in the compressive apparatus and comparison of these data with known values of tensile modulus. If the compressive moduli were within $\pm$ 5 percent of the tensile moduli, the compressive equipment was considered satisfactory.

Table II shows the results of the qualification tests on the compressive fixture, both as originally designed with the band clamps providing lateral support, and as finally used with screw fastening of the lateral support blocks. At elevated temperatures, the compressive moduli determined with the original fixtures were slightly outside the qualification range; the modified fixture with screw fastening, however, qualified at all temperatures.

Data Analysis

The strain that occurred during application of load to the compressive specimens was recorded, but the measurement of creep strain and time was initiated when the specimen first supported all of the load. The compressive creep curves (strain versus time) were recorded until 500 hours had elapsed or until one percent creep strain had occurred. During the latter part of the program, none of the evaluations were prolonged after it became clear that a desired datum point would not be reached within 500 hours.

Tabulated data in Volume 3 showing times for 0.05, 0.1, 0.2, 0.5, and 1.0 percent creep strain were obtained from the original recorded data for individual compressive creep specimens. The tables also show the deformation that occurred during loading. The creep times for these strain values were plotted as functions of stress in the compressive creep summary curves, separate plots being shown for each alloy and temperature.

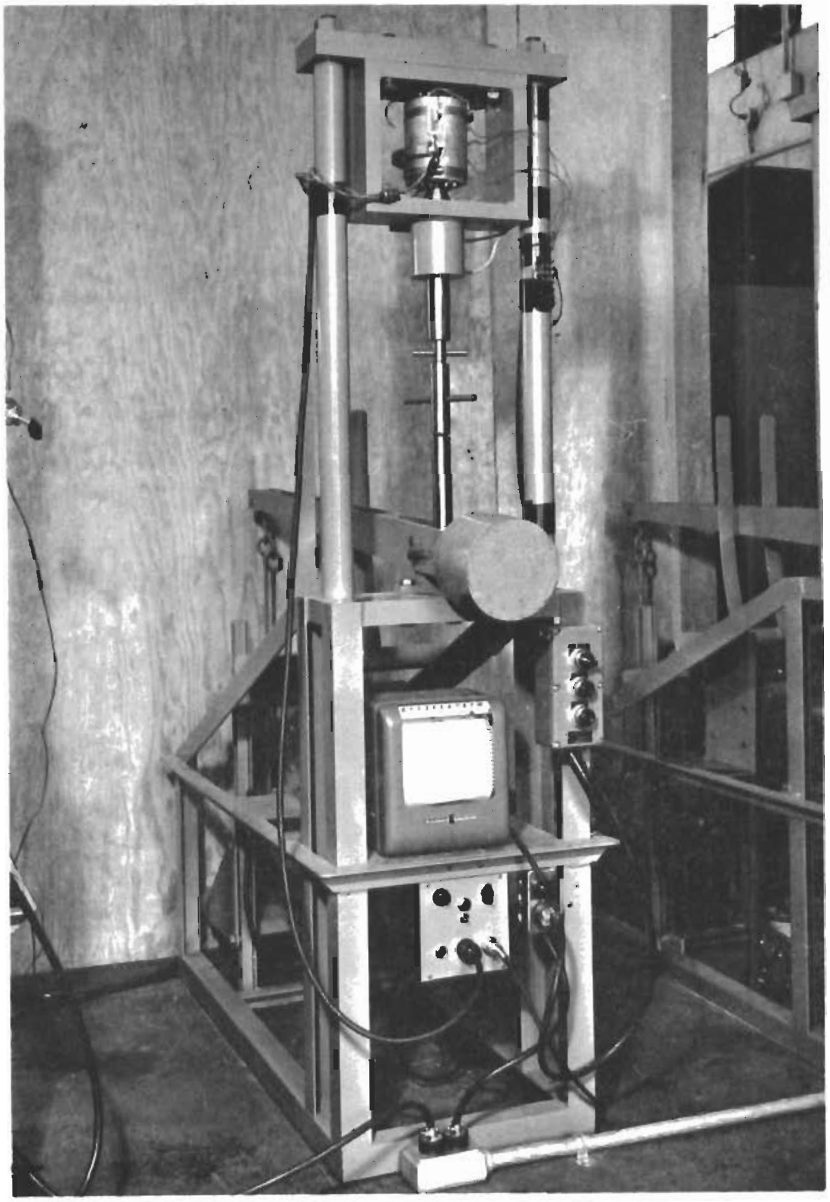


FIGURE 4 - EQUIPMENT USED IN COMPRESSIVE CREEP EVALUATIONS

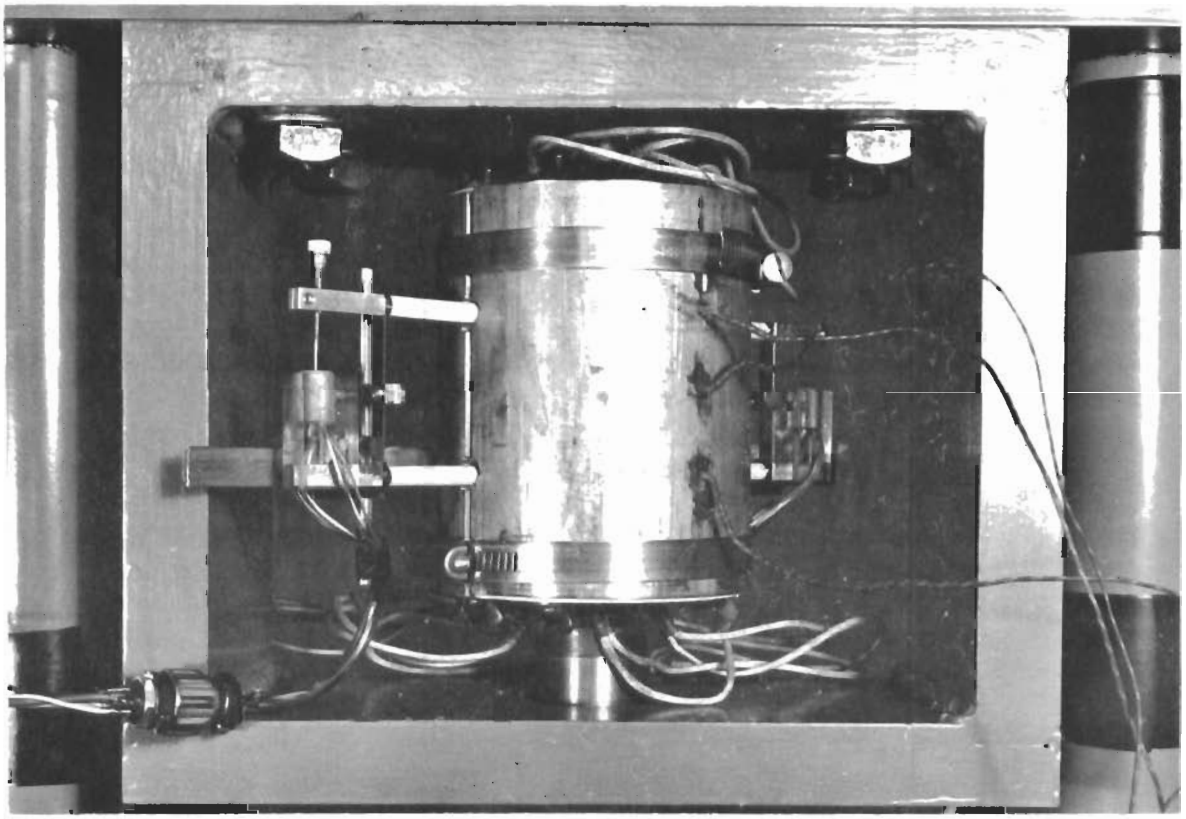


FIGURE 5 - COMPRESSIVE CREEP FIXTURE IN SUBPRESS

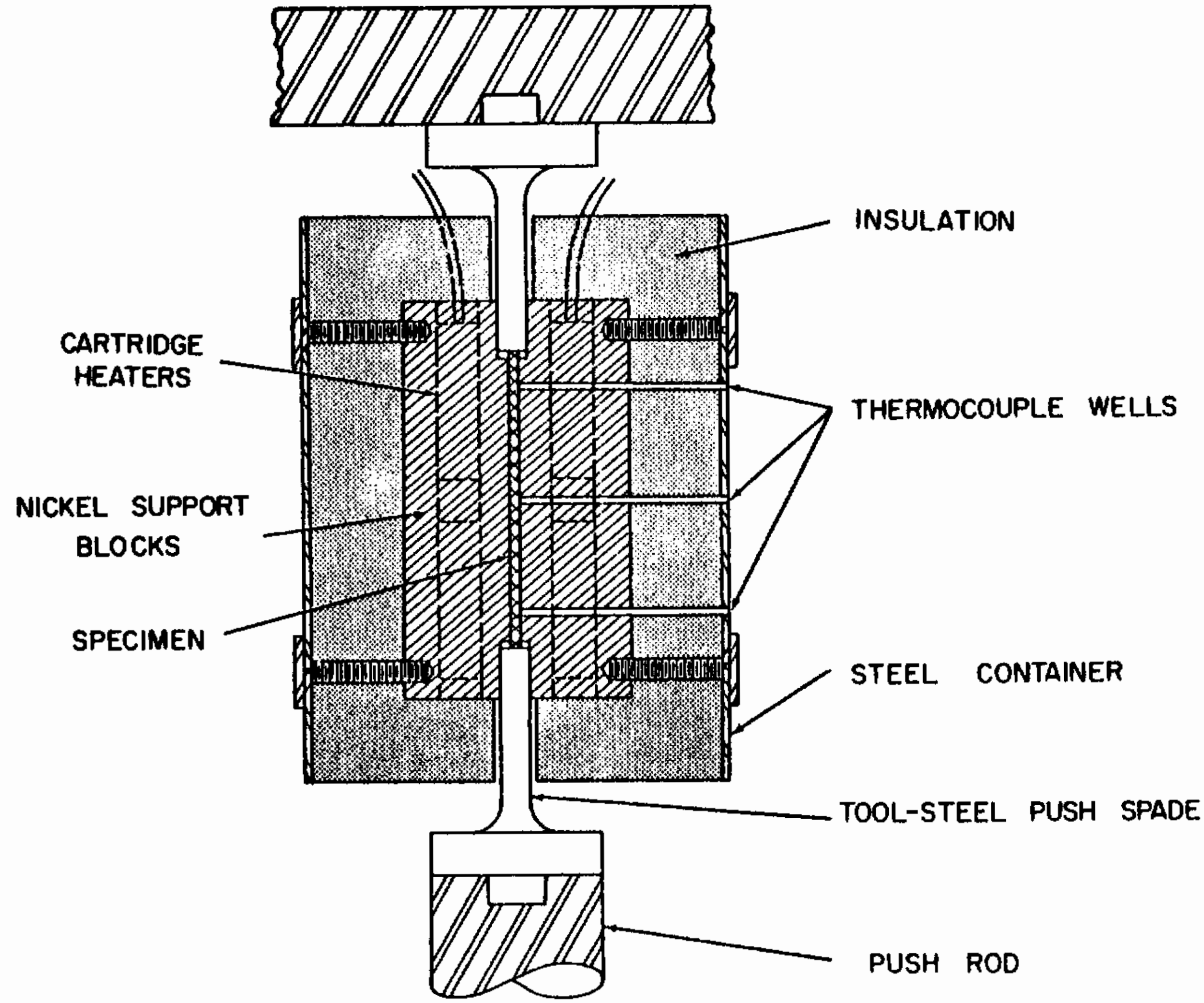


FIGURE 6 - CROSS-SECTION OF COMPRESSIVE CREEP FIXTURE

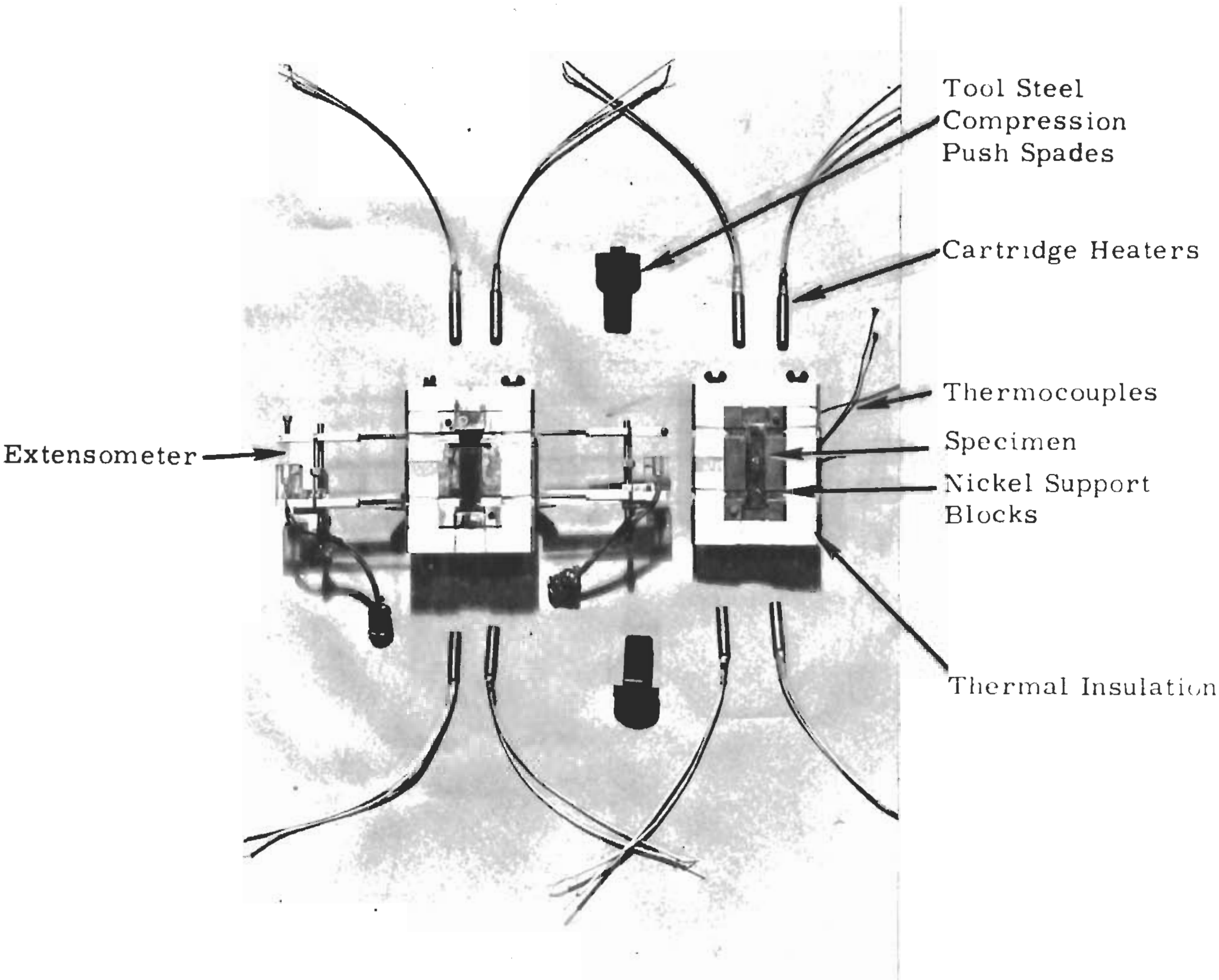


FIGURE 7 - COMPONENT PARTS OF COMPRESSIVE CREEP FIXTURE

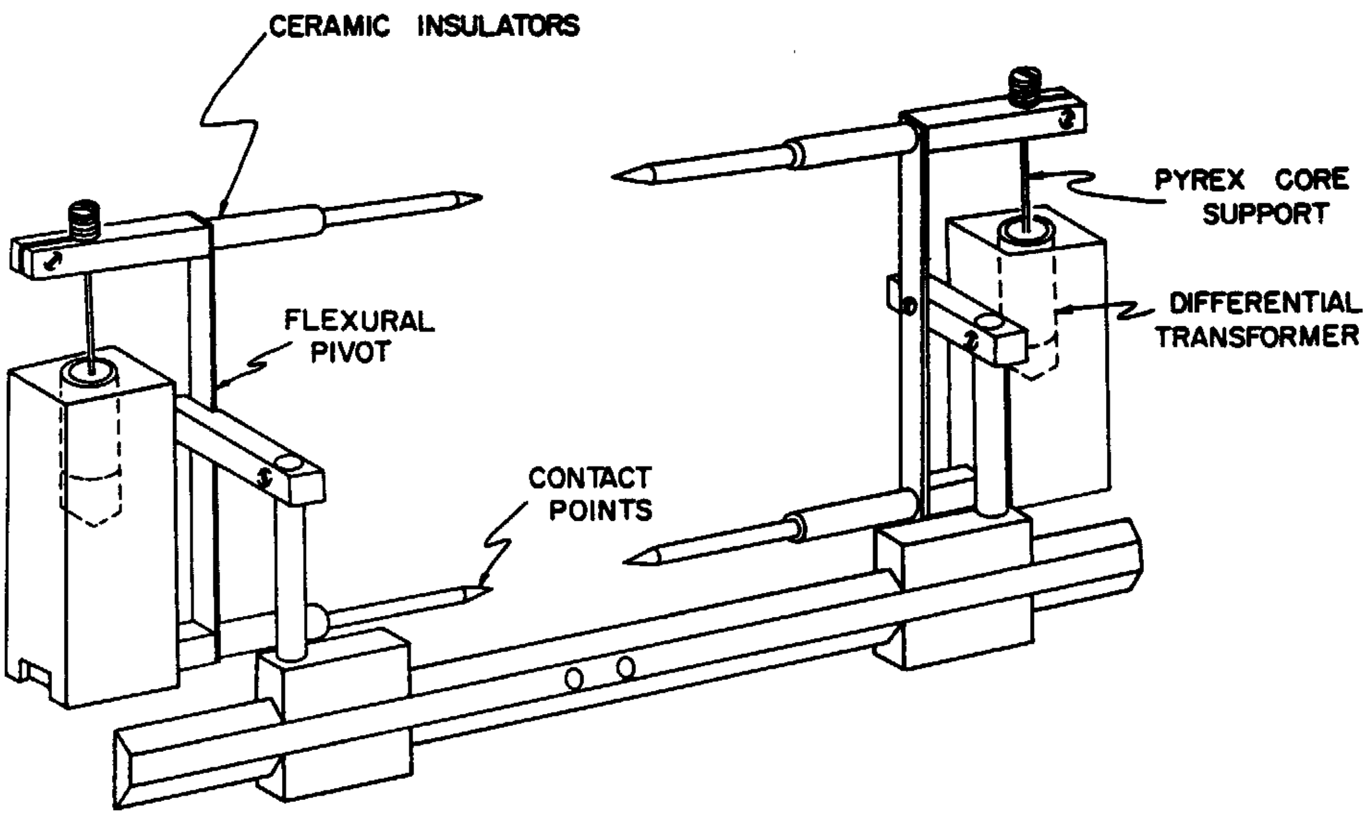
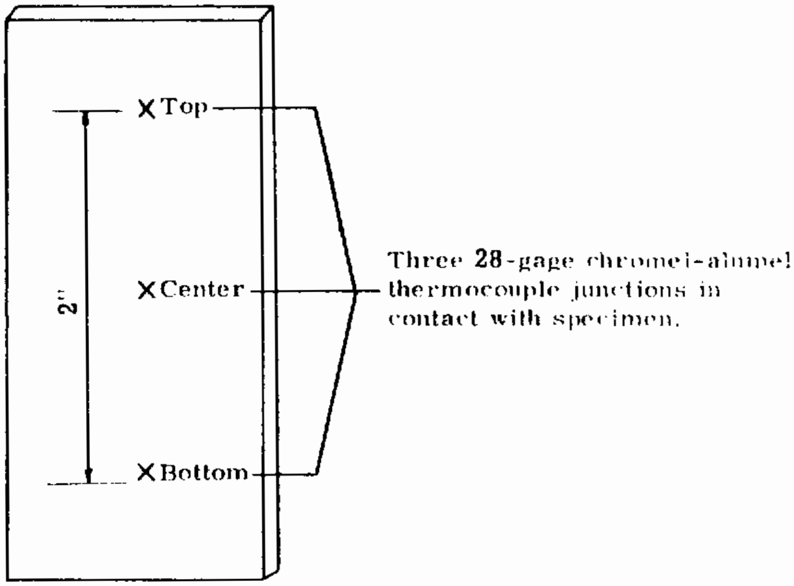


FIGURE 8 - AVERAGING EXTENSOMETER FOR COMPRESSIVE CREEP TESTS

TABLE I

TEMPERATURE DISTRIBUTION SURVEY FOR COMPRESSIVE CREEP TESTS



Run No.	Thermocouple Number Top	Center	Bottom	Max. Dev. From Center
1	600° F	602° F	600° F	2° F
2	598	601	598	3
3	599	600	598	2
4	700° F	700° F	701° F	1° F
5	698	701	699	3
6	698	700	698	2
7	798° F	801° F	798° F	3° F
8	800	800	800	0
9	800	801	800	1
10	898° F	900° F	899° F	2° F
11	898	900	899	2
12	899	900	899	1

TABLE II

COMPRESSIVE TESTS ON COMPRESSIVE CREEP FIXTURES

Temp °F	Alloy	Compressive Mod., 10^{-6} psi	Tensile Mod., 10^{-6} psi	Qualification Range, 10^{-6} psi
		Original Strap-Clamp Fixture[1]		
RT	Ti–2.5 Al–16 V[5]	14.3		
RT	Ti–2.5 Al–16 V	14.8		
Avg		14.5	14.8	14.06 - 15.54
800	Ti–2.5 Al–16 V[5]	11.9		
800	Ti–2.5 Al–16 V	12.3		
800	Ti–2.5 Al–16 V	11.9		
800	Ti–2.5 Al–16 V	12.3		
Avg		12.1	11.2[3]	10.64 - 11.76
900	Ti–2.5 Al–16 V[5]	10.05		
900	Ti–2.5 Al–16 V	10.10		
900	Ti–2.5 Al–16 V	10.10		
900	Ti–2.5 Al–16 V	10.10		
900	Ti–2.5 Al–16 V	9.93		
900	Ti–2.5 Al–16 V	10.05		
900	Ti–2.5 Al–16 V	10.30		
Avg		10.09	9.35[3]	8.88 - 9.82
		Final Screw-Fastened Fixture[2]		
RT	6061 -T6 Al	10.05		
RT	6061-T6 Al	10.10		
RT	6061-T6 Al	9.96		
RT	6061-T6 Al	9.83		
RT	6061-T6 Al	9.77		
Avg		9.94	10.0[4]	9.5 - 10.5
400	Ti–6 Al–4 V[5]	14.4		
400	Ti–6 Al–4 V	13.2		
400	Ti–6 Al–4 V	14.0		
Avg		13.9	14.4[3]	13.68 - 15.12
800	Ti–2.5 Al–16 V[5]	11.7		
800	Ti–2.5 Al–16 V	11.4		
800	Ti–2.5 Al–16 V	11.4		
Avg		11.5	11.2[3]	10.64 - 11.76

[1] The lateral support force was such that 50 lb force was required to overcome static friction between the lateral support blocks and the specimen.
[2] The lateral support force was such that 10 lb force was required to overcome static friction between the lateral support blocks and the specimen.
[3] Data obtained by Lockheed Aircraft Corporation, Marietta, Georgia.
[4] Metals Handbook, Volume 1, p 946, 1961.
[5] Solution-treated and aged.

Bearing Creep-Rupture Tests

Test Specimens

Bearing creep-rupture specimen configuration, shown in Figure 1, was modified slightly from that specified in Reference 2, to reduce machining and to increase the margin on the loading hole. All specimens had a 5/16 inch diameter bearing hole and a ratio of edge distance to bearing-hole diameter of two. Machining of the specimens was accomplished in a special jig, by stacking the specimens in stacks of two or more depending on sheet thickness. The holes were line reamed and finished specimens were deburred and inspected for cracks or other imperfections before they were measured. The bearing hole diameter was measured with precision drill blanks to tolerance, using the blanks as "go", "no go" gages. Thickness was measured to 0.0005 inch in four locations in the region of the bearing hole and the average value was used in computing bearing area.

Test Details

Southern Research Institute conducted the tests on bearing creep-rupture specimens in 6,000-pound capacity Arcweld Model M-3 creep machines with an overall load accuracy of one percent. Test fixtures of the type shown in Figure 9 were used and load was applied by hand crank in approximately two minutes.

The bearing creep-rupture fixture consisted of two clevis grips and a pair of 200 watt electrical disk heating units. The top clevis grip was designed to support the specimen from buckling under load, but was spaced such that a five pound or less force was necessary to make the specimen slip without the bearing pin in place. Mounted on the top clevis grip were two copper disk heating units which distributed heat uniformly around the test section of the specimen. A cross-sectional view of a bearing fixture is in Figure 10, and a photograph of one disassembled is shown in Figure 11.

As shown in Figure 9, the upper pair of arms of the bearing creep extensometer was attached to the loading clevis; whereas, the lower pair was attached, through point contacts, to the specimen edge on a line tangent to the loaded side of the bearing hole. With this system, bearing deformation was measured by two differential transformers positioned between the extensometer arms on opposite sides of the fixture. The transformer cores were mounted on pyrex monofilaments which were guided through eyelets at each end of the coils to maintain concentricity between the cores and the coils. The total output from the transformers, which was calibrated in terms of bearing deformation, was recorded versus time by a Varian strip-chart recorder.

Differential transformer excitation was provided by a stable source of voltage at 15,000 cycles per second. The combined output was rectified by a phase-sensitive detector, attenuated by a voltage divider and recorded.

Calibration of the bearing creep extensometer was similar to that described for the compressive creep extensometer.

The bearing creep-rupture test temperature was controlled by a Chromel-Alumel thermocouple, which actuated a Wheelco controller on the creep machine, in a hole drilled longitudinally into the bearing pin to a depth that allowed the junction to be positioned in the plane of the specimen. Specimen temperature was monitored by two Chromel-Alumel thermocouples inserted through small holes in the bearing fixture to contact the specimen just above and just below the bearing hole. The outputs of these thermocouples were measured by a Leeds and Northrup portable potentiometer.

One-quarter hour was required to heat the specimens to within $\pm 10^{o}F$ of the desired temperature and a total of one-half hour was required to achieve a temperature uniformity of $\pm 3^{o}F$. An additional half-hour soaking time was then allowed before the specimens were loaded.

To evaluate the temperature uniformity of the bearing fixture, the temperature distribution in the specimen was determined by placing four thermocouples symmetrically around the bearing hole and one control thermocouple in the center of the bearing pin. The EMF's from the thermocouples were measured with a direct reading, portable Leeds and Northrup potentiometer. Thermocouple locations and results of the temperature survey are shown in Table III.

Data Analysis

The autographically recorded curve for each bearing creep test included both deformation that occurred during the application of load and the creep deformation. Measurement of creep strain and time was begun when the specimen first sustained the entire load. The bearing creep deformation versus time curves were recorded for a 500 hour duration or until deformation equal to four percent of the bearing hole diameter had occurred. Most of the bearing creep evaluations were carried to rupture if it occurred within 500 hours. In the latter stages of the program, when machine-time was critical, the bearing creep tests were stopped when it was obvious that a desired datum point would not be reached in 500 hours.

Tables of bearing creep data in Volume 3 show times to reach 0.5, 1.0, 2.0, and 4.0 percent creep deformations and rupture for the individual bearing specimens. These data, for each alloy at each temperature, are plotted as functions of stress level in the bearing creep summary curves.

Bearing creep-rupture stress was defined as load divided by bearing area which is the product of specimen thickness and bearing hole diameter.

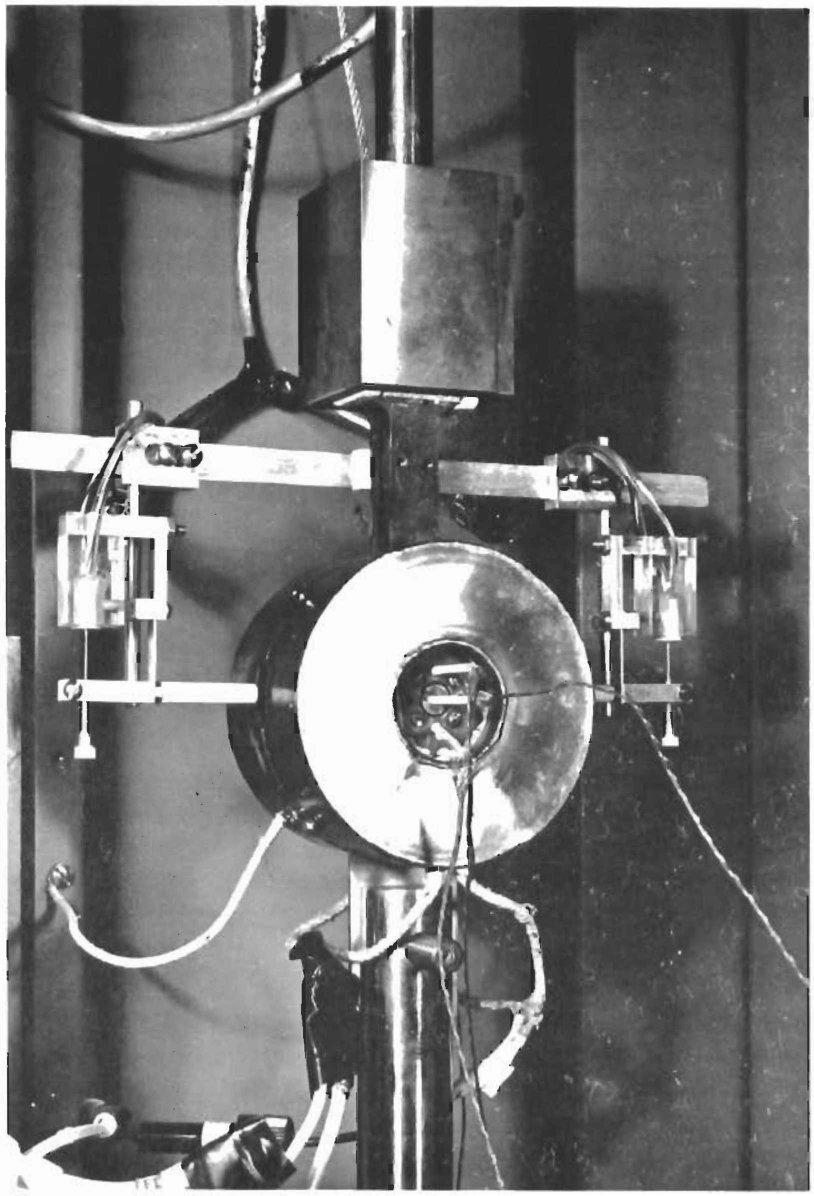


FIGURE 9 - TEST FIXTURE FOR BEARING CREEP-RUPTURE TESTS

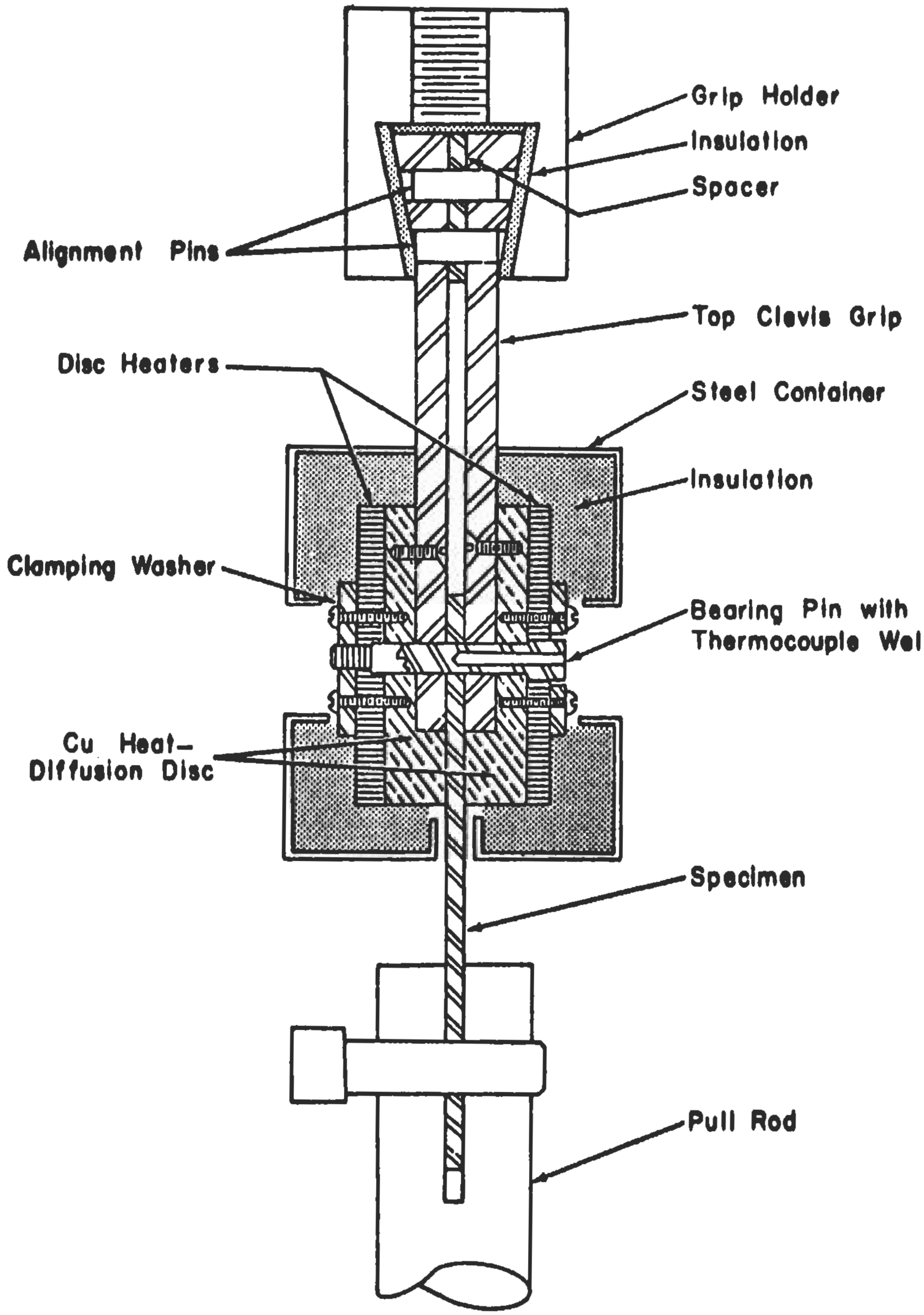


FIGURE 10 - CROSS-SECTION OF BEARING CREEP-RUPTURE FIXTURE

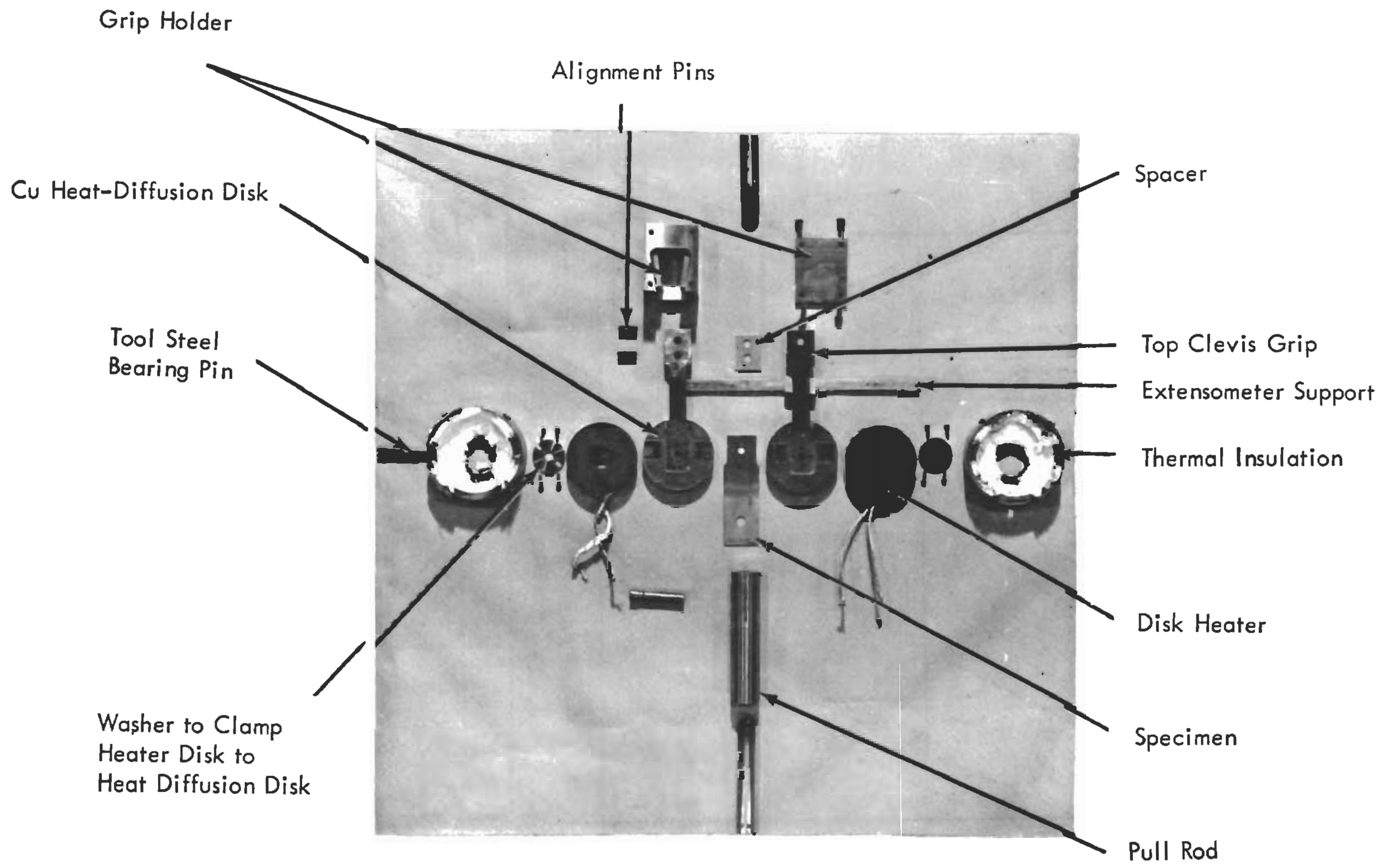
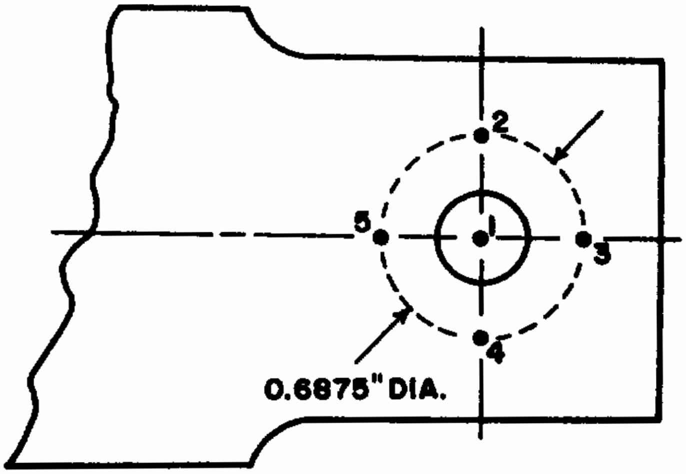


FIGURE 11 - DISASSEMBLED BEARING CREEP-RUPTURE FIXTURE

TABLE III

TEMPERATURE DISTRIBUTION SURVEY FOR BEARING CREEP-RUPTURE TESTS



Run No.	Temperature, °F, at Locations Shown on Above Diagram				
	1	2	3	4	5
1	600	600	600	602	600
2	598	598	600	601	600
3	600	598	600	602	600
4	703	701	702	704	702
5	702	700	701	704	701
6	703	702	703	704	703
7	799	798	799	801	799
8	800	798	800	802	800
9	800	798	800	801	800

Single Shear Stress-Rupture Tests

Test Specimens

Single shear stress-rupture specimens contained two offset slots, at 45 degrees to the major axis, which terminated in drilled and reamed holes as shown in Figure 1 (see References 2 and 6). The slots and holes were machined into the "as sheared" blanks. Burrs resulting from machining were carefully removed with No. 400 emery paper and each specimen was checked for tolerance. Microscopic inspection was made to assure the absence of cracks or notches around the circumferences of the drilled holes.

Specimen thickness was determined by averaging two micrometer measurements made across the test section. Several test section length measurements were made with a measuring microscope and averaged. Measurement accuracy was at least $\pm$ 0.0005 inch.

Test Details

Single shear stress-rupture tests were performed by Southern Research Institute. The tests were conducted in 6,000-pound capacity Arcweld Model M-3 creep machines with a load accuracy of $\pm$ 1.0 percent. Clevises and hardened steel pins shown in Figure 12 were used to attach the specimen to the self-aligning loading rods of the creep machine. Figure 13 shows a single shear specimen installed in a creep machine with the furnace in the raised position.

Time to rupture for the single shear stress-rupture evaluations was measured by the creep machine timer to the nearest 0.1 hour. During the first half hour of each evaluation, time was also measured with a stop watch so that very short rupture times could be reported more accurately.

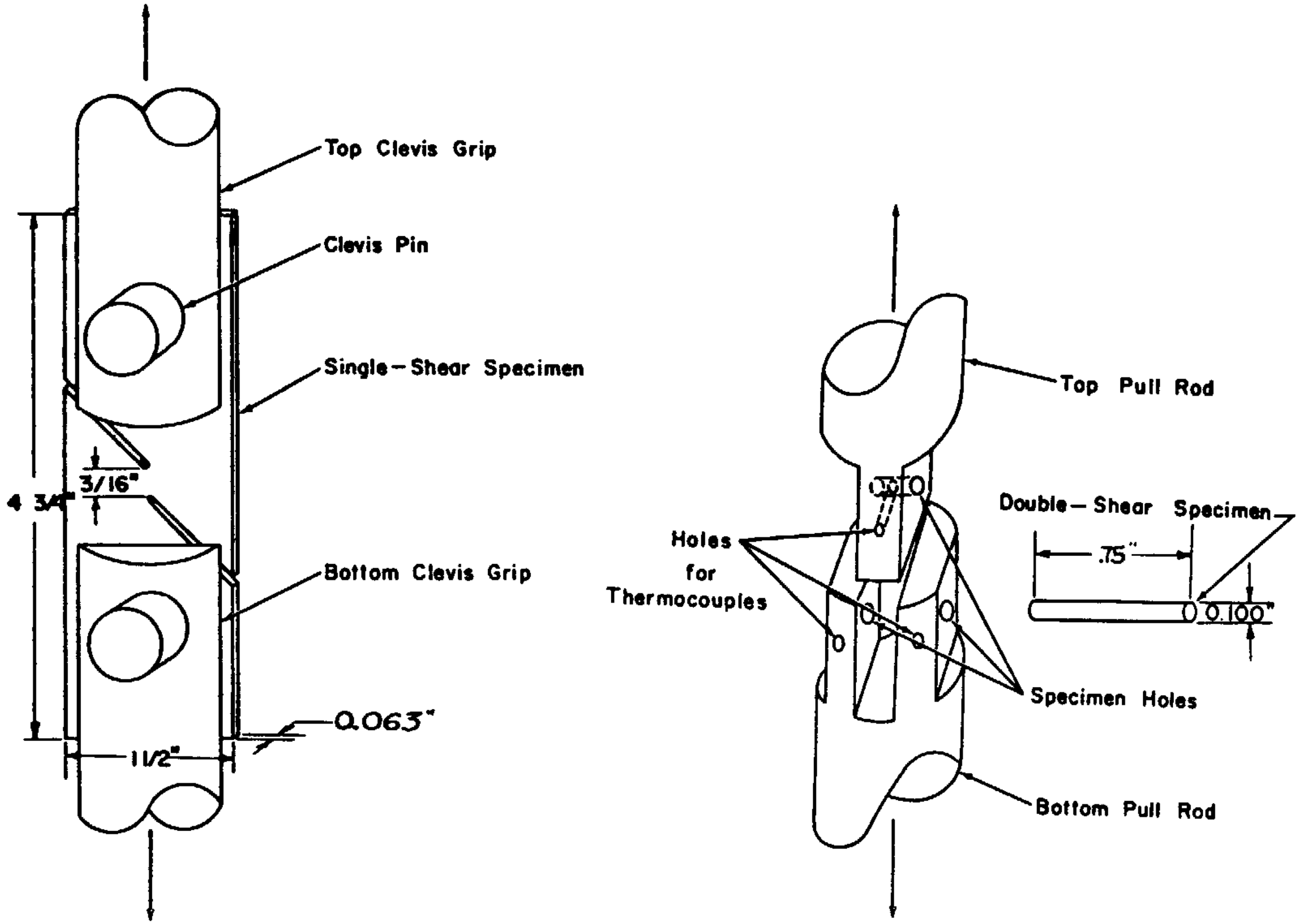
Specimens were heated in Arcweld power-positioning furnaces controlled by Wheelco saturable core reactor type controllers. The controlling thermocouple was inserted through a small opening in the side of the furnace with the junction about 0.5 inch inside the heating element. Two monitoring thermocouples were attached to each single shear specimen, on opposite sides of the shear path, and the outputs from these were measured by a Leeds and Northrup portable potentiometer.

Approximately two hours were required to attain a specimen temperature uniform within $\pm 3^{\circ}F$ of that desired. After a one-half hour soak period at this temperature, the predetermined load was applied by hand crank in approximately two minutes.

Temperature uniformity was determined for a single shear stress-rupture specimen under typical test conditions. Five 20-gage Chromel-Alumel thermocouples were placed in contact with the specimen surface for this survey, and EMF's from the thermocouples were measured with a direct reading, portable Leeds and Northrup potentiometer. Thermocouple locations and results of the survey are given in Table IV.

Data Analysis

No strain measurements were made in the single shear evaluations. Measurements of single shear stress-rupture time were initiated when the specimen first supported the entire load and were continued until either the specimen ruptured or 500 hours had elapsed. Rupture times for individual specimens, evaluated at various stresses, were tabulated and stress versus rupture time summary curves were plotted from the tabulations.



(a) Single-shear specimen and fixture

(b) Double-shear specimen and fixture

FIGURE 12 -- SHEAR STRESS-RUPTURE SPECIMENS AND LOADING FIXTURES

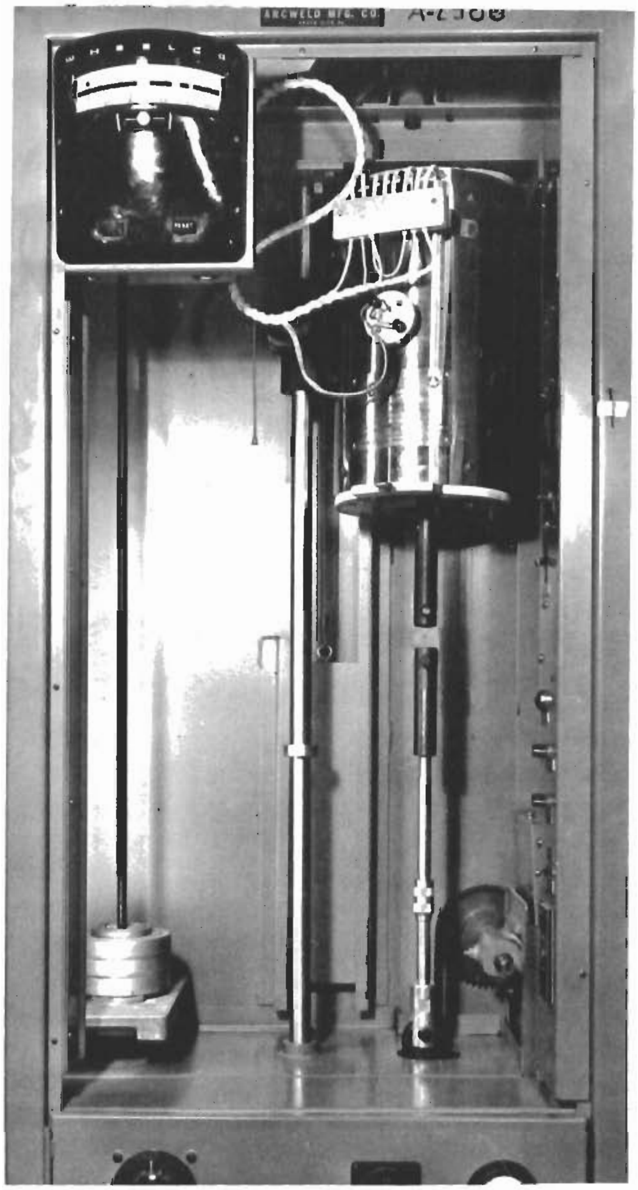
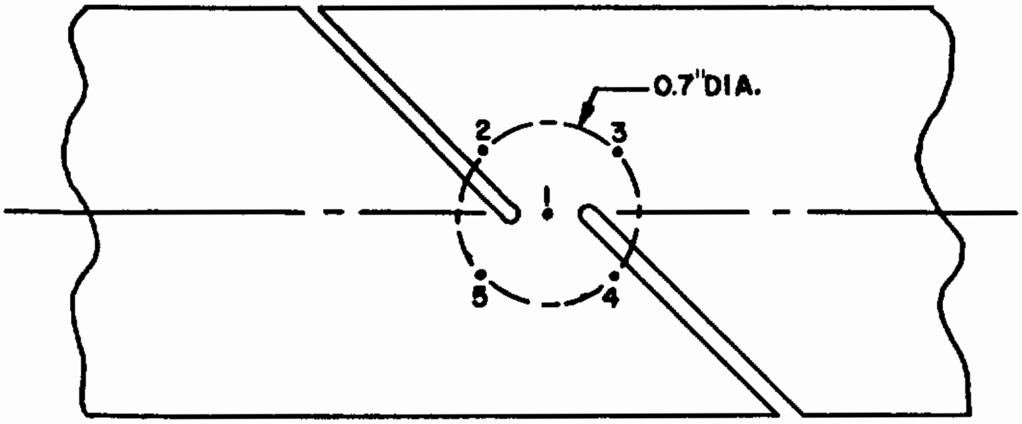


FIGURE 13 - EQUIPMENT USED FOR THE EVALUATION OF SINGLE SHEAR STRESS-RUPTURE SPECIMENS

TABLE IV

TEMPERATURE DISTRIBUTION SURVEY FOR SINGLE SHEAR STRESS-RUPTURE TESTS



Run No.	Temperature, °F, at Locations Shown on Above Diagram				
	1	2	3	4	5
1	707	707	706	708	707
2	706	706	704	708	707
3	708	706	706	710	708
4	708	706	706	708	707
5	707	707	705	709	708
6	707	705	705	708	707
7	708	704	704	708	706

Thermocouples were mechanically attached at locations 3 and 5 to monitor temperature during tests.

Double Shear Stress-Rupture Tests

Test Specimens

Figure 1 shows the double shear stress-rupture specimen. Blanks for the specimens were sheared from 0.125 inch thick sheet material, machined to within 0.001 inch of the finished diameter, and polished to the final dimension with emery cloth. A method was established in the machining procedure to mark the double shear specimens so that they were all loaded in the same direction with respect to the thickness of the sheet.

The specimens were inspected microscopically, and measurements of the diameter were made to 0.0005 inch in two places and averaged.

Test Details

Arcweld 6,000-pound capacity Model M-3 creep machines equipped with Arcweld power-positioning cylindrical testing furnaces were used by Southern Research Institute in conducting the double shear stress-rupture tests. Overall load accuracy of these machines was within $\pm$1.0 percent. Load was applied by hand crank in approximately two minutes through a self-aligning clevis arrangement, shown in Figure 12, which had close tolerances between mating parts to eliminate bending of the specimen.

Measurement of time to rupture in double shear was the same as described previously for single shear.

The heating, temperature control and temperature monitoring equipment used was the same as the type described for the single shear stress-rupture evaluations. Three monitoring thermocouples were inserted through small holes in the double shear fixture to contact the specimen at the center and near each end.

Two hours were required to heat the double shear stress-rupture specimens to a stable temperature within $\pm 3^{\circ}$F of the test temperature. An additional half hour of soaking time was then allowed before the specimens were loaded.

A survey was made prior to initiating testing to determine the temperature distribution on a double shear stress-rupture specimen installed in the loading fixture. Three 28-gage Chromel-Alumel thermocouples were placed in contact with the shear pin at the locations mentioned previously. Outputs from the thermocouples were measured by a direct reading, portable Leeds and Northrup potentiometer and are listed in Table V.

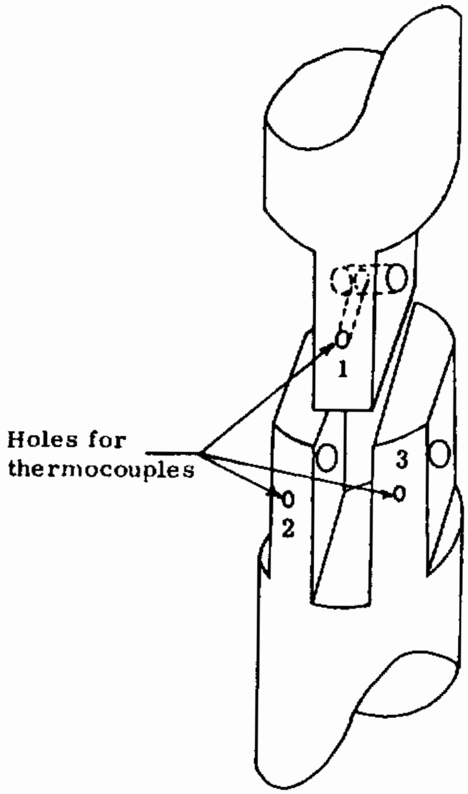
Data Analysis

Stress-rupture data, only, were obtained from the double shear tests. Double shear stress-rupture time was measured from the instant the specimen first maintained all of the load until either rupture occurred or 500 hours had elapsed. The times to rupture for double shear specimens at numerous stress levels are presented in tabular form in Volume 3. Summary curves derived from these data show rupture time plotted as a function of stress.

The stress-rupture specimens sheared cleanly, fractures being at 90 degrees to the axis with no trailing edges.

TABLE V

TEMPERATURE DISTRIBUTION SURVEY FOR DOUBLE SHEAR STRESS-RUPTURE TESTS



Run No.	Thermocouple Number 1	2	3	Max. Dev. From T/C 1
1	600° F	600° F	600° F	0° F
2	601	601	601	0
3	600	600	600	0
4	700° F	700° F	700° F	0° F
5	700	700	700	0
6	700	700	700	0
7	800° F	800° F	800° F	0° F
8	798	798	798	0
9	799	799	799	0

Fatigue Tests

Test Specimens

Dynamic axial-load fatigue specimen configuration was as shown in Figure 14. Specimens requiring a theoretical stress concentration of 2.82 were produced from the same configuration by a 1/16 inch diameter hole drilled and reamed at the center of the test section minimum width. Sheared specimen blanks, all having a longitudinal grain direction, were die punched to the desired shape; but a machining margin of 1/8 inch was left on each edge. Several die punched blanks were stacked and machined simultaneously on a Cincinnati Three Dimensional Hydro Tel. The number stacked was dependent upon sheet thickness and flatness of the blanks.

The machined specimens were cleaned in a bath of methyl ethly ketone to remove the cutting lubricant. Polishing of the machined edges was done in two stages using number 1 and number 00 grit emery paper. After polishing, the specimens were recleaned with methyl ethyl ketone.

Test specimens were inspected microscopically, and those having cracks, scratches or nicks were rejected. Dimensions of test specimen minimum sections were measured with micrometers to 0.0001 inch, and stress concentration hole diameters were measured with a Bausch and Lomb optical comparator.

Dynamic fatigue specimens from all thicknesses of the Ti-2.5Al-16V and Ti-6Al-4V exhibited a pronounced deviation from flatness even though the original sheet was furnished within the required flatness tolerance of five percent. In most cases, the 0.125 inch thick specimens contained one continuous bow or half wave, but the 0.020 and 0.063 inch thick specimens often contained from two to seven complete waves over their 18 inch length. Figures 15 and 16 show examples of specimen flatness deviation for both alloys. Because of the limited amount of material available, it was necessary to use specimens of Ti-2.5Al-16V and Ti-6Al-4V considered to have excessive flatness deviation in order to perform the required number of tests. These specimens were tested under high stress, slow cycle conditions since the stress distribution in the test section was considered to be more uniform and affected less by flatness deviation after being plastically deformed than if tested under low stress, fast cycle conditions.

The specimens for static fatigue tests were the same as shown in Figure 1 and described for tensile creep-rupture tests. The stress concentration of 2.82 was produced in these specimens by drilling a 1/32 inch diameter hole in the reduced section. Specimen material for some thicknesses of a particular alloy came from heats other than those used for dynamic fatigue tests. This was due to the limited amount of available material.

Test Details

Several types of testing machines, selected on the basis of required stress level, cycling rate and stress ratio, were utilized for obtaining fatigue data. To preface the description of testing techniques, stress ratio, A, as defined herein is the maximum alternating stress applied to the specimen divided by the mean stress which is shown diagramatically on Page 107.

Twelve Lockheed designed axial-load, tuning-fork type fatigue machines, as shown in Figures 17 and 18, were used for low stress, fast cycle tests. These machines had a static capacity of 15,000 pounds and a dynamic capacity of ±10,000 pounds at a cycling rate of 1500 to 2200 cycles per minute. Specimen mean load, other than zero, was applied with a hydraulic actuator and was kept constant during the test by an automatic hydraulic follow-up system which eliminated mean load drop as a result of specimen creep at elevated temperatures. Sinusoidal alternating load was applied by a variable eccentric wheel attached to one arm of the machine. The eccentric wheel was driven by a variable speed electric motor employing an automatic speed control device that kept the frequency constant for a given test. Desired dynamic load was obtained by: (1) preselecting one of three loading head positions between the forks, (2) changing the system mass using replaceable weights on the forks, (3) changing eccentricity of the wheel and (4) combinations of the above three. Fine adjustment of dynamic load was achieved by varying the eccentric speed.

A mechanical counter, having a least reading of one thousand cycles, attached to the shaft of the eccentric wheel and recorded the number of cycles applied; and an automatic cut-off device stopped the machine upon failure of the specimen.

A strain-gaged transducer placed in series with the test specimen, as shown in Figure 18, was used to sense the applied load. The transducer output was monitored with a twelve channel dynamic strain analyzer, Figure 19, consisting of calibrated balancing potentiometers, a three KC carrier amplifier and an oscilloscope. The desired load was set on a calibrated potentiometer and the carrier wave was amplitude modulated by the transducer signal. The oscilloscope was used only as a null balance indicator. Maximum, minimum and mean loads were monitored by this system. Transducers were gaged with Baldwin SR-4 Type ABD-7 gages to form a temperature-compensated full bridge having low hysteresis and high fatigue life. This type of gage was less affected by temperature change with the accompanying apparent strain change than the iso-elastic gages that are sometimes used for fatigue applications. The complete load analyzing system was periodically calibrated to the desired capacity within an accuracy of ±1.0 percent using a Model U1 Baldwin 20,000-pound capacity load cell and a Baldwin strain indicator as a standard.

High stress, slow cycle tests were performed in three Lockheed designed machines shown in Figure 20. Load was applied with a hydraulic jack in series with a double bridge Cox and Stevens load cell and the specimen. The output from one bridge of the cell in conjunction with a Baldwin-Lima-Hamilton Type M strain indicator and a high persistent oscilloscope was used to measure load, and the output from the other bridge energized a closed loop electrohydraulic servo loading system. Mean load was controlled by a bridge balance unit; amplitude and frequency were controlled by a Hewlett Packard function generator; and each cycle was recorded by a Hewlett Packard electronic counter. The average cycle rate was approximately four cycles per second, and the cut-off system at specimen failure was automatic. Load cells with capacities of either 10,000 or 25,000 pounds were available and were selected to give optimum sensitivity and resolution over the desired load range. These cells were calibrated periodically using a Baldwin-Lima-Hamilton 50,000-pound capacity, Model FGT, universal testing machine as a standard. Accuracy of the testing machine was 0.5 percent of indicated load or 0.1 of full range whichever was greater, as determined by proving rings certified by the National Bureau of Standards.

A 50,000-pound capacity universal testing machine was also used to obtain some fatigue data in the range of 10 to 1000 life-cycles. Variations in mechanical properties within a sheet of material made it difficult to preselect maximum stress for fatigue lives in this range of cycles based on average tensile data. As an aid in determining a suitable maximum stress level, a two inch gage length extensometer was placed on the fatigue specimen and the autographically recorded curve was observed as the load was increased. After reaching a stress judged to be very close to the tensile ultimate for the specimen, load was reduced to the proper lower limit and automatic cycling and counting devices were engaged. This procedure, to some extent, reduced the frequency of loading failures and of excessively long life tests.

In fatigue testing with the three types of machines described, great care was exercised to insure the trueness of specimen alignment. Specimens loaded in compression were laterally supported by stainless steel plates to prevent buckling. Support plates were also used in fast cycle tests at a stress ratio of 1.0 to prevent specimen buckling at zero stress, which was actually the assumption of the natural, bowed shape. If the specimens were allowed to buckle this condition affected the stiffness of the testing machine and resulted in loss of load control. The support plates used on 0.063 and 0.125 inch thick specimens for $A = \infty$ and all thickness specimens for $A = 1.0$ are shown in Figure 21. The plates were held in contact with the specimen by the clamping action obtained from adjustable tie bolts at the edge of the plates. For room-temperature tests, a sheet of Teflon impregnated fabric approximately 0.006 inch thick was placed between the support plates and the specimen to reduce friction. The lubricant used at elevated temperature consisted of a mixture of milk of magnesia and molybdenum disulfide that was applied to the plates and specimen prior to assembly. After the specimen had reached the desired temperature, the tie bolts were torqued until there was a snug fit between the specimen and plates but loosely enough for the plates to be easily slid on the specimen surface.

Plates having a somewhat different geometry were used for testing 0.020 inch thick specimens at $A = \infty$. These plates, shown in Figure 22, had a "V" section machined in each end which mated with similarly shaped projections extending from the grip. This arrangement made the unsupported length of specimen between the end of the support plate and grip discontinuous across the width of the specimen, thereby preventing buckling of the thin specimen material.

To accommodate the higher loads required on the slow cycle, high stress $A = \infty$ tests, it was necessary to use 1/2 inch thick support plates with a closer spacing of the tie bolts. These plates also employed the "V" section at each end and were used with special loading grips with conical wedge-type jaws. Design of these grips was such that the jaws extended from their housing and projected into the "V" section, thus preventing local buckling as previously described. The lateral support plates and grips are shown in Figure 20. Also shown is the lateral support bushing, which was incorporated in the arrangement to maintain concentricity of the compressive load.

Evaluations were made to determine the effect of support plate bolt torque on specimen load using both lubricant methods mentioned above. The test specimen and support plate assembly were installed in a universal testing machine and the load required to slide the specimen relative to the support plates at an arbitrary rate of 0.020 inch per second over a distance of approximately 1/4 inch was recorded. This was done for several bolt torques for each type of lubrication and the results are in Table VI. Support plate bolt torque used for a particular test was dependent upon initial specimen flatness and maximum compressive load to be applied. In no case were torques used that would affect the specimen load greater than three percent, based on the results in Table VI.

One of the several furnaces used for elevated-temperature fatigue testing is shown in Figure 23. The furnaces were quartz-lamp type with the lamps recessed in blocks of Glassrock. Power for the furnaces on the fast cycle machines was supplied and controlled by the bank of Minneapolis Honeywell controllers shown in Figure 24. The slow cycle machines were equipped with Wheelco controllers. Temperature control was maintained by a thermocouple extending through the furnace wall. Specimen temperature was sensed with two thermocouples of 28-gage selected and checked wire and was recorded on calibrated strip chart recorders having a 0°F to 1200°F measuring range and a readability of 2°F.

For tests having a stress ratio equal to 0.3, two thermocouples were mechanically attached to the specimen test section. Thermocouple beads were in contact with the specimen but insulated with asbestos from the thermocouple clamp and furnace atmosphere. For test conditions requiring lateral support, the thermocouples extended through holes in the support plate and contacted the specimen surface. Test temperatures were stabilized within ±5°F of desired prior to loading, and variation with time did not exceed ±5°F. In order to establish thermal equilibrium, each specimen was soaked at temperature for thirty minutes, during which time one end of the specimen was free in the grip to allow for thermal expansion.

Surveys to determine temperature uniformity of specimens for both loading arrangements are summarized in Tables VII and VIII. Thermocouple EMF's for the surveys were measured with a Leeds and Northrup No. 8662 Portable Precision Potentiometer.

For the stress ratio, A = 0, tensile tests were performed in a universal testing machine and stress-rupture tests were performed in creep machines. Procedures for these tests were as described for tensile tests, Volume 2a, and tensile creep-rupture tests.

Data Analysis

Specimen area was determined using measured dimensions of the minimum section. For specimens having a stress concentration of 2.82, net area was used. Specimens that failed out of the test section were rejected and replacement tests were conducted. It was necessary to discontinue some of the long life fatigue tests before failure or endurance was reached, and data obtained from such tests are tabulated with other data in Volume 3 and are noted in the same manner as endurance points.

Stress levels were selected to produce S-N curves ranging from approximately ten to ten million cycles with a minimum of 21 tests per curve. Selection of stress levels depended on the degree of scatter, i.e., stress increments were smaller in the region of the fatigue limit, and a smooth curve was drawn through the lower portion of the test scatterband.

Modified Goodman-type diagrams, in Volume 1, were prepared for each combination of alloy, thickness, test temperature and stress concentration. In construction of these diagrams, alternating stresses for stress ratios of ∞ , 1.0 and 0.3 were obtained from the S-N curves at 10^3, 10^4, 10^5, 10^6 and 10^7 life-cycles. For 600°F and below, all life-cycle curves in the diagrams were converged on the A = 0 line or zero alternating stress axis at a mean stress equal to the ultimate tensile stress obtained at the particular test temperature. This was valid since comparison of 600°F data obtained for tensile creep-rupture tests and short-time tensile tests showed the tensile stress for rupture in 500 hours and the short-time tensile ultimate to be equal within the data scatter limits.

In order to establish the A =0 life points at 800°F and 900°F, an average fatigue cycling rate of 1850 cpm was used to convert the previously stated life-cycles, with the exception of 10^3, to equivalent times. Stress at each equivalent time was determined using plots of stress versus time to rupture. Stress-rupture data obtained on smooth, 0.063 inch thick specimens from tensile creep-rupture tests and additional tests performed for the other thicknesses were used to establish the required stress versus time to rupture curves for smooth specimens. For A = 0 points at K_t = 2.82, short-time tensile tests were conducted at all pertinent temperatures and stress-rupture tests were performed at 800°F and 900°F for all three thicknesses of each alloy. The equivalent time for 10^3 life-cycles, calculated using the slow cycle rate of four cycles per second, was approximately equal to that required for short-time tensile tests; consequently, ultimate tensile stress was used as mean stress in the modified Goodman-type diagrams for A = 0 points at 10^3 life-cycles.

Since fast cycle fatigue tests were performed over the range of 1500 to 2200 cps, a large number of actual cycling rates, considered to be representative of those used for the entire fatigue program, were analyzed to determine if one rate could be used for converting life-cycles to equivalent times. As previously stated, 1850 cpm was used which was the approximate mean of the actual cycling rate and two standard deviations about the mean was $\pm$ 300 cpm. Since the actual cycling rates were approximately normally distributed about this mean, 95 percent of the fatigue tests were performed in the range of 1550 to 2150 cpm. Using equivalent times for these values and the stress versus time to rupture curve having the greatest slope, it was found that two standard deviations represented a maximum stress variation of $\pm$ 1000 psi. Since this was the worst case, all others were affected by a lesser amount. Based on this analysis, it was concluded that use of the average rate produced satisfactory results.

TABLE VI

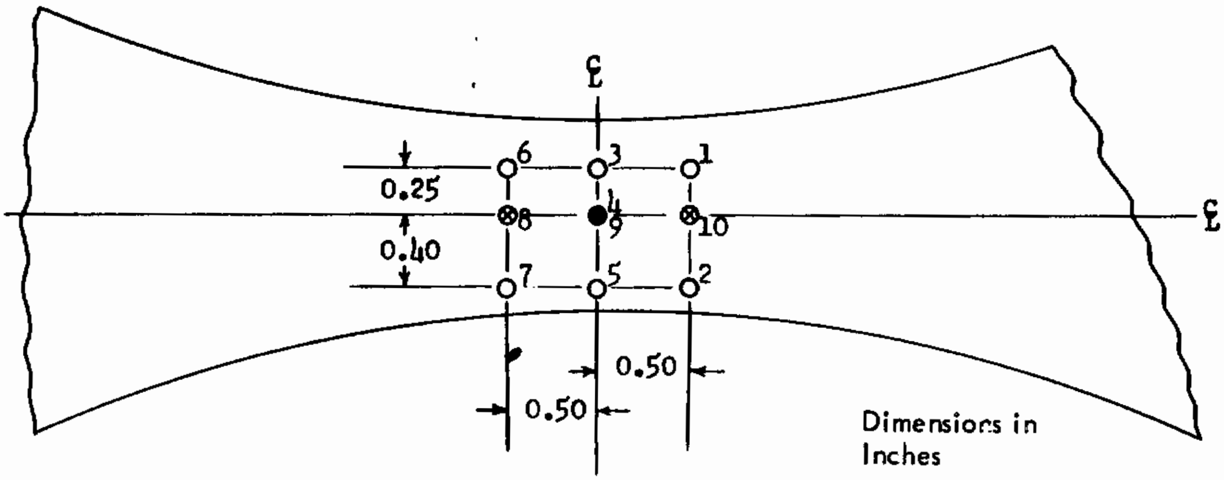
RESULTS OF FRICTION TEST FOR A $=\infty$ SUPPORT PLATES

LUBRICANT	TORQUE IN TIE BOLTS, INCH - POUNDS	LOAD TO SLIDE SPECIMEN, POUNDS (1)
Teflon	5	57
Teflon	10	117
Teflon	20	271
Molybdenum Disulfide Powder and Milk of Magnesia	1	75
	2.5	102
	5	149
	10	453

(1) Average of three runs.

TABLE VII

TEMPERATURE DISTRIBUTION SURVEY FOR A = 0.3 FATIGUE TESTS



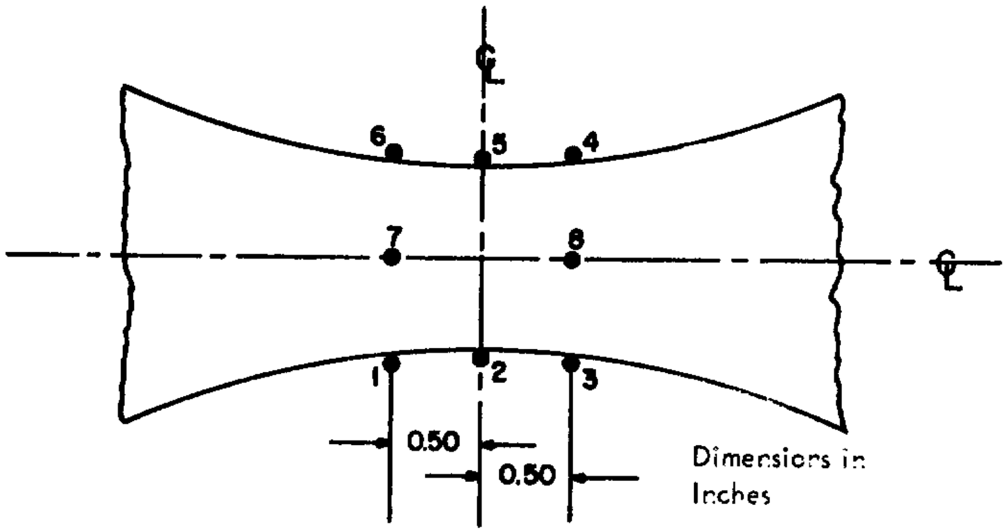
○ - Top of Specimen
⊗ - Bottom of Specimen
● - Both Top and Bottom (No. 4 is on top)

Locations at which 28 gage chromel-alumel thermocouples were spotwelded to the surface of the check specimen.

Thermo-couple Number	Run No. 1	Run No. 2	Run No. 3
	Temperature, °F	Temperature °F	Temperature, °F
1	493	923	399
2	490	924	399
3	490	920	397
4	491	926	397
5	491	924	397
6	491	928	398
7	490	928	396
8	490	922	392
9	490	923	392
10	489	926	394

TABLE VIII

TEMPERATURE DISTRIBUTION SURVEY FOR FATIGUE SPECIMENS WITH LATERAL SUPPORT PLATES



Location of Thermocouples:
No. 1 through 6 were spotwelded to edge of specimen.
No. 7 and 8 were inserted through the stainless steel support plates.

Thermo-couple Number	Run No. 1	Run No. 2	Run No. 3	Run No. 4
	Temperature, °F	Temperature, °F	Temperature, °F	Temperature, °F
1	401	600	802	902
2	402	600	802	901
3	399	600	799	898
4	398	601	798	897
5	399	599	802	902
6	406	598	803	904
7	402	598	800	900
8	402	600	804	905

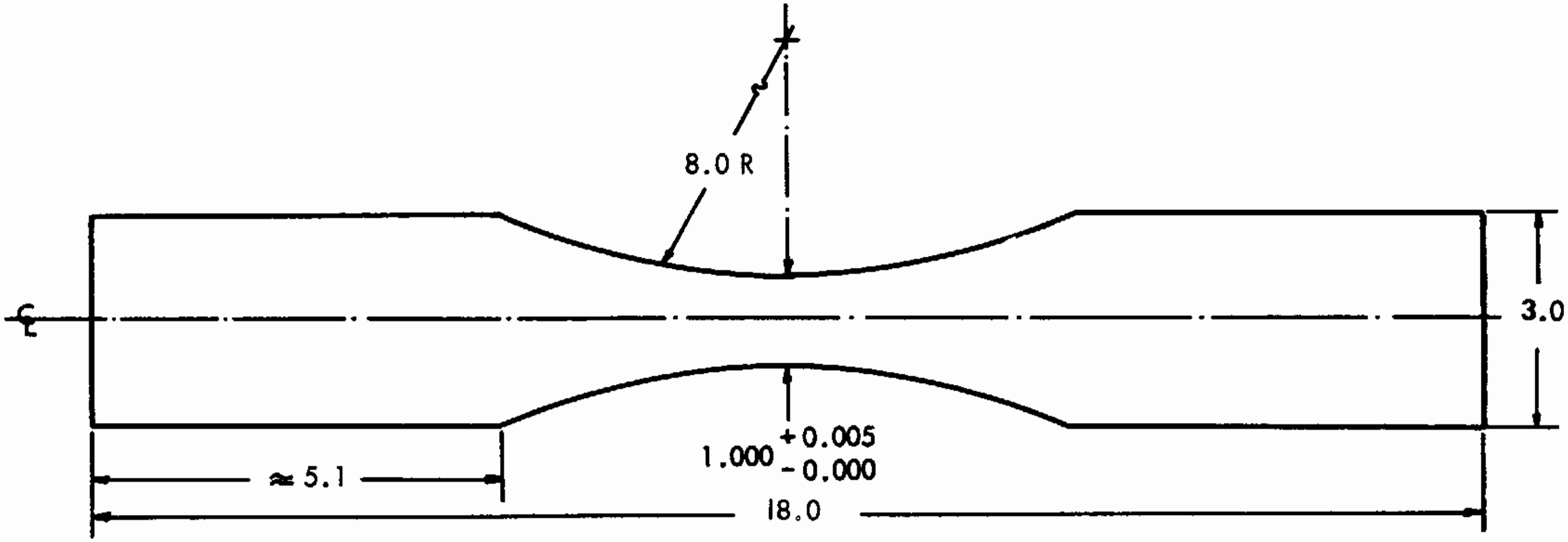
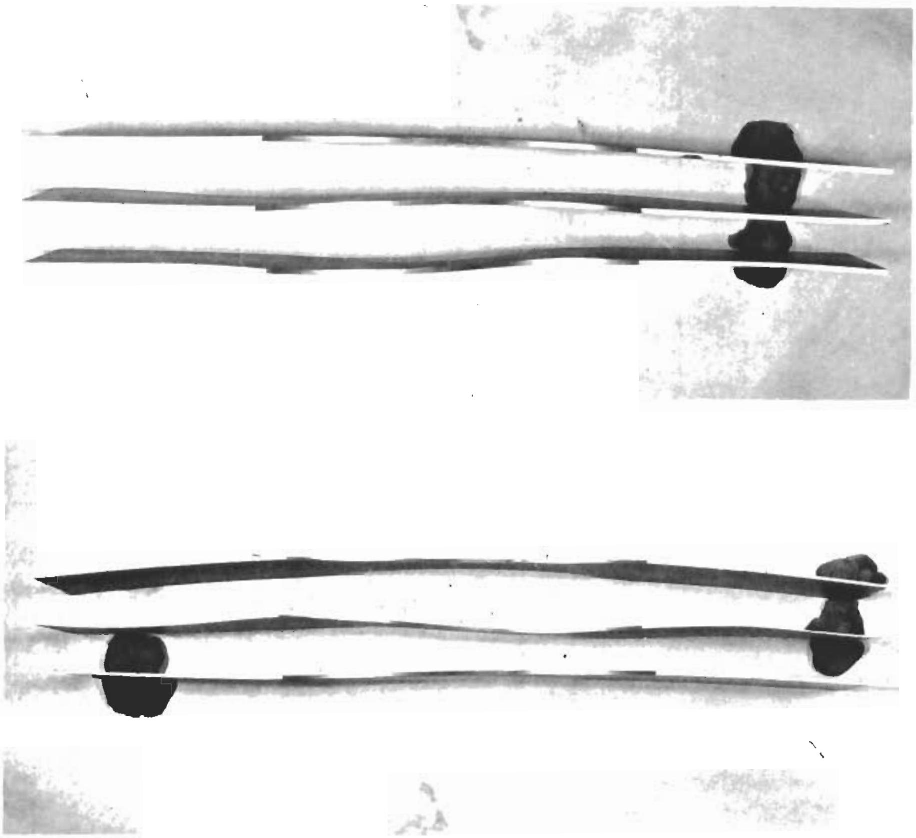


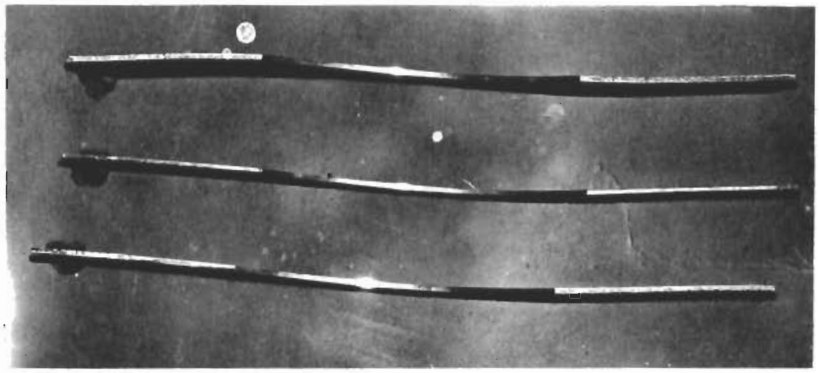
FIGURE 14 - SHEET FATIGUE SPECIMEN (1/2 SCALE)
(Dimensions in Inches)



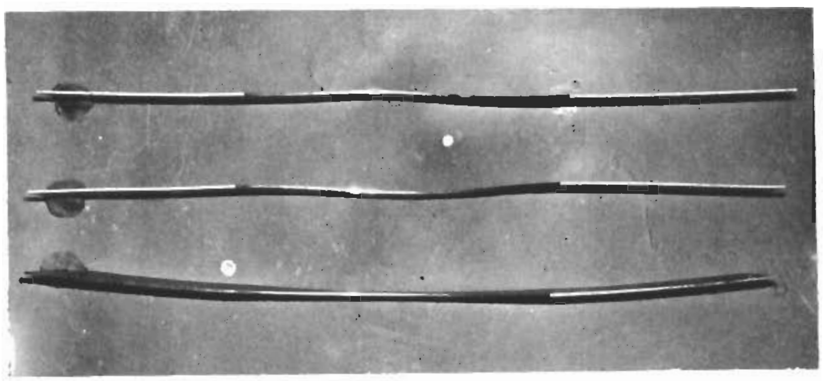
0.125 Inch Thick

0.063 Inch Thick

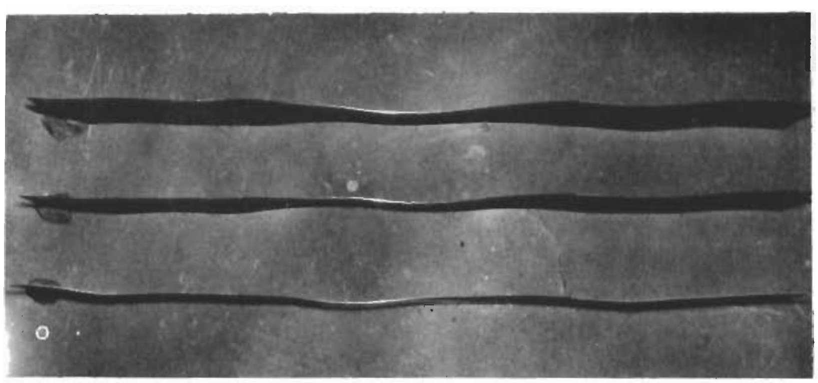
FIGURE 15 - Ti-6Al-4V FATIGUE SPECIMENS SHOWING FLATNESS DEVIATION AFTER BEING CUT FROM SHEET



0.125 Inch Thick



0.063 Inch Thick



0.020 Inch Thick

FIGURE 16 - Ti-2.5Al-16V FATIGUE SPECIMENS SHOWING FLATNESS DEVIATION AFTER BEING CUT FROM SHEET

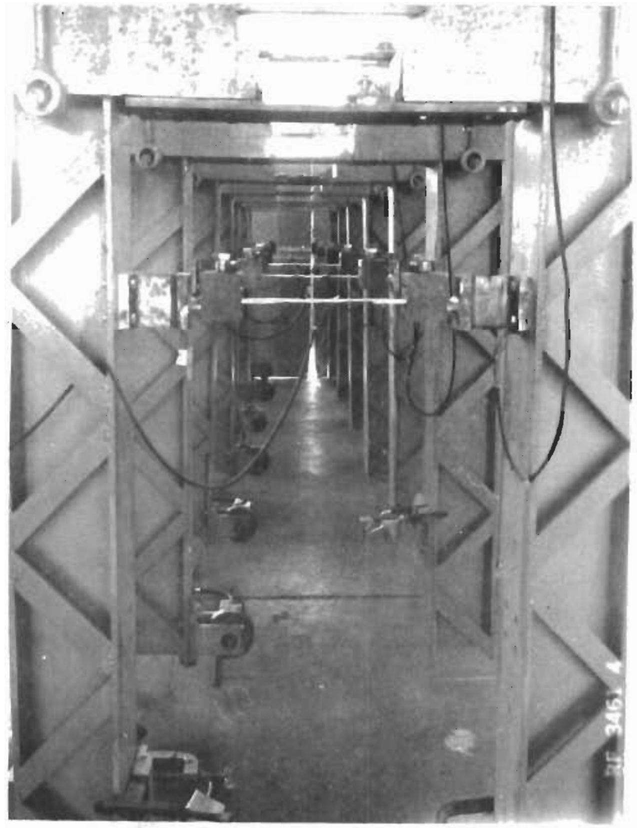


FIGURE 17 - AXIAL-LOAD, TUNING FORK TYPE FATIGUE MACHINES

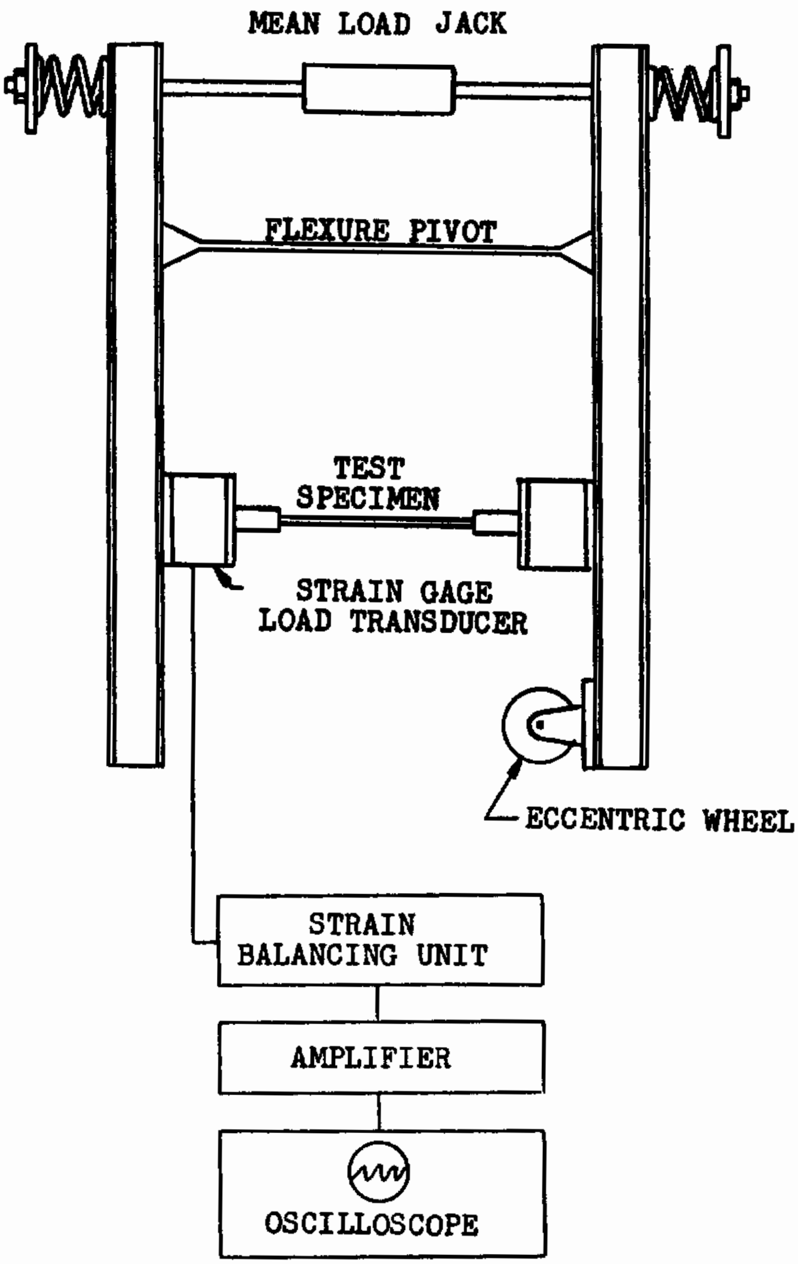


FIGURE 18 - SCHEMATIC DIAGRAM OF AXIAL-LOAD, TUNING FORK TYPE FATIGUE MACHINES

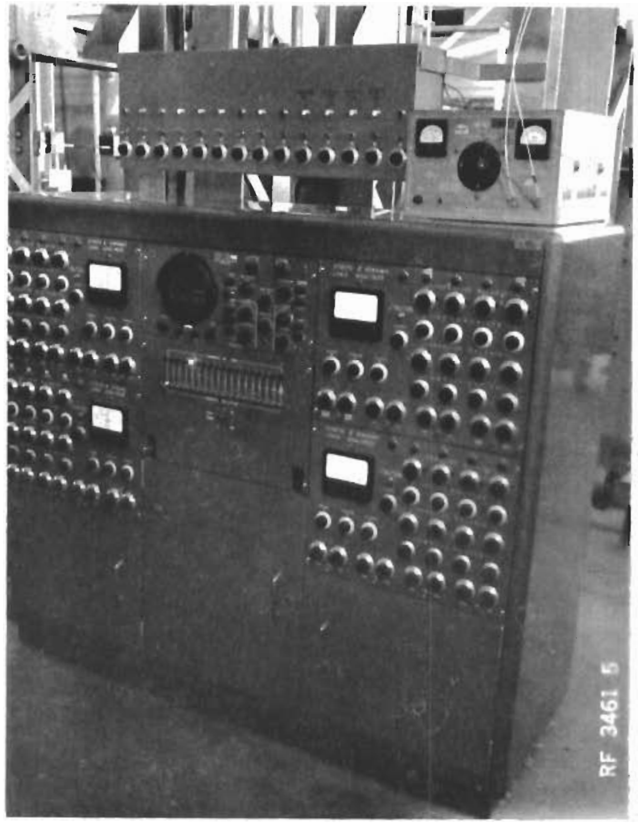


FIGURE 19 – TWELVE CHANNEL DYNAMIC STRAIN ANALYZER

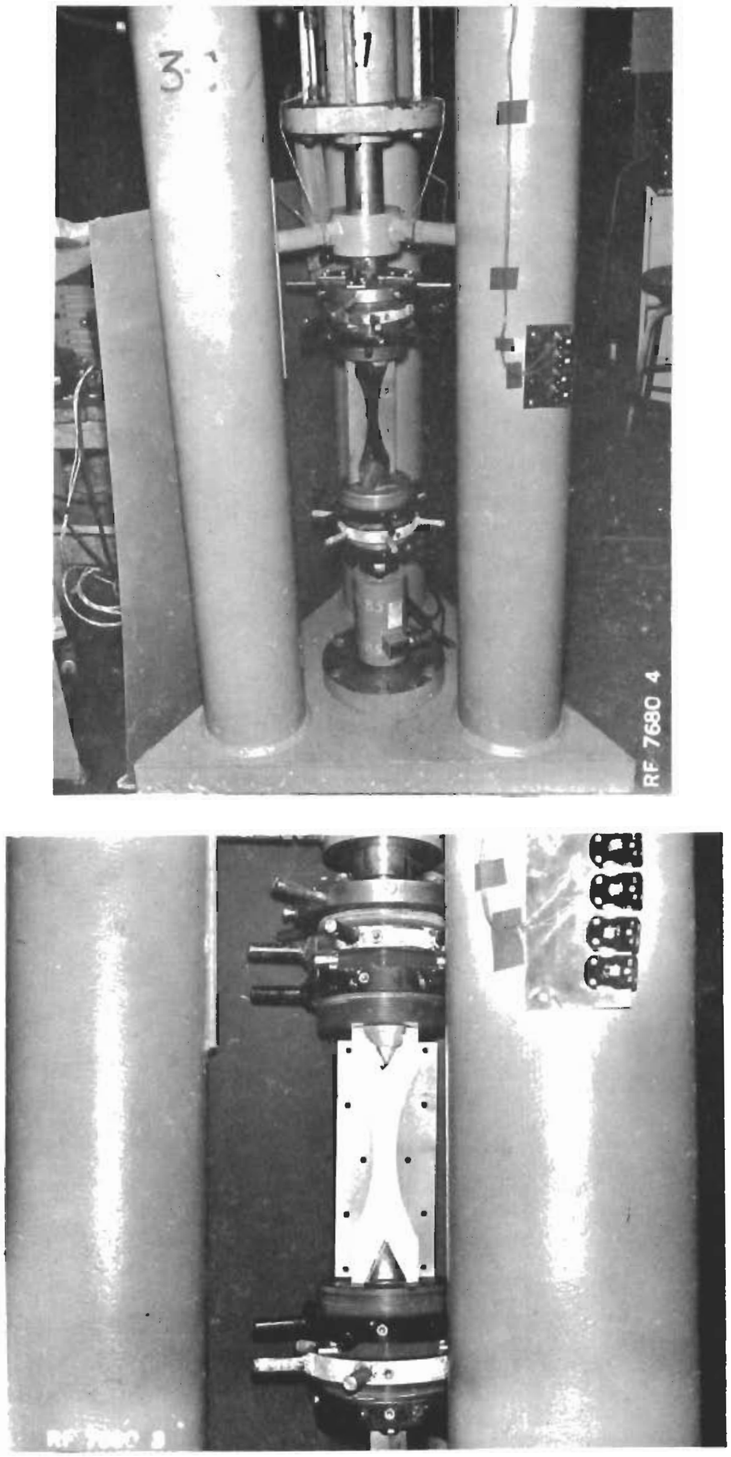


FIGURE 20 - LOADING ARRANGEMENT USED FOR A $=\infty$, HIGH STRESS, SLOW CYCLE FATIGUE TESTS

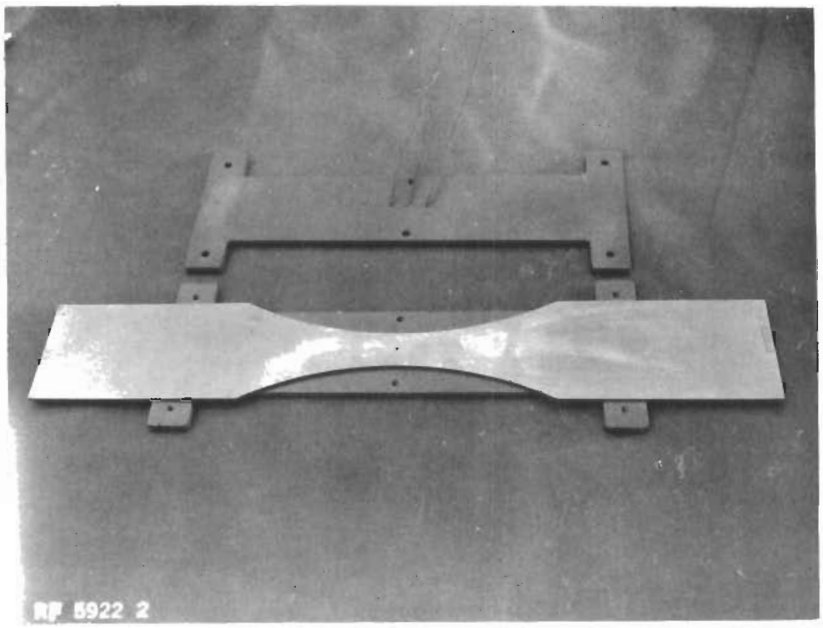
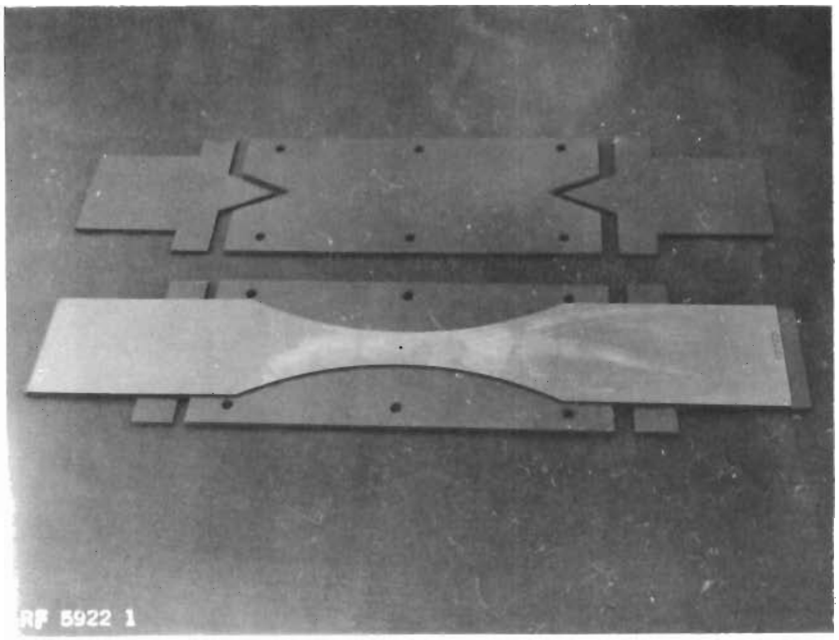


FIGURE 21 - LATERAL SUPPORT PLATES USED FOR FATIGUE TESTING AT STRESS RATIOS OF 1 AND ∞



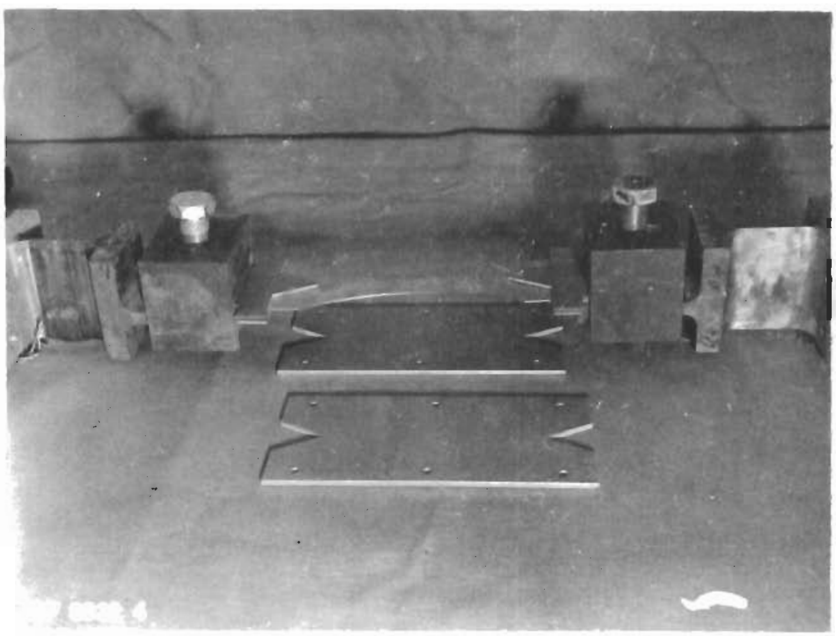
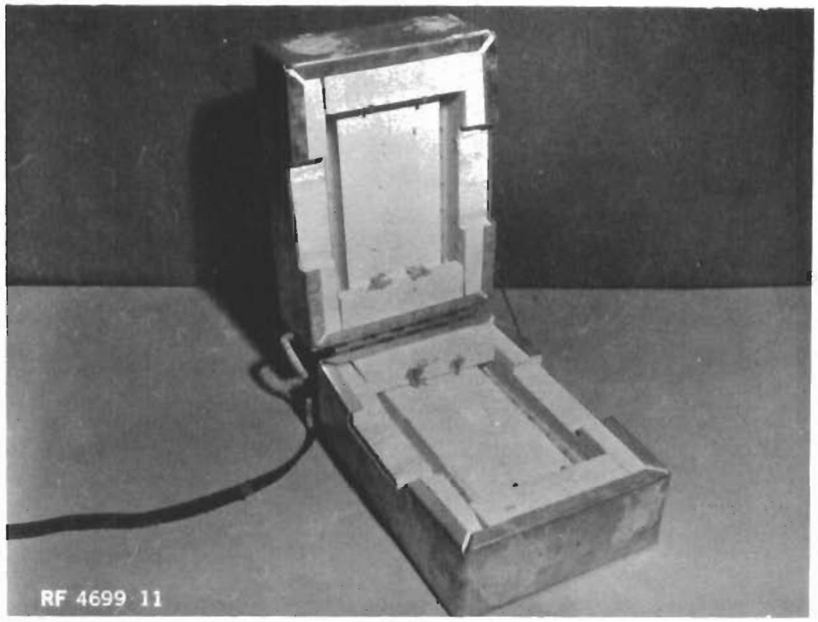


FIGURE 22 - LATERAL SUPPORT PLATES USED FOR FATIGUE TESTING 0.020 INCH THICK SPECIMENS AT A STRESS RATIO OF ∞



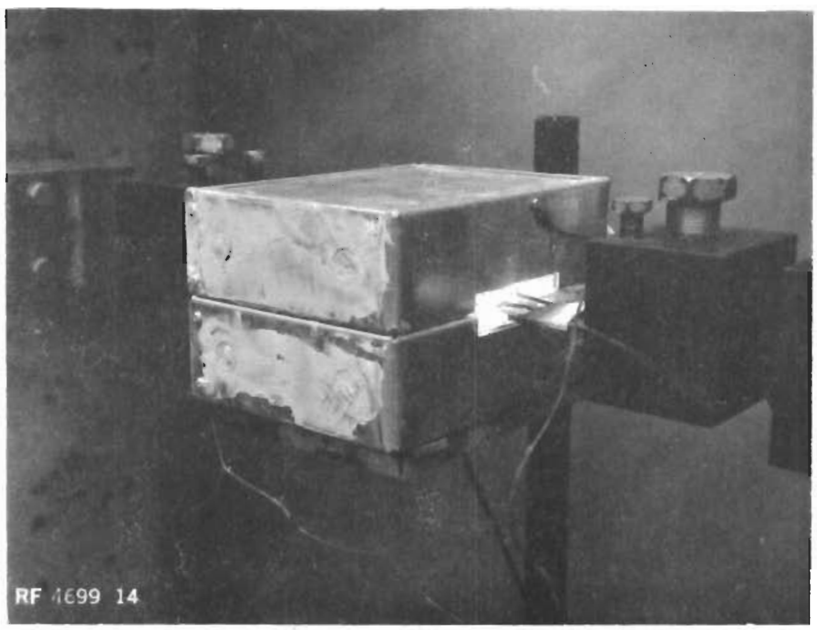


FIGURE 23 - FURNACES FOR ELEVATED TEMPERATURE FATIGUE TESTS

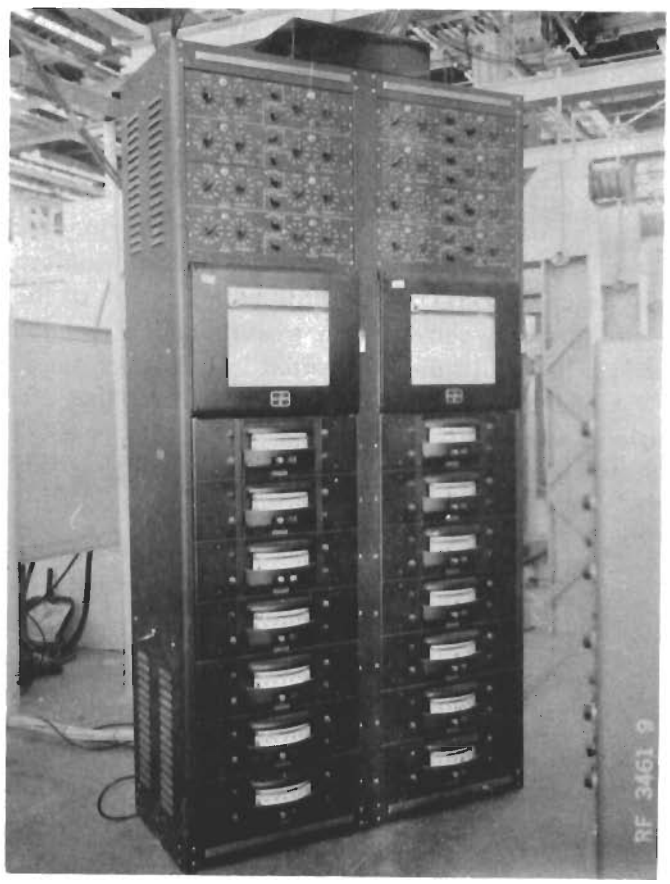


FIGURE 24 - FATIGUE TEMPERATURE CONTROL CONSOLE

IV - GENERAL CREEP-RUPTURE TEST RESULTS

The tensile creep-rupture data presented herein are from the evaluation of three heats each of 0.063 inch thick Ti-6Al-4V, Ti-2.5Al-16V and Ti-4Al-3Mo-1V. A minimum of 13 longitudinal tests per heat were conducted at 600°F, 700°F and 800°F. One heat from each alloy was further evaluated by a minimum of six transverse tests at 600°F, 700°F and 800°F and an additional five longitudinal tests at 500°F and 900°F. Strains, indicated in all of the following figures, are the result of creep only and do not include initial loading strain or thermal expansion.

To Larson-Miller master rupture and creep curves, which are presented for each alloy, have been added constant temperature lines which allow direct reading of tensile stress without the necessity of solving the parameter. Select the curve representing rupture or the limiting amount of creep strain, enter at the time axis and proceed horizontally to intersect the appropriate temperature line. Extend a vertical line from this point of intersection to the master curve, then continue parallel to the abscissa to the stress value on the ordinate.

The creep-rupture phase of the design data collection program, as originally planned, specified 20 compressive creep and bearing creep-rupture tests at 600°F, 700°F and 800°F and five compressive creep tests at 900°F on one heat of the three 0.063 inch thick titanium alloys. As the program progressed, it became evident that 20 compressive and bearing tests were not necessary at 600°F to establish the creep characteristics. At 600°F, stresses required for rupture within 500 hours were within a few percent of the average ultimate strength of the material so that small variations of tensile strength between specimens resulted in either loading failures or indefinite sustention of load. The results are illustrated in the 600°F summary curves which are essentially horizontal. Since considerable machine time was being used in attempting to obtain these data the decision was made to eliminate a portion of the 600°F tests and add them to the 700°F, 800°F and 900°F tests where more quantitative results could be obtained.

V - RESULTS FOR 6Al-4V TITANIUM ALLOY

Tensile Creep-Rupture Test Results - Ti-6Al-4V

Longitudinal and transverse stress-rupture data are summarized in Figures 25 and 26, respectively, by curves showing stress versus time to rupture. Similar type curves showing time to acquire longitudinal tensile creep strains of 1.0, 0.5, 0.2, 0.1 and 0.05 percent are shown in Figures 27 through 31. These data are further summarized, using the Larson-Miller parameter, by a master rupture curve and a master creep curve for each of the above selected percentage creep strains, Figures 32 through 37. Volume 1 contains design type curves showing percent average room-temperature ultimate tensile stress as a function of time to rupture and time to reach the various creep strains. Figures 38 through 73 show percent creep strain versus log time curves for individual tests from which summary data were obtained. The summary data are tabulated in Tables XCVI through XCIX, pages 102 through 105 of Volume 3. Initial loading deformation is also reported in these tables.

Compressive Creep Test Results - Ti-6Al-4V

Data obtained for longitudinal compressive creep tests for one heat of 0.063 inch thick sheet are summarized in Figures 74 through 77 by logarithmic curves of compressive creep stress versus time required to attain selected amounts of creep strain. Such curves are presented for creep strains of 1.0, 0.5, 0.2, 0.1 and 0.05 percent at temperatures of 600°F, 700°F, 800°F and 900°F. These data were obtained from the creep curves shown in Figures 78 through 86. The summarized data, along with percent loading deformation where measured, are tabulated in Tables C through CII, pages 106 through 109 of Volume 3.

Bearing Creep-Rupture Test Results - Ti-6Al-4V

Plots showing the variation in bearing stress with time required to produce rupture and bearing deformations of 4.0, 2.0, 1.0 and 0.5 percent of the bearing hole diameter are presented in Figures 87 through 89. These curves represent the longitudinal grain direction, only, at temperatures of 600°F, 700°F and 800°F for one heat of 0.063 inch thick sheet. Bearing deformation versus log time curves, from which the above plots were derived, are shown in Figures 90 through 99. Tabulations of the plotted data are in Tables CIV through CVI, pages 110 through 112 of Volume 3. Initial loading deformation, where obtained, is also shown in these tables.

Single Shear Stress-Rupture Test Results - Ti-6Al-4V

Single shear stress-rupture curves are presented for three heats of 0.063 inch thick Ti-6Al-4V in Figure 100. These curves summarize data from a minimum of six longitudinal tests performed at 600°F, 700°F and 800°F on each of the three heats. The results are also listed in Tables CVII and CVIII, pages 113 and 114 of Volume 3.

Double Shear Stress-Rupture Test Results - Ti-6Al-4V

Results of longitudinal double shear stress-rupture tests on three heats of 0.125 inch thick 6Al-4V titanium alloy are plotted in Figure 101. A minimum of 18 tests were conducted on each heat, six each at 600°F, 700°F and 800°F. The data are presented in tabular form in Tables CIX and CX, pages 115 and 116, of Volume 3.

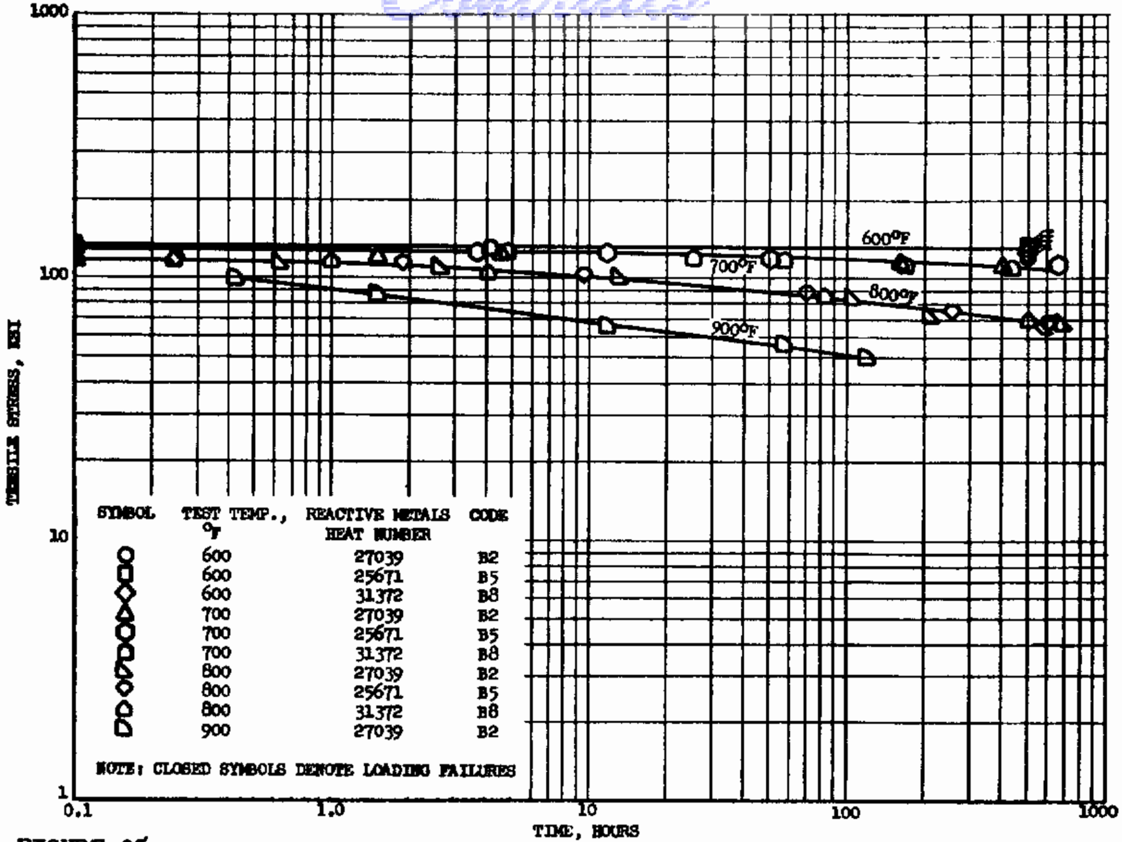


FIGURE 25 - LONGITUDINAL TENSILE STRESS-RUPTURE CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK

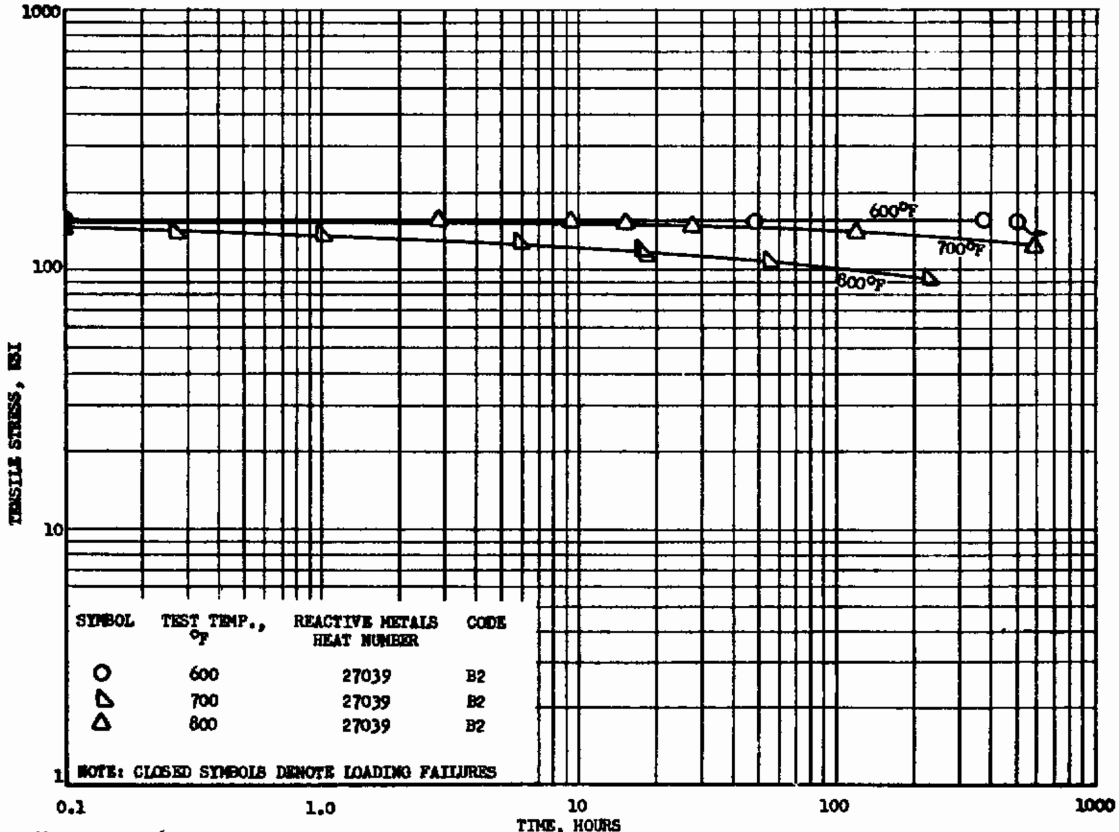


FIGURE 26 - TRANSVERSE TENSILE STRESS-RUPTURE CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK

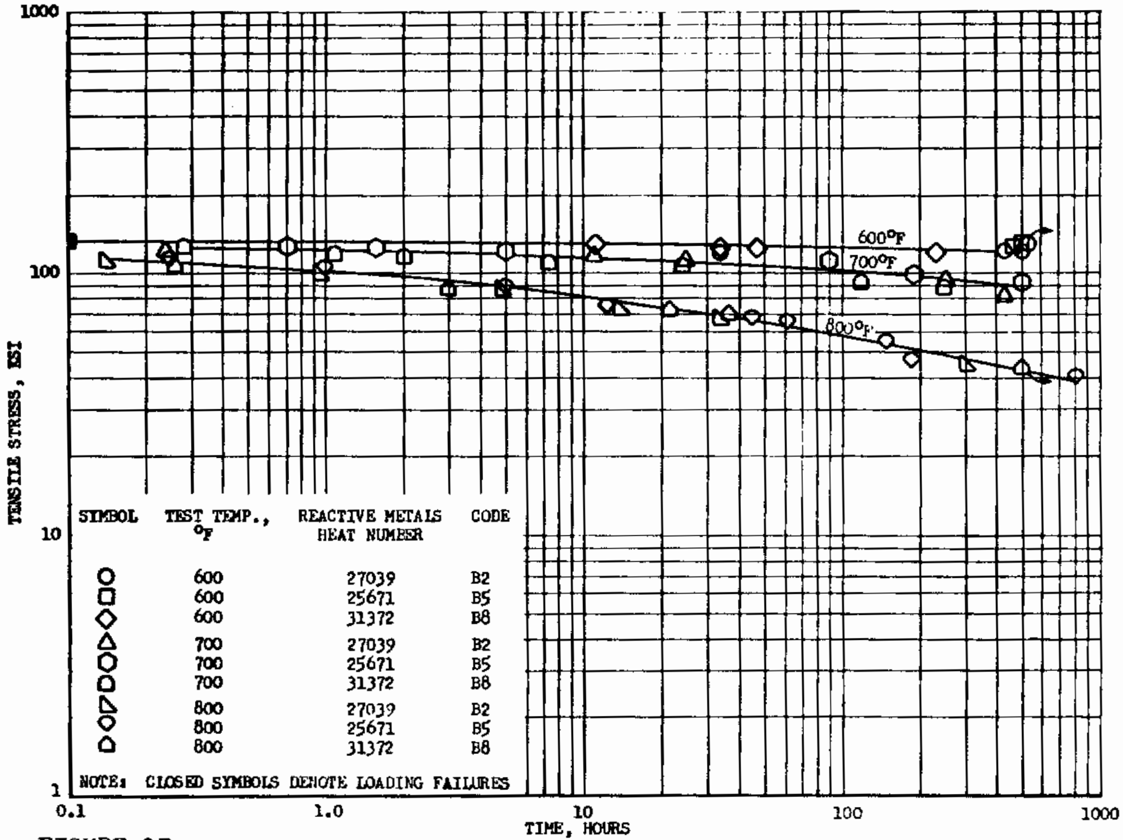


FIGURE 27 - LONGITUDINAL 1.0% TENSILE CREEP STRAIN CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK

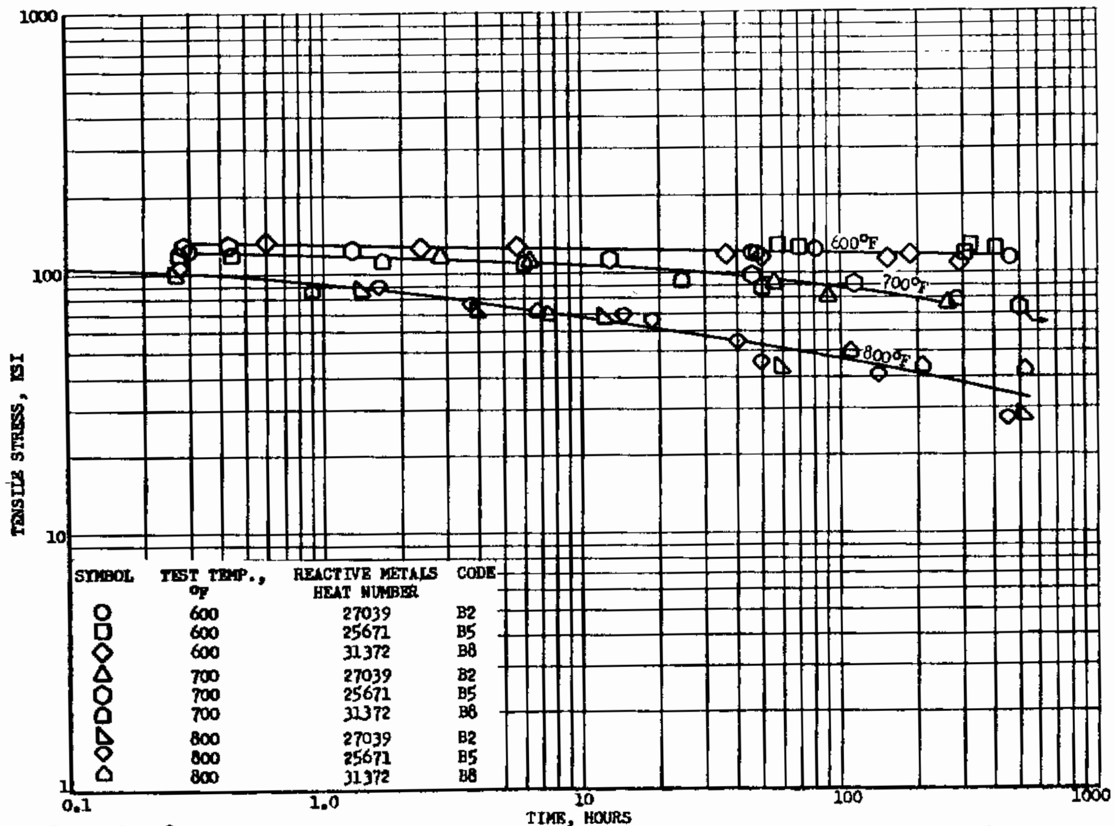


FIGURE 28 - LONGITUDINAL 0.5% TENSILE CREEP STRAIN CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK

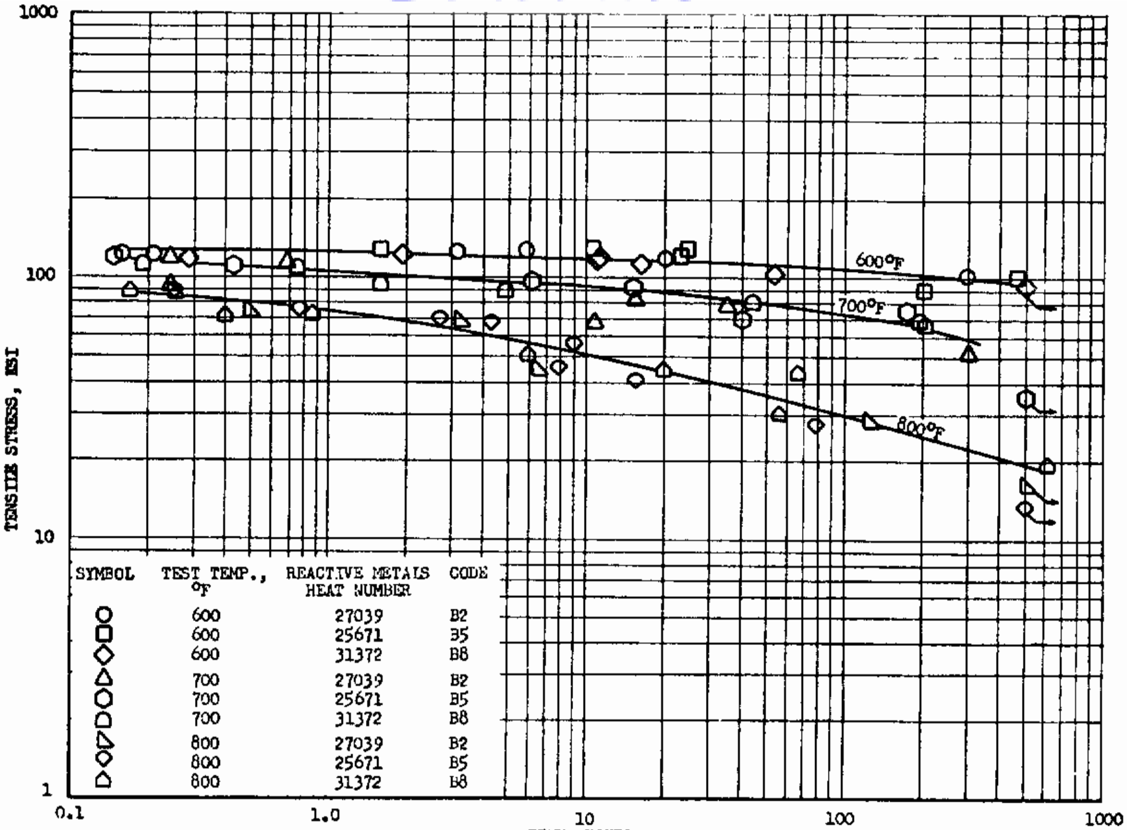


FIGURE 29 - LONGITUDINAL 0.2% TENSILE CREEP STRAIN CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK

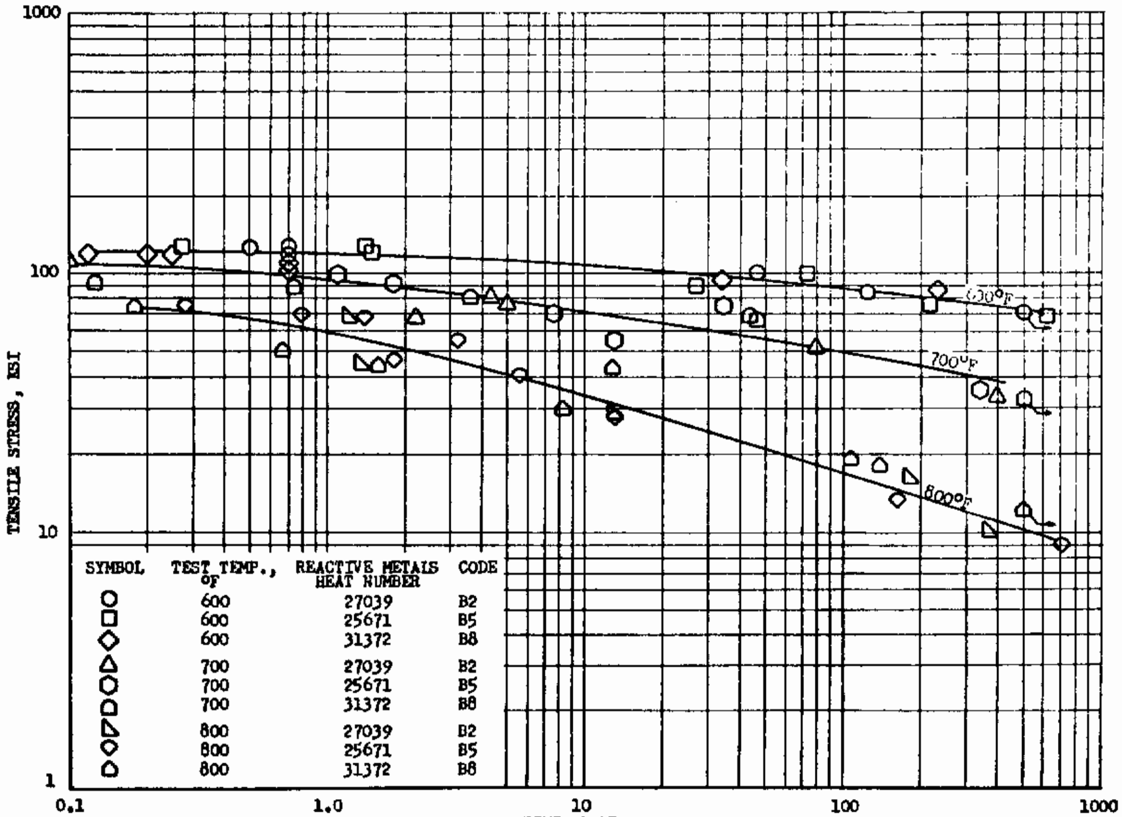


FIGURE 30 - LONGITUDINAL 0.1% TENSILE CREEP STRAIN CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK

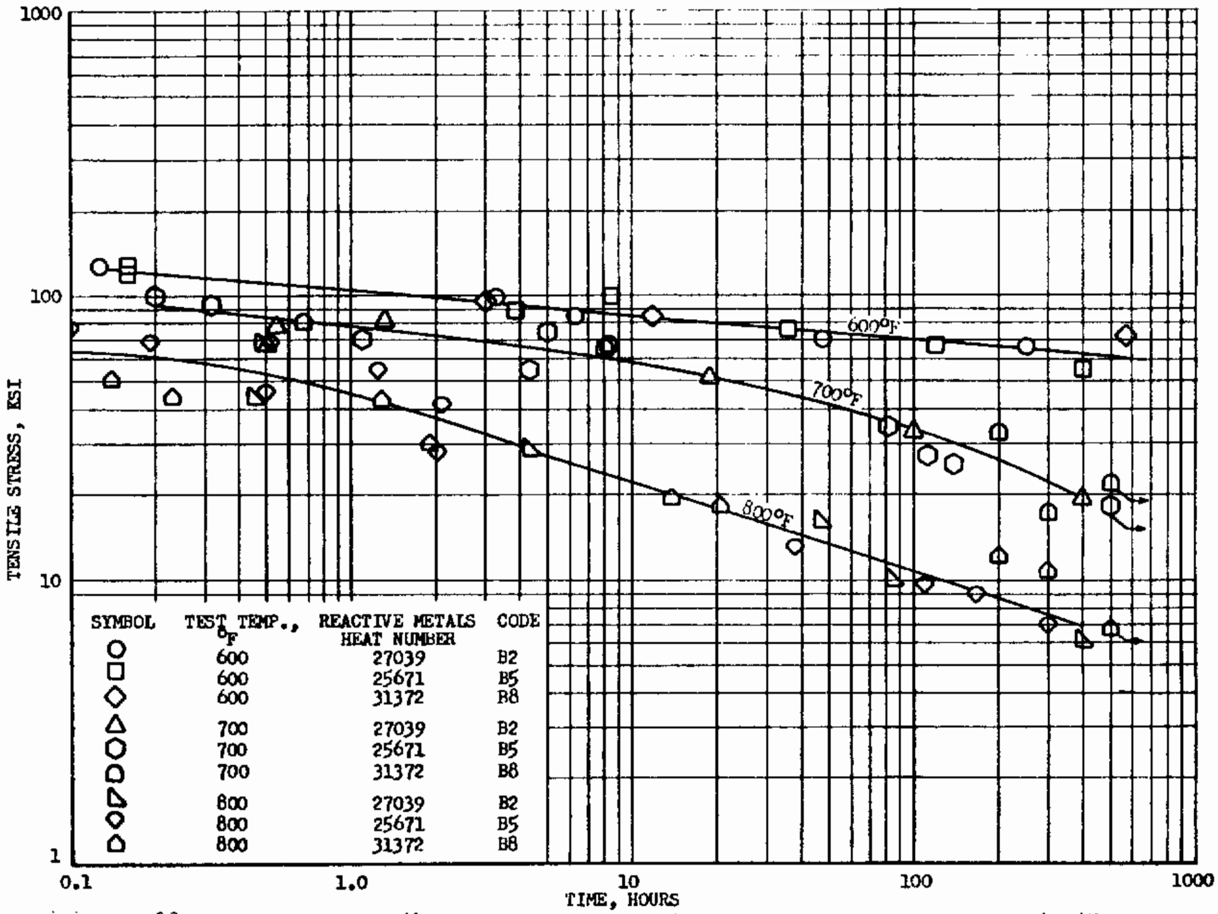


FIGURE 31 - LONGITUDINAL 0.05% TENSILE CREEP STRAIN CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK

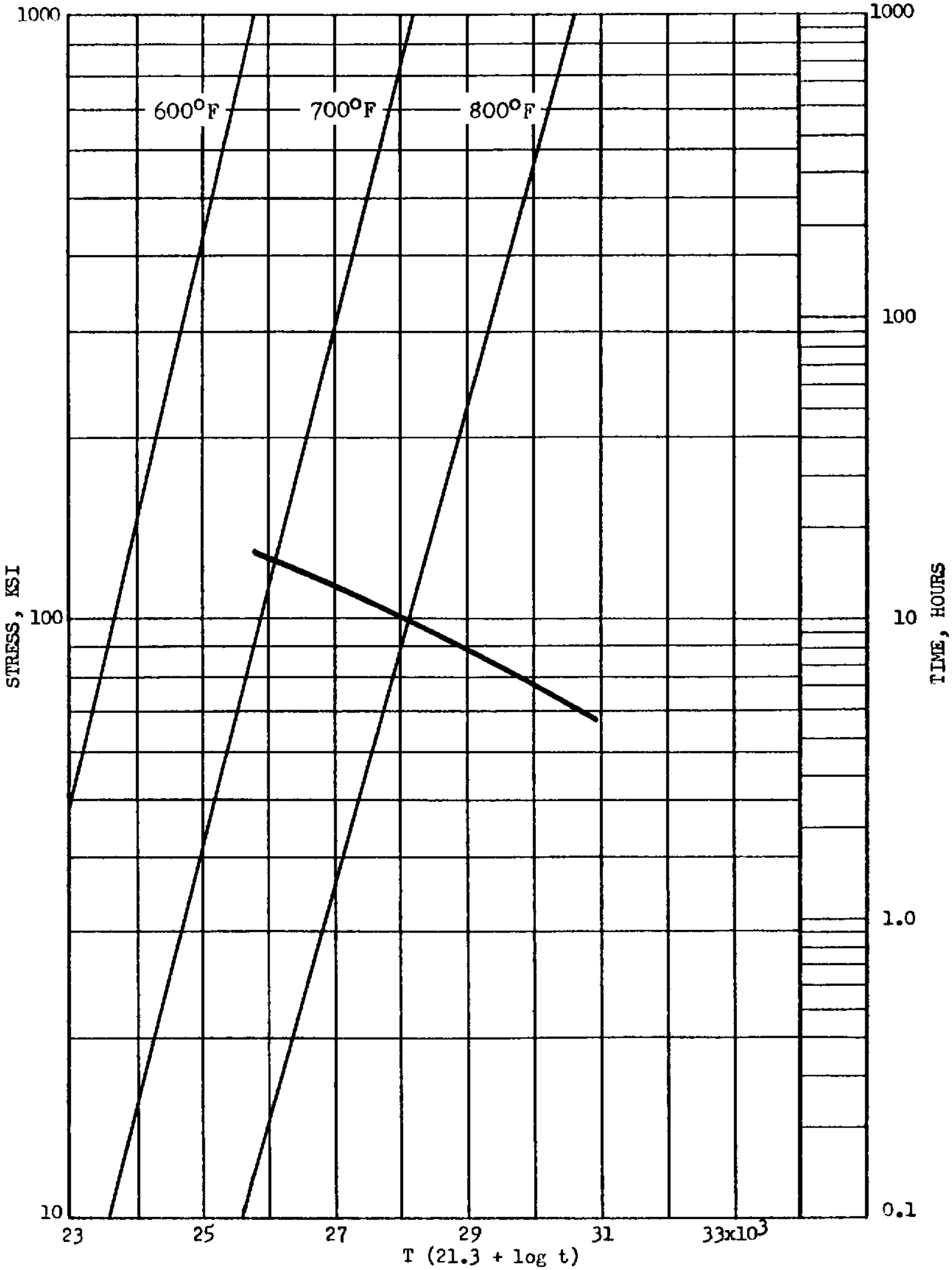


FIGURE 32 - MASTER RUPTURE CURVE FOR 6Al-4V SOLUTION TREATED AND AGED TITANIUM ALLOY (0.063 INCH THICK SHEET).

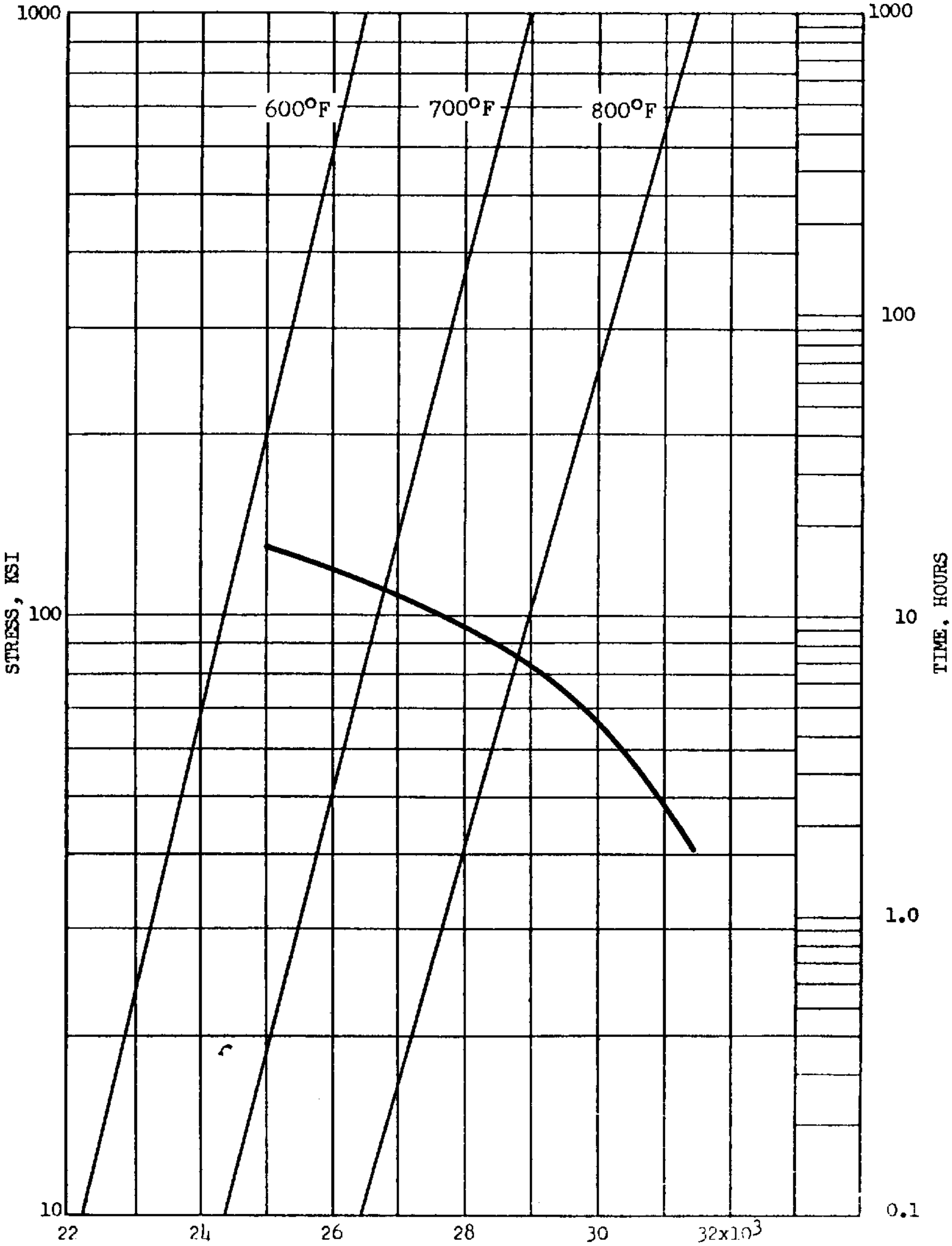


FIGURE 33 - MASTER 1.0 PERCENT CREEP STRAIN CURVE FOR 6Al-4V SOLUTION TREATED AND AGED TITANIUM ALLOY (0.063 INCH THICK SHEET).

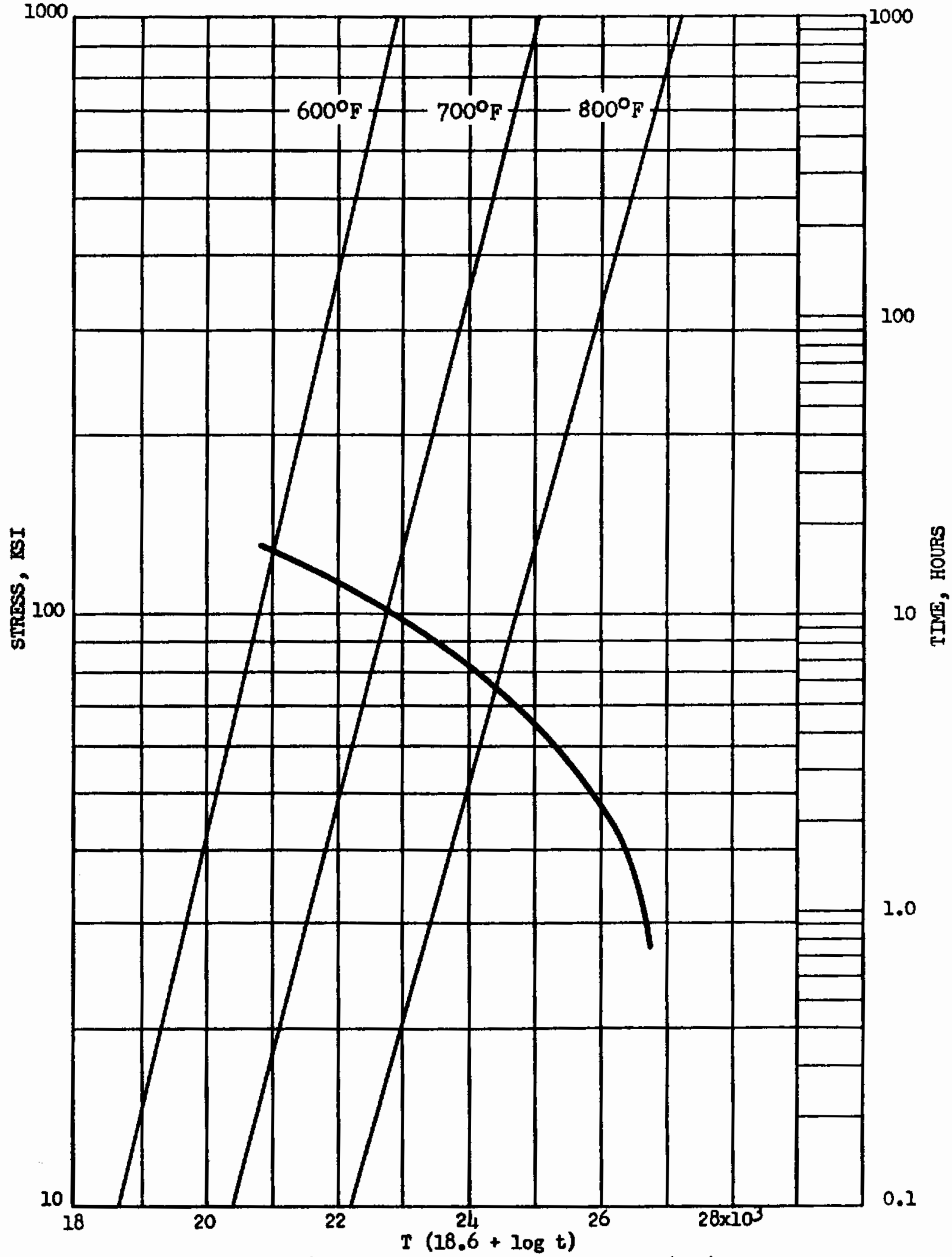


FIGURE 34 - MASTER 0.5 PERCENT CREEP STRAIN CURVE FOR 6Al-4V SOLUTION TREATED AND AGED TITANIUM ALLOY (0.063 INCH THICK SHEET).

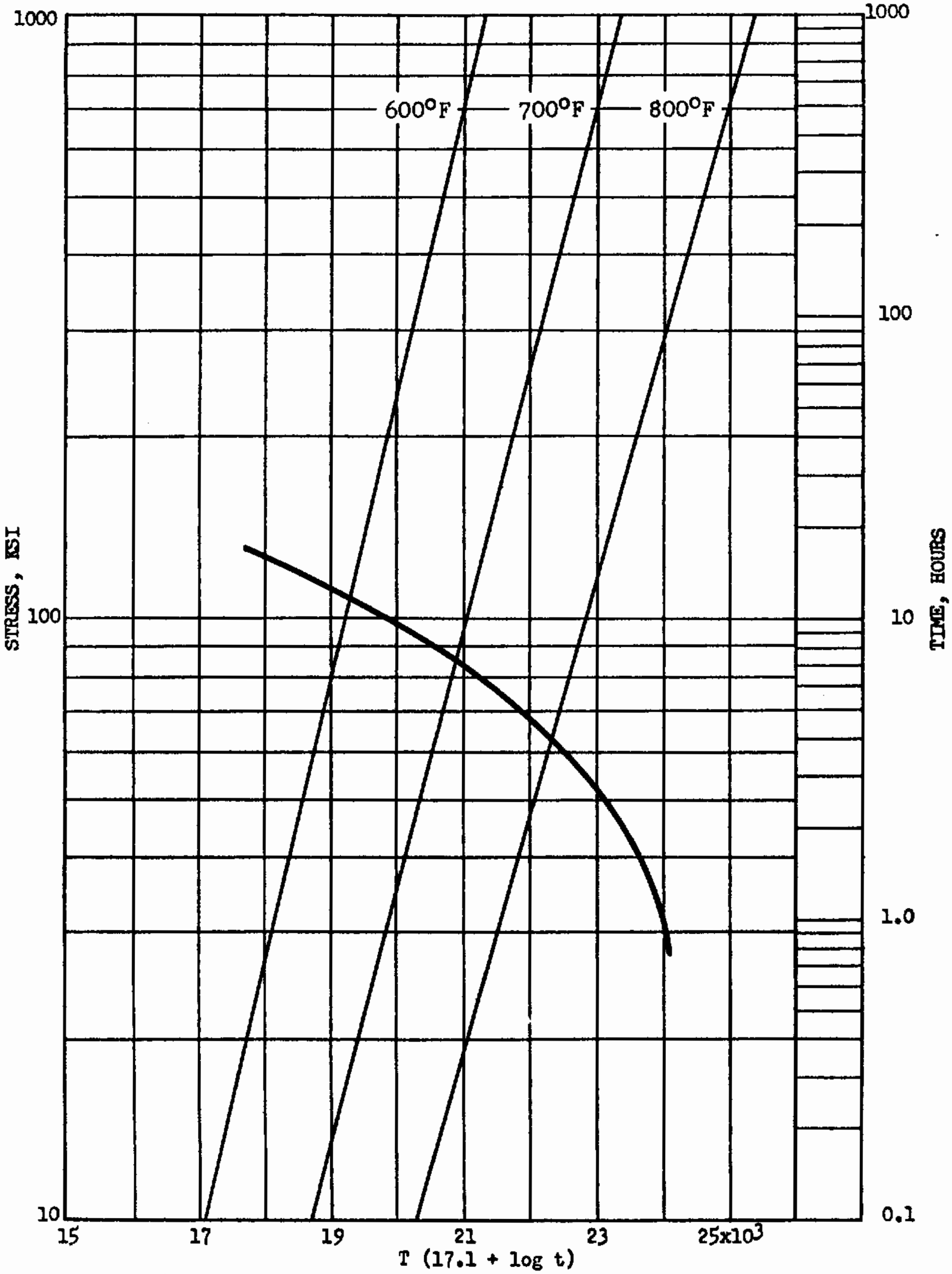


FIGURE 35 - MASTER 0.2 PERCENT CREEP STRAIN CURVE FOR 6Al-4V SOLUTION TREATED AND AGED TITANIUM ALLOY (0.063 INCH THICK SHEET).

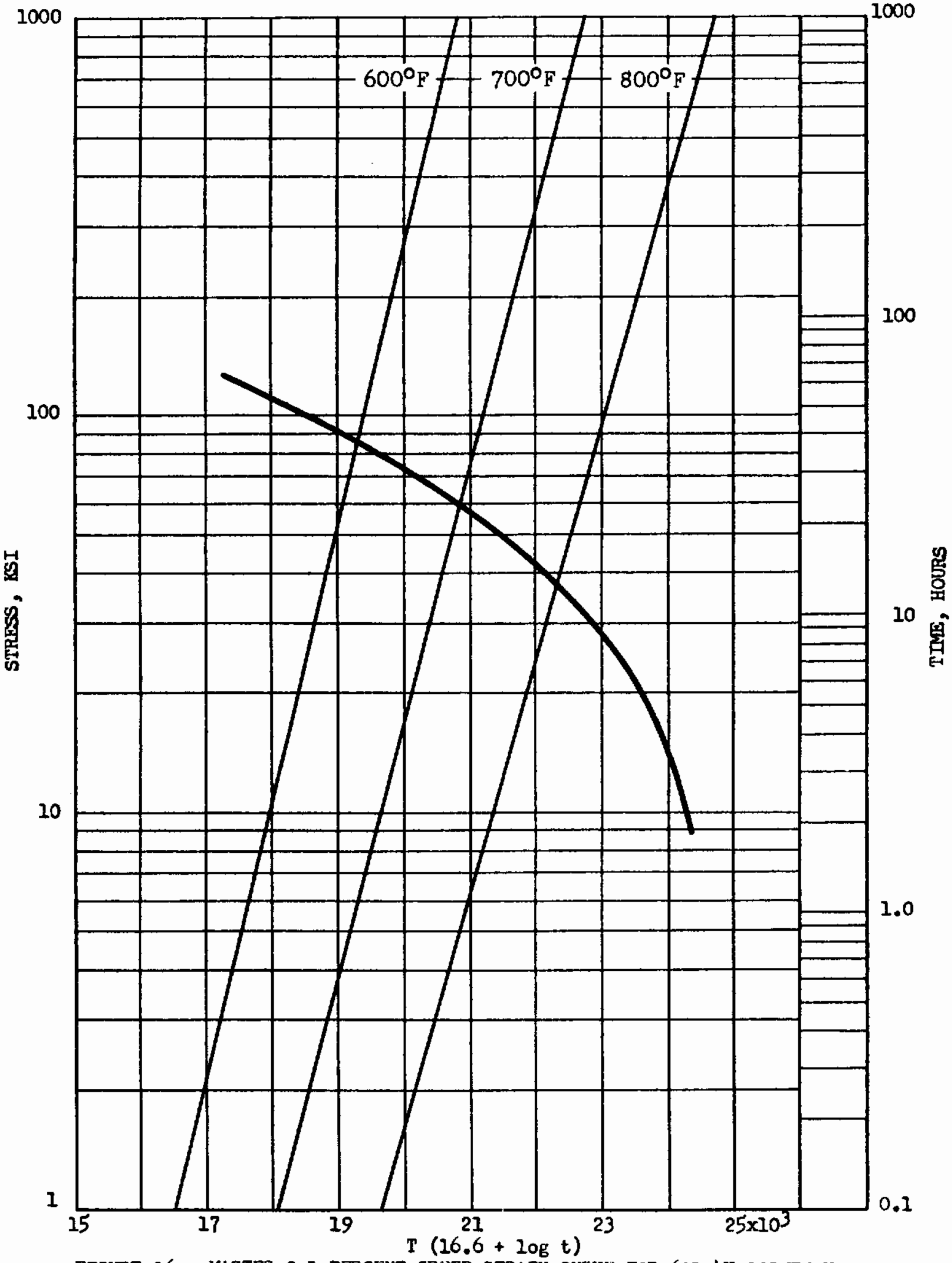


FIGURE 36 - MASTER 0.1 PERCENT CREEP STRAIN CURVE FOR 6Al-4V SOLUTION TREATED AND AGED TITANIUM ALLOY (0.063 INCH THICK SHEET).

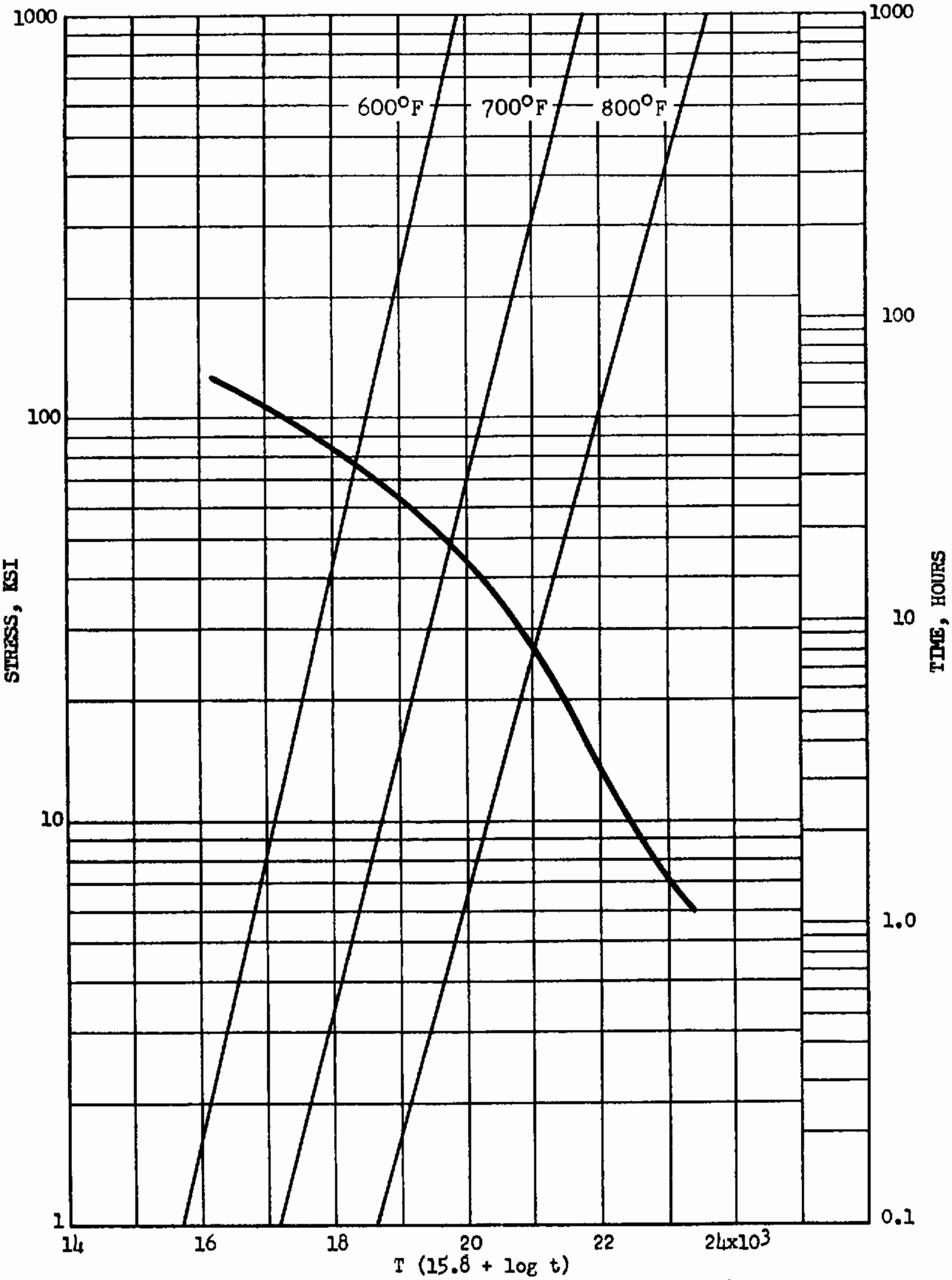


FIGURE 37 - MASTER 0.05 PERCENT CREEP STRAIN CURVE FOR 6Al-4V SOLUTION TREATED AND AGED TITANIUM ALLOY (0.063 INCH THICK SHEET).

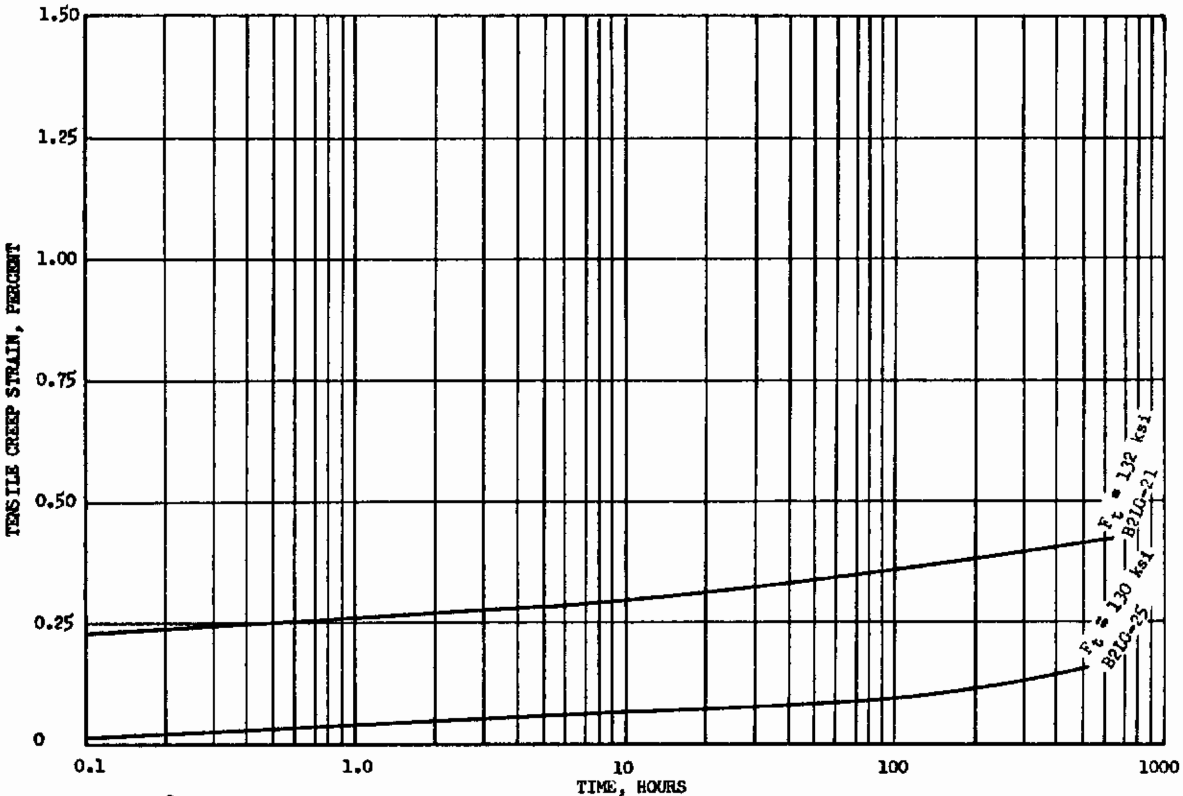


FIGURE 38 - 500°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 27039)

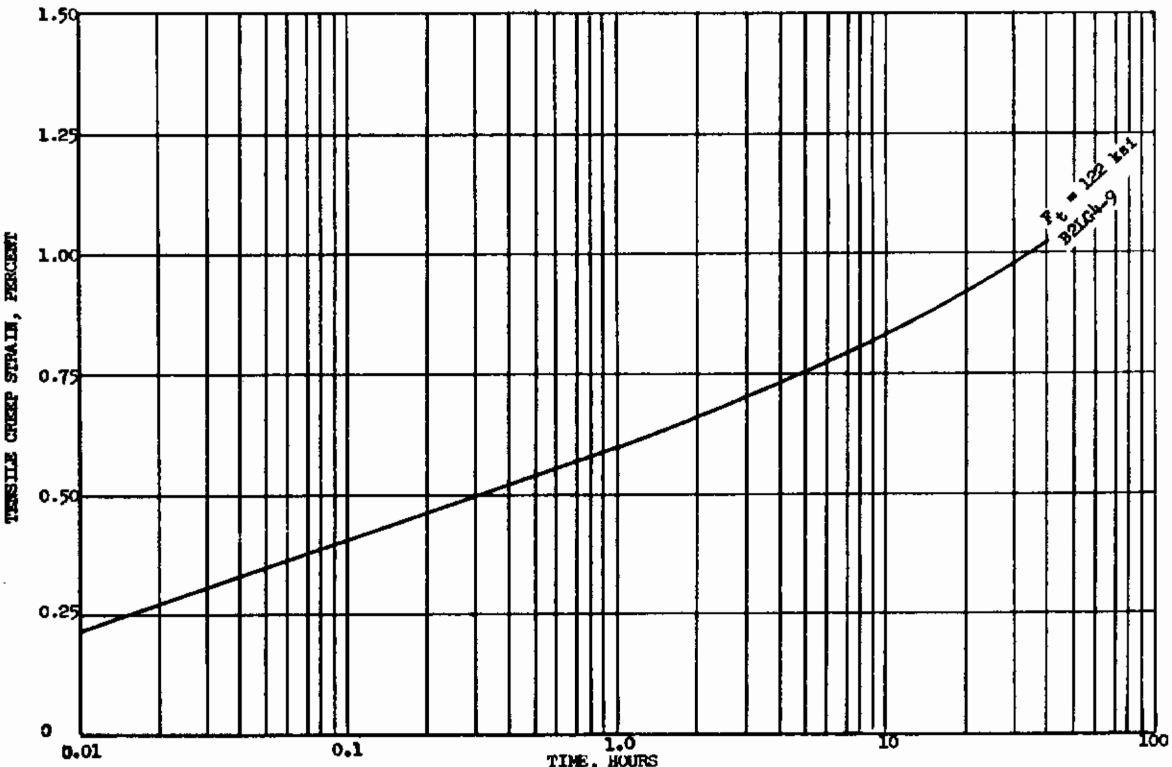


FIGURE 39 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NUMBER 27039)

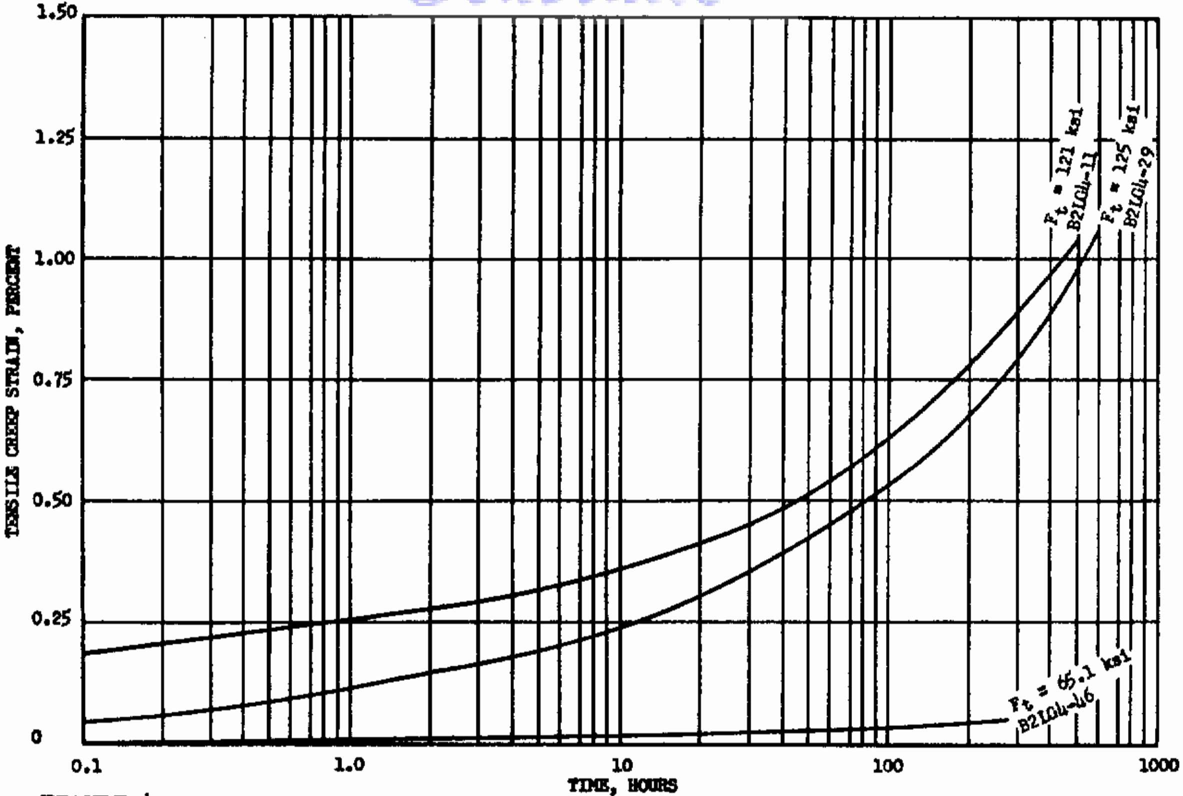


FIGURE 40 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 27039)

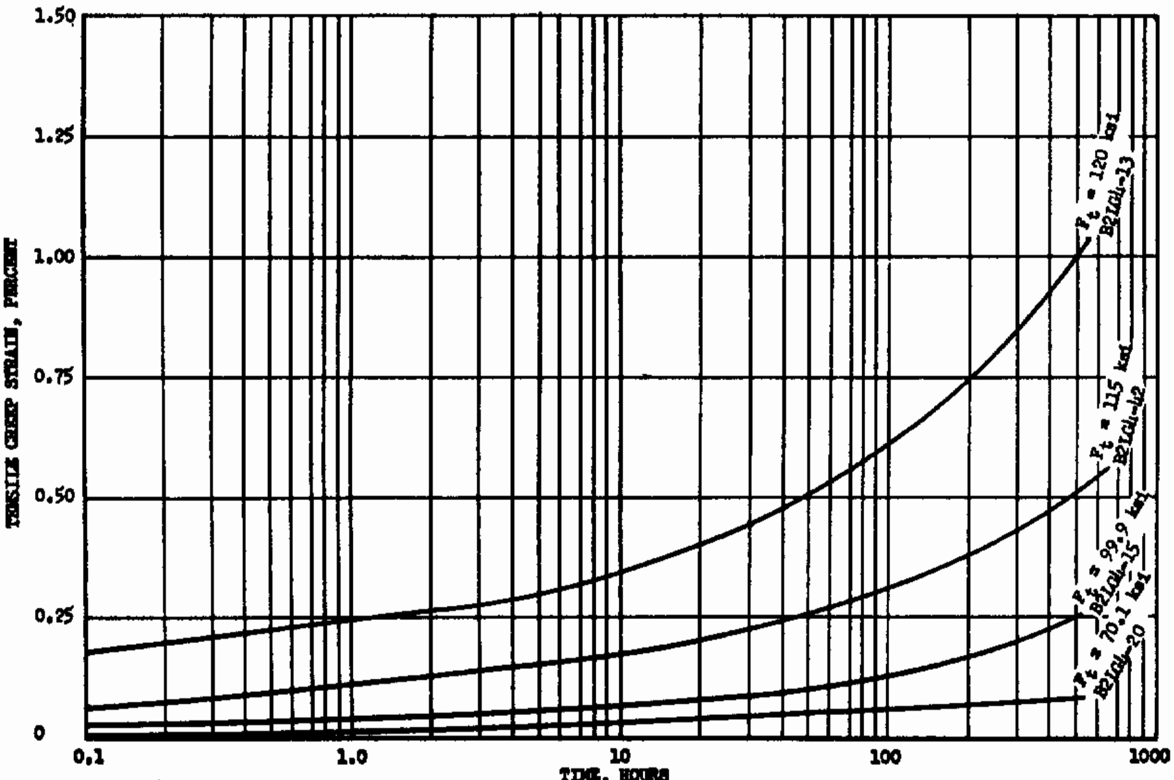


FIGURE 41 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 27039)

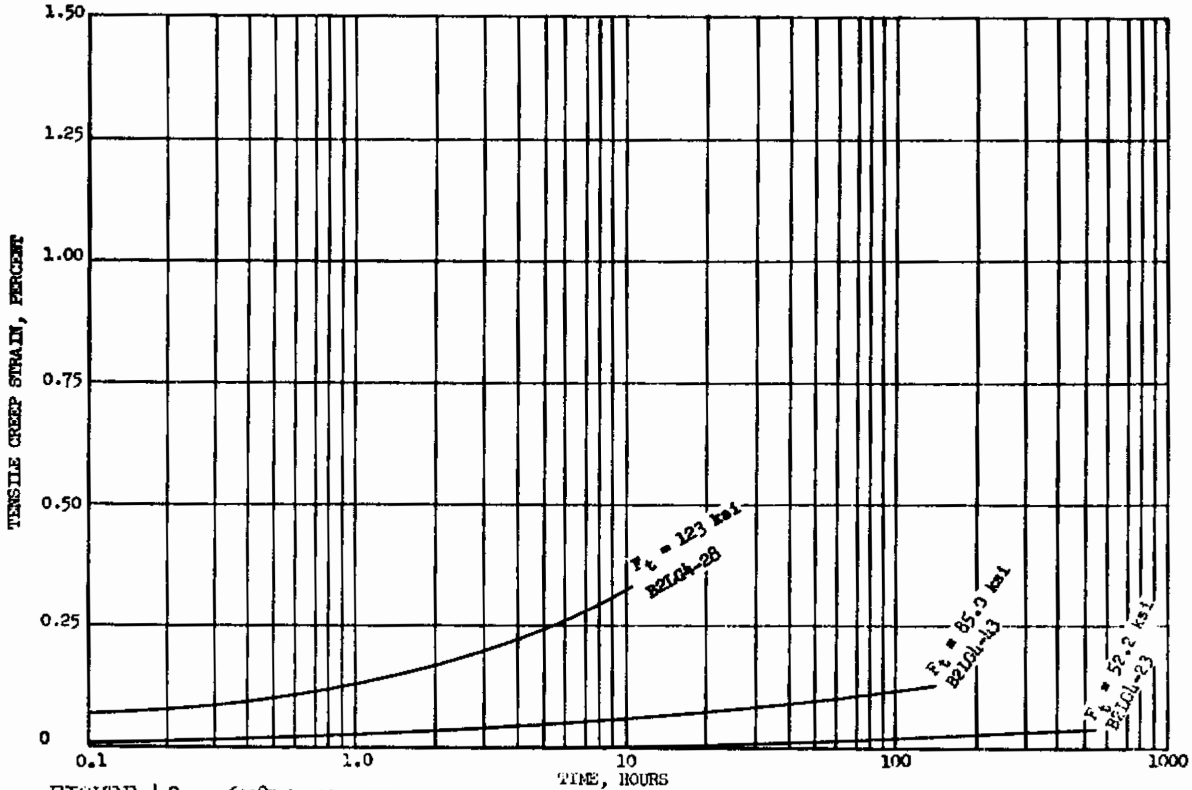


FIGURE 42 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NUMBER 27039)

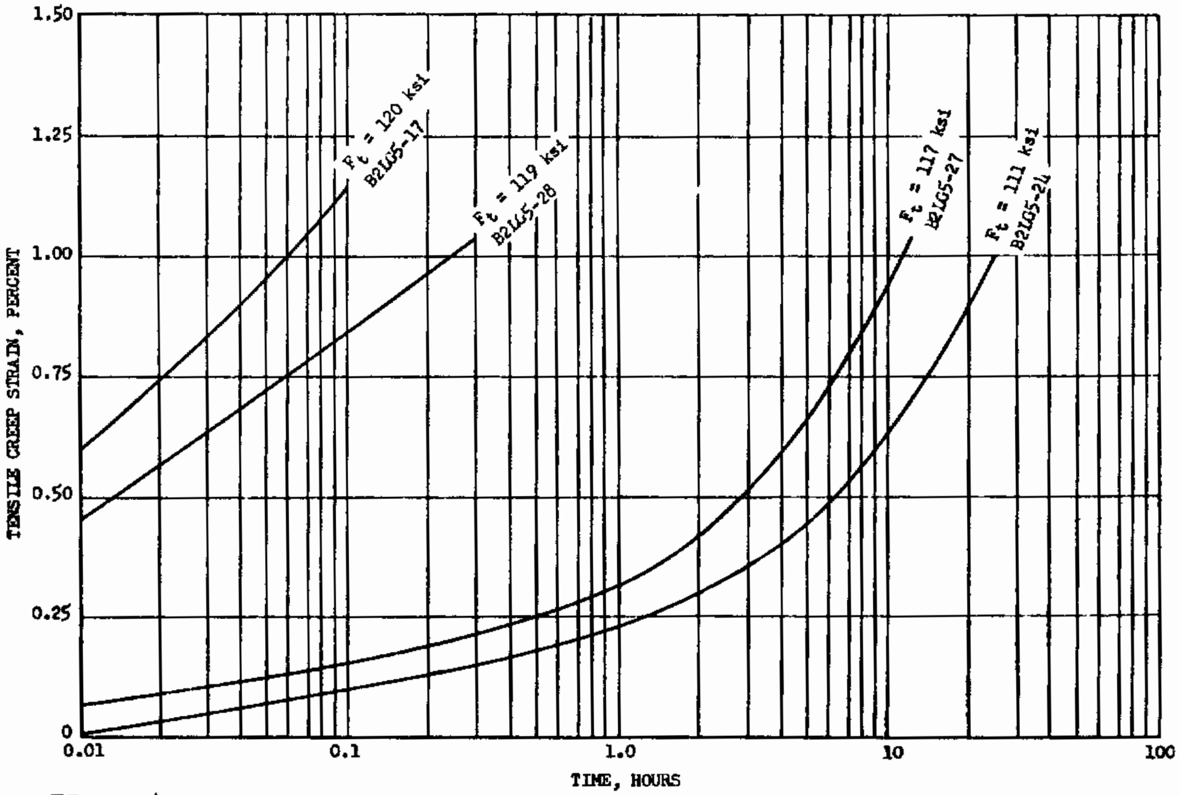


FIGURE 43 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 27039)

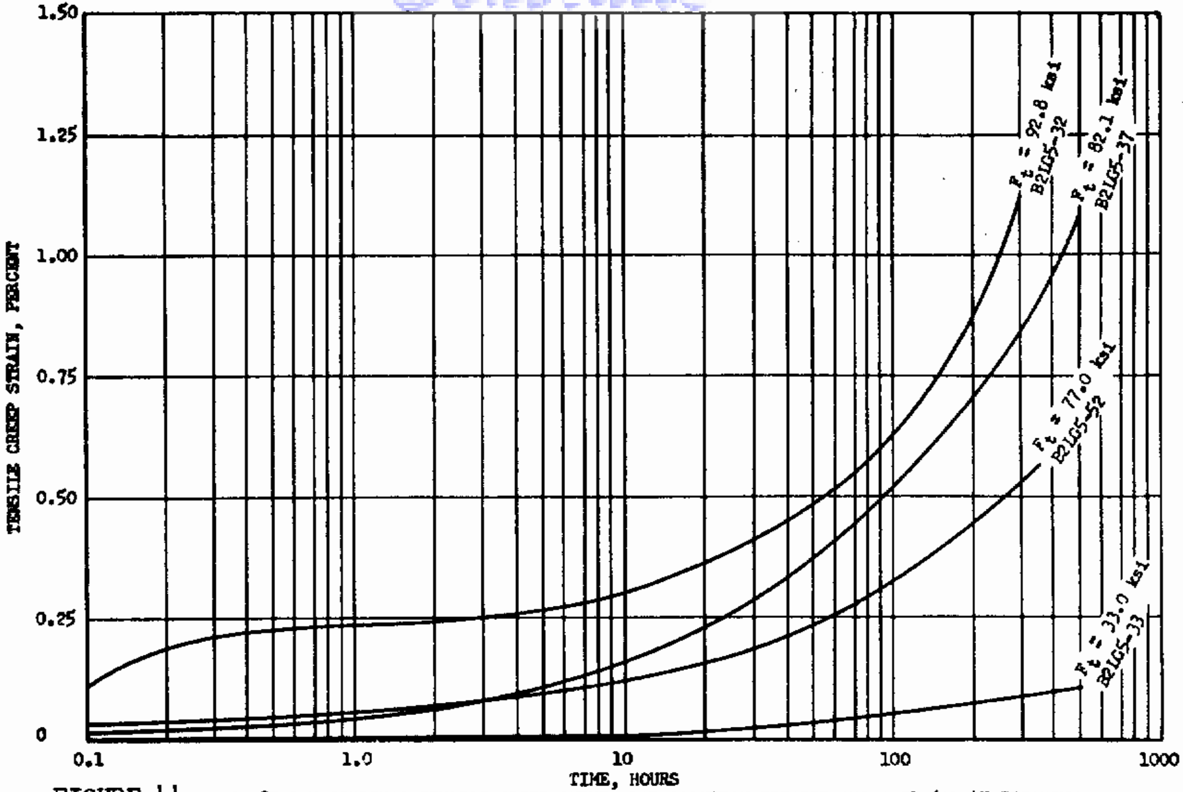


FIGURE 44 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 27039)

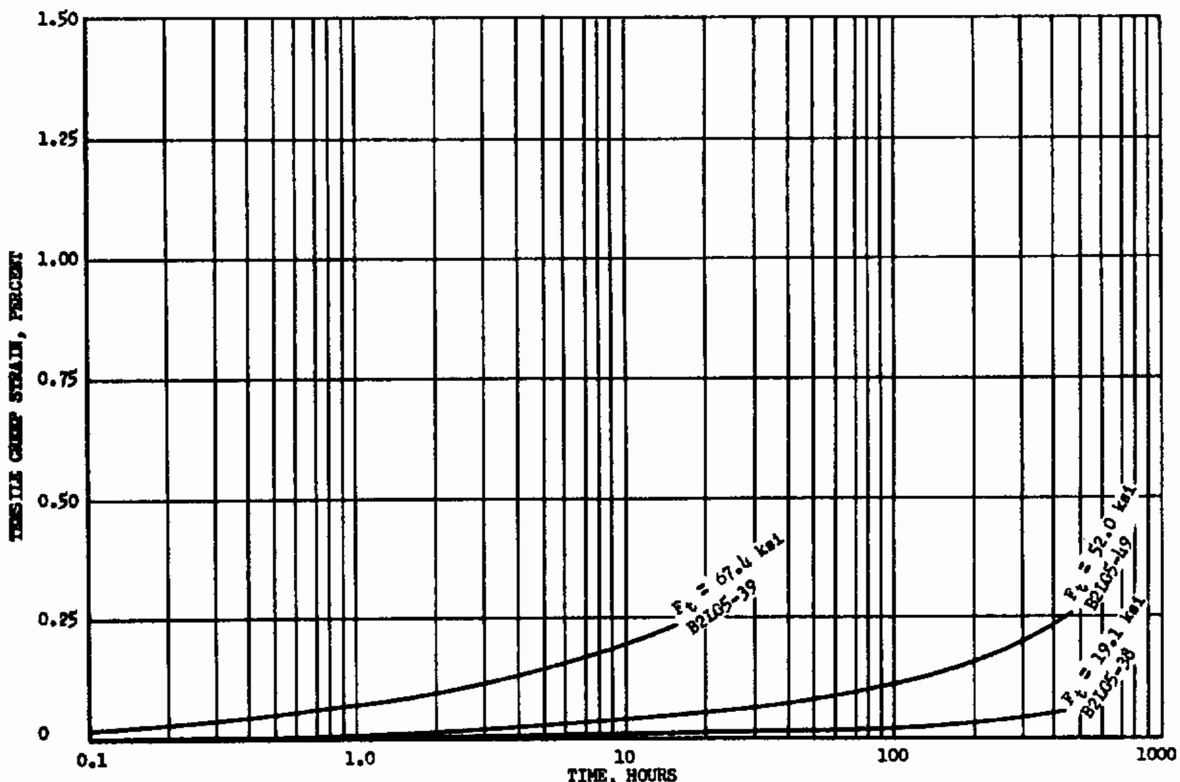


FIGURE 45 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 27039)

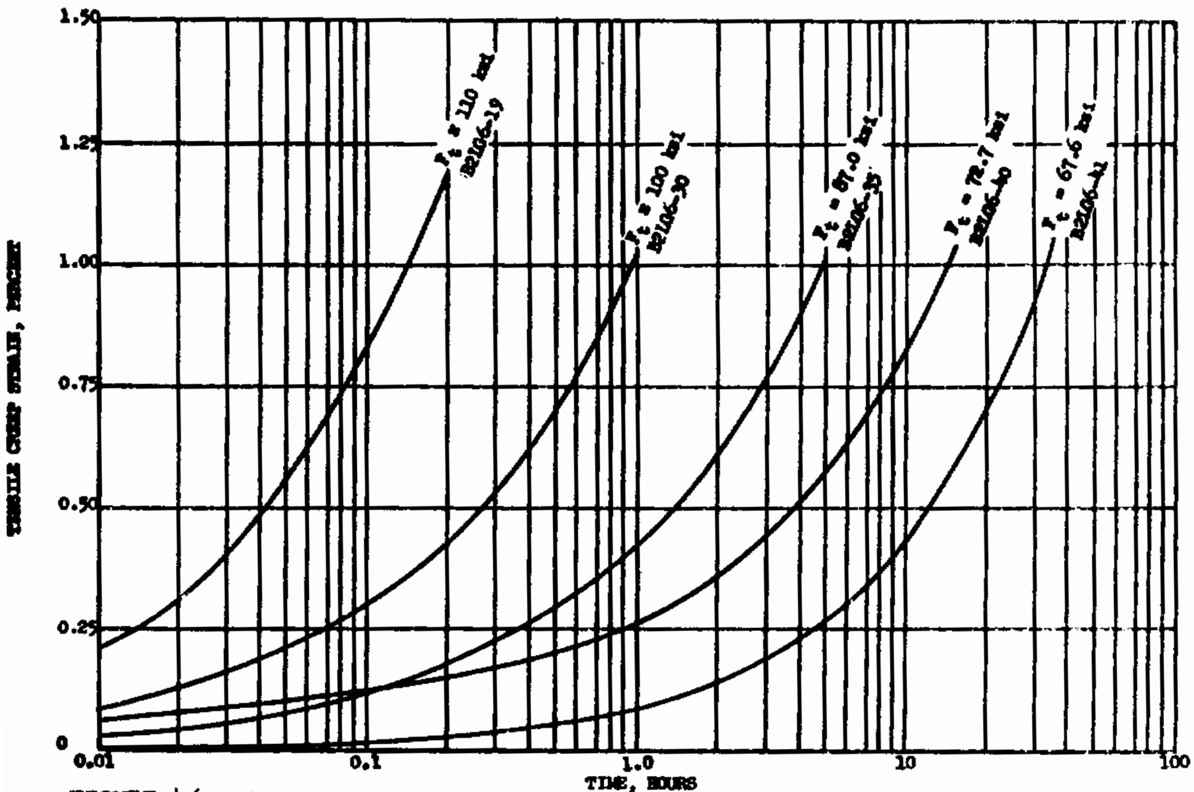


FIGURE 46 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NUMBER 27039)

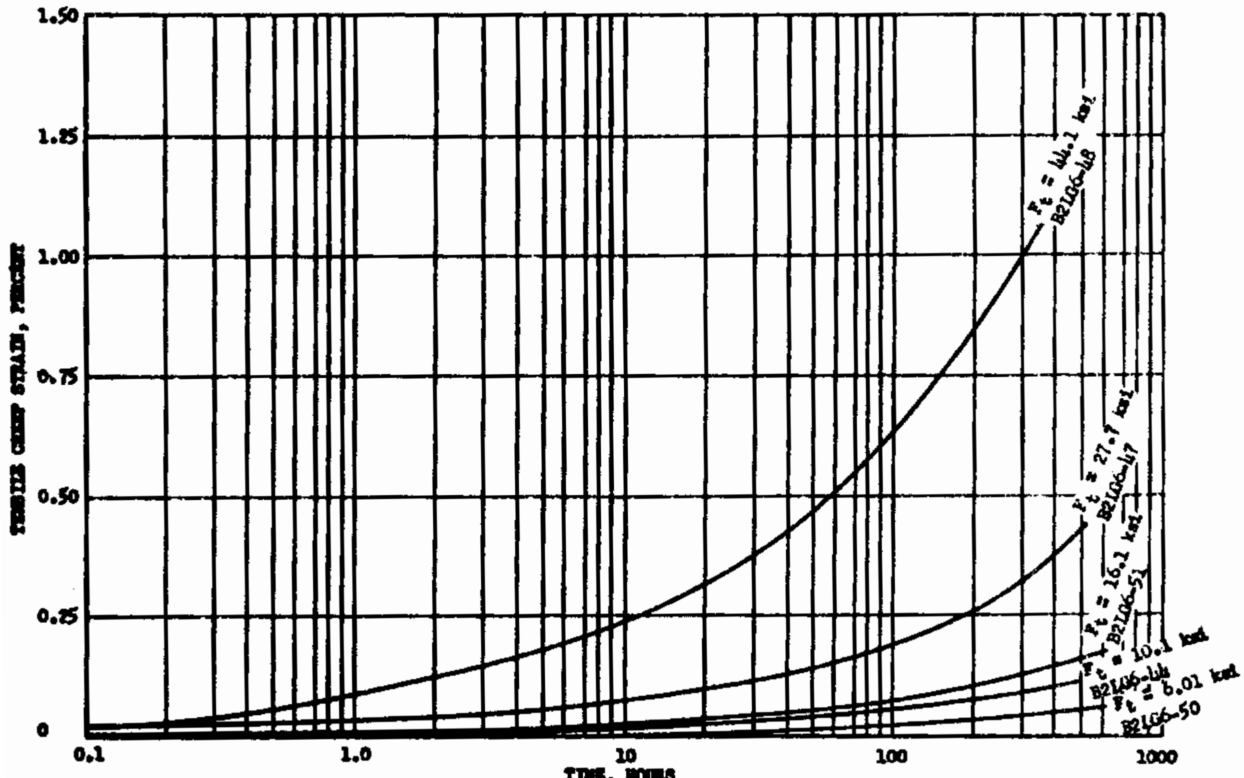


FIGURE 47 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 27039)

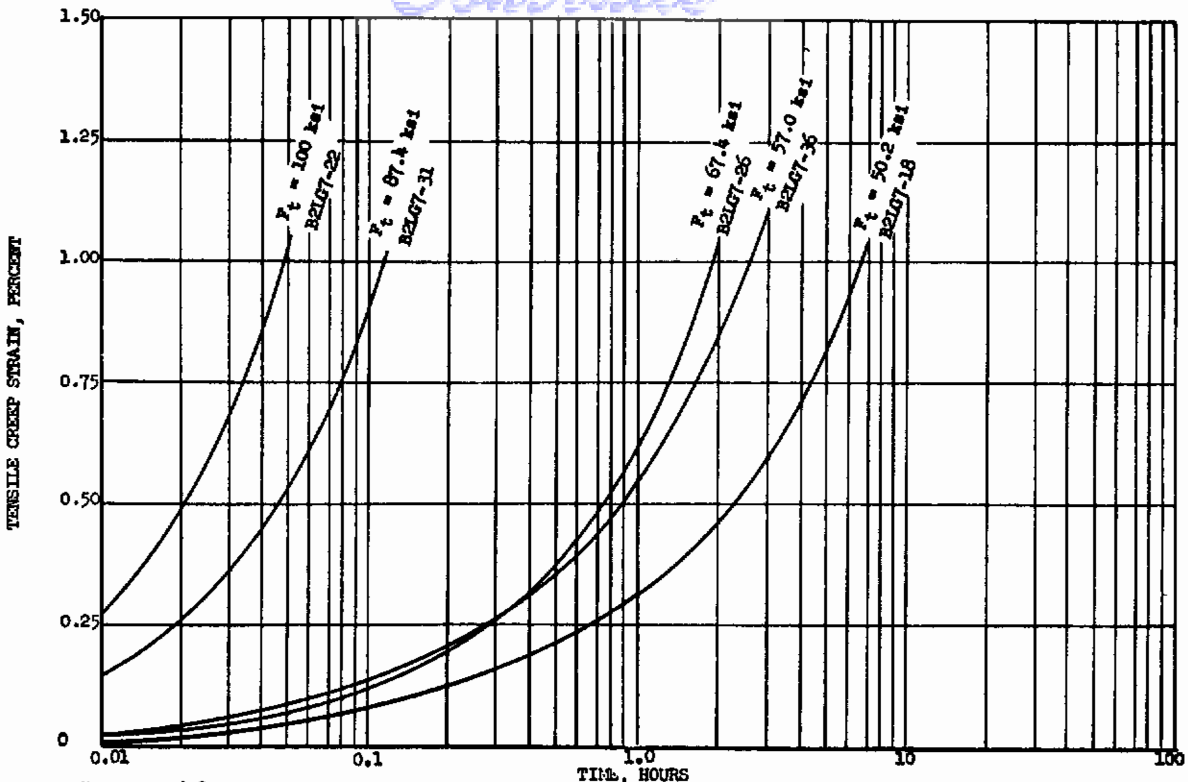


FIGURE 48 - 900°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NUMBER 27039)

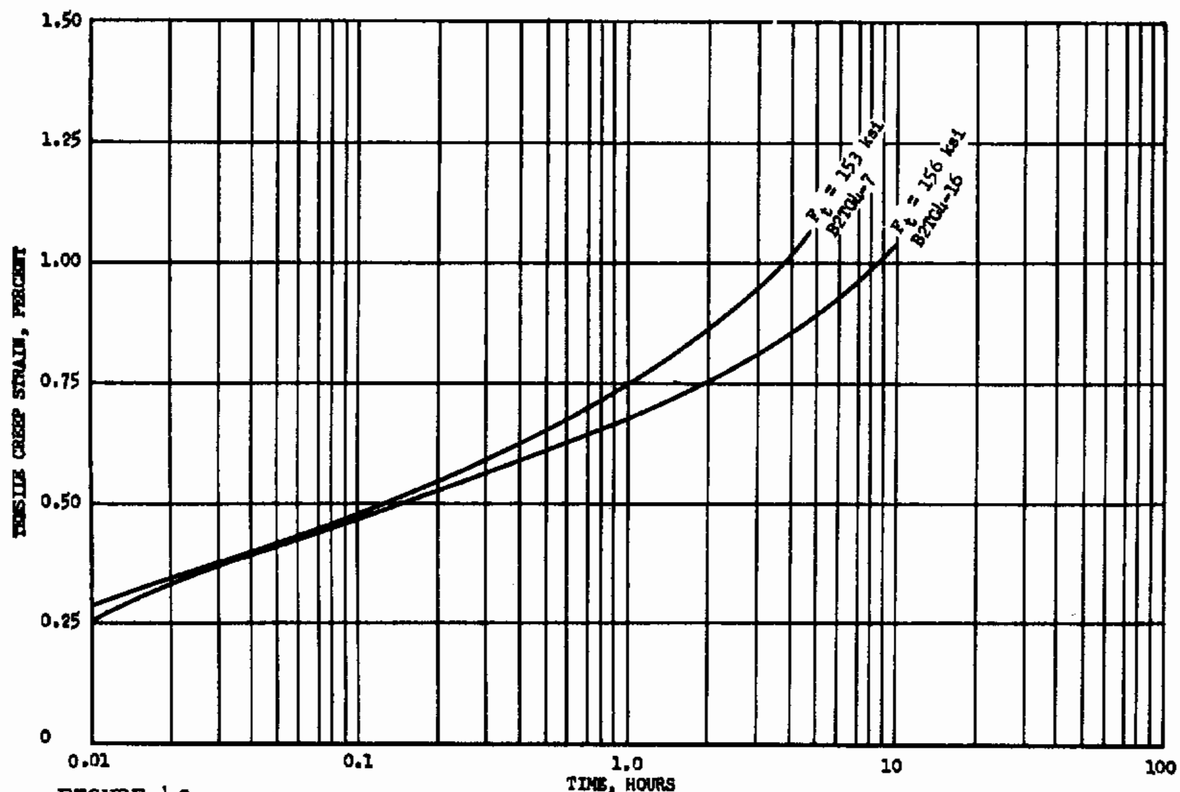


FIGURE 49 - 600°F TRANSVERSE TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 27039)

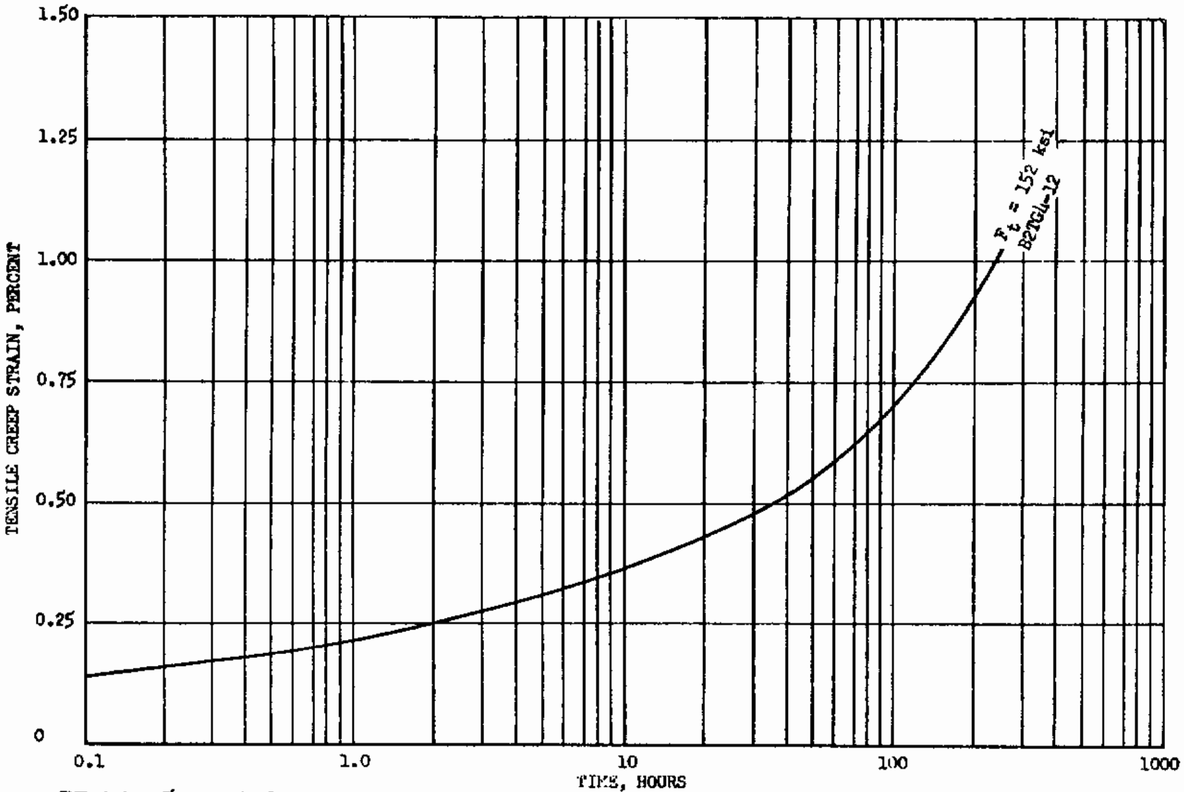


FIGURE 50 - 600°F TRANSVERSE TENSILE CREEP CURVE FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 27039)

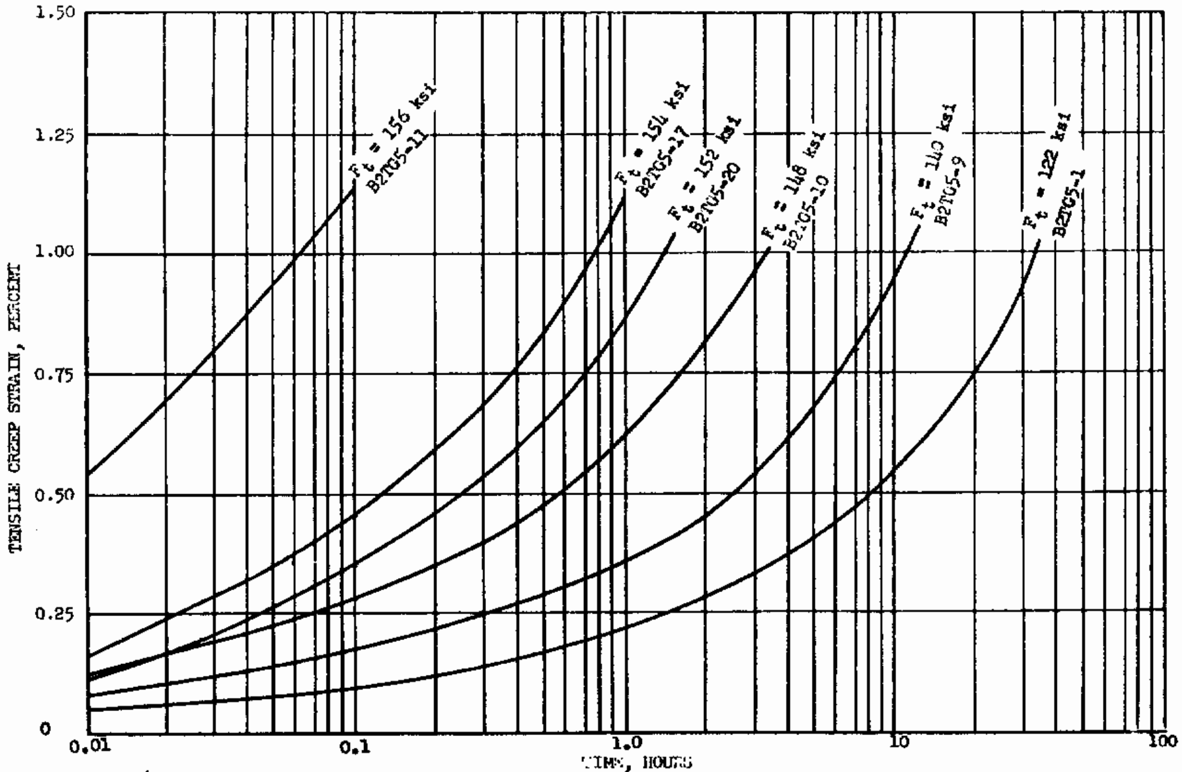


FIGURE 51 - 700°F TRANSVERSE TENSILE CREEP CURVES FOR SOLUTION-TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NUMBER 27039)

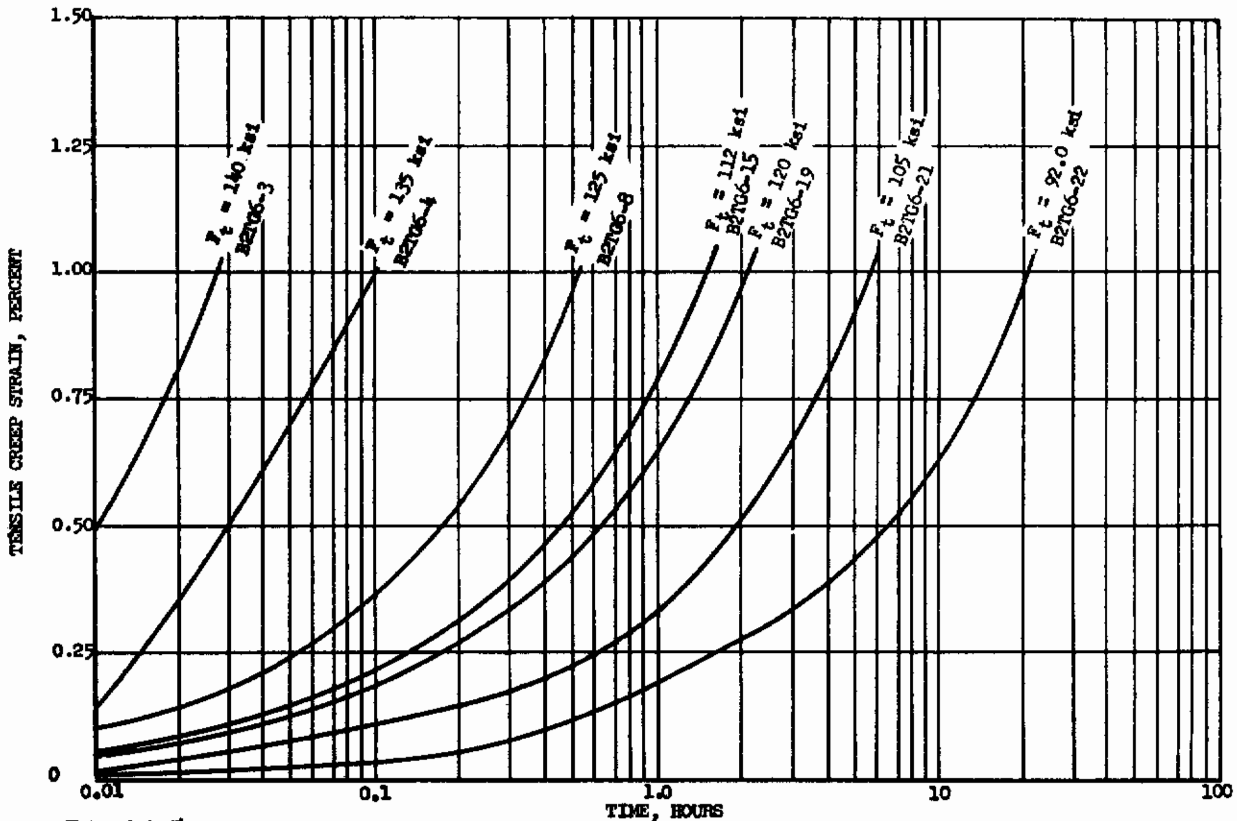


FIGURE 52 - 800°F TRANSVERSE TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NUMBER 27039)

