WHC-SD-WM-TRP-223
Revision 0

MWTF Jumper Connector Integral Seal Block Development and Leak Testing

Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management

Westinghouse
Hanford Company Richland, Washington

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7. Abstract

This technical report summarizes activities and tests for the development of an integral seal block for the PUREX style process jumper connector. The integral seal block has greater resistance to leakage, is easier to manufacture, and has fewer parts than the standard seal.

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MWTF JUMPER CONNECTOR INTEGRAL SEAL BLOCK DEVELOPMENT AND LEAK TESTING

January 1995

Edward S. Ruff

ABSTRACT

In fiscal year 1993, tests of an o-ring/tetraseal retainer designed to replace a gasket-type seal used in PUREX-type process jumper connectors encouraged the design of an improved seal block. This new seal block combines several parts into one unitized component called an integral seal block.

This report summarizes development and leak testing of the new integral seal block. The integral seal block uses a standard o-ring nested in a groove to accomplish leak tightness. This seal block eliminates the need to machine acme threads into the lower skirt casting and seal retainers, eliminates tolerance stack-up, reduces parts inventory, and eliminates an unnecessary leak path in the jumper connector assembly.

This report also includes test data on various types of o-ring materials subjected to heat and pressure. Materials tested included Viton, Kalrez[1], and fluorosilicone, with some incidental data on teflon coated silicone o-rings. Test experience clearly demonstrates the need to test each seal material for temperature and pressure in its intended application. Some materials advertised as being "better" at higher temperatures did not perform up to expectations.

Inspection of the fluorosilicone and Kalrez seals after thermal testing indicates that they are much more susceptible to heat softening than Viton.

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[1]Kalrez is a registered trademark of E.I. du Pont de Nemours and Company, Wilmington, Delaware.

The specified purpose of this series of tests (per WHC-SD-WM-TP-256 REV 0, "Jumper Connector Integral Seal Block Test Plan and Procedure") was to:

1) To investigate the effect of clamping force on ISB jumper connector leak integrity.
2) To investigate the effect of externally applied loads and moments on the leak resistance of ISB jumper connector assemblies.
3) To determine the effect of temperature and pressure on the leak resistance of ISB jumper connector seals.
4) To determine the seal compression properties of o-ring seals used in the ISB jumper connector assemblies.
5) To qualify the ISB jumper connector and various o-ring elastomers for plant service.

Objectives 1 thru 4 have been accomplished. Objective 5, qualification by test of the ISB jumper connector and various o-ring elastomers for plant service, encompasses many other areas beyond the scope of this report. These may include: radiation testing, chemical testing, corrosion testing, destructive testing, and seismic testing. This test report pertains only to leak testing under conditions of temperature, pressure, and applied moments. These leak tests were performed at temperatures and pressures that exceed operating conditions stated in the design criteria for the MWTF project.

Radiation and chemical tests of various o-ring polymers were not performed because no funds were available to do so. Hence, chemical resistance to MWTF process fluids, and radiation resistance of seal materials are not specifically addressed in this leak test report. However, the 3 primary o-ring seal materials tested (Viton, Kalrez, and Fluorosilicone) were selected on an overview basis - that is, general chemical resistance to either water or highly caustic solutions expected to be found in the tank waste. Kalrez was selected for testing primarily for it's advertised combined chemical and radiation resistance to 10^8 rads..

Nonetheless, for each specific MWTF process piping application, the piping system designer should refer to vendor data on chemical and radiation resistance of Viton, Fluorosilicone, or Kalrez, and verify seal material selection for compatibility with chemical and radiation service conditions.

Where possible, the piping designer should try to use Viton, Kalrez, or Fluorosilicone as they have been leak tested at temperature and pressure in the laboratory, in the ISB jumper configuration.

Moment loads used during this leak testing may not envelope those loads anticipated for some MWTF jumpers. There are two reasons for this: 1) design moment loads for MWTF jumper connectors were not available prior to the start of leak testing, and, 2) moment loads applied during testing were limited by the capacity of the existing test equipment. To help assure leak-tightness in actual plant operating systems, the piping designer should strive to keep design moments within the limits shown effective by this testing.

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Multi-Function Waste Tank Facility Program (MWTF)

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The contribution of the following individuals in integral seal block development is gratefully acknowledged:

Steven R. Jordan, Test Technician, Equipment Testing Laboratory, who built the test equipment and performed these tests. Steve persevered through many difficulties. He made many key observations and contributions throughout the test program. The graphs in the data appendix indicate the extent of his labor, his dedication, and his achievement.

Robert D. Pierce, Designer, who prepared the design/fabrication blueprints for the integral seal block components and test fixtures. Bob's design talent and patient thoroughness were invaluable. He also did the initial three-dimensional computer modeling of the one-piece-body connector concept.

Larry J. Robinson, Design Services Checker, who performed an exacting and exhaustive review of the component fabrication drawings to ensure accurate fit, function, and compliance to drafting standards.

Harold Byers, Larry Bray, Gordon Cox, and Farrell Coulson, Developmental Machinists, who developed the computer numerical control (CNC) machining programs and fabricated the prototype integral seal block retainers. They overcame many difficulties to produce the unique machining shapes required.

Victor J. Cruz, Susan K. Farnworth, and Thomas J. Conrads, MWTF Project Engineering and Engineering Services, who organized several key project meetings that enabled acceptance of the ISB concept in the engineering design community.

Robert L. Fritz, MWTF Project Manager, and **Jill M. Light**, Manager of MWTF Technical Studies, who early-on gave approval to proceed with ISB development and granted resources for fabrication and testing of the prototype.

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GLOSSARY

ISB	Integral seal block - the part of the jumper connector containing the o-ring seal. It is called "integral" because a previously separate seal retainer has been made integral with the block.
MWTF	Multi-Function Waste Tank Facility - a Hanford project to construct new double-shell underground radioactive-waste storage tanks.
OPB	One-piece-body - a jumper connector design that combines a number of separate parts into a unitized component.

PUREX JUMPER CONNECTOR INTEGRAL SEAL BLOCK DEVELOPMENT AND LEAK TESTING

1.0 MWTF ISB LEAK TESTING: PROJECT ORGANIZATION AND ADMINISTRATION

The decision to use an integral seal block (ISB) type of jumper connector on the Multi-Function Waste Tank Facility (MWTF) Project evolved from work on the o-ring/tetraseal type of connector (Ruff 1994a). At a meeting on January 4, 1994, with ICF Kaiser Hanford Company (ICF KH), Westinghouse Hanford Company (WHC) Project Engineering and WHC Materials and Welding Engineering, an overview of o-ring/tetraseal test results was presented. After discussion of the potential advantages of the ISB design, the MWTF Project decided to proceed with testing of the ISB concept.

Following this meeting, cost and schedule estimates were prepared to stipulate requirements for the new task, which includes the following activities:

- Testing integral seal blocks (ISB) instead of tetraseal-type seal retainers,
- Adding lateral moment testing (in addition to up-and-over moments) to the scope of work,
- Developing the design of and testing advanced three-way connector seals (ISB o-ring type).

Some thought was given to the possibility of performing lateral moment *cycling* tests on the ISBs. D. M. Squier, Jr., of the 305 Equipment Testing Laboratory, was contacted about the possibility of using a computer-controlled hydraulic system to perform lateral moment cycling tests. He stated that the hydraulic system could be adapted to the job and that the adaptation would take from three to five days to set up. He also indicated that the displacement accuracy of the hydraulics could be controlled to within 0.030 in.

Further discussion led the stress analysis group to decide not to perform lateral-moment cycling tests on the connector seals. Subsequently, in accordance with these wishes, test technician S. R. Jordan designed and fabricated a simpler fixture to perform lateral pull tests *without* cycling.

2.0 INTEGRAL SEAL BLOCK DEVELOPMENT: BACKGROUND INFORMATION

2.1 SEAL COSTS

Six commercial vendors were contacted for price and lead-time information on o-rings. From the outset, plans called for using standard-design, stock-available o-rings for the ISB connectors to minimize development costs. If initial tests with o-rings proved successful, consideration could be given to molding a special seal that would include an enhanced seal groove retainer.

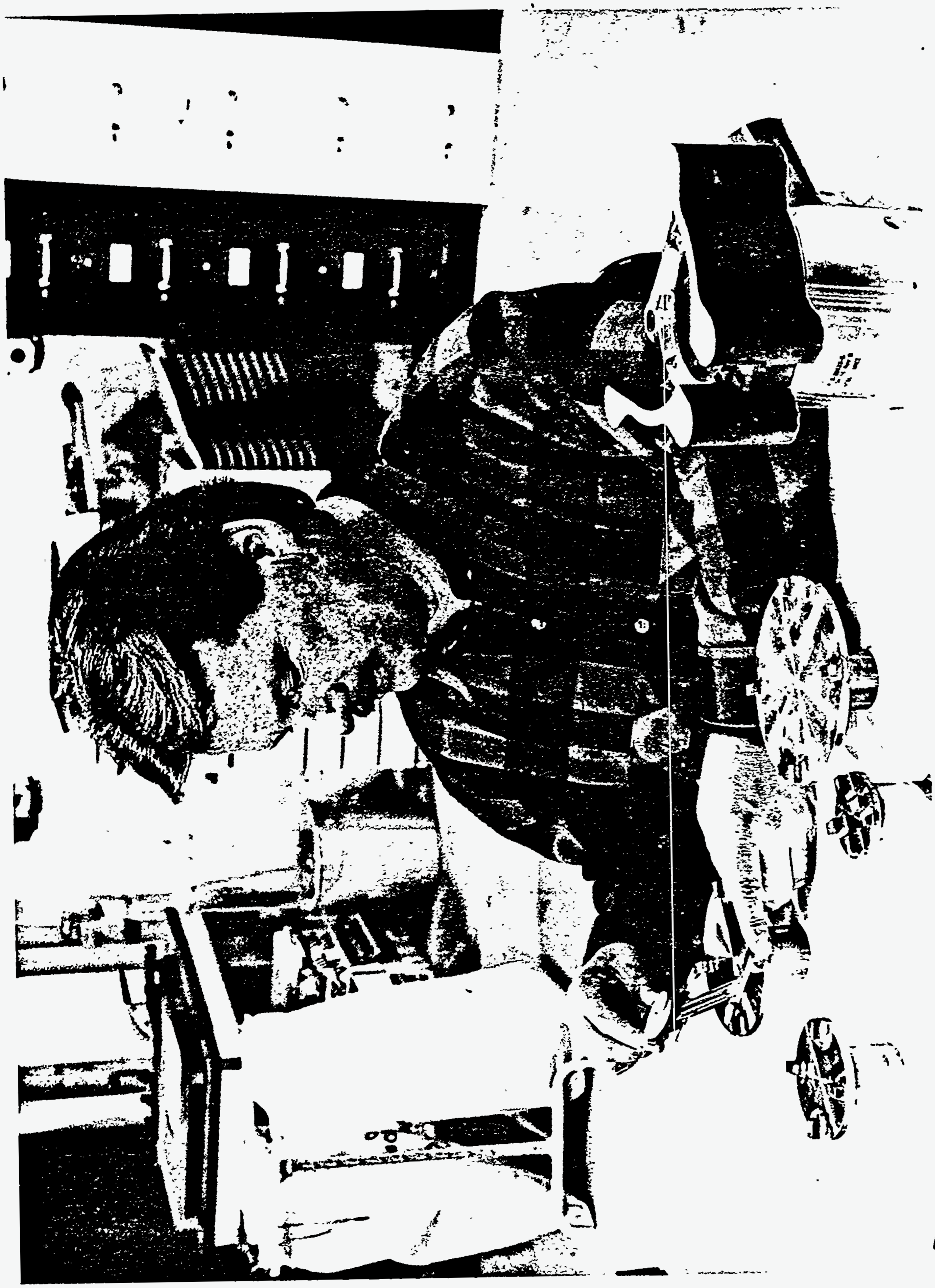
2.2 DESIGN ACTIVITY

2.2.1 Tasks Carried Over from FY 1993

Although design work on the new ISB was underway, a few "cleanup activities" remained from the previous year. Following up on FY 1993 testing activities, Design Services completed final check on H-2 drawings of the o-ring/tetraseal seal retainers. Quality Assurance (QA) review and approval were completed. The H-2 drawings of the o-ring/tetraseal seal retainers were released into the archives via an Engineering Data Transmittal. Design Services completed four-color renderings of the o-ring seal assembly to include in the annual test report and also generated a 30-second video animation of the connector. The computer animation was rendered to VHS video tape for convenient viewing.

Another task from the previous year's work was a detailed design for the removal tool for the o-ring/tetraseal seal retainer. The design was based on sketches of the tool submitted by E. G. Allen, a Hanford worker with extensive field experience on jumper connectors. Blueprints of the seal retainer removal tools were issued for seal retainers in 1- through 4-in. sizes. Subsequent fabrication of the seal removal tool prototype was performed by D. L. Powell, Jr., of the Equipment Testing Laboratory.

Photograph 1. Seal Retainer Removal Tool - Four Sizes.



Photograph 2. Demonstrating the Function of the Seal Retainer Removal Tool.

2.2.2 Single-Port Connectors

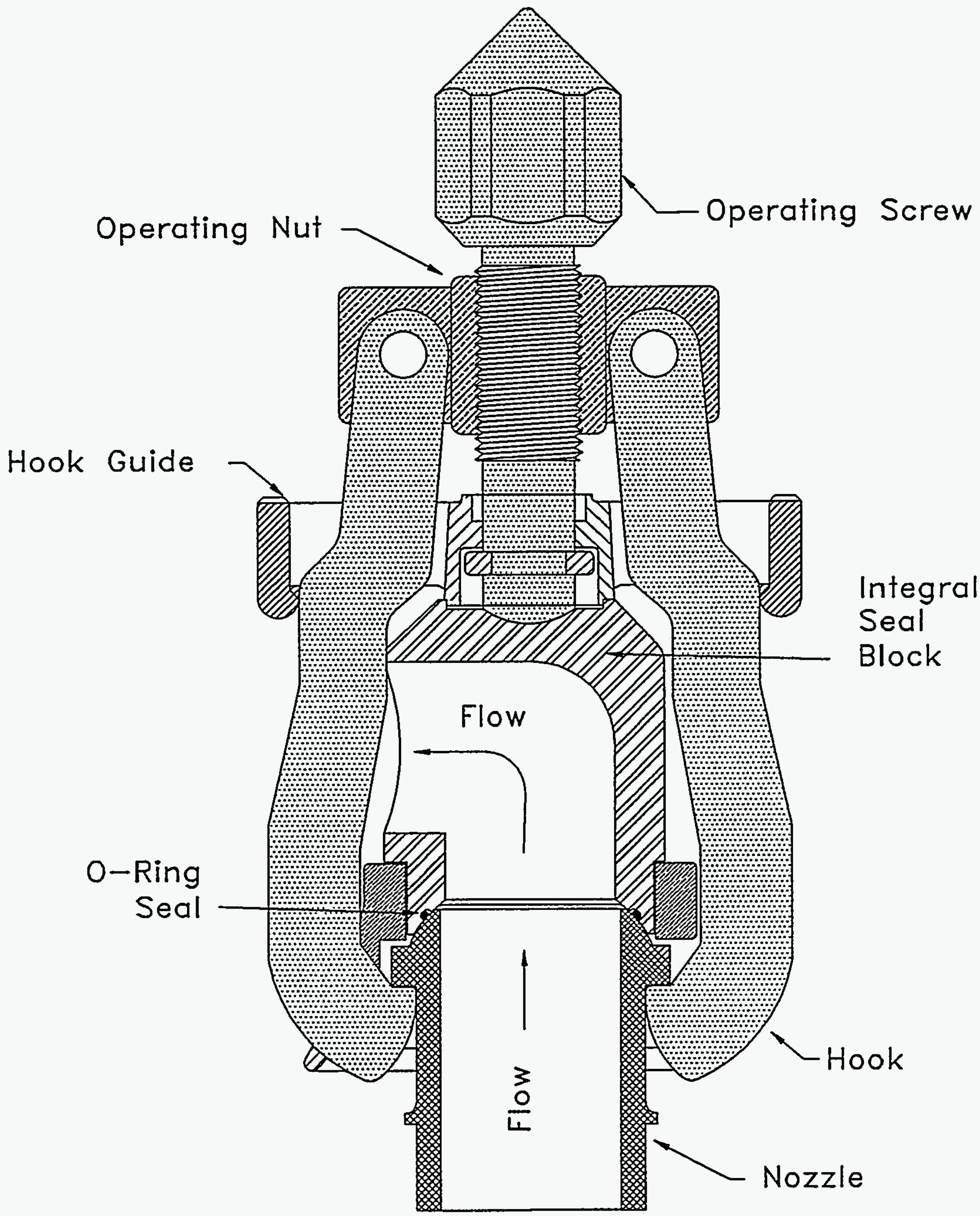
Design began with the smallest jumper connector size; a prototype design for a 2-in. ISB was sent to the jumper connector cognizant engineer, J. E. Conner, and to the fabrication shops for manufacturability review. Review comments were incorporated into the design. After further development, Design Services' R. D. Pierce prepared detailed fabrication drawings for the 2-in. ISB that included both blank blocks and through-flow single-port blocks. Engineering reviewed the drawings, and final comments were incorporated. Once the project was authorized to proceed, the drawings were transmitted to the fabrication shop for cost estimating and machining.

After the ISB had been designed, work began on the drawings for the 2-, 3-, and 4-in. threadless connector skirt and on the final assembly drawings for the ISB jumper connector. All design of the ISB jumper connector components, test fixtures, and tools was done on a desktop computer (Intel[2] 486/586 processor) with AutoCAD[3] Release 12 software.

[2]Intel is a registered trademark of the Intel Corporation, Beaverton, Oregon.

[3]AutoCAD is a registered trademark of the Autodesk, Inc., Sausalito, CA.

Figure 1. Jumper Connector Assembly.



Integral Seal Block
Jumper Connector Assembly

Illustration Showing O-Ring Seal.
Seal Is Compressed Between the Block and Nozzle.

2.2.3 Three-way Connectors

Incidental to early-stage design of the ISB was a simplified concept for three-way connectors. Materials and Welding Engineering personnel J. J. Sisk and J. P. Hauptmann met with Ed Ruff to discuss the feasibility of the design of the simplified three-way connector nozzle. The design sought to eliminate the need for machining the connector-nozzle pipe inserts separately. Accessibility of the attached piping for welding was identified as a problem with the concept. So the concept was set aside and the decision made to continue with a three-way ISB test stand design configured for use with a stock three-way connector nozzle insert.

Detailed engineering design of the test fixture for the three-way connector was very time consuming. Internal flow passages for water, air venting, and the insertion of a heater element required a great deal of attention to ensure proper fit and function. Heating elements were sized and selected. Engineering AutoCAD sketch files were transmitted to Design Services for upgrading into formal engineering drawings. Port configurations and hardware for hydraulic connectors were detailed.

Several minor modifications were made to improve the design of a Teflon[4] gasket seal for the three-way connector and released via an Engineering Change Notice (ECN). However, prototypes of these gaskets were never produced or tested. To save money, initial leak testing of the three-way connectors used off-the-shelf Teflon gaskets. Because later tests showed the o-ring ISB design to be far more resistant to applied moments than were teflon gaskets, there was no compelling reason to test the "improved" teflon gaskets.

Design work continued on the three-way integral seal block. AutoCAD drawings were forwarded to Engineering for detailed scrutiny of the o-ring groove design. After Engineering review, the o-ring groove design was modified to a 0.103-in. cross section. Subsequently, detailed H-2 drawings of the flow-through three-way connector and the three-way blank ISB were completed and forwarded to the machine shop for cost estimates and subsequent fabrication.

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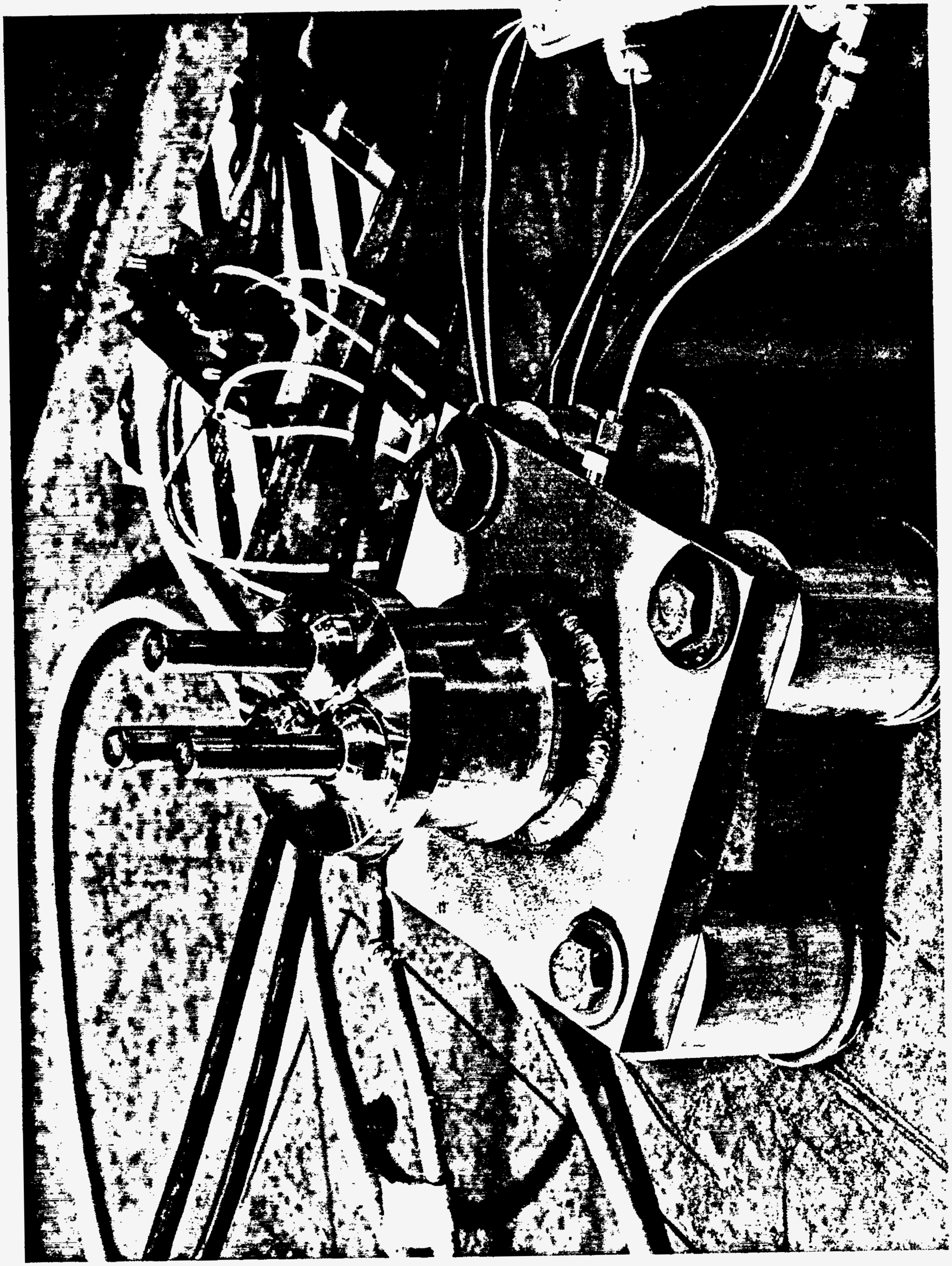
[4]Teflon is a registered trademark of the E.I. du Pont de Nemours Company, Wilmington, Delaware.

Photograph 3. Test Assembly for Three-Way Nozzle and Baseplate - Closeup View.



3.0 DESIGN CONSIDERATIONS, INTEGRAL SEAL BLOCK

3.1 INTERCHANGEABILITY

A fundamental objective of the design process was to produce a design for an integral seal block that could be brought into service with minimal changes to the existing hardware inventory of PUREX-type connectors, so that the new ISB could be used with parts currently stored in the warehouse.

An interchangeable seal design would afford cost savings by eliminating the need to re-design other connector parts, e.g., the nozzle, the block, and the lower skirt casting. It also would simplify the existing parts inventory.

3.2 LEAK PATHS

The advantage of the ISB is that there is only one leak path to consider--between the nozzle and the o-ring seal groove--in contrast to the earlier "tetraseal retainer/o-ring" design, which had two leak paths.

3.3 PRESSURIZATION

The o-ring seal grooves are designed with enough width so that after compression by clamping, there is space for fluid to enter the groove and pressurize the inside diameter (i.d.) of the seal. Fluid pressure forces the seal material toward the outside, thus seating the o-ring firmly against the outside diameter of the seal groove. This "self-energization" of the seal by the pressurized fluid is key to leak prevention.

3.4 MINIMAL STRETCH

The o-ring groove outside diameter (o.d.) was designed initially to match the outside diameter of the o-ring seal to minimize polymer stretch when the o-ring is energized. The design permits the seal to be seated firmly against the outside wall of the groove without excessive polymer stretch and strain that could cause premature failure of the seal.

3.5 SEAL GROOVE

The width and depth of the seal groove are critical dimensions for the proper operation of the seal. As a general rule, the depth of the seal groove is designed to allow about 30% compression in the vertical direction. The groove width must be sufficient (i.e., have enough internal volume) to allow the compressed seal to recess fully into the groove. An additional allowance of 10% extra volume permits allow fluid pressure to enter the i.d. side of the groove and energize the seal.

The o-rings are designed for o.d. contact with the groove at the small end of the o.d. tolerance dimension, at 80% groove volume, with 30% diametral squeeze. After compression, approximately 7% i.d. clearance allows process fluids to energize the o-ring against the o.d. of the groove.

The technical literature shows "standard o-ring grooves" as slanted outward from 1 to 5 deg. The reason given for this characteristic is "for ease of machining." However, a zero-degree slant theoretically is best for pressure retention in that it minimizes the tendency of the o-ring to extrude from the groove. Also, machinists indicate that they much preferred to machine the groove walls straight (i.e., with zero-degree slant). For these reasons, the decision was to design the grooves with 0-deg. slant. Standard shop tolerances were acceptable for the perpendicularity of the groove walls.

4.0 DESIGN REQUIREMENTS AND TEST CONDITIONS

Prior to testing, an effort was made to find out what projects on the Hanford site were planning to use jumper connector hardware. Cognizant personnel on these projects were then asked to stipulate what operating conditions would apply to connector installations. The intent was to perform leak tests that would meet or exceed the temperature and pressure requirements for all the projects - not just meet the specific needs of MWTF. This was done in the interest of saving money, and turned out to be a worthwhile excercise.

The table below identifies the temperature and pressure operating conditions for 4 projects that intended to use jumper connectors. As it turned out, HWVP required the highest temperatures (390 °F), and MWTF/C-106 Tank Sluicing required the highest pressures (400 psig).

Figure 2. Project Design Conditions Used to Determine Leak Test Parameters

SIZE	W-058 CROSS SITE TRANSFER		W-028 HANFORD WASTE VITRIFICATION PLANT (HWVP)		W-236A MULTI-FUNCTION WASTE TANK FACILITY (MWTF)[a]		W-320 C-106 TANK SLUICING[b]	
	TEMP. °F	PRESS. psig	TEMP. °F	PRESS. psig	TEMP. °F	PRESS. psig	TEMP. °F	PRESS. psig
2-In.	NS	NS	390	220	250	400	180	400
3-In.	200	250	390	220	250	400	180	400
4-In.	NS	NS	390	220	120	-10" H_2O	180	400
3-Way (2-In.)	NS	NS	390	220	125	125	NS	NS

NS = Not Specified, presumably because the project did not plan to use this particular size of connector.

[a]Letter, M. A. Rezvani to V. J. Cruz and J. M. Light, dated Dec. 6, 1993, "Qualification of Mechanical Jumpers and Electrical Connections," comment 2, page 2, MWTF Functional Design Criteria jumper classification.

[b]cc:Mail Message, E. G. Allen III to E. S. Ruff, dated April 14, 1994, "Project W320 Connector Needs."

After considering the above matrix of project needs, it was decided to perform the leak tests on ISB jumper connectors at ambient temperature and 400 °F, and at pressures incremented at 250, 500, 750, and 1,000 psig.

Figure 3. Applied Moments and Pressures Used For Leak Testing ISB Jumper Connectors.

Size	Tests at 250 psig		Tests at 500 psig		Tests at 750 psig		Tests at 1,000 psig	
	Lat. Momt. ft-lbf	Up & Over Momt. ft-lbf	Lat. Momt. ft-lbf	Up & Over Momt. ft-lbf	Lat. Momt. ft-lbf	Up & Over Momt. ft-lbf	Lat. Momt. ft-lbf	Up & Over Momt. ft-lbf
2-In.	445	1500	334	1200	223	900	165	555
3-In.	445	1200	445	1200	445	1200	445	1200
4-In.	445	1200	445	1200	445	1200	445	1200
3-Way	445	1500	356	1200	267	900	165	555

Lat. Momt. = Lateral Moment Applied to the Jumper Connector

Up & Over Momt. = Up and Over Moment Applied to the Jumper Connector

5.0 INTEGRAL SEAL BLOCK PROCUREMENT ACTIVITIES

5.1 SEAL PROCUREMENT

Purchase requisitions were prepared for small quantities of o-rings for leak testing. However, a large batch order was necessary to obtain Aflas[5] o-rings. Orders of fewer than a dozen were too small for vendors to consider. To reduce development expense, Aflas was dropped from the roster of test materials. Ultimately, the materials chosen for testing were 70-durometer (durometer is a measure of hardness) Viton, Kalrez, and fluorosilicone. Some silicone and ethylene-propylene-diene-monomer (EPDM) o-rings were obtained later for testing only with the three-way ISB connector. The o-rings procured for the ISB testing were provided by Erik's West Co. of Seattle, Washington. This vendor proved to be very cooperative and responsive in providing seal materials.

Samples of an unusual type of o-ring, called TFE-O-SIL[6], were received from Row, Inc., Addison, IL. These o-rings had a silicone elastomer core with a Teflon outer coat. They were described as having the resilience of an elastomer and the chemical resistance of Teflon. A 4-in. ISB connector using one of these o-rings was leak tested. It performed well at ambient temperature. However, high temperature applications are limited because of the relatively low softening temperature of the Teflon outer coat.

5.2 CONNECTOR HARDWARE AND MISCELLANEOUS TEST EQUIPMENT

A list of parts was developed for the required connector components, and a store order request for them was submitted to Site Warehousing Services. After the necessary tracking and follow up, Site Warehousing Services processed the request, and the components were shipped to the 305 Equipment Testing Laboratory on February 1, 1994. Examination of the parts for their suitability resulted in the discovery that one component, a vertical single-port skirt, was the wrong item. It was returned to Stores in exchange for a three-way vertical skirt.

The fabrication shops verified that stainless steel bar of the size needed to machine the 2-, 3-, and 4-in. ISB prototypes was in stock. Also, 1-in.-thick stainless steel (SS) plate was available for fabrication of nozzle baseplates.

A petty cash voucher was used to purchase hydraulic fittings for the internal water flow passages in the test stand baseplate. The hydraulic fittings were received from the Swagelock Company on February 4, 1994. Another company, the AAR Hardware Company of Cerritos, California, provided complimentary stainless steel port plugs for the test stand air vents. These port plugs proved to be ideal for the air vents in the ISB test units.

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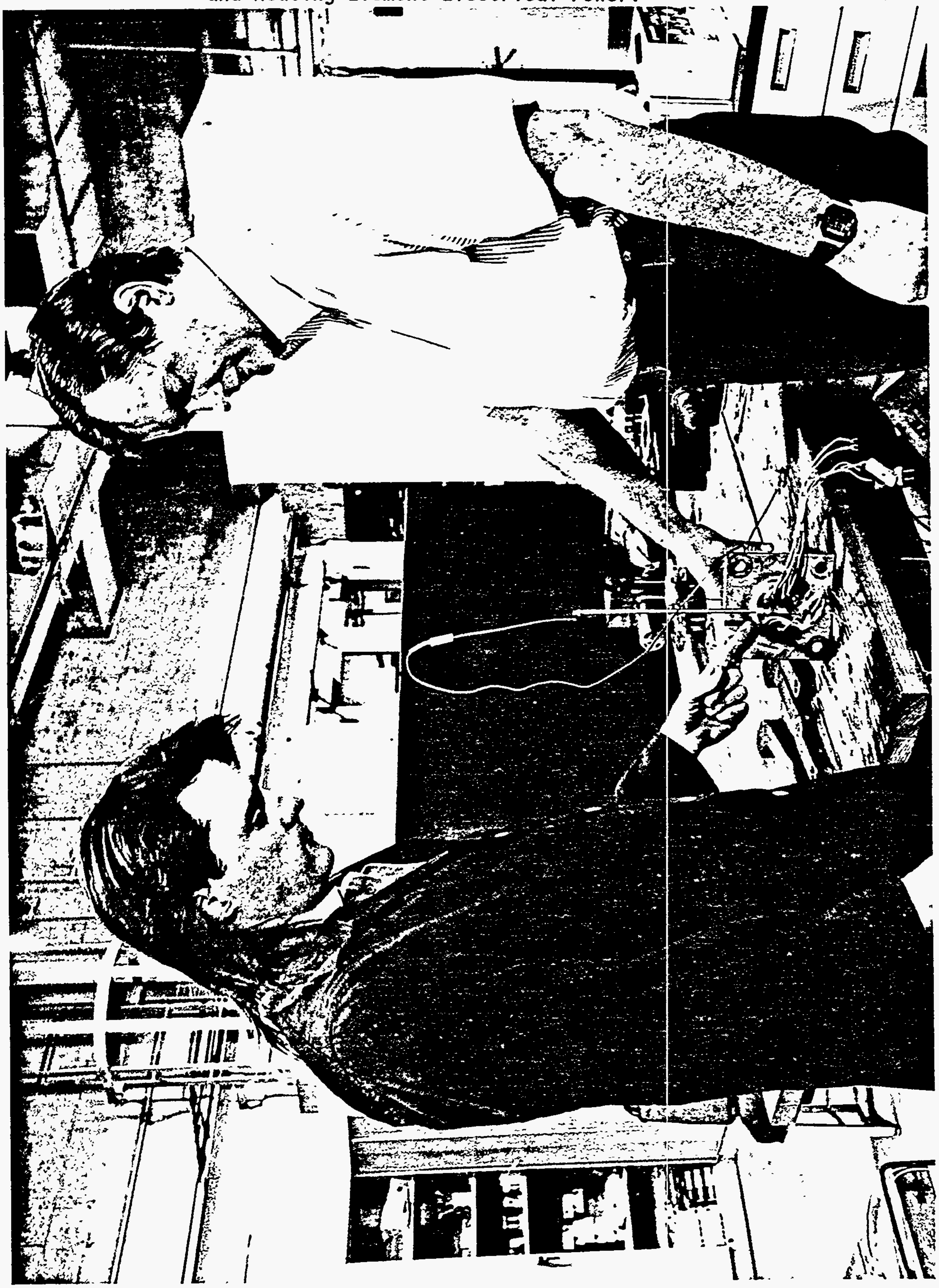
[5]Aflas is a registered trademark of the 3M Company, St. Paul, Minnesota.

[6]TFE-O-SIL is a registered trademark of Row, Inc., Addison, IL.

Three 1,000-W heater elements with internal thermocouples were procured from the Watlow Corporation. They were used as the heat source for the high-temperature test of the three-way jumper connector test assembly. The heater elements performed very well during testing, withstanding repeated temperature cycles and pressurized hot water to 2,500 lbf/in^2 (gauge).

Photograph 4. Nozzle Baseplate Showing Wire Bundles for Thermocouples and Heating-Element Electrical Power.



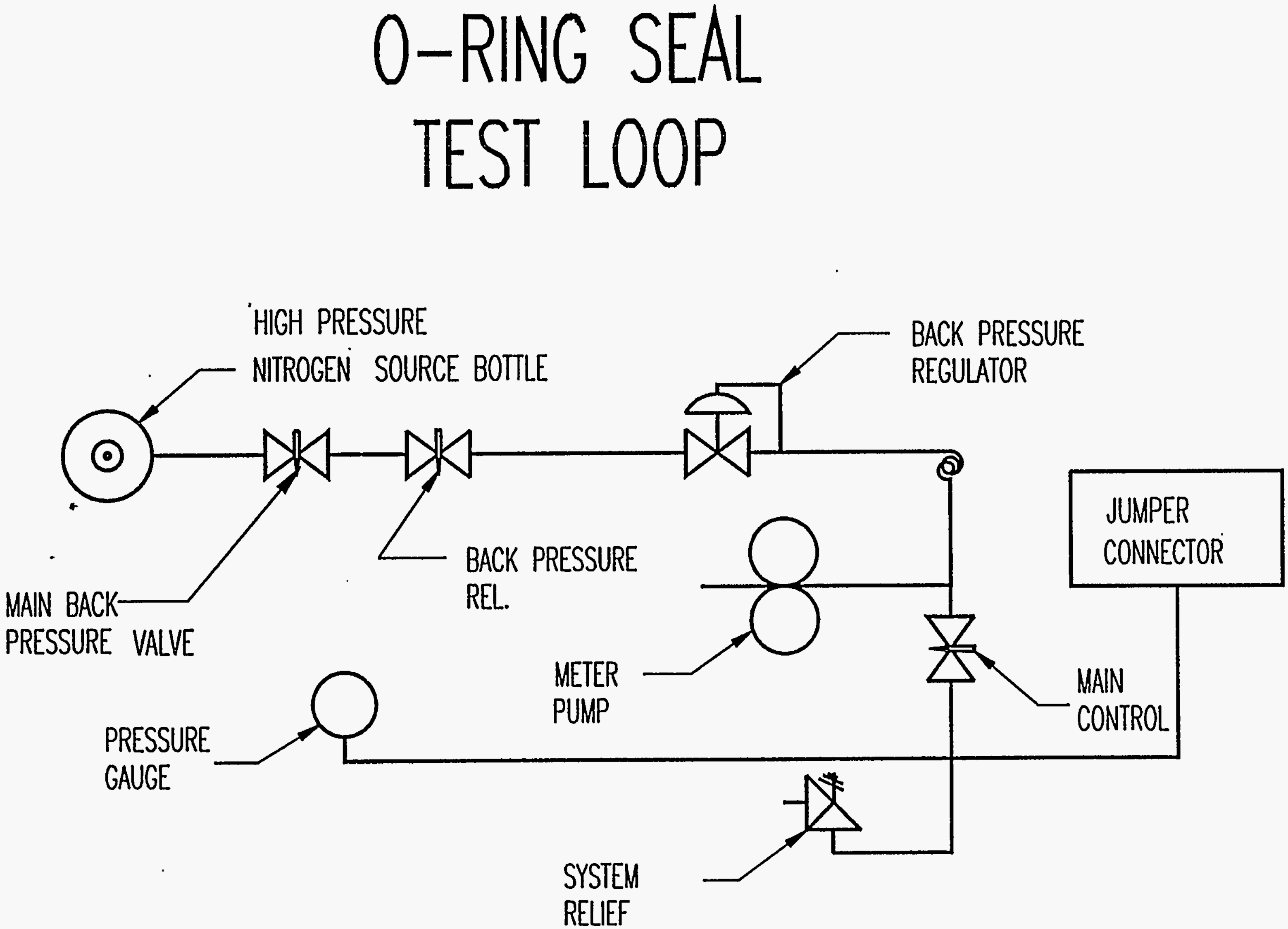
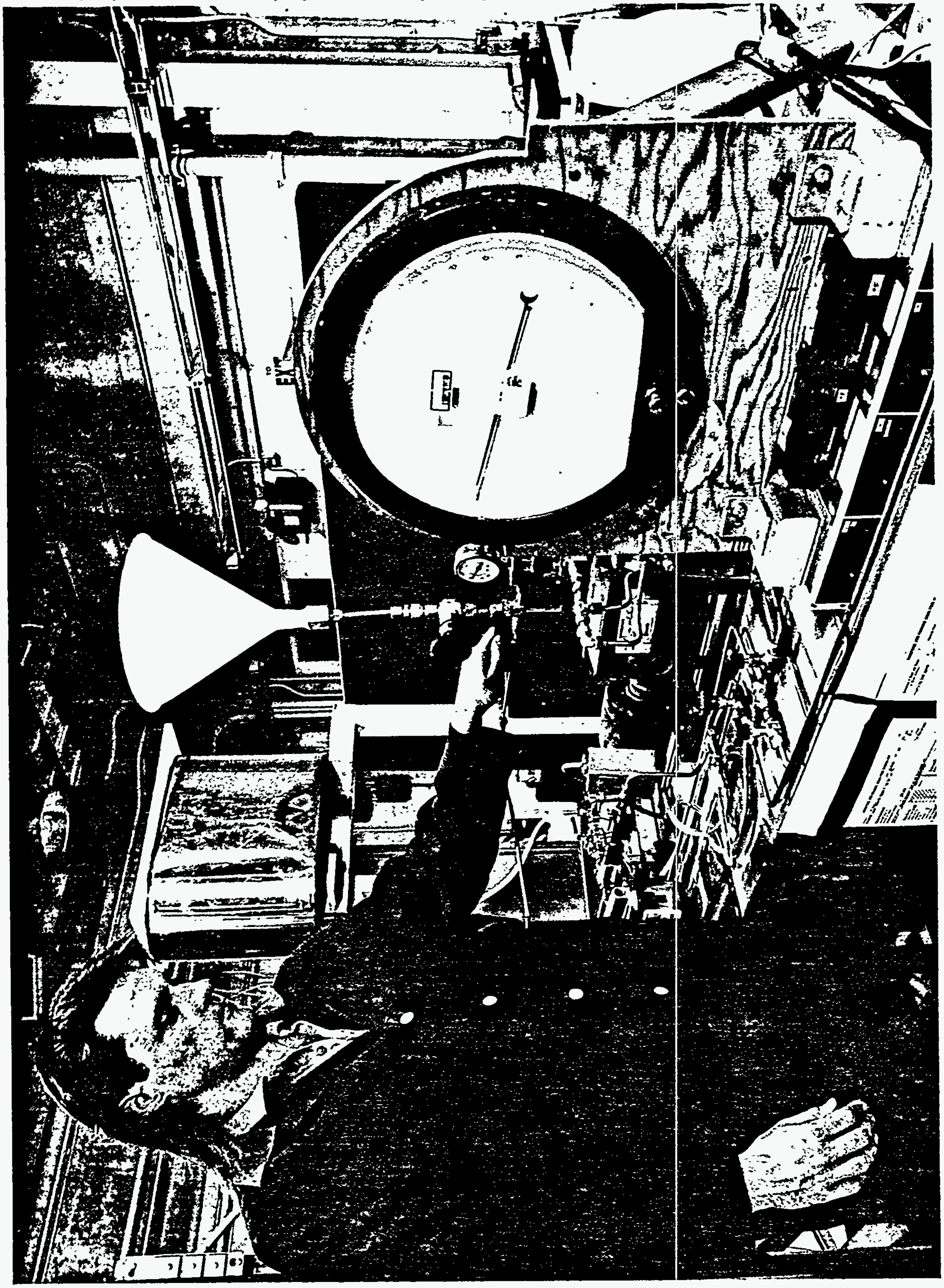


Figure 4. Schematic for Process Jumper Connector Test Loop.

Photograph 5. Test Equipment Setup, High-Pressure Pump and Instrumentation.



6.0 STRESS ANALYSIS SUPPORT ACTIVITY

Ed Ruff tried a method for converting AutoCAD drawings to a geometry database suitable for use with the COSMOS[7] finite-element analysis (FEA) program. Overcoming several minor "glitches" enabled the program to be used successfully. The part modeled for the first conversion experiment was a 3-in. jumper connector hook. Use of the converted AutoCAD database reduced the time needed to re-model complex hook geometry with the FEA program. Geometry was exported to both COSMOS and ANSYS[8] programs. This method also saved time in the FEA of other jumper connector components. Models were created for 2-, 3-, and 4-in. hooks and the 2-in. nozzle. The FEA of the 3- and 4-in. hooks used the COSMOS program and a desktop personal computer (PC).

Tentatively planned was a side experiment on the 2-in. hook model, with the same loading conditions, to compare stress analysis results from the COSMOS PC analysis and the ANSYS workstation version; however, budget and schedule limitations prevented the experiment.

[7]COSMOS is a registered trademark of the Structural Research and Analysis Corporation, Santa Monica, CA.

[8]ANSYS is a registered trademark of Swanson Analysis Systems, Inc., Houston, PA.

7.0 INTEGRAL SEAL BLOCK MACHINING

A J-10 Fabrication Request submitted to the 200 Area Fabrication Services requested the machining of an updated design three-way gasket retainer. This task was completed at the 200 West Area machine shop.

The 200 West Area machine shop also fabricated the test fixture for the three-way jumper connector test nozzle and baseplate; the 2-, 3-, and 4-in. ISB's; and the associated thread-less lower skirt castings. On delivery of these parts to the 305 Building Equipment Testing Laboratory, preliminary static leak checks were performed. Then the parts were returned to the machine shop where moment arms were welded onto the 2-, 3-, and 4-in. ISBs.

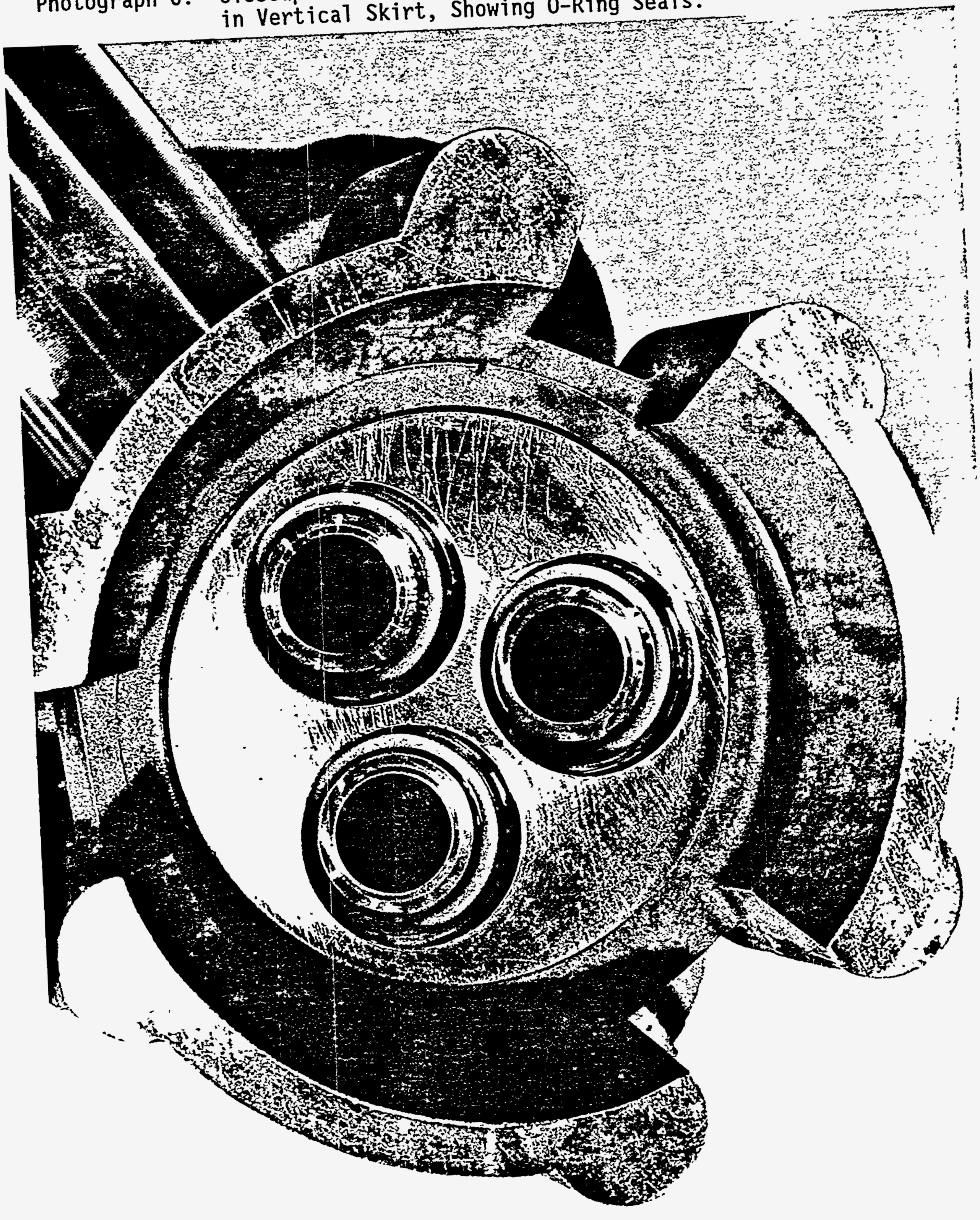
Generally, machining tolerances on the metal seal retainer can be held to ± 0.005 in. or better, but molding tolerances on the elastomer o-ring are much sloppier — frequently as bad as ± 0.025 in., or worse. Experience shows that, when these two extremes in dimensions are combined in component assembly, there is every chance that the o-ring will not stay in the groove. The solution to this problem is to intentionally machine the nominal seal-groove diameter to match the smallest o.d. in the o-ring tolerance range. This practice tends to "snug up" the o-ring in the seal groove. These provisions for o-ring "snug-up" were incorporated into the design.

After the single-port ISB's were completed, detailed fabrication drawings for the prototype of the three-way ISB were finished and forwarded to the machine shop. The machinist, L. J. Bray, developed ideas for fixtures that could be used to make the component. Basically, an off-centerline chuck setup was used to position the "flow axis" of each of the three ports with the axis of the lathe. This fixture was necessary to machine each of the three o-ring grooves into the concave spherical surface. Just as the three-way setup had been established, work on the three-way prototype was interrupted by a job to machine 1,400 sample valves for underground radioactive waste storage tanks that was of higher priority. Machining of the three-way o-ring connector was delayed for several months.

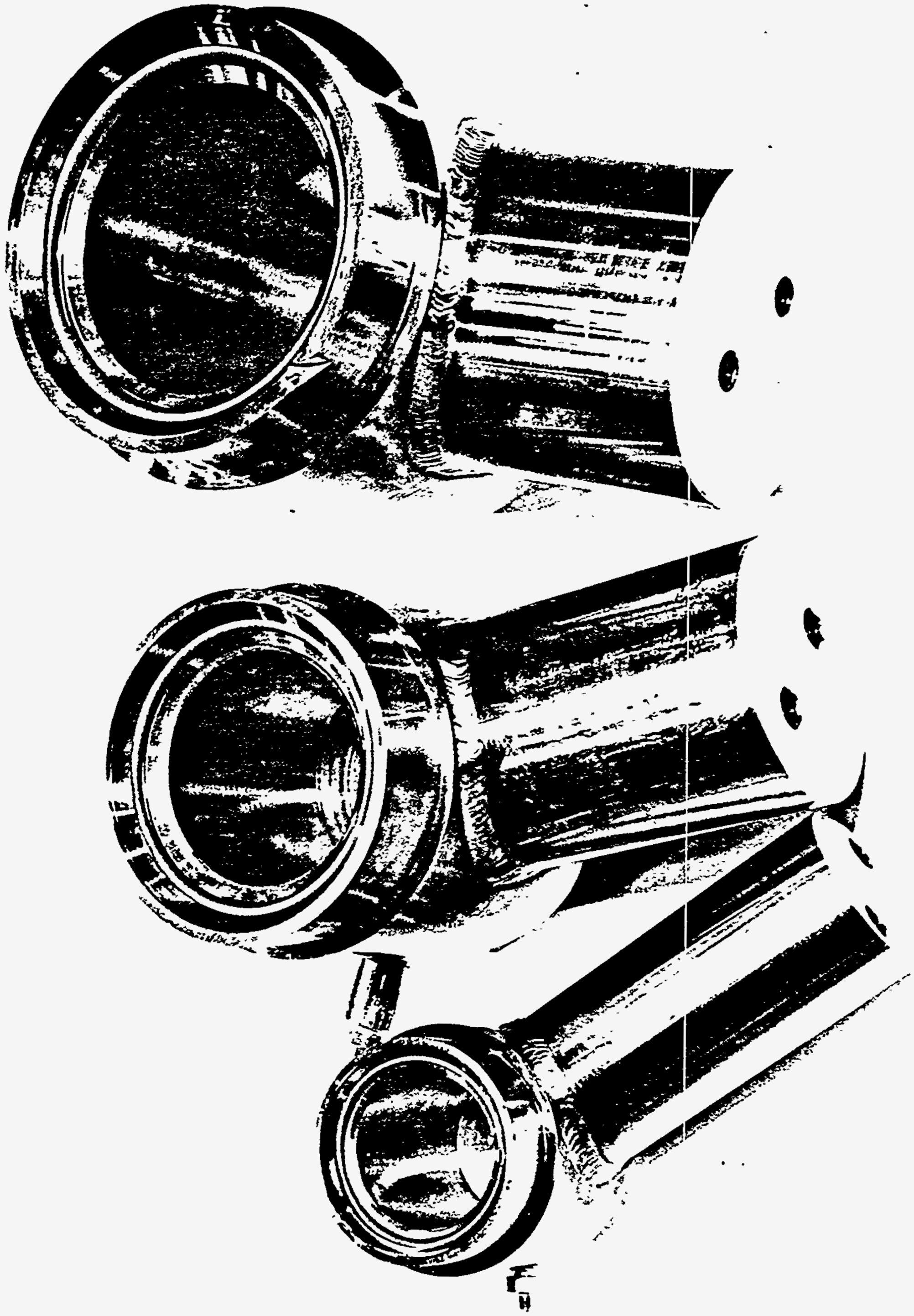
In anticipation of completion of machining activities, a work order was issued to the 305 Building Equipment Testing Laboratory to begin preparation for leak testing the ISB's. A detailed activities schedule was generated for the tests. The test technician, S. R. Jordan, prepared improvements to the test procedure and ordered additional block heater tubes. Torque wrenches and temperature and pressure instrumentation were calibrated.

Meanwhile, machining of prototypes continued. The machinist, H. H. Byers, continued to refine the CNC program. Perseverance finally resulted in completion of the 2-, 3-, and 4-in. stainless steel ISB's. After final de-burring and metrology, the components were delivered to the Equipment Testing Laboratory. Photographs 6 and 7 show the prototype components made by CNC machining.

Photograph 6. Closeup View of Three-Way Integral Seal Block Installed in Vertical Skirt, Showing O-Ring Seals.



Photograph 7. Single-Port Integral seal Blocks (2-, 3-, and 4-In.) Welded to Block Moment Arms.



8.0 EQUIPMENT TESTING LABORATORY - INITIAL SETUP

8.1 TEST OF CONVENTIONAL THREE-WAY TEFLON GASKET

The first test fixture to be completed and set up was that for a "conventional Teflon gasket" three-way jumper connector. Once the three-way nozzle assembly arrived from the machine shop, attempts were made to install the newly arrived Watlow[9] heater rods. Minor difficulties with the machined pipe thread on the heater rods led to the return of the heater rods and baseplate to the machine shop for thread adjustment and cleanup.

Meanwhile, high-pressure tubing was installed from the metering pump to the baseplate on the test fixture. The three-way block (with conventional Teflon seals) was assembled to the hook guide and lower skirt, and the size and fit of the air-bleed port plugs were verified.

Heater rod threads were reworked, and Watlow heater rods were installed into the three-way connector test fixture. The use of Grafoil[10] tape was instrumental in achieving leak-tightness in the heater rod/baseplate pipe thread. Thermocouple connections and power leads were attached to the heater rods.

Once these preparations had been made, leak testing of the conventionally gasketed three-way connector began at ambient temperature conditions. The test involved no applied moments, and conventional gaskets of 100% Teflon were used. The conventional three-way connector performed surprisingly well at ambient temperature when *not subjected to moments.* Leak-tight operation to 2,300 lbf/in^2 was demonstrated at an operating screw clamp torque of 100 ft-lb. *However, this high pressure leak-tight performance deteriorated significantly when either heat or moments were applied to the Teflon gaskets.* This was demonstrated in the next set of leak tests which involved ambient and elevated temperatures (400 °F) with "up and over" applied moments, using conventional 100% Teflon gaskets in the connector.

> **SIGNIFICANT FINDING:** The "up and over" moment tests revealed that the *conventional three-way connector is much more susceptible to externally applied moments than the single-port connector is.* (That is, the conventional 3-way connector leaks much sooner.) As shown in Appendix T, Graph 3WAM250M, the teflon-gasketed 3-way connector *completely failed to hold pressure* under the very moderate conditions of ambient temperature, 250 lbf/in^2 pressure, and only 187 ft-lbf of "up and over" moment. This is quite a contrast to the single-port conventional teflon-gasketed connector, which was able to remain leak tight at ambient temperature, 250 lbf/in^2 pressure, with 1,250 ft-lbf of "up and over" moment applied. (Austin, 1993, Appendix A, page 17). It is thought that the reason for this difference is that the moment forces in the three-way connector bear on a much smaller area (one of the small three-way nozzle inserts) compared to the single-port connector.

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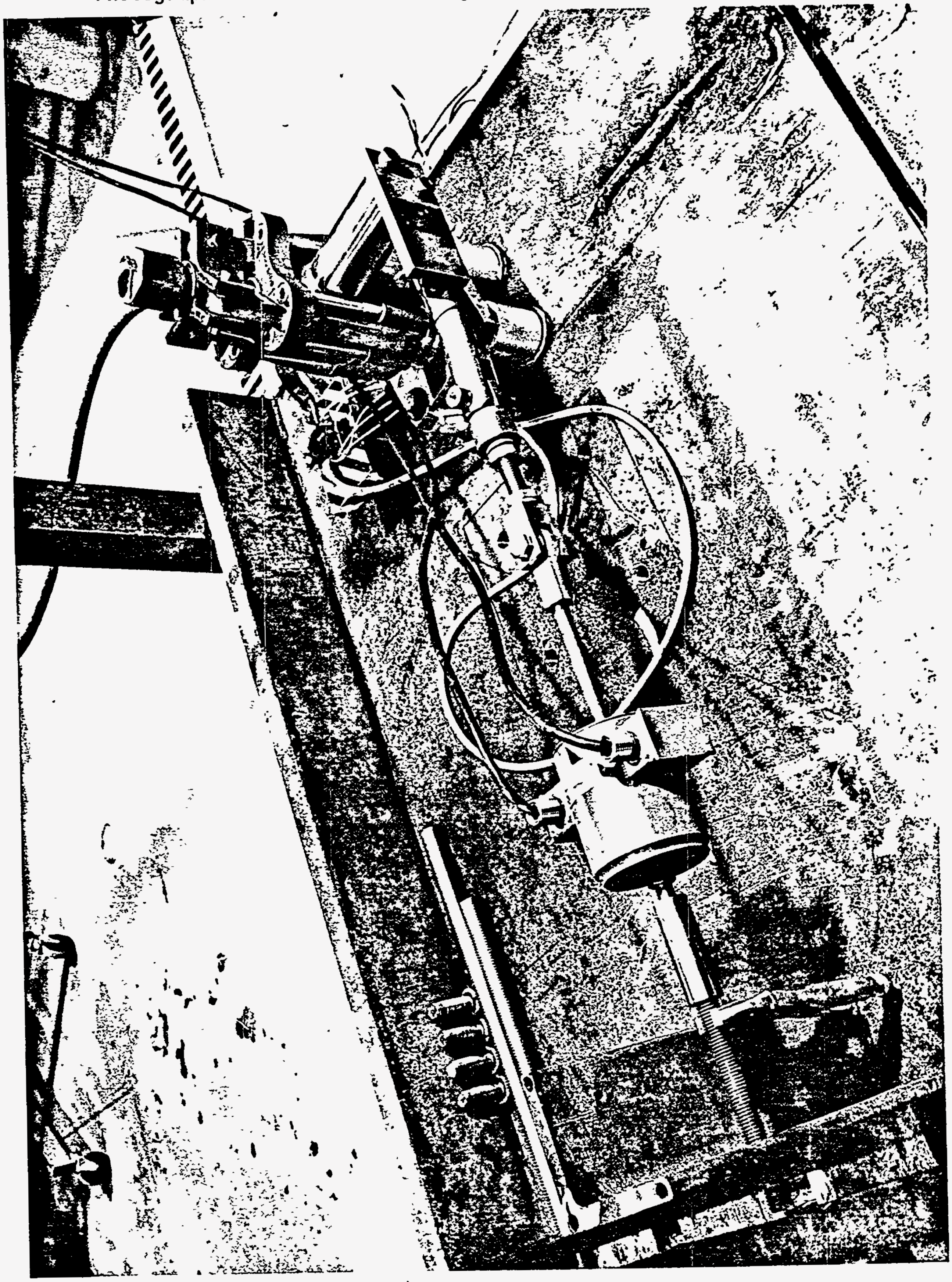
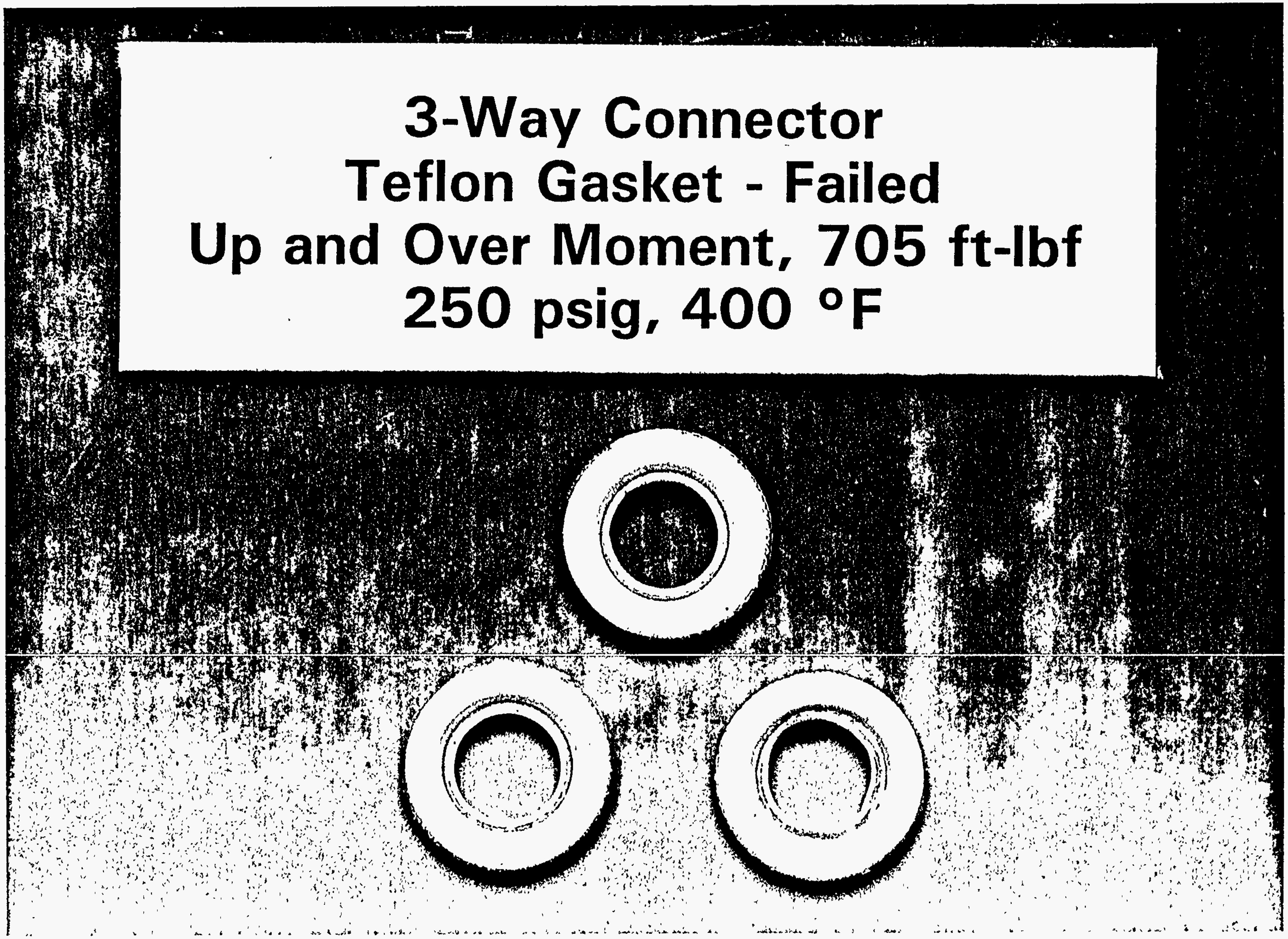
[9]Watlow is a registered trademark of Watlow, Inc., St. Louis, MO.

[10]Grafoil is a registered trademark of the UCAR Carbon Company, Cleveland, OH.

CONCLUSION: The leak tests of the conventional three-way connector in which external moments were applied revealed a significant weakness in the ability of the connector to take side loads. This finding indicated a need for an improved type of connector block. (Later on in the test program, the new-design three-way ISB using o-rings was to show much greater leak resistance under applied moments.)

Photograph 8. Test Stand Arranged for Lateral Moment Testing.





Photograph 9. Three-Way Conventional Connector with 100% Teflon Gasket, 250 lbf/in^2, 400 °F.

8.2 ADDITIONAL LABORATORY ACTIVITIES

The jumper connector test loop was modified with a vacuum pump and an isolation valve to enable connectors to be tested under vacuum conditions, should that have been necessary. A digital electronic vacuum transducer was calibrated and installed to measure vacuum levels to 10-in. water gauge (w.g.). Several new valves also were installed on the test loop: an isolation valve on the main pump and a shut-off valve on the water reservoir. Later on in the program, vacuum leak tests were deleted from the scope due to schedule and funding limitations.

The electric heater power supply was rewired to correct a problem with the high-temperature cutout switch. This unit subsequently functioned properly.

A mechanical linkage and moment-arm adapter plate was made for the lateral-moment test fixture. The structural steel of the lateral-moment fixture (which had been fabricated earlier) was bolted to the laboratory floor. Measurements necessary for fitting the jumper connector to the lateral-moment force transducer were made. Another hinge point was added to the mechanical linkage arm for the lateral-moment test fixture. The addition was to minimize bending moments in the arm during lateral-moment testing.

A new linkage for moment take-up was installed on the test stand. Previous linkages required periodic replacement as the result of thread damage. The new linkage, which had larger threads, eliminated this recurring problem.

Time and funding limitations led to a decision not to conduct leak tests at pressures from 1,000 to 2,500 lbf/in^2 (gauge). Leak tests for elevated temperatures at 1,000 lbf/in^2 (gauge) and 300 to 400 °F were thought to be more directly applicable to plant operations.

Photograph 10. Using a Wrench to tighten a threaded Rod Slowly Applies a Lateral Moment to the ISB Jumper Connector Test Assembly.

Photograph 11. Post-Test Visual Examination of O-Ring Using a Desk Microscope with 15-Power Magnification.

Photograph 12. Quality Control Engineer Verifies that Lab Notebook Data Matches Information in the Computer Database.

9.0 LEAK TESTS

9.1 2-IN. ISB O-RING SEAL

Once parts arrived, testing of the 2-in. ISB o-ring seals began in earnest. (Refer to Figure 3 for applied moment conditions). The operating screw clamping torque used for leak testing was 50 ft-lbf (nominal).

The Equipment Testing Laboratory conducted a series of high-pressure leak tests at ambient and elevated temperatures, with and without externally applied moments. Results were very good. The 2-in. o-ring seal retainer performed successfully under ambient-temperature test conditions. The high-temperature (300 and 400 °F) moment test also was successful with no apparent pressure loss at static or moment conditions, depending on the seal material used. Refer to Figure 5. for a summary of 2-In. ISB leak test results

For the elevated temperature tests, total heat-up time for the system was 1.5 hours. The temperature reading on the gasket remained at the elevated test temperature for a total of 2.5 hours (including moment testing). Total test time was approximately 4 hours. Cooling the system with a circulation fan allowed time for two elevated temperature tests per day.

Leak tests that combined high temperatures with externally applied moment constituted more arduous conditions than previous (FY 1994) thermal-cycling tests that did not include applied loads. Hence, thermal-cycling tests without an applied moment (as performed on old-style gaskets during the previous year) were judged redundant.

Re-torquing of the connector was not necessary to ensure leak tightness after thermal cycling. Elevated test data indicated good sealing capability for more than four minutes. (Note: Two minutes of hold time was selected as an arbitrary standard for establishing the minimum holding pressure of a seal; therefore, solid sealing for more than four minutes was considered adequate to justify ending the test.)

To visually compare a "good" and "bad" o-ring test result, the reader is encouraged to examine Photographs 13 and 14. In Photograph 13, the Viton o-ring is seen to be intact after testing at 400 °F, 1,000 lbf/in^2, however, the fluorosilicone o-ring in Photograph 14 has suffered irreparable damage.

PUREX TYPE JUMPER CONNECTOR - INTEGRAL SEAL BLOCK (ISB) LEAK TEST QUALIFICATION

2 In. Single Port ISB Connector

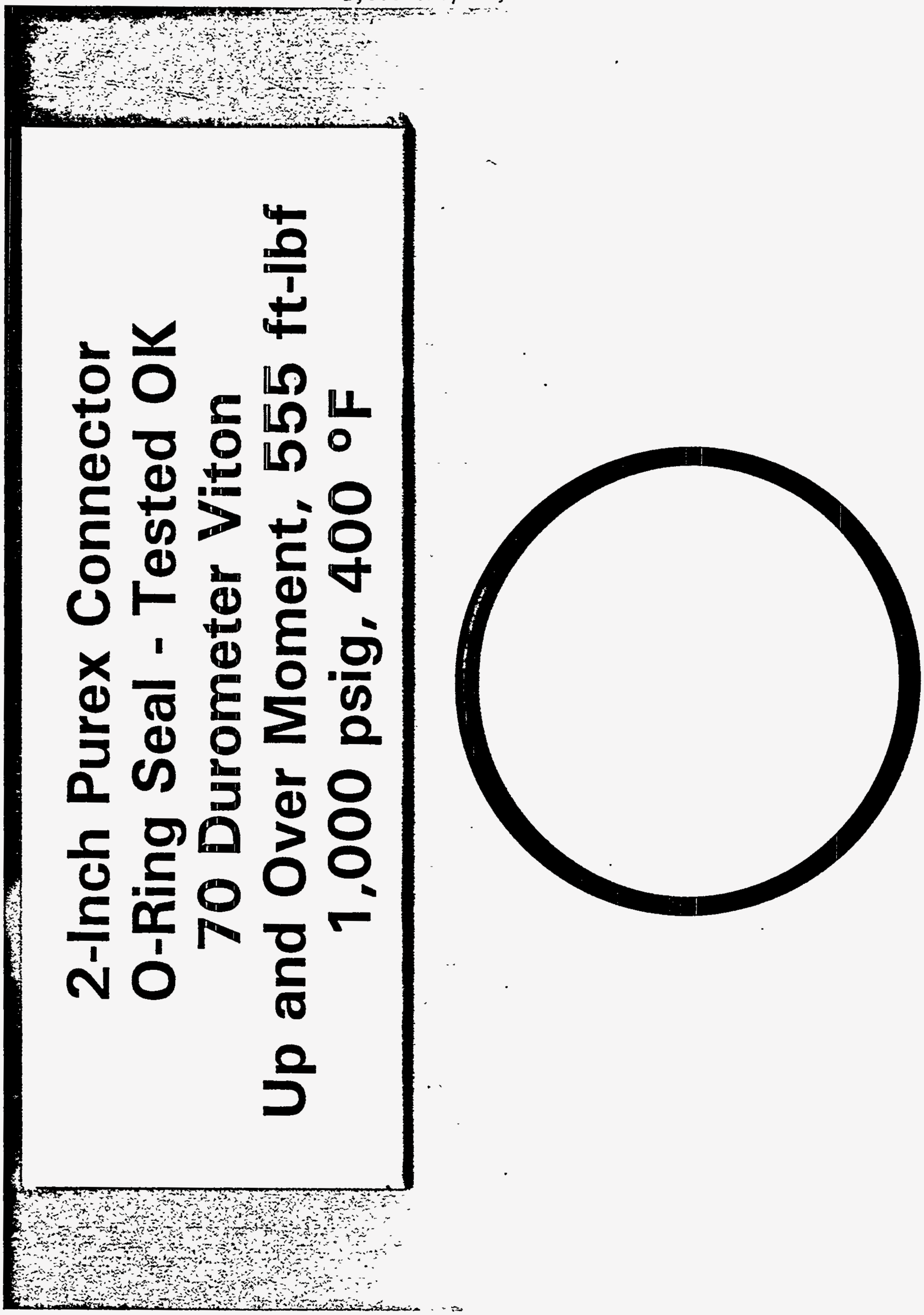
	Ambient Temperature - 70 deg. F.								High Temperature (400 Deg. F. unless otherwise indicated)							
	Up & Over Moment				Lateral Moment				Up & Over Moment				Lateral Moment			
O-Ring Material	250 psig	500 psig	750 psig	1,000 psig	250 psig	500 psig	750 psig	1,000 psig	250 psig	500 psig	750 psig	1,000 psig	250 psig	500 psig	750 psig	1,000 psig
Viton	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Kalrez	OK	OK	OK	OK	OK	OK	OK	OK	OK 300	OK 300	OK 300	OK 300	OK 300	OK 300	OK 300	OK 300
Fluorosil.	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	FAIL @400 OK 300	OK	OK	OK	OK

FAIL = Seal Failed in Actual Test.

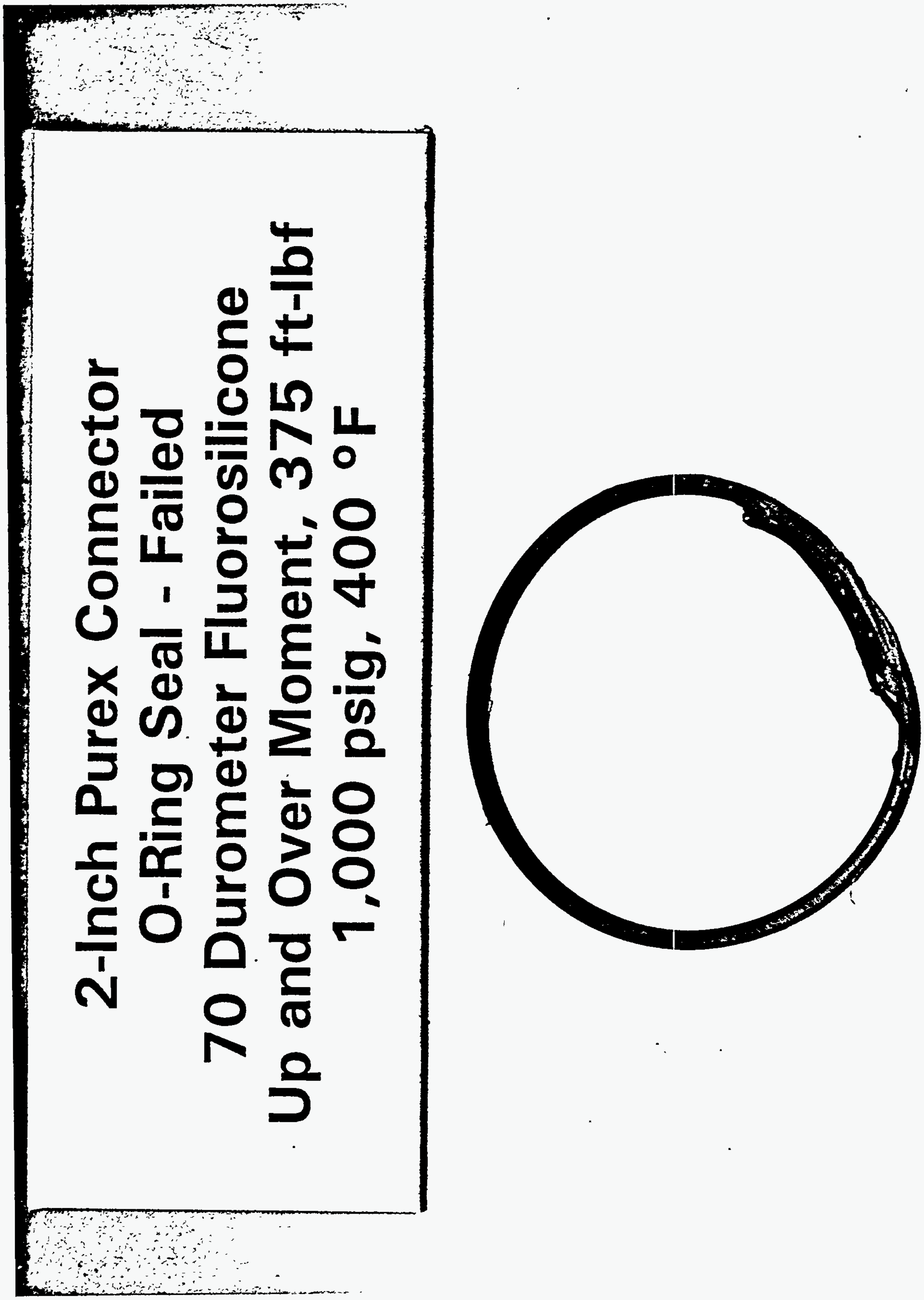
300 = Test Performed at 300 Deg. F.

Figure 5. Results of Leak Tests on 2-In. Integral Seal Block.

Photograph 13. 2-In. O-Ring Seal, 70-Durometer Viton, 1,000 lbf/in^2, 400 °F.



Photograph 14. 2-In. O-Ring Seal, 70-Durometer Fluorosilicone, 1,000 lbf/in^2, 400 °F.



9.2 3-IN. ISB O-RING SEAL

Depending on the type of material used, the 3-in. o-ring seals subjected to elevated temperature tests under the following conditions proved adequate: 1,000 lbf/in^2 at ambient temperatures and at 300 and 400 °F. (Refer to Figure 3 for applied moments). Refer to Figure 6 for a summary of leak test results on 3-In. ISB connectors.

At the beginning of the test on Kalrez at elevated temperatures (400 °F), a leak was observed underneath the connector block. Removal of the seal retainer exposed o-ring laceration/extrusion, most probably from the high pressure and high temperature in conjunction with the applied moment (see Photograph 15). Kalrez should not be used if temperatures will exceed 300 °F.

Figure 6. Results of Leak Tests on 3-In. Integral Seal Block.

