

ASIAC

INTERIM REPORT ON THE
DEVELOPMENT AND FABRICATION
OF A
BIAXIAL TEST FIXTURE

DECEMBER 1978

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AEROSPACE STRUCTURES
INFORMATION AND ANALYSIS CENTER

OPERATED FOR THE AIRFORCE FLIGHT DYNAMICS LABORATORY
BY ANAMET LABORATORIES, INC.

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This interim report describes the development, fabrication and initial testing of fixturing designed to determine the biaxial properties of materials. The fixturing was designed to be particularly compatible with composite materials although it is not limited to use with those materials. This work is being performed under ASIAC Problem No. 112.

The work was done by the Aerospace Structures Information and Analysis Center, which is operated for the Air Force Flight Dynamics Laboratory by Anamet Laboratories, under Contract Number F33615-77-C-3046.

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I. INTRODUCTION

Anamet Laboratories, Inc. has designed and fabricated a specimen load system for conducting biaxial material characterizations of composite materials. Theoretical aspects of the system have been described in Anamet Laboratories, Inc. Report No. 277.502. The test system, which is useful for examining quadrants II, III and IV of the biaxial stress plane, utilizes short cylindrical specimens. The specimens may be loaded in axial compression and either internal or external pressure. Design of the test system is such that it may be used with any standard 100 kip compression or universal testing machine.

A unique feature of the test system is that end restraints are minimized by applying all loads through hydrostatic pressures. Hoop stresses are produced by applying internal or external pressures through the use of pressurized oil. Axial stress is induced through specimen interaction with a high pressure lubricant trapped between the specimen ends and parallel platens. Because of the mechanism of loading, restraint to end dilation and twisting is governed by the viscous or plastic shear strength of the lubricant. In the preliminary tests lead foil, indium foil, polyethylene film and combination stacks of films and foils have been used for the solid high pressure lubricant. The solid lubricant serves other functions in addition to minimizing restraint. For example, the foil equalizes loading to the specimen ends and compensates for slight irregularities and mismatch between platens and specimens. It also assists in the attainment of an oil-tight seal between the specimen ends and platens. This is necessary for the application of surface oil pressures.

II. DESCRIPTION OF TEST SYSTEM

Typical test specimens and foil gaskets are shown in Fig. 1. Specimens are typically 1 inch long and 4 inches in diameter. Wall thicknesses have ranged between approximately 0.035 inches and 0.10 inches. The specimens are sandwiched between two gaskets which bear against two platens. Principal components of the platen and pressure system are shown in Fig. 2. A dimensioned drawing of the system is given in Fig. 3.

The small hollow cylinder acts as the lower platen. A step in the solid cylinder serves as the upper platen bearing surface. The upper platen is stepped to reduce the area perpendicular to the specimen axis. This reduces the axial load required to overcome the axial resultant of the oil pressure and allows a smaller testing machine to be used. The platens are made from through-hardened 4340 steel to minimize specimen damage to the platen surfaces. If damage or wear should occur, the through-hardening allows the platens to be re-ground without the necessity for repeating case hardening or heat treating.

A photograph of the fixturing installed in an MTS Model 810, 110 kip, servohydraulic testing machine is given in Fig. 4. In Fig. 4 the specimen is about to be tested under axial compression. When internal oil pressure is applied, a splash guard and catch pan are incorporated in the system. For the application of external oil pressures, the heavy pressure collet is placed about the specimen as shown in Fig. 5. The collet has been designed to withstand working pressures of 10,000 psi. An Enerpac 10,000 psi hydraulic power supply has been used to furnish the pressurized oil.



