DEVELOPMENT OF AN UNDERSTANDING OF THE FATIGUE PHENOMENA OF BONDED AND BOLTED JOINTS IN ADVANCED FILAMENTARY COMPOSITE MATERIALS

VOLUME II, FABRICATION, INSPECTION, AND TESTING

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FOREWORD

This report summarizes the work accomplished under Contract F33615-70-C-1302, "Development of an Understanding of the Fatigue Phenomena of Bonded and Bolted Joints in Advanced Filamentary Composite Materials", Project Number 4364, and was prepared by the Lockheed-Georgia Company, a Division of Lockheed Aircraft Corporation. The work reported herein was sponsored by the Advanced Composite Branch, Air Force Flight Dynamics Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio 45433. Mr. Rodman Joblove, FBC, was the Air Force Project Engineer and Mr. A. C. Fehrle was the Lockheed-Georgia Program Manager.

The authors of Volume II are Dr. E. C. Young, Mr. A. R. Holland, Mr. W. P. Lanier, Mr. G. J. Gilbert, and Mr. A. C. Fehrle. Dr. E. C. Young was responsible for the fabrication of all specimens including laminate coupons, bonded joints and mechanical joints. Mr. A. R. Holland was responsible for basic material evaluation and Mr. W. P. Lanier was responsible for the non-destructive inspections of all test specimens. Mr. G. J. Gilbert and Mr. A. C. Fehrle were responsible for specimen testing and basic data evaluation.

This technical report has been reviewed and is approved.

For internal control purposes, this report has been assigned Lockheed-Georgia Company Report Number ER-11319.

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ABSTRACT

Fabrication and inspection methods were established which resulted in specimens of uniform high quality fabricated to close tolerances. Both bonded and bolted joints of widths from one to ten inches were evaluated. Primary emphasis was on joints in boron-epoxy, and between boron-epoxy and titanium or aluminum. However, limited evaluations of graphite-epoxy/titanium and fiberglass-epoxy/titanium were included. Joint configurations evaluated were single and double splice butt joints; boron-epoxy to metal stepped single scarf joints; and surface to understructure attachments. All laminates and specimens were inspected non-destructively. Base material properties and process control measures were verified by destructive testing. Developing testing techniques and actual specimen testing was a major portion of the program.

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SECTION I
INTRODUCTION

This program was undertaken to develop an understanding of the fatigue phenomena of structural joints in advanced filamentary composite materials and to develop analytical and testing methods to support proper fatigue design of advanced composite structural joints. The program included the evaluation of both bonded and bolted joints. Primary emphasis was placed on joints in boron-epoxy; however, a limited evaluation of bonded joints in graphite-epoxy and glass-epoxy were included. Although the sizes of the joints for this investigation were small (one to ten inches in width), all configurations evaluated are representative of typical structural joints currently utilized in advanced filamentary composite structures.

The program consisted of three major areas of investigation:

- Analysis Methods
- Fabrication, Inspection and Testing
- Fatigue Analysis and Failure Mode Studies

Analytical methods for determining joint stresses were divided into two major tasks, (1) analysis of bonded joints and (2) analysis of bolted joints. Primary emphasis was placed on the development of a closed form elastic analysis procedure for bonded joints. This analysis was used to evaluate a number of joint variables. A "plastic zone" approach was used to extend the closed form analysis procedure to include joints with inelastic adhesive stress-strain behavior. The results of the elastic closed form solution were verified with finite element analyses, photoelastic analysis and strain gage data. Finite element analyses were used to evaluate the step lap bonded joints and bolted joints.

The experimental program consisted of fabrication, inspection and testing of a large quantity of joint specimens. Fabrication and inspection methods were established which resulted in specimens being fabricated to close tolerances and of uniform high quality. This provided specimens that would consistently develop stresses that were predicted by the analytical methods. Developing testing techniques and actual specimen testing was a major portion of the program. Establishing proper specimen support was essential to obtaining repeatable joint strengths within a specimen configuration. Equally important was determining the proper cyclic rate for the different stress ratios and specimen configurations to preclude specimen heating and erratic fatigue lives.

Evaluation of the experimental results was divided into two separate but related tasks. These tasks were failure mode studies and fatigue analyses. The failure mode studies mentioned were photomicrographic analyses of the failure surfaces. This failure mode analysis does not replace but augments the gross failure modes generally defined within the experimental phases of a program. The photomicrographic analysis conducted within this program established failure modes related to specific joint designs, joint loading and fatigue history. The fatigue analysis established relationships between specimen configuration, joint variables, material combinations, loading conditions and stress ratio effects for constant amplitude loading. The relationship between constant amplitude fatigue and spectrum fatigue (block and realistic) was also evaluated for specific joint configurations.

This report is divided into three separate volumes each containing the developments accomplished within a major area of investigation. Each volume is a self-contained document, complementing the other two volumes but not dependent upon them for coherence or continuity. The titles of the three volumes are:

Volume I - Analysis Methods

Volume II - Fabrication, Inspection and Testing

Volume III - Fatigue Analysis and Failure Mode Studies

Volume II is divided into three sections: Fabrication, Technical Inspection and Quality Assurance, and Test Program. The Fabrication section contains details related to laminate fabrication using boron-epoxy, graphite-epoxy, and fiberglass-epoxy. Methods for joining the various bonded and mechanical joints is also discussed in detail. The Technical and Quality Assurance section contains information related to nondestructive inspection of all laminates and specimens, destructive test verification of the base materials, and process control requirements for all specimens fabricated. The Test Program section identifies all test, instrumentation, and programming equipment used during the entire program. Also discussed are the general and specific test requirements for the different joint configurations. Test procedures and test results are included for all specimen configurations and program phases.

Included in the Appendices of this Volume are the Fabrication and Inspection Logs, Test Data Forms, and Joint Designs.

SECTION II
FABRICATION

2.1 GENERAL

2.1.1 Introduction to Specimen Configurations

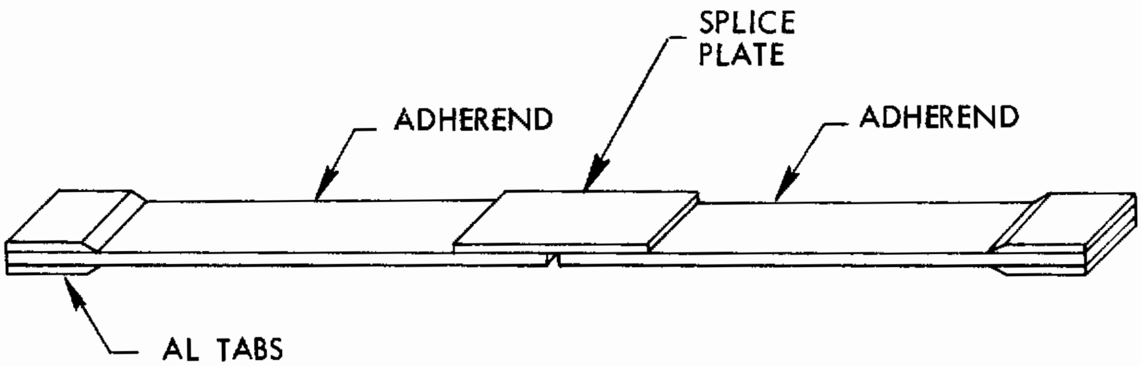
This section describes in summary fashion the types of specimens that were fabricated and provides an overview of the fabrication program. Location of precisely detailed specifications and data for individual specimens as cited in Sections 2.1.2, 2.1.3, and 2.1.4. Details of fabrication procedures are presented in Section 2.2 through Section 2.8. Specimens fabricated for this program are illustrated in Figures 1 through 6 and are listed below:

Configuration "A":	Single Splice Butt Joint - Bonded
Configuration "B":	Boron to Metal Stepped Single Scarf Joint
Configuration "C":	Surface to Understructure Attachment (Titanium tee) - Bonded
Configuration "D":	Double Splice Butt Joint - Bonded
Configuration "E":	Single Splice Butt Joint - Bolted
Configuration "F":	Surface to Understructure Attachment (aluminum tee) - Mechanical

All Phase I specimens were 1" wide as illustrated in Figures 1 through 6. These 1" wide specimens constituted the major portion of the program. Intermediate width specimens (2" or 3" wide) were investigated in Phase II,and large scale joints were investigated in Phase III, as indicated below:

TABLE I - SPECIMEN WIDTHS

Configuration	Phase I	Phase II	Phase III
"A"	1"	3"	10"
"B"	1"	3"	10"
"C"	1"	--	--
"D"	1"	--	--
"E"	1"	2"	--
"F"	1"	--	--



Size: Approx. 18" X 1" width (Phase I, illustrated)

<u>ADHEREND/SPLICE PLATE/ADHEREND</u>

Boron/Titanium/Boron

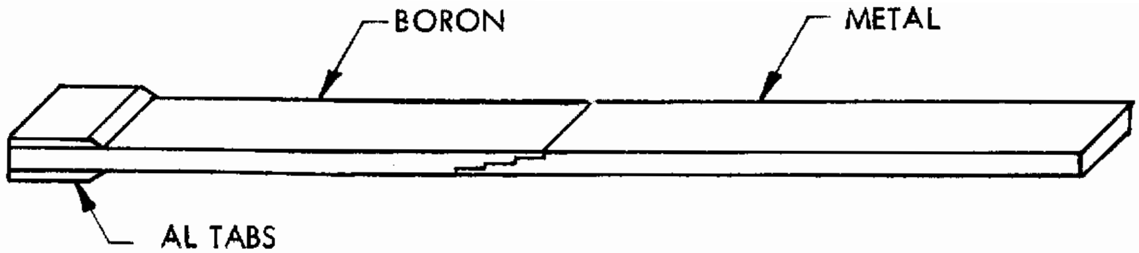
Boron/Boron/Boron

Boron/Aluminum/Boron

Graphite/Titanium/Graphite

Glass/Titanium/Glass

FIGURE 1 - CONFIGURATION "A" SINGLE SPLICE BUTT JOINT - BONDED



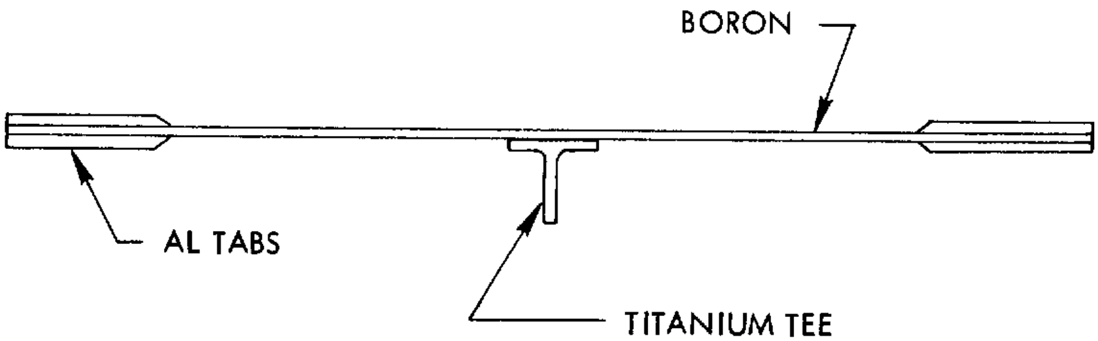
Size: Approx. 18" X 1" width (Phase I, illustrated)

<u>BORON</u>/<u>METAL</u>

Boron/Titanium

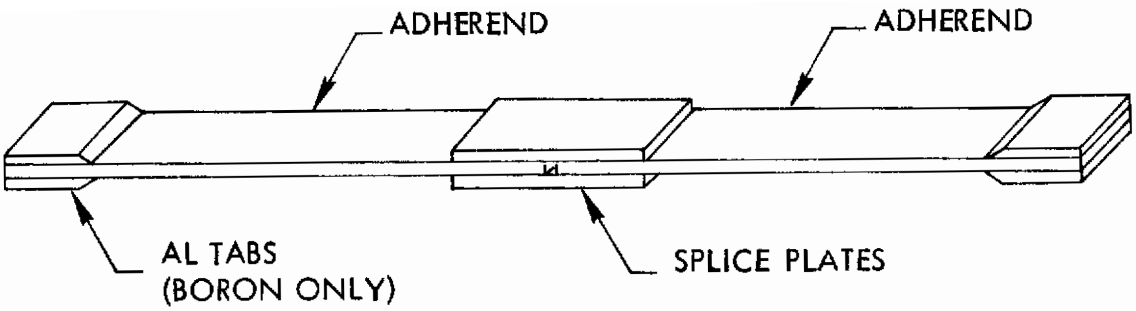
Boron/Aluminum

FIGURE 2 - CONFIGURATION "B" BORON TO METAL STEPPED SINGLE SCARF JOINT



Size: 18" X 1"

FIGURE 3 - CONFIGURATION "C" SURFACE TO UNDERSTRUCTURE ATTACHMENT-BONDED



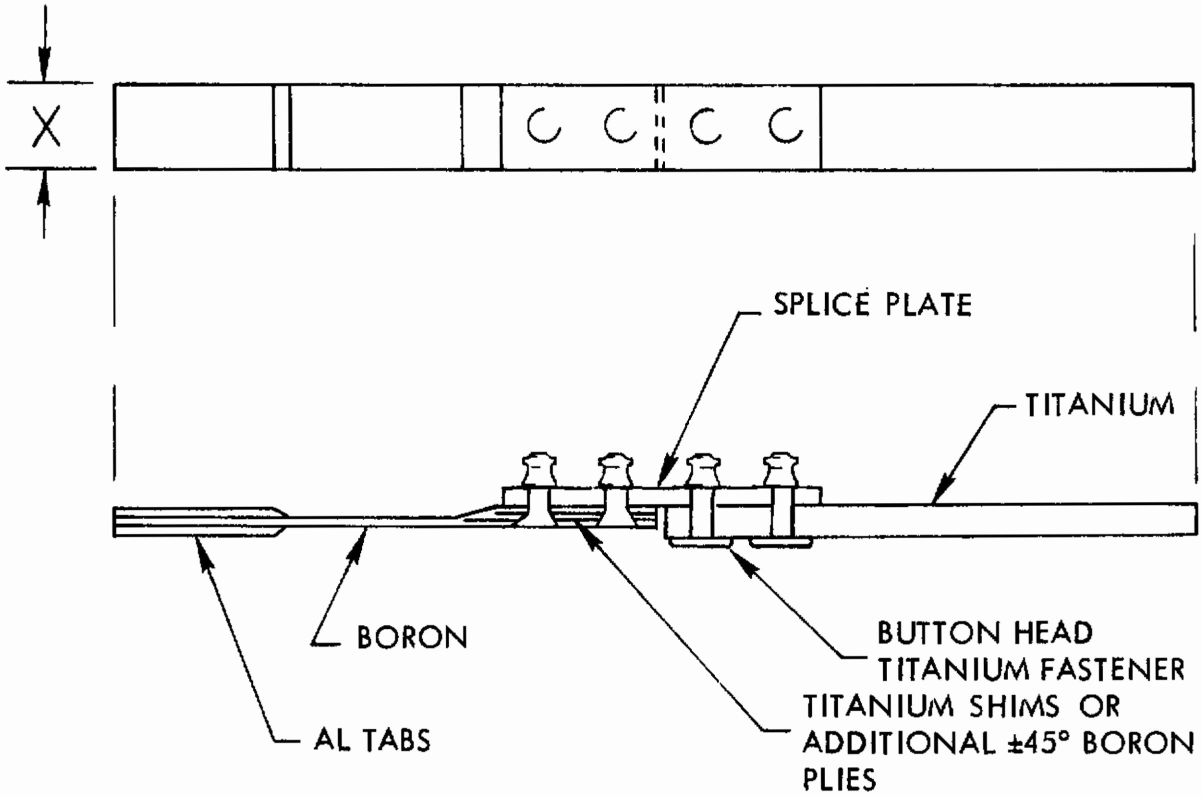
Size: Approx. 18" X 1"

ADHEREND/SPLICE PLATES/ADHEREND

Boron/Titanium/Boron

Titanium/Boron/Titanium

FIGURE 4 - CONFIGURATION "D" DOUBLE SPLICE BUTT JOINT - BONDED



Size: Approx. 18" X 1" width (Phase I, illustrated)

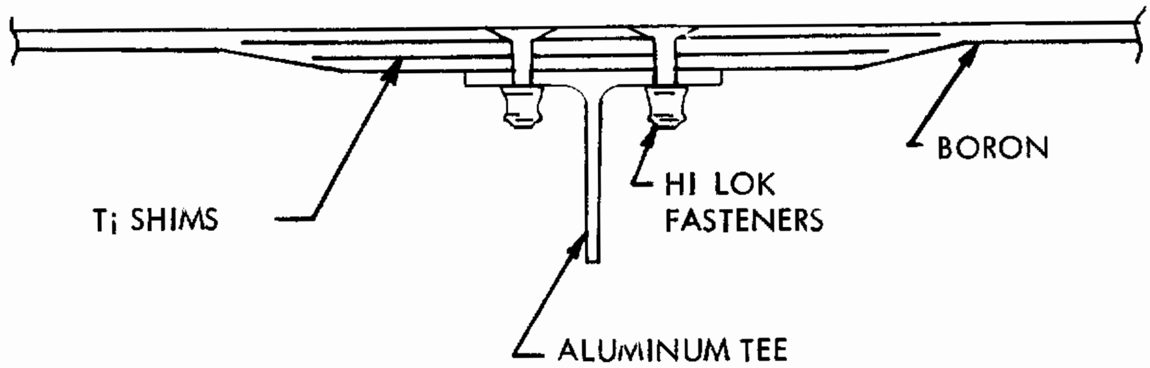
<u>ADHEREND/SPLICE/ADHEREND</u>

Boron + Ti shim buildup/Boron + Ti shim/Titanium

Boron + Ti shim buildup/Titanium/Titanium

Boron + Boron ± 45° buildup/Titanium/Titanium

FIGURE 5 - CONFIGURATION "E" SINGLE SPLICE BUTT JOINT - BOLTED



Size: 18" X 1" width

FIGURE 6 - CONFIGURATION "F" SURFACE TO UNDERSTRUCTURE ATTACHMENT - MECHANICAL

Approximately 75% of the specimens represented bonded joints; the remainder represented mechanical joints.

Material combinations across joints are listed in the appropriate figure. All bonded joints were bonded with Hysol EA 9601 adhesive previously designated Shell EPON 9601, except for some IA specimens which were used to evaluate a second adhesive, Narmco Metlbond 329. Where splice plates were used, the material of the splice plate is the second member of the triplet. For increased bearing strength, titanium shims (.012" thick Ti-6A1-4V annealed) or additional boron plies ($\pm 45^\circ$ orientation) were interleaved between boron plies of the basic laminates in the mechanical joint specimens.

"Boron", as used in Figure 1 and elsewhere, refers to boron-epoxy laminate fabricated from Narmco 5505 boron-epoxy prepreg 3" wide tape with glass fabric carrier. This prepreg contains nominal 0.004 inch diameter filaments collimated to 212 ± 4 filaments per inch. The matrix resin is a 350°F curing epoxy. Laminates cure to nominal 0.0054 inches per ply and contain approximately 50 volume percent boron filament in the cured condition. Ply orientations of $0^\circ/\pm 45^\circ$ or $0^\circ/90^\circ$ were used for bonded specimens. All bolted specimens used laminates of ply orientation $0^\circ \pm 45^\circ$, except for some unidirectional laminate specimens used for the Baseline Data Task.

The titanium alloy used throughout this program, including bearing reinforcement shims, was all Ti-6-Al-4V alloy with two exceptions. The extruded titanium tees for Configuration "C" was Ti-6Al-6V-2Sn alloy. The titanium splice plates and load plates of the Configuration "E" specimens was Ti-8Al-1Mo-1V alloy.

The aluminum splice plates (Configuration "A") and aluminum adherends (Configuration "B") were aluminum alloy 7075-T6. Extruded aluminum tees (Configuration "F") were also 7075 alloy.

Fiberglass and graphite laminates were fabricated and used for Configuration "A" specimens in the Alternate Adherend Evaluation Task. The fiberglass laminate was fabricated using 3M 1002 S glass prepreg tape. The same ply orientation, $0^\circ \pm 45^\circ$, was used as for the baseline boron specimens.

Graphite laminates were fabricated using Fiberite Hy E 131 1B graphite/epoxy tape. Graphite laminates were also balanced 8-ply 0° ±45° orientations.

2.1.2 Citation of Detailed Specification Drawings

Detailed dimensions, tolerances, and references to materials and process standards are presented in the Drawings No. 7226-13021A through 7226-13021F which appear in Appendix C.

2.1.3 Citation of Program Test Plan and Specimen Identification Charts

Tables V through X of Section 4.1, TEST PROCEDURES - GENERAL, list the quantities of specimens fabricated and tested for each major Configuration ("A", "B", "C", etc.).

These tables also provide a breakdown of the specimen quantities per Phase (width) and Program Task (Baseline Data, Thickness Effects, etc.),as well as materials combinations (Adherend Combinations for bonded joints or Joint Elements for mechanically fastened joints) and variations in subconfigurations (ply orientations, titanium shims versus added boron plies, etc.).

A guide to the specimen identification system is also presented in Section 4.1.

2.1.4 Citation of Fabrication and Inspection Logs

Fabrication and inspection details for all laminate panels and joint specimens are summarized in the log sheets of Appendix A.

2.1.5 Highlights of Lessons Learned in Fabrication

Fiberglass peel plies, Narmco 1581/2054, were used to prepare the adhesive bonding surfaces on boron laminates panels for Configuration "A", "C", "D" bonded joint specimens. Early attempts to sand the bonding surfaces, in an attempt to obtain more uniform bondline thicknesses, caused wide variations in bond joint strength. The more reliable peel ply surface preparation resulted in bondline thicknesses generally in the range 0.004 to 0.006 inch.

A floating 0.020 inch Teflon gap spacer plate was used to control the gap at the butt joint in Configuration "A" specimens. See Figure 9, item 7.

Chemical milling of the steps in the metallic adherends for the Configuration "B" scarf joint was required because of warpage encountered when mechanical milling was used.

Holes for fasteners were drilled in boron/boron assemblies using a diamond core drill. For boron/titanium assemblies an end mill was used for the titanium plate. Good back-up of boron laminates was required to prevent breakout on the back side of the hole. Holes in boron laminates were countersunk using a diamond tool.

Hi-Lok fasteners were wet installed and torqued to 30±1 inch-pounds. After 30 minutes fasteners were re-torqued to the same load to account for any relaxation due to squeeze-out of sealant from the faying surfaces.

2.2 BASIC LAMINATE PANEL FABRICATION

All panels from which material verification and acceptance specimens, basic program joint test specimens, and quality control coupons were constructed, were fabricated in essentially the same manner except for the Configuration B step-lap joint specimens. For these specimens, the laminate and joint fabrication was accomplished by the co-curing process.

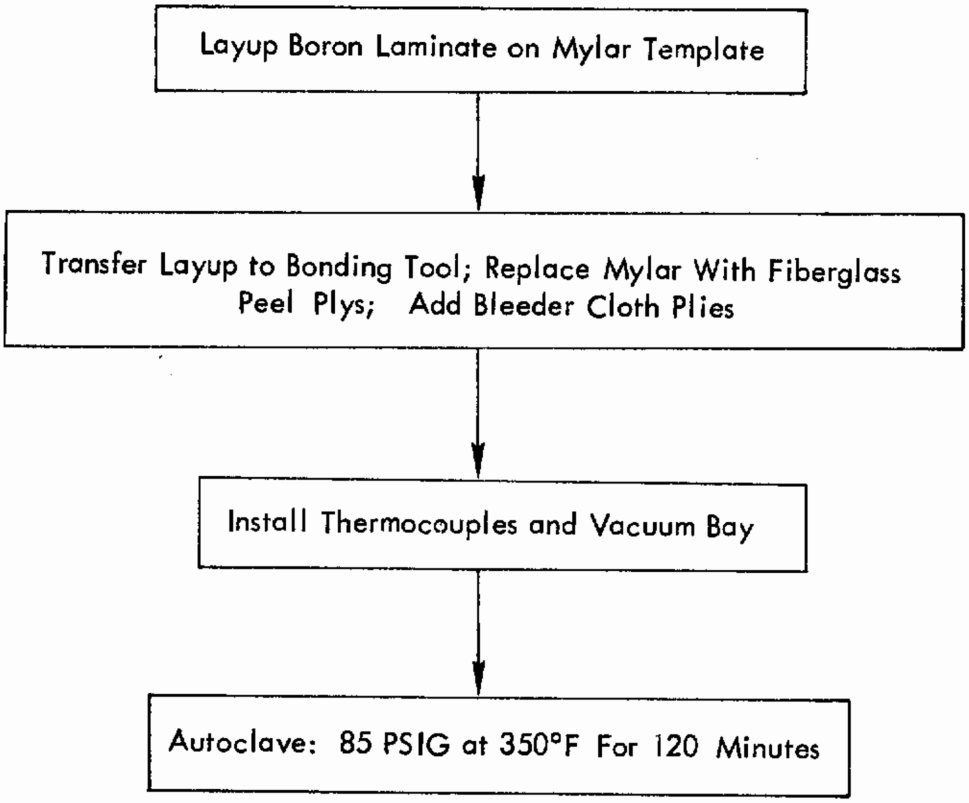


FIGURE 7 - STEP CHART FOR BASIC LAMINATE FABRICATION

The boron/epoxy laminates were fabricated using the following steps and procedures:

1. A template is prepared using 0.005" thick Mylar film. The panel dimensions are established by the number of specimens required from each panel. Panels are made slightly oversize to allow for panel trim and specimen machining. The largest panel fabricated was 36" X 56". Ninety-nine specimens one inch wide were cut from this panel.

2. The boron laminate is laid up using Narmco boron/5505 tape in accordance with the orientation and ply stacking for the given configuration. On the first ply, the scrim side of the tape is placed against the Mylar template. The final ply lay-up on the laminate is a layer of Narmco 104/2054 scrim.

   a. The tape is visually inspected during lay-up to assure that the procedure has been carried out within the laminate specifications, i.e., 0.030" maximum gap, no overlapping of plies, no crossed filaments, etc.

   b. Quality control specimens (used for determining the mechanical properties of the tape used in the lay-up) include a 15-ply, 3" X 6" flexural test coupon panel and a 6" X 9" cross-ply laminate (0°/±45° or 0°/90°) for tensile testing as an optional control specimen.

3. The bonding tool is prepared by placing, on the tool surface, a sheet of Mylar the same size as the panel and covering it with Teflon-coated, 108 glass cloth.

4. The Mylar template is removed from the laminate and a fiberglass peel ply, Narmco 1581/2054, is applied to each surface of the laminate. The laminate is placed on the tool surface over the Mylar and Teflon coated glass cloth.

   NOTE: The application of the peel plies is omitted for panels which are not to be used for subsequent joint fabrication.

5. Dams are prepared by shearing aluminum strips 1" wide, and covering them with Teflon masking tape, these are then located adjacent to the laminate, and taped to the tool surface.

   a. Dam thickness is calculated by multiplying the number of boron plies by 5.25 mils/ply, adding 0.008" for each peel ply, 0.003" for the Mylar, 0.003" for the Teflon coated glass, and 0.004" for each ply of 116 glass cloth used in the bleeder.

6. The resin bleeder system is placed over the laminate.

   a. One ply of Teflon coated 108 glass cloth is trimmed net to the inside of the dam, and placed over the laminate.

   b. The required layers of 116 glass cloth bleeder are trimmed to the inside of the dam and placed over the Teflon coated glass cloth. One ply of bleeder cloth is used for each 10 plies of laminate. One ply of bleeder is added for each two plies of peel ply prepreg used.

   c. The bleeder system is covered with 0.003" Mylar (cut net to middle of the dam). This cover is taped to the top of the dam and slit on approximately 20" centers with 1/8" long slits as a minimum, one slit is made at each corner of the panel.

7. The quality control specimens are located adjacent to the laminate on the tool, using the damming and bleeding procedure outlined in Steps 5 and 6, above.

8. Four thermocouples are on the installed tool adjacent to the dam and evenly spaced around the panel or panels.

9. The assembly is covered with two layers of 181 glass cloth. A chain is used to surround the assembly and provide air passage from the lay-up to the tool exhaust port. Extra 181 glass cloth is placed over the chain to

protect the bag during the curing cycle. The 181 glass cloth is then taped to the tool using high temperature masking tape.

10. High temperature, vacuum bag sealer compound tape is installed around the tool periphery outside the 181 glass cloth. Care is taken to be certain that no loose glass fibers are on or under the tape.

    NOTE: The thermocouple wires are stripped of insulation, separated and placed on the sealer tape; additional sealer tape is placed over the wires and pressed to assure no leakage around the wires. Care is taken to be sure that the bared wires are not grounded against the tool surface.

11. The backing paper from the sealer compound tape is removed and the whole lay-up is covered with 0.002" nylon vacuum bag film for 375°F autoclave service.

12. Vacuum is applied to the tool vacuum port and the sealed bag is checked for leaks. The tool with the laminate assembly is installed in autoclave and rechecked for leaks.

13. Autoclave pressure is applied to 10 psig, and the vacuum is released. Autoclave pressure is held at 10 psig for 10 minutes to allow the bag to stabilize at atmospheric pressure, and is then increased to 85 psig.

14. The heating cycle was initially set at heat-up rate of 7°F/minute $\pm$2°F/minute. However, the Narmco 5505 resin system appeared to be sensitive to heat-up rate in that the faster heat-up rates yielded more consistent and slightly higher laminate properties in terms of horizontal shear and transverse flexure. For this reason, the upper limit of 7°F to 9°F/minute has been used for the most recent laminates in this study. No noticeable change in laminate tensile or bond strengths were observed.

15. The autoclave cycle is maintained at 85 psig ±5 psig and 350°F ±10°F for 120 minutes.

16. After 120 minutes at curing temperature the part is allowed to cool to less than 150°F chile holding the pressure at 85 psig. The pressure is then released and the autoclave opened.

17. The part is removed from the autoclave, removed from the tool, and cleaned up. The peel ply is not removed from the boron panel until just prior to bonding tabs and splice plates.

18. The quality control specimens are prepared for testing. The 15 ply 0° laminate is cut into 0.50" X 4.0" specimens for longitudinal flexural testing, 3.0" x 0.50" for transverse flexural testing and 0.50" x 0.60" for horizontal shear. The 8-ply cross-ply laminate is fitted with 1.50" long fiberglass tabs of 0.080" thickness with the inboard ends beveled to 45° and tabs are bonded with FM123-2, 0.060 lb./ft.^{2} weight adhesive at 250°F and 20" vacuum. The 6" X 9" tabbed panel is then cut into 1" X 9" specimens using a diamond saw and specimens are ready for testing.

2.3 JOINT FABRICATION - CONFIGURATION A, SINGLE SPLICE BUTT, BONDED

Laminates fabricated by the procedures outlined in Section 2.2 were used for the basic adherends in the fabrication of the Configuration A specimens. These specimens are illustrated in Figure 1, which is repeated below. Individual specimens were fabricated according to the requirements of Dwg. No. 7226-1301A, Appendix C.

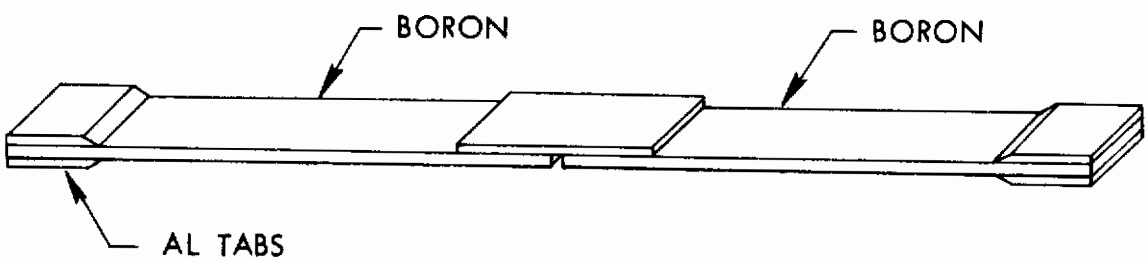


FIGURE 1 (REPEATED) - CONFIGURATION "A"
SINGLE SPLICE BUTT JOINT - BONDED

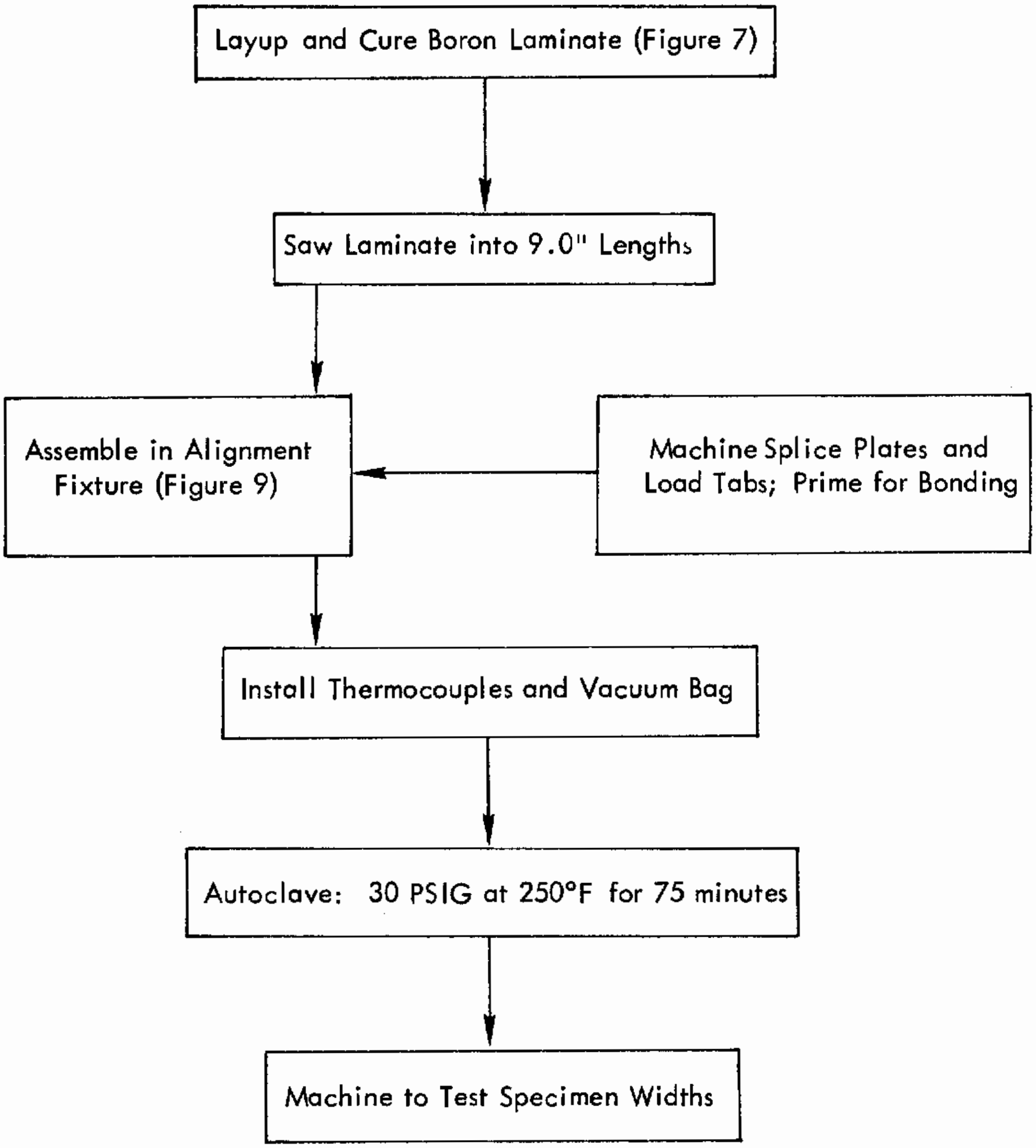


FIGURE 8 - STEP CHART FOR CONFIGURATION "A" SPECIMENS (ALSO FOR "D")

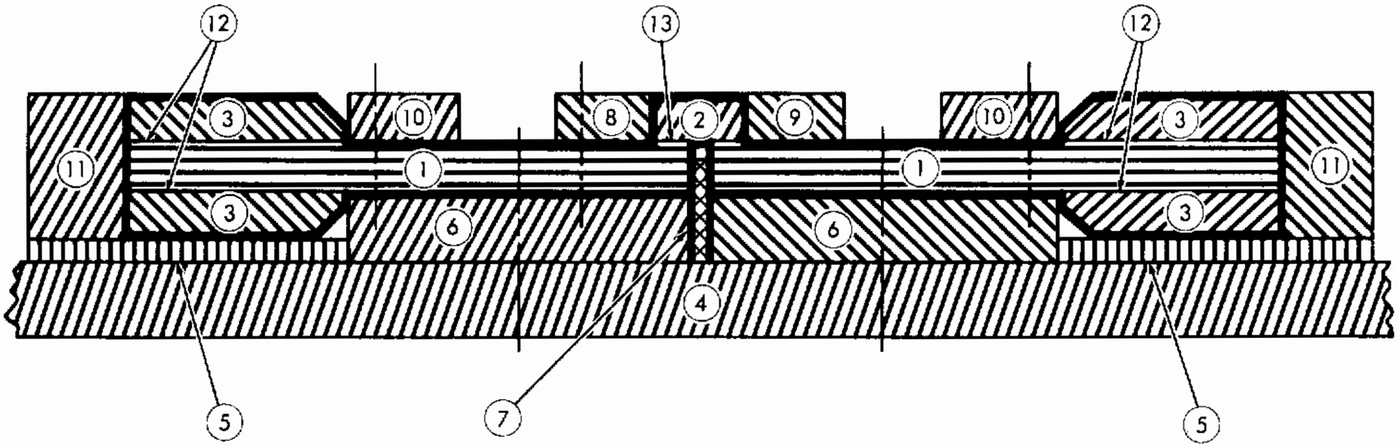
The following steps and procedures were taken to assure acceptable quality and uniformity of specimen fabrication:

1. The basic laminate is machined into 9.0" lengths (0° direction) using a diamond circular table saw normally employed for machining fiberglass panels in production. Panel widths varied from approximately 9" wide to 18" wide depending on the number of specimens to be obtained from each panel.

2. The splice plate material, either 6AL-4V annealed titanium or 7075-T6 aluminum, is machined to the thicknesses and configuration as specified on Dwg. No. 7226-13021A, Appendix C. Lengths are dictated by the panel width.

3. The load tabs are machined to the dimensions specified on Dwg. No. 7226-13021A from 2024-T3 aluminum. The tab "blanks" have lengths equal to the basic laminate width. Test panels (fabricated using fiberglass tabs) were tested to compare results for the aluminum tabs and to verify the use of aluminum tabs in the program. Figure 9 is a schematic of the alignment fixture which holds the specimens during splice and tab bonding. In Steps 4 through 8, below, reference is made to this schematic, by parenthetical number - (X), to facilitate visualization of the layup sequence.

4. The base plate (4) is placed on the metal bond fixture and the centering plates (6) are positioned on the locating pins, with the floating Teflon gap spacer plate (7) placed at the butt ends of the centering plates.



CODE

1 - BORON LAMINATE ADHEREND
2 - SPLICE PLATE
3 - ALUMINUM TAB
4 - BASE PLATE
5 - SHIMS
6 - CENTERING PLATES
7 - 0.020 GAP SPACER - FLOATING
8 - FIXED SPLICE PLATE LOCATOR
9 - FLOATING SPLICE PLATE LOCATOR
10 - TAB LOCATOR
11 - DAM
12 - TAB ADHESIVE
13 - SPLICE ADHESIVE

FIGURE 9 - ALIGNMENT FIXTURE FOR HOLDING SPECIMENS FOR SPLICE AND TAB BOND

5. The lower aluminum tabs (3) are butted against the centering plates with shims (5) placed under the tabs to level the tabs with the top of the centering plates. The tabs are cleaned, metal bond etched and primed for bonding prior to installation (clean glove operation). The AF123-2, 0.06 lb/ft^2 wt. adhesive (12) is laid on the faying surface of the tabs.

6. The laminates (1) with the peel plies removed* (clean glove operation) and the matching machined ends are positioned on top of the taps and centering plates. Dams (11) are installed at the outboard ends of the laminates adherend and held in position with locating pins.

*NOTE: The original group of specimens was prepared by sanding the bonding surfaces rather thqn using peel ply surfaces in attempt to obtain more uniform bondline thickness. This caused a wide variation in bond joint strength and was replaced with the more reliable peel ply surface preparation.

7. The upper aluminum tabs (3) are then prepared for bonding and the adhesive applied. They are placed in position butting the dam and the tab locators (10) are then positioned on the opposite ends of the tab and pinned in place.

8. The splice plate (2) is chemically prepared for bonding, primed, and adhesive (13), EA9601 0.06 lb./ft^2 wt., applied to the faying surface. The fixed splice plate locator (8) is pinned in place and the splice plate butted against it. The floating splice plate locator (9) is positioned on the opposite end of the splice plate.

9. Thermocouples are installed on the base plate adjacent to the part. Figure 10 shows a layup of three 12" X 18" bonded panel assemblies after installation of thermocouples just prior to initiating the bagging operation.

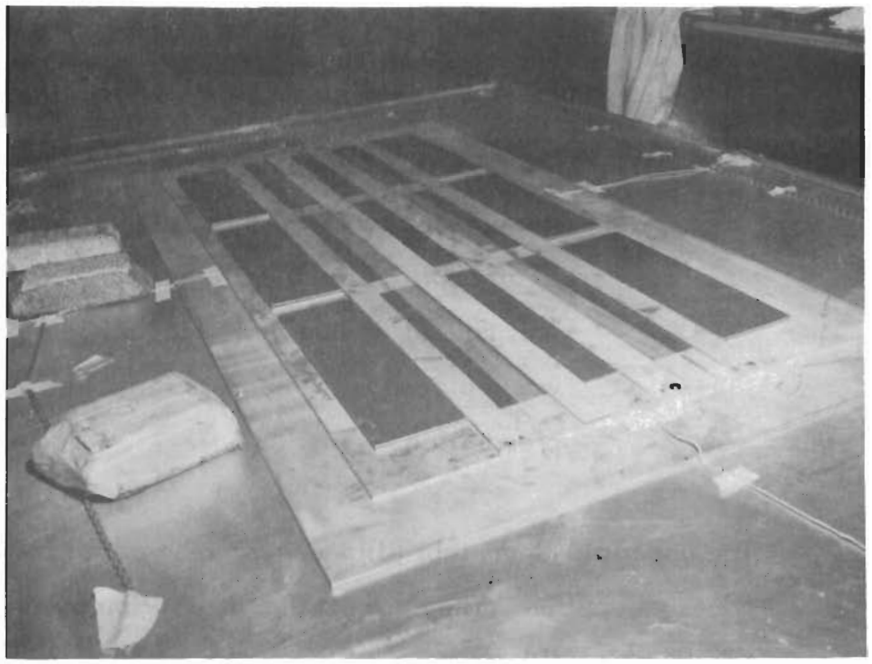


FIGURE 10 LAYUP OF THREE 12" x 18" BONDED PANEL ASSEMBLIES

10. The assembly is bagged by laying two plies of 181 glass cloth bleeder over the part. The chain is used to distribute the air bleed from all portions of the layup to the tool exhaust port. The glass cloth bleeder extends past the chain and is taped to the tool surface. The remainder of the bagging procedure is described in Steps 10 and 11 of Section 2.2.

11. The bagged assembly is then checked for leaks using 10" Hg vacuum. The assembly is installed in the autoclave and again vacuum is released, and the bag is allowed to stabilize at atmospheric pressure for 10 minutes. The pressure is then increased to 30 psig and the heat cycle started. The temperature is increased at a rate of 7°/minute ±2°/minute until the temperature reaches 250°F. The assembly is held at 30 psig ±2 psig and 250°F ±10°F from 60 to 90 minutes (75 minutes nominal). The part is allowed to cool down to 150°F under the 30 psig autoclave pressure. The pressure is then released and the autoclave opened.

12. The assembly is removed from the autoclave and the bonded panels removed from the tool, cleaned, visually inspected, and machined to the test specimen width dimension.

13. Quality control check of the bonding operation is accomplished including metal finger panels which have been processed and primed along with the metal splice plates or adherends and laid up with the same adhesive batch and rool number as used for bonding the assembly. After bonding, these test coupons are tested to determine the lap shear properties of the adhesive system.

14. For machining, the panels are mounted on the table of a milling machine with the 0° fiber orientation lined up with the table axis. The slitting wheel is a 6" diameter by 0.032" thick wheel impregnated with 80-grit diamonds on the wheel periphery. The wheel is rotated at 1750 rpm. The table speed is set for 9"/minute when cutting boron, aluminum, or fiber-

glass and at 2"/minute for cutting titanium. The panel is kept flooded with water coolant during the slitting operation. The panel edge is trimmed 0.25" and the specimens are cut 1.00" wide by indexing the table 1.04" between cuts.

15. After machining, the specimens are checked for lipover of the splice plate which may obscure the bondline. By machining from the boron into the titanium, the lipover is not as pronounced, but some lipover is evidenced on all specimens, probably due to the wiping action of the trailing edge of the blade going in the reverse direction. In order to accomplish bondling measurements (as discussed in the Technical Inspection section), it is necessary to remove all lipover of the titanium. This is done by mounting the specimen on a surface grinder and taking light cuts with the wheel along the edge of the specimen.

16. The specimens are identified with the drawing number and specimen number and a data sheet is prepared (Appendix A) with pertinent information on the fabrication of the specimen.

2.3.1 Phase II Fabrication - Configuration A

All 3" wide Configuration "A" specimens were prepared in a manner identical to that used for preparing the Phase I, Configuration "A" specimens, except for differences in final machined width. A typical specimen is shown in Figure 11.

2.3.2 Phase III Fabrication - Configuration A

The Phase III Configuration A specimens (10 inch wide single splice butt joint) were fabricated using the procedures developed under Phase I of this program. Bonded panels were fabricated 12 inches wide and 18 inches long. This size panel provided allowances for edge trim, a one inch wide control specimen and the required 10 inch wide Phase II specimen. A set of these specimens machined from one panel is shown in Figure 12.

Due to the width of this specimen, provisions had to be made for introducing end loads through bolted loading plates. For this purpose the tab configuration was changed from the basic constant thickness, 3-1/2" long aluminum tab to a stepped titanium tab. The stepped tab was fabricated by bonding an 0.018" titanium (8A1-1Mo-1V) sheet 3.5" wide, an 0.018" sheet 3" wide and an 0.035" sheet 2.5" wide such that the outboard edges of all three sheets were flush and the inboard end was stepped at 0.5" intervals. The titanium sheets were processed for bonding, primed and bonded together with FM123-4, .045 psf at 30 psig and 250°F to form a single prebonded tab. These tabs were then bonded to the ends of the specimens with the same adhesive system using 25" Hg vacuum and 225°F for two hours. These stepped loading tabs can readily be defined in Figure 12.

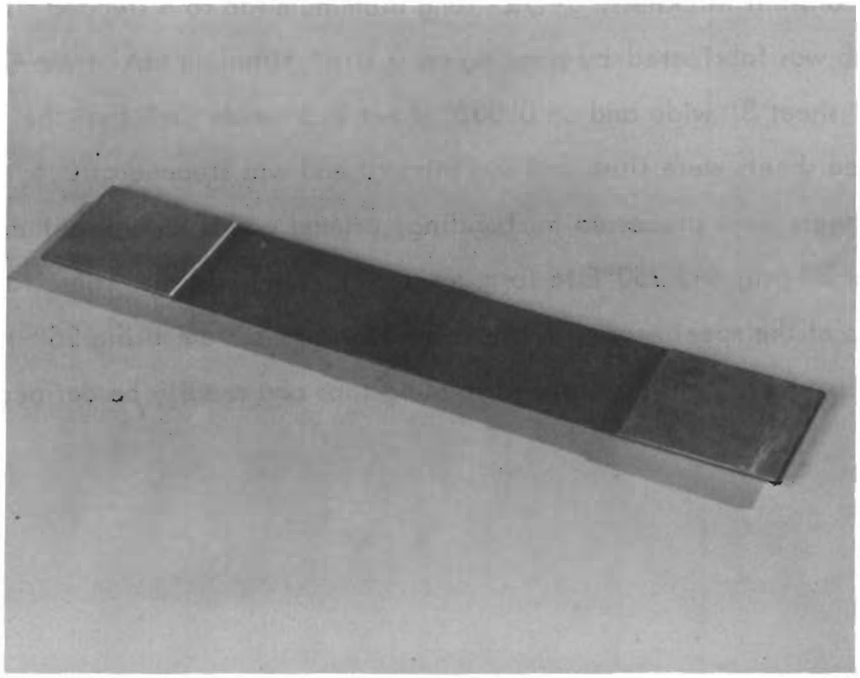


FIGURE 11 THREE INCH WIDE CONFIGURATION A SPECIMEN

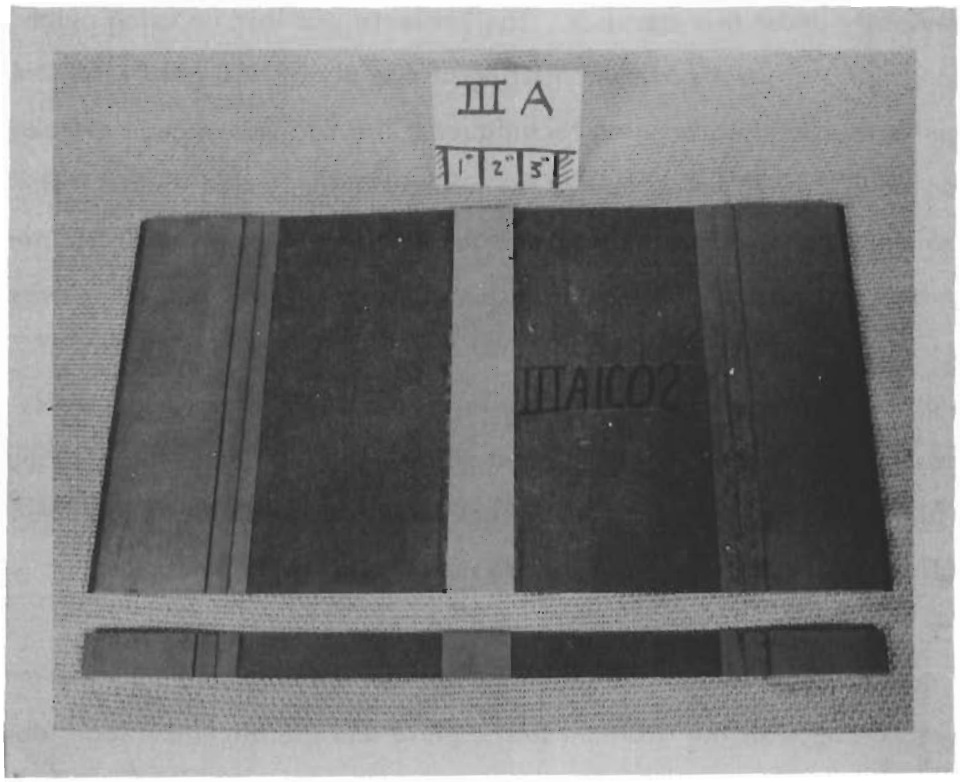


FIGURE 12 PHASE III CONFIGURATION A -
SINGLE SPLICE BUTT JOINT

2.3.3 Alternate Adherend Evaluation - Configuration A Fiberglass Specimens

The fiberglass laminate required for these specimens was fabricated using 3M 1002 S glass prepreg tape (Batch L19, Roll W329). The laminate was a basic 8 ply $(0°/\pm 45°/0°)_2$ orientation, the same ply orientation as the baseline boron specimens, Dwg No. 7226-13021A-1A. The lay-up techniques were comparable to those used for the boron panels fabricated previously under this contract. The laminate was laid up using nylon peel ply on both surfaces and a bleeder system consisting of one ply of 116 glass cloth. The assembly was bagged using standard bagging techniques. The bag was vacuum checked at 28" Hg vacuum for leaks prior to being sent to the autoclave for laminate cure. The autoclave run consisted of the normal vacuum check and the dwell at 10 psig for 10 minutes for stabilization after the vacuum was released prior to increasing the autoclave pressure to 50 psig. After stabilizing the autoclave pressure to 50 psig, a heat up rate of 7°/minute ±2°/minute was used in bringing the laminate up to the 350°F cure temperature. The part was held at this temperature and pressure for a minimum of one hour and then cooled to 150°F under full 50 psig pressure. Quality control specimens of 15 ply unidirectional laminates for flexural testing were laid up and cured with the laminate.

After quality control acceptance, the laminate was machined into two panels 9" X 15". These two panels along with the titanium splice plate and the aluminum load tabs were then prepared for bonding. The peel ply was removed from the fiberglass panel and the faying surfaces were sanded and cleaned before application of adhesive. The metal elements were cleaned and primed in the same manner as used previously for the boron specimens. Adhesive was applied to all surfaces requiring a bond and the assembly was laid up and bonded in the standard autoclave procedure used for previous Configuration A specimens. All bond lines used EA9601, 0.06 lb./ft^2 weight, adhesive cured at 250°F for one hour under 30 psig autoclave pressure.

After bonding, this panel was machined into 1" widths, thus providing 14 fiberglass-to-titanium Configuration A specimens. All specimens were then submitted for inspection and testing.

2.3.4 Alternate Adherend Evaluation - Configuration A Graphite Specimens

The graphite laminate required for these specimens was fabricated using Fiberite Hy E 1311B graphite/epoxy tape (Lot No. 1088, Roll No. 1). The laminate was laid up as an 8 ply, 0°/±45° balanced lay-up identical to that used for the baseline boron/epoxy bonded joint specimens. Lay-up procedures and bagging techniques were the same as previously used on boron and fiberglass laminate. Two plies of 116 fiberglass cloth were used as the bleeder system. Nylon peel plies were incorporated on all bonding surfaces. The standard vacuum bag was used over the laminate and was checked for leaks at 28" Hg vacuum. The autoclave cycles used to cure the graphite epoxy was recommended by the supplier and is outlined below:

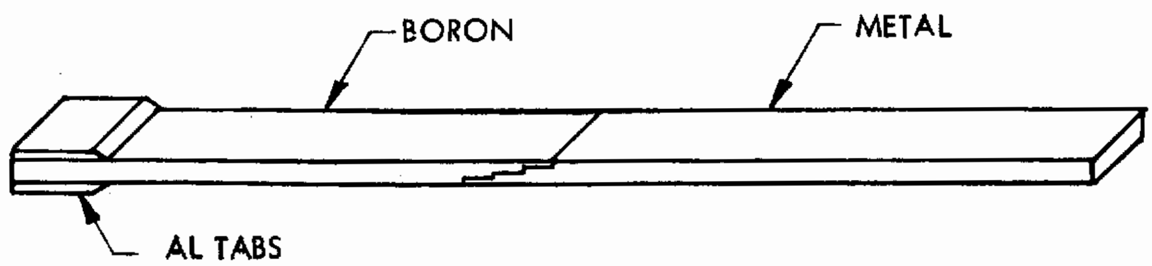
1. Apply vacuum of 28" Hg and recheck for leaks.
2. Hold vacuum and increase temperature to 200°F at a rate of 3-5° per minute.
3. Hold at vacuum and 200°F for 15 minutes.
4. Release vacuum and increase autoclave pressure to 85 psig.
5. Hold at 85 psig and 200°F for 60 minutes.
6. Increase temperature to 300°F at 3-5° F per minute and hold at 300°F for 60 minutes.
7. Increase temperature to 375°F at 3-5°F per minute.
8. Hold at 375°F and 85 psig for 240 minutes.
9. Cool to 150°F under 85 psig.

A 15-ply unidirectional quality control panel was laid up and cured with the laminate for subsequent acceptance testing. After quality control acceptance the laminate was machined into two panels 9" X 15". These two panels, the titanium splice plate, and the aluminum load tabs were prepared for bonding. Preparation for bonding and bonding procedures were the same as used for the fiberglass panel. As with previous specimens the adhesive used was EA 9601 0.06 lb./ft.^{2} weight which was cured at 250°F for one hour under 30 psig autoclave pressure.

After bonding, the panel was machined into 1" widths, thus providing 14 graphite-to-titanium Configuration A specimens. All specimens were then submitted for inspection and testing.

2.4 JOINT FABRICATION - CONFIGURATION B, BORON TO METAL STEPPED SINGLE SCARF

The Configuration B specimens were fabricated utilizing the co-curing process, i.e., curing the laminate and bonding to the metal adherend during one operation. These specimens are illustrated in Figure 2 which is repeated below. Individual specimens were fabricated according to the requirements of Dwg. No. 7226-13021B, Appendix C.



Size: Approx. 18" X 1" width (Phase I, illustrated)

FIGURE 2 - CONFIGURATION "B"
BORON TO METAL STEPPED SINGLE SCARF JOINT

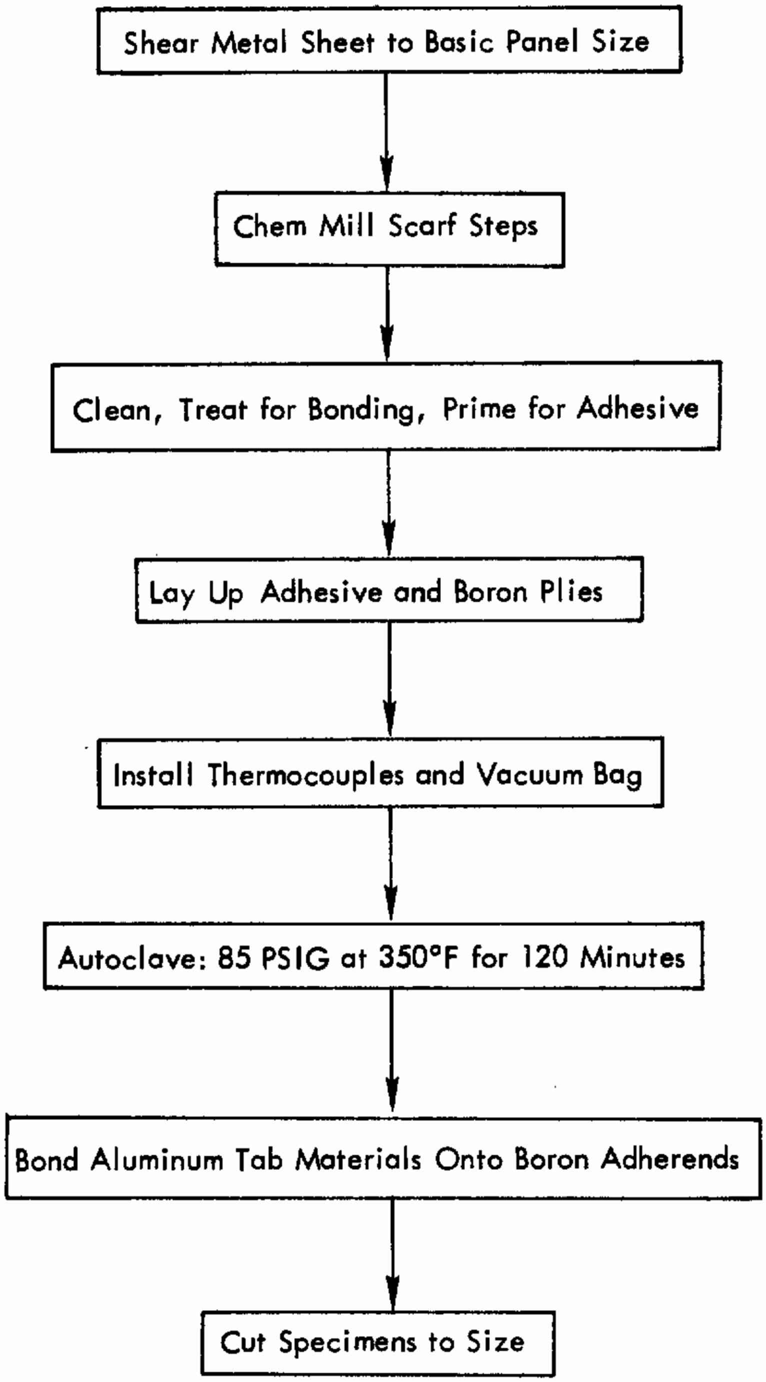


FIGURE 13 - STEP CHART FOR CONFIGURATION "B" SPECIMENS

The steps and procedures followed to produce good quality joints by this process are listed below:

1. The titanium (6Al-4V annealed) and aluminum (7075-T6) are sheared from 0.084" thick sheet into basic panel size per Dwg. No. 7226-13021B, Appendix C.

2. Due to the warpage generated in mechanically milling the steps on the metallic adherends, the steps are milled chemically. The metal is masked and the steps are generated by raising the metal sheet the required height for the step length after the material from the first step has been removed. Each of the three steps are milled in this fashion. A trim allowance was left on the final step so that it could be cleaned up by machining off the ragged edge generated in the chem-milling process. A radius was left in the corners of the steps varying from 0.010" to 0.030' for the first to the last step, respectively. The chem-milling was held within the ±0.002" specified on the drawing.

3. After machining, the chem-milled panels are recleaned, chemically treated for bonding, and primed with the adhesive primer.

4. The adhesive, EA9601, 0.045 lb/ft^2 weight, is laid up on the steps of the joint. The metal adherend is placed on the tool with a sheet of Mylar film and Teflon-coated glass between the part and the tool surface. Four plies of boron are laid up butting the edge of the first step. Four additional plies are laid up over the first step and butting the end of the second step. This layup is continued with four plies of boron per step until all steps were covered. The orientation of the laminate is specified on Dwg. No. 7226-13021B.

5. The bagging and curing procedures of these panels are identical to those described for the basic laminate fabrication (Section 2.2, Step 5 through Step 16). The metal portions of the specimens are covered with Teflon tape to prevent resin build-up during the cure cycle and the bleeder system covers only the boron laminate portion of the panel.

6. The boron adherends are tabbed with the aluminum tab materials in a secondary bonding operation.

7. The specimens are cut to size using the same techniques as described for the Configuration "A" specimens (refer to Section 2.2, Steps 14 and 15). See Figures 14 and 15.

2.4.1 Phase II Fabrication - Configuration B

Fabrication of the 3 inch wide Configuration B specimens (boron-to-metal step scarf joint) is detailed below.

The basic 6A1-4V titanium sheet (9" X 13") used for the Configuration "B" specimens was 0.084" in thickness. The titanium was chem-mill masked over all areas where the metal was not to be removed. The nominal basic steps that were chem-milled are 0.020" in depth with step lengths of 0.500" and 0.375". The protective mask was removed in incremental steps as required to obtain the three required step lengths and depths. The specimen was checked periodically during the chem-milling process to verify proper material removal and to assure acceptable step depths.

After the chem-milling process was completed, the titanium was prepared for metal bonding. The treatment used for titanium preparation was in accordance with paragraph 6.1.6 of MIL-A-9067C. The basic steps were solvent wipe, vapor degrease, acid pickle, water rinse, phosphate/flouride immersion, water rinse, hot water soak, distilled water spray, and air dry. The areas to be bonded, i.e. the steps, were primed with EA 9201 primer immediately after completion of the titanium surface treatment. The adhesive, EA 9601-045 psf, was then applied to the faying surfaces and the boron was laid up with 16 plies, 0° ±45° orientation. The total assembly (13" X 18") was cocured at 85 psig and 350°F for 2 hours.

Similar procedures were followed in the preparation of the 7075-T6 aluminum/boron step joint specimens. The metal bond preparation for the aluminum was the normal metal bond etch followed by immediate priming with the EA 9201 primer. The boron half of the cured specimen panel was tabbed using aluminum tabs. The same procedures were used in bonding the tabs as previously described for the Configuration "A" specimens.

The cured panels were then cut into 3" wide specimens and submitted to Quality Assurance for checking the titanium/boron and aluminum/boron bond lines for both integrity and thickness. A typical specimen is shown in Figure 16.

2.4.2 Phase III Fabrication - Configuration B

The ten inch wide Phase III Configuration B specimens (boron-to-metal step scarf joint) specimens were fabricated in the same manner as discussed for the Phase II, 3-inch wide specimens. Bonded panels for these specimens were fabricated 12 inches wide thus providing sufficient width for a 10-inch wide fatigue specimen, a one inch wide control specimen and edge trim. Machined specimens are shown Figure 17.

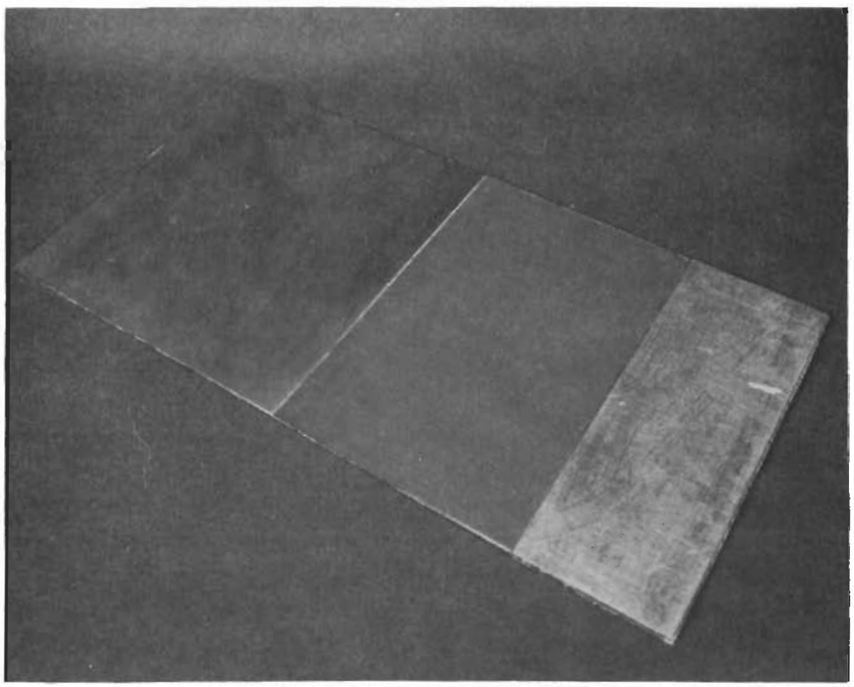


FIGURE 14 BONDED PANEL ASSEMBLY
CONFIGURATION "B" SPECIMENS

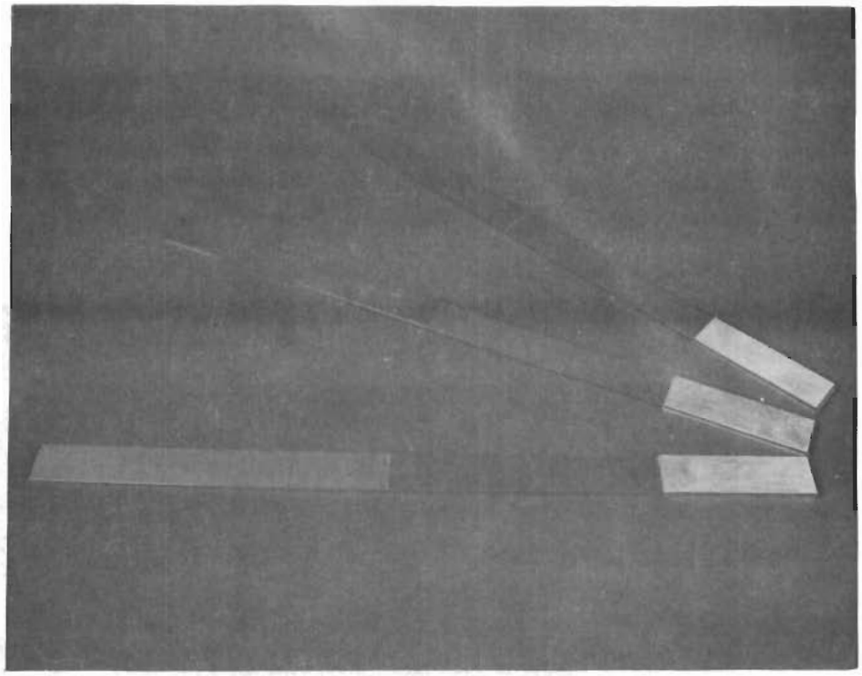


FIGURE 15 MACHINED CONFIGURATION "B" SPECIMENS

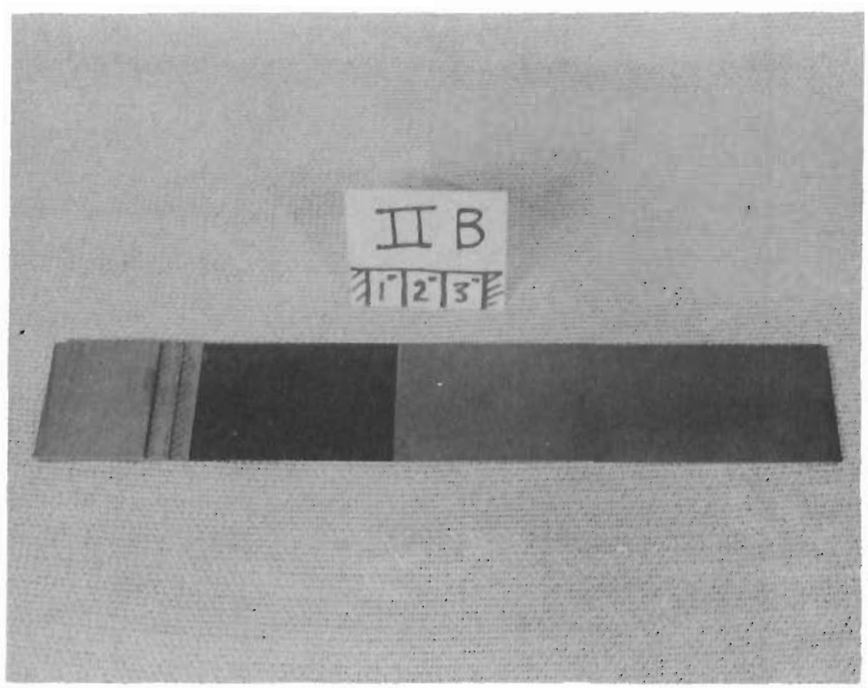


FIGURE 16 PHASE II CONFIGURATION B -
STEP SCARF BONDED JOINT

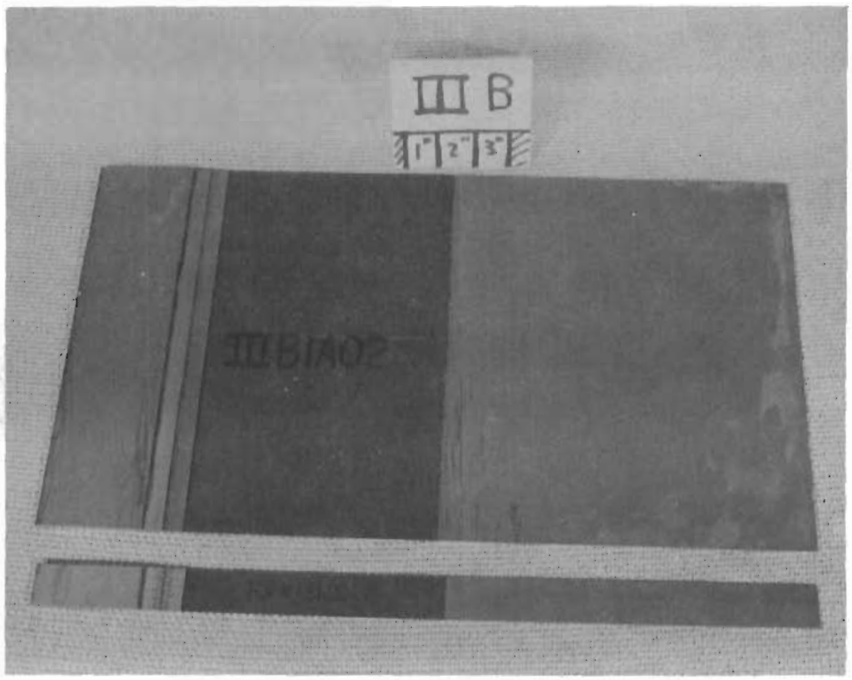
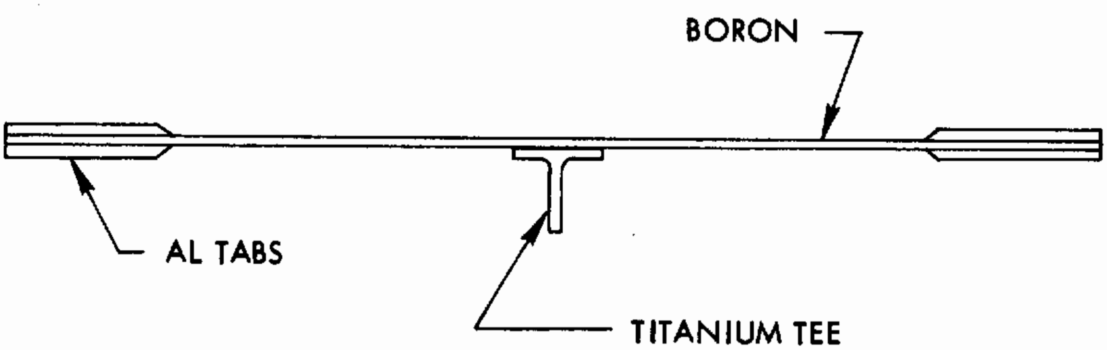


FIGURE 17 PHASE III CONFIGURATION B -
STEP SCARF BONDED JOINT

2.5 JOINT FABRICATION - CONFIGURATION C, SURFACE TO UNDERSTRUCTURE ATTACHMENT, BONDED

The Configuration C specimens were fabricated using precured laminates made as described in Section 2.2. These specimens are illustrated in Figure 3, which is repeated below. Individual specimens were fabricated according to the requirements of Dwg. No. 7226-1301C, Appendix C.



Size: 18" X 1"

FIGURE 3 - CONFIGURATION "C"
SURFACE TO UNDERSTRUCTURE ATTACHMENT - BONDED

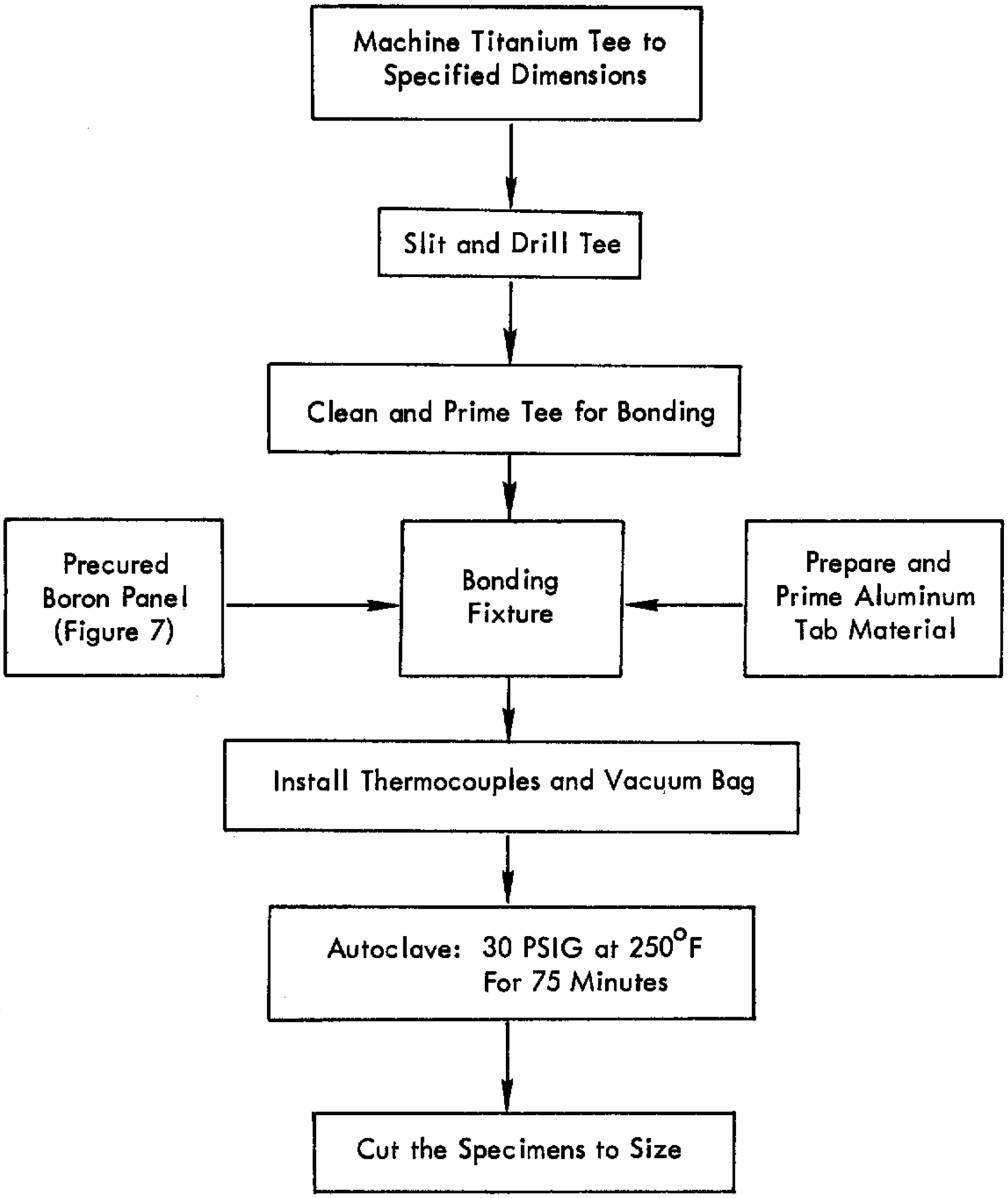


FIGURE 18 - STEP CHART FOR CONFIGURATION "C" SPECIMENS

The following steps and procedures were taken to maintain uniformity and quality of the bond joint between the metal "tee" and the boron laminate:

1. A titanium tee extrusion (6Al-6V-2Sn) is machined to the cross-sectional dimensions specified on Dwg. No. 7226-13021C (Appendix C). The tee is then slit across the leg and into the cap, allowing for the 1.00" width between cuts and leaving 0.06" on the cap for continuity. The slitting is done to minimize the machining of titanium after bonding. Holes are drilled 0.50" from the end of the leg and centered between the slits.

2. The titanium is chemically cleaned and primed for bonding.

3. The aluminum tab material is cleaned, metal bond etched, and primed for bonding.

4. The lower tabs are positioned on the bonding fixture and the AF123-2, 0.06 lb/ft^2 weight, adhesive is laid on the faying surface.

5. A precured panel with the proper ply orientation is cut the required size to produce the specified number of specimens. The peel ply is then removed from the boron panel and the panel positioned over the lower tabs.

6. The upper tabs are covered with the AF123-2, 0.06 lb/ft^2 weight, adhesive and are positioned using the pinned tab locators.

7. The primed titanium tee is prepared for bonding by applying the EA9601, 0.06 lb/ft^2 weight, adhesive to the upper cap surface which is then inverted and positioned on the boron laminate. The cap is held in place using splice plate locators and spacers to compensate for the width variation of 0.27" between the tee cap and the splice plate.

8. Conventional bagging techniques are used in bagging over the tee section. Plies of fiberglass cloth are laid up to round off the area on either side of the upstanding leg of the "tee".

9. The procedures outlined for bagging and curing the Configuration "A" specimens (Steps 9-13) are followed for this bonding operation.

10. For machining the panel into 1.00" specimens, the procedures outlined for machining Configuration "A" specimens (Steps 14 and 15) were followed. The saw cuts in the titanium are used as indexing points for cutting the laminate, tabs and the balance of the titanium tee. Since the original cut in the titanium is 0.090" wide and the diamond saw cut is 0.040" wide, the specimens are set up on a surface guider to machine the 0.025" excess off from each side of the laminate.

11. After visual inspection, the specimens are identified with the drawing number and specimen number, and a data sheet is prepared (Appendix A) with pertinent information on the fabrication of the specimen. Specimens are shown in Figures 19 and 20.

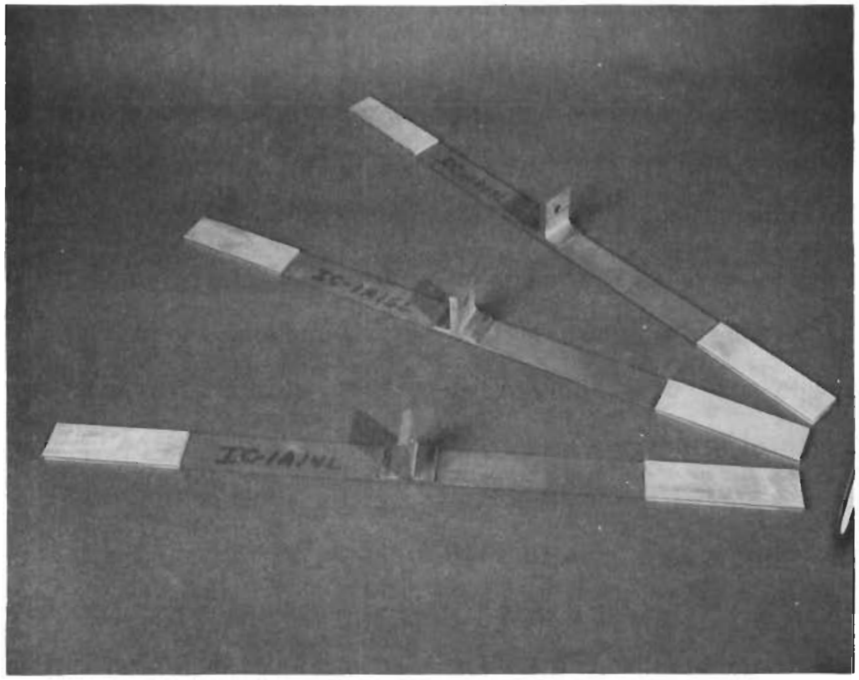


FIGURE 19 THREE CONFIGURATION "C" SPECIMENS

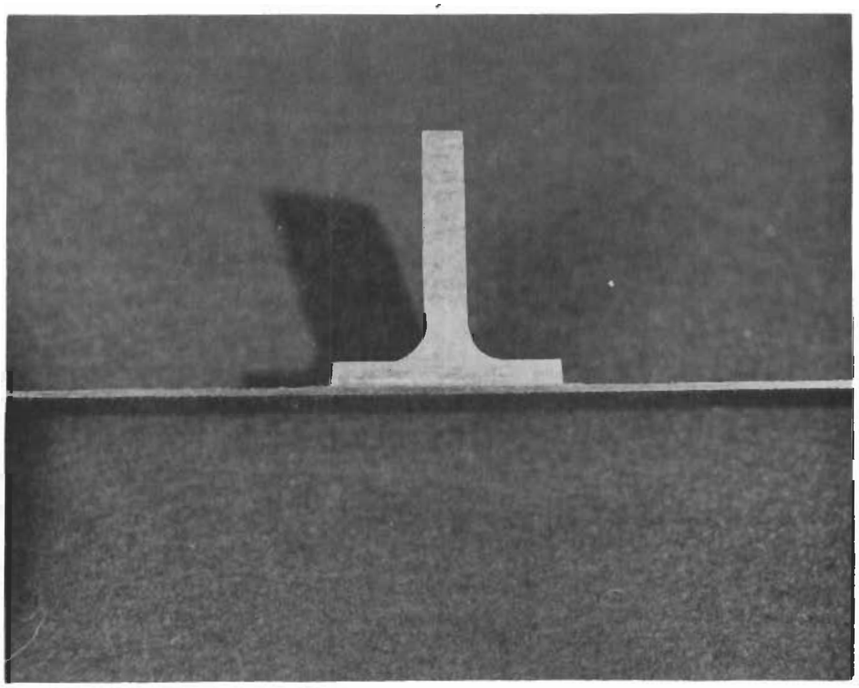
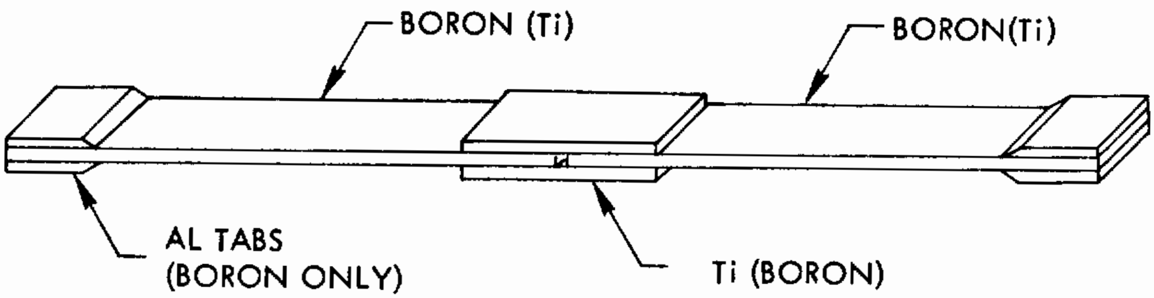


FIGURE 20 EDGE VIEW OF CONFIGURATION "C" SPECIMEN

2.6 JOINT FABRICATION - CONFIGURATION D, DOUBLE SPLICE BUTT, BONDED

Configuration "D" specimens were fabricated according to the requirements of Dwg. No. 7226-13021D, Appendix C. The same procedures were followed in fabricating the Configuration "D" specimens as were used for Configuration "A". Tooling was modified to allow for the location of the lower splice plate directly under the upper splice plate. Provisions for keeping the adhesive from flowing between the butt ends of the adherends were not made for the "D" specimens, since the presence of adhesive in this area is not deemed detrimental to the required tension-tension testing. The upper splice plate was located using the normal splice locators as discussed for Configuration "A". Configuration "D" specimens were made both with boron joined adherends (main load plates) matched with titanium splice plates, and with titanium joined adherends matched with boron splice plates. These specimens are illustrated in Figure 4, which is repeated below.



Size: Approx. 18" X 1"

FIGURE 4 - CONFIGURATION "D" DOUBLE SPLICE BUTT JOINT - BONDED

2.7 JOINT FABRICATION - CONFIGURATION E, SINGLE SPLICE BUTT, BOLTED

These specimens are illustrated in Figure 5, which is repeated below. Individual specimens were fabricated according to the requirements of Dwg. No. 7226-1301E, Appendix C.

Configuration "E" Single Splice Butt Joint - Bolted

Size: Approx. 18" X 1" width (Phase I, illustrated)

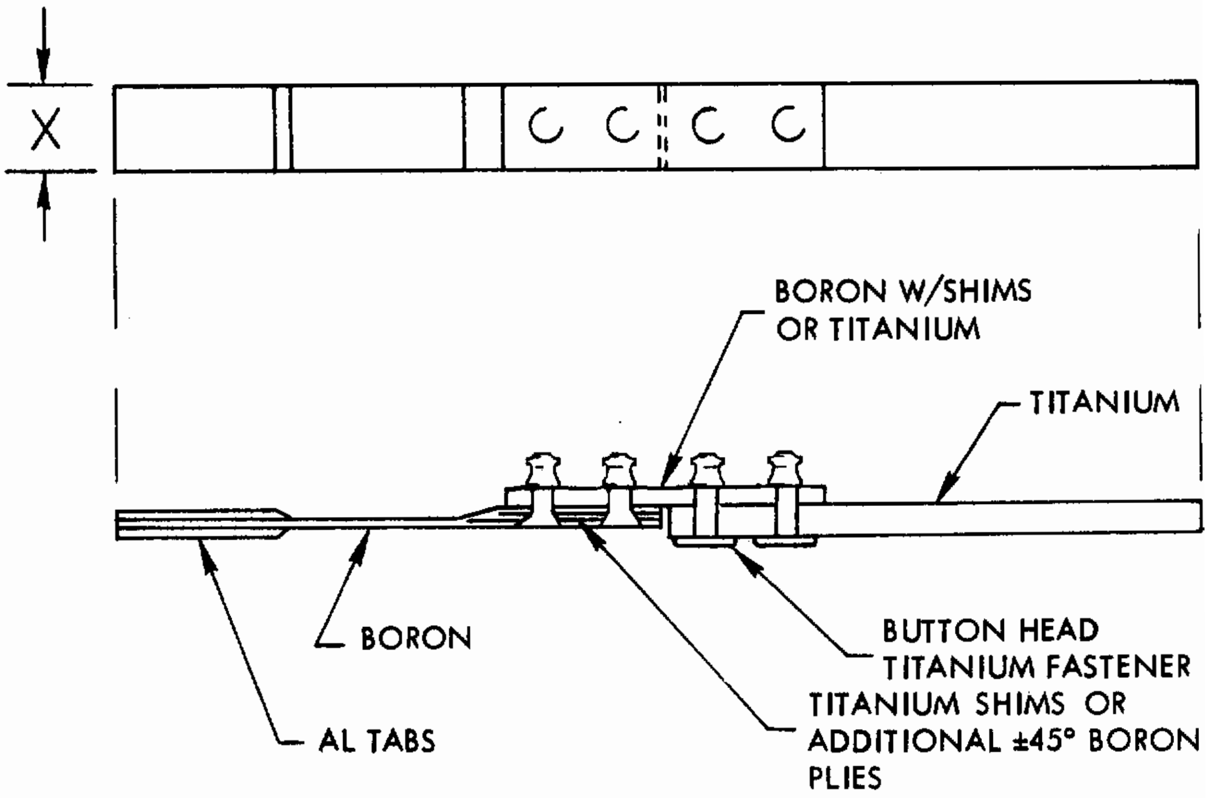


FIGURE 5 (REPEATED)

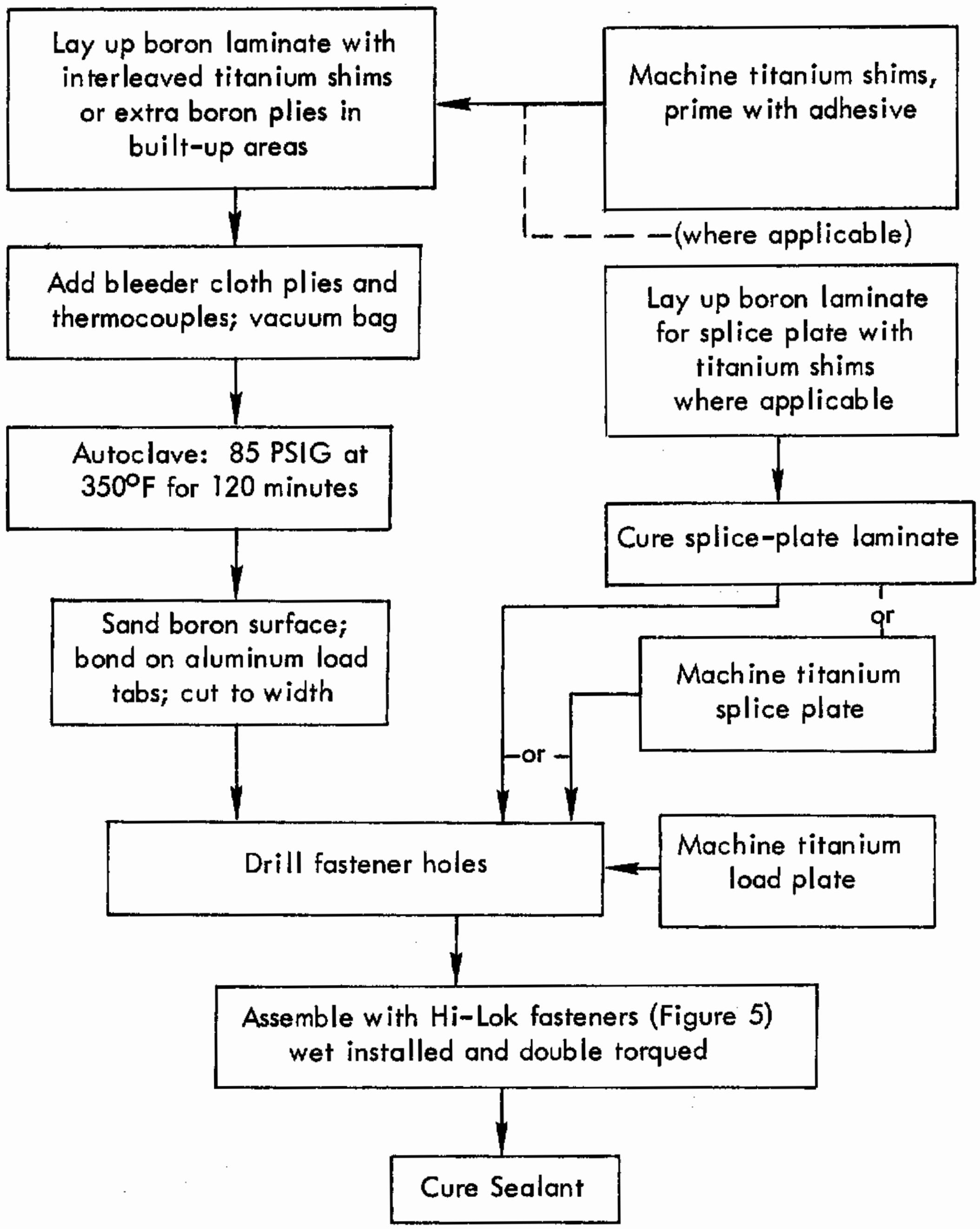


FIGURE 21 - STEP CHART FOR CONFIGURATION "E" SPECIMENS

The lay-up procedure for the basic boron panel laminate thickness for the composite side of the Configuration E specimens was similar to that described in Section 2.2. The boron plies were laid up in large sheets with the specimen details cut to length and width after the laminate had been cured. However, since the mechanical joints require additional built-up areas for providing the bearing strength to reach the fastener loads, these build-ups were incorporated in the ends of the laminate during the lay-up operation.

The build-ups were achieved either by interleaving titanium shims or additional pairs of $\pm 45^{\circ}$ boron plies among the basic laminate plies. See Drawing 7226-13021E in Appendix C for exact stacking sequences. The additional shims or plies were staggered in length to provide a smooth transition from the basic laminate to the build-up area. Prior to lay-up, titanium shims were machined to size, processed for bonding, and primed. The primed titanium shims were then overlaid with 0.045 $lb./ft^2$ weight EA9601 adhesive and placed in the laminate as required.

The resin bleeder system and the bagging procedures followed were similar to those used for the Basic Laminate Panels, Section 2.2, except that no peel plies were used. An autoclave cycle of 85 psig and $350^{\circ}F$ for 120 minutes was employed. Quality control specimens were included with the panel lay-up to verify the material properties.

After cure, the laminate was cut with a diamond saw into panels 9 inches long and of sufficient width to provide 9 to 24 one-inch-wide specimens. The load grip ends of the panel were tabbed with aluminum tabs. The boron surface was sanded, the aluminum tab material was metal bond etched and primed, adhesive was placed between the aluminum tabs and the boron, and then the assembly was bagged and cured at $250^{\circ}F$ for 60 minutes under 20" Hg vacuum. The panels were then cut into specimen details 1" wide by 9" long using a diamond saw on a milling machine. Excess coolant was used and the mill feed rate was decreased when the cut was made through the titanium-boron build-up area to reduce the possibility of laminate overheating.

The titanium joint details were machined 1" x 9" to form the second half of the joint. Also, the titanium splice plates or boron-titanium shim splice plates were machined to 1" width and to the length necessary for providing the required edge distance for the fasteners. Specimen components prior to assembly are shown in Figure 22.

The holes for the fasteners were drilled using a diamond core drill. No problems were encountered in drilling the boron-boron laminates. However, considerable difficulties were encountered in drilling the boron-titanium specimens.

In order to provide quality holes for these specimens, it was necessary to change tools during the drilling operation. This was done on a milling machine using a core drill for the boron and an end mill for the titanium. This procedure eliminated overheating of the specimen during drilling and provided a hole free from lip-over in the titanium which results from a one step diamond drilling operation. Good back-up of the laminate was used to prevent fiber breakout on the back side of the hole. The holes were countersunk using diamond countersinks. No problems were encountered and all countersunk holes had good visual surface characteristics. The specimens were spot checked by ultrasonics to determine if any delamination occurred during drilling and none was found.

Specimens were assembled using Hi-Lok fasteners. The fasteners were wet installed and the faying surfaces were coated with a sealant in accordance with standard assembly procedures for mechanically fastened joints. The fasteners were torqued to 30 inch-pounds ± 1 inch-pound and re-torqued after approximately 30 minutes to account for any squeeze-out of the faying surface sealant. The assembly was then baked for 48 hours at 160°F to cure the sealant. Three completed joints are shown in Figures 23 and 24. The three specimens shown represent thick laminate-to-metal, thin laminate-to-metal and laminate-to-laminate combinations.

Initial fatigue tests of the Configuration E specimens, composite-to-metal mechanical joint, resulted in failure of the metal portion of the joint. A number of attempts were made to correct this deficiency. The first attempt replaced the 7075-T6 aluminum portion of the joint with 8Al-1Mo-1V titanium of equal thickness but these specimens failed in the countersunk portion of the titanium. This led to the replacement of the BL19PB6 flush head fasteners by HL18PB6 button head fasteners for the metal-to-metal portion of the joint but this only moved the failure to the titanium splice plate.

This second failure mode led to the final design which consisted of the boron portion joined to 8Al-1Mo-1V titanium which was 50 percent thicker than the composite. These specimens were assembled with flush head fasteners, HL19PB6 series, used on the boron-to-titanium half and button head fasteners, HL19PB6 series, used on the titanium-to-titanium half. Fatigue tests on two specimens of this configuration resulted in fatigue failures of the boron portion of the joint. Based on these results, all of the Configuration E specimens were disassembled and new metal splice plates and metal joint halves were machined from 8Al-1Mo-1V titanium; 0.125" material was used with the 8-ply boron specimen halves and 0.250" material was used with the 16-ply boron specimen halves. The Configuration E design, Dwg. No. 7226-13021E, was revised to reflect these required changes. All specimens were reassembled to the new configuration. One baseline specimen (1A60) and one thickness effects specimen (11A06) are shown in Figure 25.