PUREX TYPE JUMPER CONNECTOR - INTEGRAL SEAL BLOCK (ISB) LEAK TEST QUALIFICATION

3 In. Single Port ISB Connector

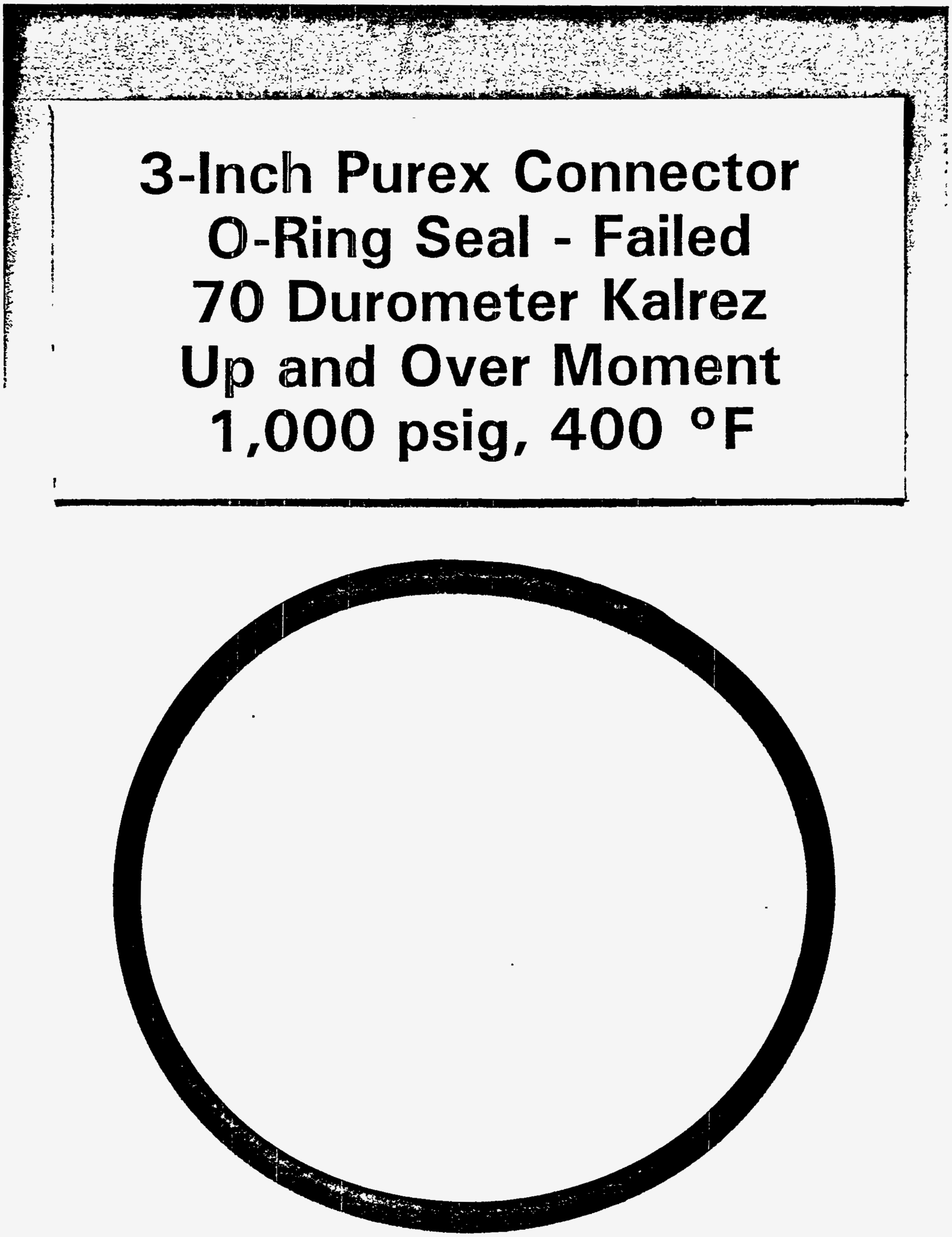
	Ambient Temperature - 70 deg. F.								High Temperature (400 Deg. F. unless otherwise indicated)							
	Up & Over Moment				Lateral Moment				Up & Over Moment				Lateral Moment			
O-Ring Material	250 psig	500 psig	750 psig	1,000 psig	250 psig	500 psig	750 psig	1,000 psig	250 psig	500 psig	750 psig	1,000 psig	250 psig	500 psig	750 psig	1,000 psig
Viton	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Kalrez	OK	OK	OK	OK	OK, NT	OK, NT	OK, NT	OK, NT	OK 300	OK 300	OK 300	FAIL @ 400 OK 300	OK 300	OK 300	OK 300	OK 300
Fluorosil.	OK	OK	OK	OK, NT	OK	OK	OK	OK	OK 300	OK 300	OK 300	OK 300	OK 300	OK 300	OK 300	OK 300

FAIL = Seal Failed in Actual Test.

OK, NT = Not Tested At This Temperature, But OK, Because The Seal Withstood More Rigorous Conditions.

300 = Test Performed at 300 Deg. F.

Photograph 15. 3-In. O-Ring Seal, 70-Durometer Kalrez, 1,000 lbf/in^2, 400 °F.



9.3 4-IN. ISB O-RING SEAL

The initial test protocol involved a standard ambient temperature (no external moments) "pressure ascension": at gauge pressures of 250, then 500, and finally 1,000 lbf/in^2. The seals performed well. No leaks or pressure drop was noted. The next test in the series involved an elevated temperature of 300 °F at 1,000 lbf/in^2 (gauge), with no external moments applied. Again, the seals performed well.

However, when testing was attempted at 1,000 lbf/in^2 and 400 °F, problems developed. When an external moment was applied to the connector, the test technician observed a leak. After cool down, the connector was disassembled and the seal inspected. The o-ring exhibited severe extrusion damage. Fraying and material separation had occurred. The fluorosilicone o-ring apparently had reached the upper limit of operating temperature.

Moment testing of the 4-in. ISB having Viton o-rings produced very good results. The 4-in. ISB, using Viton o-rings, demonstrated leak tightness both to "up and over" moments and to lateral moments. For an overall summary of 4-in. ISB test results, refer to Figure 7.

There were no leakage problems with the 4-in. ISB, *as long as temperature limits of 300 °F for Kalrez and fluorosilicone o-ring seal material were not exceeded.*

Photograph 16. 4-In. O-Ring Seal, TFE-O-SIL (Silicone Core with Teflon Outer Coating), 70-Durometer, 1,000 lbf/in^2 (gauge), 400 °F.

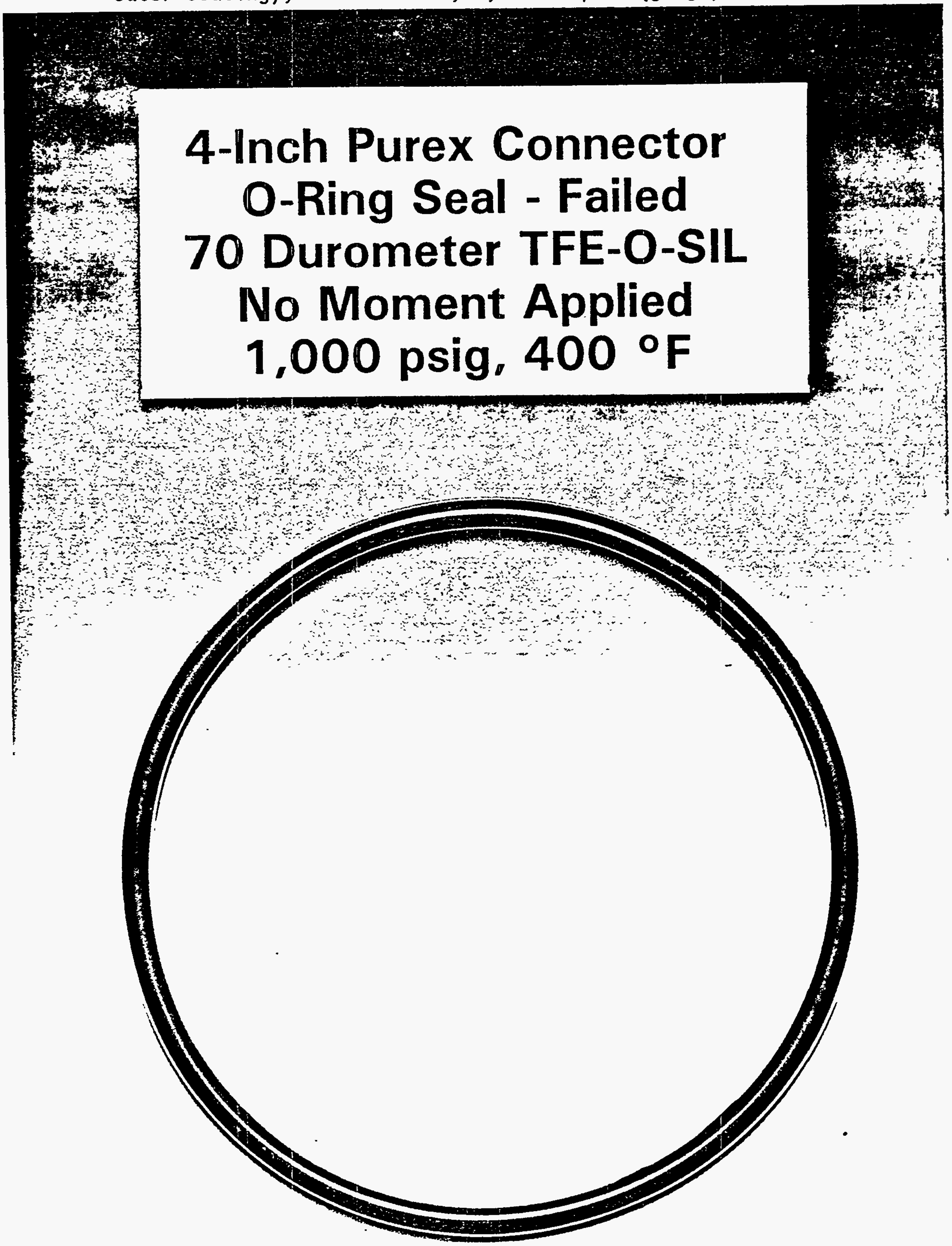


Figure 7. Results of Leak Tests on 4-In. Integral Seal Block.

PUREX TYPE JUMPER CONNECTOR - INTEGRAL SEAL BLOCK (ISB) LEAK TEST QUALIFICATION

4 In. Single Port ISB Connector

	Ambient Temperature - 70 deg. F.								High Temperature (400 Deg. F. unless otherwise indicated)							
	Up & Over Moment				Lateral Moment				Up & Over Moment				Lateral Moment			
O-Ring Material	250 psig	500 psig	750 psig	1,000 psig	250 psig	500 psig	750 psig	1,000 psig	250 psig	500 psig	750 psig	1,000 psig	250 psig	500 psig	750 psig	1,000 psig
Viton	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Kalrez	OK	OK	OK	OK	OK	OK	OK	OK	OK 300	OK 300	OK 300	OK 300	OK 300	OK 300	OK 300	OK 300
Fluorosil.	OK	OK	OK	OK	OK	OK	OK	OK	FAIL @400 OK 300	OK 300	OK 300	OK 300	OK	OK	OK	OK

FAIL = Seal Failed in Actual Test.

300 = Test Performed at 300 Deg. F.

9.4 3-WAY ISB O-RING SEAL

The 3-way ISB's performed very well. In particular, the ISB showed a marked improvement in its capability to withstand applied moments (compared to that of the conventional three-way teflon gaskets). Again, there were no leakage problems, as long as temperature limits of the o-ring seal material were not exceeded. For an overall summary of three-way ISB test results, refer to Figure 8. For the applied moment conditions used during the test, refer to Figure 3.

PUREX TYPE JUMPER CONNECTOR - INTEGRAL SEAL BLOCK (ISB) LEAK TEST QUALIFICATION

2 In. 3-Way Connector

	Ambient Temperature - 70 deg. F.								High Temperature (400 Deg. F. unless otherwise indicated)							
	Up & Over Moment				Lateral Moment				Up & Over Moment				Lateral Moment			
O-Ring Material	250 psig	500 psig	750 psig	1,000 psig	250 psig	500 psig	750 psig	1,000 psig	250 psig	500 psig	750 psig	1,000 psig	250 psig	500 psig	750 psig	1,000 psig
Viton	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Kalrez	OK	OK	OK	OK	OK	OK	OK	OK	OK 300	OK 300	OK 300	OK 300	OK 300	OK 300	OK 300	OK 300
Fluorosil.	OK	OK	OK	OK	OK	OK	OK	OK	OK 300	OK 300	OK 300	OK 300	OK 300	OK 300	OK 300	OK 300
Silicone	OK	OK	OK	OK	OK	OK	OK	OK	OK 300	OK 300	OK 300	OK 30	OK 300	OK 300	OK 300	OK 300 & 500
EPDM	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Teflon Gasket	FAIL	(F)	(F)	(F)	OK	NT	NT	NT	FAIL 212 & 400	(F)	(F)	(F)	NT	NT	NT	NT

FAIL = Seal Failed in Actual Test.

(F) = Not Tested, But Failed Under Less Rigorous Conditions, hence Failure Is Probable.

NT = Not Tested.

300 = Test Performed at 300 Deg. F.
212 = Test Performed at 212 Deg. F.

Figure 8. Results of Leak Tests on Three-Way Integral Seal Block.

10.0 CONCLUSIONS

10.1 ADVANTAGES OF INTEGRAL SEAL BLOCK DESIGN FOR JUMPER CONNECTORS

The FY 1993 design for seal retainers solved a number of problems associated with the gasket-type seal (Ruff 1994). However, the need for further improvement was obvious. The key advantage of the integral seal block design is that it eliminates a potential leak path.

The additional advantages of the ISB compared to the conventional gasket-type configuration are reiterated here from previous work (Ruff 1994a).

- At clamp loads only 1/6 to 1/10 required by Teflon gaskets, the ISB holds four to ten times higher pressure. Thus, lower wrench torques (50 ft-lbf) can be applied to the connector. These lower torques mean that smaller pneumatic torque wrenches can be used in canyon buildings; the result is easier access to connectors in small, crowded process cells. Also, 50 ft-lbf of torque can be applied easily with manual tools. Powered wrenches no longer are an absolute necessity for field applications.

- Lower clamping loads greatly reduce stresses in the nozzle flange, connector hooks, and hook pins (Kanjilal 1992). Lower stresses increase the margin of safety for operation of the connector, i.e., the connector can absorb greater applied moments generated by the piping.

- Lower stresses in the mechanical components enable greater latitude in the selection of materials for hooks and blocks. Alloys may be chosen for corrosion resistance rather than for the high tensile strength required for process service.

- The ISB eliminates problems associated with deformation and flow of conventional Teflon gasket seal deformation and flow (Squier 1992).

- The o-ring nestles protectively within a circular groove. This configuration permits a greater range of block (connector piping) motion without shear damage to the seal. (Applied moments are less likely to "wipe" the seal.)

- The o-ring provides vastly improved leak tightness during thermal cycling and operation at elevated temperatures. Teflon gasket-connector seals leak after thermal cycling. In fact, with Teflon seals, the operating screw can become so loose after operation at elevated temperatures that it can be turned by hand.

- Only 50 ft-lbf of torque is required to seal all three sizes of connectors (2, 3, 4 in.). Lower torque greatly simplifies procedures for operating remote cells. No special administrative procedures are necessary to ensure that smaller connectors are not over-torqued. Because only one torque wrench is required (instead of two), gantry space on the overhead crane is freed up and the amount of control room wiring is reduced.

10.2 ENABLING TECHNOLOGY FOR REMOTE APPLICATIONS

Integral seal blocks make it easier to use high-pressure equipment in remote cells, e.g., high-pressure chemical reaction vessels, high-pressure slurry pumps for handling very viscous mixtures.

10.3 O-RING CROSS SECTION

Within given space limits, it is generally better to use as thick an o-ring as possible (in a properly sized groove). A thicker o-ring (one having a larger cross-sectional diameter) has a greater area moment of inertia and is therefore less "flimsy." A thicker o-ring also seats much more firmly into the o-ring groove than does a thinner o-ring. For example, during testing, the o-ring groove on the 4-in. seal-retainer was redesigned to accommodate an o-ring with a 0.210-in. cross-section, as opposed to the previous 0.139-in. cross-section.

10.4 SEAL DUROMETER

The 70-durometer material is an industry standard; it is often difficult to get softer (or harder) materials without paying premium batch charges for special polymer formulation.

Testing proceeded with conventional 70-durometer o-rings. This material worked very well at ambient temperature and pressures of 1,000 lbf/in^2 (gauge) and below. This result makes procurement of seals much easier and less expensive.

However, the chemical and radiation resistance required for many process applications may vary. Elastomers must be selected on the basis of expected service conditions (chemical and radiation), and then tested at the temperature and pressure of the intended application.

10.5 SEAL MATERIAL

These proof-of-concept tests used 70-durometer Viton, fluorosilicone, and Kalrez elastomer material for the o-rings, as these o-rings are readily available, even in small lot quantities. In actual plant applications, different o-ring materials would often be needed. Actual material selection must be tailored to meet the service conditions, e.g., pH, temperature, chemical composition of the process stream, and radiation exposure.

These tests led to the following conclusions.

- The ISB o-ring seal design performed as expected. It was leak tight to 1,000 lbf/in^2 (gauge), when kept within the appropriate temperature limits of the o-ring elastomer.

- The most important factor limiting ISB connector performance is temperature resistance of the o-ring material. All o-rings performed well at ambient temperature. However, tests at elevated temperatures quickly revealed weaknesses in fluorosilicone and Kalrez.

- Viton o-rings did not leak under *any* of the tested conditions, up to and including 1,000 lbf/in^2 (gauge) and 400 °F, even when external moments were applied. Viton was the stellar performer when it came to resisting leaks under all conditions.

- Viton seals are very cost effective - reasonably priced and perform very well. Kalrez and fluorosilicone o-rings are more expensive and do not resist elevated temperatures a well as Viton. Viton seals should be used wherever possible for the best, most cost-effective leak resistance in jumper connector ISBs.

- Seal failures occurred with fluorosilicone and Kalrez o-rings, when "up and over" moments were applied at 400 °F (refer to Figure 3 for applied moments). Fluorosilicone and Kalrez o-rings subsequently were tested at 300 °F and maintained leak tightness at this temperature.

- Both fluorosilicone and Kalrez o-rings withstood lateral moments at 400 °F (refer to Figure 3 for applied moments). This information, coupled with the fact that failure occurred when up and over" moments were applied at the same temperature, indicate that the "up and over" moment is a more severe test of leak tightness for an ISB o-ring. However, the performance of these materials indicates that *Kalrez and fluorosilicone should NOT be used in applications where temperatures exceed 300 °F.* Preferably, long-term temperature exposure of these two materials should be held to temperatures less than 300 °F.

- Kalrez or fluorosilicone seals should be used only at low temperatures and only when necessary for chemical resistance to specific process fluids. This restriction should be observed especially with Kalrez, because each Kalrez o-ring costs hundreds of dollars.

Figure 9. Summary Results of Leak Tests on ISB Jumper Connectors Using O-Ring Seals.

2-In, 3-In., 4-In., and 3-Way ISB Jumper Connectors	
Test Temperatures: 70, 300, and 400 °F Test Pressures: 250, 500, 750, and 1,000 lbf/in^2 Test Moments: Refer to Figure 3.	
Seal Material	**Result**
Fluorosilicone	OK *only to 300 °F*
Kalrez	OK *only to 300 °F*
Viton	OK to 400 °F
EPDM (tested on 3-Way only)	OK to 400 °F
Silicone (tested on 3-Way only)	OK to 300 °F (see Appendix R for lateral moment leak test conducted at 1,250 lbf/in^2 and 500 °F)

10.6 FUTURE IMPROVED DESIGN - JUMPER CONNECTORS WITH ONE-PIECE BODIES

A jumper connector recently has been designed to eliminate the need for many separate parts. Dubbed the "one-piece-body" or "OPB" connector (see Figures 7 and 8), it exists only as a preliminary three-dimensional computer model.

The one-piece-body (OPB) design has the following significant advantages:

- It improves the "assembled integrity" of the jumper connector, i.e., there are no extraneous pieces to come loose.
- It reduces peak bending stresses in the jumper connector hook by 50%, because it eliminates a protrusion in the lower skirt; thus the hook is straight rather than curved.
- It does not require tie bolts; the elimination of tie bolts eliminates concerns about the possibility of counterfeit fasteners.
- It eliminates the need for fabrication, inspection, and inventory of long-lead-time castings. The results are cost savings in manufacturing, storage, and overhead.
- It simplifies the manual assembly of the jumper connector. Elimination of the need to use tie rods to connect the upper hook guide and the lower skirt casting reduces the chances of failure of the end product.
- As a unified, rigid component machined from a single section of steel, an OPB enhances the operating integrity of the part. It eliminates backlash and movement associated with assembly.
- Because there are no tie bolts to interfere with the attached piping, the OPB connector allows greater freedom to the piping designer in the direction of flow discharge from a horizontal connector. Conventional jumper connectors require that a tie bolt be removed and that the lower skirt be partially ground away to allow lateral piping attachment.

On the other hand, the one-piece-body (OPB) design has the following disadvantages:

- The greatest challenge it poses is the development of machining methods needed to produce the complex curvatures used in the component. (This, however, could be useful as a "technology driver" which could bring a new level of sophistication to current machining capability.
- Being straight, and not curved, hooks for the OPB could not be used interchangeably with the existing multi-piece connectors.
- The operating screw retaining mechanism would also have to be different than currently existing hardware. This involves designing a relatively small part that would act to keep the operating screw permanently attached to the connector body. Hence, OPB operating screws would not be interchangeable with existing hardware.

- The OPB design would not be applicable for thermocouple-type jumper connectors and leak detector-type jumper connectors. The separate-block jumper connector assembly is more useful in these 2 specific applications because the block must be removeable to enable assembly of the spring-loaded thermocouple or leak detector element.

However, after considering both the advantages and disadvantages, for fluid flow applications, the OPB design is considered to have relatively more advantages with very low technical risk in performance. A prototype of the one-piece-body (OPB) component for fluid flow applications should be developed and tested to qualify it for operating service.

Figure 10. One-Piece Body, Machined from Solid Bar Stock - Side View.

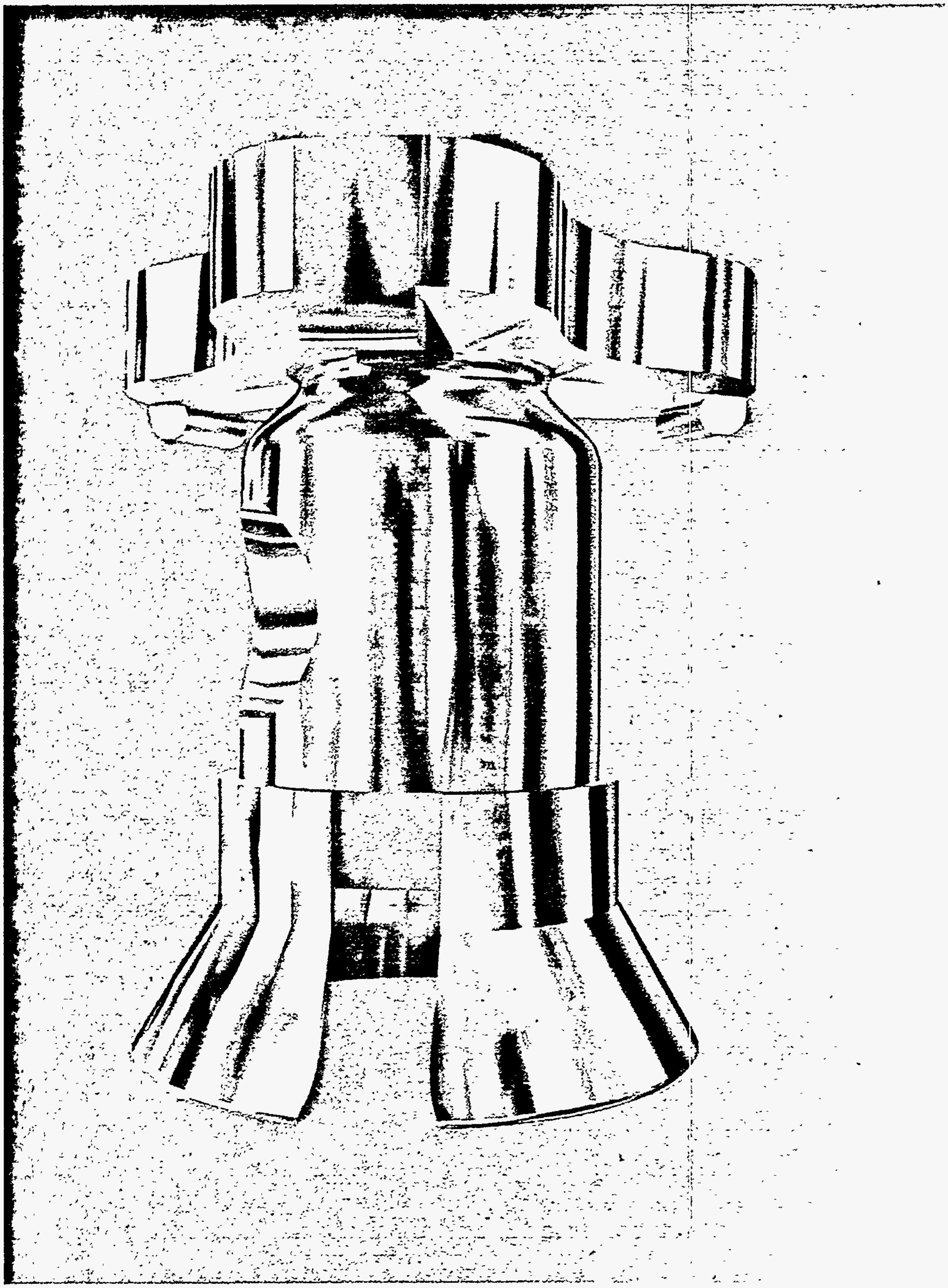
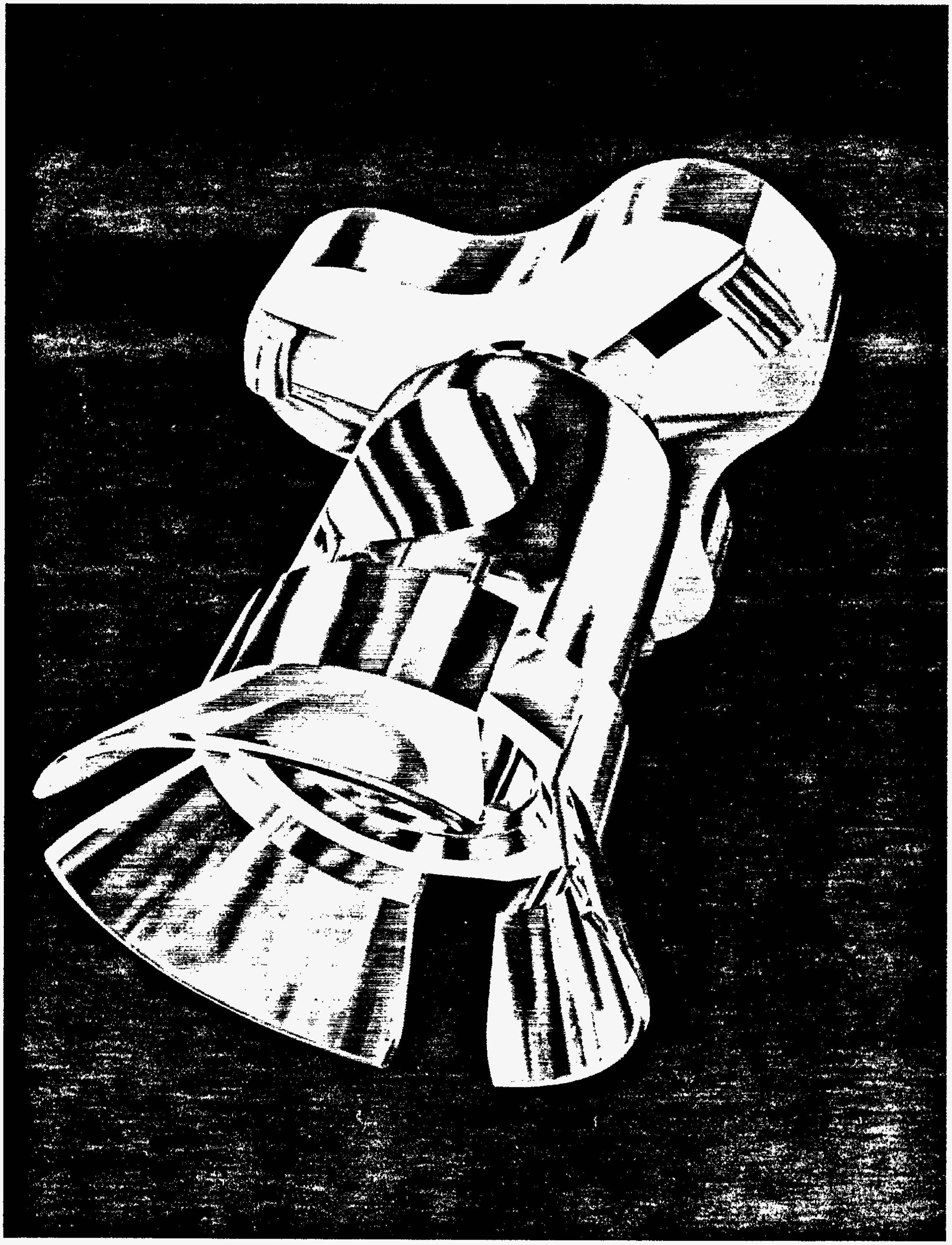


Figure 11. One-Piece Body, Machined from Solid Bar Stock - Underside View.



10.7 RECOMMENDATIONS FOR FUTURE DEVELOPMENT WORK ON JUMPER CONNECTORS

While the integral seal block using o-rings has improved jumper connector leak tightness, a number of additional development tasks related to jumper connectors remain. Further investigations, if performed, would expand the range of applications of jumper connectors, and resolve unknowns particularly in the area of load path, ultimate load capacity, rigidity and fit-up.

These tasks include:

- Increase the load capacity of the jumper connector test stand to 10,000 lb.
- Perform "stiffness testing" of the jumper connector assemblies to enable stress analysts to refine assumptions about connector rigidity during thermal expansion and seismic events.
- Perform strain-gauge testing of jumper connector assemblies that are stressed by externally applied moments to determine the load path in the connector hooks.
- Perform destructive pull testing of machined connector hooks and hook pins on the load frame to determine stress-concentration factors and ultimate breaking limits on these critical components.
- Proof test jumper connector seals that have been specially molded to enhance mechanical retention of the seal during jumper connect and disconnect operations in the field.
- Develop and test *horizontal* jumper connectors with improved hook/cam tolerances that will ensure full hook engagement to the nozzle flange (*applies to the bottom hook*).
- Develop and test OPB connectors to eliminate the need for tie-bolts and the long lead-time castings for the jumper assembly.
- Develop (and verify operation of) horizontal jumper connector lower skirts that are designed specifically to allow "side discharge" flow paths to the left and right. Current practice uses a rather crude method of removing one tie bolt, and grinding the lower skirt casting to fit the piping.
- Develop and test o-ring seal specialty connectors such as thermo-well, thermocouple, and level-detection instrumentation.

11.0 REFERENCES

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APPENDIX A: PLANNING CHARTS

MWTF Integral Seal Block Jumper Connector Development and Leak Testing					
ID	Name	Duration	% Complete	Scheduled Start	Scheduled Finish
1	*MWTF CONNECTOR SEALS*	*186d*	*90%*	*1/1/94*	*9/19/94*
2	*Test Preparation*	*111.9d*	*100%*	*1/1/94*	*6/7/94*
3	*Task Planning*	*29d*	*100%*	*1/1/94*	*2/10/94*
4	Initial Cost and Schedule Estimate	6d	100%	1/1/94	1/10/94
5	Updated Cost and Schedule Estimate	1d	100%	2/10/94	2/10/94
6					
7	*Task Research*	*13d*	*100%*	*1/1/94*	*1/19/94*
8	Request Process Solutions Info	1d	100%	1/1/94	1/3/94
9	Cog Organization Responds	1d	100%	1/4/94	1/4/94
10	Develope List of Process Solutions	2d	100%	1/5/94	1/6/94
11	Review Technical Literature	1d	100%	1/7/94	1/7/94
12	Vendor Information	1d	100%	1/10/94	1/10/94
13	Bibliographic Search	1d	100%	1/11/94	1/11/94
14	Compare Polymer Performance	3d	100%	1/12/94	1/14/94
15	Identify Data Insufficiencies	1d	100%	1/17/94	1/17/94
16	Select Polymers to Be Tested	1d	100%	1/18/94	1/18/94
17	Establish Test Parameters	1d	100%	1/19/94	1/19/94
18					
19	*Design Drawing Package*	*74d*	*100%*	*1/17/94*	*4/28/94*
20	*2 Inch 3Way Connector Fixture*	*32d*	*100%*	*1/17/94*	*3/1/94*
21	Nozzle and Plate	2d	100%	1/17/94	1/18/94
22	Heater Block	4d	100%	1/19/94	1/24/94
23	3 Way Seal Retainer	1d	100%	1/25/94	1/25/94
24	Pressure Fittings/Components	4d	100%	1/26/94	1/31/94
25	Assembly	3d	100%	2/1/94	2/3/94
26	Check	3d	100%	2/21/94	2/23/94
27	Approve	1d	100%	2/24/94	2/24/94
28	Cog. Engineer Review	7d	100%	2/21/94	3/1/94
29					
30	Prepare Assembly Color Rendering	2d	100%	2/3/94	2/5/94
31	Prepare Engineering Data Transmittal	1d	100%	2/7/94	2/7/94
32	Reproduce and Microfilm Drawing Set	1d	100%	2/8/94	2/8/94
33	Prepare Mailing Tubes	1d	100%	2/9/94	2/9/94
34	Mail Transmittals	1d	100%	2/10/94	2/10/94
35					
36	*Design Integral Seal/Block*	*22d*	*100%*	*2/1/94*	*3/2/94*
37	2" Seal Block	3d	100%	2/1/94	2/3/94
38	3" Seal Block	3d	100%	2/4/94	2/8/94
39	4" Seal Block	3d	100%	2/9/94	2/11/94
40	2" Seal Block Moment Arm Assembly	1d	100%	2/10/94	2/14/94

MWTF Integral Seal Block Jumper Connector Development and Leak Testing

ID	Name	Duration	% Complete	Scheduled Start	Scheduled Finish
41	3" Seal Block Moment Arm Assembly	1d	100%	2/11/94	2/14/94
42	4" Seal Block Moment Arm Assembly	1d	100%	2/14/94	2/14/94
43	3" Threadless Skirt - Horizontal	6d	100%	2/15/94	2/22/94
44	3" Threadless Skirt - Vertical	3d	100%	2/15/94	2/23/94
45	4" Threadless Skirt- Horizontal	5d	100%	2/23/94	3/1/94
46	4" Threadless Skirt- Vertical	3d	100%	2/28/94	3/2/94
47					
48	***Seal Block Jumper Assembly Dwgs***	***10d***	***100%***	***4/15/94***	***4/28/94***
49	2" Jumper Assembly Drawing	3d	100%	4/15/94	4/19/94
50	3" Jumper Assembly Drawing	4d	100%	4/20/94	4/25/94
51	4" Jumper Assembly Drawing	3d	100%	4/26/94	4/28/94
52					
53					
54	***Design Study 3-Way Tetraseal Retainer***	***82d***	***100%***	***3/10/94***	***7/1/94***
55	Project Go-Ahead Decision	10d	100%	3/10/94	3/23/94
56	Seal Alternatives	10d	100%	5/2/94	5/13/94
57	Investigate Machinability	10d	100%	5/16/94	5/27/94
58	Decide on Feasibility	5d	100%	5/30/94	6/3/94
59	Preliminary AutoCAD Designs	10d	100%	6/6/94	6/17/94
60	Formal AutoCAD Design	10d	100%	6/20/94	7/1/94
61					
62					
63	***Seal Retainer Removal Tool***	***44.4d***	***100%***	***5/26/94***	***7/29/94***
64	***Seal Retainer Removal Tool Dwgs***	***27.3d***	***100%***	***5/26/94***	***7/6/94***
65	2" Removal Tool	2d	100%	5/26/94	7/6/94
66	3" Removal Tool	2d	100%	5/30/94	7/6/94
67	4" Removal Tool	2d	100%	6/1/94	7/6/94
68	***Fab Removal Tool***	***12d***	***100%***	***7/13/94***	***7/29/94***
69	Submit Request for Cost Estimate	1d	100%	7/13/94	7/14/94
70	Obtain Cost Estimate	1d	100%	7/14/94	7/15/94
71	Prepare J-10 Fab Request	1d	100%	7/15/94	7/16/94
72	Approve and Submit J-10	1d	100%	7/16/94	7/18/94
73	Machine 2" Removal Tool	4d	100%	7/18/94	7/22/94
74	Machine 3" Removal Tool	3d	100%	7/22/94	7/27/94
75	Machine 4" Removal Tool	4d	100%	7/25/94	7/29/94
76					
77					
78	***Procure Material***	***77d***	***100%***	***1/17/94***	***5/3/94***
79	***Write Purchase Requisitions***	***20d***	***100%***	***1/17/94***	***2/11/94***
80	O-Rings	1d	100%	1/19/94	1/19/94

MWTF Integral Seal Block Jumper Connector Development and Leak Testing					
ID	Name	Duration	% Complete	Scheduled Start	Scheduled Finish
81	2" 3WayConnector Parts - 1 set	10d	100%	1/20/94	2/2/94
82	Issue Purchase Requisitions	5d	100%	1/17/94	1/21/94
83	Receive Bids	15d	100%	1/24/94	2/11/94
84	***Order Material***	***1d***	***100%***	***4/7/94***	***4/7/94***
85	O-Rings, 18 ea. -142	1d	100%	4/7/94	4/7/94
86	O-Rings, 18 ea. -239	1d	100%	4/7/94	4/7/94
87	O-Rings, 18 ea. -350	1d	100%	4/7/94	4/7/94
88					
89	***Receive Material***	***18d***	***100%***	***4/8/94***	***5/3/94***
90	Vendor Fulfills Order	15d	100%	4/8/94	4/28/94
91	Inspect Material	2d	100%	4/29/94	5/2/94
92	Deliver to Shop	1d	100%	5/3/94	5/3/94
93					
94	***Procure Kalrez Material***	***61.9d***	***100%***	***3/14/94***	***6/7/94***
95	***Purchase Requisitions***	***40d***	***100%***	***3/14/94***	***5/6/94***
96	O-Rings	1d	100%	3/14/94	3/14/94
97	Issue Purchase Requisitions	5d	100%	4/11/94	4/15/94
98	Receive Bids	15d	100%	4/18/94	5/6/94
99	***Order Material***	***19.1d***	***100%***	***4/13/94***	***5/10/94***
100	O-Rings, 3 ea. for 3-way	1d	100%	5/9/94	5/9/94
101	O-Rings, 3 ea. -142	1d	100%	4/13/94	5/10/94
102	O-Rings, 3 ea. -239	1d	100%	4/13/94	5/9/94
103	O-Rings, 3 ea. -350	1d	100%	4/13/94	5/9/94
104	***Receive Material***	***38.9d***	***100%***	***4/14/94***	***6/7/94***
105	Vendor Fulfills Order	25d	100%	4/14/94	6/7/94
106	Inspect Material	2d	100%	5/19/94	6/7/94
107	Deliver to Shop	1d	100%	5/23/94	6/7/94
108					
109					
110	***Fab 2" 3Way Connector Test Fixture***	***32.5d***	***100%***	***2/14/94***	***3/30/94***
111	Prepare Work Package	1d	100%	3/2/94	3/2/94
112	Obtain Final Cost Estimate	1d	100%	3/3/94	3/3/94
113	Issue Work Order	1d	100%	3/8/94	3/8/94
114	Carbide Inserts - Material Allowance	1d	100%	3/9/94	3/9/94
115	Setup Machine	1d	100%	3/10/94	3/10/94
116	Install Chuck	0.5d	100%	3/11/94	3/11/94
117	Obtain Tool Holders	0.5d	100%	3/11/94	3/11/94
118	Install Inserts	0.5d	100%	3/14/94	3/14/94
119	Install Tool Ensemble	0.5d	100%	3/14/94	3/14/94
120	Section Bar Stock	0.5d	100%	3/15/94	3/15/94

MWTF Integral Seal Block Jumper Connector Development and Leak Testing

ID	Name	Duration	% Complete	Scheduled Start	Scheduled Finish
121	Machine Base Plate	2d	100%	3/15/94	3/17/94
122	Inspect Base Plate	1d	100%	3/17/94	3/18/94
123	Machine Blank Block	1d	100%	3/18/94	3/21/94
124	Machine 3-Way Nozzle	2d	100%	3/21/94	3/23/94
125	Inspect 3-Way Nozzle	1d	100%	3/23/94	3/24/94
126	Machine Moment Arm	1d	100%	3/24/94	3/25/94
127	Machine Inserts	1d	100%	3/25/94	3/28/94
128	Weld Inserts to Nozzle	1d	100%	3/28/94	3/29/94
129	Weld Nozzle to Plate	1d	100%	3/29/94	3/30/94
130	Weld Moment Arm To Block	1d	100%	2/14/94	2/14/94
131					
132	***Fab Integral Seal Block Components***	***55d***	***100%***	***2/15/94***	***5/2/94***
133	Submit Request for Cost Estimate	1d	100%	2/15/94	2/15/94
134	Obtain Cost Estimate	1d	100%	2/16/94	2/16/94
135	Project Decision on Hardware	10d	100%	2/17/94	3/2/94
136	Prepare J-10 Fab Request	1d	100%	3/8/94	3/8/94
137	Approve and Submit J-10	1d	100%	3/9/94	3/9/94
138					
139	Machine 2" Seal Block	4d	100%	3/10/94	3/15/94
140	Metrology 2" Seal Block	1d	100%	3/16/94	3/16/94
141	Machine 2" Moment Arm	3d	100%	3/17/94	3/21/94
142	Sawcut 2" Vertical Skirt	3d	100%	3/22/94	3/24/94
143	Transport Assembly to Lab	1d	100%	3/25/94	3/25/94
144					
145	Machine 3" Seal Block	4d	100%	3/28/94	3/31/94
146	Metrology 3" Seal Block	1d	100%	4/1/94	4/1/94
147	Machine 3" Vertical Skirt	3d	100%	4/4/94	4/6/94
148	Sawcut 3" Vertical Skirt	3d	100%	4/7/94	4/11/94
149	Transport Assembly to Lab	1d	100%	4/12/94	4/12/94
150					
151	Machine 4" Seal Block	4d	100%	4/13/94	4/18/94
152	Metrology 4" Seal Block	1d	100%	4/19/94	4/19/94
153	Machine 4" Vertical Skirt	3d	100%	4/20/94	4/22/94
154	Sawcut 4" Vertical Skirt	3d	100%	4/25/94	4/27/94
155	Machine 4" Moment Arm	3d	100%	4/28/94	5/2/94
156					

MWTF Integral Seal Block Jumper Connector Development and Leak Testing

ID	Name	Duration	% Complete	Scheduled Start	Scheduled Finish
157	***Lateral Moments Preparation***	***20d***	***100%***	***3/2/94***	***3/29/94***
158	Establish Lateral Test Criteria	1d	100%	3/2/94	3/2/94
159	Cost Estimate	1d	100%	3/3/94	3/3/94
160	***Design Lateral Test Fixture***	***6d***	***100%***	***3/10/94***	***3/17/94***
161	Take Floor Measurements	1d	100%	3/10/94	3/10/94
162	Take Load Cell Measurements	1d	100%	3/11/94	3/11/94
163	End Hinge	1d	100%	3/14/94	3/14/94
164	Threaded Linkage	1d	100%	3/15/94	3/15/94
165	Reaction Base Plate	1d	100%	3/16/94	3/16/94
166	Reaction Brace	1d	100%	3/17/94	3/17/94
167	***Fabricate Lateral Test Fixture***	***5d***	***100%***	***3/18/94***	***3/24/94***
168	End Hinge	2d	100%	3/18/94	3/21/94
169	Threaded Linkage	1d	100%	3/22/94	3/22/94
170	Reaction Base Plate	1d	100%	3/23/94	3/23/94
171	Reaction Brace	1d	100%	3/24/94	3/24/94
172	***Install Lateral Test Fixture***	***3d***	***100%***	***3/25/94***	***3/29/94***
173	Drill Concrete Anchor Holes	1d	100%	3/25/94	3/25/94
174	Install Base Plate Anchors	1d	100%	3/28/94	3/28/94
175	Install Load Cell	1d	100%	3/29/94	3/29/94
176					
177					
178	***Perform Leak Tests***	***93d***	***100%***	***3/8/94***	***7/18/94***
179	Review Test Scope	1d	100%	3/8/94	3/8/94
180	Issue Work Order	1d	100%	3/9/94	3/9/94
181	***Setup Equipment***	***8.25d***	***100%***	***3/10/94***	***3/22/94***
182	Check Calibration	4.13d	100%	3/10/94	3/16/94
183	Torque Wrench	1d	100%	3/16/94	3/17/94
184	Pressure Gage	1d	100%	3/17/94	3/18/94
185	Signal Conditioners	1d	100%	3/18/94	3/21/94
186	Load Cell	1d	100%	3/21/94	3/22/94
187	Verify Heater Unit	1h	100%	3/22/94	3/22/94
188					
189	Setup 3" Connector - Viton	1d	100%	4/13/94	4/13/94
190	Install Heater Rods	1d	100%	4/14/94	4/14/94
191	3 In. Ambient	1d	100%	4/15/94	4/15/94
192	Weld 3" Moment Arm	2d	100%	4/18/94	4/19/94
193	3 In. Thermal Cycle	1d	100%	4/20/94	4/20/94
194	3 In. Thermal Cycle /Lateral	1d	100%	4/21/94	4/21/94
195	Remove 3" Connector	1d	100%	4/22/94	4/22/94
196					

MWTF Integral Seal Block Jumper Connector Development and Leak Testing

ID	Name	Duration	% Complete	Scheduled Start	Scheduled Finish
197	Setup 3" Connector - Aflas	1d	100%	4/25/94	4/25/94
198	3 In. Thermal Cycle	1d	100%	4/26/94	4/26/94
199	3 In. Thermal Cycle /Lateral	1d	100%	4/27/94	4/27/94
200	Remove 3" Connector	1d	100%	4/28/94	4/28/94
201					
202	Setup 3" Connector - Fluorosilicone	1d	100%	4/29/94	4/29/94
203	3 In. Thermal Cycle	1d	100%	5/2/94	5/2/94
204	3 In. Thermal Cycle /Lateral	1d	100%	5/3/94	5/3/94
205	Remove 3" Connector	1d	100%	5/4/94	5/4/94
206					
207	Setup 3" Connector - Kalrez	1d	100%	5/5/94	5/5/94
208	3 In. Thermal Cycle	1d	100%	5/6/94	5/6/94
209	3 In. Thermal Cycle /Lateral	1d	100%	5/9/94	5/9/94
210	Remove 3" Connector	1d	100%	5/10/94	5/10/94
211					
212	Setup 2" Connector -Viton	1d	100%	5/11/94	5/11/94
213	Install Heater Rods	1d	100%	5/12/94	5/12/94
214	2 In. Ambient	1d	100%	5/13/94	5/13/94
215	Weld 2" Moment Arm	2d	100%	5/16/94	5/17/94
216	2 In. Thermal Cycle	1d	100%	5/18/94	5/18/94
217	2 In. Thermal Cycle /Lateral	1d	100%	5/19/94	5/19/94
218	Remove 2" Connector	1d	100%	5/20/94	5/20/94
219					
220	Setup 2" Connector - Aflas	1d	100%	5/23/94	5/23/94
221	2 In. Thermal Cycle	1d	100%	5/24/94	5/24/94
222	2 In. Thermal Cycle /Lateral	1d	100%	5/25/94	5/25/94
223	Remove 2" Connector	1d	100%	5/26/94	5/26/94
224					
225	Setup 2" Connector - Fluorosilicone	1d	100%	5/27/94	5/27/94
226	2 In. Thermal Cycle	1d	100%	5/30/94	5/30/94
227	2 In. Thermal Cycle /Lateral	1d	100%	5/31/94	5/31/94
228	Remove 2" Connector	1d	100%	6/1/94	6/1/94
229					
230	Setup 2" Connector - Kalrez	1d	100%	6/2/94	6/2/94
231	2 In. Thermal Cycle	1d	100%	6/3/94	6/3/94
232	2 In. Thermal Cycle /Lateral	1d	100%	6/6/94	6/6/94
233	Remove 2" Connector	1d	100%	6/7/94	6/7/94
234					
235					
236	Setup 4" Connector - Viton	1d	100%	6/8/94	6/8/94
237	Install Heater Rods	1d	100%	6/9/94	6/9/94

MWTF Integral Seal Block Jumper Connector Development and Leak Testing

ID	Name	Duration	% Complete	Scheduled Start	Scheduled Finish
238	4 In. Ambient	1d	100%	6/10/94	6/10/94
239	Weld 4" Moment Arm	2d	100%	6/13/94	6/14/94
240	4 In. Thermal Cycle	1d	100%	6/15/94	6/15/94
241	4 In. Thermal Cycle /Lateral	1d	100%	6/16/94	6/16/94
242	Remove 4" Connector	1d	100%	6/17/94	6/17/94
243					
244	Setup 4" Connector - Aflas	1d	100%	6/20/94	6/20/94
245	4 In. Thermal Cycle	1d	100%	6/21/94	6/21/94
246	4 In. Thermal Cycle /Lateral	1d	100%	6/22/94	6/22/94
247	Remove 4" Connector	1d	100%	6/23/94	6/23/94
248					
249	Setup 4" Connector - Fluorosilicone	1d	100%	6/24/94	6/24/94
250	4 In. Thermal Cycle	1d	100%	6/27/94	6/27/94
251	4 In. Thermal Cycle /Lateral	1d	100%	6/28/94	6/28/94
252	Remove 4" Connector	1d	100%	6/29/94	6/29/94
253					
254	Setup 4" Connector - Kalrez	1d	100%	6/30/94	6/30/94
255	4 In. Thermal Cycle	1d	100%	7/1/94	7/1/94
256	4 In. Thermal Cycle /Lateral	1d	100%	7/6/94	7/6/94
257	Remove 4" Connector	1d	100%	7/7/94	7/7/94
258					
259	Setup 2" Standard 3Way Connector - Teflon	1d	100%	7/8/94	7/8/94
260	Install Heater Rods	1d	100%	7/11/94	7/11/94
261	2 In. 3Way -125F/125 psi	1d	100%	7/12/94	7/12/94
262	2 In. 3Way -125F/125 psi /Lateral	1d	100%	7/13/94	7/13/94
263	2 In. 3Way - 338F/250 psi	1d	100%	7/14/94	7/14/94
264	2 In. 3Way - 338F/250 psi /Lateral	1d	100%	7/15/94	7/15/94
265	Remove 2" 3Way Connector	1d	100%	7/18/94	7/18/94
266					
267	***ADVANCED 3-WAY CONNECTOR SEAL***	***159d***	***92%***	***1/10/94***	***8/18/94***
268					
269	***Fab HWVP Design 3-Way Retainer***	***23d***	***100%***	***1/10/94***	***2/9/94***
270	Submit Request for Cost Estimate	1d	100%	1/10/94	1/10/94
271	Obtain Cost Estimate	5d	100%	1/11/94	1/17/94
272	Prepare J-10 Fab Request	1d	100%	1/18/94	1/18/94
273	Approve and Submit J-10	1d	100%	1/19/94	1/19/94
274	Machine HWVP 3-Way Retainer	15d	100%	1/20/94	2/9/94
275					
276	***Fab HWVP Design 3-Way Gaskets***	***41d***	***100%***	***2/10/94***	***4/7/94***
277	Prepare Gasket ECN	1d	100%	2/10/94	2/10/94

MWTF Integral Seal Block Jumper Connector Development and Leak Testing

ID	Name	Duration	% Complete	Scheduled Start	Scheduled Finish
278	Review and Approve Gasket ECN	1d	100%	2/11/94	2/11/94
279	Submit Request for Cost Estimate	1d	100%	2/14/94	2/14/94
280	Obtain Cost Estimate	1d	100%	2/15/94	2/15/94
281	Project Decision on Hardware	10d	100%	3/8/94	3/21/94
282	HWVP 3-Way Gasket ECN Incorporation	1d	100%	3/22/94	3/22/94
283	Prepare J-10 Fab Request	1d	100%	3/23/94	3/23/94
284	Approve and Submit J-10	1d	100%	3/24/94	3/24/94
285	Machine HWVP 3-Way Gaskets	10d	100%	3/25/94	4/7/94
286					
287	***Design 3-Way O-Ring Integral Seal Block***	***60d***	***100%***	***2/17/94***	***5/11/94***
288	Project Go-Ahead Decision	10d	100%	2/17/94	3/2/94
289	Concept Design - Geometry/Layout	10d	100%	3/7/94	3/18/94
290	Investigate Machinability	10d	100%	3/21/94	4/1/94
291	Decide on Feasibility	5d	100%	4/4/94	4/8/94
292	Preliminary AutoCAD Designs	10d	100%	4/11/94	4/22/94
293	Formal AutoCAD Design	10d	100%	4/25/94	5/6/94
294	2" 3-Way Jumper Assembly	3d	100%	5/9/94	5/11/94
295					
296					
297	***Test 3-Way O-Ring Integral Seal Block***	***25d***	***52%***	***7/19/94***	***8/18/94***
298	Setup Advanced 2" 3Way Connector	1d	100%	7/19/94	7/19/94
299	Install Heater Rods	1d	100%	7/20/94	7/20/94
300	3Way Thermal Cycle	5d	100%	7/21/94	7/27/94
301	3Way Thermal Cycle/Lateral	5d	100%	7/28/94	8/1/94
302	Remove 2" 3Way Connector	1d	100%	8/2/94	8/2/94
303					
304	Setup Advanced 2" 3Way Connector	1d	0%	8/3/94	8/3/94
305	3Way Thermal Cycle - Kalrez	5d	0%	8/4/94	8/10/94
306	3Way Thermal Cycle/Lateral	5d	0%	8/11/94	8/17/94
307	Remove 2" 3Way Connector	1d	0%	8/18/94	8/18/94
308					

MWTF Integral Seal Block Jumper Connector Development and Leak Testing

ID	Name	Duration	% Complete	Scheduled Start	Scheduled Finish
309	***TEST REPORTING***	***56d***	***51%***	***11/1/94***	***1/30/95***
310	***Leak Test Report - Page Prep.***	***1.4d***	***14%***	***1/5/95***	***1/6/95***
311	Label Photos	0.1d	100%	1/5/95	1/5/95
312	Label Figures	0.1d	100%	1/5/95	1/5/95
313	Paginate Single Port Graphs	0.5d	0%	1/5/95	1/5/95
314	Paginate 3-Way Graphs	0.5d	0%	1/5/95	1/6/95
315	Paginate Photos	0.1d	0%	1/6/95	1/6/95
316	Paginate Figures.	0.1d	0%	1/6/95	1/6/95
317	***Leak Test Report - Completion Admin***	***30.41d***	***5%***	***12/7/94***	***1/27/95***
318	Prepare Cover Pages	0.25d	80%	12/7/94	12/7/94
319	Prepare Distribution List	0.25d	80%	12/7/94	12/7/94
320	Prepare Transmittal	0.25d	80%	12/7/94	12/7/94
321	Review Report	5d	5%	1/6/95	1/13/95
322	Incorporate Comments	5d	0%	1/13/95	1/20/95
323	Reproduction	3d	0%	1/20/95	1/25/95
324	Issue Final Report - Single Port ISB's	2d	0%	1/25/95	1/27/95
325	***SD Data Document of Lab Notebooks***	***19.75d***	***40%***	***1/3/95***	***1/30/95***
326	Xerox all single port data pages	1d	100%	1/3/95	1/3/95
327	Xerox all 3-way data pages	1d	100%	1/4/95	1/4/95
328	Number all document pages	2d	100%	1/5/95	1/6/95
329	Label all document pages	2d	100%	1/9/95	1/10/95
330	Prepare Summary page	2d	50%	1/11/95	1/12/95
331	Prepare Cover Pages	0.25d	50%	1/13/95	1/13/95
332	Prepare Distribution List	0.25d	50%	1/13/95	1/13/95
333	Prepare Transmittal EDT	0.25d	50%	1/13/95	1/13/95
334	Prepare IRR	1d	50%	1/13/95	1/16/95
335	Approvals	3d	0%	1/16/95	1/19/95
~~336~~	~~Engineering Release Station~~	~~1d~~	~~0%~~	~~1/19/95~~	~~1/20/95~~
337	Reproduction	4d	0%	1/20/95	1/26/95
338	Distribution	2d	0%	1/26/95	1/30/95
339					
340	***Task Support***	***56d***	***80%***	***11/1/94***	***1/30/95***
341	Managerial	56d	90%	11/1/94	1/30/95
342	Secretarial	56d	70%	11/1/94	1/30/95

TITLE: Qualification of Mechanical Jumpers with Integral Seal O-Ring Block, Electrical Connections and Remote Flanges

DATE: 9/28/93 Rev. 2 3

ENGR. GP/
ORG. CODE: Structural Assessment/ 8D440 CUSTOMER/ORG CODE: MWTF/7F220

PERFORMER/SIGNATURE: EC Ocoma/ ~~ES Ruff~~ COG. ENGR./SIGNATURE: VJ Cruz/ 10-4-94

MANAGER/SIGNATURE TJ Conrads/ 10/6/94 MANAGER/SIGNATURE: JM Light/ 10-4-94

IMPACT LEVEL/WORK PLAN NO: / N/A WORK ORDER/TASK PKG: / DTTC4

ESR NO./WORK PLAN NO.: MAR-93-022 CLASSIFIED/UNCLASSIFIED: UNCLASSIFIED

SCOPE OF WORK: To qualify the mechanical jumpers with Integral Seal Block (ISB), the electrical connectors, and the remote flanges under operational and seismic conditions.

(A) Qualification of jumper connectors with o-ring integrated seal block; this includes the 2-in. 3-way multi-port, 2-, 3-, and 4-in. single port jumper connector heads. The analysis and testing are defined below.

Task A-I:

Perform structural analysis of jumper connectors with o-ring integrated seal block to verify design adequacy for the following loads: torque load, seismic load, and operational load. Determine the allowable enveloping nozzle loads (see comment 1). The analysis will accept possible spray leak under seismic event at the o-ring seal interface. Therefore, the seismic analysis will only include the piping load transferred from the pipe to the connector heads from structural analysis point of view, i.e, no leak tight consideration is given.

Task A-II:

Perform a series of leak tests for the above listed connector heads. The tests will include temperature, force/moment applied in two directions, and pressure. Tests will be repeated for six thermal cycles. To qualify seal materials, each set of tests will be repeated for different O-ring materials. Materials selected for testing are Kalrez, *Viton, and Flurosilicon* (was Aflas, Sylon, and Fluorel).

(B) Qualify the electrical head connectors

Task B-I:

The electrical connectors are very heavy and strong. The only loads to be considered are the torque load and the load from the strong back attached to the electrical head (dead weight plus seismic load). The main concern in the functionality of the connectors are the springs that transmit the signal. This spring is within the housing of the electrical connector and will not be affected by the load on the connector. The analyses of the strong backs *(no configurations as of yet and how many)* will evaluate the structural integrity of the connector and the strong back.

Task B-II:

During and after a seismic event, it is essential that the signals would continuously transmit and the connector be functioning. This should be tested experimentally and is not addressed within the scope of this work. See comment (2) for details.

(C) Qualify the remote flanges. *(deleted by V. Cruz at the 9/28/94 meeting in ETC-2 since ICF-KH is already doing it)*

Task C-I:

As of now, there are three different remote flanges specified (based on mtg. with Don O'Connor and Gary Cleveland from KEH, 3/2/94). These are 6- 8-, and 10-in. remote flanges. The flanges have been used in the past and operated satisfactory. The loading would be 60 in. of water pressure at 212 °F temperature. The ASME Section VIII (or Section III, Appendices) will be used for evaluation.

Task C-II:

The leakage of the remote flanges is acceptable after a DBE as a result of the PSAR analysis. The question of possible leakage during operation was raised to see if it is worth performing experiments to verify the leak tightness or leakage rate. It was recommended that a leak test is not required because of the following reasons. (a) The PSAR analysis allows leakage in the pit. There are detectors that would detect leakage beyond the allowable limits. (b) The past experience with PUREX and other facilities that have used the flanges show good results if the gaskets are used and installed properly (phone conversation on 3/2/94 with Ed allen, Bob Campbell, and Mike Harty).

(D) Seal retainer removal tool

Task D-I: (completed)

Design and fabricate three tools to remove seal retainers from 2-, 3-, and 4-in. jumper connector lower skirt.

(E) Design study for 3-Way tetraseal type retainer.

Task E-I: (completed)

Perform a study on the feasibility of a 2-in. 3-way seal retainer that would incorporate an O-ring/tetraseal. The purpose of this retainer would be to allow retrofit of existing 3-way teflon type seals.

SCHEDULE/MILESTONES/DUE DATE:
[Cost tabulation included in Rev. 1 is removed]

COST ESTIMATE: *$489k*

DELIVERABLES: *Reports issued as Supporting Documents (SDs):* 3

Test Report	~~*Nov. 15, 1994*~~ Jan 31, 1995
Analysis Report	
2, 3, & 4-in. single port	~~*Oct. 28, 1994*~~ Jan 31, 1995
~~*Connector stiffnesses*~~	~~*Dec. 30, 1994*~~
2-in. 3-way port	~~*Jan. 30 1995*~~ Jan 31, 1995
~~*Elect. conn./strong backs*~~	~~*May 29, 1995*~~

Customer Agreement by Telecon with V.J. Cruz 2/8/95 SK Farnworth
2/8/95 ES Ruff
2/8/95 EC Ocampo

REFERENCE INFORMATION:

KEY WORDS: Multi-Function Waste Tank Facility, jumpers, piping

Rev. 1 comments

(1) The operational loads (transferred from piping to the head) are not known at this time. Per Tom Salzano's recommendation (cc:mail 2/7/94) the maximum allowable force/moment should be specified at the connector/pipe connection. Since any combination of forces and moments in any direction is possible, the analysis will provide unit loads in each direction and resulting stresses that could be scaled to the actual design load.

(2) *Discussions have been initiated with the Project and Safety staff to determine the need for connector function during a seismic event.*

(3) This work plan is a revision to the work plan dated 9/9/93, Rev. 0. The revision of Rev. 0 work plan is due to a new configuration *(o-ring or ISB vs teflon seal)* and added work scope. Total cost of rev. 0 is 278.9K and the cost of rev. 1 with added analysis and testing is 312.5 K.

Rev 2 comments: REQUEST FOR ADDITIONAL FUNDING AND SCHEDULE EXTENSION

ADDITIONAL FUNDING requested: $55k testing, $43k additional for planned testing
$12k for new stiffness testing

$122k analysis, additional for planned analysis
$177k total increase (from $312.5k of Rev. 1)

SCHEDULE EXTENSION (see attached revised schedule)

New test work: Stiffness testing deliverables
Drawings of the test fixture and loading mechanism.
Sketches showing the type and direction of loading.
Perform and record loads and deflections.
Provide raw data and tabulated data to the analysts.

Planned testing & analysis budget increase:

1. *Fabrication, test and analysis required more time and more work than was originally planned.*
2. *The test stand in the 305 Building was forced to relocate two times during the last two months. The relocation was caused by K-Basin projects moving equipment into our lab space. Also, the test stand high pressure metering pump had to be replaced.*
3. *$10k for fab. and development portion of the 3-way ISB prototype testing was inadvertently omitted from the rev. 0. This $10k is now included in rev. 2.*

3 REV 3 COMMENTS:

E.C.O. Comm 2/8/95 1. TASKS CONNECTOR STIFFNESS TESTING AND ELECT. CONNECTOR/STRONG BACKS ANALYSIS DELETED.

2. REVISED DELIVERABLES COMPLETION DATES ALL REVISED TO 1/31/95.

ESRuff 2/8/95.
[illegible] 2/8/95
Agreement by Telecon with V.J. Cruz SKF 2/8/95

STRUCTURAL QUALIFICATION OF MECHANICAL JUMPERS WITH INTEGRAL SEAL BLOCKS (ISB), ELECTRICAL CONNECTORS, AND REMOTE FLANGES

FY94 — FY95

JAN FEB MAR APR MAY JUN JUL AUG SEPT OCT NOV DEC JAN FEB

MECHANICAL JUMPERS			
Test Preparation Design/Fabrication	1/1	7/8	*(complete)*
2-in. ISB Single Port Connector Analysis	4/13	*10/28*	
Testing	5/11	6/7	
3-in. ISB Single Port Connector Analysis	5/27	*10/28*	
Testing	4/15	5/10	
4-in. ISB Single Port Connector Analysis	6/24	*10/28*	
Testing	6/8	7/7	
2-in. 3-Way Port Connector Analysis*	7/15	*1/30*	
Testing	7/8	*10/15*	
Test Report/Document	8/2	*11/15*	

* Each individual loading from the piping configuration needs to be analyzed case by case to find stresses and allowable torque for rigid connection.

wrkplan7.eco

FY95

OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG

ELECTRICAL JUMPERS

2, 3, & 4-in.

Analysis *(conn. & conduit strong back)* — *1/9* to *5/29*

Testing *(operability after DBE = TBD)*

REMOTE FLANGES *(deleted 9/28/94 per project's request)*

6-, 8-, and 10-in. flanges

Analysis — *10/24* to *1/16*

SEAL RETAINER REMOVAL TOOL (TEFLON SEAL)

Analysis (Not Applicable)

Testing — 5/26 to 7/29

DESIGN STUDY OF 3-WAY TETRASEAL RETAINER

Analysis (nothing planned or scheduled)

Testing — 7/3 to 7/29

STIFFNESS TESTING

2, 3, & 4-in. single port & 2-in. 3-way port

Test Preparation

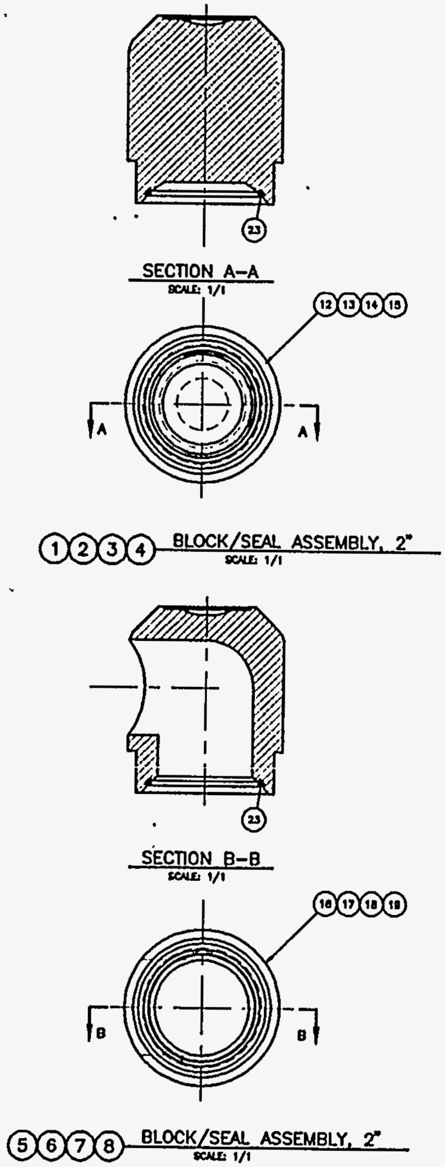
Test Stand Drawings/Sketches

Perform Stiffness Tests

Tabulate Data — *9/30* to *11/30*

Analyze Data/Issue Stiffness Report — *11/30* to *12/30*

APPENDIX B: DRAWINGS FOR 2-, 3-, and 4-IN. AND THREE-WAY INTEGRAL SEAL BLOCKS



GENERAL NOTES
(UNLESS OTHERWISE SPECIFIED)

1. BREAK ALL SHARP EDGES AND REMOVE ALL BURRS.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982. DIMENSIONS ARE IN INCHES.
   TOLERANCES: DECIMALS: .XX=±.02 .XXX=±.005
   ANGULAR: ±0°-30'
3. ALL MACHINED SURFACES SHALL BE 125 IN ACCORDANCE WITH ANSI B46.1.
4. MARK PER HS-BS-0015 TYPE 1 (VIBRATORY MARKING) OR TYPE 3 (ELECTROCHEMICAL ETCHING) WITH DRAWING NUMBER AND PART/DASH NUMBER IN LOCATION INDICATED USING 1/4" MINIMUM HIGH CHARACTERS.
5. PASSAGEWAY MAY BE PRODUCED BY INTERSECTING DRILL HOLES OF SPECIFIED DIAMETER RATHER THAN BLENDED AS SHOWN. AFTER DRILLING BOTTOM HOLE TO SPECIFIED DEPTH, DRILL INTERSECTING HOLE UNTIL FULL DIAMETER OF DRILL COMPLETELY INTERSECTS CENTERLINE OF BOTTOM HOLE. DO NOT DRILL INTO BACK WALL OF BLOCK.

For Illustration Only
Not to be Used for Fabrication

PARTS/MATERIAL LIST

QTY REQD -080	-070	-060	-050	-040	-030	-020	-010	PART/DASH NUMBER	NOMENCLATURE/DESCRIPTION	MATERIAL/REFERENCE	SHEET	ITEM NO.
							X	-010	BLOCK/SEAL ASSEMBLY, 2"		1	1
						X		-020	BLOCK/SEAL ASSEMBLY, 2"		1	2
					X			-030	BLOCK/SEAL ASSEMBLY, 2"		1	3
				X				-040	BLOCK/SEAL ASSEMBLY, 2"		1	4
			X					-050	BLOCK/SEAL ASSEMBLY, 2"		1	5
		X						-060	BLOCK/SEAL ASSEMBLY, 2"		1	6
	X							-070	BLOCK/SEAL ASSEMBLY, 2"		1	7
X								-080	BLOCK/SEAL ASSEMBLY, 2"		1	8
												9
												10
												11
							1	-001	BLOCK, BLANK, 2"	ASTM A276 304 SST	2	12
						1		-002	BLOCK, BLANK, 2"	ASTM A276 316L SST	2	13
					1			-003	BLOCK, BLANK, 2"	ASTM B574 HASTELLOY, C-22	2	14
				1				-004	BLOCK, BLANK, 2"	ASTM B166 INCONEL, 690	2	15
			1					-005	BLOCK, 1-PORT, 2"	ASTM A276 304 SST	2	16
		1						-006	BLOCK, 1-PORT, 2"	ASTM A276 316L SST	2	17
	1							-007	BLOCK, 1-PORT, 2"	ASTM B574 HASTELLOY, C-22	2	18
1								-008	BLOCK, 1-PORT, 2"	ASTM B166 INCONEL, 690	2	19
												20
												21
												22
1	1	1	1	1	1	1	1	AS 568-142	O-RING 2.362 I.D., .103 SECTION ø	SEE SEAL MATERIAL SCHEDULE	1	23

SEAL MATERIAL SCHEDULE
(GENERAL GUIDELINES)
CONSULT MANUFACTURER'S DATA REGARDING TEMPERATURE LIMITS, RADIATION AND CHEMICAL RESISTANCE FOR EACH SPECIFIC SERVICE APPLICATION.

MATERIAL	HARDNESS DUROMETER (SHORE A)
NITRILE (BUNA-N)	80-90
POLYACRYLATE	80-90
FLUOROCARBON (VITON, FLUOREL)	80-90
NEOPRENE (CHLOROPRENE)	80-90
ETHYLENE PROPYLENE (EP)	80-90
SILICONE	80-90
KALREZ	80-90
FLUOROSILICONE (SYLON)	80-90
POLYURETHANE (DISOGRIN)	80-90
AFLAS TFE	80-90

REF NUMBER	TITLE
H-2-821253	SEALS & RING 2" JMPR CONN
H-2-815354	GASKET RET PUREX TYPE
H-2-83572	2" MALE NOZZLE PUREX TYPE
H-2-32423	DETS CONN BLKS 2" CONN
H-2-32421	DETS-2" CONNECTOR INSTALL

REFERENCES
NEXT USED ON AS ALLOCATED
DRAWING TRACEABILITY LIST
REVISIONS
CAN/ECN 8821324A
CAN/CR DOE-5.9ACDE-1259

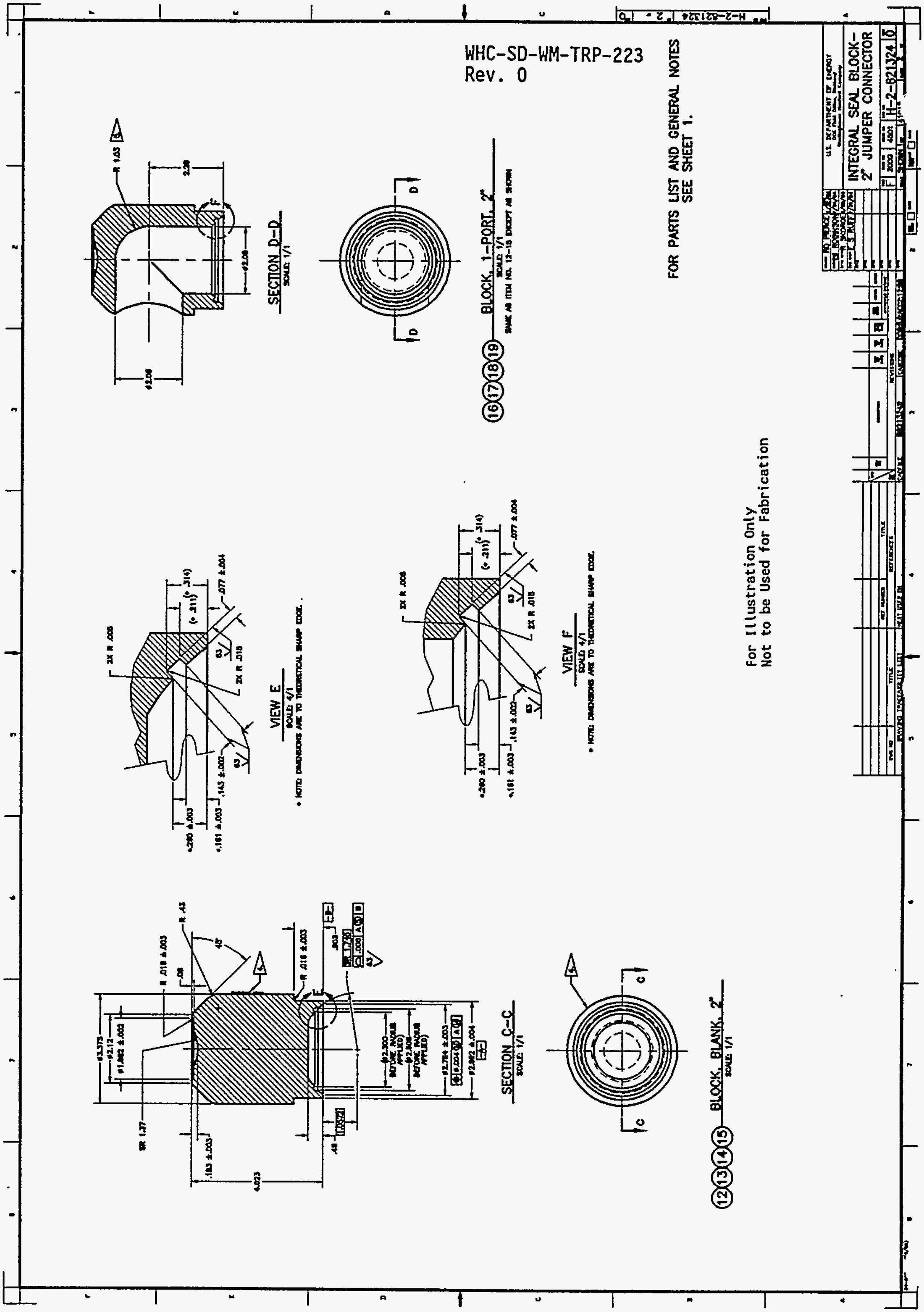
RD PIERCE 1/21/94
ED ROBINSON 1/27/94
R SKORGE 1/31/94
E S RUVIT 2/1/94

U.S. DEPARTMENT OF ENERGY
DOE Field Office, Richland
Westinghouse Hanford Company

INTEGRAL SEAL BLOCK-
2" JUMPER CONNECTOR

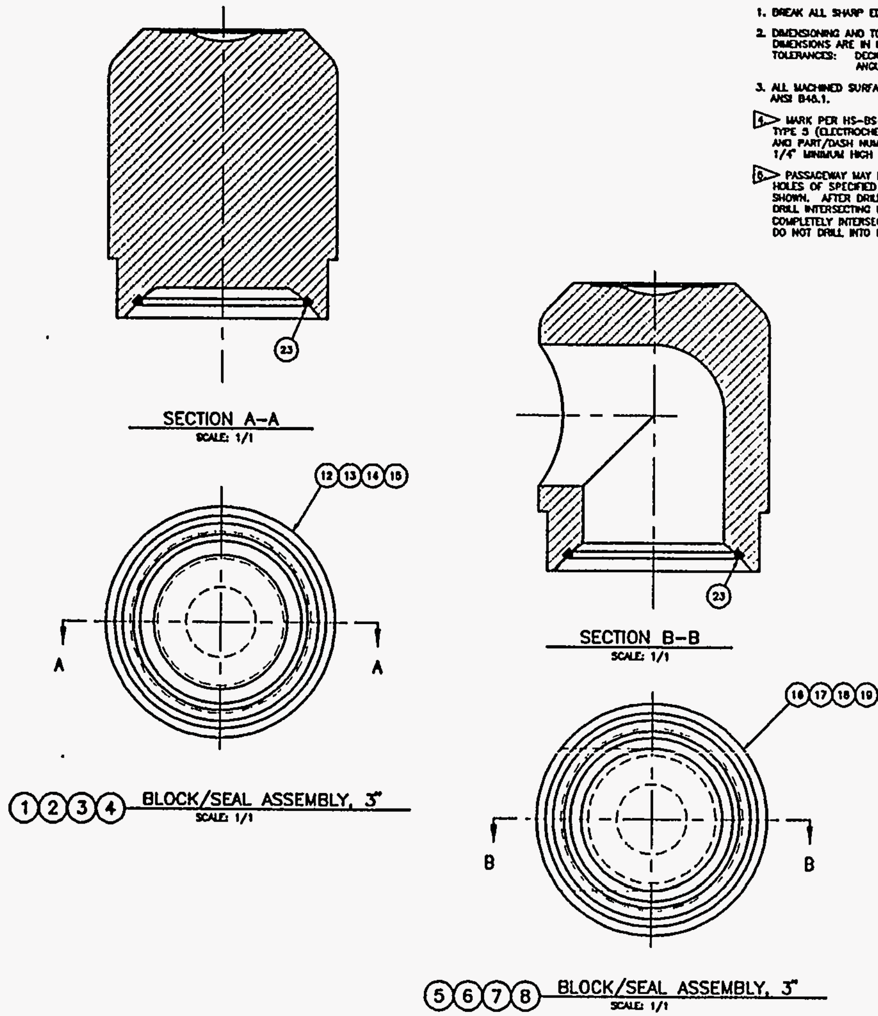
F 2000 4301 H-2-821324 0
SCALE SHOWN 141018 SHEET 1 OF 2

WHC-SD-WM-TRP-223
Rev. 0


FOR PARTS LIST AND GENERAL NOTES
SEE SHEET 1.
SECTION D-D
SCALE: 1/1
BLOCK, 1-PORT, 2"
SCALE: 1/1
VIEW E
SCALE: 4/1
VIEW F
SCALE: 4/1
SECTION C-C
SCALE: 1/1
BLOCK, BLANK, 2"
SCALE: 1/1
For Illustration Only
Not to be Used for Fabrication
INTEGRAL SEAL BLOCK-
2" JUMPER CONNECTOR
H-2-821324

GENERAL NOTES
(UNLESS OTHERWISE SPECIFIED)

1. BREAK ALL SHARP EDGES AND REMOVE ALL BURRS.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982. DIMENSIONS ARE IN INCHES.
   TOLERANCES: DECIMALS: .XX=±.02 .XXX=±.005
   ANGULAR: ±0°-30'
3. ALL MACHINED SURFACES SHALL BE 125 IN ACCORDANCE WITH ANSI B46.1.
4. MARK PER HS-BS-0015 TYPE 1 (VIBRATORY MARKING) OR TYPE 3 (ELECTROCHEMICAL ETCHING) WITH DRAWING NUMBER AND PART/DASH NUMBER IN LOCATION INDICATED USING 1/4" MINIMUM HIGH CHARACTERS.
5. PASSAGEWAY MAY BE PRODUCED BY INTERSECTING DRILL HOLES OF SPECIFIED DIAMETER INSTEAD OF BLENDED AS SHOWN. AFTER DRILLING BOTTOM HOLE TO SPECIFIED DEPTH, DRILL INTERSECTING HOLE UNTIL FULL DIAMETER OF DRILL COMPLETELY INTERSECTS CENTERLINE OF BOTTOM HOLE. DO NOT DRILL INTO BACK WALL OF BLOCK.