Fig. 1 Typical Test Specimens and Foil Gaskets

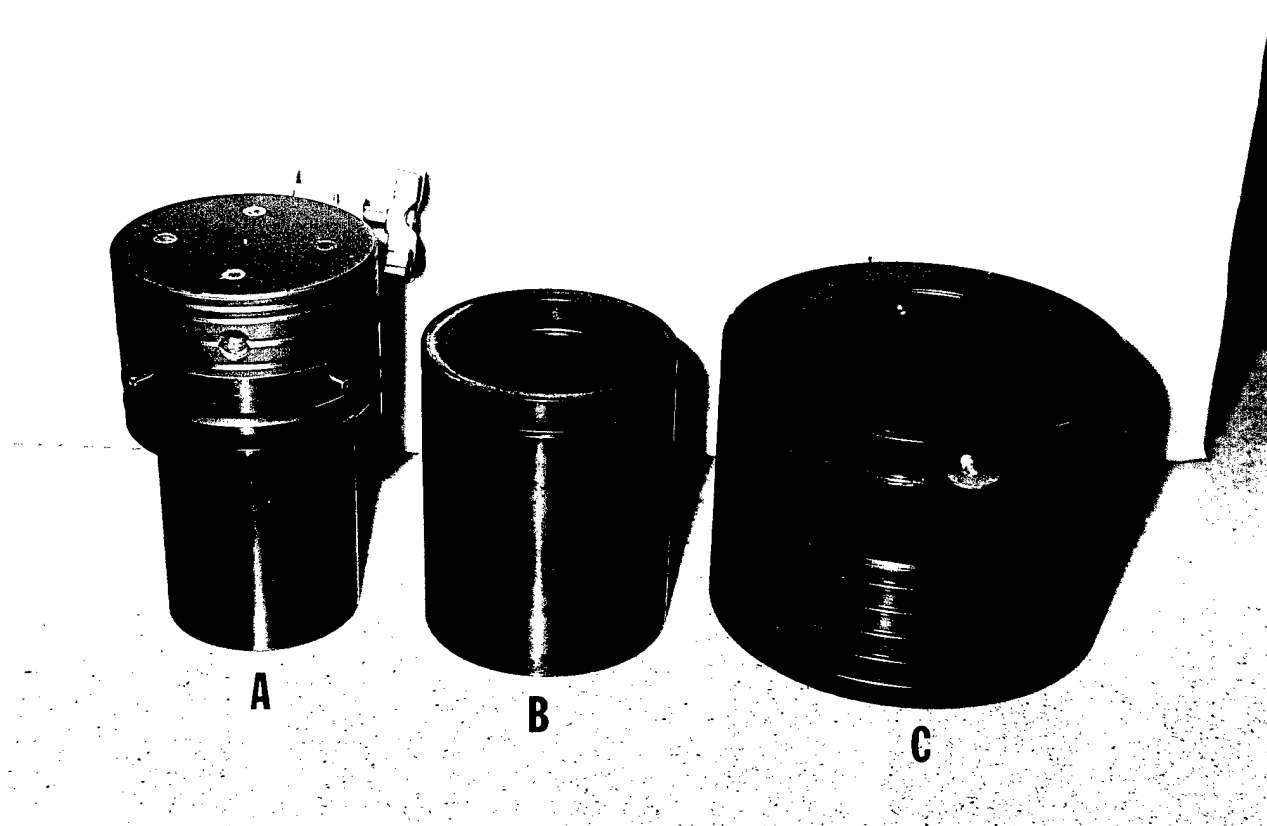


Fig. 2 Principal Components of the Platen and Pressure System