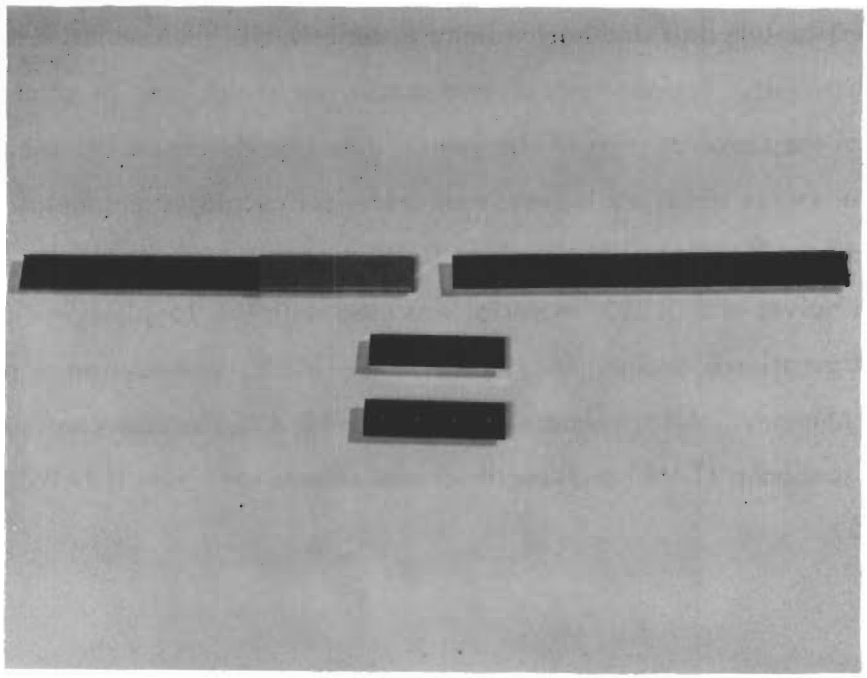


FIGURE 22 CONFIGURATION E SPECIMEN DETAILS

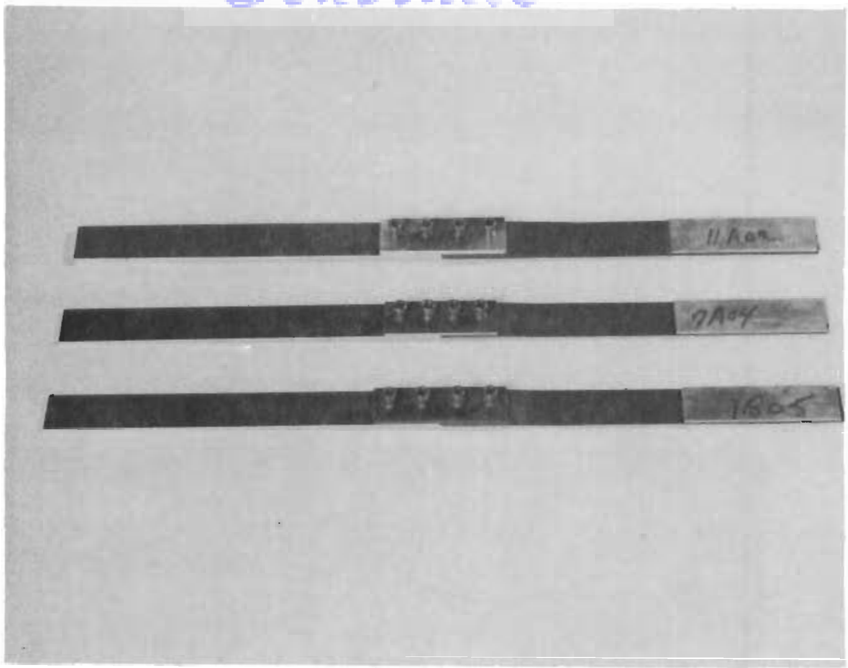


FIGURE 23   CONFIGURATION E COMPLETED SPECIMENS

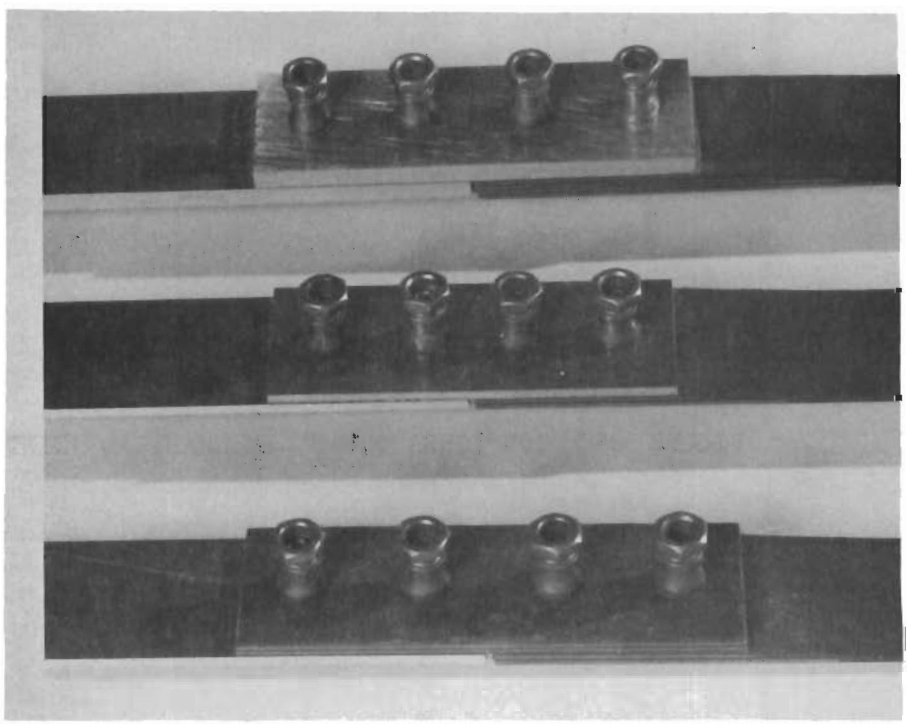


FIGURE 24   CONFIGURATION E JOINT CLOSE-UP

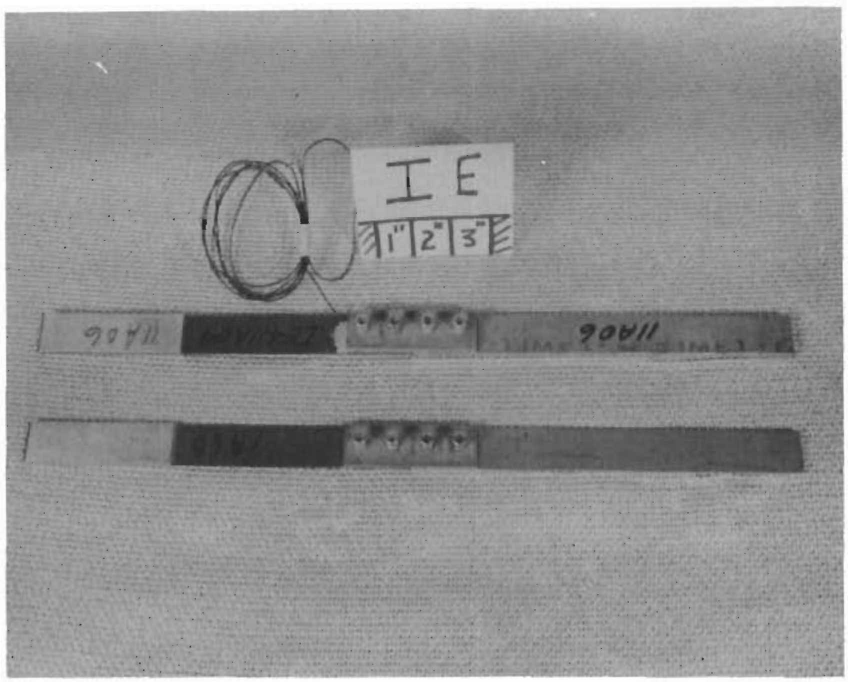


FIGURE 25 CONFIGURATION E - MECHANICAL JOINTS

2.7.1 Phase II Fabrication - Configuration E

The laminate portions and splice plates for these specimens were identical to the Phase I Configuration specimens in materials, thicknesses, and configurations except that they were wider. Phase II specimens were two inches wide and contained two rows of fasteners, whereas the Phase I specimens were one inch wide and contained only one row of fasteners.

All specimens were match drilled and countersunk in the boron. Flush head fasteners were used on the boron to splice plate portion of the joint, and button head fasteners were used on the splice plate to loading plate portion of the joint. All fasteners were wet installed with double torquing operations to account for relaxation of fastener torque due to sealant squeeze-out.

Photographs of failed specimens are included in the TEST PROGRAM section of this report.

2.8 JOINT FABRICATION - CONFIGURATION F, SURFACE TO UNDERSTRUCTURE - MECHANICAL

These specimens are illustrated in Figure 6, which is repeated below. Individual specimens were fabricated with one of two laminate thicknesses according to the requirements of Dwg. No. 7226-1301F, Appendix C.

Configuration "F" Surface to Understructure Attachment - Mechanical

Size: 18" X 1" width

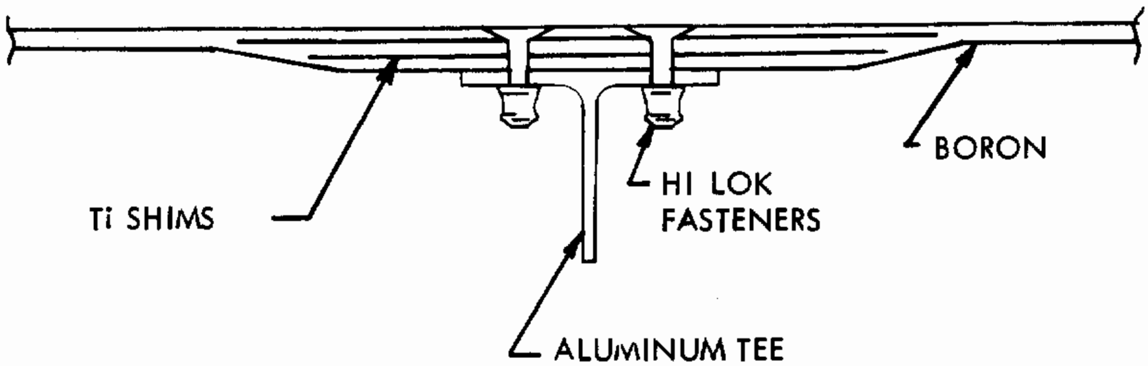


FIGURE 6 (REPEATED)

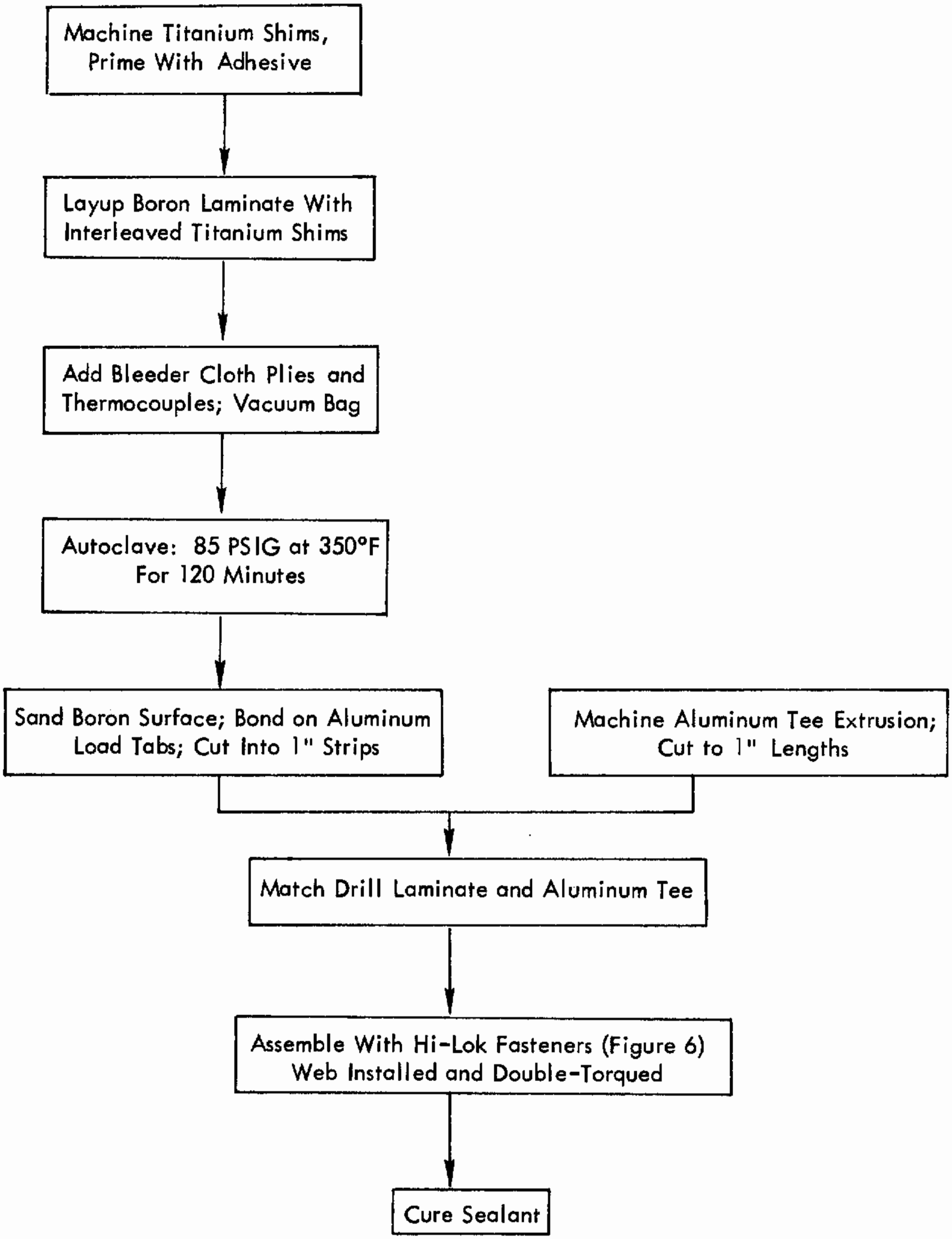


FIGURE 26 - STEP CHART FOR CONFIGURATION "F" SPECIMENS

Laminates were laid up and fabricated according to the size, orientation, and requirements of Dwg. No. 7226-13021F, Appendix C. Panels contained either 8 or 16 boron plies of 0°/±45° orientation. The 8-ply panels had titanium shims of 0.012" thickness sandwiched between the second and third, and the sixth and seventh boron plies. The 16-ply panels had titanium shims between the second and third, sixth and seventh, tenth and eleventh, and fourteenth and fifteenth plies.

The shims were staggered in length to provide a smooth transition from the build up area to the basic laminate. Prior to layup, titanium shims were machined to size, processed for bonding, and primed. The primed titanium shims were then overlaid with 0.045 lb./ft^2 weight EA9601 adhesive and placed in the laminate as required.

The resin bleeder system and the bagging procedure followed were similar to those described in Section 2.2 except that no peel plies were used. Panels were cured in an autoclave cycle of 85 PSIG and 350°F for 120 minutes. After cure the laminate surface was sanded and primed aluminum tab material was applied in a secondary bond operation (250°F for 60 minutes under 20" Hg vacuum). The laminate was then cut into 1" strips.

The aluminum tee was machined into the required one-inch long sections and match drilled with the laminate. Holes through the boron/titanium shim laminate were generated with a core drill and final sized with a diamond reamer. The laminate was countersunk with a diamond tool and the specimen was assembled using flush head fasteners, HL19PB6 series, wet installed. Fasteners were initially torqued to the required 30 inch-pounds and after 30 minutes were torqued again to 30 inch-pounds to account for any relaxation due to squeeze-out of the faying surface sealant. The assembly was then baked for 48 hours to cure the sealant.

Photographs of failed Configuration F specimens are included in the TEST PROGRAM section of this report. These photographs show a close-up of the joint area.

SECTION III

TECHNICAL INSPECTION AND QUALITY ASSURANCE

3.1 INTRODUCTION

This section contains the information related to nondestructive inspection of the fatigue phenomenon investigation specimens, destruct test verification of the base filamentary composite materials, and process and material assessment testing and evaluations. A description of techniques, summary of test data, and presentation of findings are presented below. An itemized listing of associated data are presented in Appendices A, B, and C.

3.2 NONDESTRUCTIVE EVALUATION OF BONDED COMPOSITE JOINTS

The nondestructive evaluation of the bonded joints in this investigation was intended to detect conditions apparent using current state-of-the-art techniques including ultrasonic, visual, microwave, and radiography methods where applicable. The plan by which the evaluations would be accomplished was primarily to:

- Determination of the detrimental conditions which must be nondestructively evaluated
- Determine which acceptable conditions affect the evaluation data in the same manner as the aforementioned
- Utilize specific nondestructive evaluation disciplines and techniques to detect the unwanted conditions

Although the evaluation was expected to detect conditions such as disbonds, delaminations, fiber separation, inclusions, porosity, cracks and bondline thickness variation, additional information was gained during the investigation. This information has been used to reestablish the relative effectiveness of some NDE disciplines in composite evaluations and to recommend factors to be considered in future work.

Since there are many defects which can affect the quality of a bonded joint which varies in nature and characteristics, no single nondestructive test can be expected to evaluate a composite joint for all defects. Ultrasonics, x-ray, microwave and visual tests have each been used to assure a full evaluation of the bond joint. The preferred test method appears to be ultrasonics since this procedure detected most of the defect conditions and provided additional information yielded by the attenuation of sound in the specimen.

Initially the intention was to detect a defect in the specimen with the ultrasonic procedure, then define the location of the defect with x-ray laminography. Laminography is a relatively new technique of radiography which allows an incremental radiographic analysis of a thin section within a thick sample without physically sectioning the sample. The analysis is accomplished by averaging the unwanted image over a large area while the image of interest remains defined. This result is achieved by synchronously rotating both the film and the sample during the exposure. After examining several joint specimens with this system, it was determined that conventional radiography would provide adequate information for this program.

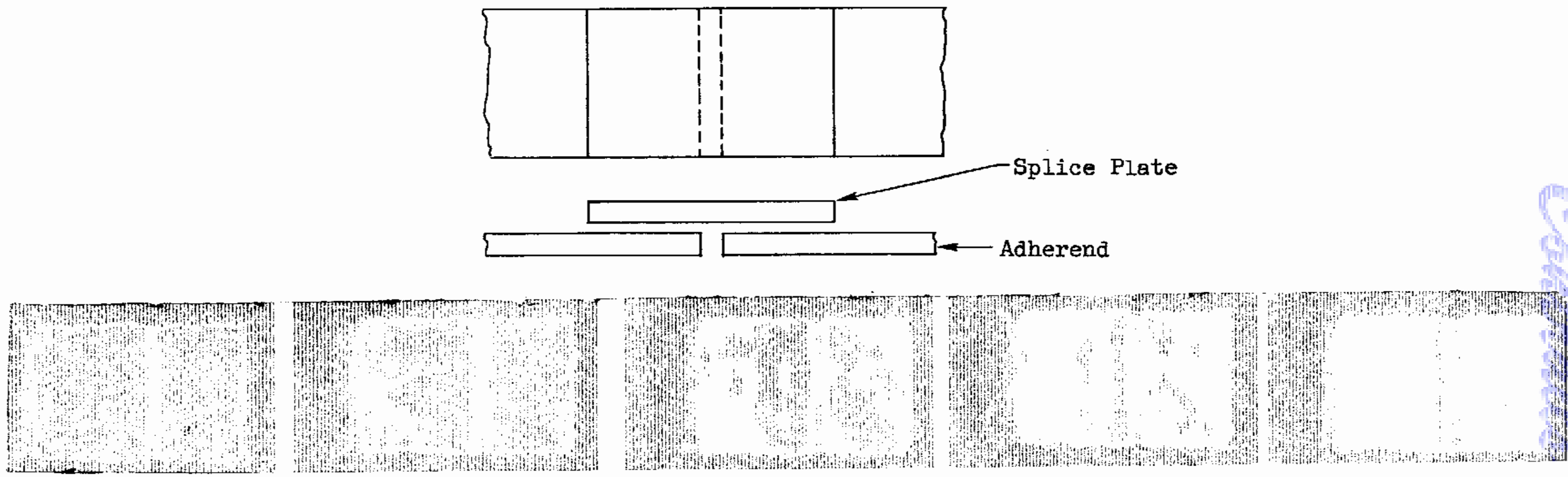
A more detailed discussion of each of these inspection methods is given in the following paragraphs.

3.2.1 Ultrasonic Inspections

All ultrasonic evaluations were performed with an immersion pulse-echo technique. A permanent C-scan recording as in Figure 27 was made for all joints evaluated ultrasonically. The equipment, shown in Figure 28, with which the inspections were made, is a Sperry Immersion C-scan System, Reflectoscope Model UM 721.

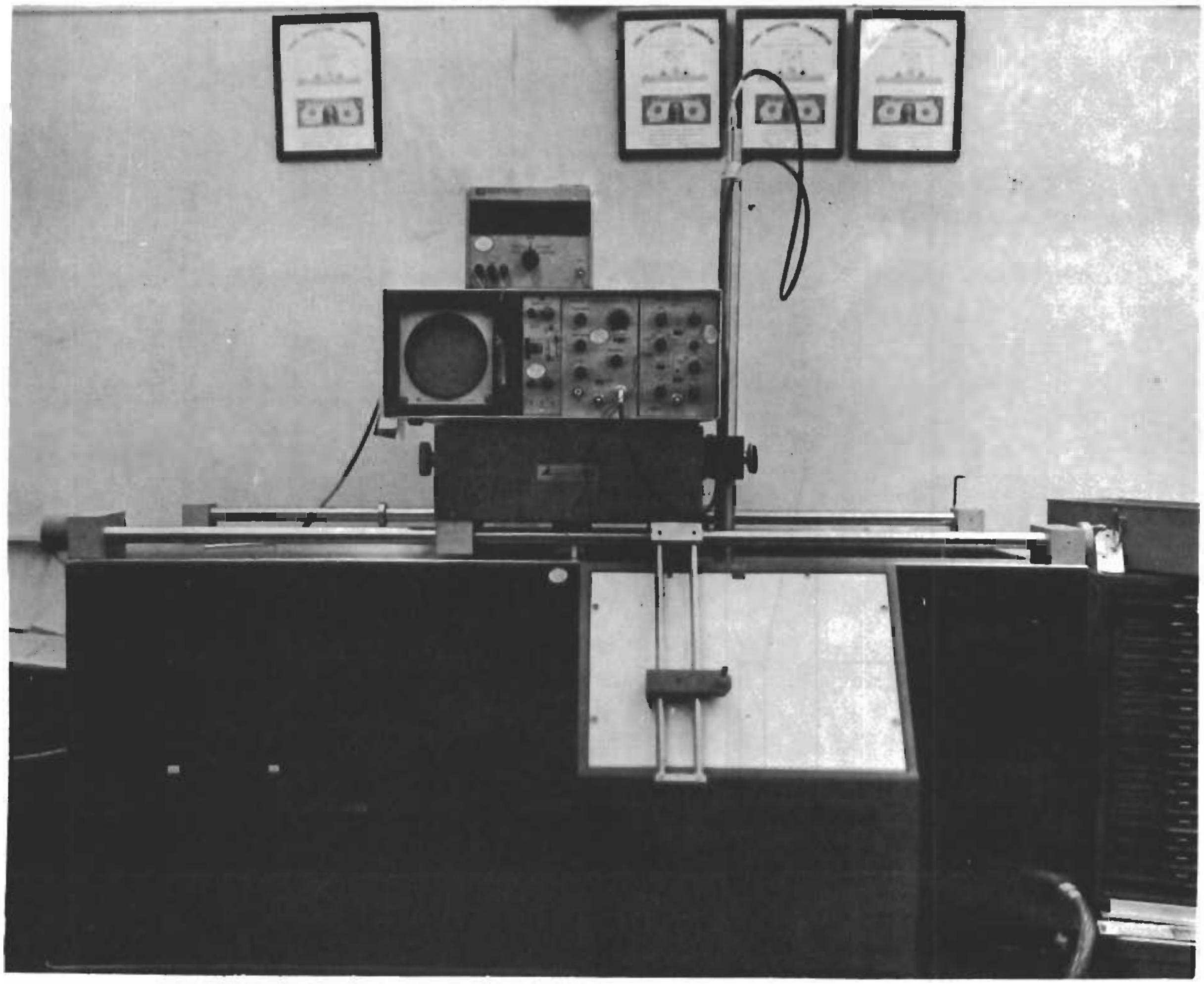
The immersion technique used measures variations in ultrasonic attenuation (loss of sound) as the sound traveled through the specimen to a mirror then back through the specimen to the part. The recorder was activated by preset strength levels of the returning ultrasonic energy as shown in Figure 29. The attenuation contributed by the water in the immersion tank and the mirror was assumed to be constant throughout this investigation.

Attenuation is increased by the presence of variation in consistency such as the following defects: porosity, disbonds, inclusions, voids (gross porosity), delaminations, specimen surface roughness, bondline thickness, and resin-starved areas of the composites.



Joint specimens are scanned five times at various gate sensitivity levels. Dark areas indicate less sound is getting through. Sensitivity is decreasing from left to right.

FIGURE 27 - TYPICAL C-SCAN RECORDING



Specimens are immersed in water and scanned automatically using the pulse-echo technique. Recordings are made of all inspections.

FIGURE 28 - ULTRASONIC C-SCAN INSPECTION SYSTEM

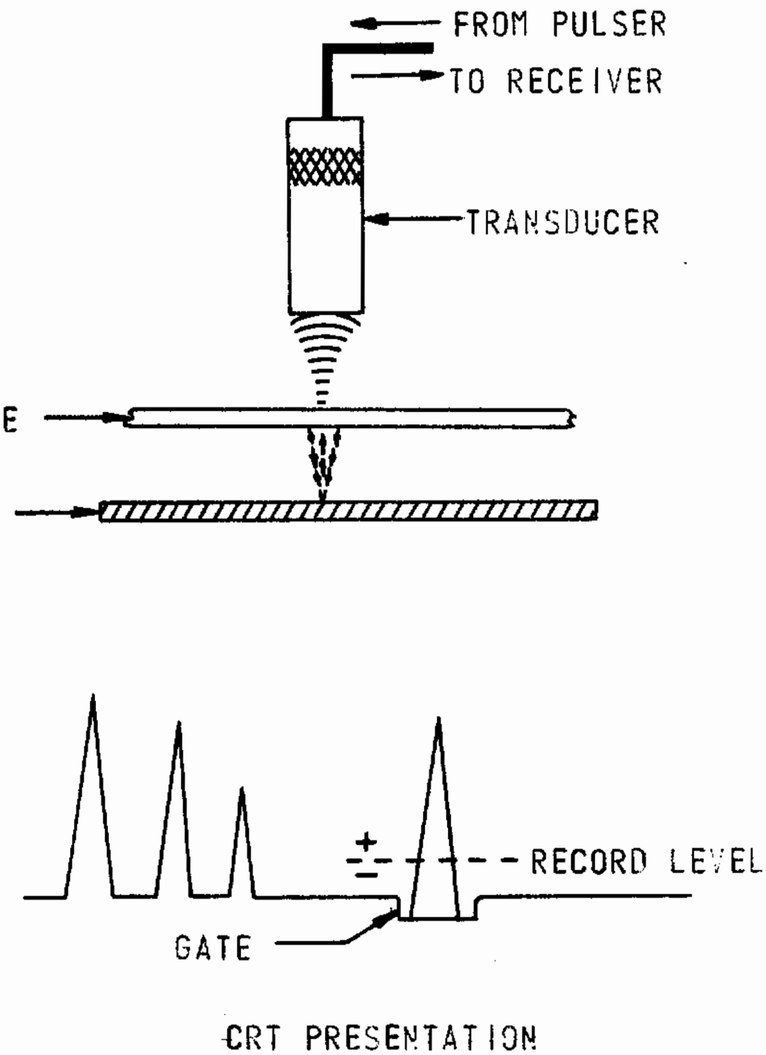


FIGURE 29 - PULSE-ECHO TECHNIQUE

3.2.1.1 Disbonds, Voids, Delaminations - These conditions completely stop penetration of ultrasonic energy through the specimen if the defect size is greater than the .117 square inch area of the ultrasonic energy beam impinging on the specimen surface. Of course the energy transmitted will be proportional to the inverse of the area above. The larger defect will be outlined on the C-scan plan recording. These conditions were rated as go or no-go since normally, if any voids, etc., exist, the specimen was usually completely bad. The evaluation was described as go or no-go since the sound is either transmitted through the specimen or completely stopped.

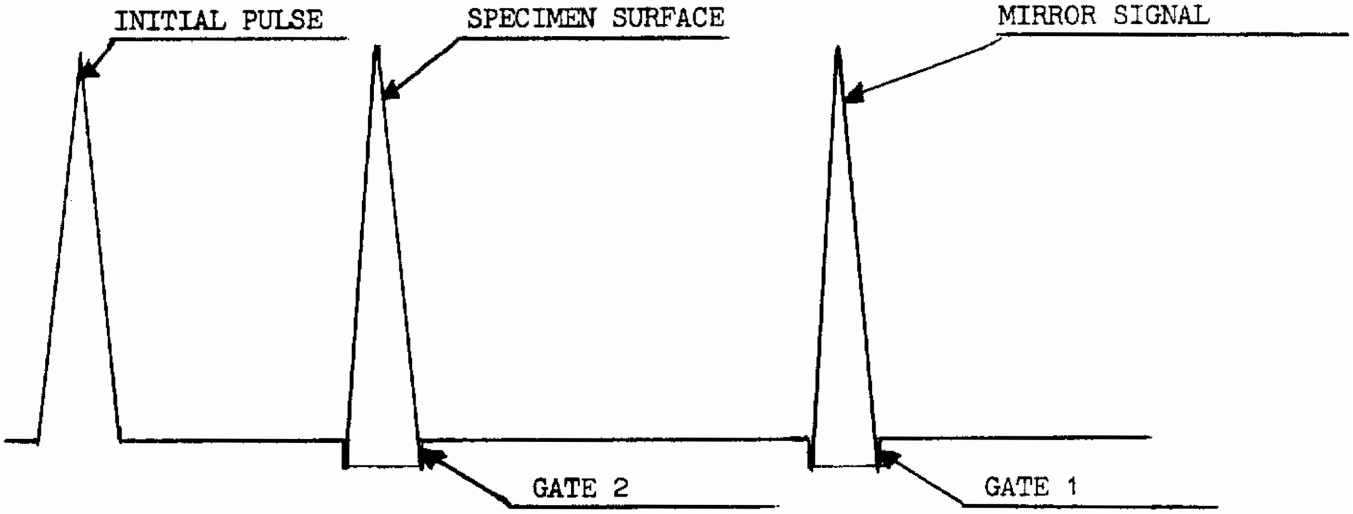
3.2.1.2 Porosity Inclusions - The effective sound blocking area of these conditions was usually less than the area of the sound beam impinging on the specimen surface. Porosity in sufficient concentration to completely block all sound could be visually detected at the edge of the bondline. Adequate in-process control can eliminate the porosity such that no significant decrease in bondline strength results. Inclusions were classified in the same evaluation category as porosity. Radiography was used to detect inclusions.

The effect of these two conditions was not considered on the C-scan read-out unless:

- o The porosity was visually detected during bondline measurements.
- o Radiographic inspection detected foreign material in the bondline or composite.

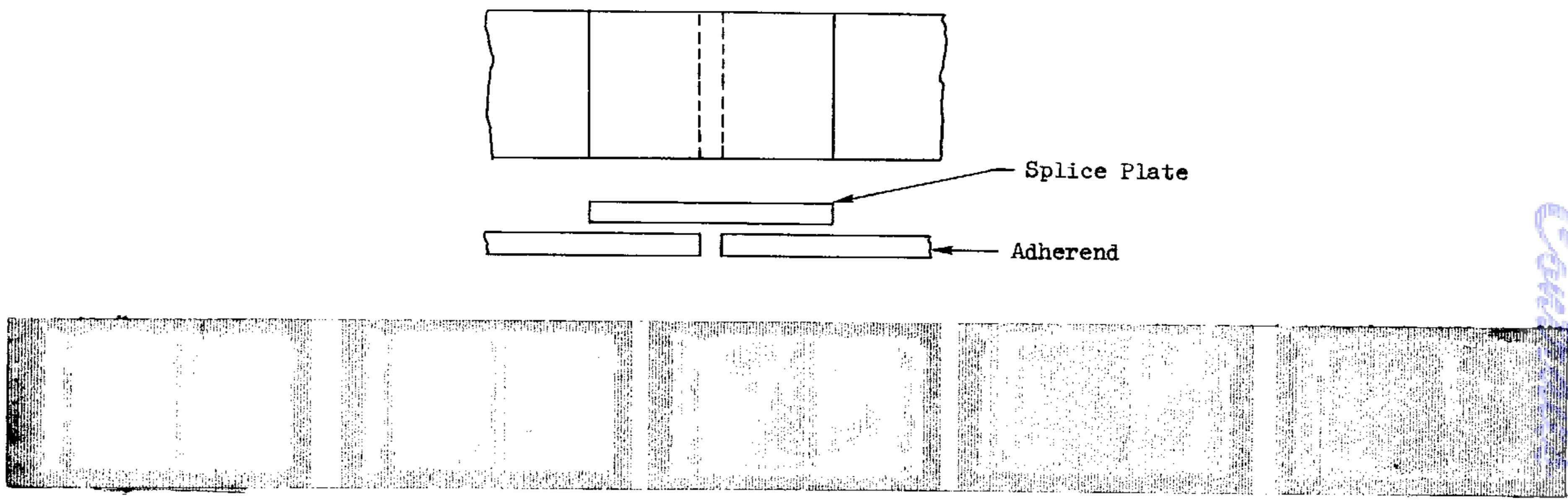
The attenuation of the ultrasonic energy was attributed to other conditions if the aforementioned did not exist.

3.2.1.3 Surface Roughness - This condition, while not always considered defective, had an adverse effect on the energy returning to the transducer. The rough surface scattered the sound away from the main beam, therefore the returning sound energy was lessened. The returning signal (Figure 29)decreased in amplitude and was printed on the C-scan chart as a high attenuation area.



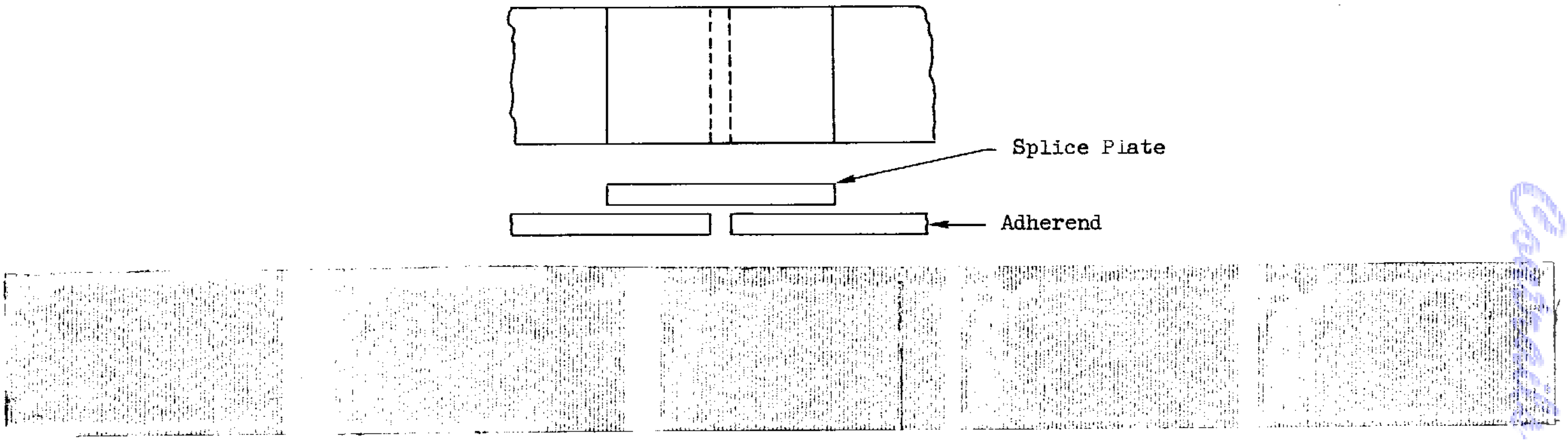
This illustrates the signal reflected from the specimen surface. The signal magnitude, affected by the surface roughness, can be gated to give some measure of energy scattered away from the sound beam.

FIGURE 30 - ULTRASONIC SIGNAL PRESENTATION ON CATHODE RAY TUBE.



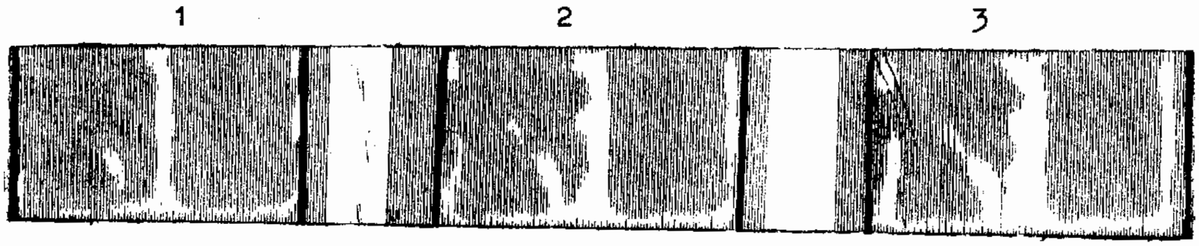
This recording was made prior to fatigue testing. The specimen failed on the left side during test. There was a noticably less amount of sound transmission on the left side which is particularly evident on the third and fourth sensitivity levels from the left. Sensitivity is decreasing from the right.

FIGURE 31 C-SCAN RECORDING OF TYPICAL JOINT SPECIMEN

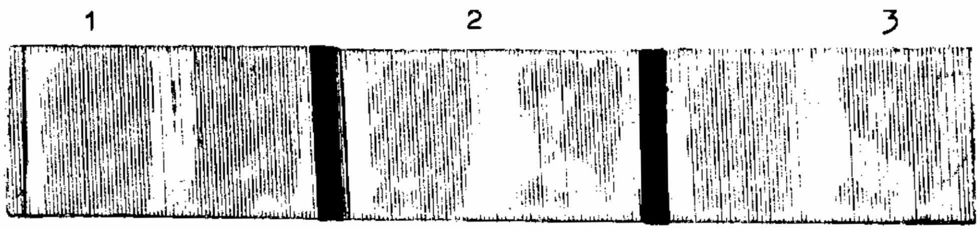


This recording was taken from a group of specimens which were not fatigue tested due to a poor bond. Notice the lack of sound transmission at all sensitivity levels.

FIGURE 32 C-SCAN RECORDING OF POORLY BONDED JOINT



ULTRASONIC C-SCAN RECORDING
C-scan of Graphite Joint G9A.
Low sound transmission shown
as white area.



ULTRASONIC C-SCAN RECORDING
C-scan of Fiberglass Joint FG7A.
Low sound transmission shown as
white area.

* Gate level above samples denotes sensitivity to low sound transmission areas wherein 1 is least sensitive.

FIGURE 33 C-SCAN RECORDINGS FROM GRAPHITE AND FIBERGLASS COMPOSITE JOINTS

This problem was eliminated by a close visual inspection which revealed any wide variation in surface roughness among the specimens. However, the visual inspection did not represent an actual measurement. A measurement can be accomplished using the first interface signal (reflection from the part surface) shown in Figure 30. This signal decreased in strength as the surface roughness increased. The surface roughness would not be a factor if the inspection was intended to detect only voids, delaminations or disbonds. It must be considered as a factor however if any future investigations are to be made to determine the strength of a bonded joint.

3.2.1.4 Bondline Thickness - Sound transmission was inversely proportional to bondline thickness. This was noted on some samples wherein the bondline was .001 inch thicker on one side of the joint specimen. At extremely high sensitivity (low energy level) the sound attenuation dropped appreciably in the thick bondline area.

This measurement would be a critical factor in any investigation to determine the strength of a bonded joint. At the high ultrasonic energy levels used in this investigation it was not a significant factor.

3.2.1.5 Summary of Test Results - Only one group of specimens were rejected using the ultrasonic system and these specimens did not undergo fatigue testing. A C-scan representing a typical specimen from this group is compared with a good joint in Figures 31 and 32.

Ultrasonic analysis of the joints gave a better overall evaluation of the specimens than any of the other NDE disciplines. Sufficient data was accumulated to affect the techniques used in the evaluation of bonded joints in future investigations.

C-scans were also made of graphite and fiberglass joint specimens. The recorder was adjusted to print good areas thus high attenuation areas were the light or white areas (Figure 33). A lower energy amplification level was noted on the graphite specimens than that required to obtain similar energy transmission levels for the fiberglass and boron specimens. This would indicate better sound transmission through the graphite specimens. The gain level was adjusted to have comparable C-scans of all specimens.

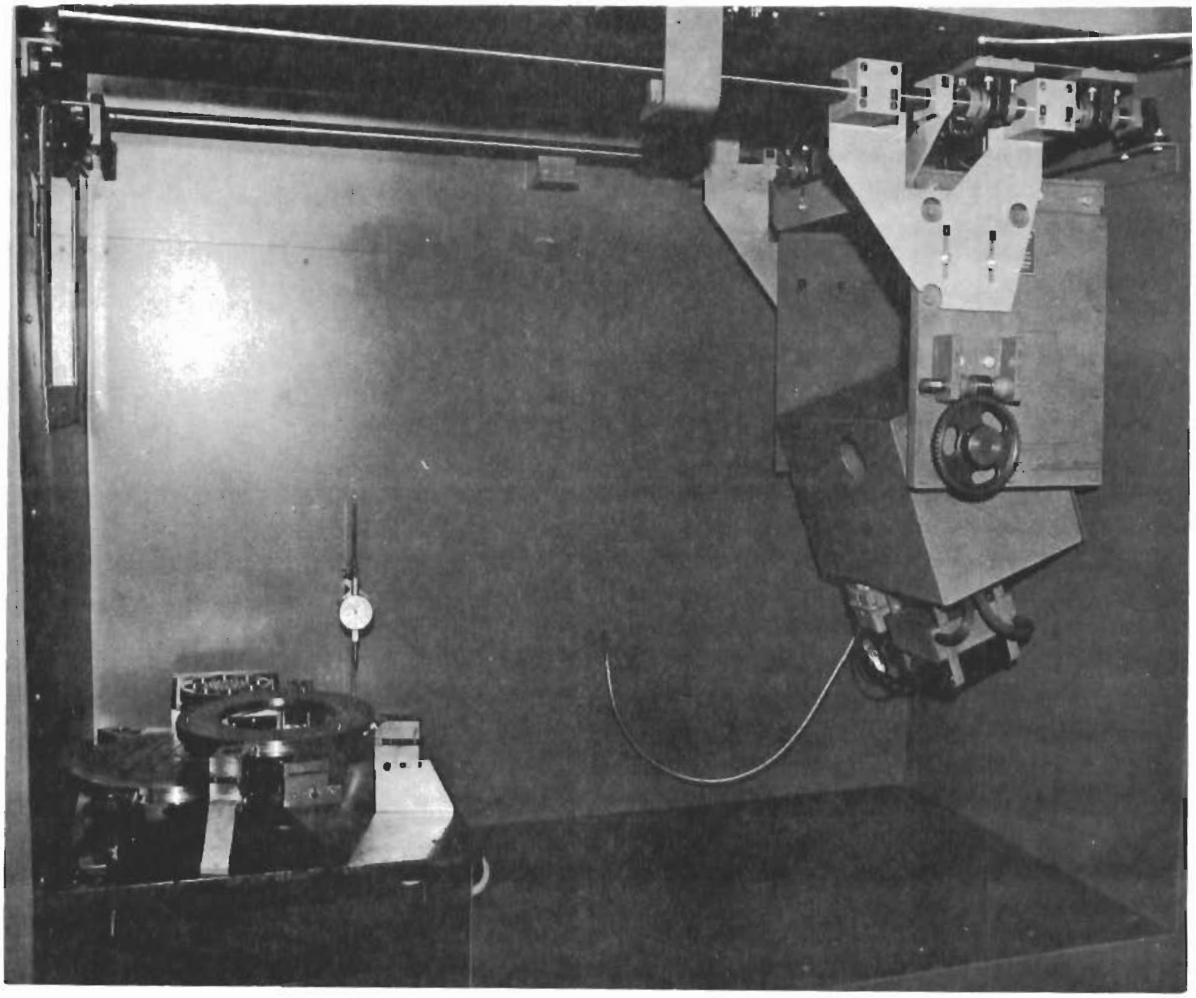
This lower energy level requirements was due in most part to two conditions found in these specimens: first, the thinner bond lines in these specimens which attenuated the sound less and second, the smoother graphite surfaces. The surface roughness was much greater in the boron specimens, which scatters the impinging sound, thereby decreasing the energy received by the transducer. The roughness is attributed to use of a fiberglass peel ply (181 style cloth) and to the large boron filaments which also scatter the sound energy as it travels through the laminate and joint. A comparison between the C-scans for fiberglass and graphite joints having the same bondline thicknesses shows more sound transmission through the graphite than the fiberglass specimens. Again the surface roughness of the fiberglass specimens was greater. A comparison of C-scans of specimens at the extreme ends of the thickness range showed slight differences in sound transmission.

3.2.2 Radiography Inspections

X-rays were made of joint specimens to detect porosity, fiber orientation, foreign material and cracks. Radiography was accomplished with a TORR Laboratories Type TX-360 unit with the following specifications: 0-120 KV, 3 or 5 ma, 0.15 inch Beryllium window and a 0.35 mm focal spot size. The equipment is shown in Figure 34.

3.2.2.1 Defect Conditions - These conditions illustrated in Figure 35, can generally be defined as or related to:

- Foreign Material - This is defined as any extraneous matter which does not resemble the surrounding material in structure or form. The image will appear on the radiograph as a less dense (light) sharply defined object.
- Fiber Spacing - The distance between two adjacent parallel fibers. This distance will generally be approximately 0.004 inches.
- Fiber Orientation - The direction fibers are running in a ply. An abnormal condition will exist when one or more fibers run unparallel to the normal direction.
- Fiber Breakage - Small lengths of fibers dispersed throughout the composite.



The x-ray source is shown on the right. The fixture shown on the left is the laminography specimen plate and film holder. The cabinet is being utilized for both conventional radiography and laminography.

FIGURE 34 - X-RAY SOURCE

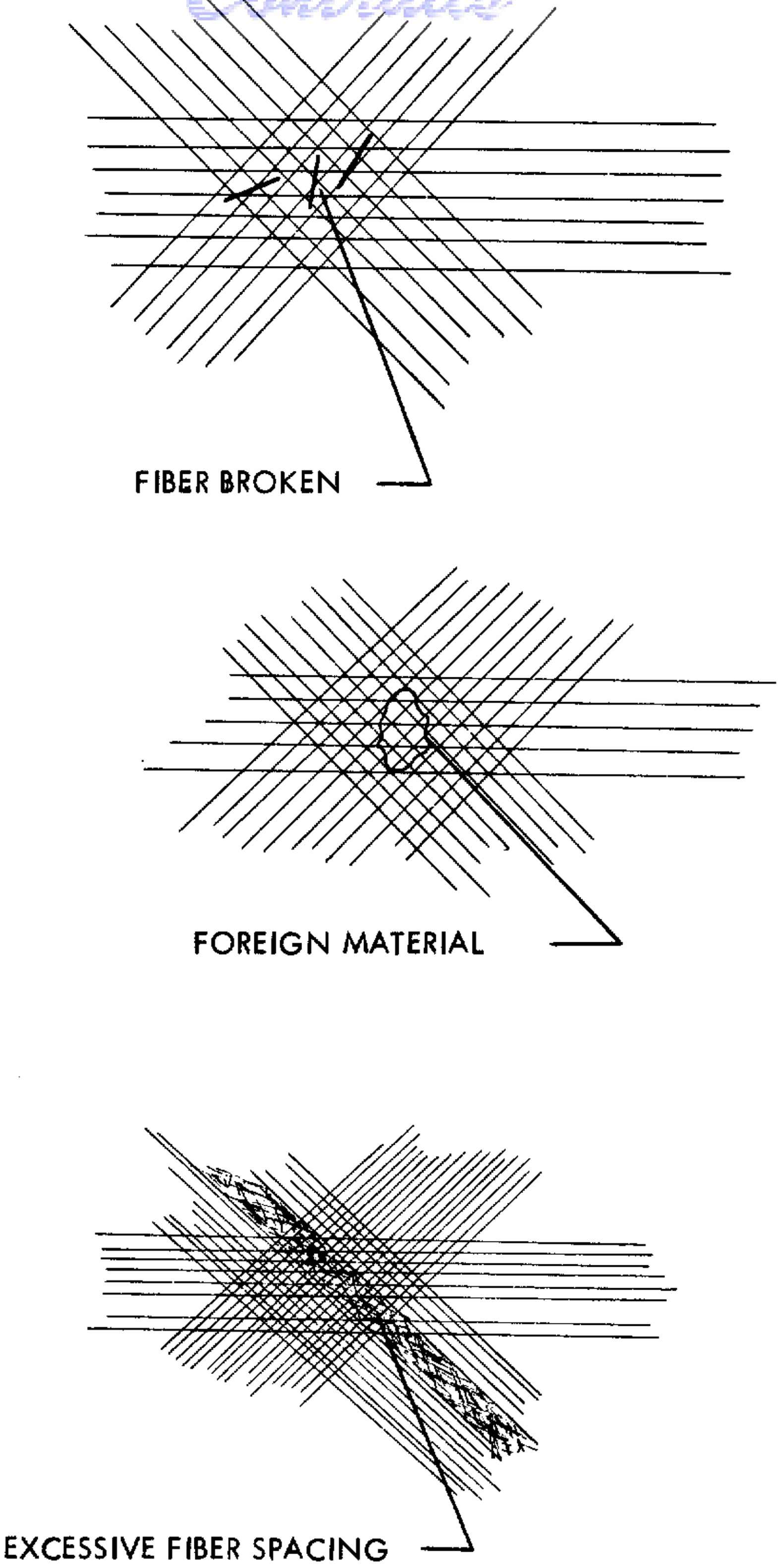


FIGURE 35 DEFECT CONDITIONS IN FILAMENTRY COMPOSITES

3.2.2.2 Summary of Test Results - Radiographs were taken of 713 joint specimens. No condition severe enough to reject any specimen was detected. However, the preceeding conditions were found in many specimens noted as follows:

- o Fiber Breakage - Broken fibers were found in 278 specimens. The fibers were either scattered throughout the joint or concentrated at the edge.
- o Fiber Spacing - Samples in which some fibers exceeded .004 inch spacing between parallel fibers totalled 36.
- o Fiber Orientation - Lack of parallelism was noted among very few fibers in 42 specimens.
- o Foreign Material - This condition was detected in 29 samples.

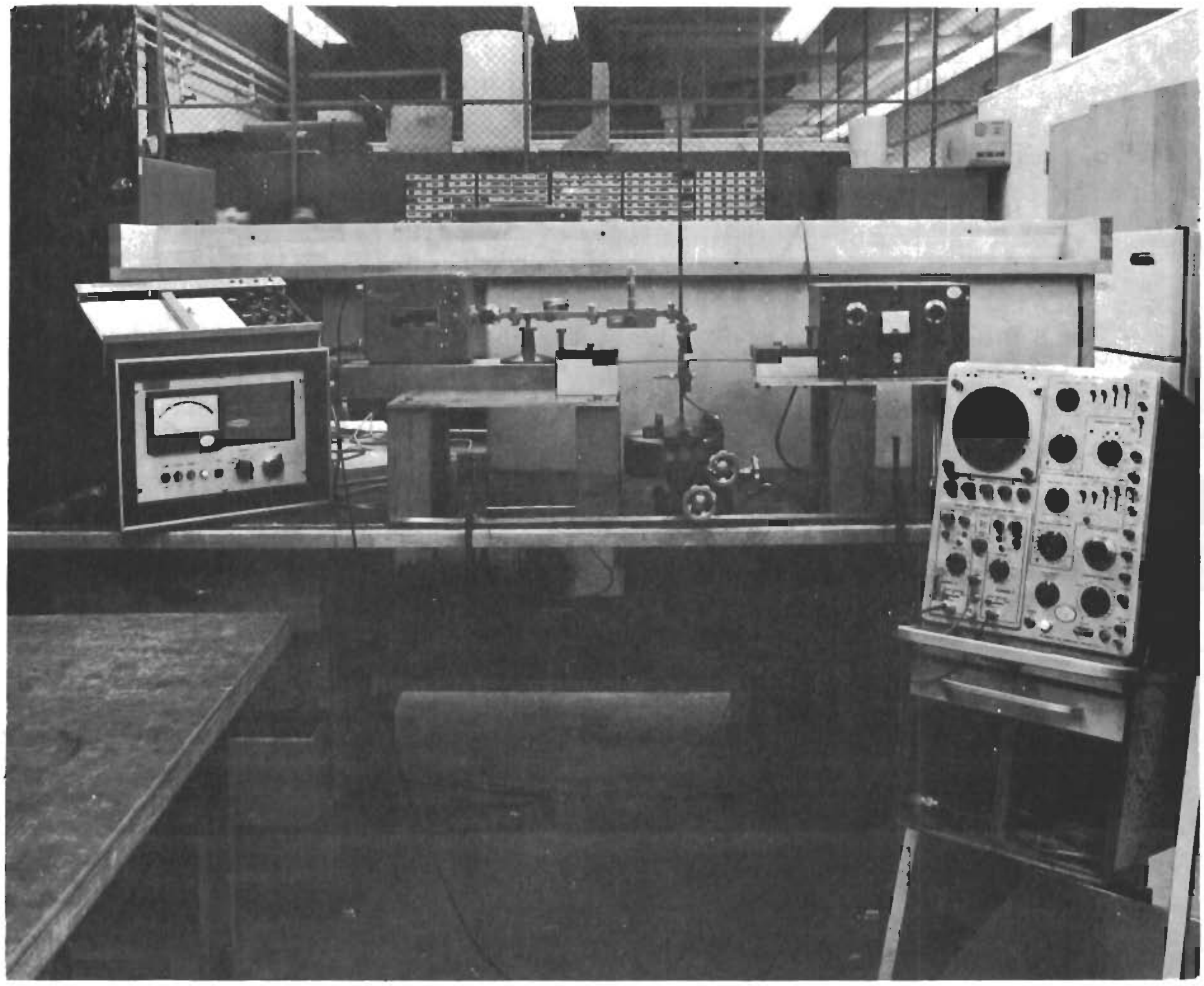
Unknown conditions indicated by abrupt changes in density were noted in 6 specimens. This may be an indication of thin bondline or light porosity.

Some specimens exhibited two of the above conditions. One or more of the defect conditions were detected in 373 of the 713 evaluated specimens. No correlation could be noted between the x-rays and the ultrasonic C-scans.

3.2.3 Microwave Inspections

Microwave testing was accomplished with Microdac Model 664 instrumentation and a Lockheed built Structural Integrity Tester (Figure 36). The tester was a swept frequency square wave generator with a range of 30 Hz to 3.2 kHz. The generator was used in conjunction with a vibrating solenoid to provide a mechanical energy input into the joint specimens. The microwave unit was used to analyze the resultant specimen vibration and determine the resonant frequency. The resonant frequency is a function of the stiffness of the specimen. It was hoped that this would also be a measure of joint quality.

Post fatigue inspection of sixteen joint specimens showed a significant drop in resonance frequency for all specimens tested. This was considered to be significant to warrent further investigation to determine the cause. In so doing it was discovered that the holding



The microwave vibration detector is shown on the left and the swept frequency generator and oscilloscope on the right. The resonant frequency is determined from the scope trace.

FIGURE 36 - MICROWAVE SYSTEM

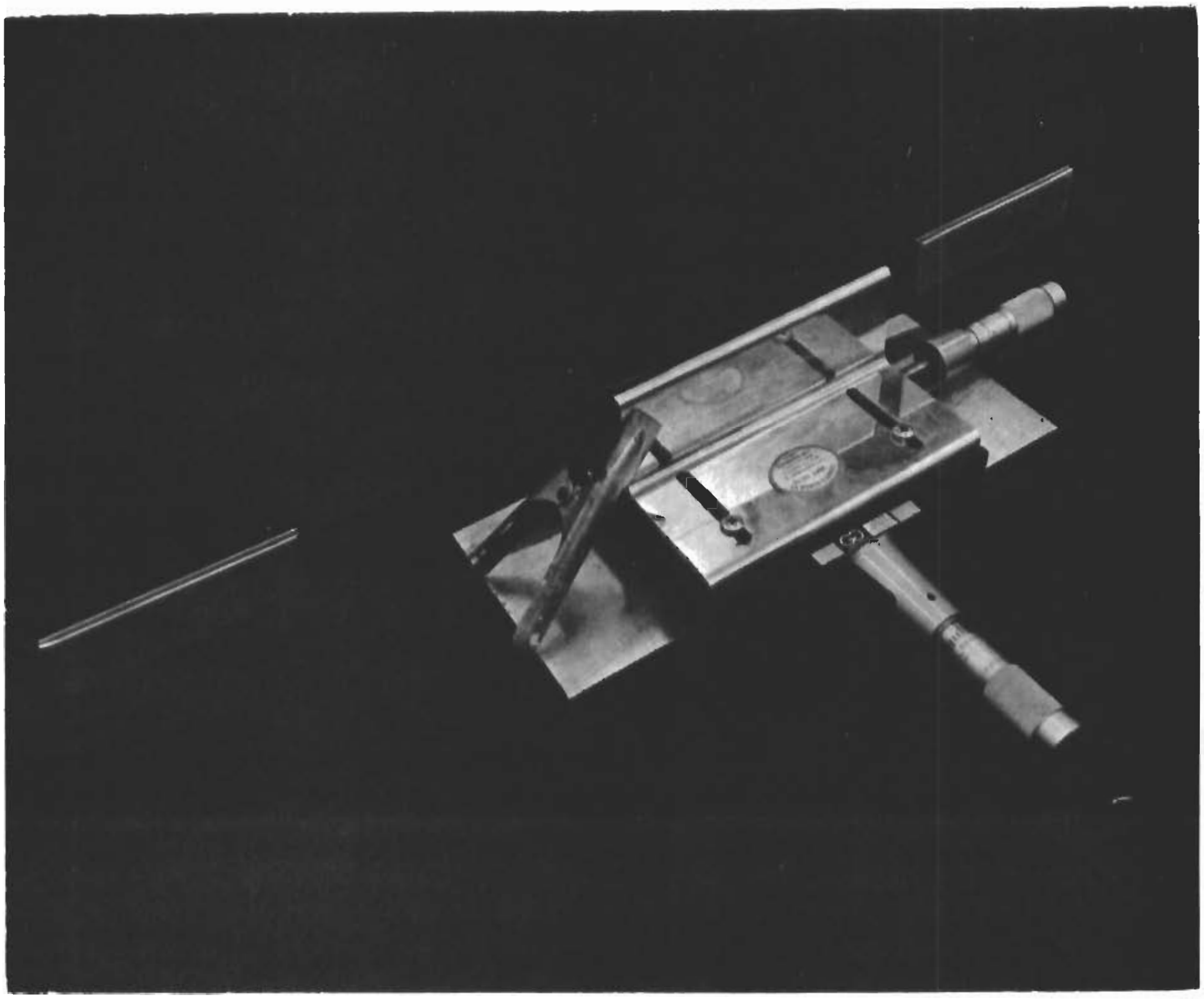
fixture had been changed to improved alignment of the specimens. Since this holding fixture changed between the two data points in the specimen history, the data cannot be directly compared and additional data is not available to verify the effect of the specimen holder on the read-out. Additional research beyond the scope of this investigation would be required.

Microwave resonance has shown promise since tests involving joint specimens with introduced voids yield significant changes in resonance frequency. The range for no voids was 53 to 74 Hz while the range for the same specimens after voids were introduced was 50 to 62. The above overlap would not be apparent if individual specimen readings were considered; i.e., 53 before to 50 after and 72 before to 62 after. This data demonstrated the capability of the microwave system. However, its use is limited since fine line measurements of actual bond quality is not comparable with the capability of current ultrasonic methods.

3.2.4 Visual Inspections: Bondline Measurement

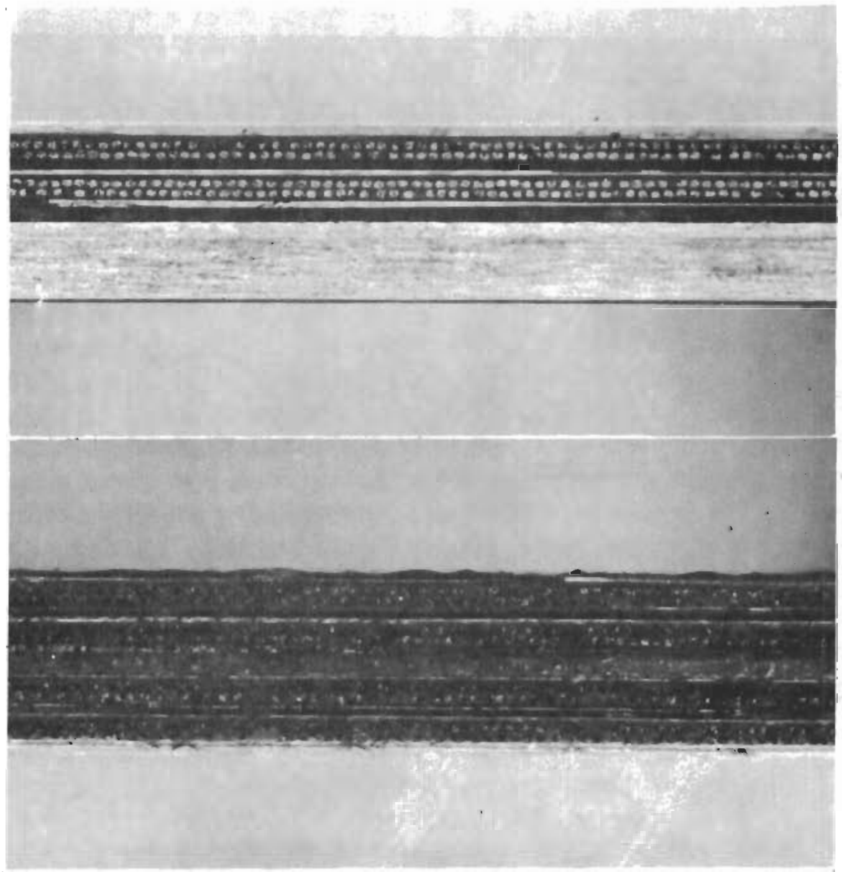
The thickness of a bondline affects the quality or strength of a bonded joint. A device was designed and built to optically measure the thickness of a bondline at the edge of a specimen (Figure 37). Initially, visible light was used to illuminate the bond joint. However, the interface between the adhesive and laminate was not well defined. After the bondline adhesive was found to fluoresce under ultraviolet light, the interface was easily defined for optical measurement (Figure 38). The technique utilized the micropositioner stage, ultraviolet light and a microscope as in Figure 39.

The bondline thickness measurement was accomplished by positioning a line in the eyepiece of the microscope on one side of the bondline, then turning the micrometer dial of the stage until the line moved to the opposite side of the bondline. The thickness was read directly from the dial with an accuracy of ± 0.0001 inch.



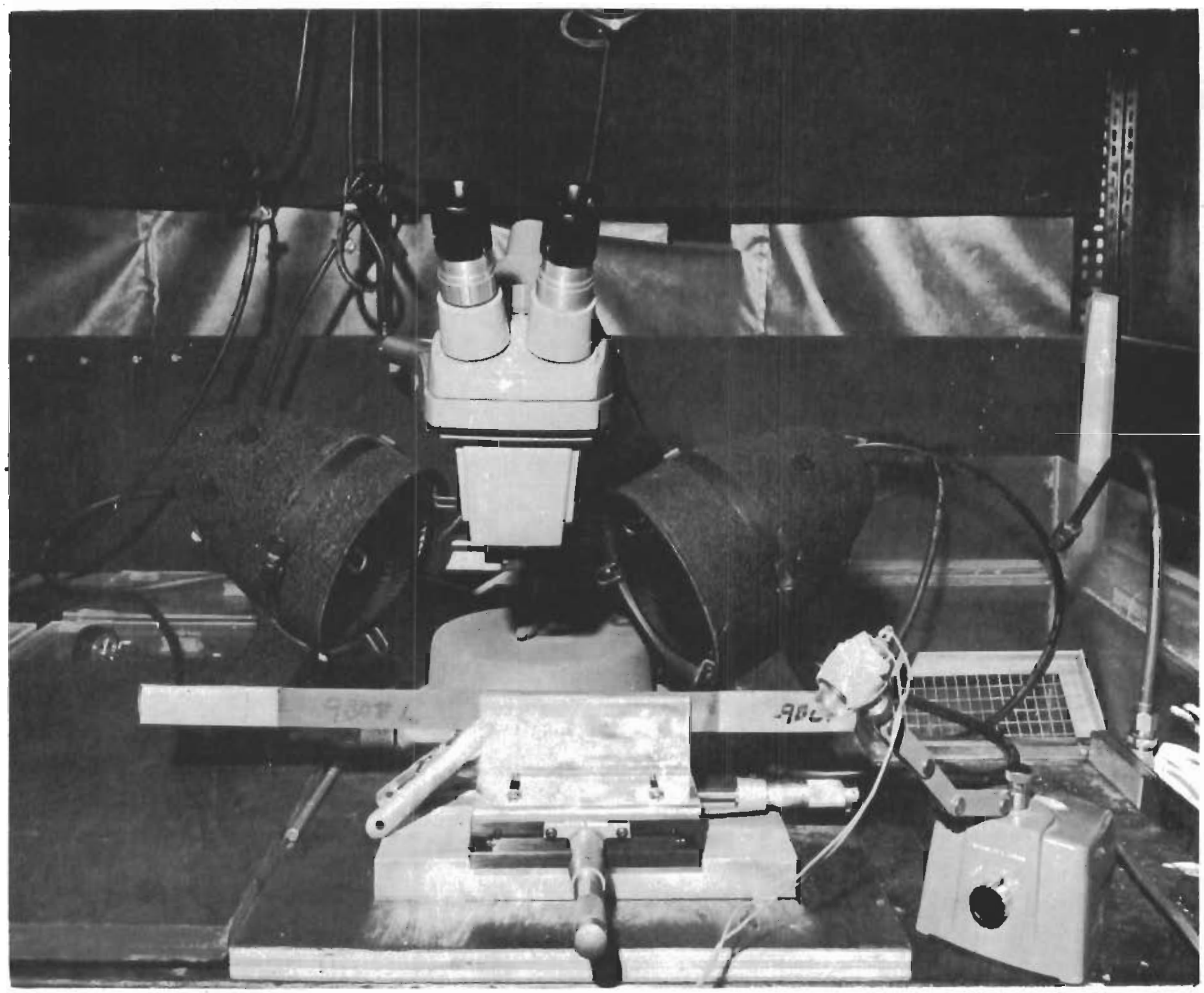
The micropositioner is mounted under the microscope and the bondline thickness reading is made directly from the micrometer dial. The dial is turned until a line in the microscope eyepiece moves from one side of the bondline to the other.

FIGURE 37 - MICROPOSITIONER AND SPECIMEN



These are two typical configurations. One has a titanium splice plate and the other a boron splice plate. Bondline measurements are center of the nearest filament ply. The distance from the center of the filament ply to the edge of the specimen is subtracted from the reading.

FIGURE 38 - JOINT SPECIMENS SHOWING BONDLINES



The joint specimens are mounted on edge and illuminated with ultraviolet light. The bond-line fluoresces and becomes easily discernable. The bondline is viewed through the microscope.

FIGURE 39 - BONDLINE MEASURING SYSTEM

Bondline measurements adjacent to boron adherends present a handicap, since the use of a peel ply on the boron laminate causes an irregular interface between the boron and the adhesive. Therefore, when boron adherends are involved, the measurement is taken to the centerline of the first ply of boron. To account for the thickness of laminate included in the measurement, 0.004" is subtracted from the recorded measurement. This correction includes the thickness of the half-ply included in the measurement and the thickness of the surface scrim and resin. When the adherend and splice are both composite, the measurement is taken from centerline to centerline of the first plies of the adherend and splice and then corrected by subtracting 0.008".

Specimens, representative of Configuration B and fabricated by the co-cured process, have also been inspected for bondline thickness by this procedure. During the curing and bonding process, the laminating resin and adhesive resin combine to such a degree that a finite bondline cannot be defined. Therefore, in joints of this type, the distance between the metal adherend and the centerline of the adjacent ply is measured. From this, an effective bondline is determined for use in analysis procedures and data correlation.

3.2.5 NDE Data Analysis and Comparison

Utilization of ultrasonic, radiographic, microwave, and visual inspection methods permitted the establishment of the relative merits of each discipline. As a result the elimination of some disciplines may be possible with the incorporation of other disciplines.

As was stated previously the ultrasonics discipline presented what is believed to be the most useful data. The possibility of expansion or refinement of the technique into a more accurate qualitative evaluation system is most promising. At least two factors which must be resolved or investigated before the refined system could be established are:

- o Rigid control of ultrasonic beam transmitted by the transducers; i.e., energy level, frequency, etc.
- o Development of more accurate calibration system for bondline joints with variance in cross-section; i.e., step joints.

Microwave investigation did not provide sufficient data to prove or disprove the merits of microwave testing. It is recommended that future analysis be made with this system using a finer control of the specimen vibration and that a device which measures the dielectric constant of the bond joint in-process be included in future investigations.

The capability of radiography was proven. However, it may not be necessary in future investigations of this sort. The defects detected were not of sufficient magnitude to warrant rejection by current standards. Therefore, it could be assumed that the joints can be sufficiently evaluated with the other disciplines.

As a result of this investigation the following recommendations for future work are made:

- Radiography be limited to sampling only.
- The dielectric constant device be utilized.
- Ultrasonic testing be expanded to more definitive data.

All measurable variables which do not deteriorate the joint strength should be determined then compensated for in the non-destructive testing evaluation data. Once this is done effective joint quality data analysis can be accomplished.

3.3 MATERIAL ACQUISITION AND ASSESSMENT

During the course of the program, it was necessary to produce supporting material property data; although, to a great extent, reliance was placed upon composite materials data generated by the Lockheed-Georgia Company during conduct of contractual and in-house developmental programs. Data from related industry programs were also used, where applicable, to reduce the amount of required testing. Sufficient information exists on the composite materials and laminate orientations being used for this program to establish complete and dependable constant-life diagrams for the basic material. Spot check tests were performed on the composite materials used in this program to assure compatibility with available data.

The adherend materials used in this program fall into two general categories: metallic and composite. The basic uniaxial stress-strain data and fatigue properties (S-N curves) were required for all materials in order to provide properties for the analysis methods. These material properties were obtained from statistically significant data so as to remove these variables from the large number of other variables which will be evaluated during the program.

The stress-strain and basic fatigue behavior of the metallic materials were obtained from Military Handbook 5. Additional data, such as the thermal coefficient of expansion, Poisson's Ratio, and shear modules for the metallic materials, were obtained from Military Handbook 5 and Aerospace Structural Metals Handbook.

The basic lamina stress-strain and fatigue behavior of the boron composite materials were obtained primarily from the data being generated on Air Force Contract F33615-5257, "Structural Airframe Application of Advanced Composite Materials", at General Dynamics/Ft. Worth. Static and fatigue specimens were fabricated and tested to assure material quality and compatibility with the General Dynamics data.

Two other composite materials were included in the program evaluation but only to a very limited extent. These were graphite-epoxy and glass-epoxy.

Since these materials were included in consideration of the effects of variations in adherend materials and not to develop basic fatigue phenomena, as with the boron material, a high degree of confidence was not required for these materials. As a result, the level of activity associated with the graphite-epoxy and glass-epoxy materials are significantly less.

3.3.1 Acquisition of Tape Materials

Each of the composite material systems was purchased in the B-staged, prepreg tape form. Pertinent information related to materials and their acquisitions are given below.

Boron filaments were produced by Hamilton Standard and furnished to the prepreg company by the Air Force for use in connection with this program. The initial deliveries of tape material, through October 1970, were produced by Narmco Materials Division of Whittaker Corporation. Subsequent deliveries were made by Avco Systems Division, Avco Corporation. All boron tape material consisted of the same resin system and was supplied to the same material specification, FMS 2001A dated 21 April 1967. The delivery of boron tape material, quantities and identification are as shown below:

Feet of Tape Delivered	Receipt Date	Batch/Roll Nos.
1050	2 April 1970	381/74, 75, 76
1950	9 July 1970	392/89 thru 94
193	2 Oct 1970	385/6
1440	2 Oct 1970	408/35, 38, 39, 40
1450	13 Jan 1971	42/1, 2, 3, 4
600	20 Jan 1971	42/5, 6

The concluding material required for evaluation under the contract was a small quantity each of unidirectional fiberglass/epoxy and unidirectional graphite/epoxy. The total amount required was approximately 20 square feet of material. The fiberglass selected for this phase of the investigation was 3M Company's SP 1002 S glass (Batch L19, Roll W329) and the graphite material was Fiberite HyE 1311B (Lot No. 1088, Roll No. 1).

3.3.2 Acceptance and Process Control Assessment

Material acceptance and in-process material evaluation specimens are tested in accordance with standard Lockheed-Georgia quality control specimen configurations and test procedures for composite materials. These methods are compatible with procedures used throughout the industry and include flexure and short beam shear evaluations of 15 ply unidirectional panels.

Fabrication details of all quality control and material acceptance panels and laminates for joints adherends are included in Appendix A, Table A1 - Composite Panel Identification, which provides a cross reference for these panels. In summary a listing of quality control panel numbers, material acceptance panel numbers, material batch numbers, and data usage is defined in Table II.

3.3.2.1 Boron Epoxy - A summary of results obtained from both the acceptance and process control testing and the standards to which the results were compared are presented in Table III, on the basis of batch numbers. The data averages in each instance includes all the different specimens and panels which were evaluated from the specified batch. Other pertinent information related to the quality of the materials of each batch is discussed below.

Batch 381: The observed failures which occurred on the initial longitudinal flexure specimens, Nos. 54949-1 and -2, had a very unusual appearance in that, rather than the clean, regular breaks normally associated with longitudinal flexure tests, the specimens exhibit extensive delaminations extending from the break as much as one-fourth of the distance to the ends of the test specimen. For this reason an additional panel No. 56136, was fabricated and tested for 0° flexure strength and based on the results of these two panels batch 381 was considered acceptable. Batch 381 continued to exhibit good quality through the test results obtained subsequently.

TABLE II

BORON-EPOXY ACCEPTANCE AND CONTROL PANEL JUSTIFICATION

Panel or Q.C. Number	Material Batch No.	Data Usage
54959	381	Material Acceptance
56136	381	Recheck Material Acceptance
56591	381	Q. C. Check on Material Verification
57836	381	Q. C. Check on Joint Panel
58392	381	Q. C. Check on Joint Panel
59038	392	Material Acceptance
59579	392	Material Acceptance
59813	381	Q. C. Check on Joint Panel
60365	381	Q. C. Check on Joint Panel
60581	392	Q. C. Check on Joint Panel
61039	392	Q. C. Check on Joint Panel
61198	392	Q. C. Check on Joint Panel
61588	392	Q. C. Check on Joint Panel
61873	408	Material Acceptance and Q. C. Check on Joint Panel
62844	385	Material Acceptance and Q. C. Check
63195	408	Q. C. Check on Joint Panel
63652	408	Q.C. Check on Joint Panel
64078	408	Q. C. Check on Joint Panel
64382	408	Q. C. Check on Joint Panel
64845	42	Material Acceptance
65418	42	Q. C. Check on Joint Panel
65745	42	Q. C. Check on Joint Panel
66858	42	Q. C. Check on Joint Panel
67326	408	Q. C. Check on Joint Panel
69552	43/3	Q. C. Check on Joint Panel
70085	43/6	Q. C. Check on Joint Panel
70085	45/11	Material Acceptance

TABLE 41

BORON-EPOXY ACCEPTANCE AND QUALITY CONTROL DATA

Material Batch No.		Longitudinal Flexure	Transverse Flexure	Horizontal Shear	Tensile Coupon $[0,90,0,90]_s$	Tensile Coupon $[0,0,90,0]_s$	Tensile Coupon $[0,\pm45,0]_s$
Acceptance Standard		225	13.0	13.0	90		
381	Avg.	247	14.3	14.6			
	Max.	268	16.2	15.3			
	Min.	237	12.7	13.6			
	Tests	23	17	18			
392	Avg.	247	12.7	13.7			
	Max.	268	15.1	14.9			
	Min.	235	10.8	12.0			
	Tests	21	21	21			
385	Avg.	259	12.8	14.0			
	Max.	268	13.6	14.1			
	Min.	247	12.2	13.8			
	Tests	3	3	3			
408	Avg.	260	11.8	13.6	85.6	138	105
	Max.	281	13.3	15.4	94.0	141	108
	Min.	231	9.6	10.6	73.2	136	103
	Tests	24	24	24	5	3	3
42	Avg.	264	12.5	14.9			
	Max.	282	13.9	15.4			
	Min.	233	11.4	13.7			
	Tests	21	21	21			

TABLE III (Continued)

Material Batch No.		Longitudinal Flexure	Transverse Flexure	Horizontal Shear	Tensile Coupon $[0,90,0,90]_s$	Tensile Coupon $[0,0,90,0]_s$	Tensile Coupon $[0,\pm45,0]_s$
43	Avg.	268	13.0	14.6			
	Max.	285	14.7	15.1			
	Min.	253	11.3	13.9			
	Tests	6	6	6			
45	Avg.	278	15.6	15.8			
	Max.	280	16.3	16.0			
	Min.	275	15.2	15.6			
	Tests	3	3	3			

Batch 392: The initial results for Batch 392 were slightly below standard, panels 59038 and 59579, but tensile coupons having 0°/±45° fiber orientation and fabricated at the same time developed 100 ksi indicating material acceptable for joint fabrication. Subsequent Q.C. tests have shown improved values for this material with the exception of transversed flexure which frequently are below standard. Control specimens of all bonded joint panels were evaluated for static strength prior to specimens being fatigue tested, as a conditional requirement for accepting this batch of material

Batch 385: This batch consisted of a single roll of material and represented a partial shipment with Batch 408. The data representing the quality of this material also indicated a low transverse flexure strength.

Batch 408: This batch was the last lot of material supplied by Narmco. Transverse flexure strengths continued to be below requirements although the horizontal shear and 0° flexure strengths were adequate for most specimens tested. The most severe variations observed for the program were detected in two panels of Batch 408 in which the transverse flexure values averaged 9.9 and 10.4 KSI. For the most part, however, the below-standard values have been near or above 12 KSI. Again, as a precaution all bonded joint panels were evaluated for static strength prior to evaluating specimens for fatigue capability. Specimens which exhibited low laminate properties were rejected and replacement specimen fabricated. Due to the very low initial results, No. 61873, additional tensile coupon tests were also performed on 0°/90° and 0°/±45° panels in conjunction with the standard Q. C. flexure specimens. Although the transverse flexure results were slightly below specification requirements (13 ksi), these laminates were used for joint specimen fabrication based on the acceptable results obtained from the tensile coupons.

Panels represented by Q.C. specimen numbers 64382 were rejected for use in the lap joint specimens. However, one panel was used for fabrication of the Configuration C specimens (Appendix C) based on acceptable tensile strength of these specimens.

Batch 42: Initial tests on Batch 42, the first batch supplied by Avco, show that it is approximately equal in quality to the material received from Narmco. It should be noted that the transverse flexure strength is marginal as it was for the last batch received from Narmco, Batch 408.

Batch 45: The test results for these panels are, for the most part, consistent with previous determinations of a similar nature. An exception is noted for Batch 45, roll 11 which exhibited significantly higher transverse flexure and horizontal shear strengths than for other batches of material evaluated under this program.

3.3.2.2 Graphite Epoxy and Glass Epoxy - Due to the small amount of laminate material required for the fiberglass and graphite bonded joint specimens, the unidirectional 15-ply quality control laminates fabricated concurrent with the joint laminates also served for acceptance of the respective materials. Test results obtained from these specimens were acceptable, and were comparable to values obtained by other investigators. Tabulated results for these materials are listed in Table IV.

3.3.3 Material Properties Verification

To take advantage of the material properties data available from outside sources, it was first necessary to verify that the materials being received were of the same quality. A comparison was made between the verification tests recorded in Appendix B and data published in AFML-TR-69-101, Volumes IV and V, "Structural Airframe Application of Advanced Composite Materials". This was done with static and fatigue properties for (0,90,0,90)s and (0,±45, 0)s laminates and the results are summarized in Appendix B1 for the individual static and fatigue property tests and in Figure 40 for the fatigue characteristics. The materials were judged to be sufficiently consistent for accepting the data base. The greatest variance is observed for the 0°/±45° fatigue testing at R = -1.0. This difference can be explained by the dissimilarity of cyclic rates during test, i.e., the General Dynamics data was developed at 1800 Hz and the Lockheed tests were made at 900 Hz. Another discrepancy is noted in the 0-90 tensile requirements but this difference was attributed to the fact that the requirement is set for sandwich beam tests which generally gives higher values than coupons.

TABLE IV

RESULTS OF CONTROL TESTING FOR GRAPHITE-EPOXY AND GLASS-EPOXY LAMINATES

Specimen No.	Longitudinal Flexure Strength (KSI)	Horizontal Shear Strength (KSI)	
74169-1	187.5	14.4	Fiberglass
-2	170.3	14.0	
-3	170.9	14.1	
Average	176.2	14.2	
74169-4	156.8	11.4	Graphite
-5	162.0	11.3	
-6	155.3	11.1	
Average	158.0	11.3	

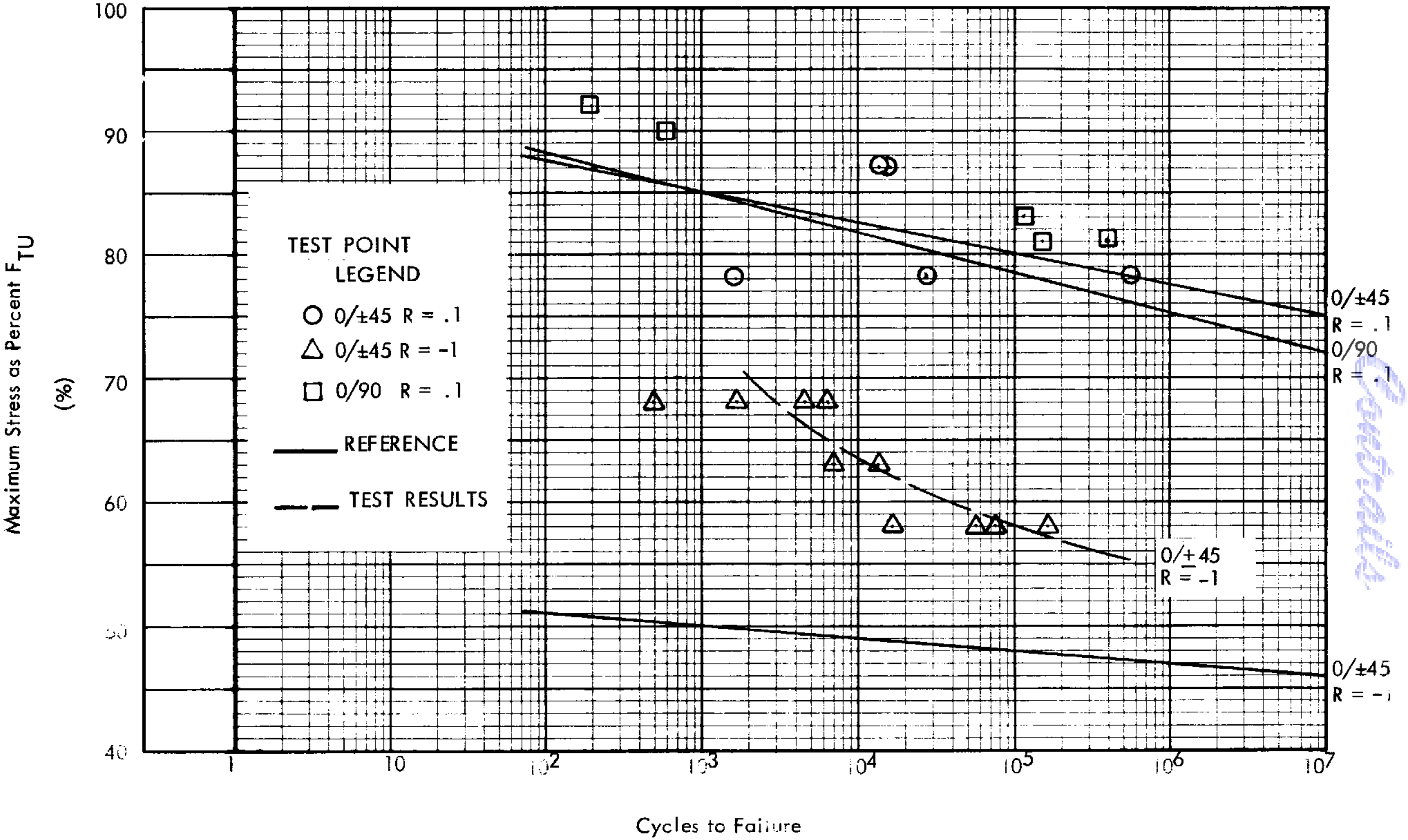


FIGURE 40 COMPARISON OF FATIGUE DATA FOR MATERIAL VERIFICATION

SECTION IV
TEST PROGRAM

4.1 GENERAL

The primary objectives of the test program were to develop improved methods for conducting fatigue design and testing of composite structural joints. Both bonded and mechanical joints were evaluated. Bonded and mechanical joint materials consisted of boron-epoxy, 7075-T6 aluminum, 6Al-4V titanium, graphite-epoxy and fiberglass-epoxy. The test specimens consisted of composite-to-composite and and composite-to-metal joints fabricated by both adhesive bonding and mechanical fastener techniques. A variety of joint designs were selected and were representative of joints that would be commonly used in aircraft structures. Specimen testing was accomplished in three main phases which were related to specimen size as follows.

Phase I - Small scale laboratory joint specimens, one-inch wide. These specimens constituted the major portion of the test program.

Phase II - Medium scale joint specimens, two inches and three inches wide.

Phase III - Large scale joint specimens, ten inches wide. Only bonded joint specimens were tested in this phase of the test program.

The complete test program is outlined in Tables V thru X Detailed test results and specimen parameters are included in tabulated form in Appendix B. Detail drawings of all specimens are included in Appendix C. All the unbalanced specimens were supported during static and fatigue testing in order to provide more consistent and representative test data.

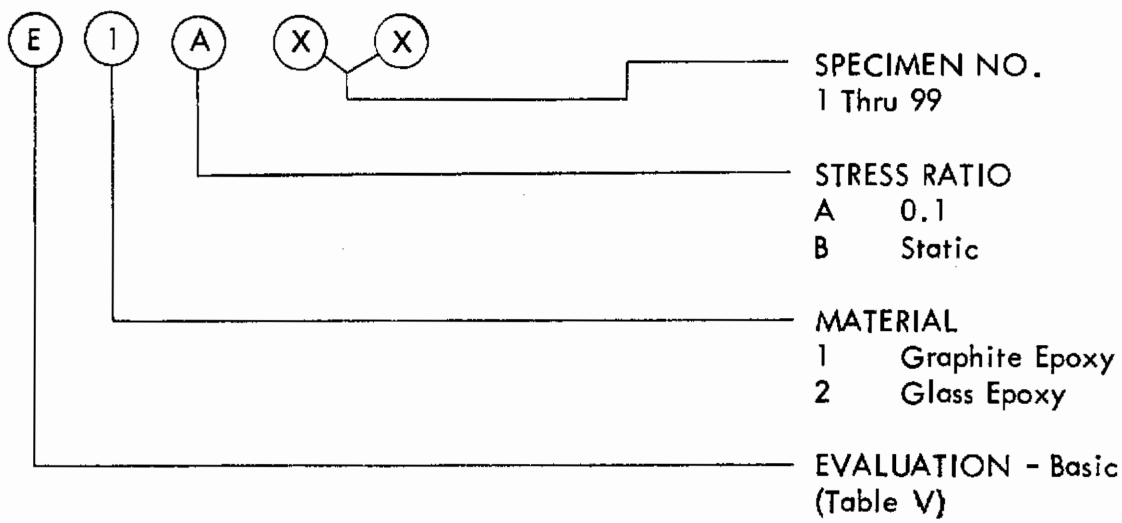
TABLE V

ALTERNATE ADHEREND MATERIALS EVALUATION
GRAPHITE EPOXY AND GLASS EPOXY COMPOSITES

COMPOSITE MATERIAL	JOINT CONFIGURATION	FATIGUE TESTS AT R = 0.1	STATIC CONTROLS
Graphite Epoxy	"A"	10	3
Glass Epoxy	"A"	11	3
TOTALS		21	6

SPECIMEN IDENTIFICATION

EVALUATION - ALTERNATE ADHERENT MATERIALS



Specimen E1B01 identifies the number one static test specimen for basic evaluation of graphite epoxy.

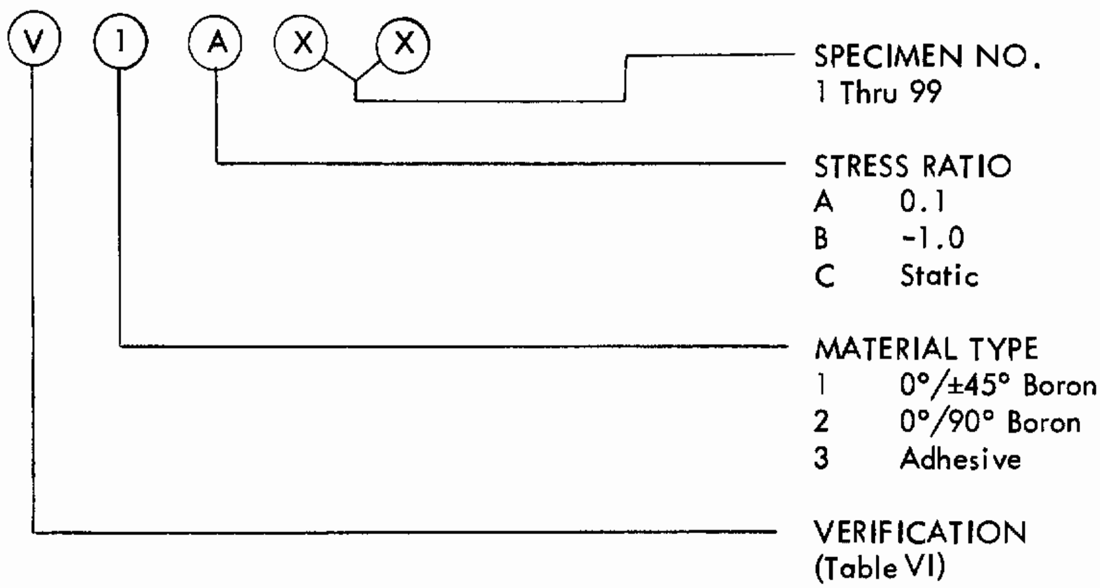
TABLE VI

MATERIAL VERIFICATION AND CHECKOUT TESTS

MATERIAL		FATIGUE TESTS		STATIC CONTROLS
TYPE	SPECIMEN	R = 0.1	R = -1.0	TENSILE STRENGTH
0°/±45° N 5505	Coupon	5	10	3
0°/90° N 5505	Coupon	5		3
Program Adhesives	Single Lap Joint	15		5
TOTALS		25	10	11

SPECIMEN IDENTIFICATION

VERIFICATION OF MATERIALS



Specimen V1B04 identifies the number 4 fatigue specimen to be tested at a stress ratio of R = - 1.0 for verification of material strength for a 0°/±45° boron laminate.

TABLE VII

BONDED JOINTS EVALUATION

PHASE I - SMALL SCALE SPECIMENS

JOINT CONFIGURATION	"A"								"B"					"C"		"D"				TOTALS	
ADHEREND COMBINATIONS	Boron/Ti				Boron/Boron		Boron/Al		Boron/Ti			Boron/Al		Boron/Ti		Boron/Ti		Ti/Boron			
LOADING STRESS RATIO	0.1	-1.0	+10	(ST)	0.1	(ST)	0.1	(ST)	0.1	10	(ST)	0.1	(ST)	0.1	(ST)	0.1	(ST)	0.1	(ST)	FAT.	(ST.)
PROGRAM TASKS	NUMBER OF SPECIMENS																				
BASELINE DATA																					
1. 0°/±45°, Std.	22	22	26	(14)	14	(4)	10	(3)	10	10	8	10	(3)	10	(3)	11	(3)	10	(3)	155	41
2. 0°/90°, Std.									10		(3)									30	9
PLY STACKING EFFECTS																					
1. ±45°/0°, Std.	10			(6)	10	(3)			10		(3)									30	12
LAP LENGTH EFFECTS																					
1. 0°/±45°, Short Lap	10			(4)	7	(3)	5	(3)	10		(3)									32	13
2. 0°/±45°, Long Lap	12		10	(9)																22	9
THICKNESS EFFECTS																					
1. 0°/±45°, Added Plies	10			(3)																10	3
2. 0°/90°, Added Plies	10			(4)																10	4
DEGRADATION OF JOINT,																					
0°/±45°, Std.	19		12	(9)					10		(3)									41	12
SECOND ADHESIVE	Not Done			(3)	10	(3)														10	6
CUMULATIVE DAMAGE STUDY																					
0°/±45°, Std.																					
1. Realistic Load Spectrum	10																			10	
2. Block Load Spectrum	11																			11	
PRELOAD/LOW CYCLE																					
0°/±45°, Std	14																			14	
TOTALS																				375	109

TABLE VII (CONTINUED)

SPECIMEN IDENTIFICATION

BONDED JOINTS – PHASE I

I A 1 1 1 A X X

SPECIMEN NO.
1 Thru 99

STRESS RATIO
- A 0.1
- B -1.0
- C 10
- D Static
- E Test Setup
- F Spectrum – Block
- G Spectrum – Realistic

SPLICE MATERIAL
- 1 Boron/Ti
- 2 Boron/A1
- 3 Boron/Boron
- 4 Ti/Boron

ORIENTATION
- 1 0/±45
- 2 0/90

PHASE TASK
- 1 Baseline Data
- 2 Ply Stacking
- 3 Lap Length – Short
- 4 Thickness
- 5 Degradation
- 6 Second Adhesive
- 7 Cumulative Damage
- 8 Preload/Load
- 9 Lap Length – Long

JOINT CONFIGURATION
- A Single Splice Butt
- B Single Scarf Butt
- C Surface to Under Structure
- D Double Splice Butt

PROGRAM PHASE
(Table VII)

Specimen number IB121A08 identifies a specimen for Phase I with a single scarf butt configuration for generating base line data on 0°/90° specimen joined to titanium and tested at a stress ratio of R = +0.1. The specimen number within this set is number 8.

TABLE VIII

BONDED JOINTS EVALUATION
PHASE II - MEDIUM SCALE SPECIMENS

JOINT CONFIGURATION	"A"			"B"			TOTALS	
ADHEREND COMBINATIONS	Boron/Ti(Al*)			Boron/Ti				
LOADING STRESS RATIO	0.1	10	(ST)	0.1	10	(ST)		
PROGRAM TASK	NUMBER OF SPECIMENS						FAT.	(ST)
BASELINE DATA	15*	5	10**	10*	6	7**	36	(17)
DEGRADATION OF JOINT PROPERTIES	10*						10	
LAP LENGTH EFFECTS								
1. Short Lap				5		(3)	5	(3)
2. Long Lap	5	5	(6)				10	(6)
CUMULATIVE DAMAGE EVALUATION FOR BLOCK SPECTRUM LOADING	[5]						5	
					TOTALS		66	26

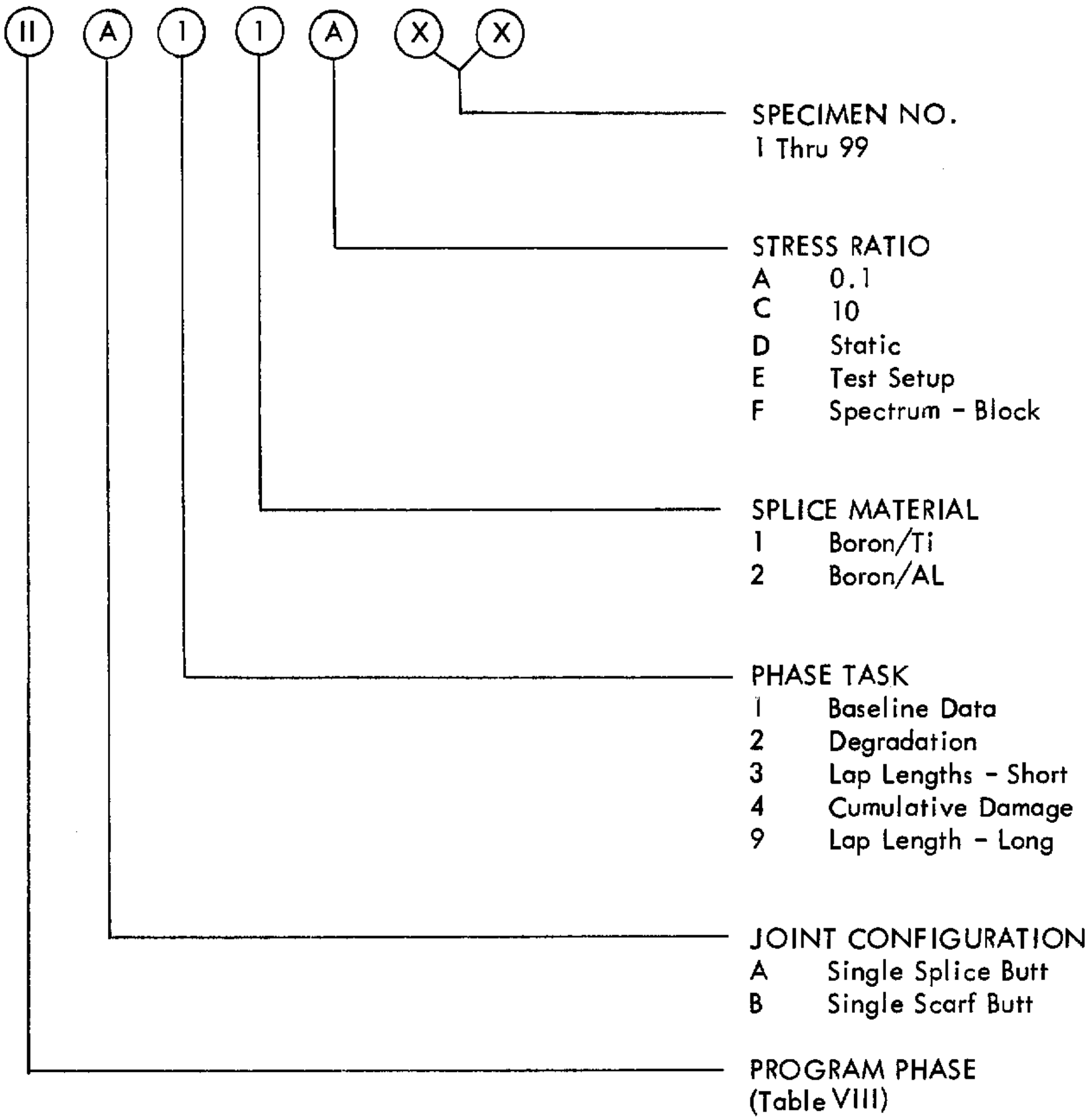
* Five (5) specimens from each of the indicated groups are to have boron composite - aluminum adherends.

** Three (3) specimens aluminum.

TABLE VIII (CONTINUED)

SPECIMEN IDENTIFICATION

BONDED JOINTS - PHASE II



Specimen number IIA32C02 identifies a specimen for Phase II with a single splice butt configuration for evaluation of overlap length with aluminum splice adherend tested as a stress ratio of R = +10. The specimen number within this set is number 2.

TABLE IX

BONDED JOINTS EVALUATION
PHASE III - LARGE SCALE SPECIMENS

JOINT TYPE	"A"				"B"			TOTALS	
ADHERENDS	Boron/Ti (Al*)				Boron/Ti				
STRESS RATIO	0.1	-1.0	10	(ST)	0.1	-1.0	(ST)	FAT.	(ST.)
PROGRAM TASK	NUMBER OF SPECIMENS								
AXIAL LOADING FOR LARGE JOINTS	2*	2*	1	(2*) 8**	1	1	(3**)	7	13
COMPLEX LOAD EVALUATION FOR BLOCK SPECTRUM CYCLING	[1]				[1]			2	
	TOTALS							9	13

* One (1) specimen of each group indicated is to have boron composite - aluminum adherends.

** 1" wide static specimens.

TABLE IX (CONTINUED)

SPECIMEN IDENTIFICATION

BONDED JOINTS - PHASE III

III A 1 1 A X

SPECIMEN NO. (X)
1 Thru 9

STRESS RATIO (A)

A	0.1
B	-1.0
C	10
D	Static
E	Test Setup
F	Spectrum - Block

SPLICE MATERIAL (1)

1	Boron/Ti
2	Boron/Al

PHASE TASK (1)

1	Axial Loading
2	Complex Loading

JOINT CONFIGURATION (A)

A	Single Splice Butt
B	Single Scarf

PROGRAM PHASE (III)
(Table IX)

Specimen number IIIA11B2 identifies a specimen for Phase III with a single titanium splice plate butt joint configuration for evaluation of axial loading a stress ratio of R = -1.0. The specimen number within this set is number 2.

