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DEVELOPMENT OF FATIGUE TEST STANDARDS AND MECHANICAL PROPERTY DATA ON INTERFERENCE FIT FASTENER SYSTEMS

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13. ABSTRACT

A multiple task program was conducted aiding the establishment of proposed test No. 21, Shear Joint Fatigue Test Specification, of MIL-STD-1312 "Fastener Test Methods," and to generate joint fatigue data utilizing two commonly used "fatigue rated" fastener systems, the Hi Lok/Hi Tigue and Taper Lok. Fatigue testing of 1008 elemental joints considered high, medium, and low load transfer joints. Six important fastener system variables were investigated consisting of fastener configuration, fastener material, amount of interference fit, faying surface treatment, sheet thickness/fastener diameter ratio, and fastener hole fabrication methods. Tests were also conducted to investigate effect on fatigue characteristics due to loading frequency, type of test machine, and specimen fixturing.

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FOREWORD

This contract with the Lockheed-California Company (a Division of Lockheed Aircraft Corporation) of Burbank, California was initiated under Air Force Contract No. F33615-72-C-1838, Project No. 7381 "Materials Applications," Task No. 738106 "Engineering and Design Data." The work was accomplished under the technical direction of Messers. Alton Brisbane and Clay Harmsworth of the Air Force Materials Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio.

This report covers work performed from July 1972 through June 1973.

Mr. Robert B. Urzi, Research Engineer Sr. was the Engineer in charge of the project and principal investigator for the program at the Lockheed-California Company. Others who cooperated in this program were Mr. Richard C. Smith and Mr. Jack C. Ekvall, Dept. 78/22, Structural Methods; Mr. Dwayne Black and Mr. W. F. Bush of Dept. 74/42, Structures Laboratory. A program of this nature would not have been possible without the encouragement and support of many individuals from all segments of government and industry. To list all the participants in this program would be to chance an error of omission. It cannot be overstated that the cooperation afforded by each organization or individual contacted was outstanding. Your comments are solicited on the potential utilization of the information contained herein as applied to your present and/or future fastener evaluation and application programs. Suggestions concerning additions and/or modification to the test methods reported herein will be appreciated.

The report was released by the author in August 1973 for publication.

This technical report has been reviewed and is approved.

Albert Olevitch

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Chief, Materials Engineering Branch
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ABSTRACT

A multiple task program was implemented to aid in the establishment of a Military Test Standard (part of MIL-STD-1312) needed to evaluate joint fatigue life improvement fasteners in fatigue and to generate joint fatigue data utilizing the two most commonly used "fatigue rated" fastener systems:

- The Hi Lok/Hi Tigue System (Hi Shear Corp)
- The Taper Lok System (Omark Industries)

The major task consisted of fatigue testing 1008 elemental joint specimen using two basic types of elemental joint specimen:

- High load transfer where all the load is transferred from one joint member to the other
- Low load transfer where a small portion of the load (approximately 5 percent) is transferred from one joint member to the other.

Within this program, six important fastener system variables were investigated:

1. Fastener configuration
2. Fastener material
3. Amount of interference fit
4. Faying surface treatment
5. Sheet thickness/fastener diameter ratio
6. Fastener hole fabrication methods

Included in the program scope were tests to investigate the effect on joint fatigue characteristics due to:

- Loading frequency (strain rate)
- Type of test machine (constant amplitude vs. constant load)
- Special specimen fixturing

The test methods used were those proposed for insertion into MIL-STD-1312, "Fastener Test Methods". These methods were in general satisfactory in the assessment of the fatigue behavior of the joint system tested. The joint fatigue behavior patterns identified in this program included:

- Increase in fatigue life with increase in interference fit
- Decrease in fatigue life with increase in the amount of the load transferred by the fastener in the joint
- Insensitivity to fastener material
- Insensitivity to hole preparation methods
- Differences in the mode of failure associated with faying surface treatment, amount of load transferred by the fastener and number of load cycles endured.

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INTRODUCTION

With modern aircraft designs utilizing thousands of different types of fasteners, the problem of fastener evaluation is one of ever increasing complexity. While there are standards for fastener fabrication and evaluation, they are often confusing, overlapping and fail to identify and standardize those parameters that are most critical to the actual performance of the entire installed fastener system. Consequently, each manufacturer has continued to expand and propagate his own line of fasteners employing his own fastener evaluation procedures. As a result it has been difficult to evaluate and compare realistically the performance of various fasteners in the "installed" condition. The task of establishing a test standard fell to the Fastener Testing and Development Group (FTDG) an Industry-Government Committee.

A research and development program was implemented in April 1971 under Navy Contract N62269-71-C-0450, Reference 1, which aided the FTDG in developing a proposed Military Test Standard (part of MIL-STD-1312) to evaluate the fatigue behavior of installed mechanical fasteners. The Navy program was divided into two tasks.

Task I consisted of a survey of twenty-two different aerospace fastener manufacturers and users to provide a basis for defining optimum requirements for an installed fastener fatigue test standard. Elemental joint configurations used in ad hoc standards ranged from simple lap joints to complicated multiple member box beams. The fatigue testing methods ranged from complex spectrum loading to simple constant amplitude. Task II was a fatigue test program to determine the suitability of six different elemental fastener joint specimens for use in the test standard.

The objectives of the current program funded by AFML under Contract F33615-72-C-1838 included the following:

1. To further develop and refine fatigue test methods proposed for insertion into MIL-STD-1312, "Fastener Test Methods".

2. To determine the suitability of proposed test standards as applied to interference fit fastener systems.

3. To provide the Air Force with joint fatigue data generated by utilizing the proposed test standard in tests of fasteners which reflect current usage.

The work reported herein provides an assessment of the proposed MIL-STD-1312 test method for establishing performance characteristics of installed interference fit fastener systems. This assessment has been implemented through the generation of fatigue data utilizing a large number of mechanically fastened joints with variations in geometric, production, and environmental parameters. In addition, the statistical significance and reproducibility of the test data was investigated. The following pages summarizes the conclusions reached. Section 1 presents the procedures used and results obtained. Section 2 discusses the presentation of the data, the computer techniques used, and statistical manipulation of the data.

CONCLUSIONS

From the data generated in this test program the following logical conclusions can be made:

1. The test method, as proposed for insertion into MIL-STD-1312, appears to be an effective experimental tool for the evaluation of behavior of fatigue installed interference fit fastener systems. The use of these methods would result in the generation of data which could characterize the fatigue behavior of elemental joint types utilized in airplane construction.

2. The specimen test lives and failure modes appear to be influenced by the joint geometry and the faying surface condition. Use of an effective antifretting coating on one series of test specimens resulted in a uniform failure mode and increased confidence that the test lives experienced were accounted for by the variables under investigation and not by fretting parameters.

3. In reviewing the individual test variables there seem to be:

   (a) no effect on fatigue characteristics of the joints tested when subjected to loading frequencies ranging from 400 to 4500 cycles per minute.

   (b) no effect on the fatigue characteristic of the simple lap joint specimens when using the "sandwich" restraint/guides as compared to using the flexure, 90° (offset) restraints.

   (c) no effect on the fatigue characteristic of the joints tested when testing at either constant amplitude or at constant load.

4. With reference to the data generated where basic fastener system variables were changed the following relationships were noted:

(a) increasing the fastener interference fit generally increased the fatigue life. This trend was evident in both high load and low load transfer joint specimens.

(b) the data gained was inconclusive in respect to the effect on fatigue characteristic due to the type of hole fabrication methods used. The use of hole fabrication techniques simulating production line practices and hole fabrication methods simulating either experimental shop or model shop practices resulted in the data falling within the same scatter band.

(c) the test methods used were very effective in showing the effect on the fatigue characteristic of both high load and low load transfer specimens due to sheet material thickness/fastener diameter ratio. As the t/d ratio increased the fatigue lives decreased.

SECTION 1

ASSESSMENT OF FASTENER TEST METHODS

1.1 BACKGROUND

At the Fall 1969 meeting of the Fastener Testing Development Group (FTDG), a newly formed sub-group was given the task of defining a test method to characterize the fatigue properties of installed permanent type airframe structural fasteners with the ultimate objective of developing a test standard suitable for insertion into MIL-STD-1312, "Fastener Test Method", Reference 2. Concurrently, there were several programs being actively pursued in industry investigating suitable test methods to be used in the fatigue evaluation of an installed mechanical fastener, (Refs. 3-6). At succeeding FTDG meetings, discussions continued concerning a proposed MIL-STD test method. The subgroup assigned the responsibility for developing the test standards became acutely aware of the lack of data and the diverse test methods used in generating data. It became apparent that a program was needed with the objective of identifying the required information and criteria for a unified test standard. A contract was awarded to the Lockheed-California Company in April 1971 to develop the information needed. The information that was gathered and the results that were obtained in that initial government funded program are reported in Reference 1. One important task accomplished in the initial program was a government-industry survey of ad hoc standards being used by various organizations which was presented in a separate report, Reference 7. The results of the survey showed generally two basic types of joint configurations being used in the evaluation of "fatigue rated" fasteners. These were:

1. High load transfer where all the load is transferred from one joint member to the other of the type shown in Figure 1.

2. Low load transfer of the type shown in Figure 3, where the object of the test is to determine the influence of the fastener on the fatigue characteristics of the sheet material in which it is installed.

The survey determined that the one and one-half "dogbone" specimen, shown in Figure 2, classified as a medium load transfer specimen, which was being considered by the FTDG Joint Fatigue Sub-Group as a test standard, found only limited acceptance by the fastener testing community.

The test program conducted per Reference 1 did arrive at certain conclusions:

- The simple lap joint/single shear specimen, fully supported (restrained from rotating), emerged as the most consistent joint geometry for the prediction of fatigue characteristics of the installed fastener system. However, fretting fatigue failures were experienced in a significant percentage of the tests placing some question on the validity of the test method as a true evaluation of the installed fastener and its influence on the joint fatigue life.

- The test data generated using the one and one-half "dogbone" geometry appeared to result in a definite discrimination between the fastener systems compared, but not with the confidence and consistency of the simple lap joint.

- The low load transfer specimens tested in the program reported in Reference 1 did not generate data exhibiting a consistent high order of confidence in the ability to discriminate between the different fastener systems tested. However, the data did indicate a sensitivity to particular fastener system/joint configuration variables such as sheet metal stackup, type of fastener fit, and the amount of torque applied to the nut. Another item of importance was that the majority of the fatigue failures experienced occurred through the fastener holes. The low load transfer joint is a highly sensitive joint responding to the fastener system variable. This greater sensitivity would account for the greater amount of test scatter in the data and correspondingly an inability, when analyzed statistically, to discern differences to the same confidence level, as, for example, in using the t-statistic to test for equality of the means of two samples (Reference 10, 11).

It should be noted that the program reported in Reference 1 and that reported herein differ in one important aspect. The referenced program objective was to assess candidate joint geometries and ad hoc standards in order to consolidate and reduce their number. Therefore, the fastener systems used in that program were chosen to provide divergence in the test data. By measuring the difference between the two mean values (one for each set of data for each fastener system) it was relatively simple to determine the discriminatory ability afforded by each of the candidate joint geometries considered. In the current program the test specimen geometries were previously defined. The objectives in this program were to obtain possible refinements and modifications to the proposed test method and to assess the proposed test standard in terms of applying it to generate design data.

1.2 MATERIAL ACQUISITION AND PREPARATION

1.2.1 Sheet Material Selection

Three aluminum alloys were considered for use in this program:

a. 7075

b. 7475

c. 7050

The 7050 material was not used as sheet material because it offers no advantage over 7075 as a sheet form. Initially 7475-T76 clad was selected, but due to procurement lead time and minimum quantity requirement established by the producer it was not used. Therefore, 7075 sheet material was used in the T76 clad condition per Federal Specification QQ-A-00250/25ASG dated 14 October 1969. The T76 temper represents the current and projected industry-wide usage of the 7075 alloy as a sheet material for airframe construction. The aluminum alloy sheet material was bought in the T6 condition and was re-heat treated to the T76 condition per MIL-H-6088-E dated February 1971. The mill certification received with the material is included in this report as Appendix I.

The titanium alloy sheet material chosen for the program was Titanium-6Al-4V in the mill annealed (MA) condition. The composition and mechanical properties of the material ordered were governed by Military Specification MIL-T-9046F, Amendment dated 15 March 1968, with the added limitation that the oxygen content, O_2, be kept to a maximum of 0.13 percent by weight. Material certification on the alloy used is attached to this report as Appendix II.

The sheet materials were sheared and contour machined to the proper dimensions using a conventional profile milling machine. The detail test specimen drawings have been reproduced for this report and are included as Figures 1, 2, and 3. The identification numbering system is also shown in Figures 1, 2, and 3. Each specimen had its identification number electric penciled on it along with an orientation reference marked "top" or "bottom". Each individual specimen identification number also codes the particular fastener system used.

1.2.2 Hole Fabrication and Fastener Definition and Installation

The two types of hole fabrication techniques utilized in this program were "production" and "precise". The "production" technique covers joint specimens required for test conditions outlined in Tables 1, 2, and 4 and the "precise" treatment is used for fastener holes of specimens defined in Table 3. Definitive data for both the fasteners and the holes are given in Figures 1 through 3. Table LXXXIX in Appendix III lists the tooling and specification used in the fabrication of holes, both "production" and "precise". The methods of hole fabrication and fastener installation for the two fastener systems used also are given in Appendix III. It should be noted that every fastener hole was inspected and recorded. These records are given in Table XC. In cases where a straight shank fastener was used the hole diameter was measured and recorded; in cases where a tapered fastener was used, the fastener protrusion was measured and recorded. Fastener protrusion is the height of the fastener shank (including head height for flush fasteners) remaining to be forced into the hole when the fastener is placed into the hole using finger pressure (30 lbs approx). This height (in inches) then divided by 48 gives the interference fit of the fastener when fully installed.

1.2.2.1 Resolution of Interference Fits Used in Test Program

A tabulation of fastener interference fits used in this program is given below. Initially in the program a different range of interference fits were to be used in the installation of the straight shank fastener system as compared to the installation of the tapered shank fastener system. Based on continued investigation, the Air Force and the contractor decided that in consideration of the size fastener used in this program, the gross amount of interference fit should be the same for both the straight shank and tapered shank fastener systems. This concurrence of fastener fit for both systems would not necessarily hold true for larger fastener diameters.

Test Program Interference Fits (3/16 Nominal Fastener)

<table>
<tr><th rowspan="2">Interference Fit Range</th><th>Production Quality Holes</th><th colspan="2">Precise Holes</th></tr>
<tr><th>Taper Lok and Hi Lok/Hi Tigue</th><th>Taper Lok</th><th>Hi Lok/Hi Tigue</th></tr>
<tr><td>Low</td><td>.0000
-.0030 mean -.0015</td><td colspan="2">Not Applicable</td></tr>
<tr><td>Std</td><td>-.0015
-.0045 mean -.0030</td><td>-.0032
-.0028</td><td>-.0035
-.0025</td></tr>
<tr><td>High</td><td>-.0030
-.0060 mean -.0045</td><td colspan="2">Not Applicable</td></tr>
</table>

Care was taken during the selective assembly of test specimens so that no overlap of interference fit occurred between specimen groups representing the low, standard, and high interference fit ranges.

1.2.2.2 Changes in H11 Fastener Coating

It had been recognized that an incompatibility problem might exist between the diffused nickel-cadmium plating on the H11 steel fasteners and the titanium-6Al-4V sheet, in which the fasteners are installed, if there is any free cadmium interface. One recommendation was to install the H11 fasteners bare in the titanium sheet. This would have added another variable to the program. The additional variable of a bare surface condition within the H11 fastener group could foreseeably cause variations in fretting conditions occurring in the fastener holes. This in turn would effect changes in test life of the various elemental joints being evaluated for a test standard. The objectives of the current program did not include an assessment of joint fatigue life due to variations in fastener surface finish or coatings. The contractor proposed that all steel fasteners installed in titanium material contain the same coating.

Elimination of the diffused nickel-cadmium coating and substitution of an alternate material as a fastener finish avoided the H11 fastener and 6Al-4V sheet material incompatibility. The coating also was required to minimize galling during fastener installation. The substituted material was selected from three candidate coatings:

1. Hi Kote I (aluminum coating)
2. Hi Kote II (inorganic coating)
3. Lubeco 2123 Type 2 (inorganic coating)

Bench tests were conducted utilizing straight shank fasteners made of steel and titanium stripped of their production coating and subsequently coated with one of the coatings listed above. Fasteners chosen for coating were taken from the same production lot, heat, and size. After coating, fasteners were installed in a three-fastener diameter thick plate of 7075 aluminum or titanium-6Al-4V (ma) material. All fasteners (steel and titanium) were installed with a minimum interference fit of -.0040 inch and a maximum interference fit of -.0043 inch based on bare fastener dimensions. Fasteners were forced into the interference fit holes using a 5X rivet gun and pushed out with a hydraulic press. The fasteners were visually examined at 20X magnification to determine the amount of fastener coating scraped off during the installation and removal process. Although the Hi Kote II and Lubeco 2123 coatings possess similar fastener adherence characteristics, the Lubeco-coated fastener sustained the installation process better than did the Hi Kote II. Based on these tests, the Lubeco 2123 was selected as the fastener coating material.

Steel fasteners which utilized the Lubeco coating had been reordered so that the Lubeco coating would be applied to a manufactured bare fastener containing pre-plating dimensions. Steel fasteners for the aluminum sheet material specimens had the standard diffused nickel-cadmium coating while the titanium fasteners for the aluminum sheet material specimens used standard cetyl alcohol lubr cation.

1.2.2.3 Nut Configuration and Torque-Up

The work statement of the contract did not define the nut configuration and amount of torque applied to the nut. The Taper Lok and Hi Tigue fasteners chosen for this program may, on occasion, utilize different nut configurations with variations in torqueup. The variable of nut configuration and amount of torqueup was not considered in this program. The nut configuration normally associated with each fastener type was used, i.e. washernut with Taper Lok and "torque off" collars with Hi Lok/Hi Tigue. Both nut configurations were made of alloy steel with both fastener systems torqued to the same value, 45 ±5 inch-pounds.

1.2.3 Faying Surface Treatment

In an attempt to preclude the influence of fretting on the fatigue strength characteristics of the various joint specimens chosen for this program, the following faying surface treatments were used:

- Aluminum Alloy Sheet Specimens

  Following the machining, hole fabricating and identifying processes, all aluminum joint specimens tested in this program received a faying surface treatment. This treatment consisted of cleaning (degrease), spray paint with epoxy primer that meets Lockheed Specification LCM 37-1035 and Boeing Specification BMS 10-11F and cure at room temperature for 24 hours. The epoxy primer used was Finch Paint and Chemical Company #463-6-3 Corrosion Resistant Primer. It is a chemically cured epoxy primer coating especially designed to provide protection for ferrous and nonferrous metals against fresh and salt water, aircraft fuels, hydraulic fluids, engine oils and corrosion causing media. It was applied using a standard spraygun at a line pressure of 35 to 45 psi. The dry film thickness was approximately 0.7 mil.

  After curing the primer and upon assembly, the faying surfaces of the joint specimens were coated with Products Research and Chemical Corporation (PRC) PR-1431-G Corrosion Inhibitive Sealant. PR-1431-G is a two-part dichromate cured, polysulfide sealant with an increased soluble chormate content to inhibit corrosion in areas subjected to galvanic action. The mixed material was applied using a standard short nap paint roller. It should be noted that all fasteners were installed dry (not coated with sealant).

- Titanium Sheet Specimens

  All titanium joint specimens received faying surface treatment consisting of the following operations.

- The surfaces to be coated were cleaned by grit blasting using 150-180 grit aluminum oxide. Immediately after cleaning the parts were spray painted with Dow Corning Molykote 106 thermosetting resin bonded lubricant. The parts were cured in an oven at 300 ±10°F for sixty minutes before assembly operations were initiated. The Molykote 106 coating is designed to meet the requirements of MIL-L-8937 (ASG).

1.3 BASELINE DATA GENERATION

1.3.1 General Description of Data Generated

Four hundred and thirty-two specimens (out of a total of 1008) were used to generate the baseline data. These 432 specimens were further divided into 36 groups of 12 specimens for each test condition for defining the S/N curves. The test requirements and conditions of the baseline data are given in Table I. Table I also serves as an index to the individual Tables and Figures where the particular sets of baseline data are presented.

The lap joint, one and one-half "dogbone" and reverse "dogbone" elemental joint specimens referred to in Table I, and subsequent Tables, are detailed in Figures 1, 2, and 3 respectively. The alpha-numeric joint geometry designation referred to in Tables V through XCVI define completely all the particulars of the joint investigated. For example, joint part number X16138-1EEE, Figure 3, identifies the specimen geometry as follows:

- X16138 is the production joint design drawing shown in Figure 3.
- The first dash number identifies the stock material (1 indicates .100 stock 7075-T76 clad aluminum alloy).
- The single, double, or triple letter designates the fastener system and interference fit (EEE indicates a HLT411-6-4 Hi Tigue Fastener utilizing a fastener material of Titanium-6Al-4V, solution treat and aged (STA), installed in a high interference fit condition (-0.0045 inch).
- Absence of the letter "P" indicates a production quality hole.

The terms "precision" and "production" quality holes are defined in Section 1.4.2 and Appendix III of this report.

1.3.2 Influence of Test Machine on Data Generated

Two types of fatigue test machines were utilized in this program. The principal machine used was a closed loop electro, hydraulic servo controlled type. In this machine the load sensing device (force transducer) is located in series with the test machine and provides the feed back signal in the servo loop. Inherent in this design is that the applied cyclic loads are continuously controlled during the test maintain a given stress level. Conversely, utilization of the machine where the identical cyclic loads are repeated until specimen failure occurs is referred to as a constant load fatigue test. The second type of fatigue test machine used was of the resonant type. This machine, consisting of a spring-mass system, is operated near its natural frequency resulting in a sinusoidal loading of constant amplitude. The output of a load transducer in series with the specimen is monitored through appropriate electronic hardware and software on a digital computer. The maximum and minimum load magnitudes of the loading cycle were recorded. These records indicate that both the maximum and minimum applied loads were within two percent of the calculated or desired values with the accuracy of readout being ±0.5 percent. This accuracy in loading was experienced in both types of fatigue test machines. The test frequency ranged between 600 and 2300 cycles per minute (cpm) with the majority of tests conducted at 1800 cpm. Furthermore, six constant amplitude and eight constant load machines were used during the course of the program with the test specimens randomly distributed among the machines.

In the course of the program, data were generated utilizing both types of test machines. Referring to Tables VI, XII, XIII, XXX, XXXI, XLII, XLIX, L, LIII, LVIII, LIX, LX, LXVI, and LXVIII comparisons can be made between specimens tested at constant amplitude and specimens tested at constant load with all other variables being equal. From the data in these tables it is concluded that neither the test frequency nor the variations in test machine characteristics had any significant or large effect on the test results.

A low load transfer joint specimen is shown installed in a constant load (servo-hydraulic) test machine in Figure 4. Figure 5 shows the same specimen geometry installed in a constant amplitude (resonant) fatigue machine.

1.3.3 Lap Joint Specimen Support Methods

Two types of joint guide arrangements were used during testing of the simple lap joint specimen. Eight percent of these specimens were tested utilizing the "sandwich" type guides. The remaining specimens were tested using the 90° "offset" flexure rod supports. Each type of guide arrangement is shown installed on a lap joint specimen in Figures 6 and 7. The design details of these guide fixtures are given in Figures 8 and 9. The need for using guides or joint rotation restraints is well established. Their design evolution and technical data substantiation is given in References 6 and 8.

During the Fall 1972 meeting of the FTDG a detail discussion was held on stiffening the simple lap joint (to reduce bending stresses). It was concluded that the stabilizing method described in the contracted program (see work statement, Attachment A, of Reference 8) may cause difficulty during set-up in certain types of fatigue test machines. A "sandwich" fixture (outside plates lined with teflon, etc. saddled around the joint) was proposed by several FTDG members. Therefore, this alternate method of stiffening the lap joint was utilized for a small portion of the lap joint tests conducted under this program for comparison purposes.

The data generated that lends itself to this comparison is presented in Tables V through XVI. In reviewing these data it did appear that the "sandwich" supported specimens sustained longer fatigue lives than specimens tested using the flexure supports. However, the limited amount of data generated does not lend itself to a high confidence statistical judgement and it appears that the individual data points of specimens tested with the "sandwich" support fall within the scatter band exhibited by the total sample tested.

1.3.4 Effect of Test Frequency on Fatigue Characteristics

A cursory investigation was undertaken to determine the effect on fatigue resulting from variance in testing frequencies. Data that are presented in

Table LXXVIII were generated using high load transfer joints. The test frequencies used for the comparison were 1800 and 500 cycles per minute. No significant difference was noted in the test lives experienced at these two frequencies with all other factors being equal.

Data are presented in Table XXXVII generated on low load transfer joints tested at 1800 or 500 cycles per minute. No significant difference in test lives was noted. In a previous program, Reference (6), a reverse "dogbone (low load transfer) specimen was instrumented with eight strain gages as shown in Figure 10. This specimen was of the same design as given in Figure 3.. The instrumented specimen was submitted to the Hi Shear Corporation which conducted an independently funded test program to investigate the effect of test frequency on the amount of load transfer in a reverse "dogbone" fatigue specimen. This Hi Shear Study (Appendix IV) covered cycling the instrumented specimen at five frequencies between 400 and 4500 cycles per minute. It is reported that there was no variation in output of any of the strain gages throughout this testing.

1.3.5 Failure Modes of the Joint

The fatigue tests were continued until failure of the specimen occurred. The fracture surfaces of the failed specimens were visually inspected and the apparent failure mode recorded. These observations are presented, along with other pertinent data, in Tables V through LXXXVIII. The appearance of the fracture surface and location of a given characteristic determined the failure mode designation assigned to the individual specimen. Four failure modes exhibiting major phenomenoligical differences were identified.

- Sheet metal failure away from the countersunk fastener holes. This is the sheet metal portion of the test specimen that supports the manufactured head of the fasteners. This failure mode is illustrated in Figure 11.
- Sheet metal failures occurring away from the plain (non-CSK) fastener holes. This is the sheet metal portion of the joint bearing against the nut. See Figure 12.

- Sheet metal failure occurring through the fastener hole with a high degree of probability that the fracture initiated in the fastener hole portion of the test specimen. This type of failure occurred in the CSK hole as shown in Figure 13.
- Sheet metal failure occurring through the fastener hole in the plain hole (nut side) as illustrated in Figure 14.

Several generalizations can be made about the failure modes experienced by the aluminum alloy joint specimens tested in this program. In the high load transfer joints, Figure 1, the failure occurred through the fastener hole when subjected to a high level of applied stress resulting in relatively short test lives. On the other hand, the same type joints failed away from the fastener hole when testing at low stress intensity levels leading to relatively long test lives. The low load transfer specimens, Figure 3, experienced the majority of the failures through the fastener holes regardless of the magnitude of the applied stress. The reason for this occurrence is not a simple one. It is related to the amount of bending stress occurring in the joint and the degree of fretting located at the faying surface in the vicinity of the fastener holes. During long test lives fretting pits are established and the peak stresses resulting from these pits (sharp notches) are higher than those occurring at the fastener hole. Exception to this behavior pattern was exhibited by all titanium specimens, which failed through the fastener holes. A typical example is shown in Figure 15. The reason for this apparent discrepency is that a special faying surface treatment was used on the titanium specimens that eliminated the fretting experienced by the aluminum joints. The titanium coating used was one that was previously investigated in an Air Force sponsored program (Ref. 9).

1.3.6 Effect of Joint Geometry on Fatigue Life

In the following discussions the terms high, medium, and low load transfer joints are used. The description high, medium and low define the amount of the total tension or compression load applied to the joint that is transferred by the installed fastener from one joint member to the other.

Figure 1 is a 100 percent load transfer specimen, i.e., the fasteners transfer, in shear, all the load from one joint member to the other joint member. This type is commonly referred to as a simple lap joint and is described in MIL-R-7885B. It is the simplest and most economical specimen to fabricate.

The one and one-half dogbone specimen, Figure 2, is considered a medium load transfer joint. Per Reference 3, this configuration transfers approximately 30 percent of the load from the continuous dogbone sheet to the half dogbone sheet. Only one fastener is used with the manufactured head of the fastener normally installed in the continuous sheet. If pin-loaded during fatigue testing, a precise location and alignment of the holes is required on the grip ends of the specimen.

The reverse dogbone specimen, Figure 3, is considered a low load transfer joint and, per Reference 5, approximately 5 percent of the axial load is transferred at each fastener location. Two fasteners are used in this configuration with both fastener-manufactured head locations occurring on the same side of the specimen.

The relationship between the amount of load transferred and the fatigue strength of the joint is that increasing load transfer decreases the fatigue strength. The obvious reason for this fatigue behavior is that the bearing, shear, bending, and tear-out stresses increase as a function of the increase in shear load across the fastener. In reviewing the S/N curves, Figures 16 through 51, the relationship appears true only for the fatigue data generated utilizing titanium sheet material joint specimens. For example, at 10^7 cycles, utilizing titanium taper shank fasteners installed in Ti-6Al-4V sheet (Tables XVI, XXVIII, and XL), the fatigue strength is; 25.0 ksi for the high load transfer joint; 38.0 ksi for the medium load transfer joint; and 43.0 ksi for the low load transfer joint. This trend was essentially the same for all fastener systems tested with titanium sheet material. The failure mode experienced for the titanium joint was fatigue cracking initiating at the fastener hole.

In contrast to the relationship observed in the titanium specimens, the aluminum specimens were not consistent in exhibiting decreasing fatigue strength with increasing load transfer capability. In general, the high and low load transfer specimens exhibited the same fatigue strength at 10^7 cycles while the medium load transfer specimens exhibited a higher value. This pattern was repeated for essentially all the baseline data generated utilizing aluminum alloy joints. The only explanation offered is that fatigue strength is related to failure mode and the failure modes experienced by the aluminum alloy and titanium alloy joint specimens were different.

1.3.7 Influence of Fastener Material on Fatigue

The influence the fastener material has on fatigue properties of the joint is in part evident from the data of Figures 16, 17 and 18. It appears, from the data plotted, that the fatigue strength of the aluminum alloy joint specimens were not affected by the fastener material used. On the other hand, the data generated utilizing titanium alloy joint specimens indicate that the use of stiffer fastener material (H11 steel) results in improved fatigue properties.

1.4 EVALUATION OF THE PROPOSED STANDARD

One of the major objectives of the test program was to establish the suitability of the proposed test standard to evaluate fasteners in the installed condition. In order to achieve this objective it became necessary to conduct fatigue tests varying several fundamental fastener system parameters. Of the 48 variables listed in Appendix V the three most influential parameters are:

(1) Interference Fit

(2) Hole fabrication processes/quality control

(3) Sheet thickness to fastener diameter ratio

1.4.1 Effect of Fastener Fit

Table II provides an index to the data generated investigating this effect of fastener fit on fatigue characteristic. Figures 52 through 67 are the individual plots of the data generated. For comparison purposes, Figures 68 through 75 are multiple data plots in which the joint configuration was kept constant and the condition of the fastener fit varied.

As shown in Figures 68 through 75 the effect of interference fit on fatigue performance was not consistent. In general the specimens with fasteners installed with the greatest amount of interference fit exhibited the longest fatigue test lifetimes.

The high load transfer joints were more sensitive to the effect of interference fit than were the low load transfer joints. This was surprising since data generated in earlier programs, Reference 5 and 6, had shown the low load transfer joint sensitive to fastener fit. The fastener material did not seem to have any significant effect on the influence of the interference fit on fatigue life.

1.4.2 Effect of Fastener Hole Conditioning

Table III provides an index to the data generated investigating fastener hole conditioning. The test data were generated utilizing two different fastener materials and two different hole fabrication methods. The hole fabrication method referred to as a "production" hole simulated current airframe production practices and represented drilling procedures generally used in the mass fabrication of fastener holes. The other hole fabrication method investigated, referred to as a "precision" hole, was introduced to simulate fastener holes usually realized in experimental test programs where time is taken to pilot drill and ream, resulting in holes of close tolerance and high quality.

In the aluminum alloy specimens tested, the effect of the hole fabrication variables appeared to be negligible. However, it should be noted that even the "production" holes were good quality holes. Experience has shown that fastener holes in aluminum which do not meet production quality can result in very poor fatigue properties.

In the titanium alloy specimen tested the effect of the hole fabrication method was difficult to ascertain and no conclusions were drawn. The reason for difficulty in reaching any conclusion was:

- The S/N curves plotted from the data were inconsistent.

- The magnitude of test scatter in this series of tests was greater than in any other series of tests conducted within the program.
- The fracture or initiation of fatigue cracking was identified to two different sources.

  (1) Fatigue due to high local stresses such as root of sharp notches and;

  (2) Fretting fatigue where the fastener experienced relative motion with the sides of the hole in which it was installed creating pits and abrasions.

1.4.3 Effect of Sheet Thickness/Fastener Diameter Ratio

The sheet material thickness, fastener diameter ratio (t/d) referred to as minimum, nominal, and maximum in this test program were arbitrarily chosen. The t/d value of .53 reflects good design practice; t/d = .33 is a marginal value approaching a feather edge condition; and the value of .85 reflects a design situation in which the sheet material can develop the full shear strength of the fastener.

Table IV provides an index to the data and the plotted S/N curves. From Figures 84 through 91, it can be concluded that keeping all the other variables constant the fatigue strength decreases with increase in sheet material thickness. This relationship appears to be valid for both the high and low load transfer joints. The degree of reproducibility experienced in this series of tests, considering the small amount of test scatter, was very encouraging.

1.5 PREPARATION OF THE TEST STANDARD

A draft of the tentative test standard was submitted to the FTDG in May 1973. The proposed specification, if approved, will become a part of MIL-STD-1312, "Fastener Test Methods". All the test procedures and specimen configurations used in this program conformed to the proposed MIL-STD-1312 test format. A great deal of the information gained in this program was applied in the drafting of the MIL-STD-1312 Specification. Pertinent sections of the proposed specification have been made available for insertion into this report. These sections have been reproduced and are presented in Appendix VI.

SECTION 2

STATISTICAL SIGNIFICANCE OF DATA

2.1 COMPUTER PLOTTING AND FIT OF DATA

Each set of data generated in this program was plotted into a standard Stress/Life (S/N) curve format utilizing an existing FORTRAN computer program especially written to provide best fit S/N curves from submitted constant amplitude fatigue data. The computer program utilizes the Least Mean Square (LMS) method of determining the best straight line fit through the data points.

The S-N curve fitting program provides the best fit curve(s) for the data points input by considering one line, all possible two line or all possible three line fits on a log stress (f) - log cycles to failure (N) basis. The best fit curves to the constant amplitude fatigue data are based on the use of equations of the form: $f = AN^B$ or $\log f = \log A + B \log N$ in log-log space. The quantities f and N are the variables, and A and B are constants determined by the program.

The two line fits to the data points are obtained by first obtaining a one line fit to the first three data points and then a one line fit thru the remaining data points. The next two line fit is obtained by taking the first four data points for a one line fit and then a one line fit thru the remaining points. This procedure continues until all possible two line fits have been obtained. The last two line fit contains only three points for the second line. A similar procedure is followed for three line fits, e.g., first line - three points, second line - three points, third line remaining points; first line three points, second line - four points, third line remaining points, etc.

For each curve fit obtained, the program computes the following:

$$S_{yx} = \sqrt{\sum_{i=1}^{E=n} [(+y_i)^2 - (-y_i)^2]}$$

where $+y_i$ = the log stress distance from the fitted curve to data points above the curve

$-y_i$ = the log stress distance from the fitted curve to data points below the line

The program selects the best fit curve which is the curve yielding the lowest value of S_{yx} and is referred to as "sigma" in the printout. If all the data points lie on the line, sigma = 0. The coefficients A and B for each fitted line are printed as part of the output. In addition to the best fit curve, the cycle value of the intersections of the first and second line and the second and third line are printed out if the best fit curve is a 2 line or 3 line curve. Also the following interpolated values of N which are within the range of the data, are printed out, 10^1, 10^2, 10^3, 3×10^3, 10^4, 3×10^4, 10^5, 3×10^5, 10^6, 10^7, 10^8, 10^9, 10^{10}.

2.2 SURVIVABILITY AND PERCENT CONFIDENCE VALUES

The computer generated best fit curve, which represents the constant amplitude fatigue data generated, can be considered as an analytically derived relationship between applied stress and joint fatigue life. The "best fit" curve can be defined as the boundary at which at least 50 percent of any future test specimens can be expected to survive when the specimens are taken from the same population, i.e., same specimen configuration under similar test conditions. The 50 percent survivability curve (best fit curve) is inherently plotted with 50 percent confidence. A second plot of the data usually shown as two straight lines to the left of the "best fit" curve is shown in Figures 16 through 67. This "second" plot is a lower bound which represents test conditions for 90 percent chance of survivability with 95 percent confidence. This lower bound is similar to the "B" basis now used in presenting static mechanical property data in MIL-HDBK-5.

The coordinates to which the lower bound 90 percent survivability with 95 percent confidence lines were drawn to were determined by utilizing techniques given in ASTM, STP91A, "Analysis of Fatigue Data", Section VB, pages 39 through 42 inclusive. The mechanics of constructing a point to which the 90 percent survivability, 95 percent confidence curve (in this report, straight line connections) can be plotted to is as follows:

> Given a sample of n cycle lives for a fixed stress level S, compute the mean, $\bar{x}$, and standard deviation, s, of the transformed cycle lives. From Table 33, ASTM STP91A, read the value of k corresponding to the percent survival, p, the confidence level, and the sample size, n, that are being considered, in this case 90 percent and 95 percent. The value $\bar{x}$ - ks is then the appropriate abscissa for the ordinate, S, on the S-N curve. The value of "k" is called a one-sided statistical tolerence limit.

The above procedures describing the 50 percent survivability with 50 percent confidence boundary curve and 90 percent survivability with 95 percent confidence boundary lines were incorporated as part of the existing software program developed for the computer plotting of S/N curves.

The statistical techniques described in the previous paragraphs were applied to a relatively small number of test data points obtained in this program. The sparse number of test points does limit the usefulness of the statistical and computer methods used. If the number of test points were increased, the effectiveness of the computer program and the statistical manipulation of the data would have been greatly enhanced. The reported test program called for three replicates at any one test condition and this number of replicates is the minimum requirement for the statistical operations performed.

SECTION 3
REFERENCES

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2. MIL-STD-1312, "Military Standard, Fastener Test Methods," 31 May 1967.

3. C. R. Smith, "Design Tips for Preventing Fatigue Failures", Assembly Engineering, May 1968.

4. R. B. Urzi, "Standardization of Fastener Tests", Lockheed-California Company Report LR 22950, December 1969.

5. W. E. Duncan, J. S. Sekhon, L. F. Ecker, "Test Methods for Fastened Assemblies", Assembly Engineering, January 1970.

6. R. B. Urzi, "Standardization of Fastener Tests", Lockheed-California Company, Report LR 24328, December 1970.

7. R. B. Urzi, "Standardization of Fatigue Tests of Installed Fastener Systems-Interim Report on Task I", Lockheed-California Report LR 24773, 16 September 1971.

8. LAC/030494, dtd. 15 August 1972, "Monthly Status Report #1, Exploratory Development of Standards and Mechanical Property Data of Interference Fit Fasteners".

9. AFML-TR-71-184, Air Force Materials Laboratory, September 1971, "Fretting Resistant Coatings for Titanium Alloys".

10. W. Volk, "Industrial Statistics", Chemical Engineering, March 1956.

11. E. L. Crow, F. A. Davis, M. W. Maxfield, Statistics Manual, Dover Publication 486-60599X, New York, New York.

O	TLV100-3-6	TAPER LOK
N	TLV100-3-2	TAPER LOK
MMM	TLV100-3-4	TAPER LOK
MM	TLV100-3-4	TAPER LOK
M	TLV100-3-4	TAPER LOK
L	TLH100-3-6	TAPER LOK
K	TLH100-3-2	TAPER LOK
J	TLHC100-3-4	TAPER LOK
HHH	TLH100-3-4	TAPER LOK
HH	TLH100-3-4	TAPER LOK
H	TLH100-3-4	TAPER LOK
	TLN1001-3	WASHER NUT
FASTENER SYSTEM IDENT. LETTER	FASTENER PART NO.	DESCRIPTION

15 (in triangle) PROTRUSION MEASURED WITH FASTENER HAND PUSHED INTO THE HOLE.

14 (in triangle) ALL STEEL AND TITANIUM FASTENERS INSTALLED IN TITANIUM SHEET MTRL MUST NOT HAVE RECEIVED CADMIUM PLATING. THESE FASTENERS TO HAVE SOLID DRY FILM LUBRICANT PLUS CETYL ALCOHOL ONLY.

13. ALL FSTNR. HEADS FLUSH $^{+.004}_{-.002}$

2. TAPERED HOLES MUST CHECKED DURING HOLE FABRICATION SETUP USING "BLUED" TAPER PINS

11. UNLESS OTHERWISE NOTED FAB. TAPERED HOLES USING COMBINATION TOOL (DRILL-REAMER-CSK)

10. UNLESS OTHERWISE NOTED FAB. STRAIGHT HOLES USING DOUBLE MARGIN DRILL, ETC. (NO REAMING)

9. RECORD ALL PROTRUSION MEASUREMENTS FOR TAPER LOK FSTNRS.

8. RECORD ALL HOLE DIAMETERS FOR HI TIGUE FASTENERS

7. ALL TITANIUM SHEET SPECIMENS TO CONTAIN "MOLYKOTE 106" BONDED LUBRICANT IN FAYING SURFACE

6. ALL ALUMINUM SHEET SPECIMENS TO HAVE ZINC CHROMATE PRIMER PLUS PR 1431 GT SEALANT IN FAYING SURFACES

5. NO SCRATCHES, GOUGES, OR SCRIBE MARKS ALLOWED ANYW: .RE ON SPECIMENS (SPECIMENS MUST BE INDIVIDUALLY WRAPPED)

4. BREAK ALL SHARP CORNERS

3. DEBURR ALL HOLES (INCLUDING FAYING SURFACE) 45° X $^{.003}_{.005}$

2. FABRICATE HOLES ON ASSEMBLY. KEEP SPECIMEN PAIRS TOGETHER USING MASKING TAPE

1 (in triangle) Ti-6Al-4V MATERIAL PER MIL-T-9046F WITH EXCEPTION THAT OXYGEN CONTENT BE KEPT TO 0.13% MAXIMUM (BY WEIGHT)

NOTE:

G	HLT411-6-6	HI TIGUE
F	HLT411-6-2	HI TIGUE
EEE	HLT411-6-4	HI TIGUE
EE	HLT411-6-4	HI TIGUE
E	HLT411-6-4	HI TIGUE
D	HLT315-6-6	HI TIGUE
C	HLT315-6-2	HI TIGUE
B	HLT15-6-4	HI TIGUE
AAA	HLT315-6-4	HI TIGUE
AA	HLT315-6-4	HI TIGUE
A	HLT315-6-4	HI TIGUE
	HL1386-6	COLLAR
FASTENER SYSTEM IDENT. LETTER	FASTENER PART NO.	DESCRIPTION

-4	LAP JOINT AS
-3	LAP JOINT AS
-2	LAP JOINT AS
-1	LAP JOINT AS
FIRST DASH NUMBER	DESCRIPTIO

A

FASTENER SYSTEM IDENT. LETTER	FASTENER PART NO.	DESCRIPTION	NOMINAL INTERFERENCE FIT	FASTENER PROTRUSION △15	FSTNR MTRL	MATERIAL SPECIFICATION	NOMINAL SHEAR STRENGTH	INSTALLATION TORQUE IN-LBS
O	TLV100-3-6	TAPER LOK	-0.0030	.072-.216	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	$45^{+}_{-}5$
N	TLV100-3-2	TAPER LOK	-0.0030	.072-.216	Ti-6Al-4V	AMS 4928	55 KSI SHEAR	$45^{+}_{-}5$
MMM	TLV100-3-4	TAPER LOK	-0.0045	.144-.288	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	$45^{+}_{-}5$
MM	TLV100-3-4	TAPER LOK	-0.0015	.000-.144	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	$45^{+}_{-}5$
M	TLV100-3-4	TAPER LOK	-0.0030	.072-.216	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	$45^{+}_{-}5$
L	TLH100-3-6	TAPER LOK	-0.0030	.072-.216	HII STL	AMS 6487	132 KSI SHEAR	$45^{+}_{-}5$
K	TLH100-3-2	TAPER LOK	-0.0030	.072-.216	HII STL	AMS 6487	132 KSI SHEAR	$45^{+}_{-}5$
J	TLHC100-3-4	TAPER LOK	-0.0030	.072-.216	HII STL	AMS 6487	156 KSI SHEAR	$45^{+}_{-}5$
HHH	TLH100-3-4	TAPER LOK	-0.0045	.144-.288	HII STL	AMS 6487	132 KSI SHEAR	$45^{+}_{-}5$
HH	TLH100-3-4	TAPER LOK	-0.0015	.000-.144	HII STL	AMS 6487	132 KSI SHEAR	$45^{+}_{-}5$
H	TLH100-3-4	TAPER LOK	-0.0030	.072-.216	HII STL	AMS 6487	132 KSI SHEAR	$45^{+}_{-}5$
	TLN1001-3	WASHER NUT			ALLOY STEEL	MIL-S-6049		

125

SYM ℄

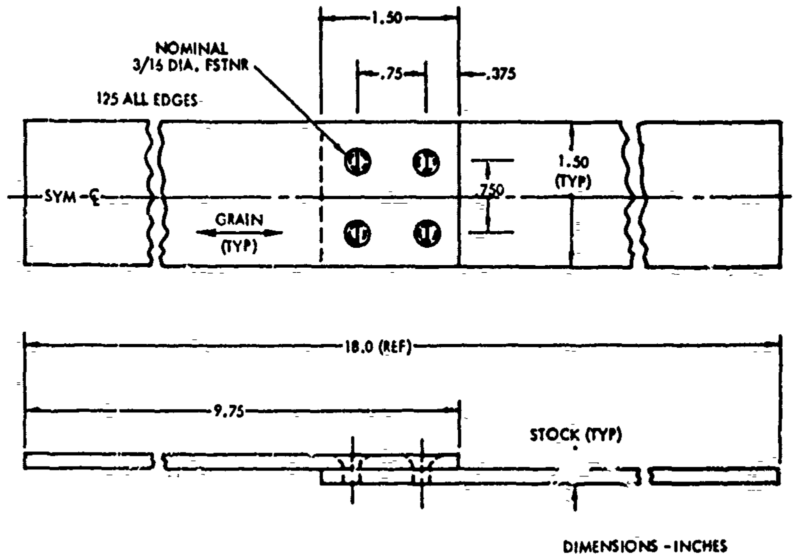
FASTENER SYSTEM IDENT. LETTER	FASTENER PART NO.	DESCRIPTION	NOMINAL INTERFERENCE FIT	HOLE DIAMETER	FSTNR DIA.	FSTNR MTRL.	MATERIAL SPECIFICATION	NOMINAL SHEAR STRENGTH	INSTALLATION TORQUE IN-LBS
G	HLT411-6-6	HITIGUE	-0.0030	$.1860^{+}_{-}.001$	.1895 / .1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	$45^{+}_{-}5$
F	HLT411-6-2	HI TIGUE	-0.0030	$.1860^{+}_{-}.001$	.1895 / .1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	$45^{+}_{-}5$
EEE	HLT411-6-4	HI TIGUE	-0.0045	$.1845^{+}_{-}.001$	.1895 / .1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	$45^{+}_{-}5$
EE	HLT411-6-4	HI TIGUE	-0.0015	$.1875^{+}_{-}.001$	.1895 / .1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	$45^{+}_{-}5$
E	HLT411-6-4	HI TIGUE	-0.0030	$.1860^{+}_{-}.001$	.1895 / .1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	$45^{+}_{-}5$
D	HLT315-6-6	HI TIGUE	-0.0030	$.1860^{+}_{-}.001$	.1895 / .1885	HII STL	AMS 6487	132 KSI SHEAR	$45^{+}_{-}5$
C	HLT315-6-2	HI TIGUE	-0.0030	$.1860^{+}_{-}.001$	.1895 / .1885	HII STL	AMS 6487	132 KSI SHEAR	$45^{+}_{-}5$
B	HLT15-6-4	HI TIGUE	-0.0030	$.1860^{+}_{-}.001$	.1895 / .1885	HII STL	AMS 6487	156 KSI SHEAR	$45^{+}_{-}5$
AAA	HLT315-6-4	HI TIGUE	-0.0045	$.1845^{+}_{-}.001$	.1895 / .1885	HII STL	AMS 6487	132 KSI SHEAR	$45^{+}_{-}5$
AA	HLT315-6-4	HI TIGUE	-0.0015	$.1875^{+}_{-}.001$	.1895 / .1885	HII STL	AMS 6487	132 KSI SHEAR	$45^{+}_{-}5$
A	HLT315-6-4	HI TIGUE	-0.0030	$.1860^{+}_{-}.001$	.1895 / .1885	HII STL	AMS 6487	132 KSI SHEAR	$45^{+}_{-}5$
	HL1386-6	COLLAR				ALLOY STEEL	MIL-S-6049		

FIRST DASH NUMBER	DESCRIPTION	SHEET MATERIAL SPECIFICATION	SHEET MATERIAL	SIZE	HEAT TREAT COND.
-4	LAP JOINT ASSY △1	MIL-T-9046F	Ti-6Al-4V	△14 .100 STOCK	MILL ANNEALED
-3	LAP JOINT ASSY	QQ-A-250/25	7075 CLAD	.160 STOCK	T76
-2	LAP JOINT ASSY	QQ-A-250/25	7075 CLAD	.063 STOCK	T76
-1	LAP JOINT ASSY	QQ-A-250/25	7075 CLAD	.100 STOCK	T76

B

6Al-4V	AMS 4928	95 KSI SHEAR	45±5
6Al-4V	AMS 4928	95 KSI SHEAR	45±5
6Al-4V	AMS 4928	95 KSI SHEAR	45±5
6Al-4V	AMS 4928	95 KSI SHEAR	45±5
6Al-4V	AMS 4928	95 KSI SHEAR	45±5
STL	AMS 6487	132 KSI SHEAR	45±5
STL	AMS 6487	132 KSI SHEAR	45±5
STL	AMS 6487	156 KSI SHEAR	45±5
STL	AMS 6487	132 KSI SHEAR	45±5
STL	AMS 6487	132 KSI SHEAR	45±5
STL	AMS 6487	132 KSI SHEAR	45±5
LOY EEL	MIL-S-6049		
TNR TRL	MATERIAL SPECIFICATION	NOMINAL SHEAR STRENGTH	INSTALLATION TORQUE IN-LBS

Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
HII STL	AMS 6487	156 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
ALLOY STEEL	MIL-S-6049		
FSTNR MTRL.	MATERIAL SPECIFICATION	NOMINAL SHEAR STRENGTH	INSTALLATION TORQUE IN-LBS



14	.100 STOCK	MILL ANNEALED
	.160 STOCK	T76
	.063 STOCK	T76
	.100 STOCK	T76
	SIZE	HEAT TREAT COND.

SPECIMEN IDENTIFICATION CODING

X16130-XXX-X

- SECOND DASH NO. - INDIVIDUAL SPECIMEN NUMBER IN GROUP OF TWELVE SPECIMENS
- ABSENCE OF LETTER "P" MEANS "STANDARD" PRODUCTION HOLES. SEE NOTES 10 & 11
- "P" SIGNIFYS PRECISION FABRICATED HOLE
- FASTENER SYSTEM INDENTIFICATION LETTER SINGLE LETTER SIGNIFIES NOMINAL INTERFERENCE FIT TWICE REPEATED LETTER SIGNIFIES LOW INTERFERENCE FIT TRIPLICITY OF LETTER SIGNIFIES HIGH INTERFERENCE FIT
- FIRST DASH NO. INDICATES JOINT SHEET MATERIAL
- BASIC IDENTIFICATION NUMBER

Figure 1. Specimen Geometry Simple Lap Joint Specimen High Load Transfer Joint

O	TLV100-3-6	TAPER LO
N	TLV100-3-2	TAPER LO
MMM	TLV100-3-4	TAPER LO
MM	TLV100-3-4	TAPER LO
M	TLV100-3-4	TAPER LO
L	TLH100-3-6	TAPER LO
K	TLH100-3-2	TAPER LO
J	TLHC100-3-4	TAPER LO
HHH	TLH100-3-4	TAPER LO
HH	TLH100-3-4	TAPER LO
H	TLH100-3-4	TAPER LO
	TLN1001-3	WASHER N
FASTENER SYSTEM IDENT. LETTER	FASTENER PART NO.	DESCRIPTI

15. PROTRUSION MEASURED WITH FASTENER HAND PUSHED INTO THE HOLE.

14. ALL STEEL AND TITANIUM FASTENERS INSTALLED IN TITANIUM SHEET MTRL MUST NOT HAVE RECEIVED CADMIUM PLATING. THESE FASTENERS TO HAVE SOLID DRY FILM LUBRICANT PLUS CETYL ALCOHOL ONLY.

13. ALL FSTNR. HEADS FLUSH $^{+.004}_{-.002}$

12. TAPERED HOLES MUST CHECKED DURING HOLE FABRICATION SETUP USING "BLUED" TAPER PINS

11. UNLESS OTHERWISE NOTED FAB. TAPERED HOLES USING COMBINATION TOOL (DRILL-REAMER-CSK)

10. UNLESS OTHERWISE NOTED FAB. STRAIGHT HOLES USING DOUBLE MARGIN DRILL, ETC. (NO REAMING)

9. RECORD ALL PROTRUSION MEASUREMENTS FOR TAPER LOK FSTNRS.

8. RECORD ALL HOLE DIAMETERS FOR HI TIGUE FASTENERS

7. ALL TITANIUM SHEET SPECIMENS TO CONTAIN "MOLYKOTE 106" BONDED LUBRICANT IN FAYING SURFACE

6. ALL ALUMINUM SHEET SPECIMENS TO HAVE ZINC CHROMATE PRIMER PLUS PR 1431 GT SEALANT IN FAYING SURFACES

5. NO SCRATCHES, GOUGES, OR SCRIBE MARKS ALLOWED ANYWHERE ON SPECIMENS (SPECIMENS MUST BE INDIVIDUALLY WRAPPED)

4. BREAK ALL SHARP CORNERS

3. DEBURR ALL HOLES (INCLUDING FAYING SURFACE) 45° X $^{.003}_{.005}$

2. FABRICATE HOLES ON ASSEMBLY. KEEP SPECIMEN PAIRS TOGETHER USING MASKING TAPE

1. TI-6AI-4V MATERIAL PER MIL-T-9046F WITH EXCEPTION THAT OXYGEN CONTENT BE KEPT TO 0.13% MAXIMUM (BY WEIGHT)

NOTE:

G	HLT411-6-6	HITIGUE
F	HLT411-6-2	HI TIGUE
EEE	HLT411-6-4	HI TIGUE
EE	HLT411-6-4	HI TIGUE
E	HLT411-6-4	HI TIGUE
D	HLT315-6-6	HI TIGUE
C	HLT315-6-2	HI TIGUE
B	HLT15-6-4	HI TIGUE
AAA	HLT315-6-4	HI TIGUE
AA	HLT315-6-4	HI TIGUE
A	HLT315-6-4	HI TIGUE
	HL1386-6	COLLAR
FASTENER SYSTEM IDENT. LETTER	FASTENER PART NO.	DESCRIPTI

-4	1 1/2 D
-1	1 1/2 D
FIRST DASH NUMBER	DESCRI

O	TLV100-3-6	TAPER LOK	-0.0030	.072-.216	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
N	TLV100-3-2	TAPER LOK	-0.0030	.072-.216	Ti-6Al-4V	AMS 4928	55 KSI SHEAR	45±5
MMM	TLV100-3-4	TAPER LOK	-0.0045	.144-.288	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
MM	TLV100-3-4	TAPER LOK	-0.0015	.000-.144	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
M	TLV100-3-4	TAPER LOK	-0.0030	.072-.216	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
L	TLH100-3-6	TAPER LOK	-0.0030	.072-.216	HII STL	AMS 6487	132 KSI SHEAR	45±5
K	TLH100-3-2	TAPER LOK	-0.[illegible]	.072-.216	HII STL	AMS 6487	132 KSI SHEAR	45±5
J	TLHC100-3-4	TAPER LOK	0.0030	.072-.216	HII STL	AMS 6487	156 KSI SHEAR	45±5
HHH	TL[illegible]100-3-4	TAPER LOK	-0.0045	.144-.288	HII STL	AMS 6487	132 KSI SHEAR	45±5
HH	TLH100-3-4	TAPER LOK	-0.0015	.000-.144	HII STL	AMS 6487	132 KSI SHEAR	45±5
H	TLH100-3-4	TAPER LOK	-0.0030	.072-.216	HII STL	AMS 6407	132 KSI SHEAR	45±5
	TLN1001-3	WASHER NUT			ALLOY STEEL	MIL-S-6049		
FASTENER SYSTEM IDENT. LETTER	FASTENER PART NO.	DESCRIPTION	NOMINAL INTERFERENCE FIT	FASTENER PROTRUSION (15)	FSTNR MTRL	MATERIAL SPECIFICATION	NOMINAL SHEAR STRENGTH	INSTALLATION TORQUE IN-LBS

1.50

G	HLT411-6-6	HITIGUE	-0.0030	.1860±.001	.1895 .1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
F	HLT411-6-2	HI TIGUE	-0.0030	.1860±.001	.1895 .1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
EEE	HLT411-6-4	HI TIGUE	-0.0045	.1845±.001	.1895 .1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
EE	HLT411-6-4	HI TIGUE	-0.0015	.1875±.001	.1895 .1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
E	HLT411-6-4	HI TIGUE	-0.0030	.1860±.001	.1895 .1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
D	HLT315-6-6	HI TIGUE	-0.0030	.1860±.001	.1895 .1885	HII STL	AMS 6487	132 KSI SHEAR	45±5
C	HLT315-6-2	HI TIGUE	-0.0030	.1860±.001	.1895 .1885	HII STL	AMS 6487	132 KSI SHEAR	45±5
B	HLT15-6-4	HI TIGUE	-0.0030	.1860±.001	.1895 .1885	HII STL	AMS 6487	156 KSI SHEAR	45±5
AAA	HLT315-6-4	HI TIGUE	-0.0045	.1845±.001	.1895 .1885	HII STL	AMS 6487	132 KSI SHEAR	45±5
AA	HLT315-6-4	HI TIGUE	-0.0015	.1875±.001	.1895 .1885	HII STL	AMS 6487	132 KSI SHEAR	45±5
A	HLT315-6-4	HI TIGUE	-0.0030	.1860±.001	.1895 .1885	HII STL	AMS 6487	132 KSI SHEAR	45±5
	HL1386-6	COLLAR				ALLOY STEEL	MIL-S-6049		
FASTENER SYSTEM IDENT. LETTER	FASTENER PART NO.	DESCRIPTION	NOMINAL INTERFERENCE FIT	HOL DIAMETER	FSTNR DIA.	FSTNR MTRL.	MATERIAL SPECIFICATION	NOMINAL SHEAR STRENGTH	INSTALLATION TORQUE IN-LBS

1.50

X16137

-4	1 1/2 DOG BONE ASSY (1)	MIL-T-9046	Ti-6Al-4V (14)	.100 STOCK	MILL ANNEALED
-1	1 1/2 DOG BONE ASSY	QQ-A-250/25	7075 CLAD	.100 STOCK	T-76
FIRST DASH NUMBER	DESCRIPTION	SHEET MATERIAL SPECIFICATION	SHEET MATERIAL	SIZE	HEAT TREAT COND.

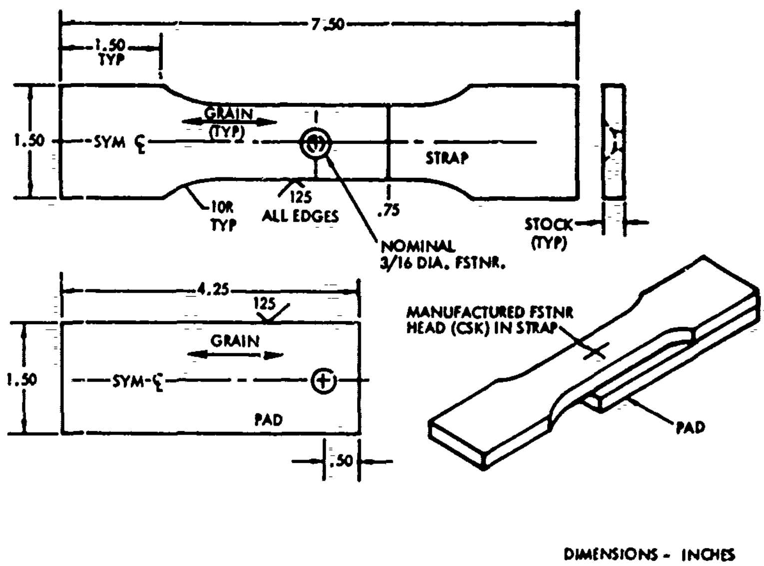
B

Prec

FSTNR MTRL	MATERIAL SPECIFICATION	NOMINAL SHEAR STRENGTH	INSTALLATION TORQUE IN-LBS
Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
Ti-6Al-4V	AMS 4928	55 KSI SHEAR	45±5
Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
HII STL	AMS 6487	156 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
ALLOY STEEL	MIL-S-6049		

FSTNR DIA.	FSTNR MTRL.	MATERIAL SPECIFICATION	NOMINAL SHEAR STRENGTH	INSTALLATION TORQUE IN-LBS
1895 1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
1895 1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
1895 1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
1895 1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
1895 1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
1895 1885	HII STL	AMS 6487	132 KSI SHEAR	45±5
1895 1885	HII STL	AMS 6487	132 KSI SHEAR	45±5
1895 1885	HII STL	AMS 6487	156 KSI SHEAR	45±5
1895 1885	HII STL	AMS 6487	132 KSI SHEAR	45±5
1895 1885	HII STL	AMS 6487	132 KSI SHEAR	45±5
1895 1885	HII STL	AMS 6487	132 KSI SHEAR	45±5
	ALLOY STEEL	MIL-S-6049		

	SIZE	HEAT TREAT COND.
14	.100 STOCK	MILL ANNEALED
	.100 STOCK	T-76



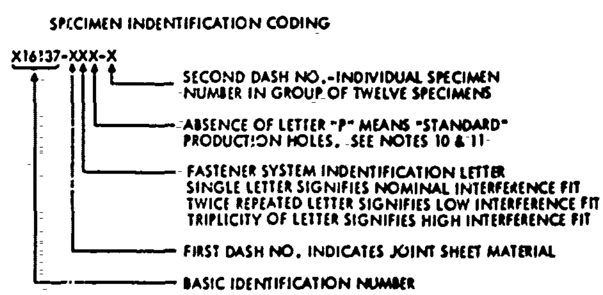


Figure 2. Specimen Geometry One and One Half Dogbone Specimen Medium Load Transfer Joint

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O	TLV100-3-6	TAPER LOK
N	TLV100-3-2	TAPER LOK
MMM	TLV100-3-4	TAPER LOK
MM	TLV100-3-4	TAPER LOK
M	TLV100-3-4	TAPER LOK
L	TLH100-3-6	TAPER LOK
K	TLH100-3-2	TAPER LOK
J	TLHC100-3-4	TAPER LOK
HHH	TLH100-3-4	TAPER LOK
HH	TLH100-3-4	TAPER LOK
H	TLH100-3-4	TAPER LOK
	TLN1001-3	WASHER NUT
FASTENER SYSTEM IDENT. LETTER	FASTENER PART NO.	DESCRIPTION

G	HLT411-6-6	HITIGUE
F	HLT411-6-2	HI TIGUE
EEE	HLT411-6-4	HI TIGUE
EE	HLT411-6-4	HI TIGUE
E	HLT411-6-4	HI TIGUE
D	HLT315-6-6	HI TIGUE
C	HLT315-6-2	HI TIGUE
B	HLT15-6-4	HI TIGUE
AAA	HLT315-6-4	HI TIGUE
AA	HLT315-6-4	HI TIGUE
A	HLT315-6-4	HI TIGUE
	HL1386-6	COLLAR
FASTENER SYSTEM IDENT. LETTER	FASTENER PART NO.	DESCRIPTION

15. PROTRUSION MEASURED WITH FASTENER HAND PUSHED INTO THE HOLE.

14. ALL STEEL AND TITANIUM FASTENERS INSTALLED IN TITANIUM SHEET MTRL MUST NOT HAVE RECEIVED CADMIUM PLATING. THESE FASTENERS TO HAVE SOLID DRY FILM LUBRICANT PLUS CETYL ALCOHOL ONLY.

13. ALL FSTNR. HEADS FLUSH $^{+.004}_{-.002}$

12. TAPERED HOLES MUST CHECKED DURING HOLE FABRICATION SETUP USING "BLUED" TAPER PINS

11. UNLESS OTHERWISE NOTED FAB. TAPERED HOLES USING COMBINATION TOOL (DRILL-REAMER-CSK)

10. UNLESS OTHERWISE NOTED FAB. STRAIGHT HOLES USING DOUBLE MARGIN DRILL, ETC. (NO REAMING)

9. RECORD ALL PROTRUSION MEASUREMENTS FOR TAPER LOK FSTNRS.

8. RECORD ALL HOLE DIAMETERS FOR HI TIGUE FASTENERS

7. ALL TITANIUM SHEET SPECIMENS TO CONTAIN "MOLYKOTE 106" BONDED LUBRICANT IN FAYING SURFACE

6. ALL ALUMINUM SHEET SPECIMENS TO HAVE ZINC CHROMATE PRIMER PLUS PR 1431 GT SEALANT IN FAYING SURFACES

5. NO SCRATCHES, GOUGES, OR SCRIBE MARKS ALLOWED ANYWHERE ON SPECIMENS (SPECIMENS MUST BE INDIVIDUALLY WRAPPED)

4. BREAK ALL SHARP CORNERS

3. DEBURR ALL HOLES (INCLUDING FAYING SURFACE) 45° X $^{.003}_{.005}$

2. FABRICATE HOLES ON ASSEMBLY. KEEP SPECIMEN PAIRS TOGETHER USING MASKING TAPE

1. TI-6AI-4V MATERIAL PER MIL-T-9046F WITH EXCEPTION THAT OXYGEN CONTENT BE KEPT TO 0.13% MAXIMUM (BY WEIGHT)

NOTE:

A

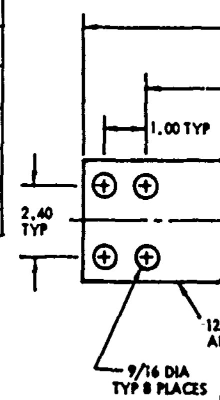
-4	REV. DOGBO
-3	REV. DOGBO
-2	REV. DOGBO
-1	REV. DOGBO
FIRST DASH NUMBER	DESCRIPTION

FASTENER SYSTEM IDENT. LETTER	FASTENER PART NO.	DESCRIPTION	NOMINAL INTERFERENCE FIT	FASTENER PROTRUSION 15	FSTNR MTRL	MATERIAL SPECIFICATION	NOMINAL SHEAR STRENGTH	INSTALLATION TORQUE IN-LBS
O	TLV100-3-6	TAPER LOK	-0.0030	.072-.216	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
N	TLV100-3-2	TAPER LOK	-0.0030	.072-.216	Ti-6Al-4V	AMS 4928	55 KSI SHEAR	45±5
MMM	TLV100-3-4	TAPER LOK	-0.0045	.144-.288	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
MM	TLV100-3-4	TAPER LOK	-0.0015	.000-.144	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
M	TLV100-3-4	TAPER LOK	-0.0030	.072-.216	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
L	TLH100-3-6	TAPER LOK	-0.0030	.072-.216	HII STL	AMS 6487	132 KSI SHEAR	45±5
K	TLH100-3-2	TAPER LOK	-0.0030	.072-.216	HII STL	AMS 6487	132 KSI SHEAR	45±5
J	TLHC100-3-4	TAPER LOK	-0.0030	.072-.216	HII STL	AMS 6487	156 KSI SHEAR	45±5
HHH	TLH100-3-4	TAPER LOK	-0.0045	.144-.288	HII STL	AMS 6487	132 KSI SHEAR	45±5
HH	TLH100-3-4	TAPER LOK	-0.0015	.000-.144	HII STL	AMS 6487	132 KSI SHEAR	45±5
H	TLH100-3-4	TAPER LOK	-0.0030	.072-.216	HII STL	AMS 6487	132 KSI SHEAR	45±5
	TLN1001-3	WASHER NUT			ALLOY STEEL	MIL-S-6049		

FASTENER SYSTEM IDENT. LETTER	FASTENER PART NO.	DESCRIPTION	NOMINAL INTERFERENCE FIT	HOLE DIAMETER	FSTNR DIA.	FSTNR MTRL.	MATERIAL SPECIFICATION	NOMINAL SHEAR STRENGTH	INSTALLATION TORQUE IN-LBS
G	HLT411-6-6	HI TIGUE	-0.0030	.1860±.001	.1895 .1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
F	HLT411-6-2	HI TIGUE	-0.0030	.1860±.001	.1895 .1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
EEE	HLT411-6-4	HI TIGUE	-0.0045	.1845±.001	.1895 .1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
EE	HLT411-6-4	HI TIGUE	-0.0015	.1875±.001	.1895 .1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
E	HLT411-6-4	HI TIGUE	-0.0030	.1860±.001	.1895 .1890	Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
D	HLT315-6-6	HI TIGUE	-0.0030	.1860±.001	.1895 .1885	HII STL	AMS 6487	132 KSI SHEAR	45±5
C	HLT315-6-2	HI TIGUE	-0.0030	.1850±.001	.1895 .1885	HII STL	AMS 6487	132 KSI SHEAR	45±5
B	HLT15-6-4	HI TIGUE	-0.0030	.1860±.001	.1895 .1885	HII STL	AMS 6487	156 KSI SHEAR	45±5
AAA	HLT315-6-4	HI TIGUE	-0.0045	.1845±.001	.1895 .1885	HII STL	AMS 6487	132 KSI SHEAR	45±5
AA	HLT315-6-4	HI TIGUE	-0.0015	.1875±.001	.1895 .1885	HII STL	AMS 6487	132 KSI SHEAR	45±5
A	HLT315-6-4	HI TIGUE	-0.0030	.1860±.001	.1895 .1885	HII STL	AMS 6487	132 KSI SHEAR	45±5
	HL1386-6	COLLAR				ALLOY STEEL	MIL-S-6049		

FIRST DASH NUMBER	DESCRIPTION	SHEET MATERIAL SPECIFICATION	SHEET MATERIAL	SIZE	HEAT TREAT COND.
-4	REV. DOGBONE ASSY ⚠1	MIL-T-9046	Ti-6AL-4V ⚠14	.100 STOCK	MILL ANNEALED
-3	REV. DOGBONE ASSY	QQ-A-250/25	7075 CLAD	.160 STOCK	T76
-2	REV. DOGBONE ASSY	QQ-A-250/25	7075 CLAD	.063 STOCK	T76
-1	REV. DOGBONE ASSY	QQ-A-250/25	7075 CLAD	.100 STOCK	T76

B



Xle1

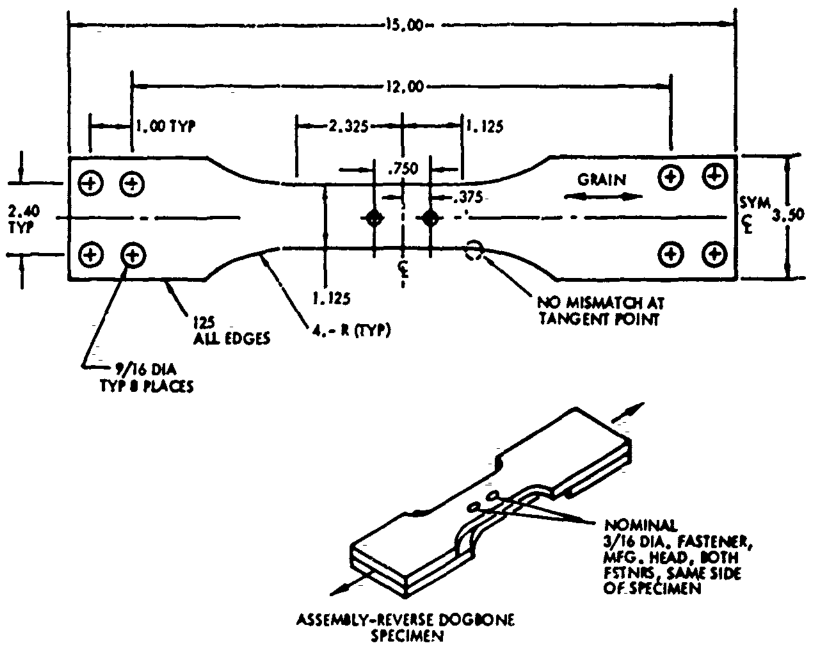
Fi

Prece

Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
Ti-6Al-4V	AMS 4928	55 KSI SHEAR	45±5
Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
HII STL	AMS 6487	156 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
ALLOY STEEL	MIL-S-6049		
FSTNR MTRL	MATERIAL SPECIFICATION	NOMINAL SHEAR STRENGTH	INSTALLATION TORQUE IN-LBS

Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
Ti-6Al-4V	AMS 4928	95 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
HII STL	AMS 6487	156 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
HII STL	AMS 6487	132 KSI SHEAR	45±5
ALLOY STEEL	MIL-S-6049		
FSTNR MTRL.	MATERIAL SPECIFICATION	NOMINAL SHEAR STRENGTH	INSTALLATION TORQUE IN-LBS

△4 .100 STOCK	MILL ANNEALED
.160 STOCK	T76
.063 STOCK	T76
.100 STOCK	T76
SIZE	HEAT TREAT COND.