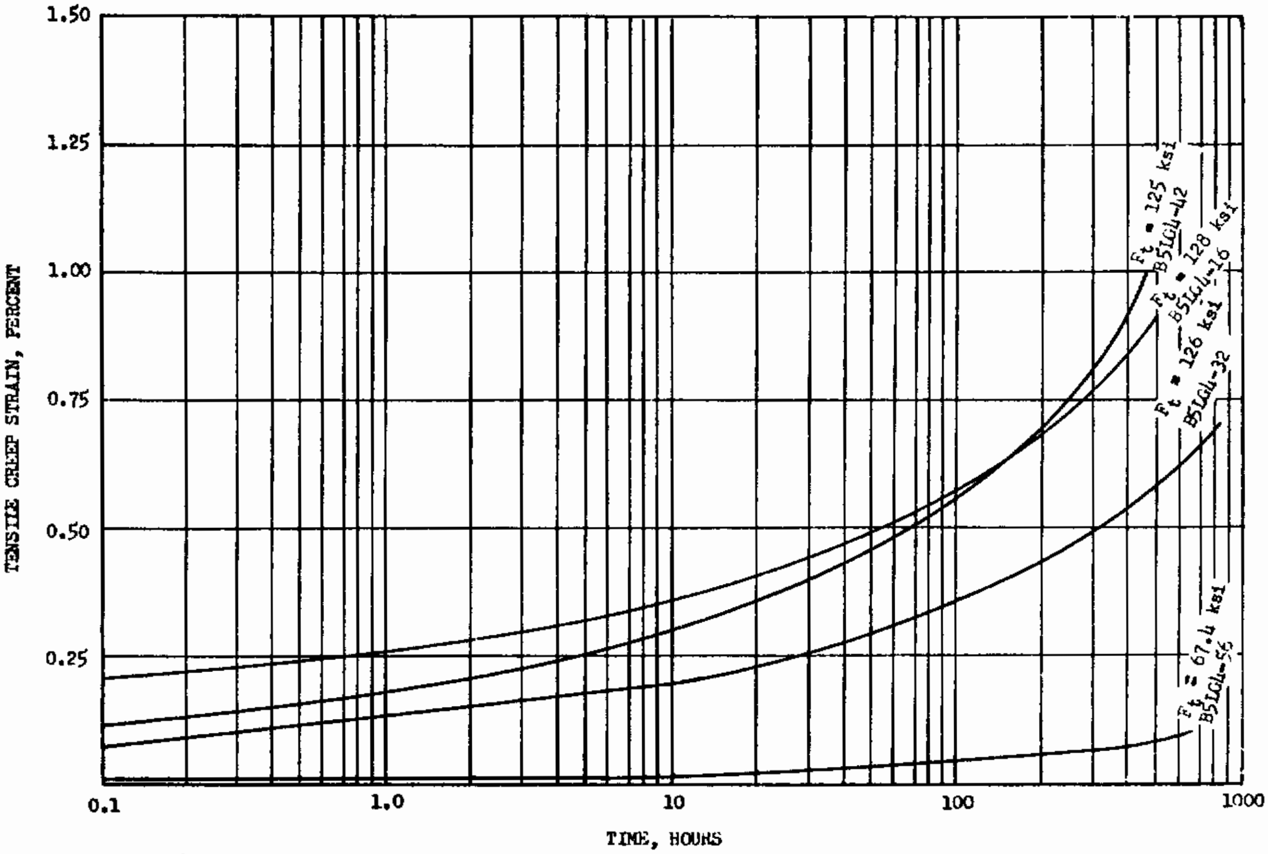


FIGURE 53 – 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 25671)

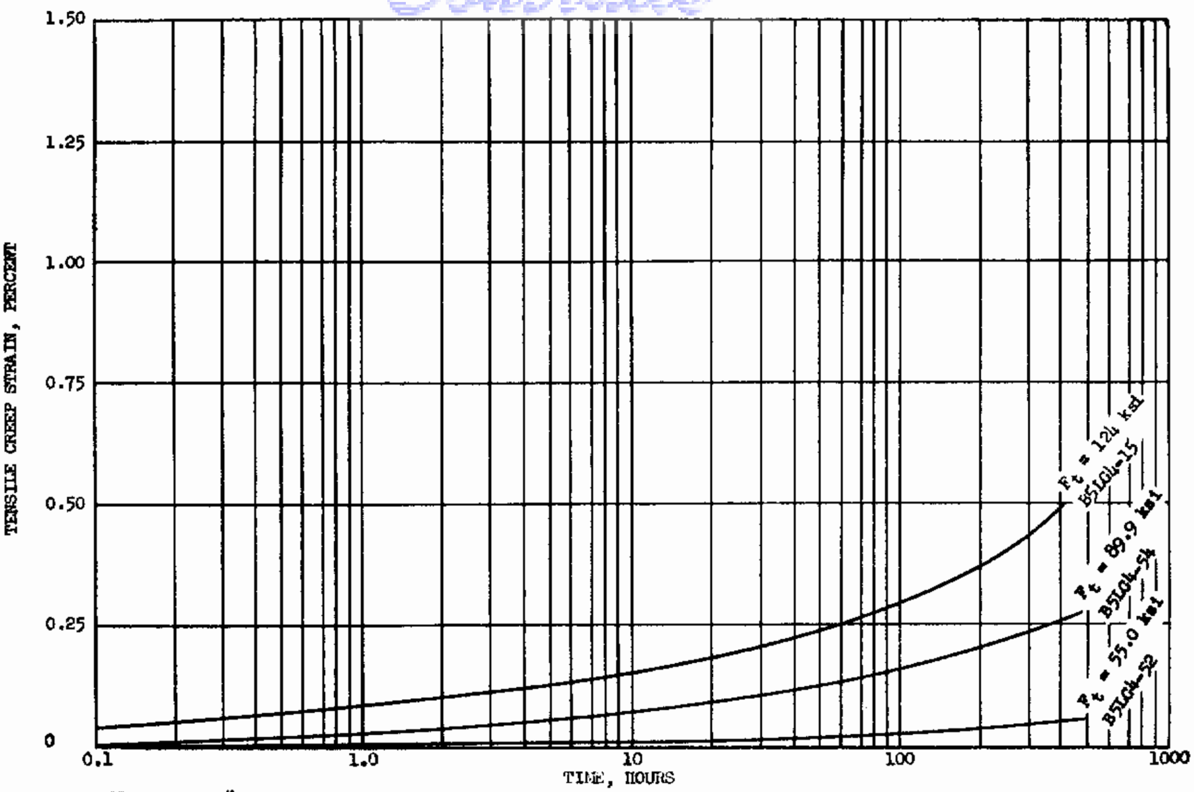


FIGURE 54 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 25671)

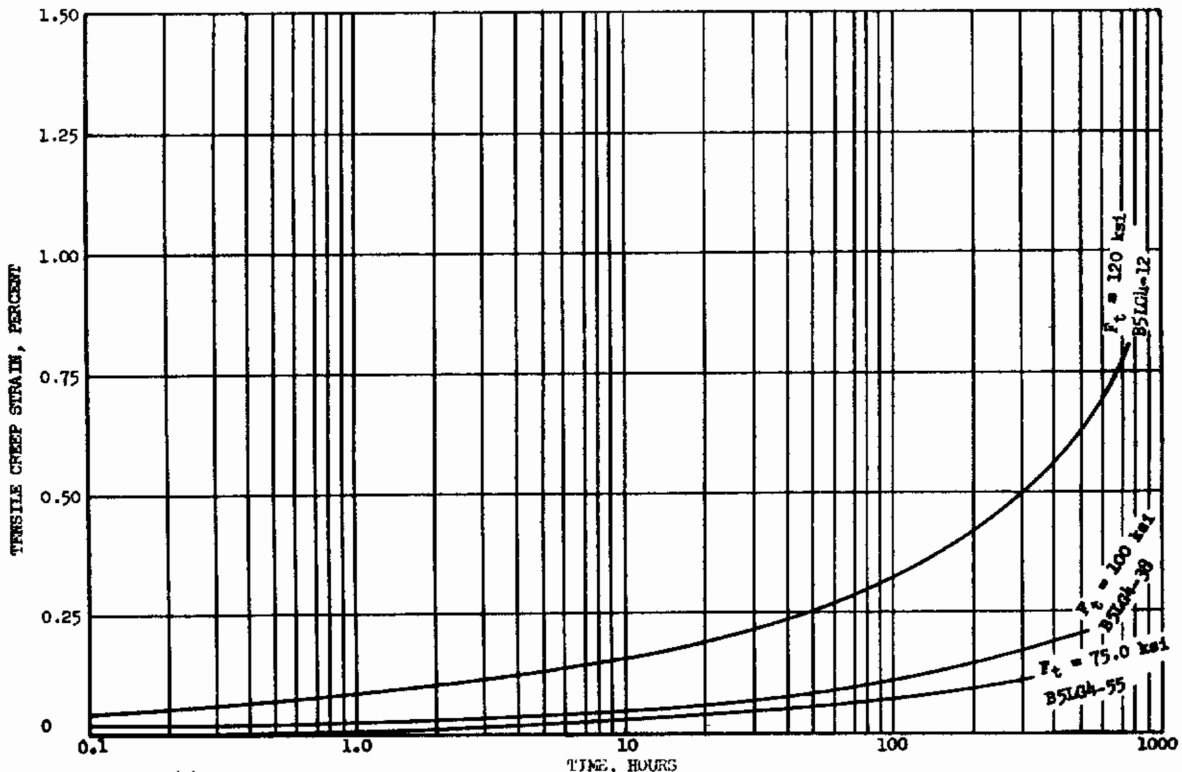


FIGURE 55 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NUMBER 25671)

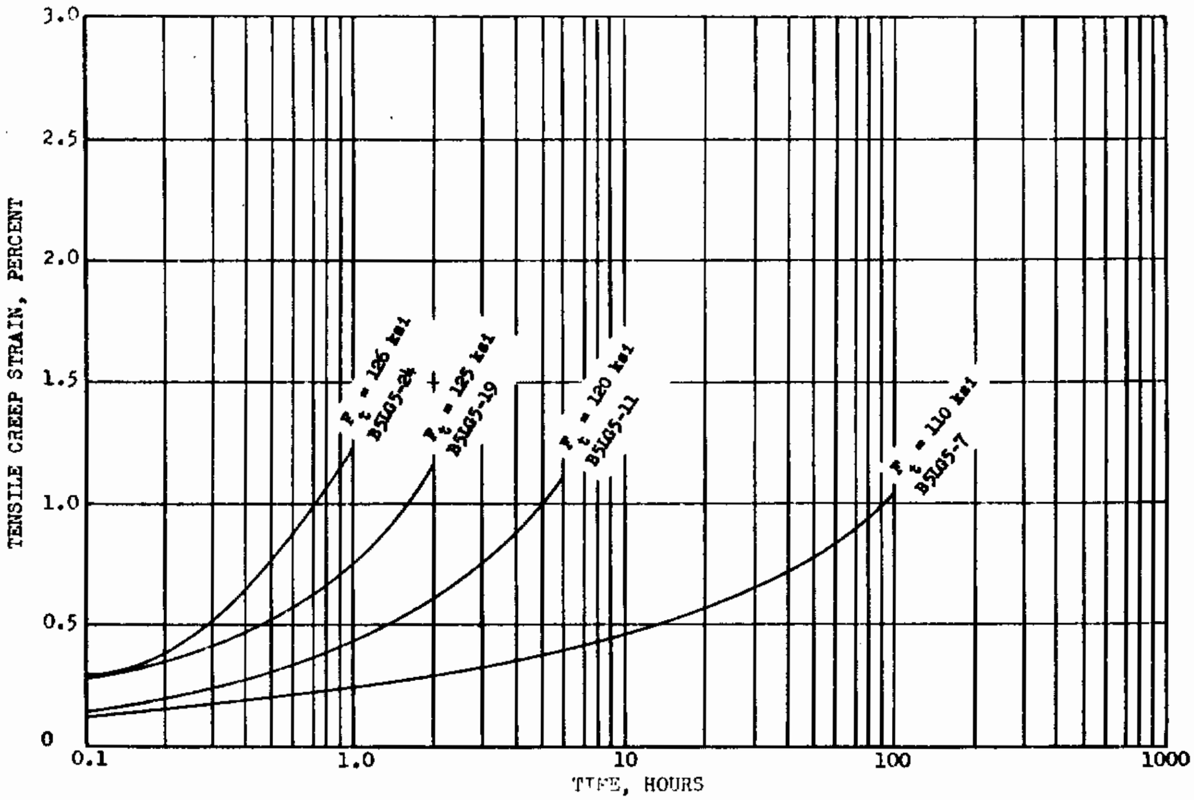


FIGURE 56 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 25671)

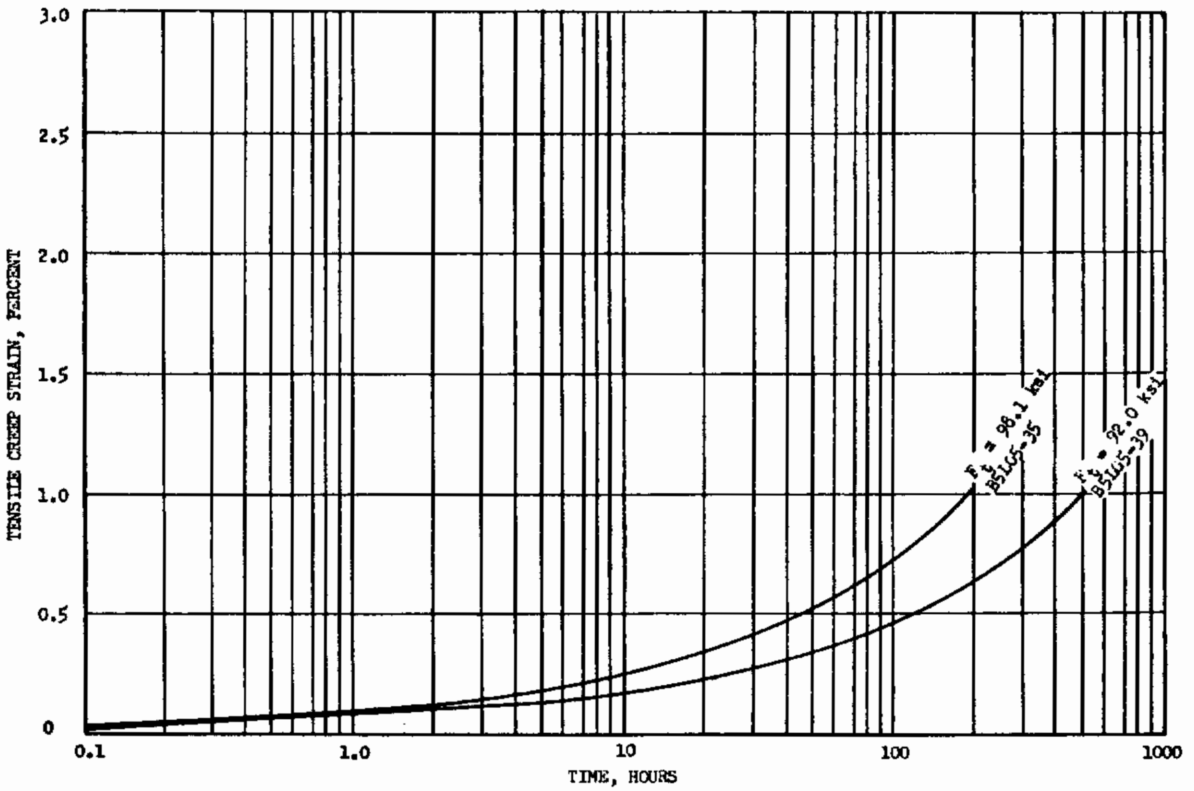


FIGURE 57 - 700°F LONGITUDINAL TENSILE CREEP CURVE FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 25671)

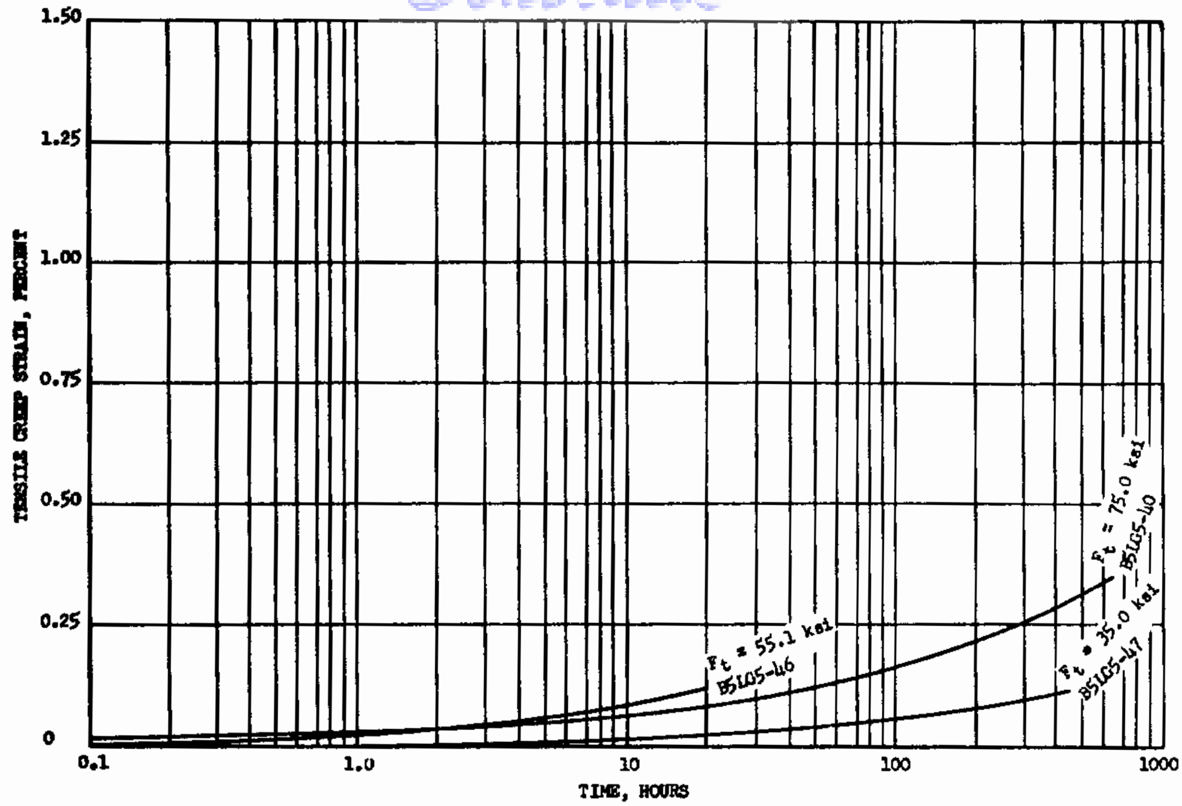


FIGURE 58 – 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 25671)

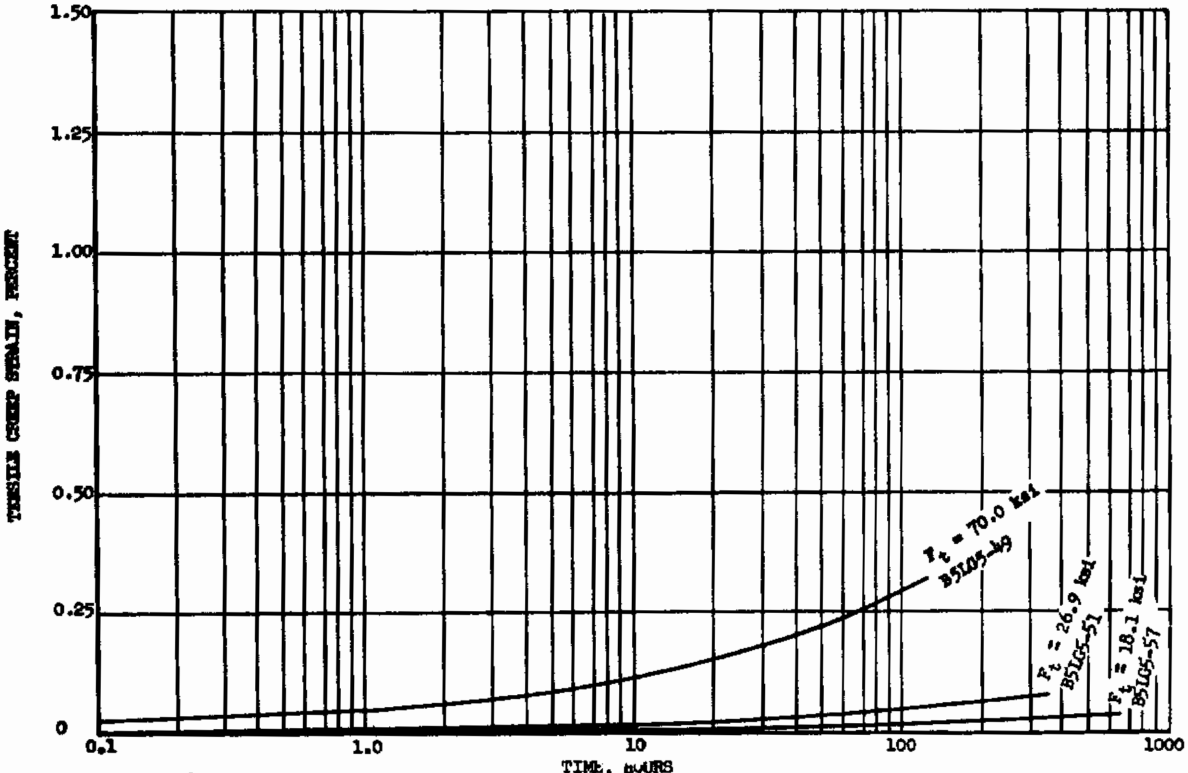


FIGURE 59 – 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NUMBER 25671)

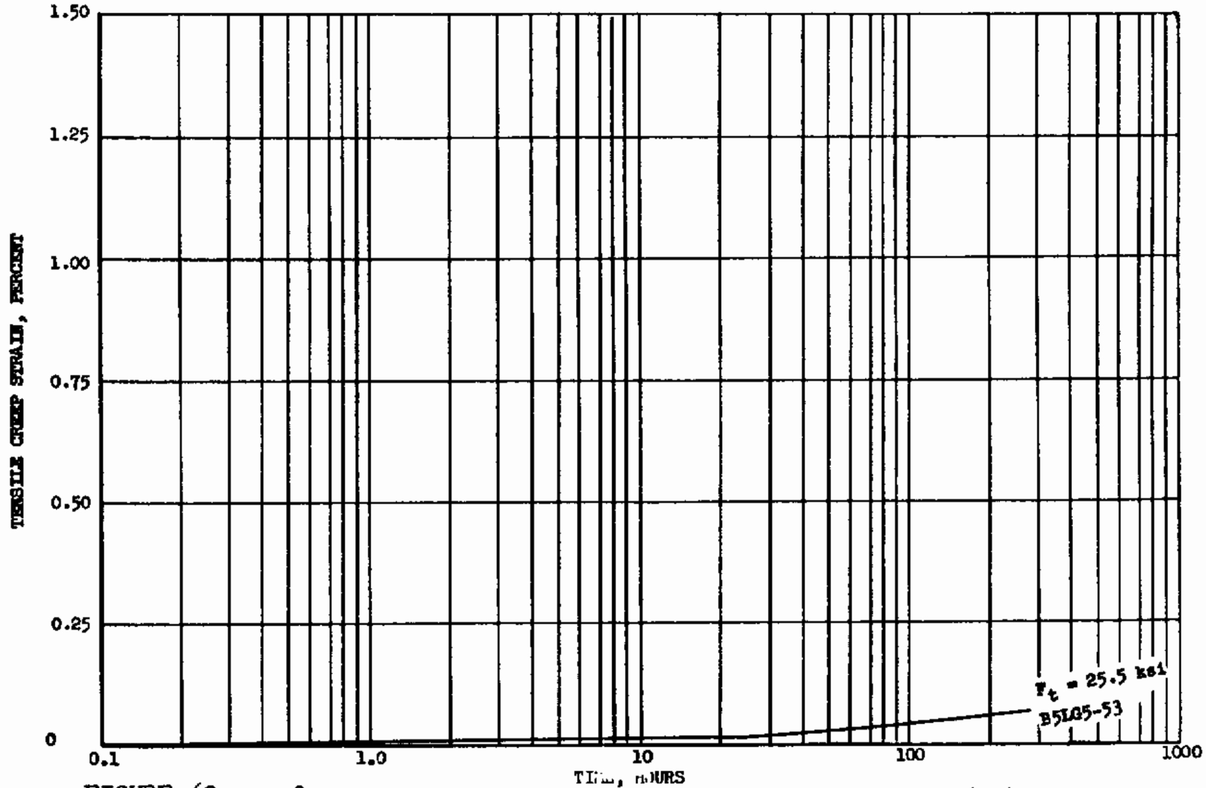


FIGURE 60 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NUMBER 25671)

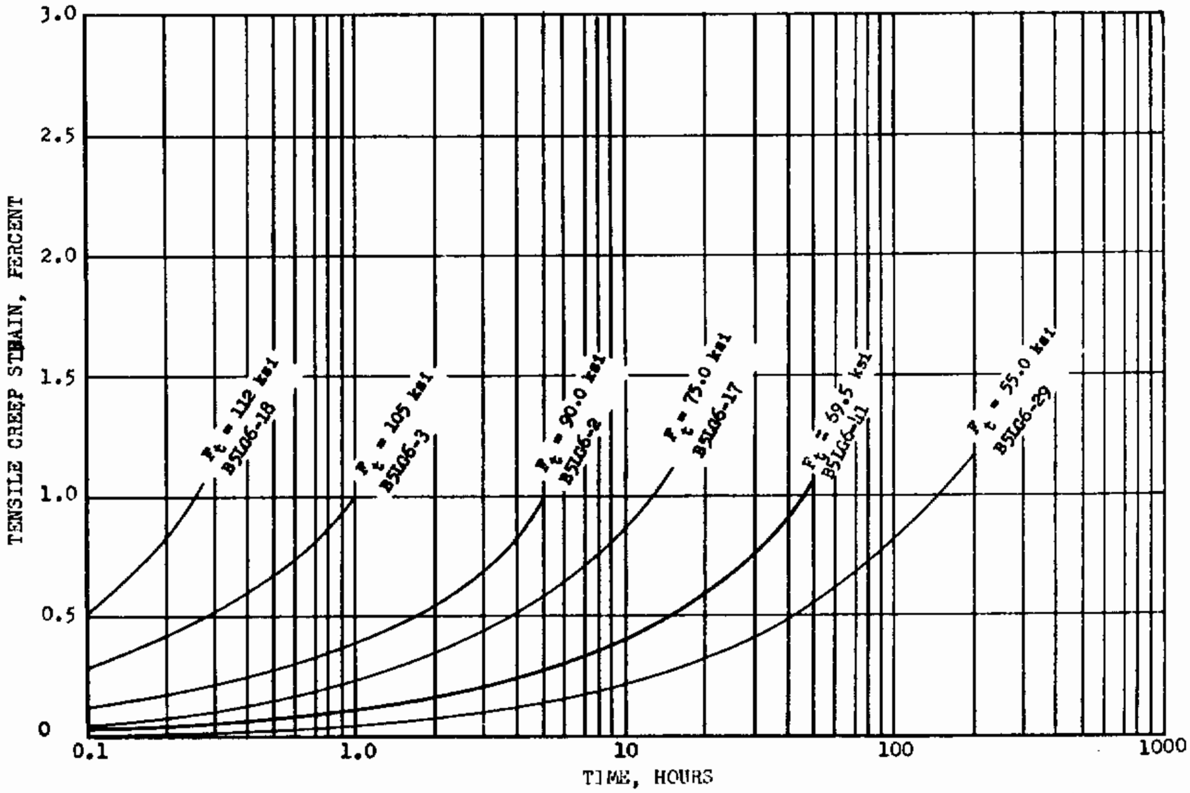


FIGURE 61 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 25671)

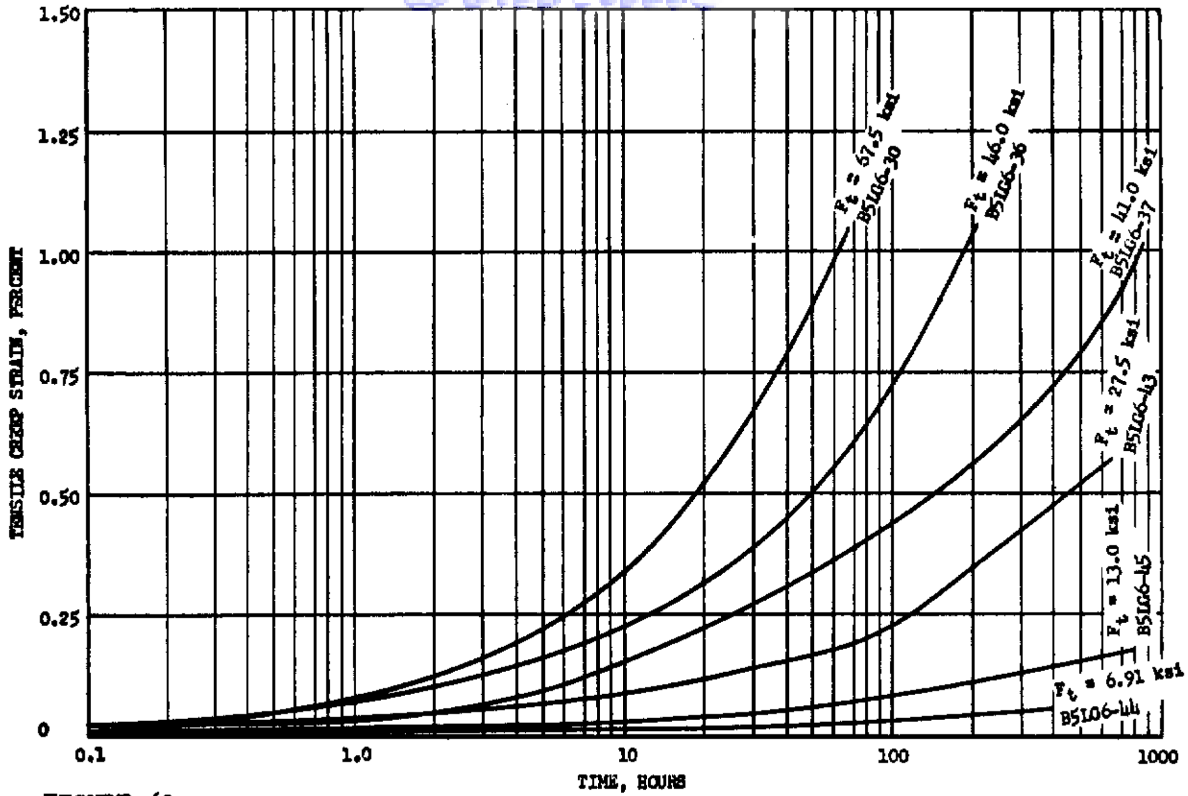


FIGURE 62 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 25671)

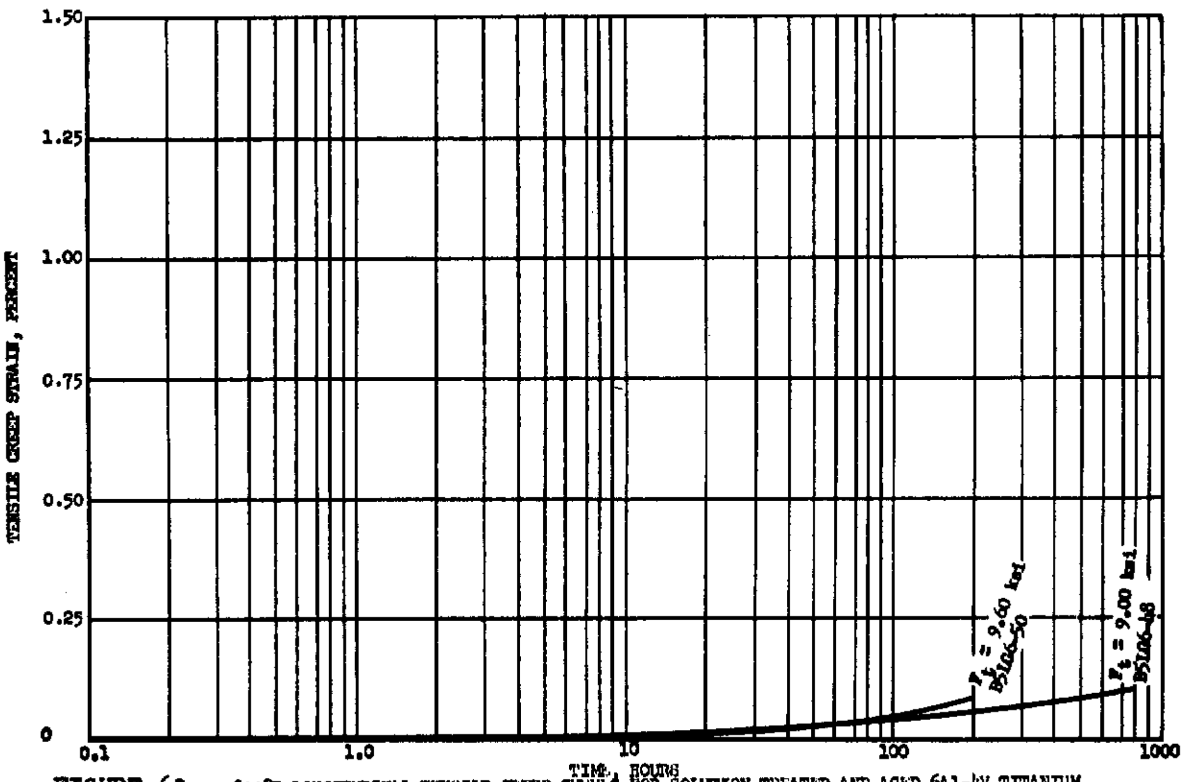


FIGURE 63 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NUMBER 25671)

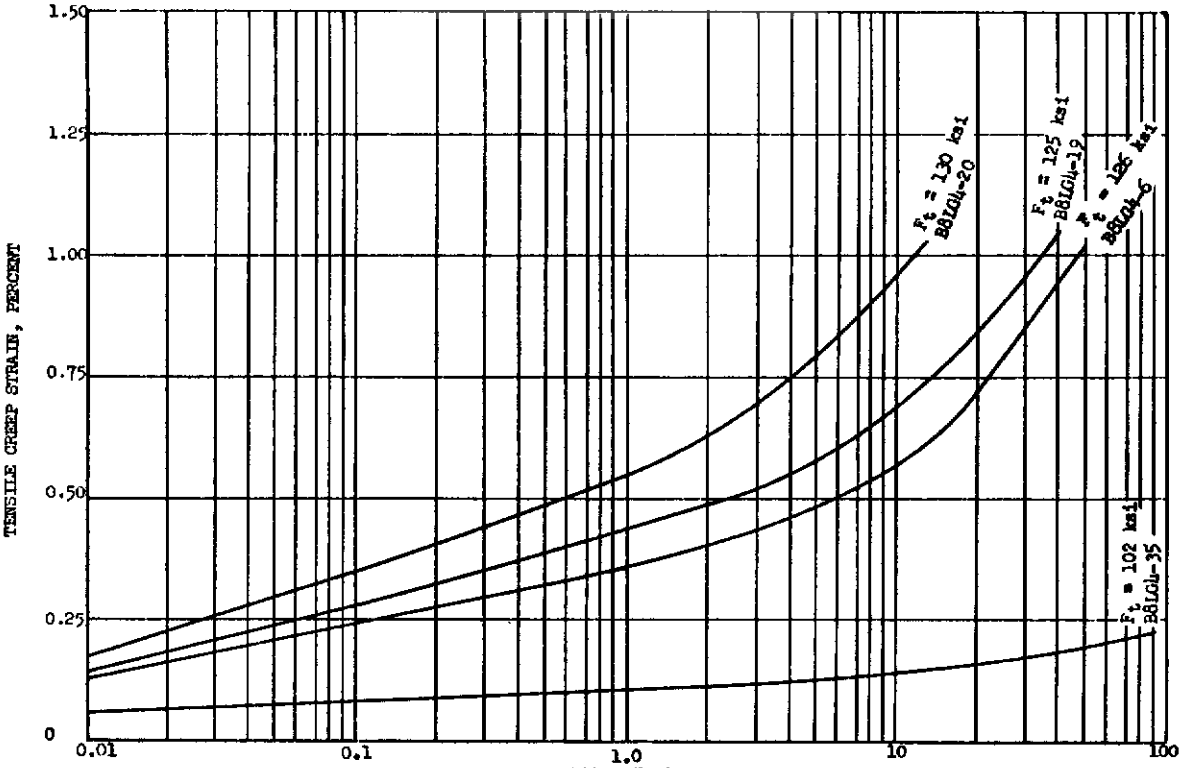


FIGURE 64 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NUMBER 31372)

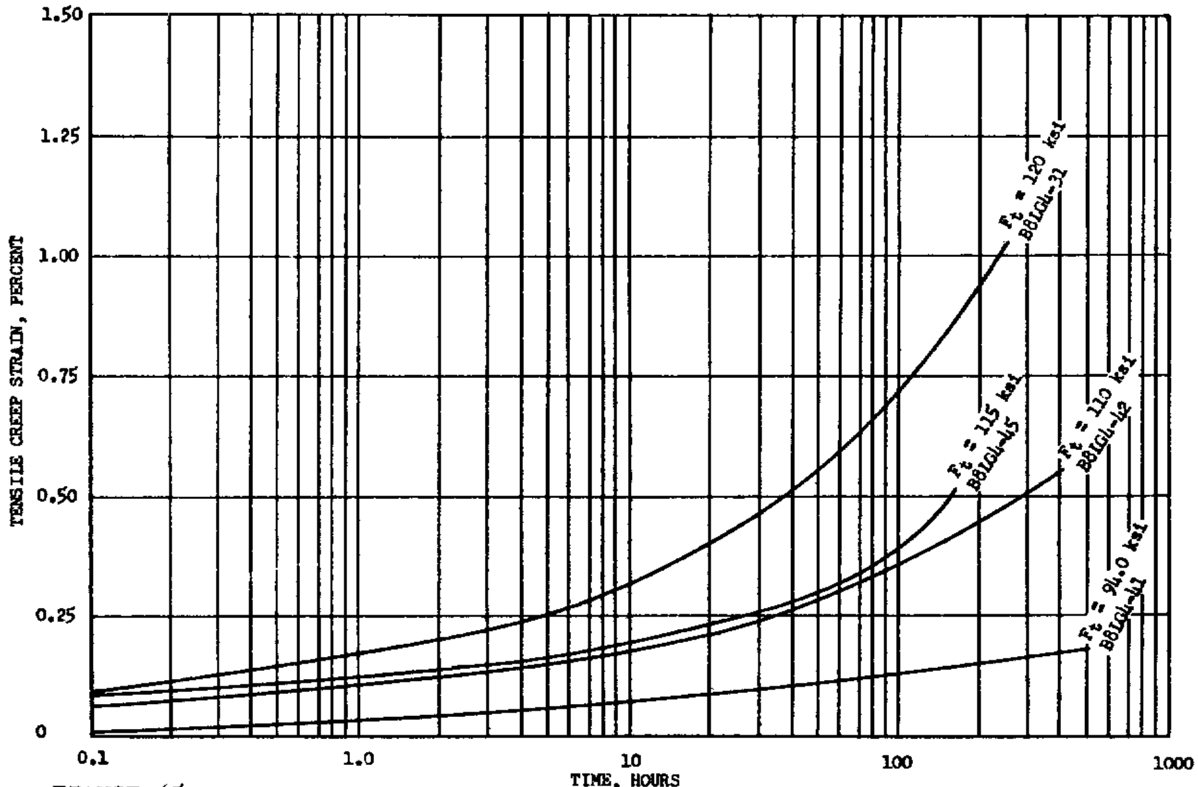


FIGURE 65 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 31372)

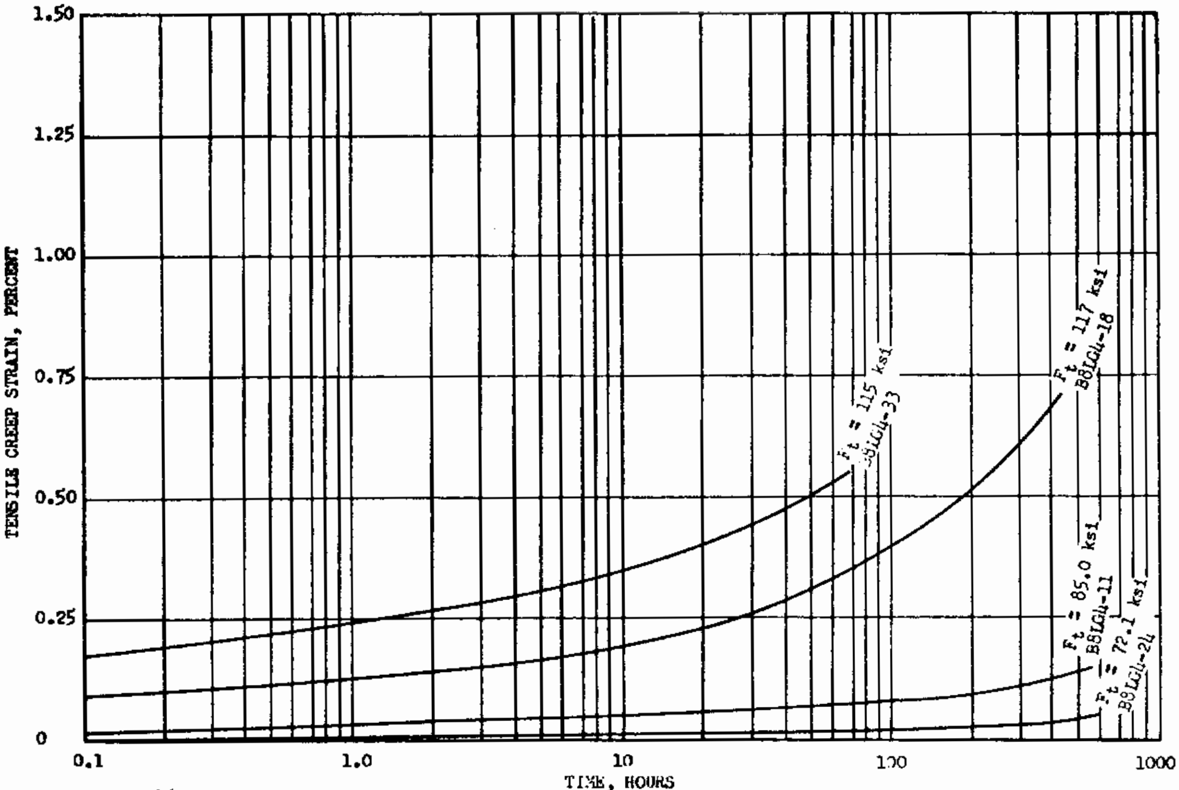


FIGURE 66 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 31372)

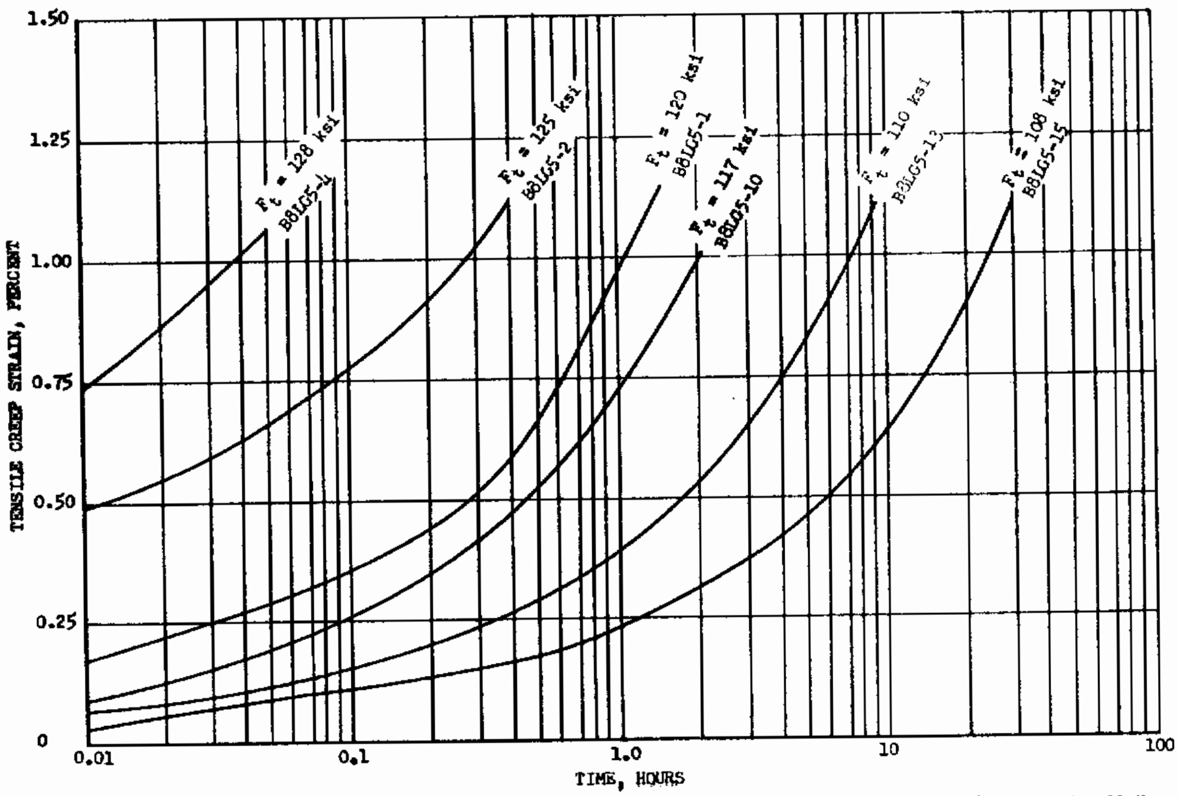


FIGURE 67 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 31372)

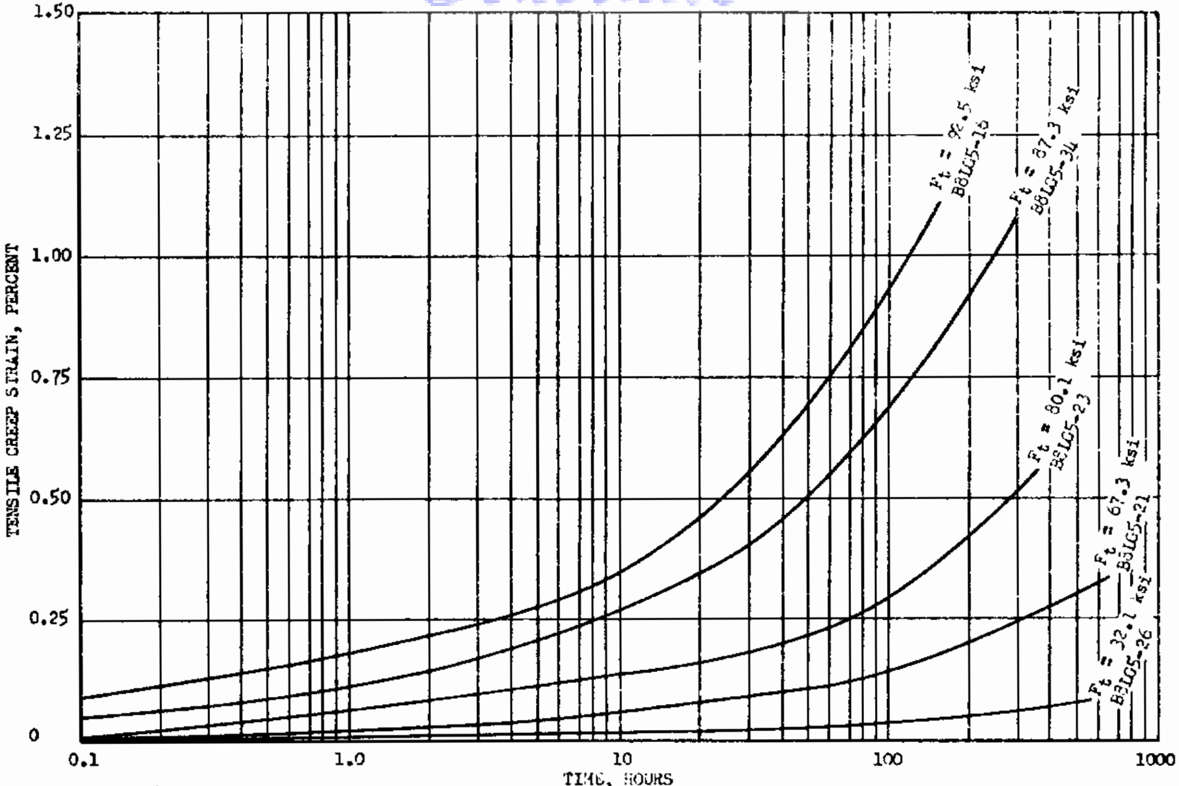


FIGURE 68 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 31372)

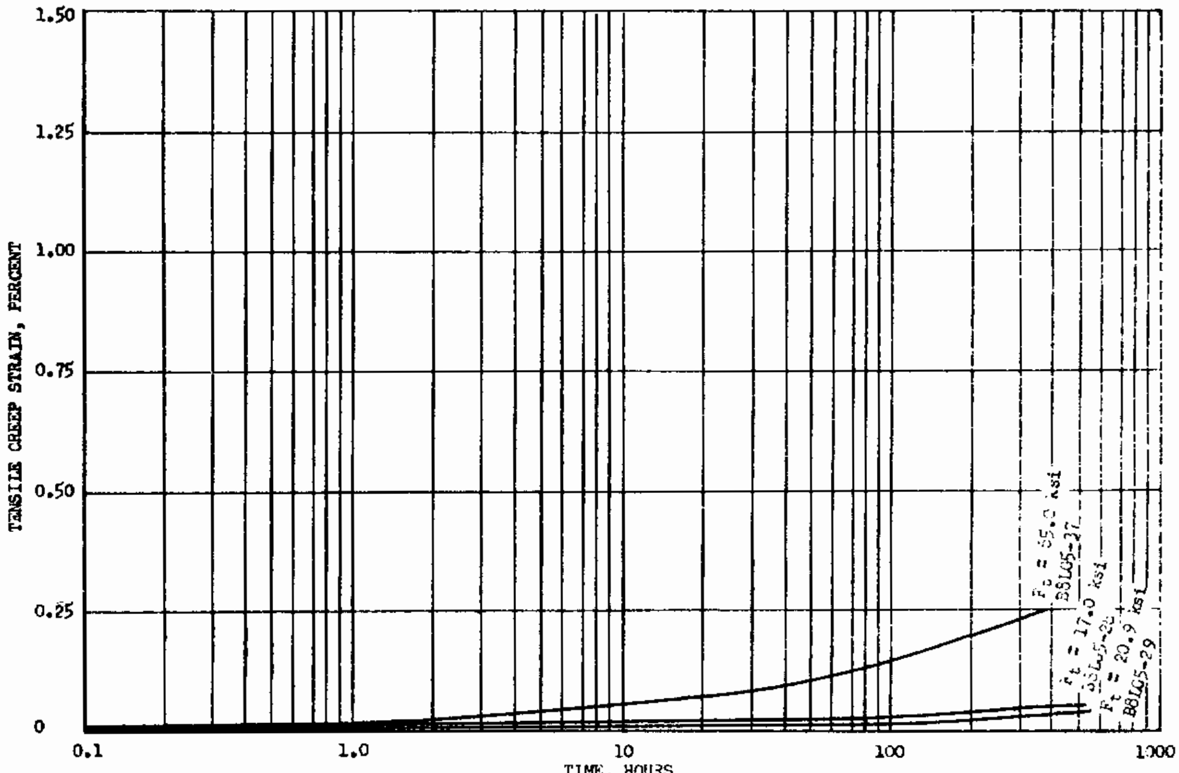


FIGURE 69 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 31372)

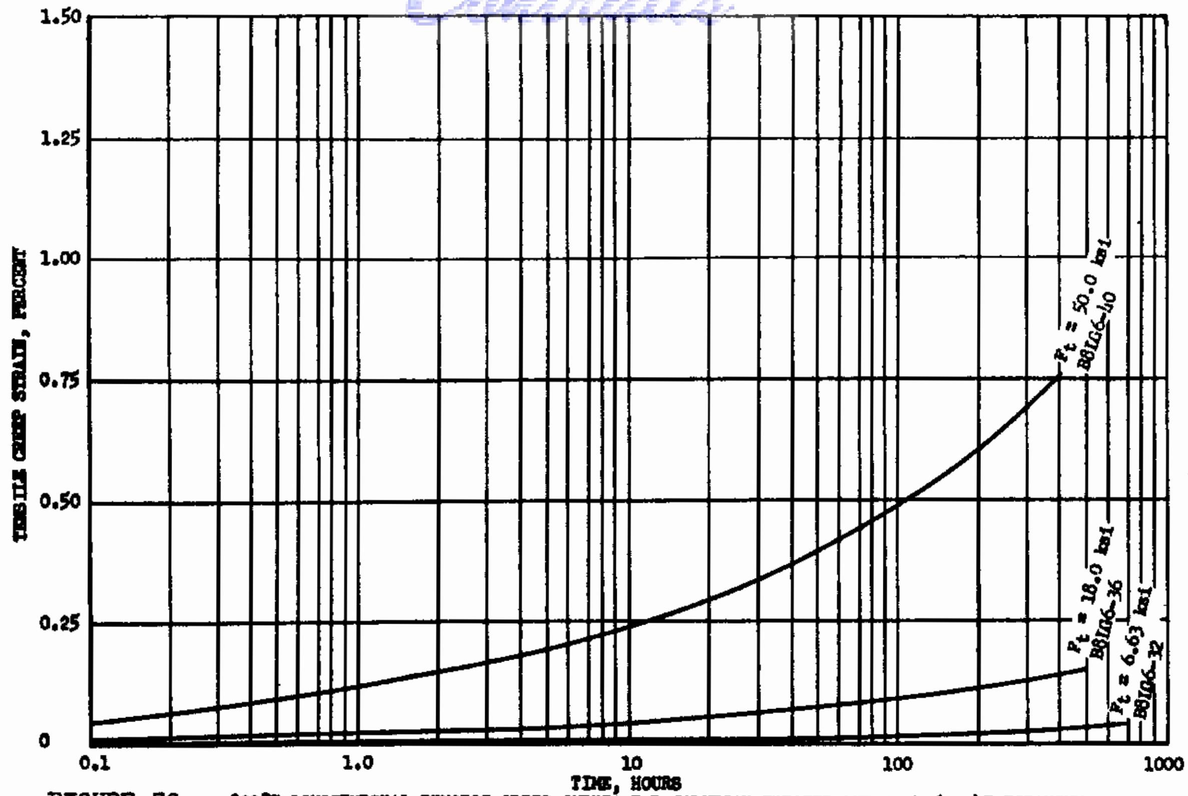


FIGURE 70 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 31372)

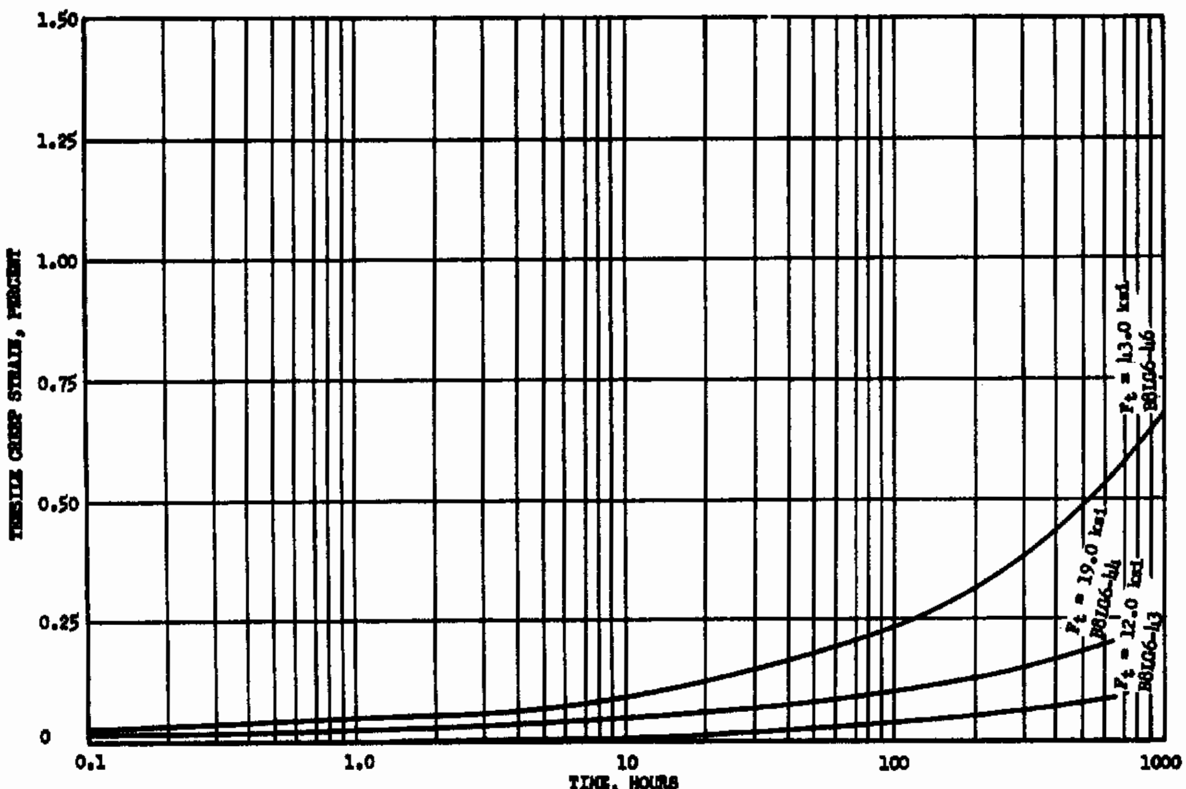


FIGURE 71 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 31372)

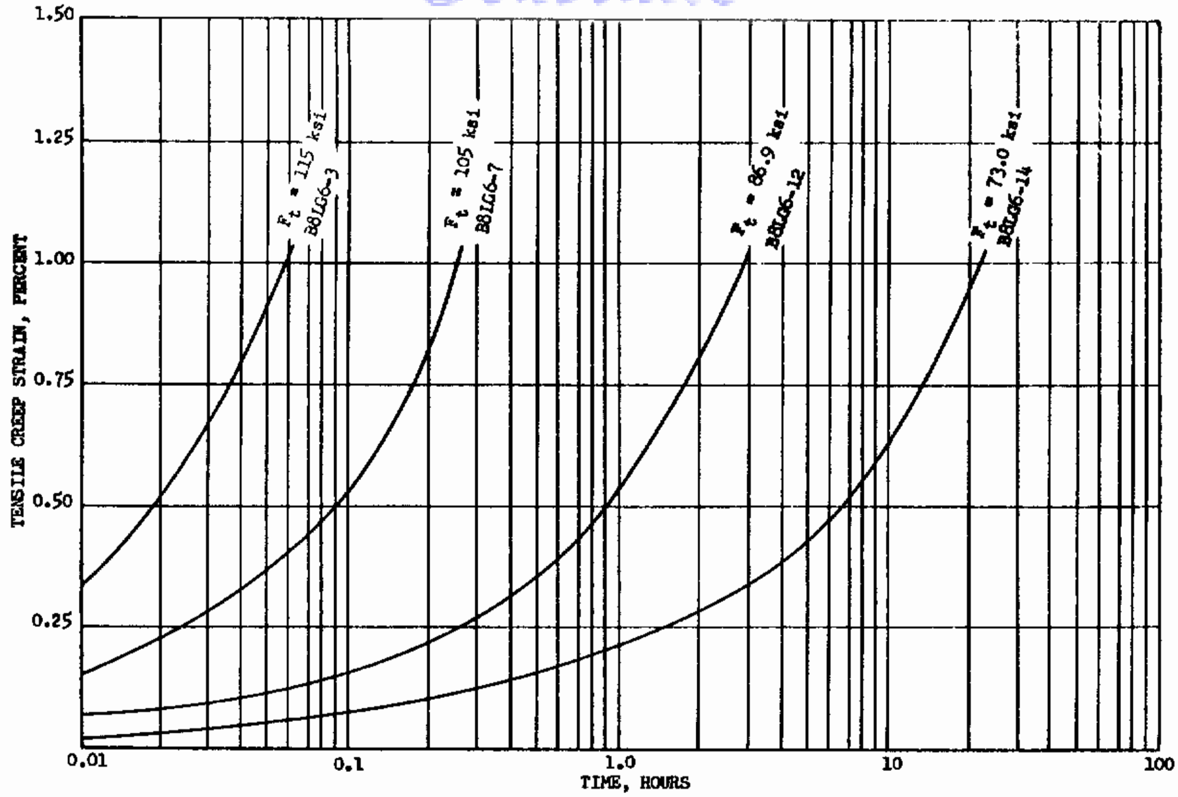


FIGURE 72 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 31372)

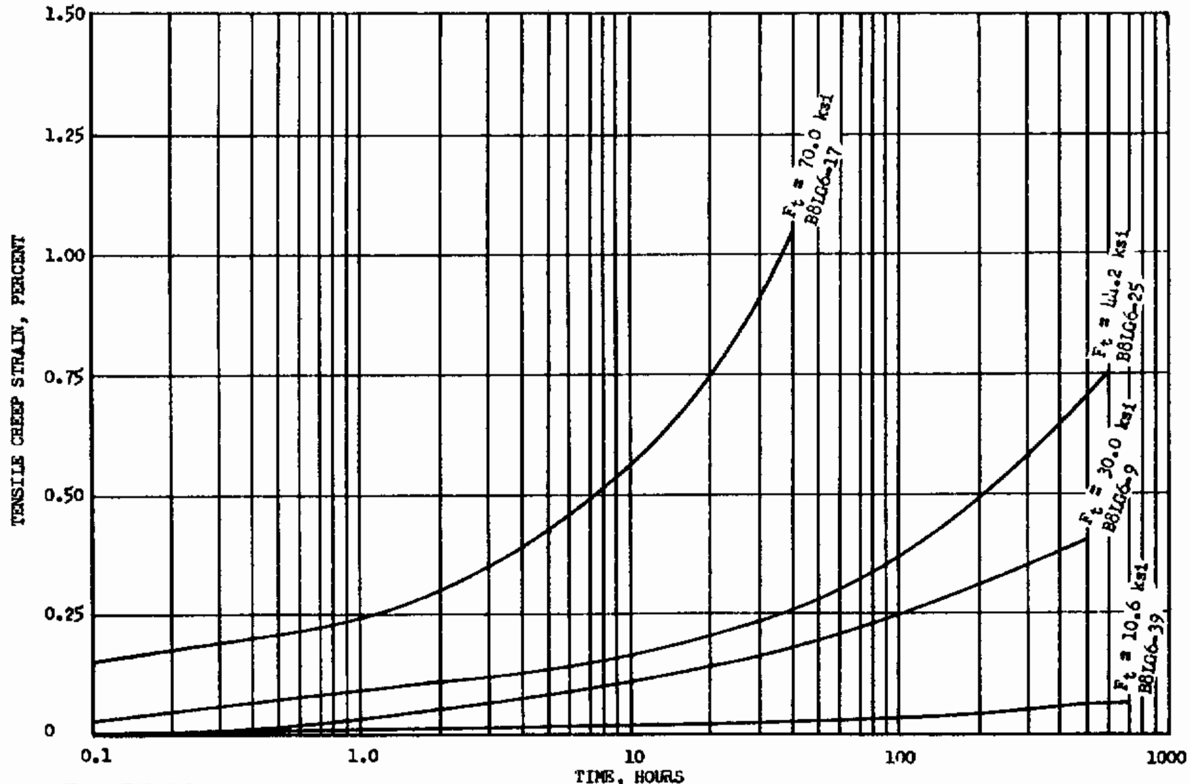


FIGURE 73 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 31372)

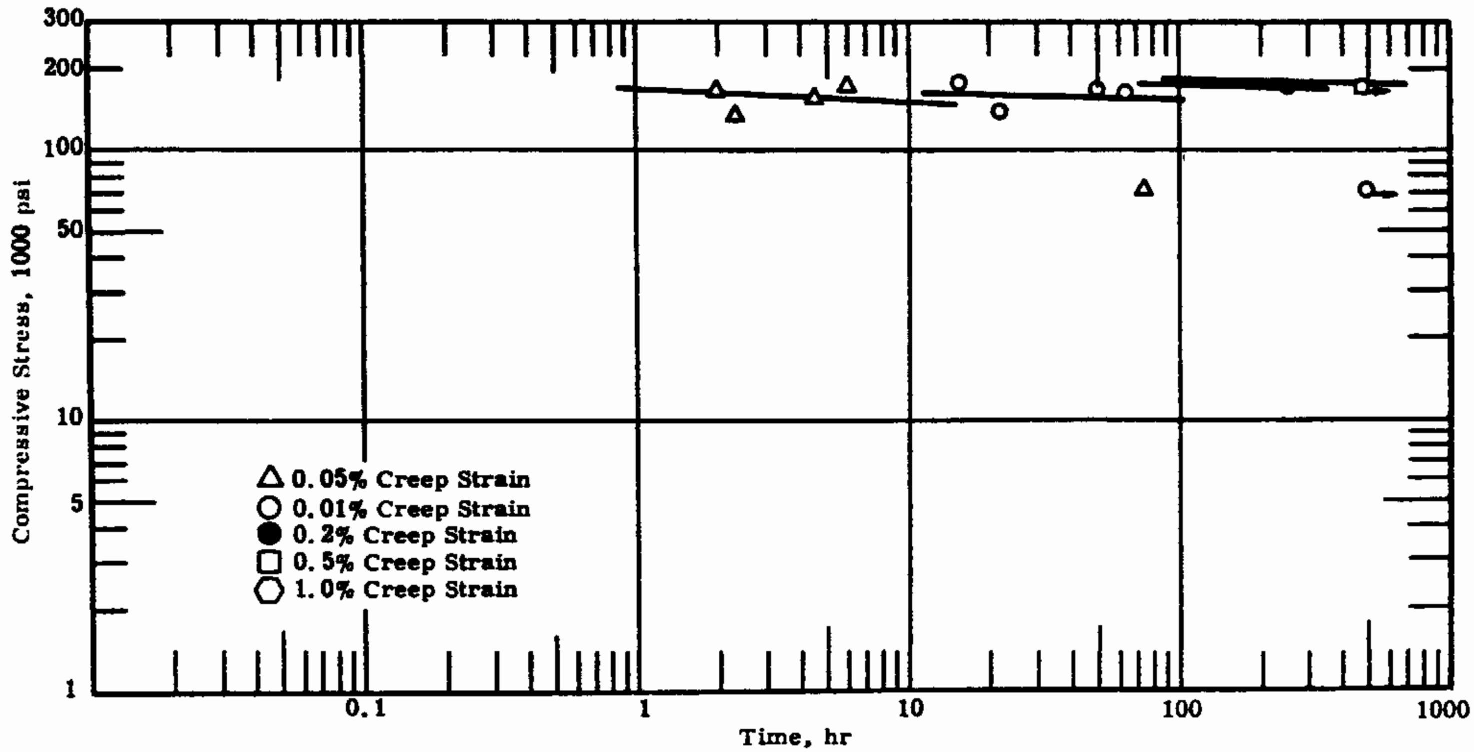


FIGURE 74 - Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Time required for various amounts of compressive creep at 600° F and at various compressive stresses. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
All specimens were heated to test temperature in approximately 2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

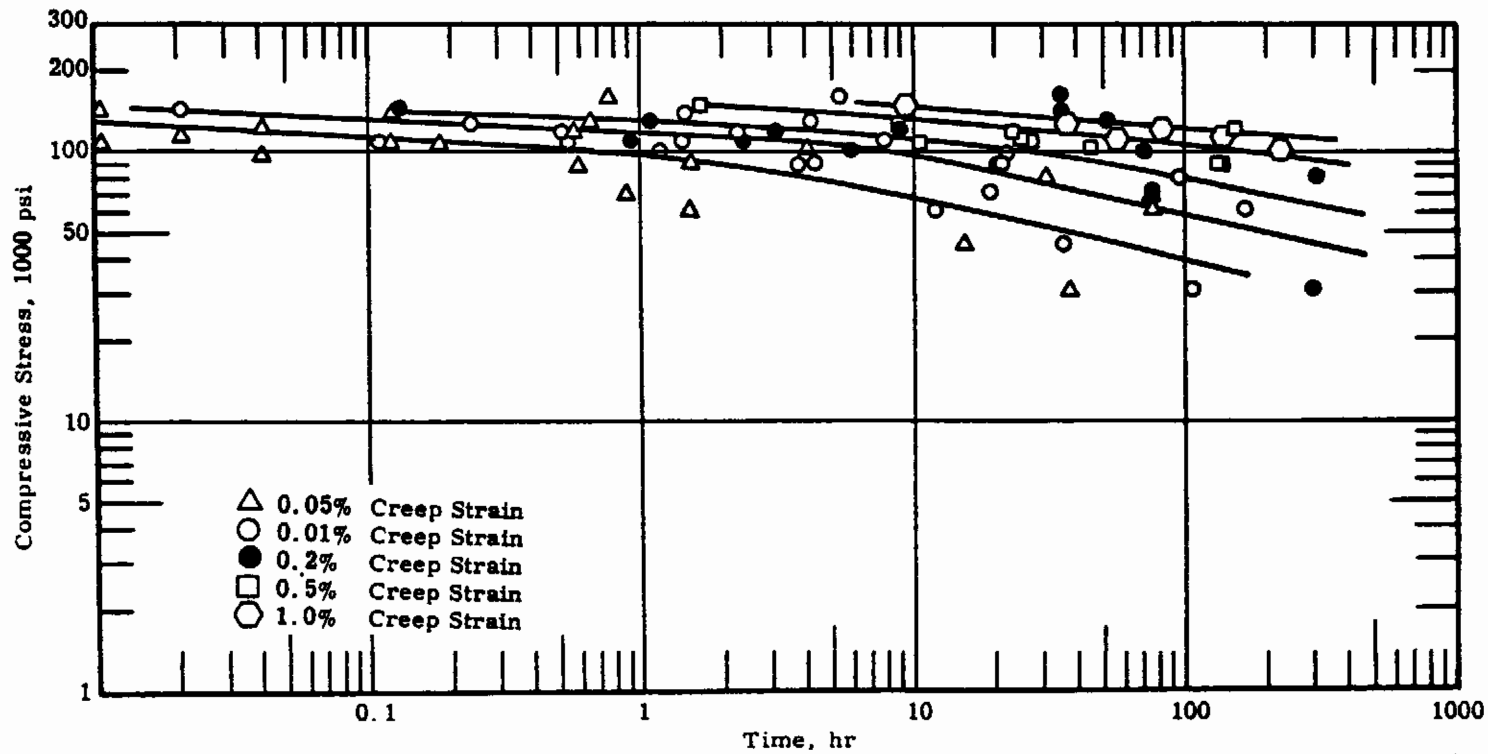


FIGURE 75 - Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Time required for various amounts of compressive creep at 700° F and at various compressive stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

---

[1] Solution treated and aged.

[2] Specimens were heated to test temperature in approximately 2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

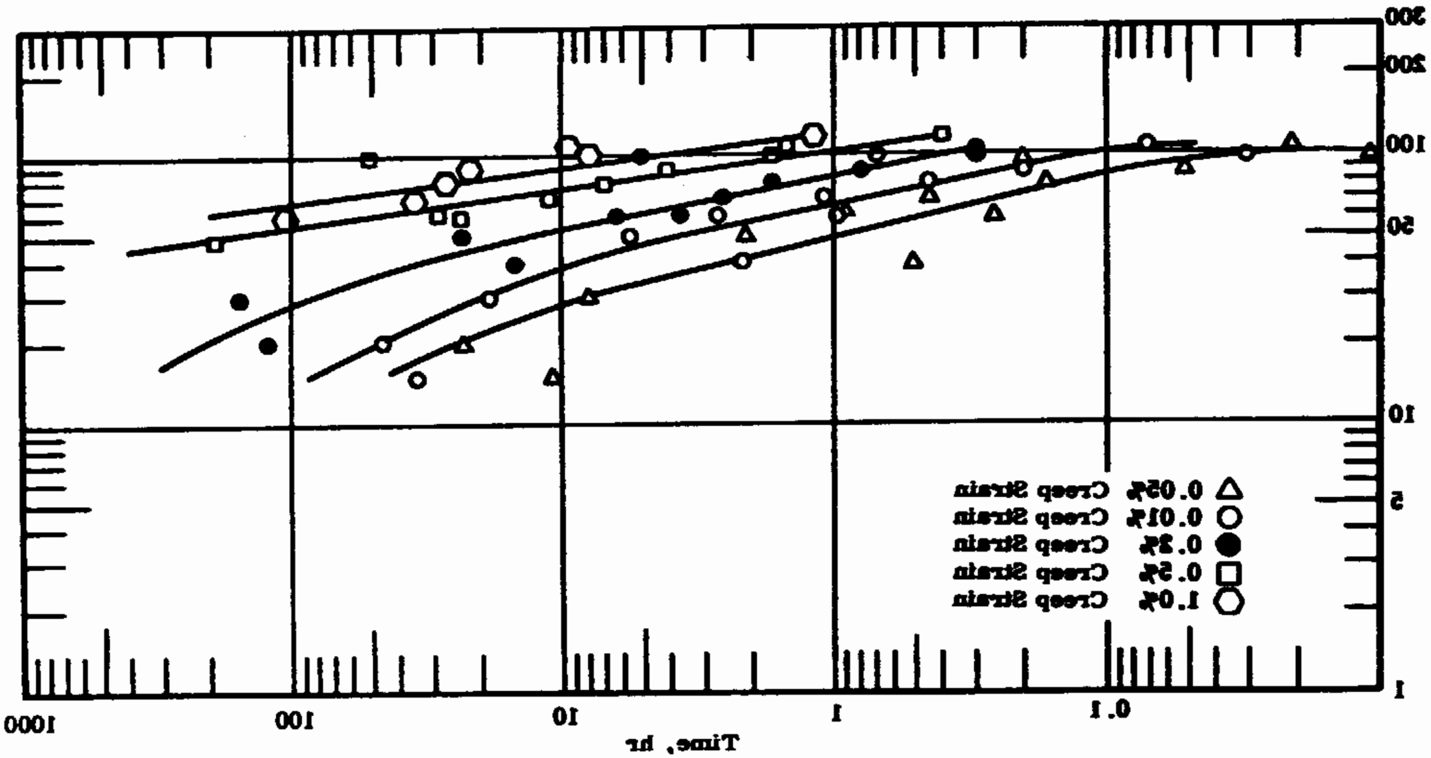


FIGURE 76 - Ti-6 Al-4 V ALLOY SHEET (Heat No. 27039)[1]—Time required for various amounts of compressive creep at 800° F and at various compressive stresses. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

---

[1] Solution treated and aged.

[2] All specimens were heated to test temperature in approximately 2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

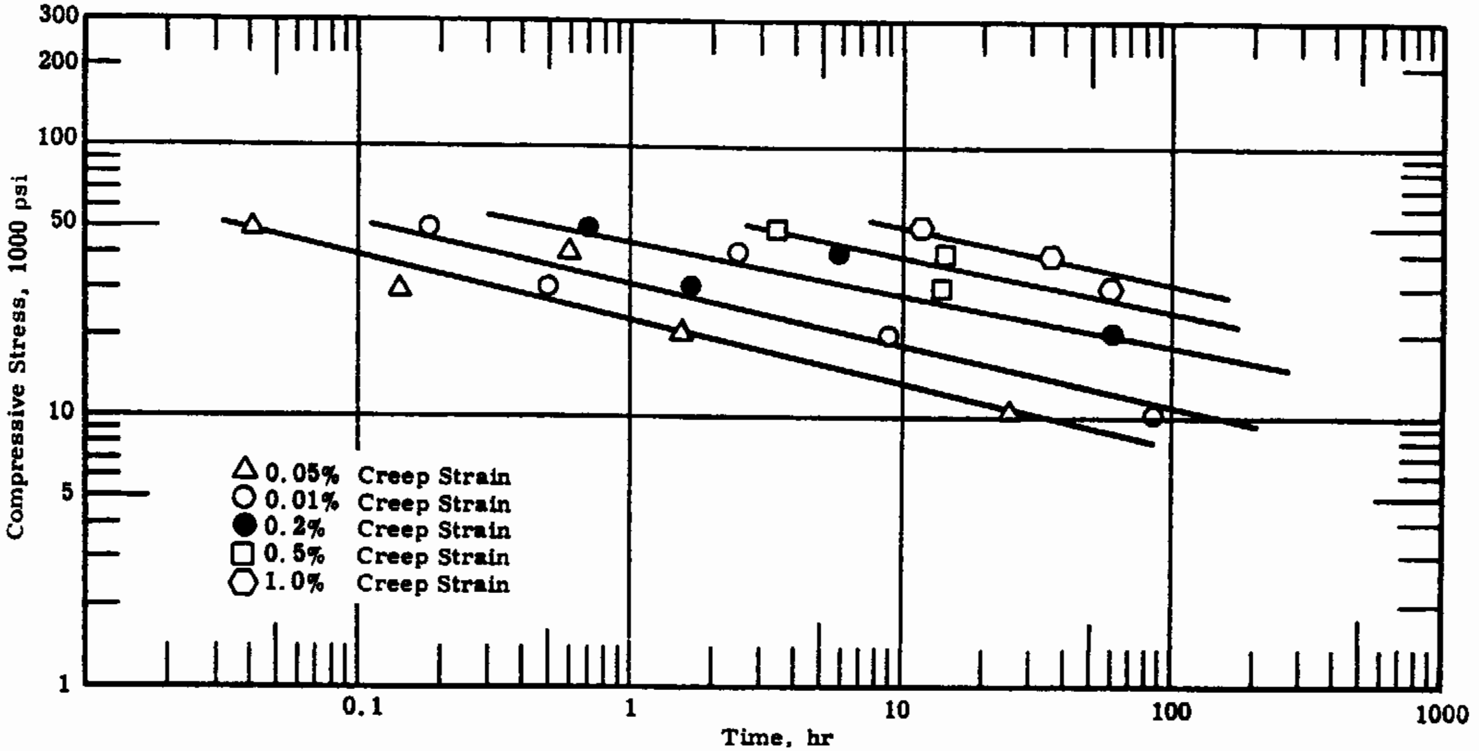


FIGURE 77 - Ti-6 Al-4 V ALLOY SHEET (Heat No. 27039)[1]—Time required for various amounts of compressive creep at 900°F and at various compressive stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

---

[1] Solution treated and aged.

[2] All specimens were heated to test temperature in approximately 2 hr. soaked at temperature 1/2 hr, then loaded within 2 min.

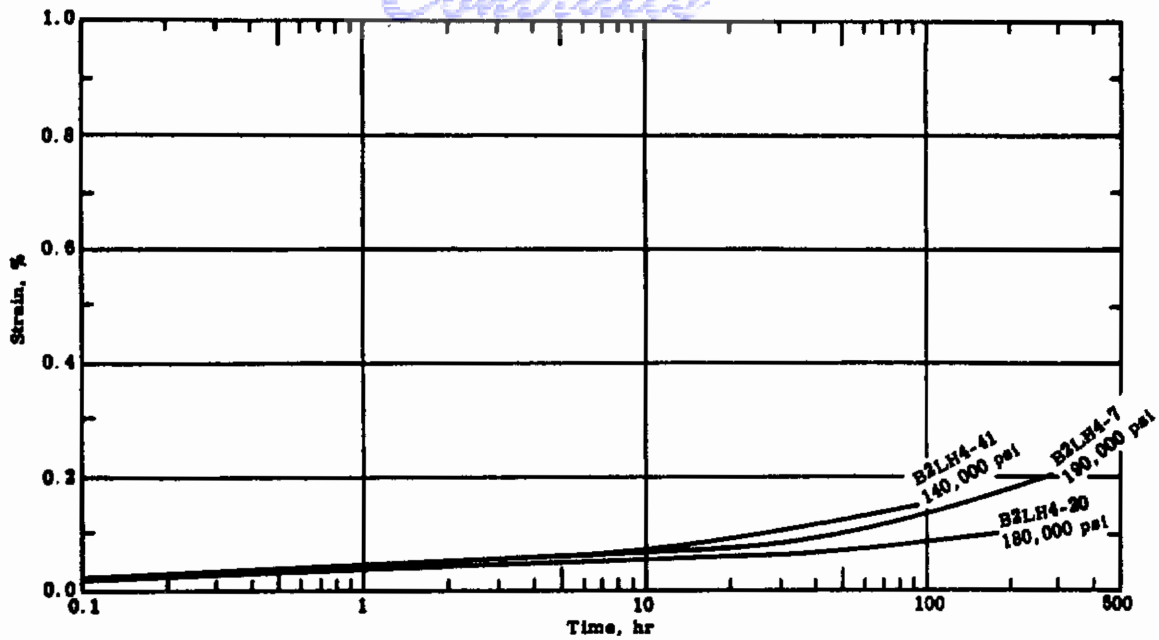


FIGURE 78 – Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Compressive creep strain-time curves at 600° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

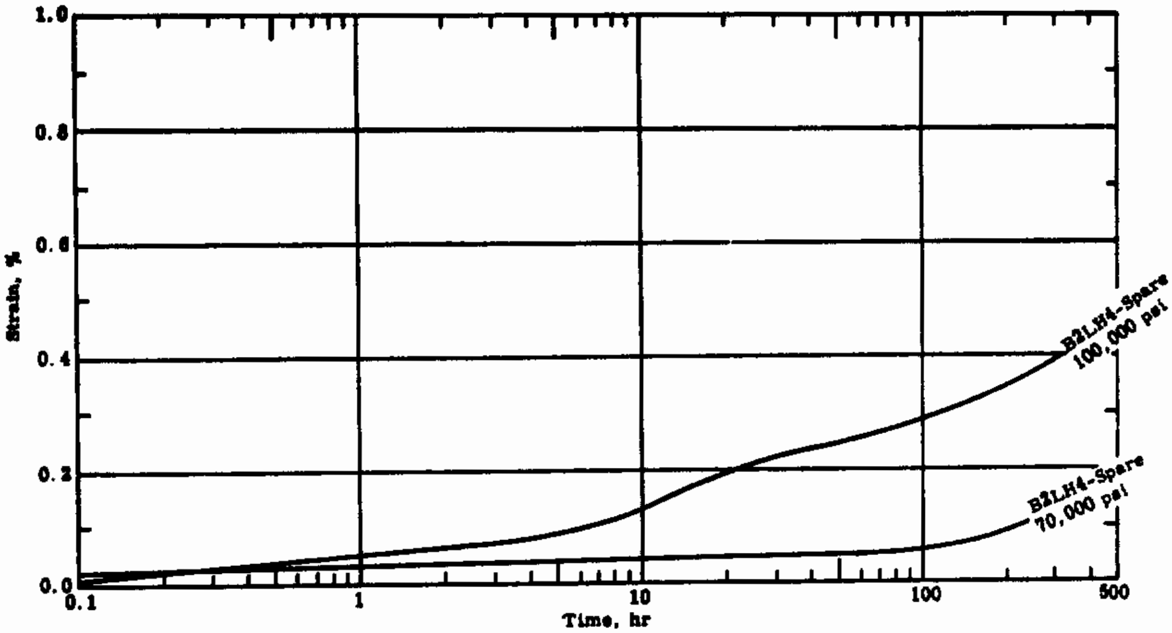


FIGURE 79 – Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Compressive creep strain-time curves at 600° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

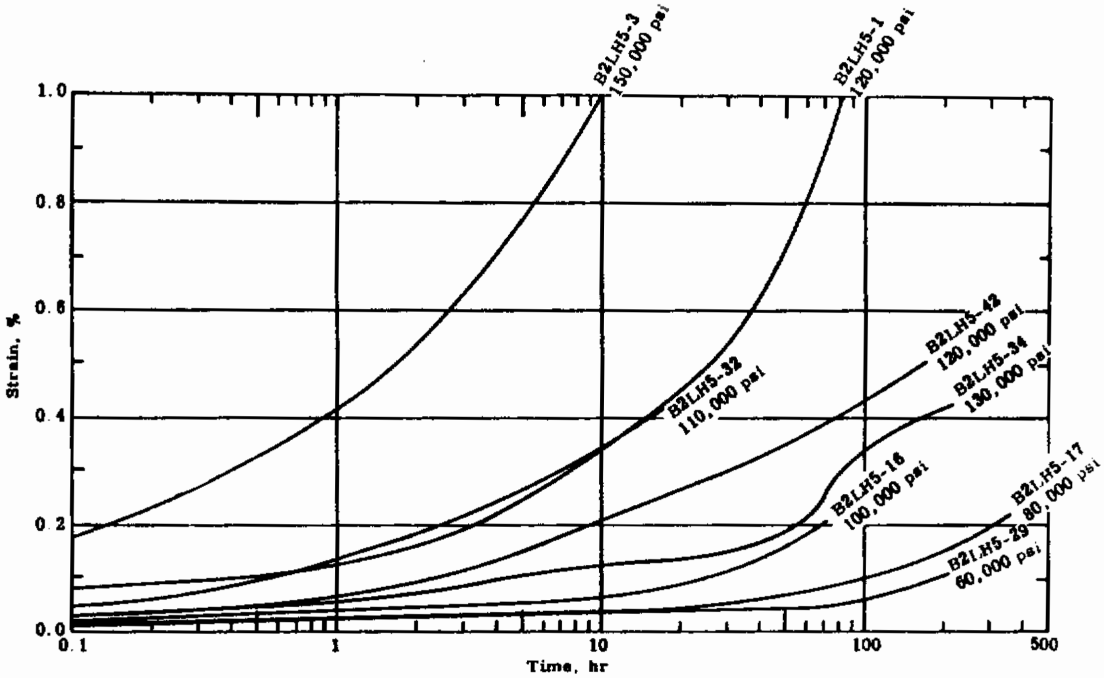


FIGURE 80 – Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Compressive creep strain-time curves at 700° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

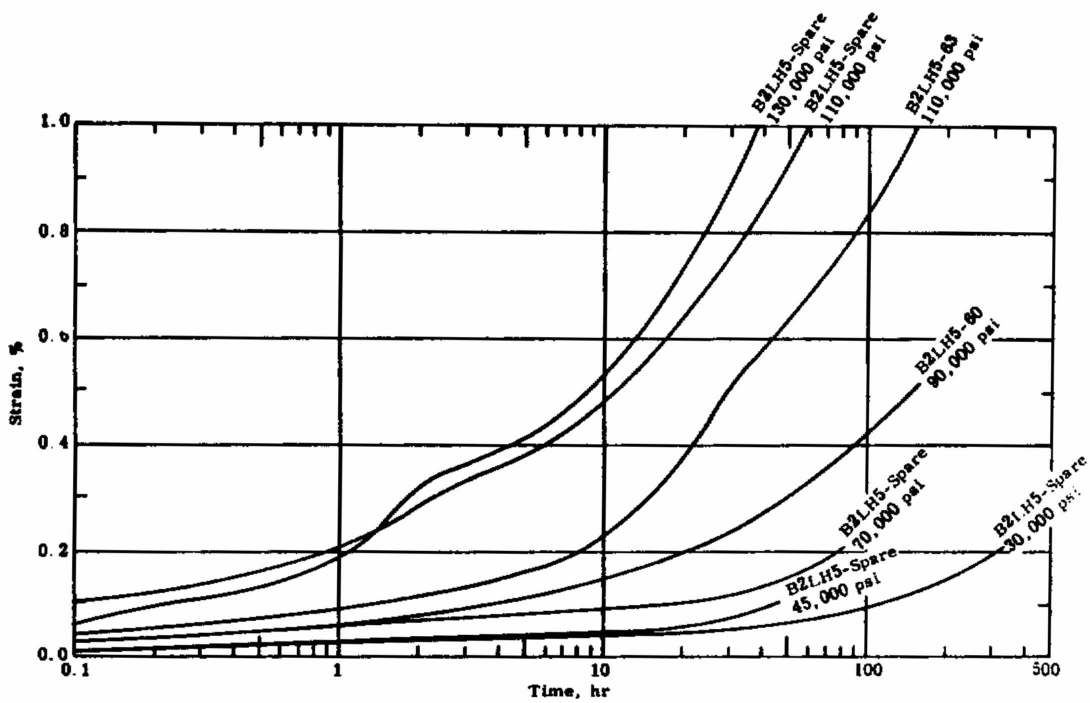


FIGURE 81 – Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Compressive creep strain-time curves at 700° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

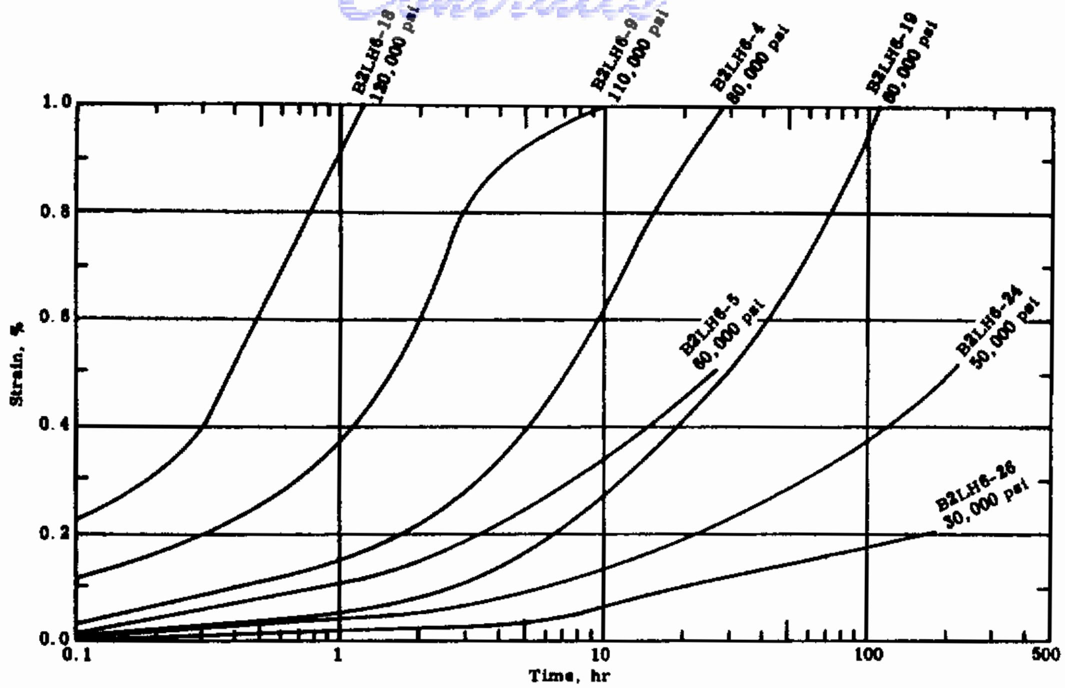


FIGURE 82 - Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Compressive creep strain-time curves at 800° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

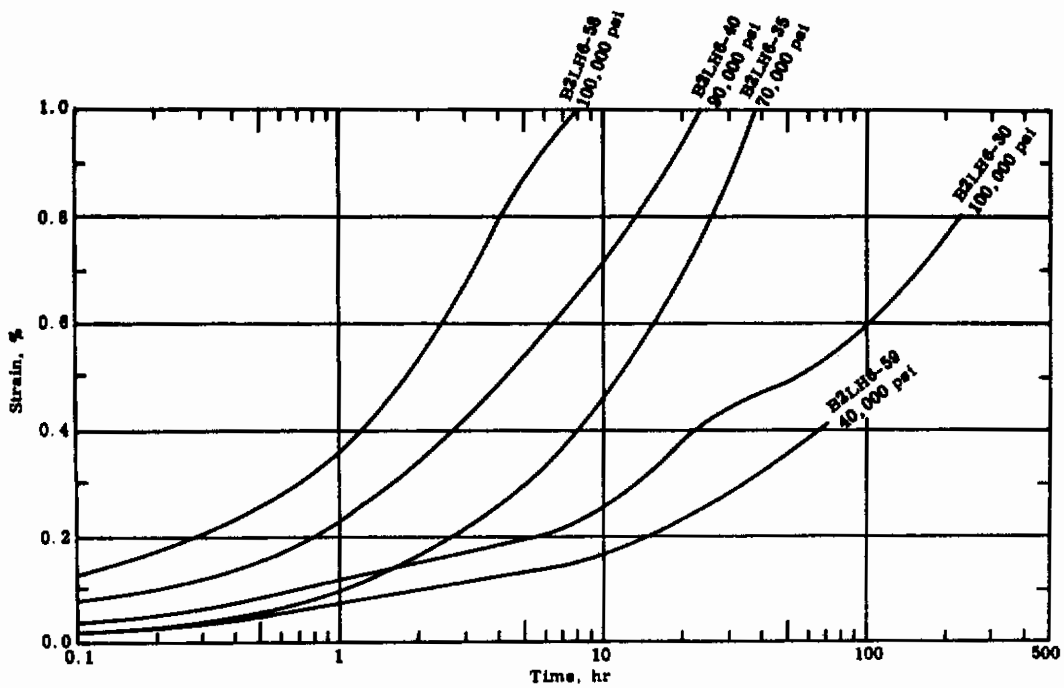


FIGURE 83 - Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Compressive creep strain-time curves at 800° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

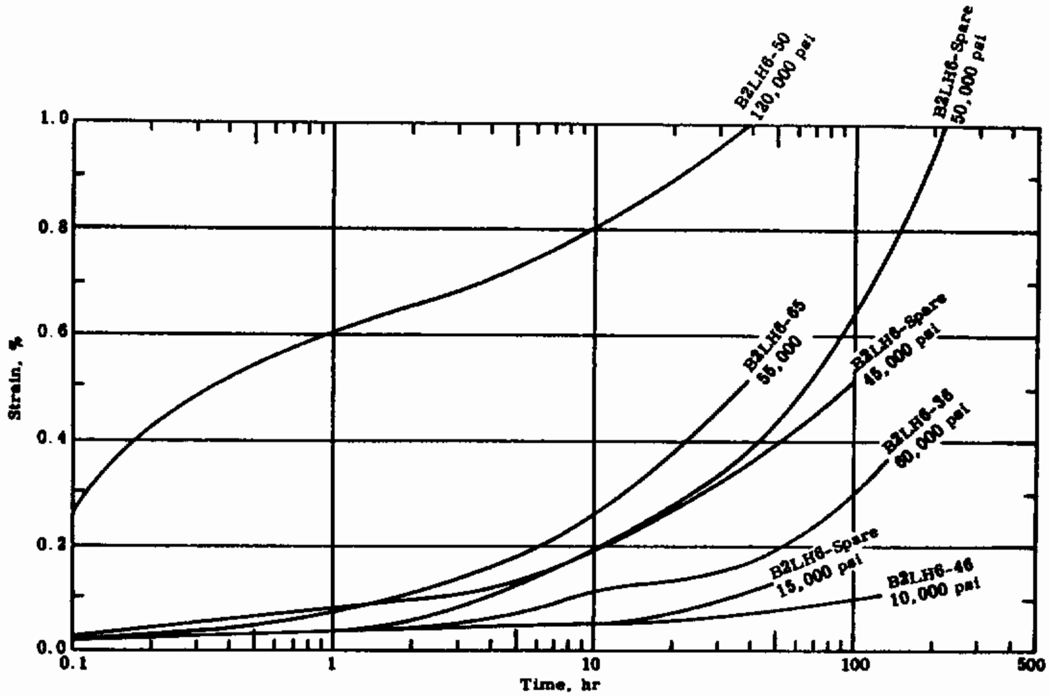


FIGURE 84 – Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Compressive creep strain-time curves at 900° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

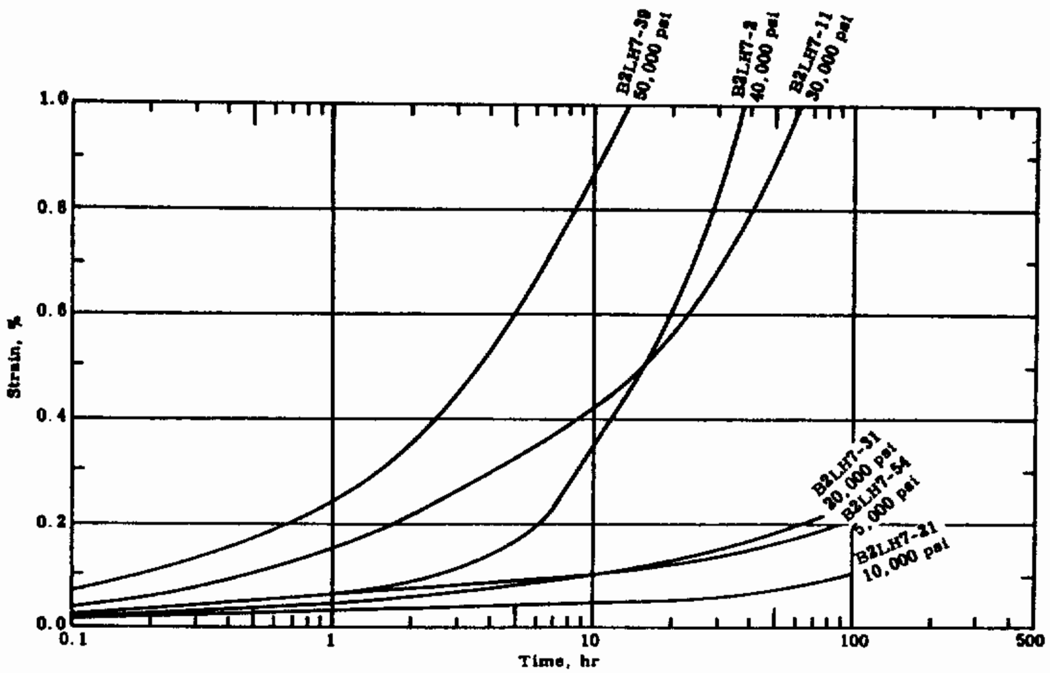


FIGURE 85 – Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Compressive creep strain-time curves at 900° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

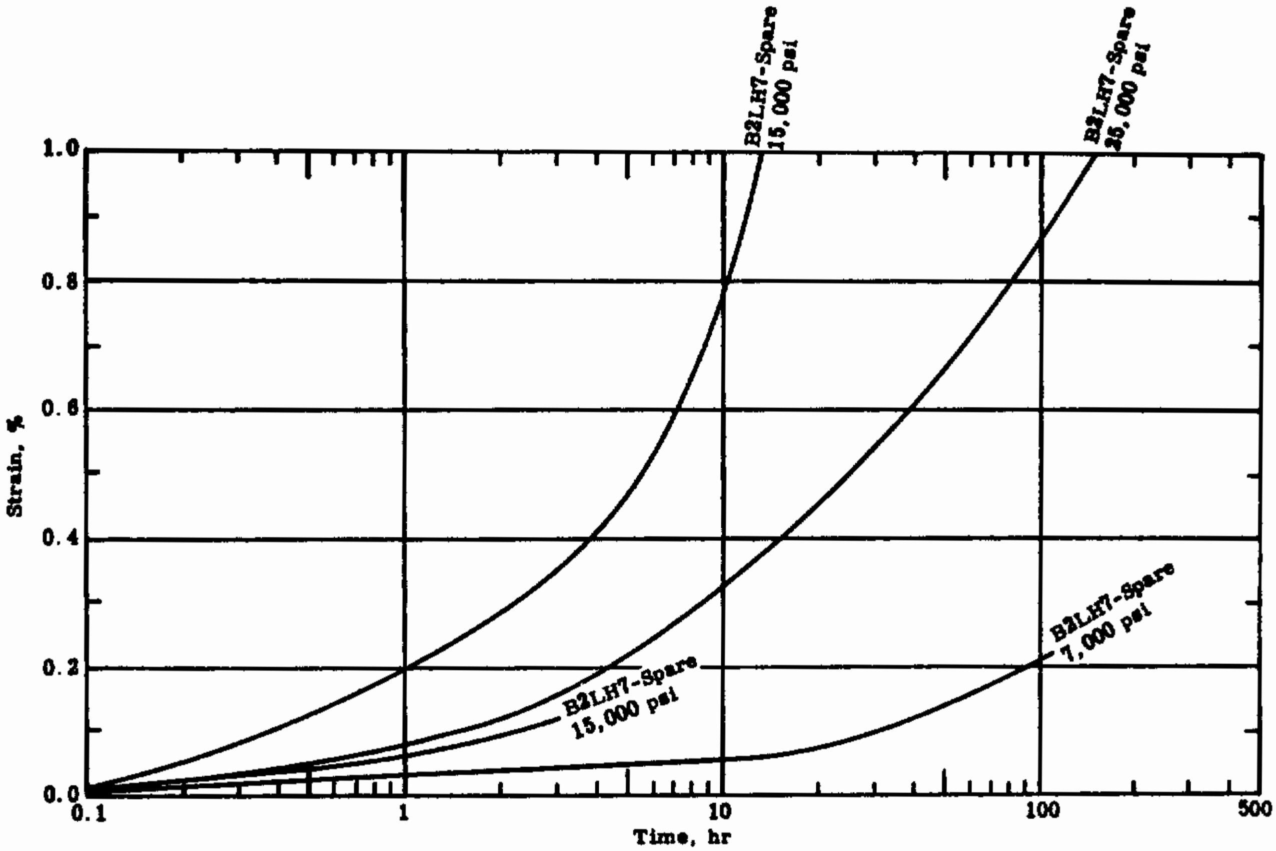


FIGURE 86 – Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Compressive creep strain-time curves at 900° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

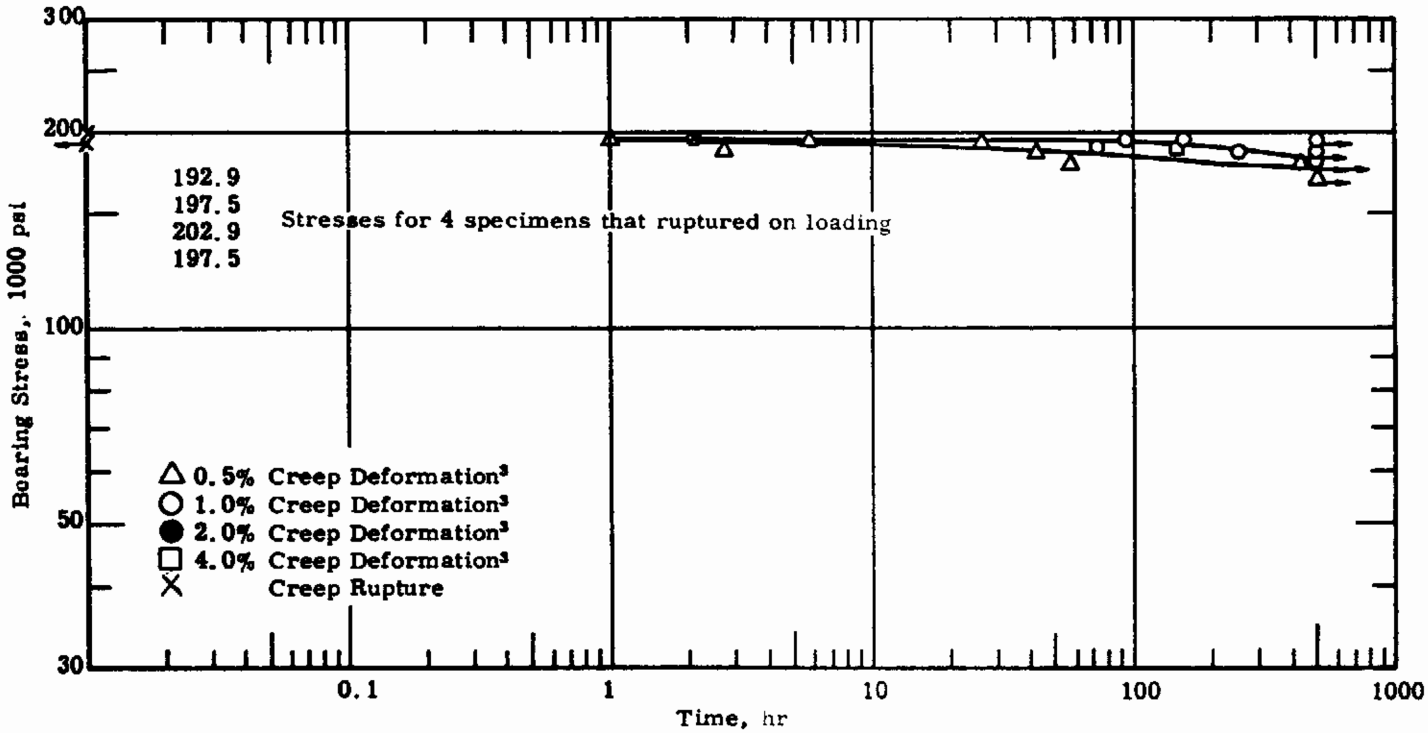


FIGURE 87 - Ti—6 Al—4 V ALLOY SHEET (Heat No. 27039)[1]—Time required for various amounts of bearing creep at 600° F and at various bearing stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

---

[1] Solution treated and aged.

[2] Specimens were heated to test temperature in approximately 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

[3] Percent of bearing-hole diameter.

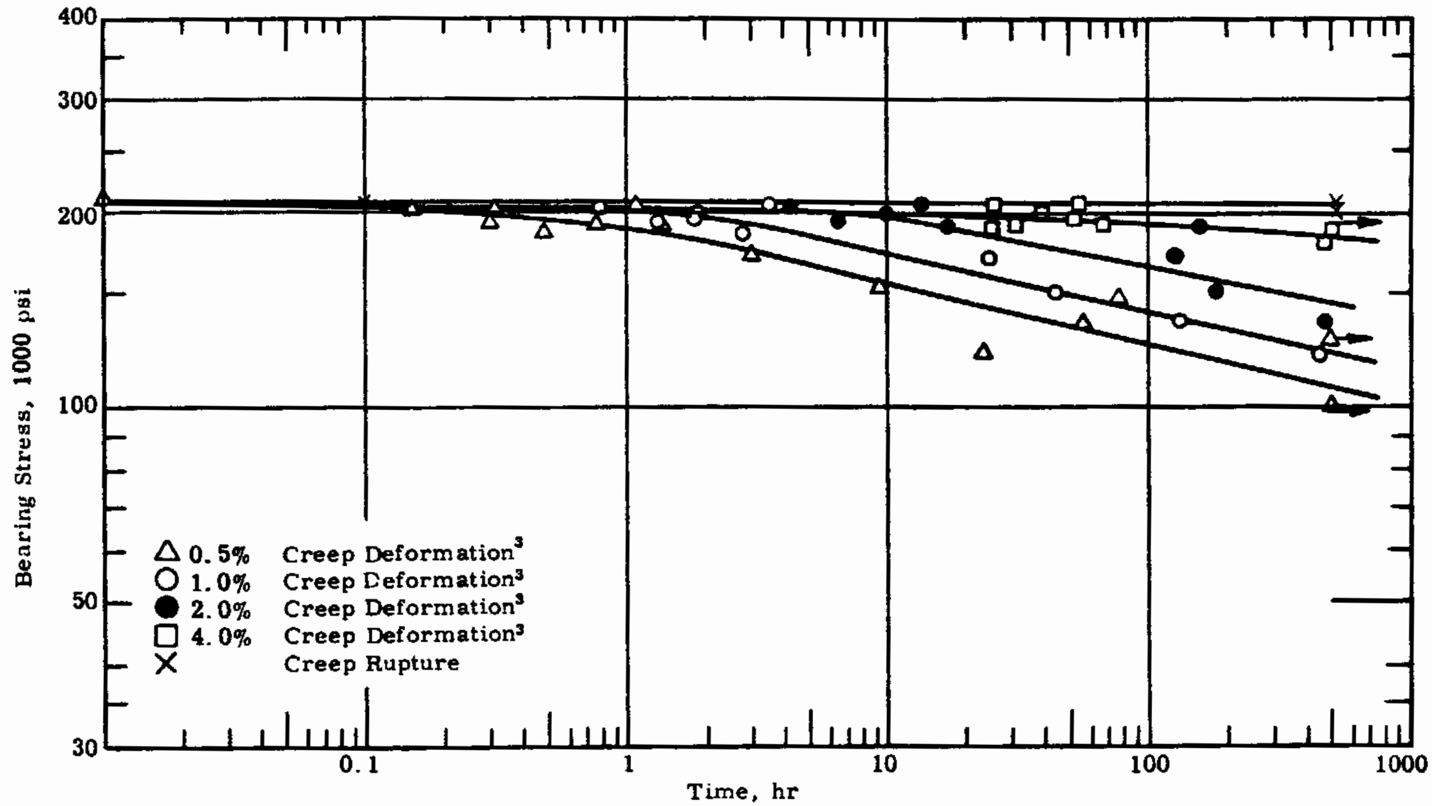


FIGURE 88 - Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Time required for various amounts of bearing creep at 700° F and at various bearing stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

---

1 Solution treated and aged.

2 Specimens were heated to test temperature in approximately 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

3 Percent of bearing-hole diameter.

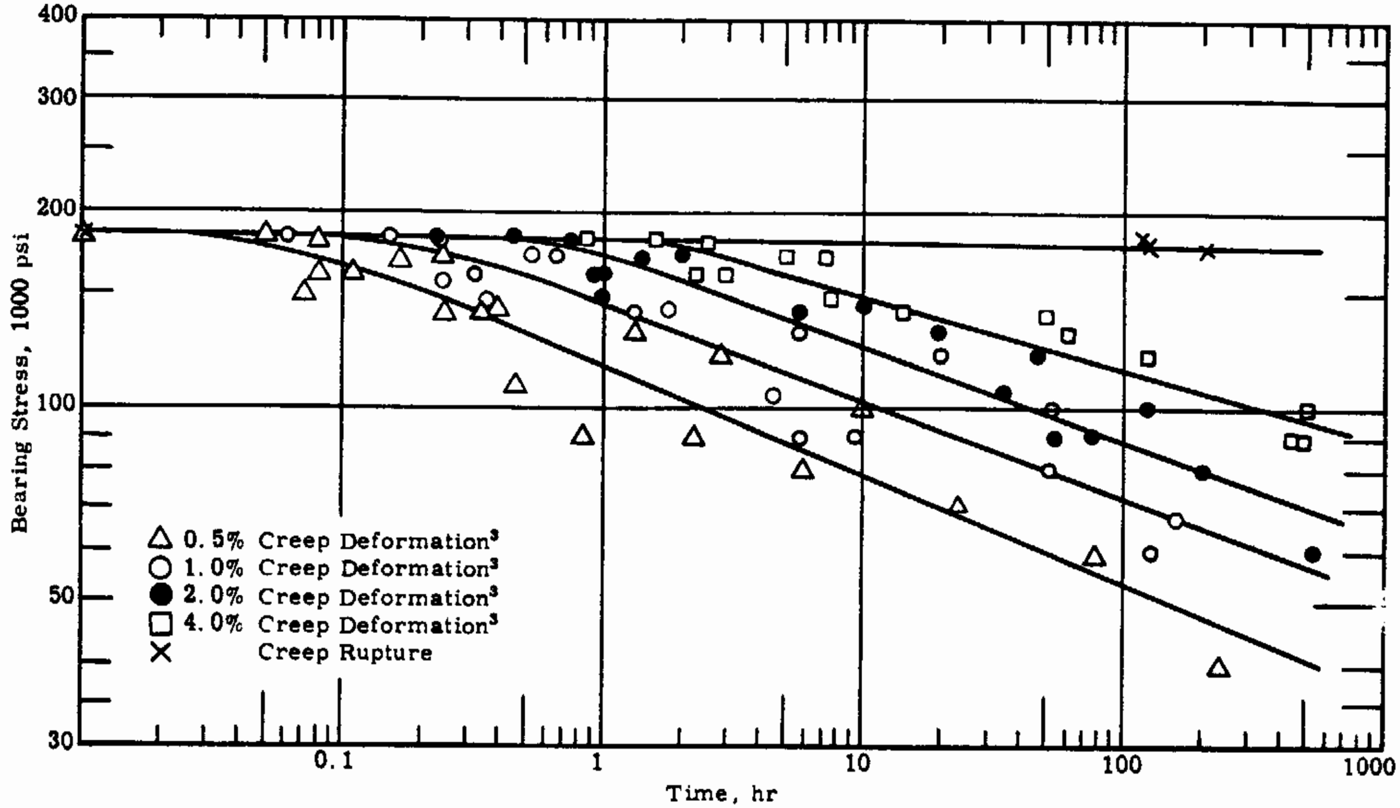


FIGURE 89 - Ti—6 Al—4 V ALLOY SHEET (Heat No. 27039)[1]—Time required for various amounts of bearing creep at 800°F and at various bearing stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

---

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in approximately 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.
[3] Percent of bearing-hole diameter.

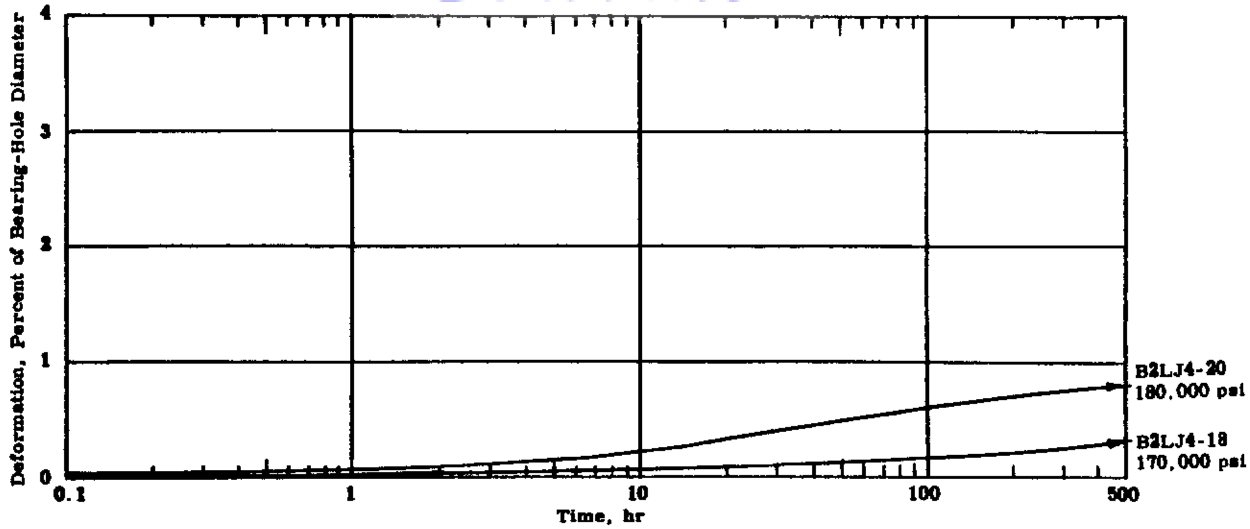


FIGURE 90 - Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Bearing creep deformation-time curves at 600°F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

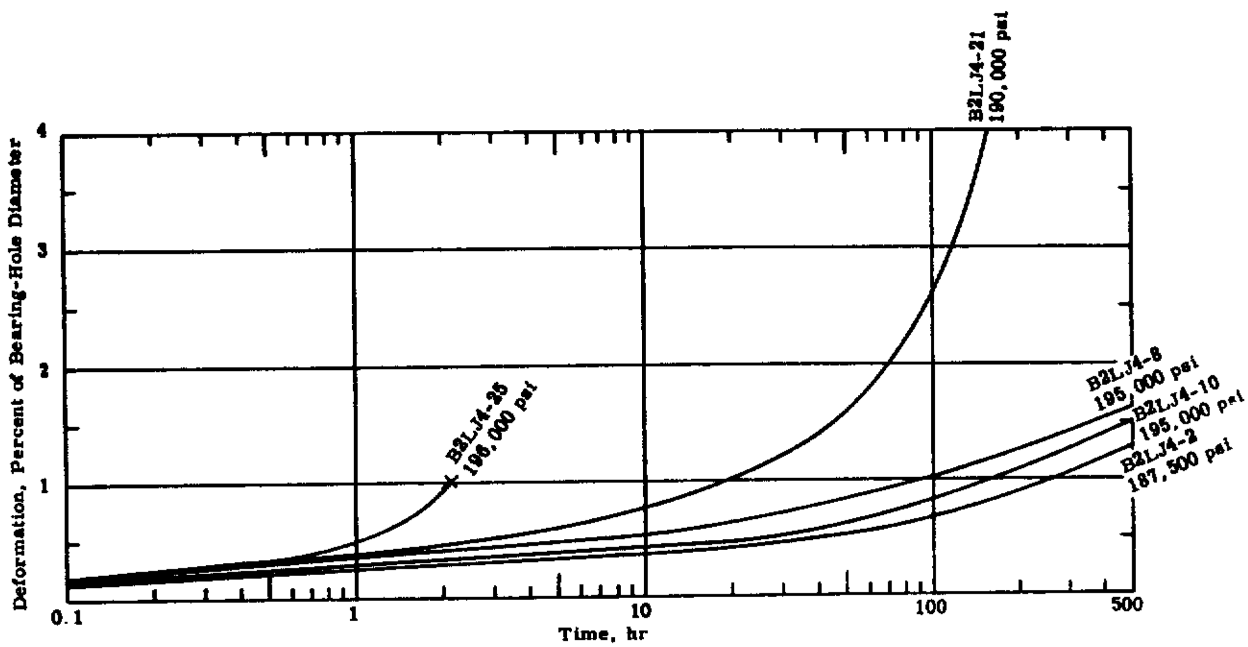


FIGURE 91 - Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Bearing creep deformation-time curves at 600°F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

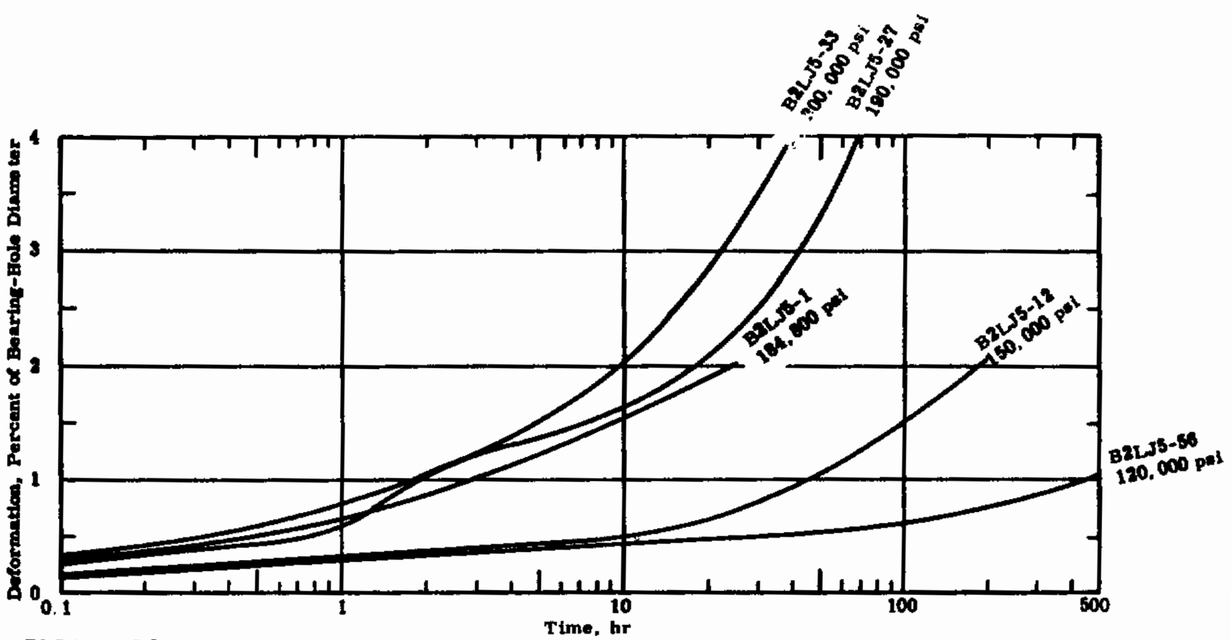


FIGURE 92 - Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Bearing creep deformation-time curves at 700° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

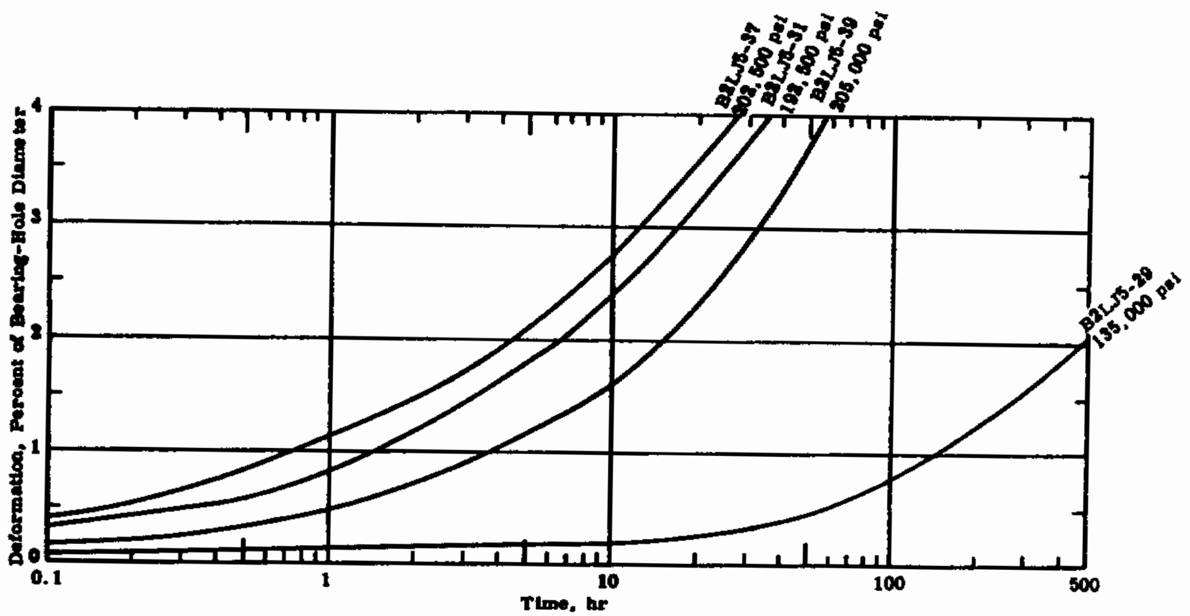


FIGURE 93 - Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Bearing creep deformation-time curves at 700° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

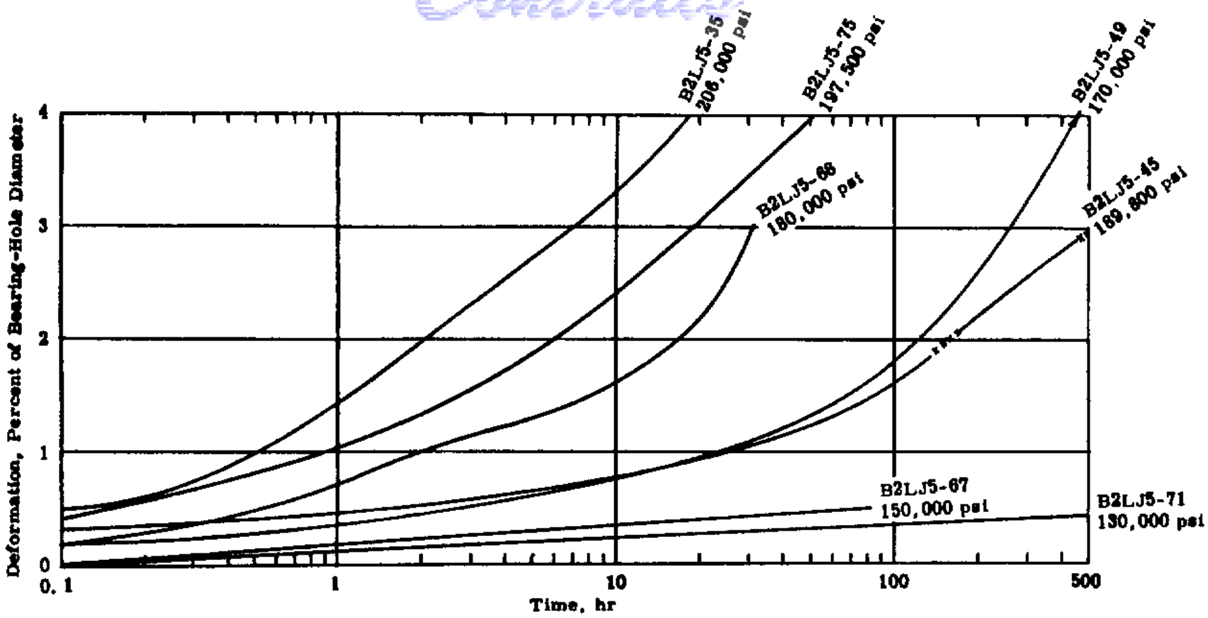


FIGURE 94 – Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Bearing creep deformation-time curves at 700° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded in about 2 min.
x Denotes portions of the curve where the temperature was not continuously within ± 3° F of 700° F but was within ± 5° F.

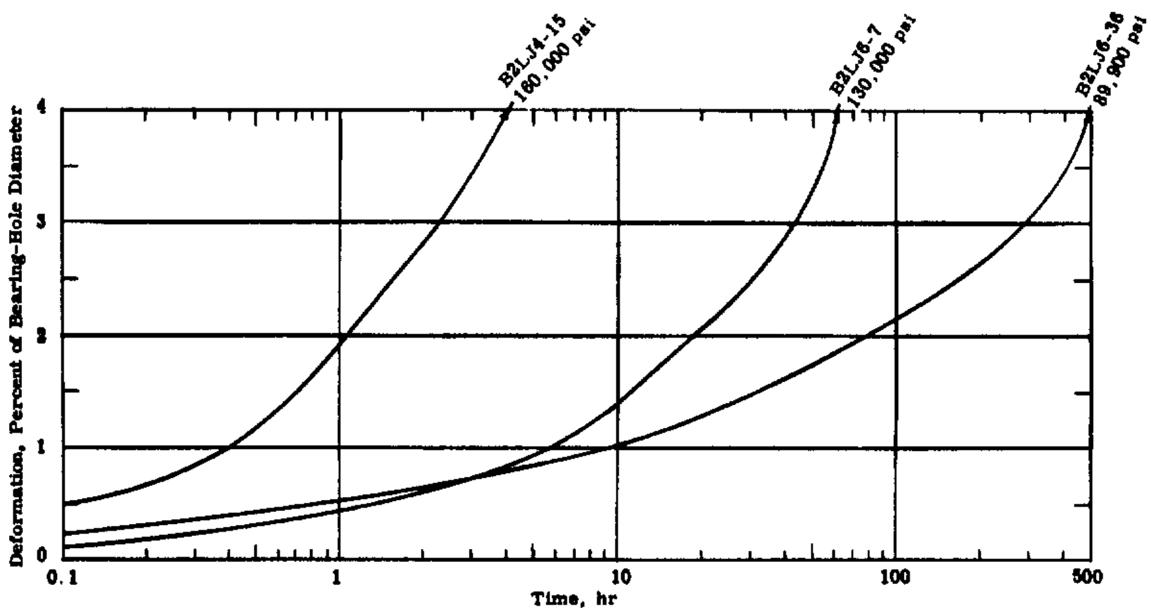


FIGURE 95 – Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Bearing creep deformation-time curves at 800° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

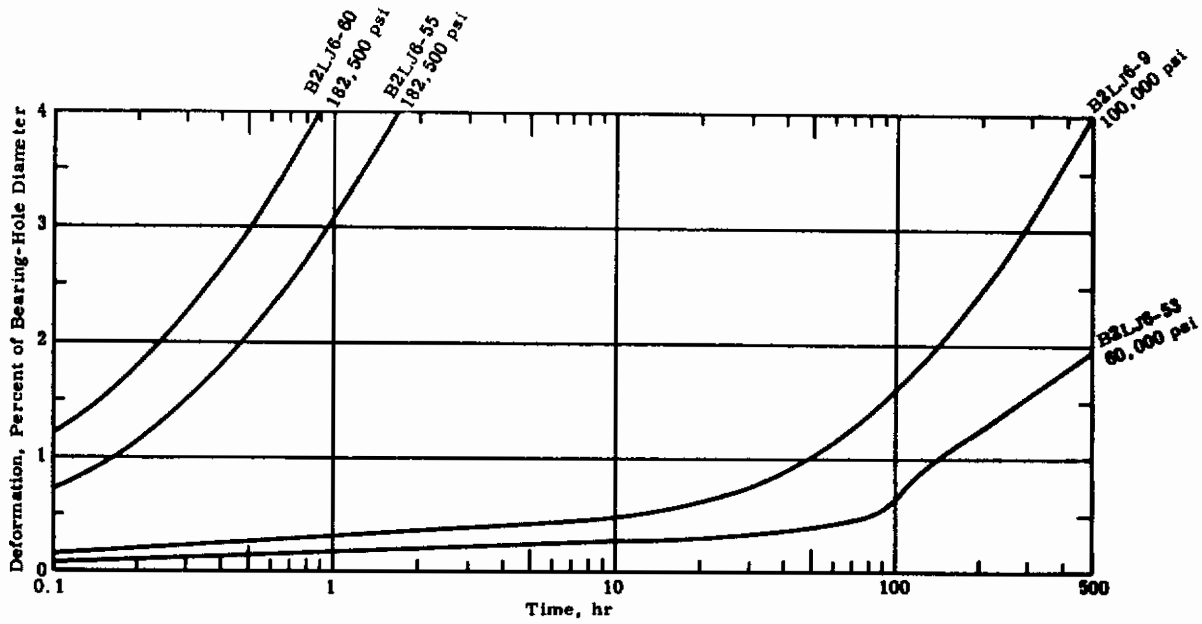


FIGURE 96 – Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Bearing creep deformation-time curves at 800° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

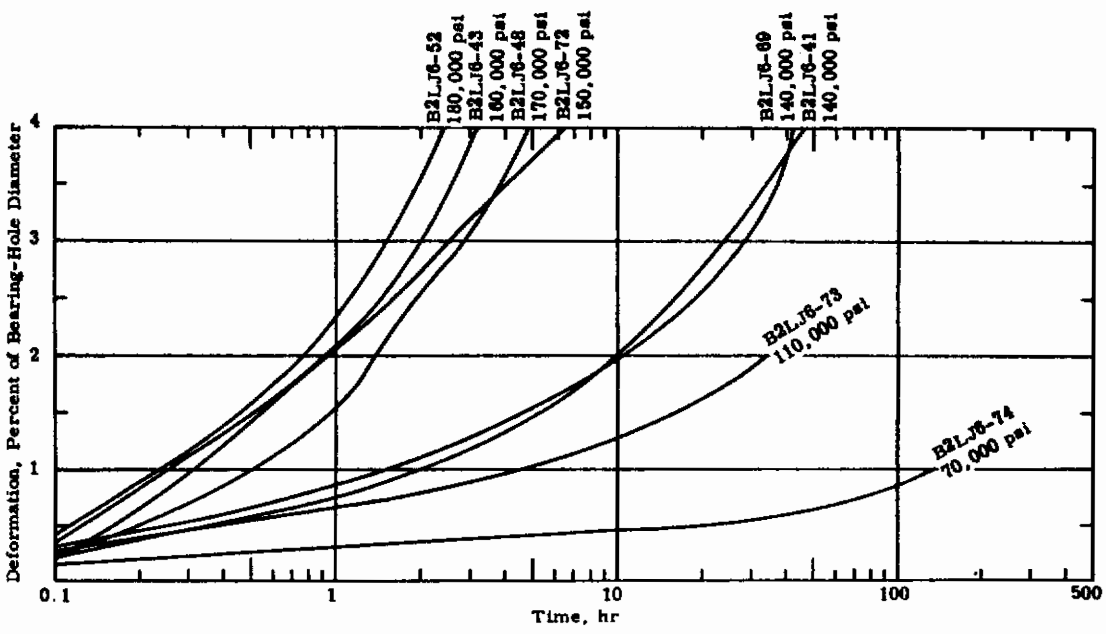


FIGURE 97 – Ti—6 Al—4 V ALLOY SHEET (Heat No. 27039)[1]—Bearing creep deformation-time curves at 800° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

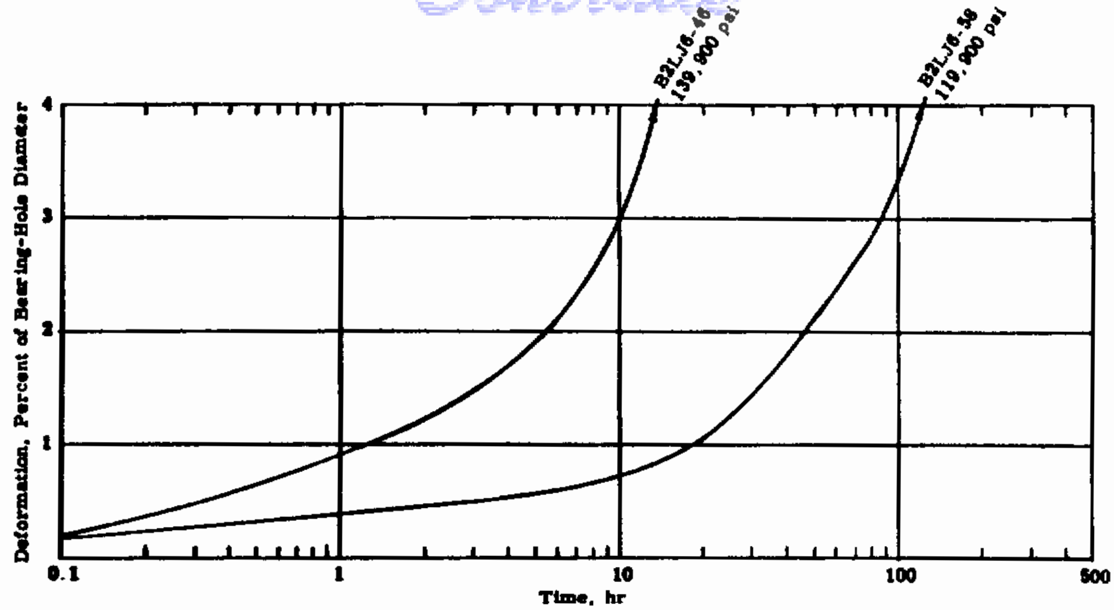


FIGURE 98 – Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Bearing creep deformation-time curves at 800° F and at various stresses[2] All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

---

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

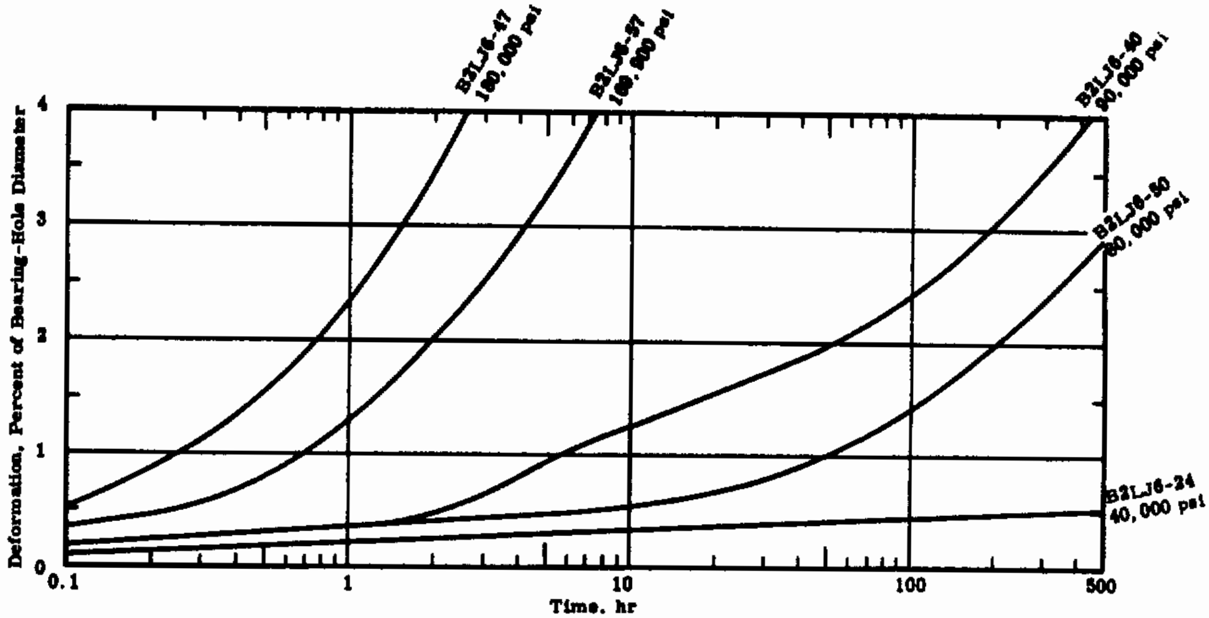


FIGURE 99 – Ti–6 Al–4 V ALLOY SHEET (Heat No. 27039)[1]—Bearing creep deformation-time curves at 800° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

---

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

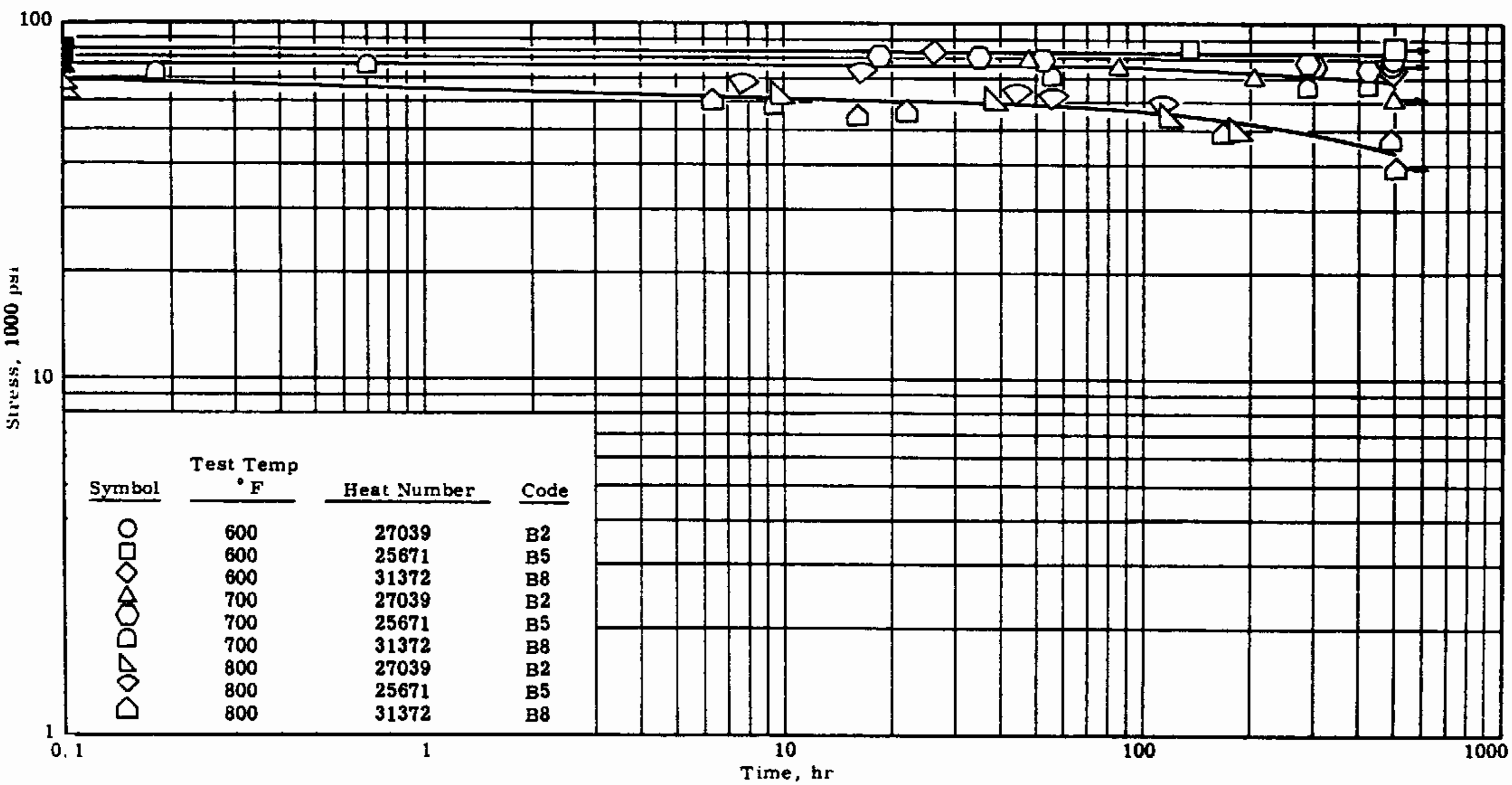


FIGURE 100 - Ti-6 Al-4 V ALLOY SHEET[1]—Time required for stress-rupture in single-shear at various stresses and temperatures[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged

[2] Specimens were heated to test temperature in 2 hr, soaked 1/2 hr, loaded within 2 min before rupture time measurements were started.

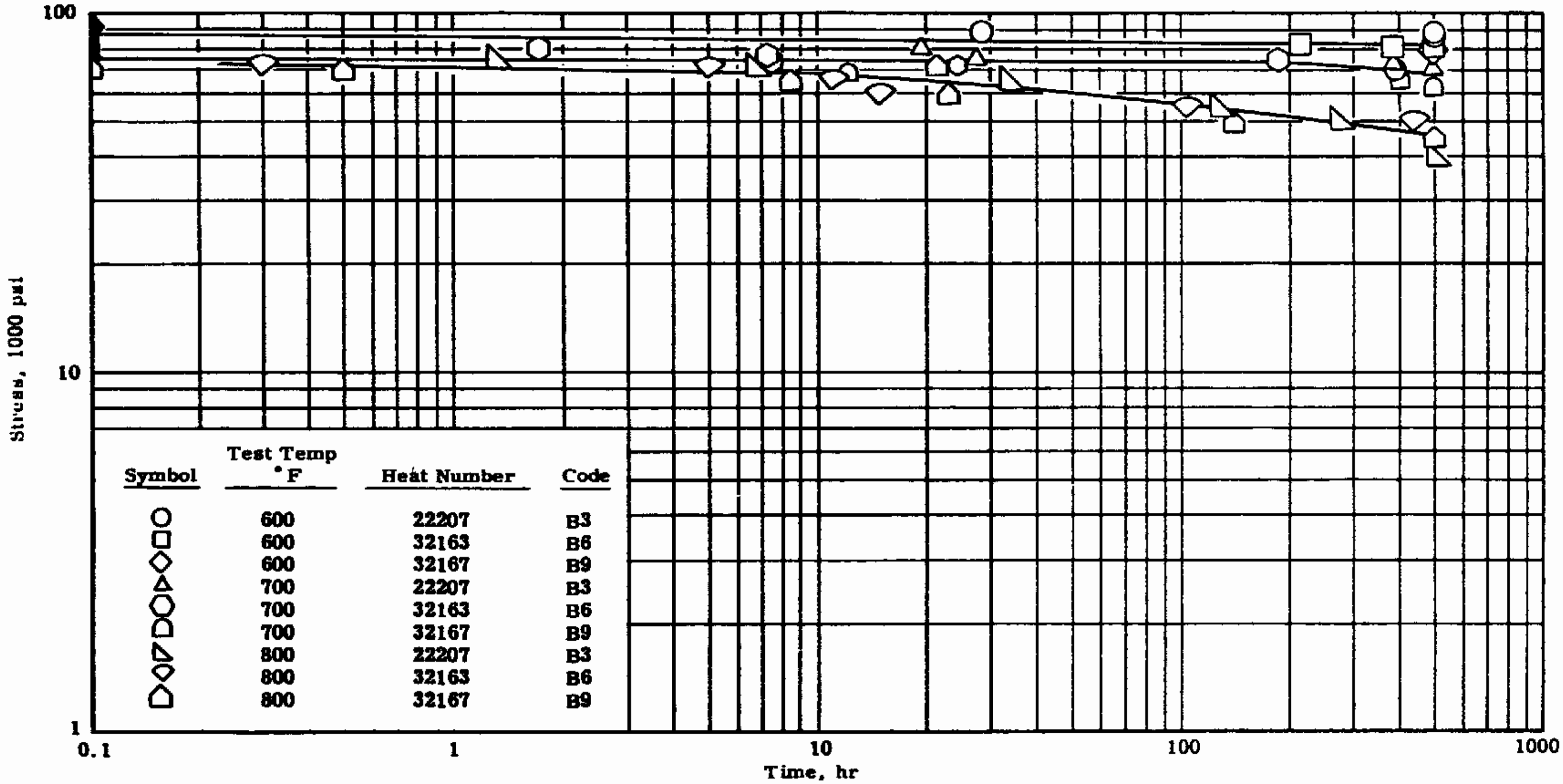


FIGURE 101 - Ti–6 Al–4 V ALLOY SHEET[1]—Time for stress-rupture in double-shear at various stresses and temperatures[2]. All specimens were taken in the longitudinal direction from 0.125 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in approximately 2 hr, soaked at temperature 1/2 hr, then loaded in about 2 min.

Fatigue Test Results - Ti-6Al-4V

Axial-load fatigue data were obtained for 0.063 inch thick sheet from two heats and 0.125 inch thick sheet from a different heat and are summarized by the 60 S-N curves in Figures 102 through 161. In addition to the two thicknesses, the data represent theoretical stress concentrations of 1.0 and 2.82; stress ratios of ∞, 1.0 and 0.3; and temperatures of 80°F, 400°F, 600°F, 800°F and 900°F. Each combination of these variables is represented by an S-N curve defined by a minimum of 21 test values. Data were obtained for the longitudinal grain direction, only, and maximum stress and life-cycles for each specimen are reported in Tables CXI through CXXII, pages 117 through 128 of Volume 3.

Data for a stress ratio of zero, which were combined with available tensile creep-rupture data and ultimate tensile stress data to construct modified Goodman-type diagrams, are in Tables IX and X. A modified Goodman-type diagram for each combination of thickness, stress concentration and temperature is presented in Volume 1. These diagrams show alternating stress to mean stress for 10^3, 10^4, 10^5, 10^6 and 10^7 life-cycles based on experimental points obtained at the stress ratios of ∞, 1.0, 0.3 and 0.

TABLE IX

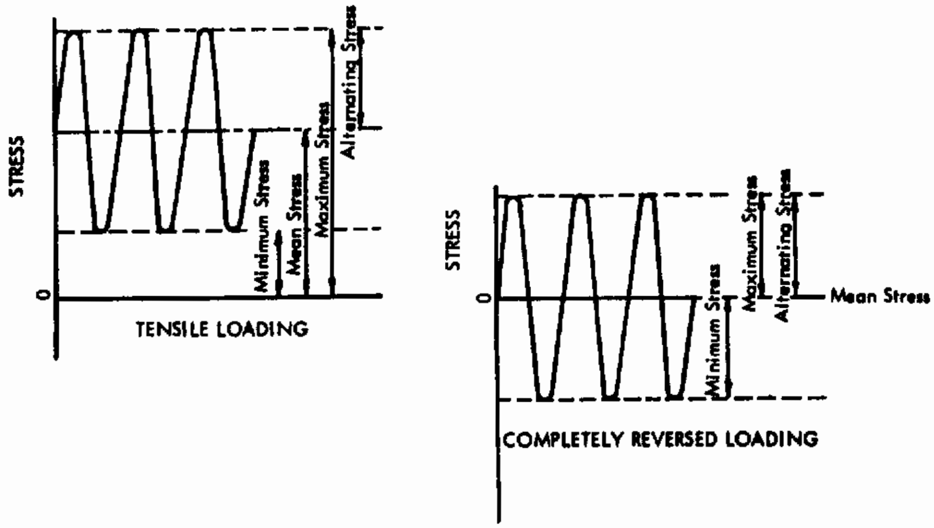
LONGITUDINAL ULTIMATE TENSILE STRESS FOR STRESS RATIO OF ZERO (A=0) FATIGUE VALUES.
SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET
STRESS CONCENTRATION (K_t) = 2.82

Thickness = 0.063 in.			Thickness = 0.125 in.		
Specimen Number	Test Temp., °F	F_{tu}, PSI	Specimen Number	Test Temp., °F	F_{tu}, PSI
B2LG1S-10	80	182,000	B3LG1S-3	80	179,000
-16	80	180,000	-9	80	180,000
-20	80	177,000	-24	80	185,000
Average		180,000	Average		181,000
B2LG3S-3	400	146,000	B3LG3S-12	400	143,000
-5	400	148,000	-18	400	147,000
-18	400	144,000	-21	400	149,000
Average		146,000	Average		146,000
B2LG4S-7	600	140,000	B3LG4S-1	600	134,000
-19	600	134,000	-20	600	138,000
-21	600	134,000			
Average		136,000	Average		136,000
B2LG6S-2	800	124,000	B3LG6S-6	800	124,000
-15	800	128,000	-19	800	128,000
-17	800	130,000			
Average		128,000	Average		126,000
B2LG7S-8	900	125,000	B3LG7S-8	900	118,000
-12	900	121,000	-14	900	119,000
-13	900	118,000	-27	900	117,000
Average		121,000	Average		118,000

TABLE X

LONGITUDINAL TENSILE STRESS-RUPTURE DATA FOR STRESS RATIO OF ZERO (A=0) FATIGUE VALUES.
SOLUTION TREATED AND AGED 6Al-4V TITANIUM ALLOY SHEET

Stress Concentration (K_t)	Thickness in.	800°F			900°F		
		Specimen Number	Tensile Stress, PSI	Time to Failure hours	Specimen Number	Tensile Stress, PSI	Time to Failure hours
1.00	0.125	B3LG6R-7	115,000	0.50	B3LG7R-23	90,000	2.80
		-22	105,000	16.3	-2	67,600	17.0
		-11	87,500	92.5	-16	50,900	110.9
2.82	0.063	B2LG6S-14	115,000	2.80	B2LG7S-11	89,900	2.43
		-6	111,000	6.80	-22	74,000	9.50
		-19	94,100	78.4	-4	57,400	70.0
	0.125	B3LG6S-10	120,000	3.50	B3LG7S-4	95,000	1.40
		-13	119,000	4.20	-25	92,600	2.60
		-15	88,300	184.5	-26	51,000	175.4



FATIGUE STRESS DIAGRAM

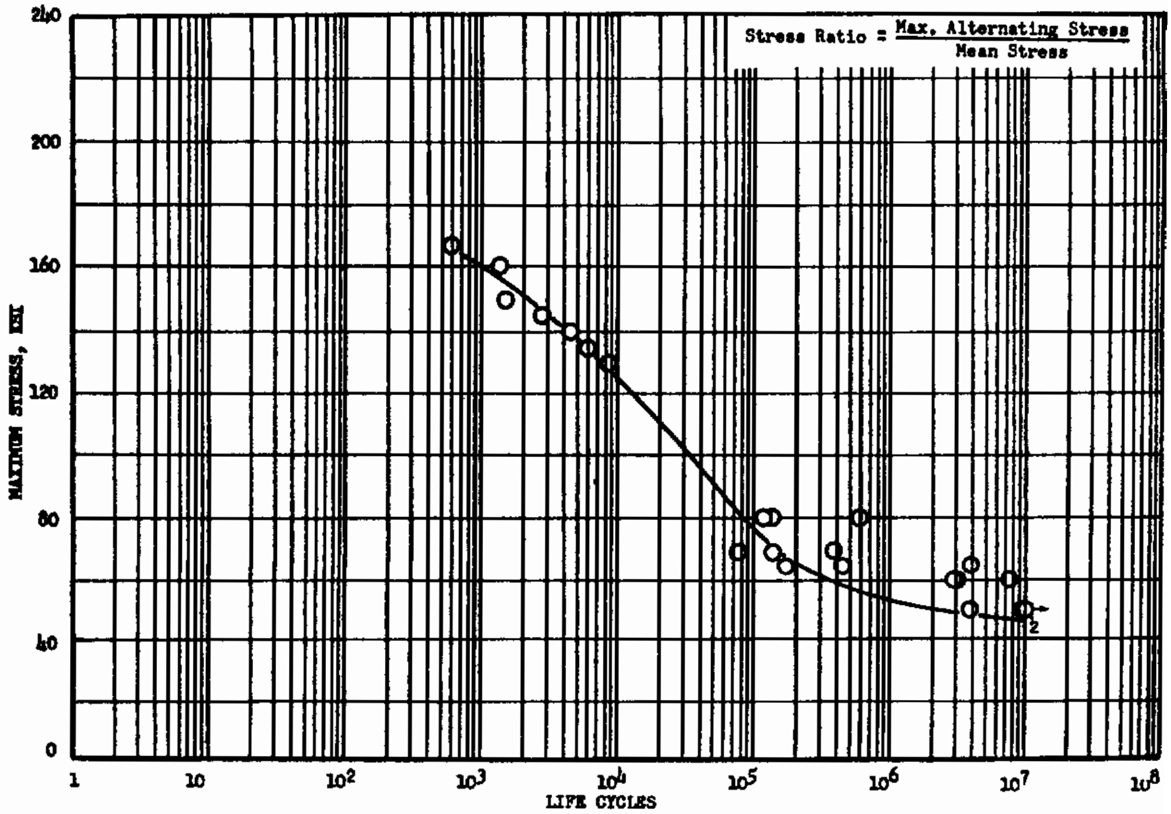


FIGURE 102 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 31372 AND 32163)

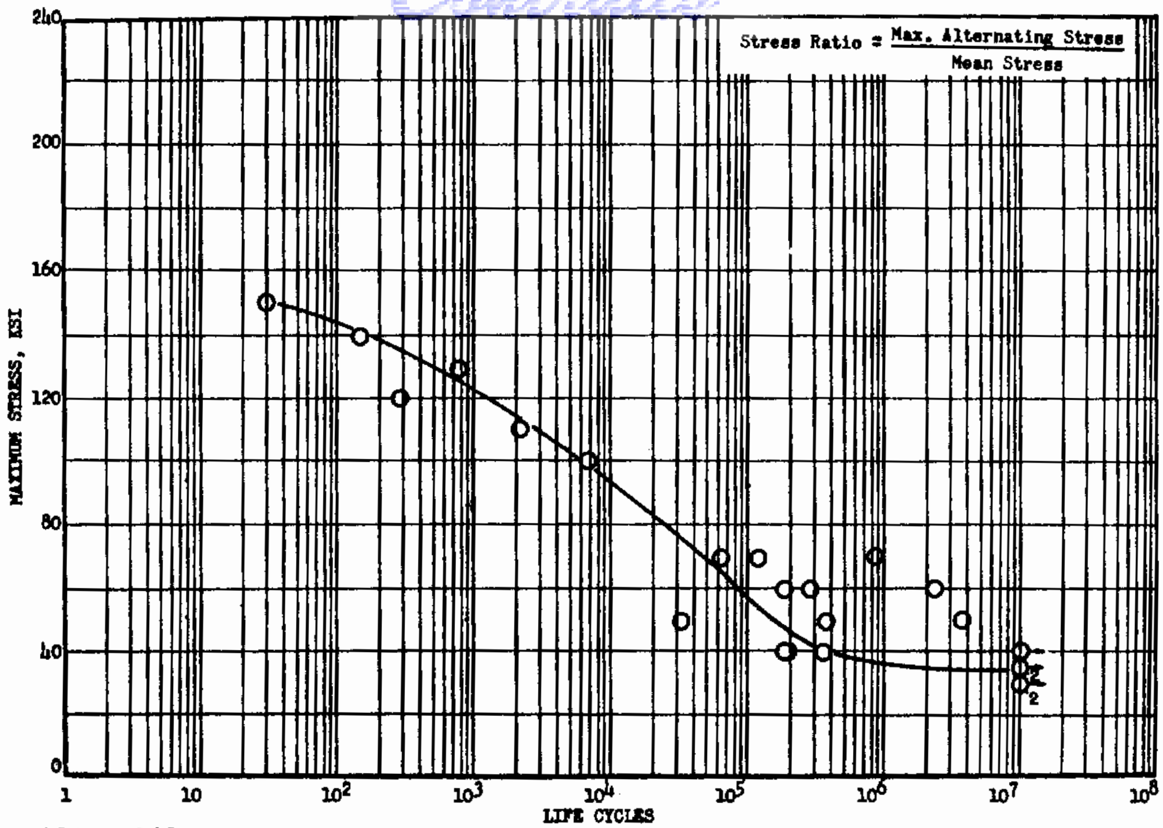


FIGURE 103 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 31372 AND 32163)

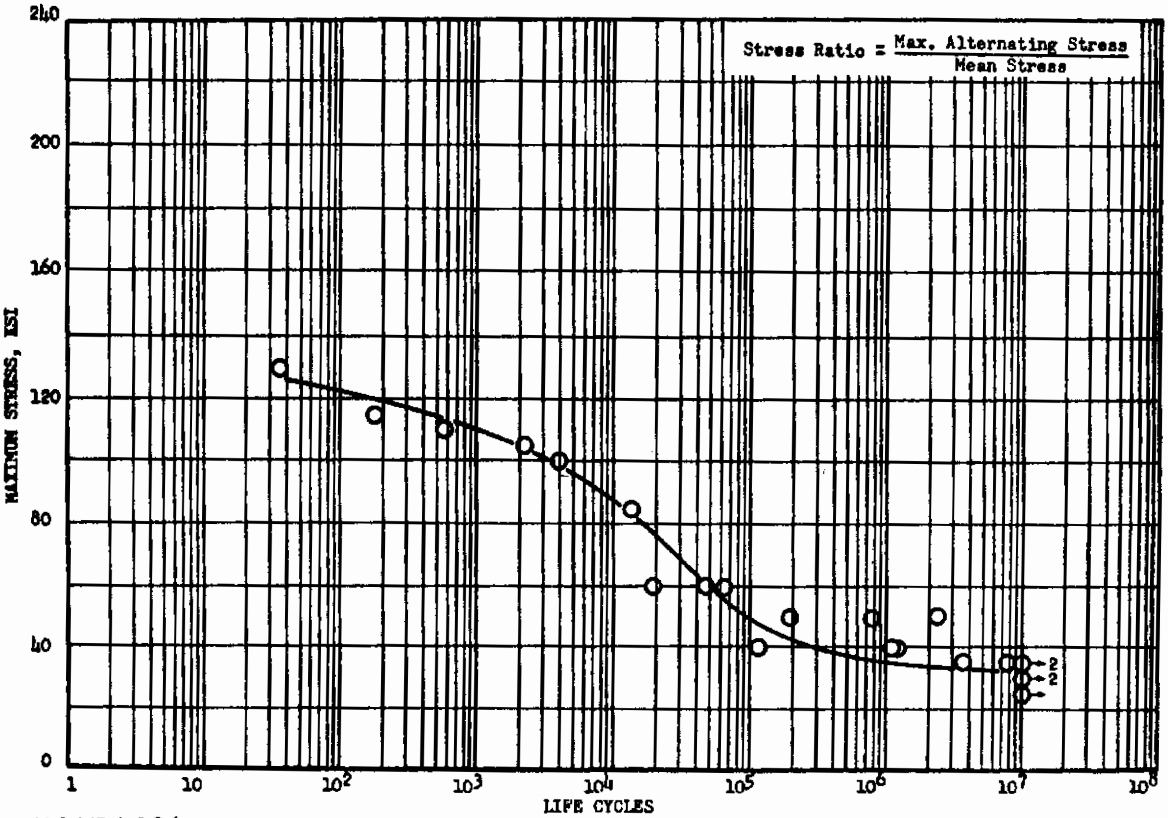


FIGURE 104 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 31372 AND 32163)

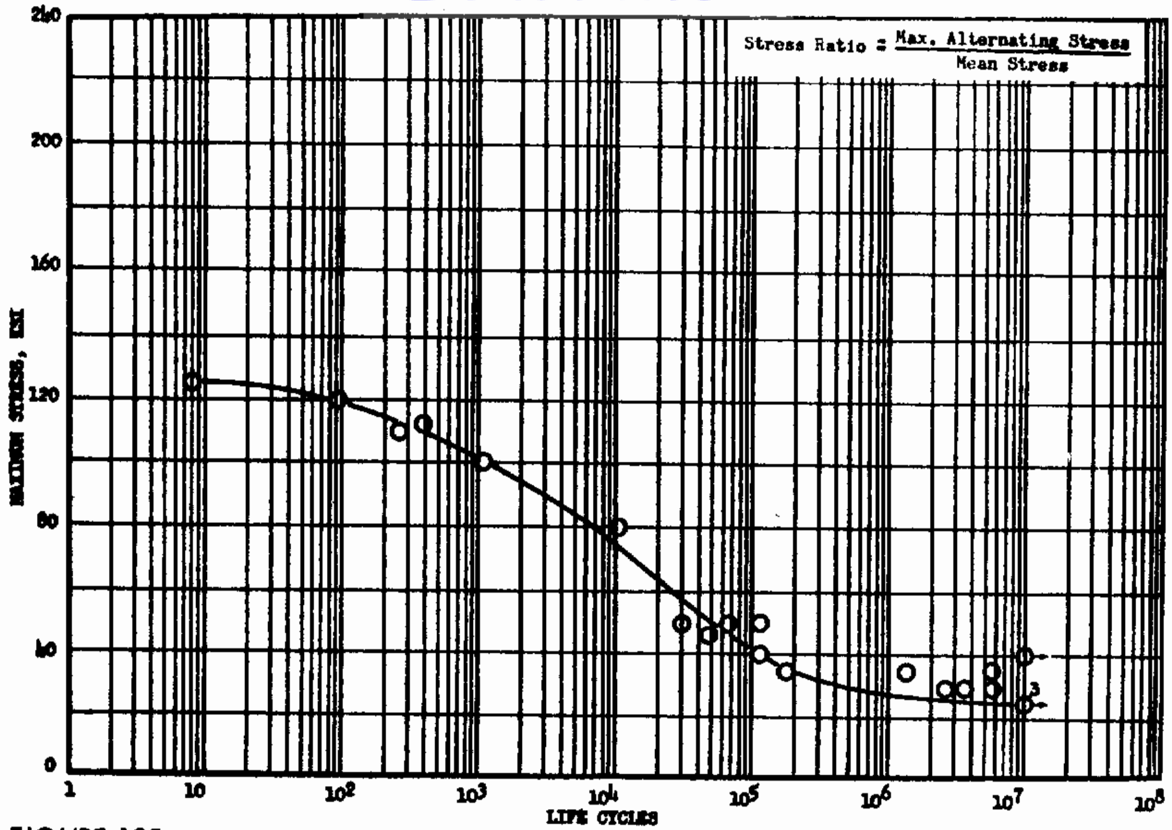


FIGURE 105 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 31372 AND 32163)

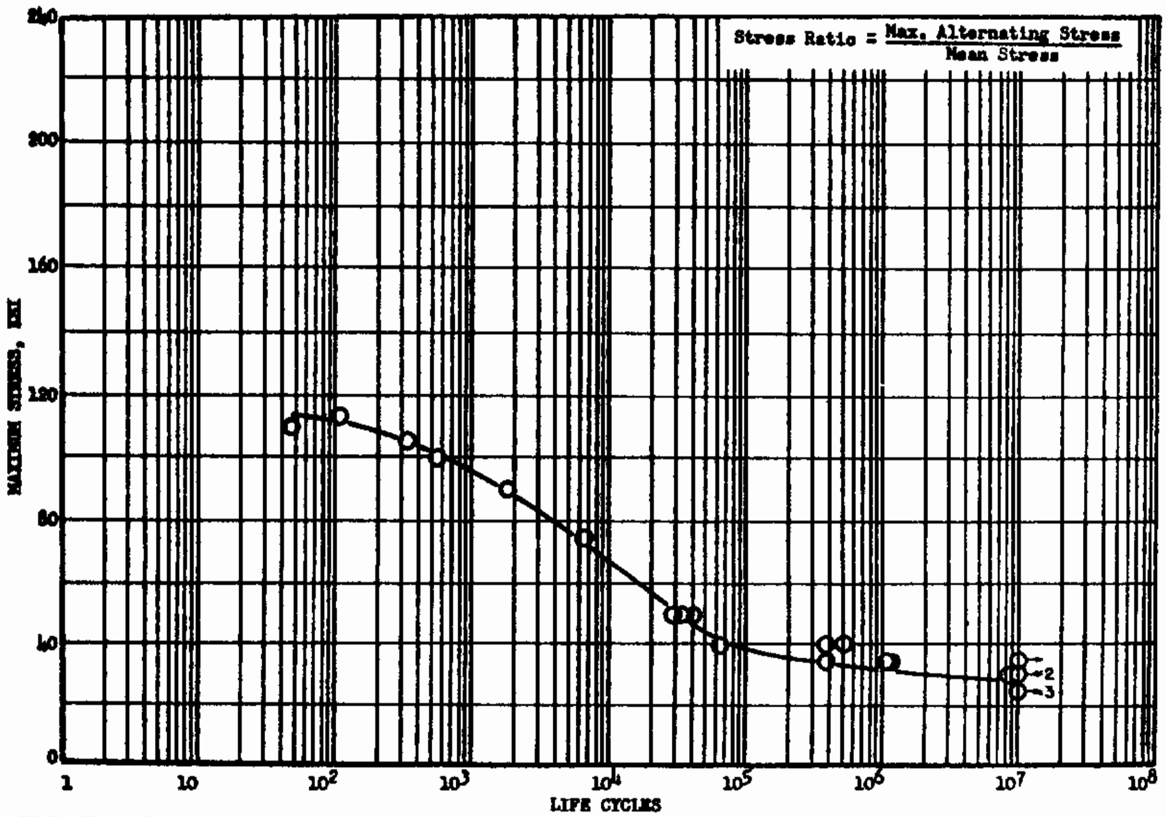


FIGURE 106 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 31372 AND 32163)

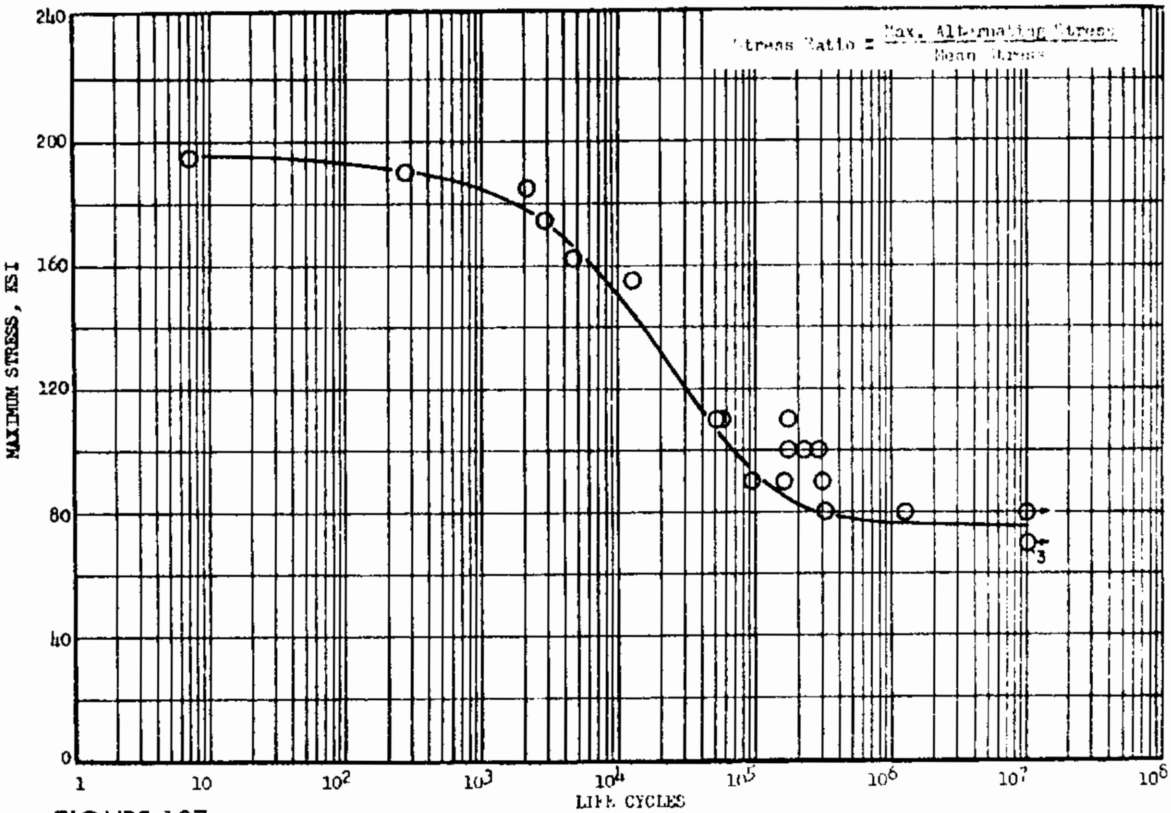


FIGURE 107 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

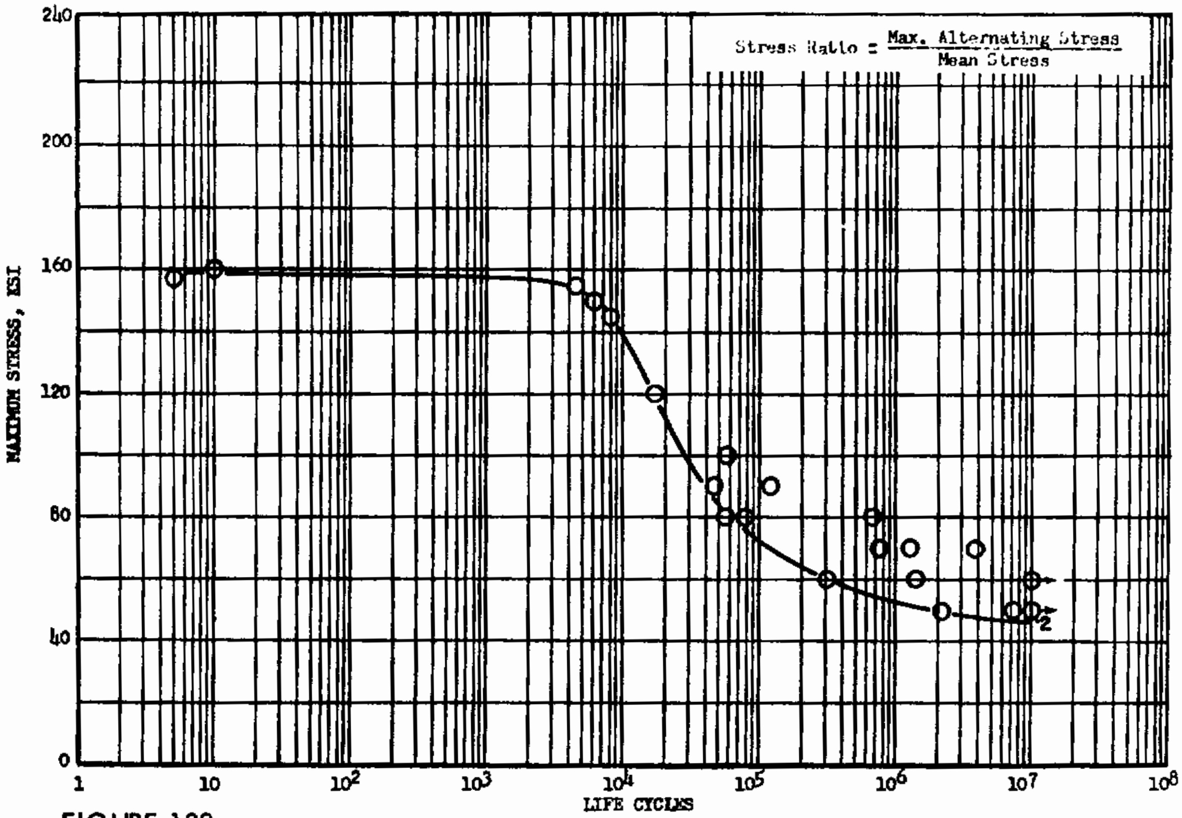


FIGURE 108 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

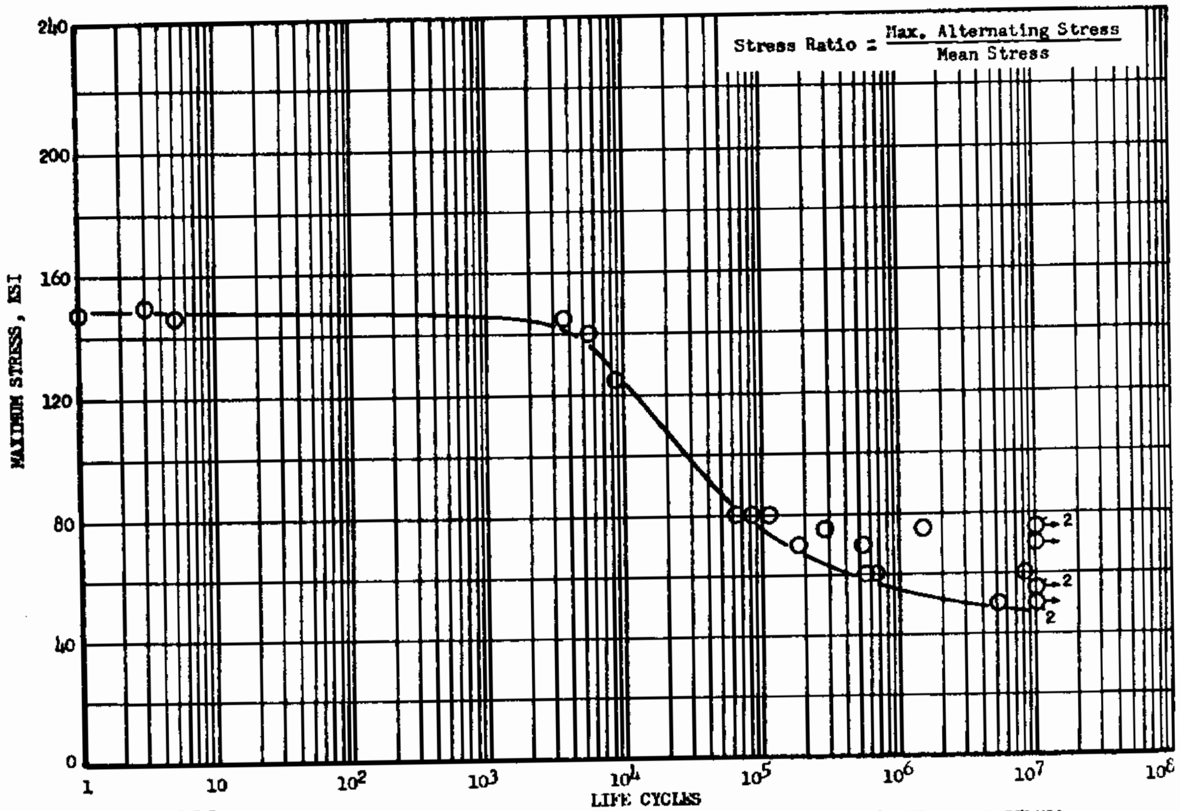


FIGURE 109 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

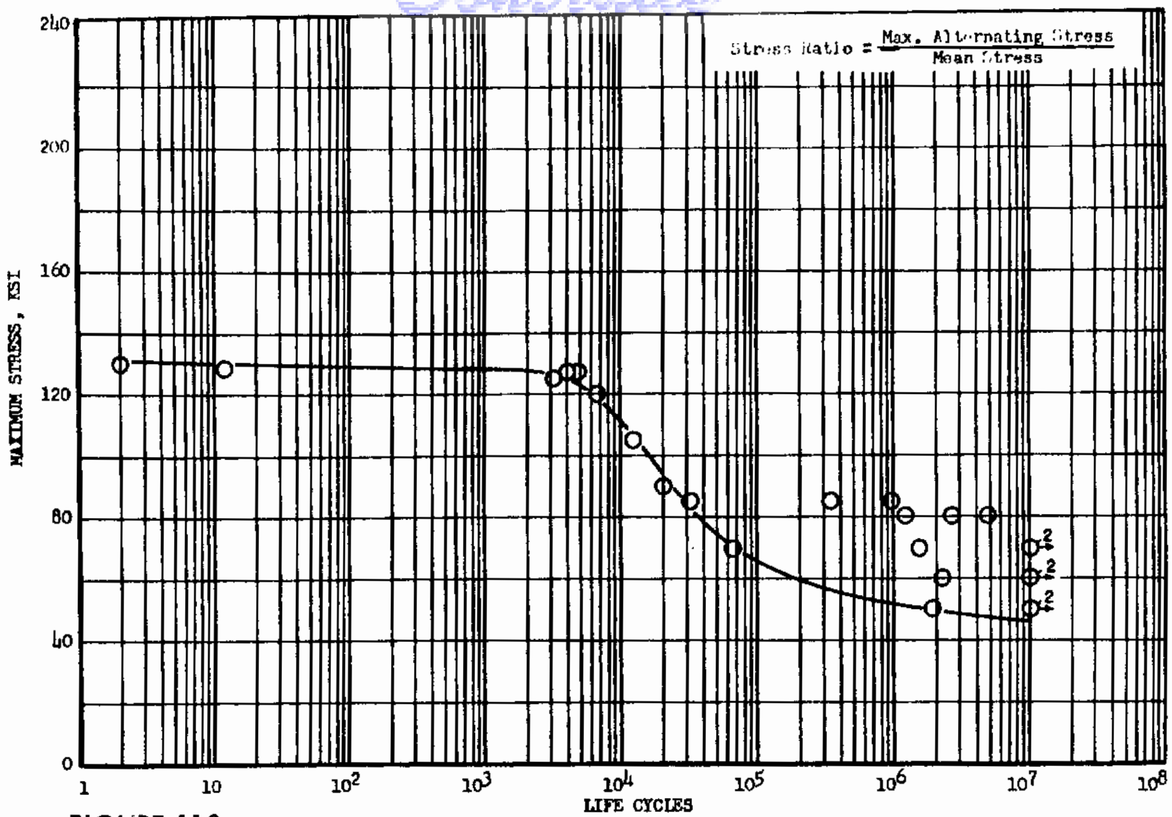


FIGURE 110 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

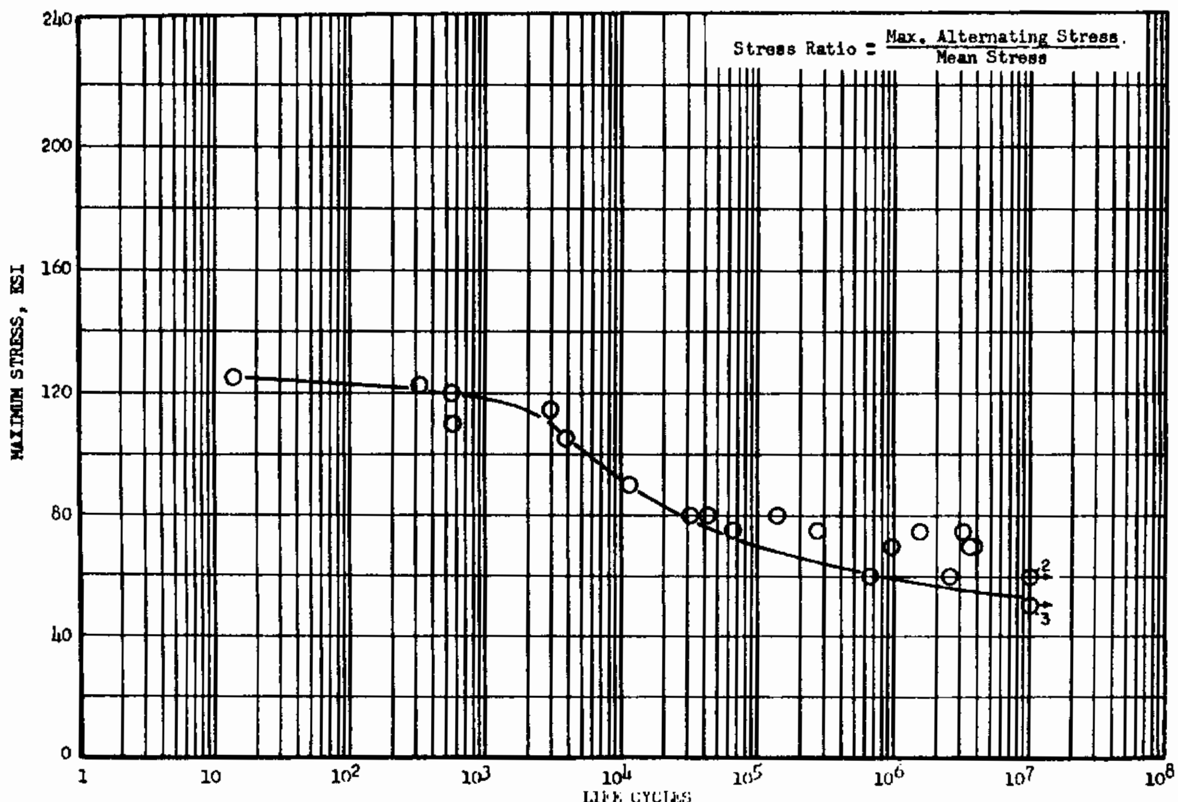


FIGURE 111 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 900 F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

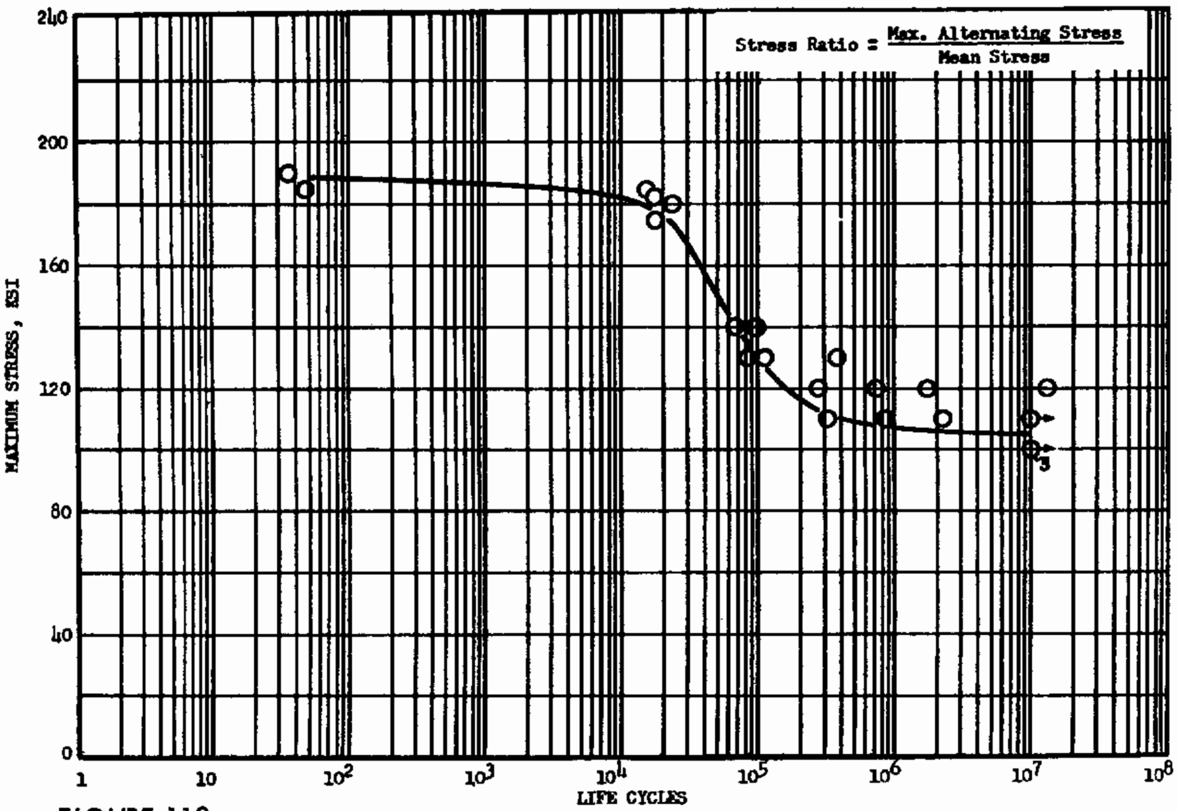


FIGURE 112 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

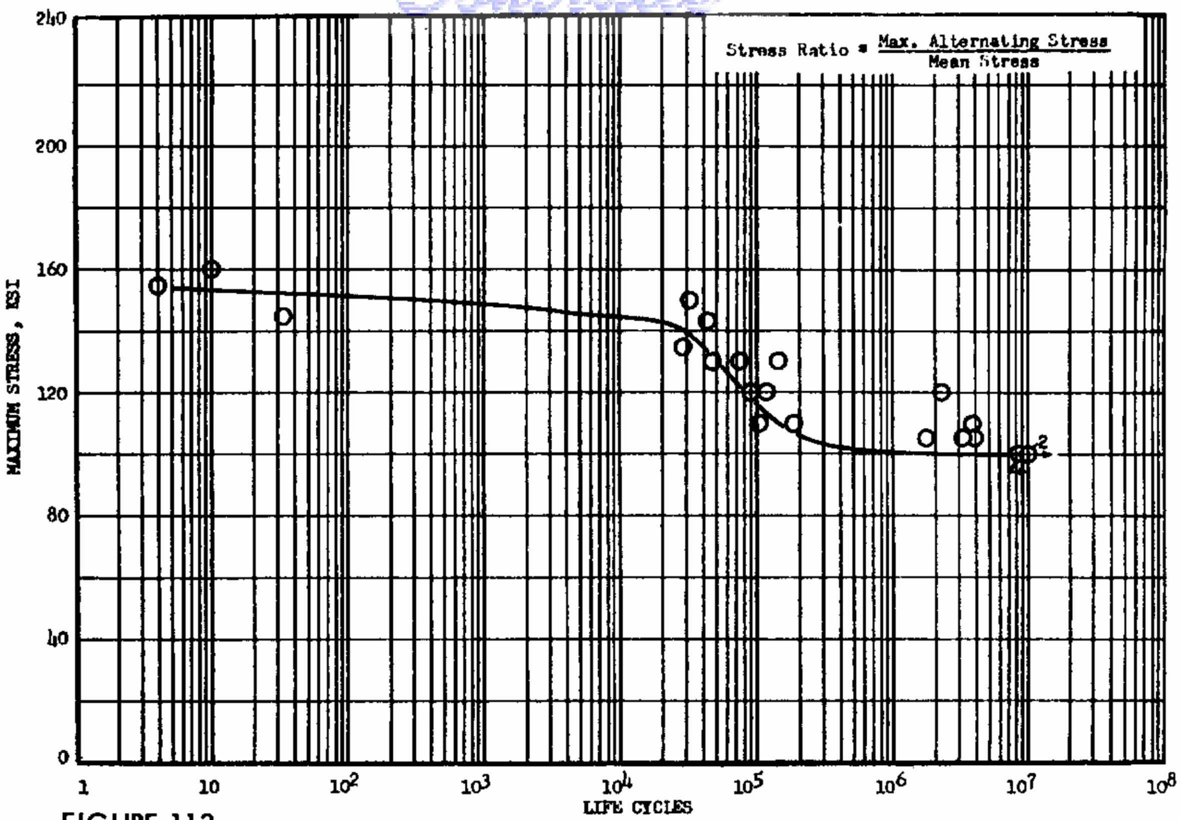


FIGURE 113 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

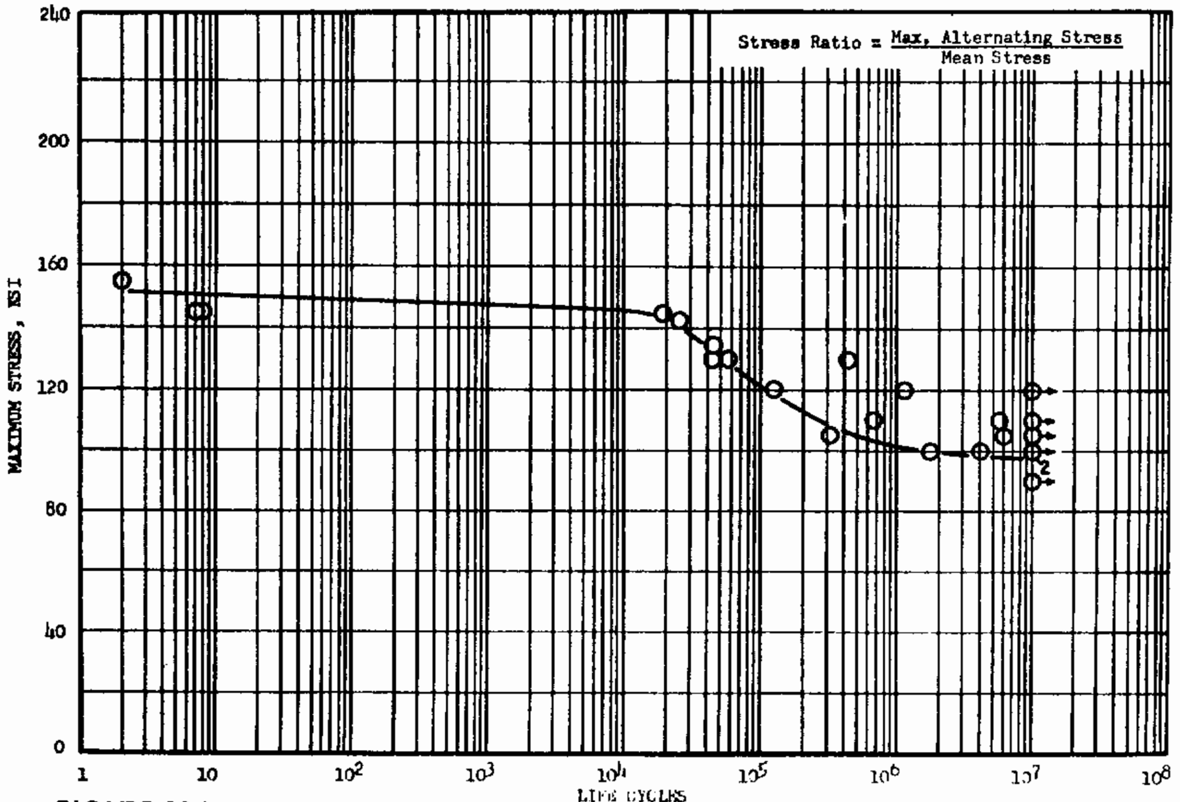


FIGURE 114 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

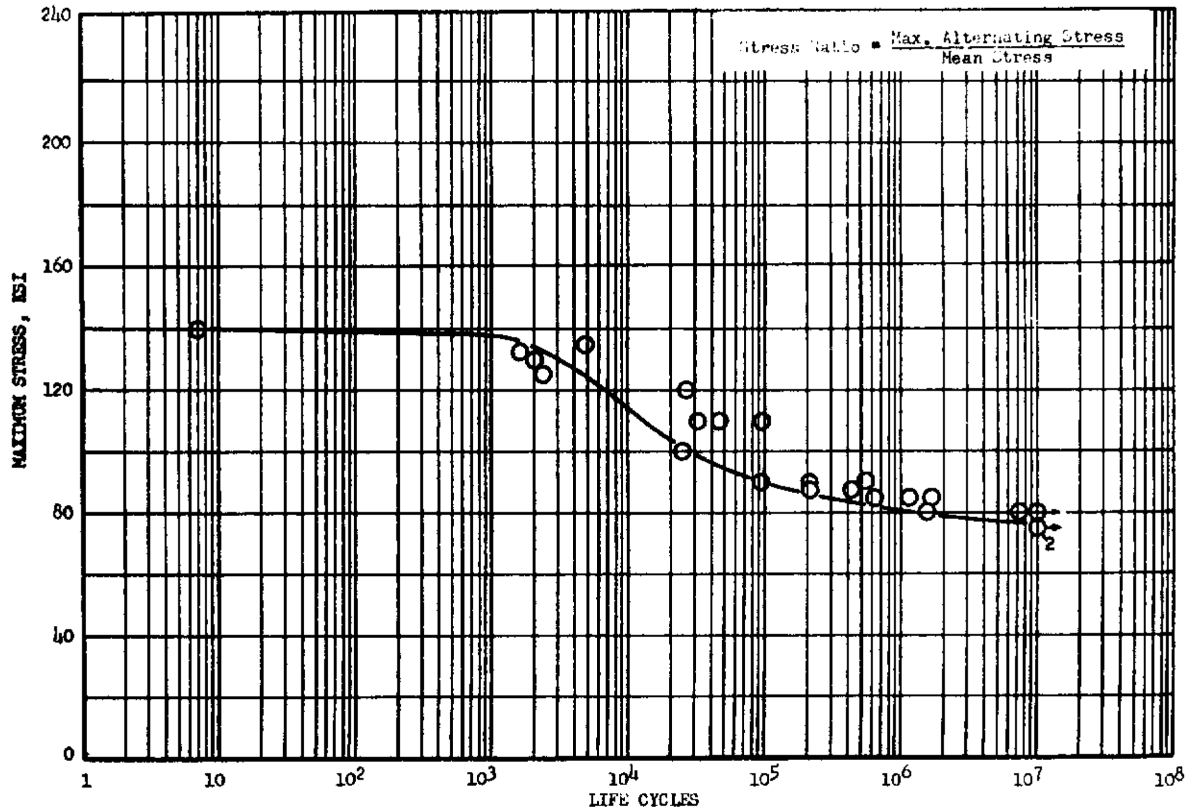


FIGURE 115 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

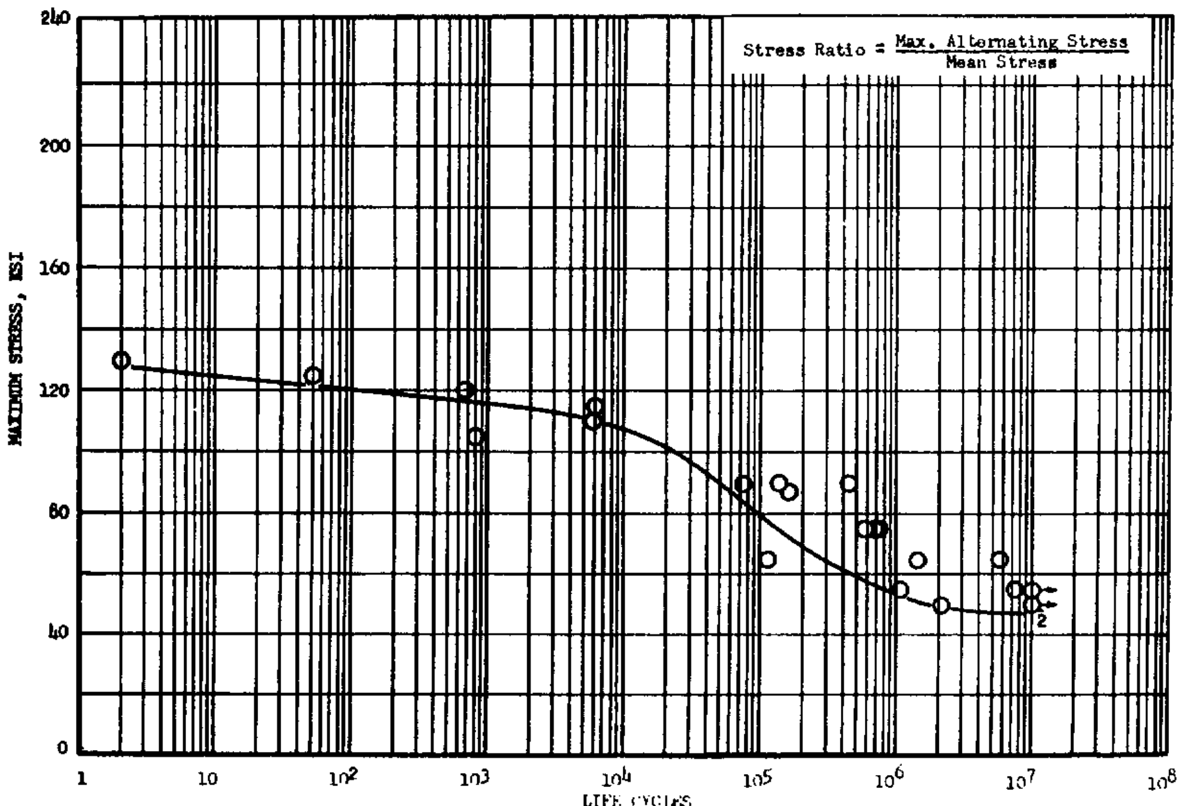


FIGURE 116 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

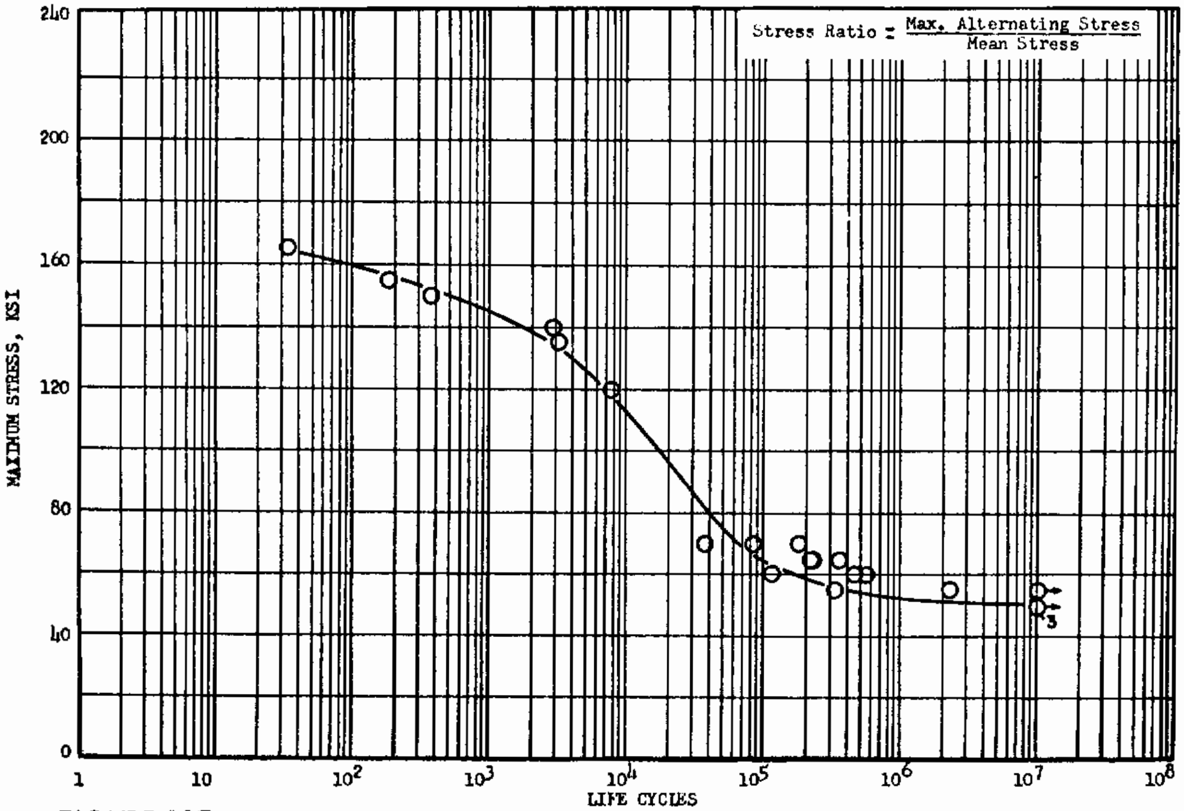


FIGURE 117 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 32167)