TABLE X

MECHANICAL JOINTS EVALUATION
SMALL AND MEDIUM SCALE SPECIMENS

PROGRAM SECTION	PHASE I - SMALL SPECIMEN								PHASE II - MEDIUM SPECIMEN				
JOINT CONFIGURATION	"E"						"F"		"E"				
JOINT ELEMENTS	Boron/Ti				Boron/Boron		Boron/Al		Boron/Ti			TOTALS	
LOADING STRESS RATIO	0.1	-1.0	10	(ST)	0.1	(ST)	0.1	(ST)	0.1	10	(ST)	FAT	(ST.)
PROGRAM TASKS	NUMBER OF SPECIMENS												
BASELINE DATA													
1. 0°/±45°, Ti Inserts	17	10	3	(5)	5	(3)	11	(3)	10		(6)	56	17
2. 0°, Ti Inserts					10	(3)						10	(3)
STACKING ORDER -													
0°/±45°, ±45° Buildup	5	5		(3)								10	3
EDGE DISTANCE													
1. 0°/±45°, Ti Inserts	5			(3)								5	(3)
2. 0°/±45°, ±45° Buildup	6			(3)								6	(3)
THICKNESS EFFECTS													
1. 0°/±45°, Ti Inserts	5			(3)			5	(3)				10	(6)
2. 0°/±45°, ±45° Buildup	5			(3)								5	(3)
PRELOAD/LOW CYCLE													
0°/±45°, Ti Inserts	10											10	
CUMULATIVE DAMAGE													
0°/±45°, Ti Inserts													
1. Realistic Spectrum	5								5			10	
2. Block Spectrum	7								5			12	
PINNED JOINTS/EDGE DISTANCE EVALUATION													
1. $(e/D)_1$, Ti Inserts	5			(3)								5	(3)
2. $(e/D)_2$, Ti Inserts	5			(3)								5	(3)
3. $(e/D)_1$, ±45° Buildup	5			(3)								5	(3)
									Sub Totals			149	47
									TOTALS				

TABLE X (CONTINUED)

SPECIMEN IDENTIFICATION

MECHANICAL JOINTS - PHASE I & II

I E 1 1 1 A X X

SPECIMEN NO.
1 Thru 99

STRESS RATIO

A	0.1
B	-1.0
C	10
D	Static
E	Test Setup
F	Spectrum - Block
G	Spectrum - Realistic

JOINT ELEMENTS

1	Boron/AL
2	Boron/Boron

TEST VARIABLE
1 Thru 3
(orient., e/D, & Ti inserts)

PHASE TASK

1	Baseline Data
2	Stacking Order
3	Edge Distance
4	Thickness Effects
5	Preload/Low Cycle
6	Cumulative Damage
7	Pinned Joints - E/D Eval.

JOINT CONFIGURATION

E	Single Splice Butt
F	Surface to Under Structure

PROGRAM PHASE

I	Small Scale Spec.
II	Medium Scale Spec. (Table X)

Specimen number IE311A03 identifies a specimen for Phase I with a single butt configuration for evaluation of fastener edge distance in a composite containing titanium skins joined to an aluminum splice plate. The specimen will be tested at a stress ratio of R = +0.1 and is specimen number 3 within the set of specimens.

4.2 GENERAL TEST EQUIPMENT

4.2.1 Static Test Machines

Static tests were performed in either a Riehle or Baldwin universal testing machine. The Riehle had a load capacity of ±30,000 pounds and the Baldwin ±50,000 pounds. Teplin or Instron grips, attached to the machine with spherically seated adaptors, were used for the tensile tests. Self-aligning hydraulic grips were used for the compression tests. The testing machines were calibrated to appropriate ASTM Specifications using standards traceable to the National Bureau of Standards.

4.2.2 Fatigue Test Machines

The majority of fatigue tests at a stress ratio, R, of +0.10 were performed in Lockheed designed fatigue machines that operate on the resonant principal. A sketch of one of these machines is illustrated in Figure 41. Each machine has flat grips which will accept specimens up to three inches wide and up to 18 inches in length. One grip is attached to an electrical resistance type strain gage load transducer and the other grip to the test machine base. Signal from the transducer is directed to a dynamic load analyzer which includes calibrated potentiometers, a carrier amplifier, and an oscilloscope. In operation, the carrier amplitude is set by the calibrated potentiometers to a value proportional to the desired load. The carrier is then amplitude modulated by the transducer signal until a null is achieved on the carrier amplitude, and the oscilloscope is used to display the null condition. Maximum, minimum, and mean loads are monitored in this manner. Each machine system is statically calibrated to an accuracy of ±0.5 percent of load. A variety of transducers having different full-scale load capacities are available. However, the machines are limited to a maximum load of 15,000 pounds. Operating frequency range of the machines is 20 to 40 cycles per second and the operating frequency is established by the speed of the variable speed motor. The dynamic load at a given frequency is a function of the variable eccentric setting, variable mass of the machine, and position of the grips in the machine. Mean load is applied by a hydraulic

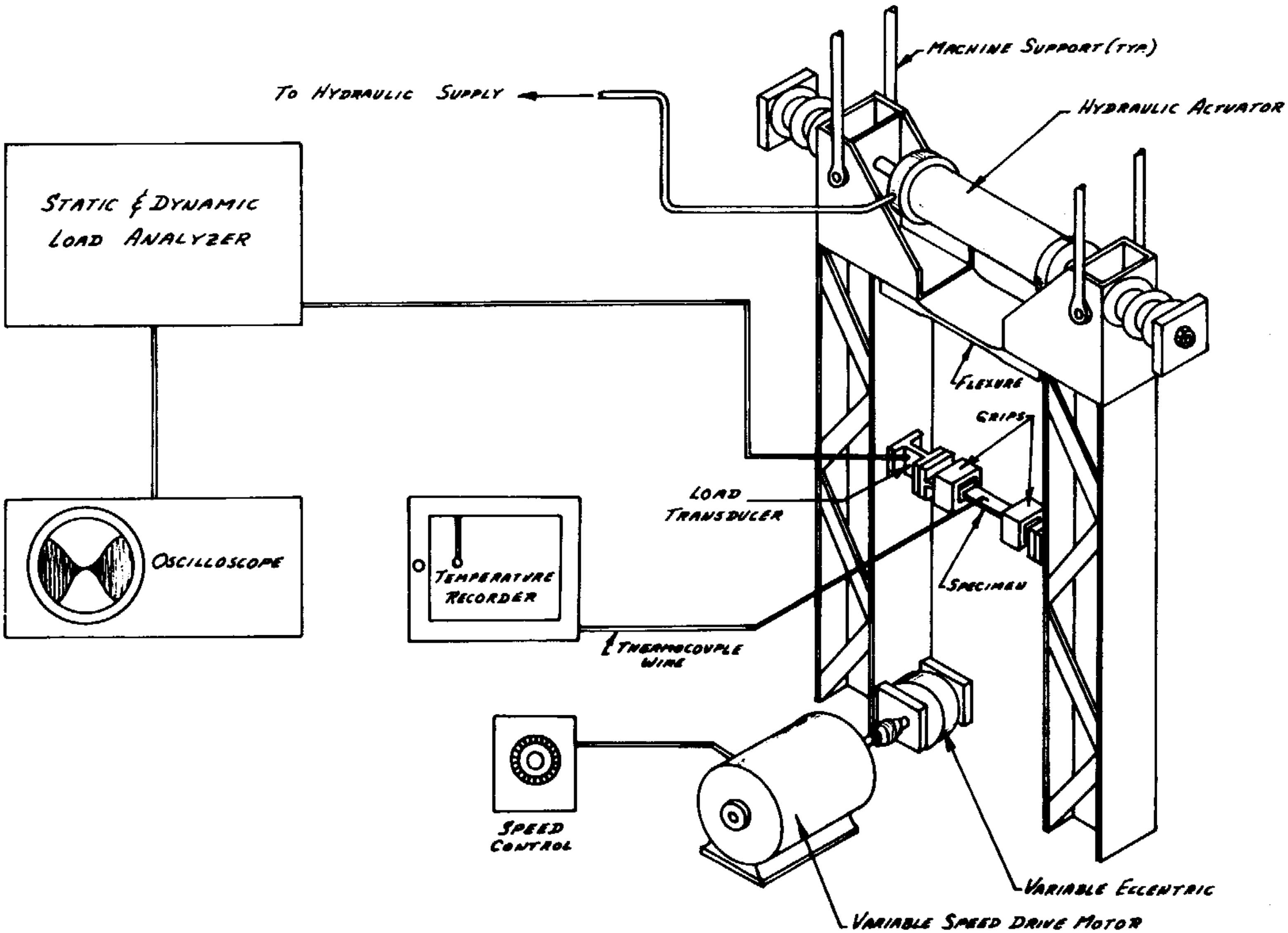


FIGURE 41 - RESONANT FREQUENCY FATIGUE MACHINE

actuator on most of the machines, although some have a mechanical screw for this purpose. Each machine has an automatic cut-off system which stops the motor and cycle counter upon specimen failure.

Fatigue tests at stress ratios of R = -1.0 and R = +10.0 were performed in electro-hydraulic servo controlled testing machines, Models 301 and 303, manufactured by MTS System Corporation. These are direct force-type machines having full scale fatigue load capacities of ±30,000 pounds and ±100,000 pounds respectively. The lowest load range is 5,000 pounds on the Model 301 and 10,000 pounds on the Model 303. Each machine is equipped with MTS Alignomatic grips. Photographs of the testing machines are presented in Figure 42 and Figure 43. The electro-hydraulic servo controlled closed loop system provides infinite control of test frequency from approaching zero to limits of system response which is a function of hydraulic supply capacity, the servo valve, and test specimen compliance. Each MTS system was statically calibrated to an accuracy of ±0.2% of load range.

4.2.3 Programming Equipment

The programming equipment used for the block loading and realistic spectrum testing was manufactured by MTS Systems Corporation. It can be used to control either of the MTS fatigue testing machines and a photograph of the Model 301 machine with the computerized programming equipment is shown in Figure 42 with the 30,000 pound MTS machine. The hardware consists of a PDP-8L computer, a model 33 ASR teletypewriter set, and an MTS 433.11 interface unit. The computer is prepared by means of an appropriate software program and test load information is input either manually on the teletype keyboard or by tape format on the tape reader. The digital format is then converted to a series of voltage commands by a digital to analogue converter located in the interface unit. Each command voltage is applied to the servo valve controller on the testing machine console and load is applied to the specimen. The load cell in the machine reacts the specimen load and a feedback voltage is created. This voltage is fed back to the interface unit where it is converted from an analogue signal to a digital value. The computer than screens and compares the digital command and feedback to verify that the specimen is subjected to the correct loadings. If any variations exist between command and feedback

FIGURE 42 - MODEL 301 MTS MACHINE - 30,000 POUNDS

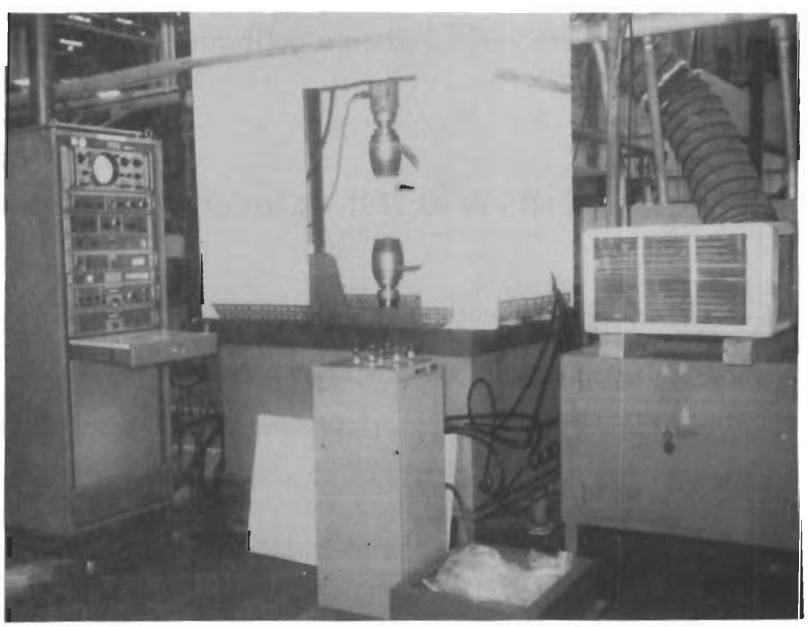


FIGURE 43 - MODEL 303 MTS MACHINE - 10,000 POUNDS

the program automatically halts. Accuracy of the programming system was found to be within ±0.5% of selected load range.

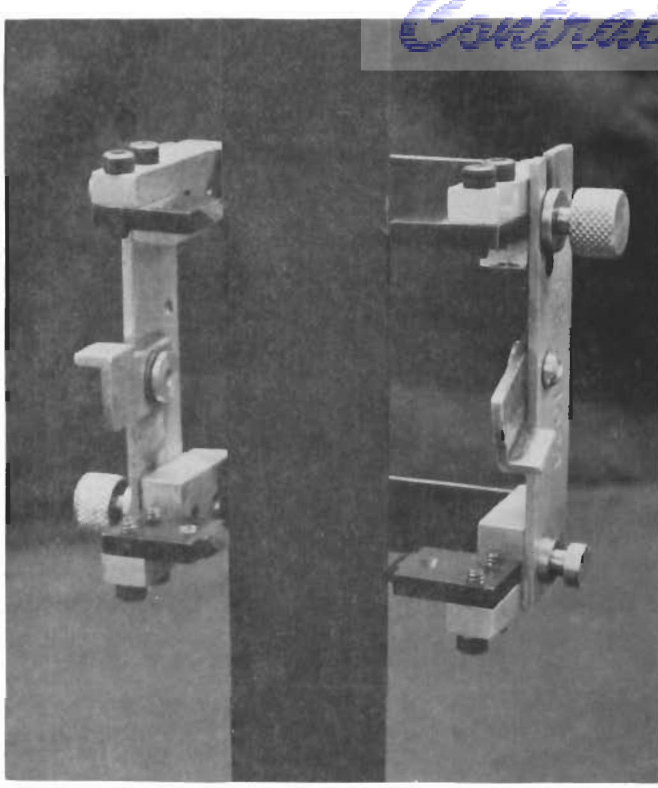
4.2.4 Instrumentation and Recording Equipment

Environmental and specimen temperatures were measured by copper-constantan thermocouples connected to Honeywell multichannel strip-chart recorders. Since it was necessary to monitor temperatures at regular intervals throughout the duration of a test, each recorder was equipped with an automatic on/off control device. This device was set to switch the recorder on for approximately thirty seconds at intervals ranging from 15 minutes to 4 hours depending upon test duration. Resistance strain gages, types FAE-03-12S13 and FAE-06N-12S13 were used on the strain survey specimens and strains were recorded on either a Baldwin strain indicator or a B&F Strain Data Acquisition System, Model SY156. Basic composite material modulus and joint stiffness were determined with an SR-4 frame extensometer equipped with strain gaged leaves as shown in Figure 44. A gage length of 2.0-inches was used for the bonded joints and a 3.25-inch gage length was used for the mechanically fastenered joints. Strain was recorded on the x-axis of an autographic recorder on the universal testing machine. During cumulative damage testing the specimen loads were monitored on a calibrated Clevite-Brush strip chart recorder, Mark 280.

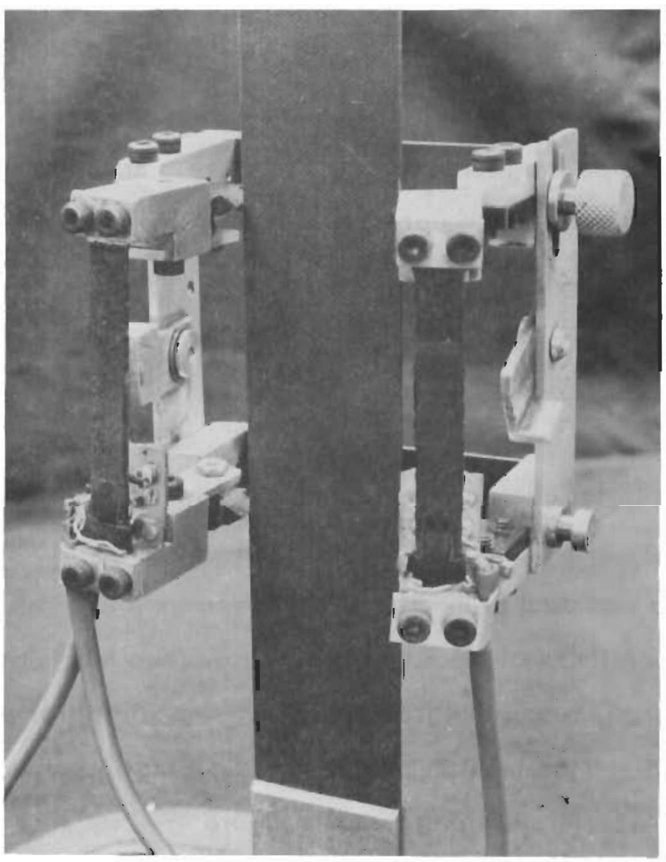
4.3 GENERAL TEST REQUIREMENTS AND TEST METHOD APPROACH

The critical dimensions of each specimen were measured and recorded along with its unique serialization. All tests were conducted at a room temperature of 72±5° Fahrenheit and any increase in specimen temperature was restricted to +10°F unless stated otherwise elsewhere in the report.

The fatigue tests were conducted at a variety of cyclic rates which were generally dependent upon stress level and stress ratio. However, the maximum frequency was limited to 1800 cycles per minute. Actual stress levels, stress ratios, and cyclic rates are given for each fatigue test in the test data tables, Appendix B.



Extensometer on Specimen



Strain Gage Leaves On
Extensometer

FIGURE 44 – EXTENSOMETER SET-UP FOR
MEASURING SPECIMEN STRAIN

4.4 MATERIAL VERIFICATION TESTS

4.4.1 Specimen Configurations

The configuration of the static tensile and axial-load fatigue test specimen at R+0.1 is shown in Figure 45. The axial-load, R = -1.0 fatigue test specimen configuration is shown in Figure 46 . Two tab materials were evaluated; half of the R = -1.0 fatigue specimens were fabricated with fiberglass tabs and the other half with aluminum tabs. The specimen configuration used for the adhesive evaluation tests is as shown in Dwg. No. 7226-13021A, but with titanium adherends and splice plate. Specimen identification information is given on Table VI.

4.4.2 Test Procedure and Results

Tests were conducted in accordance with Table VI, and the test data are reported in Appendix B, Table B1. The basic material static test specimens were instrumented with three strain gages as shown in Figure 45. A 2.0-inch gage-length extensometer was attached to each specimen and load was applied incrementally to failure. Strain gage output was recorded at each load increment and the extensometer output was plotted against load on an autographic recorder. Good correlation was obtained between the measured results of the two systems as illustrated in the response curve of Figures 47 and 48.

Constant amplitude axial-load, R = +0.10 fatigue tests were conducted in Lockheed designed resonant testing machines, Figure 41 . One thermocouple was bonded to each specimen at the center of its length and was used to monitor specimen temperature for the duration of the test. Ambient temperature was measured by a thermocouple bonded to a piece of boron-epoxy composite material, suspended from the testing machine in the proximity of the test specimen. Typical fatigue failures for the R = +0.10 fatigue specimens with 0°/+45 and 0°/90 fiber orientations are presented in Figure 49.

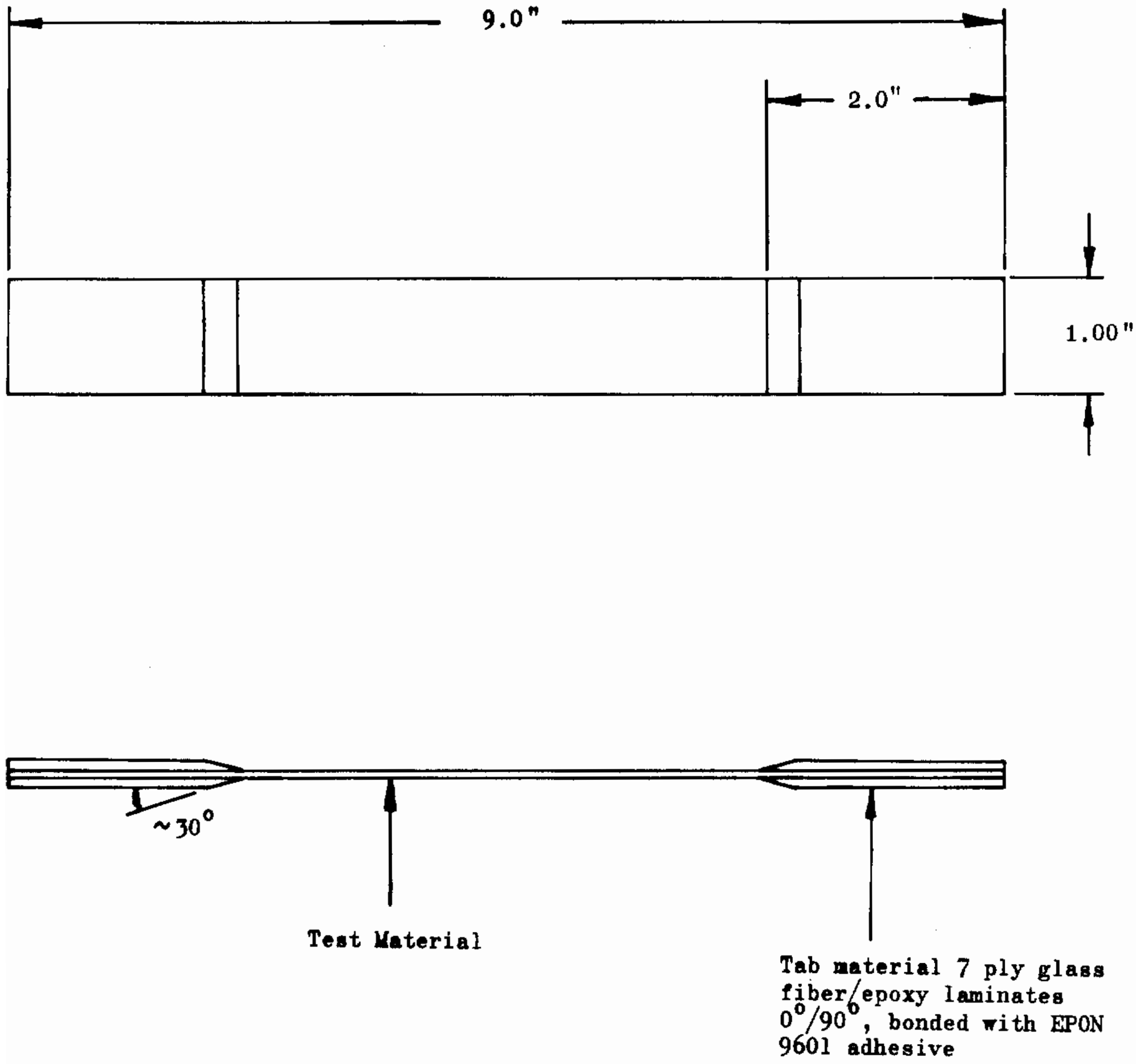


FIGURE 45 - AXIAL-LOAD FATIGUE TEST SPECIMEN CONFIGURATION R = +0.10

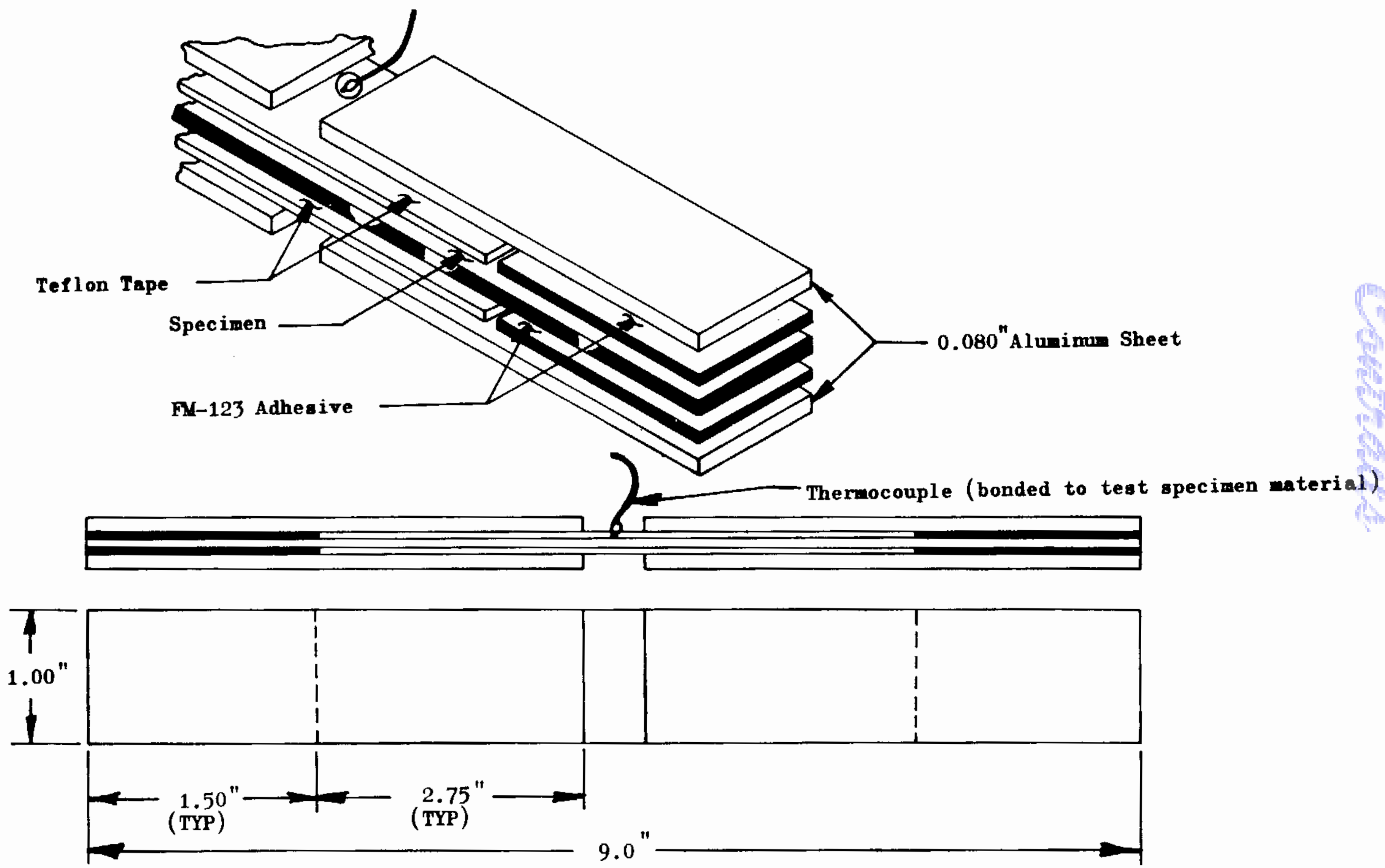


FIGURE 46- AXIAL-LOAD, NEGATIVE STRESS RATIO FATIGUE TEST SPECIMEN CONFIGURATION

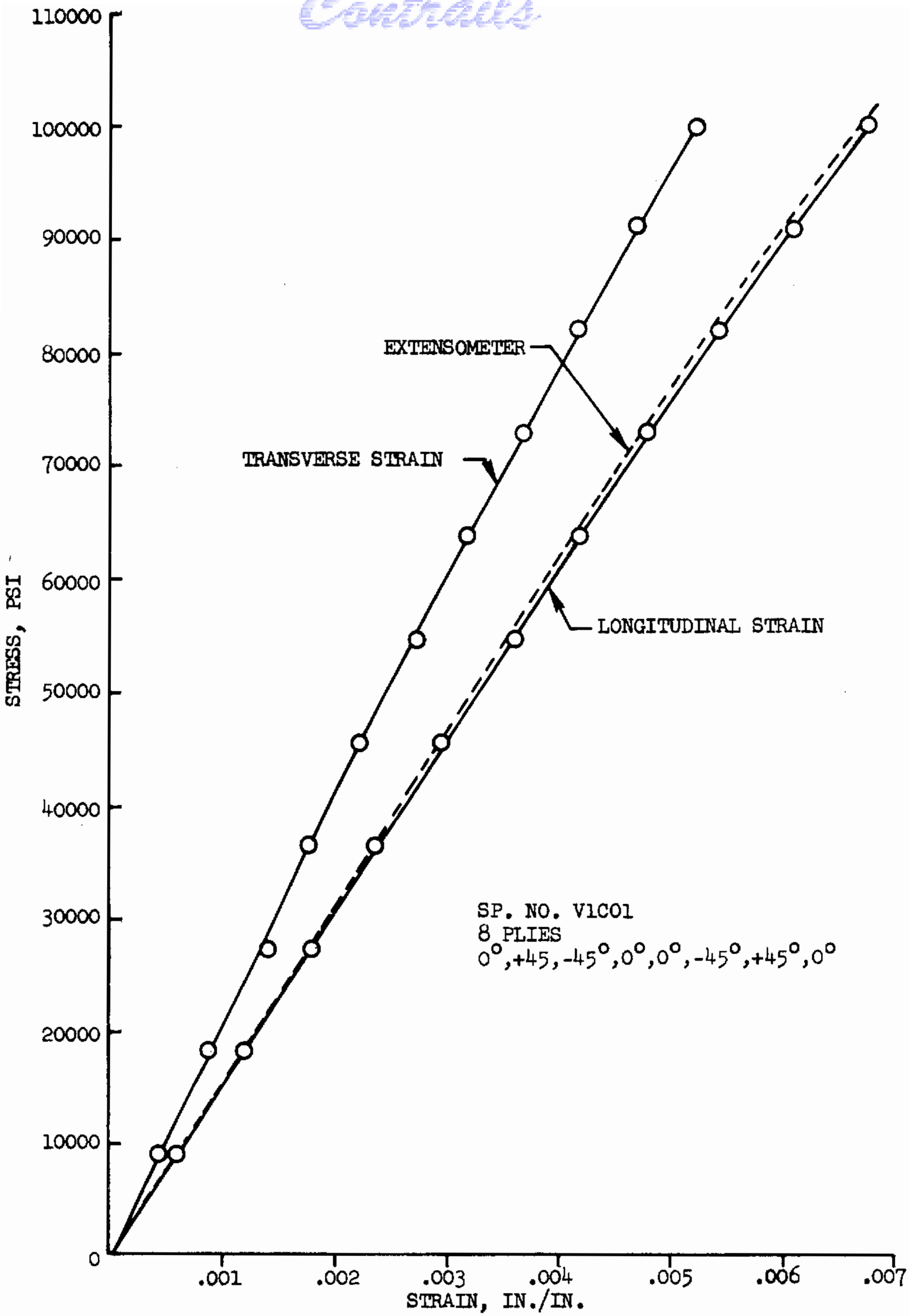


FIGURE 47 STRESS-STRAIN RELATIONSHIP TENSILE COUPON 0°±45°

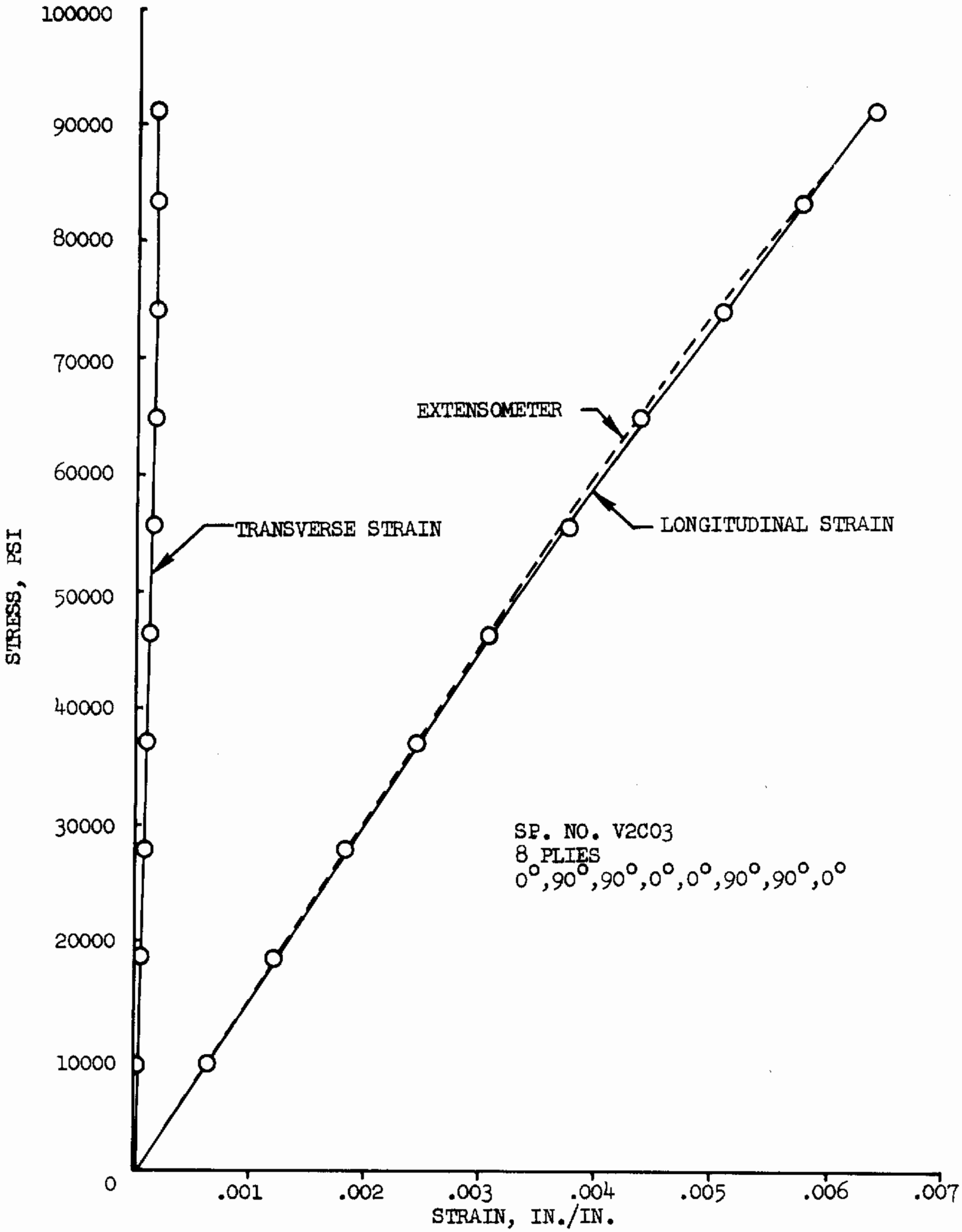


FIGURE 48 STRESS-STRAIN RELATIONSHIP TENSILE COUPON - 0°/90°

Constant amplitude axial-load, R = -1.0 fatigue tests were conducted in an MTS electro-hydraulic servo controlled closed loop testing system. One thermocouple was bonded to each test specimen at the center of its length as shown in Figure 46. Two aluminum support plates, approximately 5 inches long X 2 inches wide X 0.25-inch thick, were attached to the specimen, one on each side and held together by six 0.25-inch diameter fasteners. The fastener nuts were tightened to provide adequate lateral support for compressive loading without creating excessive friction between the plates and specimen during axial loading. Typical failures for the R = -1.0 fatigue specimens with aluminum tabs and fiberglass tabs are shown in Figure 50. Due to difficulties encountered with an excessive temperature rise in the R = -1.0 specimens, the tests were repeated and the problem was solved by restricting the test cyclic frequency to 180 cycles per minute. All previous test results had indicated that the aluminum-tabbed specimens gave comparable fatigue data to that of the fiberglass-tabbed specimens and the repeated tests confirmed this (see Figure 51. Since the aluminum tabs were more uniform in thickness and easier to use than the fiberglass tabs, it was felt that it would be advantageous to use aluminum tabs on all future joint specimens.

Prior to conducting the adhesive evaluation tests some experimental testing was carried out to determine a satisfactory support plate system. A quantity of test specimens with titanium splice plates bonded to titanium adherends were fabricated. Initially, support plates were attached to the adherends spanning the splice plate but not offering any support to the splice plate. This method was considered non-representative since the splice plate was still free to deflect a substantial amount when loaded. Using the same basic support plates, spacers were placed in the gap between the spliced area on both faces. These spacers were 1.0-inch wide and of sufficient thickness to completely fill the gap without providing an interference fit. Testing indicated that this method was successful but it was felt that, since the joint was only supported over the center 1.0 inch of its total overlap length of 1.5 inches, to offer similar support to a joint of different overlap length the spacer length would also have to be different and therefore complicate the testing procedures. Finally it was decided that the joint should be supported across the whole overlap area but still allowed to deflect a limited amount.

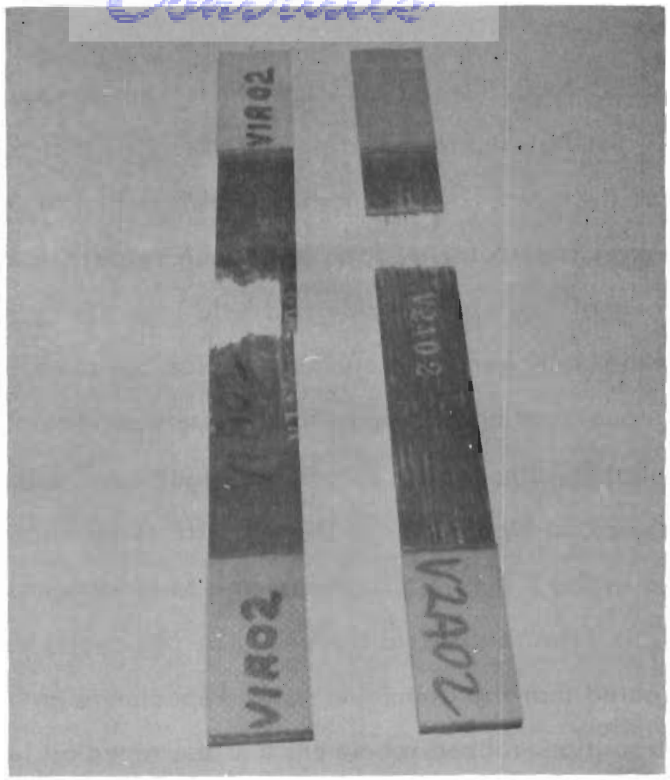


FIGURE 49 - TYPICAL FAILURE,
AXIAL FATIGUE R = +0.10

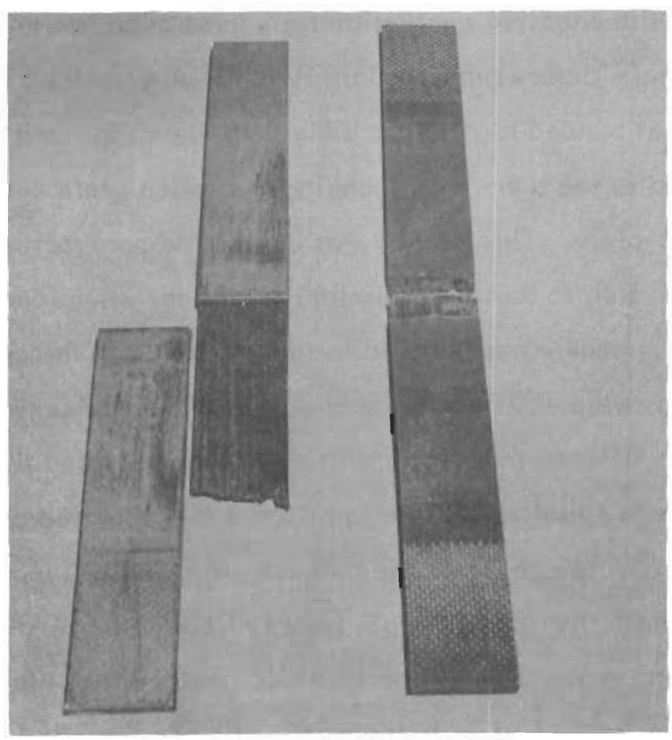


FIGURE 50 - TYPICAL FAILURE,
AXIAL FATIGUE R = -1.0

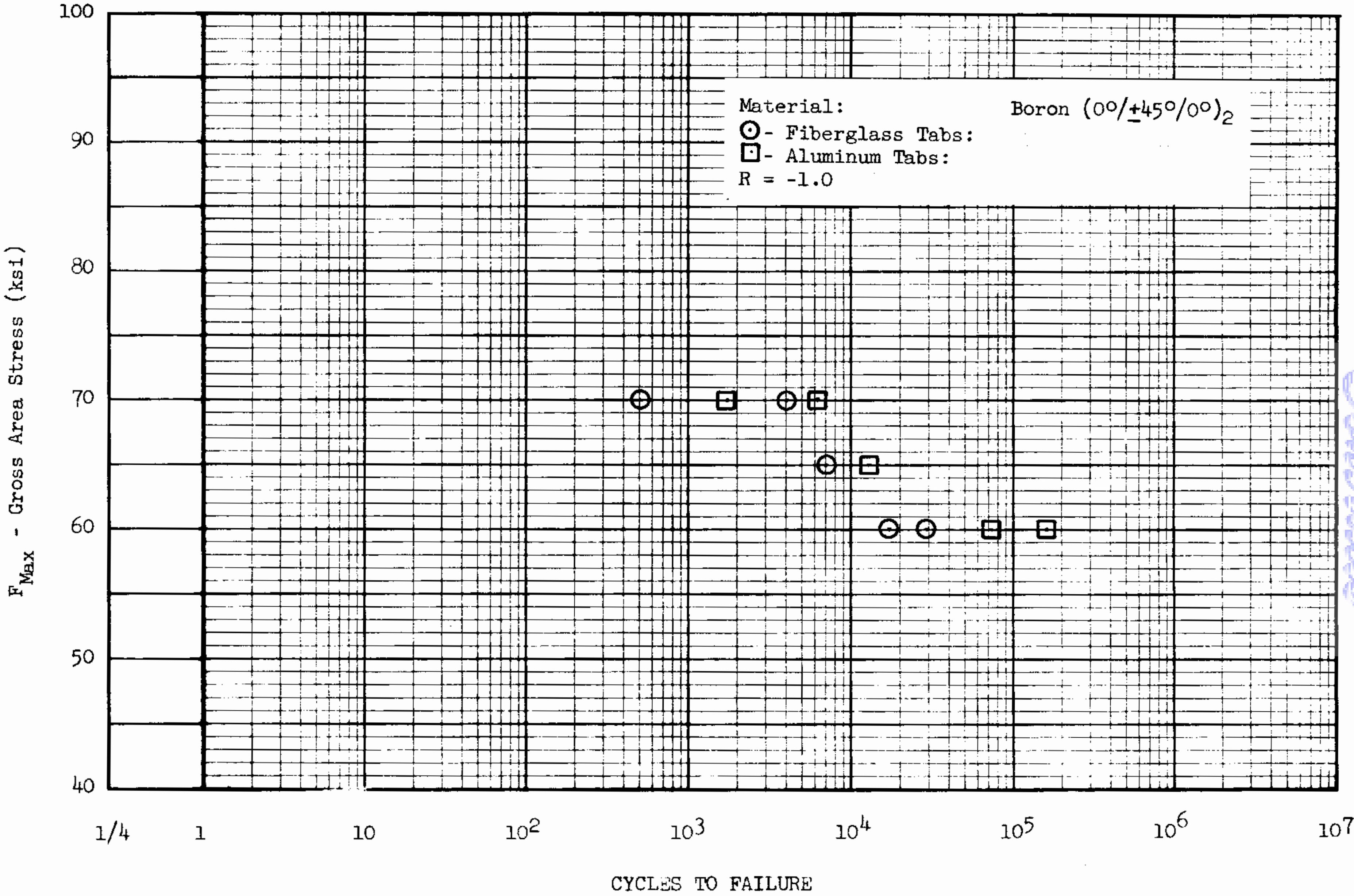
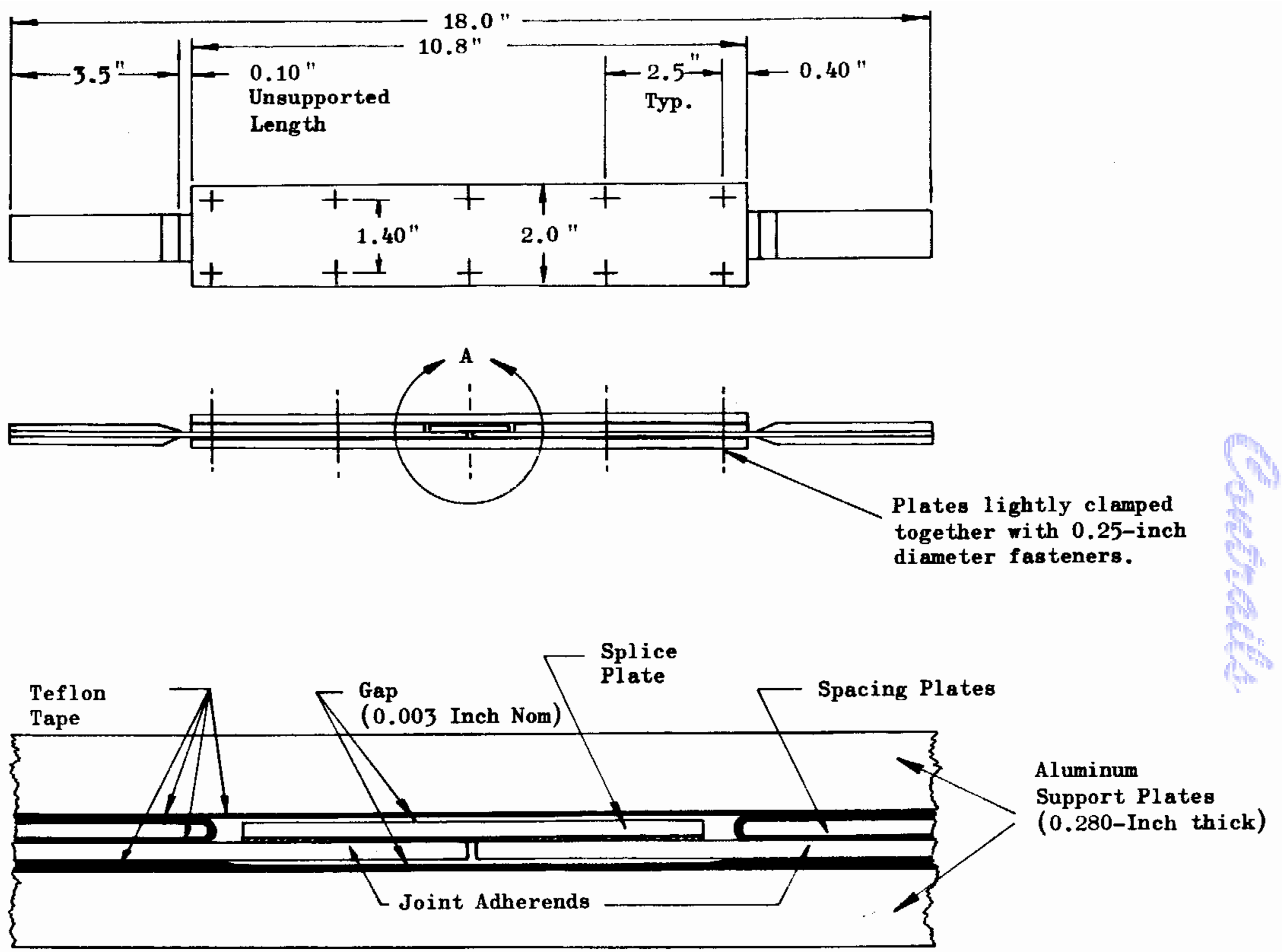


FIGURE 51 - MATERIAL VERIFICATION FATIGUE TEST

This condition was believed to be representative of a typical joint between skins bonded to a honeycomb core or supported by a substructural member. The system that satisfied these requirements was successfully checked out on additional specimens fabricated with boron composite adherends and at various stress levels and stress ratios (see Table B2, Appendix B). Details of the support system that was adopted for Configuration A bonded joint test specimens are given in the sketch, Figure 52. The gap on each side of the joint was restricted to 0.003 inch (one thickness of Teflon tape) since this provided adequate and representative support to the joint without creating any significant frictional resistance when loaded. One of the experimental joint speciments with support plates attached and mounted in a resonant fatigue machine is shown in Figure 53.

The static and fatigue adhesive evaluation tests were conducted using the support plate system described above. Typical static and fatigue failure surfaces are shown in Figures 54 and 55. The Epon 9601 adhesive exhibited high ultimate shear strength and the S-N curve, shown in Figure 56 indicates that the fatigue characteristics were also acceptable.



VIEW "A"

FIGURE 52 SUPPORT SYSTEM FOR TYPE "A" JOINT SPECIMENS

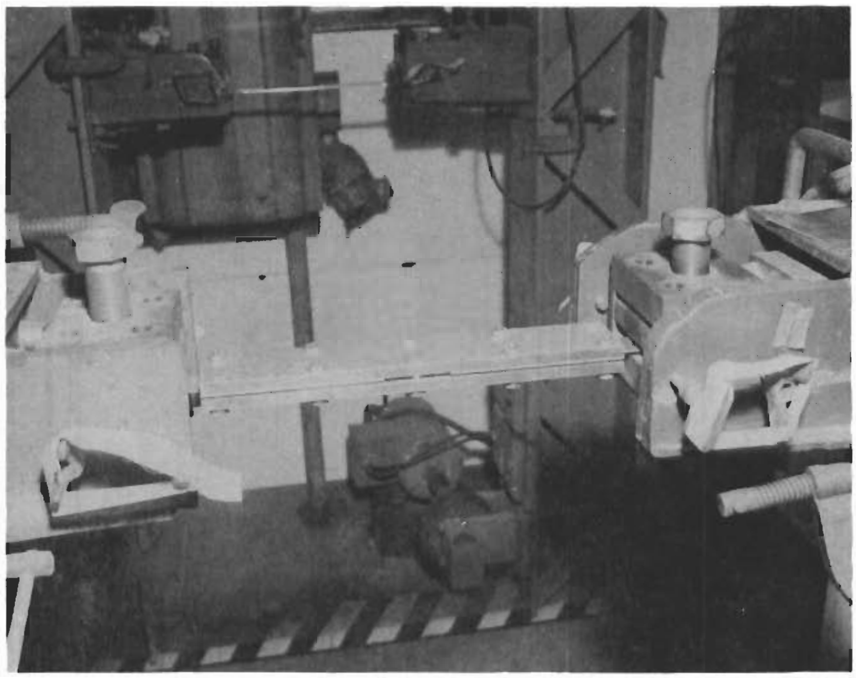


FIGURE 53 - TEST SPECIMENS WITH SUPPORT PLATES

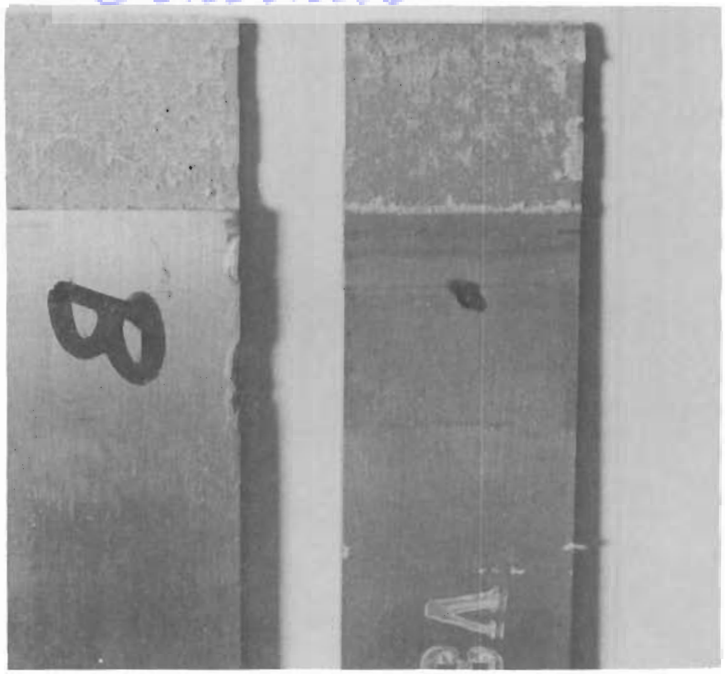


FIGURE 54 - TYPICAL STATIC FAILURE SURFACE
TITANIUM TO TITANIUM (V3C03)

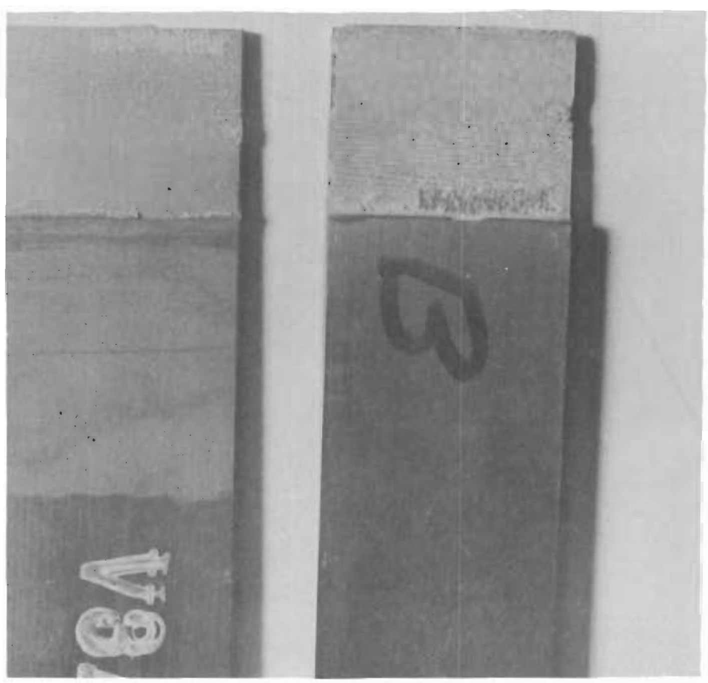


FIGURE 55 - TYPICAL FATIGUE FAILURE SURFACE
TITANIUM TO TITANIUM (V3A12)

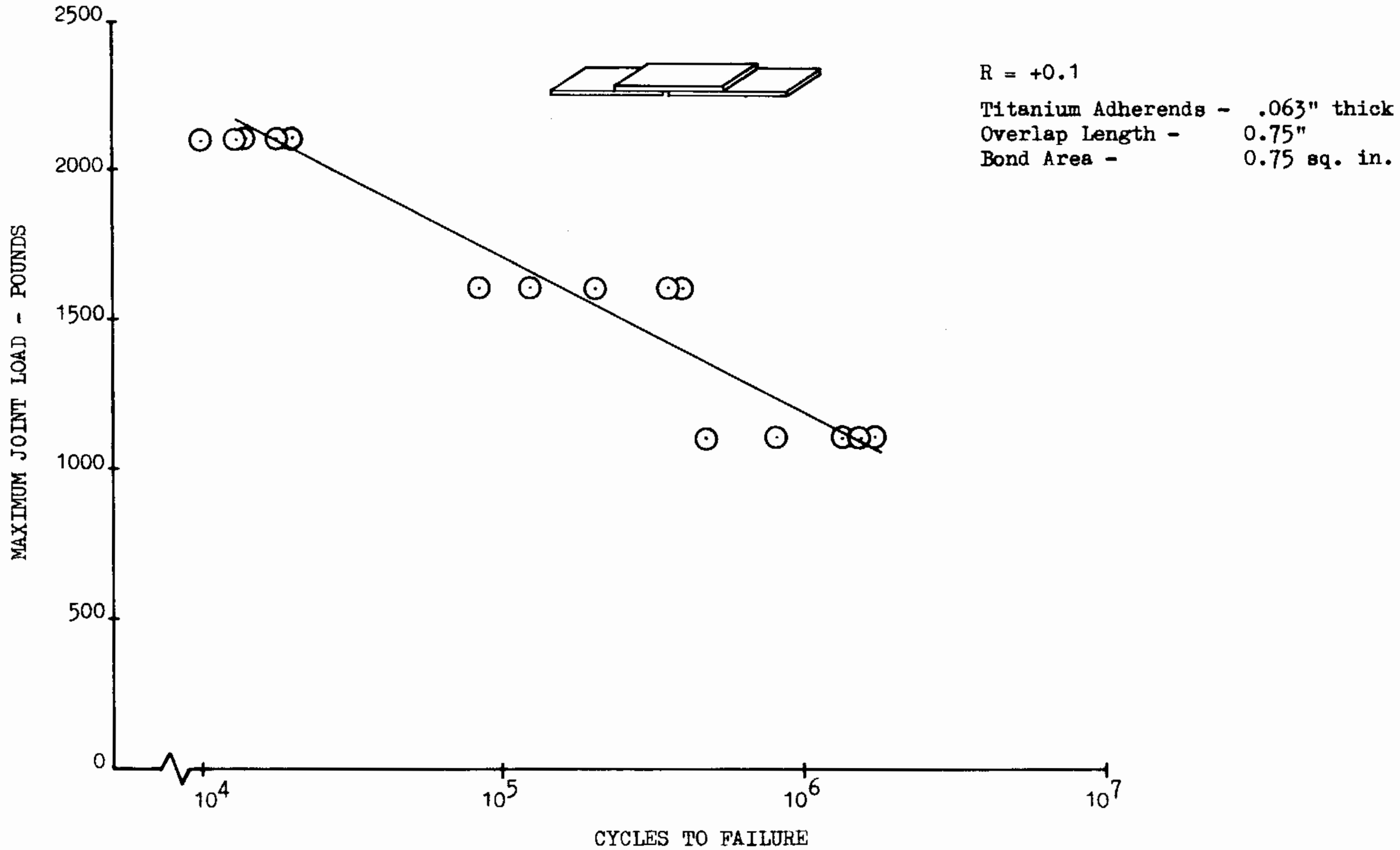


FIGURE 56 S-N CURVE FOR SINGLE SPLICE BUTT JOINT CONFIGURATION A - EPON 9601 ADHESIVE

4.5 BONDED JOINT TESTS - CONFIGURATION A - SINGLE SPLICE BUTT JOINT

4.5.1 Specimen Configuration

The Phase I, Configuration A specimen details are given in Dwg. No. 7226-13021A, Appendix C. The Phase II and Phase III specimens were fabricated to the same drawing but the width dimension was increased to 3.0 and 10.0 inches respectively. Specimen identification information is given on Tables VII, VIII, and IX.

4.5.2 Test Procedure and Results - Phase I

Tests were conducted in accordance with Table VII, and the test data are reported in Appendix B, Tables B3 thru B9.

Tests were also conducted on alternate adherend materials in accordance with Table I and the test data were reported in Appendix B, Table B17. The static tensile test specimens were supported with the modified support plates shown in Figure 57. The modification to the plates was necessary to alloy a 2.0-inch gage-length extensometer to be attached to the edges of the specimen. A typical static tensile test set-up with extensometer attached is shown in Figure 58. A minor problem was caused by the buckling of the lateral support plates during the static compression testing of the long lap joint specimens. The buckling was a result of the higher loads required to fail this type of specimen combined with the effect of the reduced stiffness of the plates due to the cut out at the center. Increased stiffness to the support plates was provided by attaching a "T" section stiffner along the length of and on one side of the support plates as shown in Figure 59 and Figure 60. A thermocouple was bonded to each specimen and was located on the adherend adjacent to the edge of the splice plate. The fatigue tests were conducted in the fatigue machines described earlier and with regular support plates. Figures 61, 62 and 63 illustrate the different failure modes obtained with the Configuration A baseline specimens when subjected to the different fatigue stress ratios of R = +0.10, R = -1.0, and R = +10.0. Failure modes associated with the ply stacking variable, surface ply at 45° to load axis, for Configuration A boron-to-titanium and

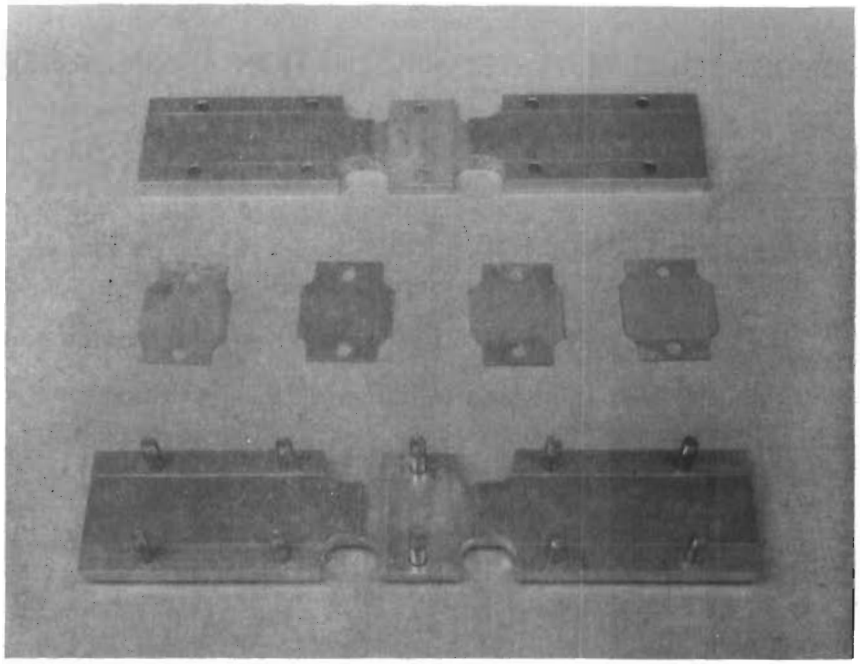


FIGURE 57 MODIFIED SUPPORT FIXTURE

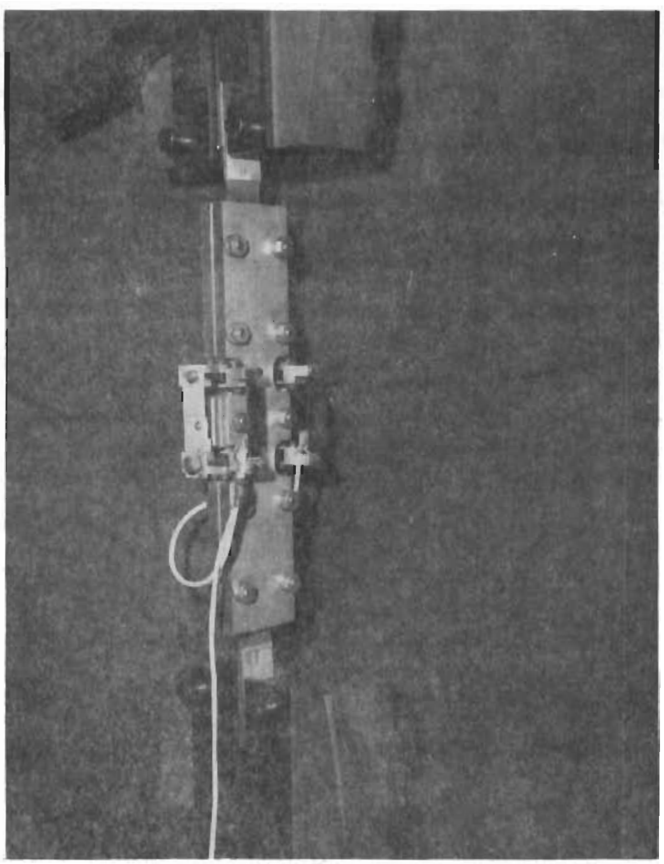


FIGURE 58

STATIC TENSILE TEST
WITH EXTENSOMETER

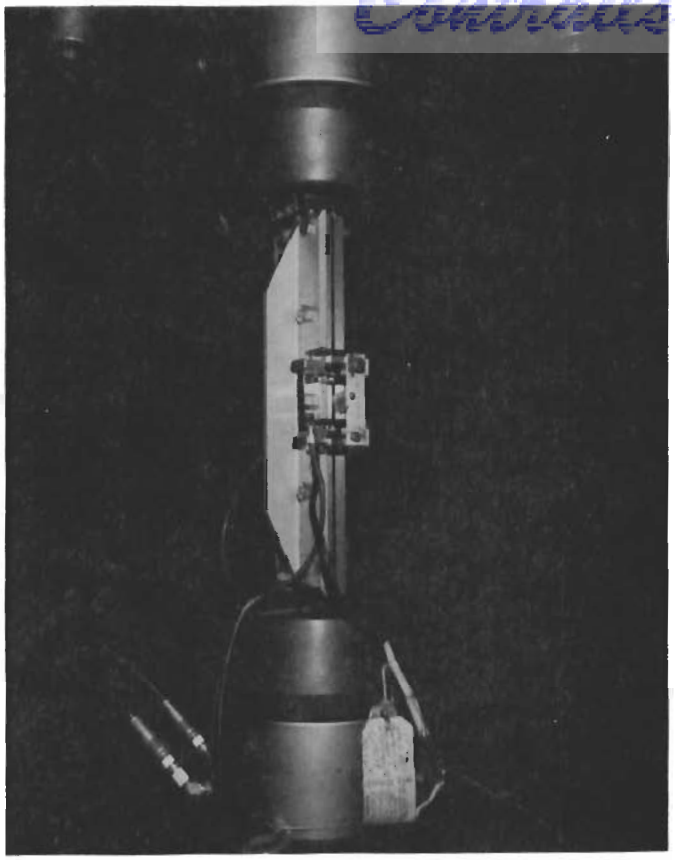


FIGURE 59
SIDE VIEW OF MODIFIED SUPPORT PLATE

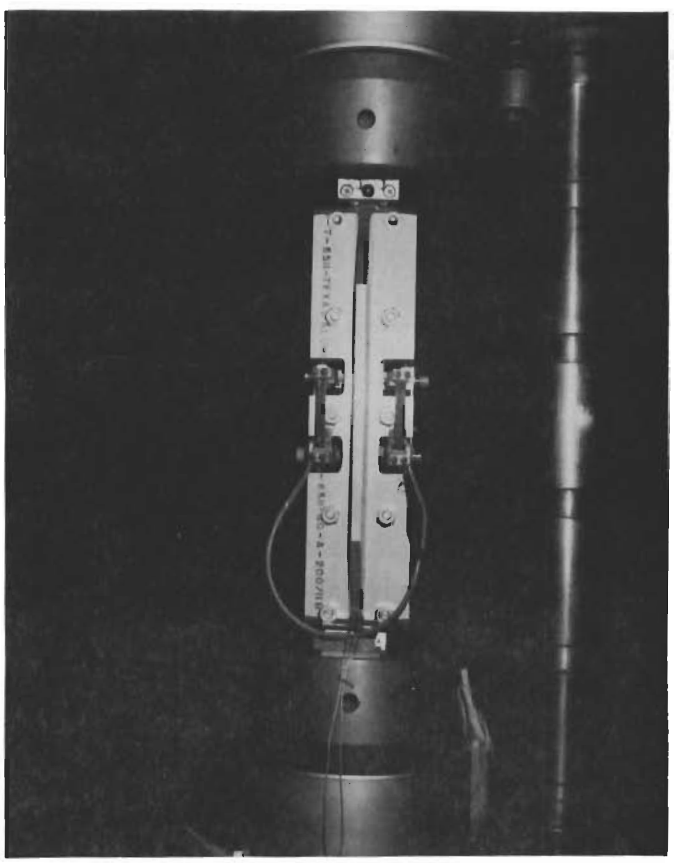


FIGURE 60
FRONT VIEW OF MODIFIED SUPPORT PLATE

-A04 shows unusual splice plate failure
-A10 shows typical failure adjacent to surface ply

FIGURE 61 - CONFIGURATION A, BORON TITANIUM BASELINE SPECIMEN
STRESS RATIO R = +0.1

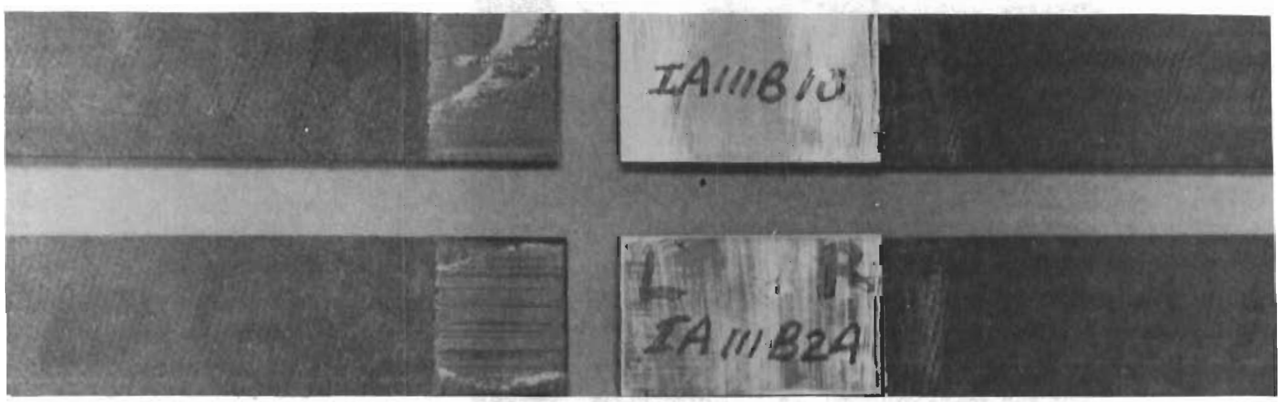


FIGURE 62 - CONFIGURATION A, BORON/TITANIUM BASELINE SPECIMEN
STRESS RATIO R = -1.0 TYPICAL FAILURES

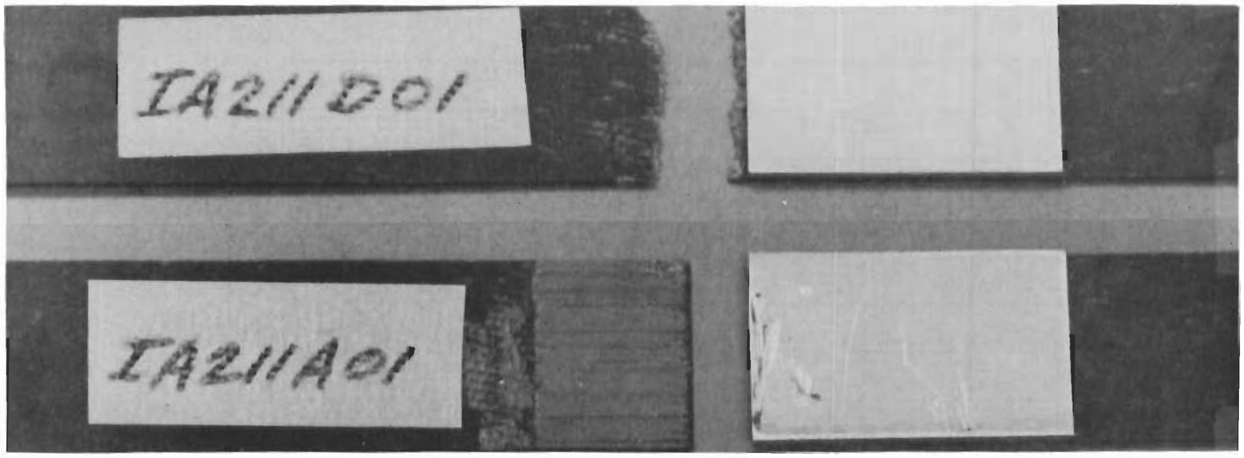
-C01 Failure adjacent to surface ply plus some end damage
-C10 Failure adjacent to surface ply and no secondary damage
-C22 Failure between surface ply and 45° ply

FIGURE 63 - CONFIGURATION A, BORON/TITANIUM BASELINE SPECIMEN STRESS RATIO R = +10.0. TYPICAL FAILURES.

boron-to-boron joints are shown in Figures 64 and 65. In addition to the degradation specimens, all other types of Configuration A fatigue specimens that had not been failed during testing were statically tested to failure. Joint deflection was recorded for each specimen to determine possible degradation in joint stiffness due to fatigue loading. The low cycle tests were conducted in an MTS electrohydraulic servo controlled closed loop system at a frequency of 5 cycles per second. An attempt was made to obtain fatigue lives of between 2500 and 5000 cycles, however this proved to be difficult and the test data produced a scatter band of about two decades.

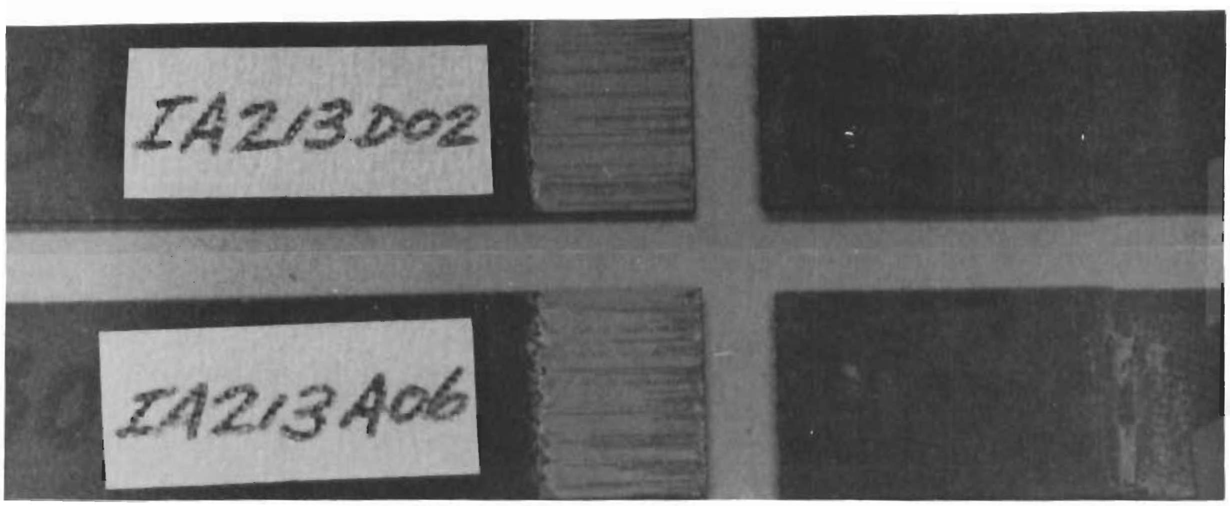
Good static shear strengths were obtained for the joints loaded in tension with values ranging from 3600 psi to 5700 psi and with an average value of 4600 psi. This spread in static strength is reasonable when comparing results from specimens representing several different batches of material bonding cycles and L/t ratios. Compressive shear strength values varied between 5500 psi and 6300 psi. Additional baseline data tests were conducted at a stress ratio of R = -1.0 and at a cyclic rate of one cycle per second to determine the influence of cyclic rate on fatigue life. These yielded the same results as tests conducted at 900 to 1800 cycles per minute, indicating that cyclic rate is not a prime factor unless it causes the specimen to overheat. Joint stiffness curves for tensile and compressive static loading before and after fatigue cycling are given in Figures 66 thru 69. Boron-to-boron joints with the second adhesive, Metlbond 329, were evaluated and the results are reported in Appendix B, Table B4 . Since static tests on boron-to-titanium joints with this same adhesive yielded low static strength values, and initial fatigue test results were also low (all specimens failed at the adhesive-titanium interface) testing on the remainder of the specimens was suspended because these specimens did not evaluate the adhesive to composite joint.

For the preload evaluation tests, static tensile preloads were determined by taking 75 percent, 85 percent, and 90 percent of a predetermined static value established as the design ultimate shear stress. This stress was 4000 psi and was determined by deducting one standard deviation from the mean value of all the static tensile ultimate values obtained for the standard boron/titanium, Configuration A joint specimens. Joint deflection was recorded during the static preload to provide additional information. Fatigue



-D01 Typical static tensile failure in boron
-A01 Typical R = +0.1 fatigue failure between surface 45° ply
and second 0° ply

FIGURE 64 - CONFIGURATION A, BORON/TITANIUM PLY STACKING SPECIMEN



-D02 Typical static tensile shear failure between surface 45° ply
and second 0° ply
-A06 Typical R = +0.1 fatigue failure (same as D02)

FIGURE 65 - CONFIGURATION A, BORON/BORON PLY STACKING SPECIMEN

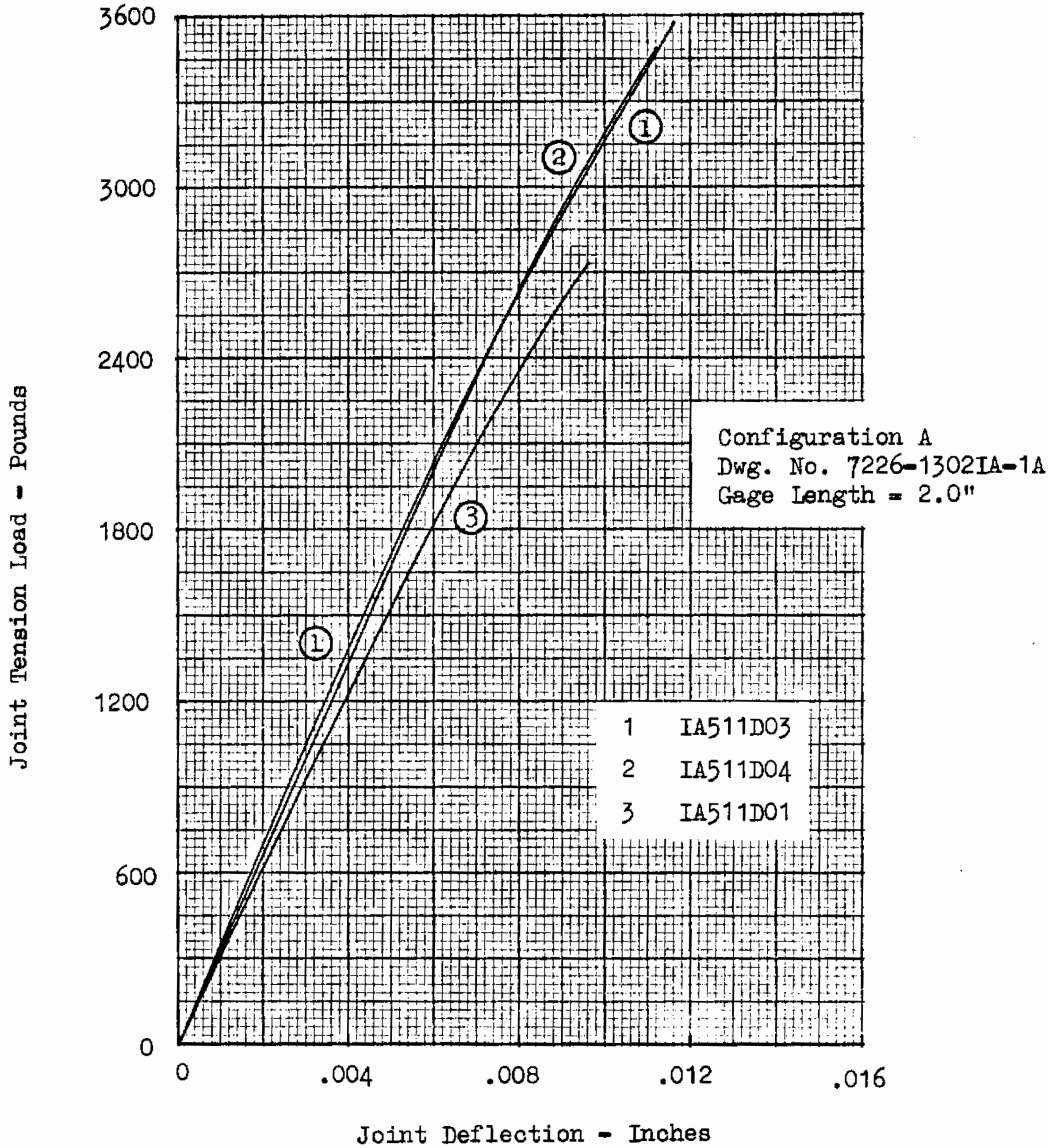
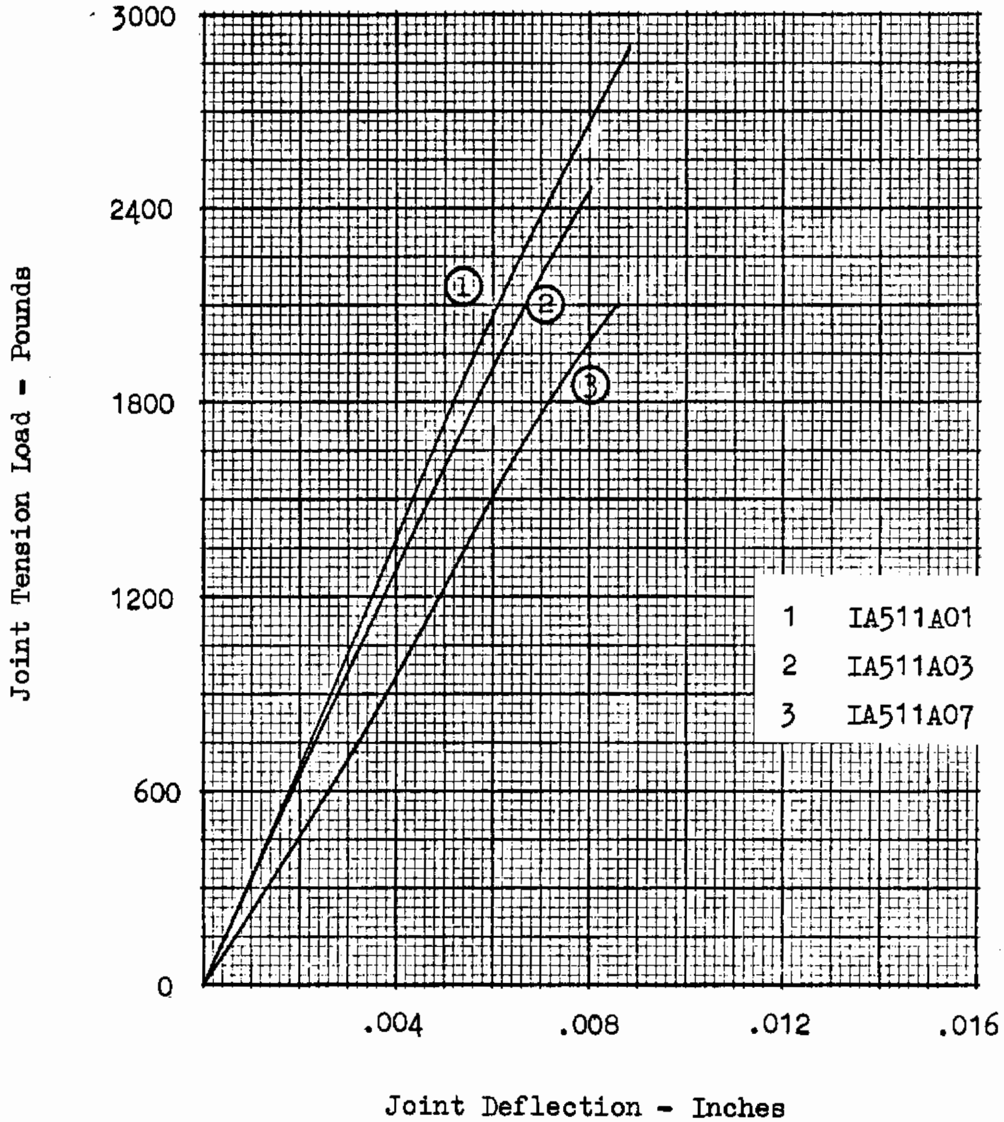
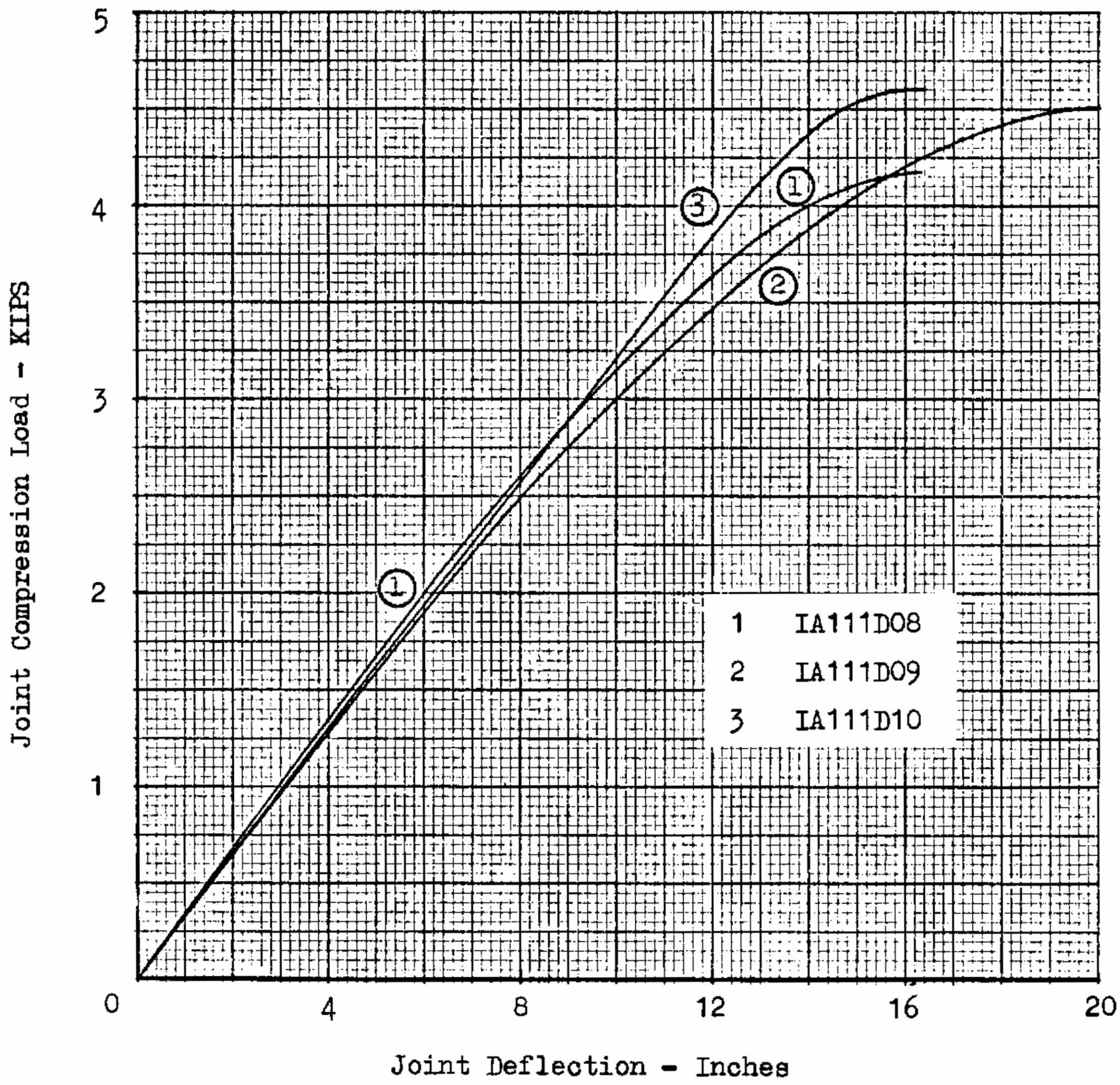


FIGURE 66 JOINT STIFFNESS - STATIC TENSILE TESTS



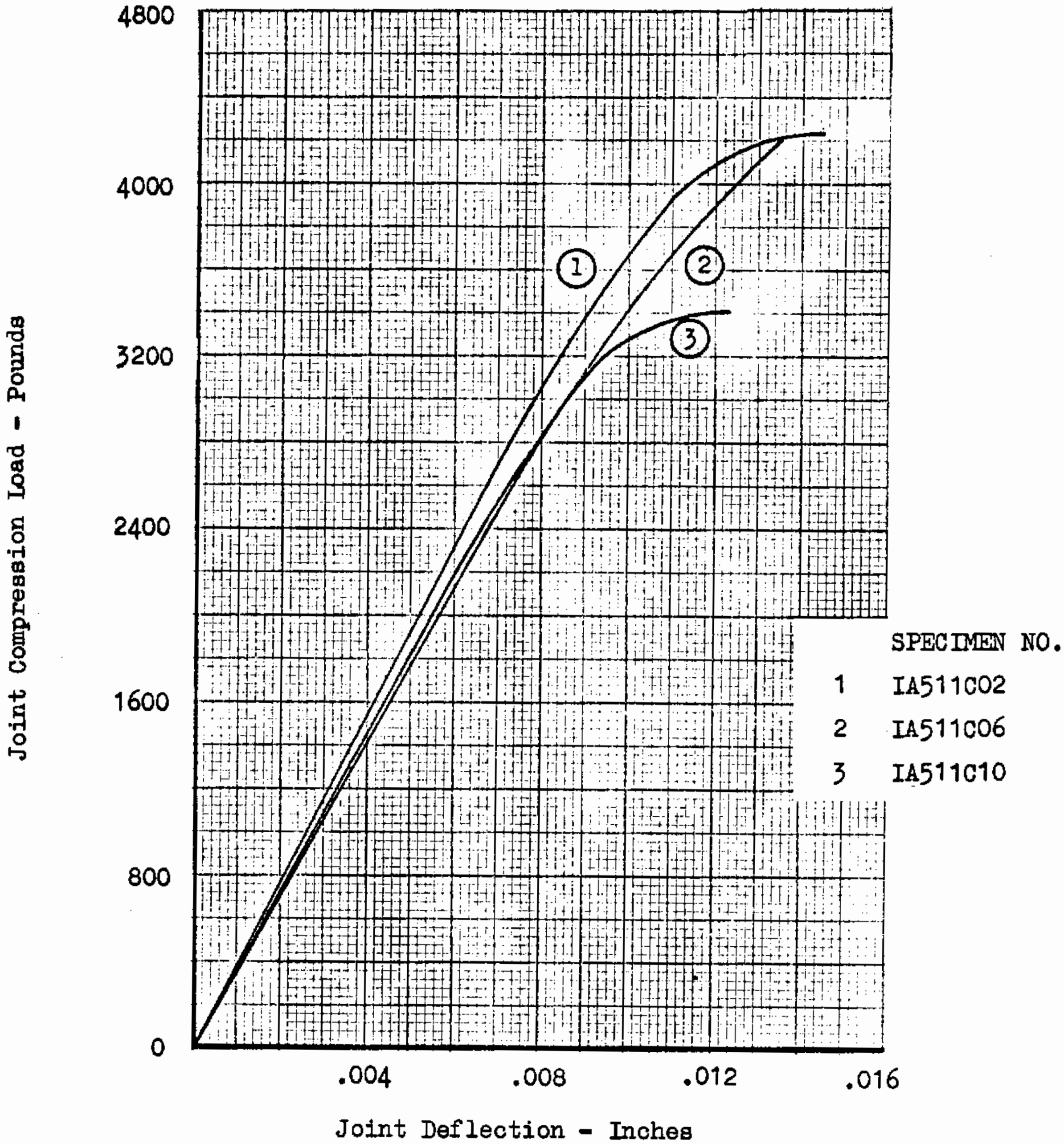
Configuration A
Dwg. No. 7226-1302IA-1A
Gage Length = 2.0"

FIGURE 67 JOINT STIFFNESS - AFTER FATIGUE CYCLING



Configuration A
Dwg. No. 7226-1302IA-1A
Gage Length = 2.0"

FIGURE 68 JOINT STIFFNESS - STATIC COMPRESSION TEST



Configuration A
Dwg. No. 7226-1302IA-1A
Gage Length = 2.0"

Stress Ratio R = +10.0
Max. Stress 2700 psi
No. of Cycles 5000

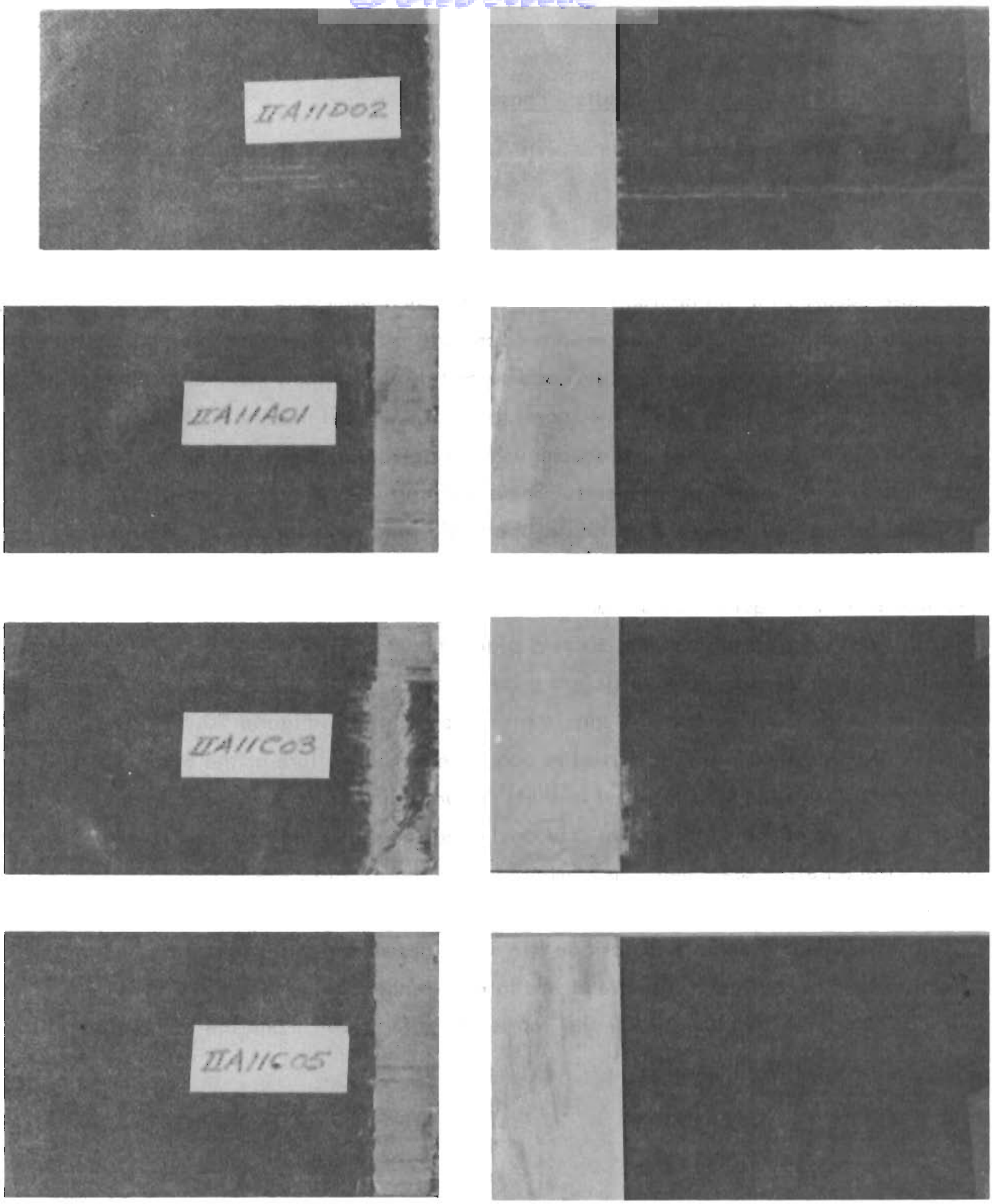
FIGURE 69 JOINT STIFFNESS - AFTER FATIGUE CYCLING tests were conducted at a stress ratio of R = +0.1 and at a stress level of 1400 psi. Results, Appendix B Table B3, indicate that the preload does not significantly affect the fatigue life of the joints.

The graphite-epoxy and glass-epoxy alternate adherend material evaluation tests were conducted in the same manner as the baseline data boron-epoxy tests. The fatigue tests were performed at a stress ratio of R = +0.10 and at stress levels that were comparable to those used for the boron-epoxy tests. The results are presented in Appendix B Table B3 . S-N curves for all data generated are presented in Volume III of this report. Analysis and comparative studies for all specimen variables are also included in Volume III.

4.5.3 Test Procedure and Results - Phase II

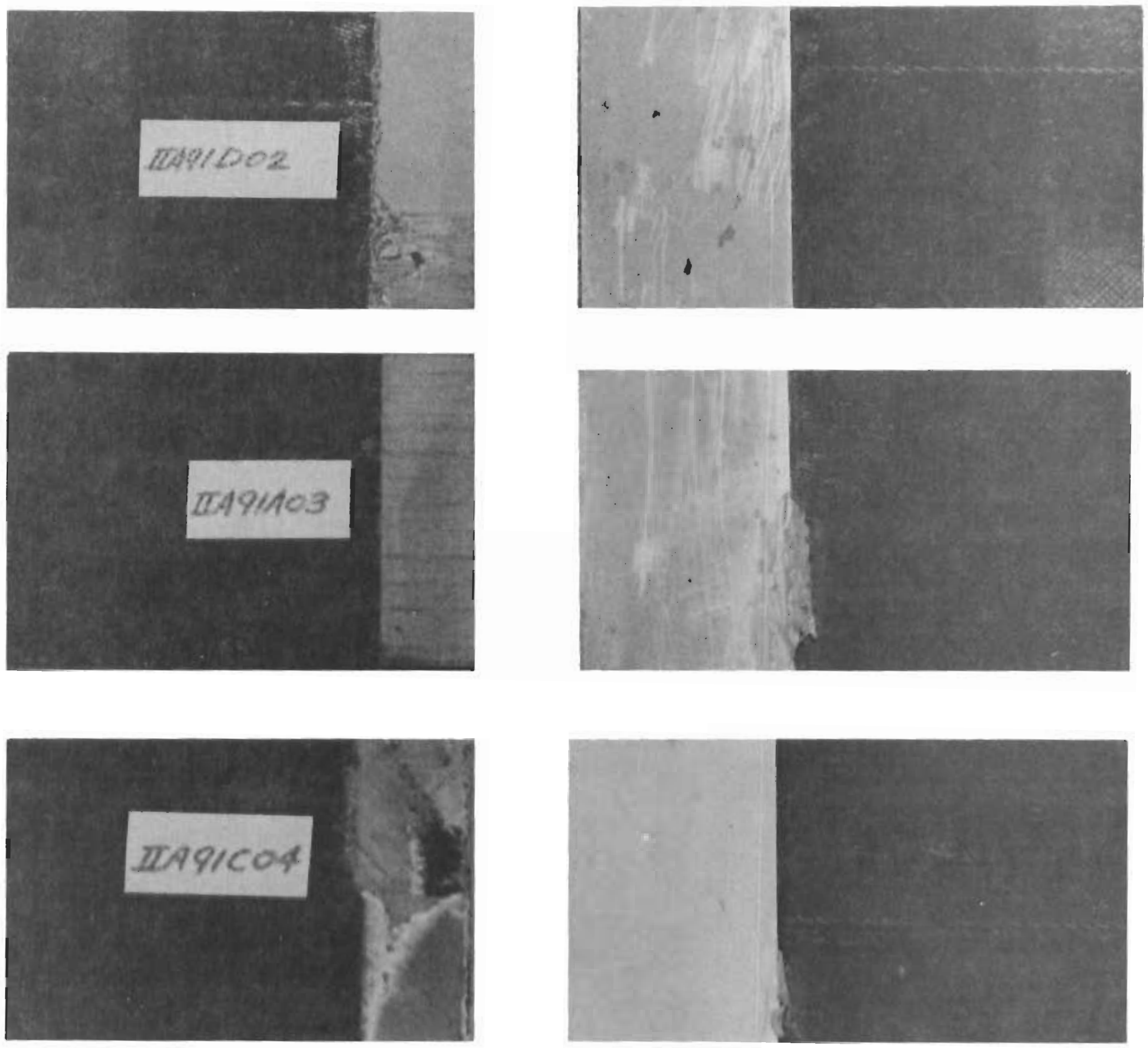
Tests were conducted in accordance with Table IX and the test data are reported in Appendix B, Table IIB1.

The three-inch wide, Configuration A bonded joints were tested using methods similar to those adopted for the appropriate Phase I one-inch wide specimens. Except for the extra width, the support plates were identical to those used on the one-inch wide specimens and the same clearance of approximately 0.003 inch was maintained in the area around the splice plate. The increased width made it necessary to modify the extensometer frame and this was accomplished by utilizing longer connecting straps and longer knife-edged attachments. Some difficulty was encountered with tab failures occurring during the testing of the static specimens. However, satisfactory joint shear strength values were obtained by removing the tab ends and gripping the laminate with a piece of coarse emergy cloth between the laminate and grip surfaces. For this method of gripping, the support planes had to be shortened by two inches at each end in order to expose sufficient gripping area. Typical failure modes for the 3.0-inch wide Configuration A specimens are presented in Figures 70, 71, and 72. Static tests resulted in either partial or complete tensile failure of the boron while the R = +0.1 fatigue tests resulted in shear failure adjacent to the first ply and partial failure of the surface plies. In analyzing the data obtained from these 3.0 inch wide baseline specimens, as compared with those data generated for similar 1.0-inch wide baseline specimens, a trend is indicated in that there is a loss in joint static shear strength and fatigue life with increase in specimen width, holding overlap length constant. This trend was later extended to the 10-inch width. A similar relationship holds true for the lap length effects data, and the boron-to-aluminum baseline data.