PARTS/MATERIAL LIST

QTY REQD -080	-070	-060	-050	-040	-030	-020	-010	PART/DASH NUMBER	NOMENCLATURE/DESCRIPTION	MATERIAL/REFERENCE	SHEET	ITEM NO.
							X	-010	BLOCK/SEAL ASSEMBLY, 3"		1	1
						X		-020	BLOCK/SEAL ASSEMBLY, 3"		1	2
					X			-030	BLOCK/SEAL ASSEMBLY, 3"		1	3
				X				-040	BLOCK/SEAL ASSEMBLY, 3"		1	4
			X					-050	BLOCK/SEAL ASSEMBLY, 3"		1	5
		X						-060	BLOCK/SEAL ASSEMBLY, 3"		1	6
	X							-070	BLOCK/SEAL ASSEMBLY, 3"		1	7
X								-080	BLOCK/SEAL ASSEMBLY, 3"		1	8
												9
												10
												11
							1	-001	BLOCK, BLANK, 3"	ASTM A276 304 SST	2	12
						1		-002	BLOCK, BLANK, 3"	ASTM A276 316L SST	2	13
					1			-003	BLOCK, BLANK, 3"	ASTM B574 HASTELLOY, C-22	2	14
				1				-004	BLOCK, BLANK, 3"	ASTM B166 INCONEL, 690	2	15
			1					-005	BLOCK, 1-PORT, 3"	ASTM A276 304 SST	2	16
		1						-006	BLOCK, 1-PORT, 3"	ASTM A276 316L SST	2	17
	1							-007	BLOCK, 1-PORT, 3"	ASTM B574 HASTELLOY, C-22	2	18
1								-008	BLOCK, 1-PORT, 3"	ASTM B166 INCONEL, 690	2	19
												20
												21
												22
1	1	1	1	1	1	1	1	AS 568-239	O-RING, CLASS 1, 3.609 I.D., .139 SECTION ø	SEE SEAL MATERIAL SCHEDULE	1	23

SEAL MATERIAL SCHEDULE
(GENERAL GUIDELINES)

CONSULT MANUFACTURER'S DATA REGARDING TEMPERATURE LIMITS, RADIATION AND CHEMICAL RESISTANCE FOR EACH SPECIFIC SERVICE APPLICATION.

MATERIAL	HARDNESS DUROMETER (SHORE A)
NITRILE (BUNA-N)	60-90
POLYACRYLATE	60-90
FLUOROCARBON (VITON, FLUOREL)	60-90
NEOPRENE (CHLOROPRENE)	60-90
ETHYLENE PROPYLENE (EP)	60-90
SILICONE	60-90
KALREZ	60-90
FLUOROSILICONE (SYLON)	60-90
POLYURETHANE (DISOGRIN)	60-90
AFLAS TFE	60-90

For Illustration Only
Not to be Used for Fabrication

REF NUMBER	TITLE
H-2-821234	SEALS & RTNR 3" JMPR CONN
H-2-815354	GASKET RET PUREX TYPE
H-2-32433	DETS CONN BLKS 3" CONN

NEXT USED ON: AS ALLOCATED

DRAWING TRACEABILITY LIST

CADFILE: B821325A

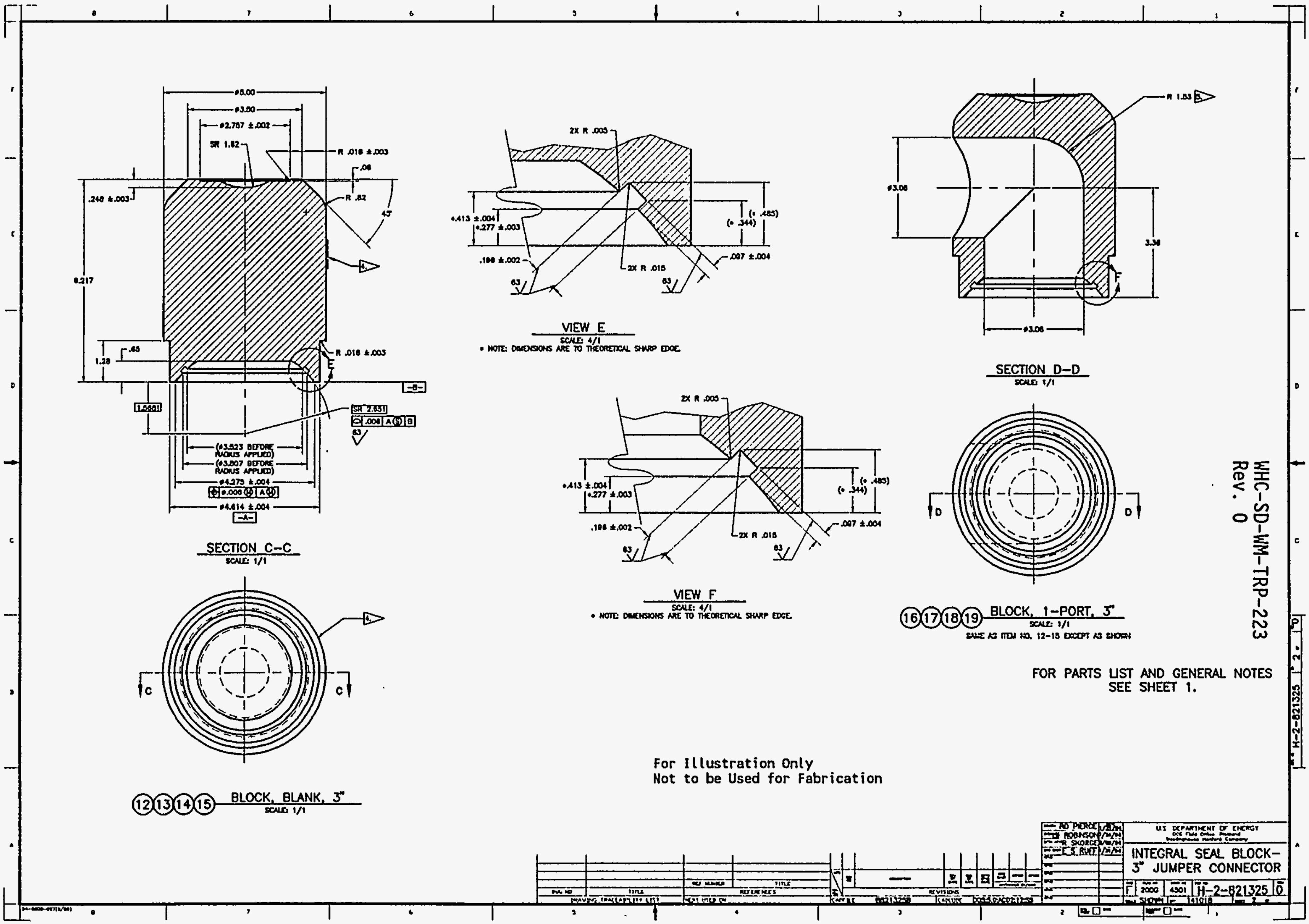
D. PIERCE
R. ROBINSON
R. SKORGE
E. S. RUFF

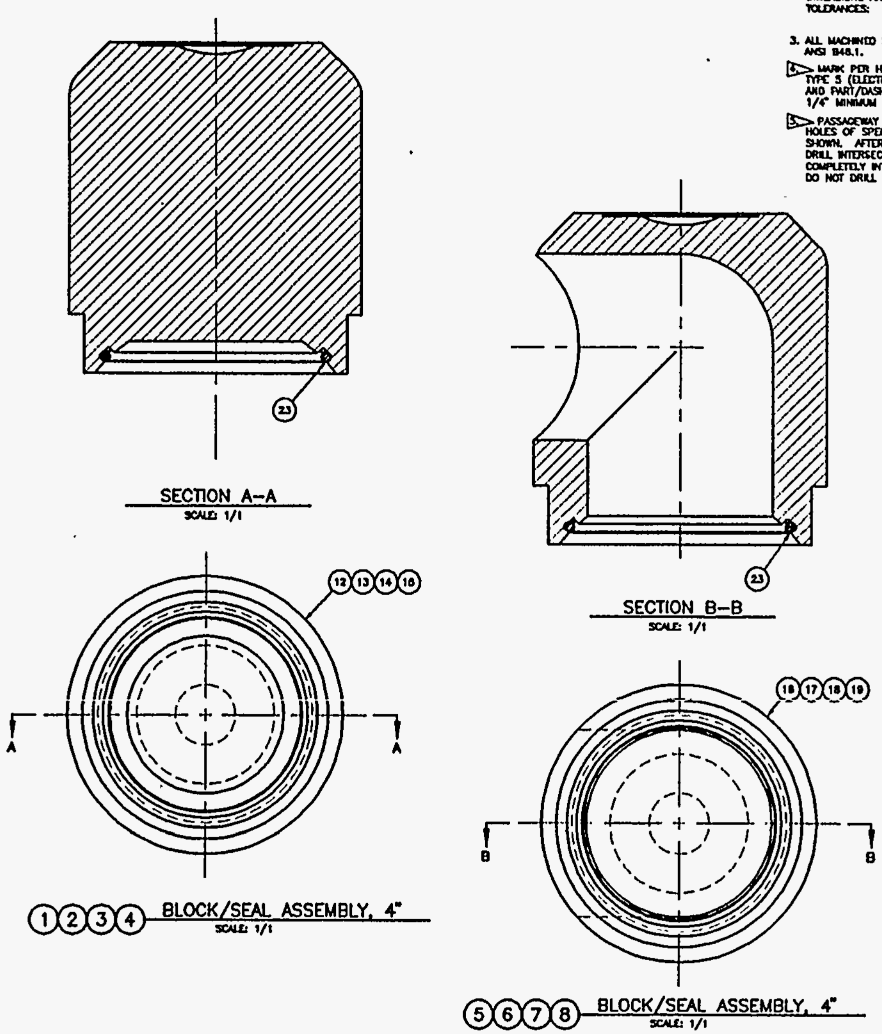
US DEPARTMENT OF ENERGY
DOE Field Office, Richland
Westinghouse Hanford Company

INTEGRAL SEAL BLOCK-3" JUMPER CONNECTOR

F 2000 4501 H-2-821325 0

SCALE: SHOWN 141018 SHEET 1 OF 2


SECTION C-C
SCALE: 1/1
VIEW E
SCALE: 4/1
* NOTE: DIMENSIONS ARE TO THEORETICAL SHARP EDGE.
VIEW F
SCALE: 4/1
* NOTE: DIMENSIONS ARE TO THEORETICAL SHARP EDGE.
SECTION D-D
SCALE: 1/1
12 13 14 15 BLOCK, BLANK, 3"
SCALE: 1/1
16 17 18 19 BLOCK, 1-PORT, 3"
SCALE: 1/1
SAME AS ITEM NO. 12-15 EXCEPT AS SHOWN
FOR PARTS LIST AND GENERAL NOTES
SEE SHEET 1.
For Illustration Only
Not to be Used for Fabrication
U.S. DEPARTMENT OF ENERGY
INTEGRAL SEAL BLOCK-
3" JUMPER CONNECTOR
H-2-821325 0



GENERAL NOTES
(UNLESS OTHERWISE SPECIFIED)

1. BREAK ALL SHARP EDGES AND REMOVE ALL BURRS.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982. DIMENSIONS ARE IN INCHES.
   TOLERANCES: DECIMALS: .XX=±.02 .XXX=±.005
   ANGULAR: ±0°-30'
3. ALL MACHINED SURFACES SHALL BE 125 IN ACCORDANCE WITH ANSI B46.1.
4. MARK PER HS-BS-0015 TYPE 1 (VIBRATORY MARKING) OR TYPE 5 (ELECTROCHEMICAL ETCHING) WITH DRAWING NUMBER AND PART/DASH NUMBER IN LOCATION INDICATED USING 1/4" MINIMUM HIGH CHARACTERS.
5. PASSAGEWAY MAY BE PRODUCED BY INTERSECTING DRILL HOLES OF SPECIFIED DIAMETER INSTEAD OF BLENDED AS SHOWN. AFTER DRILLING BOTTOM HOLE TO SPECIFIED DEPTH, DRILL INTERSECTING HOLE UNTIL FULL DIAMETER OF DRILL COMPLETELY INTERSECTS CENTERLINE OF BOTTOM HOLE. DO NOT DRILL INTO BACK WALL OF BLOCK.

PARTS/MATERIAL LIST

QTY REQD -080	-070	-060	-050	-040	-030	-020	-010	PART/DASH NUMBER	NOMENCLATURE/DESCRIPTION	MATERIAL/REFERENCE	SHEET	ITEM NO
							X	-010	BLOCK/SEAL ASSEMBLY, 4"		1	1
						X		-020	BLOCK/SEAL ASSEMBLY, 4"		1	2
					X			-030	BLOCK/SEAL ASSEMBLY, 4"		1	3
				X				-040	BLOCK/SEAL ASSEMBLY, 4"		1	4
			X					-050	BLOCK/SEAL ASSEMBLY, 4"		1	5
		X						-060	BLOCK/SEAL ASSEMBLY, 4"		1	6
	X							-070	BLOCK/SEAL ASSEMBLY, 4"		1	7
X								-080	BLOCK/SEAL ASSEMBLY, 4"		1	8
												9
												10
												11
							1	-001	BLOCK, BLANK, 4"	ASTM A276 304 SST	2	12
						1		-002	BLOCK, BLANK, 4"	ASTM A276 316L SST	2	13
					1			-003	BLOCK, BLANK, 4"	ASTM B574 HASTELLOY, C-22	2	14
				1				-004	BLOCK, BLANK, 4"	ASTM B166 INCONEL, 690	2	15
			1					-005	BLOCK, 1-PORT, 4"	ASTM A276 304 SST	2	16
		1						-006	BLOCK, 1-PORT, 4"	ASTM A276 316L SST	2	17
	1							-007	BLOCK, 1-PORT, 4"	ASTM B574 HASTELLOY, C-22	2	18
1								-008	BLOCK, 1-PORT, 4"	ASTM B166 INCONEL, 690	2	19
												20
												21
												22
1	1	1	1	1	1	1	1	AS-568-360	O-RING, CLASS 1 OR 2, 4.600 I.D., .210 SECTION ⌀	SEE SEAL MATERIAL SCHEDULE	1	23

SEAL MATERIAL SCHEDULE
(GENERAL GUIDELINES)
CONSULT MANUFACTURER'S DATA REGARDING TEMPERATURE LIMITS, RADIATION AND CHEMICAL RESISTANCE FOR EACH SPECIFIC SERVICE APPLICATION.

MATERIAL	HARDNESS DUROMETER (SHORE A)
NITRILE (BUNA-N)	60-90
POLYACRYLATE	60-90
FLUOROCARBON (VITON, FLUOREL)	60-90
NEOPRENE (CHLOROPRENE)	60-90
ETHYLENE PROPYLENE (EP)	60-90
SILICONE	60-90
KALREZ	60-90
FLUOROSILICONE (SYLON)	60-90
POLYURETHANE (DISOGRIN)	60-90
AFLAS TFE	60-90

For Illustration Only
Not to be Used for Fabrication

REF NUMBER	TITLE
H-2-821235	SEALS & RING 4" JMPR CONN
H-2-815354	GASKET RET PUREX TYPE
H-2-32443	DETS CONN BLKS 4" CONN

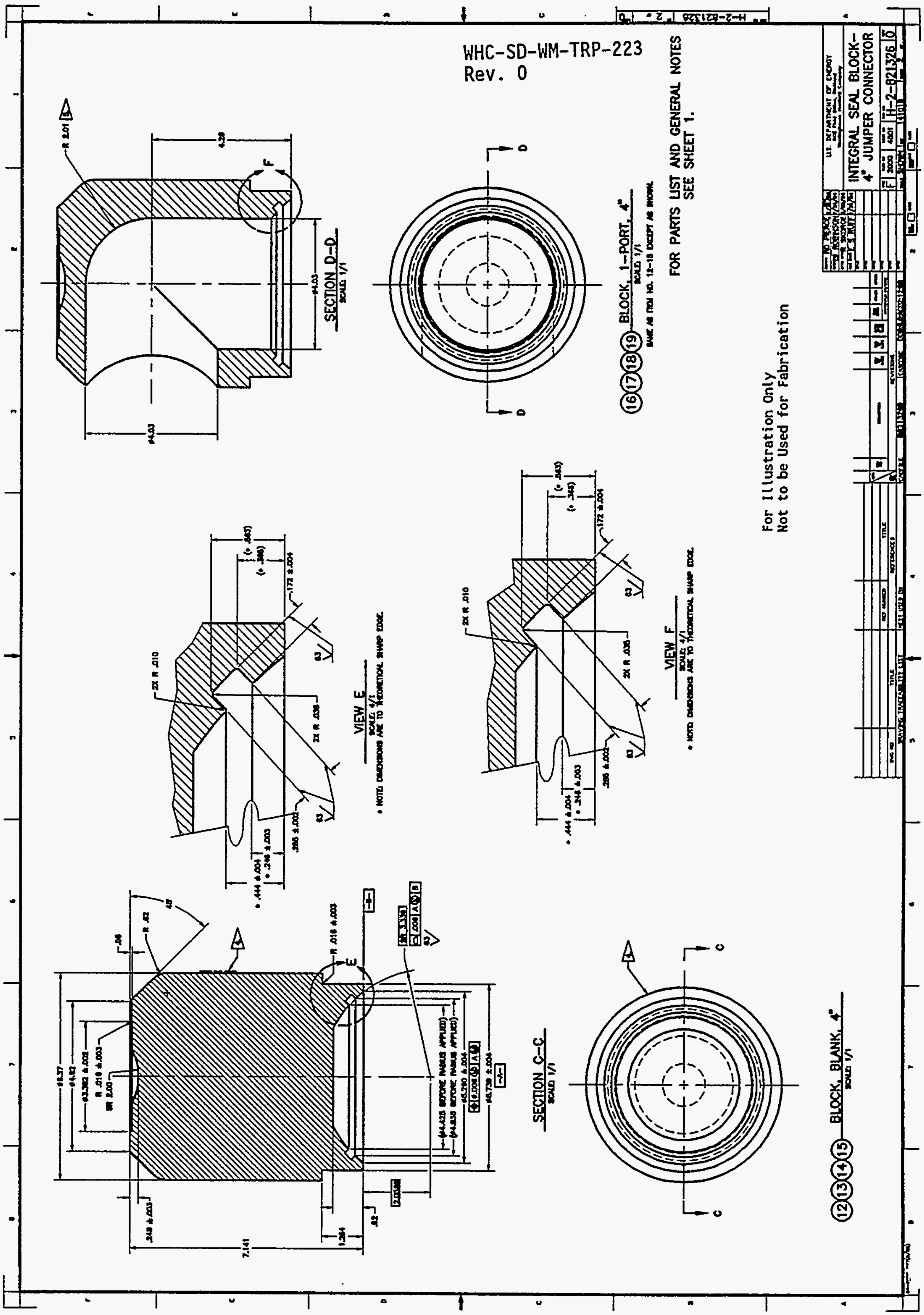
RO PIERCE
DR ROBINSON
R SKORGE
E S RUFF

US DEPARTMENT OF ENERGY
DOE Field Office, Richland
Westinghouse Hanford Company

INTEGRAL SEAL BLOCK–4" JUMPER CONNECTOR

F | 2000 | 4501 | H-2-821326 | 0

SCALE: SHOWN | 141018 | SHEET 1 OF 2


SECTION D-D
SCALE 1/1
BLOCK, 1-PORT, 4"
SCALE 1/1
FOR PARTS LIST AND GENERAL NOTES
SEE SHEET 1.
VIEW E
SCALE 4/1
VIEW F
SCALE 4/1
SECTION C-C
SCALE 1/1
BLOCK, BLANK, 4"
SCALE 1/1
For Illustration Only
Not to be Used for Fabrication
INTEGRAL SEAL BLOCK-
4" JUMPER CONNECTOR
H-2-821326

SEAL MATERIAL SCHEDULE
(GENERAL GUIDELINES)

CONSULT MANUFACTURER'S DATA REGARDING TEMPERATURE LIMITS, RADIATION AND CHEMICAL RESISTANCE FOR EACH SPECIFIC SERVICE APPLICATION.

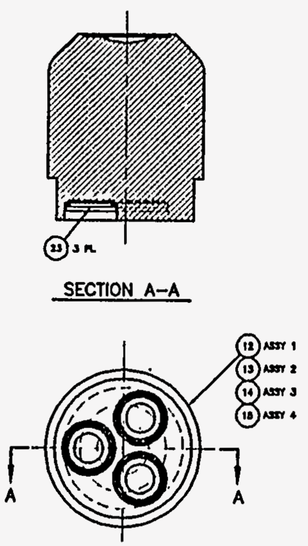
MATERIAL	HARDNESS DUROMETER (SHORE A)
NITRILE (BUNA-N)	80-90
POLYACRYLATE	80-90
FLUOROCARBON (VITON, FLUOREL)	80-90
NEOPRENE (CHLOROPRENE)	80-90
ETHYLENE PROPYLENE (EP)	80-90
SILICONE	80-90
KALREZ	80-80
FLUOROSILICONE (SYLON)	80-80
POLYURETHANE (DISOGRIN)	80-90
AFLAS TFE	80-80

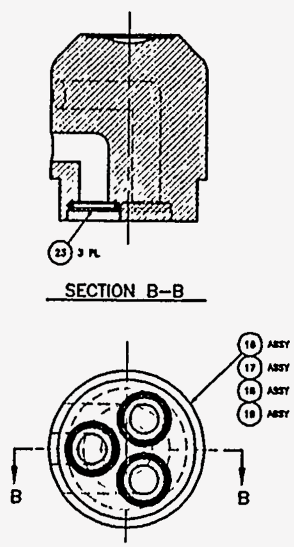
GENERAL NOTES (UNLESS OTHERWISE SPECIFIED)

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982. DIMENSIONS ARE IN INCHES.
   TOLERANCES: DECIMALS; .XX=±.02 .XXX=±.005 .XXXX=±.0005
   ANGULAR; ±0°-30'
2. BREAK ALL SHARP EDGES AND REMOVE ALL BURRS.
3. ALL MACHINED SURFACES SHALL BE 125 OR BETTER IN ACCORDANCE WITH ANSI B46.1.
4. PASSAGEWAY MAY BE PRODUCED BY INTERSECTING DRILL HOLES OF SPECIFIED DIAMETER RATHER THAN BLENDED AS SHOWN. AFTER DRILLING BOTTOM HOLE TO SPECIFIED DEPTH, DRILL INTERSECTING HOLE UNTIL FULL DIAMETER OF DRILL COMPLETELY INTERSECTS CENTERLINE OF BOTTOM HOLE. DO NOT DRILL INTO BACK WALL OF BLOCK.
5. MARK PER HS-86-0015 TYPE 1 (VIBRATORY MARKING) OR TYPE 5 (ELECTROCHEMICAL ETCHING) WITH DRAWING NUMBER AND PART/DASH NUMBER AT LOCATION INDICATED USING 1/4" MINIMUM HIGH CHARACTERS.

PARTS/MATERIAL LIST

QTY REQD -080	-070	-060	-050	-040	-030	-020	-010	PART/DASH NUMBER	NOMENCLATURE/DESCRIPTION	MATERIAL/REFERENCE	SHEET	ITEM NO
							X	-010	BLOCK/SEAL ASSEMBLY, 2" 3-WAY, BLANK		1	1
						X		-020	BLOCK/SEAL ASSEMBLY, 2" 3-WAY, BLANK		1	2
					X			-030	BLOCK/SEAL ASSEMBLY, 2" 3-WAY, BLANK		1	3
				X				-040	BLOCK/SEAL ASSEMBLY, 2" 3-WAY, BLANK		1	4
			X					-050	BLOCK/SEAL ASSEMBLY, 2" 3-WAY		1	5
		X						-060	BLOCK/SEAL ASSEMBLY, 2" 3-WAY		1	6
	X							-070	BLOCK/SEAL ASSEMBLY, 2" 3-WAY		1	7
X								-080	BLOCK/SEAL ASSEMBLY, 2" 3-WAY		1	8
												9
												10
												11
							1	-001	BLOCK, 2" 3-WAY, BLANK	ASTM A276 304 SST	2	12
						1		-002	BLOCK, 2" 3-WAY, BLANK	ASTM A276 316L SST	2	13
					1			-003	BLOCK, 2" 3-WAY, BLANK	ASTM B574 HASTELLOY, C-22	2	14
				1				-004	BLOCK, 2" 3-WAY, BLANK	ASTM B166 INCONEL 690	2	15
			1					-005	BLOCK, 2" 3-WAY	ASTM A276 304 SST	2	16
		1						-006	BLOCK, 2" 3-WAY	ASTM A276 316L SST	2	17
	1							-007	BLOCK, 2" 3-WAY	ASTM B574 HASTELLOY, C-22	2	18
1								-008	BLOCK, 2" 3-WAY	ASTM B166 INCONEL 690	2	19
												20
												21
												22
3	3	3	3	3	3	3	3	AS 568A-118	O-RING, .924 I.D., .103 SECTION	SEE SEAL MATERIAL SCHEDULE		23





1 2 3 4 BLOCK/SEAL ASSEMBLY, 2" 3-WAY, BLANK

5 6 7 8 BLOCK/SEAL ASSEMBLY, 2" 3-WAY

For Illustration Only
Not to be Used for Fabrication

NEXT USED ON	REFERENCES	
	H-2-32447	DET & ASSY SST 2" 3-WAY
	H-2-32423	DET CONN BLK 2" CONN
	H-2-32421	DET-2" CONN INSTL
AS ALLOCATED		

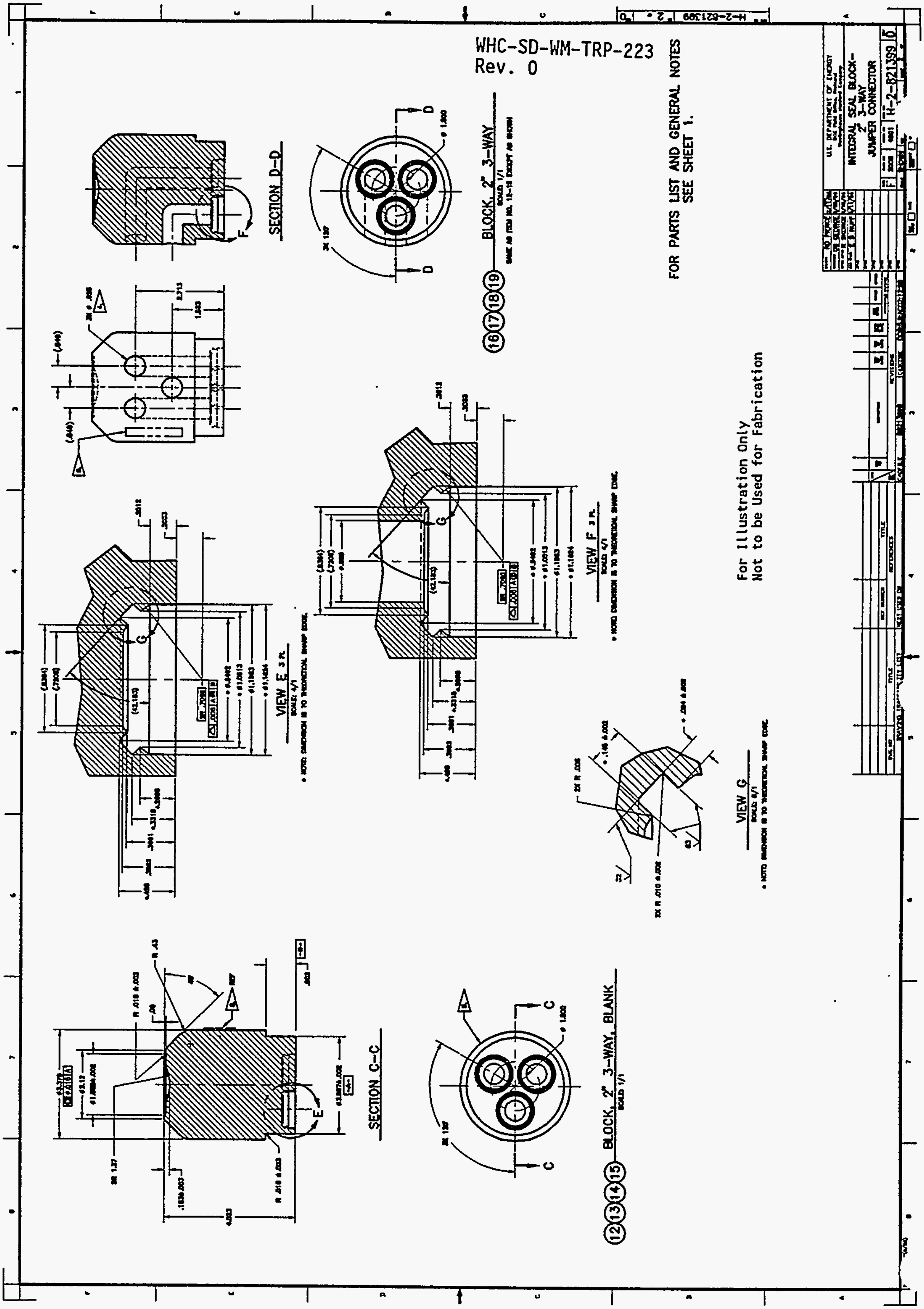
DRAWING TRACEABILITY LIST

RD PIERCE 5/11/94
OS GEORGE 5/10/94
R SKORCE 5/18/94
E S RUFF 5/11/94

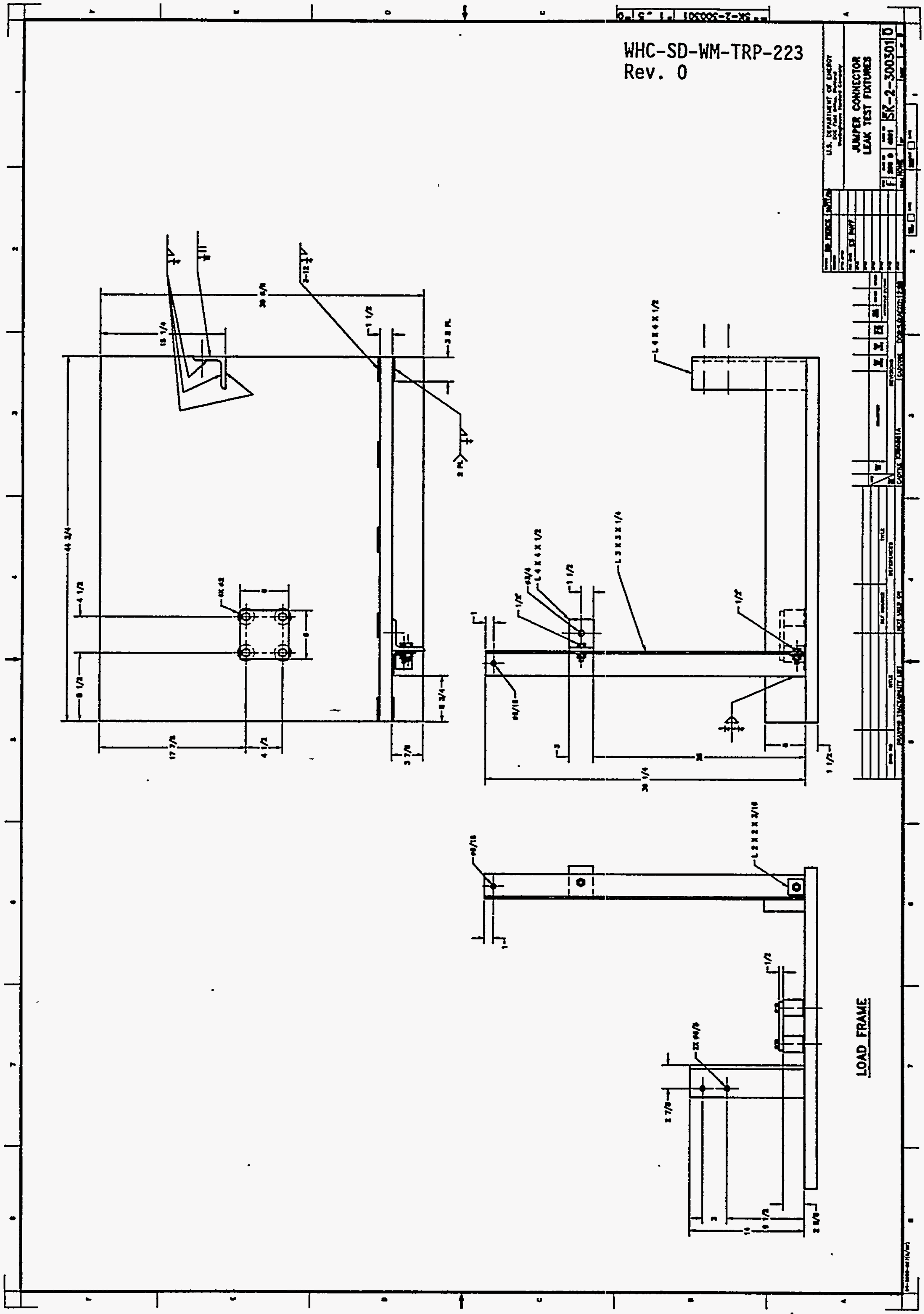
US DEPARTMENT OF ENERGY

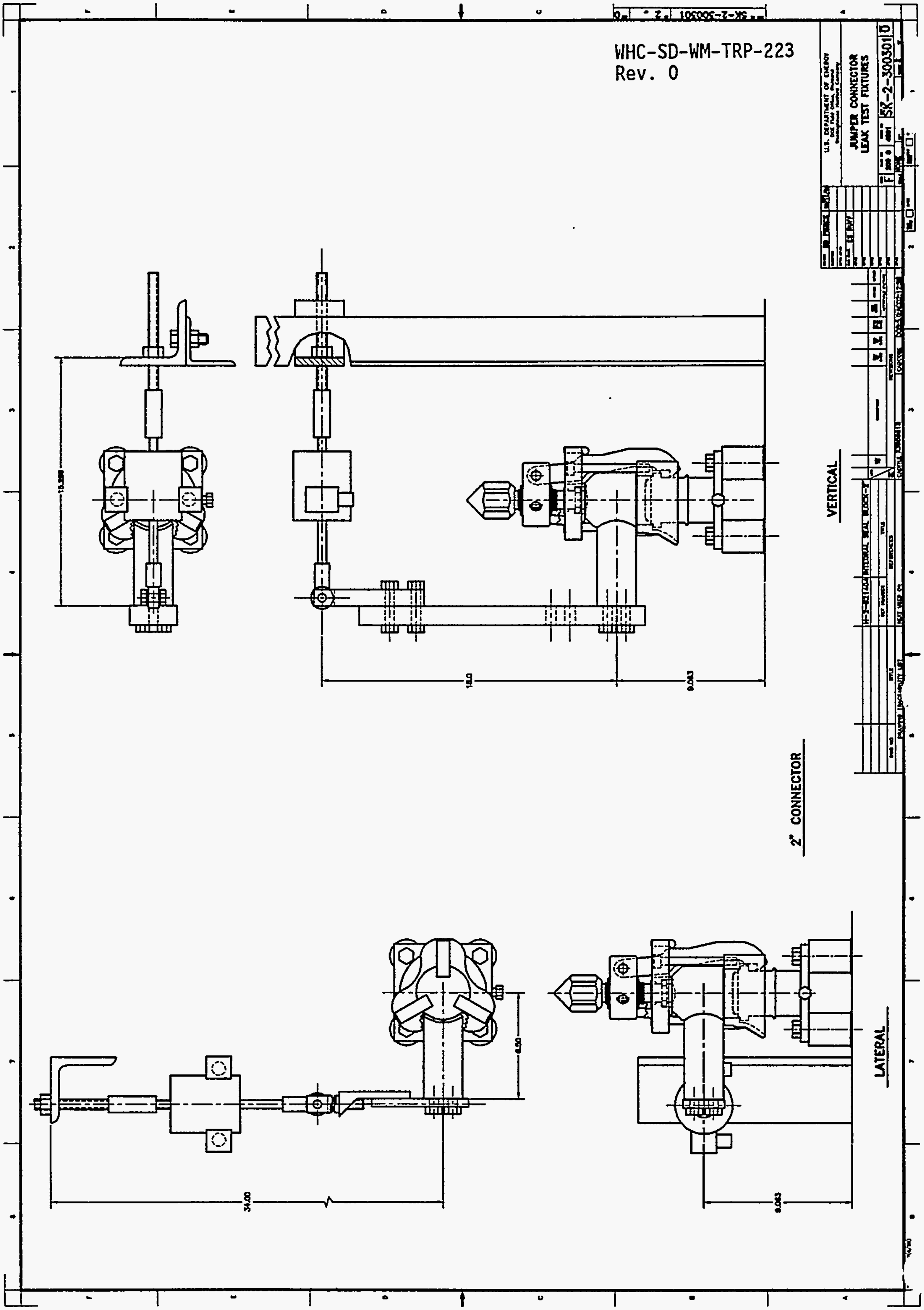
INTEGRAL SEAL BLOCK-
2" 3-WAY
JUMPER CONNECTOR

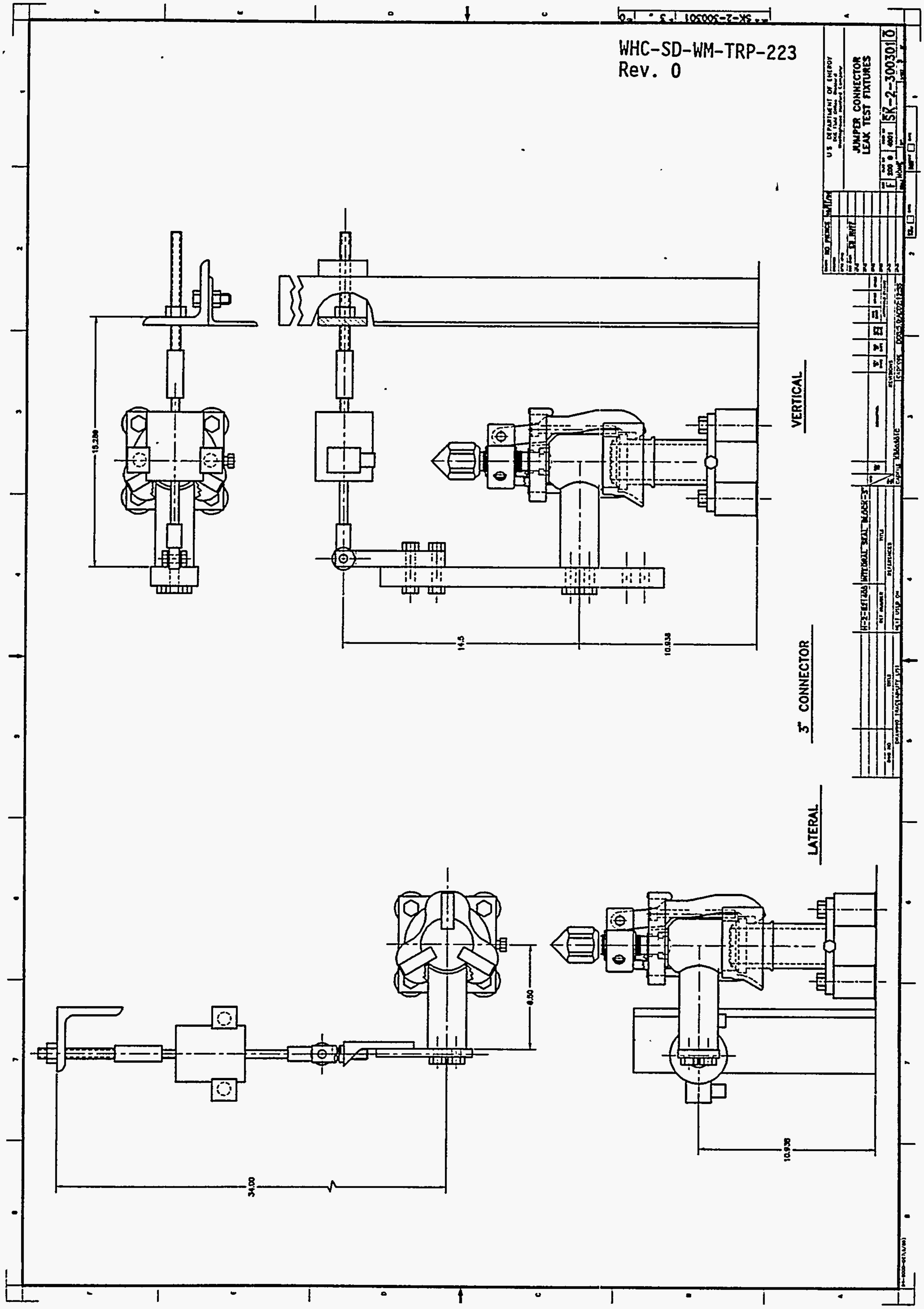
F 2000 4001 H-2-821399 0
FULL 141019 SHEET 1 OF 2

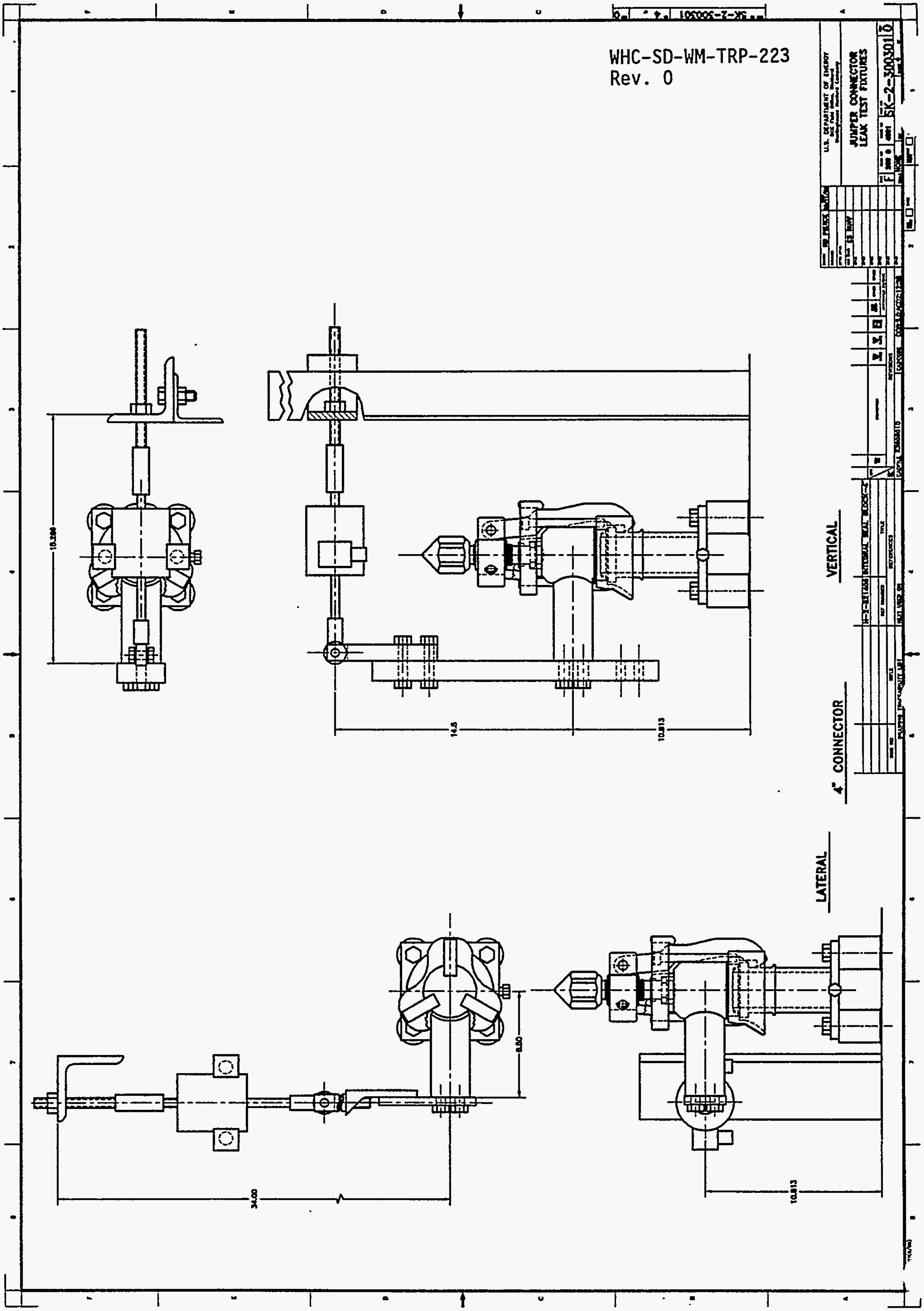

SECTION D-D
16 17 18 19 BLOCK, 2" 3-WAY
FOR PARTS LIST AND GENERAL NOTES SEE SHEET 1.
For Illustration Only
Not to be Used for Fabrication
VIEW E
VIEW F
VIEW G
SECTION C-C
12 13 14 15 BLOCK, 2" 3-WAY, BLANK
INTEGRAL SEAL BLOCK-2" 3-WAY JUMPER CONNECTOR
H-2-821399

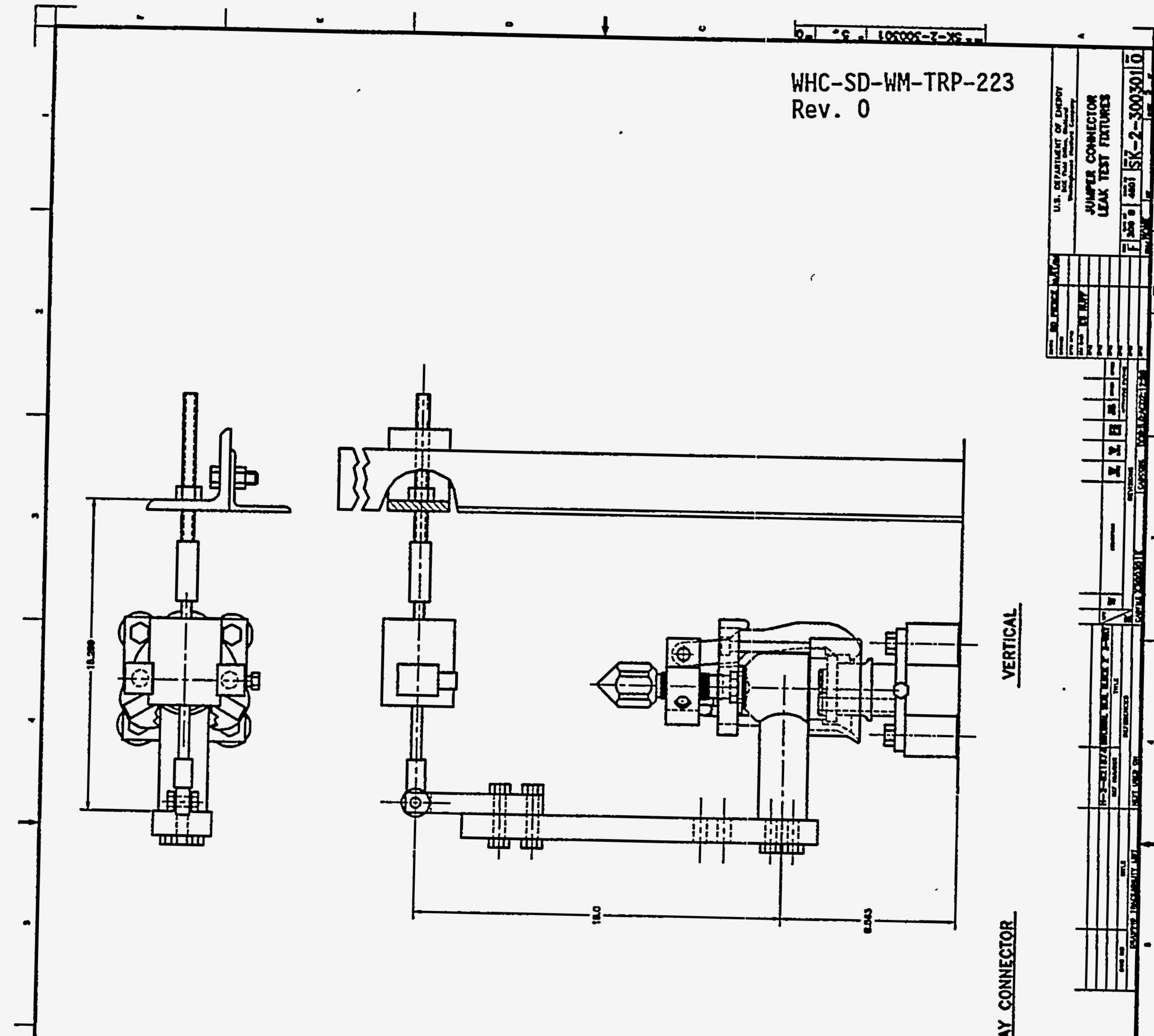
APPENDIX C: DRAWINGS FOR JUMPER CONNECTOR LEAK-TEST FIXTURE


U.S. DEPARTMENT OF ENERGY
JUMPER CONNECTOR
LEAK TEST FIXTURES
SK-2-300301
LOAD FRAME

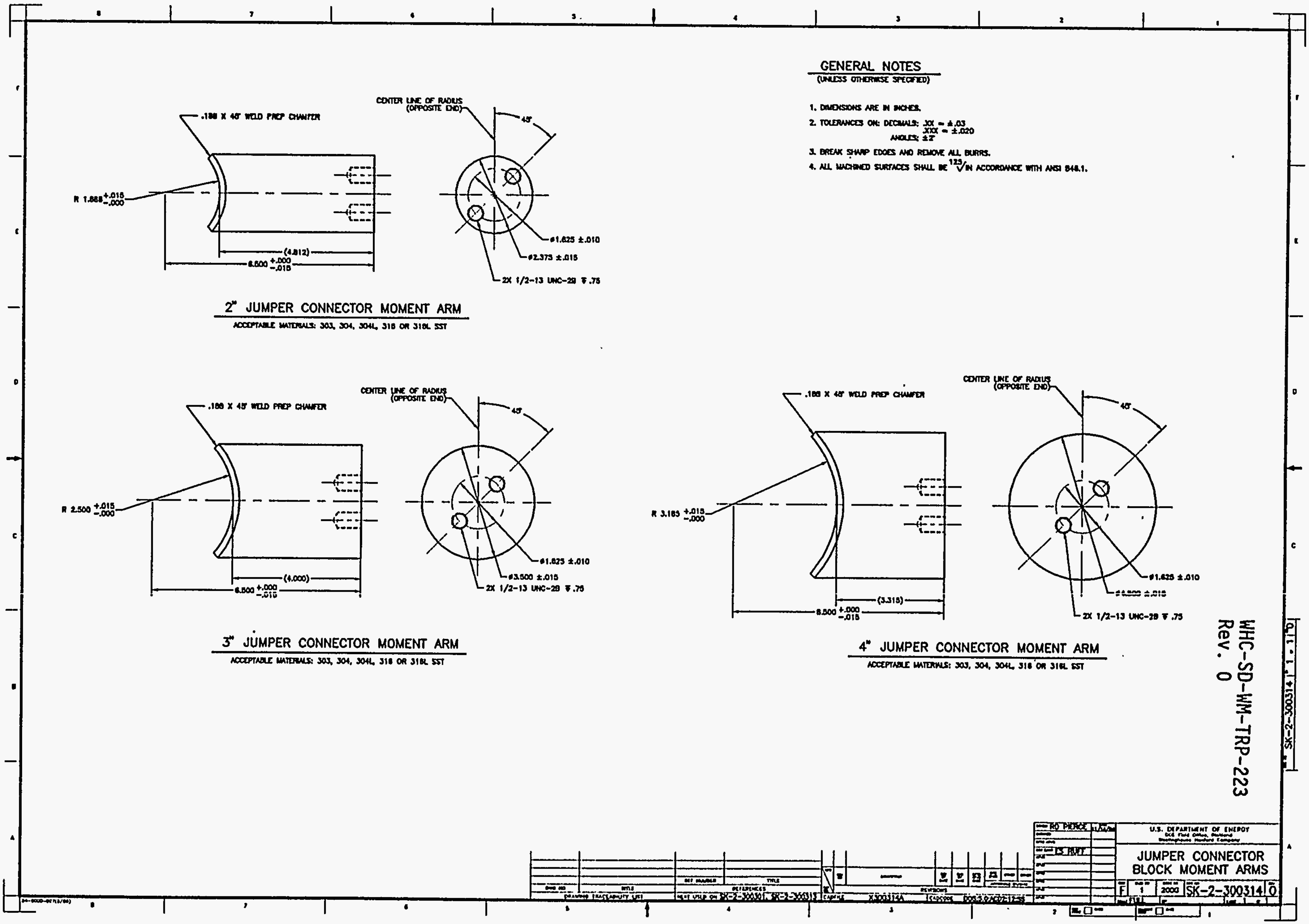

U.S. DEPARTMENT OF ENERGY
JUMPER CONNECTOR
LEAK TEST FIXTURES
SK-2-300501
VERTICAL
2" CONNECTOR
LATERAL
18.0
9.043
34.00
8.50
9.043


VERTICAL
3" CONNECTOR
LATERAL
14.5
10.938
6.50
34.00
10.938
JUMPER CONNECTOR
LEAK TEST FIXTURES
SK-2-300301
US DEPARTMENT OF ENERGY

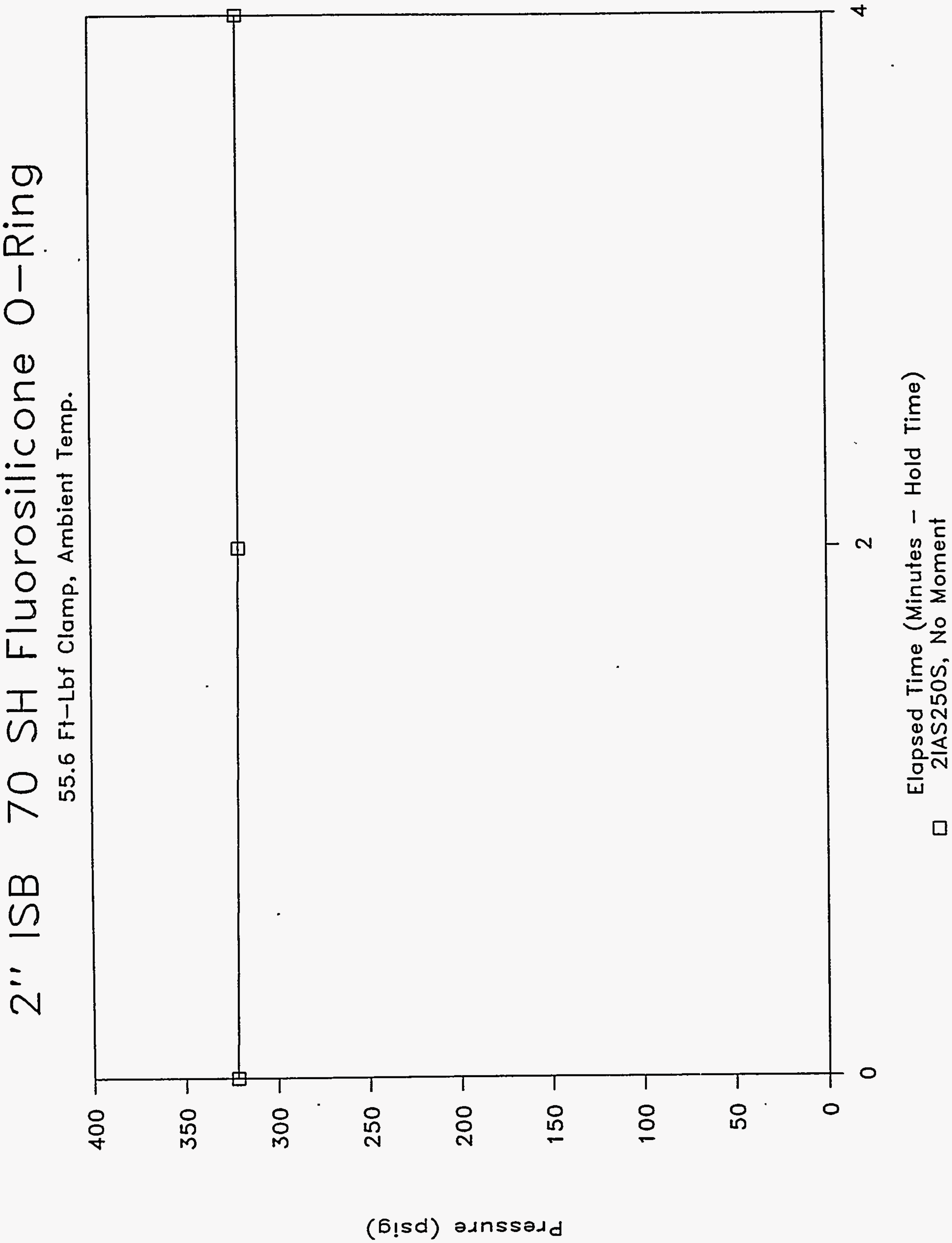

4" CONNECTOR
VERTICAL
LATERAL
JUMPER CONNECTOR
LEAK TEST FIXTURES
U.S. DEPARTMENT OF ENERGY
SK-2-300301
14.5
10.813
34.00
10.813

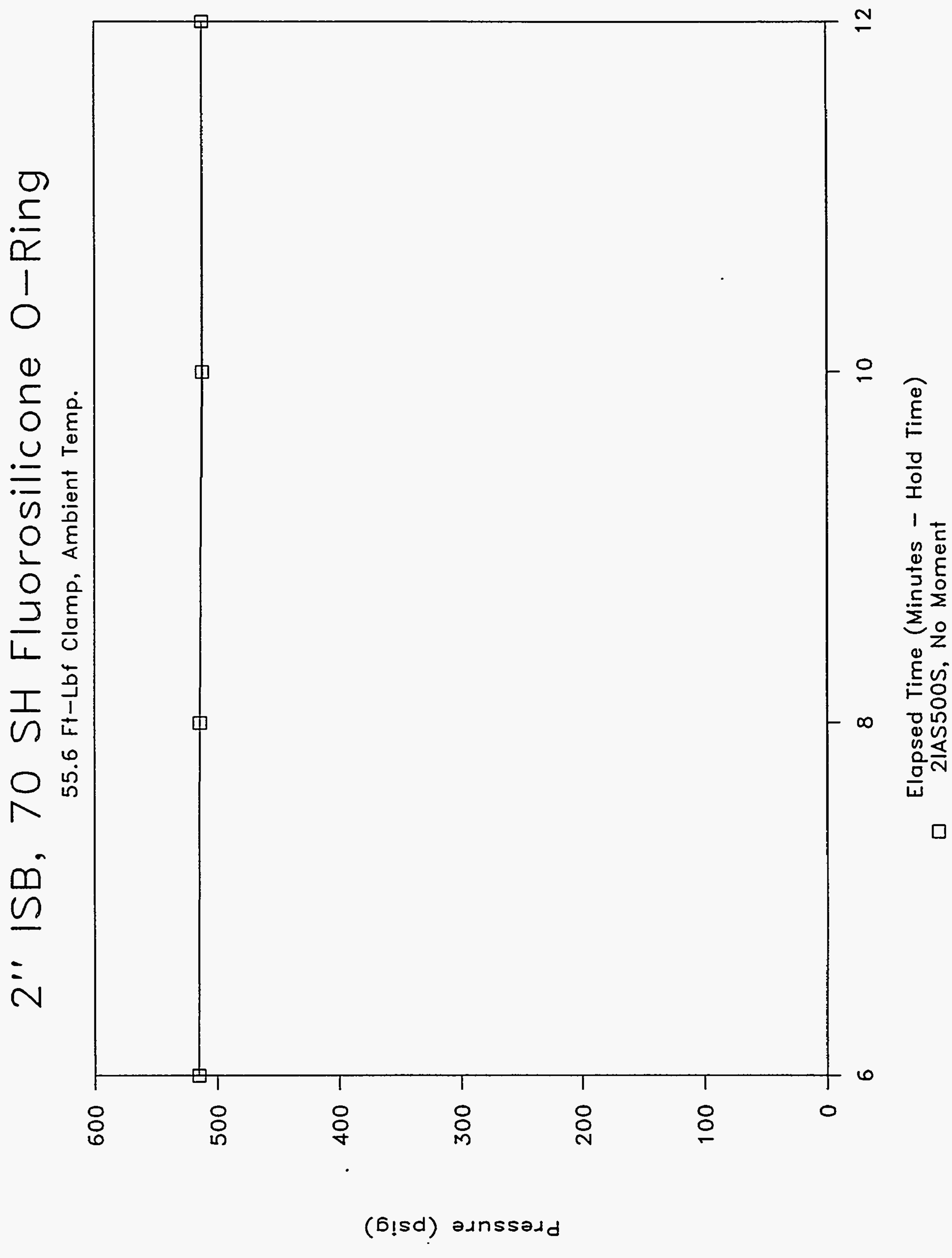

2" 3-WAY CONNECTOR
VERTICAL
LATERAL
JUMPER CONNECTOR
LEAK TEST FIXTURES
U.S. DEPARTMENT OF ENERGY
SK-2-300301
15.0
8.543
34.00
8.543

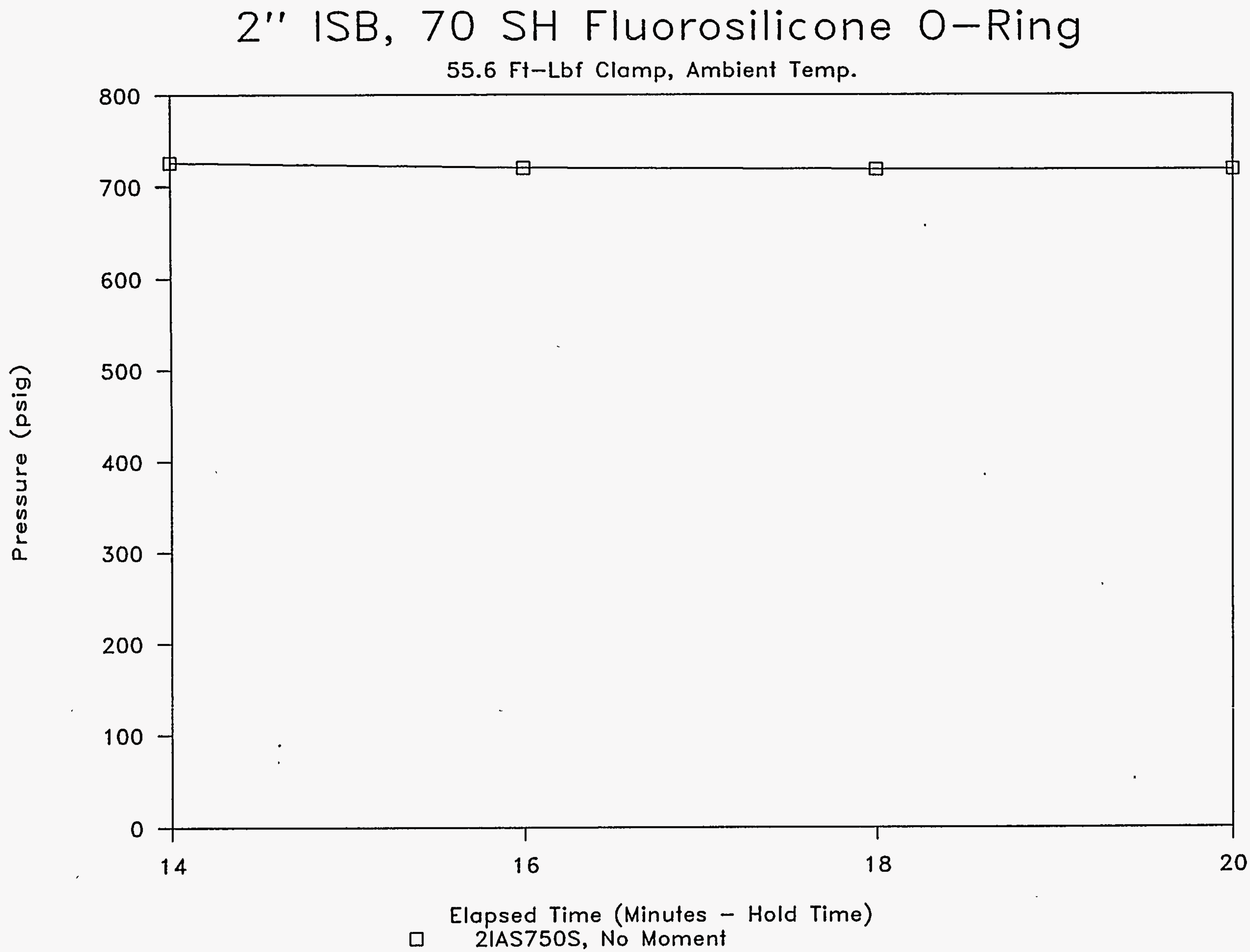
APPENDIX D: DRAWINGS FOR JUMPER CONNECTOR BLOCK MOMENT ARM


GENERAL NOTES
(UNLESS OTHERWISE SPECIFIED)
1. DIMENSIONS ARE IN INCHES.
2. TOLERANCES ON: DECIMALS: .XX = ±.03 .XXX = ±.020 ANGLES: ±2°
3. BREAK SHARP EDGES AND REMOVE ALL BURRS.
4. ALL MACHINED SURFACES SHALL BE 125/ IN ACCORDANCE WITH ANSI B46.1.
.188 X 45° WELD PREP CHAMFER
CENTER LINE OF RADIUS (OPPOSITE END)
45°
R 1.688 +.015 -.000
(4.812)
6.500 +.000 -.015
ø1.625 ±.010
ø2.375 ±.015
2X 1/2-13 UNC-2B ∓ .75
2" JUMPER CONNECTOR MOMENT ARM
ACCEPTABLE MATERIALS: 303, 304, 304L, 316 OR 316L SST
R 2.500 +.015 -.000
(4.000)
ø3.500 ±.015
3" JUMPER CONNECTOR MOMENT ARM
ACCEPTABLE MATERIALS: 303, 304, 304L, 316 OR 316L SST
R 3.185 +.015 -.000
(3.315)
4" JUMPER CONNECTOR MOMENT ARM
ACCEPTABLE MATERIALS: 303, 304, 304L, 316 OR 316L SST
U.S. DEPARTMENT OF ENERGY
JUMPER CONNECTOR BLOCK MOMENT ARMS
SK-2-300314
NEXT USED ON SK-2-300301, SK-2-300313
X300314A
DRAWING TRACEABILITY LIST
REFERENCES
REVISIONS

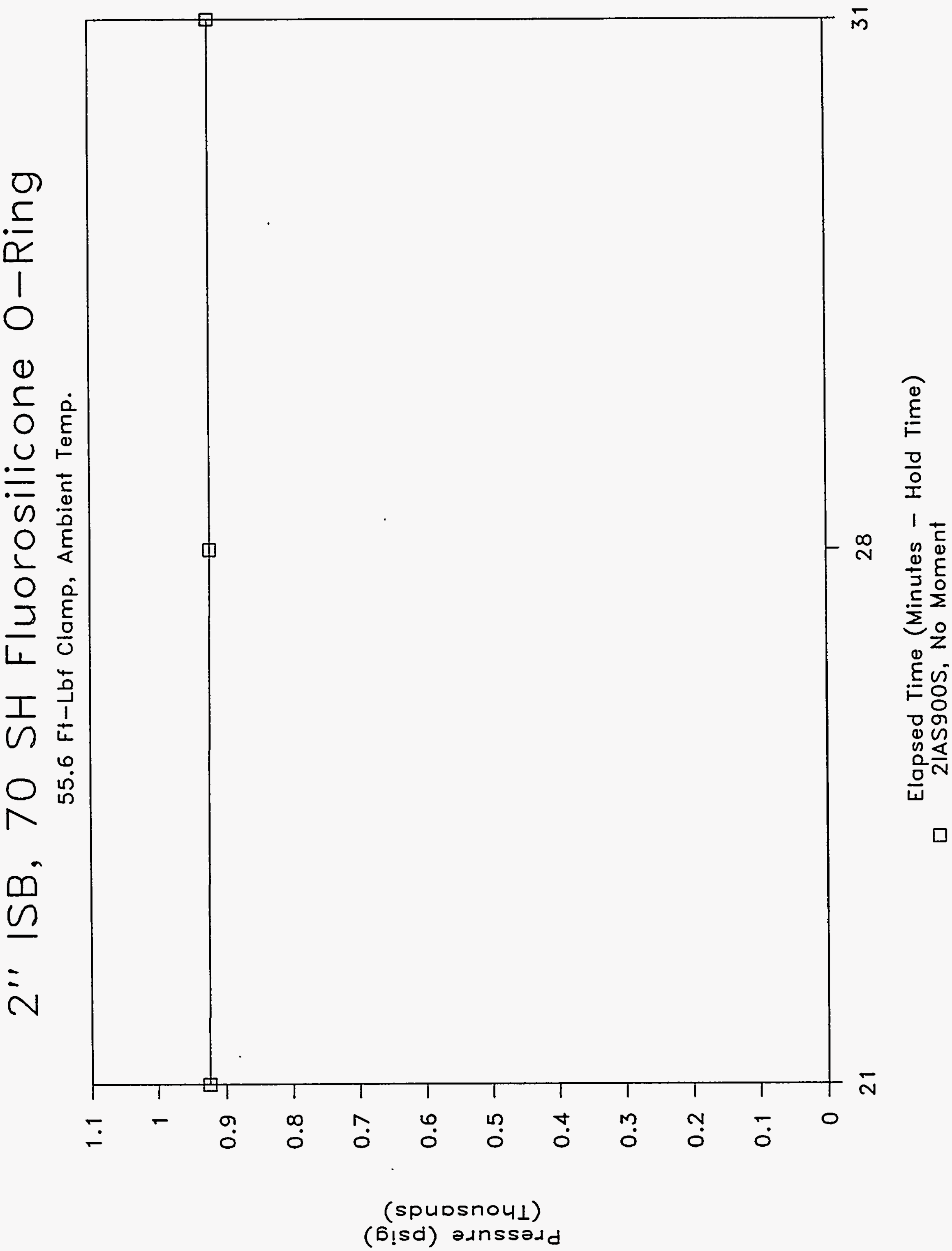
APPENDIX E: GRAPHS OF 2-IN. FLUROSILICONE TESTS


2" ISB 70 SH Fluorosilicone O-Ring
55.6 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
0
50
100
150
200
250
300
350
400
0
2
4
Elapsed Time (Minutes - Hold Time)
2IAS250S, No Moment


2'' ISB, 70 SH Fluorosilicone O-Ring
55.6 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
600
500
400
300
200
100
0
6
8
10
12
Elapsed Time (Minutes - Hold Time)
2IAS500S, No Moment



2" ISB, 70 SH Fluorosilicone O-Ring
55.6 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
800
700
600
500
400
300
200
100
0
14
16
18
20
Elapsed Time (Minutes - Hold Time)
2IAS750S, No Moment


2" ISB, 70 SH Fluorosilicone O-Ring
55.6 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
21
28
31
Elapsed Time (Minutes - Hold Time)
2IAS900S, No Moment

JUNE 23, 1994
2" ISB CONNECTOR, FLUOROSILICONE O-RING, 70 DUROMETER, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - NO MOMENT APPLIED
CLAMPING TORQUE = 55.6 FT-LBF GRAPH NAME = 2IAS250S
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	APPLIED FORCE LBS INPUT
322	0	0	0.00	0
320	2	10	2.17	0
320	4	30	4.50	0

INCREASED PRESSURE TO 500 PSIG. GRAPH NAME = 2IAS500S

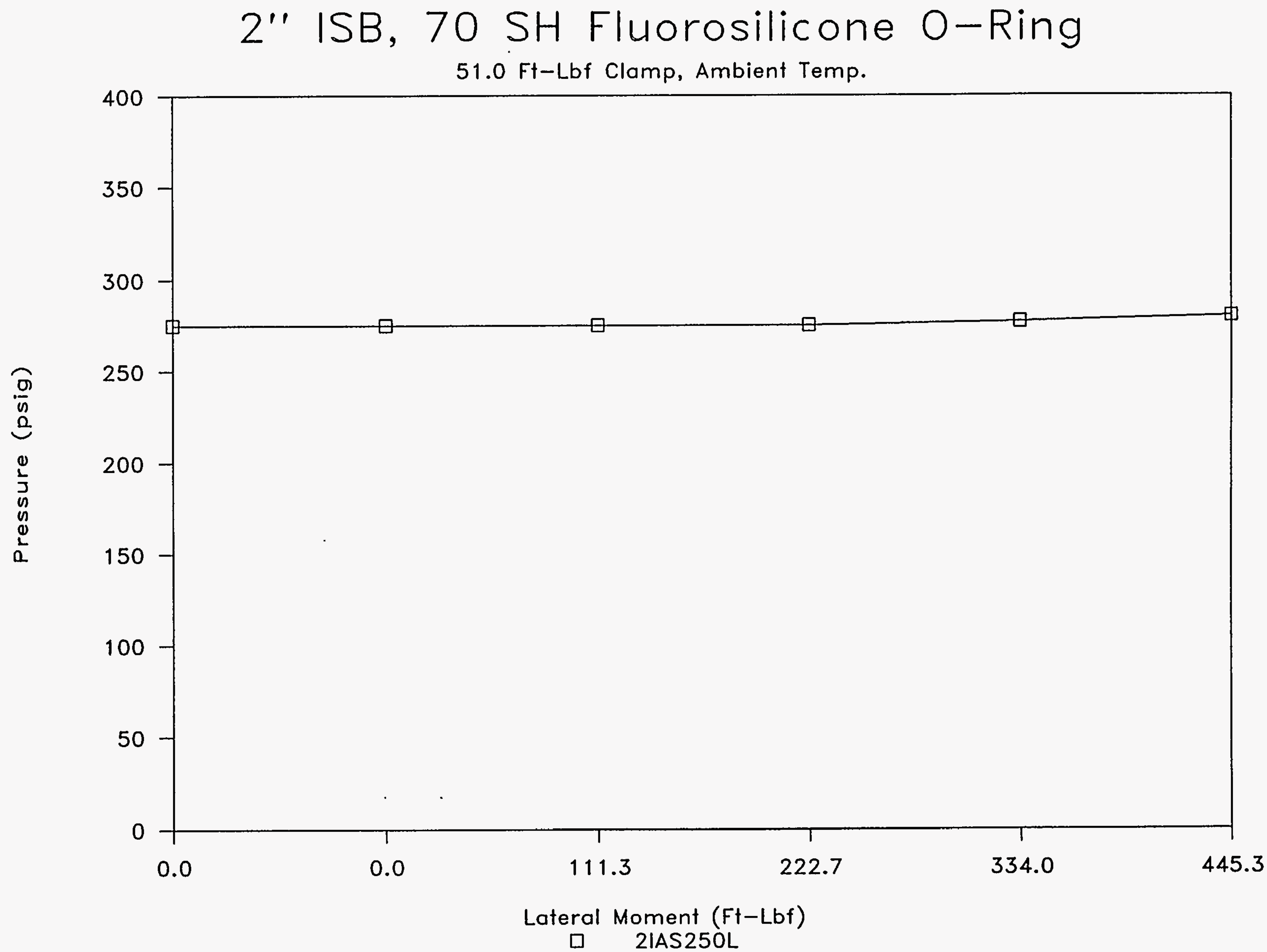
515	6	35	6.58	0
514	8	18	8.30	0
512	10	28	10.47	0
512	12	30	12.50	0