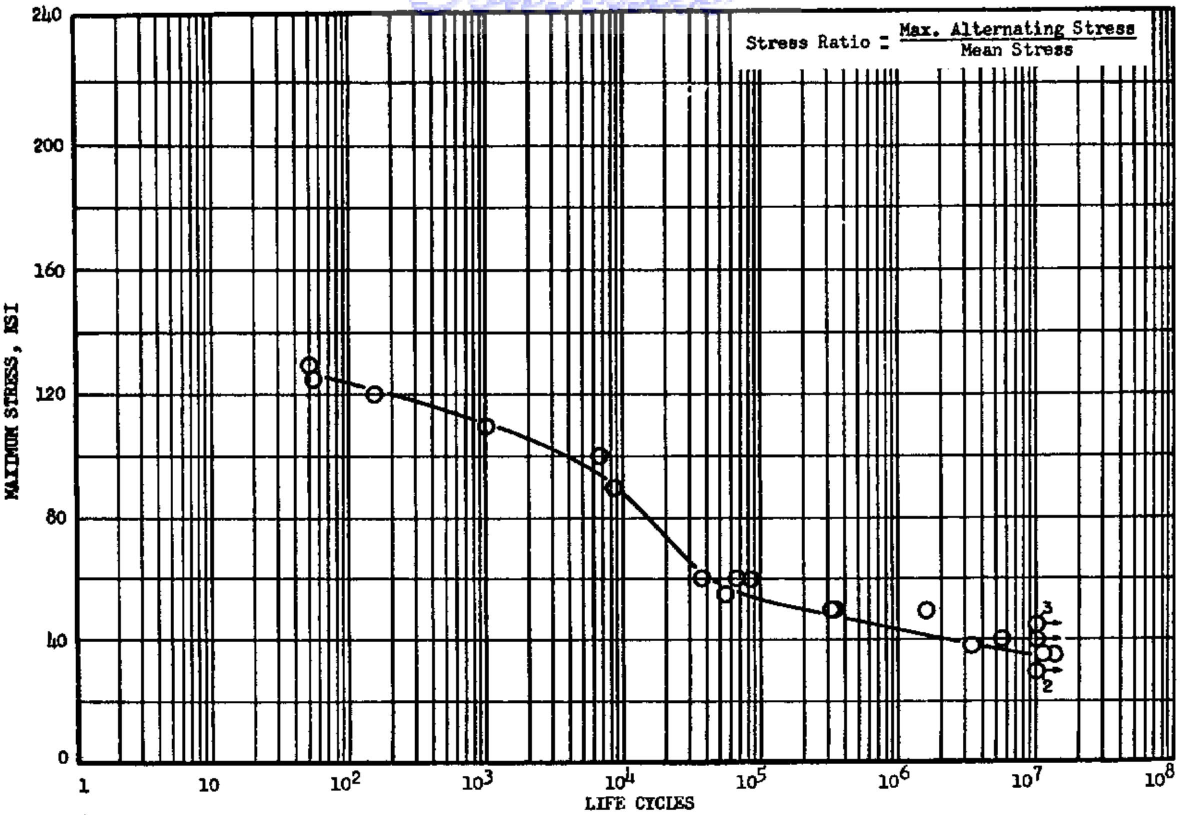


FIGURE 118 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 32167)

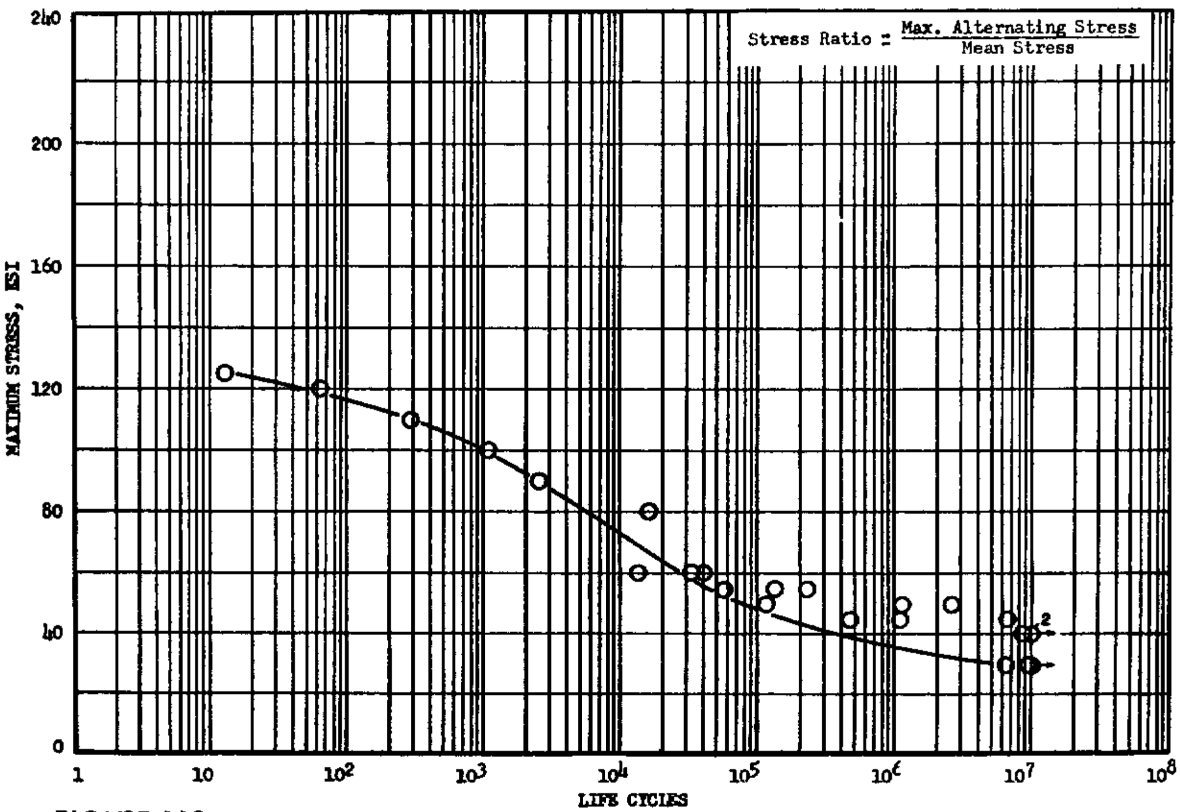


FIGURE 119 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 32167)

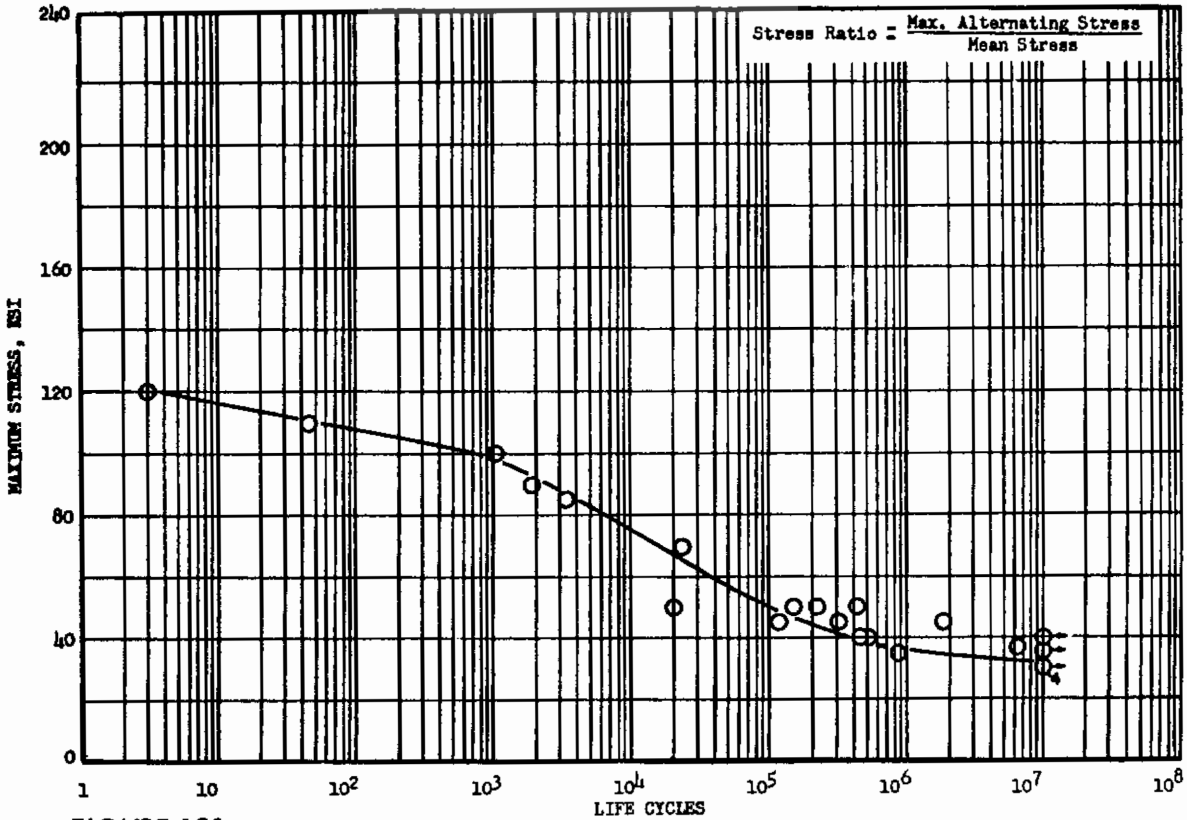


FIGURE 120 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 32167)

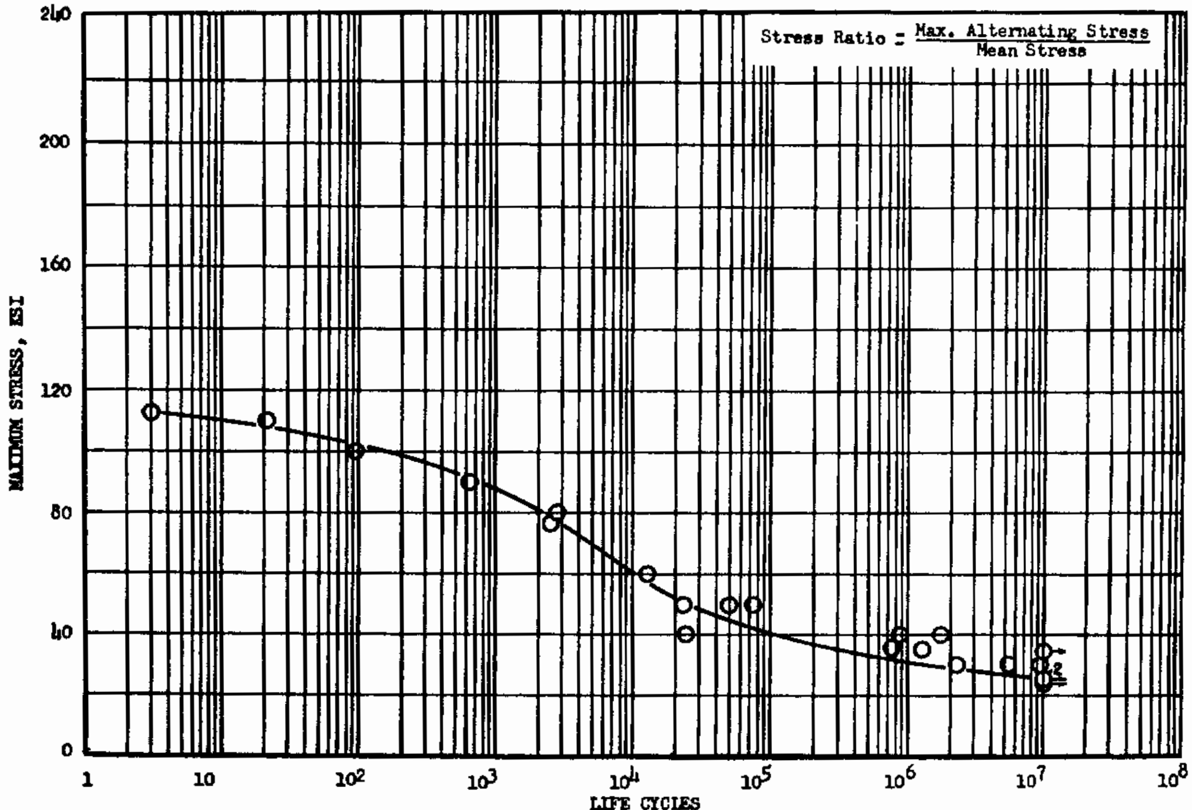


FIGURE 121 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 32167)

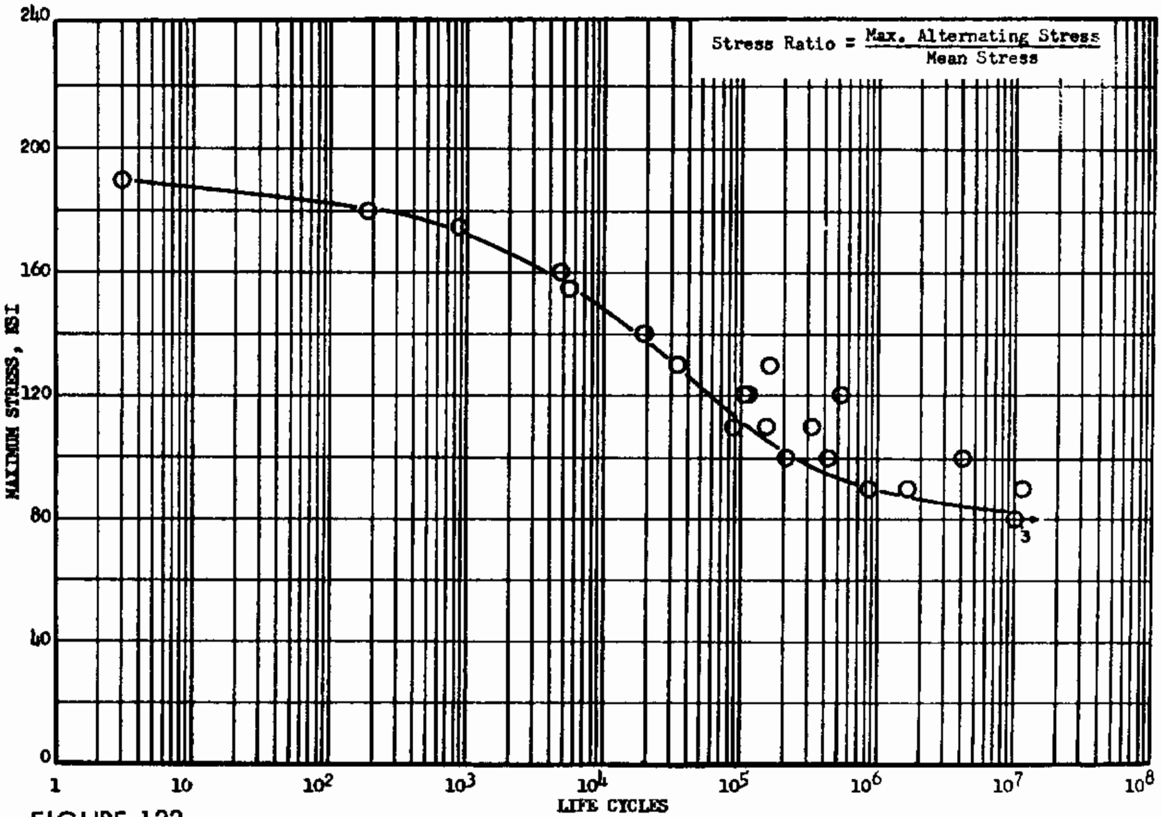


FIGURE 122 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 32167)

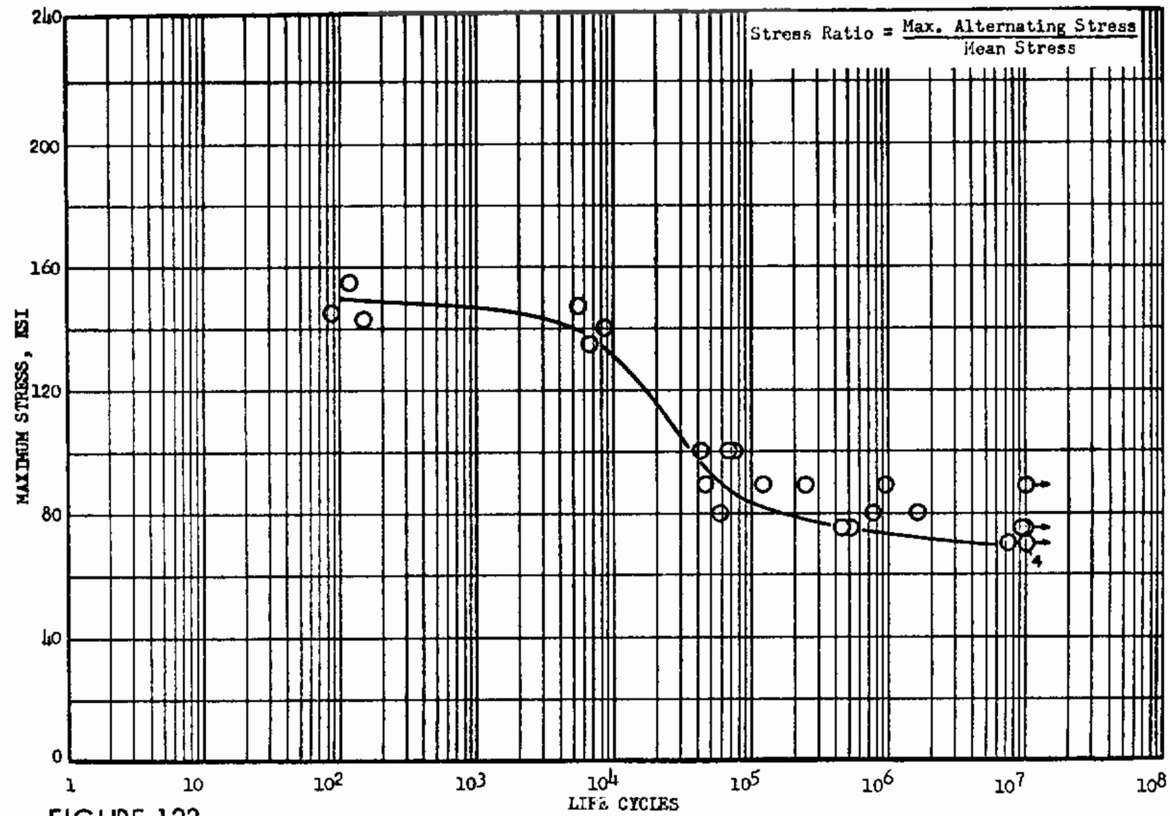


FIGURE 123 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 32167)

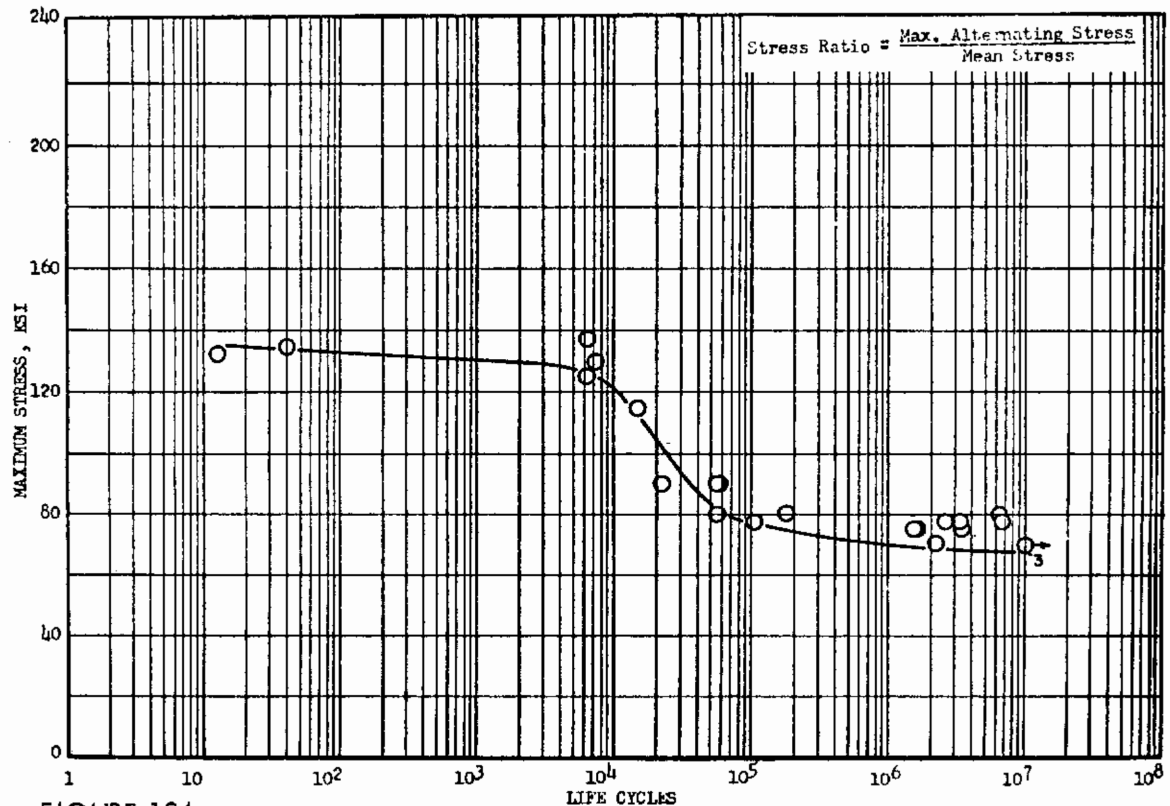


FIGURE 124 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 32167)

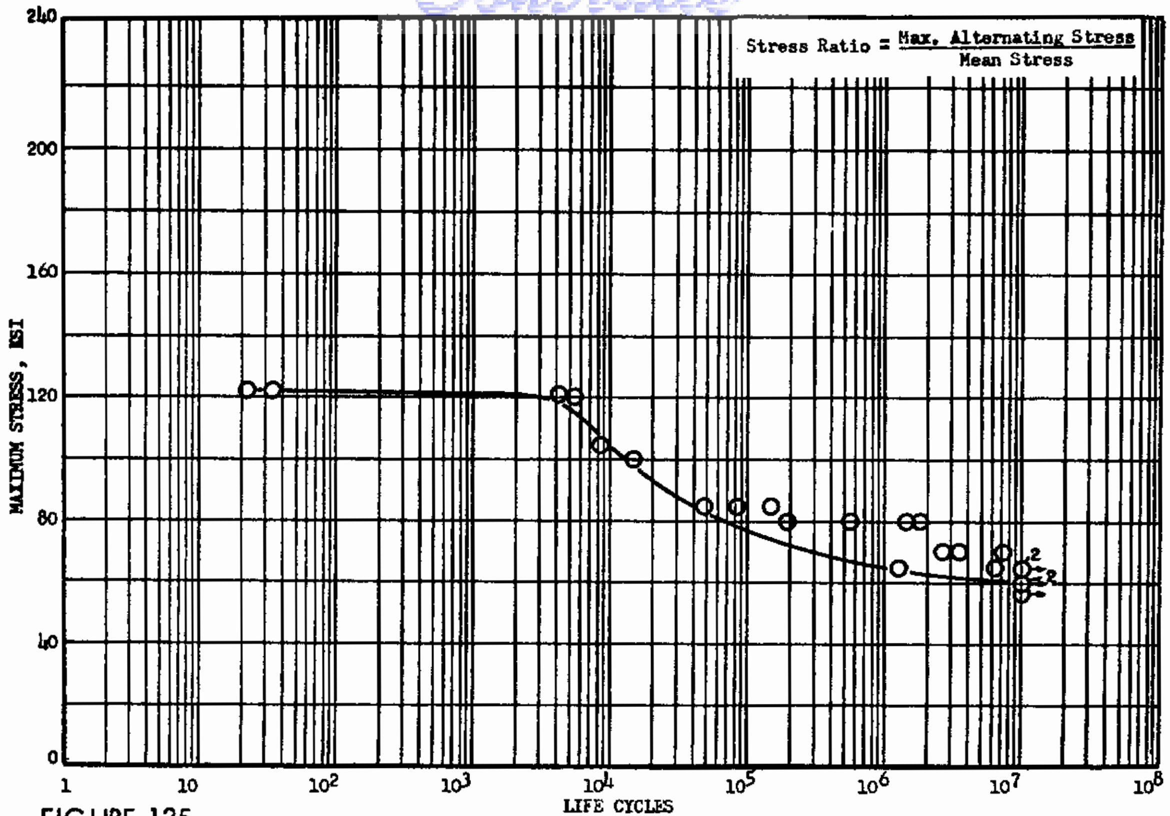


FIGURE 125 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 32167)

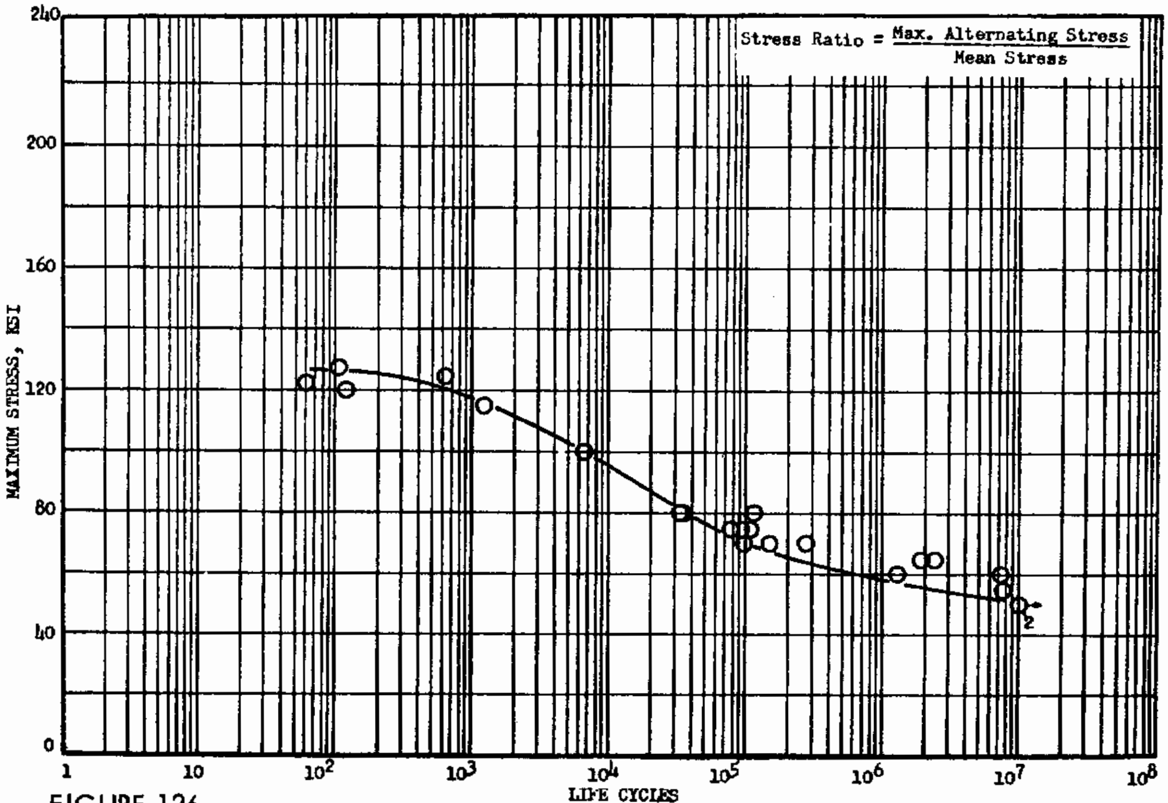


FIGURE 126 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 32167)

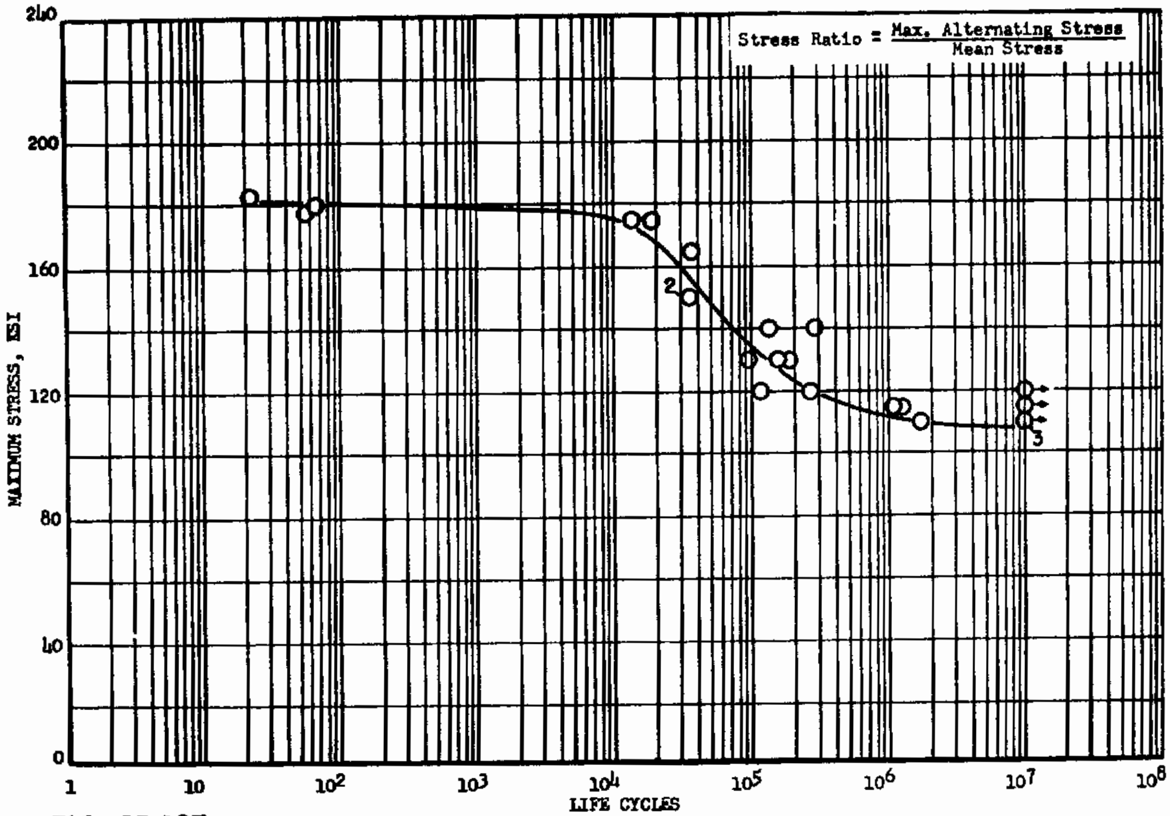


FIGURE 127 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 32167)

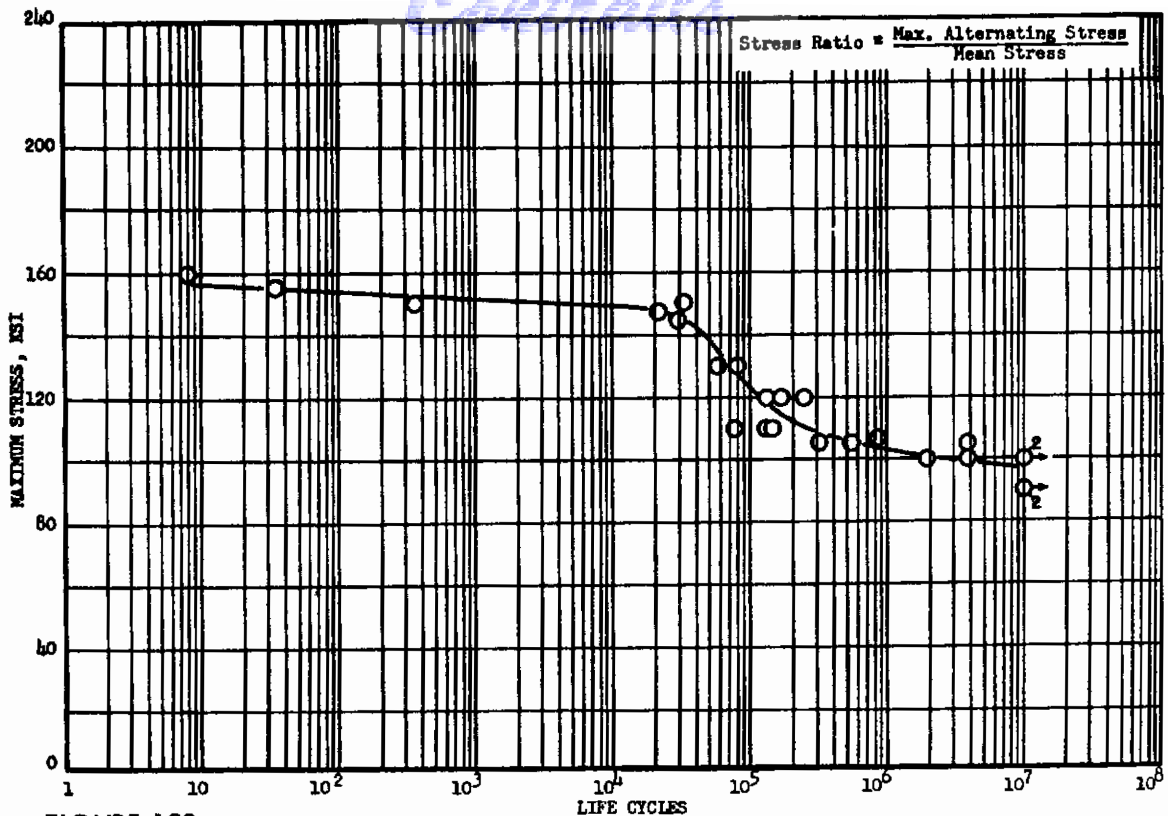


FIGURE 128 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 32167)

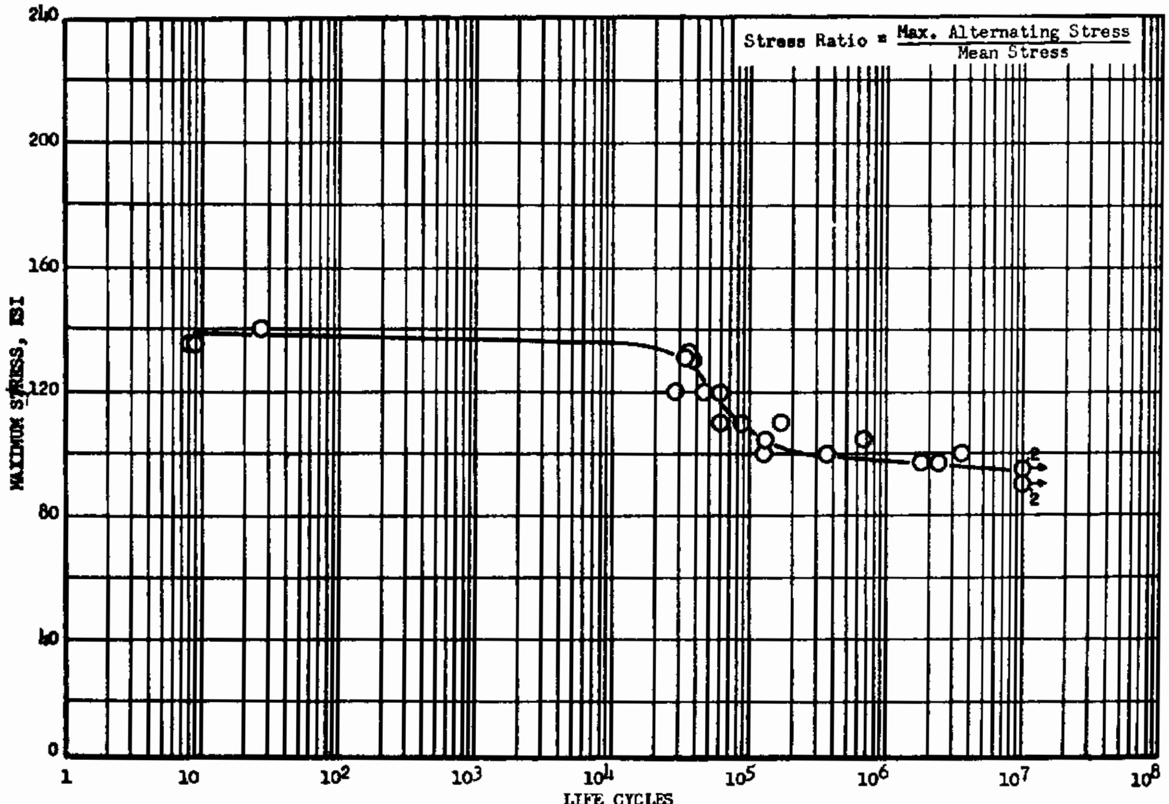


FIGURE 129 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 32167)

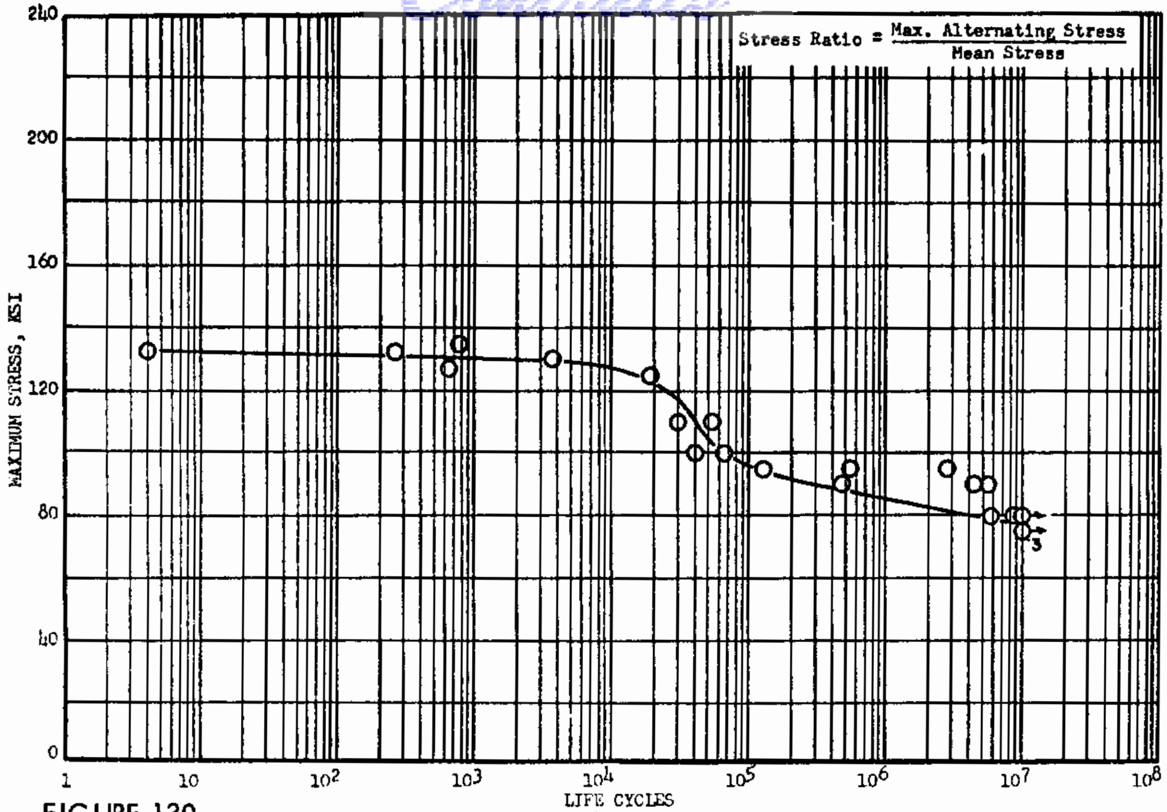


FIGURE 130 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 32167)

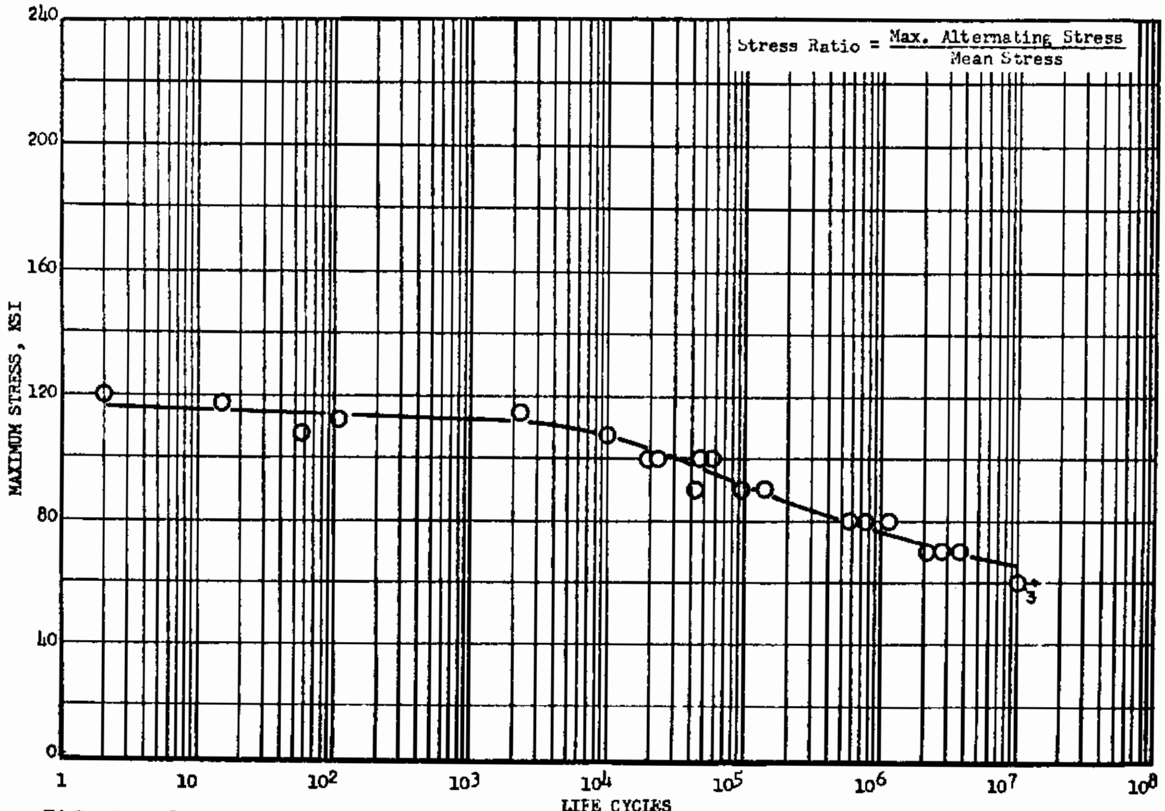


FIGURE 131 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 32167)

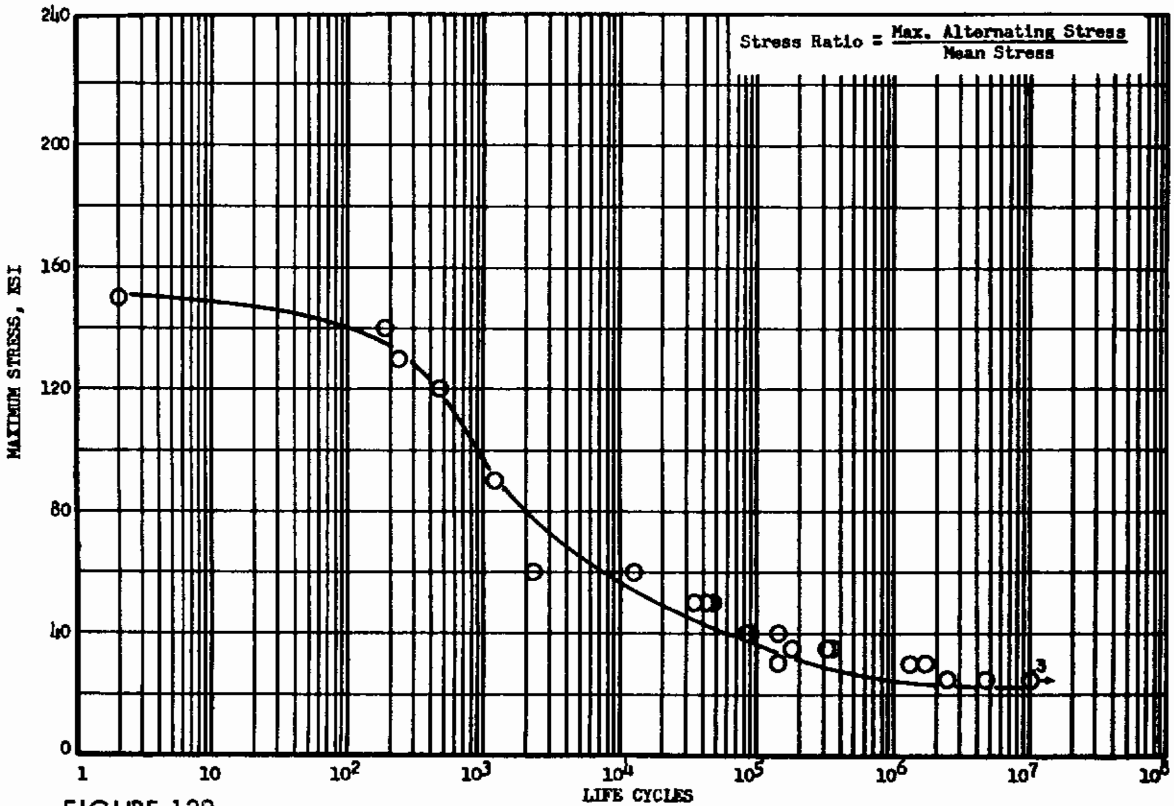


FIGURE 132 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 31372 AND 32163)

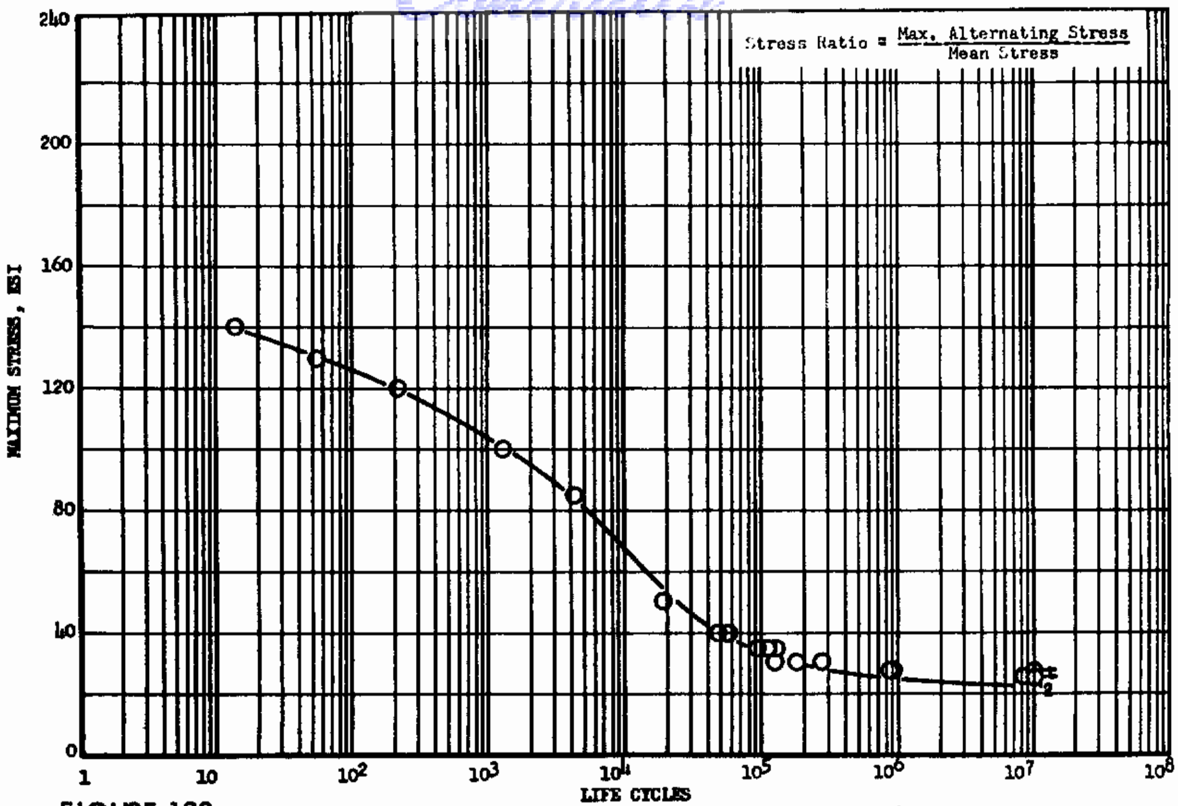


FIGURE 133 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 31372 AND 32163)

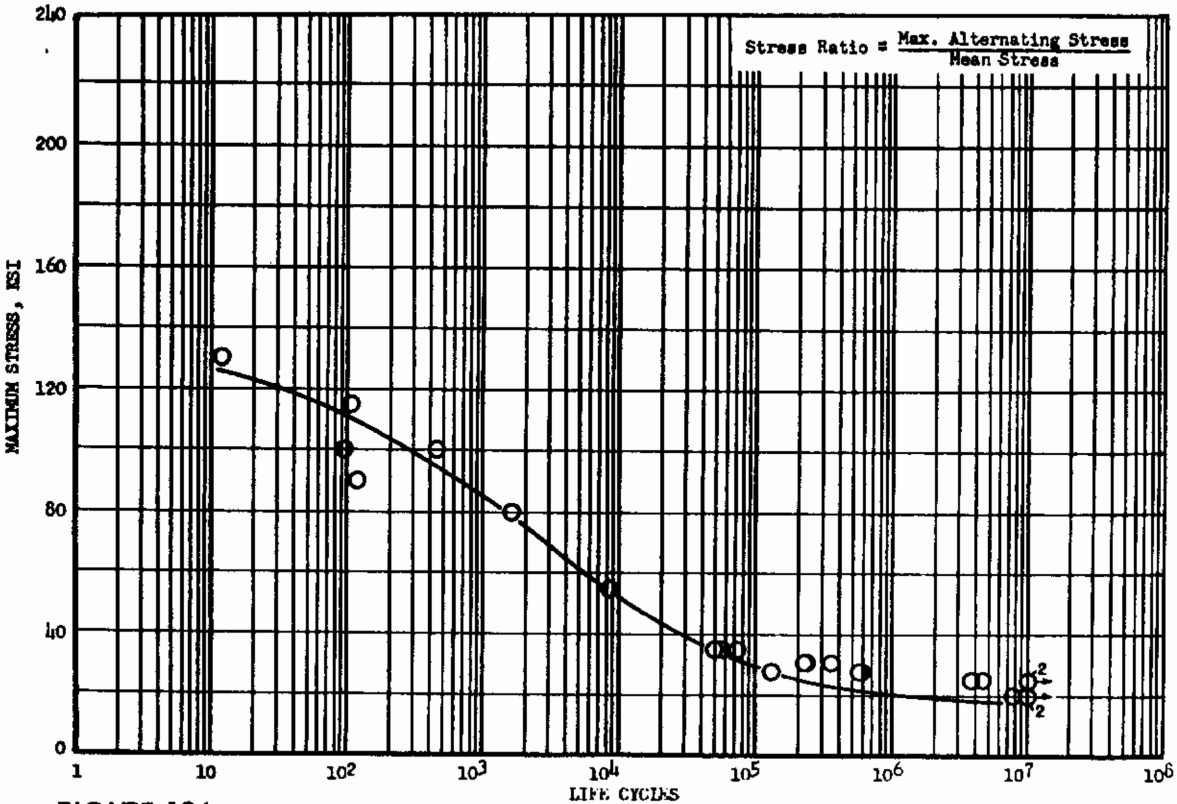


FIGURE 134 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 31372 AND 32163)

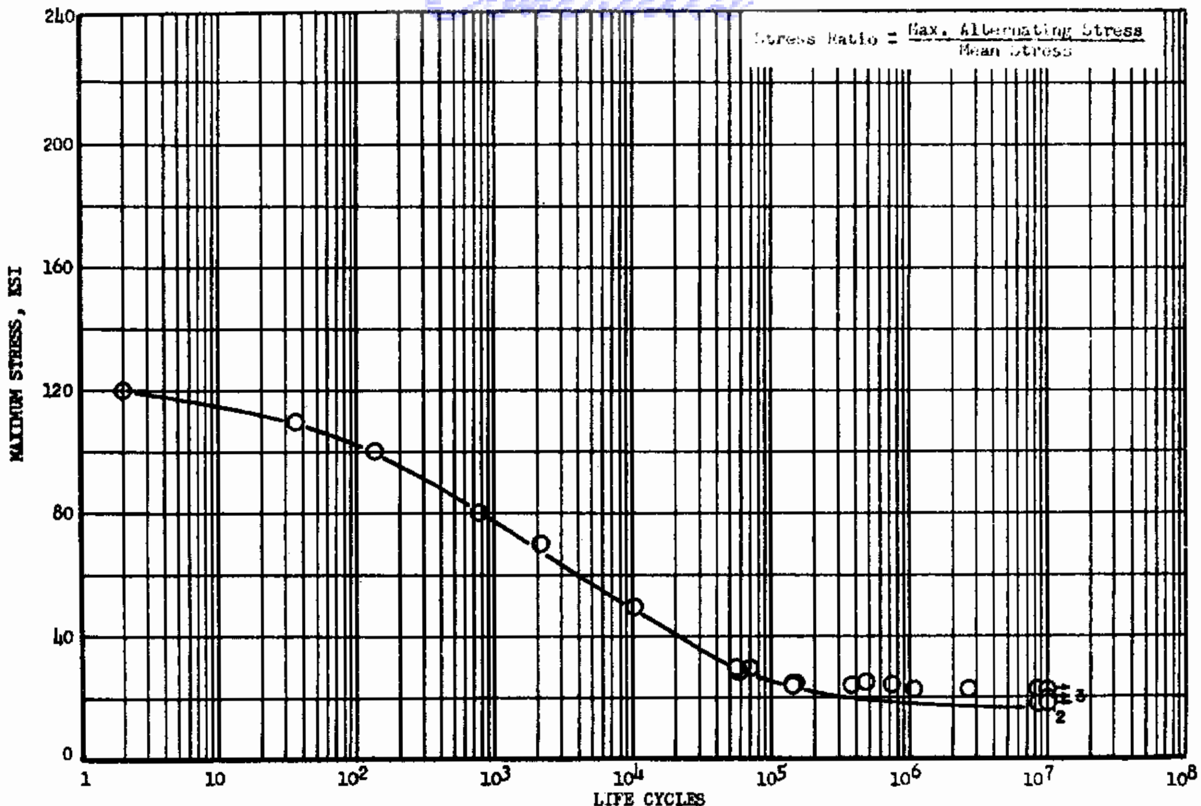


FIGURE 135 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 31372 AND 32163)

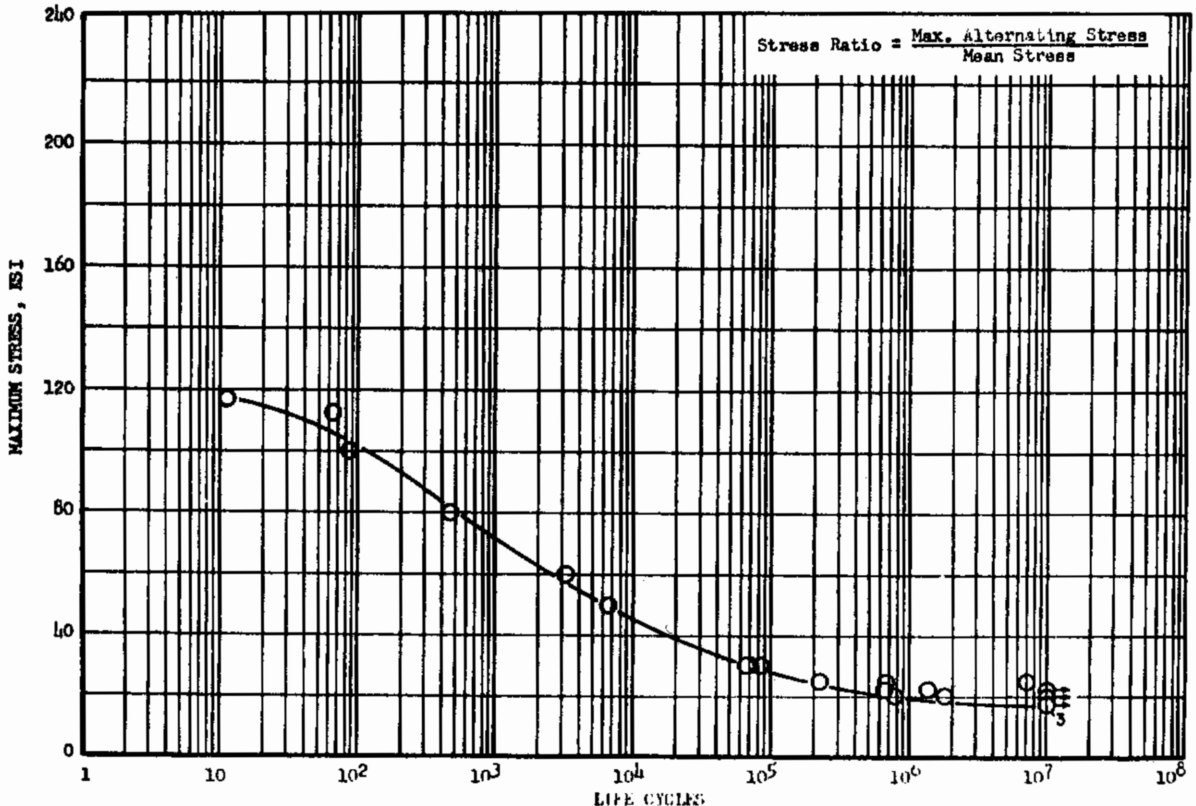


FIGURE 136 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 31372 AND 32163)

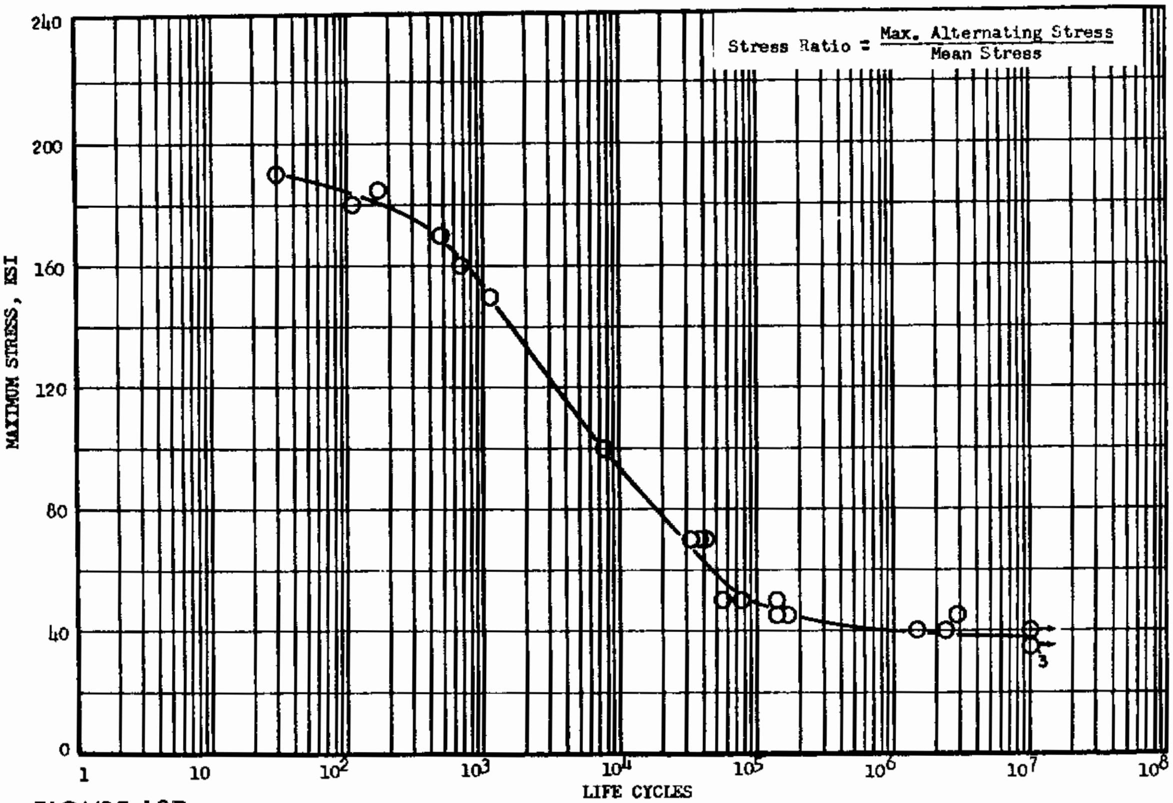


FIGURE 137 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

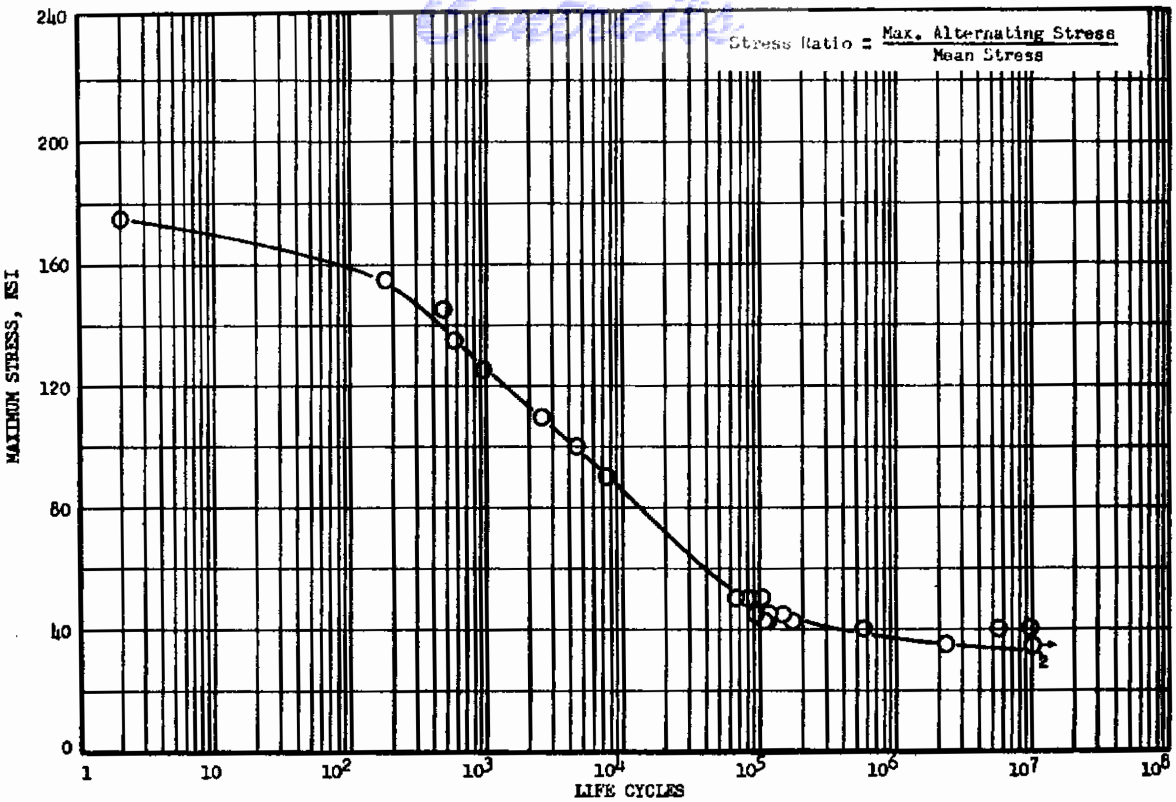


FIGURE 138 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

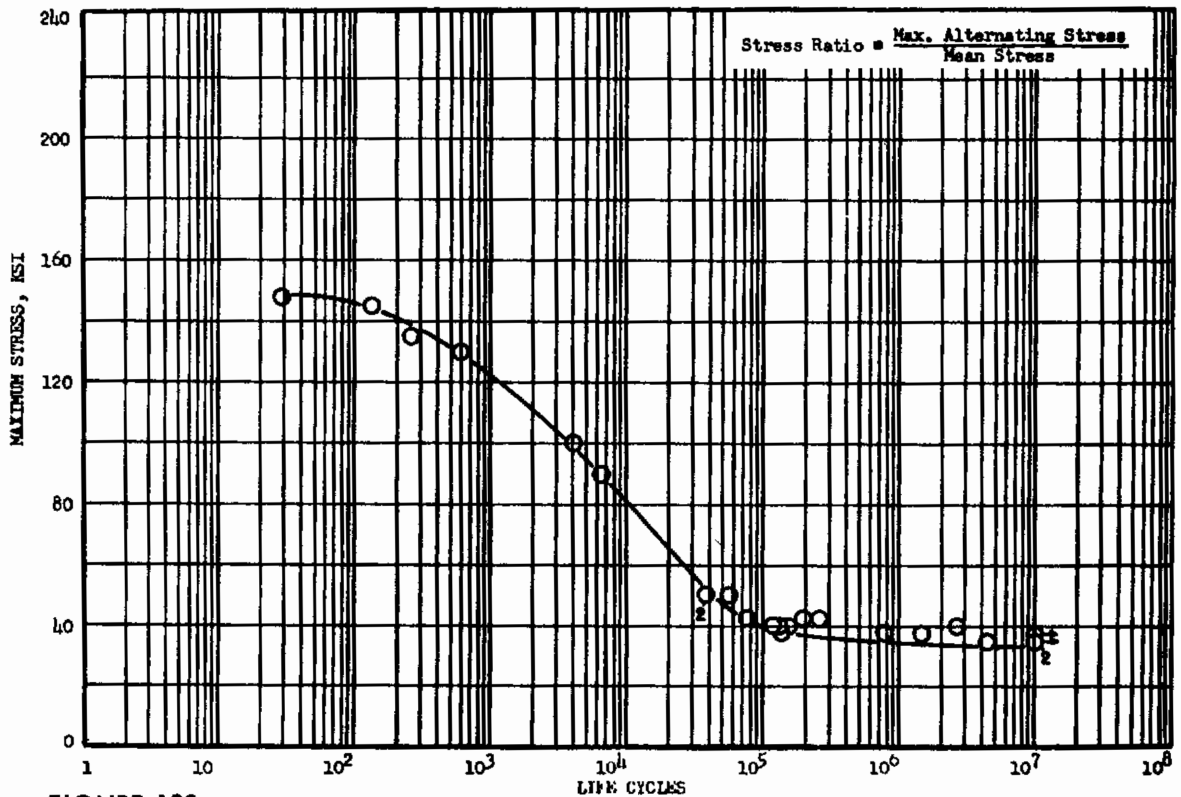


FIGURE 139 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

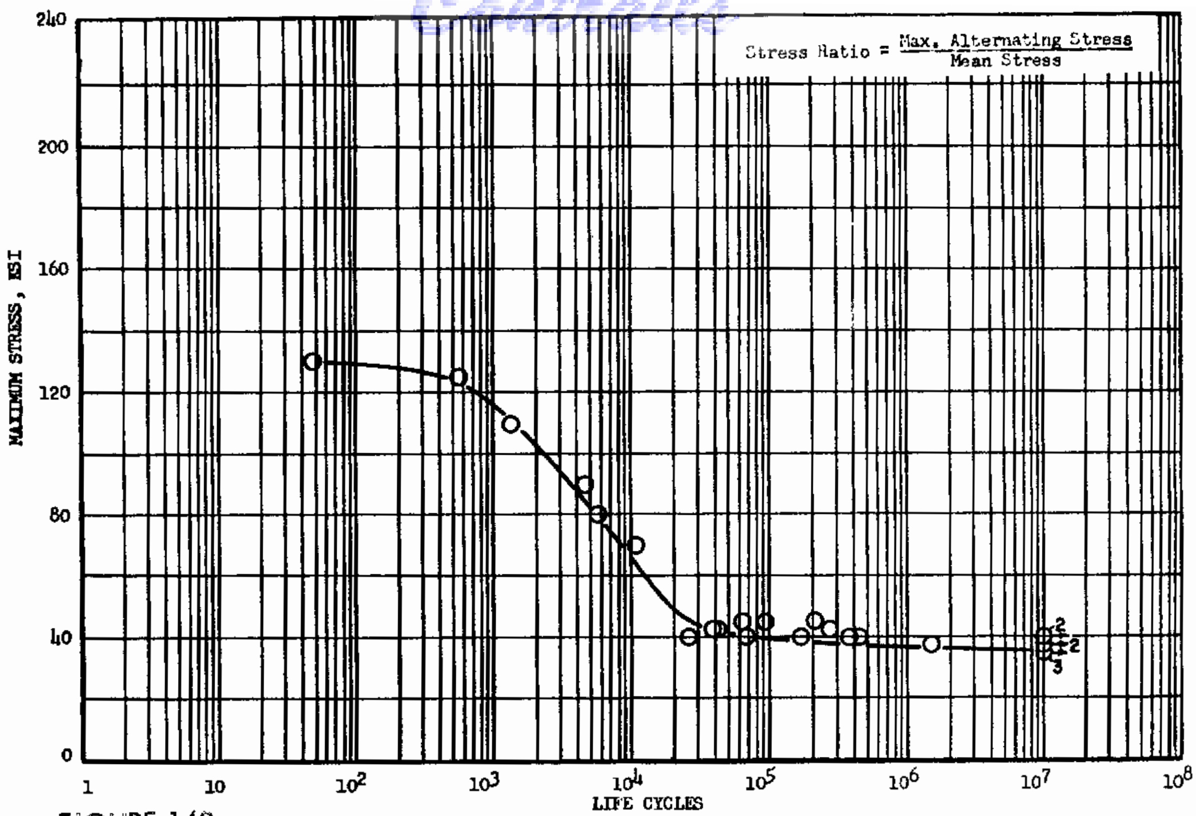


FIGURE 140 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

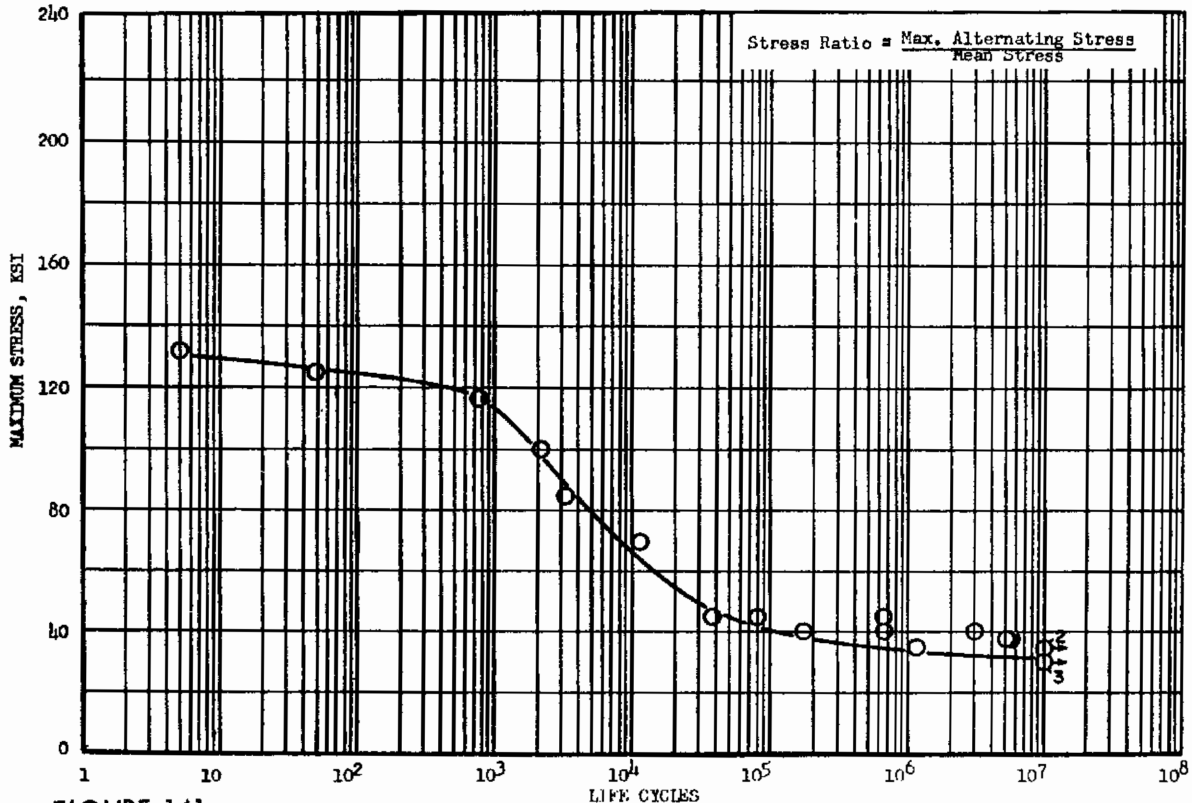


FIGURE 141 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

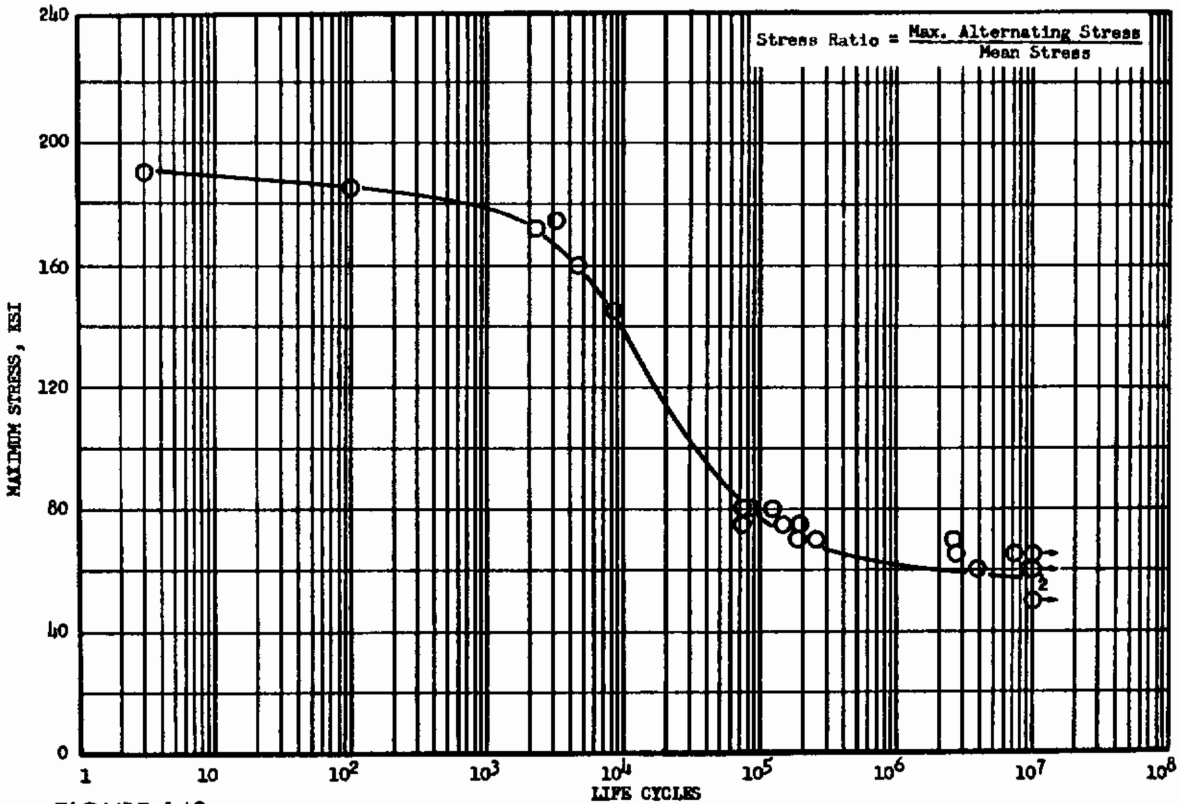


FIGURE 142 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

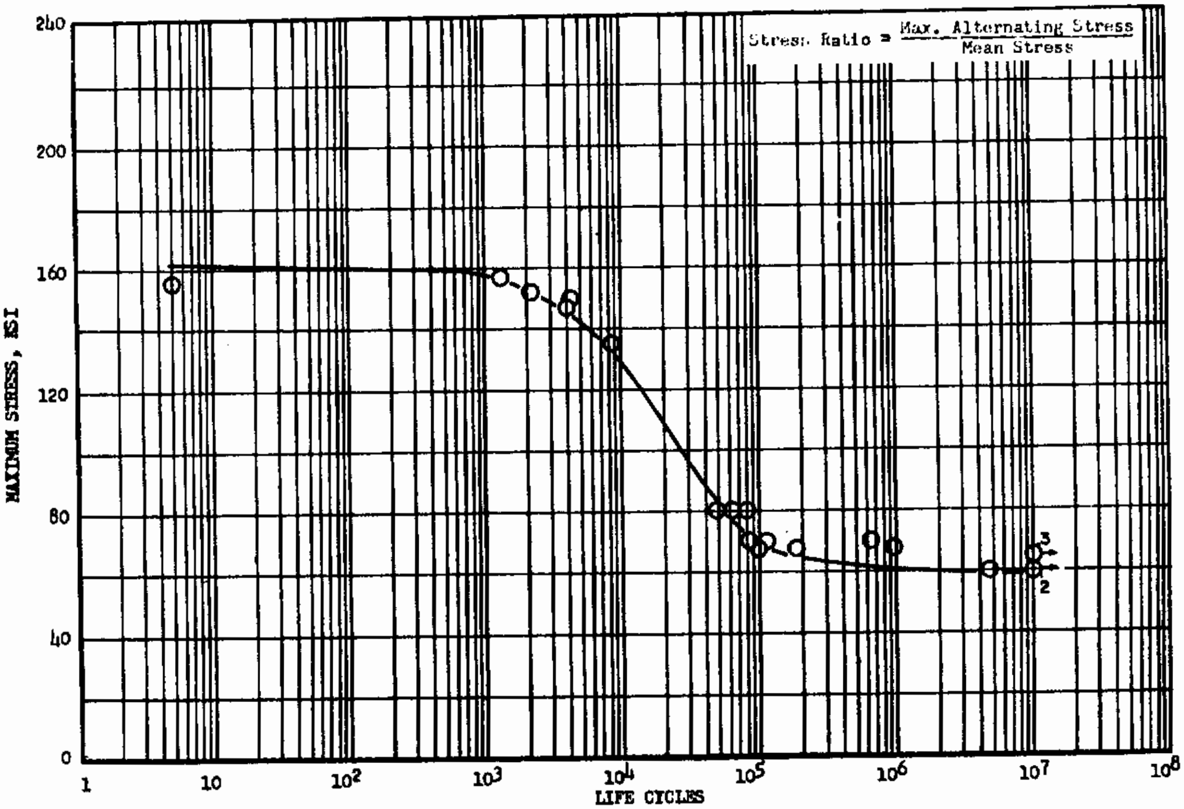


FIGURE 143 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

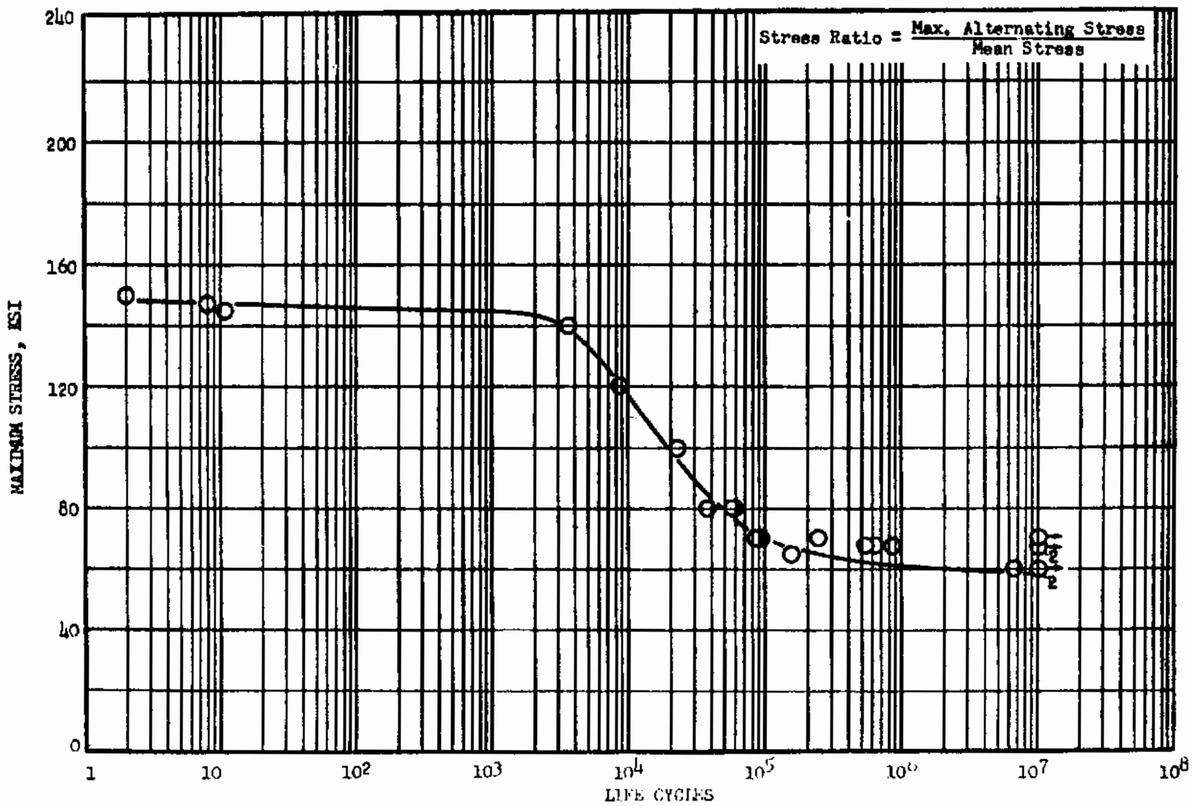


FIGURE 144 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

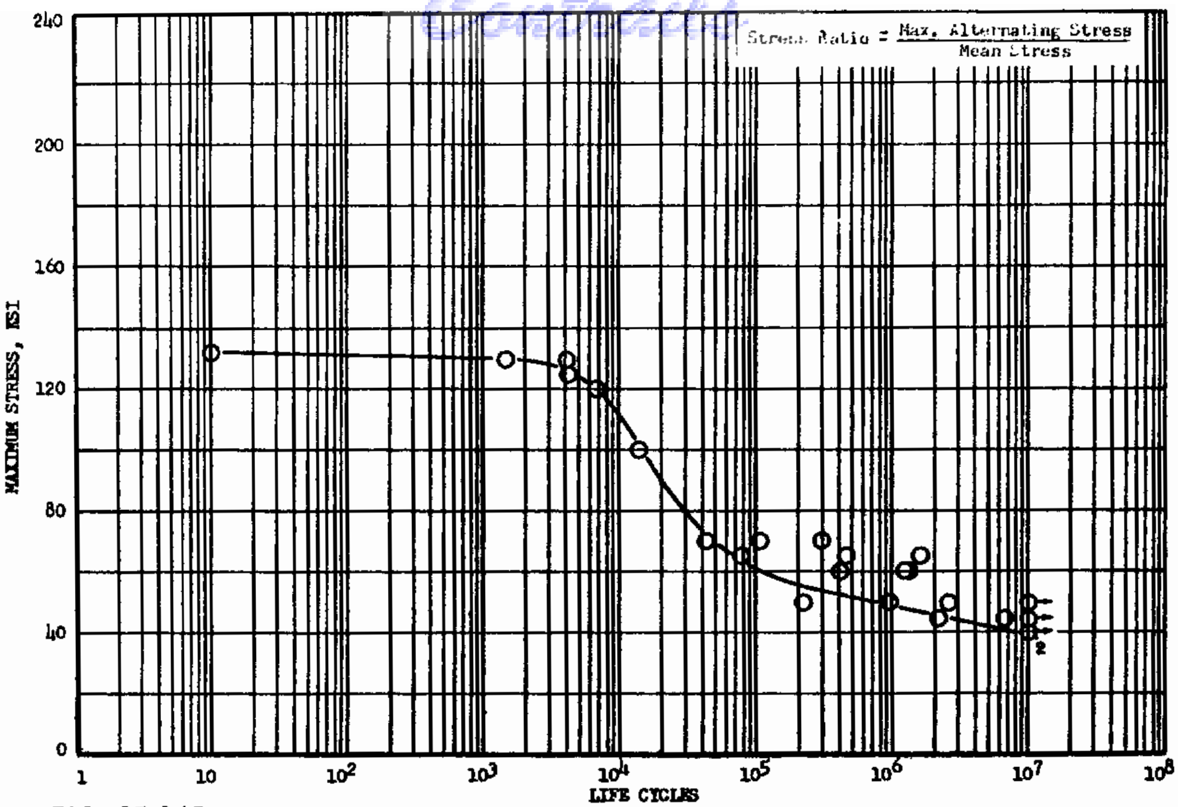


FIGURE 145 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

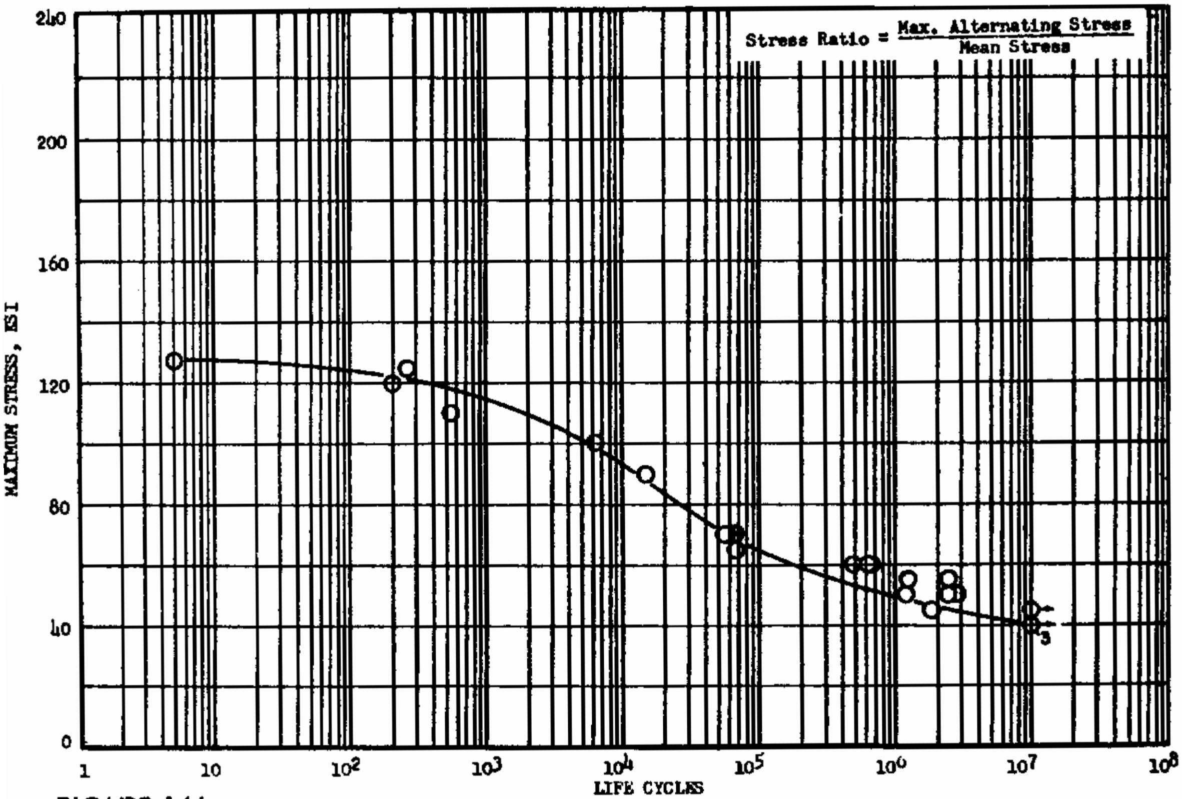


FIGURE 146 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.063 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NOS. 31372 AND 32163)

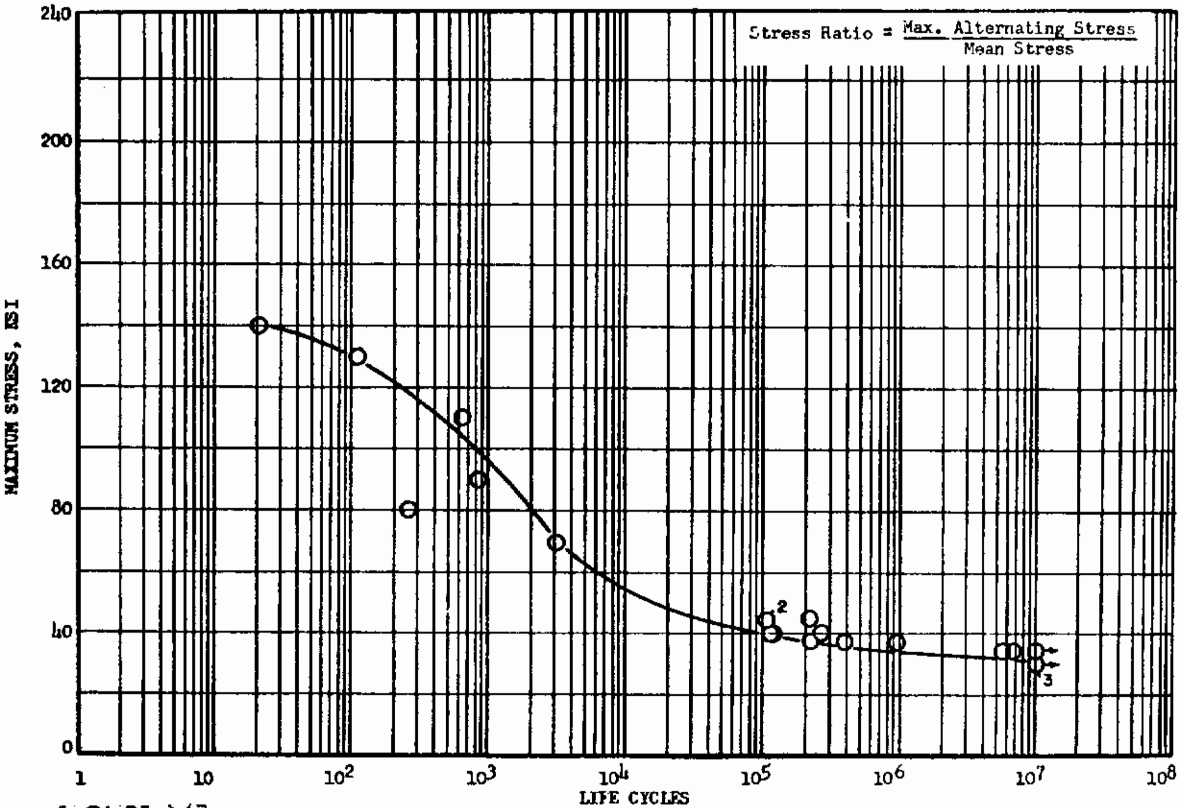


FIGURE 147 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 32167)

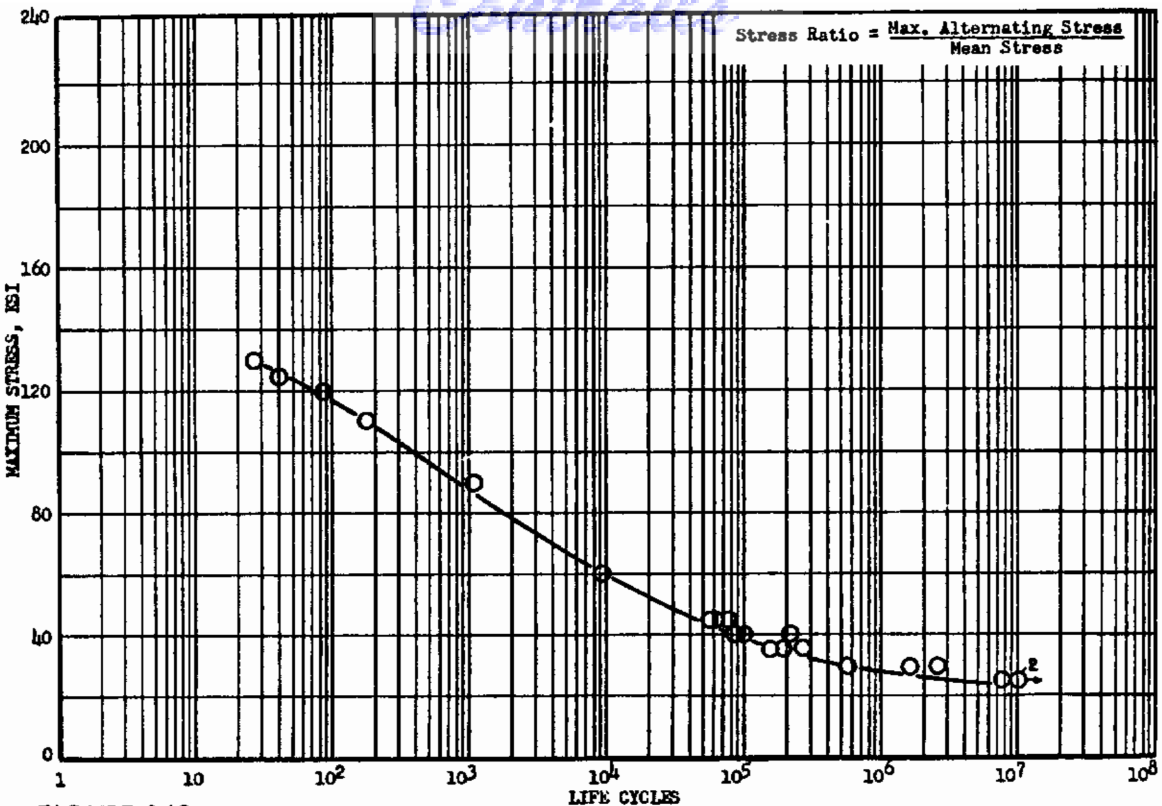


FIGURE 148 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 32167)

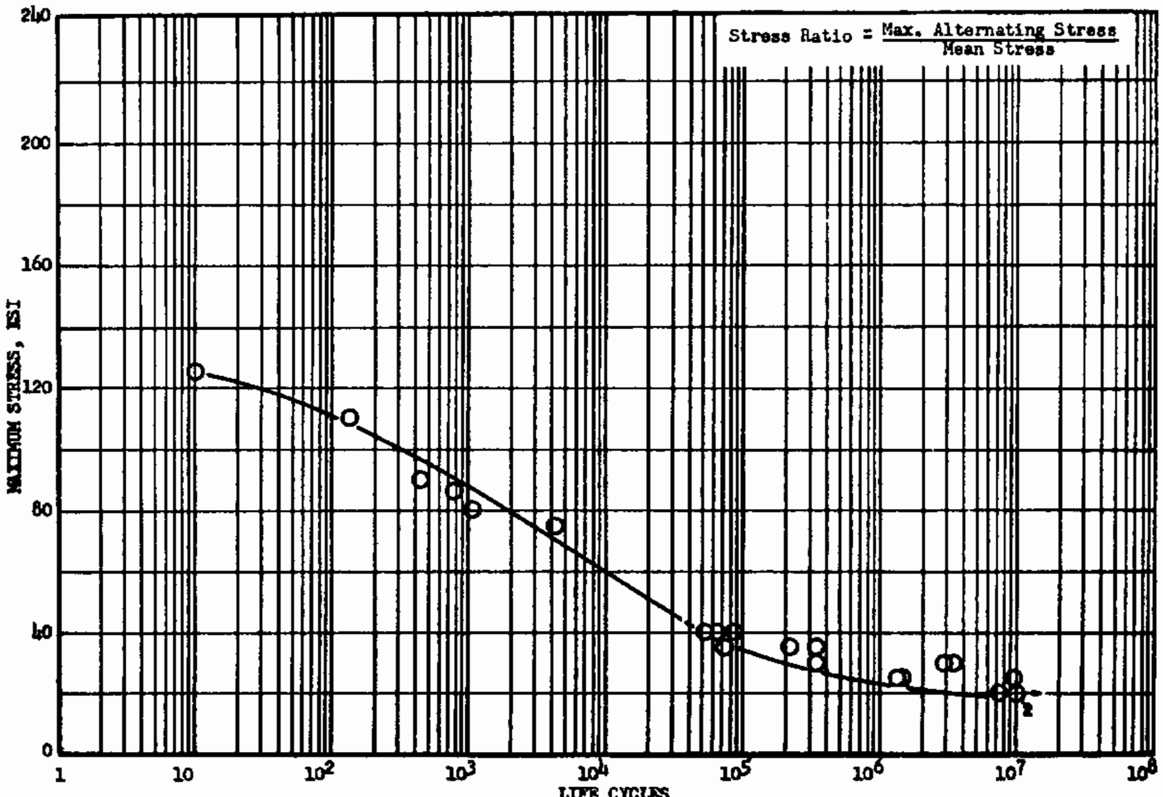


FIGURE 149 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 32167)

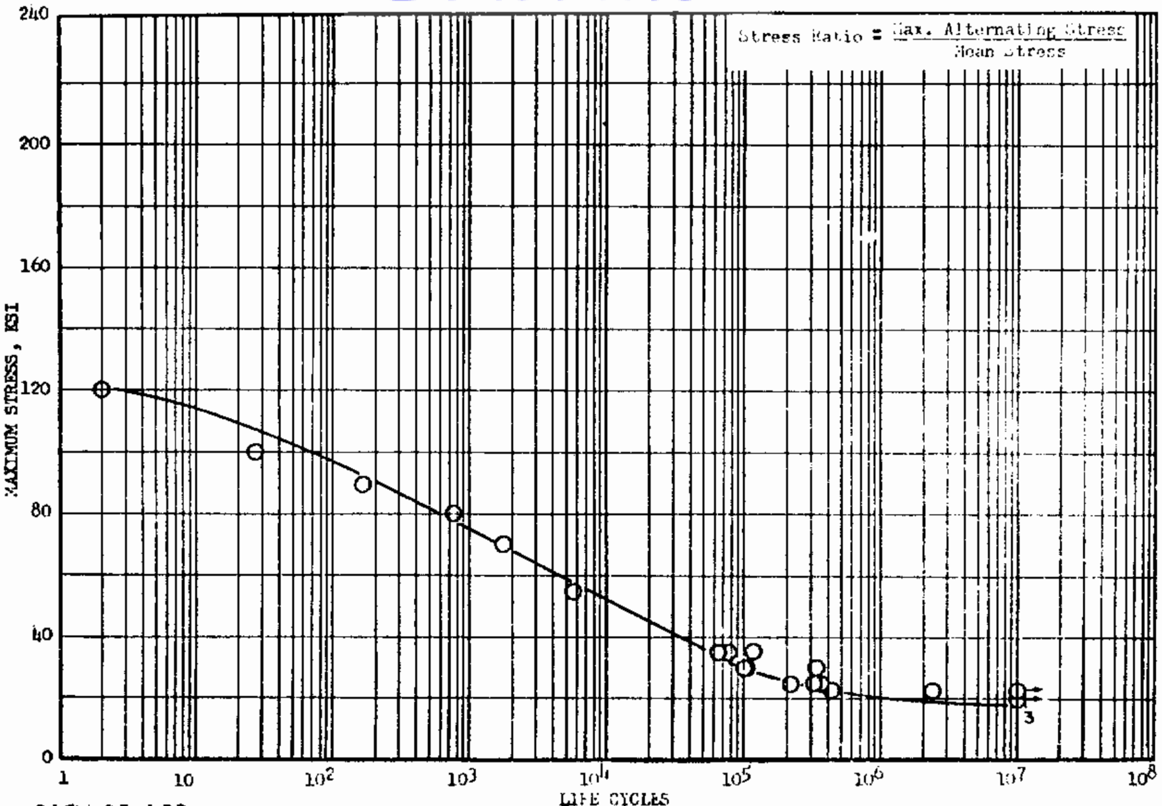


FIGURE 150 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 32167)

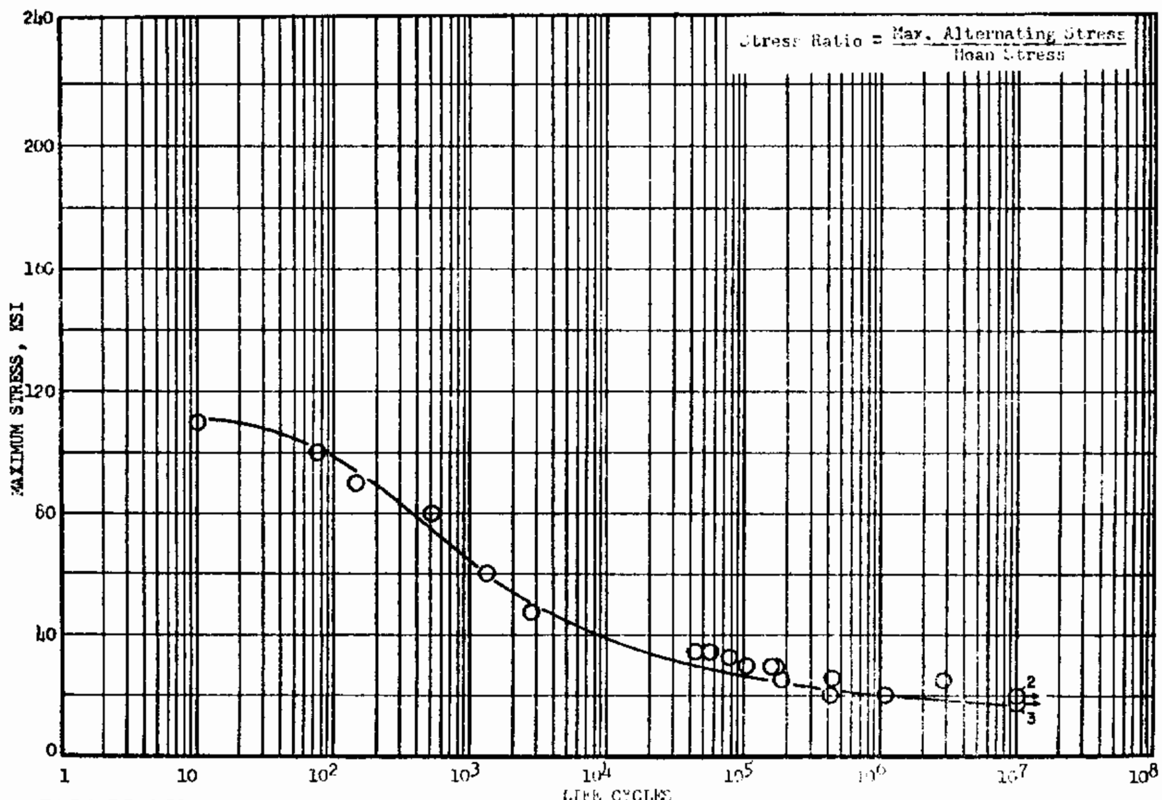


FIGURE 151 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 32167)

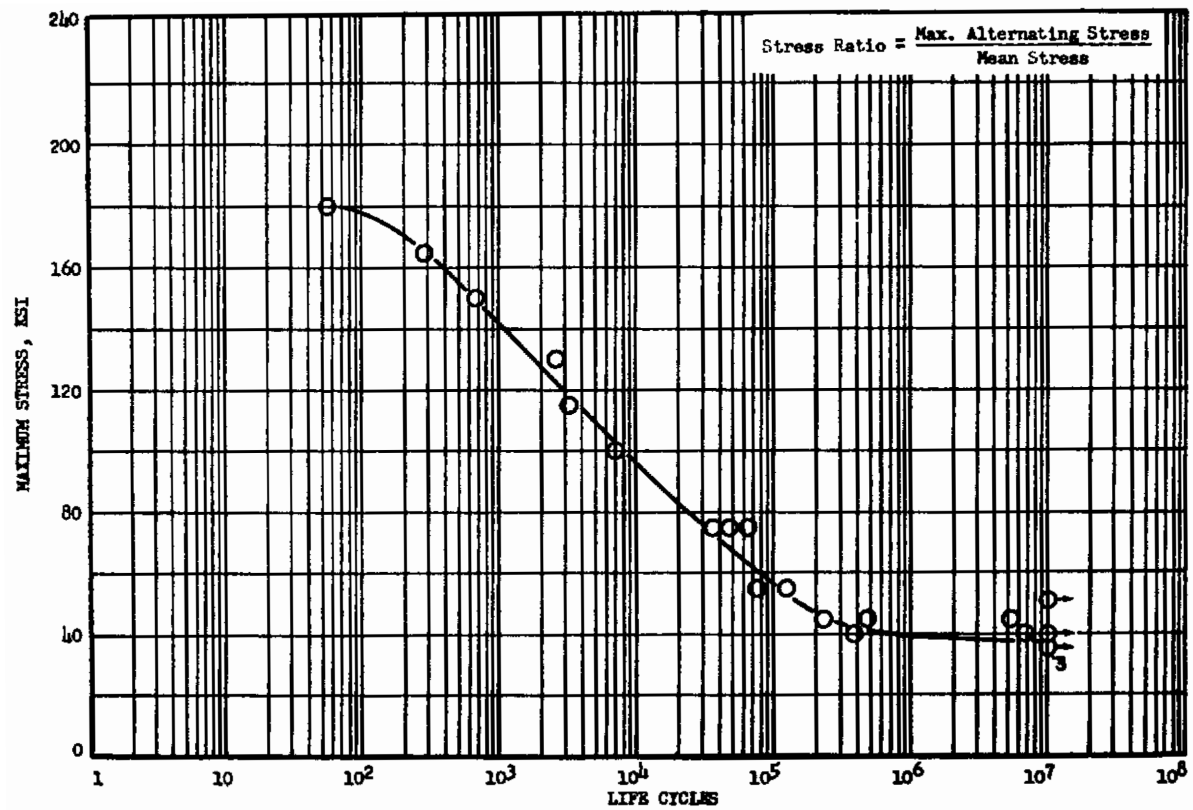


FIGURE 152 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 32167)

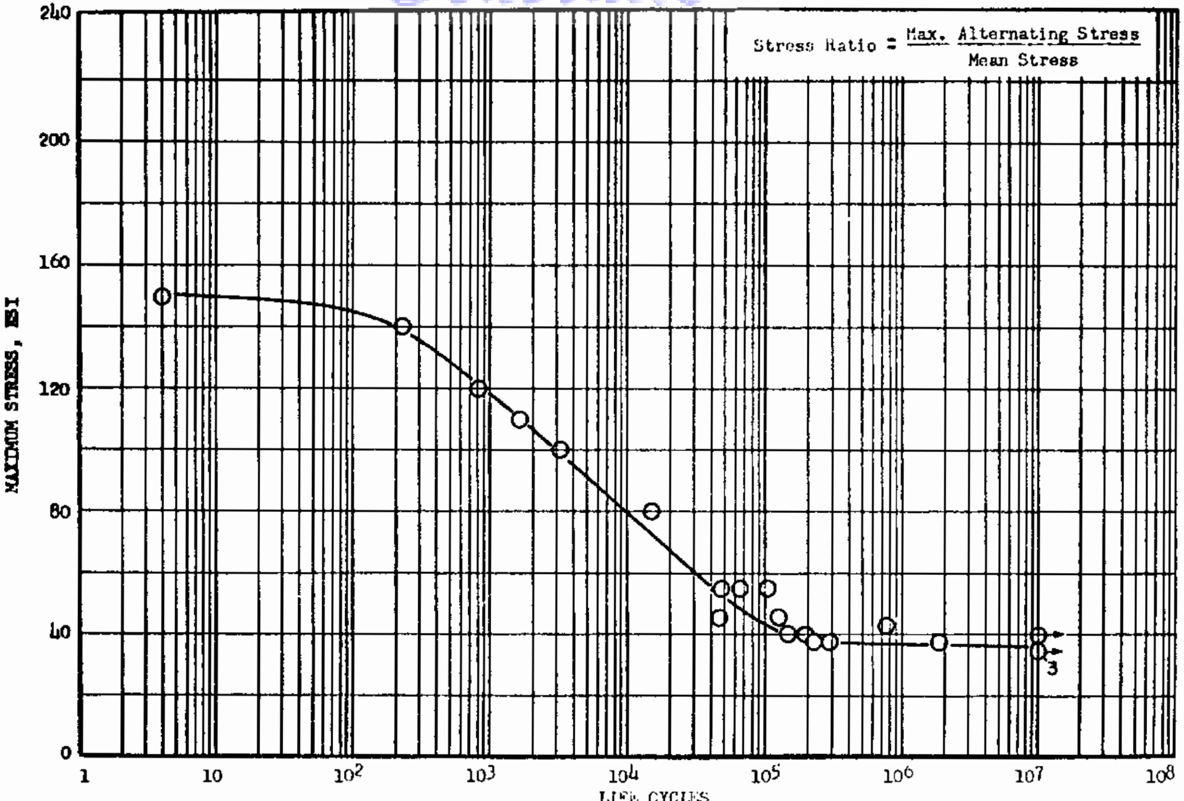


FIGURE 153 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 32167)

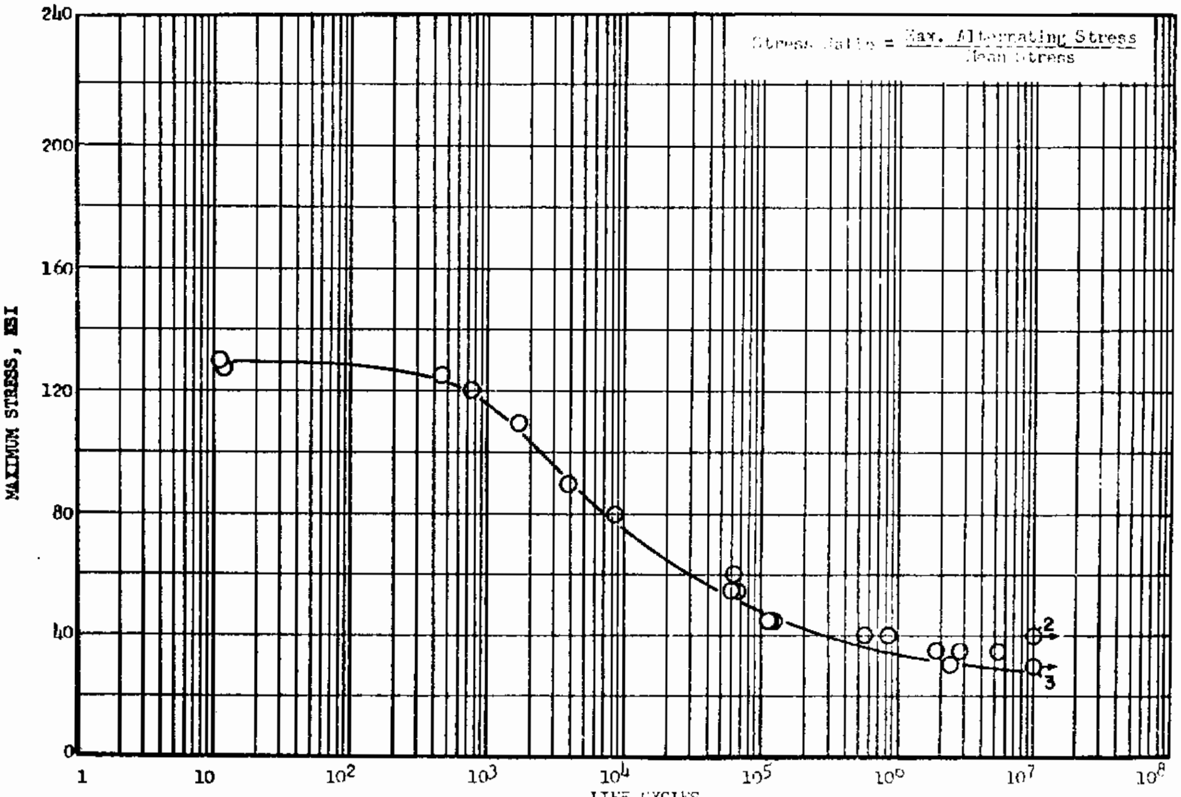


FIGURE 154 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 32167)

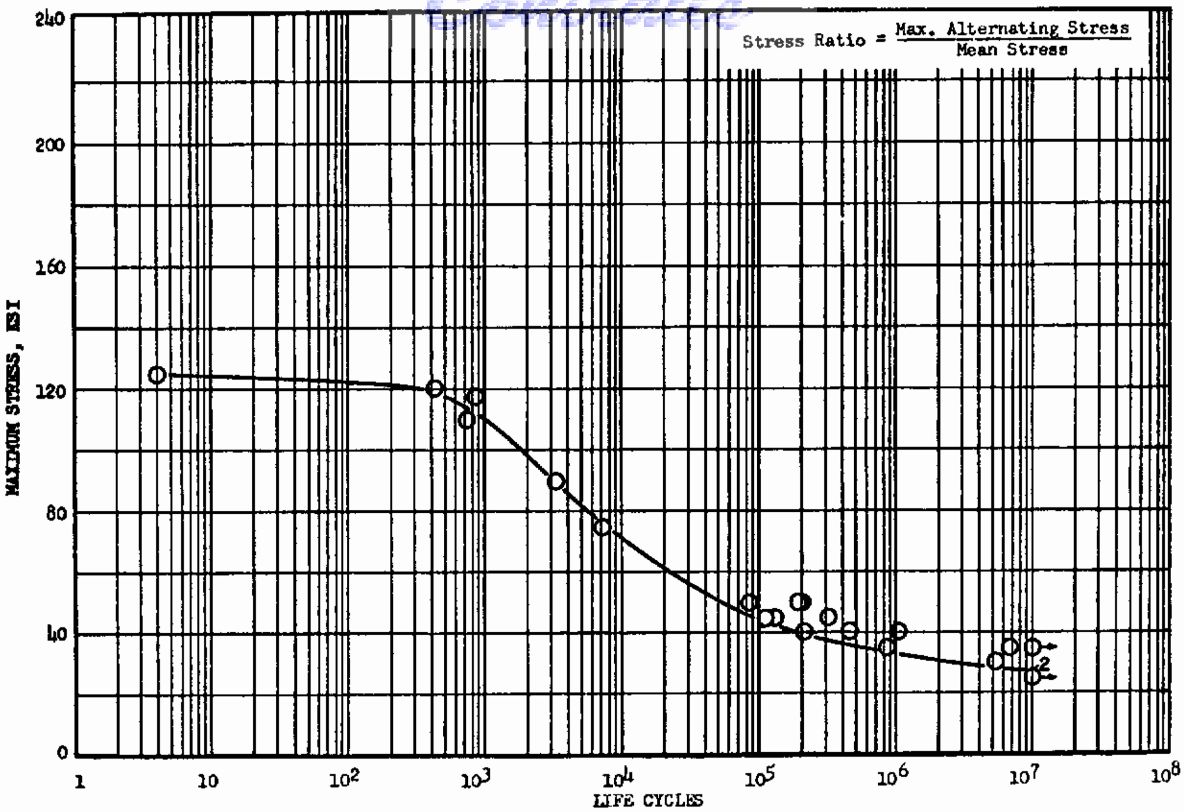


FIGURE 155 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 32167)

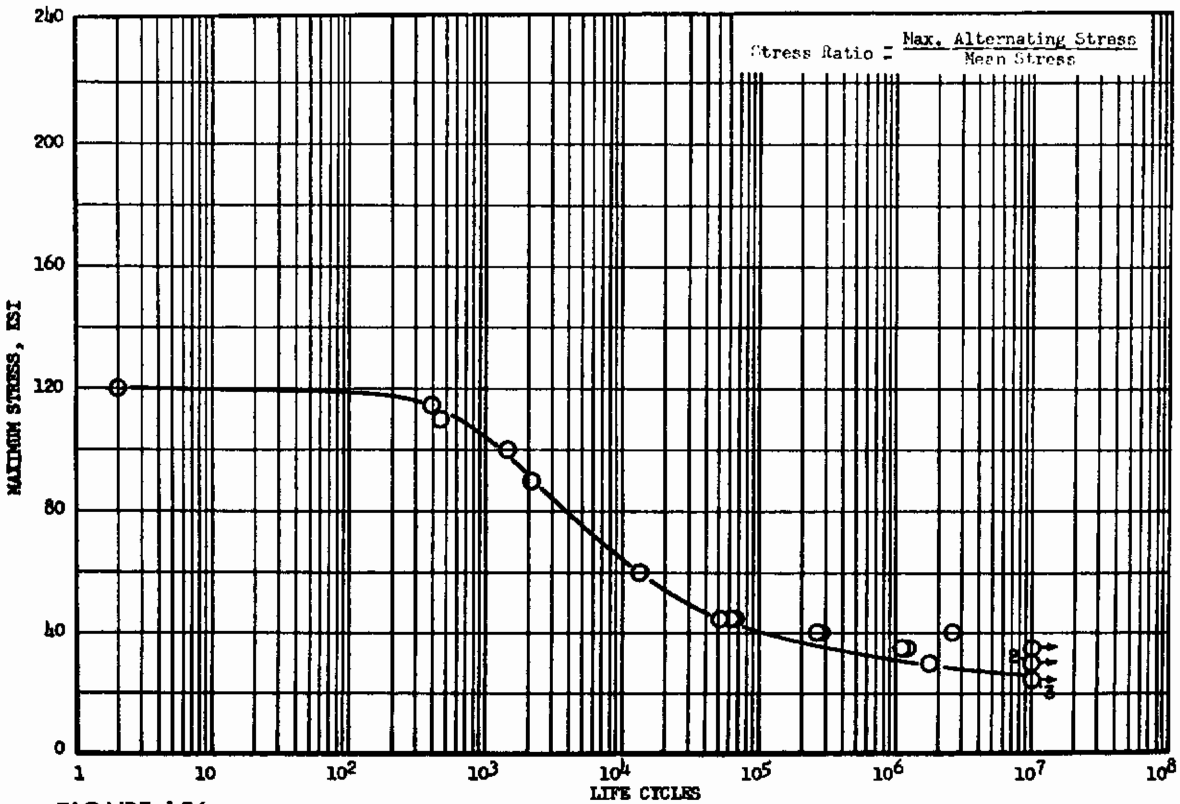


FIGURE 156 – AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 32167)

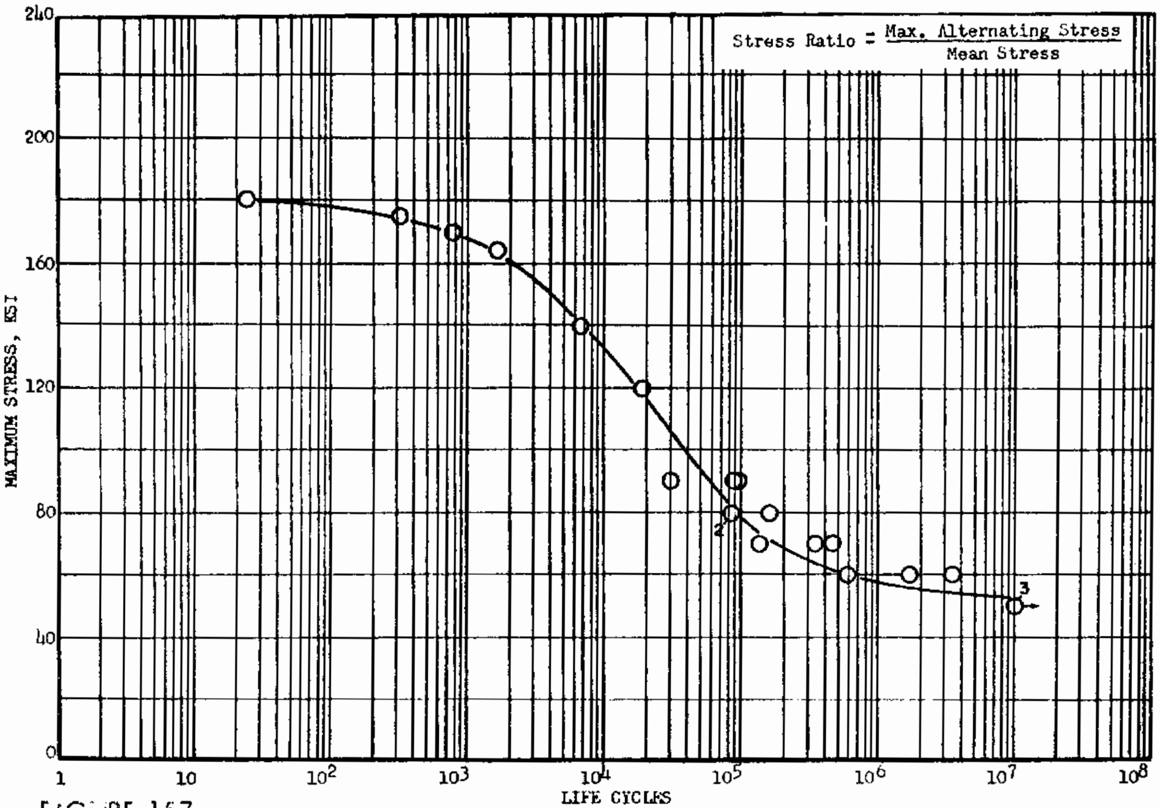


FIGURE 157 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 32167)

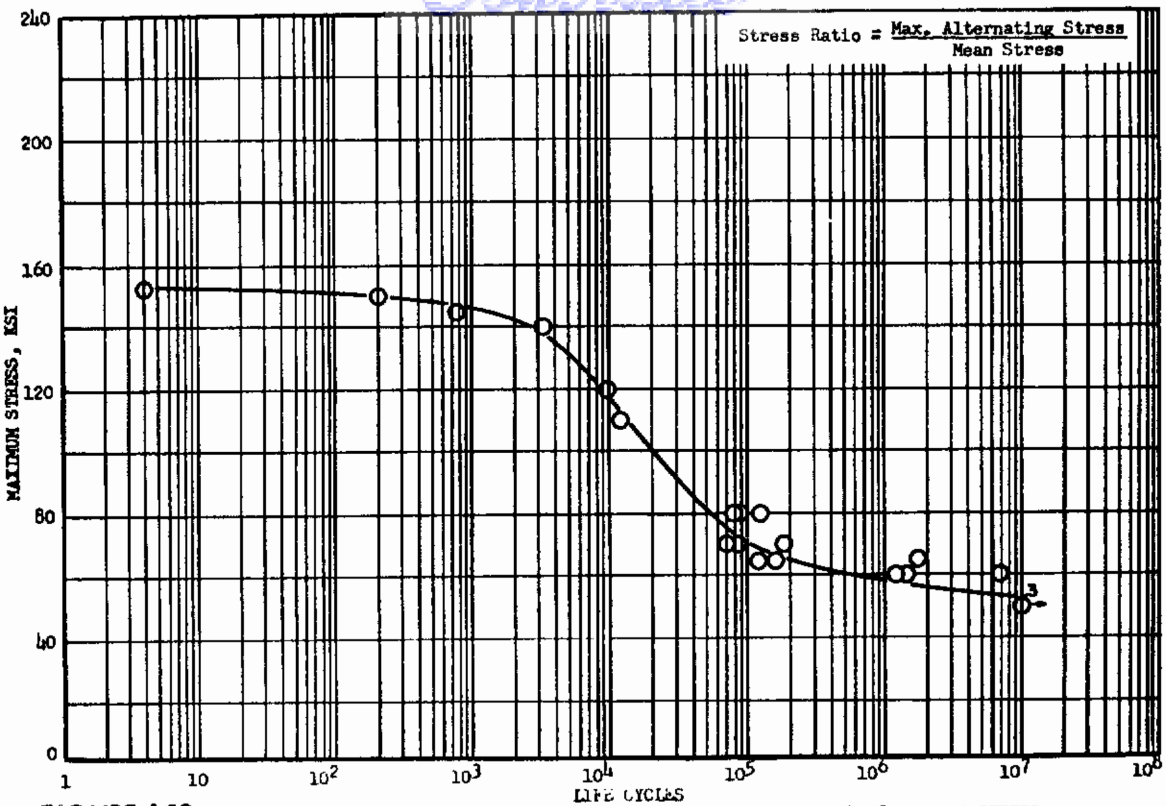


FIGURE 158 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 32167)

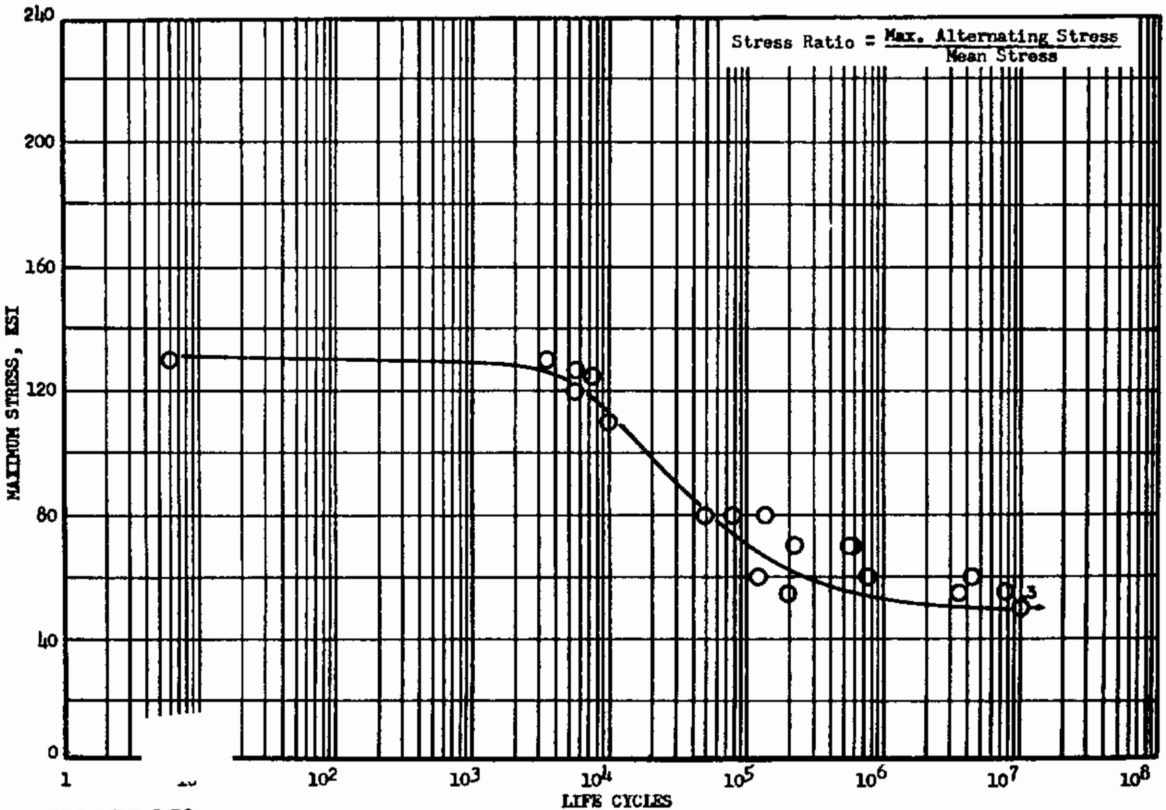


FIGURE 159 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 32167)

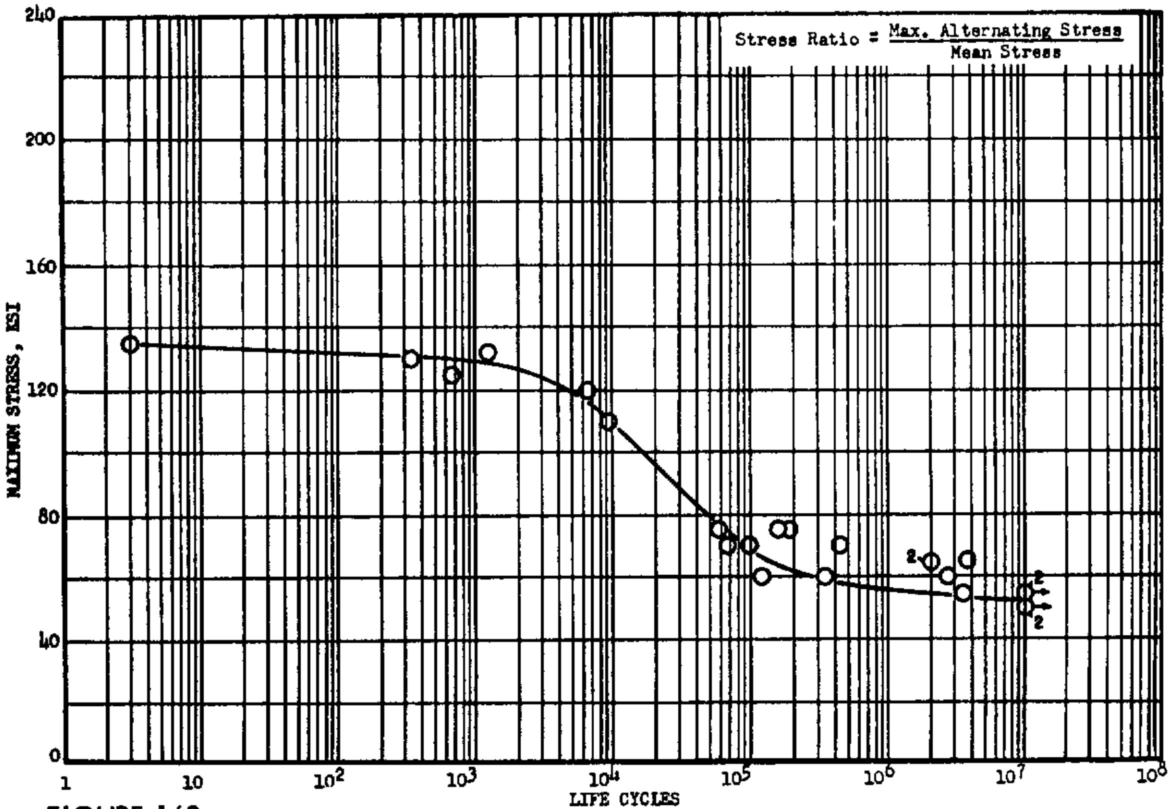


FIGURE 160 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 32167)

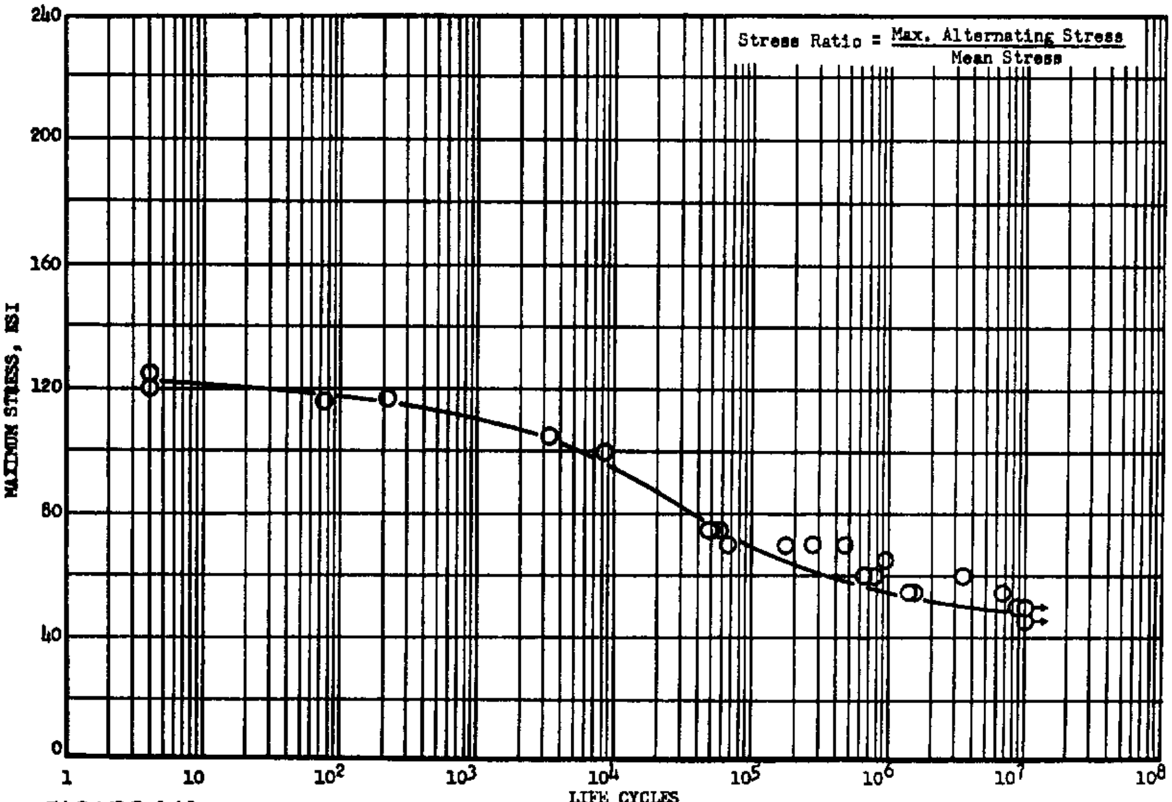


FIGURE 161 - AXIAL LOAD FATIGUE CURVE FOR Ti-6Al-4V, 0.125 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 32167)

VI - RESULTS FOR 2.5Al-16V TITANIUM ALLOY

Tensile Creep-Rupture Test Results - Ti-2.5Al-4V

Log stress versus log time to rupture curves summarizing longitudinal and transverse Ti-2.5Al-16V stress-rupture data are shown in Figures 162 and 163. Similar curves showing times to obtain longitudinal creep strains of 1.0, 0.5, 0.2, 0.1 and 0.05 percent are in Figures 164 through 168. Larson-Miller master curves, shown in Figures 169 through 174, were also used to summarize these data for rupture and the selected creep strains. Figures 175 through 220 show the creep strain versus log time curves from which the data were obtained, and Tables CLXXXIII through CLXXXVI, pages 190 through 193 of Volume 3 present the tensile creep-rupture data summarized. Initial loading deformation is also presented in these tables.

Volume 1 contains design curves showing the percentage of room temperature ultimate tensile stress as a function of time to rupture and time to reach the various amounts of creep strain.

Compressive Creep Test Results - Ti-2.5Al-16V

Log stress versus log time curves summarizing the results of longitudinal compressive creep tests at 600°F, 700°F, 800°F and 900°F on one heat of Ti-2.5Al-16V are in Figures 221 through 224. These curves show variations in stress with time required to obtain compressive creep strains of 1.0, 0.5, 0.2, 0.1 and 0.05 percent. Figures 225 through 235 are compressive creep strain curves for individual tests and tabulations of the summarized data along with initial loading deformation are in Tables CLXXXVII through CXC, pages 194 through 197 of Volume 3.

Bearing Creep-Rupture Test Results - Ti-2.5Al-16V

Bearing stress-rupture curves and similar curves showing time to obtain bearing deformations of 4.0, 2.0, 1.0 and 0.5 percent of the bearing hole diameter are in Figures 236 through 238. These curves summarize the results of longitudinal bearing creep-rupture tests performed at 600°F, 700°F and 800°F on one heat of 2.5Al-16V titanium alloy. Bearing deformation versus log time curves, from which the summarized deformation data were obtained, are shown in Figures 239 through 247 and tabulations of the data including initial loading deformations are made in Tables CXCI through CXCIII, pages 198 through 200 of Volume 3.

Single Shear Stress-Rupture Test Results - Ti-2.5Al-16V

Curves summarizing single shear stress-rupture data for three heats of 0.063 inch thick 2.5Al-16V titanium alloy are shown in Figure 248. These data were obtained by a minimum of six longitudinal tests performed at 600°F, 700°F and 800°F on each of the three heats. Tables CXCIV and CXCV, pages 201 and 202 of Volume 3 present the results of Ti-2.5Al-16V single shear stress-rupture tests in tabular form.

Double Shear Stress-Rupture Test Results - Ti-2.5Al-16V

Longitudinal double shear stress-rupture test results for three heats of 0.125 inch thick Ti-2.5Al-16V are summarized in Figure 249. A minimum of 18 tests were conducted on each heat, six each at 600°F, 700°F and 800°F. Data from these tests are in Tables CXCVI and CXCVII, pages 203 through 204 of Volume 3.

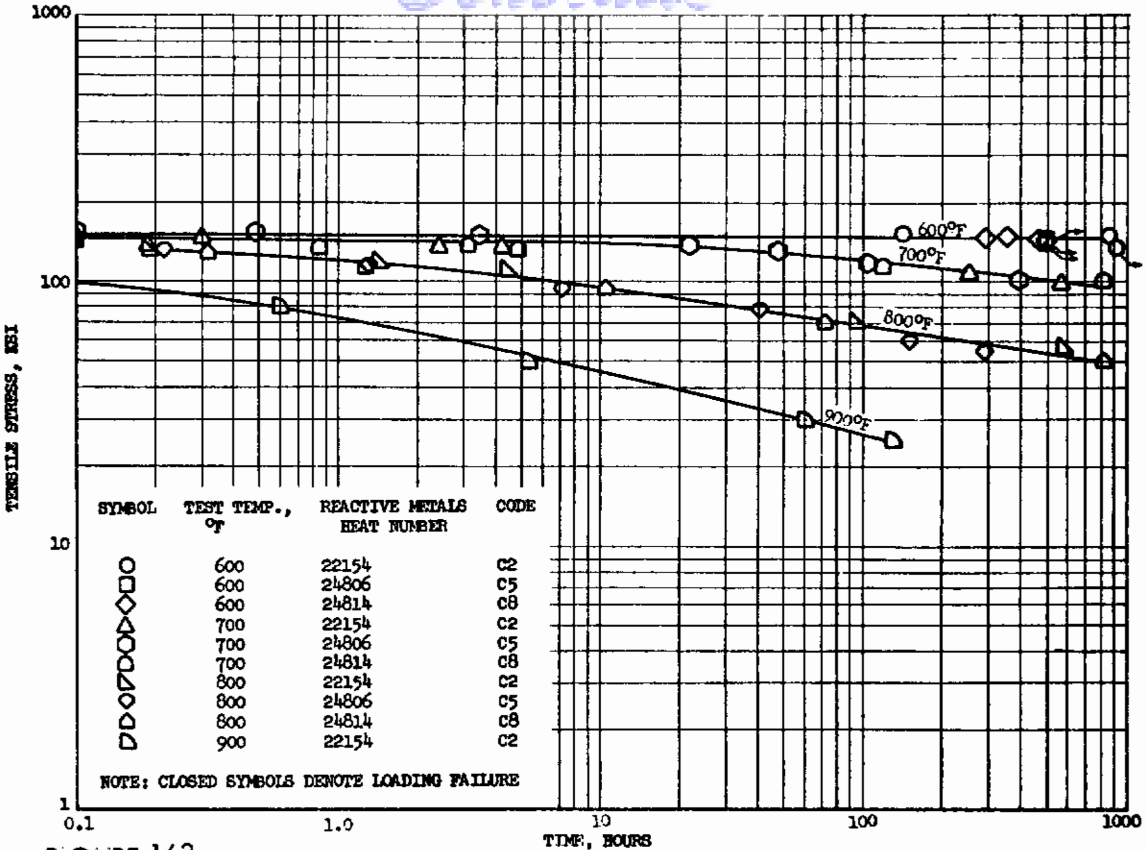


FIGURE 162 - LONGITUDINAL TENSILE STRESS-RUPTURE CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK

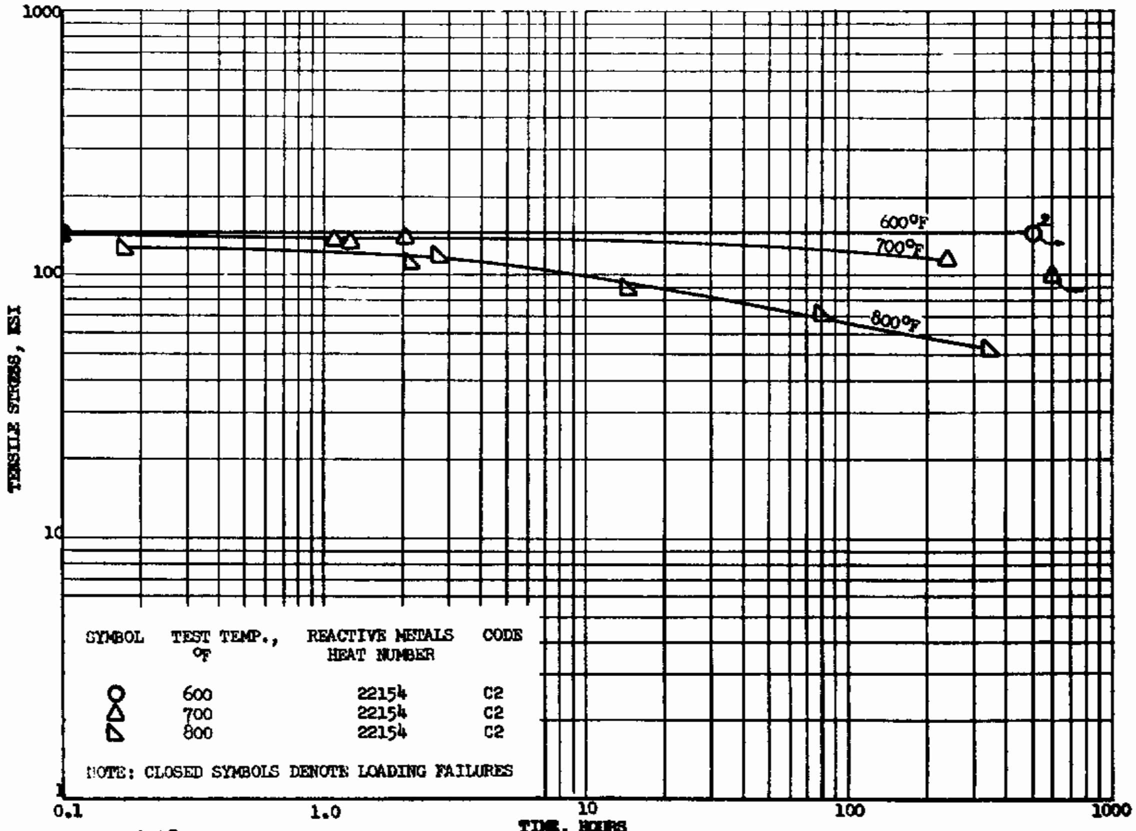


FIGURE 163 - TRANSVERSE TENSILE STRESS-RUPTURE CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK

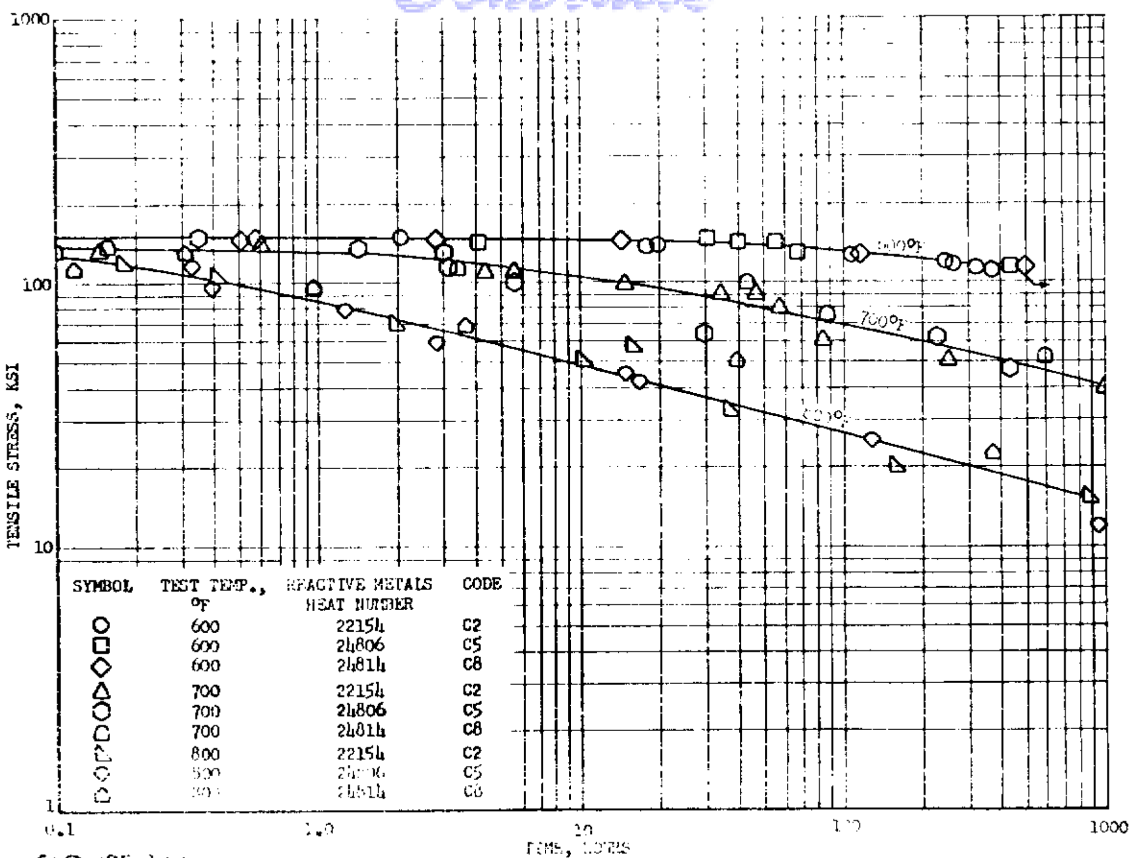


FIGURE 164 - LONGITUDINAL 1.0% TENSILE CREEP STRAIN CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK

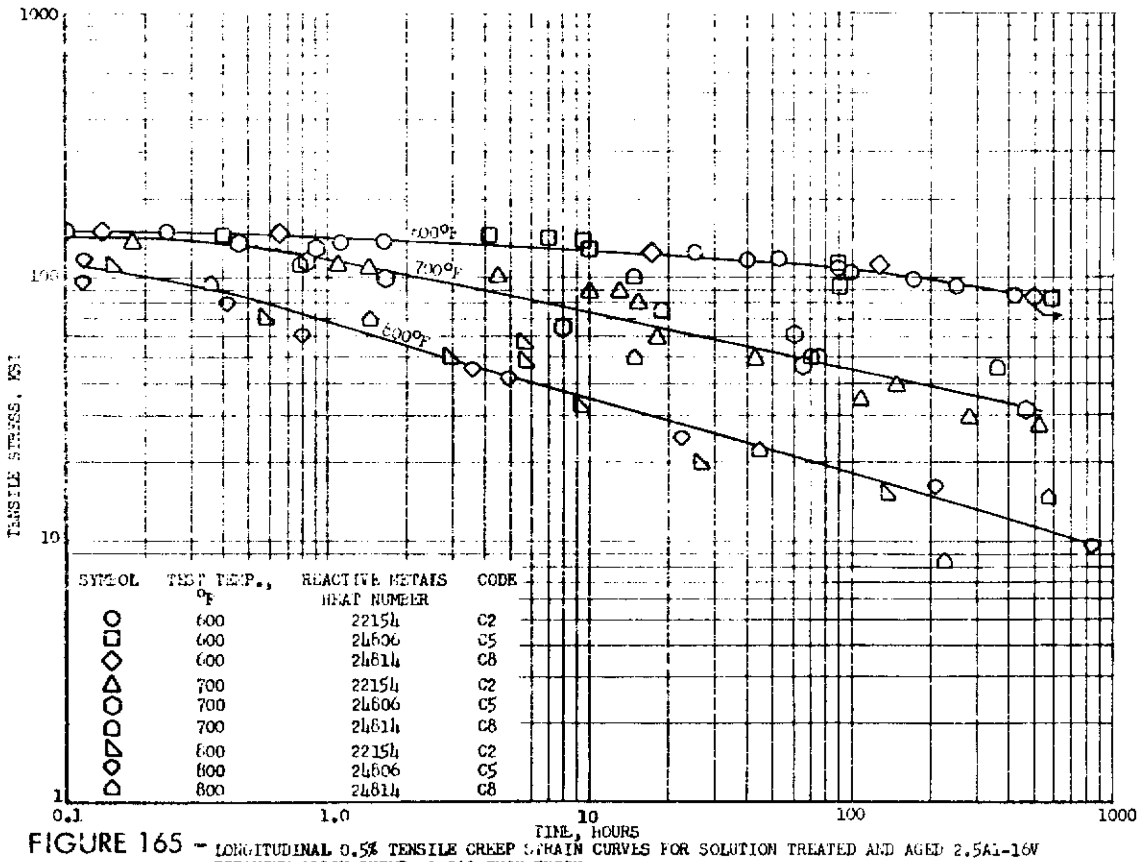


FIGURE 165 - LONGITUDINAL 0.5% TENSILE CREEP STRAIN CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK

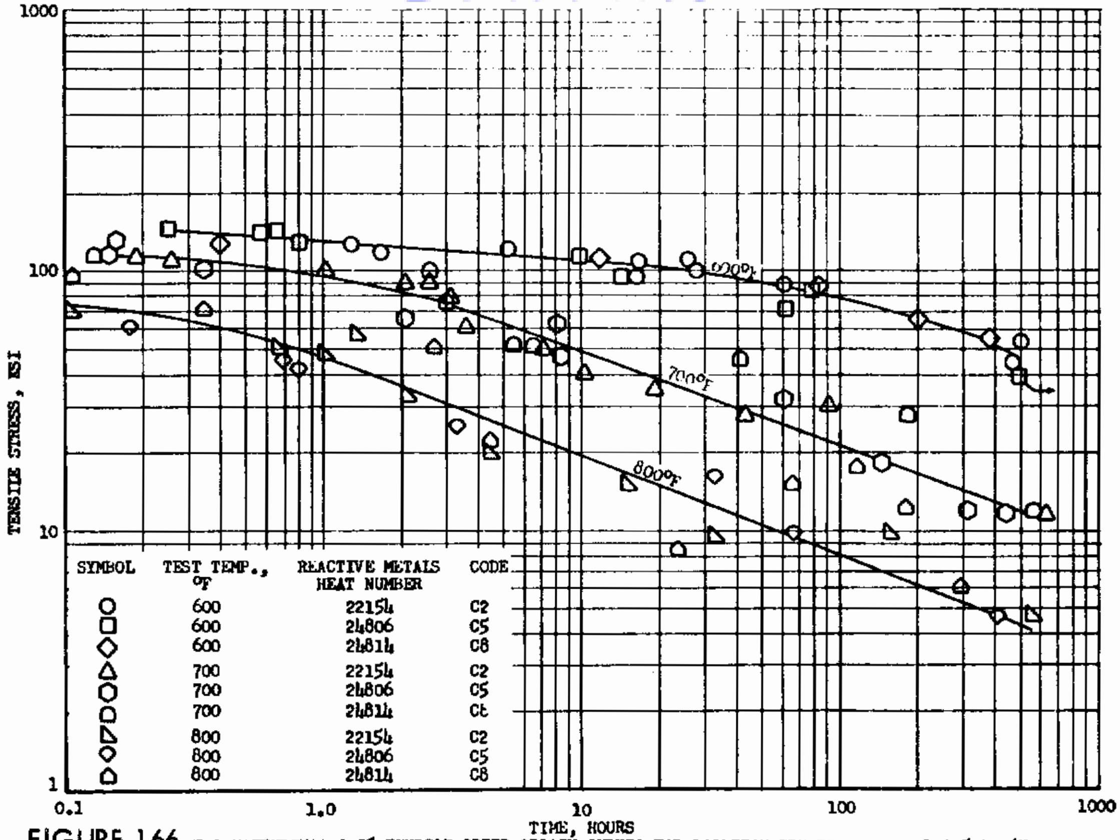


FIGURE 166 - LONGITUDINAL 0.2% TENSILE CREEP STRAIN CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK

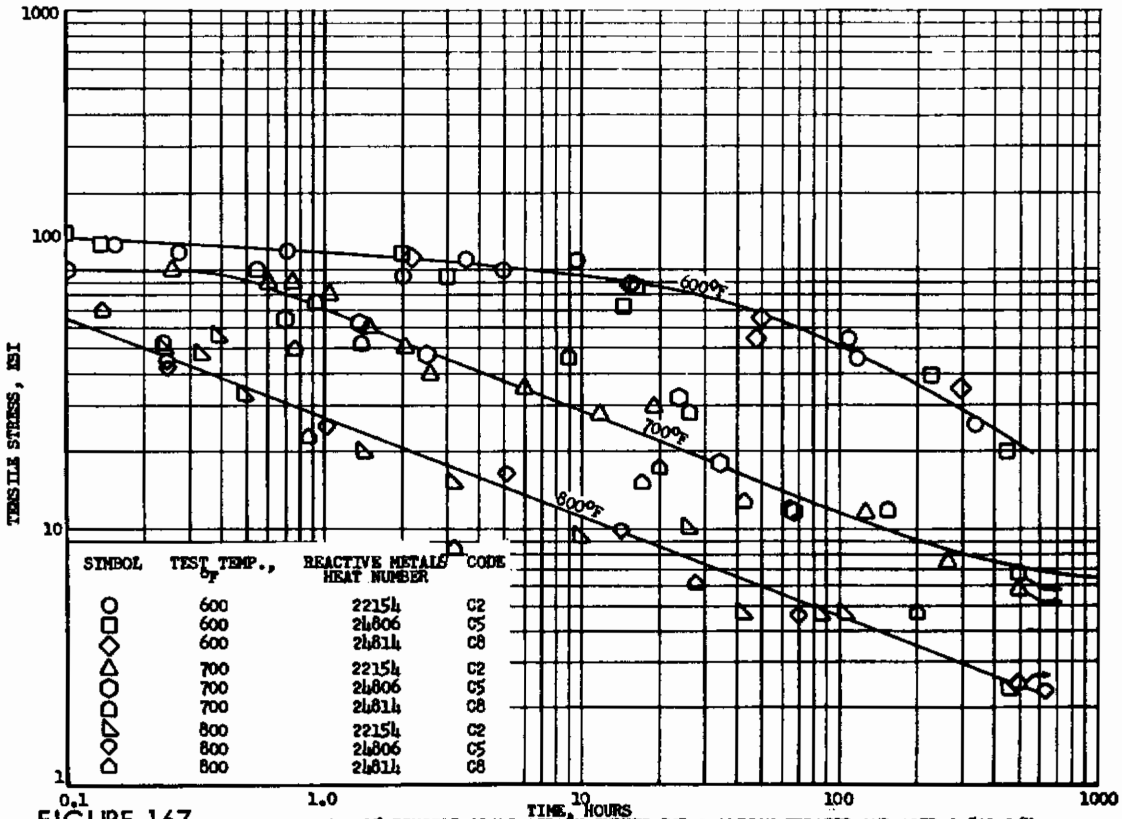


FIGURE 167 - LONGITUDINAL 0.1% TENSILE CREEP STRAIN CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK

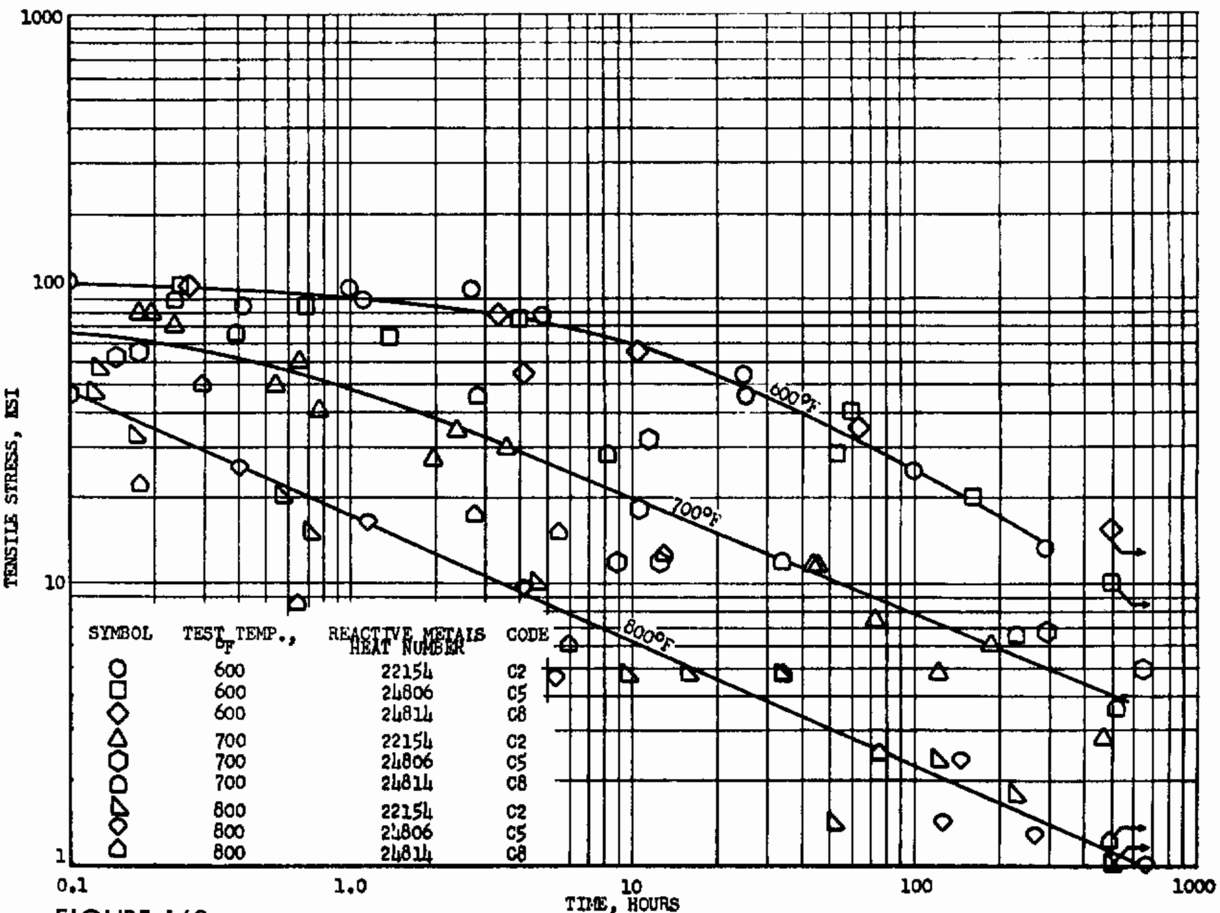


FIGURE 168 - LONGITUDINAL 0.05% TENSILE CREEP STRAIN CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM TITANIUM ALLOY SHEET, 0.063 INCH THICK

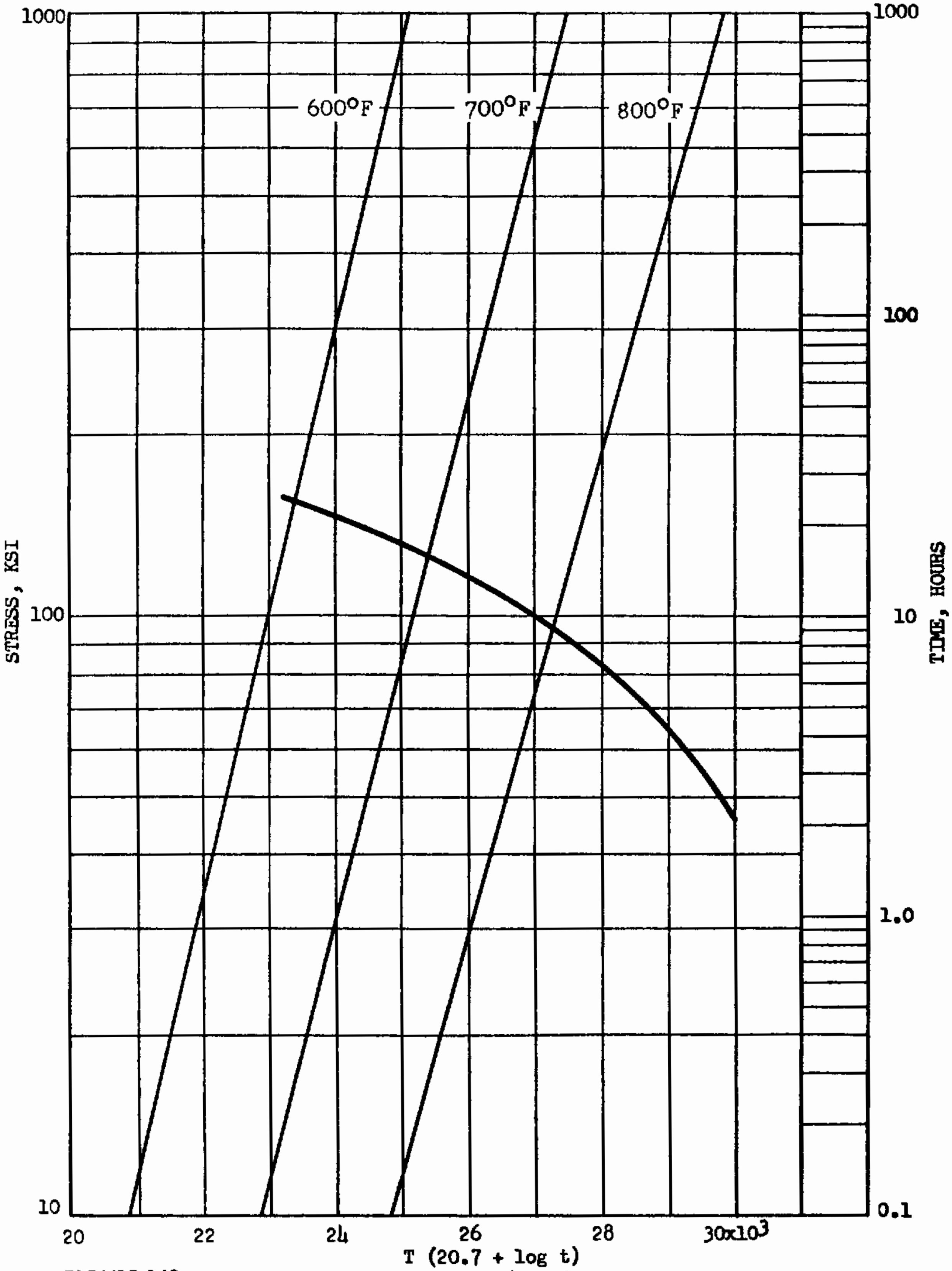


FIGURE 169 - MASTER RUPTURE CURVE FOR 2.5Al-16V SOLUTION TREATED AND AGED TITANIUM ALLOY (0.063 INCH THICK SHEET).

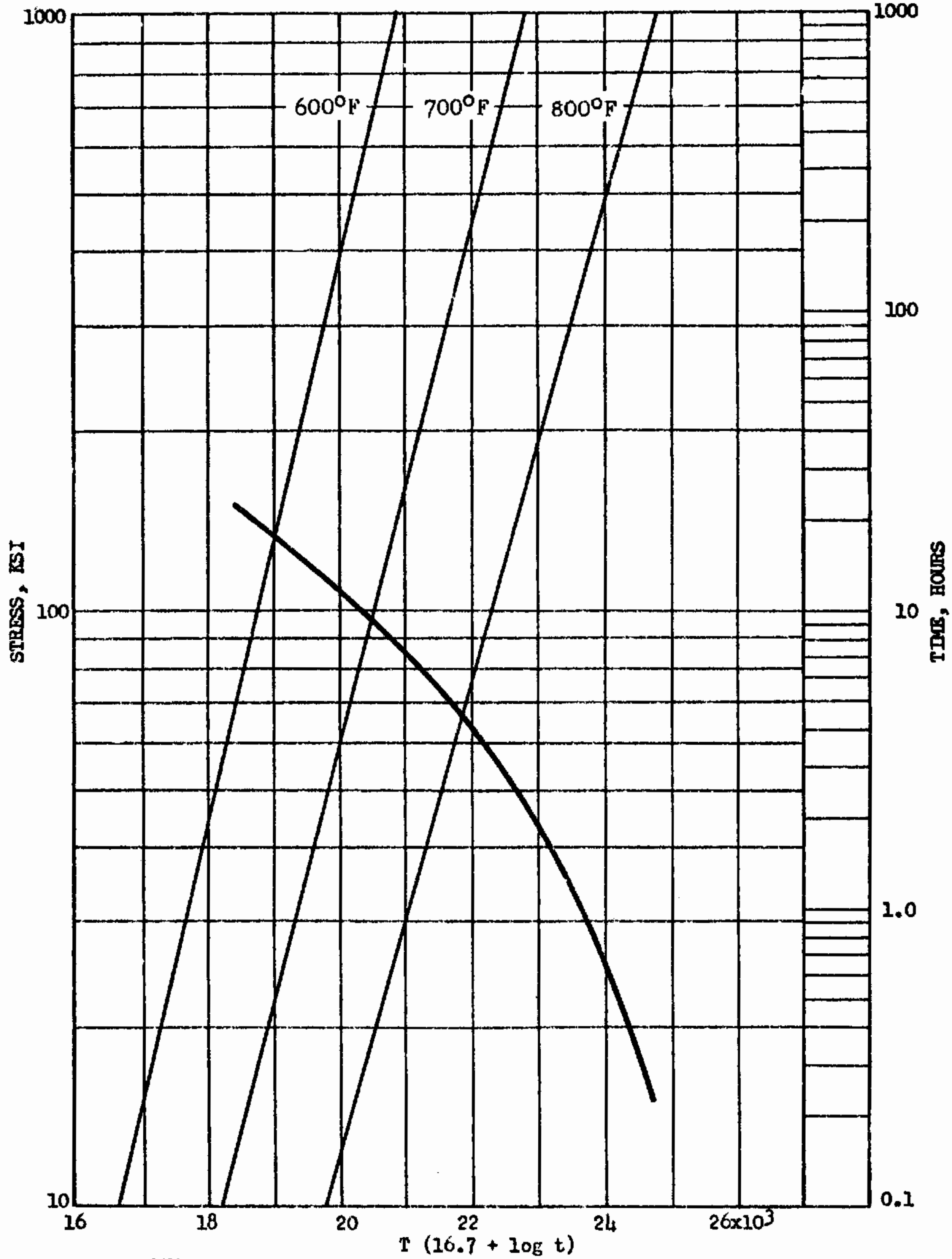


FIGURE 170 - MASTER 1.0 PERCENT CREEP STRAIN CURVE FOR 2.5Al-16V SOLUTION TREATED AND AGED TITANIUM ALLOY (0.063 INCH THICK SHEET).

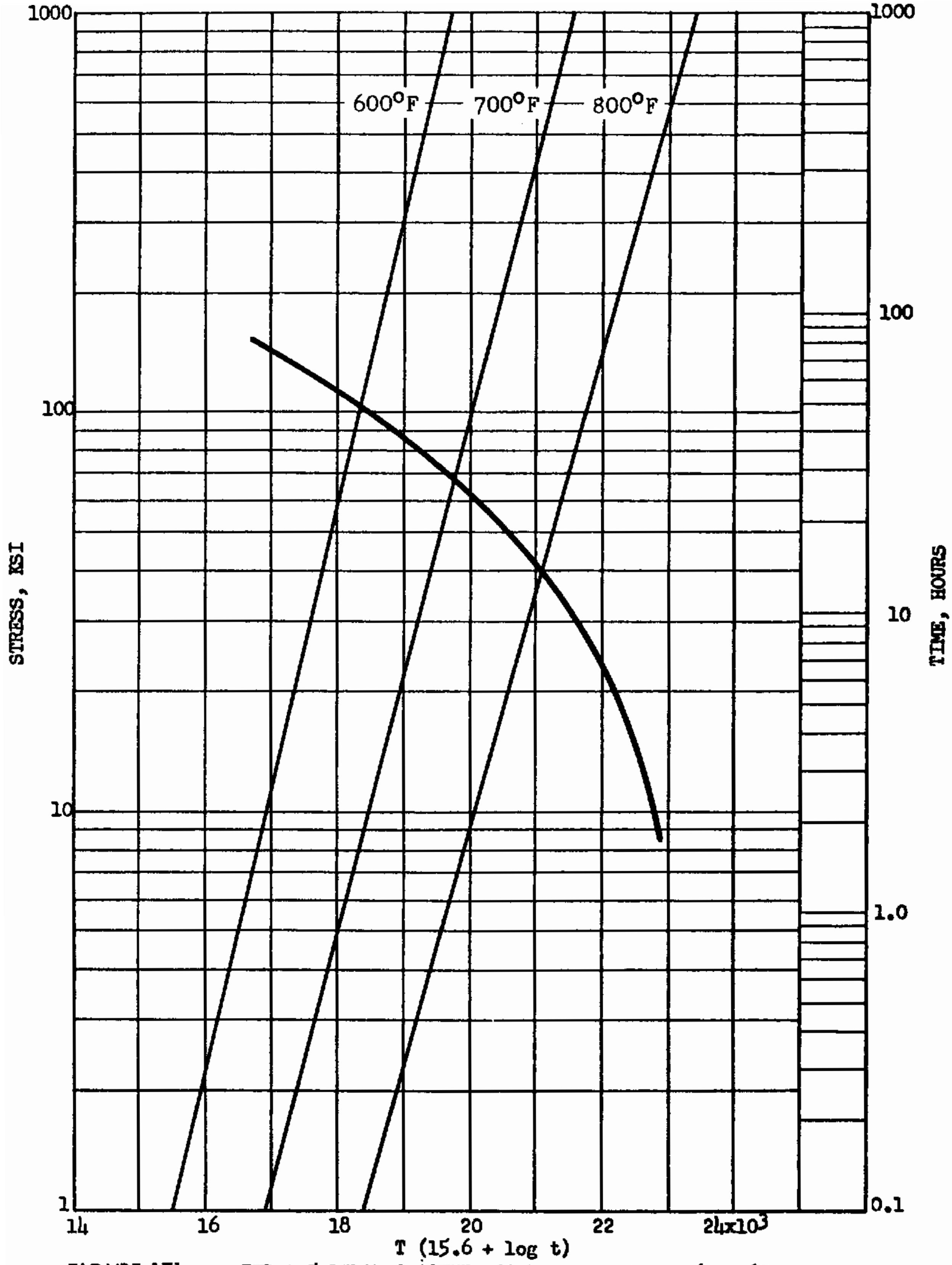


FIGURE 171 - MASTER 0.5 PERCENT CREEP STRAIN CURVE FOR 2.5Al-16V SOLUTION TREATED AND AGED TITANIUM ALLOY (0.063 INCH THICK SHEET).

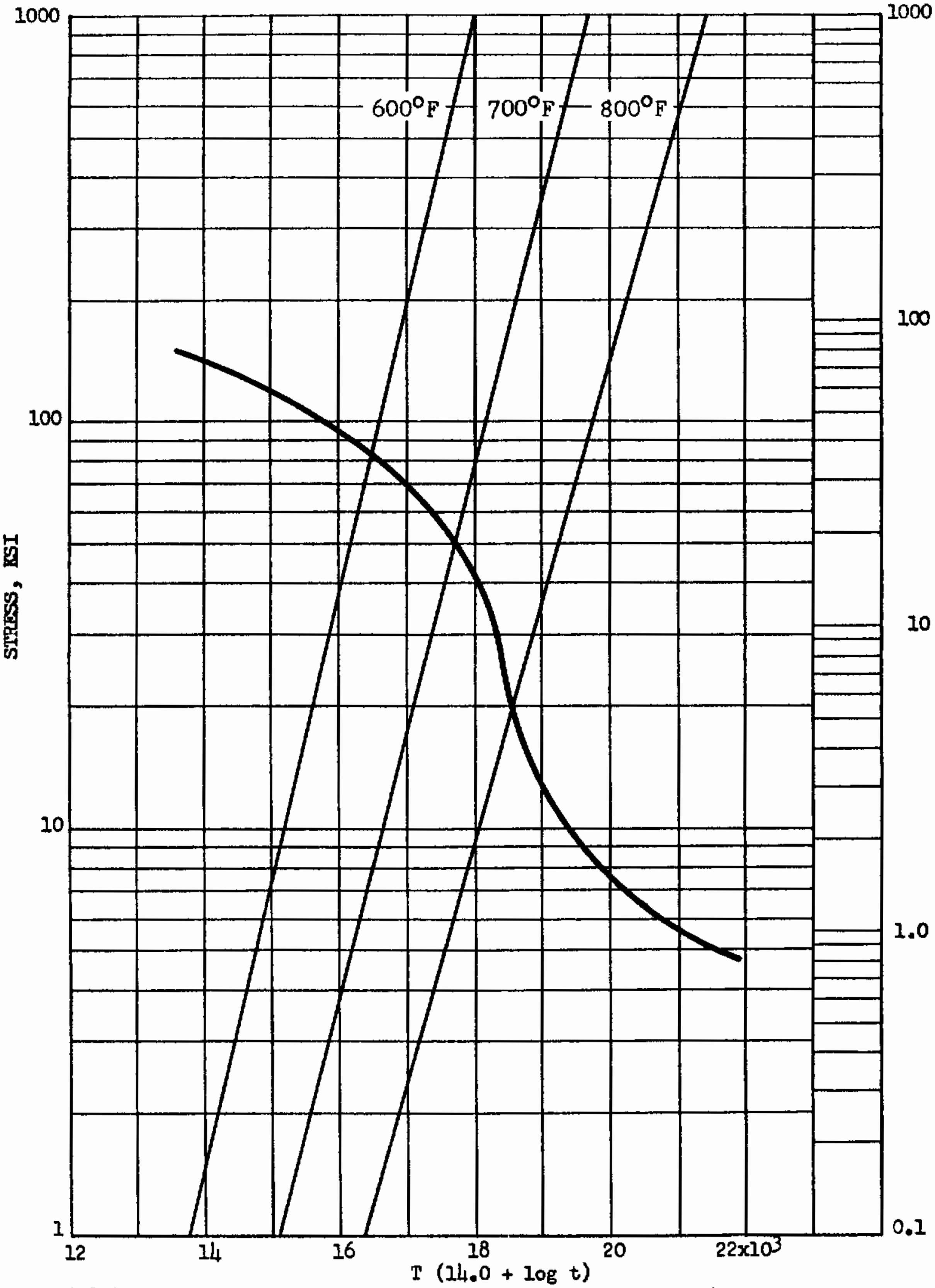


FIGURE 172 - MASTER 0.2 PERCENT CREEP STRAIN CURVE FOR 2.5Al-16V SOLUTION TREATED AND AGED TITANIUM ALLOY (0.063 INCH THICK SHEET).

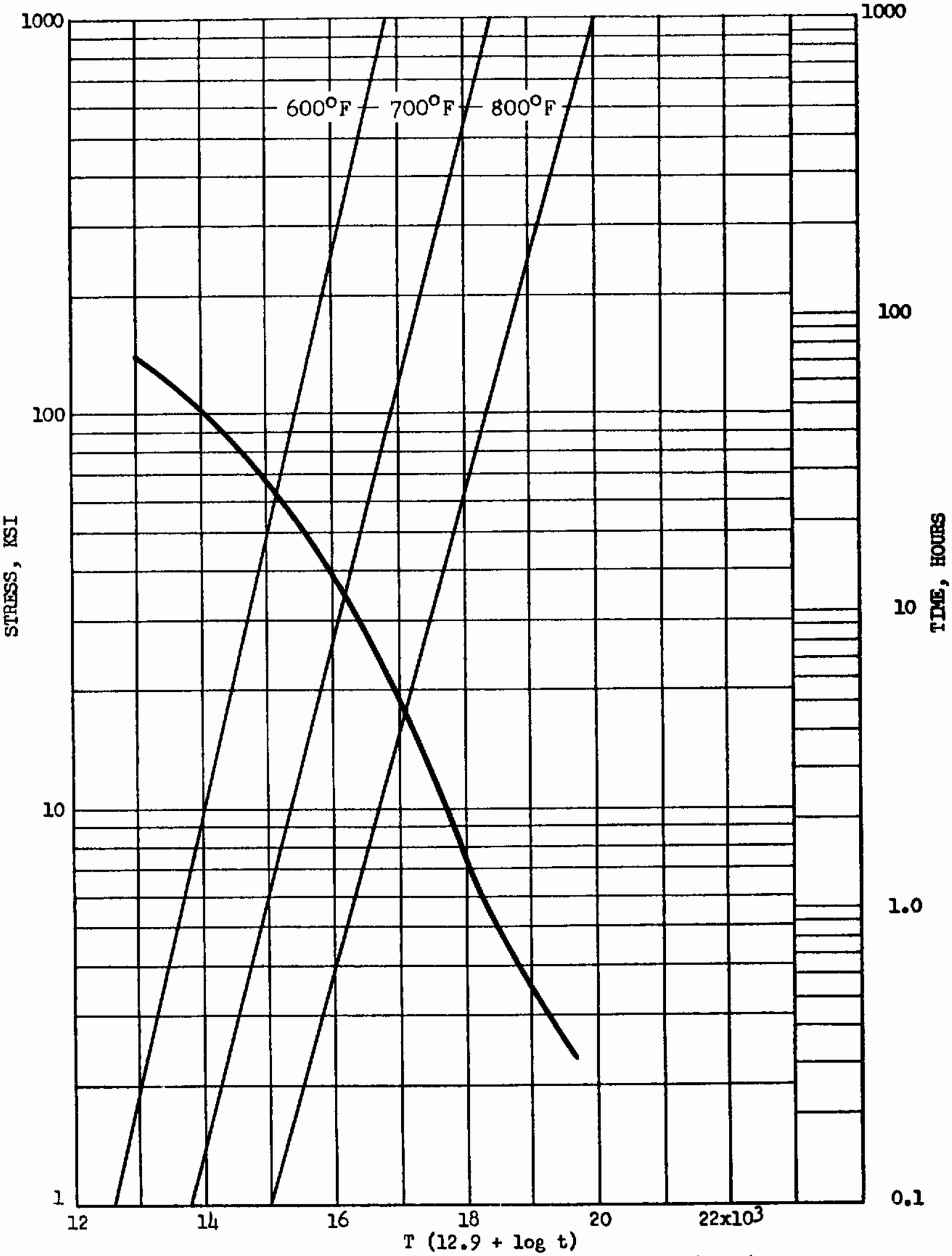


FIGURE 173 - MASTER 0.1 PERCENT CREEP STRAIN CURVE FOR 2.5Al-16V SOLUTION TREATED AND AGED TITANIUM ALLOY (0.063 INCH THICK SHEET).

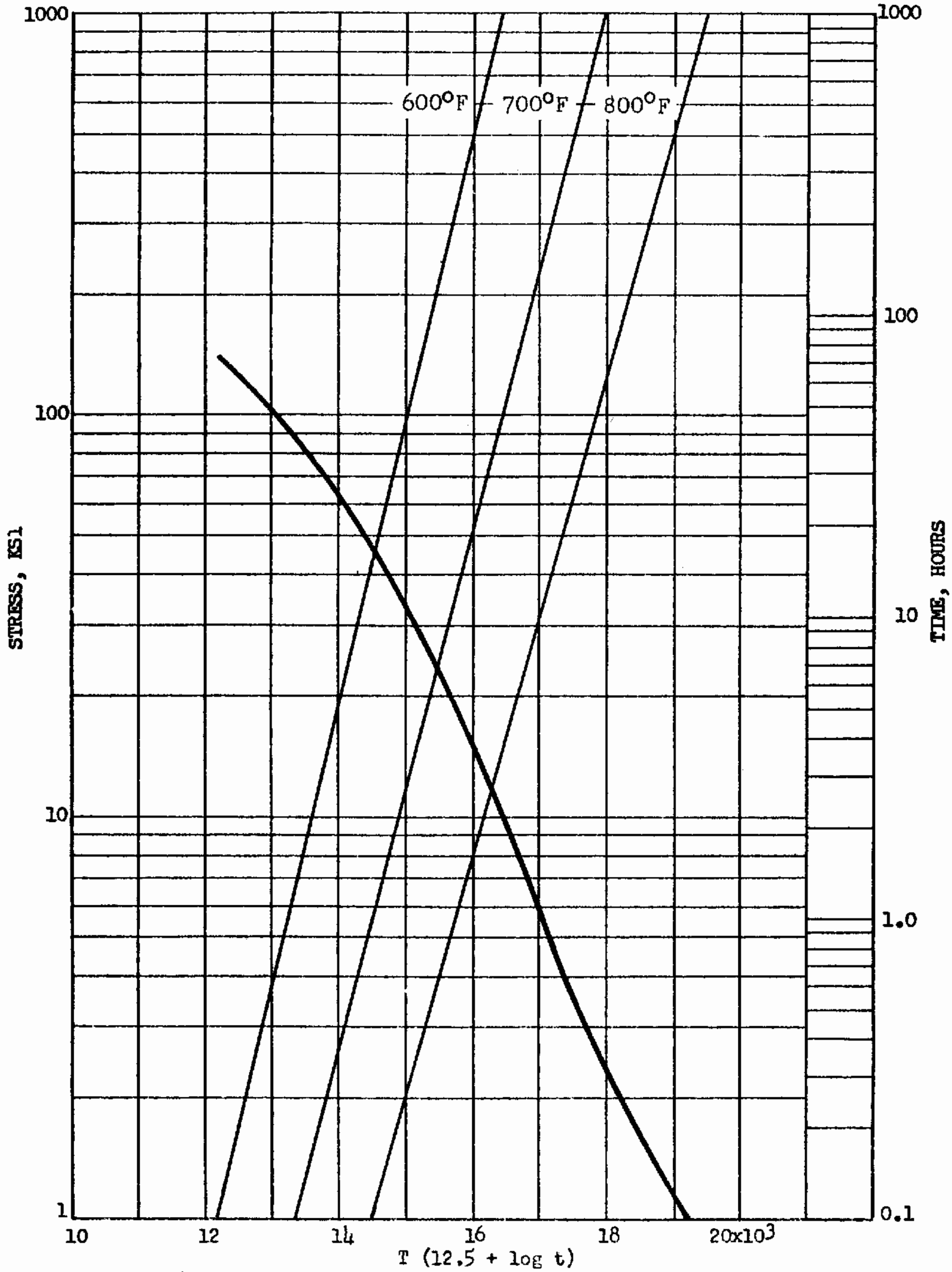


FIGURE 174 - MASTER 0.05 PERCENT CREEP STRAIN CURVE FOR 2.5Al-16V SOLUTION TREATED AND AGED TITANIUM ALLOY (0.063 INCH THICK SHEET).