DIMENSIONS - INCHES

SPECIMEN IDENTIFICATION CODING

X1e138-XXX-X

- SECOND DASH NO.-INDIVIDUAL SPECIMEN NUMBER IN GROUP OF TWELVE SPECIMENS
- ABSENCE OF LETTER "P" MEANS "STANDARD" PRODUCTION HOLES. SEE NOTES 10 & 11
- "P" SIGNIFIES PRECISSION FABRICATED HOLE
- FASTENER, SYSTEM INDENTIFICATION LETTER SINGLE LETTER SIGNIFIES NOMINAL INTERFERENCE FIT. TWICE REPEATED LETTER SIGNIFIES LOW INTERFERENCE FIT TRIPLICITY OF LETTER SIGNIFIES HIGH INTERFERENCE FIT
- FIRST DASH NO. INDICATES JOINT SHEET MATERIAL
- BASIC IDENTIFICATION NUMBER

C

Figure 3. Specimen Geometry Reverse Dogbone Specimen Low Load Transfer Joint

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Figure 4. Typical Low Load Transfer Joint Specimen Installation In Constant Load (Servo-Hydraulic) Fatigue Test Machine

Figure 5. Low Load Transfer Specimen Installed In Constant Amplitude (Resonant) Fatigue Test Machine

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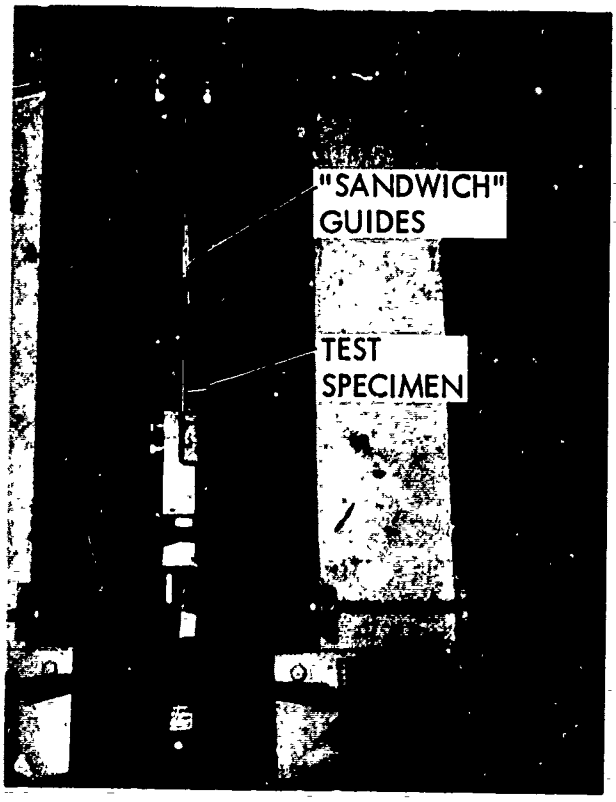


Figure 6. Illustration of "Sandwich" Support Fixture Installed On Simple Lap Joint Specimen

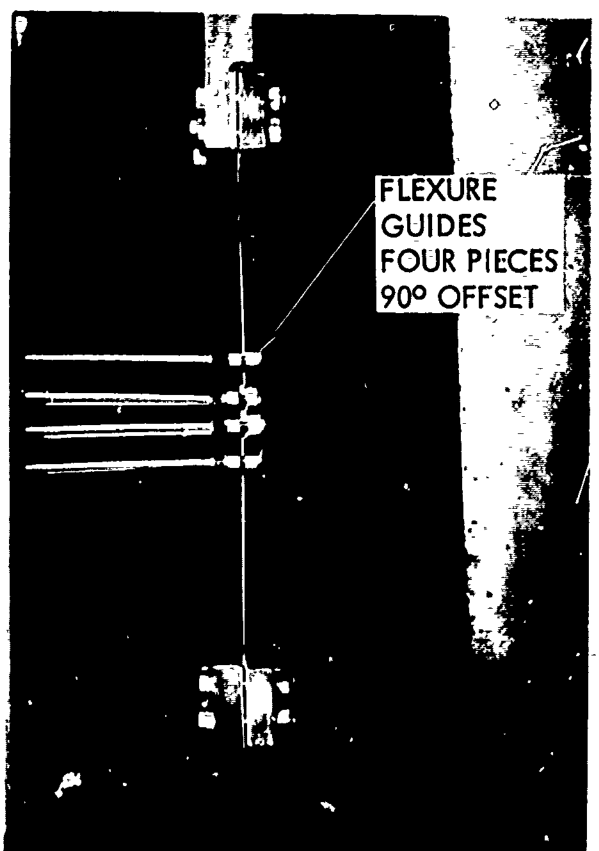
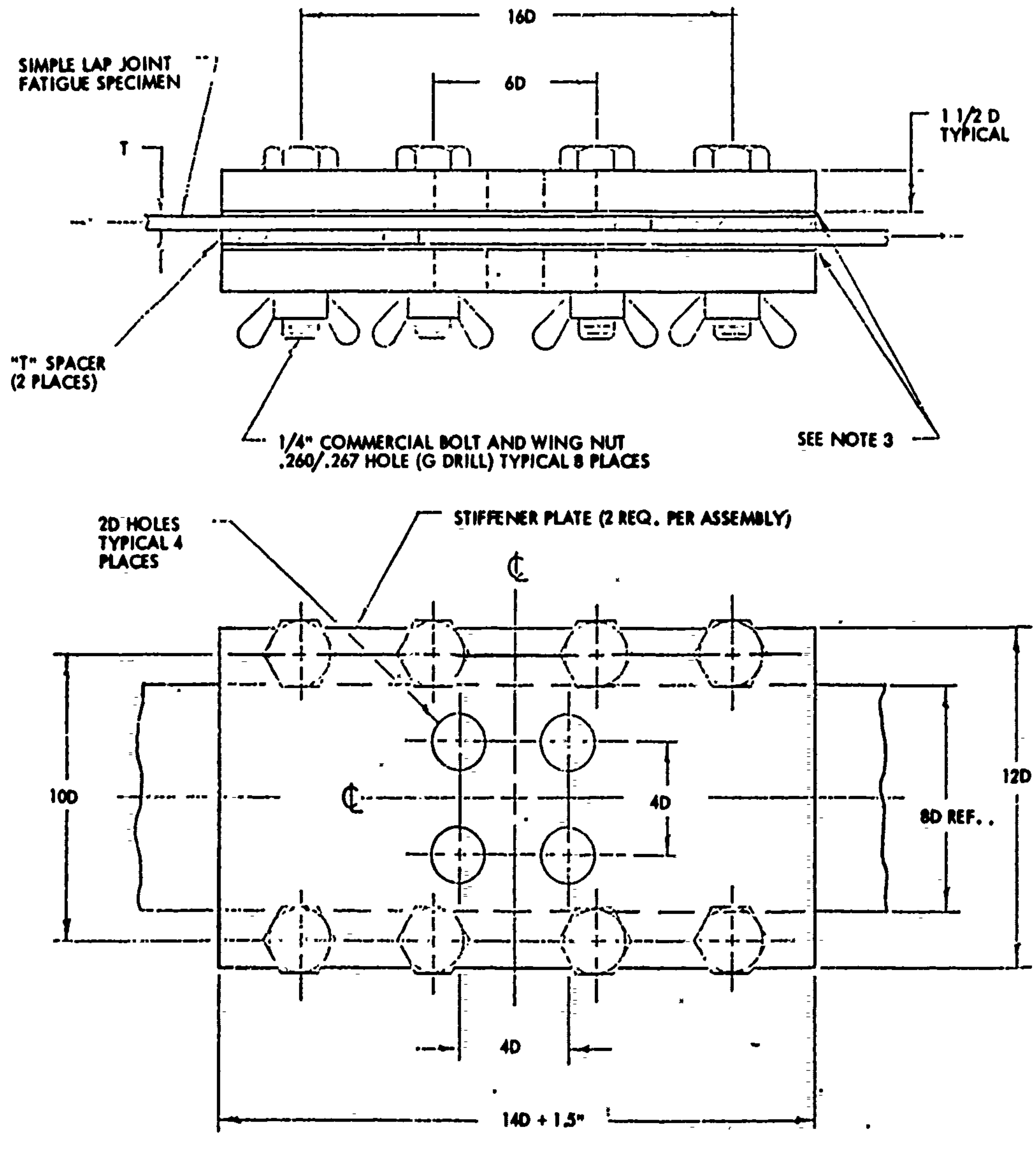


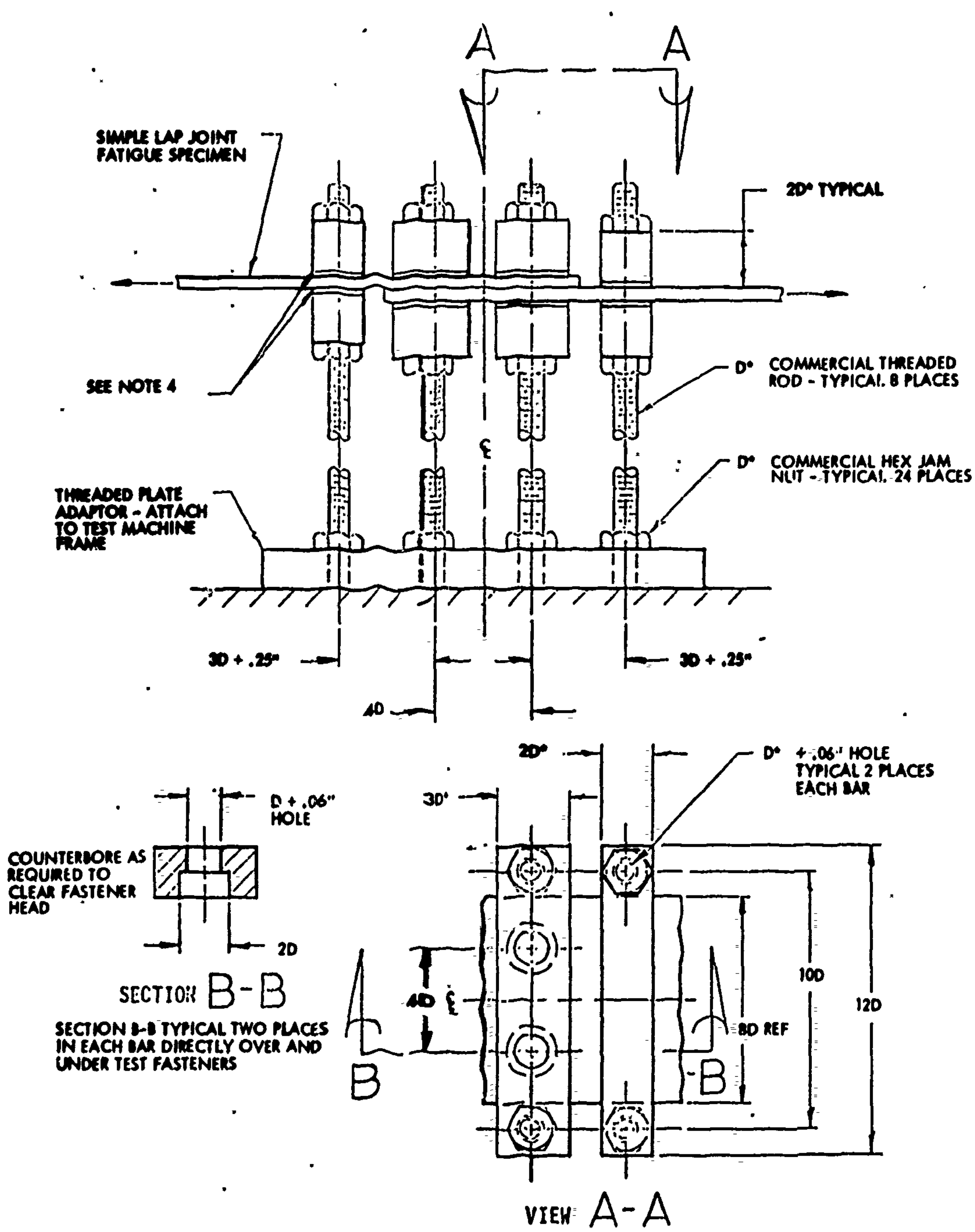
Figure 7. Illustration of Flexure Support Fixture Installed On Simple Lap Joint Specimen



4. TIGHTEN WING NUTS ONLY FINGER TIGHT.
3. TEFLON, NYLON, MICARTA, ETC. MATERIAL MUST BE INTERFACED BETWEEN STIFFENER PLATES AND TEST SPECIMEN SURFACES.
2. STIFFENER PLATE AND BOLT MATERIAL - MILD STEEL.
1. D = NOMINAL FASTENER DIAMETER UNDER TEST.

NOTE:

Figure 8. Details of "Sandwich" Type Specimen Restraint Fixture



4. TEFLON, NYLON, MICARTA, ETC. MUST BE INTERFACED BETWEEN BARS AND TEST SPECIMEN SURFACES.
3. ROD AND BAR MATERIAL - MILD STEEL.
2. *D MINIMUM FOR THESE DIMENSIONS = 3/16".
1. D = NOMINAL FASTENER DIAMETER UNDER TEST.

Figure 9. Details of Flexure Pivot (90° Offset) Test Specimen Restraint Fixture

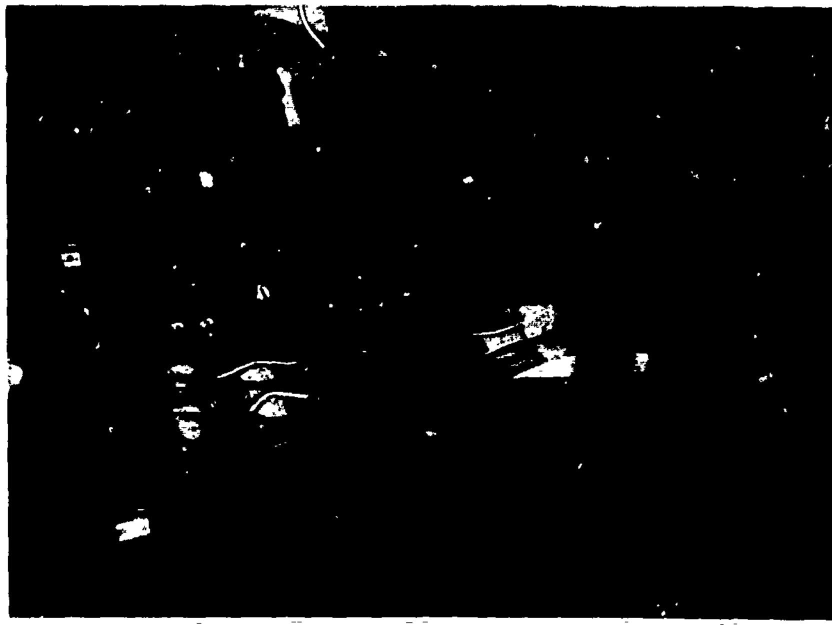


Figure 10. Instrumented Reverse Dogbone Specimen Used Only For Load Transfer and Test Frequency Response Tests

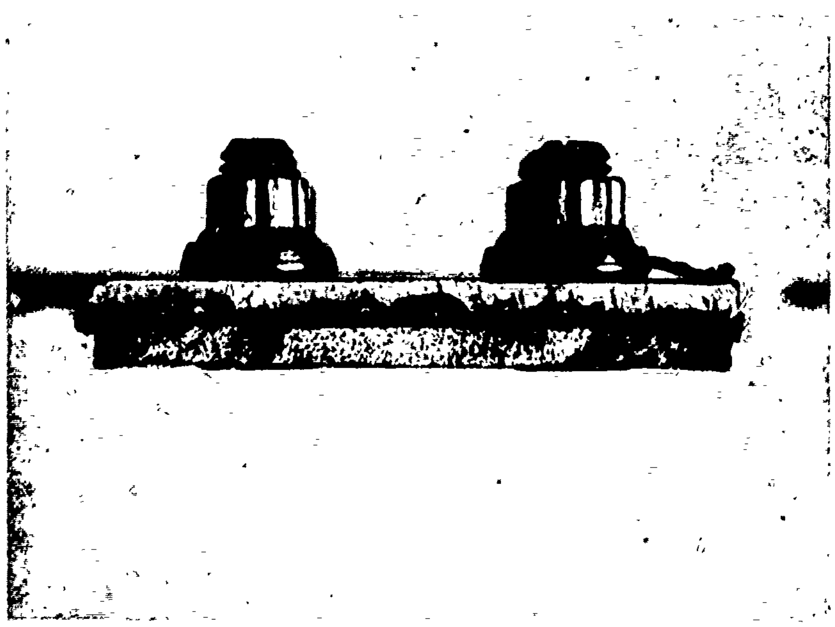


Figure 11. Example of Sheet Metal Failures Occurring Away From The Fastener Holes In The CSK Sheet

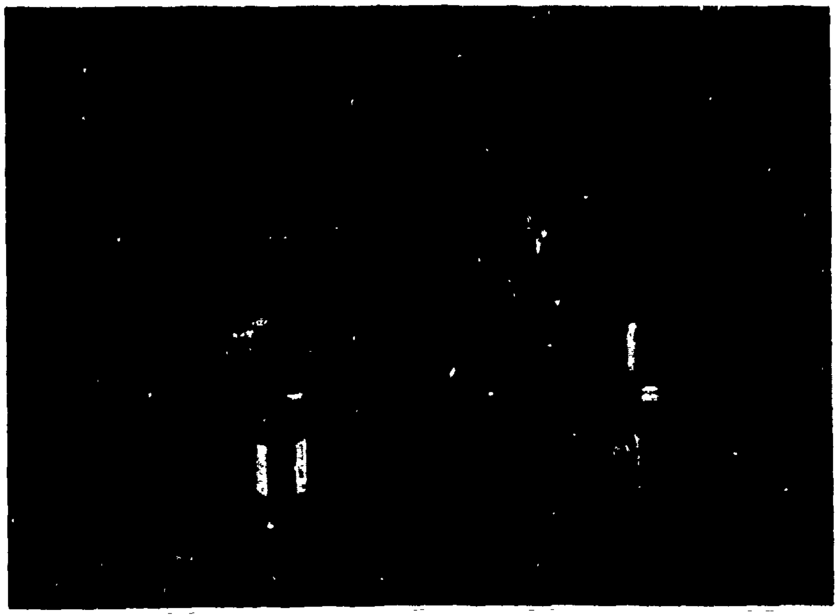


Figure 12. Example of Sheet Metal Failure Occurring Away From The Fastener Holes In The Non-Countersunk Sheet

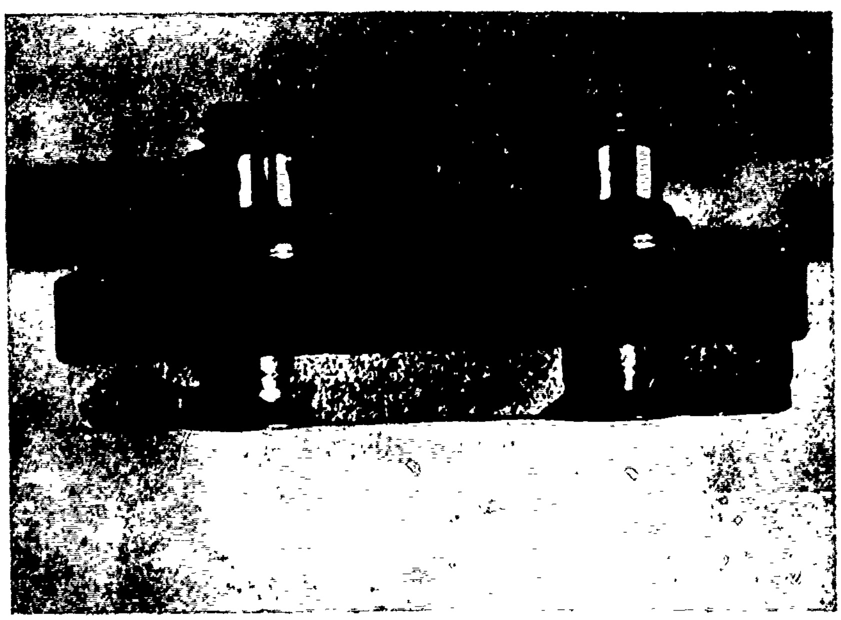


Figure 13. Example of Sheet Metal Failures Occurring Through The Fastener Holes In The CSK Sheet

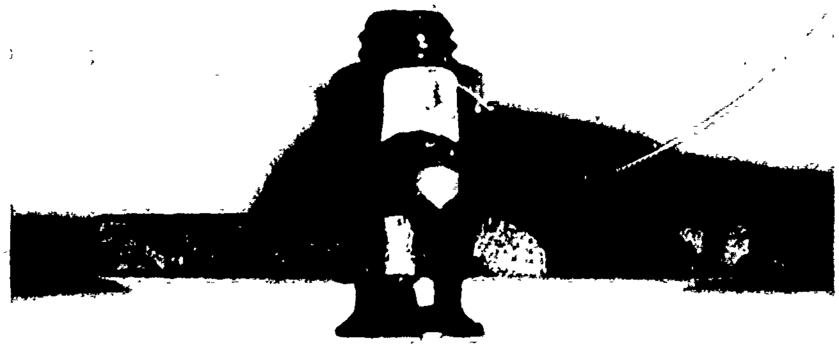


Figure 14. Example of Sheet Metal Failure Occurring Through The Fastener Hole In The Non-Countersunk Sheet

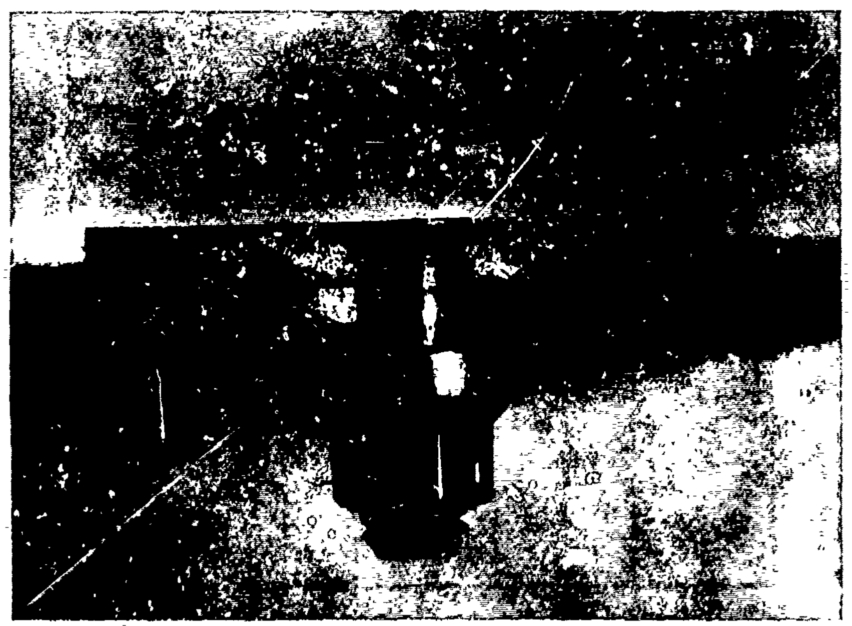


Figure 15. Typical Failure Occurring In Both Sheets Of The Joint Specimen Through The Fastener Hole

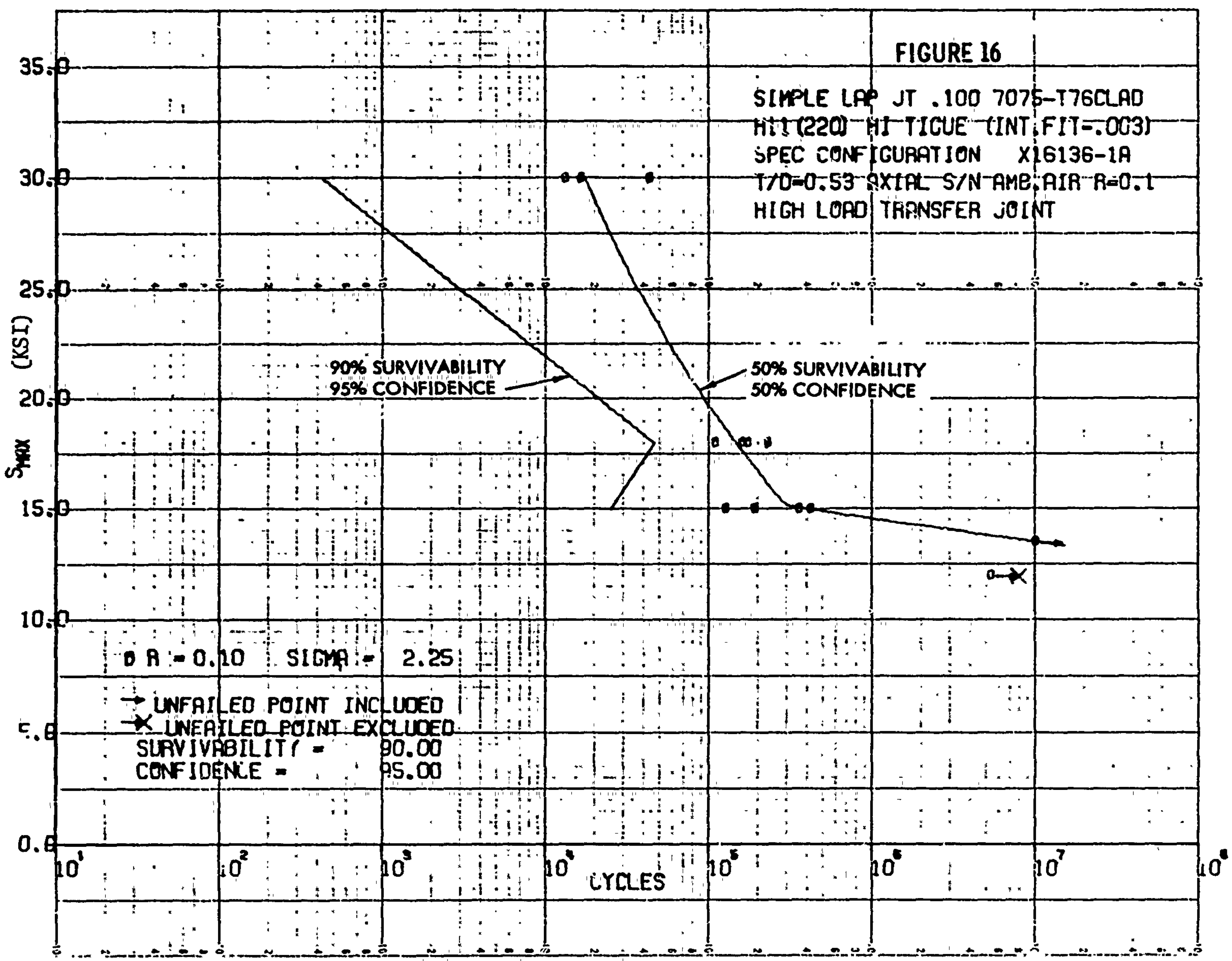


FIGURE 16
SIMPLE LAP JT .100 7075-T76CLAD
HI1(220) HI TIGUE (INT.FIT=.003)
SPEC CONFIGURATION X16136-1A
T/D=0.53 AXIAL S/N AMB.AIR R=0.1
HIGH LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
R = 0.10 SIGMA = 2.25
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S MAX (KSI)
CYCLES
35.0
30.0
25.0
20.0
15.0
10.0
0.0

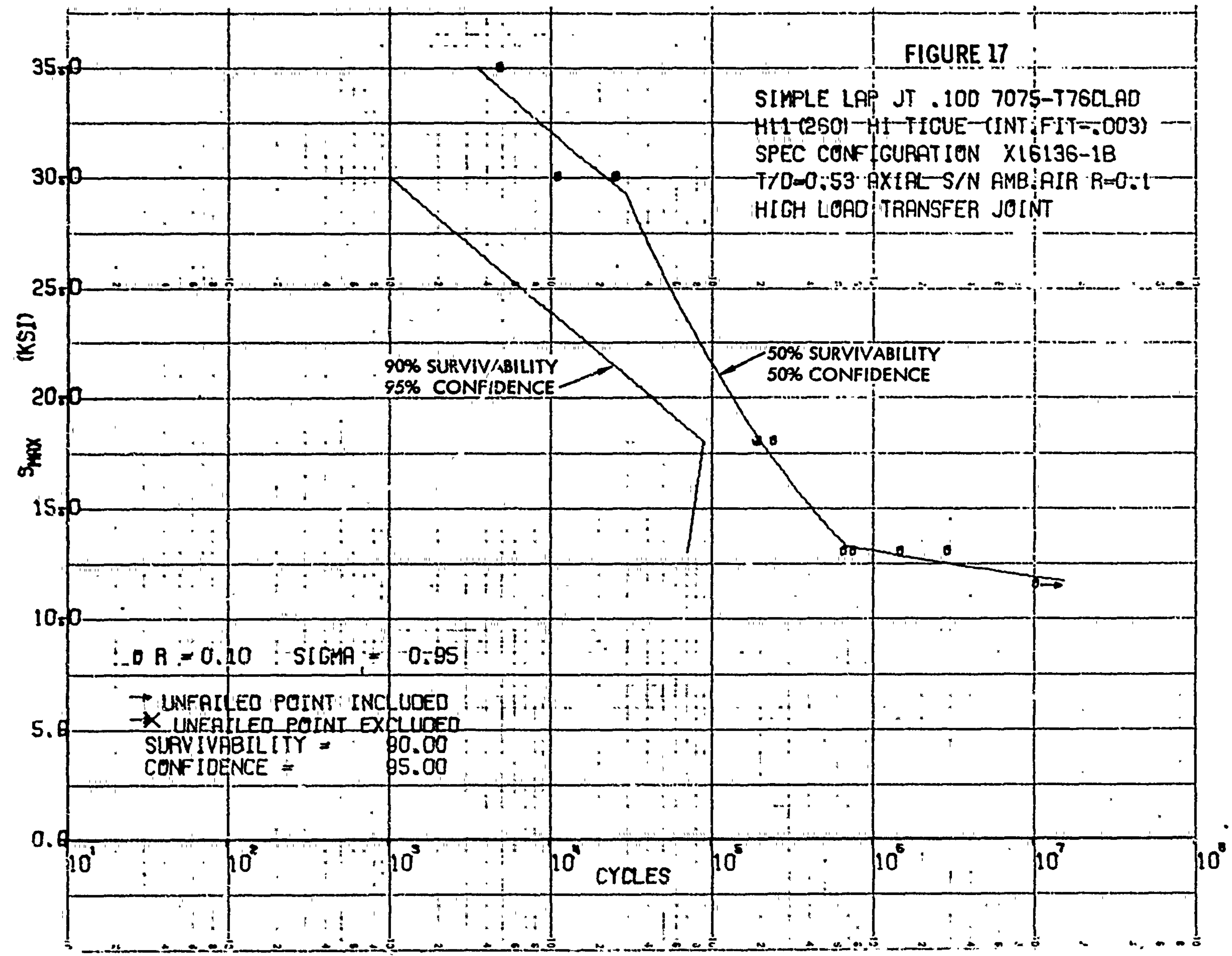


FIGURE 17
SIMPLE LAP JT .100 7075-T76CLAD
H11 (260) HI TICUE (INT FIT-.003)
SPEC CONFIGURATION X16136-1B
T/D=0.53 AXIAL S/N AMB AIR R=0.1
HIGH LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
R = 0.10 SIGMA = 0.95
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S MAX (KSI)
CYCLES

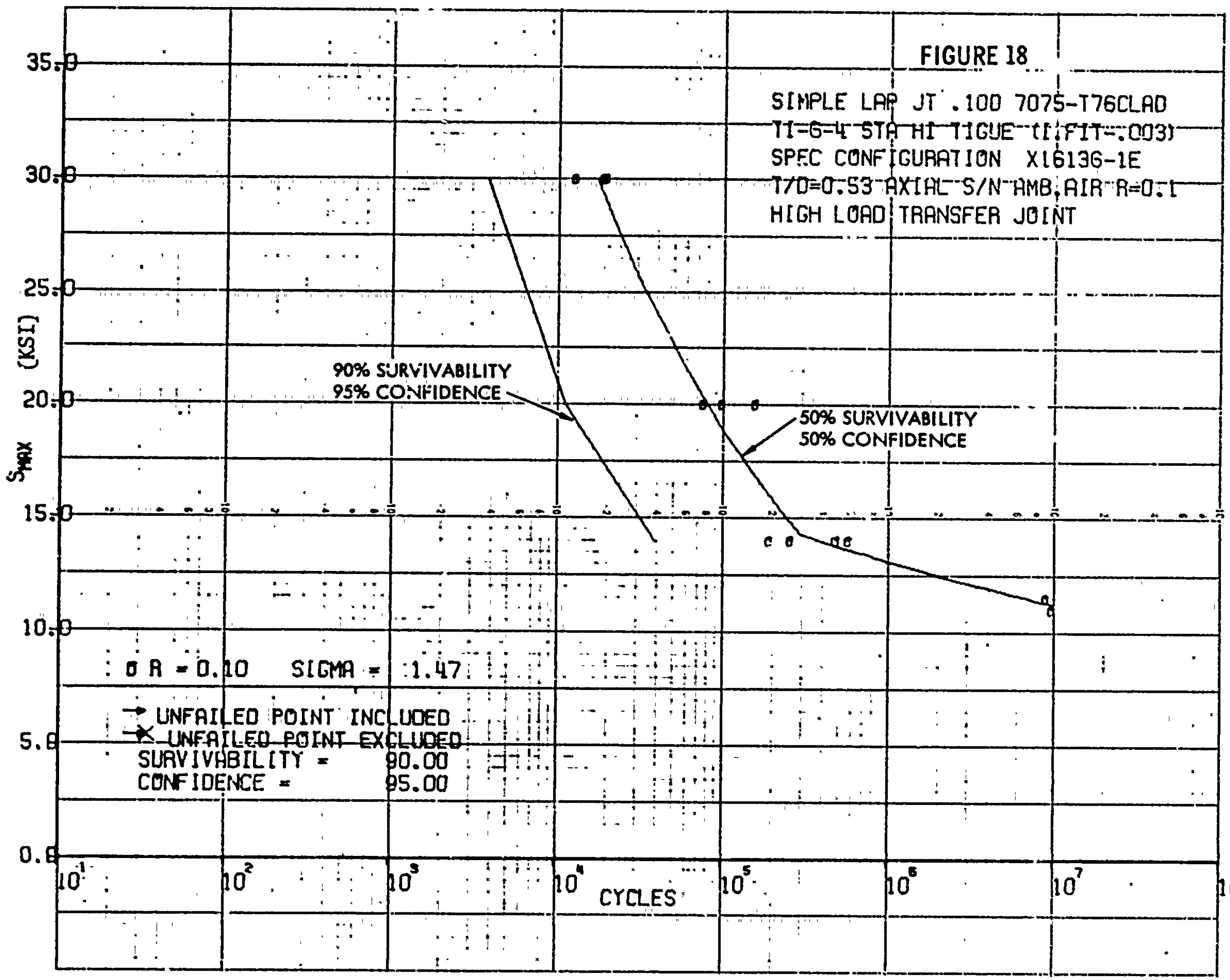


FIGURE 18
SIMPLE LAP JT .100 7075-T76CLAD
TI-6-4 STA HI TIGUE (I.FIT=.003)
SPEC CONFIGURATION X16136-1E
T/D=0.53 AXIAL S/N AMB.AIR R=0.1
HIGH LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
S_{MAX} (KSI)
ø R = 0.10 SIGMA = 1.47
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

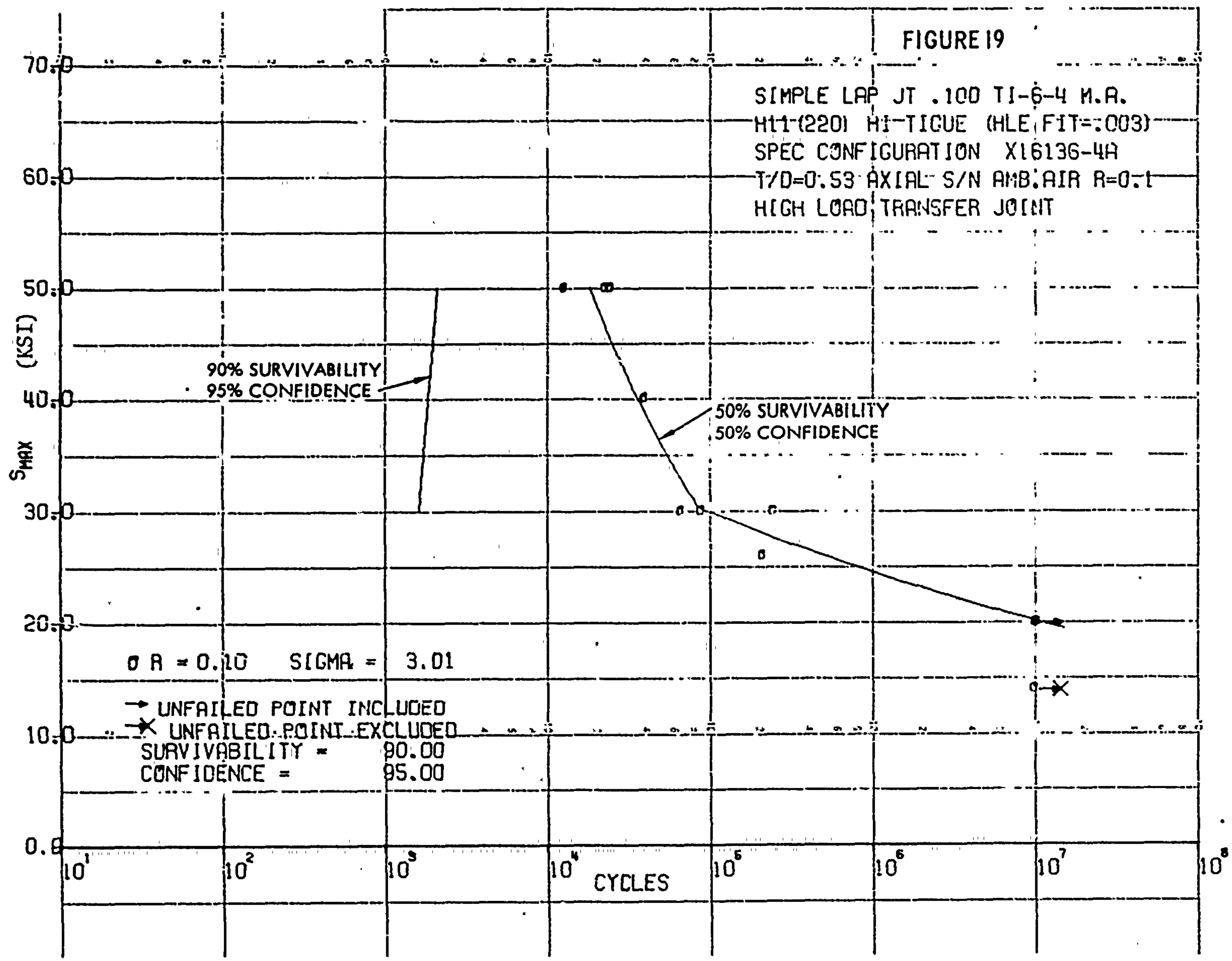


FIGURE 19
SIMPLE LAP JT .100 TI-6-4 M.A.
H11 (220) HI-TIGUE (HLE FIT=.003)
SPEC CONFIGURATION X16136-4A
T/D=0.53 AXIAL S/N AMB.AIR R=0.1
HIGH LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
σ R = 0.10 SIGMA = 3.01
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S_MAX (KSI)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

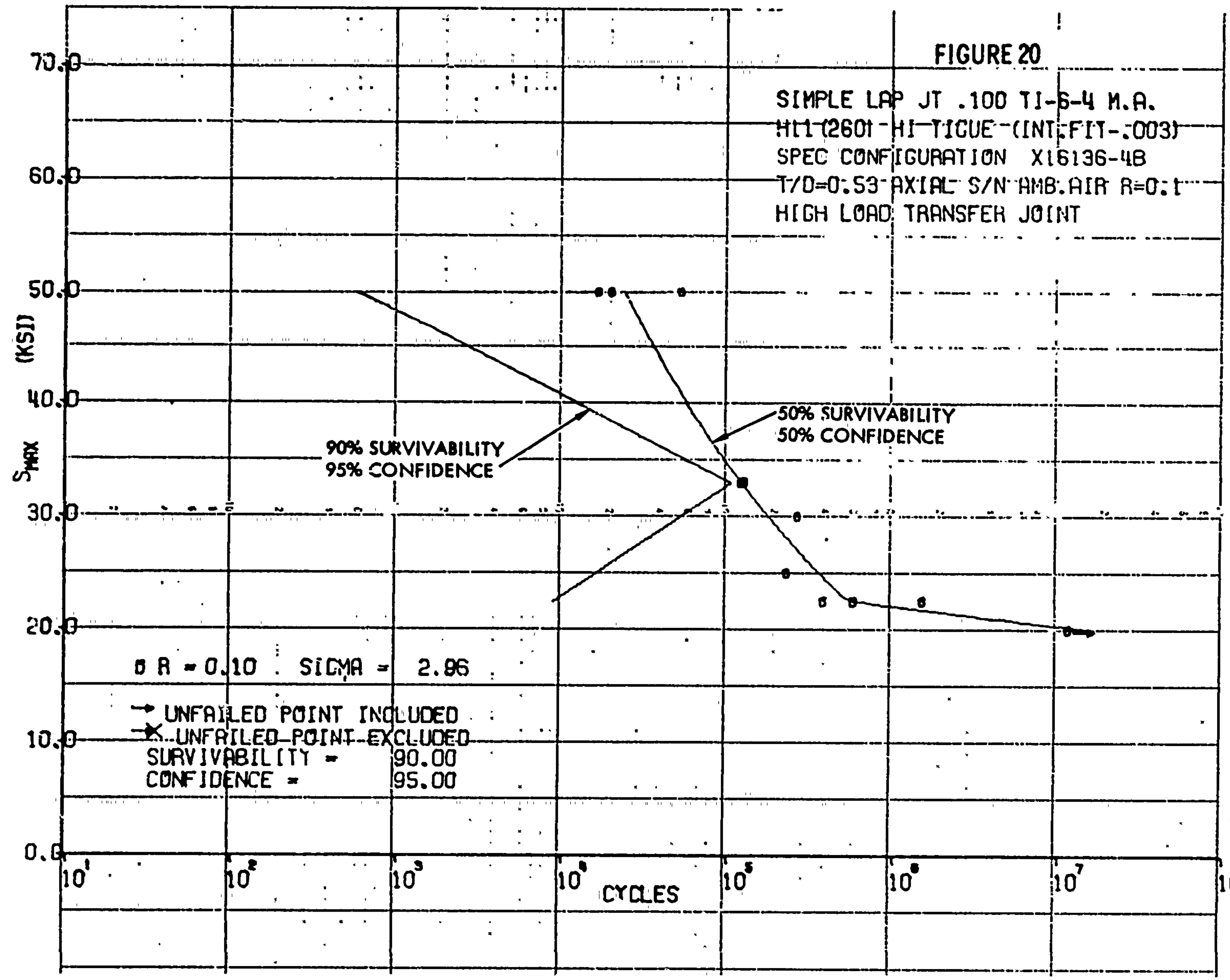

SIMPLE LAP JT .100 TI-6-4 M.A.
HI1 (2601 HI-TIGUE (INT.FIT-.003)
SPEC CONFIGURATION X16136-4B
T/D=0.53 AXIAL S/N AMB.AIR R=0.1
HIGH LOAD TRANSFER JOINT
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
S_{MAX} (KSI)
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
R = 0.10 SIGMA = 2.86
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

FIGURE 20

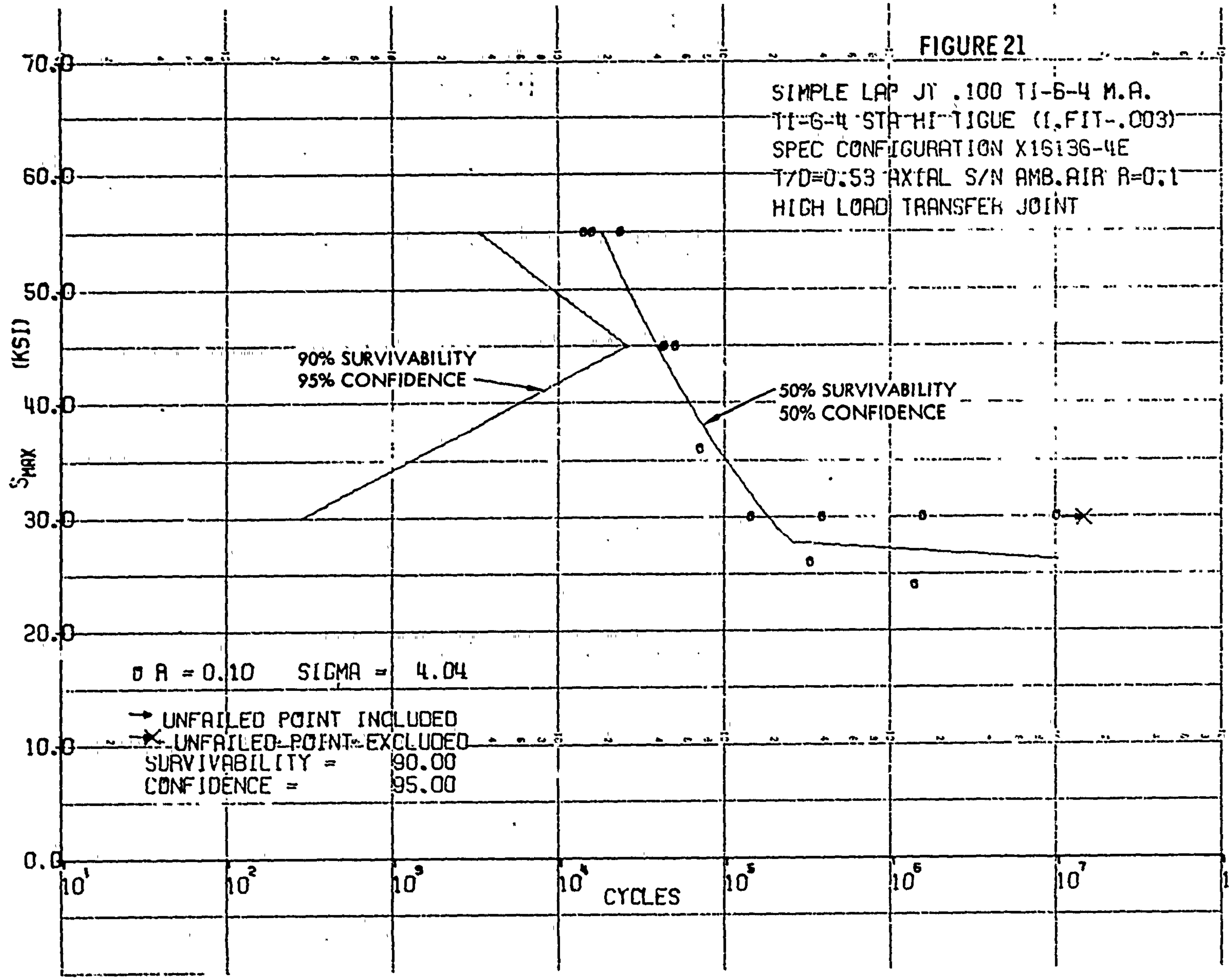


FIGURE 21
SIMPLE LAP JT .100 TI-6-4 M.A.
TI-6-4 STA HI TIGUE (1,FIT-.003)
SPEC CONFIGURATION X16136-4E
T/D=0.53 AXIAL S/N AMB.AIR R=0.1
HIGH LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
R = 0.10 SIGMA = 4.04
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
SMAX (KSI)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
CYCLES

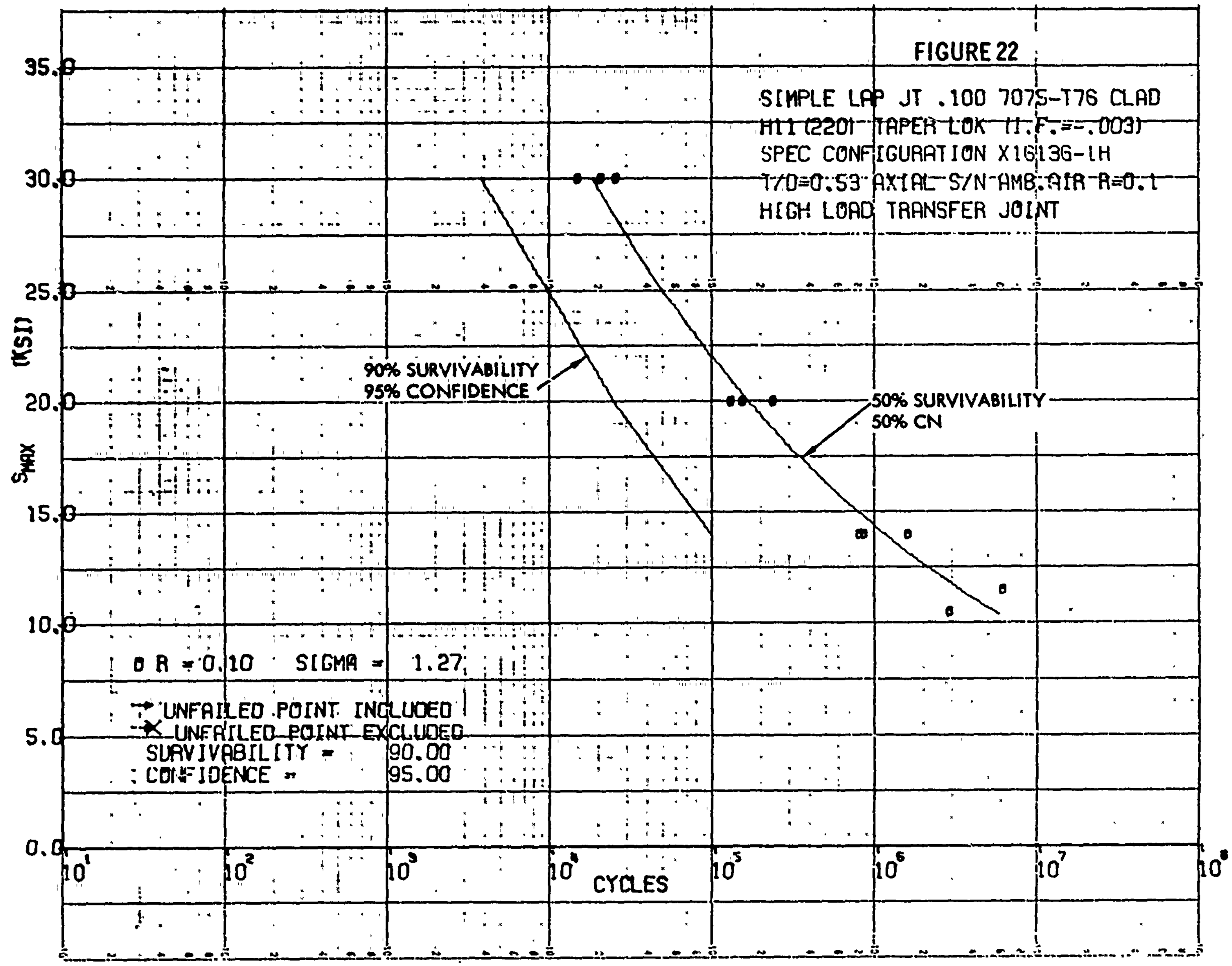


FIGURE 22
SIMPLE LAP JT .100 7075-T76 CLAD
H11 (220) TAPER LOK (I.F.=-.003)
SPEC CONFIGURATION X16136-1H
T/D=0.53 AXIAL S/N AMB.AIR R=0.1
HIGH LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CN
R = 0.10 SIGMA = 1.27
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S_{MAX} (KSI)
CYCLES
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8

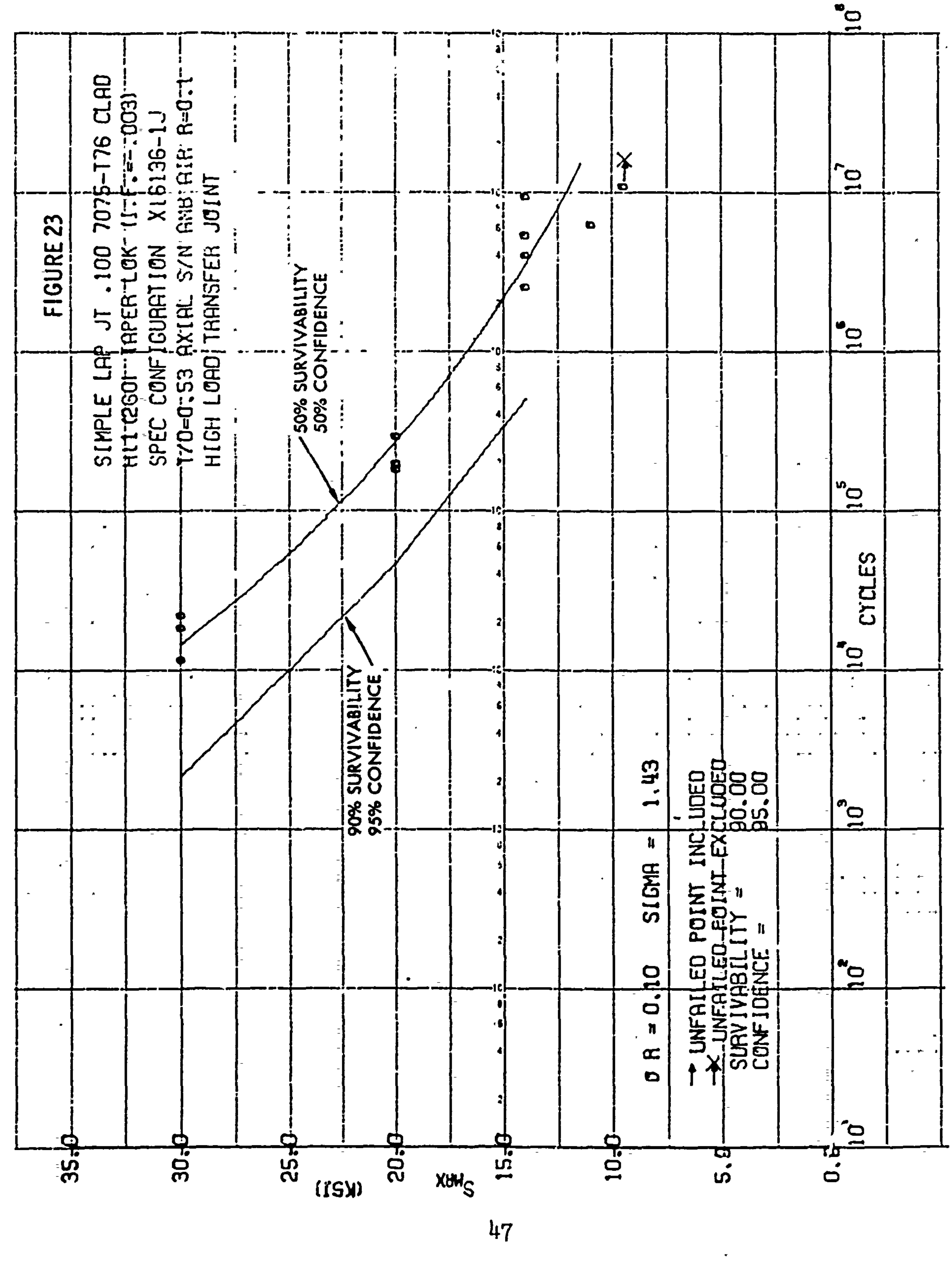

SIMPLE LAP JT .100 7075-T76 CLAD
HI1 (260I TAPER-LOK (I.F.=.003)
SPEC CONFIGURATION X16136-1J
T/D=0.53 AXIAL S/N AMB AIR R=0.1
HIGH LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
R = 0.10 SIGMA = 1.43
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
CYCLES
S MAX (KSI)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8

FIGURE 23

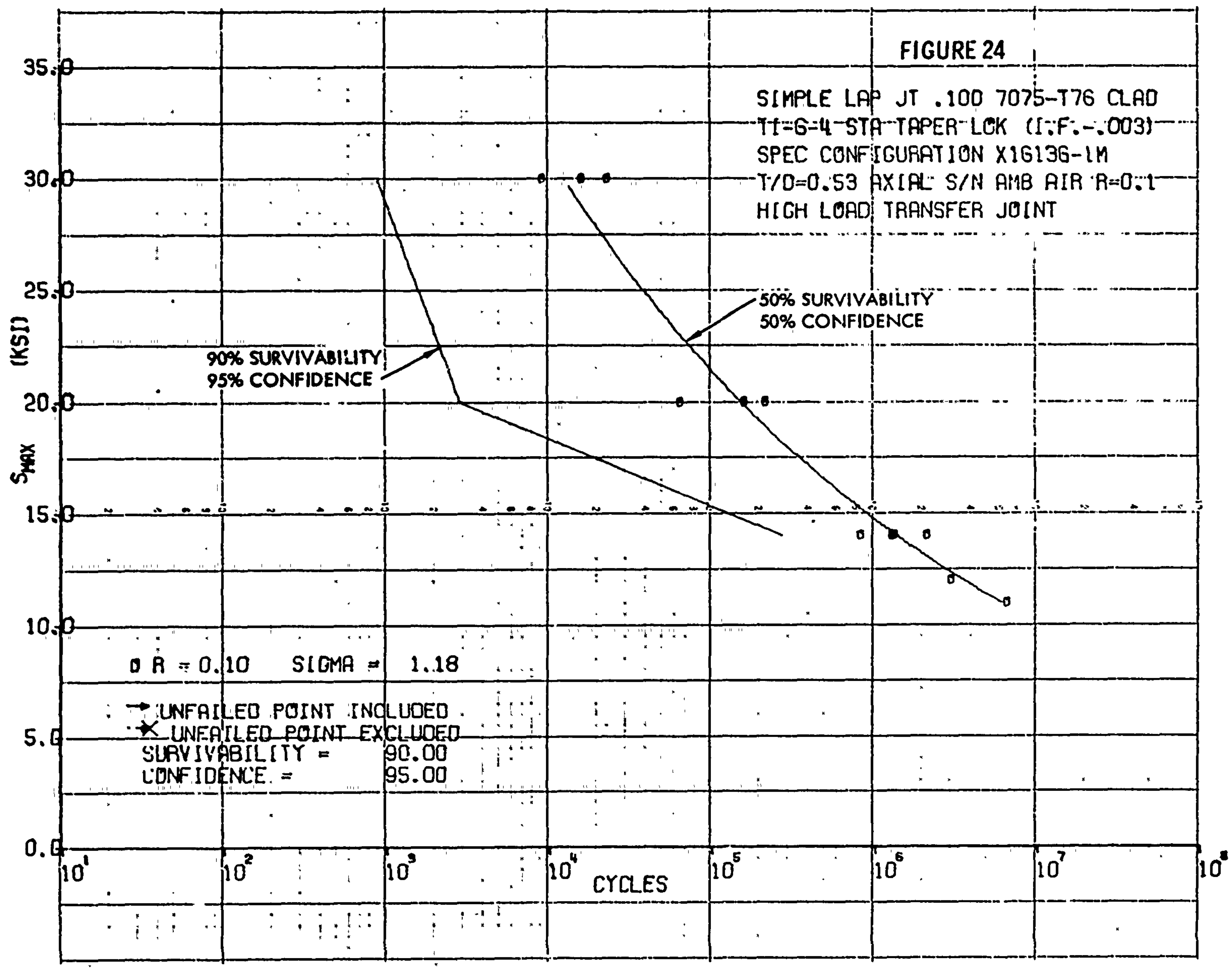
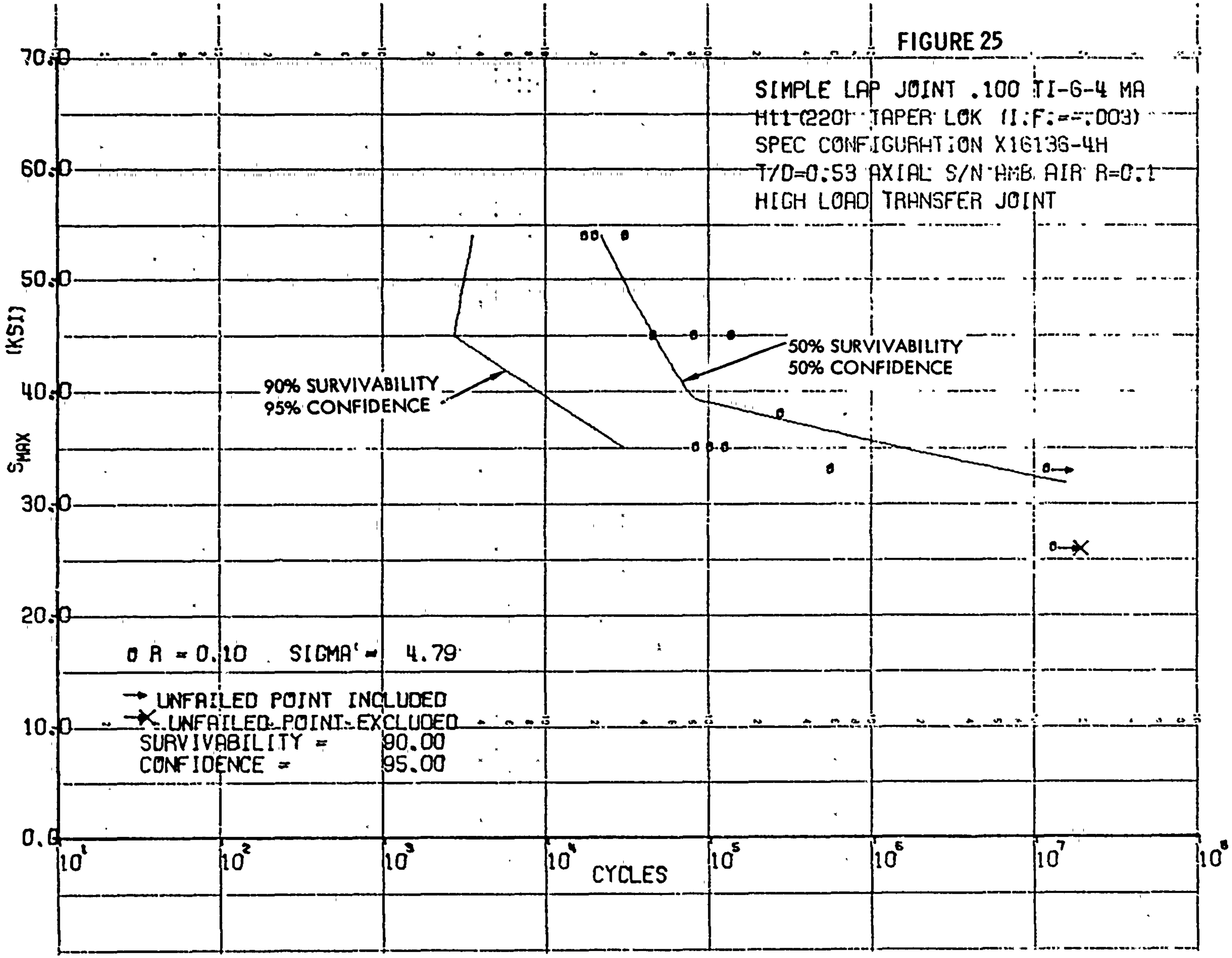


FIGURE 24
SIMPLE LAP JT .100 7075-T76 CLAD
TI-6-4 STA TAPER LCK (I.F.-.003)
SPEC CONFIGURATION X16136-1M
T/D=0.53 AXIAL S/N AMB AIR R=0.1
HIGH LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
ʘ R = 0.10 SIGMA = 1.18
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S_{MAX} (KSI)
CYCLES
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8

FIGURE 25


SIMPLE LAP JOINT .100 TI-6-4 MA
Hi1 (220) TAPER LOK (I.F.=-.003)
SPEC CONFIGURATION X16136-4H
T/D=0.53 AXIAL S/N AMB AIR R=0.1
HIGH LOAD TRANSFER JOINT
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
0 R = 0.10 SIGMA' = 4.79
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00

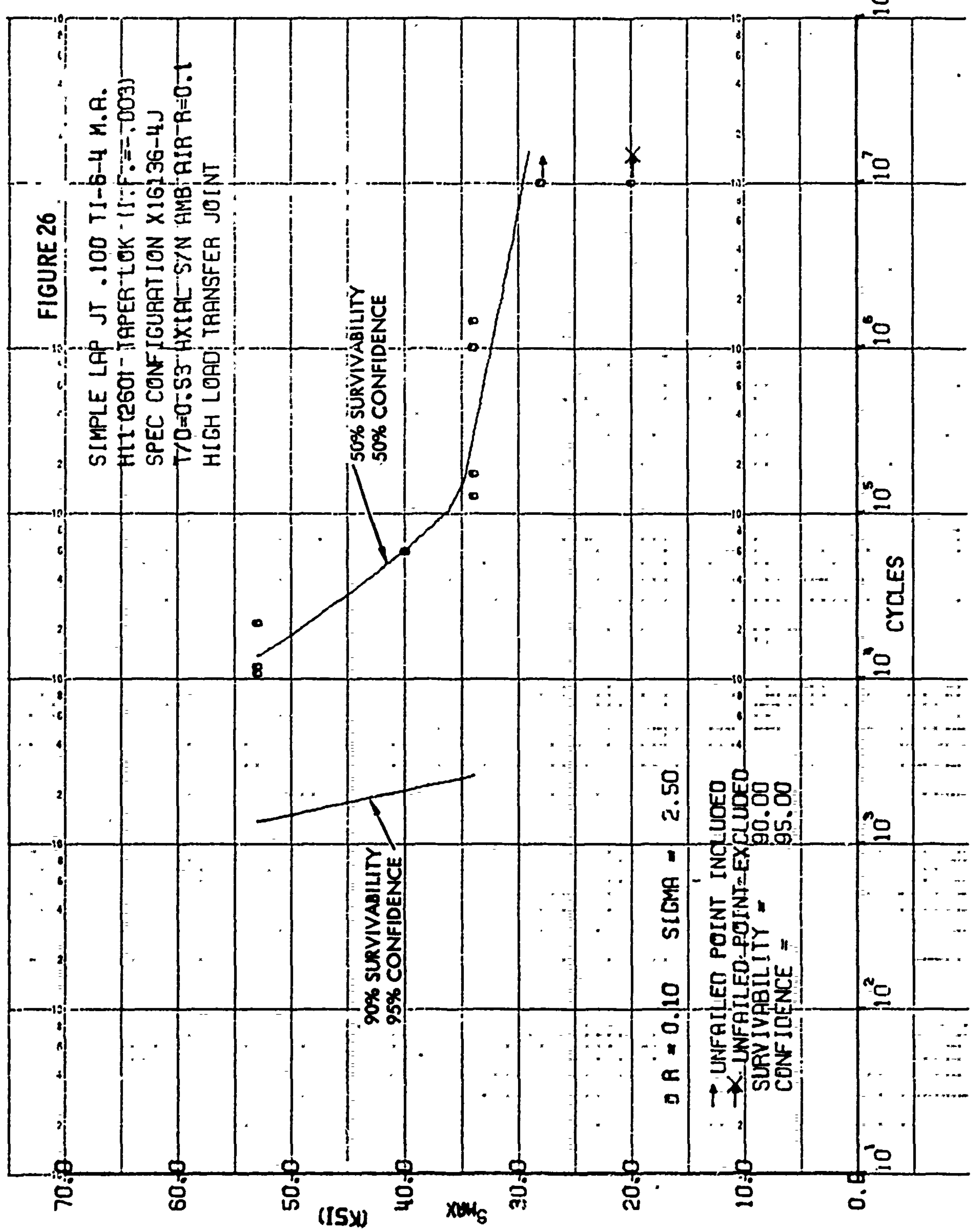


FIGURE 26
SIMPLE LAP JT .100 TI-6-4 M.A.
HI1 (2601-TAPER-LOK (I.F.=-.003)
SPEC CONFIGURATION X16136-4J
T/D=0.53 AXIAL SYN AMB AIR R=0.1
HIGH LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
R = 0.10 SIGMA = 2.50
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
CYCLES
S MAX (KSI)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0

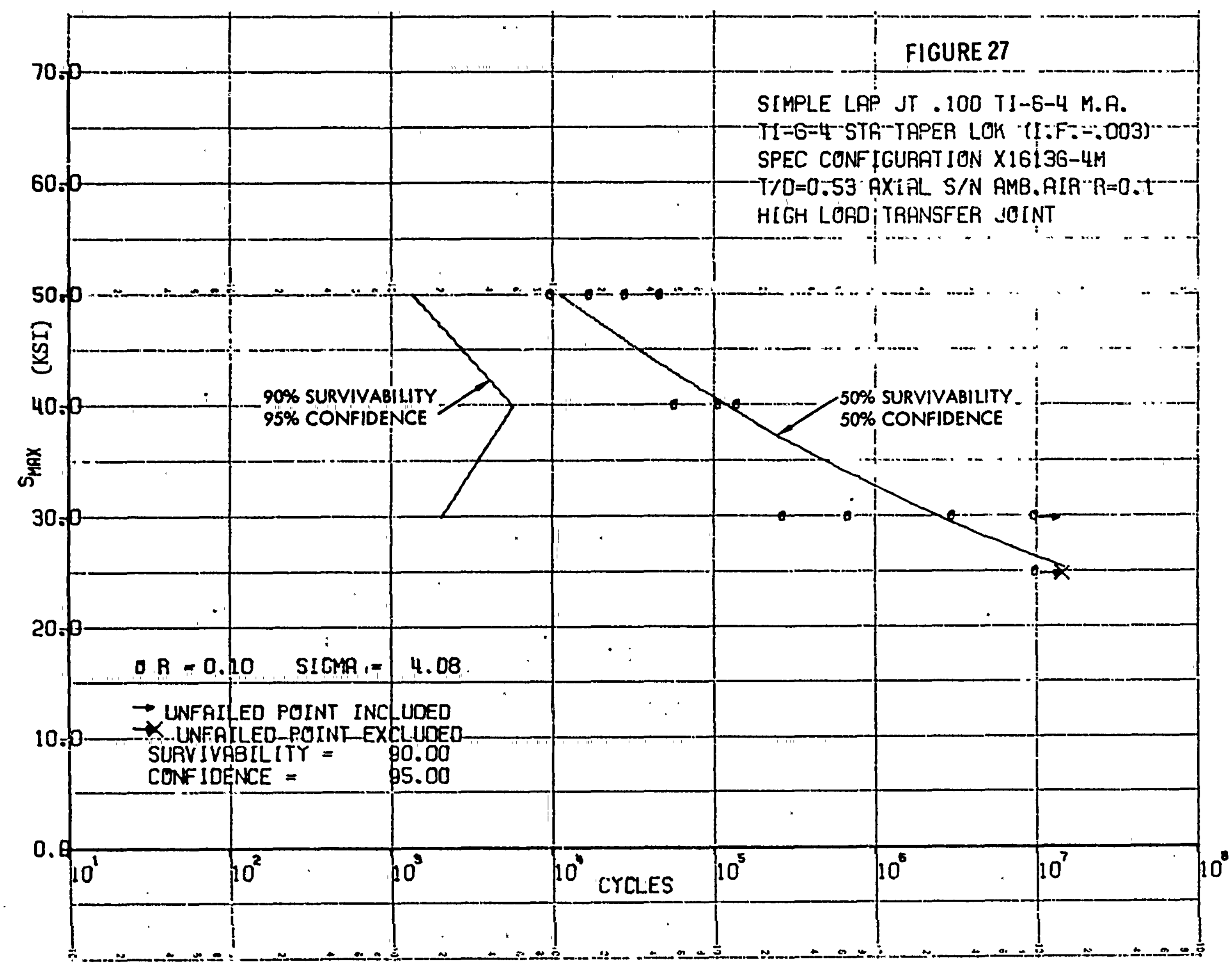


FIGURE 27
SIMPLE LAP JT .100 TI-6-4 M.A.
TI-6-4 STA TAPER LOK (I.F.-.003)
SPEC CONFIGURATION X16136-4M
T/D=0.53 AXIAL S/N AMB.AIR R=0.1
HIGH LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
R = 0.10 SIGMA = 4.08
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