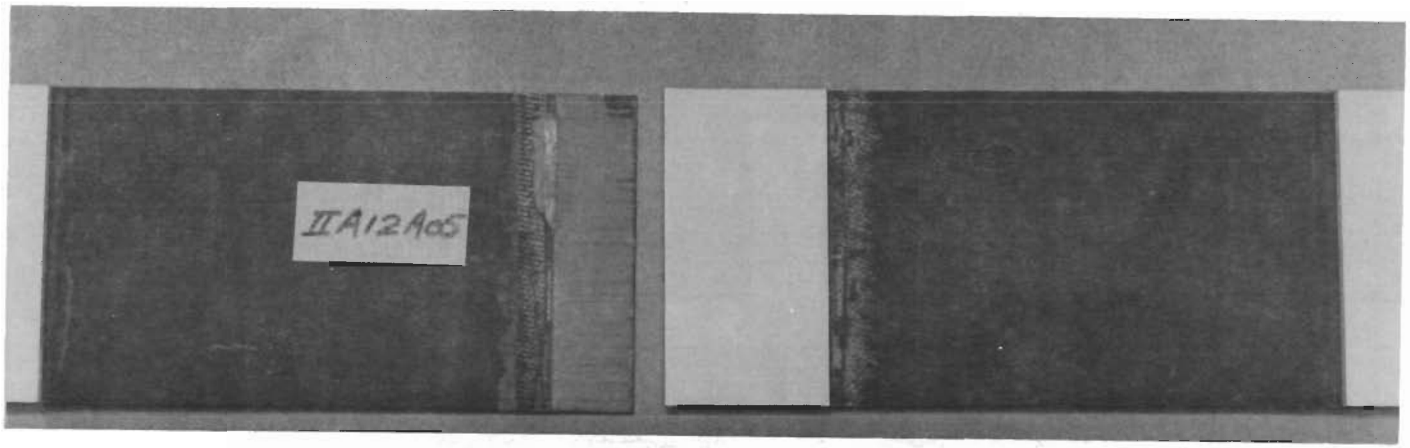
-D02 Typical tensile failure in the boron laminate
-A01 Typical R = +0.1 fatigue shear failure adjacent to first ply
-C03 R = +10.0 fatigue failure with partial failure of surface plies
-C05 R = +10.0 fatigue shear failure adjacent to first ply

FIGURE 70 - CONFIGURATION A - THREE INCHES WIDE BORON/TITANIUM, BASELINE SPECIMENS



-D02 Typical static failure in boron laminate combined with shear adjacent to surface ply
-A03 Typical R = +0.1 fatigue shear failure adjacent to first ply
-C04 Typical R = +10.0 fatigue failure with partial failure of surface plies

FIGURE 71 - CONFIGURATION A - THREE INCHES WIDE BORON/TITANIUM, LONG LAP LENGTH



-A05 typical R = + 0.1 fatigue shear failure adjacent to the first ply of boron

FIGURE 72 - CONFIGURATION A - THREE INCHES WIDE BORON/ALUMINUM BASELINE SPECIMEN

4.5.4 Test Procedure and Results - Phase III

Tests were conducted in accordance with Table IX and the test data were reported in Appendix B, Tables IIIB1. One-inch wide specimens were cut from the edge of the same panel as the 10.0-inch wide specimens and were used for evaluating the static shear strength of the bond. These tests were conducted in the same manner as the Phase I, Configuration A specimens.

The test procedures used for the ten-inch wide Phase III Configuration A joint specimens were similar to those used for the Phase I and Phase II specimens except that the load was introduced through bolted end fittings rather than hydraulic grips. All tests were carried out in an MTS testing machine equipped with steel end fittings, fabricated to the configuration shown in Figure 73. In order to ensure correct specimen alignment in the fittings, a drilling template was used to locate the holes in the specimen ends. Eleven-inch wide lateral support plates were used and a clearance of 0.003 inch was maintained in the joint area. "T" section stiffeners were fastened to the plates to provide the additional support required for the fatigue test at R = +10.0. Two thermocouples were bonded to each specimen, one at the edge and the other at the center of the width. A photograph of an R = +0.1 fatigue test specimen mounted in an MTS testing machine is shown in Figure 74. Typical failure surfaces of the static control specimens are shown in Figures 75 and 76. Photographs of four 10.0-inch wide specimens after fatigue testing are also shown in Figures 77 thru 80. Two specimens had complete failure across the 10.0-inch width, but the other two specimens had a narrow bond, approximately 2.0 inches along the edge, that did not fail. Generally, the fatigue failure modes were shear adjacent to the surface ply, and this mode appeared to initiate at the center of the joint width and move outward as illustrated in Figures 77 and 78. This theory is strengthened by the fact that the specimens, shown in Figures 79 and 80, did not fail over the complete bond width. The results of the 10.0-inch wide tests indicate that the fatigue capability is further reduced when the specimen width is increased from 3.0 inches to 10.0 inches.

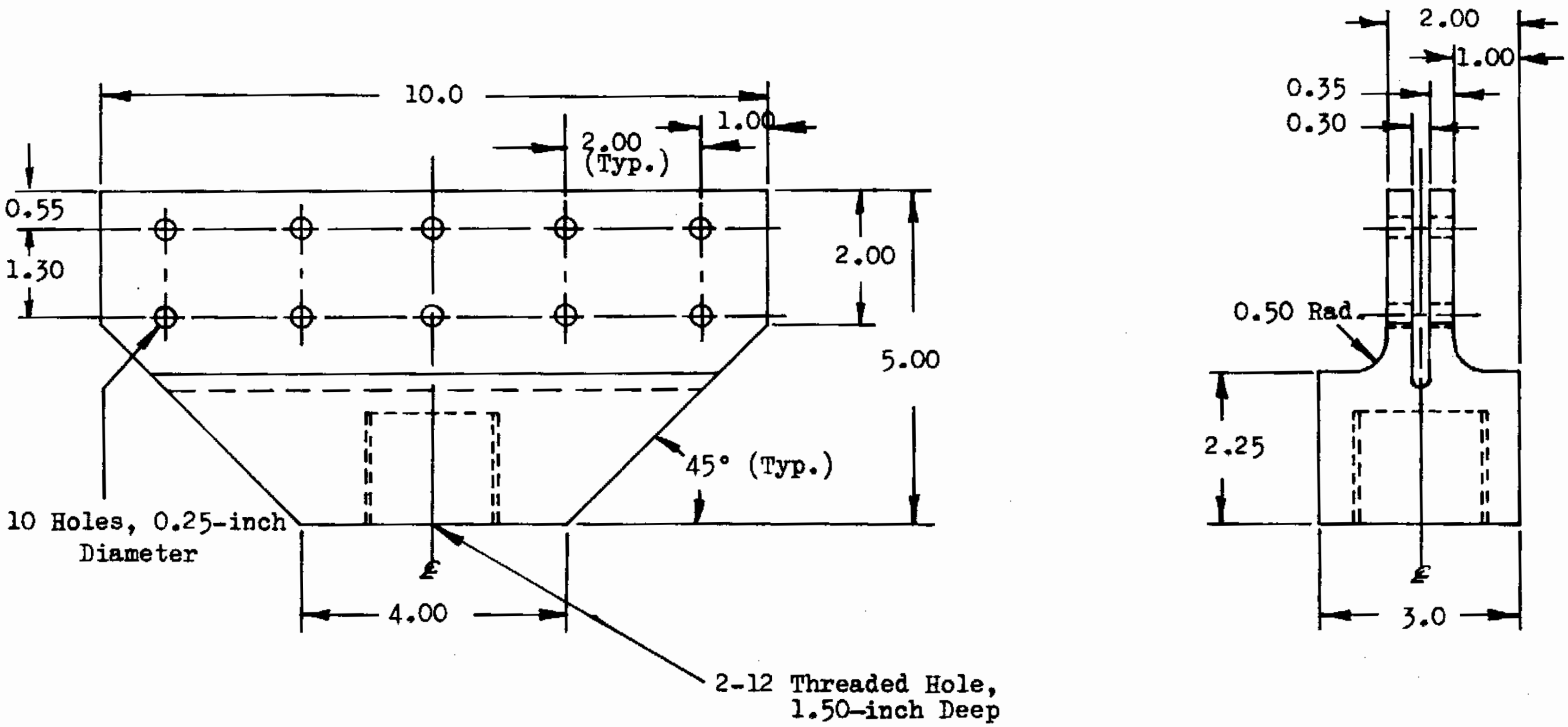


FIGURE 73 . END FITTING FOR PHASE III, 10.0-INCH WIDE SPECIMEN

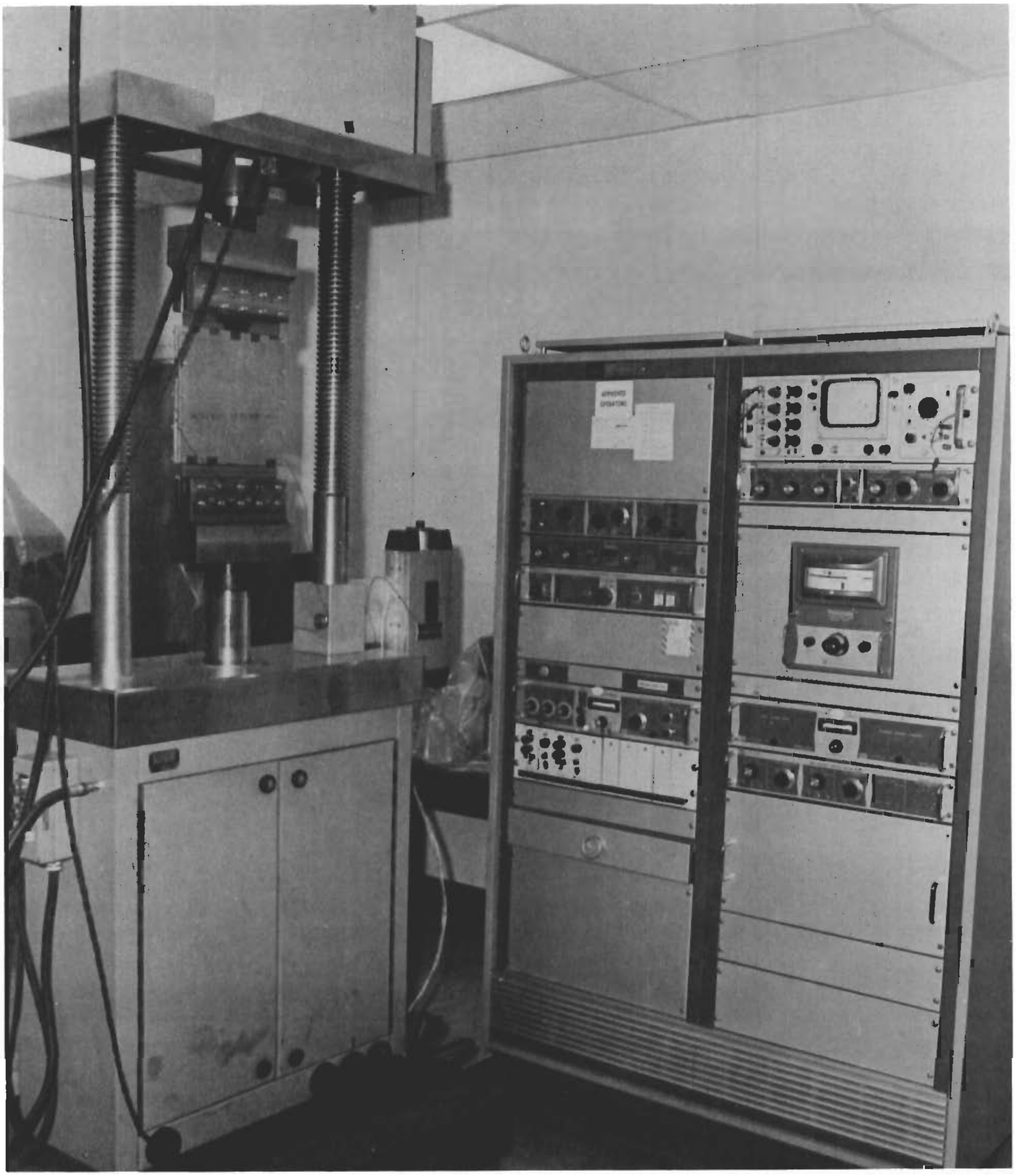


FIGURE 74 - TEST SET-UP FOR TEN-INCH WIDE CONFIGURATION A SPECIMEN

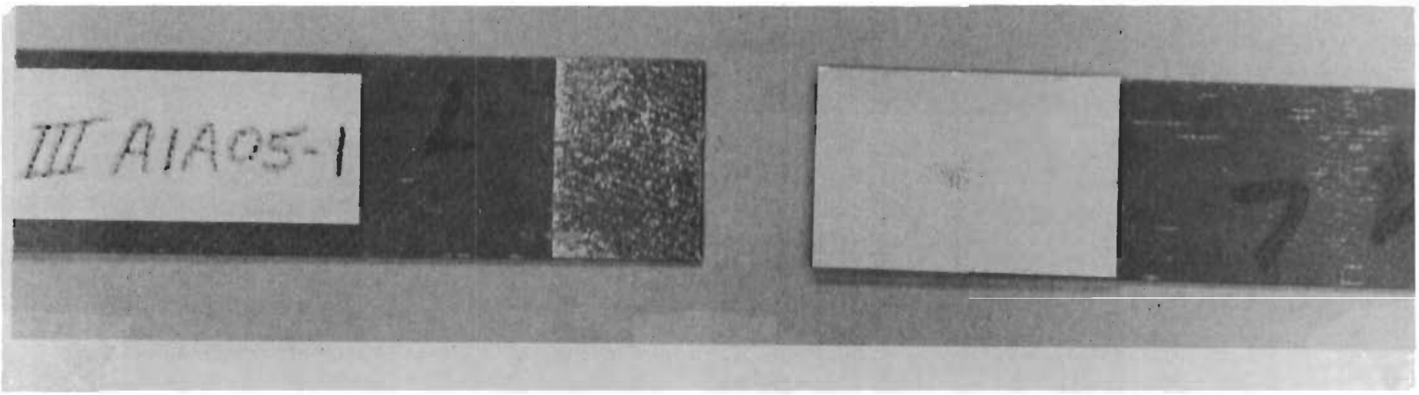


FIGURE 75 - CONTROL SPECIMEN FOR
BORON/ALUMINUM CONFIGURATION A TEN-INCH WIDE SPECIMEN

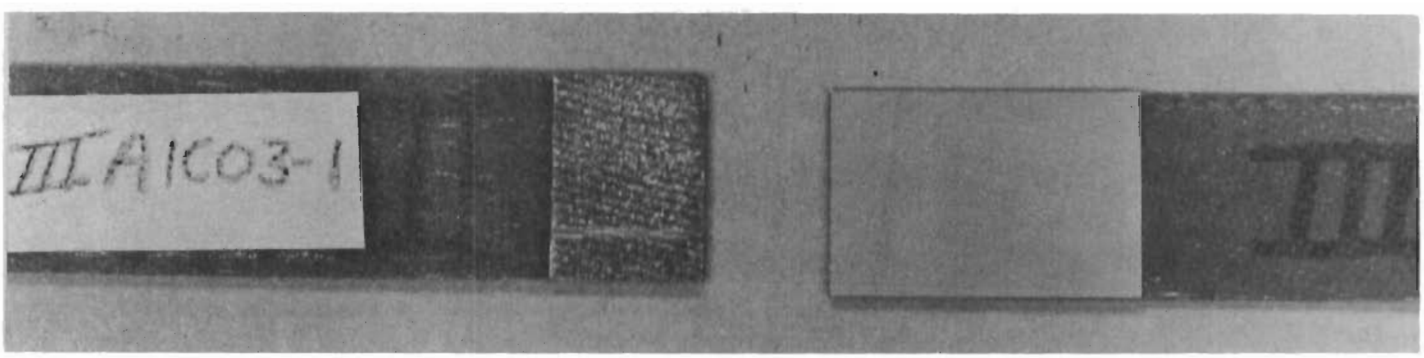
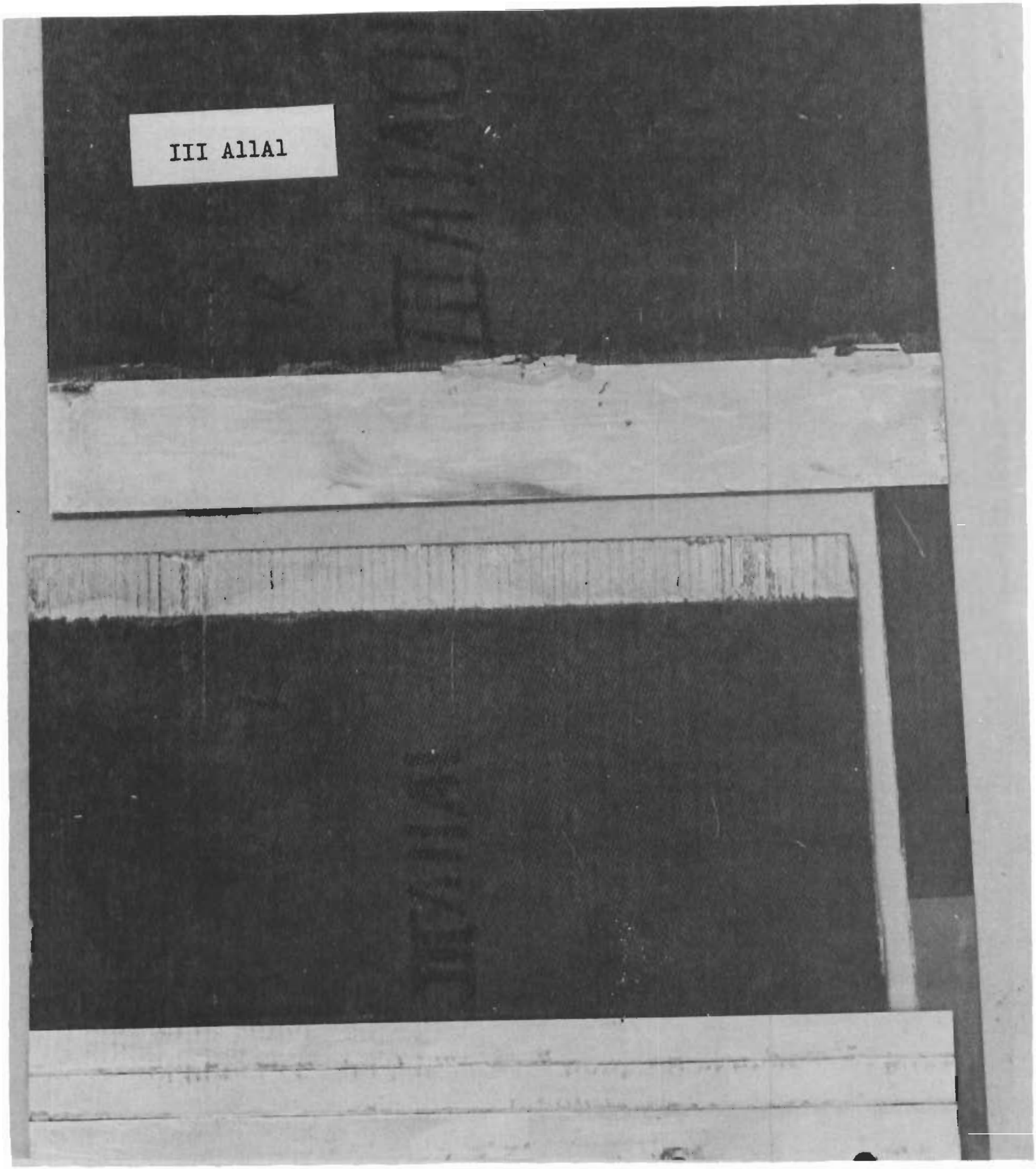
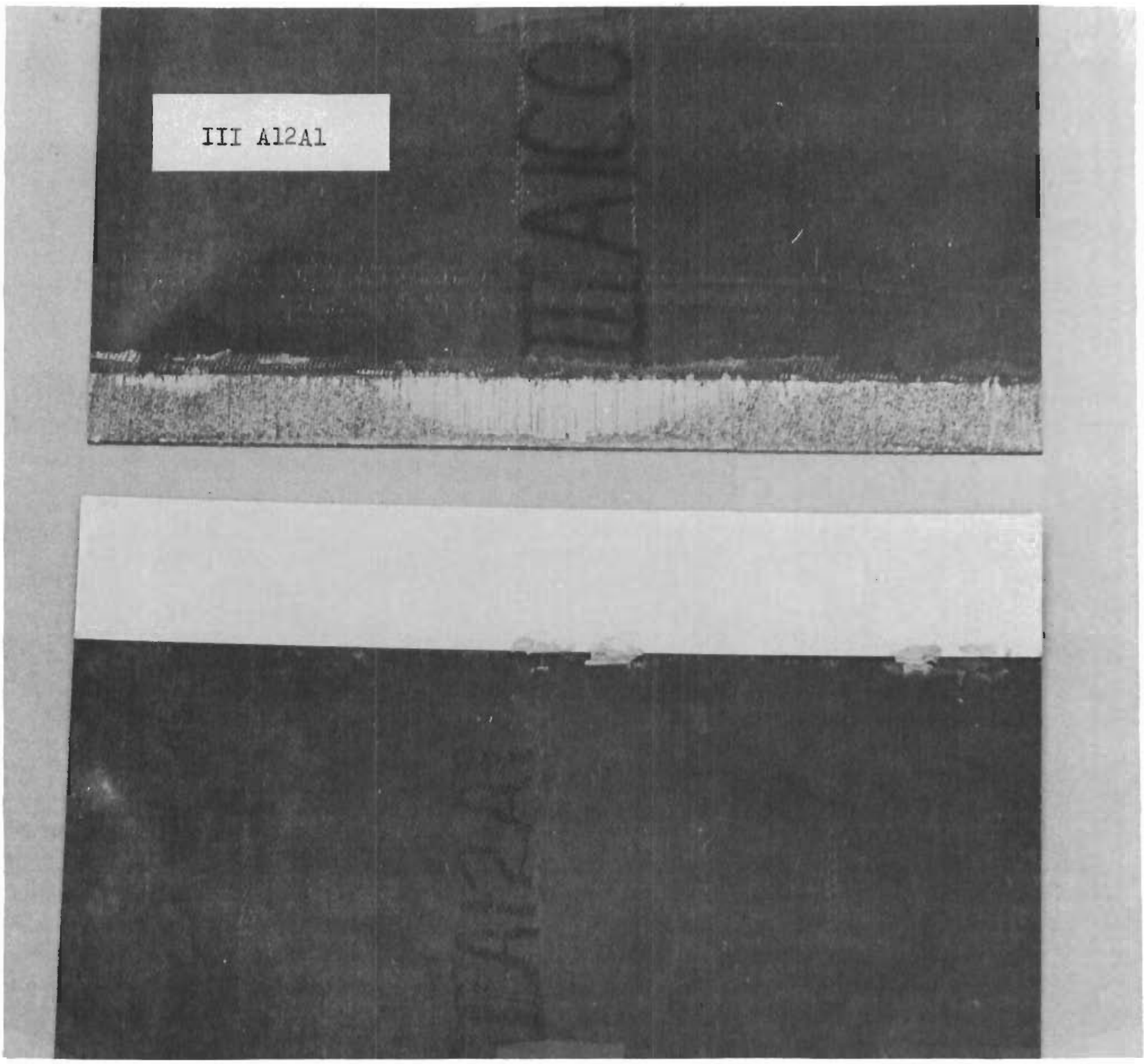


FIGURE 76 - CONTROL SPECIMEN FOR
BORON/TITANIUM CONFIGURATION A TEN-INCH WIDE SPECIMEN



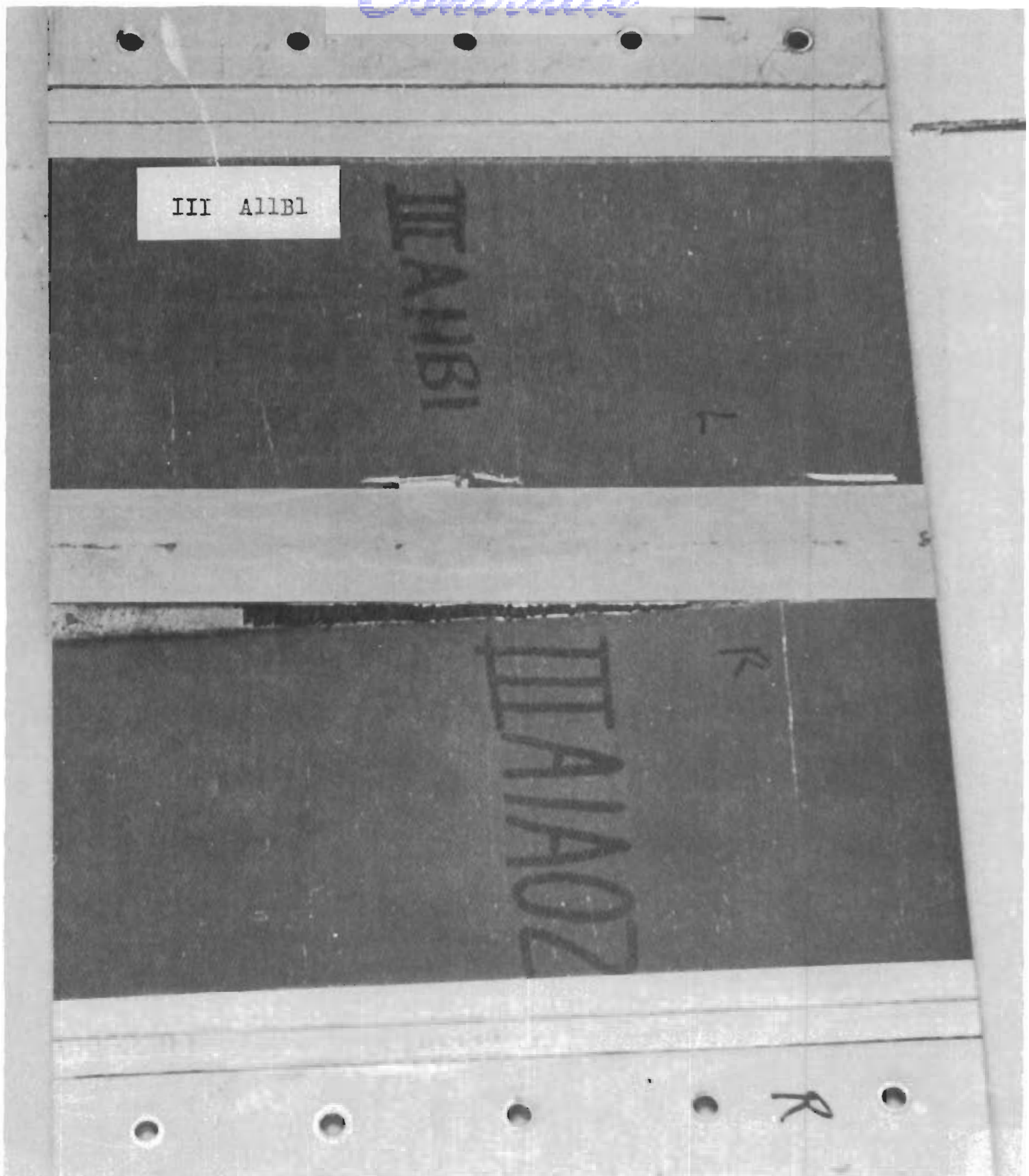
Close examination indicate failure to initiate at the center of the specimen. The splitting of the laminate is probably secondary and due to partial bond failure at the tab end.

FIGURE 77 - CONFIGURATION A - TEN INCHES WIDE BORON/TITANIUM, STRESS RATIO R = + 0.1



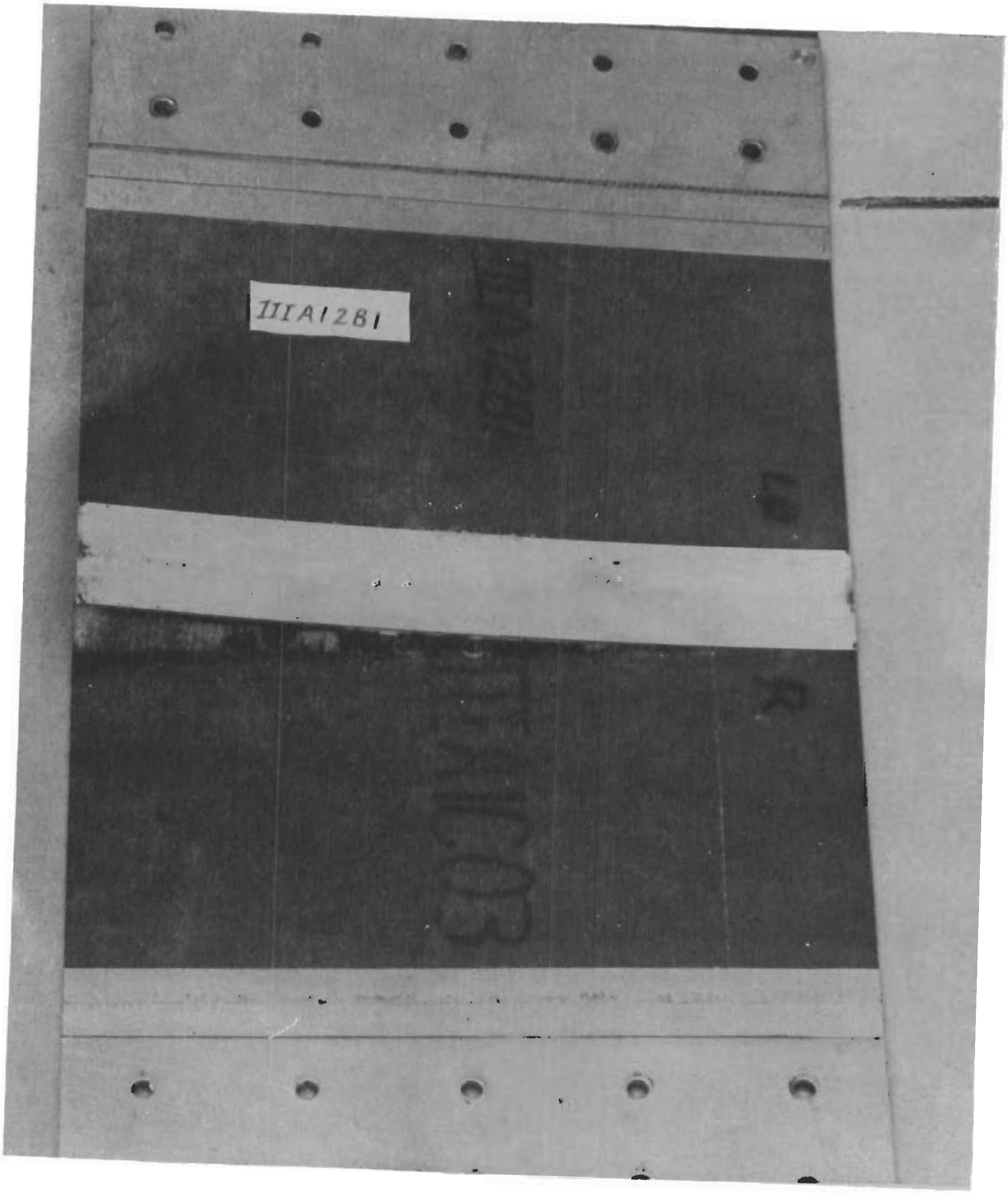
Fatigue zone can be seen at center of specimen with what appears as static failure towards the edges. Note similarity between these static zones and the static failures of Figure 51.

FIGURE 78 - CONFIGURATION A - TEN INCHES WIDE BORON/ALUMINUM, STRESS RATIO R = + 0.1



Fatigue zone can be seen at center of specimen and static zone on the left side and unfailed 2.0" section on the right side.

FIGURE 79 - CONFIGURATION A - TEN INCHES WIDE BORON/TITANIUM, STRESS RATIO R = - 1.0



Note same failure pattern as shown in Figure 54.

FIGURE 80 - CONFIGURATION A - TEN INCHES WIDE BORON/ALUMINUM STRESS RATIO R = - 1.0

4.6 BONDED JOINT TESTS - CONFIGURATION B - STEP LAP SCARF JOINT

4.6.1 Specimen Configuration

The Phase I, Configuration B specimen details are given in Dwg. No. 7226-13021B, Appendix C. The Phase II and Phase III specimens were fabricated to the same drawing but the width dimension was increased to 3.0 and 10.0 inches respectively. Specimen identification information is given in Tables VII, VIII and IX.

4.6.2 Test Procedure and Results - Phase I and Phase II

The Phase I tests were conducted in accordance with Table VII, and the test data were reported in Appendix B, Tables B10 thru B13. The Phase II tests were conducted in accordance with Table VIII, and the test data were reported in Appendix B, Table IIB2.

All the Configuration B, step lap scarf joints were supported with the same type of plates as those used on the Configuration A joints. The shim plates were modified to provide a cut-out for the thermocouple which was located at the scarf joint interface on the short side of the composite material. This convenient position was selected because a temperature survey utilizing three thermocouples positioned along the length of the joint had indicated that the temperature differential along the joint was negligible for all test stress levels. The gap between the joint and the support plates was maintained at approximately 0.003 inch on each side and over a length slightly greater than the length of the joint, as shown in Figure 81. A "T" section stiffener was added to the support plates when used on specimens that were subjected to compressive loading.

Representative failure modes for a selection of Phase I specimens are presented in Figures 82 thru 85. Typical fatigue failures for the wider Phase II specimens are shown in Figures 86 and 87. Comparison of test data for the 1.0-inch wide joints with the data for the 3.0-inch wide joints shows that a majority of the 3.0-inch wide specimens exhibited longer fatigue lines than did the 1.0-inch wide specimens. This is a reversal of what was shown by a similar comparison for the Configuration A specimens which exhibited shorter

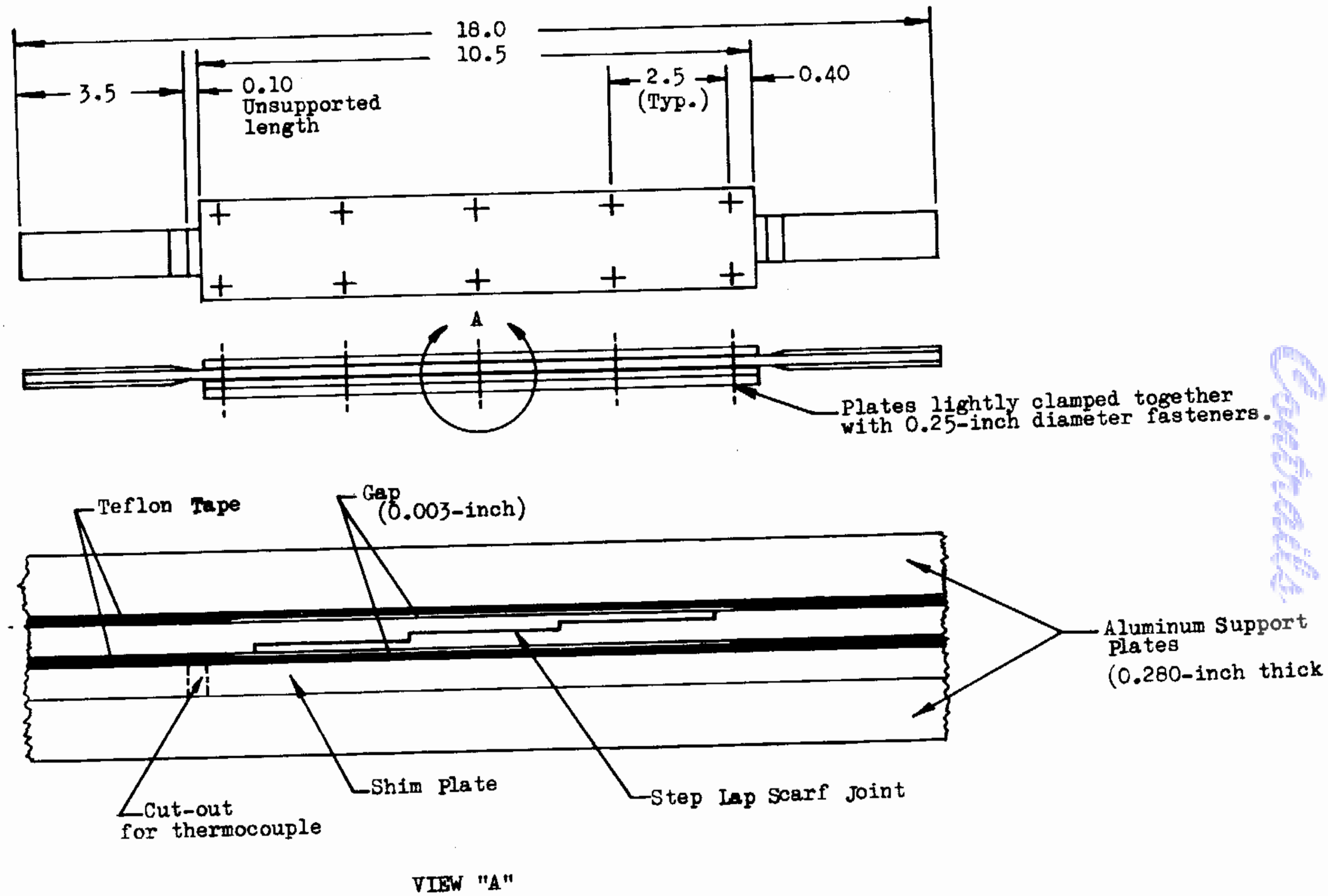
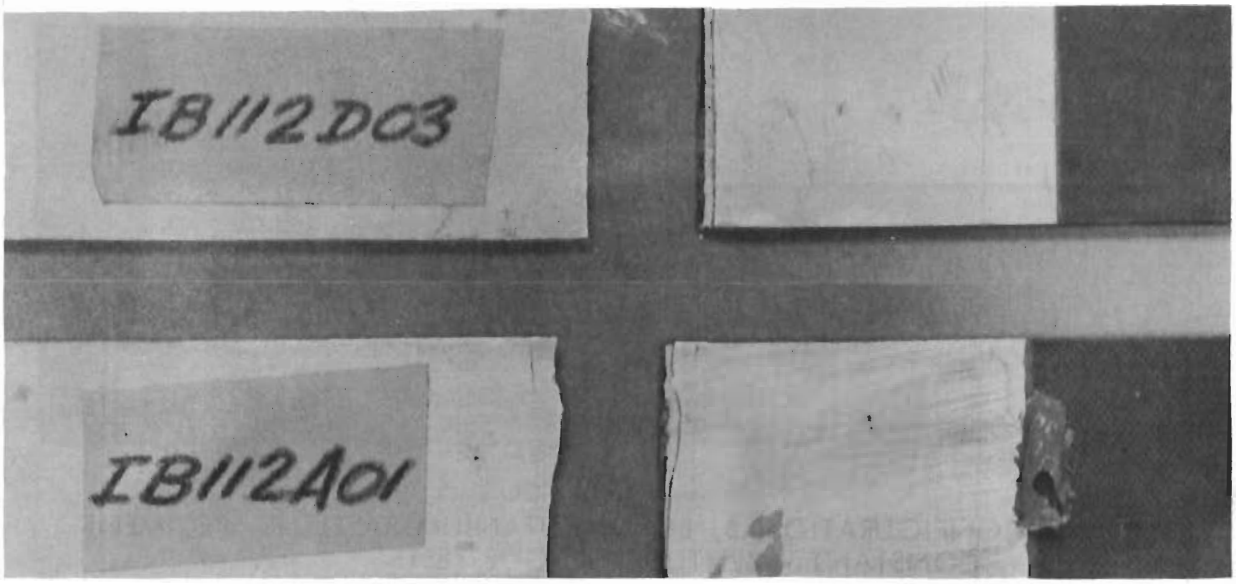
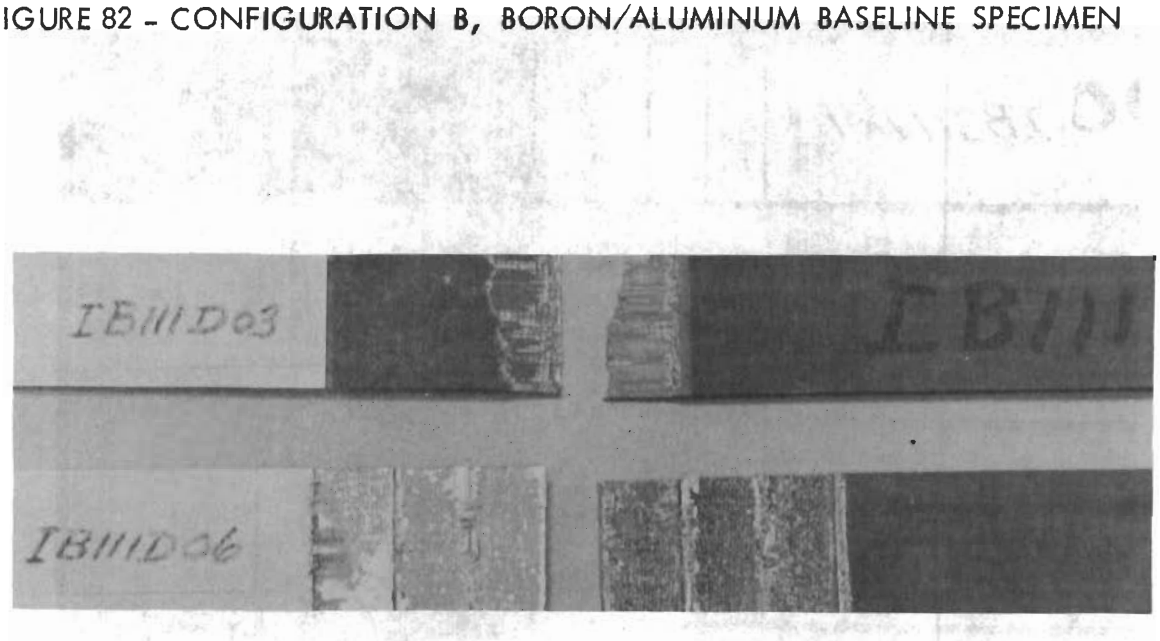


FIGURE 81 SUPPORT PLATE SYSTEM FOR TYPE "B" JOINT SPECIMEN



-D03 Typical static tensile failure in aluminum adherend
-A01 Typical R = +0.1 fatigue failure in aluminum adherend

FIGURE 82 - CONFIGURATION B, BORON/ALUMINUM BASELINE SPECIMEN



-D03 Static tensile failure with partial interlaminar shear
-D06 Static tensile shear failure
(mating fracture surfaces are shown)

FIGURE 83 - CONFIGURATION B, BORON/TITANIUM BASELINE SPECIMEN

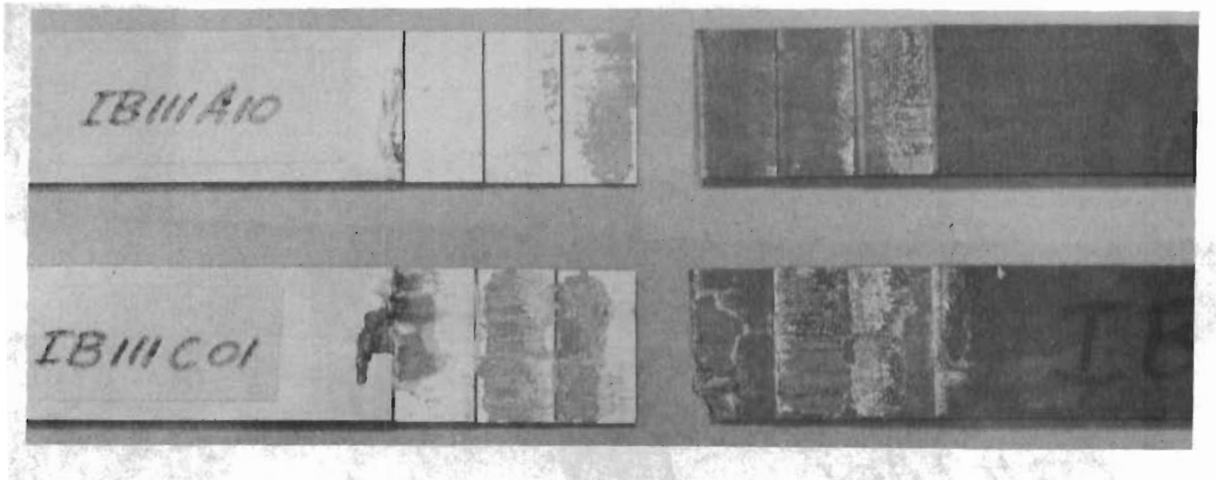


FIGURE 84 - CONFIGURATION B, BORON/TITANIUM BASELINE SPECIMENS
CONSTANT AMPLITUDE FATIGUE TESTS

-A10 Typical R = +0.1 fatigue failure in joint
-C01 Typical R = +10.0 fatigue failure in joint with minor laminate damage
(mating fracture surfaces shown)

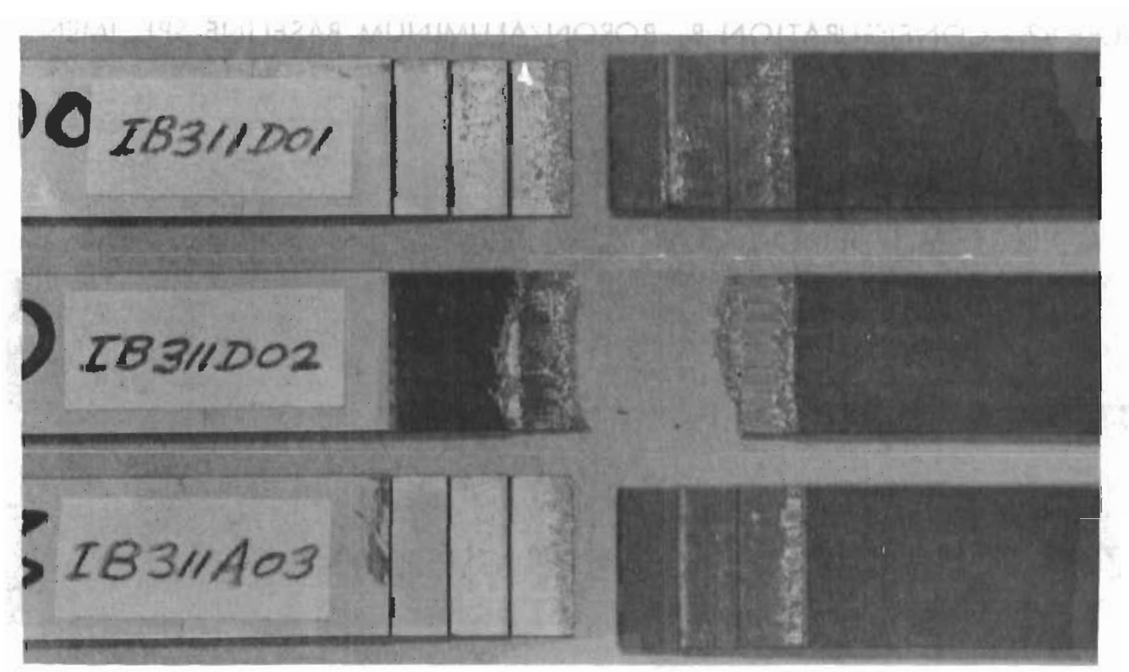
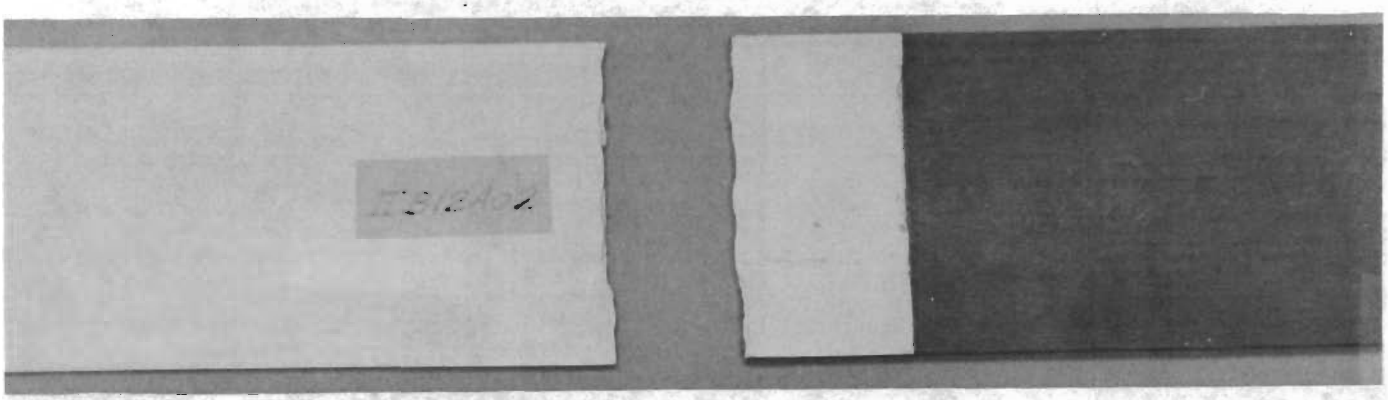


FIGURE 85 - CONFIGURATION B, BORON/TITANIUM SHORT LAP LENGTH

-D01 Static tensile shear failure
-D02 Static tensile failure with partial interlaminar shear
-A03 Typical R = +0.1 fatigue failure in joint
(mating fracture surfaces shown)



-A02 Typical R = +0.1 fatigue failure in metal

FIGURE 86 - CONFIGURATION B, THREE INCHES WIDE BORON/ALUMINUM, STEP LAP SCARF JOINT

-A05 R = +0.1 fatigue failure in joint and partial laminate failure
-A02 R = +0.1 fatigue failure in joint

FIGURE 87 - CONFIGURATION B, THREE INCHES WIDE
SHORT OVERLAP BORON/TITANIUM, STEP LAP SCARF JOINT

fatigue life with increase in specimen width. The 3.0-inch wide boron-to-aluminum specimens, however, behaved in a more predictable manner due to the mode of failure for this configuration. All failures occurred in the aluminum adherend after approximately the same number of cycles and at the same stress level as did the equivalent 1.0-inch wide step joints.

4.6.3 Test Procedures and Results - Phase III

The Phase III tests were conducted in accordance with Table IX, and the test data are reported in Appendix B, Table IIIB2.

The test procedure used for the ten-inch wide Configuration B specimens was essentially the same as those used for the Configuration A ten-inch wide specimens. A similar support plate system was used but the shim plates were modified to accommodate the different joint configuration. The increase in fatigue life exhibited by the 3.0-inch wide specimens was again exhibited by the ten-inch specimens, i.e., the ten-inch specimens developed longer fatigue life than did the one-inch and three-inch wide specimens.

4.7 BONDED JOINT TESTS - CONFIGURATION C - TEE SUPPORT JOINT

4.7.1 Specimen Configuration

The Phase I, Configuration C specimen details are given in Dwg. No. 7226-13021C, Appendix C, and specimen identification information is given on Table VII.

4.7.2 Test Procedure and Results

Tests were conducted in accordance with Table VII, and the test data are reported in Appendix B, Table B14.

A specially designed support and side loading fixture was used for all tests. The fixture was fabricated to the configuration shown in Figure 88 and consists of two lateral support plates with two stiffener plates attached to one of the lateral plates. The same plate has a cut-out at the center to allow the tee piece of the specimen to pass through. A strain-gaged link, in the form of a fork-end with a threaded shank, is attached to the tee and the threaded end passes through a reaction plate mounted to the stiffener plates. Originally a coil spring was located between the reaction plate and the end of the shank of the link and was held in place by a nut and washer. Later developments, however, resulted in the coil spring being replaced by two pieces of 0.125 inch thick rubber sandwiched between the reaction plate and a large 0.10 inch thick aluminum washer. Load was applied to the tee by turning the nut on the calibrated strain-gaged link. The magnitude and shape of the lateral deflection along the length of the specimen adherend is controlled by the type of shimming used between the specimen and the support plates, and by the magnitude of the applied axial load. After evaluating various systems it was found that a tapered aluminum shim and soft rubber sheet combination provided the desired deflection pattern. The aluminum shims were 0.150 inch thick at the tab end and feather-edged at the other end near the tee. The soft rubber was approximately 0.50 inch thick and the same length as the shim. One piece of rubber and one shim were sandwiched between the specimen adherend and the upper support plate on each side of the tee joint.

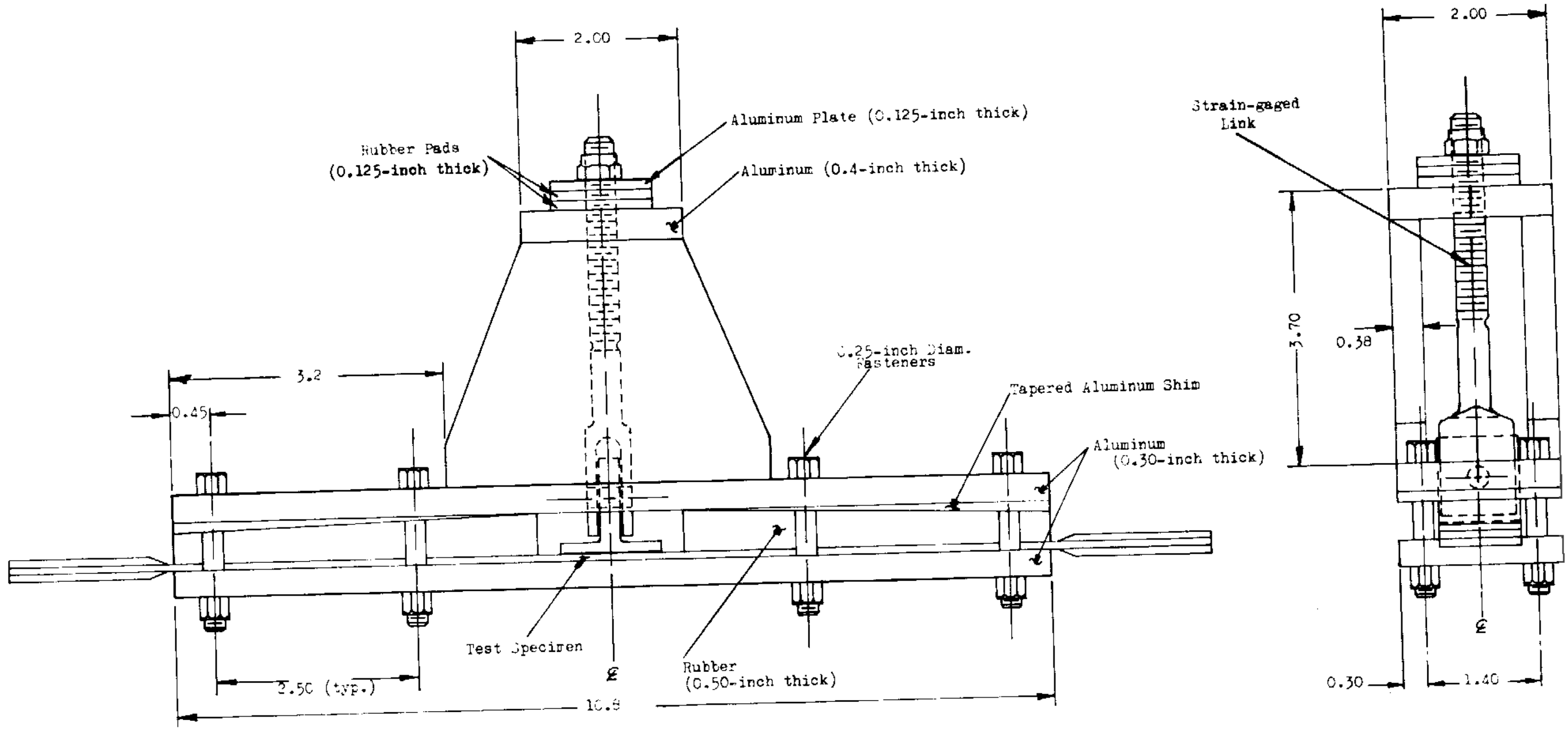


FIGURE 88 - TEST FIXTURE FOR CONFIGURATION C AND CONFIGURATION F SPECIMENS

The static tests were conducted by maintaining a selected axial load on each specimen and then determining the side load required to fail the tee-to-specimen bond. The selected axial loads were representative of the range anticipated for the fatigue tests. The test set-up for the fatigue tests is shown in Figure 89. After the mean axial load had been applied to the specimen, the side load (based on the results of the static tests) was applied to the tee. A typical test specimen with mean axial and side loads applied is shown in Figure 90. Application of the dynamic axial load caused a variation in the side load which was monitored on the calibrated stripchart recorder. Each specimen had a thermocouple bonded to the adherend at the edge of the tee. Failure of the bond between the tee and boron resulted in a straightening of the boron adherend which in turn triggered the micro-switch and stopped the machine.

A photograph of a failure specimen immediately prior to failure is presented in Figure 91.

Failures generally occurred in the resin adjacent to the fibers in the surface ply as illustrated in Figures 92 and 93. One fatigue specimen, however, had an unusual failure mode as shown in Figure 94. This specimen had a partial tensile failure in the boron resulting in interlaminar shear failure over a large portion of the laminate.

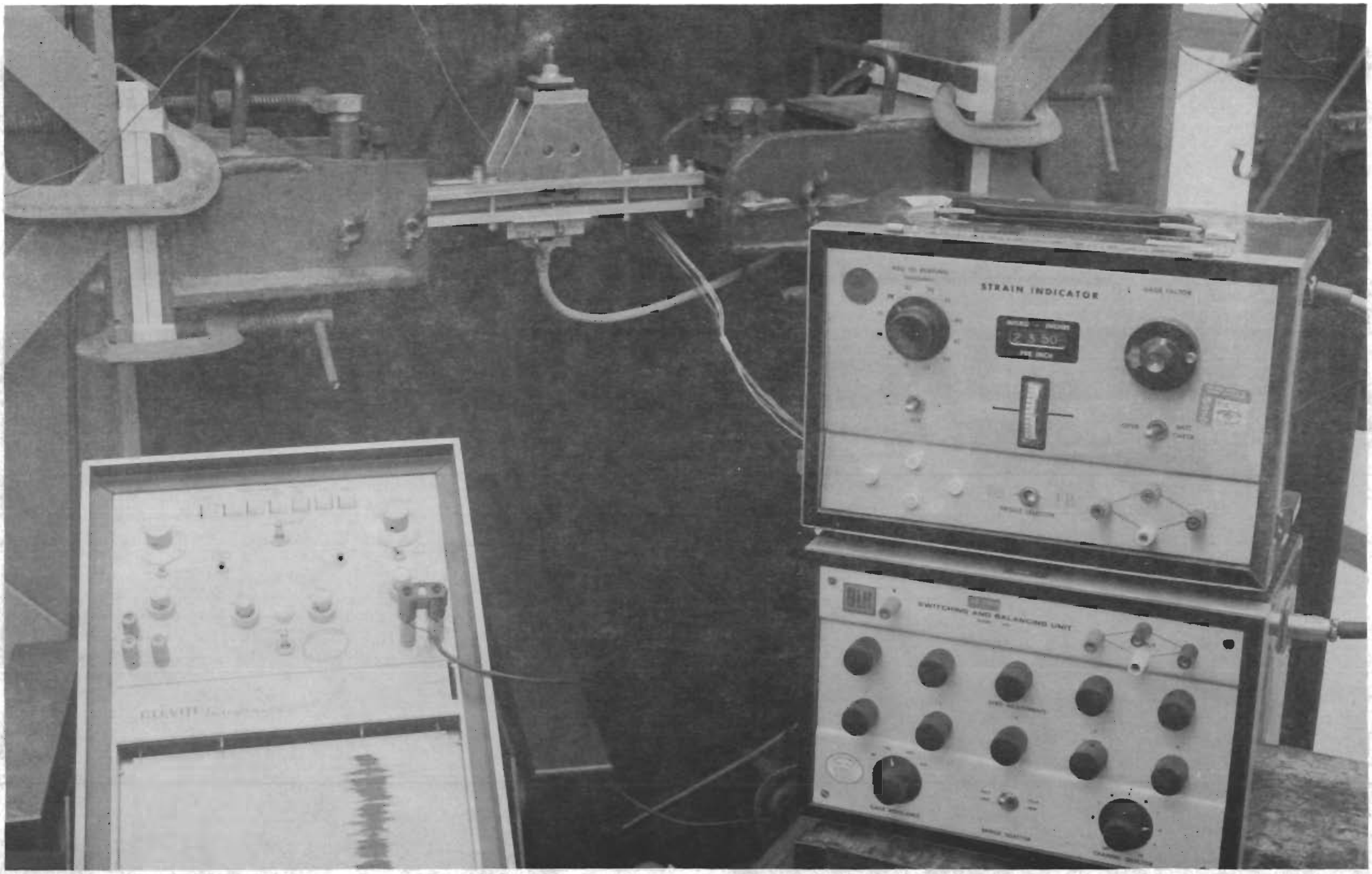


FIGURE 89

Test Fixture For Configuration C Bonded Tee Joint

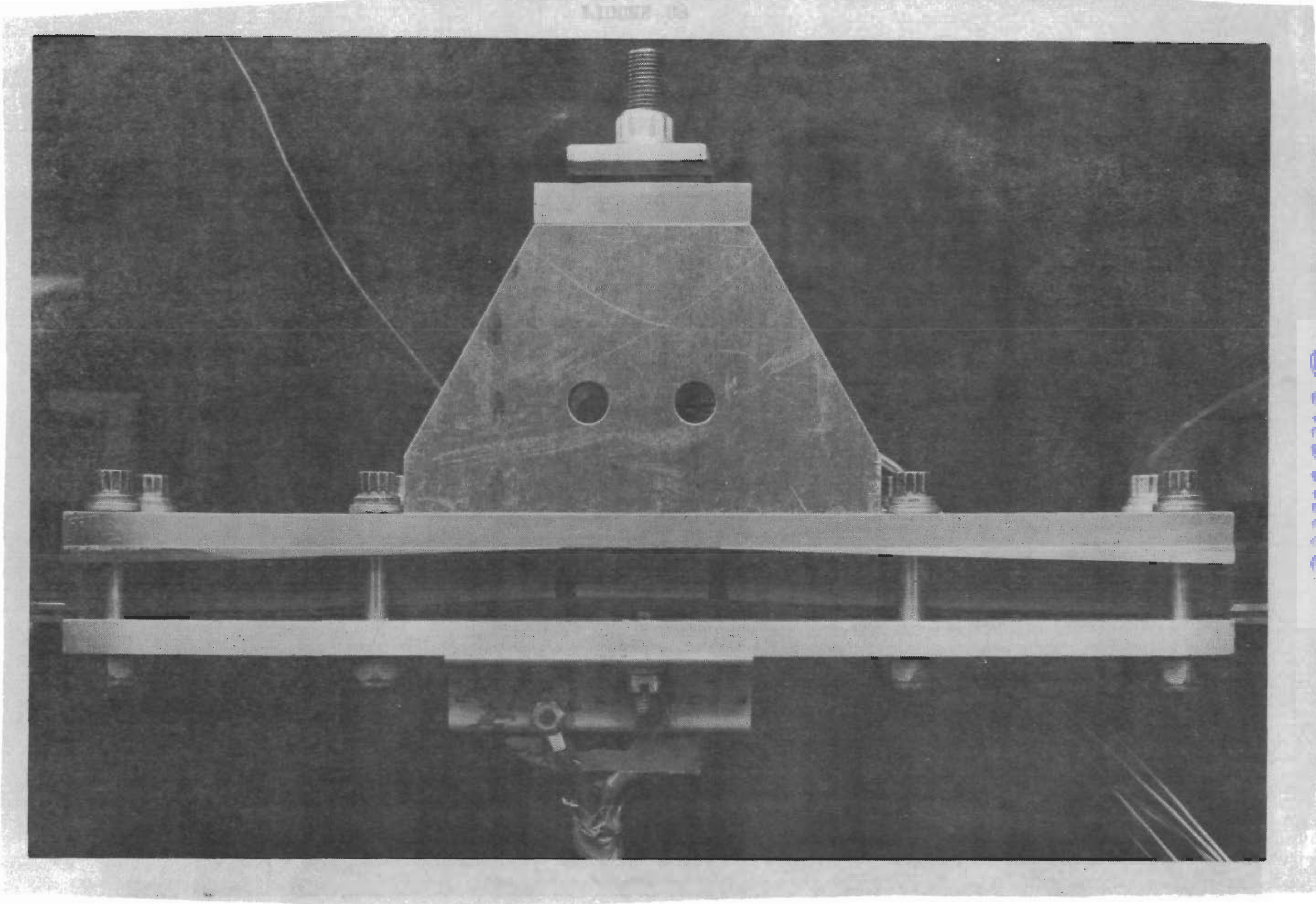


FIGURE 90

Test Set-Up for Configuration C Specimen (Mean Axial and Side Loads Applied)

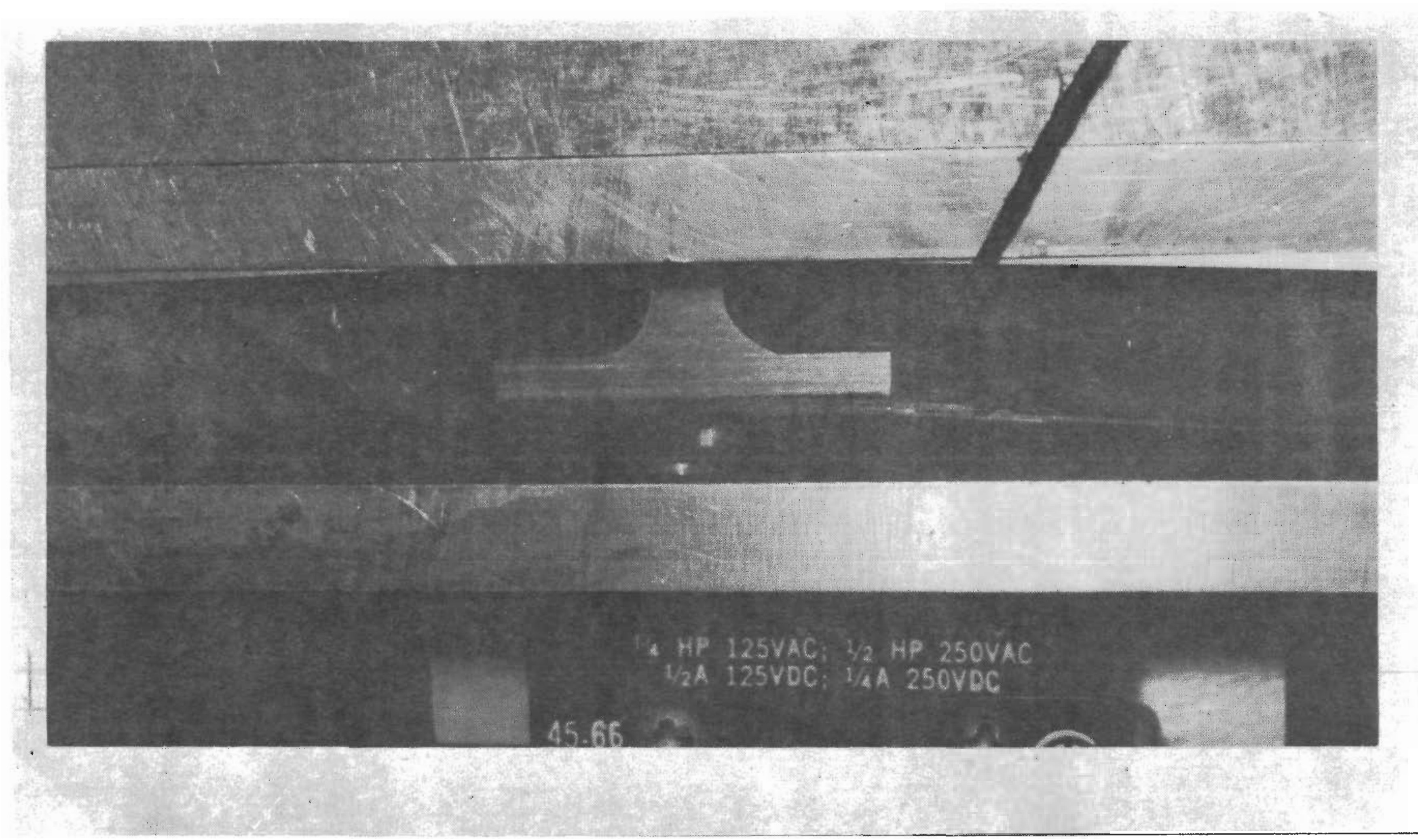


FIGURE 91

Configuration C Specimen Under Fatigue Loading Just Prior to Failure

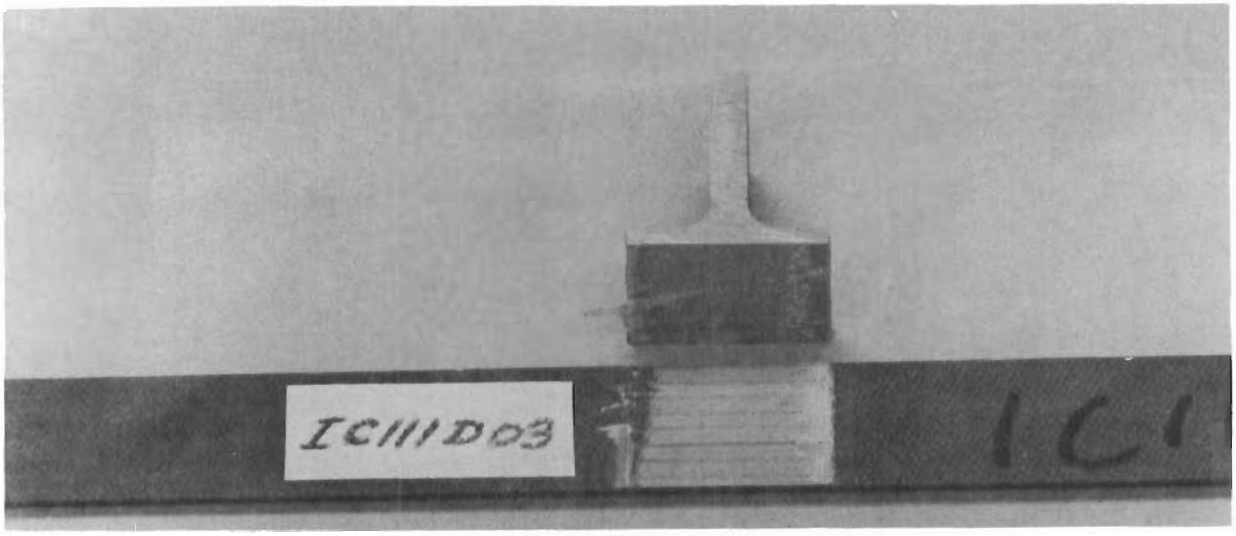


Figure 92 Configuration C, Titanium Tee/Boron Static Test

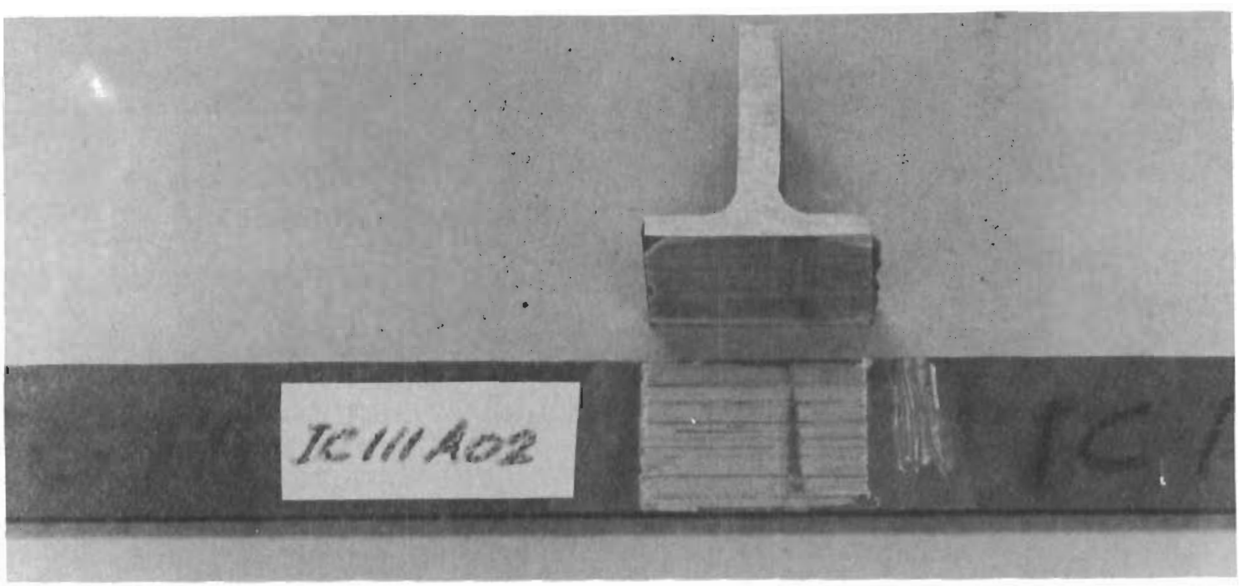
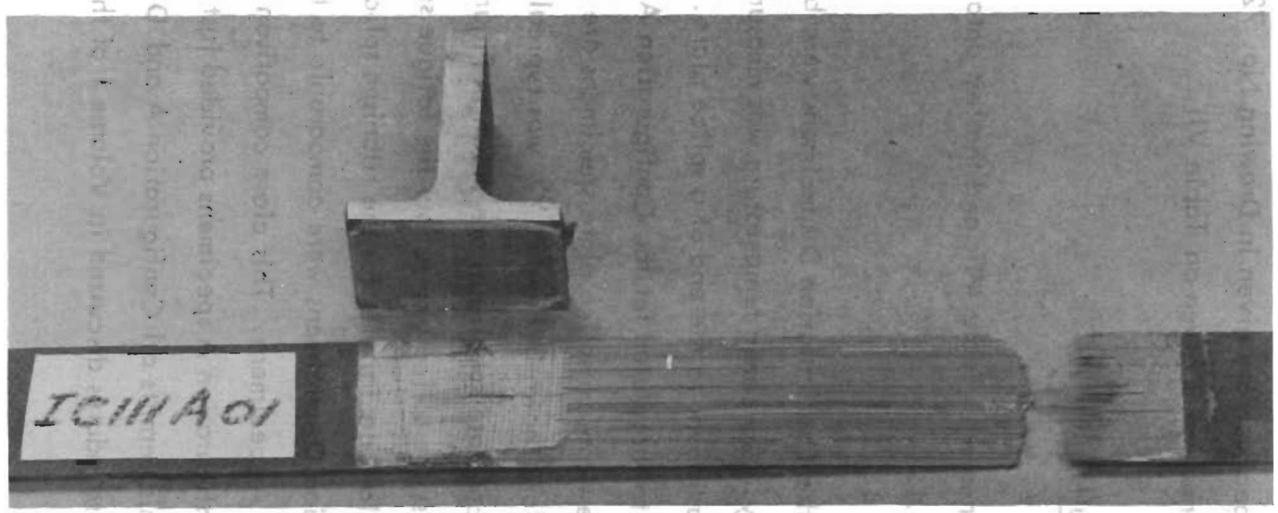


Figure 93 Configuration C, Titanium Tee/Boron
Fatigue Test R = +0.1 Typical Failure



Partial tensile failure and interlaminar shear

FIGURE 94 - CONFIGURATION C, TITANIUM TEE/BORON
FATIGUE TEST R = + 0.1

4.8 CONFIGURATION D - DOUBLE JOINT TESTS

4.8.1 Specimen Configuration

Details of the Configuration D specimen are given in Drawing No. 7226-13021D, Appendix C. Specimen identification information is given on Table VII.

4.8.2 Test Procedure and Results

Tests were conducted in accordance with Table VII, and the test data are reported in Appendix B, Tables B15 and B16.

Since the double strap joints of the Configuration D specimens were balanced, lateral support plates were not necessary. Specimen temperature was measured with a thermocouple bonded to the adherend adjacent to the end of a splice plate. In all other respects the test procedures were similar to those used for the Configuration A specimens. Static and fatigue failure modes for the titanium splice plate specimens are shown in Figures 95 and 96. The catastrophic failure shown in Figure 95 was typical for all static tests. Failure modes for the boron splice plate specimens are shown in Figure 97. Static test specimens failed in tension across the splice plates, but the fatigue specimens failed in shear at the joint similar to the fatigue failures for the titanium splice plate specimens. Test results for these Configuration D specimens were comparable to the results obtained with the baseline Configuration A specimens. This close comparison verifies that the support plates used with the Configuration A specimens provided just the correct amount of support to the joint area. This permits all Configuration A and D data to be used in conjunction with the analysis procedures discussed in Volume I of this report.

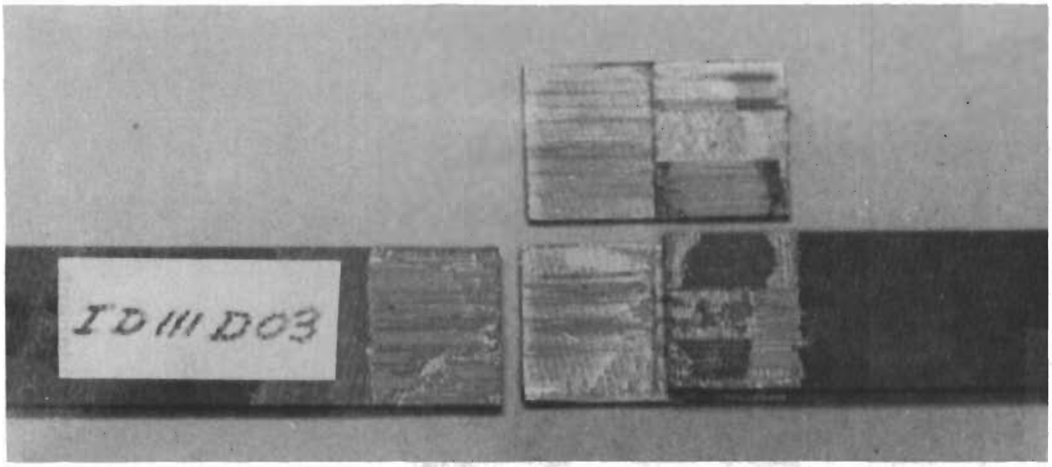


Figure 95 Configuration D, Boron/Titanium, Static Test Titanium Splice Plates

-D03 Typical static tensile failure

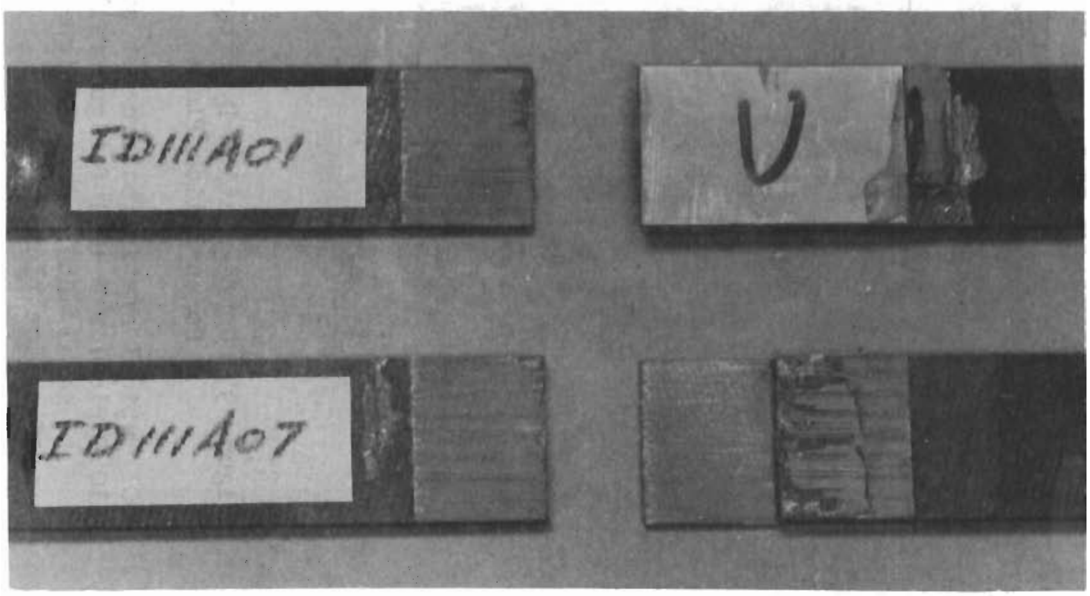


Figure 96 Configuration D, Boron/Titanium, Fatigue Tests R = +0.1 Titanium Splice Plates

-A01 Failure between boron and both splice plates on one end
-A07 Failure of one splice plate at both ends and failure of other splice plate at one end

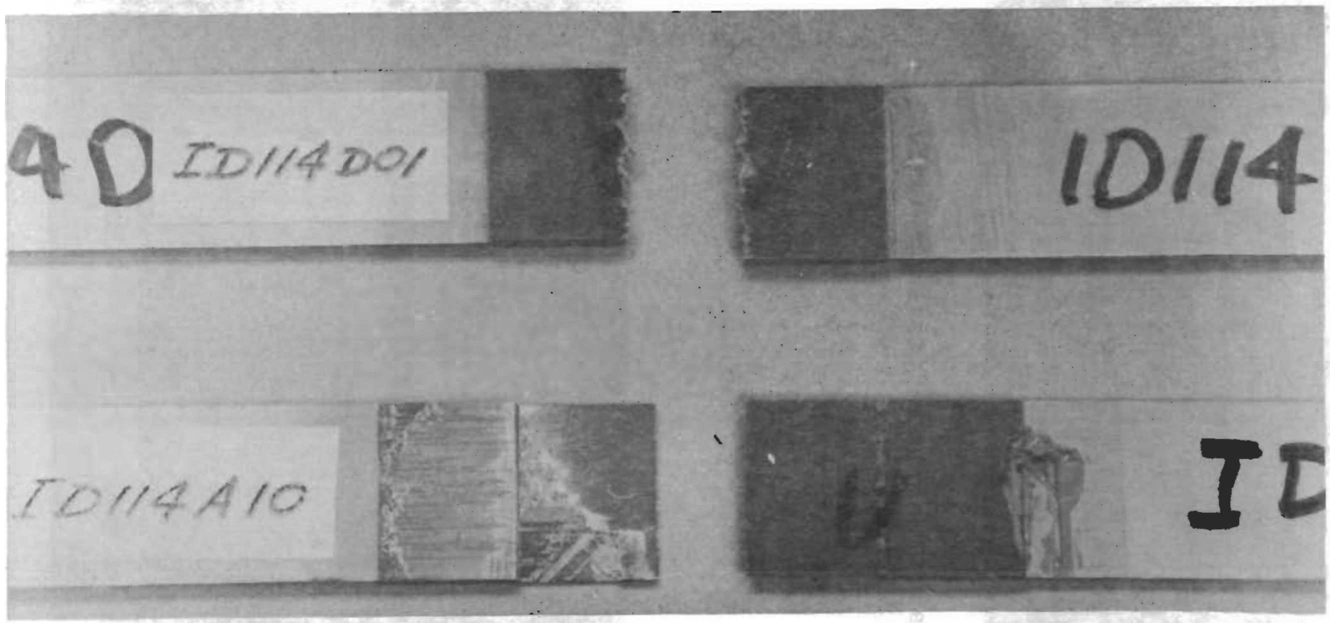


Figure 97 Configuration D, Titanium/Boron Static and Fatigue Boron Splice Plate

-D01 Typical static failure-net section in splice plate
-A10 Typical R = +0.1 fatigue failure shear failure in ply adjacent to metal adherends. Fatigue damage can also be seen at center of splice plate

4.9 BONDED JOINT-CUMULATIVE DAMAGE TESTS

4.9.1 Specimen Configuration

One-inch and three-inch wide Configuration A specimens were fabricated for the Phase I and Phase II cumulative damage tests. A ten-inch wide, modified Configuration A specimen and a ten-inch wide, modified configuration B specimen were fabricated for the Phase III cumulative damage tests.

4.9.2 Test Procedure and Results

Phase I tests were carried out in accordance with Table VII,, and the test data are reported in Appendix B, Table B3. Phase II tests were carried out in accordance with Table VIII, and the test data are reported in Appendix B, Table IIB1. Phase III tests were carried out in accordance with Table IX, and the test data are reported in Appendix B, Table IIIB.

The cumulative damage tests were conducted using the same support plate systems that were selected for the appropriate baseline data specimens tested in each of the three Phases. The same programming equipment was used for all testing and is described in detail in section 4.2.3. Two software programs were used to prepare the computer for either block loading format or realistic loading format. Both types of loading programs are described in Volume III, Section 2.3.

During the testing of the Phase I specimens, some failures occurred in the adherend material between the end of the support plates and the tab end of the specimen. The cause of these premature failures was not determined. However, sufficient contingency specimens were available to complete the required number of cumulative damage tests with valid joint failures. The maximum and minimum load levels of each individual block were measured on the MTS load amplitude measurement equipment in addition to being continually monitored on a calibrated Clevite-Brush strip-chart recorder. Correlation between the two load measuring systems was very good and since the MTS measuring equipment cannot measure single load levels the strip-chart recorder was used for determining the actual applied loads for the realistic spectrum testing. A typical strip-chart recording showing all the load levels in each of four different missions is shown in Figure 98. A one "g" value that corresponded to a joint shear stress of 330 psi was used for both the block and realistic spectrum loading in Phase I.

Since only five cumulative damage tests were scheduled in Phase II it was not possible to use both types of loading spectrum. The realistic spectrum loading was finally selected since it was believed that this type of loading would produce the most useful test data. Three specimens were tested at a one "g" value that corresponded to a joint shear stress of 290 psi and the other two at a joint shear stress of 260 psi.

The Phase III, 10.0-inch wide specimens were tested using the block loading spectrum adopted originally for the Phase I bonded joint tests. Both the Configuration A and Configuration B specimens were loaded to a maximum average joint shear stress level of 2000 psi (10 "g" load level). The same stress level was selected for each test because it was believed that the results would provide useful comparative damage data in the two joint configurations. Good failures were obtained from both tests, the Configuration A specimen failed after 2.5 lifetimes (25 blocks) and the Configuration B after about 6.1 lifetimes.

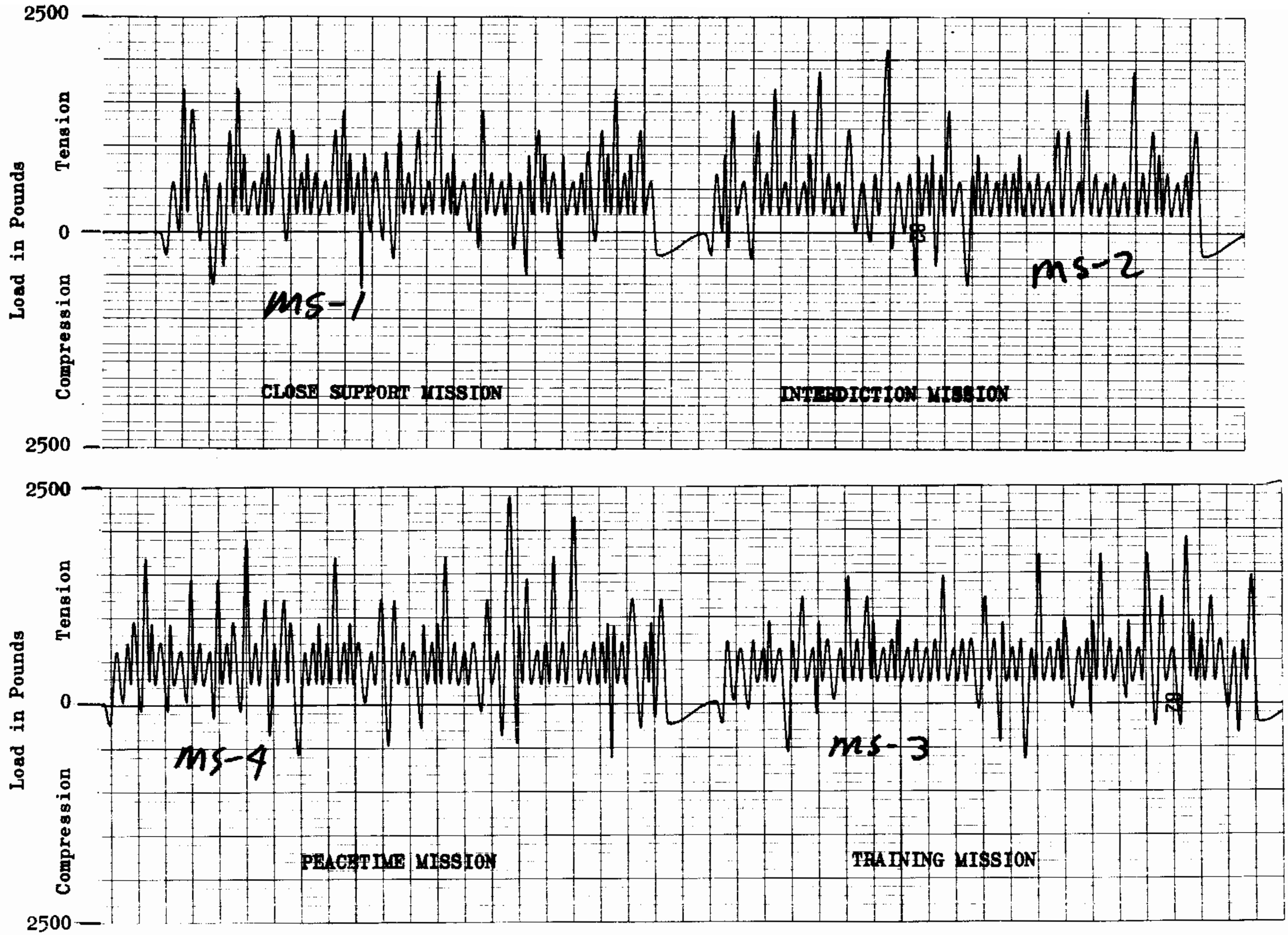


FIGURE 98 TYPICAL STRIP-CHART RECORDING OF INDIVIDUAL LOAD LEVELS IN EACH MISSION, REALISTIC LOAD SPECTRUM

4.10 MECHANICAL JOINT TESTS - CONFIGURATION E - SINGLE SPLICE BUTT JOINT

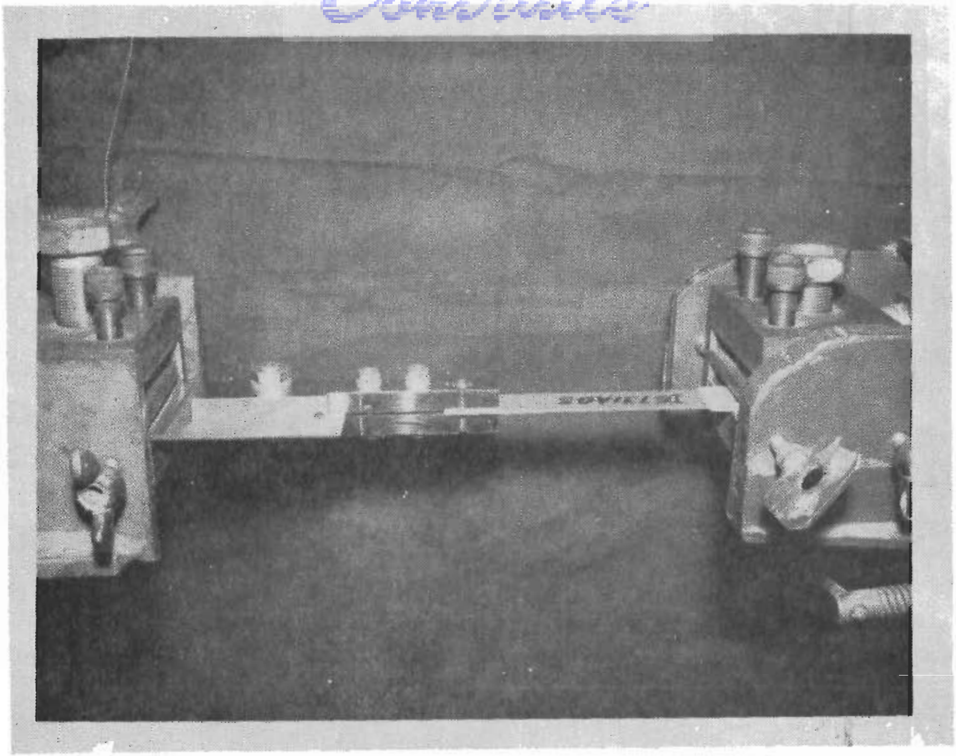
4.10.1 Specimen Configuration

Phase I, one-inch wide and Phase II, 2.0-inch wide specimen details are given in Dwg. No. 7226-13021E, Appendix C. Specimen identification information is given on Table X.

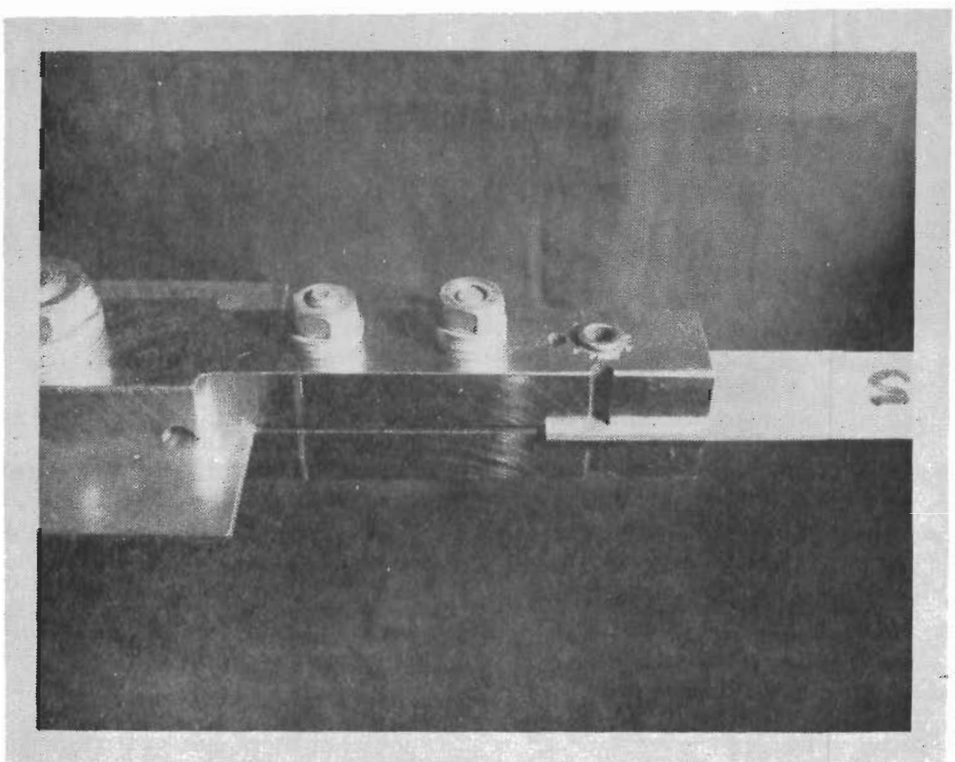
4.10.2 Test Procedure and Results

The tests were conducted in accordance with Table X and the test data are reported in Appendix B, Table IVB1 thru IVB4.

Pin bearing static strengths were determined in a universal testing machine and all fatigue tests were conducted in Lockheed designed fatigue machines. The same pinbearing test fixture was used for all tests. This fixture is shown in a typical fatigue test set-up in Figure 99. It consisted of two steel bars, one clamped on each side of the end of the test specimen, and load was introduced to the specimen through a 0.187 inch diameter steel pin. During each static test, hole deformation was measured with a 2.0-inch gage length extensometer. One pair of the extensometer knife edges were attached to the edges of the specimen in line with the pin loading hole and the other pair of knife edges were attached to the test fixture. Load versus deformation was plotted on an autographic recorder. Since there were only five fatigue specimens within a group, one specimen was fatigue tested at each of five different stress levels. Photographs of typical failures are presented in Figures 100, 101, and 102. The test data were exceptionally consistent enabling good fatigue trend lines to be determined for the different specimen configurations. Data generated included the evaluation of a 0°/±45° reinforced with titanium shims and with additional ±45° plies. The effect of edge distance was also evaluated with the specimens using titanium shims as the reinforcement material in the joint area.