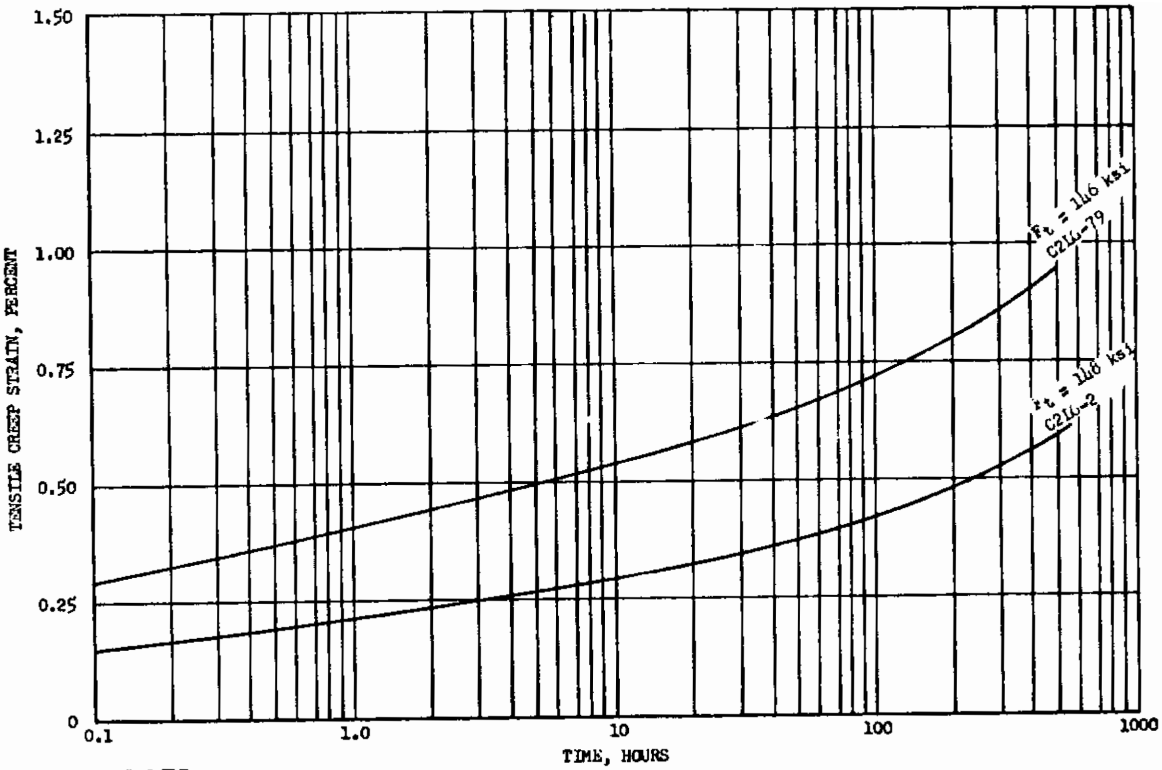


FIGURE 175 – 500°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

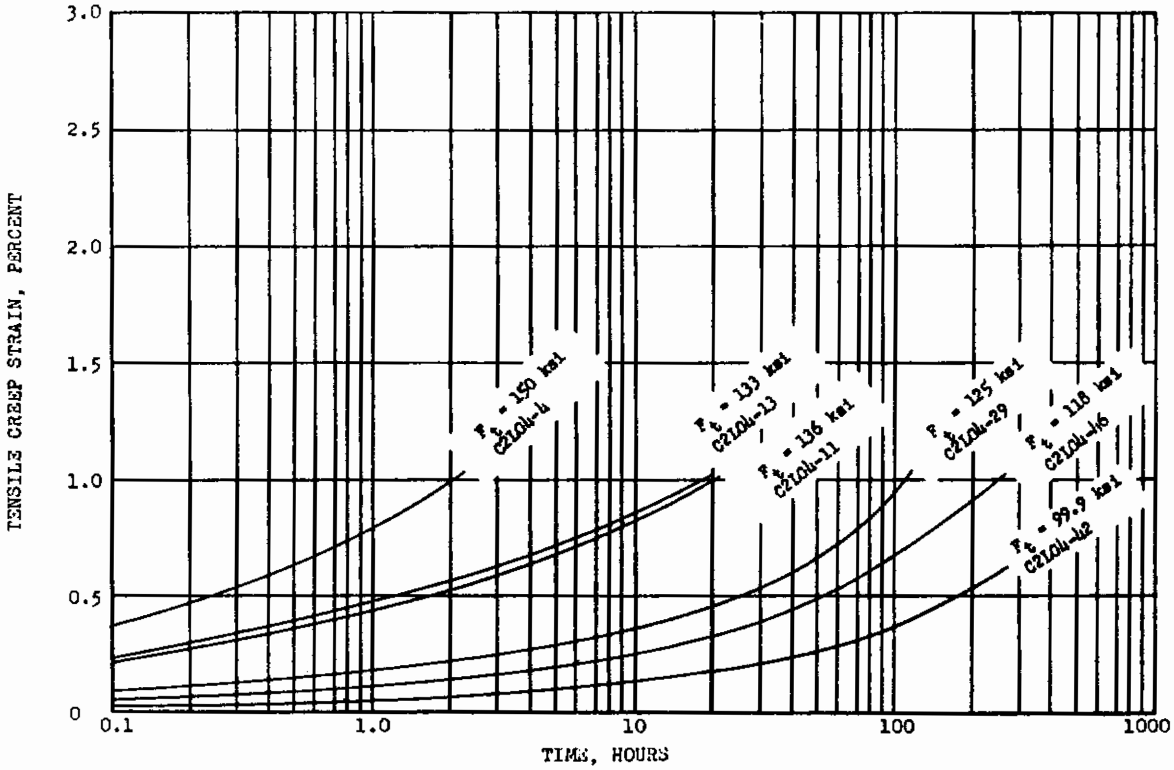


FIGURE 176 – 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

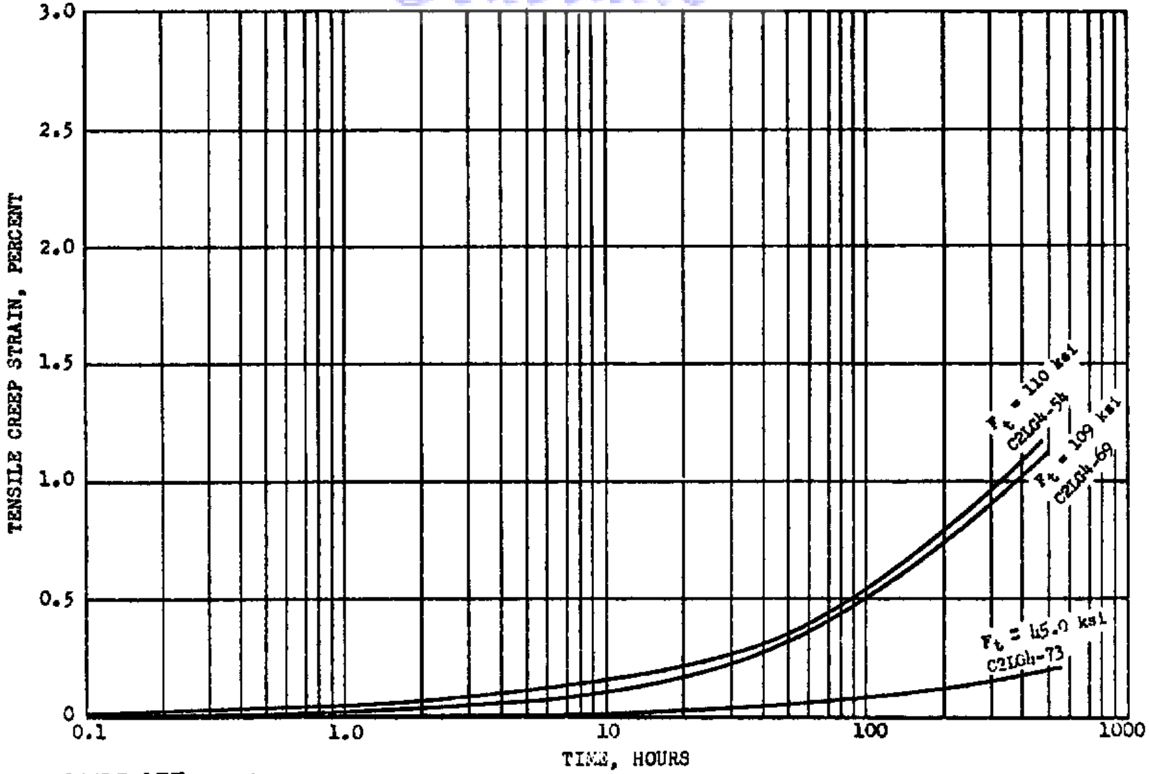


FIGURE 177 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

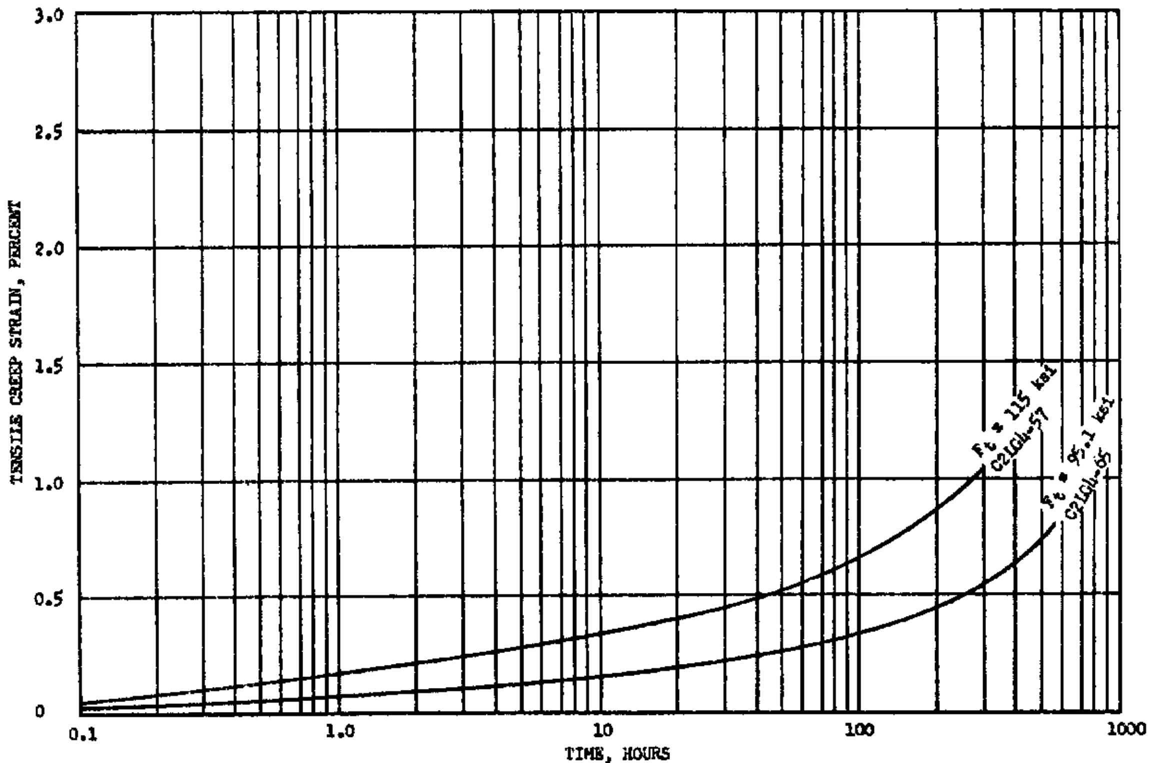


FIGURE 178 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

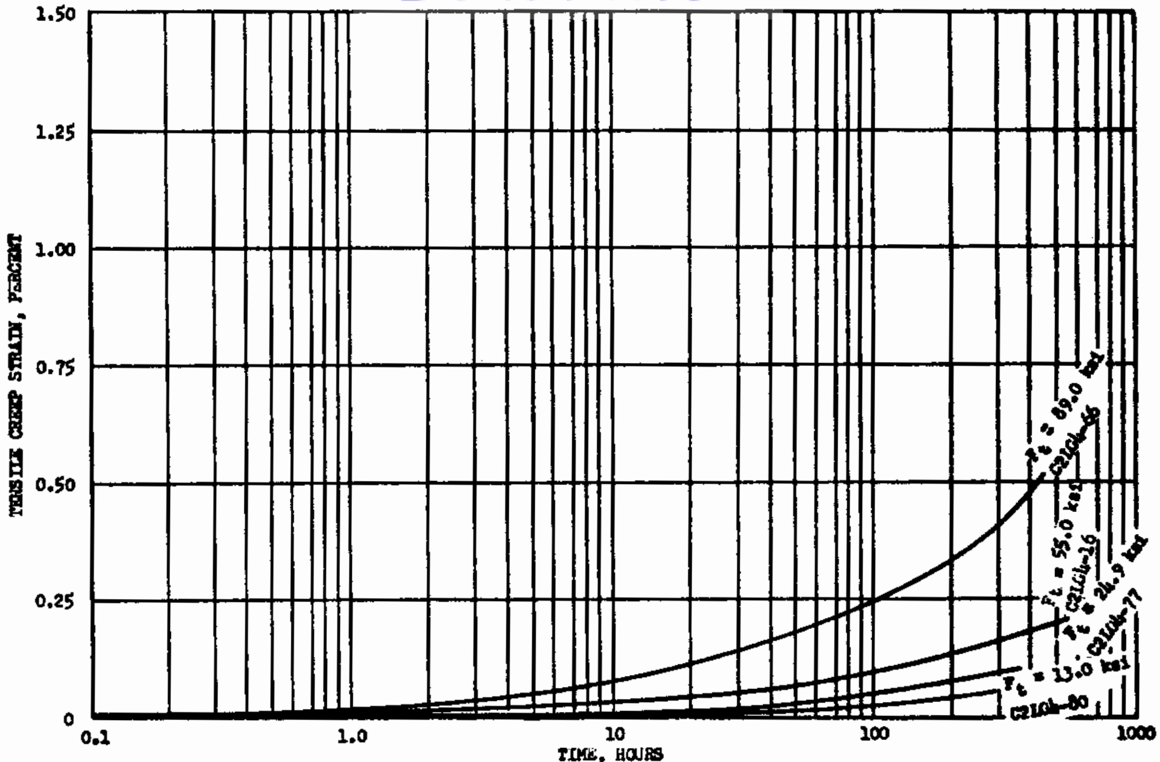


FIGURE 179 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

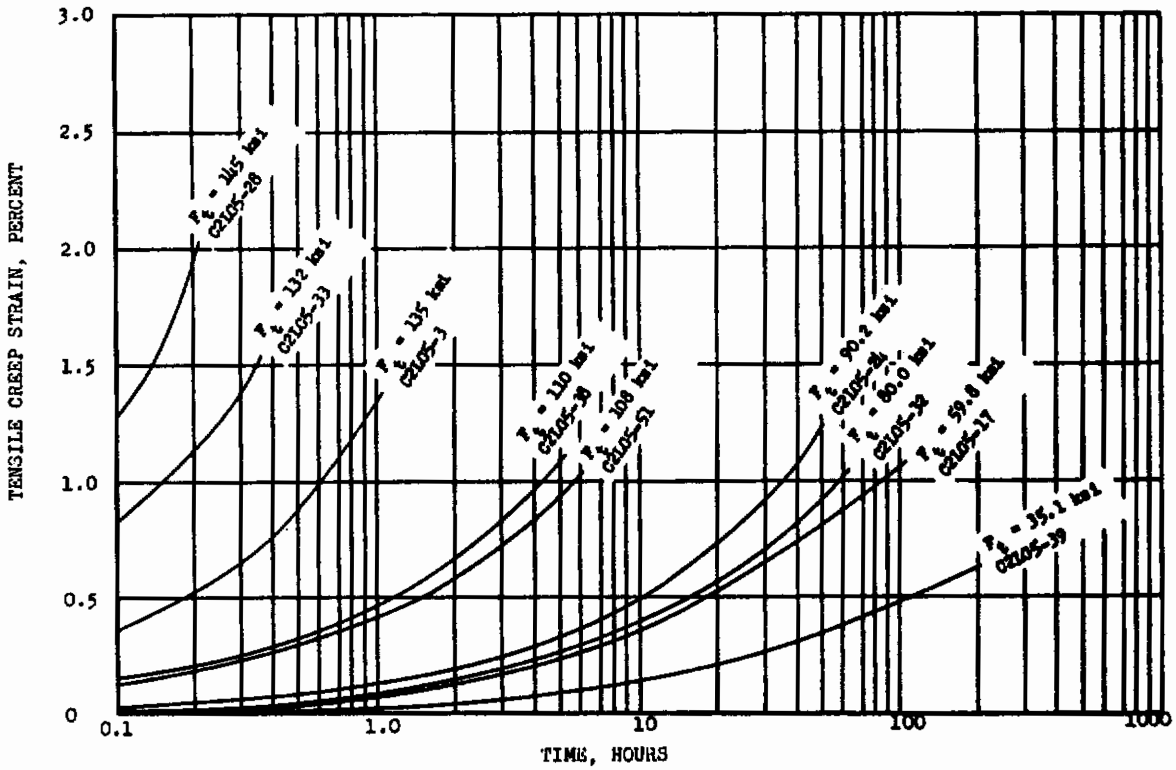


FIGURE 180 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

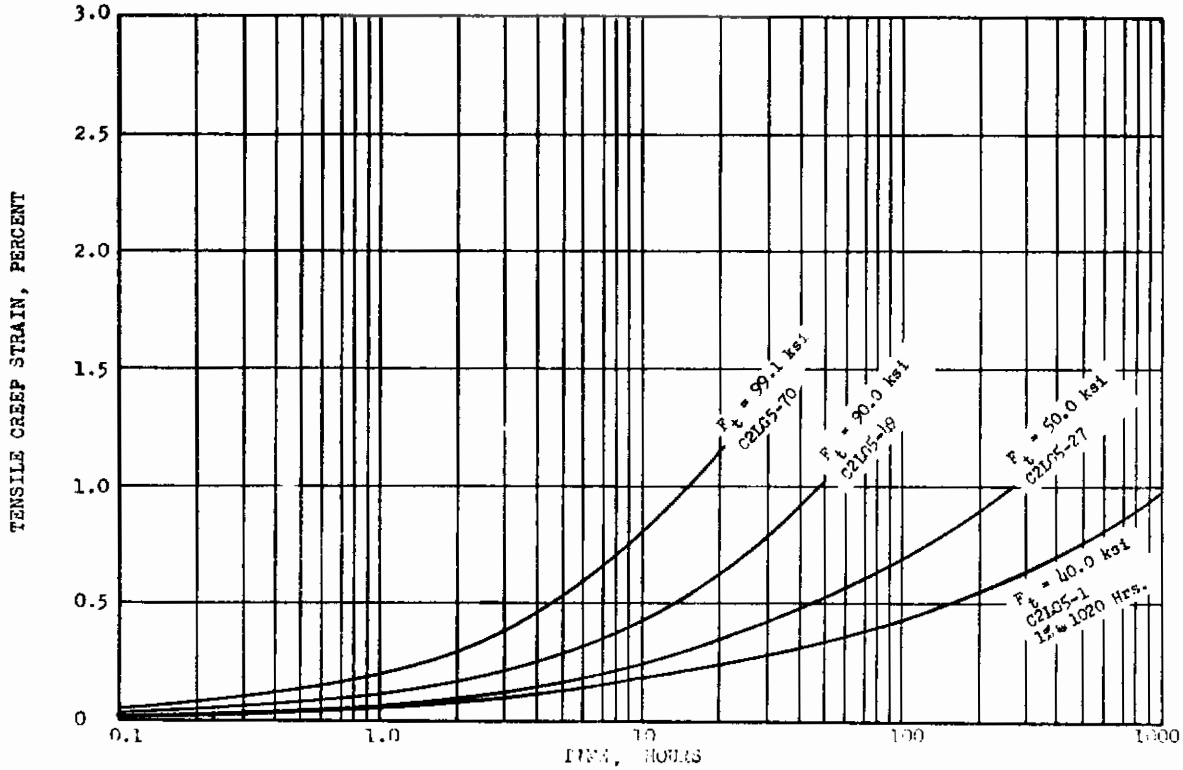


FIGURE 181 – 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

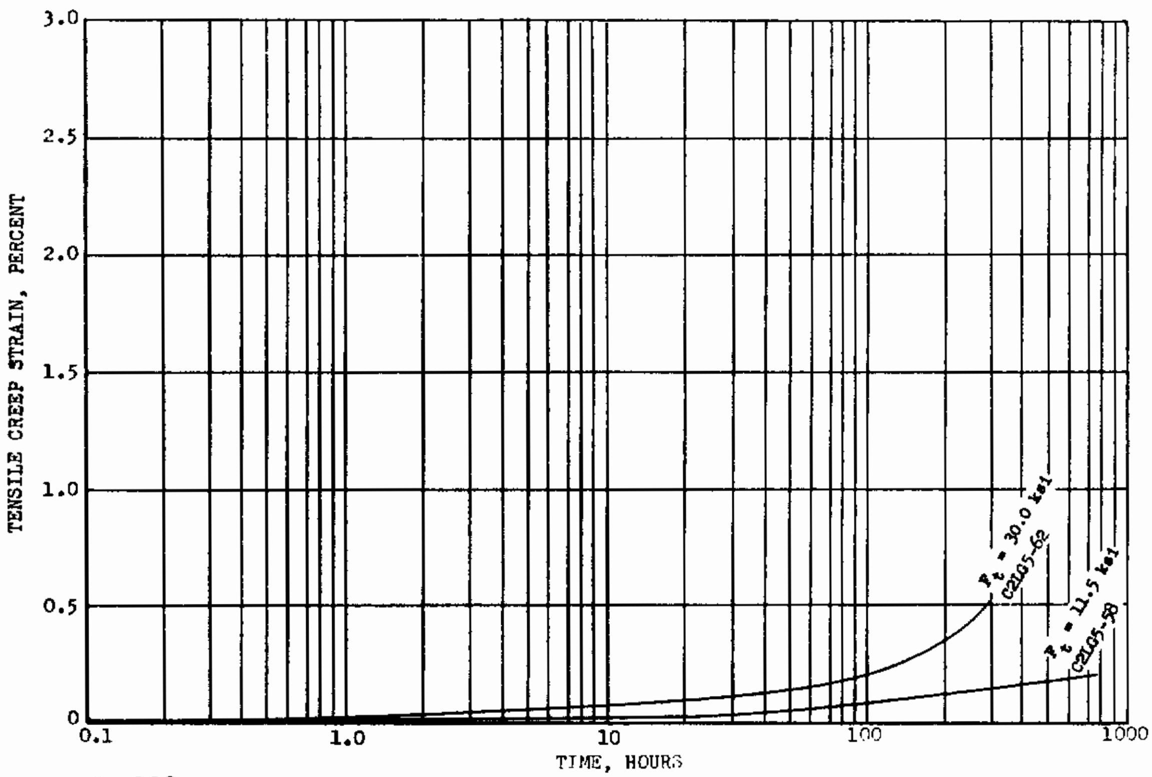


FIGURE 182 – 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

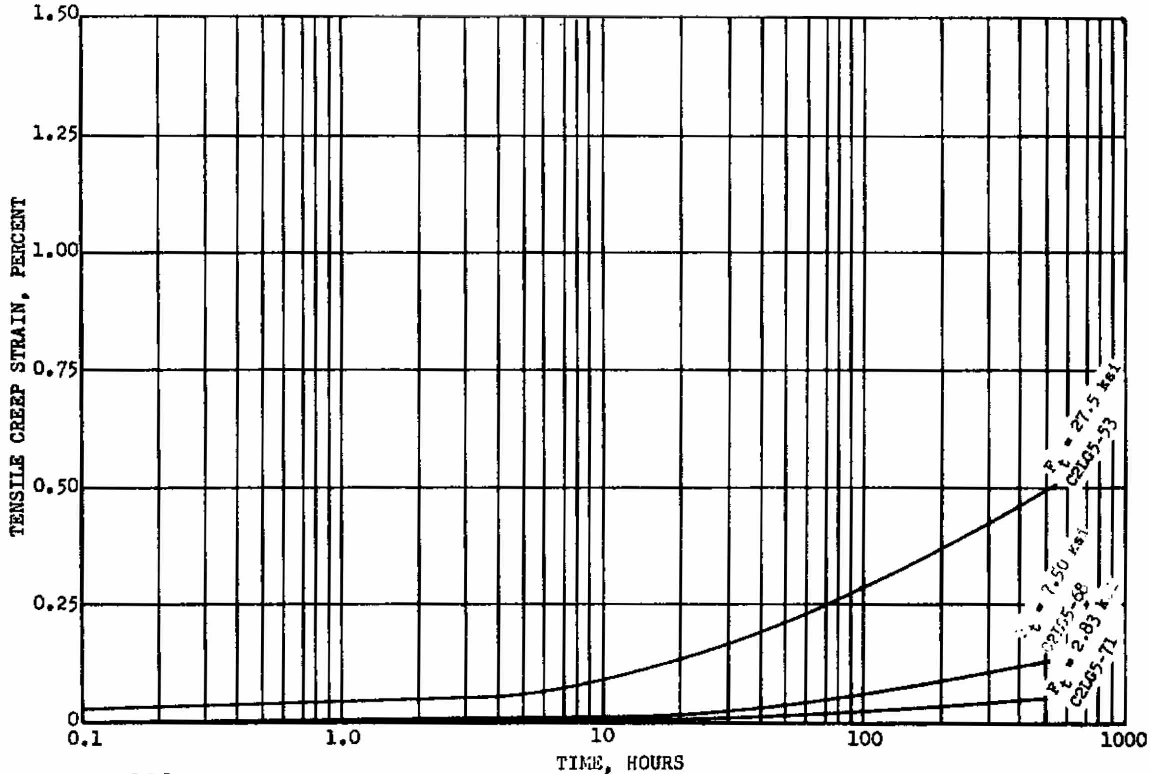


FIGURE 183 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

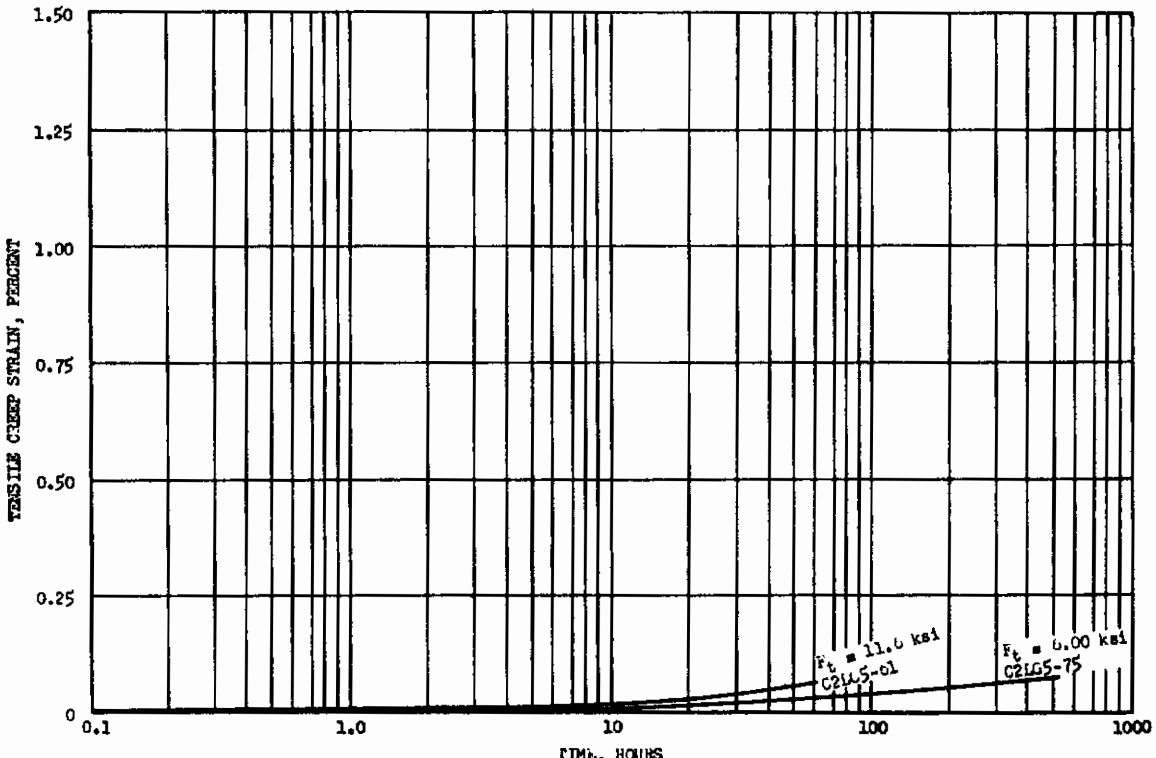


FIGURE 184 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

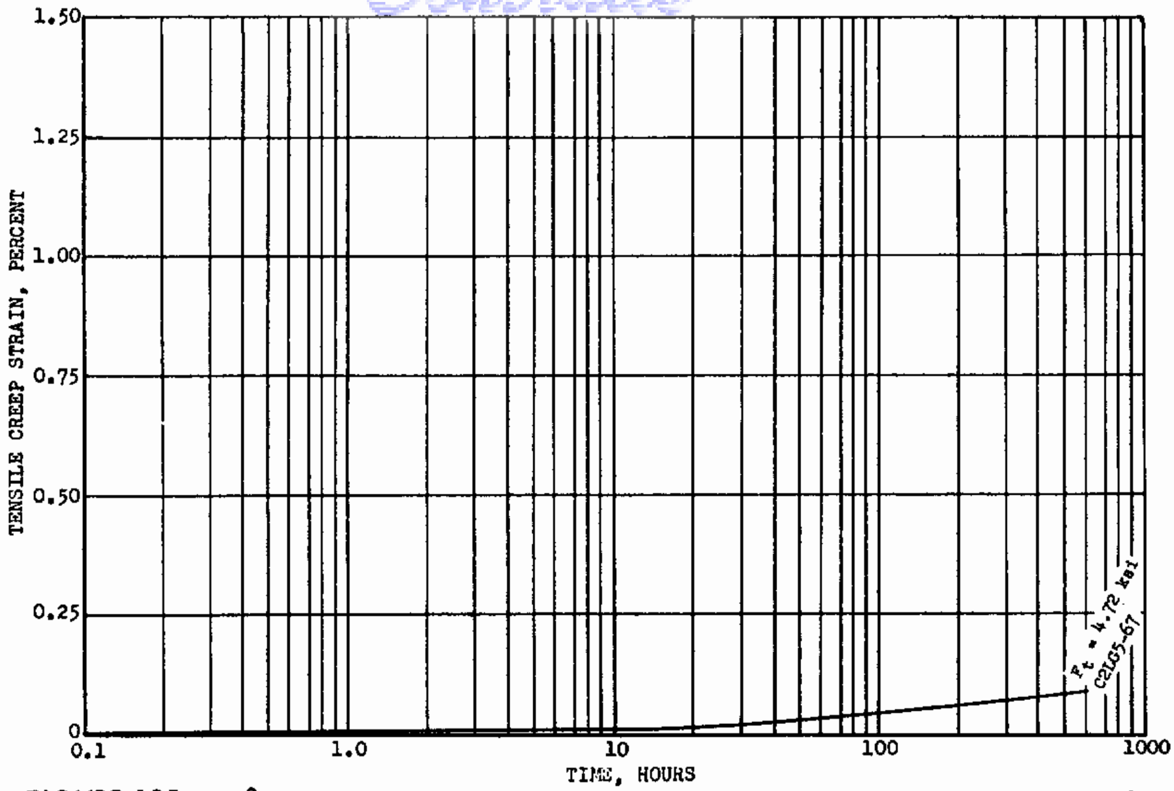


FIGURE 185 – 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

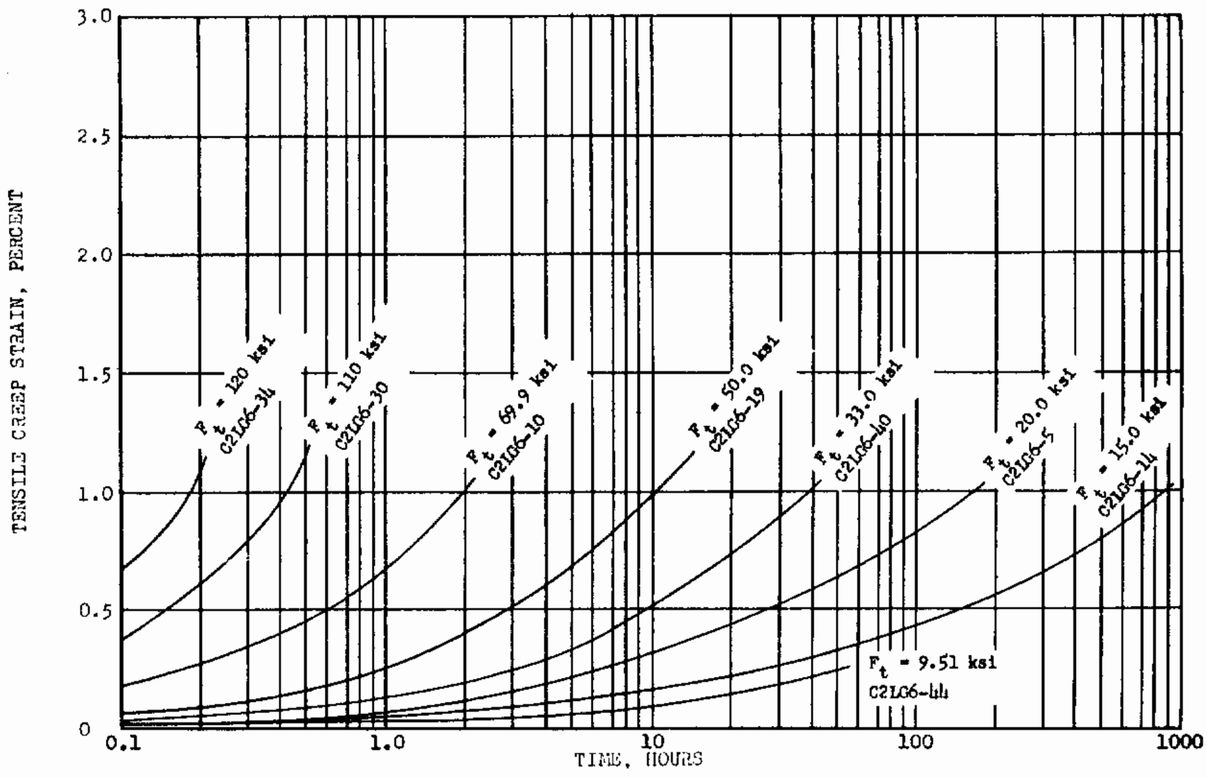


FIGURE 186 – 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

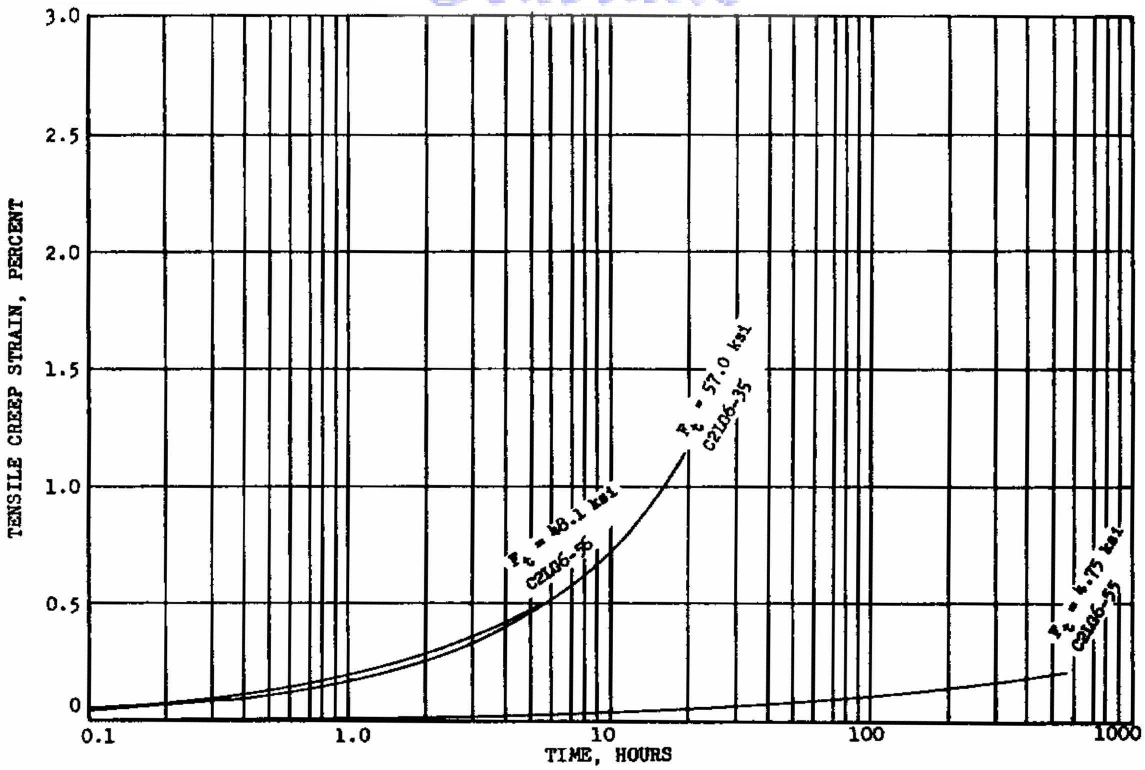


FIGURE 187 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

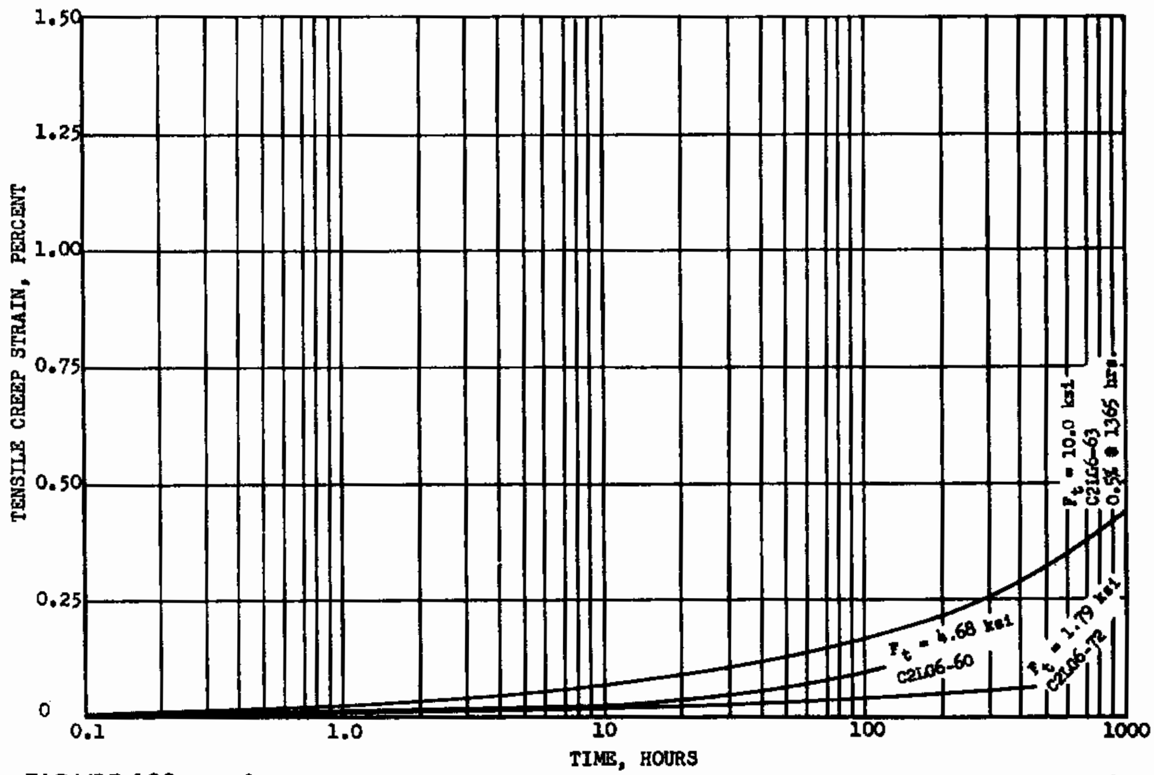


FIGURE 188 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

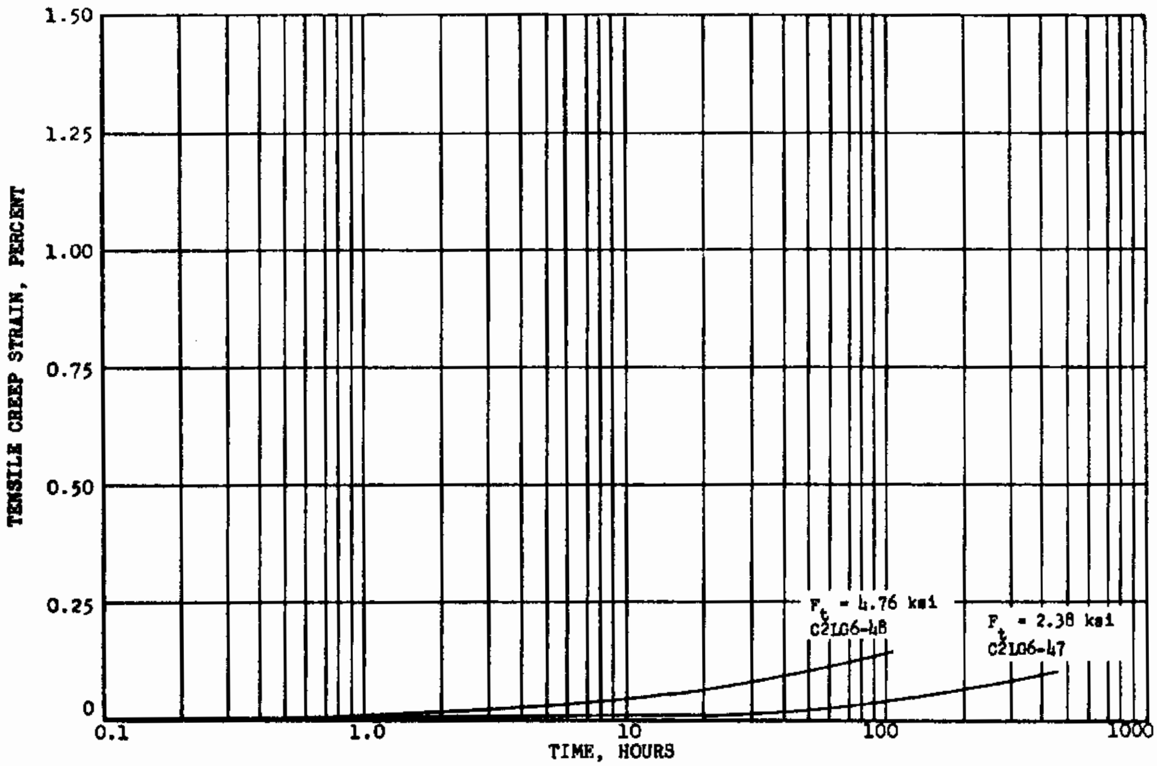


FIGURE 189 – 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

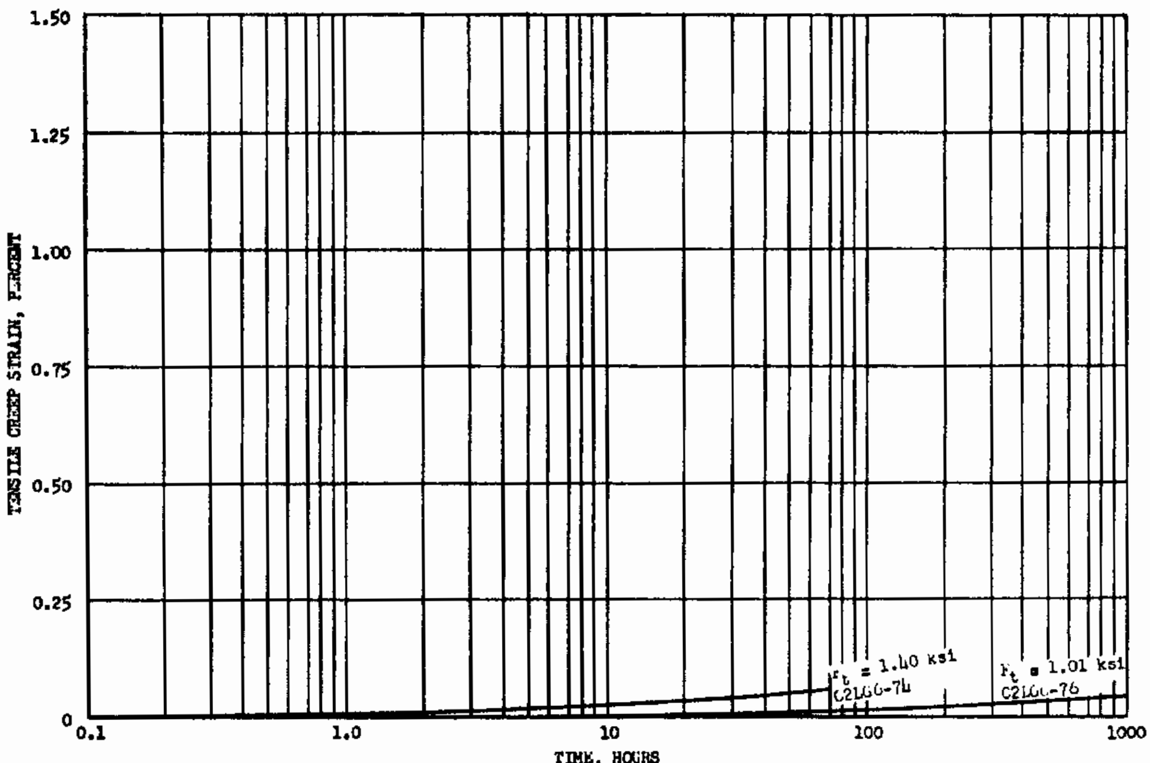


FIGURE 190 – 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

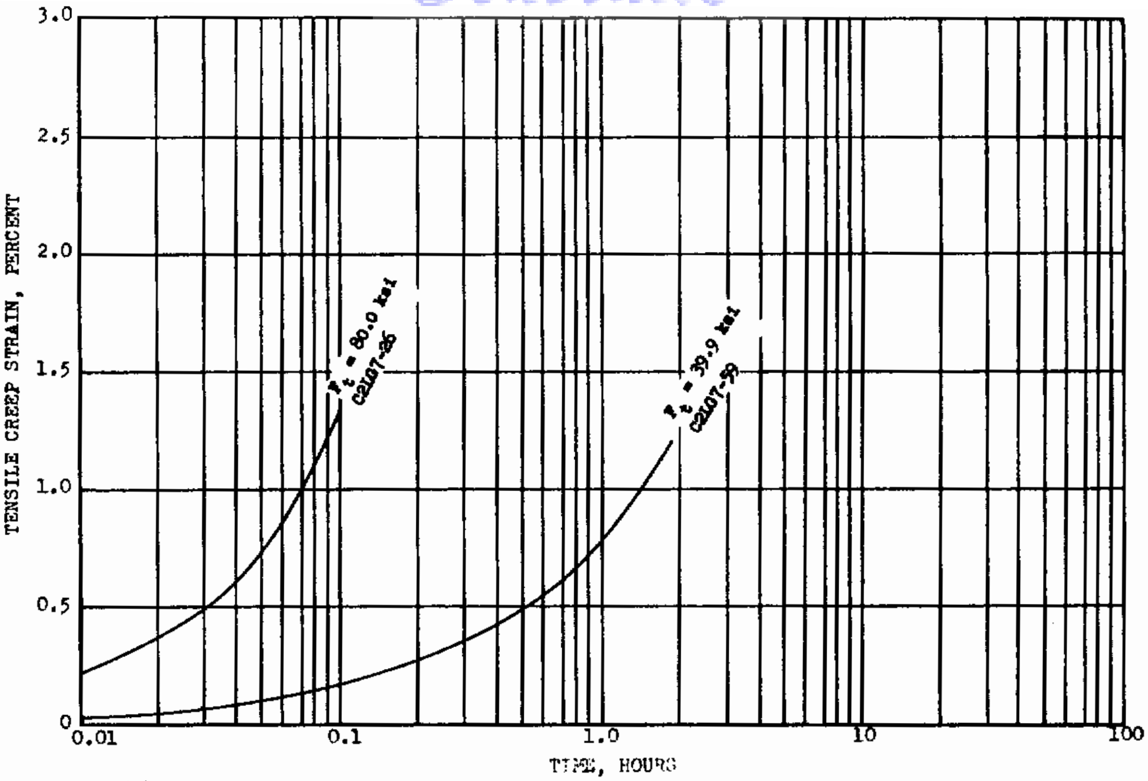


FIGURE 191 – 900°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

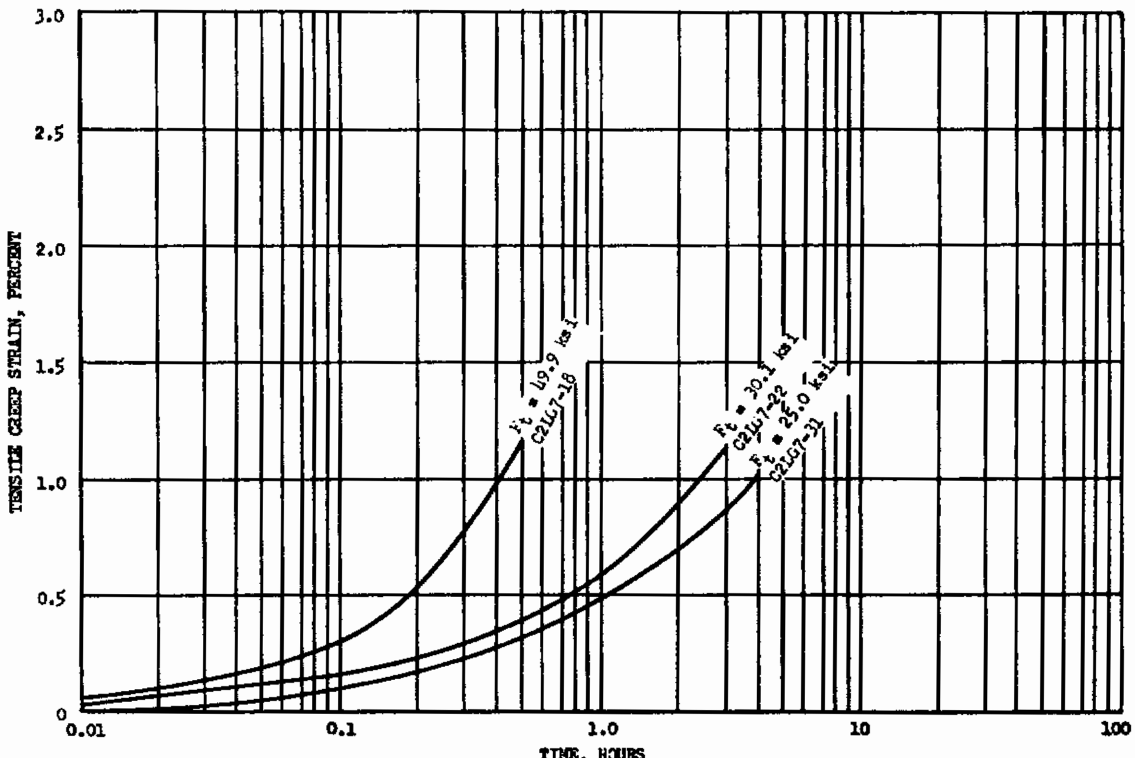


FIGURE 192 – 900°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

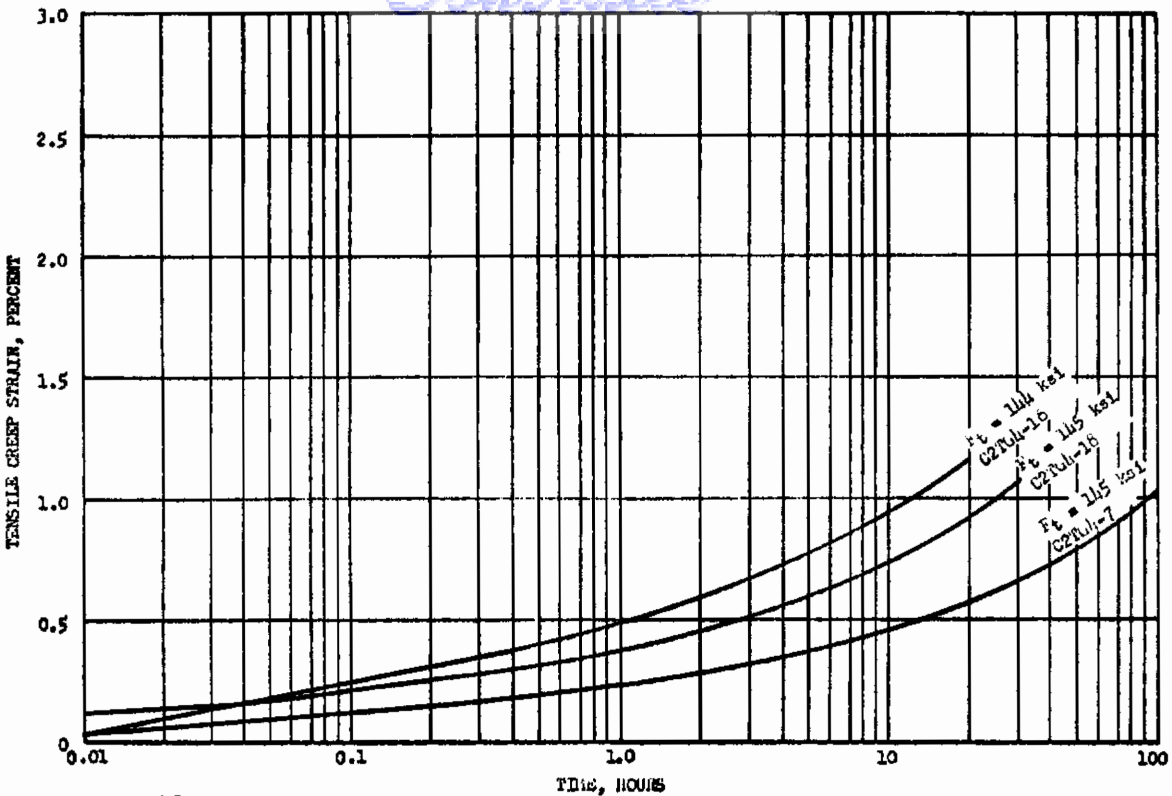


FIGURE 193 - 600°F TRANSVERSE TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

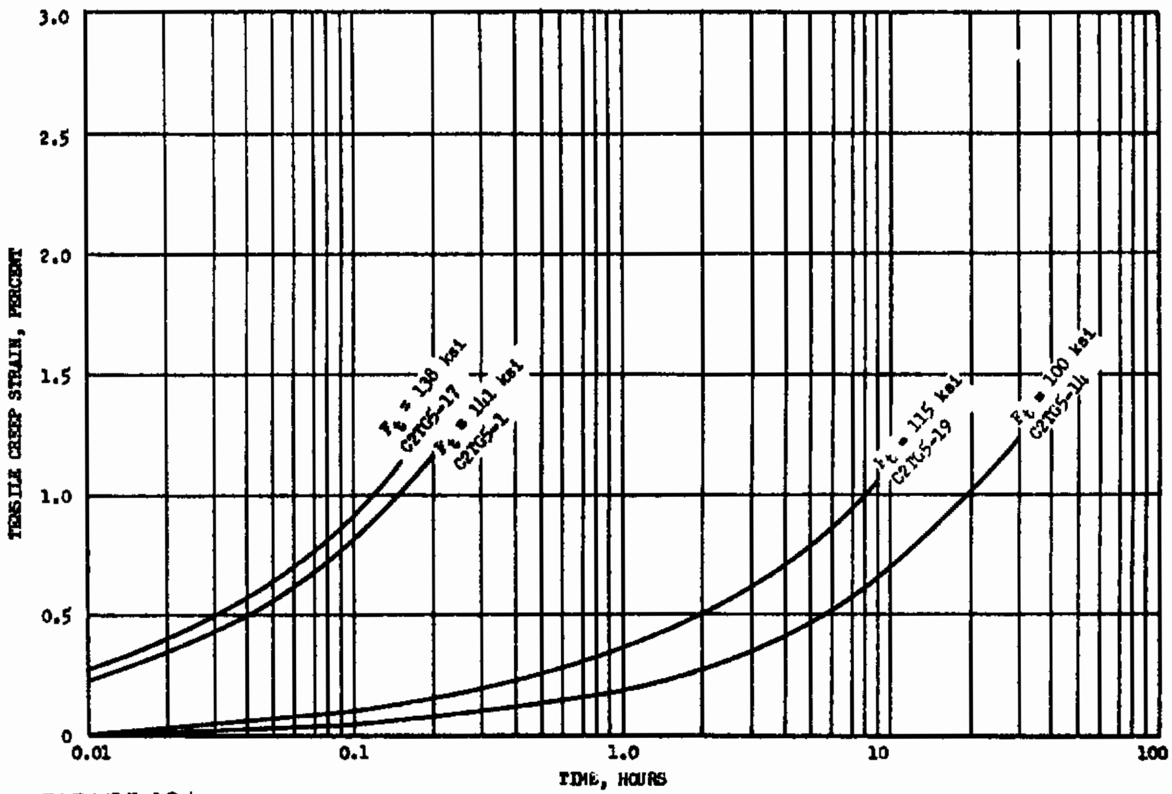


FIGURE 194 - 700°F TRANSVERSE TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

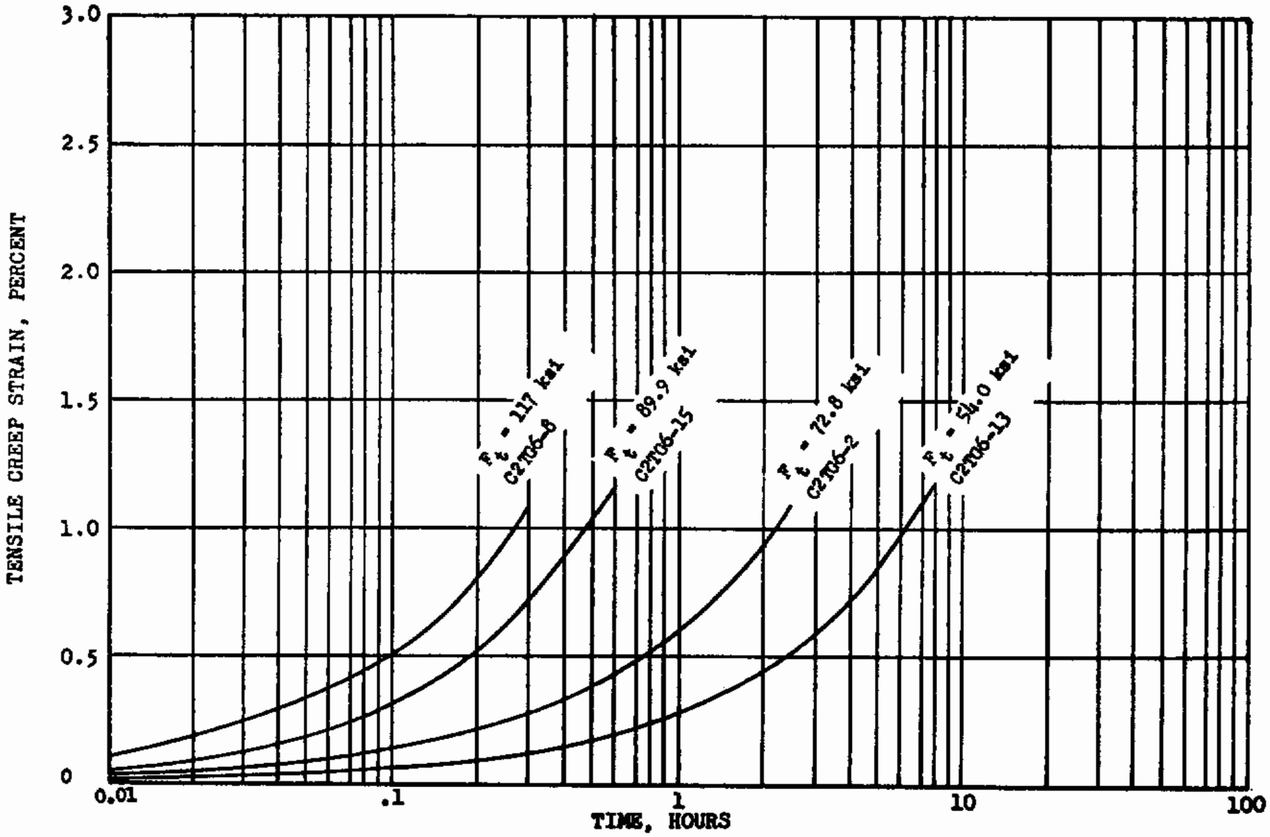


FIGURE 195 - 800°F TRANSVERSE TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 22154)

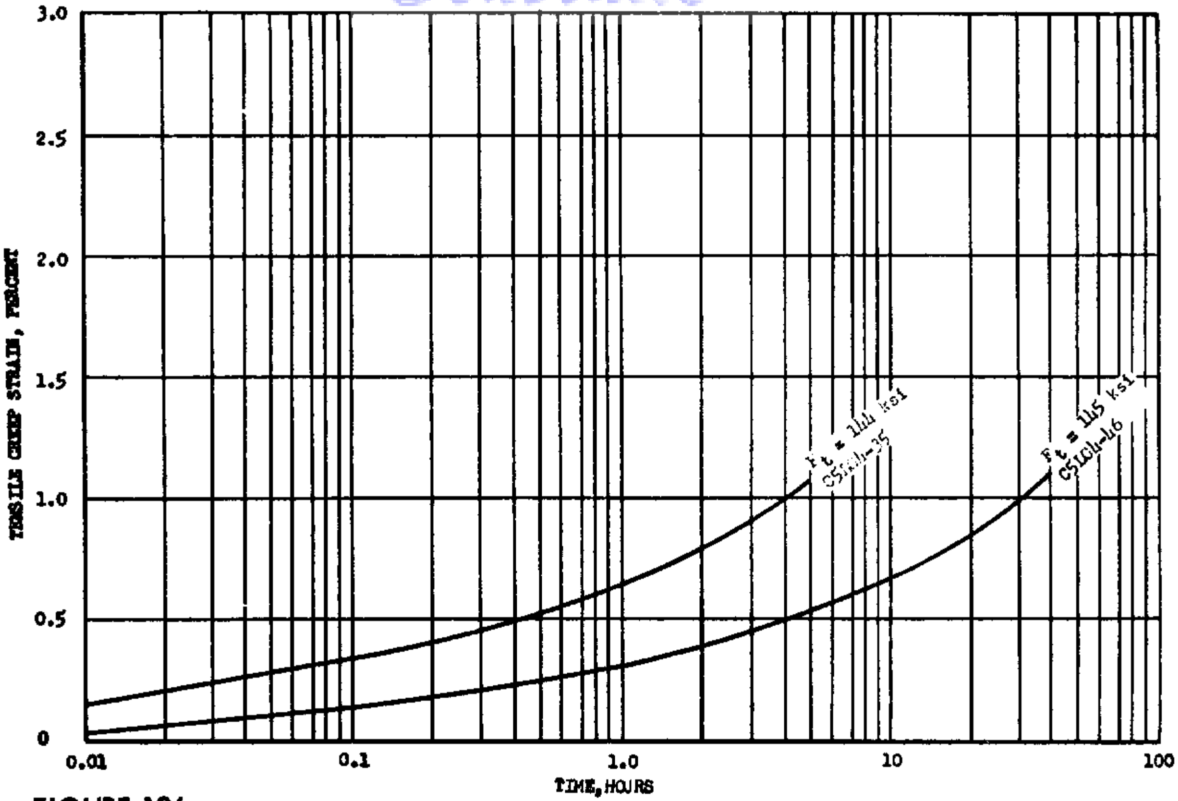


FIGURE 196 – 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24806)

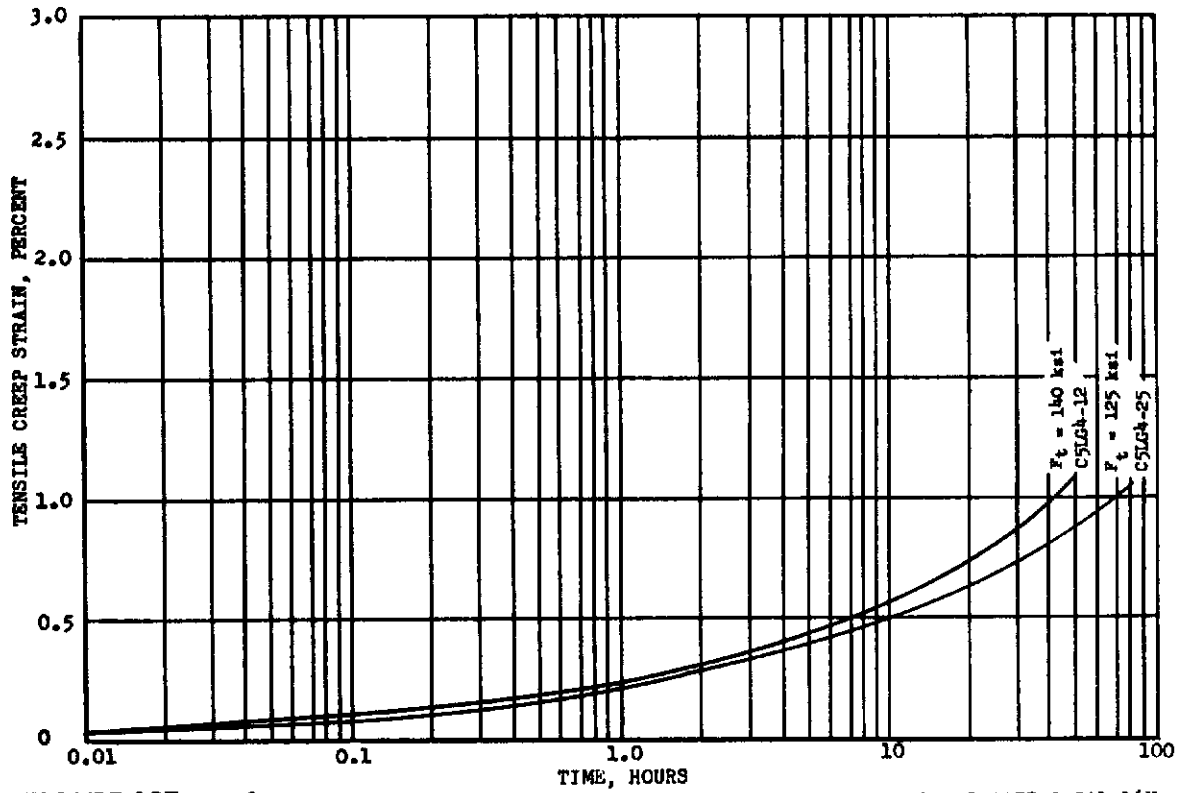


FIGURE 197 – 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24806)

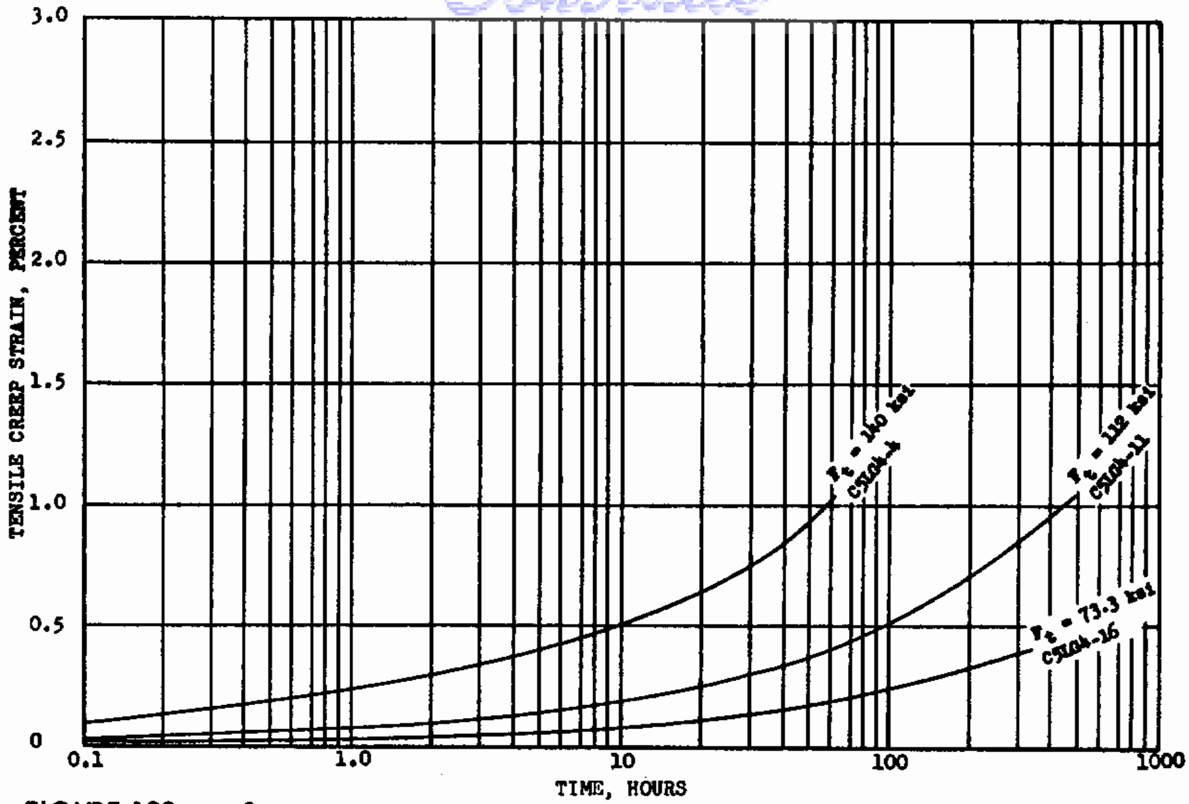


FIGURE 198 – 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24806)

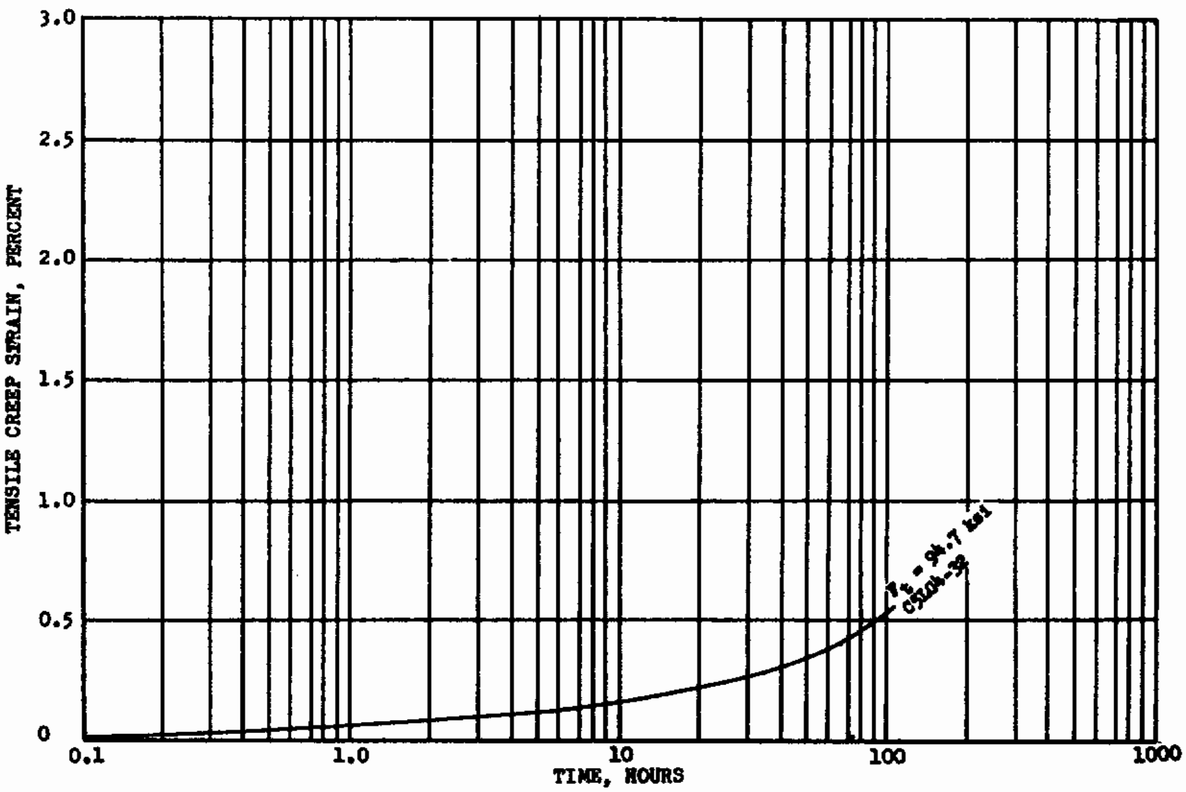


FIGURE 199 – 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24806)

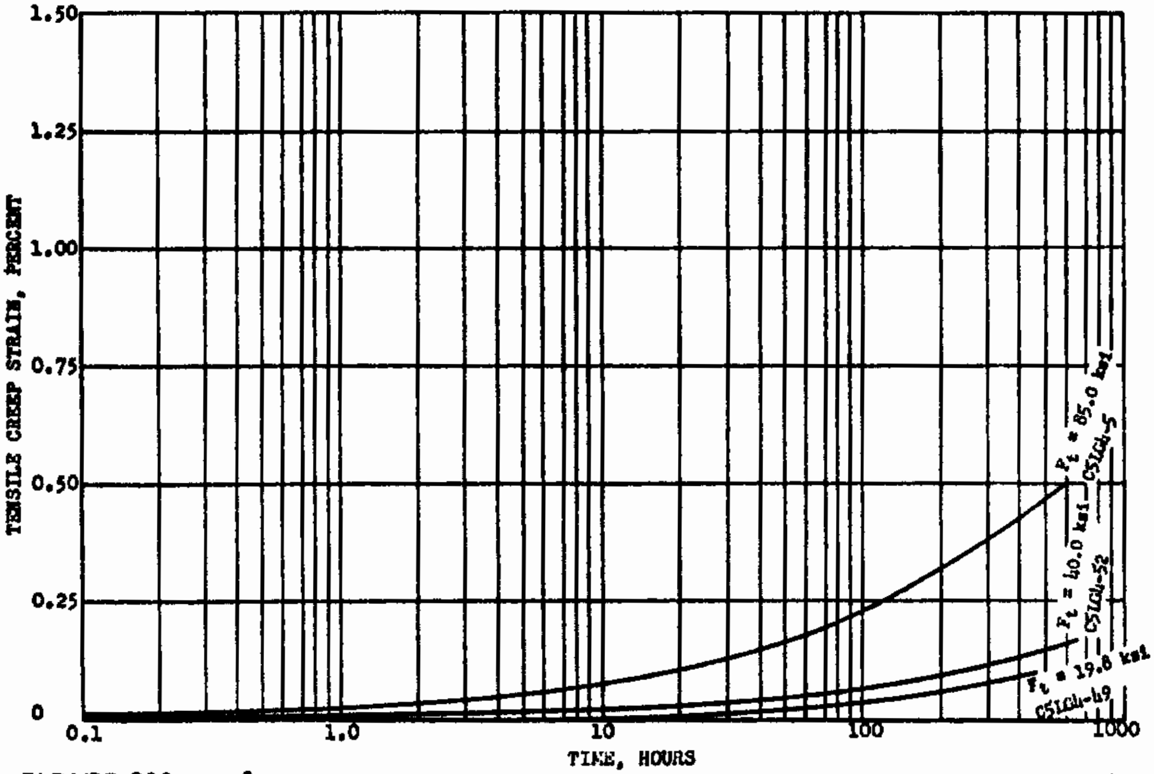


FIGURE 200 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24806)

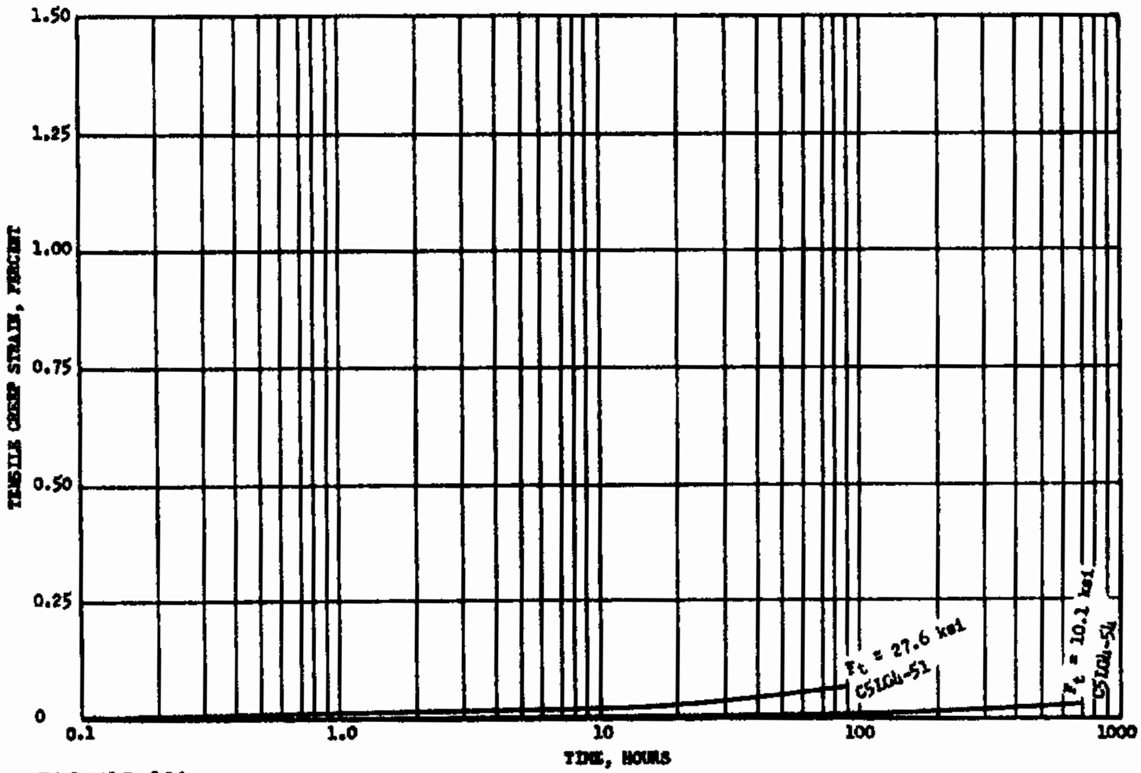


FIGURE 201 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24806)

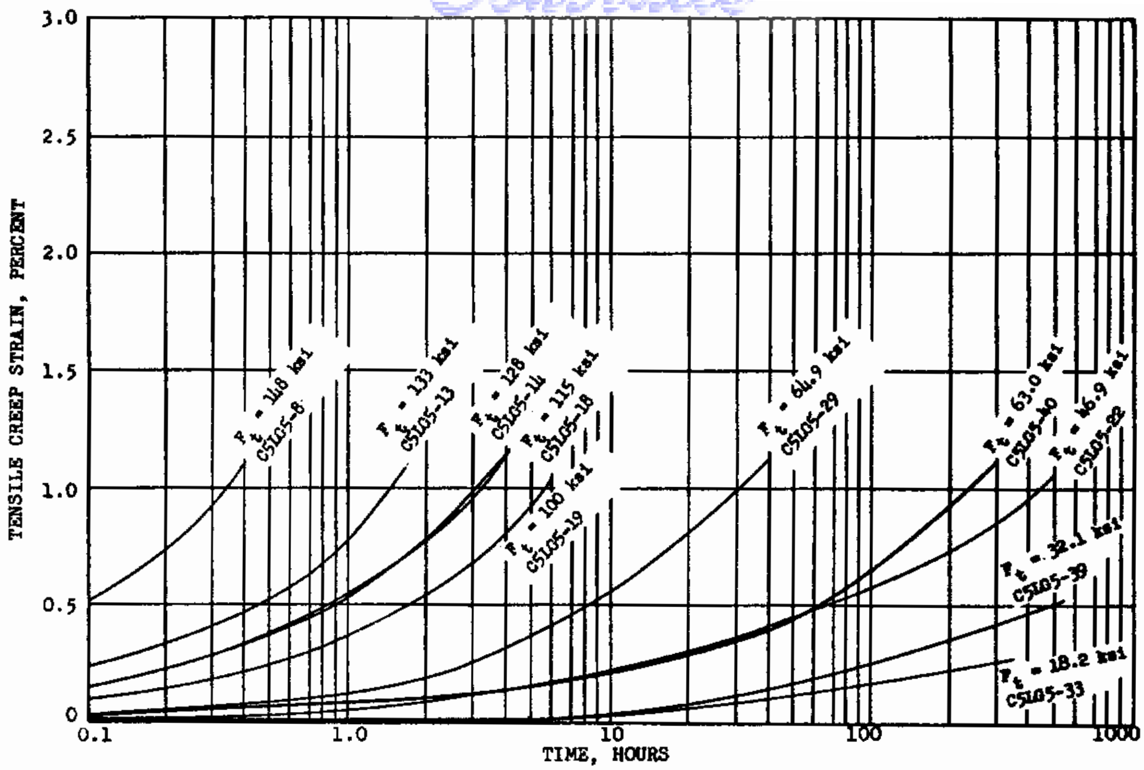


FIGURE 202 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24806)

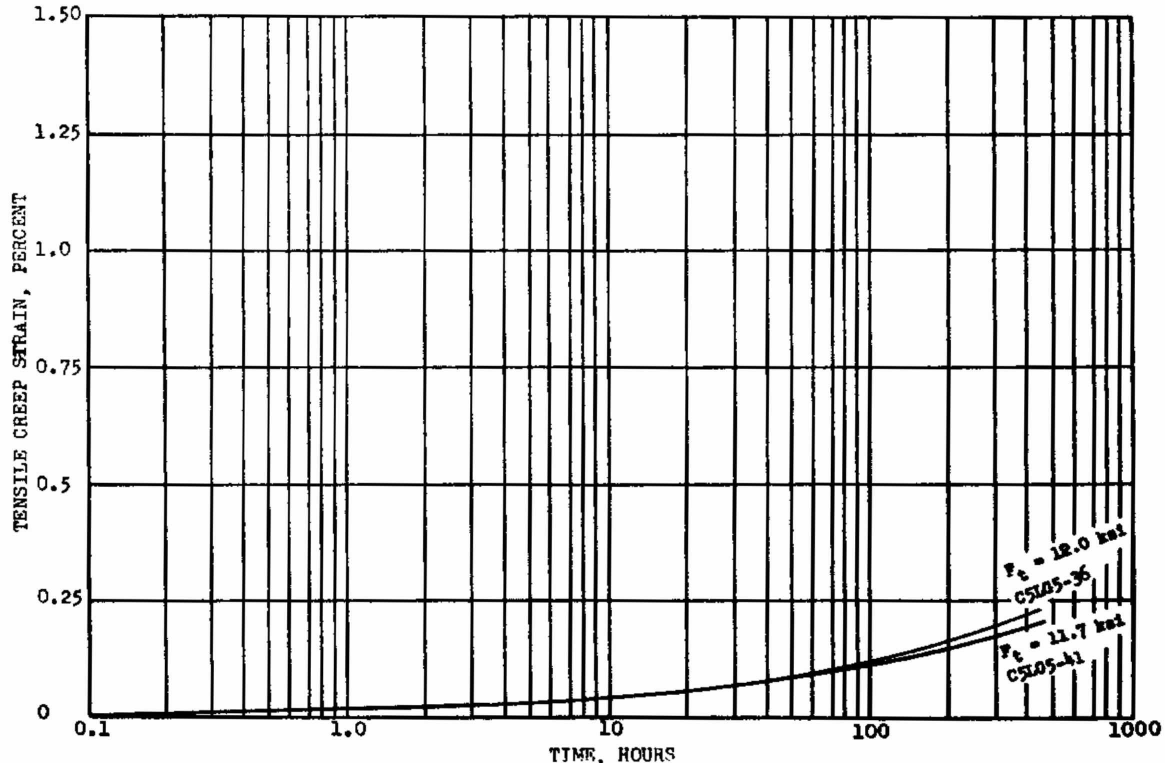


FIGURE 203 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24806)

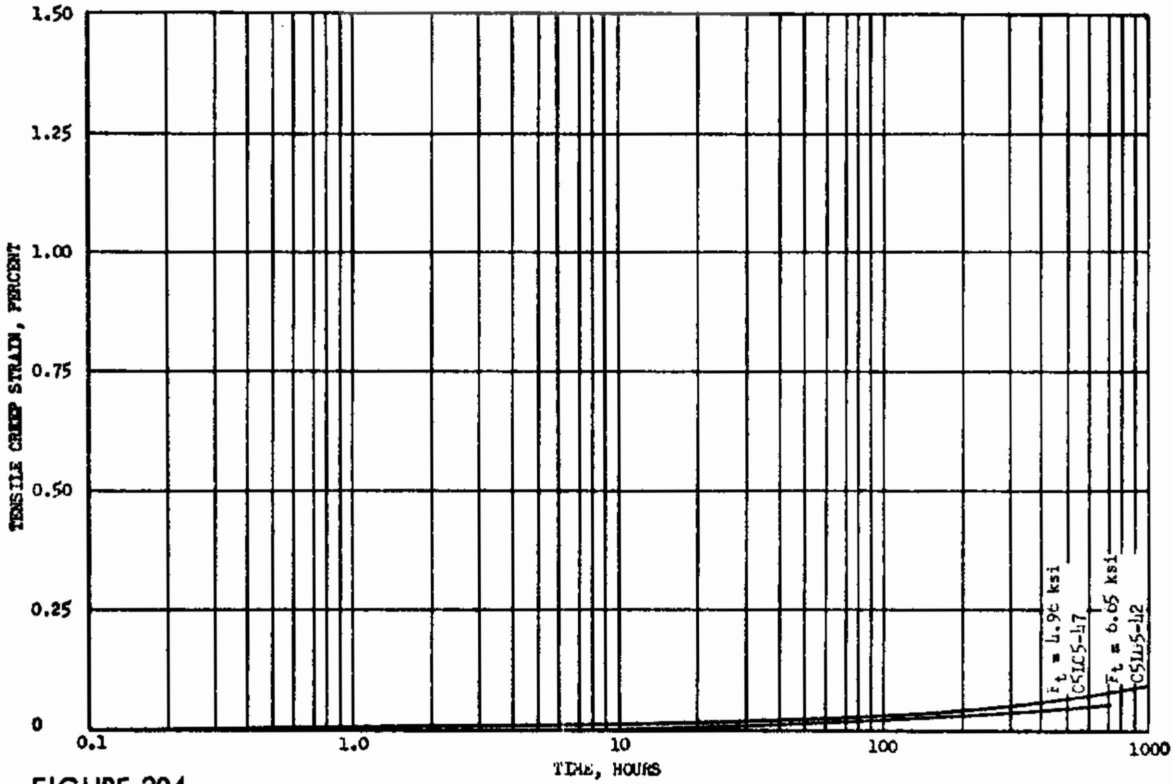


FIGURE 204 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24806)

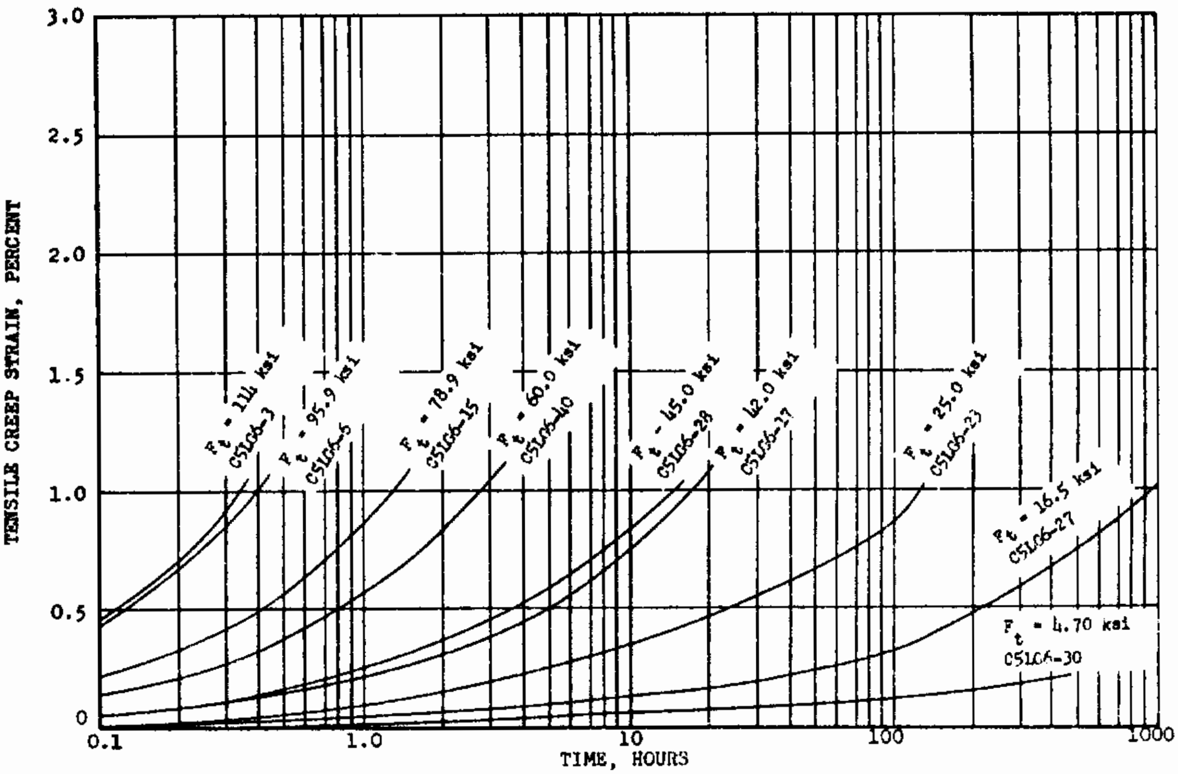


FIGURE 205 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24806)

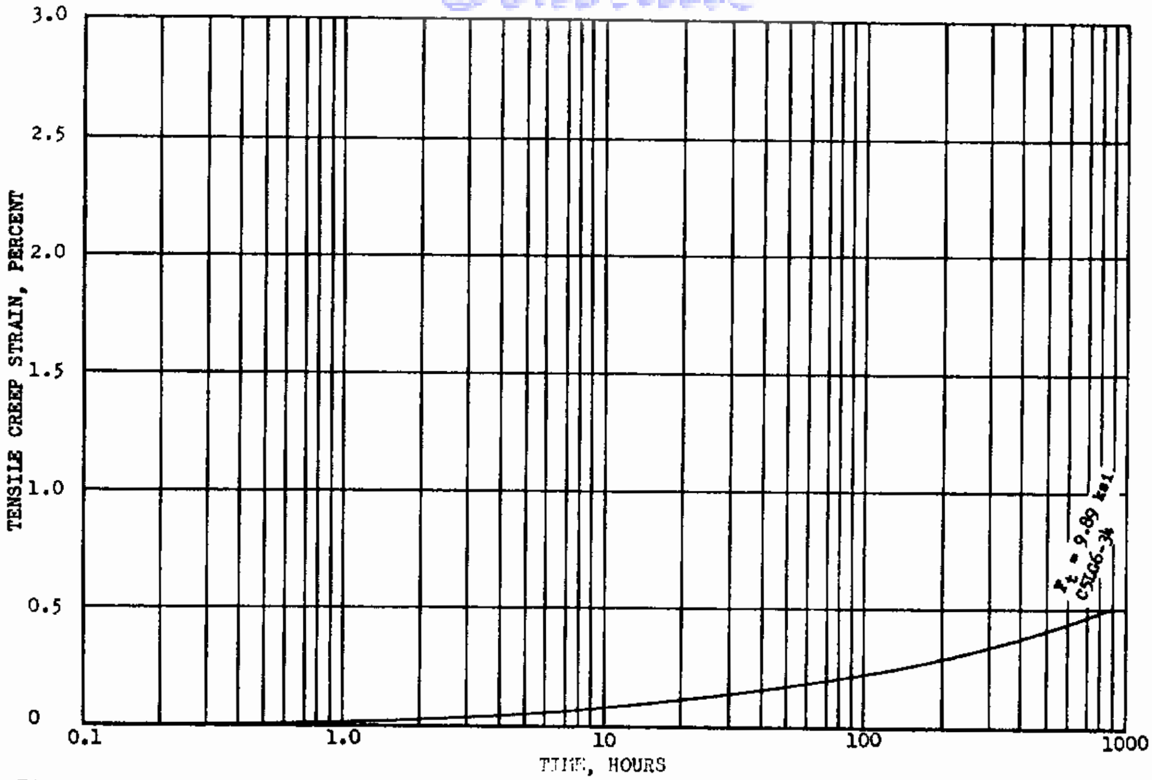


FIGURE 206 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24806)

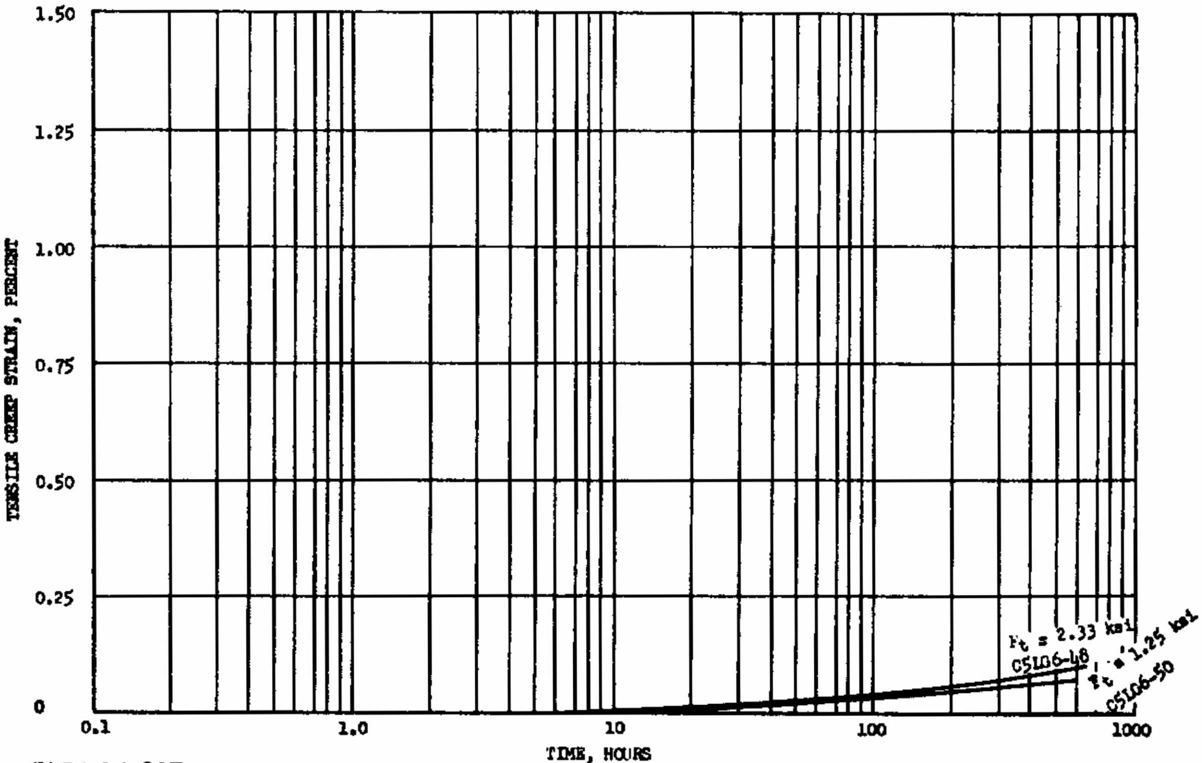


FIGURE 207 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24806)

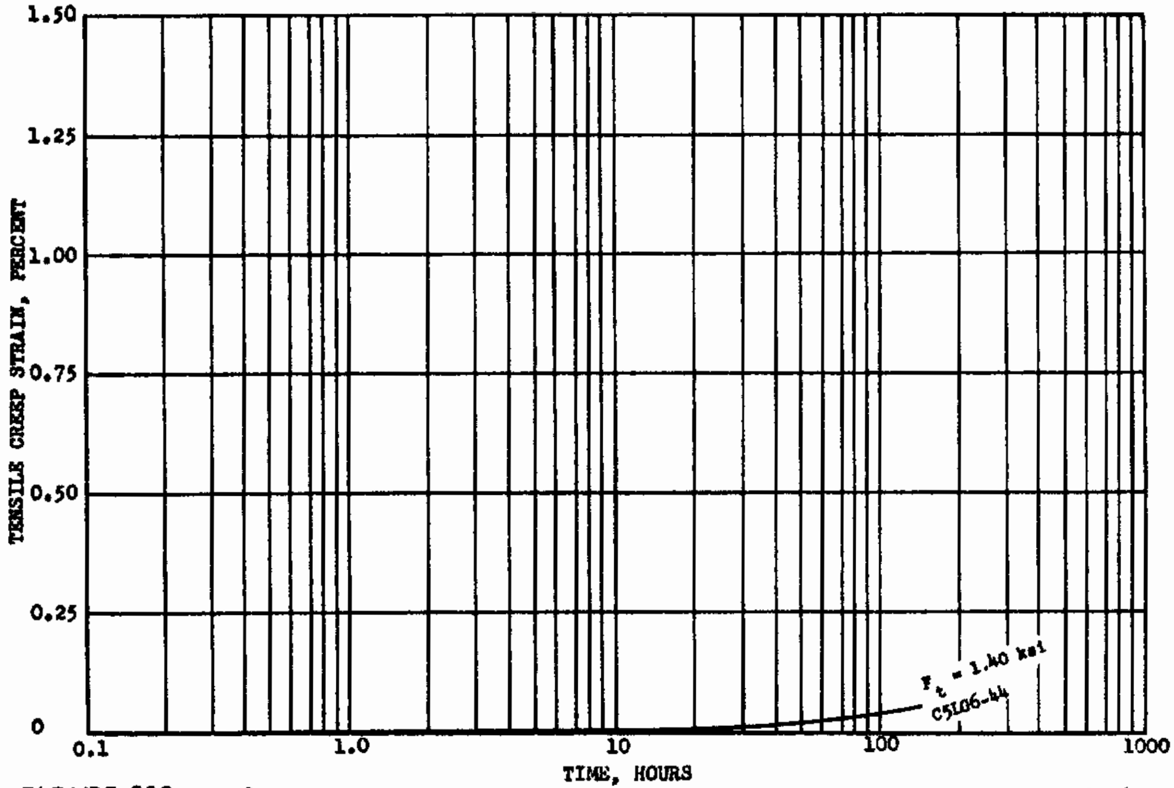


FIGURE 208 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24806)

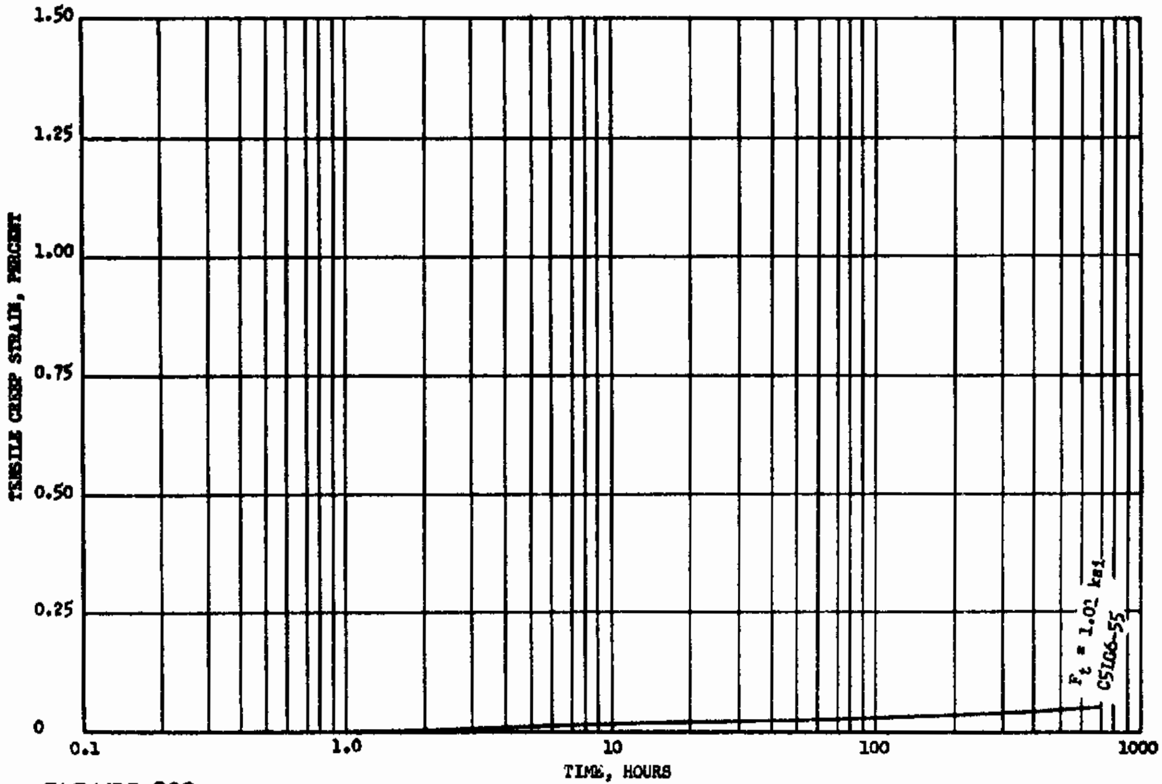


FIGURE 209 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24806)

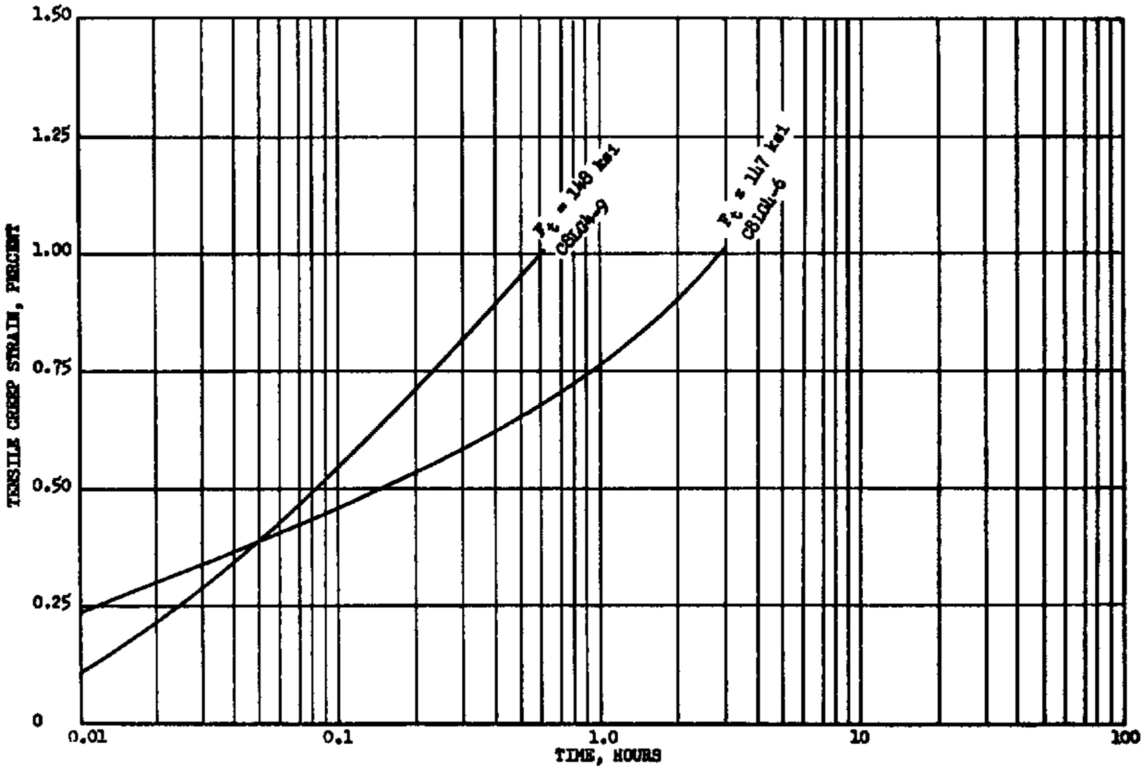


FIGURE 210 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24814)

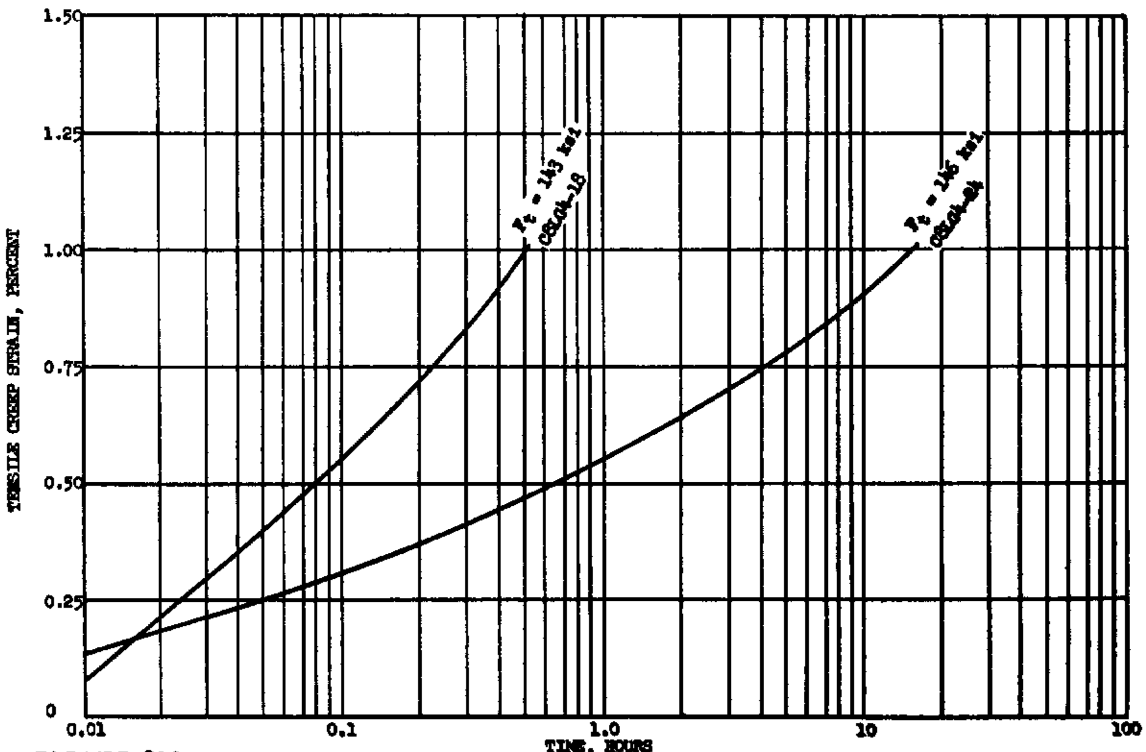


FIGURE 211 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NUMBER 24814)

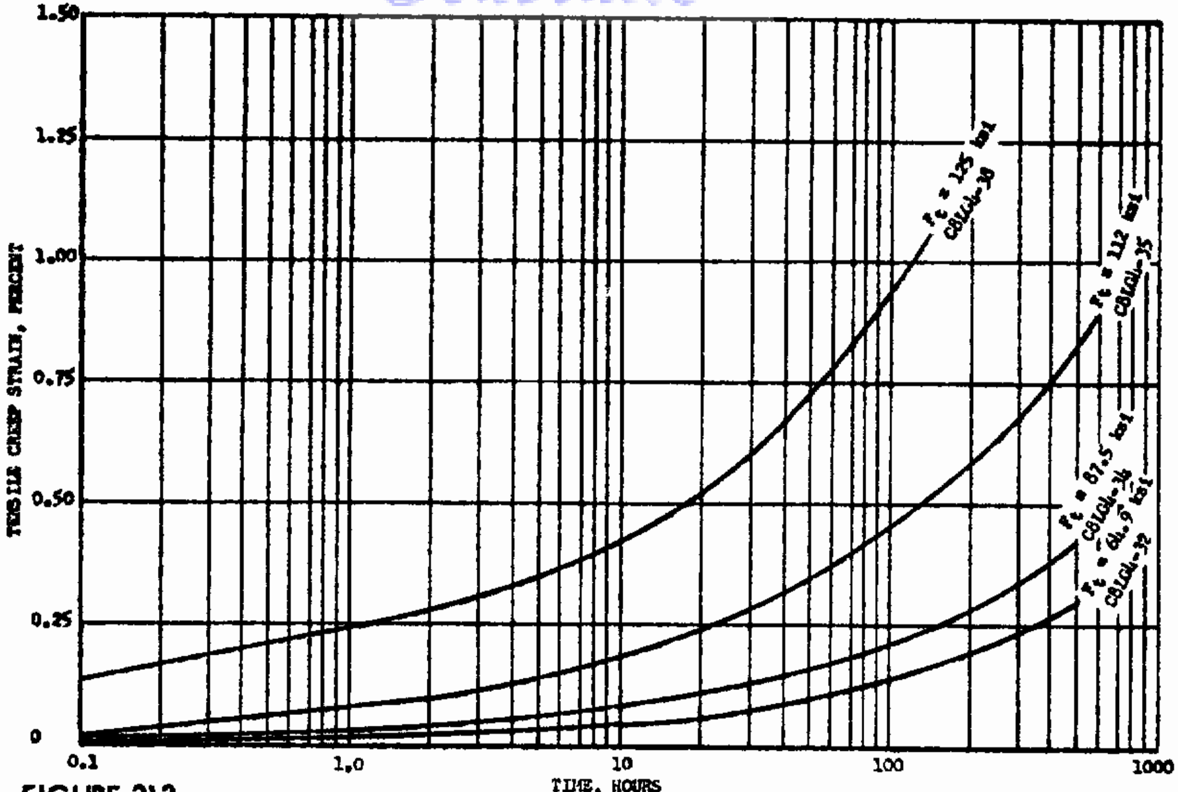


FIGURE 212 – 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24814)

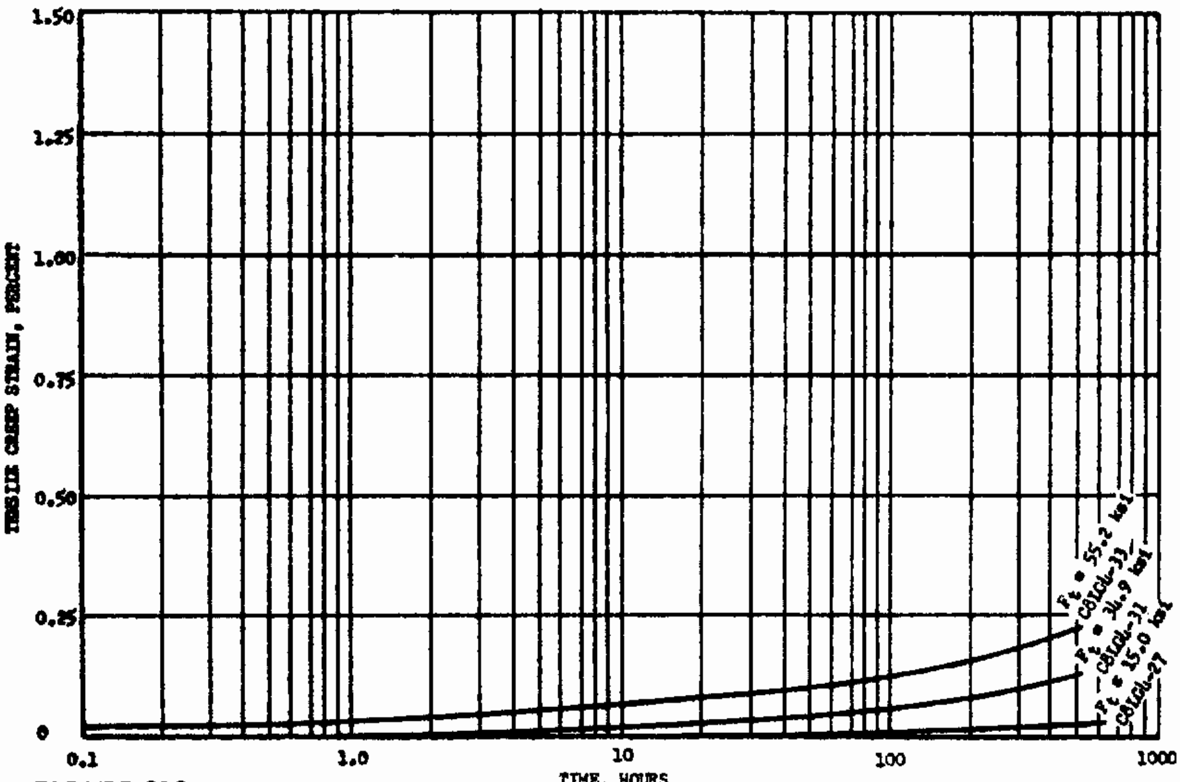


FIGURE 213 – 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24814)

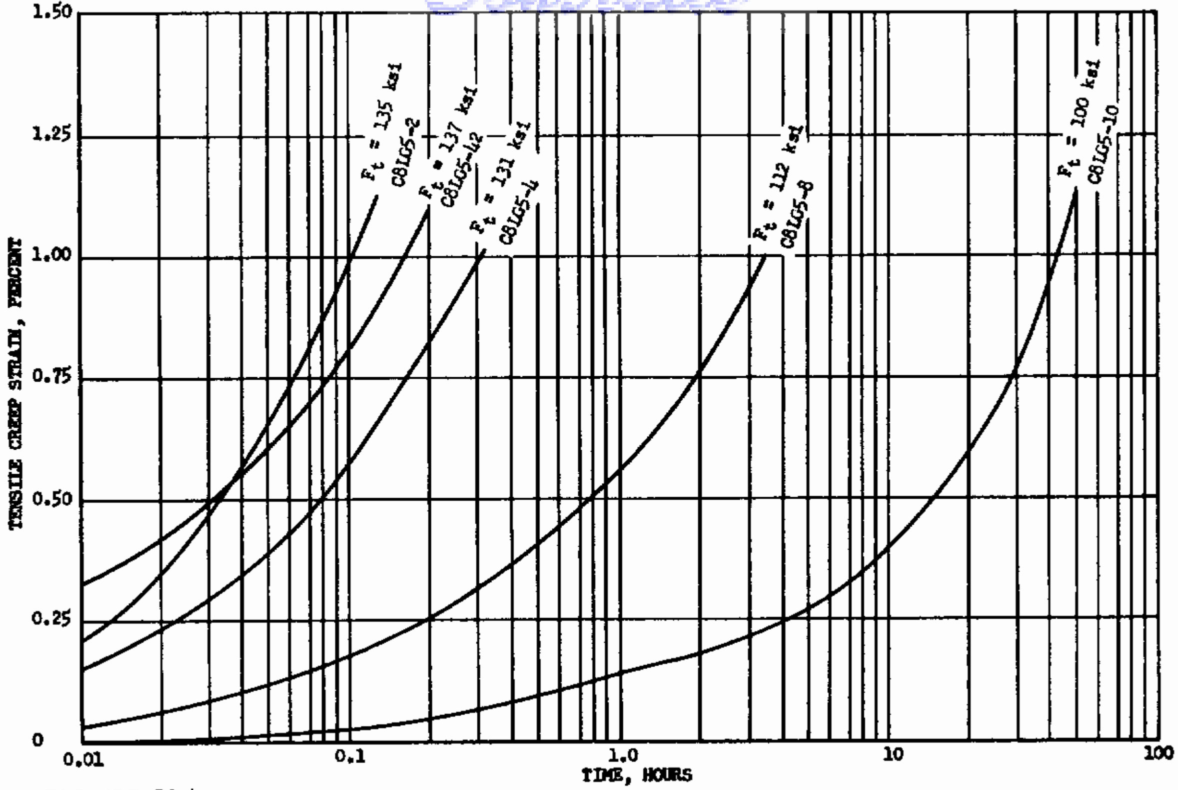


FIGURE 214 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24814)

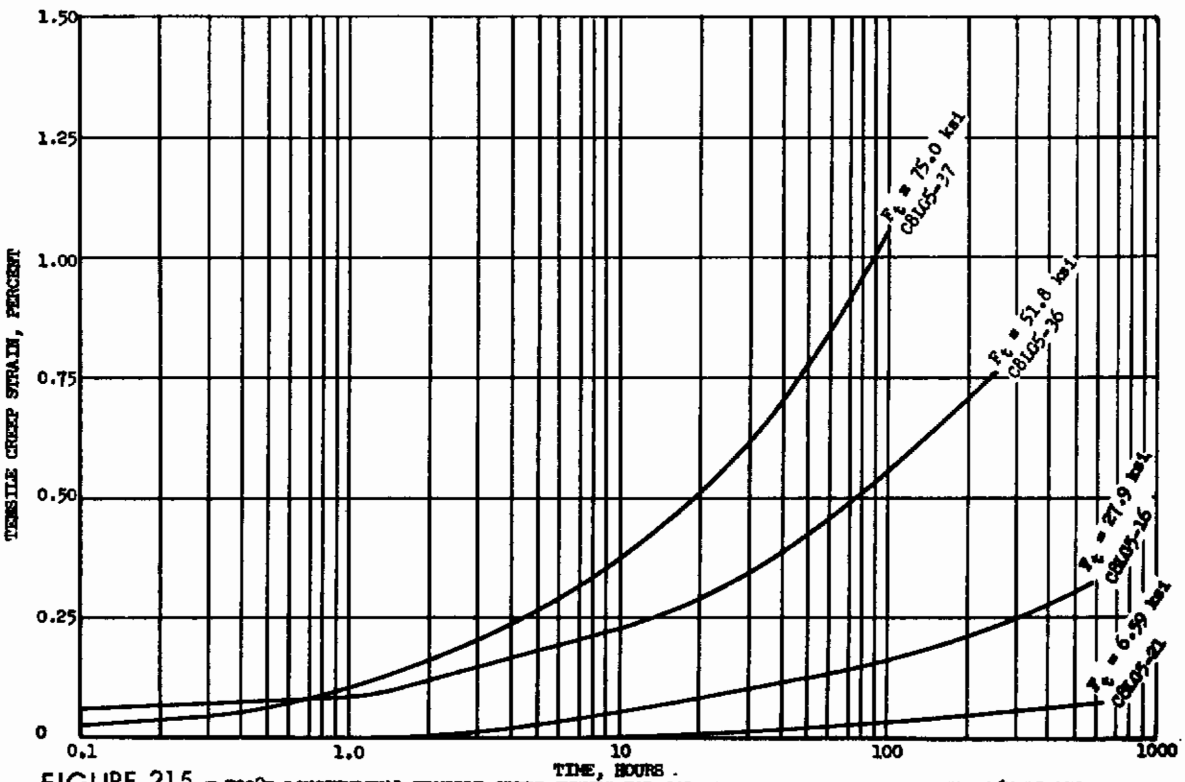


FIGURE 215 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NUMBER 24814)

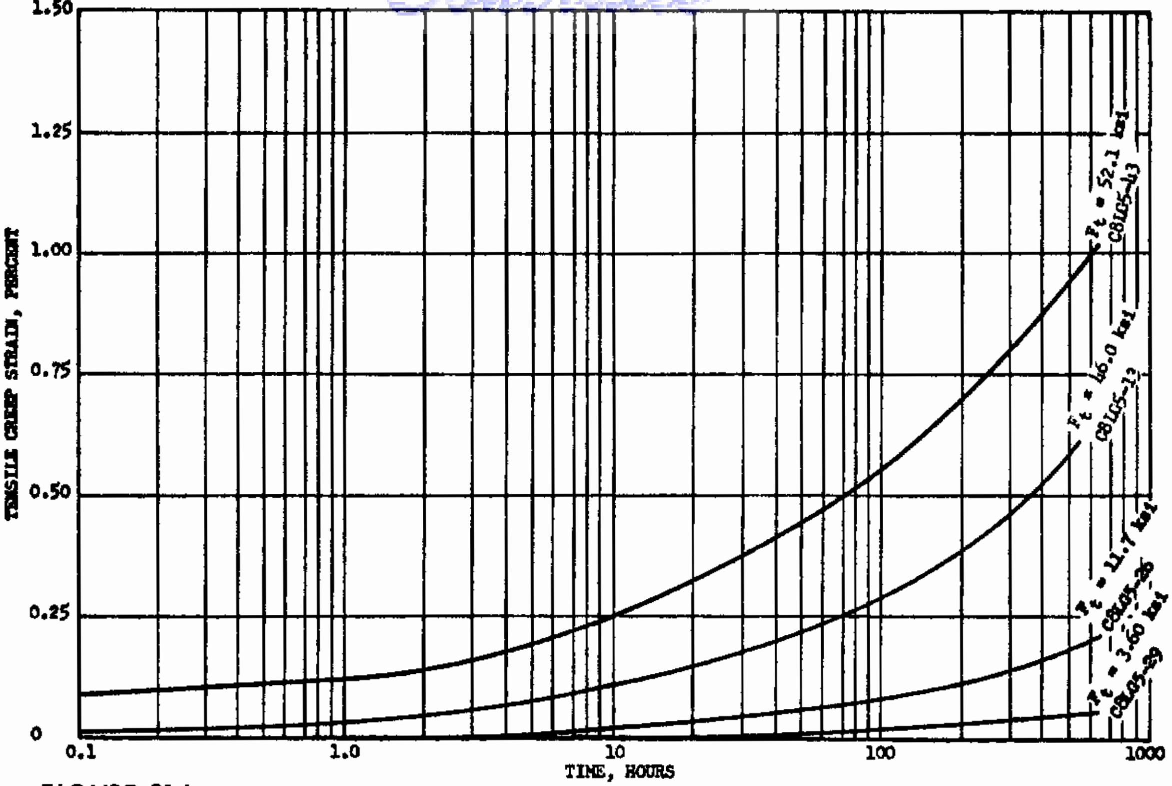


FIGURE 216 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24814)

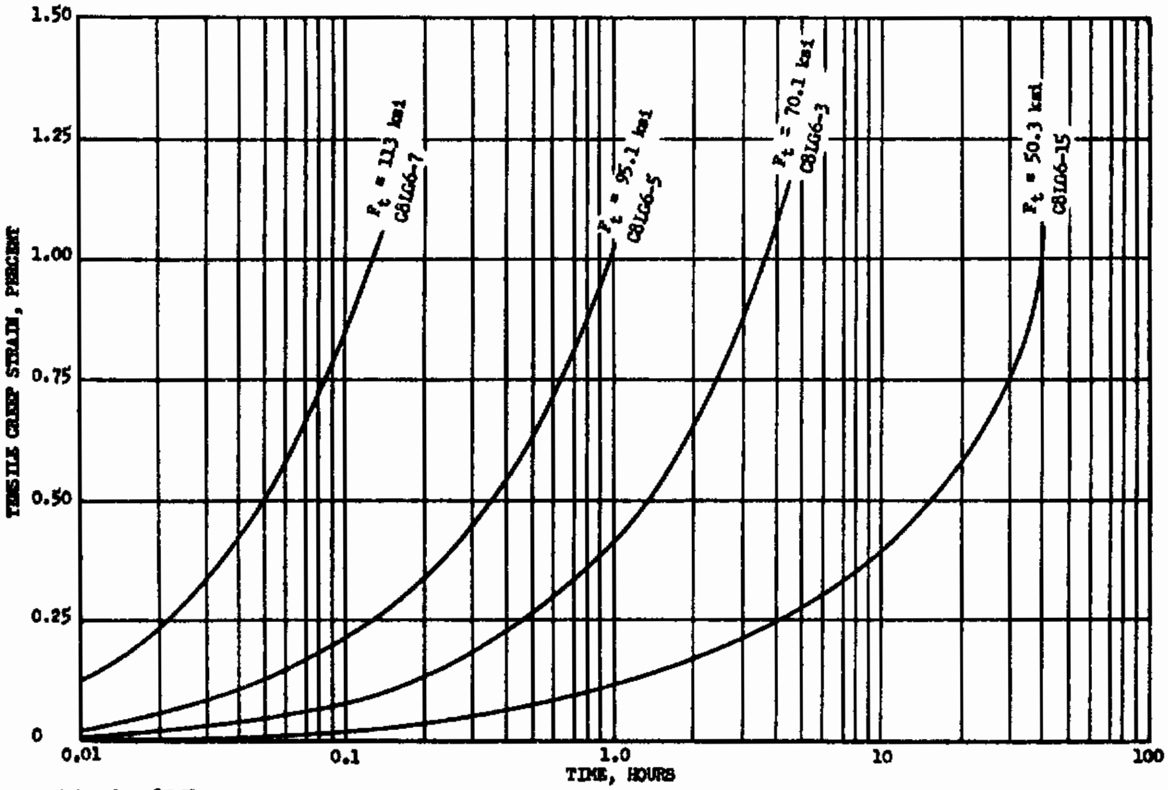


FIGURE 217 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24814)

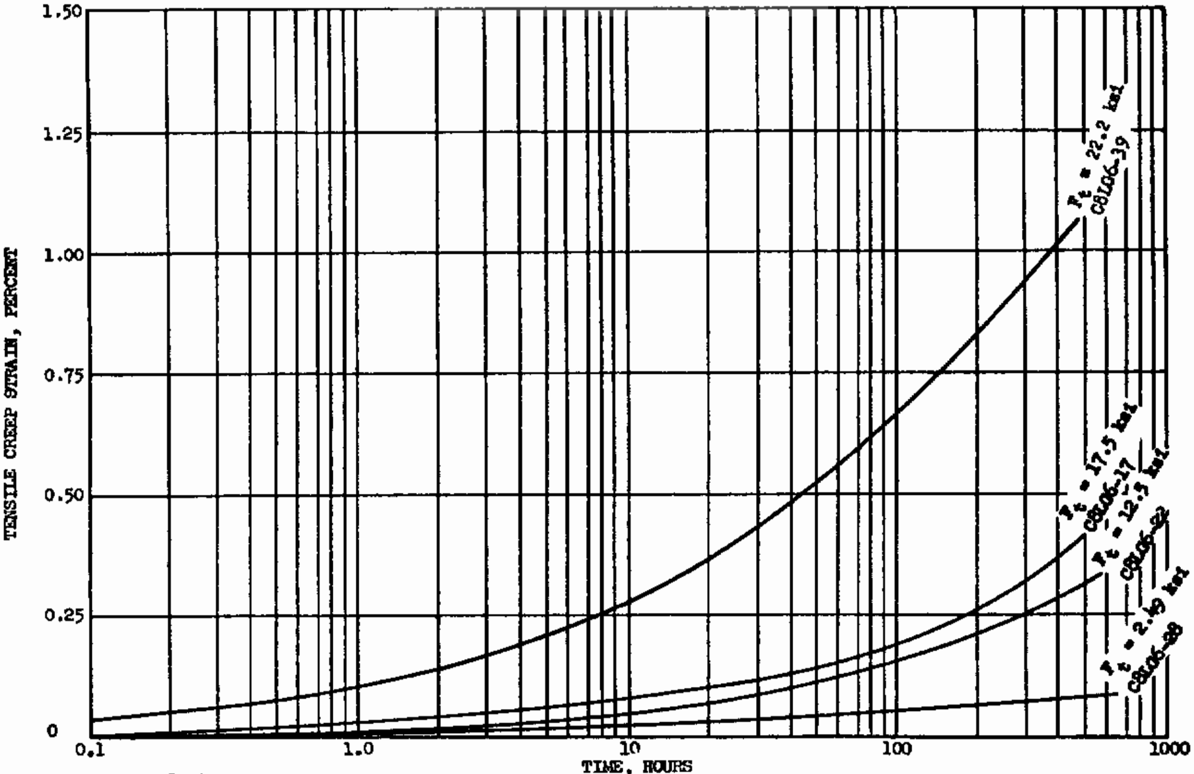


FIGURE 218 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NUMBER 24814)

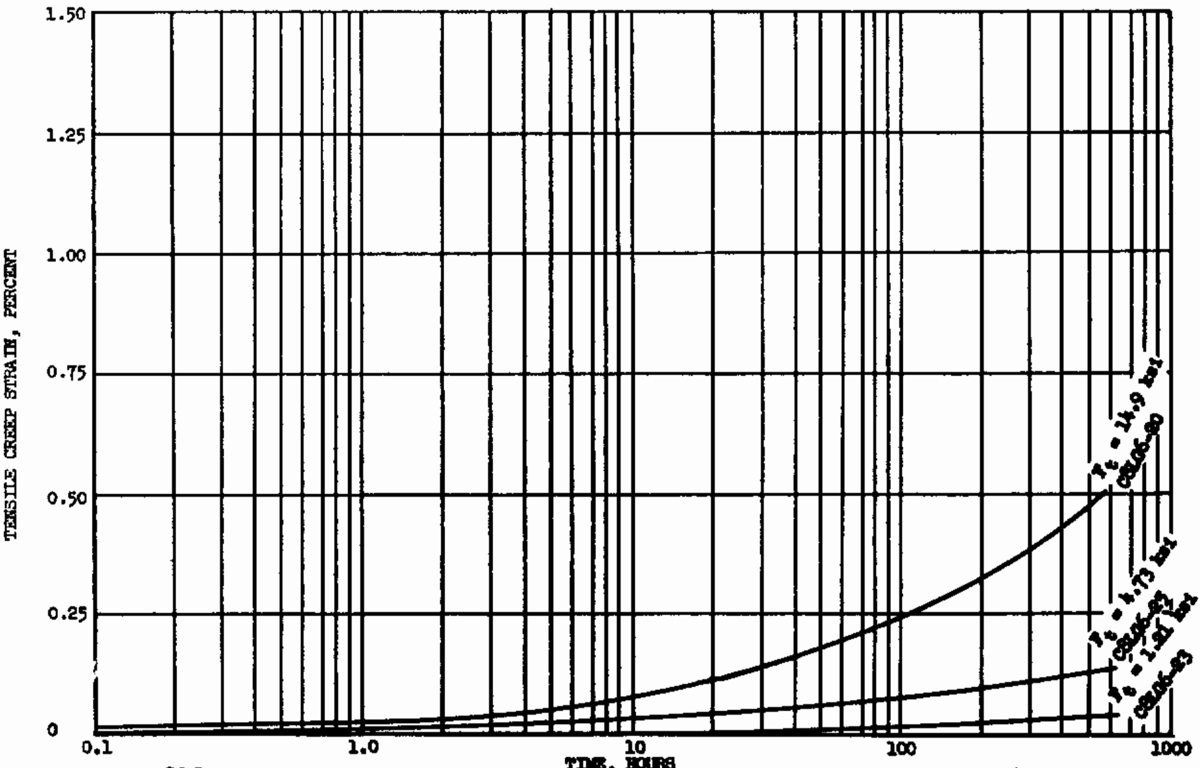


FIGURE 219 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NUMBER 24814)

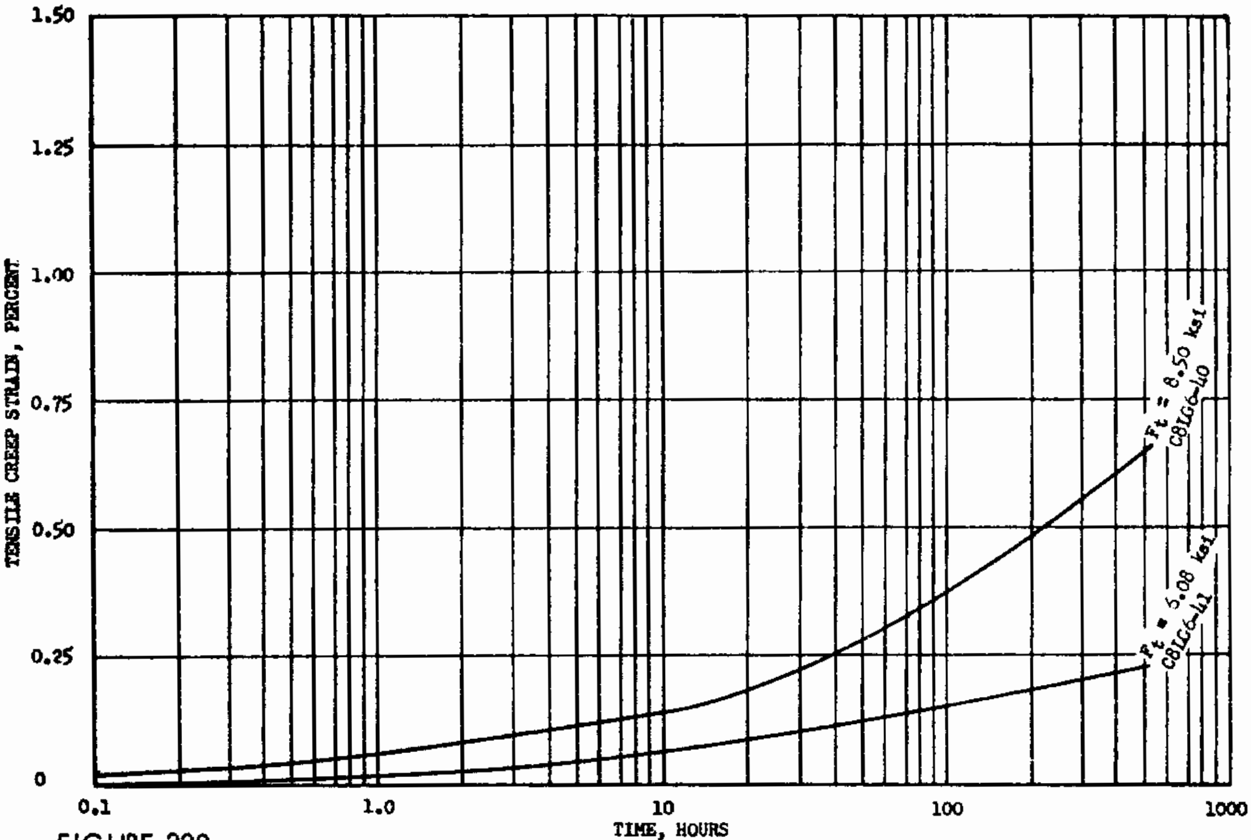


FIGURE 220 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET, 0.063 INCH THICK (REACTIVE METALS HEAT NO. 24814)

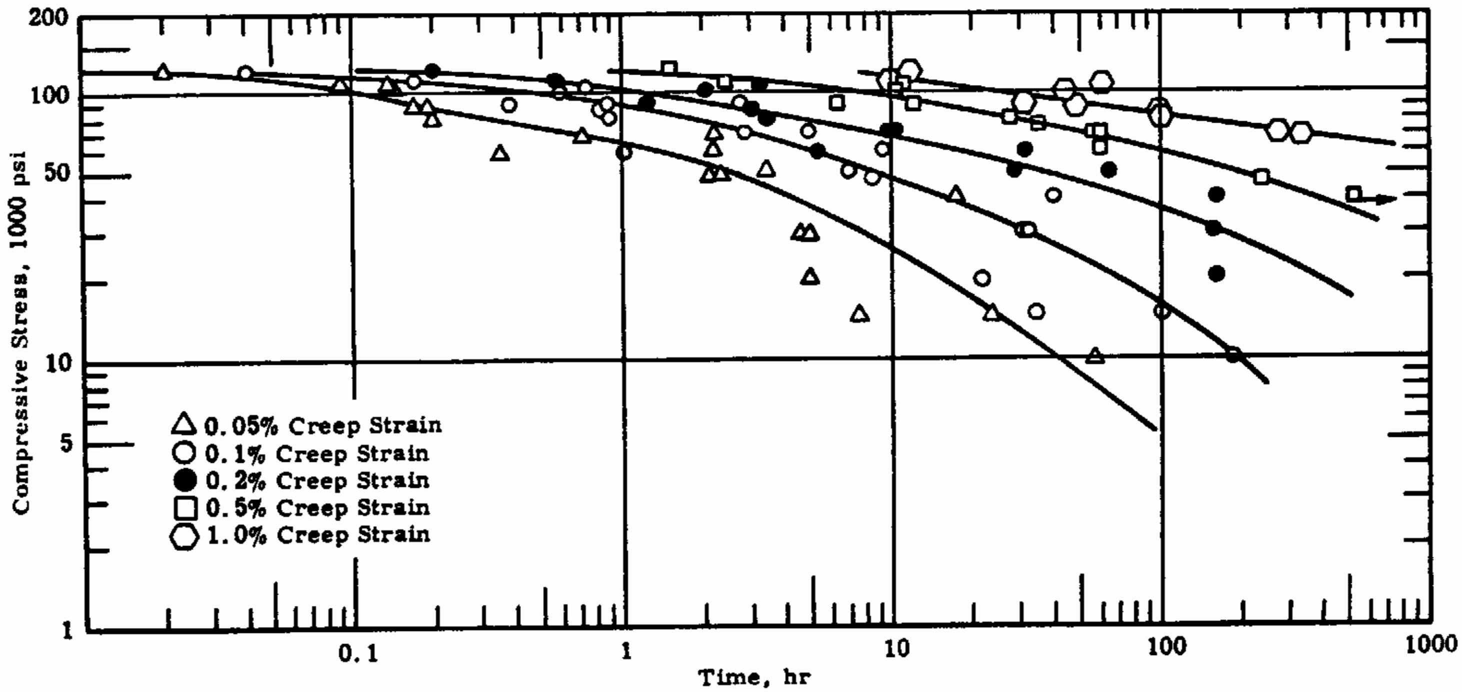


FIGURE 221 - Ti–2.5 Al–16 V ALLOY SHEET (Heat No. 22154)[1]—Time required for various amounts of compressive creep at 700° F and at various compressive stresses[2]. All specimens were taken in the longtudinal direction from 0.063 in. sheet.

---

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in approximately 2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

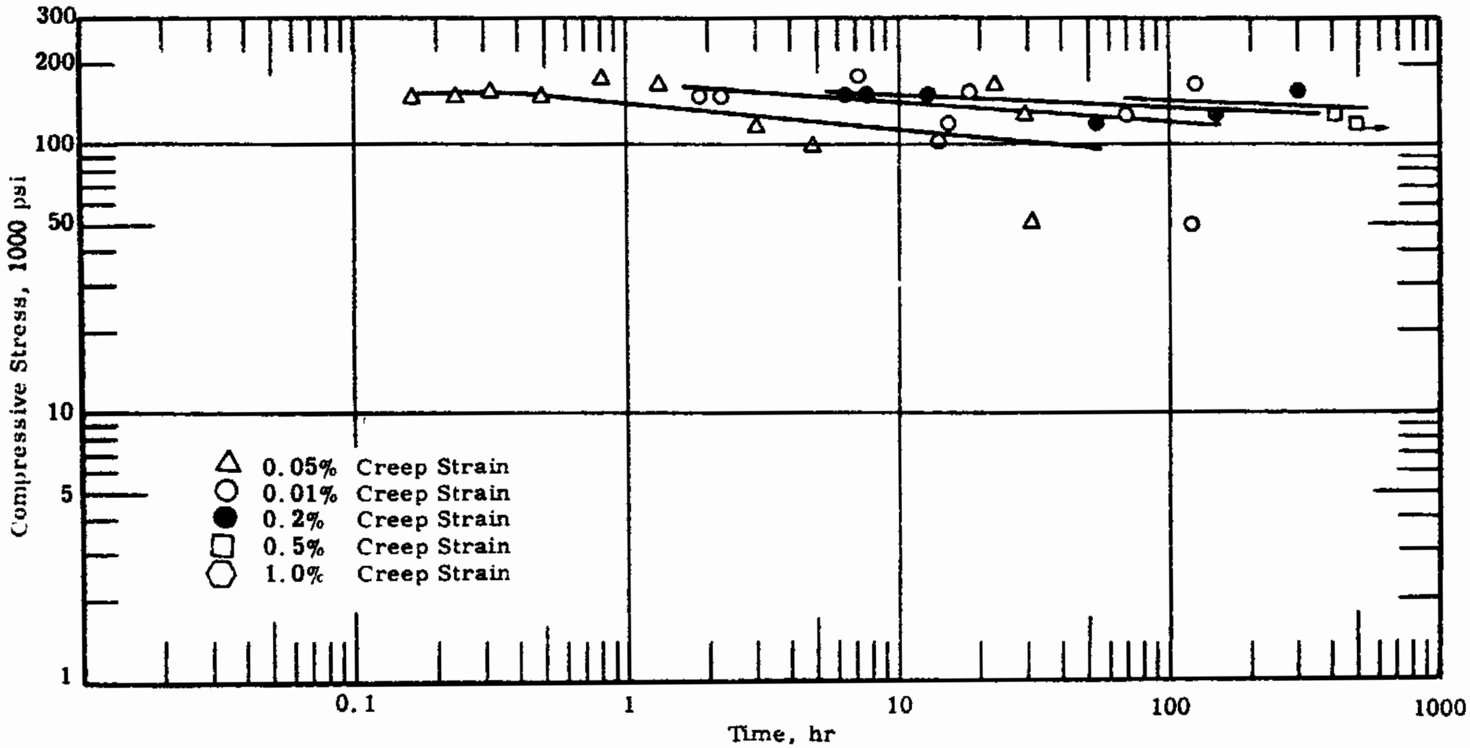


FIGURE 222 – Ti–2.5 Al–16 V ALLOY SHEET (Heat No. 22154)[1]—Time required for various amounts of compressive creep at 600°F and at various compressive stresses[2] All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.

[2] Specimens were heated to test temperature in approximately 2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

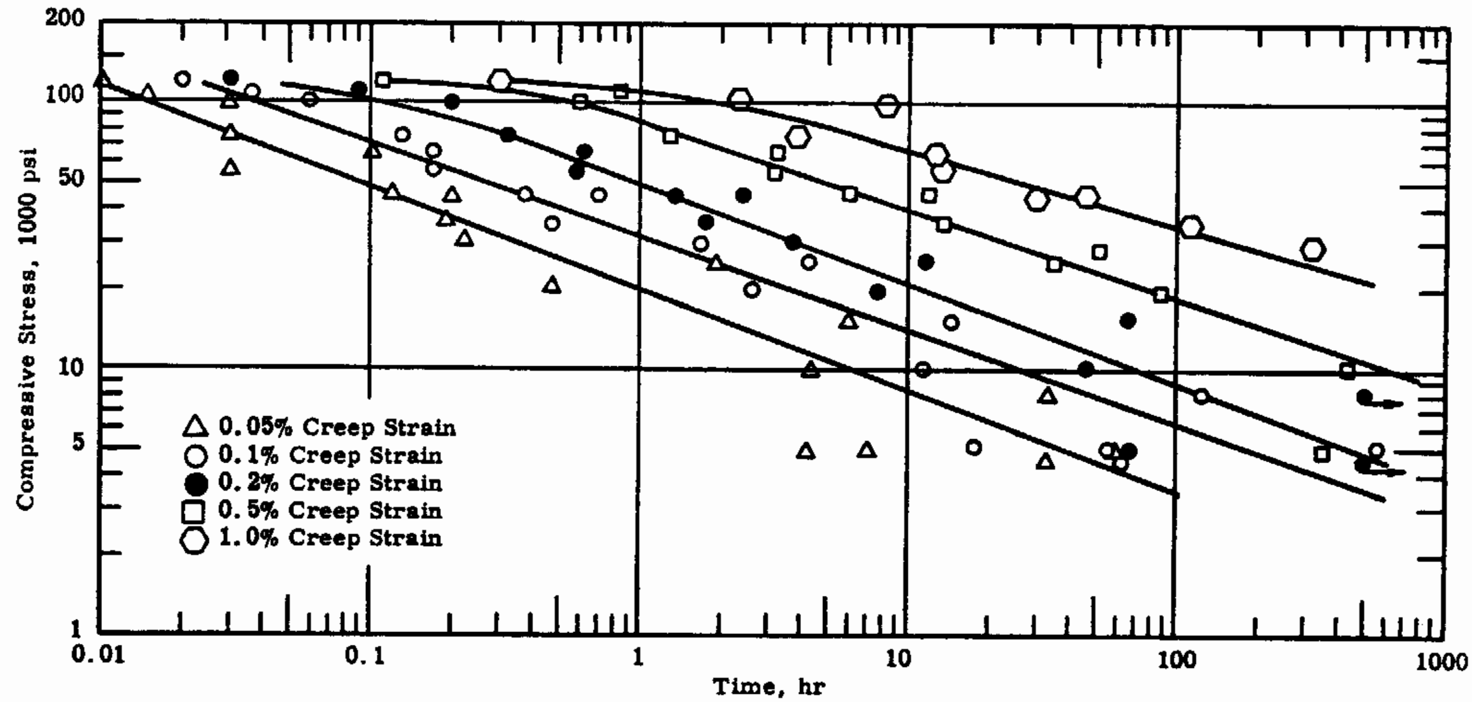


FIGURE 223 - Ti–2.5 Al–16 V ALLOY SHEET (Heat No. 22154)[1]—Time required for various amounts of compressive creep at 800° F and at various compressive stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

---

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in approximately 2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

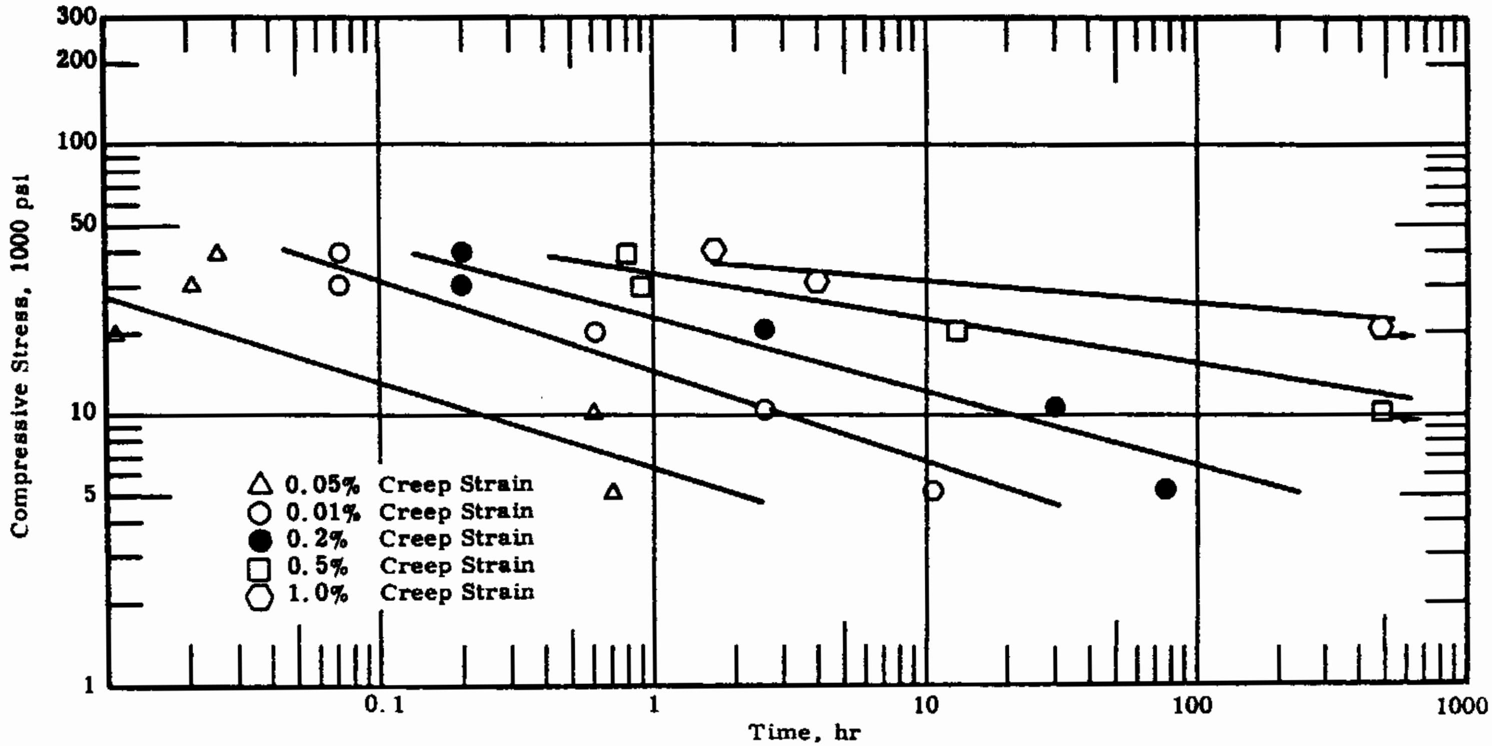


FIGURE 224 - Ti–2.5 Al–16 V ALLOY SHEET (Heat No. 22154)[1]—Time required for various amounts of compressive creep at 900° F and at various compressive stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

---

[1] Solution treated and aged.

[2] All specimens were heated to test temperature in approximately 2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

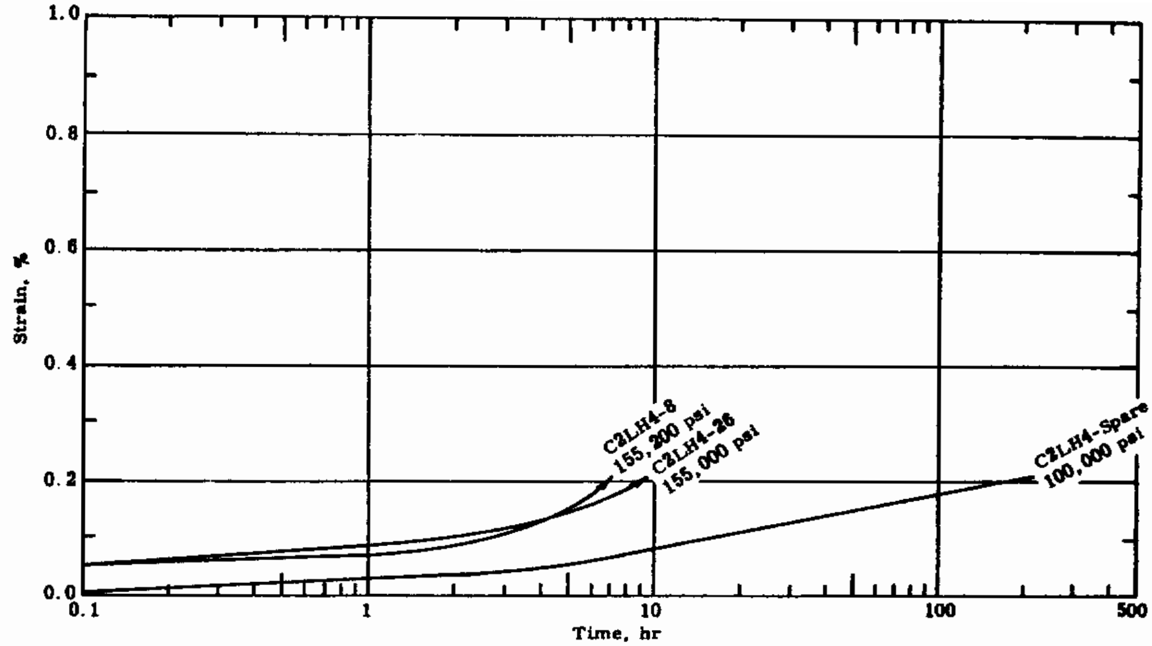


FIGURE 225 - Ti-2.5 Al-16 V ALLOY SHEET (Heat No. 22154)[1]—Compressive creep strain-time curves at 600° F and at various stresses. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

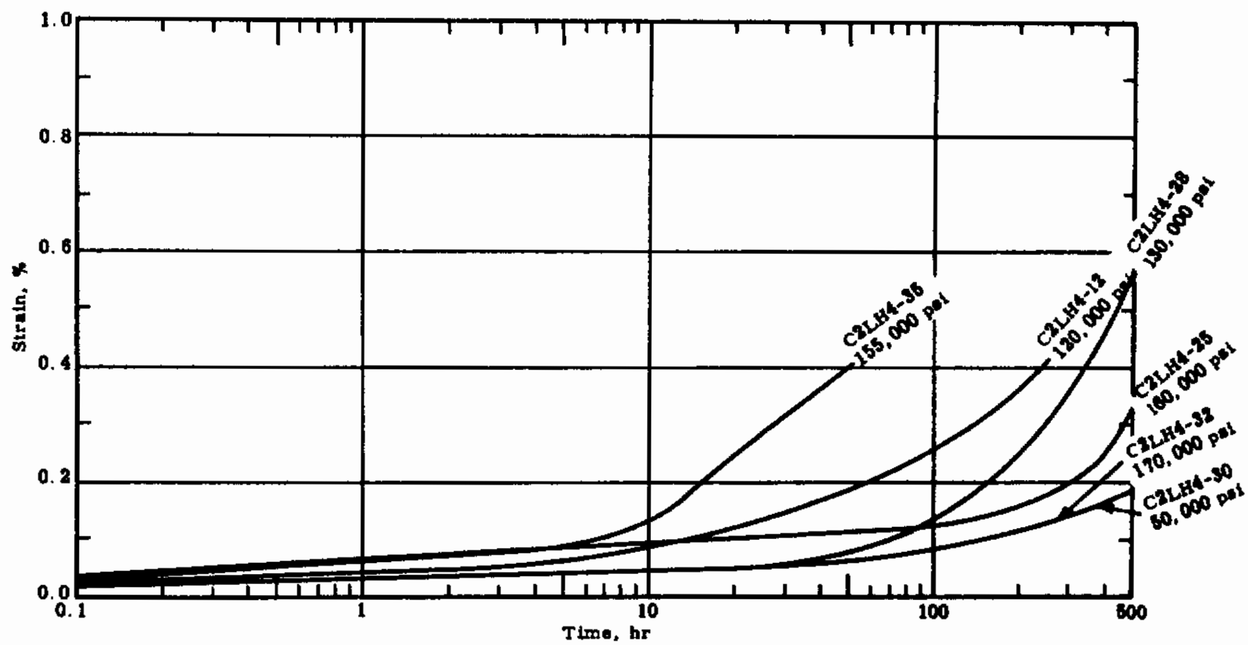


FIGURE 226 - Ti-2.5 Al-16 V ALLOY SHEET (Heat No. 22154)[1]—Compressive creep strain-time curves at 600° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

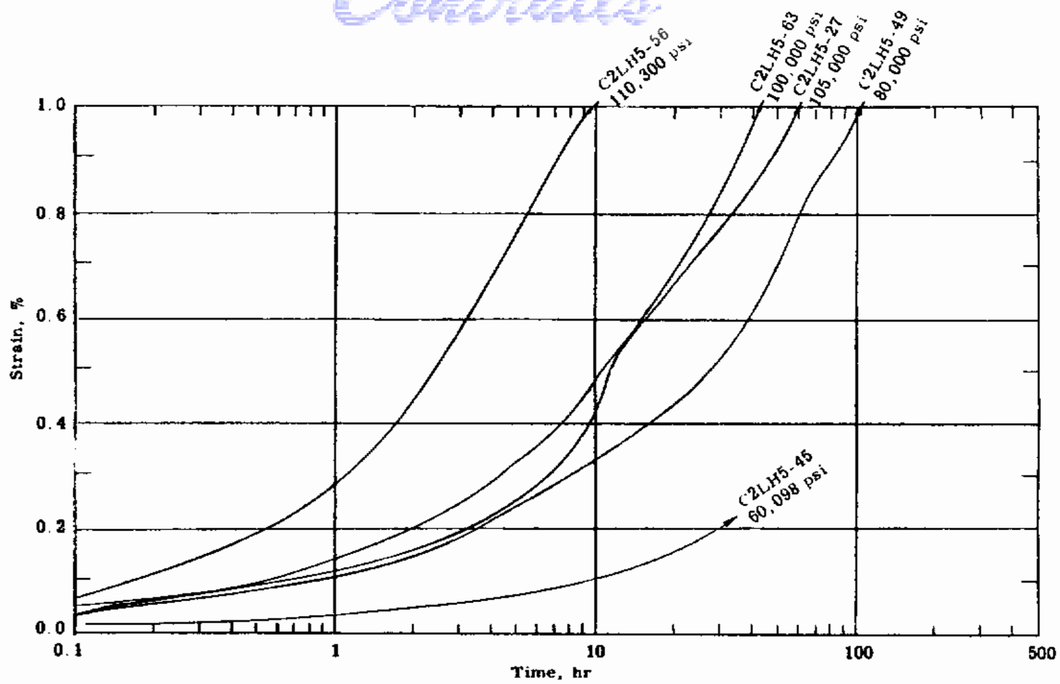


FIGURE 227 - Ti–2.5 Al–16 V ALLOY SHEET (Heat No. 22154)[1]—Compressive creep strain-time curves at 700° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

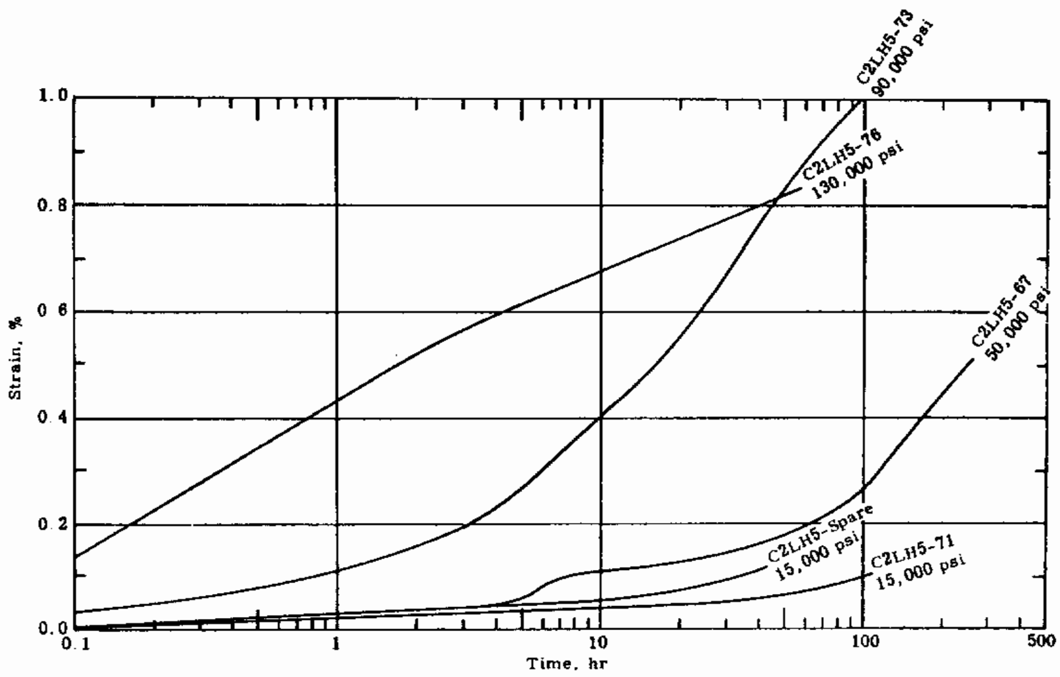


FIGURE 228 - Ti–2.5 Al–16 V ALLOY SHEET (Heat No. 22154)[1]—Compressive creep strain-time curves at 700° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

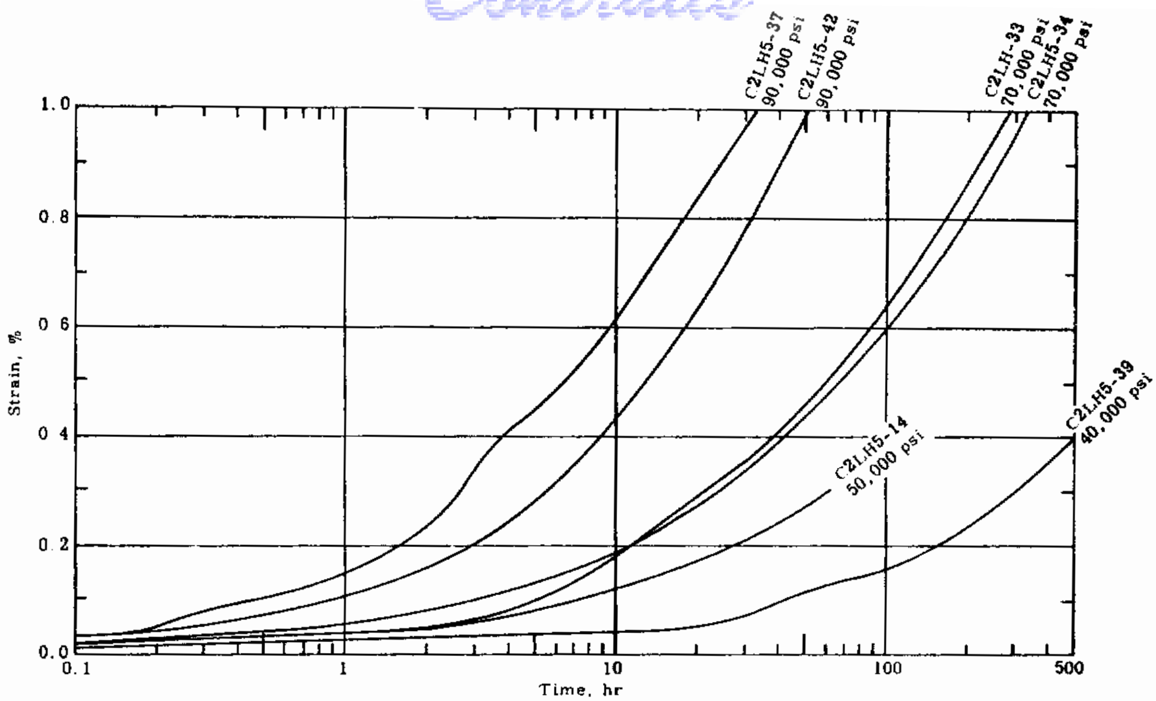


FIGURE 229 - Ti-2.5 Al-16 V ALLOY SHEET (Heat No. 22154)[1]—Compressive creep strain-time curves at 700° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1]Solution treated and aged.
[2]Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

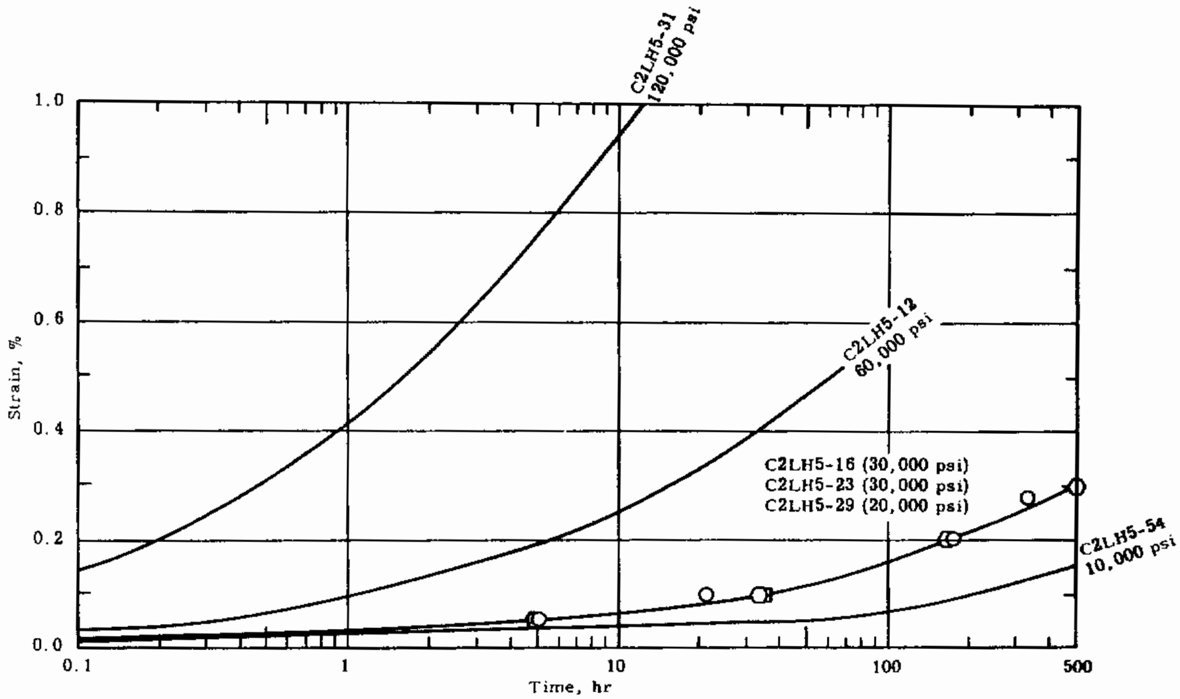


FIGURE 230 - Ti-2.5 Al-16 V ALLOY SHEET (Heat No. 22154)[1]—Compressive creep strain-time curves at 700° F. and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

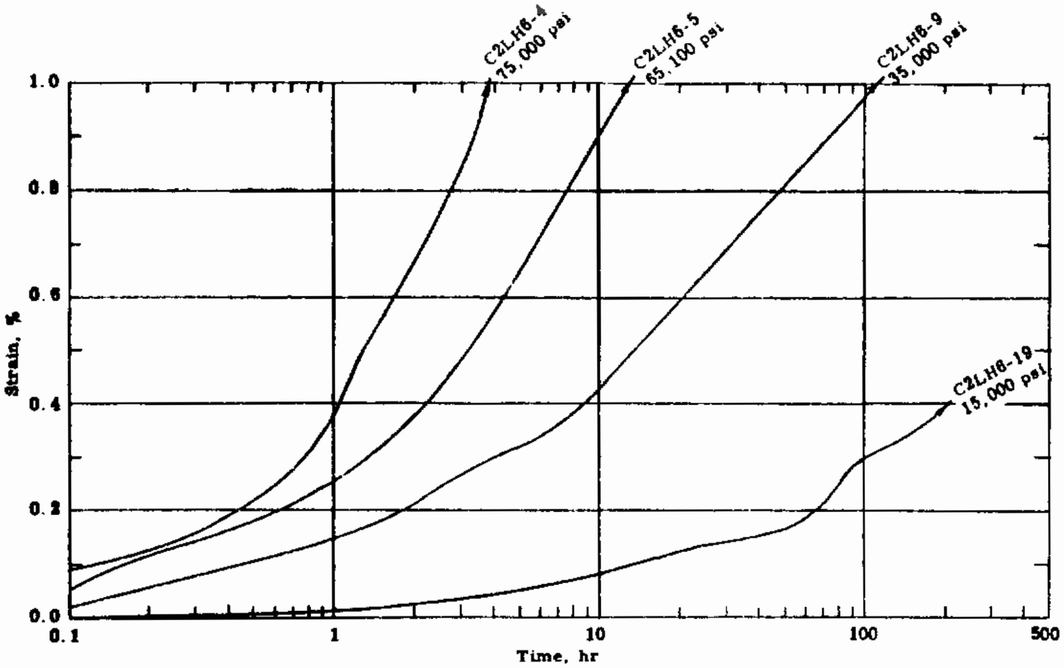


FIGURE 231 - Ti-2.5 Al-16 V ALLOY SHEET (Heat No. 22154)[1]—Compressive creep strain-time curves at 800° F and at various stresses. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

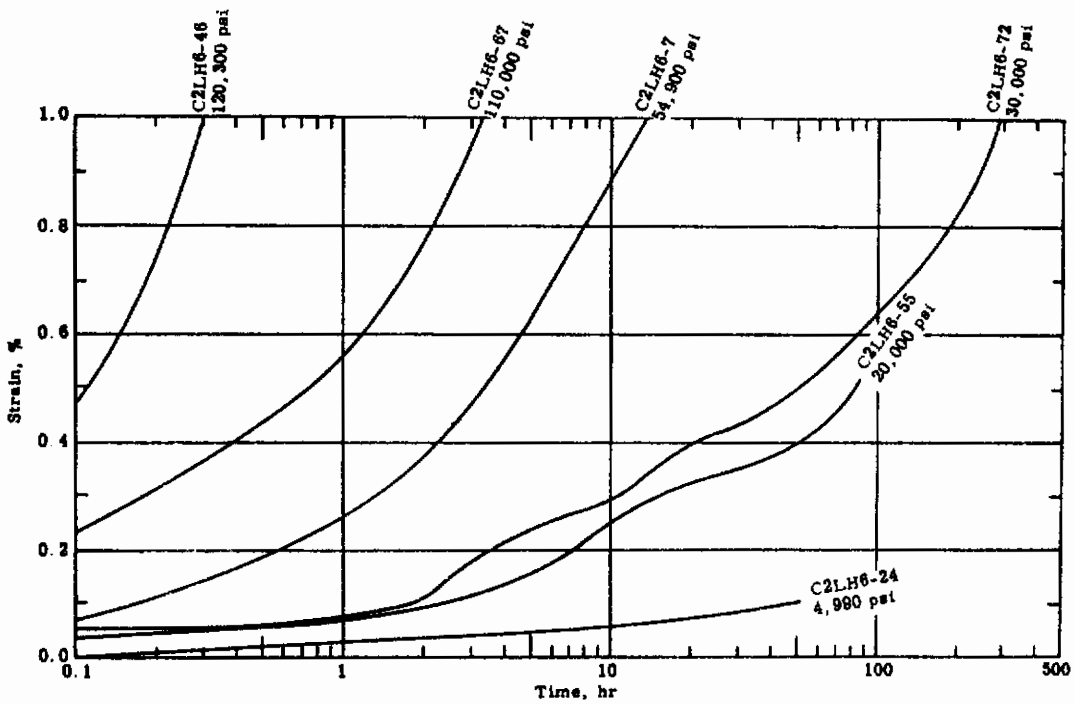


FIGURE 232 - Ti-2.5 Al-16 V ALLOY SHEET (Heat No. 22154)[1]—Compressive creep strain-time curves at 800° F and at various stresses. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

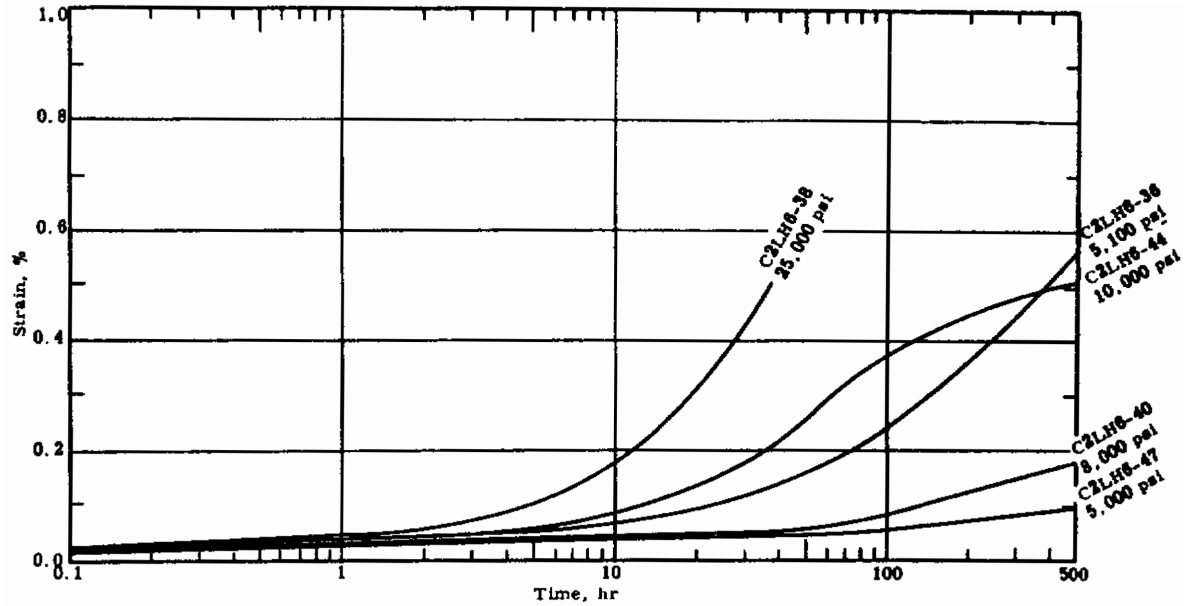


FIGURE 233 - Ti-2.5 Al-16 V ALLOY SHEET (Heat No. 22154)[1]—Compressive creep strain-time curves at 800° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

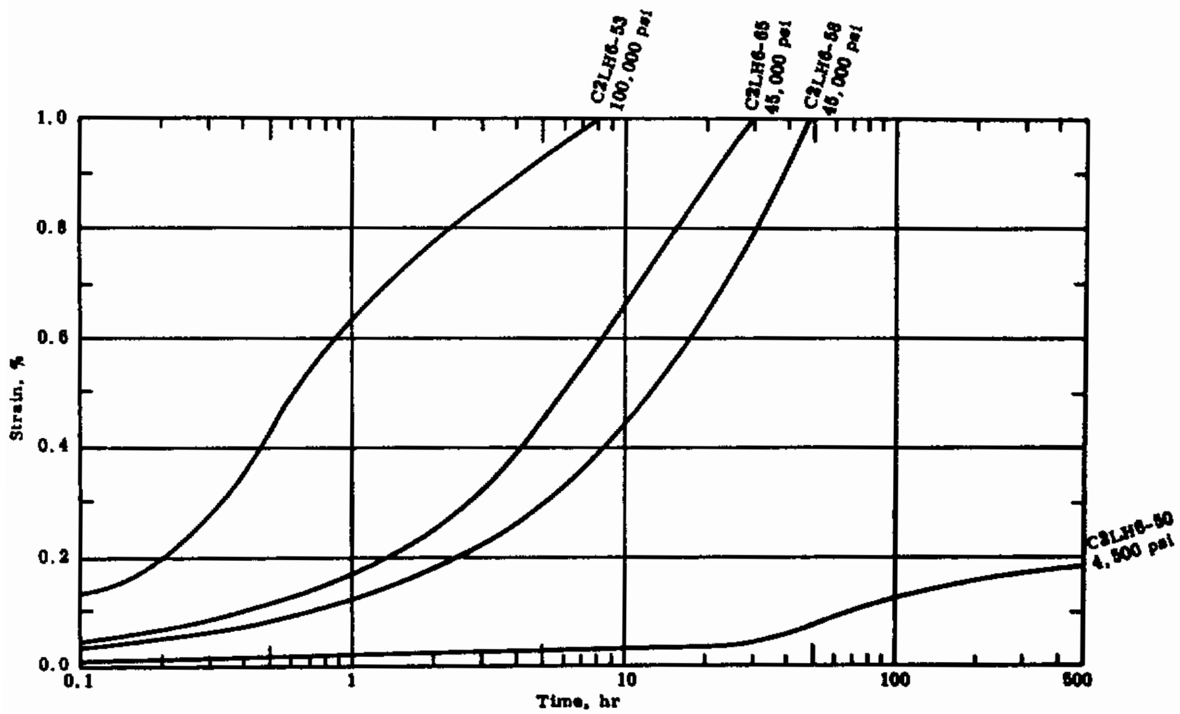


FIGURE 234 - Ti-2.5 Al-16 V ALLOY SHEET (Heat No. 22154)[1]—Compressive creep strain-time curves at 800° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

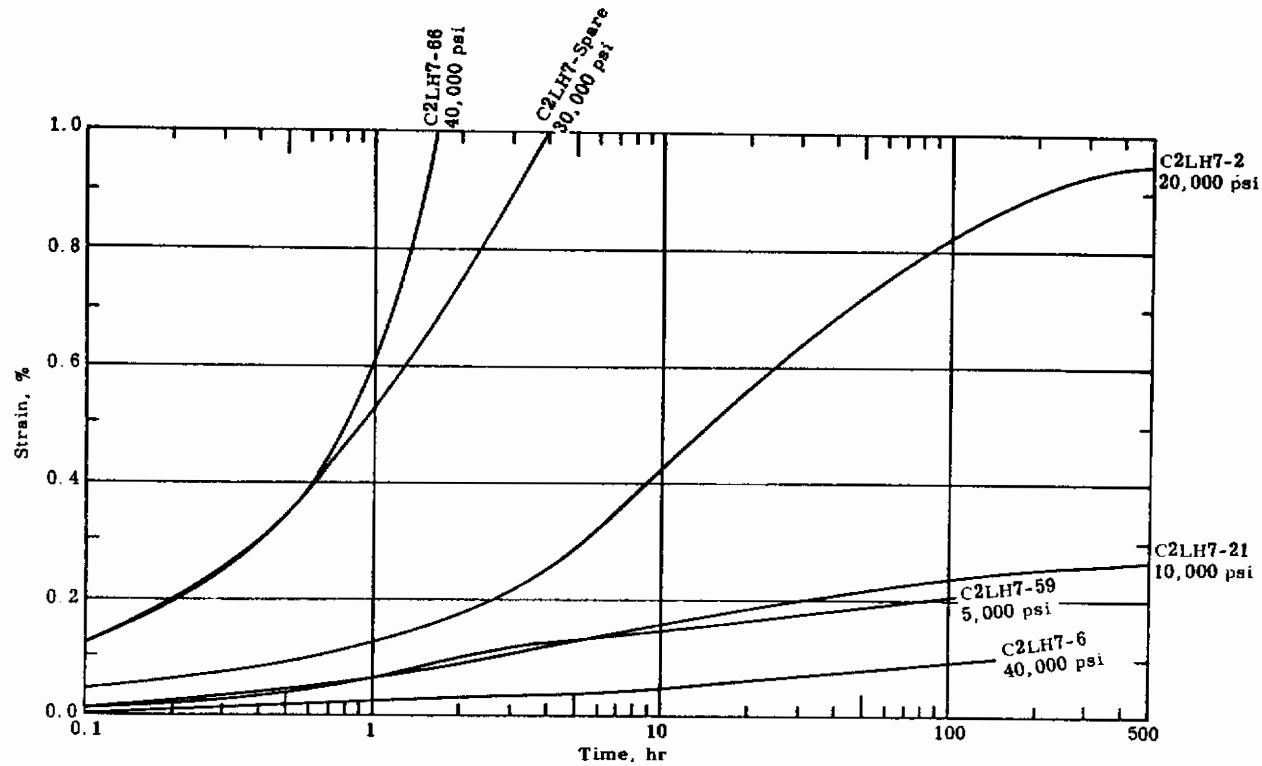


FIGURE 235 – Ti–2.5 Al–16 V ALLOY SHEET (Heat No. 22154)[1]—Compressive creep strain-time curves at 900° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

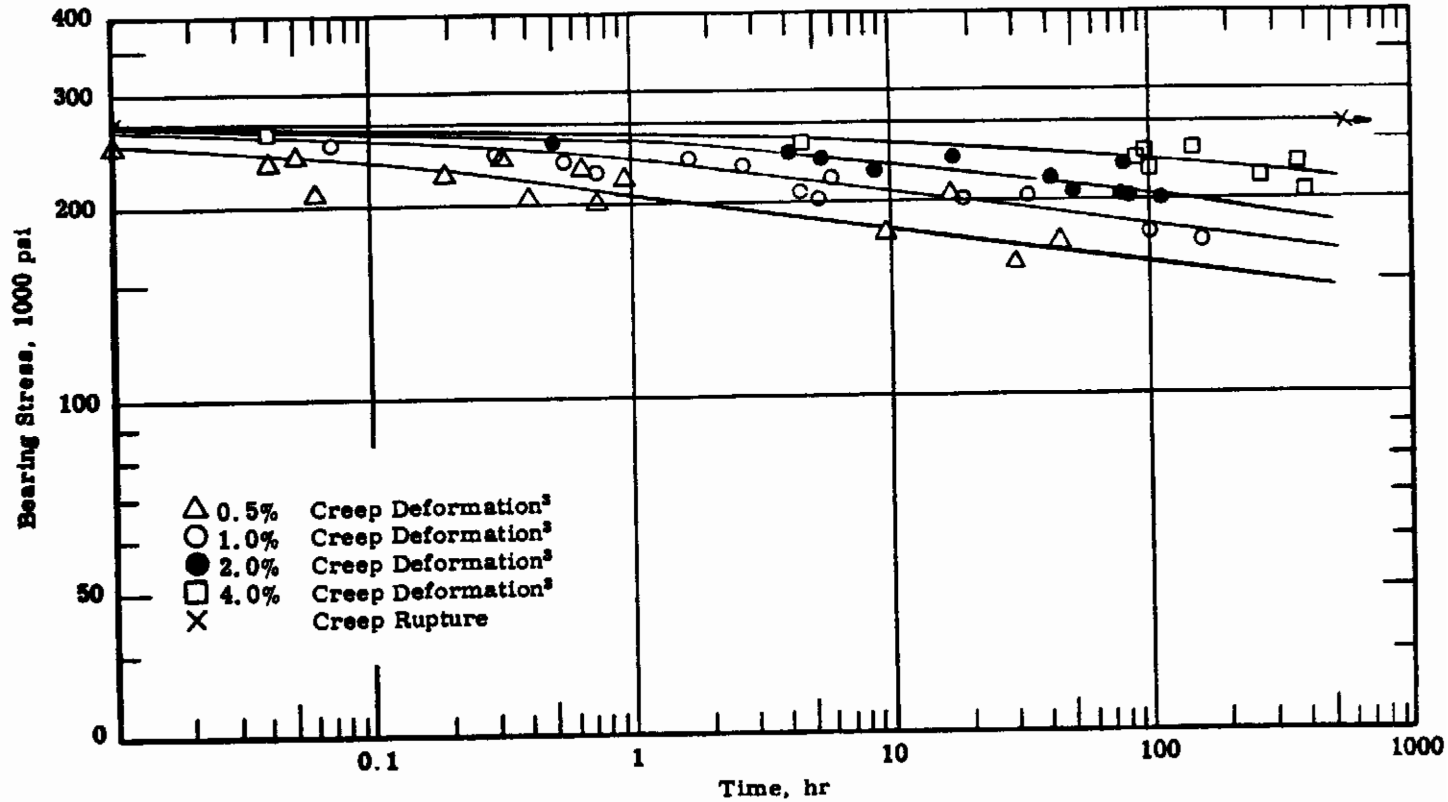


FIGURE 236 - Ti–2.5 Al–16 V ALLOY SHEET (Heat No. 22154)[1]—Time required for various amounts of bearing creep at 600° F and at various bearing stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

---

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.
[3] Percent of bearing-hole diameter.

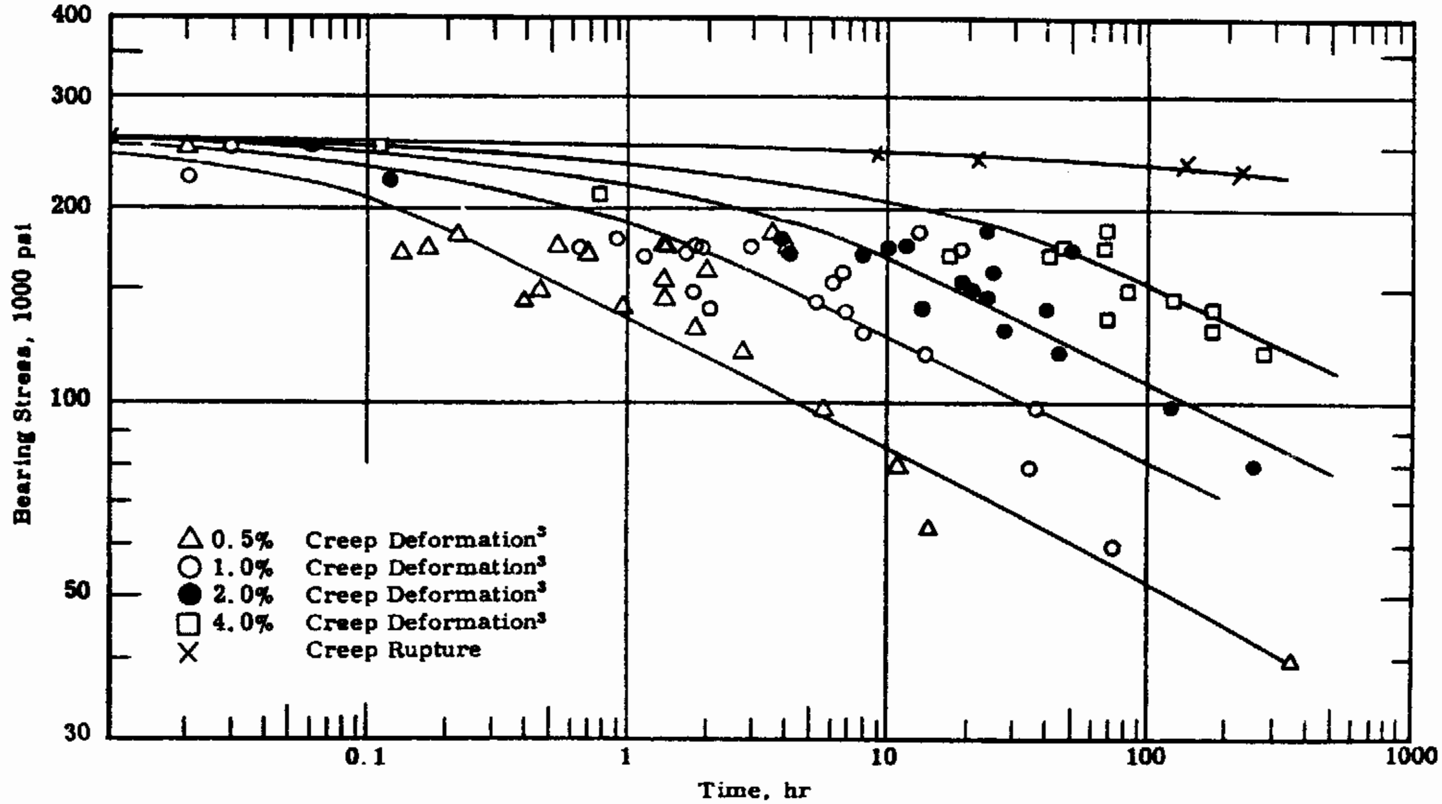


FIGURE 237 – Ti–2.5 Al–16 V ALLOY SHEET (Heat No. 22154)[1]—Time required for various amounts of bearing creep at 700° F and at various bearing stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

---

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.
[3] Percent of bearing-hole diameter.

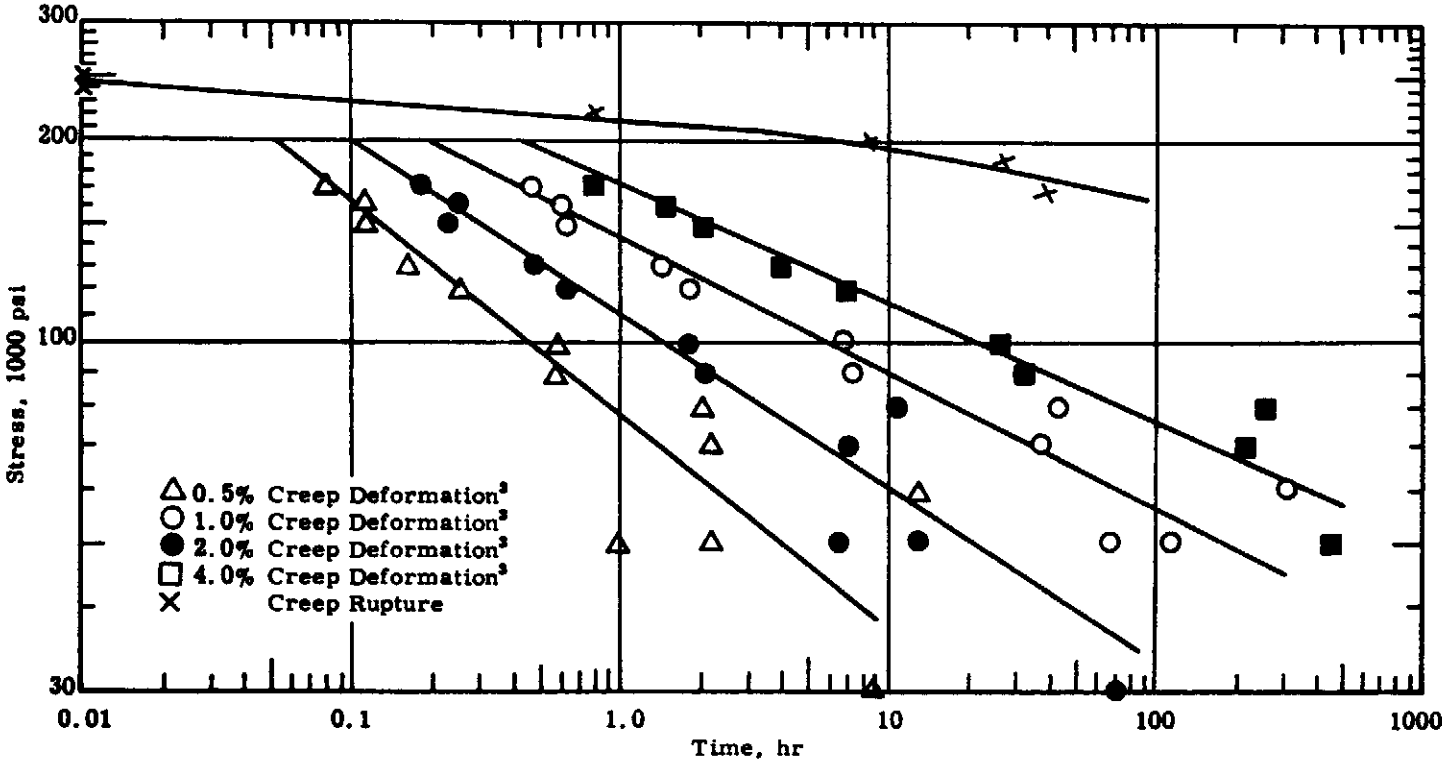


FIGURE 238 - Ti–2.5 Al–16 V ALLOY SHEET (Heat No. 22154)[1]—Time required for various amounts of bearing creep at 800° F and at various bearing stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

---

[1] Solution treated and aged.

[2] Specimens were heated to test temperatures in 1/2 hr, soaked at temperature 1/2 hr, then loaded in about 2 min.

[3] Percent of bearing-hole diameter.

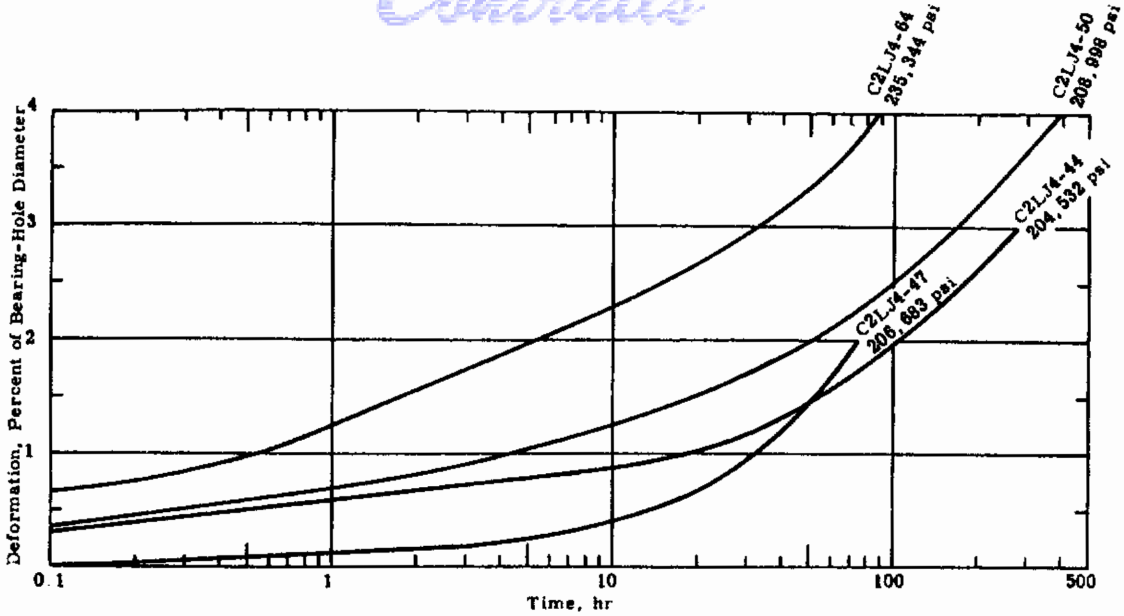


FIGURE 239 – Ti–2.5 Al–16 V ALLOY SHEET (Heat No. 22154)[1]—Bearing creep deformation-time curves at 600° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

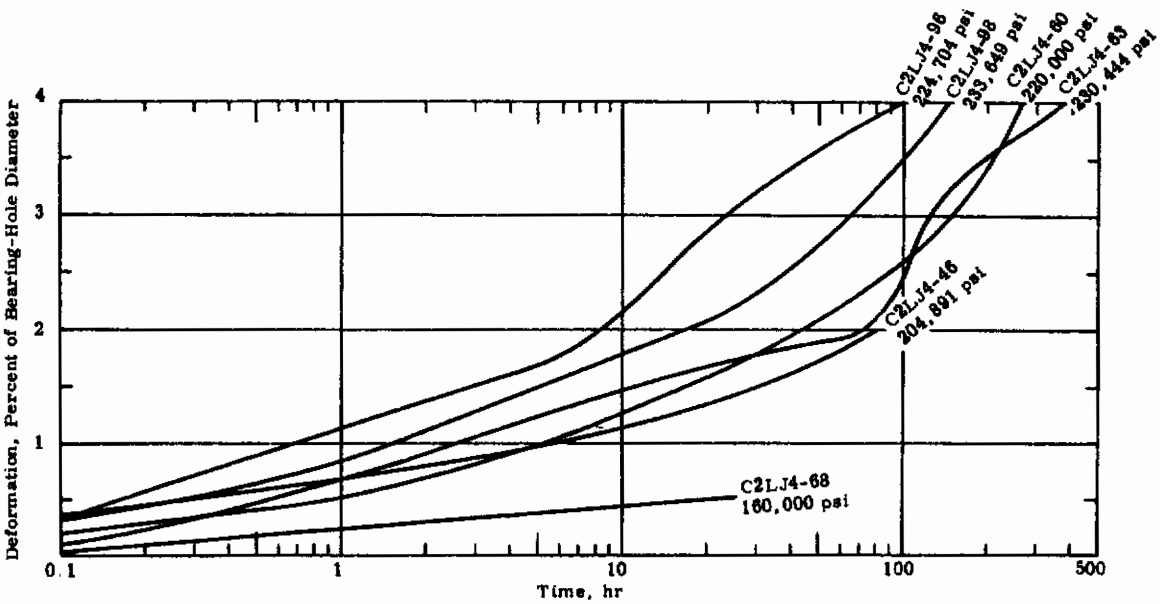


FIGURE 240 – Ti–2.5 Al–16 V ALLOY SHEET (Heat No. 22154)[1]—Bearing creep deformation-time curves at 600° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded in about 2 min.

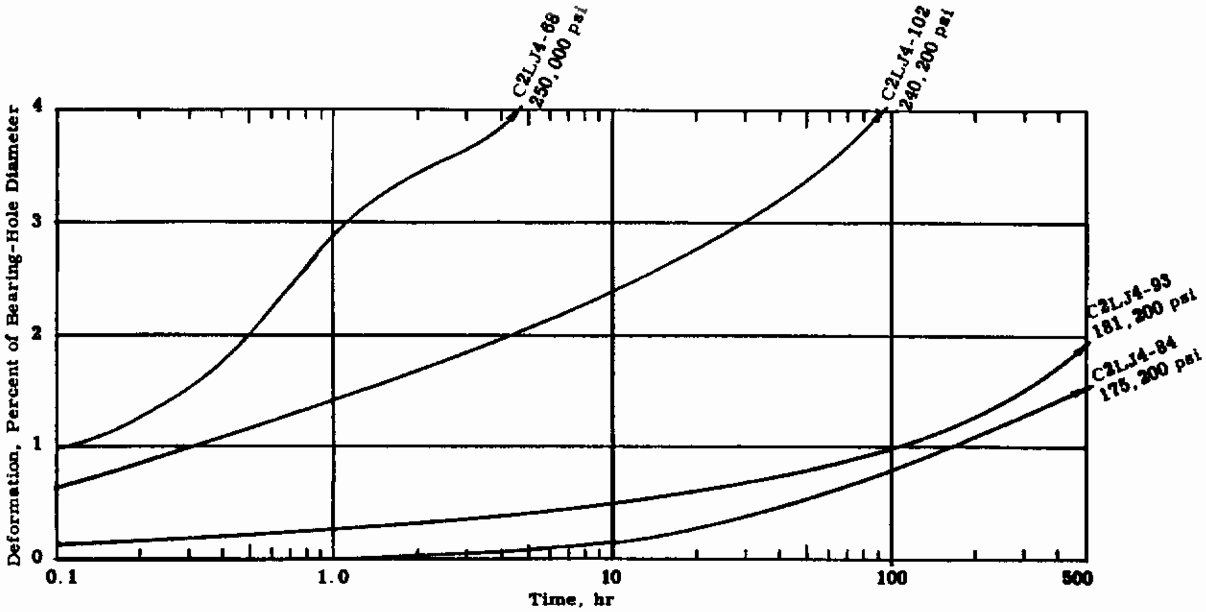


FIGURE 241 - Ti–2.5 Al–16 V ALLOY SHEET (Heat No. 22154)[1]—Bearing creep deformation-time curves at 600° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

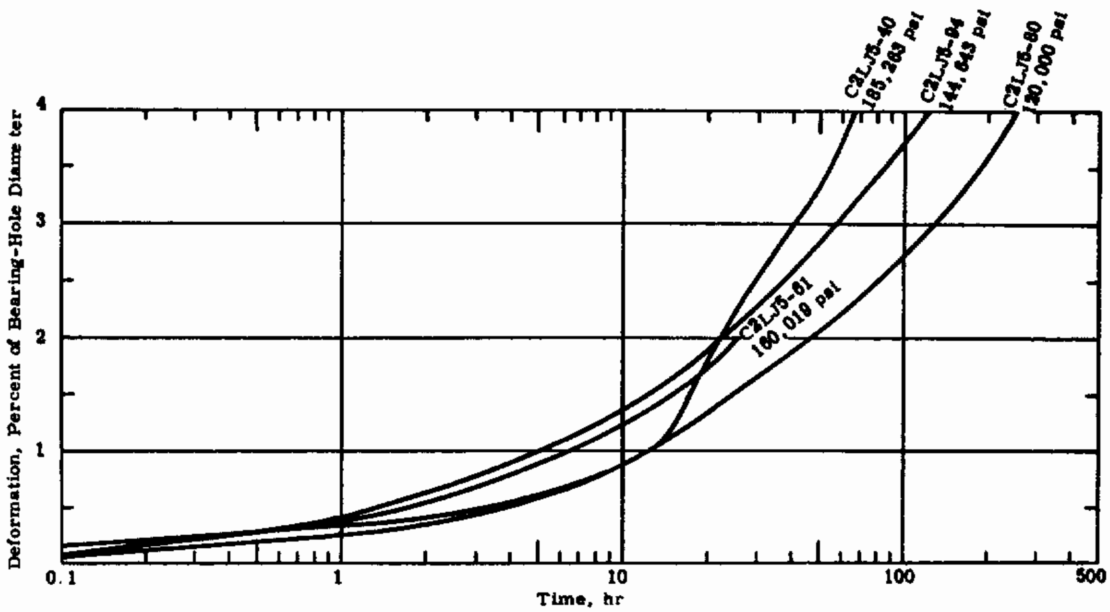


FIGURE 242 - Ti–2.5 Al–16 V ALLOY SHEET (Heat No. 22154)[1]—Bearing creep deformation-time curves at 700° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

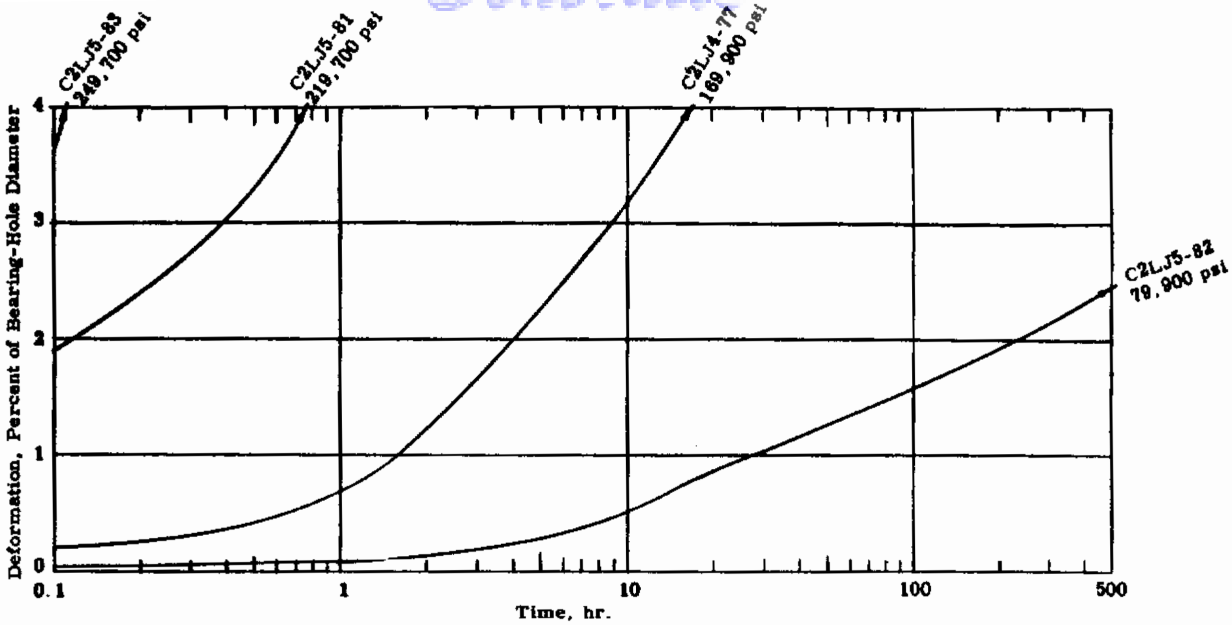


FIGURE 243 - Ti-2.5 Al-16 V ALLOY SHEET (Heat No. 22154)[1]—Bearing creep deformation-time curves at 700° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

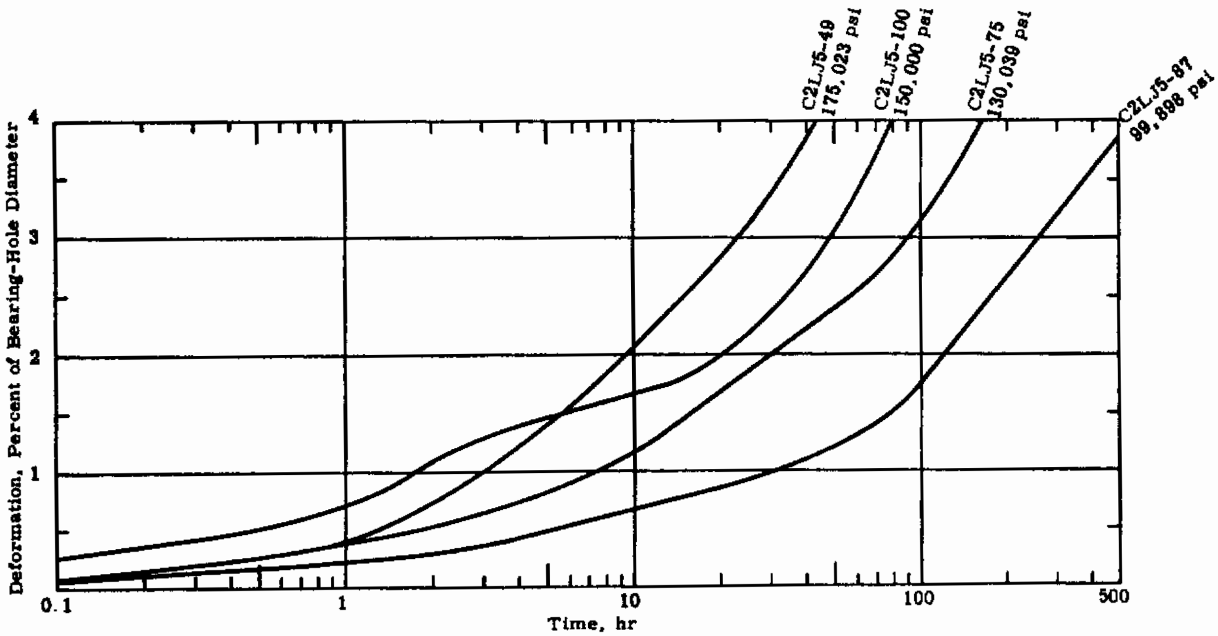


FIGURE 244 - Ti-2.5 Al-16 V ALLOY SHEET (Heat No. 22154)[1]—Bearing creep deformation-time curves at 700° F and at various stresses[2] All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

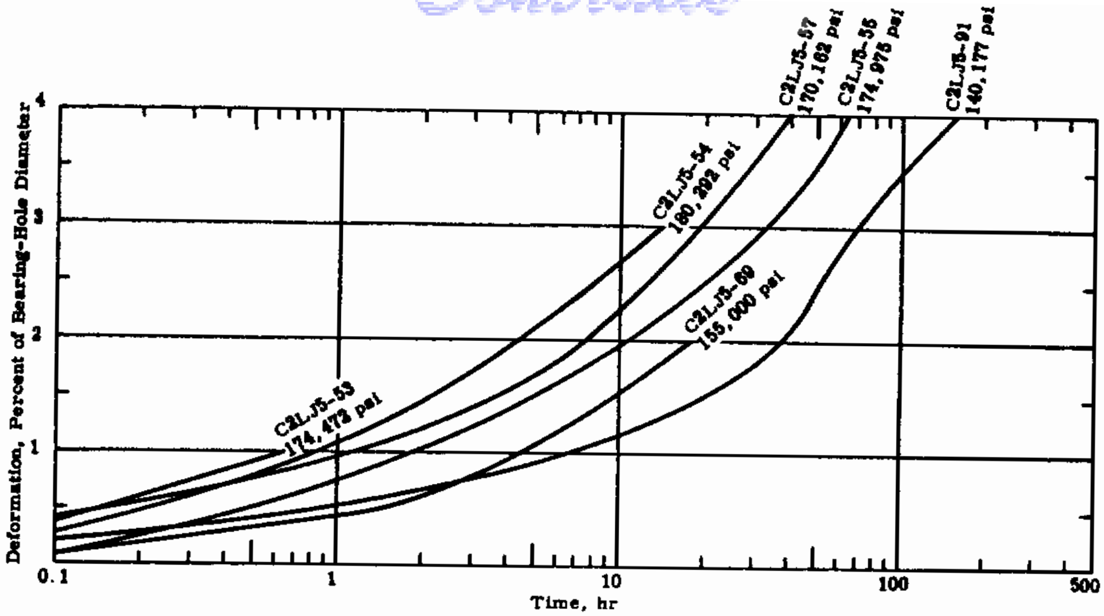


FIGURE 245 – Ti–2.5 Al–16 V ALLOY SHEET (Heat No. 22154)[1]—Bearing creep deformation-time curves at 700° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

---

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

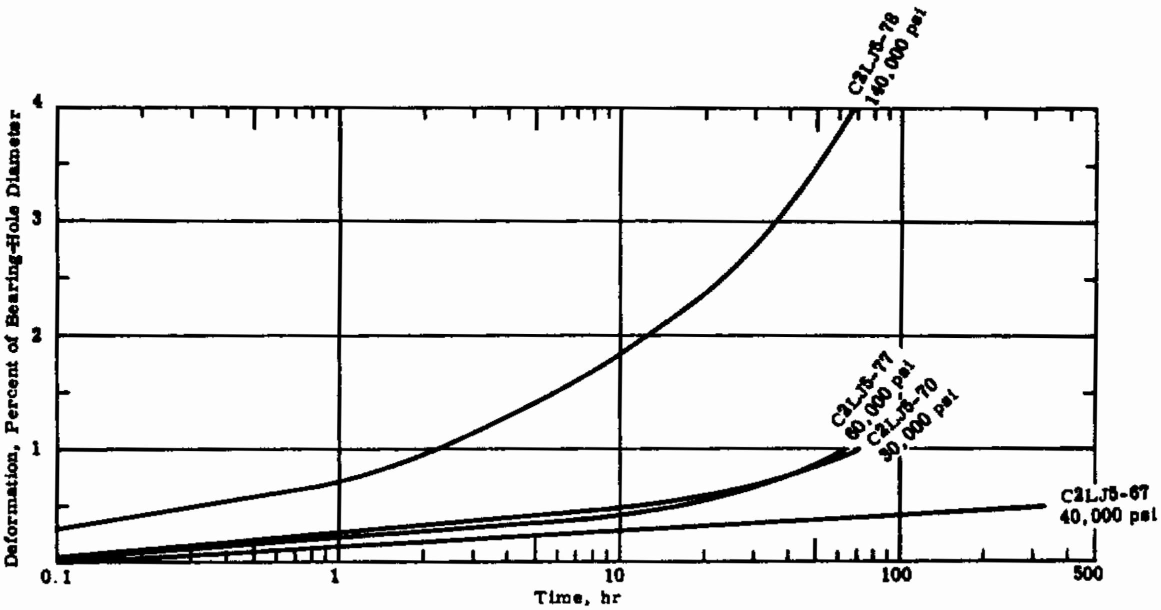


FIGURE 246 – Ti–2.5 Al–16 V ALLOY SHEET (Heat No. 22154)[1]—Bearing creep deformation-time curves at 700° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

Solution treated and aged.
Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

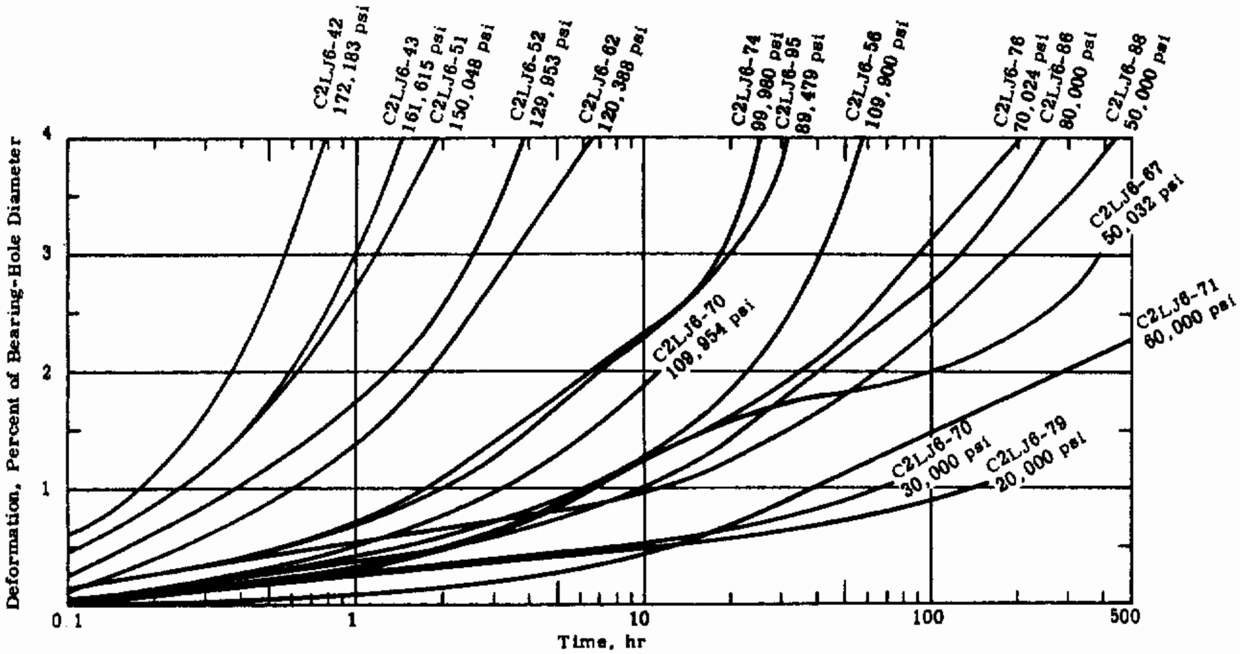


FIGURE 247 - Ti–2.5 Al–16 V ALLOY SHEET (Heat No. 22154)[1]—Bearing creep deformation-time curves at 800° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperatures in 1/2 hr, soaked at temperature 1/2 hr, then loaded in about 2 min.