INCREASED PRESSURE TO 750 PSIG. GRAPH NAME = 2IAS750S

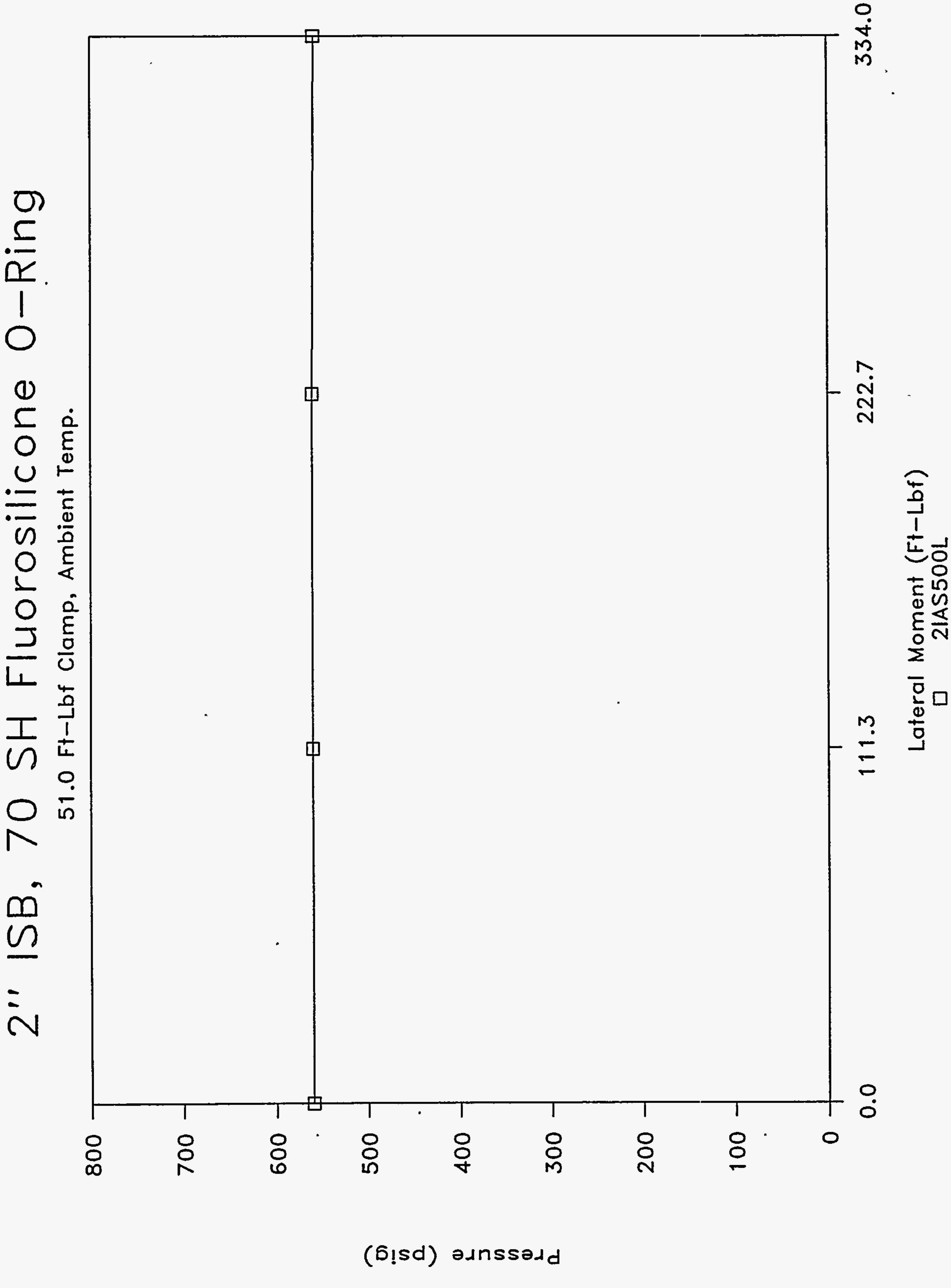
726	14	25	14.42	0
720	16	27	16.45	0
718	18	25	18.42	0
718	20	26	20.43	0

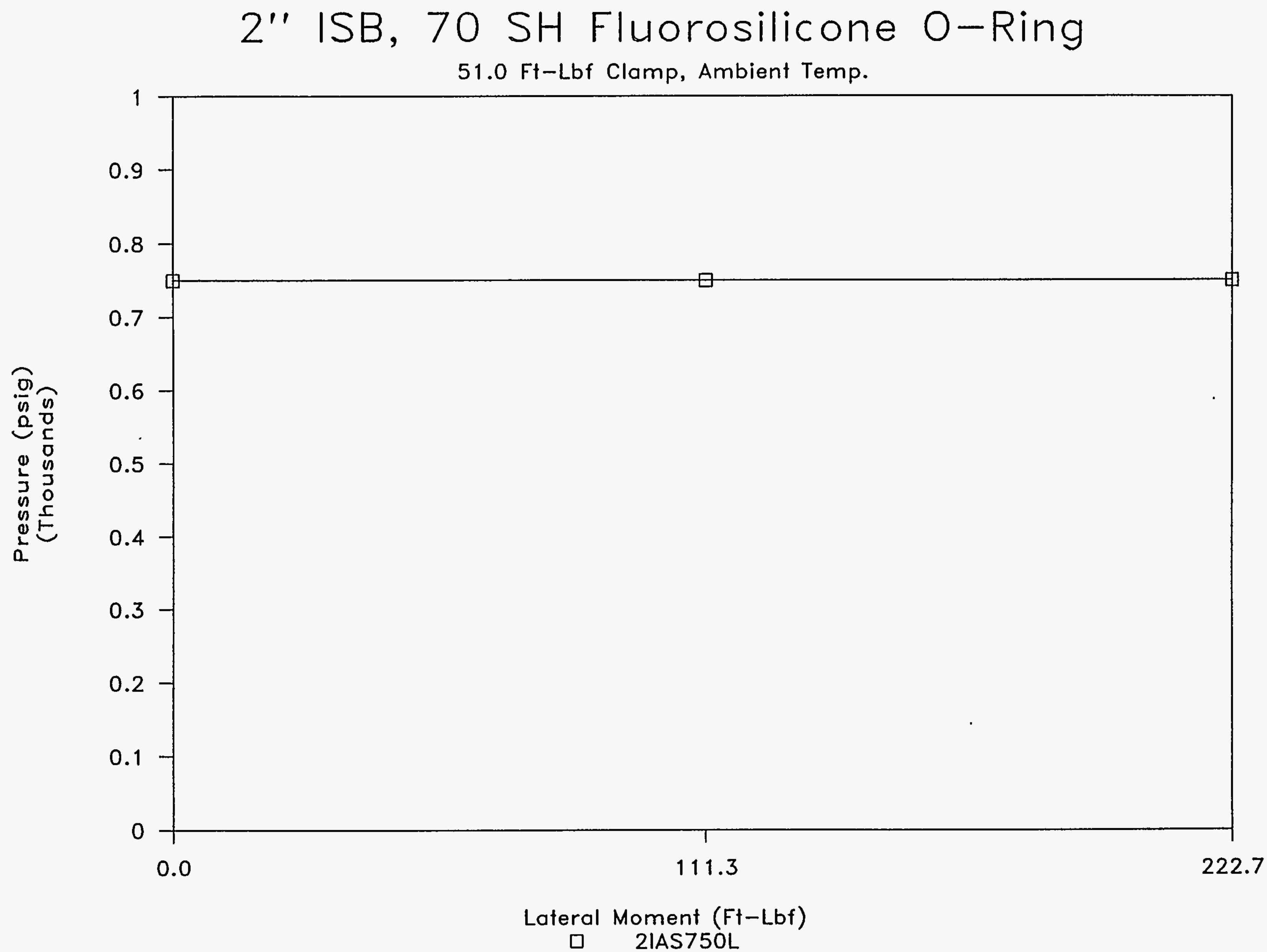
INCREASED PRESSURE TO 900 PSIG. GRAPH NAME = 2IAS900S

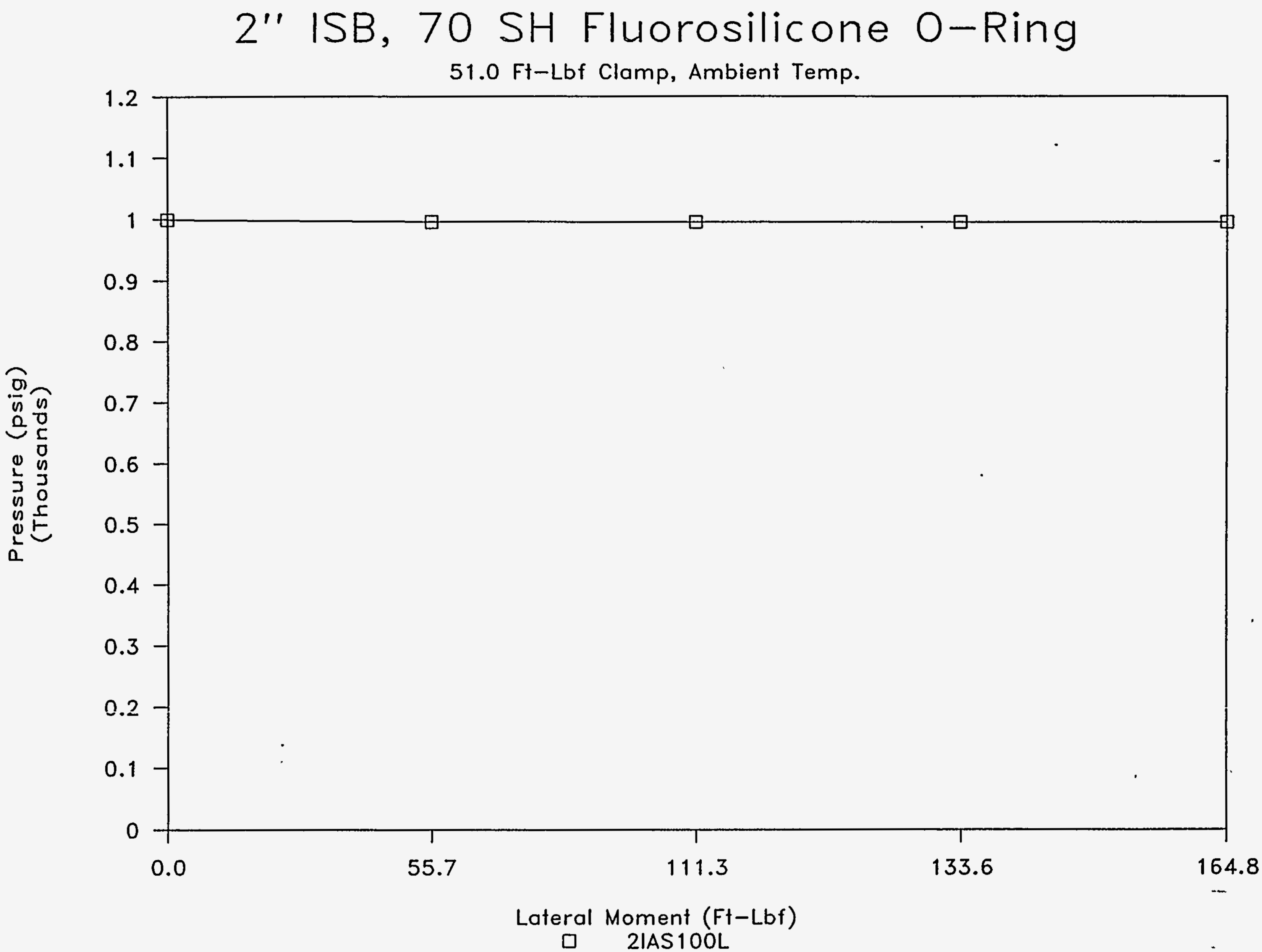
925	21	56	21.93	0
922	28	50	28.83	0
922	31	37	31.62	0



2" ISB, 70 SH Fluorosilicone O-Ring
51.0 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
400
350
300
250
200
150
100
50
0
0.0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
2IAS250L


2'' ISB, 70 SH Fluorosilicone O-Ring
51.0 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
0
100
200
300
400
500
600
700
800
Lateral Moment (Ft-Lbf)
0.0
111.3
222.7
334.0
2IAS500L

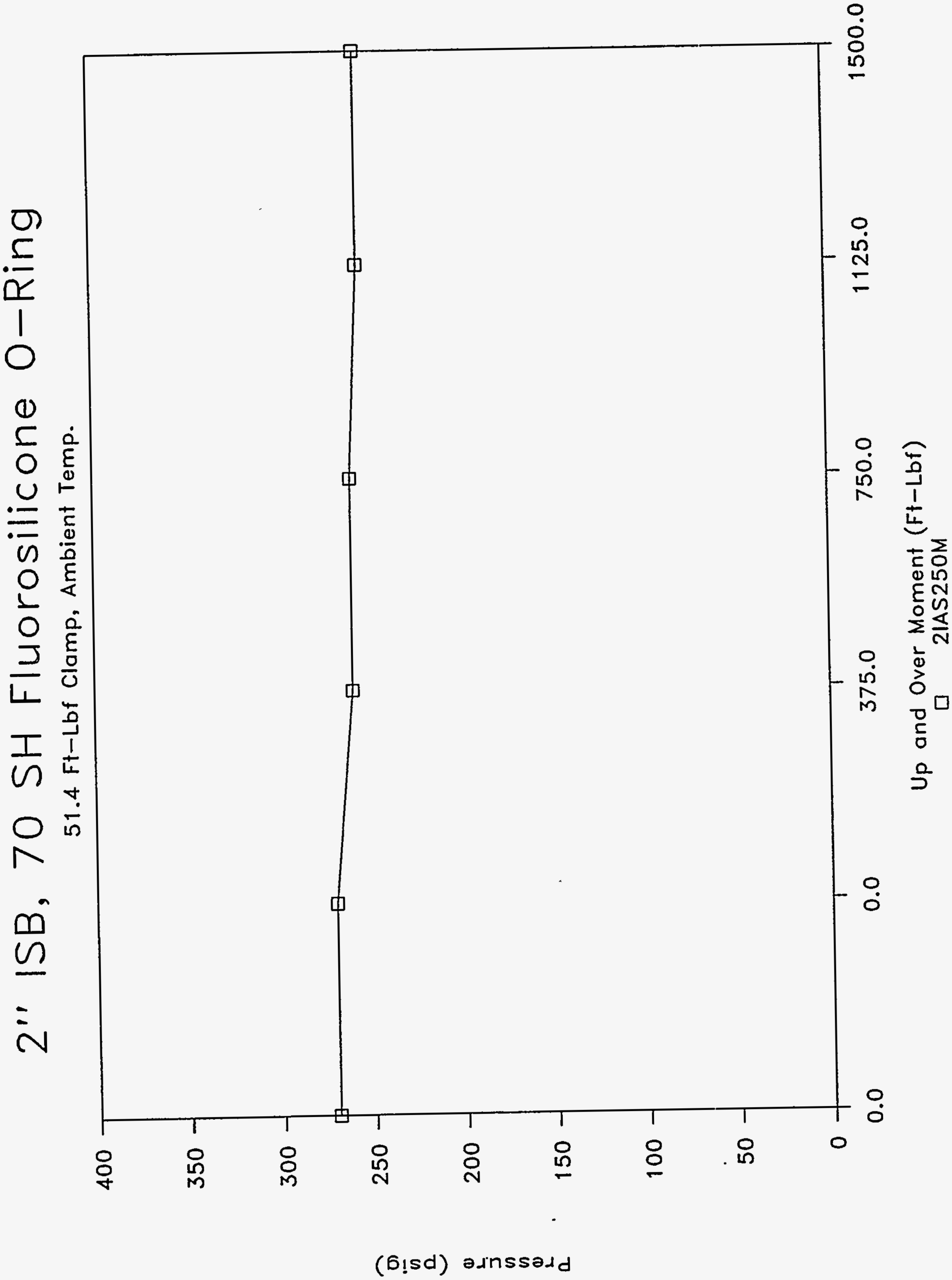

2" ISB, 70 SH Fluorosilicone O-Ring
51.0 Ft-Lbf Clamp, Ambient Temp.
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Pressure (psig)
(Thousands)
0.0
111.3
222.7
Lateral Moment (Ft-Lbf)
2IAS750L

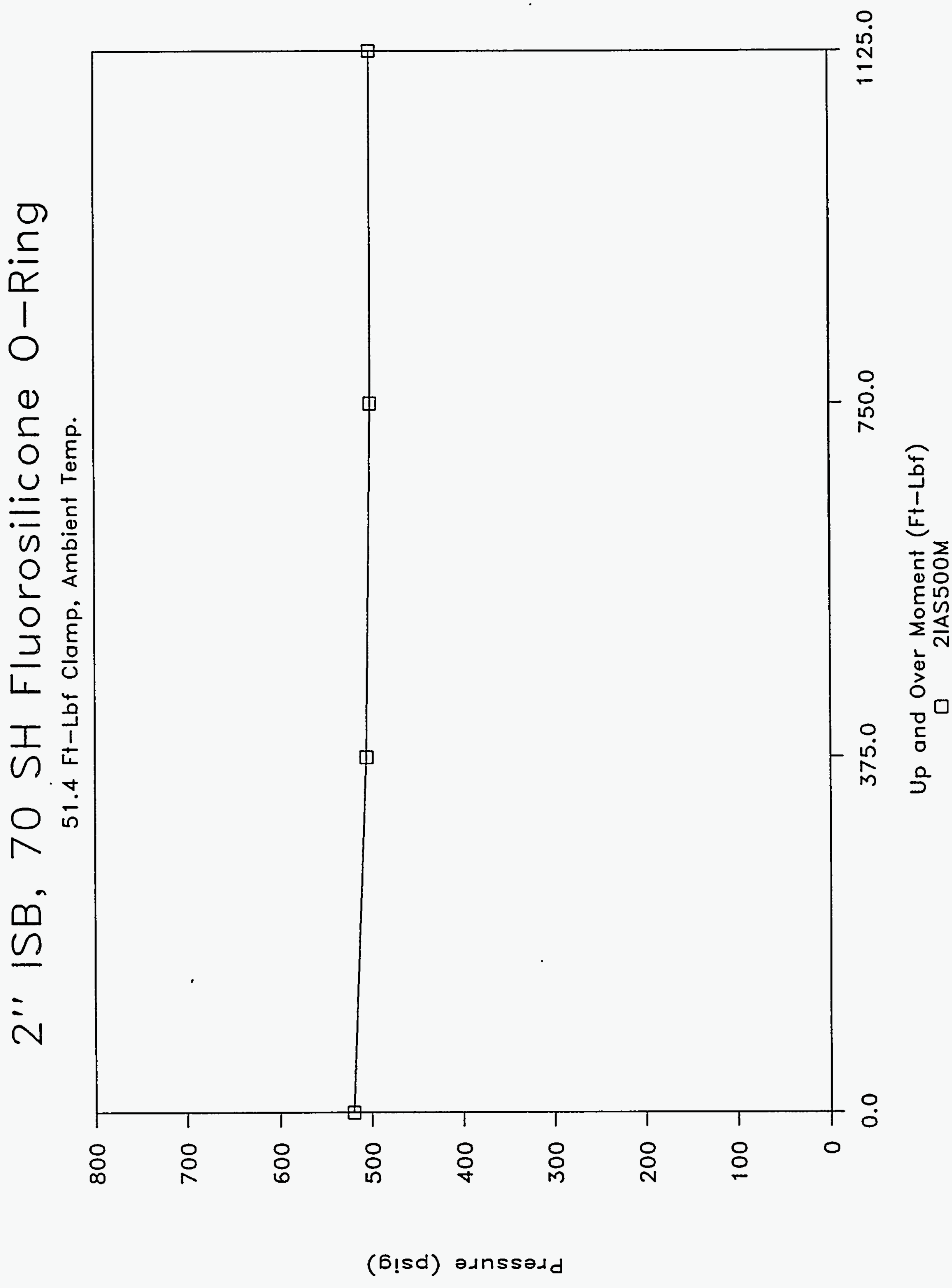


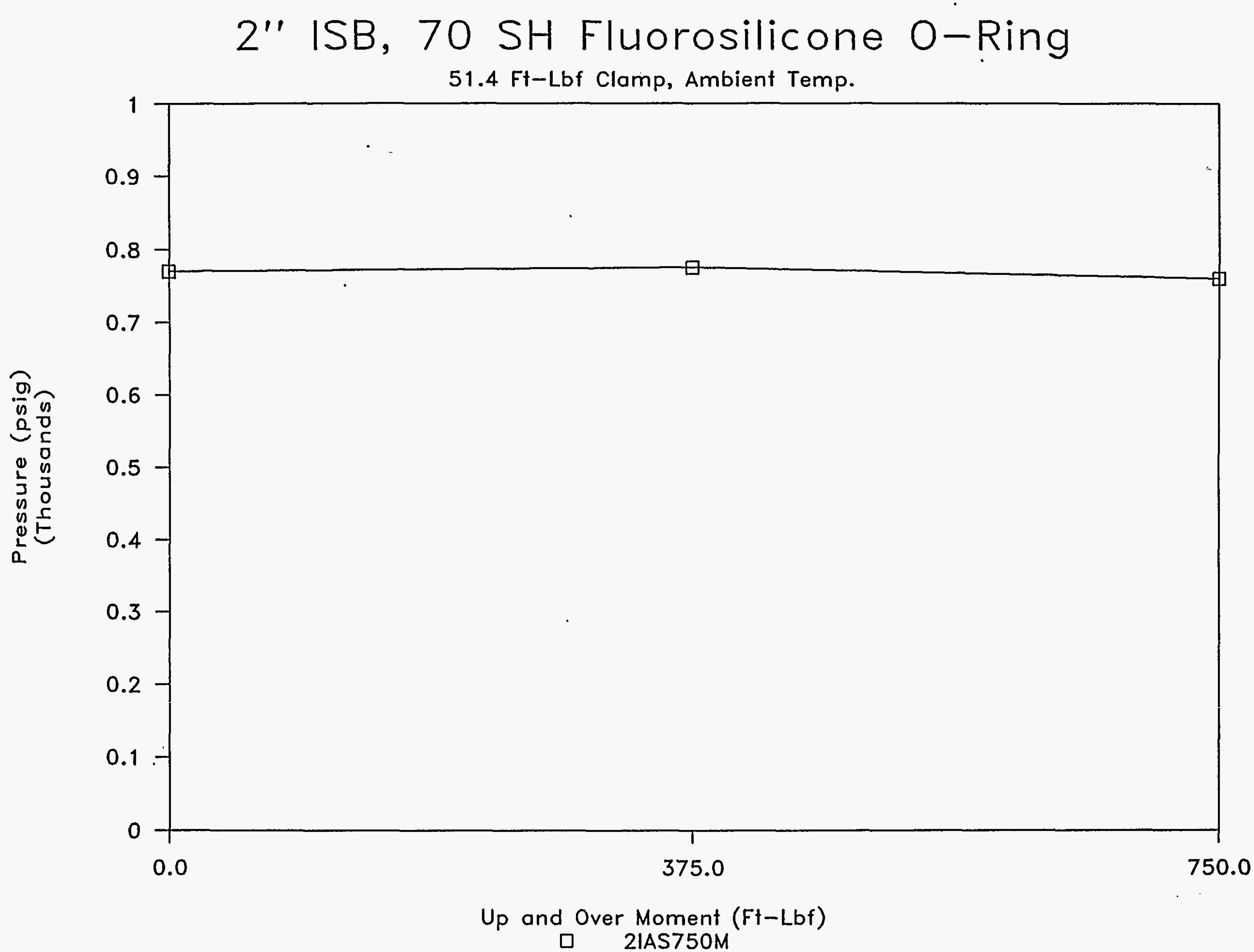
2" ISB, 70 SH Fluorosilicone O-Ring
51.0 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig) (Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
55.7
111.3
133.6
164.8
Lateral Moment (Ft-Lbf)
2IAS100L

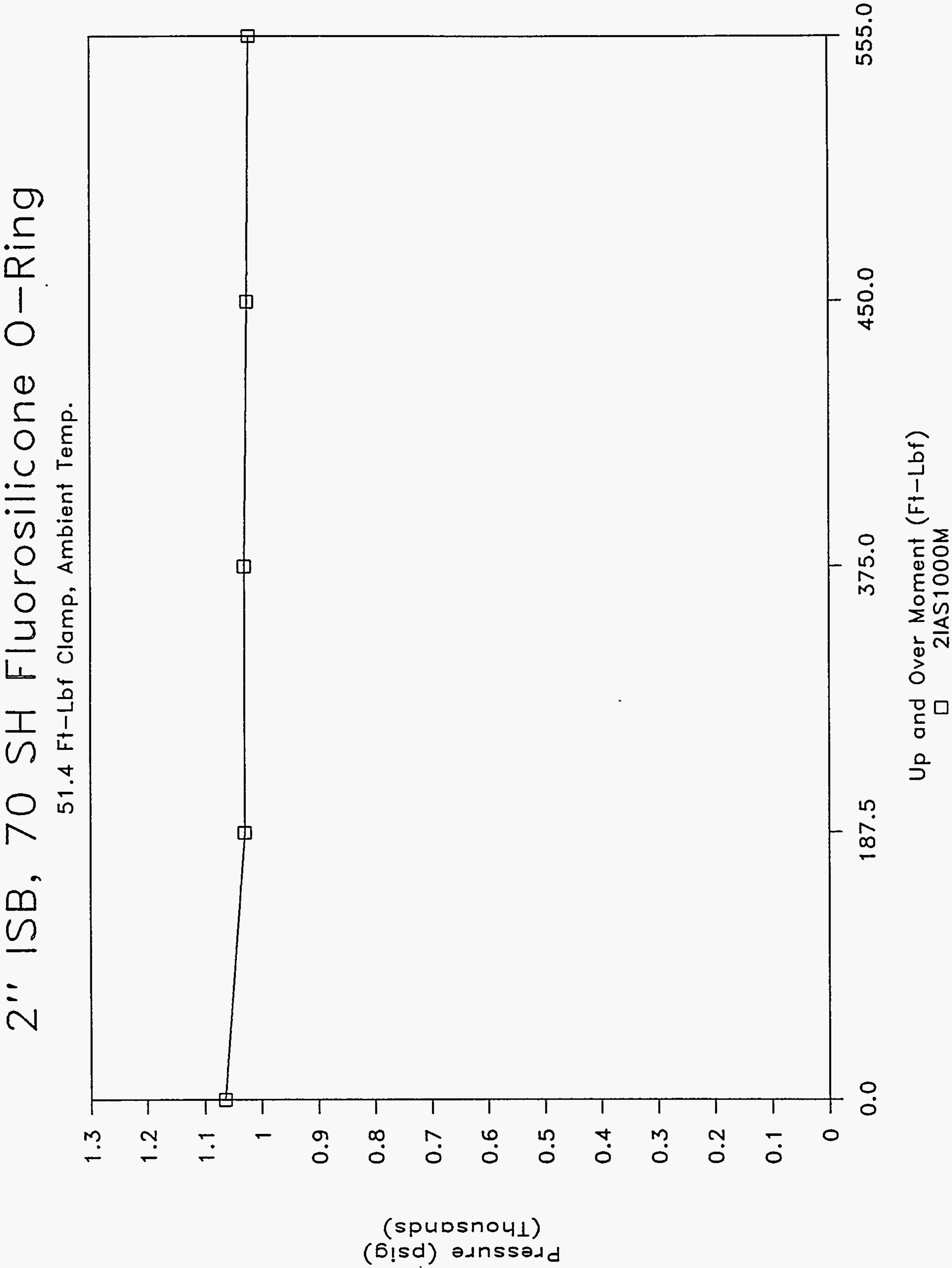
AUGUST 02, 1994
2" ISB CONNECTOR, 70 SH FLUOROSILICONE O-RING, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 51.0 FT-LBF GRAPH NAME = 2IAS250L
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
275	0	0	0.00	0	0.4453	0.0
275	2	2	2.03	0	0.4453	0.0
275	4	3	4.05	250	0.4453	111.3
275	6	3	6.05	500	0.4453	222.7
277	8	2	8.03	750	0.4453	334.0
280	10	10	10.17	1000	0.4453	445.3
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = 2IAS500L		
560	12	3	12.05	0	0.4453	0.0
560	14	2	14.03	250	0.4453	111.3
560	16	2	16.03	500	0.4453	222.7
558	18	1	18.02	750	0.4453	334.0
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = 2IAS750L		
750	20	2	20.03	0	0.4453	0.0
750	22	2	22.03	250	0.4453	111.3
750	24	2	24.03	500	0.4453	222.7
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = 2IAS100L		
1000	26	3	26.05	0	0.4453	0.0
996	28	7	28.12	125	0.4453	55.7
995	30	1	30.02	250	0.4453	111.3
995	32	2	32.03	300	0.4453	133.6
995	34	3	34.05	370	0.4453	164.8


2" ISB, 70 SH Fluorosilicone O-Ring
51.4 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
400
350
300
250
200
150
100
50
0
0.0
0.0
375.0
750.0
1125.0
1500.0
Up and Over Moment (Ft-Lbf)
2IAS250M

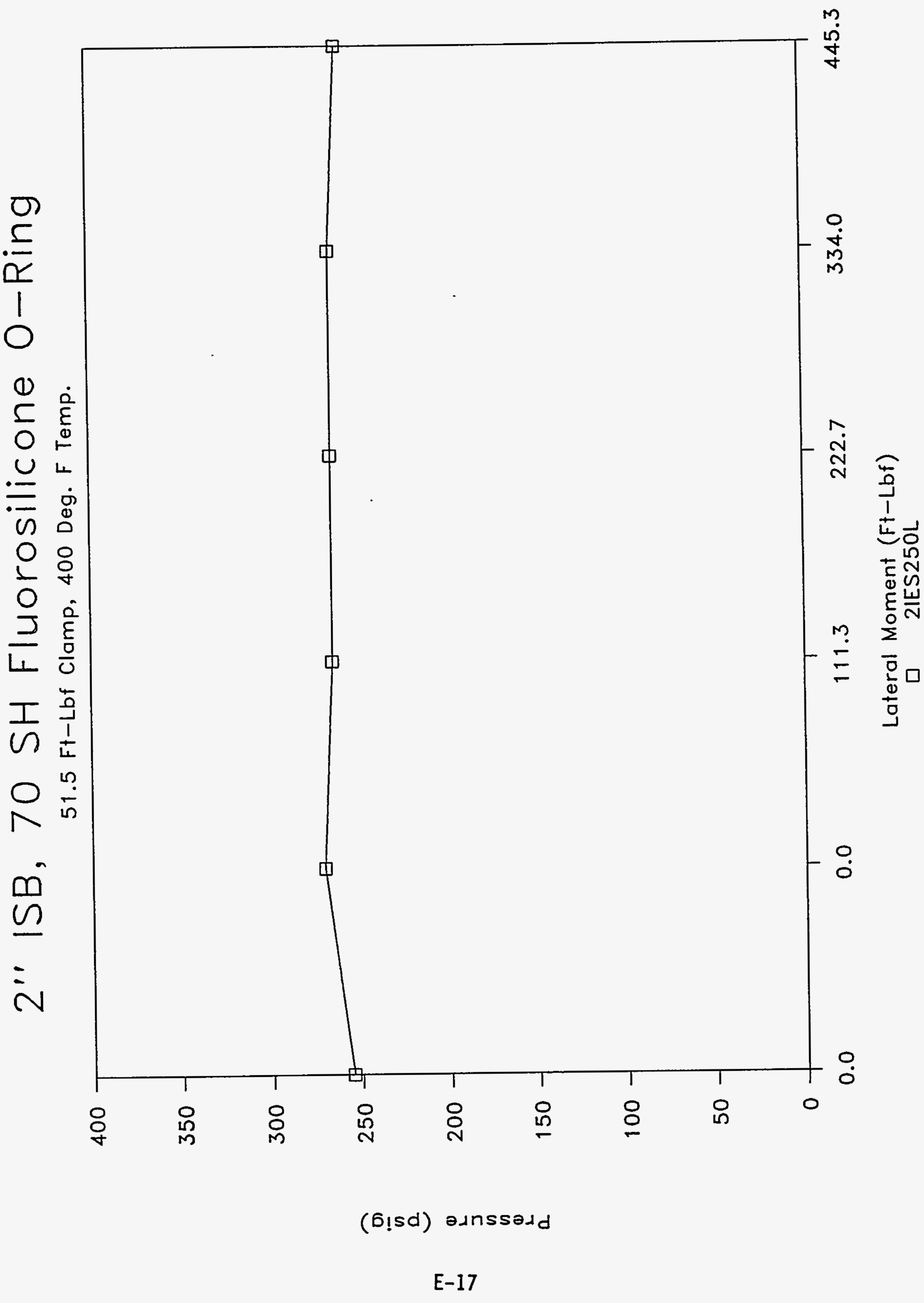

2" ISB, 70 SH Fluorosilicone O-Ring
51.4 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
0
100
200
300
400
500
600
700
800
0.0
375.0
750.0
1125.0
Up and Over Moment (Ft-Lbf)
2IAS500M


2" ISB, 70 SH Fluorosilicone O-Ring
51.4 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
375.0
750.0
Up and Over Moment (Ft-Lbf)
2IAS750M


2" ISB, 70 SH Fluorosilicone O—Ring
51.4 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
187.5
375.0
450.0
555.0
Up and Over Moment (Ft-Lbf)
2IAS1000M

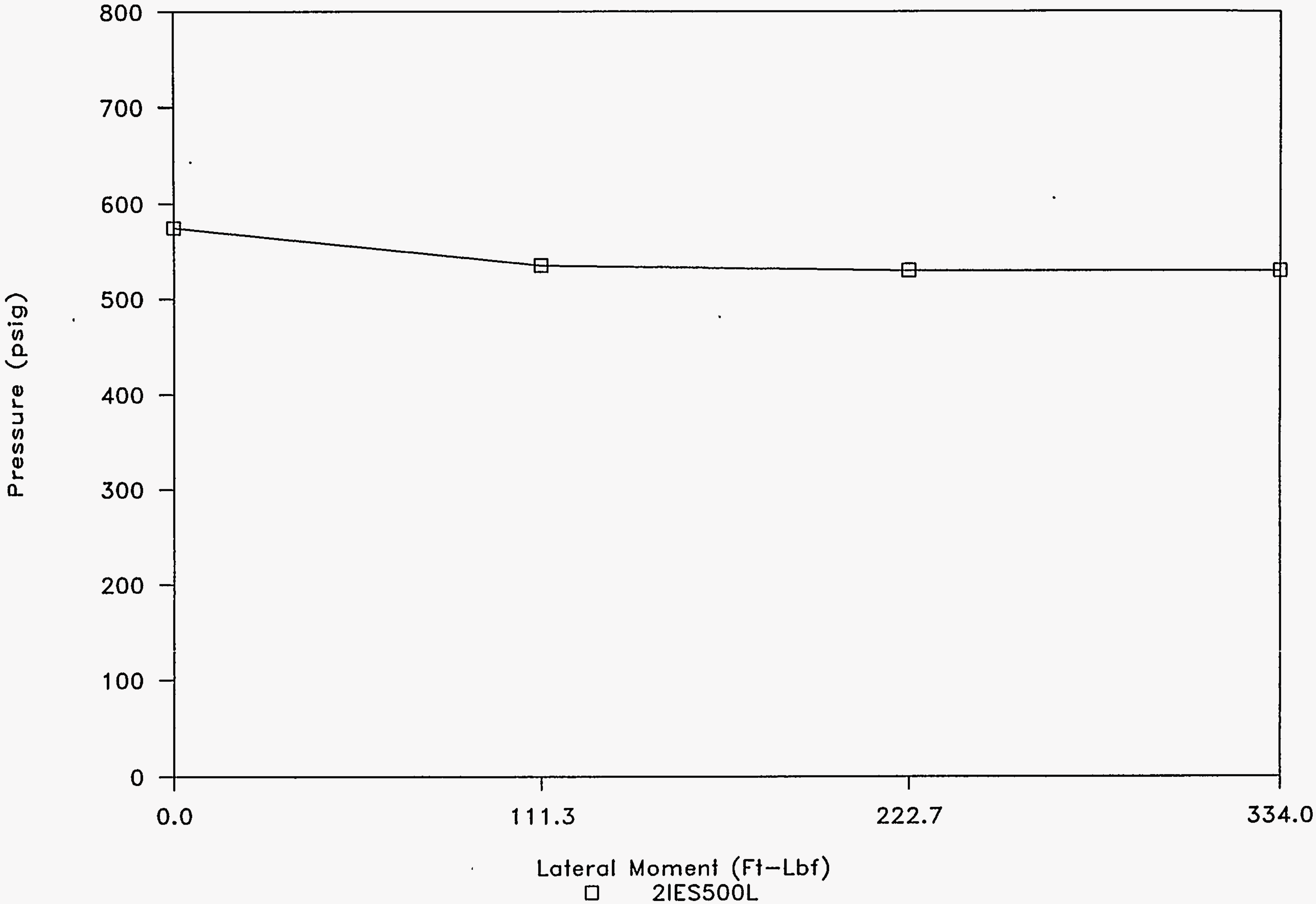
AUGUST 03, 1994
2" ISB CONNECTOR, 70 SH FLUOROSILICONE O-RING, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 51.4 FT-LBF GRAPH NAME = 2IAS250M
CHARGE PRESSURE = 250 PSIG

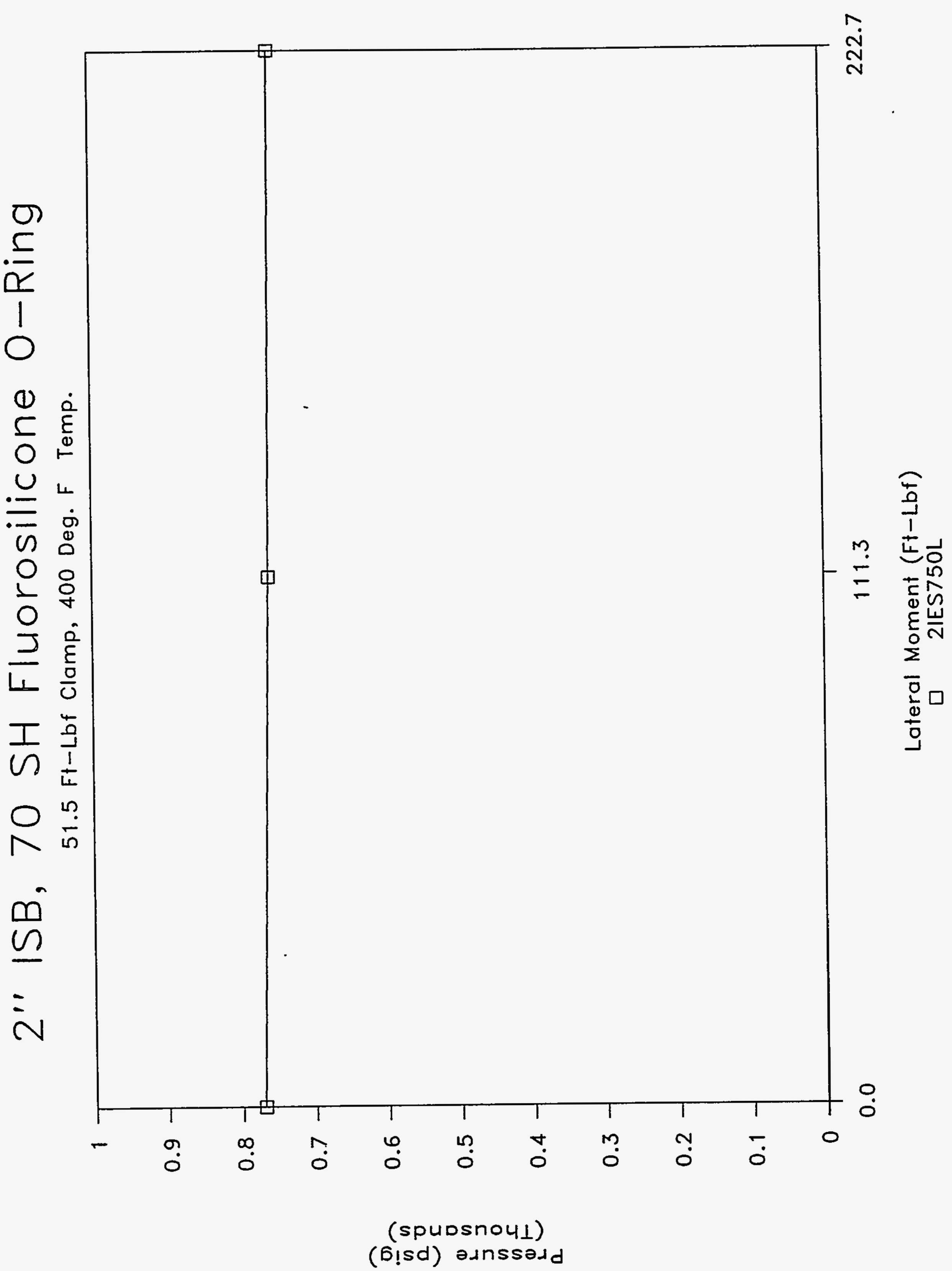
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
270	0	0	0.00	0	1.5000	0.0
270	2	4	2.07	0	1.5000	0.0
260	4	10	4.17	250	1.5000	375.0
260	6	11	6.18	500	1.5000	750.0
255	8	4	8.07	750	1.5000	1125.0
255	10	9	10.15	1000	1.5000	1500.0
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = 2IAS500M		
520	12	6	12.10	0	1.5000	0.0
505	14	9	14.15	250	1.5000	375.0
500	16	2	16.03	500	1.5000	750.0
500	18	6	18.10	750	1.5000	1125.0
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = 2IAS750M		
770	20	2	20.03	0	1.5000	0.0
775	22	13	22.22	250	1.5000	375.0
760	24	6	24.10	500	1.5000	750.0
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = 2IAS1000M		
1065	26	3	26.05	0	1.5000	0.0
1030	28	1	28.02	125	1.5000	187.5
1030	30	5	30.08	250	1.5000	375.0
1025	32	3	32.05	300	1.5000	450.0
1020	34	5	34.08	370	1.5000	555.0


2" ISB, 70 SH Fluorosilicone O-Ring
51.5 Ft-Lbf Clamp, 400 Deg. F Temp.
Pressure (psig)
0
50
100
150
200
250
300
350
400
0.0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
2IES250L

2" ISB, 70 SH Fluorosilicone O-Ring

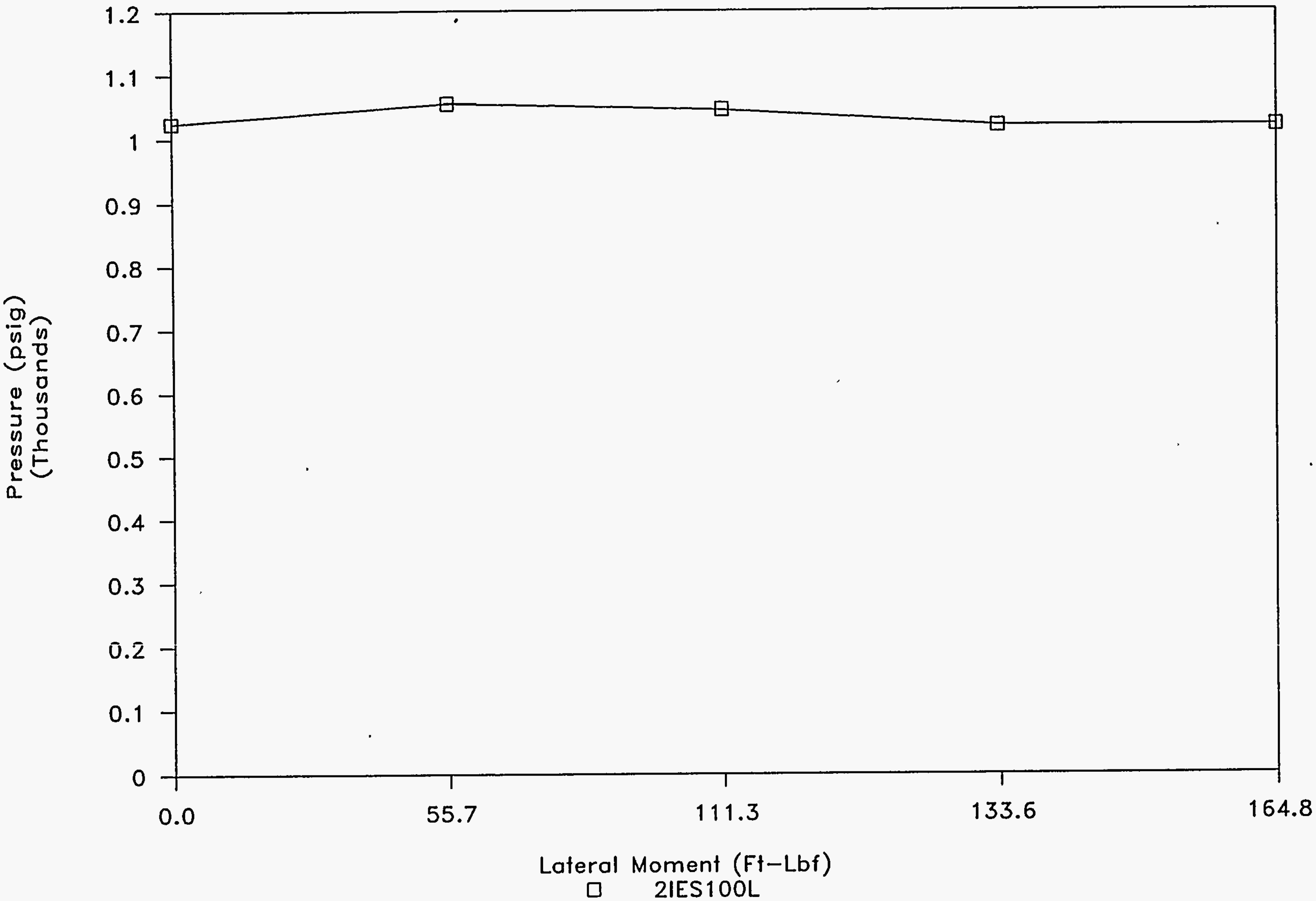
51.5 Ft-Lbf Clamp, 400 Deg. F Temp.




2" ISB, 70 SH Fluorosilicone O-Ring
51.5 Ft-Lbf Clamp, 400 Deg. F Temp.
Pressure (psig)
(Thousands)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0.0
111.3
222.7
Lateral Moment (Ft-Lbf)
2IES750L

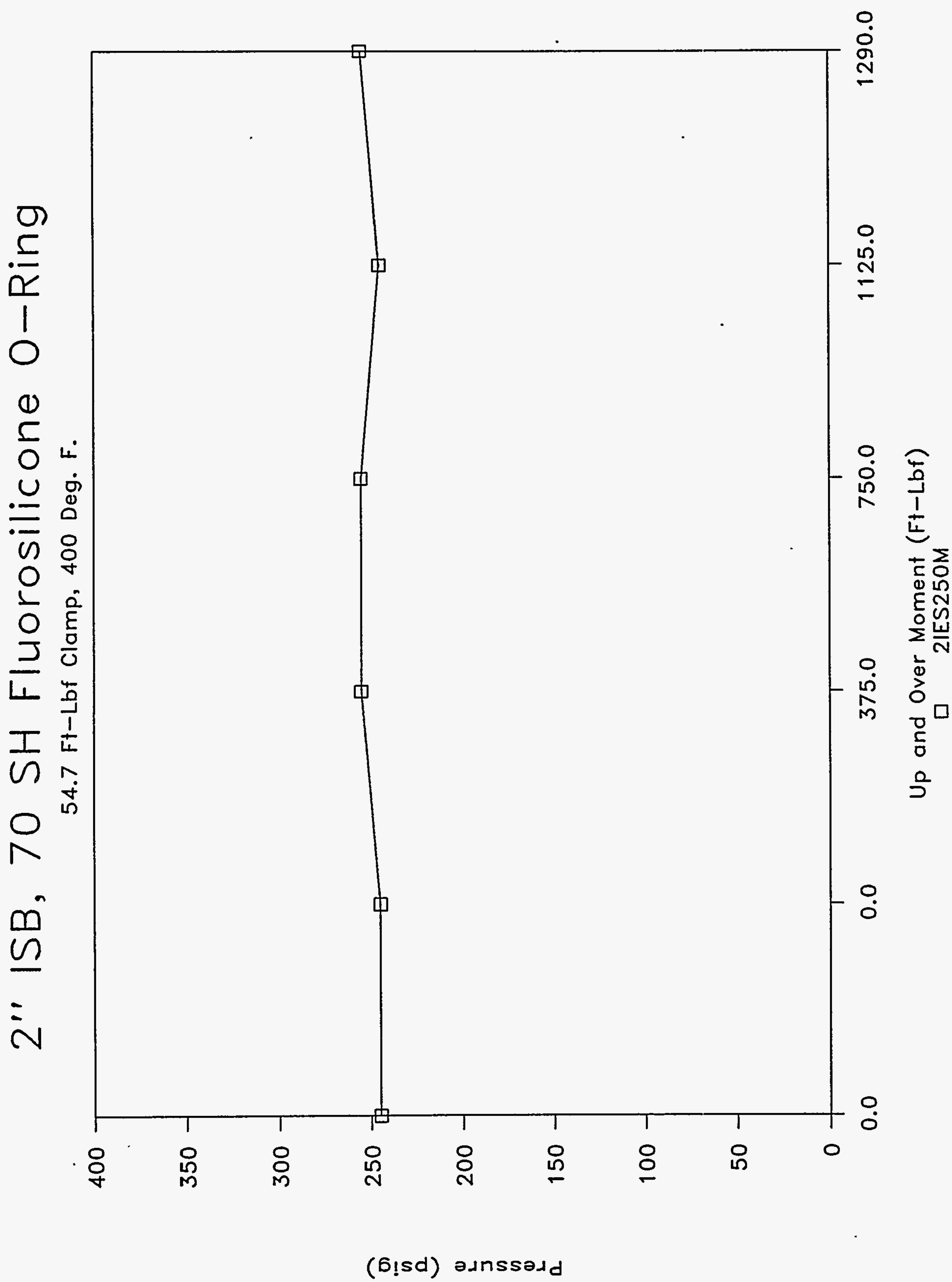
2" ISB, 70 SH Fluorosilicone O-Ring

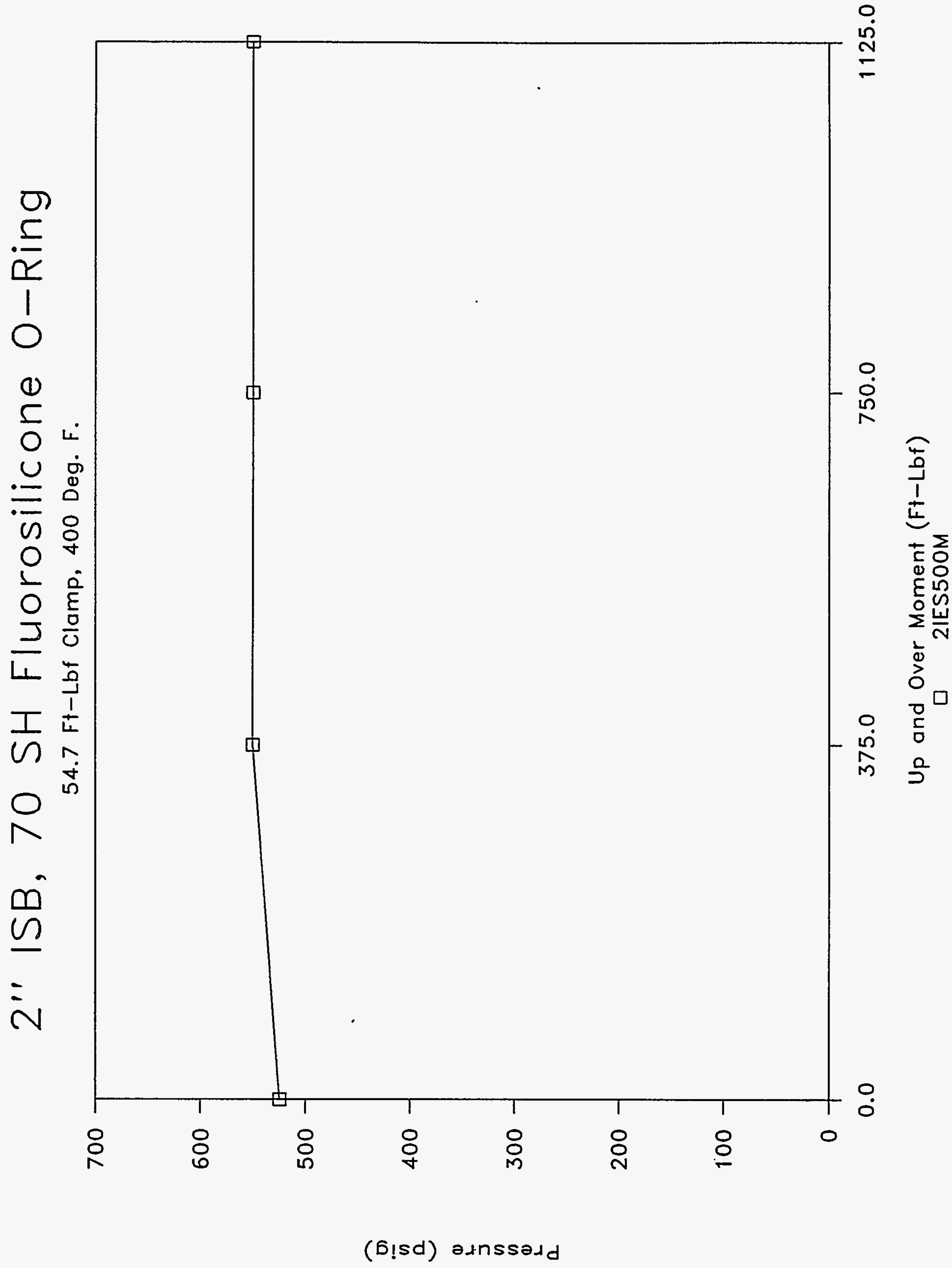
51.5 Ft-Lbf Clamp, Elevated Temp.

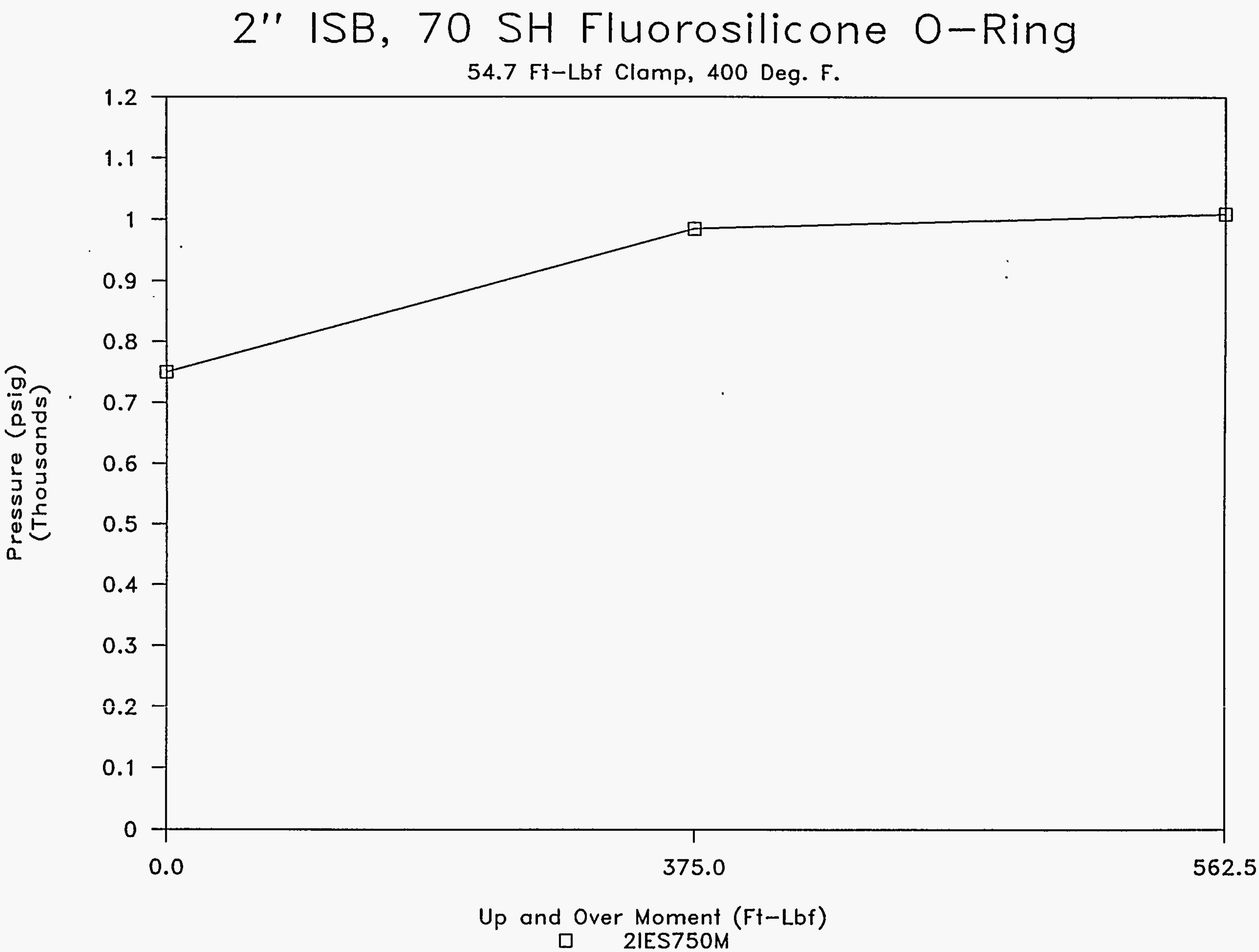


AUGUST 03, 1994
2" ISB CONNECTOR, 70 SH FLUOROSILICONE O-RING, ELEVATED TEMP.
PRESSURE ASCENSION LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 51.5 FT-LBF GRAPH NAME = 2IES250L
CHARGE PRESSURE = 250 PSIG
TEMPERATURE = 400 DEG. F

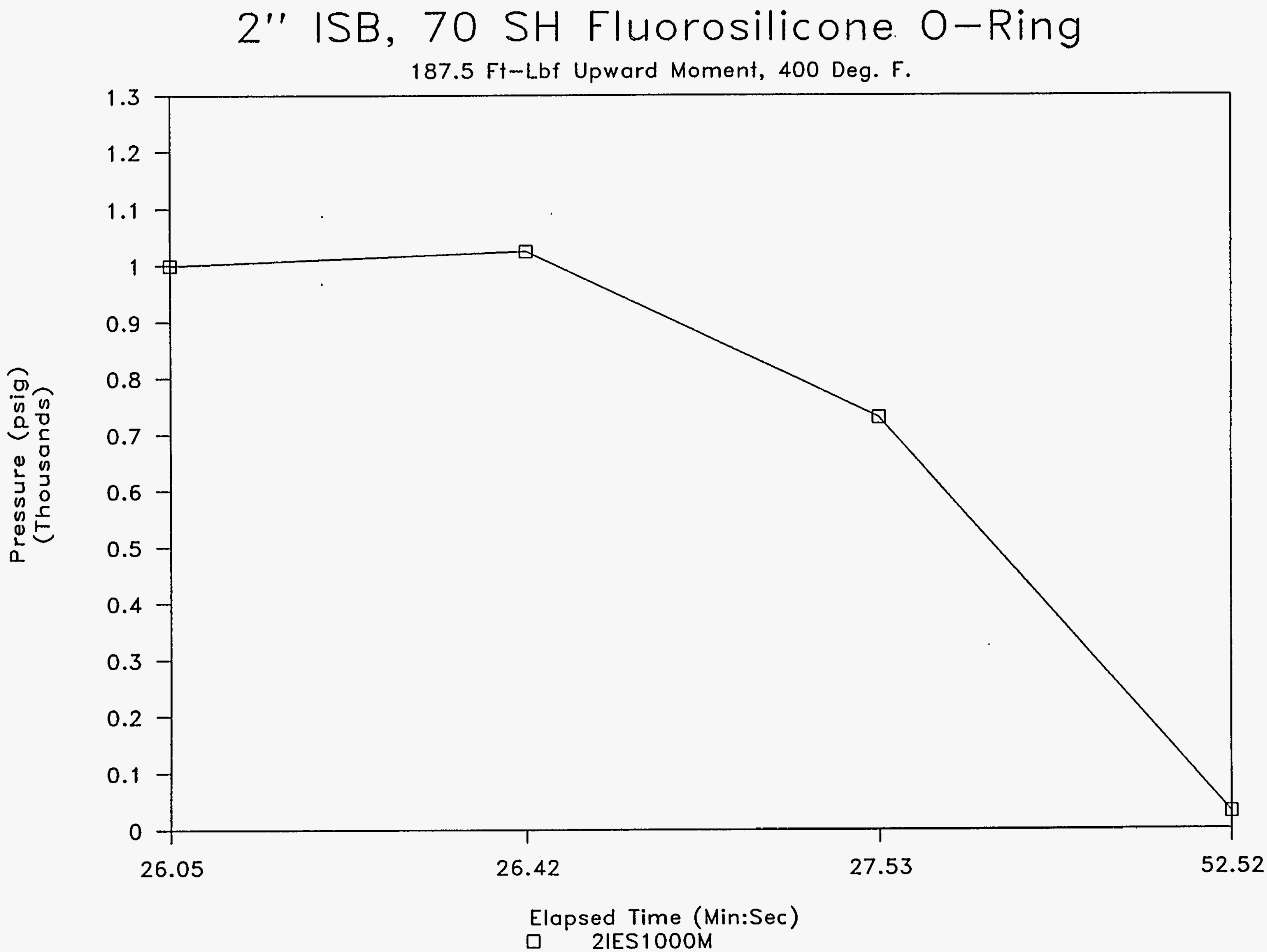
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
255	0	0	0.00	0	0.4453	0.0
270	2	17	2.28	0	0.4453	0.0
265	4	4	4.07	250	0.4453	111.3
265	6	4	0.00	500	0.4453	222.7
265	8	5	8.08	750	0.4453	334.0
260	10	10	10.17	1000	0.4453	445.3
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = 2IES500L		
575	12	3	12.05	0	0.4453	0.0
535	14	3	14.05	250	0.4453	111.3
530	16	1	16.02	500	0.4453	222.7
530	18	16	18.27	750	0.4453	334.0
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = 2IES750L		
770	20	2	20.03	0	0.4453	0.0
760	22	3	22.05	250	0.4453	111.3
755	24	5	24.08	500	0.4453	222.7
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = 2IES100L		
1025	26	3	26.05	0	0.4453	0.0
1055	28	3	28.05	125	0.4453	55.7
1045	30	2	30.03	250	0.4453	111.3
1020	32	3	32.05	300	0.4453	133.6
1020	34	5	34.08	370	0.4453	164.8


2" ISB, 70 SH Fluorosilicone O—Ring
54.7 Ft—Lbf Clamp, 400 Deg. F.
Pressure (psig)
400
350
300
250
200
150
100
50
0
0.0
0.0
375.0
750.0
1125.0
1290.0
Up and Over Moment (Ft—Lbf)
2IES250M


2" ISB, 70 SH Fluorosilicone O-Ring
54.7 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
375.0
750.0
1125.0
Up and Over Moment (Ft-Lbf)
2IES500M



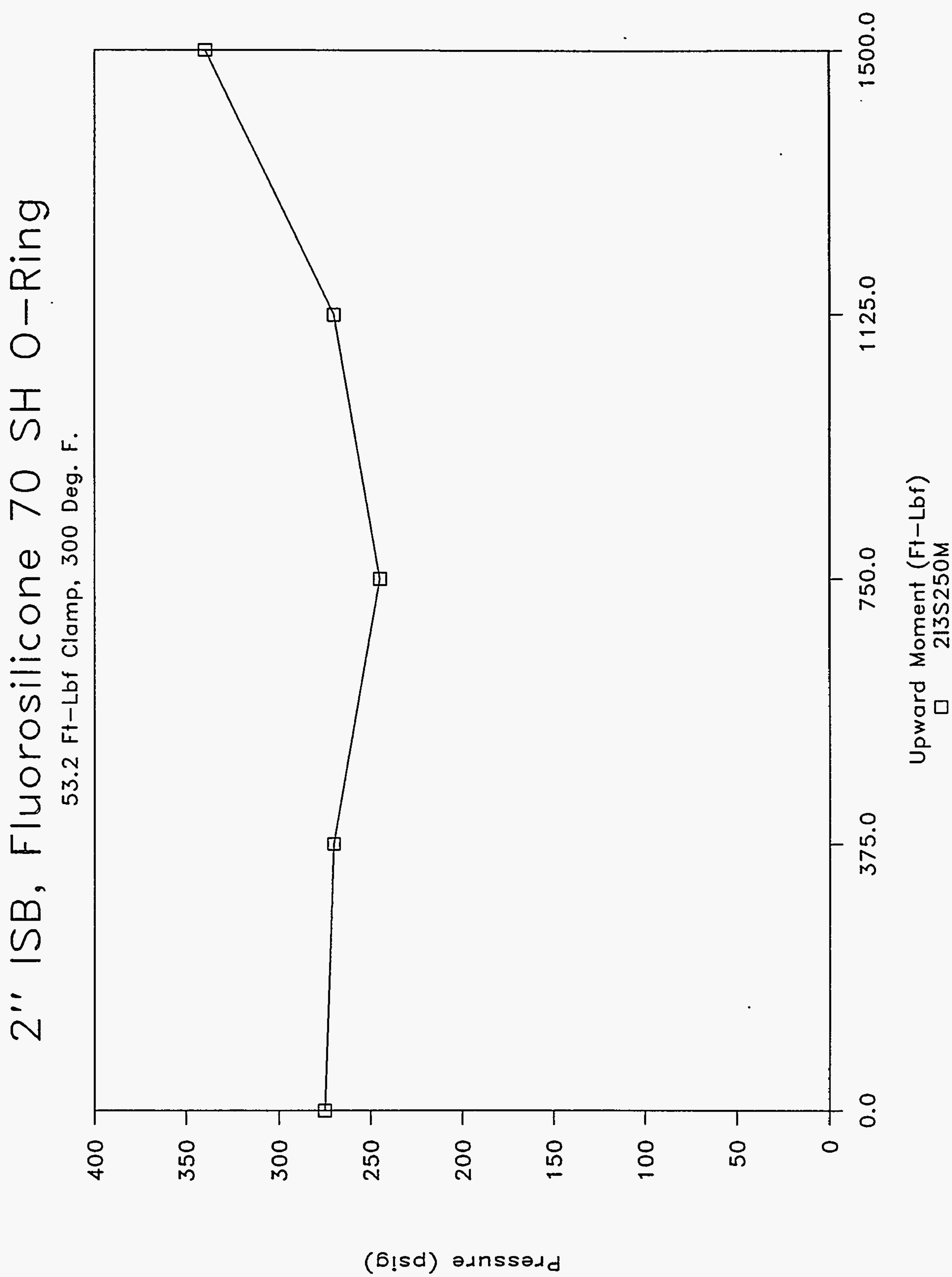
2" ISB, 70 SH Fluorosilicone O-Ring
54.7 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
375.0
562.5
Up and Over Moment (Ft-Lbf)
2IES750M



2" ISB, 70 SH Fluorosilicone O-Ring
187.5 Ft-Lbf Upward Moment, 400 Deg. F.
Pressure (psig) (Thousands)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
26.05
26.42
27.53
52.52
Elapsed Time (Min:Sec)
2IES1000M

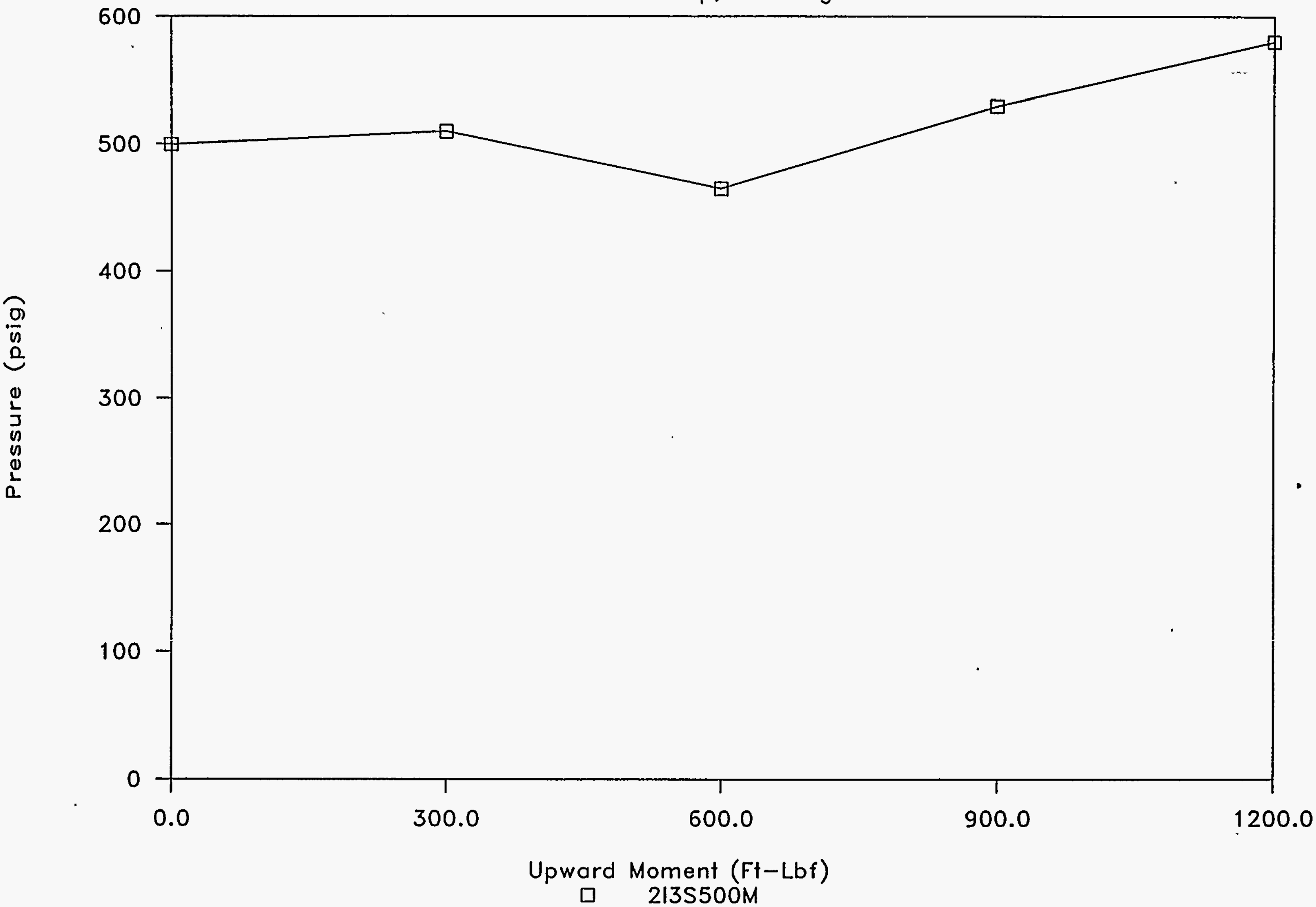
AUGUST 08, 1994
2" ISB CONNECTOR, 70 SH FLUOROSILICONE O-RING, ELEVATED TEMP.
PRESSURE ASCENSION LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 54.7 FT-LBF GRAPH NAME = 2IES250M
CHARGE PRESSURE = 250 PSIG
TEMPERATURE = 400 DEG. F

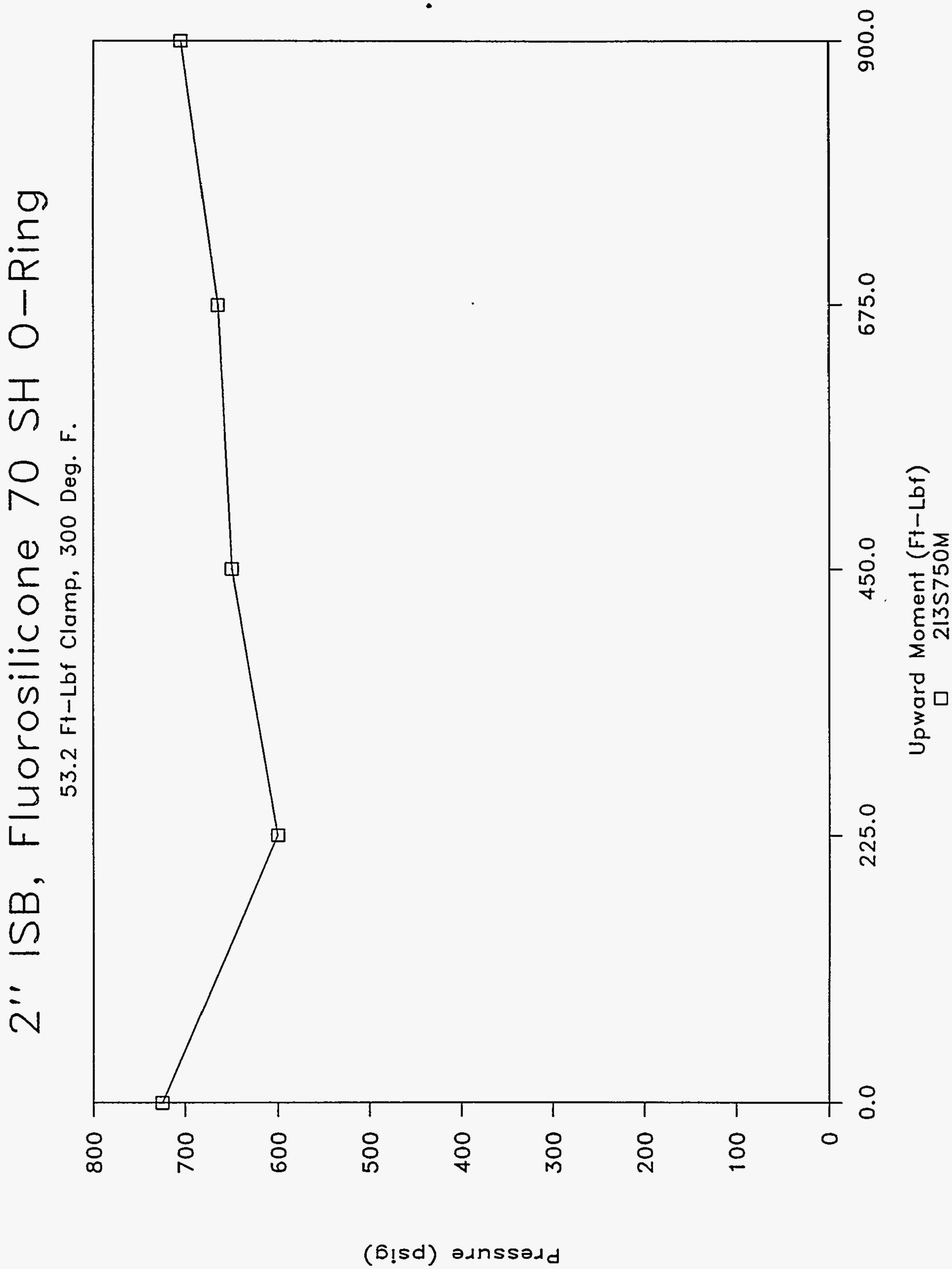
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE	
245	0	0	0.00	0	1.5000	0.0	
245	2	1	2.02	0	1.5000	0.0	
255	4	2	4.03	250	1.5000	375.0	
255	6	2	6.03	500	1.5000	750.0	
245	8	2	8.03	750	1.5000	1125.0	
255	10	22	10.37	860	1.5000	1290.0	
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = 2IES500M			
525	12	6	12.10	0	1.5000	0.0	
550	14	4	14.07	250	1.5000	375.0	
550	16	1	16.02	500	1.5000	750.0	
550	18	2	18.03	750	1.5000	1125.0	
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = 2IES750M			
750	20	1	20.02	0	1.5000	0.0	
985	22	2	22.03	250	1.5000	375.0	
1010	24	3	24.05	375	1.5000	562.5	
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = 2IES1000M			
1000	26	6	26.05	0	1.5000	0.0	
1025	26	25	26.42	125	1.5000	187.5	* O-RING
730	27	32	27.53	125	1.5000	187.5	LEAK
30	52	31	52.52	125	1.5000	187.5	

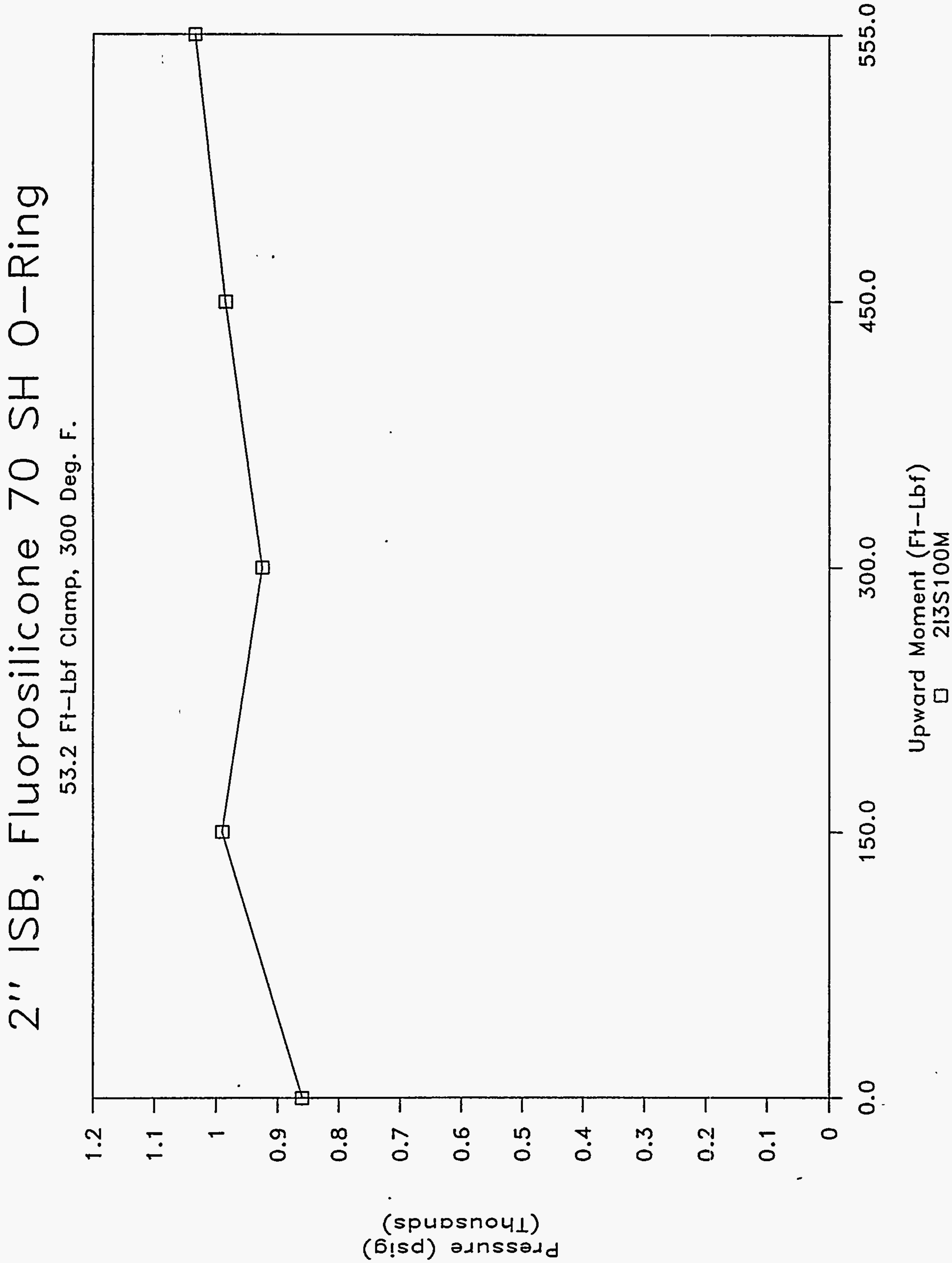

2" ISB, Fluorosilicone 70 SH O-Ring
53.2 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
400
350
300
250
200
150
100
50
0
0.0
375.0
750.0
1125.0
1500.0
Upward Moment (Ft-Lbf)
213S250M

2" ISB, Fluorosilicone 70 SH O-Ring

53.2 Ft-Lbf Clamp, 300 Deg. F.

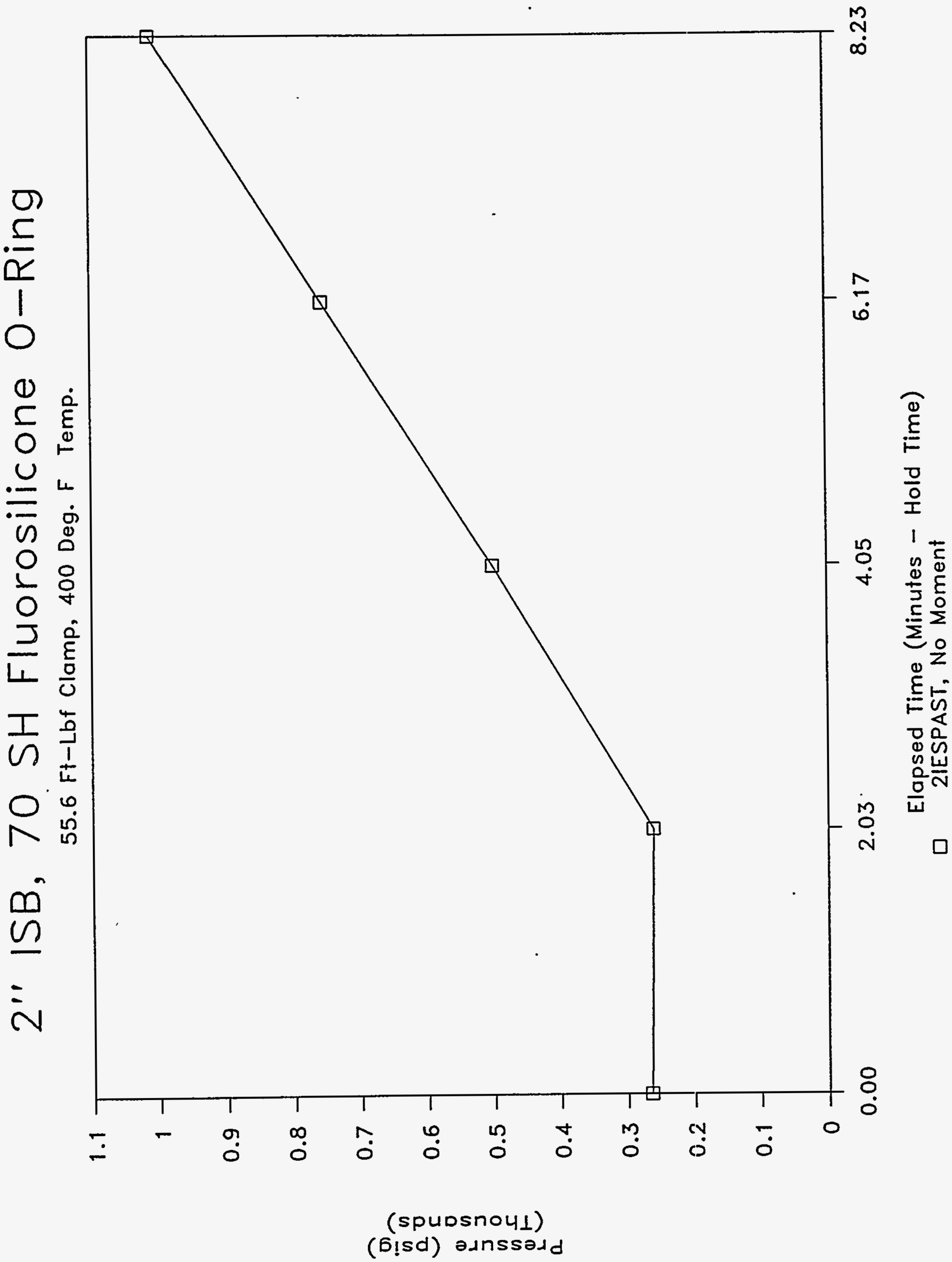



2" ISB, Fluorosilicone 70 SH O-Ring
53.2 Ft-Lbf Clamp, 300 Deg. F.
800
700
600
500
400
300
200
100
0
Pressure (psig)
0.0
225.0
450.0
675.0
900.0
Upward Moment (Ft-Lbf)
213S750M


2" ISB, Fluorosilicone 70 SH O-Ring
53.2 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
150.0
300.0
450.0
555.0
Upward Moment (Ft-Lbf)
213S100M

NOVEMBER 14, 1994
2" ISB CONNECTOR, FLUOROSILICONE O-RING, 70 DUROMETER, ELEVATED TEMP.
PART # AS568-142, CONQUEST SEAL CO., BATCH PMAF3, CURE DATE 4Q93
LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 53.2 FT-LBF GRAPH NAME = 2I3S250M
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 300 DEG. F.