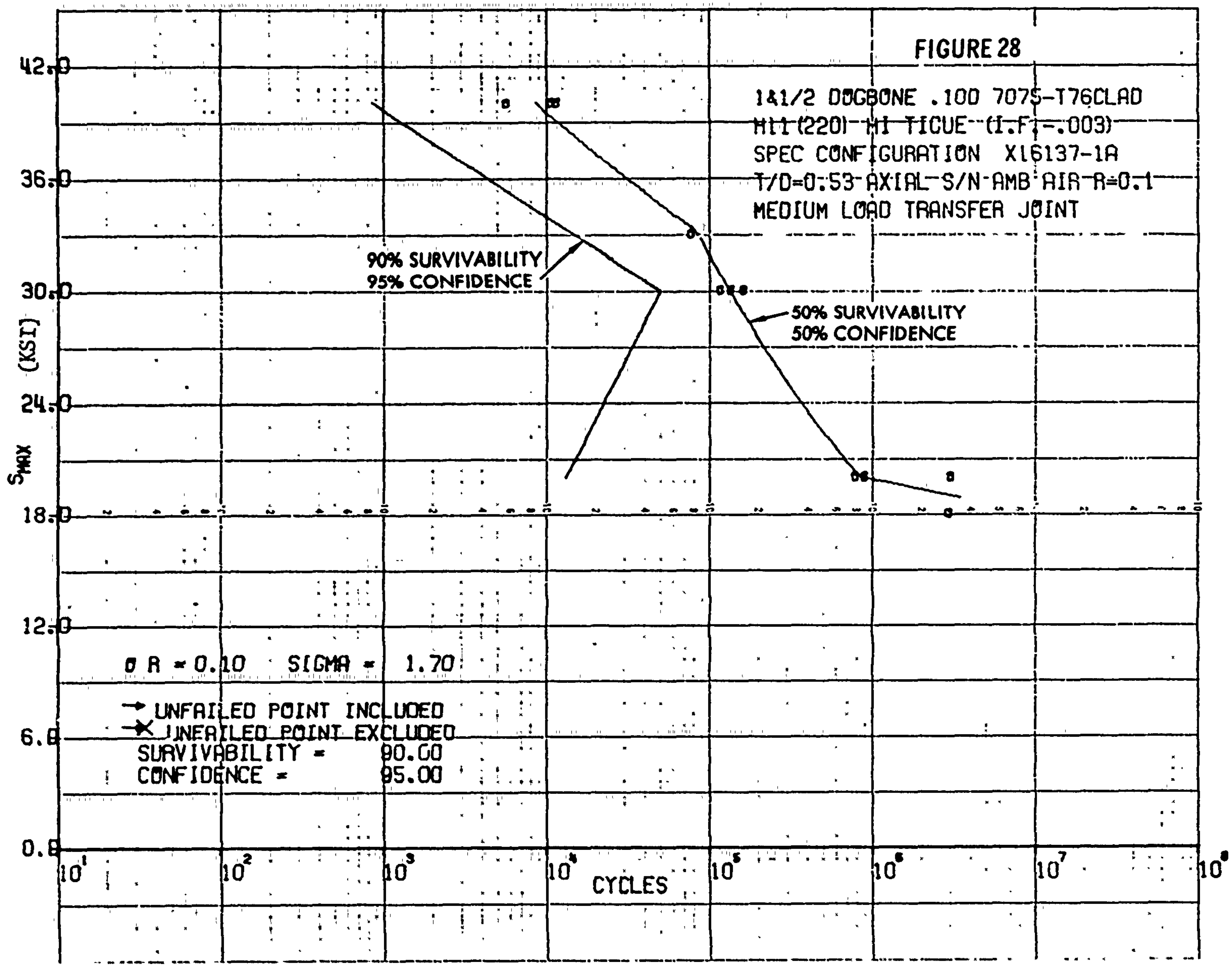

1&1/2 DOGBONE .100 7075-T76CLAD
H11 (220) HI TICUE (I.F.=.003)
SPEC CONFIGURATION X16137-1A
T/D=0.53 AXIAL S/N AMB AIR R=0.1
MEDIUM LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
42.0
36.0
30.0
24.0
18.0
12.0
6.8
0.8
S_{MAX} (KSI)
ø R = 0.10 SIGMA = 1.70
→ UNFAILED POINT INCLUDED
→✕ UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

FIGURE 28

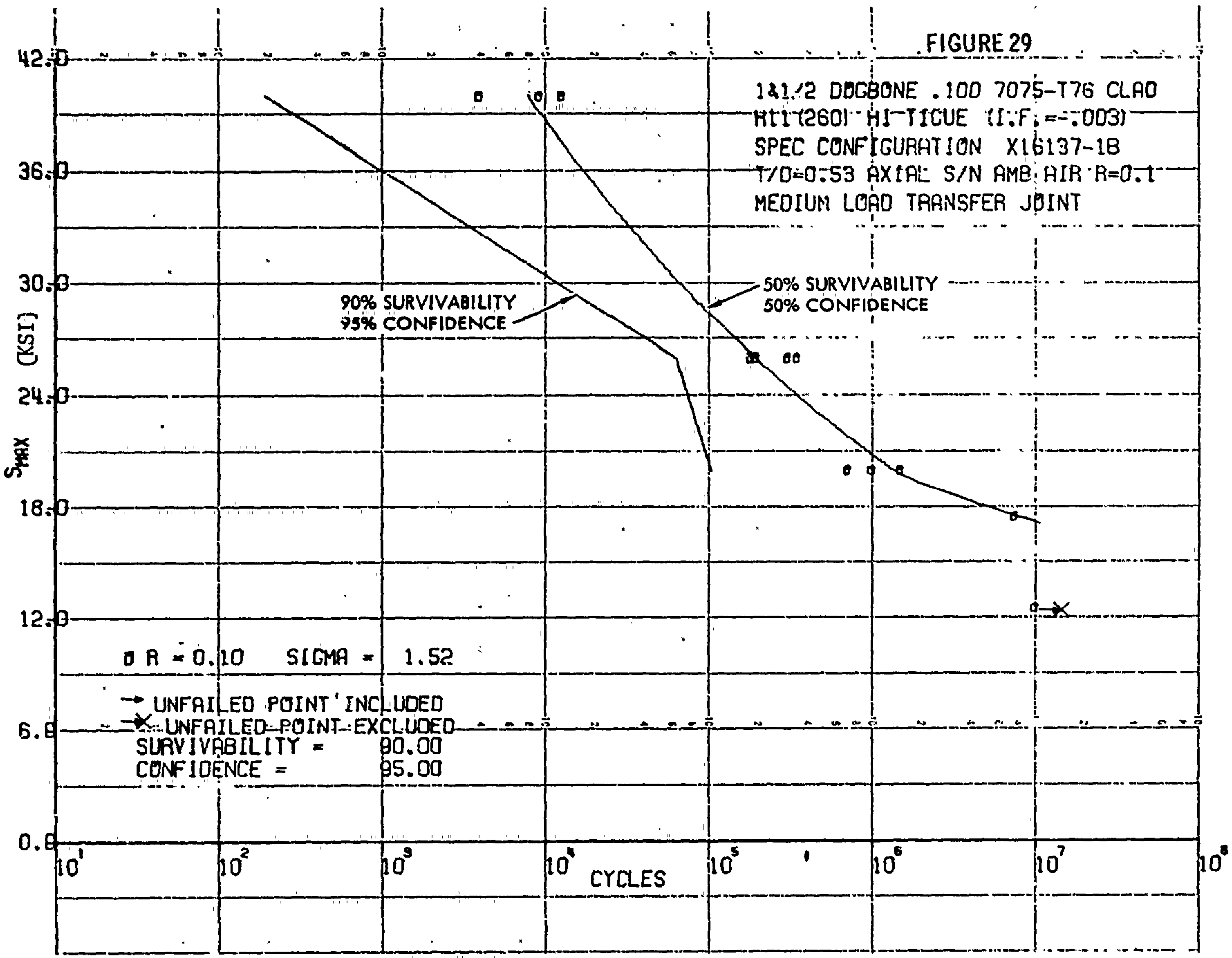

1&1/2 DOGBONE .100 7075-T76 CLAD
HI1 (260) HI-TIGUE (I.F.=-.003)
SPEC CONFIGURATION X16137-1B
T/D=0.53 AXIAL S/N AMB AIR R=0.1
MEDIUM LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
R = 0.10 SIGMA = 1.52
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
42.0
36.0
30.0
24.0
18.0
12.0
6.8
0.8
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

FIGURE 29

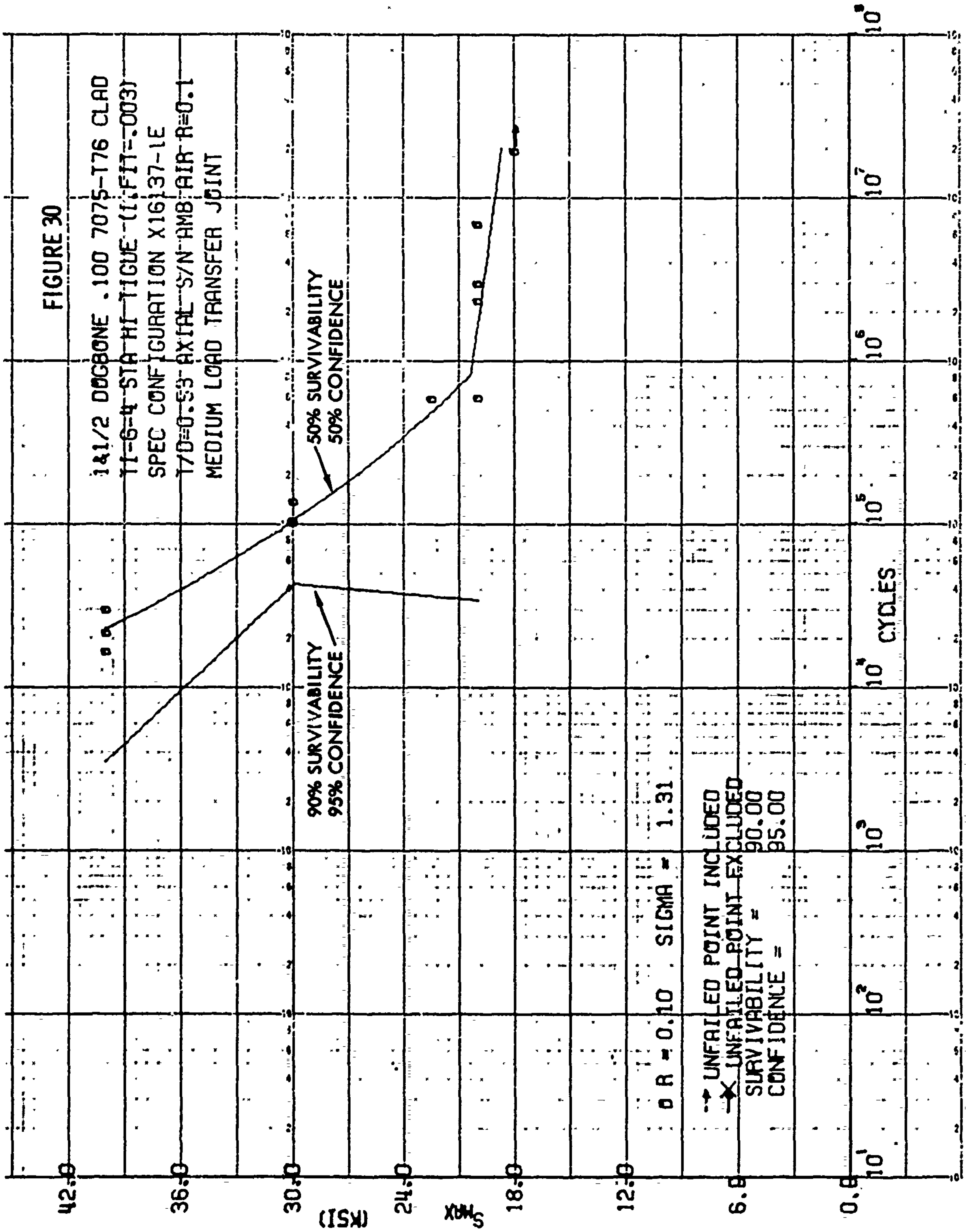

1&1/2 DOGBONE .100 7075-T76 CLAD
TI-6-4 STA HI-TIGUE (1.FIT-.003)
SPEC CONFIGURATION X16137-1E
T/D=0.53 AXIAL S/N AMB AIR R=0.1
MEDIUM LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
□ R = 0.10 SIGMA = 1.31
→ UNFAILED POINT INCLUDED
✕ UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
CYCLES
S MAX (KSI)
42.0
36.0
30.0
24.0
18.0
12.0
6.0
0.0

FIGURE 30

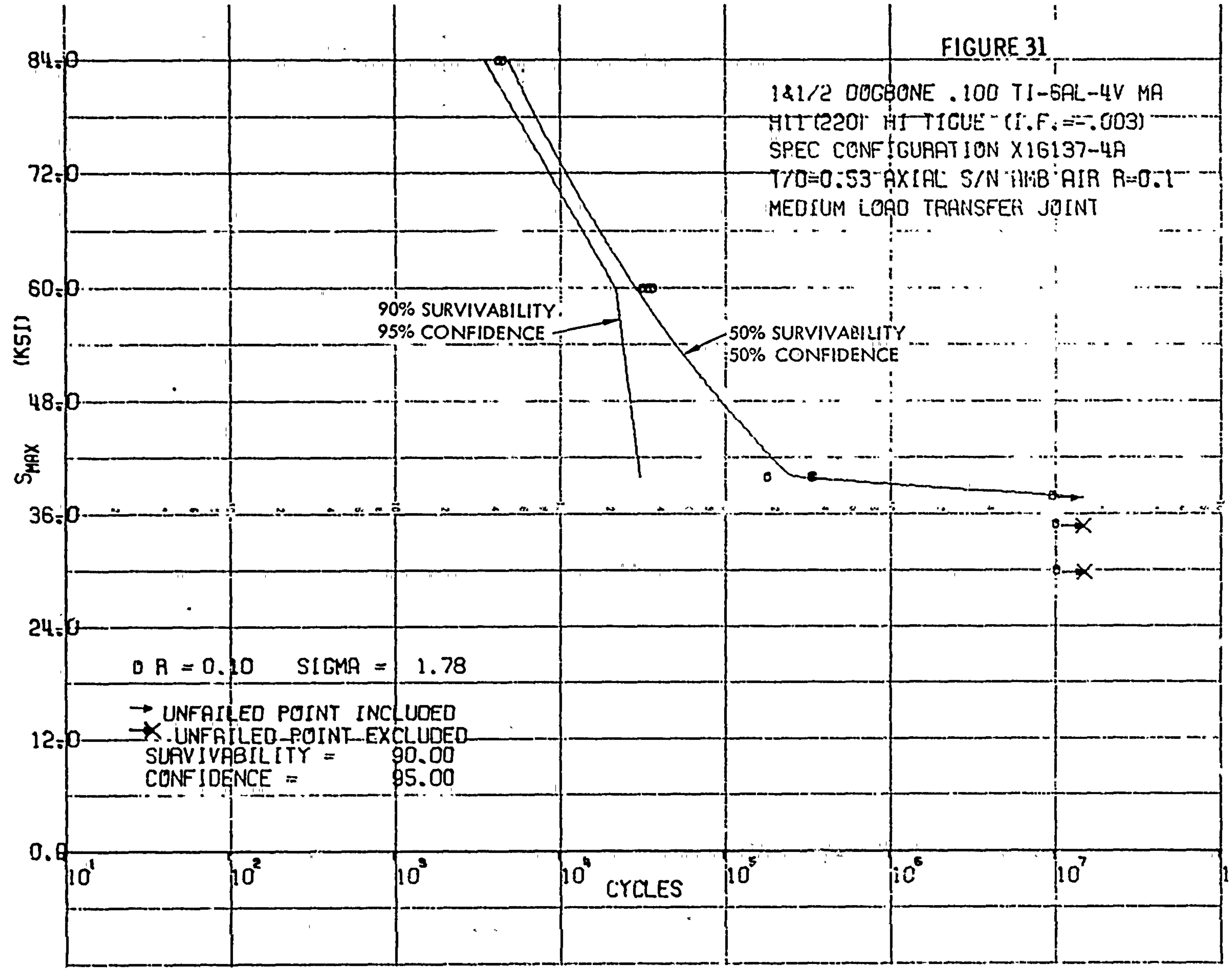


FIGURE 31
1&1/2 DOGBONE .100 TI-6AL-4V MA
HI (220) HI TIGUE (I.F.=-.003)
SPEC CONFIGURATION X16137-4A
T/D=0.53 AXIAL S/N AMB AIR R=0.1
MEDIUM LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
O R = 0.10 SIGMA = 1.78
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S MAX (KSI)
84.0
72.0
60.0
48.0
36.0
24.0
12.0
0.0
CYCLES
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8

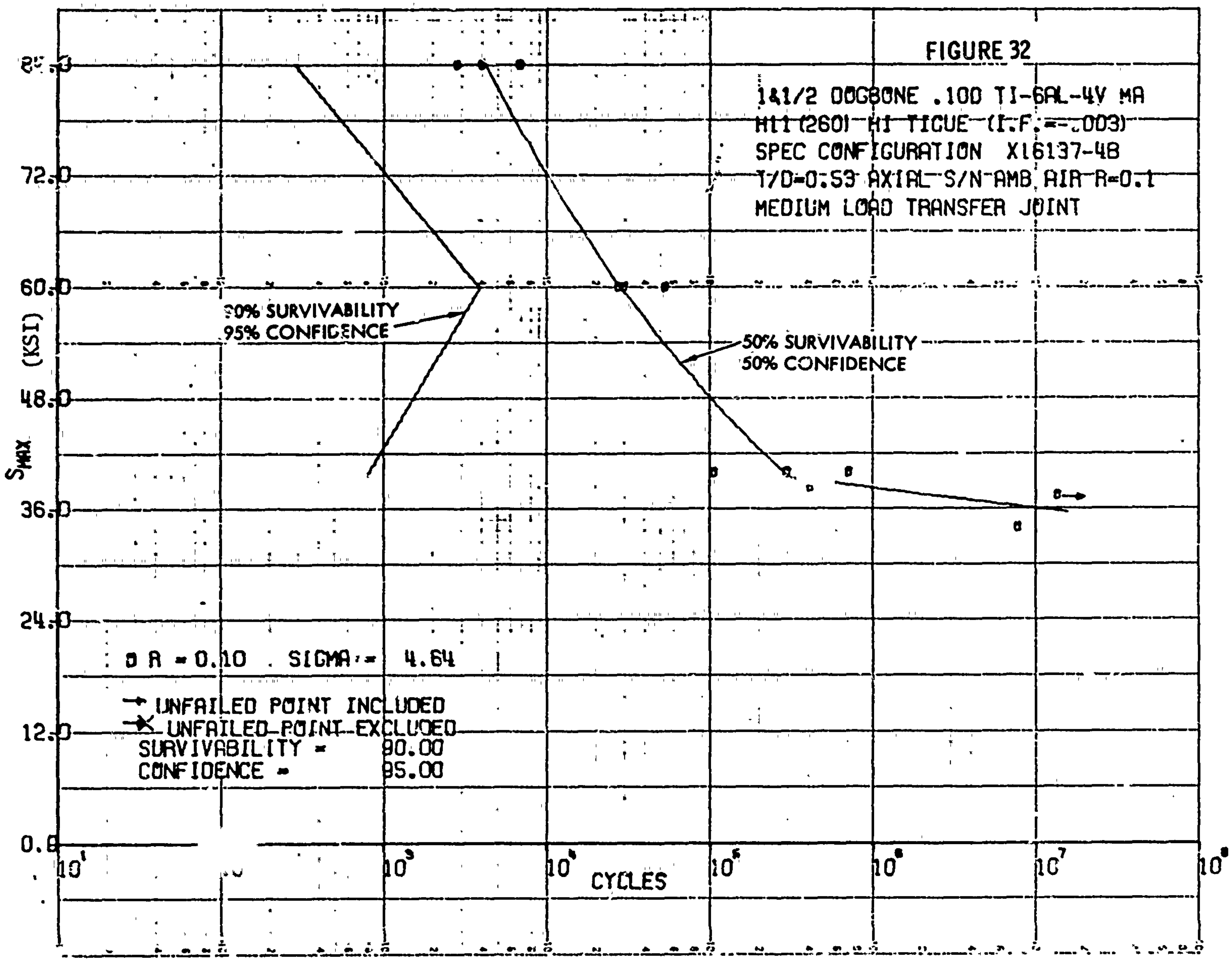


FIGURE 32
1&1/2 DOGBONE .100 TI-6AL-4V MA
H11 (260) HI TICUE (I.F.=-.003)
SPEC CONFIGURATION X16137-4B
T/D=0.53 AXIAL S/N AMB AIR R=0.1
MEDIUM LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
R = 0.10 . SIGMA = 4.64
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
72.0
60.0
48.0
36.0
24.0
12.0
0.0
S_{MAX} (KSI)
CYCLES

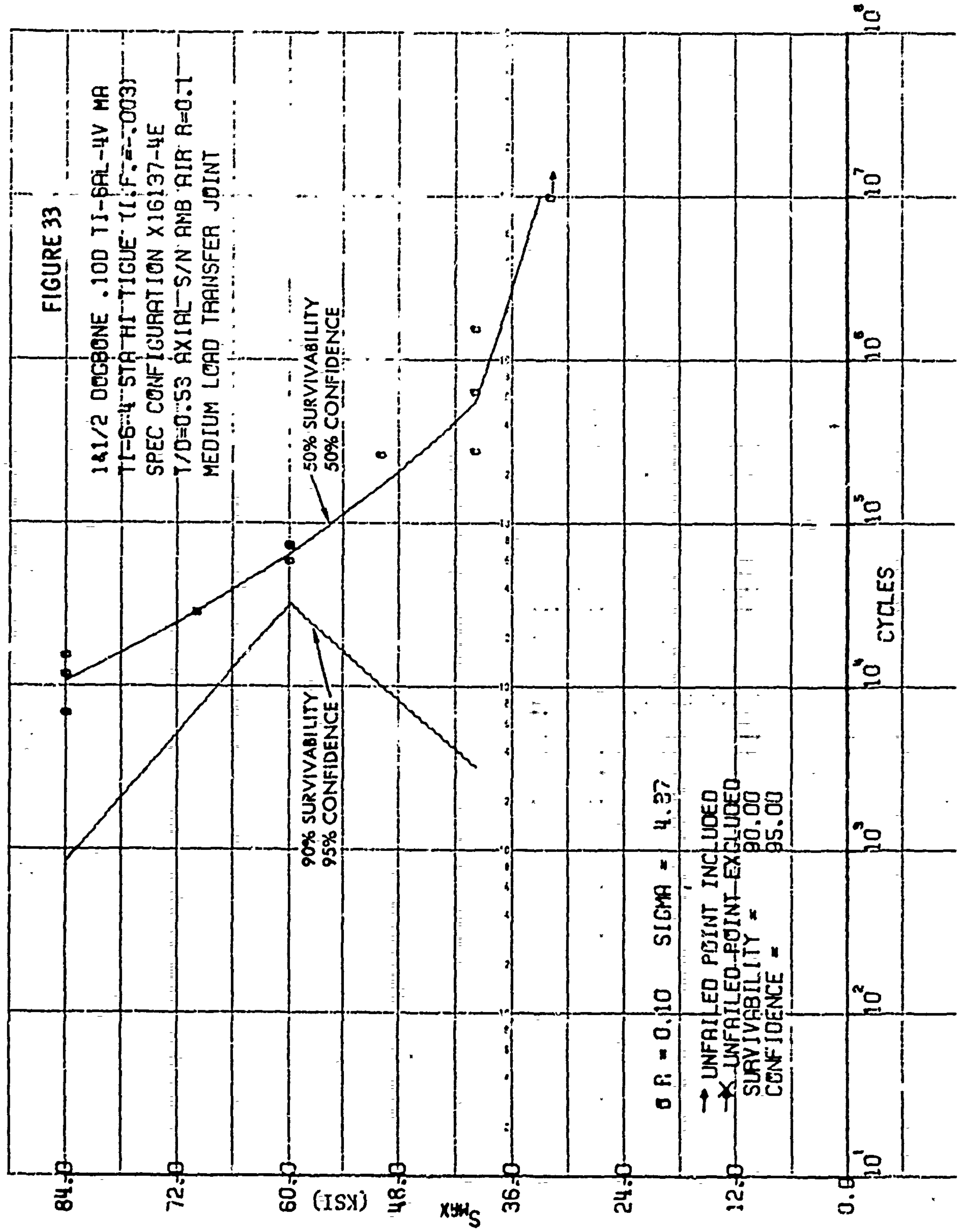


FIGURE 33
1&1/2 DOGBONE .100 TI-6AL-4V MA
TI-6-4 STA HI-TIGUE (L.F.=-.003)
SPEC CONFIGURATION X16137-4E
T/D=0.53 AXIAL S/N AMB AIR R=0.1
MEDIUM LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
R = 0.10 SIGMA = 4.37
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
84.0
72.0
60.0
48.0
36.0
24.0
12.0
0.0
S MAX (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

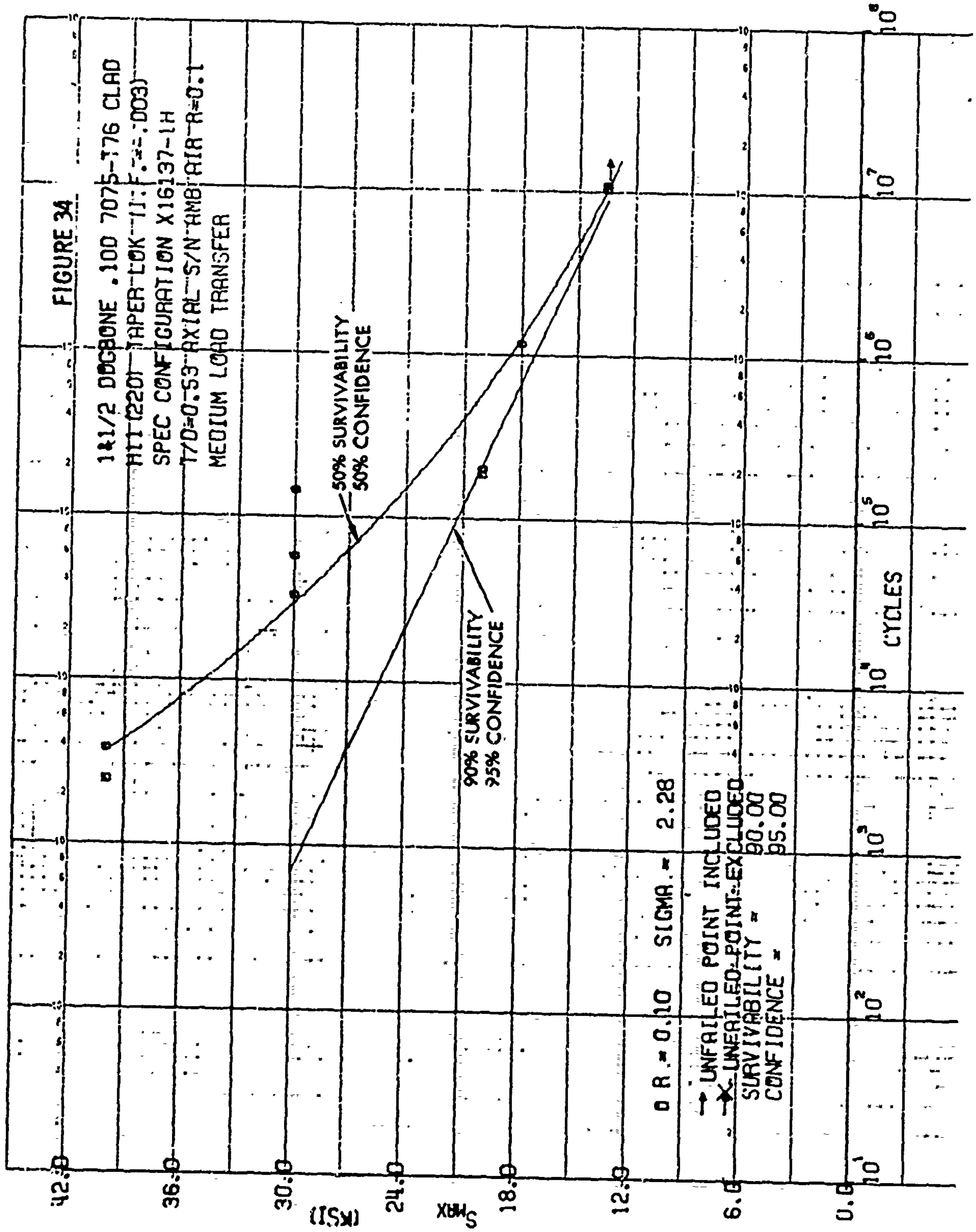


FIGURE 34
1&1/2 DOGBONE .100 7075-T76 CLAD
TAPER-LOK
SPEC CONFIGURATION X16137-1H
T/D=0.53 AXIAL S/N AMB AIR R=0.1
MEDIUM LOAD TRANSFER
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
R = 0.10 SIGMA = 2.28
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
42.0
36.0
30.0
24.0
18.0
12.0
6.0
0.0
S MAX (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

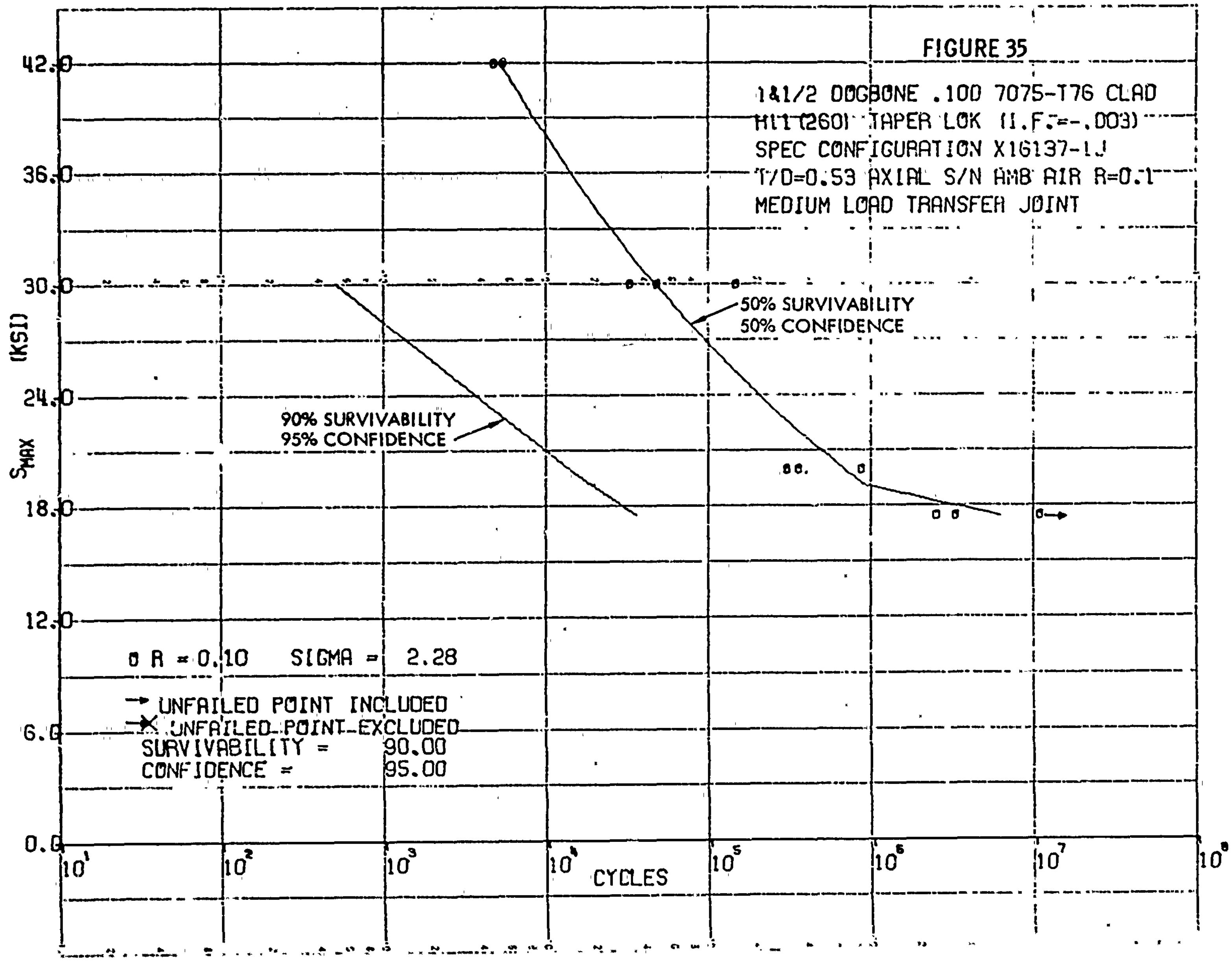


FIGURE 35
1&1/2 DOGBONE .100 7075-T76 CLAD
H11 (260) TAPER LOK (I.F.=-.003)
SPEC CONFIGURATION X16137-1J
T/D=0.53 AXIAL S/N AMB AIR R=0.1
MEDIUM LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
R = 0.10 SIGMA = 2.28
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
42.0
36.0
30.0
24.0
18.0
12.0
6.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

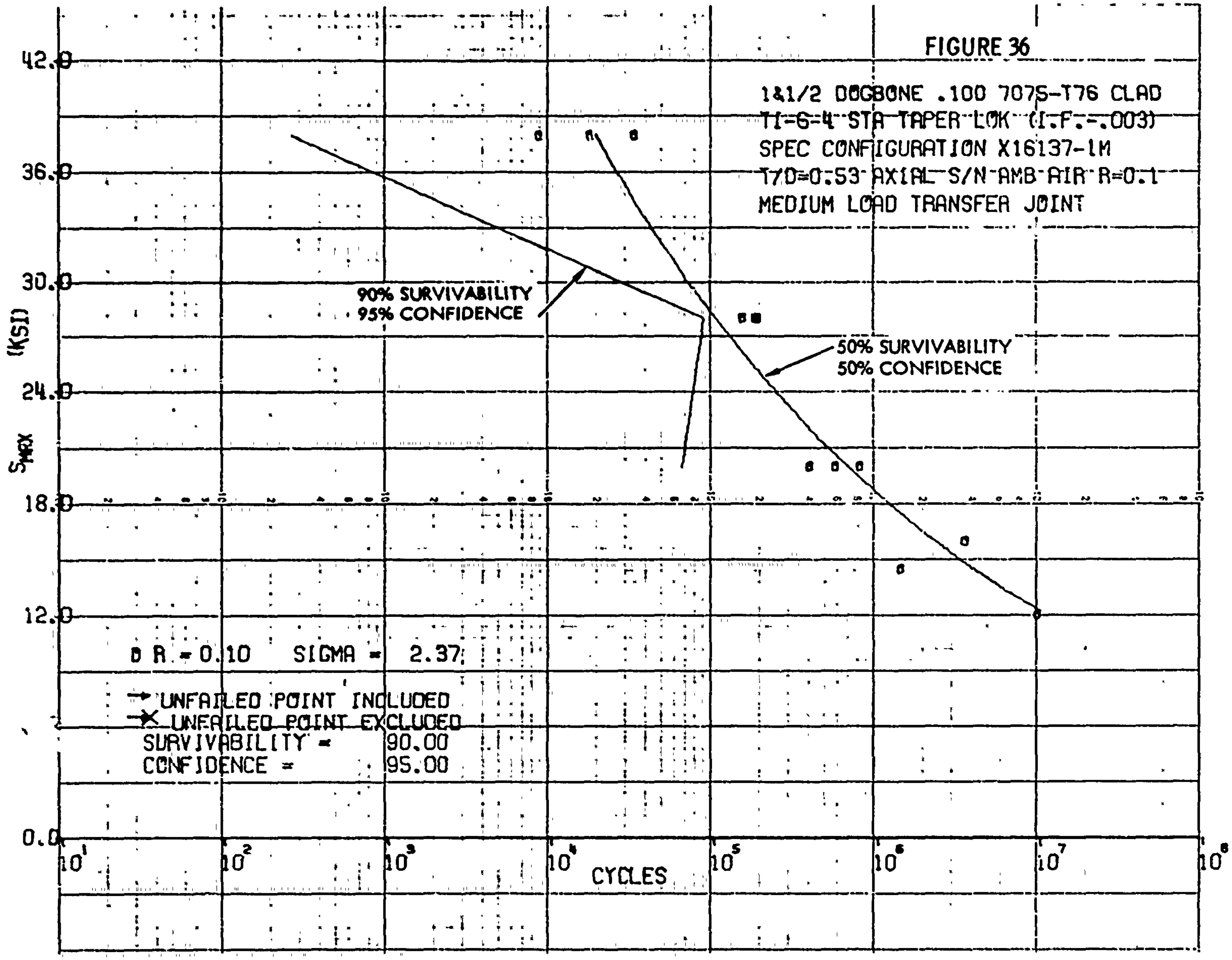


FIGURE 36
1&1/2 DOGBONE .100 7075-T76 CLAD
TI-6-4 STA TAPER LOK (I.F.-.003)
SPEC CONFIGURATION X16137-1M
T/D=0.53 AXIAL S/N AMB AIR R=0.1
MEDIUM LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
R = 0.10 SIGMA = 2.37
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
42.0
36.0
30.0
24.0
18.0
12.0
0.0
S_{MAX} (KSI)
CYCLES

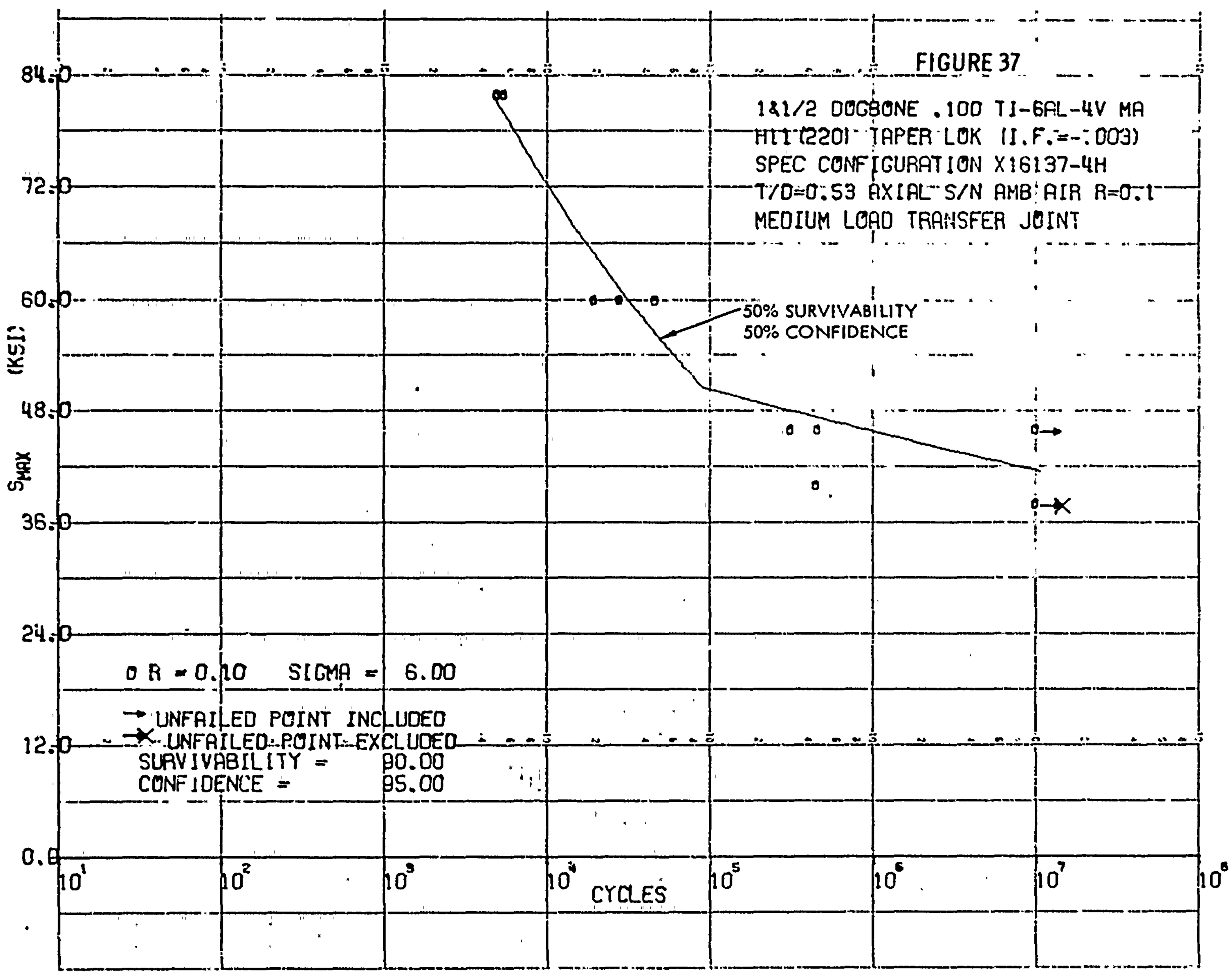

1&1/2 DOGBONE .100 TI-6AL-4V MA
HI1 (220) TAPER LOK (I.F.=-.003)
SPEC CONFIGURATION X16137-4H
T/D=0.53 AXIAL S/N AMB AIR R=0.1
MEDIUM LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
84.0
72.0
60.0
48.0
36.0
24.0
12.0
0.0
S_{MAX} (KSI)
o R = 0.10 SIGMA = 6.00
→ UNFAILED POINT INCLUDED
→X UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

FIGURE 37

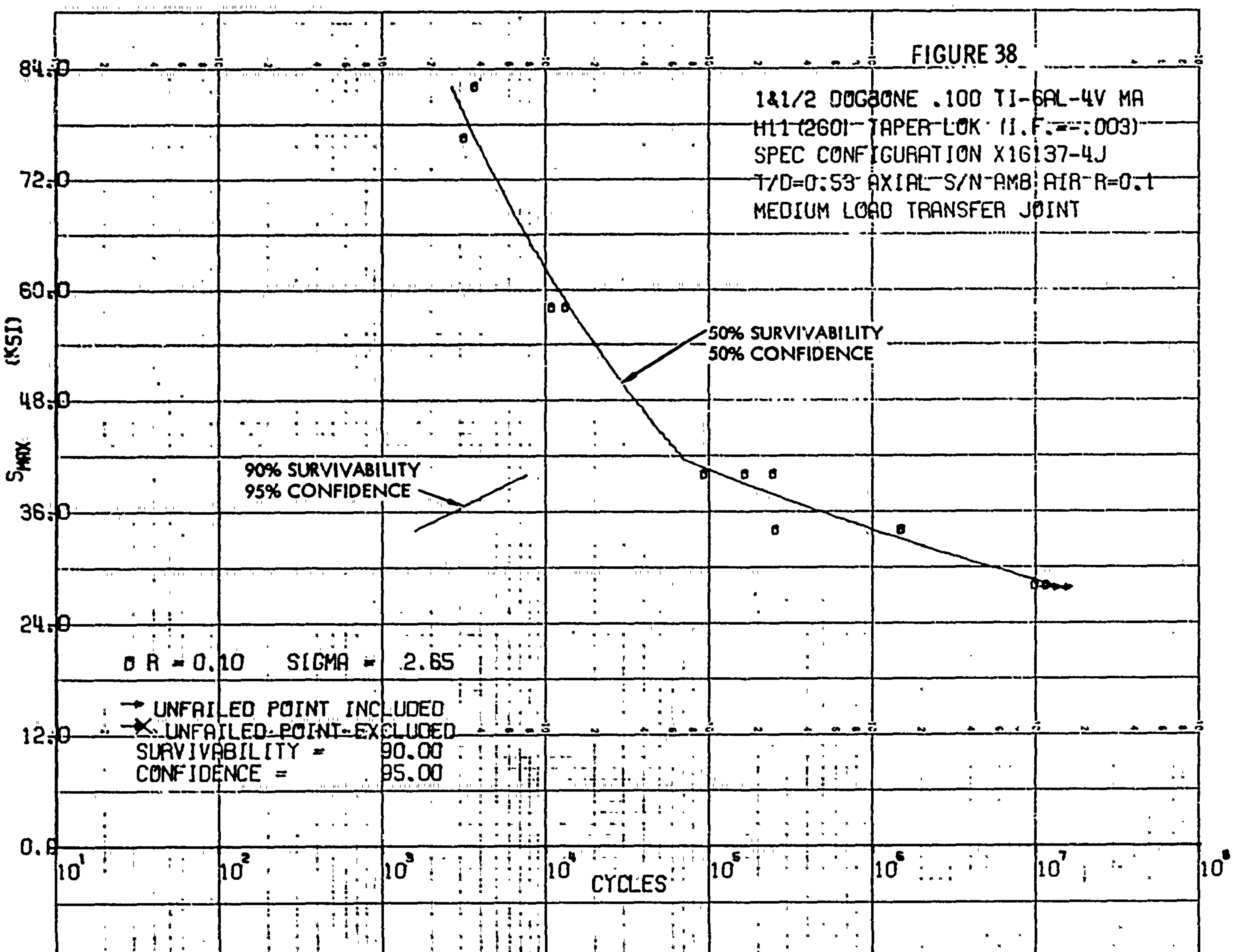

1&1/2 DOGBONE .100 TI-6AL-4V MA
H11 (2601 TAPER-LOK (I.F.=-.003)
SPEC CONFIGURATION X16137-4J
T/D=0.53 AXIAL S/N AMB AIR R=0.1
MEDIUM LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
R = 0.10 SIGMA = 2.65
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
84.0
72.0
60.0
48.0
36.0
24.0
12.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

FIGURE 38

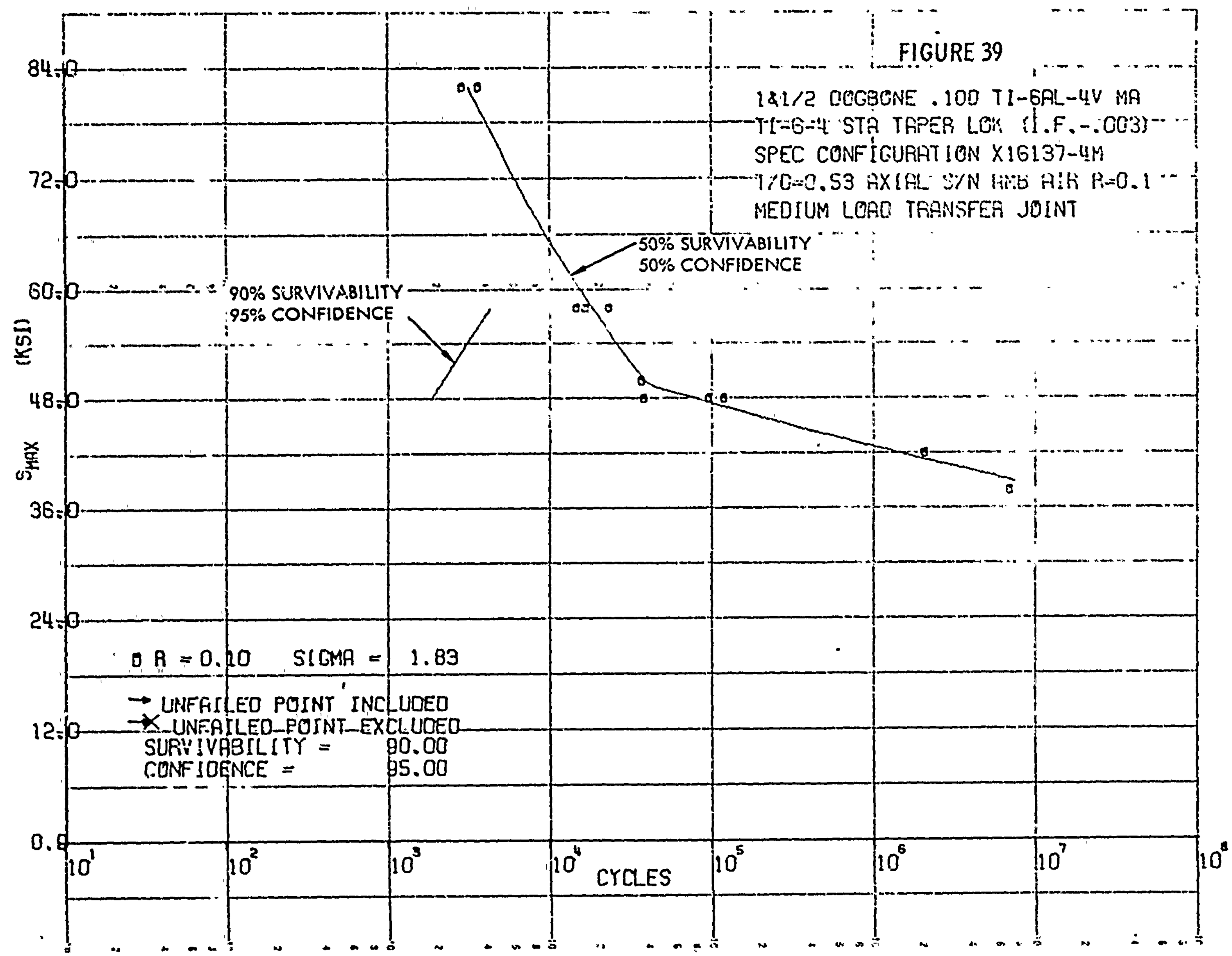


FIGURE 39
1&1/2 DOGBONE .100 TI-6AL-4V MA
TI-6-4 STA TAPER LOK (I.F.-.003)
SPEC CONFIGURATION X16137-4M
T/D=0.53 AXIAL S/N AMB AIR R=0.1
MEDIUM LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
□ R = 0.10 SIGMA = 1.83
→ UNFAILED POINT INCLUDED
→X UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S_{MAX} (KSI)
84.0
72.0
60.0
48.0
36.0
24.0
12.0
0.0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

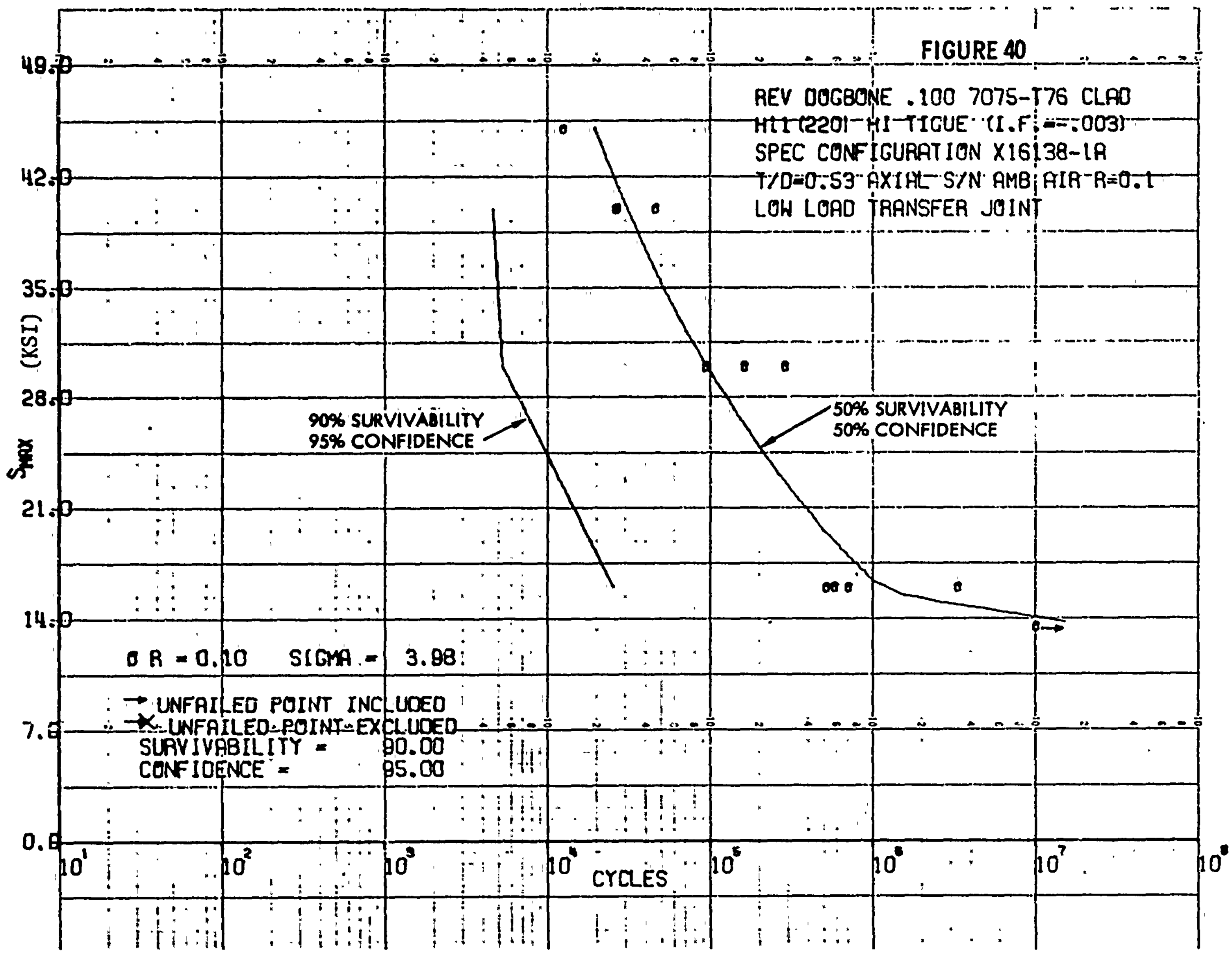


FIGURE 40
REV DOGBONE .100 7075-T76 CLAD
HI1 (220) HI TIGUE (I.F. = .003)
SPEC CONFIGURATION X16138-1A
T/D=0.53 AXIAL S/N AMB AIR R=0.1
LOW LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
R = 0.10 SIGMA = 3.98
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

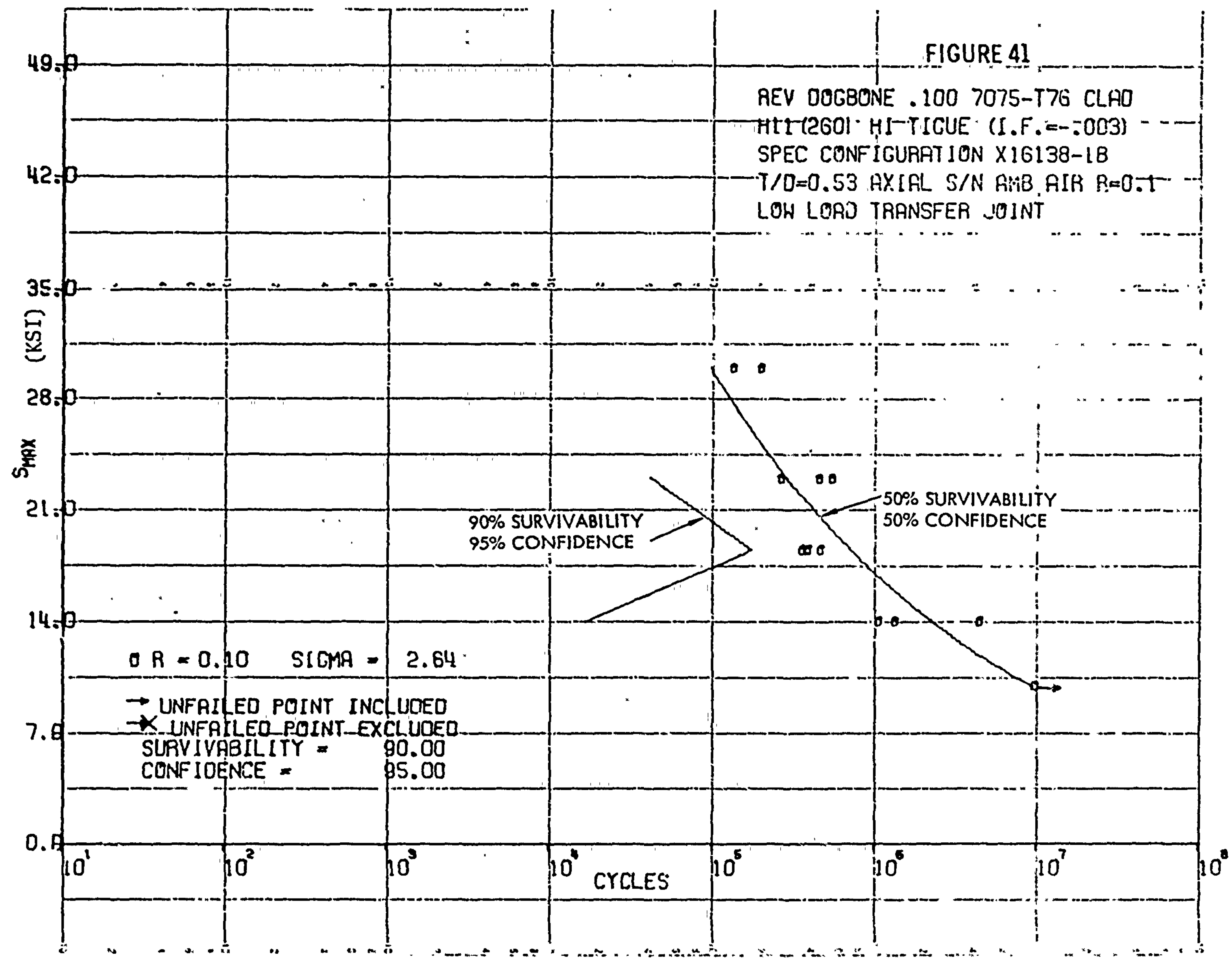


FIGURE 41
REV DOGBONE .100 7075-T76 CLAD
HI1 (260) HI-TIGUE (I.F.=-.003)
SPEC CONFIGURATION X16138-1B
T/D=0.53 AXIAL S/N AMB AIR R=0.1
LOW LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
R = 0.10 SIGMA = 2.64
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S MAX (KSI)
49.0
42.0
35.0
28.0
21.0
14.0
7.8
0.0
CYCLES
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8

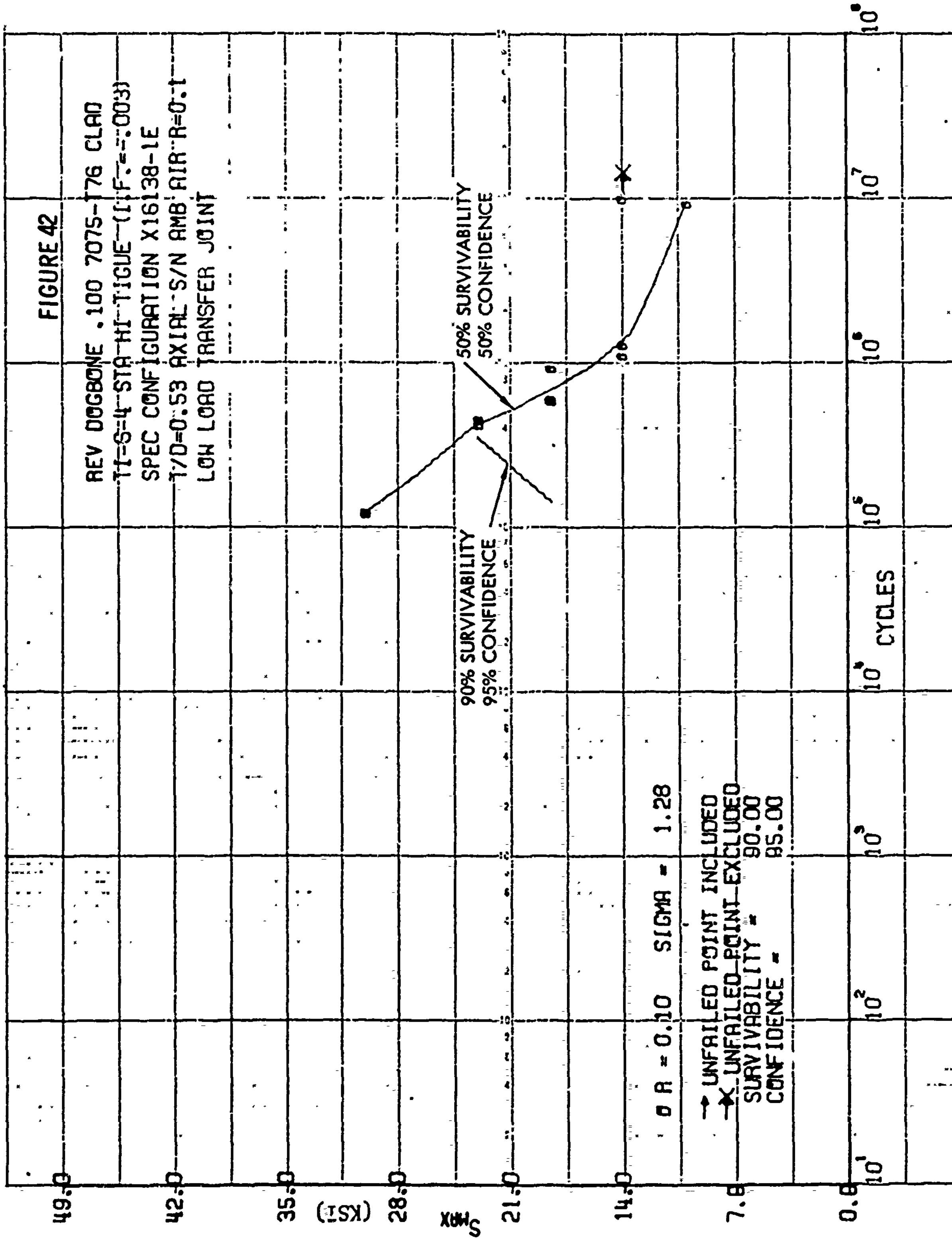


FIGURE 42
REV DOGBONE .100 7075-T76 CLAD
TI-S-4-STA-HI-TIGUE-(I.F.=-.003)
SPEC CONFIGURATION X16138-1E
T/D=0.53 AXIAL S/N AMB AIR R=0.1
LOW LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
R = 0.10 SIGMA = 1.28
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0
S MAX (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

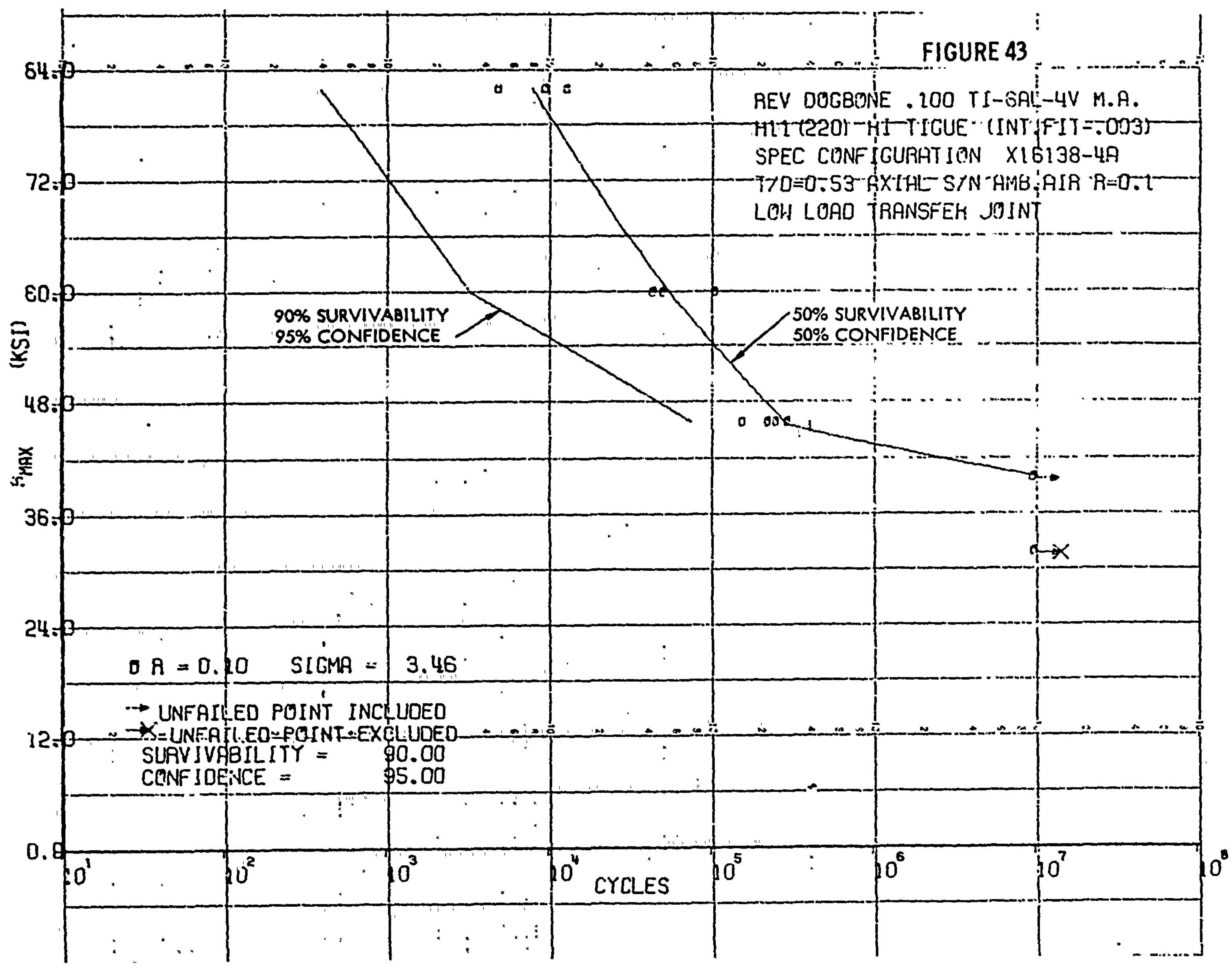

REV DOGBONE .100 TI-6AL-4V M.A.
H11(220) HI TIGUE (INT FIT=.003)
SPEC CONFIGURATION X16138-4A
T7D=0.53 AXIAL S/N AMB AIR R=0.1
LOW LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
R = 0.10 SIGMA = 3.46
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
84.0
72.0
60.0
48.0
36.0
24.0
12.0
0.8
(KSI)
S_{MAX}
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

FIGURE 43

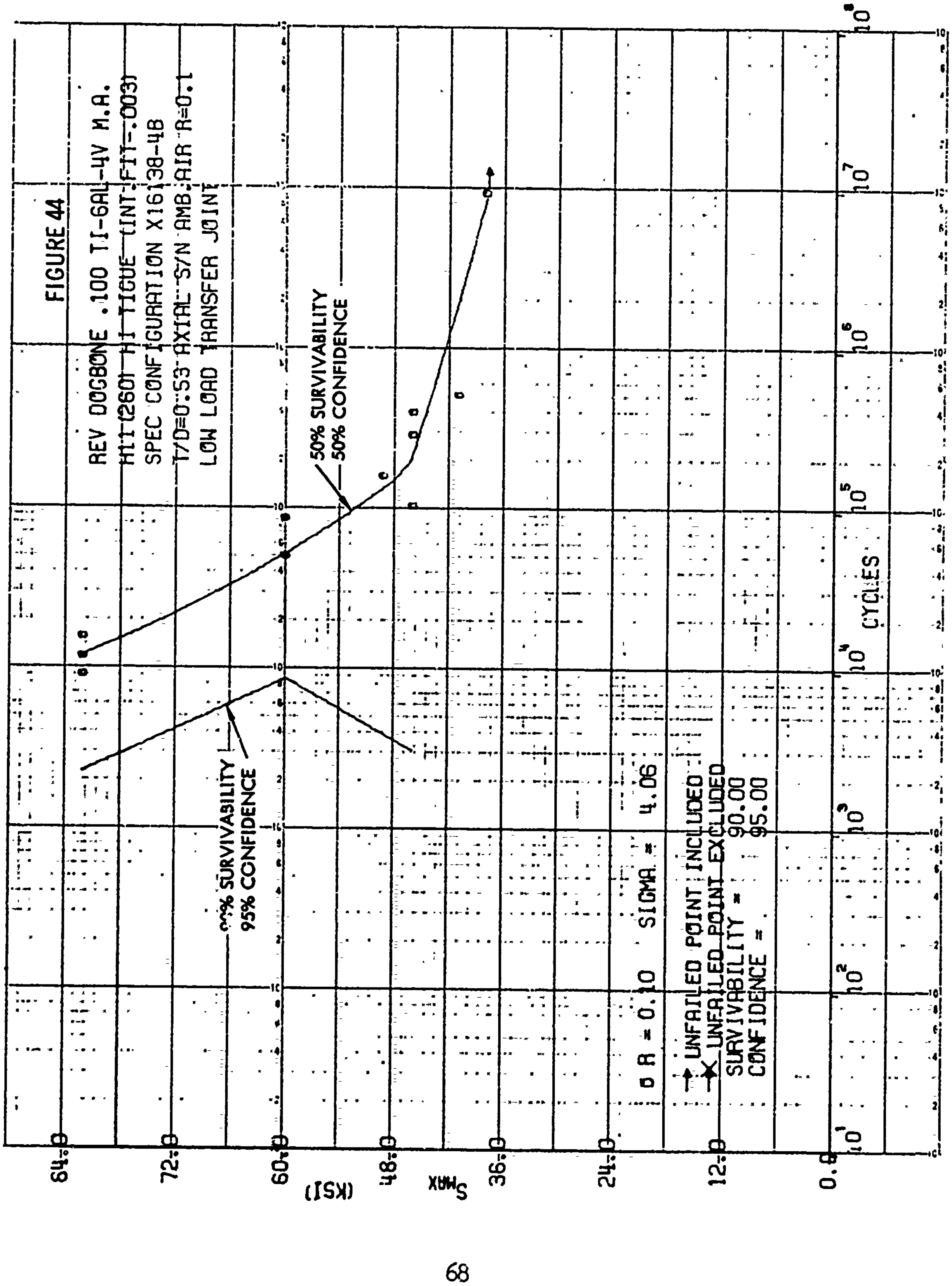


FIGURE 44
REV DOGBONE .100 TI-6AL-4V M.A.
HI (260) HI TIGUE (INT-FIT-.003)
SPEC CONFIGURATION X16138-4B
T/D=0.53 AXIAL S/N AMB AIR R=0.1
LOW LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
SURVIVABILITY
95% CONFIDENCE
R = 0.10 SIGMA = 4.06
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
CYCLES
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
84.0
72.0
60.0
48.0
36.0
24.0
12.0
0.0
S_{MAX} (KSI)

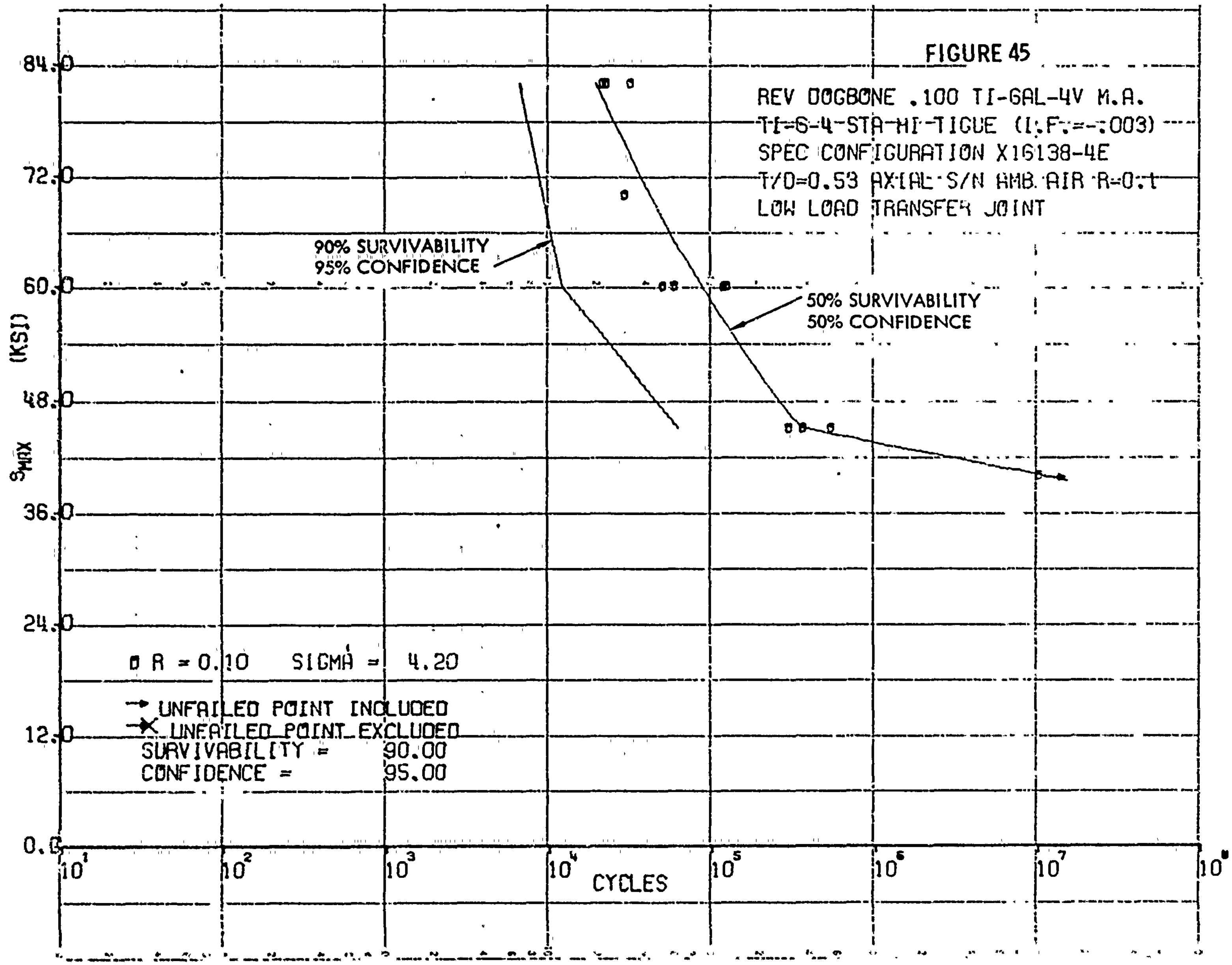


FIGURE 45
REV DOGBONE .100 TI-6AL-4V M.A.
TI-6-4-STA-HI-TIGUE (I.F.=-.003)
SPEC CONFIGURATION X16138-4E
T/D=0.53 AXIAL S/N AMB AIR R=0.1
LOW LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
84.0
72.0
60.0
48.0
36.0
24.0
12.0
0.0
(KSI)
S_{MAX}
R = 0.10 SIGMA = 4.20
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