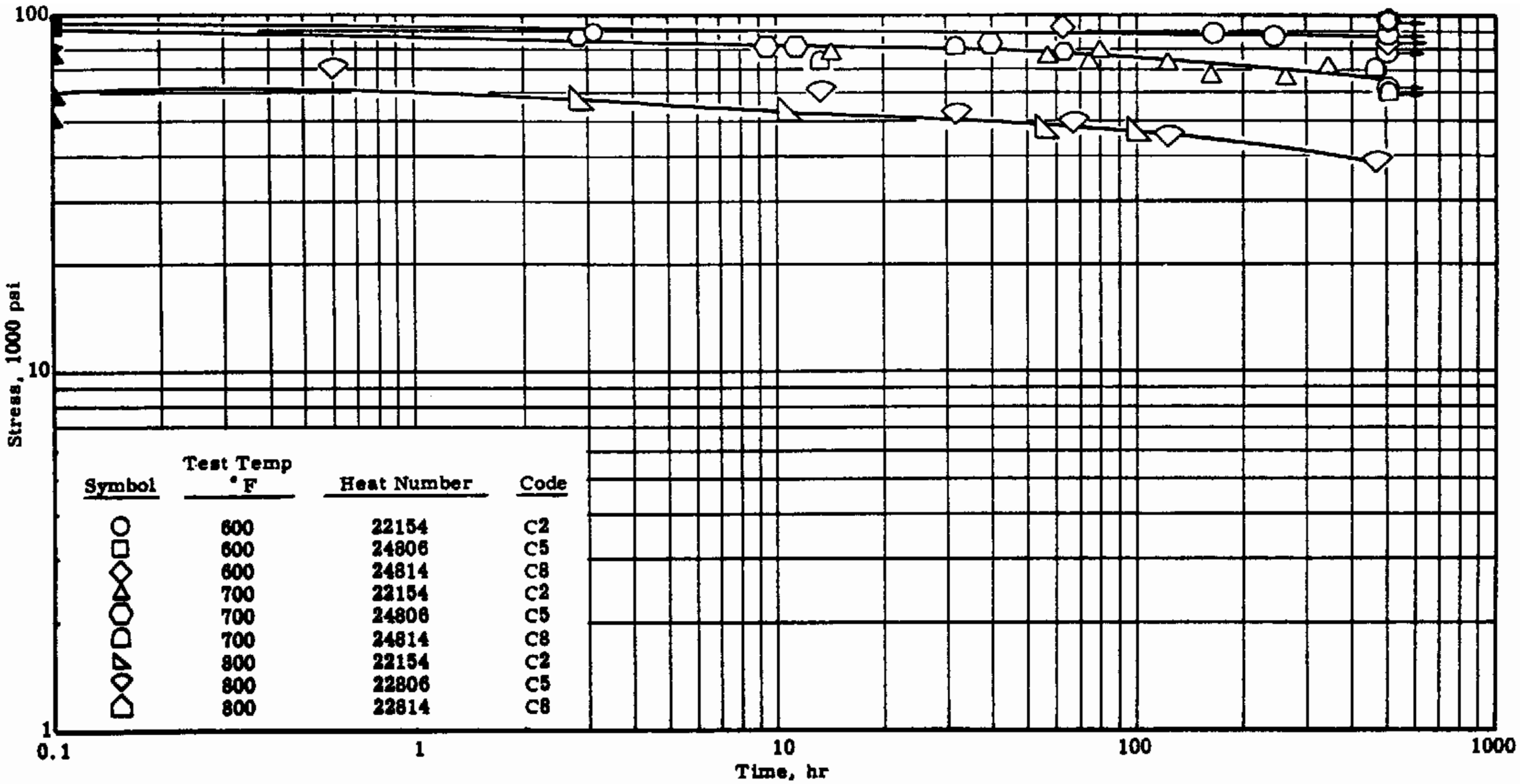


FIGURE 248 - Ti–2.5 Al–16 V ALLOY SHEET[1]—Time required for stress-rupture in single-shear at various stresses and temperatures[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

---

[1] Solution treated and aged.

[2] Specimens were heated to test temperature in 2 hr, soaked 1/2 hr, then loaded in 2 minutes, after which rupture-time measurements were initiated.

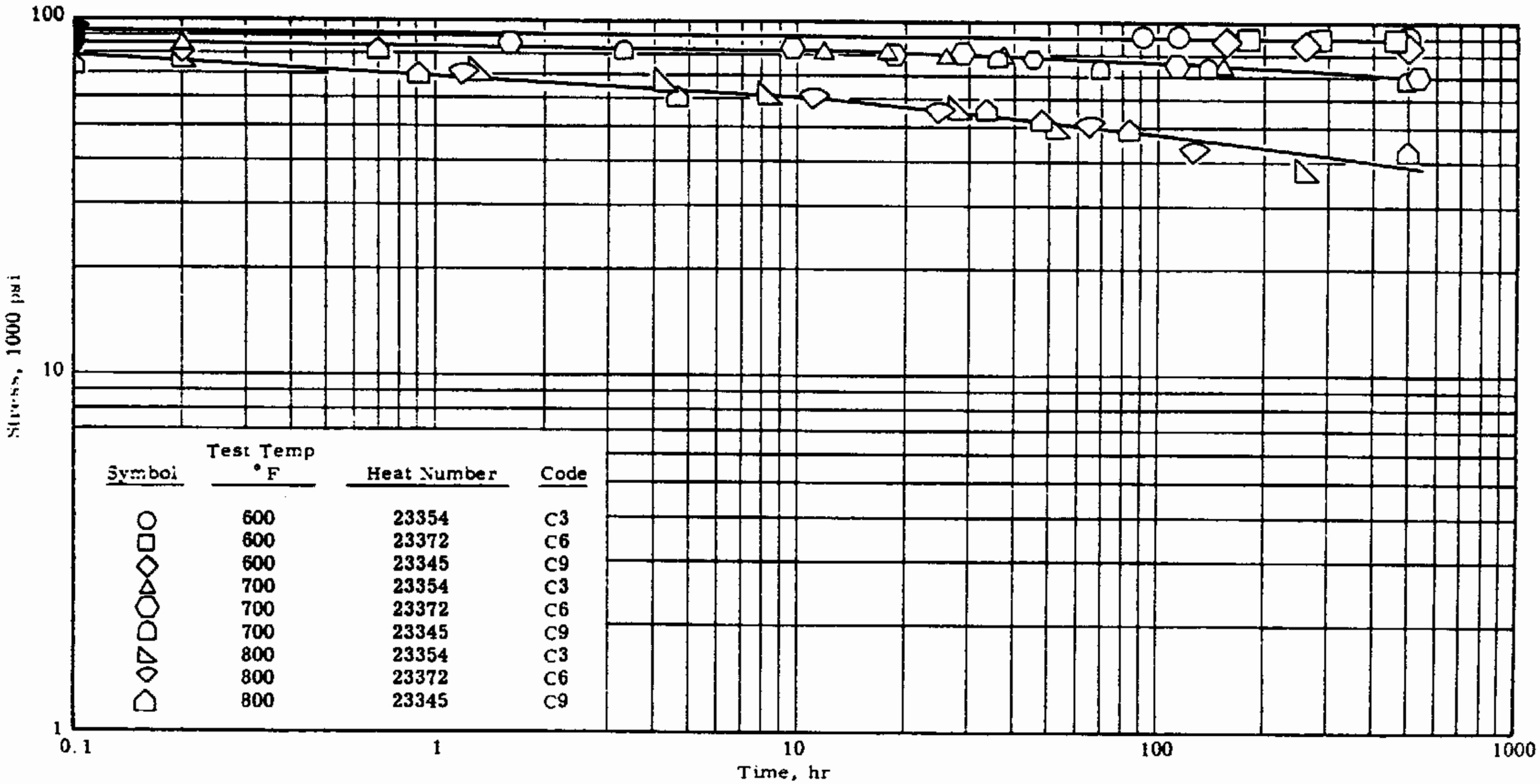


FIGURE 249 – Ti–2.5 Al–16 V ALLOY SHEET[1]—Time for stress-rupture in double-shear at various stresses and temperatures[2]. All specimens were taken in the longitudinal direction from 0.125 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in approximately 2 hr; soaked at temperature 1/2 hr, then loaded within 2 minutes.

Fatigue Test Results - Ti-2.5Al-16V

Axial-load fatigue data for the longitudinal grain direction are summarized by the 90 S-N curves in Figures 250 through 339. These data are presented in Volume 1 in modified Goodman-type diagrams relating alternating stress, mean stress and stress ratio to life-cycles of 10^3, 10^4, 10^5, 10^6 and 10^7. The data were obtained from five heats of material and represent variables for sheet thicknesses of 0.020 inch, 0.063 inch and 0.125 inch; theoretical stress concentrations of 1.0 and 2.82; stress ratios of ∞, 1.0 and 0.3; and temperatures of 80°F, 400°F, 600°F, 800°F and 900°F. An S-N curve, having a minimum of 21 datum points, is presented for each combination of these variables.

A modified Goodman-type diagram is presented for each combination of thickness, stress concentration and temperature. Data obtained for each specimen are in Tables CXCVIII through CCXV, pages 205 through 222, Volume 3.

Available tensile creep-rupture data, ultimate tensile strength data and supplemental data in Tables XI and XII were used for the modified Goodman-type diagrams to establish the life-cycles at a stress ratio of zero.

TABLE XI

LONGITUDINAL ULTIMATE TENSILE STRESS FOR STRESS RATIO OF ZERO (A=0) FATIGUE VALUES.
SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET
STRESS CONCENTRATION (K_t) = 2.82

Thickness = 0.020 in.			Thickness = 0.063 in.			Thickness = 0.125 in.		
Specimen Number	Test Temp., °F	F_{tu}, PSI	Specimen Number	Test Temp., °F	F_{tu}, PSI	Specimen Number	Test Temp., °F	F_{tu}, PSI
C4LG1S-3	80	176,000	C8LG1S-10	80	177,000	C6LG1S-2	80	181,000
-9	80	178,000	-26	80	178,000	-24	80	180,000
-24	80	178,000	-20	80	176,000	-28	80	184,000
Average		177,000	Average		177,000	Average		182,000
C4LG3S-16	400	157,000	C8LG3S-3	400	158,000	C6LG3S-16	400	164,000
-18	400	158,000	-5	400	157,000	-22	400	164,000
-28	400	155,000	-18	400	157,000	-62	400	164,000
Average		156,000	Average		157,000	Average		164,000
C4LG4S-1	600	141,000	C8LG4S-7	600	146,000	C6LG4S-1	600	154,000
-20	600	145,000	-19	600	151,000	-10	600	159,000
			-21	600	152,000	-20	600	157,000
Average		143,000	Average		150,000	Average		157,000
C4LG6S-6	800	130,000	C8LG6S-2	800	138,000	C6LG6S-6	800	142,000
-13	800	138,000	-15	800	148,000	-12	800	142,000
			-17	800	142,000	-13	800	141,000
Average		134,000	Average		143,000	Average		141,000
C5LG7S-8	900	120,000	C8LG7S-8	900	112,000	C6LG7S-8	900	111,000
-14	900	121,000	-12	900	115,000	-14	900	109,000
-27	900	123,000	-13	900	112,000	-23	900	113,000
Average		121,000	Average		113,000	Average		111,000

TABLE XII

LONGITUDINAL TENSILE STRESS-RUPTURE DATA FOR STRESS RATIO OF ZERO (A=0) FATIGUE VALUES.
SOLUTION TREATED AND AGED 2.5Al-16V TITANIUM ALLOY SHEET

Stress Concentration (K_t)	Thickness in.	800°F			900°F		
		Specimen Number	Tensile Stress, PSI	Time to Failure, hours	Specimen Number	Tensile Stress, PSI	Time to Failure, hours
1.00	0.020	C4LG6R-7	115,000	1.15	C4LG7R-23	70,000	1.60
		-11	94,900	18.0	-12	43,900	26.8
		-21	67,500	226.5	-2	30,000	53.9
	0.125	C6LG6R-11	115,000	0.80	C6LG7R-9	70,000	1.45
		-7	94,900	6.65	-19	44,000	15.1
		-21	67,600	115.3	-27	27,000	119.8
2.82	0.020	C4LG6S-5	118,000	0.30	C4LG7S-4	72,000	1.40
		-34	112,000	1.90	-25	46,400	52.4
		-15	99,800	11.6	-10	32,900	60.9
	0.063	C8LG6S-23	117,000	0.82	C8LG7S-1	72,100	2.90
		-9	100,000	0.97	-4	46,500	18.8
		-6	76,100	90.2	-11	33,000	66.7
	0.125	C6LG6S-5	117,000	1.7	C6LG7S-4	72,400	2.5
		-15	100,000	16.8	-25	48,500	15.7
		-17	71,100	283.7	-26	29,500	105.0

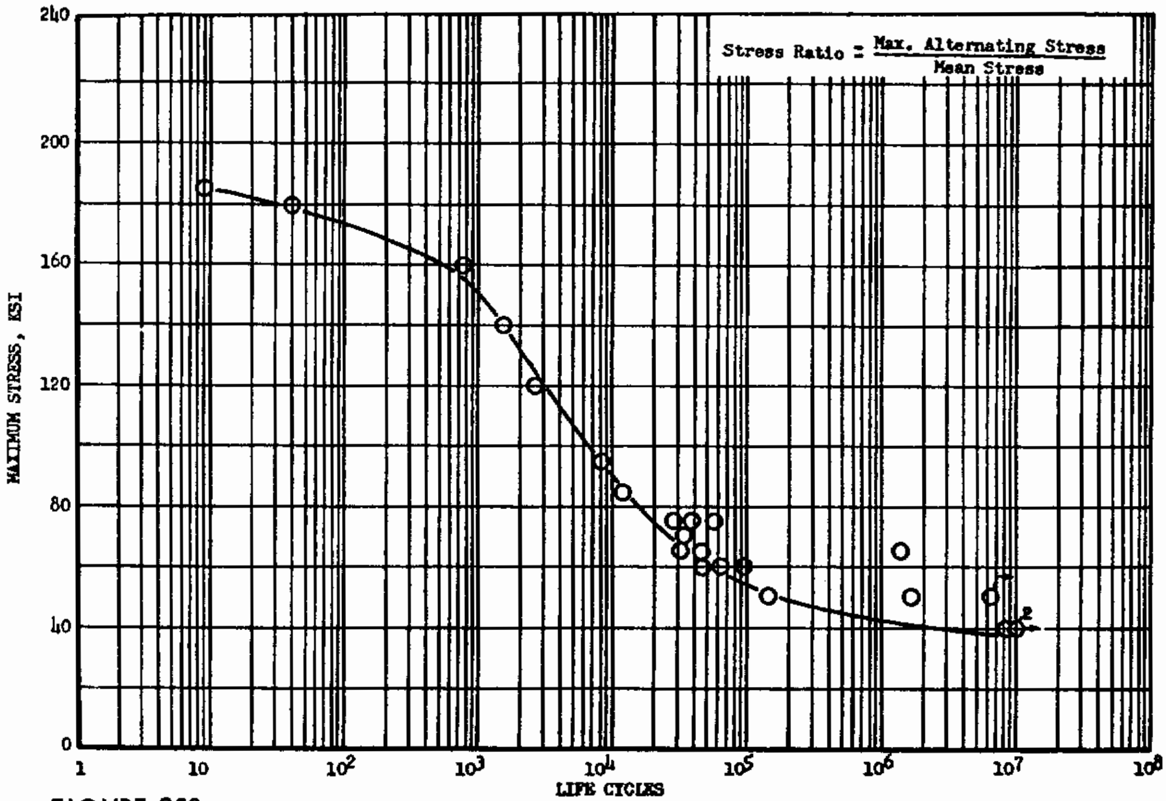


FIGURE 250 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 22093)

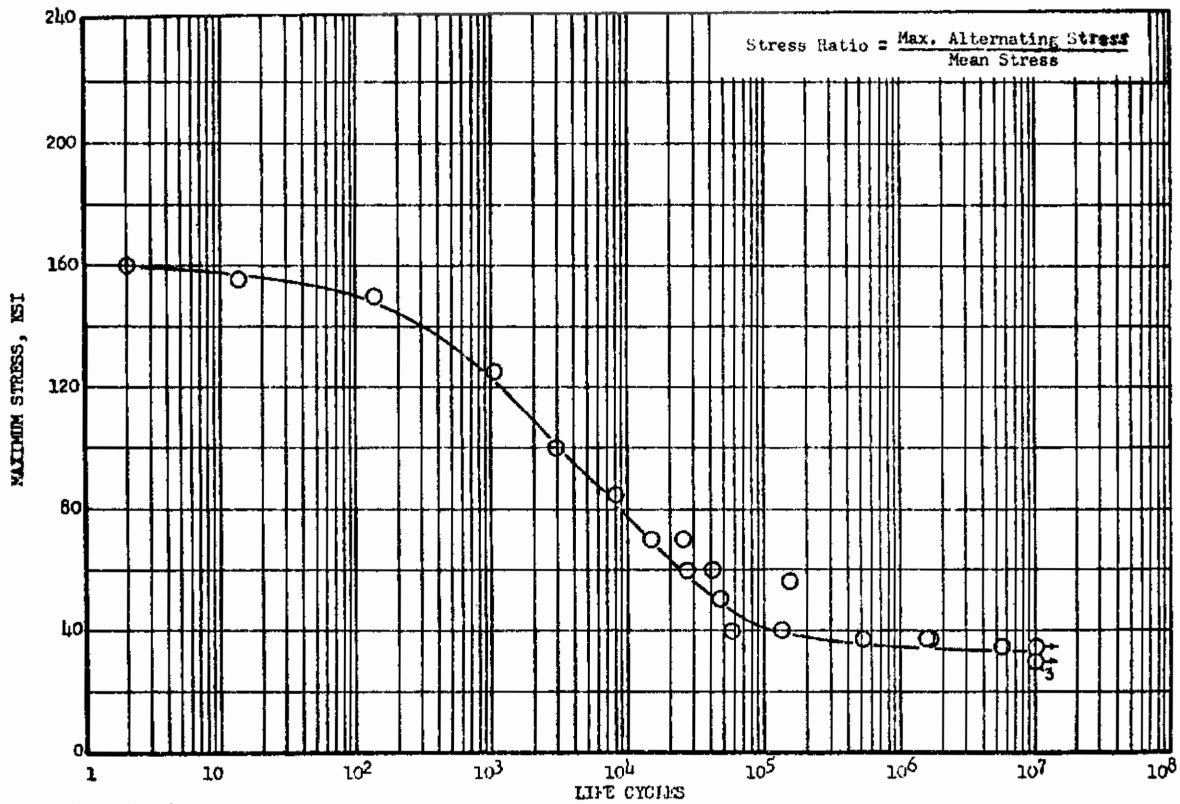


FIGURE 251 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 22093)

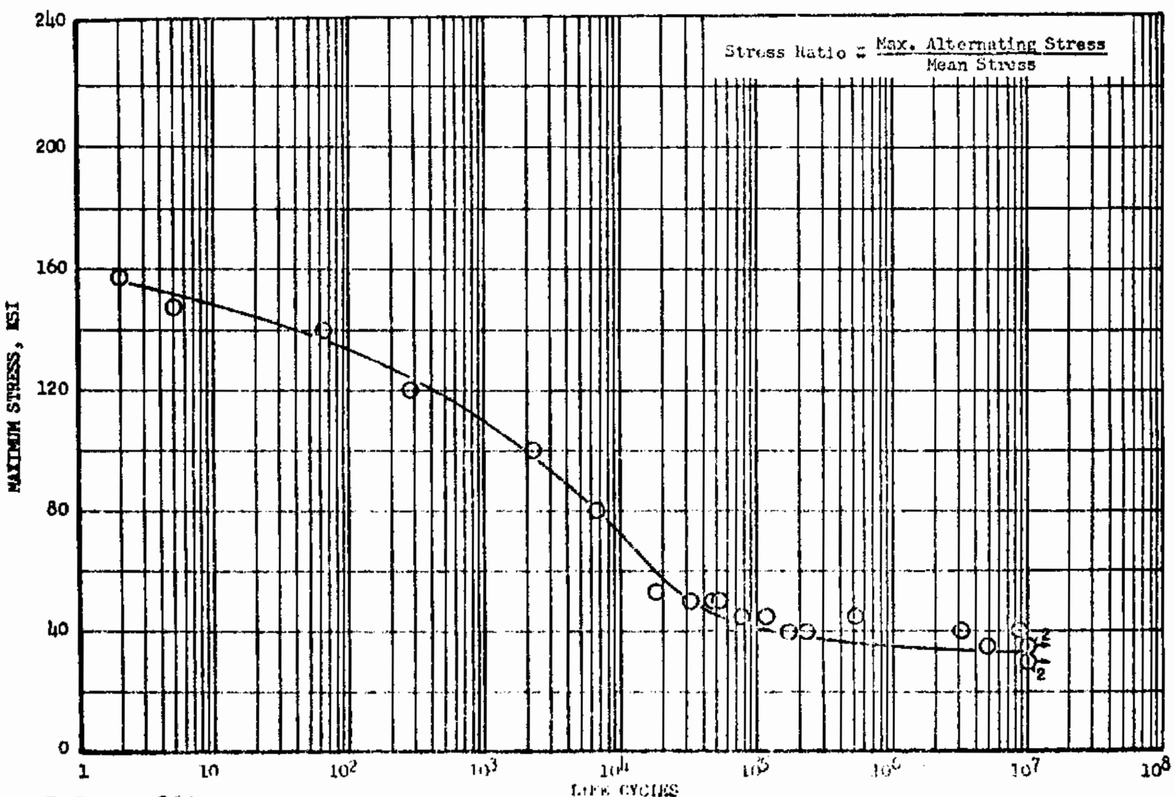


FIGURE 252 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 22093)

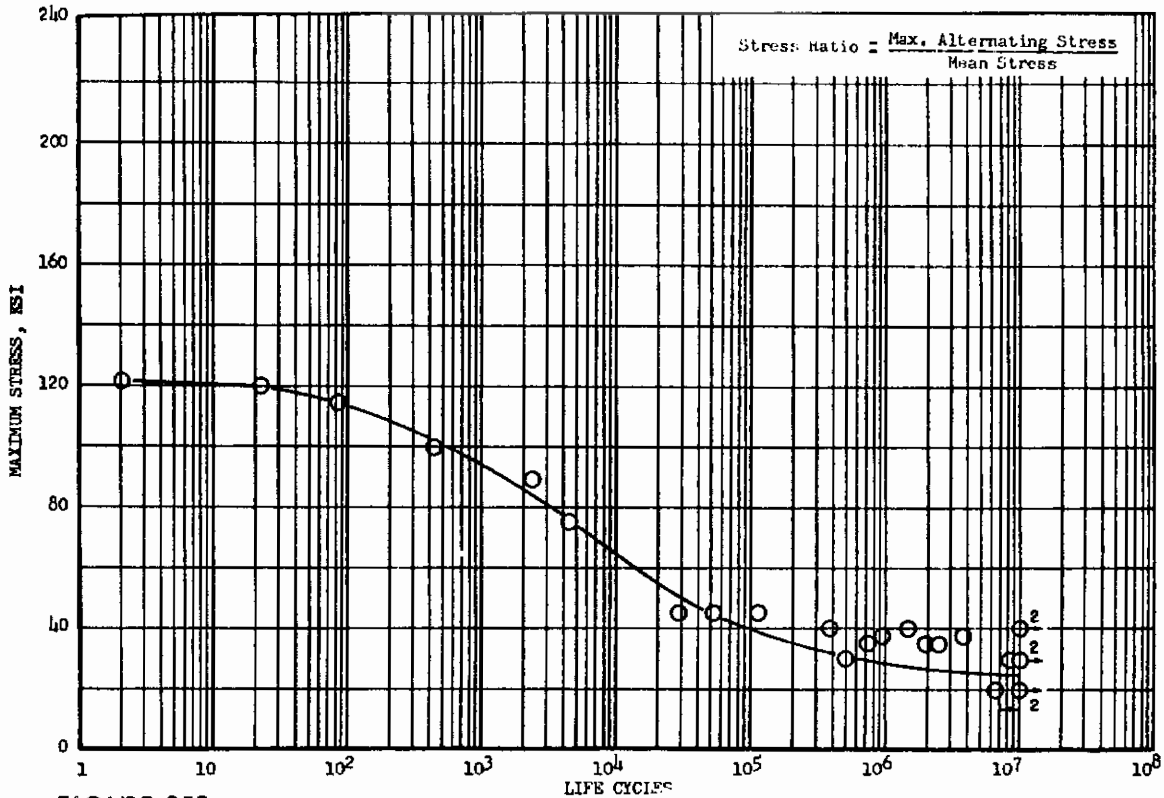


FIGURE 253 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 22093)

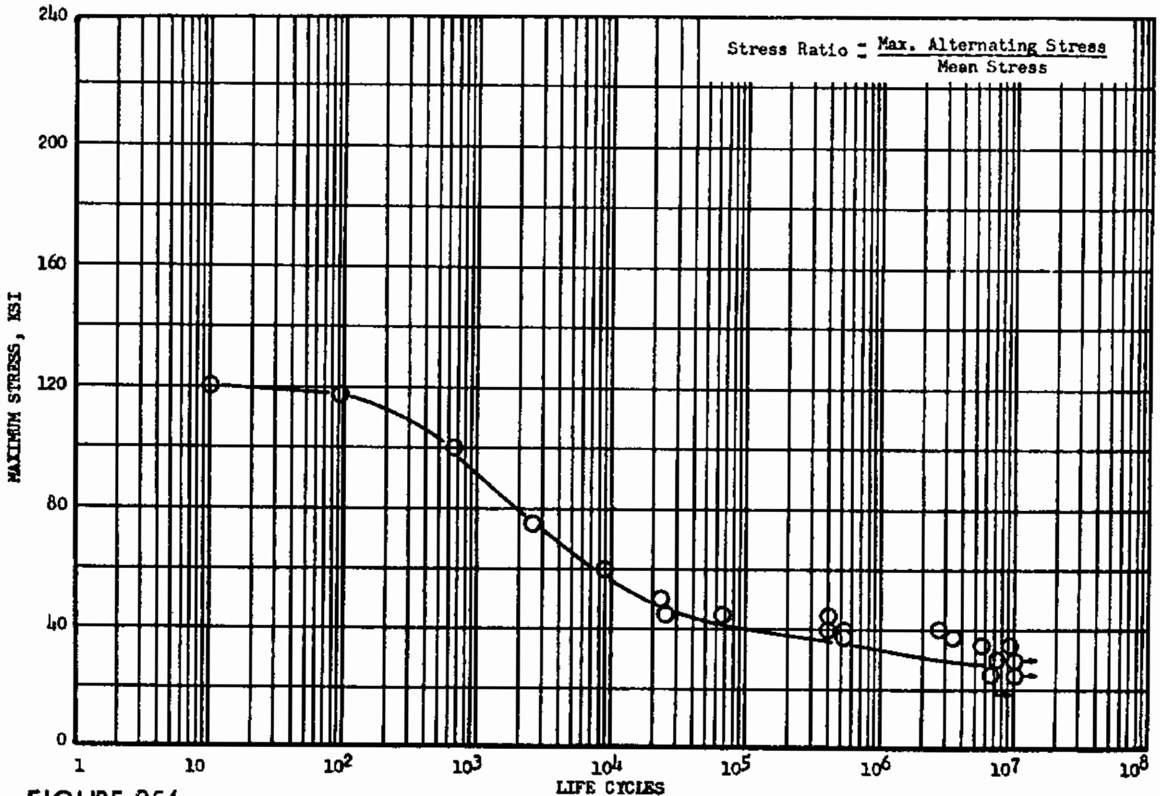


FIGURE 254 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 22093)

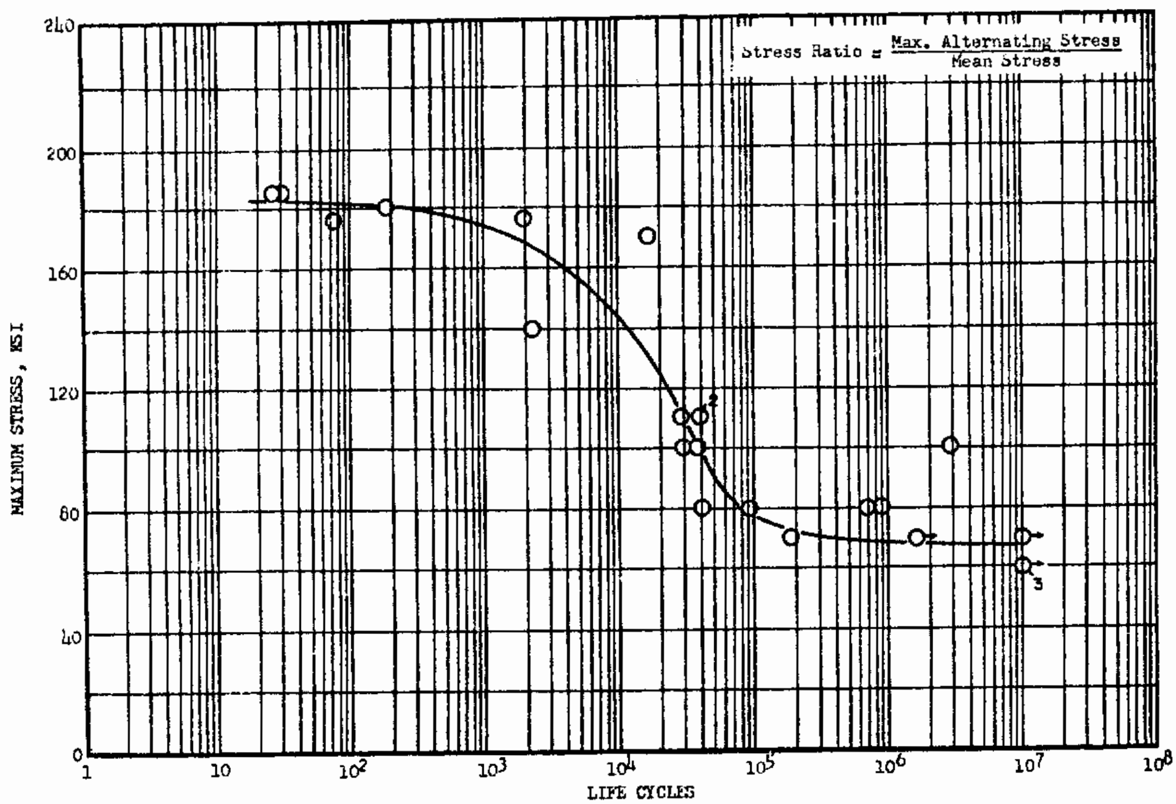


FIGURE 255 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 22093)

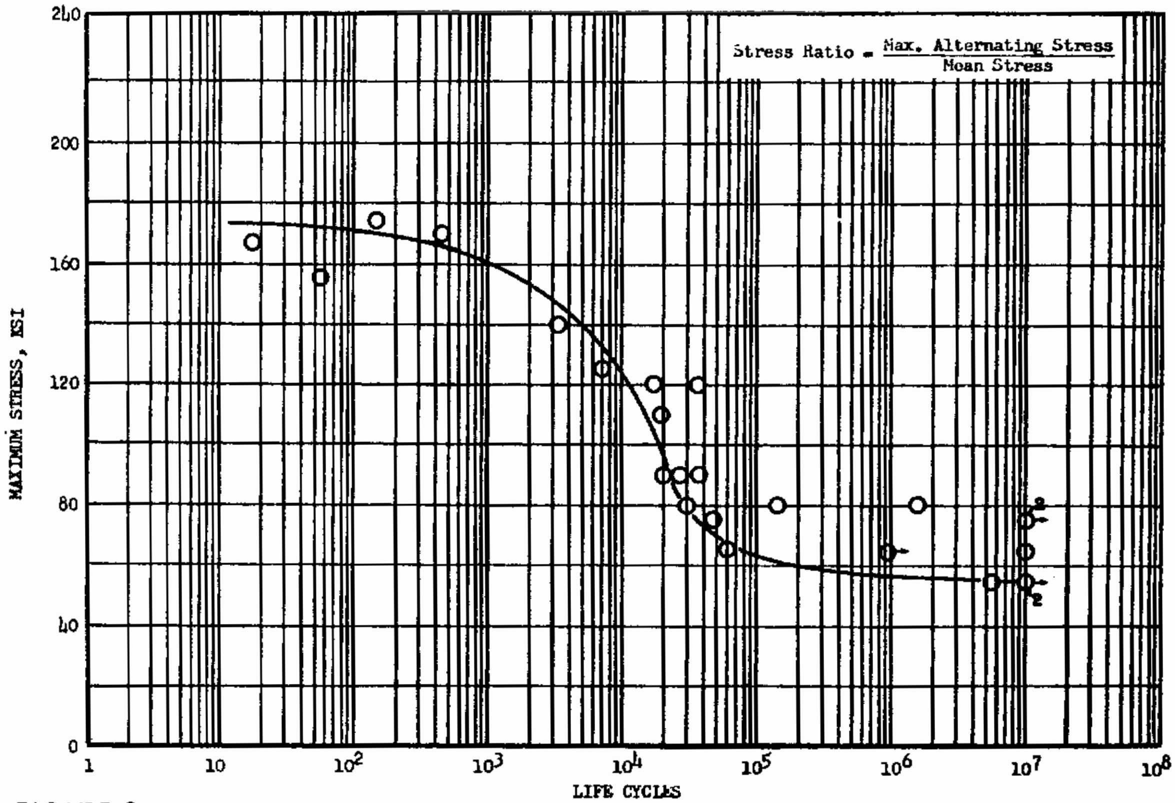


FIGURE 256 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 22093)

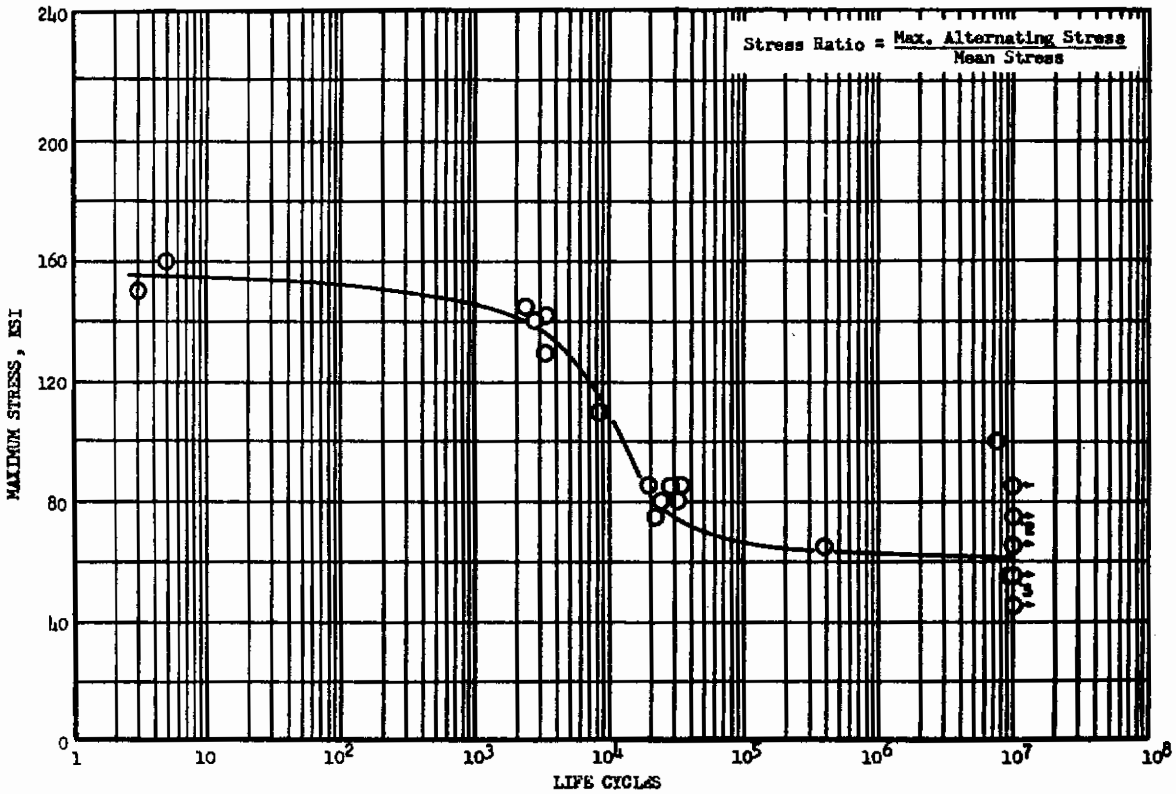


FIGURE 257 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 22093)

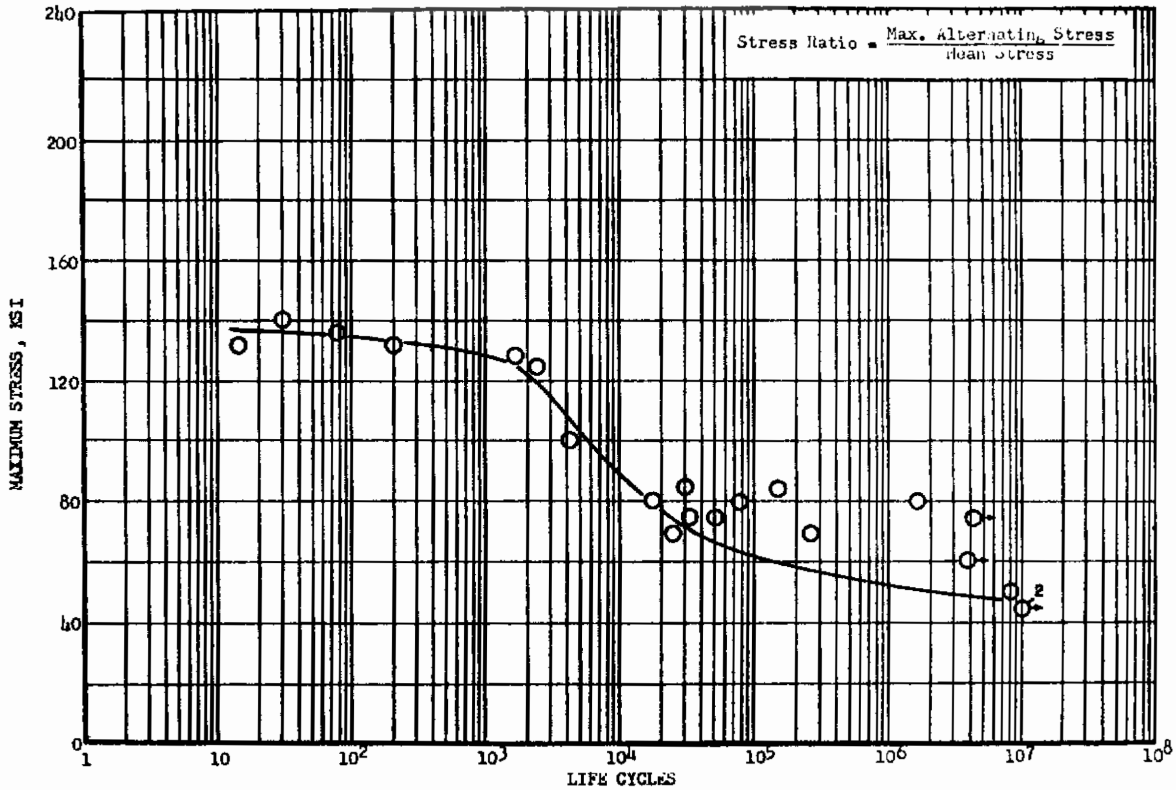


FIGURE 258 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 22093)

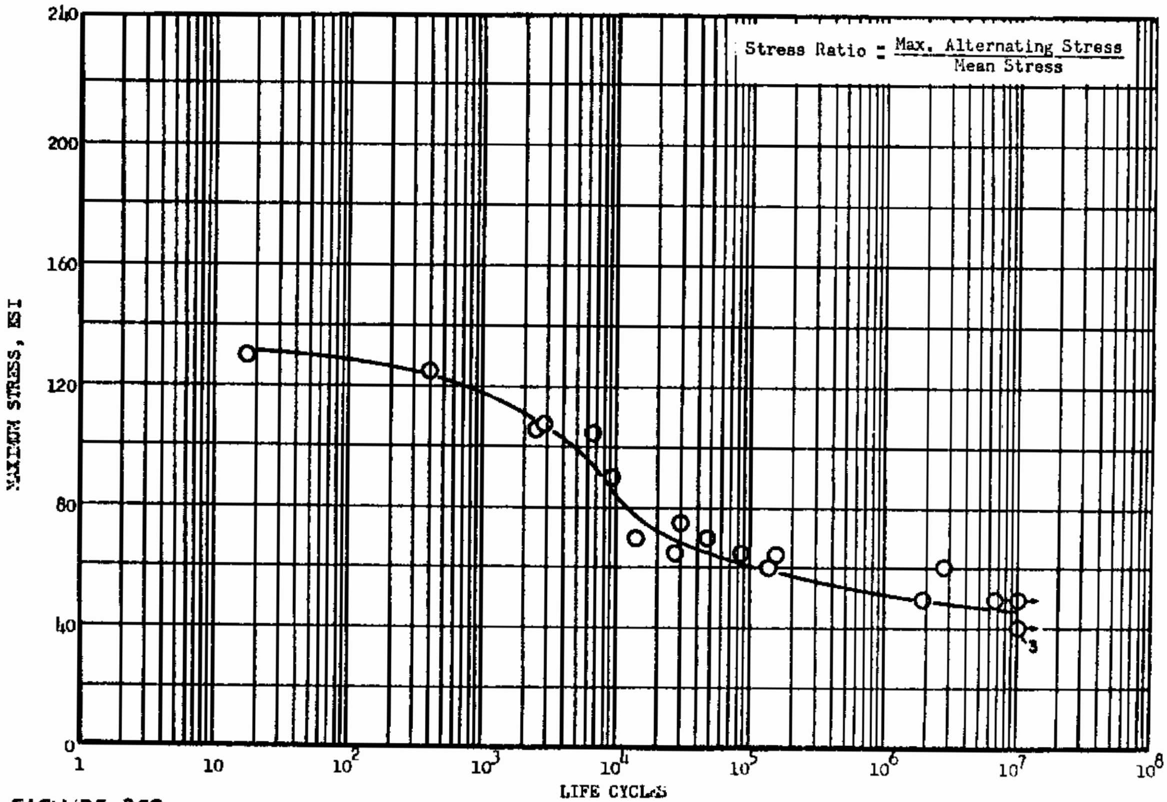


FIGURE 259 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 22093)

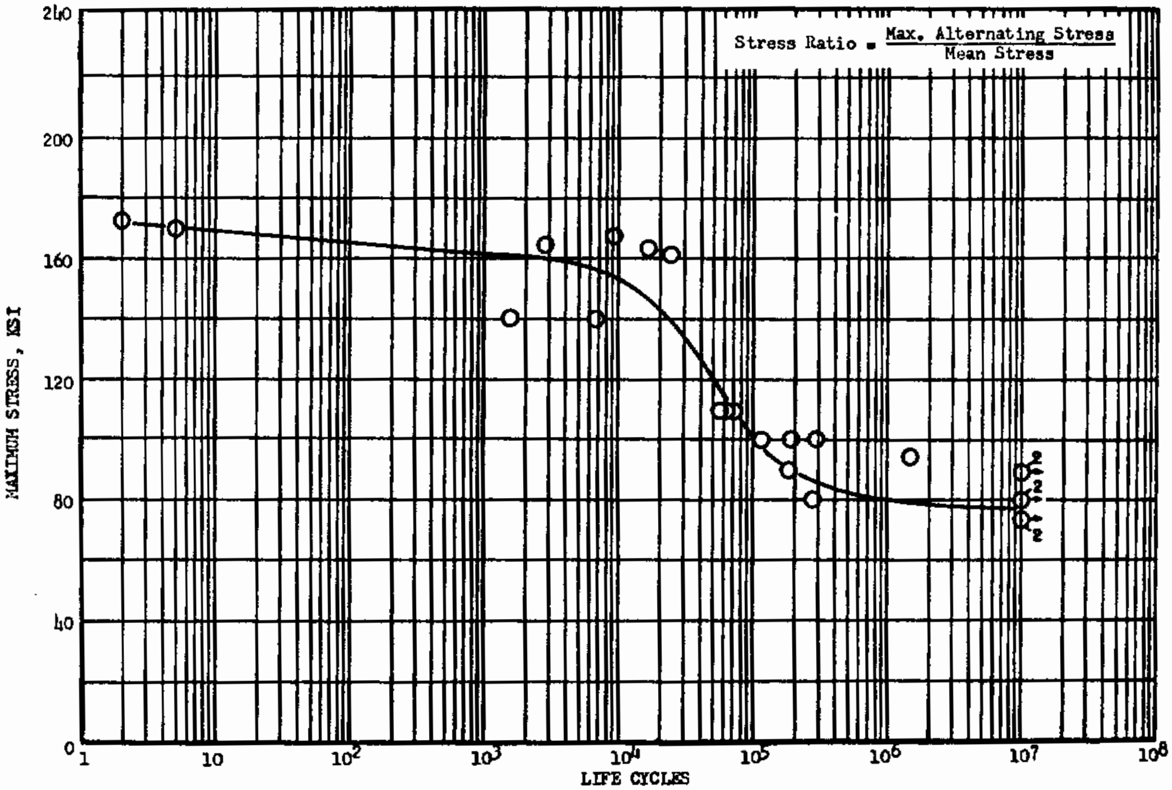


FIGURE 260 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 22093)

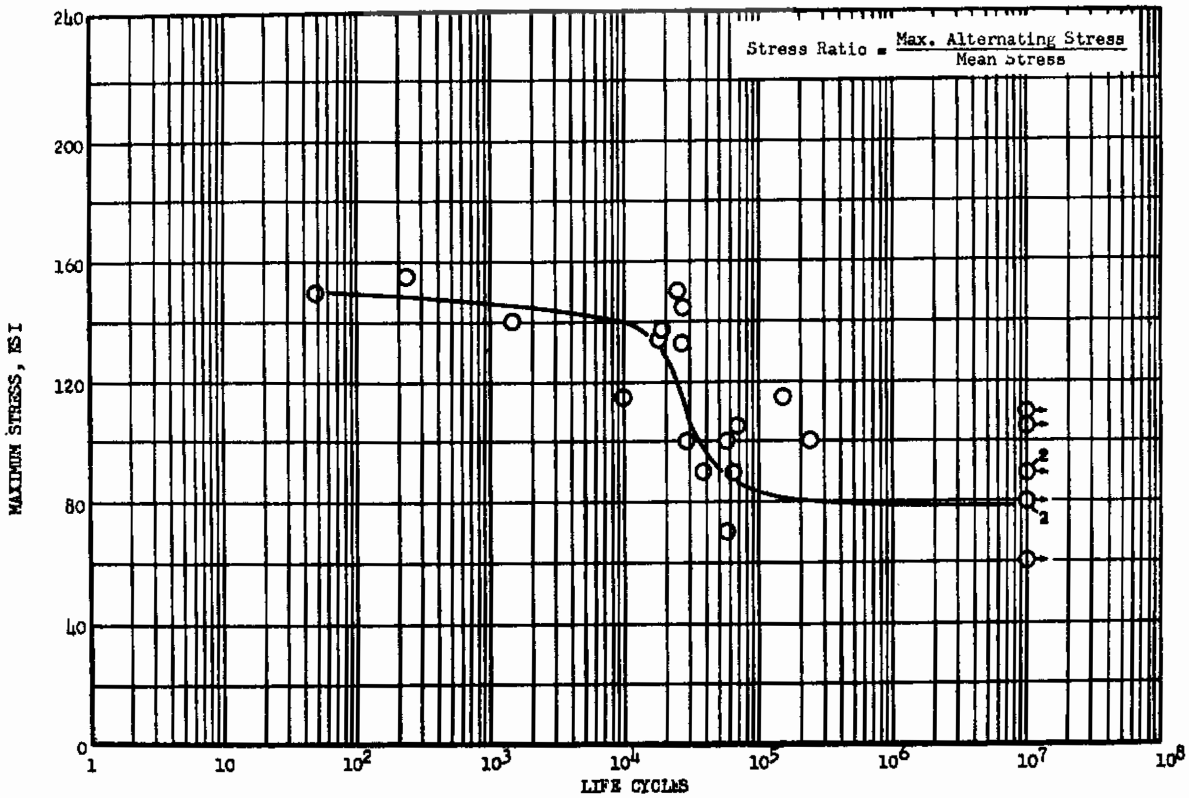


FIGURE 261 – AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 22093)

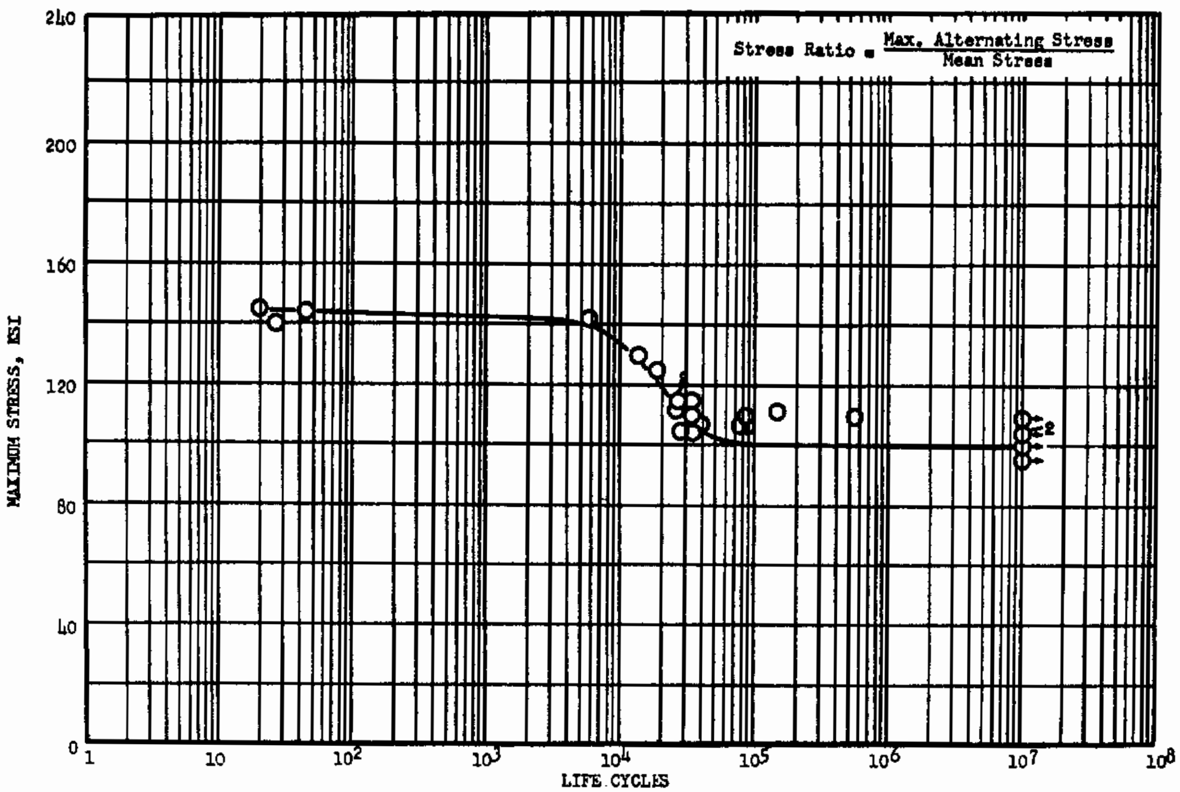


FIGURE 262 – AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 22093)

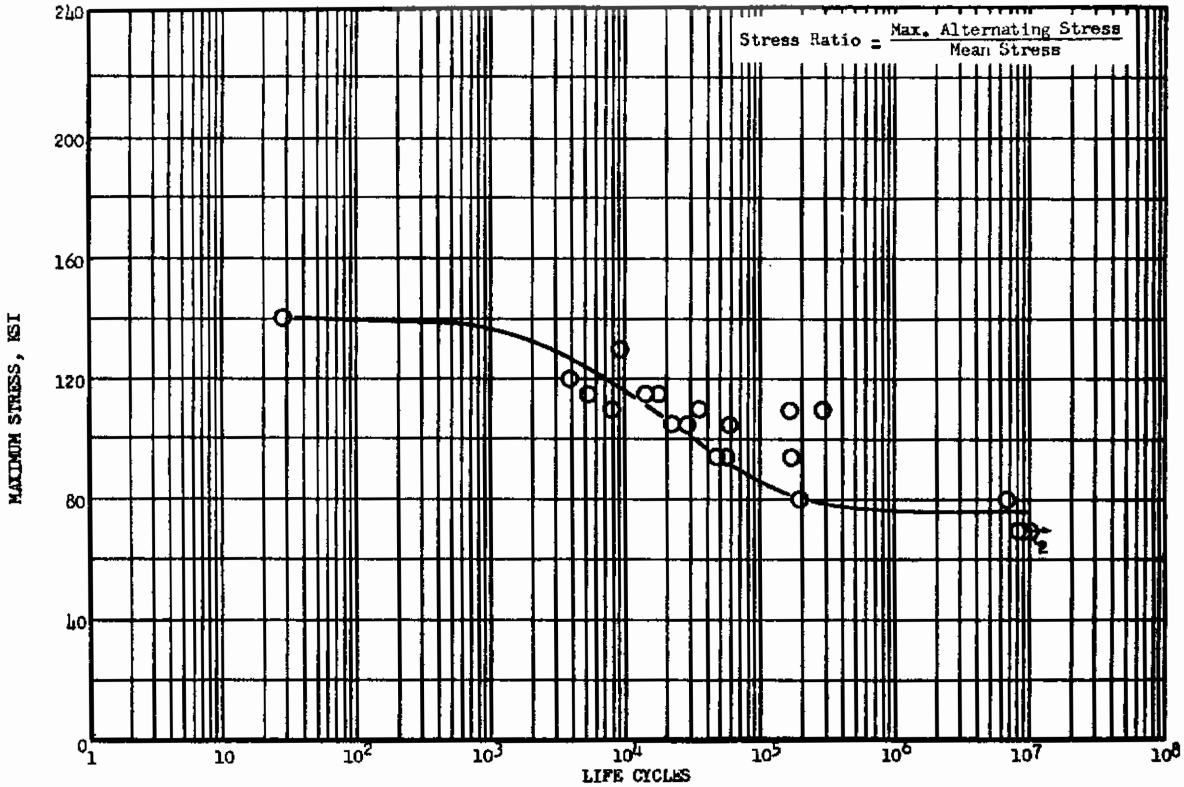


FIGURE 263 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 800°F, WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 22093)

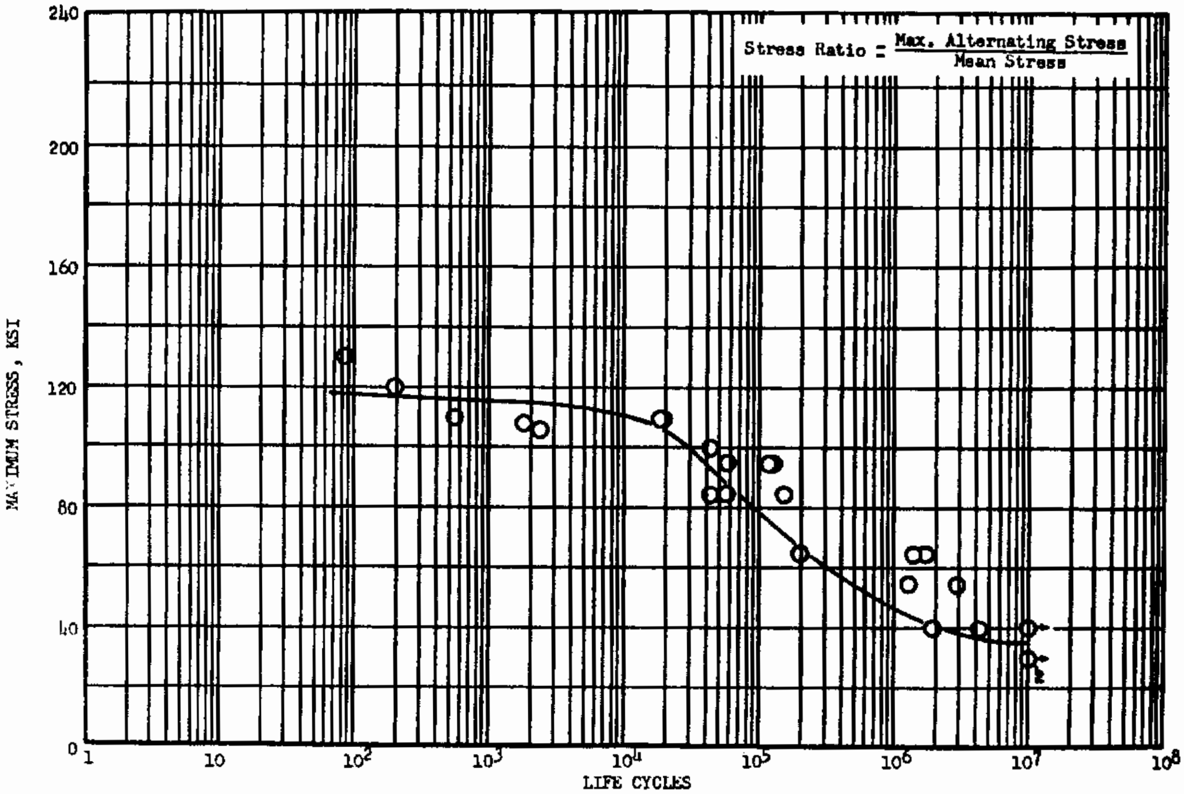


FIGURE 264 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 22093)

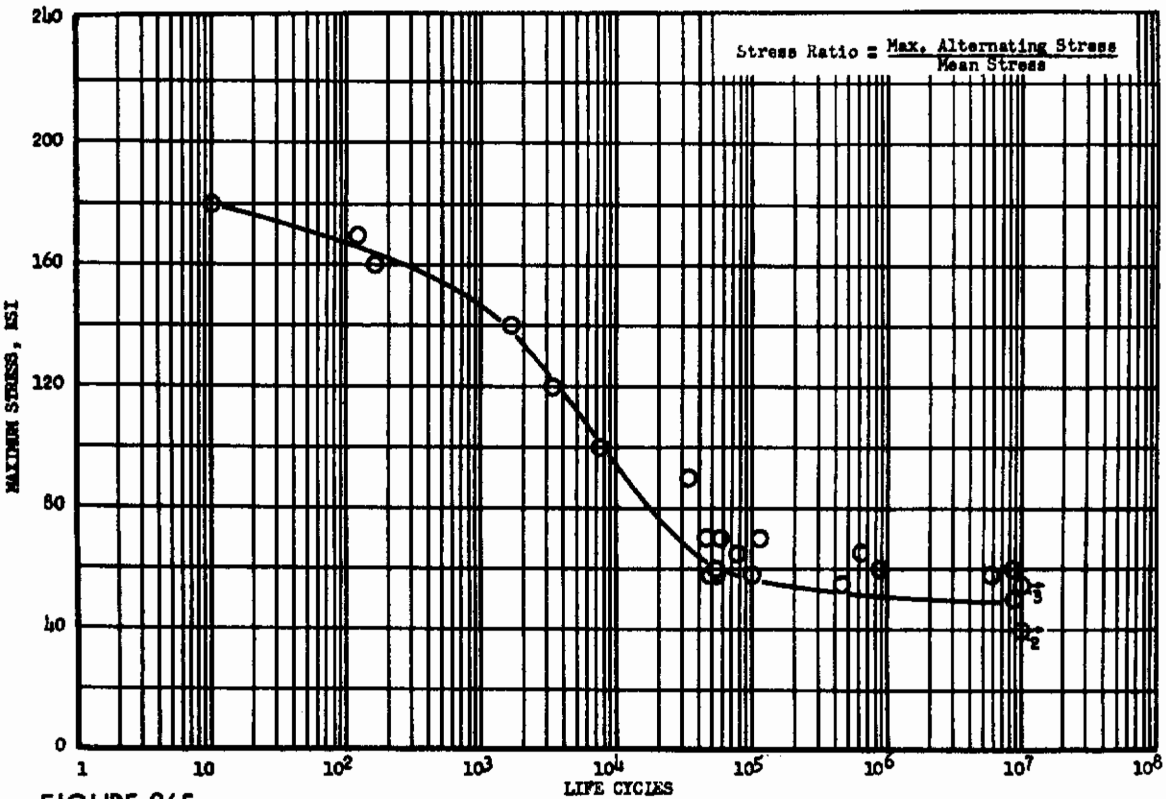


FIGURE 265 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 24806 AND 24814)

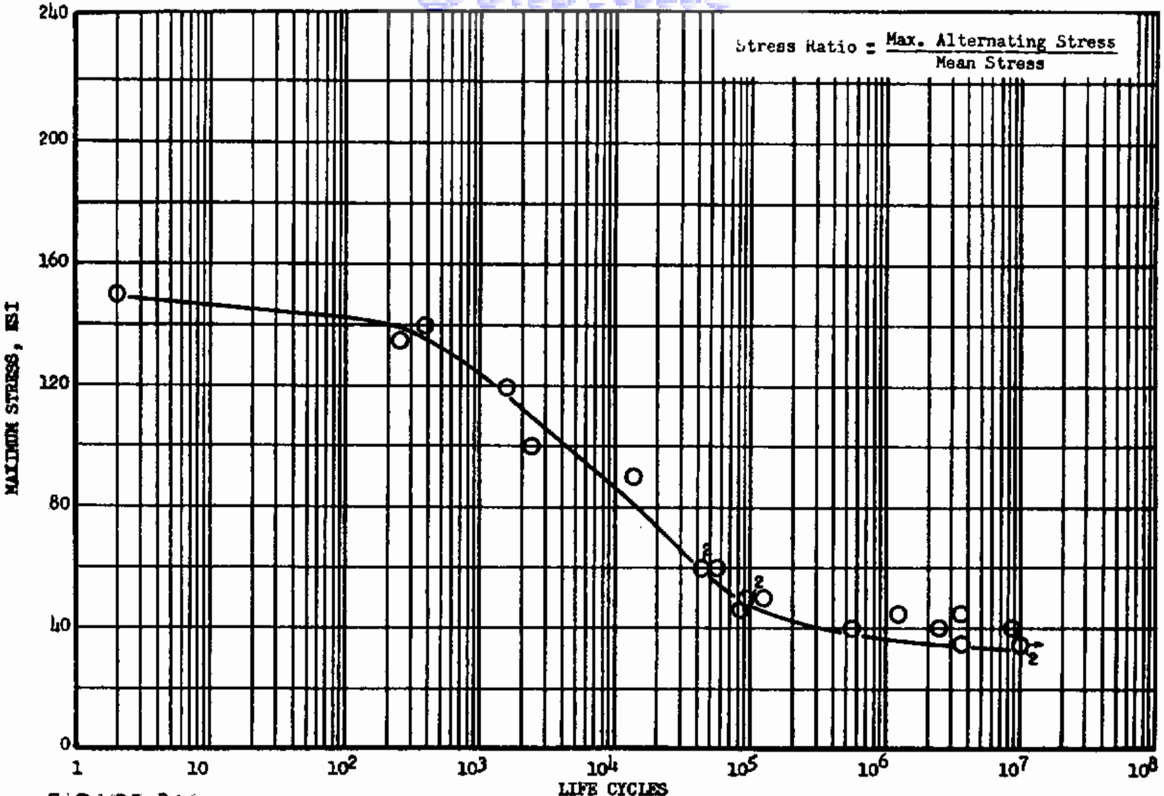


FIGURE 266 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 24806 AND 24814)

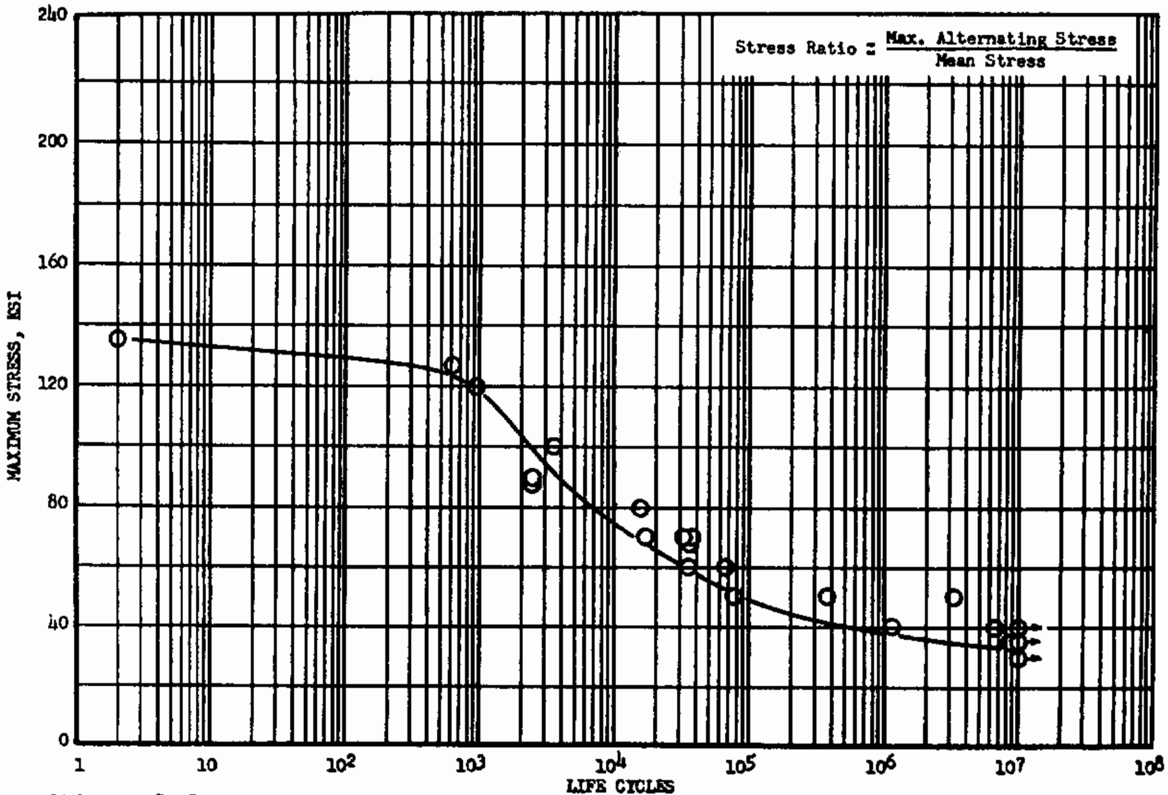


FIGURE 267 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 24806 AND 24814)

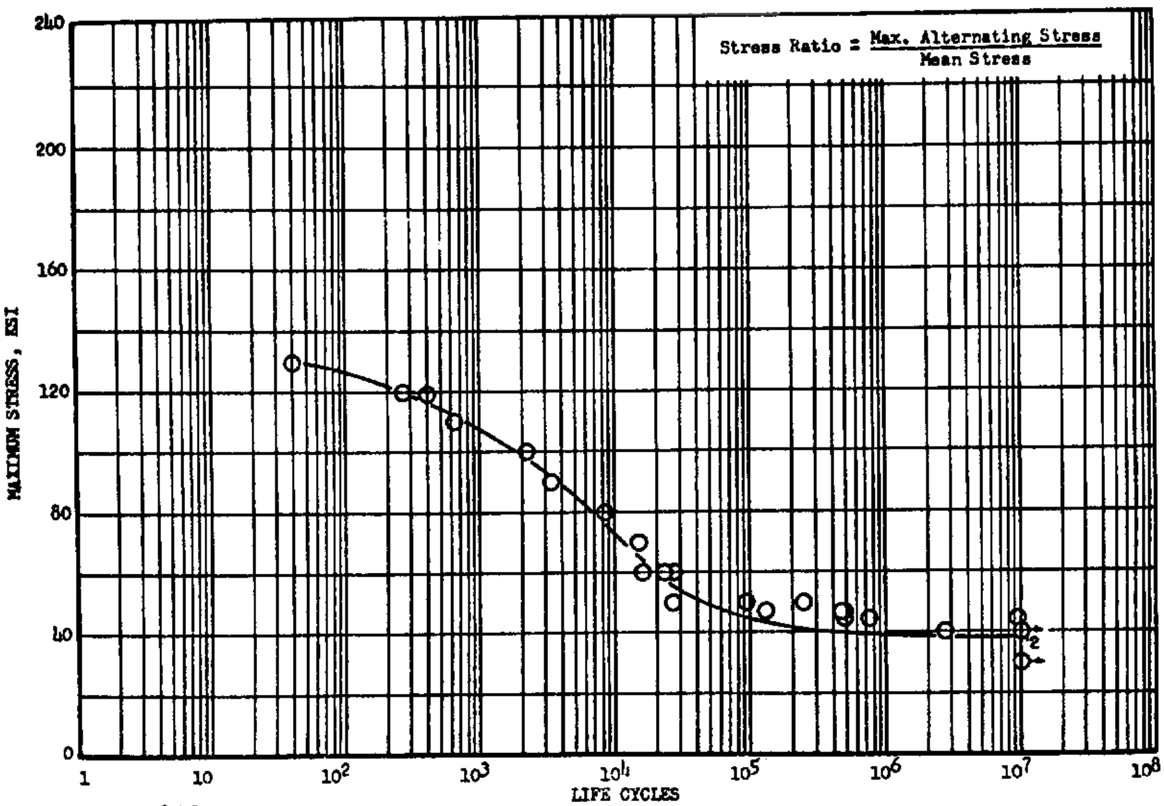


FIGURE 268 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 24806 AND 24814)

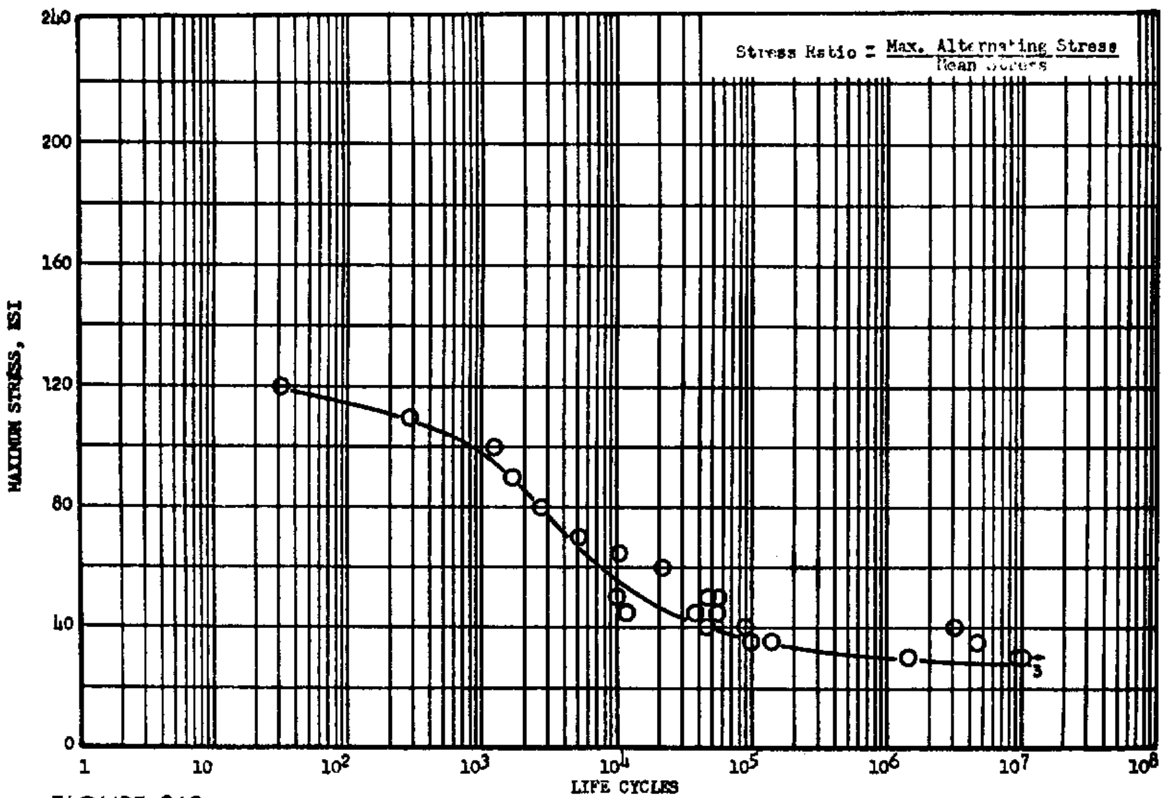


FIGURE 269 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 24806 AND 24814)

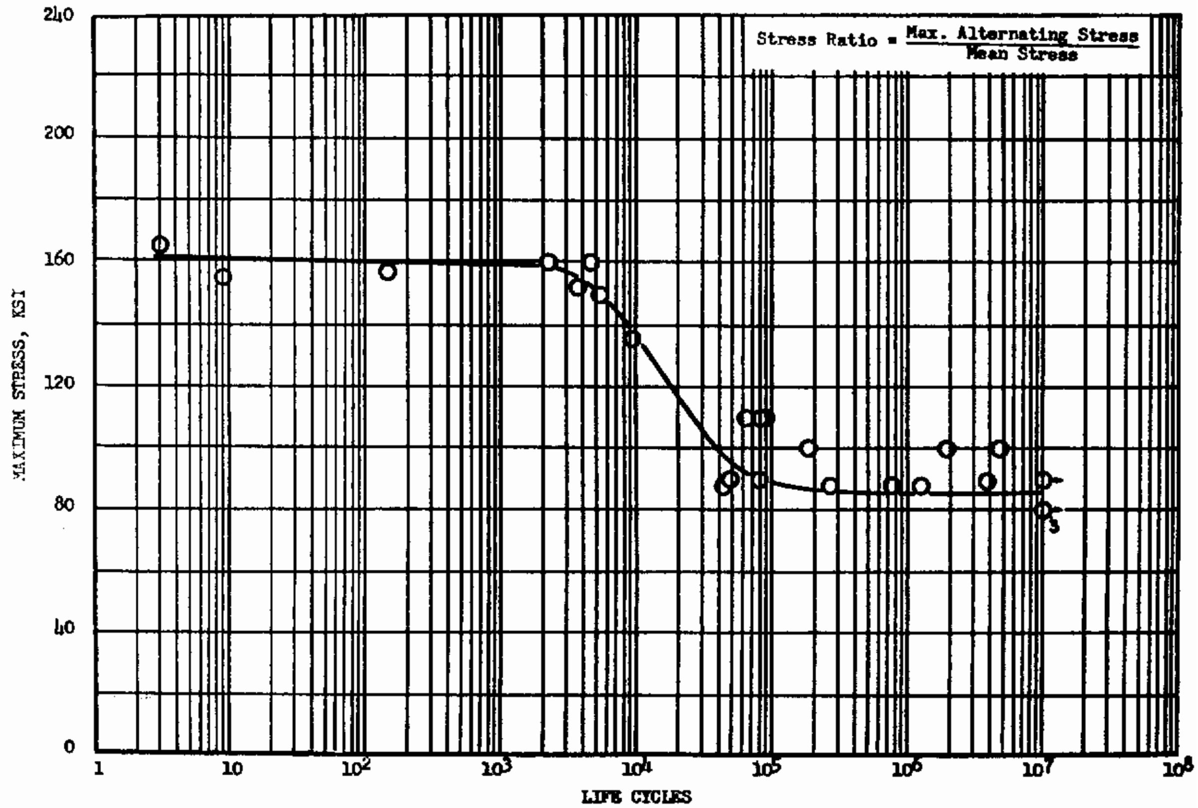


FIGURE 270 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 24806)

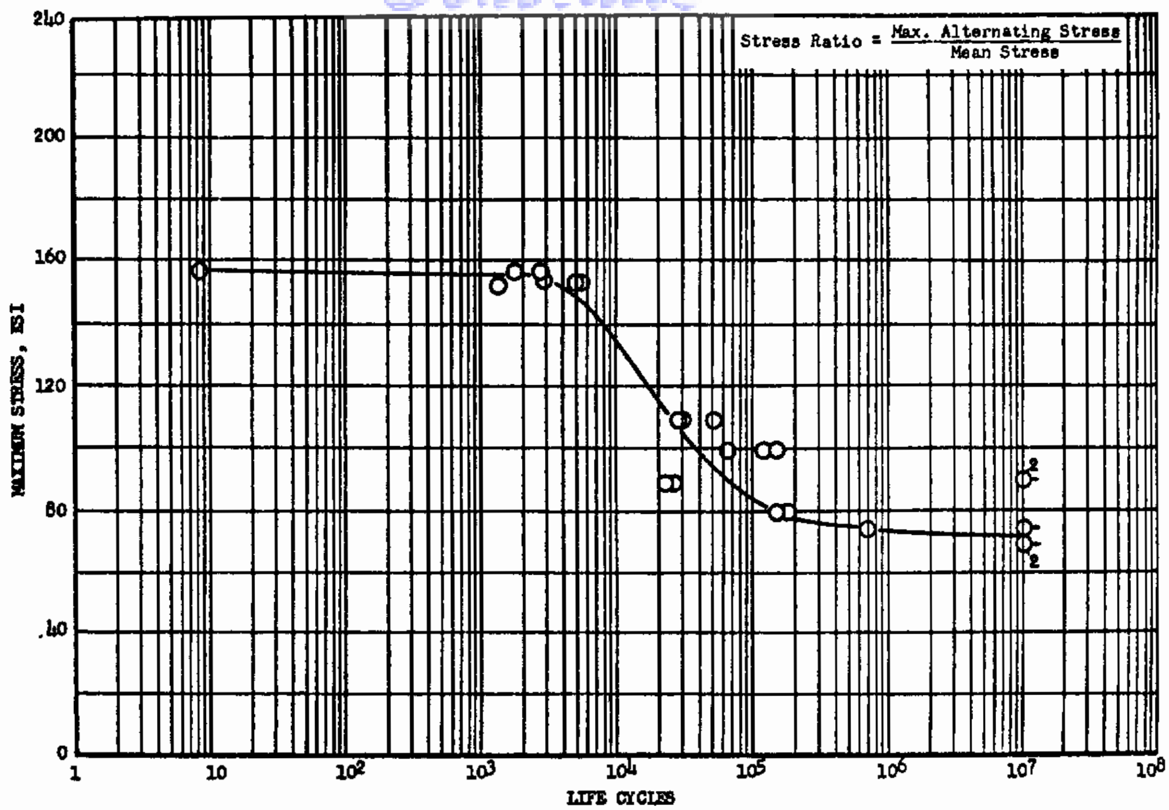


FIGURE 271 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.63 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 24806)

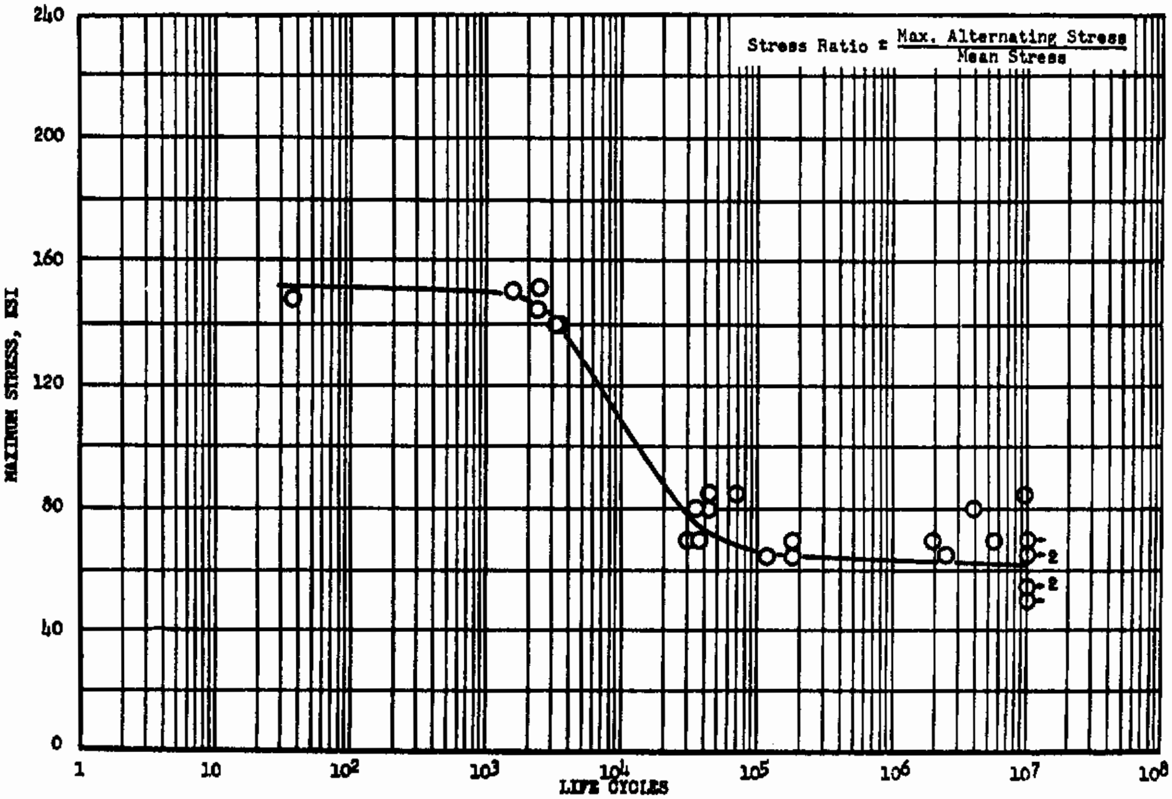


FIGURE 272 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 24806)

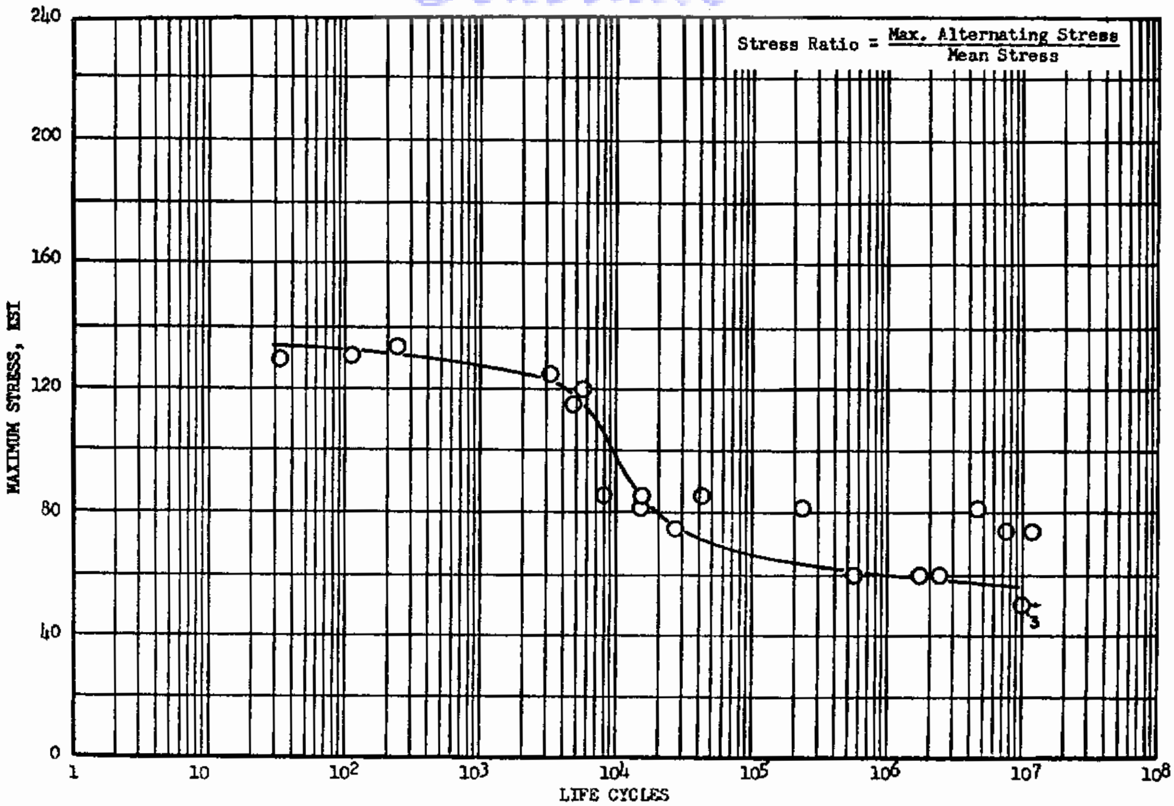


FIGURE 273 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 24806)

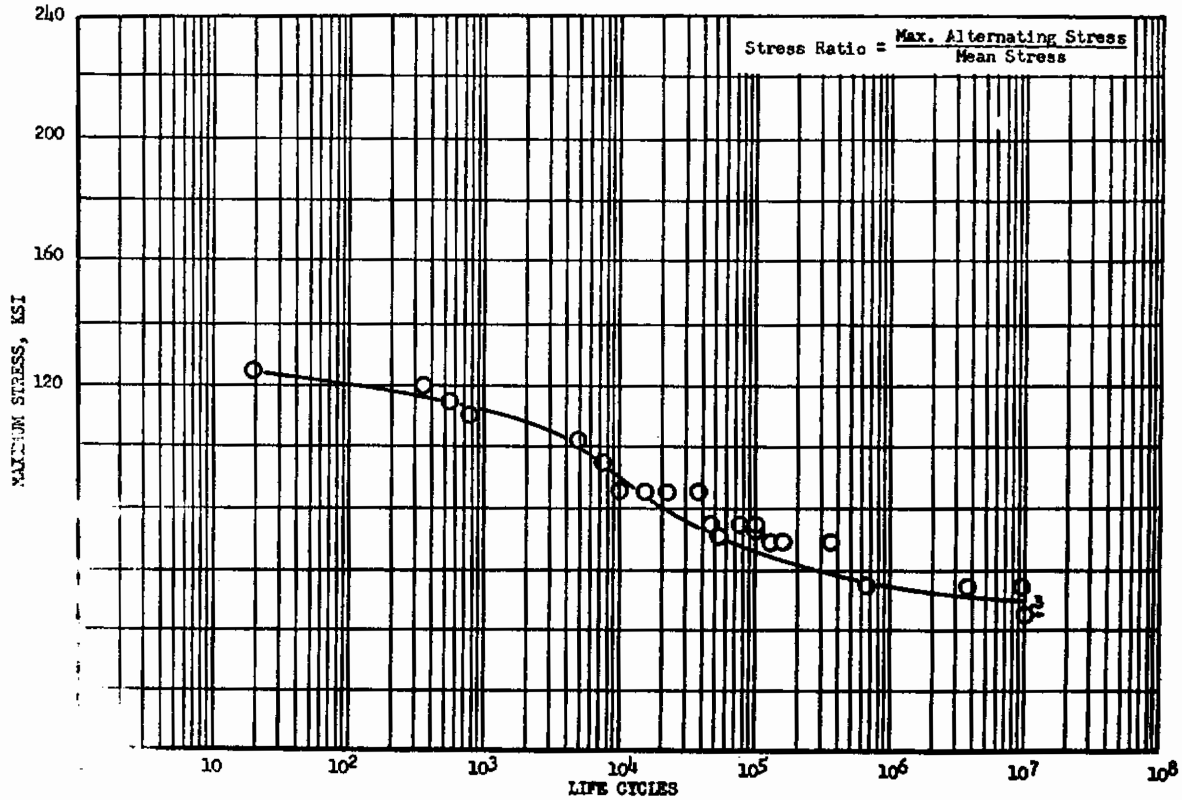


FIGURE 274 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 24806)

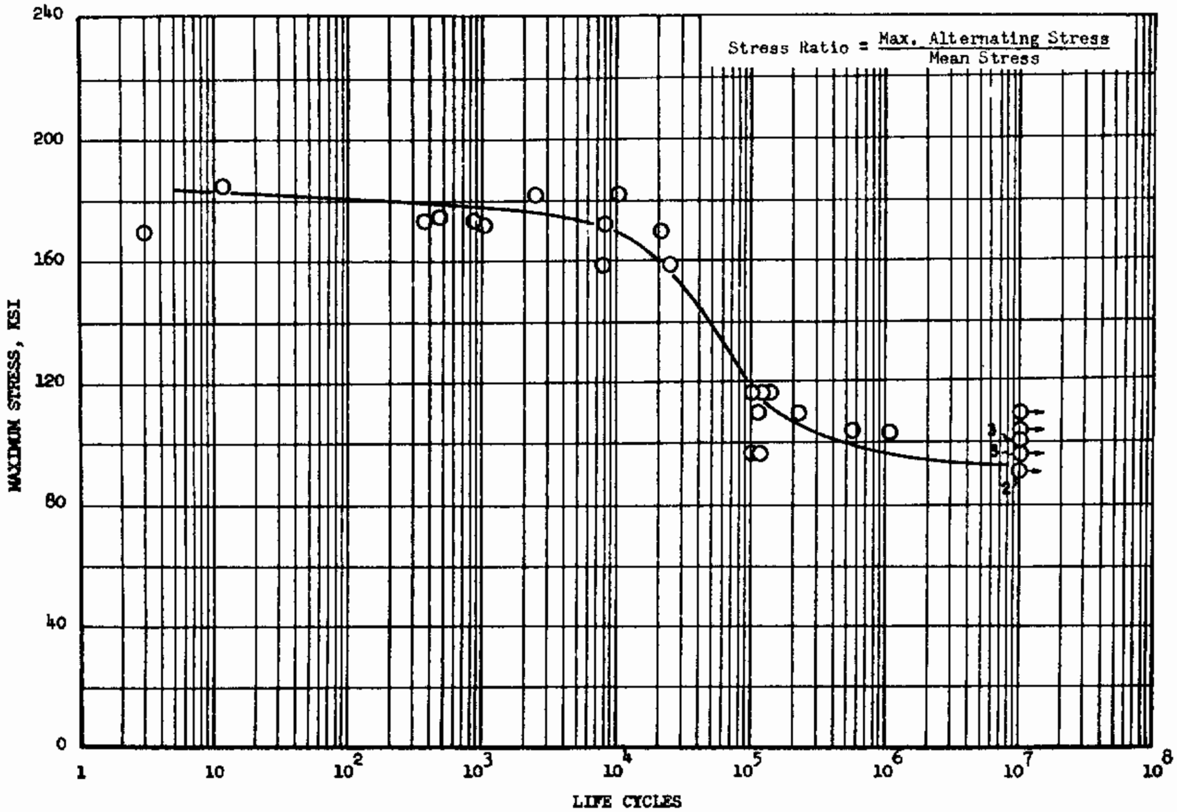


FIGURE 275 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 24806)

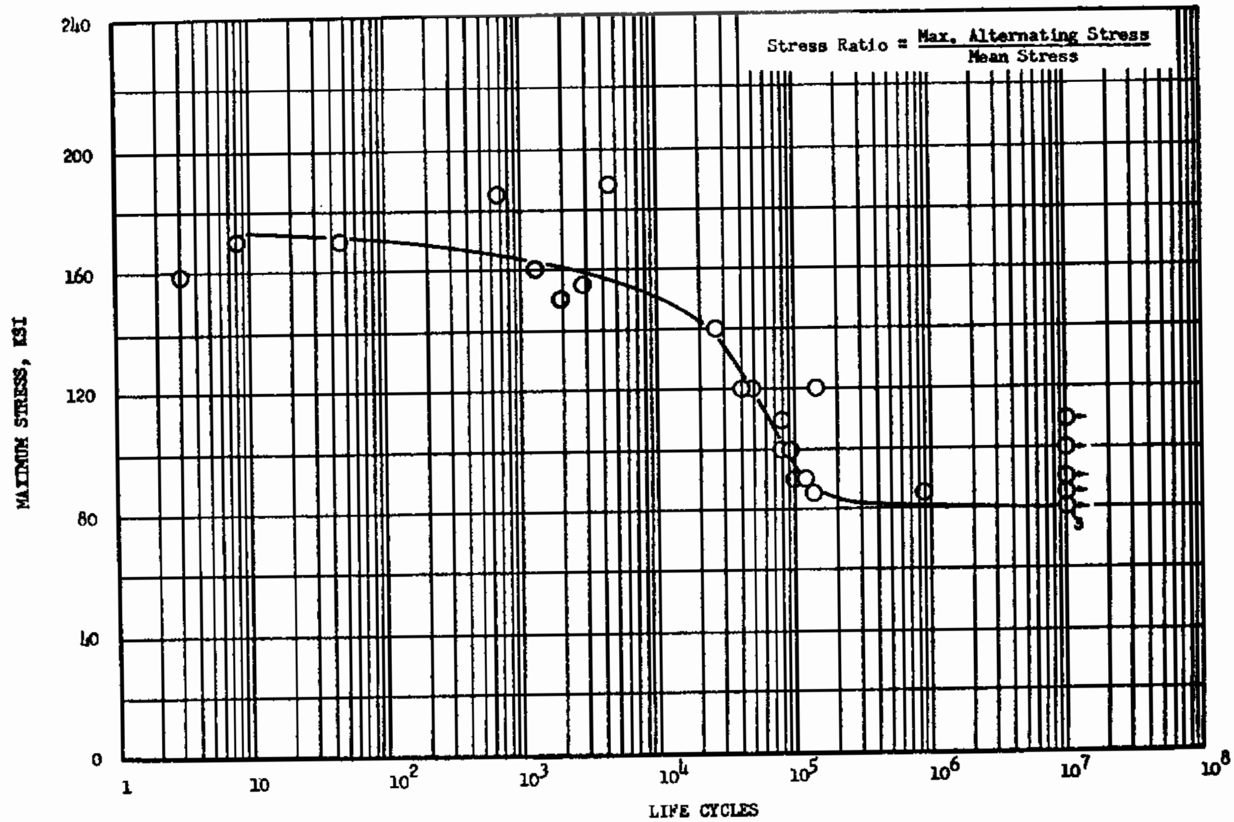


FIGURE 276 – AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 24806)

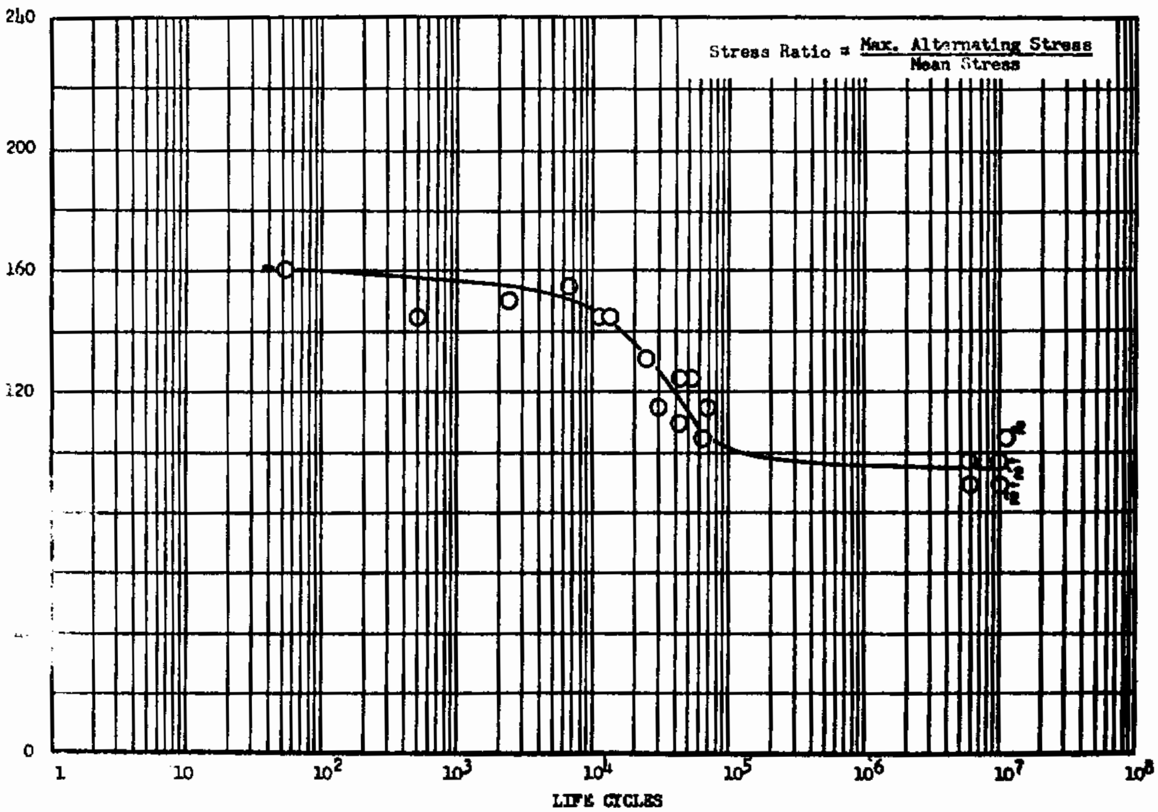


FIGURE 277 – AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 24806)

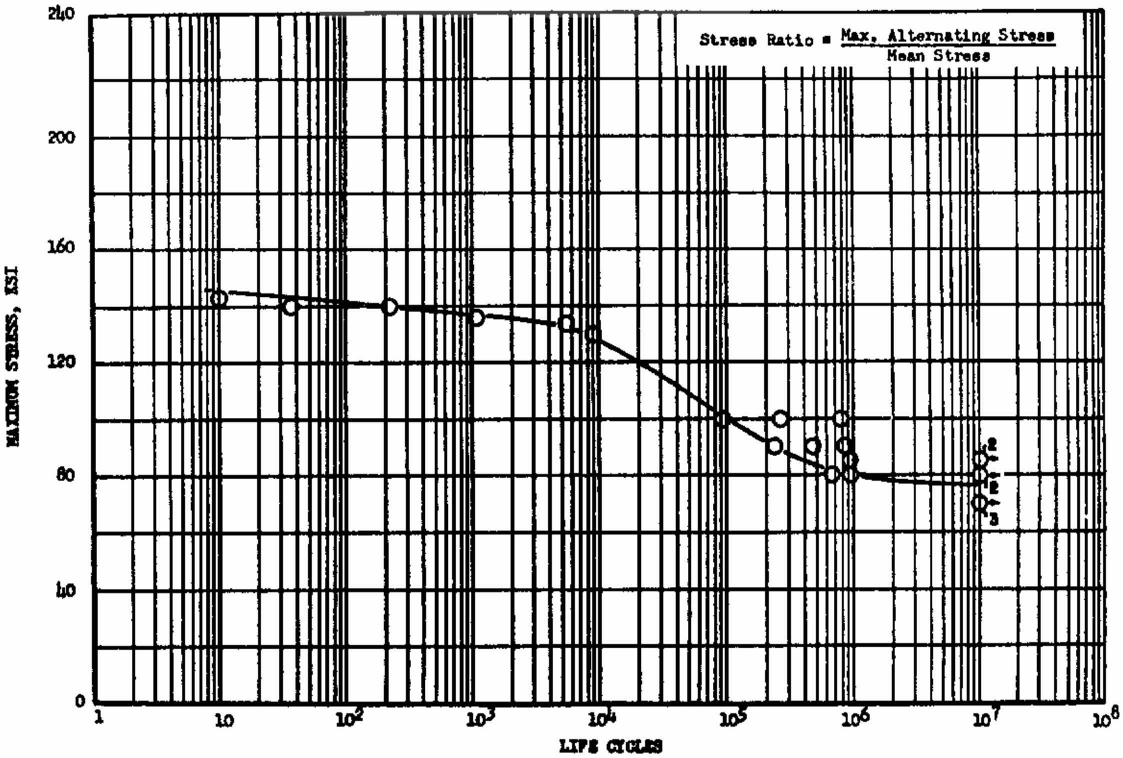


FIGURE 278 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 24806)

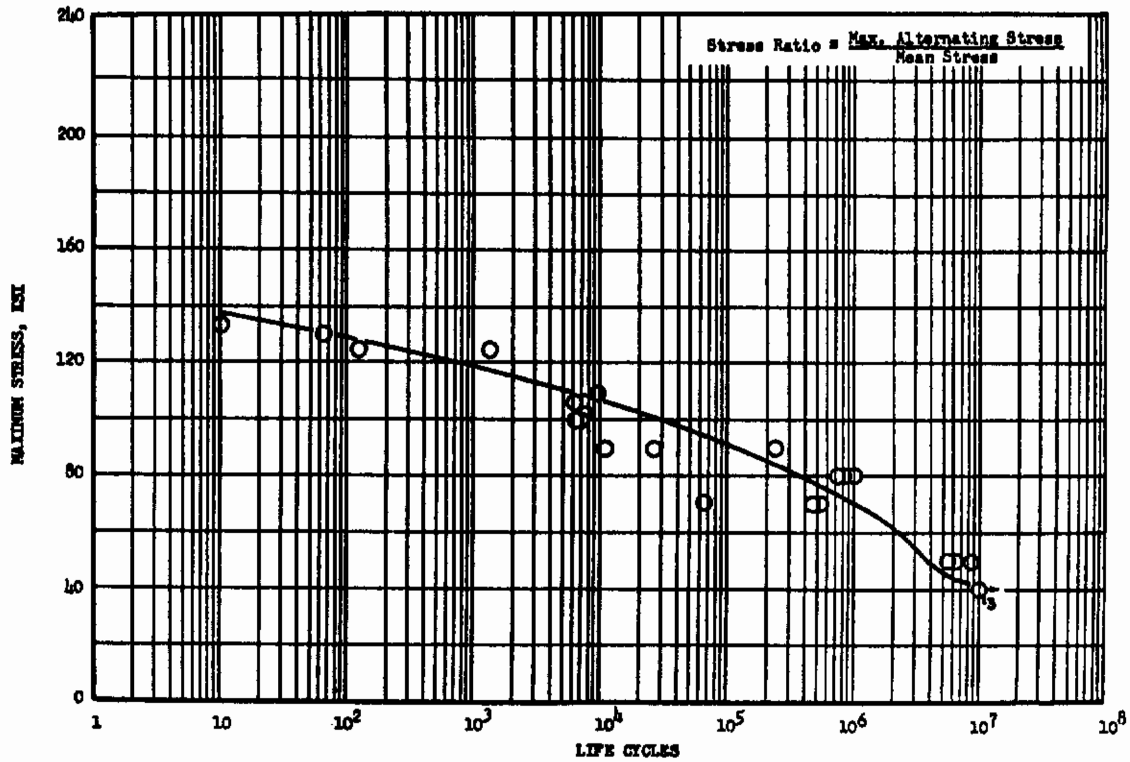


FIGURE 279 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 24806)

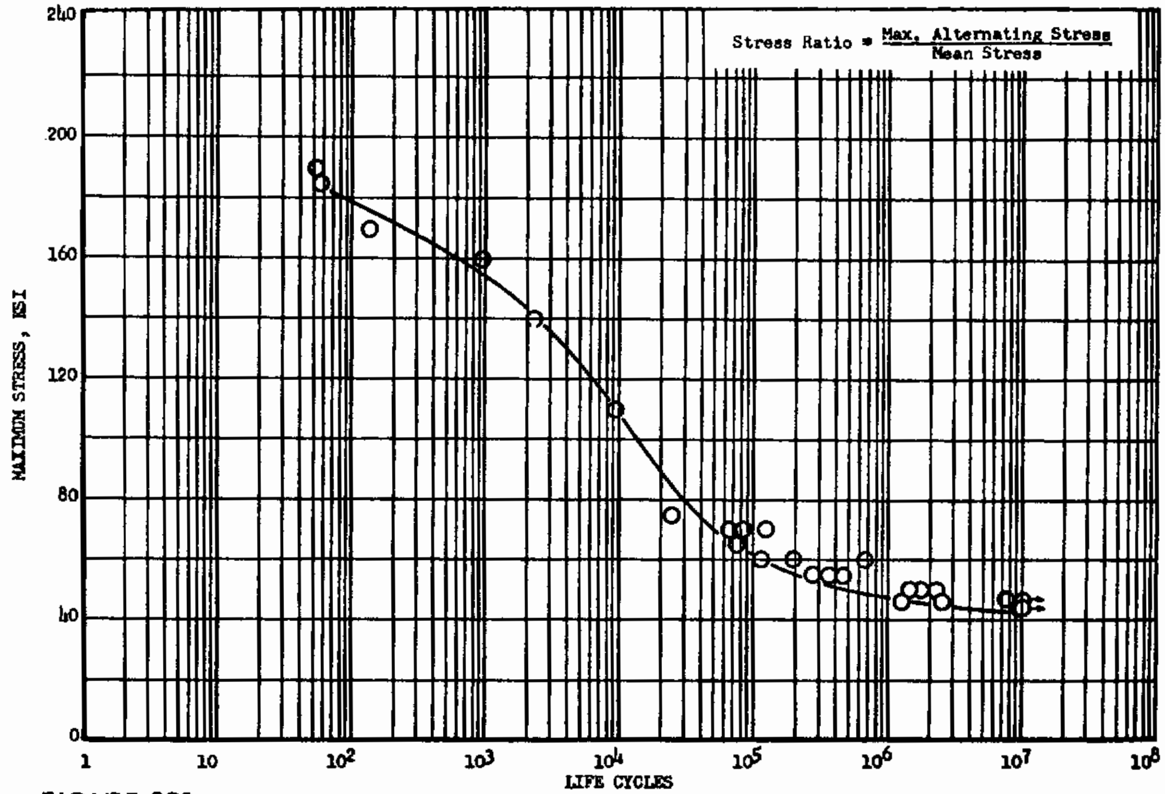


FIGURE 280 – AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 23345 AND 23372)

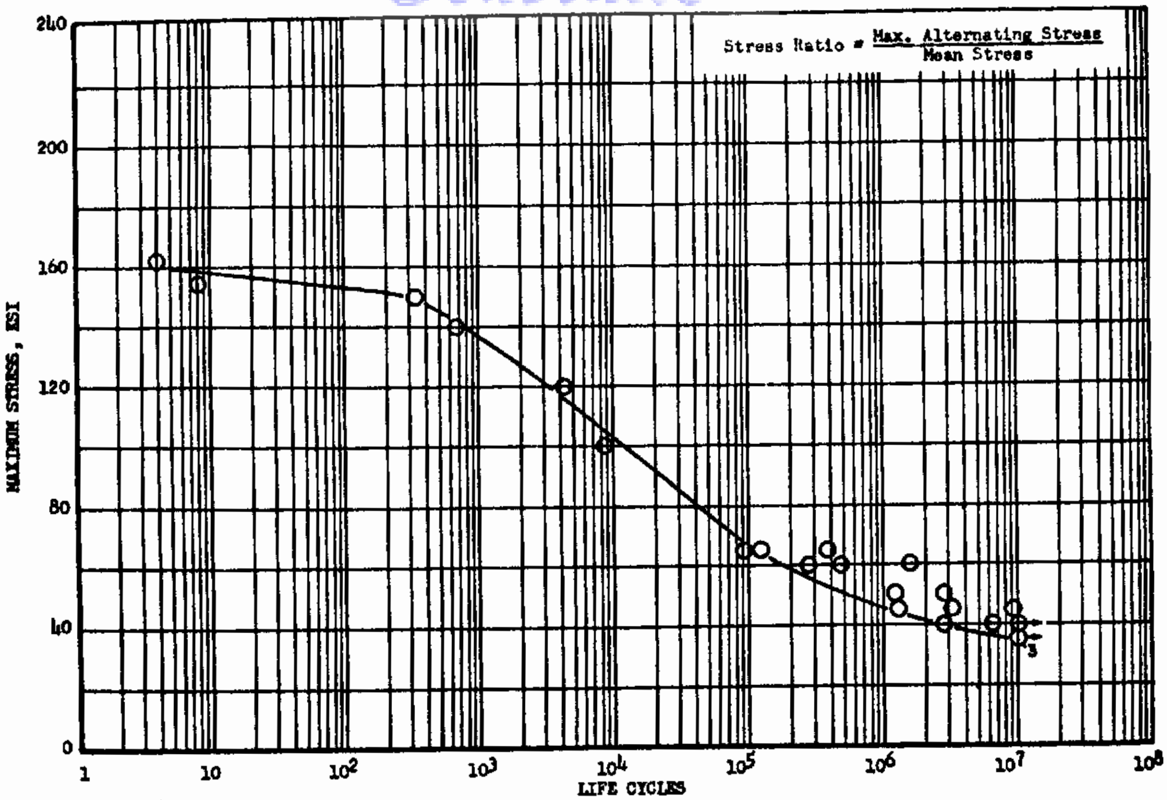


FIGURE 281 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 23345 AND 23372)

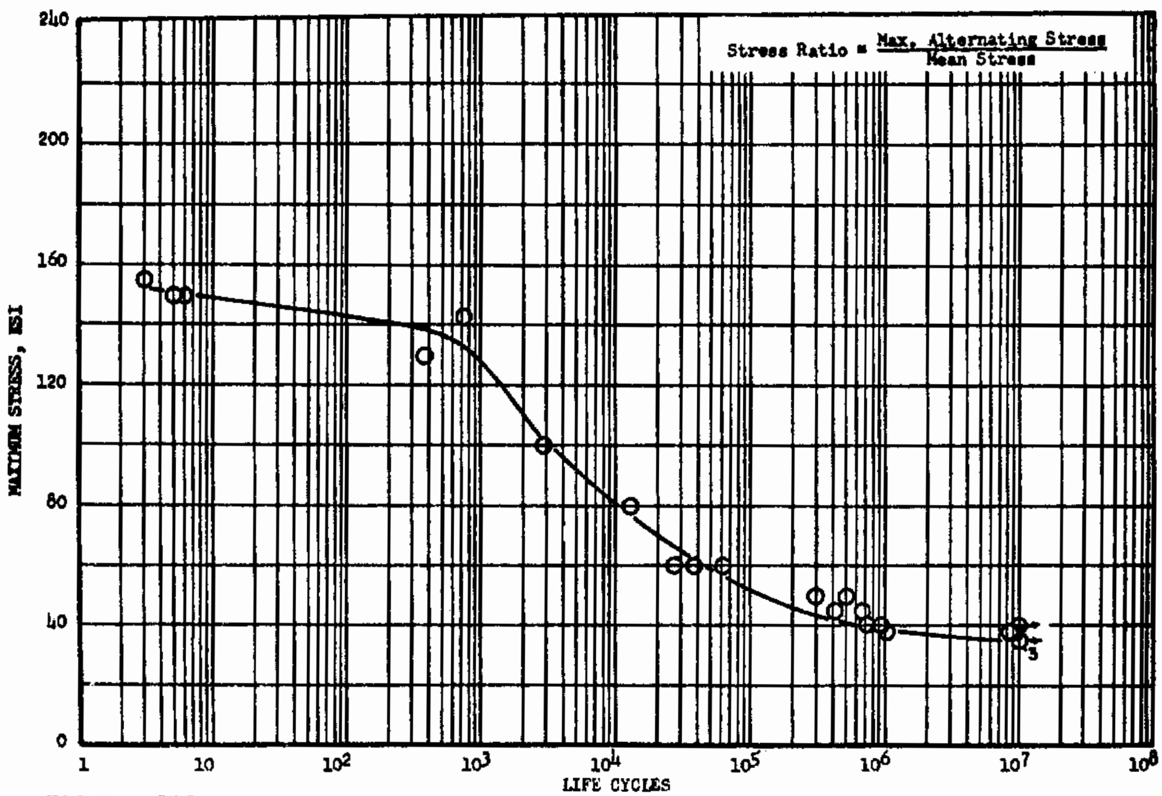


FIGURE 282 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 23345 AND 23372)

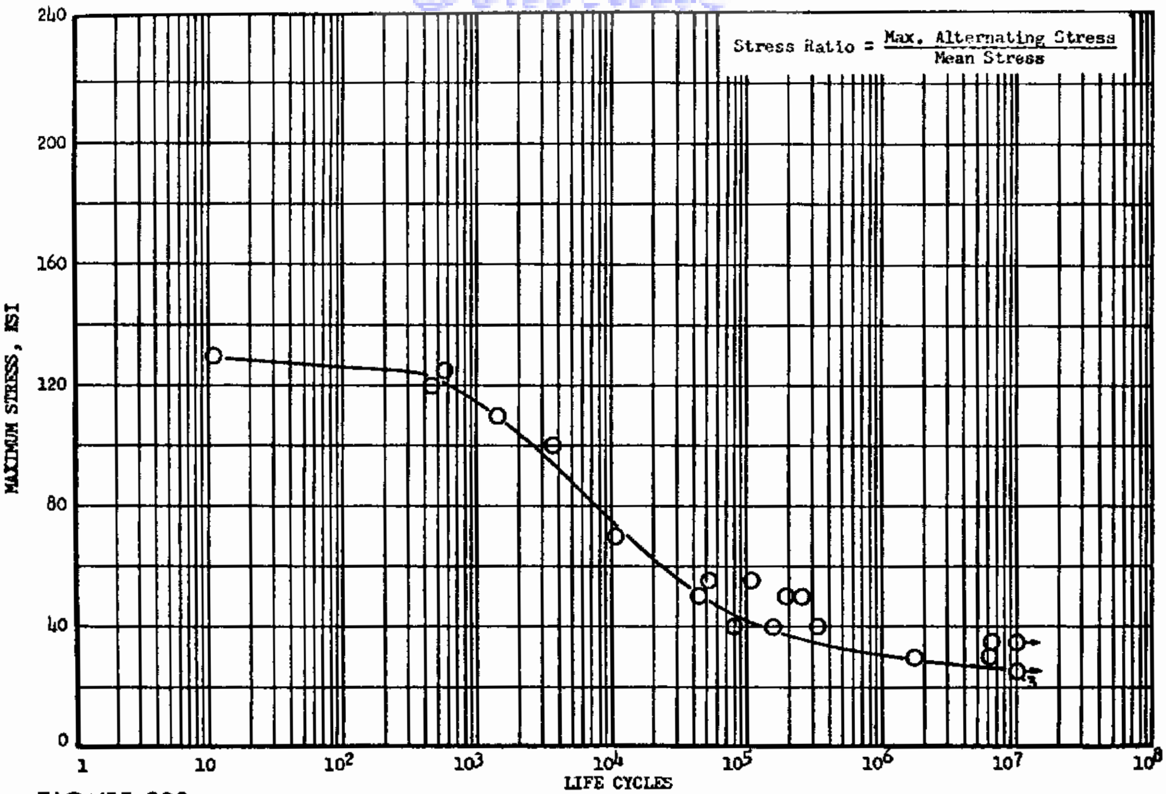


FIGURE 283 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 23345 AND 23372)

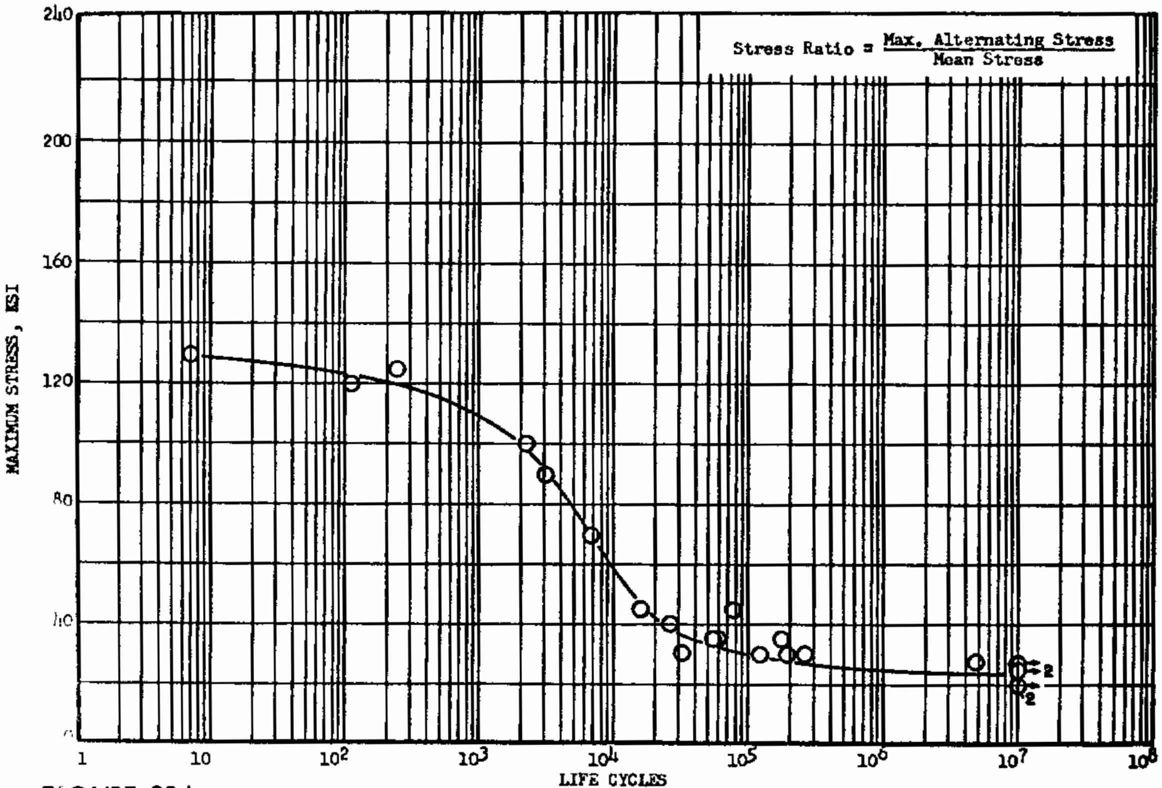


FIGURE 284 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 23345 AND 23372)

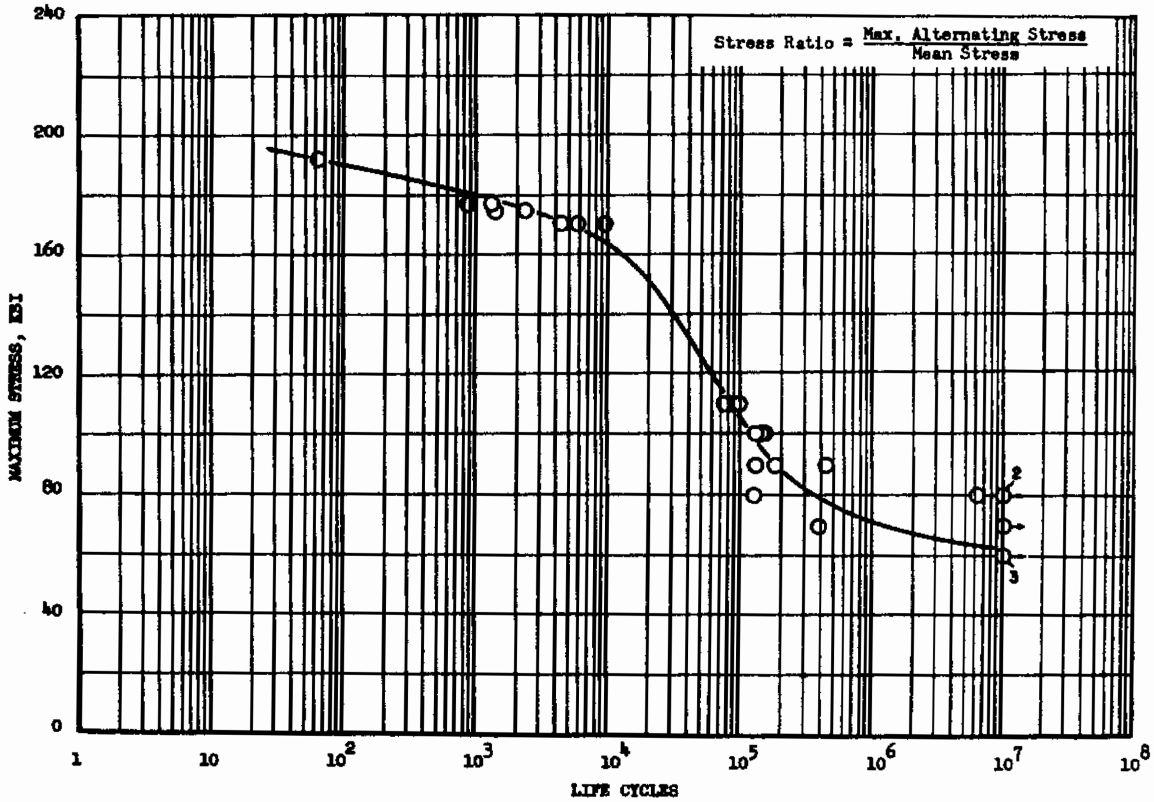


FIGURE 285 – AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 23345)

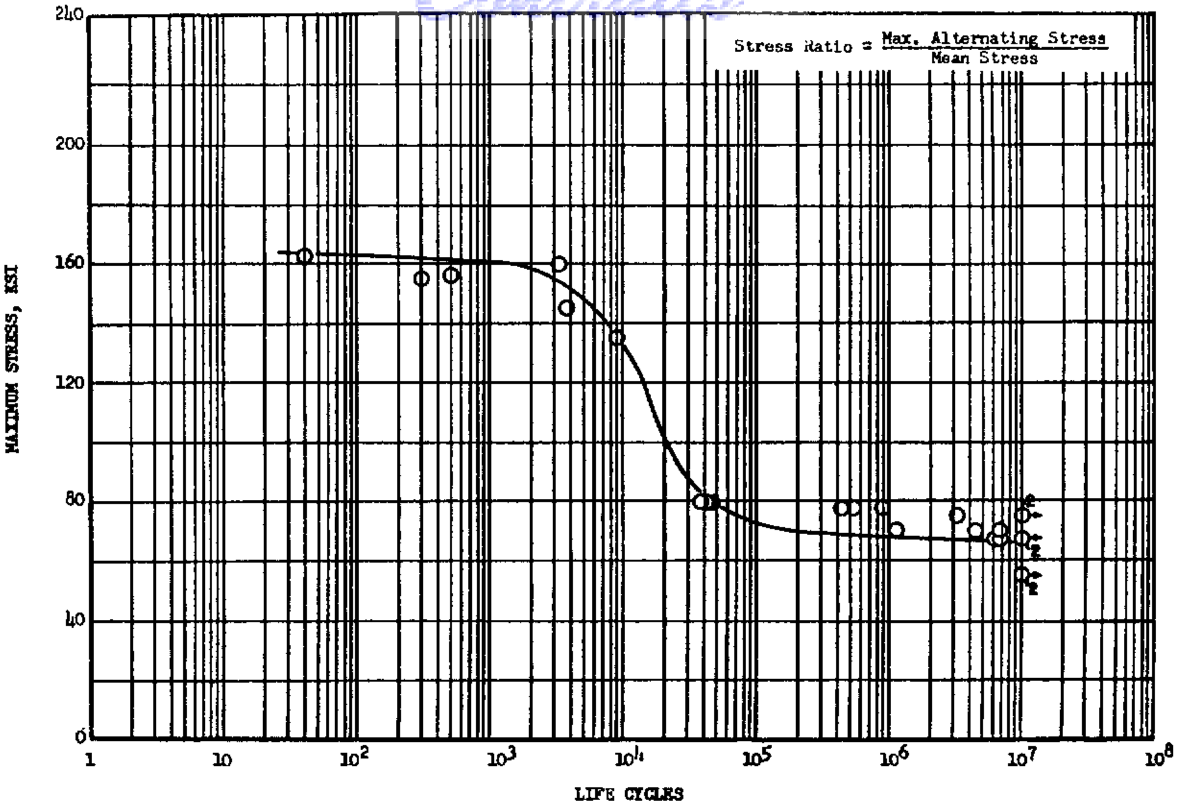


FIGURE 286 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 23345)

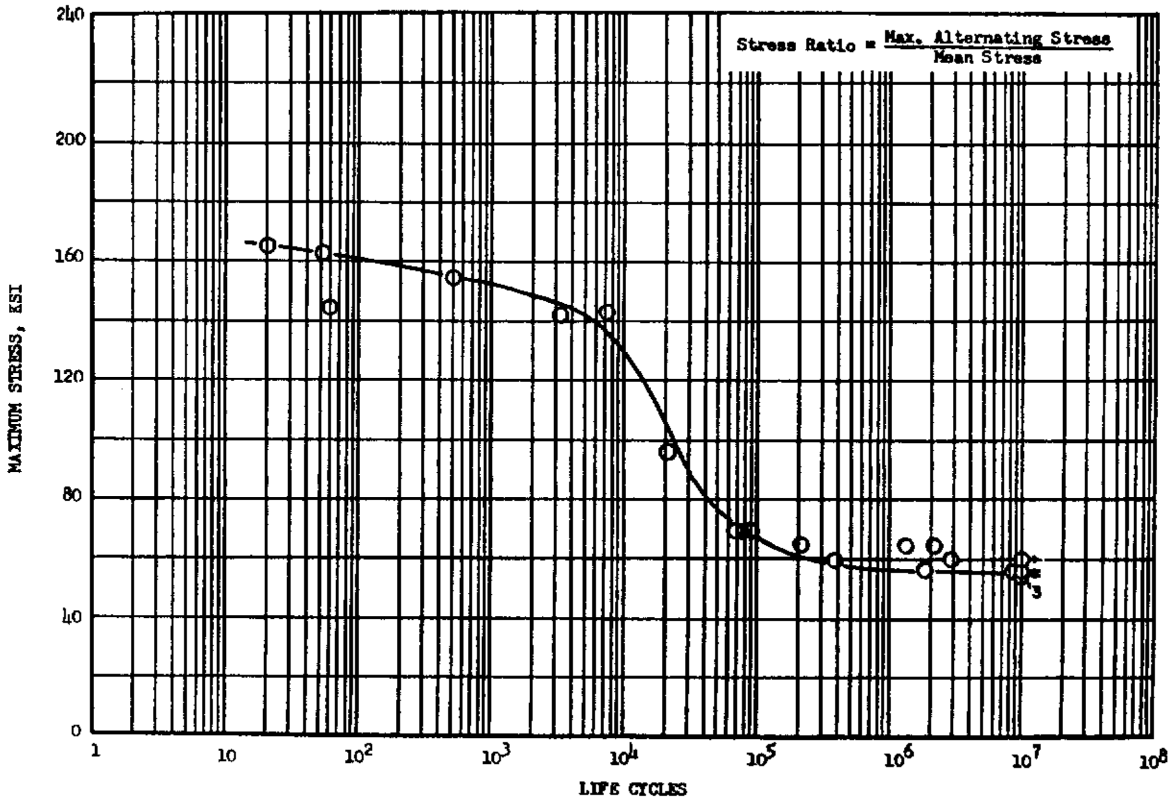


FIGURE 287 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 23345)

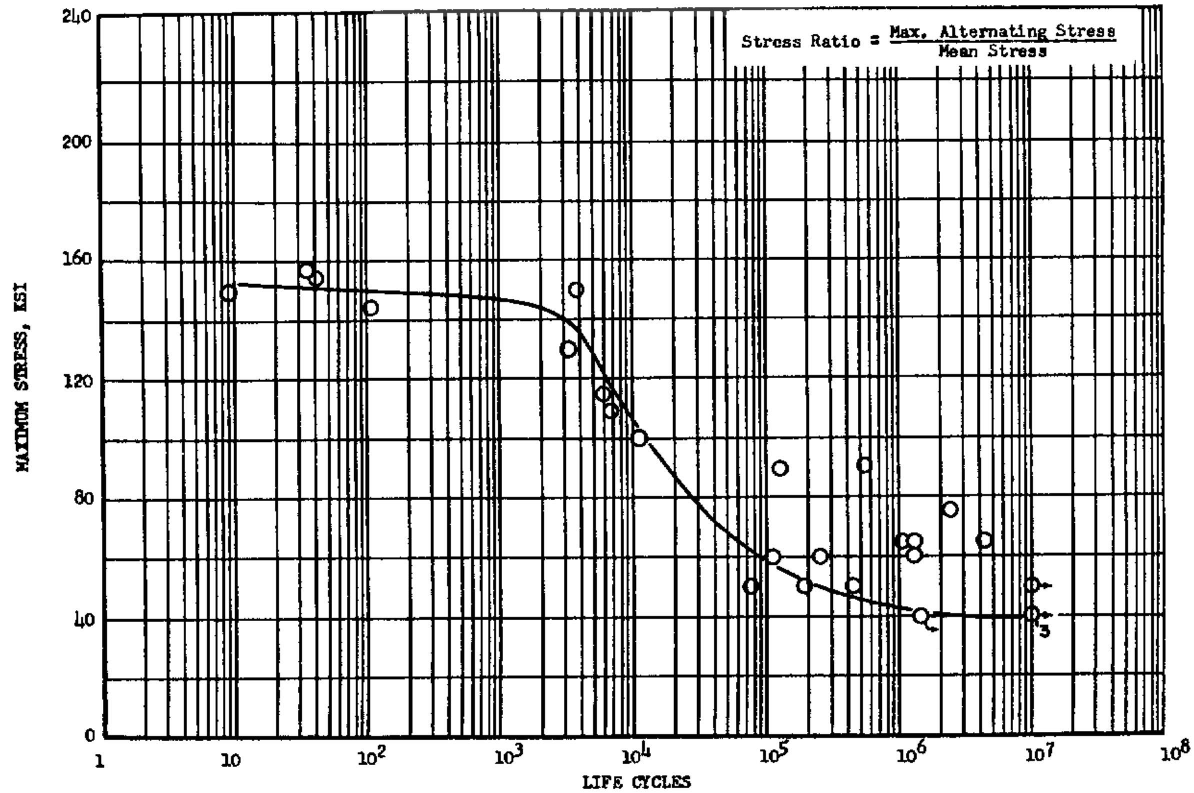


FIGURE 288 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 23345)

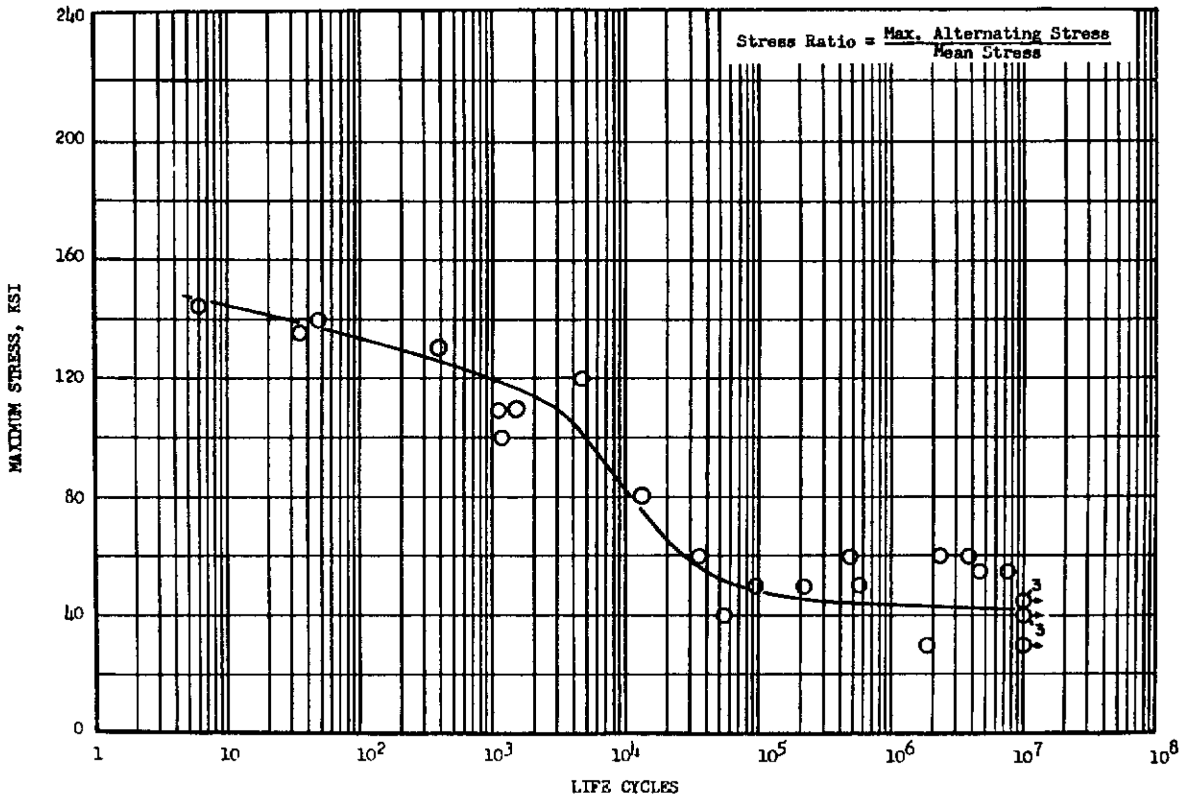


FIGURE 289 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 23345)

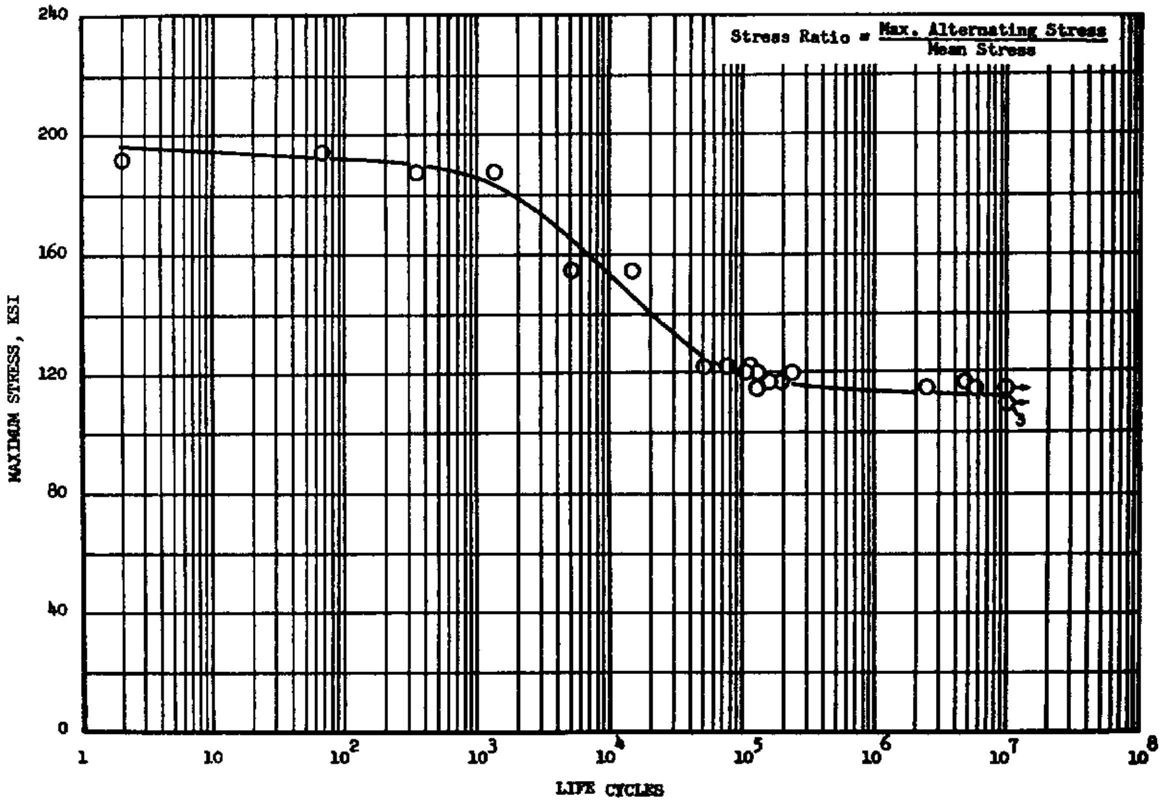


FIGURE 290 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 23345)

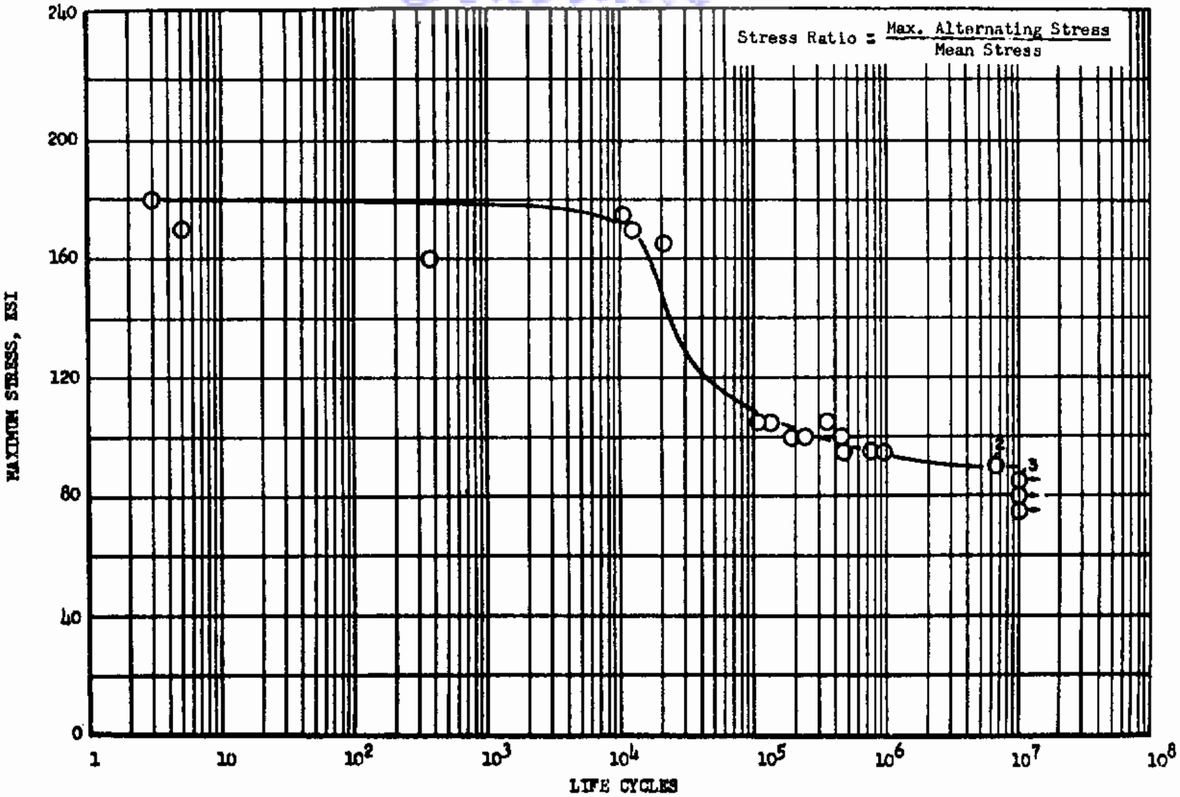


FIGURE 291 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 23345)

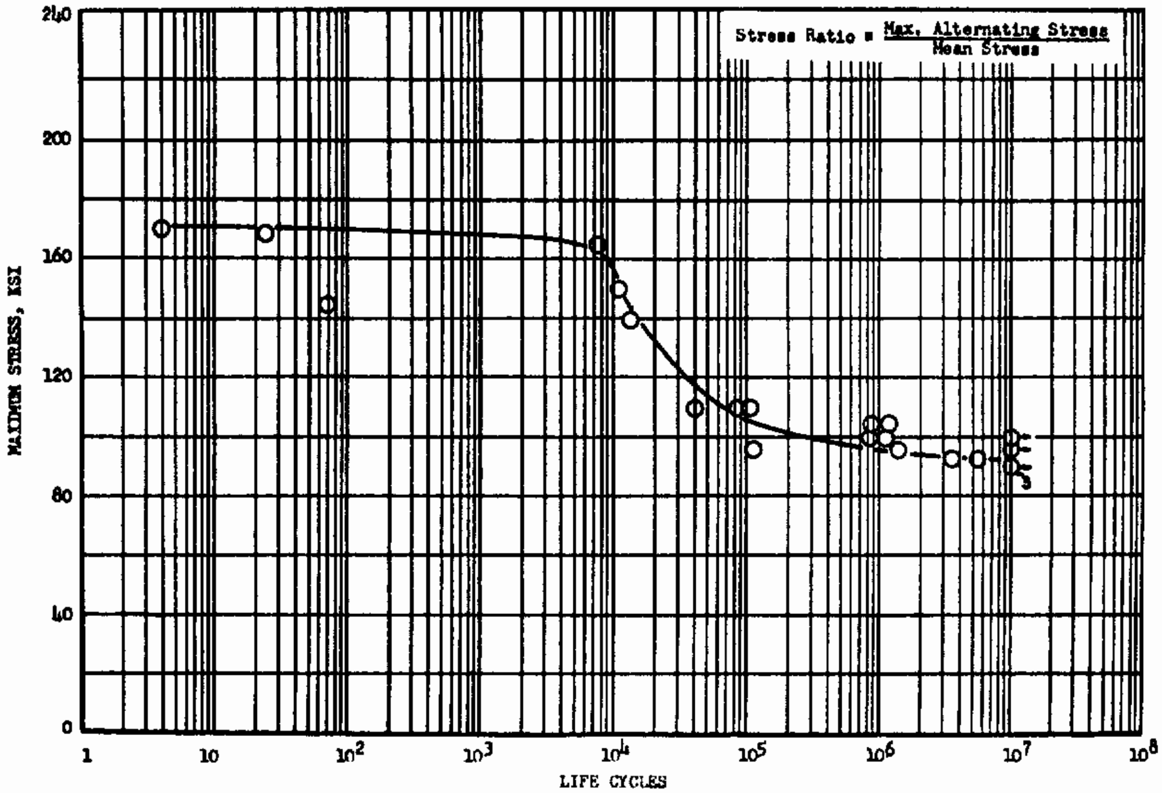


FIGURE 292 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 23345)

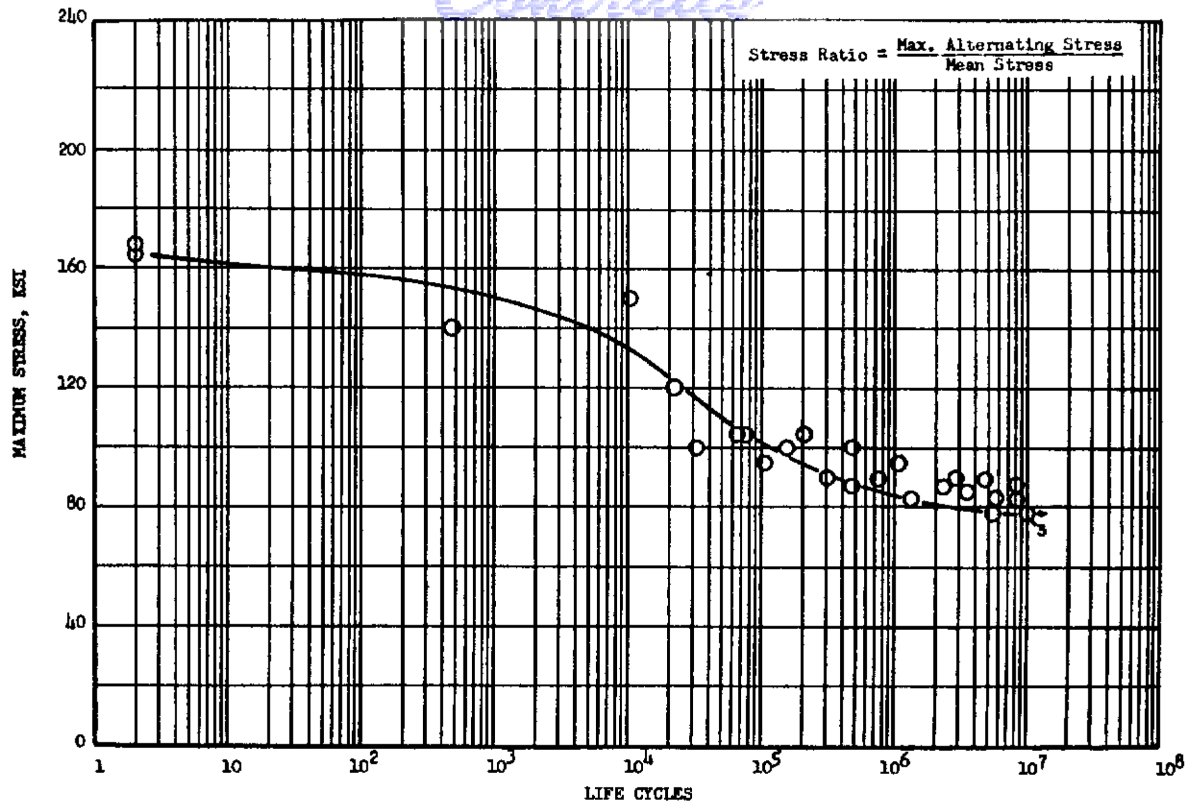


FIGURE 293 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 23345)

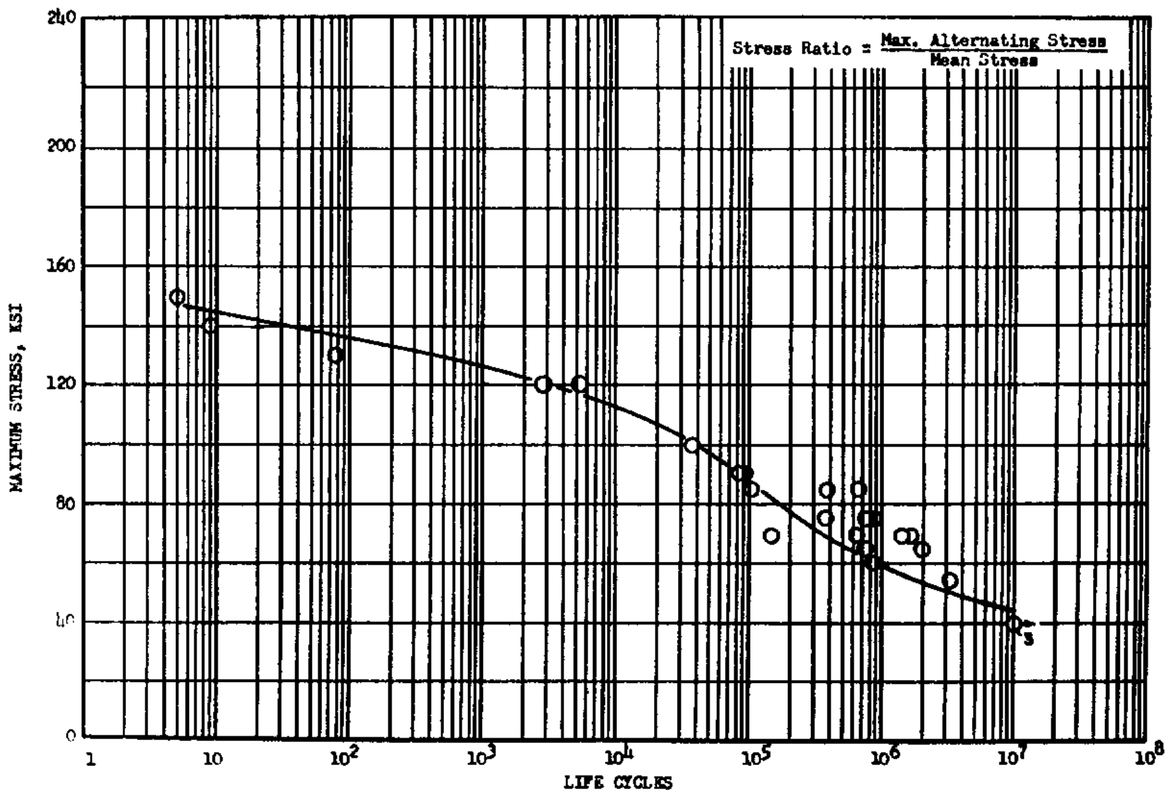


FIGURE 294 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 23345)

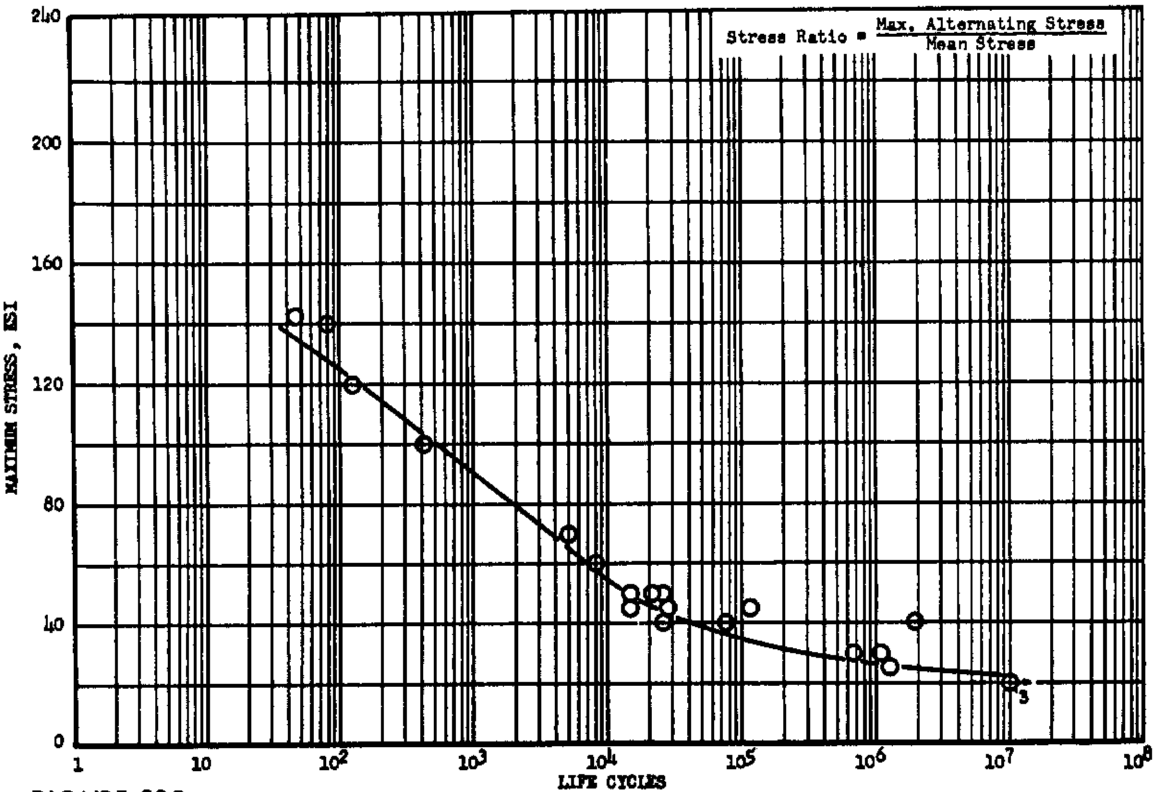


FIGURE 295 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 22093)

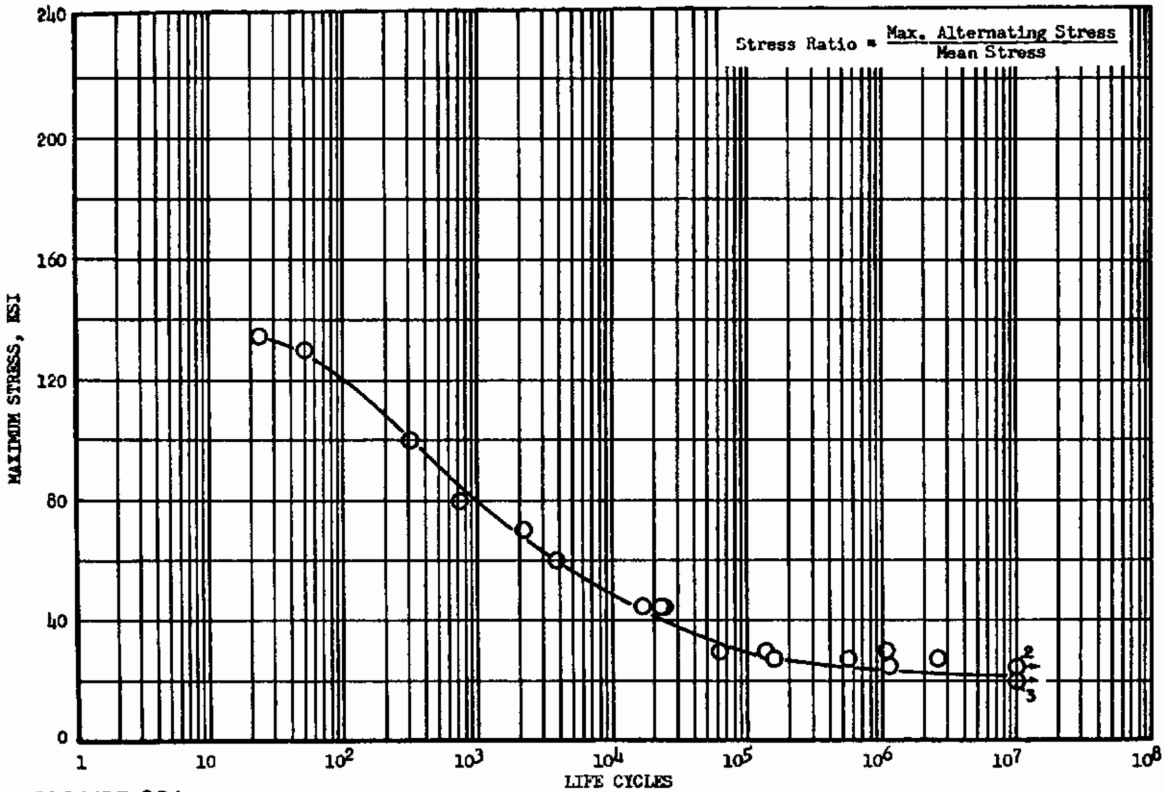


FIGURE 296 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 22093)

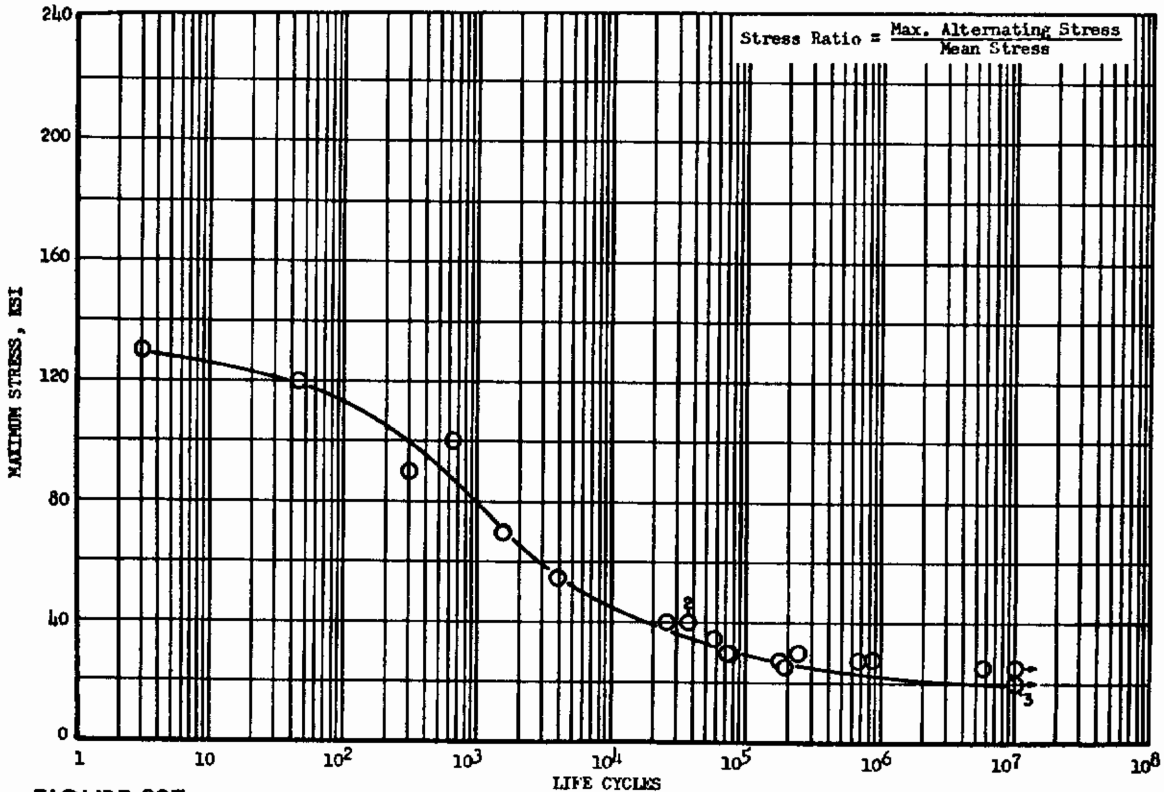


FIGURE 297 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 22093)

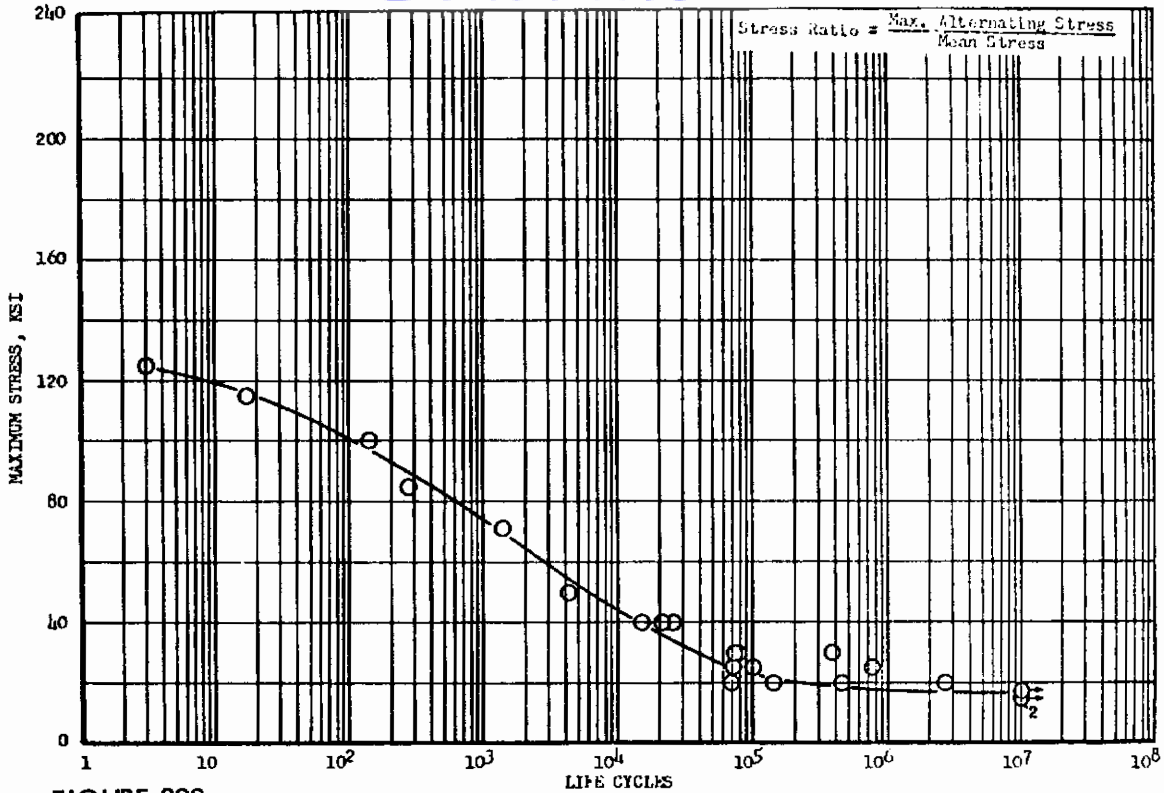


FIGURE 298 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 22093)

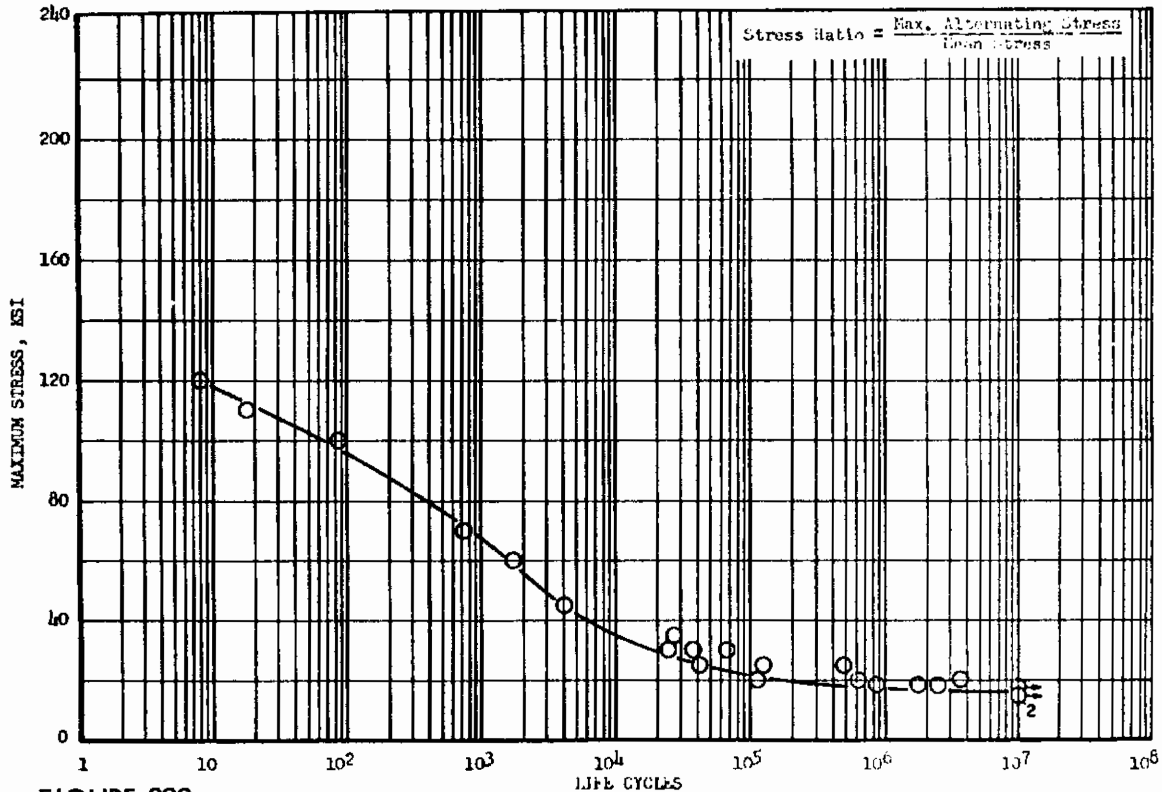


FIGURE 299 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NO. 22093)

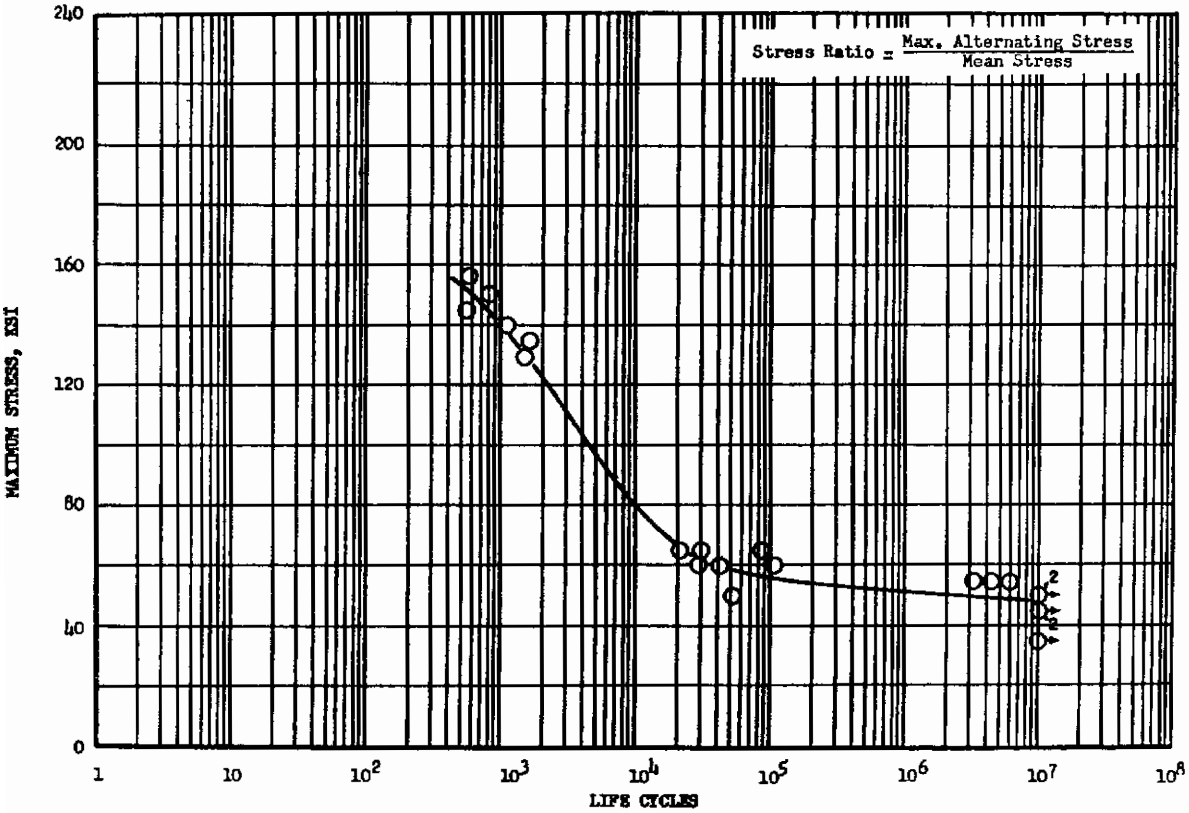


FIGURE 300 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 22093)

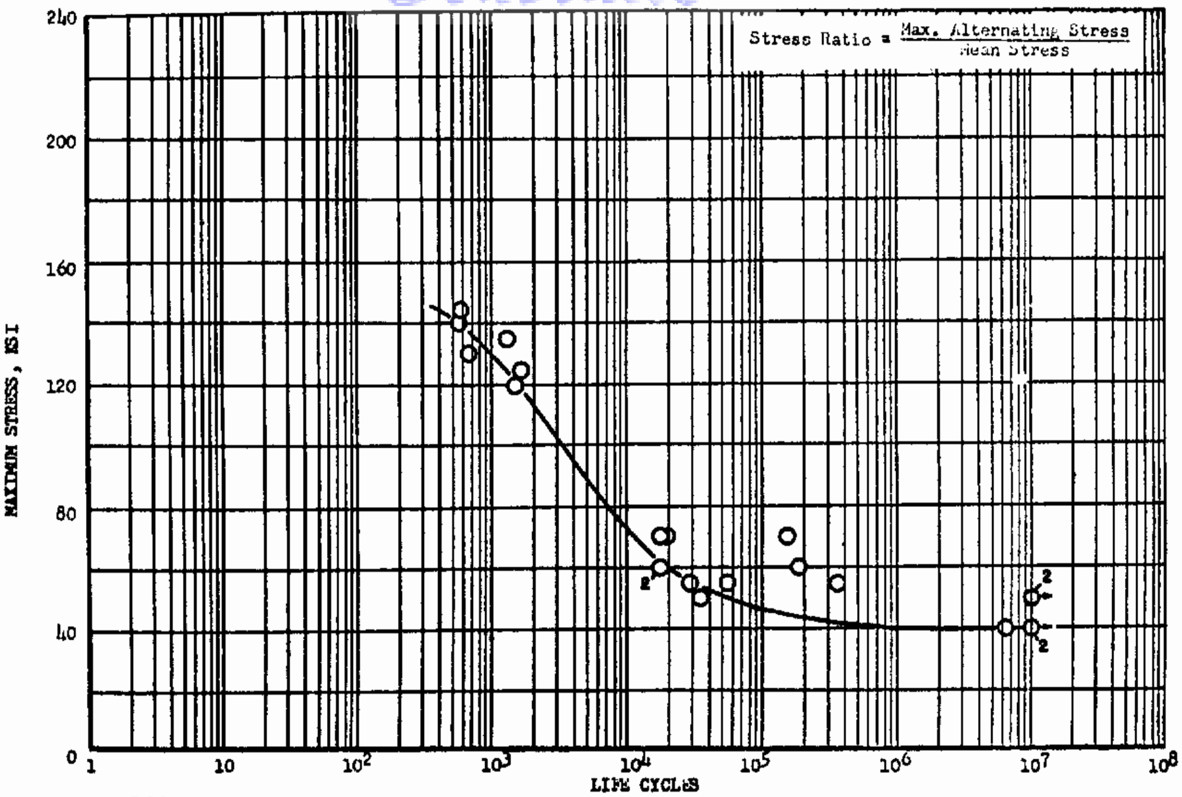


FIGURE 301 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 22093)

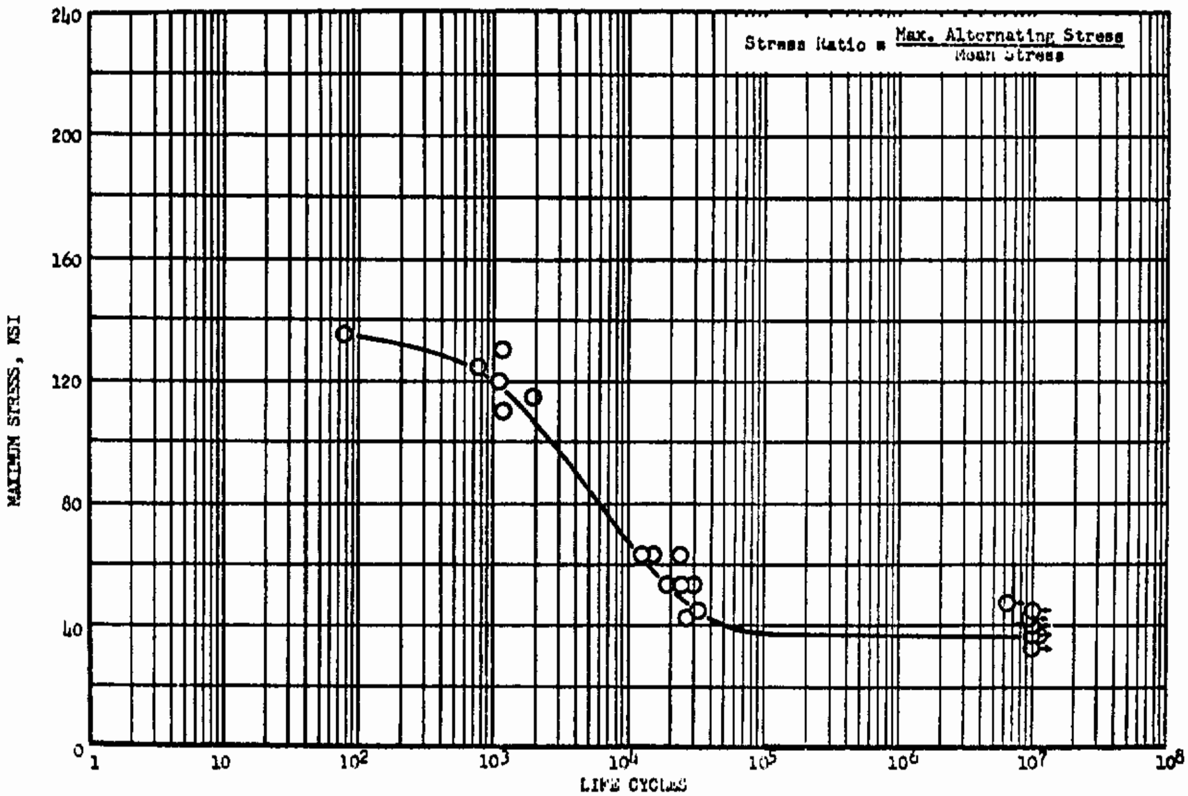


FIGURE 302 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 22093)

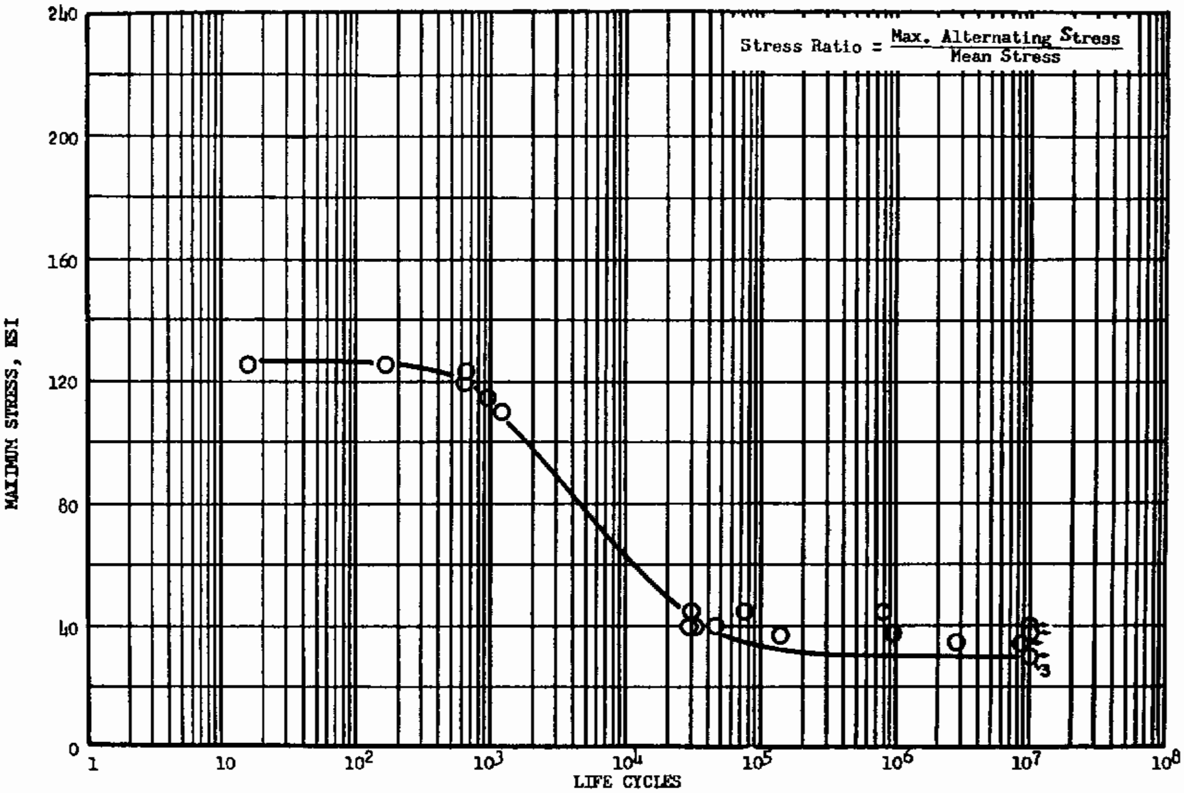


FIGURE 303 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 22093)

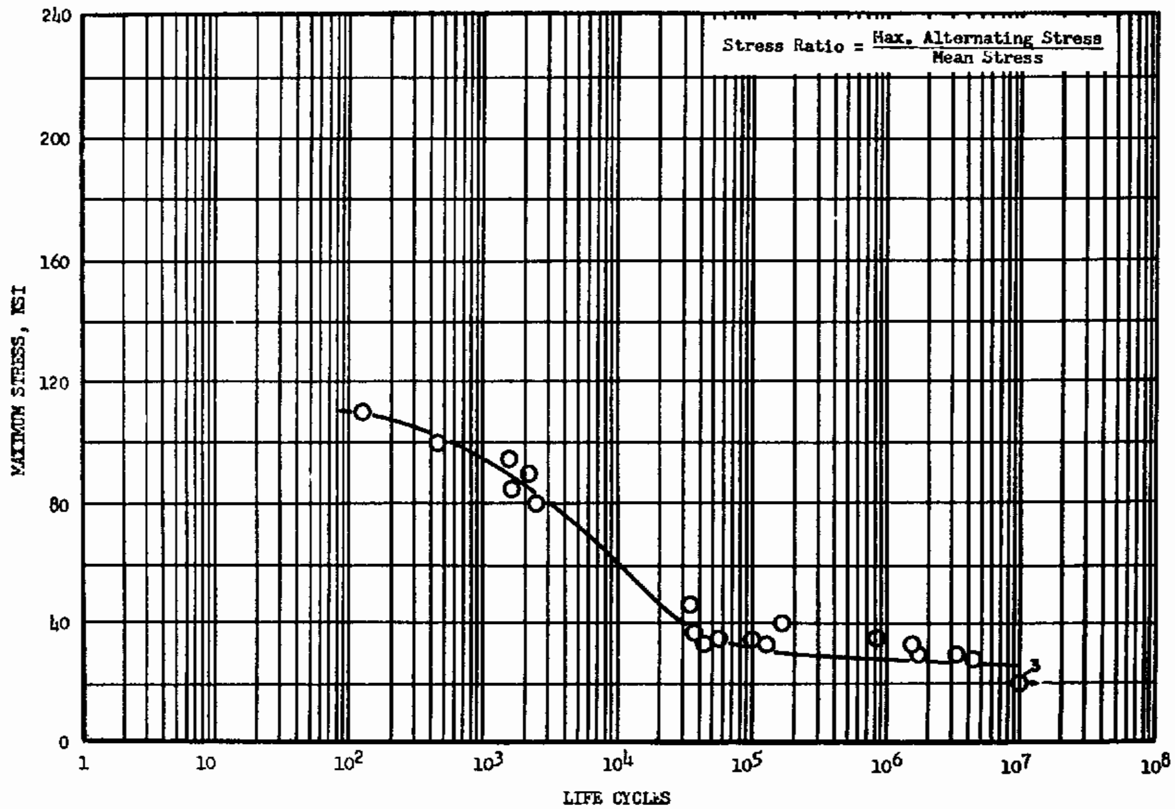


FIGURE 304 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 22093)

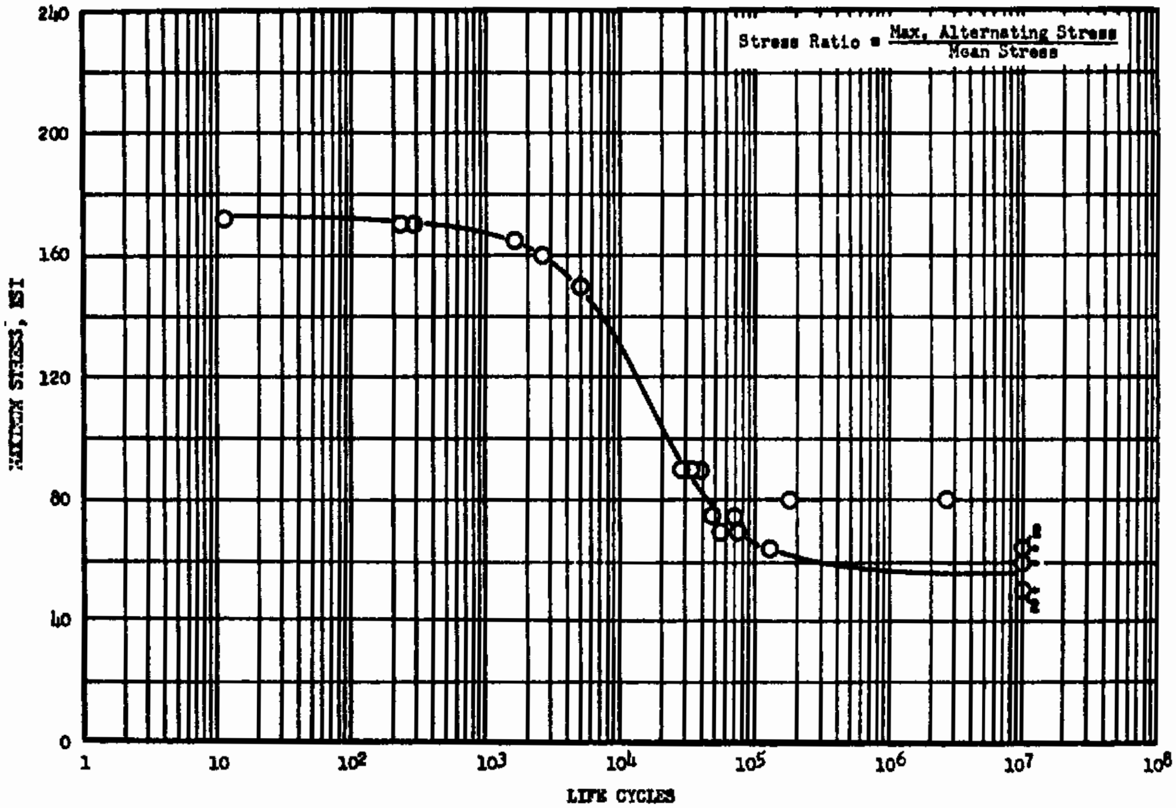


FIGURE 305 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 22093)

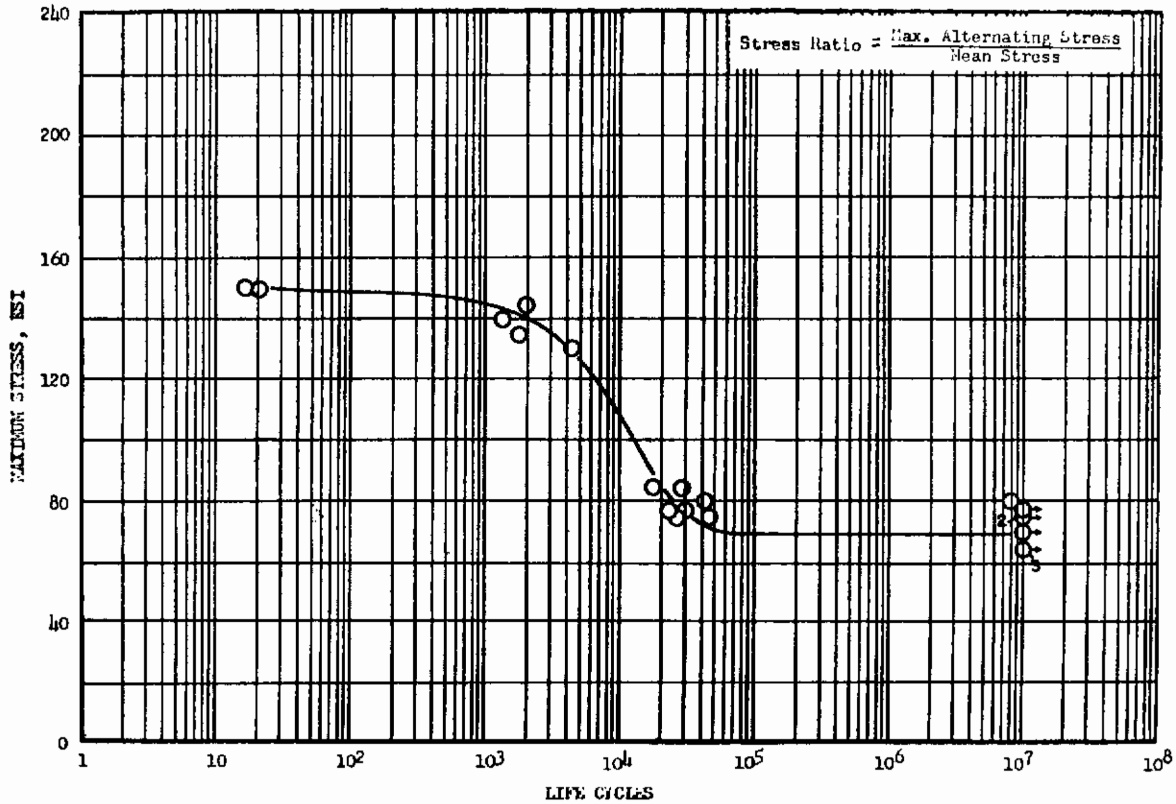


FIGURE 306 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 22093)

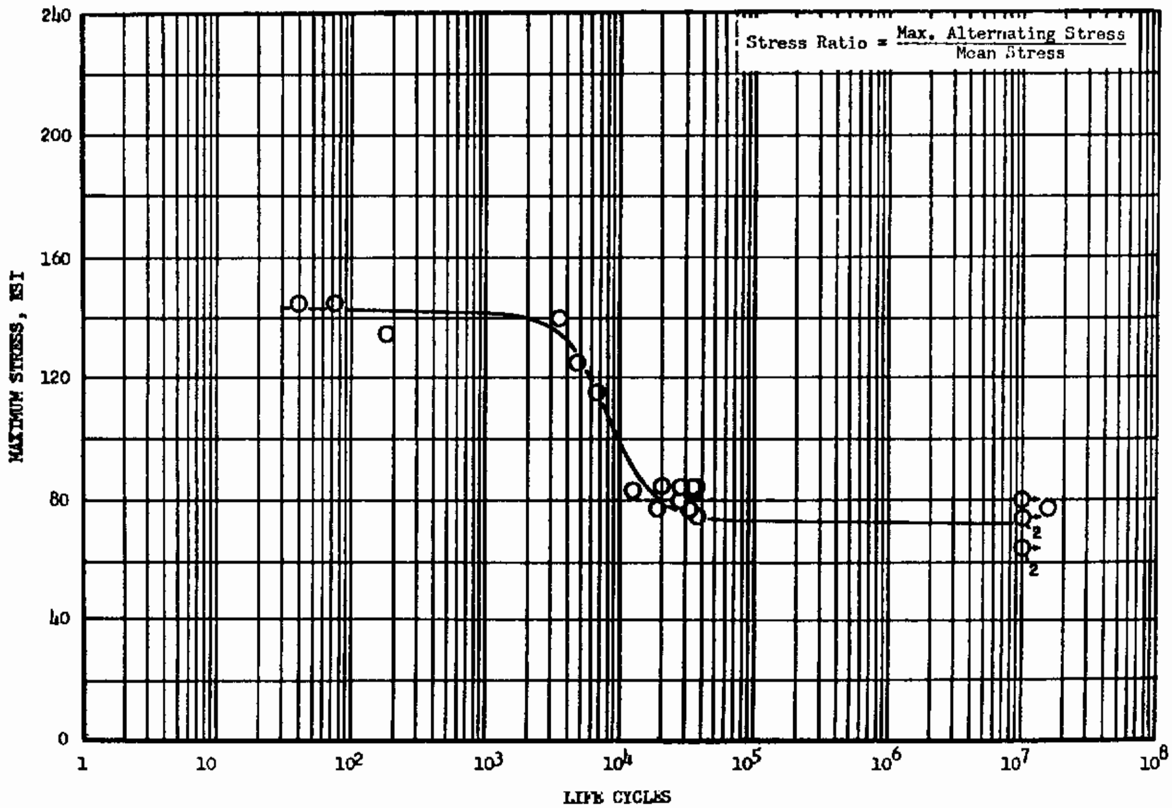


FIGURE 307 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 22093)

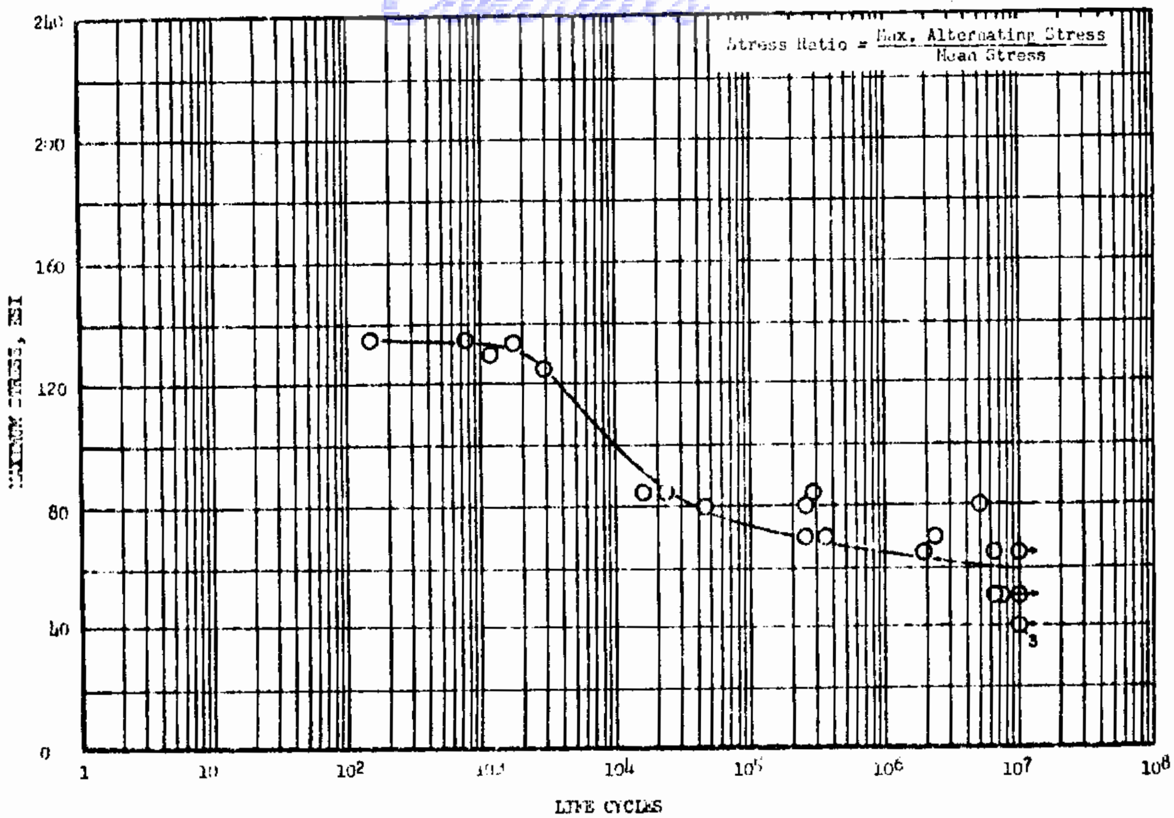


FIGURE 308 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 22093)

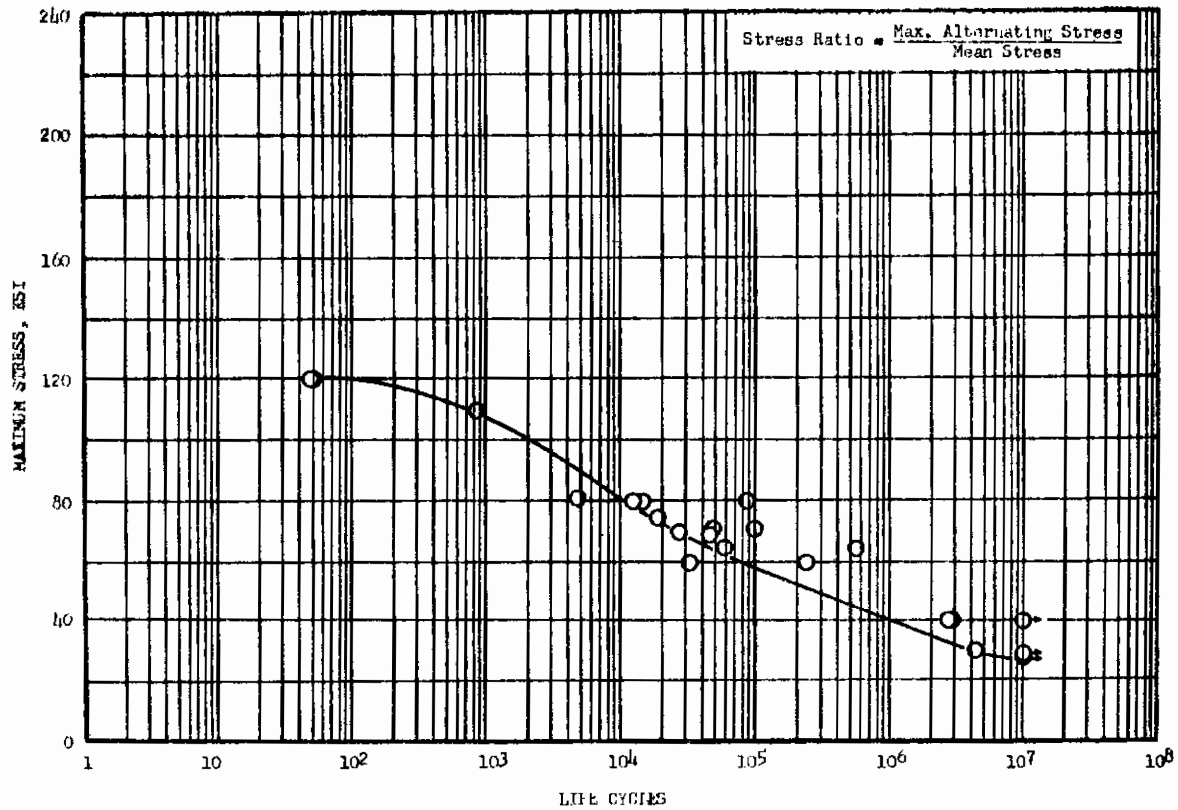


FIGURE 309 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.020 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 22093)

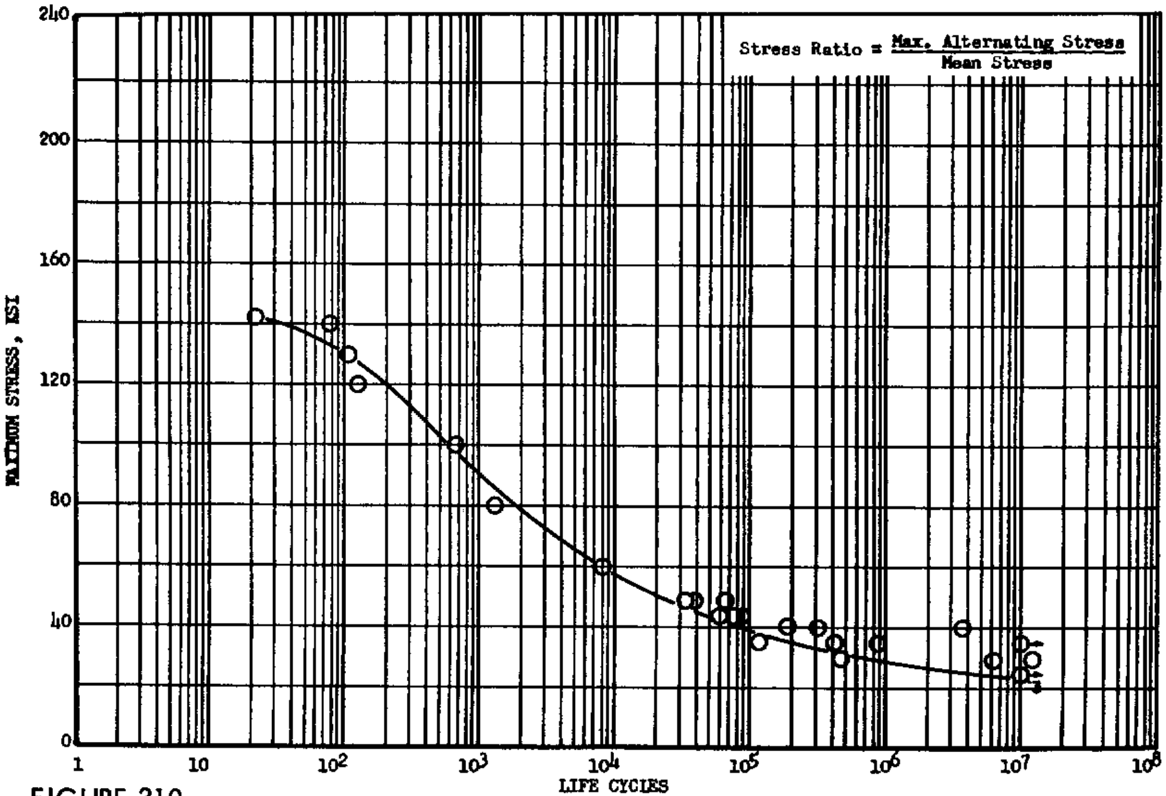


FIGURE 310 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 24806 AND 24814)