(General View)



(Close-up View)

Figure 99 Pin Bearing Test Set-Up

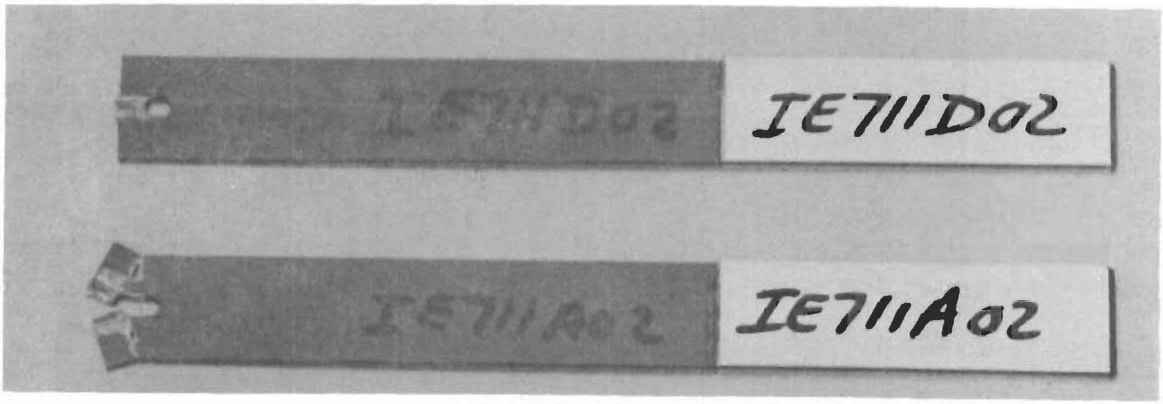


Figure 100 Pin Bearing Specimen ($0^{\circ}/\pm45^{\circ}$)
Titanium Reinforced, e/D $\cong$ 2.0
-D02 Typical Static Failure
-A02 Typical R = +0.1 Fatigue Failure

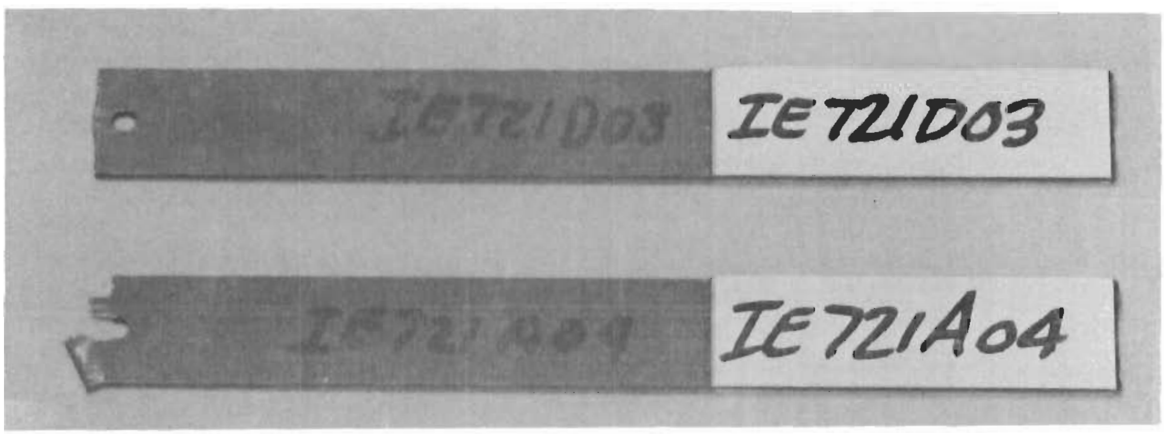


Figure 101 Pin Bearing Specimen ($0^{\circ}/\pm45^{\circ}$)
Titanium Reinforced, e/D $\cong$ 1.5
-D03 Typical Static Failure
-A04 Typical R = +0.1 Fatigue Failure

Originally, the Configuration E single splice butt joint specimens were fabricated with aluminum straps and splice plates but initial testing of these resulted in premature failures of the aluminum at the joint net sections. It was assumed that failure may have been encouraged by the countersink in the aluminum strap, therefore testing of these specimens was discontinued to allow further investigation. Two specimens were reassembled with titanium straps having the same type of flush head fastener. Premature failures still occurred at the net section of the titanium portion of the joint and the subsequent substitution of protruding head fasteners still did not produce the required boron failures. However, the final design discussed in the Fabrication Section was tested and acceptable failures were obtained in the boron material. All the mechanically fastened joint specimens were tested in the same testing machines that were used for the bonded joint specimens and a similar support plate system was used. Holes were cut in the support plates to accommodate the fastener collars and the gap between the support plates and the specimen in the splice area was maintained at approximately 0.003 inches. The specimens were supported at equal distances on each side of the joint as shown in Figure 103. The actual distance for a given group of specimens was determined by the length of the tapered section in the boron composite where the titanium shims were inserted. Allen wrenches were placed in the ends of the fasteners in order to detect any rotation of the collars or fasteners during fatigue testing. A typical fatigue test set-up with allen wrenches in position and with each location marked in relation to the support plates is shown in Figure 104. Each collar position was also marked relative to the wrench position. Numerous tests confirmed that no rotation had occurred in either the fasteners or collars therefore the procedures adopted for determining rotation were discontinued. Selection of the stress levels for the fatigue tests was based on the results of the pinned joint/edge distance evaluation tests. Excessive heating (over 10° Fahrenheit rise above ambient) was experienced during the initial fatigue testing but effective control was obtained by blowing cool air over the joints with the arrangement shown in Figure 105. Photographs of typical failures are presented for the 1.0-inch wide specimens in Figures 106 thru 111 and for the 2.0-inch wide specimens in Figures 112 and 113. Failures for specimens tested at a stress ratio of $R = +0.1$ usually occurred in the net section area of the shimmed boron through a fastener hole, or at the edge of the shim reinforcement in the basic boron laminate; however, one failure occurred in the titanium splice plate. This splice plate failure suggests that the shimmed

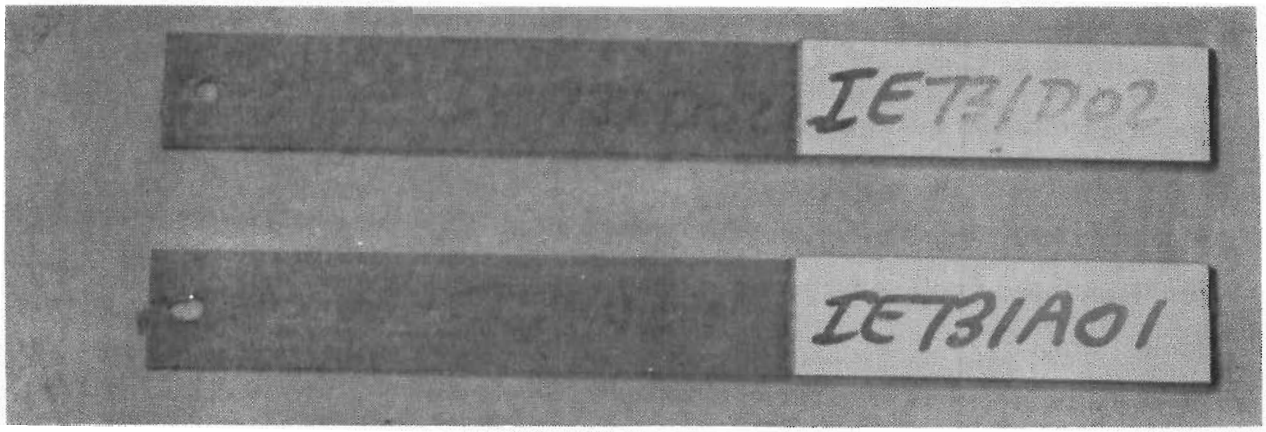


Figure 102 Pin Bearing Specimen ($0^{\circ}/\pm45^{\circ}$)
$\pm45^{\circ}$ Boron Reinforced, $e/D = 2.0$
-D02 Typical Static Failure
-A01 Typical $R = +0.1$ Fatigue Failure

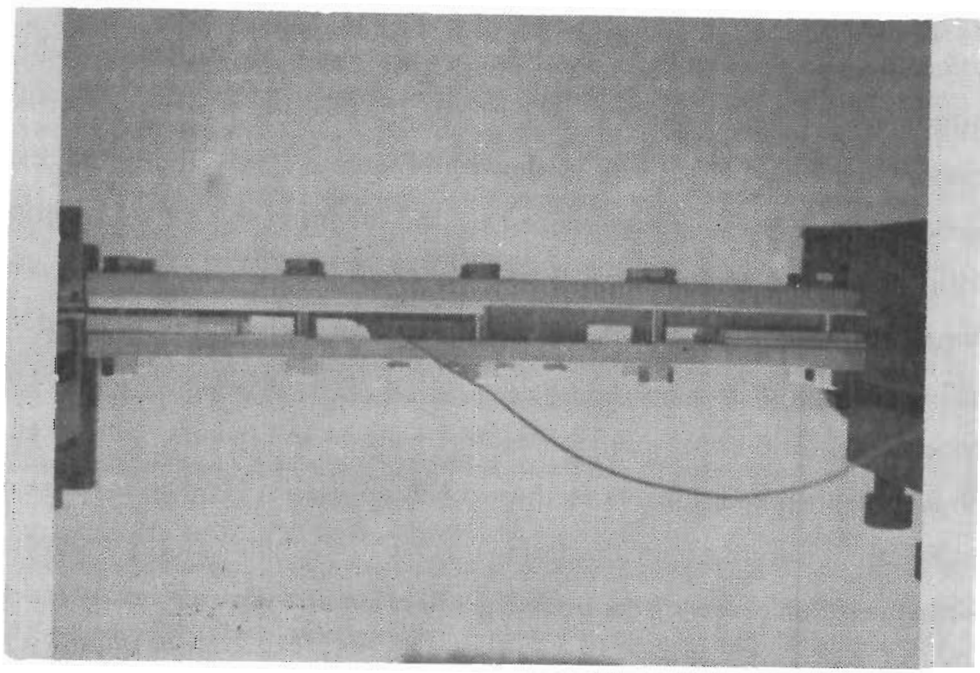


Figure 103 Mechanical Joints With Support Plates

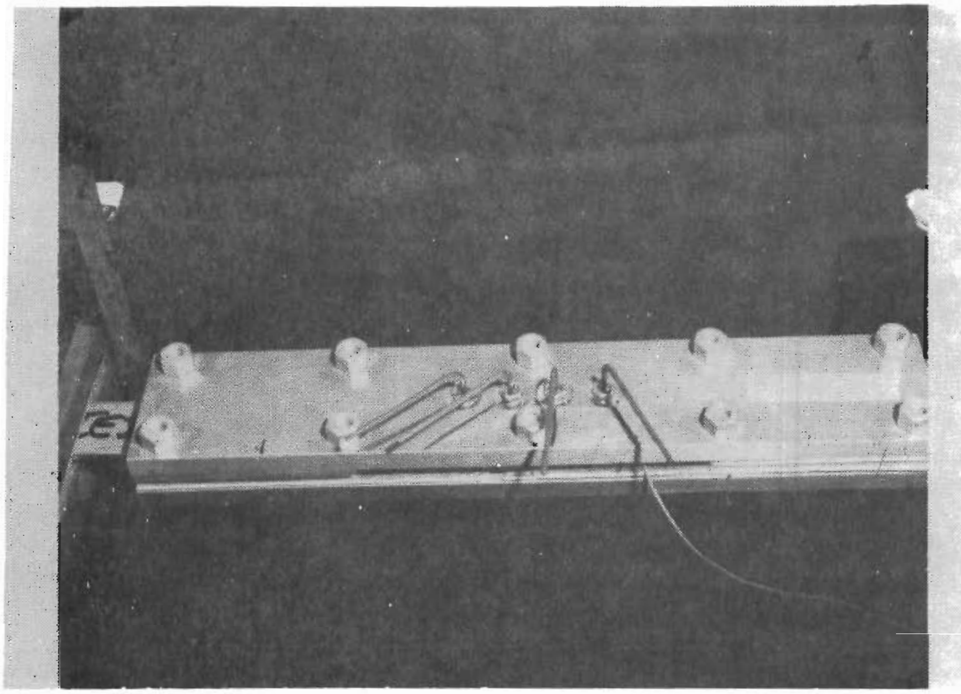


Figure 104 Test Set-Up For Monitoring Fastener Rotation

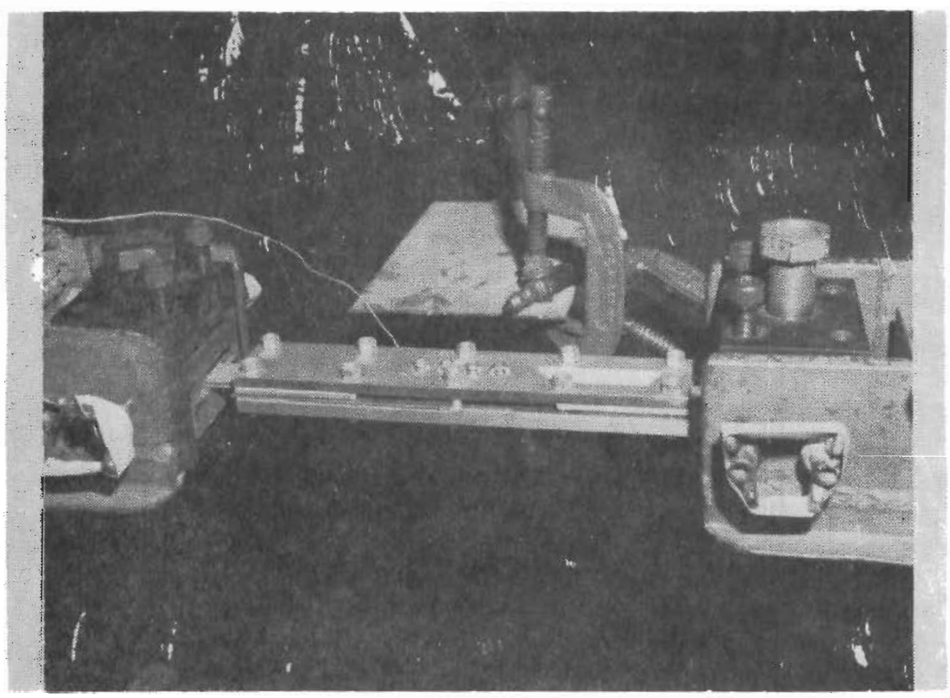


Figure 105 Set-Up For Maintaining Specimen Temperature

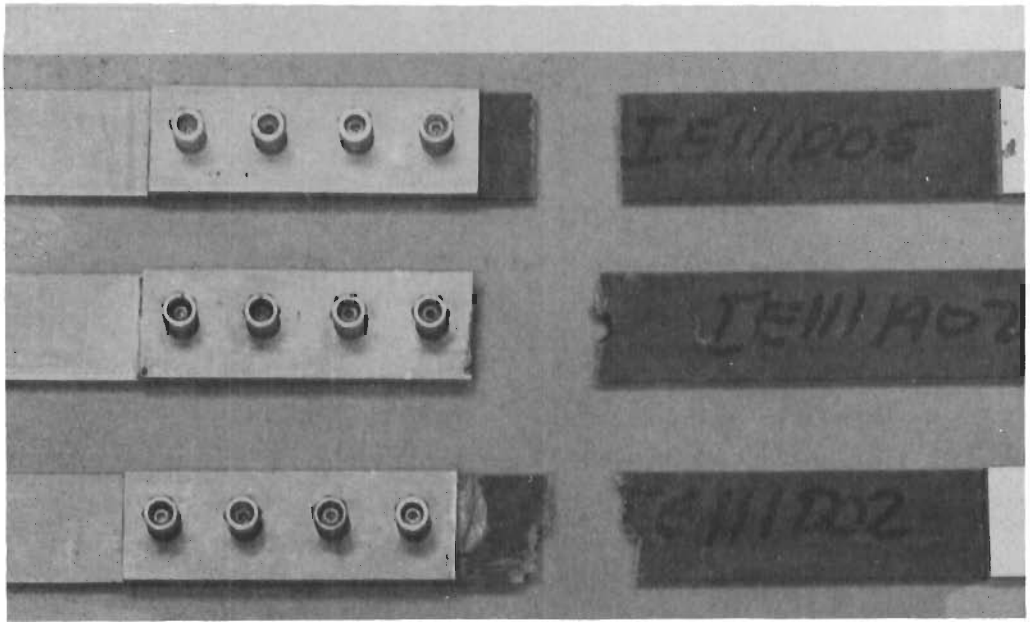


Figure 106 Configuration E, Baseline
($0^{\circ}/\pm45^{\circ}$) Boron/Titanium
-D05 Typical Static Tensile Failure
-A02 Typical R = +0.1 Fatigue Failure
-D02 Typical Static Compression Failure

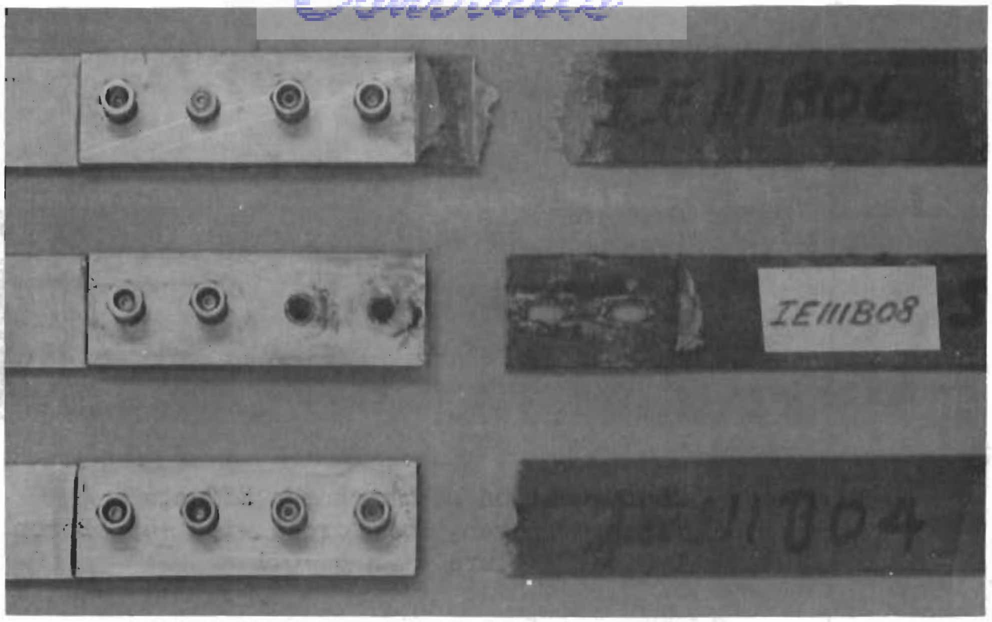


Figure 107 Configuration E, Baseline, R = -1.0
($0^o/\pm45^o$) Boron/Titanium
- Shown are three different types of failure.

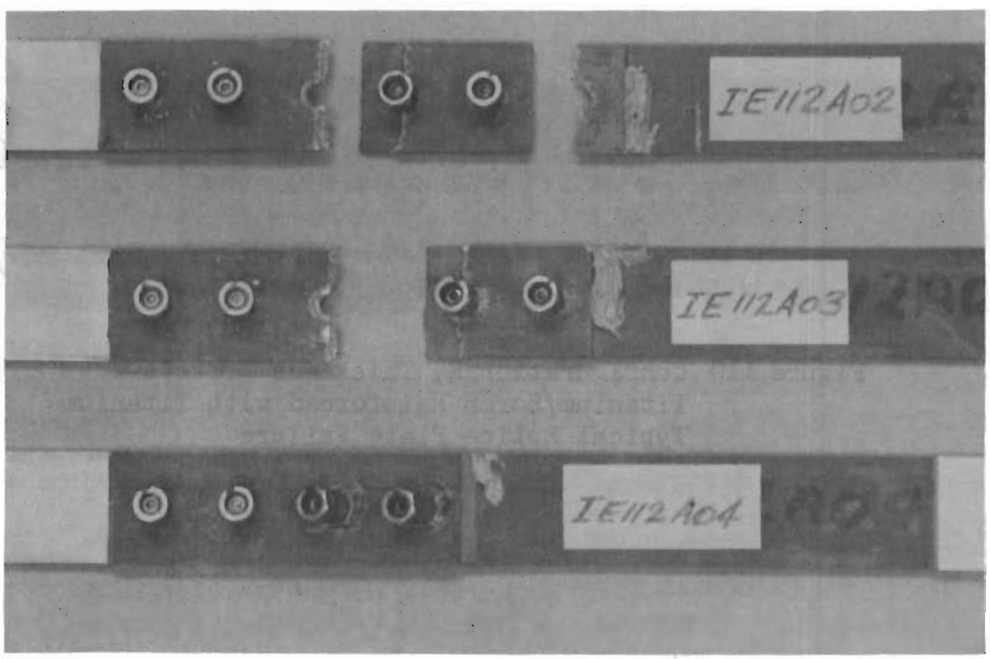


Figure 108 Configuration E, Baseline, R = +0.1
Boron/Boron ($0^o/\pm45^o$ with titanium inserts)
- Shown are three different types of failure.

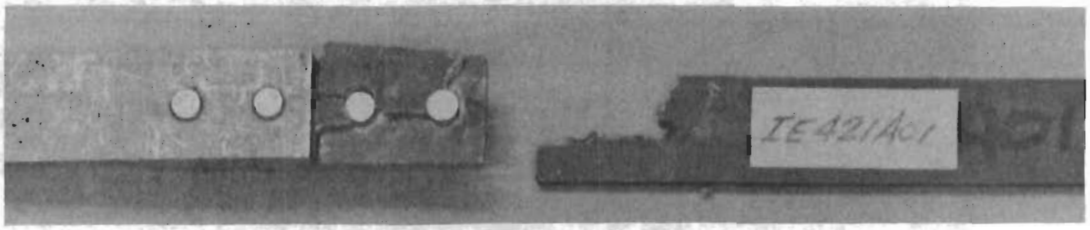


Figure 109 Configuration E, Thickness Effects
Titanium/Boron, Reinforced with $\pm 45^{\circ}$ Boron
Typical Failure at R = +0.1

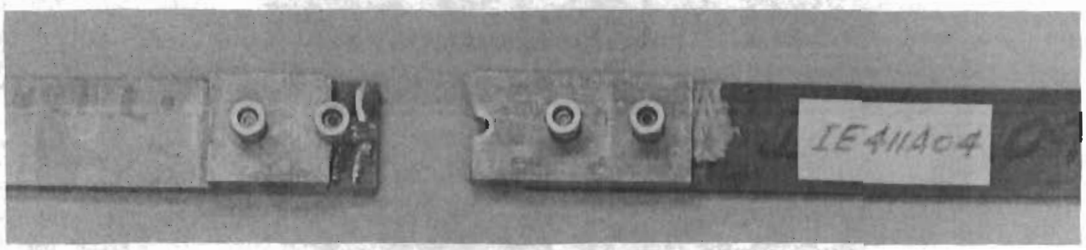


Figure 110 Configuration E, Thickness Effects
Titanium/Boron Reinforced with Titanium
Typical Splice Plate Failure

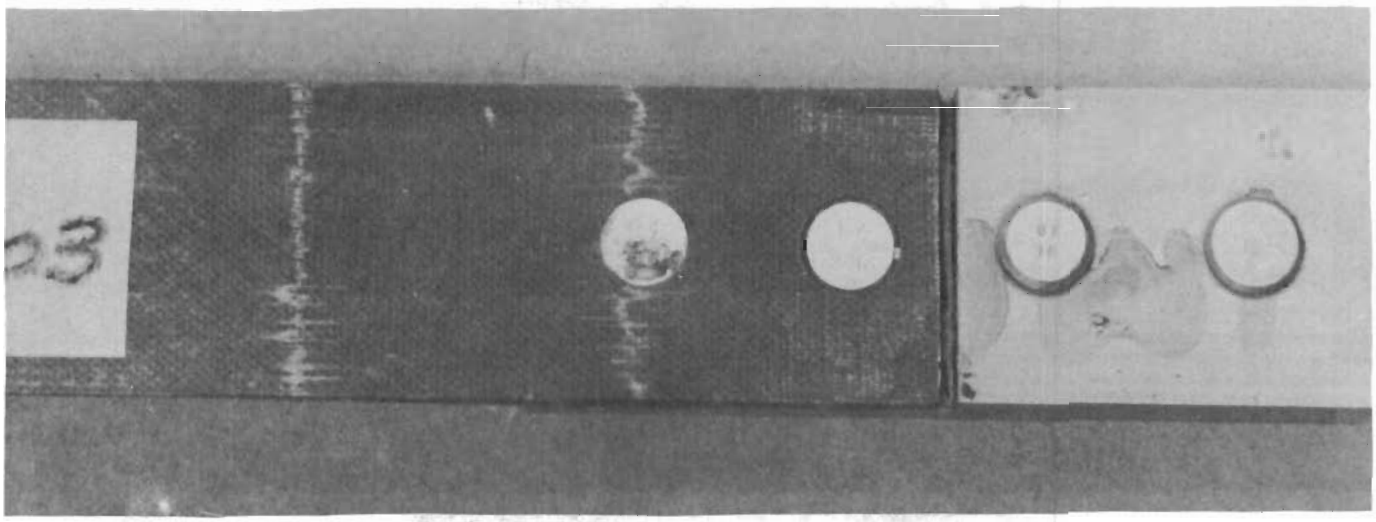


Figure 111 Configuration E, Short Edge Distance
Boron/Titanium, Titanium Shims in Boron

Fatigue damage can be seen at net section of boron and also at edge of shim build-up section. Fatigue test was discontinued after specimen (IE311A03) had endured 13 x 10^6 cycles at R = +0.1.

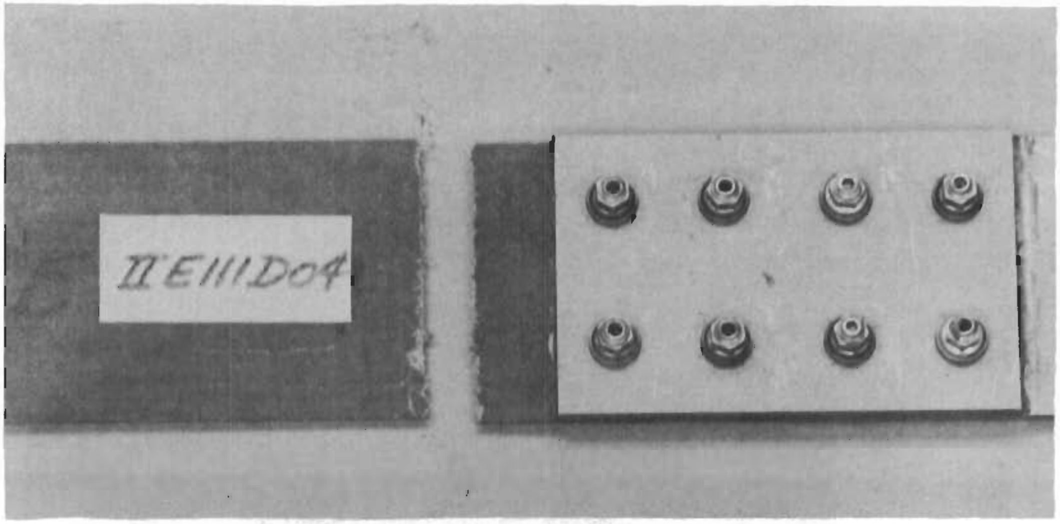


Figure 112 Configuration E, Two Inches Wide, Baseline
Typical Static Tensile Failure

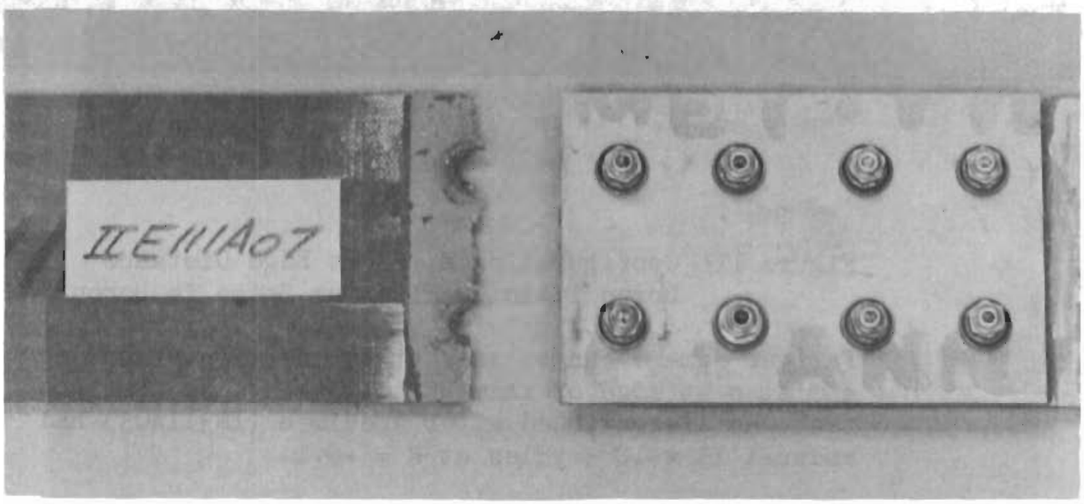


Figure 113 Configuration E, Two Inches Wide, Baseline
Typical R = +0.1 Fatigue Failure

boron has fatigue strength equal to or greater than titanium having up to 50 percent more net-section area.

Repeated attempts to obtain fatigue failures in the joints of the baseline specimens tested at a stress ratio of R = +10.0 were unsuccessful. Testing at this stress ratio was therefore discontinued, and all remaining test specimens were used for contingency or supplementary tests, as required, for providing additional test data to better define a test variable. For the specimens tested at a stress ratio of R = -1.0 the majority of failures occurred in the fasteners. Initially these failures were attributed to excessive bending action at the joint during reversed cycling. It was believed that the 0.003 inch clearance between the joint and the support plates was allowing excessive bending of the splice plate which results in repeated tension loading of the fastener through the steel collar. Subsequent testing with no clearance around the joint however, still resulted in some fastener fatigue failures.

4.11 MECHANICAL JOINT TESTS - CONFIGURATION F - TEE JOINT

4.11.1 Specimen Configuration

Specimen details are given in Dwg. No. 7226-13021F, Appendix C, and specimen identification information is given on Table X.

4.11.2 Test Procedure and Results

Tests were conducted in accordance with Table X, and test data are reported in Appendix B, table IVB5.

A different test procedure was used for the Configuration F static tests than was previously used for the Configuration C (bonded tee joint) static tests. Since the mechanically fastened tee was capable of withstanding a considerably higher load than the bonded tee, emphasis was placed on axial load carrying capability. The support fixture that was used for the bonded tee specimens was modified to accommodate the longer leg of the mechanically fastened tee. Two specimens were tested using the same transverse loads that were used previously with two of the bonded tees and then the specimens were loaded axially to failure. Both failures occurred in the boron laminate at the edge of the titanium built-up section as shown in Figure 114.

The fatigue tests were conducted in the Lockheed designed fatigue machines using a similar testing procedure to that used for the bonded tee joint specimens. The baseline data specimens were tested at a stress ratio of R = +0.1 and at a maximum axial stress of 40,000 psi at the net section of the shimmed boron. A side load of 100 pounds was used on five specimens and a sideload of 250 pounds was used on the other five. The increased thickness specimens were tested in a similar manner but the maximum axial stress level was 35,000 psi and the side load was 500 pounds. Fatigue failures occurred at either the net section or at the edge of the shimmed boron section. The test results confirmed that the fatigue strength of the joint decreased with increased side load as expected.

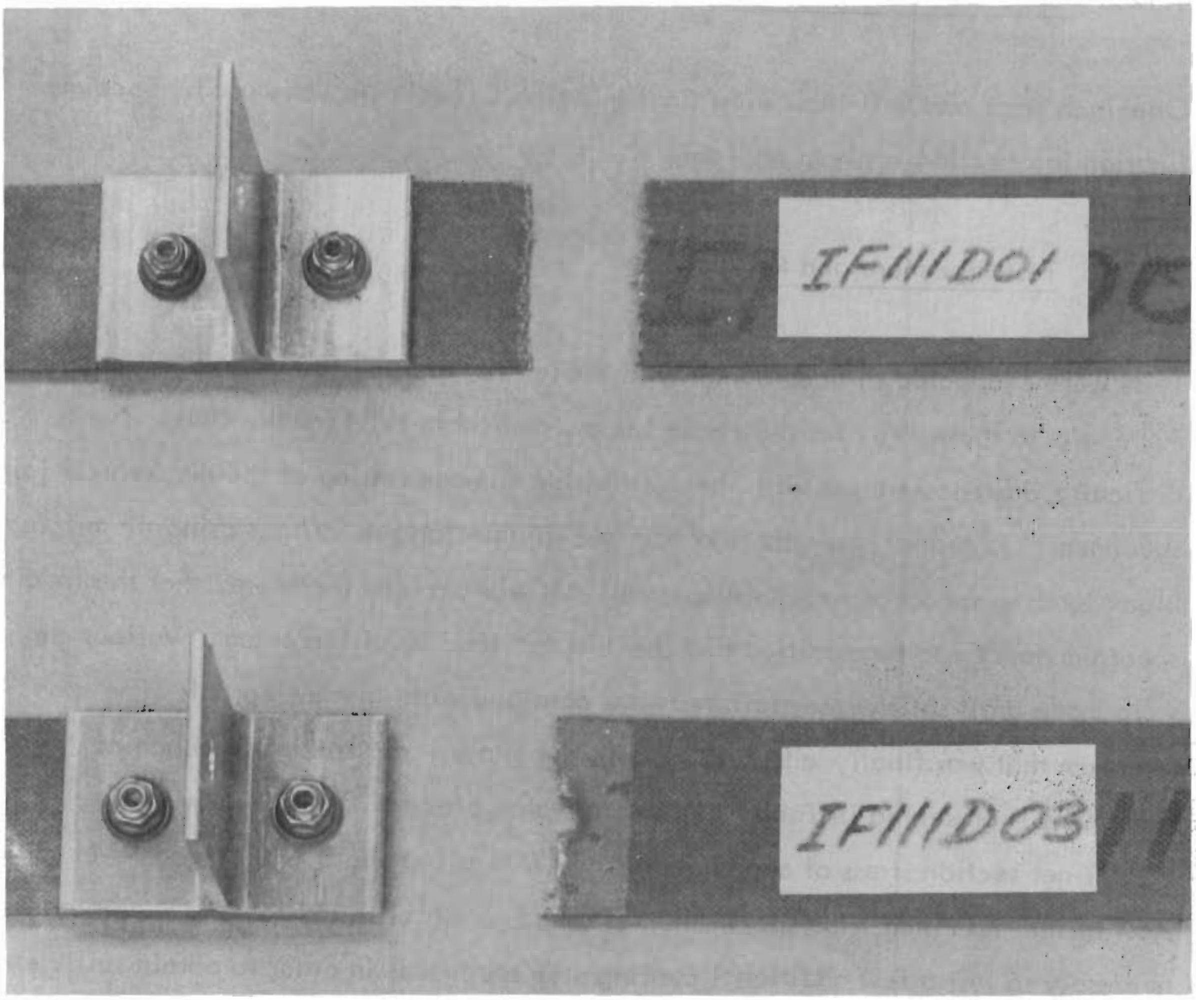


Figure 114 Configuration F Baseline Static Tests
-D01 Side Load Held Constant, Axial Load Increased to Failure
-D03 Axial Load Held Constant, Side Load Increased to Failure

4.12 MECHANICAL JOINT TESTS - CUMULATIVE DAMAGE

4.12.1 Specimen Configuration

One-inch wide and 2.0-inch wide Configuration E specimens were used. Specimen identification information is given on Table X.

4.12.2 Test Procedure and Results

Tests were conducted in accordance with Table X, and the test data are reported in Appendix B; table IVB1 for the Phase I tests, and table IVB4 for the Phase II tests. Some difficulty was encountered with the cumulative damage testing of the mechanical joint specimens. Repeated attempts to obtain acceptable fatigue failures using the original block loading spectrum were unsuccessful. It was decided therefore, that the loading spectrum needed to be modified and the 1.0 "g" load level increased. Various changes were made until satisfactory failures were obtained within an acceptable time span. The spectrum that was finally adopted for both the Phase I and Phase II mechanical joint specimens is presented in Table XI. The value of the 1.0 "g" load was selected to give a joint net section stress of approximately 39,000 psi at the 8.0 "g" load level Since most of the 1.0-inch wide specimens were used to establish the loading spectrum, it was necessary to test a few additional contingency specimens in order to obtain sufficient data points for spectrum evaluation. The Phase I and Phase II realistic loading spectrum tests were conducted without any difficulties. In both cases the selection of the 1.0 "g" load level was based on the results of the block spectrum testing. All tests were conducted in the computer controlled MTS testing machine and the specimens were supported in the same manner as the Configuration E baseline specimens. All failures occurred at either the joint net section or at the edge of the titanium shim reinforcement.

4.13 SUMMARY

All data generated during this test phase has been plotted in S-N form and is included in Volume III, Section 2, Fatigue Analysis. In that section all results are analyzed, compared,and discussed in detail.

TABLE XI

TRUNCATED BLOCK SPECTRUM LOADINGS

Load in "g's"		Cycles of Load in Block Number:									
Min.	Max.	1	2	3	4	5	6	7	8	9	10
-3.6	+1	1	0	REPEAT BLOCK 1	REPEAT BLOCK 2	REPEAT BLOCK 1	REPEAT BLOCK 2	REPEAT BLOCK 1	REPEAT BLOCK 2	REPEAT BLOCK 1	REPEAT BLOCK 2
-3.2	+1	1	1								
-2.8	+1	4	4								
-2.4	+1	8	8								
-2.0	+1	11	11								
+1	+4	3600	3600								
+1	+5	1800	1800								
+1	+6	810	810								
+1	+7	237	237								
+1	+8	53	53								

APPENDIX A

FABRICATION AND INSPECTION LOGS

Fabrication and inspection details for all panels and specimens are summaries and recorded on the forms included herein. This Appendix is separated into sections by table numbers where each of the tables represent a particular group of specimens as defined by program phase, specimen configuration, drawing number, and specimen number.

BORON PANEL IDENTIFICATION

Panel No.	V1	V2	15 PLY	15 PLY	VIR	15 PLY	IA111E	15 PLY	IA11	15 PLY
Boron Batch No.	381	381	381	381	381	381	381	381	381	381
Roll No.	74	74	74	74	74	74	74	74	74,75,76	76
Prev. Out Time Hr.	0	0	0	32	36	36	48.5	48.5	68.5,0,0	0
Start Time	4/14-0830	4/14-0830	4/14-0830	5/12-1300	5/22-1500	5/23-1100	6/23-0800	6/24-1300	7/6-1000	7/7-1415
Complete Time	4/15-1630	4/15-1630	4/15-1630	5/12-1530	5/23-1100	5/23-1300	6/24-1100	6/24-1400	7/7-1315	7/7-1530
Total Out Time Hr.	32 Hrs.	32 Hrs.	32 Hrs.	36	48.5	48.5	68.5	68.5	124.5, 24, 28	24
Clean Room Temp.	68	69	70°	73°	75°	75°	73°	73°	74°	74°
Clean Room R.H. %	44%	45%	49%	57%	56%	50%	54%	54%	52%	52%
Ply Orientation	0°/+45°	0°/90°	0°	0°	0°/±45	0°	0°/±45	0°	0°/±45	0°
Number of Plies	8	8	15	15	8	15	8	15	8	15
Bleeder System	2-116	2-116	3-116	3-116	2-116	3-116	2-116	3-116	2-116	3-116
Inspect Bag - "Hg	22"	22"	22"	10"	10"	10"	10"	10"	10"	10"
Autoclave Cycle #	303057	303057	303057	385311	303081	303081	386569	386569	386572	386572
Date/Time	4/16-1540	4/16-1540	4/16-1540	5/13-0830	5/25-0900	5/25-0900	6/25-1057	6/25-1057	7/9-1530	7/9-1530
Pressure - psig	84	84	84	85	83.5	83.5	85	85	84	84
Temperature - °F	350	350	350	355	350	350	348	348	350	350
Time at Temp.-Min.	130	130	130	135	125	125	60	60	76	76
Heat-Up Rate	7°/min	7°/min	7°/min	7.5°/min	7°/min	7°/min	7°/min	7°/min	5°/min	5°/min
LDR No.	303057	303057	303057	385311	303081	303081	386569	386569	386572	386572
Laminate Thickness	0.0432	0.0426	0.0783	.0757	.0427	.0768		.0765	.0438	.0745
Mils Per Ply	5.4	5.3	5.2	5.05	5.34	5.12		5.10	5.45	4.95
QC Lab No.	-	-	54959	56136	-	56591	-	57836	--	58392

Panel No.	15 PLY*	8 PLY*	6 PLY*	15 PLY	IA11R	15 PLY	IA11RP	15 PLY	IA11P	15 PLY
Boron Batch No.	392	392	392	392	381	381	381	381	392	392
Roll No.	89	89	89	89	76	76	76	76	89/90	90
Prev. Out Time Hr.	0	0	0	6.5	24	24	53	53	14/0	
Start Time	7/31-1100	7/31-1300	7/31-1430	8/12-1300	8/13-0800	→	9/4-1030	→	9/9-1300	→
Complete Time	7/31-1300	7/31-1430	7/31-1530	8/12-1430	8/14-1300	→	9/4-1410	→	9/10-1300	→
Total Out Time Hr.	6.5	6.5	6.5	14	53	53	59	59	38/24	→
Clean Room Temp.	73°	73°	73°	71°	72°	72°	70°	70°	68°	68°
Clean Room R.H. %	60%	60%	60%	58%	56%	56%	62%	62%	60%	60%
Ply Orientation	0°	0°/+45	0°	0°	0°/±45°	0°	0°/±45°	0°	0°/±45°	0°
Number of Plies	15	8	6	15	8	15	8	15	8	15
Bleeder System	3-116	2-116	1-116	2-116	2-116	3-116	2-116	3-116	2-116	3-116
Inspect Bag - "Hg	10"	10"	10"	10"	10"	10"	10"	10"	10"	10"
Autoclave Cycle #	386578	386578	386578	386581	386583	→	386588	→	386592	→
Date/Time	8/3-0840	8/3-0840	8/3-0840	8/13-1245	8/17-0755	→	9/9-1545	→	9/11-0830	→
Pressure - psig	85	85	85	85					**	
Temperature - °F	350	350	350	350	345	345	350	350	350	350
Time at Temp.-Min.	120	120	120	175	120	120	120	120	120	120
Heat-Up Rate	9°/min	9°/min	9°/min	7°/min	6°/min	6°/min	5°/min	5°/min	5°/min	5°/min
LDR No.	386578	386578	386578	386581	386583	→	386588	→	386592	→
Laminate Thickness	.0750	.0426	.0328	.0751	.043	.0745	***	.074	***	.074
Mils Per Ply	5.00	5.32	5.46	5.01	5.28	4.95	***	4.9	***	4.9
QC Lab No.	59038	-	-	59579	-	59813	-	60365	-	60581

NOTES:

Panel V1 lay up was 0°, +45°, -45°, 0°, 0°, -45°, +45°, 0°

Panel V2 lay up was 0°, 90°, 90°, 0°, 0°, 90°, 90°, 0°

Panel VIR " " " 0°, +45°, -45°, 0°, 0°, -45°, +45°, 0° (A rerun of Panel VI)

Panel IA11E " " " 0°, +45°, -45°, 0°, 0°, -45°, +45°, 0°

Panel IA11E " " " 0°, +45°, -45°, 0°, 0°, -45°, +45°, 0° (36" x 54" base panels)

*material qualification specimens

** autoclave malfunction resulted in an increase in pressure up to 110 psig momentarily as the temperature reached 350°F and was then reduced to 85 psig

*** Due to these panels being fabricated with a peel ply the thickness is not measured until specimen fabrication.

BORON PANEL IDENTIFICATION

Panel No.	IA10924	15 PLY	IA10929	15 PLY	IA12	IA21	IA22	IA41	IA42	15 PLY	IA11015	15 PLY	IDIIIA110	IDIIIB110	15PLY	15 PLY	15 PLY	1A1210	5A1119	3A1210
Boron Batch No.	392									→	408	→	385	385	385	408	408	408	381	408
Roll No.	91	→	91/92	92	(92/93/94)				→	94	35	→	6	6	6	35	38	35	76	39
Prev. Out Time Hr.	0	→	29/0	→	(30/0/0)				→	0	0	→	0	0	0	30	0	36	59	0
Start Time	9/22-1000	→	9/28-0945	→	10/6-0900					→	10/13-1300	→	1110-0600		→	1124-0800	→	1208-0930		→
Complete Time	9/23-1400	→	9/29-1300	→	10/9-1330					→	10/14-1400	→	1110-1330		→	1124-1400	→	1209-1630		→
Total Out Time Hr.	28	→	32/30	→	(73/27/23)				→	23	30	→	5.5	5.5	5.5	36	6	67	90	31
Clean Room Temp °F	71	71	72	72	75	75	75	75	75	75	74	74	70		→	68	→	66		→
Clean Room R. H. %	60											→	57		→	54	→	52		→
Ply Orientation	0°/±45°	0°	0°/±45°	0°	0°/90°	±45°/0°	90°/0°	0°/±45°	0°/90°	0°	0°/±45°	0°	0° ±45°	0° ±45°	0°	0°	0°	0°±45°	0°±45°	0° 90°
No. of Plies	8	15	8	15	8	8	8	16	16	15	8	15	8	16	15	15	15	8	8	8
Bleeder System	3-116	2-116	3-116	2-116	3-116	3-116	3-116	4-116	4-116	2-116	3-116	2-116	2-116	4-116	3-116	3-116	3-116	2-116	2-116	2-116
Inspect Bag - 11 Hg.	10											→	28"		→	28"	28"	28"		→
Autoclave LDR #	412755	→	412759	→	412762					→	412764	→	A412778		→	A236048	→	A412782		→
Date/Time	9/24-1100	→	9/30-1100	→	10/12-0800					→	10/15-0930	→	1111-0741		→	1128-1335	→	1210-1300		→
Pressure -psig	85	→	85	→	85					→	85	→	85		→	88	→	85		
Temperature - °F	350	→	350	→	350					→	350	→	350°		→	350	→	350		
Time at Temp. - Min.	120	→	120	→	120					→	125	→	120		→	124	→	120		
Heat-Up Rate °F/min	6.5	→	6.5	→	5.0					→	5.3	→	6.5		→	6.1	→	6.4		
Laminate Nom. Thick.	(1)	.077	(1)	.079	(1)				→	.076	(1)	.076	(1)	(1)	.076"	.076"	.76"	(1)	(1)	(1)
Miles per Ply	(1)	5.1	(1)	5.3	(1)				→	5.1	(1)	5.1			5.07	5.07	5.07			
L. C. Lab No.	–	61039	–	61198	–	–	–	–	–	61588	–	61373			62844	63195	63195			

NOTES:

(1) These panels were fabricated with a peel ply and thickness is measured during specimen preparation.

BORON PANEL IDENTIFICATION

Panel No.	8 PLY	15 PLY	7A1217	7B1217	3A1217	3B1217	15A1217	8 PLY	15 PLY	16 PLY	IB1218	IB1218	15 PLY	1A0105	7B0105	15 PLY	15 PLY	8 PLY
Boron Batch No.	408	408	408	408	408	408	408	408	408	408	408	408	408	408	408	408	42	42
Roll No.	39	39	39	39	39	38	39	39	39	39	39	40	40	40	40	40	1	1
Prev. Out Time Hr.	0	0	31	31	31	6	31	31	31	31	38.5	0	0	26	26	26	0	0
Start Time	1208/0930	→	1216-0800	→	→	→	→	→	→	→	1217-0930	→	→	0104/0830	→	→	01 01200	→
Complete Time	1209/1630	→	1216-1530	→	→	→	→	→	→	→	1218-1130	→	→	0104/1630	→	→	0 20/1600	→
Total Out Time Hr.	31	31	38.5	38.5	38.5	13.5	38.5	38.5	38.5	38.5	64.5	26	26	34	34	34	4	4
Clean Room Temp.	66	→	68	→	→	→	→	→	→	→	69	→	→	68	→	→	68	→
Clean Room R.H. %	52	→	47	→	→	→	→	→	→	→	50	→	→	48	→	→	17	→
Ply Orientation	0°/±45°	0°	90°/0°	90°/0°	0°/90°	0°/90°	0°/90°	0°/90	0°	0°90°	0/±45	0/+45	0°	0/±45	90/0	0	0	0/±45
Number of Plies	8	15	8	8	8	8	16	8	15	16	16	16	15	8	8	15	15	8
Bleeder System	1-116	2-116	2-116	2-116	2-116	2-116	3-116	1-116	2-116	2-116	2-116	2-116	2-116	1-116	1-116	2-116	2 116	1-116
Inspect Bag - "Hg	28"	→	28"	→	→	→	→	→	→	→	25"	→	→	5"	5"	5"	5"	
Autoclave LDR	A412782	→	A412784	→	→	→	→	→	→	→	A428783	→	→	A412788	→	→	A 12792	→
Date/Time	1210/1300	→	1217-1010	→	→	→	→	→	→	→	1218-1300	→	→	0105/1015	→	→	01 1/0900	→
Pressure - psig	85	→	85	→	→	→	→	→	→	→	85	→	→	85	→	→	85	→
Temperature - °F	350	→	350	→	→	→	→	→	→	→	350	→	→	350	→	→	350	→
Time at Temp.-Min.	120	→	125	→	→	→	→	→	→	→	120	→	→	122	→	→	120	→
Heat-Up Rate	6.4	→	6.2	→	→	→	→	→	→	→	6.0	→	→	5.7	→	→	7.2	→
Laminate Thickness		.076	(1)	(1)	(1)	(1)	(1)		.076				.076	(1)	(1)	.076	078	
Mils Per Ply		5.07							5.07				5.07			5.07	.2	
QC Lab No.		63652							64078				64078			64382	64 45	

NOTES

(1) These panels were fabricated with peel ply and thickness is measured during specimen inspection

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MODEL
PAGE 1

MATERIAL VERIFICATION AND CHECK OUT TEST SPECIMEN
FABRICATION AND INSPECTION LOG

Specimen No.	V1A01	V1A02	V1A03	V1A04	V1A05	V1B01	V1B02	V1B03	V1B04	V1B05	V1C01	V1C02	V1C03	V1B06	V1B07	V1B08	V1B09
Panel	V1																→
Tab Bond																	
Adhesive	123-2												→	123.2			→
Pressure	10 "Hg Vac.												→	10 "Hg Vac.			→
Temperature	250°F												→	250°F			→
Date	4-29												→	4-30			→
Time at Temp	120 min												→	120 min			→
Tab Matl.	FRP												→	AL			→
Spec. Dimensions																	
Nom. Length-in.	9.15	9.15	9.12	9.12	9.09	9.02	9.10	9.12	9.12	9.11	9.10	9.10	9.10	9.10	9.11	9.11	9.10
Nom. Width-in.	1.0012	1.0009	1.0011	0.9995	1.0006	0.9901	0.9900	0.9927	0.9938	0.9935	1.0012	1.0012	1.0006	1.0090	1.0099	1.0128	1.0060
Nom. Thickness-in.	0.0429	0.0431	0.0431	0.0432	0.0431	0.0431	0.0432	0.0430	0.0431	0.0431	0.0432	0.0434	0.0433	0.0431	0.0429	0.0432	0.0436
Comments	0.010" BOW				→	TAB AL = 0.030"				→	0.010" BOW		→	NONE			→
42-11 Sign-Off	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY
Technical Inspection		✓				✓					✓			✓			
& Sign-Off	All specimens were checked visually. Specimens with a check (✓) were inspected ultrasonically by immersion method.																
															RES		

MATERIAL VERIFICATION AND CHECK OUT TEST SPECIMEN
FABRICATION AND INSPECTION LOG

Specimen No.	V2A01	V2A02	V2A03	V2A04	V2A05	V2C01	V2C02	V2C03
Panel	V2	→						
Tab Bond								
Adhesive	FM 123-2	→						
Pressure	10 "Hg Vac.	→						
Temperature	250°F	→						
Date	4-29	→						
Time at Temp	120 min	→						
Spec. Dimensions								
Length-in. (Nom.)	9.10	9.08	9.07	9.10	9.09	9.08	9.07	9.08
Width-in. (Nom.)	0.9890	1.0005	1.0014	1.0014	0.9991	1.0017	1.0014	1.0022
Thickness-in. (Nom.)	0.0427	0.0428	0.0428	0.0428	0.0427	0.0427	0.0428	0.0428
Comments	NONE	→						
42-11 Sign-Off	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY
Technical Inspection	✓					✓		
& Sign-Off	All specimens were checked visually. Specimens with a check (✓) were inspected ultrasonically by immersion method.							
	RES							

MATERIAL VERIFICATION AND CHECK OUT TEST SPECIMEN
FABRICATION AND INSPECTION LOG

Specimen No.	VIRA01	-A02	-A03	-A04	-A05	VIRB01	-B02	-B03	-B04	-B05	-B06	-B07	-B08	-B09	-B10	VIRC01	-C02	-C03
Panel	V1R																	
Tab Bond																		
Adhesive	PM123-2																	
Pressure	30 psi																	
Temperature	250																	
Date	6-15																	
Time at Temp	60 min.																	
Tab Material	FRP	FRP	FRP	FRP	FRP	FRP	FRP	FRP	FRP	FRP	AL	AL	AL	AL	AL	FRP	FRP	FRP
LDR Run No.	303094																	
Spec. Dimensions																		
Length-in. (Nom.)	8.93	8.92	8.93	8.91	8.90	9.07	9.06	9.05	9.05	9.03	9.03	9.03	9.05	9.07	9.08	8.90	8.90	8.90
Width-in. (Nom.)	0.995	0.997	0.997	0.996	1.000	1.001	0.992	0.997	0.994	1.000	1.012	1.001	1.001	0.999	0.988	0.994	0.995	0.996
Thickness-in. (Nom.)	0.0438	0.0435	0.0439	0.0440	0.0439	0.0440	0.0448	0.0442	0.0444	0.0446	0.0442	0.0443	0.0442	0.0446	0.0446	0.0439	0.0437	0.0434
Comments	-	0.010"bow	0.010"bow	0.015"bow	.020"bow	-	-	-	-	-	.100 bow	.100bow	.080bow	.060bow	0.012 under cut in AL	-	0.010" bow	0.010"bow
42-11 Sign-Off	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY
Technical Inspection & Sign-Off																		

NOTE: Panel V1R has 0°, +45°, -45°, 0°, 0°, -45°, +45°, 0° orientation. Rerun of original VI specimens.

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MODEL TABLE A2 cont.
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MATERIAL VERIFICATION AND CHECK OUT TEST SPECIMEN
FABRICATION AND INSPECTION LOG (ADHESIVE)

Specimen No.	V3A01	V3A02	V3A03	V3A04	V3A05	V3A06	V3A07	V3A08	V3A09	V3A10	V3A11	V3A12	V3A13	V3A14	V3A15	V3C01	V3C02	V3C03	V3C04	V3C05
Panel Ident.	SEE NOTE 1																			
Tab Material	FRP																			
Tab Adhesive	FM 123-2																			
Spec. Length-in. Nom.	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Width-in. Nom.	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99
Thick-in. Nom.	.061	.061	.059	.060	.0605	.061	.061	.061	.0615	.061	.0605	.0605	.060	.060	.061	.061	.061	.0605	.061	.0615
Splice Mat.	8-1-1 TITANIUM																			
Length-in. Nom.	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500
Width-in. Nom.	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99
Thick-in. Nom.	.061	.060	.0615	.061	.060	.0605	.060	.0595	.060	.060	.059	.059	.060	.061	.060	.059	.059	.061	.061	.061
Adhesive Type	EA9601																			
Batch/Roll	347/46																			
Lay-Up Date	6/2																			
Time	1330																			
Cure Date	6/5																			
Time	1300																			
Pressure	30 psig																			
Heat-Up Rate	7°/min																			
Cure Temp.	250°F																			
Time at Temp.	60 min																			
LDR Run No.	303094																			
Joint Thickness	.1265	.126	.125	.1265	.1245	.126	.1255	.126	.127	.126	.124	.1245	.125	.126	.1255	.1255	.1255	.1265	.126	.127
Spec. + Splice	.122	.121	.1205	.1210	.1205	.1215	.121	.1205	.1215	.121	.1195	.1195	.120	.121	.121	.120	.120	.1215	.122	.1225
Bondline Thick. inches	.0045	.005	.0045	.0055	.004	.0045	.0045	.0055	.0055	.005	.0045	.005	.005	.0055	.0045	.0055	.0055	.005	.004	.0045
Inspect	RJB	RJB	RJB	RJB	RJB	RJB	RJB	RJB	RJB	RJB	RJB	RJB	RJB	RJB	RJB	RJB	RJB	RJB	RJB	RJB
Comments																				
Bondline Taper																				
Specimen Bow	.070	.080	-	.070	.020	.040	.04	.030	-	.010	.010	-	.030	-	-	-	.050	-	.060	-
Misalignment	.040	-	-	-	-	-	-	-	.030	-	-	-	-	-	.020	.010	-	-	.010	-
Ultrasonics	C-scans at 3 sensitivities were obtained for all specimens and will be kept on file for comparison with the failed joints.																			
Note 1: Panel material is 8-1-1 titanium sheet.																				

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MATERIAL VERIFICATION AND CHECK OUT TEST SPECIMEN
FABRICATION AND INSPECTION LOG (ADHESIVE)

Specimen No.	V3A21	V3A22	V3A23	V3A24	V3A25	V3A31	V3A32	V3A33	V3A34	V3A35	V3A36	V3A37	V3A38
Panel Ident.			See Note 1										
Tab Material	←		FRP		→	←			NONE				→
Tab Adhesive	←		FM 123		→	←			NONE				→
Spec. Length-in. Nom.	18"	18"	18"	18"	18"	18"	18"	18"	18"	18"	18"	18"	18"
Width-in. Nom.	0.992"	0.992"	0.991"	0.992"	0.991"	0.991"	0.992"	0.992"	0.990"	0.992"	0.992"	0.992"	0.993"
Thick-in. Nom.	0.0612	0.0612	0.0614	0.0590	0.0602	0.0610	0.0615	0.0609	0.0610	0.0605	0.0611	0.0613	0.0605
Splice Mat.	8-1-1	TITANIUM											→
Length-in. Nom.	1.50"	1.50"	1.50"	1.50"	1.50"	1.50"	1.50"	1.50"	1.50"	1.50"	1.50"	1.50"	1.50"
Width-in. Nom.	0.994"	0.992"	0.995"	0.993"	0.995"	0.995"	0.995"	0.993"	0.996"	0.994"	0.995"	0.994"	0.992"
Thick-in. Nom.	0.0605	0.0600	0.0604	0.0602	0.0603	0.0606	0.0595	0.0607	0.0605	0.0595	0.0600	0.602	0.0605
Adhesive Type	EA9601												→
Batch/Roll	347/46												→
Lay-Up Date	6/2												→
Time	1330												→
Cure Date	6/5												→
Time	1300												→
Press	30 psig												→
Heat-Up Rate	7°/min												→
Cure Temp.	250°F												→
Time at Temp.	60 min.												→
LDR Run No.	303094												→
Joint Thickness	0.1263	0.1255	0.1265	0.1245	0.1252	0.1260	0.1265	0.1272	0.1262	0.1252	0.1257	0.1260	0.1264
Spec. + Splice	0.1217	0.1212	0.1218	0.1192	0.1205	0.1216	0.1210	0.1216	0.1215	0.1210	0.1211	0.1215	0.1210
Bondline Thick, inches	.0046	.0043	.0047	.0053	.0047	.0044	.0055	.0057	.0047	.0042	.0046	.0045	.0054
Inspect	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY	ECY
Comments	-	-	-	-	-	-	-	-	-	-	-	-	-
Bondline Taper	1.0 mils	-	-	-	-	-	-	-	-	1.5 mils	-	1.0 mils	0.5 mils
Specimen Bow	-	-	-	-	-	-	-	-	-	-	.050	-	-
Misalignment	-	-	-	-	-	-	-	-	-	0.20"	-	0.040"	-

NOTES: 1. Panel material is 8-1-1 titanium sheet.
2. The specimens on this page are for use in establishing joint support procedures prior to testing the composite joints.

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PAGE 1

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION A (4)

Specimen No.	IA111E01	IA111E02	IA111E03	IA111E04	IA111E05	IA111E06	ID111P01 (3)
Panel Ident.	IA111E	→	→	→	→	→	→
Tab Ident.	Fiberglass	→	→	→	→	→	→
Adherend Thickness							
Left	.042 (1)	→	→	→	→	→	→
Right	.042 (1)	→	→	→	→	→	→
Splice Material	6Al-4V-Titanium Annealed	→	→	→	→	→	→
Splice Thickness							
Left	.039 (1)	→	→	→	→	→	2/.039
Right	.039 (1)	→	→	→	→	→	2/.039
Adhesive Type	EA 9601-.06	→	→	→	→	→	→
Adh. Batch/Roll	362-5/2	→	→	→	→	→	→
Lay-Up Date	7-1-70	→	→	→	→	→	7-7-70
Lay-Up Time	1530	→	→	→	→	→	1000
Cure Date	7-2-70	→	→	→	→	→	7-7-70
Cure Time	.0800	→	→	→	→	→	1800
Cure Pressure	30 PSI	→	→	→	→	→	→
Heat-Up Rate	-	-	-	-	-	-	-
Cure Temp./Time	260°F/60	→	→	→	→	→	→
Joint Thickness							
Left	.0855	.0850	.0860	.0855	.0850	.0850	.128
Right	(2)	→	→	→	→	→	→
Bondline Thick. Mils							
Left	.0455	.004	.005	.004	.004	.004	2/.004
Right	(2)						
Inspect	RJB	→	→	→	→	→	→
Quality Assur.	Ultrasonic C-Scans and X-Ray Performed on all Specimens R.E.S.						

Notes (1) Nominal thickness are used

(2) Right side is the same as left since nominal thicknesses recorded

(3) Double overlap butt joint for photo-stress evaluation

Joints IA111E01 thru IA111E06 are to evaluate test set up procedures

(4) All specimens on this sheet are trial specimens to establish testing procedures and limitations. These are not part of the basis Phase I required specimens but will be used to complement the required tests.

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MODEL Table A-3
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BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION A

Specimen No. IA11	1D01	1D02	1D03	1A01	1A02	1A03	1A04	1A05	1A06	1A07	1A08	1A09	1A10	1B01	1B02	1B03	1B04	1B05	1B06	1B07
Panel Ident.	IA11																			
Tab Ident.	7075T6	Aluminum																		
Adherend Thickness																				
Left	.0437	.0438	.0434	.0440	.0441	.0441	.0436	.0435	.0449	.0440	.0437	.0436	.0433	.0439	.0439	.0438	.0438	.0438	.0435	.0439
Right	.0435	.0434	.0433	.0435	.0438	.0434	.0441	.0436	.0437	.0437	.0438	.0435	.0434	.0436	.0440	.0440	.0435	.0437	.0434	.0435
Splice Mat.	6Al-4V-Titanium	Annealed																		
Splice Thickness																				
Left	.0401	.0401	.0400	.0401	.0399	.0401	.0398	.0399	.0398	.0399	.0402	.0412	.0415	.0414	.0414	.0411	.0407	.0407	.0405	.0405
Right	.0401	.0401	.0401	.0401	.0399	.0399	.0398	.0398	.0399	.0400	.0401	.0414	.0414	.0411	.0412	.0409	.0406	.0405	.0404	.0405
Adhesive Type	EA 9601-06																			
Adh. Batch/Roll	364-51AA																			
Lay-Up Date	7-31																			
Lay-Up Time	0945																			
Cure Date	7-31																			
Cure Time	1500																			
Cure Pressure	30 psi																			
Heat-Up Rate	7°/min	LDR # 386579																		
Cure Temp./Time	250°/75																			
Joint Thickness																				
Left	.0885	.0883	.0881	.0881	.0899	.0882	.0877	.0875	.0887	.0879	.0879	.0844	.0891	.0892	.0895	.0889	.0886	.0886	.0883	.0884
Right	.0881	.0880	.0880	.0879	.0877	.0875	.0883	.0875	.0876	.0877	.0880	.0894	.0890	.0889	.0894	.0890	.0885	.0884	.0882	.0883
Bondline Thick. Mils																				
Left	4.5	4.4	4.7	4.0	4.4	4.0	4.3	4.1	4.0	4.0	4.0	4.6	4.3	3.9	4.2	4.0	4.1	4.1	4.3	4.2
Right	4.5	4.5	4.6	4.3	4.0	4.2	4.4	4.1	4.0	4.0	4.1	4.5	4.2	4.1	4.2	4.1	4.4	4.2	4.4	4.3
Inspect																				
Quality Assur.	Ultrasonic C-scans and x-ray performed on all specimens R. E. Shupe																			
										REJECT SPECIMENS (1)										

NOTES:

(1) All specimens recorded on this page and considered unacceptable due to very poor bond quality and will not be used for fatigue evaluation. Specimens will be replaced.

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BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION A

Specimen No. IA11	1B08	1B09	1B10	1C01	1C02	1C03	1C04	1C05	1C06	1C07	1C08	1C09	1C10	1D04	1D05	1D06	1A11	1A12	1A13	1A14
Panel Ident.	IA11 →													IA11 →						
Tab Ident.	7075 T-6 Al →													7075T-6 Al →						
Adherend Thickness																				
Left	.0433	.0436	.0436	.0439	.0436	.0436	.0438	.0435	.0438	.0435	.0428	.0427	.0428	.0435	.0435	.0431	.0435	.0432	.0433	.0434
Right	.0434	.0437	.0434	.0438	.0435	.0437	.0439	.0438	.0437	.0434	.0431	.0432	.0428	.0432	.0431	.0435	.0436	.0438	.0434	.0435
Splice Material	6Al-4V-Titanium Annealed →																			
Splice Thickness																				
Left	.0406	.0408	.0411	.0414	.0413	.0412	.0414	.0411	.0411	.0411	.0399	.0398	.0399	.0400	.0402	.0402	.0405	.0401	.0399	.0400
Right	.0408	.0409	.0412	.0413	.0412	.0412	.0413	.0410	.0411	.0399	.0398	.0397	.0398	.0400	.0401	.0400	.0402	.0399	.0400	.0398
Adhesive Type	EA9601-06 →													EA9601-06 →						
Adh. Batch/Roll	364-5/AA →													364-60 /Y →						
Lay-up Date	7-31 →													8/6						
Lay-up Time	0945 →													1000						
Cure Date	7-31 →													8/7						
Cure Time	1500 →													0800	→	LDR 389610 →				
Cure Pressure	30													30						
Heat-Up Rate	7°/min	→ LDR #386579 →												7°/min						
Cure Temp./Time	250°/75 m													260°/75 min						
Joint Thickness																				
Left	.0881	.0886	.0891	.0907	.0895	.0890	.0892	.0889	.0891	.0888	.0877	.0877	.0875	(2)	.0886	.0880	.0889	.0880	.0879	.0883
Right	.0887	.0887	.0890	.0846	.0891	.0890	.0892	.0891	.0890	.0880	.0879	.0877	.0880	(2)	.0883	.0880	.0887	.0883	.0882	.0880
Bondline Thick. Mils																				
Left	4.2	4.2	4.4	5.4	4.6	4.2	4.0	4.3	4.2	4.2	5.0	5.2	4.8	(2)	4.9	4.7	4.9	4.7	4.7	4.9
Right	4.5	4.1	4.4	4.5	4.4	4.1	4.0	4.3	4.2	4.7	5.0	4.8	5.4	(2)	5.1	4.5	4.9	4.6	4.8	4.7
Inspect																				
Quality Assur.	Ultrasonic C-scans and X-rays performed on all specimens - R. E. Shupe →																			
DWG #7226-1302IA-														1A78	1A79	1A80	1A81	1A82	1A83	1A84
	← REJECT SPECIMENS(1) →																			

NOTES:

(1) Specimens 1B08 thru 1C10 are considered unacceptable due to very poor bond quality and will not be used for fatigue evaluation.

(2) Specimen number IA111D04 was static tested at time of machining and was not measured for joint thickness. Bond line is assumed to be approximately 5 mils thick.

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION A

Specimen No. 1A11	1A15	1A16	1A17	1A18	1A19	1A20	1B11	1B12	1B13	1B14	1B15	1B16	1B17	1B18	1B19	1B20	1C11	1C12	1C13	1C14
Panel Ident.	1A11 →																			
Tab Ident.	7075-T6 Al →																			
Adherend Thickness																				
Left	.0394	.0434	.0436	.0434	.0441	.0437	.0439	.0438	.0442	.0440	.0442	.0436	.0438	.0437	.0437	.0437	.0441	.0442	.0441	.0442
Right	.0390	.0434	.0434	.0437	.0441	.0440	.0438	.0444	.0443	.0442	.0439	.0440	.0439	.0442	.0442	.0435	.0439	.0442	.0436	.0436
Splice Material	6AL-4V-Titanium Annealed →																			
Splice Thickness																				
Left	.0399	.0400	.0399	.0402	.0404	.0406	.0406	.0406	.0409	.0405	.0405	.0404	.0407	.0406	.0406	.0406	.0404	.0405	.0405	.0404
Right	.0397	.0397	.0397	.0402	.0403	.0404	.0404	.0405	.0404	.0405	.0406	.0404	.0406	.0404	.0407	.0405	.0404	.0400	.0402	.0405
Adhesive Type	EA 9601-06 →																			
Adh. Batch/Roll	364-60/Y →																			
Lay-Up Date	8/6 →																			
Lay-Up Time	1000 →																			
Cure Date	8/7 →																			
Cure Time	0800																			
Cure Pressure	30 psi	LDR # 389610 →																		
Heat-Up Rate	7°/min.																			
Cure Temp./Time	260°/75																			
Joint Thickness																				
Left	.0836	.0883	.0883	.0878	(1)	.0891	.0892	.0889	.0900	.0891	.0895	.0888	.0887	.0893	.0889	.0888	.0891	.0888	.0888	.0893
Right	.0836	.0881	.0879	.0880	(1)	.0889	.0890	.0893	.0895	.0894	.0893	.0892	.0889	.0897	.0892	.0885	.0891	.0885	.0889	.0889
Bondline Thick. Mils																				
Left	4.8	4.9	4.8	4.2	(1)	4.9	4.7	4.5	4.9	4.6	4.8	4.8	4.2	5.0	4.6	4.5	4.6	4.1	4.2	4.7
Right	4.9	5.0	4.8	4.1	(1)	4.5	4.8	4.4	4.8	4.7	4.8	4.8	4.4	5.1	4.3	4.5	4.7	4.3	4.1	4.8
Inspect	Inspection for fabrication defects performed on all specimens - E. C. Young →																			
Quality Assur.	Ultrasonic C-scans and X-rays performed on all specimens - R. E. Shupe →																			
Dwg #7226-1302IA-	1A85	1A86	1A87	1A88	1A89	1A90	1A91	1A92	1A93	1A94	1A95	1A96	1A97	1A98	1A99	1A100	1A101	1A102	1A103	1A104
					← RETAINED SPECIMENS (1A19 – 1B19) →															

NOTES:

(1) Specimen IA111A19 was static tested at the time of machining and was not measured for joint thickness. Bond line is assumed to be approximately 5 mils thick.

(2) Due to this panel exhibiting slightly low bond strength the remainder of the specimens are held in abeyance and not presently scheduled for fatigue evaluation.

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BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION A

Specimen No. IA11-	1C15	1C16	1C17	1C18	1C19	1C20	IA-	111D01	511C01	111C01	(2)	811A01	511A01	311A02	(2)	111B01	511A02	711F01		
Panel Ident.	IA11 →						IA11RP	→												
Tab Ident.	7075-T6 Al →							7075-T6	Aluminum →											
Adherend Thickness																				
Left	.0434	.0438	.0439	.0437	.0434	.0433		(1)	.0425	.0430	.0426	.0428	.0427	.0427	.0423	.0426	.0433	.0430		
Right	.0437	.0439	.0440	.0438	.0436	.0434		(1)	.0425	.0427	.0430	.0426	.0429	.0428	.0432	.0424	.0434	.0428		
Splice Material	6Al-4V-Titanium Annealed →							6 Al - 4V - titanium annealed →												
Splice Thickness																				
Left	.0408	.0409	.0410	.0407	.0409	.0412		.040 " NOMINAL →												
Right	.0405	.0406	.0406	.0407	.0409	.0411		.040 " NOMINAL →												
Adhesive Type	EA 9601-06 →							EA9601-06 →												
Adh. Batch/Roll	364-60/Y →							364-46/B2 →												
Lay-Up Date	8/6 →							9/8 →												
Lay-Up Time	1000 →							1500 →												
Cure Date	8/7							9/8												
Cure Time	0800							1600												
Cure Pressure	30	LDR # 389610 →						30	LDR # 386589 →											
Heat-Up Rate	7°/Min.							5°												
Cure Temp./Time	260°/75							260°/95												
Joint Thickness																				
Left	.0886	.0890	.0891	.0890	.0887	(1)		(3) →												
Right	.0885	.0888	.0889	.0893	.0889	(1)		(3) →												
Bondline Thick. Mils																				
Left	4.4	4.3	4.2	4.6	4.4	(1)		(1)	4.6	5.1	5.0	5.0	4.9	4.7	4.5	5.1	4.9	4.5		
Right	4.3	4.3	4.3	4.8	4.4	(1)		(1)	4.9	5.1	4.9	4.8	4.7	4.7	5.1	4.7	4.7	5.0		
Inspect	Fabrication inspection performed on all specimens - E.C. Young																			
Quality Assur.	Ultrasonic C-scans and X-rays performed on all specimens. Specimens DWG. #1A67 thru 1A77 checked for bondline thickness - R. E. Shupe.																			
DWG # 7226-1302IA	1A105	1A106	1A1[illegible]	1A108	1A109	1A110		1A67	1A68	1A69	1A70	1A71	1A72	1A73	1A74	1A75	1A76	1A77		

NOTES:

(1) Specimen numbers IA11IC20 & IA111D01 were static tested at the time of machining and were not measured for joint or bondline thickness. The bondline for IA11IC20 is assumed to be 4.5 mils and for IA111D01 is assumed to be 5.0 mils.

(2) These specimens are to be held for contingency and when selected for testing they will be assigned a specimen number.

(3) Bondline thickness was measured optically on these specimens therefore joint thickness was not required and will not be recorded on subsequent data sheets.

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BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION A

DWG # 7226-13021A-	1A01	1A02	1A03	1A04	1A05	1A06	1A07	1A08	1A09	1A10	1A11	1A12	1A13	1A14	1A15	1A16	1A17	1A18	1A19	1A20
Specimen No. 1A-	(1)	711~~G01~~ F07	(1)	111B02	111C02	111D02	711F02	511A03	111C03	511C02	111B03	111A01	111C04	(1)	511D01	111B04	111A02	511A04	811A03	511A05
Panel Ident.	IA11P	→																		→
Tab Ident.	7075-T6	Aluminum →																		→
Adherend Thickness																				
Inches	.0435	.0438	.0438	.0440	.0440	.0440	.0440	.0440	.0480	.0481	.0476	.0445	.0441	.0438	.0440	.0440	.0443	.0447	.0441	.0429
Splice Material	6 Al - 4V Titanium annealed →																			→
Splice Thickness																				
Inches - Nom.	.041 →																			→
Adhesive Type	EA 9601-06 →																			→
Adh. Batch/Roll	364-46/B2 →																			→
Lay-Up Date	0800 →																			→
Cure Date	9-15																			
Cure Time	1130																			
Cure Pressure	30	→ LDR # 386394 →																		→
Heat-Up Rate	4.7																			
Cure Temp./Time	260°/85																			
Bondline Thick. Mils																				
Left	5.3	6.2	5.9	6.7	5.9	6.5	5.5	6.6	6.9	6.5	6.4	5.8	5.6	7.0	5.6	6.0	6.7	6.3	6.4	6.3
Right	5.4	5.4	5.7	6.1	6.1	6.2	6.0	6.3	6.7	7.0	6.5	6.7	5.2	6.1	6.5	6.4	6.2	6.2	6.6	6.3
Inspect	Fabrication inspection per drawing performed on all specimens E. C. Young																			
Quality Assur.	All specimens checked for bondline thickness. Ultrasonic C-scan and X-rays performed on all specimens R. E. Shupe																			

NOTES:

(1) These specimens are to be held for contingency and when selected for testing they will be assigned a specimen number

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION A

Dwg # 72261302IA -	1A21	1A22	1A23	1A24	1A25	1A26	1A27	1A28	1A29	1A30	1A31	1A32	1A33	1A34	1A35	1A36	1A37	1A38	1A39	1A40
Specimen No. IA -	111A03	811A04	511C03	811A05	111C05	811A06	111B05	(1)	511D02	703 ~~711C02~~	511C04	511A06	111C06	(1)	511C05	111B06	511A07	111A04	811A07	511D03
Panel Ident.	TA11P	→																		→
Tab Ident.	7075-T6	aluminum →																		→
Adherend Thickness																				
Inches	.0435	.0440	.0438	.0440	.0440	.0440	.0434	.0432	.0432	.0431	.0425	.0429	.0424	.043	.043	.043	.043	.044	.044	.043
Splice Material	6 Al-4V-	Titanium annealed →																		→
Splice Thickness																				
Inches - Nom	.041	→																		→
Adhesive Type	EA9601-06	→																		→
Adh. Batch/Roll	364-46/B2	→																		→
Lay-Up Date	9/15	→											→	9/16	→					→
Lay-Up Time	0800	→											→	1100	→					→
Cure Date	9/15													9/17						
Cure Time	1130													1000						
Cure Pressure	30	LDR # 396394 →											→	30	LDR # 386597 →					→
Heat-Up Rate	4.7													5.5						
Cure Temp/Time	260/35													260/65						
Bondline Thick. Mils																				
Left	6.3	5.9	5.5	5.8	5.5	6.0	5.6	5.4	5.7	6.1	5.8	5.4	5.7	5.5	6.1	5.1	5.4	5.2	5.5	5.5
Right	6.5	5.6	5.7	5.2	6.5	5.8	5.7	5.5	5.4	4.7	5.3	5.5	5.4	6.0	6.0	5.6	6.0	6.0	5.5	5.8
Inspect	Fabrication inspection per drawing performed on all specimens E. C. YOUNG																			
Quality Assur.	All specimens checked for bondline thickness. Ultrasonic C-scan and X-rays performed on all specimens R. E. SHUPE																			

NOTES:

(1) These specimens are to be held for contingency and when selected for testing they will be assigned a specimen.

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE 1 - CONFIGURATION A

DWG # 7726-1302IA-	1A41	1A42	1A43	1A44	1A45	1A46	1A47	1A48	1A49	1A50	1A51	1A52	1A53	1A54	1A55	1A56	1A57	1A58	1A59	1A60
Specimen No. IA-	111C07	111B07	111A05	(1)	111B08	711F03	511C06	311A03	(1)	111A06	711C03	511D04	111C08	111A07	111B09	711F04	111D03	(1)	111C09	111A08
Panel Ident.	IA11F																			
Tab Ident.	7075-T6																			
Adherend Thickness																				
Inches	.044	.048	.049	.049	.042	.042	.042	.042	.042	.042	.043	.043	.043	.043	.043	.044	.044	.043	.044	.044
Splice Material	6 Al - 4V - Titanium annealed																			
Splice Thickness																				
Inches - Nom	.041																			
Adhesive Type	EA 960 - 06																			
Adh. Batch/Roll	364-46/E2																			
Lay-Up Date	9/16																			
Lay-Up Time	1100																			
Cure Date	9/17																			
Cure Time	1000																			
Cure Pressure	30	LDR # 386597																		
Heat-Up Rate	5.5																			
Cure Temp./Time	260/65																			
Bondline Thick. Mils																				
Left	6.8	6.4	6.0	5.8	5.1	5.4	4.7	4.9	5.0	5.2	5.5	5.5	5.2	5.1	5.1	4.7	4.8	5.2	5.2	5.2
Right	6.2	5.5	5.7	6.2	5.0	5.0	4.7	5.1	5.0	4.6	4.6	4.8	5.0	5.0	4.7	5.5	5.3	5.2	5.1	5.3
Inspect	Fabrication inspection per drawing performed on all specimens E. C. YOUNG																			
Quality Assur.	All specimens checked for bondline thickness. Ultrasonic C-scan and X-rays performed on all specimens R. E. SHUPE																			

NOTES

(1) These specimens are to be held for contingency and when selected for testing they will be assigned a specimen number

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION A

DWG #7226-1302IA-	1A61	1A62	1A63	1A64	1A65	1A66	1C01	1C02	1C03	1C04	1C05	1C06	1C07	1C08	1C09	1C10	1C11	1C12	1C13
Specimen No. IA-	(1)	711A04 F78	111C10	111B10	111A09	511C07	112AC1	112A02	112D01	112A03	112A04	112A05	112D02	112A06	112A07	112A08	112D03	112A09	112A10
Panel Ident.	IA11P						IA110929												
Tab Ident.	7075-T6 Aluminum						7075-T6 Aluminum												
Adhered Thickness																			
Inches	.044	.044	.044	.043	.043	.044													
Splice Material	6AL-4V Titanium Annealed						7075-T6 Aluminum												
Splice Thickness																			
Inches-Nom.	.041						.060												
Adhesive Type	EA9601-06						EA9601-06												
Adh. Batch/Roll	364-46/B2						364-46/B2												
Lay-Up Date	9/16						10/13/70												
Lay-Up Time	1100						1000												
Cure Date	9/17						10/14												
Cure Time	1000						1055												
Cure Pressure	30	LDR #386597					30	LDR #412763											
Heat-Up Rate °/Min.	5.5						5												
Cure Temp./Time	260/65						275°/85												
Bondline Thick. Mils																			
Left	5.0	4.9	5.0	4.7	5.1	5.3													
Right	5.7	5.4	5.4	5.0	5.1	5.1													
Inspect	Fabrication inspection per drawing performed on all specimens - E. C. Young																		
Quality Assur.	All specimens checked for bondline thickness. Ultrasonic C-scan and X-rays performed on all specimens - R. E. Shupe																		

NOTES:

(1) These specimens are to be held for contingency and when selected for testing they will be assigned a specimen number.

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BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION A

DWG #7226-1302IA-	1A111	1A112	1A113	1A114	1A115	1A116	1A117	1A118	1A119	1A120	1A121	1A122	1A123	1A124	1A125	1A126	1A127	1A128	1A129
Specimen No. IA-	111B21	511A08	111A10	811A09	511D05	111A21	511C08	(1)	711F05	811A10	511A09	(1)	111B25	111B22	511C09	111A22	111C21	511A10	(1)
Panel Ident.	IA111015 →																		
Tab Ident.	7075-T6	ALUMINUM →																	
Adherend Thickness																			
Inches	.046	.046	.046	.046	.047	.047	.047	.047	.047	.047	.047	.047	.047	.047	.047	.047	.047	.047	.047
Splice Material	6AL-4V - TITANIUM ANNEALED →																		
Splice Thickness																			
Inches-Nom.	.040 →																		
Adhesive Type	EA9601-06 →																		
Adh. Batch/Roll	364-153/F →																		
Lay-Up Date	10/29/70																		
Lay-Up Time	1100																		
Cure Date	10/29/70																		
Cure Time	1430		→ LDR	428758 →															
Cure Pressure	3																		
Heat-Up Rate °/Min.	5°F																		
Cure Temp./Time	265°/75 Min.																		
Bondline Thick. Mils																			
Left	5.5	4.9	4.9	6.3	5.6	6.9	5.8	5.9	7.2	7.1	6.0	7.0	6.7	6.4	6.8	7.0	6.6	6.5	6.8
Right	5.5	5.5	5.9	5.6	6.5	7.3	6.6	6.6	9.6 (2)	7.0	6.9	6.2	5.9	6.7	7.5	7.4	6.5	6.9	6.5
Inspect	Fabrication inspection per drawing performed on all specimens - R. J. Bradley.																		
Quality Assur.	All specimens checked for bondline thickness. Ultrasonic c-scan and x-rays per R. F. Shupe.																		

NOTES:

(1) These specimens are to be held for contingency and when selected they will be assigned a specimen number.

(2) This had a very thick bondline but will be tested and compared with other data.

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION A

DWG #7226-1302IA-	1A130	1A131	1A132	1A133	1A134	1A135	1A136	1A137	1A138	1A139	1A140	1A141	1A142	1A143	1A144	1A145	1A146	1A147	1A148	1A149
Specimen No. IA-	11C22	511C10	111A24	711F11	511D06	(1)	111B26	111B27	111B28	(1)	111B29	111B30	(1)	111B31	111B32	511A14	511A11	511C1	511D07	511A12
Panel Ident.	IA111015															IA1210				
Tab Ident.	7075-T6	ALUMINUM																		
Adherend Thickness																				
Inches	.047	.047	.047	.047	.047	.046	.046	.047	.047	.047	.047	.047	.047	.047	.047	.0445				
Splice Material	6AL-4V	Titanium Annealed																		
Splice Thickness																				
Inches-Nom.	.040																			
Adhesive Type	EA9601-06															EA 9601-6				
Adh. Batch/Roll	364-153/F															364-160/0				
Lay-Up Date	10/29/70															12/16/70				
Lay-Up Time	1100															1145				
Cure Date	10/29/70		LDR 428758													12/16/70		LDR 412783		
Cure Time	1430															1345				
Cure Pressure	30															30				
Heat-Up Rate °/Min.	5°F															5				
Cure Temp./Time	265°/75 min.															260°F/90				
Bondline Thick. Mils																				
Left	6.1	7.0	6.0	6.6	6.4	6.3	6.3	5.2	5.5	5.7	5.2	6.2	5.8	6.2	6.2	5.3	5.4	5.7	6.0	6.2
Right	6.9	7.2	6.7	7.0	6.0	6.6	6.0	5.1	5.5	6.4	6.0	6.0	7.0	6.0	6.3	6.2	5.1	6.2	5.4	5.9
Inspect	Fabrication inspection per drawing performed on all specimens - R. J. Bradley.																			
Quality Assur.	All specimens checked for bondline thickness. Ultrasonic c-scan and x-rays performed on all specimens - R. E. Shupe																			

NOTES:

(1) These specimens are to be held for contingency and when selected for testing they will be assigned a specimen number.

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BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION A

DWG #7226-1302IA-	1A150	1A151	1A152	1A153	1A154	1A155	1A156	1A157	1A158	1A159	1A160	1A161	1A162	1A163	1A164	1A165
Specimen No. IA-	511C12	511A13	511A15	711G01	511A17	711G02	511D08	711G03	111B33	511A16	711G04	511A18	511D09	711F06	511A19	711G05
Panel Ident.	IA1210 →			IA111015												
Tab Ident.	7075-T6	Alum. →														
Adherend Thickness																
Inches	.0445 →			.0420	.0425	.0420	.0420	.0420	.0430	.0425	.0420	.0420	.0425	.0425	.0415	.0415
Splice Material	6-4-Ti Annealed →															
Splice Thickness																
Inches-Nom.	.040 →															
Adhesive Type	EA 9601-06 →															
Adh. Batch/Roll	364-160/0	LDR 412783		383-5/T												
Lay-Up Date	12/16/70			1/19/71												
Lay-Up Time	1145			0900												
Cure Date	12/16/70		→	1-19-72			LDR	412791 →								
Cure Time	1345			1305												
Cure Pressure	30			30												
Heat-Up Rate °/Min.	5°F			5												
Cure Temp./Time	260°/90	Min.		265/90												
Bondline Thick. Mils																
Left	6.1	6.1	5.3	5.7	5.6	5.4	5.3	5.6	5.5	5.1	5.5	5.8	5.5	5.2	5.9	5.6
Right	6.2	5.8	5.8	5.1	5.5	5.4	4.8	5.8	5.2	5.4	5.5	5.8	5.7	5.7	5.3	5.5
Inspect.	Fab. insp. per dwg. all specimen - R. J. Bradley															
Quality Assur.	Bondline thickness, c-scan and x-ray inspection on all specimens - R. E. Shupe.															

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BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION A

DWG #7226-1302IA-	1B01	1B02	1B03	1B04	1B05	1B06	1B07	1B08	1B09	1B10	1B11	1B12	1B13	1B14	1B15	1B16	1B17	1B18	1B19	1B20
Specimen No. IA-	113A01	11D01	(1)	113A02	113A11	113A03	(1)	113D02	113A12	113A04	113A05	(1)	(2)	113A06	113A07	(1)	113D03	113A08	113A13	113A09
Panel Ident.	IA11924 →																			
Tab Ident.	7075-T6 Aluminum →																			
Adherend Thickness																				
Inches	Nominal .044 →																			
Splice Material	8-Ply Boron 0°/±45° IA11924 →																			
Splice Thickness																				
Inches-Nom.	.044 →																			
Adhesive Type	EA 9601-06																			
Adh. Batch/Roll	364-46/B2																			
Lay-Up Date	10/2/70																			
Lay-Up Time	1000																			
Cure Date	10/2/70																			
Cure Time	1440		LDR 412760 →																	
Cure Pressure	30																			
Heat-Up Rate °/Min.	5.3																			
Cure Temp./Time	260°F/90 Min.																			
Bondline Thick. Mils																				
Left	5.1	5.7	6.5	6.1	6.2	5.9	5.7	6.3	5.6	6.6	5.5	6.3		5.7	6.1	5.9	5.7	5.5	5.4	5.5
Right	5.9	5.7	5.6	6.1	5.7	6.4	6.1	6.1	6.4	6.5	6.8	5.5		5.5	6.1	5.6	6.3	5.3	5.5	5.5
Inspect	Fabrication inspection per dwg. on all specimens - R. J. Bradley.																			
Quality Assur.	Bondline, ultrasonic c-scan and x-ray inspection on all specimens - R. E. Shupe.																			

NOTES:

(1) These specimen held for contingency and when selected for testing they will be assigned a specimen number.

(2) Damaged in machining.

BONDED JOINT SPECIMEN - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION A

DWG #7226-1302IA-	1B21	1B22	1B23	1B24	1B25	1BX01	1BX02	1BX03	1BX04	1BX05	1BX06	1BX07	1BX08	1BX09	1BX10	1BX11	1BX12	1BX13
Specimen No. IA-	113D04	(1)	113A14	113A10	(1)	613A01	613A02	613D01	613A03	613A04	613A05	613D02	613A06	613A07	613A08	613D03	613A09	613A10
Panel Ident.	IA11924 →					IA110929 →												
Tab Ident.	7075-T6 Aluminum →																	
Adherend Thickness																		
Inches	Nominal .044 →					.043 Nominal →												
Splice Material	8-Ply Boron 0°/±45° IA11924 →					IA110924 →												
Splice Thickness																		
Inches-Nom.	.044 →					.043 →												
Adhesive Type	EA 9601-06					MB 329/095 →												
Adh. Batch/Roll	364-46/B2					—	—	—	—	—	—	—	—	—	—	—	—	—
Lay-Up Date	10/2/70					10/27/70												
Lay-Up Time	1000					1330												
Cure Date	10/2/70		LDR 412760 →			10/28/70												
Cure Time	1440					0930		LDR 412773 →										
Cure Pressure	30					45												
Heat-Up Rate °/Min.	5.3					4												
Cure Temp./Time	260°F/90 Min.					350°F/60 Min.												
Bondline Thick. Mils																		
Left	5.1	5.0	4.9	5.3	5.6	7.7	7.8	8.2	8.2	7.8	8.0	7.7	8.4	8.4	8.8	8.6	8.7	9.0
Right	5.0	5.4	5.6	5.8	6.0	7.2	8.5	8.6	7.6	8.3	8.4	8.2	8.4	7.7	8.0	8.8	8.7	8.2
Inspect	Fabrication inspection per Dwg. on all specimens - R. J. Bradley.																	
Quality Assur.	Bondline, ultrasonic c-scan and x-ray inspection on all specimens - R. E. Snupe.																	

NOTES:

(1) These specimens held for contingency and when selected for testing they will be assigned a specimen number.

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BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION A

DWG #7226-1302IA-	9A01	9A02	9A03	9A04	9A05	9A06	9A07	9A08	9A09	9A10	9A11	9A12	9A13	9A14	9A15	9A16	9A17	9A18	9A19	9A20
Specimen No. IA-	311A01	311D01	311A02	311A10	311A03	311D02	311A04	311A05	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	311A11	311A12	311D04	311A13
Panel Ident.	IA110910 →																IA1210 →			
Tab Ident.	7075-T6 Aluminum →																			
Adherend Thickness																				
Inches	.047 →																.0445 →			
Splice Material	6AL-4V Titanium Annealed																			
Splice Thickness																				
Inches-Nom.	.040 →																			
Adhesive Type	EA 9601-06								EA 9601-06								EA 9601-06			
Adh. Batch/Roll	364-46/B2								364-46/B2								364-160/0			
Lay-Up Date	10/6/70								10/13/70								12/16/70			
Lay-Up Time	1000								1000								1145			
Cure Date	10/7/70	→	LDR 412761 →						10/14/70	→	LDR 412763 →						12/16/70	→	LDR 412783	
Cure Time	1345								1055								1345			
Cure Pressure	30								30								30			
Heat-Up Rate °/Min.	7								5								5			
Cure Temp./Time	260°/70 Min.								275°/85 Min.								260°/90 Min.			
Bondline Thick. Mils																				
Left	5.1	5.9	6.7	6.1	6.7	4.9	5.4	6.1	4.7/8.4	4.6/7.9	4.8/6.9	5.5	5.4	4.6	4.6	4.6	4.5	5.0	4.8	5.6
Right	6.3	6.4	6.7	6.4	6.9	5.0	6.4	6.5	5.2	4.9	5.0	4.5/5.9	4.0/5.7	4.3	4.7	5.4	4.4	4.9	5.8	5.0
Inspect	Fabrication inspection per drawing performed on all spec. - R. J. Bradley																			
Quality Assur.	All specimens checked for bondline thickness. Ultrasonic c-scan and x-ray - R. E. Shupe.																			

NOTES:

(1) Due to bondline taper all specimens cut from this panel are held in abeyance.

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BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION A

DWG #7226-1302IA-	9A21	9A22	9A23	9A24	11A01	11A02	11A03	11A04	11A05	11A06	11A07	11A08	11A09	11A10	11A11	11A12	11A13	11A14	11A15	11A16
Specimen No. IA-	(1)	311D05	311A14	311A15	911A01	911C01	(1)	911D01	911A02	911C02	(1)	911A03	911C03	911D02	(1)	911A04	911C04	911A05	911C05	(1)
Panel Ident.	IA1210				IA11924															
Tab Ident.	7075-T6 Aluminum				7075-T6 Aluminum															
Adherend Thickness																				
Inches	.0445																			
Splice Material	6AL-4V Ti Annealed																			
Splice Thickness																				
Inches-Nom.	.040																			
Adhesive Type	EA 9601-06				EA 9601-06															
Adh. Batch/Roll	364-160/0				364-46/B-2															
Lay-Up Date	12/16/70				10/6/70															
Lay-Up Time	1145				1000															
Cure Date	12/16/70				10/7/70															
Cure Time	1345		LDR 412783		1345		LDR 412761													
Cure Pressure	30				30															
Heat-Up Rate °/Min.	5				7															
Cure Temp./Time	260/90 Min.				260/70 Min.															
Bondline Thick. Mils																				
Left	5.8	5.8	5.2	5.2	(2)	5.6	5.5	6.5	6.4	6.2	6.3	6.0	5.5	6.3	5.8	5.6	4.8	5.4	7.1	6.6
Right	6.0	6.5	6.4	5.7	(2)	6.0	5.9	6.2	5.8	5.9	6.0	6.6	5.2	5.4	5.0	5.8	5.1	5.7	7.0	7.0
Inspect	Fabrication inspection per drawing on all specimens - R. J. Bradley.																			
Quality Assur.	Bondline measurements, c-scan and x-ray inspection - R. E. Shupe.																			

NOTES:

(1) These specimens held as contingency and when selected for testing they will be assigned a specimen number.

(2) Bondline thickness was not measured on this specimen; however thickness should correspond to the thicknesses of the other bondlines in this group.

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION A

DWG #7226-1302IA-	11A17	11A18	11A19	11A20	11A21	11A22	11A23	11A24	11A25	11A26	11A27	11A28	11A29	11A30	11A31	11A32	11A33	11A34
Specimen No. IA-	911D03	911A06	911C06	(1)	911A07	911C07	911D04	(1)	911A08	911C08	(1)	911A09	911C09	911D05	911D06	911A10	911C10	(1)
Panel Ident.	IA11924										IA1210							
Tab Ident.	7075-T6 Aluminum																	
Adherend Thickness																		
Inches											.0445							
Splice Material	6AL-4V - Titanium Annealed																	
Splice Thickness																		
Inches-Nom.	.040																	
Adhesive Type	EA 9601-06										EA 9601-06							
Adh. Batch/Roll	364-46/B2										364-160/0							
Lay-Up Date	10/6/70										12/16/70							
Lay-Up Time	1000										1145							
Cure Date	10/7/70		LDR 412761								12/16/70		LDR 412783					
Cure Time	1345										1345							
Cure Pressure	30										30							
Heat-Up Rate °/Min.	7										5							
Cure Temp./Time	260/70 Min.										260/90 Min.							
Bondline Thick. Mils																		
Left	7.0	6.5	5.2	5.2	6.1	5.7	6.2	6.3	6.7	5.9	5.9	6.0	5.3	5.6	6.1	6.4	5.6	5.8
Right	6.0	6.2	6.2	6.7	6.2	5.1	5.7	5.5	5.8	5.9	5.6	6.0	6.3	5.8	5.6	5.8	6.6	6.4
Inspect	Fabrication inspection per drawing on all specimens - R. J. Bradley.																	
Quality Assur.	Bondline measurements, C-scan and X-ray inspection - R. E. Shupe.																	

NOTES:

(1) These specimens held as contingency and when selected for testing they will be assigned a specimen number.

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION A

DWG 7226-1302IA	1A166	1A167	1A168	1A169	1A170	1A171	1A172	1A173	1A174	1A175	1A176	1A177
Specimen No. IA -	111B345	111B355	111B36.	111D12	111B375	111B385	711G08	711G06	711G09	111D13	711G07	711G10
Panel Ident.	IIA021D											
Tab Ident.	Aluminum											
Adherend Thickness												
Inches	0.044	Nom.										
Splice Material	Ti -6-4											
Splice Thickness												
Inches - Nom.	0.040											
Adhesive Type	EA9601-.06											
Adh. Batch/Roll	383-5/U2											
Lay-up Date	2/22/71											
Lay-up Time	1100			LDR 412799								
Cure Date	2/23/71											
Cure Time	1023											
Cure Pressure	30											
Heat-Up Rate °Min.	5.75											
Cure Temp./Time	260°F/78 Min.											
Bondline Thick. Mils	4.6	4.8	4.5	4.4	4.0	4.3	4.3	4.5	4.1	4.5	5.2	4.3
Left	4.1	5.1	4.0	4.5	4.0	4.5	4.3	4.7	4.4	5.0	5.2	4.3
Inspect.	Fab. insp. per dwg. all specimen - R. J. Bradley											
Quality Assur.	Bondline thickness, c-scan and x-ray inspection on all specimens - R. E. Shupe.											

LOCKHEED-GEORGIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

TABLE A4
I

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION D

DWG #7226-1302ID-	1A01	1A02	1A03	1A04	1A05	1A06	1A07	1A08	1A09	1A10	1A11	1A12	1A13	1A14	1A15
Specimen No. ID-	11A01	11A02	111D01	(1)	111A03	111A04	111A05	111D02	111A06	111A07	111A08	(1)	111D03	111A09	111A10
Panel Ident.	ID-1A1210 →														
Tab Ident.	7075-T6 Aluminum →														
Adherend Thickness															
Left-Inches	.0835	.083	.084	.084	.084	.084	.084	.084	.084	.084	.084	.084	.083	.0835	.0835
Right-Inches	.0835	.083	.083	.084	.084	.084	.084	.084	.084	.0835	.084	.084	.084	.084	.0835
Splice Material	6AL-4V Titanium Annealed →														
Splice Thickness															
Upper-Inches	.040 →														
Lower-Inches	.040 →														
Adhesive Type	EA 9601-06														
Adh. Batch/Roll	364-160/0														
Lay-Up Date	12/17/70														
Lay-Up Time	1410														
Cure Date	12/18/70	→		LDR 428782 →											
Cure Time	1130														
Cure Pressure	30														
Heat-Up Rate °/Min.	6														
Cure Temp./Time	260/90 Min.														
Bondline Thick. Mils															
Upper Left	7.7	6.2	6.2	7.0	6.7	7.0	7.5	7.0	7.0	7.0	7.2	6.0	6.0	7.0	6.0
Upper Right	8.0	6.7	6.0	7.0	7.2	7.0	7.0	7.0	7.0	7.2	6.5	7.5	6.0	6.7	6.7
Lower Left	6.5	6.5	6.2	6.7	6.5	6.2	7.2	6.7	7.0	6.7	7.0	6.7	6.0	6.2	7.0
Lower Right	5.7	6.5	6.5	6.5	6.2	6.2	6.7	7.0	7.0	7.2	6.7	6.7	6.5	6.5	6.7
Inspect	Fabrication inspection per drawing performed on all specimens - R. J. Bradley.														
Quality Assur.	Bondline thickness, ultrasonic c-scan and x-ray inspection - R. E. Shupe.														

NOTES:

(1) These specimens held as contingency and when selected for testing they will be assigned a specimen number.

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION C

DWG #7226-1302IC-	1A01	1A02	1A03	1A04	1A05	1A06	1A07	1A08	1A09	1A10	1A11	1A12	1A13	1A14	1A15
Specimen No. IC-															
Panel Ident.	IC-0105														
Spec. Thick. Inches	.049	.049	.049	.049	.049	.049	.050	.050	.050	.049	.049	.049	.049	.049	.049
Tee Thickness															
Left - Inches	.119	.120	.119	.112	.120	.121	.120	.119	.121	.119	.119	.121	.120	.121	.120
Right - Inches	.128	.127	.129	.131	.129	.130	.129	.127	.129	.128	.129	.128	.127	.129	.127
Adhesive Type	EA9601-06														
Adh. Batch/Roll	383-5/T														
Lay-Up Time	1330														
Lay-Up Date	1/21/71														
Cure Time	.0820		LDR 412793												
Cure Date	1/22/71														
Cure Pressure	30														
Heat-Up Rate °/Min.	6.4														
Cure Temp./Time	260°F/80 Min.														
Bondline Thick. Mils															
Left	6.2	6.0	6.0	6.0	6.2	6.0	6.2	6.0	6.2	6.2	6.0	6.0	6.0	6.2	6.2
Right	5.7	5.8	5.7	6.0	5.5	6.0	5.7	5.7	6.0	6.0	5.6	5.9	5.8	5.8	5.7
Inspect	Fabrication inspection per drawing performed on all specimens - R. J. Bradley.														
Quality Assur.	Bondline thickness, ultrasonic c-scan and x-ray inspection - R. E. Shupe.														