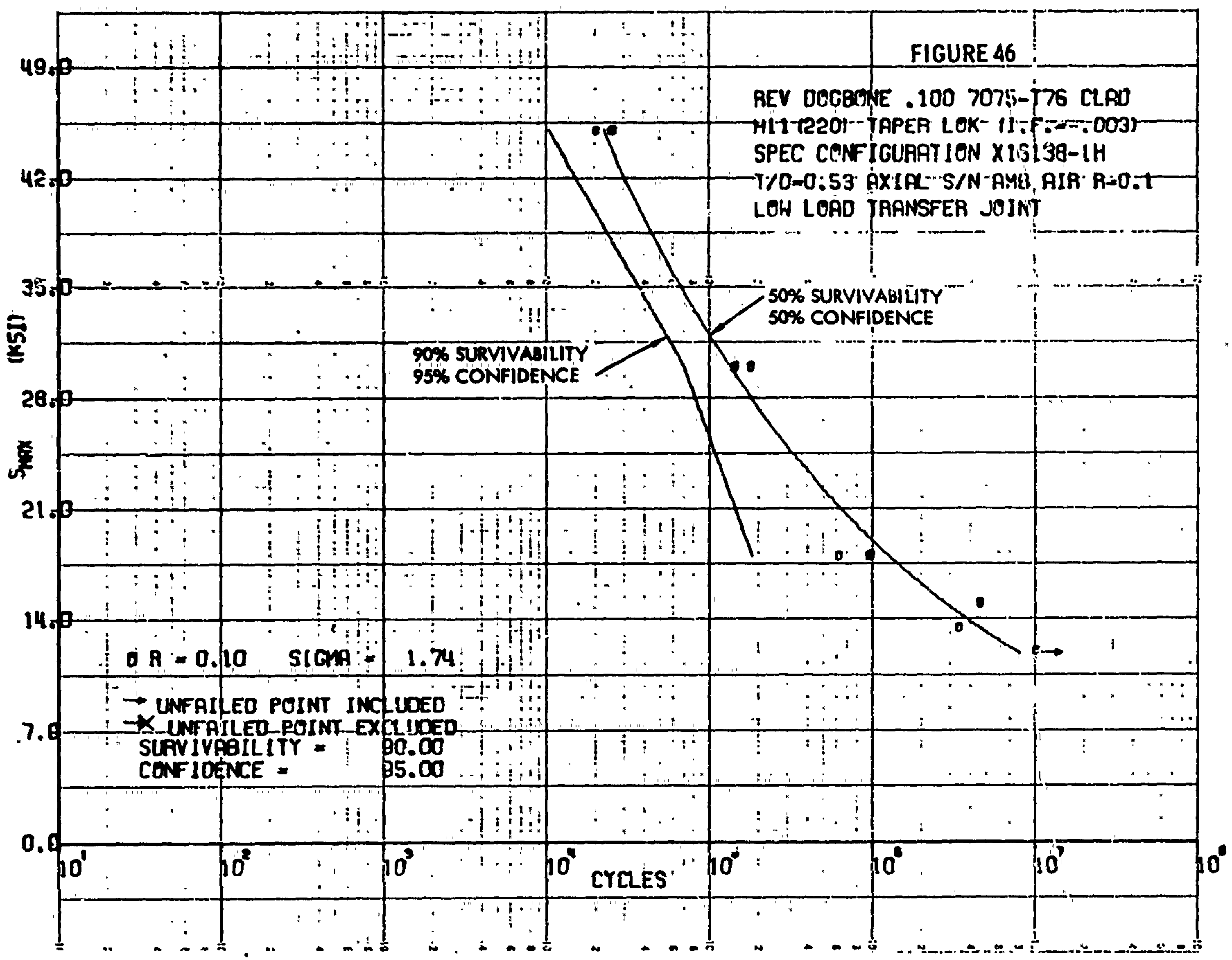


FIGURE 46
REV DOGBONE .100 7075-T76 CLAD
H11 (220) TAPER LOK (I.F.=-.003)
SPEC CONFIGURATION X1G138-1H
T/D=0.53 AXIAL S/N AMB AIR R=0.1
LOW LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
0 R = 0.10 SIGMA = 1.74
→ UNFAILED POINT INCLUDED
→X UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

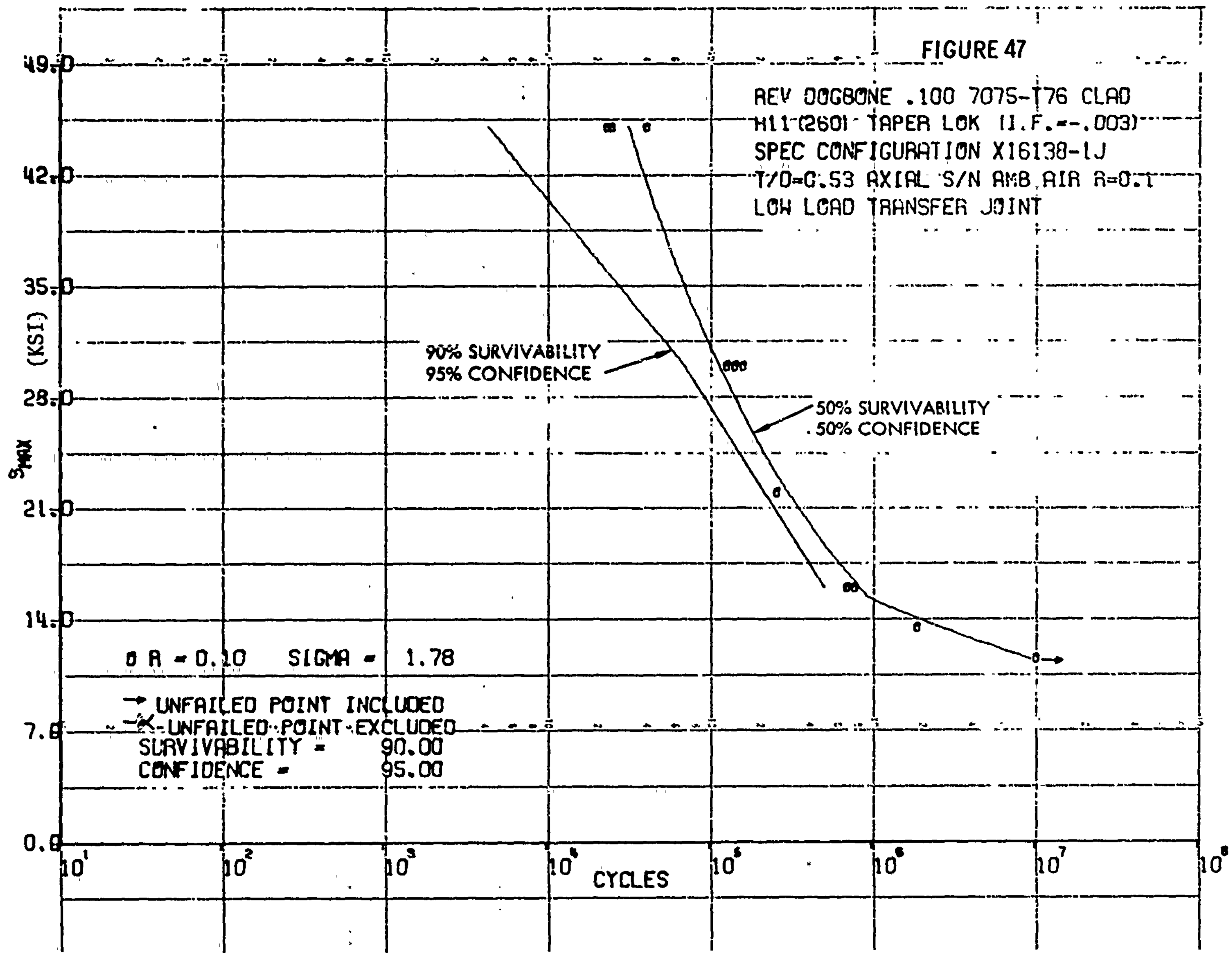


FIGURE 47
REV DOGBONE .100 7075-T76 CLAD
H11 (260) TAPER LOK (I.F.=-.003)
SPEC CONFIGURATION X16138-1J
T/D=0.53 AXIAL S/N AMB AIR R=0.1
LOW LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0
(KSI)
S_{MAX}
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES
0 R = 0.10 SIGMA = 1.78
→ UNFAILED POINT INCLUDED
→X UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00

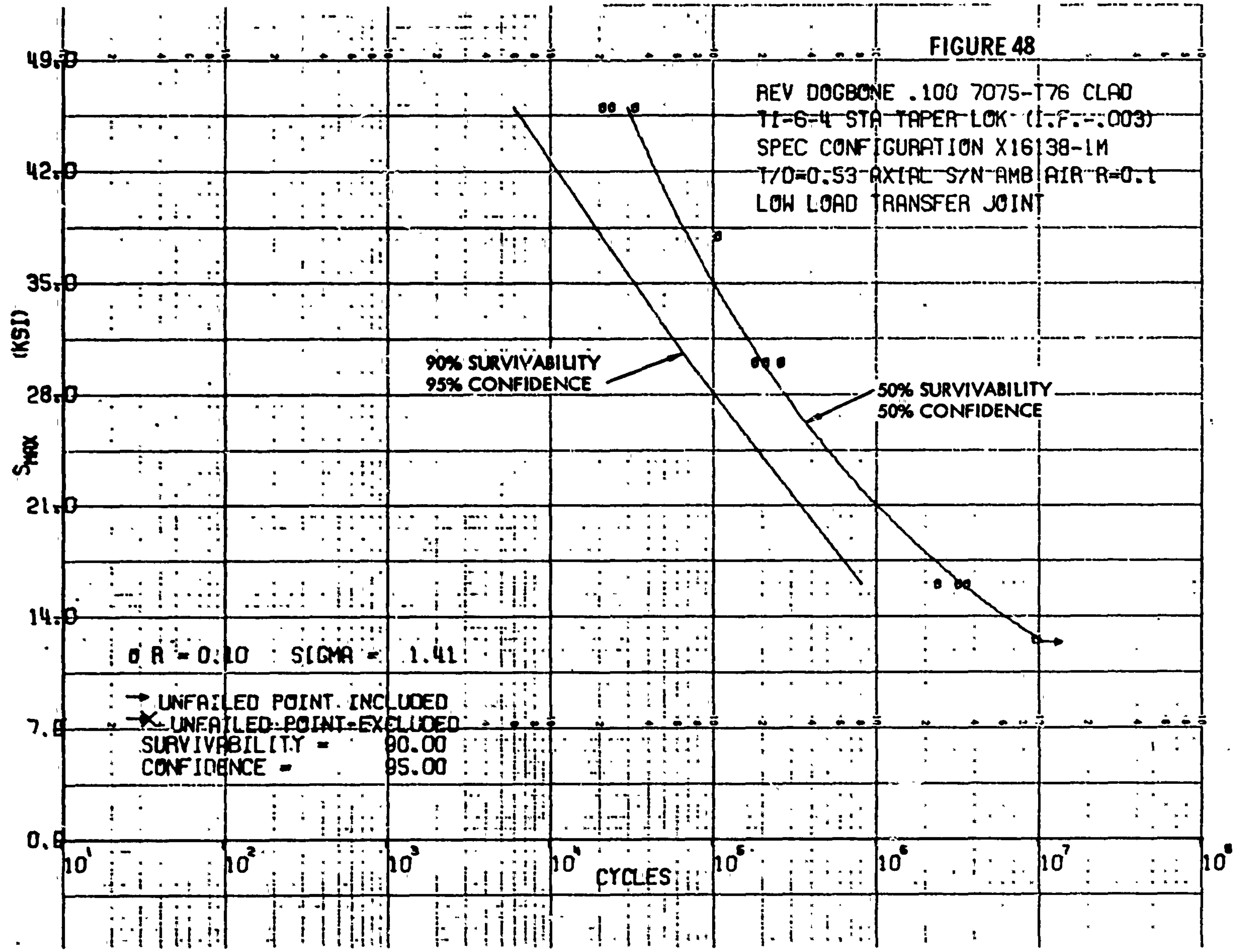


FIGURE 48
REV DOGBONE .100 7075-T76 CLAD
TI-6-4 STA TAPER-LOK (I.F.-.003)
SPEC CONFIGURATION X16138-1M
T/D=0.53 AXIAL S/N AMB AIR R=0.1
LOW LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
R = 0.10 SIGMA = 1.41
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

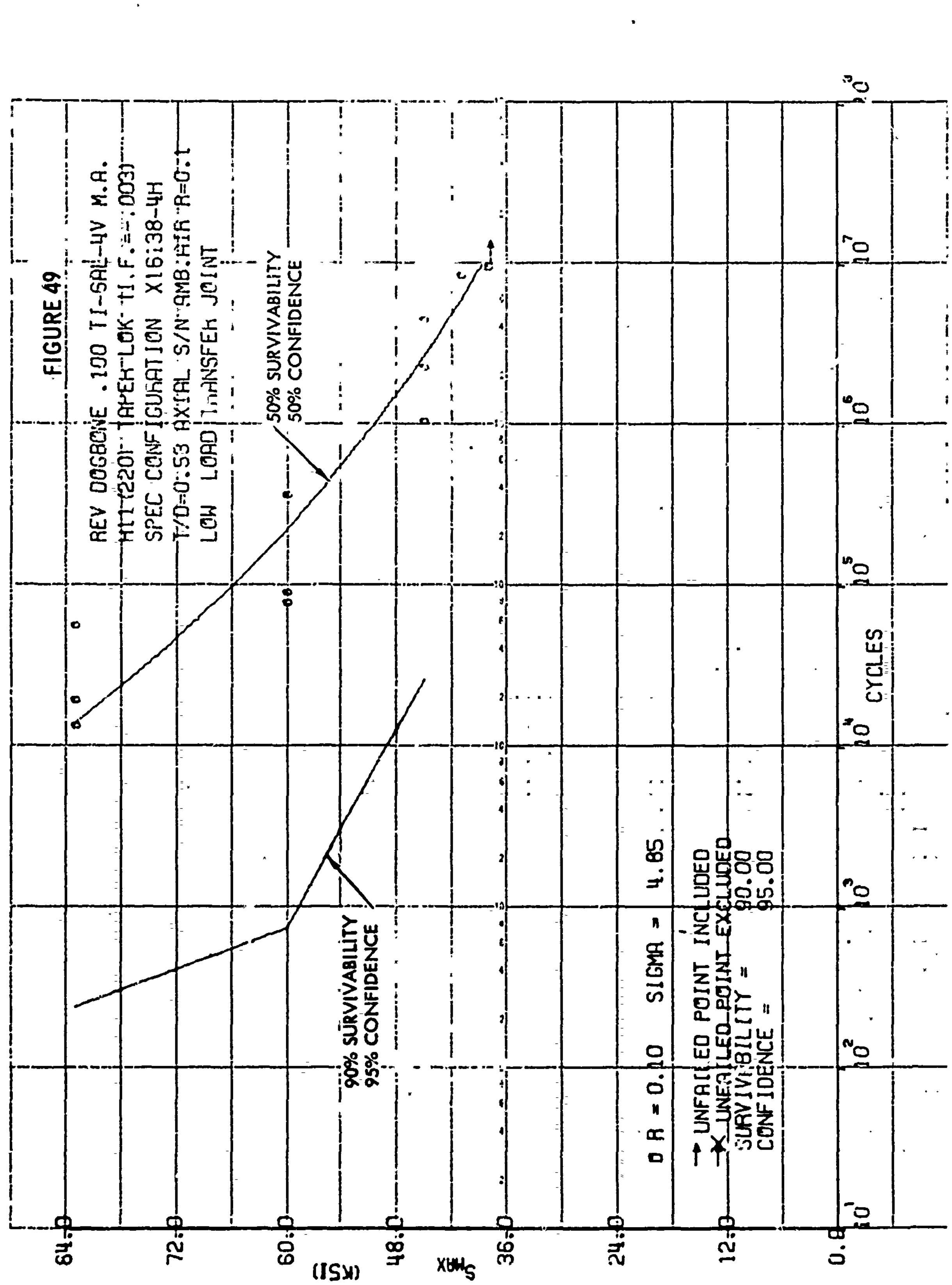


FIGURE 49
REV DOGBONE .100 TI-6AL-4V M.A.
HI-(220) TAPER-LOK (I.F.=-.003)
SPEC CONFIGURATION X16:38-4H
T/D=0.53 AXIAL S/N AMB.AIR R=0.1
LOW LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
R = 0.10 SIGMA = 4.85
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
CYCLES
S MAX (KSI)
0.0
12.0
24.0
36.0
48.0
60.0
72.0
84.0

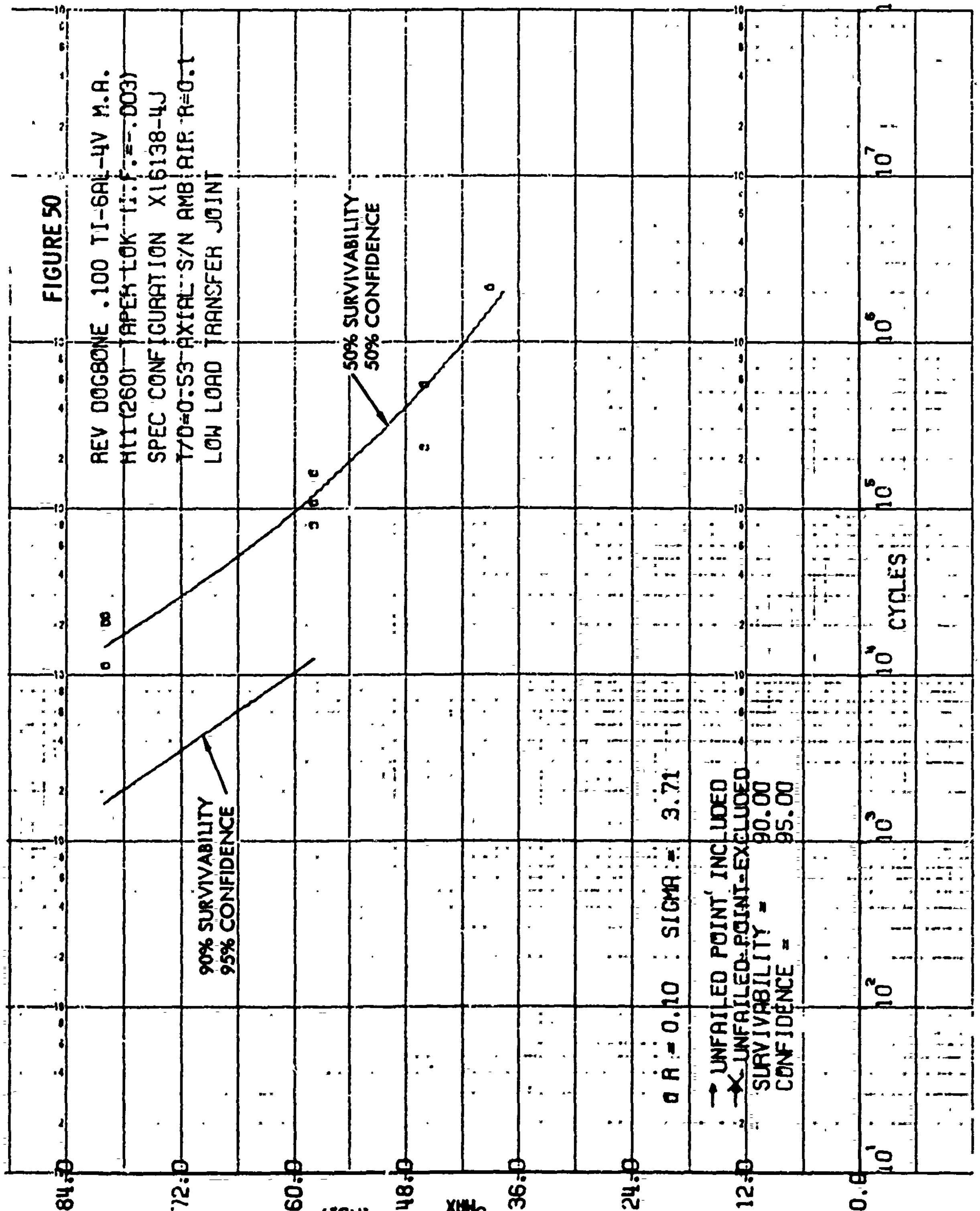


FIGURE 50
REV DOGBONE .100 TI-6AL-4V M.A.
HI1(2601-TAPER-LOK (I.F.=-.003)
SPEC CONFIGURATION X16138-4J
T/D=0.53 AXIAL S/N AMB AIR R=0.1
LOW LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
o R = 0.10 SIGMA = 3.71
→ UNFAILED POINT INCLUDED
→x UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S_MAX (KSI)
84.0
72.0
60.0
48.0
36.0
24.0
12.0
0.0
CYCLES
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8

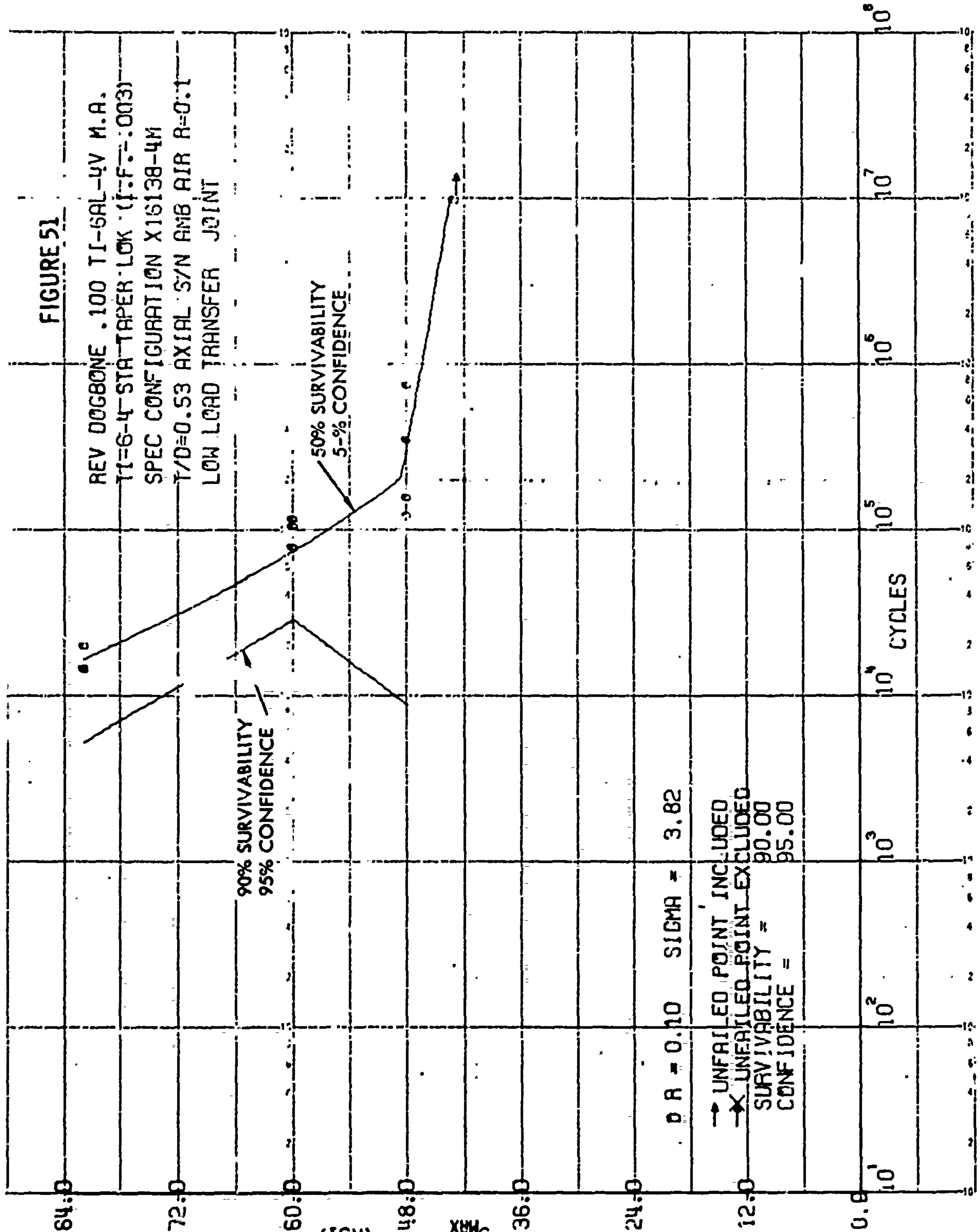


FIGURE 51
REV DOGBONE .100 TI-6AL-4V M.A.
TI=6-4 STA TAPER LOK (I.F.=.003)
SPEC CONFIGURATION X16138-4M
T/D=0.53 AXIAL S/N AMB AIR R=0.1
LOW LOAD TRANSFER JOINT
50% SURVIVABILITY
5-% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
R = 0.10 SIGMA = 3.82
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S_{MAX} (KSI)
CYCLES

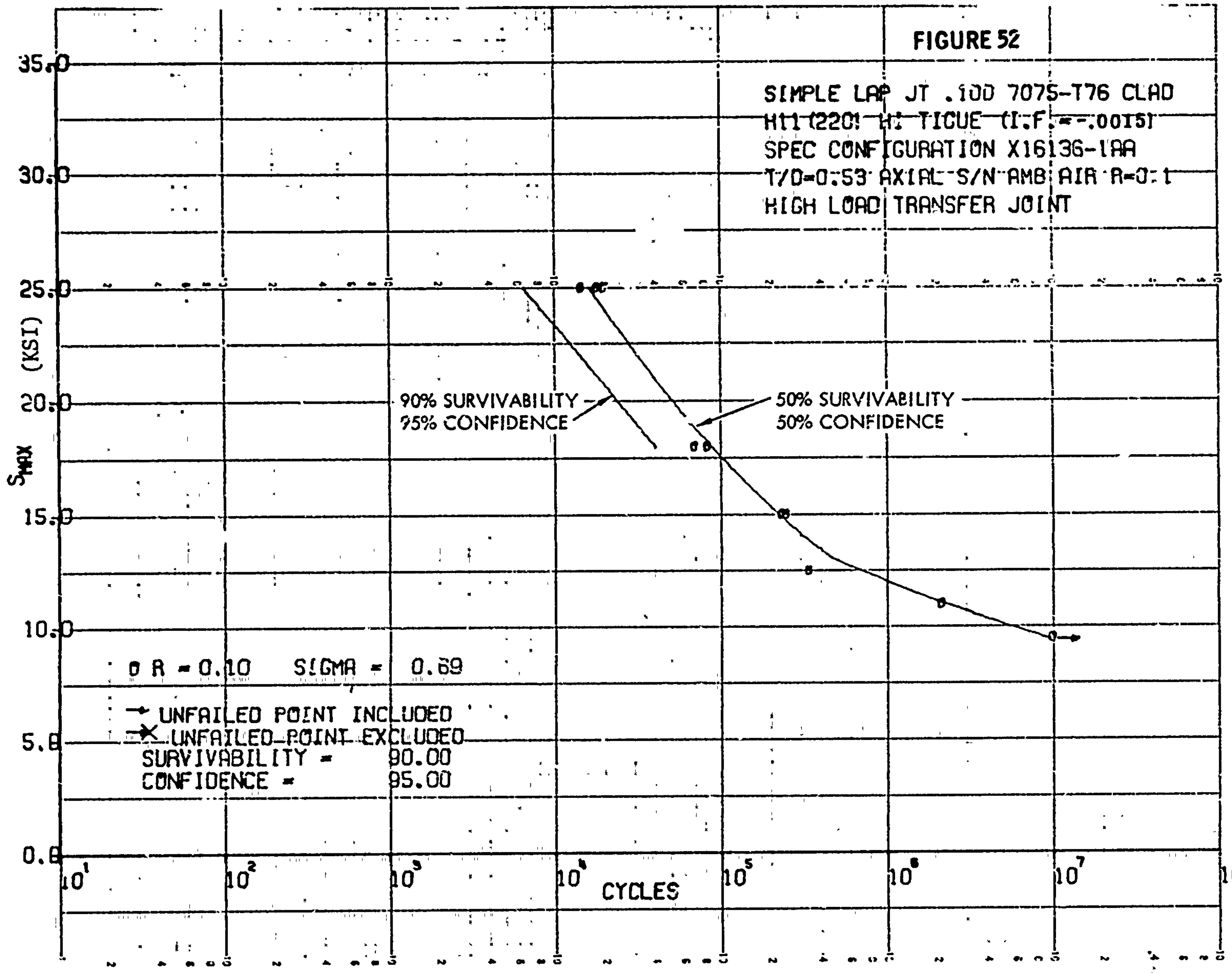


FIGURE 52
SIMPLE LAP JT .100 7075-T76 CLAD
H11 (220) HI TIGUE (I.F. = -.0015)
SPEC CONFIGURATION X16136-1AA
T/D=0.53 AXIAL S/N AMB AIR R=0.1
HIGH LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
0 R = 0.10 SIGMA = 0.69
→ UNFAILED POINT INCLUDED
→X UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S MAX (KSI)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
CYCLES

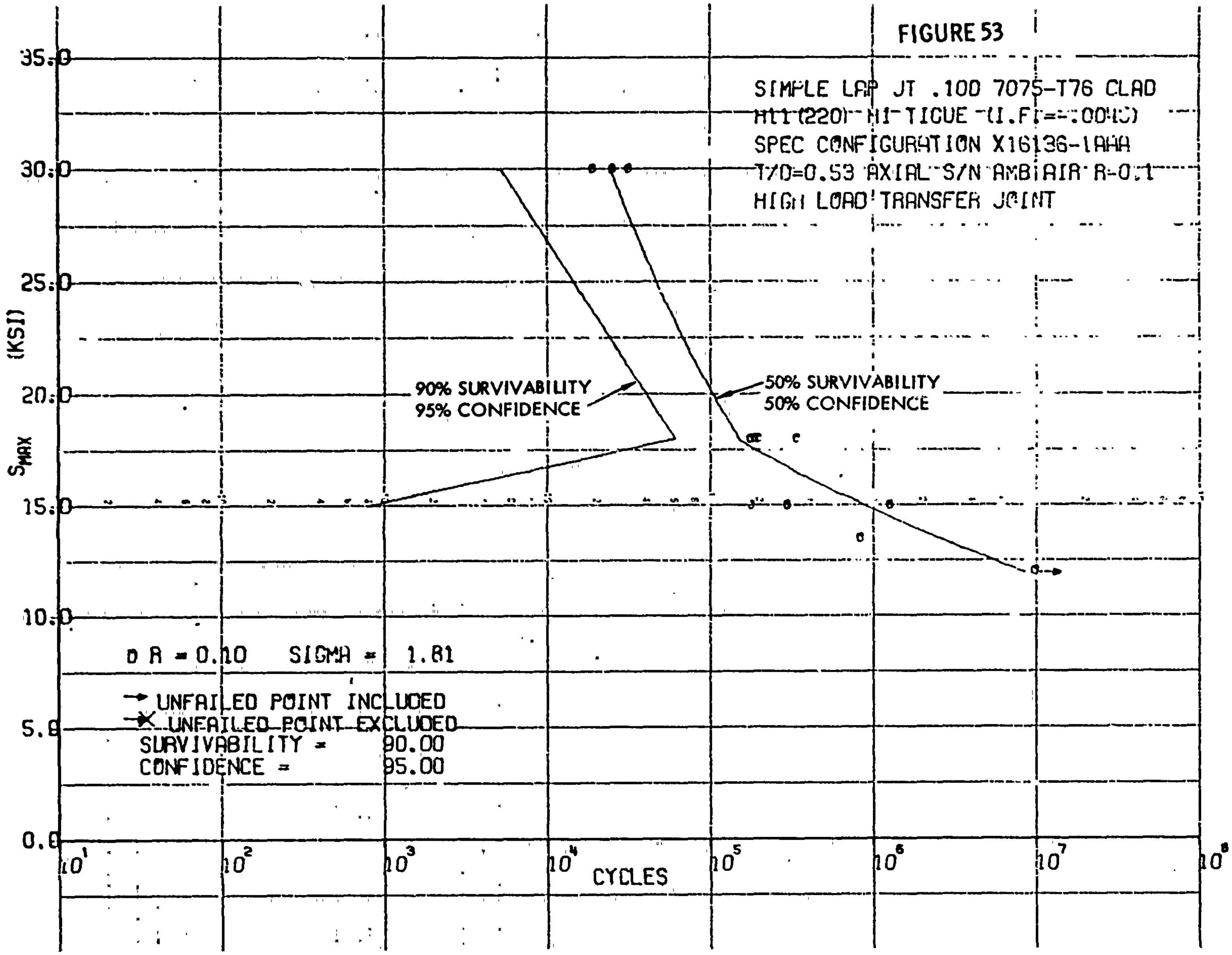


FIGURE 53
SIMPLE LAP JT .100 7075-T76 CLAD
HI1(220)-HI-TIGUE (I.F=-.0040)
SPEC CONFIGURATION X16136-1AAA
T/D=0.53 AXIAL S/N AMBIAIR R-0.1
HIGH LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
o R = 0.10 SIGMA = 1.81
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S_MAX (KSI)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
CYCLES

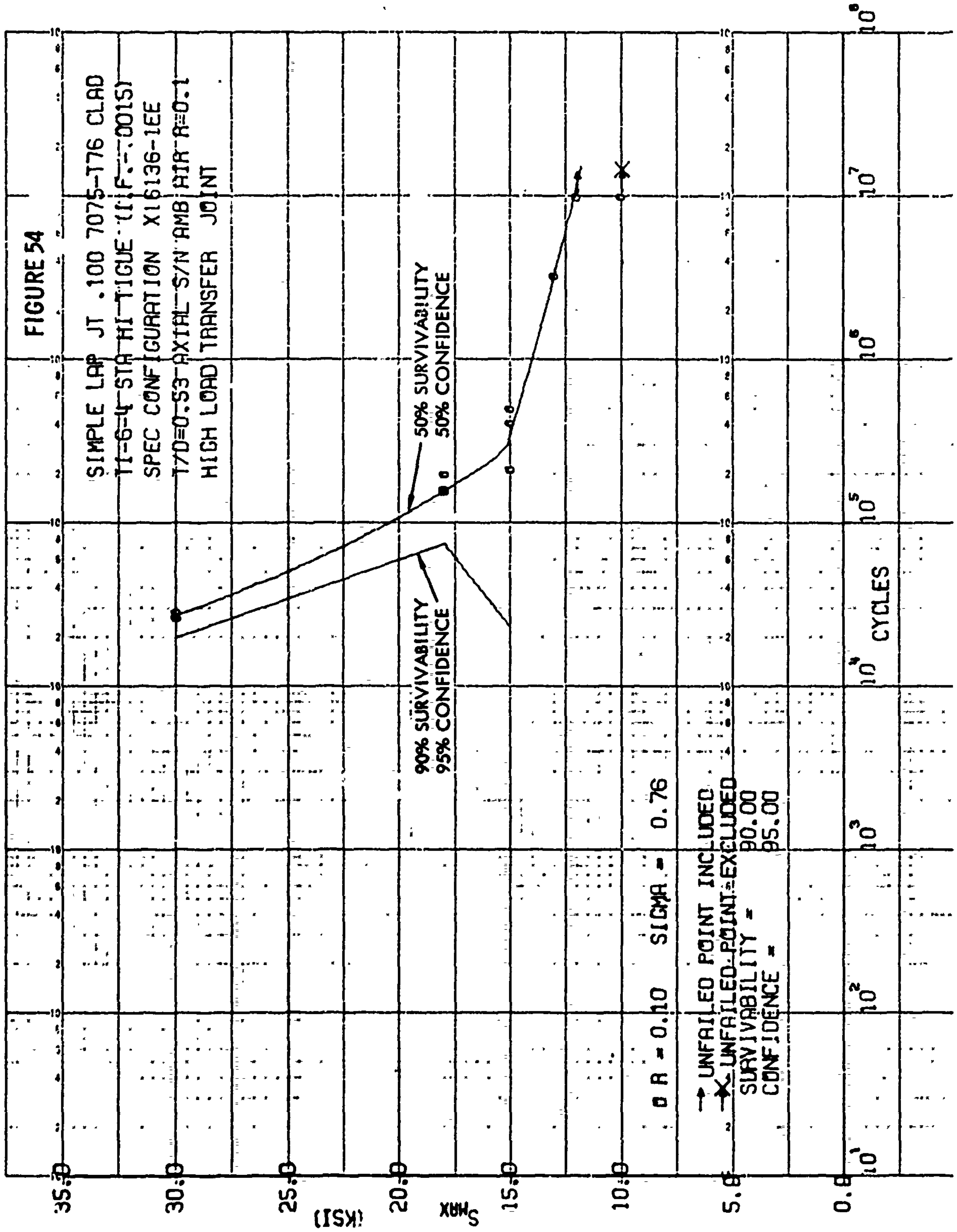


FIGURE 54
SIMPLE LAP JT .100 7075-T76 CLAD
TI-6-4 STA HI-TIGUE (I.F.=.0015)
SPEC CONFIGURATION X16136-1EE
T/D=0.53 AXIAL S/N AMB AIR R=0.1
HIGH LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
□ R = 0.10 SIGMA = 0.76
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
CYCLES
S MAX (KSI)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0

FIGURE 55

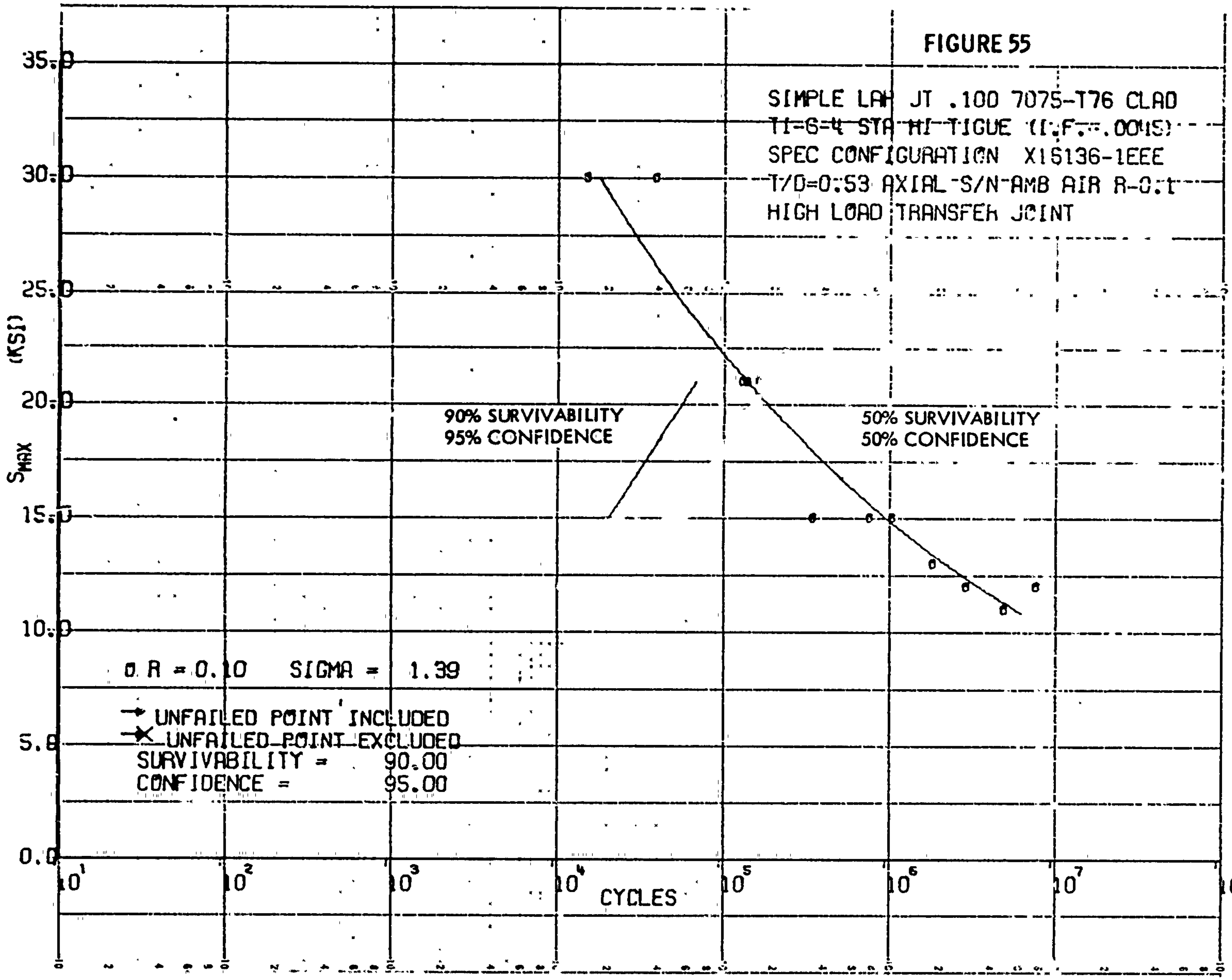
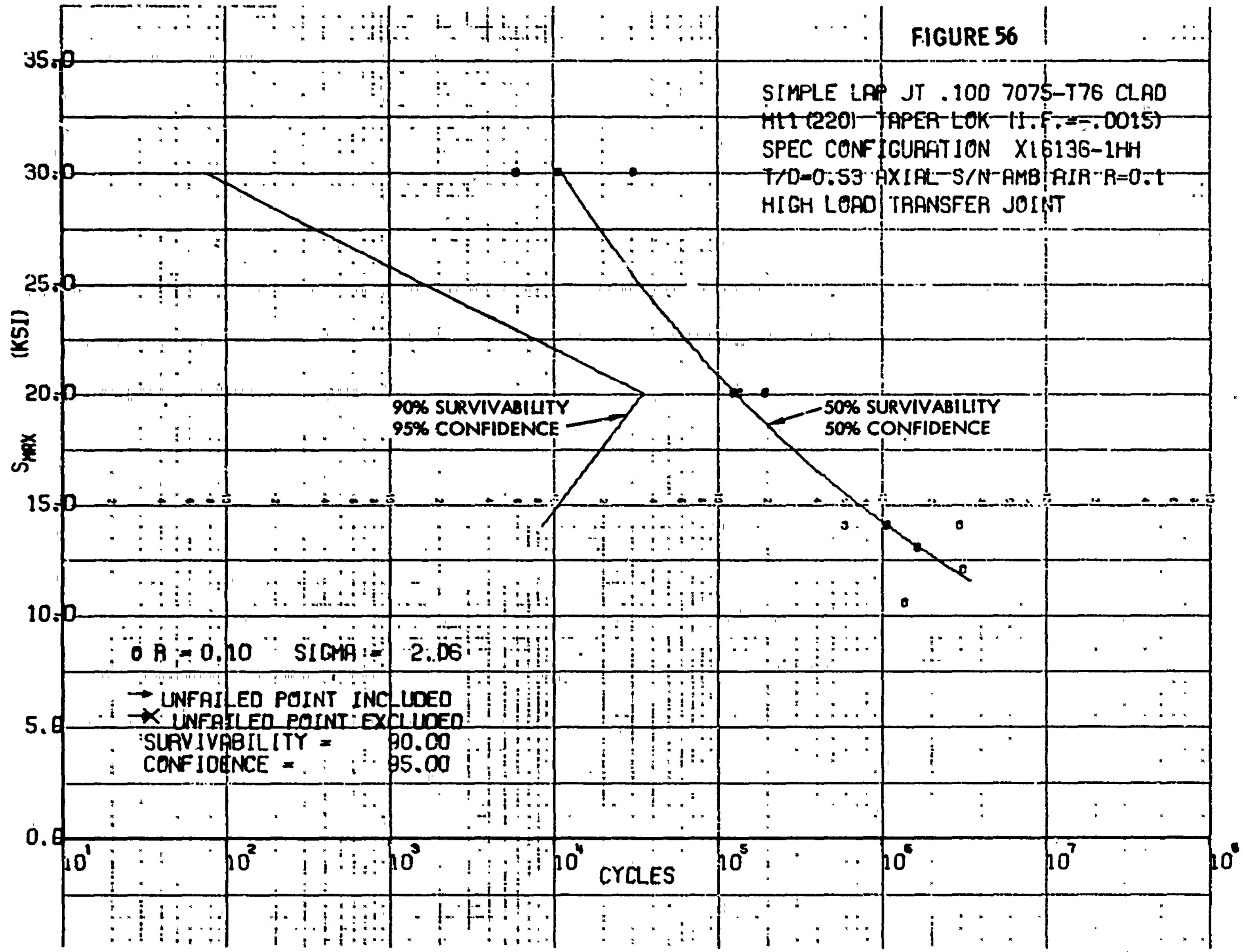

SIMPLE LAP JT .100 7075-T76 CLAD
TI-6-4 STA HI-TIGUE (I.F.=.0045)
SPEC CONFIGURATION X15136-1EEE
T/D=0.53 AXIAL-S/N-AMB AIR R-0.1
HIGH LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
R = 0.10 SIGMA = 1.39
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S_{MAX} (KSI)
CYCLES
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8

FIGURE 56


SIMPLE LAP JT .100 7075-T76 CLAD
Hl1 (220) TAPER LOK (I.F.=-.0015)
SPEC CONFIGURATION X16136-1HH
T/D=0.53 AXIAL S/N AMB AIR R=0.1
HIGH LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
o R = 0.10 SIGMA = 2.06
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

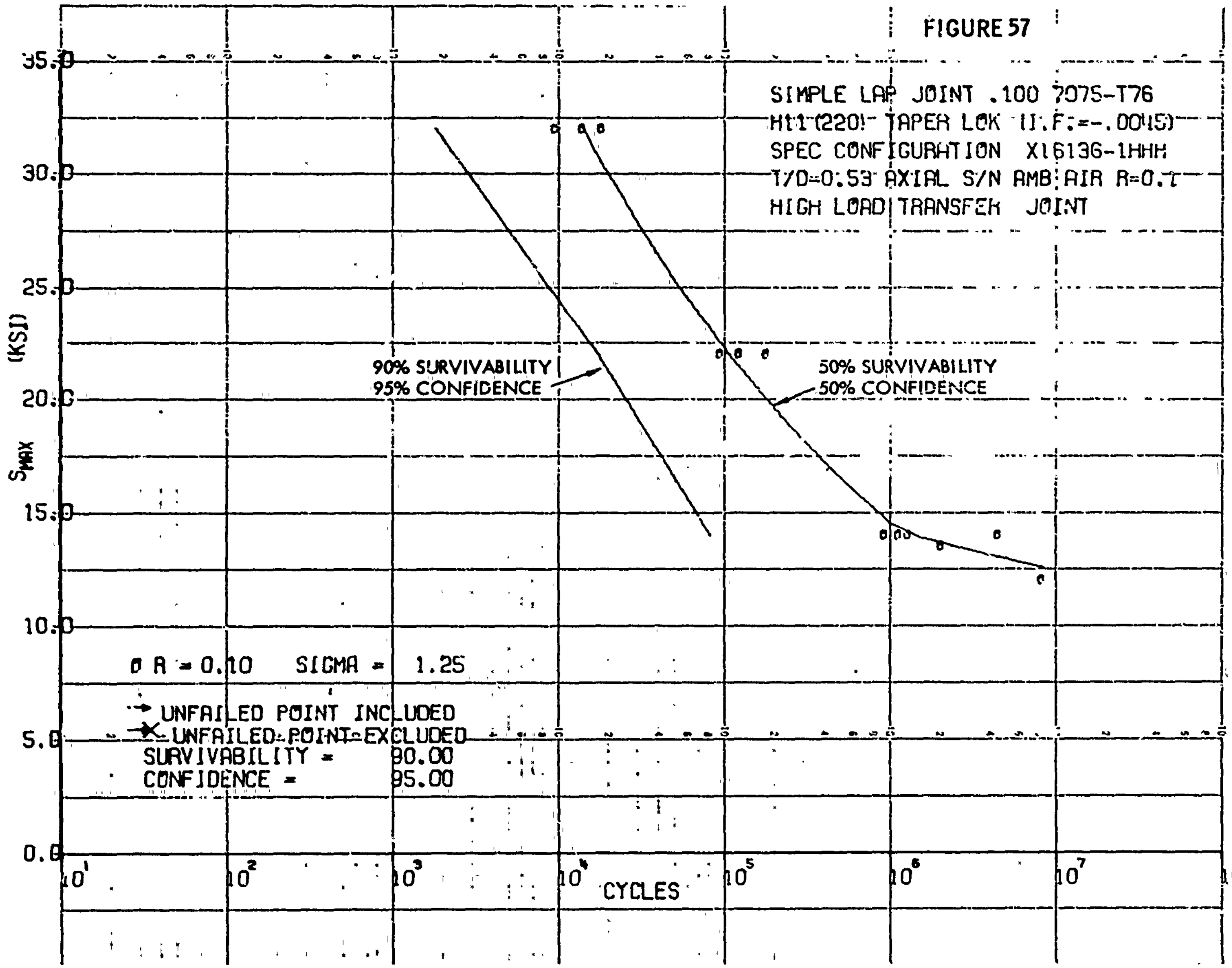


FIGURE 57
SIMPLE LAP JOINT .100 7075-T76
H11 (220) TAPER LOK (I.F.=-.0045)
SPEC CONFIGURATION X16136-1HHH
T/D=0.53 AXIAL S/N AMB AIR R=0.1
HIGH LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
R = 0.10 SIGMA = 1.25
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S_{MAX} (KSI)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

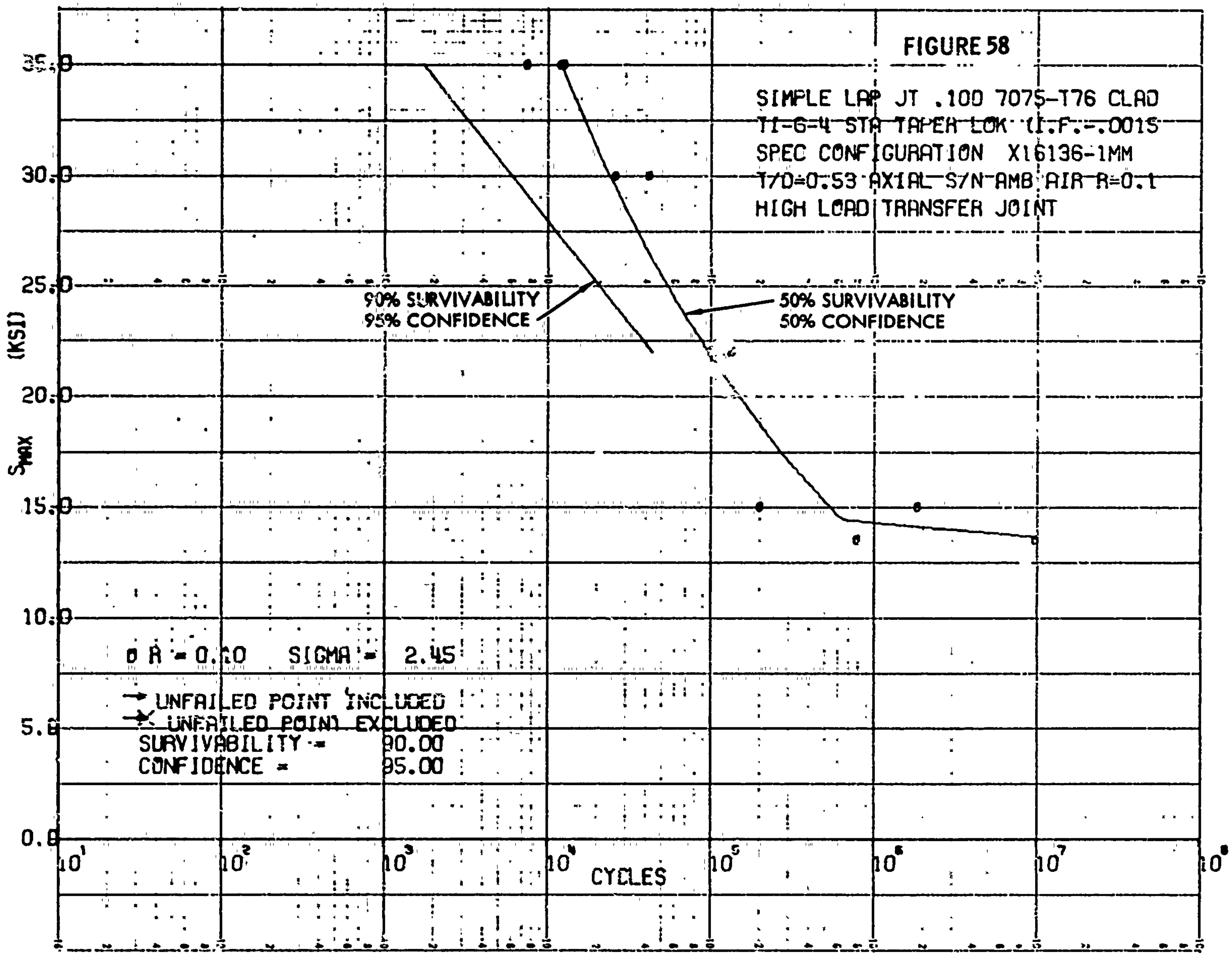


FIGURE 58
SIMPLE LAP JT .100 7075-T76 CLAD
TI-6-4 STA TAPER LOK (I.F.-.0015
SPEC CONFIGURATION X16136-1MM
T/D=0.53 AXIAL S/N AMB AIR R=0.1
HIGH LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
R = 0.10 SIGMA = 2.45
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S MAX (KSI)
CYCLES

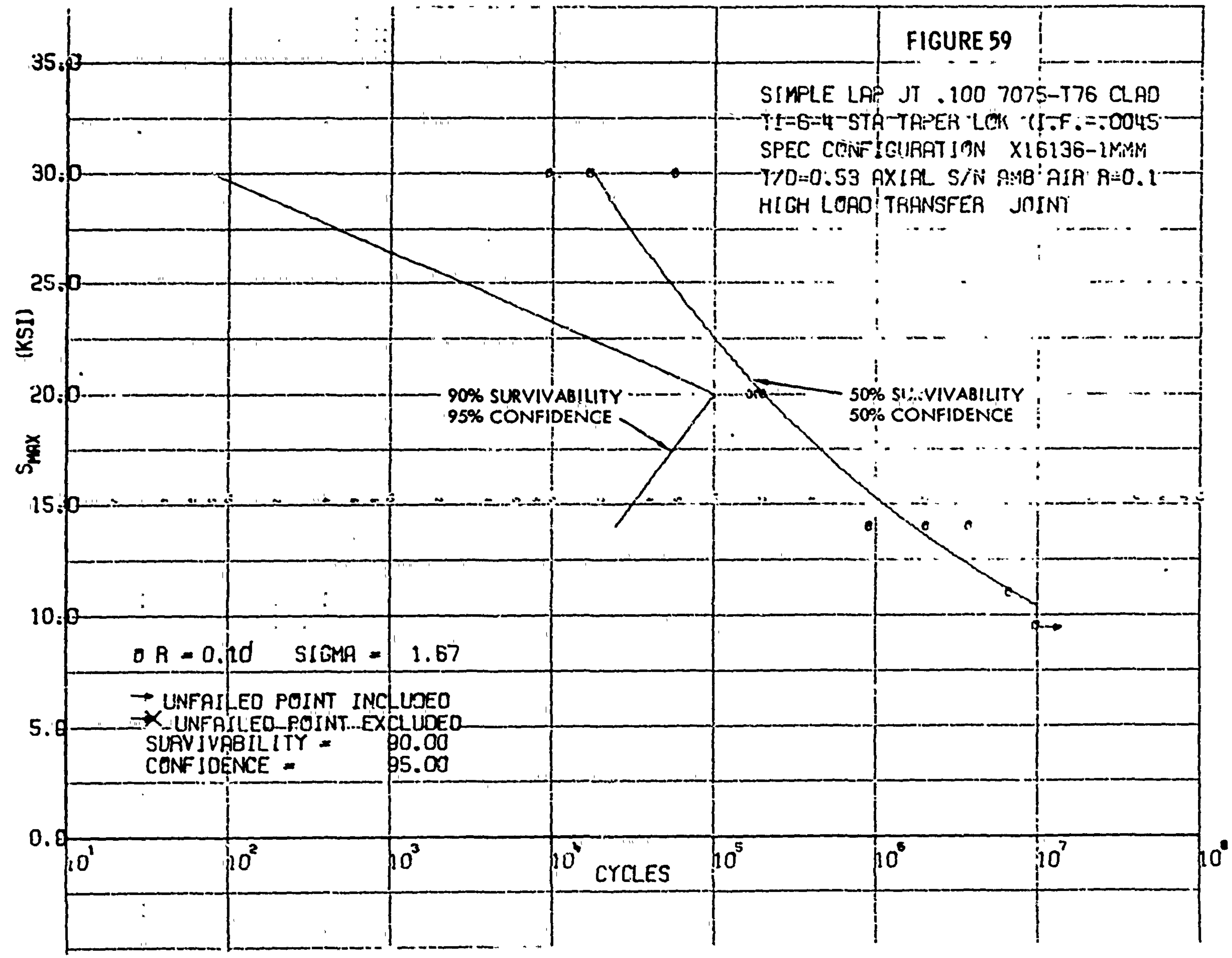


FIGURE 59
SIMPLE LAP JT .100 7075-T76 CLAD
TI=6-4 STA TAPER LOK (I.F.=.0045
SPEC CONFIGURATION X16136-1MMM
T/D=0.53 AXIAL S/N AMB AIR R=0.1
HIGH LOAD TRANSFER JOINT
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
S_{MAX} (KSI)
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
R = 0.10 SIGMA = 1.67
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

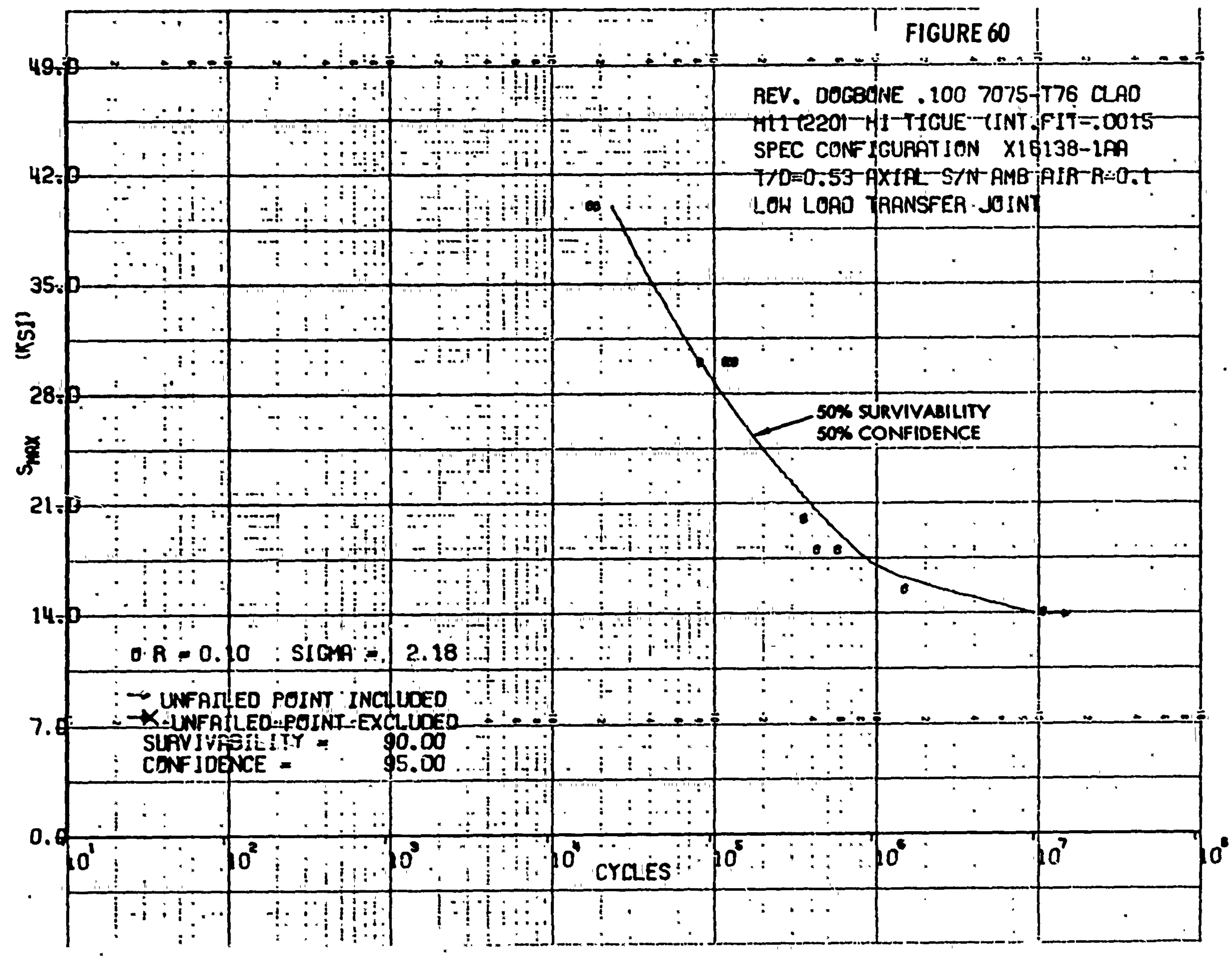


FIGURE 60
REV. DOGBONE .100 7075-T76 CLAD
H11 (220) HI-TIGUE (INT. FIT=.0015
SPEC CONFIGURATION X16138-1AA
T/D=0.53 AXIAL S/N AMB AIR R=0.1
LOW LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0
S MAX (KSI)
R = 0.10 SIGMA = 2.18
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
10¹
10²
10³
10⁴
10⁵
10⁶
10⁷
10⁸
CYCLES

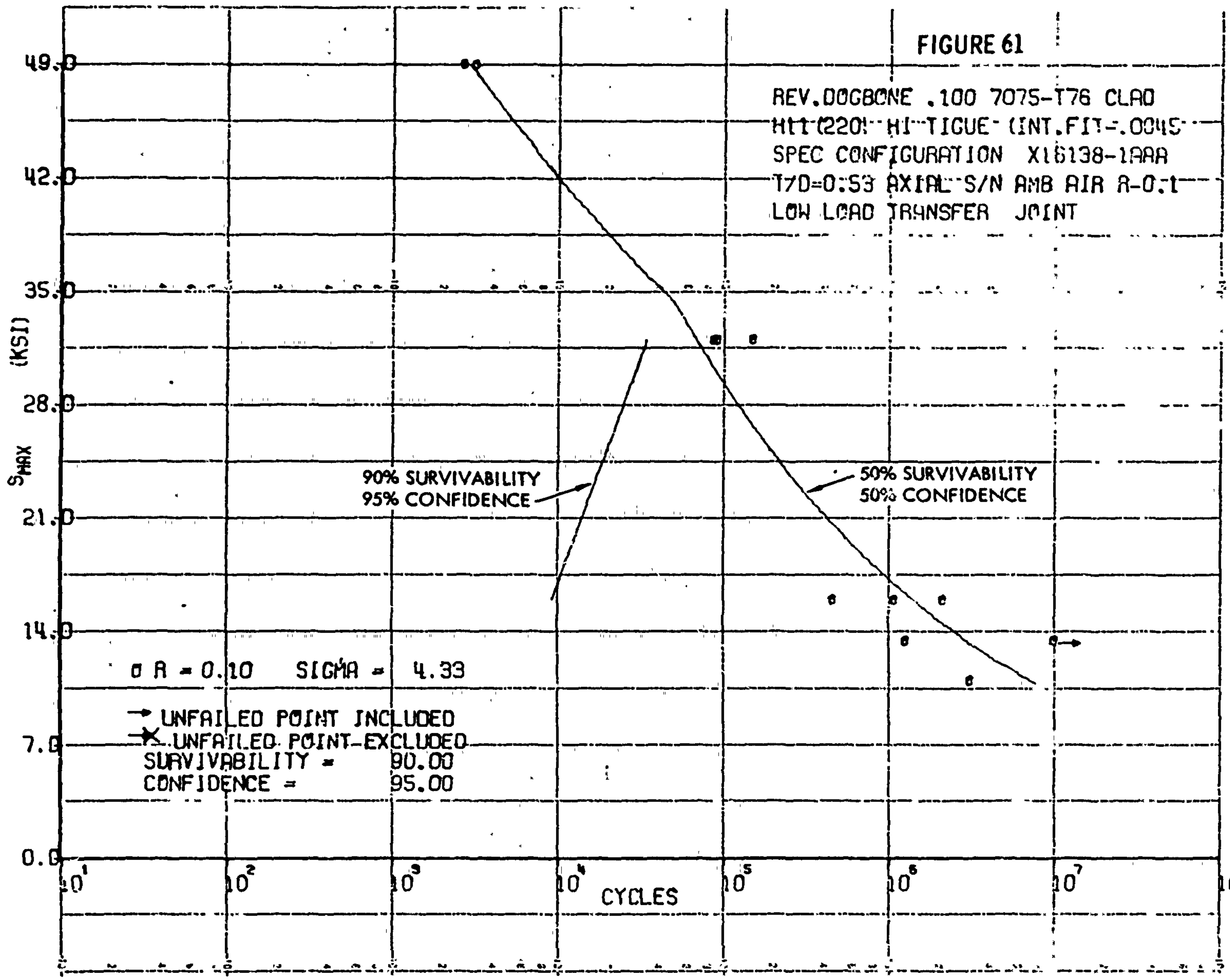


FIGURE 61
REV.DOGBONE .100 7075-T76 CLAD
HI1 (220) HI-TIGUE (INT.FIT=.0045
SPEC CONFIGURATION X16138-1AAA
T/D=0.53 AXIAL S/N AMB AIR R=0.1
LOW LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
R = 0.10 SIGMA = 4.33
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S_{MAX} (KSI)
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

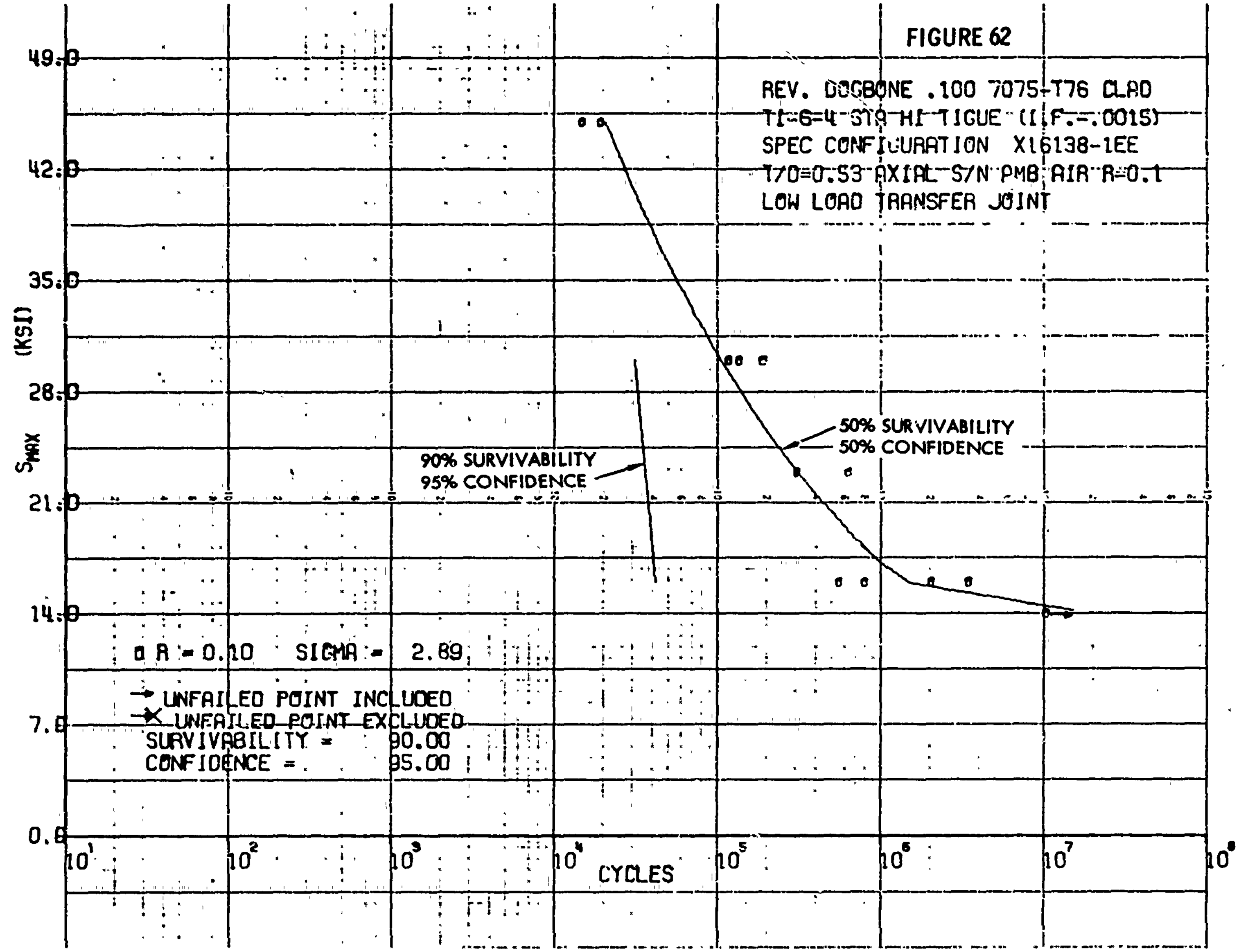

REV. DOGBONE .100 7075-T76 CLAD
TI-6-4 STA HI TIGUE (I.F.-.0015)
SPEC CONFIGURATION X16138-1EE
T/D=0.53 AXIAL S/N PMB AIR R=0.1
LOW LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES
□ R = 0.10 SIGMA = 2.89
→ UNFAILED POINT INCLUDED
→✕ UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00

FIGURE 62

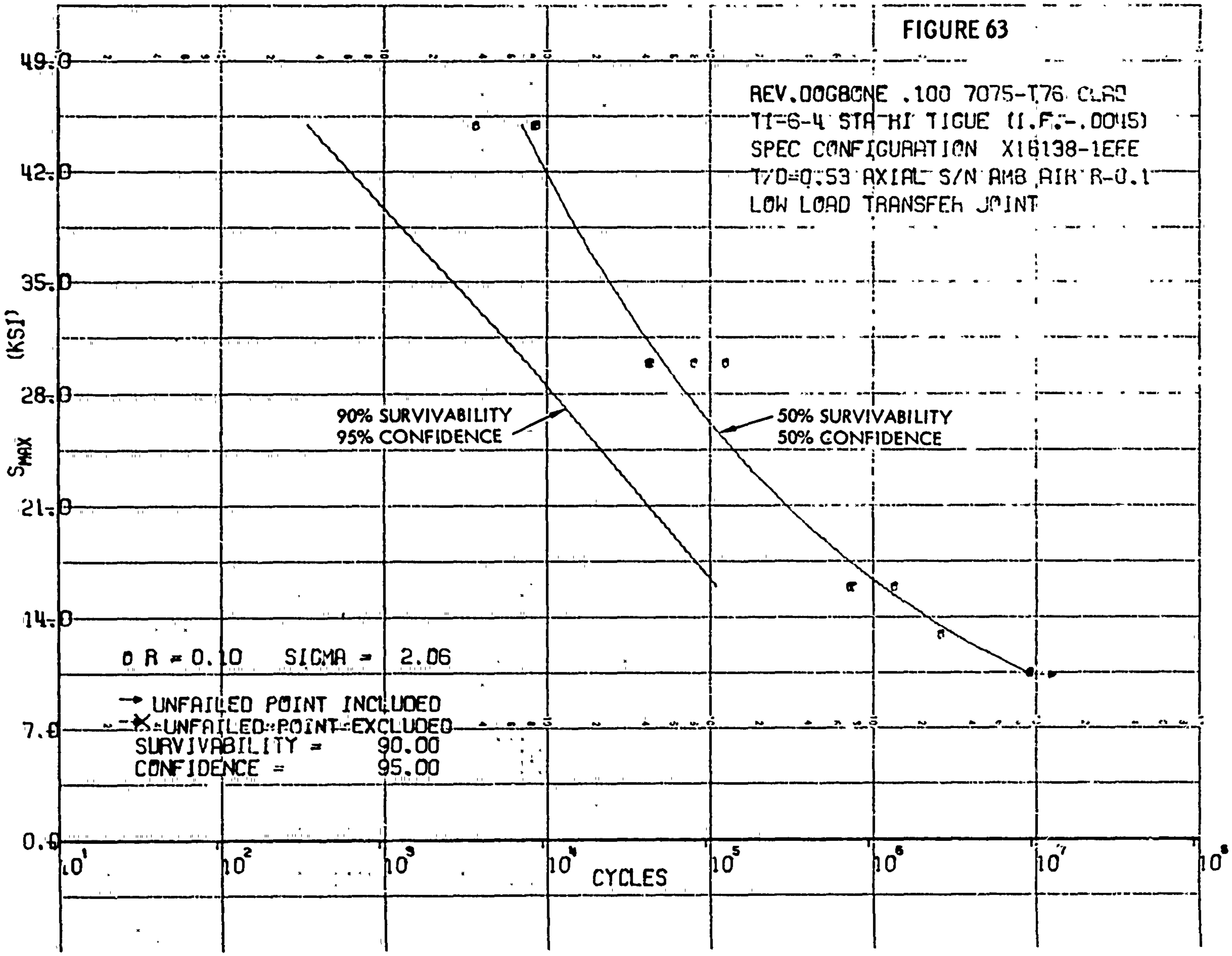

REV.DOGBONE .100 7075-T76 CLAD
TI-6-4 STA HI TIGUE (I.F.-.0045)
SPEC CONFIGURATION X16138-1EEE
T/D=0.53 AXIAL S/N AMB AIR R-0.1
LOW LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
0 R = 0.10 SIGMA = 2.06
→ UNFAILED POINT INCLUDED
✕ UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S_{MAX} (KSI)
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0
CYCLES
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8