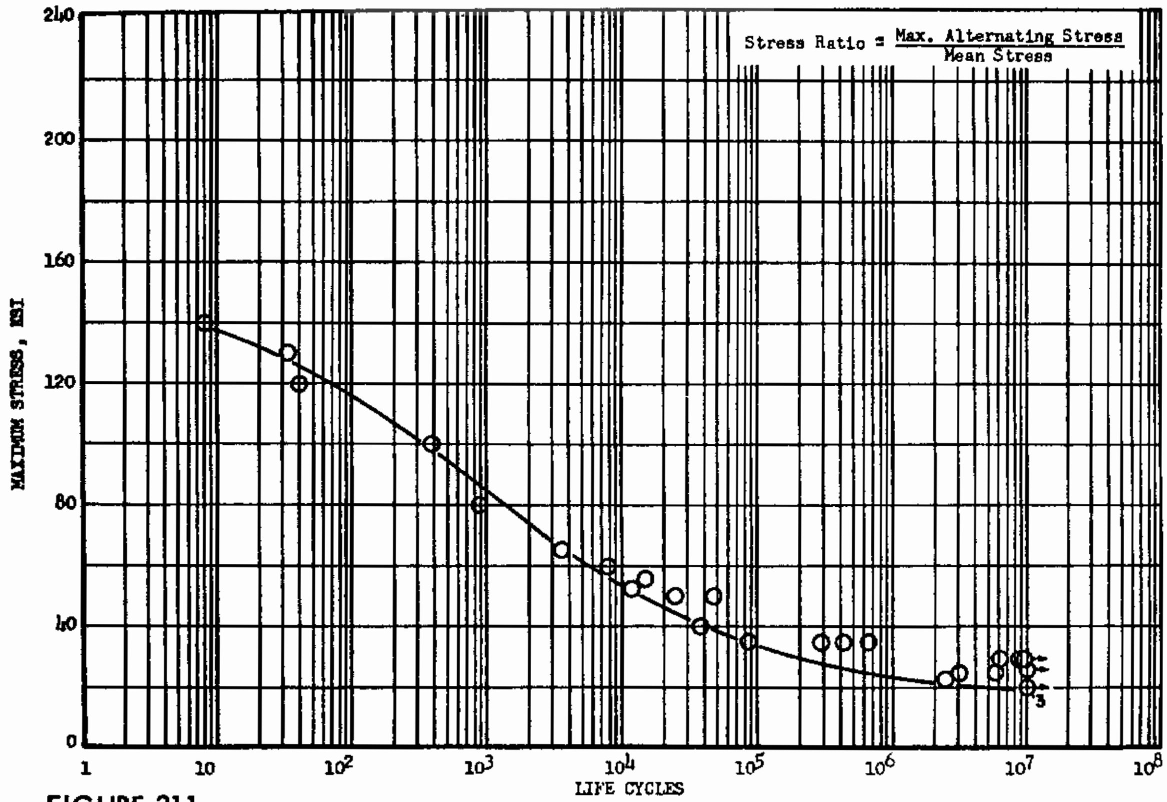


FIGURE 311 – AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 24806 AND 24814)

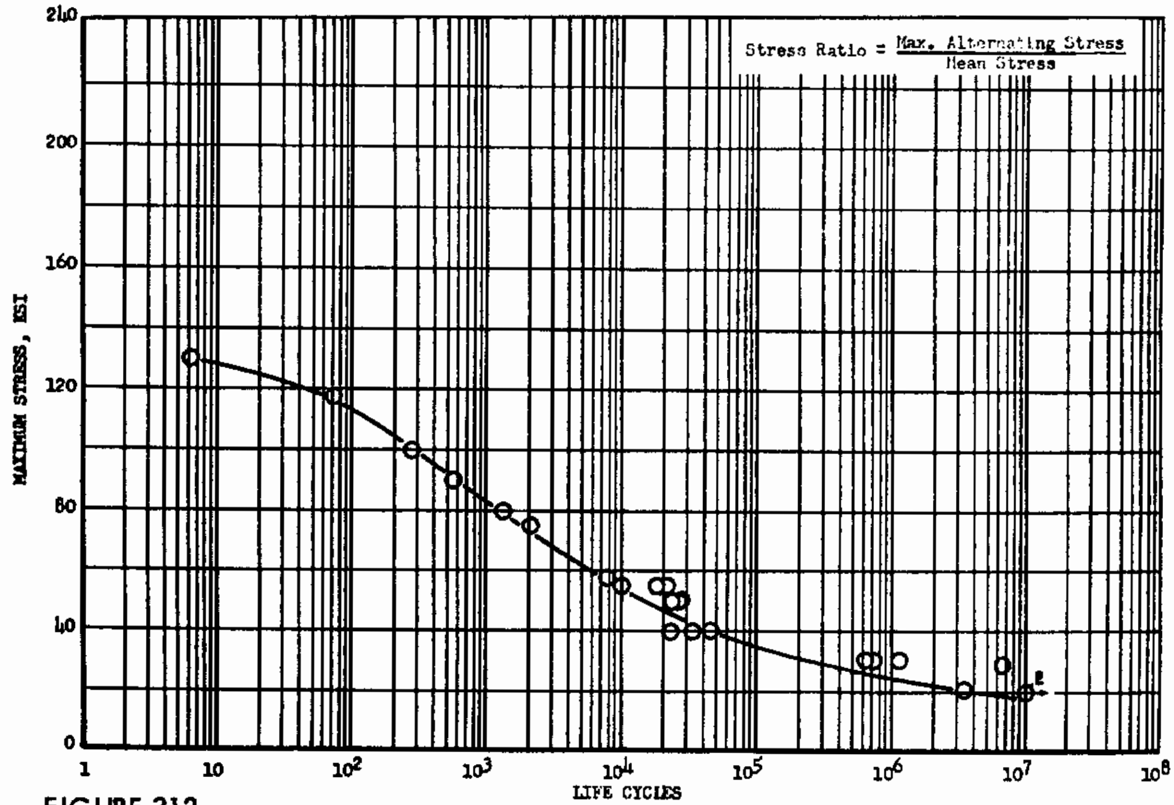


FIGURE 312 – AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 24806 AND 24814)

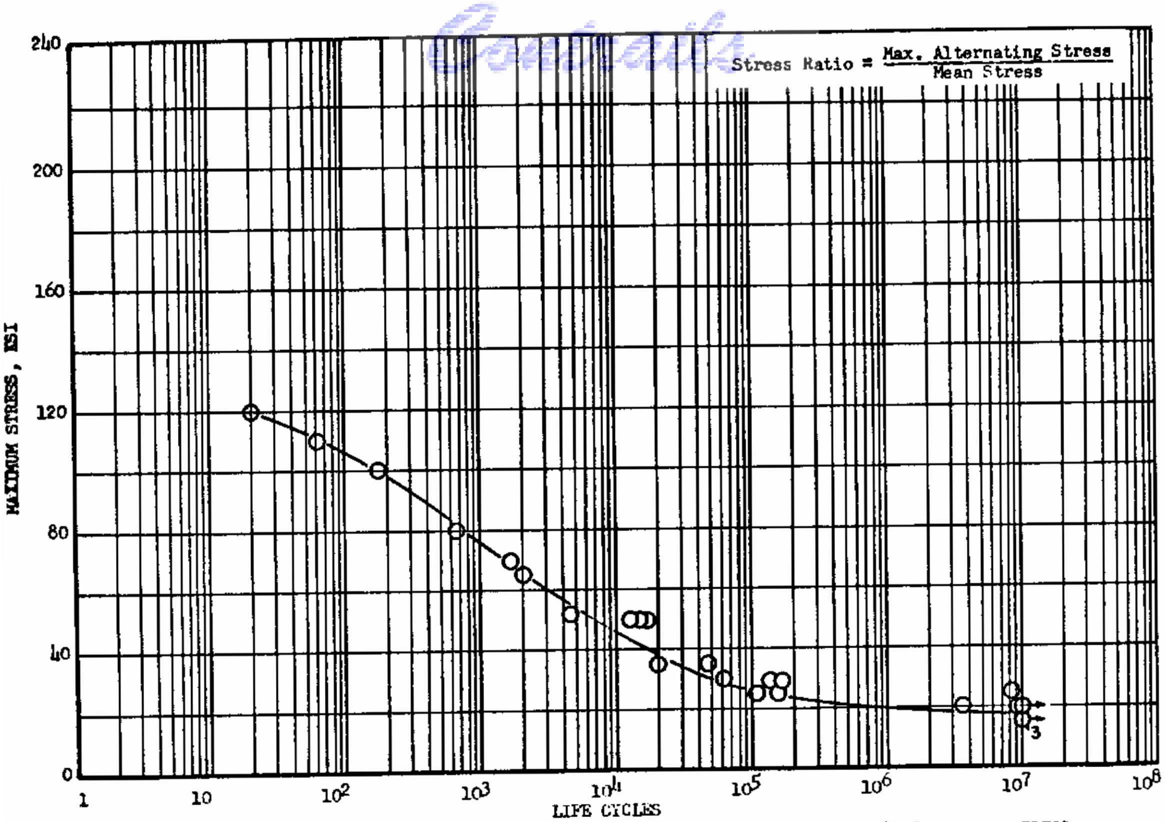


FIGURE 313 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 24806 AND 24814)

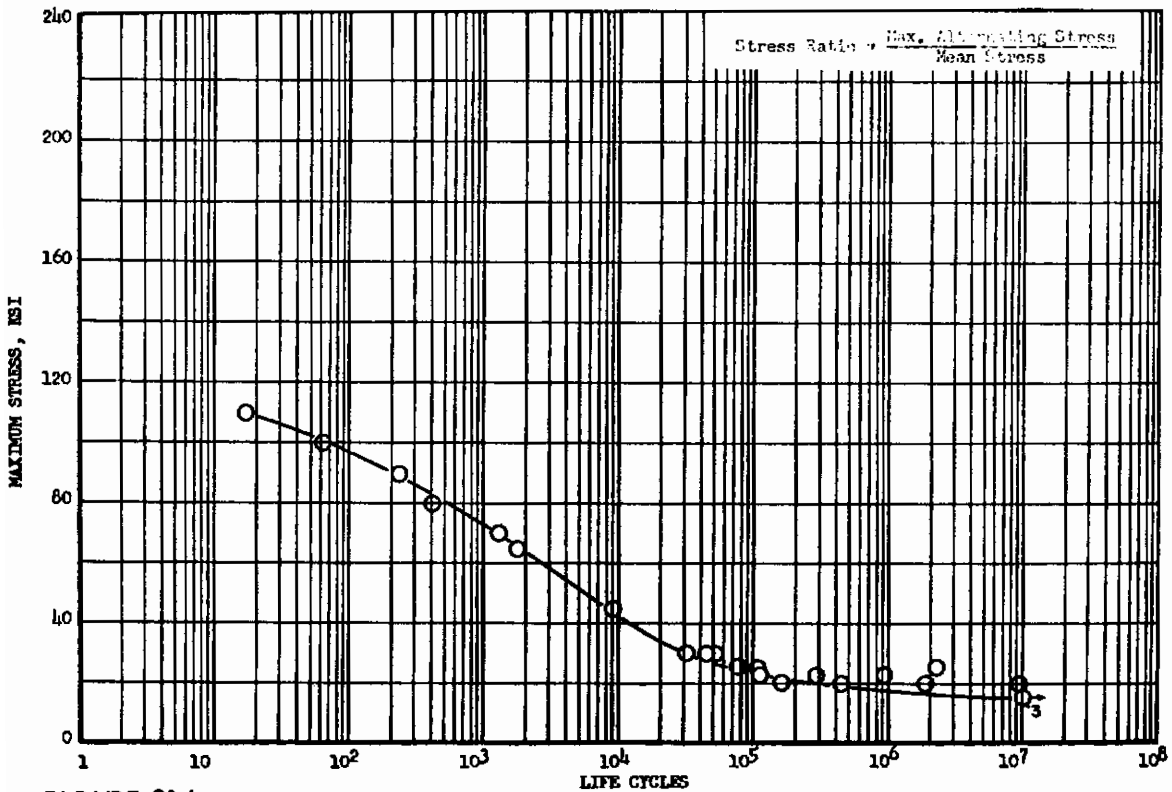


FIGURE 314 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 24806 AND 24814)

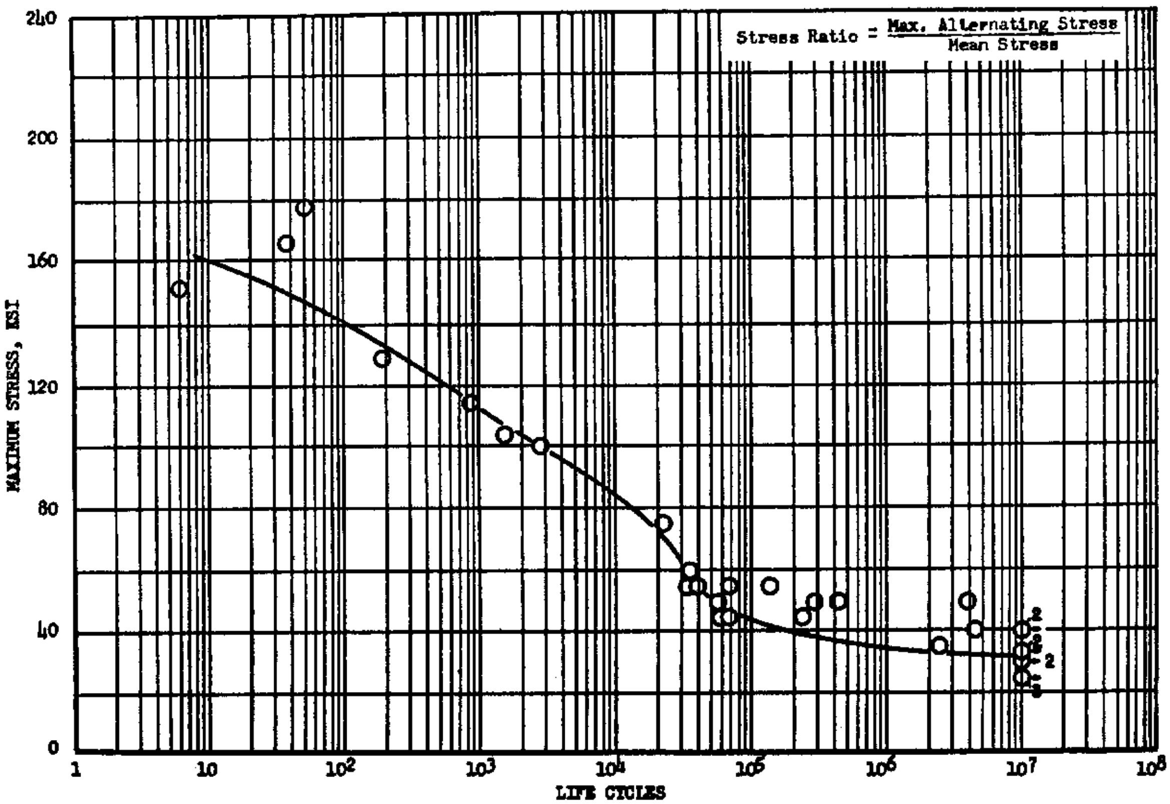


FIGURE 315 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 24806)

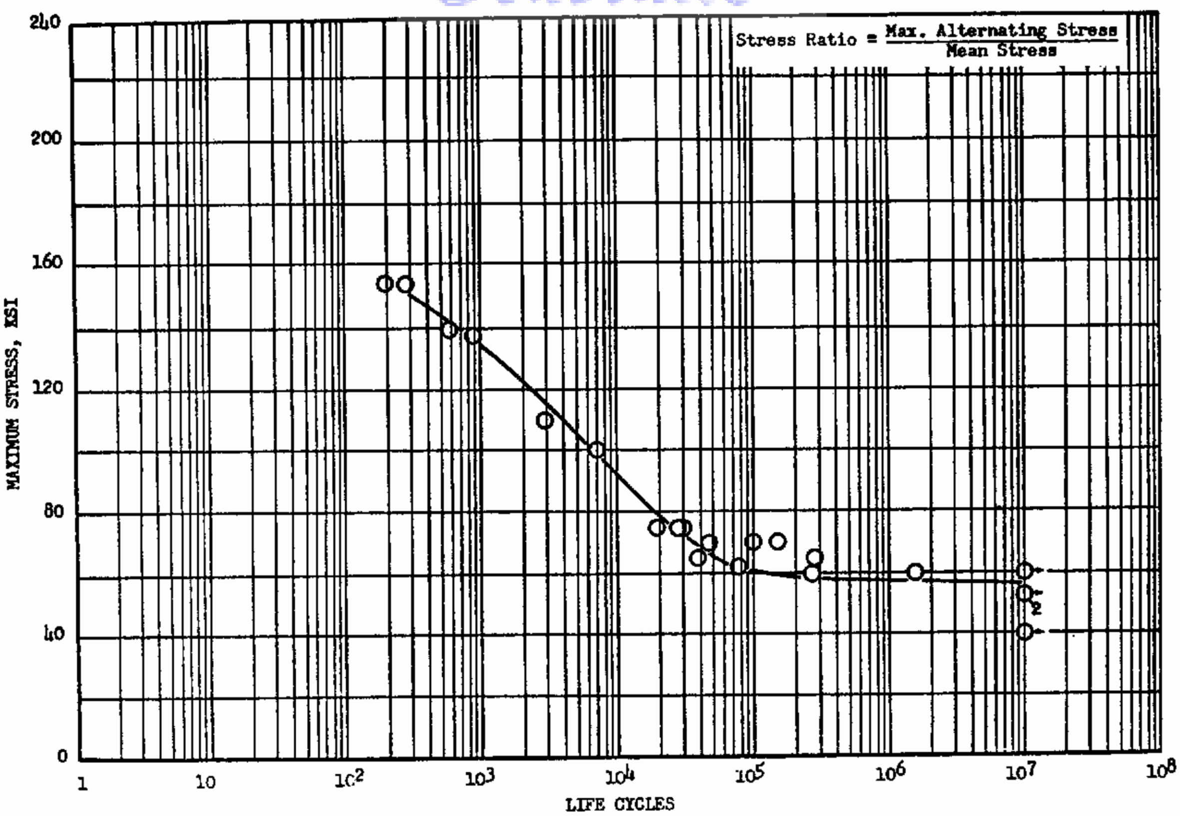


FIGURE 316 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 24806)

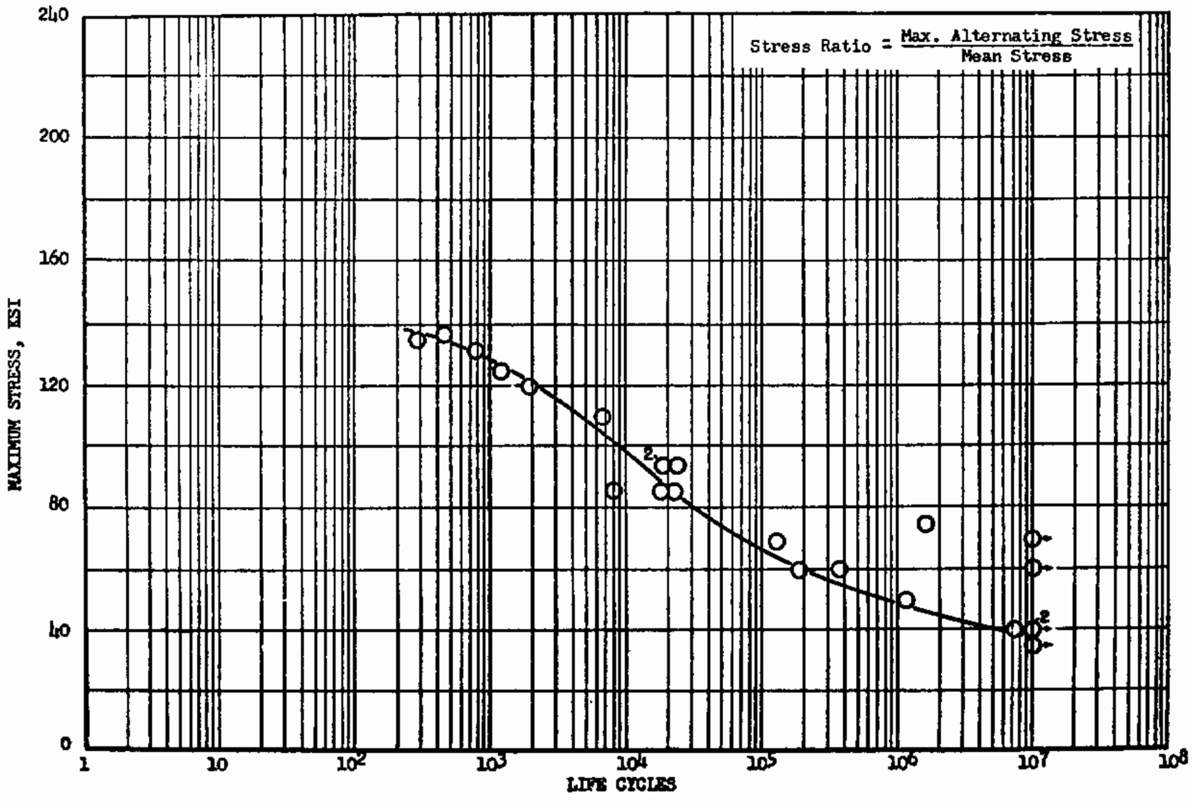


FIGURE 317 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE HEAT NO. 24806)

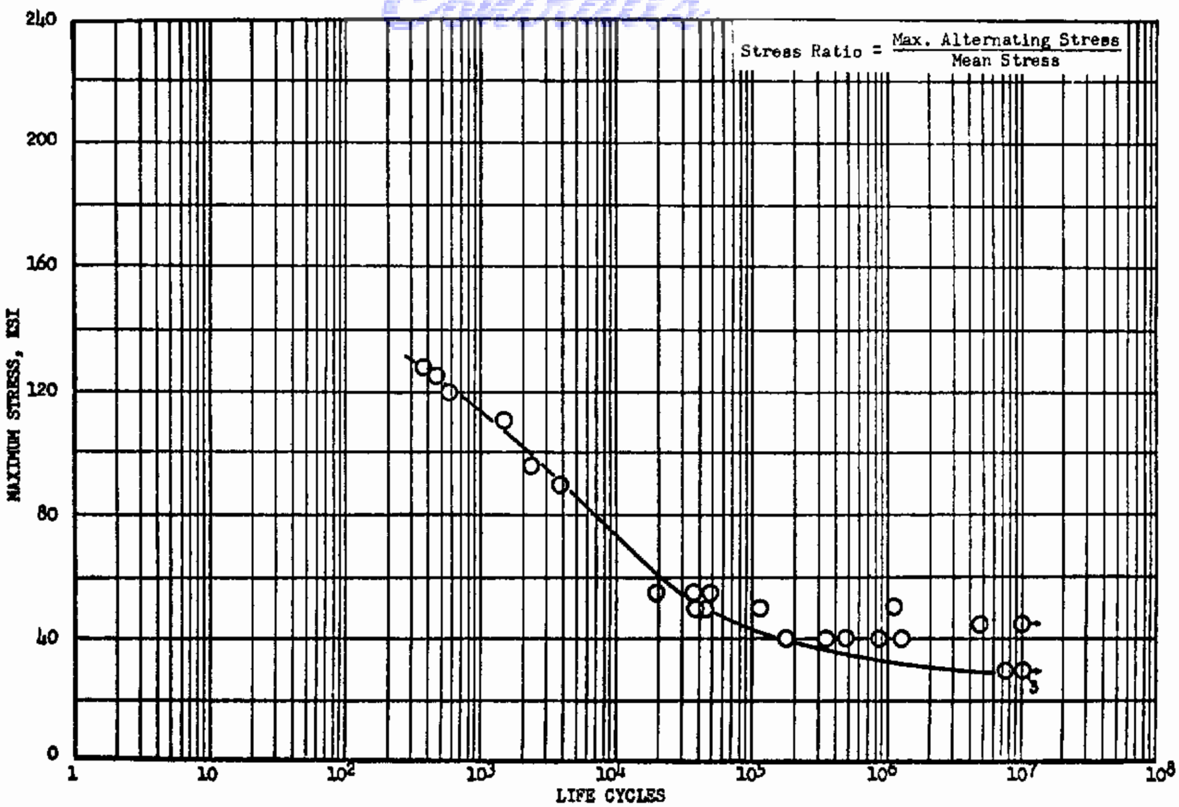


FIGURE 318 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 24806)

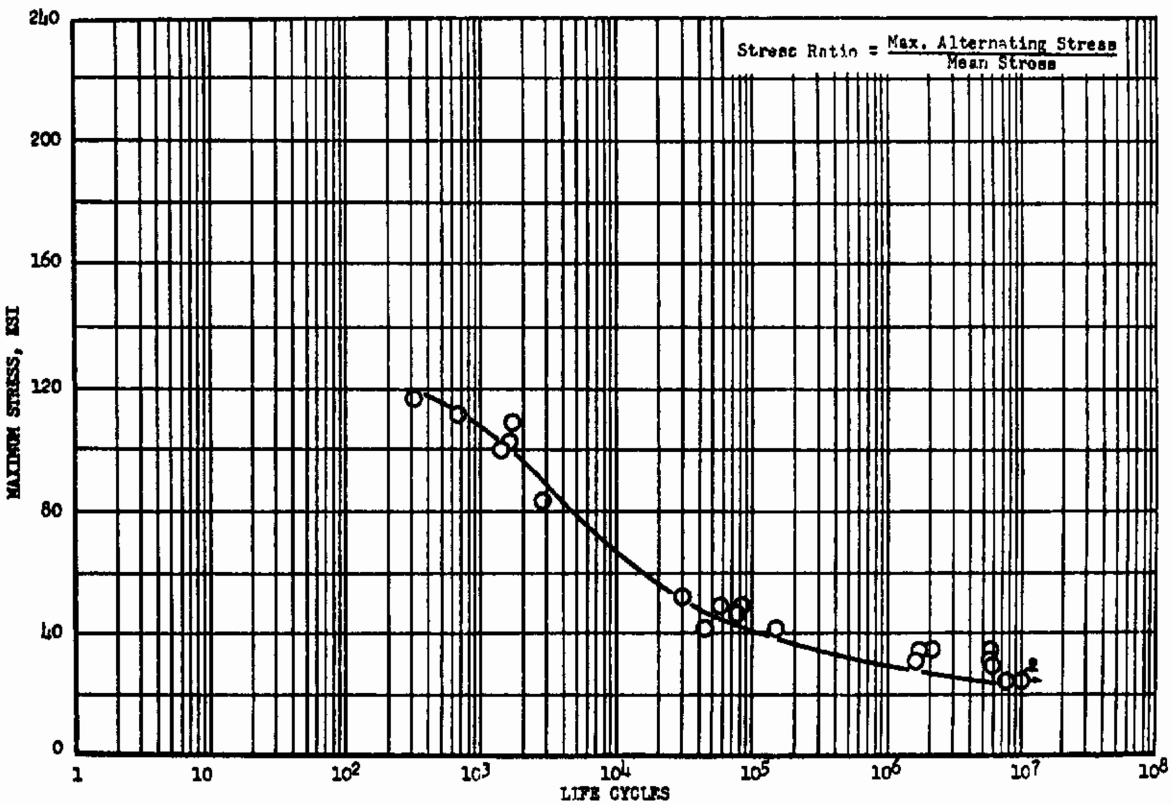


FIGURE 319 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 24806)

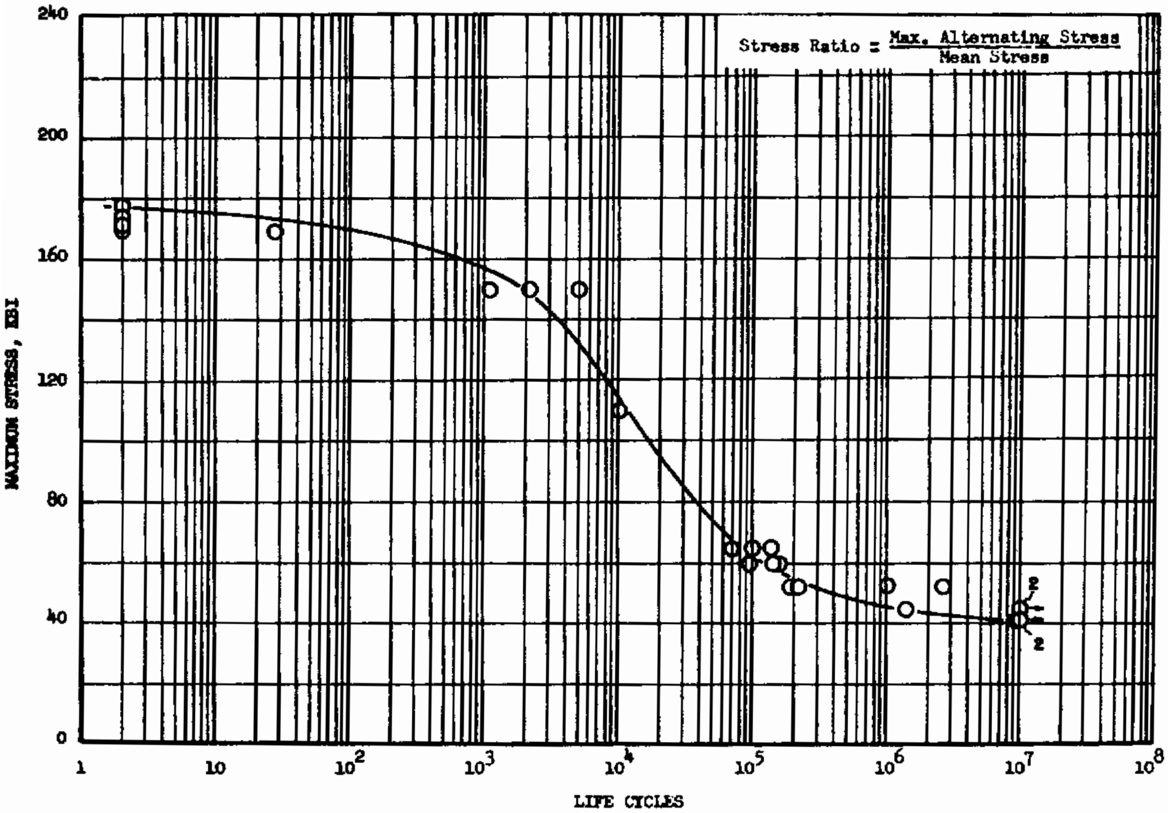


FIGURE 320 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (MALLORY-SHARON HEAT NO. 24806)

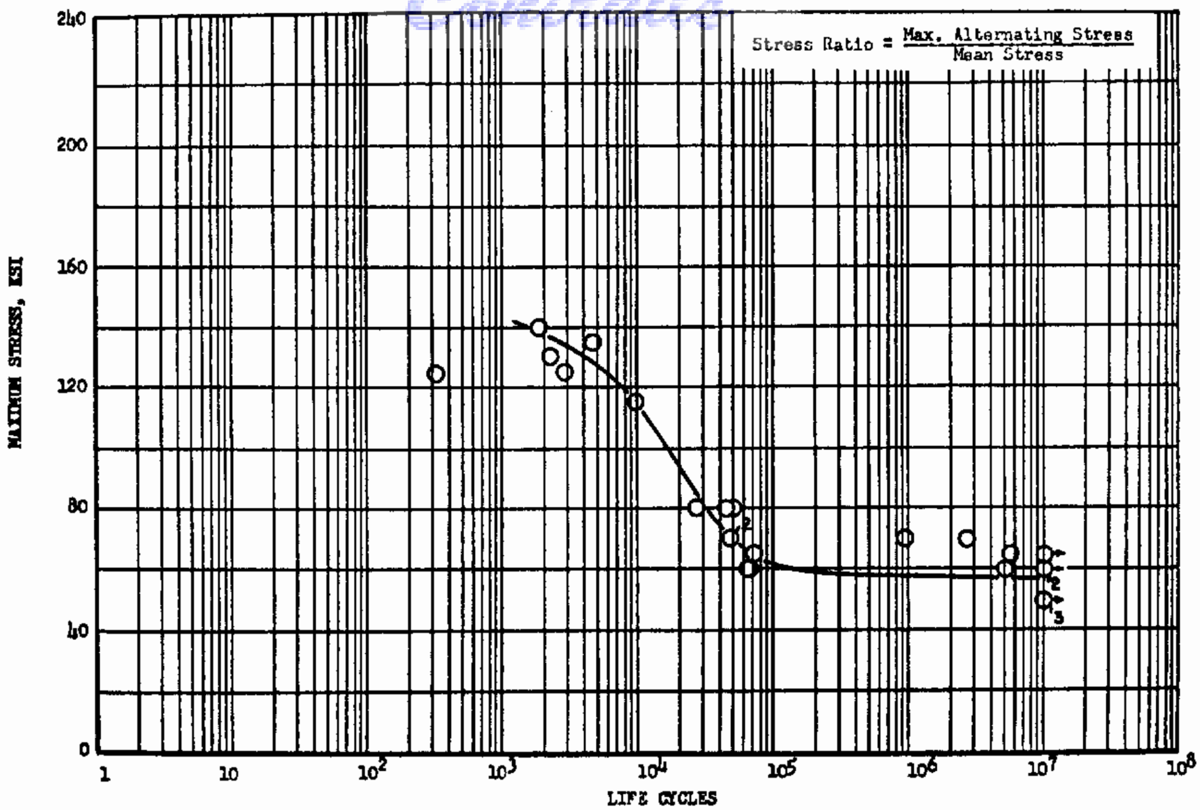


FIGURE 321 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 400°F WITH A STRESS CONCENTRATI N OF 2.82 AND A STRESS RATIO OF 0.3 (MALLORY-SHARON HEAT NO. 24806)

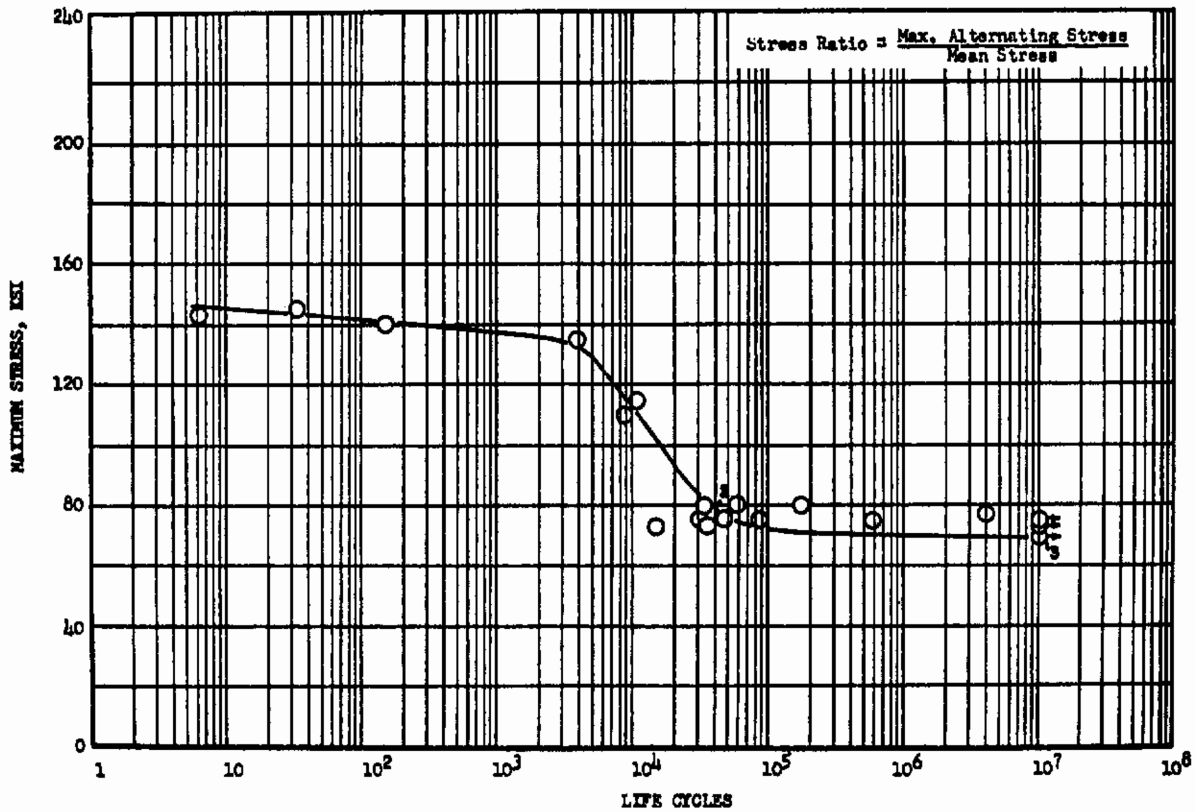


FIGURE 322 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (MALLORY-SHARON HEAT NO. 24806)

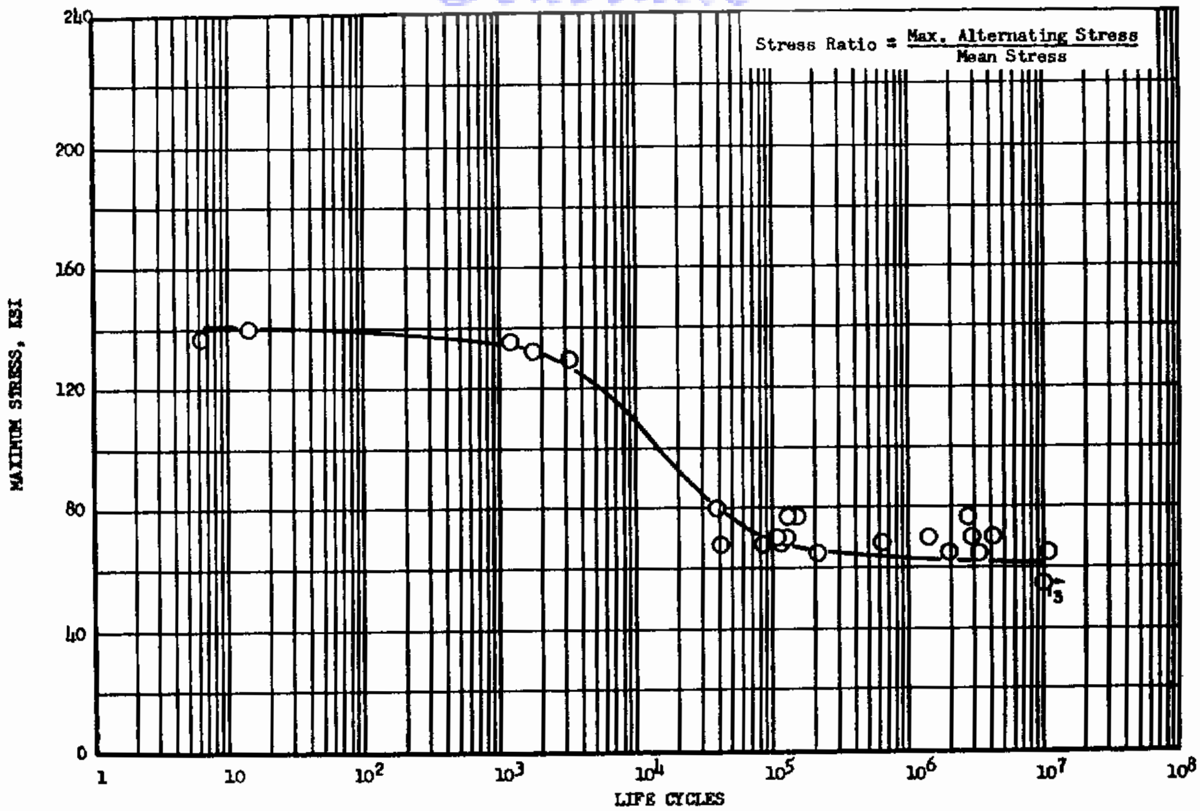


FIGURE 323 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (MALLORY-SHARON HEAT NO. 24806)

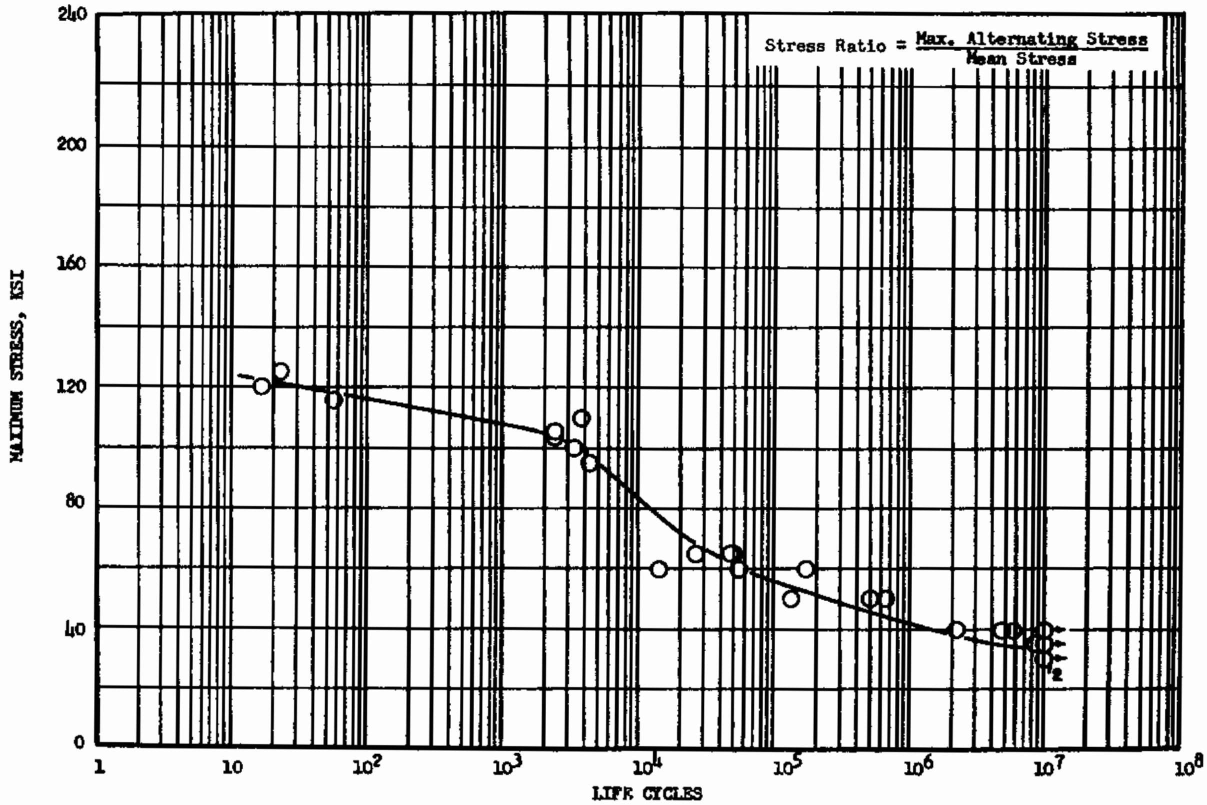


FIGURE 324 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.063 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (MALLORY-SHARON HEAT NO. 24806)

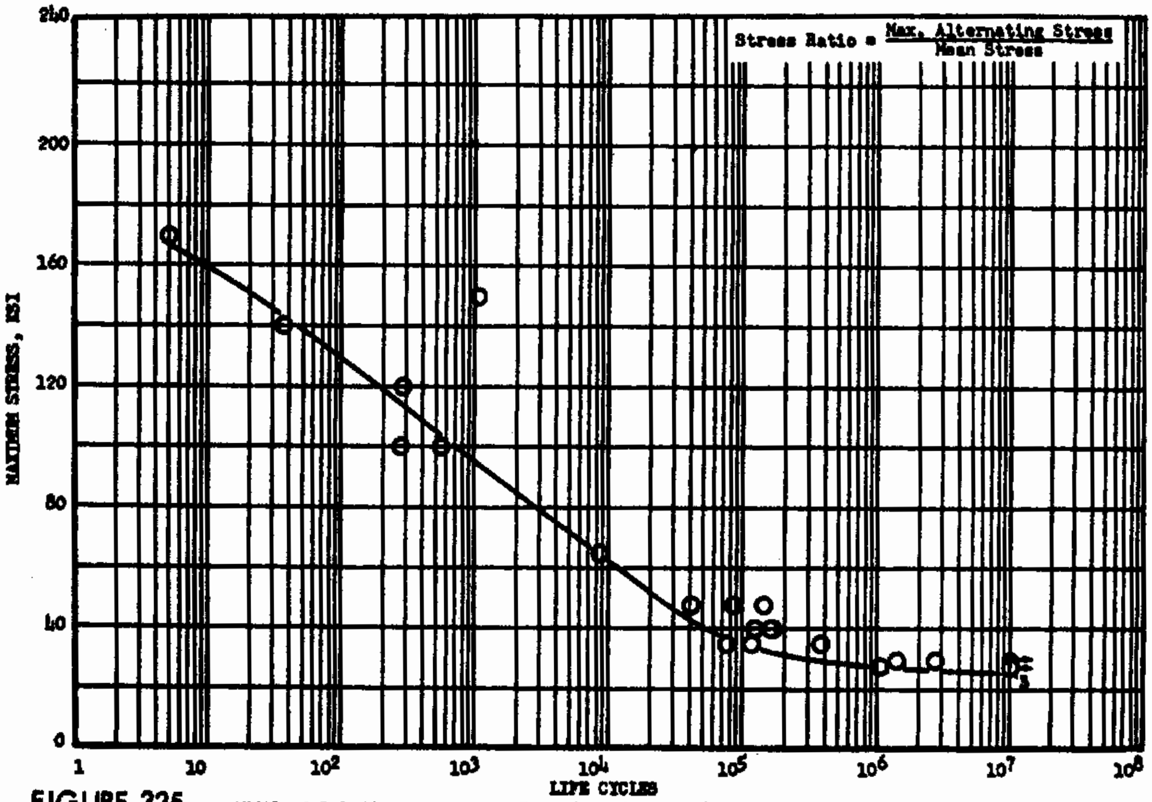


FIGURE 325 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 23345 AND 23372)

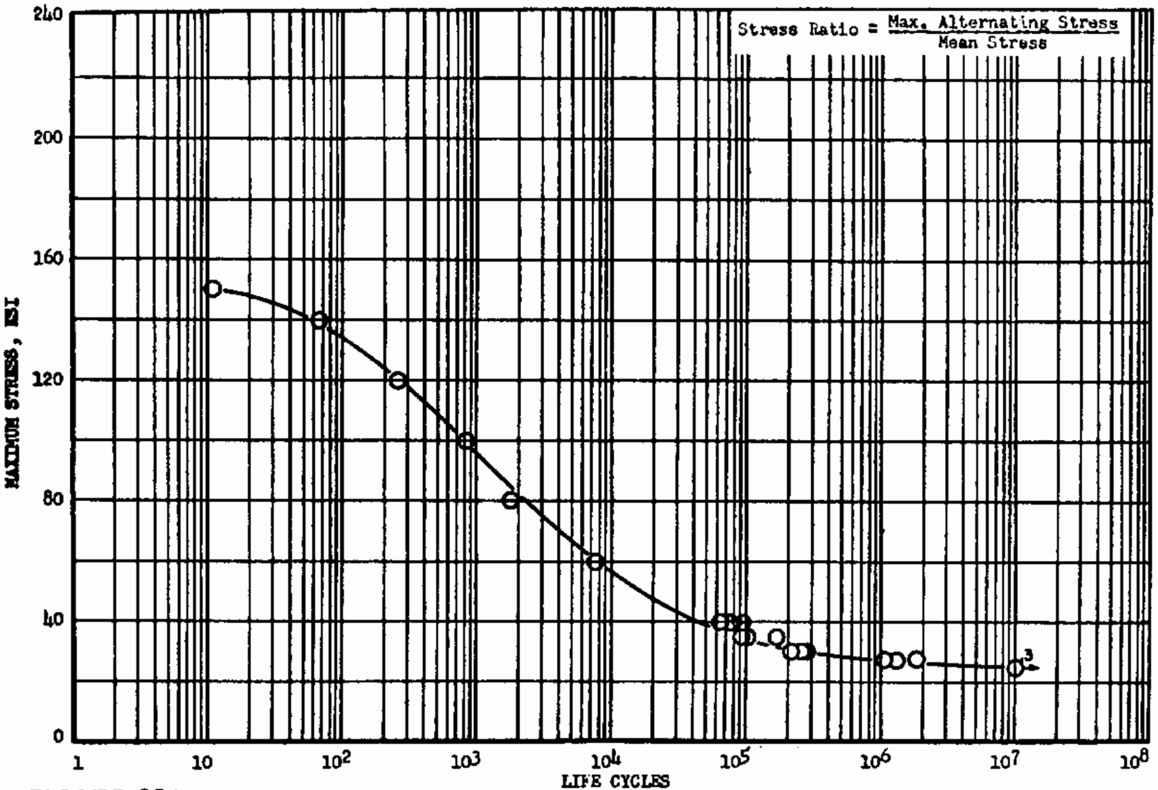


FIGURE 326 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 23345 AND 23372)

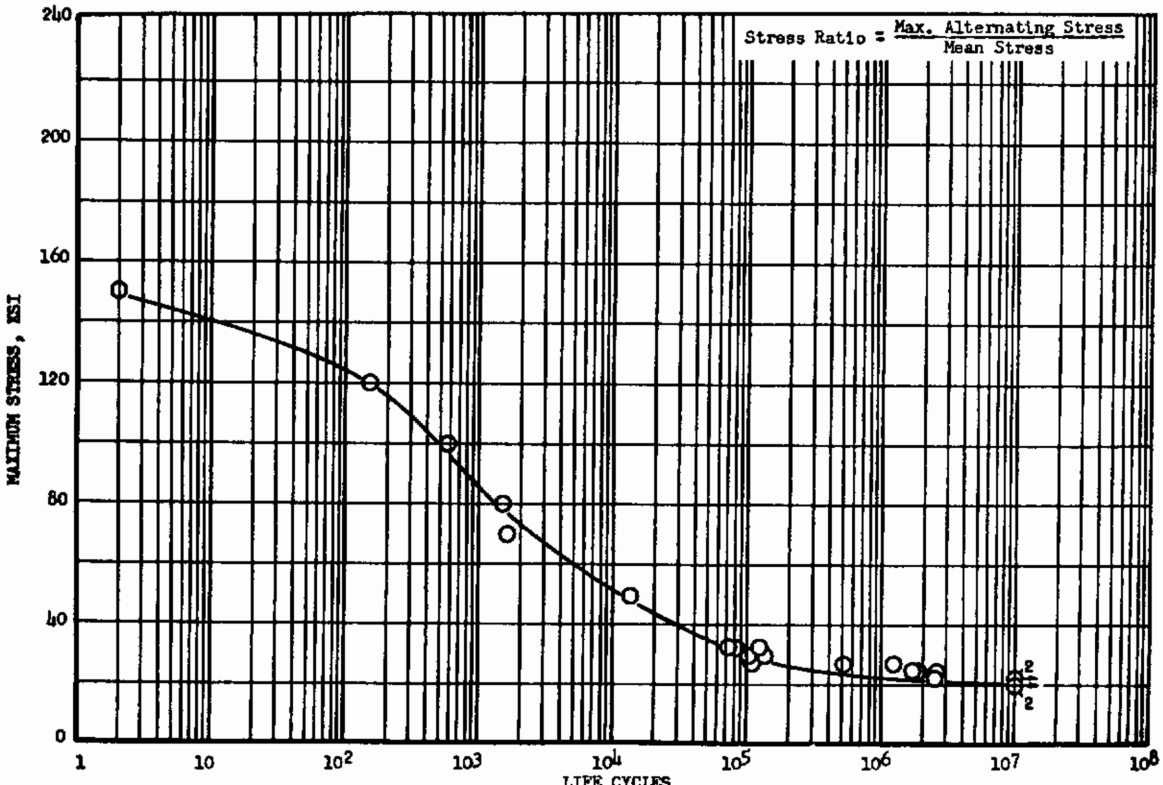


FIGURE 327 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 23345 AND 23372)

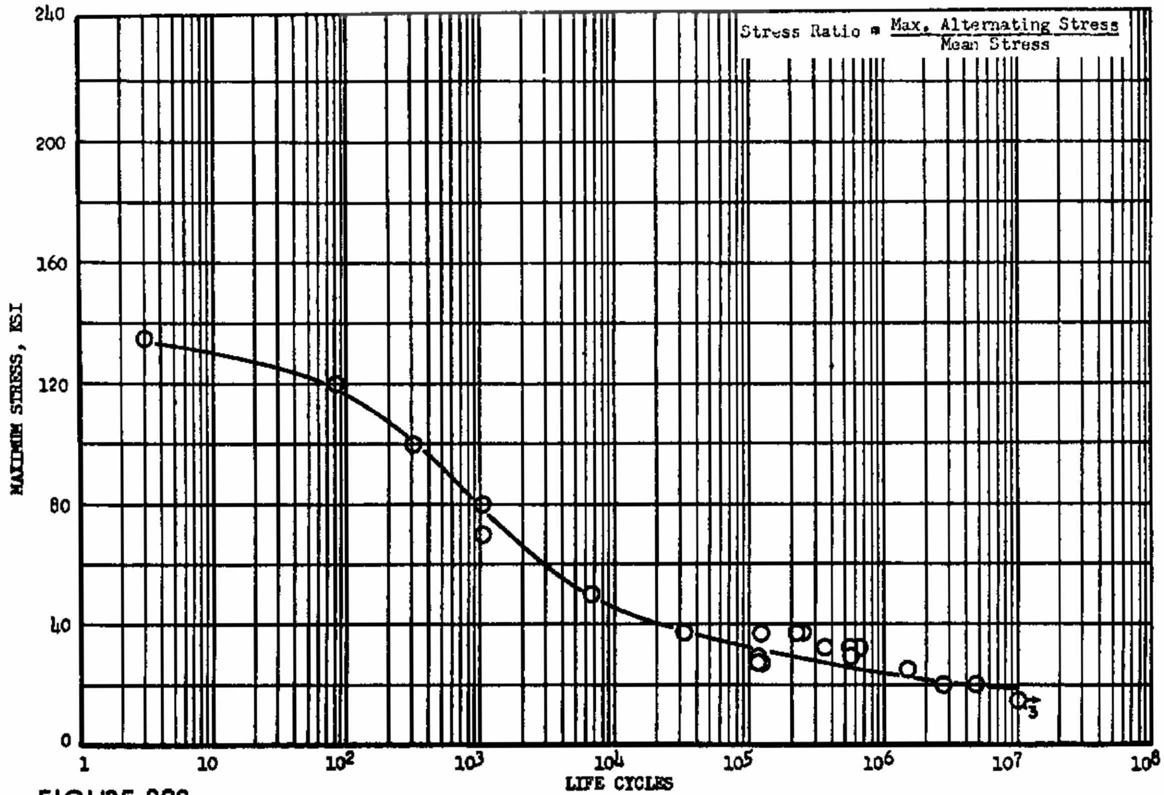


FIGURE 328 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 23345 AND 23372)

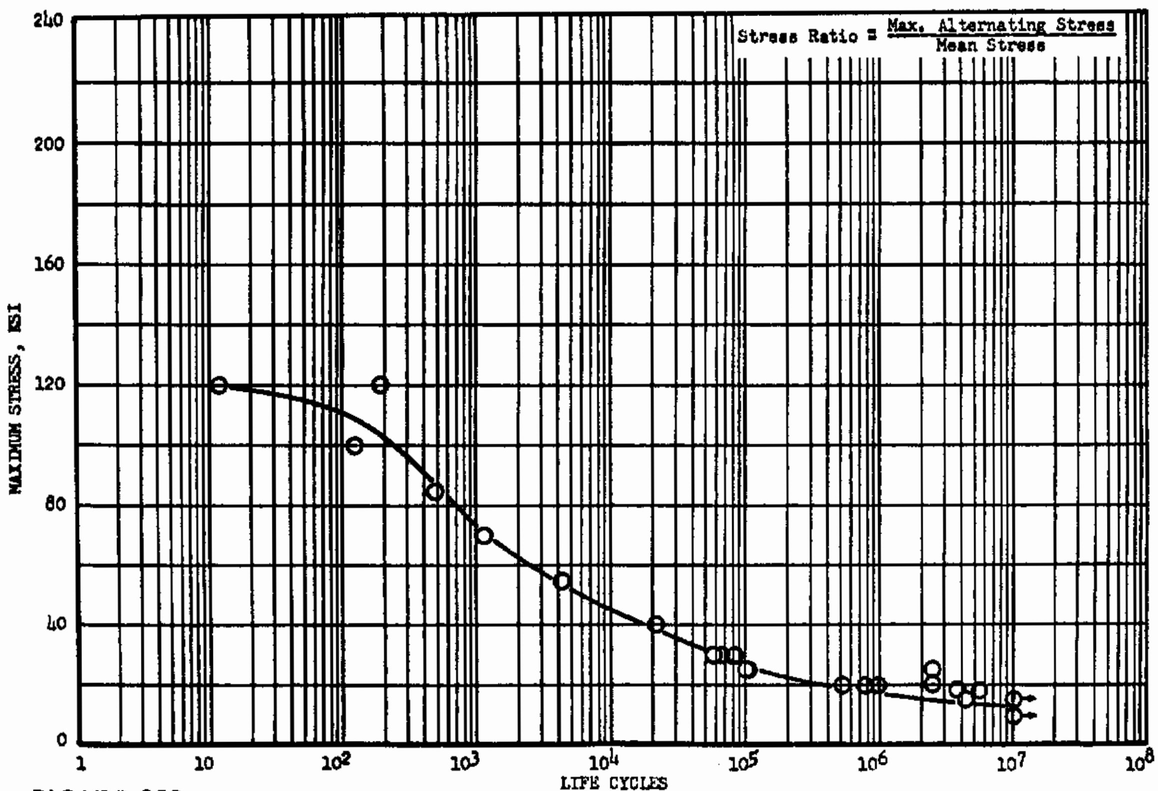


FIGURE 329 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (REACTIVE METALS HEAT NOS. 23345 AND 23372)

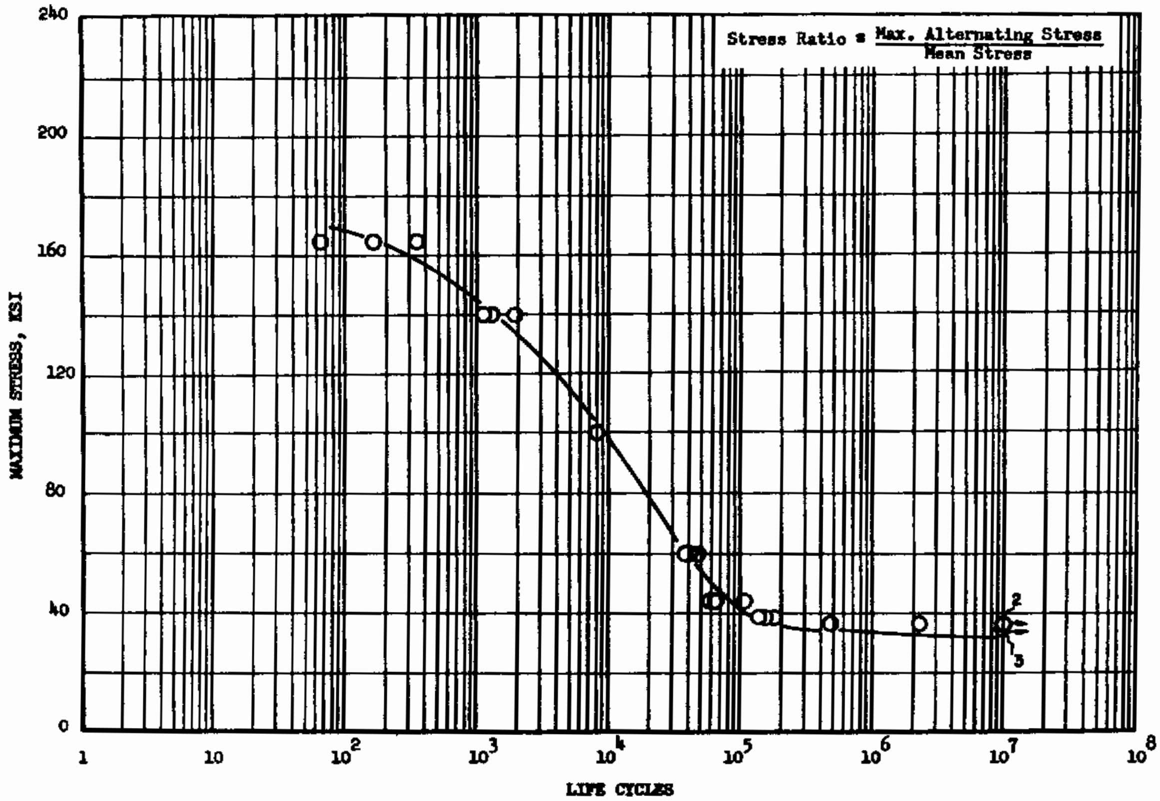


FIGURE 330 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 23345)

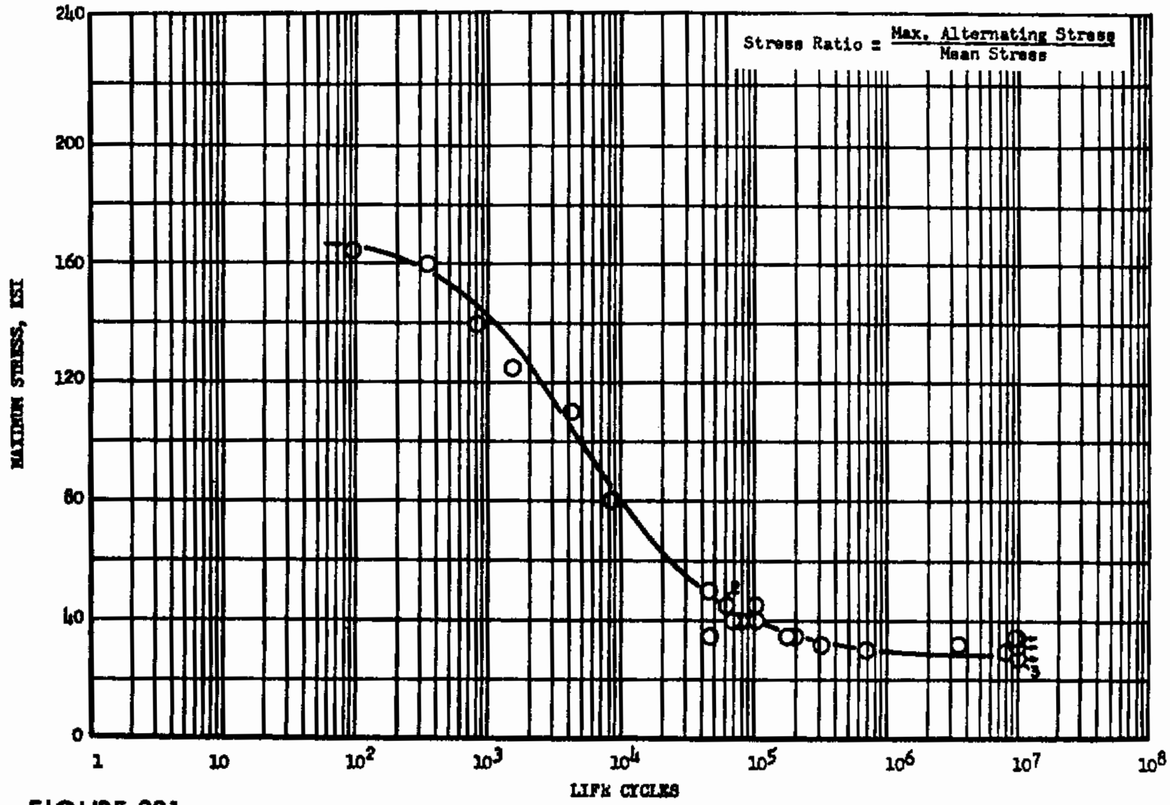


FIGURE 331 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 23345)

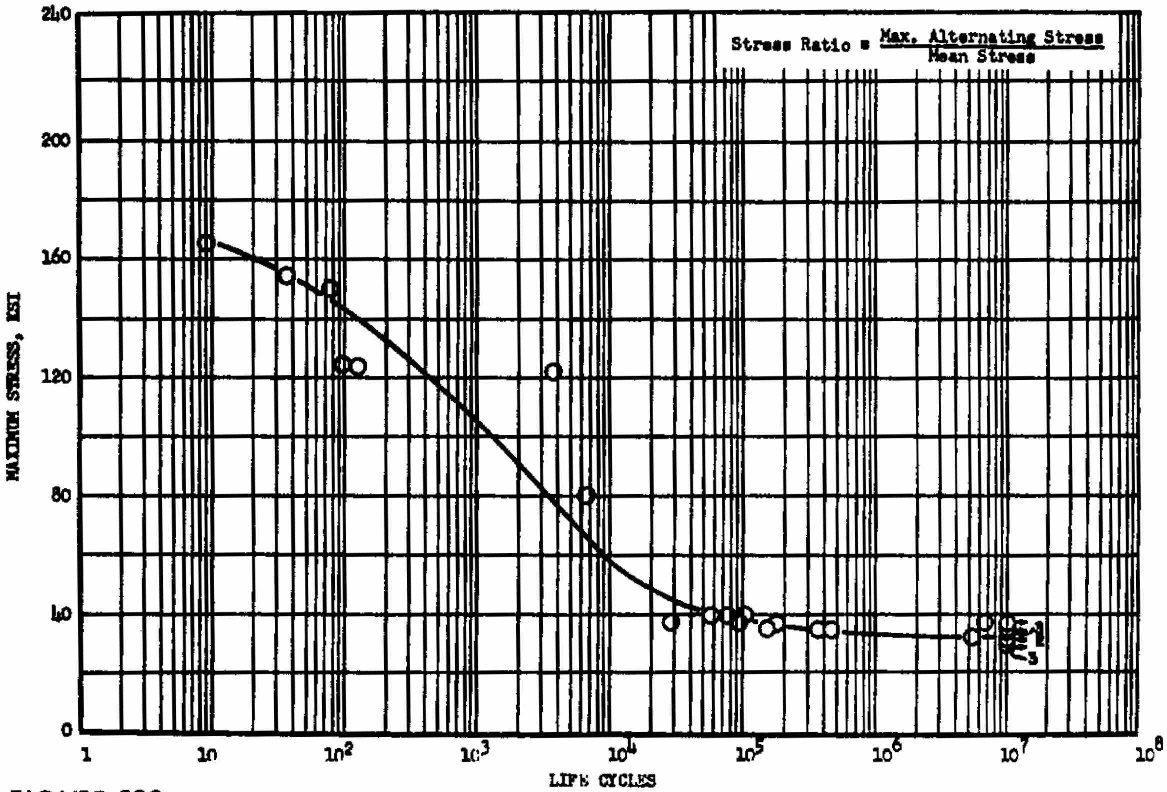


FIGURE 332 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 23345)

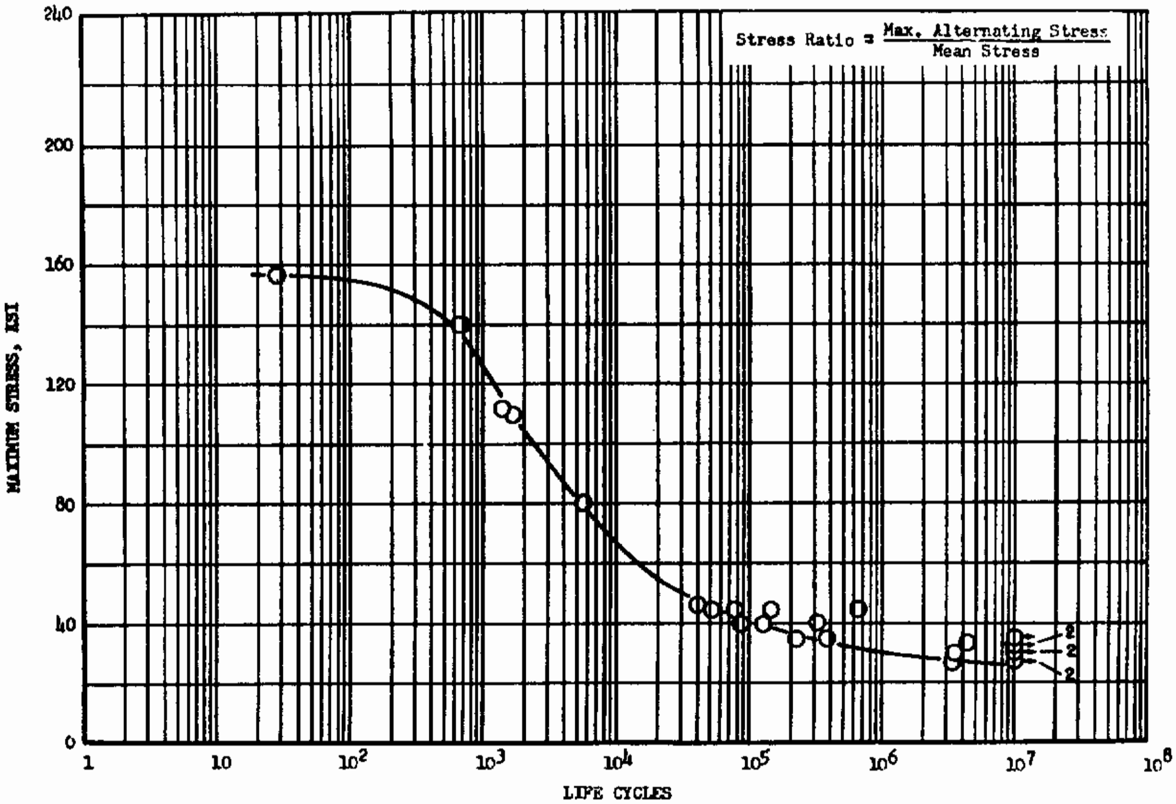


FIGURE 333 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 23345)

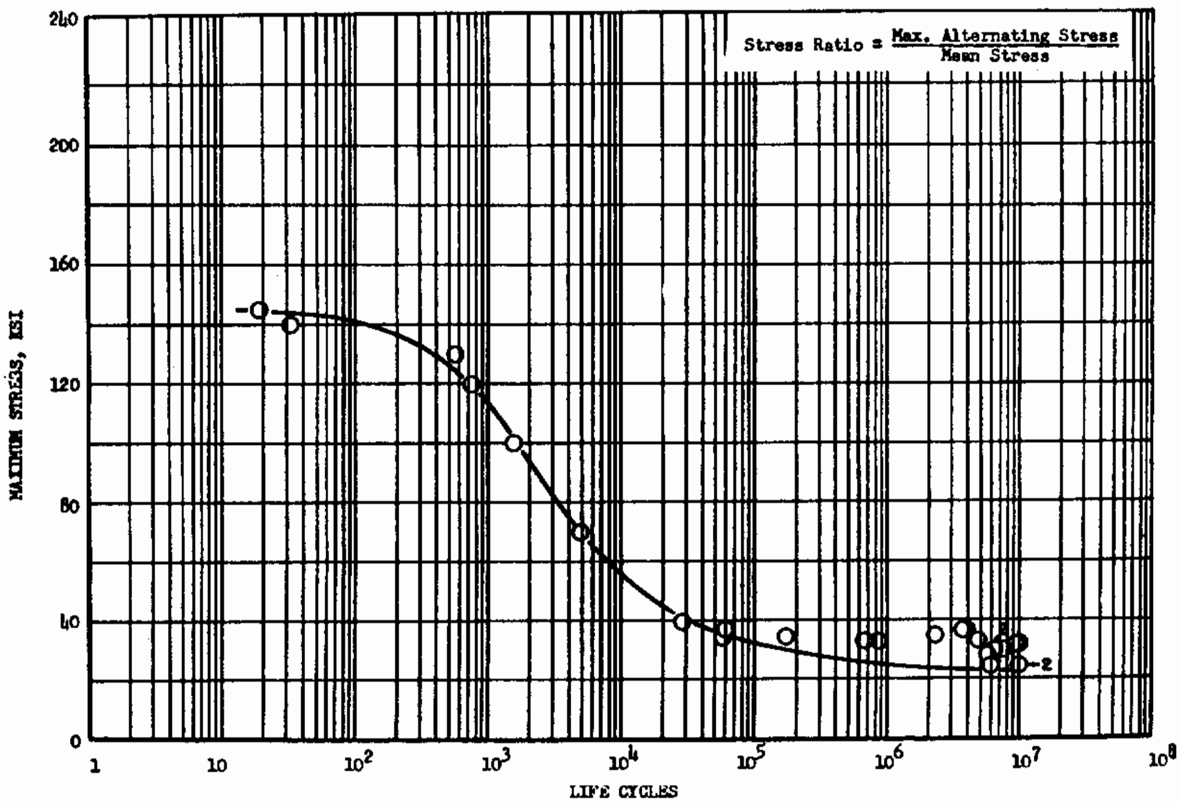


FIGURE 334 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (REACTIVE METALS HEAT NO. 23345)

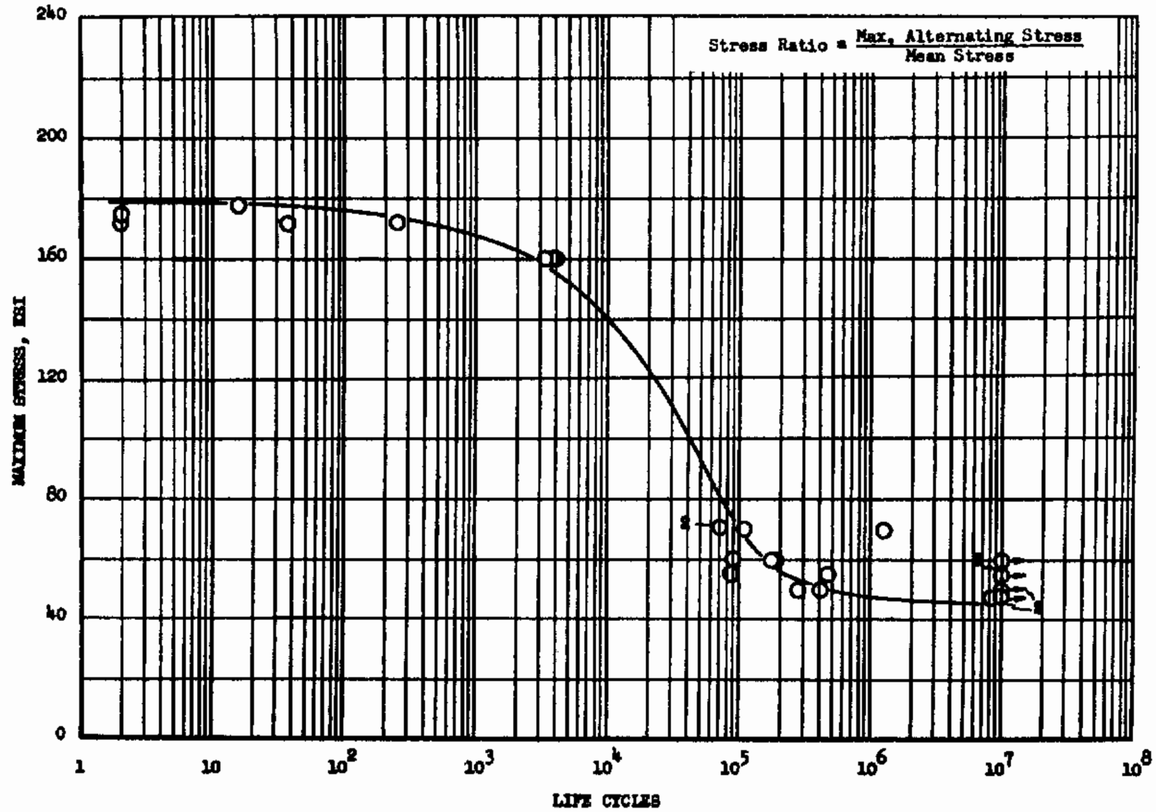


FIGURE 335 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 23345)

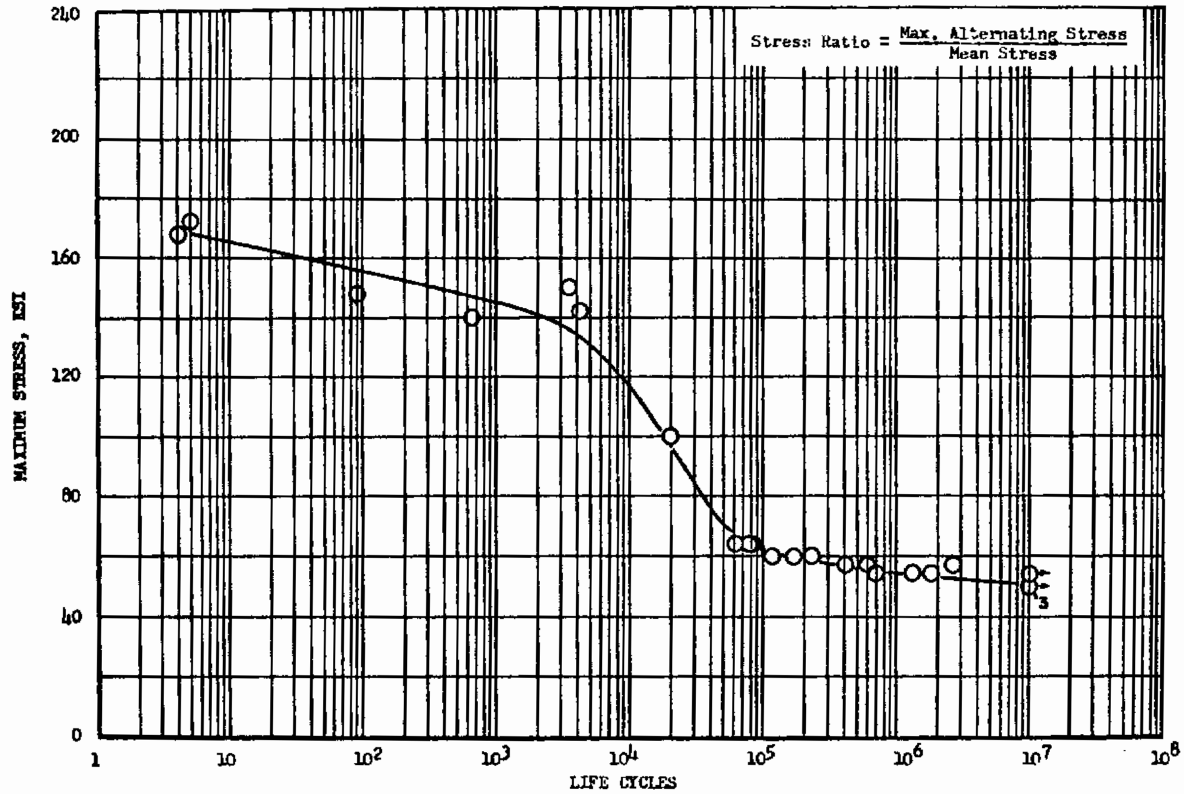


FIGURE 336 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 23345)

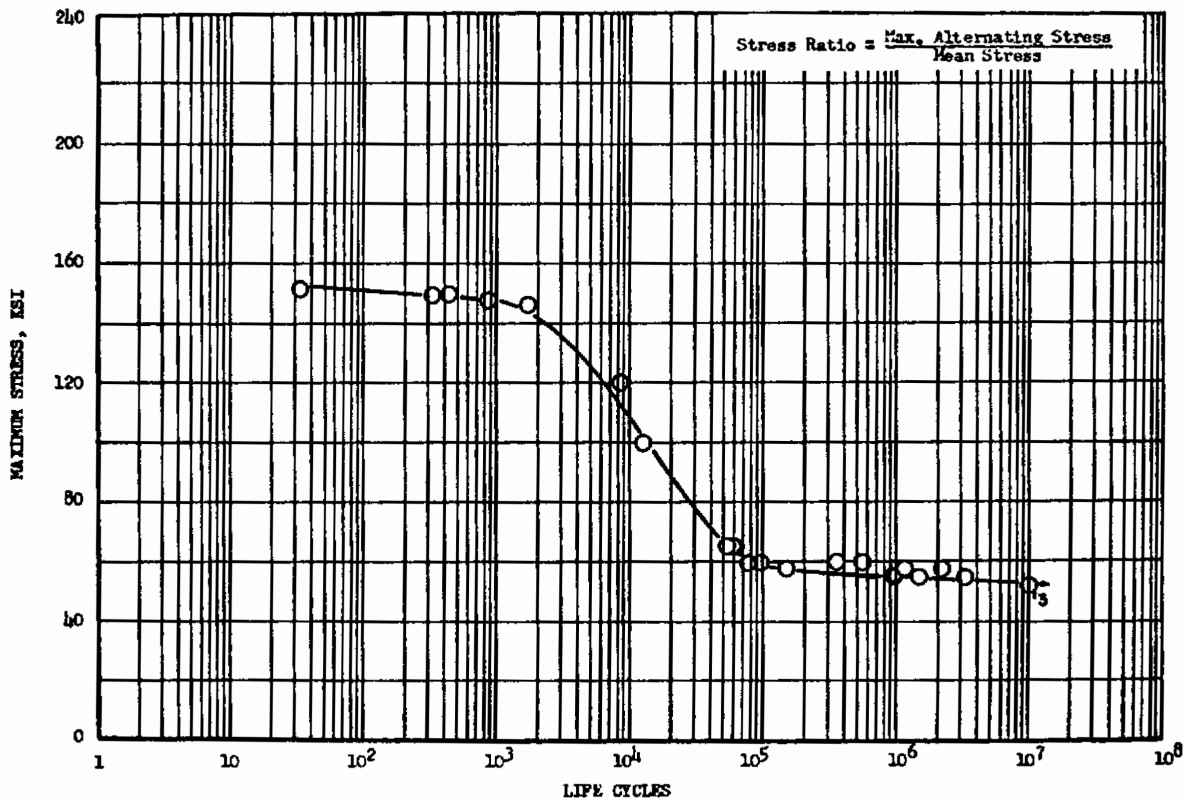


FIGURE 337 - AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 23345)

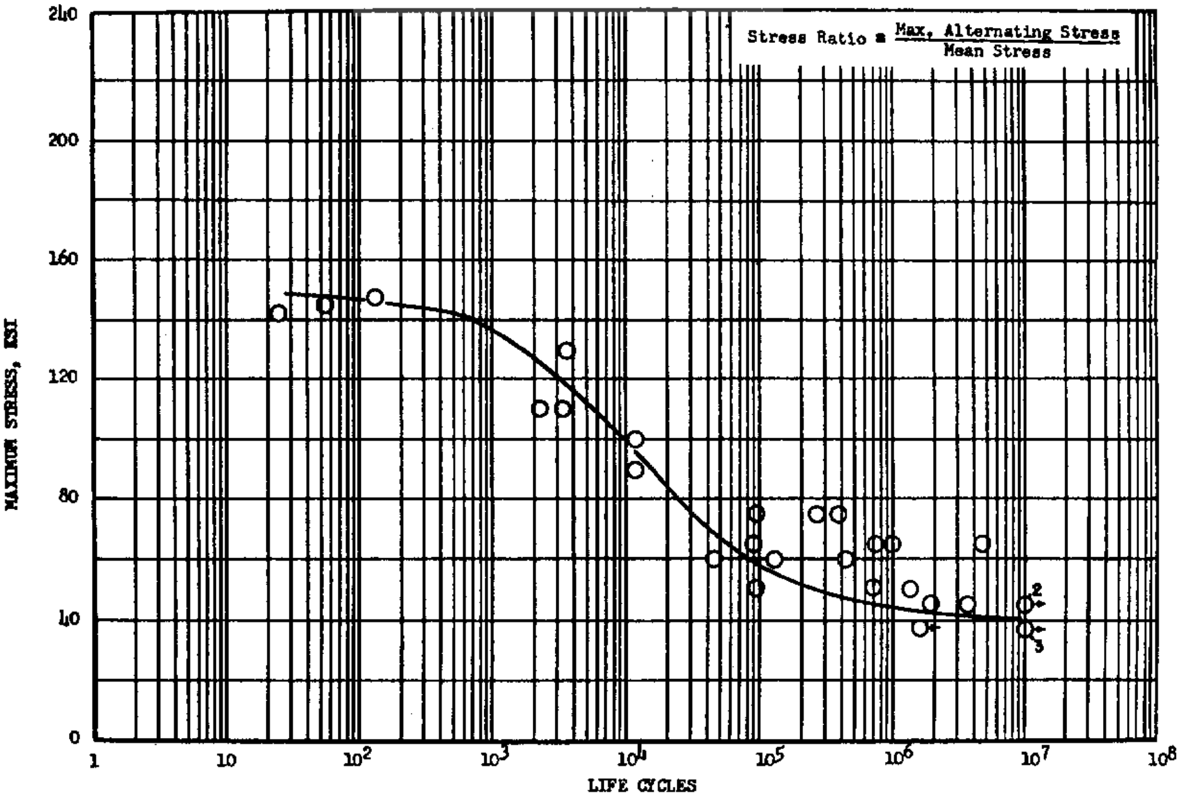


FIGURE 338 – AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 23345)

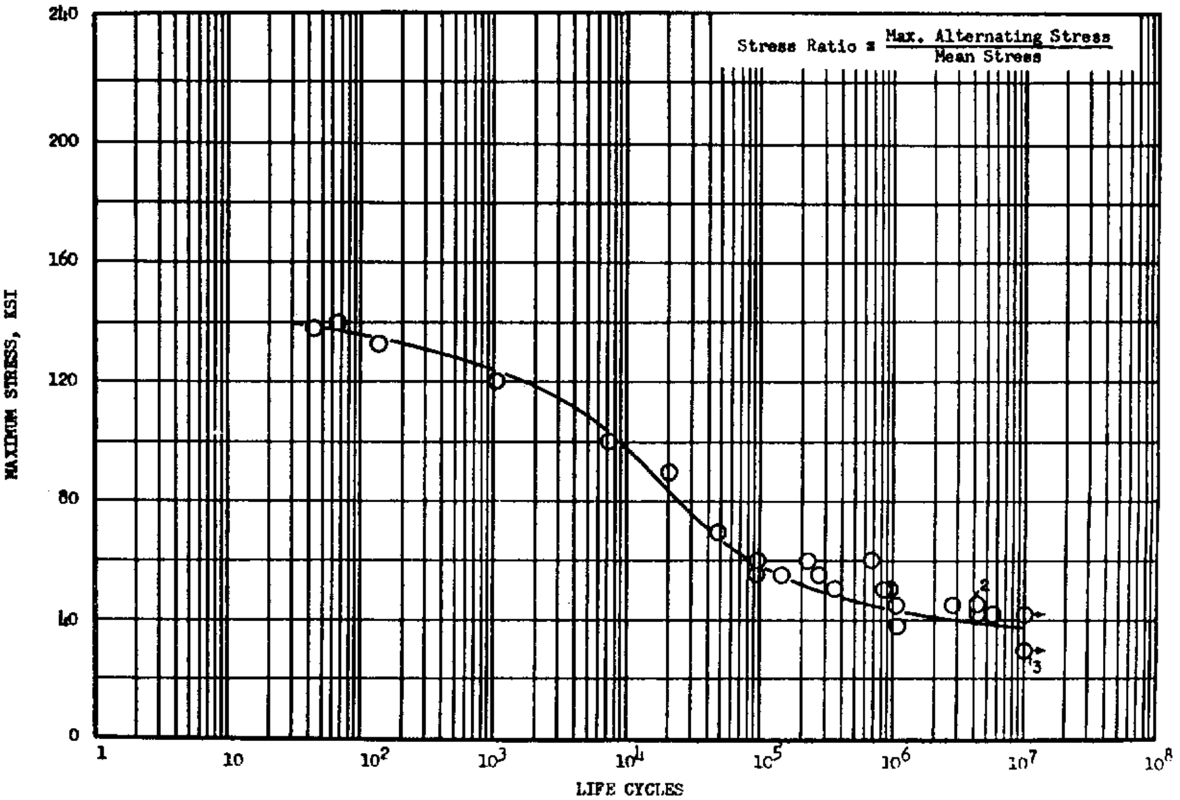


FIGURE 339 – AXIAL LOAD FATIGUE CURVE FOR Ti-2.5Al-16V, 0.125 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (REACTIVE METALS HEAT NO. 23345)

VII - RESULTS FOR 4Al-3Mo-1V TITANIUM ALLOY

Tensile Creep-Rupture Test Results - Ti-4Al-3Mo-1V

Longitudinal and transverse stress-rupture data for 4Al-3Mo-1V titanium alloy are summarized by the curves in Figures 340 and 341 showing log stress versus log time to rupture. Similar curves are shown in Figures 342 through 346 for times to obtain longitudinal creep strains of 1.0, 0.5, 0.2, 0.1 and 0.05 percent. Figures 347 through 351 show these same data summarized by a master rupture curve and master creep strain curves for each specific strain using the Larson-Miller parameter. Creep strain versus log time curves from which the summarized data were obtained, are presented in Figures 352 through 387 and tabulations of the data summarized are in Tables CCLXXV through CCLXXVIII, pages 283 through 286 of Volume 3. These tables also contain tabulations of initial loading deformation.

Design curves plotted as percentage of room-temperature ultimate tensile stress versus time to rupture and times to reach the specified creep strains are in Volume 1.

Compressive Creep Test Results - Ti-4Al-3Mo-1V

The compressive creep data are summarized in Figures 388 through 391 by curves of log stress versus log time to obtain creep strains of 1.0, 0.5, 0.2, 0.1 and 0.05 percent. These data represent temperatures of 600°F, 700°F, 800°F and 900°F for longitudinal compressive creep tests on one heat of Ti-4Al-3Mo-1V. Compressive creep strain curves, used to obtain strain data for the summary plots, are shown in Figures 392 through 399, and the rupture and strain data summarized are in Tables CCLXXIX through CCLXXXII, pages 287 through 290 of Volume 3.

Bearing Creep-Rupture Test Results - Ti-4Al-3Mo-1V

Curves for bearing stress-rupture and bearing deformations of 4.0, 2.0, 1.0 and 0.5 percent of the bearing hole diameter are presented in Figures 400 through 402. These curves summarize the results of longitudinal bearing creep-rupture tests performed at 600°F, 700°F and 800°F on one heat of 4Al-3Mo-1V titanium alloy, and show the variation of stress with time required for rupture and time required to obtain each specified deformation. Bearing deformation versus log time curves, used to obtain the summary data, are shown in Figures 403 through 410 and tabulations of the data summarized are in Tables CCLXXXIII through CCLXXXV, pages 291 through 293 of Volume 3. Also contained in these tables are initial loading deformations.

Single Shear Stress-Rupture Test Results - Ti-4Al-3Mo-1V

Single shear stress-rupture data for three heats of 0.063 inch thick 4Al-3Mo-1V titanium alloy are summarized by the curves in Figure 411. These data are the results of a minimum of six longitudinal tests performed at 600°F, 700°F and 800°F on each of the three heats. Tables CCLXXXVI and CCLXXXVII, pages 294 and 295 of Volume 3 present the results of the Ti-4Al-3Mo-1V single shear stress-rupture tests in tabular form.

Double Shear Stress-Rupture Test Results - Ti-4Al-3Mo-1V

Results of longitudinal double shear stress-rupture tests on three heats of 0.125 inch thick Ti-4Al-3Mo-1V are summarized in Figure 412. On each heat, a minimum of 18 tests were conducted, six each at 600°F, 700°F and 800°F. Data from these tests are also presented in Tables CCLXXXVIII and CCLXXXIX, pages 296 and 297 of Volume 3.

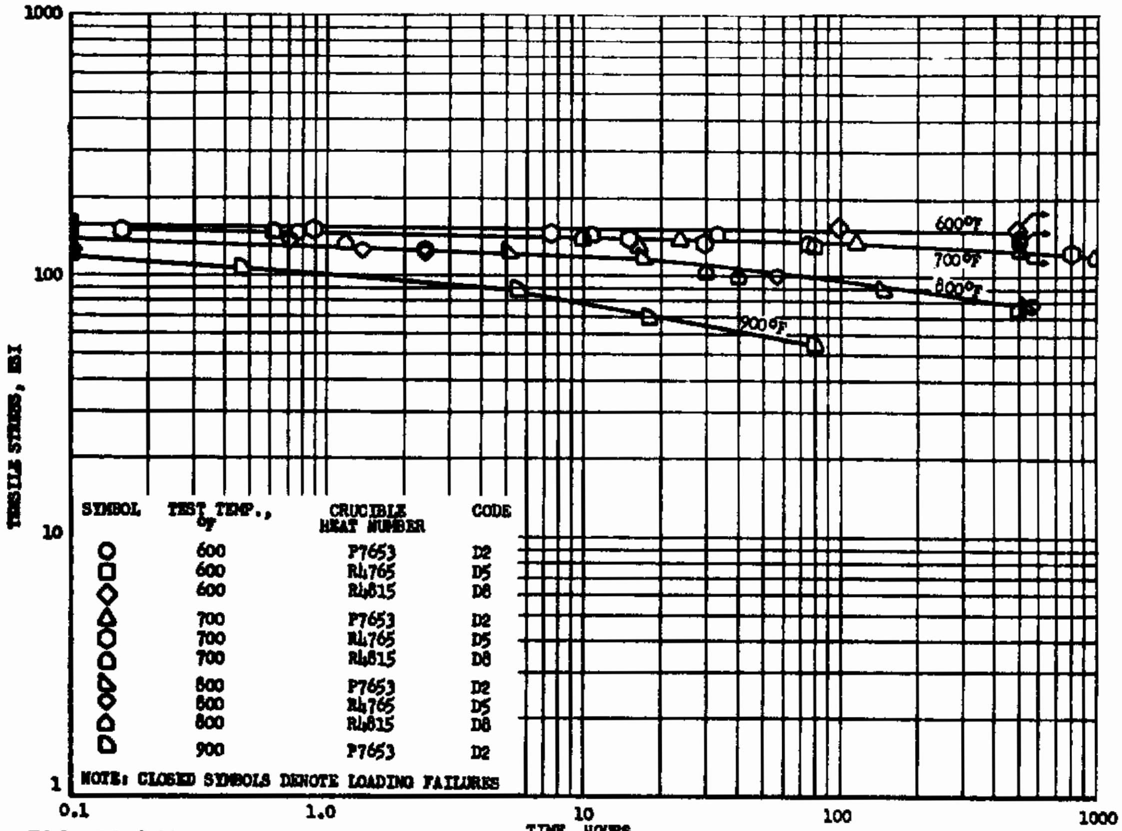


FIGURE 340 – LONGITUDINAL TENSILE STRESS-RUPTURE CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK

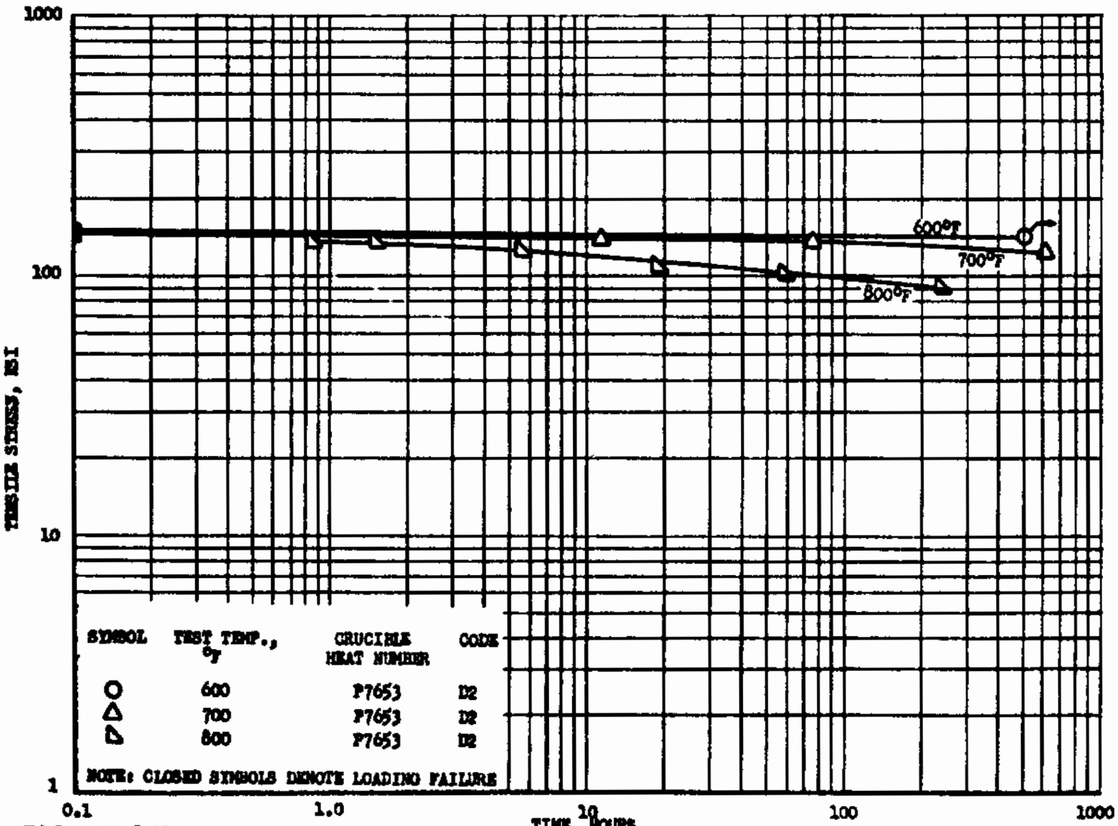


FIGURE 341 – TRANSVERSE TENSILE STRESS-RUPTURE CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK

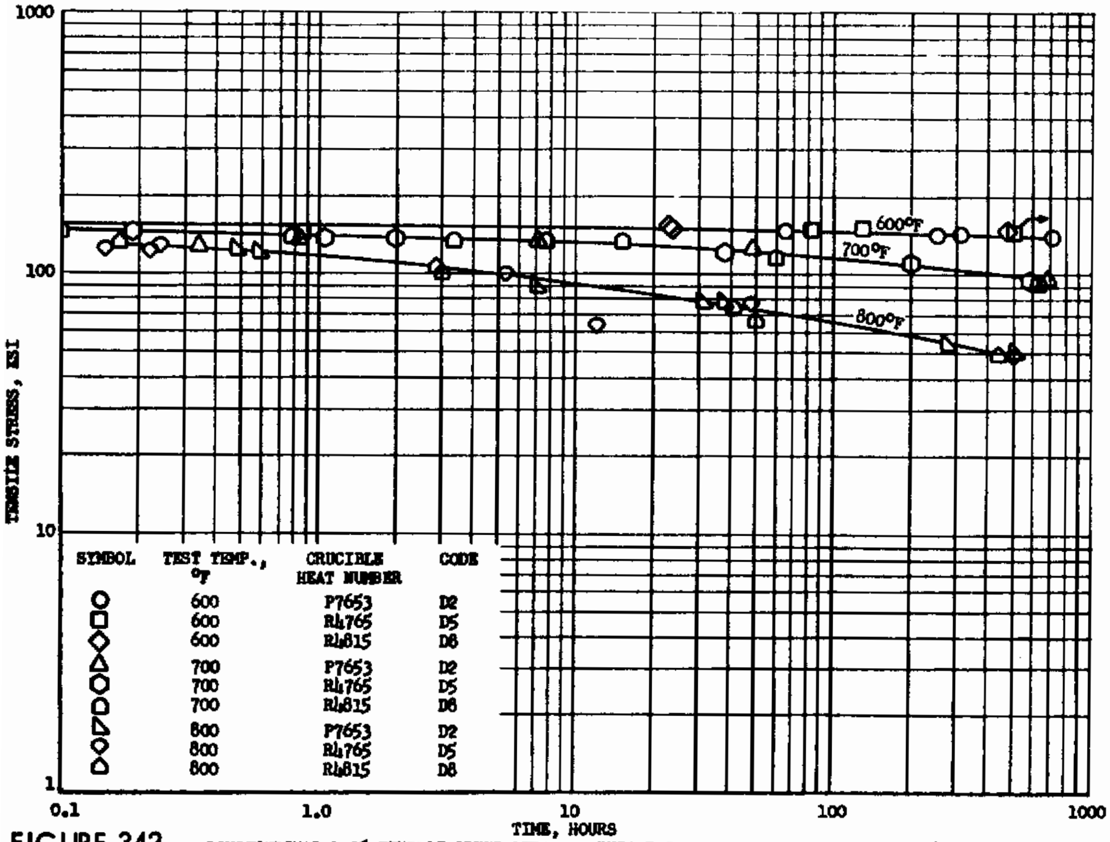


FIGURE 342 - LONGITUDINAL 1.0% TENSILE CREEP STRAIN CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK

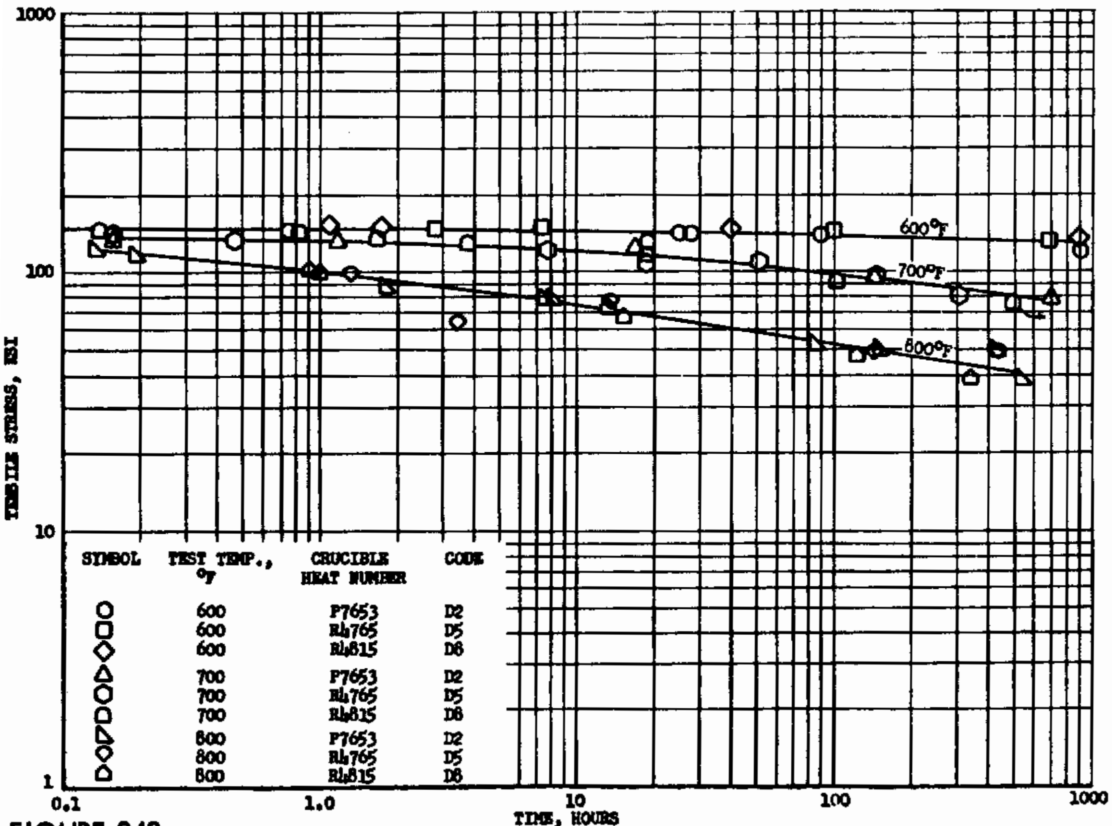


FIGURE 343 - LONGITUDINAL 0.5% TENSILE CREEP STRAIN CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK

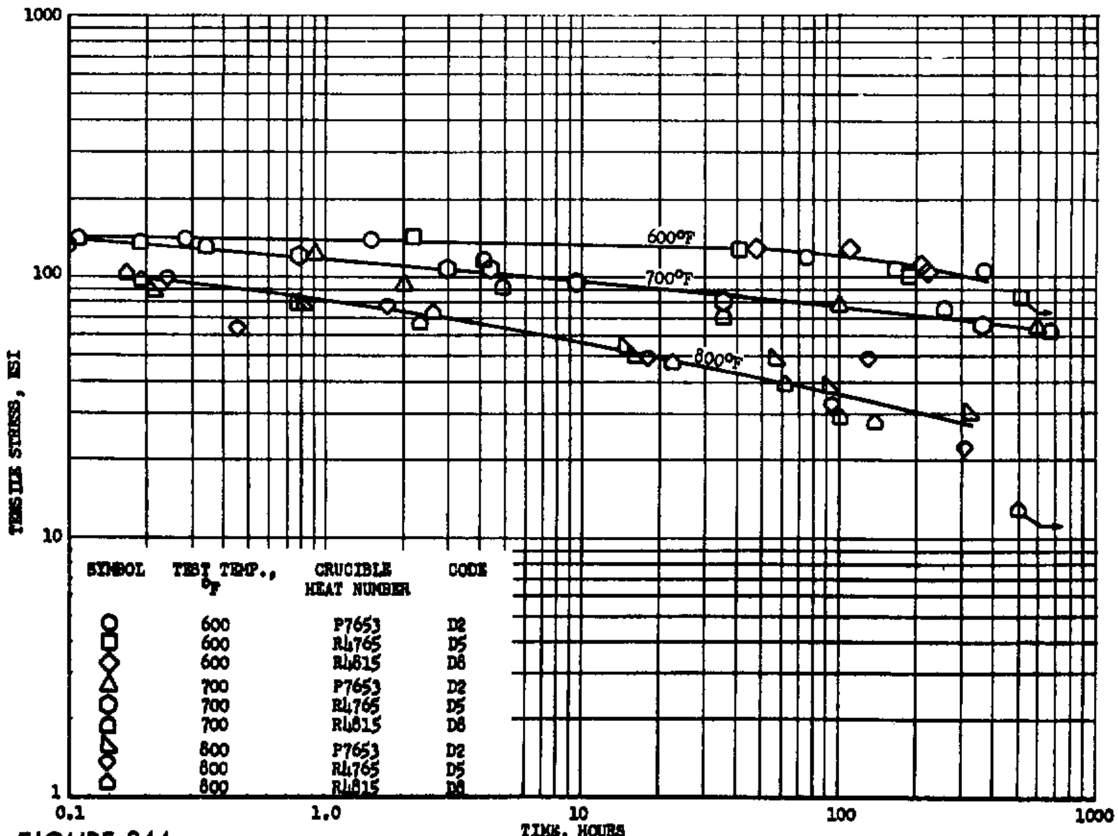


FIGURE 344 - LONGITUDINAL 0.2% TENSILE CREEP STRAIN CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK

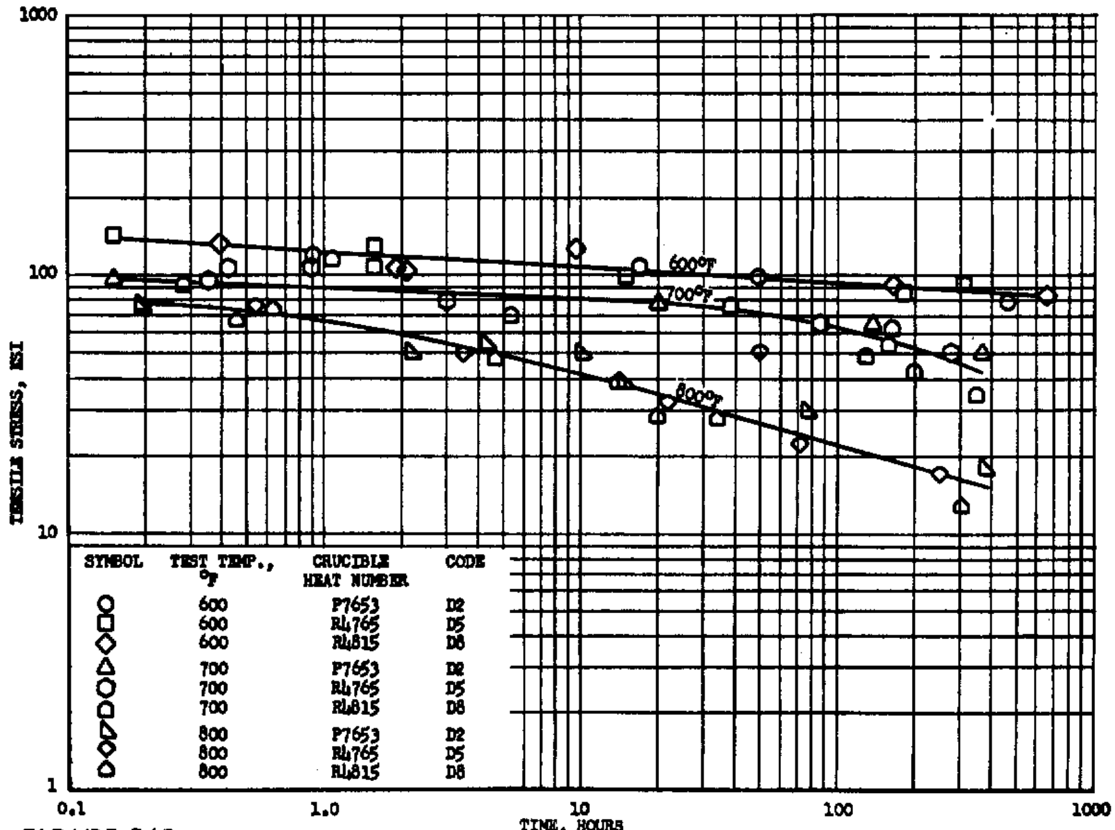


FIGURE 345 - LONGITUDINAL 0.1% TENSILE CREEP STRAIN CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK

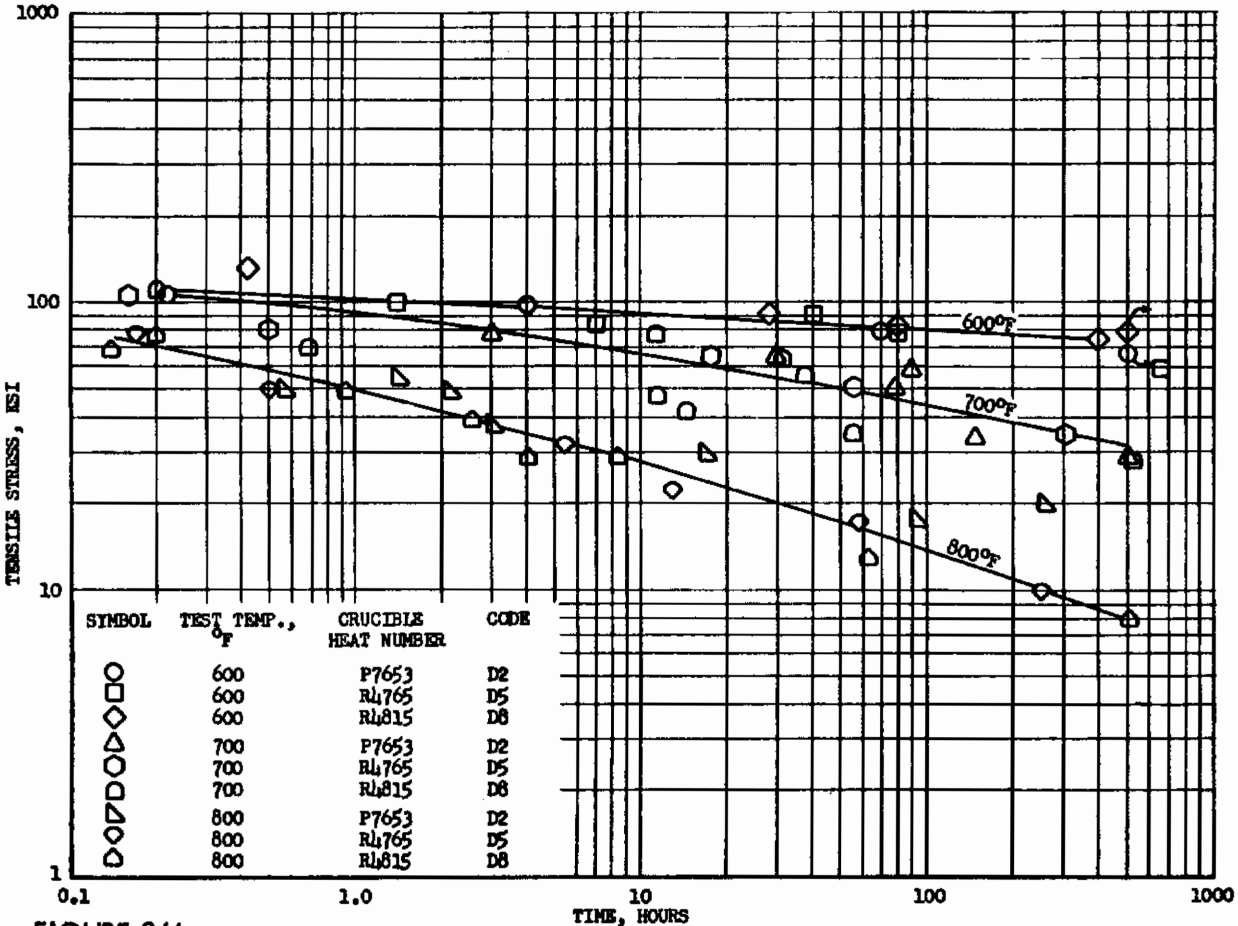


FIGURE 346 - LONGITUDINAL 0.05% TENSILE CREEP STRAIN CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK

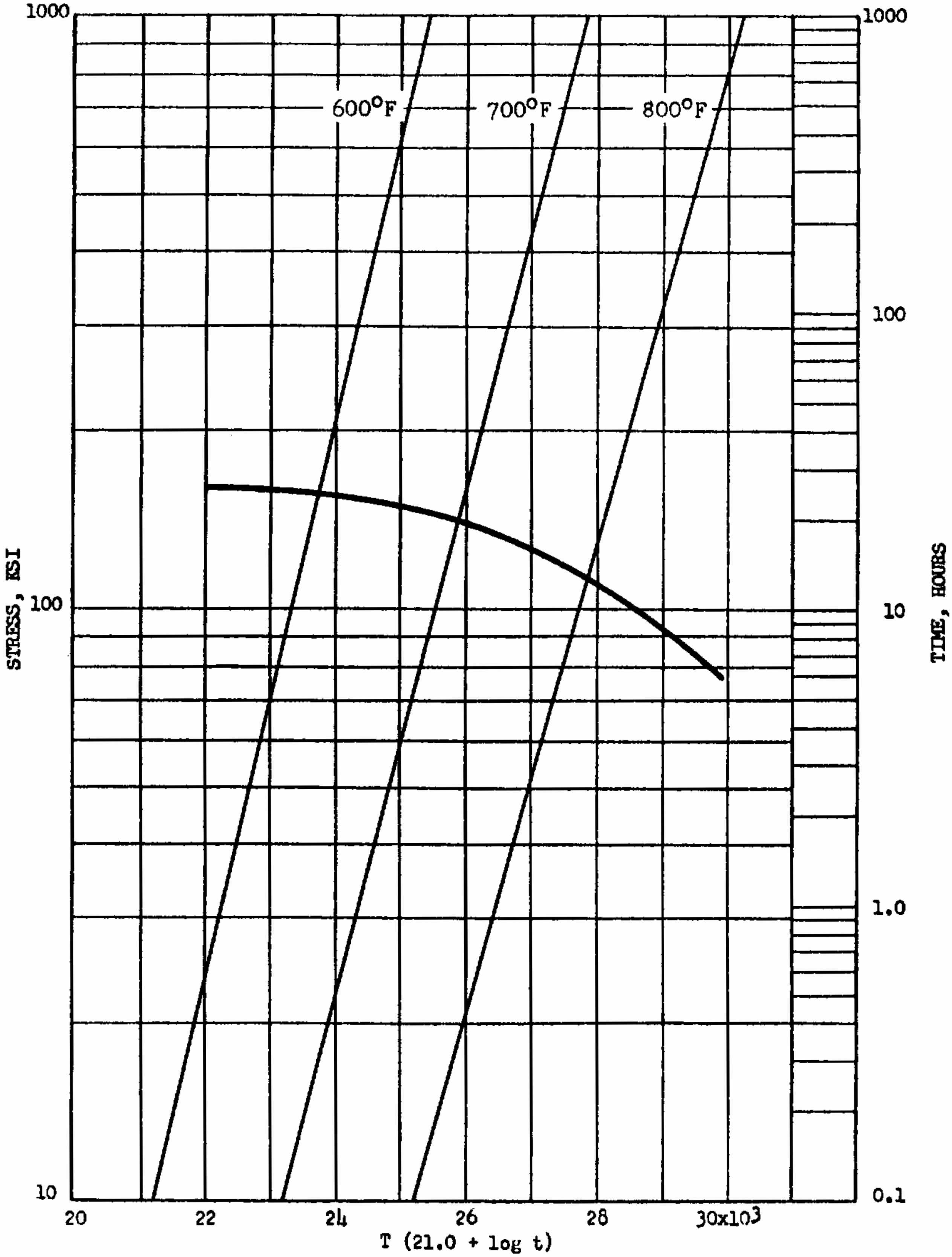


FIGURE 347 - MASTER RUPTURE CURVE FOR 4Al-3Mo-1V SOLUTION TREATED AND AGED TITANIUM ALLOY (0.063 INCH THICK SHEET)

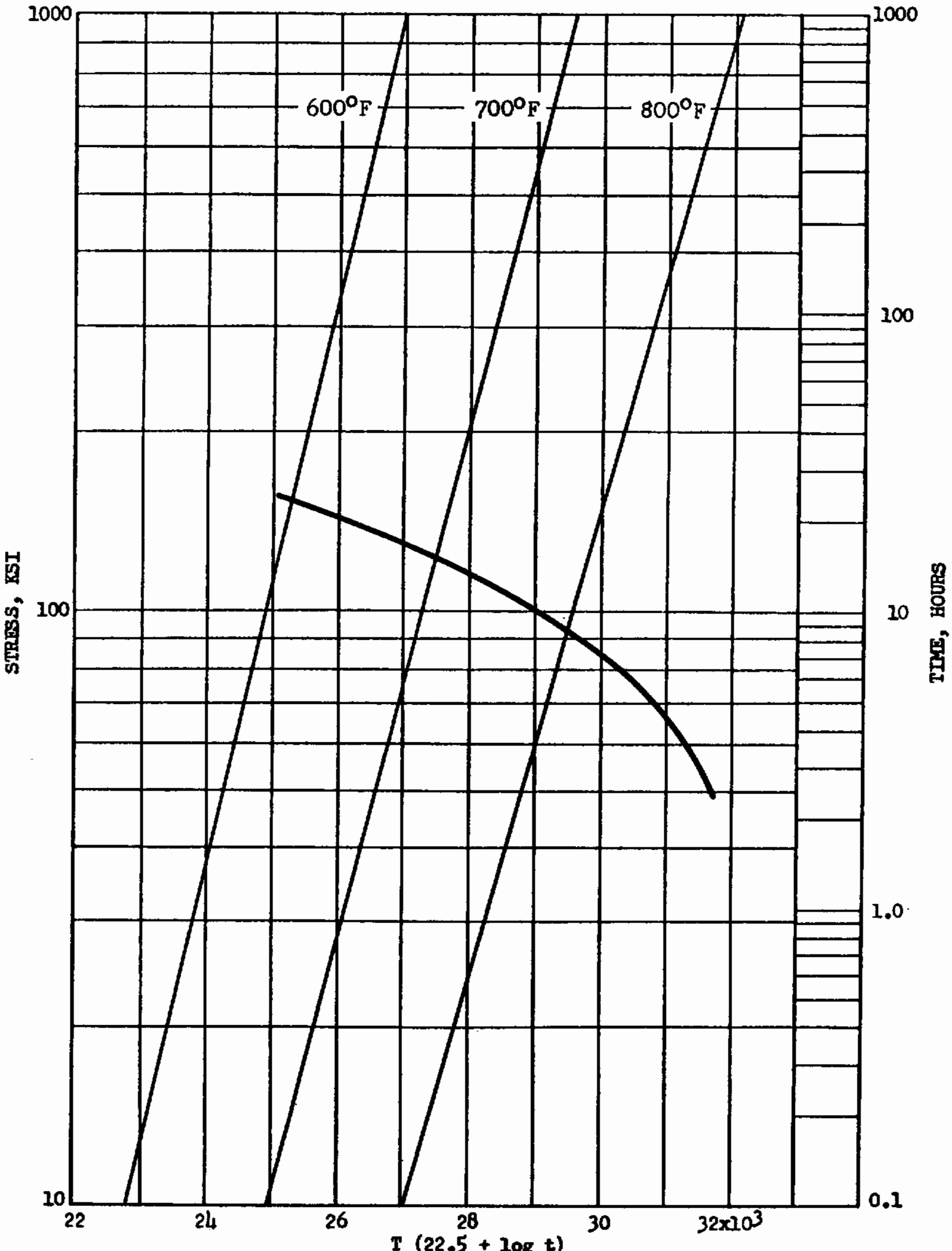


FIGURE 348 - MASTER 1.0 PERCENT CREEP STRAIN CURVE FOR 4Al-3Mo-1V SOLUTION TREATED AND AGED TITANIUM ALLOY (0.063 INCH THICK SHEET).

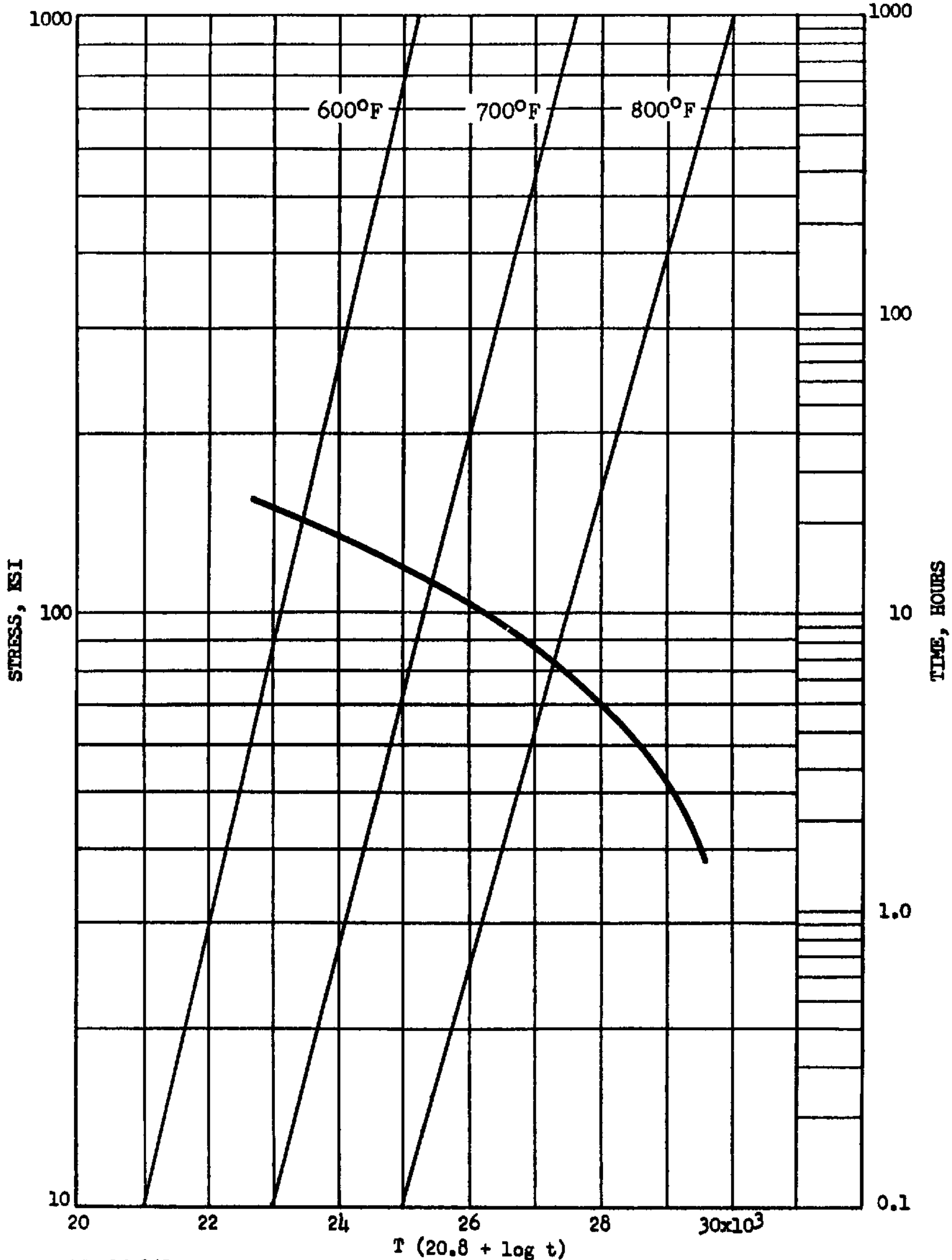


FIGURE 349 - MASTER 0.5 PERCENT CREEP STRAIN CURVE FOR 4Al-3Mo-1V SOLUTION TREATED AND AGED TITANIUM ALLOY (0.063 INCH THICK SHEET).

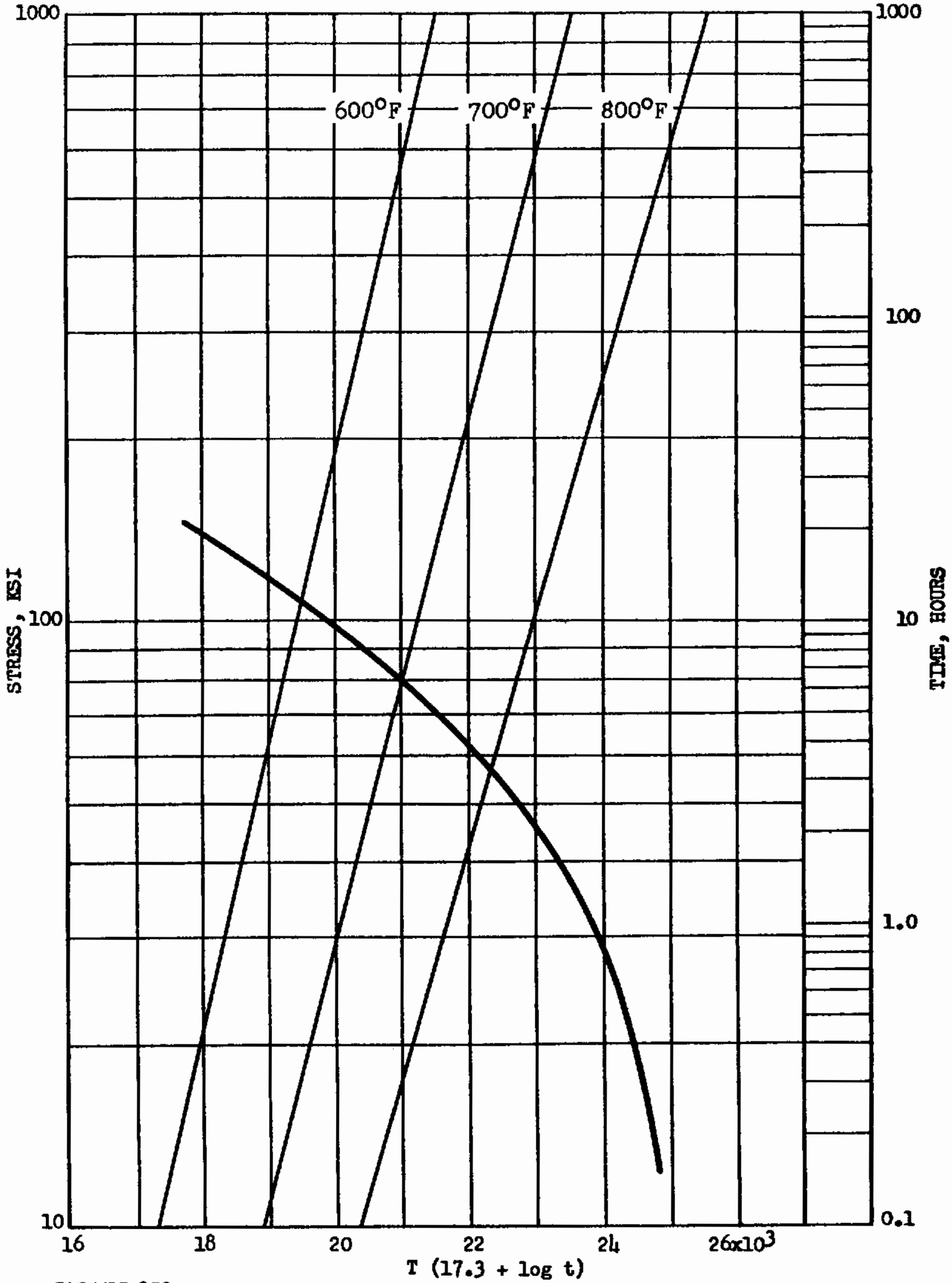


FIGURE 350 - MASTER 0.1 PERCENT CREEP STRAIN CURVE FOR 4Al-3Mo-1V SOLUTION TREATED AND AGED TITANIUM ALLOY (0.063 INCH THICK SHEET).

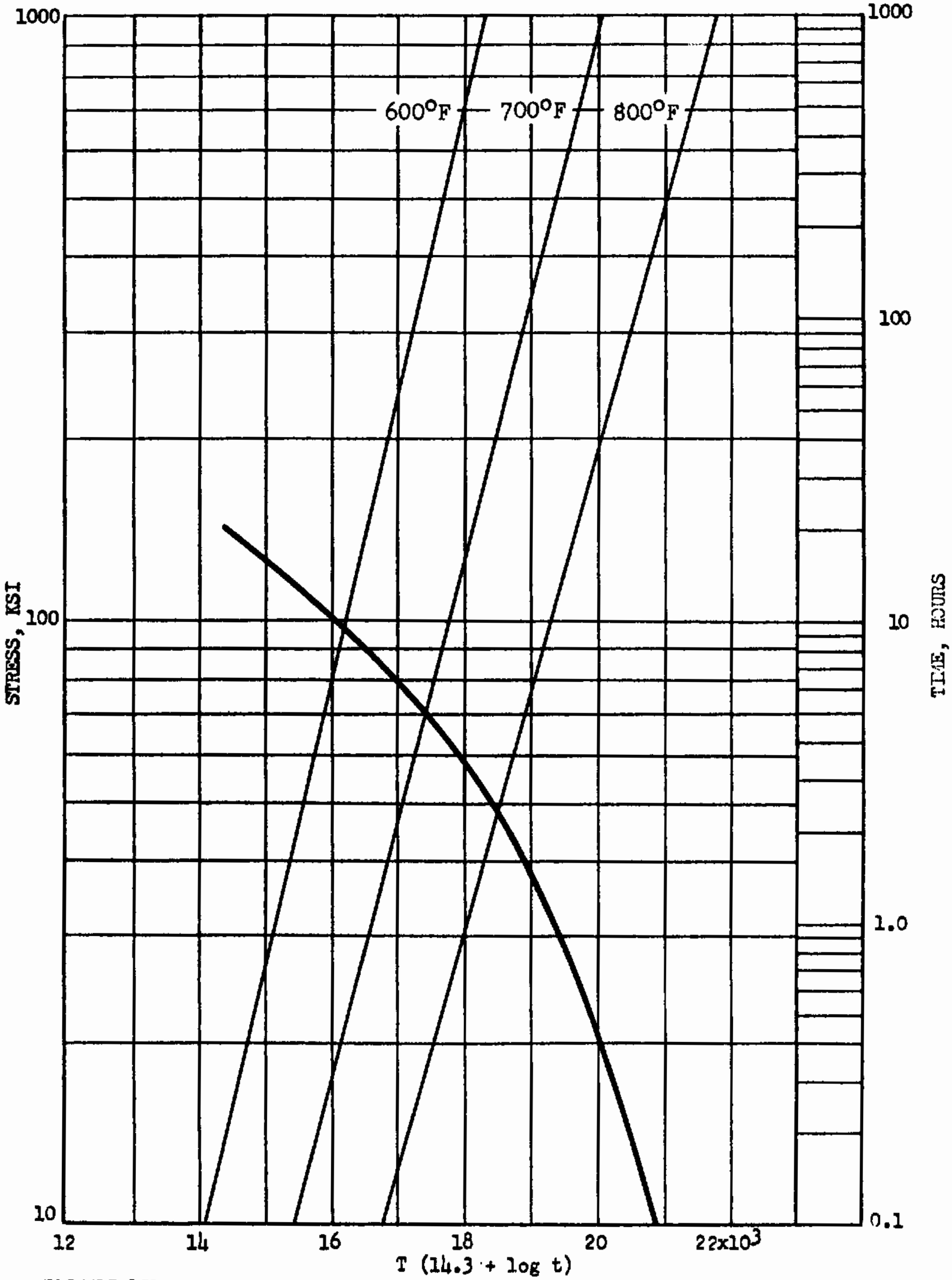


FIGURE 351 - MASTER 0.05 PERCENT CREEP STRAIN CURVE FOR 4Al-3Mo-1V SOLUTION TREATED AND AGED TITANIUM ALLOY (0.063 INCH THICK SHEET).

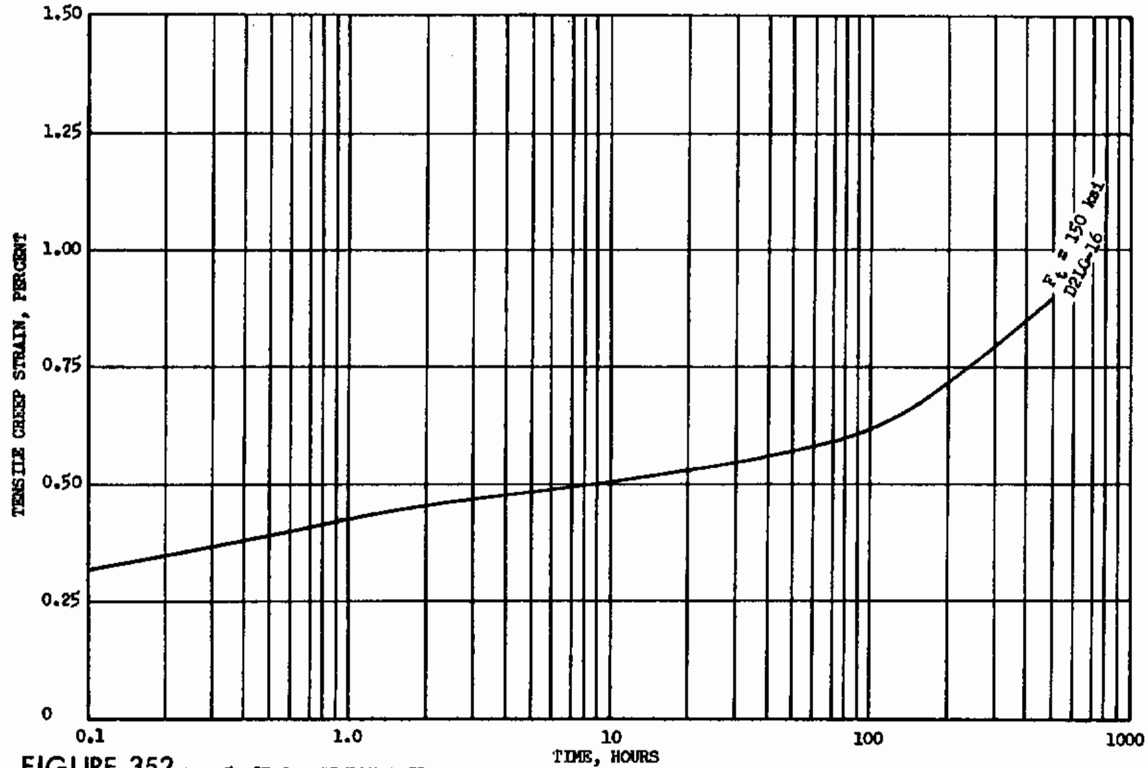


FIGURE 352 - 500°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. P7653)

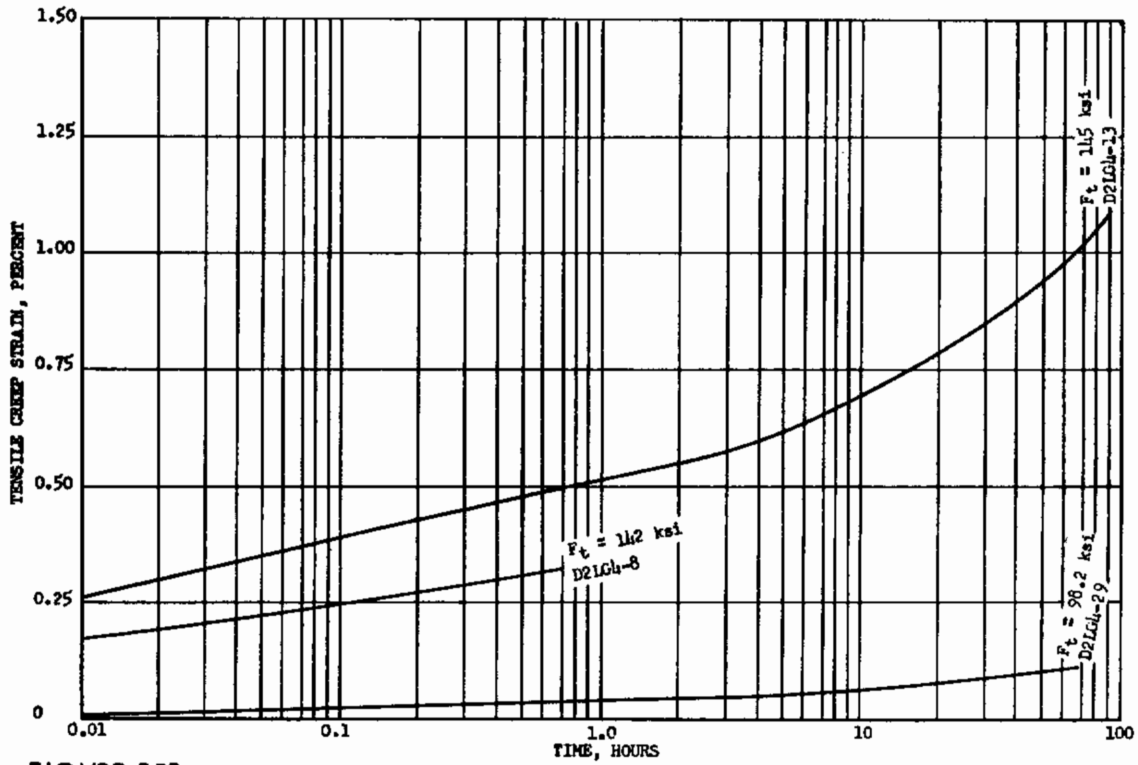


FIGURE 353 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. P7653)

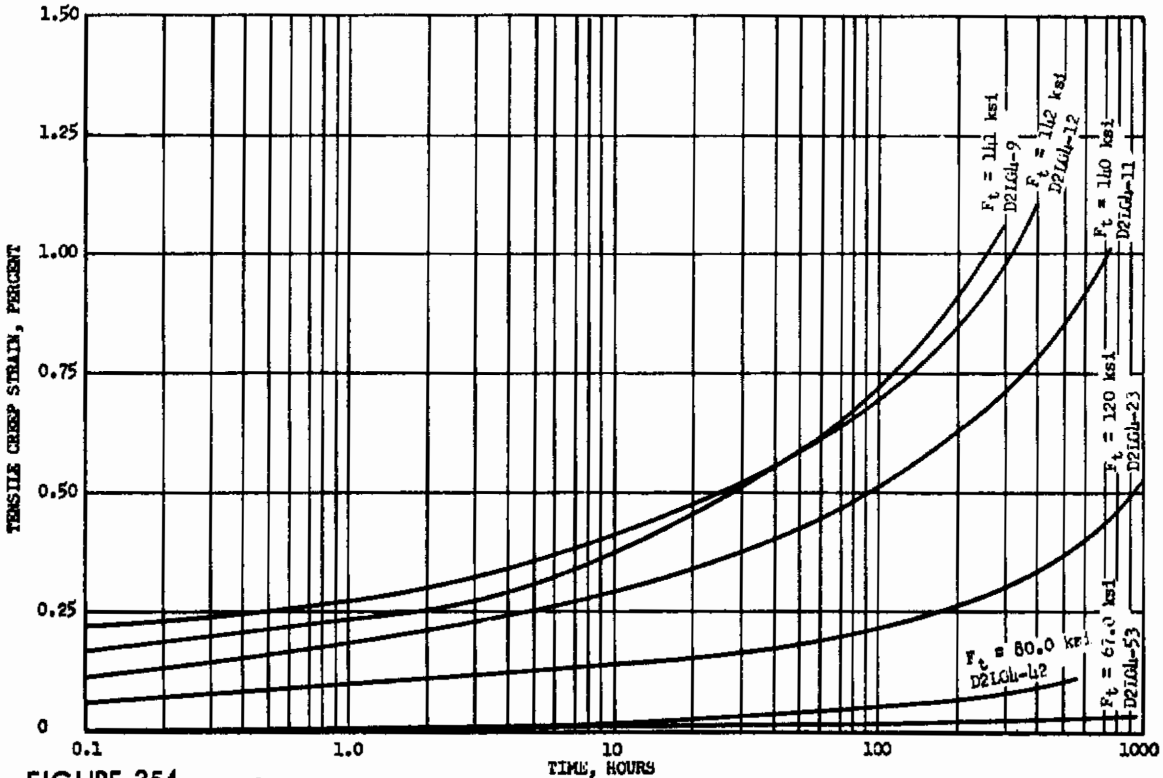


FIGURE 354 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. P7653)

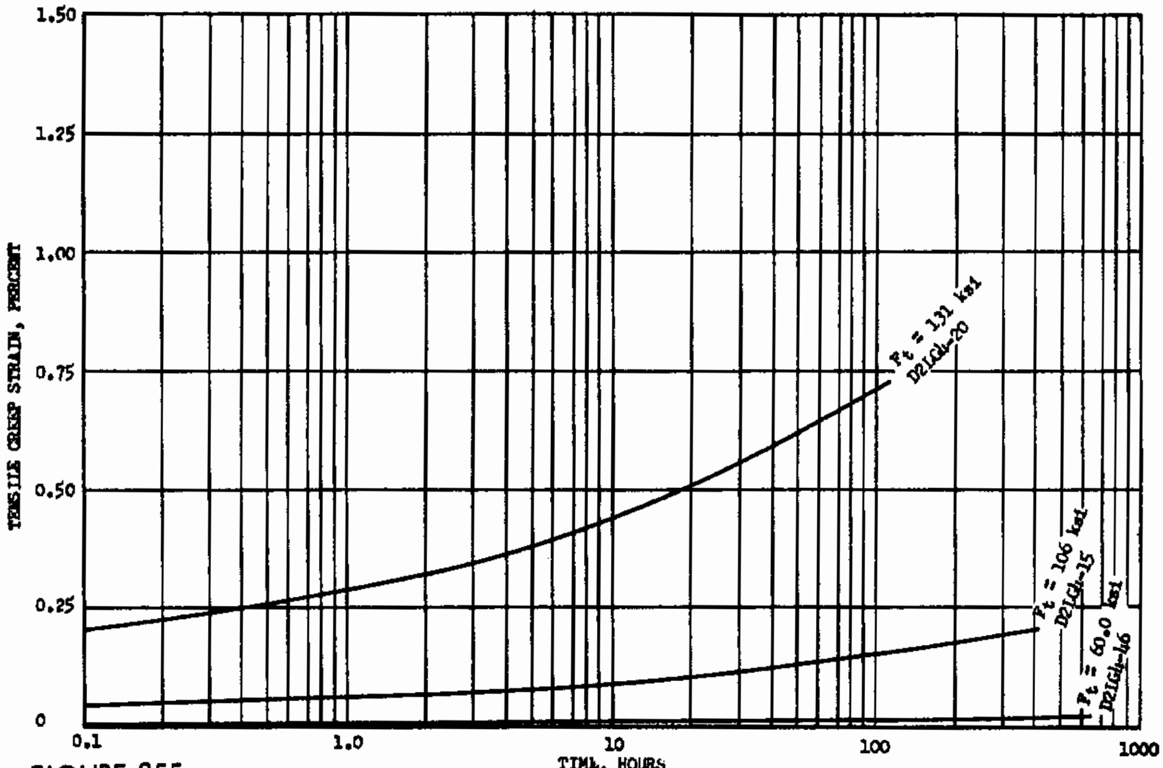


FIGURE 355 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. P7653)

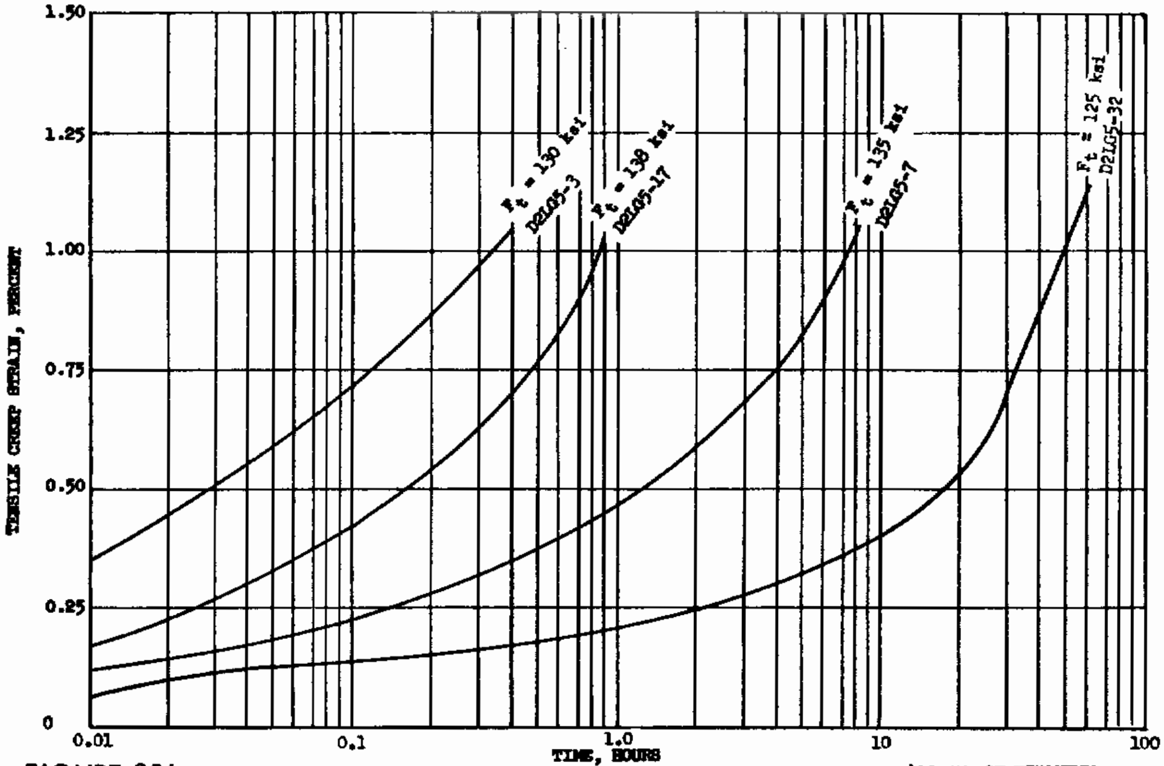


FIGURE 356 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NUMBER P7653)

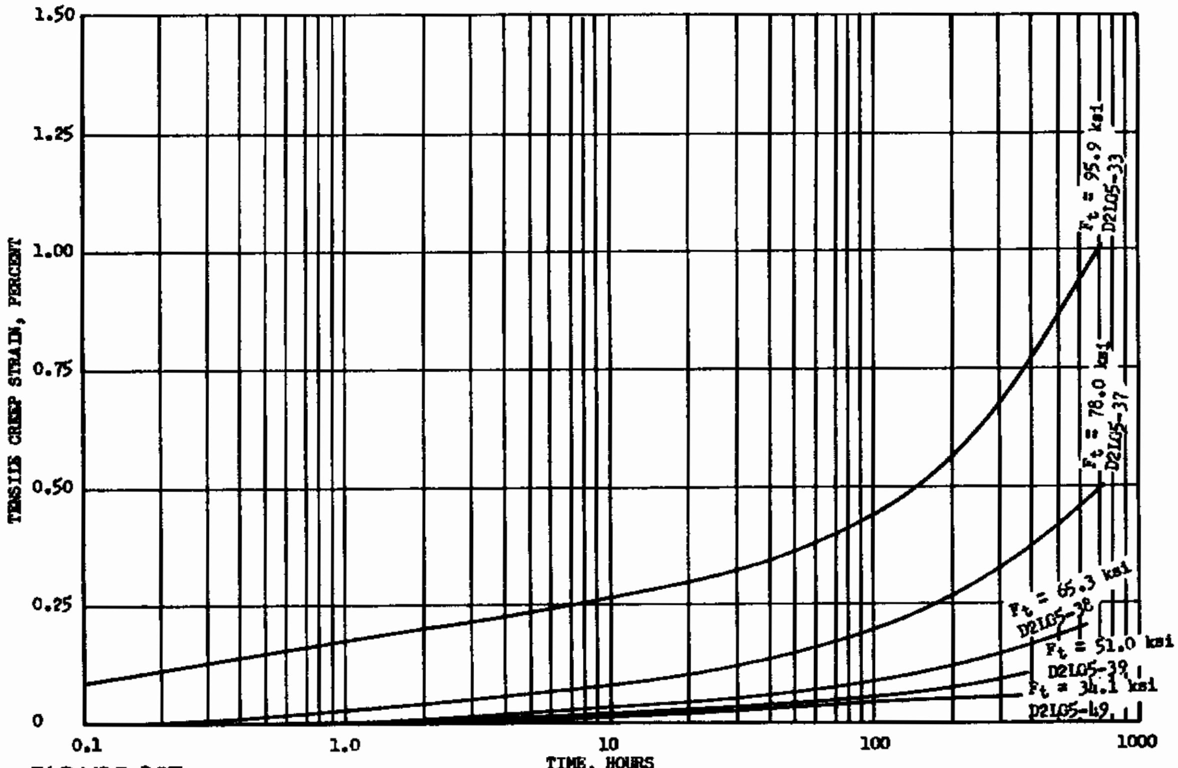


FIGURE 357 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. P7653)

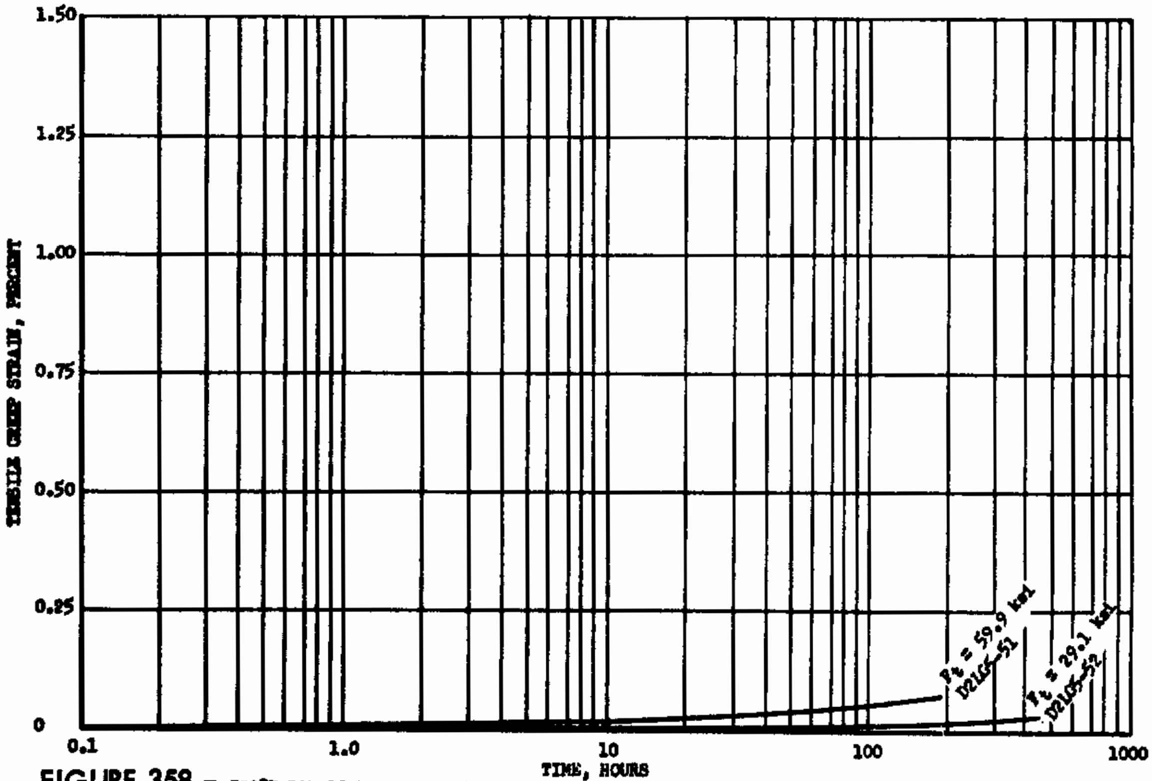


FIGURE 358 – 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. P7653)

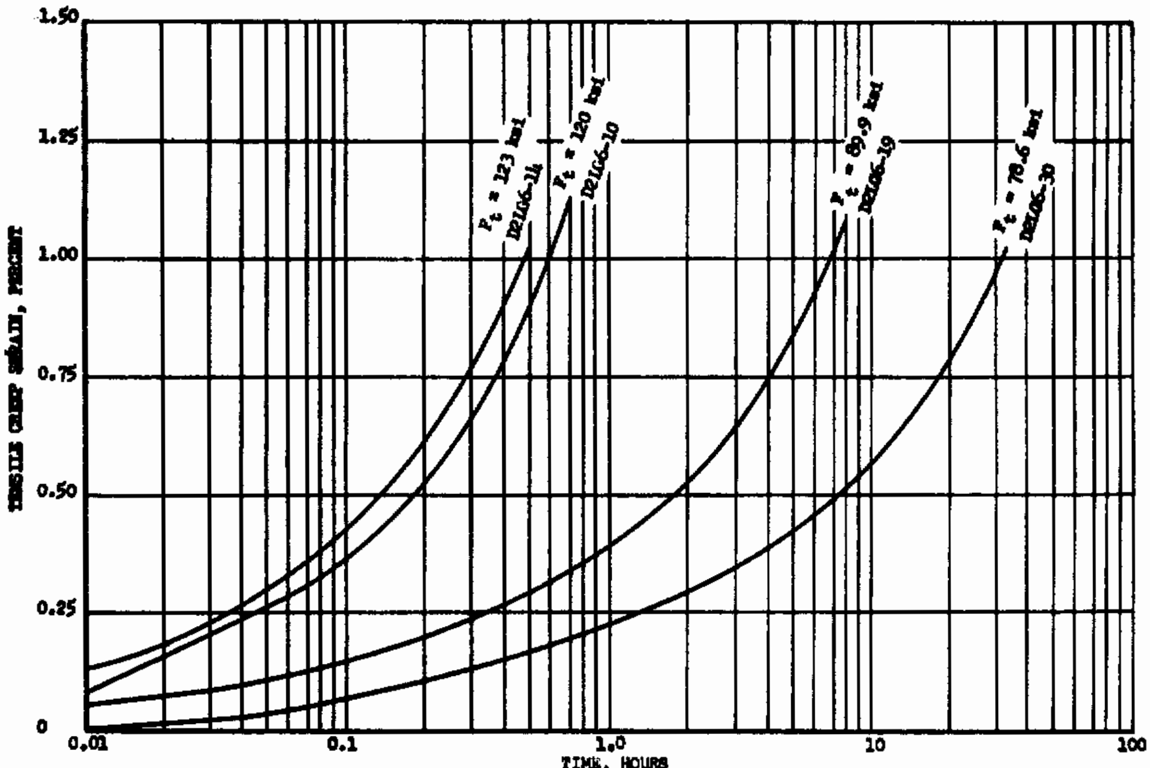


FIGURE 359 – 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. P7653)

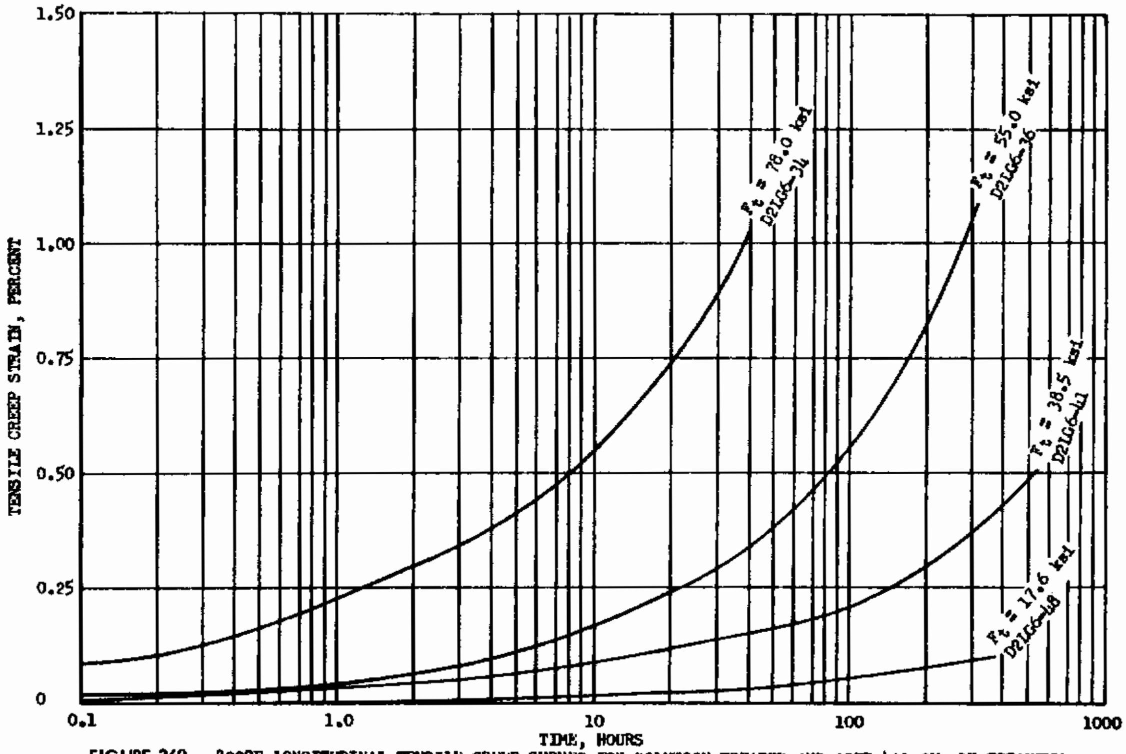


FIGURE 360 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. P7653)

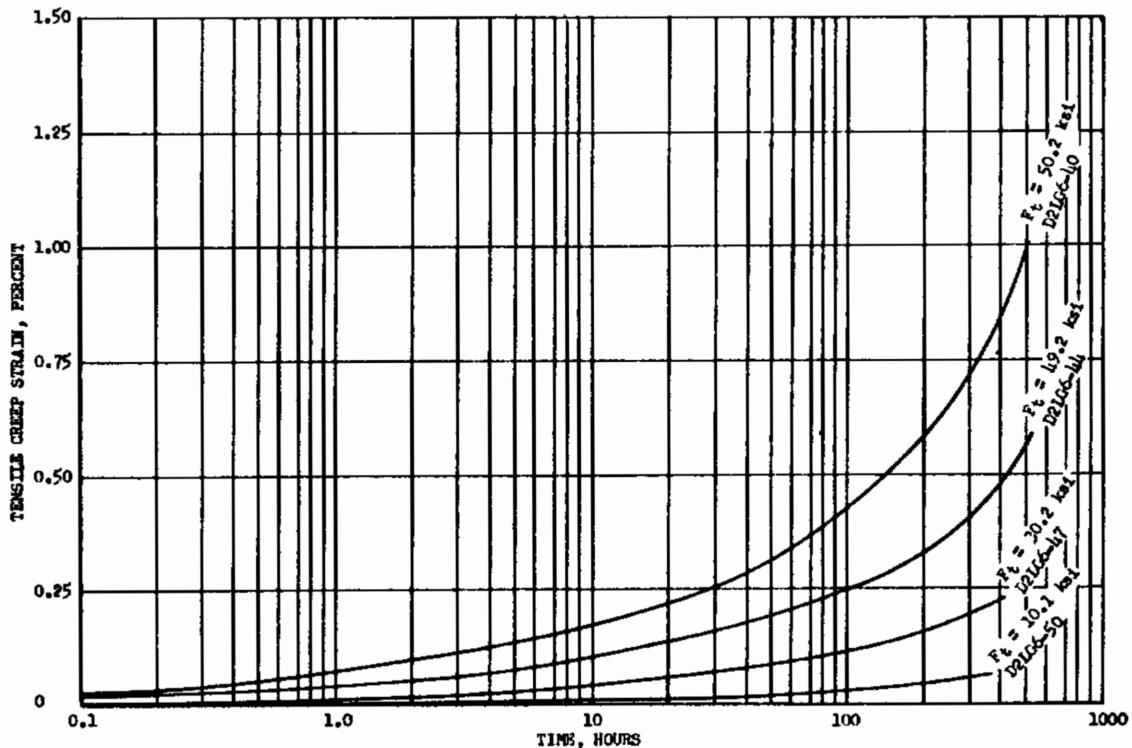


FIGURE 361 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. P7653)

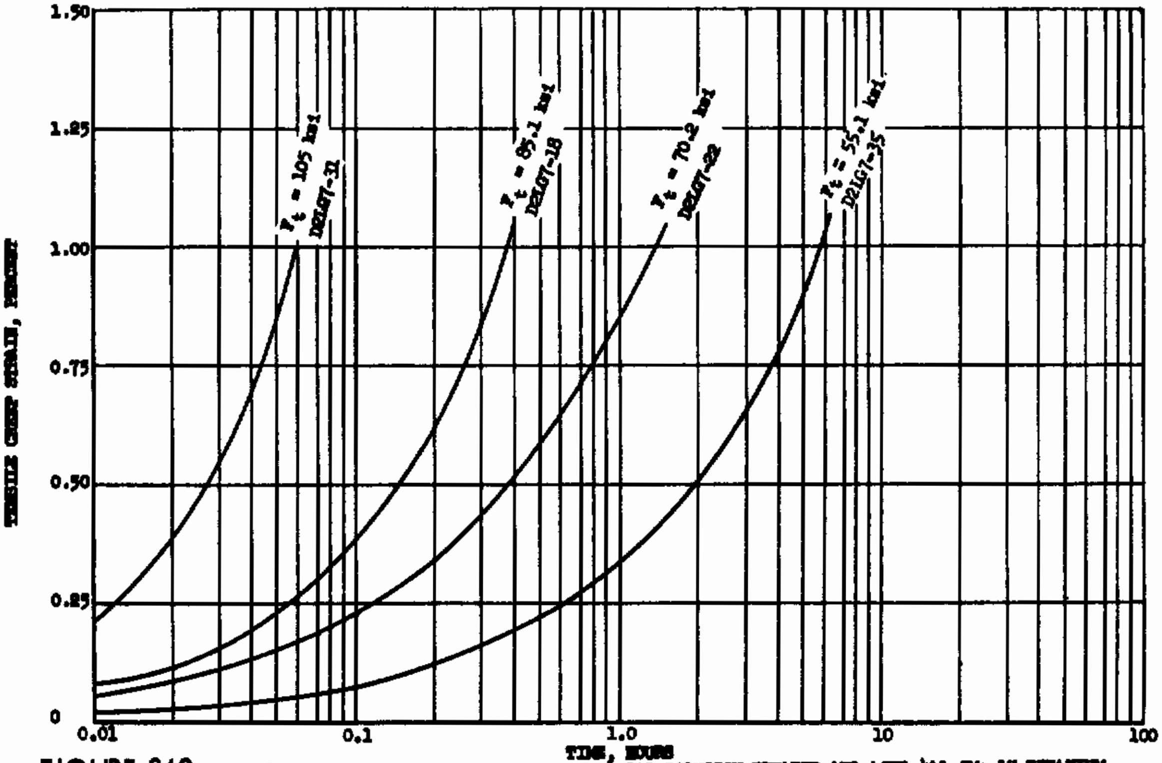


FIGURE 362 - 900°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NUMBER P7653)

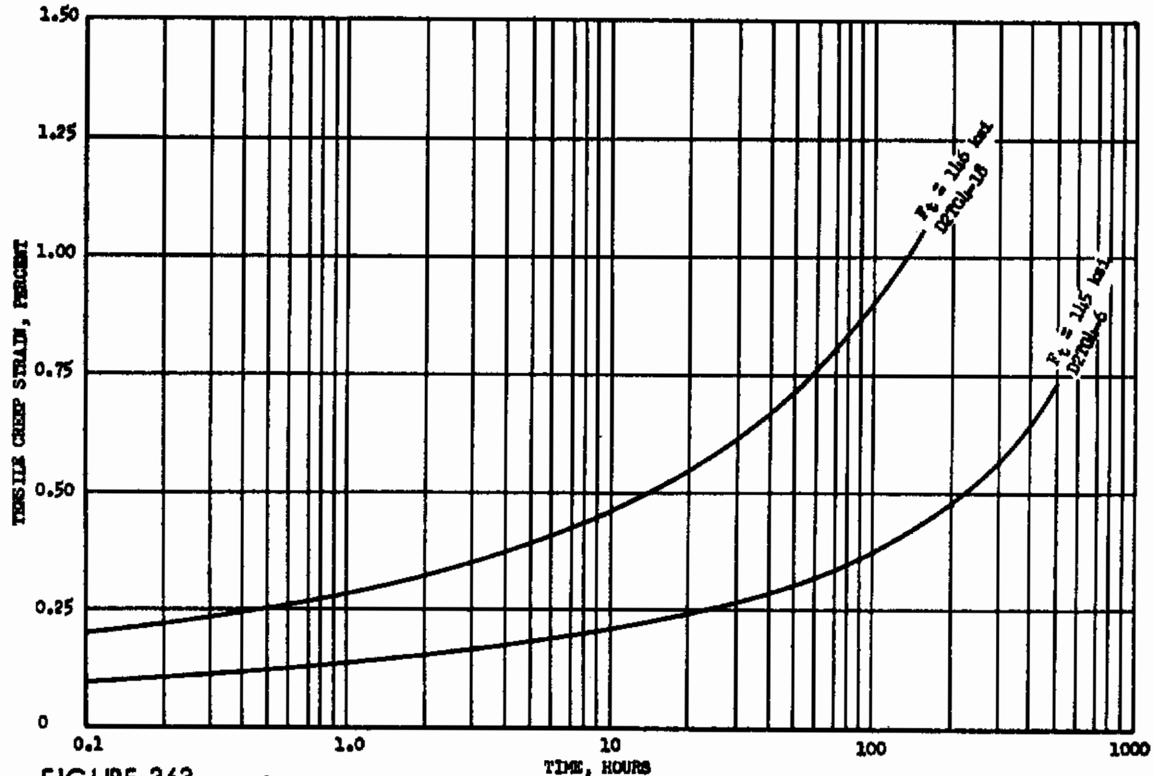


FIGURE 363 - 600°F TRANSVERSE TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. P7653)

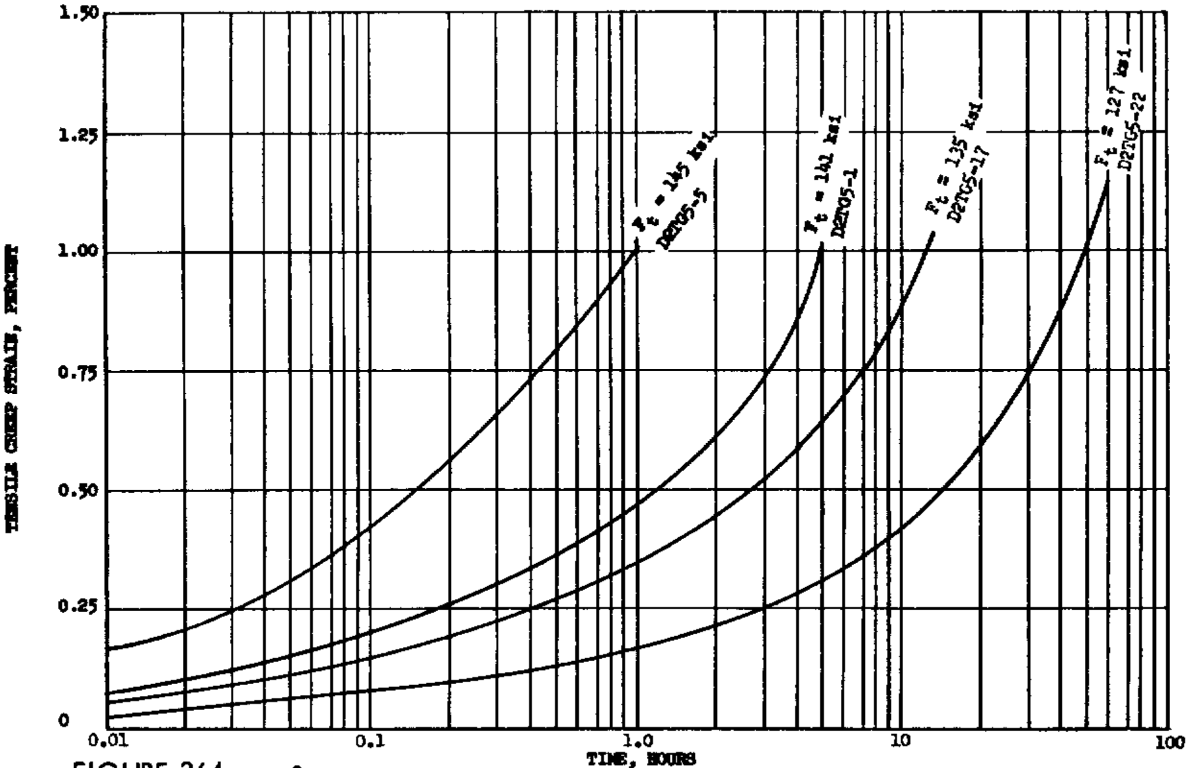


FIGURE 364 - 700°F TRANSVERSE TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NUMBER P7653)

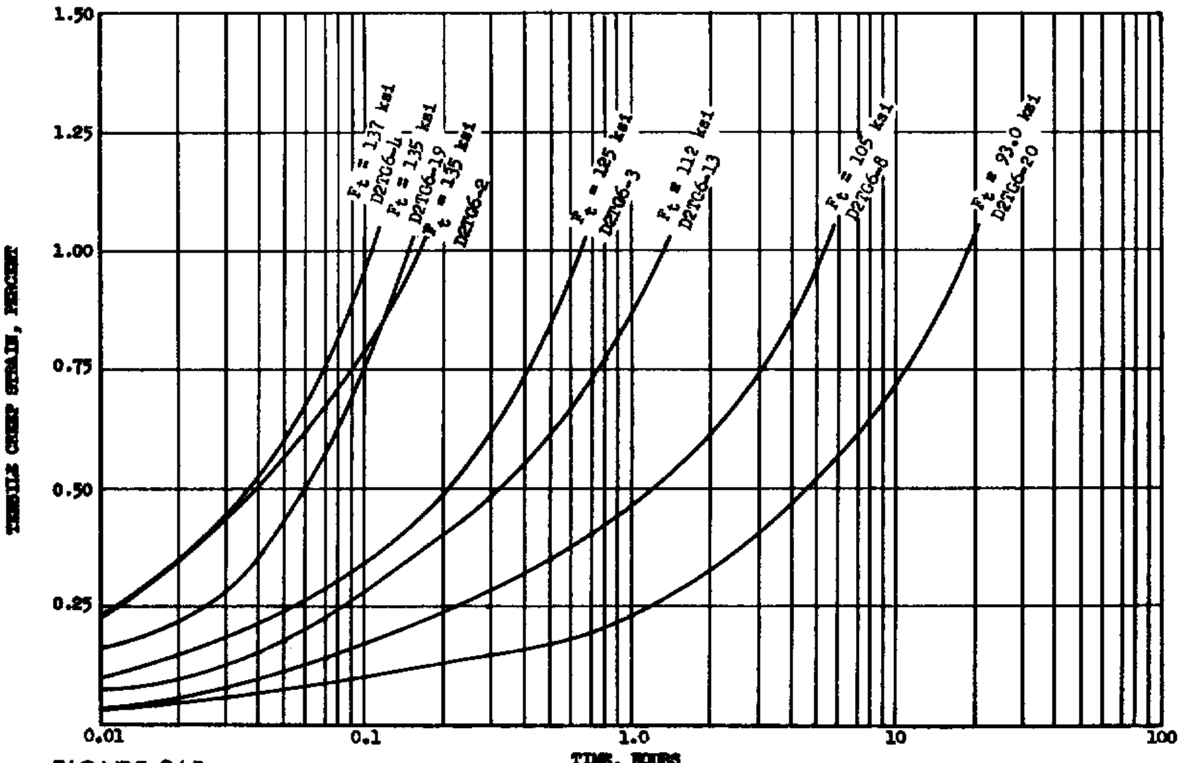


FIGURE 365 - 800°F TRANSVERSE TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NUMBER P7653)

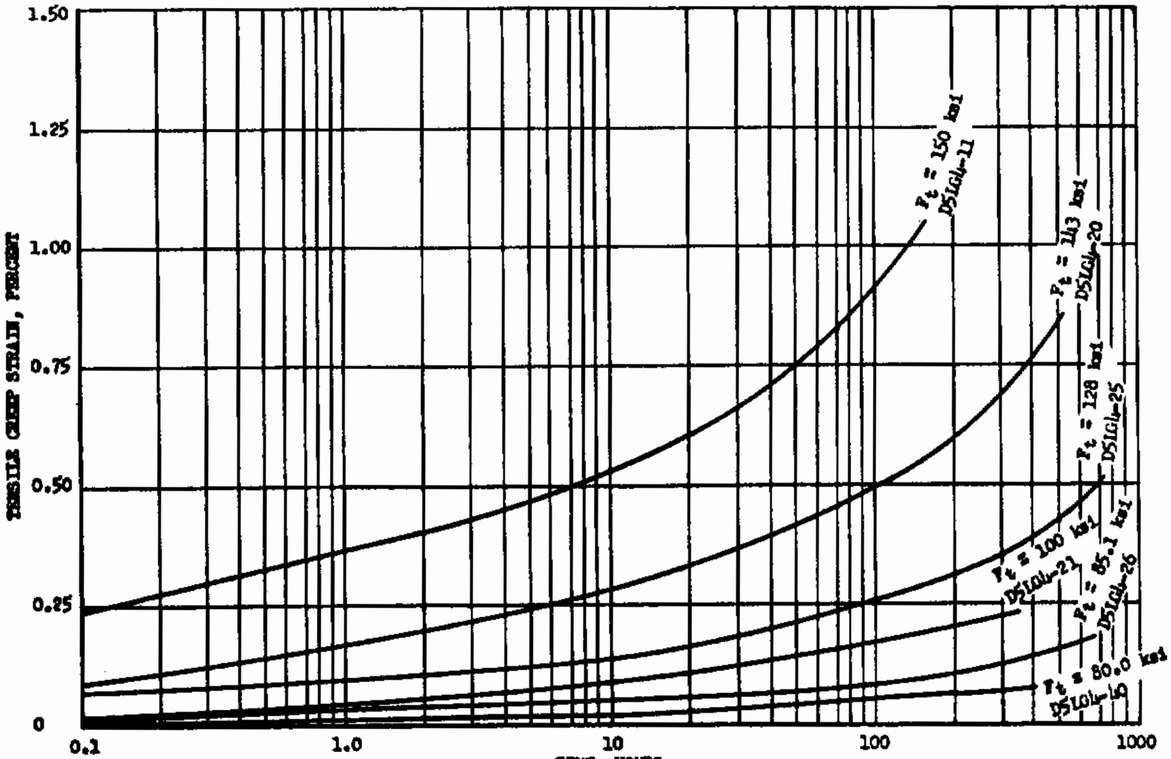


FIGURE 366 – 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. R4765)

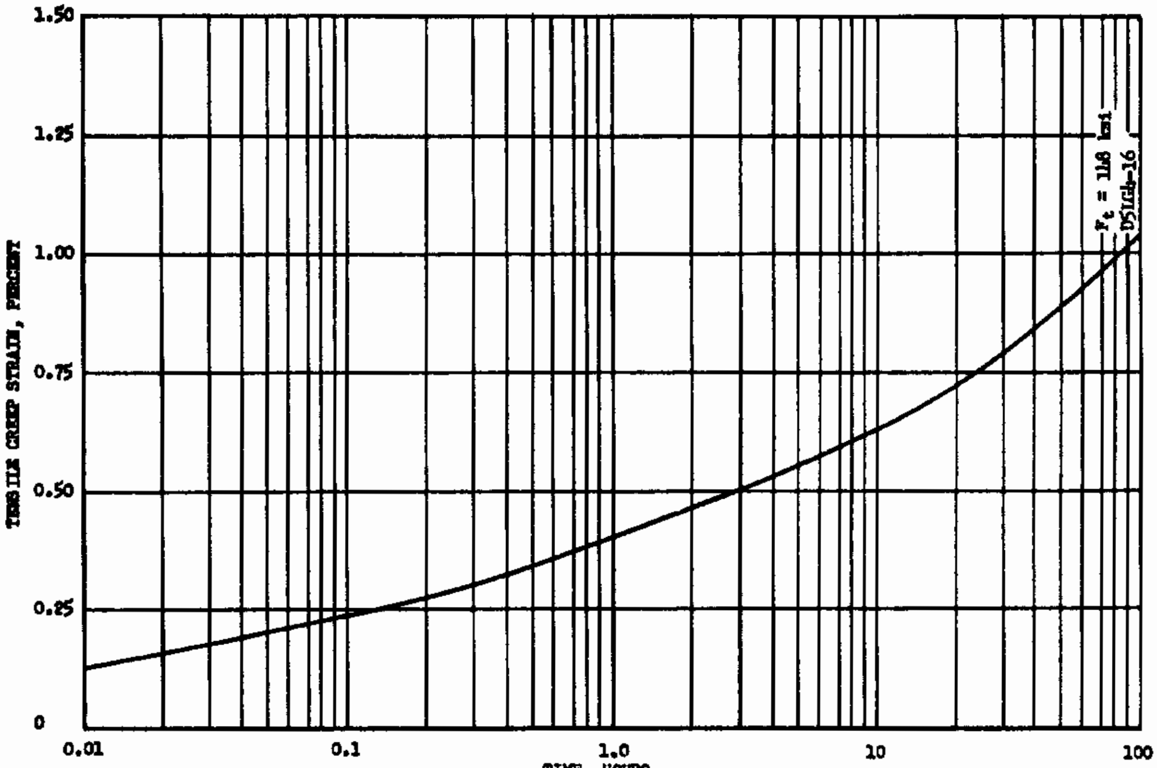


FIGURE 367 – 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. R4765)

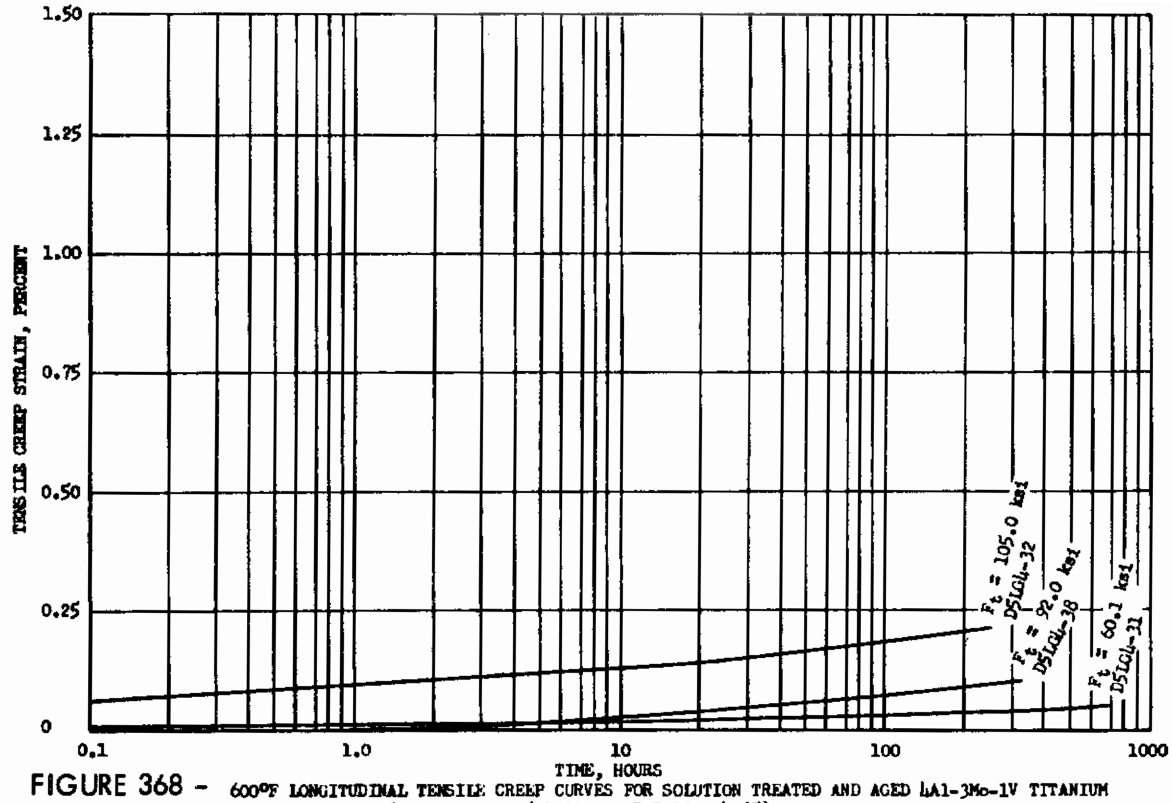


FIGURE 368 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. R4765)

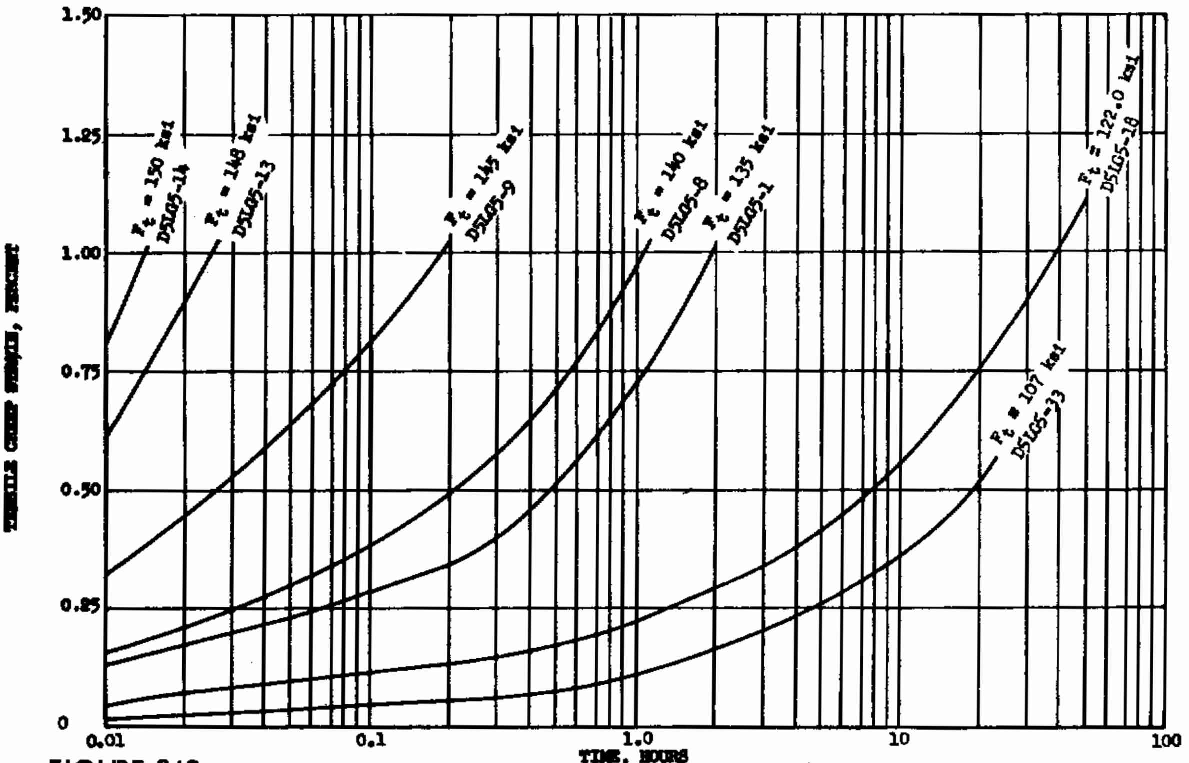


FIGURE 369 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NUMBER R4765)

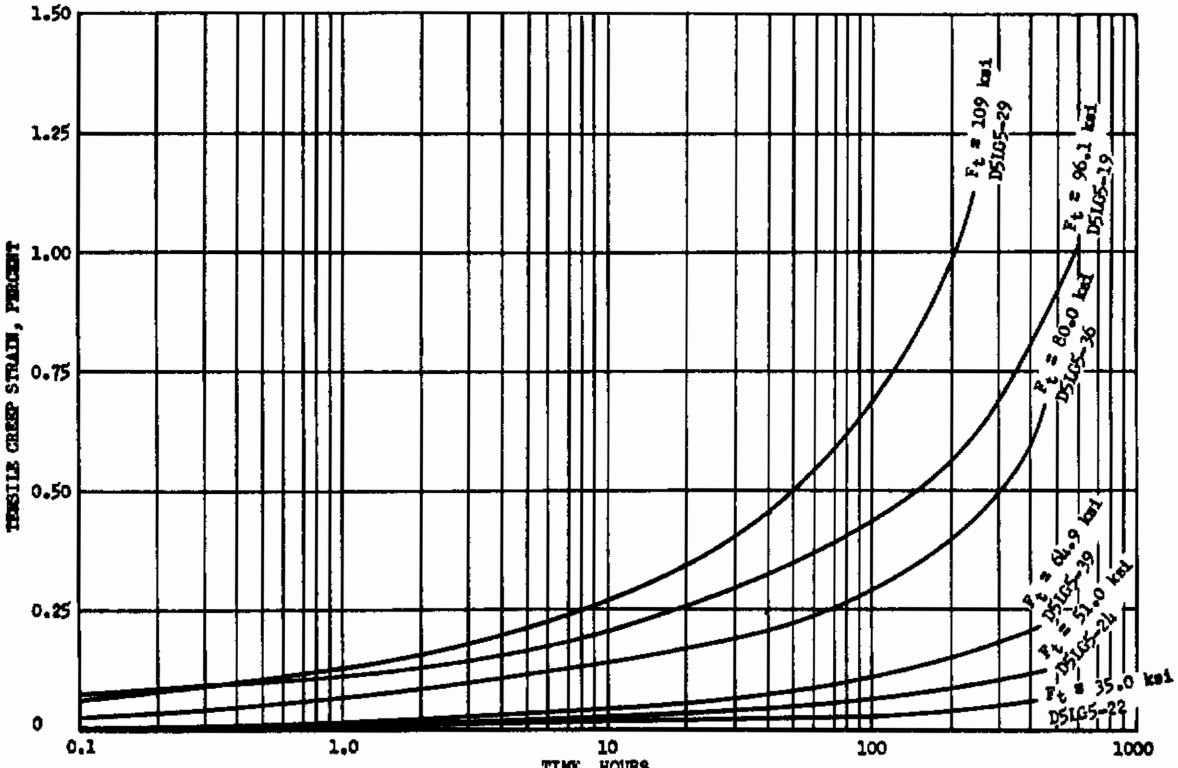


FIGURE 370 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. R4765)

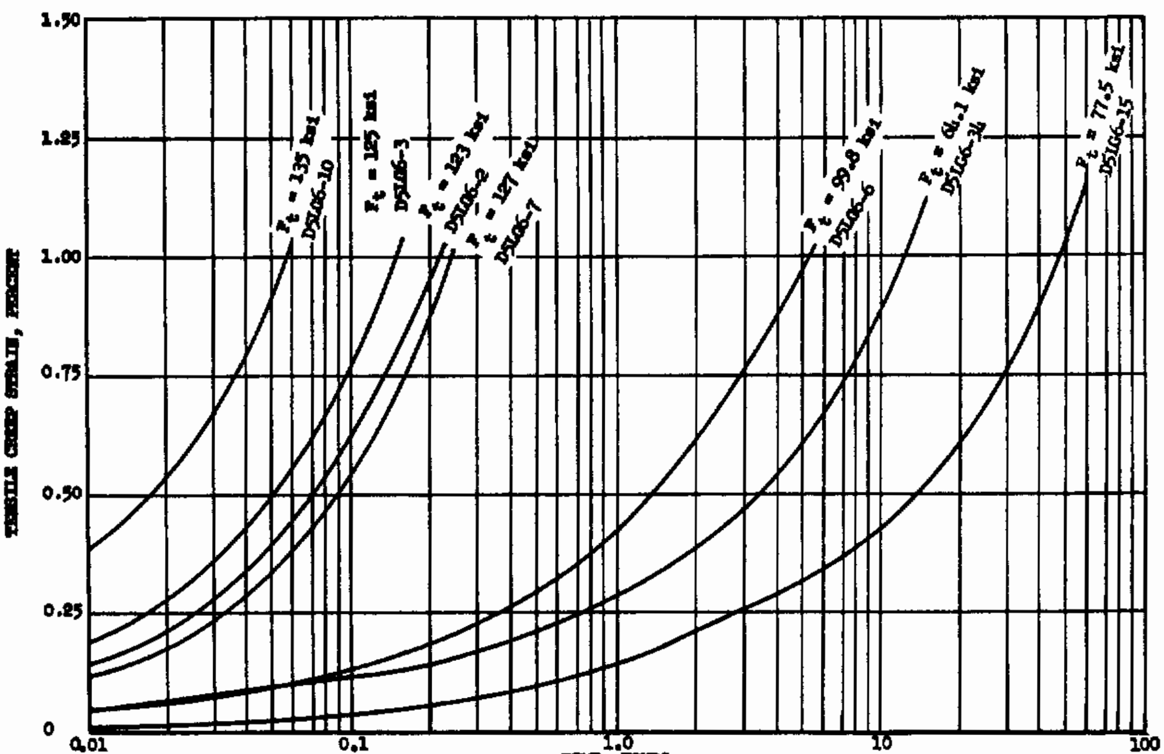


FIGURE 371 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NUMBER R4765)

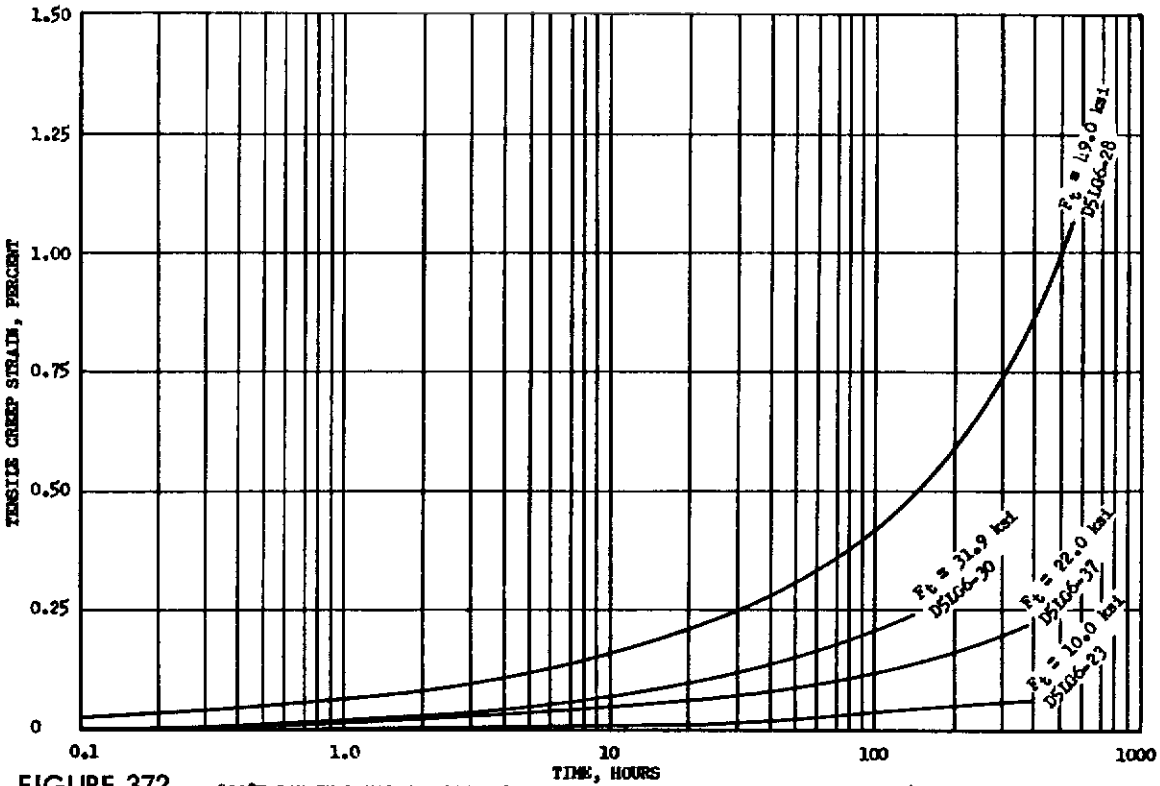


FIGURE 372 – 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. R4765)

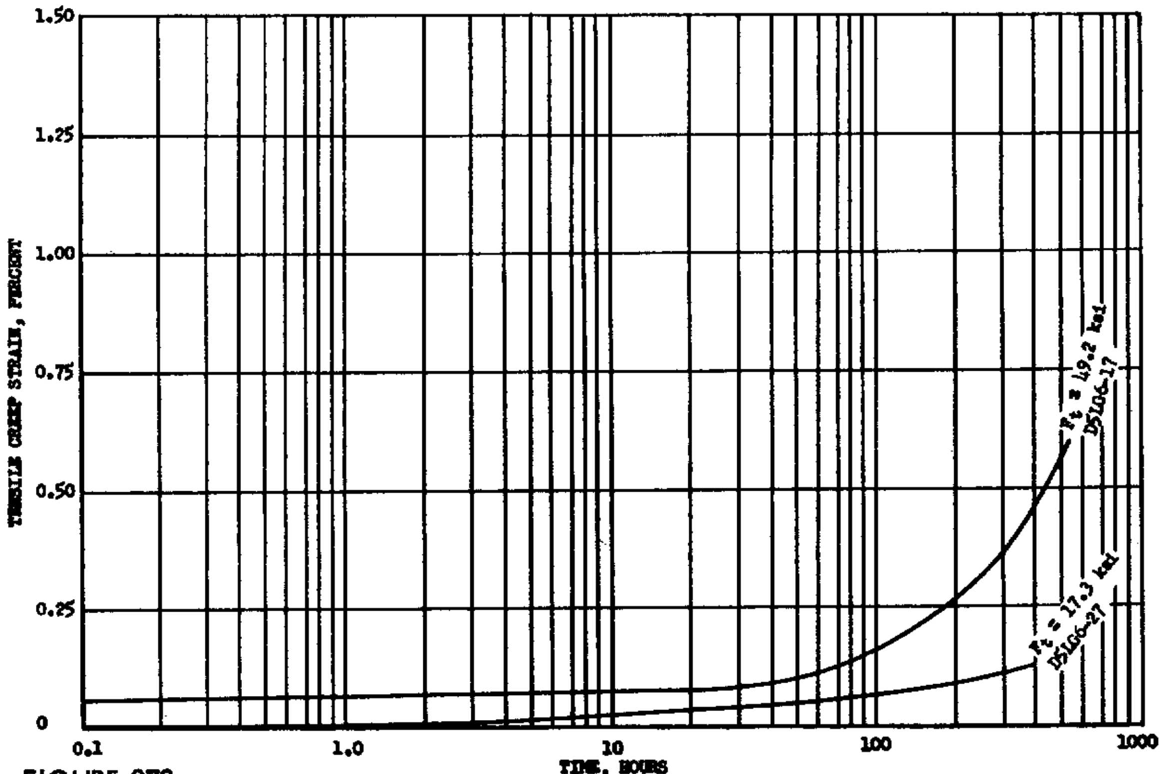


FIGURE 373 – 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. R4765)