- A - Upper Platen
- B - Lower Platen
- C - External Pressure Collet

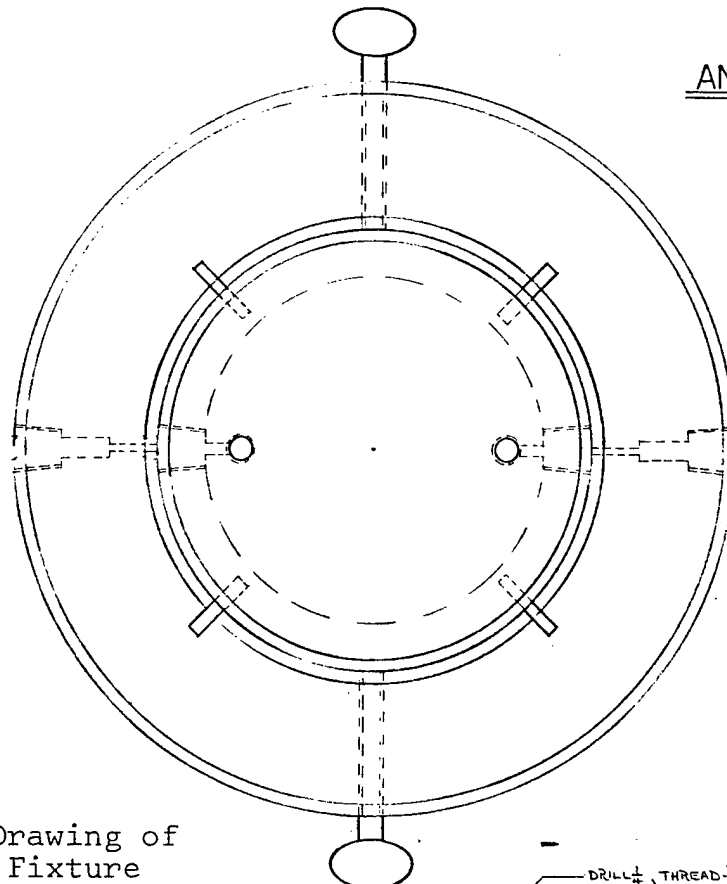
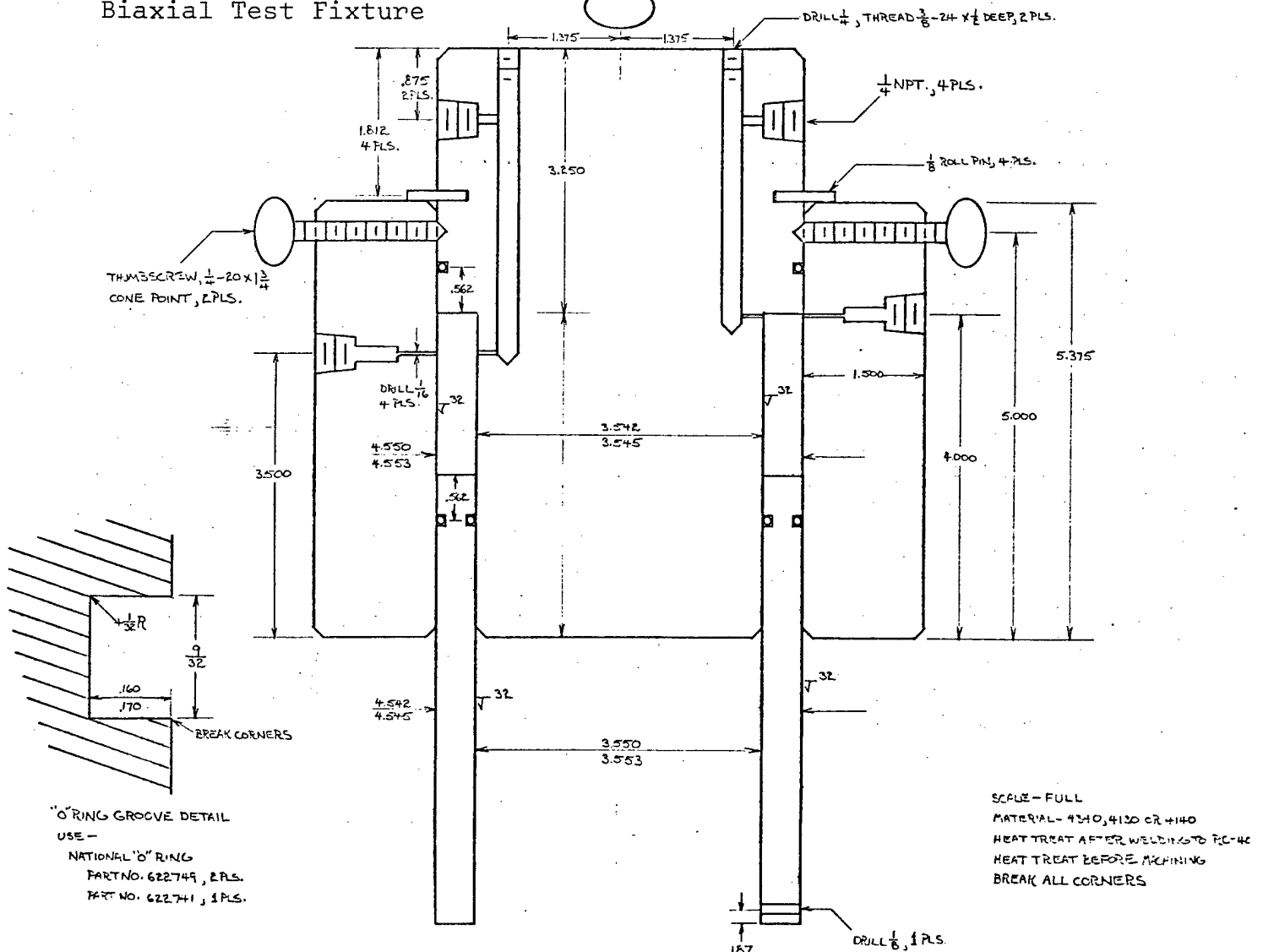