LOCKHEED-GEORGIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	REPORT NO. ______ MODEL TABLE A6 PAGE 1

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION B

Specimen No. IB-	111C01	111A01	111D01	111A02	111C11	111C02	111D02	111C03	111D03	111A04	(Cont.)	111C04	111D04	111D04	111C05	111A05
DWG #7226-1302IB	1A01	1A02	1A03	1A04	1A05	1A06	1A07	1A08	1A09	1A10	1A11	1A12	1A13	1A14	1A15	1A16
Composite Thickness	.085	.085	.0855	.084	.085	.085	.084	.084	.0845	.0845	.0845	.085	.085	.084	.085	.084
Metal Material	T.															
Metal Thickness	.086	.086	.086	.086	.086	.086	.086	.086	.0835	.0835	.0835	.0835	.0835	.083	.082	.081
Step 1	.0584	.0587	.0592	.0586	.0590	.0600	.0597	.0600	.0587	.0590	.0595	.0585	.0595	.0585	.0575	.0560
" 2	.0369	.0407	.0400	.0354	.0384	.0350	.0405	.0375	.0390	.0390	.0390	.0380	.0395	.0385	.0370	.0355
" 3	.0175	.0180	.0180	.0180	.0180	.0180	.0170	.0165	.0180	.0190	.0180	.0170	.0180	.0170	.0175	.0160
Bondline Thickness																
Step 1	5.2	4.2	4.2	4.5	4.4	3.8	4.5	4.5	4.5	4.3	4.7	4.3	4.0	4.0	4.5	4.3
" 2	5.1	4.5	4.5	4.5	4.3	4.5	4.0	4.0	5.0	4.0	3.8	4.0	3.8	4.3	4.8	4.5
" 3	4.5	4.0	4.0	4.3	3.8	4.5	4.5	4.5	4.3	4.0	4.0	4.0	4.0	4.0	4.0	4.9
Step Length																
Step 1	.509	.502	.509	.511	.510	.503	.506	.507	.489	.488	.491	.493	.500	.503	.507	.500
" 2	.501	.500	.494	.498	.491	.494	.490	.486	.510	.509	.508	.508	.505	.504	.502	.506
" 3	.513	.495	.512	.507	.503	.492	.504	.505	.509	.512	.517	.520	.495	.498	.502	.500
Adhesive / Wt.	EA9601/.045 →															
Adh. Batch / Roll	364-65 / 7 →															
Layup Time	1000 →															
Layup Date	12/18/70 →															
Cure Time	1300 →															
Cure Date	12/18/70 →															
Cure Pressure	85 →															
Heatup Rate (^{o}F/MIM)	6 →															
Total Cure Time/Temp	120/350 →															
LDR No.	428783 →															
Inspection	Fabrication inspection per drawing performed on all specimens - R. J. Bradley															
Quality Assur.	Bondline thickness, ultrasonic C-scan and X-ray inspections - R. E. Shupe															

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION B

Specimen No., IB-	111A06	111C06	111D06	111C07	(Cont.)	111A07	111D05	111A08	111C08	111D08	111C09	(Cont.)	111A09	111D07	111A10	111C10
DWG #7226-13021B	1A17	1A18	1A19	1A20	1A21	1A22	1A23	1A24	1A25	1A26	1A27	1A28	1A29	1A30	1A31	1A32
Composite Thickness	.0845	.085	.085	.0855	.0845	.0845	.0845	.0845	.084	.0845	.084	.0845	.0845	.0845	.0845	.085
Metal Material	Ti →															
Metal Thickness	.086	.0855	.086	.086	.086	.0855	.085	.085	.085	.086	.0865	.0865	.087	.087	.0855	.0855
Step 1	.0619	.0595	.0610	.0595	.0600	.0615	.0615	.0505	.0695	.0619	.0615	.0615	.0625	.0625	.0620	.0619
Step 2	.0377	.0373	.0380	.0385	.0380	.0380	.0378	.0370	.0390	.0499	.0410	.0405	.0415	.0405	.0405	.0410
Step 3	.0170	.0180	.0173	.0190	.0180	.0182	.0175	.0170	.0180	.0170	.0180	.0180	.0185	.0185	.0190	.0170
Bondline Thickness																
Step 1	3.5	3.9	3.9	4.7	3.5	4.0	3.6	4.4	4.0	4.2	4.7	3.8	4.6	4.3	4.7	4.3
Step 2	3.9	3.9	3.5	4.4	3.5	3.8	4.3	4.4	3.7	5.0	4.0	4.2	3.7	4.2	4.2	3.6
Step 3	3.8	4.2	4.0	3.7	4.4	5.0	4.2	4.0	4.0	3.9	3.7	4.4	3.7	4.0	4.5	4.0
Step Length -																
Step 1	.507	.508	.510	.511	.512	.514	.516	.516	.503	.505	.502	.500	.502	.501	.500	.497
Step 2	.486	.487	.486	.486	.486	.487	.484	.484	.500	.498	.497	.497	.493	.493	.494	.496
Step 3	.511	.511	.510	.509	.512	.507	.512	.515	.492	.499	.499	.493	.488	.487	.487	.485
Adhesive / Wt.	EA9601/.045 →															
Batch / Roll	364-65/7 →															
Layup Time	1000 →															
Layup Date	12/18/70 →															
Cure Time	1300 →															
Cure Date	12/18/70 →															
Cure Pressure	85 →															
Heat up Rate ($^{\circ}$F/Min)	6 →															
Total Cure Time/Temp	120/350 →															
L.D.R.No	428783 →															
Inspection	Fabrication inspection per drawing performed on all specimens - R. J. Bradley															
Quality Assur.	Bondline thickness, ultrasonic C-scan and X-Ray inspections - R. E. Shupe															

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION B

Specimen No. IB -	511A01	511A02	511D01	511A03	511A04	511D02	511A05	511A06	511A07	511A08	511D03	511A09	511A10
DWG #7226-1802IB -	1A41	1A42	1A43	1A44	1A45	1A46	1A47	1A48	1A49	1A50	1A51	1A52	1A53
Composite Thickness	.0845	.0845	.0845	.085	.0855	.085	.0855	.085	.082	.083	.083	.083	.083
Metal Material	Ti												
Metal Thickness	.084	.084	.084	.084	.0845	.084	.084	.084	.086	.086	.085	.084	.084
Step 1	.058	.060	.060	.059	.058	.059	.058	.058	.016	.016	.016	.016	.016
Step 2	.036	.037	.036	.037	.037	.038	.037	.037	.033	.032	.033	.032	.032
Step 3	.017	.018	.016	.017	.017	.017	.018	.018	.030	.030	.030	.030	.030
Bondline Thickness													
Step 1									5.5	5.5	5.5	5.5	5.5
Step 2									6.0	5.9	5.9	6.0	6.0
Step 3									5.5	5.4	5.4	5.5	5.5
Step Length													
Step 1									.506	.507	.508	.505	.511
Step 2									.487	.500	.501	.500	.506
Step 3									.502	.505	.509	.510	.510
Adhesive / Wt	EA9601/.045								EA9601/.045				
Batch / Roll	364-154/Q								383-103/EE				
Layup Time	1600								1600				
Layup Date	2/2/71								7/16/71				
Cure Time	1045								1045				
Cure Date	2/3/71								7/19/71				
Cure Pressure	90								85				
Heatup Rate (°F/Min.)	5								4.4				
Total Cure Time/Temp	120/350								120/350				
L.D.R. No.	412794								428276				
Inspection	Fabrication inspection per drawing performed on all specimens - R. J. Bradley												
Quality Assur.	Bondline thickness, ultrasonic C-scan and X-ray inspections - R. E. Shupe												

LOCKHEED-GEORGIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

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BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOT
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION B

Specimen No. 1B -	(Lost)	112A01	112A02	112D01	112A03	112A04	112A05	112D02	(Cont.)	112A06	112A07	112A08	112D03	112A09	112A10	(Cont.)
DWG #7226-1302IB-	1B01	1B02	1B03	1B04	1B05	1B06	1B07	1B08	1B09	1B10	1B11	1B12	1B13	1B14	1B15	1B16
Composite Thickness	.086	.086	.086	.0865	.088	.0885	.0885	.0885	.089	.089	.089	.0885	.0885	.0885	.088	.0865
Metal Material	Alum.															
Metal Thickness	.082	.082	.082	.0825	.0825	.0825	.0825	.0825	.0825	.0825	.0825	.0825	.0825	.0825	.0825	.0825
Step 1	.059	.058	.059	.058	.059	.058	.059	.059	.059	.058	.059	.058	.059	.058	.059	.059
Step 2 (1)	.036	.036	.036	.035	.036	.036	.035	.036	.036	.036	.036	.036	.036	.036	.036	.036
Step 3 (1)	.015	.015	.015	.0145	.015	.015	.015	.015	.015	.015	.015	.015	.015	.015	.015	.015
Bondline Thickness																
Step 1	3.4	3.5	3.6	3.4	3.4	3.6	3.2	3.4	3.4	3.6	3.7	3.5	3.5	3.0	3.4	3.3
Step 2	3.6	4.0	3.7	3.5	3.5	3.6	3.5	3.5	3.6	3.9	4.0	3.9	3.2	3.6	3.5	3.4
Step 3	3.8	4.0	4.0	3.5	3.6	3.4	3.3	4.0	3.4	4.0	4.0	4.0	3.6	3.4	3.7	3.9
Step Length																
Step 1	.512	.510	.510	.512	.513	.510	.512	.510	.512	.509	.512	.512	.512	.510	.512	.510
Step 2	.502	.509	.513	.508	.508	.511	.508	.508	.508	.508	.510	.510	.509	.508	.509	.510
Step 3	.518	.513	.511	.513	.516	.516	.511	.513	.511	.513	.511	.513	.513	.513	.514	.513
Adhesive / Wt	EA9601/.045															
Batch / Roll	364-154/Q															
Layup Time	1600															
Layup Date	2/2/71															
Cure Time	1045															
Cure Date	2/3/71															
Cure Pressure	90															
Heat up Rate (^{o}F/Min)	5															
Cure Time -Total/Temp.	120/340^{o}F															
L.D.R. No.	412794															
Inspection	Fabrication inspection per drawing performed on all specimens - R. J. Bradley															
Quality Assur.	Bondline thickness, ultrasonic C-scan and X-ray inspections - R. E. Shupe															

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOT
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION B

Specimen No. 1B	(Cont.)	121A01	121A02	121D01	121A03	121A04	121A05	121D02	(Cont.)	121A06	121A07	121A08	121D03	121A09	121A10	(Cont.)
DWG. 7226-13021B	3A01	3A02	3A03	3A04	3A05	3A06	3A07	3A08	3A09	3A10	3A11	3A12	3A13	3A14	3A15	3416
Composite Thickness	.0825	.083	.082	.0825	.083	.082	.0825	.082	.0825	.082	.0825	.083	.0835	.0835	.083	.0835
Metal Material	Ti															
Metal Thickness	.0865	.087	.087	.087	.087	.0865	.085	.0845	.083	.0835	.084	.084	.0845	.0845	.0825	.0835
Step 1	.059	.060	.060	.059	.060	.060	.059	.060	.060	.060	.059	.060	.059	.060	.059	.059
Step 2	.039	.038	.038	.038	.038	.038	.038	.038	.039	.039	.038	.038	.038	.038	.038	.038
Step 3	.017	.018	.017	.018	.018	.018	.017	.018	.017	.018	.018	.017	.018	.017	.018	.018
Bondline Thickness																
Step 1	4.3	4.2	4.0	4.4	4.0	4.0	4.0	4.2	4.0	4.4	4.0	4.0	3.8	4.0	4.4	4.2
Step 2	3.7	3.7	3.5	3.7	3.6	3.5	3.6	3.6	3.9	3.9	3.7	3.6	3.7	3.9	3.8	3.7
Step 3	3.5	3.6	3.5	3.6	3.6	3.7	3.5	3.7	4.1	3.6	3.5	3.7	3,6	3.6	3.6	3.5
Step Length																
Step 1	.475	.480	.482	.475	.478	.478	.493	.475	.490	.492	.475	.478	.480	.470	.475	.476
Step 2	.510	.508	.509	.504	.511	.510	.510	.509	.498	.499	.510	.509	.510	.509	.510	.508
Step 3	.505	.507	.505	.502	.507	.504	.505	.507	.499	.498	.505	.507	.507	.505	.505	.506
Adhesive / Wt.	EA9601	.045														
Batch / Roll	364-154/Q															
Layup Time	0930															
Layup Date	2/5/71															
Cure Time	1512															
Cure Date	2/5/71															
Cure Pressure	90															
Heat-up Rate (^{o}F/Min)	7															
Cure Time - Total/Temp	120/360															
L.D.R. No.	412795															
Inspection	Fabrication inspection per drawing performed on all specimens - R. J. Bradley															
Quality Assur.	Bondline thickness, ultrasonic C-scan and X-ray inspections - R. E. Shupe															

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION B

Specimen No. IB	(Cont.)	211A01	211A02	211D01	211A03	211A04	211A05	(Cont.)	211D02	211A06	211A07	211A08	211D03	211A09	211A10	
DWG #7226-1302IB	5A01	5A02	5A03	5A04	5A05	5A06	5A07	5A08	5A09	5A10	5A11	5A12	5A13	5A14	5A15	5A16
Composite Thickness	.0825	.0825	.0825	.083	.083	.083	.083	.083	.083	.083	.083	.083	.0825	.0825	.083	.083
Metal Material	Ti															
Metal Thickness	.088	.088	.088	.088	.0875	.087	.087	.087	.086	.086	.086	.0855	.085	.085	.0845	.0835
Step 1	.059	.059	.060	.059	.059	.059	.058	.058	.058	.059	.059	.058	.059	.059	.058	.059
Step 2	.038	.038	.038	.038	.039	.038	.037	.037	.038	.037	.038	.038	.037	.037	.038	.038
Step 3 (1)	.019	.019	.019	.019	.019	.019	.019	.019	.019	.019	.019	.019	.019	.019	.019	.019
Bondline Thickness																
Step 1	3.7	3.7	3.7	3.5	3.7	3.8	3.6	3.7	3.6	3.6	3.5	3.5	3.8	3.5	3.5	3.6
Step 2	3.7	3.8	3.8	3.6	3.7	4.0	3.5	3.6	3.6	3.6	3.6	3.7	3.6	3.6	3.8	3.7
Step 3	414	416	414	415	414	416	3.8	3.8	3.8	4.2	4.2	4.5	4.0	4.0	4.5	4.5
Step Length																
Step 1	.500	.504	.502	.504	.500	.501	.500	.502	.501	.500	.503	.501	.500	.500	.502	.500
Step 2	.487	.490	.486	.486	.490	.488	.487	.488	.487	.490	.485	.485	.487	.490	.485	.487
Step 3	.518	.518	.519	.518	.516	.518	.517	.518	.519	.517	.513	.525	.517	.518	.518	.518
Adhesive / Wt	EA9601/.045															
Batch / Roll	364-154/Q															
Layup Time	0930															
Layup Date	2/5/71															
Cure Time	1512															
Cure Date	2/5/71															
Cure Pressure	90															
Heat-Up Rate (^oF/Min)	7															
Cure Time-Total/Temp	120/360															
L.D.R. No.	412795															
Inspection	Fabrication inspection per drawing performed on all specimens - R. J. Bradley															
Quality Assur.	Bondline thickness, ultrasonic C-scan and X-ray inspections - R. E. Shrape															
(1)	Step 3 Metal Thickness .001" over tolerance															

BONDED JOINT SPECIMENS- FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE I - CONFIGURATION B

Specimen No. 1B	311A01	311A02	311D01	311A03	(Cont.)	311A04	311A05	311D02	311A06	311A07	(Cont.)	311A08	311D03	311A09	311A10
DWG #7226-1302 1B	9A01	9A02	9A03	9A04	9A05	9A06	9A07	9A08	9A09	9A10	9A11	9A12	9A13	9A14	9A15
Composite Thickness	.085	.0855	.0855	.086	.085	.085	.085	.0845	.0855	.0855	.0855	.0855	.0855	.0855	.085
Metal Material	Ti														
Metal Thickness	.085	.086	.087	.087	.0875	.0875	.088	.084	.084	.084	.0845	.0845	.084	.0845	.084
Step 1	.060	.060	.060	.061	.060	.060	.061	.060	.060	.060	.060	.060	.060	.060	.060
Step 2	.039	.039	.039	.040	.039	.040	.040	.039	.039	.039	.039	.039	.039	.039	.039
Step 3	.017	.017	.016	.017	.017	.017	.017	.018	.018	.018	.018	.018	.018	.017	.018
Bondline Thickness															
Step 1	4.6	4.1	4.3	4.5	4.7	4.3	3.5	4.3	4.7	3.6	4.2	3.6	4.5	3.6	4.5
Step 2	3.7	4.0	3.8	4.5	4.0	3.8	4.2	4.0	4.2	3.5	3.8	4.2	4.2	4.2	4.0
Step 3	4.2	4.0	4.2	4.7	4.5	4.2	4.7	4.4	3.5	3.7	4.4	4.2	4.0	4.5	3.9
Step Length															
Step 1	.339	.345	.349	.354	.356	.360	.365	.369	.367	.369	.368	.365	.369	.363	.365
Step 2	.373	.373	.370	.367	.368	.368	.364	.375	.380	.381	.377	.373	.375	.373	.385
Step 3	.394	.393	.394	.397	.396	.400	.402	.392	.395	.393	.397	.398	.390	.390	.394
Adhesive /Wt	EA9601/.045														
Batch / Roll	364-154/Q														
Layup Time	0930														
Layup Date	2/5/71														
Cure Time	1512														
Cure Date	2/5/71														
Cure Pressure	90														
Heat-Up Rate (°F/Min)	7														
Cure Time-Total/Temp	120/360														
L.D.R. No.	412795														
Inspection	Fabrication inspection per drawing performed on all specimens - R. J. Bradley														
Quality Assur.	Bondline thickness, ultrasonic C-scan and X-Ray inspections - R. E. Shupe														

LOCKHEED-GEORGIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

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MECHANICAL JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PHASE I - CONFIGURATION E

DWG # 7226-1302IE-	1A01	1A02	1A03	1A04	1A05	1A06	1A07	1A08	1A09	1A10	1A11	1A12	1A13	1A14	1A15	1A16	1A17	1A18	1A19	1A20
Specimen No. IE-	111C01	111A01	111A02	511A01	111B01	111C02	111C03	611F01	111A03	111B02	111A04	(Cont)	111D01	(Cont)	511A02	611F02	(Cont)	611G01	111B03	111A05
Panel Identification	IE210318 A																			
Adherend Thickness																				
Basic	.046	.047	.047	.0465	.0475	.0475	.047	.0475	.048	.047	.047	.041/.0465	.036	.046	.0465	.045	.0465	.047	.046	.044
1st Build Up	.070	.0695	.0705	.0695	.069	.0695	.070	.069	.069	.070	.0695	.0667/.070	.0685	.0695	.067	.0675	.069	.068	.0675	.067
2nd Build Up	.093	.093	.093	.0935	.093	.0935	.093	.0935	.0935	.0935	.094	.0895/.093	.088	.0925	.092	.0925	.093	.0905	.0905	.0905
3rd Build Up	NA																			
4th Build Up	NA																			
Splice Material	Ti-8-1-1																			
Splice Thickness	.126																			
Metal Joint Half	Ti-8-1-1																			
Fastener Torque	30 in.-lbs.																			
Fay Surface Sealant	111-B2																			
Batch No.	Crib Mix																			
DWG NO. 7226-1302IE	1A21	1A22	1A23	1A24	1A25	1A26	1A27	1A28	1A29	1A30	1A31	1A32	1A33	1A34	1A35	1A36	1A37	1A38	1A39	1A40
Specimen No. IE-	111B04	111C04	511A03	111A06	111D02	611G03	111C05	111B05	111B06	611F05	111A07	511A04	111D03	511A05	611F04	611F03	511A06	111C06	(Cont)	511A07
Panel Identification	IE210318 A					IE210318 B														
Adherend Thick (in)																				
Basic	.046	.046	.0465	.0465	.0455	.046	.048	.0475	.047	.0475	.048	.047	.0465	.047	.047	.0485	.047	.0465	.0475	.046
1st Build Up	.0665	.0635	.0675	.0675	.0655	.068	.067	.0685	.0665	.068	.0665	.067	.0675	.065	.068	.070	.068	.068	.067	.068
2nd Build Up	.0895	.0895	.088	.0885	.088	.090	.091	.0935	.092	.093	.0935	.0935	.093	.0945	.0935	.093	.0935	.093	.0925	.092
3rd Build Up	NA																			
4th Build Up	NA																			
Splice Material	Ti-8-1-1																			
Splice Thickness	.126																			
Metal Joint Half	Ti-8-1-1																			
Fastener Torque	30 in.-lbs.																			
Fay Surface Sealant	111-B2																			
Batch No.	Crib Mix																			

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MECHANICAL JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PHASE I - CONFIGURATION E

DWG. NO. 7226-1302IE	-1A41	1A42	1A43	1A44	1A45	1A46	1A47	1A48	1A49	1A50	1A51	1A52	1A53	1A54	1A55	1A56	1A57	1A58	1A59	1A60
Specimen No. IE-	511A08	(Lost)	611F06	111A08	111D04	111A09	611G02	111B07	611G06	111C09	111A10	511A09	611F07	(Lost)	611G04	111A11	111D05	(Cont)	111B08	111G05
Panel Identification	IE210318B										IE210318C									
Adherend Thick (In)																				
Basic	.047		.047	.046	.047	.046	.046	.048	.046	.046	.046	.046	.046		.047	.047	.046	.047	.046	.047
1st Build Up	.066		.065	.066	.065	.063	.066	.065	.068	.065	.056	.065	.066		.068	.067	.067	.066	.068	.066
2nd Build Up	.091		.091	.086	.087	.090	.091	.091	.091	.090	.093	.095	.094		.090	.094	.093	.094	.091	.091
Splice Material	8-1-1																			
Splice Thickness	.126																			
Metal Joint Half	8-1-1 Ti .126																			
Fay Surface Sealant	STM 40	111-B2																		
Batch No.	54639																			
Collar Torque	30 in.-	lbs.																		
DWG. NO. 7226-1302IE	1A61	1A62	1A63	1A64	5A01	5A02	5A03	5A04	5A05	5A06	5A07	5A08	5A09	5A10	5A11	5A12	5A13	5A14		
Specimen No. IE	111A12	511A10	111B09	111A13	211D01	211B01	211A01	211A04	211A02	211B02		211D03	211B03	211B04	211A05	211A03	211B05	211D05		
Panel Identification	IE210318C				IE250312															
Adherend Thickness																				
Basic	.047	.047	.047	.047	.046	.045	.046	.0455	.044	.045		.046	.045	.0455	.0455	.0455	.045	.0455		
1st Build Up	.064	.066	.067	.072	.0605	.055	.052	.054	.055	.051		.053	.045	.055	.056	.055	.055	.056		
2nd Build Up	.082	.080	.080	.095	.065	.0655	.065	.065	.0665	.065		.0655	.065	.0655	.066	.0655	.065	.0655		
Splice Material	Ti-8-1-1																			
Splice Thickness	.126																			
Metal Joint Half	Ti-8-1-1																			
Fastener Torque	30 in.-	lbs.																		
Fay Surface Sealant	111-B2																			
Batch No.	54639				98278															

MECHANICAL JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PHASE I - CONFIGURATION E

DWG. NO. 7226-1302IE	7A01	7A02	7A03	7A04	7A05	7A06	7A07	7A08	7A09	9A01	9A02	9A03	9A04	9A05	9A06	9A07	9A08	9A09
Specimen No. IE-	311A01	311D01	311A02	(Cont)	311D02	311A03	311A04	311D03	311A05	321A01	321D01	(Cont)	321A02	321D02	321A03	321A04	321D03	321A05
Panel Identification	IE210318C →		IE210318D →							IE250312 →								
Adherend Thick (in)																		
Basic	.046	.045	.046	.047	.046	.047	.047	.047	.047	.045	.0455	.046	.0455	.0445	.044	.0455	.0455	.0455
1st Build Up	.070	.070	.069	.069	.070	.071	.071	.070	.070	.062	.055	.055	.055	.055	.0555	.055	.054	.056
2nd Build Up	.094	.093	.091	.091	.093	.093	.093	.093	.093	.0655	.066	.0665	.066	.064	.0655	.066	.066	.0655
Splice Material	Ti-8-1-1 →																	
Splice Thickness	0.126" →																	
Metal Joint Half	Ti-8-1-1 →																	
Fastener Torque	30 in.-lbs. →																	
Fay Surface Seal.	STM 40	112-82 →																
Batch No.	Crib Mix →																	
DWG. NO. 7226-1302IE-	11A01	11A02	11A03	11A04	11A05	11A06	11A07	11A08	11A09	13A01	13A02	13A03	13A04	13A05	13A06	13A07	13A08	13A09
Specimen No. IE-	411A01	411D01	411A02	411A03	411D02	411A04	(Cont)	411D03	411A05	421A01	421D01	421A02	421A03	421D02	421A04	(Cont)	421D03	421A05
Panel Identification	IE270312 →									IE240312 →								
Adherend Thick (In)																		
Basic	.085	.085	.085	.085	.085	.085	.085	.085	.085	.083	.083	.083	.0835	.083	.083	.0825	.083	.0835
1st Build Up	.105	.107	.106	.105	.105	.107	.105	.106	.105	.087	.090	.089	.090	.088	.085	.090	.089	.090
2nd Build Up	.128	.129	.128	.129	.128	.126	.127	.127	.126	.103	.102	.100	.101	.103	.101	.103	.102	.103
3rd Build Up	.149	.148	.148	.1485	.148	.146	.147	.148	.148	.106	.106	.105	.104	.105	.104	.107	.104	.106
4th Build Up	.171	.170	.170	.170	.169	.170	.168	.170	.168	.123	.124	.123	.123	.125	.123	.124	.123	.123
Splice Material	Ti-8-1-1 →																	
Splice Thickness	.242 →																	
Metal Joint Half	Ti-8-1-1 →																	
Fastener Torque	30 in.-lbs. →																	
Fay Surface Sealant	STM 40	111-132 →																
Batch No.	98278 →																	

MECHANICAL JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PHASE I - CONFIGURATION E

DWG. NO. 7226-1302IE	15A01	15A02	15A03	15A04	15A05	15A06	15A07	15A08	15A09	17A01	17A02	17A03	17A04	17A05	17A06	17A07	17A08	17A09
Specimen No. IE-	711A01	711D01	711A02	711A06	711D02	711A03	711A04	711D03	711A05	721A01	721D01	721A02	721A03	721D02	(Cont)	721A04	721D03	721A05
Panel Identification	IE210318D 8-16									IE210318D 17-25								
Adherend Thick (in)																		
Basic	.047															.048	.048	.048
1st Build Up	.071	.071	.072	.072	.072	.072	.073	.073	.072	.072	.072	.071	.072	.072	.072	.072	.073	.072
2nd Build Up	.094	.094	.095	.095	.096	.096	.096	.096	.096	.096	.095	.096	.096	.096	.097	.096	.097	.095

DWG. 7226-1302IE	19A01	19A02	19A03	19A04	19A05	19A06	19A07	19A08	19A09
Specimen No. IE	731A01	731D01	731A02	731A03	731D02	731A04	731A06	731D03	731A05
Panel Identification	IE250413								
Adherend Thick (in)									
Basic	.044	.044	.044	.044	.044	.044	.044	.044	.044
1st Build Up	.049	.053	.055	.055	.053	.053	.054	.054	.054
2nd Build Up	.065	.064	.067	.065	.065	.064	.064	.065	.065

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MECHANICAL JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PHASE I - CONFIGURATION E

DWG. NO. 7226-1302IE-	1B01	1B02	1B03	1B04	1B05	1B06	1B07	1B08	1B09					
Specimen No. IE-	112A01	112D01	(Cont)	112A02	112D02	112A03	112A04	112D03	112A05					
Panel Identification	IE210318C 15-23													
Adherend Thick (in)														
Basic	.046	.047	.047	.048	.047	.047	.047	.048	.046					
1st Build Up	.072	.072	.072	.072	.072	.072	.070	.070	.069					
2nd Build Up	.096	.096	.095	.096	.095	.096	.095	.094	.093					
Splice Material	IE410318													
Splice Thickness	.094	.094	.094	.094	.093	.094	.094	.094	.094					
Metal Joint Half	.126 8-1-1 Ti.													
Fastener Torque	30 in.-lbs.													
Fay Surface Sealant	STM 40 111-B2													
Batch No.	54639													
DWG. NO. 7226-1302IE	3B01	3B02	3B03	3B04	3B05	3B06	3B07	3B08	3B09	3B10	3B11	3B12	3B13	3B14
Specimen No. IE-	122A01	122A02	122D01	122A03	122A04	122A05	122D02	(Cont)	122A06	122A07	122A08	122D03	122A09	122A10
~~Panel Identification~~	IE230312													
Adherend Thick (in)														
Basic	.045	.046	.046	.045	.043	.045	.045	.046	.045	.045	.045	.045	.045	.045
1st Build Up	.071	.071	.071	.070	.068	.072	.071	.070	.072	.071	.071	.071	.072	.072
2nd Build Up	.088	.088	.088	.088	.086	.089	.089	.090	.090	.090	.091	.091	.091	.091
Splice Material	IE430318													
Splice Thickness	.097	.097	.097	.097	.097	.097	.094	.097	.099	.095	.097	.095	.096	.098
Metal Joint Half	.126 8-1-1 Ti													
Fastener Torque	30 in. lbs.													
Fay Surface Sealant	STM40 111-B2													
Batch No.	54639													

MECHANICAL JOINT SPECIMEN - FABRICATION AND INSPECTION LOG
PHASE I - CONFIGURATION F

DWG # 7226-13021F-	1A01	1A02	1A03	1A04	1A05	1A06	1A07	1A08	1A09	1A10	1A11	1A12	1A13	1A14
Specimen Number IF	111A01	111A02	111D01	111A03	111A04	111A05	111A11	111D02	111A06	111A07	111A08	111D03	111A09	111A10
Panel Identification	IF1A0804													
Adherend Thick (in)														
Basic	.043	.043	.045	.043	.043	.043	.043	.044	.044	.044	.043	.043	.043	.043
Total	.084	.084	.084	.084	.084	.084	.084	.085	.085	.085	.085	.084	.084	.084
Shim Material/Thick	Ti/012													
Number of Shims	2													
Adhesive Type/Wt.	EA9601/.045													
Batch / Roll	383-103/EE													
Layup-Time	1300													
Layup Date	8/3/71													
Cure Time - Start	1540													
Cure Date	8/4/71													
Cure Pressure	85													
Heat Up Rate(^{o}F/Min)	4													
Cure Total Time/Temp	135/350													
L.D.R. No.	382382													
Fay Surface Sealant	STM 40													
	112-B12													
Batch No.	Crib Mix													
Application Date	9/3/71													
Torque Application	30 in-lbs													
Torque - 30 Min.	30 in-lbs													
Cure Temp	140^{o}F													
Cure Time	48 Hrs.													

MECHANICAL JOINT SPECIMEN - FABRICATION AND INSPECTION LOG
PHASE I - CONFIGURATION F

DWG No. 7226-B02IF	3A01	3A02	3A03	3A04	3A05	3A06	3A07	3A08	3A09
Specimen Number IF -	411A01	411D01	411A02	(Cont.)	411D02	411A03	411A04	411D03	411A05
Panel Identification	IF1A0804								
Adherend Thick (in)									
Basic	.084	.083	.083	.083	.083	.083	.083	.083	.084
Total	.170	.170	.170	.171	.171	.171	.170	.170	.169
Shim Material/Thick	Ti/.012								
Number of Shims	4								
Adhesive Type/Wt	EA9601/.045								
Batch/Roll	383-108/EE								
Layup Time	1300								
Layup Date	8/3/71								
Cure Time - Start	1540								
Cure Date	8/4/71								
Cure Pressure psi	85								
Heat up Rate (°F/Min	4								
Cure Time/Temp	135/350								
L.D.R. No.	382382								
Fay Surface Sealant	STM 40 -112-B12								
Batch No.	Crib Mix								
Application Time	10:00								
Application Date	9/3/71								
Torque-At Application	70 in-lbs.								
Torque - At 30 Min	70 in-lbs								
Cure Temp	140°F								
Cure Time	48 Hrs.								
Cure Date (Com.)	9/9/71								

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PHASE II - CONFIGURATION A

DWG 7226-1302IA-IIA	1A01	1A02	1A03	1A04	1A05	1A06	1A07	1A08	1A09	1A10	1A11	1A12	1A13	1A14	1A15	1A16	1A17	1A18	1A19	1A20
Specimen No. IIA	11D01	21A01	11A01	11D04	11A02	11C01	41F01	11C02	41F02	21A02	11A03	11A04	21A03	11D02	11D05	11C03	41F03	11A06	11C04	11A07
Panel Identification	IIA0210																			
Splice Material	Ti																			
Splice Thickness	.040																			
Specimen Material	Boron																			
Specimen Thickness	0435																			
Bondline Thickness																				
Left	5.7	5.3	5.4	4.8	5.6	5.6	5.6	5.1	5.3	5.6	5.4	5.1	5.1	5.7	5.7	5.5	5.5	5.6	5.3	5.5
Right	5.0	4.7	5.0	5.4	5.6	5.3	5.3	5.0	5.6	5.4	5.7	5.1	5.0	5.6	5.5	5.0	5.1	5.6	5.7	5.5
Adhesive Type/Wt.	EA9601/06																			
Batch/Roll	383-5/U2																			
Layup Time	1300												1100							
Layup Date	2/18/71												2/22/71							
Cure Time Start	1327												1023							
Cure Date	2/19/71												2/23/71							
Cure Pressure (PSI)	30												30							
Heat Up Rate (°F/Min)	7.8												5.75							
Cure Time/Temp.	73/260												78/260							
L.D.R. No.	412798												412799							

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BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PHASE II - CONFIGURATION A

DWG 7226-1302IA-IIA	1A21	1A22	1A23	1A24	1A25	1A26	1A27	1A28	1A29	11A01	11A02	11A03	11A04	11A05	11A06	11A07	11A08	11A09	11A10
Specimen No. - IIA	111A08	11D03	21A04	41F04	11D06	21A05	11C05	11A10	41F05	91D01	91D04	91C01	91A01	91A02	91A03	91C02	91D02	91D05	91C03
Panel Identification	IIA0216																		
Splice Material	Ti																		
Splice Thickness	.040																		
Specimen Material	Boron																		
Specimen Thickness*	.0435			.0415/.0435			.0435												
Bondline Thickness																			
Left	4.9	5.0	4.8	5.4	5.1	5.7	5.6	5.4	5.0	4.0	4.9	4.7	4.7	5.0	4.9	4.9	5.0	4.7	4.9
Right	5.0	4.8	5.0	4.8	5.5	5.5	4.8	4.7	5.1	4.0	4.8	5.0	5.0	4.7	5.0	5.0	4.9	4.5	4.9
Adhesive Type/Wt.	EA9601/.06																		
Batch/Roll	383-5/U2																		
Layup Time	1400									1430				1400					
Layup Date	3/1/71									2/25/71				3/3/71					
Cure Time - Start	0930									1055				1028					
Cure Date	3/2/71									2/26/71				3/4/71					
Cure Pressure (PSI)	30																		
Heatup Time (^{o}F/Min)	5.3									5.5				5.9					
Cure Time/Temp.	90/260									95/260				77/260					
L.D.R. No.	428252									428251				428253					

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BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PHASE II - CONFIGURATION A

DWG. 7226-1302IA-	1A30	1A31	1A32	1A33	11A11	11A12	11A13	11A14	11A15	11A16	1C11	1C12	1C13	1C14
Specimen No. IIA-	11H05	11D07	11A09	(Cont)	91A04	91C04	91D03	91A05	91C05	91D06	22A04	12A05	22A05	12D03
Panel Identification	IIA0324				IIA0216						IIA0210			
Splice Material	T1				T1						Al			
Splice Thickness	.040				.040									
Specimen Material	Boron				Boron						Boron			
Specimen Thickness	.0445	.0445	.0445	.044	.043	.0435	.043	.0435	.0435	.044	.0435	.043	.043	.0435
Bondline Thickness														
Left	5.1	5.0	5.3	5.0	5.4	5.5	5.1	5.2	5.0	5.4	5.0	4.9	5.0	4.5
Right	4.8	4.9	5.3	5.1	5.5	5.5	5.5	5.2	5.1	6.0	4.9	5.0	5.0	4.8
Adhesive Type/Wt.	9601/06				9601/06						9601/06			
Batch/Roll	383-5/U2				383-5/T8						383-5/T2			
Layup Time	1500				1000						1000			
Layup Date	3-29-71				3/23/71						3/23/71			
Cure Time - Start	0931				1425						1425			
Cure Date	3-30-71				3/23/71						3/23/71			
Curing Pressure	30				30						30			
Heatup Rate (^{o}F/Min)	6.5				4.7						4.7			
Cure Time/Temp.	90/260				80/250						80/250			
L.D.R. No.	428259				428257						428257			

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BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PHASE II - CONFIGURATION B

Specimen No. IIB	11D01	11A01	11C01	11D02	11C02	11A02	11C03	11D03	11A03	11A04	11C04	11D04	11C05	11A05	11C06	31D03	31A05	(Cont)
DWG No. 7226-1302IB-IIB	1A01	1A02	1A03	1A04	1A05	1A06	1A07	1A08	1A09	1A10	1A11	1A12	1A13	1A14	1A15	9A07	9A08	9A09
Composite Thickness	.083	.083	.082	.083	.083	.083	.083	.083	.083	.083	.083	.083	.083	.083	.083	.081	.081	.081
Metal Material	T1																	
Metal Thickness																		
Basic	.084	.084	.084	.086	.086	.085	.081	.081	.082	.083	.083	.083	.083	.085	.085	.086	.086	.085
Step 1	.016	.017	.016	.016	.016	.016	.016	.016	.015	.016	.016	.017	.017	.016	.016	.017	.017	.017
Step 2	.038	.038	.038	.039	.038	.038	.038	.038	.038	.038	.038	.039	.038	.039	.038	.038	.039	.038
Step 3	.061	.061	.061	.060	.061	.061	.061	.060	.060	.061	.061	.060	.060	.060	.061	.060	.060	.060
Bondline Thickness (mils)																		
Step 1	5.5	5.5	5.4	5.5	5.5	5.5	5.4	5.5	5.5	5.5	5.5	5.5	5.4	5.5	5.5	4.9	5.0	4.9
Step 2	6.0	6.0	6.0	5.9	6.0	5.9	5.9	6.0	6.0	5.9	5.9	6.0	5.9	6.0	6.0	5.0	5.0	5.0
Step 3	5.9	6.0	6.0	5.9	5.9	5.9	6.0	5.9	6.0	6.0	6.0	6.0	6.0	6.0	5.9	6.0	6.0	6.0
Step Length																		
Step 1	.525	.523	.524	.525	.525	.525	.523	.525	.525	.525	.525	.525	.525	525	.525	.388	.389	.388
Step 2	.509	.509	.509	.510	.509	.509	.509	.510	.510	.509	.510	.509	.509	509	.509	.385	.385	.386
Step 3	.516	.514	.515	.516	.516	.517	.516	.516	.516	.516	.515	.516	.516	.515	.516	.375	.375	.376
Adhesive / Wt	9601/.045																	
Batch / Roll	383-103/EE																	
Layup Time	1600																	
Layup Date	7-16-71																	
Cure Date	1345																	
Cure Pressure (PSI)	85																	
Heatup Rate ($^{o}F/M$)	4.4																	
Cure - Total Time/Temp	120/350																	
L.D.R. No.	428276																	

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PHASE II - CONFIGURATION B

Specimen No. IIB	12A01	12D01	12A02	12A03	12D02	12A04	12A05	12D03	(Cont.)	31A01	31D01	31A02	31A03	31D02	31A04
DWG NO. 7226-1302IB-IIB	1B01	1B02	1B03	1B04	1B05	.B06	1B07	1B08	1B09	9A01	9A02	9A03	9A04	1A05	9A06
Composite Thickness	.082	.082	.082	.082	.082	.082	.082	.082	.082	.082	.082	.083	.083	.083	.083
Metal Material	Alum									Ti					
Metal Thickness															
Basic	.081	.081	.081	.081	.081	.081	.081	.081	.081	.087	.086	.085	.085	.085	.085
Step 1	.017	.017	.017	.017	.017	.017	.017	.017	.017	.018	.019	.018	.018	.018	.018
Step 2	.037	.037	.038	.038	.037	.037	.037	.037	.037	.040	.040	.040	.040	.040	.040
Step 3	.057	.061	.059	.060	.057	.061	.060	.059	.061	.061	.061	.061	.061	.061	.061
Bondline Thickness															
Step 1	5.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.0	5.9	5.5	5.9	5.9	5.5
Step 2	4.9	5.9	6.0	5.9	6.0	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
Step 3	5.0	5.5	5.9	5.9	5.5	5.9	5.5	5.5	5.5	5.9	6.0	5.9	.0	5.9	6.0
Step Cap Length															
Step 1	.533	.534	.533	.533	.534	.533	.533	.534	.533	.391	.384	.385	.385	.390	.390
Step 2	.527	.526	.526	.527	.527	.526	.526	.526	.527	.375	.376	.375	.376	.375	.375
Step 3	.526	.514	.520	.521	.524	.520	.518	.515	.515	.387	.388	.387	.387	.387	.387
Adhesive/Wt	EA9601	.045													
Batch/Roll	383-103	/EE													
Layup Time	1600														
Layup Date	7-16-71														
Cure Time	1345														
Cure Date	7-19-71														
Cure Pressure	85														
Heat-up Rate (^{o}F/Min)	4.4														
Cure-Total Time/Temp	120/150														
L.D.R. No.	428276														

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MECHANICAL JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER

PHASE II - CONFIGURATION E

DWG. NO. 7226-1302IIE	1A01	1A02	1A03	1A04(1)	1A05	1A06	1A07	1A08	1A09	1A10	1A11	1A12	1A13	1A14(3)	1A15(2)	1A16	1A17	1A18	1A19	1A20
Specimen No. IIE-	111A01	611F01	611G01	111D01	111A02	611F02	11D02	111A03	611G02	111D03	611F03	111A04	611G03	(Cont)	(Cont)	111A05	611F04	111D04	611G04	111A06
Panel Identification	IIE250804-1							IIE250804-2							IIE250804-3					
Adherend Thick (in)																				
Basic	.043	.044	.043	.044	.044	.043	.044	.044	.044	.044	.044	.045	.044	.044	.045	.045	.045	.045	.044	.044
1st Build Up	.064	.065	.065	.066	.067	.066	.066	.067	.068	.070	.070	.070	.068	.070	.069	.070	.070	.070	.070	.070
2nd Build Up	.084	.084	.084	.086	.086	.086	.086	.089	.089	.090	.090	.090	.090	.089	.088	.088	.090	.090	.090	.090
Splice Material	Ti																			
Splice Thickness	.125"																			
Metal Joint Half	Ti																			
Metal Thickness	.125"																			
Fastener Torque	30 in.-lbs.																			
Fay Surface Sealant	STM 40	112-B12																		
Batch No.	Crib Mix																			

DWG. NO. 7226-1302IIE-	1A21	1A22	1A23	1A24	1A25	1A26	1A27	1A28
Specimen No. IIE-	111A07	611F05	111A08	111D05	111A09	611G05	11D06	111A10
Panel Identification	IIE250 804-3	IIE250804-4						IIE250804-4
Adherend Thick (in)								
Basic	.044	.044	.044	.043	.043	.044	.043	.043
1st Build Up	.070	.068	.068	.067	.068	.067	.067	.066
2nd Build Up	.088	.087	.087	.087	.087	.087	.086	.086
Splice Material	Ti							
Splice Thickness	.125							
Metal Joint Half	Ti							
Metal Thickness	.125							
Fastener Torque	30 in.-lbs.							
Fay Surface Sealant	STM40	112-B12						
Batch No.	Crib Mix							

(1) Countersunk for HL19PB-8 Hi-Lok S/B for -6

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PHASE III - CONFIGURATION A

SPECIMEN NO. IIIA	11A1	11D2	11B1	11D3	11C1	HD4	11D1	11D5	21F1	11D6		12A1	12D2	12D1	12D3	12B1	12D4
DWG. NO. 7226-1302IA	1A01	1A01-1(1)	1A02	1A02-1	1A03	1A03-1	1A04(2)	1A04-1	1A05	1A05-1		1C01	1C01-1	1C02	1C02-1	1C03	1C03-1
Panel Identification	IIIA-1A618											IIIA-1A618		IIIA-1C719			
Splice Material	Ti											Alum					
Splice Thickness	.040	.040	.040	.040	.040	.040	.040	.040	.040	.040		.060					
Specimen Material	Boron											Boron					
Specimen Thickness(3)	.044	.044	.044	.044	.0445	.0445	.044	.044	.044	.044		.043	.043	.042	.042	.042	.043
Bondline Thickness																	
Left	9.0	8.5	9.0	8.4	9.0	8.5	9.0	8.2	9.5	8.5		8.5	7.5	8.5	8.0	8.5	7.9
Right	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5		8.2	7.2	8.5	7.5	8.2	7.5
Adhesive Type/Wt.	EA9601/.06											EA9601/.06					
Batch/Roll	383-5/41											383.5/41					
Layup Time	1500						1400					1030					
Layup Date	7-8-71						7-13-71					7-27-71					
Cure Time	1320						1400					1350					
Cure Date	7-9-71						7-20-71					7-27-71					
Cure Pressure (PSI)	30						30					30					
Heat-Up Rate ($^oF/M$)	7						4.7					5.1					
Cure Time/Temp.	80/245						90/260					85/260					
L.D.R. No.	428275						A251896					A251899					

(1) - 1 specimens are 1" wide and for static tests.

NOTE - Tabs are laminated Ti and bonded using FM123-4 .045 PSI.

(2) - Specimen was cut 9" wide.

(3) - Specimen thickness less 0.004".

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PROGRAM PHASE AND SPECIMEN IDENTIFICATION

PHASE III CONFIGURATION B

SPECIMEN NO. IIIB-	11A1	11D01	21F1	11D2	11B1	11D3
DWG. No. 7226-1302IB-	1A01	1A01-1 (1)	1A02	1A02-1	1A03	1A03-1
Composite Thickness	.081	.080	.081	.081	.086	.083
Metal Material	Ti →					
Metal Thickness						
Basic	.085	.086	.086	.085	.084	.085
Step 1	.019	.018	.019	.017	.019	.018
Step 2	.040	.039	.039	.039	.040	.039
Step 3	.060	.060	.060	.059	.060	.060
Bondline Thickness						
Step 1	6.2	5.9	6.0	6.0	6.2	5.9
Step 2	6.0	5.9	6.0	5.9	6.0	6.0
Step 3	6.5	6.0	6.5	5.9	6.2	6.0
Lap Length						
Step 1	.502	.512	.503	.509	.503	.511
Step 2	.498	.496	.498	.496	.499	.495
Step 3	.494	.501	.495	.501	.495	.500
Adhesive/Wt.	EA9601/.045 →					
Batch/Roll	383-103/EE →					
Layup Time	1300 →					
Layup Date	8/3/71 →					
Cure Time -	1540 →					
Cure Date	8/4/71 →					
Cure Pressure (PSI)	85 →					
Heat-Up Rate ($^oF/M$)	4.1 →					
Cure Total Time/Temp.	135/350 →					
LDR No.	382382 →					

(1) One inch wide specimen to be used for static tests. (All -1 specimens).

BONDED JOINT SPECIMENS - FABRICATION AND INSPECTION LOG
PHASE I - CONFIGURATION A - GRAPHITE

DWG NO. 7226-1302IA	G-1A	G-2A	G-3A	G-4A	G-5A	G-6A	G-7A	G-8A	G-9A	G-10A	G-11A	G-12A	G-13A	G-14A
Specimen No.	E1A01	E1A02	E1D01	E1A03	E1A04	E1A05	E1D02		E1A06	E1A07	E1A08	E1D03	E1A09	E1A10
Panel Identification	GIA1225													
Specimen Thickness	.055	.058	.057	.056	.059	.055	.057	.057	.054	.056	.057	.054	.056	.056
Specimen Material	Graphite													
Splice Material	Ti													
Splice Thickness	.040													
Bondline Thickness														
Left (mils)	3.0	4.0	4.0	3.0	4.0	5.0	5.0	5.0	3.0	4.0	5.0	3.5	4.0	4.0
Right (mils)	3.0	4.0	4.0	4.0	4.0	5.0	4.0	4.5	5.0	4.0	5.0	3.5	4.0	4.0
Adhesive Type/Wt	EA9601/.045													
Batch/Roll	383-103/EE													
Layup Time	1600													
Layup Date	1-4-72													
Cure Time	1010													
Cure Date	1-5-72													
Cure Pressure	30													
Heat-up Rate (°F/Min	3.9													
Cure Temp/Time	250°F/60 Min													
L.D.R. No	436605													
Composite Material Supplier - Fiberite Corp.														
Composite Material Designation HY-E 1311B 904 Resin System														
Composite Material Batch & Roll: Lot #1088 Roll #1														
Layup-Time	1000													
Layup Date	12-22-71													
Cure Time	0800													
Cure Date	12-23-71													
Heatup Rate	3-5°F/M													
Cure Temp/Time	375/4Hr													
L.D.R. No	441883													

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BONDED JOINT SPECIMEN-FABRICATION AND INSPECTION LOG
PHASE I - CONFIGURATION A - S-GLASS

DWG NO. 7226-1302IA -	FG1A	FG2A	FG3A	FG4A	FG5A	FG6A	FG7A	FG8A	FG9A	FG10A	FG11A	FG12A	FG13A	FG14A
Specimen No.	E2A01	E2A02	E2D01	E2A03	E2A04	E2A05	E2D02	E2A11	E2A06	E2A07	E2A08	E2D03	E2A09	E2A10
Panel Identification	FGIA/1124													
Specimen Material	"S" Glass													
Splice Material	TI													
Splice Thickness	.040													
Bondline Thickness														
Left (mils)	3.5	3.0	3.0	3.5	4.0	5.0	3.0	3.5	4.5	5.0	4.0	4.5	4.0	3.5
Right (mils)	3.5	4.0	3.5	4.0	4.0	4.5	4.0	3.5	4.5	4.5	4.0	4.5	4.5	3.5
Adhesive Type/Wt	9601/.045													
Batch / Roll	383-103/EE													
Layup Time	1600													
Layup Date	1-4-72													
Cure Time	1010													
Cure Date	1-5-72													
Cure Pressure	30													
Heatup Rate ($^{o}F/M$)	3.9													
Cure Temp/Time	250 ^{o}F/60 M													
L.D.R. No.	436605													
Panel Identification														
Composite Material Designation - 3M1002S														
Composite Material Batch/Roll No.: 19/W329														
Layup Time	1600													
Layup Date	11/23/71													
Cure Time	9:10													
Cure Date	11/24/71													
Heatup Rate	7.2													
Cure -Temp/Time	350^{o}F/73 Min.													
L.D.R. No.	428298													

APPENDIX B

TEST DATA FORMS

The results of mechanical properties testing, both static and fatigue, are tabulated in this Appendix for the joints and their constituent materials. These data records provide material properties, specimen configurations, specimen identification, and test conditions and include all material verification and joint test results derived under this program. This information is included in the following order:

Table	Contents
B1	Material Verification and Checkout
B2	Support Fixture Checkout
B3-B16	Bonded Joint Tests - Phase I
IIB--	Bonded Joint Tests - Phase II
IIIB--	Bonded Joint Tests - Phase III
IVB--	Mechanical Joint Tests
VB--	Graphite and Glass Joint Tests
VIB--	Failure Mode Studies

MATERIAL VERIFICATION AND CHECKOUT TESTS - TEST DATA

Specimen No.	V1C01	V1C02	V1C03	V2C01	V2C02	V2C03	V1A01	V1A02	V1A03	V1A04	V1A05	V2A01	V2A02	V2A03	V2A04	V2A05
Type of Test	←		STATIC	TENSILE		→	←				FATIGUE					→
Test Temp. °F	←		AMBIENT			→	←				AMBIENT					→
Temp. Rise																
During Test °F	—	—	—	—	—	—	6	3	8	10	10	2	3	6	6	2
No. of Plies	←		8			→	←				8					→
Ply Orient.	←	0°/±45°	→	←	0°/90°	→	←		0°/±45°		→	←		0°/90°		→
Tab Mat'l	←		FRP			→	←				FRP					→
Specimen Dimensions																
Length - In.	9.10	9.10	9.10	9.08	9.07	9.08	9.15	9.15	9.12	9.12	9.09	9.10	9.08	9.07	9.10	9.09
Avg. - Width - In.	1.001	1.001	1.001	1.002	1.002	1.002	1.001	1.001	1.001	.999	1.001	.988	1.000	1.001	1.001	.999
Avg. - Thick - In.	.0439	.0438	.0437	.0432	.0436	.0432	.0431	.0432	.0434	.0435	.0435	.0429	.0431	.0430	.0432	.0432
Avg. X-Sect. Area-In.^{2}	.0439	.0438	.0437	.0433	.0437	.0433	.0431	.0432	.0434	.0435	.0435	.0424	.0431	.0430	.0432	.0432
Ultimate Load																
P_{tu} Pounds	4480	4360	4660	3820	3560	3940										
Ult. Stress F_{tu}																
K.S.I.	102	99.5	107	88.2	81.5	91.0										
Mod. of Elast.																
x 10^6 P.S.I.																
By Strain Gage	15.2	15.5	15.5	14.9	15.0	15.1										
By Extensometer	15.3	15.4	N/A	15.5	14.9	15.2										
Stress Ratio							←				R=+0.10					→
Max. Load Pounds							3450	3890	3910	3475	3485	3465	3125	3015	3027	3450
Max. Stress KSI							80	90	90	80	80	80	72.5	70	70	80
Cycle Rate - CPM							900	900	900	900	900	600	900	900	900	600
Fatigue Life																
Cycles x 10^{-3}							28.1	16.5	15.5	1.720	605.0	.58	110.0	406.8	166.7	.19

LOCKHEED-GEORGIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

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MATERIAL VERIFICATION AND CHECKOUT TESTS - TEST DATA

Specimen No.	V1B01	V1B02	V1B03	V1B04	V1B05	V1B06	V1B07	V1B08	V1B09	V1RB01	V1RB02	V1RB03	V1RB04	V1RB05	V1RB06	V1RB07	V1RB08	V1RB09	V1RB10
Type of Test	←				FATIGUE				→	←				FATIGUE (REPEAT RUN)					→
Test Temp. °F	←				AMBIENT				→	←				AMBIENT					→
Temp. Rise																			
During Test °F	27	9	18	N/A	11	0	23	9	11	3	4	8	6	5	7	6	7	9	10
No. of Plies					8									8					
Ply Orient.	←				0°/±45°				→	←				0°/+45°					→
Tab Mat'l	←	FRP			→	←	ALUMINUM		→	←		FRP		→	←		ALUMINUM		→
Specimen Dimensions																			
Length - In.	9.02	9.10	9.12	9.12	9.11	9.10	9.11	9.11	9.10	9.07	9.06	9.05	9.05	9.03	9.03	9.03	9.05	9.07	9.08
Avg. - Width - In.	.989	.990	.992	.993	.994	1.009	1.010	1.013	1.006	1.000	.992	.995	.995	.999	1.010	1.003	1.001	.999	.987
Avg. - Thick - In.	.0431	.0435	.0432	.0433	.0434	.0434	.0433	.0434	.0438	.0441	.0442	.0440	.0438	.0442	.0441	.0438	.0439	.0442	.0441
Avg. X-Sect. Area-In.^{2}	.0426	.0431	.0429	.0431	.0431	.0438	.0437	.0440	.0441	.0441	.0439	.0438	.0436	.0442	.0445	.0439	.0439	.0442	.0435
Ultimate Load																			
F_{tu} Pounds																			
Ult. Stress F_{tu}																			
K.S.I.																			
Mod. of Elast.																			
x 10^6 P.S.I.																			
By Strain Gage																			
By Extensometer																			
Stress Ratio	←				R=-1.0				→	←				R=-1.0					→
Max. Load Pounds	3410	3445	3215	2585	3020	3505	3280	3080	2645	3085	3070	2845	2615	2650	3120	3075	2855	2650	2610
Max. Stress KSI	80	80	75	60	70	80	75	70	60	70	70	65	60	60	70	70	65	60	60
Cycle Rate - CPM	480	480	480	120/480	120/480	480	480	120/480	120/480	180	180	180	180	180	180	180	180	180	180
Fatigue Life																			
Cycles x 10^{-3}	2.05	.05	.83	132.0	2.91	.21	1.4	3.22	120.0	.51	4.05	7.07	29.00	17.35	1.80	6.27	13.85	72.95	160.8

NOTES: 1. Recorded cyclic rates of 120/480 represent a variation in CPM during testing to preclude overheating of the specimen.

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MATERIAL VERIFICATION AND CHECKOUT TESTS - TEST DATA

Specimen No.	V3C01	V3C02	V3C03	V3C04	V3C05	V3A01	V3A02	V3A03	V3A04	V3A05	V3A06	V3A07	V3A08	V3A09	V3A10	V3A11	V3A12	V3A13	V3A14	V3A15
Type of Test	←	STATIC	TENSILE	ADHESIVE	EVAL. →	←				FATIGUE	~	ADHESIVE EVALUATION								→
Test Temp. °F	←		AMBIENT		→	←							AMBIENT							→
Temp. Rise																				
During Test °F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Adherend Matl.	←					TITANIUM	8AL -	1Mo- 1V	ANNEALED											→
Splice Plate Matl.	←					TITANIUM	8AL -	1Mo -1V	ANNEALED											→
Adhesive	←					EPON EA	9601													→
Specimen Dimensions																				
Length - In.	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Avg. Width - In	.995	.994	.994	.993	.994	.994	.994	.994	.995	.994	.993	.993	.993	.994	.994	.993	.994	.995	.998	.995
Overlap Length - In																				
Left Side	.75	.75	.74	.74	.74	.74	.75	.73	.74	.75	.74	.74	.75	.74	.74	.74	.74	.74	.74	.74
Right Side	.74	.74	.75	.75	.75	.74	.74	.75	.73	.74	.75	.74	.74	.74	.74	.74	.75	.74	.74	.74
Bondline Thick. In	.0055	.0055	.0050	.0040	.0045	.0045	.0050	.0045	.0055	.0040	.0045	.0045	.0055	.0055	.0050	.0045	.0050	.0050	.0055	.0045
Failure Side	L	R	L	L	R	R	L	L	L	L	L	R	L	R	R	R	L	R	R	R
Failure Area - In²	.746	.736	.736	.735	.746	.736	.746	.726	.736	.746	.735	.735	.745	.736	.736	.735	.736	.736	.739	.736
Ultimate Load																				
Psu Pounds	4220	4140	4300	4150	4200															
Ultimate Shear																				
Stress F_{su} - PSI	5700	5600	5800	5600	5600															
Stress Ratio						←						R = +0.10								→
Max. Load - Pounds						1100	1100	1100	1100	2100	1600	1600	1600	1600	2100	2100	2100	1600	1100	2100
Max. Shear																				
Stress - PSI						1500	1500	1500	1500	2800	2200	2200	2200	2200	2900	2900	2900	2200	1500	2900
Cycle Rate - CPM						1800	1700	1700	1800	1800	1800	1800	1800	1800	1725	1775	1750	1650	1800	1775
Fatigue Life																				
Cycles x 10^{-3}						480	1710	1350	1550	20	205	360	125	400	13	14	10	84	810	18

SUPPORT FIXTURE CHECKOUT TESTS - TEST DATA

SPECIMEN NO.	IA111E01	IA111E02	IA111E03	IA111E04	IA111E05	IA111E06
TYPE OF TEST	←		FATIGUE			→
TEST TEMP °F	←		AMBIENT			→
TEMP RISE						
DURING TEST °F	-	-	3	6	4	*
ADHEREND MATL.	8-PLY	BORON/EPOXY		0°/±45°		
SPLICE PLATE MATL	←	6-4 TITANIUM				→
ADHESIVE	←	EPON 9601				→
SPECIMEN DIMENSIONS						
LENGTH - IN	18.0	18.0	18.0	18.0	18.0	18.0
AVG. WIDTH-IN	.996	.996	.997	.996	.996	.996
OVERLAP LENGTH-IN						
LEFT SIDE	.74	.74	.75	.74	.75	.74
RIGHT SIDE	.74	.74	.74	.74	.74	.74
BONDLINE THICK. IN	.0045	.0040	.0050	.0040	.0040	.0040
FAILURE SIDE	-	-	-	-	-	-
FAILURE AREA-IN^2	←	NOMINALLY	0.74			→
ULTIMATE LOAD						
Psu POUNDS						
ULTIMATE SHEAR						
STRESS Fsu-Psi						
STRESS RATIO (R)	-1.0	+10.0	-1.0	+10.0	-1.0	-1.0
MAX. LOAD-POUNDS	1600	-3000	1300	-2100	1300	800
MAX. SHEAR STRESS-PSI						
CYCLE RATE - CPM	300	300/600	300	600	300	*
FATIGUE LIFE						
CYCLES X 10^{-3}	1.31	47.15	4.00	100.	4.30	44.0

* NOTE: This specimen was subjected to different cyclic rates between 600 and 1500 CPM with 2°F temp rise at 600 CPM, 3°F temp rise at 900 CPM, 6°F temp rise at 1200 CPM and 10°F temp rise at 1500 CPM.

PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-1302IA-1A

SPECIMEN NO. IA-	111B20	111C11	111C20	111D04	111D05	111D06	111D01	111D02	111D03	111A01	111A02	111A03	111A04	111A05	111A06	111A07	111A08	111A09	111A10	111A11
DRAWING NO. 7226-1302IA	1A100	1A101	1A110	1A78	1A79	1A80	1A67	1A6	1A57	1A12	1A17	1A21	1A38	1A43	1A50	1A54	1A60	1A65	1A113	1A81
TYPE OF TEST	STATIC TENSILE									FATIGUE - BASELINE DATA										
R.T. RANGE °F	74	75	77	77	75	75	77	75	75	70/72	70/71	72	69/71	71/72	69/71	70/71	69/75	70	71	71
SPEC. TEMP. RISE																				
DURING TEST °F	-	-	-	-	-	-	-	-	-	9	6	0	4	1	3	4	4	1	4	4
ADHEREND MATL.	8 PLY BORON 0°/+45°																			
SPLICE PLATE MATL.	TITANIUM 6AL-4V ANNEALED																			
ADHESIVE	EPON EA 9601-06																			
SPECIMEN DIMENSIONS																				
LENGTH - IN.	NOMINALLY 18.0																			
AVG. WIDTH - IN.	1.000	1.003	1.004	1.005	1.001	1.002	.996	.984	.983	.978	.974	.994	.969	.976	.983	.980	.977	.983	.983	1.002
OVERLAP LENGTH - IN.																				
LEFT SIDE	.73	.74	.74	.75	.75	.75	.74	.74	.74	.74	.74	.75	.74	.74	.74	.75	.75	.75	.74	.75
RIGHT SIDE	.75	.75	.74	.75	.74	.75	.75	.74	.75	.74	.74	.75	.74	.75	.75	.74	.75	.74	.75	.74
BONDLINE THICK. IN.	.0045	.0047	Not known	Not known	.0049	.0047	Not known	.0062	.0048	.0067	.0062	.0063	.0052/ .0060	.0057	.0046	.0051	.0052	.0051	.0059	.0049
FAILURE SIDE	L	R	R	R	L	L	L	R	L	R	L	L	(1)	R	R	L	L	L	R	R
FAILURE AREA - IN.^{2}	.730	.752	.743	.754	.751	.752	.737	.728	.727	.724	.721	.746	(1)	.732	.737	.735	.733	.737	.741	.741
ULTIMATE LOAD																				
Psu POUNDS	3330	3280	3030	3530	3490	3470	3400	3230	3460											
ULTIMATE SHEAR																				
STRESS Fsu - PSI	4600	4400	4100	4700	4600	4600	4600	4400	4800											
STRESS RATIO (R)										R = +0.10										
MAX. LOAD POUNDS										1000	1000	1500	800	1450	800	1230	800	1230	1020	1500
MAX. SHEAR STRESS-PSI										1400	1400	2000	1100	2000	1100	1700	1100	1700	1400	2000
CYCLE RATE - CPM										1800	1600	1775	1500	1800	1575	1700	1550	1500	1625	1600
FATIGUE LIFE																				
CYCLES X 10^{-3}										1080	1680	8	500	16	1958	85	4860	17	52	18
JOINT STIFFNESS																				
(LBS/IN/IN WIDTH)10^{-3}								313,(2)	325,(2)											

NOTES:

(1) A splice plate failure occurred on this specimen.

(2) Joint stiffness on static specimen determined from slope of load vs. deflection curve for 2.0" gage length.

PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-1302IA-1A

SPECIMEN NO. IA-	111A12	111A13	111A14	111A15	111A16	111A17	111A18	111A21	111A22	111C01	111C02	111C03	111C04	111C05	111C06	111C07	111C08	111C09	111C10	111C21
DRAWING NO. 7226-1302IA	1A82	1A83	1A84	1A85	1A86	1A87	1A88	1A116	1A124	1A69	1A5	1A9	1A13	1A25	1A33	1A41	1A53	1A59	1A63	1A127
TYPE OF TEST	FATIGUE - BASELINE DATA																			
R. T. RANGE °F	70/71	71/72	68/74	-	70/71	69/71	70/73	73	72/73	-	74	68/75	74/77	69/77	-	-	68/77	74	72	74
SPEC. TEMP. RISE																				
DURING TEST °F	6	2	4	0	5	5	6	0	4	0	4	5	7	9	-	-	9	4	2	1
ADHEREND MATL.	8 PLY BORON 0°/±45°																			
SPLICE PLATE MATL.	TITANIUM 6AL-4V ANNEALED																			
ADHESIVE	EPON EA 9601-06																			
SPECIMEN DIMENSIONS																				
LENGTH - IN.	NOMINALLY 18.0																			
AVG. WIDTH - IN.	1.001	1.003	1.000	.998	1.001	1.002	1.000	0.998	0.998	.999	.990	.984	.976	.989	.978	.974	.978	.977	.979	.995
OVERLAP LENGTH - IN.																				
LEFT SIDE	.74	.75	.75	.74	.74	.74	.74	.74	.74	.75	.74	.75	.74	.75	.74	.74	.74	.74	.74	.75
RIGHT SIDE	.75	.75	.75	.75	.76	.76	.75	.75	.75	.75	.74	.74	.75	.75	.75	.74	.73	.75	.74	.74
BONDLINE THICK. IN.	.0046	.0047	.0049/.0047	.0048/.0049	.0050	.0048	.0041	.0073	.0064	.0051	.0059	.0069/.0067	.0056	.0055/.0065	.0057/.0054	.0068/.0062	.0050	.0051	.0054	.0065
FAILURE SIDE	R	L	L*	(2)	R	L	R	R	L	(2)	L	(1)	L	(1)	(2)	(2)	R	R	R	R
FAILURE AREA - IN.^{2}	.751	.752		(2)	.761	.741	.750	.748	.738	(2)	.733	(1)	.722	(1)	(2)	(2)	.713	.732	.724	.736
ULTIMATE LOAD																				
Psu POUNDS			2640																	
ULTIMATE SHEAR																				
STRESS Fsu - PSI			3500																	
STRESS RATIO (R)	R = 0 + .10									R = +10.0 (3)										
MAX. LOAD POUNDS	1250	1500	800	1500	1000	1250	1000	1480	810	-2020	-1980	-1160	-1520	-1190	-1520	-1150	-1140	-1520	-1950	-2500
MAX. SHEAR STRESS-PSI	1700	2000	1100	2000	1400	1700	1400	2000	1800	-2700	-2700	-1600	-2100	-1600	-2100	-1600	-1600	-2100	-2700	-3400
CYCLE RATE - CPM	1725	1750	1500	(2)	1650	1700	1600	1800	1700	900	900	1800	1200	1800	(2)	(2)	1800	1200	900	900
FATIGUE LIFE																				
CYCLES X 10^{-3}	38	10	(1)	(2)	715	34	185	4	429	(2)	13.8	2402	254	3555	(2)	(2)	4390	162.8	40	1.810
JOINT STIFFNESS																				
(LBS/IN/IN WIDTH)10^{-3}			286*																	

NOTES:

(1) No failure, fatigue test discontinued after 10^7 cycles.

(2) No test due to machine malfunction.

(3) For the R = + 10.0 test, the maximum load quoted are the max. compressive loads but correspond to min. load used in stress ratio relationship.

* Adherend failure, residual strength test.

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PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-1302IA-1A

SPECIMEN NO. IA-	111C12	111C13	111C14	111C15	111C16	111C17	111C18	111C19	111C22	111B01	111B02	111B03	111B04	111B05	111B06	111B07	111B08	111B09	111B10	111D11
DRAWING NO. 7226-1302 IA	1A102	1A103	1A104	1A105	1A106	1A107	1A108	1A109	1A110	1A75	1A4	1A11	1A16	1A27	1A36	1A42	1A45	1A55	1A64	1A142
TYPE OF TEST	←							FATIGUE - BASELINE DATA											→	
R. T. RANGE °F	70/76	-	73/74	68	68/69	67/77	68/72	68	74/75	-	71/74	70/74	70/71	71/72	68/73	72/73	73/74	72/73	72/73	75
SPEC. TEMP. RISE																				
DURING TEST °F	0	0	4	0	4	9	9	4	3	0	3	3	5	4	3	-	-	2	3	-
ADHEREND MATL.	←							8 PLY BORON 0°/±45°											→	
SPLICE PLATE MATL.	←							TITANIUM 6AL-4V	ANNEALED										→	
ADHESIVE	←							EPON EA	9601-06										→	
SPECIMEN DIMENSIONS																				
LENGTH - IN.	←							NOMINALLY 18.0											→	
AVG. WIDTH - IN.	1.001	1.000	1.001	1.001	1.000	.999	.999	.998	.993	.994	.988	.993	.977	.981	.981	.972	.979	.983	.979	.995
OVERLAP LENGTH - IN.																				.74
LEFT SIDE	.73	.75	.73	.73	.73	.74	.74	.75	.74	.75	.73	.74	.75	.75	.74	.74	.74	.75	.74	.75
RIGHT SIDE	.75	.73	.75	.75	.75	.74	.75	.74	.75	.75	.74	.74	.74	.75	.74	.74	.74	.74	.75	
BONDLINE THICK. IN.	.0041	.0041	.0048	.0044	.0043	.0042	.0048	.0044	(4)	.0051/.0040	.0061	.0064/.0065	.0060	.0056	.0051/.0056	.0064	.0051	.0047	.0050	.0058
FAILURE SIDE	R	(2)	R	L	R	L	R	R	R	(2)	R	R*	L	L	(3)	L	L	R	R	L
FAILURE AREA - IN.^{2}		(2)	.751	.731	.750		.749	.739	.744	(2)	.731		.733	.736	(3)	.719	.724	.727	.734	.736
ULTIMATE LOAD	.751					.739														
Psu POUNDS	3120					3620						2400								3500
ULTIMATE SHEAR																				
STRESS Fsu - PSI	4200					4900						3300								4800
STRESS RATIO (R)	←			R = +10.0 (5)					→	←				R = -1.0					→	
MAX. LOAD POUNDS	-1000	-2500	-2500	-2000	-1500	-1000	-1550	-2500	-1980	750	580	370	725	885	435	575	870	580	435	
MAX. SHEAR STRESS-PSI	-1400	-3400	-3400	-2700	-2100	-1400	-2100	-3400	-2700	1000	800	500	1000	1200	600	800	1200	800	600	
CYCLE RATE - CPM	900	(2)	900	1200	1200	1800	1200	900	900	900	900	1800	1200	900	1800	1200	900	1200	1800	
FATIGUE LIFE																				
CYCLES X 10^{-3}	(1)	(2)	3.41	17.5	86	(1)	1520	5.2	6.9	(2)	279	(1)	84.8	44.6	1267	200	33.7	231	790	
JOINT STIFFNESS																				
(LBS/IN/IN WIDTH)10^{-3}	352					351						366								354

NOTES:

(1) No fatigue failure, test discontinued after 10^7 cycles.

(2) No test due to machine malfunction.

(3) Failure occurred in splice plate during loading.

(4) Specimen tested prior to bondline measurement.

(5) See Note 3 page B3-2.

PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-1302IA-1A

SPECIMEN NO. IA-	511D01	511D02	511D03	511D04	511D05	511D06	511A01	511A02	511A03	511A04	511A05	511A06	511A07	511A08	511A09	511A10	111D08	111D09	111D10	111D07
DRAWING NO. 7226-1302IA	1A15	1A29	1A40	1A52	1A115	1A134	1A72	1A76	1A08	1A18	1A20	1A32	1A37	1A112	1A121	1A128	1A03	1A61	1A28	1A70
TYPE OF TEST	STATIC TENSILE						FATIGUE - DEGRADATION OF JOINT										STATIC COMPRESSION			
R. T. RANGE °F	75	75	75	75	75	75	69	67/73	70	68/71	71/72	70/72	71/72	(4)	73	(4)	73	76	73	76
SPEC. TEMP. RISE																				
DURING TEST °F	-	-	-	-			1	3	0	4	2	3	0	(4)	0	(4)	-	-	-	
ADHEREND MATL.	8 PLY BORON 0°/±45°																			
SPLICE PLATE MATL.	TITANIUM 6AL-4V ANNEALED																			
ADHESIVE	EPON EA 9601-06																			
SPECIMEN DIMENSIONS																				
LENGTH - IN.	NOMINALLY 18.0																			
AVG. WIDTH - IN.	.983	.988	.972	.980	1.000	.993	.999	.996	.985	.978	.980	.970	.978	.986	.995	.993	.989	.984	.981	.999
OVERLAP LENGTH - IN.																				
LEFT SIDE	.75	.75	.74	.75	.74	.74	.75	.75	.75	.74	.75	.74	.75	.74	.73	.74	.74	.74	.75	.74
RIGHT SIDE	.75	.74	.75	.74	.74	.74	.75	.75	.75	.74	.75	.75	.75	.74	.74	.74	.74	.74	.74	.75
BONDLINE THICK. IN.	.0065	.0054	.0058	.0055	.0065	.0064	.0047	.0049	.0063	.0062	.0063	.0054/.0055	.0060	.0055	.0069	.0065	.0059	.0057	.0055	.0050/.0049
FAILURE SIDE	R	R	R	L	R	L	R	L	R	R	R	(3)	R	R	R	L	L	R	R	L&R Adherend
FAILURE AREA - IN.^{2}	.737	.731	.729	.735	.740	.735	.749	.747	.739	.724	.735	(3)	.734	.730	.736	.735	.732	.728	.726	.739
ULTIMATE LOAD																				
Psu POUNDS	2740	2930	3580	3510	2680	3500	2960	2540	2120	2990	2450	(3)	2490				4180	4560	4600	4100
ULTIMATE SHEAR																				
STRESS Fsu - PSI	3700	4000	4900	4800	3600	4800	4000	3400	2900	4100	3300		3400				5700	6300	6300	5500
STRESS RATIO (R)							R = +0.10													
MAX. LOAD POUNDS							1500	800	1500	800	1500	800	1500	800	1450	810				
MAX. SHEAR STRESS-PSI							2000	1100	2000	1100	2000	1100	2000	1100	2000	1100				
CYCLE RATE - CPM							1800	1550	1775	1500	1775	1550	1775	1500	-	1750				
FATIGUE LIFE																				
CYCLES X 10^{-3}							5	2000	5	2000	5	489	5	260	1	515				
JOINT STIFFNESS																				
(LBS/IN/IN WIDTH)10^{-3}	305(1)	330(1)	352(1)	329(1)	333(1)	330(1)	349(2)	337(2)	272(2)	323(2)	299(2)	(3)	320(2)	(5)	(5)	(5)	333(1)	314(1)	320(1)	333

NOTES:

(1) Joint stiffness on static specimen determined from slope of load v deflection curve for 2.0" gage length.

(2) Joint stiffness on fatigue specimen determined from slope of load v deflection curve for 2.0" gage length.

(3) Failure occurred in splice plate during fatigue loading.

(4) No temperature obtained due to recorder malfunction.

(5) Specimen failed during fatigue cycling, but still qualifies for baseline data list.

PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-1302IA-1A

SPECIMEN NO. IA-	811A01	811A02	811A03	811A06	811A07	811A08	811A04	811A05	811A09	811A10	811A11	811A12	811A13	811A14
DRAWING NO. 7226-1302IA	1A71	1A73	1A19	1A26	1A39	1A48	1A22	1A24	1A114	1A120	1A118	1A135	1A139	1A122
TYPE OF TEST	← STATIC PRELOAD AND FATIGUE →						→		← LOW CYCLE →					
R. T. RANGE °F	72	73	72	73	73	73	73	73	71-72	73	70	72-73	72	72-73
SPEC. TEMP. RISE														
DURING TEST °F	3	2	3	1	3	3	-	-	0	3	2	0	1	0
ADHEREND MATL.	← 8 PLY BORON 0°/±45° →													→
SPLICE PLATE MATL.	← TITANIUM 6AL-4V ANNEALED →													→
ADHESIVE	← EPON EA 9601-06 →													→
SPECIMEN DIMENSIONS														
LENGTH - IN.	← NOMINALLY 18.0 →													→
AVG. WIDTH - IN.	.993	.995	.978	.981	.964	.976	.990	.989	.999	.994	.994	.994	.991	.994
OVERLAP LENGTH - IN.														
LEFT SIDE	.74	.75	.74	.74	.74	.74	.75	.75	.74	.74	.74	.74	.75	.74
RIGHT SIDE	.75	.75	.76	.74	.74	.74	.75	.75	.75	.75	.75	.75	.75	.76
BONDLINE THICK. IN.	.0048	.0047	.0064	.0058	.0055	.0051	.0056	.0052	.0063	.0070	.0066	.0063	.0064	.0070
FAILURE SIDE	R	L	L	R	R	R	R	R	L	R	R	L	R	L
FAILURE AREA - IN.^{2}	.745	.746	.724	.726	.713	.722	.742	.742	.739	.746	.746	.736	.743	.746
PRELOAD														
Psu POUNDS	2200	2700	2200	2600	2450	2450	2790	2760						
SHEAR														
STRESS Fsu - PSI	3000	3600	3000	3600	3400	3400	3800	3700						
STRESS RATIO (R)	← R = +0.10 →													→
MAX. LOAD POUNDS	1030	1050	1030	1020	1000	1020			1700	1860	1790	1720	1750	1750
MAX. SHEAR STRESS-PSI	1400	1400	1400	1400	1400	1400			2300	2500	2400	2300	2400	2300
CYCLE RATE - CPM	1650	1675	1650	1650	1600	1625			300	300	300	300	300	300
FATIGUE LIFE														
CYCLES X 10^{-3}	1031	240	5160	166	6420	965	(2)	(2)	3.700	.005	.014	5.300	.760	3.760
JOINT STIFFNESS														
(LBS/IN/IN WIDTH)10^3	332(1)	355(1)	345(1)	336(1)	341( )	348(1)								

NOTES:

(1) Joint stiffness on static speci.en determined from slope of load vs. deflection curve for 2.0" gage length.

(2) Specimen failed during static pre-load.

PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-13021A-1A

SPECIMEN NO. IA-	111A23	111A24	111C23	111C24	111C25	111C26	111B21	111B22	111B23	111B24	111B25	111B26	111B27	111B28	111B29	111B30	111B31	111B32
DRAWING NO. 7226-1302IA	1A34	1A132	1A01	1A44	1A49	1A58	1A111	1A124	1A74	1A14	1A123	1A136	1A137	1A138	1A140	1A141	1A143	1A144
TYPE OF TEST	FATIGUE - BASELINE DATA																	
ROOM TEMP. RANGE °F	72/73	72/73	68/74	73	73/74	74/75	70/76	72	74/75	73	73	72/73	73	73	72	73	72	72/73
SPEC. TEMP. RISE																		
DURING TEST °F	2	2	8	4	5	5	5	0	2	3	1	2	2	2	1	1	2	1
ADHEREND MATL.	8-PLY BORON 0°/±45°																	
SPLICE PLATE MATL.	TITANIUM 6AL-4V ANNEALED																	
ADHESIVE	EPON EA 9601-06																	
SPECIMEN DIMENSIONS																		
LENGTH - IN.	NOMINALLY 18.0																	
AVG. WIDTH - IN.	.954	.991	.988	.979	.980	.981	.980	1.000	.998	.990	.992	1.003	.990	.988	.981	.994	.995	.986
OVERLAP LENGTH - IN.																		
LEFT SIDE	.74	.74	.75	.76	.73	.74	.74	.74	.75	.75	.74	.74	.74	.74	.74	.74	.74	.74
RIGHT SIDE	.74	.74	.74	.75	.74	.75	.74	.74	.75	.75	.74	.75	.75	.74	.75	.75	.75	.74
BONDLINE THICK. IN.	.0055/.006	.0060	.0053	.0058	.0050	.0052	.0055	.0065	.0051	.0070	.0067	.0063	.0052	.0055	.0060	.0060	.0060	.0063
FAILURE SIDE	(1)	L	L	L	R	L	L	L	R	L	L	L	L	R	R	R	R	R
FAILURE AREA - IN.^{2}	(1)	.733	.741	.744	.725	.726	.725	.740	.749	.743	.734	.742	.733	.731	.736	.746	.746	.730
ULTIMATE LOAD																		
Psu POUNDS																		
ULTIMATE SHEAR																		
STRESS Fsu - Psi																		
STRESS RATIO (R)	R = +0.10		R = +10.0				R = -1.0											
MAX. LOAD POUNDS (2)	780	1250	-1540	-2500	-1930	-2470	360	890	370	1040	1030	595	1030	585	365	1030	880	1020
MAX. SHEAR STRESS-PSI	1100	1700	-2100	-3400	-2700	-3400	500	1200	500	1400	1400	800	1400	800	500	1400	1200	1400
CYCLE RATE - CPM	1750	1800	1200	900	900	900	1800	900	1800	1200	900	1200	900	1200	1800	900	900	900
FATIGUE LIFE																		
CYCLES X 10^{-3}	575	15	127	15.4	76.4	20.5	2600	2.11	2000	8.7	3.25	75.1	6.65	47.5	1160	4.05	14.92	5
JOINT STIFFNESS																		
(LBS./IN/IN WIDTH)10^3																		

NOTES:

(1) Splice plate failure occurred on this specimen.

(2) For the R = +10.0 tests the maximum loads quoted are the maximum compressive loads but correspond to the minimum load used in the stress ratio relationship.

PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-1302IA-1A

SPECIMEN NO. IA	511D07	511D08	511D09	111D11	511A11	511A12	511A13	511A14	511A15	511A16	511A17	511A18	511A19
DWG. NO. 7226-1302IA	1A148	1A156	1A162	1A142	1A146	1A149	1A151	1A145	1A152	1A159	1A154	1A161	1A164
TYPE OF TEST			STATIC	TENSILE					FATIGUE - DEGRADATION				
R.T. RANGE °F	75	73	73	75	70/72	70	70/72	74	68/75	68/69	67/68	69/71	NA
SPEC. TEMP. RISE													
DURING TEST °F					1	0	2	0	3	3	7	2	-
ADHEREND MATERIAL								8-PLY BORON 0°/±45°					
SPLICE PLATE MATERIAL								TITANIUM 6Al-4V ANNEALED					
ADHESIVE								EPON EA 9601-06					
SPECIMEN DIMENSIONS													
LENGTH - IN.								NOMINALLY 18.0					
AVG. WIDTH - IN.	.994	.999	1.000	.995	.996	1.003	1.011	1.009	1.001	.999	.998	.998	1.011
OVERLAP LENGTH - IN.													
LEFT SIDE	.75	.74	.73	.74	.75	.74	.75	.75	.75	.73	.73	.74	.72
RIGHT SIDE	.74	.74	.75	.75	.74	.74	.73	.75	.75	.75	.75	.74	.74
BONDLINE THICK. IN.	.0054	.0053 .0048	.0059 .0057	.0058	.0054	.0059	.0061	.0053	.0058	.0051	.0055	.0058	.0053
FAILURE SIDE	R	L*	R*	L	L	R	L	L	R	L	R	R	R
FAILURE AREA - IN.^{2}	.736	.739		.736	.747	.742	.758	.757	.751	.729	.749	.739	.748
ULTIMATE LOAD													
Psu POUNDS	3460	4100	4160	3500				2160	3210				
ULT. SHEAR STRESS-PSI	4700	5500	5700	4800				2900	4300				
STRESS RATIO (R)			+0.10						+0.10				
MAX. LOAD POUNDS					810	1480	810	1440	750	800	730	665	655
MAX. SHEAR STRESS - PSI					1100	2000	1100	1900	1000	1100	1000	900	900
CYCLE RATE - CPM					1800	1625	1800	1700	1550	1575	1550	1625	1625
FATIGUE LIFE													
CYCLES x 10^{-3}					1790	3	640	5	2000	350	746	1356	1320
JOINT STIFFNESS													
(LBS/IN/IN WIDTH) 10^{-3}	388	355	376	354				339	351				

NOTE: * - Failure occurred in adherend.

PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-1302IA-1A

SPECIMEN NO. IA	511C01	511C02	511C03	511C04	511C05	511C06	511C07	511C08	511C09	511C10	511C11	511C12	111D12	111D13	111B33S	111B34S	111B35S	111B36S	111B37S	111B38S
DRAWING NO. 7226-1302IA	1A68	1A10	1A23	1A31	1A35	1A47	1A66	1A117	1A125	1A131	1A147	1A150	1A169	1A175	1A158	1A166	1A167	1A168	1A170	1A171
TYPE OF TEST				FATIGUE	-	DEGRADATION							STATIC	TENSILE		FATIGUE	SLOW	CYCLIC	RATE	
R.T. RANGE °F	72/75	74	72/74	75	67/73	75	72/76	73	73	73/74	78/83	78	73	73	73/75	76/77	76/77	76	77	77
SPEC. TEMP. RISE																				
DURING TEST °F	3	1	2	2	3	2	4	0	1	0	3	0	-	-	0	0	0	0	0	0
ADHEREND MATERIAL			8-PLY	BORON	0°/±45°															
SPLICE PLATE MATERIAL			TITANIUM	6Al -	4V ANNEALED															
ADHESIVE				EPON	EA 9601	- 06														
SPECIMEN DIMENSIONS																				
LENGTH - IN.				NOMINALLY	18.0															
AVG. WIDTH - IN.	.990	.984	.988	.962	.962	.977	.979	.993	.994	1.001	1.007	.998	1.000	1.003	1.001	1.001	1.000	1.001	1.001	1.001
OVERLAP LENGTH - IN.																				
LEFT SIDE	.74	.75	.75	.74	.74	.74	.75	.74	.74	.74	.75	.75	.75	.74	.75	.75	.74	.75	.74	.74
RIGHT SIDE	.74	.74	.74	.75	.75	.74	.74	.75	.74	.74	.74	.74	.74	.74	.75	.74	.74	.74	.74	.74
BONDLINE THICK. IN.	.0051 .0051	.0065	.0052 .0057	.0058 .0058	.0065 .0060	.0047 .0047	.0053 .0051	.0066	.0075	.0070	.0057 .0062	.0062	.0045	.0045 .0050	.0052	.0041	.0051	.0040	.0040	.0045
FAILURE SIDE	L*	L	L*	R*	R*	*	*	R	R	L	R*	R	R	R*	R	R	R	R	R	R
FAILURE AREA - IN.^{2}		.738						.745	.736	.741		.739	.740	.742	.751	.741	.740	.740	.741	.741
ULTIMATE LOAD																				
Psu POUNDS	3600	4220	4260	3540	3580	4220	4280			3400	4280	4440	3720	3880						
ULTIMATE SHEAR																				
STRESS Fsu - Psi	4900	5700	5800	5000	5000	5800	5900			4600	5700	6000	5000	5200						
STRESS RATIO (R)					R	+ 10.0										R - 1.0				
MAX. LOAD POUNDS	-1170	-1970	-1160	-1920	-1140	-1950	-1160	-1980	-1180	-2000	-1190	-1990			1050	1040	1040	1040	1040	1040
MAX. SHEAR STRESS PSI	-1600	-2700	-1600	-2700	-1600	-2700	-1600	-2700	-1600	-2700	-1600	-2700			1400	1400	1400	1400	1400	1400
CYCLE RATE - CPM	1800	900	1800	900	1800	900	1800	900	1800	900	1800	900								
FATIGUE LIFE																				
CYCLES x 10^{-3}	2000	5	2000	5	2000	5	2000	.080	228	5	2000	5			4.410	2.210	***	3.680	3.300	2.510
JOINT STIFFNESS																				
(LBS/IN/IN WIDTH)10^{-3}	381	379	373	374	354	352	356			368	335	347	351	350						

NOTES: * - Failure occurred in Adherend.

*** - Failed on loading.

PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-13021A-1A

SPECIMEN NO. IA	711F01	711F02	711F03	711F04	711F05	711F06	711F07	711F08	711F09	711F10	711F11
DWG. NO. 7226-13021A	1A77	1A07	1A46	1A56	1A119	1A63	1A02	1A30	1A51	1A62	1A133
TYPE OF TEST	FATIGUE - BLOCK SPECTRUM LOADING										
R.T. RANGE °F	75	75	74/75	75	75	NOT RECORDED	69/76	79/81	77/78	77	73/74
SPEC. TEMP. RISE DURING TEST °F	0	1	0	0	0	-	1	0	0	0	0
ADHEREND MATERIAL	8-PLY BORON 0°/±45°										
SPLICE PLATE MATL.	TITANIUM 6Al-4V ANNEALED										
ADHESIVE	EPON EA 9601-06										
SPECIMEN DIMENSIONS											
LENGTH - IN.	NOMINALLY 18.0										
AVG. WIDTH - IN.	1.001	.988	.987	.978	.998	.999	.988	.971	.979	.976	.995
OVERLAP LENGTH - IN.											
LEFT SIDE	.74	.75	.74	.75	.74	.73	.74	.74	.73	.75	.74
RIGHT SIDE	.75	.75	.74	.75	.75	.75	.75	.75	.74	.74	.74
BONDLINE THICK. IN.	.0045 .0056	.0055 .0060	.0054 .0050	.0047 .0055	.0096	.0052	.0062	.0061	.0055 .0046	.0049 .0054	.0070
FAILURE SIDE	L*	R*	R*	L*	R	L	L	L	R*	L*	R
FAILURE AREA - IN.²					.748	.729	.731	.719			.736
FAILURE BLOCK NO.	1	1	1	1	1	1	4	3	1	1	5
FAILURE LOAD NO.	19	20	20	17	15	19	17(2)	18	20	18	19
FAILURE LOAD IN "g"s	+9	+10	+10	+7	+5	+9	+7	+8	+10	+8	+9
NO. OF CYCLES IN LAST LOAD LEVEL	1.25	.25	.25	156	1743	.25	71	42	.25	.25	.25
TOTAL NO. OF CYCLES CYCLES x 10^3	17.595	17.601	17.601	17.469	16.446	17.594	52.935	52.800	17.601	17.550	88.010

NOTE: * - Failure occurred in adherend.

BLOCK SPECTRUM LOADING DETAILS

LOAD NO.	LOAD IN "g"s MIN.	LOAD IN "g"s MAX.	CYCLIC RATE C.P.S.	CYCLES IN BLOCK NO. 1	2	3	4 etc
1	-3.6	+1	1	1	-	REPEAT BLOCK 1 FOR ALL ODD NUMBERED BLOCKS	REPEAT BLOCK 2 FOR ALL EVEN NUMBERED BLOCKS
2	-3.2	+1	1	1	1		
3	-2.8	+1	1	4	4		
4	-2.4	+1	1	8	8		
5	-2.0	+1	1	11	11		
6	-1.6	+1	1	15	15		
7	-1.2	+1	5	18	18		
8	-1.0	+1	10	400	400		
9	-0.8	+1	5	34	35		
10	-0.4	+1	5	76	76		
11	0	+1	5	233	234		
12	+1	+2.56	10	3802	3803		
13	+1	+3	10	6500	6500		
14	+1	+4	10	3600	3600		
15	+1	+5	10	1800	1800		
16	+1	+6	10	810	810		
17	+1	+7	5	237	237		
18	+1	+8	5	44	45		
19	+1	+9	1	7	8		
20	+1	+10	1	1	1		

NOTES: (1) A load of 1g corresponded to a joint shear stress of 330 p.s.i.

(2) Block 2 was applied after Block 1 but in reverse order.

PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-1302IA-1A

SPECIMEN NO. IA	711G01	711G02	711G03	711G04	711G05	711G06	711G07	711G08	711G09	711G10
DWG. NO. 7226-1302IA-1A	1A153	1A155	1A157	1A160	1A165	1A173	1A176	1A172	1A174	1A177
TYPE OF TEST	FATIGUE - REALISTIC SPECTRUM LOADING									
R.T. RANGE °F	77	76	75/76	75/76	76	74/75	73/74	76	75	75/76
SPEC. TEMP. RISE DURING TEST °F	0	1	2	3	2	5	3	2	0	4
ADHEREND MATERIAL	8 PLY BORON - 0°/±45°									
SPLICE PLATE MATERIAL	TITANIUM - 6Al-4V ANNEALED									
ADHESIVE	EPON EA - 9601-06									
SPECIMEN DIMENSIONS										
LENGTH - IN.	NOMINALLY 18.0									
AVG. WIDTH - IN.	.997	.999	1.000	.999	1.011	1.001	1.003	1.001	1.001	1.003
OVERLAP LENGTH - IN.										
LEFT SIDE	.75	.74	.74	.73	.72	.74	.74	.74	.74	.74
RIGHT SIDE	.75	.75	.75	.75	.75	.74	.75	.74	.74	.75
BONDLINE THICK. IN.	.0051	.0054	.0058	.0055	.0055	.0045 .0047	.0052	.0043 .0043	.0044	.0043 .0043
FAILURE SIDE	R	L	R	R	R	L*	R	L*	R	L*
FAILURE AREA - IN.^{2}	.748	.739	.750	.749	.758		.752		.741	
FAILURE OCCURRED DURING MISSION TYPE NO.	4	SEE NOTE (1)	4	4	4	4	3	4	4	4
TEST SEQUENCE NO. (TABLES PGS)	134	401	5	127	36	142	178	124	142	69
CYCLIC SEQUENCE NO. (TABLES PGS)	21	SEE NOTE (1)	56	6	21	64	42	21	64	21
LOAD LEVEL IN "g"s	+8.0	+9.0	+10.0	+7.0	+8.0	+9.0	+7.0	+8.0	+9.0	+8.0
ACTUAL FAILING LOAD - POUNDS	1910	2010	2160	1700	1720	2120	1700	1810	2180	1900

REALISTIC SPECTRUM LOADING DETAILS

LOAD NUMBER		LOAD LEVEL "g"	LOAD (LBS)	LOAD TIME (SEC.)
1		-3.6	875	.3
2		-3.2	780	.2
3		-2.8	680	.1
4		-2.4	585	.3
5		-2.0	485	.2
6		-1.6	390	.1
7		-1.2	290	.3
8		-1.0	245	.2
9		-0.8	195	.1
10		-0.4	95	.3
11		0	.5	.2
12		1.0	245	.1
13		2.56	625	.3
14		3.0	730	.2
15		4.0	975	.1
16		5.0	1215	.3
17		6.0	1460	.2
18		7.0	1700	.2
19		8.0	1945	.3
20		9.0	2190	.4
21		10.0	2430	.4
22	SEE NOTE (2)	0	.50	2.0

NOTES: (1) Failure occurred during additional loading after first 400 flight group.
* Failure occurred in adherend.
(2) This load level was added for testing convenience only.

PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-13021A-1B

SPECIMEN NO. IA-	113D01	113D02	113D03	113D04	113A01	113A02	113A03	113A04	113A05	113A06	113A07	113A08	113A09	113A10	113A11	113A12	113A13	113A14
DRAWING NO. 7226-1302IA	1B02	1B08	1B17	1B22	1B01	1B04	1B06	1B10	1B11	1B14	1B15	1B18	1B20	1B24	1B05	1B09	1B19	1B23
TYPE OF TEST	STATIC TENSILE				FATIGUE - BASELINE DATA													
R.T. RANGE °F	74	74	73	74	69/70	68/71	69/71	71	70	70/71	72	69/72	73	(1)	69/71	70/72	70/73	70/71
SPEC. TEMP. RISE																		
DURING TEST °F	0	0	0	0	3	6	3	0	1	4	0	5	0		3	5	3	0
ADHEREND MATL.	8-PLY BORON 0°/±45°																	
SPLICE PLATE MATL.	8-PLY BORON 0°/±45°																	
ADHESIVE	EPON EA 9601-06																	
SPECIMEN DIMENSIONS																		
LENGTH - IN.	NOMINALLY 18.0																	
AVG. WIDTH - IN.	1.004	.999	1.005	.989	1.012	1.016	1.003	.997	1.025	1.004	1.004	1.016	1.014	1.009	1.000	.998	1.014	1.013
OVERLAP LENGTH - IN.																		
LEFT SIDE	.73	.73	.74	.75	.72	.73	.72	.73	.73	.74	.74	.74	.74	.75	.73	.74	.74	.75
RIGHT SIDE	.75	.75	.74	.75	.74	.74	.75	.74	.74	.73	.74	.74	.74	.74	.75	.74	.75	.74
BONDLINE THICK. IN.	.0057	.0061	.0063	.0050	.0059	.0061	.0059 .0064	.0065	.0055	.0057	.0061	.0055	.0055	.0053 .0058	.0062	.0056	.0054	.0049
FAILURE SIDE	L	R	R	L	R	L	(4)	R	L	L	R	L	R	(1)	L	L	L	L
FAILURE AREA - IN.^{2}	.733	.749	.744	.742	.749	.742	(4)	.738	.748	.743	.743	.752	.750	(1)	.730	.739	.750	.760
ULTIMATE LOAD																		
Psu POUNDS	3010	3060	2920	2880			3300					2680					3170	
ULTIMATE SHEAR																		
STRESS Fsu - Psi	4100	4100	3900	3900			4600					3600					4200	
STRESS RATIO (R)					R = +0.10													
MAX. LOAD POUNDS					950	1190	940	1460	1200	1470	1190	980	1200	(1)	950	1180	975	1200
MAX. SHEAR STRESS-PSI					1300	1600	1300	2000	1600	2000	1600	1300	1600		1300	1600	1300	1600
CYCLE RATE - CPM					1650	1700	1600	1725	1650	1750	1675	1625	1650		1600	1725	1625	1725
FATIGUE LIFE																		
CYCLES X 10^{-3}					10,660	1910	(2)	18	10	375	12	(2)	15	(1)	1660	280	(2)	15
JOINT STIFFNESS																		
(LBS/IN/IN WIDTH)10^{-3}	332 (3)	340 (3)	341(3)	341(3)			324(3)					333(3)					321(3(	

NOTES:

(1) Specimen failed during installation.

(2) No fatigue failure, test discontinued after 10 cycles.

(3) Joint stiffness determined from slope of load vs. deflection curve for 2.0" gage length.

(4) Splice plate failure.

PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-1302IA-1BX AND 1AX

SPECIMEN NO. IA	613D01	613D02	613D03	613A01	613A02	613A03	613A04	613A05	613A06	613A07	613A08	613A09	613A10	611D01	611D02	611D03
DRAWING NO. 7226-1302IA	1BX03	1BX07	1BX11	1BX01	1BX02	1BX04	1BX05	1BX06	1BX08	1BX09	1BX10	1BX12	1BX13	1AX03	1AX07	1AX11
TYPE OF TEST	← STATIC TENSILE →			← FATIGUE - SECOND ADHESIVE →										← STATIC TENSILE →		
R.T. RANGE °F	74	74	75	70/72	72/76	74	73/77	74/76	72/74	74/75	71/77	71/75	75/76	75	75	75
SPEC. TEMP. RISE																
DURING TEST °F	-	-	-	3	3	0	5	0	3	0	3	4	0	-	-	-
ADHEREND MATERIAL	← 8-PLY BORON 0°/±45° →															
SPLICE PLATE MATERIAL	← 8-PLY BORON 0°/±45° →													→ TITANIUM 6Al-4V ANNEALED →		
ADHESIVE	← METAL BOND 329 - .095 →															
SPECIMEN DIMENSIONS																
LENGTH - IN.	NOMINALLY 18.0															
AVG. WIDTH - IN.	1.017	1.011	.999	1.011	.996	.998	1.006	.995	1.006	.997	1.008	.998	1.004	.975	.977	.975
OVERLAP LENGTH - IN.																
LEFT SIDE	.73	.74	.75	.73	.73	.73	.74	.74	.74	.74	.74	.74	.74	.74	.74	.74
RIGHT SIDE	.74	.74	.74	.75	.74	.74	.74	.74	.74	.74	.74	.75	.75	.75	.75	.74
BONDLINE THICK. IN.	.0082 .0086	.0077	.0086 .0086	.0077	.0085	.0076	.0078	.0080	.0084	.0084	.0080	.0087	.0082	.0079	.0079	.0072
FAILURE SIDE	S/PLATE	L	S/PLATE	L	R	R	L	L	R	L	R	R	R	L	L	L
FAILURE AREA - IN.^{2}		.748		.738	.737	.739	.744	.736	.744	.738	.746	.749	.753	.722	.723	.722
ULTIMATE LOAD																
Psu POUNDS	3430	3280	3590		1990		2060							2100	1860	1610
ULTIMATE SHEAR																
STRESS Fsu - Psi	4600	4400	4800		2700		2800							2900	2600	2200
STRESS RATIO (R)				← + 0.10 →												
MAX. LOAD POUNDS				960	800	950	745	955	855	960	860	960	890			
MAX. SHEAR STRESS -PSI				1300	1100	1300	1000	1300	1150	1300	1150	1300	1200			
CYCLE RATE - CPM				1400	1600	1750	1550	1800	1800	1775	1600	1750	1650			
FATIGUE LIFE																
CYCLES x 10^{-3}				46	10210	20	5290	45	188	19	139	16	16			
JOINT STIFFNESS																
(LBS/IN/IN WIDTH)10^{-3}	341	344	339		352		333							ULDC	284	330

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PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-1302IA-1C

SPECIMEN NO. IA-	112D01	112D02	112D03	112A01	112A02	112A03	112A04	112A05	112A06	112A07	112A08	112A09	112A10
DRAWING NO. 7226-1302IA	1C03	1C07	1C11	1C01	1C02	1C04	1C05	1C06	1C08	1C09	1C10	1C12	1C13
TYPE OF TEST	STATIC TENSILE			FATIGUE - BASELINE DATA									
R.T. RANGE °F	76	76	76	71	71	71	70	71	70/71	72	73	72	70/72
SPEC. TEMP. RISE													
DURING TEST °F	0	0	0	0	3	0	4	0	3	2	0	0	3
ADHEREND MATL.	8-PLY BORON 0°/±45°												
SPLICE PLATE MATL.	ALUMINUM 7075-T6												
ADHESIVE	EPON EA 9601-06												
SPECIMEN DIMENSIONS													
LENGTH - IN.	NOMINALLY 18.0												
AVG. WIDTH - IN.	.997	.995	1.013	.983	.940	.980	.979	.977	.984	.961	1.001	.983	1.002
OVERLAP LENGTH - IN.													
LEFT SIDE	.73	.74	.74	.74	.75	.74	.74	.74	.74	.74	.75	.74	.75
RIGHT SIDE	.76	.75	.74	.75	.75	.77	.76	.76	.76	.75	.75	.75	.74
BONDLINE THICK. IN.	.0043	.0044	.0044	.0045	.0045 .0046	.0044	.0046 .0041	.0043	.0048	.0045 .0044	.0045	.0046	.0045
FAILURE SIDE	R	L	L	L	(1)	R	(1)	L	R	(1)	R	L	L
FAILURE AREA - IN.^{2}	.758	.736	.750	.727	(1)	.755	(1)	.723	.748	(1)	.751	.727	.752
ULTIMATE LOAD													
Psu POUNDS	4340	4180	3910										
ULTIMATE SHEAR													
STRESS Fsu - Psi	5700	5700	5200										
STRESS RATIO (R)				R = +0.10									
MAX. LOAD POUNDS				1240	850	1230	940	1230	950	1000	1350	1240	1040
MAX. SHEAR STRESS-PSI				1700	1200	1600	1300	1700	1300	1400	1800	1700	1400
CYCLE RATE - CPM				1700	1800	1700	1550	1675	1750	1800	1800	1800	1650
FATIGUE LIFE													
CYCLES X 10^{-3}				3	109	9	110	18	30	161	2	18	55
JOINT STIFFNESS													
(LBS/IN/IN WIDTH)10^{-3}	334 (2)	323 (2)	298 (2)										

NOTES:

(1) A splice plate failure occurred on this specimen.

(2) Joint stiffness on static specimens determined from slope of load vs. deflection curve for 2.0" gage length.

PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-1302IA-5B

SPECIMEN NO. IA	213D01	213D02	213D03	213A01	213A02	213A03	213A04	213A05	213A06	213A07	213A08	213A09	213A10
DRAWING NO. 7226-1302 IA	5B03	5B07	5B11	5B01	5B02	5B04	5B05	5B06	5B08	5B09	5B10	5B12	5B13
TYPE OF TEST	STATIC TENSILE			FATIGUE - PLY STACKING EFFECTS									
R.T. RANGE ^oF	71	73	73	73/75	72/75	69	70/71	69/71	69	67/69	70	70/71	69
SPEC. TEMP. RISE													
DURING TEST ^oF	0	0	0	2	4	0	1	3	0	2	2	4	0
ADHEREND MATL.	8-PLY BORON $\pm 45^o/0^o$												
SPLICE PLATE MATL.	8-PLY BORON - $\pm 45^o/0^o$												
ADHESIVE	EPON IA 9601-.06												
SPECIMEN DIMENSIONS													
LENGTH - IN.	NOMINALLY 18.0												
AVG. WIDTH - IN.	1.003	.999	1.007	1.009	1.004	1.006	1.002	1.003	1.004	1.000	1.007	1.012	1.000
OVERLAP LENGTH - IN.													
LEFT SIDE	.76	.75	.76	.76	.76	.76	.76	.76	.76	.75	.76	.76	.76
RIGHT SIDE	.74	.74	.75	.74	.74	.74	.75	.74	.75	.75	.75	.75	.74
BONDLINE THICK. IN.	.0057	.0057	.0052	.0057	.0057	.0057	.0055	.0057	.0050	.0057	.0060	.0050	.0050
FAILURE SIDE	R	L	L	R	R	R	R	R	L	R	R	R	L
FAILURE AREA - $IN.^2$	.742	.749	.765	.747	.743	.744	.751	.742	.763	.750	.755	.759	.760
ULTIMATE LOAD													
Psu POUNDS	2700	2560	2370										
ULTIMATE SHEAR													
STRESS Fsu - Psi	3600	3400	3100										
STRESS RATIO (R)				R = +0.10									
MAX. LOAD POUNDS				955	1040	1190	1200	965	1200	975	1210	985	1180
MAX. SHEAR STRESS-PSI				1300	1400	1600	1600	1300	1600	1300	1600	1300	1600
CYCLE RATE - CPM				1800	1800	1675	1800	1500	1800	1700	1800	1800	1650
FATIGUE LIFE													
CYCLES X 10^{-3}				438	170	17	36	2550	18	172	25	120	8
JOINT STIFFNESS													
(LBS/IN/IN WIDTH)10^{-3}	331(1)	330(1)	317(1)										

NOTES:

(1) Joint stiffness on static specimens determined from slope of load vs. deflection curve for 2.0" gage length.

PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-1302IA-5A

SPECIMEN NO. IA	211D01	211D02	211D03	211D04	211D05	211D06	211A11	211A12	211A13	211A14	211A15	211A16	211A17	211A18	211A19	211A20
DWG. NO. 7226-1302IA	5A03	5A07	5A11	5A17	5A21	5A25	5A15	5A16	5A18	5A19	5A20	5A22	5A24	5A26	5A27	5A28
TYPE OF TEST	← STATIC TENSILE →						← FATIGUE - PLY STACKING →									
R.T. RANGE °F	76	75	75	77	77	74	70/75	70/71	68/69	71	70/71	70/71	69/70	68	70/71	70
SPEC. TEMP. RISE DURING TEST °F	-	-	-	-	-	-	6	1	3	0	3	2	2	0	3	0
ADHEREND MATERIAL	← 8-PLY BORON ±45°/0° →															
SPLICE PLATE MATL.	← TITANIUM 6Al - 4V ANNEALED →															
ADHESIVE	← EPON EA 9601 - .06 →															
SPECIMEN DIMENSIONS																
LENGTH - IN.	← NOMINALLY 18.0 →															
AVG. WIDTH - IN.	.979	.980	.980	1.000	1.000	1.001	1.000	1.000	1.005	1.002	1.013	1.011	1.009	.999	1.004	1.005
OVERLAP LENGTH - IN.																
LEFT SIDE	.75	.75	.74	.74	.75	.75	.75	.75	.74	.74	.75	.75	.75	.75	.76	.76
RIGHT SIDE	.74	.74	.75	.75	.74	.74	.75	.75	.74	.74	.74	.74	.74	.74	.74	.73
BONDLINE THICK. IN.	.0048	.0048	.0040	.0053	.0053 .0050	.0055 .0053	.0048	.0048	.0050	.0053	.0053	.0057	.0050	.0053	.0050	.0055
FAILURE SIDE	R	R	R	R	L*	L*	L	L	L	R	R	R	R	R	R	R
FAILURE AREA - IN.^{2}	.724	.725	.735	.750			.750	.750	.744	.741	.750	.748	.747	.739	.743	.734
ULTIMATE LOAD																
Psu POUNDS	2170	1860	2240	5300	5500	5500										
ULTIMATE SHEAR																
STRESS Fsu-Psi	3000	2600	3000	3980	4070	4070										
STRESS RATIO (R)							← +0.10 →									
MAX. LOAD POUNDS							1120	1500	1260	1480	1200	1500	1200	1480	1190	1470
MAX. SHEAR STRESS-PSI							1500	2000	1700	2000	1600	2000	1600	2000	1600	2000
CYCLE RATE - CPM							1575	1800	1800	1750	1800	1775	1800	1750	1750	1750
FATIGUE LIFE																
CYCLES x 10^{-3}							4200	5	85	7	365	11	76	4	122	2
JOINT STIFFNESS																
(LBS/IN/IN WIDTH)10^{-3}	ULDC	ULDC	298	375	379	347										

NOTES: * - Failure occurred in Adherend.

PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-13021A-9B & 9C

SPECIMEN NO. IA	313D01	313D02	313D03	313A01	313A02	313A03	313A04	313A05	313A06	313A07	312D01	312D02	312D03	312A01	312A02	312A03	312A04	312A05
DRAWING NO. 7226-13021A	9B02	9B06	9B09	9B01	9B03	9B04	9B05	9B07	9B08	9B10	9C02	9C04	9C07	9C01	9C03	9C05	9C06	9C08
TYPE OF TEST	STATIC TENSILE			FATIGUE-LAP LENGTH EFFECTS							STATIC TENSILE			FATIGUE-LAP LENGTH EFFECTS				
R.T. RANGE °F	75	75	76	71/72	69	71	72	71/72	69/71	(2)	75	75	75	67/74	72/74	71/73	71/75	71/74
SPEC. TEMP. RISE																		
DURING TEST °F	0	0	0	0	0	0	0	1	3	(2)	0	0	0	1	0	3	2	2
ADHEREND MATL.	8-PLY BORON 0°/±45°																	
SPLICE PLATE MATL.	8-PLY BORON 0°/±45°										ALUMINUM 7075-T6							
ADHESIVE	EPON EA 9601-06																	
SPECIMEN DIMENSIONS																		
LENGTH - IN.	NOMINALLY 18.0																	
AVG. WIDTH - IN.	1.002	1.007	.987	1.007	1.004	1.003	1.006	1.007	.977	1.003	.978	.983	.980	.980	.986	.988	.981	.990
OVERLAP LENGTH - IN.																		
LEFT SIDE	.50	.51	.50	.51	.51	.50	.51	.51	.50	.50	.49	.49	.49	.49	.49	.50	.49	.51
RIGHT SIDE	.50	.50	.50	.50	.49	.49	.49	.49	.50	.49	.49	.49	.50	.49	.50	.49	.50	.49
BONDLINE THICK. IN.	.0051	.0053	.0050	.0047	.0050	.0054	.0051	.0047	.0056	.0053	.0046	.0045	.0046	.0045	.0044	.0048 .0045	.0041	.0048 .0041
FAILURE SIDE	R	L	L	L	L	L	R	L	R	R	R	L	R	L	L	(1)	L	(1)
FAILURE AREA - IN.^{2}	.501	.514	.494	.514	.512	.502	.493	.514	.489	.491	.479	.482	.490	.480	.483	(1)	.481	(1)
ULTIMATE LOAD																		
Psu POUNDS	2230	2660	2450								3090	3020	2650					
ULTIMATE SHEAR																		
STRESS Fsu - Psi	4500	5200	5000								6500	6300	5400					
STRESS RATIO (R)				R = +0.10										R = +0.10				
MAX. LOAD POUNDS				910	790	690	690	690	680	690				670	680	680	670	680
MAX. SHEAR STRESS-PSI				1800	1500	1400	1400	1300	1400	1400				1400	1400	1400	1400	1400
CYCLE RATE - CPM				1625	1475	1600	1425	1600	1600	1450				1700	1400	1600	1700	1600
FATIGUE LIFE																		
CYCLES X 10^{-3}														130	80	433	110	350
JOINT STIFFNESS				9	5	108	565	48	828	73								
(LBS/IN/IN WIDTH)10^{-3}	277(3)	273(3)	253(3)								246(3)	262(3)	251(3)					

NOTES:

(1) A splice plate failure occurred on this specimen.

(2) No temperature record.

(3) Joint stiffness determined from slope of load vs. deflection curve for 2.0" gage length.

PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-13021A-9A

SPECIMEN NO. IA	311D01	311D02	311D04	311D05	311A01	311A02	311A03	311A04	311A05	311A11	311A12	311A13	311A14	311A15
DWG. NO. 7226-1302IA	9A02	9A06	9A19	9A22	9A01	9A03	9A05	9A07	9A08	9A17	9A18	9A20	9A23	9A24
TYPE OF TEST	← STATIC TENSILE →				← FATIGUE-LAP LENGTH →									
R.T. RANGE °F	75	75	76	76	70/71	70/71	68/70	69/70	69/71	68/69	70/71	70/72	71	69/70
SPEC. TEMP. RISE														
DURING TEST °F	-	-	-	-	4	2	3	0	2	2	1	1	2	1
ADHEREND MATERIAL	← 8-PLY BORON 0°/±45° →													
SPLICE PLATE MATERIAL	← TITANIUM 6Al - 4V ANNEALED →													
ADHESIVE	← EPON EA 9601 - .06 →													
SPECIMEN DIMENSIONS														
LENGTH - IN.	← NOMINALLY 18.0 →													
AVG. WIDTH - IN.	1.009	.997	1.009	1.001	1.011	1.000	.997	.994	.998	1.008	.998	1.000	1.009	1.005
OVERLAP LENGTH - IN.														
-LEFT SIDE	.49	.48	.50	.51	.49	.49	.49	.48	.48	.50	.49	.50	.49	.50
RIGHT SIDE	.49	.50	.49	.50	.50	.50	.50	.49	.50	.50	.50	.50	.50	.50
BONDLINE THICK. IN.	.0064	.0050	.0058	.0058	.0063	.0067	.0067	.0064	.0065	.0044	.0050	.0050	.0052	.0057
FAILURE SIDE	R	R	R	L	R	L	L	R	R	R	L	R	L	R
FAILURE AREA - IN.^{2}	.494	.499	.494	.511	.506	.490	.489	.487	.499	.504	.489	.500	.494	.502
ULTIMATE LOAD														
Pau POUNDS	2170	2130	2740	2280										
ULTIMATE SHEAR														
STRESS Fsu - Psi	4400	4300	5500	4500										
STRESS RATIO (R)					← R +0.10 →									
MAX LOAD POUNDS					840	690	680	810	620	855	635	850	640	855
MAX. SHEAR STRESS-PSI					1700	1400	1400	1700	1200	1700	1300	1700	1300	1700
CYCLE RATE - CPM					1550	1600	1425	1650	1420	1725	1575	1600	1550	1800
FATIGUE LIFE														
CYCLES x 10^{-3}					15	194	100	16	1370	40	767	51	1995	35
JOINT STIFFNESS														
(LBS/IN/IN WIDTH)10^{-3}	278	274	288	293										

NOTES: * - Failure occurred in Adherend.

LOCKHEED-GEORGIA COMPANY
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REPORT NO.
MODEL TABLE B8
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PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-1302IA-11A

SPECIMEN NO. IA	911D01	911D02	911D03	911D04	911D05	911D06	911A01	911A02	911A03	911A04	911A05	911A06	911A07	911A08	911A09	911A10	911A11	911A12		
DWG. NO. 7226-1302IA	11A04	11A10	11A17	11A23	11A30	11A31	11A01	11A05	11A03	11A12	11A14	11A1C	11A21	11A25	11A28	11A32	11A16	11A20		
TYPE OF TEST	← STATIC TENSILE →						← FATIGUE — LAP LENGTH EFFECTS →													
R.T. RANGE °F	76	76	76	76	76	77	69/72	71	71	69/71	70/71	70	70/71	70/72	68/69	68/71	71/74	72/73		
SPEC. TEMP. RISE																				
DURING TEST °F	-	-	-	-	-	-	3	0	0	2	4	0	8	1	4	3	5	2		
ADHEREND MATERIAL	← 8 PLY BORON 0°/±45° →																			
SPLICE PLATE MATERIAL	← TITANIUM 6Al-4V ANNEALED →																			
ADHESIVE	← EPON EA 9601-06 →																			
SPECIMEN DIMENSIONS																				
LENGTH - IN.	← NOMINALLY 18.0 →																			
AVG. WIDTH - IN.	1.000	.994	.991	.997	1.003	.999	.992	.995	.994	.994	.996	.992	.993	.999	1.015	1.006	.993	.993		
OVERLAP LENGTH - IN.																				
LEFT SIDE	.98	.98	.98	.98	.98	.99	.98	.98	.98	.98	.98	.98	.98	.98	.99	.99	.98	.98		
RIGHT SIDE	.99	.98	.98	.99	1.00	1.00	.98	.99	.98	.98	.98	.98	.99	.99	1.00	1.00	.98	.99		
BONDLINE THICK. IN.	.0065	.0063 .0054	.0070 .0060	.0062 .0057	.0056	.0061 .0056	NOT KNOWN	.0064	.0060	.0058	.0057	.0065	.0062	.0067	.0060	.0058	.0070	.0067		
FAILURE SIDE	L	L*	R*	L*	L	L*	R	L	L	R	R	L	R	L	R	R	R	R		
FAILURE AREA - IN.^{2}	.980				.983		.972	.975	.974	.974	.976	.972	.983	.979	1.015	1.006	.973	.983		
ULTIMATE LOAD																				
Psu POUNDS	3630	4130	4000	3960	3130	4510														
ULTIMATE SHEAR																				
STRESS Fsu - Psi	3700	4200	4100	4100	3200	4600														
STRESS RATIO (R)							← +0.1 →													
MAX. LOAD POUNDS							870	1560	1560	1560	1270	1560	1070	1570	900	895	880	880		
MAX. SHEAR STRESS - PSI							900	1600	1600	1600	1300	1600	1100	1600	900	900	900	900		
CYCLE RATE - CPM							1550	1800	1800	1800	1750	1750	1750	1850	1800	1500	1550	1800		
FATIGUE LIFE																				
CYCLES x 10^{-3}							720	5	6	22	37	9	60	7	1530	5620	376	108		
JOINT STIFFNESS																				
(IBS/IN/IN WIDTH) 10^{-3}	455	476	402	375	451	558														

NOTES: * - Failure occurred in adherend.

PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-1302IA-11A

SPECIMEN NO. IA	911D07	911D08	911D09	911C01	911C02	911C03	911C04	911C05	911C06	911C07	911C08	911C09	911C10
DWG. NO. 7226-1302IA	11A07	11A24	11A27	11A02	11A06	11A09	11A13	11A15	11A19	11A22	11A26	11A29	11A33
TYPE OF TEST	STATIC COMPRESSION			FATIGUE - LAP LENGTH EFFECTS									
R.T. RANGE °F	77	78	76	69/70	72/73	69/70	70/71	72/74	70/71	67/70	69/70	67/75	67/85
SPEC. TEMP. RISE													
DURING TEST °F	-	-	-	6	6	7	2	5	0	4	0	5	4
ADHEREND MATERIAL	8- PLY BORON 0°/±45°												
SPLICE PLATE MATL.	TITANIUM 6Al-4V ANNEALED												
ADHESIVE	EPON EA 9601 - 06												
SPECIMEN DIMENSIONS													
LENGTH - IN.	NOMINALLY 18.0												
AVG. WIDTH - IN.	.995	.997	.999	.997	.995	1.005	.993	.991	.993	.996	.993	.998	.998
OVERLAP LENGTH - IN.													
-LEFT SIDE	.98	.98	.99	.99	.99	.99	.99	.98	.98	.99	.98	.99	.99
RIGHT SIDE	.98	1.00	1.00	.99	.98	.99	.98	1.00	.99	.98	.99	1.00	1.00
BONDLINE THICK. IN.	.0063 .0060	.0063 .0055	.0059 .0056	.0056	.0059	.0052	.0051	.0070	.0062	.0051	.0059	.0053 .0063	.0056 .0066
FAILURE SIDE	AT TAB	AT TAB	AT TAB	L	R	R	R	R	R	R	L	R*	L*
FAILURE AREA - IN.^{2}				.987	.975	.995	.973	.991	.983	.976	.973		
ULTIMATE LOAD													
Psu POUNDS	4240	4320	5740									5640	4500
ULTIMATE SHEAR													
STRESS Fsu - Psi	4300	4400	5800									5700	4600
STRESS RATIO (R)				± 10.0									
MAX. LOAD POUNDS				-1480	-1460	-2090	-2040	-1460	-2040	-1460	-2040	-1480	-1580
MAX. SHEAR STRESS-PSI				-1500	-1500	-2100	-2100	-1500	-2100	-1500	-2100	-1500	-1600
CYCLE RATE - CPM				1800	1800	1200	1200	1800	1200	1800	1200	1800	1800
FATIGUE LIFE													
CYCLES x 10^{-3}				286.3	323	54	24	487	3.20	415	10	3104	2465
JOINT STIFFNESS													
(LBS/IN/IN WIDTH) 10^{-3}	ULDC	385	448									407	456

NOTES: ULDC - Unusable Load - Deformation Curve
* - Adherend Failure.

PHASE I BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-1302IA-13A

SPECIMEN NO. IA -	411D01	411D02	411D03	411A01	411A02	411A03	411A04	411A05	411A06	411A07	411A08	411A09	411A10
DRAWING NO. 7226-1302IA	13A03	13A07	13A11	13A01	13A02	13A04	13A05	13A06	13A08	13A09	13A10	13A12	13A13
TYPE OF TEST	← STATIC TENSILE →			← FATIGUE - THICKNESS EFFECTS →									
R.T. RANGE °F	77	76	76	71	70/71	72/73	73	72	72/73	72	71	73	73
SPEC. TEMP. RISE													
DURING TEST °F	0	0	0	1	0	2	2	2	3	0	0	0	2
ADHEREND MATL.	← 16-PLY BORON 0°/+45° →												
SPLICE PLATE MATL.	← TITANIUM 6AL-4V ANNEALED →												
ADHESIVE	← EPON EA 9601-06 →												
SPECIMEN DIMENSIONS													
LENGTH - IN.	← NOMINALLY 18.0 →												
AVG. WIDTH - IN.	.981	.993	.989	.995	.994	.978	.986	.988	.992	.987	.985	.995	.999
OVERLAP LENGTH - IN.													
LEFT SIDE	.74	.74	.76	.74	.74	.74	.75	.74	.75	.75	.75	.75	.75
RIGHT SIDE	.75	.74	.74	.74	.75	.74	.74	.76	.75	.75	.74	.75	.75
BONDLINE THICK. IN.	.0045	.0062	.0049	(1)	.0045	.0055	.0053	.0061	.0054	.0054	.0054	.0058	.0049
FAILURE SIDE	R	R	L	R	R	R	R	R	R	R	L	L	R
FAILURE AREA - IN.^{2}	.736	.735	.752	.736	.746	.724	.730	.751	.744	.740	.739	.746	.749
ULTIMATE LOAD													
Psu POUNDS	3400	3820	3760										
ULTIMATE SHEAR													
STRESS Fsu - Psi	4600	5200	5000										
STRESS RATIO (R)				← R = +0.10 →									
MAX. LOAD POUNDS				1180	1180	940	950	1170	1040	1180	950	1190	970
MAX. SHEAR STRESS-PSI				1600	1600	1300	1300	1600	1400	1600	1300	1600	1300
CYCLE RATE - CPM				1750	1800	1800	1800	1800	1800	1775	1750	1800	1800
FATIGUE LIFE													
CYCLES X 10^{-3}				120	71	256	144	55	150	65	759	37	262
JOINT STIFFNESS													
(LBS/IN/IN WIDTH)10^{-3}	415(2)	382	417 (2)										

NOTES:

(1) Bondline thickness not known.

(2) Joint stiffness determined from slope of load vs. deflection curve for 2.0" gage length.

PHASE I BONDED JOINT TEST - CONFIGURATION A - DWG. NO. 7226-1302IA-15A

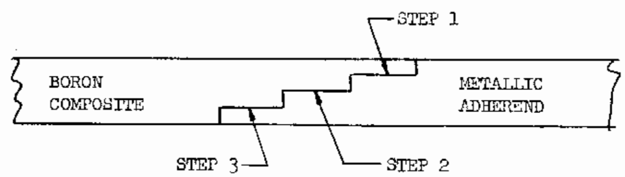
SPECIMEN NO. IA	421D01	421D02	421D03	421D04	421D05	421D06	421A11	421A12	421A13	421A14	421A15	421A16	421A17	421A18	421A19	421A20
DWG. NO. 7226-1302IA	15A03	15A07	15A11	15A16	15A21	15A26	15A14	15A15	15A17	15A19	15A20	15A22	15A23	15A24	15A27	15A28
TYPE OF TEST		STATIC TENSILE - THICKNESS EFFECTS								FATIGUE				THICKNESS EFFECTS		
R.T. RANGE °F	75			77	77	77	68/69	70	69/70	69/70	72/74	71	69/70	72	70/71	69/70
SPEC. TEMP. RISE																
DURING TEST °F	-			-	-	-	2	2	0	2	3	2	3	4	3	3
ADHEREND MATERIAL	← 16-PLY BORON 0°/90° →															
SPLICE PLATE MATL.	← TITANIUM 6Al - 4V ANNEALED →															
ADHESIVE	← EPON EA 9601-06 →															
SPECIMEN DIMENSIONS																
LENGTH - IN.	← NOMINALLY 18.0 →															
AVG. WIDTH - IN.	.965	.969	.986	.999	1.006	1.007	.997	1.006	1.005	1.014	.993	.997	1.004	1.005	1.001	1.008
OVERLAP LENGTH - IN.																
LEFT SIDE	.75	.75	.75	.73	.73	.72	.73	.73	.73	.73	.73	.73	.73	.72	.72	.72
RIGHT SIDE	.74	.74	.74	.74	.74	.75	.74	.74	.74	.74	.74	.74	.74	.75	.75	.75
BONDLINE THICK. IN.	.0058 .0056	.0062 .0060	.0053 .0053	.0070 .0065	.0057 .0057	.0062 .0062	.0065	.0060	.0062	.0067	.0062	.0060	.0065	.0062	.0065	.0057
FAILURE SIDE	L*			L*	R*	R*	L	L	L	L	L	L	L	L	R	R
FAILURE AREA - IN.^{2}							.728	.734	.734	.740	.725	.728	.733	.724	.751	.756
ULTIMATE LOAD																
Psu POUNDS	2030	**	**	2590	2730	2610										
ULTIMATE SHEAR																
STRESS Fsu - Psi																
STRESS RATIO (R)							← +0.10 →									
MAX. LOAD POUNDS							945	1250	955	1330	940	1310	950	1300	935	1310
MAX. SHEAR STRESS-PSI							1300	1700	1300	1800	1300	1800	1300	1800	1200	1700
CYCLE RATE - CPM							1725	1800	1725	1800	1750	1800	1725	1800	1725	1775
FATIGUE LIFE																
CYCLES x 10^{-3}							345	27	220	24	241	21	521	41	202	40
JOINT STIFFNESS																
(LBS/IN/IN WIDTH)10^{-3}	NOT AVAILABLE	**	**	395	436	425										

NOTES: * - Failure occured in adherend.
** - Specimens not tested, adherend material unacceptable.

PHASE I BONDED JOINTS CONFIGURATION B - DWG. NO. 7226-1302IB-1A

SPECIMEN NO. IB	111D01	111D03	111D05	111D07	111A01	111A02	111A03	111A04	111A05	111A06	111A07	111A08	111A09	111A10	111D02	111D04	111D06	111D08
DRAWING NO. 7226-1302IB	1A03	1A10	1A23	1A30	1A02	1A04	1A09	1A11	1A16	1A17	1A22	1A24	1A29	1A31	1A07	1A14	1A19	1A26
TYPE OF TEST	STATIC TENSILE				FATIGUE - BASELINE DATA										STATIC COMPRESSION			
R.T. RANGE °F	74	74	76	76	70	72/73	72	70/72	71/72	72	73	72/73	72	72/74	75	76	73	72
SPEC. TEMP. RISE																		
DURING TEST °F	-	-	-	-	2	2	0	2	1	1	3	4	4	3	-	-	-	-
ADHEREND MATERIAL 1	16-PLY BORON 0°/±45°																	
ADHEREND MATERIAL 2	TITANIUM 6A-4V ANNEALED																	
ADHESIVE	EPON EA.9601-.045																	
SPECIMEN DIMENSIONS																		
LENGTH - IN.	NOMINALLY 18.0																	
AVG. WIDTH - IN.	1.000	.999	1.002	1.001	1.000	1.000	1.001	1.003	1.001	1.003	1.003	1.003	.999	1.000	1.000	1.001	1.003	1.001
OVERLAP LENGTH - IN.	1.48	1.47	1.45	1.44	1.47	1.47	1.47	1.47	1.48	1.45	1.45	1.45	1.44	1.44	1.47	1.46	1.46	1.44
BONDLINE THICK. - IN.																		
STEP 1	.0042	.0043	.0036	.0043	.0042	.0045	.0045	.0047	.0043	.0035	.0040	.0044	.0046	.0047	.0045	.0040	.0039	.0042
STEP 2	.0045	.0040	.0043	.0042	.0045	.0045	.0050	.0038	.0045	.0039	.0038	.0044	.0037	.0042	.0040	.0043	.0035	.0050
STEP 3	.0040	.0040	.0042	.0040	.0040	.0043	.0043	.0040	.0049	.0038	.0050	.0040	.0037	.0045	.0045	.0040	.0040	.0039
FAILURE AREA - IN.²	*B	*B	*B	*B	1.47	1.47	1.47	1.47	1.48	1.45	1.45	1.45	1.44	1.44	1.47	1.46	1.46	1.44
ULTIMATE LOAD																		
Psu POUNDS	5175	5875	5375	5675											8360	8360	8560	8360
ULTIMATE SHEAR																		
STRESS Fsu - Psi	3500	4000	3700	3900											5700	5700	5900	5800
STRESS RATIO (R)					R = +0.10													
MAX. LOAD POUNDS					2060	1320	2060	1320	2070	1300	2030	1300	2020	1300				
MAX. SHEAR STRESS-PSI					1400	900	1400	900	1400	900	1400	900	1400	900				
CYCLE RATE - CPM					1725	1750	1725	1800	1700	1700	1775	1800	1800	1775				
FATIGUE LIFE																		
CYCLES X10⁻³					24	197	11	389	34	482	43	322	47	316				
JOINT STIFFNESS																		
(IBS/IN/IN WIDTH)10⁻³	580	535	564	581											600	628	610	619

NOTE: *B - FAILURE OCCURRED IN BORON ADHEREND.



PHASE I BONDED JOINTS CONFIGURATION B - DWG. NO. 7226-1302IB-1A

SPECIMEN NO. IB	111C01	111C02	111C03	111C04	111C05	111C06	111C07	111C08	111C09	111C10	111C11
DRAWING NO. 7226-1302IB	1A01	1A06	1A08	1A13	1A15	1A18	1A20	1A25	1A27	1A32	1A05
TYPE OF TEST	FATIGUE - BASELINE DATA										
R.T. RANGE °F		74/77	77/78	76/77	76/77	75/79	75	76/78	74/75	76/78	75/77
SPEC. TEMP. RISE											
DURING TEST °F		4	3	7	7	2	3	3	2	5	0
ADHEREND MATERIAL 1	16-PLY BORON 0°/±45°										
ADHEREND MATERIAL 2	TITANIUM 6AL-4V ANNEALED										
ADHESIVE	EPON EA.9601-.045										
SPECIMEN DIMENSIONS											
LENGTH - IN.	NOMINALLY 18.0										
AVG. WIDTH - IN.	1.001	.999	.999	1.002	1.003	1.002	1.002	1.002	1.002	1.005	.999
OVERLAP LENGTH - IN.	1.47	1.47	1.47	1.48	1.47	1.47	1.46	1.45	1.45	1.44	1.47
BONDLINE THICK. - IN.											
STEP 1	.0052	.0038	.0045	.0040	.0045	.0039	.0047	.0040	.0047	.0043	.0044
STEP 2	.0051	.0045	.0040	.0038	.0048	.0039	.0044	.0037	.0040	.0036	.0043
STEP 3	.0045	.0045	.0045	.0040	.0040	.0042	.0037	.0040	.0037	.0040	.0038
FAILURE AREA - IN.^{2}		1.47	1.47	1.48	1.47	1.47	1.46	1.45	1.45	1.45	1.47
ULTIMATE LOAD											
Psu POUNDS											
ULTIMATE SHEAR											
STRESS Fsu - Psi											
STRESS RATIO (R)	R = +10.0										
MAX. LOAD POUNDS		-2940	-2790	-3550	-3530	-2790	-4090	-2610	-4060	-3770	-2650
MAX. SHEAR STRESS-PSI		-2000	-1900	-2400	-2400	-1900	-2800	-1800	-2800	-2600	-1800
CYCLE RATE - CPM		1200	1200	900	900	1600	600	1500	600	900	1200
FATIGUE LIFE											
CYCLES X10^{-3}	1	144.8	143.4	29.1	65.3	105	5.8	201.8	11.6	37.5	205.5
JOINT STIFFNESS											
(LBS/IN/IN WIDTH)10^{-3}											

NOTE: 1 - THIS SPECIMEN WAS USED FOR CONDUCTING A TEMPERATURE SURVEY AND WAS NOT TESTED TO FAILURE.

PHASE I BONDED JOINTS CONFIGURATION B - DWG. NO. 7226-1302IB-1A

SPECIMEN NO. IB	511D01	511D02	511D03	511A01	511A02	511A03	511A04	511A05	511A06	511A07	511A08	511A09	511A10
DRAWING NO. 7226-1302IB	1A43	1A46	1A51	1A41	1A42	1A44	1A45	1A47	1A48	1A49	1A50	1A52	1A53
TYPE OF TEST	←	STATIC	TENSILE			FATIGUE -		DEGRADATION					→
R.T. RANGE °F	77	77	75	72/73	73/74	73	72/73	74	73	70	70	73	70
SPEC. TEMP. RISE													
DURING TEST °F	-	-	-	0	2	0	1	2	1	1	1	0	3
ADHEREND MATERIAL (1)	←							16 PLY BORON 0°/±45°					→
ADHEREND MATERIAL (2)	←							TITANIUM 6Al-4V ANNEALED					→
ADHESIVE	←						EPON	EA 9601 - .045					→
SPECIMEN DIMENSIONS													
LENGTH - IN.	←							NOMINALLY	18.0				→
AVG. WIDTH - IN.	1.002	1.000	1.000	1.004	1.003	1.003	1.002	1.001	1.000	.998	1.001	1.002	1.000
OVERLAP LENGTH - IN.	1.47	1.47	1.45	1.47	1.48	1.47	1.47	1.47	1.47	1.46	1.47	1.47	1.47
BONDLINE THICK. - IN.													
STEP 1	(NOT		.0055		(NOT RECORDED BUT					.0055	.0055	.0055	.0055
STEP 2	RECORDED)		.0059		NOMINALLY .005 — .006)					.0060	.0059	.0060	.0060
STEP 3			.0054							.0055	.0054	.0055	.0055
FAILURE AREA - $IN.^2$	*B	*B	*B	*B	*B	*B	*B	*B	*B	*B	*B	*B	*B
ULTIMATE LOAD													
Psu POUNDS	5840	5370	5590	5570	5500	6100	5700	6070	5300	5920	5740	5540	5820
ULTIMATE SHEAR													
STRESS Fsu - Psi	4000	3700	3900	3800	3700	4100	3900	4100	3600	4100	3900	3800	4000
STRESS RATIO (R)				←				+0.10					→
MAX. LOAD POUNDS				2070	1180	2060	1180	2060	1180	2060	1170	2040	1170
MAX. SHEAR STRESS - PSI				1400	800	1400	800	1400	800	1400	800	1400	800
CYCLE RATE - CPM				1800	1600	1775	1550	1800	1450	1800	1650	1800	1750
FATIGUE LIFE													
CYCLES x 10^{-3}				5	200	5	200	5	200	5	200	5	200
JOINT STIFFNESS													
(IBS/IN/IN WIDTH) 10^{-3}	554	527	590	527	570	570	572	570	576	590	610	561	563

*B - FAILURE OCCURRED IN BORON ADHEREND.

LOCKHEED-GEORGIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

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MODEL
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PHASE I BONDED JOINTS CONFIGURATION B - DWG. NO. 7226-1302IB-1B

SPECIMEN NO. IB	112D01	112D02	112D03	112A01	112A02	112A03	112A04	112A05	112A06	112A07	112A08	112A09	112A10
DRAWING NO. 7226-1302IB	1B04	1B08	1B13	1B02	1B03	1B05	1B06	1B07	1B10	1B11	1B12	1B14	1B15
TYPE OF TEST	STATIC-TENSILE			FATIGUE - BASELINE DATA									
R.T. RANGE °F	69	69	69	70/72	72/75	68	71/74	70/72	72/73	72	70/75	73	73/75
SPEC. TEMP. RISE													
DURING TEST °F	-	-	-	1	3	1	10	3	5	2	4	4	2
ADHEREND MATERIAL 1	16-PLY BORON 0°/±45°												
ADHEREND MATERIAL 2	ALUMINUM 7075-T6												
ADHESIVE	EPON EA9601-.045												
SPECIMEN DIMENSIONS													
LENGTH - IN.	NOMINALLY 18.0												
AVG. WIDTH - IN.	.996	.995	.997	.996	.997	.998	.994	.994	.995	.996	.996	.996	.994
OVERLAP LENGTH - IN.	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.47	1.48	1.47	1.47	1.47
BONDLINE THICK - IN.													
STEP 1	.0034	.0034	.0035	.0035	.0036	.0034	.0036	.0032	.0036	.0037	.0035	.0030	.0034
STEP 2	.0035	.0035	.0032	.0040	.0037	.0035	.0036	.0035	.0029	.0040	.0039	.0036	.0035
STEP 3	.0035	.0040	.0036	.0040	.0040	.0036	.0034	.0033	.0040	.0040	.00 40	.0034	.0037
FAILURE AREA - IN.^{2}	*A	*A	*A	*A	*A	*A	*A	*A	*A	*A	*A	*A	*A
ULTIMATE LOAD													
Psu POUNDS	4830	4870	4830										
ULTIMATE SHEAR													
STRESS Fsu - Psi	3300	3300	3300										
STRESS RATIO (R)				R - +0.10									
MAX. LOAD POUNDS				1910	1330	1920	1320	1910	1310	1910	1310	1900	1310
MAX. SHEAR STRESS-PSI				1300	900	1300	900	1300	900	1300	900	1300	900
CYCLE RATE - CPM				1625	1600	1700	1750	1575	1800	1675	1800	1550	1600
FATIGUE LIFE													
CYCLES X10^{-3}				20	470	20	2390	22	330	16	1320	25	539
JOINT STIFFNESS													
(LBS/IN/IN WIDTH)10^{-3}	495	432	460										

NOTE: *A - FAILURE OCCURRED IN ALUMINUM ADHEREND.

PHASE I BONDED JOINTS CONFIGURATION B - DWG. NO. 7226-1302IB-3A

SPECIMEN NO. IB	121D01	121D02	121D03	121A01	121A02	121A03	121A04	121A05	121A06	121A07	121A08	121A09	121A10
DRAWING NO. 7226-1302IB	3A04	3A08	3A13	3A02	3A03	3A05	3A06	3A07	3A10	3A11	3A12	3A14	3A15
TYPE OF TEST	← STATIC TENSILE →			← FATIGUE - BASELINE DATA →									
R.T. RANGE °F	73	73	73	73/74	66/68	74/75	69	64/70	72	70/75	72	72/75	70
SPEC. TEMP. RISE													
DURING TEST °F	-	-	-	5	1	4	6	5	4	3	6	0	1
ADHEREND MATERIAL 1	← 16-PLY BORON 0°/90° →												
ADHEREND MATERIAL 2	← TITANIUM 6AL-4V ANNEALED →												
ADHESIVE	← EPON EA 9601-.045 →												
SPECIMEN DIMENSIONS													
LENGTH - IN.	← NOMINALLY 18.0 →												
AVG. WIDTH - IN.	1.000	1.001	1.001	1.000	1.001	1.000	1.000	1.001	1.002	1.001	1.002	1.002	1.002
OVERLAP LENGTH - IN.	1.47	1.48	1.47	1.43	1.45	1.46	1.47	1.47	1.47	1.46	1.46	1.45	1.46
BONDLINE THICK. - IN.													
STEP 1	.0044	.0042	.0038	.0042	.0040	.0040	.0040	.0040	.0044	.0040	.0040	.0040	.0044
STEP 2	.0037	.0036	.0037	.0037	.0035	.0036	.0035	.0036	.0039	.0037	.0036	.0039	.0038
STEP 3	.0036	.0037	.0036	.0036	.0035	.0036	.0037	.0035	.0036	.0035	.0037	.0036	.0036
FAILURE AREA - IN.^{2}	*B	*B	*B	1.43	1.45	1.46	1.47	1.47	*B	1.46	*B	1.45	*B
ULTIMATE LOAD													
Psu POUNDS	4560	5660	4820										
ULTIMATE SHEAR													
STRESS Fsu - Psi	3100	3800	3300										
STRESS RATIO (R)				← R = +0.10 →									
MAX. LOAD POUNDS				2000	2610	1900	2650	2060	2650	1900	2630	1880	2630
MAX. SHEAR STRESS-PSI				1400	1800	1300	1800	1400	1800	1300	1800	1300	1800
CYCLE RATE - CPM				1800	1725	1750	1800	1775	1800	1775	1750	1775	1800
FATIGUE LIFE													
CYCLES X10^{-3}				223	30	803	68	220	21	535	25	783	13
JOINT STIFFNESS													
(LBS/IN/IN WIDTH)10^{-3}	600	554	585										

*B - FAILURE OCCURRED IN BORON ADHEREND.

PHASE I BONDED JOINTS CONFIGURATION B - DWG. NO. 7226-1302IB-5A

SPECIMEN NO. IB	211D01	211D02	211D03	211A01	211A02	211A03	211A04	211A05	211A06	211A07	211A08	211A09	211A10
DRAWING NO. 7226-1302IB	5A04	5A09	5A13	5A02	5A03	5A05	5A06	5A07	5A10	5A11	5A12	5A14	5A15
TYPE OF TEST	← STATIC-TENSILE →			← FATIGUE - PLY STACKING EFFECTS →									
R.T. RANGE °F	68	68	68	72/73	70/76	73	73/75	72/73	74/75	73/74	74/76	73	74/76
SPEC. TEMP. RISE													
DURING TEST °F	-	-	-	4	8	0	4	0	0	7	0	6	3
ADHEREND MATERIAL 1	← 16-PLY BORON 0°/±45° →												
ADHEREND MATERIAL 2	← TITANIUM 6AL-4V ANNEALED →												
ADHESIVE	← EPON EA-9601-.045 →												
SPECIMEN DIMENSIONS													
LENGTH - IN.	← NOMINALLY 18.0 →												
AVG. WIDTH - IN.	1.000	1.002	1.002	1.003	1.000	1.000	.998	1.001	1.000	1.000	1.001	1.001	1.001
OVERLAP LENGTH - IN.	1.45	1.48	1.46	1.46	1.45	1.46	1.46	1.46	1.47	1.47	1.47	1.47	1.49
BONDLINE THICK. - IN.													
STEP 1	.0035	.0036	.0038	.0037	.0037	.0037	.0038	.0036	.0036	.0035	.0035	.0035	.0035
STEP 2	.0036	.0036	.0036	.0038	.0038	.0037	.0040	.0035	.0035	.0036	.0037	.0036	.0038
STEP 3	.0045	.0038	.0040	.0046	.0044	.0044	.0046	.0028	.0042	.0042	.0045	.0040	.0045
FAILURE AREA - IN.^{2}	*B	*B	*B	1.46	1.45	1.46	1.46	1.46	1.47	1.47	1.47	1.47	1.49
ULTIMATE LOAD													
Psu POUNDS	5960	5720	5860										
ULTIMATE SHEAR													
STRESS Fsu - Psi	4100	3900	4000										
STRESS RATIO (R)				← R = +0.10 →									
MAX. LOAD POUNDS				2040	1600	2190	1900	2190	1760	2200	1760	2200	1790
MAX. SHEAR STRESS-PSI				1400	1100	1500	1300	1500	1200	1500	1200	1500	1200
CYCLE RATE - CPM				1800	1725	1800	1800	1800	1775	1775	1800	1775	1750
FATIGUE LIFE													
CYCLES X10^{-3}				51	4438	12	97	15	1770	40	770	41	275
JOINT STIFFNESS													
(LBS/IN/IN WIDTH)10^{-3}	562	576	560										

*B - FAILURE OCCURRED IN BORON ADHEREND.

PHASE I BONDED JOINTS CONFIGURATION B - DWG. NO. 7226-1302IB-9A

SPECIMEN NO. IB	311D01	311D02	311D03	311A01	311A02	311A03	311A04	311A05	311A06	311A07	311A08	311A09	311A10
DRAWING NO. 7226-1302IB	9A03	9A08	9A13	9A01	9A02	9A04	9A06	9A07	9A09	9A10	9A12	9A14	9A15
TYPE OF TEST	← STATIC-TENSILE →			← FATIGUE - LAP LENGTH EFFECTS →									
R.T. RANGE °F	72	74	78	68/71	58/74	70/71	72/75	68/69	71/77	70/73	64/75	69/71	73/74
SPEC. TEMP. RISE													
DURING TEST °F	-	-	-	2	2	2	5	3	2	3	3	6	0
ADHEREND MATERIAL 1	←					16-PLY BORON 0°/±45° →							
ADHEREND MATERIAL 2	←					TITANIUM 6AL-4V ANNEALED →							
ADHESIVE	←					EPON EA-9601-.045 →							
SPECIMEN DIMENSIONS													
LENGTH - IN.	←					NOMINALLY 18.0 →							
AVG. WIDTH - IN.	.999	1.000	1.001	1.000	1.001	1.000	.999	1.001	1.000	1.001	1.003	1.002	1.001
OVERLAP LENGTH - IN.	1.10	1.13	1.14	1.10	1.10	1.10	1.11	1.12	1.13	1.13	1.14	1.14	1.14
BONDLINE THICK. - IN.													
STEP 1	.0043	.0043	.0045	.0046	.0041	.0045	.0043	.0035	.0047	.0036	.0036	.0036	.0045
STEP 2	.0038	.0040	.0042	.0037	.0040	.0045	.0038	.0042	.0042	.0035	.0042	.0042	.0040
STEP 3	.0042	.0044	.0040	.0042	.0040	.0047	.0042	.0047	.0035	.0037	.0042	.0045	.0039
FAILURE AREA - IN.^{2}	1.10	*B	1.14	1.10	1.10	1.10	1.11	1.12	1.13	1.13	1.14	1.14	1.14
ULTIMATE LOAD													
Psu POUNDS	2920	5110	5340	4920	3800								
ULTIMATE SHEAR													
STRESS Fsu - Psi	2700	4500	4700	4500	3500								
STRESS RATIO (R)				←		R = +0.10 →							
MAX. LOAD POUNDS				550	990	990	1220	1790	1240	1810	1250	1820	1820
MAX. SHEAR STRESS-PSI				500	900	900	1100	1600	1100	1600	1100	1600	1600
CYCLE RATE - CPM				1450	1600	1700	1775	1650	1800	1700	1800	1800	1800
FATIGUE LIFE													
CYCLES X10^{-3}				10000 (1)	4480 (1)	22	324	26	5878	428	3420	155	25
JOINT STIFFNESS													
(LBS/IN/IN WIDTH)10^{-3}	623	585	608	634	576								

*B - Failure occurred in boron adherend.

(1) - No fatigue failure, test discontinued and specimens tested for residual strength.

LOCKHEED-GEORGIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

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PHASE I BONDED JOINT TESTS - CONFIGURATION C - DWG. NO. 7226-1302IC-1A

SPECIMEN NO. IC	111A01	111A02	111A03	111A04	111A05	111A06	111A07	111A08	111A09	111A10	111D01	111D02	111D03
DWG. NO. 7226-1302IC	1A02	1A03	1A05	1A06	1A07	1A09	1A10	1A11	1A13	1A14	1A04	1A08	1A10
TYPE OF TEST			BASELINE DATA		FATIGUE							STATIC	
R.T. RANGE ^{o}F	75	73	70/72	72/74	72	74/75	75	72/74	74	72	71	71	71
SPEC. TEMP. RISE ^{o}F	0	0	0	0	0	2	0		0	0	-	-	-
ADHEREND MATL.						8 PLY BORON $0^{o}/\pm 45^{o}$							
"T" MATERIAL						TITANIUM	6AL-4V	ANNEALED					
ADHESIVE						EPON EA	9601-06						
SPECIMEN DIMENSIONS													
LENGTH - IN.						NOMINALLY 18.0							
AVG. WIDTH - IN.	.916	.980	.961	.965	.934	.979	.982	.929	.974	.975	.981	.955	.974
"T" BONDED LENGTH - IN.	1.24	1.25	1.25	1.25	1.26	1.25	1.25	1.26	1.26	1.25	1.25	1.25	1.25
BONDED AREA - IN.^{2}		1.23	1.20	1.21	1.18	1.22	1.23	1.17	1.23	1.22	1.23	1.19	1.22
AVG. BONDLINE THICK IN.	.0059	.0059	.0059	.0060	.0060	.0061	.0061	.0058	.0059	.0060	.0060	.0059	.0060
STATIC AXIAL													
LOAD - POUNDS	-	-	-	-	-	-	-	-	-	-	1000	2000	200
ULTIMATE SIDE													
LOAD - POUNDS	-	-	-	-	-	-	-	-	-	-	175	240	105
STRESS RATIO (R)			R = +0.10								-	-	-
MAXIMUM DYNAM													
AXIAL LOAD - POUNDS	970	1440	1630	925	1380	1040	1450	800	1625	825	-	-	-
APPLIED SIDE LOAD-LBS	50	60	70	50	60	50	60	40	70	40	-	-	-
DYNAMIC SIDE LOAD													
MAXIMUM POUNDS	75	82	105	63	93	74	82	60	106	62	-	-	-
MINIMUM	25	39	26	25	24	21	21	21	43	19	-	-	-
CYCLE RATE - CPM	1400	1500	1600	1350	1550	1400	1550	1350	1600	1350	-	-	-
FATIGUE LIFE													
CYCLES x 10^{-3}	86	18	5	175	8	125	16	591	5	809	-	-	-

PHASE I BONDED JOINT TESTS - CONFIGURATION D - DWG. NO. 7226-1302ID-1A

SPECIMEN NO. ID	111D01	111D02	111D03	111A01	111A02	111A03	111A04	111A05	111A06	111A07	111A08	111A09	111A10	111A11
DWG. NO. 7226-1302ID	1A03	1A08	1A15	1A01	1A02	1A05	1A06	1A07	1A09	1A10	1A11	1A14	1A15	1A04
TYPE OF TEST		STATIC				BASELINE DATA FATIGUE								
R.T. RANGE °F	77	77	76	69	67/77	71/72	68/70	68/70	70/71	4	72	72	70/71	69/70
SPEC. TEMP RISE														
DURING TEST °F	-	-	-	3	4	3	3	3	4	4	0	3	3	
ADHEREND MATL.				8 PLY BORON 0°/±45°										
SPLICE PLATE MATL.				TITANIUM 6AL-4V ANNEALED										
ADHESIVE				EPON EA 9601 ADHESIVE										
SPECIMEN DIMENSIONS														
LENGTH - IN.				NOMINALLY 18.0										
AVG. WIDTH - IN.	.990	.990	.991	.987	.990	.991	.991	.991	.991	.991	.991	.990	.991	.991
OVERLAP LENGTH - IN.														
LEFT SIDE	.78/.75	.76/.74	.76/.74	.77/.75	.76/.77	.77/.75	.76/.74	.76/.74	.77/.75	.75/.77	.76/.74	.76/.75	.76/.74	.77/.74
RIGHT SIDE	.77/.78	.76/.77	.76/.78	.77/.78	.77/.75	.76/.77	.76/.77	.76/.77	.76/.77	.77/.75	.76/.77	.77/.78	.76/.77	.77/.78
BONDLINE THICK. IN. 1	6.0/6.5	7.0/6.5	6.0/6.0	7.7/6.5	-	6.7/6.5	6.2/7.0	7.5/7.2	7.0/7.0	6.9/7.2	7.2/7.0	7.0/6.2	6.0/7.0	.0070/.0067
FAILURE SIDE	R	2	L	L	3	L	LL/RU	L	R	4	L	L	L	L
FAILURE AREA - IN.²	1.53		1.49	1.50	-	1.51	1.49	1.49	1.52	-	1.49	1.50	1.49	1.50
ULTIMATE LOAD														
Psu POUNDS	8350	8200	8025	-	-	-	-	-	-	-	-	-	-	-
ULTIMATE SHEAR														
STRESS Fsu - Psi	5500	5500	5400	-	-	-	-	-	-	-	-	-	-	-
STRESS RATIO (R)	-	-	-					R = +0.10						
MAX. LOAD POUNDS	-	-	-	2250	1950	1950	1940	1940	2550	2700	2685	2530	2530	2550
MAX. SHEAR STRESS-PSI	-	-	-	1500	1300	1300	1300	1300	1700	1800	1800	1700	1700	1700
CYCLE RATE - CPM	-	-	-	1800	1800	1750	1800	1800	1775	4	1800	1800	1775	1800
FATIGUE LIFE														
CYCLES X10⁻³	-	-	-	62	15300	445	342	968	67	4	4	22	8	6
JOINT STIFFNESS														
(LBS/IN/IN WIDTH)10⁻³	798	771	761	-	-	-	-	-	-	-	-	-	-	

1. WHERE BONDLINE FAILURE DID NOT OCCUR THE AVERAGE VALUES OF THE RIGHT AND LEFT BONDLINE ARE GIVEN.
2. FAILURE OCCURRED IN ADHEREND
3. NOT FAILED
4. FAILED ON LOADING

"L" & "U" IN FAILURE MODES REFER TO "LOWER" & "UPPER" SPLICE PLATES

PHASE I BONDED JOINT TESTS - CONFIGURATION D - DWG. NO. 7226-1302ID-1B

SPECIMEN NO. ID	114D01	114D02	114D03	114A01	114A02	114A03	114A04	114A05	114A06	114A07	114A08	114A09	114A10
DWG. NO. 7226-1302ID	1B01	1B07	1B12	1B02	1B03	1B04	1B05	1B08	1B09	1B10	1B11	1B13	1B14
TYPE OF TEST		STATIC						FATIGUE					
R.T. RANGE °F	73	73	73	1	71/72	70/71	72/73	1	70/71	1	1	1	1
SPEC. TEMP. RISE													
DURING TEST °F	-	-	-	1	2	1	2	1	0	1	1	1	1
ADHEREND MATL.						TITANIUM 6AL-4V ANNEALED							
SPLICE PLATE MATL.						8-PLY BORON 0°/±45°							
ADHESIVE						EPON EA 9601 ADHESIVE							
SPECIMEN DIMENSIONS													
LENGTH - IN.						NOMINALLY 18.0							
AVG. WIDTH - IN.	1.004	1.011	1.000	.999	.997	1.001	.997	1.011	1.008	1.011	1.000	1.002	1.001
OVERLAP LENGTH - IN.													
LEFT SIDE	.74/.73	.74/.74	.74/.74	.74/.74	.74/.74	.74/.74	.74/.73	.74/.74	.74/.74	.73/.74	.74/.74	.74/.75	.75/.75
RIGHT SIDE	.78/.78	.77/.77	.77/.77	.77/.78	.77/.78	.77/.78	.77/.78	.77/.77	.76/.77	.77/.77	.76/.77	.76/.77	.77/.76
BONDLINE THICK. IN.	5.8/6.0	5.9/5.9	6.2/6.0	5.4/5.9	6.2/5.9	5.8/5.5	5.5/5.6	5.9/6.7	6.0/6.4	5.9/5.9	5.8/5.7	6.1/5.8	5.9/6.3
FAILURE SIDE	L&U (2)	L&U (2)	L&U (2)	RU/LL	RU/LL	LU/RL	RL	RU/LL	RU/LL	RU/LL	RU/LL	R	RL/LU
FAILURE AREA - IN.²	-	-	-	1.51	1.51	1.52	1.55	1.53	1.51	1.53	1.50	1.53	1.51
ULTIMATE LOAD													
Psu POUNDS	8225	8525	8675	-	-	-	-	-	-	-	-	-	-
ULTIMATE SHEAR													
STRESS Fsu - Psi	5600	5700	5900	-	-	-	-	-	-	-	-	-	-
STRESS RATIO (R)						R = +0.10							
MAX. LOAD POUNDS	-	-	-	2070	2520	1920	2650	2100	2830	2085	2810	2085	2850
MAX. SHEAR STRESS-PSI	-	-	-	1400	1700	1300	1800	1400	1900	1400	1900	1400	1900
CYCLE RATE - CPM	-	-	-	1725	1750	1800	1800	1775	1775	1750	1800	1800	1800
FATIGUE LIFE													
CYCLES X10^{-3}	-	-	-	502	116	933	79	1030	116	2836	165	957	76
JOINT STIFFNESS													
(LBS/IN/IN WIDTH)10^{-3}	853	887	909	-	-	-	-	-	-	-	-	-	-

1 NO TEMPERATURE RECORD DUE TO MALFUNCTION OF RECORDING EQUIPMENT.
"L" & "U" IN FAILURE MODES REFER TO "LOWER" & "UPPER" SPLICE PLATES.

2 SPLICE PLATE FAILURE.

PHASE II - BONDED JOINTS CONFIGURATION A - DWG. NO. 7226-1302IIA-1A

SPECIMEN NO. IIA	11D01	11D02	11D03	11D07	11D04	11D05	11D06	11A01	11A02	11A03	21A03	11A05	11A06	11A07	21A04	11A09	11A10	11C01	11C02	11C03
DWG NO. 7226-1302IIA	1A01	1A14	1A22	1A31	1A04	1A15	1A25	1A03	1A05	1A11	1A13	1A30	1A18	1A20	1A23	1A32	1A28	1A06	1A08	1A16
TYPE OF TEST	STATIC-TENSILE				STATIC-COMPRESSION			FATIGUE-BASELINE DATA												
R.T. RANGE °F	72	74	72	-	73	72	72	72	74/79	72	72/73	74	75/80	74	74/76	73/74	74	67/70	66/77	77
SPEC. TEMP. RISE DURING TEST °F								2	1	0	1	0	4	3	1	1	3	5	7	1
ADHEREND MATL.	8 PLY BORON 0°/± 45°																			
SPLICE PLATE MATL.	TITANIUM 6AL-4V ANNEALED																			
ADHESIVE	EPON EA 9601-.06																			
SPECIMEN DIMENSIONS																				
LENGTH - IN.	NOMINALLY 18.0																			
AVG. WIDTH - IN.	3.004	3.002	3.006	3.008	3.002	3.002	3.004	3.004	3.005	3.005	3.011	3.008	3.004	3.002	3.005	3.006	3.005	3.002	3.001	3.000
OVERLAP LENGTH - IN.																				
LEFT SIDE	.74	.74	.74	.75	.74	.75	.74	.74	.74	.74	.75	.75	.74	.74	.75	.75	.74	.74	.74	.74
RIGHT SIDE	.75	.74	.74	.74	.75	.74	.75	.75	.75	.74	.73	.74	.75	.74	.73	.73	.75	.74	.75	.75
BONDLINE THICK. IN.	.0050	.0057 .0056	.0050	.0050 .0049	.0054	.0057	.0055	.0050	.0056	.0057	.0050	.0051	.0056	.0055	.0048	.0053	.0054	.0053	.0051	.0055
FAILURE SIDE	R	R*	L		R*	L*	R*	R	L	R	R	L	R	R	L	L	L	R	L	L
FAILURE AREA - IN.^{2}	2.25		2.22		2.25			2.25	2.22	2.22	2.20	2.26	2.25	2.22	2.25	2.26	2.22	2.22	2.22	2.22
ULTIMATE LOAD																				
Psu POUNDS	8000	11200	11100	**	8800	6680	9000													
ULTIMATE SHEAR																				
STRESS Fsu - Psi	3600	5000	5000	**	4000	3000	4100													
STRESS RATIO (R)								R = +.10										R = +10.0		
MAX. LOAD POUNDS								3110	2440	3110	2420	3120	2440	3110	2410	3070	2440	-4660	-4660	-4660
MAX. SHEAR STRESS-PSI								1400	1100	1400	1100	1400	1100	1400	1100	1400	1100	-2100	-2100	-2100
CYCLE RATE - CPM								1750	1625	1800	1675	1720	1775	1800	1600	1800	1750	1200	1200	1200
FATIGUE LIFE																				
CYCLES X10^{-3}								68	473	7	146	45	1185	36	145	18	87	33.5	32	12.5
JOINT STIFFNESS																				
(LBS/IN/IN WIDTH)10^{-3}	332	328	332		236	227	204				***				***					

NOTE * FAILURE OCCURRED IN ADHEREND.

** SPECIMEN IIAD07 NOT TESTED: WILL BE USED FOR STRAIN SURVEY AND PHOTOELASTIC STUDY.

*** THESE SPECIMENS WERE DEGRADATION SPECIMENS THAT HAD FAILED AND THEREFORE SUBSTITUTED AS BASELINE DATA TESTS.

PHASE II - BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-1302IIA-1A & 1C

SPECIMEN NO. IIA	11C04	11C05	12D01	12D02	12D03	12A01	12A02	12A03	12A04	12A05	21A01	21A02	21A05	11A04	11A08	22A01	22A02	22A03	22A04	22A05
DWG. No. 7226-1302IIA	1A19	1A27	1C03	1C08	1C14	1C01	1C04	1C06	1C09	1C12	1A02	1A10	1A26	1A12	1A21	1C02	1C07	1C10	1C11	1C13
TYPE OF TEST	FATIGUE		STATIC-TENSILE			FATIGUE-BASELINE DATA					FATIGUE-DEGRADATION									
R.T. RANGE °F	72/75	-	74	72	72	73	74/75	74/75	76	74/76	73/75	73/74	73/74	72/74	75	74	74	75/76	75	75
SPEC. TEMP. RISE																				
DURING TEST °F	5	-	-	-	-	2	1	1	0	2	2	0	1	2	0	0	0	0	0	0
ADHEREND MATL.						8-PLY BORON 0°/±45°														
SPLICE PLATE MATL.	T.-6AL-4V. ANN		ALUMINUM 7075-T6								TIT. 6AL-4V ANNEALED					ALUMINUM 7075-T6				
ADHESIVE						EPON	EA 9601	.06												
SPECIMEN DIMENSIONS																				
LENGTH - IN.						NOMINALLY		18.0												
AVG. WIDTH - IN.	3.003	3.004	3.005	3.005	2.256	3.005	3.006	3.005	3.004	3.008	3.003	3.006	3.005	3.005	3.005	3.006	3.008	3.003	3.009	3.008
OVERLAP LENGTH - IN.																				
LEFT SIDE	.75	.75	.76	.75	.74	.75	.75	.76	.74	.74	.74	.75	.75	.75	.75	.75	.77	.76	.74	.74
RIGHT SIDE	.74	.75	.76	.76	.75	.75	.75	.74	.75	.75	.75	.74	.74	.74	.74	.75	.73	.76	.75	.75
BONDLINE THICK. IN.	.0057	.0056	.0054	.0053	.0045	.0051	.0051	.0049	.0057	.0050	.0047	.0056	.0055	.0051	.0049	.0053	.0050	.0053	.0049	.0050
FAILURE SIDE	R	L	R	R	L	R	R	R	R	R	R	L	R	R	L	R	R	R	R	R
FAILURE AREA - IN.^{2}	2.22	2.25	2.28	2.28	1.67	2.25	2.25	2.22	2.25	2.26	2.25	2.25	2.22	2.22	2.25	2.25	2.20	2.28	2.26	2.26
ULTIMATE LOAD																				
Psu POUNDS			6060	6400	6540						7800	6040		9060	5300	9420	5420	7540	5920	7860
ULTIMATE SHEAR																				
STRESS Fsu - Psi			2700	2800	3900						3500	2700		4100	2400	4200	2500	3300	2600	3500
STRESS RATIO (R)	R - +10.0										R - +.10									
MAX. LOAD POUNDS	-4660	-4725				2920	2920	2890	2890	2890	2440	2440	2440	2440	2440	2930	2860	2960	2900	2900
MAX. SHEAR STRESS - PSI	-2100	-2100				1300	1300	1300	1300	1300	1100	1100	1100	1100	1100	1300	1300	1300	1300	1300
CYCLE RATE - CPM	1200	1200				1775	1800	1750	1800	1775	1625	1800	1700	1750	1800	1775	1750	1775	1775	1650
FATIGUE LIFE																				
CYCLES X10^{-3}	35.9	8.6				59	73	36	5	29	200	200	82	200	200	5	5	5	5	5
JOINT STIFFNESS																				
(LBS/IN/IN WIDTH)10^{-3}			299	310	NR						323	327	NR	320	287	305	301	325	316	314
	NR - NOT RECORDED																			

PHASE II - BONDED JOINT TESTS - CONFIGURATION A - DWG. NO. 7226-1302IIA-1A

SPECIMEN NO. IIA	41G01	41G02	41G03	41G04	41G05
DWG. NO. 7226-1302IIA	1A07	1A09	1A17	1A24	1A29
TYPE OF TEST	← FATIGUE-REALISTIC SPECTRUM →				
R.T. RANGE °F	74/77	77	76/78	74/75	73/76
SPEC. TEMP. RISE DURING TEST °F	2	1	2	2	3
ADHEREND MATL.	← 8-PLY BORON 0°/±45° →				
SPLICE PLATE MATL.	← TITANIUM - 6AL-4V ANNEALED →				
ADHESIVE	← EPON EA 9601 - .06 →				
SPECIMEN DIMENSIONS					
LENGTH - IN.	← NOMINALLY 18.0 →				
AVG. WIDTH - IN.	3.004	3.007	3.004	3.006	3.017
OVERLAP LENGTH - IN.					
LEFT SIDE	.75	.74	.75	.74	.75
RIGHT SIDE	.74	.74	.74	.74	.74
BONDLINE THICK. IN.	.0056	.0056	.0055	.0048	.0050
FAILURE SIDE	L	R	L	R	L
FAILURE AREA - IN.^{2}	2.25	2.23	2.25	2.22	2.26
FAILURE OCCURRED DURING					
MISSION TYPE NO.	4	4	4	4	4
TEST SEQUENCE NO. (TABLES 33 ③)	196	5	184	142	142
CYCLIC SEQUENCE NO. (TABLES 27 to 31 ③)	6	56	21	64	64
LOAD LEVEL IN "g"s	+7.0	+10.0	+8.0	+9.0	+9.0
ACTUAL FAILING LOAD - POUNDS	4450	5850	5175	4950	4950

REALISTIC SPECTRUM LOADING DETAILS

LOAD NO.		LOAD LEVEL "g"	LOAD (POUNDS) FOR SPECIMEN NOS. G01	G02	G03	G04	G05	LOAD TIME (SECONDS)
1		-3.6						.3
2		-3.2						.2
3		-2.8	-1600	-1600	-1550	-1600	-1600	.1
4		-2.4	-1500	-1475	-1450	-1400	-1400	.3
5		-2.0	-1200	-1150	-1150	-1150	-1150	.2
6		-1.6	-1000	-950	-950	-900	-850	.1
7		-1.2	-750	-750	-700	-700	-650	.3
8		-1.0	-650	-650	-650	-575	-575	.2
9		-0.8	-500	-500	-500	-400	-450	.1
10		-0.4	-250	-250	-200	-250	-300	.3
11		0	0	0	0	0	0	.2
12		1.0	650	650	650	600	575	.1
13		2.56	1600	1600	1600	1500	1500	.3
14		3.0	1900	1875	1900	1675	1700	.2
15		4.0	2650	2650	2600	2300	2300	.1
16		5.0	3250	3250	3250	2850	2950	.3
17		6.0	3850	3900	3900	3400	3400	.2
18		7.0	4500	4500	4500	4000	4000	.2
19		8.0	5150	5150	5175	4650	4650	.3
20		9.0	5800	5750	5800	5200	5200	.4
21		10.0	6400	①	6400	5750	5700	.4
22	②	0	0	0	0	0	0	2.0

NOTES: ① FAILURE OCCURRED DURING THE FIRST APPLICATION OF THIS LOAD.

② THIS LOAD LEVEL WAS ADDED FOR TESTING CONVENIENCE ONLY.

③ TABLES IN AFFDL-TR-71-44

PHASE II - BONDED JOINTS CONFIGURATION A - DWG. NO. 7226-1302IIA-11A

SPECIMEN NO. IIA	91D01	91D02	91D03	91D04	91D05	91D06	91A01	91A02	91A03	91A04	91A05	91C01	91C02	91C03	91C04	91C05
DWG. NO. 7226-1302IIA	11A01	11A08	11A13	11A02	11A09	11A16	11A04	11A05	11A06	11A11	11A14	11A03	11A07	11A10	11A12	11A15
TYPE OF TEST	← STATIC-TENSILE →			← STATIC-COMPRESSION →			← FATIGUE-LAP LENGTH EFFECTS →									
R.T. RANGE °F	73	73	73	74	75	75	70/76	74	75/76	74	70/71	70/77	70/73	70/77	71/72	73/75
SPEC. TEMP RISE																
DURING TEST °F	-	-	-	-	-	-	2	0	1	2	2	6	6	6	6	3
ADHEREND MATL.					8-PLY BORON		0°/±45°									
SPLICE PLATE MATL.						TITANIUM	6AL-4V ANNEALED									
ADHESIVE	←						EPON	EA 9601	0 .06 →							
SPECIMEN DIMENSIONS																
LENGTH - IN.	←						NOMINALLY			18.0 →						
AVG. WIDTH - IN.	1.498	3.005	3.007	2.005	3.005	3.005	3.002	3.001	3.003	3.005	3.006	3.003	3.004	3.006	3.006	3.005
OVERLAP LENGTH - IN.																
LEFT SIDE	1.01	.98	1.00	.98	1.00	.98	.98	1.00	.99	.99	1.01	.99	.98	1.00	1.00	.99
RIGHT SIDE	.98	1.01	.99	1.01	.99	1.01	1.00	.99	.99	.99	.99	1.00	.99	1.00	.99	1.01
BONDLINE THICK. IN.	.0040	.0050	.0051 .0055	.0049 .0048	.0047 .0045	.0054 .0060	.0047 .0050	.0047	.0049	.0055	.0052	.0050	.0050	.0049	.0055	.0050
FAILURE SIDE	L	L	L*	AT TAB	AT TAB	AT TAB	(1)	R	L	R	R	R	R	L	R	L
FAILURE AREA - IN.²	1.51	2.94					2.94	2.97	2.97	2.97	2.98	3.003	2.97	3.01	2.98	2.97
ULTIMATE LOAD																
Psu POUNDS	5830	11600	11400	5300	7700	9600										
ULTIMATE SHEAR																
STRESS Fsu - Psi	3900	3900	3800	2700	2600	3300										
STRESS RATIO (R)							←		R = +.10		→	←		R = +10.0 (2)		→
MAX. LOAD POUNDS							2650	3270	3270	3270	3280	-4460	-4410	-4510	-4470	-4460
MAX. SHEAR STRESS-PSI							900	1100	1100	1100	1100	-1500	-1500	-1500	-1500	-1500
CYCLE RATE - CPM							1700	1700	1700	1800	1800	1500	1500	1500	1500	1500
FATIGUE LIFE																
CYCLES X10⁻³																
JOINT STIFFNESS																
(LBS/IN/IN WIDTH)10^{-3}	NR	399	357	NR	320	272	(1)	39	56	40	91	108	294.4	122.7	52.6	29

NOTES:
* FAILURE OCCURRED IN ADHEREND.
NR NOT RECORDED.
(1) NO FAILURE TEST DISCONTINUED AFTER 10^7 CYCLES.
(2) SEE NOTE 2 TABLE B3 PAGE 6.

PHASE II BONDED JOINTS - CONFIGURATION B - DWG. NO. 7226-1302IIB-1A

SPECIMEN NO. IIB	11D01	11D03	11A01	11A02	11A03	11A04	11A05	11D02	11D04	11C01	11C02	11C03	11C04	11C05	11C06
DWG. NO. 7226-1302IIB	1A01	1A08	1A02	1A06	1A09	1A10	1A14	1A04	1A12	1A03	1A05	1A07	1A11	1A13	1A15
TYPE OF TEST	STATIC TEN		FATIGUE-BASELINE DATA					STATIC COMP		FATIGUE-BASELINE DATA					
R.T. RANGE °F	74	74	70/74	76/77	74/75	69/74	74/75	74	74	68/70	67/70	72/73	68/73	71/73	71
SPEC. TEMP. RISE															
DURING TEST °F	-	-	5	3	6	4	8	-	-	6	8	4	3	1	0
ADHEREND MATERIAL 1	16 PLY BORON 0°/±45°														
ADHEREND MATERIAL 2	TITANIUM 6Al-4V ANNEALED														
ADHESIVE	EPON EA 9601 -.045														
SPECIMEN DIMENSIONS															
LENGTH - IN.	NOMINALLY 18.0														
AVG. WIDTH - IN.	3.009	3.008	3.010	3.009	3.008	3.009	3.009	3.008	3.007	3.007	3.008	3.008	3.006	3.006	3.008
OVERLAP LENGTH - IN.	1.50	1.53	1.50	1.54	1.54	1.48	1.55	1.54	1.50	1.53	1.53	1.53	1.53	1.53	1.54
BONDLINE THICK. - IN.															
STEP 1	.0055	.0055	.0055	.0055	.0055	.0055	.0055	.0055	.0055	.0054	.0055	.0054	.0055	.0054	.0055
STEP 2	.0060	.0060	.0060	.0059	.0060	.0059	.0060	.0059	.0060	.0060	.0060	.0059	.0059	.0059	.0060
STEP 3	.0059	.0059	.0060	.0059	.0060	.0060	.0060	.0059	.0060	.0060	.0059	.0060	.0060	.0060	.0059
FAILURE AREA - IN.^{2}	*B	*B	*B	4.63	4.63	*B	4.66	4.63	(1)	(2)	4.60	4.60	4.60	4.60	4.63
ULTIMATE LOAD															
Psu POUNDS	16700	17200	16500			17300		23000	18500	19500					
ULTIMATE SHEAR															
STRESS Fsu - Psi	3700	3700	3700			3900		5000	4100	4200					
STRESS RATIO (R)			R = +0.1							R = +10.0					
MAX. LOAD POUNDS			4070	6480	6480	4000	6520			-575	-920	-1105	-1105	-1105	-1110
MAX. SHEAR STRESS-PSI			900	1400	1400	900	1400			-125	-200	-240	-240	-240	-240
CYCLE RATE - CPM			1800	1600	1625	1750	1800			1800	1200	1200	1200	1200	1200
FATIGUE LIFE															
CYCLES x 10^{-3}			9000	105	364	9000	408			452	197	52.2	21.8	12.4	4.7
JOINT STIFFNESS															
(LBS/IN/IN WIDTH)10^{-3}	653	550	660			680		657	667	650					

NOTES: *B - Failure occurred in boron adherend.
1 - Titanium adherend failed in buckling.
2 - Boron adherend failed in buckling at tab.

PHASE II BONDED JOINTS - CONFIGURATION B - DWG. NO. 7226-1302IIB-1B&9A

SPECIMEN NO. IIB	12D01	12D02	12D03	12A01	12A02	12A03	12A04	12A05	31D01	31D02	31D03	31A01	31A02	31A03	31A04	31A05
DWG. NO. 7226-1302IIB	1B02	1B05	1B08	1B01	1B03	1B04	1B06	1B07	9A02	9A05	9A07	9A01	9A03	9A04	9A06	0A08
TYPE OF TEST	←	STATIC TENSILE	→	←	FATIGUE-BASELINE DATA			→	←	STATIC TENSILE	→	←	FATIGUE-LAP LENGTH EFFECTS			→
R.T. RANGE °F	74	74	74	76	75/76	75	74/76	75	74	74	74	72/75	72/75	70/76	73/75	72/75
SPEC. TEMP. RISE	-	-	-	1	3	3	6	3	-	-	-	3	6	6	5	5
DURING TEST °F	-	-	-	1	3	3	6	3	-	-	-	3	6	6	5	5
ADHEREND MATERIAL 1	←						16 PLY BORON 0°/±45°									→
ADHEREND MATERIAL 2	←	ALUMINUM 7075-76						→	←			TITANIUM 6Al - 4V ANNEALED				→
ADHESIVE	←						EPON EA 9601 - .045									→
SPECIMEN DIMENSIONS																
LENGTH - IN.	←						NOMINALLY 18.0									→
AVG. WIDTH - IN.	3.008	3.002	2.994	2.995	3.006	3.007	2.999	2.995	3.007	3.008	3.001	3.008	3.006	3.008	3.010	3.002
OVERLAP LENGTH - IN.	1.56	1.54	1.55	1.56	1.55	1.52	1.52	1.55	1.09	1.09	1.10	1.10	1.09	1.07	1.09	1.10
BONDLINE THICK. - IN.																
STEP 1	.0055	.0055	.0055	.0050	.0055	.0055	.0055	.0055	.0059	.0059	.0049	.0050	.0055	.0059	.0055	.0050
STEP 2	.0059	.0060	.0059	.0049	.0060	.0059	.0059	.0059	.0059	.0059	.0050	.0059	.0059	.0059	.0059	.0050
STEP 3	.0055	.0055	.0055	.0050	.0059	.0059	.0059	.0055	.0060	.0059	.0060	.0059	.0059	.0060	.0060	.0060
FAILURE AREA - IN.^{2}	*A	*A	*A	*A	*A	*A	*A	*A	*B	*B	*B	3.31	3.28	3.22	3.28	3.30
ULTIMATE LOAD																
Psu POUNDS	15200	14800	14700						17700	16500	16600					
ULTIMATE SHEAR																
STRESS Fsu - Psi	3200	3200	3200						5400	5000	5000					
STRESS RATIO (R)				←	R = +0.10			→				←	R = +0.10			→
MAX. LOAD POUNDS				6070	6060	5940	5930	6030				4630	4590	4510	4590	4480
MAX. SHEAR STRESS-PSI				1300	1300	1300	1300	1300				1400	1400	1400	1400	1400
CYCLE RATE - CPM				1800	1550	1525	1775	1800				1800	1800	1750	1800	1775
FATIGUE LIFE																
CYCLES x 10^{-3}				14	22	26	28	21				1440	3770	11140	260	939
JOINT STIFFNESS																
(LBS/IN/IN WIDTH)10^{-3}	480	493	510						643	633	637					

NOTES: *A - Failure occurred in aluminum adherend.
*B - Failure occurred in boron adherend.

PHASE III - BONDED JOINTS CONFIGURATION A

Specimen No. IIIA-	11D2	11D4	11D6	11D3	11D5	11A1	11B1	11C1			12D2	12D3	12D4	12A1	12B1
DWG#7226-1302IA-IIIA	1A01-1	1A03-1	1A05-1	1A02-1	1A04-1	1A01	1A02	1A03			1C01-1	1C02-1	1C03-1	1C01	1C03
Type of Test		Static Tension			Static Comp		Fatigue					Static Tension		Fatigue	
R.T. Range °F	76	76	76	74	74	68	73	70			75	75	74	70	72
Spec. Temp. Rise															
During Test	0	0	0	0	0	0	0	3			0	0	0	-	0
Adherend Matl.			Boron 8	Ply 0/± 45								Boron 8	Ply 0/±	45	
Splice Plate Matl.			Ti-6-4									AL 7075	-T-6		
Adhesive			EA9601	- .06WT								EA9601	- .06 WT		
Specimen Dimensions															
Length			18.0 In.	Nom.								18.0 In.	Nom.		
Width	1.000	1.008	1.001	1.000	1.001	10.00	10.00	10.00			1.001	1.000	0.998	10.00	10.00
Overlap Length															
Left Side	.73	.75	.75	.74	.74	.74	.74	.74			.76	.76	.74	.74	.75
Right Side	.75	.74	.75	.74	.75	.74	.75	.75			.74	.74	.75	.75	.75
Bondline Thick.(Mils)			(SEE	TABLE A12)								(SEE	TABLE A12)		
Failure Side	L	L	L	-	-	L	R	L			R	R	R	R	R
Failure Area - IN.^{2}	.730	.746	.751	.740	.741	7.40	7.40	7.40			.741	.740	.748	7.40	7.50
Ultimate Load															
Psu - Pounds	3890	3750	3400	3540	3360						3670	3860	3860		
Ultimate Shear															
Fsu - Stress	5300	5000	4500	4800	4500						5000	5200	5200		
Stress Ratio (R)						0.1	-1.0	10.0						0.1	-1.0
Max. Load Pounds						8140	5920	-1184						9620	6000
Max. Shear Stress						1100	800	-160						1300	800
Cycle Rate - CPM						300	300	480						300	300
Fatigue Life															
Cycles X 10^{-3}						195.9	11.4	1090						9.2	9.57
Joint Stiffness															
(Lb./In.Width) 10^{-3}	338	348	340	-	325						359	335	323		

PHASE III - BONDED JOINTS CONFIGURATION B

Specimen No. IIIB	11D1	11D2	11D3	11A1	11B1
DWG #7226-1302IB	1A01-1	1A02-1	1A03-1	1A01	1A03
Type of Test	←	Static	→	Fatigue	→
R. T. Range °F	73	73	74	75	75
Spec. Temp. Rise				2	2
Adherend Material 1	←	Boron 15 Ply		0/± 45	→
Adherend Material 2	←	Ti-	6-4		→
Adhesive	←	EA9601	.945		→
Specimen Dimensions					
Lenght - In.	←		18.0 In. Nom.		→
Width - In.	1.003	1.001	1.003	10.00	10.00
Bondline Thick.	(SEE	TABLE A13)			
Failure Area - IN.^{2}	1.48	1.47	1.48	14.9	14.8
Ultimate Load					
Psu - Lbs.	4990	5490	5990		
Ultimate Shear					
Fsu - PSI	3400	3700	4000		
Stress Ration (R)				0.1	-1.0
Max. Load - Lbs.				20860	11840
Max. Shear - PSI.				1400	800
Cycle Rate - CPM				420	180
Fatigue Life					
Cycle X 10^{-3}				183	500
Joint Stiffness					
(LBS/IN/IN WIDTH)10^{-3}	668	659	612		

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PHASE I - MECHANICAL JOINTS - CONFIGURATION E - DWG. NO. 7226-1302IE-1A

SPECIMEN NO. IE	111D01	111D03	111D05	111A01	111A02	111A03	111A04	111A05	111A06	111A07	111A08	111A09	111A10	111A11	111A12	111A13	111A14	111A15	111A16	111A17
DWG. NO. 7226-1302IE	1A13	1A33	1A57	1A02	1A03	1A09	1A11	1A20	1A24	1A31	1A44	1A46	1A51	1A56	1A61	1A64	1A39	1A58	1A22	1A38
TYPE OF TEST	STATIC TENSILE			FATIGUE - BASELINE DATA																
R. T. Range °F	76	76	77	73	73	NA	72/77	74/76	76/77	NA	76/77	74/76	73/77	73/76	73	70/73	71	71	72	72
SPEC. TEMP. RISE DURING TEST °F	-	-	-	-	-	NA	9	8	2	NA	3	2	8	9	9	7	3	4	-	1
STRAP MATERIAL	8-PLY BORON, 0/±45° + TWO TITANIUM SHIMS																			
SPLICE PLATE MATL.	T1-8A1-1MO-1V																			
STRAP MATERIAL	T1-8A1-1MO-1V																			
JOINT SEALANT	3TM 40-111-B2																			
LENGTH - IN.	18.0																			
BORON STRAP WIDTH - IN.	.999	.999	.997	.998	.997	1.002	.998	1.003	.999	.996	.999	.998	.999	1.000	.999	.998	1.001	.998	1.002	1.001
TI. STRAP WIDTH - IN.	.999	.999	.996	1.000	.999	1.005	1.001	.997	1.002	.996	.997	1.001	.998	.997	1.001	.999	.998	.997	1.000	1.000
SPLICE PLATE WIDTH - IN	.998	.998	.999	.999	.999	1.005	.998	.998	1.000	.998	.997	.997	.996	.998	.996	.994	.999	.995	.999	.994
BORON STRAP THICK - IN	.042	.046	.046	.047	.047	.048	.047	.044	.046	.048	.046	.046	.046	.047	.047	.047	.048	.047	.046	.046
SHIMMED SECT. THICK IN	.088	.093	.093	.093	.093	.094	.094	.090	.088	.094	.086	.090	.093	.094	.092	.095	.093	.094	.090	.093
TI. STRAP THICK - IN	.127	.127	.128	.127	.127	.132	.127	.131	.126	.131	.129	.126	.127	.128	.133	.128	.128	.127	.127	.127
SPLICE PLATE THICK IN	0.126																			
FASTENER HOLE DIAMETER - IN.	0.188																			
SHIMMED BORON NET SECTION AREA - IN.²	.0714	.0754	.0752	.0753	.0752	.0765	.0761	.0733	.0714	.0760	.0697	.0729	.0754	.0763	.0746	.0770	.0756	.0761	.0733	.0756
JOINT ULTIMATE LOAD POUNDS	2710	3310	3290																	
STRESS RATIO (R)				R = +0.10																
MAX. LOAD POUNDS				1580	2180	1600	1600	1390	2070	2500	2090	1460	2260	1680	2310	2310	2570	2590	2490	2570
SHIMMED BORON NET SECT. STRESS - KSI.	38	44	44	21.0	29.0	20.9	21.0	19.0	29.0	32.9	30.0	20.0	30.0	22.0	31.0	30.0	34.0	34.0	34.0	34.0
CYCLE RATE - CPM				1600	1700	1800	1675	1650	1675	1800	1625	1650	1800	1600	1800	1800	1775	1800	NA	NA
FATIGUE LIFE CYCLES X 10^{-3}				163	22	595	735	10500	68	2	32	10300	387	2737	6	1070	20	1	2	1
JOINT STIFFNESS (LBS/IN/IN WIDTH)10^{-3}	NA	207	223																	
FAILURE LOCATION																				
FAILURE MODE	S	S	S	T	T	T	T	①	T	S	S	NF	T	T	T	U/T	T	T	T	T

① NO FAILURE, TEST DISCONTINUED

LOCKHEED-GEORGIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

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PHASE I - MECHANICAL JOINTS - CONFIGURATION E - DWG. NO. 7226-1302IE-1A

SPECIMEN NO. IE	111D02	111D04	111B01	111B02	** 111B03	111B04	111B05	111B06	111B07	111B08	111B09	111B10	111C01	111C02	111C03
DWG. NO. 7226-1302IE	1A25	1A45	1A05	1A10	1A19	1A21	1A28	1A29	1A48	1A59	1A63	1A14	1A01	1A06	1A07
TYPE OF TEST	STATIC COMPRESSIVE		FATIGUE - BASELINE DATA												
R. T. RANGE °F	74	74	73/74	74/76	70/75	76/77	NA	77/78	76/77	76/78	74	71/76	73/76	76/77	NA
SPEC. TEMP. RISE DURING TEST °F	-	-	10	11	9	10	NA	7	4	9	29	9	8	9	NA
STRAP MATERIAL	8 PLY BORON, 0/±45° + TWO TITANIUM SHIMS														
SPLICE PLATE MATL.	Ti-8Al-1Mo-1V														
STRAP MATERIAL	Ti-8Al-1Mo-1V														
JOINT SEALANT	STM40-111-B2														
LENGTH - IN.	18.0														
BORON STRAP WIDTH - IN	.996	1.000	.998	.997	1.000	1.000	1.001	1.002	.999	.999	1.000	1.000	.999	1.000	.999
TI. STRAP WIDTH - IN.	.995	.998	.997	.999	1.001	.999	.999	1.002	1.000	.999	.994	.998	1.000	.999	.997
SPLICE PLATE WIDTH - IN	.998	1.001	.998	.996	1.000	.999	.998	.999	.994	.999	.999	1.001	.999	.998	.999
BORON STRAP THICK - IN	.046	.047	.048	.047	.046	.046	.048	.047	.048	.046	.047	.046	.046	.048	.047
SHIMMED SECT. THICK IN	.088	.087	.093	.094	.091	.090	.094	.093	.091	.091	.090	.092	.093	.094	.093
TI. STRAP THICK - IN.	.127	.127	.127	.128	.127	.126	.128	.128	.126	.127	.126	.126	.127	.127	.126
SPLICE PLATE THICK - IN	0.126														
FASTENER HOLE DIAMETER - IN.	0.188														
SHIMMED BORON NET SECTION AREA - IN^2	.0711	.0706	.0753	.0760	.0739	.0731	.0764	.0758	.0738	.0738	.0731	.0747	.0754	.0763	.0754
JOINT ULTIMATE LOAD - POUNDS	4500	4960													
STRESS RATIO (R)			R = - 1.0										R = + 10.0 (2)		
MAX. LOAD POUNDS			1200	1220	1180	1610	1680	1670	1620	1620	1170	1200	-2260	-3050	-3020
SHIMMED BORON NET SECTION STRESS - KSI	63	70	15.9	16.0	16.0	22.0	22.0	22.0	22.0	22.0	16.0	16.0	-30	-40	-40
CYCLE RATE - CPM			180	180	180	120/180	120	120	120	120	120/180	180	300/600	400/500	300/600
FATIGUE LIFE CYCLES X 10^{-3}			114	820	500	119	5.5	55.3	17.4	245	1009	300	751	265	188
JOINT STIFFNESS (LBS/IN/IN WIDTH)10^{-3}	298	303													
FAILURE LOCATION															
FAILURE MODE	S	S	Q	P	P	T	Q	S	Q	P	(1)	P	(1)	O	Q

NOTES: O = Compressive failure in boron at edge of shim build-up.
P = Fastener fatigue failure.
Q = Tab failure.
(1) = No failure, test discontinued.
(2) = See Note (3), Table B5, Page 2.

** = Tapered-shim surface away from splice plate.

PHASE I - MECHANICAL JOINTS - CONFIGURATION E - DWG. NO. 7226-1302IE-1A

SPECIMEN NO. IE	511A01	511A03	511A05	511A07	511A09	511A02	511A04	511A06	511A08	511A10
DWG. NO. 7226-1302IE	1A04	1A23	1A34	1A40	1A52	1A15	1A32	1A37	1A41	1A62
TYPE OF TEST	← STATIC PRELOAD-FATIGUE →					← LOW CYCLE →				
R.T. RANGE °F	71/73	70/75	70/77	71/73	76	(2)	74	74	74	74
SPEC. TEMP. RISE DURING TEST °F	7	2	0	2	4	(2)	2	2	4	5
STRAP MATERIAL	← 8-PLY BORON, 0°/±45° + TWO TITANIUM SHIMS →									
SPLICE PLATE MATL.	← TITANIUM 8AL-1MO-1V →									
STRAP MATERIAL	← TITANIUM 8AL-1MO-1V →									
JOINT SEALANT	← STM 40-111-B2 →									
SPECIMEN LENGTH - IN.	← 18.0 →									
BORON STRAP WIDTH - IN.	.999	.996	1.000	1.003	1.000	1.000	1.007	1.000	1.003	.999
TI. STRAP WIDTH - IN.	1.001	.995	.998	.999	1.000	.997	.997	1.000	.999	.999
SPLICE PLATE WIDTH - IN	.997	1.002	1.002	1.000	.999	1.001	1.002	.999	1.003	1.000
BORON STRAP THICK - IN	.046	.046	.047	.046	.046	.046	.047	.047	.047	.047
SHIMMED SECT. THICK - IN	.094	.088	.094	.092	.095	.092	.094	.094	.091	.090
TI. STRAP THICK - IN.	.127	.128	.126	.128	.127	.126	.129	.126	.127	.126
SPLICE PLATE THICK - IN	← 0.126 →									
FASTENER HOLE DIAMETER - IN.	← 0.188 →									
SHIMMED BORON NET SECTION AREA - IN²	.0762	.0711	.0763	.0750	.0771	.0747	.0770	.0763	.0742	.0730
STATIC PRELOAD LBS.	2450	2500	2650	2800	2800					
STRESS RATIO (R)	← R= + 0.10 →									
MAXIMUM FATIGUE LOAD POUNDS	1680	1560	1680	1650	1700	2610	2850	2750	2670	2630
SHIMMED BORON NET SECT. STRESS - KSI	22	22	22	22	22	35	37	36	36	36
CYCLE RATE - CPM	1700	1600	1575	1675	1650	600	600	420	600	600
FATIGUE LIFE CYCLES x 10^{-3}	1855	6925	4500	1000	1450	5.02	0.13	0.80	0.45	0.80
JOINT STIFFNESS (LBS/IN/IN WIDTH)10^{-3}										
FAILURE LOCATION										
FAILURE MODE	T	(1)	(1)	S	T	T	S	S	S	T

NOTES: (1) No Failure, Test Discontinued
(2) Thermocouple Malfunction

PHASE I - MECHANICAL JOINTS - CONFIGURATION E - DWG. NO. 7226-1302IE-1A

SPECIMEN NO. IE	611F01	611F02	611F03	611F04	611F05	611F06	611F07
DWG. NO. 7226-1302IE	1A08	1A16	1A36	1A35	1A30	1A43	1A53
TYPE OF TEST	FATIGUE - BLOCK SPECTRUM						
R. T. RANGE °F	69/76	70/76	69/79	68/76	70/79	70	70
SPEC. TEMP. RISE DURING TEST °F	4	4	6	4	3	2	3
STRAP MATERIAL	8-PLY BORON, 0°/±45° + TWO TITANIUM SHIMS						
SPLICE PLATE MATL.	TITANIUM 8AL-1MO-1V						
STRAP MATERIAL	TITANIUM 8AL-1MO-1V						
JOINT SEALANT	STM 40-111-B2						
SPECIMEN LENGTH - IN.	18.0						
BORON STRAP WIDTH - IN	.998	1.001	1.002	1.001	1.002	1.002	1.000
TI. STRAP WIDTH - IN.	1.003	.998	1.000	.999	.999	1.000	.999
SPLICE PLATE WIDTH - IN	1.000	.998	.999	.998	.999	.999	.999
BORON STRAP THICK. - IN	.048	.045	.048	.047	.048	.047	.046
SHIMMED SECT. THICK-IN	.094	.092	.093	.094	.093	.091	.094
TI. STRAP THICK - IN.	.126	.126	.127	.125	.125	.126	.126
SPLICE PLATE THICK-IN	0.126						
FASTENER HOLE DIAMETER - IN	0.188						
SHIMMED BORON NET SECT. AREA - IN²	.0761	.0748	.0757	.0764	.0757	.0741	.0763
SPECTRUM NO.	4	5	5	4	5	4 (2)	4 (2)
FAILURE BLOCK NO.	7	1	3	34 (1)	1	1	3
FAILURE LOAD NO.	18	18	18	14 (1)	18	18	18
FAILURE LOAD IN 'g's	8	8	8	5 (1)	8	8	8
NO. OF CYCLES IN LAST LOAD LEVEL	30	1	1	500	10	7	45
TOTAL NO. OF CYCLES (3)	123204	17551	52759	594331	17560	6479	19566
FAILURE LOCATION							
FAILURE MODE	T	T	S	(1)	S	S	T

NOTES: (1) No Failure, Test Discontinued.
(2) An Abbreviated Version Of Spectrum No. 4 Was Used, Load Number 6 Thru 13 Were Omitted.
(3) Does Not Include Previous Load History, See Table Above.

PREVIOUS LOAD HISTORY

SPECIMEN	SPECTRUM NO. 1			SPECTRUM NO. 2			SPECTRUM NO. 3			TOTAL
NO.	NO. OF BLOCKS	LAST LOAD NO.	CYCLES	NO. OF BLOCKS	LAST LOAD NO.	CYCLES	NO. OF BLOCKS	LAST LOAD NO.	CYCLES	CYCLES
IE611F01	1	19	17595	-	-	-	16	13	277059	294654
IE611F02	10	2	352080	-	-	-	-	-	-	352080
IE611F03	11	8	352538	96	15	1675279	-	-	-	2027817
IE611F04	1	19	17595	-	-	-	-	-	-	17595
IE611F05	1	19	17595	-	-	-	-	-	-	17595

PHASE I - MECHANICAL JOINTS - CONFIGURATION E - DWG. NO. 7226-1302IE-1A

SPECIMEN NO. IE	611G02	611G03	611G04	611G05	611G06
DWG. NO. 7226-1302IE	1A47	1A26	1A55	1A60	1A49
TYPE OF TEST	FATIGUE - REALISTIC SPECTRUM				
R.T. RANGE °F	73/74	72/73	72	72/73	71/73
SPEC. TEMP. RISE DURING TEST °F	0	0	1	0	0
STRAP MATERIAL	8-PLY BORON 0°/+45° 2 TI. SHIMS				
SPLICE PLATE MATL.	TITANIUM 6AL-1MO-1V				
STRAP MATERIAL	TITANIUM 8AL-1MO-1V				
JOINT SEALANT	STM40-111-B2				
SPECIMEN LENGTH - IN.	18.0				
BORON STRAP WIDTH - IN	.999	1.001	1.000	.999	.999
TI. STRAP WIDTH - IN.	.998	.999	1.000	.997	.998
SPLICE PLATE WIDTH IN	.997	.999	.999	1.000	.997
BORON STRAP THICK -IN	.046	.046	.047	.047	.046
SHIMMED SECT. THICK-IN	.091	.091	.090	.091	.091
TI. STRAP THICK - IN.	.127	.126	.126	.126	.129
SPLICE PLATE THICK IN	0.126				
FASTENER HOLE DIA. IN	0.188				
SHIMMED BORON NET SECT. AREA - IN.^{2}	.0738	.0740	.0731	.0738	.0738
FAILURE OCCURRED DURING					
MISSION TYPE NO.	4	4	4	4	2
TEST SEQUENCE NO. (TABLES 33 (1))	1157	1815	5	710	1660
CYCLIC SEQUENCE NO. (TABLES 27-31 (1))	21	21	56	21	55
LOAD LEVEL IN 'g's	8	8	8	8	8
ACTUAL FAILING LOAD - POUNDS	2650	2870	2670	2880	2750
FAILURE LOCATION & FAILURE MODE	S	S	S	T	S

LOAD NO.	LOAD LEVEL 'g'	LOAD (LBS.)	LOAD TIME (SEC.)
1	-3.6	-1300	0.3
2	-3.2	-1150	0.2
3	-2.8	-1010	0.1
4	-2.4	-865	0.3
5	-2.0	-720	0.2
6	-1.6	-575	0.1
7	-1.2	-430	0.3
8	-1.0	-360	0.2
9	-0.8	-290	0.1
10	-0.4	-145	0.3
11	0	0	0.2
12	1.0	360	0.1
13	2.56	920	0.3
14	3.0	1080	0.2
15	4.0	1440	0.1
16	5.0	1800	0.3
17	6.0	2160	0.2
18	7.0	2520	0.1
19	8.0	2870	0.4
20	8.0	2880	0.4
21	8.0	2880	0.4
22 (2)	0	0	2.0

NOTES: (1) Tables In AFFDL-TR-71-44.
(2) This Load Level Was Added For Testing Convenience Only.