FIGURE 63

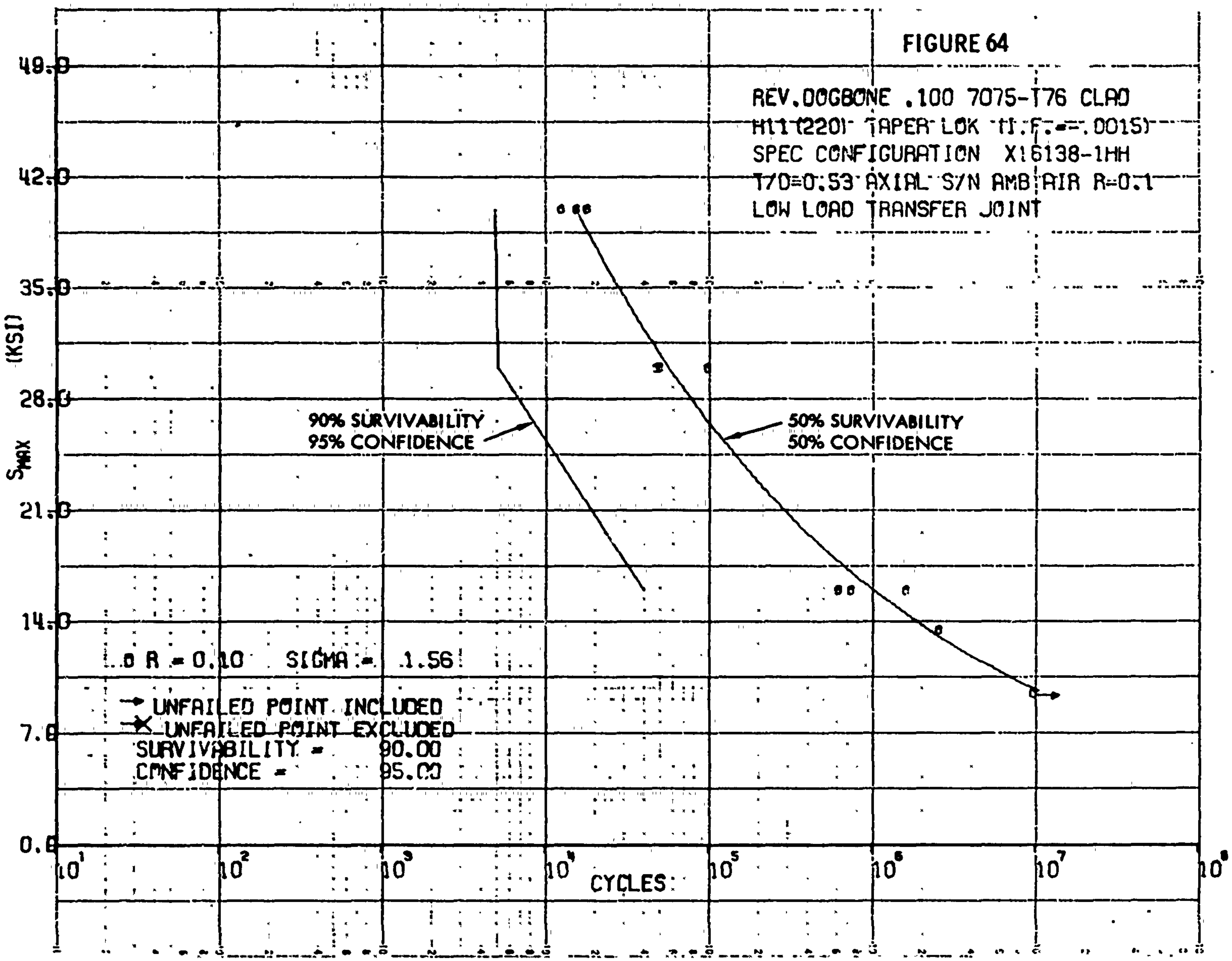


FIGURE 64
REV.DOGBONE .100 7075-T76 CLAD
H11 (220) TAPER LOK (I.F. = .0015)
SPEC CONFIGURATION X16138-1HH
T/D=0.53 AXIAL S/N AMB AIR R=0.1
LOW LOAD TRANSFER JOINT
90% SURVIVABILITY
95% CONFIDENCE
50% SURVIVABILITY
50% CONFIDENCE
R = 0.10 SIGMA = 1.56
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S MAX (KSI)
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0
CYCLES

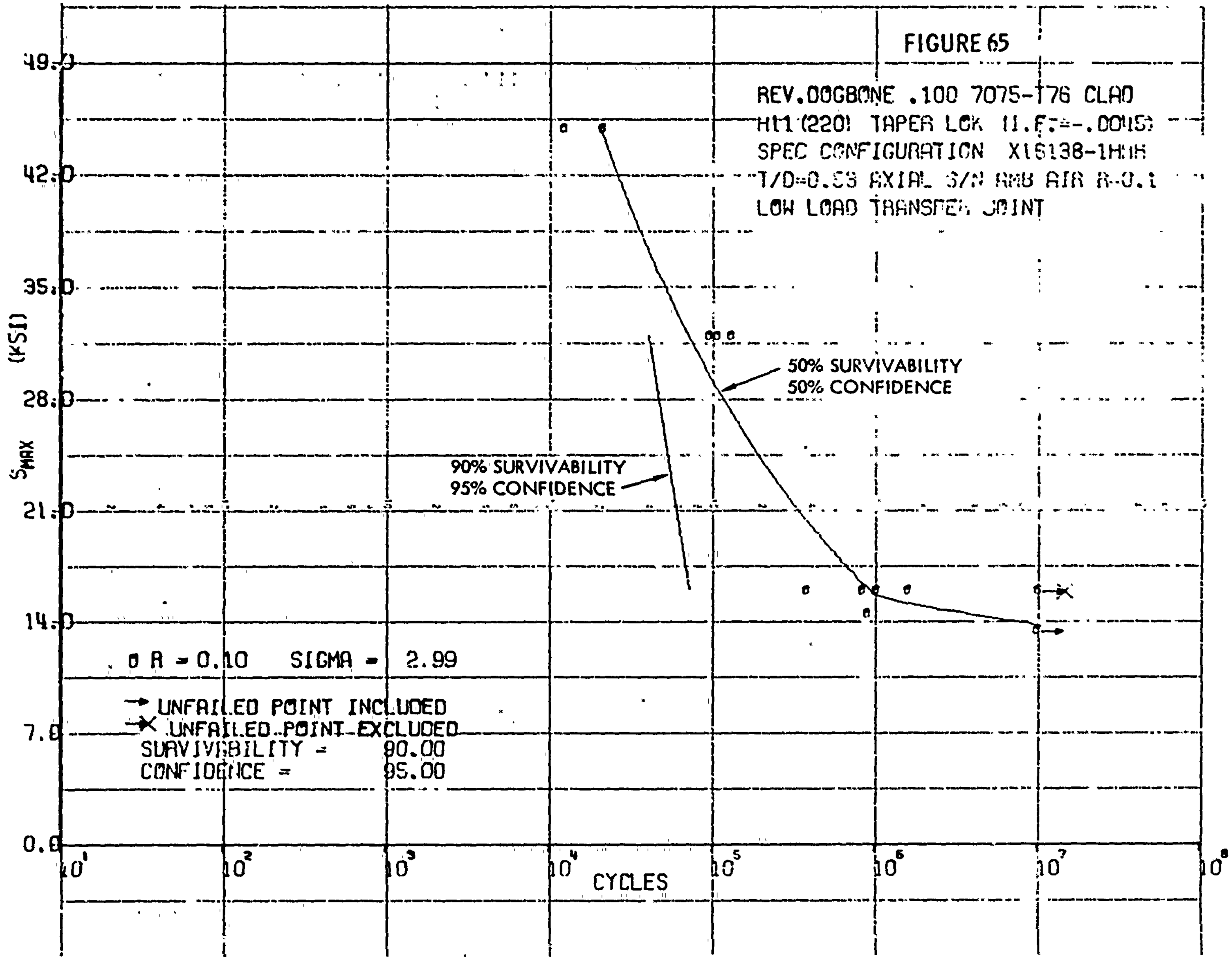
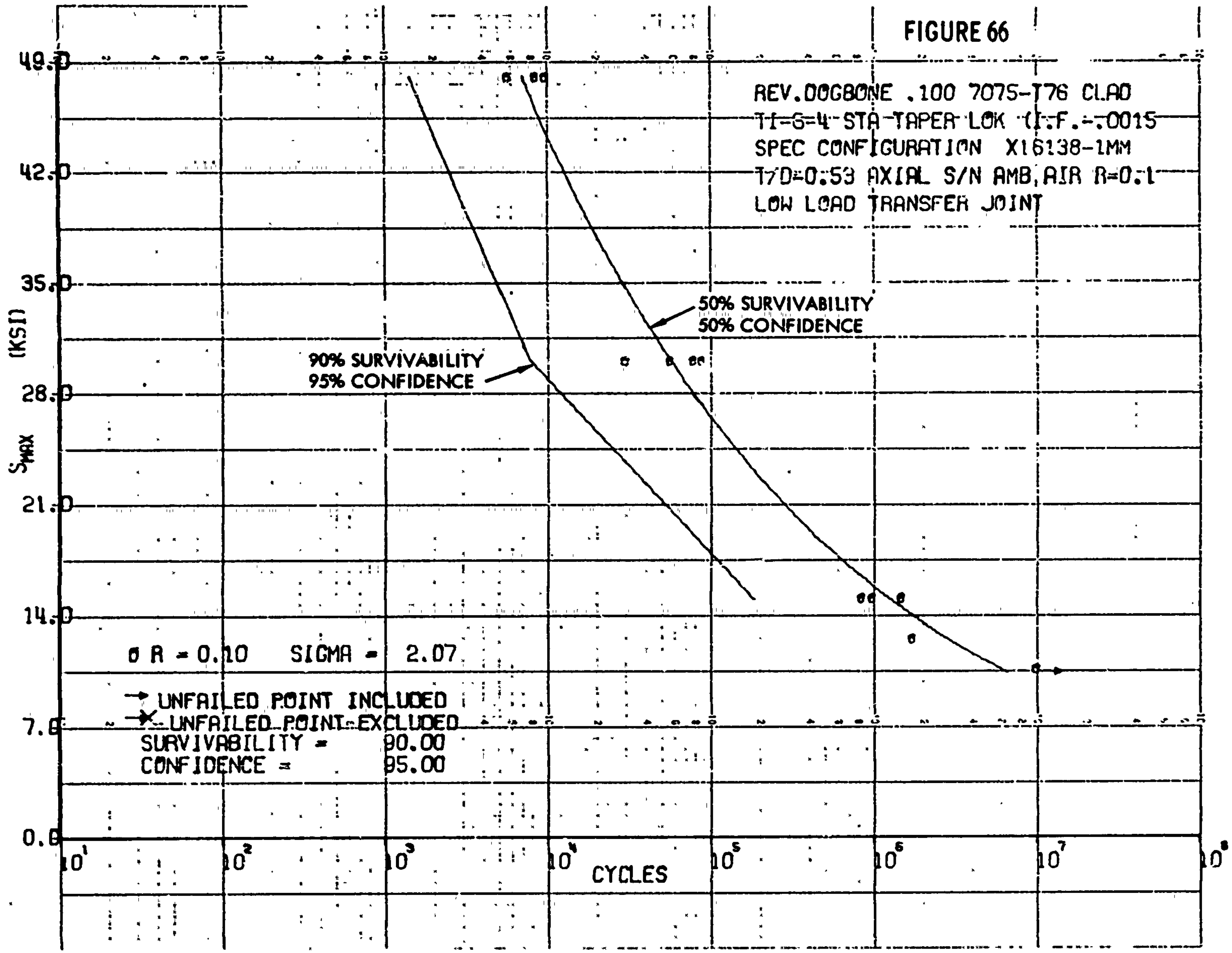


FIGURE 65
REV.DOGBONE .100 7075-T76 CLAD
HI1 (220) TAPER LOK (I.F.=-.0015)
SPEC CONFIGURATION X16138-1HHB
T/D=0.53 AXIAL S/N AMB AIR R-0.1
LOW LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
R = 0.10 SIGMA = 2.99
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

FIGURE 66


REV.DOGBONE .100 7075-T76 CLAD
TI-6-4 STA-TAPER-LOK (I.F.-.0015
SPEC CONFIGURATION X16138-1MM
T/D=0.53 AXIAL S/N AMB,AIR R=0.1
LOW LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
R = 0.10 SIGMA = 2.07
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
S_{MAX} (KSI)
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

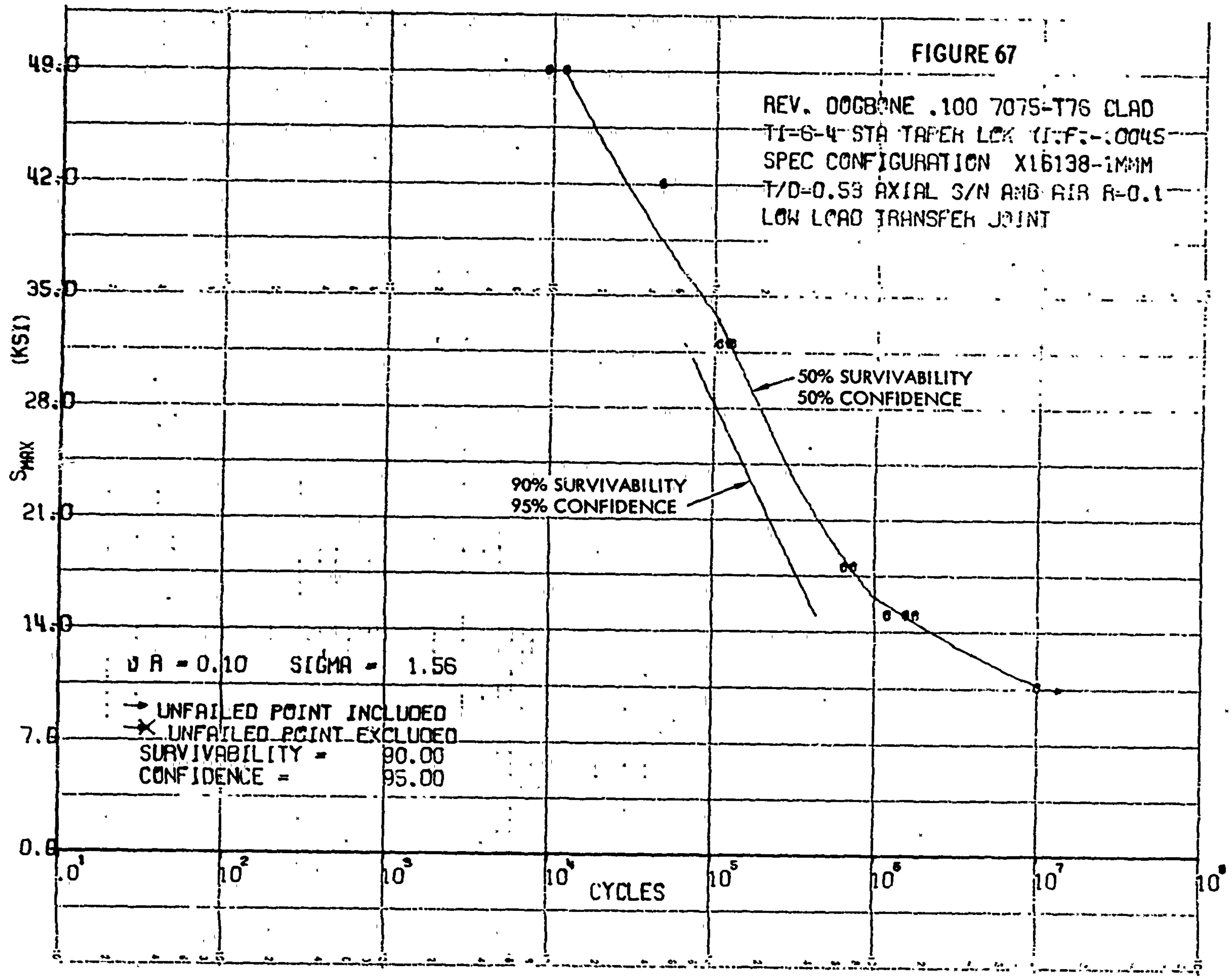

REV. DOGBONE .100 7075-T76 CLAD
TI-6-4 STA TAPER LCK (I:F:-.0045
SPEC CONFIGURATION X16138-1MMM
T/D=0.53 AXIAL S/N AMB AIR R=0.1
LOW LOAD TRANSFER JOINT
50% SURVIVABILITY
50% CONFIDENCE
90% SURVIVABILITY
95% CONFIDENCE
R = 0.10 SIGMA = 1.56
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SURVIVABILITY = 90.00
CONFIDENCE = 95.00
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

FIGURE 67

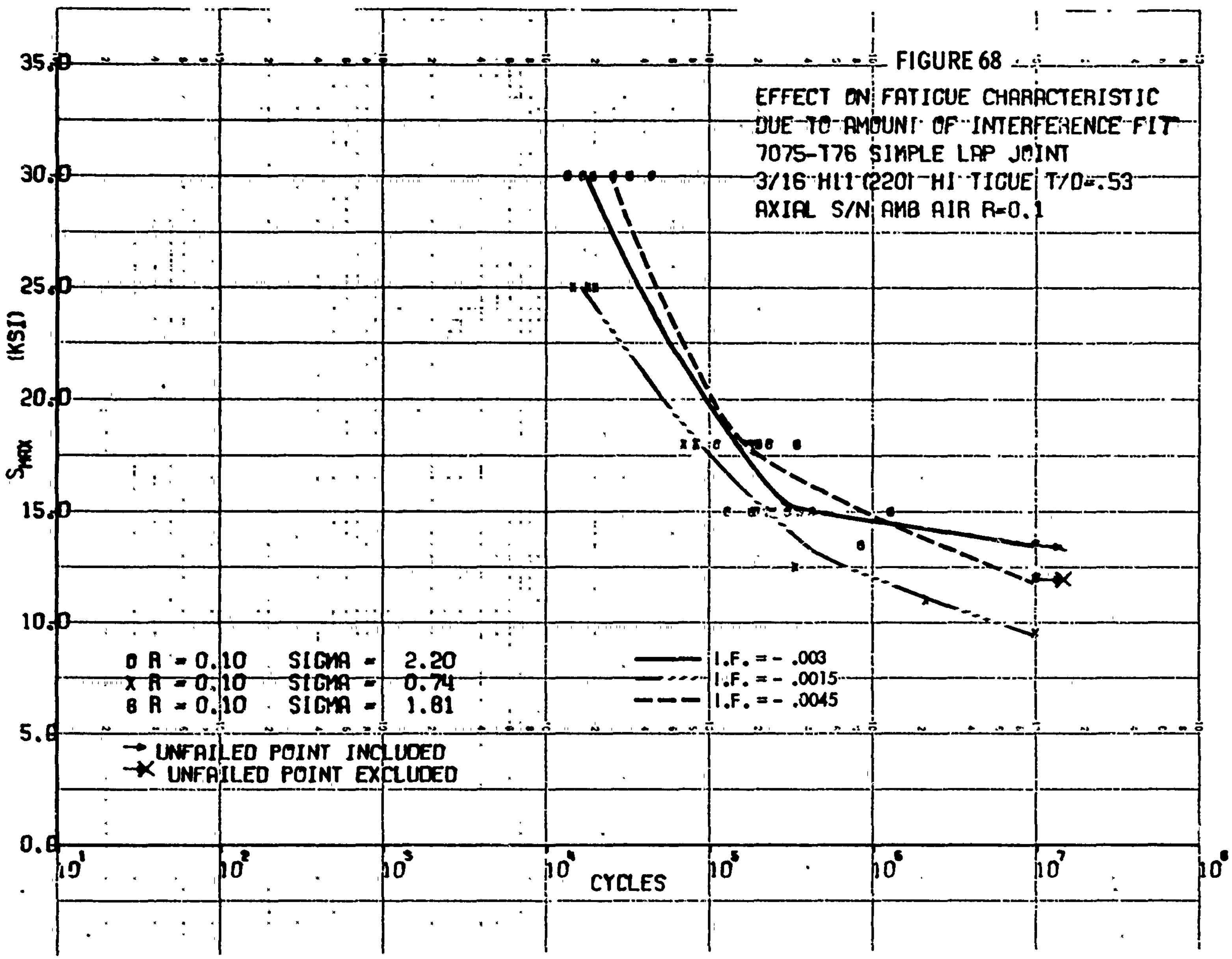


FIGURE 68
EFFECT ON FATIGUE CHARACTERISTIC
DUE TO AMOUNT OF INTERFERENCE FIT
7075-T76 SIMPLE LAP JOINT
3/16 HI1 (220) HI TIGUE T/D=.53
AXIAL S/N AMB AIR R=0.1
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES
θ R = 0.10 SIGMA = 2.20
x R = 0.10 SIGMA = 0.74
8 R = 0.10 SIGMA = 1.81
I.F. = - .003
I.F. = - .0015
I.F. = - .0045
→ UNFAILED POINT INCLUDED
→✕ UNFAILED POINT EXCLUDED

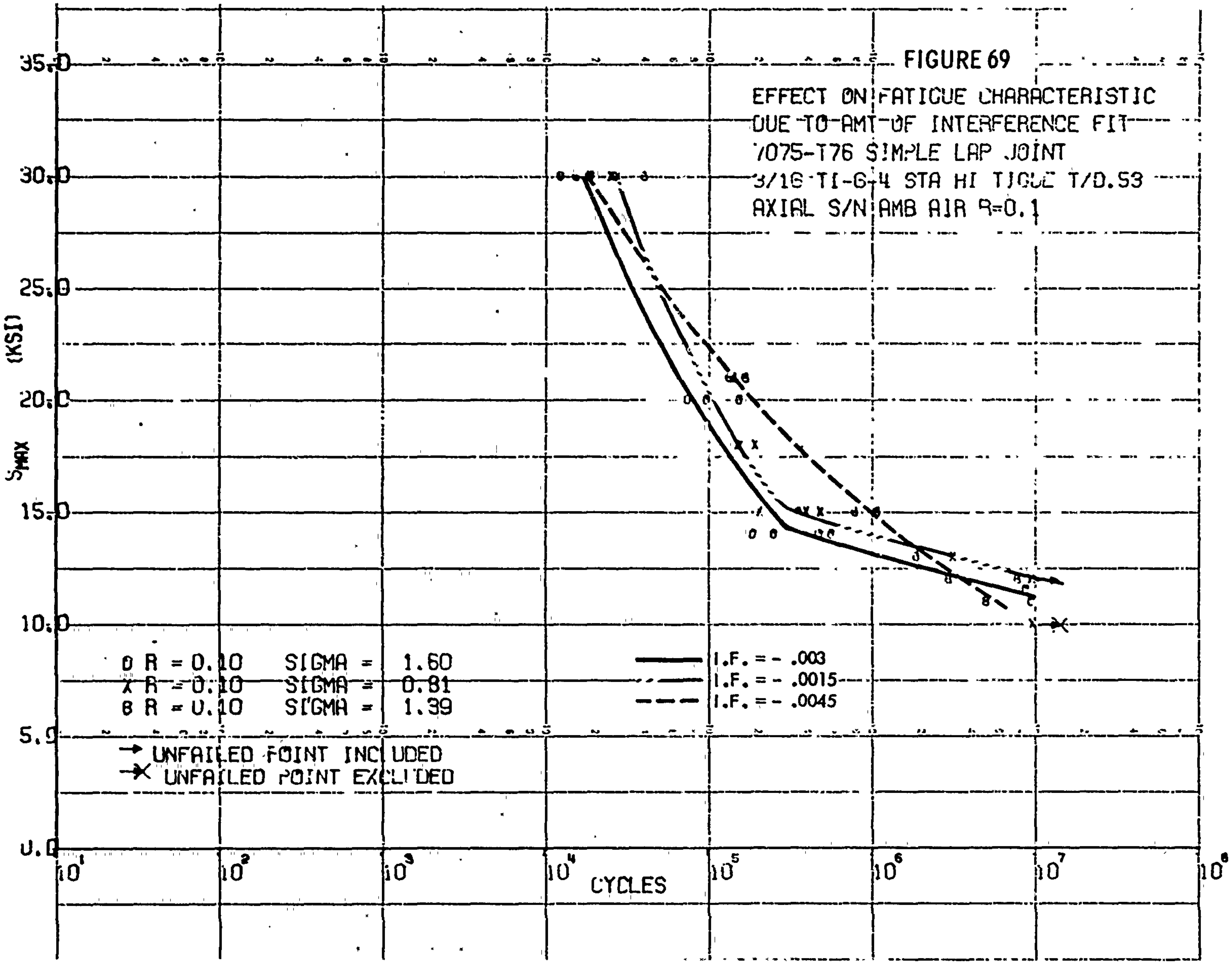


FIGURE 69
EFFECT ON FATIGUE CHARACTERISTIC
DUE TO AMT OF INTERFERENCE FIT
7075-T76 SIMPLE LAP JOINT
3/16 TI-6-4 STA HI TIGUE T/D.53
AXIAL S/N AMB AIR R=0.1
0 R = 0.10 SIGMA = 1.60
X R = 0.10 SIGMA = 0.81
8 R = 0.10 SIGMA = 1.39
I.F. = - .003
I.F. = - .0015
I.F. = - .0045
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
S MAX (KSI)
CYCLES

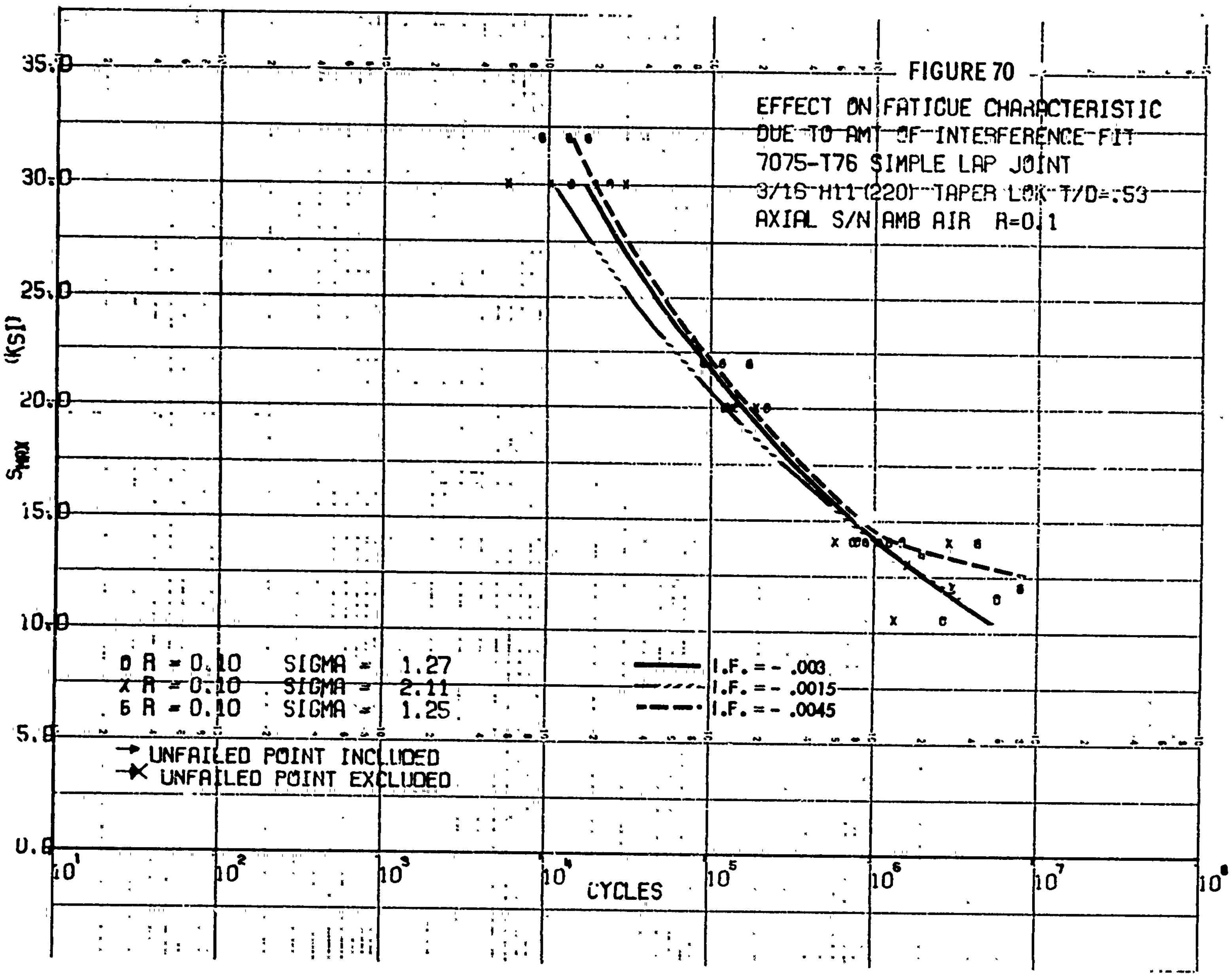


FIGURE 70
EFFECT ON FATIGUE CHARACTERISTIC
DUE TO AMT OF INTERFERENCE FIT
7075-T76 SIMPLE LAP JOINT
3/16 H11 (220) TAPER LOK T/D=.53
AXIAL S/N AMB AIR R=0.1
O R = 0.10 SIGMA = 1.27
X R = 0.10 SIGMA = 2.11
6 R = 0.10 SIGMA = 1.25
I.F. = - .003
I.F. = - .0015
I.F. = - .0045
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
SMAX (KSI)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
CYCLES

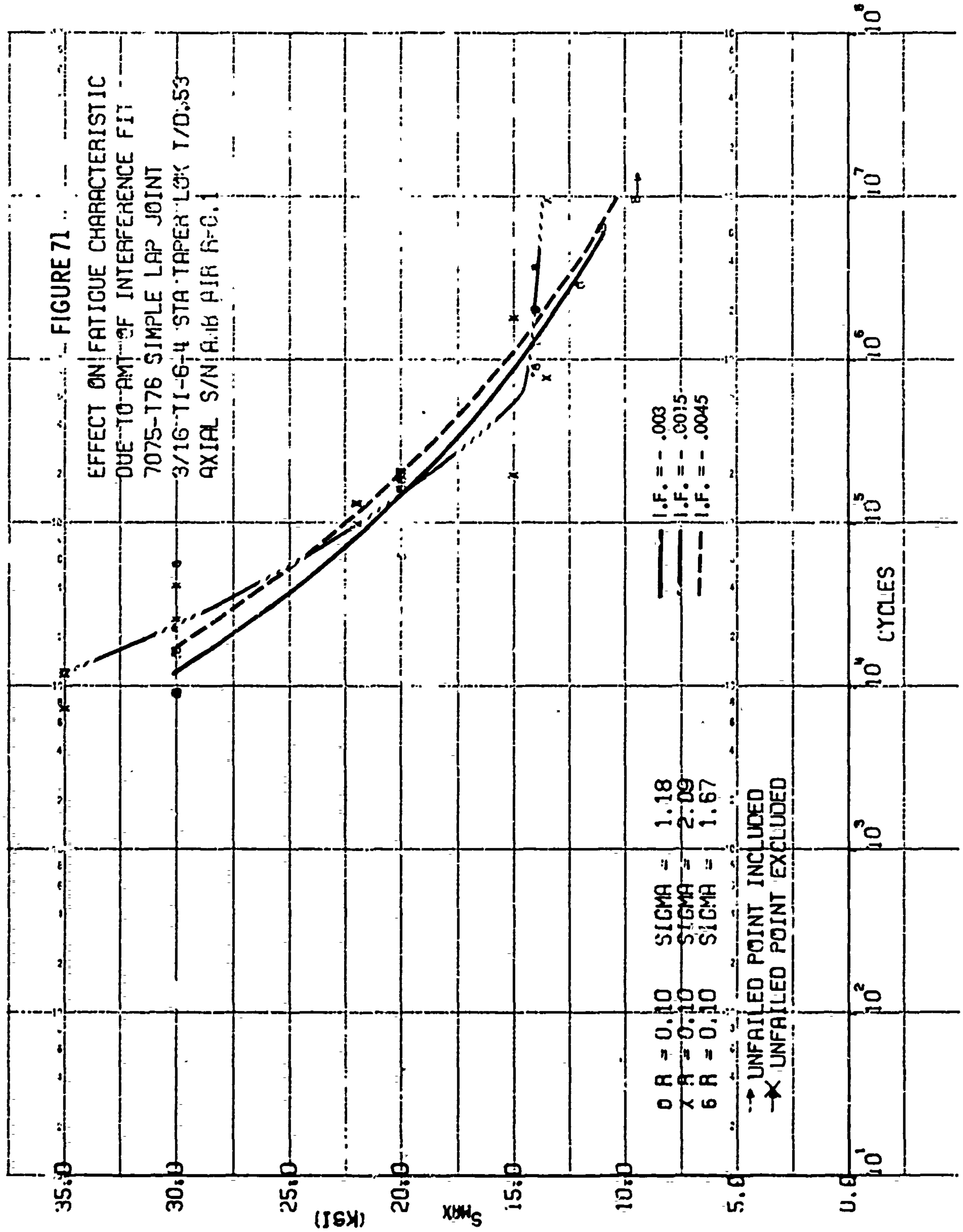


FIGURE 71
EFFECT ON FATIGUE CHARACTERISTIC
DUE TO AMT OF INTERFERENCE FIT
7075-T76 SIMPLE LAP JOINT
3/16 TI-6-4 STA TAPER LOK T/D.53
AXIAL S/N A.B AIR R=0.1
O R = 0.10 SIGMA = 1.18
X R = 0.10 SIGMA = 2.09
6 R = 0.10 SIGMA = 1.67
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
I.F. = - .003
I.F. = - .0015
I.F. = - .0045
S_{MAX} (KSI)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
CYCLES
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8

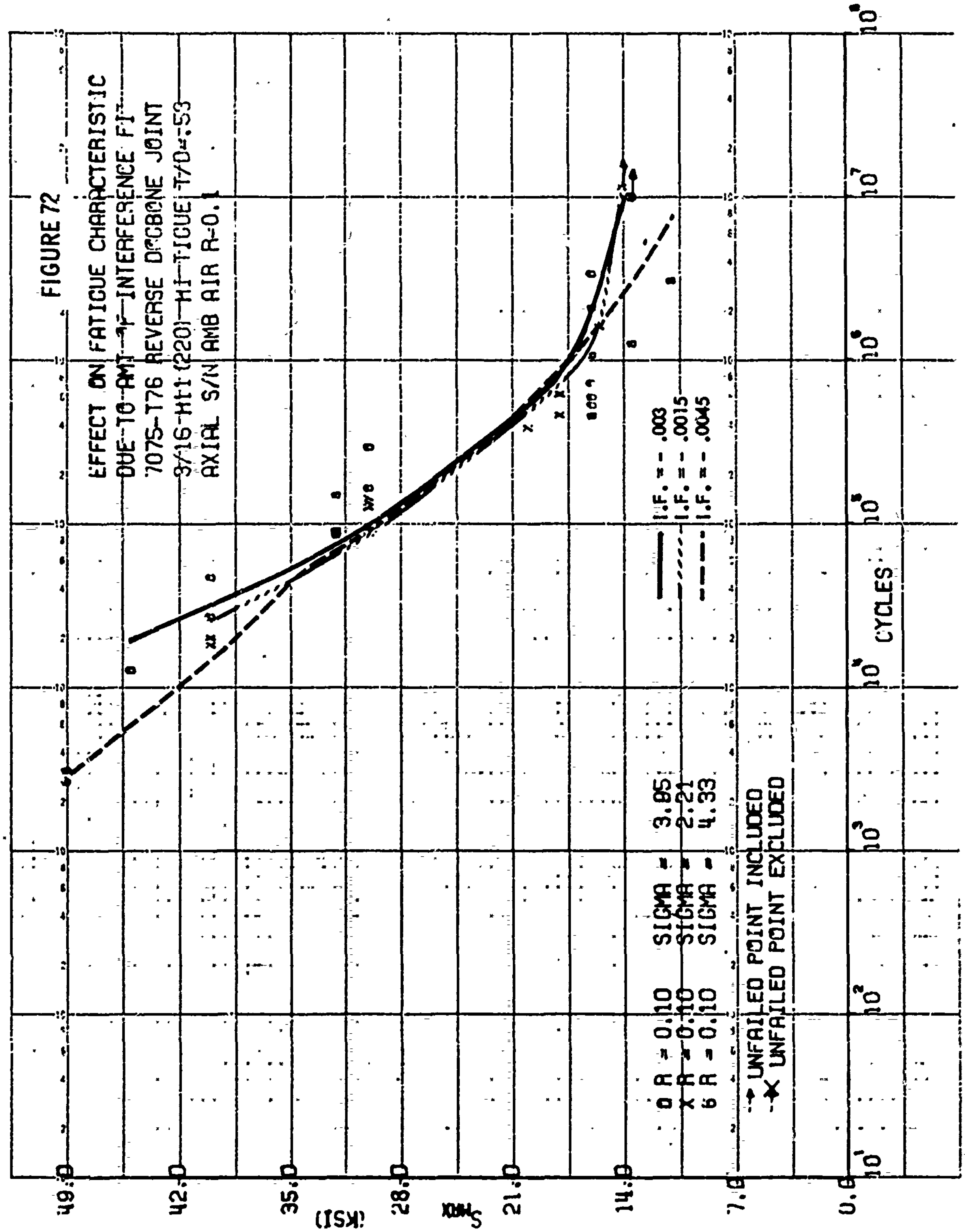


FIGURE 72
EFFECT ON FATIGUE CHARACTERISTIC
DUE TO AMT OF INTERFERENCE FIT
7075-T76 REVERSE DOGBONE JOINT
3/16-HI1(220) HI-TIGUE T/D=.53
AXIAL S/N AMB AIR R=0.1
I.F. = .003
I.F. = .0015
I.F. = .0045
o R = 0.10 SIGMA = 3.05
x R = 0.10 SIGMA = 2.21
6 R = 0.10 SIGMA = 4.33
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
CYCLES
S MAX (KSI)
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0

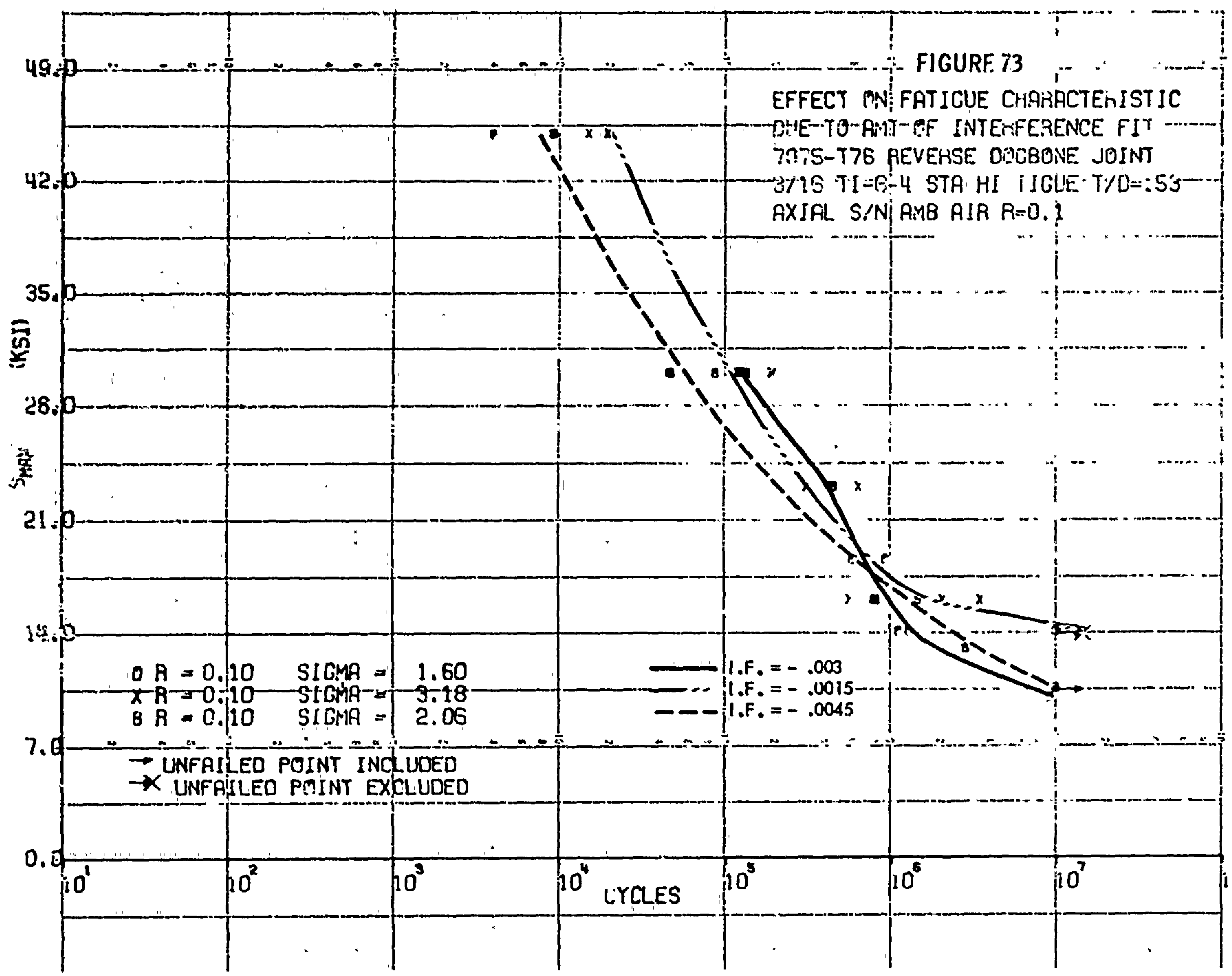


FIGURE 73

EFFECT ON FATIGUE CHARACTERISTIC DUE TO AMT OF INTERFERENCE FIT 7075-T76 REVERSE DOGBONE JOINT 3/16 TI-6-4 STA HI TIGUE T/D=.53 AXIAL S/N AMB AIR R=0.1

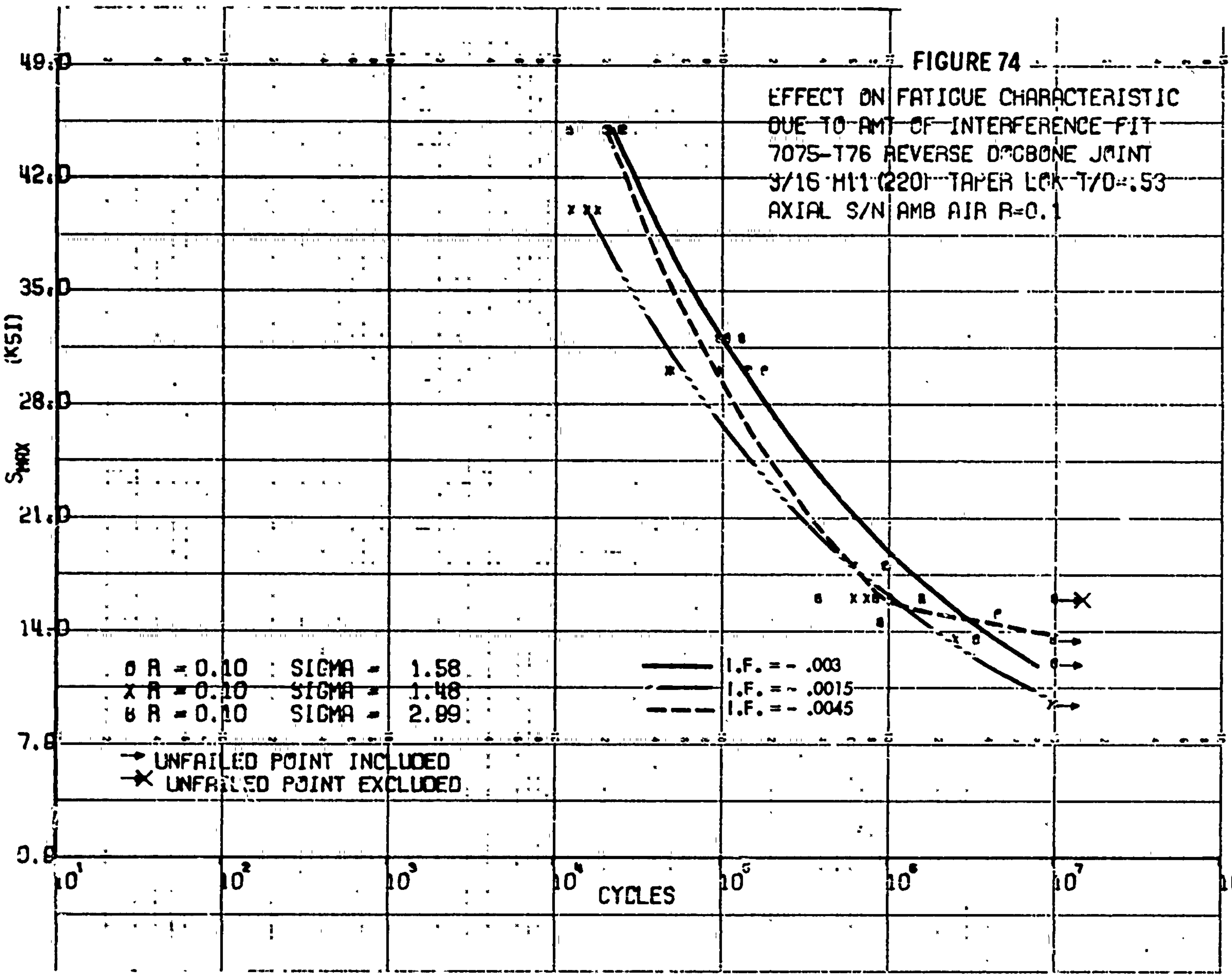


FIGURE 74
EFFECT ON FATIGUE CHARACTERISTIC
DUE TO AMT OF INTERFERENCE FIT
7075-T76 REVERSE DOGBONE JOINT
3/16 H11 (220) TAPER LOK T/D=.53
AXIAL S/N AMB AIR R=0.1

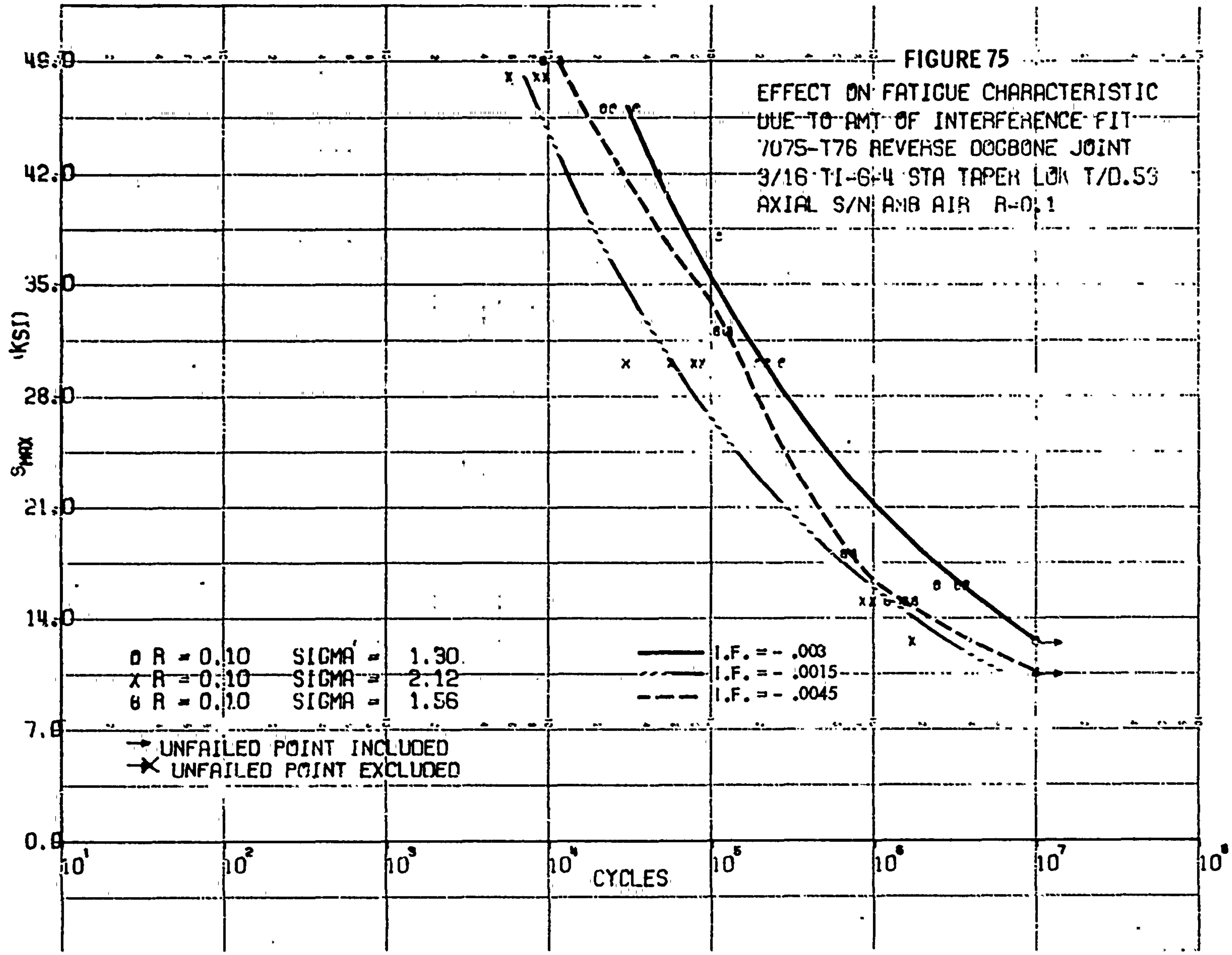


FIGURE 75
EFFECT ON FATIGUE CHARACTERISTIC DUE TO AMT OF INTERFERENCE FIT
7075-T76 REVERSE DOGBONE JOINT
3/16 TI-6-4 STA TAPER LOK T/D.53
AXIAL S/N AMB AIR R=0.1

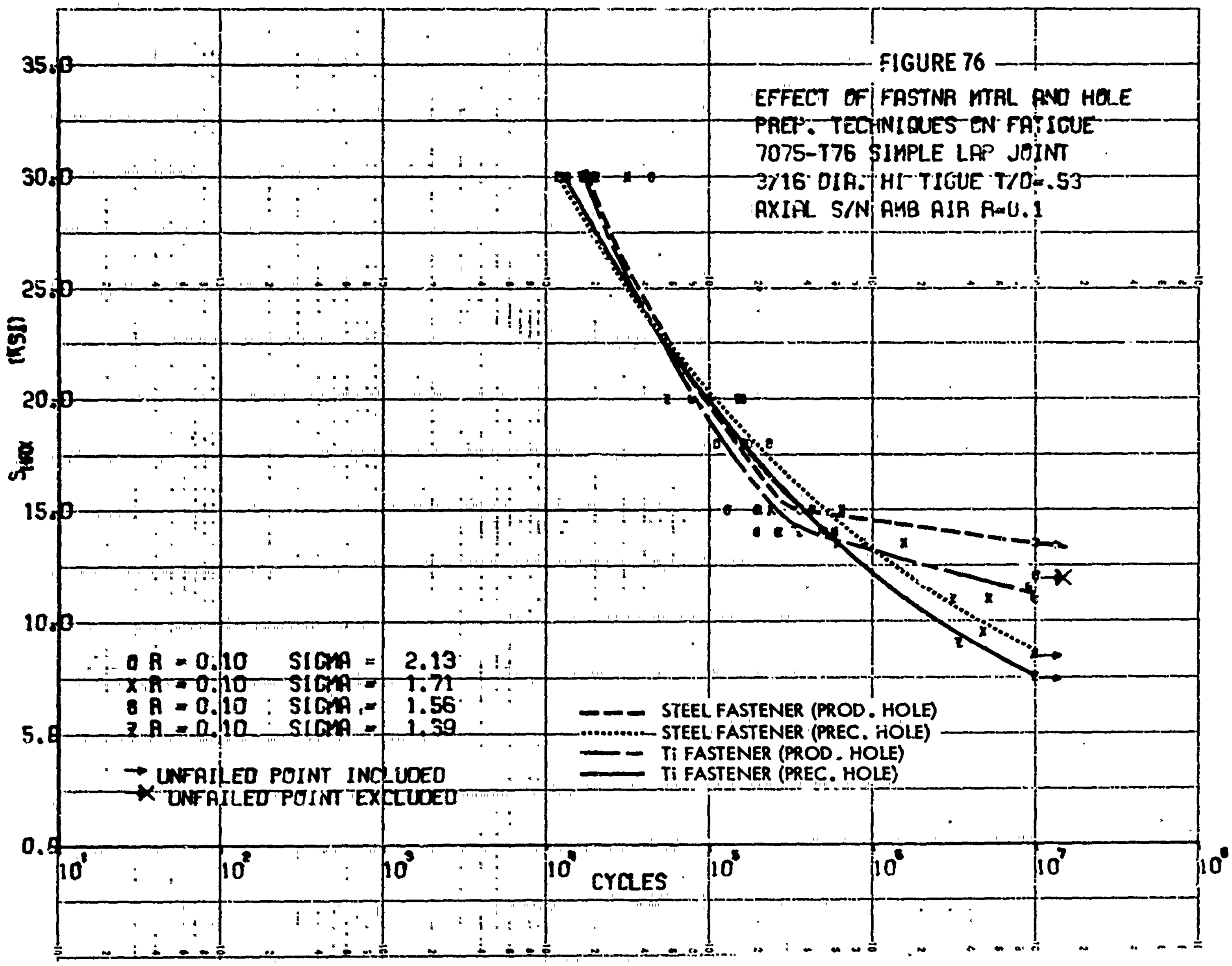


FIGURE 76
EFFECT OF FASTNR MTRL AND HOLE
PREP. TECHNIQUES ON FATIGUE
7075-T76 SIMPLE LAP JOINT
3/16 DIA. HI TIGUE T/D=.53
AXIAL S/N AMB AIR R=0.1
S MAX (KSI)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES
0 R = 0.10 SIGMA = 2.13
X R = 0.10 SIGMA = 1.71
6 R = 0.10 SIGMA = 1.56
Z R = 0.10 SIGMA = 1.39
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
STEEL FASTENER (PROD. HOLE)
STEEL FASTENER (PREC. HOLE)
Ti FASTENER (PROD. HOLE)
Ti FASTENER (PREC. HOLE)

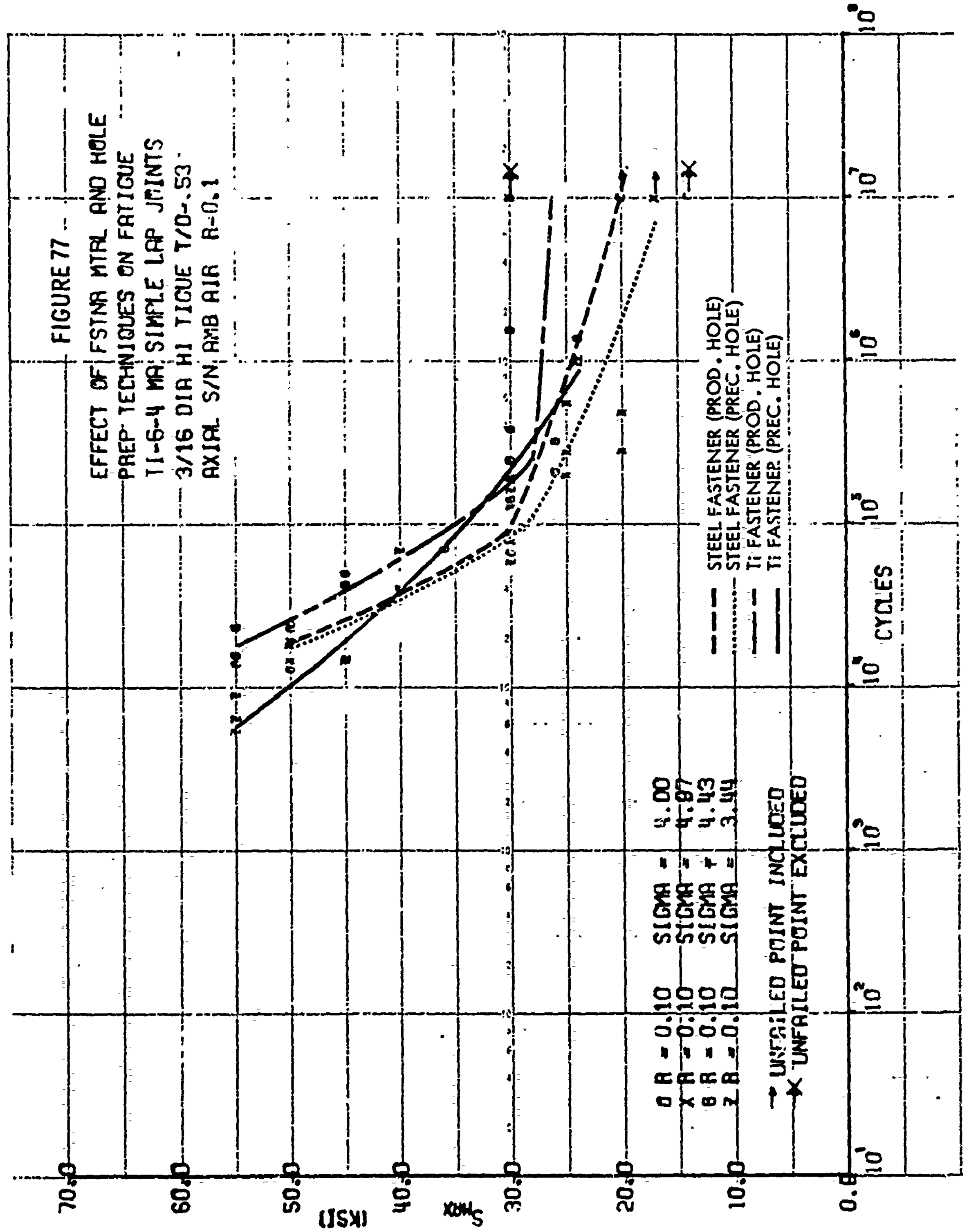


FIGURE 77 -
EFFECT OF FSTNR MTRL AND HOLE
PREP TECHNIQUES ON FATIGUE
TI-6-4 MA SIMPLE LAP JOINTS
3/16 DIA HI TIGUE T/D-.53
AXIAL S/N AMB AIR R-0.1
STEEL FASTENER (PROD. HOLE)
STEEL FASTENER (PREC. HOLE)
Ti FASTENER (PROD. HOLE)
Ti FASTENER (PREC. HOLE)
o R = 0.10 SIGMA = 4.00
x R = 0.10 SIGMA = 4.97
8 R = 0.10 SIGMA = 4.43
z R = 0.10 SIGMA = 3.44
→ UNFAILED POINT INCLUDED
✕ UNFAILED POINT EXCLUDED
S_{MAX} (KSI)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

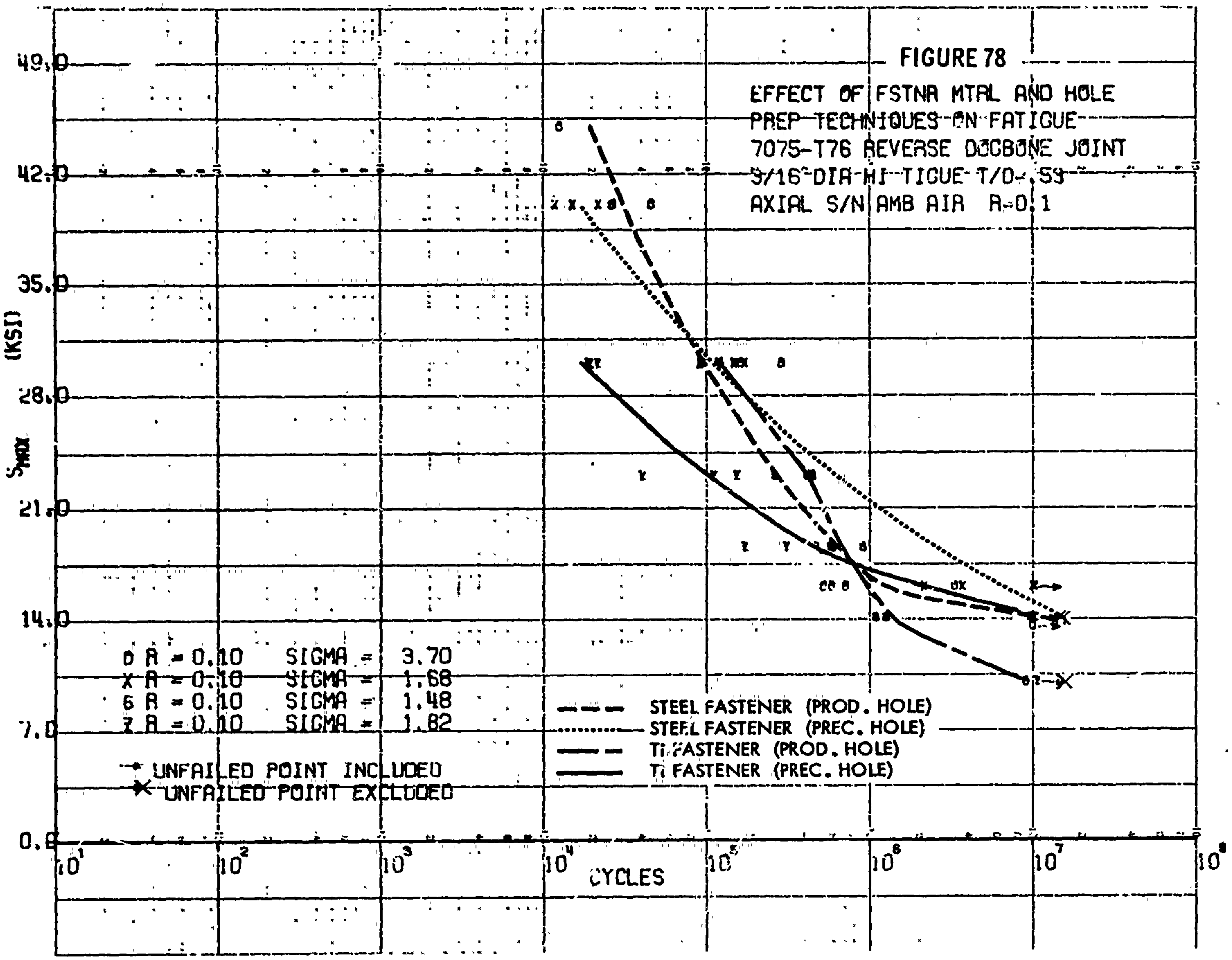


FIGURE 78
EFFECT OF FSTNR MTRL AND HOLE
PREP TECHNIQUES ON FATIGUE
7075-T76 REVERSE DOGBONE JOINT
3/16 DIA HI-TIGUE T/D-.53
AXIAL S/N AMB AIR R-0.1
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0
S_{MAX} (KSI)
CYCLES
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
0 R = 0.10 SIGMA = 3.70
X R = 0.10 SIGMA = 1.68
6 R = 0.10 SIGMA = 1.48
Z R = 0.10 SIGMA = 1.82
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
STEEL FASTENER (PROD. HOLE)
STEEL FASTENER (PREC. HOLE)
Ti FASTENER (PROD. HOLE)
Ti FASTENER (PREC. HOLE)

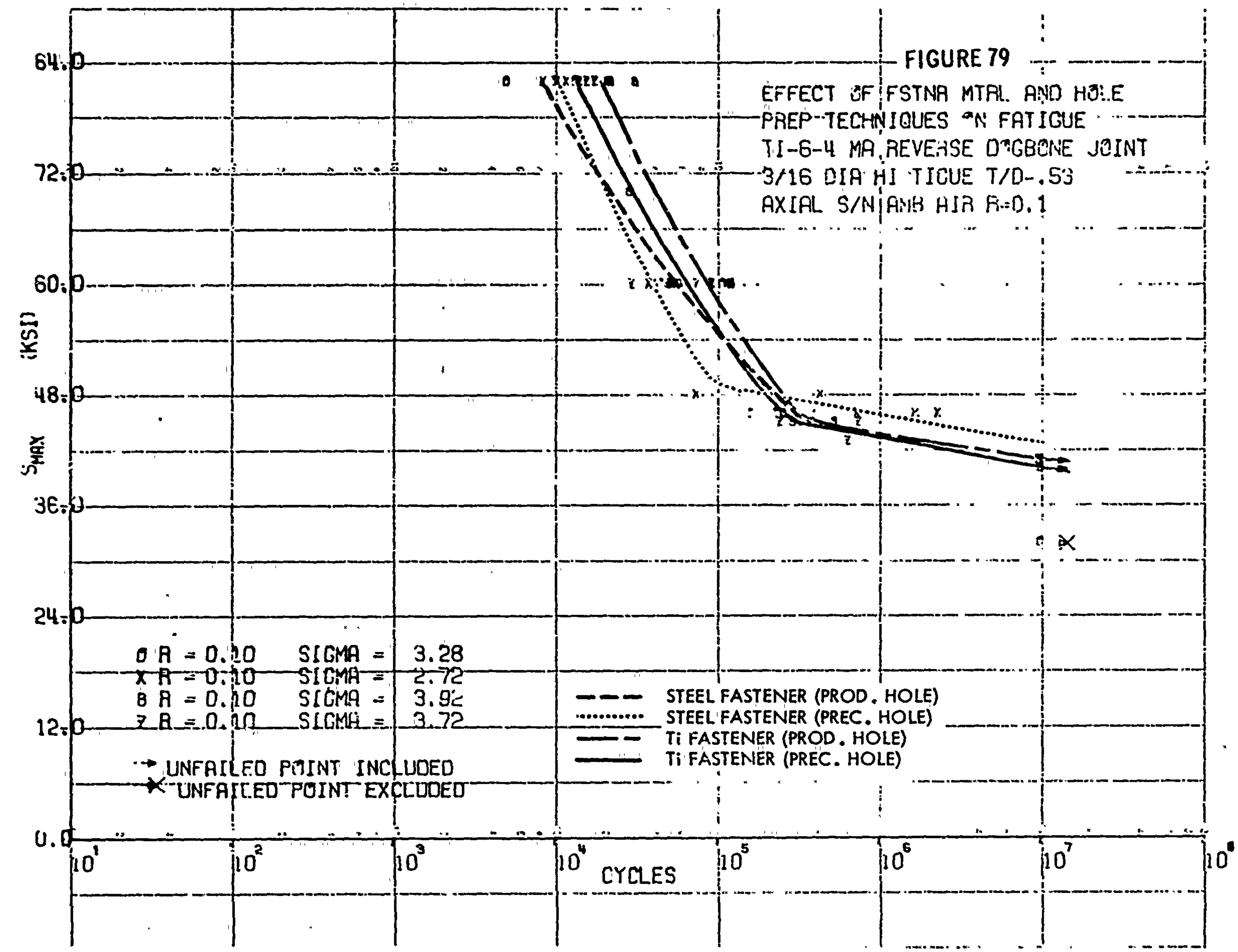


FIGURE 79
EFFECT OF FSTNR MTRL AND HOLE
PREP TECHNIQUES ON FATIGUE
TI-6-4 MA REVERSE DOGBONE JOINT
3/16 DIA HI TIGUE T/D-.53
AXIAL S/N AMB AIR R=0.1
64.0
72.0
60.0
48.0
36.0
24.0
12.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES
0 R = 0.10 SIGMA = 3.28
X R = 0.10 SIGMA = 2.72
8 R = 0.10 SIGMA = 3.92
Z R = 0.10 SIGMA = 3.72
→ UNFAILED POINT INCLUDED
X UNFAILED POINT EXCLUDED
STEEL FASTENER (PROD. HOLE)
STEEL FASTENER (PREC. HOLE)
Ti FASTENER (PROD. HOLE)
Ti FASTENER (PREC. HOLE)

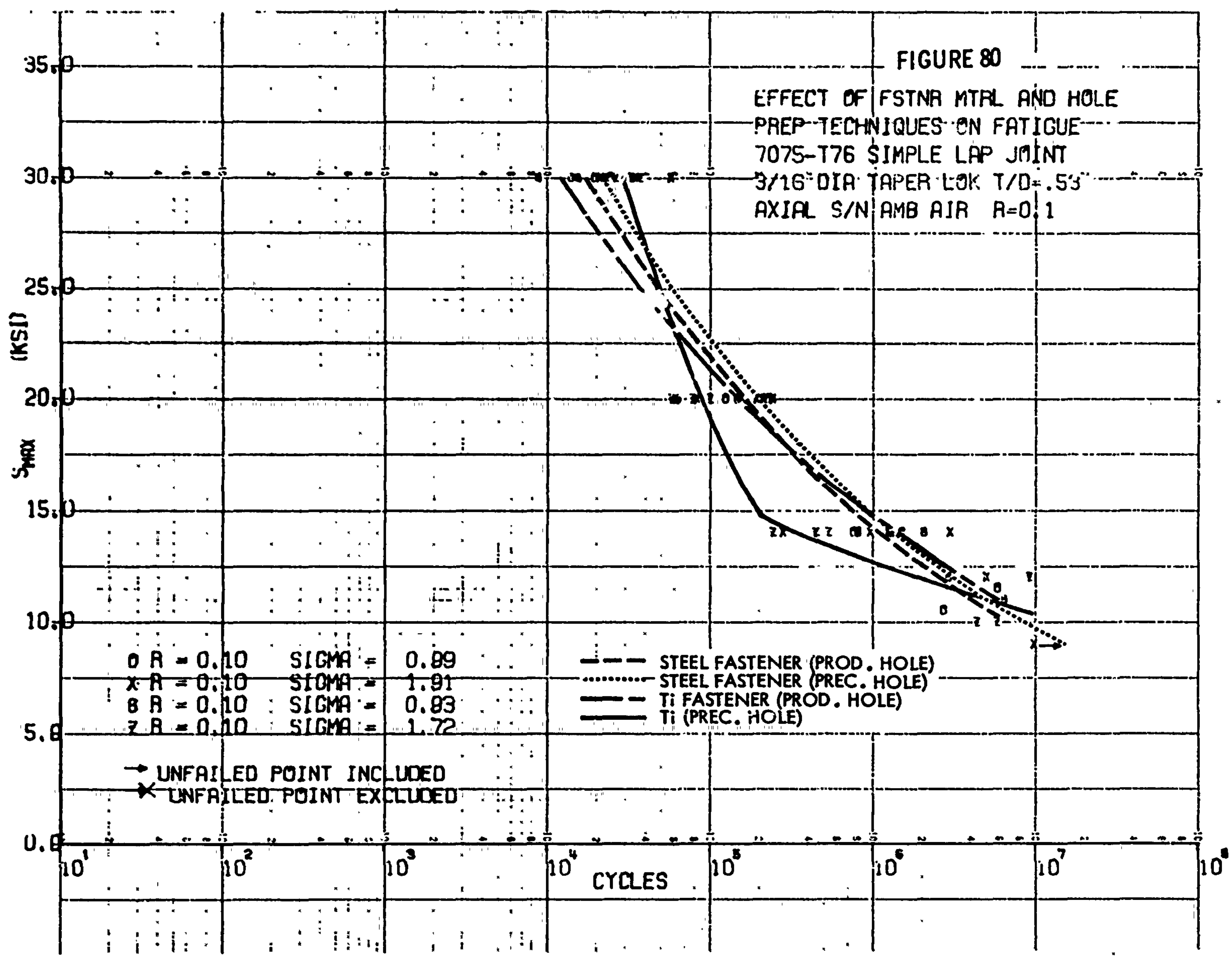


FIGURE 80

EFFECT OF FSTNR MTRL AND HOLE PREP TECHNIQUES ON FATIGUE
7075-T76 SIMPLE LAP JOINT
3/16" DIA TAPER LOK T/D=.53
AXIAL S/N AMB AIR R=0.1