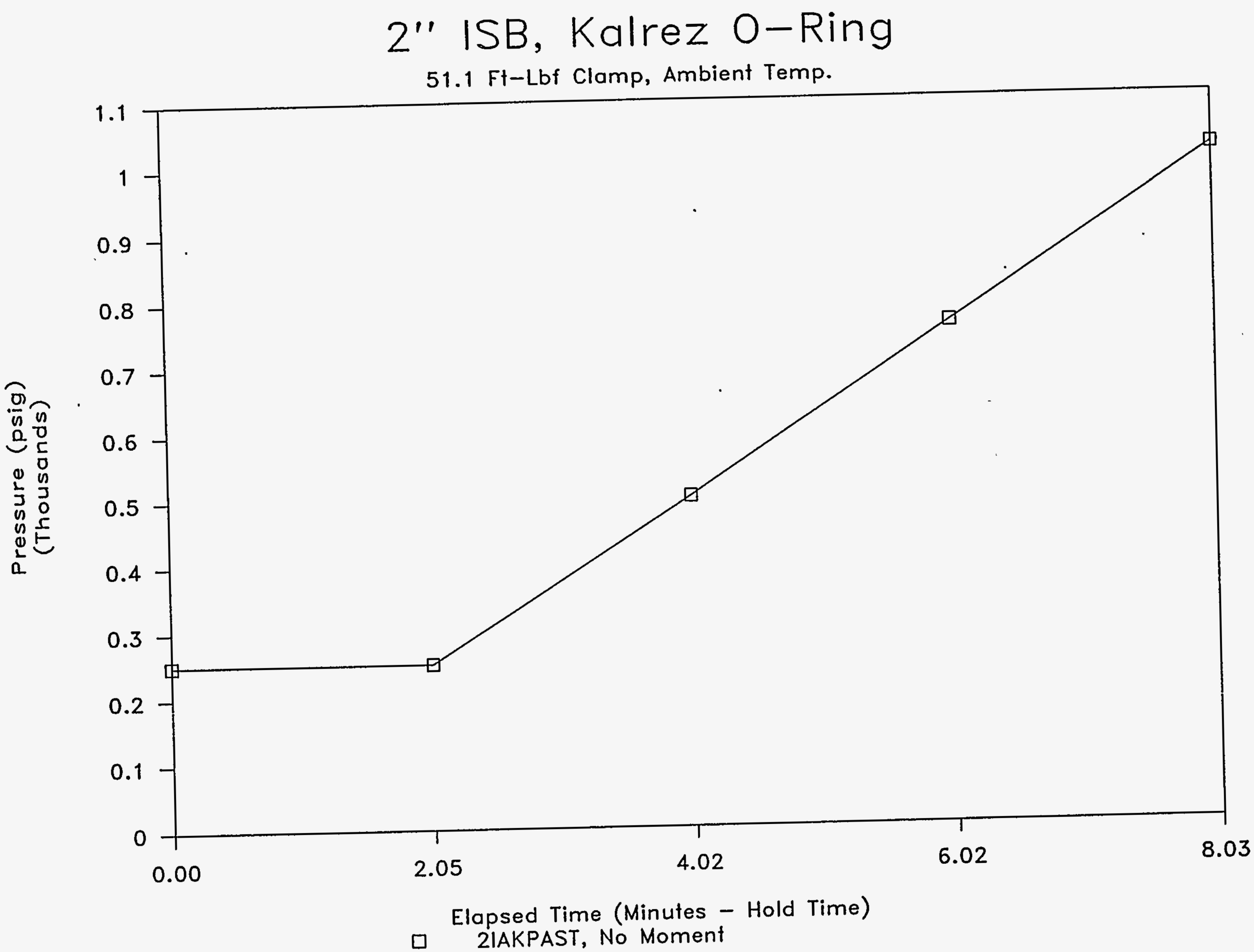
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
275	0	0	0.00	0	1.5000	0.0
275	2	6	2.10	0	1.5000	0.0
270	4	1	4.02	250	1.5000	375.0
245	6	2	6.03	500	1.5000	750.0
270	8	1	8.02	750	1.5000	1125.0
340	10	4	10.07	1000	1.5000	1500.0
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = 2I3S500M		
500	12	3	12.05	0	1.5000	0.0
510	14	3	14.05	200	1.5000	300.0
465	16	4	16.07	400	1.5000	600.0
530	18	1	18.02	600	1.5000	900.0
580	20	0	20.00	800	1.5000	1200.0
INCREASED PRESSURE TO "750" PSIG				GRAPH NAME = 2I3S750M		
725	22	6	22.10	0	1.5000	0.0
600	24	2	24.03	150	1.5000	225.0
650	26	1	26.02	300	1.5000	450.0
665	28	1	28.02	450	1.5000	675.0
705	30	3	30.05	600	1.5000	900.0
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = 2I3S100M		
860	32	1	32.02	0	1.5000	0.0
990	34	2	34.03	100	1.5000	150.0
925	36	1	36.02	200	1.5000	300.0
985	38	4	38.07	300	1.5000	450.0
1035	40	2	40.03	370	1.5000	555.0


2" ISB, 70 SH Fluorosilicone O—Ring
55.6 Ft—Lbf Clamp, 400 Deg. F Temp.
Pressure (psig)
(Thousands)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.00
2.03
4.05
6.17
8.23
Elapsed Time (Minutes - Hold Time)
2IESPAST, No Moment

AUGUST 03, 1994
2" ISB CONNECTOR, 70 SH FLUOROSILICONE O-RING, ELEVATED TEMP.
PRESSURE ASCENSION LEAK TEST - NO MOMENT APPLIED
CLAMPING TORQUE = 55.6 FT-LBF GRAPH NAME = 2IESPAST
CHARGE PRESSURE = 250 PSIG TO 1000 PSIG
TEMPERATURE = 400 Deg. F

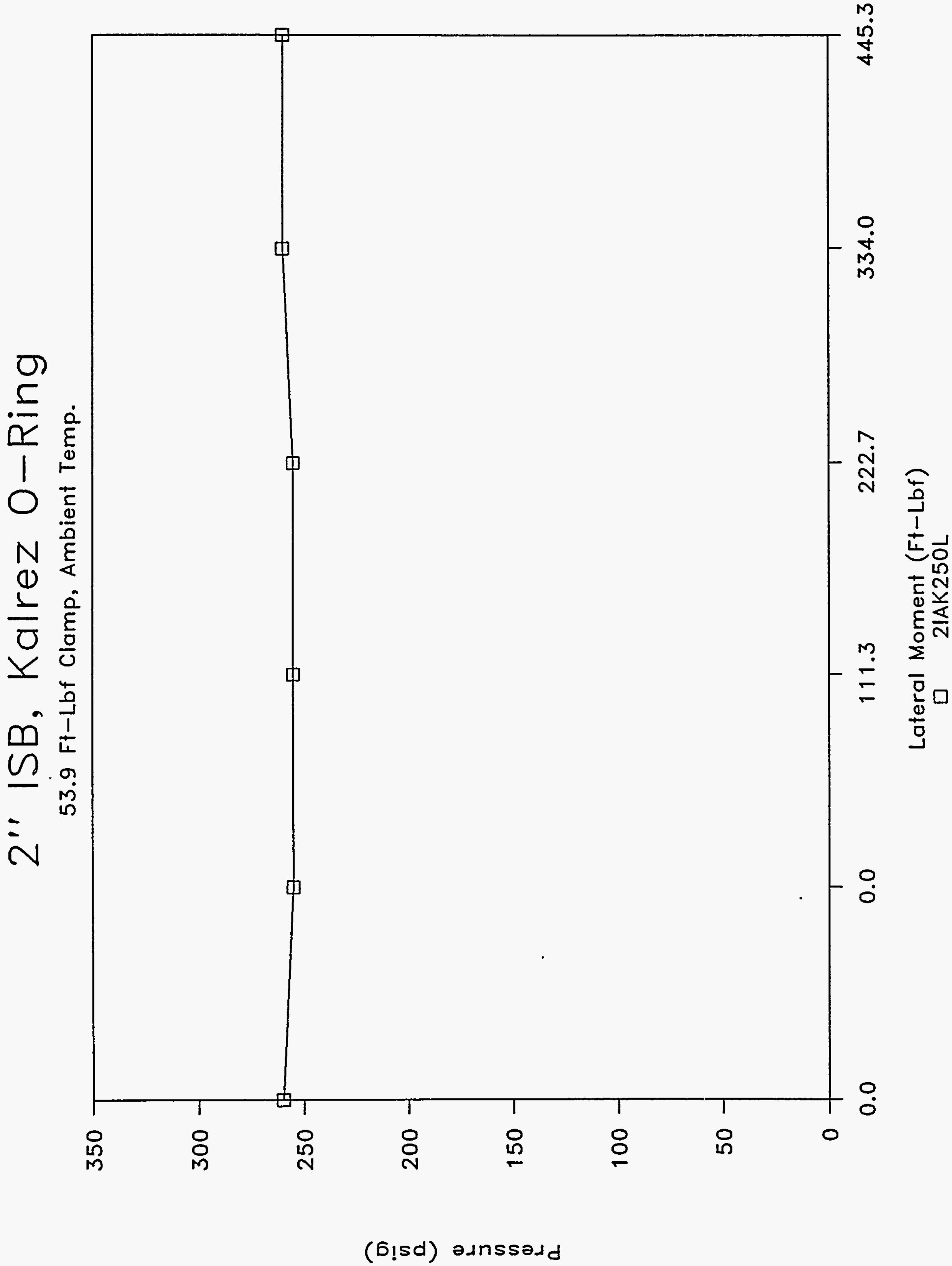
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	APPLIED FORCE LBS INPUT
265	0	0	0.00	0
261	2	2	2.03	0
500	4	3	4.05	0
755	6	10	6.17	0
1010	8	14	8.23	0

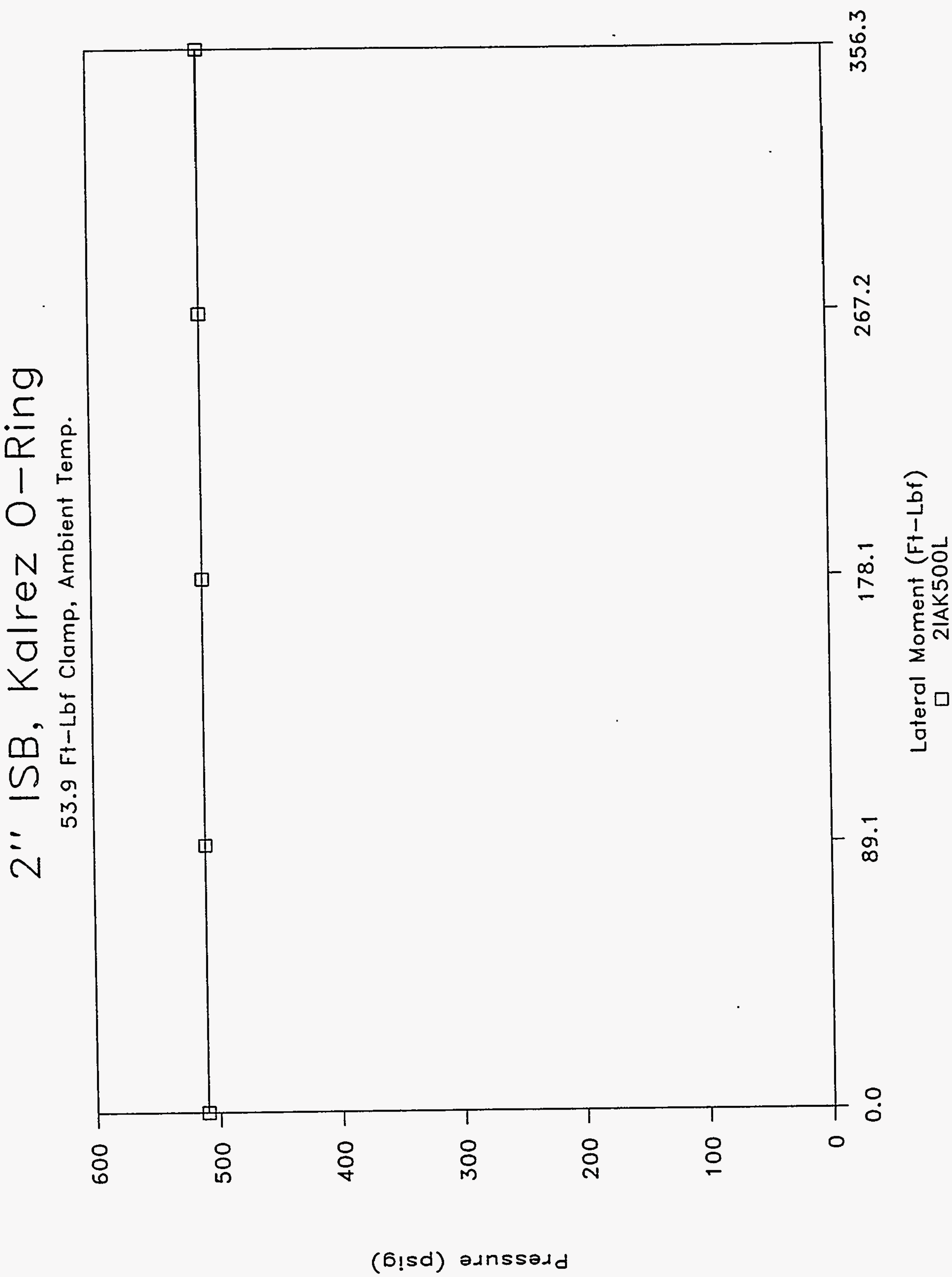
APPENDIX F: GRAPHS OF 2-IN. KALREZ TESTS

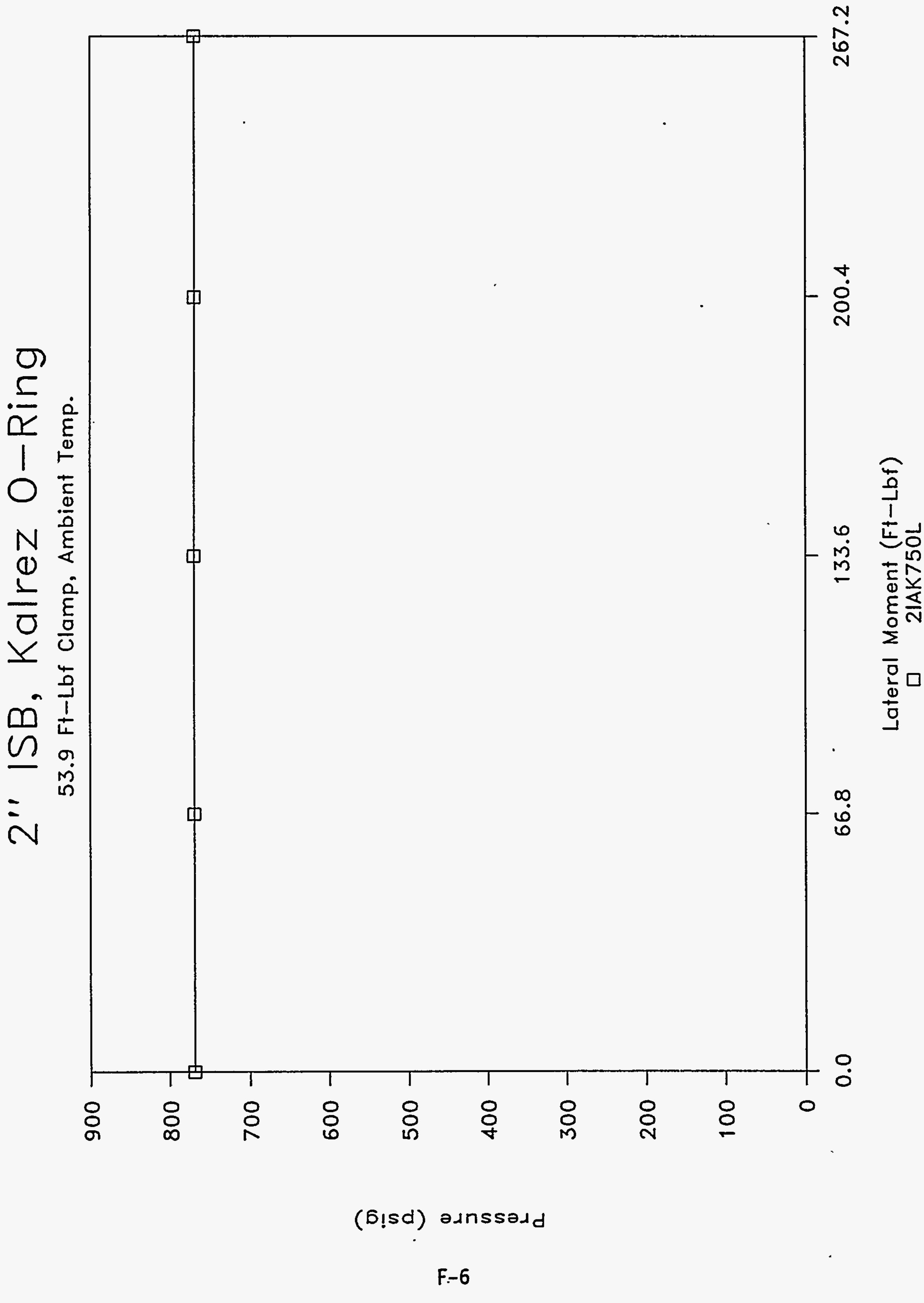

2" ISB, Kalrez O-Ring
51.1 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.00
2.05
4.02
6.02
8.03
Elapsed Time (Minutes - Hold Time)
2IAKPAST, No Moment

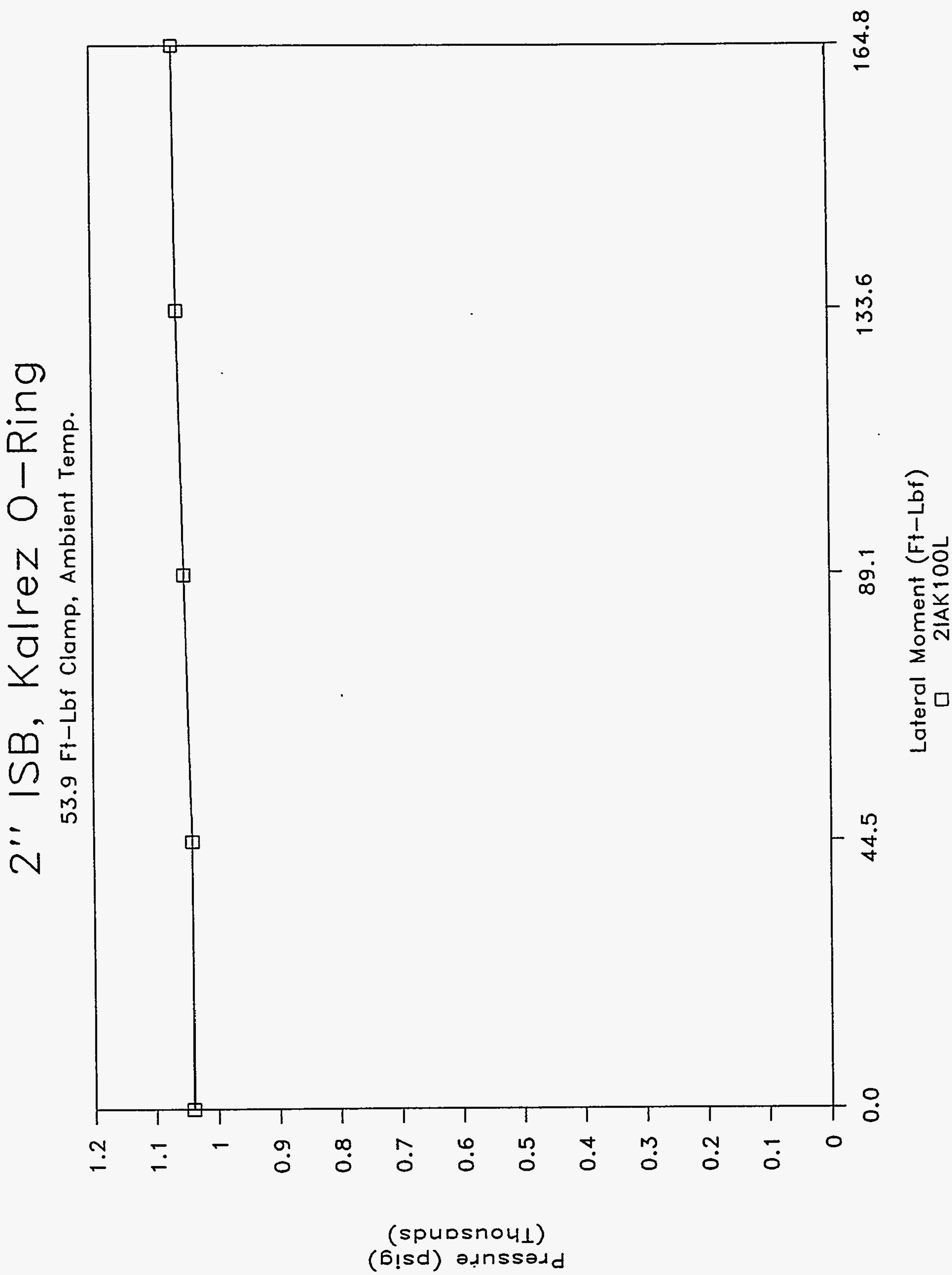
SEPTEMBER 30, 1994
2" ISB CONNECTOR, KALREZ O-RING, 70 DUROMETER, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - NO MOMENTS
CLAMPING TORQUE = 51.1 FT-LBF GRAPH NAME = 2IAKPAST
CHARGE PRESSURE = GRADUALLY INCREMENTED HIGHER

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	APPLIED FORCE LBS INPUT
250	0	0	0.00	0
250	2	3	2.05	0
500	4	1	4.02	0
760	6	1	6.02	0
1020	8	2	8.03	0


2" ISB, Kalrez O—Ring
53.9 Ft—Lbf Clamp, Ambient Temp.
Pressure (psig)
0
50
100
150
200
250
300
350
0.0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft—Lbf)
2IAK250L

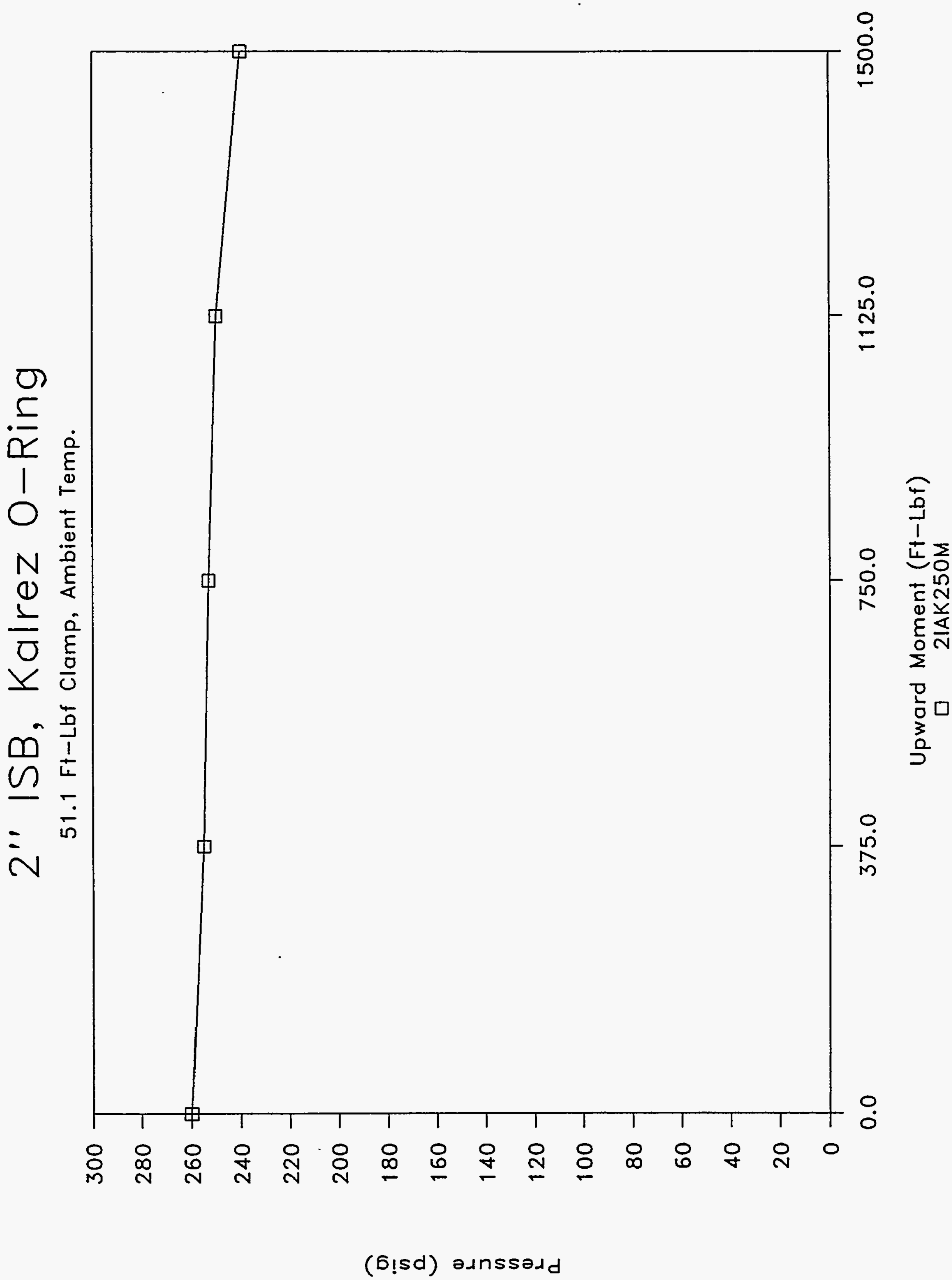

2" ISB, Kalrez O-Ring
53.9 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
600
500
400
300
200
100
0
0.0
89.1
178.1
267.2
356.3
Lateral Moment (Ft-Lbf)
2IAK500L

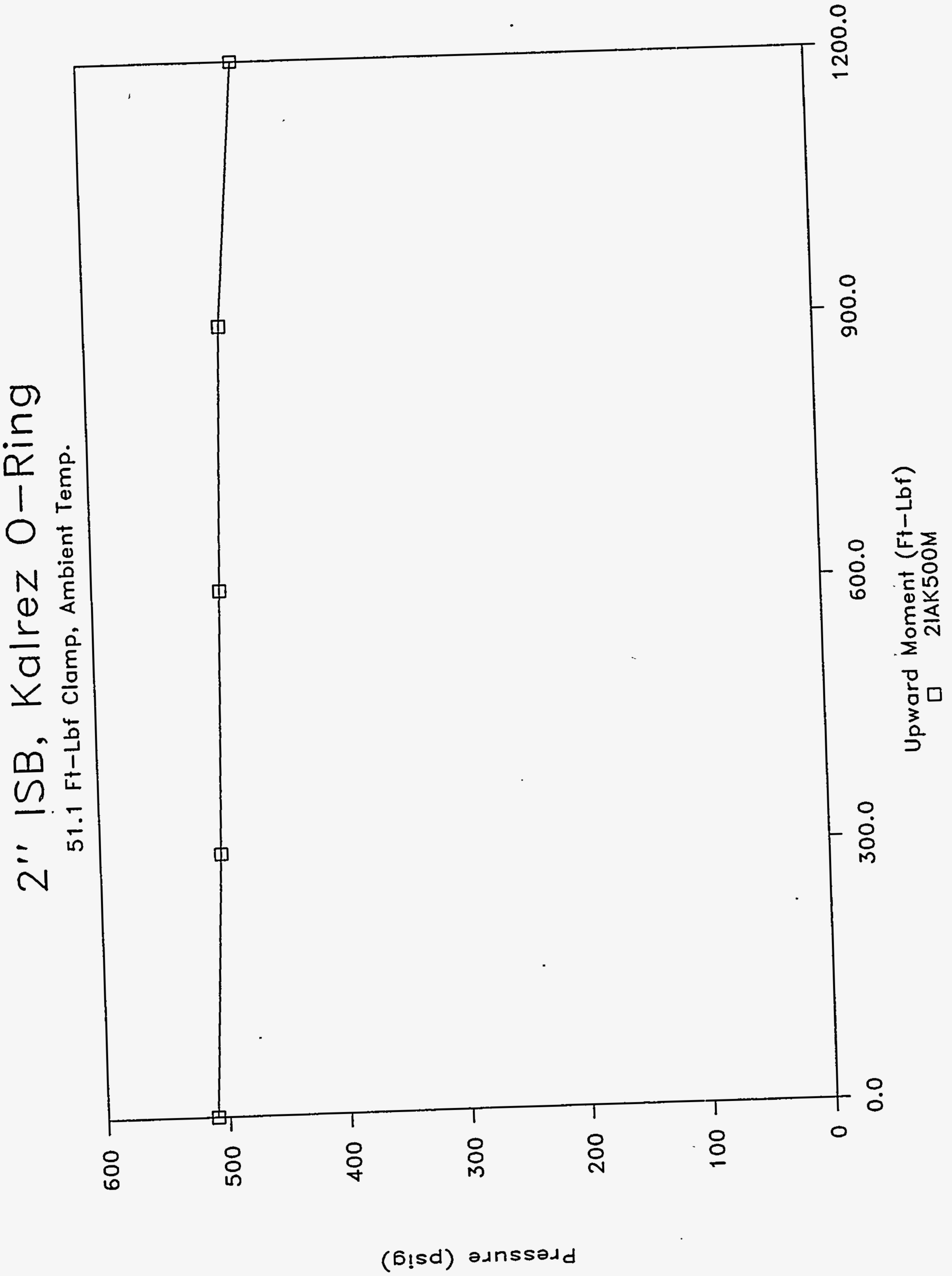

2'' ISB, Kalrez O-Ring
53.9 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
66.8
133.6
200.4
267.2
Lateral Moment (Ft-Lbf)
21AK750L


2'' ISB, Kalrez O-Ring
53.9 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
44.5
89.1
133.6
164.8
Lateral Moment (Ft-Lbf)
2IAK100L

OCTOBER 03, 1994
2" ISB CONNECTOR, KALREZ O-RING, 70 DUROMETER, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 53.9 FT-LBF GRAPH NAME = 2IAK250L
CHARGE PRESSURE = 250 PSIG

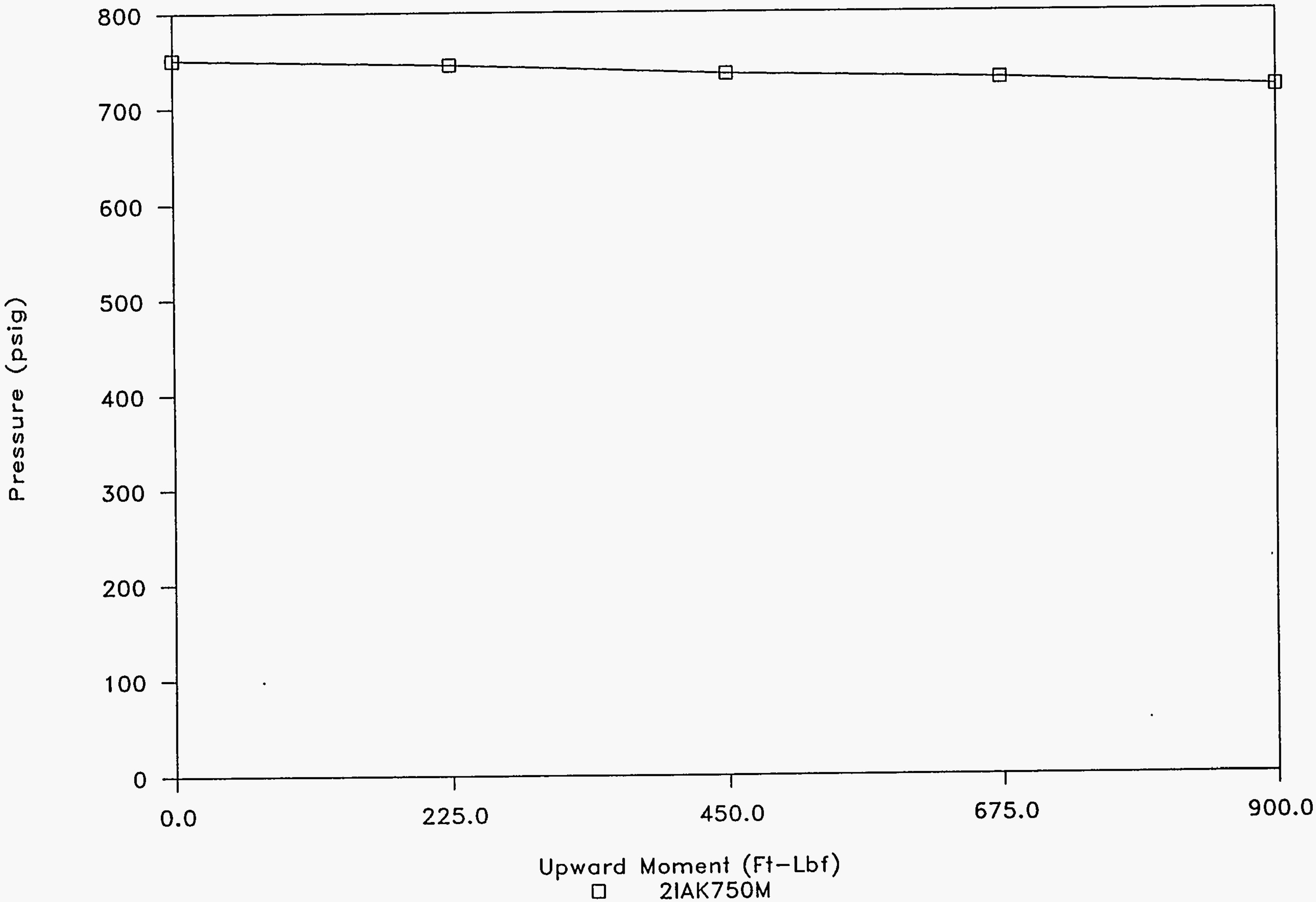
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
260	0	0	0.00	0	0.4453	0.0
255	2	1	2.02	0	0.4453	0.0
255	4	2	4.03	250	0.4453	111.3
255	6	5	6.08	500	0.4453	222.7
260	8	2	8.03	750	0.4453	334.0
260	10	7	10.12	1000	0.4453	445.3
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = 2IAK500L		
510	12	1	12.02	0	0.4453	0.0
510	14	2	14.03	200	0.4453	89.1
510	16	1	16.02	400	0.4453	178.1
510	18	3	18.05	600	0.4453	267.2
510	20	1	20.02	800	0.4453	356.3
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = 2IAK750L		
770	22	1	22.02	0	0.4453	0.0
770	24	1	24.02	150	0.4453	66.8
770	26	1	26.02	300	0.4453	133.6
770	28	0	28.00	450	0.4453	200.4
770	30	1	30.02	600	0.4453	267.2
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = 2IAK100L		
1040	32	9	32.15	0	0.4453	0.0
1040	34	4	34.07	100	0.4453	44.5
1052	36	3	36.05	200	0.4453	89.1
1061	38	4	38.07	300	0.4453	133.6
1066	40	5	40.08	370	0.4453	164.8

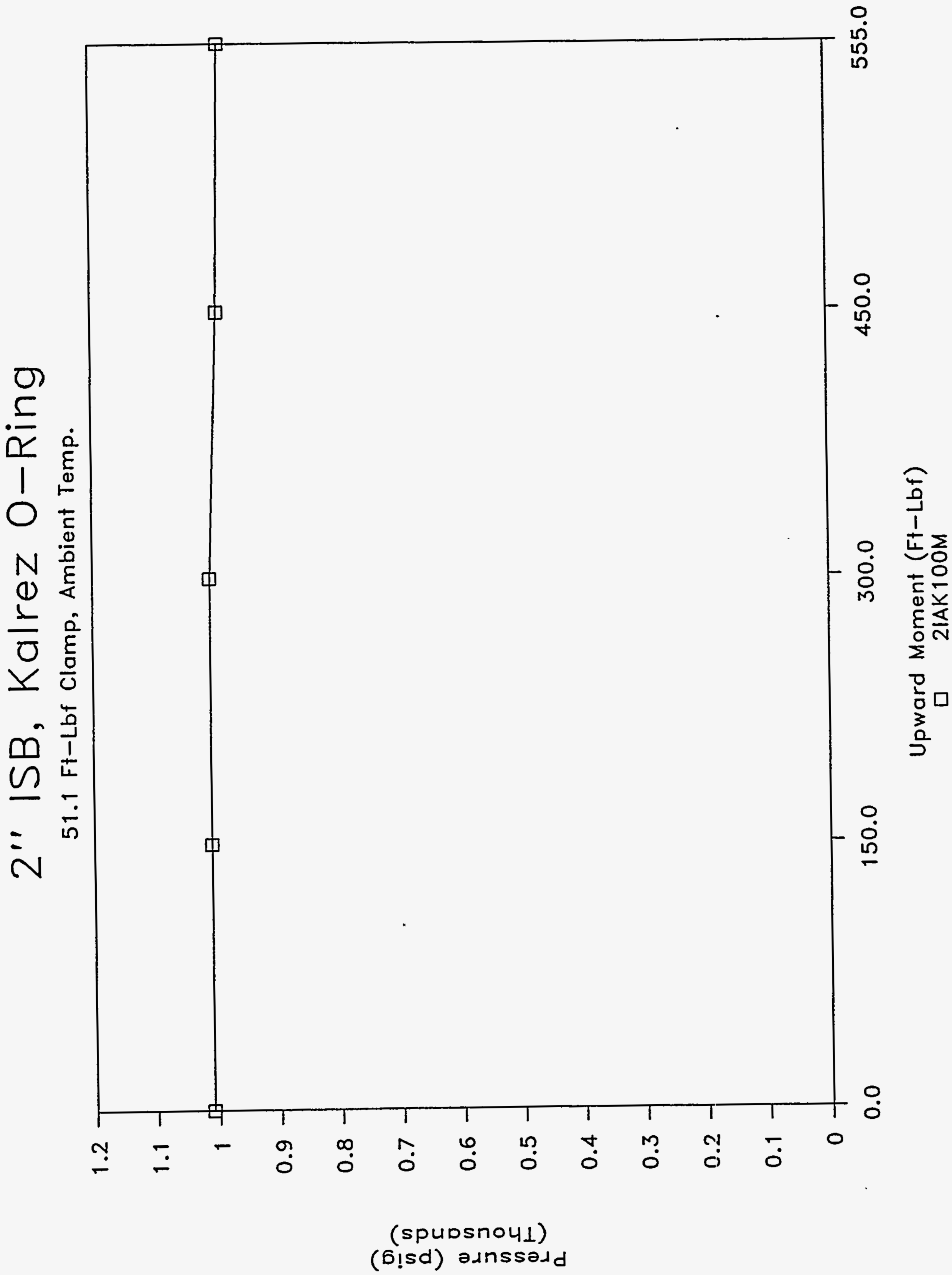

2" ISB, Kalrez O-Ring
51.1 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
0.0
375.0
750.0
1125.0
1500.0
Upward Moment (Ft-Lbf)
2IAK250M


2" ISB, Kalrez O-Ring
51.1 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
0
100
200
300
400
500
600
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft-Lbf)
21AK500M

2" ISB, Kalrez O-Ring

51.1 Ft-Lbf Clamp, Ambient Temp.




2" ISB, Kalrez O-Ring
51.1 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
150.0
300.0
450.0
555.0
Upward Moment (Ft-Lbf)
2IAK100M

OCTOBER 03, 1994
2" ISB CONNECTOR, KALREZ O-RING, 70 DUROMETER, AMBIENT TEMP.
LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 52.7 FT-LBF GRAPH NAME = 2IAK250M
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
260	0	0	0.00	0	1.5000	0.0
260	2	0	2.00	0	1.5000	0.0
255	4	3	4.05	250	1.5000	375.0
253	6	2	6.03	500	1.5000	750.0
250	8	1	8.02	750	1.5000	1125.0
240	10	1	10.02	1000	1.5000	1500.0

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = 2IAK500M

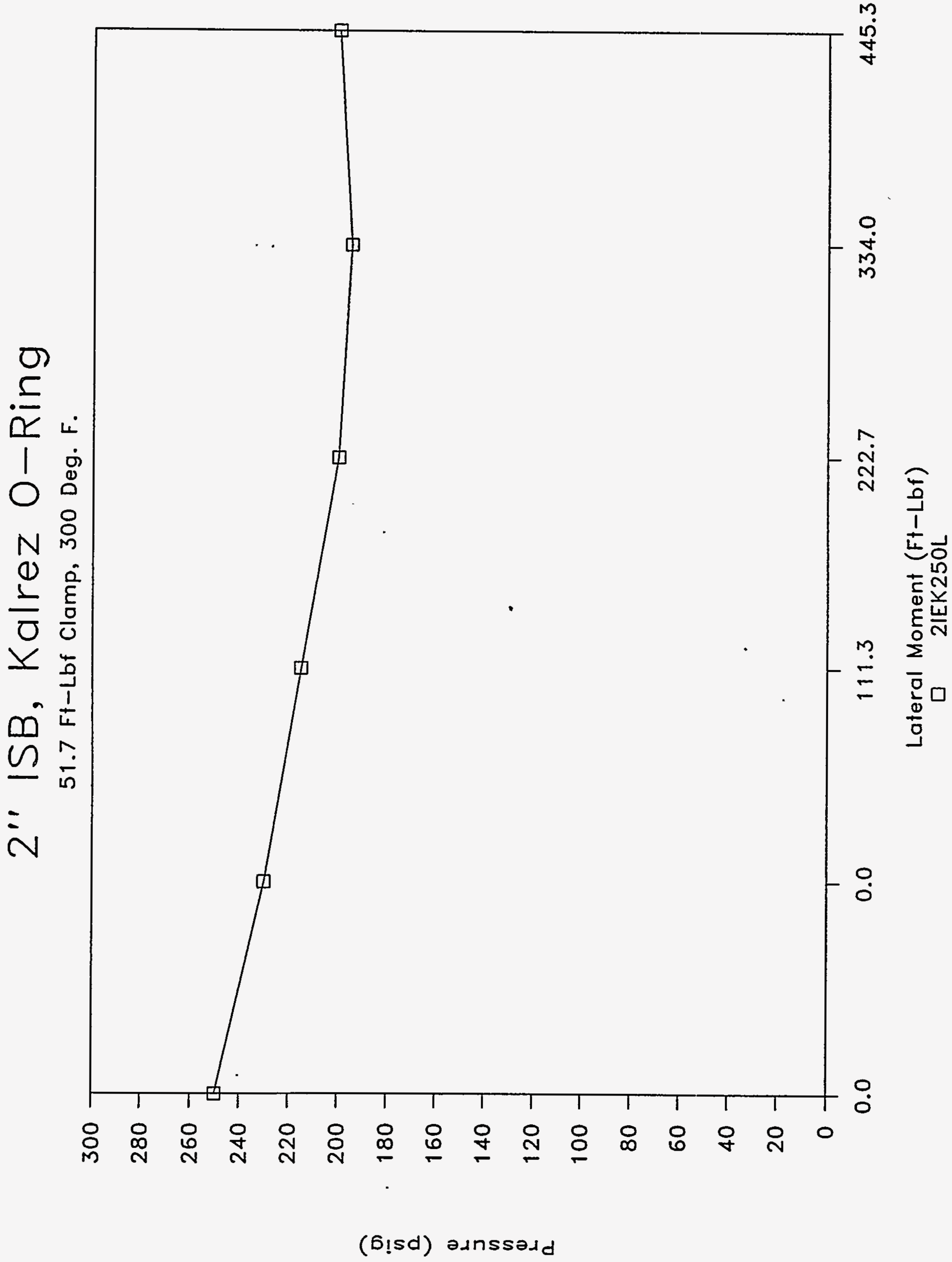
510	12	1	12.02	0	1.5000	0.0
501	14	2	14.03	200	1.5000	300.0
495	16	2	16.03	400	1.5000	600.0
489	18	1	18.02	600	1.5000	900.0
473	20	1	20.02	800	1.5000	1200.0

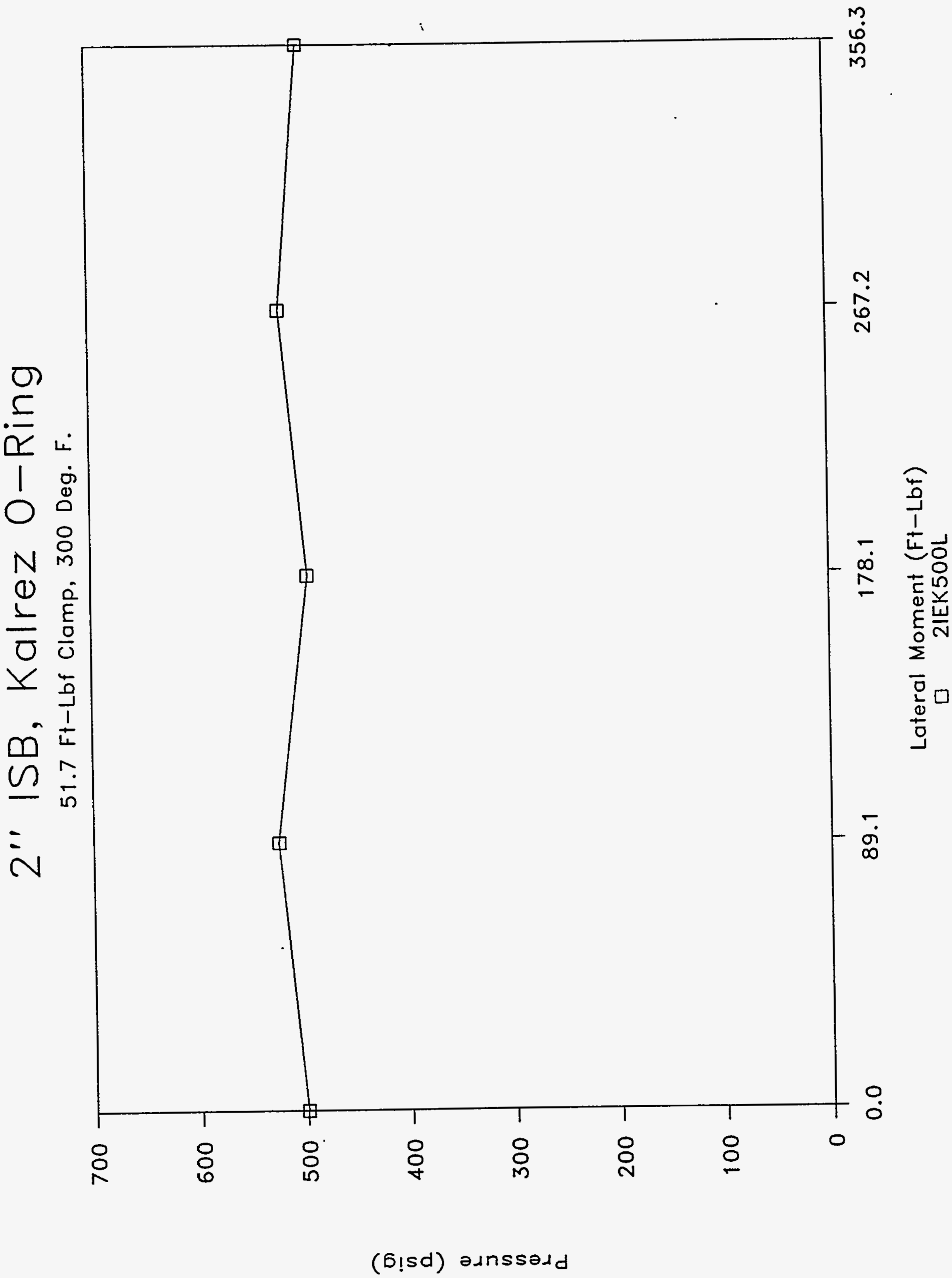
INCREASED PRESSURE TO 750 PSIG GRAPH NAME = 2IAK750M

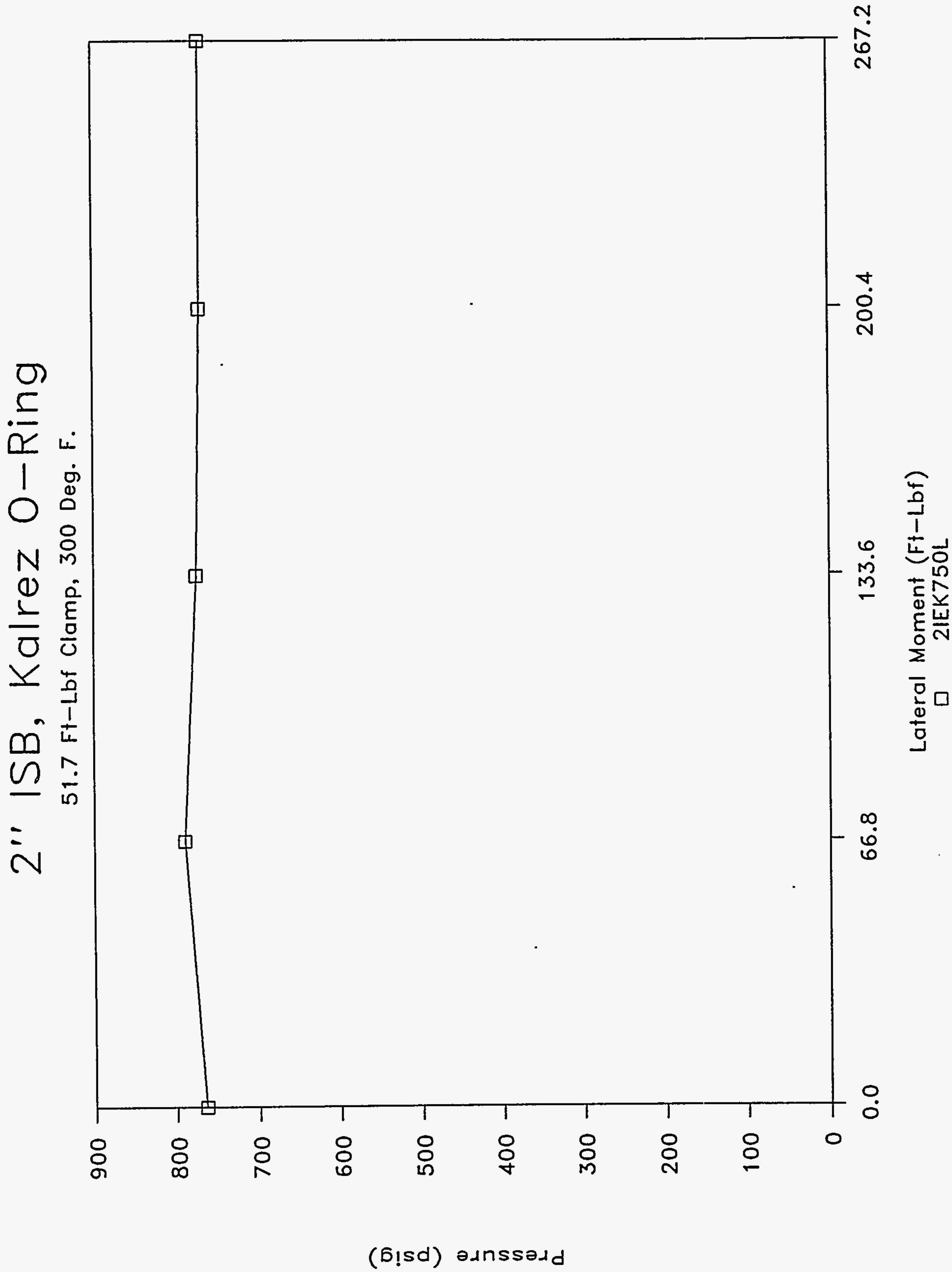
751	22	17	22.28	0	1.5000	0.0
745	24	1	24.02	150	1.5000	225.0
735	26	2	26.03	300	1.5000	450.0
730	28	2	28.03	450	1.5000	675.0
720	30	2	30.03	600	1.5000	900.0

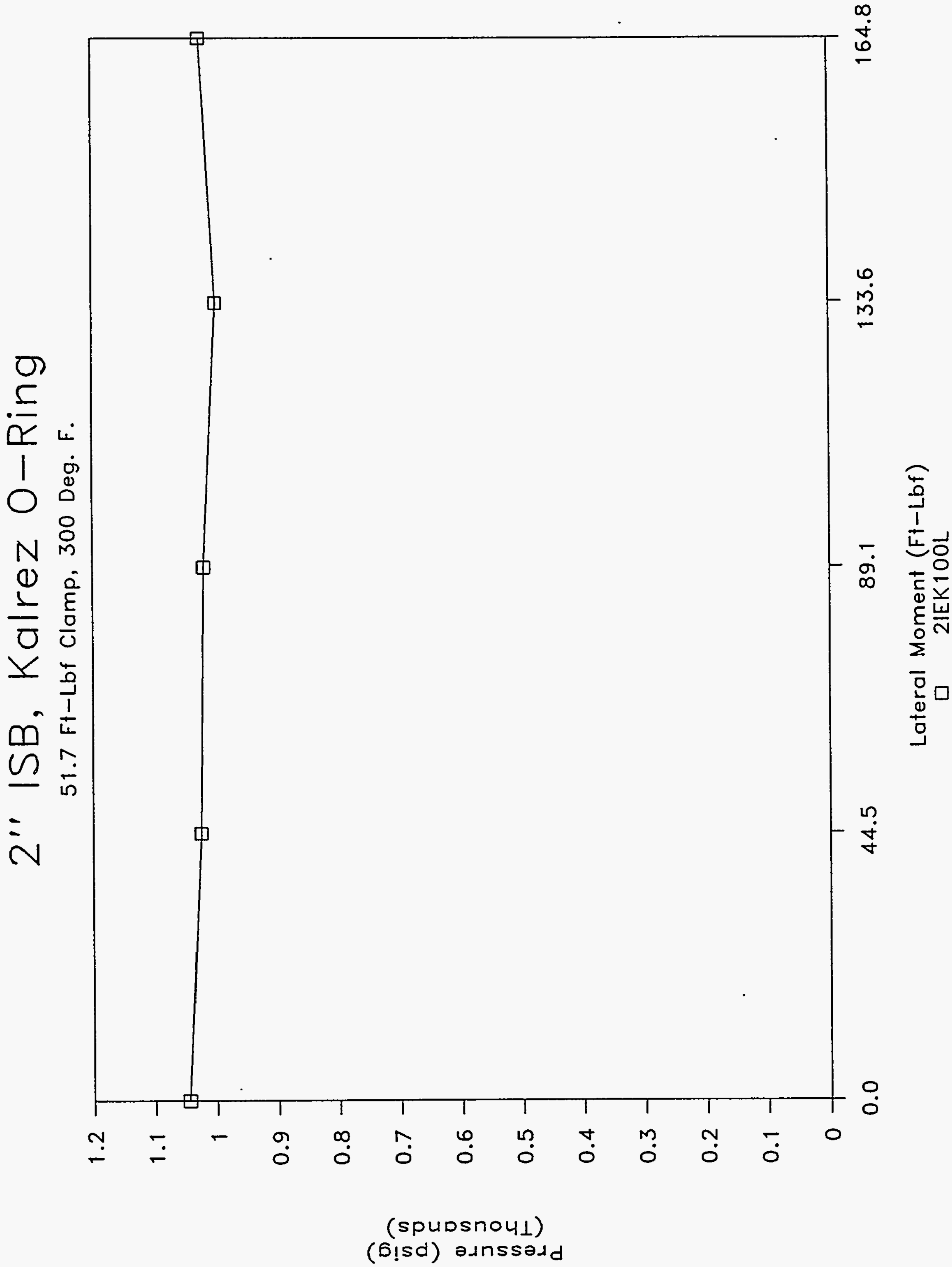
INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = 2IAK100M

1010	32	2	32.03	0	1.5000	0.0
1010	34	1	34.02	100	1.5000	150.0
1010	36	3	36.05	200	1.5000	300.0
996	38	1	38.02	300	1.5000	450.0
990	40	3	40.05	370	1.5000	555.0


2" ISB, Kalrez O-Ring
51.7 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
0.0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
2IEK250L


2" ISB, Kalrez O-Ring
51.7 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
89.1
178.1
267.2
356.3
Lateral Moment (Ft-Lbf)
2IEK500L


2" ISB, Kalrez O-Ring
51.7 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
66.8
133.6
200.4
267.2
Lateral Moment (Ft-Lbf)
2IEK750L


2" ISB, Kalrez O-Ring
51.7 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
44.5
89.1
133.6
164.8
Lateral Moment (Ft-Lbf)
2IEK100L

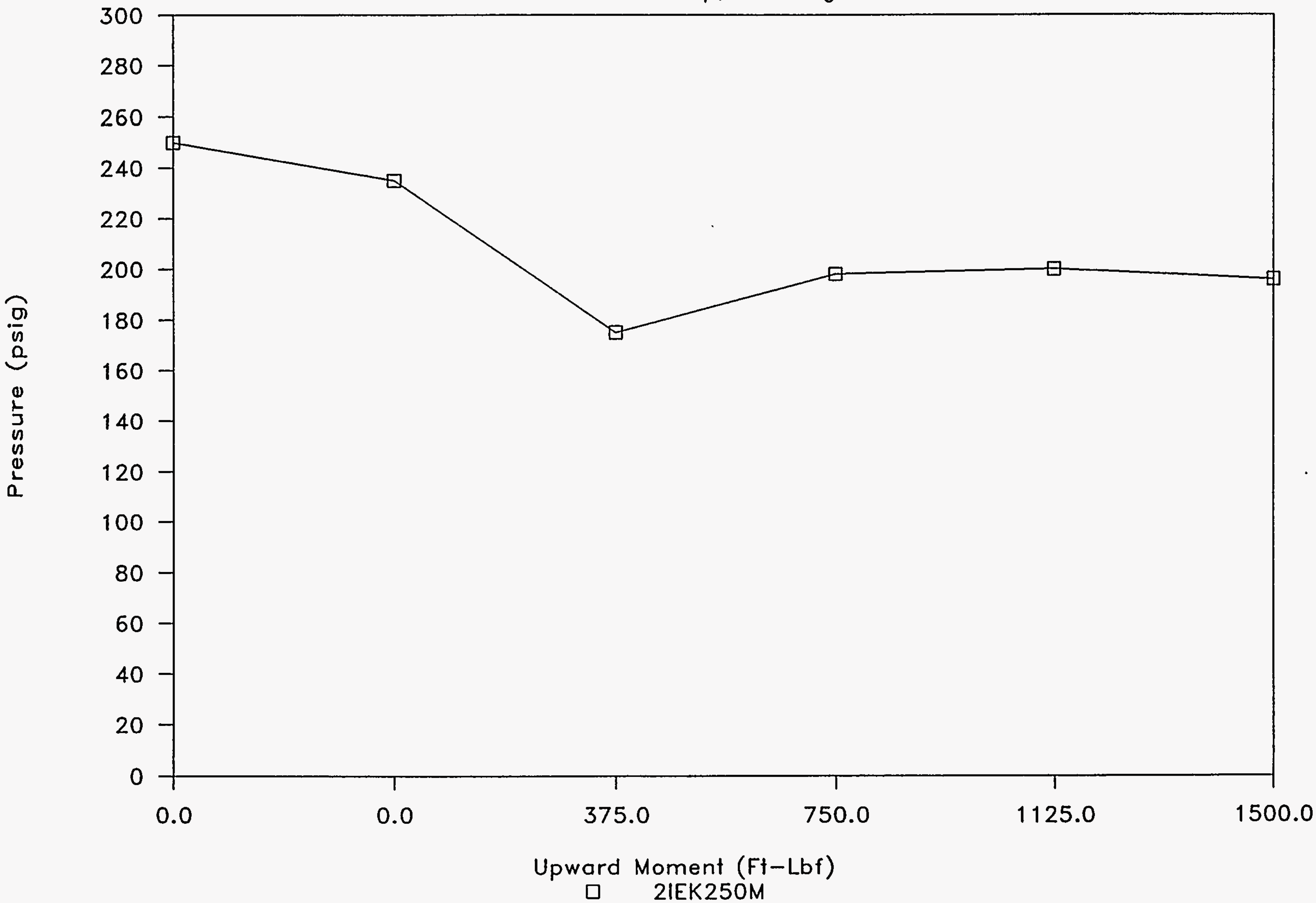
OCTOBER 05, 1994
2" ISB CONNECTOR, KALREZ O-RING, 70 DUROMETER, ELEVATED TEMP.
LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 51.7 FT-LBF GRAPH NAME = 2IEK250L
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 300 DEG. F.

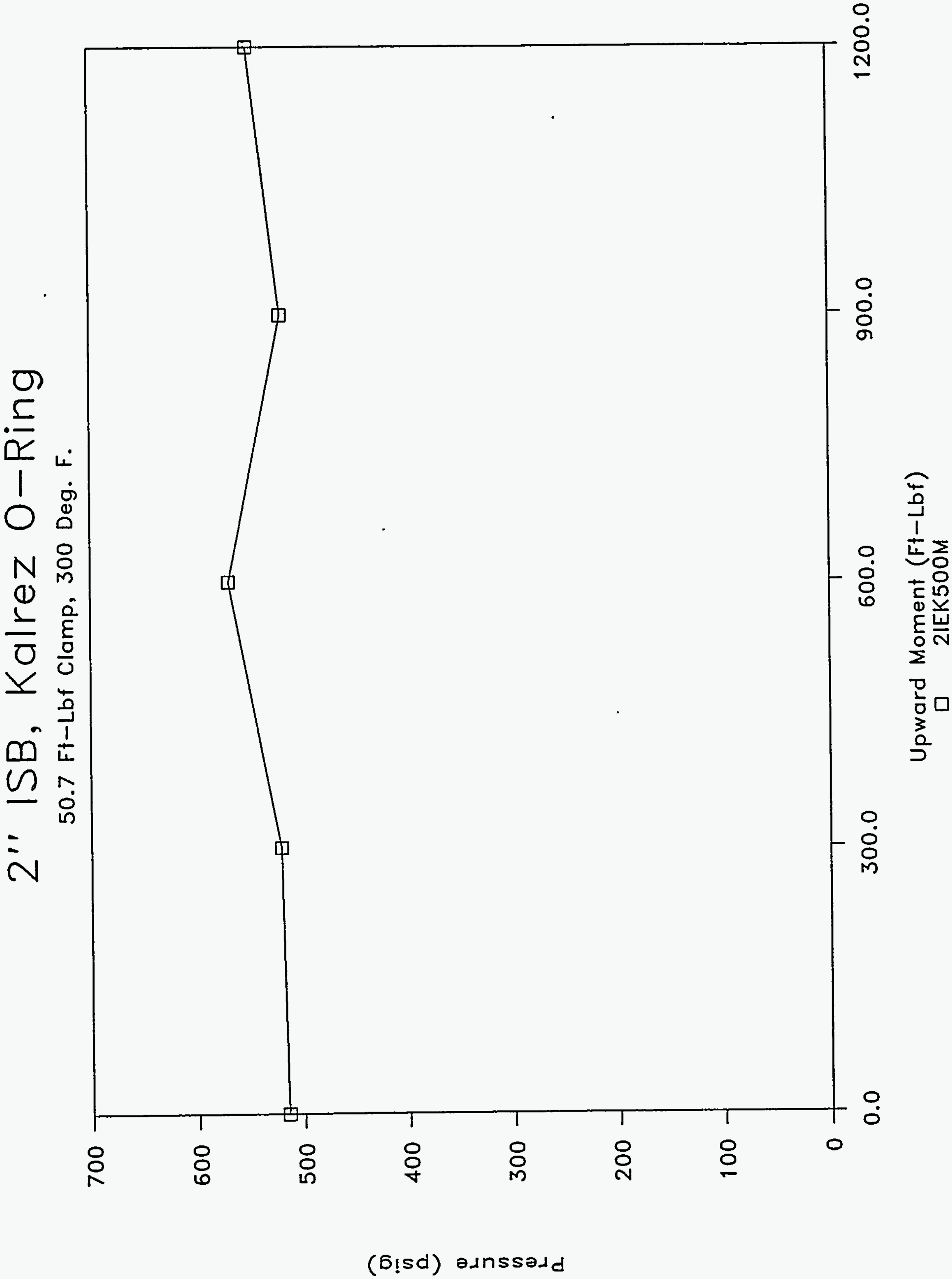
NOTE: THIS TEST WAS PERFORMED AT 300 DEG. F. INSTEAD OF 400 DEG. F. PREVIOUS TESTS WITH KALREZ SHOWED THAT THE O-RING SUSTAINED DEFORMATION DAMAGE AND LEAKED AT 400 DEG. F. and 1,000 PSIG.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
250	0	0	0.00	0	0.4453	0.0
230	2	2	2.03	0	0.4453	0.0
215	4	1	4.02	250	0.4453	111.3
200	6	5	6.08	500	0.4453	222.7
195	8	1	8.02	750	0.4453	334.0
200	10	2	10.03	1000	0.4453	445.3
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = 2IEK500L		
500	12	1	12.02	0	0.4453	0.0
525	14	1	14.02	200	0.4453	89.1
495	16	1	16.02	400	0.4453	178.1
520	18	2	18.03	600	0.4453	267.2
500	20	2	20.03	800	0.4453	356.3
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = 2IEK750L		
765	22	2	22.03	0	0.4453	0.0
790	24	1	24.02	150	0.4453	66.8
775	26	3	26.05	300	0.4453	133.6
770	28	1	28.02	450	0.4453	200.4
770	30	2	30.03	600	0.4453	267.2
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = 2IEK100L		
1045	32	2	32.03	0	0.4453	0.0
1025	34	1	34.02	100	0.4453	44.5
1020	36	3	36.05	200	0.4453	89.1
1000	38	2	38.03	300	0.4453	133.6
1025	40	4	40.07	370	0.4453	164.8

2" ISB, Kalrez O-Ring

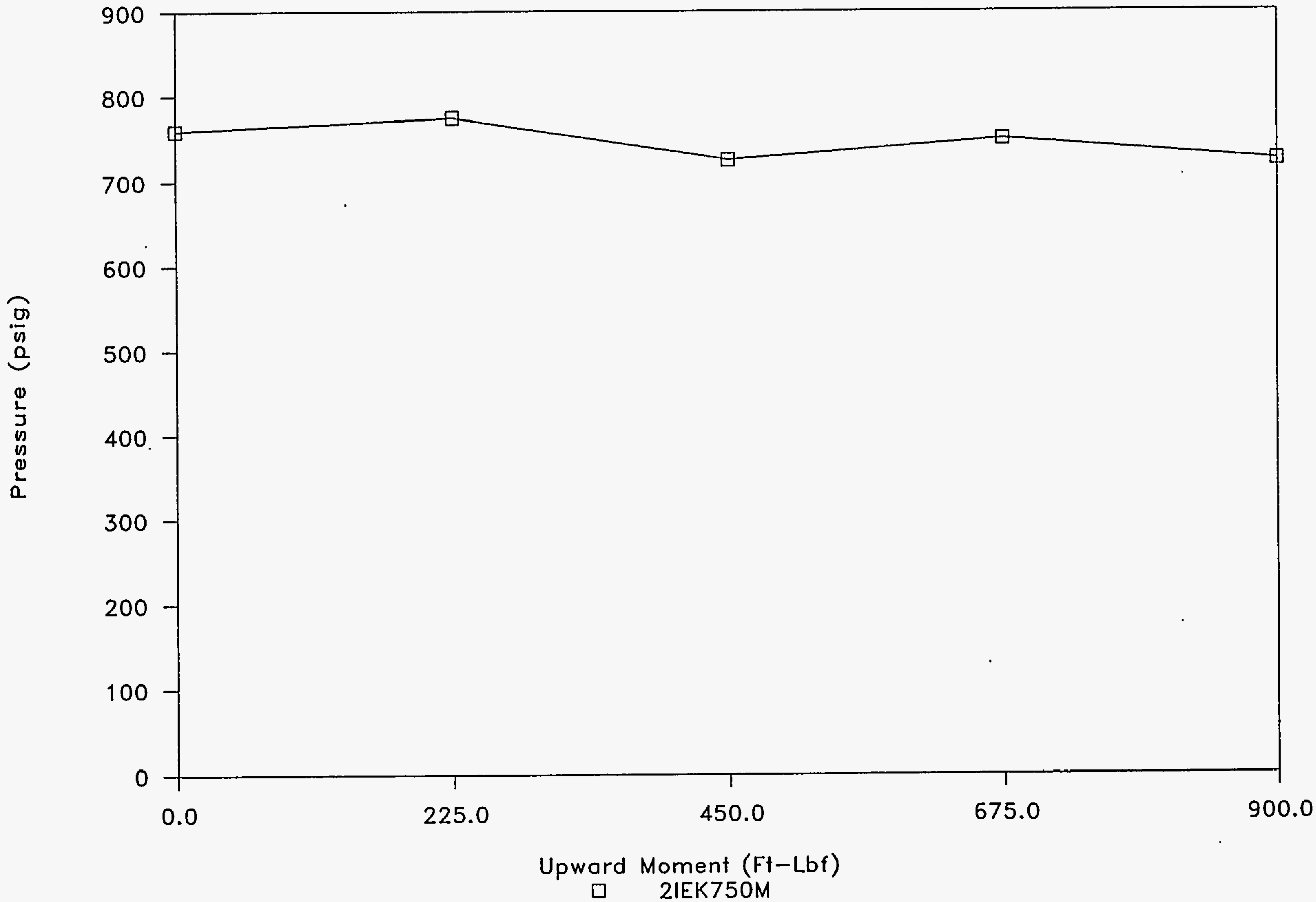
50.7 Ft-Lbf Clamp, 300 Deg. F.