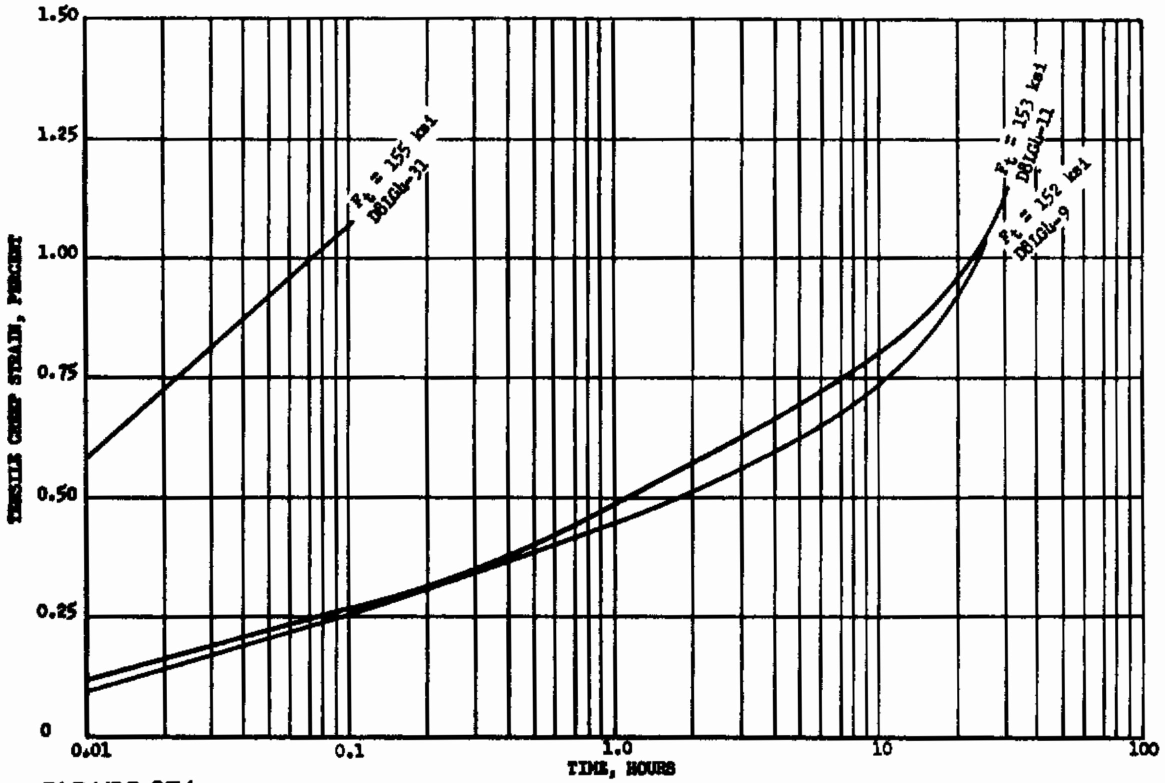


FIGURE 374 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. R4815)

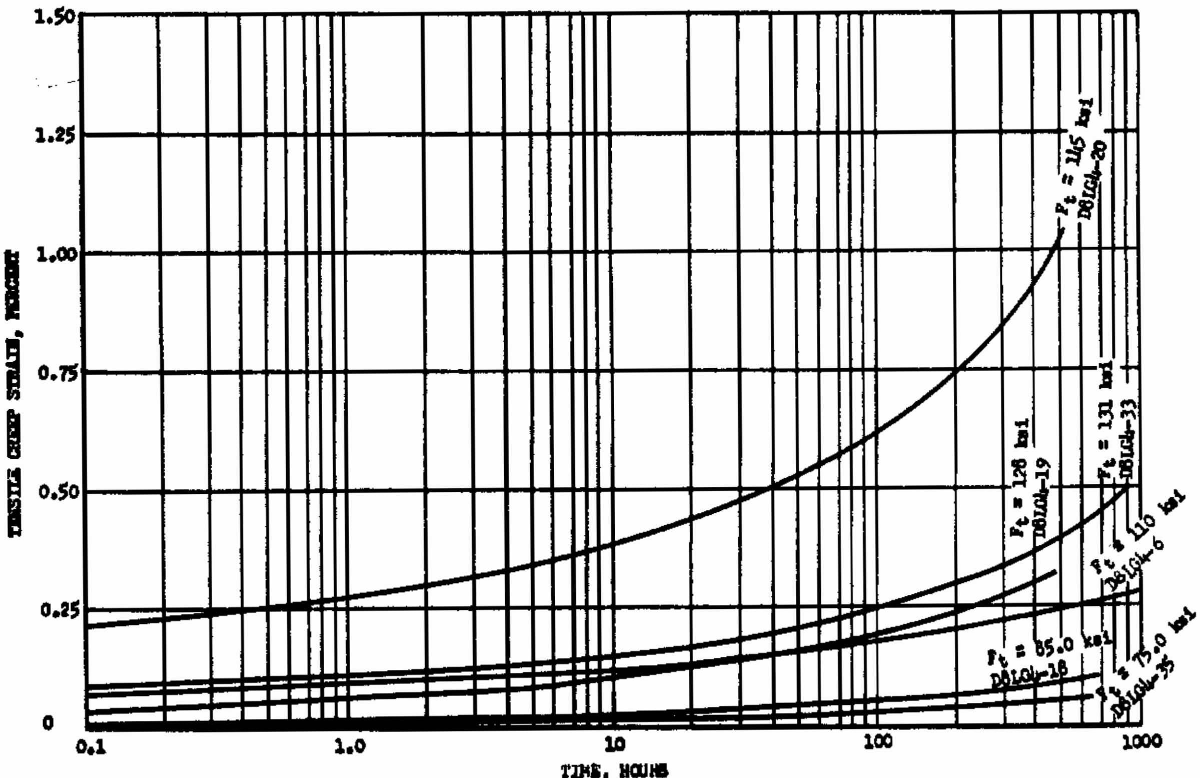


FIGURE 375 - 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. R4815)

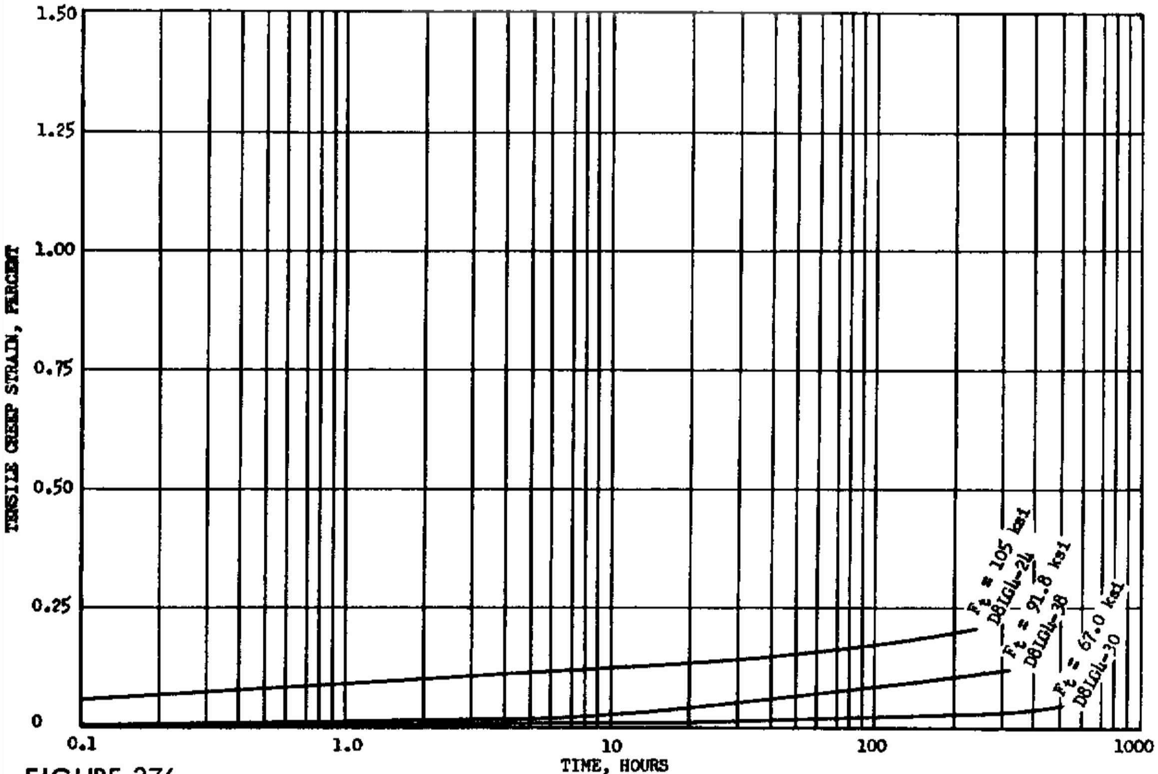


FIGURE 376 – 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. R4815)

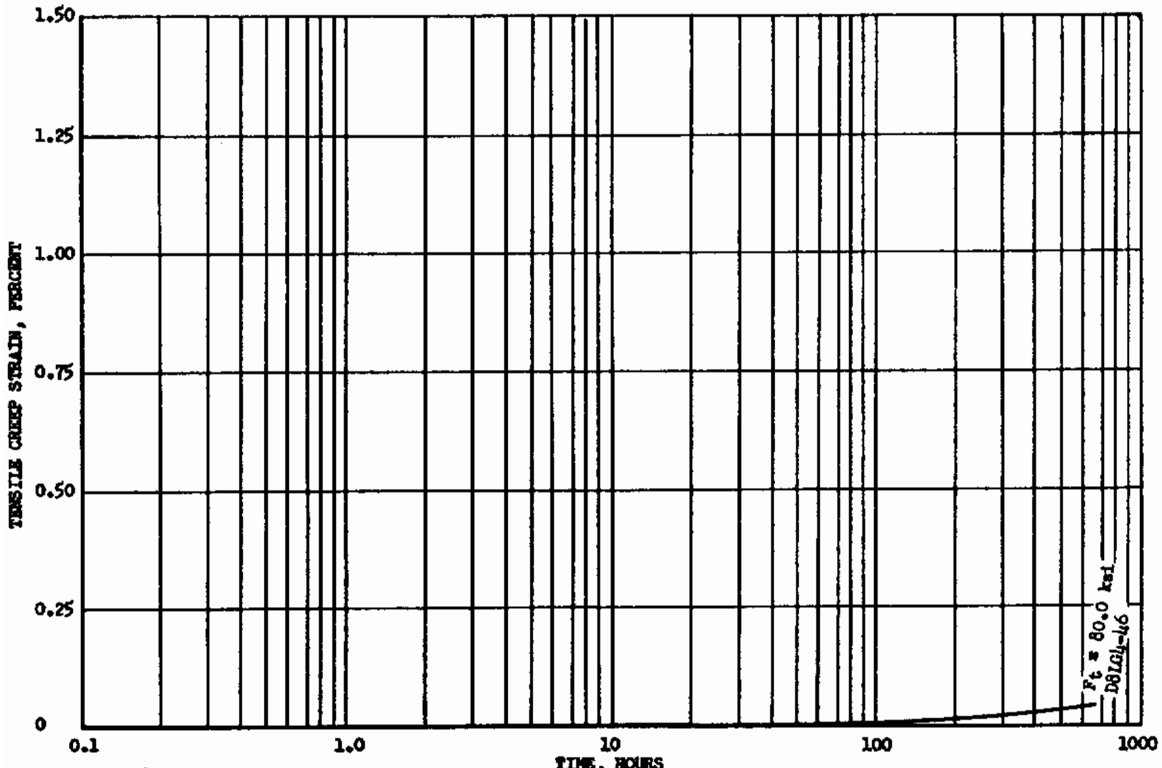


FIGURE 377 – 600°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. R4815)

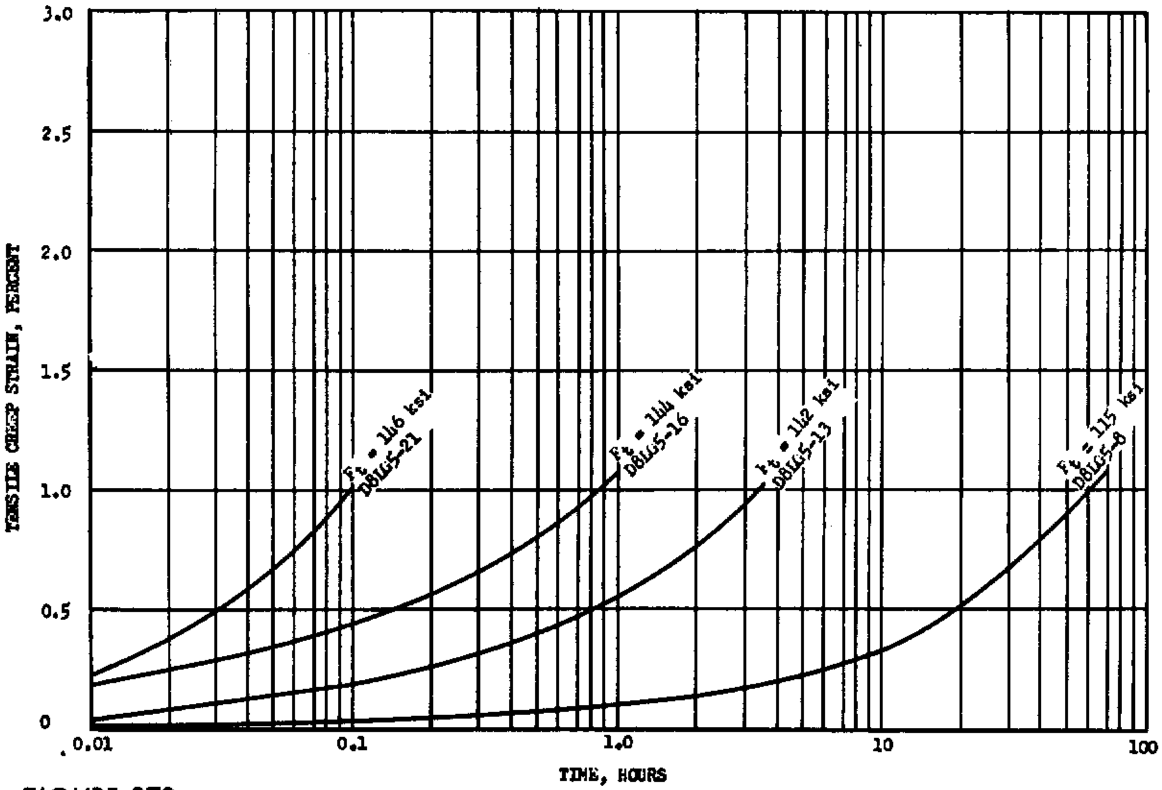


FIGURE 378 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. R4815)

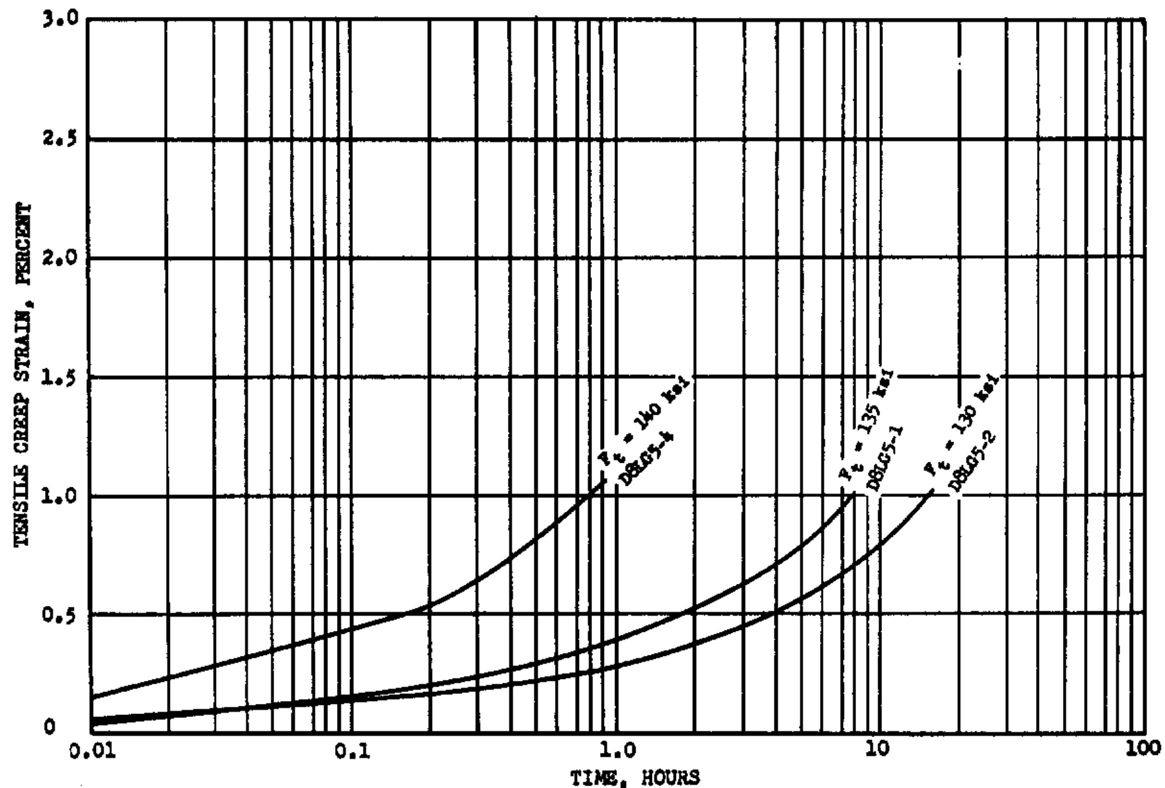


FIGURE 379 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NUMBER R4815)

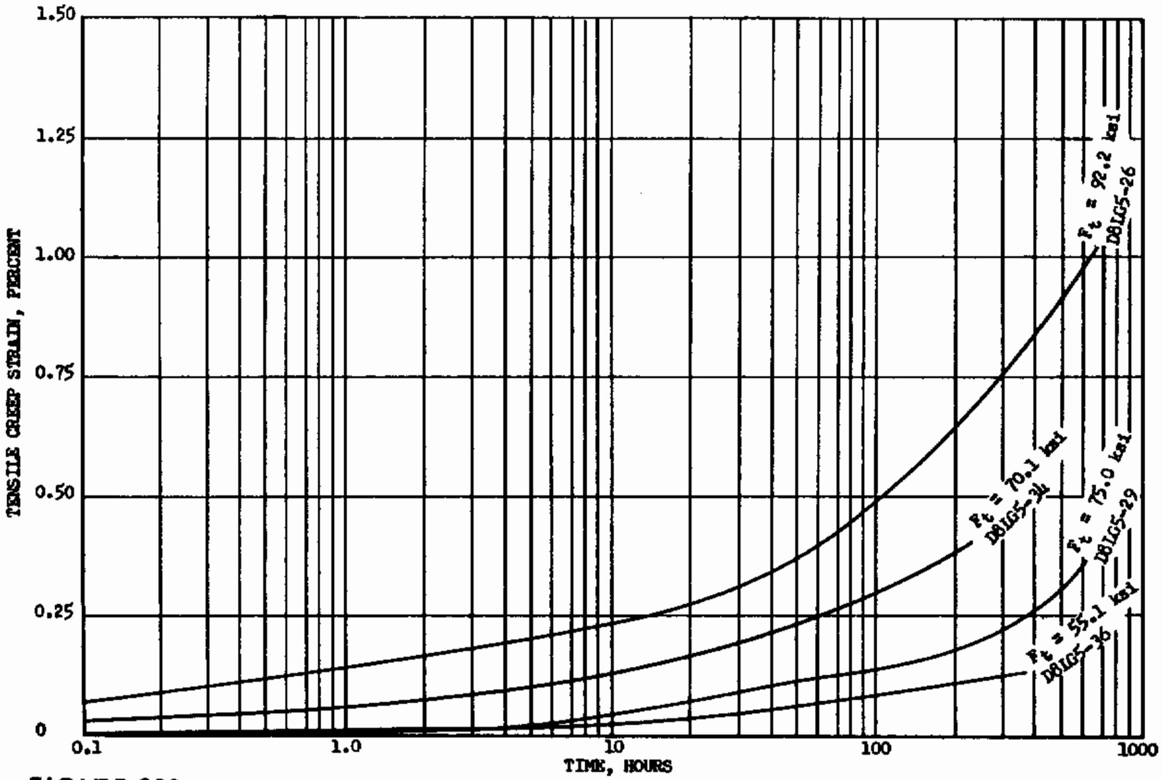


FIGURE 380 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. R4815)

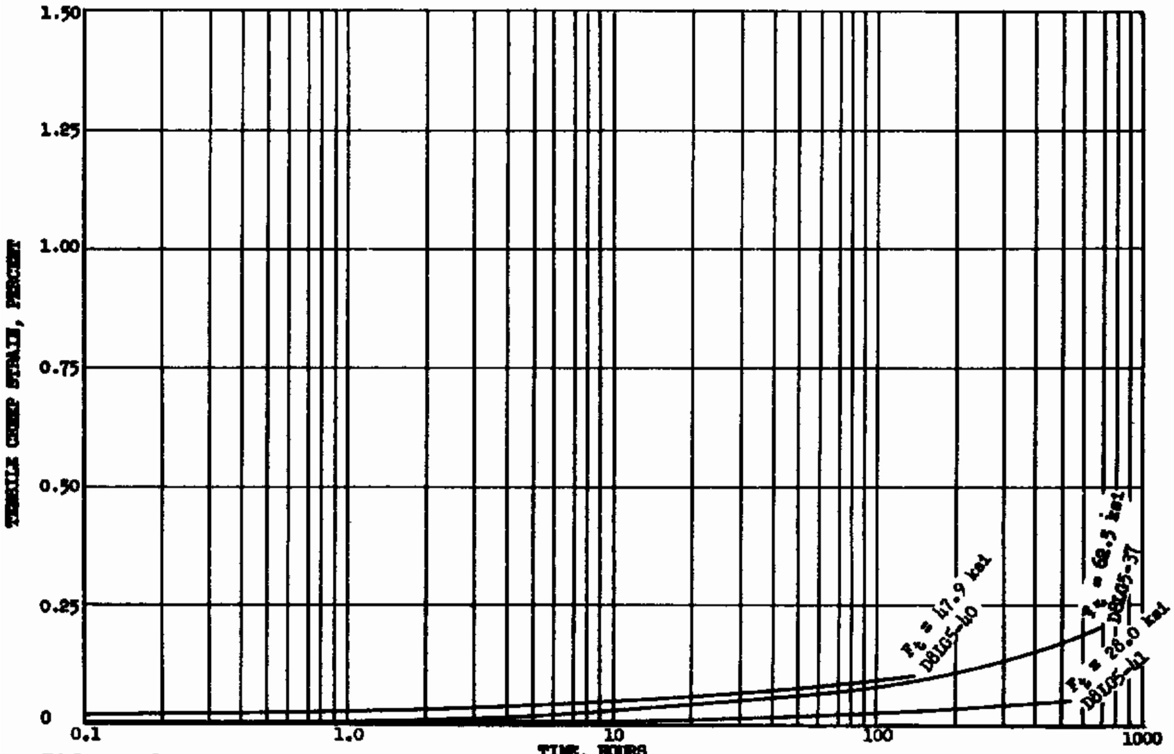


FIGURE 381 - 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. R4815)

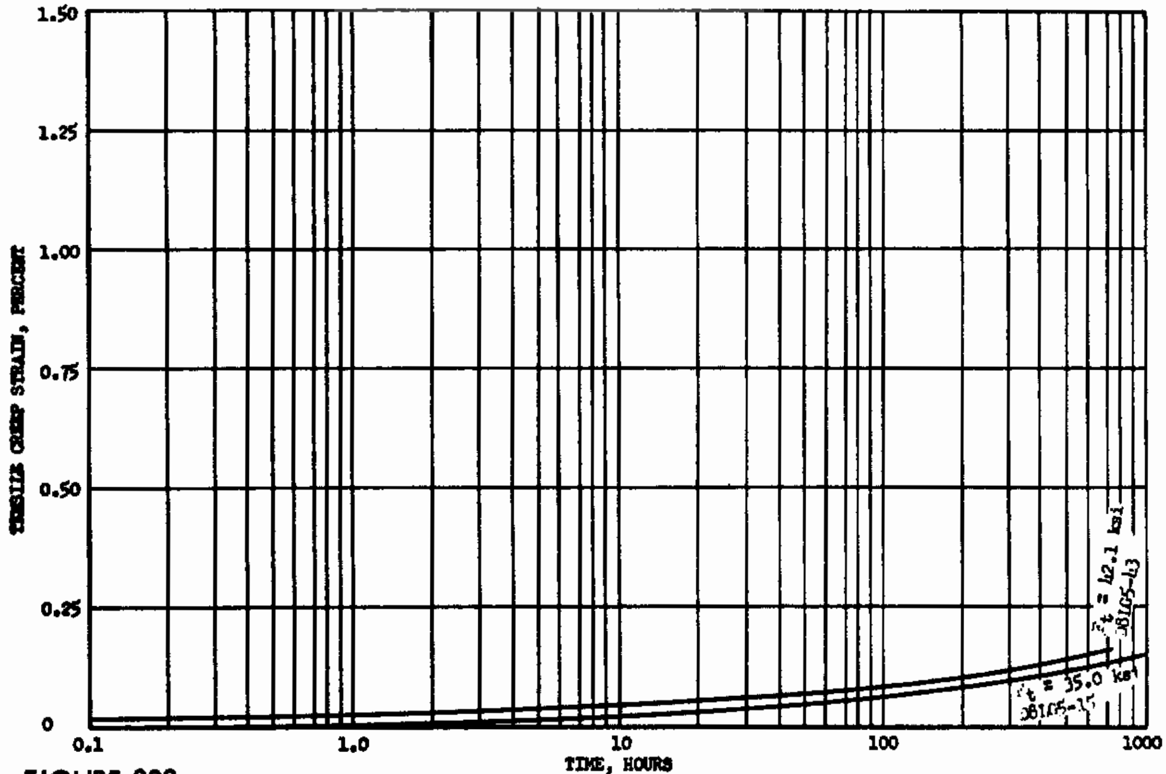


FIGURE 382 – 700°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. R4815)

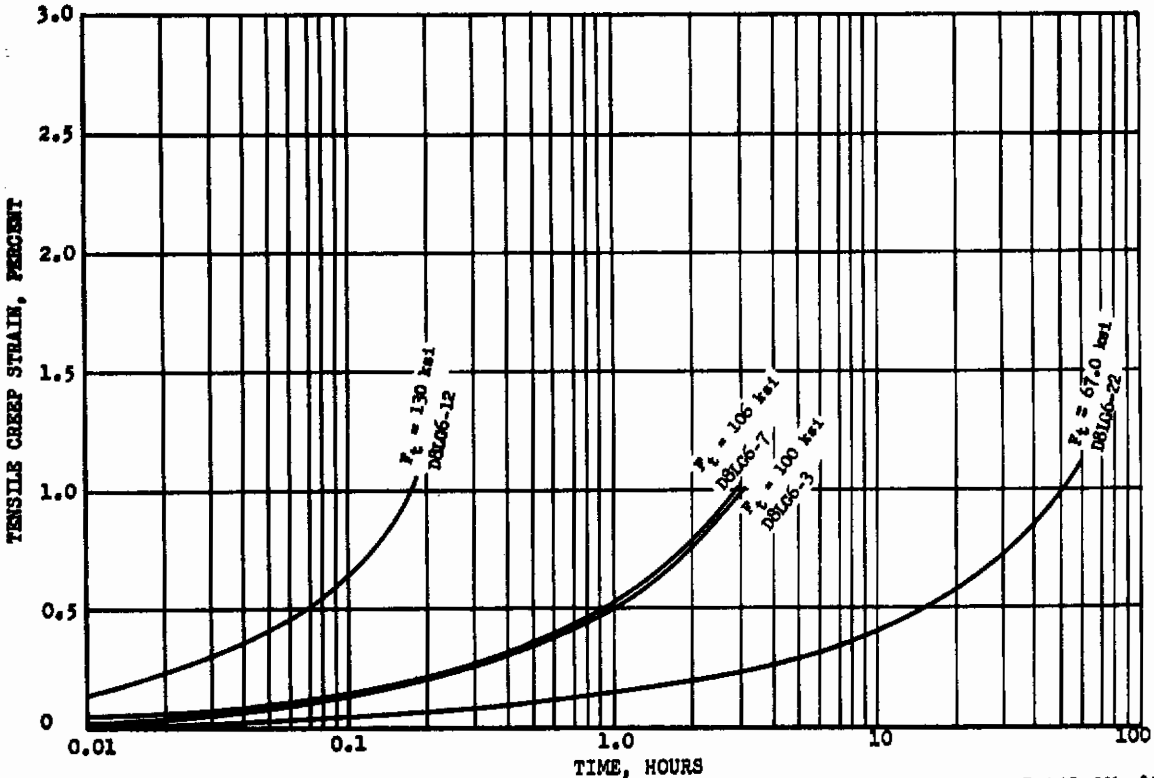


FIGURE 383 – 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NUMBER R4815)

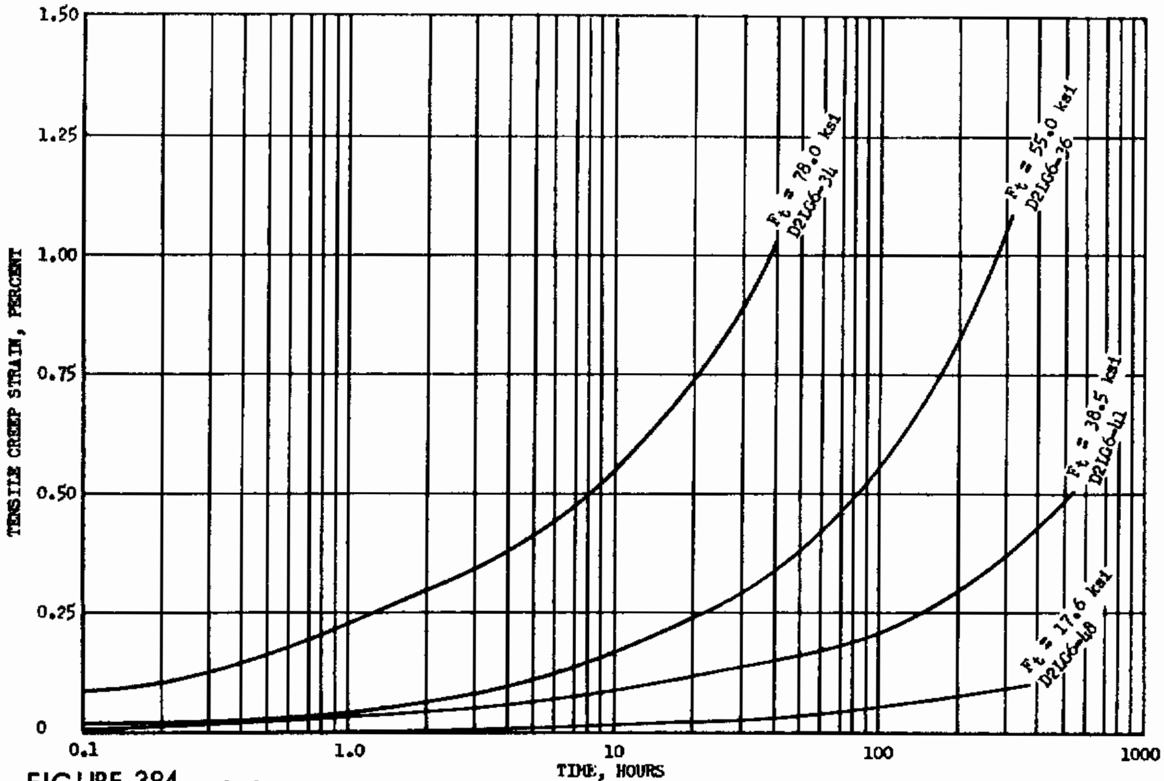


FIGURE 384 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. P7653)

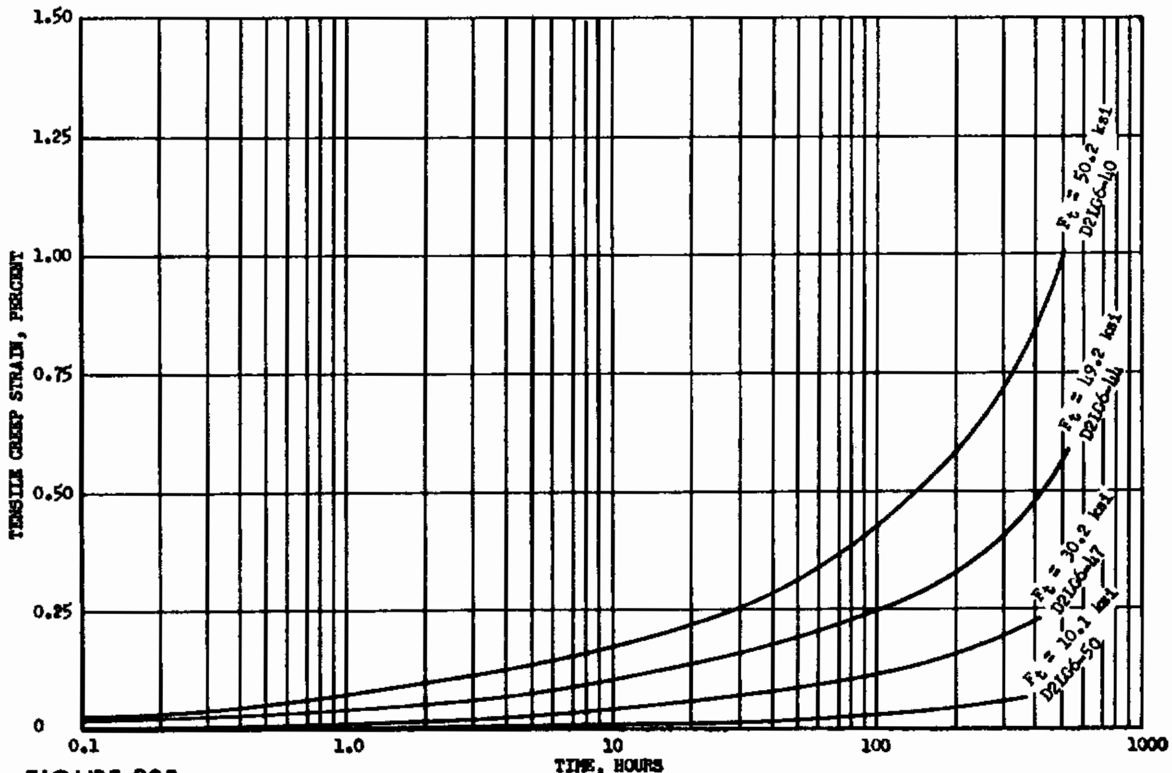


FIGURE 385 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. P7653)

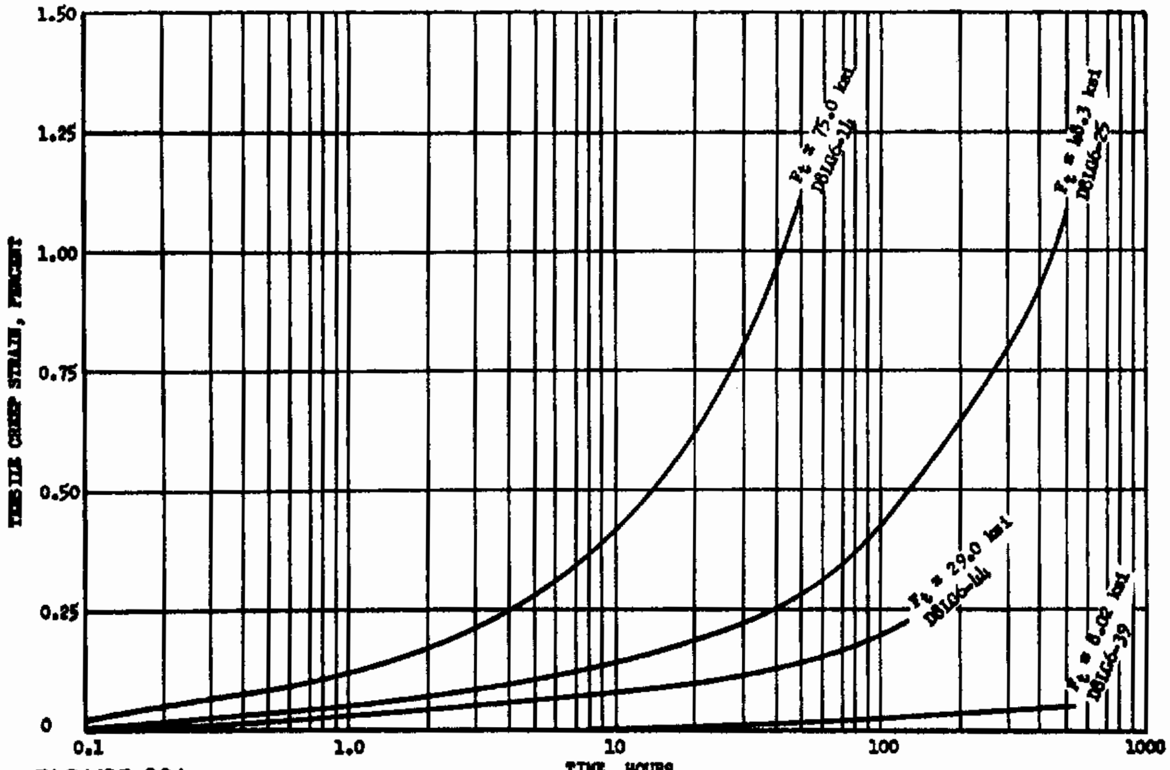


FIGURE 386 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NO. R4815)

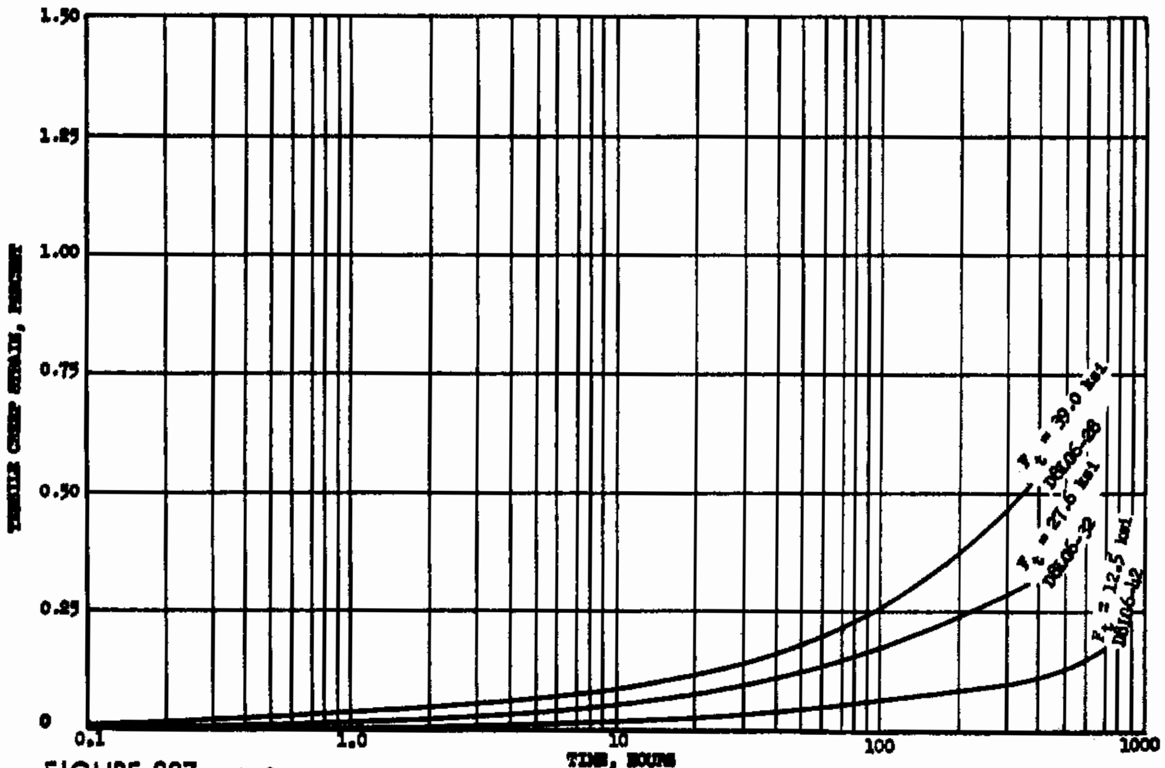


FIGURE 387 - 800°F LONGITUDINAL TENSILE CREEP CURVES FOR SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET, 0.063 INCH THICK (CRUCIBLE HEAT NUMBER R4815)

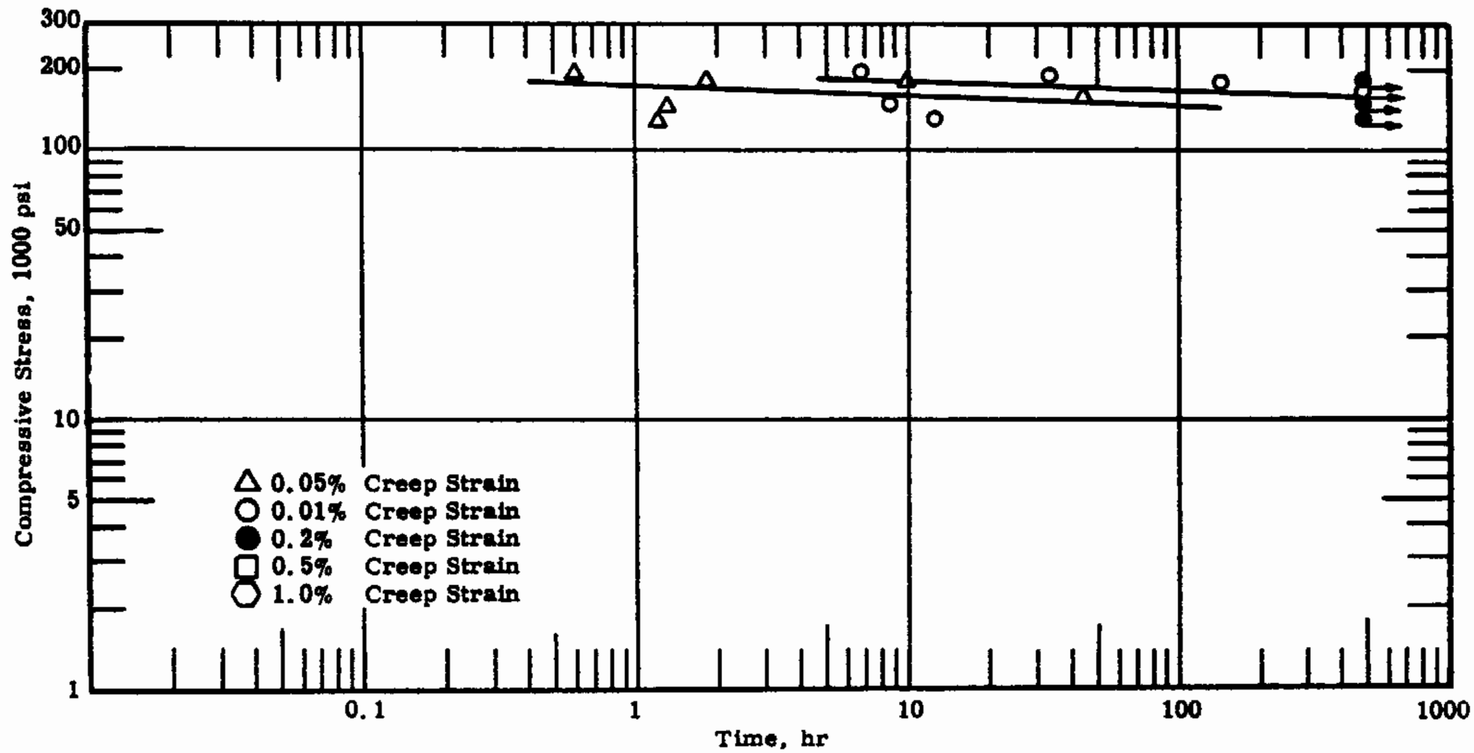


FIGURE 388 - Ti—4.0 Al—3 Mo—1 V ALLOY SHEET (Heat No. P7653)[1]—Time required for various amounts of compressive creep at 600° F and at various compressive stresses. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
All specimens were heated to test temperature in 2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

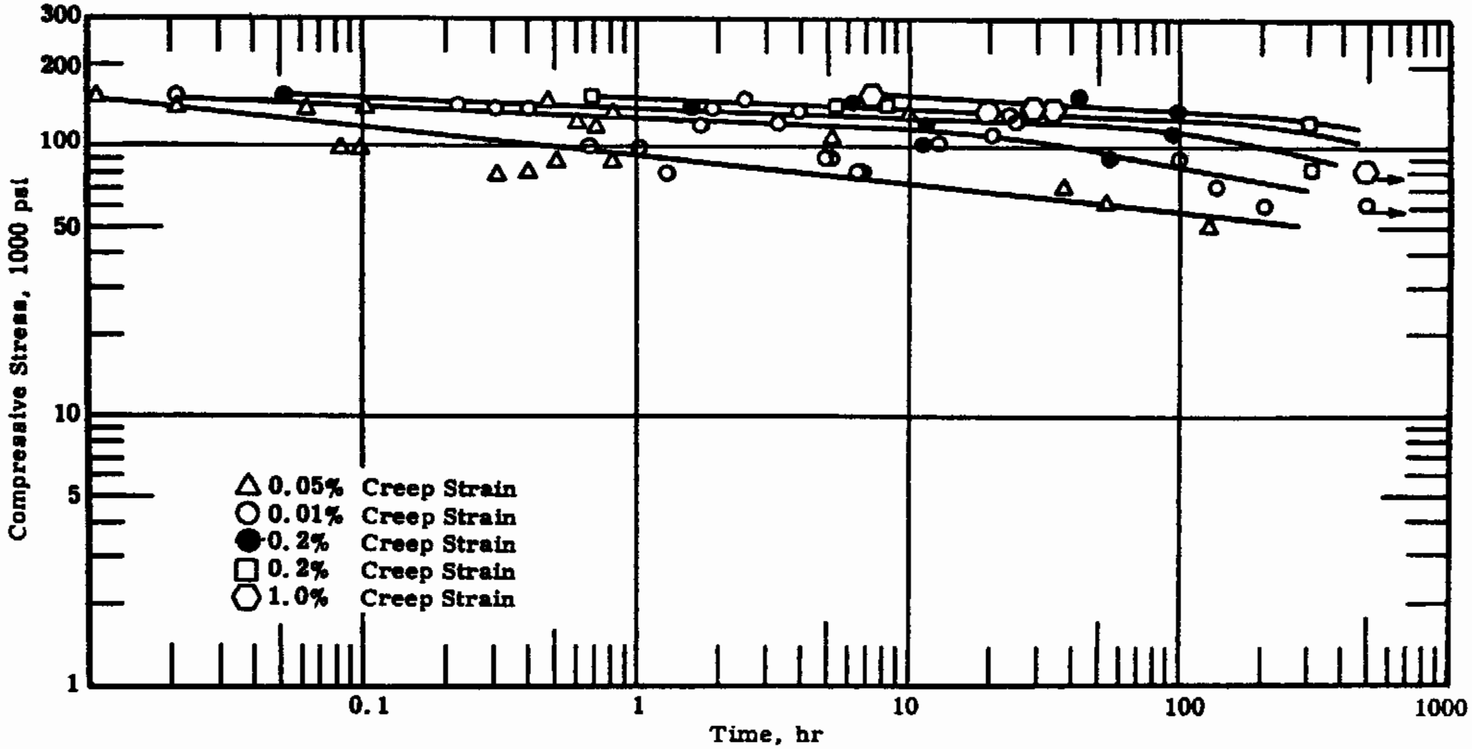


FIGURE 389 - Ti—4.0 Al—3 Mo—1 V ALLOY SHEET (Heat No. P7653)[1]—Time required for various amounts of compressive creep at 700° F and at various compressive stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

---

[1] Solution treated and aged.

[2] All specimens were heated to test temperature in 2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

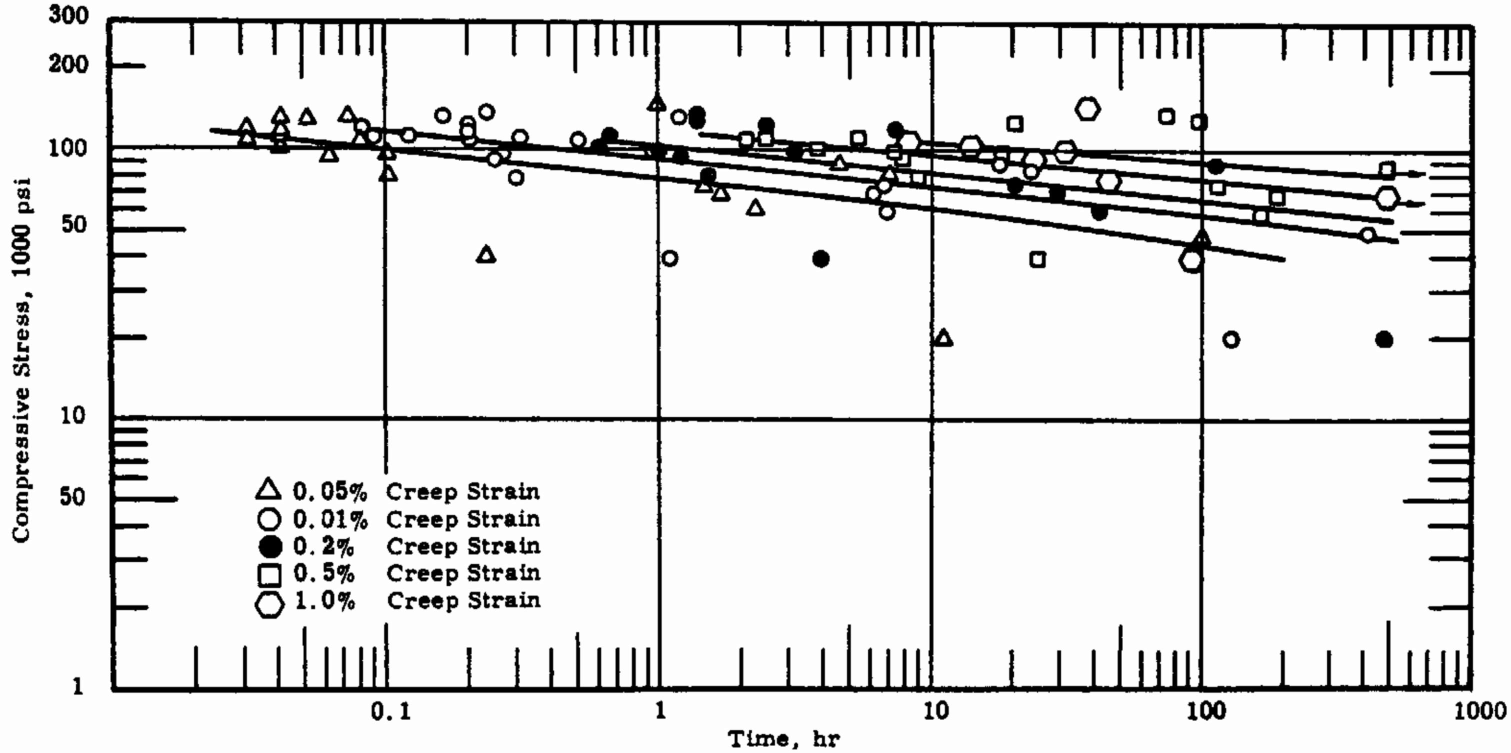


FIGURE 390 - Ti–4.0 Al–3 Mo–1 V ALLOY SHEET (Heat No. P7653)[1]—Time required for various amounts of compressive creep at 800° F and at various compressive stresses. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
All specimens were heated to test temperature in 2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

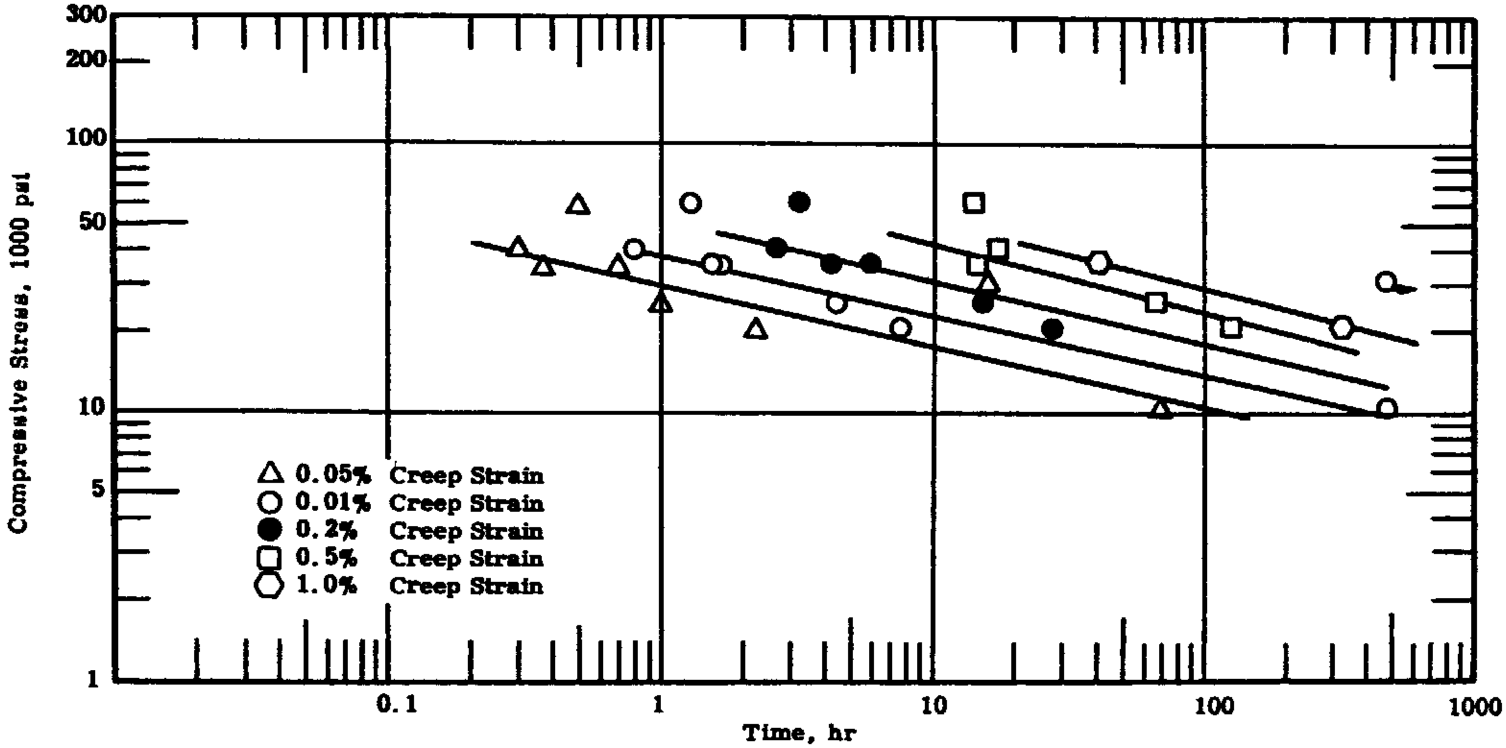


FIGURE 391 - Ti–4.0 Al–3 Mo–1 V ALLOY SHEET (Heat No. P7653)[1]—Time required for various amounts of compressive creep at 900° F and at various compressive stresses. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

---

1 Solution treated and aged.
All specimens were heated to test temperature in 2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

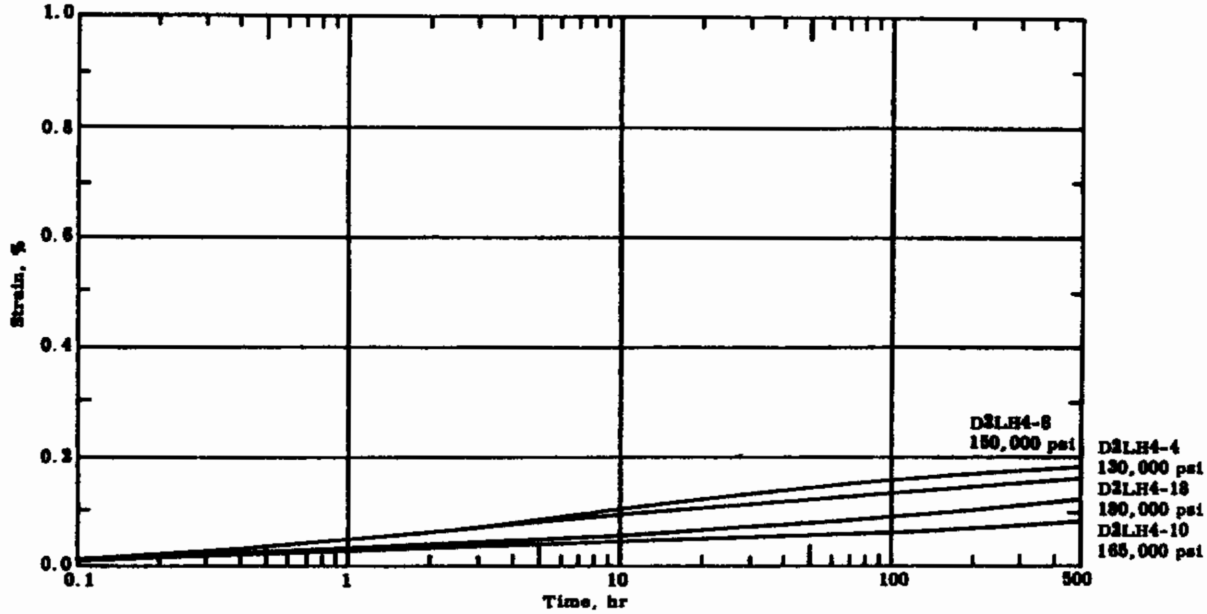


FIGURE 392 – Ti–4.0Al–3 Mo–1 V ALLOY SHEET (Heat No. P7653)[1]—Compressive creep strain-time curves at 600° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at tempe… …re 1/2 hr, then loaded within 2 min.

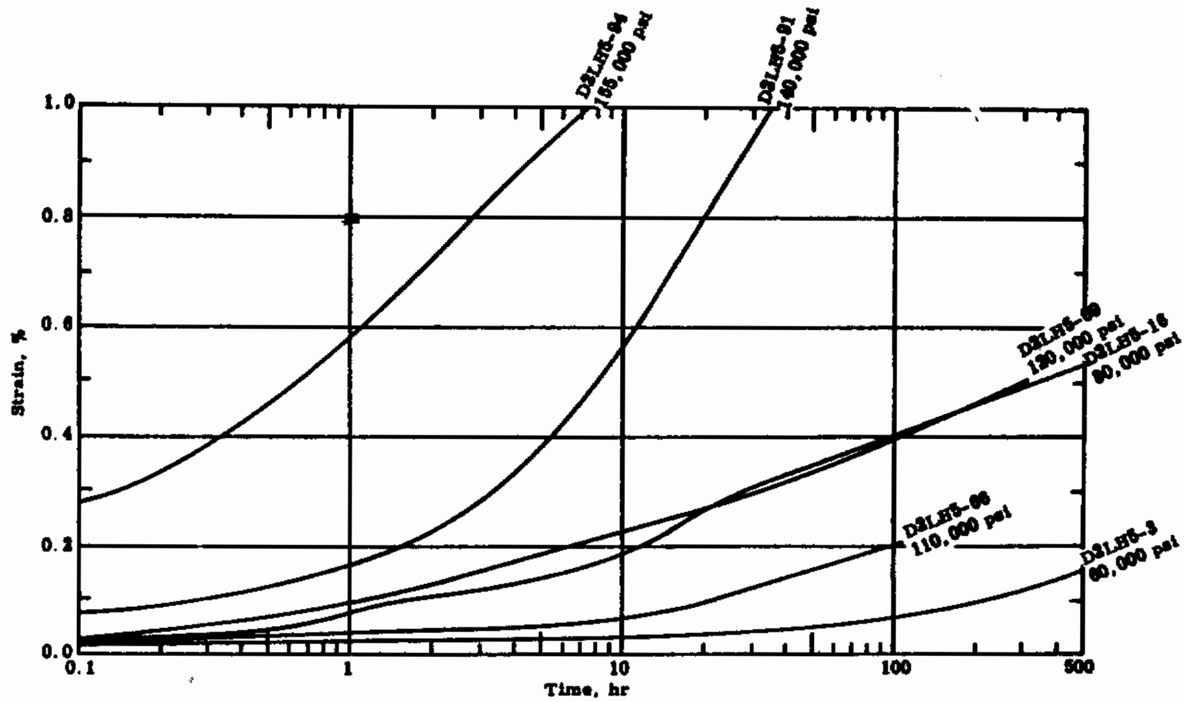


FIGURE 393 – Ti–4.0Al–3 Mo–1 V ALLOY SHEET (Heat No. P7653)[1]—Compressive creep strain-time curves at 700° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

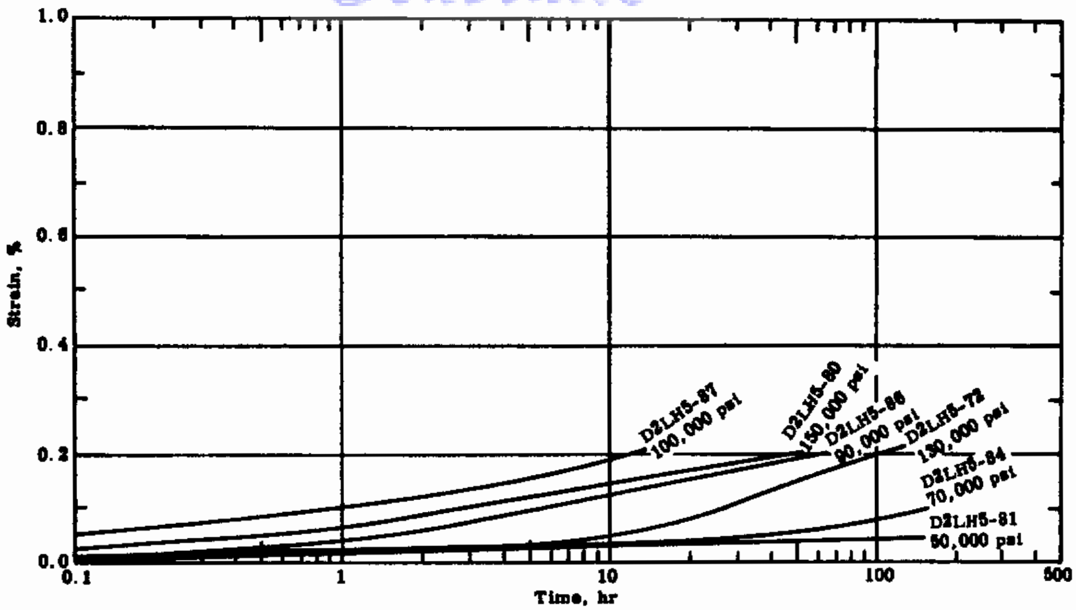


FIGURE 394 - Ti-4.0Al-3 Mo-1 V ALLOY SHEET (Heat No. P7653)[1]—Compressive creep strain-time curves at 700° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

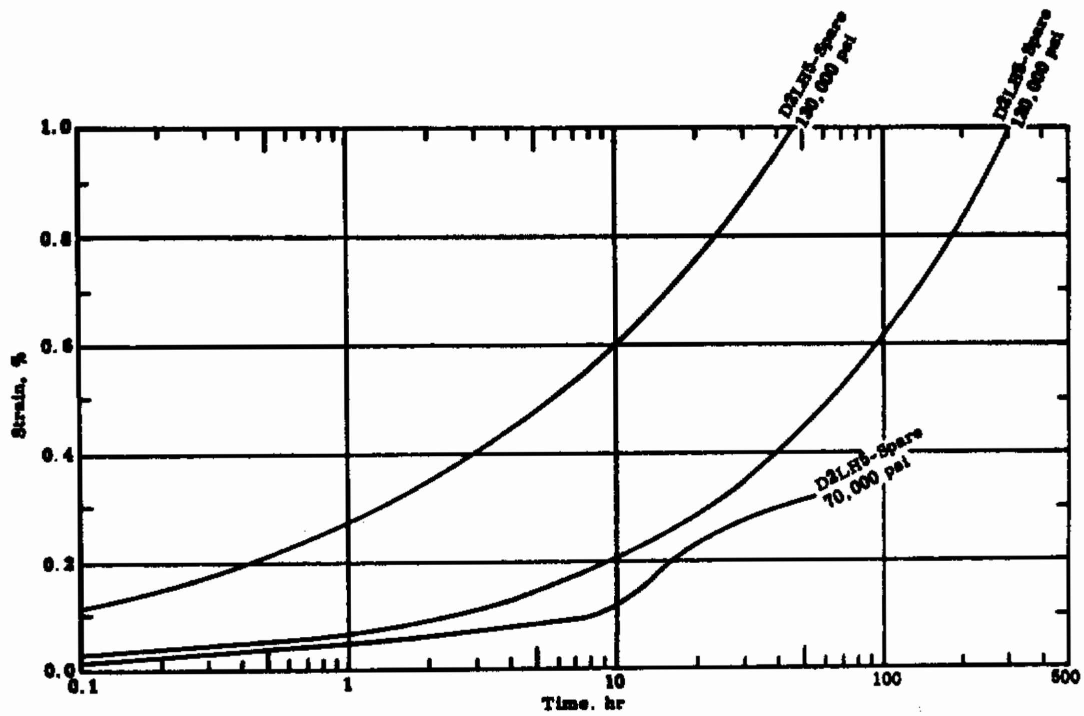


FIGURE 395 - Ti-4.0Al-3 Mo-1 V ALLOY SHEET (Heat No. P7653)[1]—Compressive creep strain-time curves at 700° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

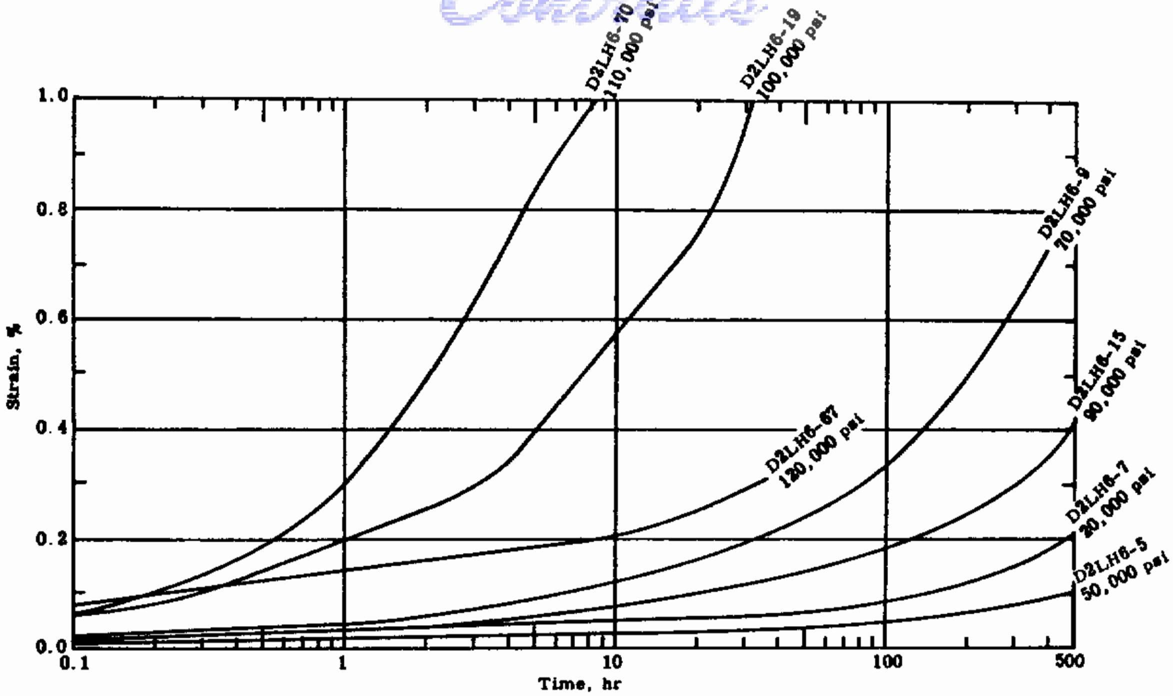


FIGURE 396 – Ti–4.0 Al–3 Mo–1 V ALLOY SHEET (Heat No. P7653)[1]—Compressive creep strain-time curves at 800° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

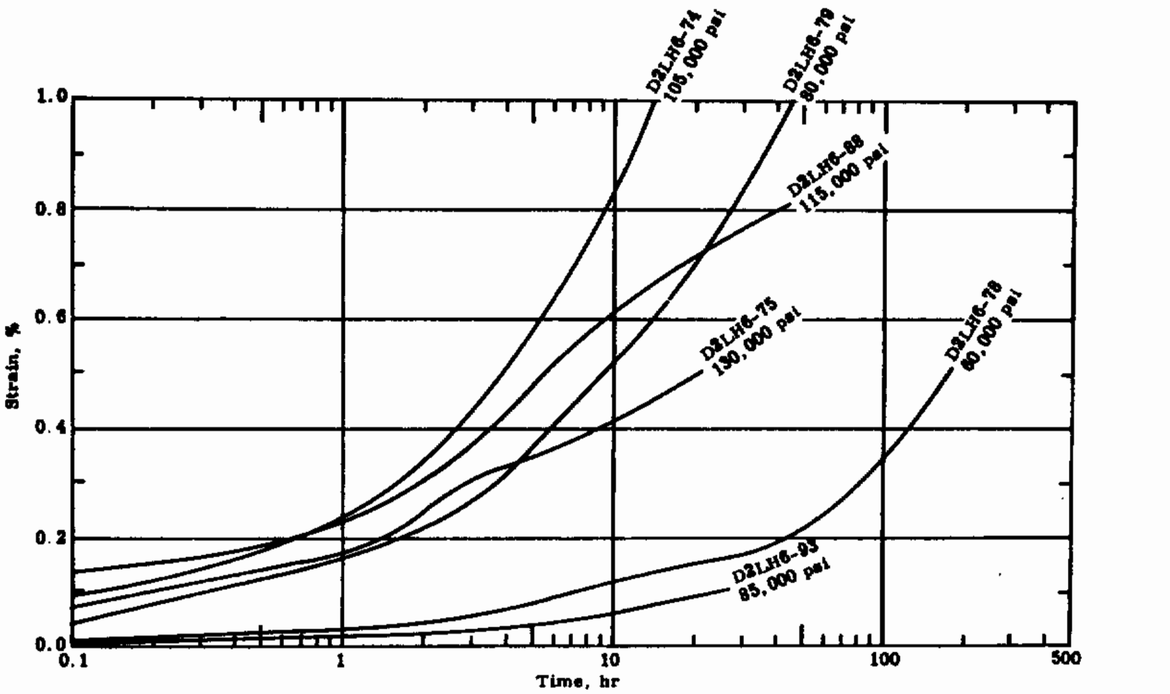


FIGURE 397 – Ti–4.0 Al–3 Mo–1 V ALLOY SHEET (Heat No. P7653)[1]—Compressive creep strain-time curves at 800° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

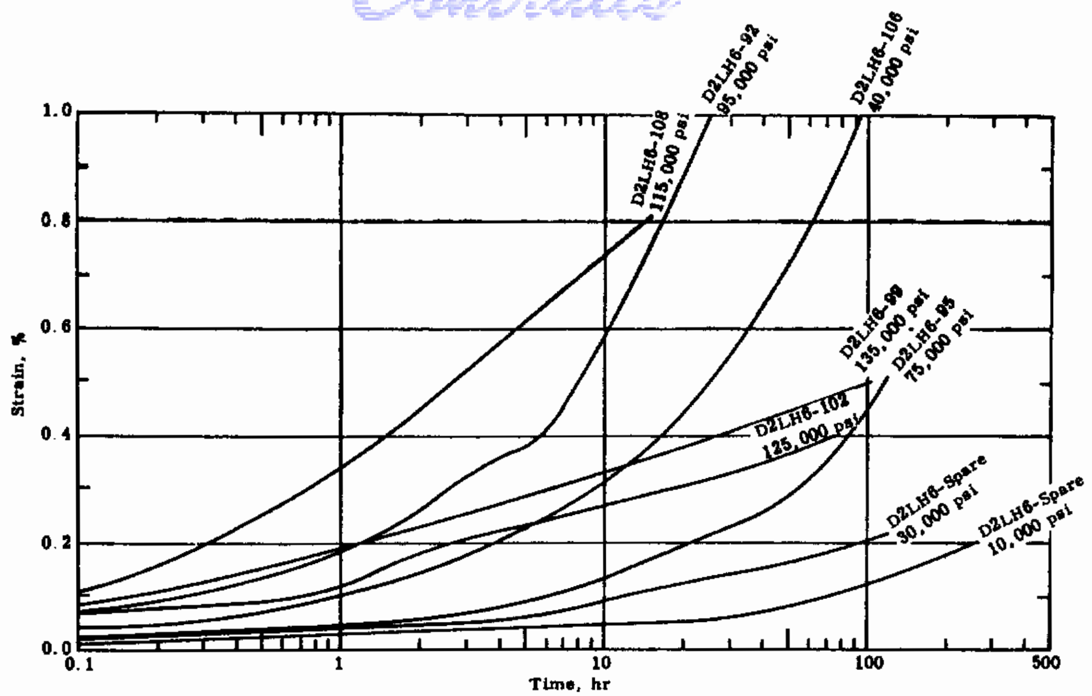


FIGURE 398 – Ti–4.0Al–3 Mo–1 V ALLOY SHEET (Heat No. P7653)[1]—Compressive creep strain-time curves at 800° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

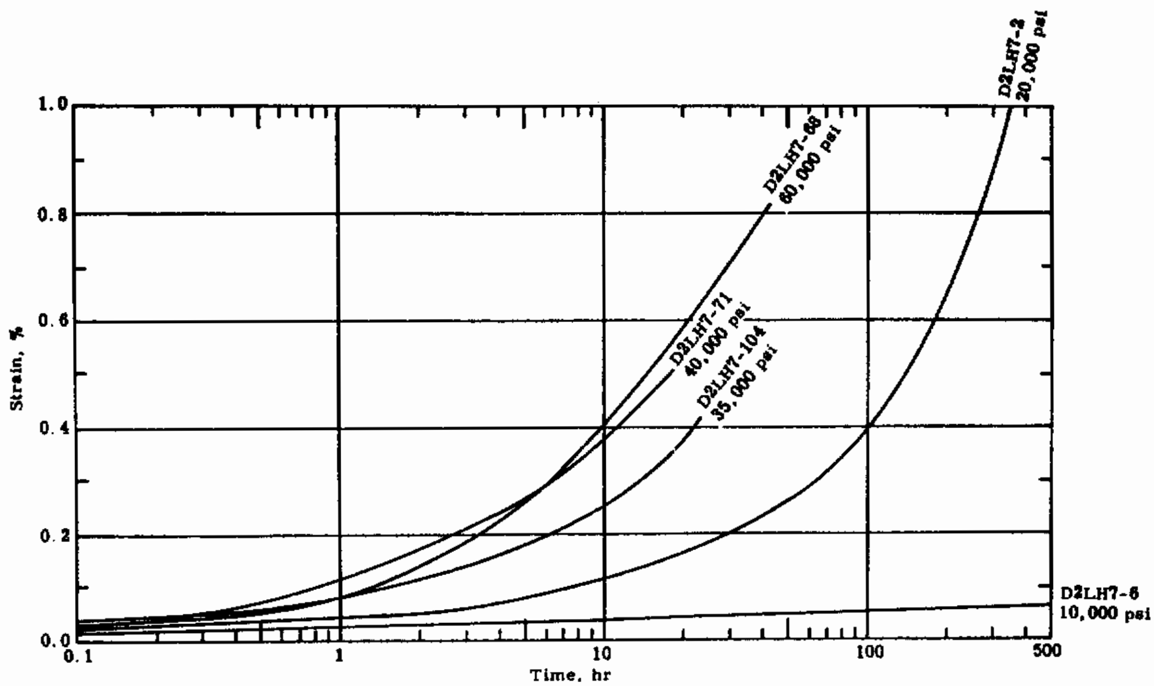


FIGURE 399 – Ti–4.0Al–3 Mo–1V ALLOY SHEET (Heat No. P7653) —Compressive creep strain-time curves at 900° F and at various stresses , All specimens were taken in the longitudinal direction from 0.063 in. sheet.

Solution treated and aged.
Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

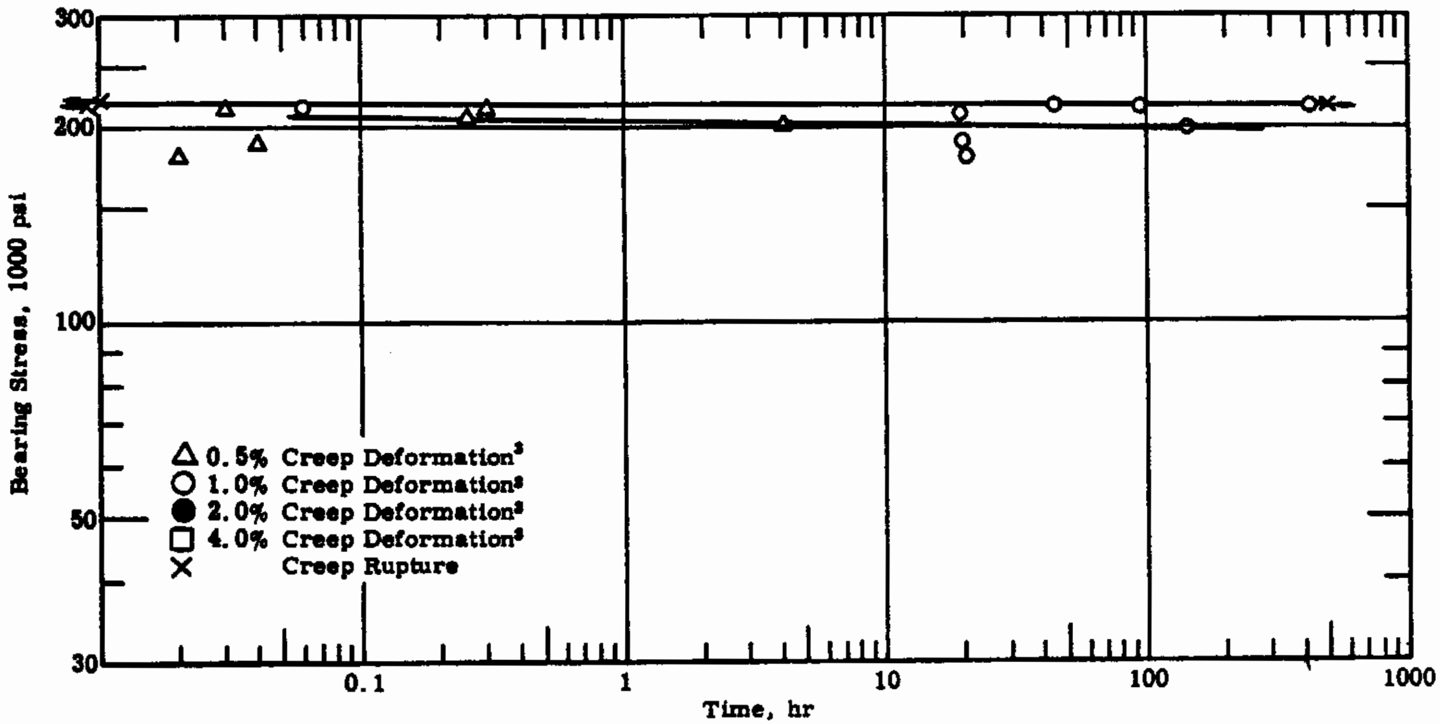


FIGURE 400 - Ti–4.0 Al–3 Mo–1 V ALLOY SHEET (Heat No. P7653)[1]—Time required for various amounts of bearing creep at 600° F and at various bearing stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.
[3] Percent of bearing-hole diameter.

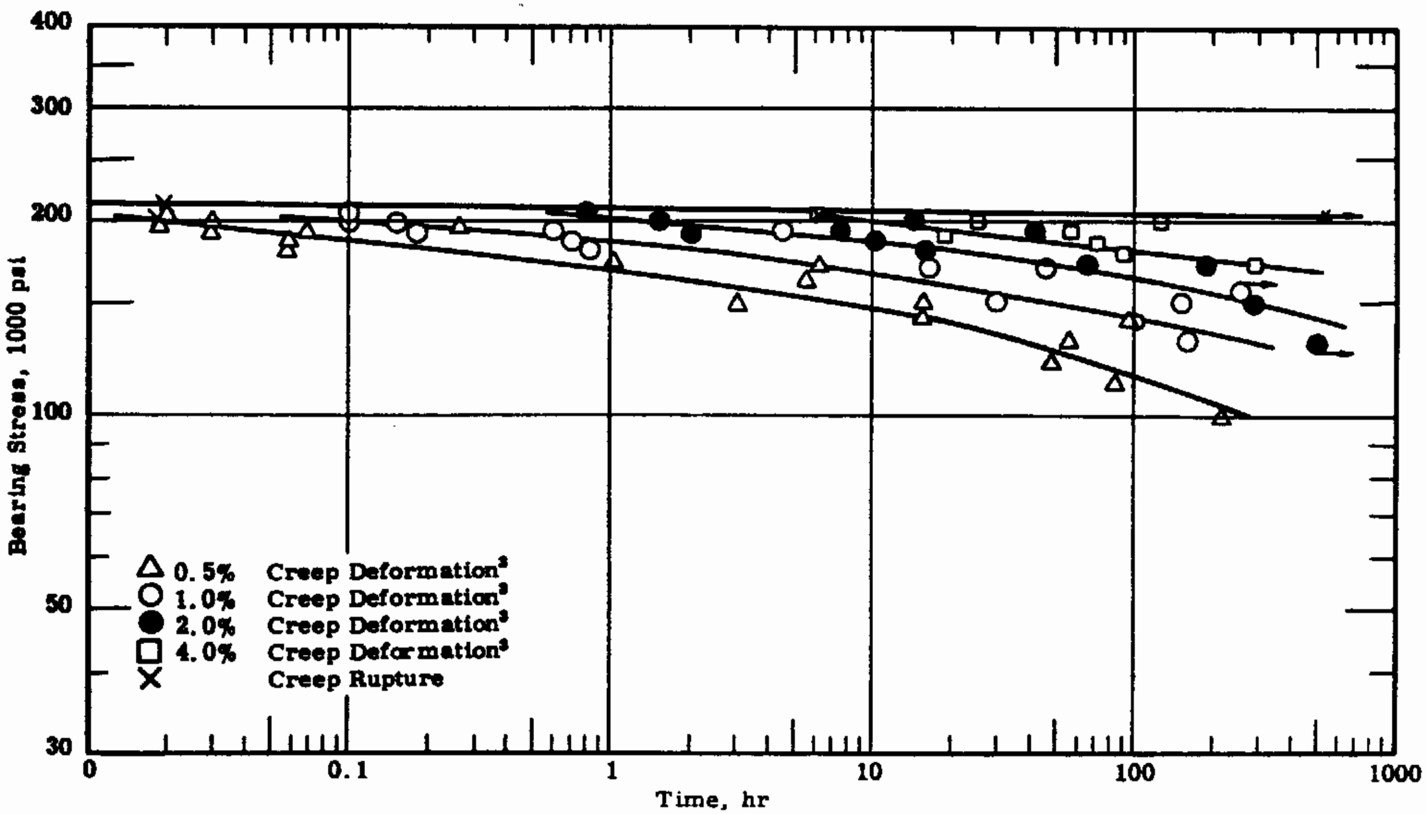


FIGURE 401 - Ti—4.0 Al—3 Mo—1 V ALLOY SHEET (Heat No. P7653)[1]—Time required for various amounts of bearing creep at 700° F and at various bearing stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

---

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.
[3] Percent of bearing-hole diameter.

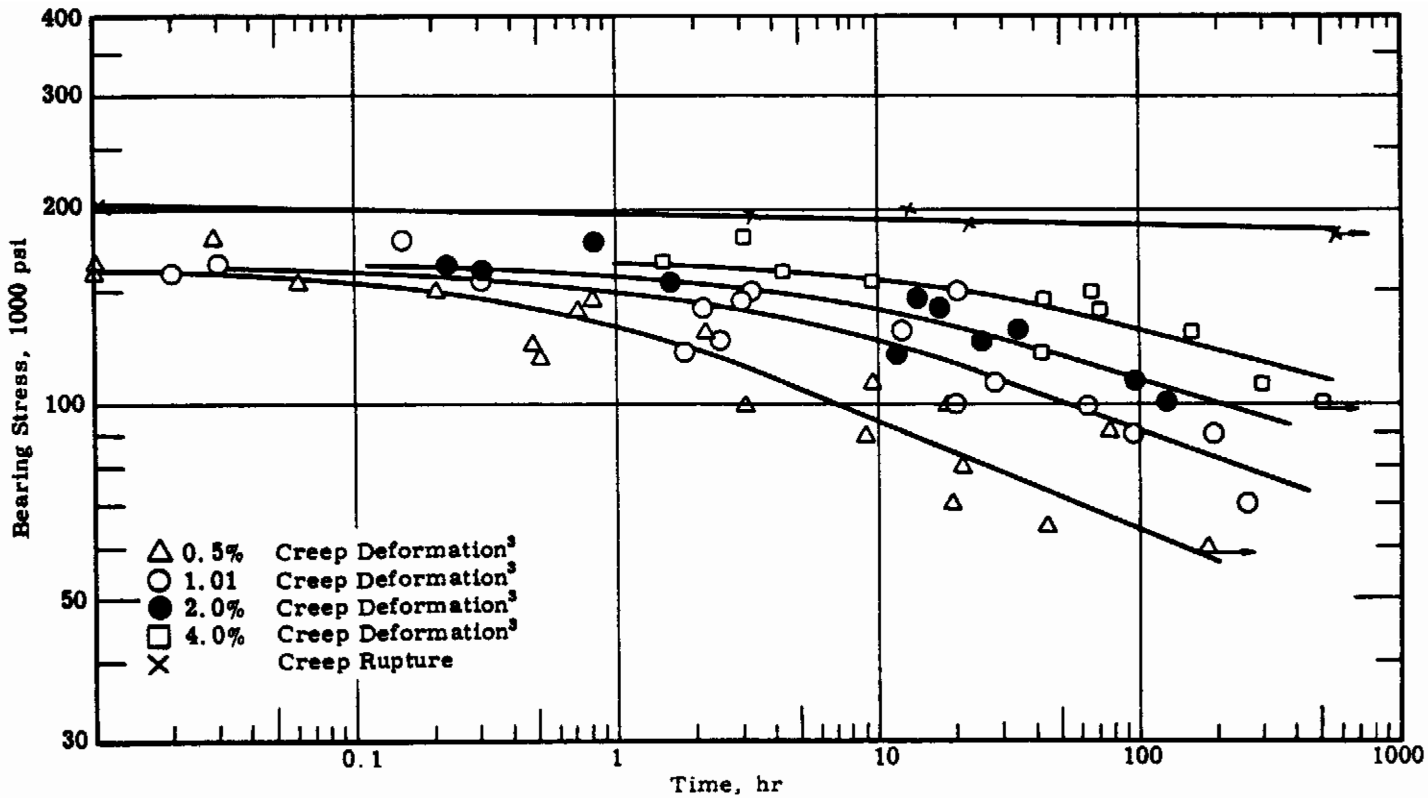


FIGURE 402 - Ti—4.0 Al—3 Mo—1V ALLOY SHEET (Heat No. P7653)[1]—Time required for various amounts of bearing creep at 800° F and at various bearing stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

---

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.
[3] Percent of bearing-hole diameter.

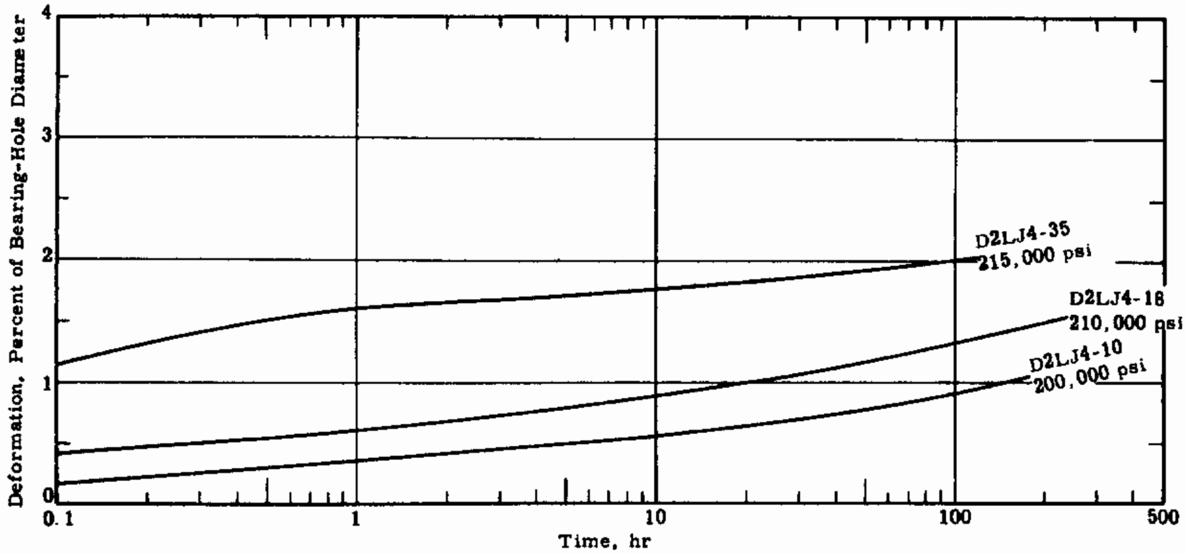


FIGURE 403 - Ti—4.0 Al—3 Mo—1 V ALLOY SHEET (Heat No. P7653)[1]—Bearing creep deformation-time curves at 600° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

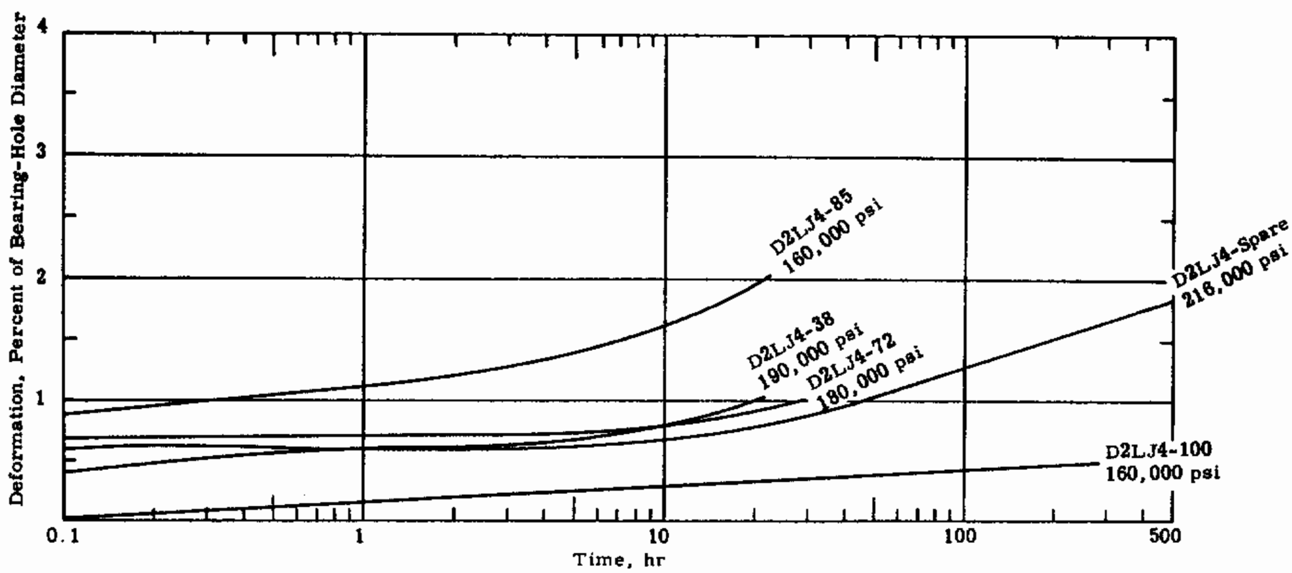


FIGURE 404 - Ti—4.0 Al—3 Mo—1 V ALLOY SHEET (Heat No. P7653)[1]—Bearing creep deformation-time curves at 600° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

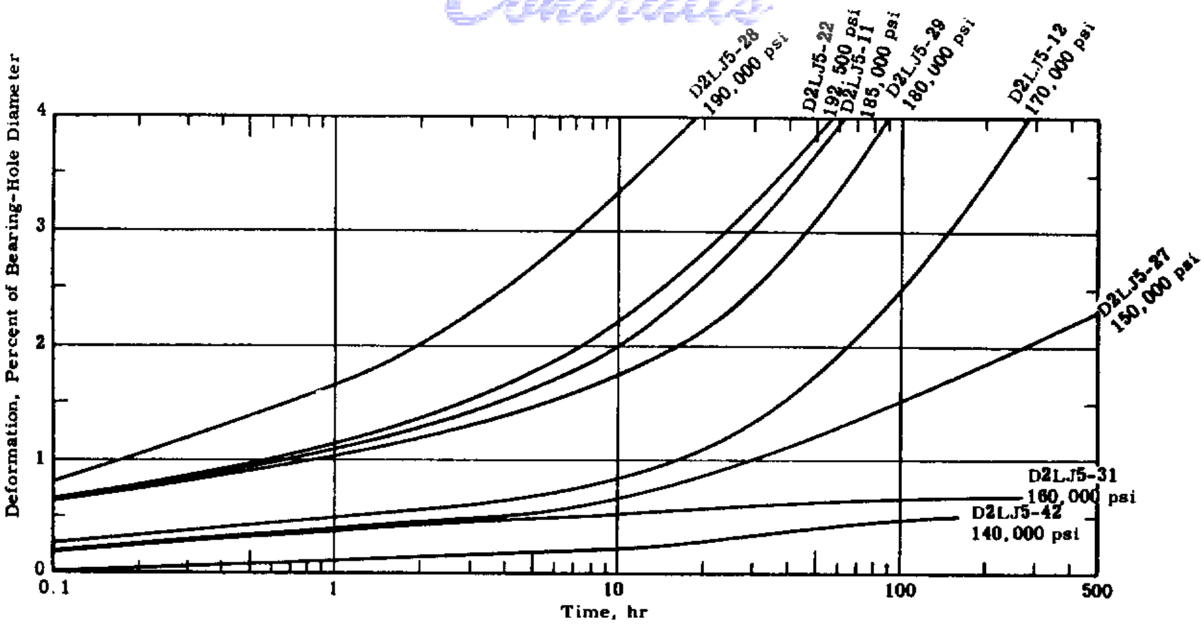


FIGURE 405 - Ti-4.0 Al-3 Mo-1 V ALLOY SHEET (Heat No. P7653)[1]—Bearing creep deformation-time curves at 700° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.

[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

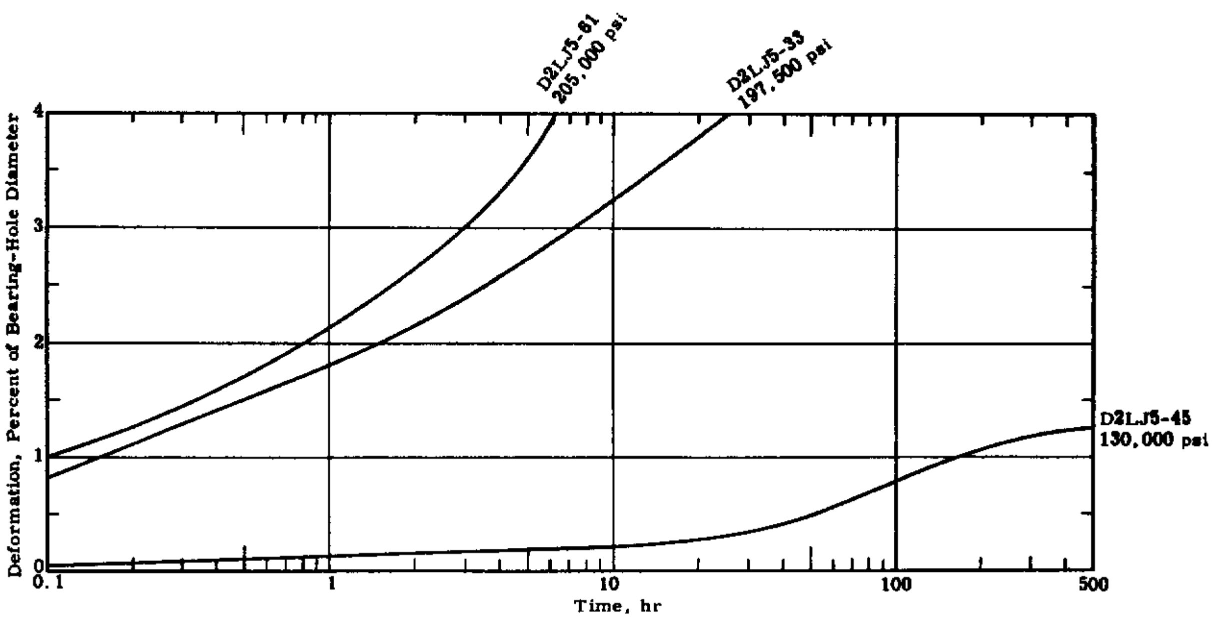


FIGURE 406 - Ti-4.0 Al-3 Mo-1 V ALLOY SHEET (Heat No. P7653)[1]—Bearing creep deformation-time curves at 700° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.

[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

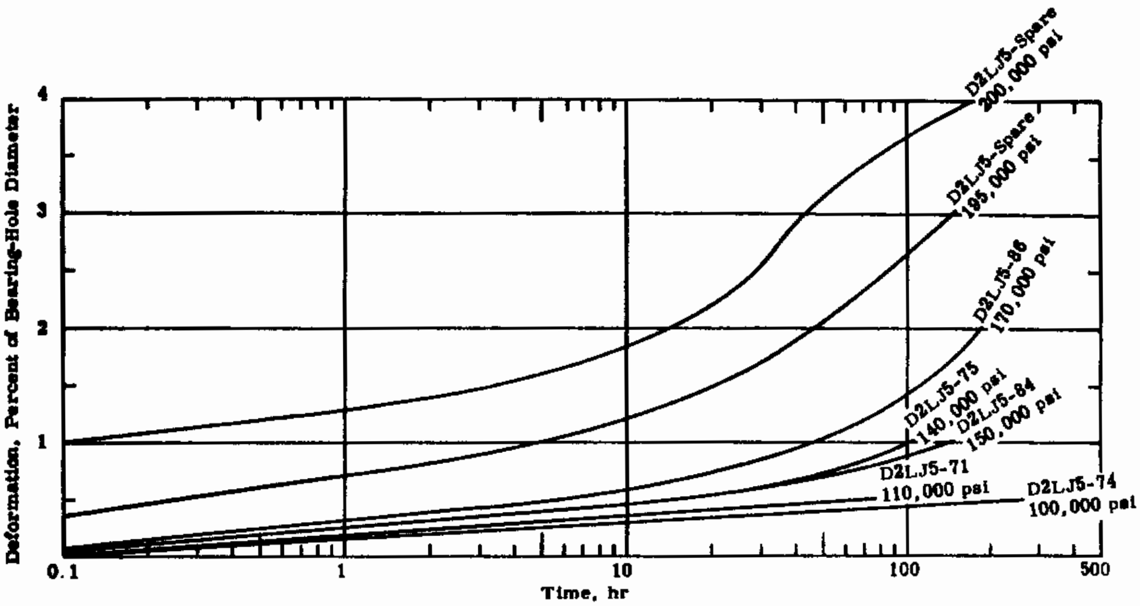


FIGURE 407 - Ti-4.0Al-3 Mo-1 V ALLOY SHEET (Heat No. P7653)[1]—Bearing creep deformation-time curves at 700° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

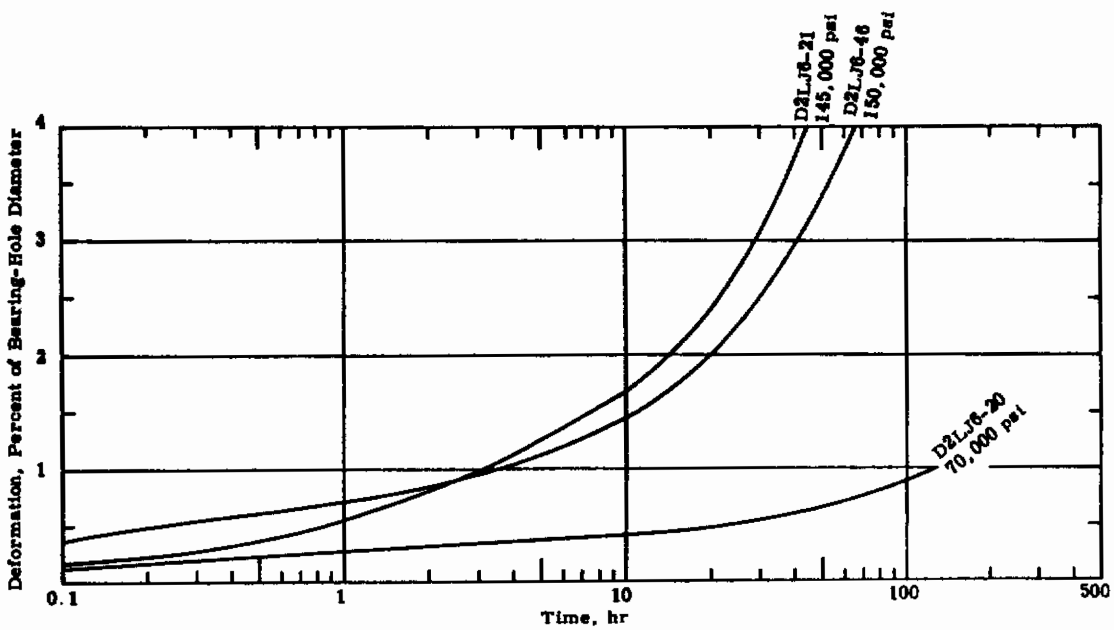


FIGURE 408 - Ti-4.0Al-3 Mo-1V ALLOY SHEET (Heat No. P7653)[1]—Bearing creep deformation-time curves at 800° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

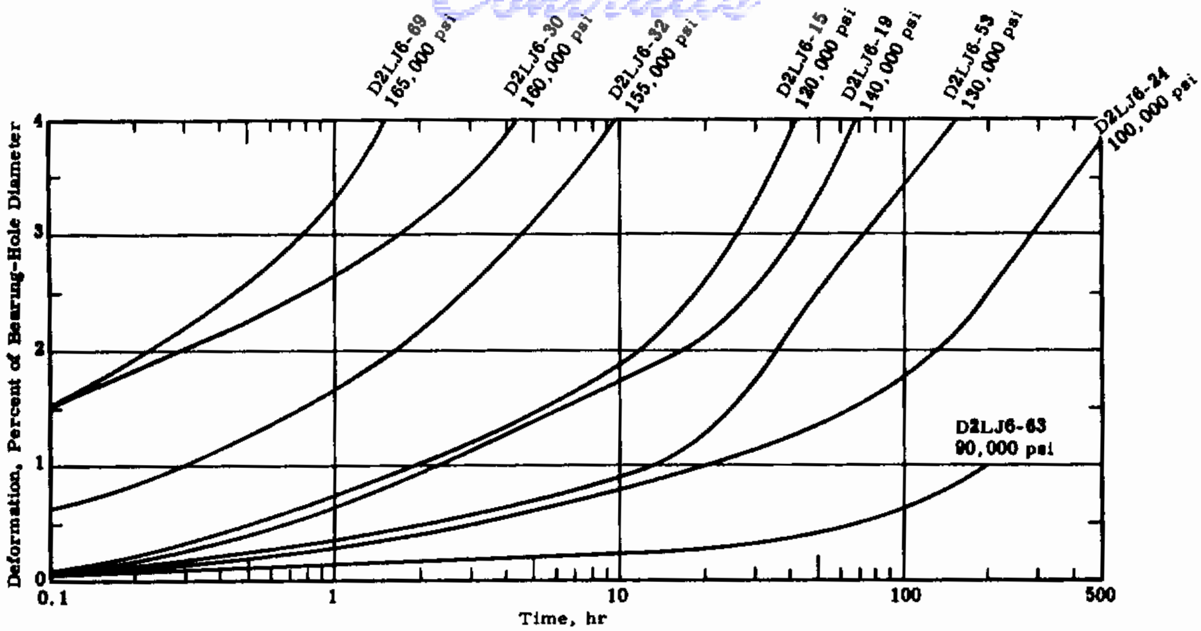


FIGURE 409 - Ti-4.0 Al-3 Mo-1 V ALLOY SHEET (Heat No. P7653)[1]—Bearing creep deformation-time curves at 800° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

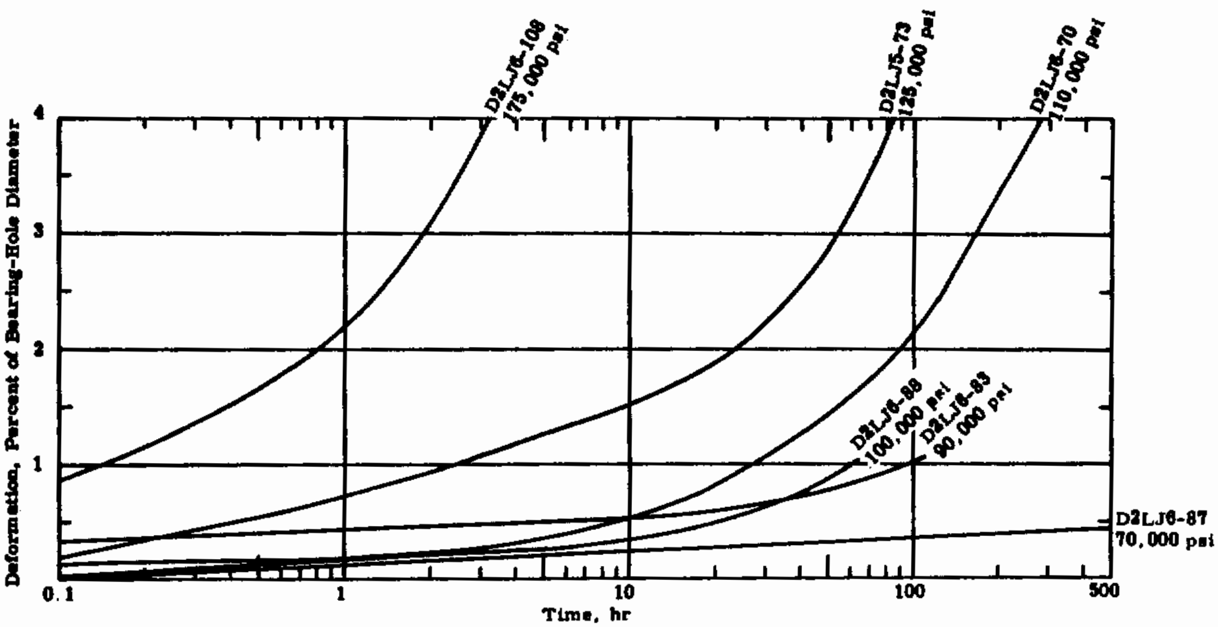


FIGURE 410 - Ti-4.0 Al-3 Mo-1 V ALLOY SHEET (Heat No. P7653)[1]—Bearing creep deformation-time curves at 800° F and at various stresses[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet and have e/d = 2.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in 1/2 hr, soaked at temperature 1/2 hr, then loaded within 2 min.

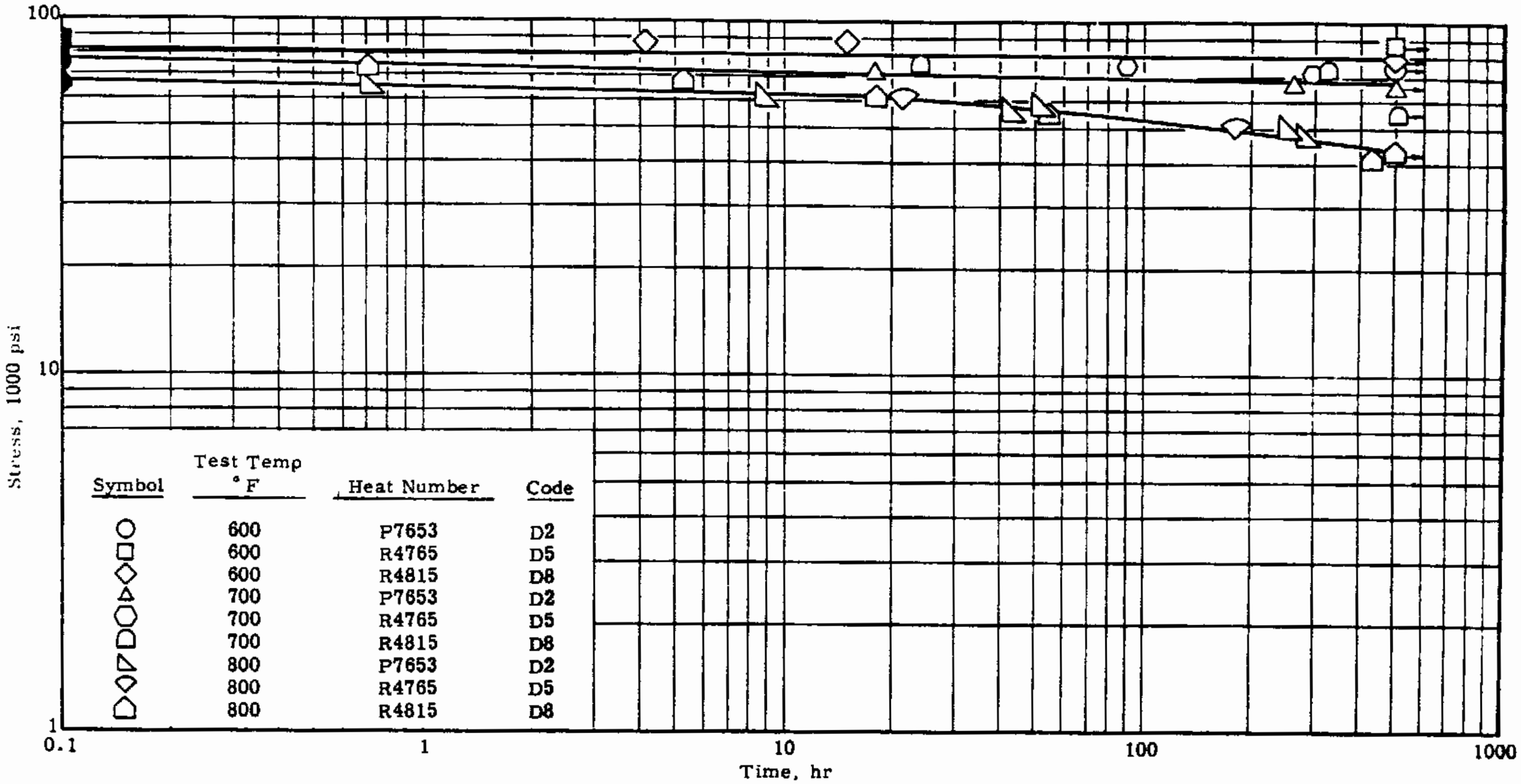


FIGURE 411 - Ti–4.0 Al–3 Mo–1 V ALLOY SHEET[1]—Time required for stress-rupture in single-shear at various stresses and temperatures[2]. All specimens were taken in the longitudinal direction from 0.063 in. sheet.

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in approximately 2 hr, soaked at temperature 1/2 hr, then loaded in about 2 min.

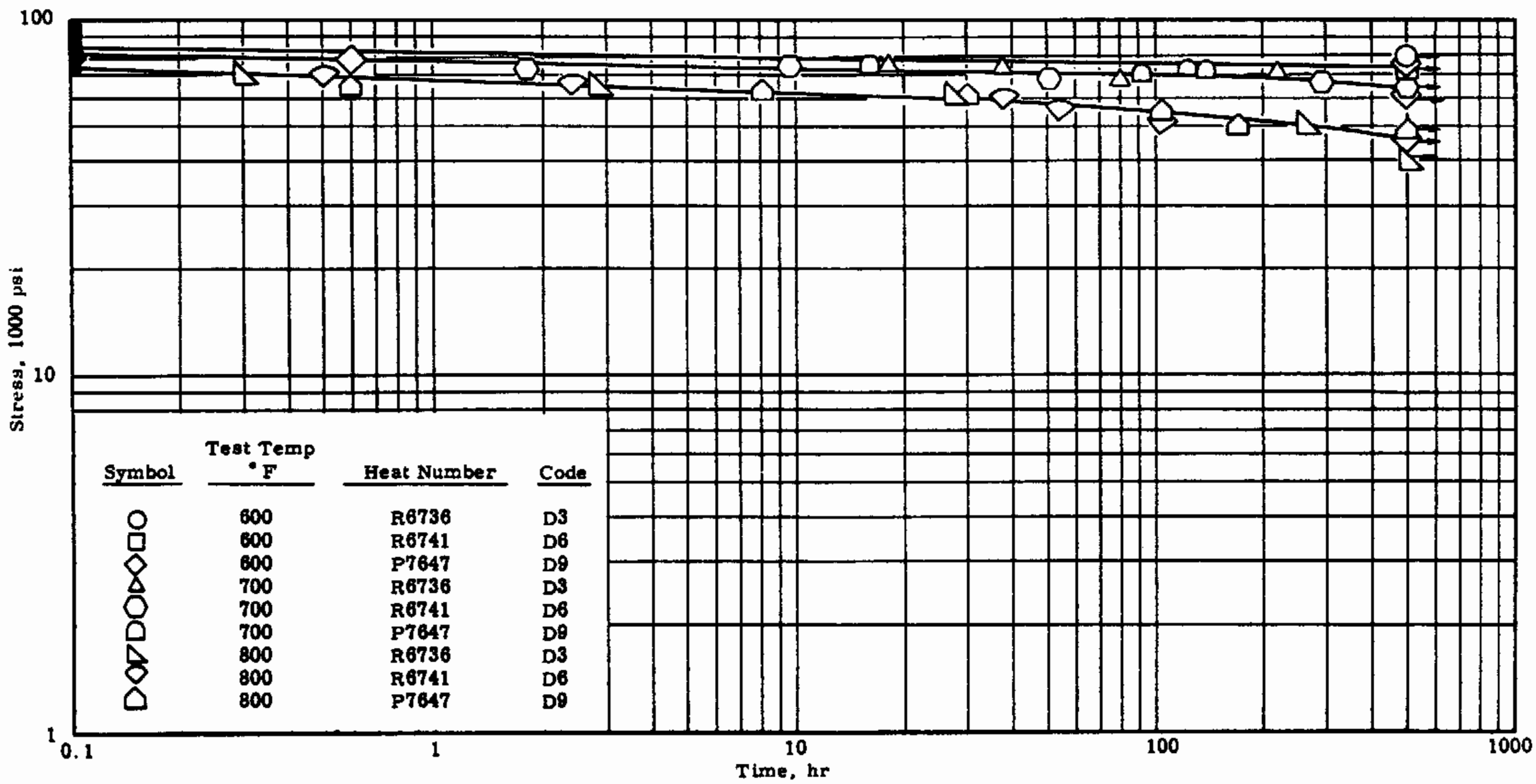


FIGURE 412 - Ti–4.0 Al–3 Mo–1 V ALLOY SHEET[1]—Time for stress-rupture in double-shear at various stresses and temperatures[2]. All specimens were taken in the longitudinal direction from 0.125 in. sheet.

---

[1] Solution treated and aged.
[2] Specimens were heated to test temperature in approximately 2 hr, soaked at temperature 1/2 hr, then loaded in about 2 min.

Fatigue Test Results - Ti-4Al-3Mo-1V

The 90 S-N curves in Figures 413 through 502 summarize axial-load fatigue data obtained in the longitudinal grain direction for eight heats and sheet thickness of 0.020 inch, 0.063 inch and 0.125 inch. Data in the S-N curves represent theoretical stress concentrations of 1.0 and 2.82; stress ratios of ∞ , 1.0 and 0.3; and temperatures of 80°F, 400°F, 600°F, 800°F and 900°F. An S-N curve, defined by a minimum of 21 test values, is presented for each combination of these variables, and maximum stress and life-cycles for each specimen are reported in Tables CCXC through CCCVII, pages 298 through 315 of Volume 3. In addition to S-N curves, a modified Goodman-type diagram relating stress and stress ratio for 10^3, 10^4, 10^5, 10^6 and 10^7 life-cycles is presented in Volume 1 for each combination of thickness, stress concentration and temperature.

Data for a stress ratio of zero, which were combined with available tensile creep-rupture data and ultimate tensile stress data to construct modified Goodman-type diagrams, are in Tables XIII and XIV.

TABLE XIII

LONGITUDINAL ULTIMATE TENSILE STRESS FOR STRESS RATIO OF ZERO (A=0) FATIGUE VALUES.
SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET
STRESS CONCENTRATION (K_t) = 2.82

Thickness = 0.020 in.			Thickness = 0.063 in.			Thickness = 0.125 in.		
Specimen Number	Test Temp., °F	F_{tu}, PSI	Specimen Number	Test Temp., °F	F_{tu}, PSI	Specimen Number	Test Temp., °F	F_{tu}, PSI
D13LG1S-3	80	204,000	D2LG1S-10	80	185,000	D9LG1S-3	80	190,000
-9	80	202,000	D8LG1S-16	80	206,000	-9	80	190,000
-24	80	202,000	D8LG1S-20	80	205,000	-24	80	194,000
Average		203,000	Average		199,000	Average		191,000
D13LG3S-16	400	166,000	D5LG3S-3	400	168,000	D9LG3S-12	400	154,000
-18	400	161,000	D2LG3S-8	400	163,000	-16	400	156,000
-21	400	162,000	D2LG3S-12	400	159,000	-21	400	154,000
Average		163,000	Average		163,000	Average		155,000
D13LG4S-20	600	145,000	D2LG4S-5	600	151,000	D9LG4S-1	600	141,000
-28	600	154,000	D5LG4S-7	600	155,000	-20	600	141,000
Average		149,000	Average		153,000	Average		141,000
D13LG6S-6	800	142,000	D5LG6S-2	800	141,000	D9LG6S-6	800	130,000
-13	800	141,000	D2LG6S-15	800	137,000	-19	800	130,000
-19	800	140,000	D8LG6S-17	800	143,000			
Average		141,000	Average		141,000	Average		130,000
D13LG7S-8	900	128,000	D8LG7S-18	900	130,000	D9LG7S-8	900	119,000
-14	900	128,000	-19	900	129,000	-14	900	119,000
-27	900	131,000	-21	900	134,000	-27	900	120,000
Average		129,000	Average		131,000	Average		119,000

TABLE XIV

LONGITUDINAL TENSILE STRESS-RUPTURE DATA FOR STRESS RATIO OF ZERO (A=0) FATIGUE VALUES.
SOLUTION TREATED AND AGED 4Al-3Mo-1V TITANIUM ALLOY SHEET

Stress Concentration (K_t)	Thickness, in.	800°F			900°F		
		Specimen Number	Tensile Stress, PSI	Time to Failure, hours	Specimen Number	Tensile Stress, PSI	Time to Failure, hours
1.00	0.020	D13LG6R-7	130,000	0.52	D13LG7R-2	99,700	1.67
		-11	120,000	8.80	-18	77,900	9.55
		-22	93,100	54.7	-23	53,100	98.2
	0.125	D9LG6R-7	120,000	1.20	D9LG7R-23	100,000	0.49
		-11	117,000	2.19	-2	78,100	12.6
		-12	93,000	95.1	-18	53,100	136.0
2.82	0.020	D13LG6S-15	126,000	0.90	D13LG7S-4	103,000	1.00
		-5	120,000	7.25	-25	82,400	19.2
		-17	93,800	158.7	-10	63,800	55.1
	0.063	D2LG6S-14	130,000	1.00	D2LG7S-11	99,900	2.00
		D5LG6S-6	127,000	2.50	D5LG7S-1	84,000	6.90
		D2LG6S-9	97,500	64.8	D5LG7S-4	63,900	38.7
	0.125	D9LG6S-10	126,000	0.40	D9LG7S-4	103,000	0.50
		-5	124,000	0.40	-25	82,200	6.60
		-13	118,000	3.20	-26	58,500	168.0

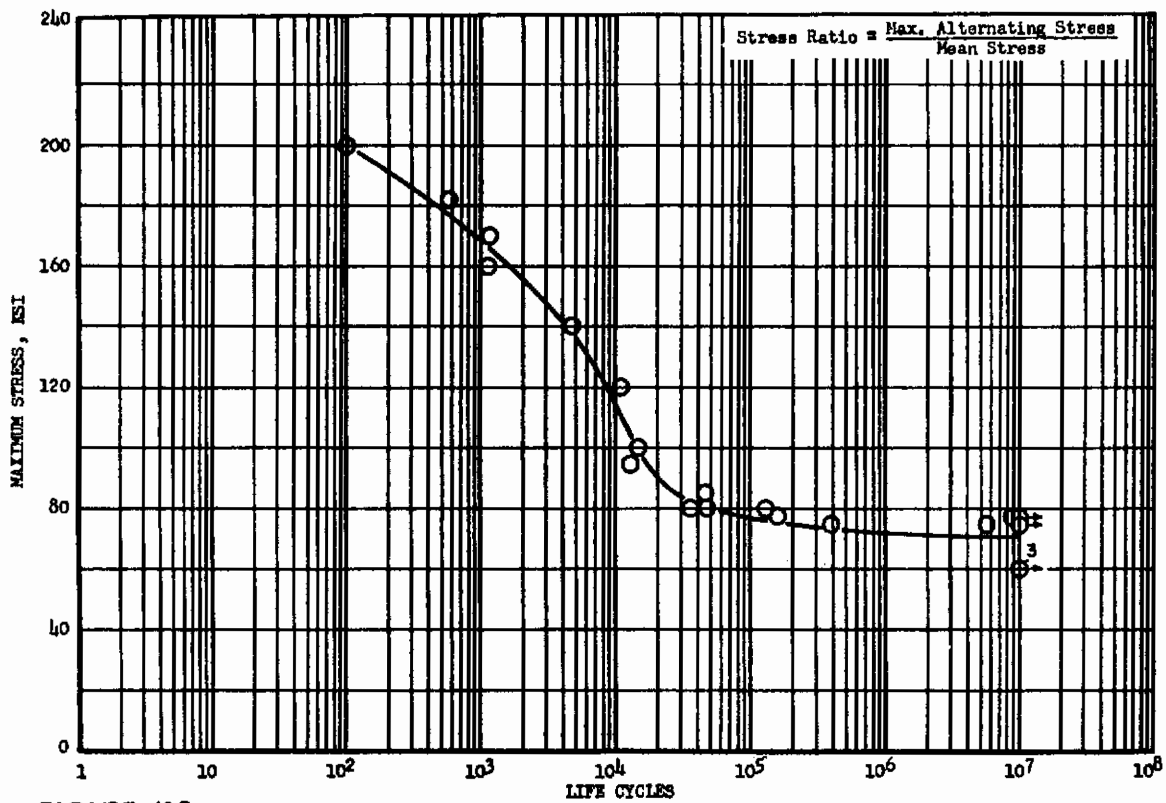


FIGURE 413 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R4815, R4810, AND R4805)

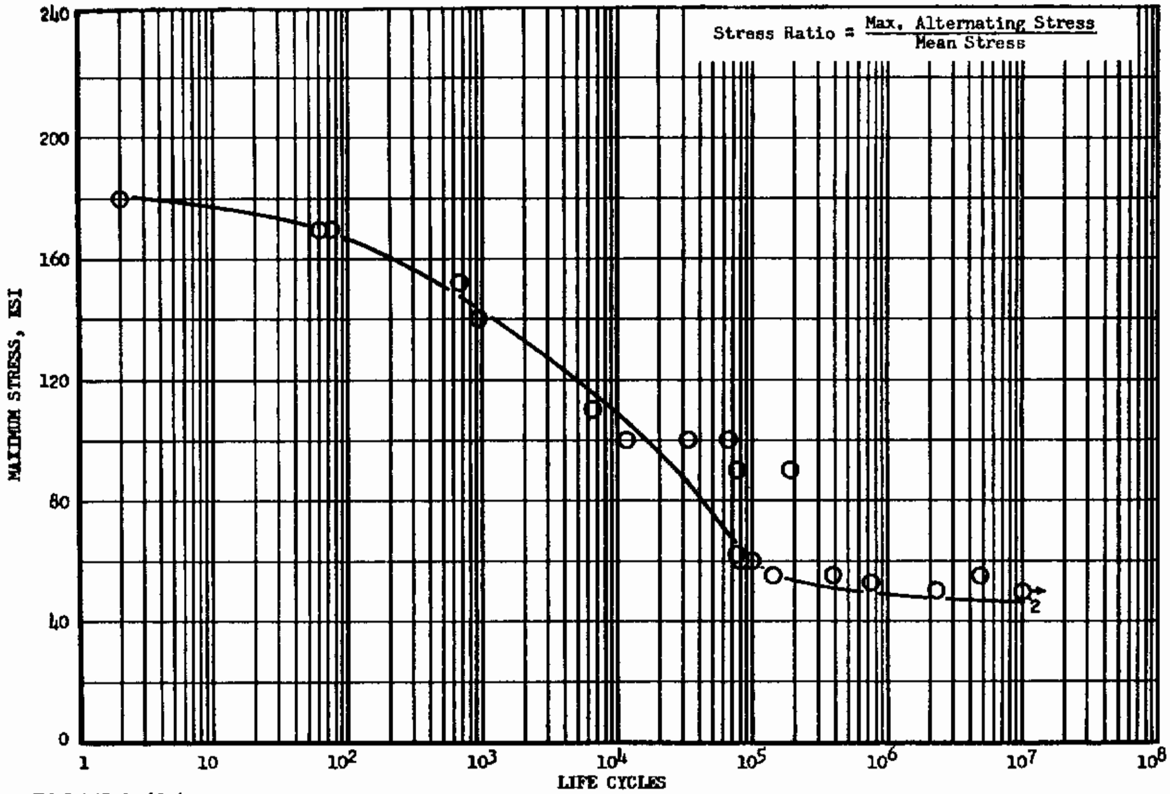


FIGURE 414 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R4815, R4810, AND R4805)

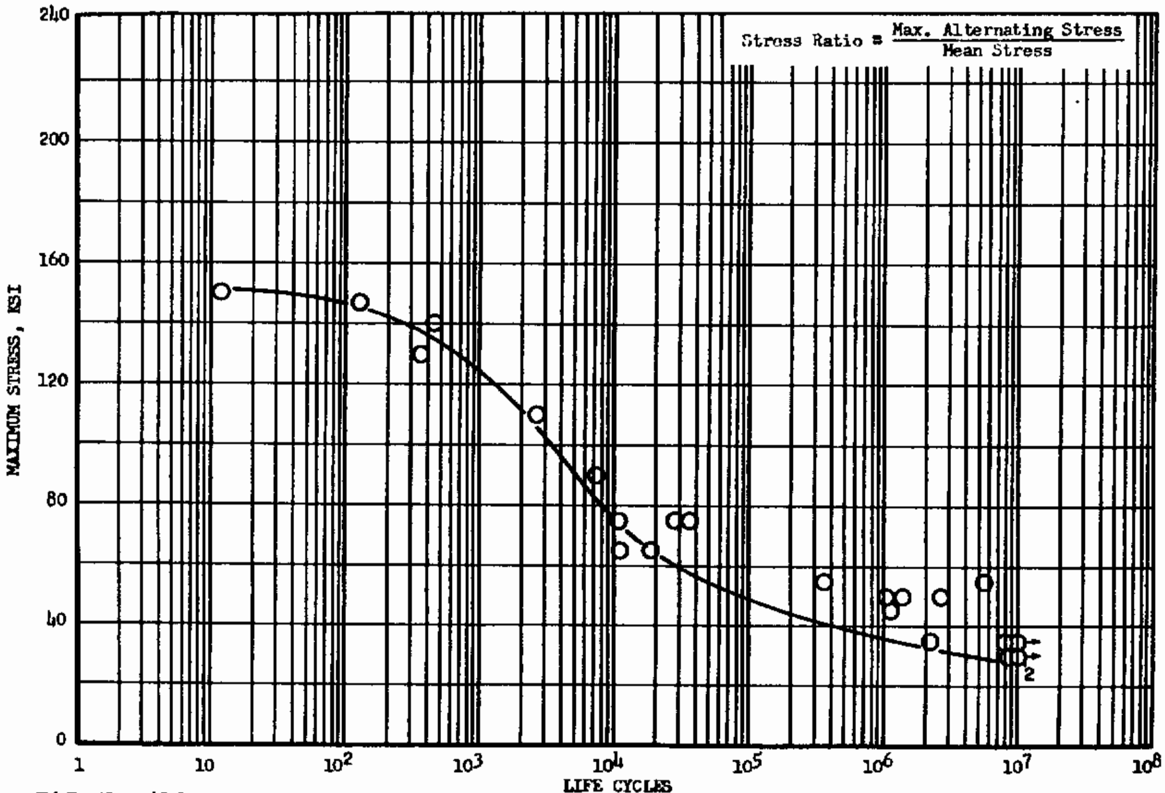


FIGURE 415 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R4815, R4810, AND R4805)

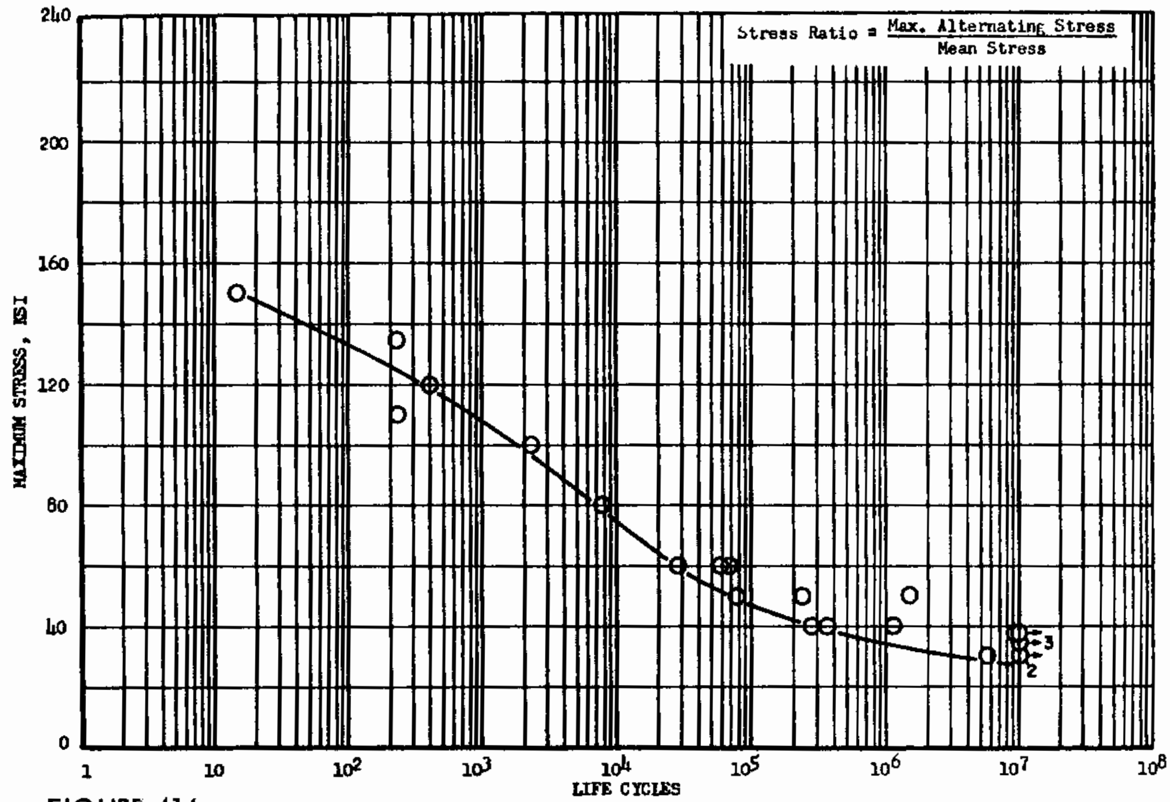


FIGURE 416 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R4815, R4810, AND R4805)

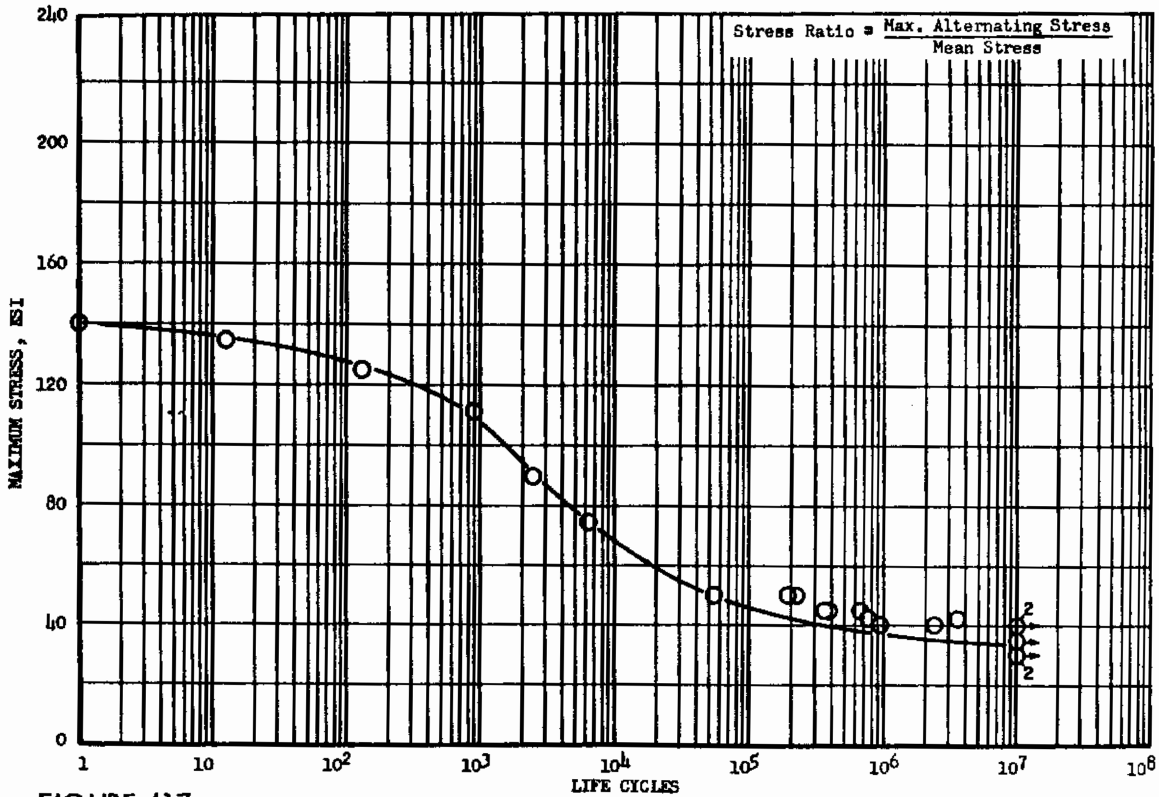


FIGURE 417 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R4815, R4810, AND R4805)

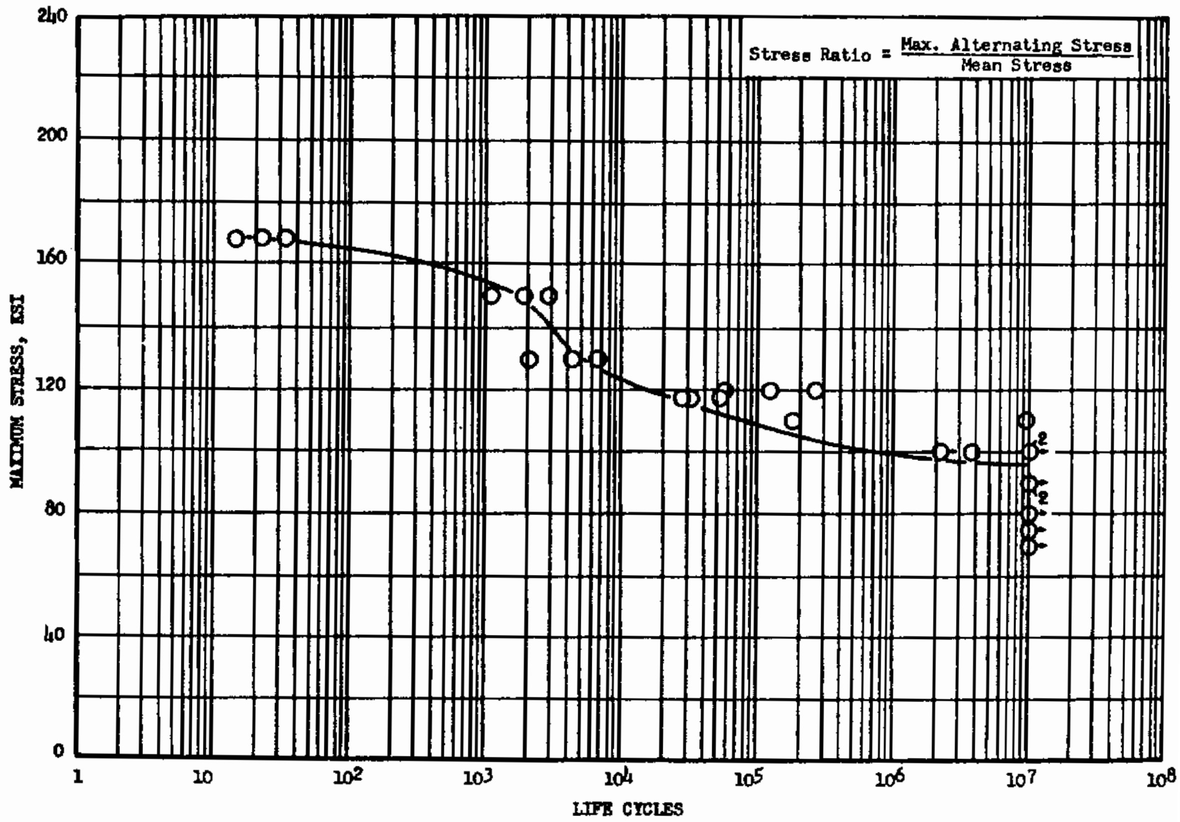


FIGURE 418 – AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R4815 AND R4810)

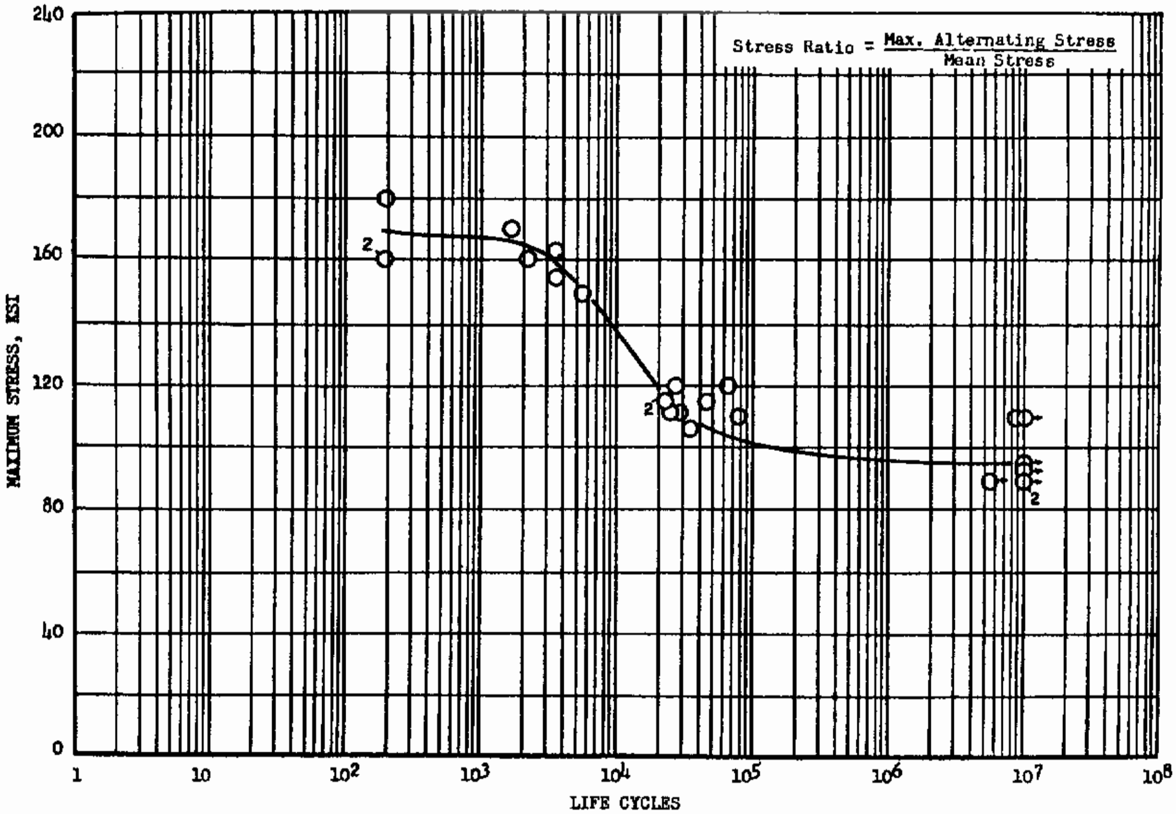


FIGURE 419 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R4815 AND R4810)

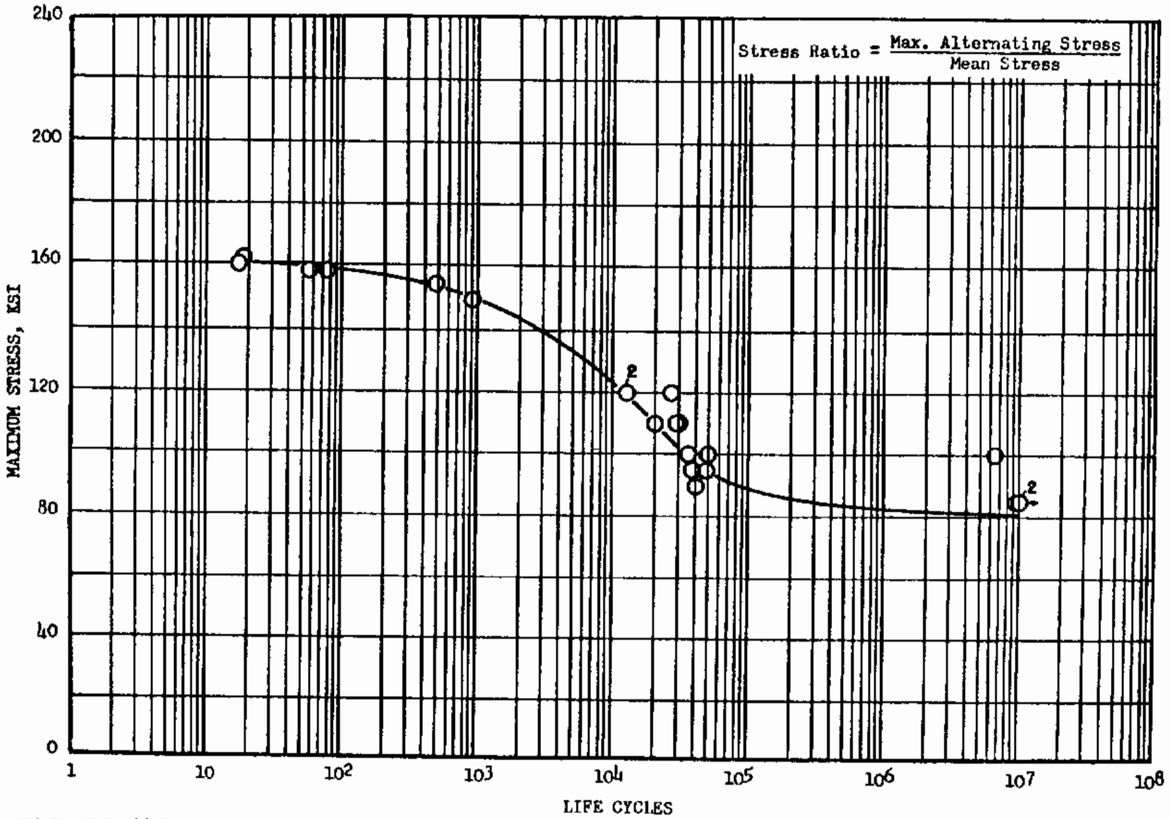


FIGURE 420 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R4815 AND R4810)

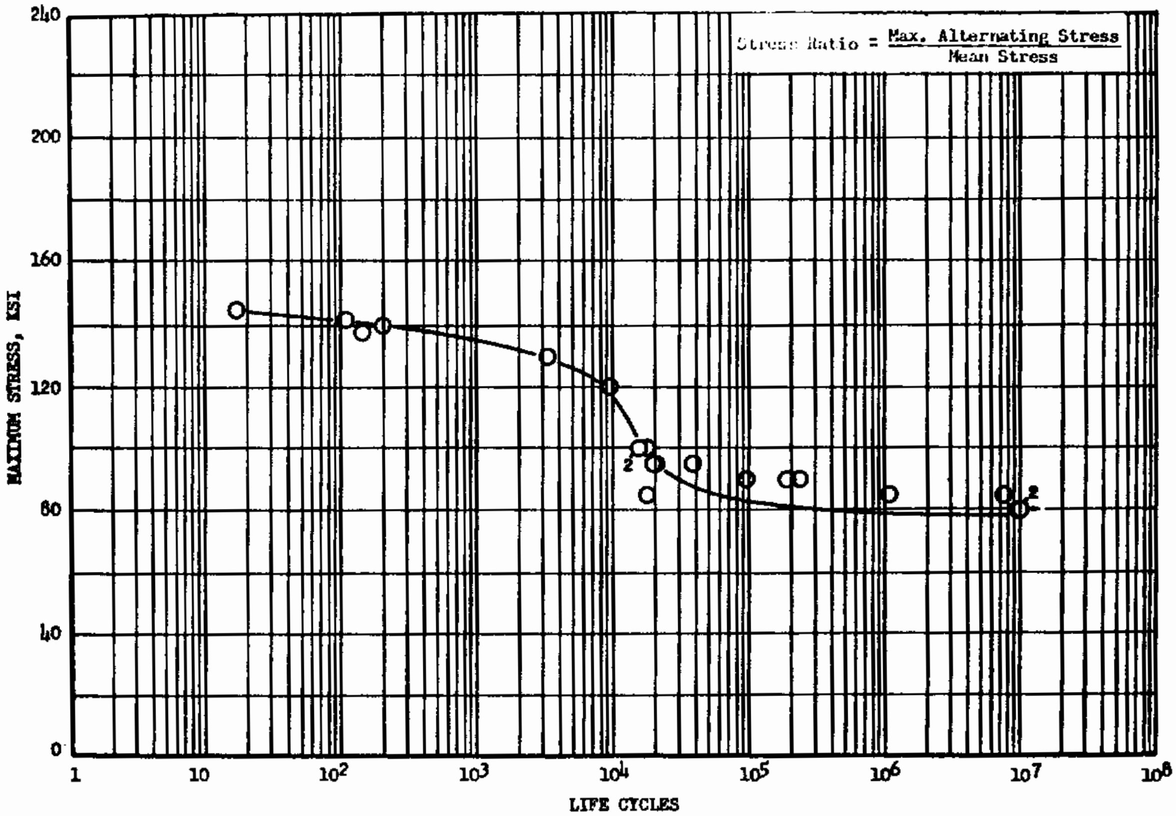


FIGURE 421 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R4815 AND R4810)

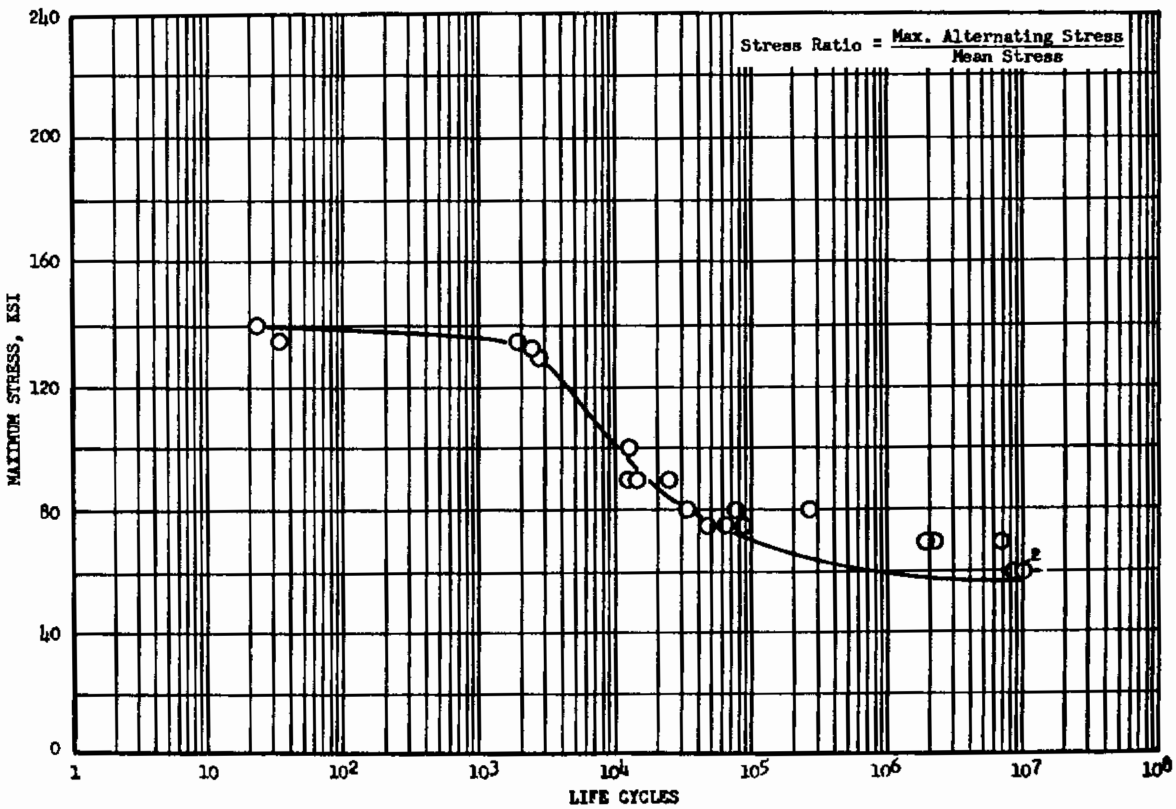


FIGURE 422 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R4815 AND R4810)

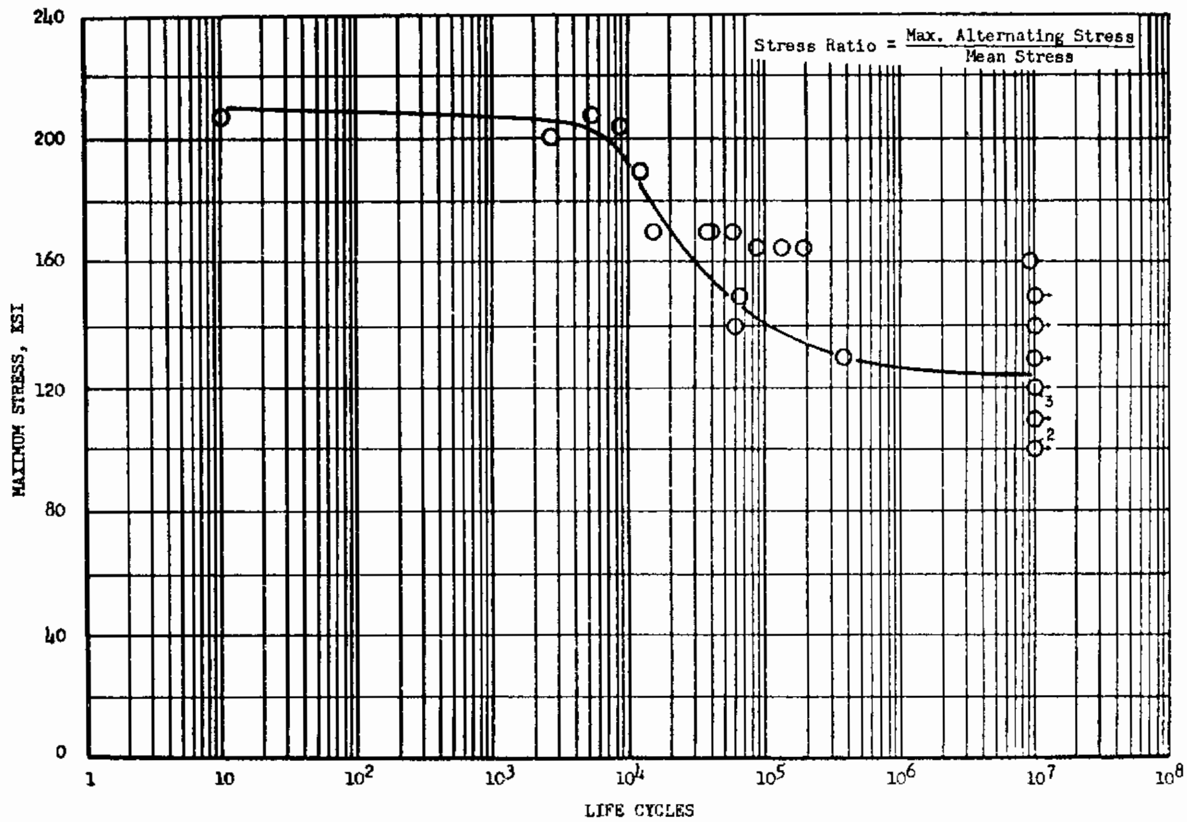


FIGURE 423 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R4815 AND R4810)

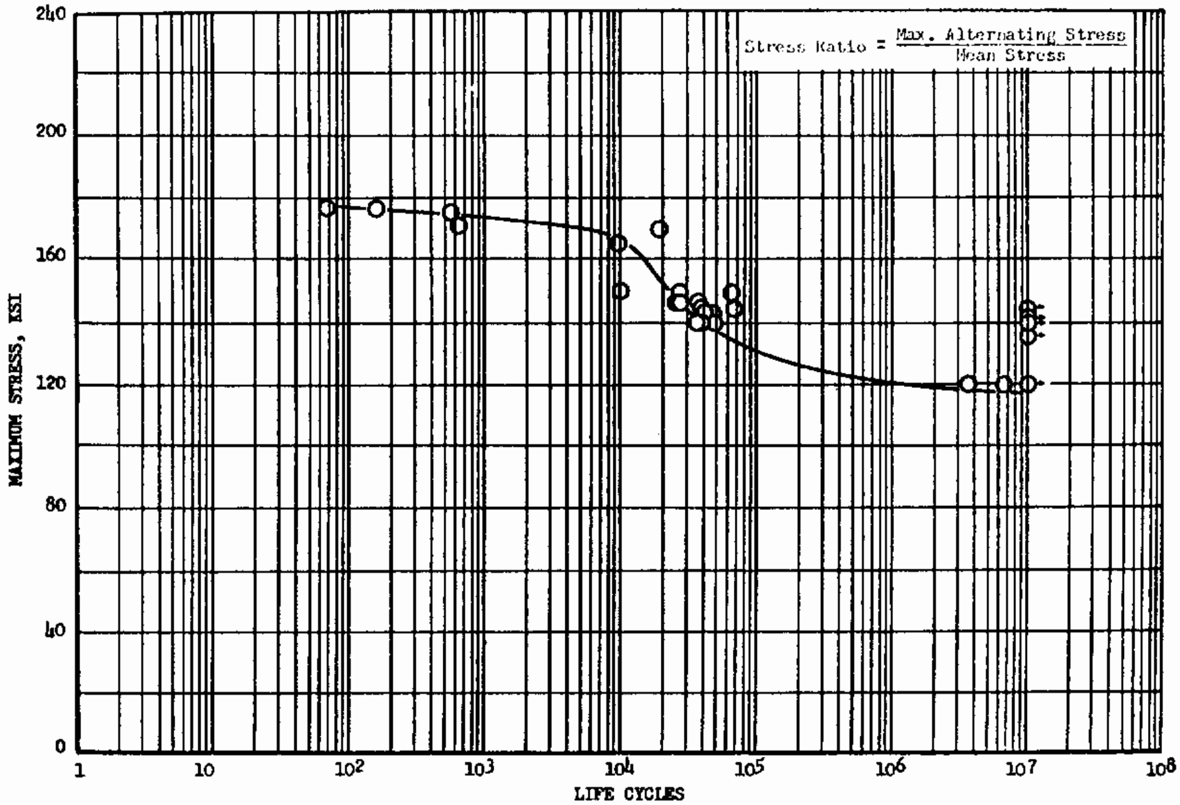


FIGURE 424 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R4815 AND R4810)

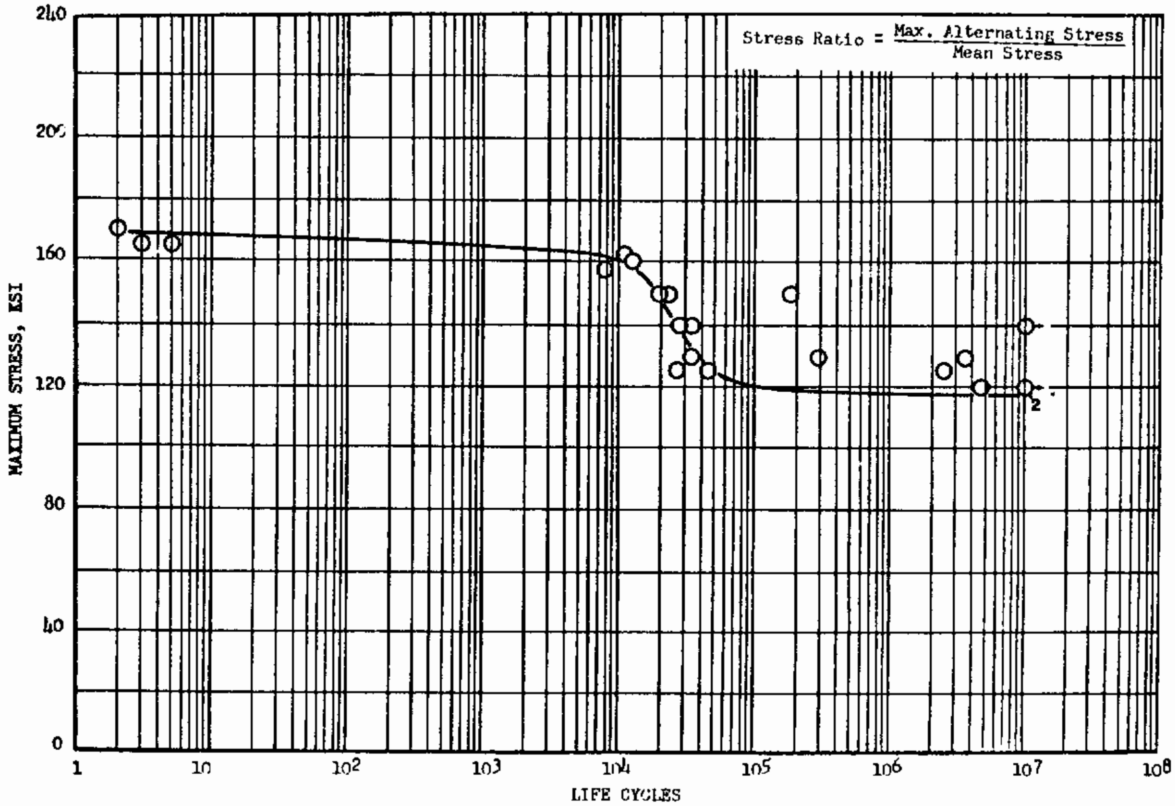


FIGURE 425 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R4815 AND R4810)

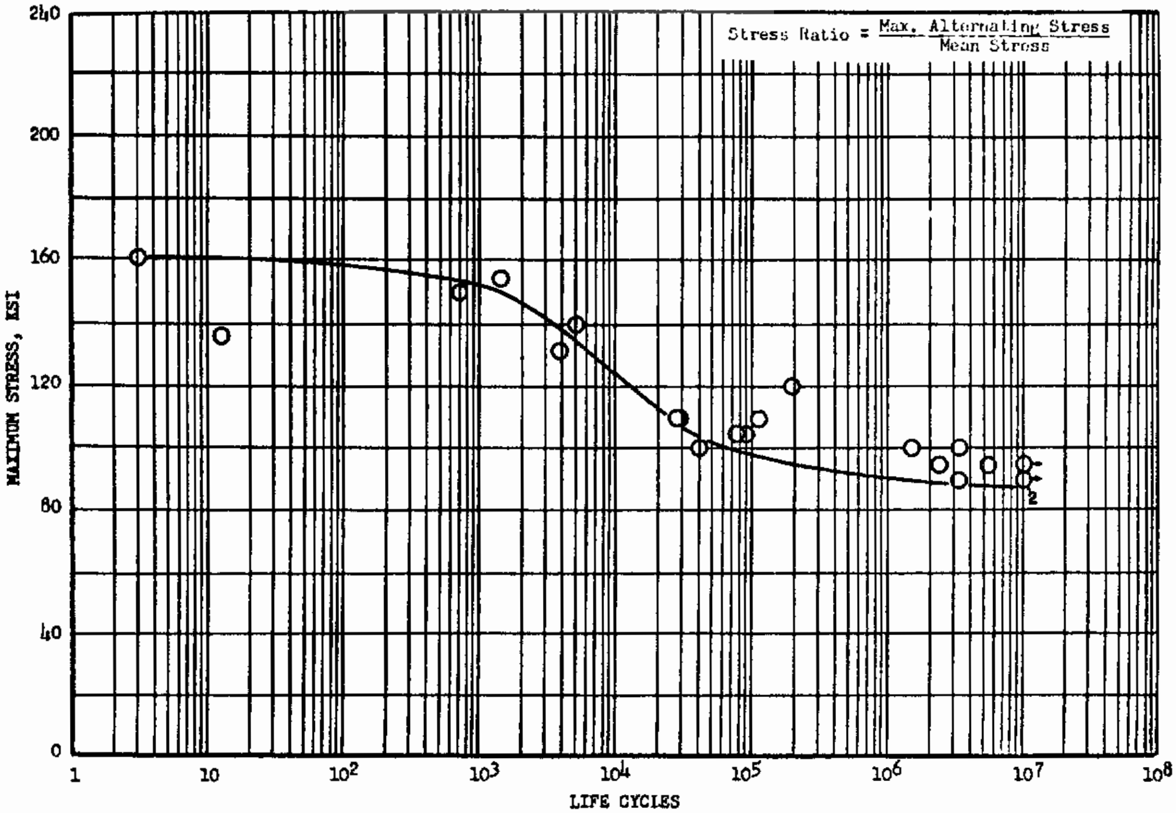


FIGURE 426 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R4815 AND R4810)

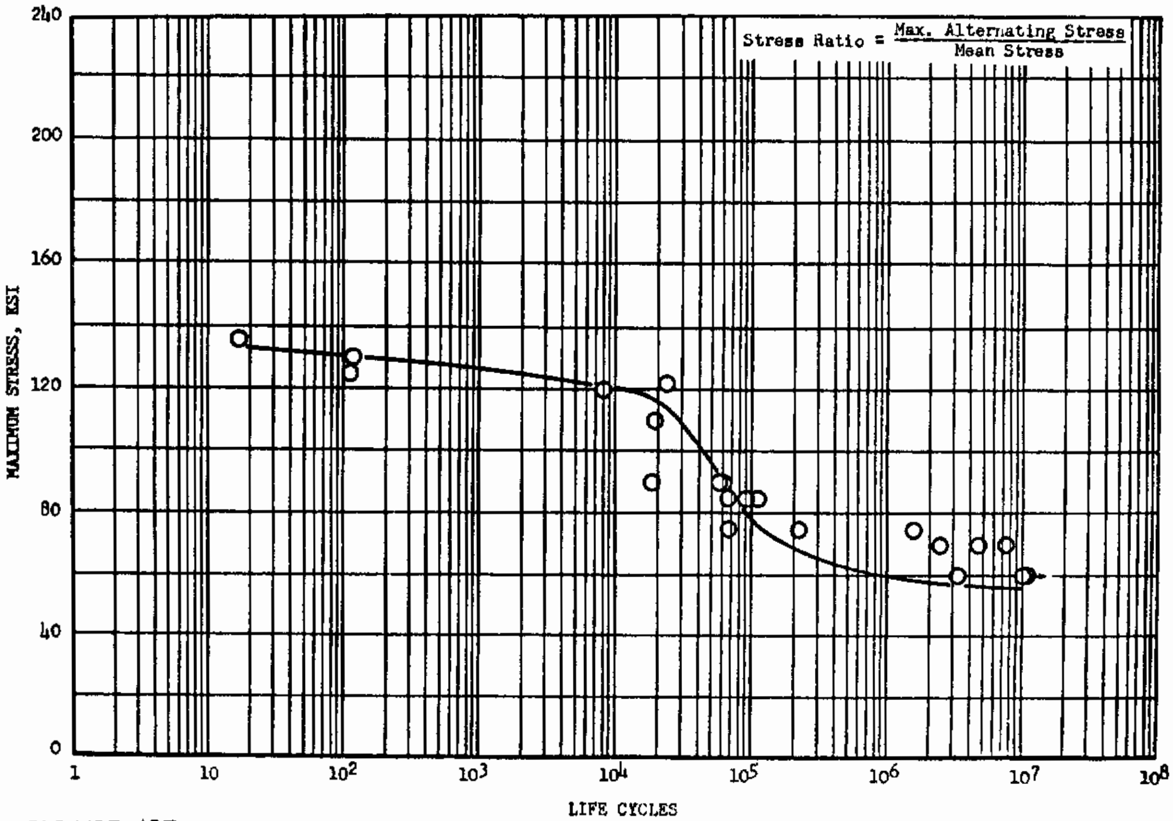


FIGURE 427 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R4815 AND R4810)

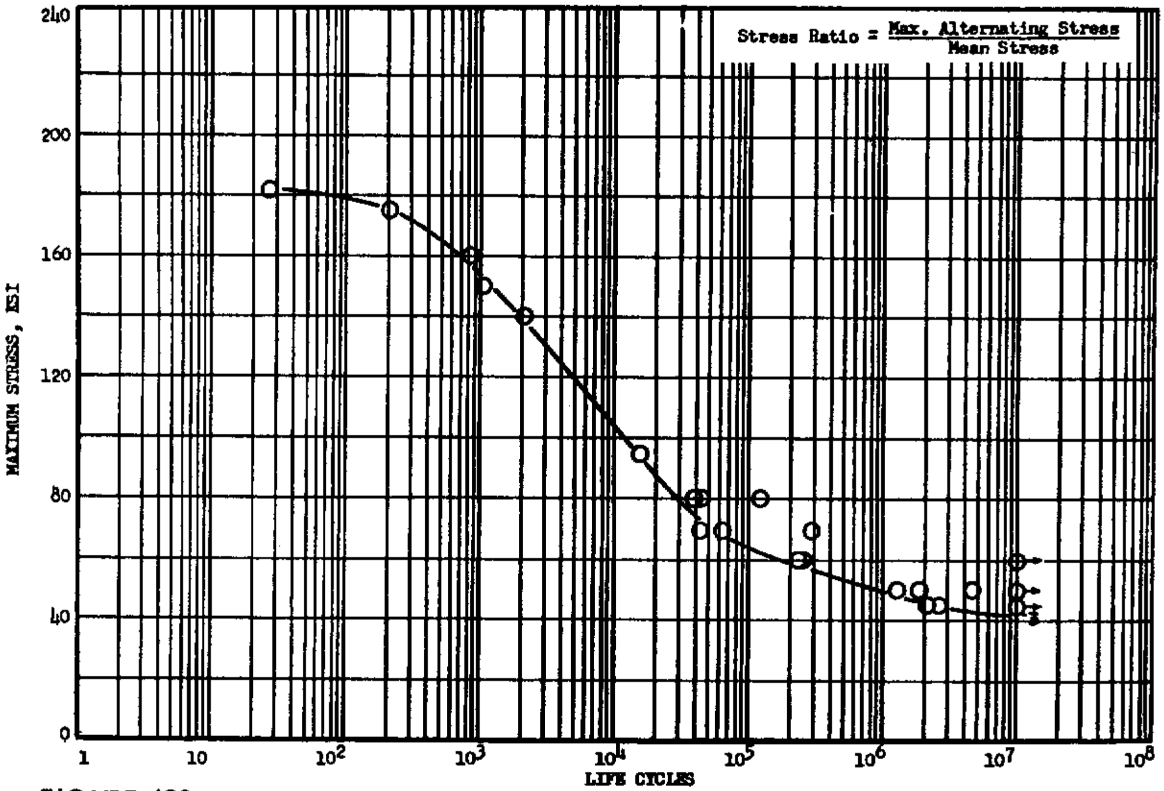


FIGURE 428 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. P7653 AND H4765)

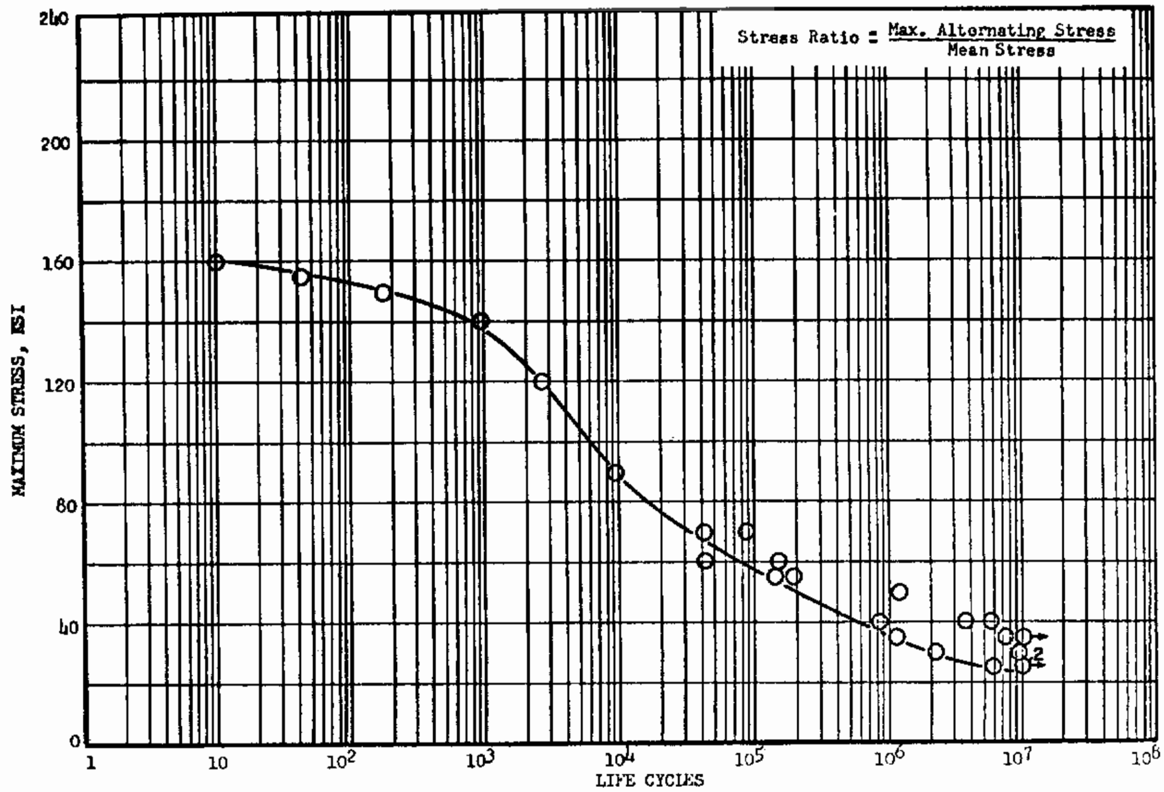


FIGURE 429 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. P7653 AND R4765)

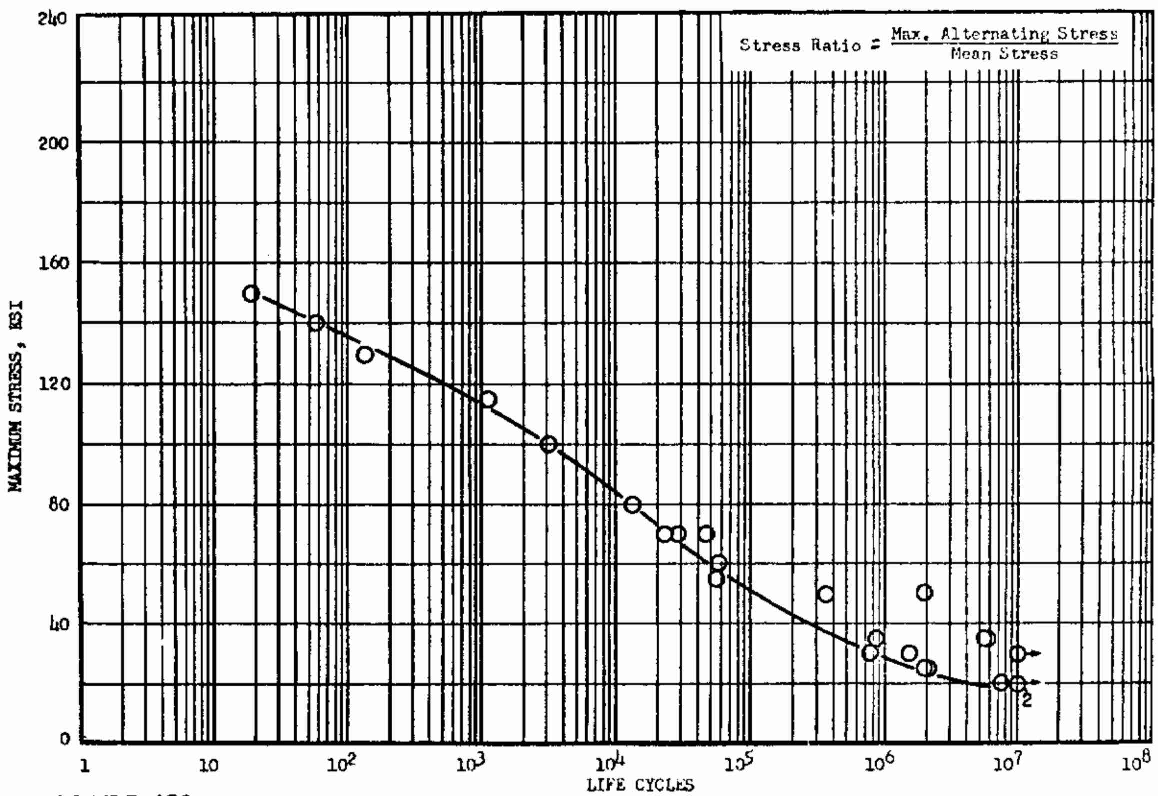


FIGURE 430 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. P7653 AND R4765)

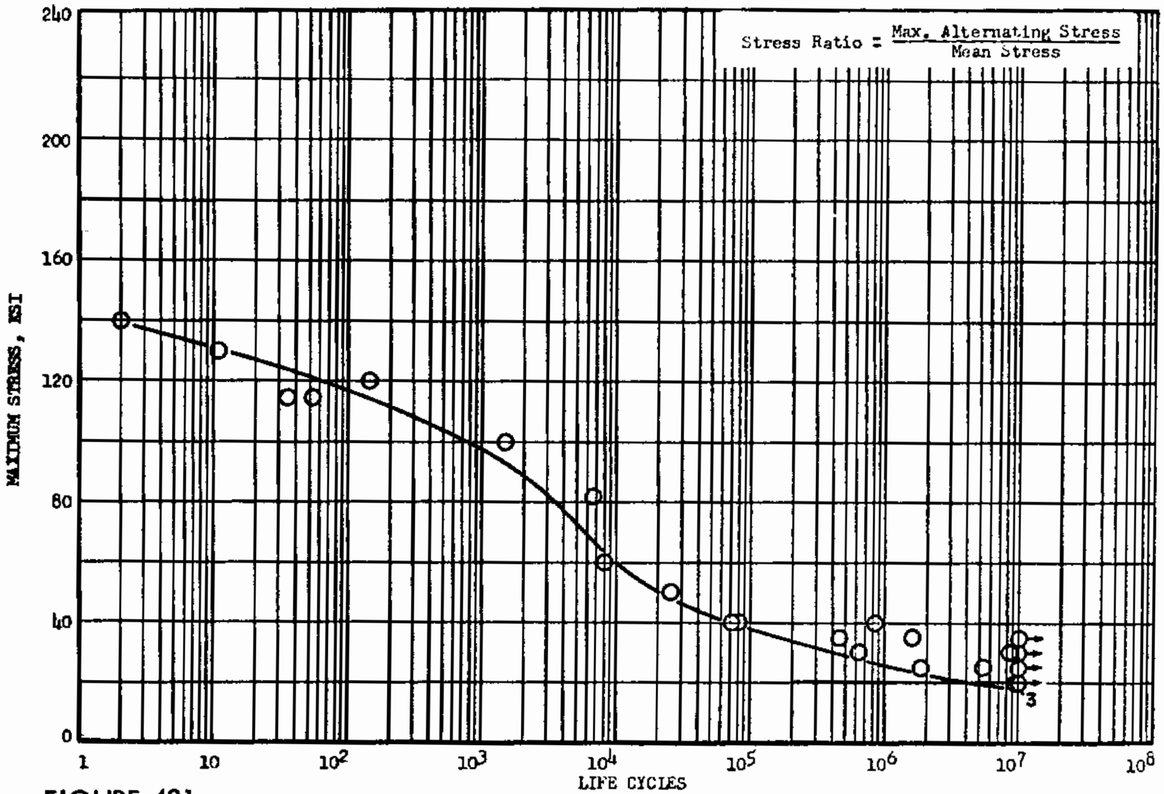


FIGURE 431 – AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. P7653 AND R4765)

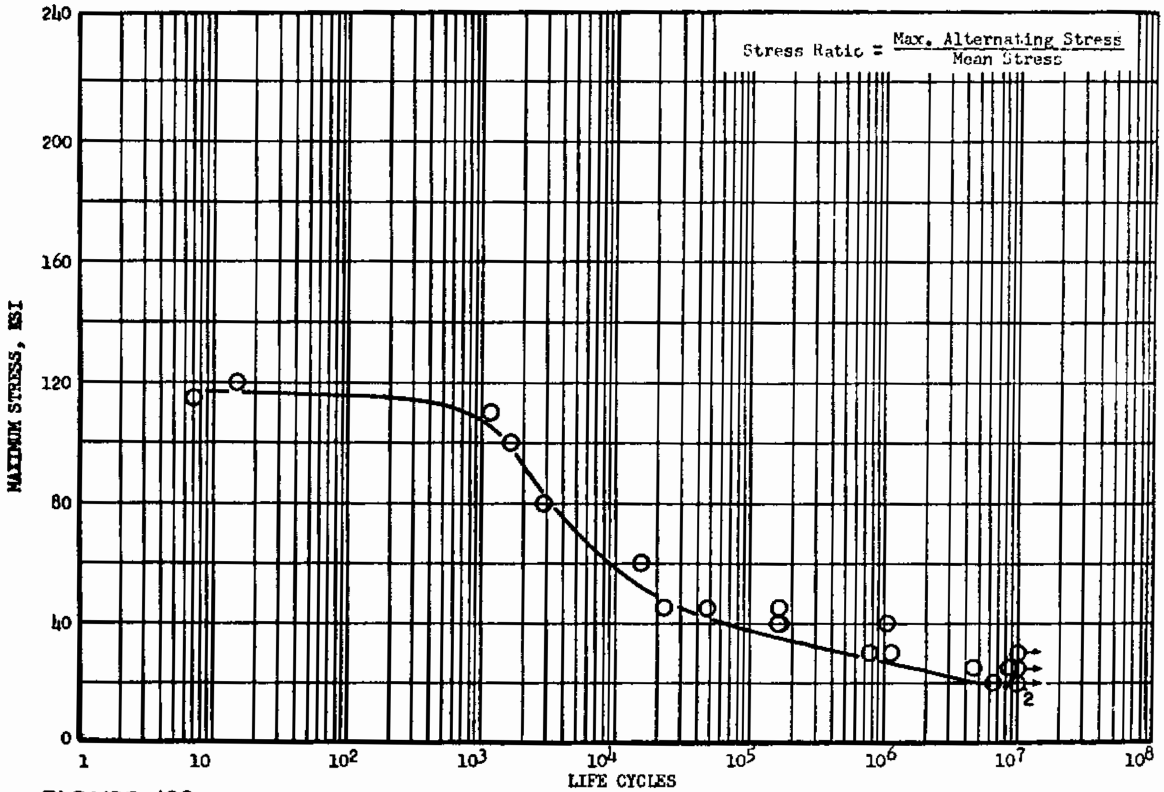


FIGURE 432 – AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. P7653 AND R4765)

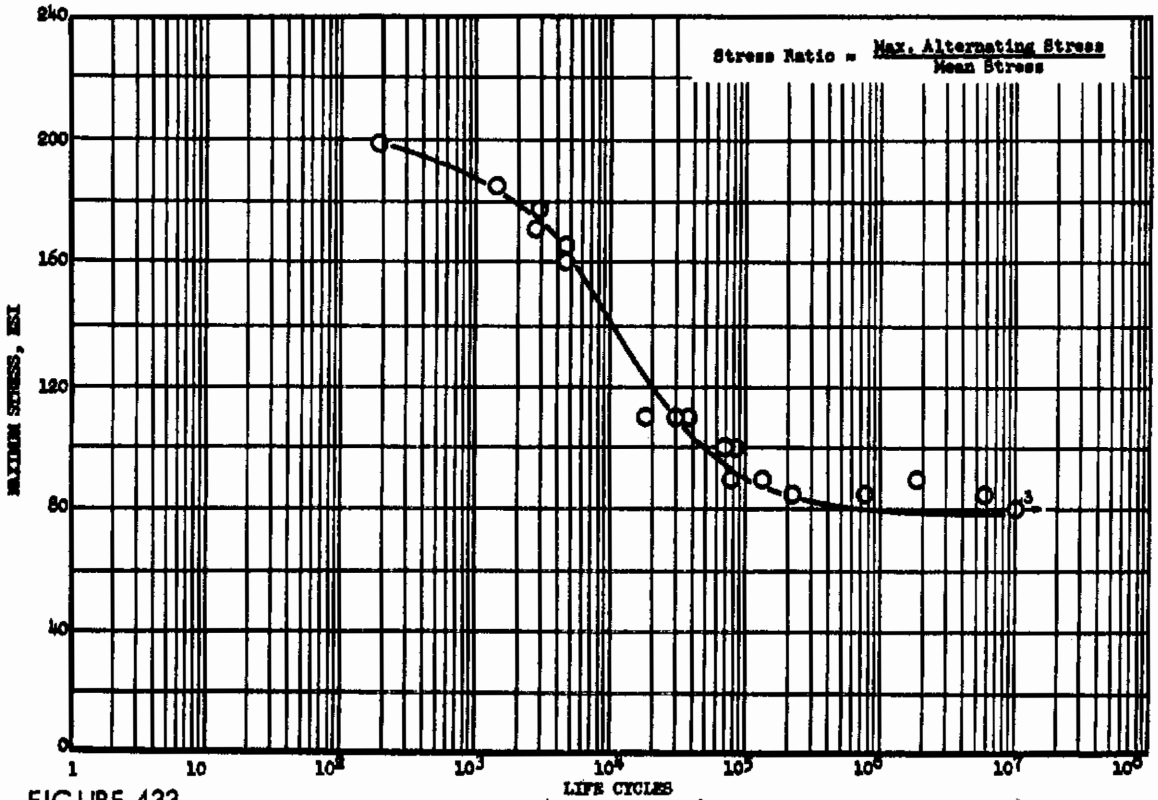


FIGURE 433 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NO. P7653)

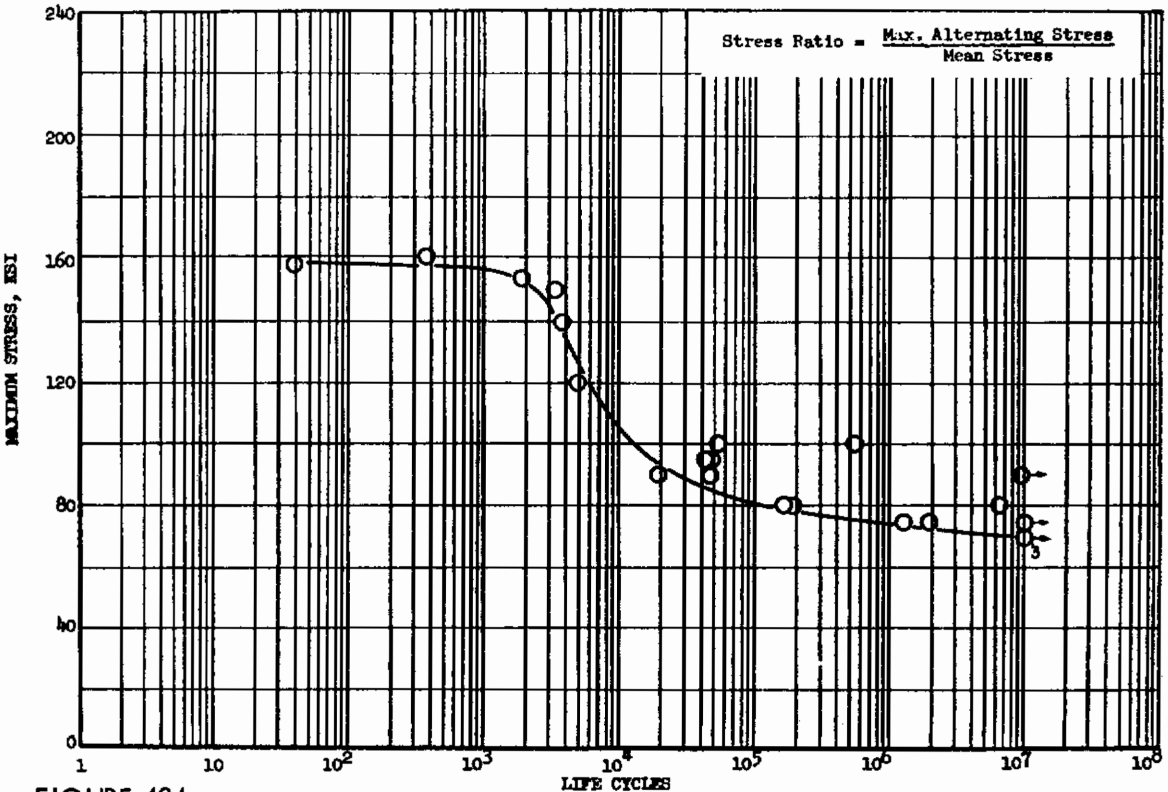


FIGURE 434 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 400° WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NO. P7653)

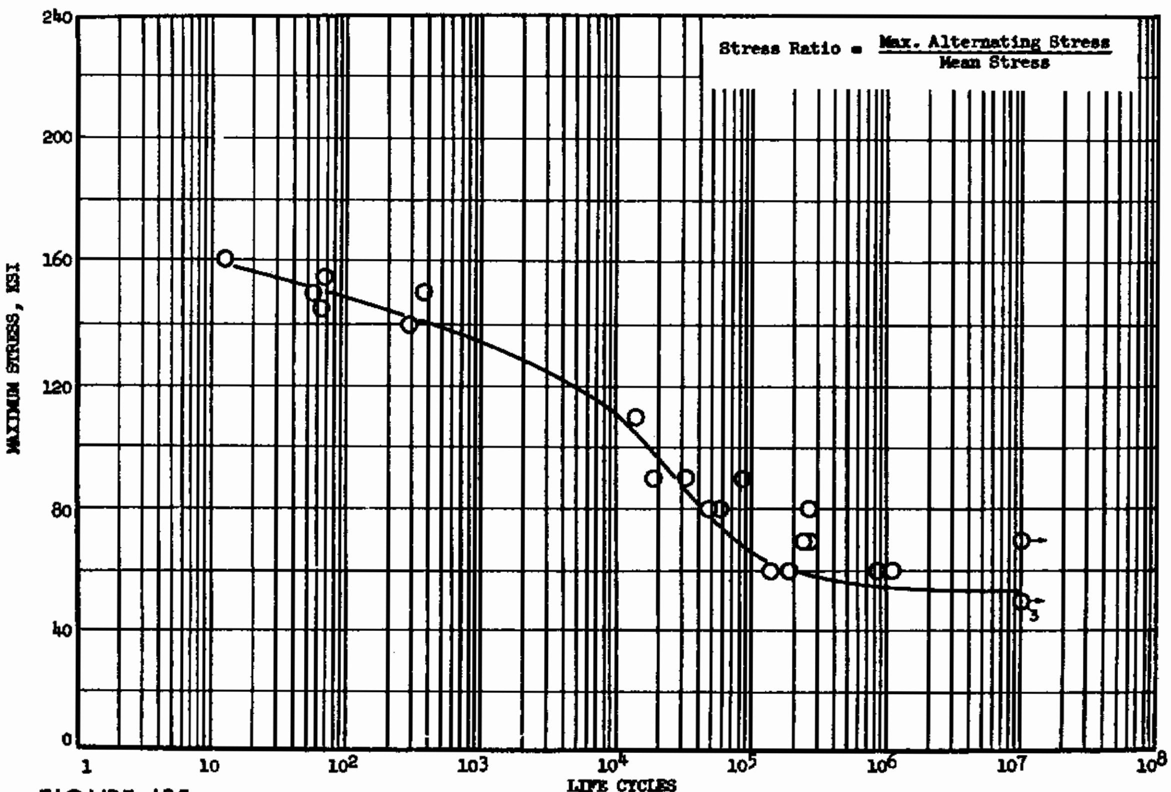


FIGURE 435 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 600° WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NO. P7653)

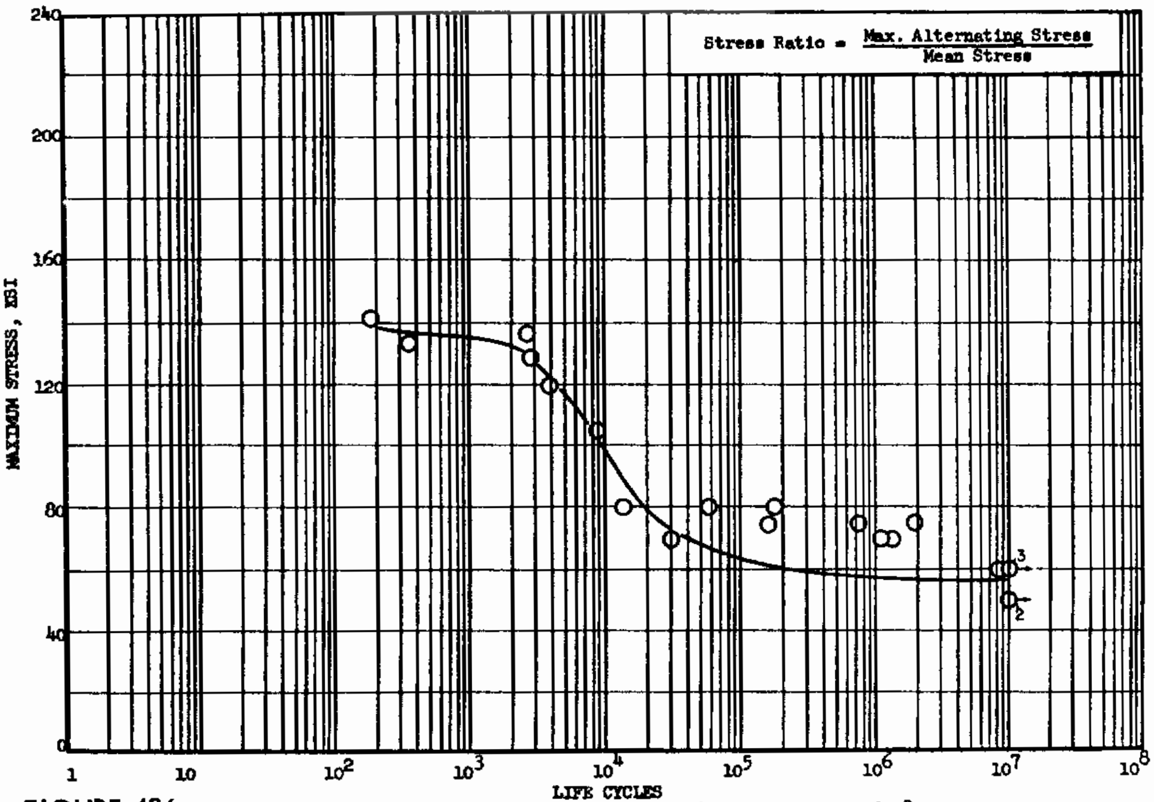


FIGURE 436 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 800° WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NO. P7653)

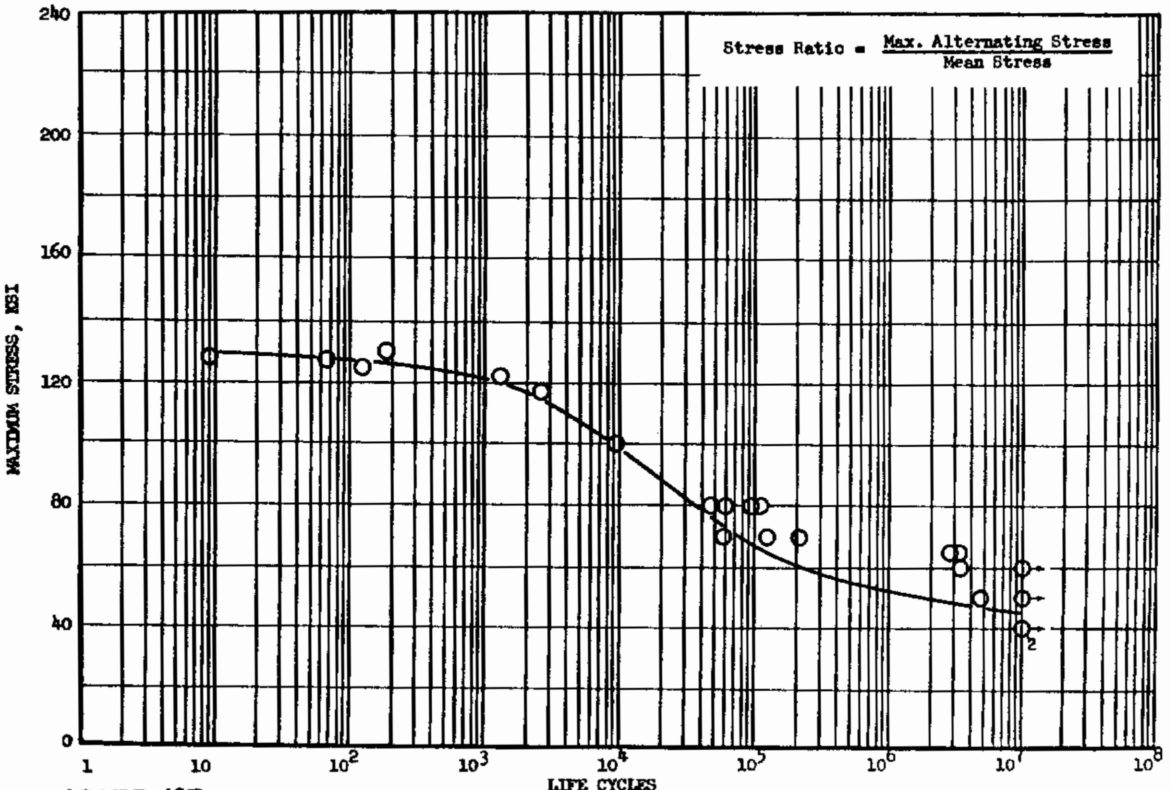


FIGURE 437 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 900° WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NO. P7653)