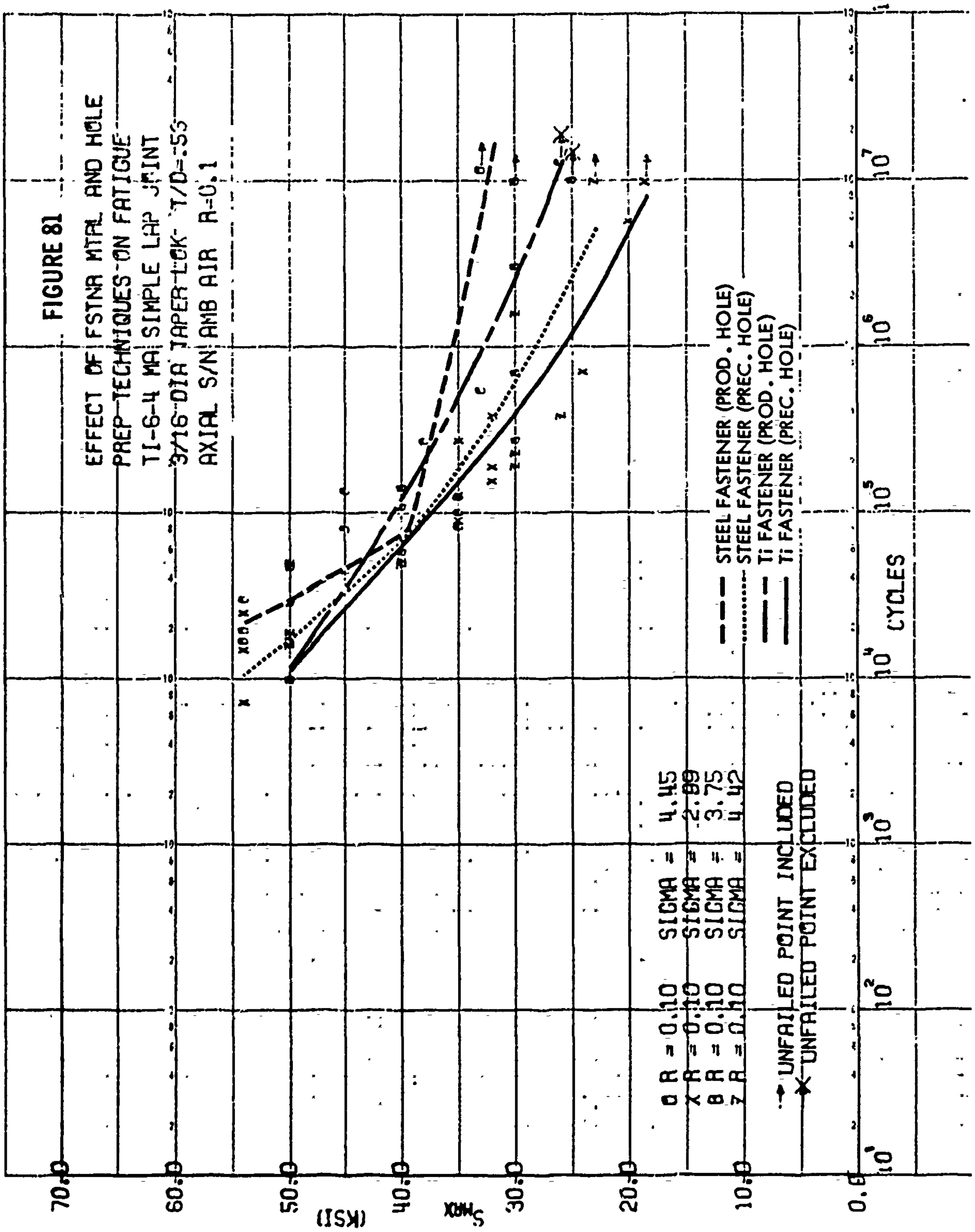


FIGURE 81
EFFECT OF FSTNR MTRL AND HOLE PREP TECHNIQUES ON FATIGUE
TI-6-4 MA SIMPLE LAP JOINT
3/16 DIA TAPER-LOK T/D=.55
AXIAL S/N AMB AIR R=0.1

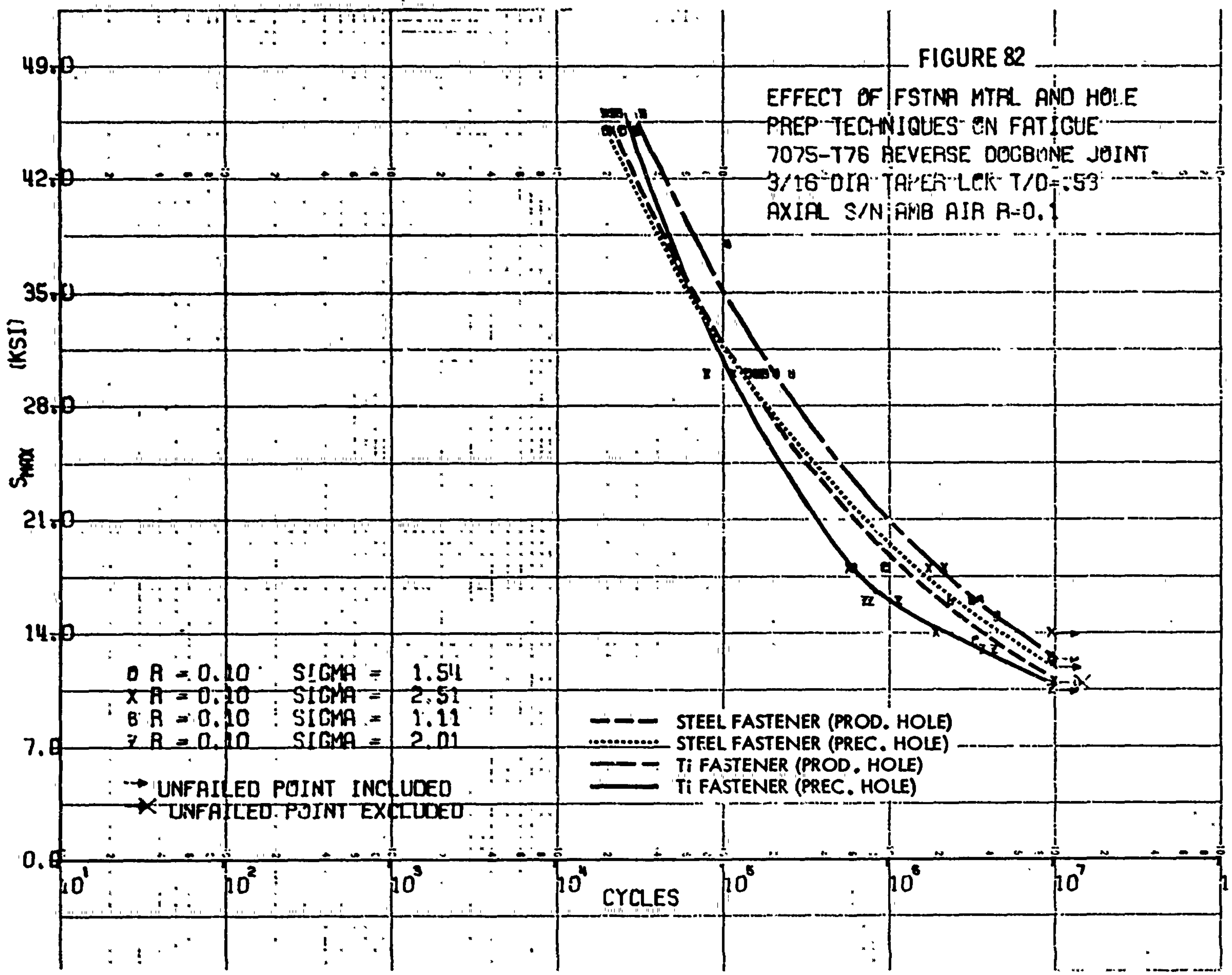


FIGURE 82
EFFECT OF FSTNR MTRL AND HOLE
PREP TECHNIQUES ON FATIGUE
7075-T76 REVERSE DOGBONE JOINT
3/16 DIA TAPER LCK T/D=.53
AXIAL S/N AMB AIR R=0.1
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES
0 R = 0.10 SIGMA = 1.54
X R = 0.10 SIGMA = 2.51
8 R = 0.10 SIGMA = 1.11
7 R = 0.10 SIGMA = 2.01
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
STEEL FASTENER (PROD. HOLE)
STEEL FASTENER (PREC. HOLE)
Ti FASTENER (PROD. HOLE)
Ti FASTENER (PREC. HOLE)

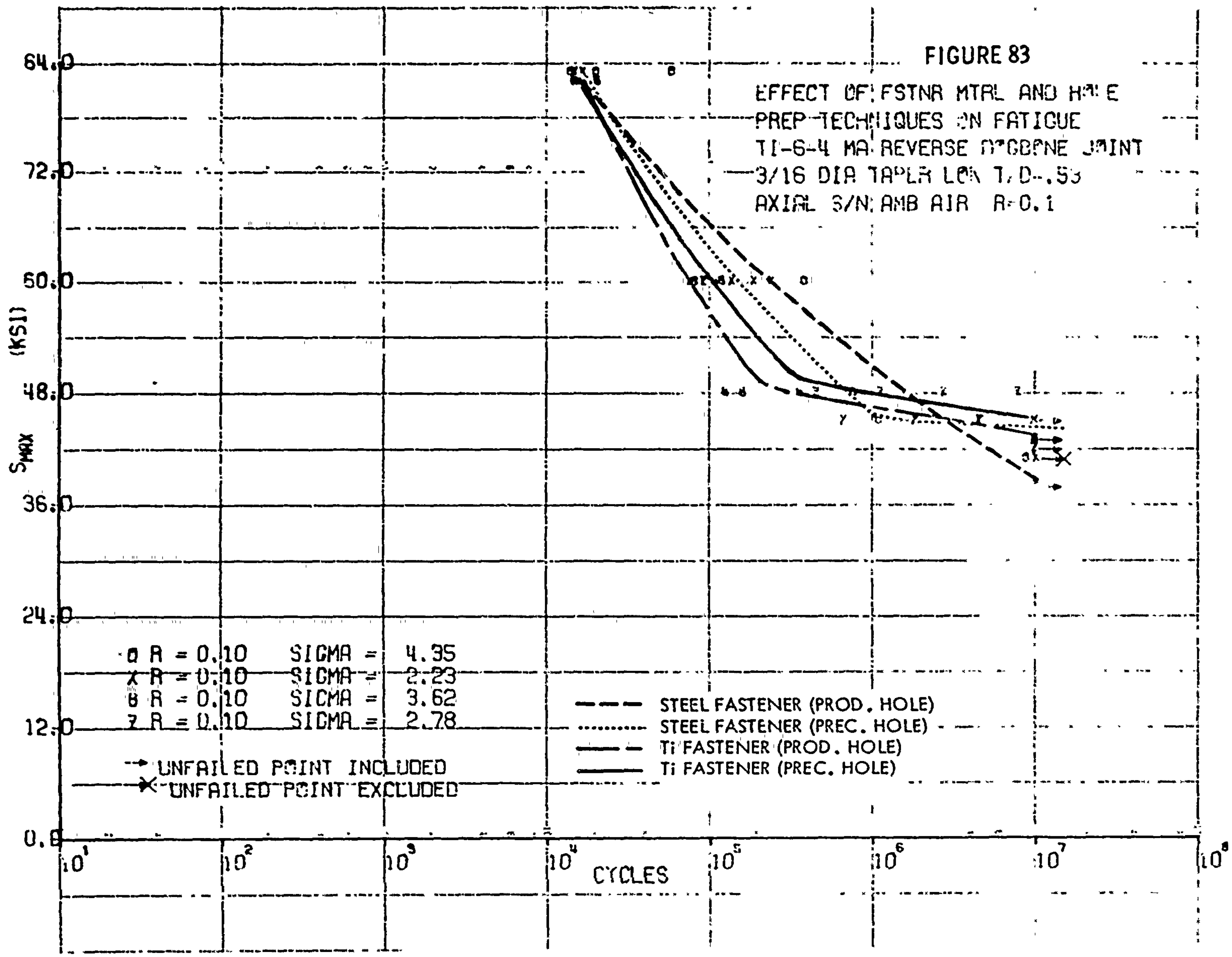


FIGURE 83

EFFECT OF FSTNR MTRL AND HOLE PREP TECHNIQUES ON FATIGUE
TI-6-4 MA REVERSE DOGBONE JOINT
3/16 DIA TAPER LOK T/D=.53
AXIAL S/N AMB AIR R=0.1

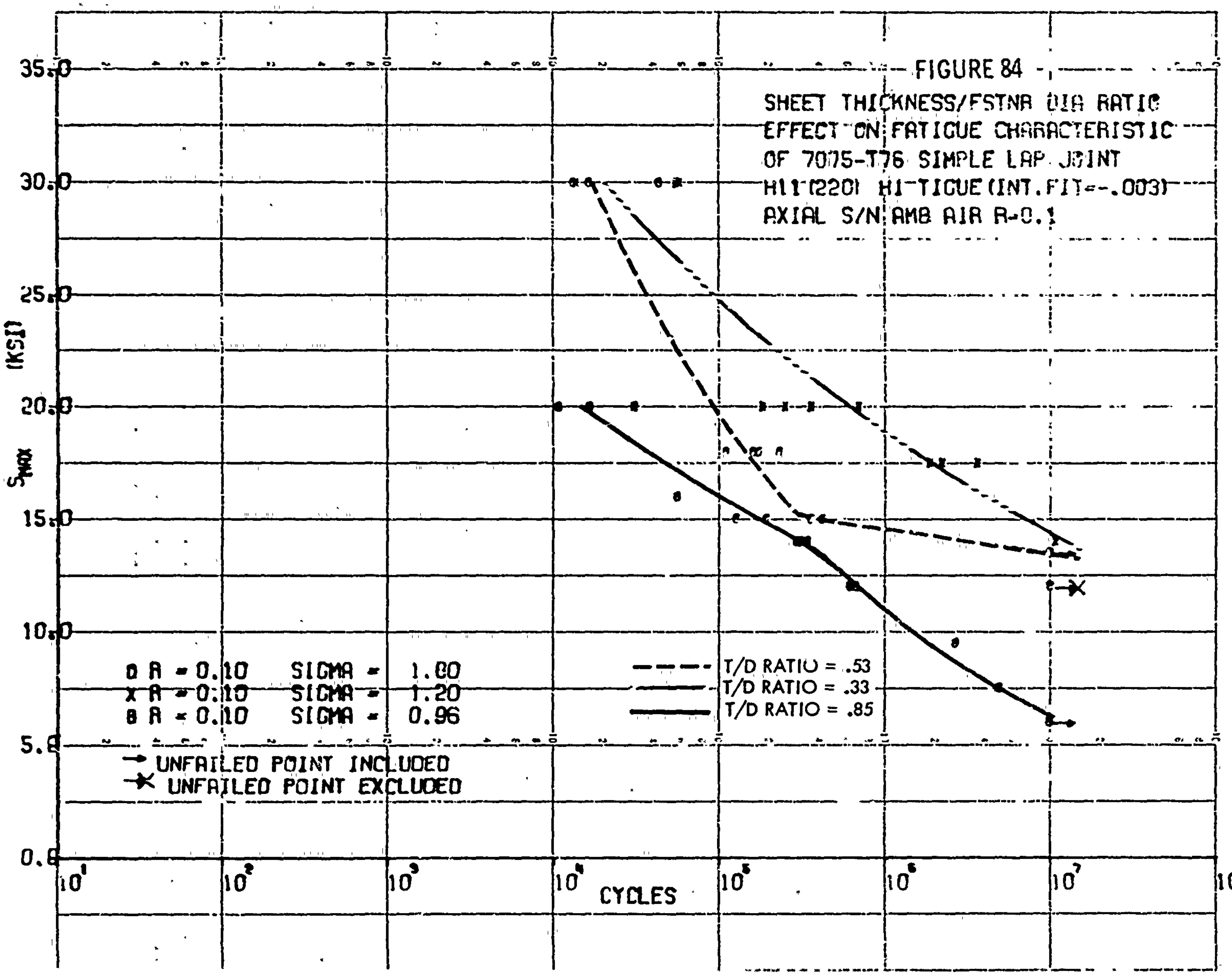


FIGURE 84
SHEET THICKNESS/FSTNR DIA RATIO
EFFECT ON FATIGUE CHARACTERISTIC
OF 7075-T76 SIMPLE LAP JOINT
HI1 (220) HI-TIGUE (INT. FIT=-.003)
AXIAL S/N AMB AIR R=0.1
O R = 0.10 SIGMA = 1.00
X R = 0.10 SIGMA = 1.20
B R = 0.10 SIGMA = 0.96
→ UNFAILED POINT INCLUDED
→✕ UNFAILED POINT EXCLUDED
T/D RATIO = .53
T/D RATIO = .33
T/D RATIO = .85
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

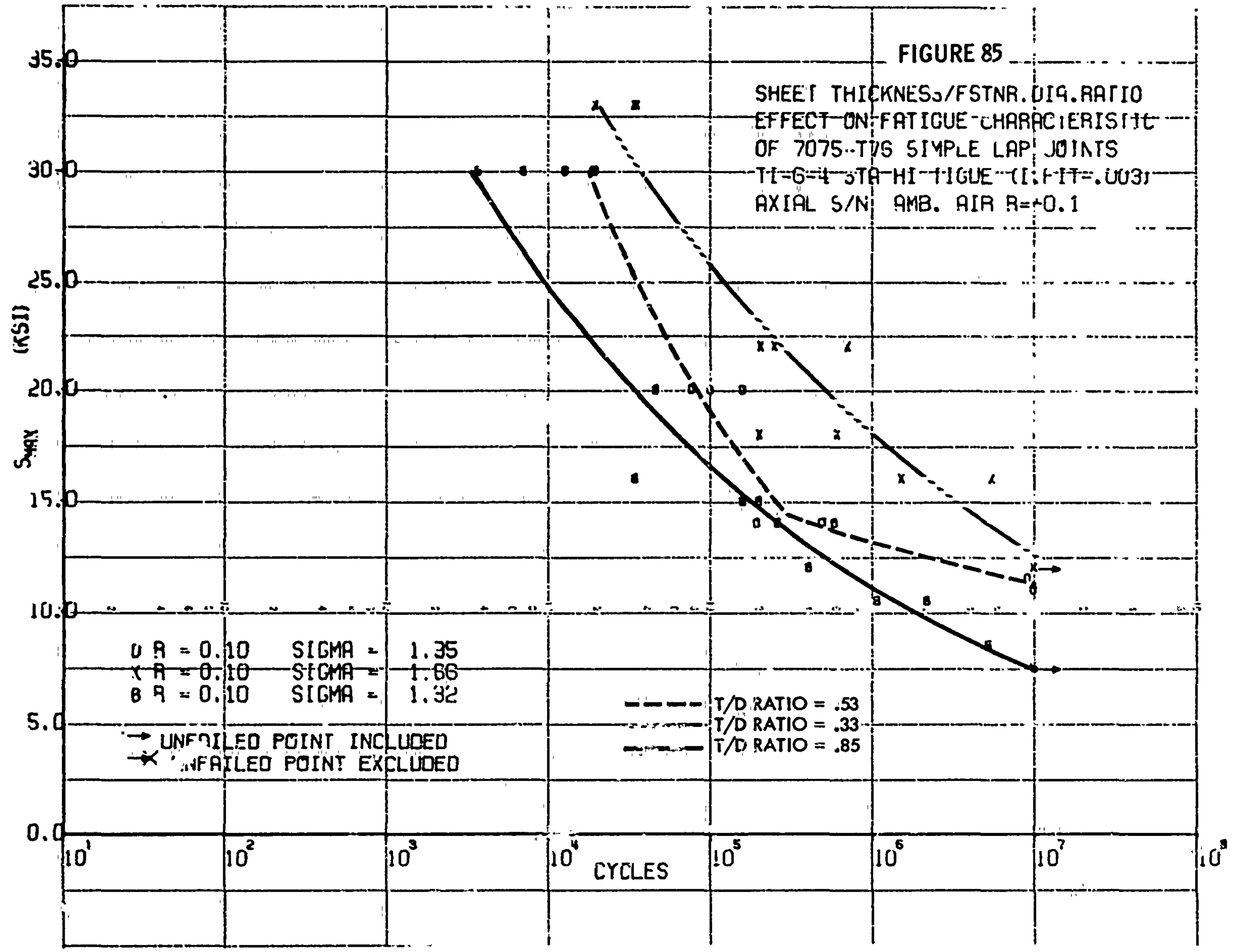


FIGURE 85
SHEET THICKNESS/FSTNR.DIA.RATIO
EFFECT ON FATIGUE CHARACTERISTIC
OF 7075-T76 SIMPLE LAP JOINTS
TI-6-4 STA HI-TIGUE (I.FIT=.003)
AXIAL S/N AMB. AIR R=+0.1
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES
O R = 0.10 SIGMA = 1.35
X R = 0.10 SIGMA = 1.66
B R = 0.10 SIGMA = 1.32
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
T/D RATIO = .53
T/D RATIO = .33
T/D RATIO = .85

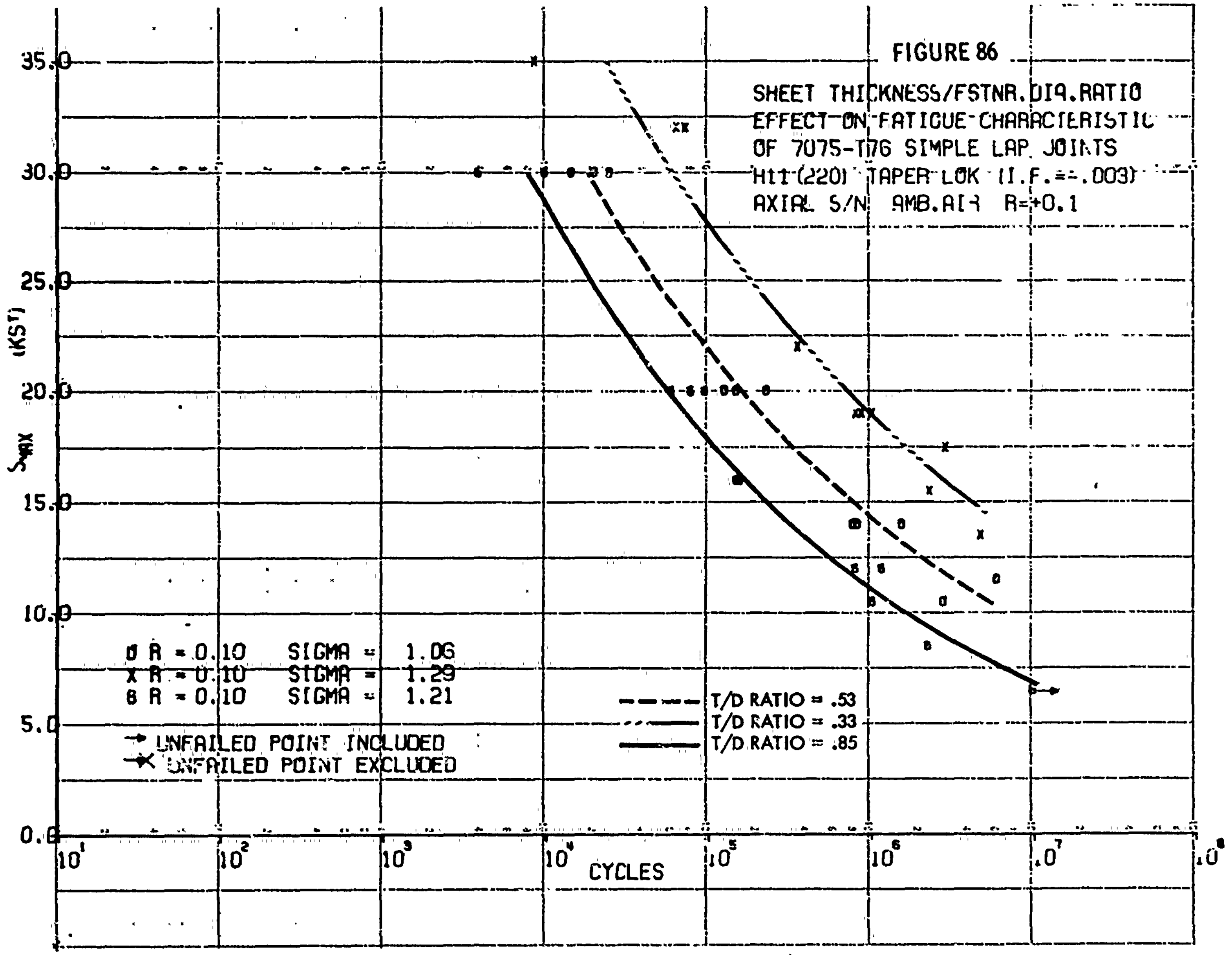


FIGURE 86
SHEET THICKNESS/FSTNR.DIA.RATIO
EFFECT ON FATIGUE CHARACTERISTIC
OF 7075-T76 SIMPLE LAP JOINTS
H11 (220) TAPER LOK (I.F.=-.003)
AXIAL S/N AMB.AIR R=+0.1
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES
0 R = 0.10 SIGMA = 1.06
X R = 0.10 SIGMA = 1.29
8 R = 0.10 SIGMA = 1.21
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
T/D RATIO = .53
T/D RATIO = .33
T/D RATIO = .85

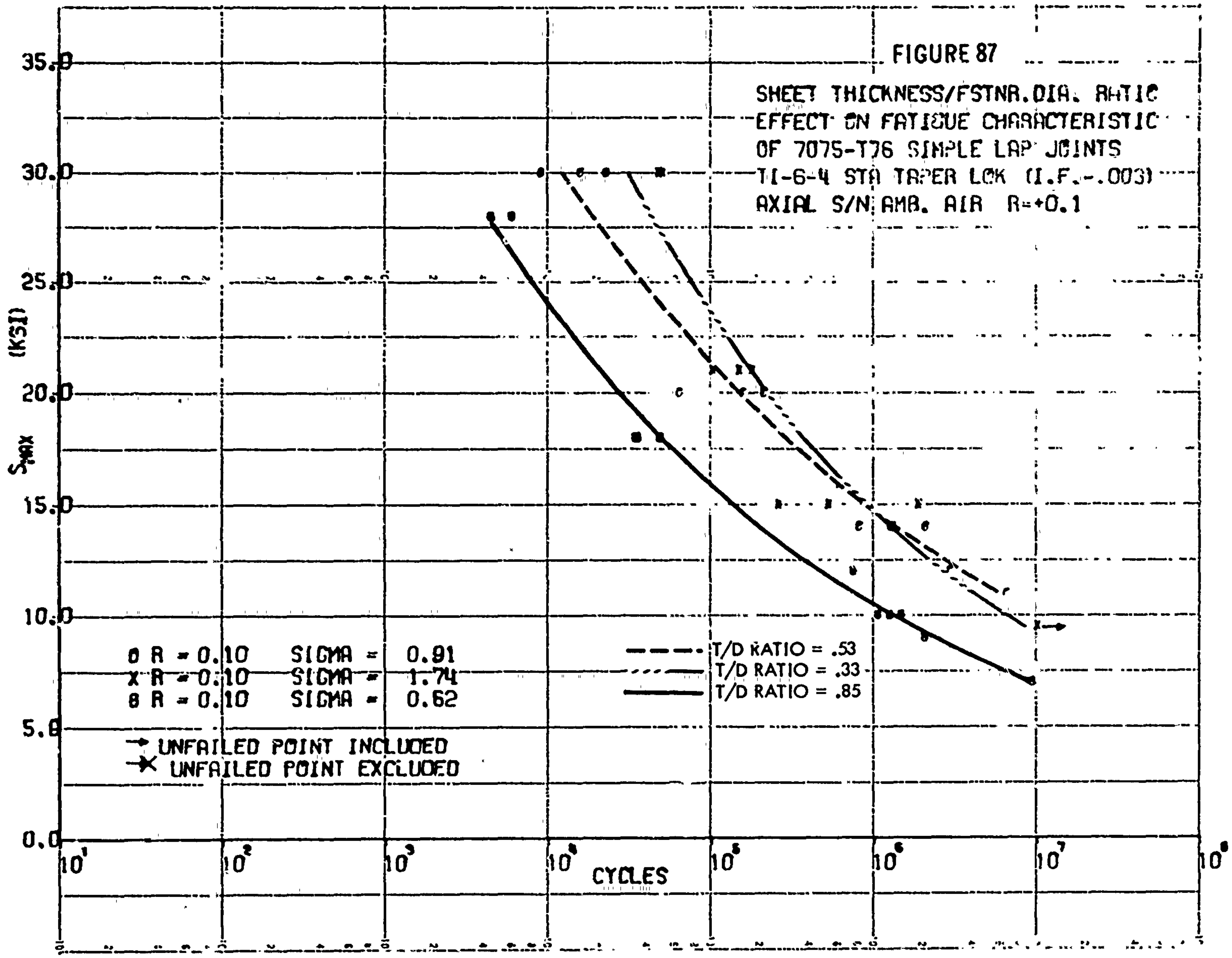


FIGURE 87
SHEET THICKNESS/FSTNR.DIA. RATIO
EFFECT ON FATIGUE CHARACTERISTIC
OF 7075-T76 SIMPLE LAP JOINTS
TI-6-4 STA TAPER LOK (I.F.-.003)
AXIAL S/N AMB. AIR R=+0.1
T/D RATIO = .53
T/D RATIO = .33
T/D RATIO = .85
0 R = 0.10 SIGMA = 0.91
X R = 0.10 SIGMA = 1.74
8 R = 0.10 SIGMA = 0.62
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES

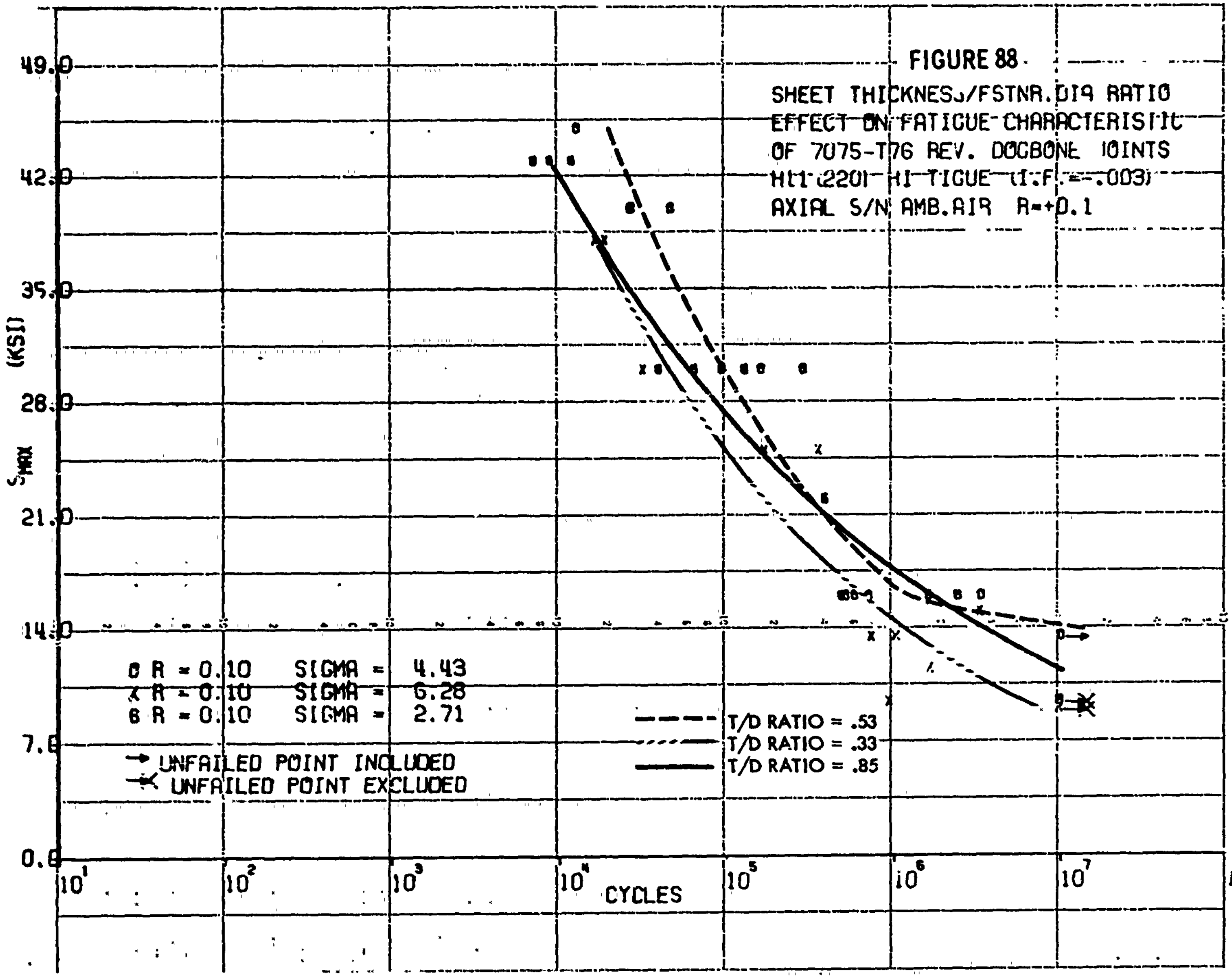
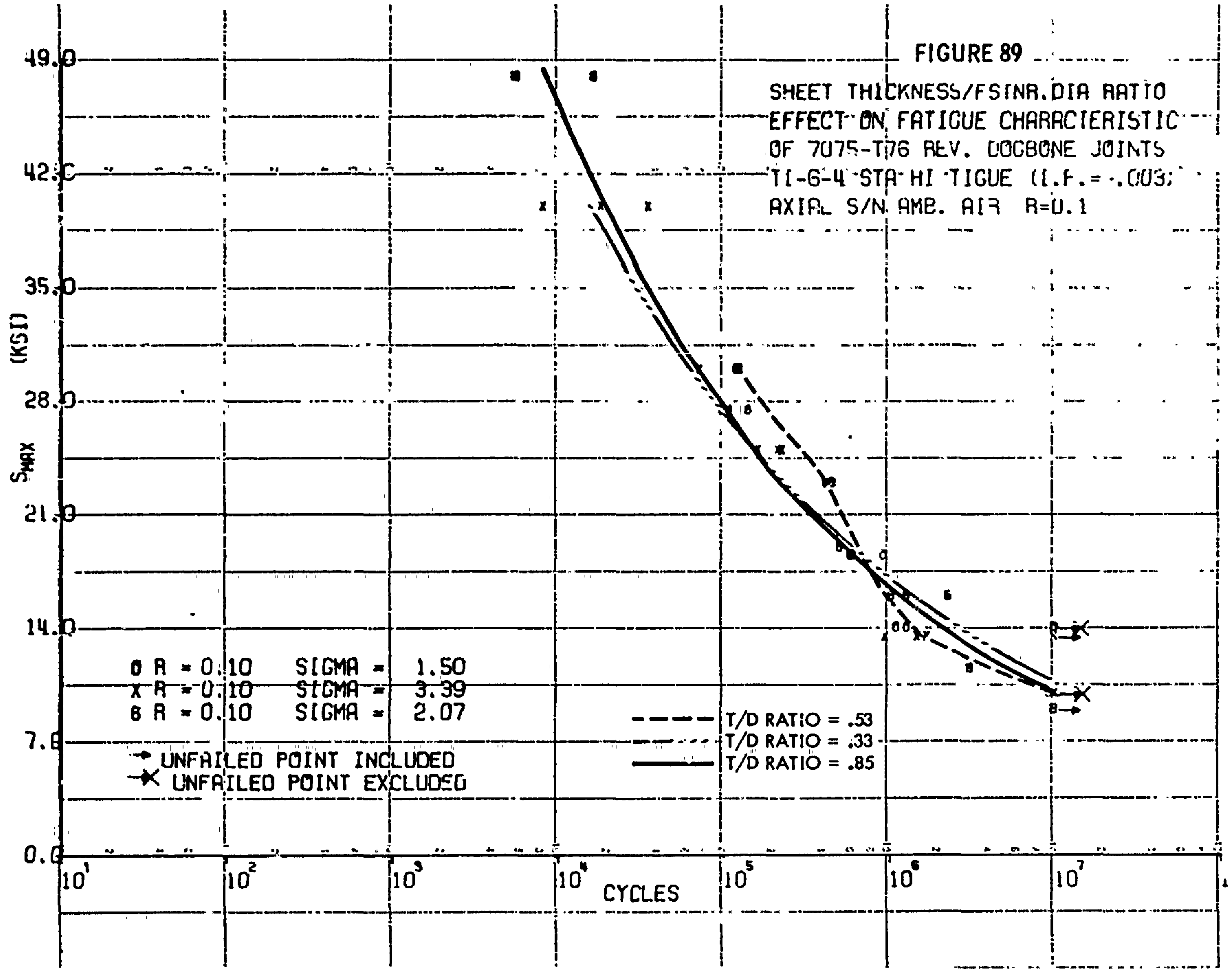


FIGURE 88
SHEET THICKNESJ/FSTNR.DIA RATIO
EFFECT ON FATIGUE CHARACTERISTIC
OF 7075-T76 REV. DOGBONE JOINTS
HI1 (220) HI TIGUE (I.F.=-.003)
AXIAL S/N AMB.AIR R=+0.1

FIGURE 89


SHEET THICKNESS/FSTNR.DIA RATIO
EFFECT ON FATIGUE CHARACTERISTIC
OF 7075-T76 REV. DOGBONE JOINTS
TI-6-4 STA HI TIGUE (I.F. = .003;
AXIAL S/N AMB. AIR R=0.1
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES
0 R = 0.10 SIGMA = 1.50
X R = 0.10 SIGMA = 3.39
8 R = 0.10 SIGMA = 2.07
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
T/D RATIO = .53
T/D RATIO = .33
T/D RATIO = .85

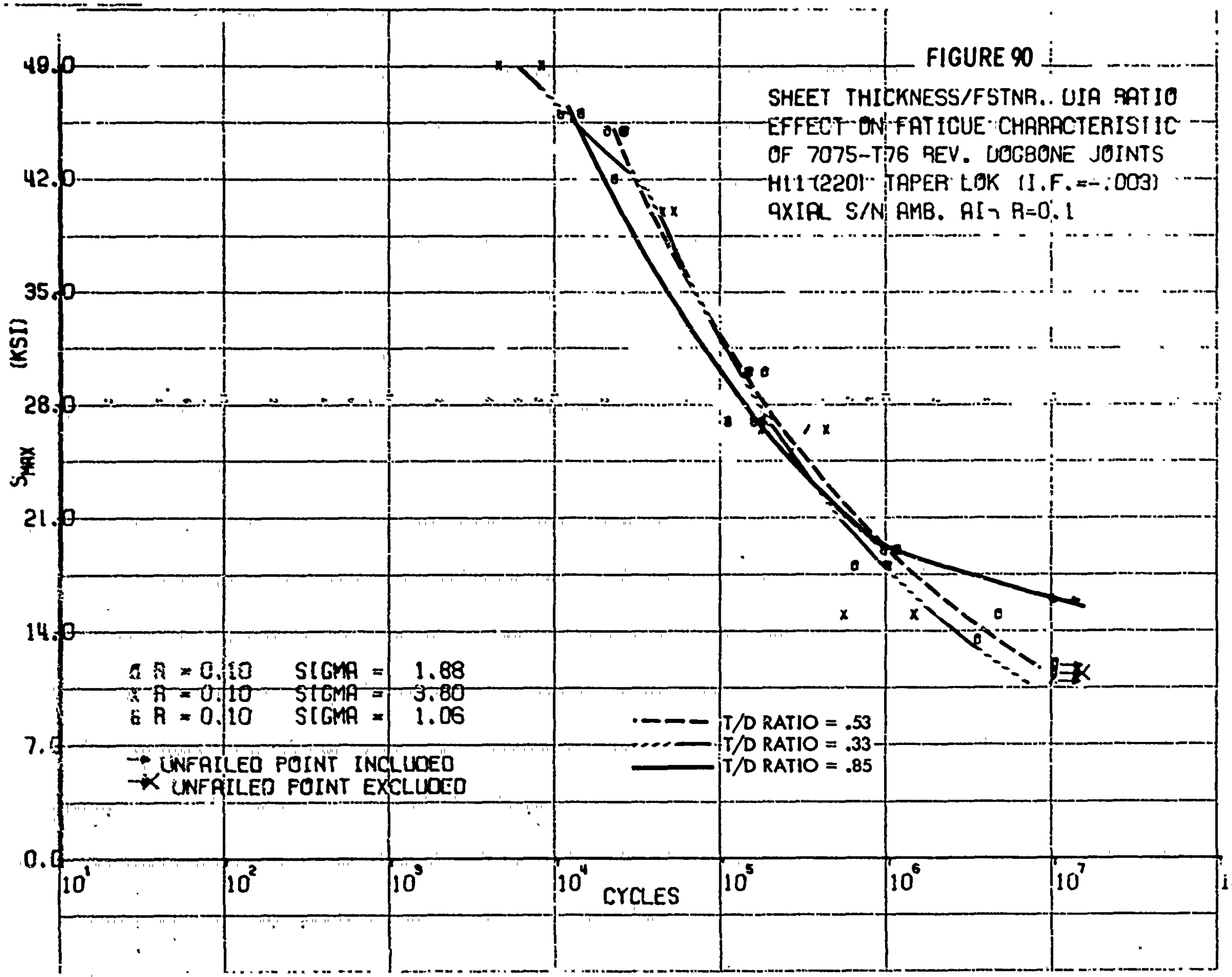


FIGURE 90
SHEET THICKNESS/FSTNR. DIA RATIO
EFFECT ON FATIGUE CHARACTERISTIC
OF 7075-T76 REV. DOGBONE JOINTS
H11 (220) TAPER LOK (I.F.=-.003)
AXIAL S/N AMB. AIR R=0.1
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0
S_{MAX} (KSI)
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
CYCLES
R = 0.10 SIGMA = 1.88
R = 0.10 SIGMA = 3.80
R = 0.10 SIGMA = 1.06
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
T/D RATIO = .53
T/D RATIO = .33
T/D RATIO = .85

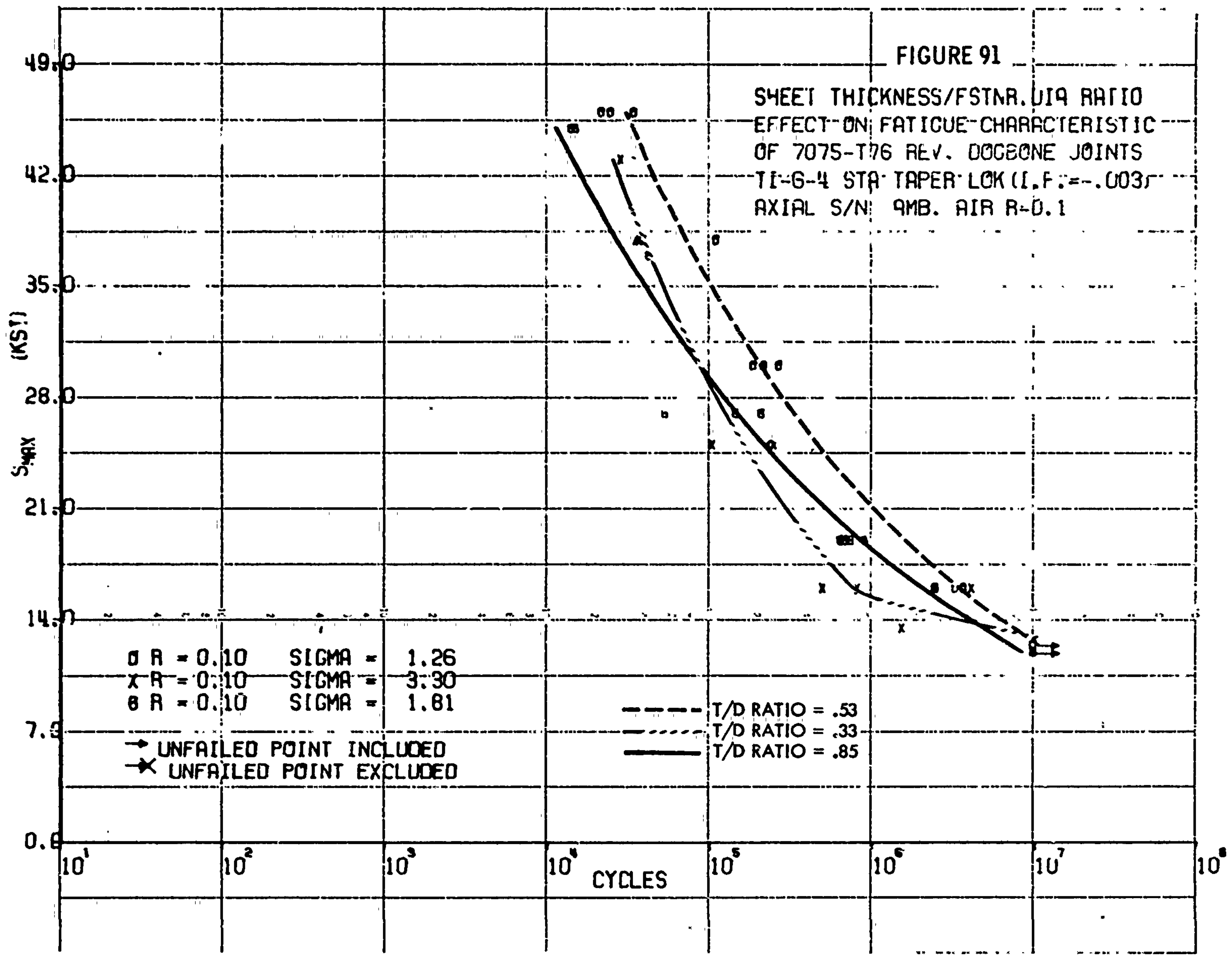


FIGURE 91
SHEET THICKNESS/FSTNR.DIA RATIO
EFFECT ON FATIGUE CHARACTERISTIC
OF 7075-T76 REV. DOGBONE JOINTS
TI-6-4 STA TAPER LOK (I.F.=-.003)
AXIAL S/N AMB. AIR R=0.1
49.0
42.0
35.0
28.0
21.0
14.0
7.5
0.8
S_{MAX} (KSI)
10¹
10²
10³
10⁴
10⁵
10⁶
10⁷
10⁸
CYCLES
σ R = 0.10 SIGMA = 1.26
X R = 0.10 SIGMA = 3.30
θ R = 0.10 SIGMA = 1.81
UNFAILED POINT INCLUDED
UNFAILED POINT EXCLUDED
T/D RATIO = .53
T/D RATIO = .33
T/D RATIO = .85

TABLE I. INDEX TO BASELINE DATA GENERATION

Joint Geometry	Amount of Load Transfer	Fastener System	Fastener Material: H11 (220) 132 KSI Shear		H11 (260) 156 KSI Shear		Ti-6-4-STA 95 KSI Shear		Sheet Material
			Table	Figure	Table	Figure	Table	Figure	
Lap Joint	100%	Hi Tigue	5	16	6	17	7	18	7075-T76 Clad
Lap Joint	100%	Hi Tigue	8	19	9	20	10	21	Ti-6Al-4V M.A.
Lap Joint	100%	Taper Lok	11	22	12	23	13	24	7075-T76 Clad
Lap Joint	100%	Taper Lok	14	25	15	26	16	22	Ti-6Al-4V M.A.
1-1/2 Dogbone	Approx. 30%	Hi Tigue	17	28	18	29	19	30	7075-T76 Clad
1-1/2 Dogbone	Approx. 30%	Hi Tigue	20	31	21	32	22	33	Ti-6Al-4V M.A.
1-1/2 Dogbone	Approx. 30%	Taper Lok	23	34	24	35	25	36	7075-T76 Clad
1-1/2 Dogbone	Approx. 30%	Taper Lok	26	37	27	38	28	39	Ti-6Al-4V M.A.
Reverse Dogbone	Approx. 5%	Hi Tigue	29	40	30	41	31	42	7075-T76 Clad
Reverse Dogbone	Approx. 5%	Hi Tigue	32	43	33	44	34	45	Ti-6Al-4V M.A.
Reverse Dogbone	Approx. 5%	Taper Lok	35	46	36	47	37	48	7075-T76 Clad
Reverse Dogbone	Approx. 5%	Taper Lok	38	49	39	50	40	51	Ti-6Al-4V M.A.

1. R = +0.1 = S Min/S Max
2. Test Environment: Laboratory Air
3. Fastener Diameter: Nominal 3/16 inch
4. Fastener Coating: For Alum. Structure: Titanium Fasteners, acetyl/alcohol; Steel Fasteners, Diffused Nickel Cad. per AMS 2416
   For Titanium Structure: Titanium and Steel Fasteners, Lubeco 2123 Type 2
5. Fastener Interference: Production Tolerances
6. Faying Surface Condition: Aluminum Sheet-Epoxy Zinc Chromate Primer plus Corrosion Inhibiting Sealant; Titanium Sheet - Molykote 106 Lubricant
7. Standard Production, Equipment and Procedures were used for Hole Fabrication.

TABLE II. INDEX TO TABULAR DATA AND FIGURES

Joint Geometry[4]	Amount of Load Transfer	Fastener System Steel H11 (220) Titanium-6Al-4V	Amount of Interference: Low 1		Production 2		High 3		Comparison Curves Shown In
			Table	Figure	Table	Figure	Table	Figure	
Lap Joint	100%	Hi-Tigue - Stl.	41	52	5	16	42	53	Figure 68
Lap Joint	100%	Hi-Tigue - Ti.	43	54	7	18	44	55	Figure 69
Lap Joint	100%	Taper Lok - Stl.	45	56	11	22	46	57	Figure 70
Lap Joint	100%	Taper Lok - Ti.	47	58	13	24	48	59	Figure 71
Reverse Dogbone	Approx. 5%	Hi-Tigue - Stl.	49	60	29	40	50	61	Figure 72
Reverse Dogbone	Approx. 5%	Hi-Tigue - Ti.	51	62	31	42	52	63	Figure 73
Reverse Dogbone	Approx. 5%	Taper Lok - Stl.	53	64	35	46	54	65	Figure 74
Reverse Dogbone	Approx. 5%	Taper Lok - Ti.	55	66	37	48	56	67	Figure 75

1. Low Interference: Hi-Tigue / Taper Lok -0.0015 mean -.0000 / -.0030 limits
2. Production: Hi-Tigue / Taper Lok -0.0030 mean -.0015 / -.0045 limits
3. High Interference: High Tigue / Taper Lok -0.0045 mean -.0030 / -.0060 limits
4. All specimens used for this series of tests made from .100 stock 7075-T76 Clad Material.

TABLE III. INDEX TO TABULAR DATA AND FIGURES (EFFECT OF FASTENER HOLE CONDITIONING)

Joint Geometry	Amount of Load Transfer	Fastener System Steel, H11 (220) Titanium-6Al-4V	Hole Preparation		Comparison Curves Shown In	Sheet Material
			Standard Production	Precise		
			Table	Table		
Lap Joint	100%	Hi Tigue - Stl.	5	57	Figure 76	7075-T76 Clad
Lap Joint	100%	Hi Tigue - Stl.	8	58	Figure 77	Ti-6Al-4V M.A.
Lap Joint	100%	Hi Tigue - Ti.	7	59	Figure 76	7075-T76 Clad
Lap Joint	100%	Hi Tigue - Ti.	10	60	Figure 77	Ti-6Al-4V M.A.
Reverse Dogbone	5%	Hi Tigue - Stl.	29	61	Figure 78	7075-T76 Clad
Reverse Dogbone	5%	Hi Tigue - Stl.	32	62	Figure 79	Ti-6Al-4V M.A.
Reverse Dogbone	5%	Hi Tigue - Ti.	31	63	Figure 78	7075-T76 Clad
Reverse Dogbone	5%	Hi Tigue - Ti.	34	64	Figure 79	Ti-6Al-4V M.A.
Lap Joint	100%	Taper Lok - Stl.	11	65	Figure 80	7075-T76 Clad
Lap Joint	100%	Taper Lok - Stl.	14	66	Figure 81	Ti-6Al-4V M.A.
Lap Joint	100%	Taper Lok - Ti.	13	67	Figure 80	7075-T76 Clad
Lap Joint	100%	Taper Lok - Ti.	16	68	Figure 81	Ti-6Al-4V M.A.
Reverse Dogbone	5%	Taper Lok - Stl.	35	69	Figure 82	7075-T76 Clad
Reverse Dogbone	5%	Taper Lok - Stl.	38	70	Figure 83	Ti-6Al-4V M.A.
Reverse Dogbone	5%	Taper Lok - Ti.	37	71	Figure 82	7075-T76 Clad
Reverse Dogbone	5%	Taper Lok - Ti.	40	72	Figure 83	Ti-6Al-4V M.A.

1. Standard Production - All holes were prepared using std. drill jig; No Reaming.

2. Precise Hole Generation - All holes were fabricated using tool and die maker equipment. All holes were inspected for roundness and taper.

TABLE IV. INDEX TO TABULAR DATA AND FIGURES (EFFECT OF SHEET THICKNESS/FASTENER DIAMETER RATIO)

Joint Geometry	Amount of Load Transfer	Fastener System Steel, H11 (220) Titanium-6A1-4V	Thickness/Diameter Ratio t/d			Comparison Curves Shown In
			Min. 0.33	Nominal 0.53	Max. 0.85	
			Table	Table	Table	
Lap Joint	100%	Hi Tigue - Stl.	73	5	74	Figure 84
Lap Joint	100%	Hi Tigue - Ti.	75	7	76	Figure 85
Lap Joint	100%	Taper Lok - Stl.	77	11	78	Figure 86
Lap Joint	100%	Taper Lok - Ti.	79	13	80	Figure 87
Reverse Dogbone	Approx. 5%	Hi Tigue - Stl.	81	29	82	Figure 88
Reverse Dogbone	Approx. 5%	Hi Tigue - Ti.	83	31	84	Figure 89
Reverse Dogbone	Approx. 5%	Taper Lok - Stl.	85	35	86	Figure 90
Reverse Dogbone	Approx. 5%	Taper Lok - Ti.	87	37	88	Figure 91

1. All Specimens used for this series of tests made from .100 stock 7075-T76 Clad Material.
2. All Specimens used for this series of tests made from .063 stock 7075-T76 Clad Material.
3. All Specimens used for this series of tests made from .160 stock 7075-T76 Clad Material.

TABLE V

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

HI-TIGUE, 7075-T76 CLAD HIGH LOAD TRANSFER JOINT

JOINT GEOMETRY: X16136-1A, Figure 1

FASTENER SYSTEM: HLT 315-6-4 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220) 132 ksi Shear

FASTENER COATING: Diffused Nickel-Cadmium

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2400 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
1A11	30	Flexure	13,520	CSKH	
1A7	30	Flexure	16,929	CSKH	
1A3	30	Sandwich	44,676	CSKH	
1A4	18	Flexure	111,672	PLA	
1A1	18	Flexure	161,680	PLA	
1A9	18	Sandwich	175,367	PLA	
1A2	18	Flexure	235,000	PLA	
1A12	15	Sandwich	130,000	PLA	
1A6	15	Sandwich	196,700	PLA	
1A10	15	Flexure	364,700	PLA	
1A5	15	Flexure	429,780	PLA	
1A8	13.5	Flexure	5,500,000 N.F.		
1A7	12	Flexure	10,200,000 N.F.		

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE VI

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

HI TIGUE, 7075-T76 CLAD HIGH LOAD TRANSFER JOINT

JOINT GEOMETRY: X16136-1B, Figure 1

FASTENER SYSTEM: HLT 15-6-4 Pin, HL 1386 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (260) 156 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2400 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
1B7	35	Flexure	5,080	CSKH	Constant Load
1B5	30	Flexure	11,500	CSKH	Constant Load
1B3	30	Sandwich	26,160	PLH	Constant Load
1B11	30	Flexure	26,750	PLH	Constant Load
1B1	18	Flexure	194,000	PLA,PLH	Constant Load
1B6	18	Sandwich	200,000	PLA,PLH	Constant Ampl.
1B2	18	Flexure	250,700	PLA,PLH	Constant Load
1B9	13	Sandwich	673,943	PLA,PLH	Constant Ampl.
1B12	13	Flexure	773,000	PLA,PLH	Constant Load
1B5	13	Flexure	1,522,000	PLA	Constant Load
1B10	11.5	Flexure	10,580,000 N.F.		Constant Ampl.

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE VII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

HI TIGUE, 7075-T76 CLAD HIGH LOAD TRANSFER JOINT

JOINT GEOMETRY: X16136-1E, Figure 1

FASTENER SYSTEM: HLT 411-6-4 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V STA, 95 ksi Shear

FASTENER COATING: Cetyl Alcohol Lube

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2400 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
1E10	30	Flexure	12,994	PLH	
1E9	30	Sandwich	19,260	CSKH	
1E11	30	Flexure	19,992	CSKA	
1E2	20	Flexure	77,970	PLA	
1E1	20	Flexure	101,000	PLA	
1E3	20	Sandwich	160,500	PLA	
1E6	14	Sandwich	195,312	PLA	
1E12	14	Flexure	261,500	PLA	
1E4	14	Flexure	493,350	PLA	
1E5	14	Flexure	589,200	PLA	
1E8	11.5	Flexure	9,110,800	PLA	
1E7	11	Flexure	9,863,200	PLA	

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE VIII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

HI TIGUE, Ti-6Al-4V M.A. HIGH LOAD TRANSFER JOINT

JOINT GEOMETRY: X16136-4A, Figure 1

FASTENER SYSTEM: HLT 315-6-4 No Ni-Cad, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220) 132 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: Production Cobalt Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2400 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
4A1	50	Flexure	12,800	CSKH	
4A3	50	Sandwich	22,800	CSKH	
4A2	50	Flexure	24,700	CSKH	
4A4	40	Flexure	40,000	CSKH	
4A7	30	Flexure	66,400	CSKH	
4A8	30	Flexure	89,200	CSKH	
4A6	30	Sandwich	246,900	PLH	
4A10	26	Flexure	210,330	CSKH	
4A12	20	Flexure	10,150,000 N.F.		
4A9	20	Sandwich	10,000,000 N.F.		
4A11	14	Flexure	10,000,000 N.F.		

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE IX

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
HI TIGUE, Ti-6Al-4V M.A. HIGH LOAD TRANSFER JOINT

JOINT GEOMETRY: X16136-4B, Figure 1

FASTENER SYSTEM: HLT 15-6-4 No Ni-Cad, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (260) 156 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: Production Cobalt Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2400 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
4B1	50	Flexure	16,400	CSKH	
4B2	50	Flexure	19,700	CSKH	
4B3	50	Sandwich	51,800	CSKH	
4B7	33	Flexure	120,500	CSKH	
4B12	33	Flexure	123,900	CSKH	
4B6	33	Sandwich	127,300	CSKH	
4B4	30	Flexure	267,900	CSKH	
4B8	25	Flexure	230,000	CSKH	
4B10	22.5	Flexure	381,100	CSKH	
4B11	22.5	Flexure	580,800	CSKH	
4B9	22.5	Sandwich	1,520,000	CSKH	
4B5	20	Flexure	11,668,000 N.F.		

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE X

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

HI TIGUE, Ti-6Al-4V M.A. HIGH LOAD TRANSFER JOINT

JOINT GEOMETRY: X16136-4E, Figure 1

FASTENER SYSTEM: HLT 411-6-4 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V STA, 95 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: Production Cobalt Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2400 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
4E4	55	Flexure	13,900	CSKH	
4E2	55	Flexure	15,700	CSKH	
4E3	55	Sandwich	23,400	CSKH	
4E9	45	Flexure	42,000	CSKH	
4E5	45	Flexure	42,800	CSKH	
4E6	45	Sandwich	49,800	CSKH	
4E7	36	Flexure	70,500	CSKH	
4E8	30	Flexure	143,625	PLH	
4E11	30	Flexure	380,475	PLH	
4E1	30	Flexure	1,550,800	PLH	
4E2	30	Flexure	10,000,000 N.F.		
4E10	26	Flexure	324,800	CSKH	
4E12	24	Flexure	1,385,200	PLH	

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XI

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TAPER LOK, 7075-T76 CLAD HIGH LOAD TRANSFER JOINT

JOINT GEOMETRY: X16136-1H, Figure 1

FASTENER SYSTEM: TLH 100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220) 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production HSS Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2400 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
1H7	30	Flexure	14,555	CSKH	
1H8	30	Flexure	20,050	CSKH	
1H9	30	Sandwich	24,875	CSKH	
1H3	20	Sandwich	126,250	PLA	
1H2	20	Flexure	150,150	PLA	
1H1	20	Flexure	231,000	PLA	
1H6	14	Sandwich	779,300	PLA	
1H5	14	Flexure	825,630	PLA	
1H4	14	Flexure	1,548,300	PLA	
1H10	11.5	Flexure	5,931,700	PLH	
1H11	10.5	Flexure	2,777,900	CSKH	

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TAPER LOK, 7075-T76 CLAD HIGH LOAD TRANSFER JOINT

JOINT GEOMETRY: X16136-1J, Figure 1

FASTENER SYSTEM: TLHC 100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (260) 156 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production HSS Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2400 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
1J1	30	Flexure	11,800	CSKH	Constant Load
1J3	30	Sandwich	18,800	CSKH	Constant Ampl.
1J2	30	Flexure	22,650	PLA	Constant Load
1J4	20	Flexure	186,420	CSKH	Constant Load
1J5	20	Flexure	200,460	PLA	Constant Load
1J6	20	Sandwich	297,850	PLA	Constant Ampl.
1J7	14	Flexure	2,591,100	PLA	Constant Load
1J9	14	Sandwich	4,100,600	CSKA	Constant Ampl.
1J8	14	Flexure	5,445,180	CSKH	Constant Load
1J12	14	Flexure	9,555,250	PLA	Constant Ampl.
1J10	11	Flexure	6,375,810	CSKH	Constant Ampl.
1J11	9.5	Flexure	11,211,000 N.F.		Constant Ampl.

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XIII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TAPER LOK, 7075-T76 CLAD HIGH LOAD TRANSFER JOINT

JOINT GEOMETRY: X16136-1M, Figure 1

FASTENER SYSTEM: TLV 100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V, STA 95 ksi Shear

FASTENER COATING: Cetyl Alcohol Lube

HOLE FABRICATION: Production HSS Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2400 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
1M5	30	Flexure	9,130	CSKH	
1M4	30	Flexure	15,980	PLH	
1M3	30	Sandwich	22,880	CSKH	
1M2	20	Flexure	64,980	CSKH	
1M1	20	Flexure	159,570	CSKH	
1M6	20	Sandwich	215,215	PLH	
1M7	14	Flexure	825,160	PLA	
1M8	14	Flexure	1,292,230	PLA	
1M9	14	Sandwich	1,335,500	CSKH	
1M12	14	Flexure	2,107,500	PLA	Constant Load
1M10	12	Flexure	2,981,500	CSKH	
1M11	11	Flexure	6,555,100	PLA	Constant Load

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XIV

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TAPER LOK, Ti-6Al-4V M.A. HIGH LOAD TRANSFER JOINT

JOINT GEOMETRY: X16136-4H, Figure 1

FASTENER SYSTEM: TLH 100-3-4 No Ni-Cad, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220) 132 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: Production Cobalt Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2400 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
4H2	54	Flexure	17,150	CSKH	
4H1	54	Flexure	19,960	CSKH	
4H3	54	Sandwich	30,500	CSKH	
4H5	45	Flexure	45,100	CSKH	
4H7	45	Flexure	79,500	CSKH	
4H6	45	Sandwich	136,000	CSKH	
4H8	38	Flexure	272,000	CSKH	
4H11	35	Flexure	83,300	CSKH	
4H12	35	Flexure	101,400	CSKH	Rerun
4H10	35	Flexure	125,300	CSKH	
4H9	33	Sandwich	552,600	CSKH	
4H4	33	Flexure	11,620,000 N.F.		
4H12	26	Flexure	12,800,000 N.F.		

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XV

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TAPER LOK, Ti-6Al-4V M.A. HIGH LOAD TRANSFER JOINT

JOINT GEOMETRY: X16136-4J, Figure 1

FASTENER SYSTEM: TLHC 100-3-4 No. Ni-Cad, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (260) 156 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: Production Cobalt Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2400 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
4J1	53	Flexure	10,800	CSKH	
4J2	53	Flexure	11,910	CSKH	
4J3	53	Sandwich	21,855	CSKH	
4J12	40	Flexure	59,520	CSKH	
4J5	34	Flexure	126,200	CSKH	
4J8	34	Flexure	173,200	CSKH	
4J4	34	Flexure	1,003,300	CSKH	
4J6	34	Sandwich	1,436,170	CSKH	
4J9	28	Sandwich	10,000,000 N.F.		
4J7	20	Flexure	10,000,000 N.F.		

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XVI

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TAPER LOK, Ti-6Al-4V M.A. HIGH LOAD TRANSFER JOINT

JOINT GEOMETRY: X16136-4M, Figure 1

FASTENER SYSTEM: TLV 100-3-4 STA, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V, 95 ksi shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: Production Cobalt Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
4M5	50	Flexure	10,000	CSKH	
4M8	50	Flexure	17,400	CSKH	
4M7	50	Flexure	28,900	CSKH	
4M4	50	Flexure	47,000	CSKH	
4M9	40	Sandwich	58,300	CSKH	
4M11	40	Flexure	109,600	CSKH	
4M10	40	Flexure	143,200	CSKH	
4M2	30	Flexure	276,000	CSKH	
4M3	30	Sandwich	700,200	CSKH	
4M1	30	Flexure	3,072,500	CSKH	
4M12	30	Flexure	10,000,000 N.F.		
4M6	25	Sandwich	10,000,000 N.F.		

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XVII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
HI TIGUE, 7075-T76 CLAD MEDIUM LOAD TRANSFER JOINT

JOINT GEOMETRY: X16137-1A, Figure 2

FASTENER SYSTEM: HLT 315-6-4 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Diffused Nickel-Cadmium

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 1,2,3,4	REMARKS
1A2	40	5,900	CSKH	
1A1	40	10,900	CSKH	
1A9	40	11,850	CSKH	
1A7	33	78,760	Not Noted	
1A10	30	119,400	CSKA	
1A4	30	136,800	CSKA	
1A3	30	166,300	CSKA	
1A6	20	796,000	CSKH	
1A11	20	919,000	Not Noted	
1A5	20	3,095,250	CSKA	
1A8	18	3,011,000	CSKH	

1. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
2. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
3. PLH = Sheet metal failure through the fastener holes in the plain sheet.
4. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XVIII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
HI TIGUE, 7075-T76 CLAD MEDIUM LOAD TRANSFER JOINT

JOINT GEOMETRY: X16137-1B, Figure 2

FASTENER SYSTEM: HL? 15-6-4 Pin, HL 1386 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (260) 156 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 1,2,3,4	REMARKS
1B3	40	3,980	CSKH	
1B2	40	9,200	CSKH	
1B1	40	12,700	CSKH	
1B10	26	179,100	CSKA	
1B12	26	193,700	CSKA	
1B9	26	303,000	CSKH	
1B8	26	345,700	CSKA	
1B4	20	709,000	CSKH	
1B6	20	1,001,100	Not Noted	
1B5	20	1,497,600	CSKA	
1B11	17.5	7,438,700	CSKH	
1B7	12.5	10,059,000 N.F.		

1. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
2. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
3. PLH = Sheet metal failure through the fastener holes in the plain sheet.
4. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XIX

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

HI TIGUE, 7075-T76 CLAD MEDIUM LOAD TRANSFER JOINT

JOINT GEOMETRY: X16137-1E, Figure 2

FASTENER SYSTEM: HLT 411-6-4 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V STA, 95 ksi Shear

FASTENER COATING: Cetyl Alcohol Lube

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 1,2,3,4	REMARKS
1E1	40	16,700	CSKH.	
1E5	40	21,790	CSKH.	
1E4	40	30,400	CSKH	
1E9	30	102,600	CSKA	
1E8	30	105,800	Not Noted	
1E3	30	137,200	CSKH	
1E12	22.5	589,500	CSKH	
1E2	20	597,100	CSKH	
1E10	20	2,356,200	Not Noted	
1E7	20	3,005,200	Not Noted	
1E6	20	6,862,100	CSKH	
1E11	18	19,400,000 N.F.		

1. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
2. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
3. PLH = Sheet metal failure through the fastener holes in the plain sheet.
4. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XX

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
HI TIGUE, Ti-6Al-4V M.A. MEDIUM LOAD TRANSFER JOINT

JOINT GEOMETRY: X16137-4A, Figure 2

FASTENER SYSTEM: HL? 315-6-4 No Ni-Cad, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: Production Cobalt Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 1,2,3,4	REMARKS
4A1	85	4,430	CSKH	
4A2	85	4,700	CSKH	
4A9	85	4,750	CSKH	
4A7	60	32,900	CSKH	
4A4	60	36,000	CSKH	
4A3	60	38,300	CSKH	
4A12	40	189,200	CSKH	
4A5	40	346,000	CSKH	
4A11	40	356,400	CSKH	
4A10	38	10,087,800 N.F.		
4A8	35	10,400,000 N.F.		
4A6	30	10,600,000 N.F.		

1. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
2. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
3. PIH = Sheet metal failure through the fastener holes in the plain sheet.
4. PIA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXI

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

HI TIGUE, Ti-6Al-4V M.A. MEDIUM LOAD TRANSFER JOINT

JOINT GEOMETRY: X16137-4B, Figure 2

FASTENER SYSTEM: HLT 15-6-4, No Ni-Cad, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (260), 156 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: Production Cobalt Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 1,2,3,4	REMARKS
4B7	85	2,900	CSKH	
4B2	85	4,000	CSKH	
4B1	85	6,900	CSKH	
4B6	60	28,000	CSKH	
4B8	60	30,500	CSKH	
4B3	60	54,270	CSKH	
4B9	40	108,500	CSKH	
4B4	40	301,500	CSKH	
4B5	40	725,100	CSKH	
4B12	38.5	422,000	CSKH	
4B11	37.5	13,765,000 N.F.		
4B10	34	7,817,400	CSKH	

1. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
2. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
3. PLH = Sheet metal failure through the fastener holes in the plain sheet.
4. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
HI TIGUE, Ti-6Al-4V M.A. MEDIUM LOAD TRANSFER JOINT

JOINT GEOMETRY: X16137-4E, Figure 2

FASTENER SYSTEM: HLT 411-6-4 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V STA, 95 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: Production Cobalt Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 1,2,3,4	REMARKS
4E8	85	7,000	CSKH	
4E1	85	12,000	CSKH	
4E5	85	15,780	CSKH	
4E2	70	28,800	CSKH	
4E11	60	59,900	CSKH	
4E10	60	73,600	CSKH	
4E12	60	75,200	CSKH	
4E3	50	266,400	CSKH	
4E4	40	279,800	CSKH	
4E9	40	643,500	CSKH	
4E6	40	1,571,500	CSKH	
4E7	32	10,000,000 N.F.		

1. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
2. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
3. PLH = Sheet metal failure through the fastener holes in the plain sheet.
4. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXIII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TAPER LOK, 7075-T76 CLAD MEDIUM LOAD TRANSFER JOINT

JOINT GEOMETRY: X16137-1H, Figure 2

FASTENER SYSTEM: TLH 100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production HSS Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 1,2,3,4	REMARKS
1H2	40	2,500	CSKH	
1H1	40	3,800	CSKH	
1H6	30	33,400	CSKH	
1H3	30	57,600	CSKH	
1H4	30	144,500	CSKA	
1H5	20	186,700	CSKA	
1H7	20	202,000	CSKA	
1H12	18	1,170,900	CSKH	
1H11	16	11,000,000 N.F.		
1H10	13.5	10,365,100	CSKH	
1H9	13.5	10,900,000 N.F.		

1. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
2. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
3. PLH = Sheet metal failure through the fastener holes in the plain sheet.
4. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXIV

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TAPER LOK, 7075-T76 CLAD MEDIUM LOAD TRANSFER JOINT

JOINT GEOMETRY: X16137-1J, Figure 2

FASTENER SYSTEM: TLHC 100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (260), 156 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production HSS Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 1,2,3,4	REMARKS
1J2	42	4,700	CSKH	
1J1	42	5,400	CSKH	
1J3	30	32,600	CSKH	
1J5	30	47,200	CSKH	
1J4	30	144,700	CSKH	
1J6	20	298,000	CSKH	
1J7	20	351,000	CSKH	
1J12	20	853,600	Not Noted	
1J8	17.5	2,469,000	CSKH	
1J10	17.5	3,241,000	CSKA	
1J9	17.5	10,900,000 N.F.		

1. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
2. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
3. PLH = Sheet metal failure through the fastener holes in the plain sheet.
4. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXV

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TAPER LOK, 7075-T76 CLAD MEDIUM LOAD TRANSFER JOINT

JOINT GEOMETRY: X16137-1M, Figure 2

FASTENER SYSTEM: TLV 100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V, STA, 95 ksi Shear

FASTENER COATING: Cetyl Alcohol Lube

HOLE FABRICATION: Production HSS Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 1,2,3,4	REMARKS
1M1	38	8,500	CSKH	
1M9	38	17,600	CSKH	
1M2	38	33,000	CSKH	
1M3	28	151,700	CSKA	
1M8	28	182,500	CSKA	
1M4	28	188,400	CSKH	
1M10	20	386,400	CSKH	
1M5	20	554,800	CSKH	
1M6	20	782,300	CSKH	
1M7	16	3,493,500	CSKH	
1M11	14.5	1,398,000	CSKH	
1M12	12	9,712,800	CSKH	

1. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
2. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
3. PLH = Sheet metal failure through the fastener holes in the plain sheet.
4. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXVI

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
TAPER LOK, Ti-6Al-4V M. A. MEDIUM LOAD TRANSFER JOINT

JOINT GEOMETRY: X16137-4H, Figure 2

FASTENER SYSTEM: TLH 100-3-4, No Ni-Cad, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: Production Cobalt Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 1,2,3,4	REMARKS
4H2	82	5,000	CSKH	
4H1	82	5,500	CSKH	
4H4	60	19,750	CSKH	
4H11	60	28,200	CSKH	
4H7	60	47,000	CSKH	
4H10	46	312,350	CSKH	
4H6	46	459,700	CSKH	
4H12	46	10,000,000 N.F.		
4H5	40	452,000	CSKH	
4H8	38	10,000,000 N.F.		

1. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
2. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
3. PIH = Sheet metal failure through the fastener holes in the plain sheet.
4. PIA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXVII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TAPER LOK, Ti-6Al-4V M.A. MEDIUM LOAD TRANSFER JOINT

JOINT GEOMETRY: X16137-4J, Figure 2

FASTENER SYSTEM: TLHC 100-3-4, No Ni-Cad, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (260), 156 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: Production Cobalt Taper Lok Drill Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 1,2,3,4	REMARKS
4J1	82	3,790	CSKH	
4J2	76.5	3,250	CSKH	
4J3	58	11,150	CSKH	
4J4	58	13,600	CSKH	
4J5	40	94,200	CSKH	
4J7	40	169,300	CSKH	
4J6	40	251,550	CSKH	
4J12	34	258,200	CSKH	
4J11	34	1,518,750	CSKH	
4J9	28	1,492,750	CSKH	
4J8	28	10,004,000 N.F.		
4J10	28	11,700,000 N.F.		

1. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
2. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
3. PLH = Sheet metal failure through the fastener holes in the plain sheet.
4. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXVIII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
TAPER LOK, Ti-6Al-4V M.A. MEDIUM LOAD TRANSFER JOINT

JOINT GEOMETRY: X16137-4M, Figure 2

FASTENER SYSTEM: TLV 100-3-4, STA, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V, 95 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: Production Cobalt Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 1,2,3,4	REMARKS
4M1	82	3,000	CSKH	
4M2	82	3,760	CSKH	
4M9	58	15,250	CSKH	
4M3	58	17,250	CSKH	
4M4	58	24,000	CSKH	
4M7	50	38,400	CSKH	
4M11	48	39,400	CSKH	
4M12	48	99,900	CSKH	
4M6	48	123,100	CSKH	
4M10	42	2,098,500	CSKH	
4M8	42	2,104,600	CSKH	
4M5	38	7,083,700	CSKH	

1. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
2. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
3. PLH = Sheet metal failure through the fastener holes in the plain sheet.
4. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXIX

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

HI TIGUE, 7075-T76 CLAD LOW LOAD TRANSFER JOINT

JOINT GEOMETRY: X16138-1A, Figure 3

FASTENER SYSTEM: HLT 315-6-4 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
1A11	45	12,840	CSKH, PLH	
1A9	40	27,120	CSKH, PLH	
1A6	40	27,600	CSKH, PLH	
1A5	40	47,100	PLH	
1A2	30	95,720	CSKA, PLH	
1A10	30	164,460	CSKH, PLH	
1A1	30	292,230	CSKH, PLH, PLA	
1A4	16	533,920	CSKH, PLH	
1A3	16	600,250	CSKH, PLH	
1A12	16	724,940	CSKH, PLH	
1A8	16	3,424,000	CSKH, PLH	
1A7	13.5	10,247,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXX

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
HI TIGUE, 7075-T76 CLAD LOW LOAD TRANSFER JOINT

JOINT GEOMETRY: X16138-1B, Figure 3

FASTENER SYSTEM: HLT 15-6-4 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (260), 156 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production ESS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
1B1	30	137,000	CSKH,PLH	
1B9	30	206,100	CSKH,PLH	
1B2	23	276,600	CSKH,PLH	
1B8	23	470,300	CSKH,PLH	
1B11	23	565,750	CSKH,PLA	Constant Ampl.
1B3	18.5	369,200	CSKH,PLH	
1B6	18.5	404,000	CSKH,PLH	
1B12	18.5	483,600	CSKH	Constant Ampl.
1B4	14	1,101,200	CSKH,PLH	
1B7	14	1,379,100	CSKH,PLH	
1B10	14	4,613,100	CSKH,PLH	
1B5	10	10,000,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXXI

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

HI TIGUE, 7075-T76 CLAD LOW LOAD TRANSFER JOINT

JOINT GEOMETRY: X16138-1E, Figure 3

FASTENER SYSTEM: HLT 411-6-4 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V STA, 95 ksi Shear

FASTENER COATING: Cetyl Alcohol Lube

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
1E9	30	120,200	CSKH	
1E1	30	124,300	CSKH, PLH	
1E8	23	425,100	CSKH, PLH	
1E11	23	450,300	CSKH, PLH	Constant Ampl.
1E2	23	458,500	CSKH, PLH	
1E3	18.5	585,200	CSKH, PLH	
1E12	18.5	610,100	CSKH	Constant Ampl.
1E6	18.5	931,500	CSKH, PLH	
1E4	14	1,115,500	CSKH, PLH	
1E7	14	1,301,400	CSKH, PLH	
1E10	14	10,000,000 N.F.		
1E5	10	9,325,500	CSKH, PLH	

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXXII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

HI TIGUE, Ti-6Al-4V M.A. LOW LOAD TRANSFER JOINT

JOINT GEOMETRY:	X16138-4A, Figure 3
FASTENER SYSTEM:	HLT 315-6-4, No Ni-Cad, HL 1386-6 Collar
INTERFERENCE FIT:	-0.003 inch
FASTENER MATERIAL:	H11 (220), 132 ksi Shear
FASTENER COATING:	Inorganic Solid Dry Film Lube
HOLE FABRICATION:	Production Cobalt Double Margin Drill
STRESS RATIO, S_{min}/S_{max}:	R = 0.1, Constant Load Unless Otherwise Noted
TEST SPEED:	600-2300 cpm Unless Otherwise Noted
TEST ENVIRONMENT:	Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
4A8	82	5,100	CSKH	
4A9	82	10,000	CSKH	
4A12	82	13,500	CSKH	
4A6	60	45,400	CSKH	
4A1	60	52,100	CSKH	
4A4	60	110,000	PLH	
4A3	46	163,155	CSKH, PLH	
4A10	46	232,000	CSKH, PLH	
4A2	46	259,900	CSKH, PLH	
4A11	46	306,900	CSKH, PLH	
4A7	40	10,000,000 N.F.		
4A5	32	10,000,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXXIII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
HI TIGUE, Ti-6Al-4V M.A. LOW LOAD TRANSFER JOINT

JOINT GEOMETRY: X16138-4B, Figure 3

FASTENER SYSTEM: HLT 15-6-4, No Ni-Cad, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (260), 156 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: Production Cobalt Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
4B1	82	9,720	CSKH	
4B11	82	12,700	CSKH	
4B2	82	16,800	CSKH	
4B4	60	53,700	CSKH, PLH	
4B7	60	53,800	CSKH, PLH	
4B3	60	93,400	CSKH	
4B9	49.2	171,600	CSKH, PLH	
4B5	46	111,600	CSKH, PLH	
4B12	46	306,100	CSKH, PLH	
4B6	46	428,900	CSKH, PLH	
4B8	41	550,000	CSKH, PLH	
4B10	38	10,000,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXXIV

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
HI TIGUE, Ti-6Al-4V M.A. LOW LOAD TRANSFER JOINT

JOINT GEOMETRY: X16138-4E, Figure 3

FASTENER SYSTEM: HLT 411-6-4 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V STA, 95 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: Production Cobalt Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
4E9	82	21,500	CSKH, PLH	
4E5	82	22,600	CSKH, PLH	
4E6	82	32,100	CSKH, PLH	
4E12	70	29,500	CSKH	
4E8	60	50,900	CSKH	
4E11	60	59,100	CSKH, PLH	
4E10	60	118,500	PLH	
4E7	60	124,200	CSKH, PLH	
4E4	45	300,460	CSKH	Constant Ampl.
4E2	45	361,950	CSKH	Constant Ampl.
4E3	45	536,400	PLH	Constant Ampl.
4E1	40	10,200,000 N.F.		Constant Ampl.

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXXV

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TAPER LOK, 7075-T76 CLAD LOW LOAD TRANSFER JOINT

JOINT GEOMETRY: X16138-1H, Figure 3

FASTENER SYSTEM: TLH 100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production HSS Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
1H6	45	20,300	CSKH	
1H10	45	25,200	CSKH,PLH	
1H11	45	26,100	CSKH	
1H5	30	142,100	CSKH	
1H1	30	148,200	CSKH,PLH	
1H3	30	181,700	CSKH	
1H8	18	640,800	CSKH,PLH	
1H4	18	977,500	CSKH,PLH	
1H7	18	1,006,000	CSKH,PLA	
1H2	15	4,640,000	PLA,GRIP	
1H9	13.5	3,465,000	CSKH,PLA	
1H12	12	10,230,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXXVI

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
TAPER LOK, 7075-T76 CLAD LOW LOAD TRANSFER JOINT

JOINT GEOMETRY: X16138-1J, Figure 3

FASTENER SYSTEM: TLHC 100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (260), 156 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production HSS Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
1J9	45	24,300	PLH	
1J10	45	25,800	CSKH	
1J11	45	42,400	CSKH,PLH	
1J5	30	131,300	CSKH	Constant Ampl.
1J1	30	146,500	CSKH	Constant Ampl.
1J2	30	165,800	CSKH	Constant Ampl.
1J12	22	264,200	CSKH,PLH	
1J4	16	713,100	CSKH	Constant Ampl.
1J6	16	722,100	CSKH	Constant Ampl.
1J3	16	798,500	CSKH	Constant Ampl.
1J7	13.5	1,948,500	CSKH	Constant Ampl.
1J8	11.5	10,437,000 N.F.		Constant Ampl.

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXXVII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TAPER LOK, 7075-T76 CLAD LOW LOAD TRANSFER JOINT

JOINT GEOMETRY:	X16138-1M, Figure 3
FASTENER SYSTEM:	TLV 100-3-4 Pin, TLN 1001-3 Washernut
INTERFERENCE FIT:	-0.003 inch
FASTENER MATERIAL:	Titanium-6Al-4V, 95 ksi Shear
FASTENER COATING:	Cetyl Alcohol Lube
HOLE FABRICATION:	Production HSS Tap : Lok Drill-Reamer
STRESS RATIO, S_{min}/S_{max}:	R = 0.1, Constant Load Unless Otherwise Noted
TEST SPEED:	600-2300 cpm Unless Otherwise Noted
TEST ENVIRONMENT:	Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
1M9	46	21,800	CSKH	
1M12	46	25,000	PIA	
1M10	46	34,700	CSKH	
1M7	38	112,200	CSKH, PLH	
1M1	30	188,500	CSKH, PLH	1800 cpm
1M2	30	220,200	CSKH, PLH	500 cpm
1M3	30	270,200	CSKH, PLH	500 cpm
1M4	16	2,450,300	CSKH, PLH	1800 cpm
1M5	16	3,314,000	CSKH, PLH	500 cpm
1M11	16	3,721,000	CSKH, PLH	
1M8	12.5	10,000,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PIA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXXVIII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
TAPER LOK, Ti-6Al-4V M.A. LOW LOAD TRANSFER JOINT

JOINT GEOMETRY: X16138-4H, Figure 3

FASTENER SYSTEM: TLH 100-3-4, No Ni-Cad, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: Production Cobalt Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
4H1	83	13,900	CSKH	
4H2	83	20,000	CSKH	
4H3	83	58,900	CSKH	
4H4	60	82,000	CSKH, PLH	
4H8	60	94,200	CSKH	
4H5	60	380,400	CSKH, PLH	
4H12	45	1,100,000	CSKH, PLH	
4H6	45	2,366,700	CSKH, PLH	
4H9	45	4,683,500	CSKH, PLH	
4H10	41	8,877,430	PLH	
4H11	38	10,000,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XXXIX

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
TAPER LOK, Ti-6Al-4V M.A. LOW LOAD TRANSFER JOINT

JOINT GEOMETRY: X16138-4J, Figure 3

FASTENER SYSTEM: TLHC 100-3-4, No Ni-Cad, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (260, 156 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: Production Cobalt Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
4J6	80	11,700	CSKH	
4J5	80	21,000	CSKH,PLH	
4J8	80	23,500	CSKH	
4J1	58	81,600	CSKH	
4J2	58	112,200	CSKH	
4J7	58	167,350	CSKH,PLH	
4J11	46	238,200	CSKH,PLH	
4J10	46	564,500	CSKH,PLH	
4J12	39	2,172,000	CSKH,PLH	

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XL

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TAPER LOK, Ti-6Al-4V M.A. LOW LOAD TRANSFER JOINT

JOINT GEOMETRY: X16138-4M, Figure 3

FASTENER SYSTEM: TLV 100-3-4 STA, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V, 95 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: Production Cobalt Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
4M2	82	14,800	CSKH	
4M12	82	14,900	CSKH	
4M1	82	20,500	CSKH	
4M4	60	80,370	CSKH, PLH	
4M6	60	108,370	CSKH	
4M11	60	119,500	CSKH	
4M5	48	124,000	CSKH, PLH	
4M10	48	160,700	CSKH, PLH	
4M9	48	359,600	CSKH, PLH	
4M8	48	760,800	PLA	
4M7	43	10,000,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XLI

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

ALLOY STEEL HI TIGUE, 7075-T76 CLAD HIGH LOAD TRANSFER JOINT -

LOW INTERFERENCE FIT

JOINT GEOMETRY: X16136-1AA, Figure 1

FASTENER SYSTEM: HLT 315-6-4 Pin, HL 1386 Collar

INTERFERENCE FIT: -0.0015 inch

FASTENER MATERIAL: H11 (220) 132 ksi Shear

FASTENER COATING: Diffused Nickel-Cadmium

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
1AA12	25	Flexure	14,600	CSKH	
1AA10	25	Flexure	18,000	CSKH	
1AA11	25	Flexure	20,000	CSKH	
1AA2	18	Flexure	69,700	CSKH	
1AA9	18	Flexure	83,500	PIA	
1AA1	18	Flexure	84,500	PIA	
1AA3	15	Flexure	235,200	PIA	
1AA4	15	Flexure	250,200	PIA	
1AA5	12.5	Flexure	341,600	PIA	
1AA6	11	Flexure	2,160,000	PIA	
1AA7	9.5	Flexure	10,000,000 N.F.		

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PIA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XLII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

ALLOY STEEL HI TIGUE, 7075-T76 CLAD HIGH LOAD TRANSFER JOINT - HIGH INTERFERENCE FIT

JOINT GEOMETRY: X16136-1AAA, Figure 1

FASTENER SYSTEM: HLT 315-6-4 Pin, HL 1386 Collar

INTERFERENCE FIT: -0.0045 inch

FASTENER MATERIAL: H11 (220) 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
1AAA5	30	Flexure	19,400	CSKH	
1AAA11	30	Flexure	25,600	CSKH	
1AAA6	30	Flexure	32,300	CSKH	
1AAA8	18	Flexure	178,000	PIA	
1AAA1	18	Flexure	190,800	PIA	
1AAA12	18	Flexure	202,500	PIA	Constant Load
1AAA2	18	Flexure	348,200	PIA	
1AAA3	15	Flexure	182,200	PIA	
1AAA4	15	Flexure	305,600	PIA	
1AAA7	15	Flexure	1,290,300	PIA	
1AAA10	13.5	Flexure	861,000	PIA	
1AAA9	12	Flexure	10,000,000 N.F.		

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PIA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XLIII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TITANIUM HI TIGUE, 7075-T76 CLAD HIGH LOAD TRANSFER JOINT -

LOW INTERFERENCE FIT

JOINT GEOMETRY: X16136-1EE, Figure 1

FASTENER SYSTEM: HLT 411-6-4 Pin, HL 1386 Collar

INTERFERENCE FIT: -0.0015 inch

FASTENER MATERIAL: Titanium-6Al-4V STA, 95 ksi Shear

FASTENER COATING: Cetyl Alcohol Lube

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
1EE10	30	Flexure	26,200	CSKH	
1EE9	30	Flexure	26,400	CSKH	
1EE11	30	Flexure	28,700	CSKH	
1EE3	18	Flexure	157,700	CSKH	
1EE5	18	Flexure	161,800	CSKH	
1EE6	18	Flexure	202,600	CSKH	
1EE4	15	Flexure	215,900	PLA	
1EE1	15	Flexure	412,900	PLA	
1EE2	15	Flexure	508,300	PLA	
1EE12	13	Flexure	3,278,000	CSKH,PLA	
1EE8	12	Flexure	10,000,000 N.F.		
1EE7	10	Flexure	10,000,000 N.F.		

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XLIV

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
TITANIUM HI TIGUE, 7075-T76 CLAD HIGH LOAD TRANSFER JOINT - HIGH INTERFERENCE FIT

JOINT GEOMETRY: X16136-1EEE, Figure 1

FASTENER SYSTEM: HLT 411-6-4 Pin, HL 1386 Collar

INTERFERENCE FIT: -0.0045 inch

FASTENER MATERIAL: Titanium-6Al-4V STA, 95 ksi shear

FASTENER COATING: Cetyl Alcohol Lube

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
1EEE10	30	Flexure	16,100	CSKH	
1EEE11	30	Flexure	41,200	CSKH	
1EEE5	21	Flexure	137,100	CSKH	
1EEE7	21	Flexure	147,700	CSKA	
1EEE6	21	Flexure	174,400	PIA	
1EEE2	15	Flexure	372,600	PIA	
1EEE3	15	Flexure	820,000	CSKH	
1EEE1	15	Flexure	1,123,900	PIA	
1EEE4	13	Flexure	1,966,500	PIA	
1EEE9	12	Flexure	3,069,400	PLH	
1EEE8	11	Flexure	5,200,300	PLH	
1EEE12	12	Flexure	8,207,000	CSKA	

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PIA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XLV

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

ALLOY STEEL TAPER LOK, 7075-T76 CLAD HIGH LOAD TRANSFER JOINT - LOW INTERFERENCE FIT

JOINT GEOMETRY: X16136-1HH, Figure 1

FASTENER SYSTEM: TLH 100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.0015 inch

FASTENER MATERIAL: H11 (220) 132 ksi Shear

FASTENER COATING: Diffused Nickel-Cadmium

HOLE FABRICATION: Production HSS Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
1HH1	30	Flexure	6,000	CSKH	
1HH7	30	Flexure	11,000	CSKH	
1HH2	30	Flexure	31,500	CSKH	
1HH3	20	Flexure	126,100	CSKA	
1HH4	20	Flexure	137,000	PLA	
1HH8	20	Flexure	197,000	PLH	
1HH9	14	Flexure	607,000	PLA	
1HH5	14	Flexure	1,093,600	PLA	
1HH6	14	Flexure	3,018,500	PLA	
1HH10	13	Flexure	1,696,000	CSKA	
1HH11	12	Flexure	3,174,000	CSKA	
1HH12	10.5	Flexure	1,406,200	CSKA	

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XLVI

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
ALLOY STEEL TAPER LOK, 7075-T76 CLAD HIGH LOAD TRANSFER JOINT - HIGH INTERFERENCE FIT

JOINT GEOMETRY: X16136-1HHH, Figure 1

FASTENER SYSTEM: TLH 100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.0045 inch

FASTENER MATERIAL: H11 (220) 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production HSS Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
1HHH7	32	Flexure	9,500	CSKH	
1HHH2	32	Flexure	14,100	CSKH	
1HHH1	32	Flexure	18,100	PLH	
1HHH3	22	Flexure	94,200	PLA	
1HHH8	22	Flexure	123,400	PLA	
1HHH4	22	Flexure	180,000	PLA	
1HHH11	14	Flexure	935,300	CSKA	
1HHH6	14	Flexure	1,135,300	CSKA	
1HHH10	14	Flexure	1,290,300	PLA	
1HHH5	14	Flexure	4,470,800	CSKH	
1HHH12	13.5	Flexure	2,039,600	PLA	
1HHH9	12	Flexure	8,273,600	PLA	

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XLVII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TITANIUM TAPER LOK, 7075-T76 CLAD HIGH LOAD TRANSFER JOINT -

LOW INTERFERENCE FIT

JOINT GEOMETRY: X16136-1MM, Figure 1

FASTENER SYSTEM: TLV 100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.0015 inch

FASTENER MATERIAL: Titanium-6Al-4V, STA, 95 ksi Shear

FASTENER COATING: Cetyl Alcohol Lube

HOLE FABRICATION: Production HSS Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
1MM11	35	Flexure	7,300	CSKH	
1MM3	35	Flexure	12,200	CSKH	
1MM7	35	Flexure	12,800	PLH	
1MM2	30	Flexure	26,500	CSKH	
1MM1	30	Flexure	42,900	CSKH	
1MM9	22	Flexure	101,900	PLH	
1MM5	21	Flexure	135,600	PLA	
1MM4	22	Flexure	138,000	PLA	
1MM6	15	Flexure	206,200	CSKH	
1MM12	15	Flexure	1,886,000	CSKA	
1MM8	13.5	Flexure	805,500	PLA	
1MM10	13.5	Flexure	9,904,100	PLA	

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XLVIII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT TITANIUM TAPER LOK, 7075-T76 CLAD HIGH LOAD TRANSFER JOINT - HIGH INTERFERENCE FIT

JOINT GEOMETRY: X16136-1MMM, Figure 1

FASTENER SYSTEM: TLV100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.0045 inch

FASTENER MATERIAL: Titanium-6Al-4V, STA, 95 ksi Shear

FASTENER COATING: Ceytl Alcohol Lube

HOLE FABRICATION: Production HSS Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
1MMM4	30	Flexure	9,700	CSKH	
1MMM5	30	Flexure	17,200	CSKH	
1MMM6	30	Flexure	57,300	PLA	
1MMM1	20	Flexure	168,300	CSKA	
1MMM3	20	Flexure	189,300	PLA	
1MMM2	20	Flexure	206,100	PLA	
1MMM7	14	Flexure	924,700	PLA	
1MMM12	14	Flexure	2,080,300	CSKA	
1MMM8	14	Flexure	3,796,600	CSKA	
1MMM10	11	Flexure	6,845,000	PLA	
1MMM11	9.5	Flexure	10,000,000 N.F.		

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE XLIX

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

ALLOY STEEL HI TIGUE, 7075-T76 CLAD

LOW LOAD TRANSFER JOINT - LOW INTERFERENCE FIT

JOINT GEOMETRY:	X16138-1AA, Figure 3
FASTENER SYSTEM:	HLT 315-6-4 Pin, HL 1386-6 Collar
INTERFERENCE FIT:	-0.0015 inch
FASTENER MATERIAL:	H11 (220), 132 ksi Shear
FASTENER COATING:	Diffused Nickel Cadmium
HOLE FABRICATION:	Production HSS Double Margin Drill
STRESS RATIO, S_{min}/S_{max}:	R = 0.1, Constant Load Unless Otherwise Noted
TEST SPEED:	600-2300 cpm Unless Otherwise Noted
TEST ENVIRONMENT:	Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
1AA11	40	18,600	CSKH,PLH	
1AA6	40	20,500	CSKH,PLH	
1AA2	30	87,900	CSKH	Constant Ampl.
1AA9	30	127,000	CSKH	Constant Ampl.
1AA3	30	135,600	CSKH	Constant Ampl.
1AA1	30	143,800	CSKH,PLH	Constant Ampl.
1AA4	20	391,300	CSKH	Constant Ampl.
1AA8	18	468,500	CSKH,PLH	
1AA10	18	627,800	CSKH	Constant Ampl.
1AA12	15.5	1,636,500	CSKH,PLH	
1AA7	14	11,600,000 N.F.		Constant Ampl.

1. Test specimen installation shown in Figure 4 and 5
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE L

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

ALLOY STEEL HI TI UE, 7075-T76 CLAD

LOW LOAD TRANSFER JOINT - HIGH INTERFERENCE FIT

JOINT GEOMETRY: X16138-1AAA, Figure 3

FASTENER SYSTEM: HLT 315-6-4 Pin, HL 1306 Collar

INTERFERENCE FIT: -0.0045 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
1AAA12	50	2,600	CSKH	
1AAA10	50	3,100	CSKH	
1AAA9	32	86,000	CSKA	Constant Ampl.
1AAA2	32	86,900	CSKH	Constant Ampl.
1AAA11	32	91,200	CSKH	
1AAA1	32	150,300	CSKH	Constant Ampl.
1AAA4	16	456,300	CSKH	Constant Ampl.
1AAA3	16	1,088,600	CSKH	Constant Ampl.
1AAA6	16	2,107,500	CSKH	Constant Ampl.
1AAA5	13.5	1,270,700	CSKH	Constant Ampl.
1AAA8	13.5	10,000,000 N.F.		Constant Ampl.
1AAA7	11	3,082,500	CSKH	Constant Ampl.

1. Test specimen installation shown in Figure 4 and 5
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LI

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TITANIUM HI TIGUE, 7075-T76 CLAD

LOW LOAD TRANSFER JOINT - LOW INTERFERENCE FIT

JOINT GEOMETRY: X16138-1EE, Figure 3

FASTENER SYSTEM: HLT 411-6-4 Pin, HL 1386 Collar

INTERFERENCE FIT: -0.0015 inch

FASTENER MATERIAL: Titanium-6Al-4V, STA, 95 ksi Shear

FASTENER COATING: Cetyl Alcohol Lube

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
1EE11	45	15,400	CSKH	
1EE10	45	19,800	CSKH, PLH	
1EE8	30	118,600	CSKH, PLH	
1EE12	30	138,000	CSKH, PLH	
1EE7	30	193,000	CSKH, PLA	
1EE2	23	315,200	CSKH	
1EE1	23	648,000	CSKH, PLH	
1EE3	16	568,000	CSKH, PLH	
1EE4	16	813,200	CSKH, PLH	
1EE9	16	2,077,200	CSKH, PLH	
1EE5	16	3,511,000	CSKH, PLH	
1EE6	14	10,000,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TITANIUM HI TIGUE, 7075-T76 CLAD

LOW LOAD TRANSFER JOINT - HIGH INTERFERENCE FIT

JOINT GEOMETRY:	X16138-1EEE, Figure 3
FASTENER SYSTEM:	HLT 411-6-4 Pin, HL 1386-6 Collar
INTERFERENCE FIT:	-0.0045 inch
FASTENER MATERIAL:	Titanium-6Al-4V, STA, 95 ksi Shear
FASTENER COATING:	Cetyl Alcohol Lube
HOLE FABRICATION:	Production HSS Double Margin Drill
STRESS RATIO, S_{min}/S_{max}:	R = 0.1, Constant Load Unless Otherwise Noted
TEST SPEED:	600-2300 cpm Unless Otherwise Noted
TEST ENVIRONMENT:	Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
1EEE11	45	4,000	CSKH	
1EEE3	45	9,100	PLH	
1EEE4	45	9,300	PLH	
1EEE7	30	45,700	PLH	
1EEE2	30	47,600	CSKH,PLH	
1EEE1	30	136,500	CSKH	
1EEE5	16	792,300	CSKH,PLH	
1EEE9	16	832,100	CSKH,PLH	
1EEE6	16	1,481,300	CSKH,PLH	
1EEE8	13	2,859,600	CSKH,PLH	
1EEE10	10.5	10,000,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LIII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
ALLOY STEEL TAPER LOK, 7075-T76 CLAD LOW LOAD TRANSFER JOINT -
LOW INTERFERENCE FIT

JOINT GEOMETRY: X16138-1HH Figure 3

FASTENER SYSTEM: TLH100-3-4 Pin, TLN1001-3 Washernut

INTERFERENCE FIT: -0.0015 inch

FASTENER MATERIAL: H11(220) 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production HSS Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
1HH8	40	12,900	PLH	Constant Ampl.
1HH12	40	16,000	PLH	Constant Ampl.
1HH9	40	18,400	CSKH,PLH	Constant Ampl.
1HH1	30	49,000	CSKH,PLH	
1HH2	30	51,000	CSKH,PLH	
1HH10	30	101,000	CSKH	Constant Ampl.
1HH3	16	633,200	CSKH,PLH	
1HH6	16	761,900	CSKH	
1HH4	16	1,648,000	CSKH,PLH	
1HH11	13.5	2,624,400	PLA	Constant Ampl.
1HH7	9.5	10,000,000 N.F.		Constant Ampl.

1. Test specimen installation shown in Figure 4 and 5
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LIV

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

ALLOY STEEL TAPER LOK, 7075-T76 CLAD LOW LOAD TRANSFER JOINT - HIGH INTERFERENCE FIT

JOINT GEOMETRY: X16138-1HHH Figure 3

FASTENER SYSTEM: TLH100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.0045 inch

FASTENER MATERIAL: H11(220) 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production HSS Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
1HHH12	45	12,400	CSKH	
1HHH11	45	21,600	CSKH,PLH	
1HHH1	32	97,000	CSKH	Constant Ampl.
1HHH2	32	110,100	PLH	Constant Ampl.
1HHH9	32	134,600	CSKH	Constant Ampl.
1HHH4	16	390,800	CSKH	Constant Ampl.
1HHH7	16	858,000	CSKH	Constant Ampl.
1HHH10	16	1,039,300	CSKH	Constant Ampl.
1HHH13	16	1,618,400	CSKH	Constant Ampl.
1HHH6	16	10,177,000 N.F.		
1HHH8	14.5	914,600	CSKH	Constant Ampl.
1HHH5	13.5	10,100,000 N.F.		Constant Ampl.

1. Test specimen installation shown in Figure 4 and 5
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LV

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TITANIUM TAPER LOK, 7075-T76 CLAD LOW LOAD TRANSFER JOINT - LOW INTERFERENCE FIT

JOINT GEOMETRY:	X16138-1MM Figure 3
FASTENER SYSTEM:	TLV100-3-4 Pin, TLN1001-3 Washernut
INTERFERENCE FIT:	-0.0015 inch
FASTENER MATERIAL:	Titanium-6Al-4V, STA, 95 ksi Shear
FASTENER COATING:	Cetyl Alcohol Lube
HOLE FABRICATION:	Production HSS Taper Lok Drill-Reamer
STRESS RATIO, S_{min}/S_{max}:	R = 0.1, Constant Load Unless Otherwise Noted
TEST SPEED:	600-2300 cpm Unless Otherwise Noted
TEST ENVIRONMENT:	Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
1MM2	48	5,750	PLH	
1MM10	48	8,500	PLH	
1MM1	48	9,800	CSKH,PLH	
1MM6	30	30,200	CSKH,PLH	
1MM12	30	56,400	CSKH,PLH	
1MM5	30	78,700	CSKH,PLH	
1MM3	30	88,500	PLH	
1MM8	15	855,800	CSKH,PLH	
1MM7	15	988,300	CSKH,PLH	
1MM4	15	1,491,500	CSKH,PLH	
1MM11	12.5	1,731,500	CSKH,PLA	
1MM9	10.5	10,000,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LVI

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
TITANIUM TAPER LOK, 7075-T76 CLAD LOW LOAD TRANSFER JOINT -
HIGH INTERFERENCE FIT

JOINT GEOMETRY: X16138-1MMM Figure 3

FASTENER SYSTEM: TLV100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.0045 inch

FASTENER MATERIAL: Titanium-6Al-4V, STA, 95 ksi Shear

FASTENER COATING: Ceytl Alcohol Lube

HOLE FABRICATION: Production HSS Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
1MMM10	50	9,200	PLH	
1MMM6	50	11,800	PLH	
1MMM5	42	47,300	CSKH,PLA	
1MMM1	32	107,300	CSKH	
1MMM2	32	123,100	CSKH	
1MMM8	32	129,300	CSKH,PLH	
1MMM4	18	662,300	CSKH,PLH	
1MMM3	18	750,600	CSKH,PLA	
1MMM7	15	1,198,000	CSKH,PLH	
1MMM11	15	1,360,700	CSKH,PLH	
1MMM9	15	1,783,000	CSKH,PLH	
1MMM12	10.5	10,000,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LVII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
STEEL HI TIGUE, 7075-T76 CLAD HIGH LOAD TRANSFER JOINT - PRECISION HOLE FABRICATION

JOINT GEOMETRY: X16136-1AP, Figure 1

FASTENER SYSTEM: HLT 315-6-4 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220) 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: 11/64 Pilot, 4 Flute (Straight) HSS Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
1AP2	30	Flexure	11,900	CSKH	
1AP1	30	Flexure	12,000	CSKH	
1AP3	30	Sandwich	32,000	CSKH	
1AP4	15	Flexure	202,800	PIA	
1AP6	15	Sandwich	243,000	PIA	
1AP5	15	Flexure	655,000	PIA	
1AP8	13.5	Flexure	615,200	PIA	
1AP9	13.5	Sandwich	879,700	PIA	
1AP7	13.5	Flexure	1,568,500	PIA	
1AP10	11	Flexure	5,201,800	PIA	
1AP11	9.5	Flexure	4,795,000	CSKA	
1AP12	8.5	Flexure	10,000,000 N.F.		

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PIA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LVIII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

STEEL HI TIGUE, Ti-6Al-4V, M.A. HIGH LOAD TRANSFER JOINT -

PRECISION HOLE FABRICATION

JOINT GEOMETRY: X16136-4AP, Figure 1

FASTENER SYSTEM: HLT 315-6-4 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220) 132 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: 11/64 Pilot, 6 Flute (Straight) Cobalt Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
4AP1	50	Flexure	14,600	CSKH	Constant Load
4AP2	50	Flexure	18,300	CSKH	Constant Load
4AP3	50	Sandwich	19,300	CSKH	
4AP5	30	Flexure	79,100	CSKH	Constant Load
4AP4	30	Flexure	127,800	CSKH	Constant Load
4AP6	30	Sandwich	196,200	CSKH	
4AP9	25	Sandwich	201,700	CSKH	
4AP7	25	Flexure	281,200	CSKH	Constant Load
4AP10	25	Flexure	560,300	CSKH	Constant Load
4AP11	20	Flexure	284,800	CSKH	
4AP12	20	Flexure	490,100	CSKH	
4AP8	17	Flexure	10,000,000 N.F.		

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LVIX

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TITANIUM HI TIGUE, 7075-T76 CLAD HIGH LOAD TRANSFER JOINT -

PRECISION HOLE FABRICATION

JOINT GEOMETRY: X16136-1EP, Figure 1

FASTENER SYSTEM: HLT 411-6-4 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V, STA, 95 ksi Shear

FASTENER COATING: Cetyl Alcohol Lube

HOLE FABRICATION: 11/64 Pilot, 4 Flute (Straight) HSS Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
1EP1	30	Flexure	11,800	PLH	Constant Load
1EP3	30	Sandwich	16,600	CSKH	
1EP2	30	Flexure	20,600	CSKH	Constant Load
1EP6	20	Sandwich	54,600	PLH	
1EP5	20	Flexure	96,900	PLA	Constant Load
1EP4	20	Flexure	149,000	PLA	Constant Load
1EP7	14	Flexure	272,400	PLA	Constant Load
1EP9	14	Sandwich	325,200	PLA	
1EP8	14	Flexure	505,500	PLA	
1EP10	11	Flexure	3,154,200	PLA	Constant Load
1EP11	9	Flexure	3,402,500	PLA	Constant Load
1EP12	7.5	Flexure	10,000,000 N.F.		Constant Load

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE IX

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
TITANIUM HI TIGUE, Ti-6Al-4V M.A. HIGH LOAD TRANSFER JOINT -
PRECISION HOLE FABRICATION

JOINT GEOMETRY: X16136-4EP, Figure 1

FASTENER SYSTEM: HLT 411-6-4 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V, STA, 95 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: 11/64 Pilot, 6 Flute (Straight) Cobalt Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
4EP3	55	Sandwich	5,400	CSKH	
4EP2	55	Flexure	6,500	CSKH	
4EP1	55	Flexure	9,000	CSKH	
4EP4	45	Flexure	14,500	CSKH	
4EP5	45	Flexure	15,100	CSKH	
4EP6	45	Sandwich	42,100	CSKH	
4EP12	40	Flexure	69,000	CSKH	
4EP8	30	Flexure	58,700	CSKH	Constant Load
4EP7	30	Flexure	161,800	CSKH	Constant Load
4EP9	30	Sandwich	181,200	CSKH	
4EP11	24	Flexure	953,200	CSKH	
4EP10	24	Flexure	1,043,100	CSKH	

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXI

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

STEEL HI TIGUE, 7075-T76 CLAD

LOW LOAD TRANSFER JOINT -

PRECISION HOLE FABRICATION

JOINT GEOMETRY: X16138-1AP, Figure 3

FASTENER SYSTEM: HLT 315-6 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: 11/64 Pilot, 4 Flute (Straight) HSS Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
1AP3	40	12,300	PLH	
1AP2	40	15,700	PLH	
1AP1	40	22,500	CSKH,PLH	
1AP4	30	94,900	PLH	Constant Ampl.
1AP5	30	123,300	CSKH	Constant Ampl.
1AP6	30	151,400	GRIP	Constant Ampl.
1AP12	30	175,100	GRIP	Constant Ampl.
1AP9	16	2,229,800	CSKH,PLH	Constant Ampl.
1AP7	16	3,819,400	PLH	Constant Ampl.
1AP8	16	10,460,000 N.F.		Constant Ampl.
1AP11	16	10,468,000 N.F.		Constant Ampl.
1AP10	14	10,554,000 N.F.		Constant Ampl.

1. Test specimen installation shown in Figure 4 and 5
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
STEEL HI TIGUE, Ti-6Al-4V M.A. LOW LOAD TRANSFER JOINT -
PRECISION HOLE FABRICATION

JOINT GEOMETRY: X16138-4AP, Figure 3

FASTENER SYSTEM: HLT 315-6-4 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: 11/64 Pilot, 6 Flute (Straight) Cobalt Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
4AP3	82	8,800	CSKH	
4AP2	82	10,700	CSKH	
4AP1	82	12,000	CSKH	
4AP6	60	39,000	CSKH	
4AP5	60	41,800	CSKH, PLH	
4AP4	60	54,300	CSKH	
4AP9	48	76,800	CSKH, PLH	
4AP12	48	440,900	CSKH, PLH	
4AP11	46	746,000	CSKH, PLH	
4AP7	46	1,724,600	CSKH	
4AP8	46	2,370,000	CSKH, PLA	
4AP10	41	10,076,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXIII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TITANIUM HI TIGUE, 7075-T76 CLAD

LOW LOAD TRANSFER JOINT - PRECISION HOLE FABRICATION

JOINT GEOMETRY:	X16138-1EP, Figure 3
FASTENER SYSTEM:	HLT 411-6-4 Pin, HL 1386-6 Collar
INTERFERENCE FIT:	-0.003 inch
FASTENER MATERIAL:	Titanium-6Al-4V, STA, 95 ksi Shear
FASTENER COATING:	Cetyl Alcohol Lube
HOLE FABRICATION:	11/64 Pilot, 4 Flute (Straight) HSS Reamer
STRESS RATIO, S_{min}/S_{max}:	R = 0.1, Constant Load Unless Otherwise Noted
TEST SPEED:	600-2300 cpm Unless Otherwise Noted
TEST ENVIRONMENT:	Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
1EP2	30	19,400	CSKH, PLH	Constant Ampl.
1EP10	30	19,700	PLH	Constant Ampl.
1EP3	30	20,000	CSKH, PLH	Constant Ampl.
1EP1	30	22,300	CSKH, PLH	Constant Ampl.
1EP11	23	41,3000 Rerun	PLH	Constant Ampl.
1EP5	23	114,500	CSKH, PLH	Constant Ampl.
1EP6	23	156,500	CSKH	Constant Ampl.
1EP4	23	268,300	CSKH	Constant Ampl.
1EP8	18.5	177,300	CSKH, PLH	Constant Ampl.
1EP7	18.5	320,500	PLH	Constant Ampl.
1EP9	18.5	487,200	PLH	Constant Ampl.
1EP12	14	10,800,000 N.F.		Constant Ampl.
1EP11	10	10,900,000 N.F.		Constant Ampl.

1. Test specimen installation shown in Figure 5
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXIV

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
TITANIUM HI TIGUE, Ti-6Al-4V M.A. LOW LOAD TRANSFER JOINT -
PRECISION HOLE FABRICATION

JOINT GEOMETRY:	X16138-4EP, Figure 3
FASTENER SYSTEM:	HLT 411-6-4 Pin, HL 1386- Collar
INTERFERENCE FIT:	-0.003 inch
FASTENER MATERIAL:	Titanium-6Al-4V, STA, 95 ksi Shear
FASTENER COATING:	Inorganic Solid Dry Film Lube
HOLE FABRICATION:	11/64 Pilot, 6 Flute (Straight) Cobalt Reamer
STRESS RATIO, S_{min}/S_{max}:	R = 0.1, Constant Load Unless Otherwise Noted
TEST SPEED:	600-2300 cpm Unless Otherwise Noted
TEST ENVIRONMENT:	Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
4EP2	82	14,500	CSKH,PLH	
4EP1	82	16,100	CSKH	
4EP3	82	17,900	CSKH	
4EP11	60	30,400	CSKH,PLH	
4EP5	60	56,700	CSKH	
4EP4	60	76,500	CSKH	
4EP6	60	94,800	CSKH	
4EP9	45	251,700	CSKH,PLH	
4EP8	45	389,100	CSKH,PLH	
4EP7	45	761,400	CSKH,PLH	
4EP12	43	661,500	CSKH,PLH	
4EP10	41	10,200,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXV

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
STEEL TAPER LOK, 7075-T76 CLAD HIGH LOAD TRANSFER JOINT -
PRECISION HOLE FABRICATION

JOINT GEOMETRY: X16136-1HP, Figure 1

FASTENER SYSTEM: TLH 100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: 11/64 Pilot, 3 Flute (Spiral) OMARK 2030 AR Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
1HP2	30	Flexure	21,800	CSKH	
1HP1	30	Flexure	35,900	CSKH	
1HP3	30	Sandwich	60,000	PLH	
1HP6	20	Sandwich	85,500	PIA	
1HP4	20	Flexure	199,100	PIA	
1HP5	20	Flexure	248,600	PIA	
1HP9	14	Sandwich	289,700	PIA	
1HP8	14	Flexure	990,000	CSKA	
1HP7	14	Flexure	1,431,600	CSKH	
1HP12	14	Flexure	3,087,600	PLH,PIA	
1HP11	12	Flexure	5,126,200	CSKA	
1HP10	9	Flexure	10,000,000 N.F.		

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PIA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXVI

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

STEEL TAPER LOK, Ti-6Al-4V, N.A. HIGH LOAD TRANSFER JOINT -

PRECISION HOLE FABRICATION

JOINT GEOMETRY: X16136-4HP, Figure 1

FASTENER SYSTEM: TLH100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: 11/64 Pilot, 6 Flute (Straight) OMARK 2060 AR Cobalt Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
4HP3	54	Sandwich	7,500	CSKH	
4HP1	54	Flexure	15,100	CSKH	Constant Load
4HP2	54	Flexure	25,300	CSKH	Constant Load
4HP6	35	Sandwich	90,600	CSKH	
4HP5	35	Flexure	130,700	CSKH	Constant Load
4HP4	35	Flexure	274,300	CSKH	Constant Load
4HP7	32	Flexure	156,000	CSKH	Constant Load
4HP9	32	Sandwich	191,300	CSKH	
4HP8	32	Flexure	388,000	CSKH	Constant Load
4HP10	24	Flexure	709,700	CSKH	Constant Load
4HP11	20	Flexure	5,730,700	PLH	Constant Load
4HP12	18.5	Flexure	10,000,000 N.F.		Constant Load

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXVII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
TITANIUM TAPER LOK. 7075-T76 CLAD HIGH LOAD TRANSFER JOINT - PRECISION HOLE FABRICATION

JOINT GEOMETRY: X16136-1MP, Figure 1

FASTENER SYSTEM: TLV 100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V, STA, 95 ksi Shear

FASTENER COATING: Cetyl Alcohol Lube

HOLE FABRICATION: 11/64 Pilot, 3 Flute (Spiral) OMARK 2030 AR, Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
1MP2	30	Flexure	27,100	PLA,PLH	
1MP1	30	Flexure	33,800	PLA	
1MP3	30	Sandwich	37,900	PLA	
1MP4	20	Flexure	59,500	PLA,PLH	
1MP5	20	Flexure	80,500	PLA,PLH	
1MP6	20	Sandwich	102,100	PLA,PLH	
1MP7	14	Flexure	251,100	PLA,PLH	
1MP9	14	Sandwich	457,700	PLA,PLH	
1MP8	14	Flexure	549,500	PLA,PLH	
1MP11	12	Flexure	9,382,800		
1MP10	10	Flexure	4,534,350	PLA	
1MP12	10	Flexure	6,002,200	PLA	

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXVIII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TITANIUM TAPER LOK, Ti-6Al-4V M.A. HIGH LOAD TRANSFER JOINT -

PRECISION HOLE FABRICATION

JOINT GEOMETRY: X16136-4MP, Figure 1

FASTENER SYSTEM: TLV 100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V, STA, 95 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: 11/64 Pilot, 6 Flute (Straight) OMARK 2060 AP Cobalt Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
4MP1	50	Flexure	15,100	CSKH	Constant Load
4MP2	50	Flexure	19,200	CSKH	Constant Load
4MP3	50	Sandwich	50,700	CSKH	
4MP4	40	Flexure	48,800	CSKH	Constant Load
4MP5	40	Flexure	51,800	CSKH	Constant Load
4MP6	40	Sandwich	71,400	CSKH	
4MP9	30	Sandwich	192,700	CSKH	
4MP7	30	Flexure	231,600	CSKH	Constant Load
4MP8	30	Flexure	1,604,100	CSKH	Constant Load
4MP10	35	Flexure	383,300	CSKH	Constant Load
4MP11	23	Flexure	10,197,900 N.F.		Constant Load

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXVIX

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

STEEL TAPER LOK, 7075-T76 CLAD

LOW LOAD TRANSFER JOINT - PRECISION HOLE FABRICATION

JOINT GEOMETRY: X16138-1HP, Figure 3

FASTENER SYSTEM: TLH 100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: 11/64 Pilot, 3 Flute (Spiral) OMARK 2030 AR Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
1HP1	45	22,500	CSKH,PLH	Constant Ampl.
1HP2	45	31,300	CSKH,PLH	Constant Ampl.
1HP3	45	32,300	CSKH	Constant Ampl.
1HP6	30	84,000	PLA	Constant Ampl.
1HP5	30	120,200	CSKH	Constant Ampl.
1HP4	30	156,200	CSKA	Constant Ampl.
1HP9	18	600,300	CSKH,PLH	Constant Ampl.
1HP7	18	1,181,000	CSKH,PLH	Constant Ampl.
1HP8	18	2,253,700	CSKH,PLA	Constant Ampl.
1HP10	14	2,000,500	CSKA	Constant Ampl.
1HP12	14	10,000,000 N.F.		Constant Ampl.
1HP11	11	10,438,000 N.F.		Constant Ampl.

1. Test specimen installation shown in Figure 5
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXX

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

STEEL TAPER LOK, Ti-6Al-4V M.A. LOW LOAD TRANSFER JOINT -

PRECISION HOLE FABRICATION

JOINT GEOMETRY: X16138-4HP, Figure 3

FASTENER SYSTEM: TLH 100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: 11/64 Pilot, 6 Flute (Straight) OMARK 2060 AR, Cobalt Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
4HP1	83	14,900	CSKH	
4HP3	83	15,000	CSKH	
4HP2	83	16,900	CSKH, PLH	
4HP4	60	137,300	CSKH, PLH	
4HP6	60	188,500	CSKH, PLH	
4HP5	60	240,900	CSKH	
4HP8	45	672,300	CSKH, PLH	
4HP7	45	1,844,000	CSKH, PLH	
4HP9	45	4,598,000	CSKH	
4HP12	45	10,000,000 N.F.		
4HP11	43	10,000,000 N.F.		
4HP10	41	10,200,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXXI

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TITANIUM TAPER LOK, 7C75-T76 CLAD LOW LOAD TRANSFER JOINT

PRECISION HOLE FABRICATION

JOINT GEOMETRY:	X16138-1MP, Figure 3
FASTENER SYSTEM:	TLV 100-3-4 Pin, TLN 1001-3 Washernut
INTERFERENCE FIT:	-0.003 inch
FASTENER MATERIAL:	Titanium-6Al-4V, STA, 95 ksi Shear
FASTENER COATING:	Ceytl Alcohol Lube
HOLE FABRICATION:	11/64 Pilot, 3 Flute (Spiral) OMARK 2030 AR Reamer
STRESS RATIO, S_{min}/S_{max}:	R = 0.1, Constant Load Unless Otherwise Noted
TEST SPEED:	600-2300 cpm Unless Otherwise Noted
TEST ENVIRONMENT:	Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
1MP3	46	20,300	CSKH	Constant Ampl.
1MP2	46	23,600	CSKH	Constant Ampl.
1MP1	46	34,200	PLA	Constant Ampl.
1MP5	30	83,100	CSKH	Constant Ampl.
1MP4	30	164,400	CSKH	Constant Ampl.
1MP6	30	171,400	CSKH	Constant Ampl.
1MP7	16	734,200	CSKH	Constant Ampl.
1MP9	16	795,600	CSKH,PLH	Constant Ampl.
1MP8	16	1,197,500	CSKH	Constant Ampl.
1MP12	13	3,833,100	CSKH,PLH	Constant Ampl.
1MP10	13	4,503,000	CSKH,PLH	Constant Ampl.
1MP11	10.5	10,000,000 N.F.		Constant Ampl.

1. Test specimen installation shown in Figure 5
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXXII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
TITANIUM TAPER LOK, Ti-6Al-4V, M.A. LOW LOAD TRANSFER JOINT
PRECISION HOLE FABRICATION

JOINT GEOMETRY: X16138-4MP, Figure 3

FASTENER SYSTEM: TLV 100-3-4 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V, STA, 95 ksi Shear

FASTENER COATING: Inorganic Solid Dry Film Lube

HOLE FABRICATION: 11/64 Pilot, 6 Flute (Straight) OMARK 2060 AR, Cobalt Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
4MP3	82	15,000	CSKH	
4MP1	82	15,800	CSKH	
4MP2	82	20,600	CSKH,PLH	
4MP5	60	75,000	CSKH	
4MP4	60	91,600	CSKH	
4MP7	48	454,000	CSKH,PLH	
4MP12	48	1,129,300	CSKH	
4MP8	48	2,752,200	CSKH,PLH	
4MP9	48	7,901,000	CSKH	
4MP11	42	10,000,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXXIII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

STEEL HI TIGUE, 7075-T76 CLAD

HIGH LOAD TRANSFER JOINT - T/D = .33

JOINT GEOMETRY: X16136-2C, Figure 1

FASTENER SYSTEM: HLT 315-6-2 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
2C5	30	Flexure	14,200	PIA	
2C1	30	Flexure	56,300	PIA	
2C3	30	Flexure	59,800	PIA	
2C6	20	Flexure	188,700	PIA	
2C11	20	Flexure	259,000	PIA	
2C8	20	Flexure	372,400	PIA	
2C2	20	Flexure	713,500	PIA	
2C10	17.5	Flexure	1,903,500	PIA	
2C9	17.5	Flexure	2,258,000	PIA	
2C12	17.5	Flexure	3,694,500	PIA	
2C7	14	Flexure	10,900,000 N.F.		

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PIA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXXIV

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

STEEL HI TIGUE, 7075-T76 CLAD, HIGH LOAD TRANSFER JOINT T/D = .85

JOINT GEOMETRY: X16136-3D, Figure 1

FASTENER SYSTEM: HLT 315-6-6 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 135 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
3D1	20	Flexure	11,000	PLH	Constant Load
3D2	20	Flexure	16,900	PLH	Constant Load
3D5	20	Flexure	31,500	CSKH	Constant Load
3D4	16	Flexure	57,100	CSKH	Constant Load
3D10	14	Flexure	300,600	PLH	Constant Load
3D3	14	Flexure	312,000	PIA	Constant Load
3D9	14	Flexure	344,500	CSKA	Constant Load
3D7	12	Flexure	627,600	CSKA	Constant Load
3D6	12	Flexure	680,900	PIA	Constant Load
3D8	9.5	Flexure	2,703,600	PIA	Constant Load
3D11	7.5	Flexure	4,991,500	PIA	Constant Load
3D12	6	Flexure	10,000,000 N.F.		Constant Load

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PIA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXXV

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
TITANIUM HI TIGUE, 7075-T76 CLAD,
HIGH LOAD TRANSFER JOINT T/D = .33

JOINT GEOMETRY: X16136-2F, Figure 1

FASTENER SYSTEM: HLT 411-6-2 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V, STA, 95 ksi Shear

FASTENER COATING: Cetyl Alcohol Lube

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
2F7	39	Flexure	3,650	CSKH	
2F2	33	Flexure	19,900	CSKH	
2F1	33	Flexure	34,600	PLA	
2F12	33	Flexure	35,900	PLA	
2F11	22	Flexure	208,300	CSKH	
2F4	22	Flexure	254,700	CSKH	
2F3	22	Flexure	712,400	CSKA	
2F6	18	Flexure	206,500	CSKH	
2F5	18	Flexure	618,900	CSKH	
2F8	16	Flexure	1,532,400	PLA	
2F10	16	Flexure	5,488,700	PLA	
2F9	12	Flexure	10,000,000 N.F.		

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXXVI

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
TITANIUM HI TIGUE, 7075-T76 CLAD,
HIGH LOAD TRANSFER JOINT T/D = .85

JOINT GEOMETRY: X16136-3G, Figure 1

FASTENER SYSTEM: HLT 411-6-6 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V, STA, 95 ksi Shear

FASTENER COATING: Cetyl Alcohol Lube

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
3G1	30	Flexure	3,700	PLH	
3G2	30	Flexure	7,100	CSKH	
3G3	20	Flexure	46,200	PLH	
3G5	16	Flexure	34,500	PLH	
3G6	15	Flexure	160,500	PIA	
3G7	15	Flexure	202,000	PIA	
3G8	12	Flexure	408,500	CSKH	
3G12	10.5	Flexure	1,077,000	PIA	
3G9	10.5	Flexure	2,173,100	PIA	
3G10	8.5	Flexure	5,249,600	CSKA	
3G11	7.5	Flexure	10,000,000 N.F.		

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PIA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXXVII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
STEEL TAPER LOK, 7075-T76 CLAD,
HIGH LOAD TRANSFER JOINT - T/D = .33

JOINT GEOMETRY: X16136-2K, Figure 1

FASTENER SYSTEM: TL 100-3-2 Pin, TL 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production Taper Lok HSS Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
2K6	37	Flexure	8,600	CSKH	
2K12	32	Flexure	64,500	PLA	
2K2	32	Flexure	72,800	PLA	
2K1	32	Flexure	73,200	PLA	
2K3	22	Flexure	355,900	PLA	
2K5	19	Flexure	810,800	PLA	
2K8	19	Flexure	889,900	PLA	
2K9	19	Flexure	1,017,800	PLA	
2K4	17.5	Flexure	2,897,000	PLA	
2K10	15.5	Flexure	2,280,300	CSKH	
2K11	13.5	Flexure	4,741,500	PLA	

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXXVIII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

STEEL TAPER LOK, 7075-T76 CLAD,

HIGH LOAD TRANSFER JOINT - T/D = .85

JOINT GEOMETRY: X16136-3L, Figure 1

FASTENER SYSTEM: TLH 100-3-6 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production-Taper Lok HSS Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
3L2	30	Flexure	3,800	CSKH	
3L1	30	Flexure	9,900	CSKH	
3L4	20	Flexure	59,100	CSKH	1800 cpm
3L3	20	Flexure	79,100	CSKH	500 cpm
3L5	20	Flexure	95,200	CSKH	1800 cpm
3L7	16	Flexure	149,000	PLH	1800 cpm
3L6	16	Flexure	157,600	PLH	500 cpm
3L10	12	Flexure	804,900	PLA	
3L8	12	Flexure	1,165,600	PLA	
3L9	10.5	Flexure	1,026,000	PLA	
3L11	8.5	Flexure	2,242,200	CSKA	
3L12	6.5	Flexure	10,000,000 N.F.		

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXXIX

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TITANIUM TAPER LOK, 7075-T76 CLAD,

HIGH LOAD TRANSFER JOINT -

T/D = .33

JOINT GEOMETRY: X16136-2N, Figure 1

FASTENER SYSTEM: TLV 100-3-2 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V, STA, 95 ksi Shear

FASTENER COATING: Cetyl Alcohol Lube

HOLE FABRICATION: Production Taper Lok HSS Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Amplitude Unless Otherwise Noted

TEST SPEED: 1800-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
2N4	38	Flexure	4,000	PLA	
2N11	38	Flexure	34,000	PLA	
2N2	30	Flexure	49,000	PLA	
2N1	30	Flexure	49,200	PLA	
2N12	30	Flexure	51,700	PLA	
2N8	21	Flexure	103,800	PLA	
2N3	21	Flexure	153,200	PLA	
2N4	21	Flexure	181,000	PLA	
2N7	15	Flexure	267,000	PLA	
2N6	15	Flexure	540,000	PLA	
2N5	15	Flexure	1,903,500	PLA	
2N10	9.5	Flexure	10,200,000 N.F.		

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXXX

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
TITANIUM TAPER LOK, 7075-T76 CLAD,
HIGH LOAD TRANSFER JOINT - T/D = .85

JOINT GEOMETRY:	X16136-3"0", Figure 1
FASTENER SYSTEM:	TLV 100-3-6 Pin, TLN 1001-3 Washernut
INTERFERENCE FIT:	-0.003 inch
FASTENER MATERIAL:	Titanium-6Al-4V, STA, 95 ksi Shear
FASTENER COATING:	Cetyl Alcohol Lube
HOLE FABRICATION:	Production Taper Lok WSS Drill-Reamer
STRESS RATIO, S_{min}/S_{max}:	R = 0.1, Constant Amplitude Unless Otherwise Noted
TEST SPEED:	1800-2300 cpm Unless Otherwise Noted
TEST ENVIRONMENT:	Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	SPEC. SUPPORT METHOD 1,2	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 3,4,5,6	REMARKS
3"0"1	28	Flexure	4,500	CSKH	
3"0"2	28	Flexure	5,000	CSKH	
3"0"7	18	Flexure	34,400	CSKH	
3"0"9	18	Flexure	36,000	CSKH	
3"0"3	18	Flexure	49,300	CSKH	
3"0"4	12	Flexure	767,000	PLA	
3"0"6	10	Flexure	1,078,800	CSKH	
3"0"5	10	Flexure	1,271,700	PLH	
3"0"10	10	Flexure	1,495,200	CSKH	
3"0"12	9	Flexure	2,083,500	CSKH	
3"0"8	7	Flexure	9,501,900	CSKH	

1. Four flexures (90° offset), see Figure 7
2. "Sandwich" guide and restraint, see Figure 6
3. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
4. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
5. PLH = Sheet metal failure through the fastener holes in the plain sheet.
6. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXXXI

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
STEEL HI TIGUE, 7075-T76 CLAD,
LOW LOAD TRANSFER JOINT - T/D = .33

JOINT GEOMETRY: X16138-2C, Figure 3

FASTENER SYSTEM: HLT 315-6-2 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
2C6	38	16,700	CSKH	
2C10	38	19,000	CSKH,PLH	
2C1	30	32,300	CSKH,PLH	
2C2	25	172,600	CSKH,PLH	
2C4	25	365,300	CSKH,PLH	
2C3	15	3,334,400	CSKH,PLH	
2C7	13.5	751,300	CSKH,PLH	
2C8	13.5	1,048,300	CSKH,PLH	
2C9	11.5	1,688,300	CSKA,PLA	
2C11	9.5	953,300	CSKH,PLA	
2C12	9	10,000,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXXXII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
STEEL HI TIGUE, 7075-T76 CLAD,
LOW LOAD TRANSFER JOINT - T/D = .85

JOINT GEOMETRY:	X16138-3D, Figure 3
FASTENER SYSTEM:	HLT 315-6-6 Pin, HL 1386-6 Collar
INTERFERENCE FIT:	-0.003 inch
FASTENER MATERIAL:	H11 (220), 132 ksi Shear
FASTENER COATING:	Diffused Nickel Cadmium
HOLE FABRICATION:	Production HSS Double Margin Drill
STRESS RATIO, S_{min}/S_{max}:	R = 0.1, Constant Load Unless Otherwise Noted
TEST SPEED:	600-2300 cpm Unless Otherwise Noted
TEST ENVIRONMENT:	Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
3D8	43	7,100	PLH	
3D11	43	8,900	CSKH	
3D12	43	12,000	CSKH,PLH	
3D1	30	39,900	CSKH,PLH	
3D5	30	65,500	CSKH,PLH	
3D4	30	130,900	CSKH,PLA	
3D2	22	395,900	CSKH,PLA	
3D6	16	499,200	CSKH,PLH	
3D3	16	1,639,000	CSKH,PLH	
3D9	16	2,472,300	CSKH,PLH	
3D10	9.5	10,000,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXXXIII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT
TITANIUM HI TIGUE, 7075-T76 CLAD,
LOW LOAD TRANSFER JOINT - T/D = .33

JOINT GEOMETRY: X16138-2F, Figure 3

FASTENER SYSTEM: HLT 411-6-2 Pin, HL 1386-6 Collar

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V, STA, 95 ksi Shear

FASTENER COATING: Cetyl Alcohol Lube

HOLE FABRICATION: Production HSS Double Margin Drill

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
2F2	40	8,300	CSKH	
2F1	40	18,500	CSKH	
2F6	40	35,800	CSKH	
2F12	30	72,100	CSKH	
2F3	25	164,000	CSKH, PLH	
2F8	25	220,000	CSKH, PLH	
2F10	25	231,000	CSKH, PLH	
2F5	13.5	963,900	CSKH, PLA	
2F11	13.5	1,490,000	Not Noted	
2F4	13.5	1,704,200	CSKH, PLH	
2F7	13.5	10,000,000 N.F.		
2F9	10	10,000,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXXXIV

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TITANIUM HI TIGUE, 7075-T76 CLAD,

LOW LOAD TRANSFER JOINT - T/D = .85

JOINT GEOMETRY:	X16138-3G, Figure 3
FASTENER SYSTEM:	HLT 411-6-6 Pin, HL 1386-6 Collar
INTERFERENCE FIT:	-0.003 inch
FASTENER MATERIAL:	Titanium-6Al-4V, STA, 95 ksi Shear
FASTENER COATING:	Cetyl Alcohol Lube
HOLE FABRICATION:	Production HSS Double Margin Drill
STRESS RATIO, S_{min}/S_{max}:	R = 0.1, Constant Load Unless Otherwise Noted
TEST SPEED:	600-2300 cpm Unless Otherwise Noted
TEST ENVIRONMENT:	Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
3G11	48	5,500	PLH	
3G12	48	5,600	PLH	
3G10	48	16,700	PLH	
3G7	27.5	99,000	PLA	Constant Ampl.
3G9	27.5	108,900	CSKH	Constant Ampl.
3G8	27.5	143,300	CSKH	Constant Ampl.
3G2	19	507,600	CSKH	Constant Ampl.
3G4	16	1,042,900	CSKH	Constant Ampl.
3G1	16	1,298,300	CSKH	Constant Ampl.
3G5	16	2,293,600	PLH	Constant Ampl.
3G3	11.5	3,108,000	CSKH	Constant Ampl.
3G6	9	10,000,000 N.F.		Constant Ampl.

1. Test specimen installation shown in Figure 4 and 5
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXXXV

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

STEEL TAPER LOK, 7075-T76 CLAD,

LOW LOAD TRANSFER JOINT - T/D = .33

JOINT GEOMETRY: X16138-2K, Figure 3

FASTENER SYSTEM: TLH 100-3-2 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
2K11	50	4,600	CSKH	
2K7	50	8,200	CSKH	
2K1	40	44,100	CSKH, PLH	
2K2	40	51,900	CSKH	
2K5	26.5	173,600	CSKH, PLH	
2K4	26.5	327,400	CSKH, PLH	
2K8	26.5	430,300	CSKH, PLH	
2K3	25	262,100	CSKH, PLH	
2K12	15	545,200	CSKH, PLH	
2K10	15	1,446,500	CSKH, PLH	
2K9	15	1,450,700	CSKH, PLA	
2K6	11	10,000,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXXXVI

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

STEEL TAPER LOK, 7075-T76 CLAD,

LOW LOAD TRANSFER JOINT - T/D = .85

JOINT GEOMETRY: X16138-3L, Figure 3

FASTENER SYSTEM: TLH 100-3-6 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: H11 (220), 132 ksi Shear

FASTENER COATING: Diffused Nickel Cadmium

HOLE FABRICATION: Production Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
3L11	46	10,700	CSKH	
3L10	46	14,200	CSKH	
3L9	42	22,500	CSKH	
3L1	27	110,500	CSKH, PLH	
3L12	27	156,500	CSKH	
3L8	27	175,200	CSKH, PLH	
3L5	27	194,800	CSKH, PLH	
3L2	19	937,600	CSKH, PLA	
3L7	19	1,093,200	CSKH, PLA	
3L6	19	1,151,600	CSKH, PLH	
3L3	16	10,000,000 N.F.		
3L4	11.5	10,000,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXXXVII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TITANIUM TAPER LOK, 7075-T76 CLAD,

LOW LOAD TRANSFER JOINT - T/D = .33

JOINT GEOMETRY: X16138-2N, Figure 3

FASTENER SYSTEM: TLV 100-3-2 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V, STA, 95 ksi Shear

FASTENER COATING: Cetyl Alcohol Lube

HOLE FABRICATION: Production Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
2N12	43	28,700	CSKH	
2N10	38	36,000	CSKA	
2N7	38	37,700	CSKH	
2N8	38	39,900	CSKA	
2N3	25	106,100	CSKH,PLH	
2N2	25	233,000	CSKH,PLH	
2N1	25	251,100	CSKH,PLH	
2N4	16	502,800	CSKH,PLH	
2N5	16	822,800	CSKH,PLH	
2N11	16	4,122,700	CSKA,PLA	
2N9	13.5	1,551,400	CSKH,PLH	
2N6	12	10,166,000 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

TABLE LXXXVIII

AXIAL FATIGUE STRENGTH - INTERFERENCE FIT

TITANIUM TAPER LOK, 7075-T76 CLAD,

LOW LOAD TRANSFER JOINT - T/D = .85

JOINT GEOMETRY: X16138-3"0", Figure 3

FASTENER SYSTEM: TLV 100-3-6 Pin, TLN 1001-3 Washernut

INTERFERENCE FIT: -0.003 inch

FASTENER MATERIAL: Titanium-6Al-4V, STA, 95 ksi Shear

FASTENER COATING: Cetyl Alcohol Lube

HOLE FABRICATION: Production Taper Lok Drill-Reamer

STRESS RATIO, S_{min}/S_{max}: R = 0.1, Constant Load Unless Otherwise Noted

TEST SPEED: 600-2300 cpm Unless Otherwise Noted

TEST ENVIRONMENT: Laboratory Air

SPECIMEN IDENTIFICATION	MAX STRESS GROSS AREA KSI	CYCLES TO FAILURE N.F. = NO FAILURE	MODE OF FAILURE 2,3,4,5	REMARKS
3"0"9	45	14,400	PLH	
3"0"8	45	15,100	CSKH,PLH	
3"0"6	37	42,600	PLH	
3"0"2	27	54,300	CSKH,PLH	
3"0"1	27	148,400	CSKH,PLH	
3"0"11	27	210,800	CSKH,PLA	
3"0"7	19	641,900	CSKH,PLH	
3"0"12	19	691,100	CSKA,PLH	
3"0"3	19	745,800	CSKH,PLH	
3"0"10	19	919,600	CSKH,PLH	
3"0"4	16	2,482,900	CSKA,PLA	
3"0"5	12	10,579,400 N.F.		

1. Test specimen installation shown in Figure 4
2. CSKH = Sheet metal failure through the fastener holes in the CSK sheet.
3. CSKA = Sheet metal failure away from the fastener holes in the CSK sheet.
4. PLH = Sheet metal failure through the fastener holes in the plain sheet.
5. PLA = Sheet metal failure away from the fastener holes in the plain sheet.

APPENDIX I

SHEET MATERIAL CERTIFICATION FOR 7075 ALUMINUM ALLOY

PIONEER METALS, INC.
Subsidiary of N L Industries, Inc
3800 East 26th Street Los Angeles, California 90023

HOME & BRANCH OFFICE CODE
(L) Home office: Los Angeles, Calif. (213) 268 3561
(M) Marietta, Georgia; (404) 422 2110
(W) Wichita, Kansas; (316) 682-1521
(K) Kent, Washington; (206) 854-1500

PRODUCTION ORDER NO. 30291

CUST. NO.	SALESMAN	TAX
45653	N	2

DATE	O/D	CUSTOMER P.O. NO.
9/6/72	10	VERBAL

DATE REQD	SHIP CODE	TAXABLE	DATE SHIPPED
10/6/72	T		

ROUTING: O

F.O.B. DES	F.O.B. ORIG	FREIGHT PPD	FREIGHT COL.	COMM'L NNTD	RENEG. RATING NO
X		X		C	

TERMS: Days Net 30

SOLD TO: M & N MACHINE COMPANY
11625 VAN OWEN
NO. HOLLYWOOD, CA

SHIP TO: SAME UNLESS NOTED

CUST. ITEM NO	FEET	POUNDS	PIECES	LENGTH	DESCRIPTION	PKGS	WEIGHT	PIECES BACK ORDERED	SHIPPED
1		88	2	ATS	.063 X 48 X 144 ALCLAD ALUM SHEET 7075-T6 QQA250/13 PC 12C			0	2
2		418	6	ATS	.100 X 48 X 144 ALCLAD SHEET 7075-T6X QQA250/13 PC 12			0	6
3		158	2	ATS	.160 X 48 X 102" ALCLAD ALUM SHEET 7075-T6 QQA250/13 PC 12			0	2
				SP IN	ALL 3 ITEMS MUST BE SCRATCH FREE AS POSSIBLE. STENCIL & INTERLEAVE				

We hereby certify that the material covered by this certification has been tested in accordance with the above specifications and has been found to meet the applicable requirements for the material, including any specifications forming a part of the description. Test reports are on file subject to examination

T. Kimura
PIONEER METALS, INC.

MECHANICAL PROPERTIES

ITEM	PIECES	LOT NO	NO. OF TESTS	ULTIMATE STRENGTH K.S.I MINIMUM	ULTIMATE STRENGTH K.S.I MAXIMUM	YIELD STRENGTH K.S.I MINIMUM	YIELD STRENGTH K.S.I MAXIMUM	ELONGATION % 2" MINIMUM	ELONGATION % 2" MAXIMUM	MINIMUM	MAXIMUM

I certify that these are correct copies of reports on file at Pioneer Metals, Inc.
BY

THIS MATERIAL HAS BEEN RECEIVED AND INSPECTED BY
DATE

3. TEST REPORT—PACKING SLIP

FORM P/POD 20M.00101

CAR

CHEMICAL ANALYSIS IN PER CENT

SI	FE	CU	MN	MG	CR	NI	ZN	TI	Others Each	Others Total	Alloy Nos.
1.0 Max	1.0 Max	.20 Max	06. Max				.10 Max		.05 Max	0.15 Max	1100
.50–1.20	.7 Max	3.9–5.0	.40–1.2	.20–.80	.10 Max		.25 Max	.15 Max			2014
.50 Max	.50 Max	3.8–4.8	.30–.90	1.2–1.8	.10 Max		.25 Max				2024
.45 Max	.45 Max	.10 Max	.10 Max	2.2–2.8	.15–.35		.10 Max				5052
.40 Max	.40 Max	.10 Max	.30–1.0	4.0–4.9	.05–.25		.25 Max	.15 Max			5083
.40–.80	.70 Max	.15–.40	.15 Max	.80–1.20	.04–.35		.25 Max	.15 Max			6061 (1)
.20–.60	.35 Max	.10 Max	.10 Max	.45–90	.10 Max		.10 Max	.10 Max			6063
.40 Max	.50 Max	1.2–2.0	.30 Max	2.1–2.9	.18–.35		5.1–6.1	.20 Max			7075
.30 Max	.40 Max	.40–.80	.10–.30	2.9–3.7	.10–.25		3.8–4.8	.10 Max			7079
.40 Max	.50 Max	1.6–2.4	.30 Max	2.4–3.1	.18–.55		6.3–7.3	.20 Max	↓	↓	7178

NOTE: (1) Minimum chromium content for bar, sheet, plate and drawn tube in 6061 alloy is .15

APPENDIX II

SHEET MATERIAL CERTIFICATION FOR TITANIUM-6A1-4V ALLOY

Continental Metals Inc.
CERTIFIED TEST REPORT

13406 Saticoy St.,
No. Hollywood, Ca. 91605

Telephone (213) 873-7411 997-0022

32-15 Lawrence Street, Flushing, New York 11354
Tel. 212-961-2750 · TWX-710-582-2960

SOLD TO
M & N Machine Company
11625 Van Owen Street
North Hollywood, Calif. 91605

SHIP TO
Same

This is to certify that the material shipped to you on September 14, 1972 on the listed purchase order numbers complies with the following chemical analysis and physical properties:

HEAT NO.	YOUR ORDER NO	OUR ORDER NO	SIZE	SPEC	QUAN	TEST NO.
321290	1631	163767	.100 x 3-3/4" x 15-1/4" 6AL-4V Titanium (grain with 15-1/4")	MIL T 9046 F Type 3 Comp C	252 Pcs.	321290R
321290	1631	163767	.100 x 1-3/4" x 10" 6AL-4V Titanium -(Grain with10")	" " "	252 Pcs.	321290R

PHYSICAL PROPERTIES

HEAT NO	YIELD STRENGTH P.S.I.	TENSILE STRENGTH P.S.I.	ELONGATION % IN 2"	RED. OF AREA %	HARDNESS	REMARKS
321290	147,700	156.200	13.5			Bend OK

CHEMICAL ANALYSIS

HEAT NO	C	N	Fe	Al	V	O	H	Cu	Mo	Ti	Cb
321290	.03	.01	.24	6.2	4.2	10.3	113 ppm				

Sworn ... this ... 1972

OFFICIAL SEAL
LINDA R. ...
NOTARY PUBLIC - CALIFORNIA
LOS ANGELES COUNTY
My Commission Expires ... 1976

Continental Metals Inc

BY [signature]

Continental Metals Inc.
CERTIFIED TEST REPORT

13406 Saticoy St.,
No. Hollywood, Ca. 91605

Telephone (213) 873-7411   997-0022

32-15 Lawrence Street, Flushing, New York 11354
Tel. 212-961-2750 • TWX 710-582-2960

SOLD TO
M & N Machine Company
11625 Van Owen Street
North Hollywood, Calif. 91605

SHIP TO
SAME

This is to certify that the material shipped to you on September 14, 1972 on the listed purchase order numbers complies with the following chemical analysis and physical properties:

HEAT NO.	YOUR ORDER NO	OUR ORDER NO	SIZE	SPEC	QUAN.	TEST NO.
291203	1631	163767	.100 x 1/3/4" x 7-3/4" (Grain with 7-3/4")	MIL T 9046 F Type 3 Comp C	78 Pcs.	291203R
"	"	"	.100 x 1-3/4" x 4-1/2" (Grain with 4-1/2")	" " "	"	"

6AL-4V Titanium

PHYSICAL PROPERTIES

HEAT NO	YIELD STRENGTH PSI	TENSILE STRENGTH PSI	ELONGATION % in 2"	RED. OF AREA %	HARDNESS	REMARKS
291203	129,500	138,500	14.5			Bend OK

CHEMICAL ANALYSIS

HEAT NO.	C	N	Fe	Al	V	O	H	Cu	Mo	Ti	Cb		
291203	.02	.01	.17	6.1	4.1	10.9	47 ppm						

Sworn ... this ... 19 72
...COUNTY
My Commission ... June 11, 1974.