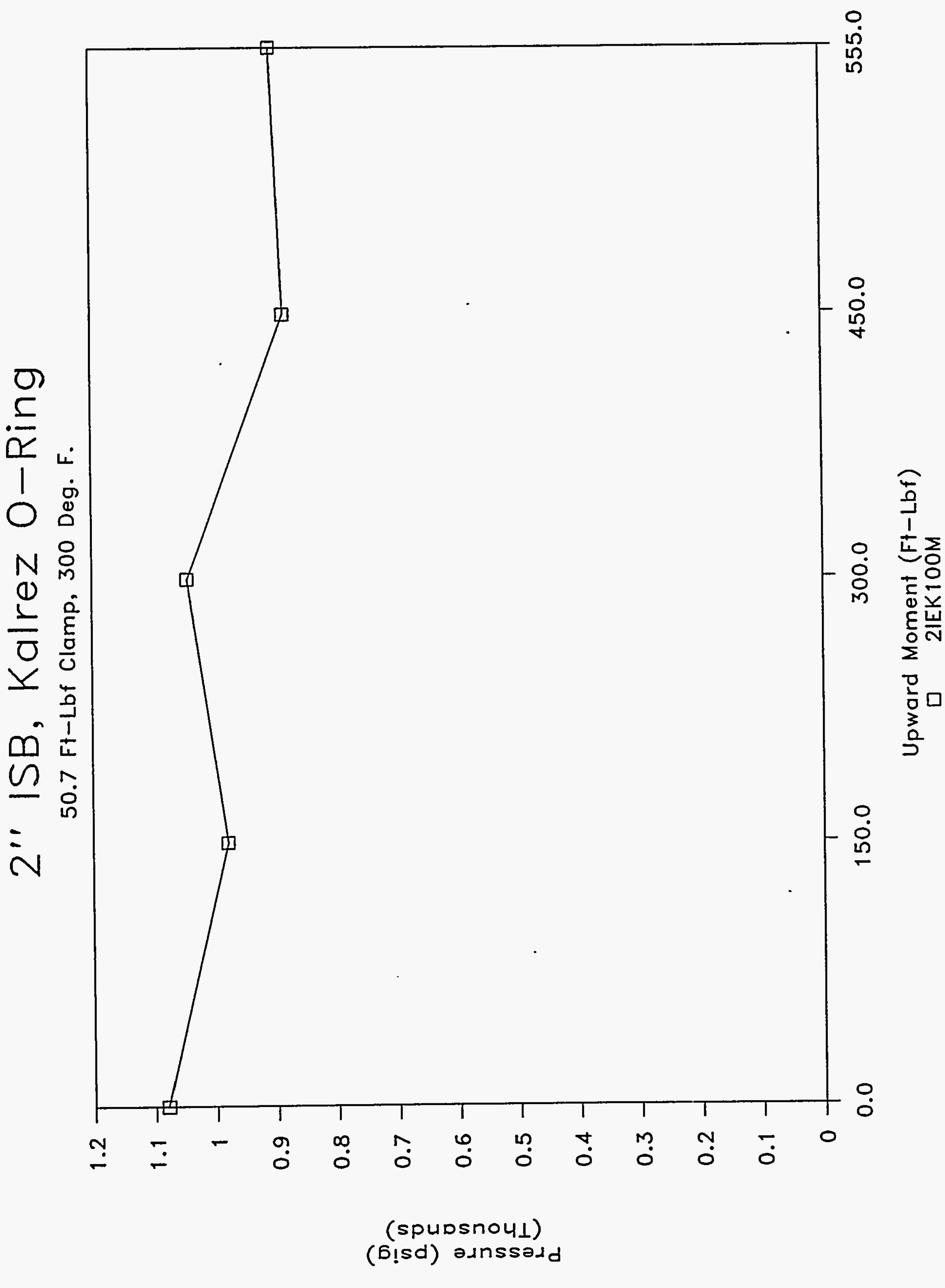



2'' ISB, Kalrez O-Ring
50.7 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft-Lbf)
2IEK500M

2" ISB, Kalrez O-Ring

50.7 Ft-Lbf Clamp, 300 Deg. F.




2'' ISB, Kalrez O-Ring
50.7 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
150.0
300.0
450.0
555.0
Upward Moment (Ft-Lbf)
2IEK100M

OCTOBER 04, 1994
2" ISB CONNECTOR, KALREZ O-RING, 70 DUROMETER, ELEVATED TEMP.
LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 50.7 FT-LBF GRAPH NAME = 2IEK250M
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 300 DEG. F.

NOTE: THIS TEST WAS PERFORMED AT 300 DEG. F. INSTEAD OF 400 DEG. F. PREVIOUS TESTS WITH KALREZ SHOWED THAT THE O-RING SUSTAINED DEFORMATION DAMAGE AND LEAKED AT 400 DEG. F. and 1,000 PSIG.

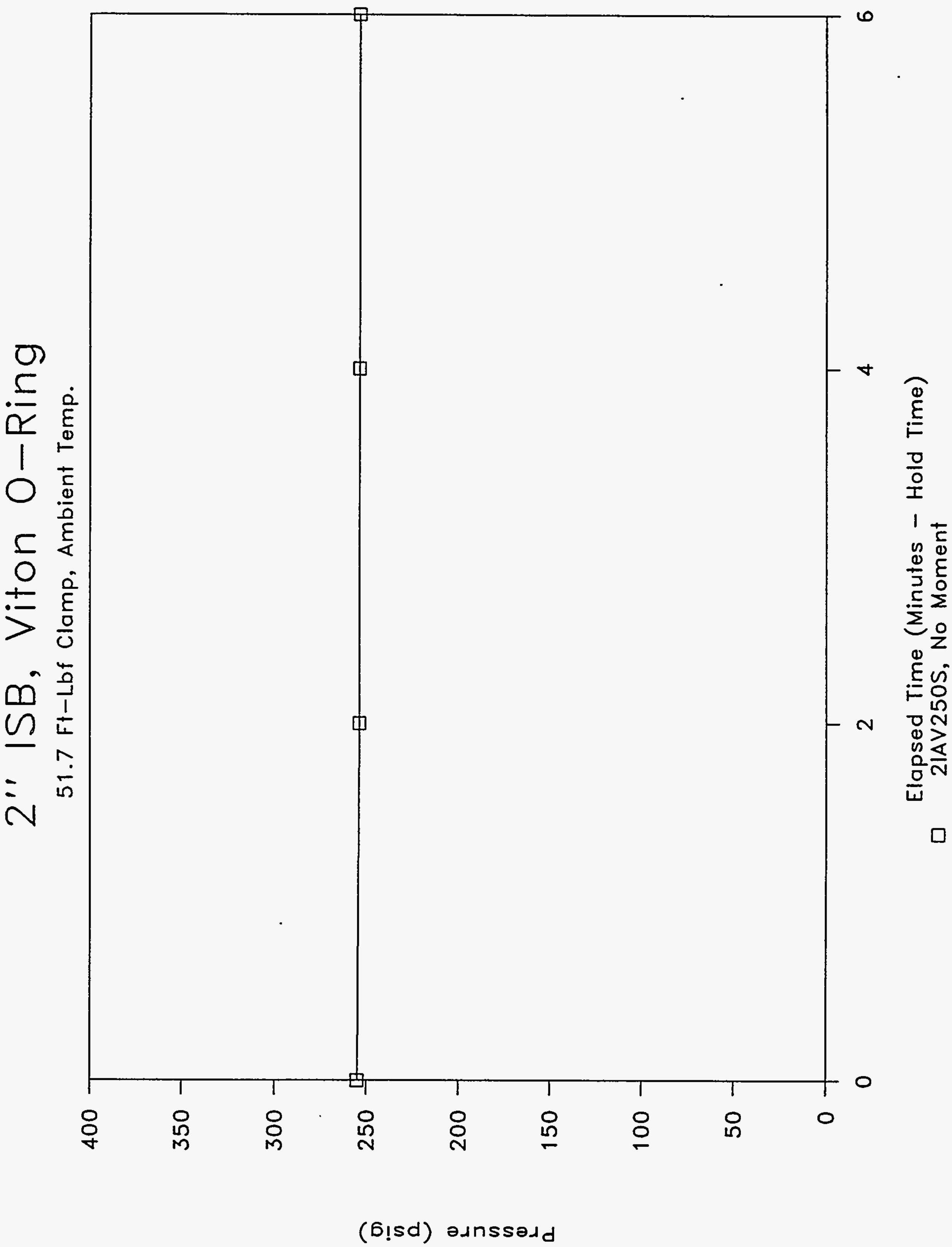
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
250	0	0	0.00	0	1.5000	0.0
235	2	1	2.02	0	1.5000	0.0
175	4	1	4.02	250	1.5000	375.0
198	6	2	6.03	500	1.5000	750.0
200	8	1	8.02	750	1.5000	1125.0
196	10	1	10.02	1000	1.5000	1500.0
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = 2IEK500M		
515	12	3	12.05	0	1.5000	0.0
521	14	1	14.02	200	1.5000	300.0
570	16	2	16.03	400	1.5000	600.0
520	18	1	18.02	600	1.5000	900.0
550	20	1	20.02	800	1.5000	1200.0
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = 2IEK750M		
760	22	1	22.02	0	1.5000	0.0
775	24	2	24.03	150	1.5000	225.0
725	26	2	26.03	300	1.5000	450.0
750	28	2	28.03	450	1.5000	675.0
725	30	1	30.02	600	1.5000	900.0
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = 2IEK100M		
1080	32	1	32.02	0	1.5000	0.0
980	34	3	34.05	100	1.5000	150.0
1045	36	1	36.02	200	1.5000	300.0
885	38	1	38.02	300	1.5000	450.0
905	40	2	40.03	370	1.5000	555.0

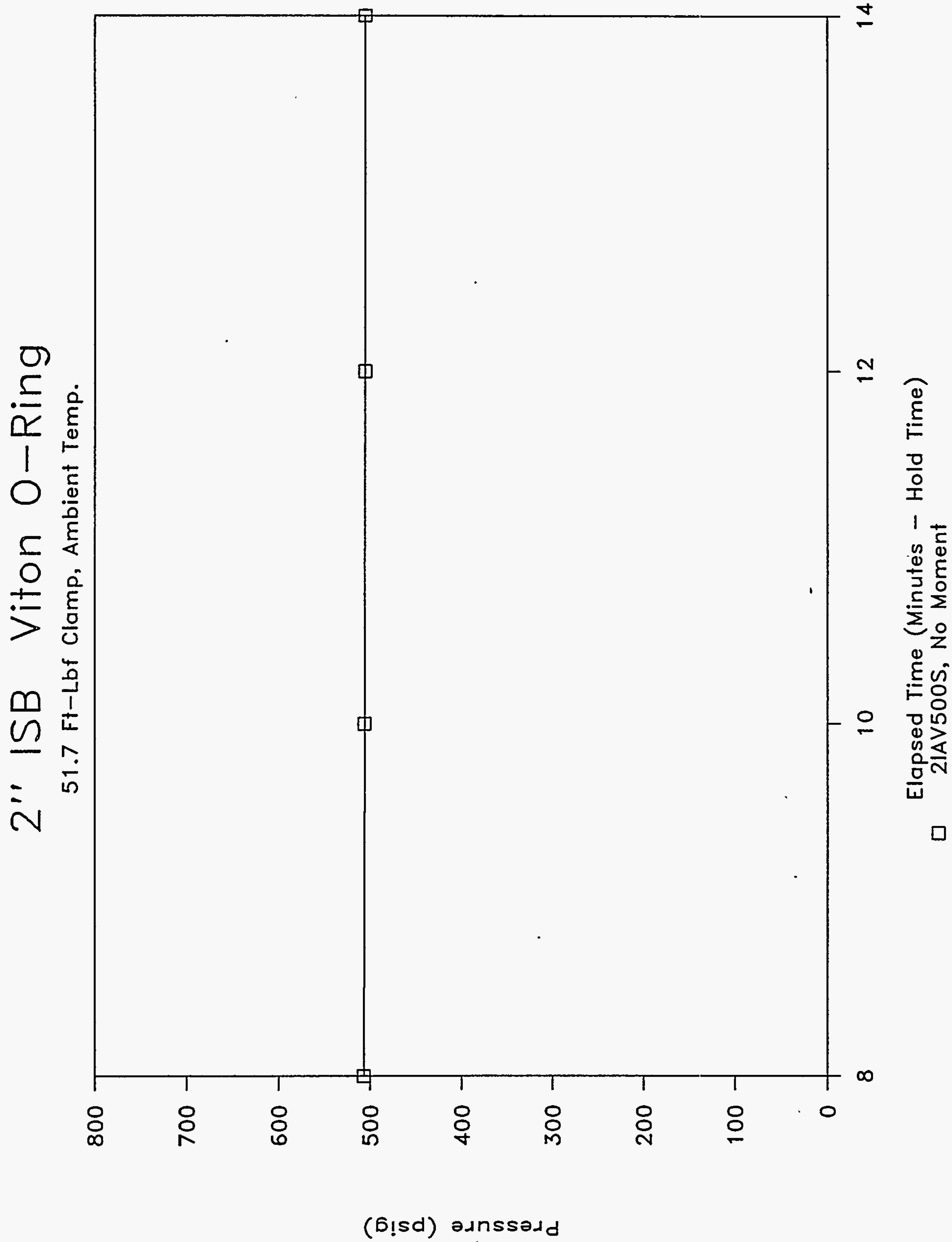
APPENDIX G: GRAPHS OF 2-IN. VITON TESTS

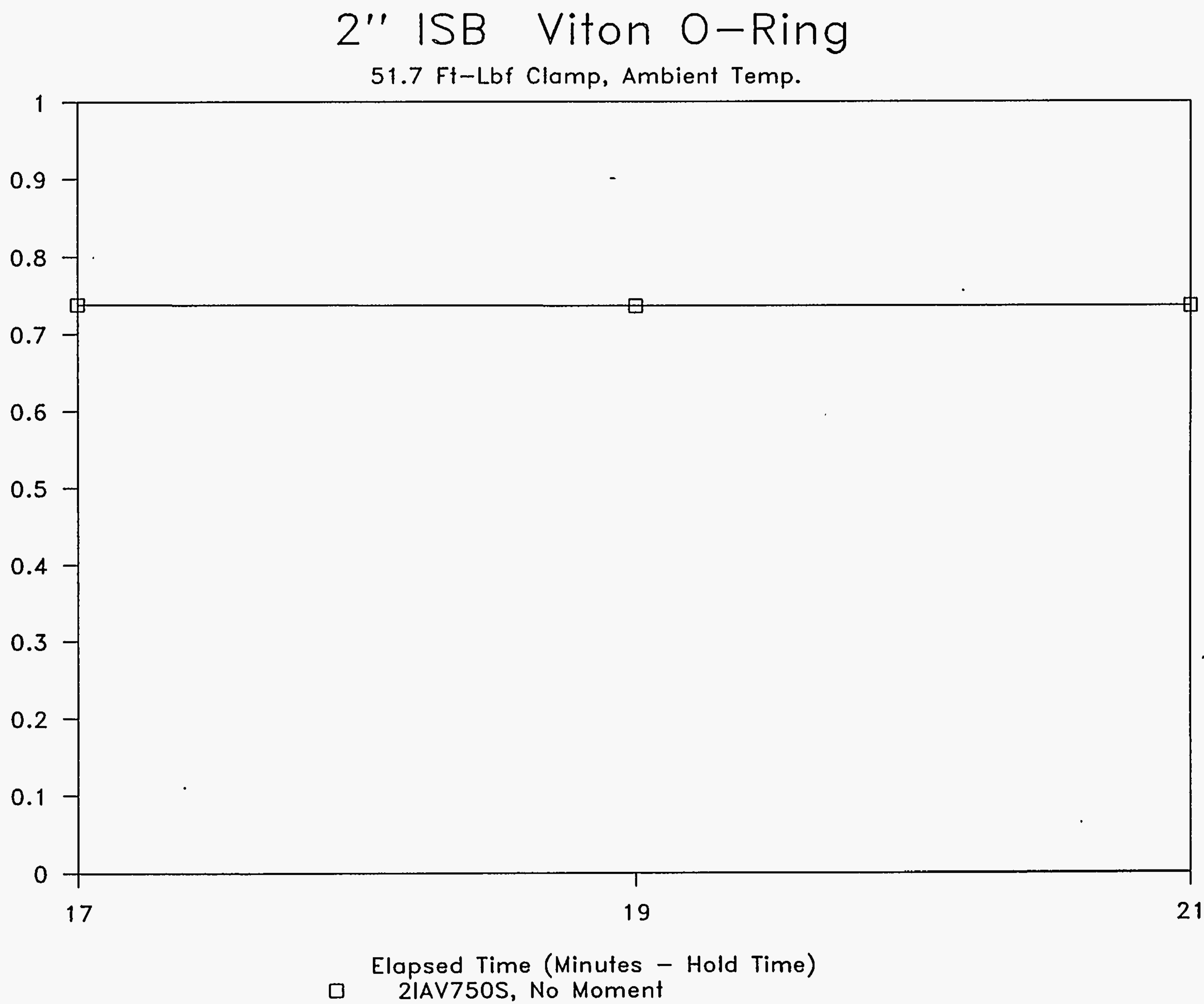
JUNE 09, 1994
2" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - NO MOMENT APPLIED
CLAMPING TORQUE = 50.3 FT-LBF
CHARGE PRESSURE 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	APPLIED FORCE LBS INPUT	PRESSURE HOLD CONDITION INPUT
270	0	0	0.00	0	HOLD
270	2	5	2.08	0	HOLD
500	5	43	5.72	0	HOLD
720	9	17	9.28	0	LEAK
					INCREASED PRESSURE TO 750 PSIG
755	11	3	11.05	0	LEAK
740	13	29	13.48	0	LEAK
730	14	34	14.57	0	LEAK
730	15	32	15.53	0	HOLD
					INCREASED PRESSURE TO 1000 PSIG
1020	19	50	19.83	0	LEAK
950	21	52	21.87	0	LEAK

THE TEST WAS TERMINATED DUE TO PRESSURE LOSS.
IT WAS DETERMINED THAT THE PRESSURE LOSSES WERE DUE TO A LEAKING VALVE IN THE SYSTEM.

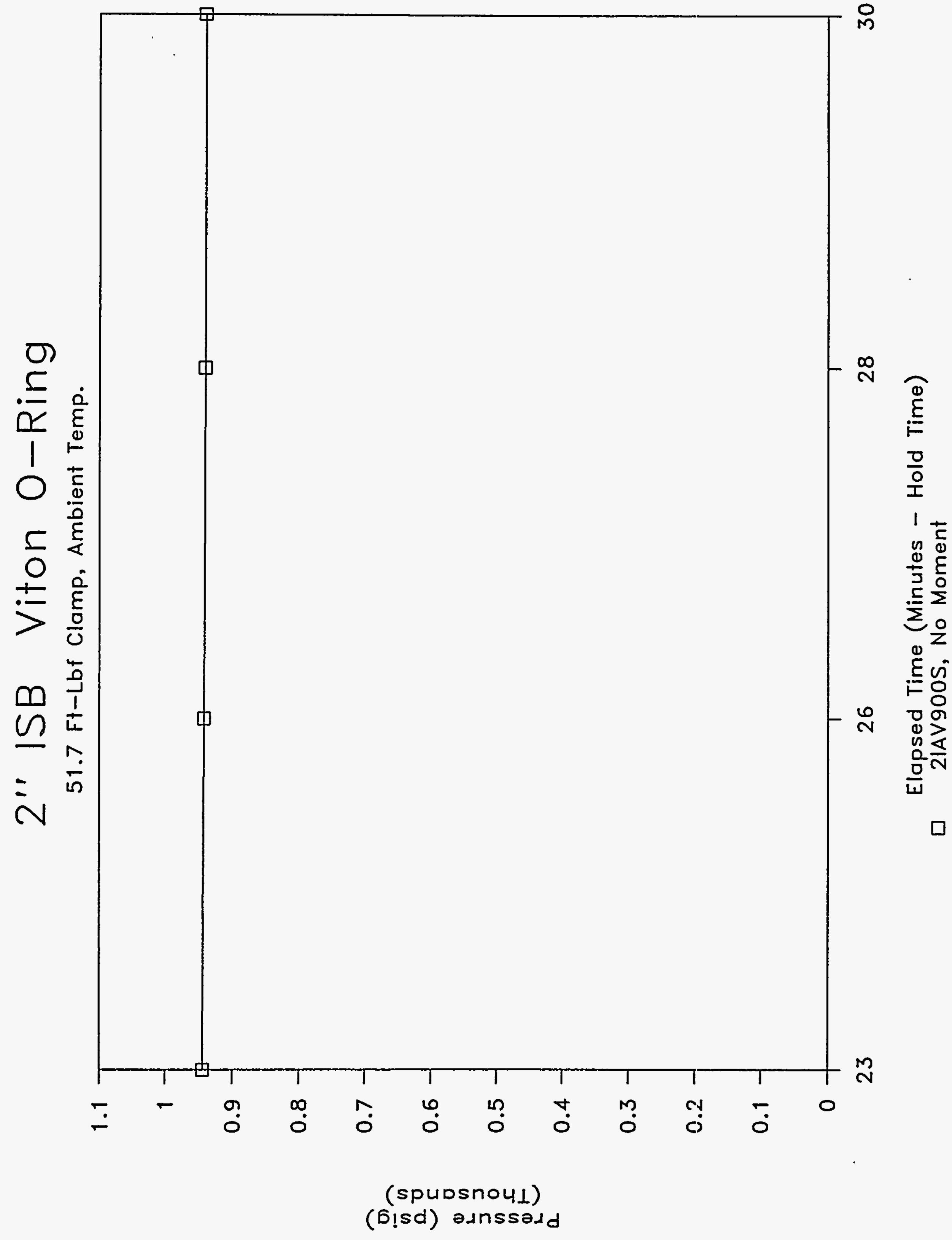

2" ISB, Viton O-Ring
51.7 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
400
350
300
250
200
150
100
50
0
0
2
4
6
Elapsed Time (Minutes - Hold Time)
21AV250S, No Moment


2'' ISB Viton O-Ring
51.7 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
0
100
200
300
400
500
600
700
800
8
10
12
14
Elapsed Time (Minutes - Hold Time)
2IAV500S, No Moment



2" ISB Viton O-Ring
51.7 Ft-Lbf Clamp, Ambient Temp.
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Pressure (psig)
(Thousands)
17
19
21
Elapsed Time (Minutes - Hold Time)
2IAV750S, No Moment

G-5


2" ISB Viton O-Ring
51.7 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
23
26
28
30
Elapsed Time (Minutes - Hold Time)
2IAV900S, No Moment

JUNE 23, 1994
2" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - NO MOMENT APPLIED
CLAMPING TORQUE = 51.7 FT-LBF GRAPH NAME = 2IAV250S
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	APPLIED FORCE LBS INPUT
255	0	0	0.00	0
254	2	8	2.13	0
254	4	18	4.30	0
254	6	18	6.30	0

INCREASED PRESSURE TO 500 PSIG. GRAPH NAME = 2IAV500S

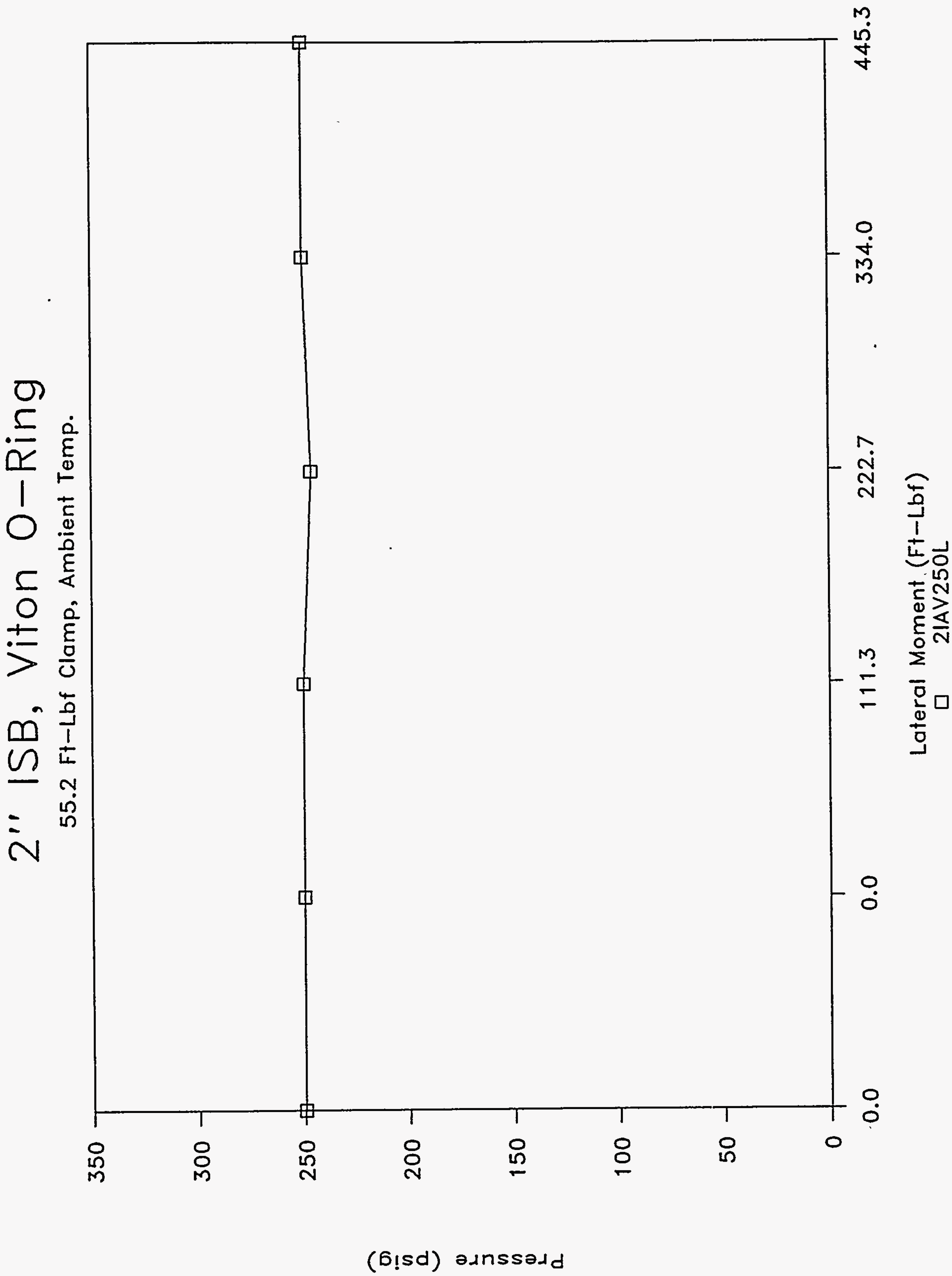
507	8	23	8.38	0
506	10	24	10.40	0
505	12	27	12.45	0
505	14	28	14.47	0

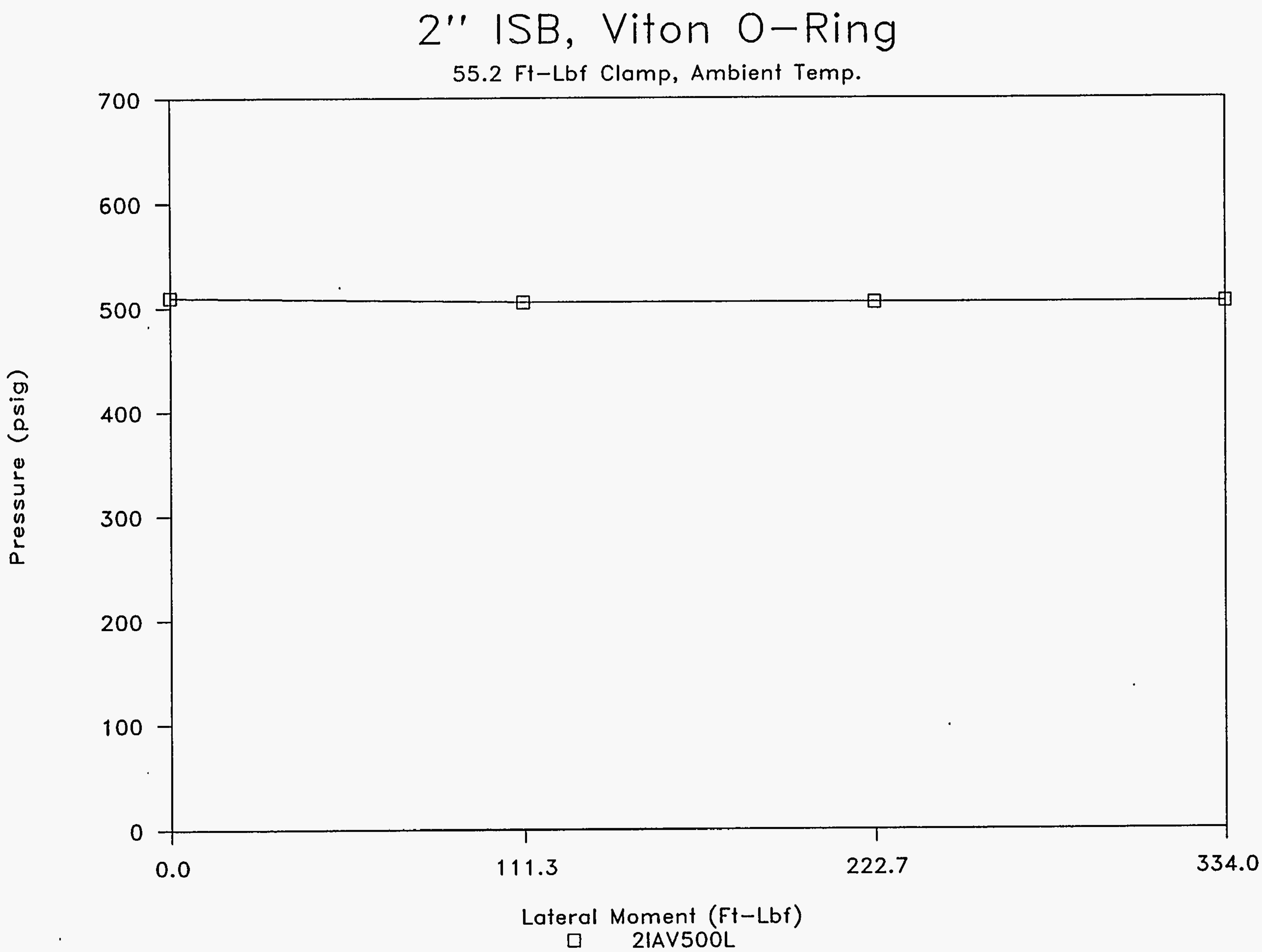
INCREASED PRESSURE TO 750 PSIG. GRAPH NAME = 2IAV750S

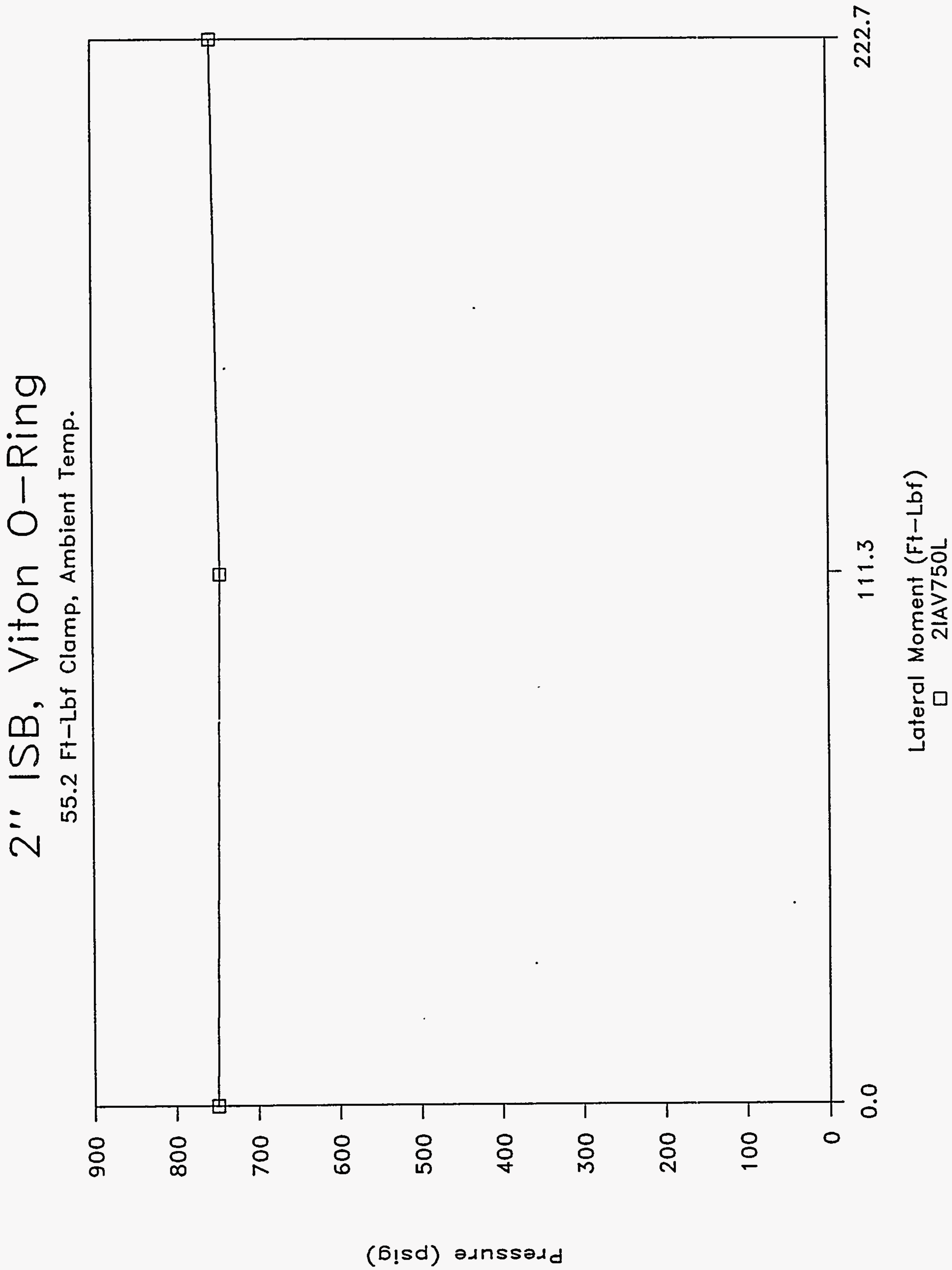
738	17	55	17.92	0
736	19	47	19.78	0
736	21	51	21.85	0

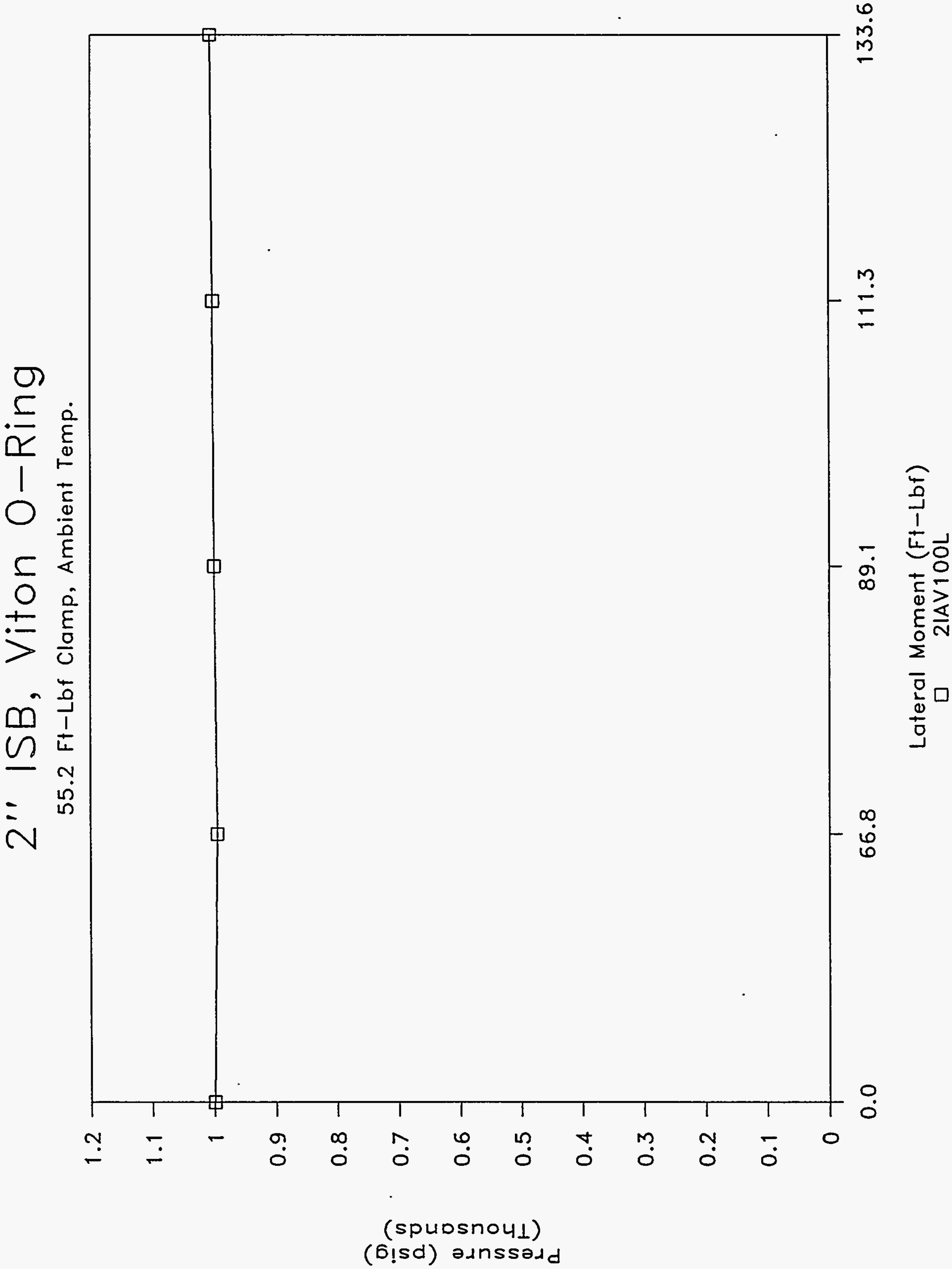
INCREASED PRESSURE TO 900 PSIG. GRAPH NAME = 2IAV900S

945	23	51	23.85	0
943	26	2	26.03	0
941	28	10	28.17	0
941	30	10	30.17	0


2" ISB, Viton O-Ring
55.2 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
350
300
250
200
150
100
50
0
0.0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
2IAV250L


2" ISB, Viton O-Ring
55.2 Ft-Lbf Clamp, Ambient Temp.
700
600
500
400
300
200
100
0
Pressure (psig)
0.0
111.3
222.7
334.0
Lateral Moment (Ft-Lbf)
2IAV500L


2'' ISB, Viton O-Ring
55.2 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
111.3
222.7
Lateral Moment (Ft-Lbf)
2IAV750L


2" ISB, Viton O-Ring
55.2 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
66.8
89.1
111.3
133.6
Lateral Moment (Ft-Lbf)
2IAV100L

JULY 26, 1994
2" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 55.2 FT-LBF GRAPH NAME = 2IAV250L
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
250	0	0	0.00	0	0.4453	0.0
250	2	2	2.03	0	0.4453	0.0
250	4	17	4.28	250	0.4453	111.3
246	6	5	6.08	500	0.4453	222.7
250	8	7	8.12	750	0.4453	334.0
250	10	2	10.03	1000	0.4453	445.3

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = 2IAV500L

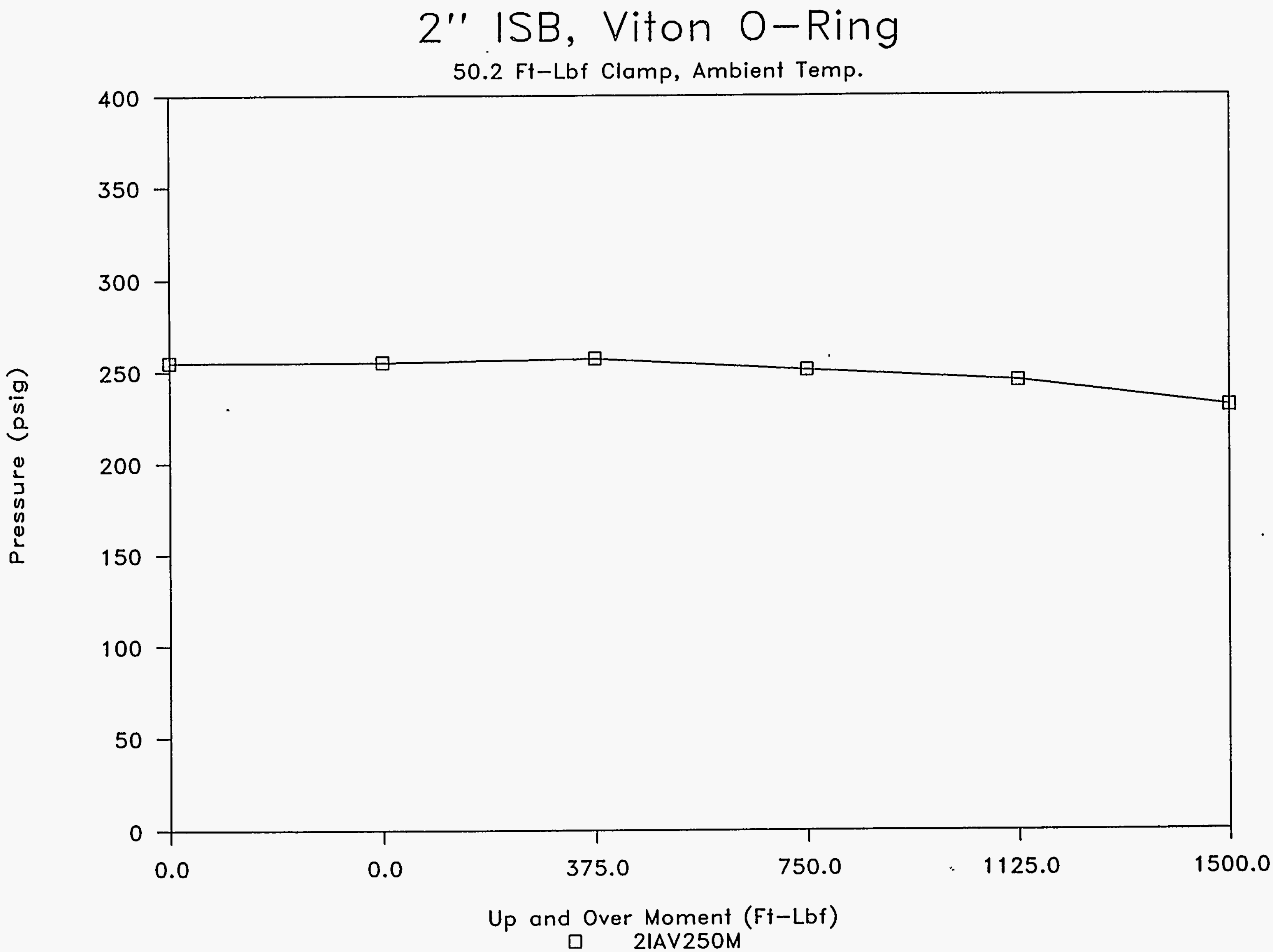
510	12	4	12.07	0	0.4453	0.0
505	14	3	14.05	250	0.4453	111.3
505	16	10	16.17	500	0.4453	222.7
505	18	3	18.05	750	0.4453	334.0

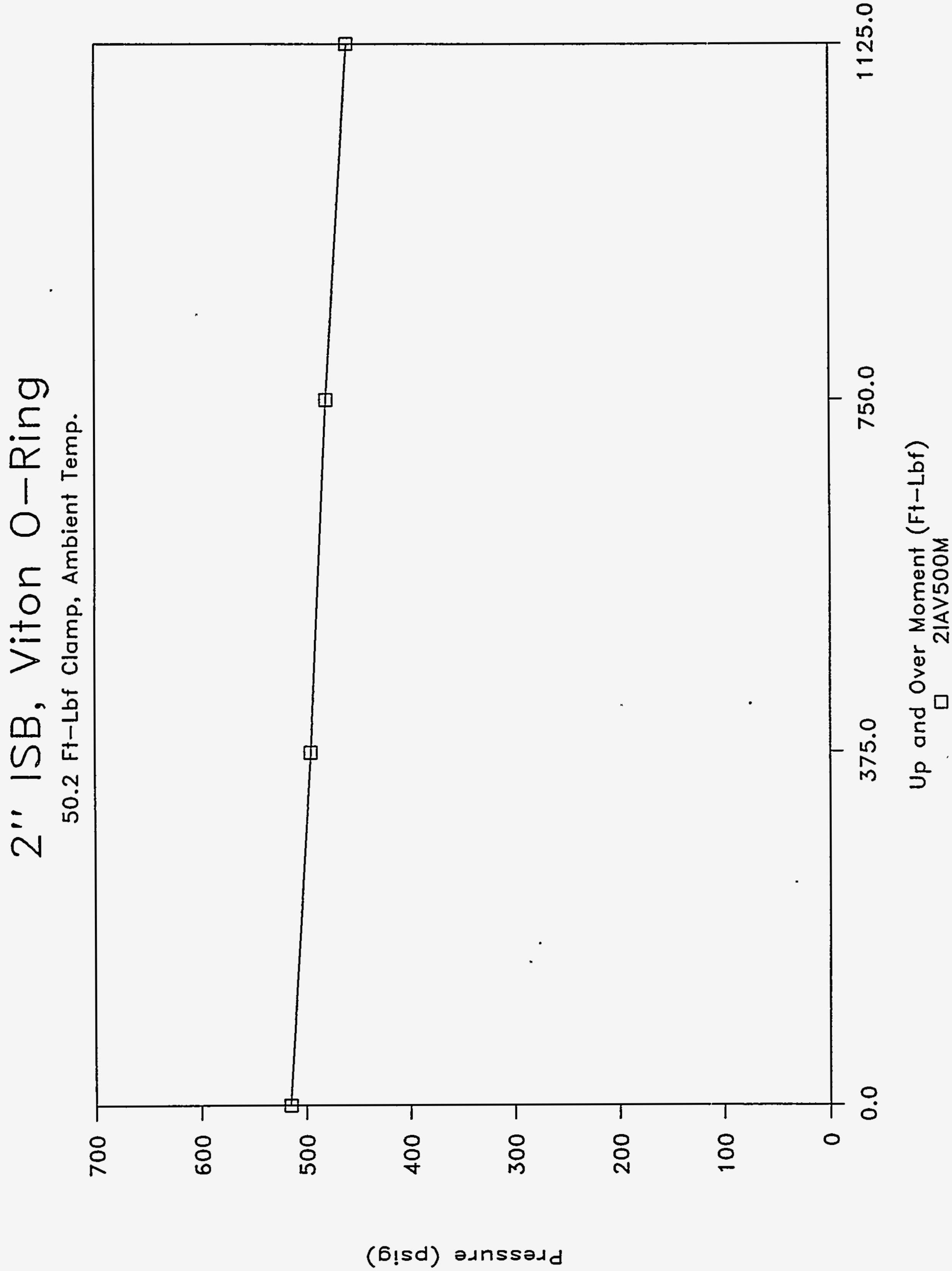
INCREASED PRESSURE TO 750 PSIG GRAPH NAME = 2IAV750L

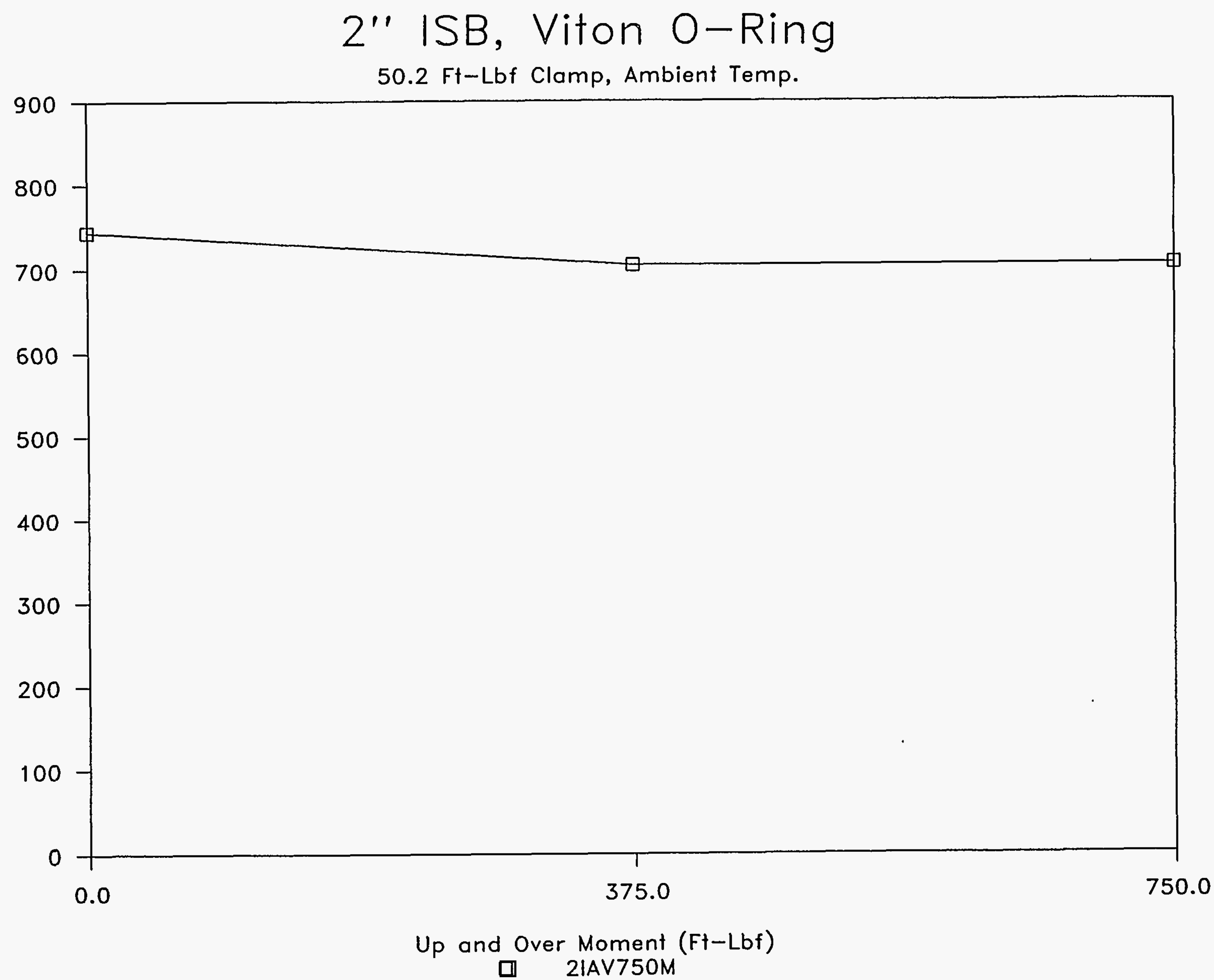
750	20	2	20.03	0	0.4453	0.0
745	22	8	22.13	250	0.4453	111.3
755	24	4	24.07	500	0.4453	222.7

INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = 2IAV1000L

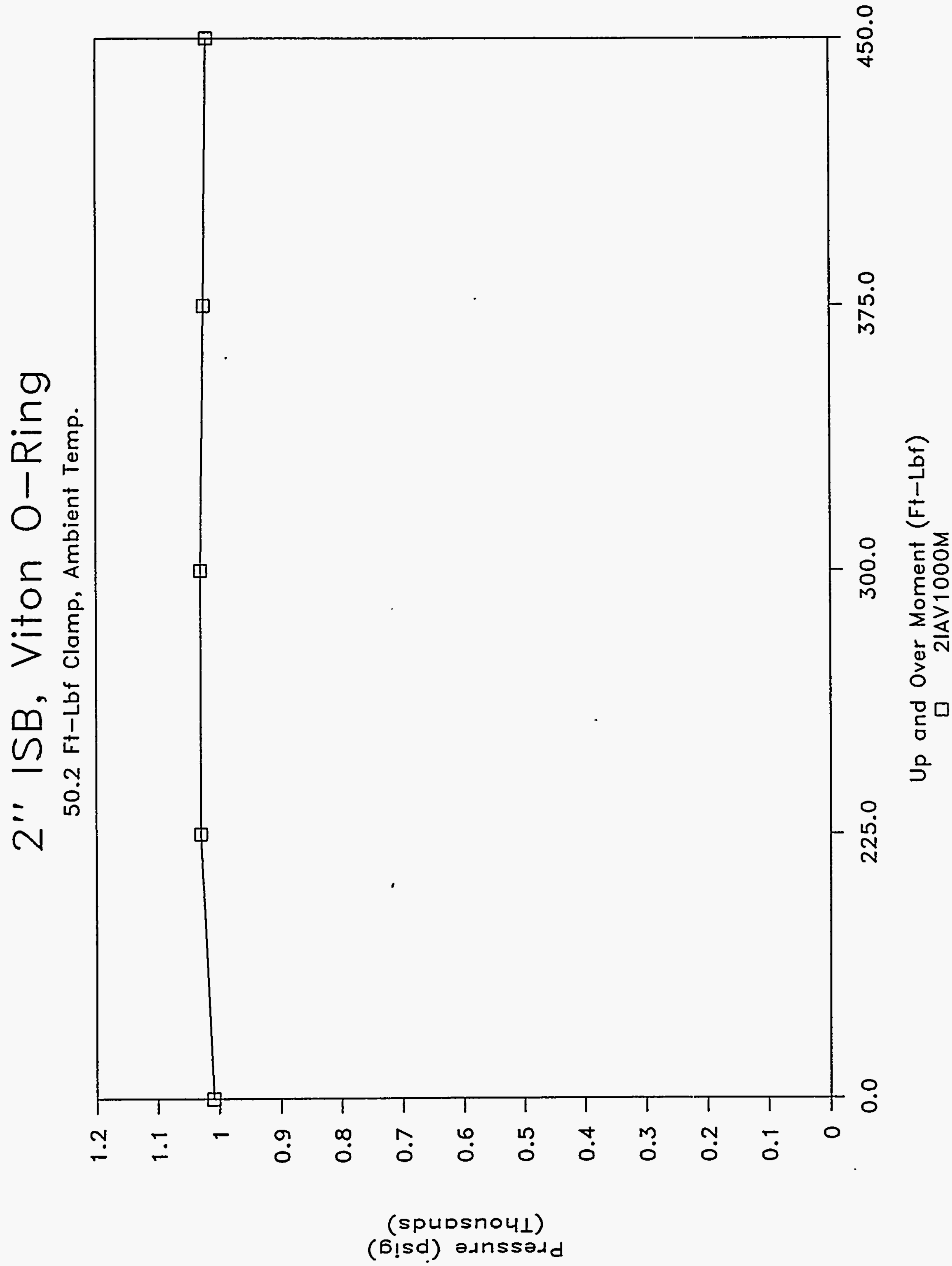
1000	26	11	26.18	0	0.4453	0.0
995	28	3	28.05	150	0.4453	66.8
1000	30	11	30.18	200	0.4453	89.1
1002	32	8	32.13	250	0.4453	111.3
1006	34	15	34.25	300	0.4453	133.6


2" ISB, Viton O-Ring
50.2 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
400
350
300
250
200
150
100
50
0
0.0
0.0
375.0
750.0
1125.0
1500.0
Up and Over Moment (Ft-Lbf)
2IAV250M


2'' ISB, Viton O-Ring
50.2 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
375.0
750.0
1125.0
Up and Over Moment (Ft-Lbf)
2IAV500M

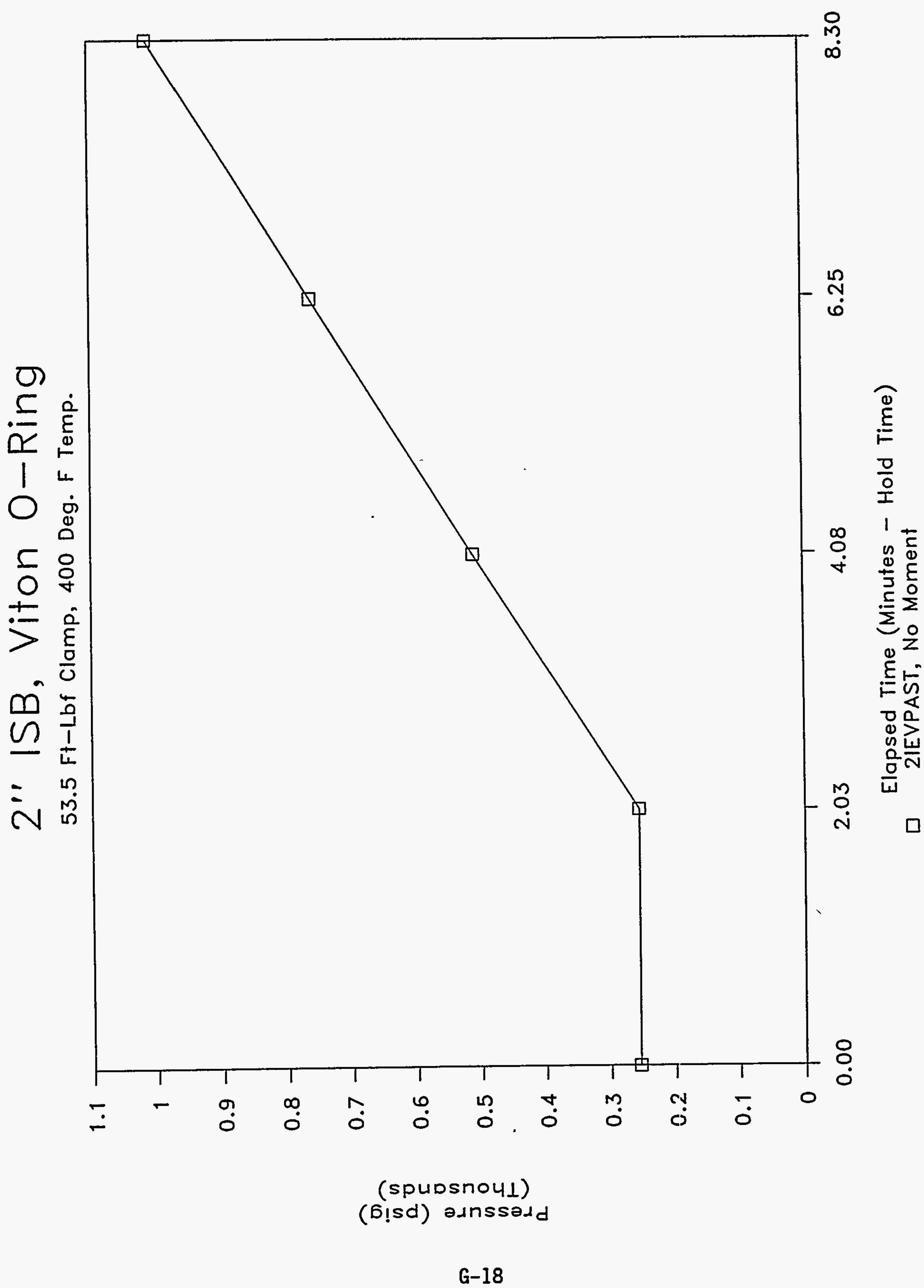


2" ISB, Viton O-Ring
50.2 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
375.0
750.0
Up and Over Moment (Ft-Lbf)
2IAV750M


2" ISB, Viton O-Ring
50.2 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
225.0
300.0
375.0
450.0
Up and Over Moment (Ft-Lbf)
2IAV1000M

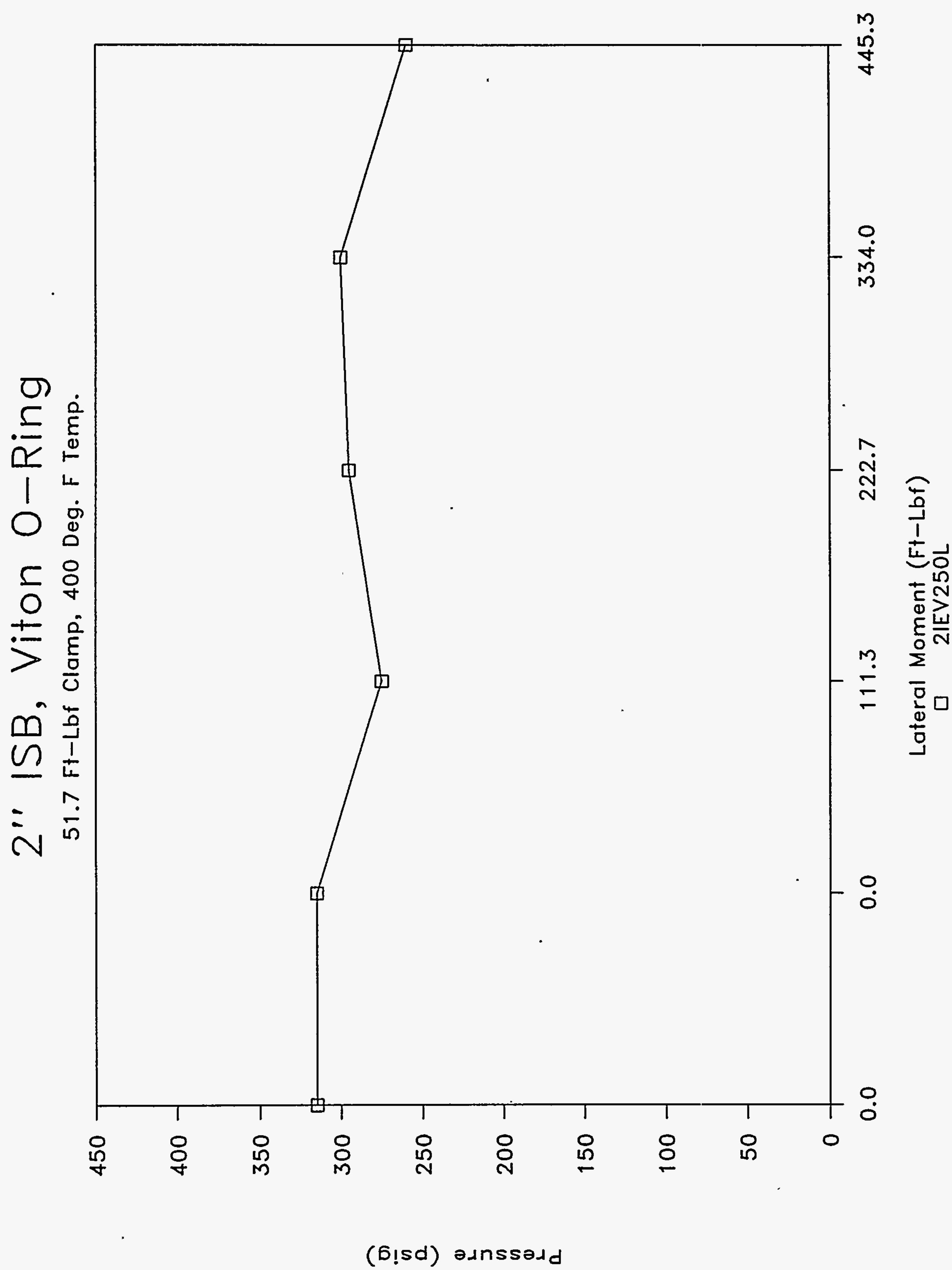
JULY 25, 1994
2" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 50.2 FT-LBF GRAPH NAME = 2IAV250M
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
255	0	0	0.00	0	1.5000	0.0
255	2	2	2.03	0	1.5000	0.0
257	4	3	4.05	250	1.5000	375.0
251	6	5	6.08	500	1.5000	750.0
245	8	1	8.02	750	1.5000	1125.0
231	10	5	10.08	1000	1.5000	1500.0
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = 2IAV500M		
515	12	2	12.03	0	1.5000	0.0
495	14	9	14.15	250	1.5000	375.0
480	16	2	16.03	500	1.5000	750.0
460	18	3	18.05	750	1.5000	1125.0
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = 2IAV750M		
745	20	4	20.07	0	1.5000	0.0
705	22	4	22.07	250	1.5000	375.0
705	24	6	24.10	500	1.5000	750.0
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = 2IAV1000M		
1010	26	10	26.17	0	1.5000	0.0
1030	28	4	28.07	150	1.5000	225.0
1030	30	4	30.07	200	1.5000	300.0
1025	32	16	32.27	250	1.5000	375.0
1020	34	6	34.10	300	1.5000	450.0


2" ISB, Viton O-Ring
53.5 Ft-Lbf Clamp, 400 Deg. F Temp.
Pressure (psig)
(Thousands)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.00
2.03
4.08
6.25
8.30
Elapsed Time (Minutes - Hold Time)
2IEVPAST, No Moment

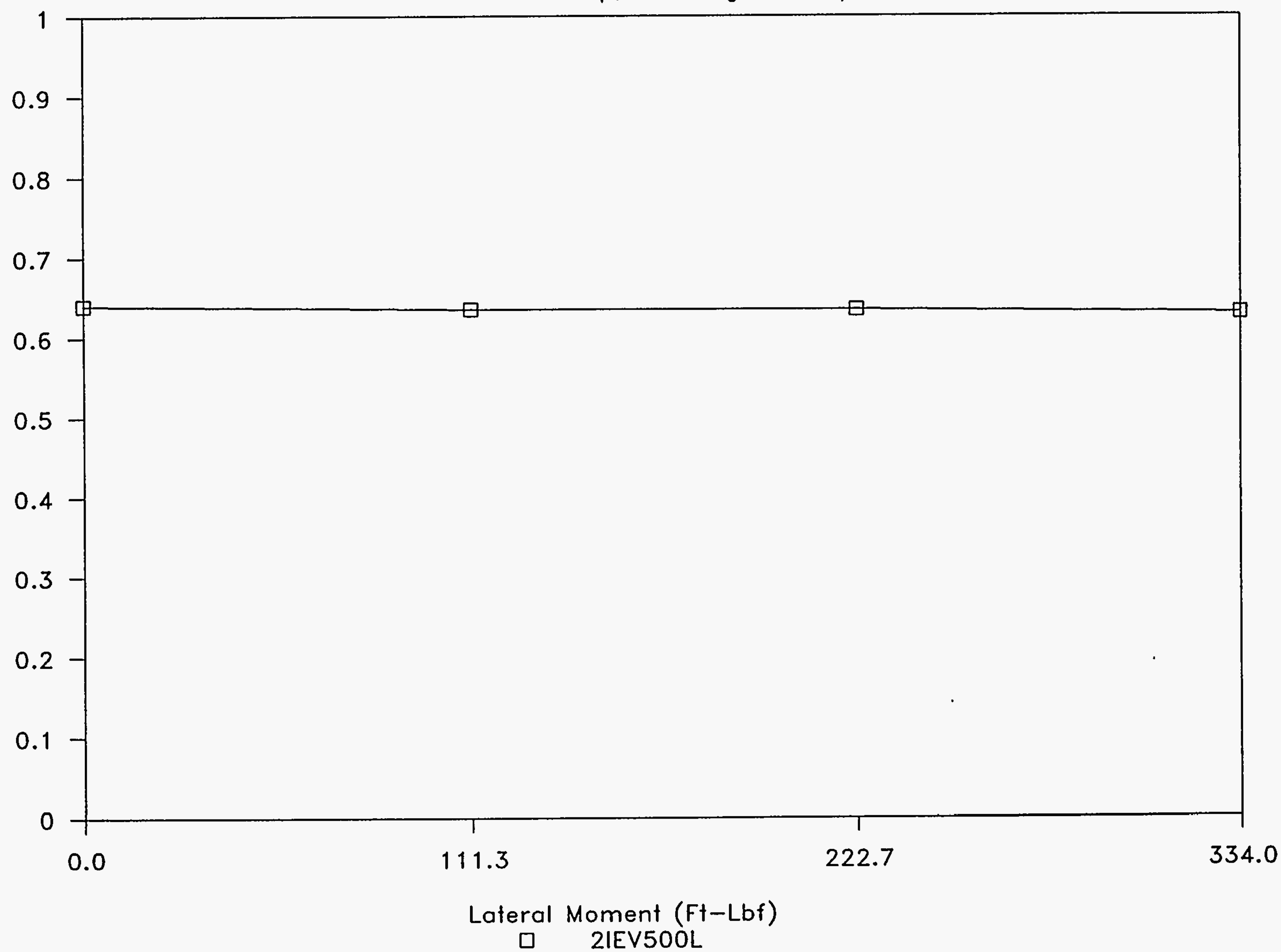
JULY 27, 1994
2" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, ELEVATED TEMP.
PRESSURE ASCENSION LEAK TEST - NO MOMENT APPLIED
CLAMPING TORQUE = 53.5 FT-LBF GRAPH NAME = 2IEVPAST
CHARGE PRESSURE = 250 PSIG TO 1000 PSIG
TEMPERATURE = 400 Deg. F

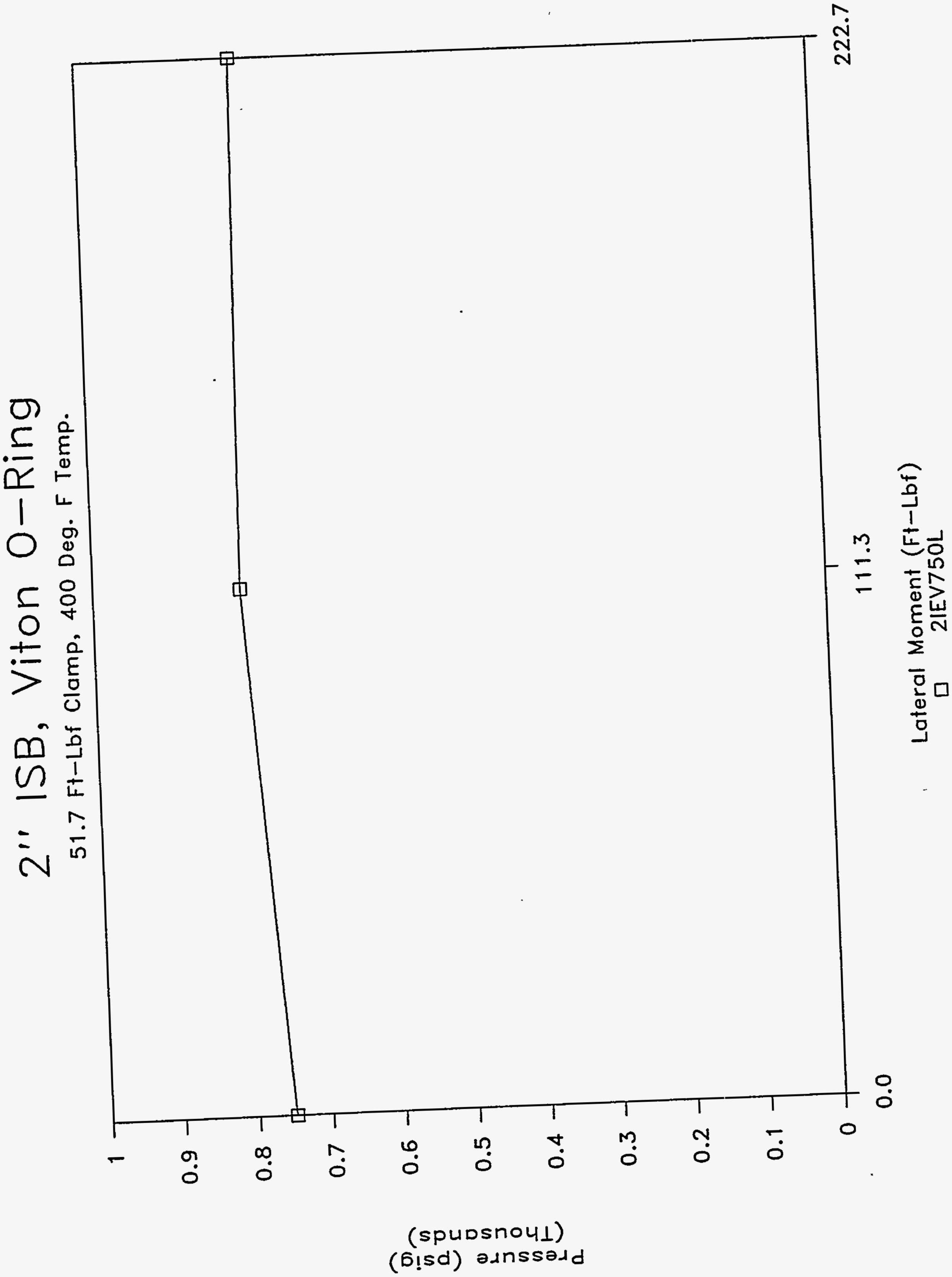
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	APPLIED FORCE LBS INPUT
255	0	0	0.00	0
255	2	2	2.03	0
510	4	5	4.08	0
760	6	15	6.25	0
1010	8	18	8.30	0

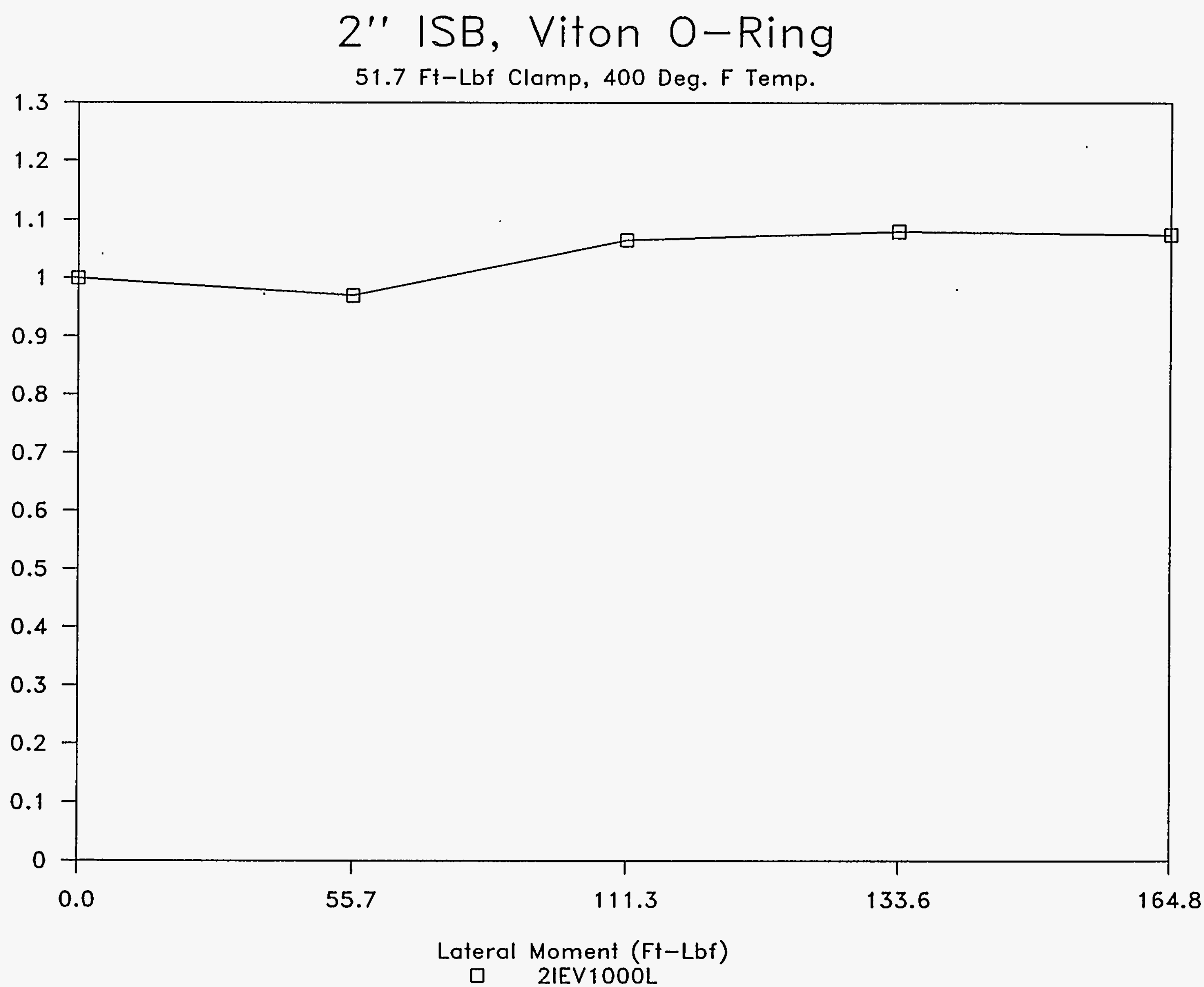

2" ISB, Viton O–Ring
51.7 Ft–Lbf Clamp, 400 Deg. F Temp.
Pressure (psig)
450
400
350
300
250
200
150
100
50
0
0.0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft–Lbf)
2IEV250L