Fig. 3

Dimensioned Drawing of Biaxial Test Fixture



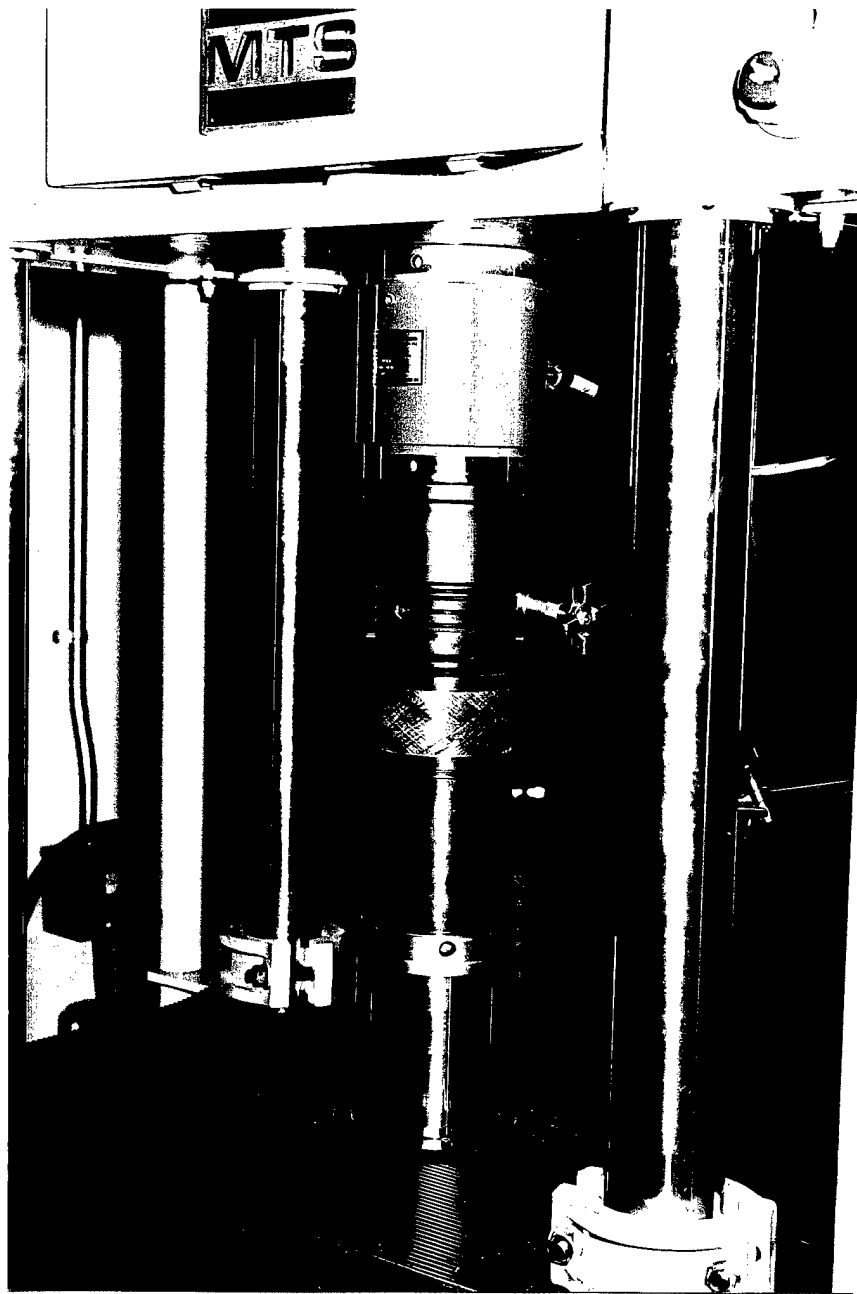


Fig. 4 Fixture Installed in Testing Machine
Prior to Axial Compression Test

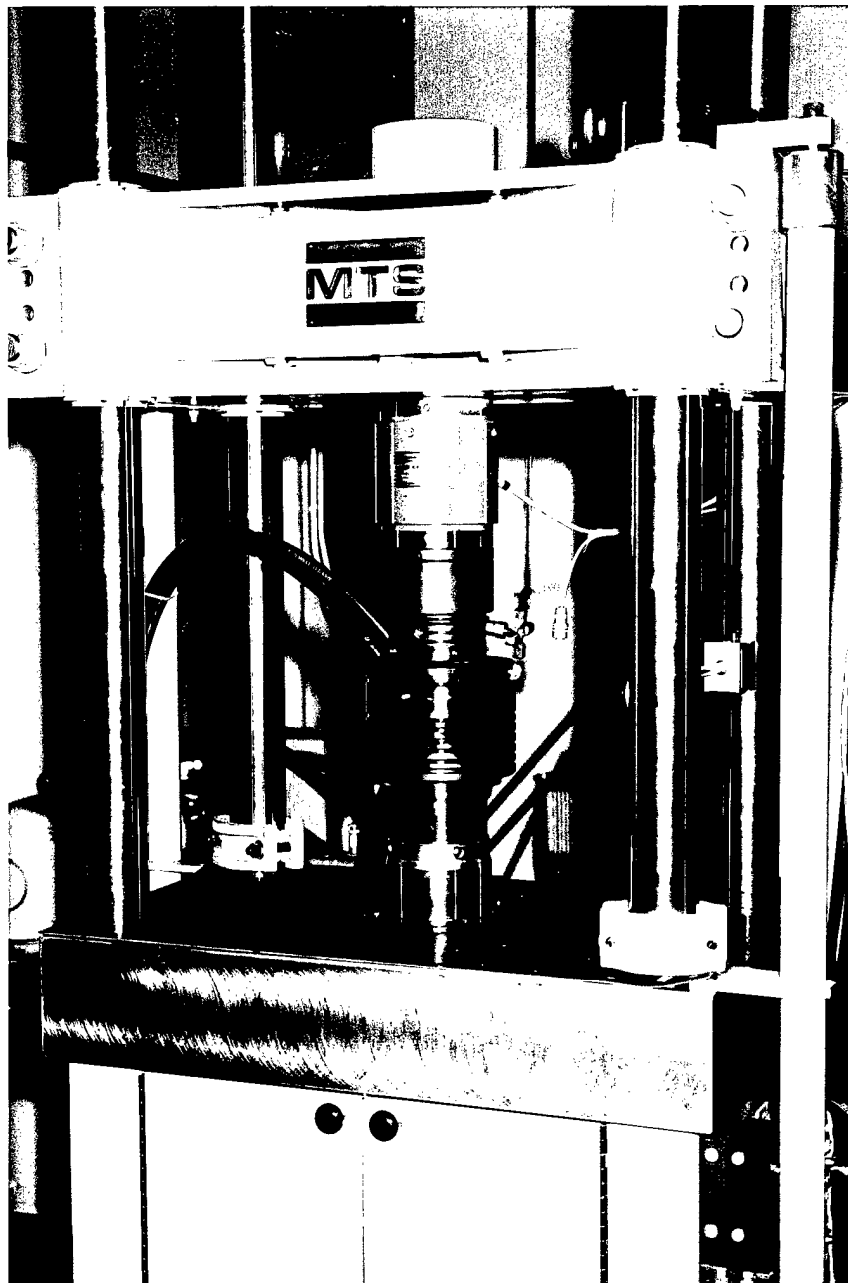


Fig. 5 Fixture Installed in Testing Machine Prior to External Pressure and Axial Compression Test

III. PRELIMINARY TESTS

No tests have yet been run to determine actual material properties. The testing done to date has instead been aimed at qualitatively evaluating various solid lubricants and sealing techniques. Fig. 6 shows two typical specimens failed during the qualitative testing. The specimens were made from Bondstrand 2000 Fiberglass reinforced epoxy resin pipe. This material was chosen for many of the preliminary tests due to its ready availability and attractive cost. Details of the ply layup are unknown; however, it appears to be a wound $\pm 45^\circ$ structure. The specimen on the left was ruptured under internal pressure. A 200 pound axial load was applied to the specimen in an attempt to affect sealing. Although complete sealing was not achieved, the hydraulic power supply was able to keep up with the leakage and rupture the specimen. Other tests where the specimens were ruptured under internal pressure also exhibited considerable undesirable oil leakage. Leakage is undesirable as it hinders the precise control of the oil pressure. A constrained oil bag solution to the problem has been designed; however, it has not yet been fabricated.