Continental Metals Inc

BY

APPENDIX III

HOLE FABRICATION AND FASTENER INSTALLATION DETAILS

Hole fabrication details are given in Table LXXXIX. Fastener hole diameter (Hi Tigue) or fastener protrusion (Taper Lok) measurements are given in Table XC. Measurements of straight shank Hi Tigue fastener diameter obtained by random sampling are given in Table XCVI.

General Instructions: Hi Tigue Installed in Aluminum and Titanium Alloy (3/16 Dia.)

Drill and/or ream holes as required in parts. Countersink holes in top sheet using fastener head to ensure correct countersink diameter depth is achieved. Parts to be tightly clamped during hole preparation. Holes to be deburred on both entrance and exit side (0.001-0.005 x 45° chamfer). On completion of hole preparation each hole diameter shall be measured using calibrated equipment and recorded. Hole surface to be inspected. Fastener to be installed will be a 100 degree flush shear head H-11 steel Hi-Tigue, with a diffused nickel cadmium plating and acetyl alcohol coating. Check and record pin diameter prior to installation. Pin shall be inserted in the hole and driven continuously unitl head is fully seated using a medium size (3X) rivet gun. Rivet gun shall keep pin moving continuously until seated. Gun shall be held perpendicular to the pin axis throughout the driving sequence. At all times during the pin installation, a hollow backup surface shall be provided. Nuts shall be installed while parts are firmly clamped. If a 0.0015 inch feeler can be inserted between the parts, at the faying surface on either side, until it touches the pin surface the part shall be scrapped. Record operations to be performed on a planning sheet or suitable alternative document and provide space for inspection at each operation.

General Instructions: Taperlok Installed in Aluminum and Titanium Alloy (3/16 Dia.)

Hole preparation shall not be done until test holes have been made in equivalent thickness scrap material. Taperloks shall be "blued" and inserted into the holes until the acceptable protrusion condition has been reached. Measurement of the protrusion shall be made using calibrated depth micrometer. The Taperlok fastener shall then be withdrawn from the test hole and the extent of surface contact between the Taperlok shank and the hole surface shall be measured. If the surface contact is less than 80 percent of the total contact involved, the hole is unacceptable and further test holes shall be made.

When the technique for making the tapered holes has been developed on scrap material, use data and make holes in test specimens. After nuts have been installed to the approved torque, check the gap between the plates with a 0.0015 inch feeler gage. If the feeler gage can touch the fastener shank, the parts shall be scrapped. Record protrusion height of Taperloks before torqueing up and record torque value used to assemble parts on a planning sheet or equivalent engineering document.

TABLE LXXXIX
HOLE FABRICATION DETAILS

Fastener	Hole Quality	Sheet Material	DRILL Pilot	DRILL RPM	DRILL Feed inch/rev.	DRILL Tool	REAM Speed/Feed	REAM Tool	Coolant
Hi Tigue	Production	Aluminum	No	860	.002	Dbl. Margin H.S. Steel	None		Soluble Oil
	Production	Titanium	No	240	.001	135° Cobalt	None		Soluble Oil
	Precise (3)	Aluminum	11/64	860	.002	Std. 118° H.S. Stl.	860/.002	4 Flute (Straight) HS Steel Reamer	Soluble Oil
	Precise (3)	Titanium	11/64	240	.001	135° Cobalt	240/.001	6 Flute (Straight) Cobalt Reamer	Soluble Oil
Taper Lok	Production	Aluminum		1500	.002	TLD2040AR (1)	None		Dry
	Production	Titanium	5/32	375	.001	TLD2030AR (1)	None		Dry
	Precise (3)	Aluminum	11/64	1500	.002	STD 118° H.S. Stl.	1500/.002	3 Flute Spiral TLD2030 R (2)	Soluble Oil
	Precise (3)	Titanium	11/64	375	.001	135° Cobalt	375/.001	6 Flute Spiral TL2060R (2)	Soluble Oil

(1) TLDXXXX is a Drill-Reamer-CSK Combination Tool designation for tapered holes by OMARK Industries, El Segundo, California.

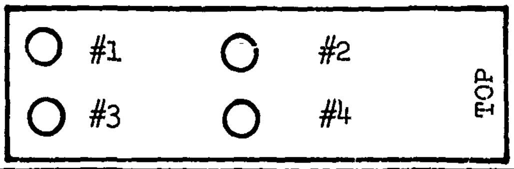
(2) These tools are tapered reamers and must be used in conjunction with pilot holes.

(3) Precise hole fabrication process used only for specimens called out in Table III

TABLE XC

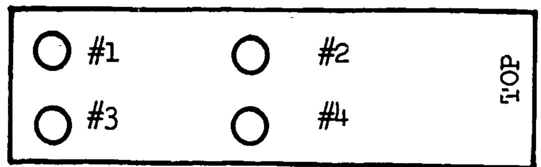
HIGH LOAD TRANSFER JOINTS

Tapered Fastener Protrusion Before Installation (inches)



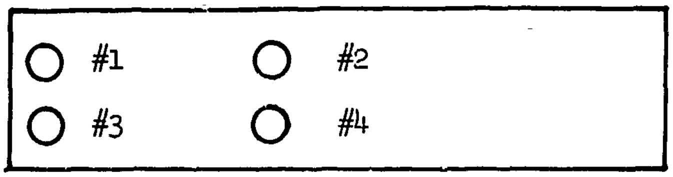
Part Number	Hole #1	Hole #2	Hole #3	Hole #4
X16136-4HP-1	.118	.116	.116	.114
-2	.120	.121	.120	.121
-3	.118	.116	.118	.116
-4	.115	.118	.115	.118
-5	.119	.116	.119	.116
-6	.117	.117	.117	.118
-7	.115	.115	.116	.116
-8	.113	.113	.115	.115
-9	.112	.115	.115	.112
-10	.114	.114	.116	.116
-11	.116	.116	.117	.117
-12	.116	.116	.115	.115
X16136-4MP-1	.142	.144	.142	.144
-2	.147	.146	.147	.146
-3	.148	.148	.149	.149
-4	.143	.143	.143	.143
-5	.145	.145	.145	.145
-6	.148	.148	.149	.149
-7	.147	.147	.149	.149
-8	.146	.146	.146	.144
-9	.145	.146	.146	.146
-10	.148	.148	.148	.145
-11	.147	.146	.146	.146
-12	.143	.143	.143	.142
X16136-1HP-1	.136	.135	.136	.135
-2	.139	.138	.139	.137
-3	.137	.137	.137	.137
-4	.139	.137	.139	.137
-5	.131	.134	.131	.134
-6	.129	.128	.129	.128
-7	.132	.134	.133	.133
-8	.133	.133	.132	.133
-9	.133	.132	.133	.133
-10	.132	.133	.133	.134
-11	.134	.135	.134	.136
-12	.134	.134	.135	.134

TABLE XC (Continued)



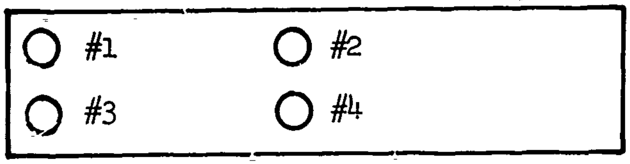
Part Number	Hole #1	Hole #2	Hole #3	Hole #4
X16136-3L-1	.153	.153	.153	.153
-2	.151	.150	.150	.150
-3	.155	.154	.154	.154
-4	.159	.159	.159	.158
-5	.157	.157	.157	.158
-6	.158	.157	.159	.159
-7	.159	.159	.159	.159
-8	.158	.158	.159	.159
-9	.159	.159	.159	.158
-10	.157	.158	.158	.158
-11	.160	.161	.161	.161
-12	.159	.159	.159	.159
X16136-2K-1	.069	.069	.070	.070
-2	.071	.071	.071	.071
-3	.070	.070	.070	.070
-4	.072	.072	.072	.072
-5	.069	.069	.069	.069
-6	.068	.069	.069	.068
-7	.071	.072	.072	.072
-8	.073	.073	.073	.073
-9	.068	.068	.068	.069
-10	.069	.067	.067	.069
-11	.070	.069	.069	.070
-12	.071	.071	.071	.071
X16136-3"O"-1	.138	.138	.138	.139
-2	.136	.136	.136	.136
-3	.136	.136	.136	.137
-4	.138	.138	.137	.138
-5	.139	.139	.138	.139
-6	.133	.133	.133	.134
-7	.133	.133	.134	.134
-8	.134	.134	.134	.135
-9	.136	.136	.136	.137
-10	.137	.137	.137	.137
-11	.135	.135	.136	.135
-12	.129	.129	.129	.130

TABLE XC (Continued)



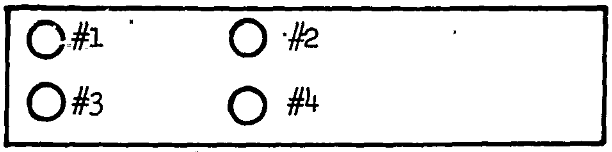
Part Number	Hole #1	Hole #2	Hole #3	Hole #4
X16136-4H-1	.119	.121	.121	.121
-2	.120	.120	.119	.119
-3	.118	.118	.118	.118
-4	.120	.120	.120	.120
-5	.123	.123	.123	.124
-6	.121	.121	.121	.121
-7	.124	.124	.124	.124
-8	.124	.124	.124	.124
-9	.125	.125	.125	.124
-10	.123	.123	.123	.123
-11	.126	.126	.126	.126
-12	.124	.124	.124	.124
X16136-4M-1	.147	.147	.148	.149
-2	.148	.148	.149	.149
-3	.146	.146	.145	.145
-4	.143	.143	.144	.144
-5	.144	.144	.144	.143
-6	.143	.143	.143	.143
-7	.145	.145	.145	.146
-8	.143	.143	.144	.143
-9	.142	.142	.143	.143
-10	.144	.144	.144	.144
-11	.147	.147	.147	.146
-12	.146	.145	.145	.145
16136-1M-1	.143	.143	.14	.143
-2	.140	.140	.140	.140
-3	.139	.139	.139	.140
-4	.141	.140	.140	.140
-5	.142	.142	.142	.142
-6	.145	.145	.145	.145
-7	.143	.143	.143	.143
-8	.143	.142	.142	.142
-9	.142	.142	.142	.142
-10	.140	.140	.140	.140
-11	.141	.141	.141	.141
-12	.142	.142	.142	.141

TABLE XC (Continued)



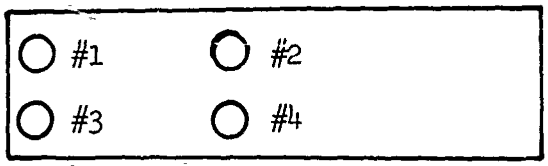
Part Number	Hole #1	Hole #2	Hole #3	Hole #4
X16136-1H-1	.124	.124	.124	.123
-2	.123	.123	.123	.123
-3	.122	.122	.123	.123
-4	.125	.125	.125	.125
-5	.117	.119	.119	.118
-6	.124	.124	.124	.124
-7	.123	.123	.123	.123
-8	.121	.121	.122	.122
-9	.122	.122	.122	.122
-10	.111	.111	.112	.112
-11	.119	.119	.120	.120
-12	.123	.123	.123	.123
X16136-1HHH-1	.206	.206	.206	.206
-2	.205	.205	.205	.205
-3	.203	.203	.203	.203
-4	.205	.205	.205	.204
-5	.205	.205	.204	.204
-6	.206	.206	.207	.207
-7	.207	.208	.208	.208
-8	.208	.209	.209	.209
-9	.207	.207	.207	.207
-10	.209	.209	.209	.209
-11	.210	.210	.210	.209
-12	.209	.209	.210	.210
X16136-1J-1	.128	.128	.127	.127
-2	.126	.126	.126	.125
-3	.126	.125	.125	.125
-4	.125	.125	.126	.126
-5	.126	.124	.124	.126
-6	.122	.123	.124	.123
-7	.123	.126	.126	.124
-8	.125	.124	.126	.124
-9	.123	.126	.122	.124
-10	.124	.126	.123	.122
-11	.126	.123	.124	.126
-12	.126	.124	.123	.123

TABLE XC (Continued)



Part Number	Hole #1	Hole #2	Hole #3	Hole #4
X16136-1MMM-1	.209	.209	.210	.209
-2	.211	.211	.209	.209
-3	.209	.211	.211	.211
-4	.211	.211	.212	.212
-5	.211	.212	.212	.212
-6	.213	.213	.211	.211
-7	.209	.209	.210	.210
-8	.210	.210	.210	.211
-9	.211	.211	.212	.212
-10	.209	.209	.209	.210
-11	.210	.210	.210	.210
-12	.212	.212	.211	.211
X13136-4J-1	.130	.130	.130	.130
-2	.130	.129	.129	.130
-3	.131	.130	.130	.131
-4	.127	.128	.128	.127
-5	.130	.130	.130	.130
-6	.125	.125	.125	.125
-7	.127	.128	.128	.127
-8	.130	.129	.129	.130
-9	.127	.127	.127	.127
-10	.130	.131	.131	.130
-11	.129	.128	.129	.129
-12	.128	.128	.129	.128
X16136-2N-1	.073	.073	.073	.074
-2	.094	.092	.094	.094
-3	.096	.098	.098	.098
-4	.099	.099	.099	.099
-5	.095	.095	.096	.096
-6	.092	.092	.092	.091
-7	.089	.089	.086	.086
-8	.090	.090	.089	.089
-9	.073	.072	.072	.072
-10	.070	.072	.072	.073
-11	.071	.070	.070	.070
-12	.072	.072	.071	.072

TABLE XC (Continued)



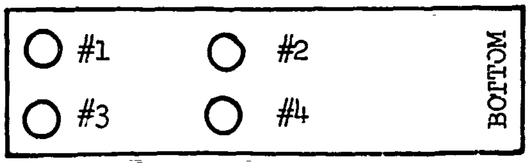
Part Number	Hole #1	Hole #2	Hole #3	Hole #4
X16136-1MP-1	.138	.138	.138	.138
-2	.139	.138	.138	.138
-3	.137	.136	.137	.138
-4	.137	.138	.138	.137
-5	.133	.133	.132	.133
-6	.132	.133	.132	.133
-7	.134	.134	.134	.134
-8	.135	.136	.138	.137
-9	.133	.134	.133	.134
-10	.132	.134	.133	.133
-11	.133	.136	.137	.136
-12	.134	.135	.134	.135
X16136-1HH-1	.027	.027	.028	.027
-2	.026	.025	.025	.025
-3	.031	.030	.031	.031
-4	.029	.029	.029	.029
-5	.029	.029	.029	.029
-6	.024	.024	.024	.024
-7	.026	.026	.026	.026
-8	.025	.024	.024	.024
-9	.027	.027	.027	.027
-10	.028	.027	.028	.028
-11	.030	.030	.031	.031
-12	.029	.029	.029	.029
X16136-1MM-1	.039	.039	.040	.040
-2	.037	.037	.038	.038
-3	.036	.036	.036	.036
-4	.035	.035	.035	.035
-5	.037	.037	.037	.037
-6	.035	.035	.035	.035
-7	.033	.033	.033	.034
-8	.036	.036	.036	.037
-9	.030	.031	.031	.031
-10	.030	.030	.031	.031
-11	.033	.033	.033	.034
-12	.038	.038	.038	.038

TABLE XCI

FASTENER HOLES SIZES

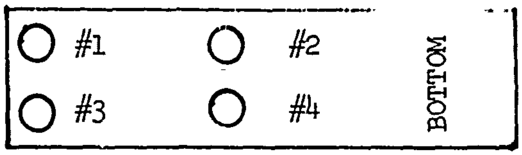
HIGH LOAD TRANSFER JOINTS

Hole Diameter For Straight Shank Fasteners (inches)



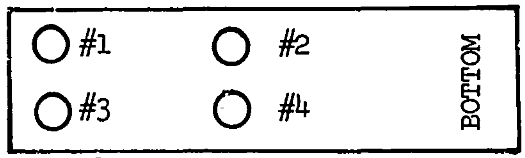
Part Number	Hole #1	Hole #2	Hole #3	Hole #4
X16136-4E-1	.1853	.1853	.1853	.1854
-2	.1854	.1858	.1858	.1856
-3	.1855	.1857	.1858	.1857
-4	.1857	.1855	.1859	.1856
-5	.1858	.1854	.1857	.1858
-6	.1856	.1856	.1856	.1855
-7	.1856	.1853	.1853	.1855
-8	.1854	.1855	.1852	.1852
-9	.1856	.1857	.1854	.1857
-10	.1855	.1853	.1854	.1854
-11	.1857	.1855	.1857	.1858
-12	.1854	.1854	.1857	.1855
X16136-4A-1	.1858	.1854	.1856	.1860
-2	.1857	.1856	.1858	.1857
-3	.1861	. .859	.1858	.1860
-4	.1856	.1857	.1858	.1859
-5	.1858	.1860	.1858	.1860
-6	.1858	.1857	.1858	.1856
-7	.1860	.1859	.1859	.1859
-8	.1861	.1861	.1860	.1860
-9	.1860	.1862	.1862	.1862
-10	.1862	.1862	.1862	.1861
-11	.1858	.1860	.1859	.1861
-12	.1859	.1860	.1858	.1861
X16136-4B-1	.1857	.1858	.1858	.1859
-2	.1856	.1854	.1855	.1856
-3	.1851	.1856	.1859	.1857
-4	.1859	.1856	.1857	.1856
-5	.1857	.1856	.1855	.1855
-6	.1858	.1856	.1858	.1855
-7	.1857	.1857	.1855	.1853
-8	.1852	.1855	.1848	.1853
-9	.1856	.1856	.1857	.1855
-10	.1855	.1857	.1857	.1855
-11	.1858	.1857	.1859	.1859
-12	.1856	.1853	.1856	.1852

TABLE XCI (Continued)



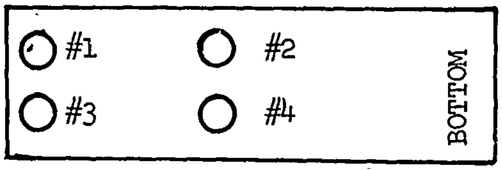
Part Number	Hole #1	Hole #2	Hole #3	Hole #4
X16136-1EP-1	.1865	.1866	.1865	.1865
-2	.1866	.1866	.1866	.1866
-3	.1864	.1864	.1864	.1866
-4	.1864	.1866	.1866	.1866
-5	.1867	.1867	.1868	.1867
-6	.1864	.1864	.1865	.1864
-7	.1865	.1866	.1865	.1865
-8	.1865	.1867	.1867	.1865
-9	.1867	.1868	.1868	.1868
-10	.1868	.1868	.1867	.1867
-11	.1868	.1868	.1867	.1868
-12	.1868	.1868	.1868	.1868
X16136-4AP-1	.1862	.1861	.1861	.1862
-2	.1858	.1858	.1858	.1858
-3	.1859	.1860	.1860	.1860
-4	.1860	.1860	.1860	.1860
-5	.1858	.1858	.1858	.1858
-6	.1859	.1858	.1859	.1859
-7	.1858	.1859	.1858	.1858
-8	.1858	.1858	.1858	.1858
-9	.1859	.1859	.1859	.1859
-10	.1859	.1860	.1859	.1859
-11	.1859	.1860	.1860	.1860
-12	.1858	.1858	.1859	.1859
X16136-1AP-1	.1868	.1868	.1867	.1866
-2	.1865	.1867	.1865	.1867
-3	.1867	.1868	.1867	.1867
-4	.1863	.1863	.1863	.1863
-5	.1867	.1867	.1867	.1867
-6	.1867	.1867	.1867	.1867
-7	.1866	.1865	.1865	.1865
-8	.1866	.1864	.1864	.1865
-9	.1866	.1865	.1863	.1865
-10	.1863	.1863	.1863	.1863
-11	.1865	.1862	.1862	.1864
-12	.1867	.1867	.1867	.1867

TABLE XCI (Continued)



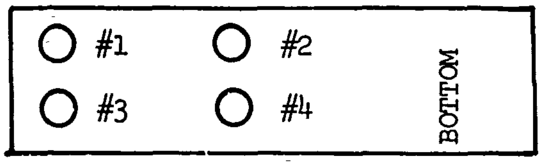
Part Number	Hole #1	Hole #2	Hole #3	Hole#4
X16136-4EP-1	.1863	.1863	.1865	.1863
-2	.1864	.1865	.1864	.1864
-3	.1865	.1865	.1865	.1865
-4	.1864	.1864	.1864	.1866
-5	.1864	.1864	.1864	.1865
-6	.1864	.1864	.1864	.1865
-7	.1865	.1865	.1865	.1865
-8	.1864	.1864	.1865	.1865
-9	.1865	.1865	.1865	.1865
-10	.1865	.1865	.1865	.1867
-11	.1867	.1867	.1867	.1867
-12	.1875	.1875	.1872	.1872
X16136-1A-1	.1853	.1856	.1855	.1856
-2	.1857	.1859	.1858	.1858
-3	.1858	.1857	.1855	.1856
-4	.1855	.1857	.1855	.1854
-5	.1856	.1856	.1857	.1857
-6	.1855	.1855	.1856	.1855
-7	.1857	.1856	.1857	.1857
-8	.1855	.1856	.1856	.1855
-9	.1855	.1856	.1856	.1856
-10	.1856	.1857	.1857	.1856
-11	.1858	.1858	.1859	.1858
-12	.1856	.1857	.1856	.1857
X16136-1AA-1	.1871	.1871	.1871	.1873
-2	.1869	.1870	.1868	.1868
-3	.1871	.1872	.1871	.1871
-4	.1871	.1872	.1872	.1872
-5	.1870	.1871	.1872	.1871
-6	.1868	.1868	.1869	.1869
-7	.1867	.1868	.1867	.1868
-8	.1866	.1865	.1870	.1867
-9	.1871	.1873	.1870	.1872
-10	.1872	.1872	.1871	.1872
-11	.1870	.1870	.1871	.1871
-12	.1872	.1872	.1871	.1870

TABLE XCI (Continued)



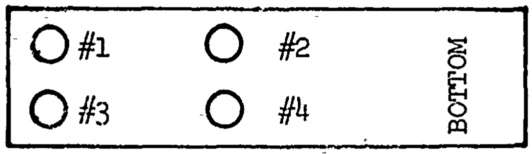
Part Number	Hole #1	Hole #2	Hole #3	Hole #4
X16136-3D-1	.1855	.1854	.1855	.1858
-2	.1856	.1855	.1854	.1856
-3	.1853	.1856	.1856	.1855
-4	.1853	.1856	.1856	.1854
-5	.1856	.1856	.1857	.1857
-6	.1855	.1858	.1856	.1856
-7	.1855	.1856	.1856	.1855
-8	.1855	.1855	.1856	.1855
-9	.1856	.1854	.1856	.1854
-10	.1857	.1856	.1857	.1854
-11	.1854	.1854	.1854	.1856
-12	.1853	.1853	.1854	.1854
X16136-3G-1	.1856	.1856	.1857	.1857
-2	.1860	.1860	.1859	.1861
-3	.1856	.1856	.1856	.1855
-4	.1855	.1856	.1855	.1857
-5	.1857	.1858	.1858	.1856
-6	.1857	.1856	.1858	.1858
-7	.1857	.1858	.1860	.1859
-8	.1858	.1858	.1857	.1858
-9	.1857	.1856	.1857	.1855
-10	.1859	.1860	.1860	.1860
-11	.1857	.1857	.1858	.1860
-12	.1862	.1860	.1861	.1861
X16136-1EE-1	.1869	.1869	.1870	.1869
-2	.1870	.1870	.1870	.1872
-3	.1870	.1871	.1871	.1870
-4	.1869	.1869	.1870	.1869
-5	.1870	.1872	.1873	.1872
-6	.1870	.1871	.1871	.1870
-7	.1871	.1871	.1870	.1871
-8	.1870	.1871	.1870	.1872
-9	.1871	.1870	.1869	.1870
-10	.1871	.1872	.1858	.1872
-11	.1871	.1871	.1870	.1872
-12	.1871	.1873	.1873	.1872

TABLE XCI (Continued)



Part Number	Hole #1	Hole #2	Hole #3	Hole #4
X16136-1B-1	.1856	.1857	.1858	.1857
-2	.1858	.1857	.1857	.1856
-3	.1856	.1856	.1856	.1857
-4	.1857	.1856	.1858	.1857
-5	.1857	.1856	.1858	.1857
-6	.1859	.1857	.1858	.1858
-7	.1858	.1857	.1856	.1857
-8	.1857	.1857	.1858	.1856
-9	.1857	.1856	.1857	.1860
-10	.1858	.1857	.1858	.1858
-11	.1857	.1856	.1857	.1857
-12	.1856	.1855	.1856	.1856
X16136-1E-1	.1856	.1856	.1858	.1858
-2	.1858	.1858	.1857	.1857
-3	.1856	.1857	.1857	.1857
-4	.1860	.1860	.1859	.1858
-5	.1862	.1862	.1861	.1861
-6	.1859	.1860	.1859	.1860
-7	.1861	.1862	.1862	.1864
-8	.1857	.1856	.1858	.1858
-9	.1857	.1858	.1857	.1857
-10	.1858	.1858	.1857	.1858
-11	.1857	.1857	.1857	.1857
-12	.1856	.1855	.1857	.1857
X16136-2F-1	.1855	.1854	.1855	.1855
-2	.1854	.1854	.1855	.1855
-3	.1855	.1856	.1853	.1854
-4	.1855	.1855	.1855	.1855
-5	.1854	.1855	.1855	.1855
-6	.1856	.1854	.1857	.1854
-7	.1855	.1854	.1854	.1856
-8	.1856	.1855	.1856	.1856
-9	.1855	.1854	.1855	.1856
-10	.1858	.1854	.1855	.1855
-11	.1856	.1855	.1854	.1856
-12	.1856	.1855	.1856	.1855

TABLE XCI (Continued)



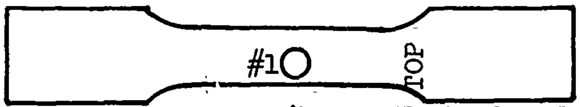
Part Number	Hole #1	Hole #2	Hole #3	Hole #4
X16136-1AAA-1	.1844	.1843	.1845	.1845
-2	.1843	.1843	.1845	.1846
-3	.1845	.1844	.1844	.1845
-4	.1846	.1844	.1844	.1845
-5	.1844	.1844	.1845	.1844
-6	.1844	.1844	.1845	.1845
-7	.1843	.1844	.1843	.1845
-8	.1844	.1845	.1843	.1846
-9	.1844	.1844	.1845	.1844
-10	.1844	.1848	.1844	.1844
-11	.1845	.1843	.1845	.1845
-12	.1845	.1845	.1846	.1846
X16136-2C-1	.1856	.1856	.1856	.1856
-2	.1857	.1855	.1856	.1856
-3	.1855	.1855	.1855	.1856
-4	.1856	.1857	.1856	.1855
-5	.1857	.1855	.1855	.1855
-6	.1855	.1856	.1855	.1856
-7	.1855	.1855	.1854	.1855
-8	.1855	.1854	.1854	.1855
-9	.1855	.1856	.1854	.1856
-10	.1855	.1856	.1854	.1855
-11	.1856	.1856	.1856	.1857
-12	.1856	.1855	.1855	.1855
X16136-1EEE-1	.1846	.1848	.1850	.1849
-2	.1847	.1848	.1845	.1847
-3	.1849	.1846	.1846	.1849
-4	.1849	.1848	.1849	.1849
-5	.1846	.1845	.1844	.1845
-6	.1846	.1847	.1847	.1847
-7	.1846	.1848	.1845	.1850
-8	.1847	.1846	.1847	.1847
-9	.1846	.1847	.1849	.1848
-10	.1847	.1847	.1848	.1849
-11	.1847	.1846	.1847	.1847
-12	.1850	.1849	.1849	.1850

TABLE XCII

FASTENER HOLE SIZES

MEDIUM LOAD TRANSFER JOINTS

Tapered Fastener Protrusion Before Installation (inches)



Part Number	Hole #1	Part Number	Hole #1
X16137-4M-1	.144	X16137-1M-1	.132
-2	.144	-2	.136
-3	.143	-3	.138
-4	.144	-4	.137
-5	.143	-5	.139
-6	.144	-6	.133
-7	.144	-7	.137
-8	.144	-8	.139
-9	.145	-9	.137
-10	.145	-10	.137
-11	.144	-11	.138
-12	.145	-12	.132
X16137-4J-1	.139	X16137-1J-1	.139
-2	.134	-2	.141
-3	.144	-3	.138
-4	.142	-4	.139
-5	.141	-5	.137
-6	.143	-6	.140
-7	.139	-7	.139
-8	.142	-8	.141
-9	.143	-9	.138
-10	.140	-10	.140
-11	.139	-11	.141
-12	.137	-12	.140
X16137-4H-1	.141	X16137-1H-1	.137
-2	.137	-2	.138
-3	.139	-3	.136
-4	.142	-4	.139
-5	.139	-5	.141
-6	.144	-6	.136
-7	.142	-7	.139
-8	.140	-8	.137
-9	.141	-9	.138
-10	.141	-10	.140
-11	.143	-11	.141
-12	.143	-12	.139

TABLE XCIII

FASTENER HOLE SIZES

MEDIUM LOAD TRANSFER JOINTS

Hole Diameter For Straight Shank Fasteners (inches)

#1 

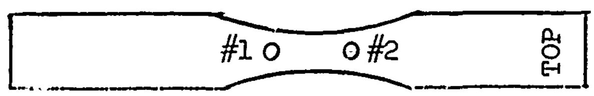
Part Number	Hole #1	Part Number	Hole #1
X16137-4A-1	.1853	X16137-1A-1	.1853
-2	.1854	-2	.1856
-3	.1854	-3	.1852
-4	.1856	-4	.1851
-5	.1853	-5	.1853
-6	.1855	-6	.1851
-7	.1854	-7	.1851
-8	.1853	-8	.1851
-9	.1857	-9	.1851
-10	.1854	-10	.1851
-11	.1856	-11	.1857
-12	.1853	-12	.1856
X16137-4B-1	.1853	X16137-1B-1	.1852
-2	.1854	-2	.1859
-3	.1851	-3	.1854
-4	.1852	-4	.1856
-5	.1853	-5	.1852
-6	.1856	-6	.1851
-7	.1853	-7	.1854
-8	.1854	-8	.1852
-9	.1854	-9	.1851
-10	.1853	-10	.1853
-11	.1855	-11	.1851
-12	.1854	-12	.1853
X16137-4E-1	.1856	X16137-1E-1	.1853
-2	.1857	-2	.1857
-3	.1855	-3	.1856
-4	.1855	-4	.1857
-5	.1855	-5	.1856
-6	.1856	-6	.1857
-7	.1854	-7	.1852
-8	.1854	-8	.1854
-9	.1855	-9	.1855
-10	.1856	-10	.1860
-11	.1855	-11	.1854
-12	.1854	-12	.1854

TABLE XCIV

FASTENER HOLE SIZES

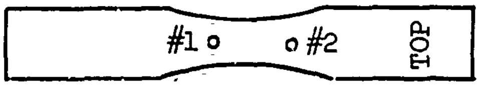
LOW LOAD TRANSFER JOINTS

Tapered Fastener Protrusion Before Installation (inches)



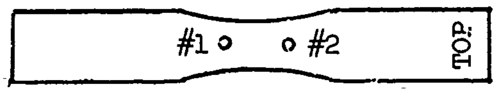
Part Number	Hole #1	Hole #2	Part Number	Hole #1	Hole #2
X16138-1HHH-1	.218	.217	X16138-1MMM-1	.215	.213
-2	.216	.218	-2	.214	.214
-3	.216	.216	-3	.216	.214
-4	.218	.219	-4	.213	.213
-5	.211	.212	-5	.212	.210
-6	.215	.216	-6	.212	.214
-7	.217	.218	-7	.215	.213
-8	.219	.217	-8	.216	.215
-9	.216	.217	-9	.212	.213
-10	.216	.218	-10	.214	.215
-11	.218	.217	-11	.216	.216
-12	.219	.219	-12	.214	.214
X16138-3"0"-1	.135	.136	X16138-1H-1	.107	.109
-2	.138	.138	-2	.106	.107
-3	.136	.136	-3	.105	.107
-4	.139	.138	-4	.109	.108
-5	.138	.138	-5	.107	.108
-6	.138	.137	-6	.109	.109
-7	.138	.138	-7	.108	.107
-8	.136	.136	-8	.108	.109
-9	.136	.137	-9	.107	.107
-10	.137	.136	-10	.106	.106
-11	.135	.135	-11	.108	.107
-12	.136	.136	-12	.109	.108
X16138-1M-1	.148	.148	X16138-1HH-1	.027	.027
-2	.146	.147	-2	.028	.027
-3	.144	.144	-3	.026	.026
-4	.140	.143	-4	.024	.024
-5	.139	.139	-5	.024	.025
-6	.140	.140	-6	.026	.026
-7	.139	.140	-7	.024	.024
-8	.139	.139	-8	.024	.025
-9	.141	.141	-9	.027	.027
-10	.143	.143	-10	.028	.027
-11	.141	.141	-11	.024	.024
-12	.140	.140	-12	.025	.025

TABLE XCIV (Continued)



Part Number	Hole #1	Hole #2	Part Number	Hole #1	Hole #2
X16138-4HP-1	.137	.137	X16138-2K-1	.067	.070
-2	.127	.127	-2	.073	.075
-3	.129	.129	-3	.073	.072
-4	.131	.131	-4.	.067	.070
-5	.132	.133	-5	.071	.072
-6	.129	.130	-6	.073	.071
-7	.134	.133	-7	.075	.072
-8	.128	.129	-8	.070	.072
-9	.129	.127	-9	.071	.073
-10	.131	.129	-10	.069	.071
-11	.133	.133	-11	.071	.073
-12	.131	.130	-12	.049	.065
X16138-4J-1	.130	.130	X16138-2N-1	.070	.070
-2	.131	.131	-2	.069	.069
-3	.129	.129	-3	.074	.074
-4	.129	.129	-4	.073	.073
-5	.125	.125	-5	.071	.071
-6	.127	.128	-6	.073	.073
-7	.128	.128	-7	.076	.076
-8	.133	.133	-8	.075	.075
-9	.129	.129	-9	.076	.076
-10	.128	.128	-10	.076	.075
-11	.131	.131	-11	.074	.073
-12	.130	.130	-12	.072	.072
X16138-4M-1	.156	.161	X16138-4H-1	.124	.124
-2	.158	.158	-2	.127	.127
-3	.160	.160	-3	.125	.125
-4	.162	.162	-4	.127	.127
-5	.159	.159	-5	.128	.128
-6	.157	.159	-6	.126	.126
-7	.158	.160	-7	.125	.124
-8	.159	.159	-8	.126	.125
-9	.160	.160	-9	.128	.127
-10	.157	.157	-10	.127	.127
-11	.159	.159	-11	.129	.129
-12	.160	.160	-12	.126	.126

TABLE XCIV (Continued)



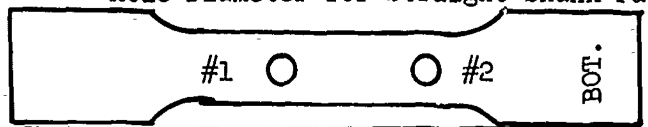
Part Number	Hole #1	Hole #2	Part Number	Hole #1	Hole #2
X16138-1J-1	.146	.146	X16138-3L-1	.142	.143
-2	.145	.147	-2	.144	.150
-3	.143	.145	-3	.145	.146
-4	.144	.146	-4	.144	.144
-5	.145	.145	-5	.146	.145
-6	.146	.145	-6	.150	.150
-7	.146	.146	-7	.145	.146
-8	.143	.144	-8	.146	.146
-9	.144	.145	-9	.145	.145
-10	.147	.148	-10	.147	.148
-11	.140	.148	-11	.146	.147
-12	.147	.145	-12	.150	.151
X16138-1MM-1	.037	.037	X16138-1HP-1	.101	.101
-2	.037	.036	-2	.130	.130
-3	.038	.038	-3	.133	.133
-4	.038	.039	-4	.122	.122
-5	.041	.041	-5	.113	.113
-6	.039	.039	-6	.115	.115
-7	.039	.039	-7	.117	.117
-8	.038	.038	-8	.122	.122
-9	.037	.038	-9	.124	.124
-10	.038	.039	-10	.118	.118
-11	.018	.029	-11	.129	.129
-12	.039	.040	-12	.133	.133
X16138-4MP-1	.122	.122	X16138-1MP-1	.129	.129
-2	.138	.138	-2	.127	.127
-3	.132	.132	-3	.129	.129
-4	.129	.129	-4	.129	.129
-5	.129	.129	-5	.133	.133
-6	.130	.131	-6	.129	.129
-7	.134	.132	-7	.124	.124
-8	.127	.130	-8	.126	.126
-9	.130	.133	-9	.126	.126
-10	.128	.130	-10	.124	.124
-11	.131	.131	-11	.130	.130
-12	.129	.127	-12	.126	.126

TABLE XCV

FASTENER HOLES SIZES

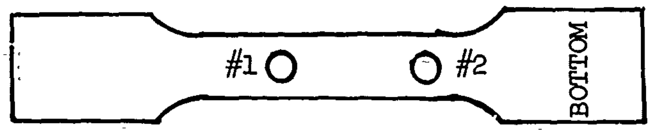
LOW LOAD TRANSFER JOINTS

Hole Diameter for Straight Shank Fasteners (inches)



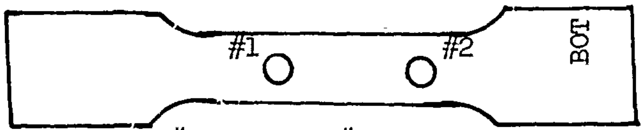
Part Number	Hole #1	Hole #2	Part Number	Hole #1	Hole #2
X16138-1AA-1	.1867	.1872	X16138-1E-1	.1851	.1852
-2	.1870	.1868	-2	.1852	.1855
-3	.1872	.1869	-3	.1856	.1855
-4	.1874	.1870	-4	.1854	.1855
-5	.1875	.1872	-5	.1853	.1855
-6	.1873	.1872	-6	.1853	.1856
-7	.1869	.1870	-7	.1854	.1854
-8	.1869	.1870	-8	.1854	.1856
-9	.1870	.1870	-9	.1856	.1854
-10	.1871	.1870	-10	.1855	.1852
-11	.1868	.1869	-11	.1853	.1852
-12	.1873	.1870	-12	.1854	.1855
X16138-1A-1	.1853	.1855	X16138-1EE-1	.1873	.1872
-2	.1853	.1852	-2	.1871	.1872
-3	.1855	.1853	-3	.1873	.1872
-4	.1855	.1853	-4	.1869	.1871
-5	.1854	.1856	-5	.1870	.1871
-6	.1855	.1853	-6	.1875	.1872
-7	.1850	.1853	-7	.1869	.1869
-8	.1855	.1855	-8	.1874	.1872
-9	.1853	.1852	-9	.1871	.1870
-10	.1854	.1856	-10	.1873	.1873
-11	.1854	.1852	-11	.1870	.1870
-12	.1852	.1848	-12	.1870	.1870
X16138-1B-1	.1850	.1852	X16138-2F-1	.1852	.1852
-2	.1852	.1851	-2	.1853	.1851
-3	.1853	.1852	-3	.1852	.1851
-4	.1852	.1854	-4	.1853	.1852
-5	.1852	.1853	-5	.1852	.1852
-6	.1852	.1851	-6	.1853	.1849
-7	.1851	.1852	-7	.1850	.1850
-8	.1852	.1855	-8	.1851	.1852
-9	.1854	.1857	-9	.1851	.1851
-10	.1852	.1850	-10	.1849	.1850
-11	.1852	.1851	-11	.1851	.1850
-12	.1850	.1853	-12	.1850	.1851

TABLE XCV (Continued)



Part Number	Hole #1	Hole #2	Part Number	Hole #1	Hole #2
X16138-4A-1	.1855	.1854	X16138-4EP-1	.1863	.1863
-2	.1853	.1853	-2	.1859	.1859
-3	.1855	.1855	-3	.1861	.1861
-4	.1856	.1856	-4	.1861	.1861
-5	.1859	.1859	-5	.1862	.1862
-6	.1856	.1857	-6	.1861	.1861
-7	.1857	.1854	-7	.1862	.1862
-8	.1856	.1857	-8	.1861	.1861
-9	.1858	.1859	-9	.1861	.1861
-10	.1856	.1857	-10	.1860	.1860
-11	.1854	.1855	-11	.1860	.1860
-12	.1855	.1855	.12	.1861	.1861
X16138-4E-1	.1854	.1854	X16138-4AP-1	.1871	.1871
-2	.1856	.1855	-2	.1869	.1869
-3	.1856	.1856	-3	.1870	.1871
-4	.1855	.1855	-4	.1871	.1870
-5	.1858	.1857	-5	.1870	.1870
-6	.1858	.1858	-6	.1871	.1871
-7	.1854	.1855	-7	.1872	.1872
-8	.1855	.1855	-8	.1871	.1871
-9	.1859	.1859	-9	.1869	.1869
-10	.1854	.1854	-10	.1870	.1871
-11	.1854	.1855	-11	.1870	.1870
-12	.1855	.1856	-12	.1869	.1869
X16138-1EP-1	.1851	.1852	X16138-1AP-1	.1852	.1853
-2	.1853	.1851	-2	.1851	.1852
-3	.1852	.1851	-3	.1852	.1853
-4	.1855	.1854	-4	.1852	.1852
-5	.1851	.1853	-5	.1852	.1852
-6	.1853	.1850	-6	.1853	.1852
-7	.1850	.1853	-7	.1852	.1852
-8	.1855	.1850	-8	.1850	.1850
-9	.1851	.1851	-9	.1851	.1851
-10	.1851	.1853	-10	.1853	.1852
-11	.1854	.1853	-11	.1851	.1851
-12	.1854	.1853	-12	.1853	.1852

TABLE XCV (Continued)



Part Number	Hole #1	Hole #2	Part Number	Hole #1	Hole #2
X16138-2C-1	.1853	.1850	X16138-3D-1	.1853	.1851
-2	.1851	.1848	-2	.1855	.1853
-3	.1852	.1850	-3	.1855	.1856
-4	.1850	.1851	-4	.1853	.1852
-5	.1853	.1850	-5	.1854	.1853
-6	.1853	.1851	-6	.1852	.1852
-7	.1850	.1850	-7	.1853	.1855
-8	.1851	.1851	-8	.1852	.1851
-9	.1852	.1851	-9	.1852	.1851
-10	.1850	.1849	-10	.1850	.1[illegible]53
-11	.1850	.1851	-11	.1854	.1854
-12	.1852	.1853	-12	.1856	.1854
X16138-3G-1	.1853	.1857	X16138-1AAA-1	.1844	.1843
-2	.1852	.1853	-2	.1844	.1843
-3	.1853	.1853	-3	.1844	.1843
-4	.1851	.1851	-4	.1845	.1845
-5	.1852	.1851	-5	.1847	.1845
-6	.1857	[illegible]	-6	.1843	.1845
-7	.1850	.1852	-7	.1846	.1847
-8	.1852	.1851	-8	.1848	.1845
-9	.1854	.1852	-9	.1846	.1844
-10	.1851	.1850	-10	.1844	.1844
-11	.1851	.1852	-11	.1844	.1843
-12	.1853	.1856	-12	.1850	.1850
X16138-4B-1	.1854	.1853	X16138-1EEE-1	.1845	.1845
-2	.1854	.1855	-2	.1844	.1843
-3	.1852	.1852	-3	.1845	.1844
-4	.1856	.1855	-4	.1844	.1844
-5	.1857	.1856	-5	.1846	.1843
-6	.1853	.1854	-6	.1844	.1845
-7	.1853	.1853	-7	.1843	.1844
-8	.1854	.1854	-8	.1843	.1843
-9	.1857	.1856	-9	.1844	.1845
-10	.1858	.1856	-10	.1843	.1843
-11	.1854	.1854	-11	.1843	.1843
-12	.1854	.1854	-12	.1845	.1845

TABLE XCVI
RANDOM SAMPLING OF STRUCTURAL FASTENERS
(FINISHED DIAMETERS IN INCHES)

HLT 315-6-4 Nickel Cad Std.

.1894	.1892	.1893	.1893	.1892	.1892	.1890	.1892

HLT 411-6-4 Plain Ti with Ceytl Alcohol

.1891	.1891	.1893	.1890	.1891	.1891	.1890	.1890

HLT 411-6-2 Plain Ti with Ceytl Alcohol

.1891	.1892	.1890	.1891	.1895	.1890	.1890	.1889

HLT 411-6-6 Plain Ti with Ceytl Alcohol

.1891	.1890	.1890	.1891	.1890	.1892	.1890	.1890

HLT 15-6-4 Lubeco 2123 with Ceytl Alcohol

.1891	.1890	.1892	.1890	.1889	.1890	.1888	.1890

HLT 315-6-4 Lubeco 2123 with Ceytl Alcohol

.1893	.1893	.1890	.1892	.1889	.1890	.1890	.1890

HLT 411-6-4 Plain Ti with Lubeco 2123

.1896	.1895	.1893	.1897	.1896	.1895	.1897	.1898

HLT 315-6-2 Nickel Cad Std

.1888	.1888	.1890	.1887	.1887	.1888	.1885	.1886

HLT 15-6-4 Nickel Cad Std

.1888	.1889	.1890	.1889	.1890	.1890	.1888	.1889

APPENDIX IV

HI SHEAR CORPORATION REPORT 4-33002 EFFECT OF TEST FREQUENCY ON AMOUNT OF LOAD TRANSFER IN A REVERSE DOG BONE FATIGUE SPECIMEN

hi-shear CORPORATION

EFFECT OF TEST FREQUENCY

ON AMOUNT OF LOAD TRANSFER IN A

REVERSE DOG BONE FATIGUE SPECIMEN

Report No. 4-33002
Issue Date: February 15, 1973

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hi-shear
CORPORATION
2600 SKYPARK DRIVE
TORRANCE CALIFORNIA 90509
AREA CODE 213 · 326-8110 · 775-3181

Report No.: 4-33002
Issue Date: 2/15/73

ABSTRACT

This study investigates load transfer in a strain gaged reverse dogbone specimen versus various fatigue test frequencies.

KEY WORDS

Fatigue Test Frequency
Low load transfer

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2600 SKYPARK DRIVE
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1.0 INTRODUCTION

Questions have come up in the past regarding the effect on load transfer in reverse dogbone type fatigue specimens due to variations in test machine operating frequency. Lockheed-California Company supplied a strain gaged low load transfer reverse dog bone specimen to investigate this phenomena. This specimen was cycled at five frequencies between 5 HZ and 76 HZ. Strain gage readings were recorded at each frequency.

2.0 CONCLUSIONS

The oscillograph recordings of all gages indicate no apparent change in strain magnitude with test machine frequency changes. The strain gage recordings taken on this specimen would indicate no effect on load transfer in the range of test frequencies explored.

3.0 TEST SPECIMEN

The aluminum fatigue test specimen is a typical reverse dog bone type low load transfer specimen.

The specimen reduced section dimensions are 1.128 wide x .378 thick. Two sheets are each .189 thick. Two 3/16" diameter HL51 pins were installed with Hi-Lok collars along the C/L of the load axis.

4.0 STRAIN GAGES

Eight strain gages were installed on the specimen.

Four gages were bonded to each sheet in a symetrical manner. Two gages were placed 1/2 inch above and below the Hi-Loks on each sheet.

All the strain gages were wired in the three wire convention technique for individual readout.

5.0 TEST MACHINE

The fatigue test machine used is an MTS electrohydraulic resonant fatigue test machine. Tests were run on 25 KIP load range. Test frequencies were 5, 10, 48, 62 and 76 HZ. The two low frequencies were achieved operating the test machine in the standard electro-hydraulic closed loop test mode.

The three high speed runs were made in the resonant mode. In this mode the operating frequency is dictated by the specimen spring rate and the weight of the test machine moving mass.

6.0 INSTRUMENTATION

6.1 W. T. Bean, Model 206B Digital Strain Indicator

6.2 W. T. Bean, Model 306B Switch and Balance Unit

6.3 Systems Research Incorporated, Model 2531 Bridge Signal Conditioner

6.4 Ectron, Model A614, Differential DC Amplifier

6.5 Honeywell, Model 2106, Visicorder Light Beam Oscillograph

7.0 TEST PROCEDURE

7.1 Static Loading

Before dynamically running the specimen, we took static strain reading from each gage. The Bean strain indicator and switch and balance units were used for read out. The specimen was loaded to 6340 pounds (approximately 15,000 psi gross area stress). This data is tabulated in the Test Result section. (Section 8.0)

7.2 Dynamic Loading

For dynamic operation, the strain gages were mated with the instruments listed in 6.3, 6.4, and 6.5. Only two channels are available on the oscillograph for recording. Therefore, a pair of gages were mated with the instrumentation and readings taken at each frequency. This was repeated for each pair of strain gages. The specimen was cycled between 6340 pounds and 634 pounds for all runs.

Bridge supply voltage and amplifier gain was fixed in all cases. The amount of oscillograph deflection was arbitrarily selected. The distance at 6340 pounds will vary between different gages, just as the static strain readings indicated.

8.0 TEST RESULTS

8.1 Static Load

Strain Gage	Position	Strain ($X10^{-6}$)
1	Collar side bottom left	1424
2	Collar side bottom right	1401
3	Head side bottom left	1413
4	Head side bottom right	1426
5	Collar side bottom left	1546
6	Collar side bottom right	1527
7	Head side top left	1271
8	Head side top right	1299

Notes

1. Applied load 6340 pounds.
2. Gage factor was assumed to be 2.00
   Shunt calibration resistor 29,800 Ohms
   Equivalent micro strain = 2000

8.2 Dynamic Loading

The oscillograph strip charts were identified with strain gage number and test conditions. These charts are being submitted to Lockheed-California Company.

APPENDIX V

VARIABLES BELIEVED TO INFLUENCE THE FATIGUE LIFE OF JOINTS

Table XCVII is a compilation of joint variables known to or assumed to effect the fatigue characteristics of mechanically fastened joints. This list, dated 6 August 1973, was obtained from Major Thomas K. Moore, ASD/ENFSS, Wright-Patterson AFB, Ohio. An earlier listing of variables believed to influence fatigue life of mechanically fastened joints which includes many of the variables listed in Table XCVII was given by R. B. Urzi in Lockheed-California Company Report LR 25183 dated 20 March 1972 which was the proposal leading to contract F33615-72-C-1838 being reported in this document.
this document.

TABLE XCVII. VARIABLES BELIEVED TO INFLUENCE THE FATIGUE LIFE OF MECHANICALLY FASTENED SHEAR JOINTS

NO.	VARIABLE	RANGE
1.	Amount of Load Transfer	0-100%
2.	Stress Level in Material Fastened	0-100% Ultimate Strength
3.	Stress Ratio "R"	-1.0 to 1.0
4.	Physical Environment	Vacuum to Severely Corrosive
5.	Countersink Depth/Sheet Thickness Ratio	0 to More Than 1.0
6.	Head Sheet Material	Al, Ti, or Steel Alloys
7.	Nut/Collar Sheet Material	Al, Ti, or Steel Alloys
8.	Stack-up Thickness/Shank Diameter Ratio	0.1 to 10.0
9.	Type of Loading	Constant Amplitude or Spectrum
10.	Sheet Corrosion Protection	Bare, Clad, Primed, Anodized, Alodined
11.	Degree of Cold Work of Sheet Material	None to Severe
12.	Sealing	None to Heavy
13.	Fretting Protection	None, Shims, Lubricants, Adhesives
14.	Shim Materials	Soft Al, Hard Al, CRES, Brass, Bronze
15.	Paint/Primer Thickness	0 to 0.010"
16.	Gap Between Sheets	0 to 0.050"

TABLE XCVII. VARIABLES BELIEVED TO INFLUENCE THE FATIGUE LIFE OF MECHANICALLY FASTENED SHEAR JOINTS (Continued)

NO.	VARIABLE	RANGE
17.	Corrosion Protection at Installation	None, Dry, Wet Primer
18.	Test Temperature	Any Desired
19.	Temperature Cycling	Any Desired
20.	Edge Distance/Diameter Ratio	0 to 4.0+
21.	Fastener Spacing and Pattern	Any Desired
22.	Hole Smoothness	25 to 300 Microinches
23.	Hole-countersink Concentricity	0 to 1/4 Diameter Error
24.	Hole Perpendicularity	0° to 2.0° Error
25.	Countersink Perpendicularity	0° to 2.0° Error
26.	Hole Circularity	Circular, Oval, Lobed
27.	Countersink Circularity	Circular, Oval, Lobed
28.	Hole Taper	0° to 2.0° Taper
29.	Degree of Clamp-up (Fastener Preload)	0 to 100% Fastener Ultimate Strength
30.	Interference Level	0 to 5% of Fastener Diameter
31.	Degree of Hole Cold Work	0 to 8% of Hole Diameter
32.	Amount of Fastener Shank Contact	0 to 100%
33.	Hole Cleam-up	None or Destack and Deburr
34.	Radius Under the Head or Countersink	0 to 1.0 Fastener Diameter
35.	Fastener Finish Smoothness	25 to 300 Microinches
36.	Fastener Driving Method	Pulled, Squeezed, Driven, Upset
37.	Fastener Corrosion Protection	None, Plated, Sealed, Primed, Anodized
38.	Type of Fastener Material	Steel, Ti, Al, Monel, MP35N, etc.
39.	Nut/Collar Material	Steel, Ti, Al, Monel, MP35N, etc.
40.	Nut/Collar Configuration	Coining or Non-coining
41.	Type of Nut	Threaded or Upset
42.	Type of Shank	Straight, Tapered, or Lobed
43.	Countersink Angle	60°, 70°, 82°, 100°
44.	Strength of Fastener Material	50 to 300 KSI
45.	Type of Head	Countersunk or Protruding
46.	Type of Recess	Hi-Torque, Torque-Set, Triwing, etc.
47.	Hole Straightness	0 to 0.1 D Error
48.	Number of Times the Fastener is Removed	Any Number
49.	Fastener Head to Shank Perpendicularity	0 to 1.0° Error
50.	Metalurgical Microstructure and Grainsize	Any
51.	Precrack or Flaw Size and Orientation	Any

APPENDIX VI

PERTINENT EXCERPTS FROM THE PROPOSED SHEAR JOINT FATIGUE TEST SPECIFICATION FOR MIL-STD-1312 "FASTENER TEST METHODS"

4. SPECIMEN CONFIGURATION

One of the three specimens shown in Figure 92, Figure 93, or Figure 94 may be used depending on the load characteristic to be investigated. The specimen shown in Figure 92 shall be used for high-load transfer testing; the Figure 93 specimen shall be used for low-load transfer testing; and the Figure 94 specimen shall be used for no-load transfer testing.

4.1 Method for Loading

The configuration of the joint specimen outside the lap area is optional. Certain parent sheet materials may be relatively low strength or thin enough to permit satisfactory gripping in standard friction type holding fixtures. However, for higher strength parent sheet materials and for cases where grip slipping may be encountered, the use of pin loading holes is recommended. When pin loading holes are used, they shall be located so that the load will pass through the centerline of the fastener hole pattern within 0.005 inch.

4.2 PREPARATION

Unless otherwise specified, specimens shall be fabricated from either 2024-T3 (or 2024-T351) or 6Al-4V titanium. Tooling holes must be confined to the grip area.

4.2.1 Sheet Thickness

Unless otherwise specified, the sheet thickness (t) shall be

0.75D where D is the value shown on Figure 92, Figure 93, and Figure 94.

4.2.2 Sheet Surface Preparation

Unless otherwise specified, the faying sheet surface shall be prepared by degreasing for the full-load transfer joint and the no-load transfer joint, and prepared with zinc chromate in accordance with TT-P-1757 for the low-load specimen.

4.3 STRIP MATERIAL MECHANICAL PROPERTIES

Three samples of each sheet or plate material employed in the actual joint strength evaluation shall be tested for tensile properties. Test procedures and method for determination of strip mechanical properties shall be in accordance with ASTM E8. The values for ultimate, yield and elongation shall be determined. The grain direction shall be the same as the lap joint specimen.

4.4 FASTENER HOLES

Fastener holes shall be line drilled perpendicular to the sheet surface within 1/2 degree. Holes shall be deburred on both sides of each sheet not to exceed .005 radius or chamfer. Surface finish of the hole shall be RHR 63 or better.

4.4.1 Countersink Fastener Holes

Holes for countersink fastener shall be prepared with an integral drill - countersink tool in order to maintain concentricity of the countersink with the hole. The depth of countersink shall be maintained such that the installed fastener is flush within +.002" - .005".

4.4.2 Protruding Fastener Holes

The holes for protruding fasteners shall be relieved on the head side the minimum amount necessary to clear the fastener head-to-shank fillet radius. There shall be no gap between the head and the sheet.

4.4.3 Hole Straightness

Holes shall be straight within .0016 inch per inch diameter.

4.4.4 Fastener Orientation

The manufactured heads of the fastener shall be on the same side of the sheet material.

4.5 ASSEMBLY

4.5.1 Fastener Installation

If the fastener installation requires a torquing procedure, the applied torque shall be the minimum specified value for the particular fastener. If the fastener installation requires controlled material deformation, the deformation shall be the minimum specified value for the particular fastener.

If these techniques are used, they shall be reported.

Unless otherwise specified, lubrication and corrosion protection media, except as part of the product specification, shall not be used.

4.5.2 Sheet Gap

Particular care shall be taken to assure no gap exists between the sheets subsequent to assembly. The gap shall be considered excessive if a .002" thick gage can be slid between the sheets and contact any fastener.

5. PROCEDURE

5.1 Installation

The specimen shall be installed in the holding fixture and clamped in position. The load shall be transmitted along a line passing through the centerline of the faying surface of the specimen within .005 inch.

5.2.1 Joint Static Strength

5.2 Test Conditions

In order to establish the joint static ultimate strength a specimen similar to that used for the fatigue test shall be prepared and tested. The ultimate strength shall be the value indicated at the first peak of the stress-strain curve.

5.2.2 Load Level

Four load levels shall be used to establish an S-N curve. One value shall be chosen which does not fail at less than 3,000,000 cycles; the other three shall be 67, 50, and 30 percent of the joint static strength. A minimum of three specimens shall be tested at each load level.

5.2.3 Fatigue Test Type

The load applied shall be sinusoidal constant amplitude.

5.2.4 Load Ratio

Unless otherwise specified, the low load shall be 10 percent of the maximum load.

5.2.5 Test Speed

The maximum test speed shall be selected so as not to cause the specimen temperature to exceed 150°F.

5.2.6 Specimen Restraints

In order to preserve the initial alignment, a restraint of the type shown in Figure 8 or Figure 9 shall be used with the high load transfer specimen shown in Figure 92. Care shall be taken in the use of either device to assure that the restraint does not transfer a portion of the load.

5.2.7 Failure

The specimen will be considered to have failed when the test machine will no longer maintain the load due to the failure of the specimen.

6. TEST REPORT

6.1 The test report shall contain the following data:

(a) Description of the fastener and part number (and components if more than one piece).
(b) Fastener material by alloy and condition.
(c) Fastener lot identification.
(d) Sheet material by alloy and condition.
(e) Sheet thickness (actual).
(f) Hole size - individual measurements of each hole.
(g) Radius of sheet to hole for protruding head fasteners.
(h) Specimen configuration.

(i) Primer thickness.

(j) Static data of sheet and joint determined by Paragraph 4.3 and Paragraph 5.2.1.2.

(k) Gross area stress level.

(l) Actual interference level and the method used in determination.

(m) Type of test restraint.

(n) Description of actual test installation such as special techniques, installation torque, special tools and conformance to any applicable specification.

(o) Actual value of cycles to failure.

(p) Description and location of failure mode.

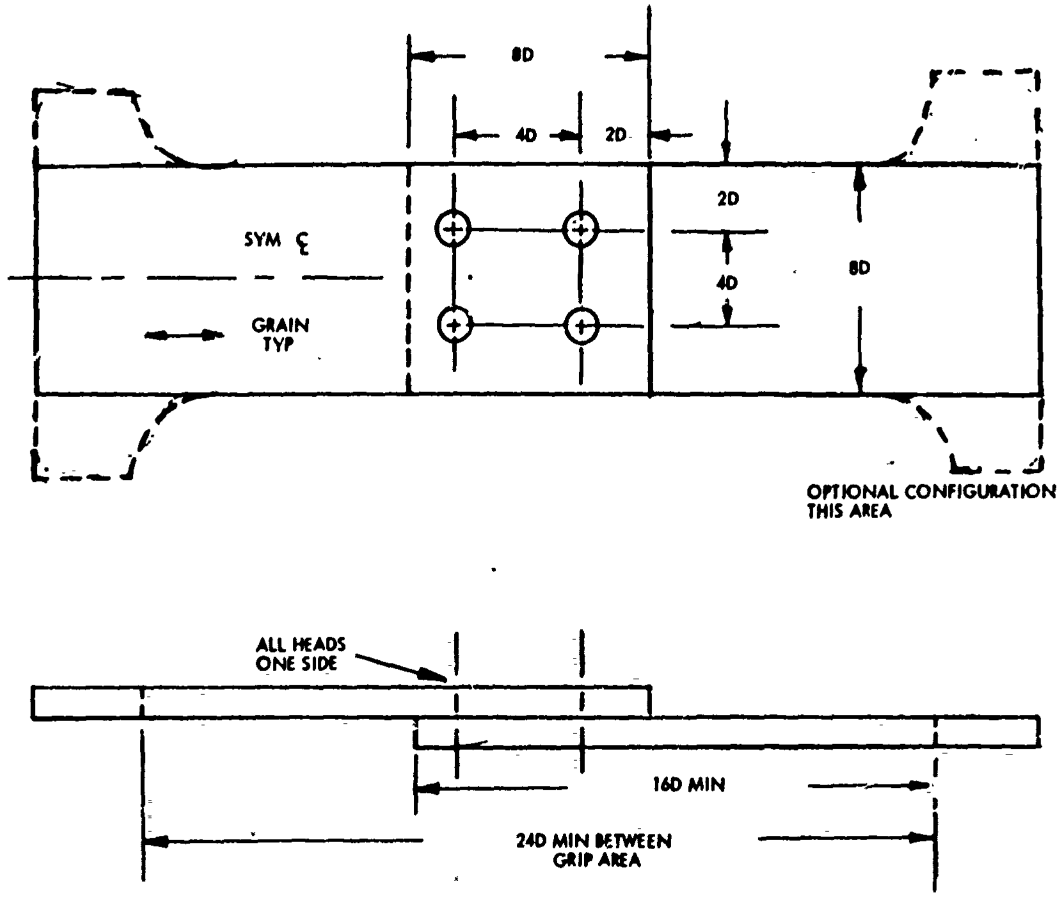
(q) Machine tes speed.

(r) Machine manufacturer and type.

(s) Machine Calibration data.

6.2 S-N Presentation

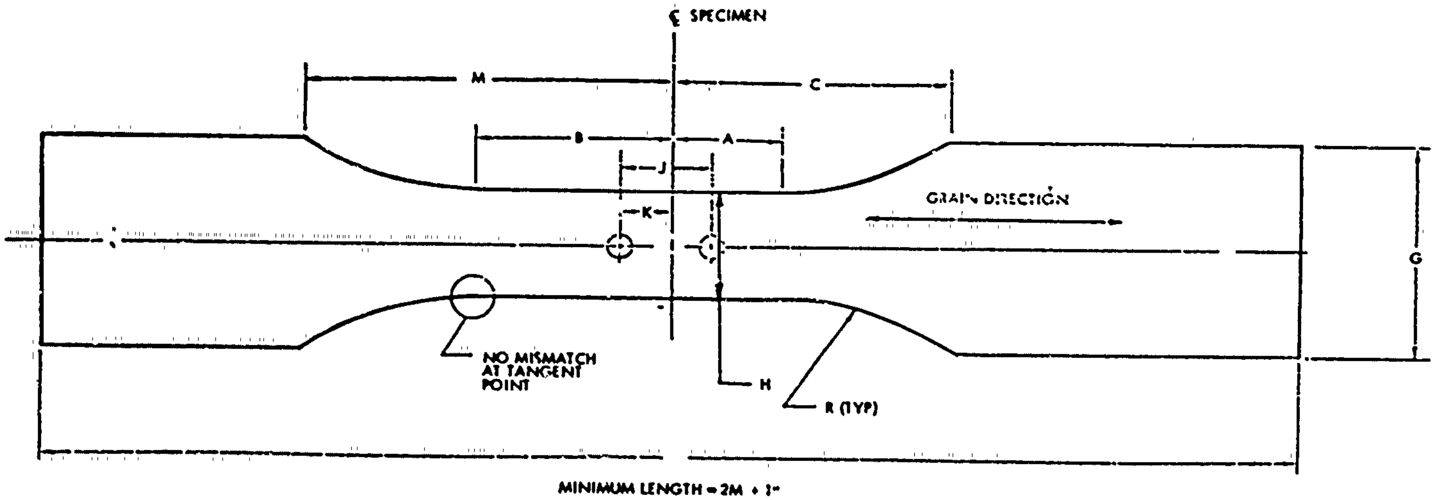
The data shall be plotted on semi-log paper with the load as the ordinate, expressed as percent of ultimate joint static strength on a linear scale, and cycles to failure on a logarithmic scale as the abscissa.



NOM DIAM	D
3/32	.093
1/8	.125
5/32	.156
3/16	.188
7/32	.219
1/4	.250
5/16	.313
3/8	.375
7/16	.438
1/2	.50

NOTE:
1. ALL EDGES MACHINE 63 OR BETTER
2. NO SCRATCHES, GOUGES, OR SCRIBE MARKS IN 24D AREA
3. TOLERANCE ON 2D AND 4D DIMENSIONS SHALL BE ±.005
4. CHAMFER OR RADIUS HOLES .005 MAX.

Figure 92. Lap Joint Specimen - Single Shear 100% Load Transfer



NOM. DIAM.	D
3/32	.093
1/8	.125
5/32	.156
3/16	.188
7/32	.219
1/4	.250
5/16	.313
3/8	.375
7/16	.438
1/2	.500

NOMINAL FASTENER SIZE	G	H ± .005	M (REF)	C (REF)	B	A	R	J ± .005	K ± .005
1/8	2.50	.750	3.190	2.370	1.570	.750	2.0	.500	.250
5/32	2.50	.938	3.800	2.705	2.033	.938	2.5	.625	.313
3/16	2.50	1.125	4.237	3.037	2.325	1.125	3.0	.750	.375
1/4	3.50	1.500	5.345	4/145	2.700	1.500	4.0	1.000	.500
5/16	3.50	1.875	5.990	4.790	3.075	1.875	5.0	1.250	.625
3/8	3.50	2.250	6/116	4.916	3.450	2.250	6.0	1.500	.750
1/2	5.00	3.000	8.442	6.317	5.125	3.000	6.0	2.000	1.000

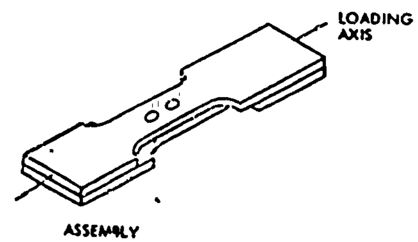
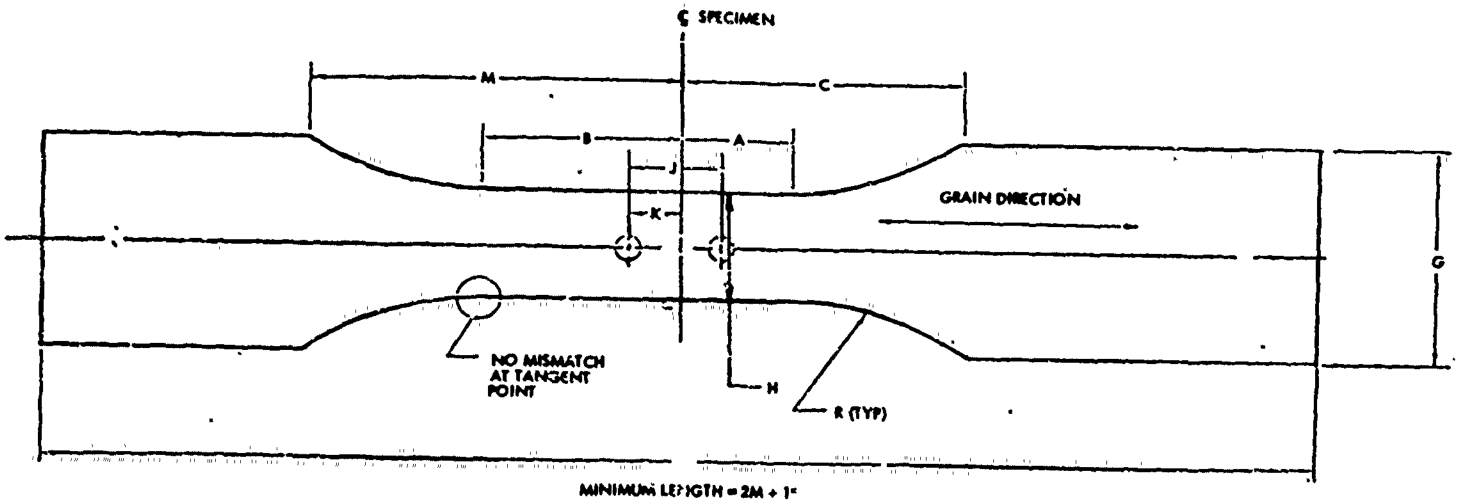


Figure 93. Specimen Detail, Lcw Load Transfer Test Specimen Joint



NOM. DIAM.	D
3/32	.093
1/8	.125
5/32	.156
3/16	.188
7/32	.219
1/4	.250
5/16	.313
3/8	.375
7/16	.438
1/2	.500

NOMINAL FASTENER SIZE	G	H ± .005	M (REF)	C (REF)	B	A	R	J ± .005	K ± .005
1/8	2.50	.750	3.190	2.370	1.570	.750	2.0	.500	.250
5/32	2.50	.938	3.800	2.705	2.033	.938	2.5	.625	.313
3/16	2.50	1.125	4.237	3.037	2.325	1.125	3.0	.750	.375
1/4	3.50	1.500	5.345	4.145	2.700	1.500	4.0	1.000	.500
5/16	3.50	1.875	5.990	4.790	3.075	1.875	5.0	1.250	.625
3/8	3.50	2.250	6.116	4.916	3.450	2.250	6.0	1.500	.750
1/2	5.00	3.000	8.442	6.317	5.125	3.000	6.0	2.000	1.000

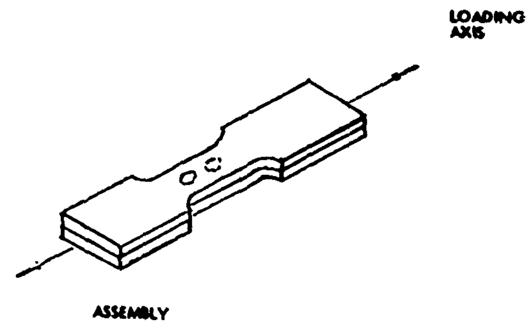


Figure 94. Specimen Detail, No Load Transfer Test Specimen Joint