2" ISB, Viton O-Ring

51.7 Ft-Lbf Clamp, 400 Deg. F Temp.

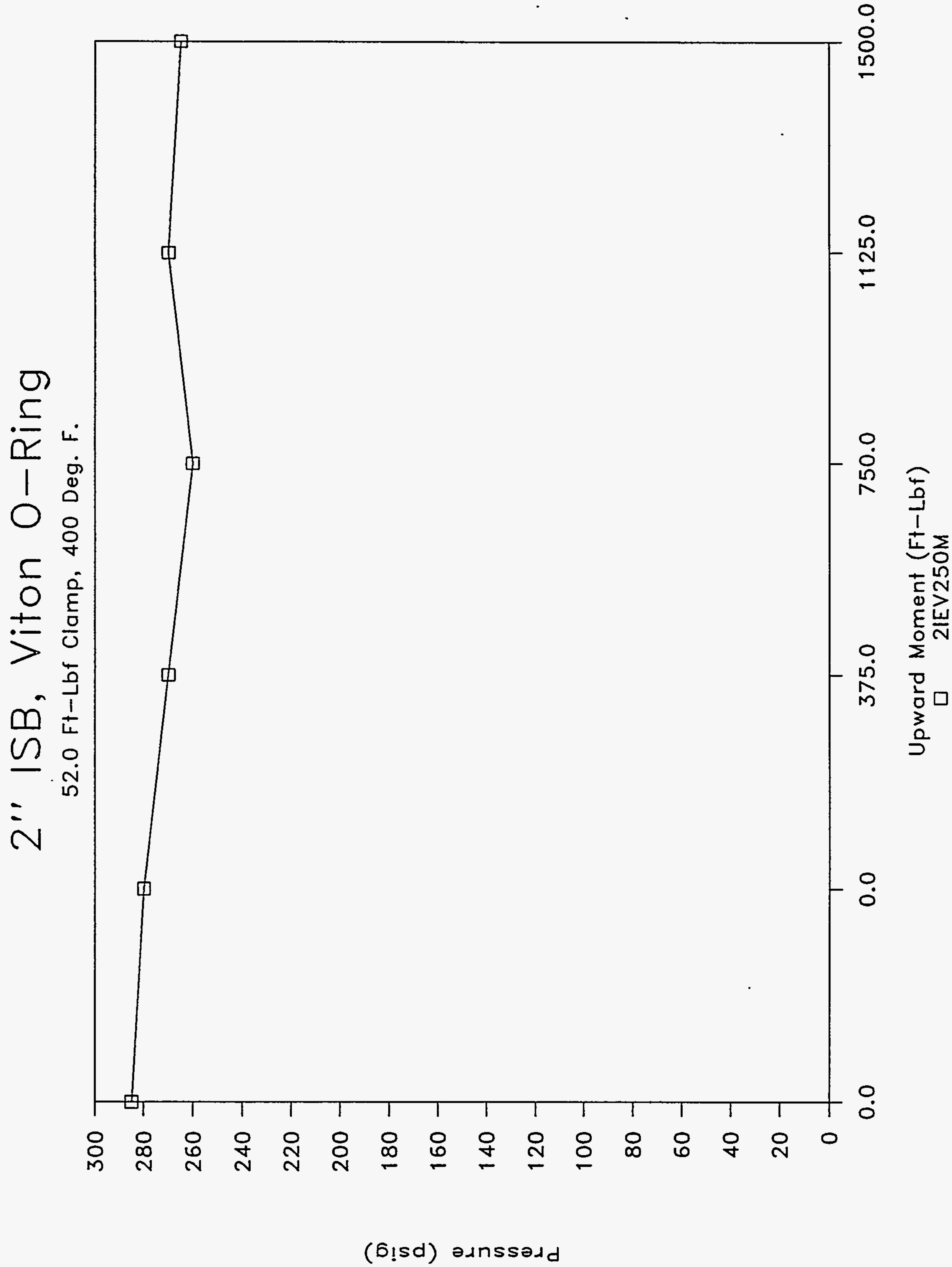


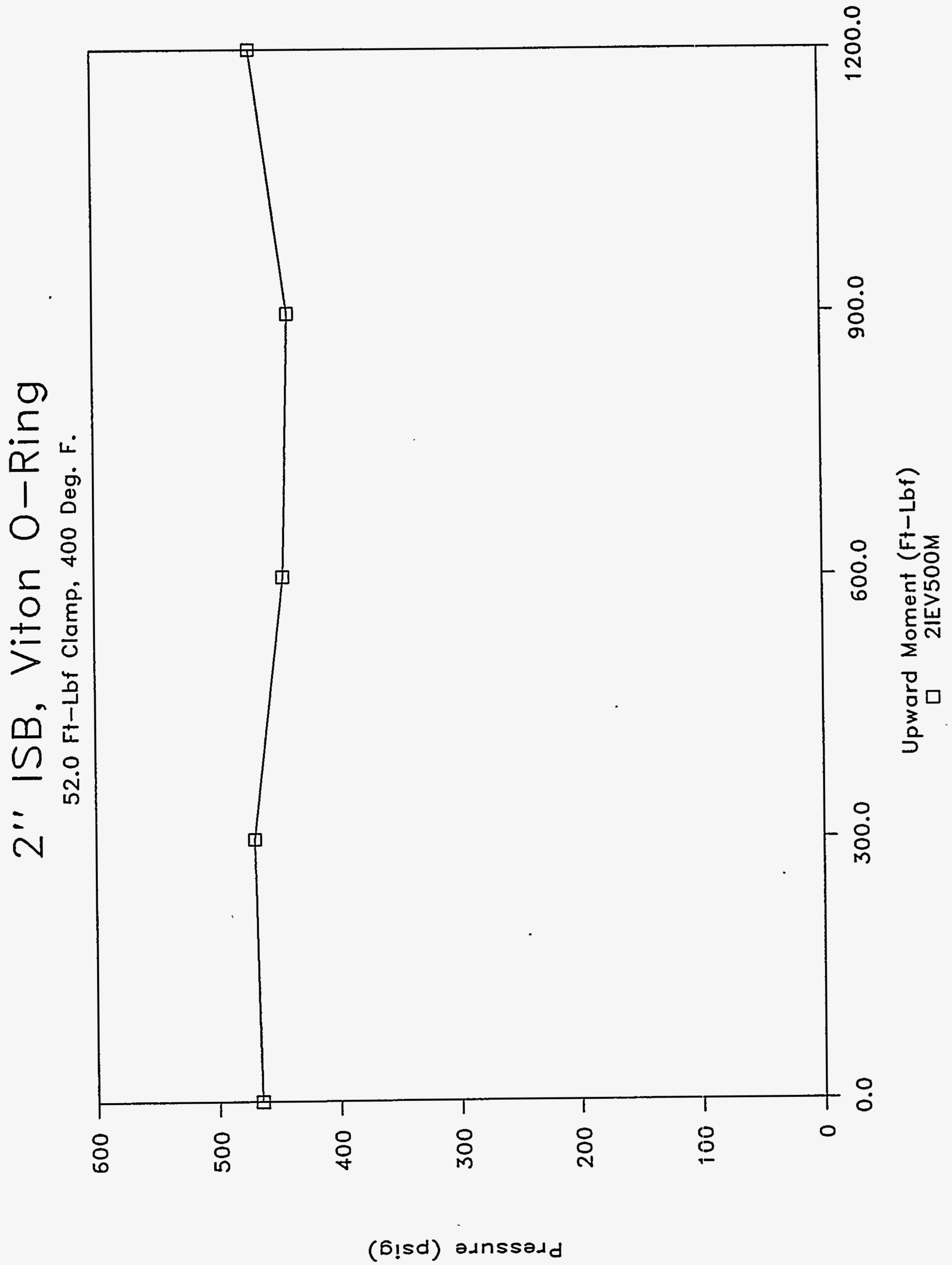

2'' ISB, Viton O-Ring
51.7 Ft-Lbf Clamp, 400 Deg. F Temp.
Pressure (psig)
(Thousands)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
111.3
222.7
Lateral Moment (Ft-Lbf)
2IEV750L


2" ISB, Viton O-Ring
51.7 Ft-Lbf Clamp, 400 Deg. F Temp.
Pressure (psig)
(Thousands)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
55.7
111.3
133.6
164.8
Lateral Moment (Ft-Lbf)
2IEV1000L

AUGUST 01, 1994
2" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, ELEVATED TEMP.
PRESSURE ASCENSION LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 51.7 FT-LBF GRAPH NAME = 2IEV250L
CHARGE PRESSURE = 250 PSIG
TEMPERATURE = 400 DEG. F

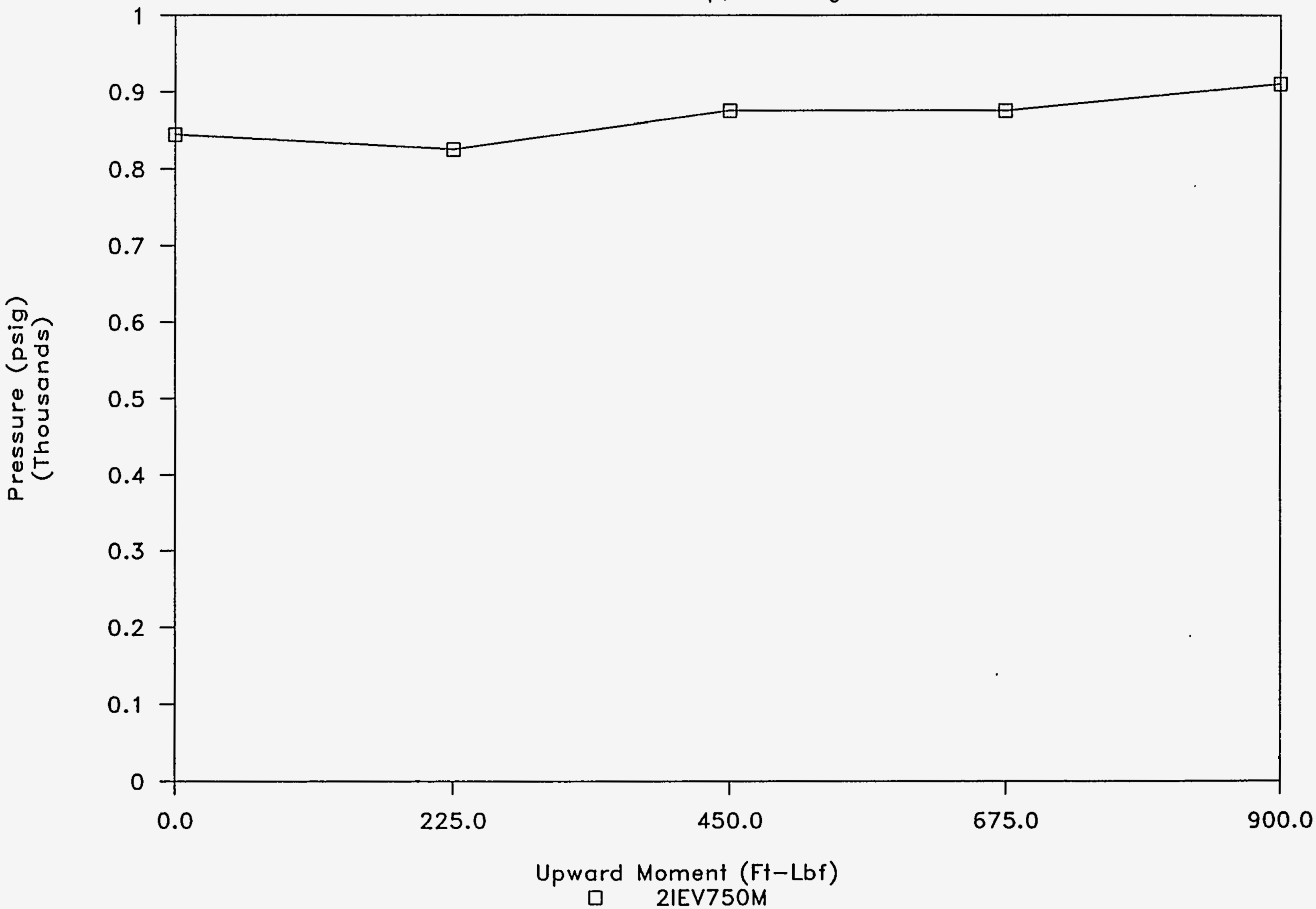
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
315	0	0	0.00	0	0.4453	0.0
315	2	4	2.07	0	0.4453	0.0
275	4	1	4.02	250	0.4453	111.3
295	6	2	6.03	500	0.4453	222.7
300	8	2	8.03	750	0.4453	334.0
260	10	5	10.08	1000	0.4453	445.3
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = 2IEV500L		
640	12	2	12.03	0	0.4453	0.0
635	14	4	14.07	250	0.4453	111.3
635	16	1	16.02	500	0.4453	222.7
630	18	2	18.03	750	0.4453	334.0
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = 2IEV750L		
750	20	4	20.07	0	0.4453	0.0
800	22	1	22.02	250	0.4453	111.3
790	24	2	24.03	500	0.4453	222.7
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = 2IEV1000L		
1000	26	2	26.03	0	0.4453	0.0
970	28	3	28.05	125	0.4453	55.7
1065	30	2	30.03	250	0.4453	111.3
1080	32	3	32.05	300	0.4453	133.6
1075	34	6	34.10	370	0.4453	164.8

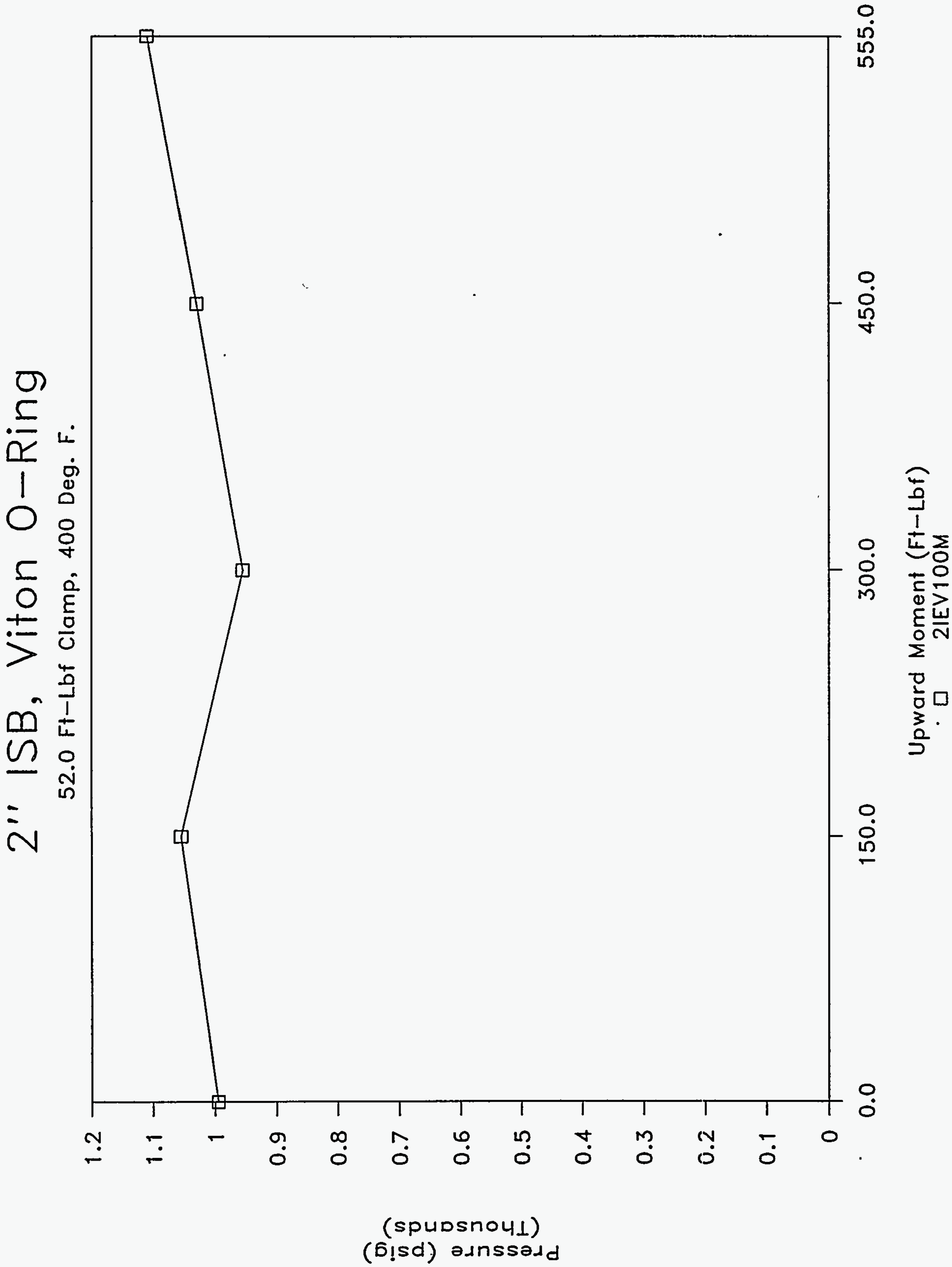

2" ISB, Viton O-Ring
52.0 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
0.0
0.0
375.0
750.0
1125.0
1500.0
Upward Moment (Ft-Lbf)
2IEV250M


2" ISB, Viton O-Ring
52.0 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
600
500
400
300
200
100
0
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft-Lbf)
2IEV500M

2" ISB, Viton O-Ring

52.0 Ft-Lbf Clamp, 400 Deg. F.




2" ISB, Viton O—Ring
52.0 Ft—Lbf Clamp, 400 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
150.0
300.0
450.0
555.0
Upward Moment (Ft—Lbf)
2IEV100M

NOVEMBER 14, 1994
2" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, ELEVATED TEMP.
PART # 2-142 V884-75, PARKER SEAL CO., BATCH 311986, CURE DATE 3Q93
LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 52.0 FT-LBF GRAPH NAME = 2IEV250M
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 400 DEG. F.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
285	0	0	0.00	0	1.5000	0.0
280	2	1	2.02	0	1.5000	0.0
270	4	1	4.02	250	1.5000	375.0
260	6	2	6.03	500	1.5000	750.0
270	8	0	8.00	750	1.5000	1125.0
265	10	1	10.02	1000	1.5000	1500.0

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = 2IEV500M

465	12	2	12.03	0	1.5000	0.0
470	14	1	14.02	200	1.5000	300.0
445	16	2	16.03	400	1.5000	600.0
440	18	3	18.05	600	1.5000	900.0
470	20	3	20.05	800	1.5000	1200.0

INCREASED PRESSURE TO "750" PSIG GRAPH NAME = 2IEV750M

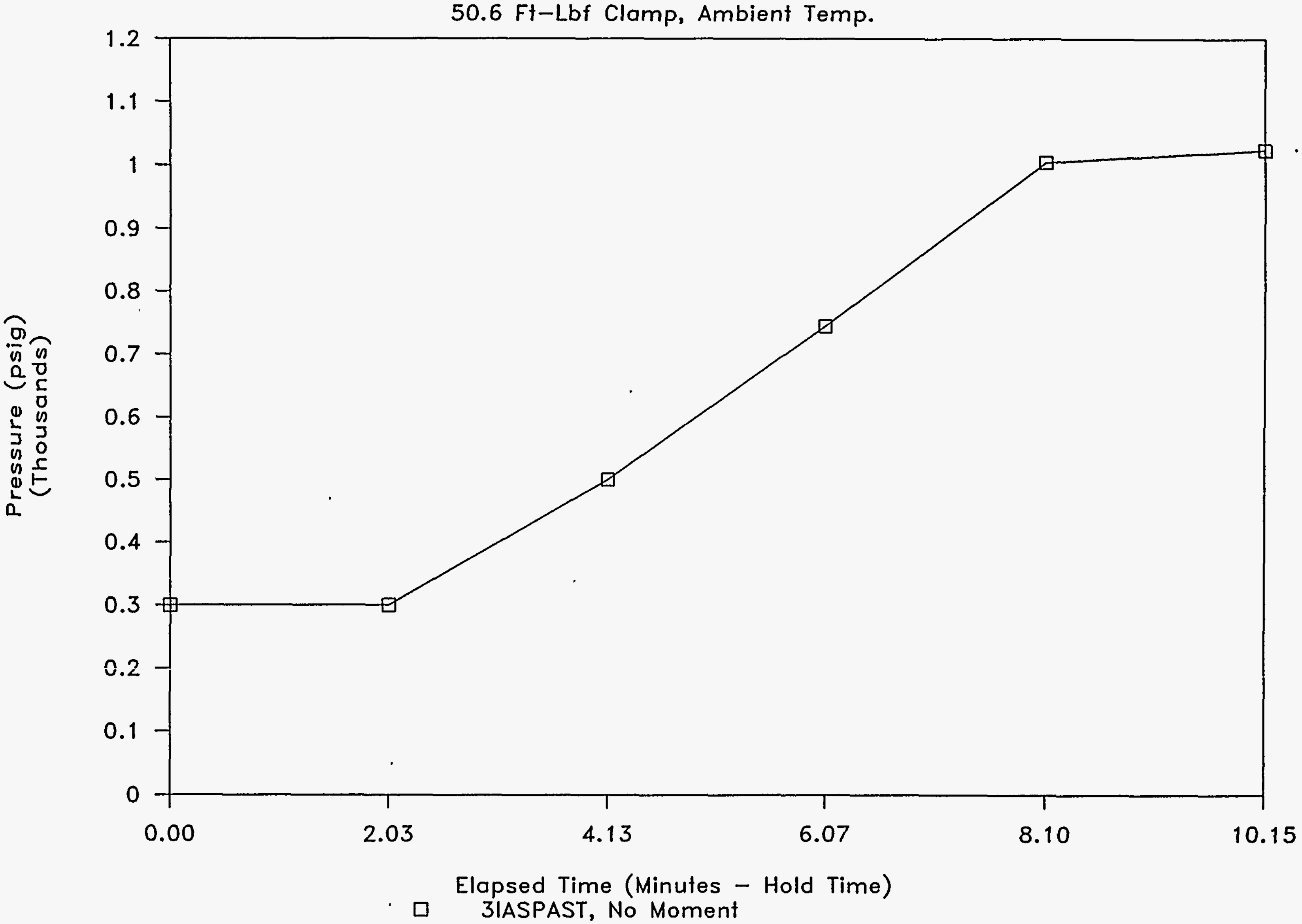
845	22	1	22.02	0	1.5000	0.0
825	24	2	24.03	150	1.5000	225.0
875	26	2	26.03	300	1.5000	450.0
875	28	1	28.02	450	1.5000	675.0
910	30	2	30.03	600	1.5000	900.0

INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = 2IEV100M

995	32	3	32.05	0	1.5000	0.0
1055	34	1	34.02	100	1.5000	150.0
955	36	2	36.03	200	1.5000	300.0
1030	38	1	38.02	300	1.5000	450.0
1110	40	3	40.05	370	1.5000	555.0

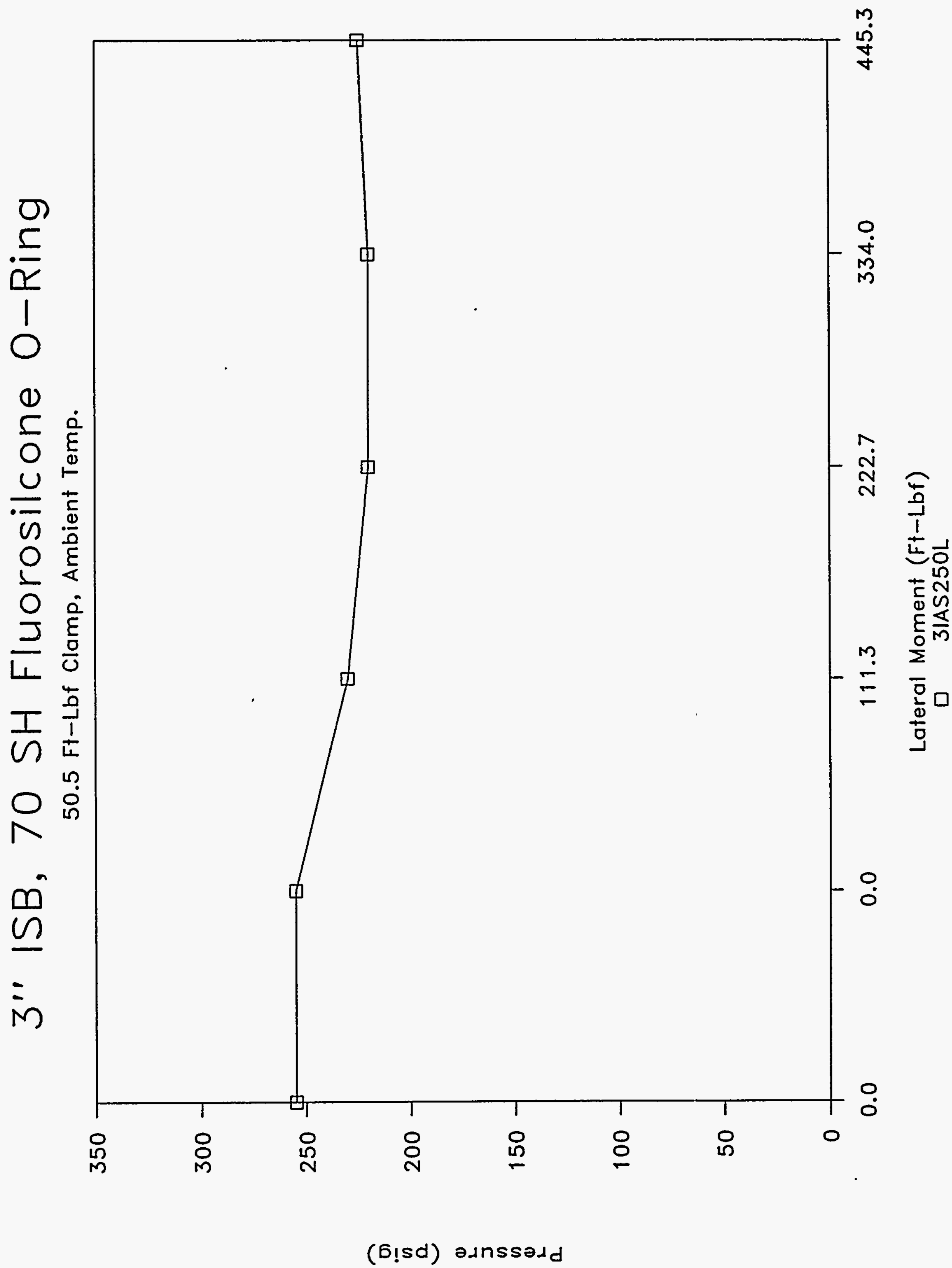
APPENDIX H: GRAPHS OF 3-IN. FLUOROSILICONE TESTS

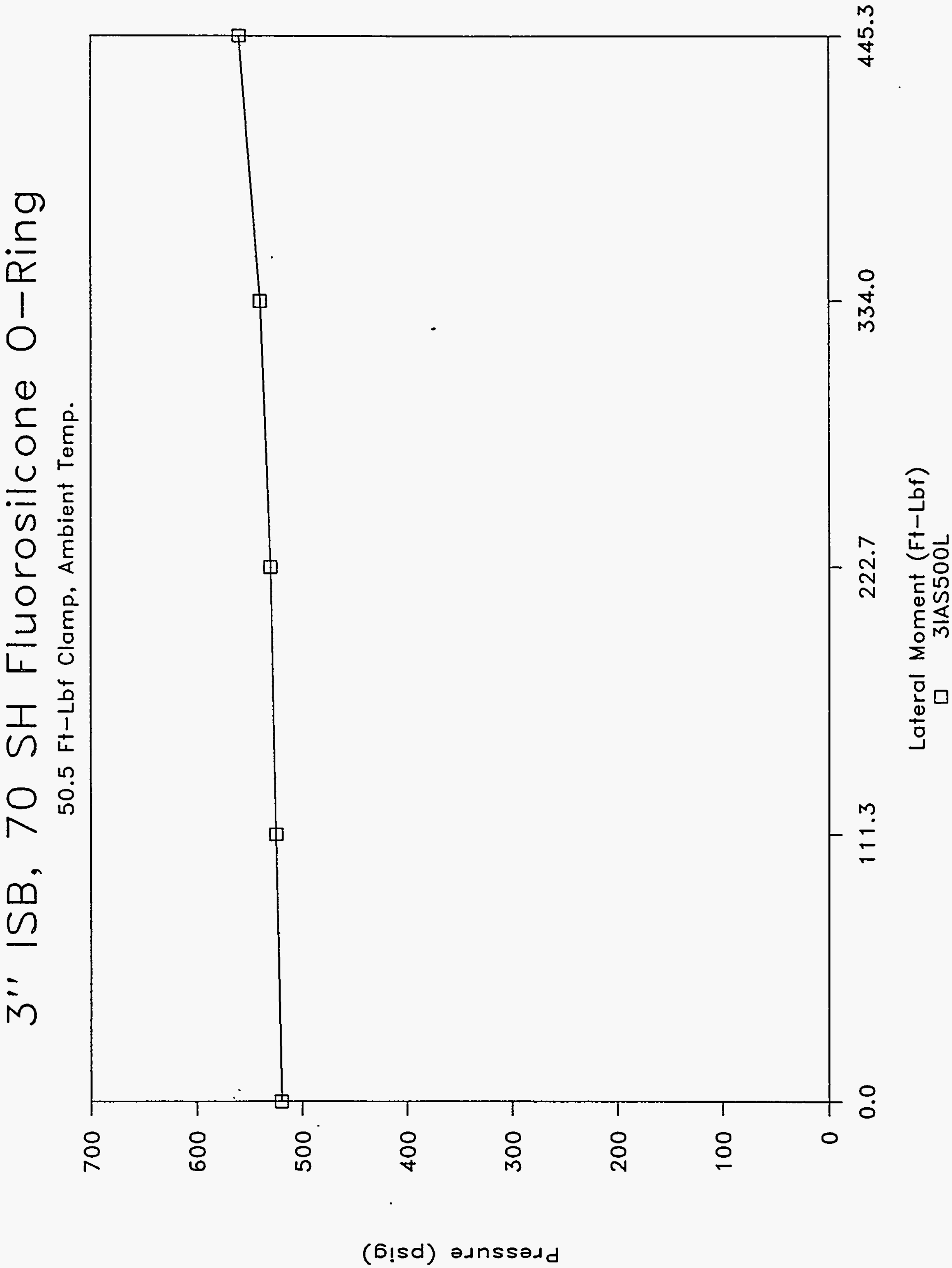
3" ISB, 70 SH Fluorosilicone O-Ring



JULY 20, 1994
3" ISB CONNECTOR, 70 SH FLUOROSILICONE O-RING, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - NO MOMENT APPLIED
CLAMPING TORQUE = 50.6 FT-LBF GRAPH NAME = 3IASPAST
CHARGE PRESSURE = 250 PSIG TO 1025 PSIG

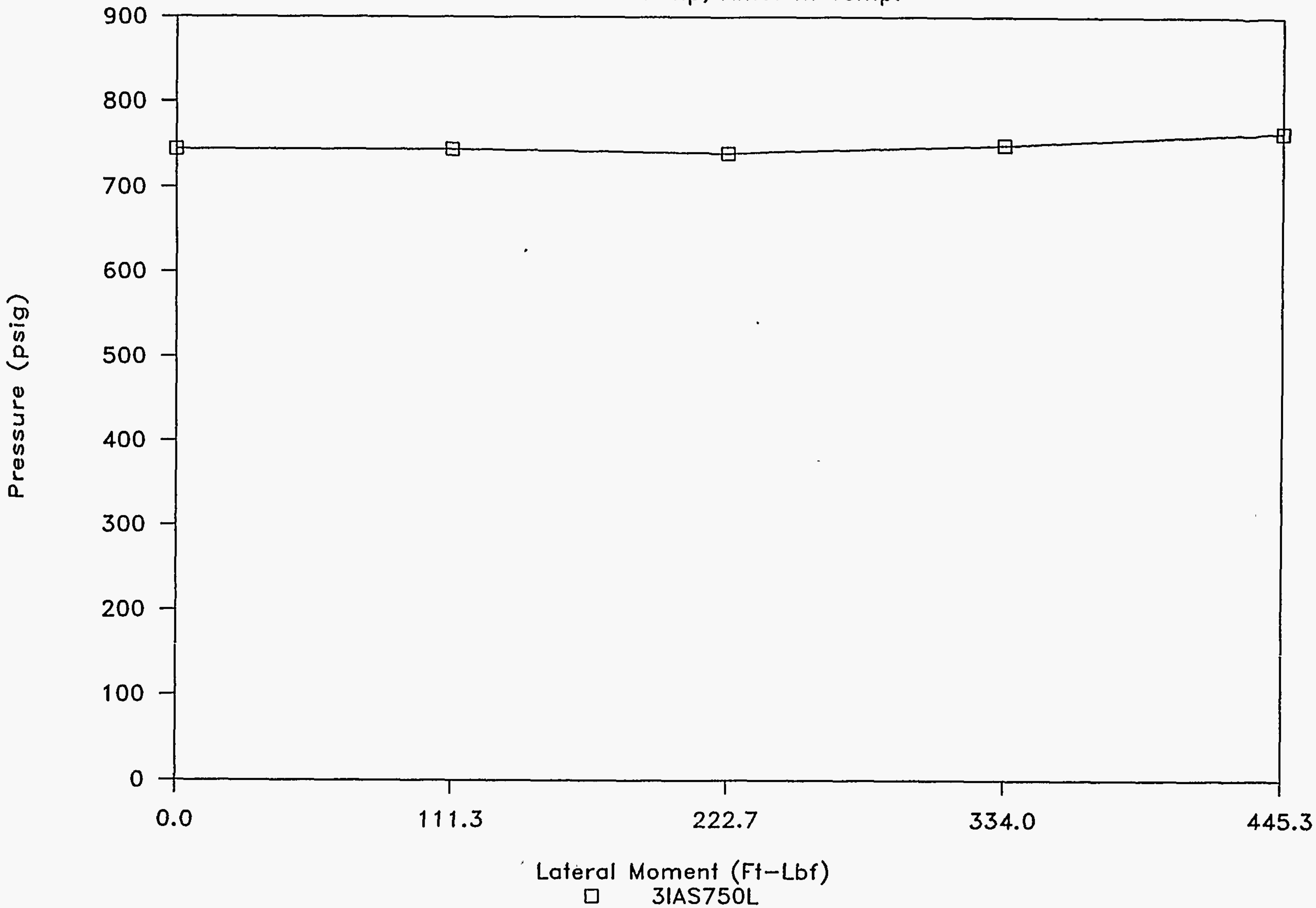
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	APPLIED FORCE LBS INPUT
300	0	0	0.00	0
300	2	2	2.03	0
500	4	8	4.13	0
745	6	4	6.07	0
1005	8	6	8.10	0
1025	10	9	10.15	0

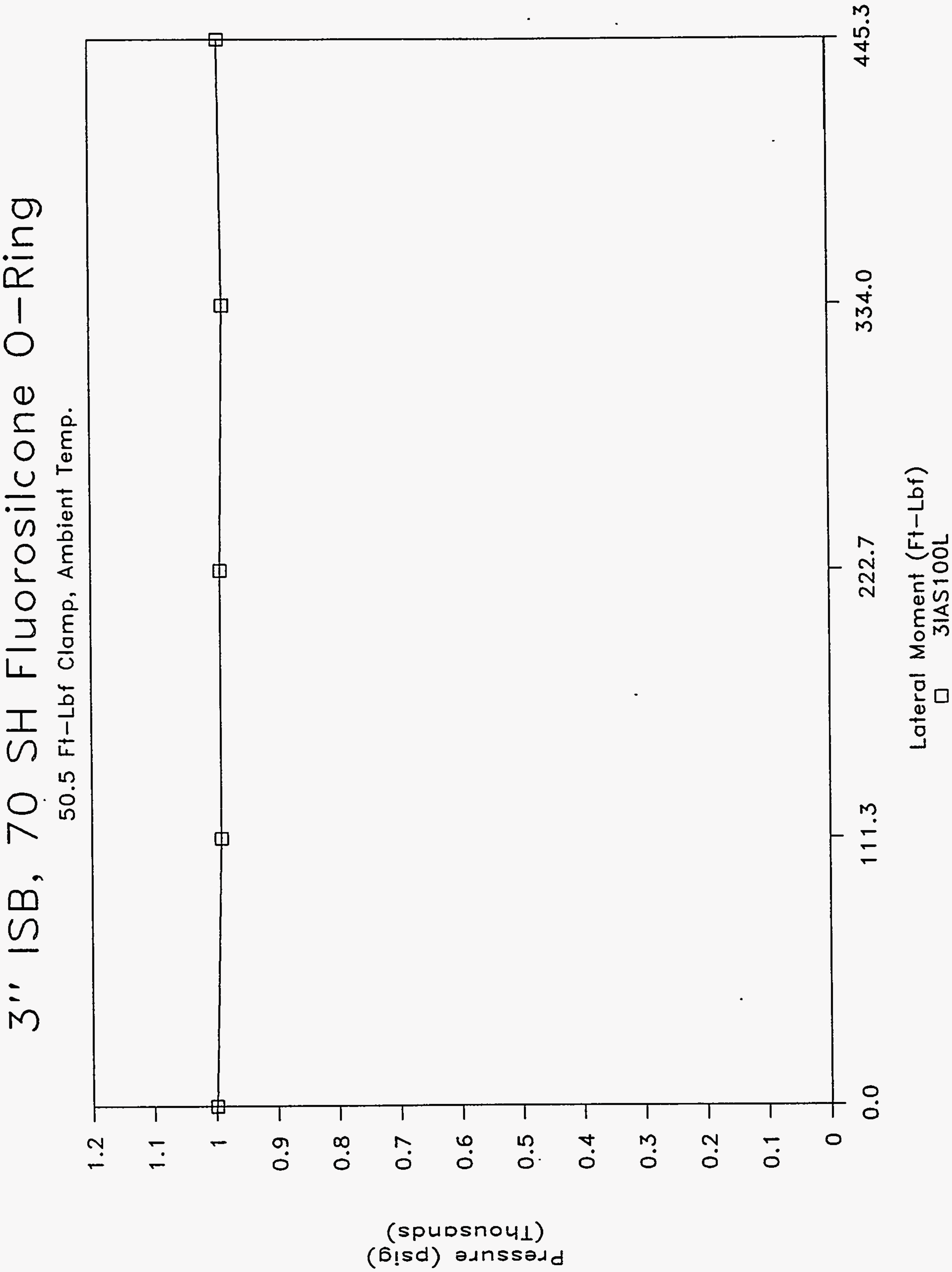

3" ISB, 70 SH Fluorosilcone O-Ring
50.5 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
350
300
250
200
150
100
50
0
0.0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
3IAS250L


3" ISB, 70 SH Fluorosilcone O-Ring
50.5 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
3IAS500L

3" ISB, 70 SH Fluorosilcone O-Ring

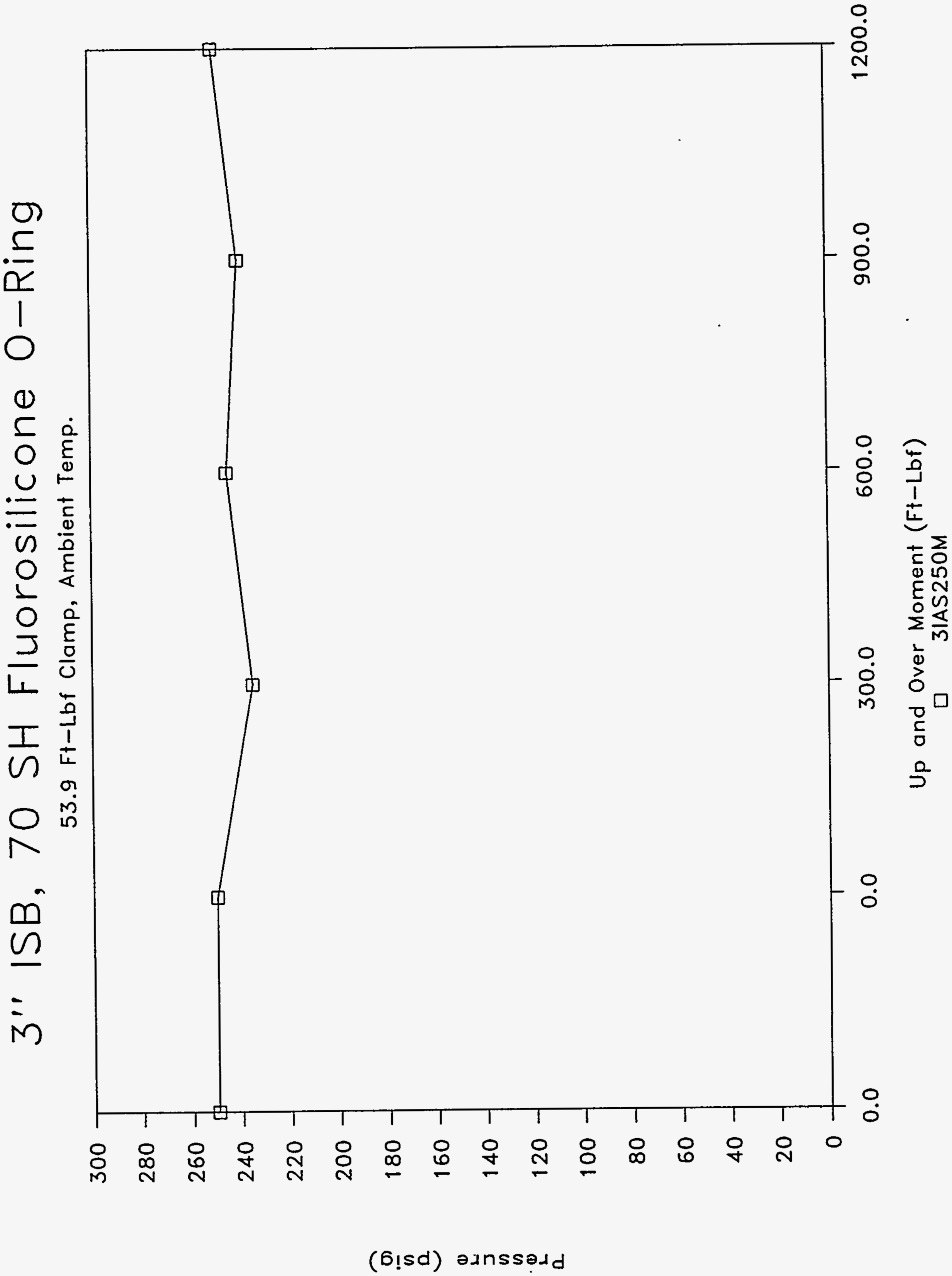
50.5 Ft-Lbf Clamp, Ambient Temp.

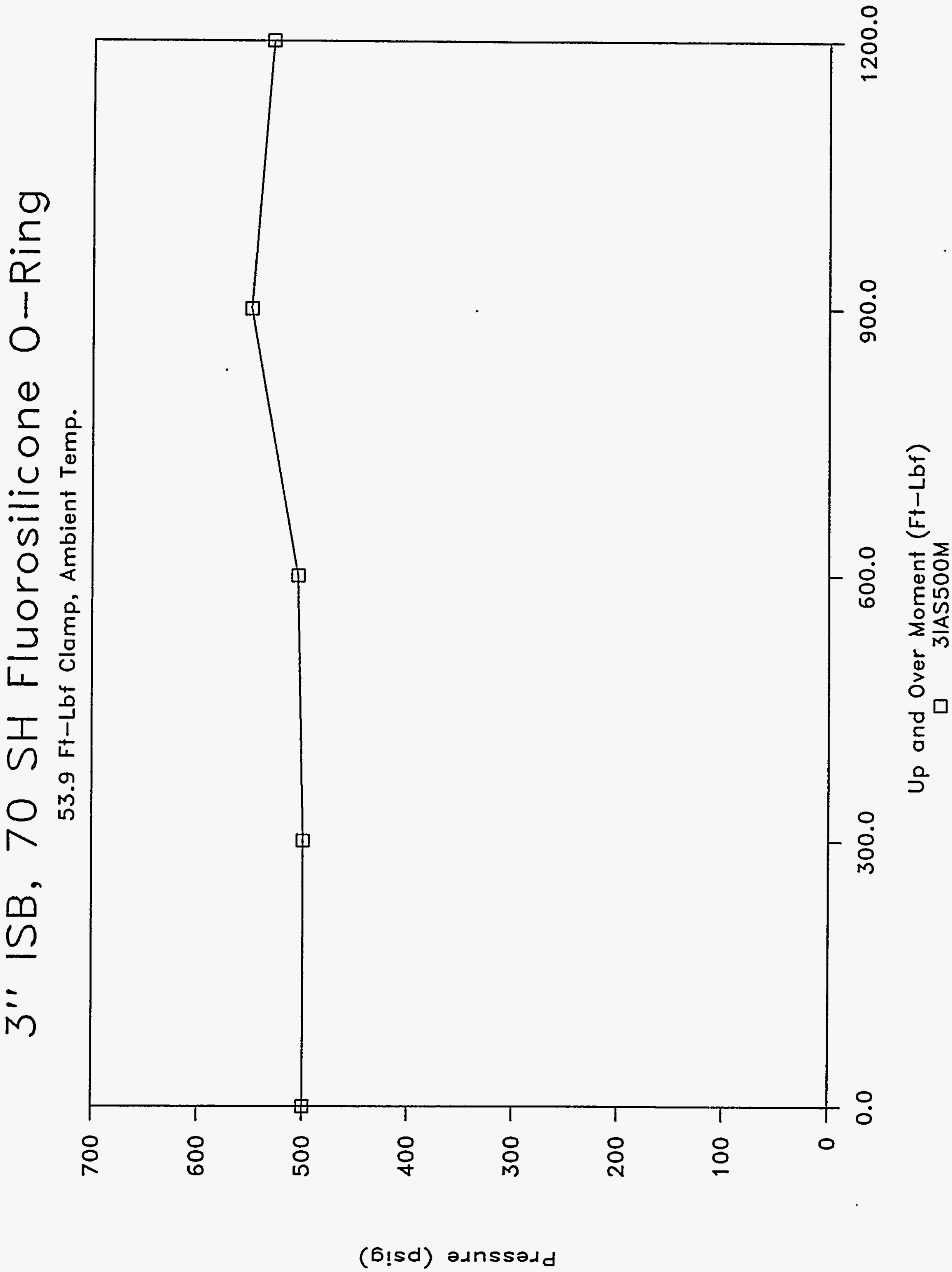


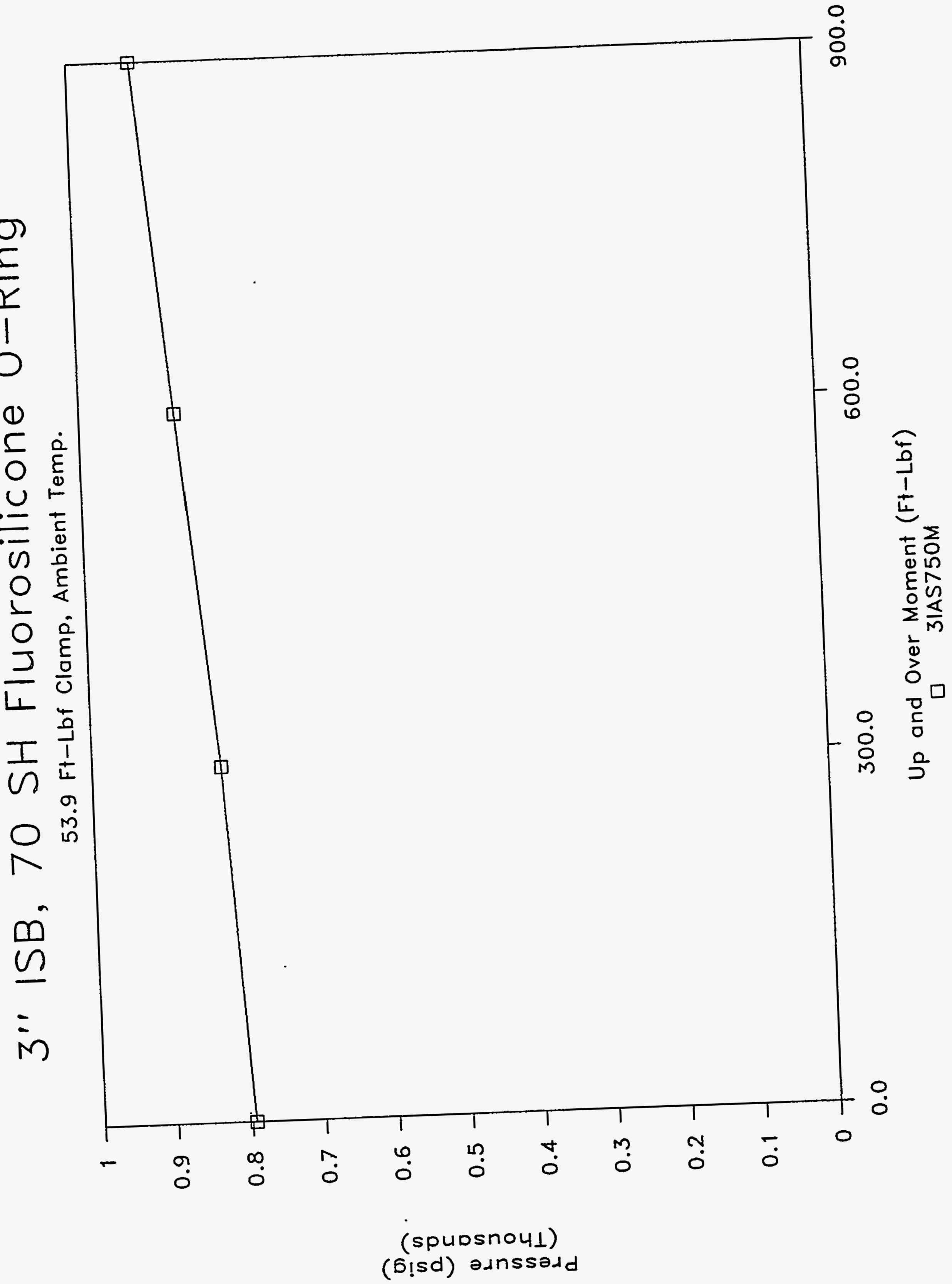

3'' ISB, 70 SH Fluorosilcone O-Ring
50.5 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
3IAS100L

JULY 20, 1994
3" ISB CONNECTOR, 70 SH FLUOROSILICONE O-RING, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 52.8 FT-LBF GRAPH NAME = 3IAS250L
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
255	0	0	0.00	0	0.4453	0.0
255	2	2	2.03	0	0.4453	0.0
230	4	3	4.05	250	0.4453	111.3
220	6	4	6.07	500	0.4453	222.7
220	8	10	8.17	750	0.4453	334.0
225	10	8	10.13	1000	0.4453	445.3
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = 3IAS500L		
520	12	2	12.03	0	0.4453	0.0
525	14	9	14.15	250	0.4453	111.3
530	16	13	16.22	500	0.4453	222.7
540	18	5	18.08	750	0.4453	334.0
560	20	3	20.05	1000	0.4453	445.3
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = 3IAS750L		
745	22	3	22.05	0	0.4453	0.0
745	24	5	24.08	250	0.4453	111.3
740	26	9	26.15	500	0.4453	222.7
750	28	10	28.17	750	0.4453	334.0
765	30	8	30.13	1000	0.4453	445.3
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = 3IAS100L		
1000	32	11	32.18	0	0.4453	0.0
990	34	8	34.13	250	0.4453	111.3
990	36	3	36.05	500	0.4453	222.7
985	38	6	38.10	750	0.4453	334.0
990	40	10	40.17	1000	0.4453	445.3


3" ISB, 70 SH Fluorosilicone O-Ring
53.9 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
0.0
0.0
300.0
600.0
900.0
1200.0
Up and Over Moment (Ft-Lbf)
31AS250M


3" ISB, 70 SH Fluorosilicone O-Ring
53.9 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
300.0
600.0
900.0
1200.0
Up and Over Moment (Ft-Lbf)
3IAS500M


3" ISB, 70 SH Fluorosilicone O-Ring
53.9 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
300.0
600.0
900.0
Up and Over Moment (Ft-Lbf)
3IAS750M

JUNE 29, 1994
3" ISB CONNECTOR, 70 SH FLUOROSILICONE O-RING, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 53.9 FT-LBF GRAPH NAME = 3IAS250M
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
250	0	0	0.00	0	1.2000	0.0
250	2	8	2.13	0	1.2000	0.0
235	5	3	5.05	250	1.2000	300.0
245	8	10	8.17	500	1.2000	600.0
240	11	12	11.20	750	1.2000	900.0
250	14	6	14.10	1000	1.2000	1200.0

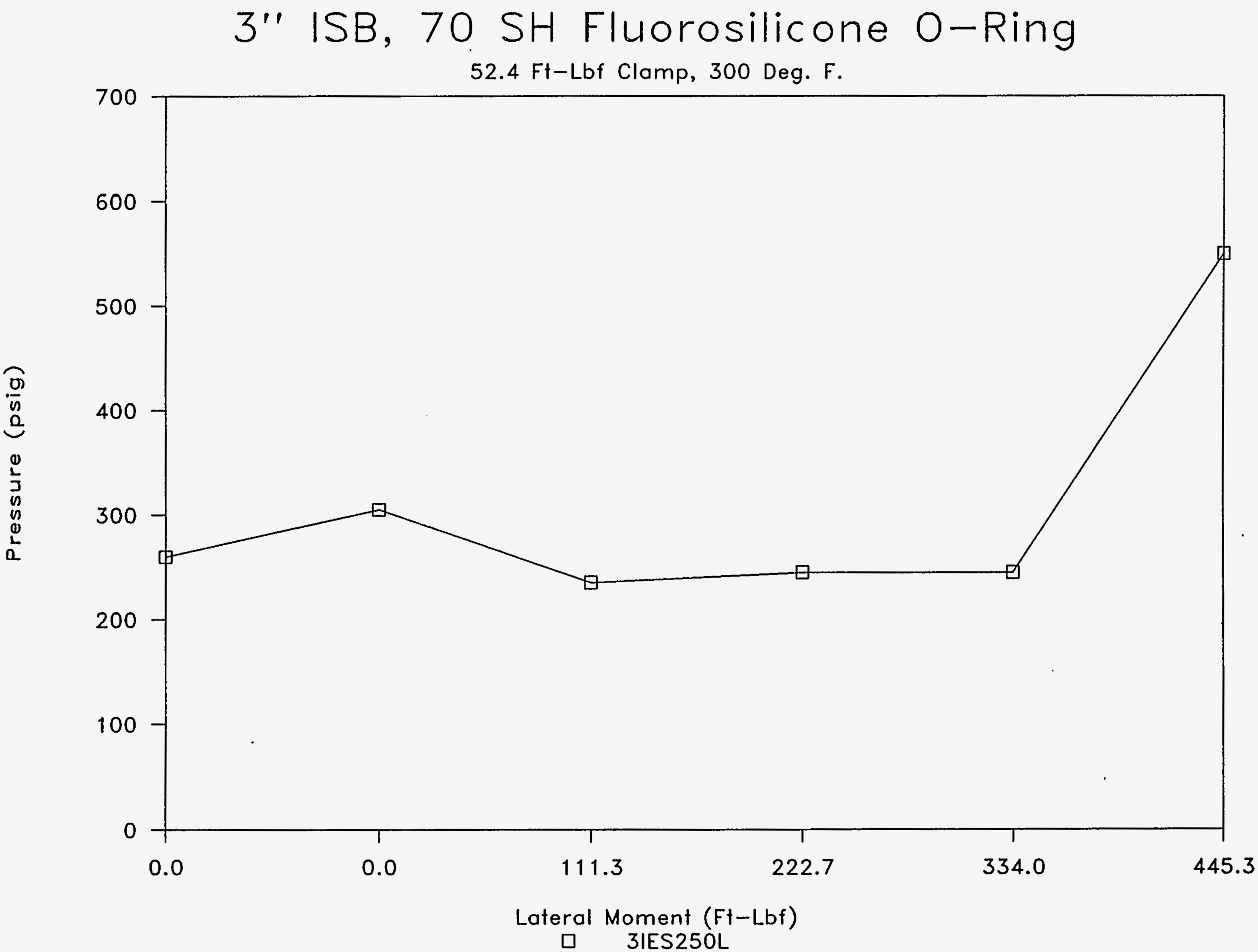
INCREASED PRESSURE TO 500 PSIG GRAPH NAME = 3IAS500M

500	17	8	17.13	0	1.2000	0.0
500	20	10	20.17	250	1.2000	300.0
505	22	12	22.20	500	1.2000	600.0
550	24	35	24.58	750	1.2000	900.0
530	26	37	26.62	1000	1.2000	1200.0

INCREASED PRESSURE TO 750 PSIG GRAPH NAME = 3IAS750M

795	28	32	28.53	0	1.2000	0.0
825	30	47	30.78	250	1.2000	300.0
870	33	13	33.22	500	1.2000	600.0
915	35	39	35.65	750	1.2000	900.0

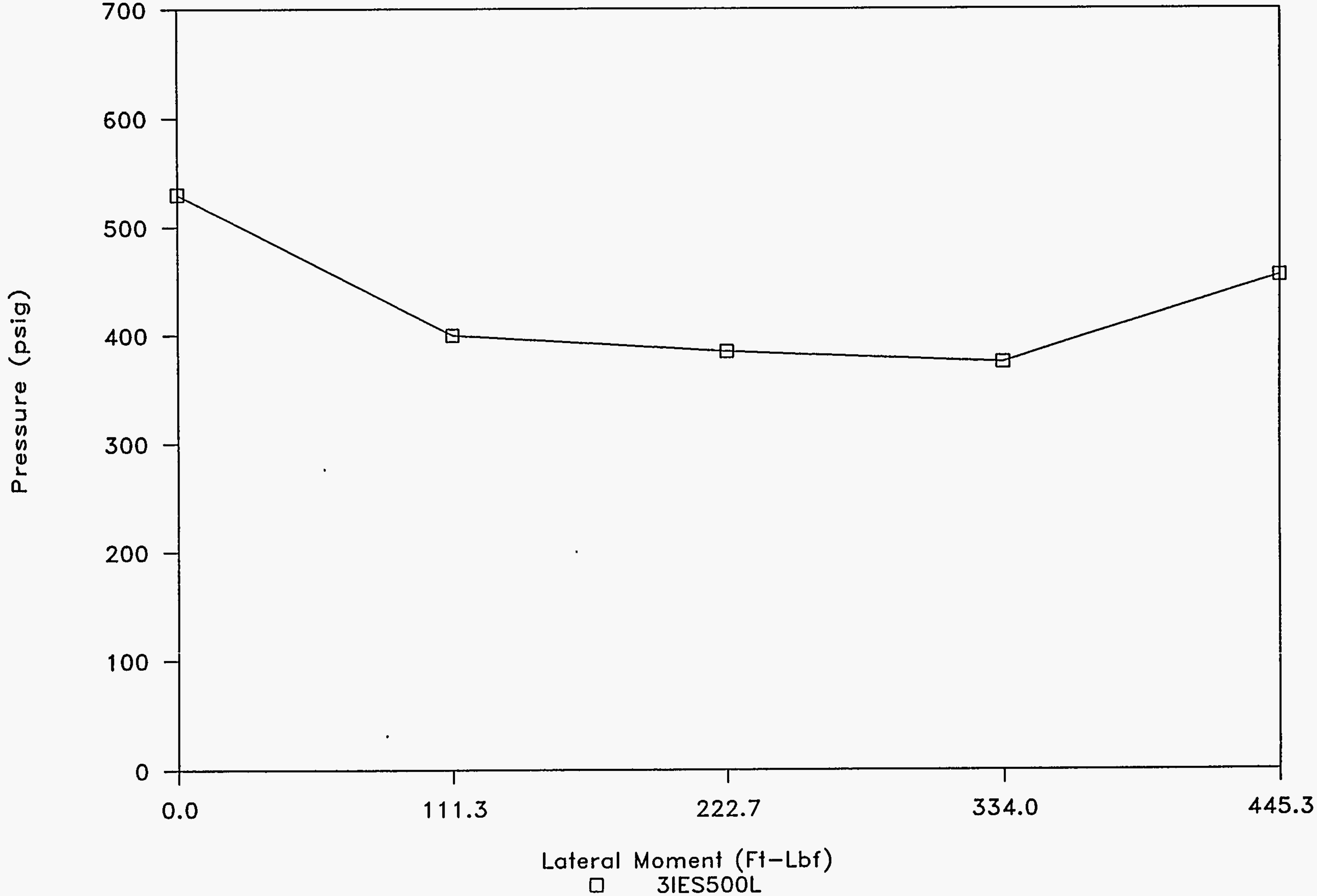
** ISB LEAKING AT THERMOCOUPLE PORT. TEST TERMINATED. **

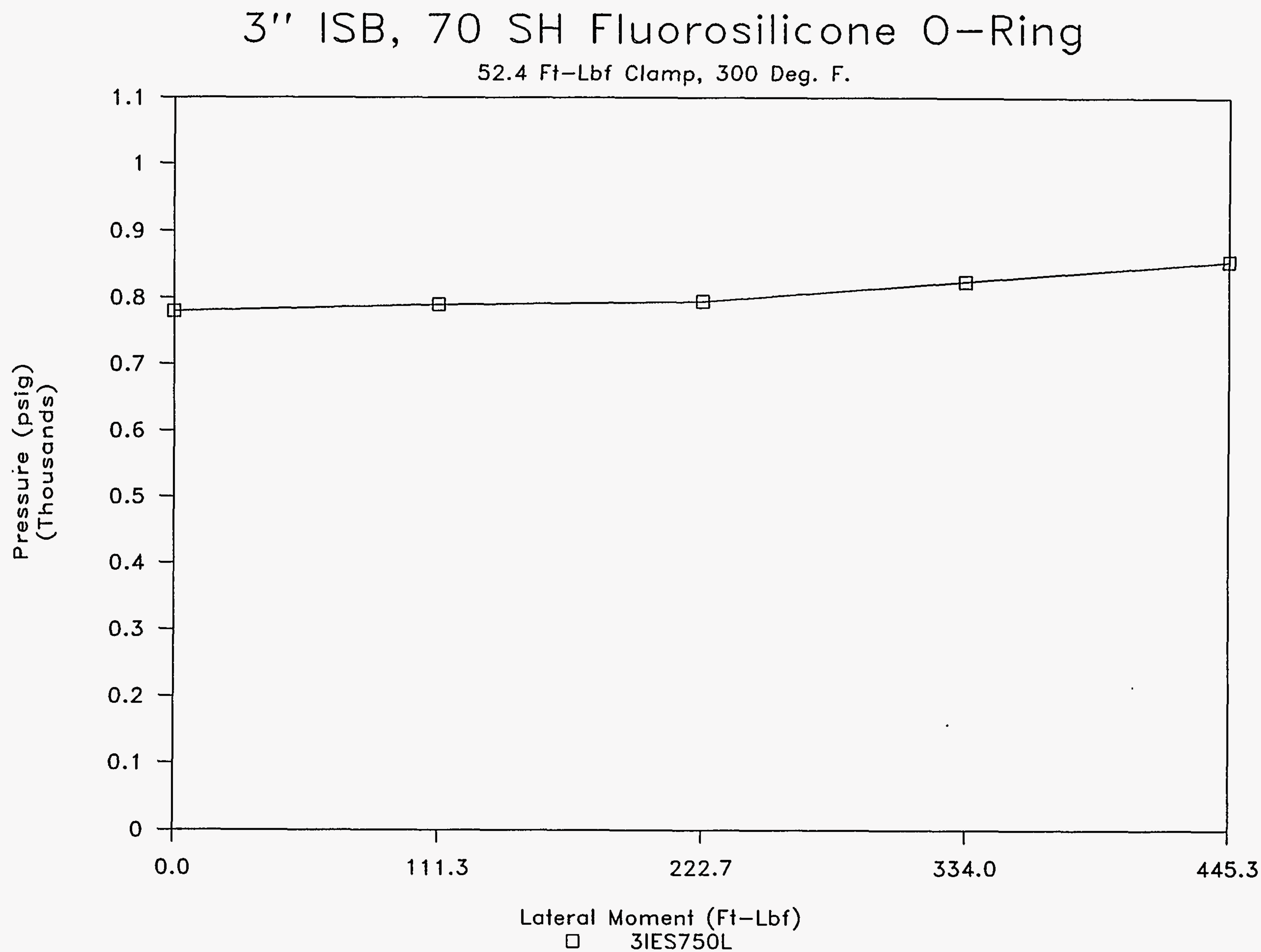


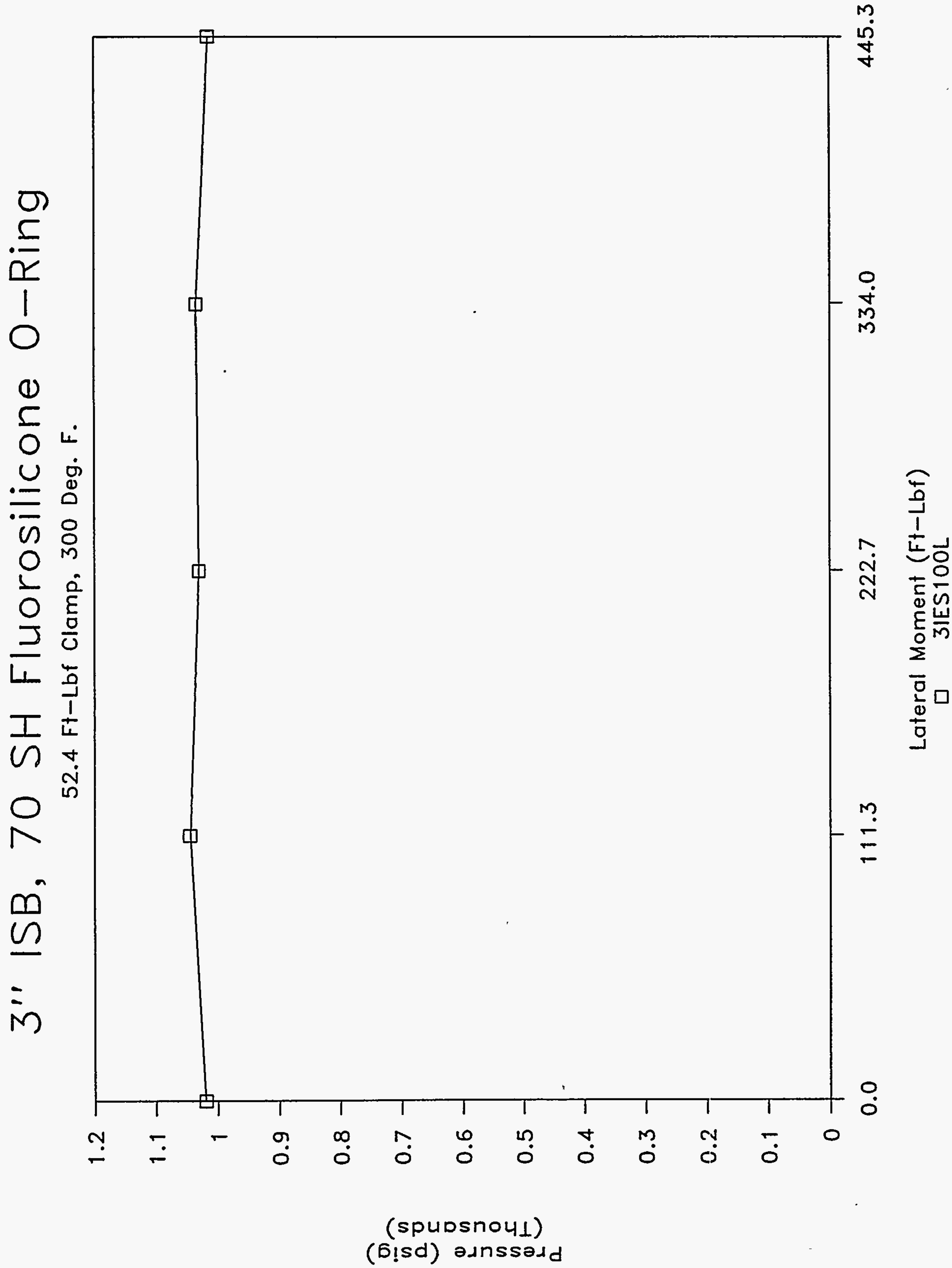
3" ISB, 70 SH Fluorosilicone O-Ring
52.4 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
3IES250L

3" ISB, 70 SH Fluorosilicone O-Ring

52.4 Ft-Lbf Clamp, 300 Deg. F.

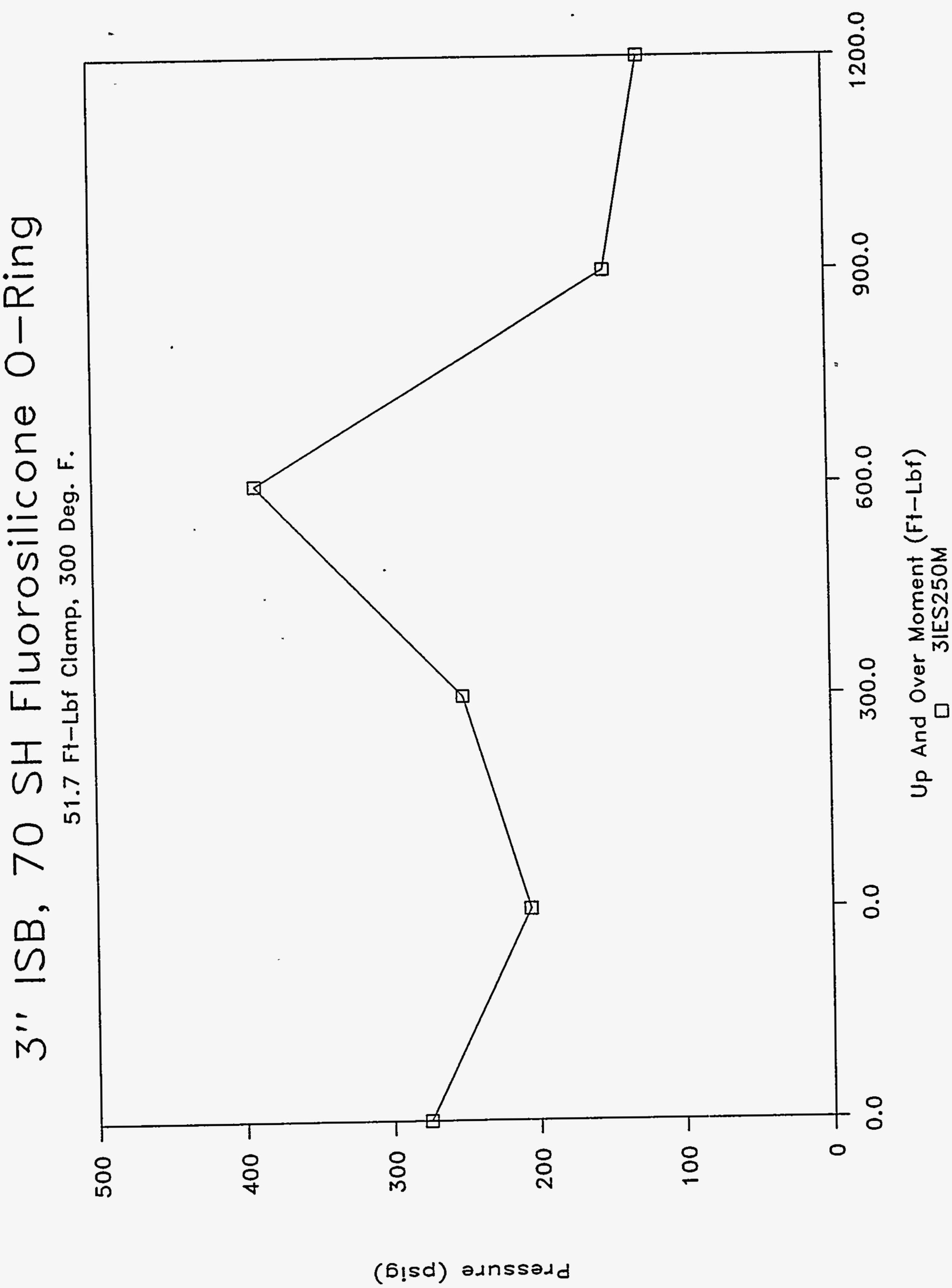


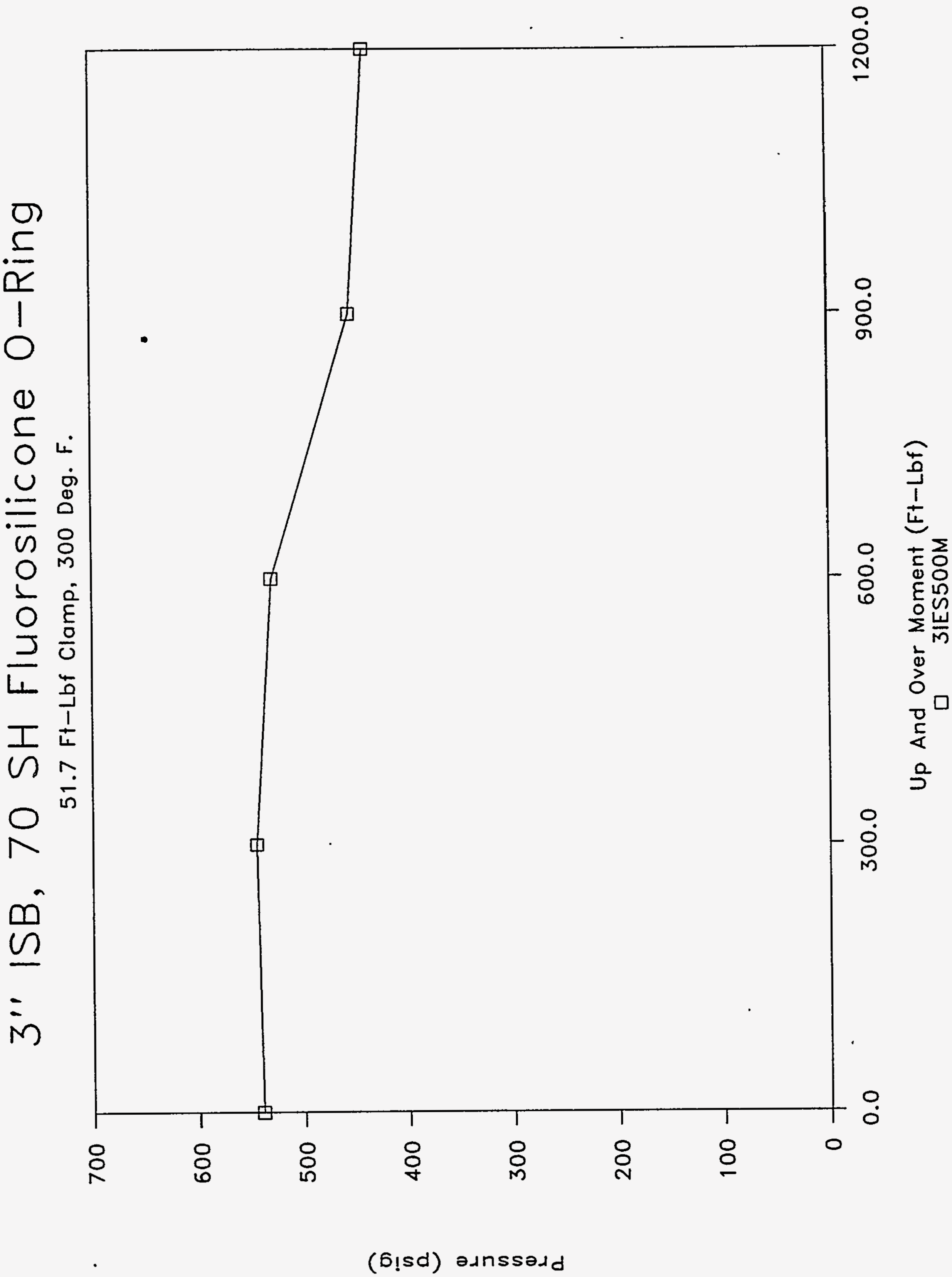

3" ISB, 70 SH Fluorosilicone O-Ring
52.4 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
(Thousands)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
3IES750L


3" ISB, 70 SH Fluorosilicone O—Ring
52.4 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
3IES100L

OCTOBER 31, 1994
3" ISB CONNECTOR, 70 SH FLUOROSILICONE O-RING, ELEVATED TEMP.(300 DEG. F
LEAK TEST - LATERAL MOMENT (SIDEWAYS)
CLAMPING TORQUE = 52.4 FT-LBF GRAPH NAME = 3IES250L
CHARGE PRESSURE = 250 PSIG

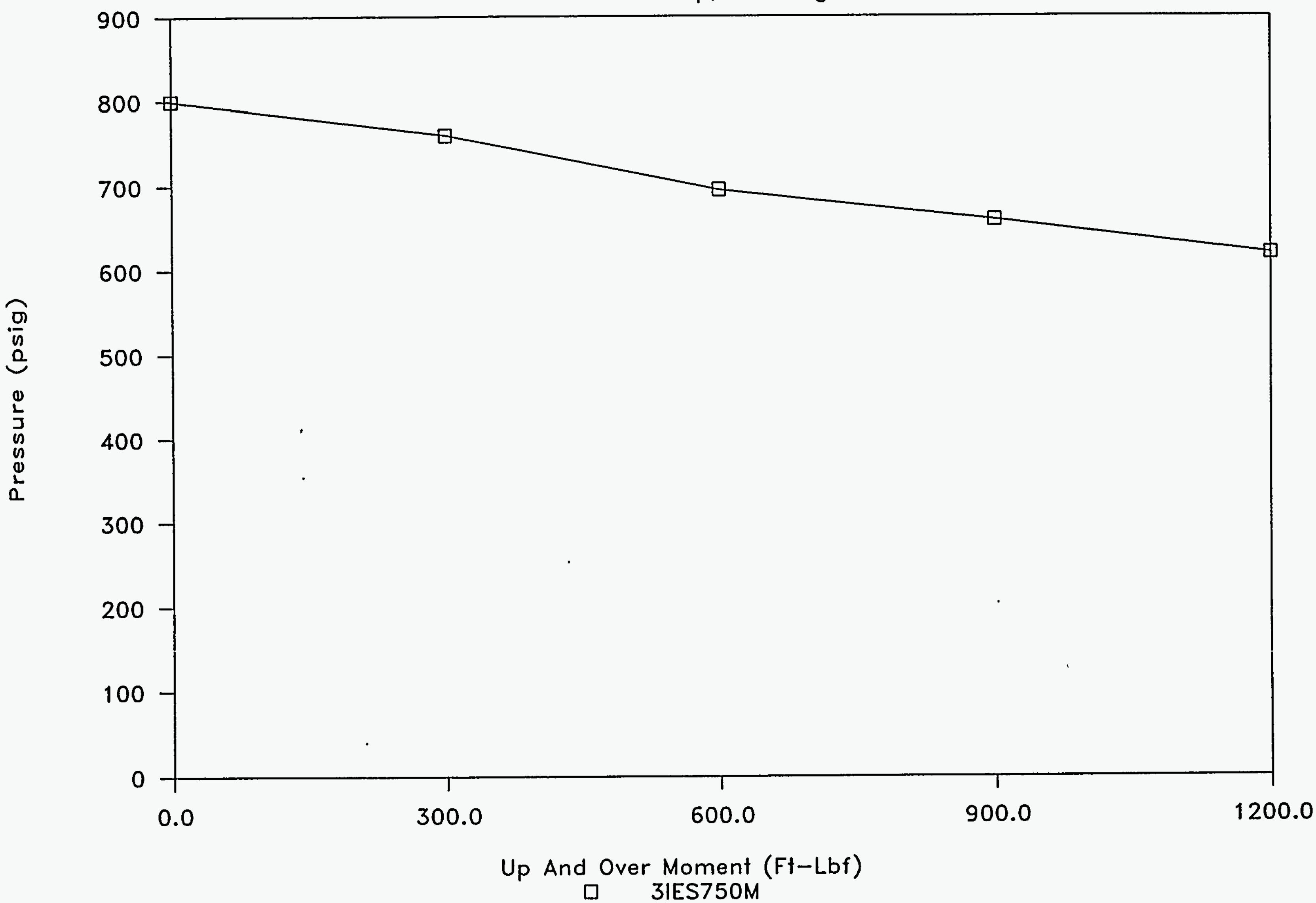
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
260	0	0	0.00	0	0.4453	0.0
305	2	4	2.07	0	0.4453	0.0
235	4	1	4.02	250	0.4453	111.3
245	6	3	6.05	500	0.4453	222.7
245	8	2	8.03	750	0.4453	334.0
550	10	1	10.02	1000	0.4453	445.3
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = 3IES500L		
530	12	3	12.05	0	0.4453	0.0
400	14	2	14.03	250	0.4453	111.3
385	16	4	16.07	500	0.4453	222.7
375	18	3	18.05	750	0.4453	334.0
455	20	2	20.03	1000	0.4453	445.3
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = 3IES750L		
780	22	1	22.02	0	0.4453	0.0
790	24	1	24.02	250	0.4453	111.3
795	26	2	26.03	500	0.4453	222.7
825	28	3	28.05	750	0.4453	334.0
855	30	1	30.02	1000	0.4453	445.3
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = 3IES100L		
1020	32	3	32.05	0	0.4453	0.0
1045	34	2	34.03	250	0.4453	111.3
1030	36	1	36.02	500	0.4453	222.7
1035	38	2	38.03	750	0.4453	334.0
1015	40	2	40.03	1000	0.4453	445.3