The right-hand specimen in Fig. 6 was crushed under only axial load. Of the gasket systems qualitatively evaluated for axial tests, a layer of polyethylene film sandwiched between two layers of lead foil gave the best performance. Relative performance of the gasket systems was evaluated by crushing specimens whose outside diameters were monitored at two locations with dial gages. One dial gage spindle tip would contact the specimen approximately 1/8 inch in from the end. The second dial gage would contact the specimen at mid-length and directly below the first dial gage location. Generally, up to 10% compressions of the Fiberglass pipe specimens and graphite reenforced epoxy specimens could be achieved without

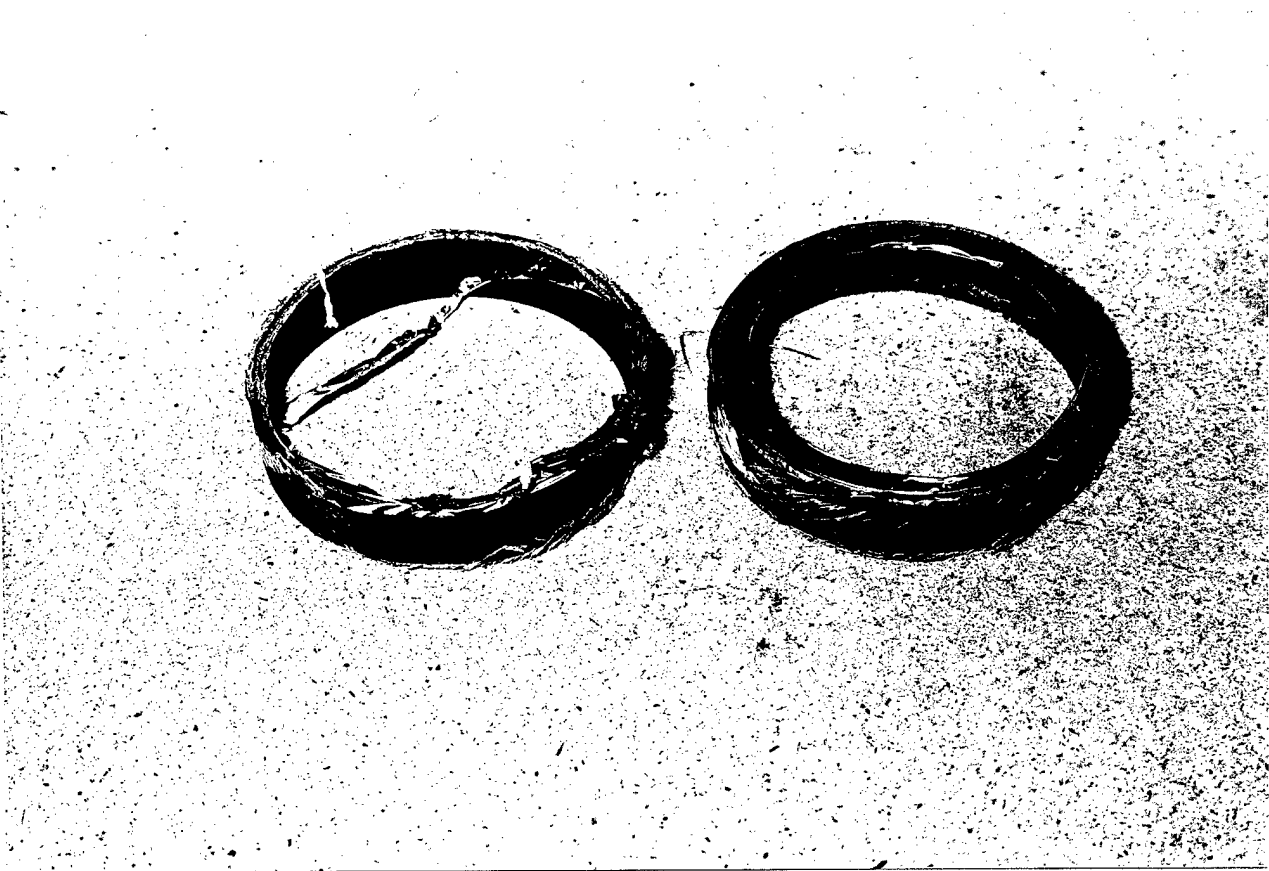


Fig. 6 Typical Failed Specimens. Left-hand Specimen Ruptured by Internal Pressure. Right-hand Specimen Crushed by Axial Load

noticeable barreling or hourglassing. Compressions up to 20% of the specimen height were occasionally achieved prior to specimen failure for both specimen types. The 20% compressions were achieved largely without gross buckling. When barreling or hourglassing occurred, the specimens had an equal propensity to do one as another. It was not uncommon to see specimens with one end barreled and the opposite end hourglassed.

Some blooming of the specimen ends was observed. The blooming usually occurred at high compressions in those specimens with 90° outside plys. It is possible blooming may be controlled by inverting ply layup sequences such that 0° plys are on the surfaces.