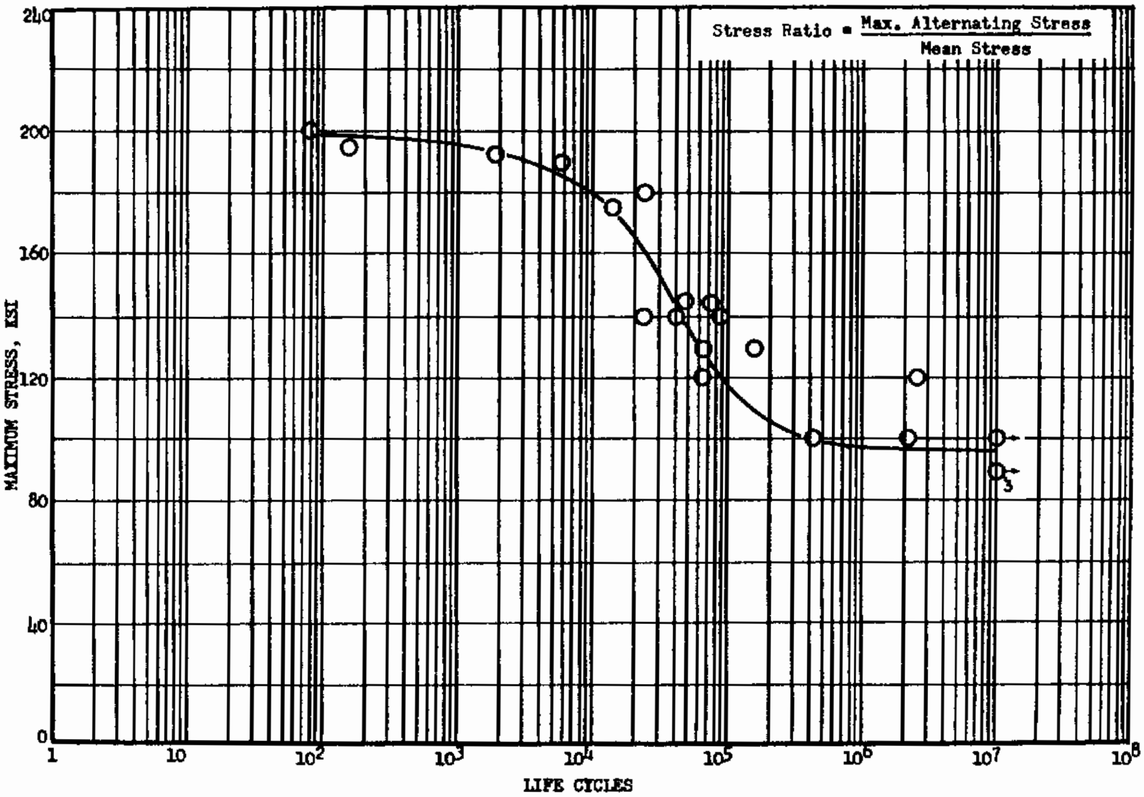


FIGURE 438 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NO. P7653)

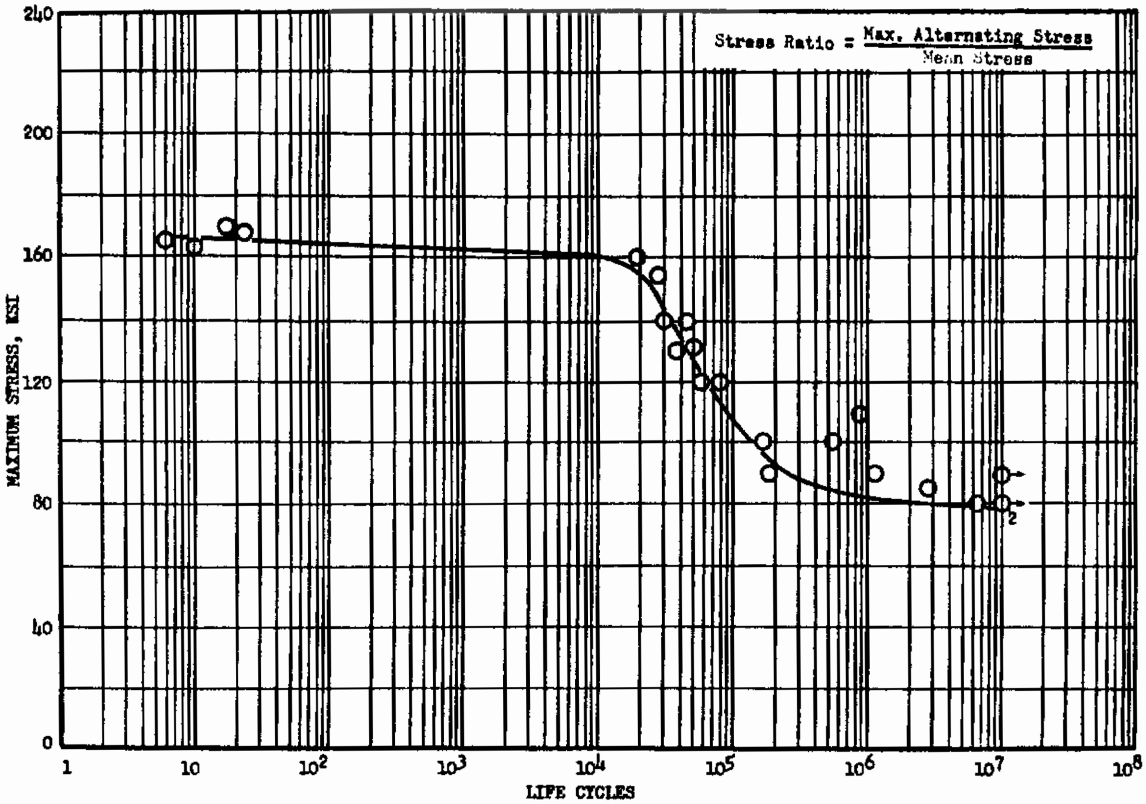


FIGURE 439 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NO. P7653)

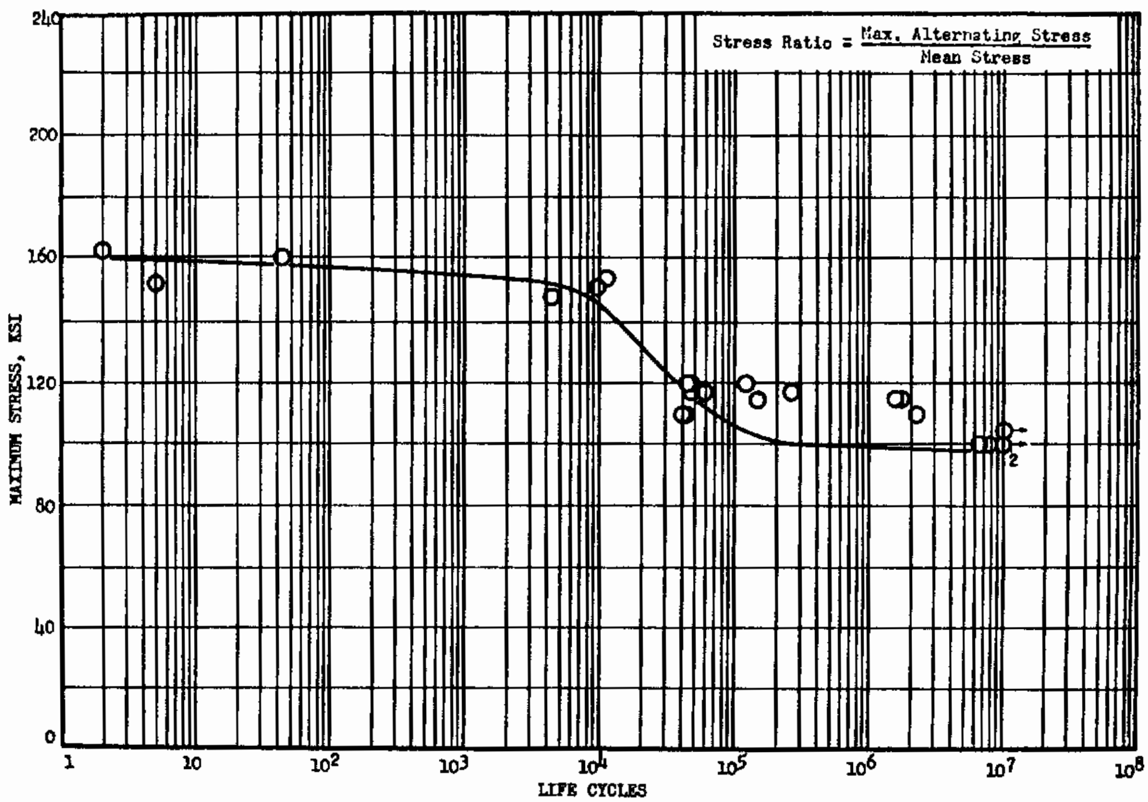


FIGURE 440 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NO. P7653)

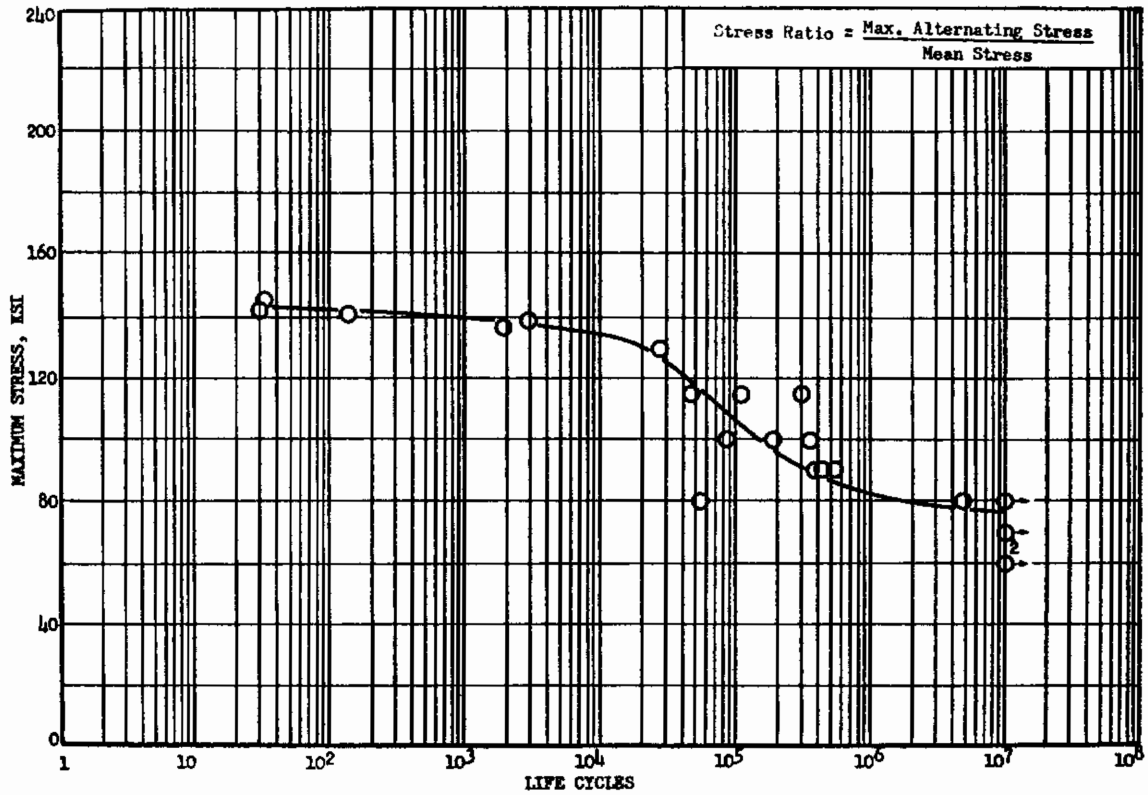


FIGURE 441 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NO. P7653)

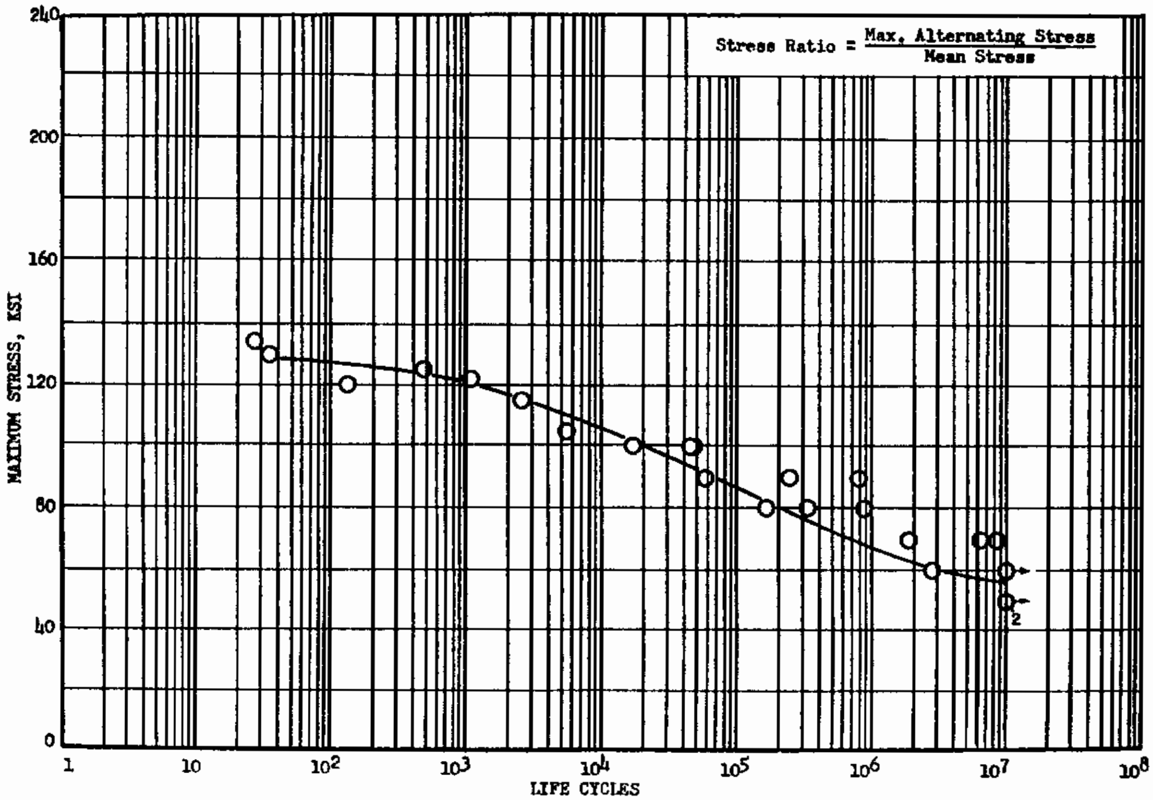


FIGURE 442 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NO. P7653)

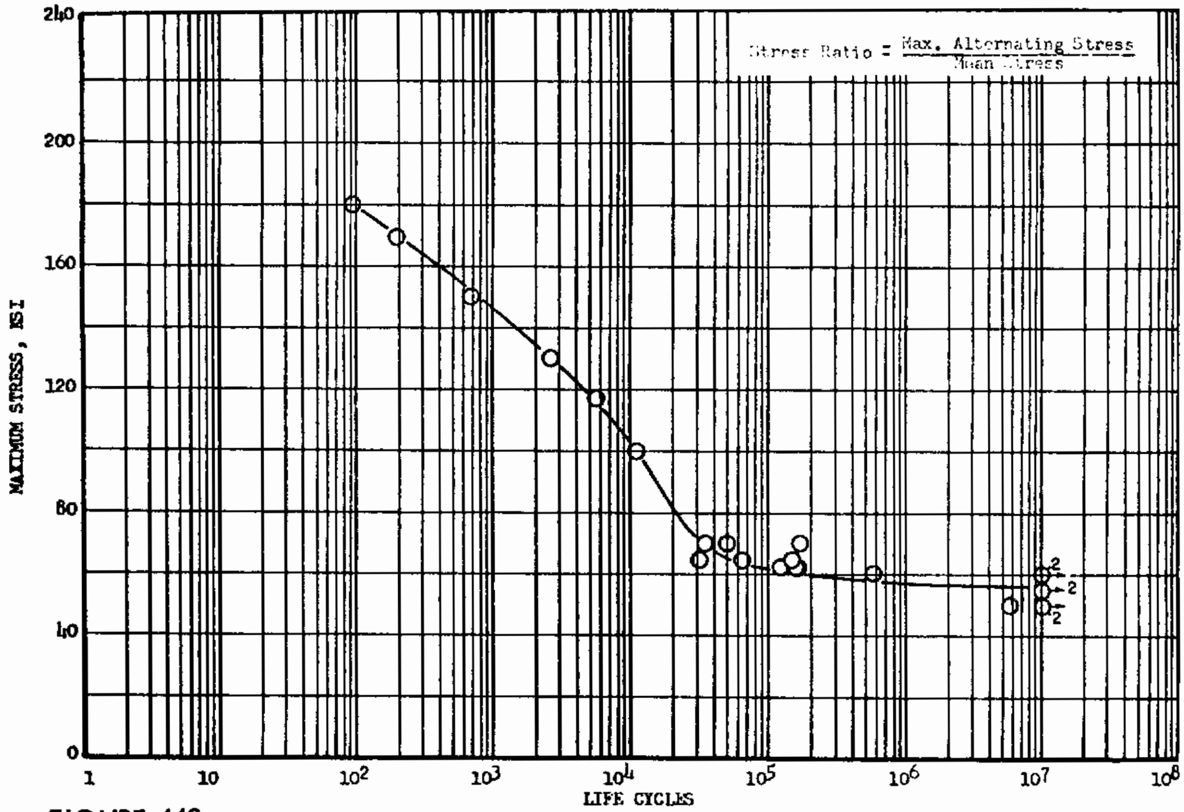


FIGURE 443 – AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R6741, R6736, AND P7647)

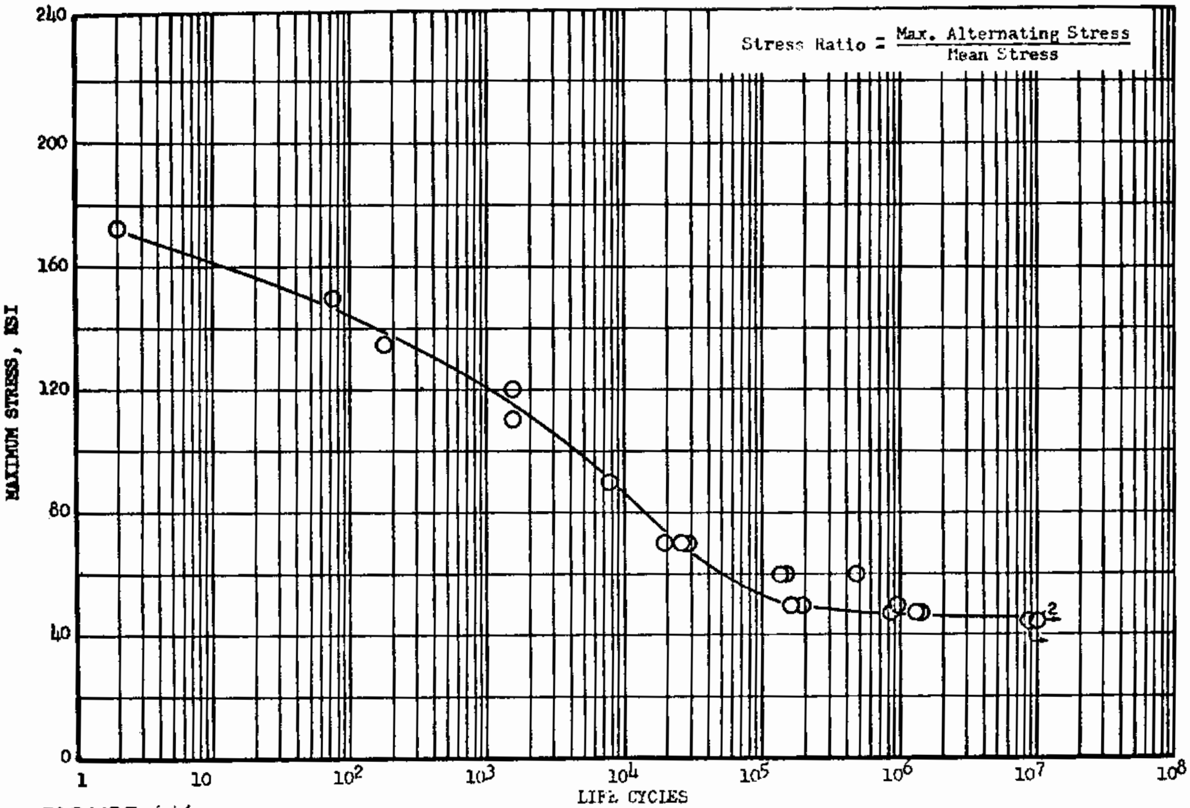


FIGURE 444 – AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R6741, R6736, AND P7647)

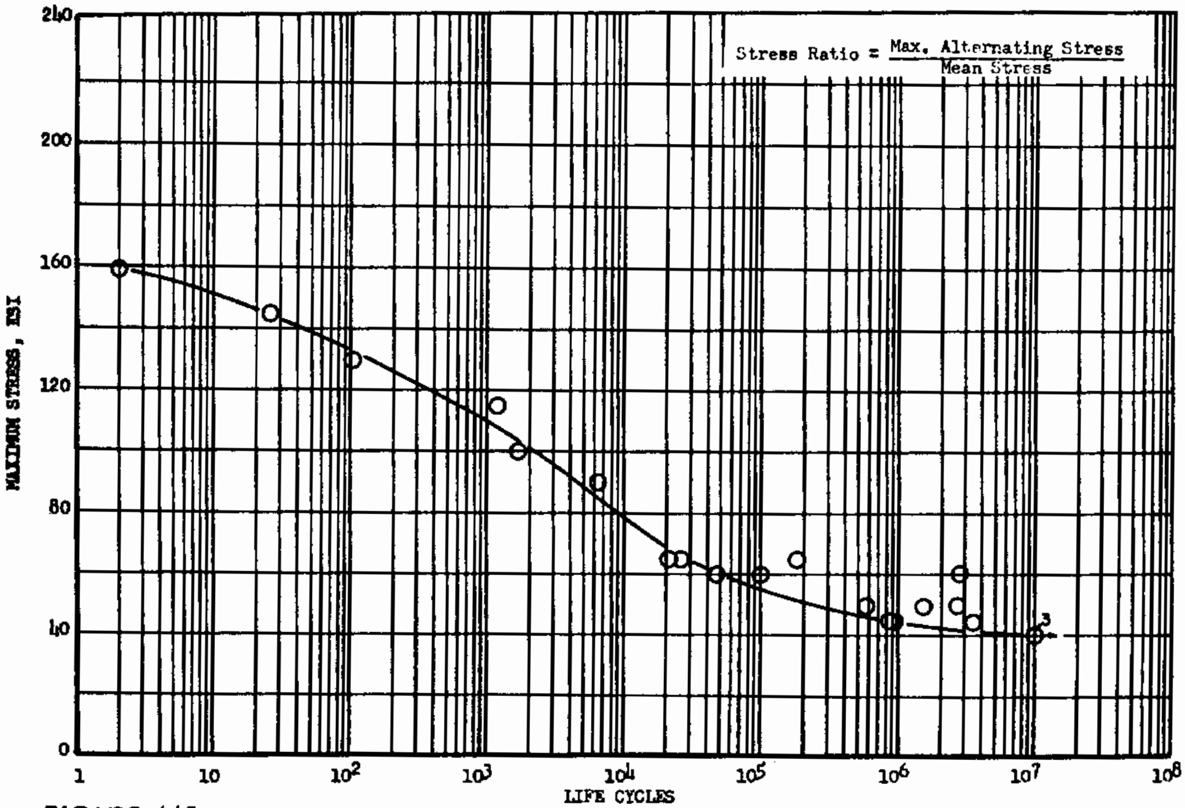


FIGURE 445 – AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R6741, R6736, AND P7647)

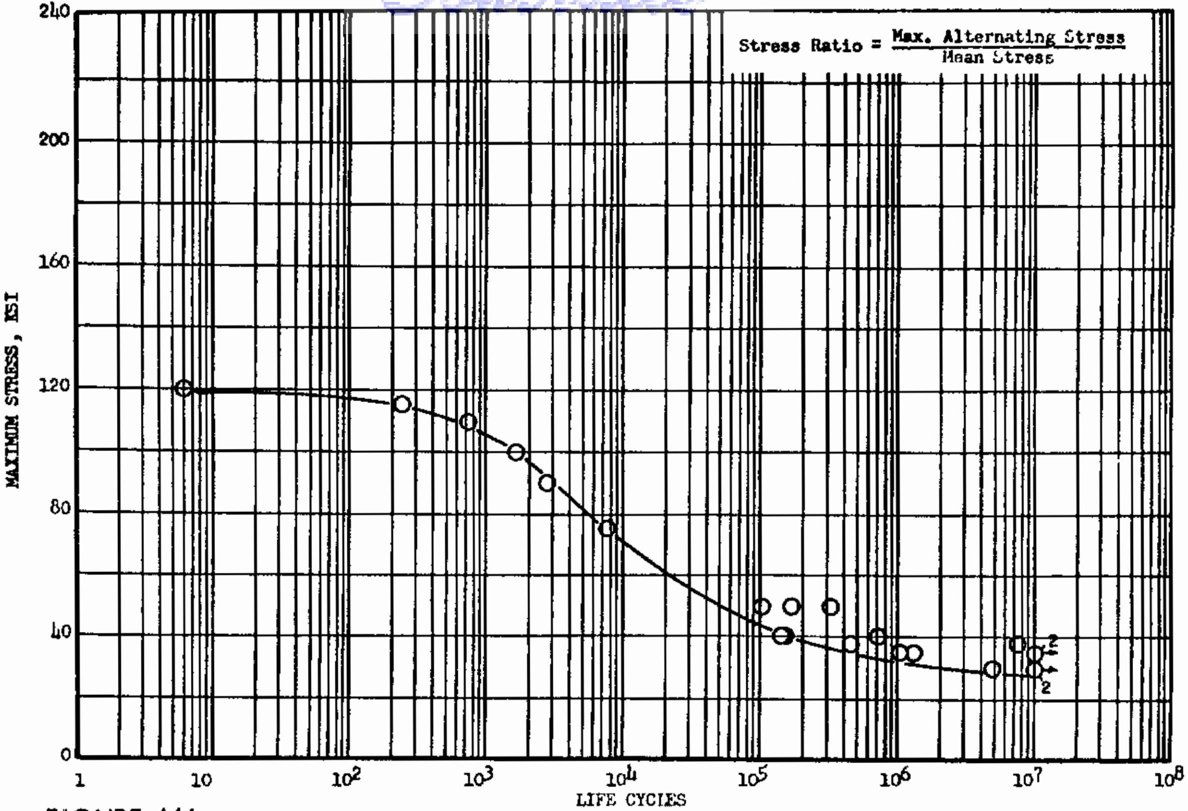


FIGURE 446 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R6741, R6736, AND P7647)

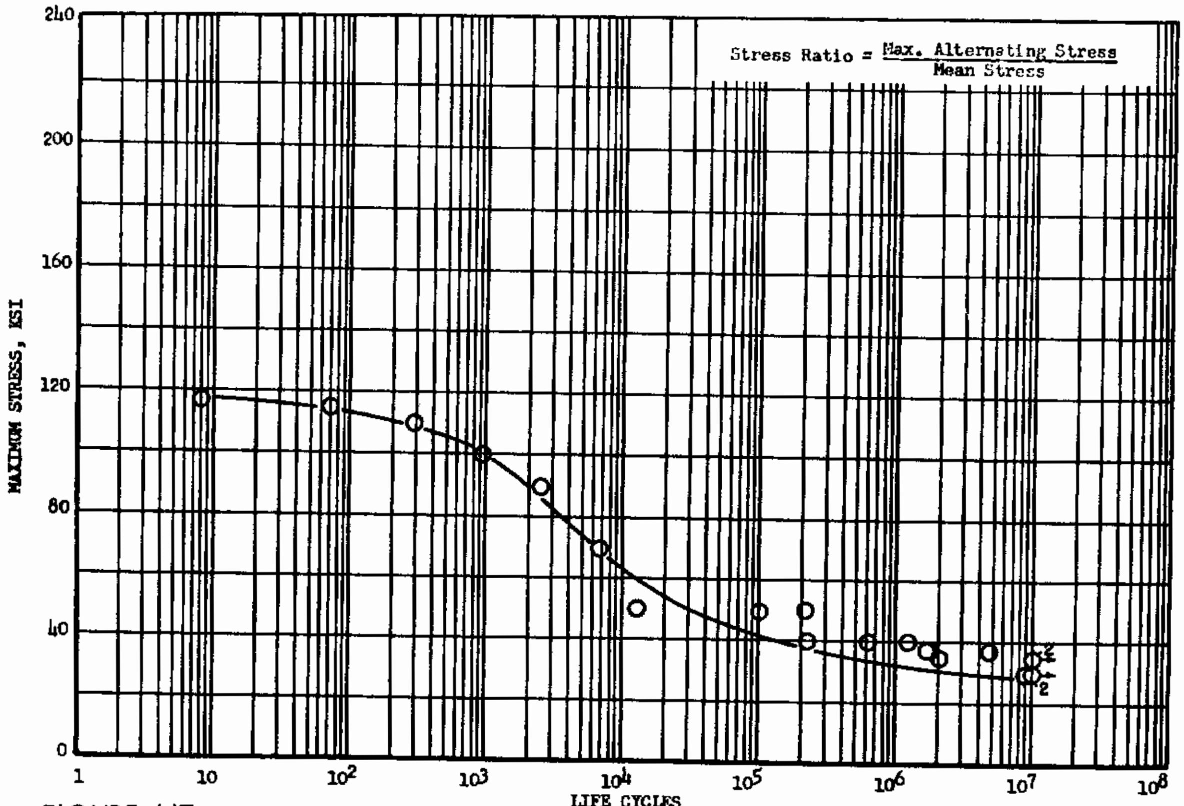


FIGURE 447 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R6741, R6736, AND P7647)

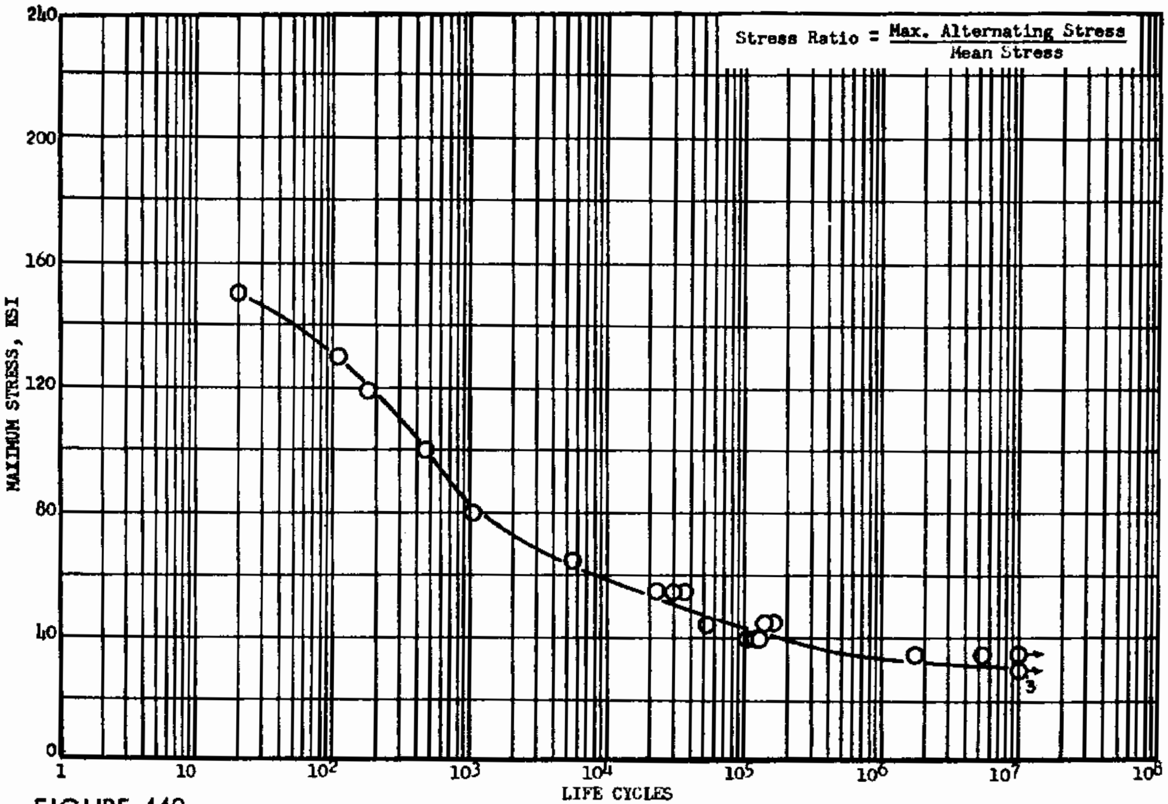


FIGURE 448 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R6741, R6736, AND P7647)

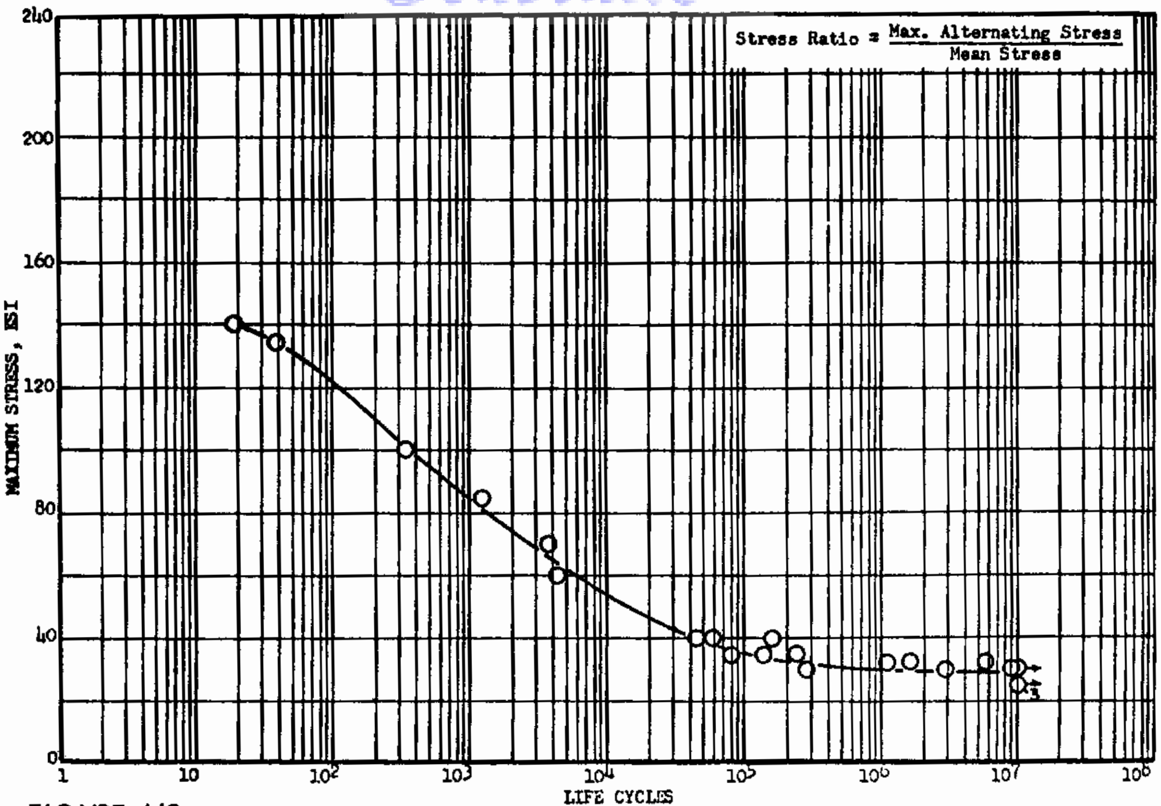


FIGURE 449 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R6741, R6736, AND P7647)

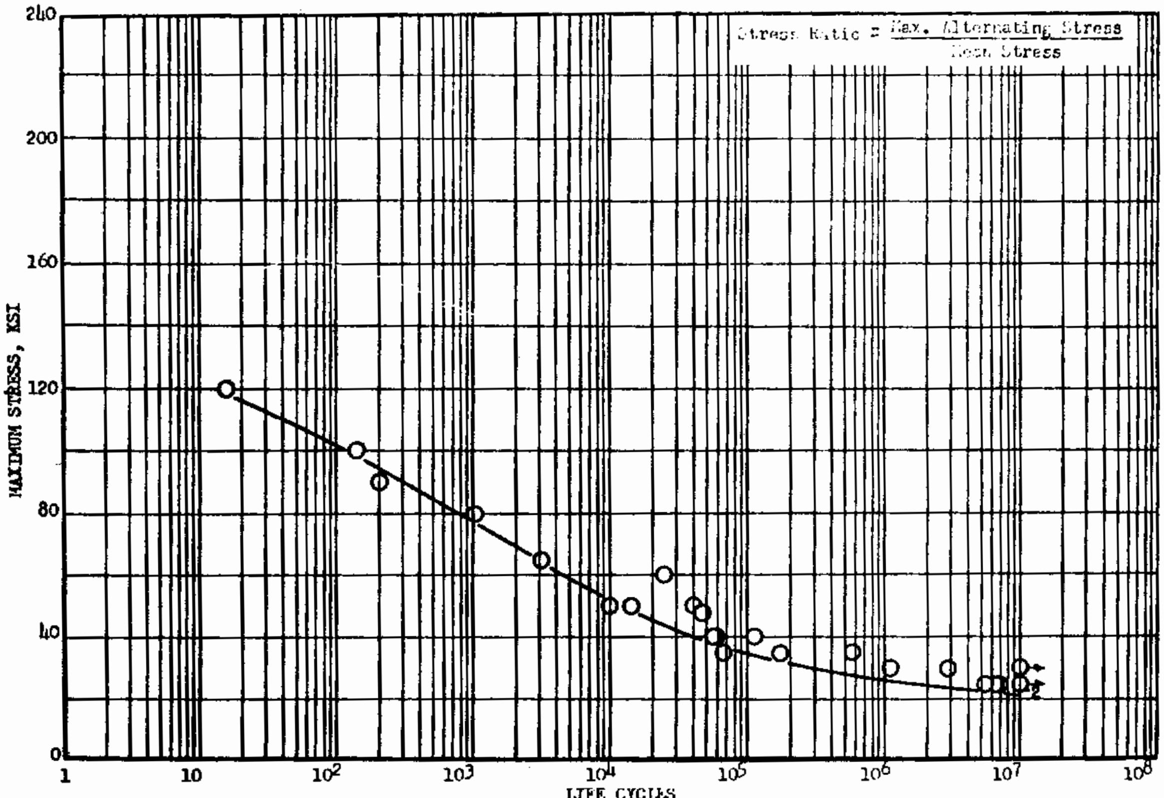


FIGURE 450 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R6741, R6736, AND P7647)

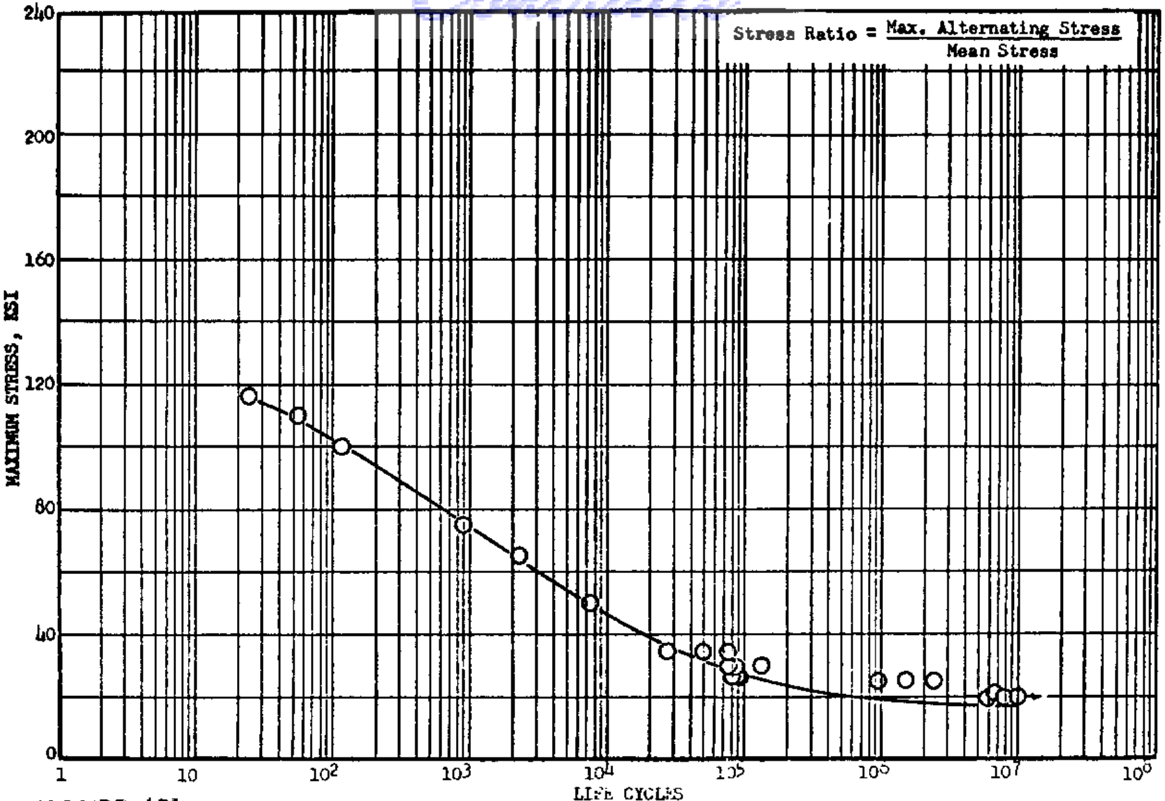


FIGURE 451 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R6741, R6736, AND P7647)

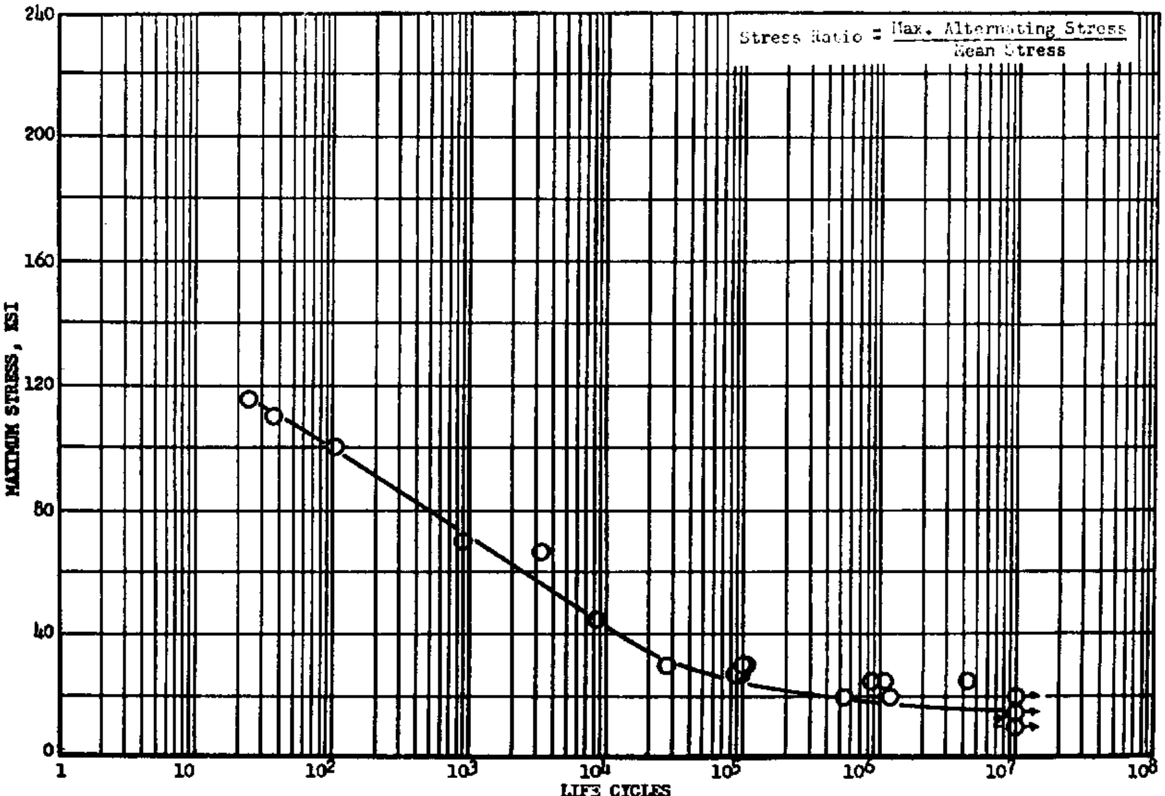


FIGURE 452 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R6741, R6736, AND P7647)

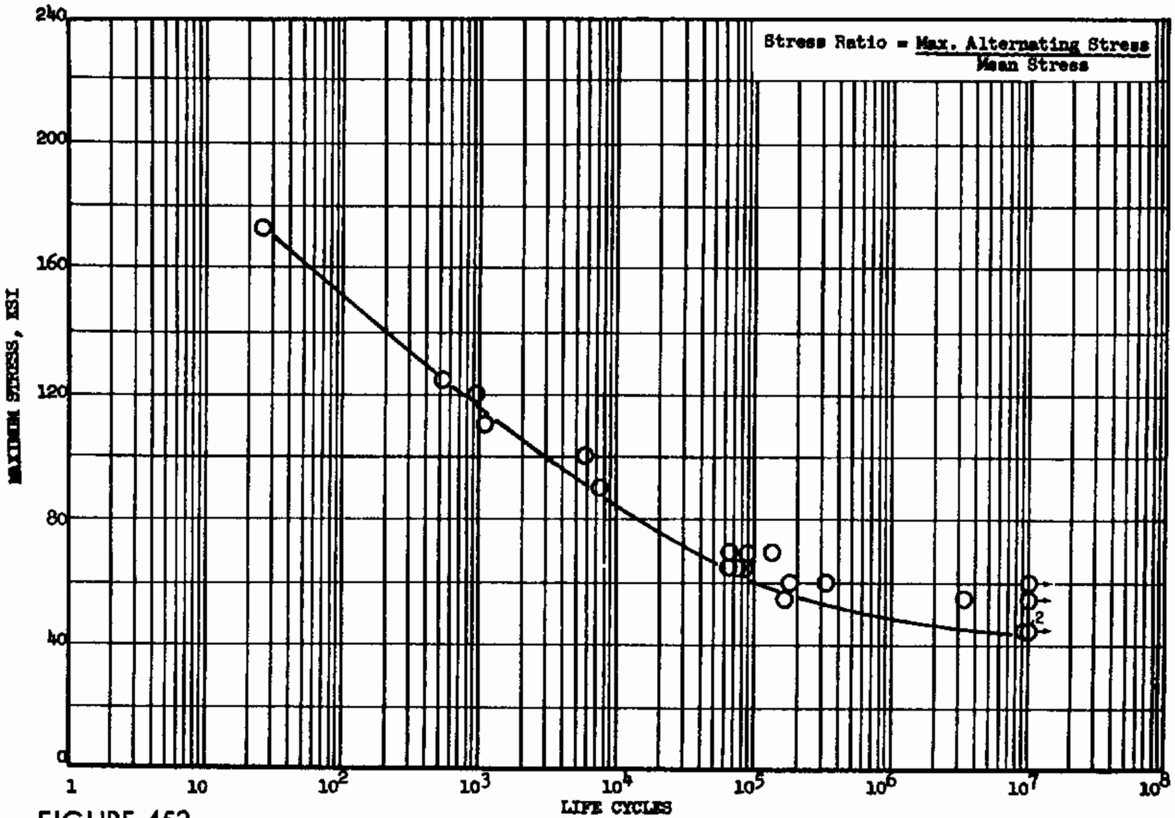


FIGURE 453 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R6741, R6736, AND P7647)

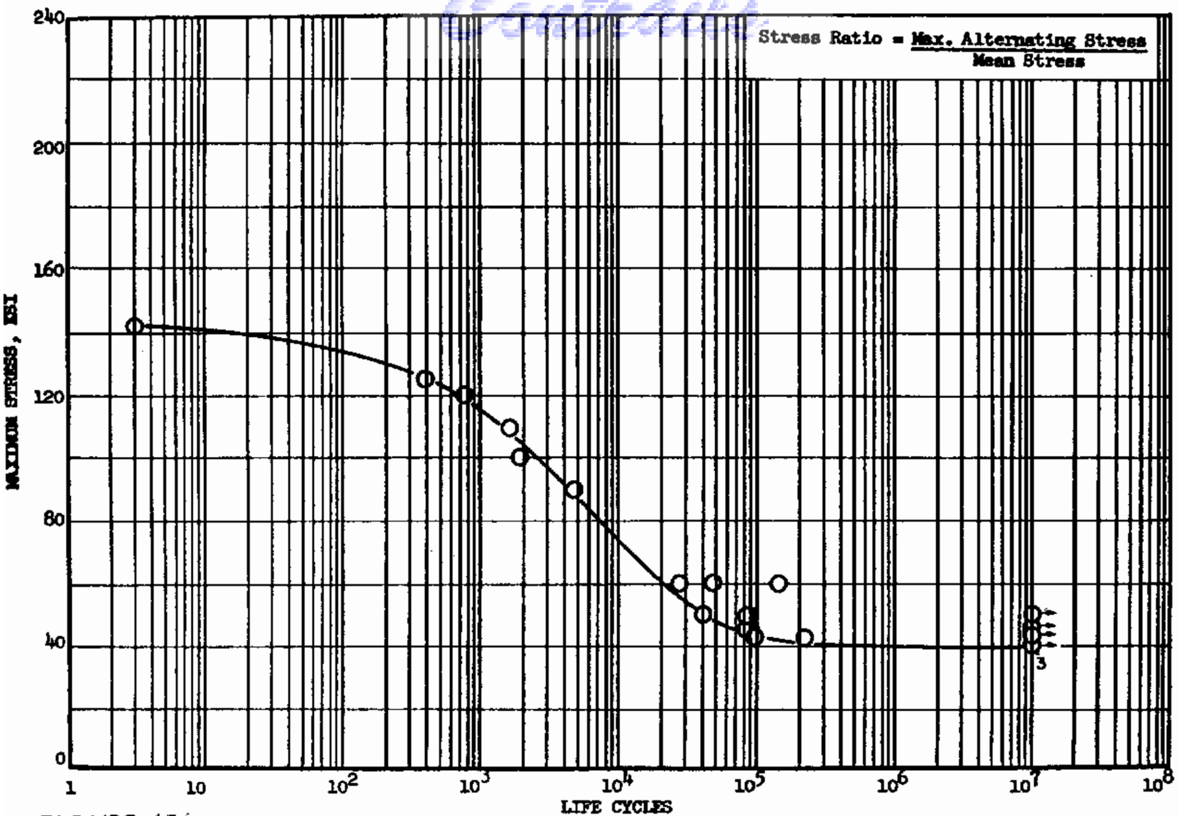


FIGURE 454 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 400° WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R6741, R6736 AND P7647)

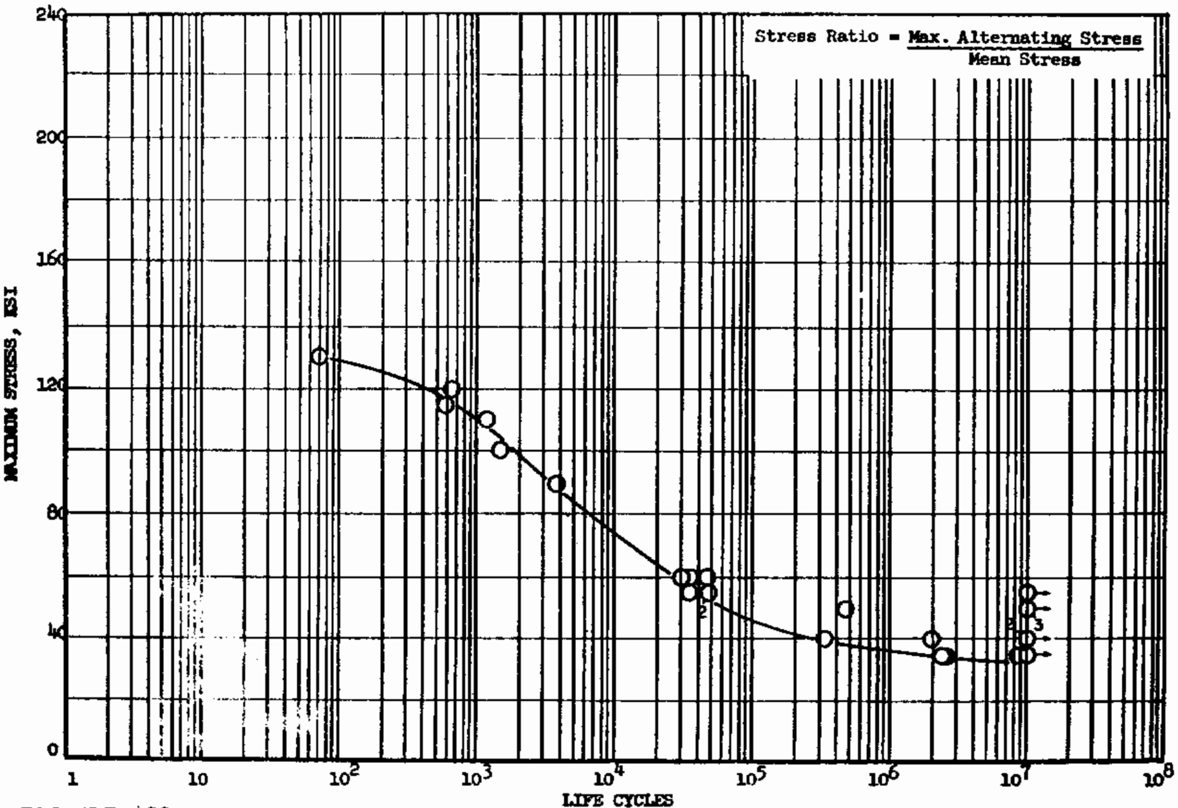


FIGURE 455 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 600° WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R6741, R6736 AND P7647)

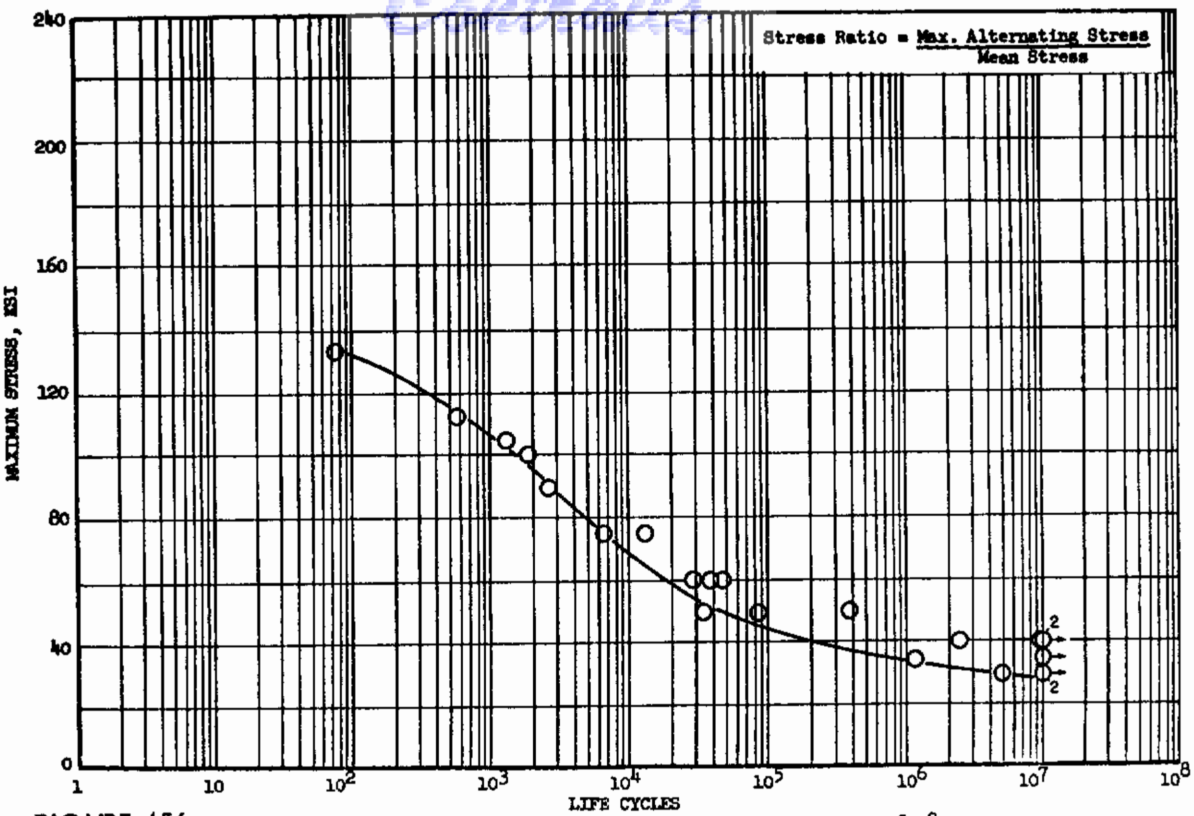


FIGURE 456 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 800° WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R6741, R6736, AND P7647)

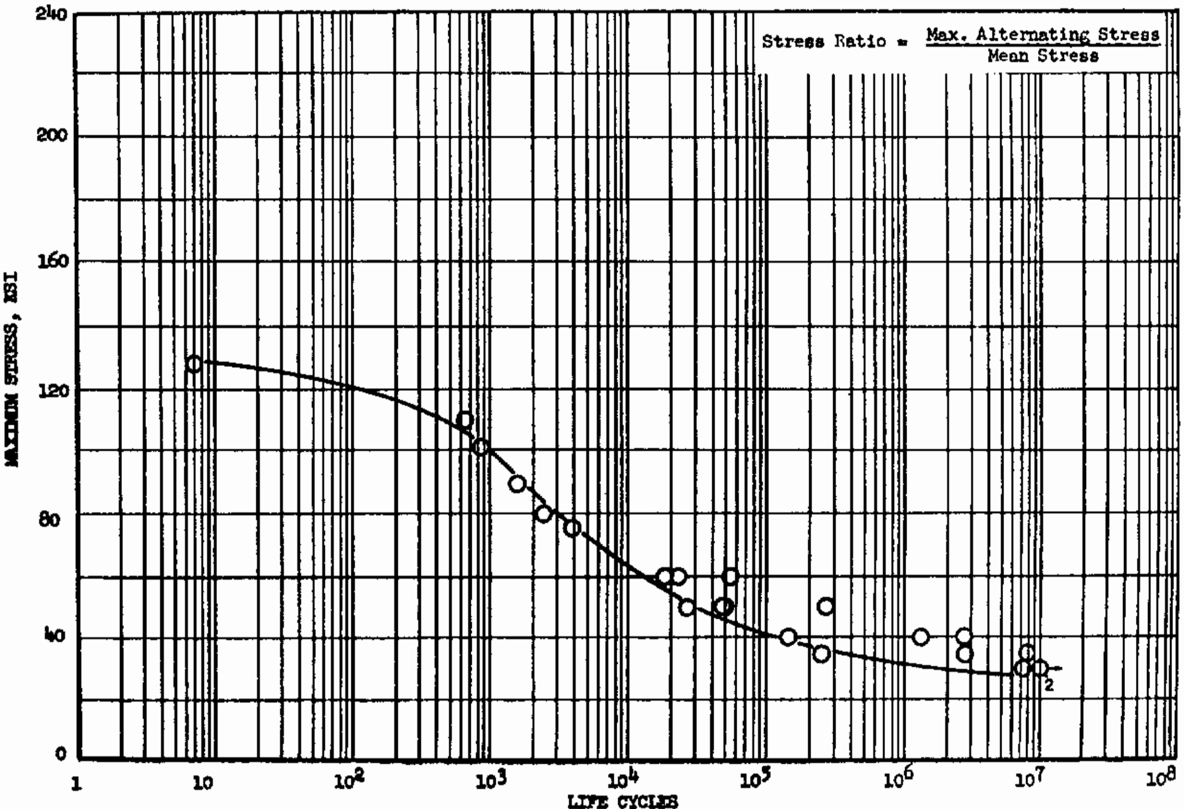


FIGURE 457 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 900° WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R6741, R6736 AND P7647)

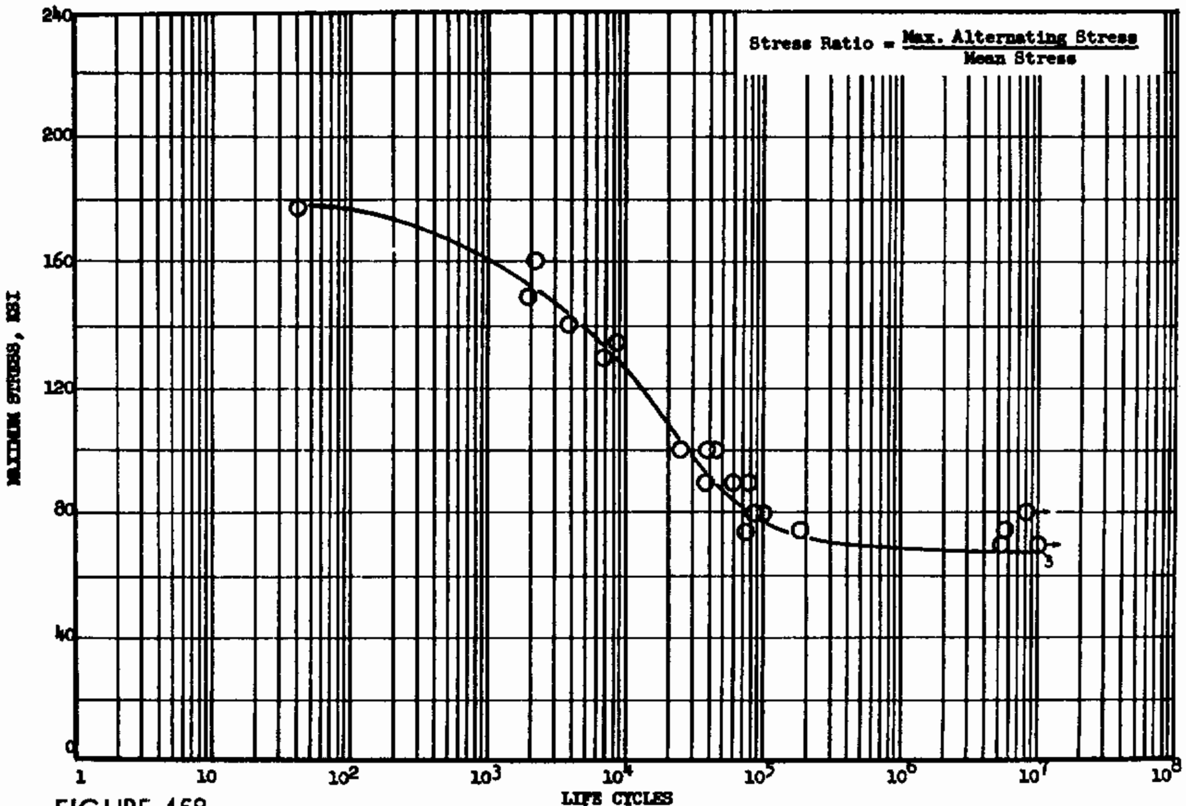


FIGURE 458 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R6741, R6736, AND P7647)

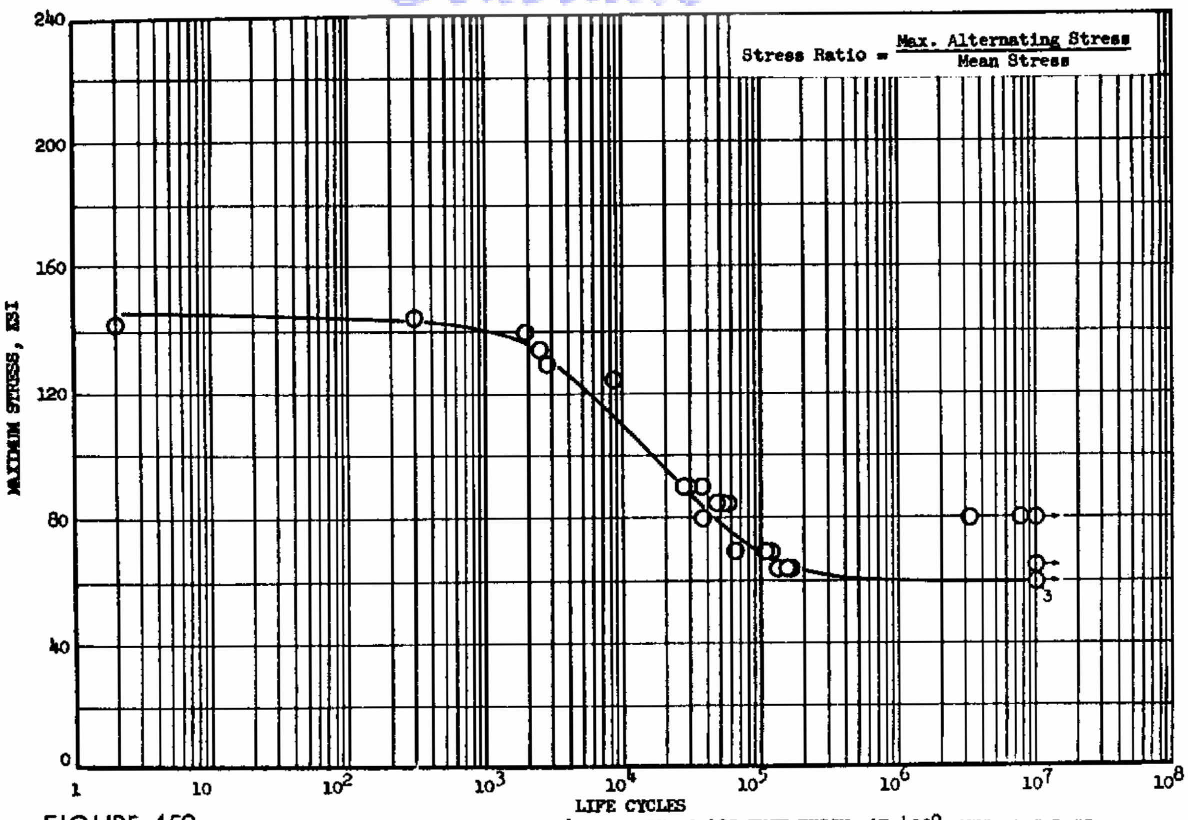


FIGURE 459 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 400°, WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R6741, R6736, AND P7647)

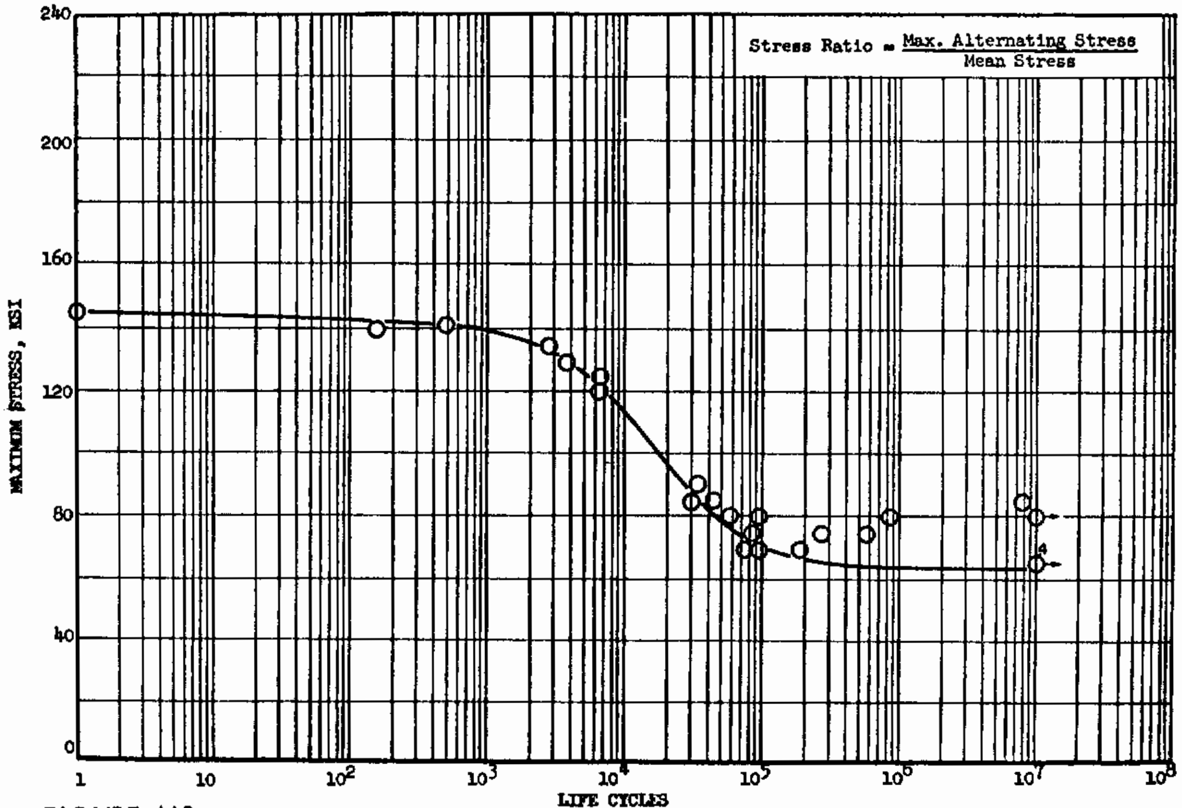


FIGURE 460 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 600° WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R6741, R6736 AND P7647)

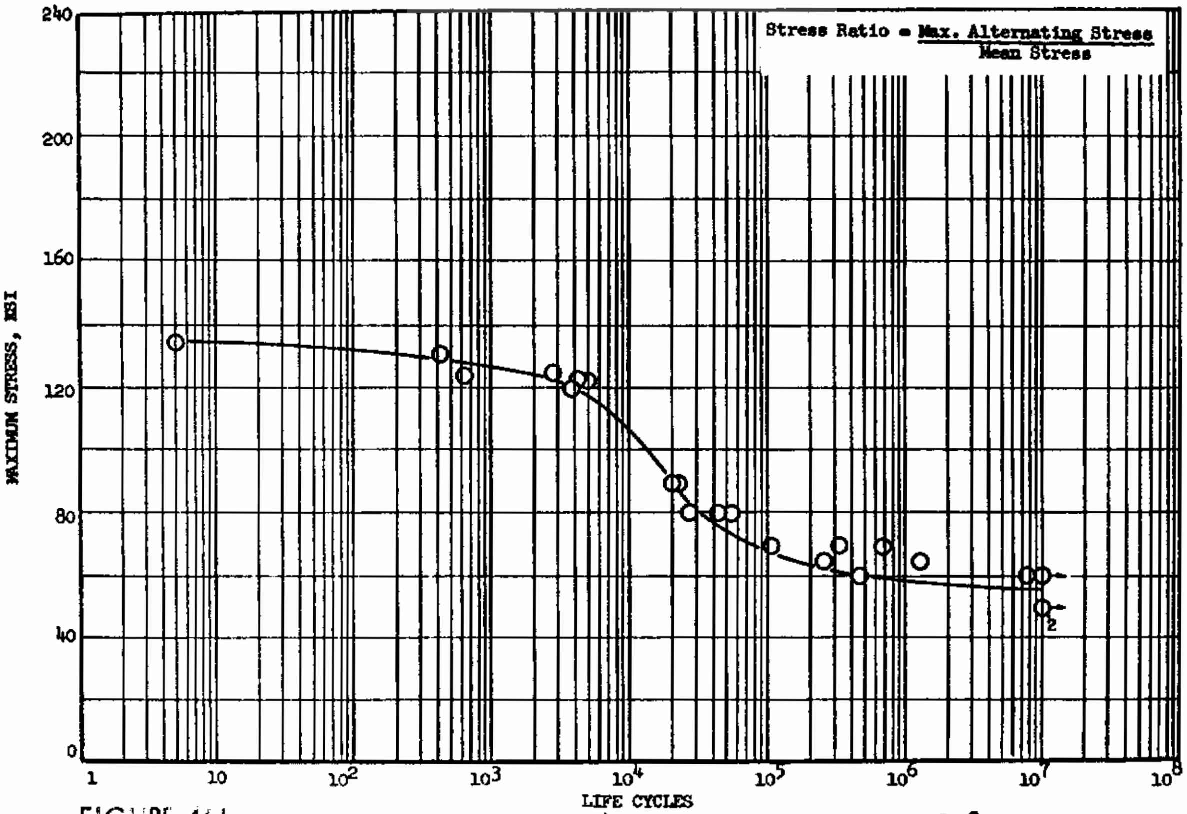


FIGURE 461 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 800° WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R6741, R6736, AND P7647)

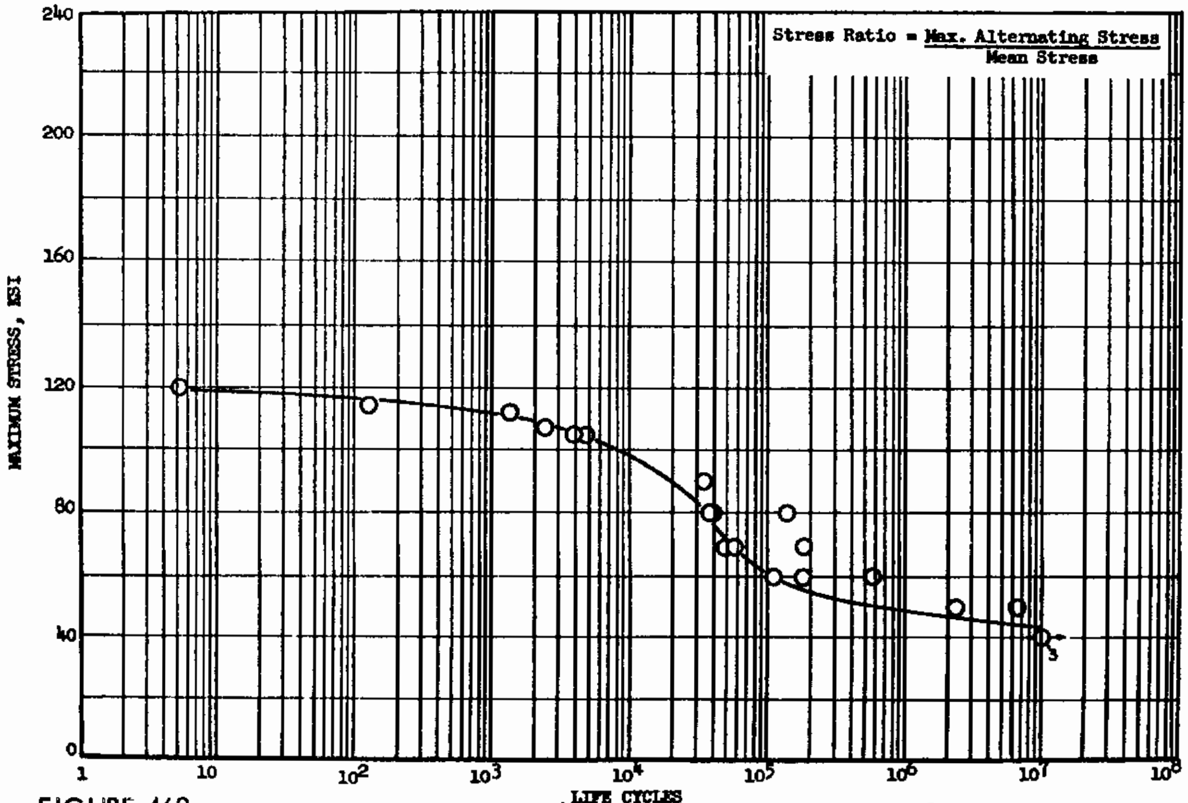


FIGURE 462 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 900° WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R6741, R6736 AND P7647)

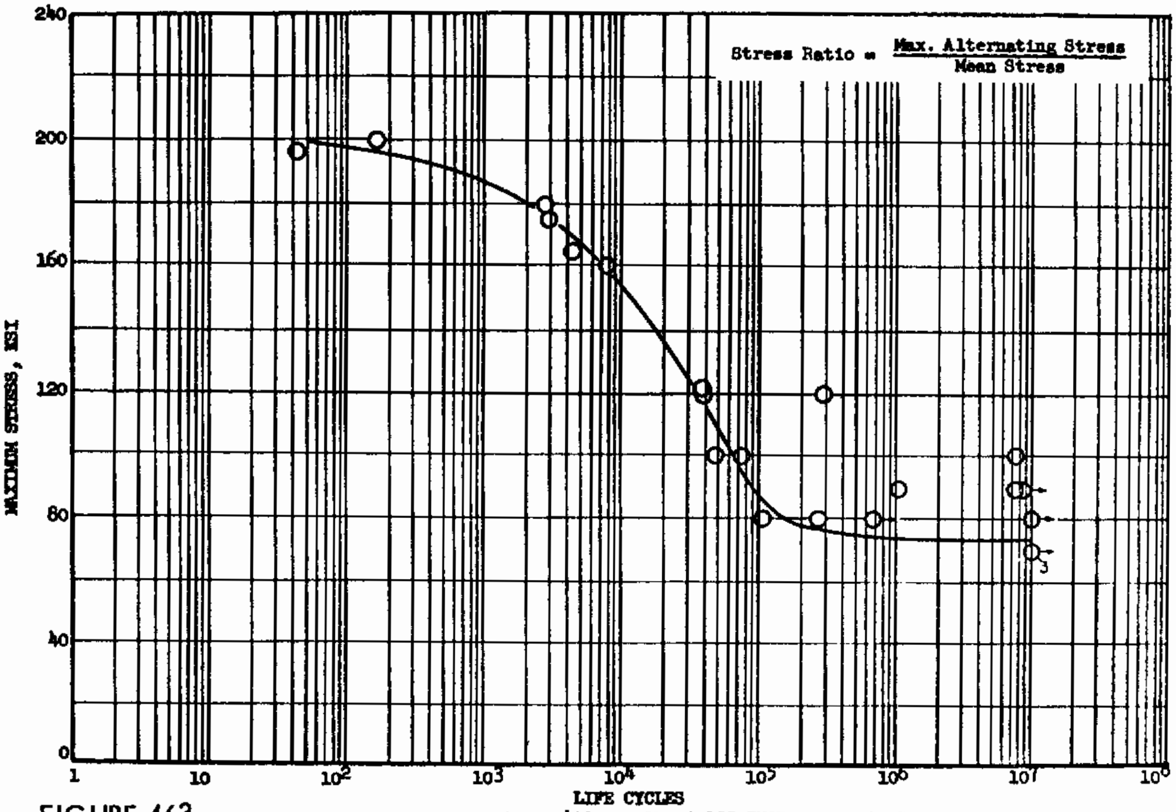


FIGURE 463 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT ROOM TEMPERATURE, WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R6741, R6736, AND P7647)

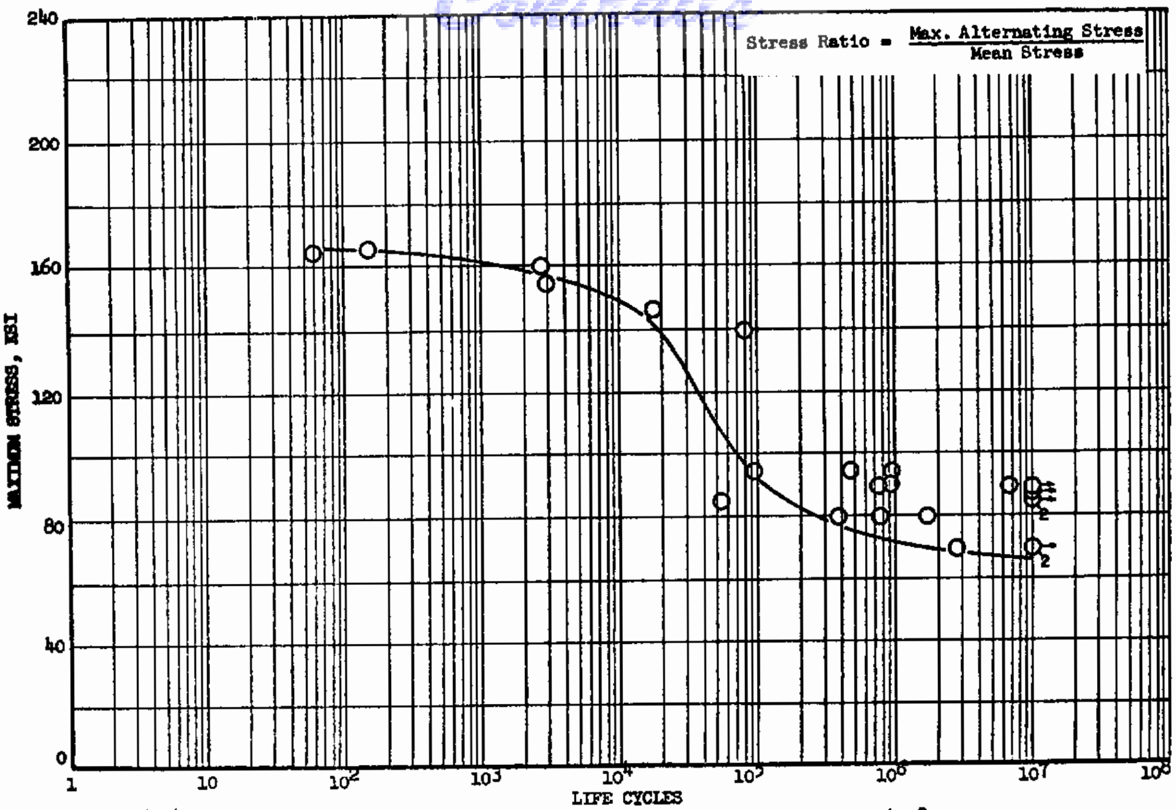


FIGURE 464 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R6741, R6736 AND P7647)

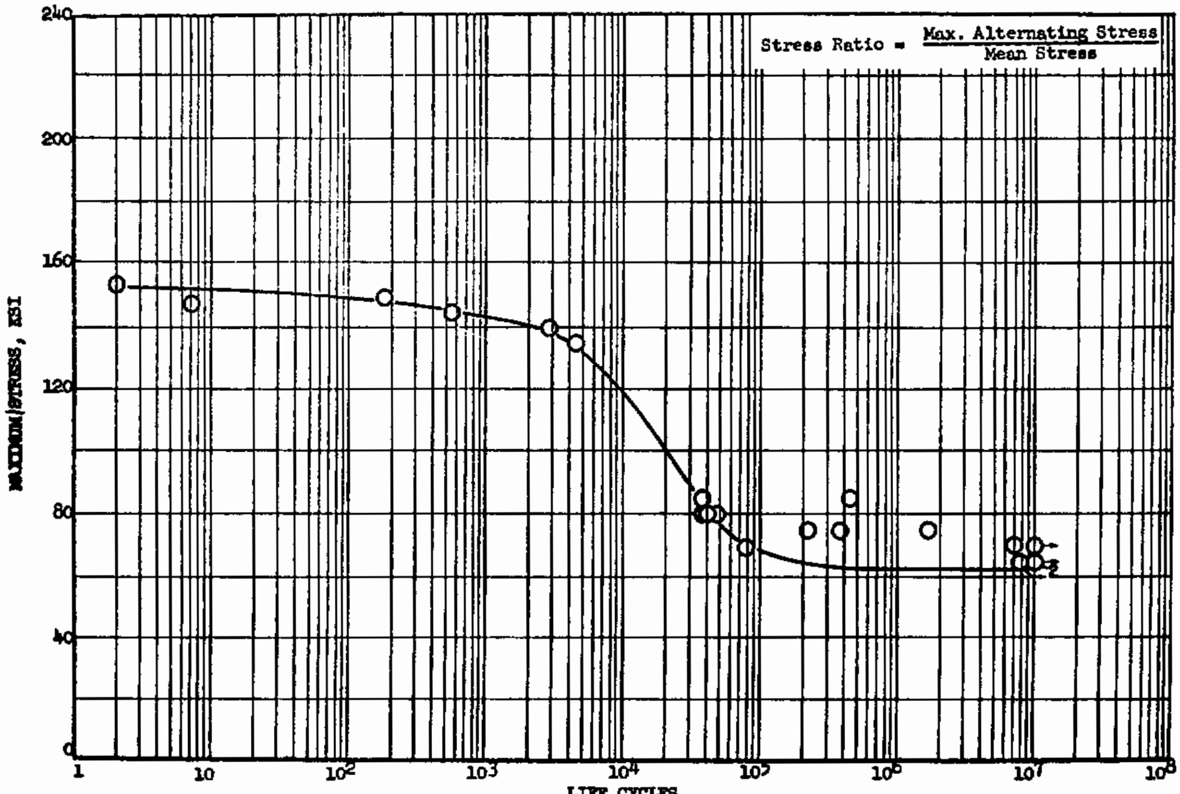


FIGURE 465 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R6741, R6736 AND P7647)

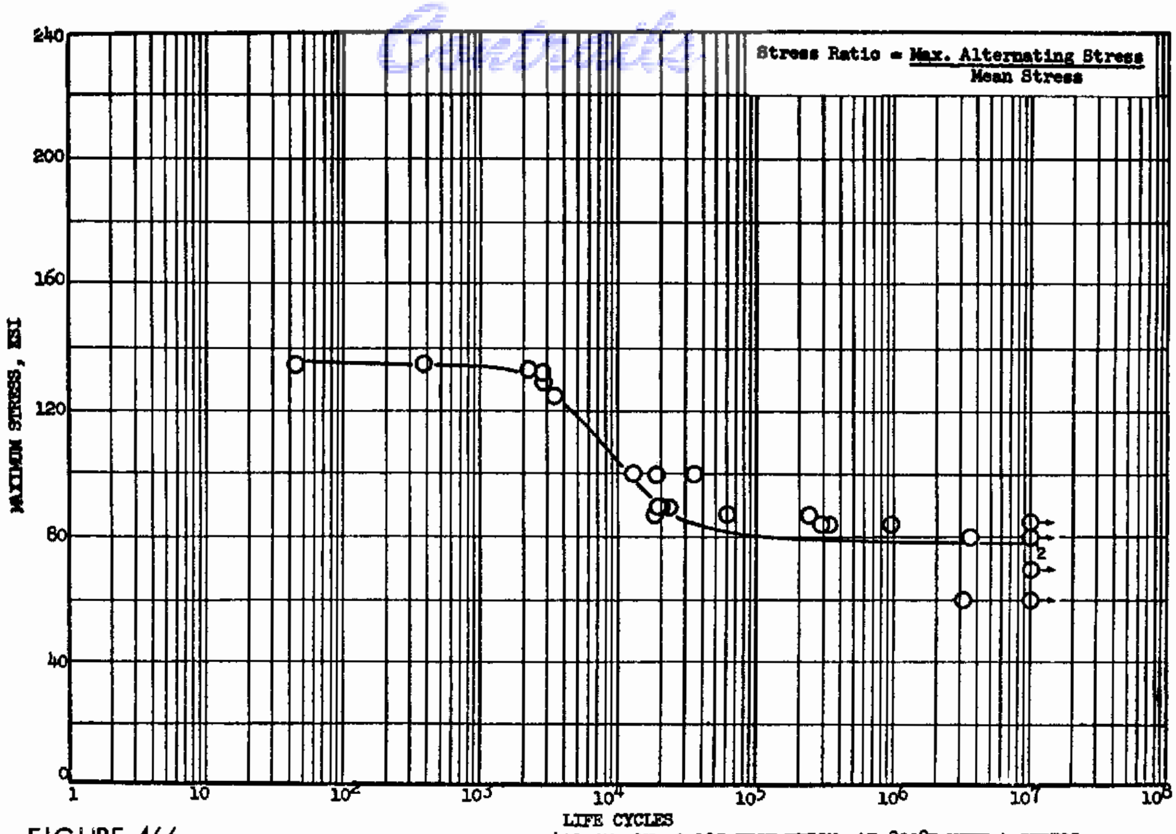


FIGURE 466 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R6741, R6736 AND P7647)

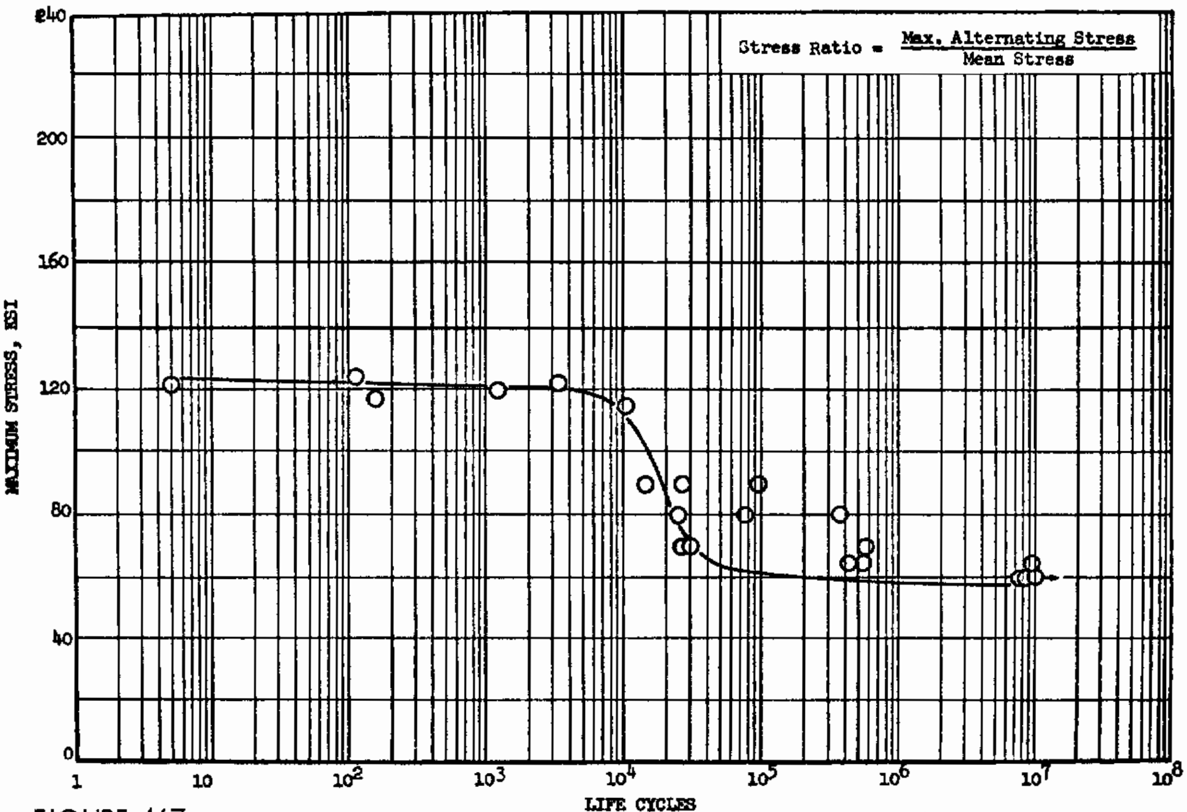


FIGURE 467 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R6741, R6736 AND P7647)

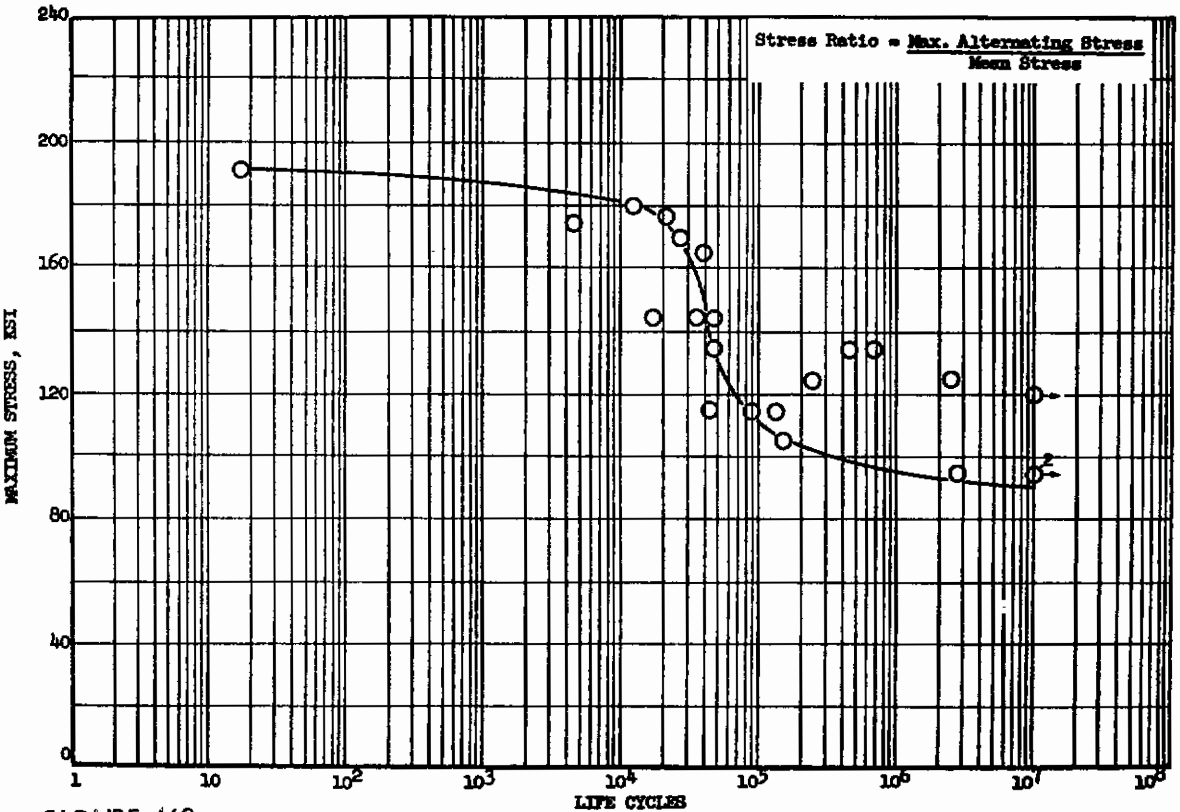


FIGURE 468 – AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R6741, R6736 AND P7647)

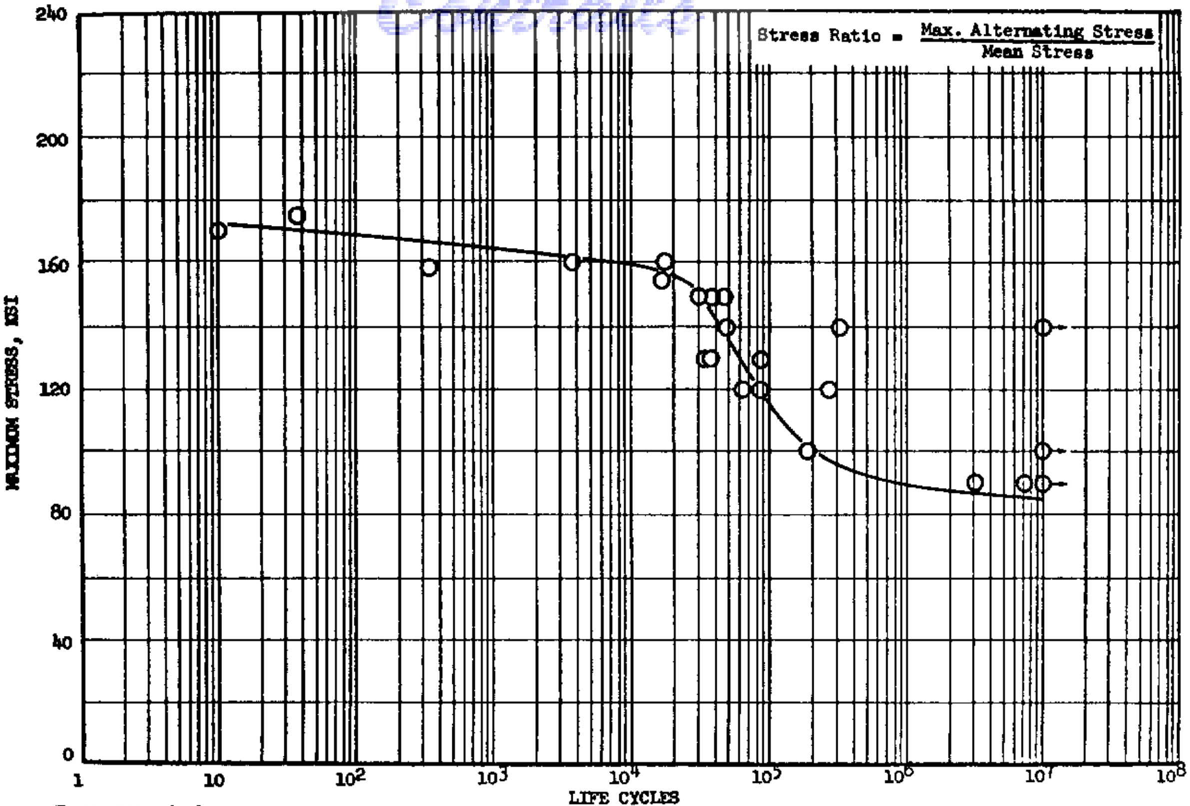


FIGURE 469 – AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R6741, R6736 AND P7647)

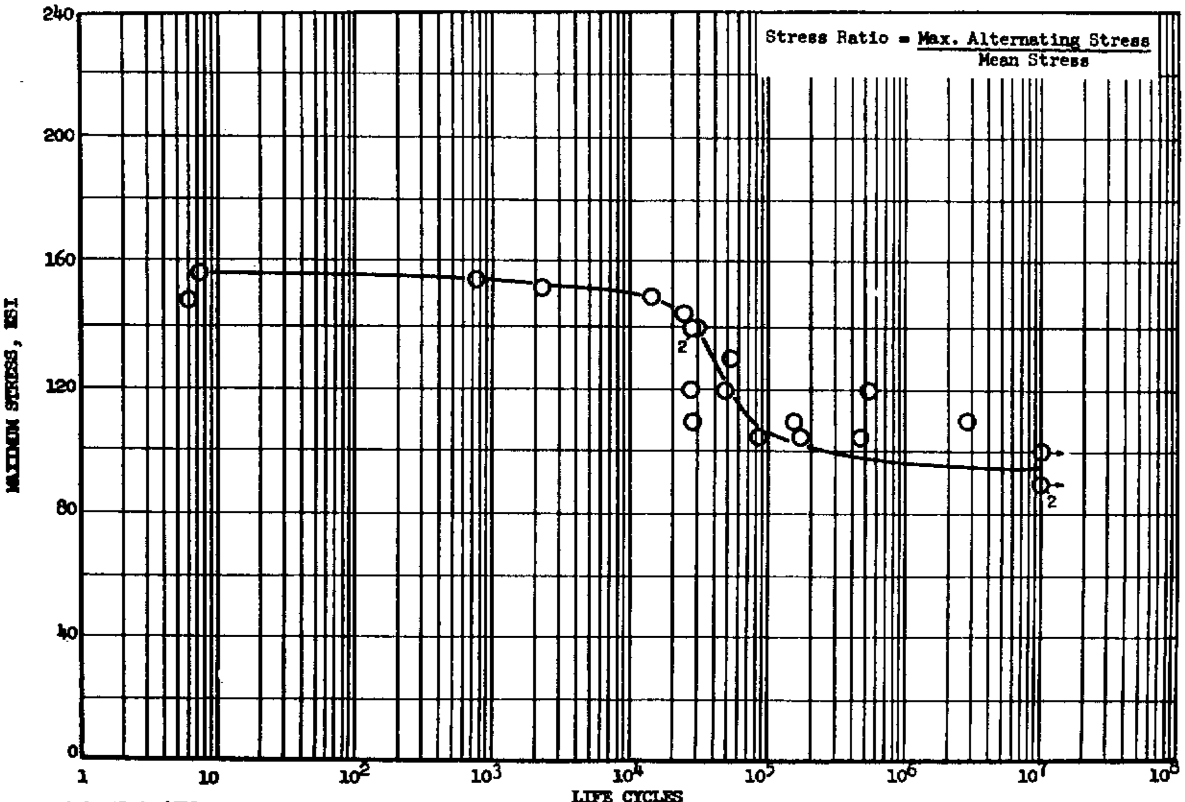


FIGURE 470 – AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R6741, R6736 AND P7647)

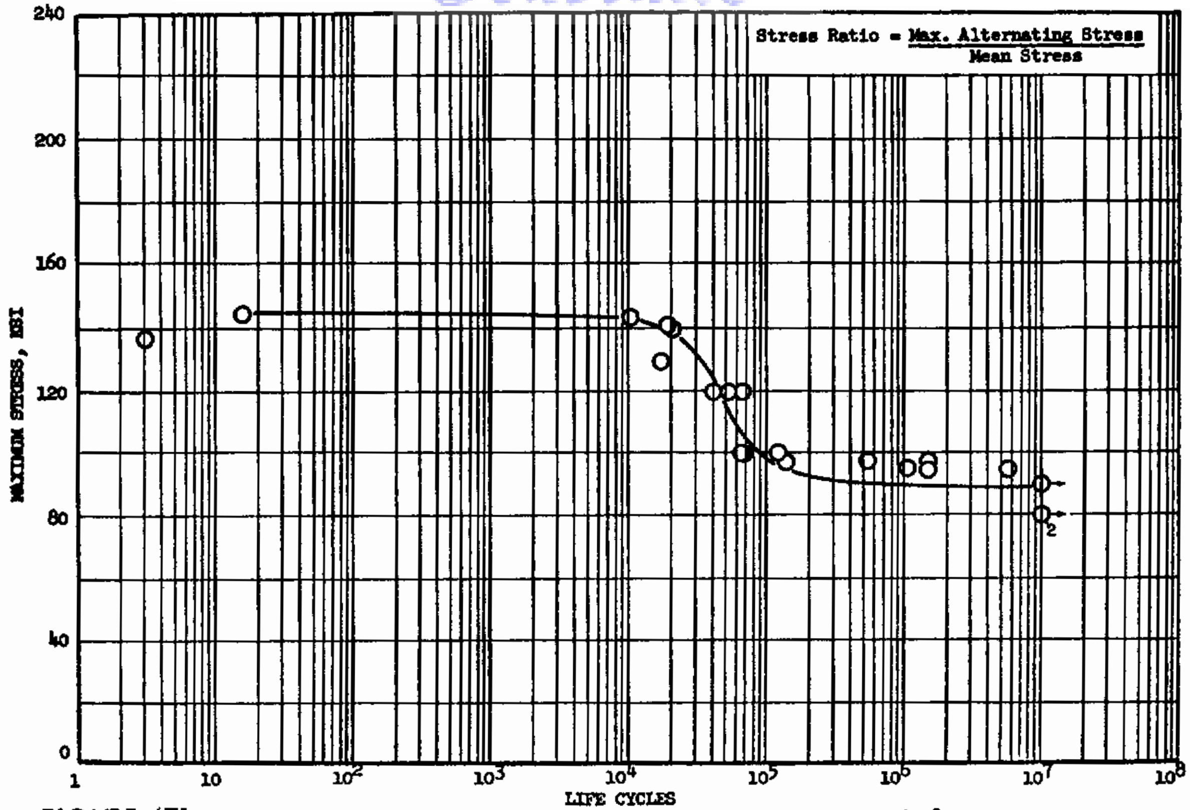


FIGURE 471 – AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R6741, R6736, AND P7647)

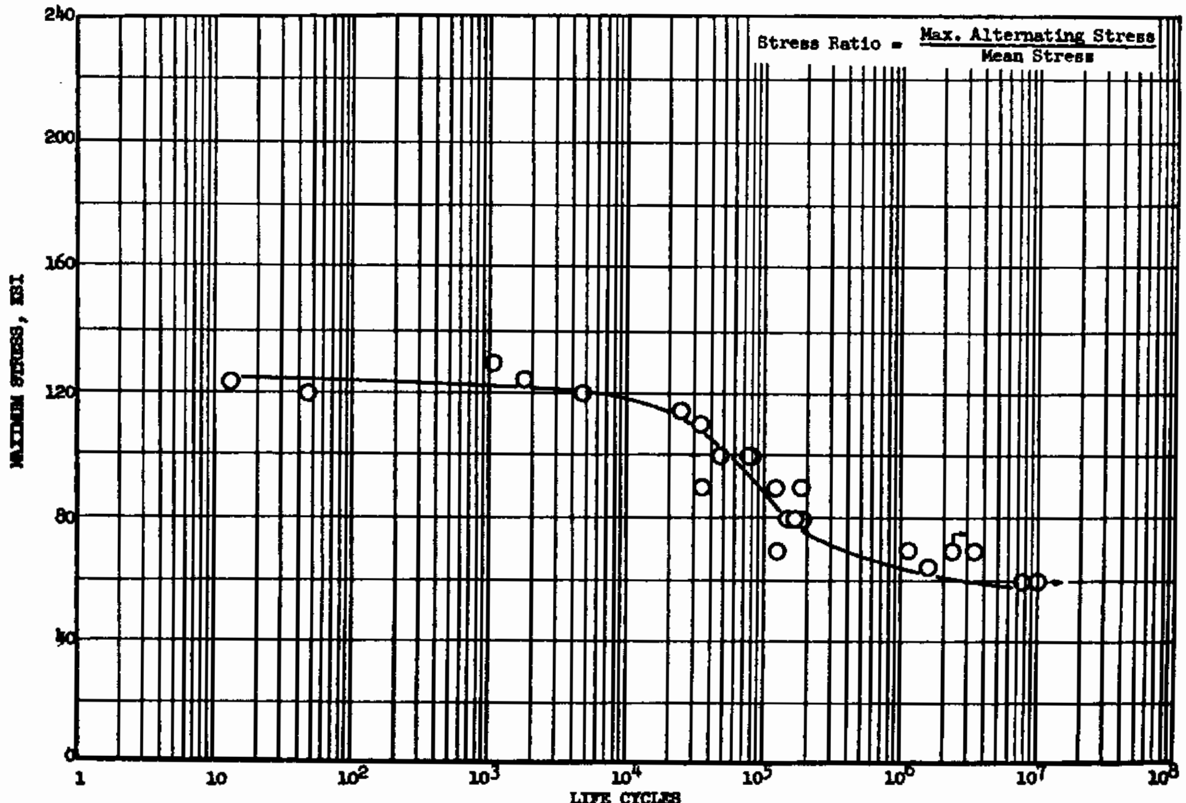


FIGURE 472 – AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.125 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 1.0 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R6741, R6736, AND P7647)

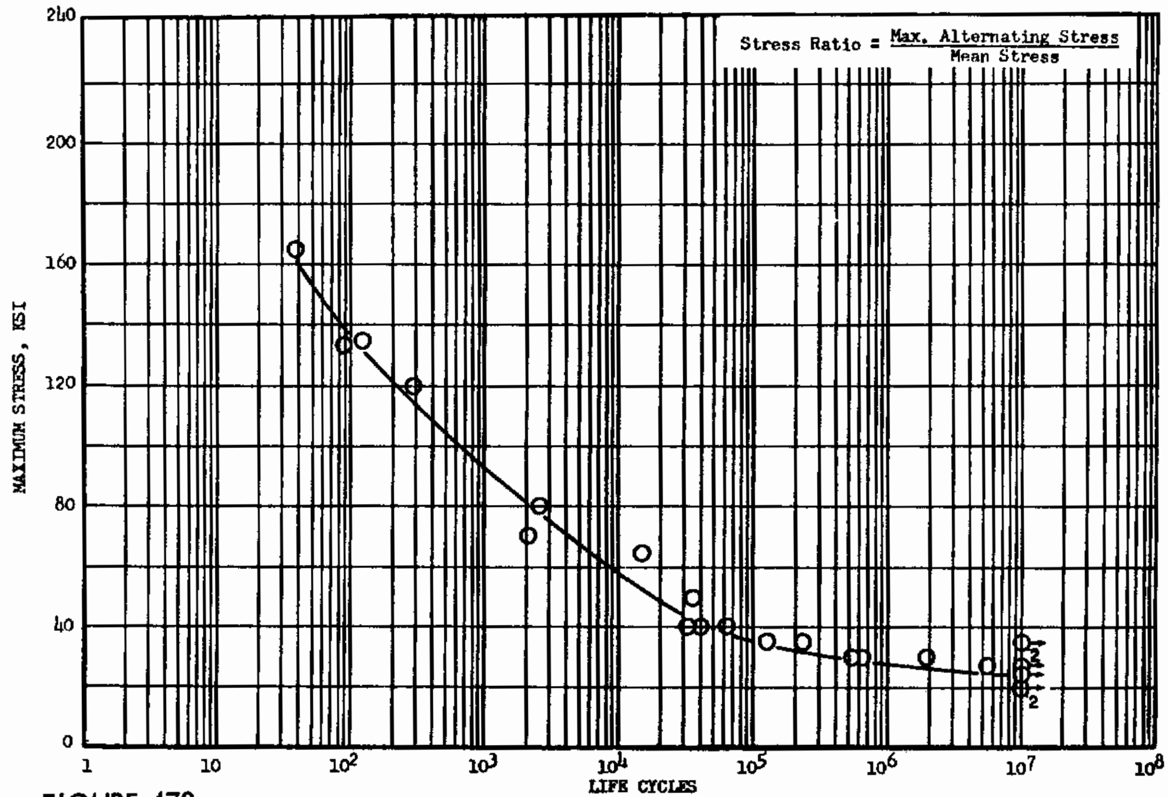


FIGURE 473 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R4815, R4810, AND R4805)

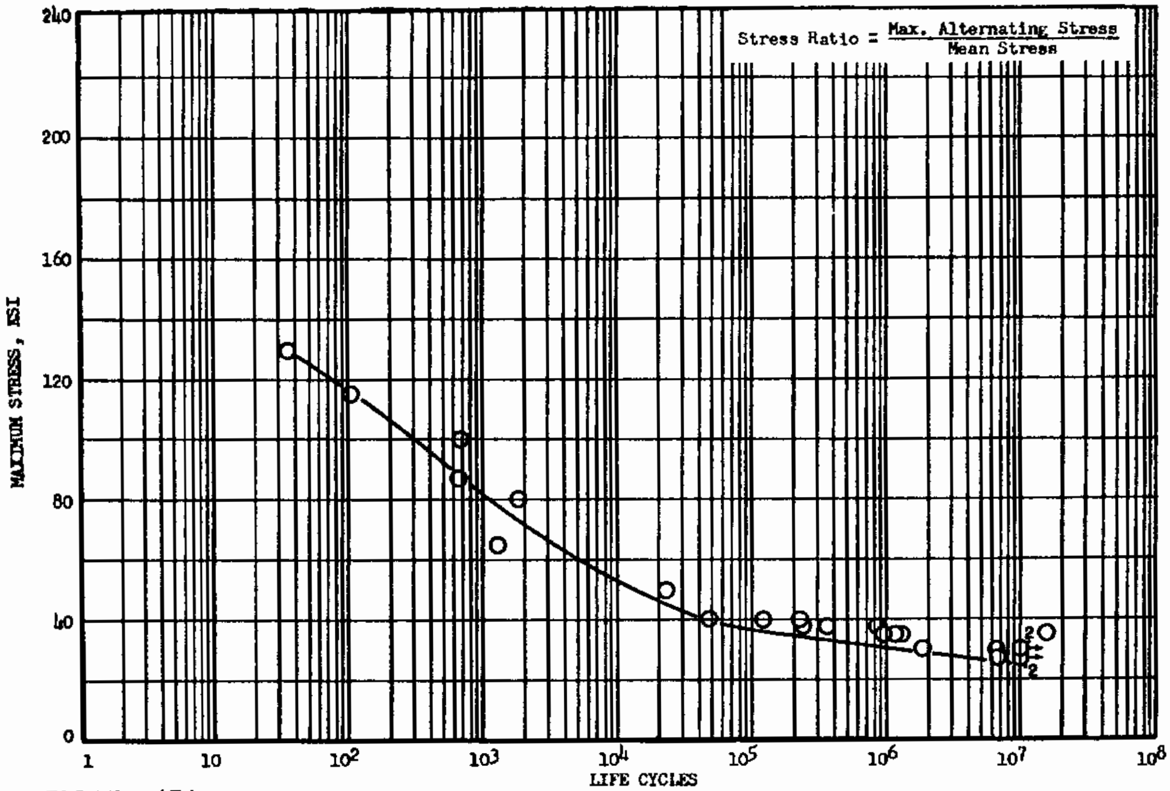


FIGURE 474 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R4815, R4810, AND R4805)

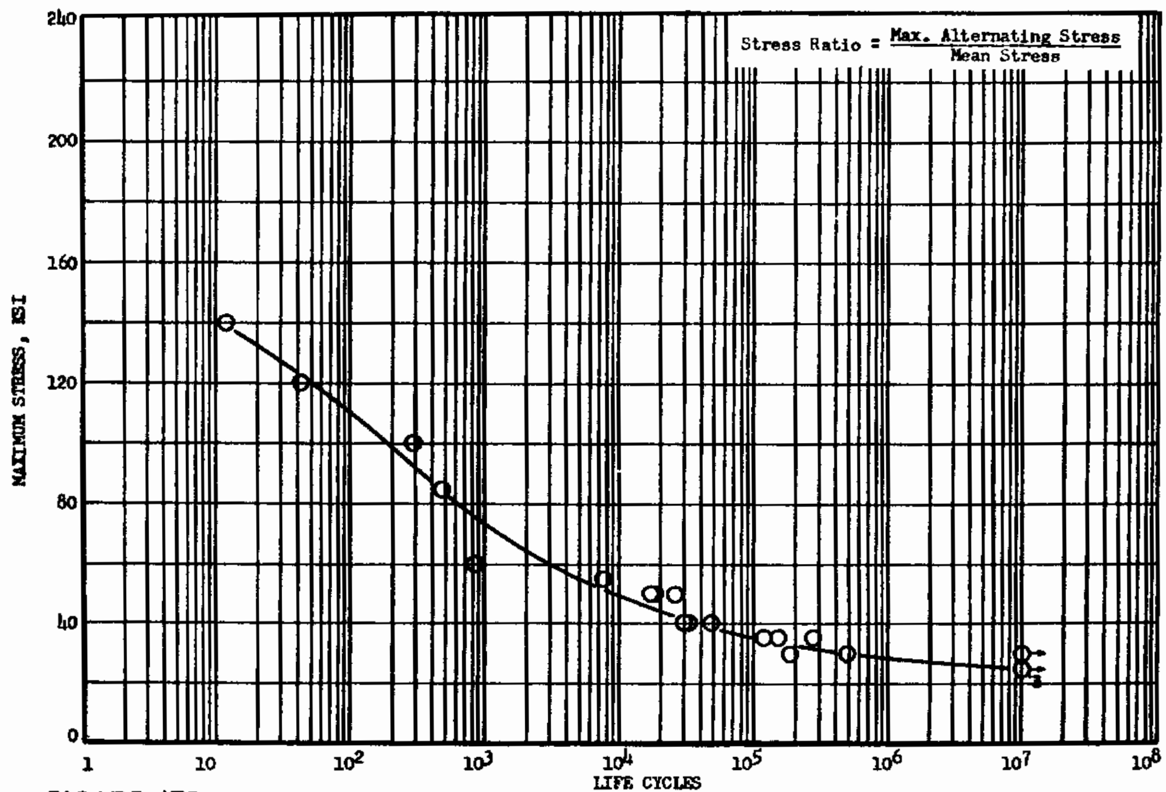


FIGURE 475 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R4815, R4810, AND R4805)

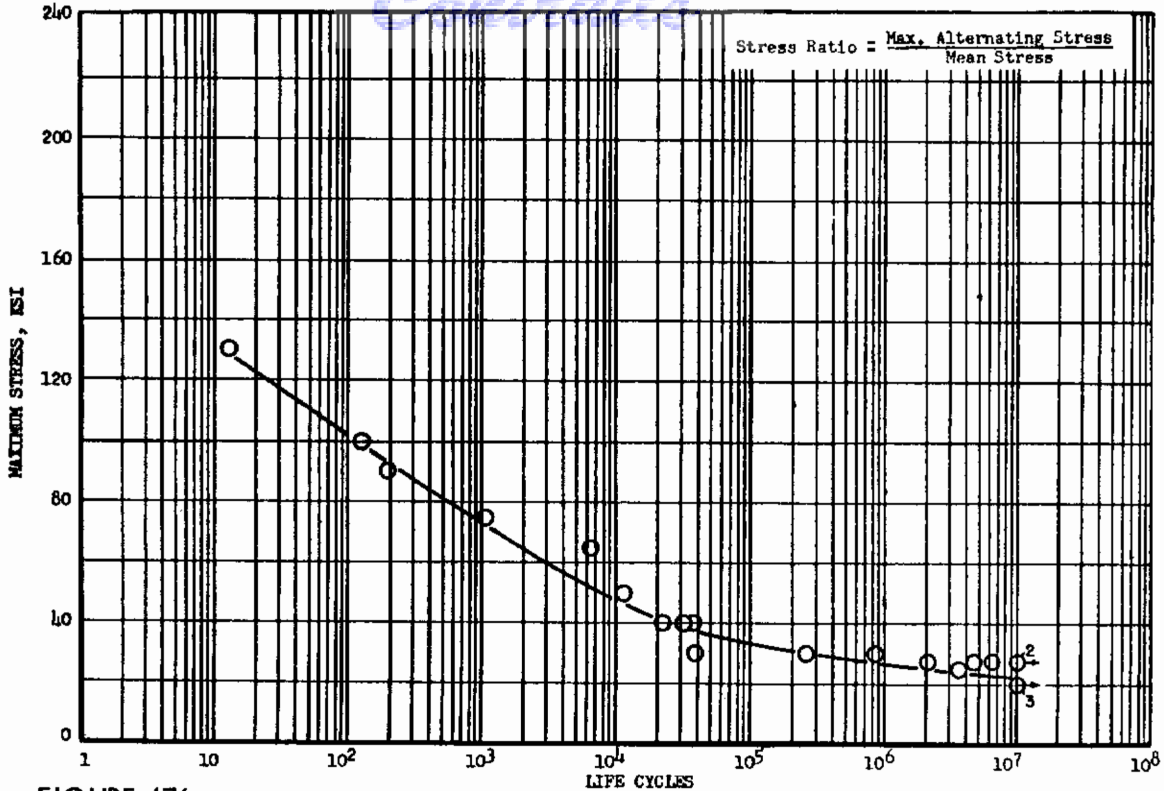


FIGURE 476 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R4815, R4810, AND R4805)

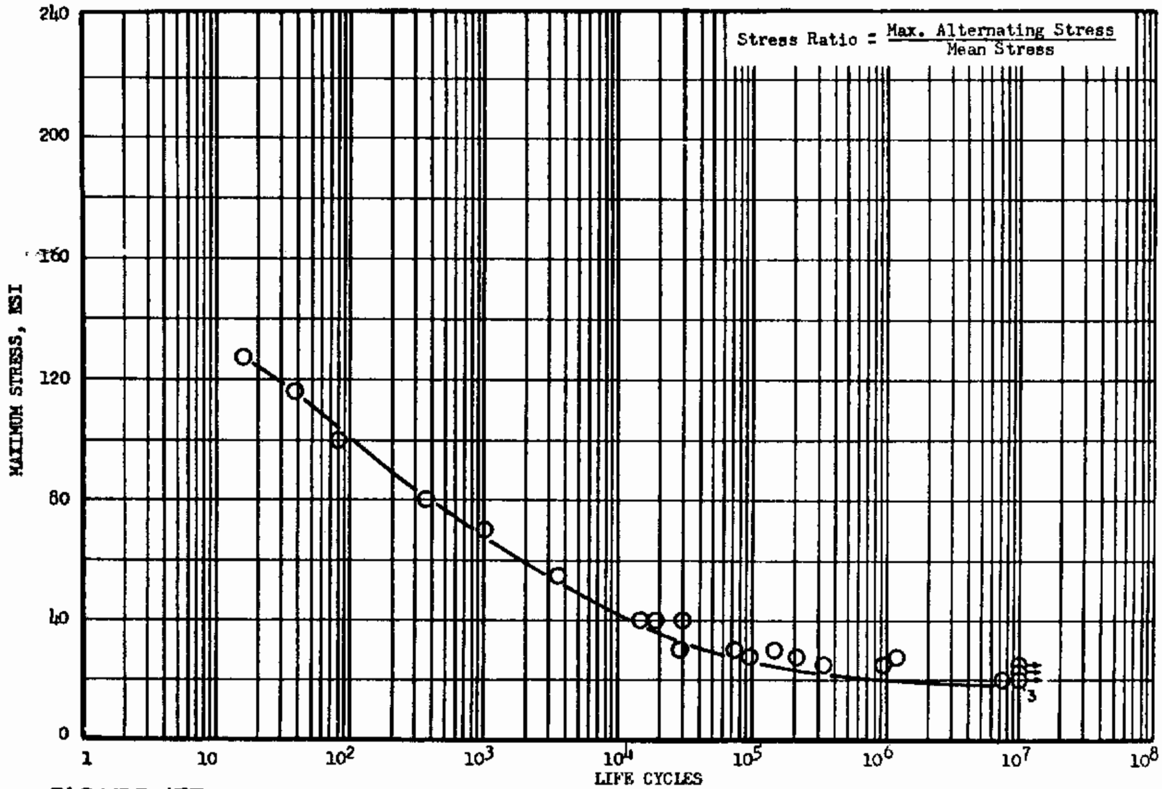


FIGURE 477 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. R4815, R4810, AND R4805)

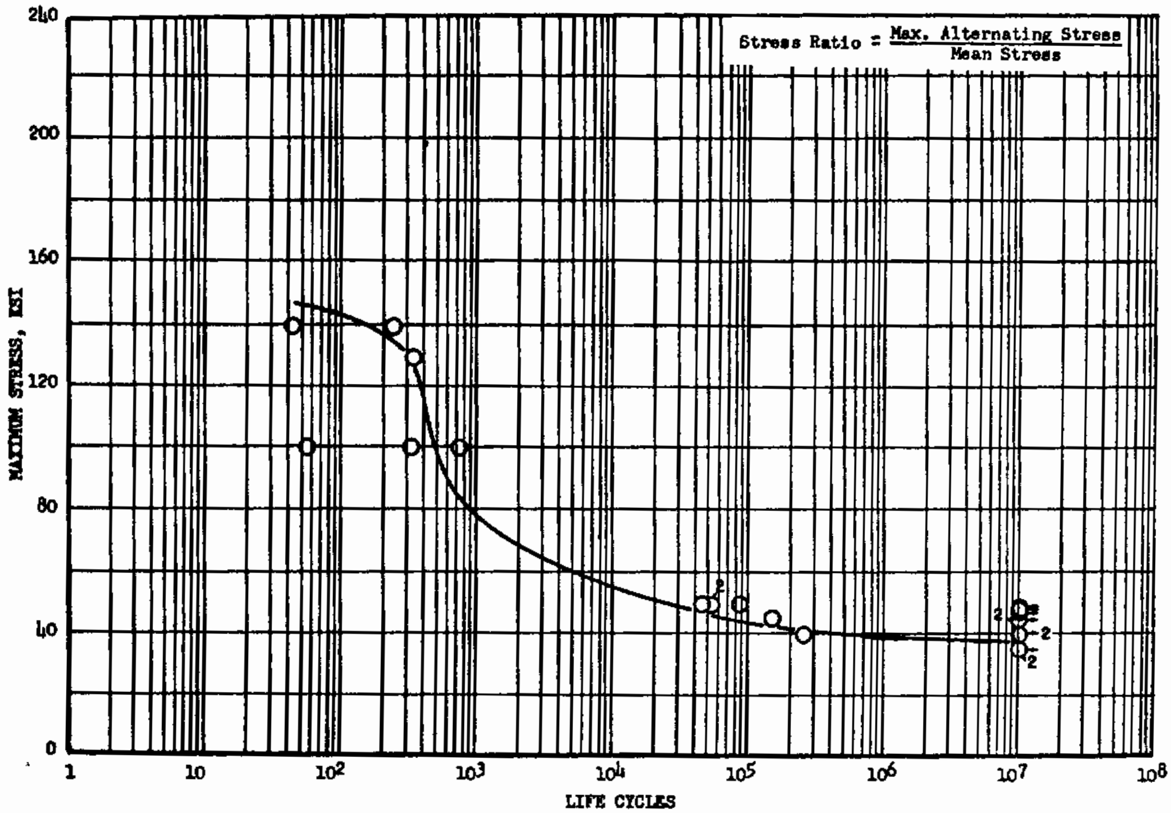


FIGURE 478 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R4815 AND R4810)

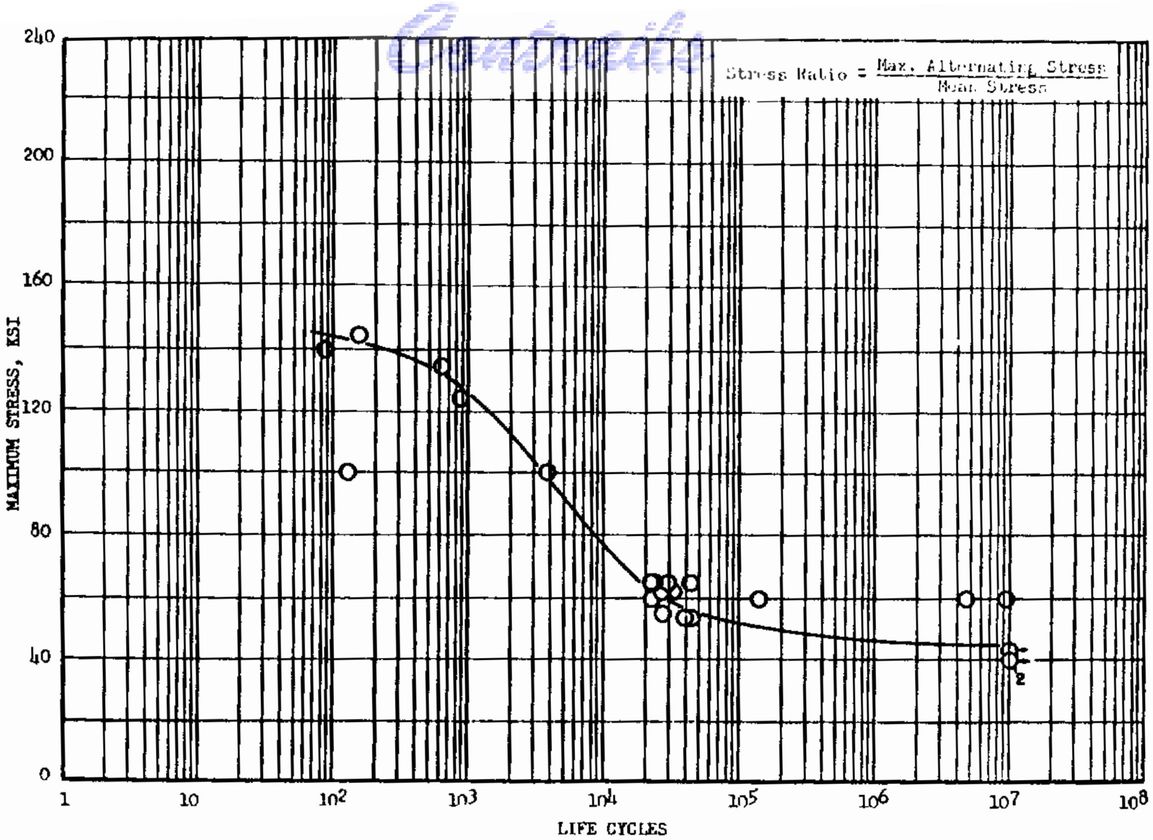


FIGURE 479 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R4815 AND R4810)

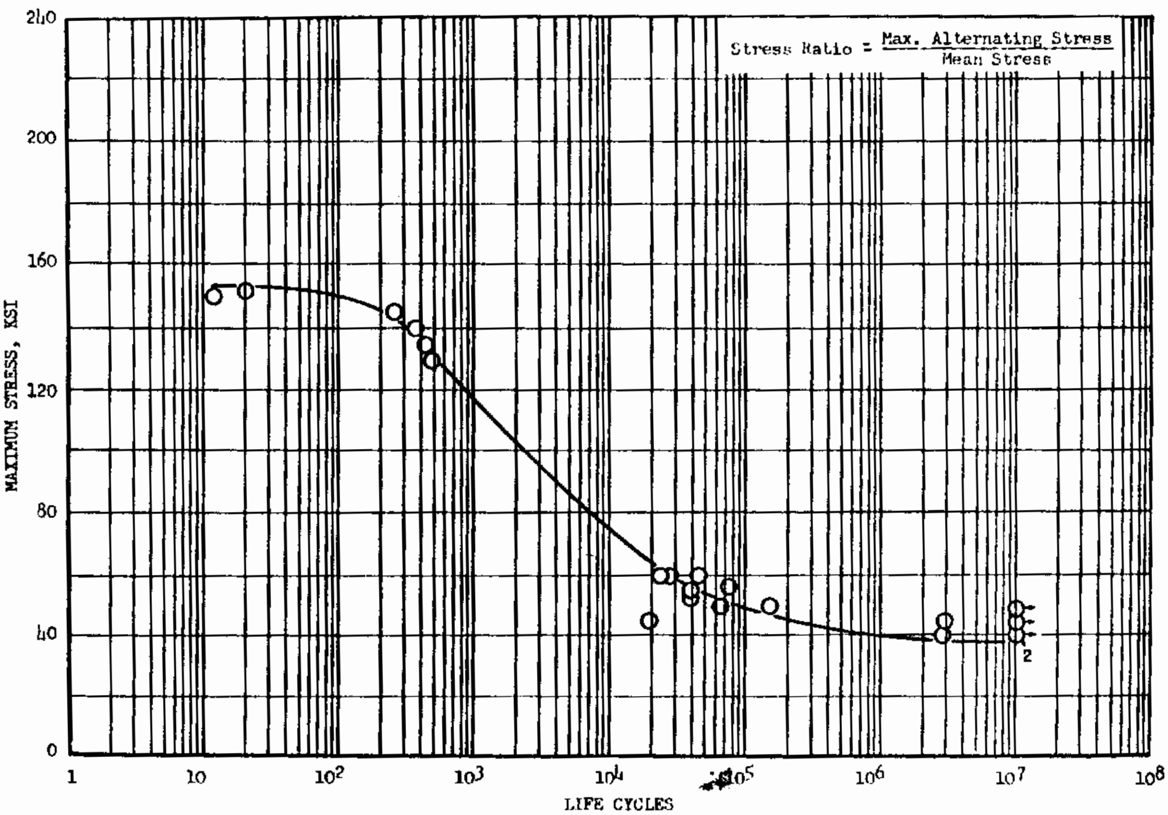


FIGURE 480 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R4815 AND R4810)

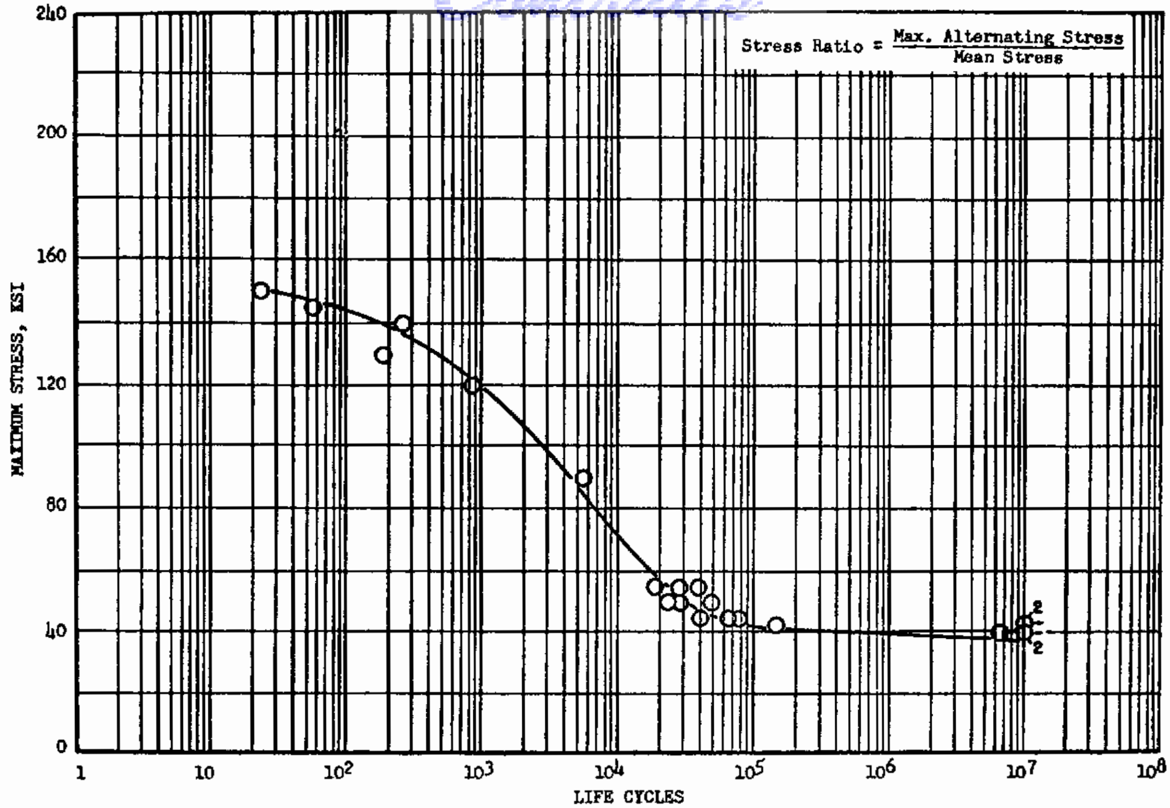


FIGURE 481 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R4815 AND R4810)

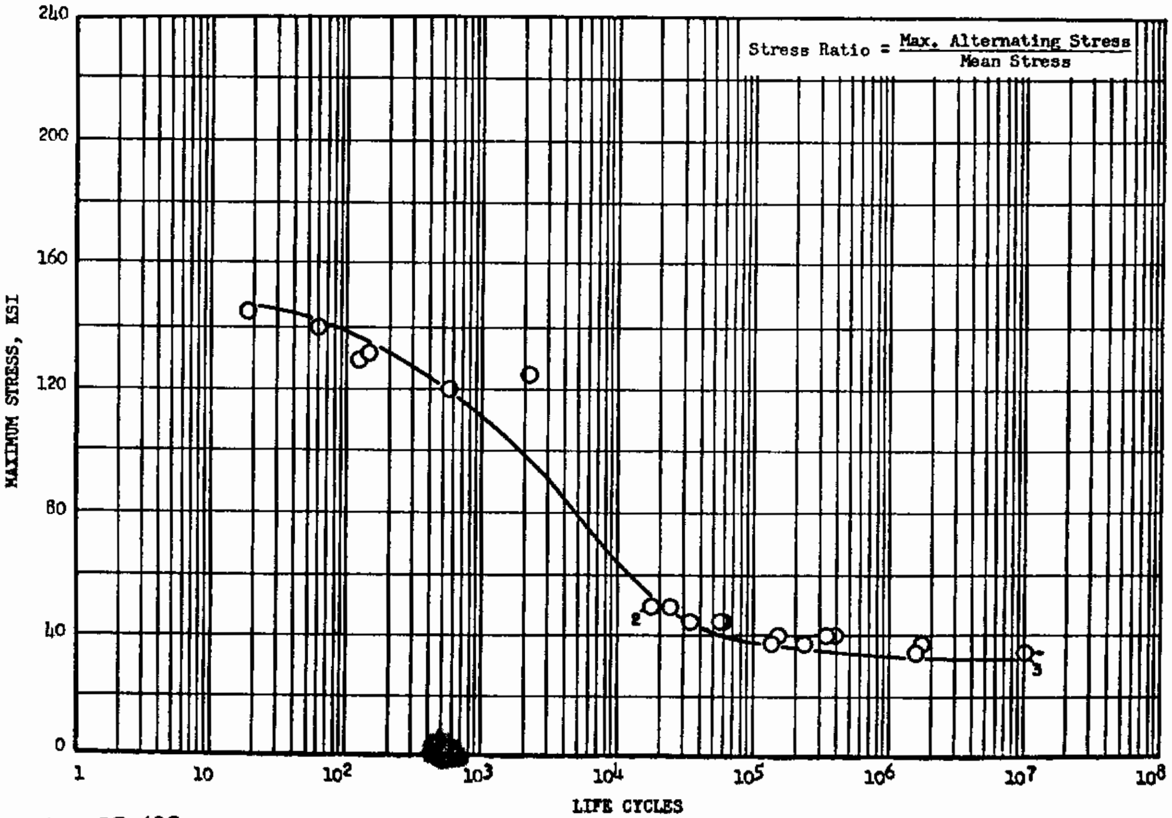


FIGURE 482 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. R4815 AND R4810)

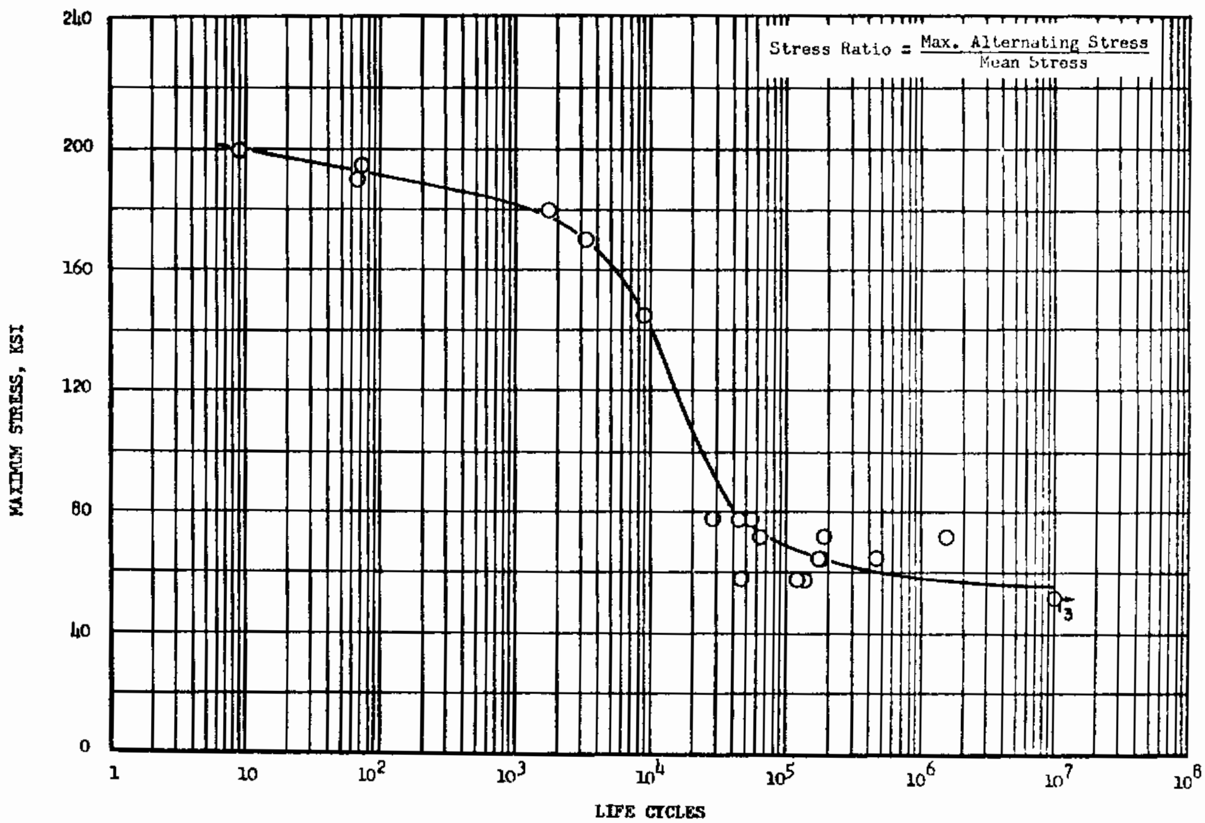


FIGURE 483 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R4815 & R4810)

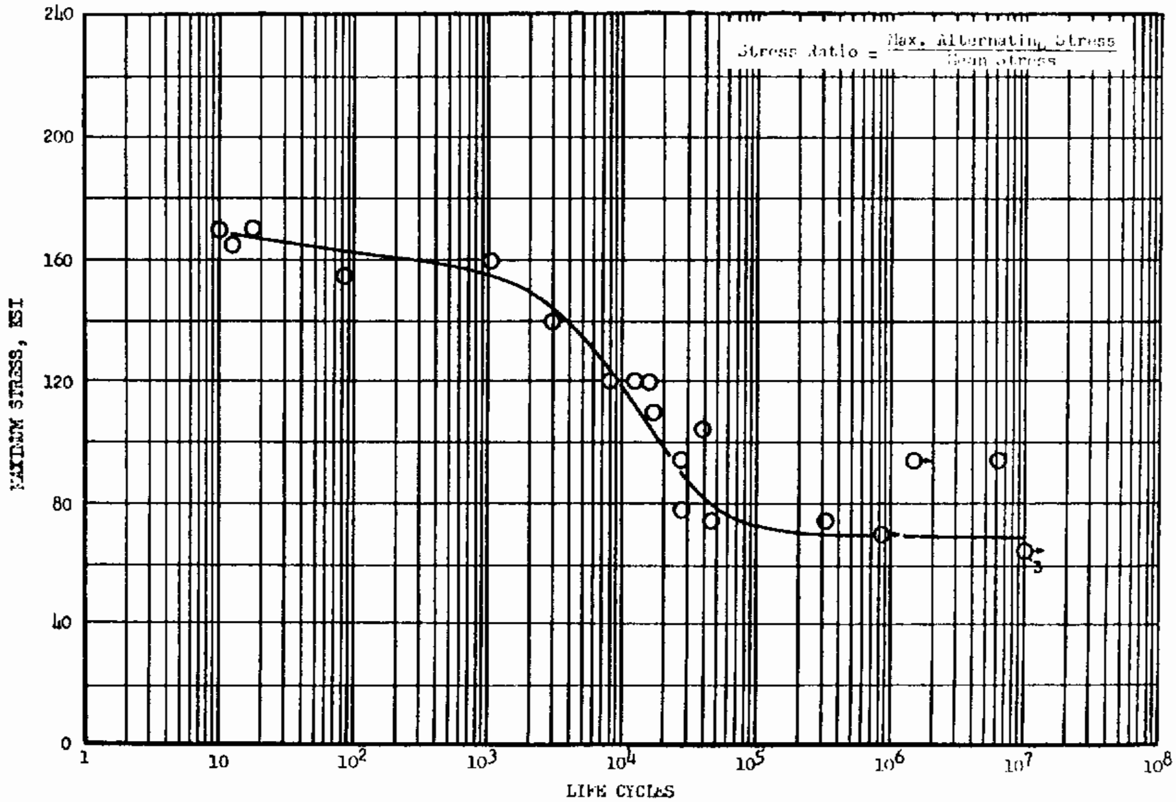


FIGURE 484 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R4815 & R4810)

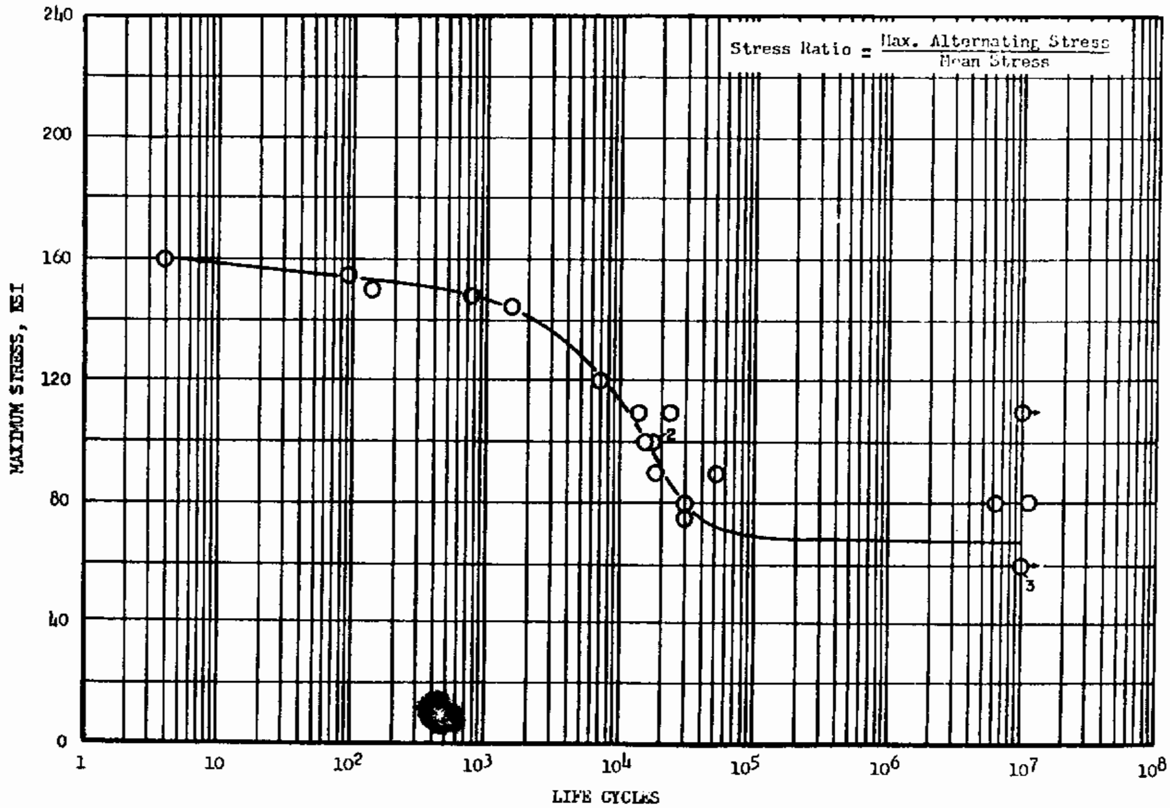


FIGURE 485 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R4815 & R4810)

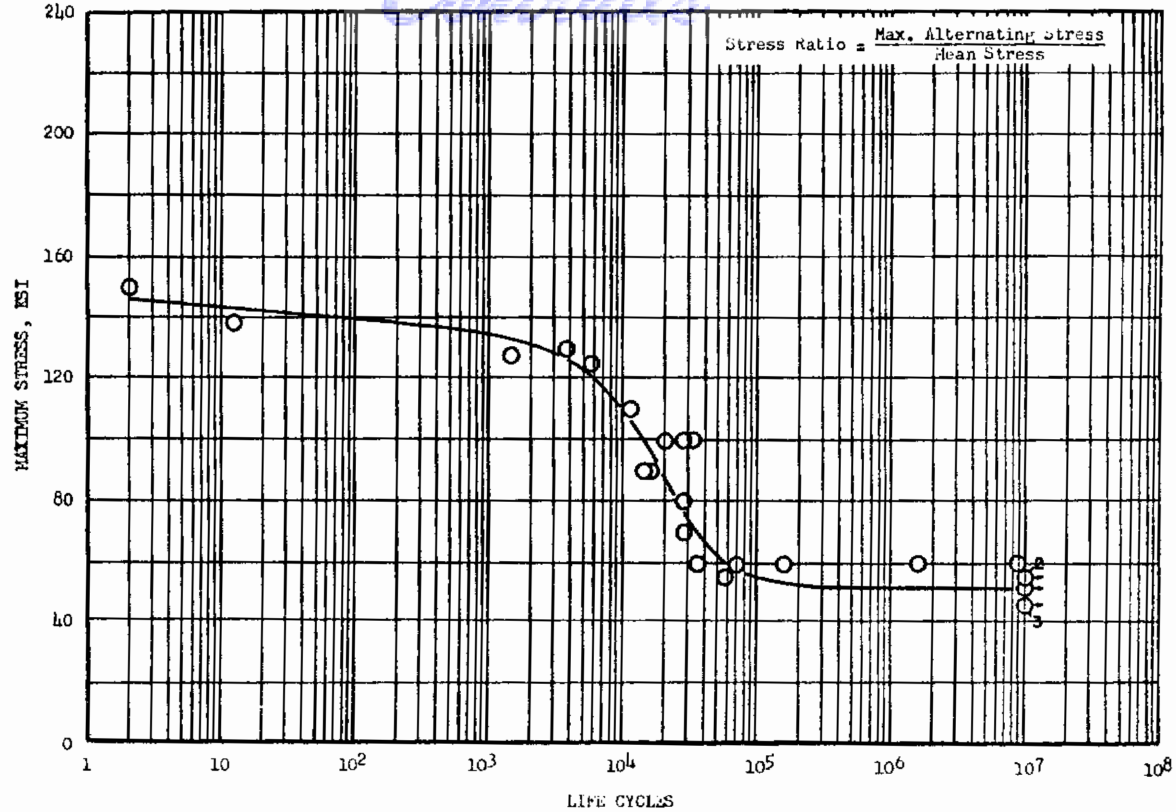


FIGURE 486 – AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R4815 & R4810)

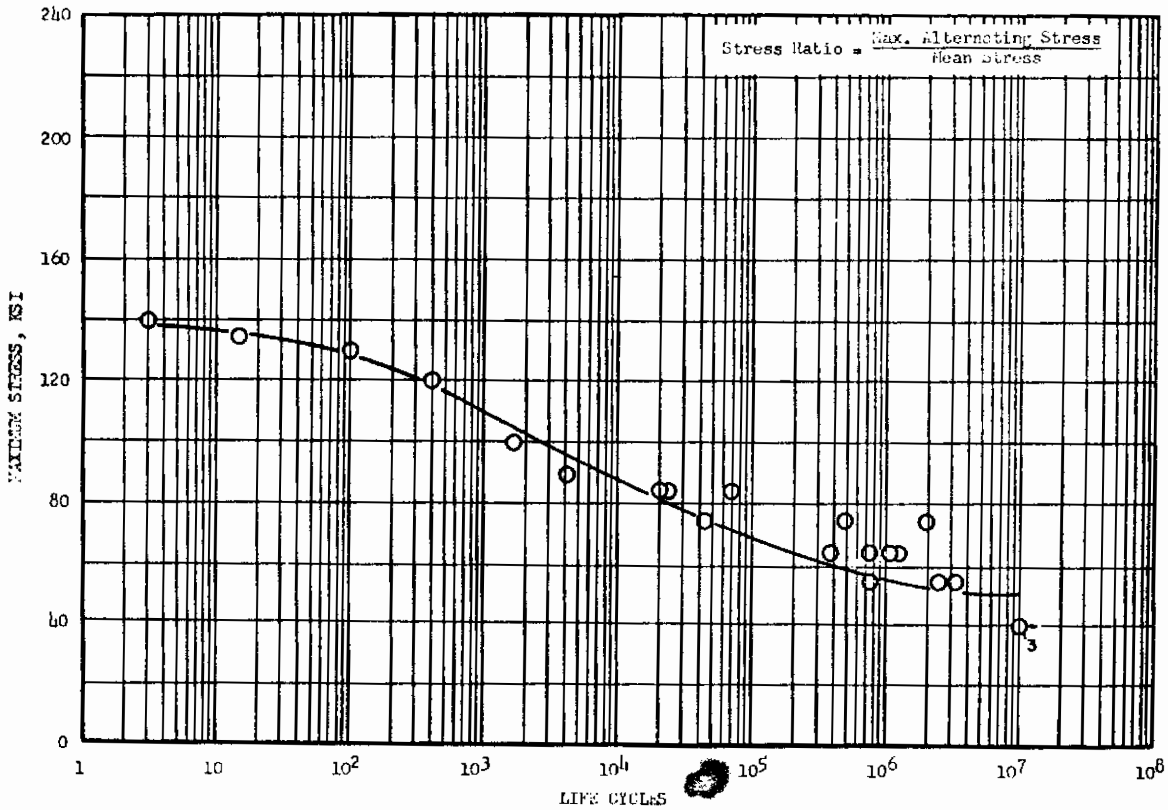


FIGURE 487 – AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.020 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. R4815 & R4810)

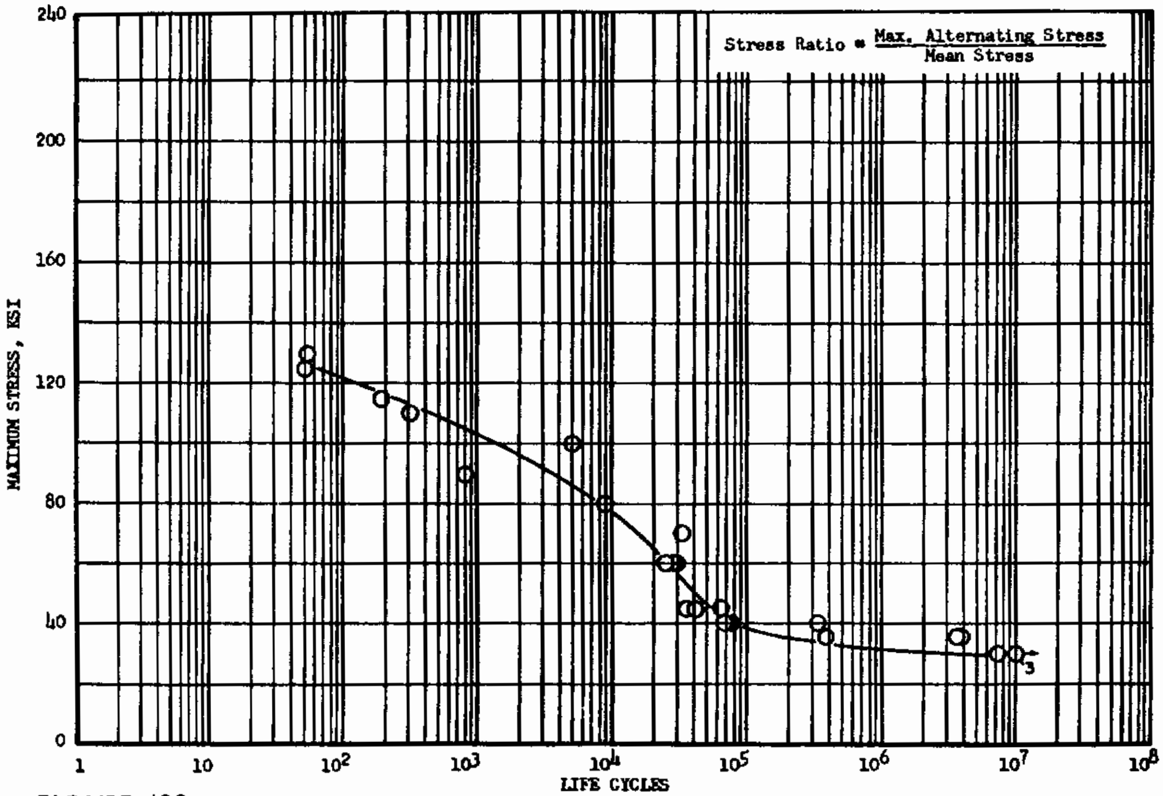


FIGURE 488 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. P7653 AND R4765)

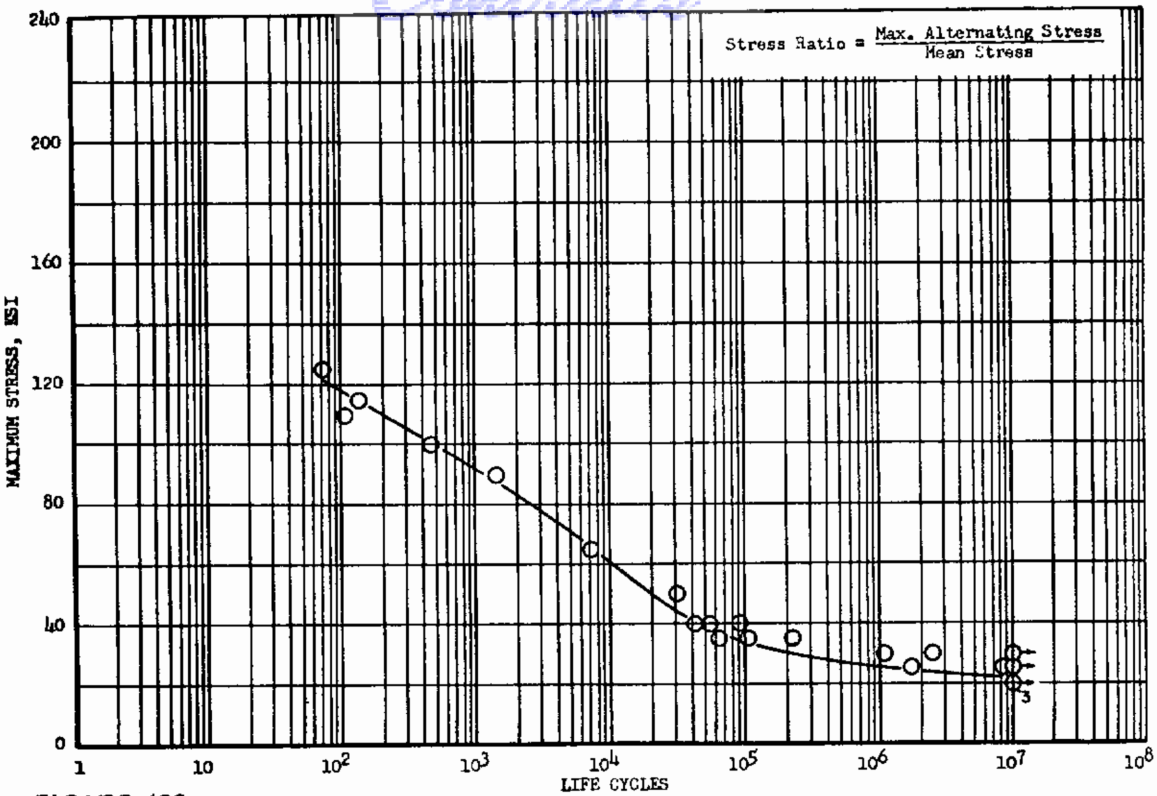


FIGURE 489 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. P7653 AND R4765)

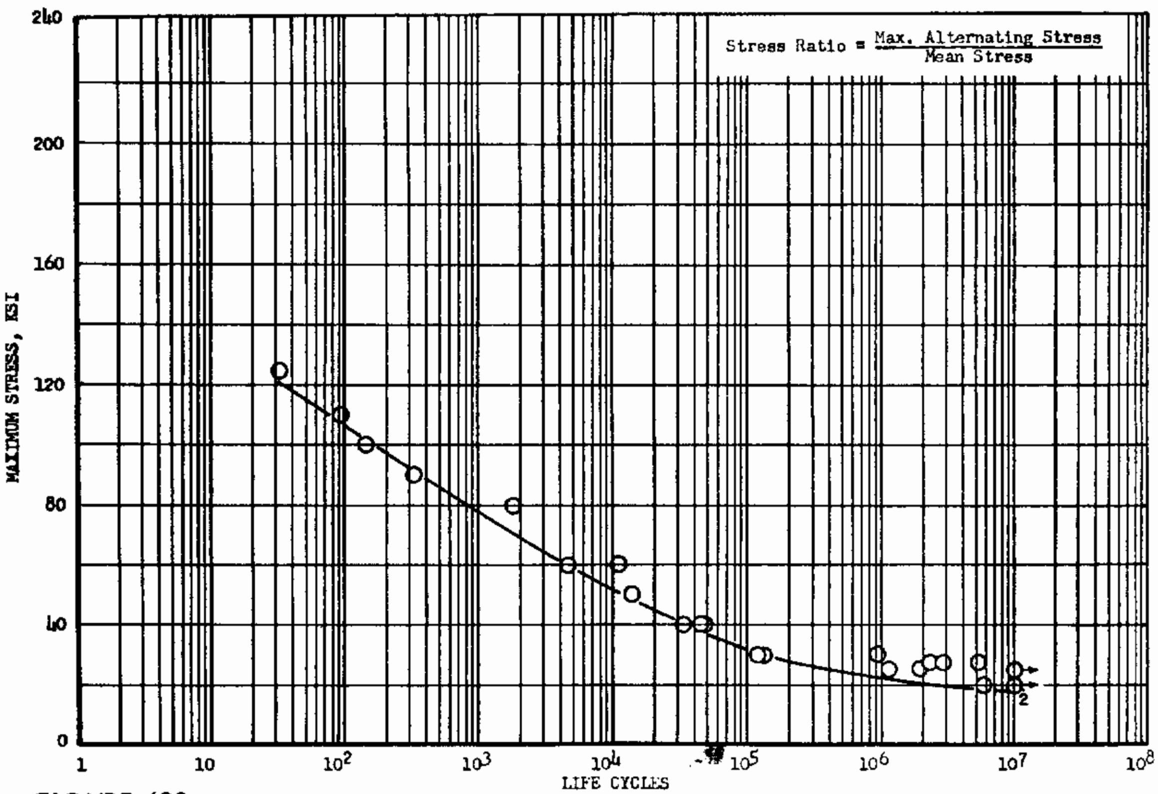


FIGURE 490 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. P7653 AND R4765)

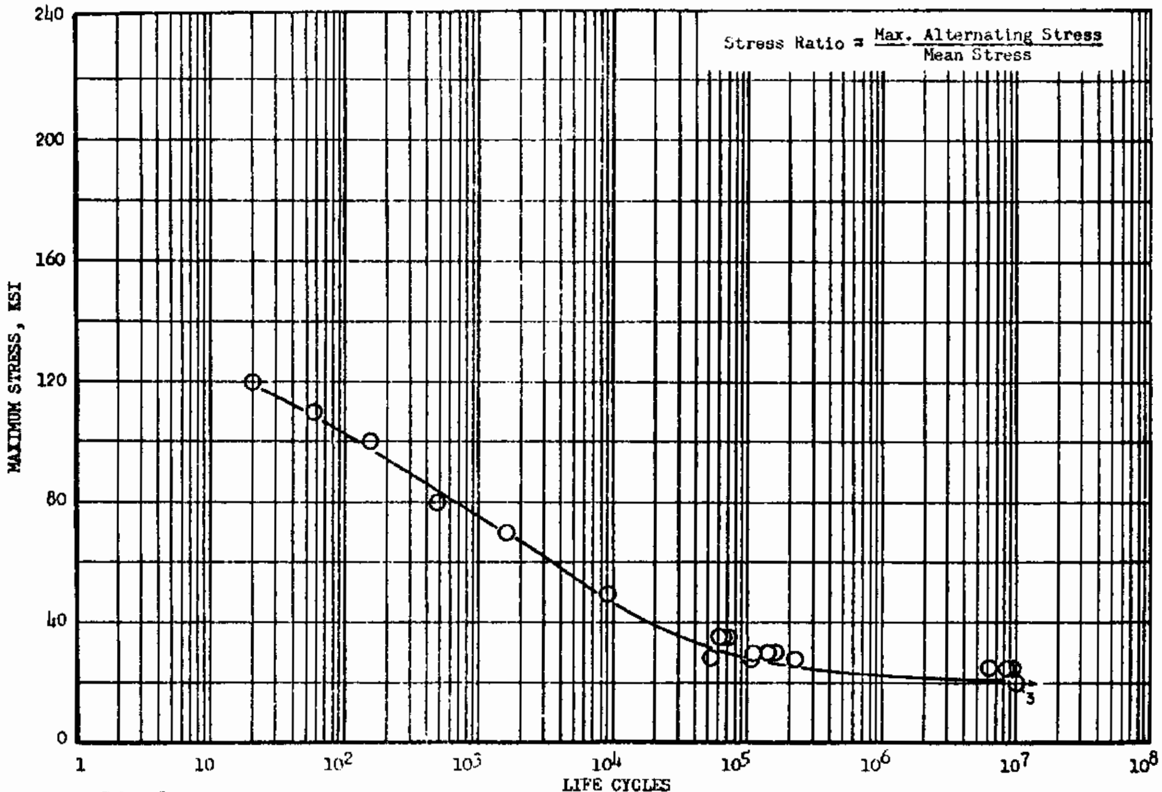


FIGURE 49? - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. P7653 AND R4765)

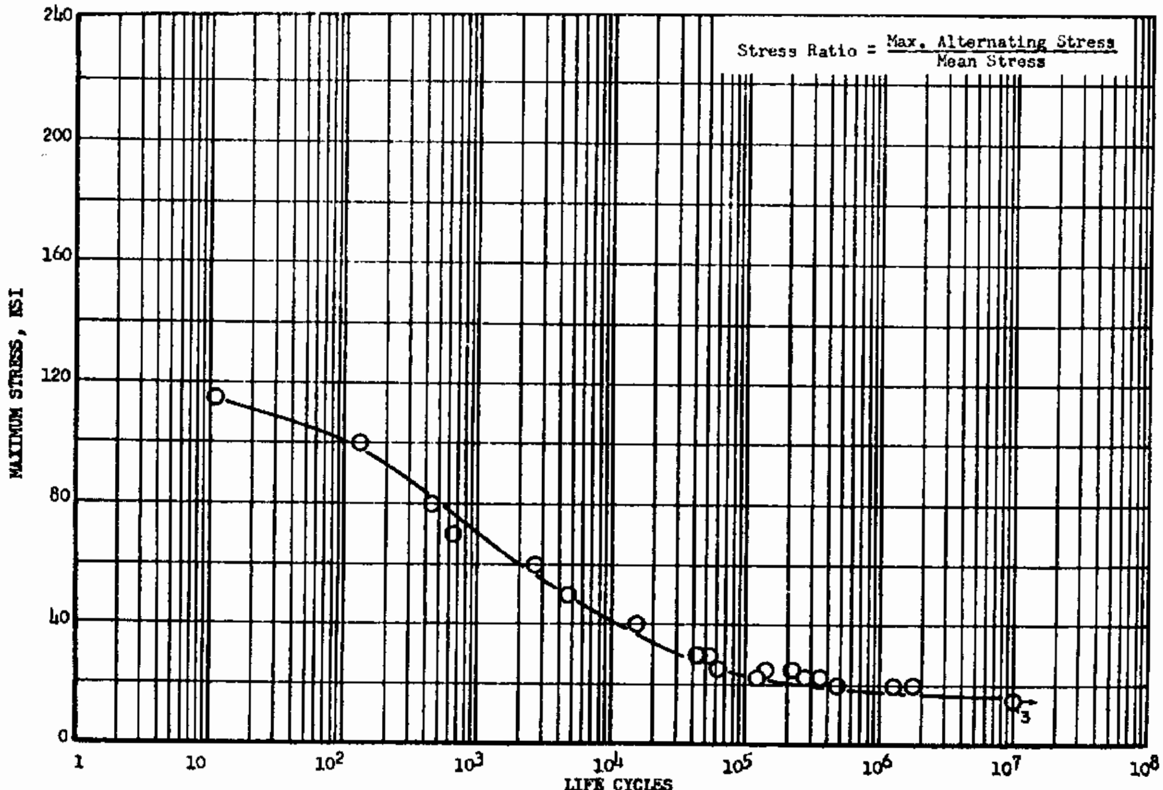


FIGURE 49? - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF ∞ (CRUCIBLE HEAT NOS. P7653 AND R4765)

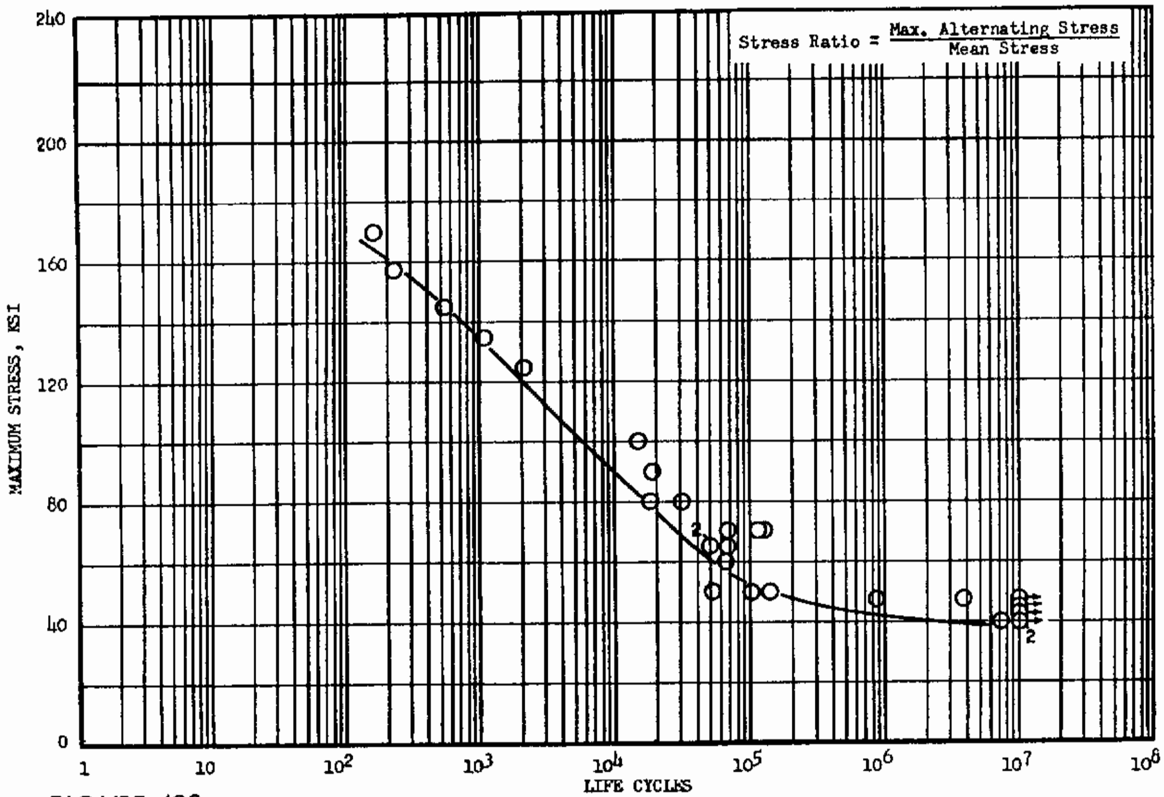


FIGURE 493 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT ROOM TEMPERATURE WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. P7653 AND R4765)

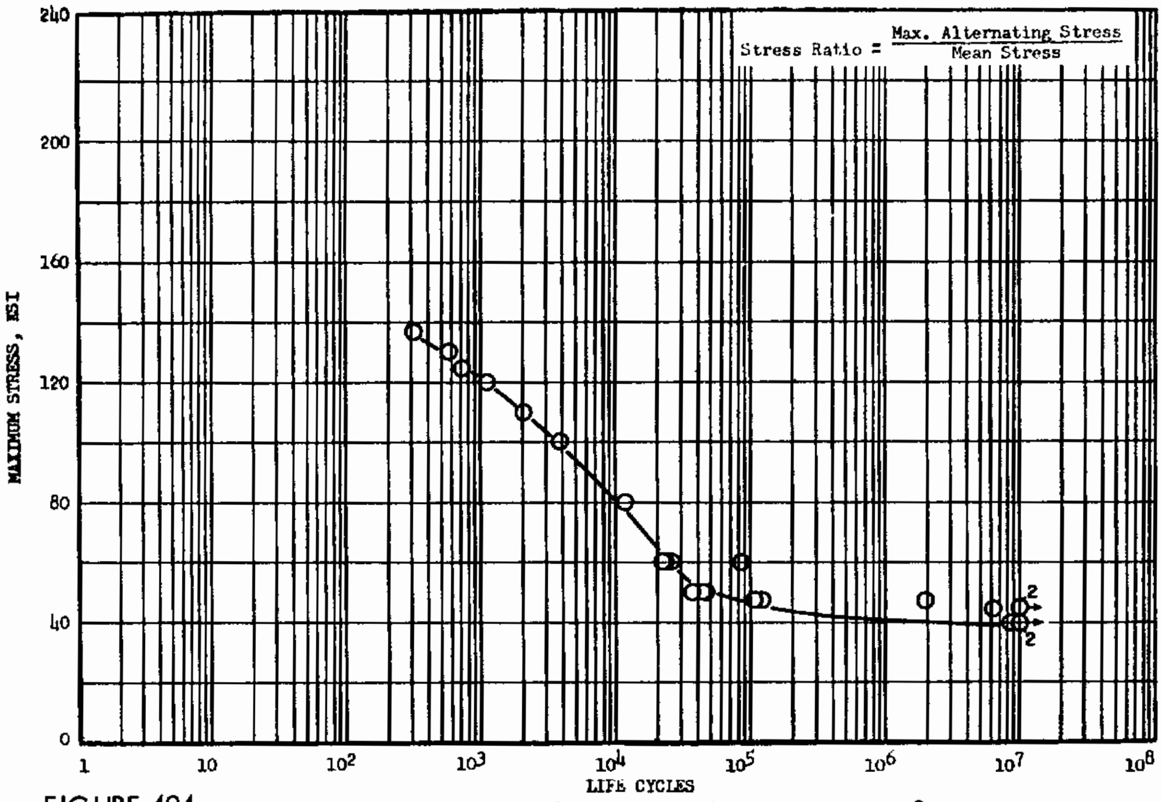


FIGURE 494 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. P7653 AND R4765)

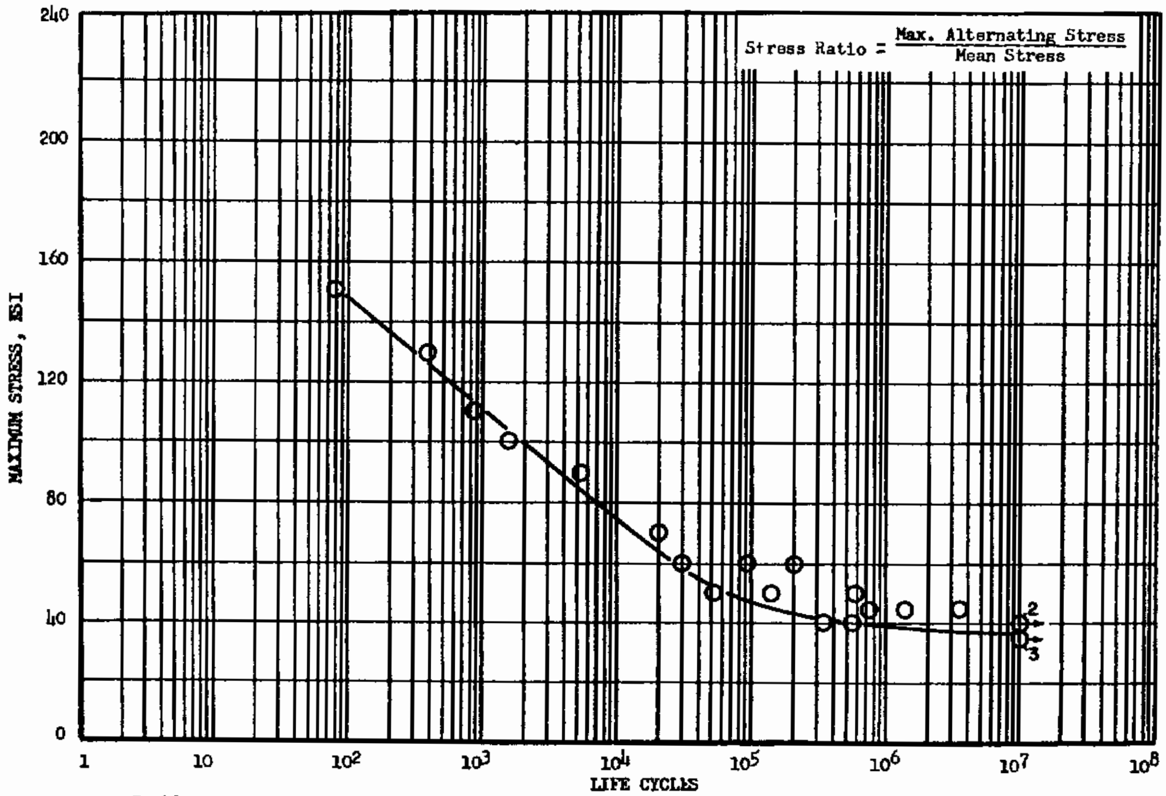


FIGURE 495 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. P7653 AND R4765)

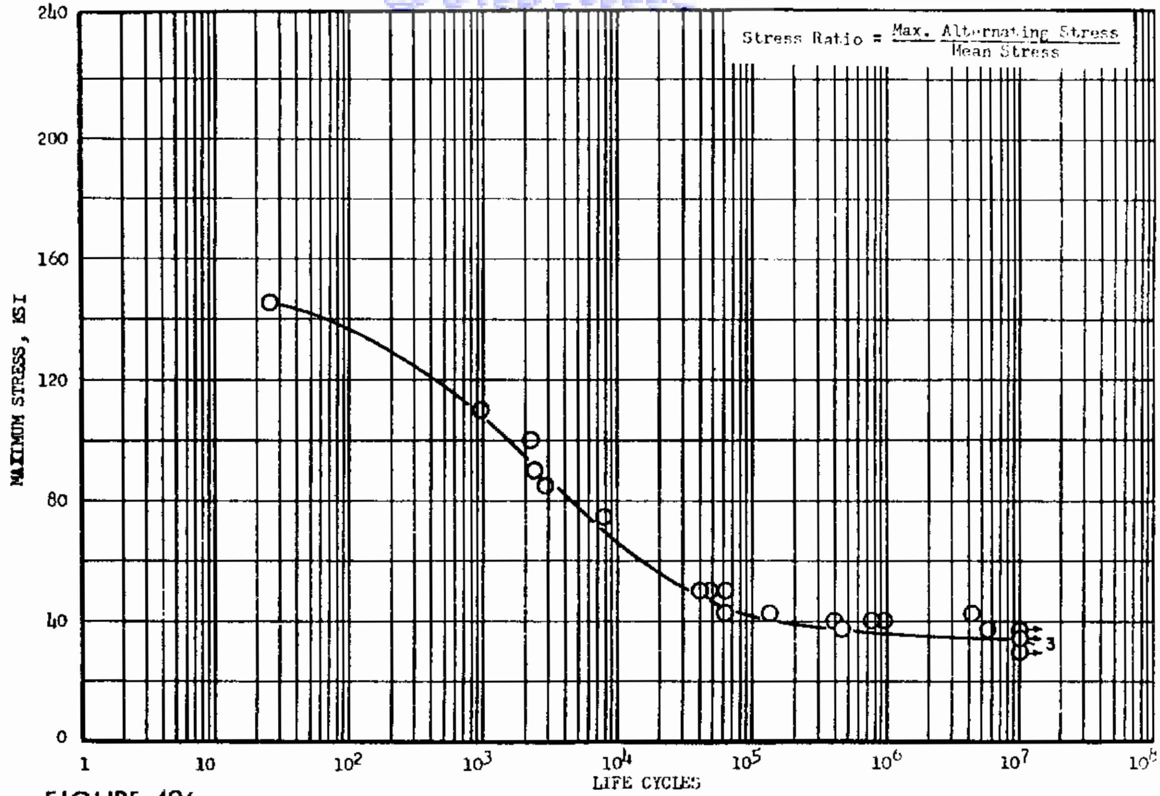


FIGURE 496 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. P7653 AND R4765)

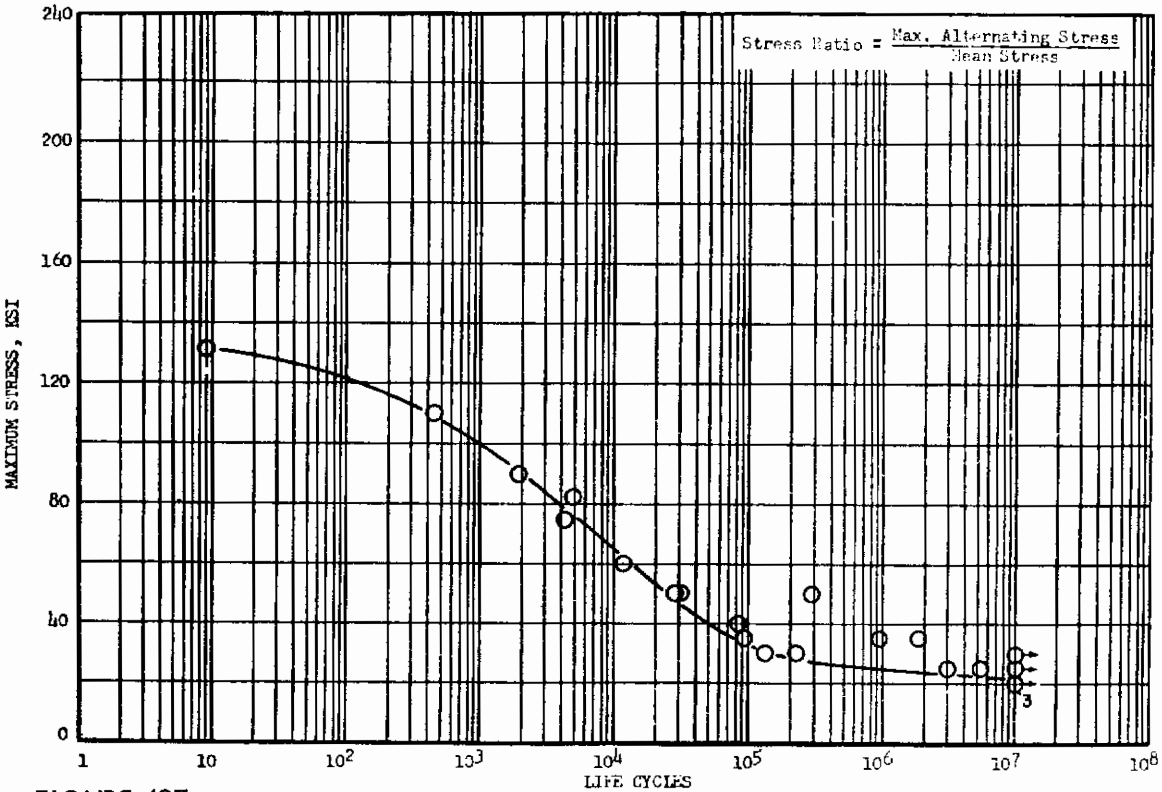


FIGURE 497 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 1.0 (CRUCIBLE HEAT NOS. P7653 AND R4765)

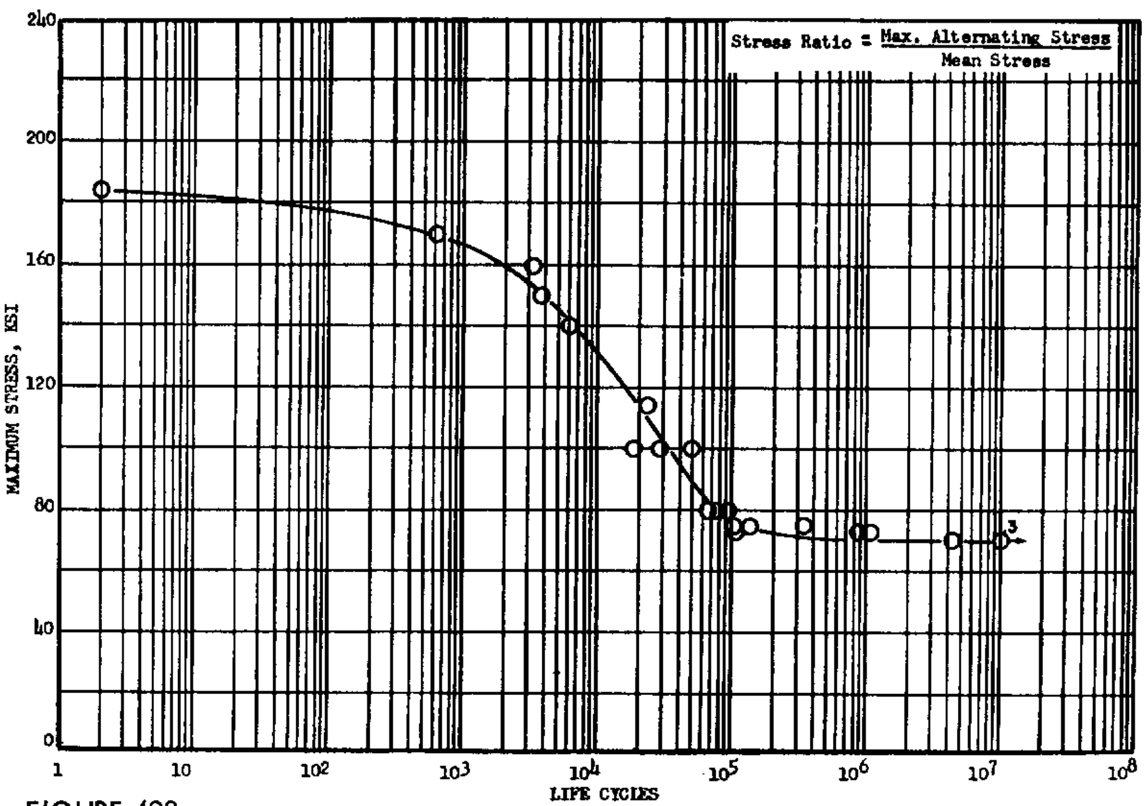


FIGURE 498 – AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT ROOM TEMPERATURE WITH A CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. P7653 AND R 4765)

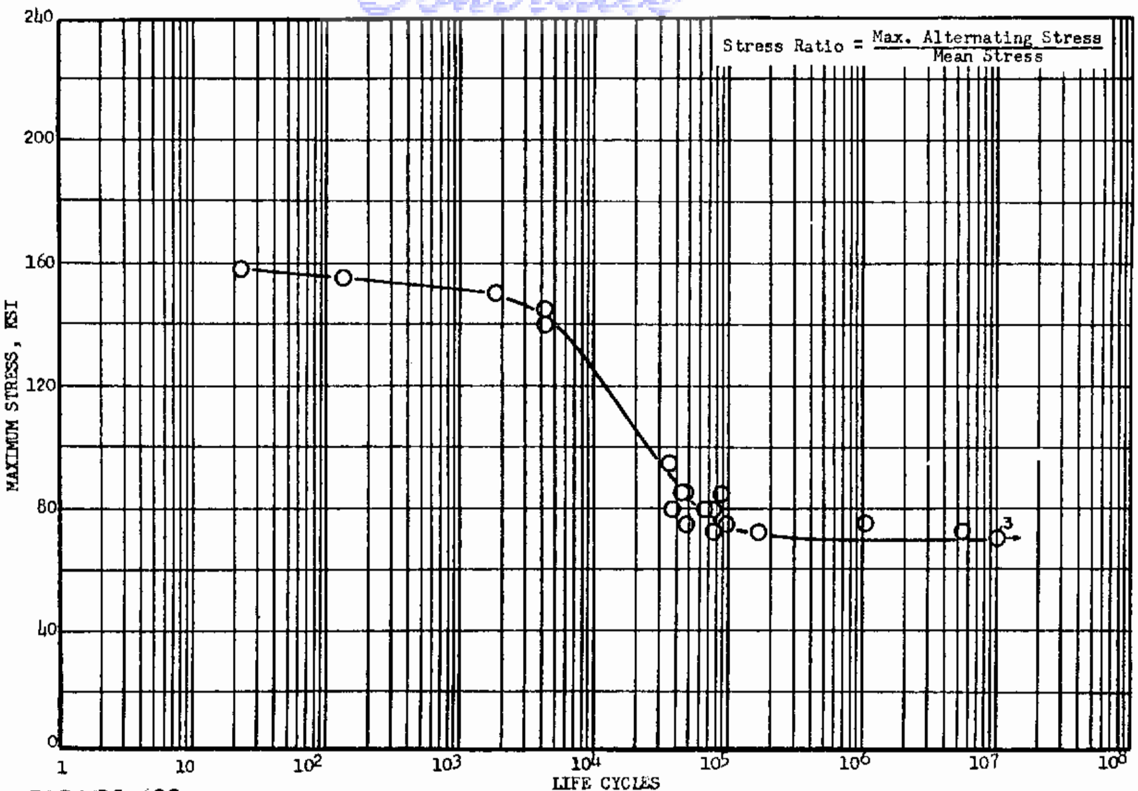


FIGURE 499 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 400°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. P7653 AND R4765)

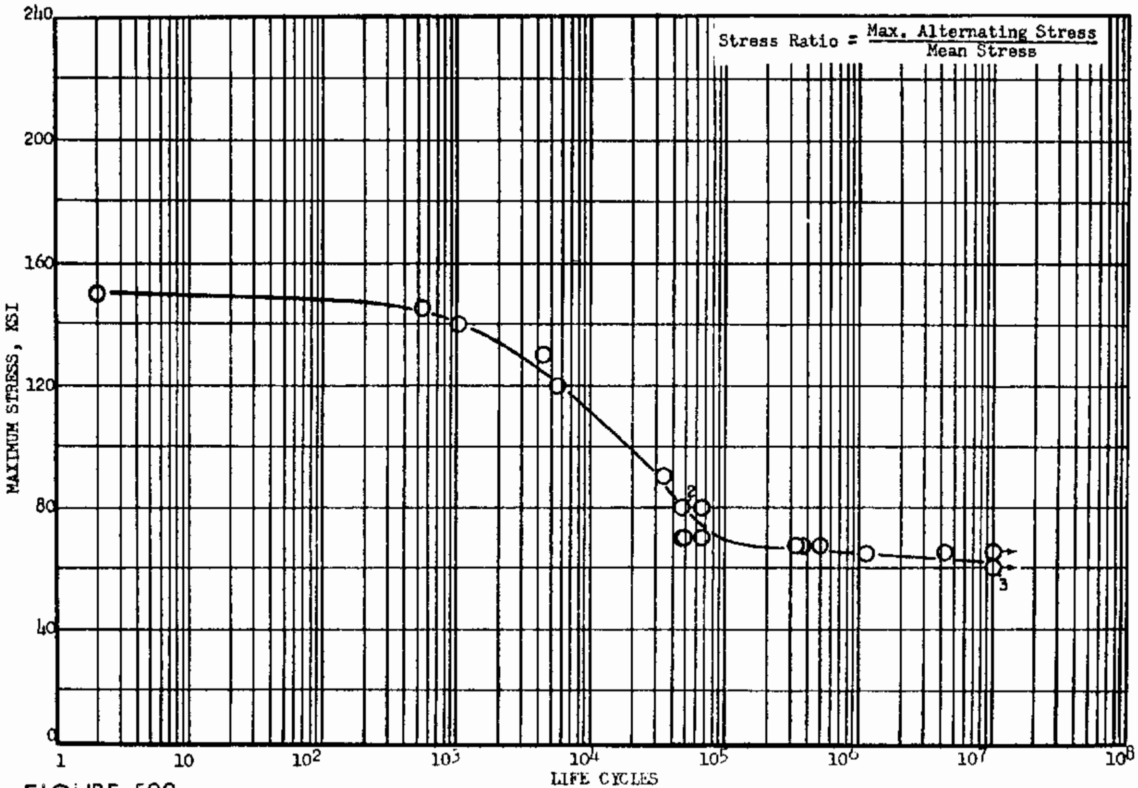


FIGURE 500 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 600°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. P7653 AND R4765)

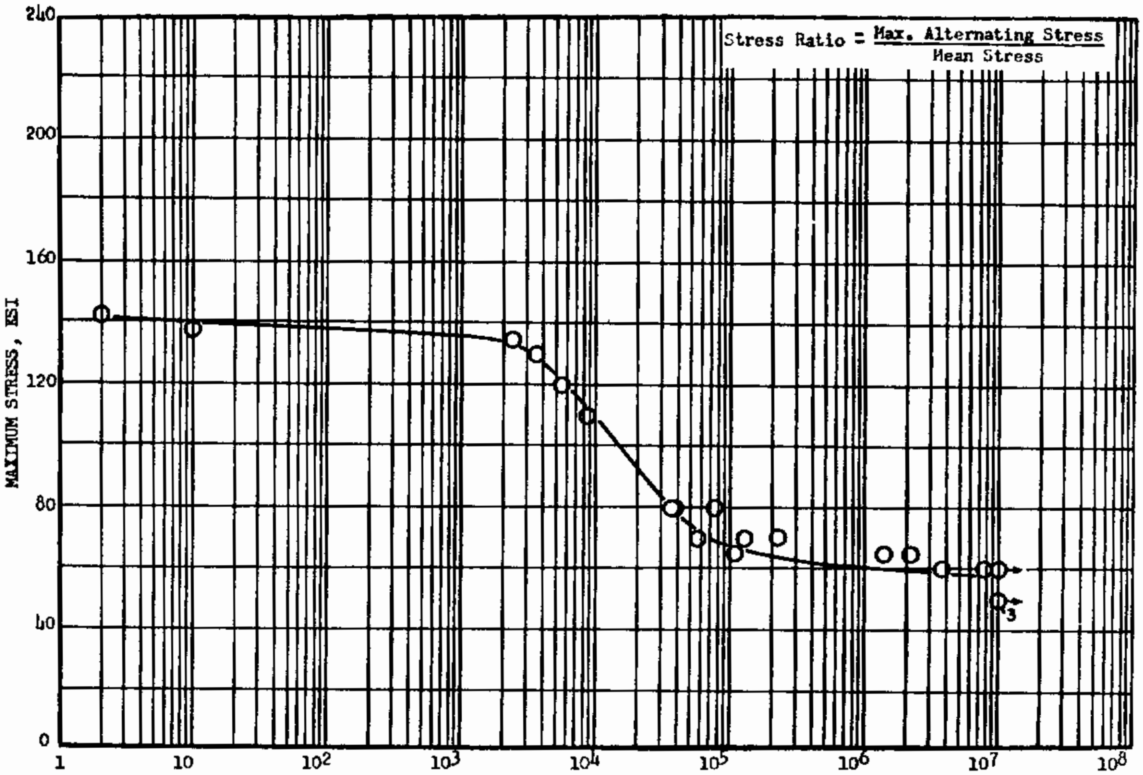


FIGURE 501 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 800°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. P7653 AND R4765)

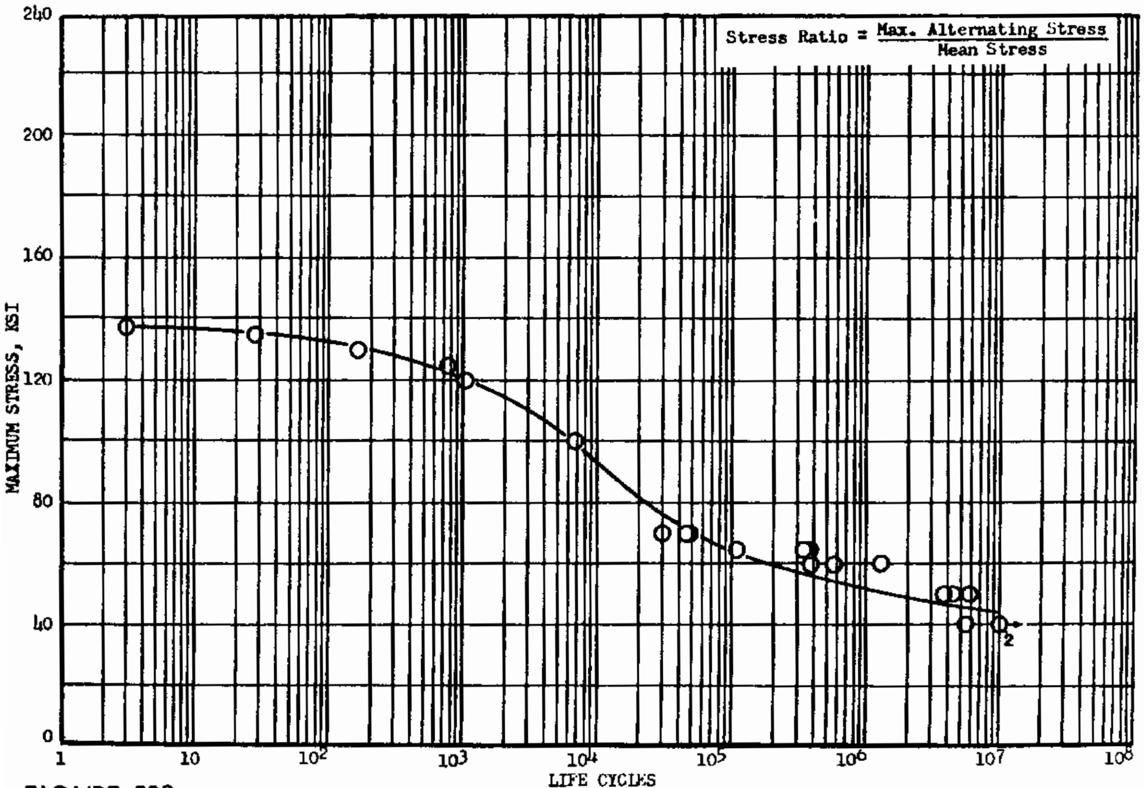


FIGURE 502 - AXIAL LOAD FATIGUE CURVE FOR Ti-4Al-3Mo-1V, 0.063 INCH THICK, AT 900°F WITH A STRESS CONCENTRATION OF 2.82 AND A STRESS RATIO OF 0.3 (CRUCIBLE HEAT NOS. P7653 AND R4765)

REFERENCES

1. H. L. Lessley and J. R. Kattus, "Creep Rupture Properties of Titanium Alloys Under Bearing, Compression, and Shear Loading", Southern Research Institute, Birmingham 5, Alabama, December, 1961.

2. Subpanel on Uniform Procedures for Structural Design Data Collection, "Uniform Testing Procedures for Sheet Materials, Creep Testing Procedures", Materials Advisory Board Report MAB-148-M, National Academy of Sciences - National Research Council, Washington, D.C., May 29, 1959.

3. "Tentative Method of Verification and Classification of Extensometers", American Society for Testing Materials Designation E83-52T, ASTM Standards, Part 2, p. 1286, 1952.

4. F. R. Larson and James Miller, "A Time-Temperature Relationship for Rupture and Creep Stresses", Paper No. 51-A-36, Transactions of the ASME, Vol. 74, (No. 5), p. 765, July, 1952.

5. S. S. Manson and A. Mendelson, "Optimization of Parametric Constants for Creep-Rupture Data by Means of Least Squares", NASA Memo 3-10-59E, National Aeronautics and Space Administration, Washington, D.C., March 1959.

6. Subpanel on Uniform Procedures for Structural Design Data Collection, "Uniform Testing Procedures for Sheet Materials", Defense Metals Information Center Report No. 46D, Battelle Memorial Institute, Columbus 1, Ohio, September 12, 1958.