PHASE I - MECHANICAL JOINTS - CONFIGURATION E - DWG. NO. 7226-13021E-1A SPECTRUM LOAD DETAILS

LOAD NO.	CYCLIC RATE CPS.	SPECTRUM NO. 1, 1 'g' = 260 LBS, LOAD MIN.	SPECTRUM NO. 1, LBS MAX	SPECTRUM NO. 2, 1 'g' = 300 LBS, LOAD MIN.	SPECTRUM NO. 2, LBS MAX	NO. OF CYCLES, BLOCK NO. 1	NO. OF CYCLES, BLOCK NO. 2(1)
1	1	-935	260	-1080	300	1	-
2	1	-830	260	-960	300	1	1
3	1	-730	260	-840	300	4	4
4	1	-625	260	-720	300	8	8
5	1	-520	260	-600	300	11	11
6	1	-415	260	-480	300	15	15
7	5	-310	260	-360	300	18	18
8	10	-260	260	-300	300	400	400
9	5	-210	260	-240	300	34	35
10	5	-105	260	-120	300	76	76
11	5	0	260	0	300	233	234
12	10	260	665	300	710	3802	3803
13	10	260	780	300	900	6500	6500
14	10	260	1040	300	1200	3600	3600
15	10	260	1300	300	1500	1800	1800
16	10	260	1560	300	1800	810	810
17	5	260	1820	300	2100	237	237
18	5	260	2080	300	2400	44	45
19	1	260	2340	300	2700	7	8
20	1	260	2600	300	3000	1	1
			TOTAL	CYCLES/BLOCK		17602	17606

LOAD NO.	CYCLIC RATE CPS.	SPECTRUM NO. 3, 1 'g' = 340 LBS, LOAD MIN.	SPECTRUM NO. 3, LBS MAX	SPECTRUM NO. 4, 1 'g' = 360 LBS, LOAD MIN.	SPECTRUM NO. 4, LBS MAX	SPECTRUM NO. 5, 1 'g' = 375 LBS, LOAD MIN.	SPECTRUM NO. 5, LBS MAX	NO. OF CYCLES, BLOCK NO. 1	NO. OF CYCLES, BLOCK NO. 2(1)
1	1	-1225	340	-1300	360	-1350	375	1	-
2	1	-1090	340	-1150	360	-1200	375	1	1
3	1	-950	340	-1010	360	-1050	375	4	4
4	1	-815	340	-865	360	-900	375	8	8
5	1	-680	340	-720	360	-750	375	11	11
6	1	-545	340	-575	360	-600	375	15	15
7	5	-410	340	-430	360	-450	375	18	18
8	10	-340	340	-360	360	-375	375	400	400
9	5	-270	340	-290	360	-300	375	34	35
10	5	-135	340	-145	360	-150	375	76	76
11	5	0	340	0	360	0	375	233	234
12	10	340	870	360	920	375	960	3802	3803
13	10	340	1020	360	1080	375	1125	6500	6500
14	10	340	1360	360	1440	375	1500	3600	3600
15	10	340	1700	360	1800	375	1875	1800	1800
16	10	340	2040	360	2160	375	2250	810	810
17	5	340	2380	360	2520	375	2625	237	237
18	1	340	2720	360	2880	375	3000	53	53
					TOTAL	CYCLES/BLOCK		17603	17605

(1) Block Number 2 was applied in the reverse order of Block Number 1; Number 3 was a repeat of Number 1, and Number 4 was a repeat of Number 2, etc.

PHASE I - MECHANICAL JOINTS - CONFIGURATION E - DWG. NO. 7226-1302IE-3B & 1B

SPECIMEN NO. IE	122D01	122D02	122D03	122A01	122A02	122A03	122A04	122A05	122A06	122A07	122A08	122A09	122A10	112D01	112D02	112D03
DWG. NO. 7226-1302IE	3B03	3B07	3B12	3B01	3B02	3B04	3B05	3B06	3B09	3B10	3B11	3B13	3B14	1B02	1B05	1B08
TYPE OF TEST	← STATIC-TENSILE →			← FATIGUE - BASELINE DATA →										← STATIC-TENSILE →		
R.T. RANGE °F	74	74	74	74/75	72/74	74	74	74/75	74/75	72/74	70/71	72	72/73	74	74	74
SPEC. TEMP. RISE DURING TEST °F	-	-	-	2	22	0	12	21	8	4	14	20	18	-	-	-
STRAP MATERIAL	← 8-PLY BORON 0° WITH TWO TITANIUM SHIMS →													← 8-PLY BORON 0°/±45° + TWO TITANIUM SHIMS		
SPLICE PLATE MATERIAL	← 8-PLY BORON 0° WITH TWO TITANIUM SHIMS →													← 8-PLY BORON 0°/±45° + TWO TITANIUM SHIMS		
STRAP MATERIAL	← TITANIUM 8Al-1Mo-1V →															
JOINT SEALANT	← STM 40-111-B2 →															
SPEC. LENGTH - IN.	← 18.0 →															
BORON STRAP WIDTH - IN	1.002	1.003	.999	1.004	1.003	1.003	1.002	1.003	1.005	1.005	1.003	.999	.995	.999	.999	.999
TI. STRAP WIDTH - IN.	.995	.999	1.001	1.005	.998	1.000	.998	.995	1.001	.999	.999	1.001	1.000	.995	1.001	1.000
SPLICE PLATE WIDTH - IN	.997	.997	.998	1.004	.999	1.004	.998	.994	1.002	.999	.998	.998	1.001	1.001	1.000	.998
BORON STRAP THICK - IN.	.046	.045	.045	.045	.046	.045	.043	.045	.045	.045	.045	.045	.045	.047	.047	.048
SHIMMED SECT. THICK IN	.088	.089	.091	.088	.088	.088	.086	.089	.090	.090	.091	.091	.091	.096	.095	.094
TI. STRAP THICK - IN.	.127	.127	.128	.127	.126	.127	.126	.125	.128	.127	.133	.127	.124	.127	.128	.125
SPLICE PLATE THICK. IN.	.097	.094	.095	.097	.097	.097	.097	.097	.099	.095	.097	.096	.098	.094	.094	.093
FASTENER HOLE DIA. IN.	← 0.188 →															
SHIMMED BORON NET SECT. AREA - IN.^{2}	.0716	.0725	.0738	.0718	.0717	.0717	.0700	.0725	.0735	.0735	.0741	.0738	.0734	.0779	.0770	.0762
JOINT ULTIMATE LOAD - POUNDS	3030	2990	3090											2990	3030	3040
STRESS RATIO (R)				← R = +0.10 →												
MAX. LOAD POUNDS				2150	2140	1800	2090	1820	1760	1760	2210	1770	2220			
SHIMMED BORON NET SECTION STRESS - KSI	42	41	42	30	30	25	30	25	24	24	30	24	30	38	39	40
CYCLE RATE - CPM				1700	1700	1700	1800	1800	1800	1600	1700	1700	1680			
FATIGUE LIFE CYCLES X 10^{-3}				25	249	22	39	83	392	256	14	10	37			
JOINT STIFFNESS (LBS/IN/IN WIDTH)10^{-3}	139	140	137											126	130	135
FAILURE LOCATION AND FAILURE MODE	W	W	W	W	V	W	V	V	V	V	W	W	V	W	W	W

W = Fastener head pull-thru in boron laminate.

V = Fastener head pull-thru and net section failure of boron laminate fastener hole.

U = Net section failure of splice plate at fastener hole.

T = Net section failure of boron at fastener hole.

S = Boron laminate failure at edge of shim build-up.

PHASE I - MECHANICAL JOINTS - CONFIGURATION E - DWG. NO. 7226-1302IE-5A & 1B

SPECIMEN NO. IE	211D01	211D05	211A01	211A02	211A03	211A04	211A05		211D03		211B01	211B02	211B03	211B04	211B05	112A01	112A02	112A03	112A04	112A05
DWG. NO. 7226-1302IE	5A01	5A14	5A03	5A05	5A12	5A04	5A11		5A08		5A02	5A06	5A09	5A10	5A13	1B01	1B04	1B06	1B07	1B09
TYPE OF TEST	STATIC TENSILE		FATIGUE-STACKING ORDER						COMPRESSION STATIC		FATIGUE-STACKING ORDER					FATIGUE BASELINE DATA				
R. T. RANGE °F	72	72	73/77	71/77	73/74	74	72/76		74		66/67	70/79	73/74	70/72	70/72	74/77	74/78	74	76/78	72/73
SPEC. TEMP. RISE																				
DURING TEST °F	-	-	3	1	1	1	2		—		2	9	12	7	0	20	26	2	13	1
STRAP MATERIAL	8-PLY BORON, 0°/±45° + TWO TITANIUM SHIMS															8-PLY BORON, 0°/± 45° + TWO TITANIUM SHIMS				
SPLICE PLATE MATERIAL	TITANIUM 8Al-1Mo-1V																			
STRAP MATERIAL	TITANIUM 8Al-1Mo-1V																			
JOINT SEALANT	STM 40-111-B2																			
SPEC. LENGTH - IN.	18.0																			
BORON STRAP WIDTH - IN.	1.003	1.001	1.006	.999	1.002	1.001	1.001		1.003		1.006	.998	.995	1.001	1.000	.999	.999	1.001	.998	.999
TI. STRAP WIDTH - IN.	.999	.996	1.000	1.001	.999	.996	1.000		1.000		1.001	1.002	.998	.997	.997	.997	.999	.996	1.000	1.000
SPLICE PLATE WIDTH IN.	.997	.998	.994	.999	1.000	1.001	.998		.999		.999	.999	.994	1.000	.998	.999	1.000	.999	.999	.999
BORON STRAP THICK - IN.	.046	.046	.046	.044	.046	.046	.046		.046		.045	.045	.045	.046	.045	.046	.048	.047	.047	.046
SHIMMED SECT. THICK IN	.065	.066	.065	.066	.066	.065	.066		.066		.066	.065	.065	.066	.065	.096	.096	.096	.095	.093
TI. STRAP THICK - IN.	.127	.126	.128	.127	.125	.126	.123		.127		.127	.127	.128	.127	.126	.127	.128	.126	.127	.123
SPLICE PLATE THICK IN.	0.126															.094	.094	.094	.094	.094
FASTENER HOLE DIA. IN.	0.188																			
SHIMMED BORON NET SECTION AREA - IN^2	.0530	.0537	.0532	.0535	.0537	.0528	.0537		.0538		.0540	.0526	.0525	.0537	.0528	.0779	.0779	.0780	.0770	.0754
JOINT ULTIMATE																				
LOAD - POUNDS	1725	1790							3060											
STRESS RATIO (R)			R = +0.10								R = -1.0					R = +0.1				
MAX. LOAD POUNDS			1060	1070	1180	1160	1180				1190	1160	1260	1180	1160	1710	1710	1720	1690	1660
SHIMMED BORON NET SECTION STRESS - KSI	33	33	20	20	22	22	22		57		22	22	24	22	22	22	22	22	22	22
CYCLE RATE - CPM			1600	1550	1550	1575	1500				300	600	300/600	300/600	600	1600	1700	1650	1650	1650
FATIGUE LIFE																				
CYCLES X 10^{-3}			2000	2000	75	70	2200				2.1	733.4	124.6	31.7	1009	460	1181	1090	71	541
JOINT STIFFNESS																				
(LBS/IN/IN WIDTH)10^{-3}	285	255							268											
FAILURE LOCATION																				
AND FAILURE MODE	T	T	(1)	(1)	T	T	T		X		X	Q	X	T	(1)	U	U/T	U	W	U

(1) = No failure, test discontinued.

PHASE I - MECHANICAL JOINTS - CONFIGURATION E - DWG. NO. 7226-1302IE-7A, 9A

SPECIMEN NO. IE	311D01	311D02	311D03	311A01	311A02	311A03	311A04	311A05	321D01	321D02	321D03	321A01	321A02	321A03	321A04	321A05	321A06
DRWG. NO. 7226-1302IE	7A02	7A05	7A08	7A01	7A03	7A06	7A07	7A09	9A02	9A05	9A08	9A01	9A04	9A06	9A07	9A09	9A03
TYPE OF TEST	STATIC-TENSILE			FATIGUE-EDGE DISTANCE					STATIC-TENSILE			FATIGUE-EDGE DISTANCE					
R.T. RANGE °F	74	74	74	74/77	71/79	70/76	76/81	74/76	74	74	74	74/78	71/81	-	70/72	70/72	76/78
SPEC. TEMP. RISE DURING TEST °F	-	-	-	1	10	20	14	9	-	-	-	0	5	-	7	4	0
STRAP MATERIAL	8-PLY BORON 0°/±45° + TWO TITANIUM SHIMS								8-PLY BORON 0°/±45° + TWO ±45° BORON SHIMS								
SPLICE PLATE MATERIAL	TITANIUM 8Al-1Mo-1V																
STRAP MATERIAL	TITANIUM 8Al-1Mo-1V																
JOINT SEALANT	STM 40-112-B2																
SPEC. LENGTH - IN.	18.0																
BORON STRAP WIDTH - IN	.997	1.000	1.000	.999	.998	1.000	1.000	.999	1.000	1.002	.999	1.002	1.002	1.003	1.000	.997	1.001
TI. STRAP WIDTH - IN.	1.000	1.004	1.000	.999	1.005	1.001	.999	.999	.999	.999	.999	.999	.998	1.002	.997	.995	.999
SPLICE PLATE WIDTH IN	.997	.993	.993	.996	.994	.994	.997	.998	.993	.993	.993	.997	.993	.993	.994	.994	.994
BORON STRAP THICK - IN	.046	.046	.047	.046	.046	.047	.047	.047	.044	.044	.045	.045	.045	.044	.045	.044	.046
SHIMMED SECTION THICK	.093	.093	.093	.094	.091	.093	.093	.093	.066	.064	.066	.066	.066	.066	.066	.066	.066
TI. STRAP THICK - IN	.128	.127	.126	.126	.127	.127	.127	.127	.126	.127	.128	.127	.127	.125	.126	.126	.127
SPLICE PLATE THICK IN	.126	.126	.126	.126	.126	.126	.126	.126	.126	.126	.126	.126	.126	.126	.126	.126	.126
FASTENER HOLE DIA. IN.	0.188																
SHIMMED BORON NET SECTION AREA - $IN.^2$	.0753	.0755	.0755	.0762	.0737	.0755	.0755	.0754	.0536	.0521	.0535	.0537	.0537	.0538	.0536	.0534	.0537
JOINT ULTIMATE LOAD - POUNDS	3390	2920	2890						1410	1520	1550						
STRESS RATIO (R)				R = + 0.10								R = + 0.10					
MAX. LOAD POUNDS				1220	1180	1280	1280	1280				910	910	(2)	1020	1070	1070
SHIMMED BORON NET SECTION STRESS KSI	45	39	38	16	16	17	17	17	26	29	29	17	17		19	20	20
CYCLE RATE - CPM				1550	1800	1800	1675	1550				1700	1725		1550	1500	1525
FATIGUE LIFE CYCLES X 10^{-3}				785	10650	13840	3310	752				10450	16460	(2)	1688	733	75
JOINT STIFFNESS (LBS/IN/IN WIDTH)10^{-3}	196	194	178						151	157	195						
FAILURE LOCATION AND FAILURE MODE	S	S	S	Z	(1)	(1)	Z	Z	X	X	X	(1)	(1)	(2)	Z	Z	Z

NOTES: (1) No failure, test discontinued.
(2) Specimen failed on loading.

PHASE I - MECHANICAL JOINTS CONFIGURATIONS E - DWG. NO. 7226-1302IE-11A & 13A

SPECIMEN NO. IE	411D01	411D02	411D03	411A01	411A02	411A03	411A04	411A05	421D01	421D02	421D03	421A01	421A02	421A03	421A04	421A05
DWG. NO. 7226-1302IE	11A02	11A05	11A08	11A01	11A03	11A04	11A06	11A09	13A02	13A05	13A08	13A01	13A03	13A04	13A06	13A09
TYPE OF TEST	←STATIC TENSILE→			←FATIGUE-THICKNESS EFFECTS→					←STATIC TENSILE→			←FATIGUE-THICKNESS EFFECTS→				
R.T. RANGE °F	74	74	74	73	72	72	72	74	74	74	74	74	72	72	72/76	72
SPEC. TEMP. RISE DURING TEST °F	-	-	-	5	6	2	12	12	-	-	-	-	6	3	4	4
STRAP MATERIAL	←16-PLY BORON 0°/±45° + FOUR TITANIUM SHIMS→								16-PLY BORON 0°/±45° + FOUR ±45° BORON SHIMS→							
SPLICE PLATE MATERIAL	←Ti-8AL-1MO-1V→															
STRAP MATERIAL	←Ti-8AL-1MO-1V→															
JOINT SEALANT	←STM40-111-B2→															
LENGTH - IN.	←18.0→															
BORON STRAP WIDTH - IN	1.008	1.005	1.008	1.005	1.007	1.004	1.005	1.007	1.004	1.006	1.005	1.007	1.004	1.008	1.009	1.005
TI. STRAP WIDTH - IN.	1.000	1.003	1.002	.999	1.003	1.001	1.001	1.000	.999	1.002	1.001	1.000	1.001	.999	.998	1.000
SPLICE PLATE WIDTH - IN	.999	.990	1.002	.997	1.000	.998	.998	.998	.998	.998	.999	1.001	1.003	1.002	1.001	.994
BORON STRAP THICK - IN	.085	.085	.085	.085	.085	.085	.085	.085	.083	.083	.083	.083	.083	.084	.083	.084
SHIMMED SECTION THICK IN	.170	.169	.170	.171	.170	.170	.170	.168	.124	.125	.123	.123	.123	.123	.123	.123
TI. STRAP THICK - IN.	.239	.240	.244	.242	.243	.241	.239	.243	.243	.239	.243	.243	.241	.242	.242	.239
SPLICE PLATE THICK - IN	←0.242→															
FASTENER HOLE DIA. IN.	←0.188→															
SHIMMED BORON NET SECTION AREA - IN^2	.139	.138	.139	.140	.139	.139	.139	.138	.101	.102	.100	.101	.100	.101	.101	.100
JOINT ULTIMATE LOADS - POUNDS	6250	6250	6150						2825	2620	2360					
STRESS RATIO (R)				←R = +0.10→								←R = + 0.10→				
MAX. LOAD POUNDS				3070	3060	3050	3060	3030				2215	2210	2220	2220	2210
SHIMMED BORON NET SECTION STRESS - KSI	45	45	44	22	22	22	22	22	28	26	24	22	22	22	22	22
CYCLE RATE - CPM				1800	1600	1600	1800	1750				1750	1800	1700	1800	1725
FATIGUE LIFE CYCLES X 10^{-3}				187	132	116	243	70				20	842	12	1131	28
JOINT STIFFNESS $(LBS/IN/IN\ WIDTH)10^{-3}$	242	244	239						250	247	269					
FAILURE LOCATION AND FAILURE MODE	R	R	R	U	U	U	U	R	X	X	X	T	T	T	U	T

R = Fastener shear failure on boron side of joint.

LOCKHEED-GEORGIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

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PHASE I - MECHANICAL JOINTS CONFIGURATION E - DWG. NO. 7226-13021E-15A & 17A

SPECIMEN NO. IE	711D01	711D02	711D03	711A01	711A02	711A03	711A04	711A06	721D01	721D02	721D03	721A01	721A02	721A03	721A04	721A05
DWG. NO. 7226-13021E	15A02	15A05	15A08	15A01	15A03	15A06	15A07	15A04	17A02	17A05	17A08	17A01	17A03	17A04	17A07	17A09
TYPE OF TEST		STATIC			FATIGUE - PIN BEARING				STATIC			FATIGUE - PIN BEARING				
R. T. RANGE °F	86	86	86	84	84	79	79	76	77	77	77	76	76	78	76	78
SPEC. TEMP. RISE																
DURING TEST °F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
COUPON MATERIAL				8-PLY	BORON	0°/±45°	WITH TWO TITANIUM SHIM INSERTS									
SPECIMEN DIMENSIONS																
LENGTH - IN.							9.0									
AVG. WIDTH - IN.	.999	.999	.995	.996	1.000	.997	.996	.999	.997	1.002	1.003	.997	1.003	1.002	1.002	1.004
COUPON THICK. - IN.	.0474	.0466	.0473	.0469	.0472	.0473	.0476	.0471	.0474	.0478	.0481	.0473	.0474	.0477	.0476	.0462
SHIMMED SECTION																
THICK. - IN.	.0942	.0952	.0963	.0943	.0946	.0962	.0962	.0946	.0946	.0957	.0961	.0957	.0952	.0955	.0961	.0947
PIN HOLE DIAM. - IN.	.1882	.1909	.1882	.1900	.1924	.1887	.1883	.1880	.1920	.1920	.1894	.1910	.1895	.1878	.1897	.1888
EDGE DISTANCE - IN.	.3753	.3804	.3770	.3796	.3808	.3709	.3731	.3729	.2721	.2762	.2715	.2711	.2706	.2681	.2752	.2751
PIN BEARING AREA - IN^2	.0177	.0182	.0181	.0179	.0182	.0182	.0181	.0178	.0182	.0184	.0182	.0183	.0180	.0179	.0182	.0179
YIELD LOAD P_{BRY} - LBS.	2060	1900	1940						1340	1310	1350					
ULT. LOAD P_{BRU} - LBS.	2100	1980	1970						1425	1400	1420					
YIELD STRESS F_{BRY} - KSI	116	105	107						73.8	71.3	74.2					
ULT. STRESS F_{BRU} - KSI	118	109	109						78.5	76.2	78.0					
STRESS RATIO (R)					R = +0.10									R=+0.10		
MAX. LOAD POUNDS				1400	1200	1000	500	800				800	600	500	700	450
MAX. BEARING STRESS KSI				78.1	65.9	55.1	27.6	45.0				43.8	33.3	27.9	38.4	25.2
CYCLE RATE - CPM				1800	1600	1800	1525	1650				1680	1600	1600	1500	1500
FATIGUE LIFE																
CYCLES X 10^{-3}				20	29	45	12052	237				18	100	586	34	1046
FAILURE MODE	X	X	X	Z	Y	Z	(1)	Z	X	X	X	X	Z	X	Y	X

Z = Net Section Tensile Failure
Y = Net Section Tensile/Tear Out
X = Shear Failure From Hole.
(1) = No Failure, Test Discontinued.

PHASE I - MECHANICAL JOINTS CONFIGURATION E - DWG. NO. 7226-1302IE-19A

SPECIMEN NO. IE	731D01	731D02	731D03	731A01	731A02	731A04	731A05	731A06
DWG. NO. 7226-1302IE	19A02	19A05	19A08	19A01	19A03	19A06	19A09	19A07
TYPE OF TEST	← STATIC →			FATIGUE - PIN BEARING →				
R.T. RANGE °F	78	78	78	80	77	76	78	80
SPEC. TEMP. RISE								
DURING TEST °F	-	-	-	-	-	-	-	-
COUPON MATERIAL	← 8-PLY BORON 0°/±45° WITH TWO ±45° BORON INSERTS →							
SPECIMEN DIMENSIONS								
LENGTH - IN.	← 9.0 →							
AVG. WIDTH - IN.	1.002	1.003	1.001	1.006	1.002	1.003	1.003	1.003
COUPON THICK. - IN.	.0445	.0441	.0434	.0438	.0443	.0442	.0443	.0445
SHIMMED SECTION								
THICK. - IN.	.0651	.0638	.0643	.0638	.0655	.0643	.0664	.0643
PIN HOLE DIAMETER - IN.	.1896	.1907	.1886	.1891	.1896	.1907	.1910	.1874
EDGE DISTANCE - IN.	.3764	.3803	.3785	.3786	.3729	.3760	.3815	.3753
PIN BEARING AREA - IN.^{2}	.0123	.0122	.0121	.0121	.0124	.0123	.0127	.0121
YIELD LOAD P_{BRY} - LBS.	(1)	(1)	(1)					
ULT. LOAD P_{BRU} - LBS.	750	780	760					
YIELD STRESS F_{BRY} - KSI	(1)	(1)	(1)					
ULT. STRESS F_{BRU} - KSI	60.8	64.1	62.7					
STRESS RATIO (R)				← R = +0.10 →				
MAX. LOAD POUNDS				500	400	300	350	600
MAX. BEARING STRESS-KSI				41.5	32.2	24.5	27.6	49.8
CYCLE RATE - CPM				1500	1500	1550	1550	1550
FATIGUE LIFE								
CYCLES X 10^{-3}				39	125	3303	863	6
FAILURE MODE	X	X	X	X	X	X	X	X

NOTE: (1) Yield Unobtainable From Load - Deformation Curve.

PHASE II - MECHANICAL JOINTS - CONFIGURATION E - DWG. NO. 7226-1302IIE-1A

SPECIMEN NO. IIE	111D02	111D04	111D05	111D91	111D03	111D06	111A01	111A02	111A03	111A04	111A05	111A06	111A07	111A08	111A09	111A10
DWG. NO. 7226-1302IIE	1A07	1A18	1A24	1A04	1A10	1A27	1A01	1A05	1A08	1A12	1A16	1A20	1A21	1A23	1A25	1A28
TYPE OF TEST	STATIC TENSILE			STATIC COMPRESSION			FATIGUE-BASELINE DATA									
R. T. RANGE °F	73	74	74	74	74	74	70	70/72	70/71	69/70	70	68/71	70	72/74	70/71	72/74
SPEC. TEMP. RISE DURING TEST °F	-	-	-	-	-	-	10	8	5	4	5	3	7	6	6	4
STRAP MATERIAL	8-PLY BORON, 0°/±45° + TWO TITANIUM SHIMS															
SPLICE PLATE MATERIAL	TITANIUM 8AL-1MO-1V															
STRAP MATERIAL	TITANIUM 8AL-1MO-1V															
JOINT SEALANT	STM 40-112-B12															
SPECIMEN LENGTH - IN.	18.0															
BORON STRAP WIDTH - IN	1.966	1.964	1.965	1.962	1.971	1.970	2.001	1.999	1.998	2.002	1.999	2.000	1.999	2.000	1.999	2.000
TI. STRAP WIDTH - IN.	1.967	1.961	1.965	1.957	1.969	1.970	1.995	1.995	2.000	2.003	2.003	1.999	2.000	1.995	1.993	1.998
SPLICE PLATE WIDTH IN.	1.970	1.965	1.965	1.964	1.971	1.970	2.001	2.003	1.998	1.996	2.001	2.001	2.002	2.002	2.003	2.003
BORON STRAP THICK - IN	.044	.045	.043	.044	.044	.043	.043	.044	.044	.045	.045	.044	.044	.044	.043	.043
SHIMMED SECT. THICK IN	0.86	.090	.087	.086	.090	.086	.084	.086	.089	.090	.088	.090	.088	.087	.087	.086
TI. STRAP THICK - IN	.129	.130	.129	.130	.129	.128	.130	.129	.129	.129	.128	.131	.129	.131	.129	.130
SPLICE PLATE THICK - IN	0.125															
FASTENER HOLE DIA. - IN	0.188															
SHIMMED BORON NET SECT. AREA - IN^2	.137	.143	.138	.136	.144	.137	.137	.140	.144	.146	.143	.146	.143	.141	.141	.140
JOINT ULTIMATE LOAD - POUNDS	7700	7580	7180	8340	7160	7500										
STRESS RATIO (R)							R = +0.10									
MAX. LOAD POUNDS							4100	3070	4330	3220	4290	3220	4290	3110	4240	3080
SHIMMED BORON NET SECT. STRESS - KSI	56	53	52	61	50	55	30	22	30	22	30	22	30	22	30	22
CYCLE RATE - CPM							1600	1625	1626	1800	1700	1800	1800	1800	1625	1775
FATIGUE LIFE CYCLES X 10^{-3}							66	838	8	338	16	2035	36	1236	71	1872
JOINT STIFFNESS (LBS/IN/IN WIDTH)10^{-3}	333	333	337	382	390	411										
FAILURE LOCATION & FAILURE MODE	S	S	S	Q	Q	Q	T	T	T	T	T	T	T	T	T	T

PHASE II - MECHANICAL JOINTS, CONFIGURATION E - DWG. NO. 7226-1302IIE-1A

SPECIMEN NO. IIE	611F01	611F02	611F03	611F04	611F05
DWG. NO. 7226-1302IIE	1A02	1A06	1A11	1A17	1A22
TYPE OF TEST	← FATIGUE-BLOCK SPECTRUM →				
R. T. RANGE °F	71	70/72	72	72/73	70
SPEC. TEMP. RISE DURING TEST °F	4	4	5	5	3
STRAP MATERIAL	← 8-PLY BORON, 0°/±45° + 2 TITANIUM SHIMS				
SPLICE PLATE MATERIAL	← TITANIUM 8AL-1MO-1V →				
STRAP MATERIAL	← TITANIUM 8AL-1MO-1V →				
JOINT SEALANT	← STM 40-112-B12 →				
SPECIMEN LENGTH - IN.	← 18.0 →				
BORON STRAP WIDTH - IN.	1.961	1.966	1.971	1.966	1.967
TI. STRAP WIDTH - IN.	1.960	1.965	1.969	1.965	1.966
SPLICE RATE WIDTH - IN.	1.960	1.966	1.970	1.966	1.967
BORON STRAP THICK - IN.	.044	.043	.044	.045	.044
SHIMMED SECT. THICK IN.	.084	.086	.090	.090	.087
TI. STRAP THICK - IN.	.128	.128	.130	.131	.130
SPLICE PLATE THICK - IN.	← 0.125 →				
FASTENER HOLE DIA. - IN.	← 0.188 →				
SHIMMED BORON NET SECTION AREA - IN^2	.133	.137	.144	.143	.138
FAILURE BLOCK NO.	3	12	9	9	13
FAILURE LOAD NO.	10	10	10	10	10
FAILURE LOAD IN 'g's	8	8	8	8	8
NO. OF CYCLES IN LAST LOAD LEVEL	44	25	1	25	1
TOTAL NO. OF CYCLES	19565	71795	58668	58692	84767
FAILURE LOCATION AND FAILURE MODE	S	T	T	T	S

LOAD NO.	CYCLIC RATE CPS	"g" VALUE MIN	"g" VALUE MAX	BLOCK NO. 1 LOAD MIN	BLOCK NO. 1 POUNDS MAX	BLOCK NO. 1 NO. OF CYCLES	BLOCK NO. 2 LOAD MIN	BLOCK NO. 2 POUNDS MAX	BLOCK NO. 2 NO. OF CYCLES
1	1	-3.6	1.0	-2480	690	1	-	-	-
2	1	-3.2	1.0	-2210	690	1	-2210	690	1
3	1	-2.8	1.0	-1930	690	4	-1930	690	4
4	1	-2.4	1.0	-1660	690	8	-1660	690	8
5	1	-2.0	1.0	-1380	690	11	-1380	690	11
6	10	1.0	4.0	690	2760	3600	690	2760	3600
7	10	1.0	5.0	690	3450	1800	690	3450	1800
8	10	1.0	6.0	690	4140	810	690	4140	810
9	5	1.0	7.0	690	4830	237	690	4830	237
10	1	1.0	8.0	690	5520	53	690	5520	53
		TOTAL CYCLES/BLOCK				6525			6524

PHASE II - MECHANICAL JOINTS, CONFIGURATION E - DWG. NO. 7226-1302IIE-1A

SPECIMEN NO. IIE	611G01	611G02	611G03	611G04	611G05
DWG. NO. 7226-1302IIE	1A03	1A09	1A13	1A19	1A26
TYPE OF TEST	FATIGUE-REALISTIC SPECTRUM				
R. T. RANGE °F	71/72	71/74	71/72	72	73/74
SPEC. TEMP. RISE DURING TEST °F	2	1	2	1	2
STRAP MATERIAL	8-PLY BORON 0/±45°+2 TITANIUM SHIMS				
SPLICE PLATE MATERIAL	TITANIUM 8AL-1MO-1V				
STRAP MATERIAL	TITANIUM 8AL-1MO-1V				
JOINT SEALANT	STM 40-111-B12				
SPECIMEN LENGTH - IN.	18.0				
BORON STRAP WIDTH - IN	1.966	1.967	1.963	1.964	1.971
TI. STRAP WIDTH - IN.	1.966	1.965	1.962	1.963	1.970
SPLICE PLATE WIDTH IN.	1.967	1.968	1.965	1.964	1.972
BORON STRAP THICK - IN.	.043	.044	.044	.044	.044
SHIMMED SECT. THICK IN.	.084	.089	.090	.090	.087
TI. STRAP THICK - IN.	.131	.129	.128	.129	.131
SPLICE PLATE THICK - IN	0.125				
FASTENER HOLE DIA. IN.	0.188				
SHIMMED BORON NET SECTION AREA - IN^2	.137	.142	.143	.143	.139
FAILURE OCCURRED DURING MISSION TYPE NO	2	4	4	4	4
TEST SEQUENCE NO. (TABLES 33 (1))	1854	810	1703	810	1830
CYCLIC SEQUENCE NO. TABLES (27-31 (1))	48	21	21	21	21
LOAD LEVEL IN 'g's	5	8	8	8	8
ACTUAL FAILING LOAD - POUNDS	3600	5800	5820	5800	5620
FAILURE LOCATION & FAILURE MODE	T	S	T	S	T

LOAD NO.	LOAD LEVEL 'g'	LOAD LBS	LOAD TIME (SEC)
1	-3.6	-2590	0.3
2	-3.2	-2300	0.2
3	-2.8	-2020	0.1
4	-2.4	-1730	0.3
5	-2.0	-1440	0.2
6	-1.6	-1150	0.1
7	-1.2	-860	0.3
8	-1.0	-720	0.2
9	-0.8	-580	0.1
10	-0.4	-290	0.3
11	0	0	0.2
12	1.0	720	0.1
13	2.56	1840	0.3
14	3.0	2160	0.2
15	4.0	2880	0.1
16	5.0	3600	0.3
17	6.0	4320	0.2
18	7.0	5040	0.3
19	8.0	5740	0.4
20	8.0	5760	0.4
21	8.0	5760	0.4
22 (2)	0	0	2.0

NOTES: (1) Tables in AFFDL-TR-71-44
(2) This load level was added for testing convenience only.

PHASE I - MECHANICAL JOINTS - CONFIGURATION F - DWG. NO. 7226-1302IF-1A

SPECIMEN NO. IF	111D01	111D02	111D03	111A01	111A02	111A03	111A04	111A05	111A06	111A07	111A08	111A09	111A10	111A11
DWG. NO. 7226-1302IF	1A03	1A08	1A12	1A01	1A02	1A04	1A05	1A06	1A09	1A10	1A11	1A13	1A14	1A07
TYPE OF TEST	←	STATIC	→	←			FATIGUE - BASELINE DATA							→
R. T. RANGE °F	75	77	76	78	70/73	69/70	70	71	70	70/71	69/70	70	70	70/73
SPEC. TEMP. RISE DURING TEST °F	-	-	-	1	10	6	8	8	10	9	6	6	6	6
STRAP MATERIAL	←			8-PLY BORON, 0°/±45° + TWO TITANIUM SHIMS										→
"T" MATERIAL	←					ALUMINUM 7075-T6								→
JOINT SEALANT	←					STM 40-112-B12								→
SPECIMEN DIMENSIONS LENGTH - IN.	←					18.0								→
BORON STRAP WIDTH - IN / "T" FLANGE WIDTH - IN / "T" STEM WIDTH - IN	1.001	1.005	1.003	1.002	1.004	1.002	1.003	1.004	1.004	1.002	1.003	1.002	1.003	1.002
BORON STRAP THICK - IN	.043	.043	.044	.043	.043	.043	.043	.044	.044	.043	.043	.043	.043	.044
SHIMMED SECT. THICK IN	.084	.085	.084	.084	.084	.084	.084	.084	.085	.085	.085	.084	.084	.084
"T" FLANGE THICK - IN	←					0.127								→
"T" STEM THICK - IN	.082	.082	.083	.083	.083	.083	.083	.083	.083	.083	.082	.082	.084	.082
FASTENER HOLE DIA. IN	←					0.188								→
SHIMMED BORON NET SECTION AREA - IN^2	.0638	.0694	.0685	.0684	.0685	.0684	.0685	.0685	.0694	.0692	.0693	.0684	.0685	.0684
STATIC AXIAL LOAD AT FAILURE - POUNDS	3780	4490	3800											
STATIC SIDE LOAD AT FAILURE - POUNDS	100	250	640											
STRESS RATIO (R)				←				R = ±0.10						→
MAXIMUM DYNAMIC AXIAL LOAD - POUNDS				3000	2740	2740	2740	2740	2780	2770	2770	2740	2740	2740
DYNAMIC AXIAL NET SECT. STRESS - KSI				44	40	40	40	40	40	40	40	40	40	40
DYNAMIC SIDE LOAD MAXIMUM - POUNDS				105	105	105	265	105	265	265	105	265	265	105
MINIMUM - POUNDS				95	95	95	235	95	235	235	95	235	235	95
CYCLE RATE - CPM				1400	1550	1550	1675	1550	1650	1675	1725	1675	1675	1675
FATIGUE LIFE CYCLES X 10^{-3}				18	355	390	19	40	17	25	180	18	17	253
FAILURE MODE	S	S	T	T	T	S	T	S	T	T	T	T	T	T

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PHASE I - MECHANICAL JOINTS - CONFIGURATION F - DWG. NO. 7226-1302IF-3A

SPECIMEN NO. IF	411D01	411D02	411D03	411A01	411A02	411A03	411A04	411A05
DWG. NO. 7226-1302IF	3A02	3A05	3A08	3A01	3A03	3A06	3A07	3A09
TYPE OF TEST	←	STATIC	→	←	FATIGUE-THICKNESS EFFECTS			→
R. T. RANGE °F	79	79	79	70/71	73/74	73	71	72
SPEC. TEMP. RISE DURING TEST °F	-	-	-	10	7	8	7	6
STRAP MATERIAL	←	16-PLY BORON, 0°/±45 + FOUR TITANIUM SHIMS						→
"T" MATERIAL	←		ALUMINUM 7075-T6					→
JOINT SEALANT	←		STM 40-112-B12					→
SPECIMEN DIMENSIONS								
LENGTH - IN.	←			18.0				→
BORON STRAP WIDTH - IN. "T" FLANGE WIDTH - IN. "T" STEM WIDTH - IN.	1.003	1.003	1.004	1.005	1.004	1.003	1.004	1.004
BORON STRAP THICK IN.	.084	.084	.084	.083	.084	.084	.084	.083
SHIMMED SECT. THICK IN	.170	.171	.170	.170	.170	.171	.170	.169
"T" FLANGE THICK - IN.	←				0.127			→
"T" STEM THICK - IN.	.083	.083	.083	.083	.083	.083	.083	.083
FASTENER HOLE DIAMETER - IN.	←				0.188			→
SHIMMED BORON NET SECTION AREA - IN²	.139	.139	.139	.139	.139	.139	.139	.138
STATIC AXIAL LOAD AT FAILURE - LBS.	8275	8275	6525					
STATIC SIDE LOAD AT FAILURE - POUNDS	200	500	1060					
STRESS RATIO (R)				←	R =	+0.10		→
MAXIMUM DYNAMIC AXIAL LOAD - POUNDS				4860	4850	4880	4850	4830
DYNAMIC AXIAL NET SECTION STRESS - KSI				35	35	35	35	35
DYNAMIC SIDE LOAD								
MAXIMUM - POUNDS				520	520	520	520	520
MINIMUM - POUNDS				480	480	480	480	480
CYCLE RATE - CPM				1500	1675	1675	1675	1650
FATIGUE LIFE CYCLES x 10^{-3}				54	30	35	39	28
FAILURE MODE	T	S	T	T	T	T	T	T

LOCKHEED-GEORGIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

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BONDED JOINT TESTS - GRAPHITE EPOXY ADHERENDS - CONFIGURATION A

Specimen No.	E1D01	E1D02	E1D03	E1A01	E1A02	E1A03	E1A04	E1A05	E1A06	E1A07	E1A08	E1A09	E1A10
DWG#7226-1302IA-G	3A	7A	12A	1A	2A	4A	5A	6A	9A	10A	11A	13A	14A
Type of Test		Static						Fatigue					
R.T.Range ^oF	76	76	76	76	73	76	70	70	72	76	70	72	72
Spec. Temp. Rise													
During Test	-	-	-	2	4	0	7	1	5	0	7	-	6
Adherend Matl.			Graphite Epoxy - 8 Ply $0^o/\pm 45^o$										
Splice Plate Matl.			Ti-6-4										
Adhesive			EA9601 - .045 Wt.										
Specimen Dimensions													
Length			Nominally 18.0 In.										
Width	1.004	1.004	1.010	1.003	1.004	1.005	1.004	1.004	1.003	1.006	1.012	1.016	1.017
Overlap Length													
Left Side	.74	.73	.74	.74	.74	.74	.74	.74	.74	.74	.75	.75	.75
Right Side	.75	.74	.74	.75	.75	.75	.74	.74	.74	.74	.73	.72	.73
Bondline Thick.(Mils)	4.0	4.5	3.5	3.0	4.0	3.0	4.0	5.0	4.0	4.0	5.0	4.0	4.0
Failure Side	L	L	R	R	R	L	R	R	R	R	R	L	R
Failure Area -IN.^{2}	.743	.733	.747	.742	.743	.744	.743	.743	.742	.744	.739	.732	.742
Ultimate Load													
Psu - Pounds	2840	3060	2820										
Ultimate Shear													
Fsu - Stress	3800	4200	3800										
Stress Ratio (R)						R = 0.1							
Max. Load Pounds				1480	1040	1490	1040	1410	1040	1490	1030	1390	1040
Max. Shear Stress				2000	1400	2000	1400	1900	1400	2000	1400	1900	1400
Cycle Rate - CPM				1800	1750	1700	1750	1800	1600	1700	1650	1800	1750
Fatigue Life													
Cycles X 10^{-3}				6	1623	3	1001	5	831	9	233	3	1002
Joint Stiffness													
(Lb./In.Width) 10^{-3}	304	301	286										

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BONDED JOINT TESTS - GLASS EPOXY ADHERENDS - CONFIGURATION A

Specimen No.	E2A01	E2A02	E2D01	E2A03	E2A04	E2A05	E2D02	E2A11	E2A06	E2A07	E2A08	E2D03	E2A09	E2A10
DWG. #7226-1302IA-FG	1A	2A	3A	4A	5A	6A	7A	8A	9A	10A	11A	12A	13A	14A
Type of Test	Fatigue	→	Static	←	Fatigue	→	Static	←	Fatigue	→	Static	←	Fatigue	→
R. T. Range °F	75	73	76	72	74	73	76	72	74	75	72	76	74	72
Spec. Temp. Rise														
During Test	3	9	-	15	13	10	-	2	15	1	3	-	10	10
Adherend Matl.	← S-Glass, Epoxy - 8 Ply 0°/± 45° →													
Splice Plate Matl.	← Ti-6-4 →													
Adhesive	← EA9601-.045 Wt. →													
Specimen Dimensions														
Length	← Nominally 18.0 In. →													
Width	1.009	1.005	1.008	1.005	1.006	1.006	1.007	1.007	1.007	1.007	1.008	1.009	1.006	1.027
Overlap Length														
Left Side	.75	.75	.75	.75	.75	.74	.74	.75	.74	.74	.74	.73	.73	.73
Right Side	.73	.73	.73	.73	.74	.74	.74	.73	.74	.75	.74	.75	.75	.75
Bondline Thick. (Mils)	3.5	3.5	3.2	3.7	4.0	4.7	3.5	3.5	4.5	4.7	4.0	4.5	4.2	3.5
Failure Side	L	L	R	R	R	R	R	R	R	R	R	R	R	R
Failure Area - IN.²	.737	.734	.736	.734	.744	.744	.745	.735	.745	.745	.748	.757	.734	.750
Ultimate Load														
Psu - Pounds			3330				3360					3650		
Ultimate Shear														
Fsu - Stress			4500				4500					4800		
Stress Ratio (R)	0.1	→	-	←	0.1	→		←	0.1		→	-	←	0.1 →
Max. Load Pounds	1470	1030	-	1470	1040	1490	-	1030	1040	1490	1040	-	1470	1050
Max. Shear Stress	2000	1400	-	2000	1400	2000	-	1400	1400	2000	1400	-	2000	1400
Cycle Rate - CPM	1550	1525	-	1600	1550	1600	-	1425	1525	1550	1425	-	1550	1600
Fatigue Life														
Cycles X 10^{-3}	5	230	-	52	526	75	-	1250	143	19	336	-	450	672
Joint Stiffness														
(Lb./In.Width) 10^{-3}			213				211							

FAILURE MODES - BONDED JOINTS

ADHESIVE EVALUATION TESTS

SPECIMEN NO.	TYPE AND PERCENTAGE OF FAILURE AREA: AM	C
V3C01	30	70
V3C02	40	60
V3C03	40	60
V3C04	30	70
V3C05	40	60
V3A01	10	90
V3A02	10	90
V3A03	20	80
V3A04	50	50
V3A05	10	90
V3A06	10	90
V3A07	20	80
V3A08	20	80
V3A09	30	70
V3A10	20	80
V3A11	10	90
V3A12	10	90
V3A13	10	90
V3A14	10	90
V3A15	20	80

A_M - Adhesive to metal failure

A_B - Adhesive to boron failure

C - Cohesive failure

I_B - Failure of resin to surface ply of boron

I_L - Interlaminar failure of boron composite

PHASE I - CONFIGURATION A - BASELINE DATA

SPECIMEN NO.	TYPE AND PERCENTAGE OF FAILURE AREA: A_M	A_B	C	I_B	I_L
IA111 B20					
IA111 C11					
111 C20					
111 D04					
111 D05					
111 D06		Failure Mode			
111 D01		not recorded			
111 D02					
111 D03					
511 D01					
511 D02					
511 D03					
511 D04					
511 D05	5	(50% Adherend)			45
511 D06	5				45
111 D11	Failure not recorded				
111 D10	10		20	70	
111 D07	Adherend Failure				
111 D08	40			60	
111 D09	10		10	70	10
111 A01				100	
111 A02	10			90	
111 A03				100	
111 A04	Splice Plate Failure				
111 A05				100	
111 A06	10			90	
111 A07				100	
111 A08	20			80	
111 A09				100	
111 A10	10			85	5
111 A11		10		90	
111 A12		10		90	
111 A13		100			
111 A14		Adherend Failure			
111 A15		Adherend Failure			

PHASE I - CONFIGURATION A - BASELINE DATA

SPECIMEN NO.	TYPE AND PERCENTAGE OF FAILURE AREA: A_M	A_B	C	I_B	I_L
111 A16		70	20	10	
111 A17	5			95	
111 A18	(30% Adherend)		50	20	
111 A21				90	10
111 A22	30			70	
111 B01		Failed on loading			
111 B02	10			90	
111 B03	Adherend Failure				
111 B04	50			50	
111 B05				90	10
111 B06			Splice Plate Failure		
111 B07	40		10	50	
111 B08	5			90	5
111 B09	60			40	
111 B10	60			40	
111 B21	90		10		
111 B22	30		40	10	20
111 B25	30		40	30	
111 B26	50			50	
111 B27				90	10
111 B28	5			85	10
111 B29	90			10	
111 B30	10		10	80	
111 B31	10			85	5
111 B32	10		10	80	
111 C01	Failure not recorded				
111 C02	5			55	40
111 C03		No failure			
111 C04	20			80	
111 C05		No failure			
111 C06		Failure not recorded			
111 C07		Failure not recorded			
111 C08	60		40		
111 C09	30		40	30	
111 C10			100		

FAILURE MODES - BONDED JOINTS

PHASE I - CONFIGURATION A - BASELINE DATA

SPECIMEN NO.	TYPE AND PERCENTAGE OF FAILURE AREA A_M	A_B	C	I_B	I_L
IA111C21					100
111C12	10	90			
111C13		Failed on loading			
111C14		90		10	
111C15	10	80		10	
111C16		80		20	
111C17	10	90			
111C18	10	90			
111C19	10	80		10	
111C22					100
111C23	60			40	
111C24	10			70	20
111C25	30		50	20	
111C26	10			80	10
111A23		Splice Plate Failure			
111A24	10			80	10
111B23	90			10	
111B24	20			70	10
PHASE I - CONF. A - DEGRADATION					
511A01				90	10
511A02	5			95	
511A03	10			80	10
511A04				30	70
511A05					100
511A06		Splice Plate Failure			
511A07				90	10
511A08	70	(30% Adherend)			
511A09	10			70	20
511A10	45			50	5
511C01		Adherend Failure			
511C02	30		20	50	
511C03		Adherend Failure			
511C04		Adherend Failure			

PHASE I - CONFIGURATION A - DEGRADATION

SPECIMEN NO.	TYPE AND PERCENTAGE OF FAILURE AREA A_M	A_B	C	I_B	I_L
511 C05		Adherend Failure			
511 C06		Adherend Failure			
511 C07		Adherend Failure			
511 C10	10		20	50	20
PHASE I - CONFIGURATION A - PRELOAD/LOW CYCLE					
811 A01				90	10
811 A02				100	
811 A03	10			90	
811 A06				60	40
811 A07				60	40
811 A08				100	
811 A04					100
811 A05				10	90
811 A09	(30% Adherend)			70	
811 A10	10			70	20
811 A11				70	30
811 A12	10			70	20
811 A13				90	10
811 A14	10			90	
511 A11				100	
511 A12	10			80	10
511 A13				100	
511 A14				50	50
511 A15				90	10
511 A16				100	
511 A17				100	
511 A18	40			60	
511 A19	40	(20% Adherend)		40	
511 C11		Adherend Failure			
511 C12	10		40	50	
511 D07		(20% Adherend)			80
511 D08		Adherend Failure			
511 D09		Adherend Failure			

PHASE I - CONFIGURATION A - SLOW CYCLIC RATE

SPECIMEN NO.	TYPE AND PERCENTAGE OF FAILURE AREA A_M	A_B	C	I_B	I_L
111 D12		(40% Adherend)		50	10
111 D13		Adherend Failure			
111 B33S	10			90	
111 B34S				100	
111 B35S				100	
111 B36S				100	
111 B37S				100	
111 B38S				100	
PHASE I - SPECTRUM					
711 F01		Adherend Failure			
711 F02		Adherend Failure			
711 F03		Adherend Failure			
711 F04		Adherend Failure			
711 F05	10			50	40
711 F06				90	10
711 F07	20			70	10
711 F08	10			80	10
711 F09		Adherend Failure			
711 F10		Adherend Failure			
711 F11	30			70	
711 G01				90	10
711 G02				90	10
711 G03	(20% Adherend)			80	
711 G04				90	10
711 G05	20			80	
711 G06		Adherend Failure			
711 G07				100	
711 G08		Adherend Failure			
711 G09				90	10
711 G10		Adherend Failure			

FAILURE MODES - BONDED JOINTS

PHASE I - CONFIGURATION A - BASELINE DATA					
SPECIMEN	TYPE AND PERCENTAGE OF FAILURE AREA				
NO.	A_M	A_B	C	I_B	I_L
IA113D01		(Splice Plate)			100
113D02			" "		100
113D03			" "		100
113D04			" "		100
113A01				50	50
113A02				90	10
113A03		Splice Plate Failure			
113A04				90	10
113A05				100	
113A06		30		70	
113A07		100			
113A08				100	
113A09		90			10
113A10		Failed on Loading			
113A11				100	
113A12				100	
113A13					100
113A14	5			95	
PHASE I - CONF. A - SECOND ADHESIVE					
IA613D01		Splice Plate Failure			
613D02				100	
613D03		(Splice Plate)		100	
613A01				100	
613A02				100	
613A03				100	
613A04				100	
613A05				100	
613A06				100	
613A07				100	
613A08				100	
613A09				100	
613A10				100	
611D01	20			80	
611D02	10			90	
611D03	10			90	

PHASE I - CONFIGURATION A - BASELINE DATA						
SPECIMEN		TYPE AND PERCENTAGE OF FAILURE AREA				
NO.		A_M	A_B	C	I_B	I_L
IA112	D01		Adherend Failure			
112	D02		"	"		
112	D03		"	"		
112	A01				100	
112	A02		Splice Plate Failure			
112	A03				100	
112	A04		Splice Plate Failure			
112	A05				90	10
112	A06				100	
112	A07		Splice Plate Failure			
112	A08				100	
112	A09				100	
112	A10				100	
PHASE I - CONFIGURATION A - PLY STACKING						
IA213	D01					100
213	D02					100
213	D03					100
213	A01					100
213	A02					100
213	A03					100
213	A04					100
213	A05					100
213	A06					100
213	A07					100
213	A08					100
213	A09					100
213	A10					100
211	D01	20				80
211	D02	25				75
211	D03					100
211	D04		(40% Adherend)			60
211	D05		Adherend Failure			
211	D06		"			
211	A11	10				90
211	A12					100

PHASE I - CONFIGURATION A - PLY STACKING EFFECTS						
SPECIMEN		TYPE AND PERCENTAGE OF FAILURE AREA				
NO.		A_M	A_B	C	I_B	I_L
IA211	A13					100
211	A14					100
211	A15					100
211	A16					100
211	A17					100
211	A18					100
211	A19				10	90
211	A20					100
PHASE I - CONFIGURATION A - LAP-LENGTH EFFECTS						
IA313D	01			20	80	
313	D02		(Splice Plate)			100
313	D03		"			100
313	A01				100	
313	A02				100	
313	A03				100	
313	A04				100	
313	A05		10		90	
313	A06				100	
313	A07				100	
312	D01			50	50	
312	D02			50	50	
312	D03			50	50	
312	A01				100	
312	A02				100	
312	A03		Splice Plate Failure			
312	A04				100	
312	A05		Splice Plate Failure			

FAILURE MODES - BONDED JOINTS

PHASE I - CONFIGURATION A - LAP LENGTH EFFECTS

SPECIMEN NO.	TYPE AND PERCENTAGE OF FAILURE AREA A_M	A_B	C	I_B	I_L
IA311D01				30	70
311D02				50	50
311D04			20	80	
311D05				10	90
311A01				70	30
311A02				100	
311A03				100	
311A04				90	10
311A05				90	10
311A11				100	
311A12				70	30
311A13				100	
311A14				90	10
311A15				100	
IA911D01				10	90
911D02		Adherend	Failure		
911D03		"			
911D04		"			
911D05		"		100	
911D06		Adherend	Failure		
911A01	30			70	
911A02	10			80	10
911A03	10			80	10
911A04	10			80	10
911A05				80	20
911A06				70	30
911A07	10			80	10
911A08				90	10
911A09				100	
911A10				100	
911A11	10			80	10
911A12	40			60	
911D07		Adherend	Failure		
911D08		"			
911D09		"			

PHASE I - CONFIGURATION A-LAP LENGTH EFFECTS

SPECIMEN NO.		TYPE AND PERCENTAGE OF FAILURE AREA A_M	A_B	C	I_B	I_L
IA911	C01	50			50	
911	C02	10			80	10
911	C03	30		20	30	20
911	C04	10		10	80	
911	C05	40			60	
911	C06	10			20	70
911	C07	20			80	
911	C08	20			80	
911	C09		Adherend	Failure		
911	C10		"			
PHASE I - CONFIGURATION A - THICKNESS EFFECTS						
IA411	D01	5			95	
411	D02	20			80	
411	D03	20		10	70	
411	A01	10			90	
411	A02	10			90	
411	A03	10			90	
411	A04	10			90	
411	A05	10			90	
411	A06	10			90	
411	A07	10			90	
411	A08	10			90	
411	A09	20		10	70	
411	A10	10			90	
421	D01		Adherend	Failure		
421	D04		Adherend	Failure		
421	D05		"			
421	D06		"			
421	A11	60			30	10
421	A12	20			50	30
421	A13	70			30	
421	A14					100

PHASE I - CONFIGURATION A - LAP LENGTH EFFECTS

SPECIMEN NO.		TYPE AND PERCENTAGE OF FAILURE AREA A_M	A_B	C	I_B	I_L
IA421	A15	10			20	70
421	A16	10			80	10
421	A17	40			40	20
421	A18	10			70	20
421	A19	10			80	10
421	A20	10			40	50
PHASE I - CONFIGURATION B - BASELINE						
IB111	D01		Adherend	Failure		
111	D03		"			
111	D05		"			
111	D07		"			
111	A01	50		30	20	
111	A02	70		10	20	
111	A03	70		20	10	
111	A04	80		20		
111	A05	60		20	10	
111	A06	70		10	20	
111	A07	70		30		
111	A08	80			20	
111	A09	80		10	10	
111	A10	80		10	10	
111	D02	20		50	30	
111	D04	20		50	(30% Adherend)	
111	D06	20		70	10	
111	D08	20		30	20 (30% Adherend)	
111	C02	60		30	10	
111	C03	60		30	10	
111	C04	70		20	10	
111	C05	60		20	20	
111	C06	60		20	20	
111	C07	50		20	30	
111	C08	70		10	20	
111	C09	80		10	10	
111	C10	40		20	40	
111	C11	80		10	10	

FAILURE MODES - BONDED JOINTS

PHASE I - CONFIGURATION B - DEGRADATION

SPECIMEN NO.	A_M	A_B	C	I_B	I_L
	TYPE AND PERCENTAGE OF FAILURE AREA				
IB511D01		Adherend Failure			
511D02			"		
511D03			"		
511A01			"		
511A02					
511A03			"		
511A04			"		
511 A05			"		
511A06			"		
511A07			"		
511A08			"		
511A09			"		
511A10			"		
PHASE I - CONFIGURATION B - BASELINE DATA					
IB112D01		ALUMINUM ADHEREND FAILURE			
112D02			"		
112D03			"		
112A01			"		
112A02			"		
112A03			"		
112A04			"		
112A05			"		
112A06			"		
112A07			"		
112A08			"		
112A09			"		
112A10			"		
121D01		BORON ADHEREND FAILURE			
121D02			"		
121D03			"		
121A01	30		30	40	
121A02	20		20	30	30
121A03	40		20	40	
121A04	30	(10% Adh)		30	30
121A05	40		30	30	

PHASE I - CONFIGURATION B - BASELINE DATA

SPECIMEN NO	A_M	A_B	C	I_B	I_L
	TYPE AND PERCENTAGE OF FAILURE AREA				
IB121A06		Boron Adherend Failure			
121A07	50		20	30	
121A08		Boron Adherend Failure			
121A09	30		30	40	
121A10		Boron Adherend Failure			
PHASE I - CONFIGURATION B - PLY STACKING EFFECTS					
IB211D01		Boron Adherend Failure			
211D02			"		
211D03			"		
211A01	10	(10% Boron Adherend)			80
211A02	40	(10% Boron Adh)	20		30
211A03	30		10		60
211A04	30		10		60
211A05	10	(10% Boron Adherend)			80
211A06	50		20		30
211A07	10		20		70
211A08	40		20		40
211A09	40		20		40
211A10	40		20		40
PHASE I - CONFIGURATION B - LAP LENGTH EFFECTS					
IB311D01	90		10		
311D02		BORON ADHEREND FAILURE			
311D03	50		50		
311A01	10	(30% Adhesive)		60	
311A02	70		10	20	
311A03	90			10	
311A04	80		10	10	
311A05	60		20	20	
311A06	70		20	10	
311A07	70		10	20	
311A08	50		40	10	
311A09	60		30	10	
311A10	70		20	10	

PHASE I - CONFIGURATION C - BASELINE DATA

SPECIMEN NO	A_M	A_B	C	I_B	I_L
	TYPE AND PERCENTAGE OF FAILURE AREA				
IC111A01				100	
111A02				100	
111A03				90	10
111A04	10			90	
111A05	10			90	
111A06	20			80	
111A07	20			80	
111A08	20			80	
111A09				100	
111A10	30			70	
111D01				100	
111D02				100	
111D03				100	
PHASE I - CONFIGURATION D - BASELINE DATA					
ID111D01				90	10
111D02		ADHEREND FAILURE			
111D03				80	20
111A01				90	10
111A02		NO FAILURE			
111A03				100	
111A04	10			80	10
111A05				100	
111A06				100	
111A07		FAILED ON LOADING			
111A08				100	
111A09				100	
111A10				100	
111A11				100	
ID114D01		SPLICE PLATE FAILURE			
114D02		(50% Splice Plate)			50
114D03		SPLICE PLATE FAILURE			
114A01	40			50	10
114A02	40			60	
114A03	40			40	20
114A04	30			60	10

FAILURE MODES - BONDED JOINTS

PHASE I - CONFIGURATION D - BASELINE (CONT)

SPECIMEN NO.	TYPE AND PERCENTAGE OF FAILURE AREA A_M	A_B	C	I_R	I_L
ID114A05	30	(30% Adherend)		40	
114A06	40			50	10
114A07	30			60	10
114A08	30			50	20
114A09	30			60	10
114A10	40			30	30
PHASE II - CONFIGURATION A - BASELINE DATA					
IIA11D01		(50% Adherend)		50	
11D02		ADHEREND FAILURE			
11D03		(80% Adherend)			20
11D04		ADHEREND FAILURE			
11D05		"			
11D06		"			
11A01				90	10
11A02				90	10
11A03				90	10
21A03		(10% Adherend)		90	
11A05		(50% Adherend)		50	
11A06		(10% Adherend)		90	
11A07				90	10
21A04	10	(10% Adherend)		80	
11A09				100	
11A10				100	
IIA11C01				20	80
11C02				10	90
11C03				20	80
11C04				30	70
11C05				100	
IIA12D01				80	20
12D02			10	90	
12D03				70	30
12A01				90	10
12A02				90	10
12A03				90	10

PHASE II - CONFIGURATION A - BASELINE (CONT)

SPECIMEN NO.	TYPE AND PERCENTAGE OF FAILURE AREA A_M	A_B	C	I_B	I_L
IIA12A04				100	
12A05				90	10
PHASE II - CONFIGURATION A - DEGRADATION					
IIA21A01		(30% Adherend)		60	10
21A02		(30% Adherend)		70	
21A05				90	10
11A04		(30% Adherend)		70	
11A08	10			90	
22A01		(20% Adherend)		40	40
22A02				90	10
22A03			10	90	
22A04				90	10
22A05				80	20
PHASE II - CONFIGURATION A - REALISTIC SPECTRUM					
IIA41G01	10			90	
41G02				80	20
41G03				90	10
41G04	10			90	
41G05	10			90	
PHASE II - CONFIGURATION A - LAP LENGTH EFFECTS					
IIA91D01		(30% Adherend)		10	60
91D02		(30% Adherend)		10	60
91D03		ADHEREND FAILURE			
91D04		"			
91D05		"			
91D06		"			
91A01		NO FAILURE			
91A02				100	
91A03				100	
91A04	20			70	10
91A05	20	(10% Adherend)		60	10
91C01				60	40
91C02	10			30	60
91C03	20			20	60
91C04	40			10	50

PHASE II - CONFIGURATION A - LAP LENGTH (CONT)

SPECIMEN NO.	TYPE AND PERCENTAGE OF FAILURE AREA A_M	A_B	C	I_B	I_L
IIA91C05	20			20	60
PHASE II - CONFIGURATION B - BASELINE DATA					
IIB11D01		BORON ADHEREND FAILURE			
11D03			"		
11A01			"		
11A02	60		40		
11A03	40		40	20	
11A04		BORON ADHEREND FAILURE			
11A05	10		40	10	(40% Adh.)
11D02	(20% Adherend)		50	30	
11D04	TITANIUM ADHEREND BUCKLED				
11C01	BORON ADHEREND FAILURE				
11C02	20		70	10	
11C03	10		60	30	
11C04	10		90		
11C05	20		70	10	
11C06	20		80		
IIB12D01	ALUMINUM ADHEREND FAILURE				
12D02		"			
12D03		"			
12A01		"			
12A02		"			
12A03		"			
12A04		"			
12A05		"			
PHASE II - CONFIGURATION B - LAP LENGTH EFFECTS					
IIB31D01	BORON ADHEREND FAILURE				
31D02		"			
31D03		"			
31A01	30		60	10	
31A02	90		10		
31A03	80		10	(10% Adherend)	
31A04	30		60	10	
31A05	(30% Adherend)		40	30	

FAILURE MODES - BONDED JOINTS

PHASE III - CONFIGURATION A - ALL TESTS

SPECIMEN NO.	TYPE AND PERCENTAGE OF FAILURE AREA A_M	A_B	C	I_B	I_L
IIIA11D1		NO FAILURE			
11D2					100
11D3		ADHEREND FAILURE			
11D4		ADHEREND FAILURE			
11D5			"		
11D6		100			
11A1		(10% Adherend)		90	
11B1	(20% Unfailed)		30	50	
11C1			10	90	
IIIA21F1	30	30		40	
IIIA12D1		30	50	20	
12D2		30	70		
12D3		30	70		
12D4		50	50		
12A1	10	60		30	
12B1		40	10		

PHASE III - CONFIGURATION B - ALL TESTS

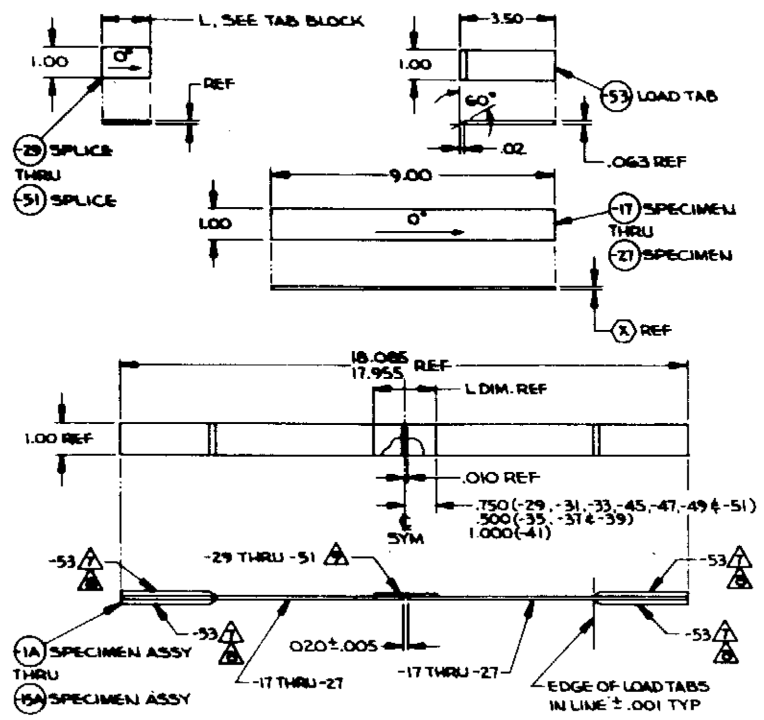
SPECIMEN NO.	TYPE AND PERCENTAGE OF FAILURE AREA A_M	A_B	C	I_B	I_L
IIIB11D1		ADHEREND FAILURE			
11D2			"		
11D3			"		
11A1	60		30	10	
11B1		NO FAILURE			
21F1	30		50	20	

APPENDIX C

JOINT DESIGNS

This section contains the detail design drawings for test specimen configurations under the evaluation program. Given below is a complete list of drawings and their usage.

Phase	Configuration	Status
I	A, B, C, & D	Included
II	A & B	Provided as notes to Phase IA & B drawings
III	A & B	Provided as notes to Phase IA & B drawings
I	E & F	Included
II	E	Provided as notes to Phase IE drawings



1 (-17, -31 & -37): 45° PLY NO. 2 & 7; 0° PLY NO. 1, 4, 5 & 8; 45° PLY NO. 3 & 6

2 (-19 & -47): 90° PLY NO. 2, 4, 5 & 7; 0° PLY NO. 1, 3, 6 & 8

3 (-21 & -49): 45° PLY NO. 1 & 8; 0° PLY NO. 2, 4, 5 & 7; 45° PLY NO. 3 & 6

4 (-23 & -51): 90° PLY NO. 1, 3, 6 & 8; 0° PLY NO. 2, 4, 5 & 7

5 (-25): 45° PLY NO. 2, 7, 10 & 15; 0° PLY NO. 1, 4, 5, 8, 9, 12, 13 & 16; 45° PLY NO. 3, 6, 11 & 14

6 (-27): 90° PLY NO. 2, 4, 6, 8, 9, 11, 13 & 15; 0° PLY NO. 1, 3, 5, 7, 10, 12, 14 & 16

QTY	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	MATL SIZE	MATL SPEC
4	-53	LOAD TAB	2024-T3 △4	.063 X 1 X 4	QQ-A-250/4
1	-51	SPLICE	△ △	(4) X 1 X 1.5	△
1	-49		△ △	(3) X 1 X 1.5	△
1	-47		△ △	(2) X 1 X 1.5	△
1 1	-45		TI-6AL-4V ANNEALED △	.083 X 1 X 1.5	STM07-306
1	-41		TI-6AL-4V ANNEALED △	.040 X 1 X 2	STM07-306
1	-39		7075-T6 △	.060 X 1 X 1	QQ-A-250/12
1	-37		△ △	(1) X 1 X 1	△
1	-35		TI-6AL-4V ANNEALED △	.040 X 1 X 1	STM07-306
1	-33		7075-T6 △	.060 X 1 X 1.5	QQ-A-250/12
1	-31		△ △	(1) X 1 X 1.5	△
1 1 1 1	-29	SPLICE	TI-6AL-4V ANNEALED △	.040 X 1 X 1.5	STM07-306
2	-27	SPECIMEN	△ △	(6) X 1 X 9	△
2	-25			(5) X 1 X 9	
2 2	-23			(4) X 1 X 9	
2 2	-21			(3) X 1 X 9	
2 2	-19			(2) X 1 X 9	
2 2 2 2 2 2 2	-17	SPECIMEN	△ △	(1) X 1 X 9	△
1	-15A	SPECIMEN ASSY	△		
1	-13A				
1	-11A				
1 1 1	-9A -9B -9C				
1 1	-7A -7B				
1 1	-5A -5B				
1 1	-3A -3B				
1 1 1	-1A -1B -1C	SPECIMEN ASSY	△		

LIST OF MATERIAL

PART NO.	-29	-31	-33	-35	-37	-39	-41		-45	-47	-49	-51
L	1.520			1.020			2.020		1.520			

NOTE:

1. FAB PER STP 60-202
2. REMOVED
3. CLOSE TOLERANCE PER DS 30009 —— FAB PER STP 51-304
4. FAB PER DS 30004
5. REMOVED
6. NARMCO 5505 BORON FILAMENT
7. BOND USING STM 30-102 TYPE III .045 PSF
8. OUTER SURFACES SHALL BE FLAT AND PARALLEL WITHIN .002
9. BOND USING STM 30-102 TYPE III .060 PSF - BOND LINE TOLERANCE ±.0015
10. FABRICATE 13 -1A SPECIMEN ASSYS AND 13 -1B SPECIMEN ASSYS WITH EXCEPTION: BOND -29 SPLICE AND -31 SPLICE USING METLBOND 329 ADHESIVE - CURE AT 350°F FOR ONE HOUR AT 15 PSI TO 50 PSI WITH HEATUP RATE THIRTY MINUTES TO TWO HOURS. - IDENTIFY AS -1AX SPECIMEN ASSY AND -1BX SPECIMEN ASSY RESPECTIVELY
11. FAB PER STP 51-304

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON: FRACTIONS ±1/16; DECIMALS X ±.1, XX ±.03, XXX ±.010; ANGLES ±2°

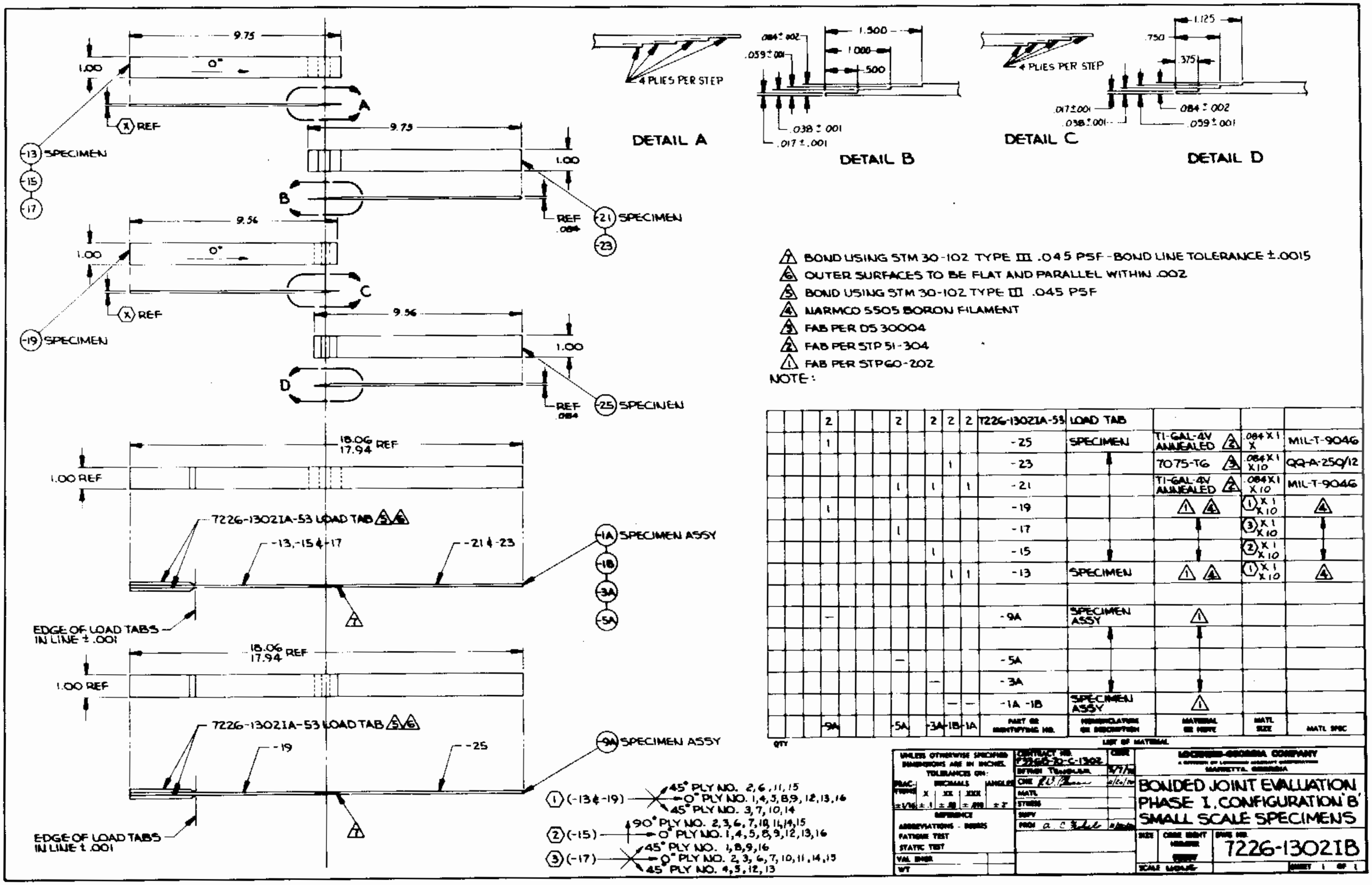
REFERENCE: ABBREVIATIONS - MIRRS; FATIGUE TEST; STATIC TEST; VAL ENGR; WT

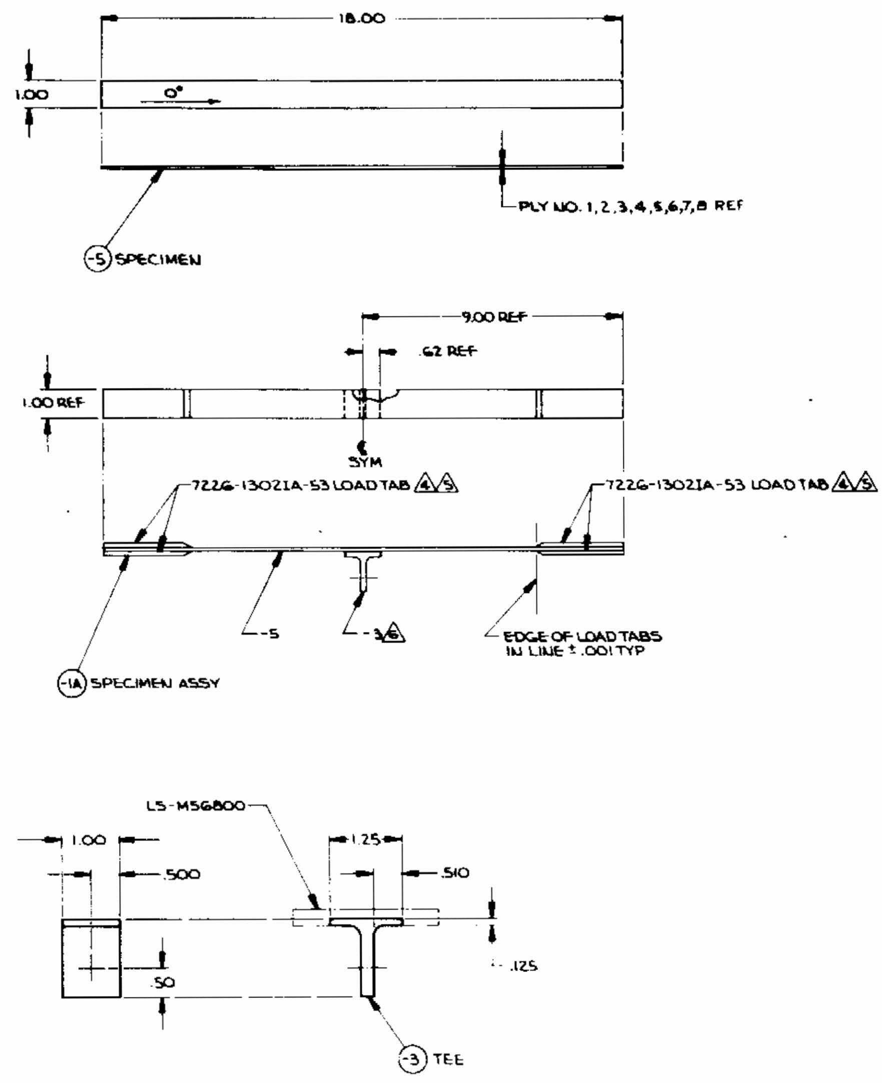
CONTRACT NO. F33615-70-C-1302 | DWN TANDLUN 3/4/70 | CHK | MATL | STRESS | SUPV | PROJ

LOCKHEED-GEORGIA COMPANY, A DIVISION OF LOCKHEED AIRCRAFT CORPORATION, MARIETTA, GEORGIA

BONDED JOINT EVALUATION PHASE I, CONFIGURATION 'A' SMALL SCALE SPECIMENS

SIZE | CODE IDENT NUMBER 98897 | DWG NO. 7226-13021A | SCALE NONE | SHEET 1 OF 1


DETAIL A
4 PLIES PER STEP
DETAIL B
DETAIL C
DETAIL D
-13 SPECIMEN
-19 SPECIMEN
-21 SPECIMEN
-25 SPECIMEN
-1A SPECIMEN ASSY
-9A SPECIMEN ASSY
7226-13021A-53 LOAD TAB
EDGE OF LOAD TABS IN LINE ±.001
1.00 REF
18.06 REF 17.94
1 (-13 & -19) 45° PLY NO. 2, 6, 11, 15 0° PLY NO. 1, 4, 5, 8, 9, 12, 13, 16 45° PLY NO. 3, 7, 10, 14
2 (-15) 90° PLY NO. 2, 3, 6, 7, 10, 11, 14, 15 0° PLY NO. 1, 4, 5, 8, 9, 12, 13, 16
3 (-17) 45° PLY NO. 1, 8, 9, 16 0° PLY NO. 2, 3, 6, 7, 10, 11, 14, 15 45° PLY NO. 4, 5, 12, 13
NOTE:
7 BOND USING STM 30-102 TYPE III .045 PSF - BOND LINE TOLERANCE ±.0015
6 OUTER SURFACES TO BE FLAT AND PARALLEL WITHIN .002
5 BOND USING STM 30-102 TYPE III .045 PSF
4 NARMCO 5505 BORON FILAMENT
3 FAB PER DS 30004
2 FAB PER STP 51-304
1 FAB PER STP60-202
LIST OF MATERIAL
7226-13021A-53 LOAD TAB
-25 SPECIMEN TI-6AL-4V ANNEALED .084 X 1 X MIL-T-9046
-23 7075-T6 .084 X 1 X 10 QQ-A-250/12
-21 TI-6AL-4V ANNEALED .084 X 1 X 10 MIL-T-9046
-19, -17, -15, -13 SPECIMEN
-9A SPECIMEN ASSY
-5A, -3A, -1A -1B SPECIMEN ASSY
LOCKHEED-GEORGIA COMPANY
MARIETTA, GEORGIA
BONDED JOINT EVALUATION
PHASE I, CONFIGURATION 'B'
SMALL SCALE SPECIMENS
7226-13021B



(1) (-5) 45° PLY NO. 2,7 / 0° PLY NO. 1,4,5,8 / 45° PLY NO. 3,6

6. BOND USING STM 30-102 TYPE III .060 PSF - BOND LINE TOLERANCE ± .0015
5. OUTER SURFACES SHALL BE FLAT AND PARALLEL WITHIN .002
4. BOND USING STM 30-102 TYPE III .045 PSF
3. NARMCO 5505 BORON FILAMENT
2. MACHINE PER DS 30003 125/ ALL MACHINED SURFACES
1. FAB PER STP 60-202

NOTE:

QTY	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	MATL SIZE	MATL SPEC
4	7226-13021A-53	LOAD TAB			
1	-5	SPECIMEN	1 3	1 X1 X18	3
1	-3	TEE	LS-M56800 (ALTER) 2	1	STM 04-302
—	-1A	SPECIMEN ASSY	1		
	-1A				

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON: FRACTIONS ±1/16; DECIMALS .X ±.1, .XX ±.03, .XXX ±.010; ANGLES ±2°

REFERENCE

ABBREVIATIONS - MMMS

FATIGUE TEST

STATIC TEST

VAL ENGR

WT

CONTRACT NO F33615-70-C-1302

LOCKHEED-GEORGIA COMPANY, MARIETTA, GEORGIA

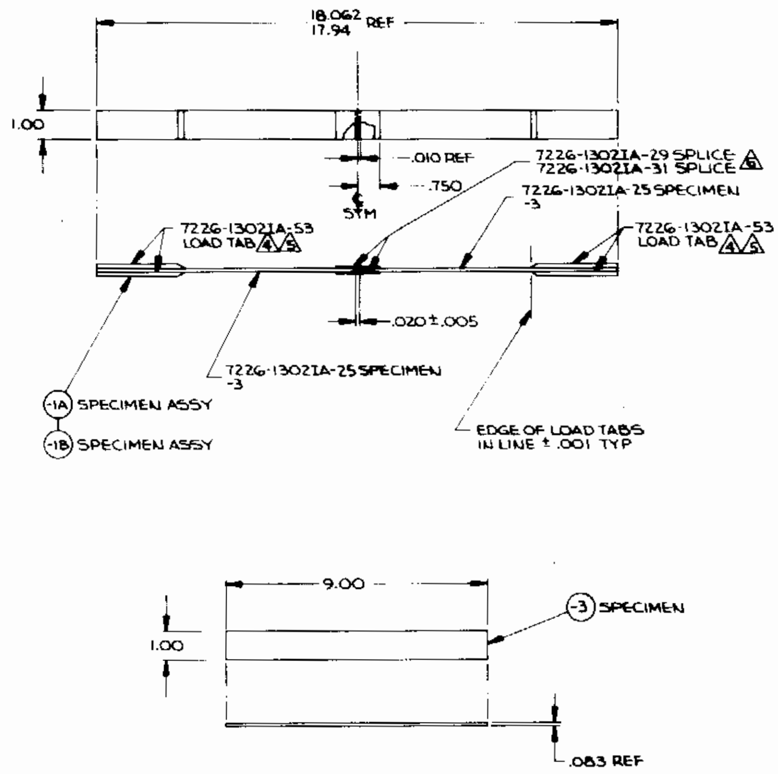
BONDED JOINT EVALUATION PHASE I, CONFIGURATION 'C' SMALL SCALE SPECIMENS

CODE IDENT NUMBER 98897

DWG NO. 7226-1302IC

SCALE NONE

SHEET 1 OF 1



6. BOND USING STM 30-102 TYPE III .060 PSF – BOND LINE TOLERANCE ± .0015
5. OUTER SURFACES SHALL BE FLAT AND PARALLEL WITHIN .002
4. BOND USING STM 30-102 TYPE III .045 PSF
3. FAB PER STP 51-304
2. CLOSE TOLERANCE PER DS 30009
1. FAB PER STP 60-202

NOTE:

-1B	-1A	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	MATL SIZE	MATL SPEC
4	4	7226-1302IA-53	LOAD TAB			
2		7226-1302IA-31	SPLICE			
	2	7226-1302IA-29	SPLICE			
	2	7226-1302IA-25	SPECIMEN			
2		-3	SPECIMEN	TI-6AL-4V ANNEALED 2 3	.083 X 1 X 9	STM07-306
—	—	-1A -1B	SPECIMEN ASSY	1		

QTY LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON: FRACTIONS ±1/16; DECIMALS .X ±.1, .XX ±.03, .XXX ±.010; ANGLES ±2°

CONTRACT NO. F33615-70-C-1302

LOCKHEED-GEORGIA COMPANY
MARIETTA, GEORGIA

BONDED JOINT EVALUATION,
PHASE I, CONFIGURATION 'D'
SMALL SCALE SPECIMENS

DWG NO. 7226-1302ID

SCALE NONE SHEET 1 OF 1

(1)(-21 -41) — 45° PLY NO. 2 & 7; 0° PLY NO. 1, 4, 5 & 8; 45° PLY NO. 3 & 6

(2)(-23 -43) — 0° PLY NO. 1 THRU 8

(3)(-25) — 45° PLY NO. 2 & 7; 0° PLY NO. 1, 4, 5 & 8; 45° PLY NO. 3 & 6

(4)(-27) — 45° PLY NO. 2, 7, 10 & 15; 0° PLY NO. 1, 4, 5, 8, 9, 12, 13 & 16; 45° PLY NO. 3, 6, 11 & 14

(5)(-29) — 45° PLY NO. 2, 7, 10 & 15; 0° PLY NO. 1, 4, 5, 8, 9, 12, 13 & 16; 45° PLY NO. 3, 6, 11 & 14

NOTE:

1. FAB PER STP 60-202
2. SHIMS - .012 TI-6AL-4V ANNEALED STM07-306 FAB PER STP 51-304
3. YBD - STSAE015D + STSAE007
4. FAB PER DS 30004
5. INSTALL FASTENERS PER DS 5055
6. NORMCO 5505 BORON FILAMENT
7. BOND USING STM 30-102 TYPE III .045 PSF
8. OUTER SURFACES SHALL BE FLAT AND PARALLEL WITHIN .002
9. WET INSTALL FASTENERS PER STP 56-105
10. FOR PIN BEARING TEST USE STSAF009DOGLN (HI-LOK) OR EQUIVALENT MANUFACTURED PIN HAVING $^{.1895}_{.1880}$ DIA SHANK
11. TORQUE TO 30 $^{\pm 5}$ IN. LBS.
12. TI-6AL-4V-IM DA STM07-306 FAB PER STP 51-304
13. HL 18 PB 6 PIN & HL87-6 COLLAR
14. HL 19 PB 6 PIN & HL87-6 COLLAR

-19A	-17A	-15A	-13A	-11A	-9A	-7A	-5A	-3B	-1B	-1A	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	MATL SIZE	MATL SPEC
2	2	2	2	2	2	2	2	2	2	2	7226-1302IA-53	LOAD TAB			
								1			-43	SPLICE	Δ1 Δ6 Δ2	(2) X1 X4	
									1		-41		Δ1 Δ6 Δ2	(1) X1 X4	
			1	1							-39		Δ[illegible]	.234X1 X4	
					1	1					-37			.120X1 X3	
							1			1	-35	SPLICE		.120X1 X4	
			1	1							-33	SPECIMEN		.234X1 X9	
					1	1	1	1	1	1	-31		Δ[illegible]	.120X1 X9	
			1								-29		Δ1 Δ6	(5) X1 X9	
				1							-27		Δ1 Δ6 Δ2	(4) X1 X9	
1					1		1				-25		Δ1 Δ6	(3) X1 X9	
								1			-23		Δ1 Δ6 Δ2	(2) X1 X9	
	1	1				1			1	1	-21	SPECIMEN	Δ1 Δ6 Δ2	(1) X1 X9	
—											-19A	SPECIMEN ASSY	Δ1		
	—										-17A				
		—									-15A				
			—								-13A				
				—							-11A				
					—						-9A				
						—					-7A				
							—				-5A				
								—			-3B				
									—	—	-1A -1B	SPECIMEN ASSY	Δ1		

QTY — LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON: FRACTIONS ±1/32; DECIMALS .X ±.1, .XX ±.03, .XXX ±.010; ANGLES ±.5°

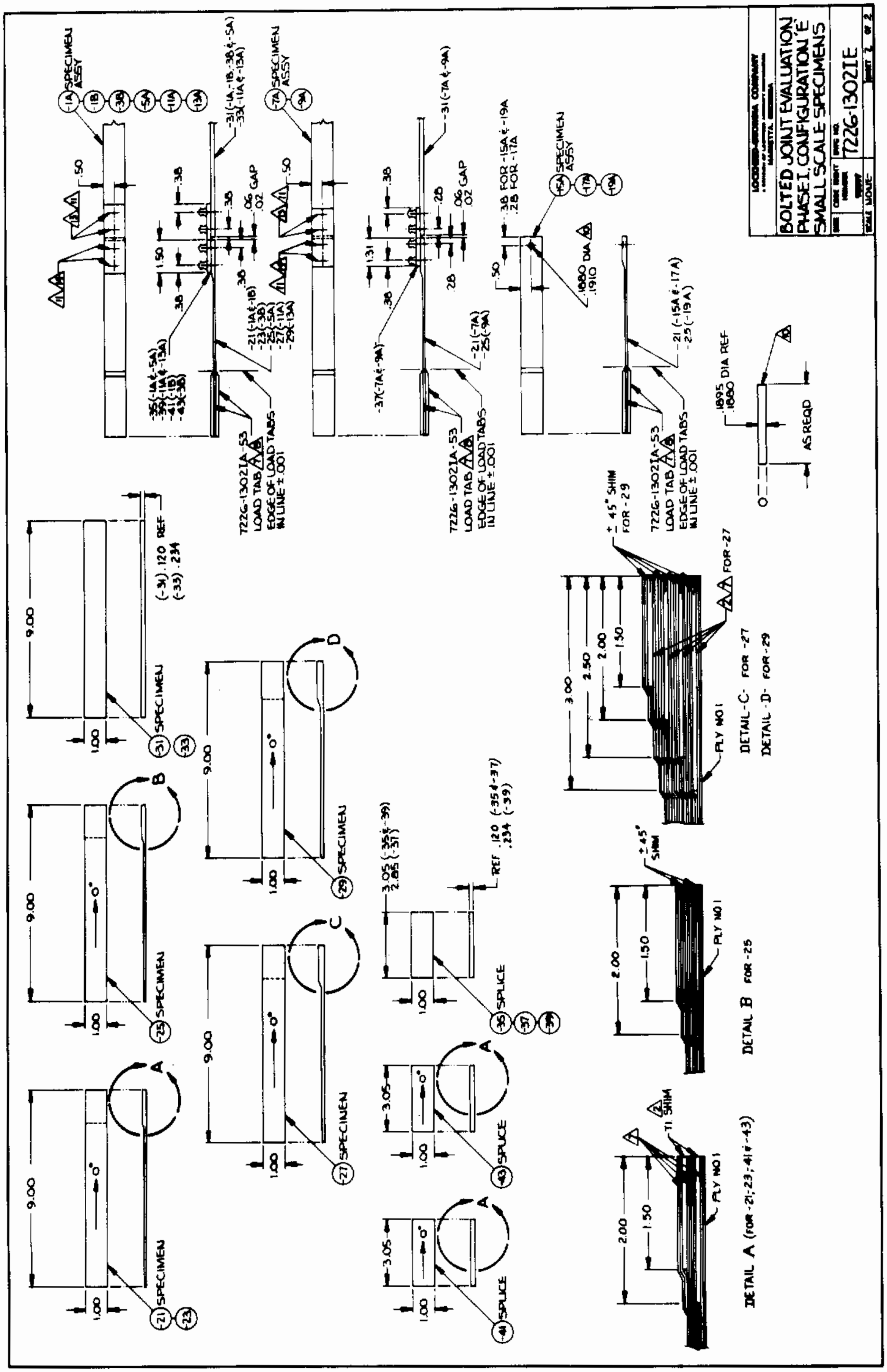
CONTRACT NO. F33615-70-C-1302
DRAWN TENDLER

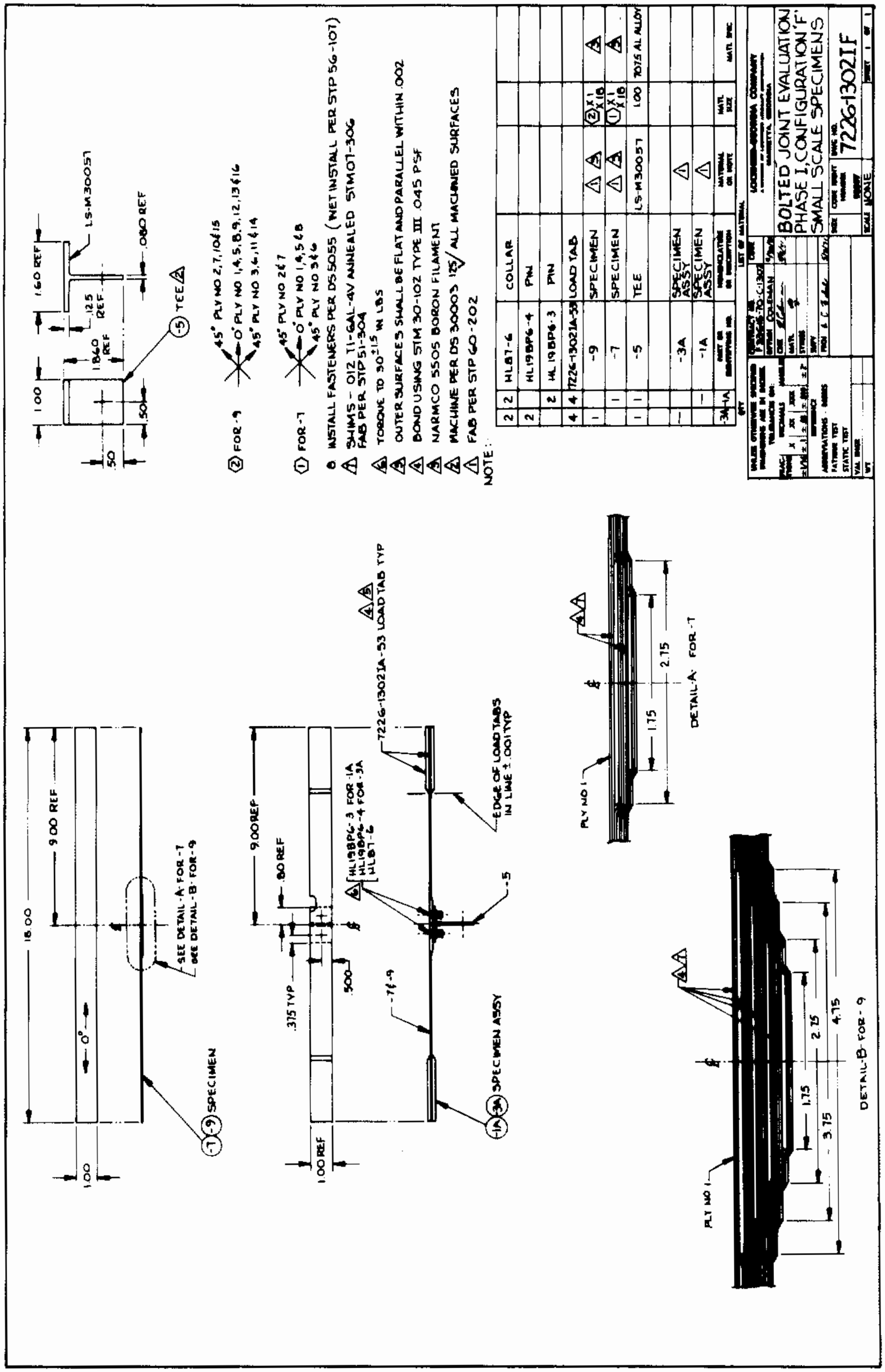
LOCKHEED-GEORGIA COMPANY, MARIETTA, GEORGIA

BOLTED JOINT EVALUATION PHASE I, CONFIGURATION 'E' SMALL SCALE SPECIMENS

DWG NO. 7226-1302IE

SCALE NONE — REVISION 'A' — SHEET 1 OF 2


BOLTED JOINT EVALUATION
PHASE I, CONFIGURATION 'E'
SMALL SCALE SPECIMENS
T226-13021E
DETAIL A (FOR -21, -23, -41 & -43)
DETAIL B FOR -25
DETAIL C FOR -27
DETAIL D FOR -29


NOTE:
FAB PER STP 60-202
MACHINE PER DS 30003 125/ ALL MACHINED SURFACES
NARMCO 5505 BORON FILAMENT
BOND USING STM 30-102 TYPE III .045 PSF
OUTER SURFACES SHALL BE FLAT AND PARALLEL WITHIN .002
TORQUE TO 30±15 IN LBS
SHIMS - .012 TI-6AL-4V ANNEALED STM01-306 FAB PER STP51-304
INSTALL FASTENERS PER DS5055 (WET INSTALL PER STP 56-107)
FOR-7
FOR-9
TEE
LS-M30051
SPECIMEN
SPECIMEN ASSY
DETAIL-A- FOR-7
DETAIL-B- FOR-9
PLY NO 1
EDGE OF LOAD TABS IN LINE ± .001 TYP
7226-13021A-53 LOAD TAB TYP
HL19BP6-3 FOR -1A
HL19BP6-4 FOR -3A
HL87-6
SEE DETAIL-A- FOR-7
SEE DETAIL-B- FOR-9
COLLAR
PIN
LOAD TAB
7075 AL ALLOY
LIST OF MATERIAL
BOLTED JOINT EVALUATION
PHASE I, CONFIGURATION "F"
SMALL SCALE SPECIMENS
7226-13021F

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Security Classification

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13. ABSTRACT

This is Volume II of a final report presented in three volumes; Vol I - Analysis Methods; Vol II - Fabrication, Inspection and Testing; Volume III - Fatigue Analysis and Failure Mode Studies. Fabrication and inspection methods were established which resulted in specimens of uniform high quality fabricated to close tolerances. Both bonded and bolted joints of widths from one to ten inches were evaluated. Primary emphasis was on joints in boron-epoxy, and between boron-epoxy and titanium or aluminum; however limited evaluations of graphite-epoxy/titanium and fiberglass-epoxy/titanium were included.

Joint configuration evaluated were: single and double splice butt joints; boron-epoxy to metal stepped single scarf joints; and surface to understructure attachments.

All laminates and specimens were inspected non-destructively. Base material properties and process control measures were verified by destructive testing. Developing testing techniques and actual specimen testing was a major portion of the program.

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UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
bonded joints						
mechanical joints						
boron-epoxy						
composite materials						
Graphite-epoxy composite materials						
fiberglass-epoxy composite materials						
fatigue testing						
fatigue endurance						
fatigue analysis						
photoelastic stress analysis						
material properties						
joint fabrication						
non-destructive inspection						