IV. CONCLUSIONS

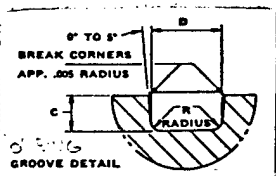
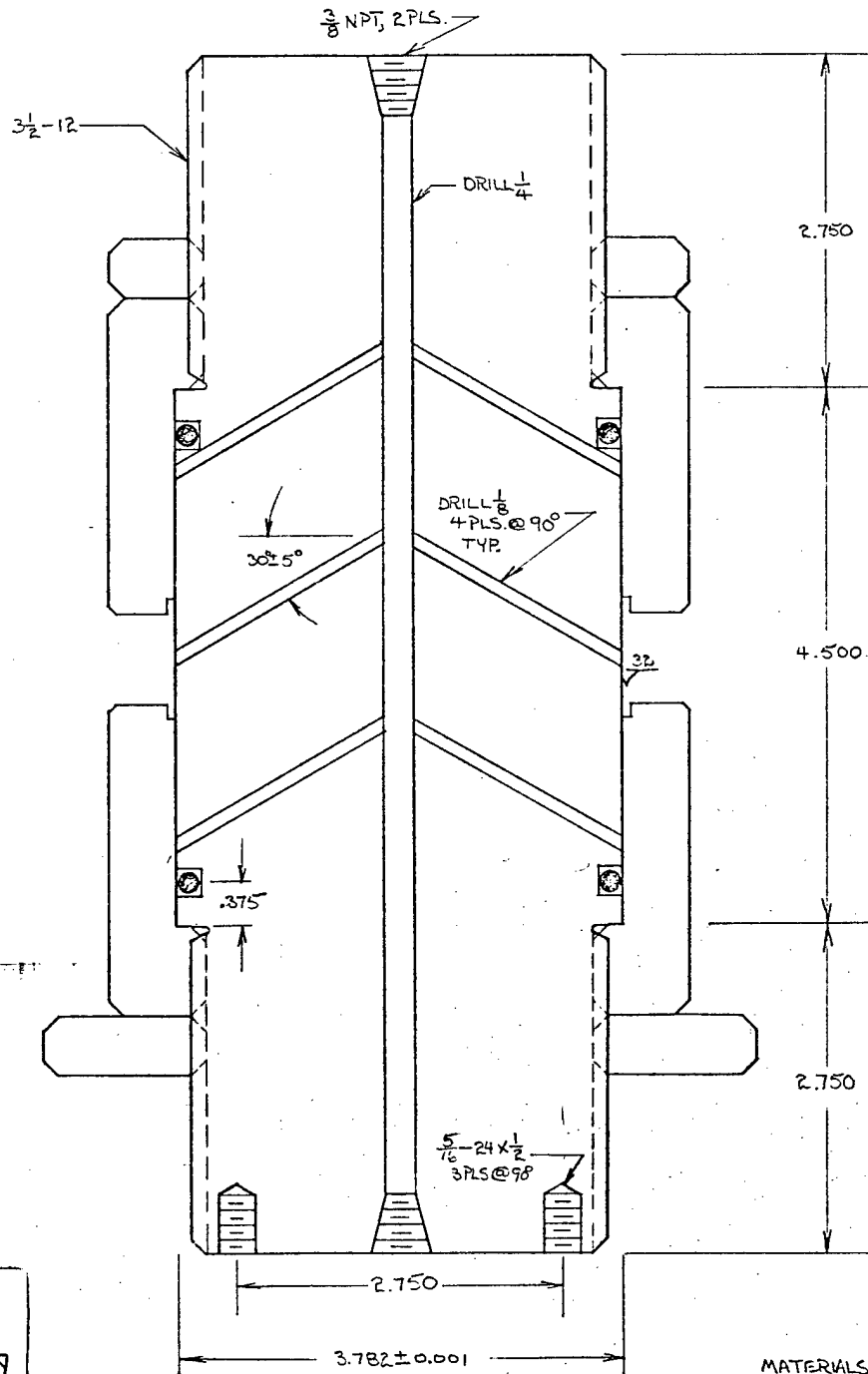
Based on the preliminary testing, the test technique is promising as a viable and simple test system for determining the biaxial properties of materials. Those problems which exist in the system, such as oil leakage and blooming, may be solved at little additional expense. Once these problems are solved, the system should be evaluated through a systematic, fully instrumented, series of tests on a well characterized material.

APPENDIX A

RING TESTER

As part of Problem No. 112, an internal pressure-only tube test fixture was designed and built. The design of the fixture is essentially the same as that of a fixture successfully used by IITRI under contract to AFFDL. A drawing of the fixture is given in Fig. A.1 and a photograph showing the fixture is presented as Fig. A.2. No tests to date have been performed using this fixture.

— HYDROSTATIC TEST FIXTURE —



D = .280
 C = .124
 R = .050 (MIN)
 SUPPLY & INSTALL 2 PC.,
 3/16 NOM. NEOPRENE O RINGS

Fig. A.1 Dimensioned Drawing of Internal Pressure Only Fixture

MATERIALS: BODY - STEEL
 LOCKNUTS - STEEL
 COLLETS - 4340, R_c - 45

SCALE - FULL
 TOL. ± 0.000, EXCEPT AS NOTED
 BREAK ALL CORNERS

N.L.H.
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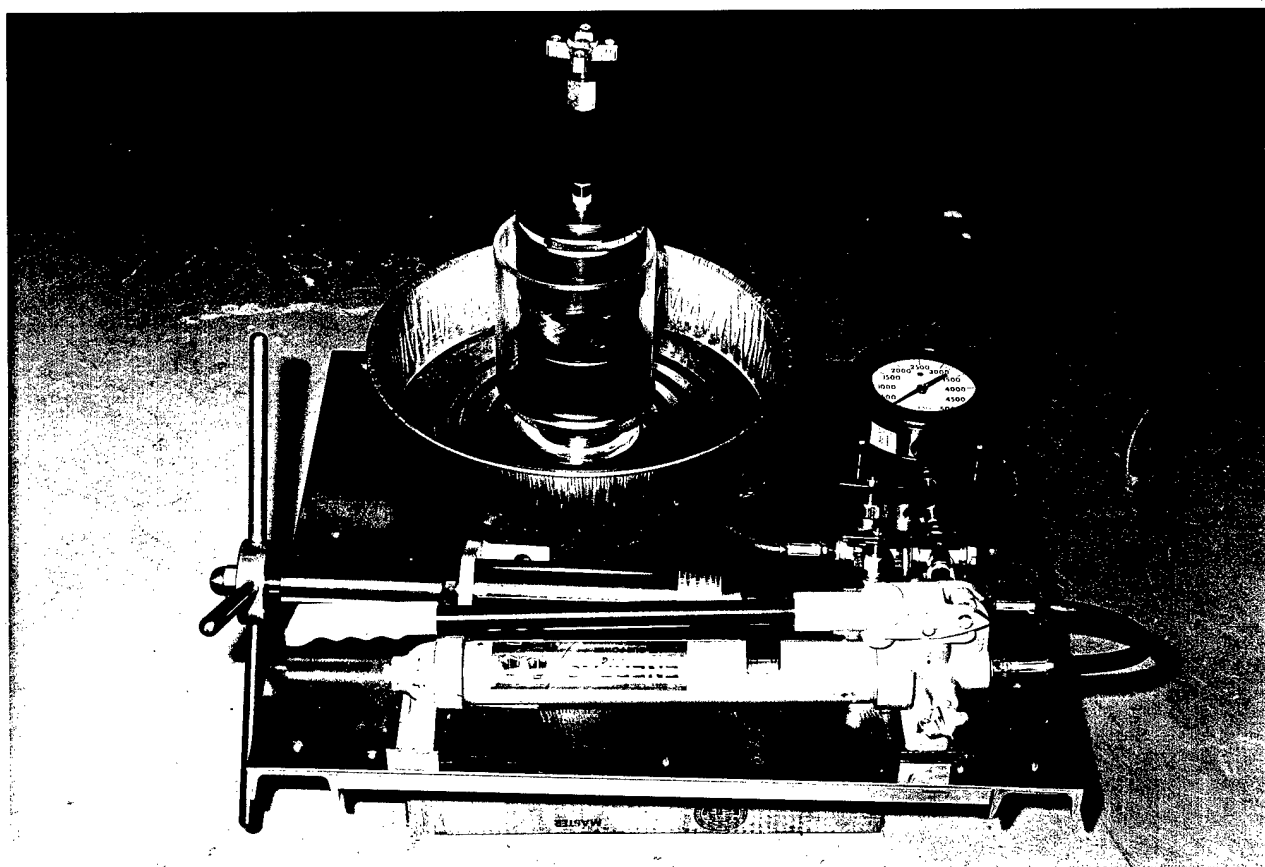


Fig. A.2 Internal Pressure Only Test Fixture