3'' ISB, 70 SH Fluorosilicone O-Ring
51.7 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
500
400
300
200
100
0
0.0
0.0
300.0
600.0
900.0
1200.0
Up And Over Moment (Ft-Lbf)
3IES250M


3" ISB, 70 SH Fluorosilicone O-Ring
51.7 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
300.0
600.0
900.0
1200.0
Up And Over Moment (Ft-Lbf)
3IES500M

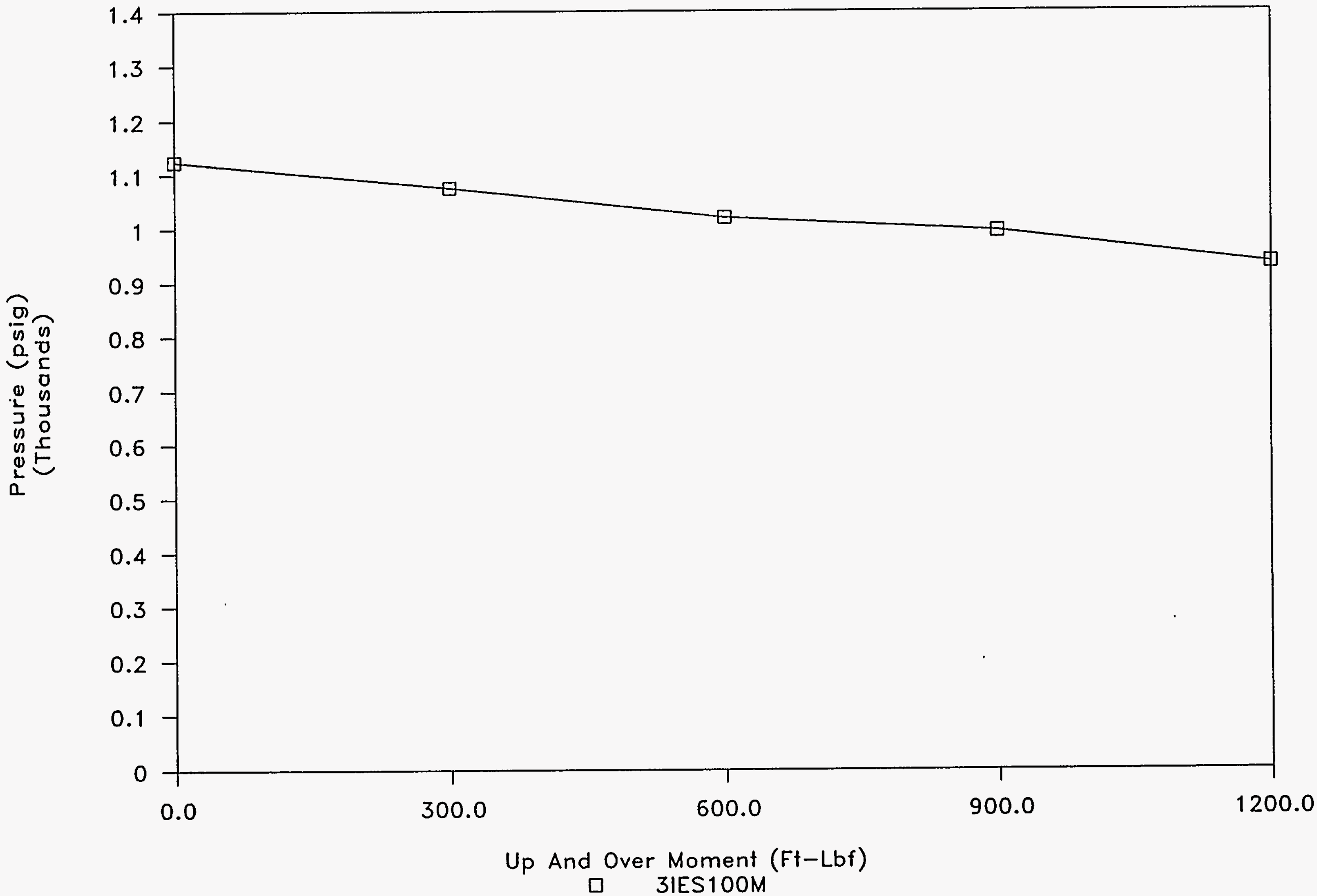
3" ISB, 70 SH Fluorosilicone O-Ring

51.7 Ft-Lbf Clamp, 300 Deg. F.



3" ISB, 70 SH Fluorosilicone O-Ring

51.7 Ft-Lbf Clamp, 300 Deg. F.



OCTOBER 27, 1994
3" ISB CONNECTOR, 70 SH FLUOROSILICONE O-RING, ELEVATED TEMP.(300 DEG. F
LEAK TEST - UP AND OVER MOMENT (UPWARD)
CLAMPING TORQUE = 51.7 FT-LBF GRAPH NAME = 3IES250M
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
275	0	0	0.00	0	1.2000	0.0
205	2	1	2.02	0	1.2000	0.0
250	4	2	4.03	250	1.2000	300.0
390	6	1	6.02	500	1.2000	600.0
150	8	3	8.05	750	1.2000	900.0
125	10	1	10.02	1000	1.2000	1200.0

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = 3IES500M

540	12	1	12.02	0	1.2000	0.0
545	14	2	14.03	250	1.2000	300.0
530	16	4	16.07	500	1.2000	600.0
455	18	3	18.05	750	1.2000	900.0
440	20	1	20.02	1000	1.2000	1200.0

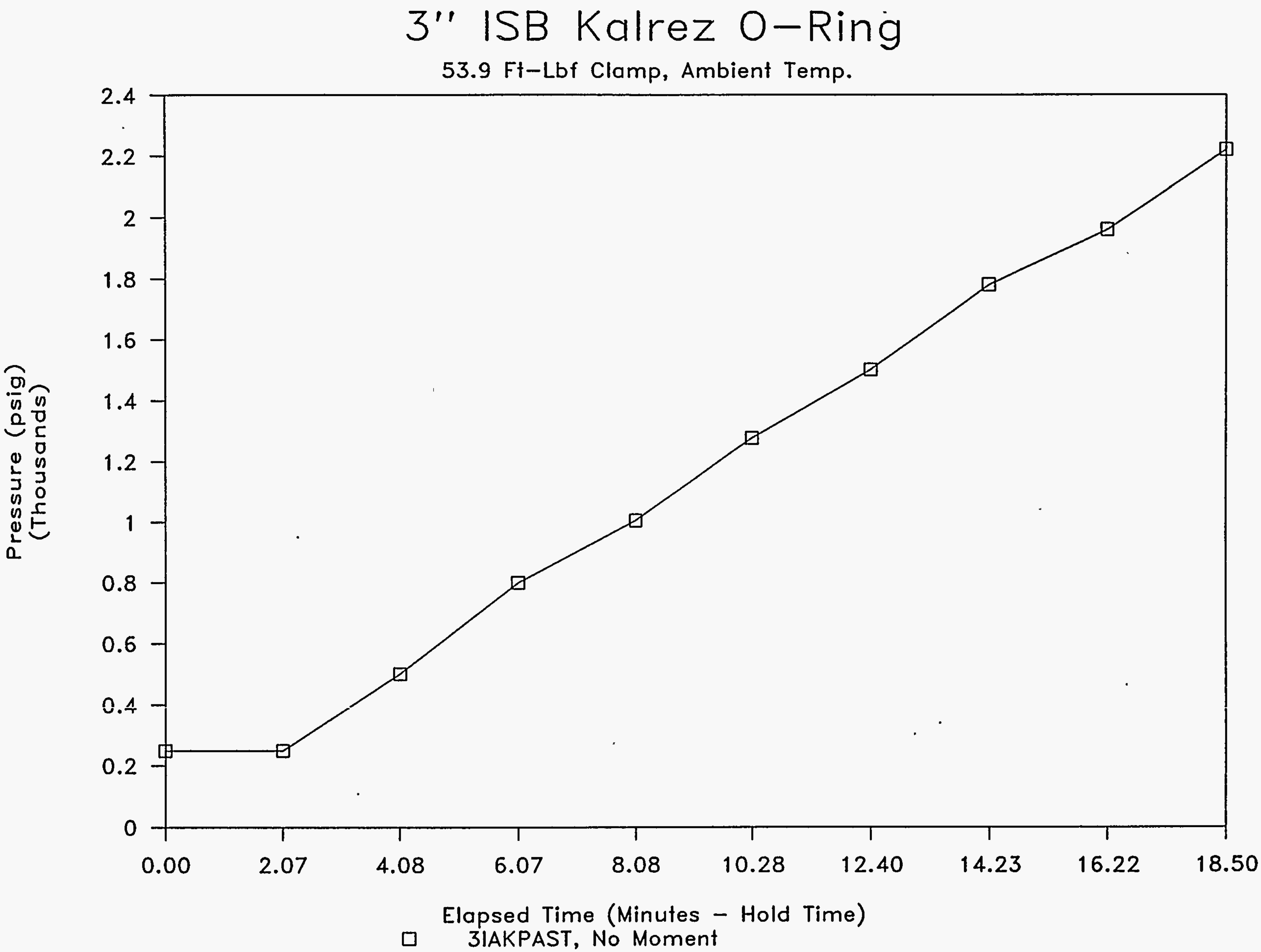
INCREASED PRESSURE TO 750 PSIG GRAPH NAME = 3IES750M

800	22	2	22.03	0	1.2000	0.0
760	24	2	24.03	250	1.2000	300.0
695	26	1	26.02	500	1.2000	600.0
660	28	1	28.02	750	1.2000	900.0
620	30	5	30.08	1000	1.2000	1200.0

INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = 3IES100M

1125	32	1	32.02	0	1.2000	0.0
1075	34	3	34.05	250	1.2000	300.0
1020	36	3	36.05	500	1.2000	600.0
995	38	1	38.02	750	1.2000	900.0
935	40	1	40.02	1000	1.2000	1200.0

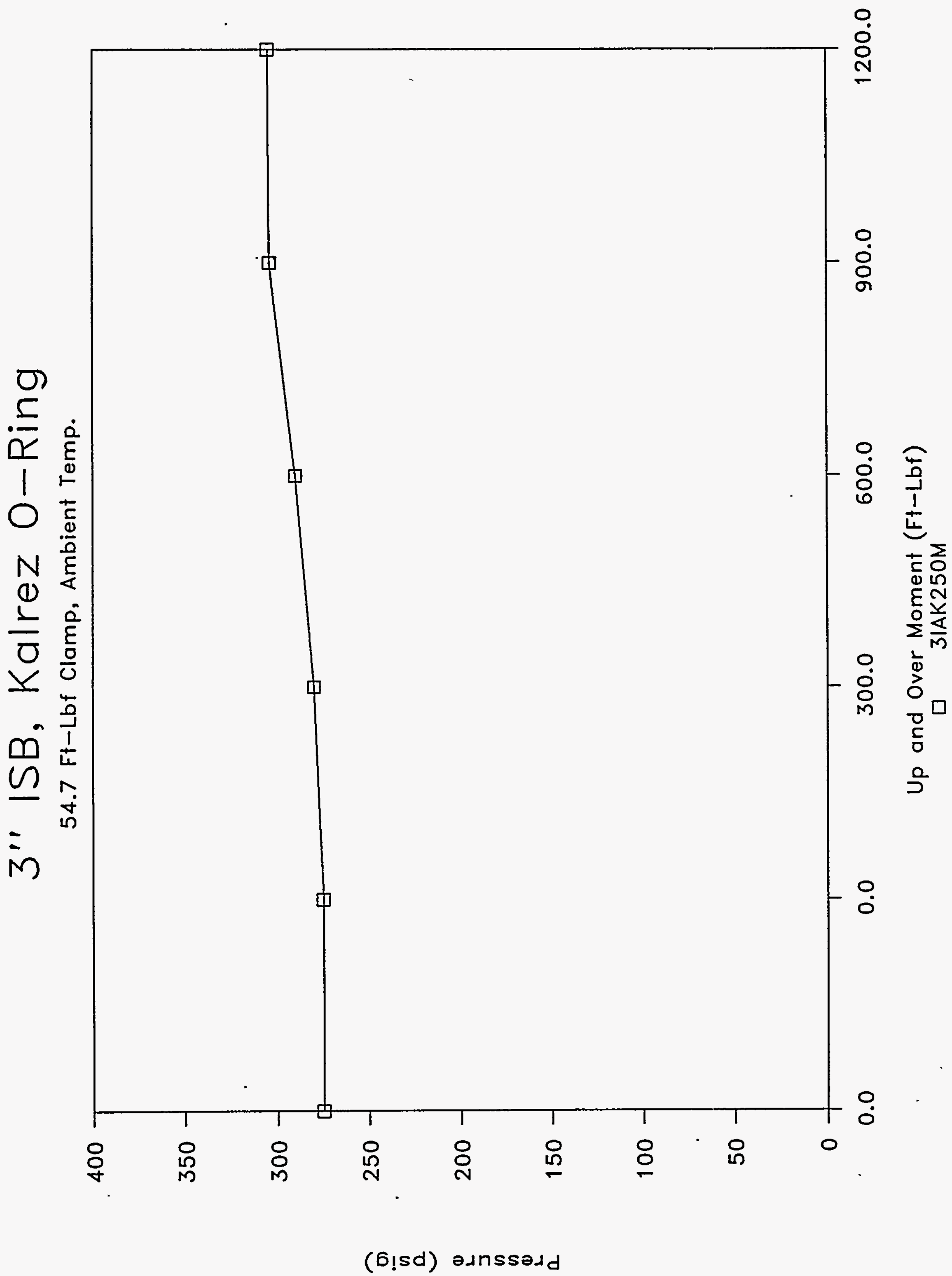
APPENDIX I: GRAPHS OF 3-IN. KALREZ TESTS

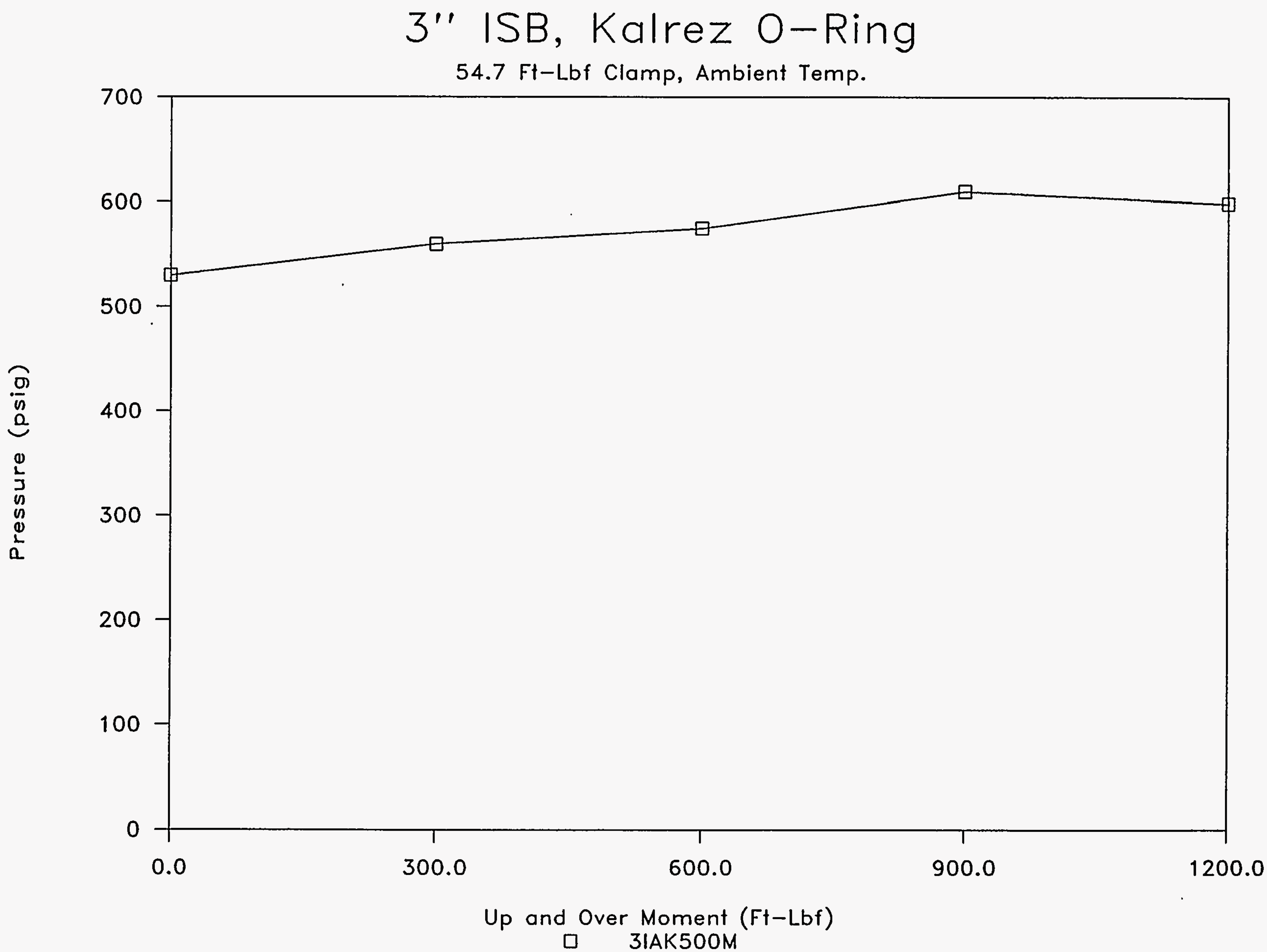


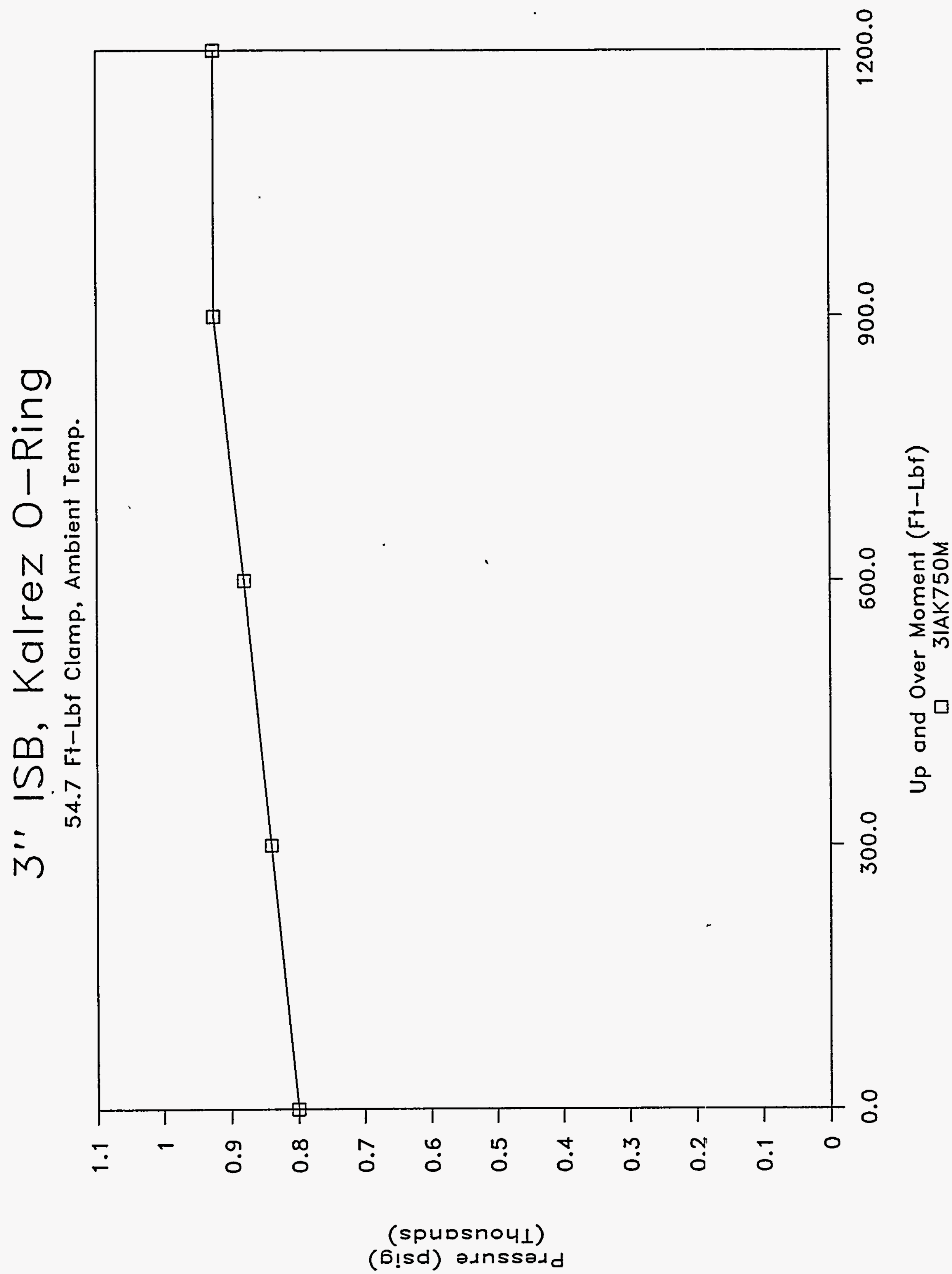
3" ISB Kalrez O-Ring
53.9 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.00
2.07
4.08
6.07
8.08
10.28
12.40
14.23
16.22
18.50
Elapsed Time (Minutes - Hold Time)
3IAKPAST, No Moment

JUNE 30, 1994
3" ISB CONNECTOR, KALREZ O-RING, 70 DUROMETER, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - NO MOMENT APPLIED
CLAMPING TORQUE = 53.9 FT-LBF GRAPH NAME = 3IAKPAST
CHARGE PRESSURE = 250 PSIG TO 2220 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	APPLIED FORCE LBS INPUT
250	0	0	0.00	0
250	2	4	2.07	0
500	4	5	4.08	0
800	6	4	6.07	0
1005	8	5	8.08	0
1275	10	17	10.28	0
1500	12	24	12.40	0
1780	14	14	14.23	0
1960	16	13	16.22	0
2220	18	30	18.50	0

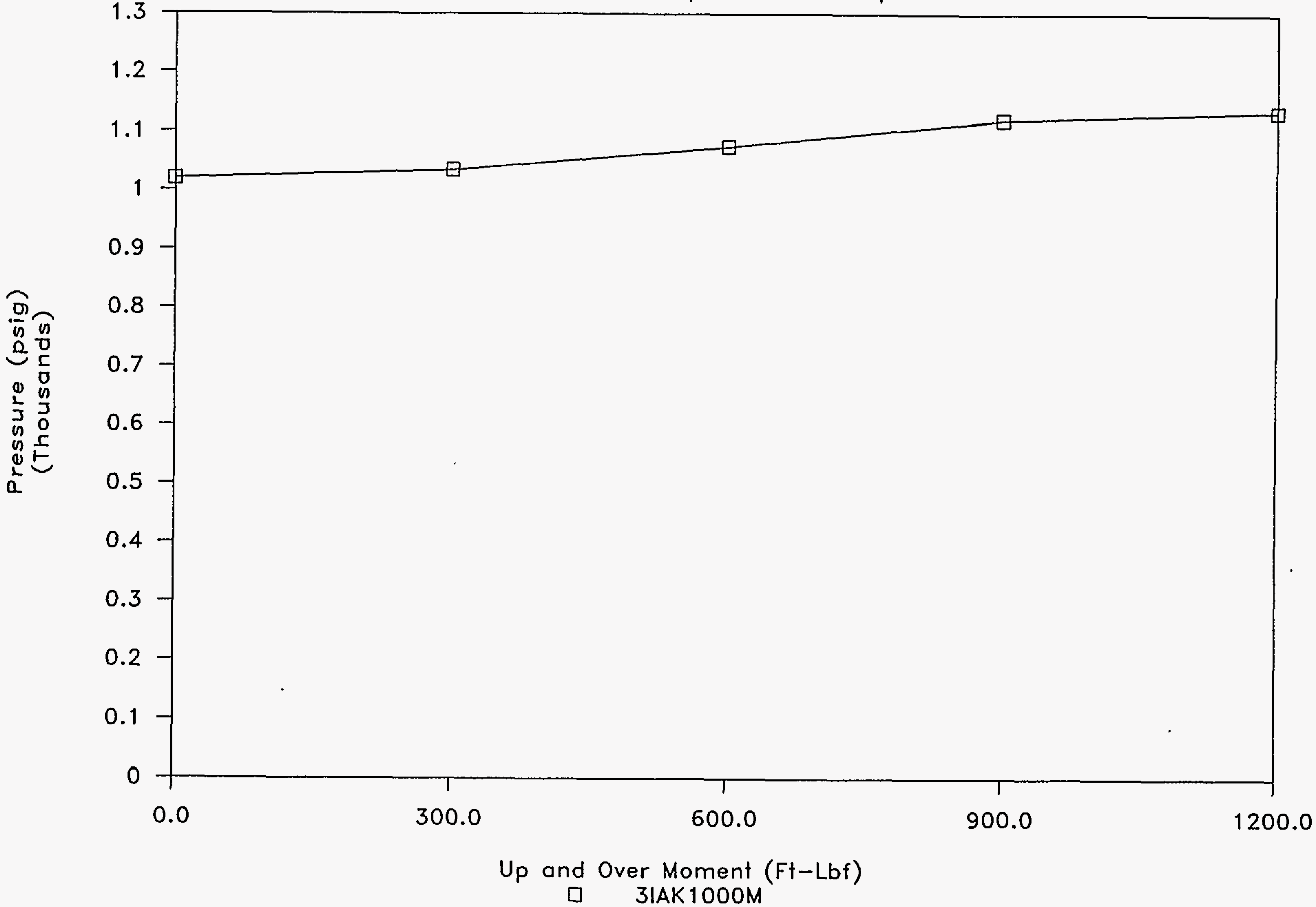

3" ISB, Kalrez O—Ring
54.7 Ft—Lbf Clamp, Ambient Temp.
Pressure (psig)
400
350
300
250
200
150
100
50
0
0.0
0.0
300.0
600.0
900.0
1200.0
Up and Over Moment (Ft—Lbf)
3IAK250M

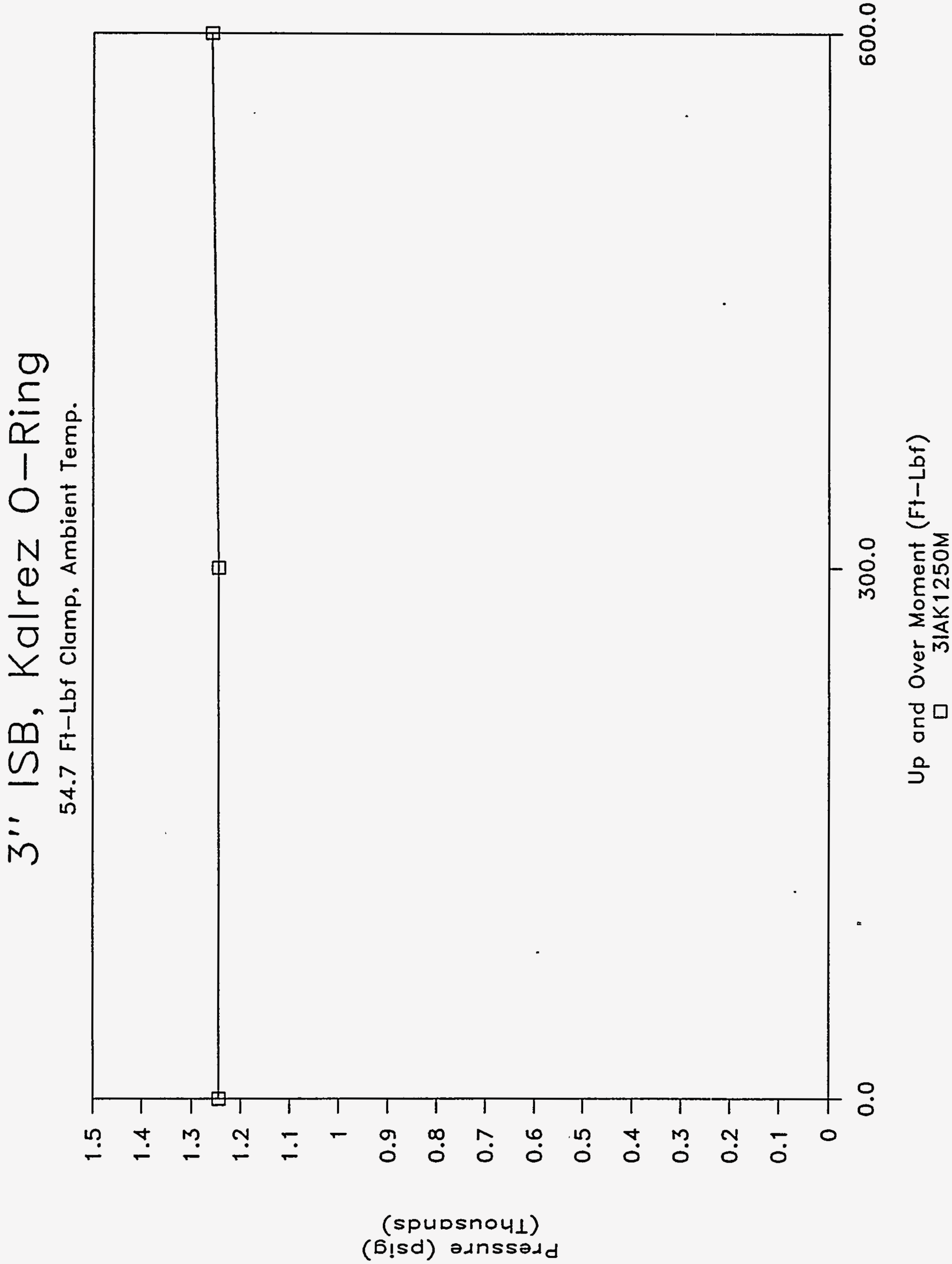

3" ISB, Kalrez O-Ring
54.7 Ft-Lbf Clamp, Ambient Temp.
700
600
500
400
300
200
100
0
Pressure (psig)
0.0
300.0
600.0
900.0
1200.0
Up and Over Moment (Ft-Lbf)
3IAK500M


3" ISB, Kalrez O-Ring
54.7 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
300.0
600.0
900.0
1200.0
Up and Over Moment (Ft-Lbf)
3IAK750M

3" ISB, Kalrez O-Ring

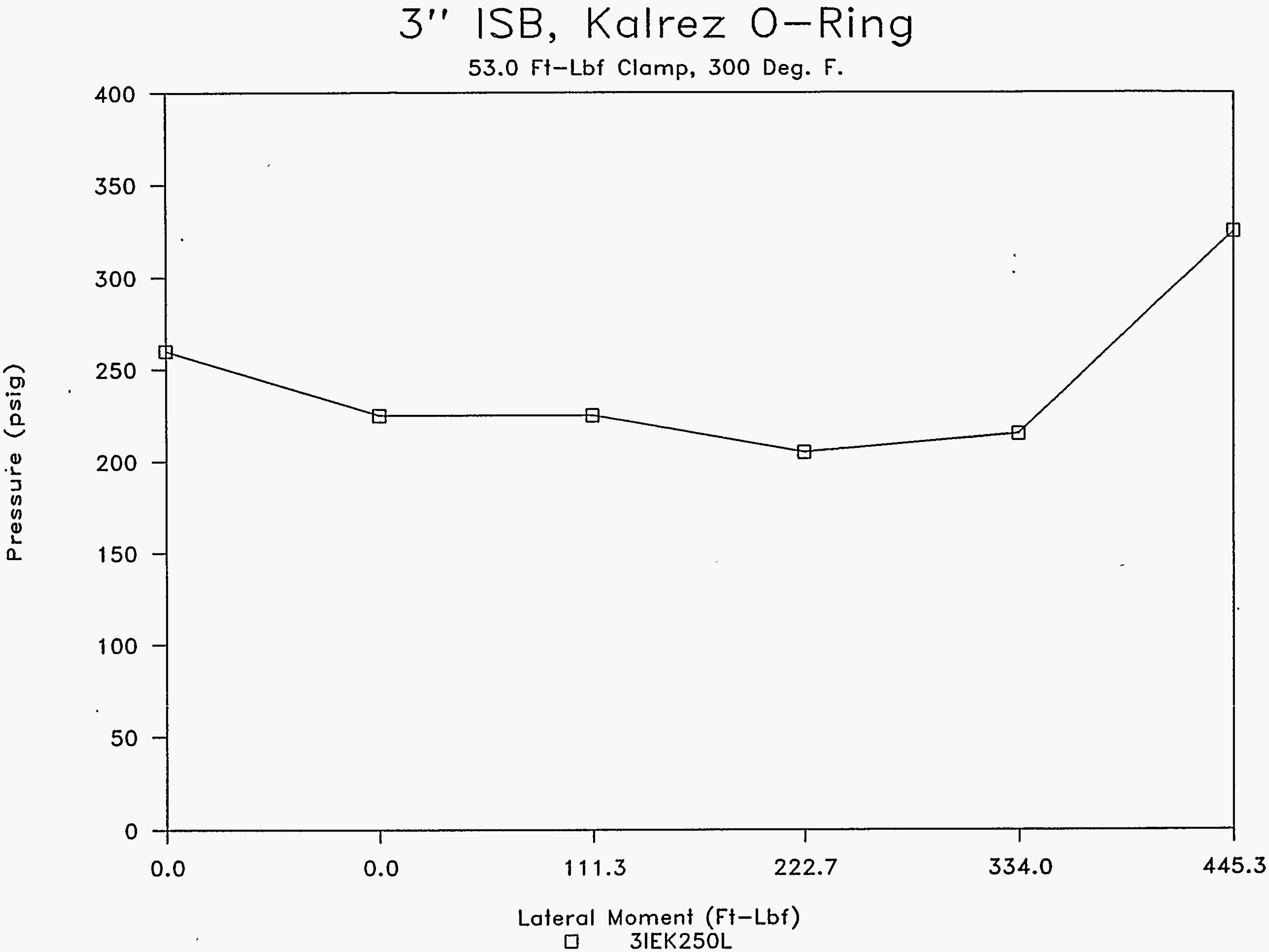
54.7 Ft-Lbf Clamp, Ambient Temp.



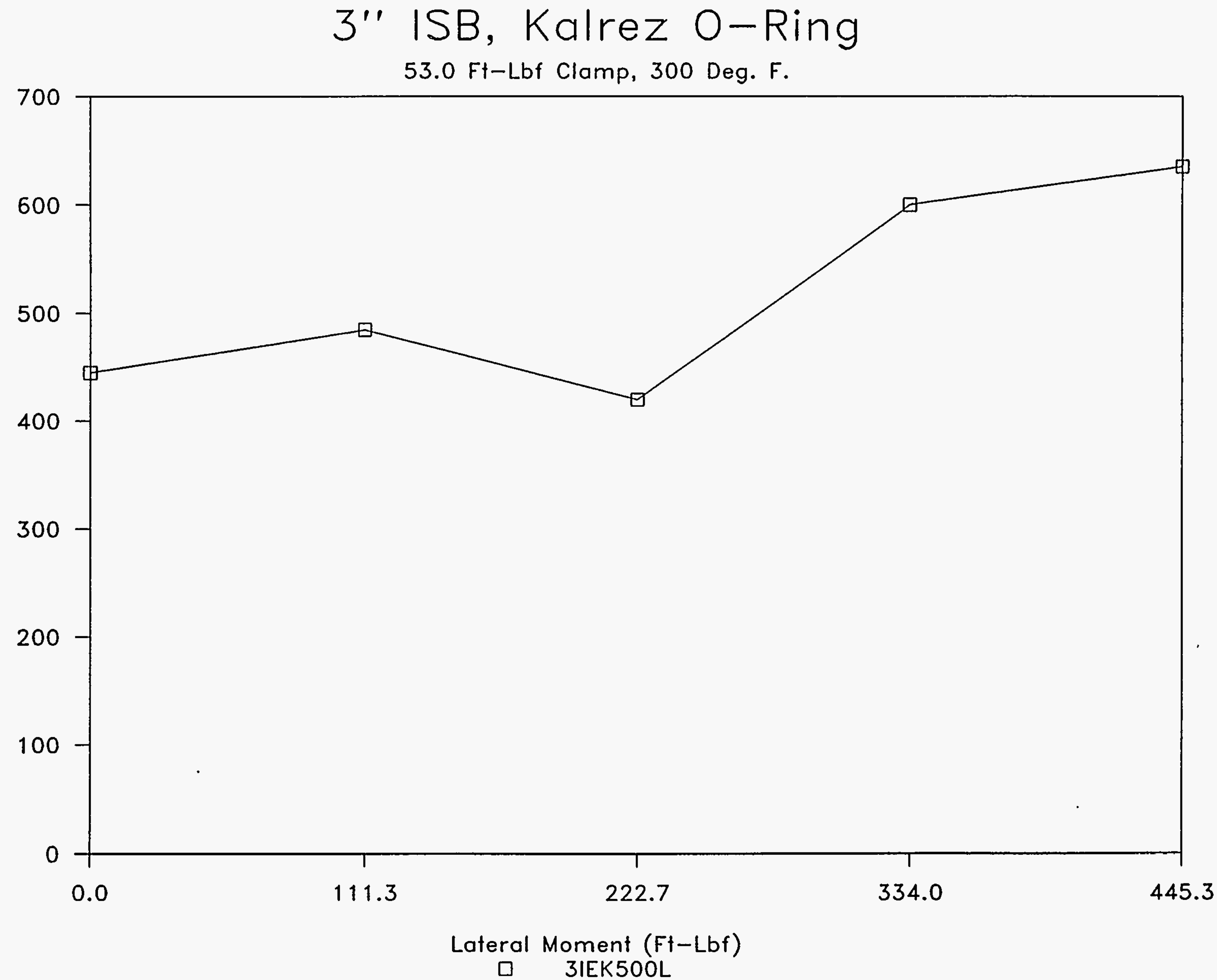

3" ISB, Kalrez O-Ring
54.7 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
300.0
600.0
Up and Over Moment (Ft-Lbf)
3IAK1250M

JULY 06, 1994
3" ISB CONNECTOR, KALREZ O-RING, 70 DUROMETER, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 54.7 FT-LBF GRAPH NAME = 3IAK250M
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
275	0	0	0.00	0	1.2000	0.0
275	2	2	2.03	0	1.2000	0.0
280	4	1	4.02	250	1.2000	300.0
290	6	18	6.30	500	1.2000	600.0
304	8	6	8.10	750	1.2000	900.0
305	10	4	10.07	1000	1.2000	1200.0
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = 3IAK500M		
530	12	4	12.07	0	1.2000	0.0
560	14	4	14.07	250	1.2000	300.0
575	16	2	16.03	500	1.2000	600.0
610	18	3	18.05	750	1.2000	900.0
599	20	12	20.20	1000	1.2000	1200.0
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = 3IAK750M		
800	22	2	22.03	0	1.2000	0.0
840	24	2	24.03	250	1.2000	300.0
880	26	6	26.10	500	1.2000	600.0
925	28	11	28.18	750	1.2000	900.0
925	30	9	30.15	1000	1.2000	1200.0
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = 3IAK1000M		
1020	32	3	32.05	0	1.2000	0.0
1035	34	3	34.05	250	1.2000	300.0
1075	36	13	36.22	500	1.2000	600.0
1120	38	2	38.03	750	1.2000	900.0
1135	40	5	40.08	1000	1.2000	1200.0
INCREASED PRESSURE TO 1250 PSIG				GRAPH NAME = 3IAK1250M		
1245	42	3	42.05	0	1.2000	0.0
1245	44	3	44.05	250	1.2000	300.0
1260	46	3	46.05	500	1.2000	600.0

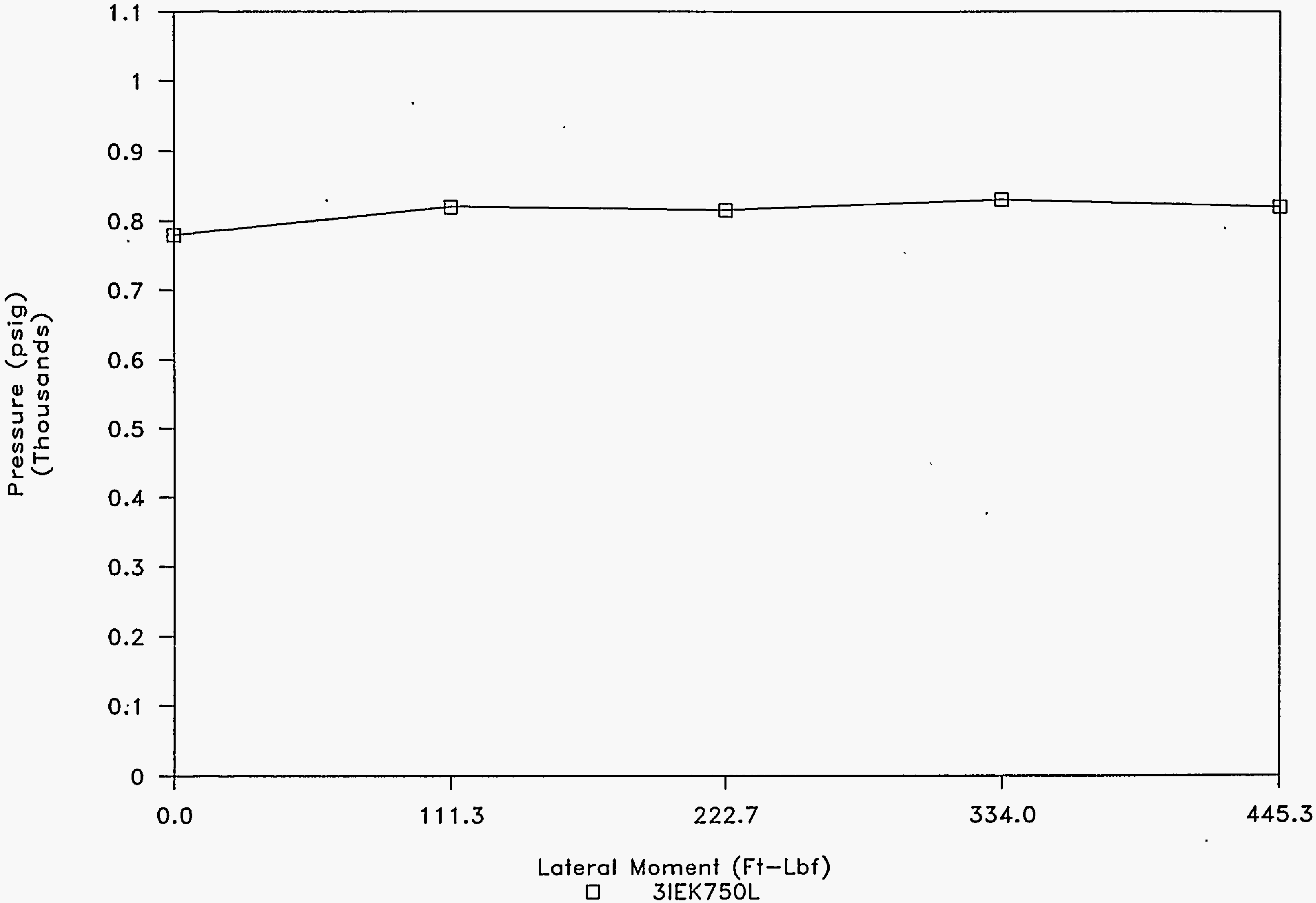


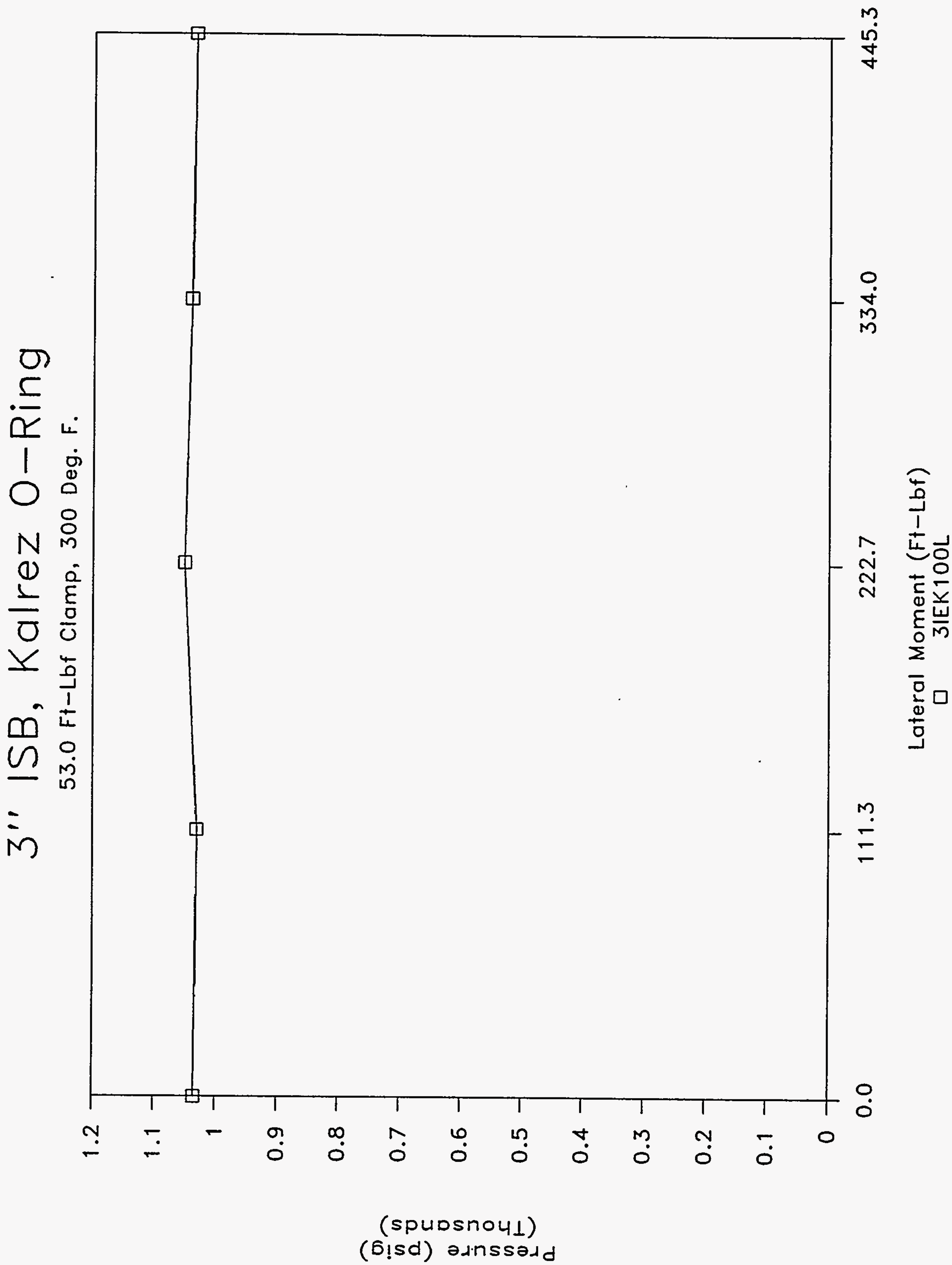
3" ISB, Kalrez O-Ring
53.0 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
400
350
300
250
200
150
100
50
0
0.0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
3IEK250L


3" ISB, Kalrez O-Ring
53.0 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
3IEK500L

3" ISB, Kalrez O-Ring

53.0 Ft-Lbf Clamp, 300 Deg. F.




3" ISB, Kalrez O-Ring
53.0 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
3IEK100L

NOVEMBER 03, 1994
3" ISB CONNECTOR, KALREZ O-RING, ELEVATED TEMP.(300 DEG. F)
LEAK TEST - LATERAL MOMENT (SIDEWAYS)
CLAMPING TORQUE = 53.0 FT-LBF GRAPH NAME = 3IEK250L
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
260	0	0	0.00	0	0.4453	0.0
225	2	1	2.02	0	0.4453	0.0
225	4	1	4.02	250	0.4453	111.3
205	6	2	6.03	500	0.4453	222.7
215	8	1	8.02	750	0.4453	334.0
325	10	3	10.05	1000	0.4453	445.3

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = 3IEK500L

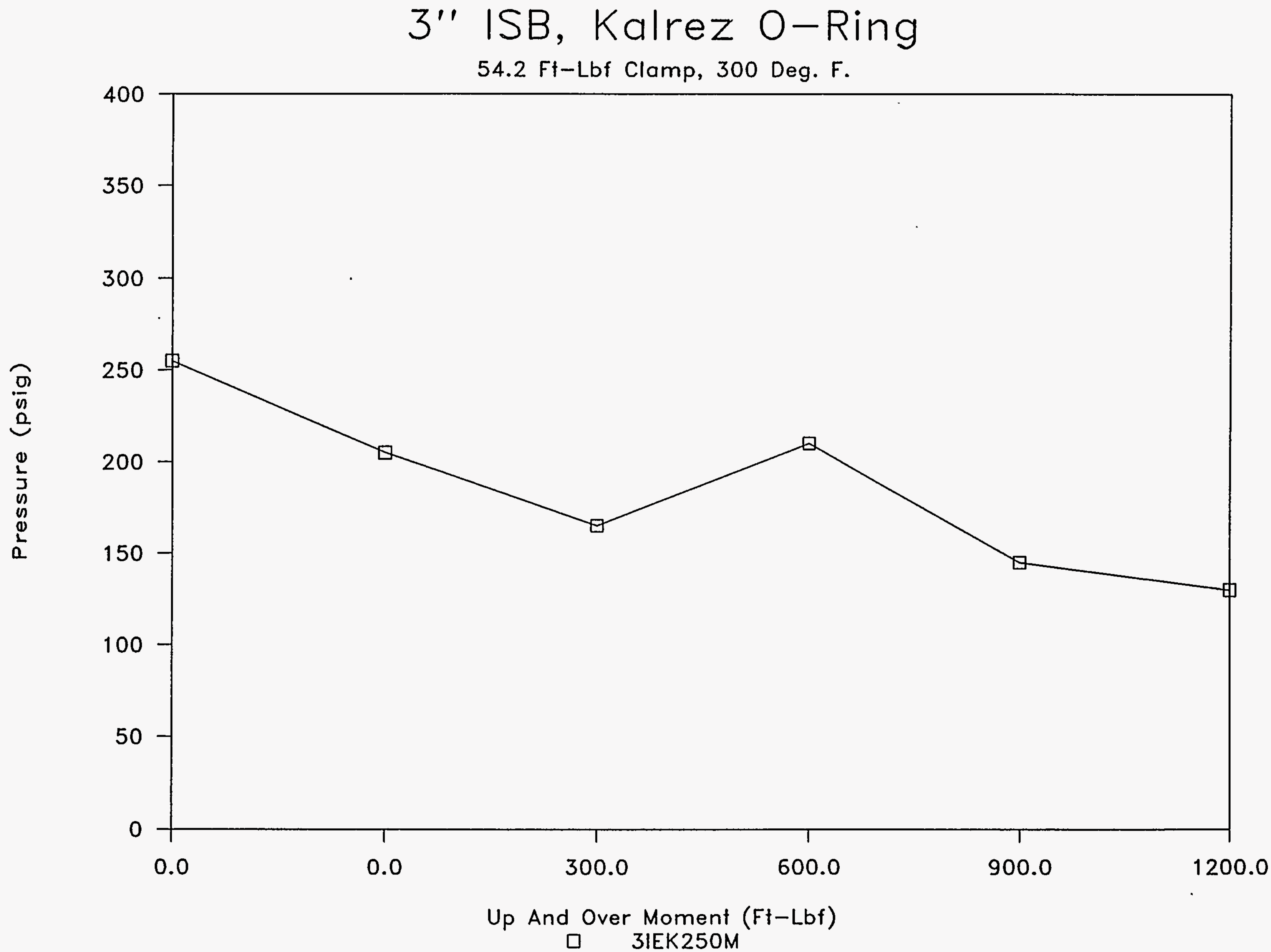
445	12	7	12.12	0	0.4453	0.0
485	14	1	14.02	250	0.4453	111.3
420	16	3	16.05	500	0.4453	222.7
600	18	2	18.03	750	0.4453	334.0
635	20	1	20.02	1000	0.4453	445.3

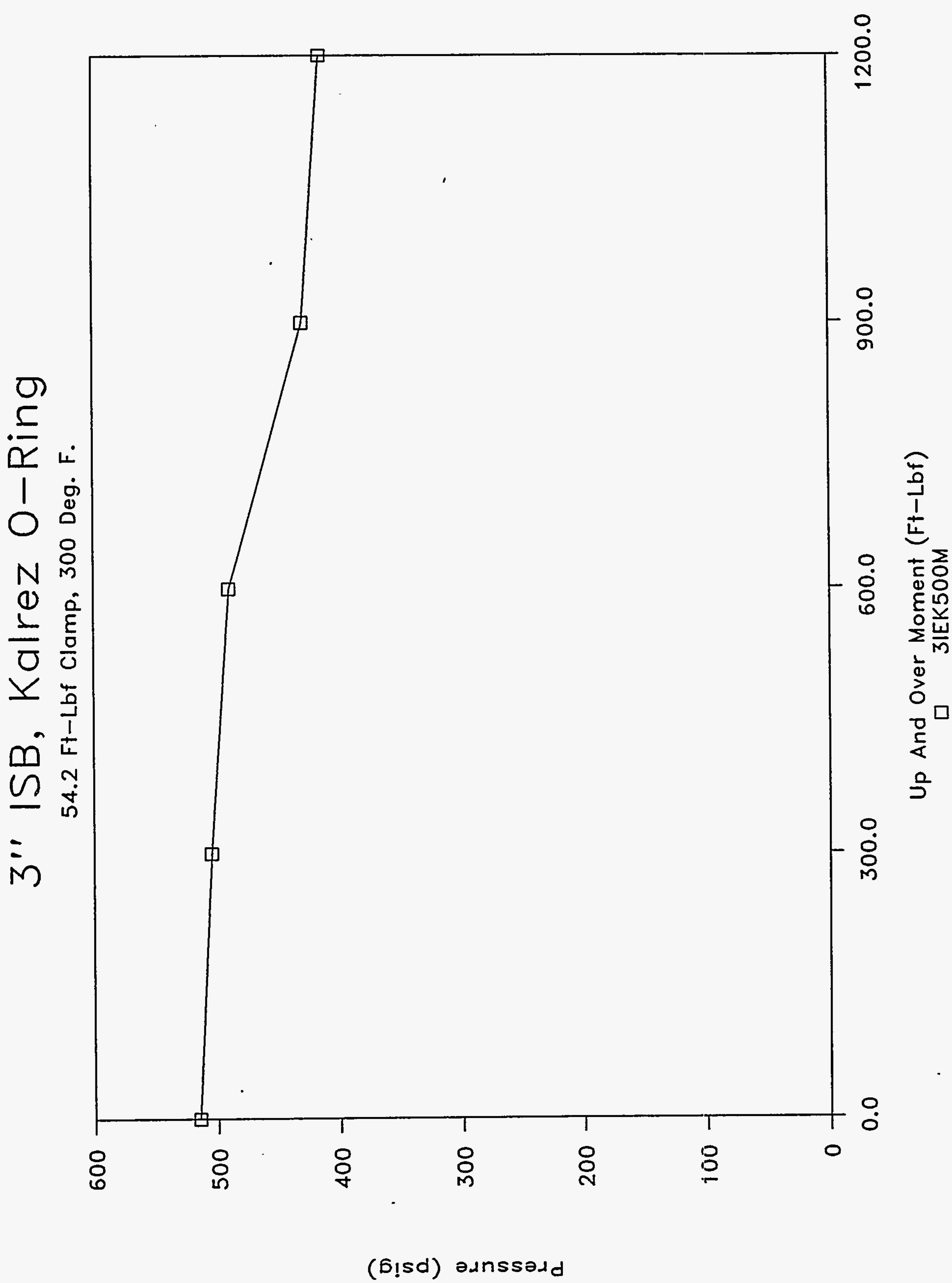
INCREASED PRESSURE TO 750 PSIG GRAPH NAME = 3IEK750L

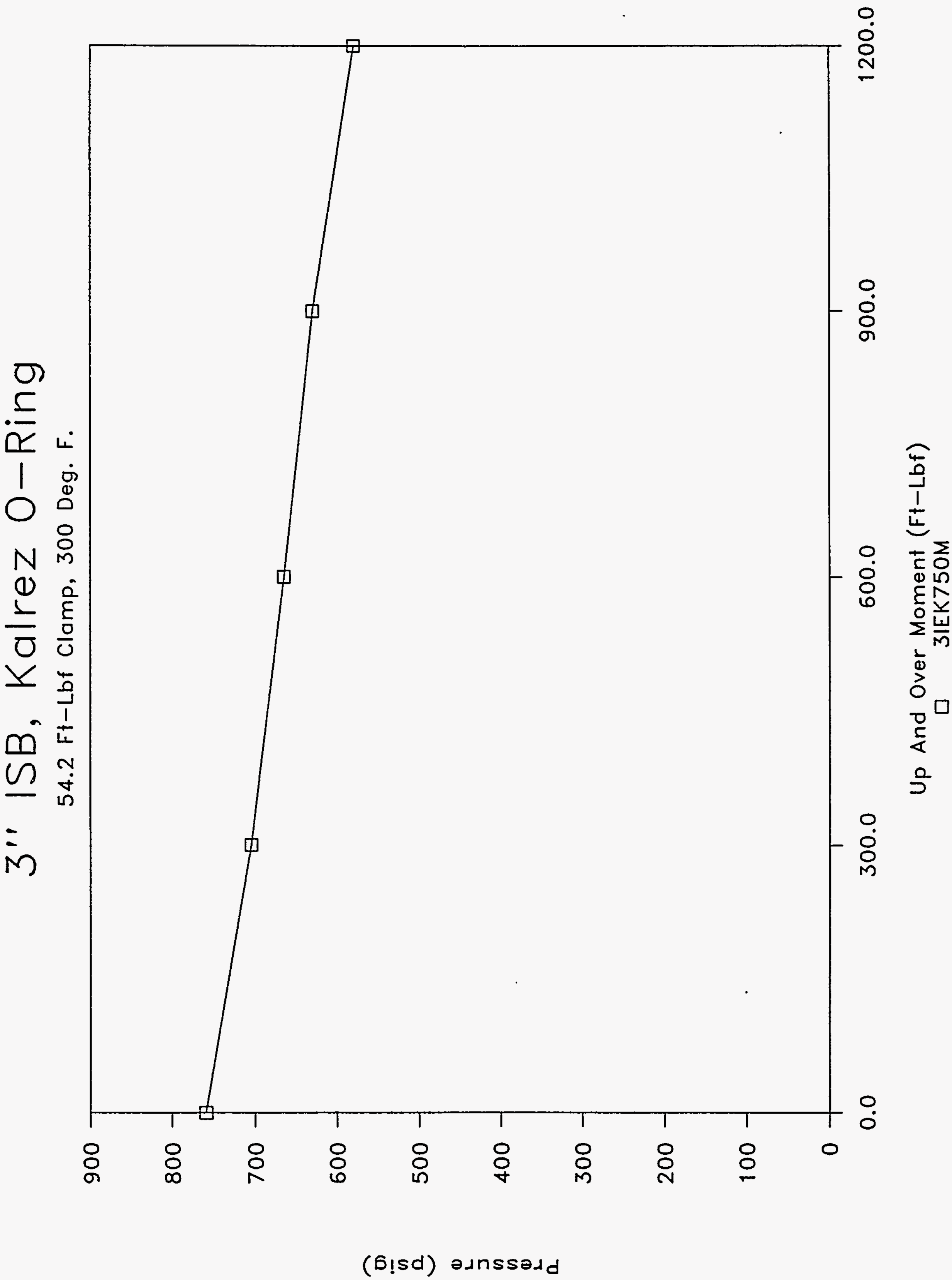
780	22	0	22.00	0	0.4453	0.0
820	24	3	24.05	250	0.4453	111.3
815	26	2	26.03	500	0.4453	222.7
830	28	0	28.00	750	0.4453	334.0
820	30	1	30.02	1000	0.4453	445.3

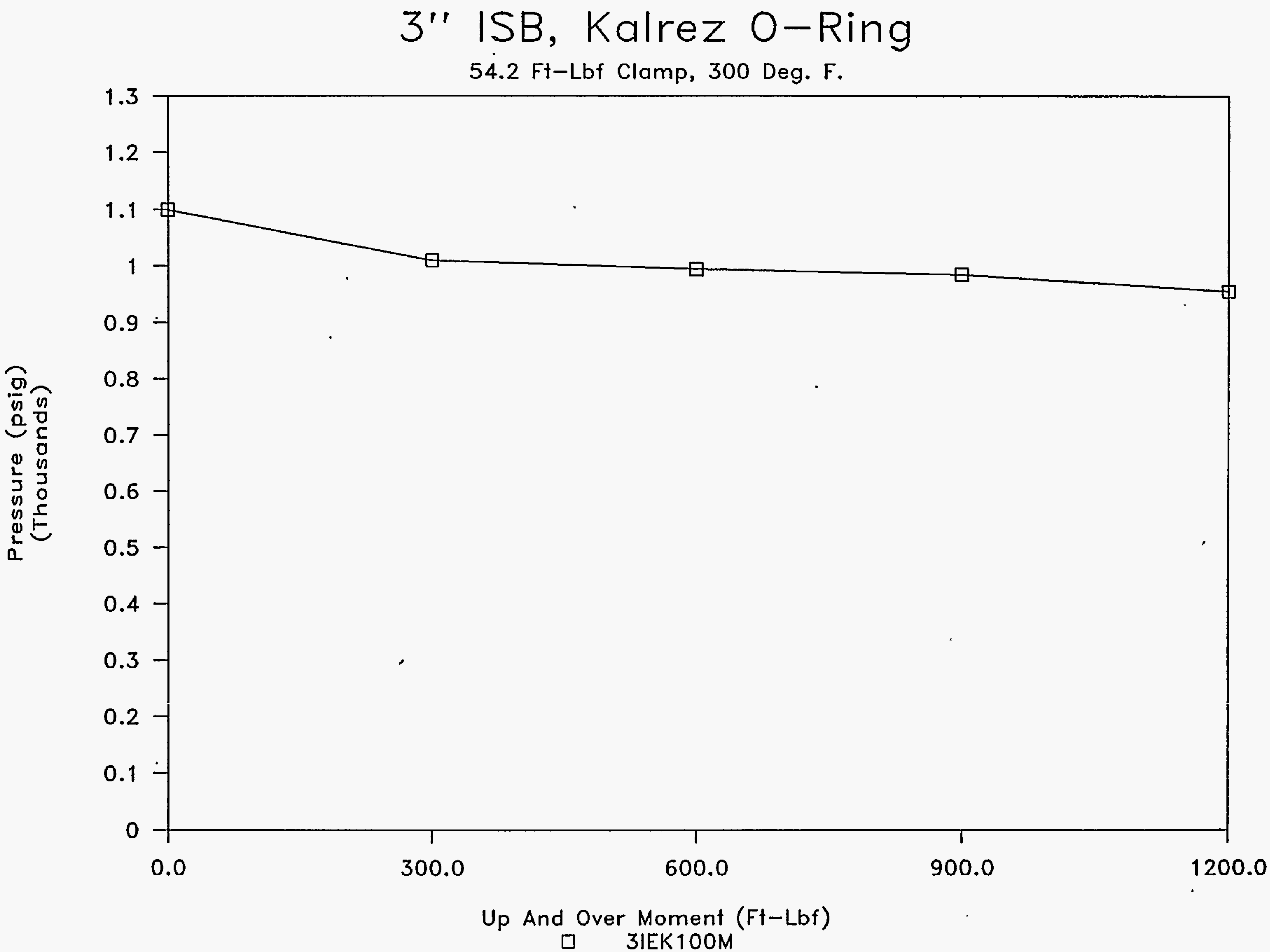
INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = 3IEK100L

1035	32	1	32.02	0	0.4453	0.0
1030	34	2	34.03	250	0.4453	111.3
1050	36	1	36.02	500	0.4453	222.7
1040	38	3	38.05	750	0.4453	334.0
1035	40	2	40.03	1000	0.4453	445.3


3" ISB, Kalrez O-Ring
54.2 Ft-Lbf Clamp, 300 Deg. F.
400
350
300
250
200
150
100
50
0
Pressure (psig)
0.0
0.0
300.0
600.0
900.0
1200.0
Up And Over Moment (Ft-Lbf)
3IEK250M


3'' ISB, Kalrez O-Ring
54.2 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
600
500
400
300
200
100
0
0.0
300.0
600.0
900.0
1200.0
Up And Over Moment (Ft-Lbf)
3IEK500M


3'' ISB, Kalrez O-Ring
54.2 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
300.0
600.0
900.0
1200.0
Up And Over Moment (Ft-Lbf)
3IEK750M


3'' ISB, Kalrez O-Ring
54.2 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
(Thousands)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
300.0
600.0
900.0
1200.0
Up And Over Moment (Ft-Lbf)
3IEK100M

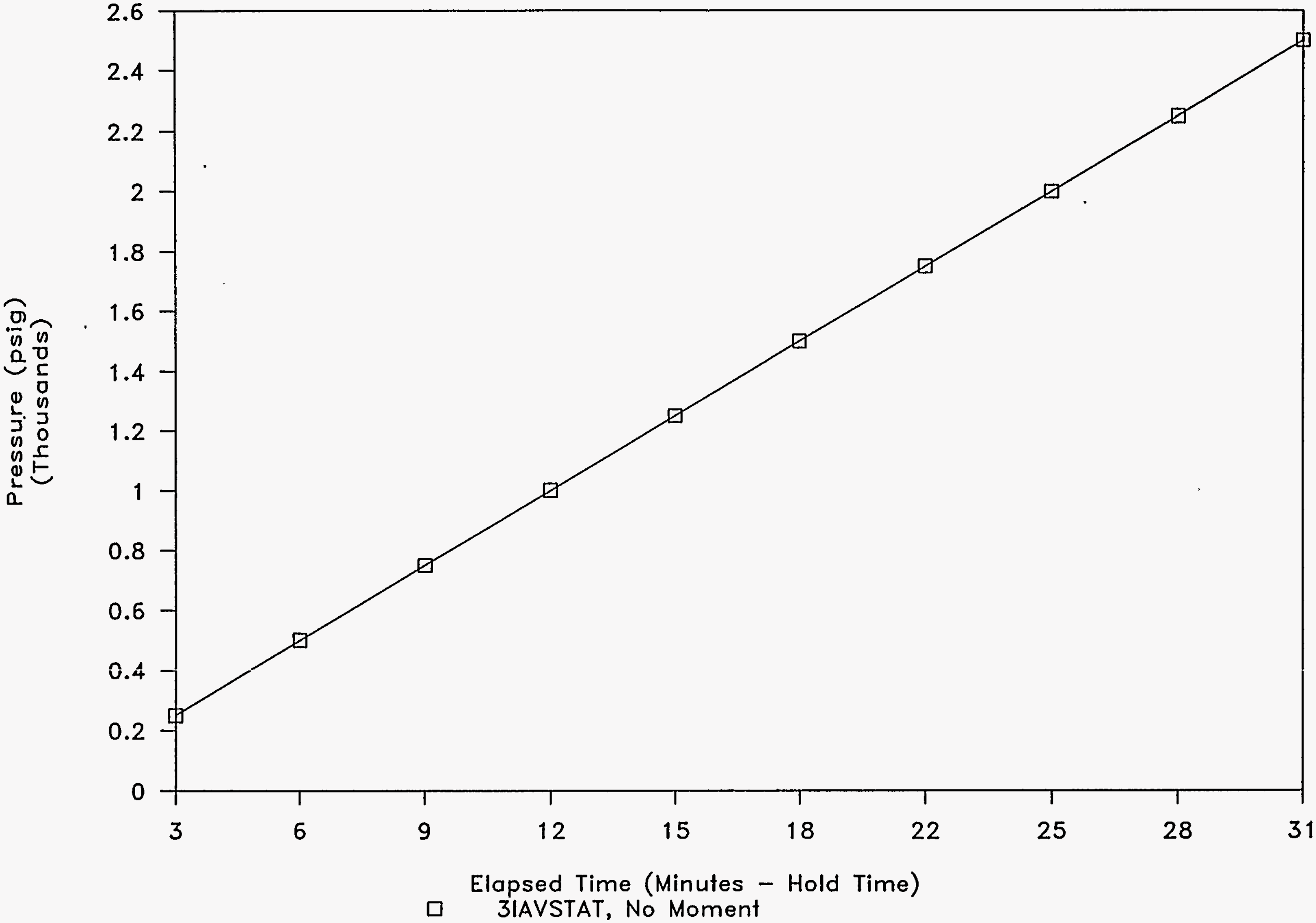
NOVEMBER 02, 1994
3" ISB CONNECTOR, KALREZ O-RING, ELEVATED TEMP.(300 DEG. F)
LEAK TEST - UP AND OVER MOMENT (UPWARD)
CLAMPING TORQUE = 54.2 FT-LBF GRAPH NAME = 3IEK250M
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
255	0	0	0.00	0	1.2000	0.0
205	2	5	2.08	0	1.2000	0.0
165	4	3	4.05	250	1.2000	300.0
210	6	1	6.02	500	1.2000	600.0
145	8	2	8.03	750	1.2000	900.0
130	10	1	10.02	1000	1.2000	1200.0
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = 3IEK500M		
515	12	1	12.02	0	1.2000	0.0
505	14	3	14.05	250	1.2000	300.0
490	16	2	16.03	500	1.2000	600.0
430	18	2	18.03	750	1.2000	900.0
415	20	1	20.02	1000	1.2000	1200.0
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = 3IEK750M		
760	22	3	22.05	0	1.2000	0.0
705	24	1	24.02	250	1.2000	300.0
665	26	1	26.02	500	1.2000	600.0
630	28	2	28.03	750	1.2000	900.0
580	30	1	30.02	1000	1.2000	1200.0
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = 3IEK100M		
1100	32	2	32.03	0	1.2000	0.0
1010	34	5	34.08	250	1.2000	300.0
995	36	1	36.02	500	1.2000	600.0
985	38	3	38.05	750	1.2000	900.0
955	40	3	40.05	1000	1.2000	1200.0

APPENDIX J: GRAPHS OF 3-IN. VITON TESTS

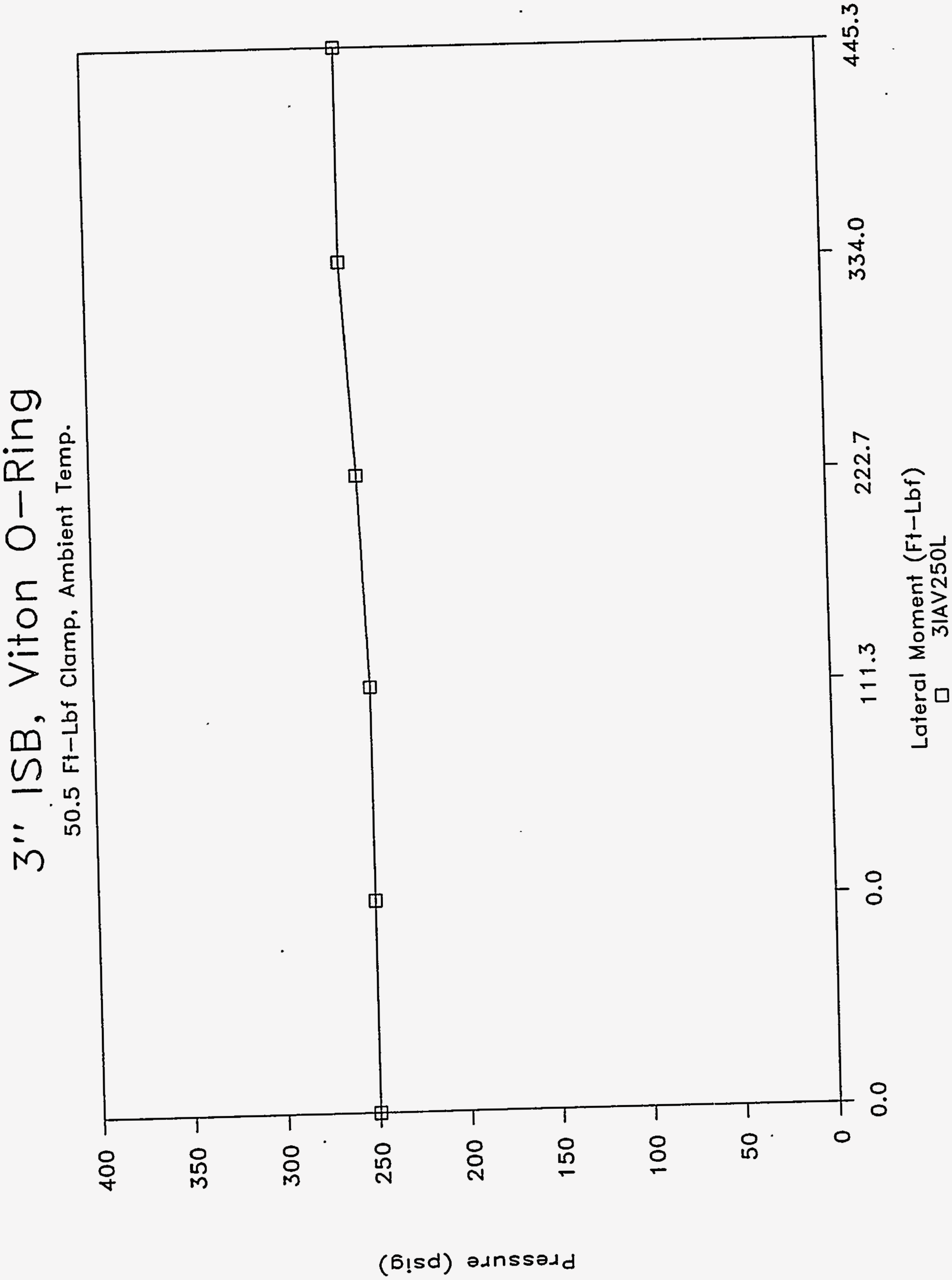
3'' ISB Viton O-Ring

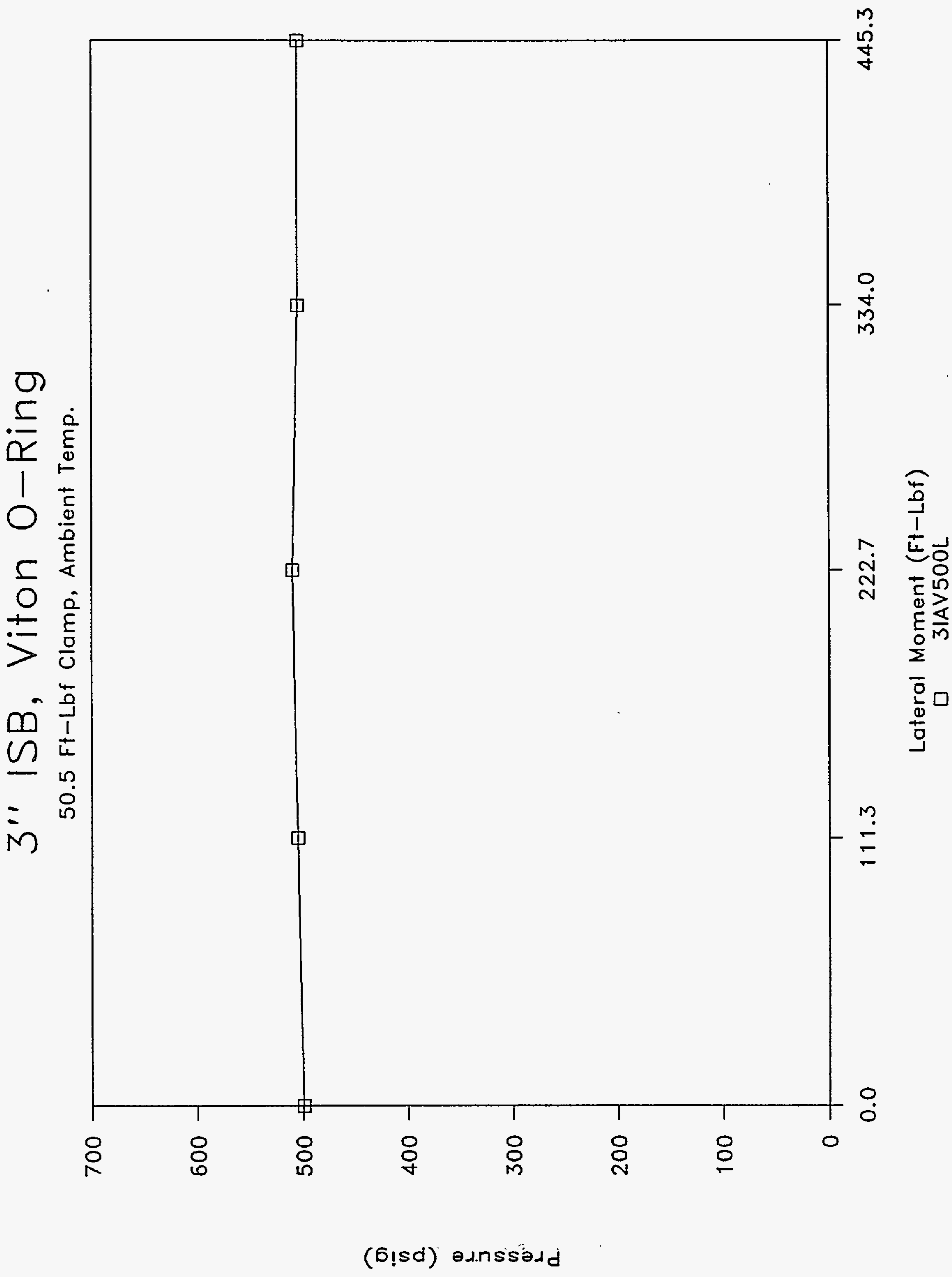
52.8 Ft-Lbf Clamp, Ambient Temp.

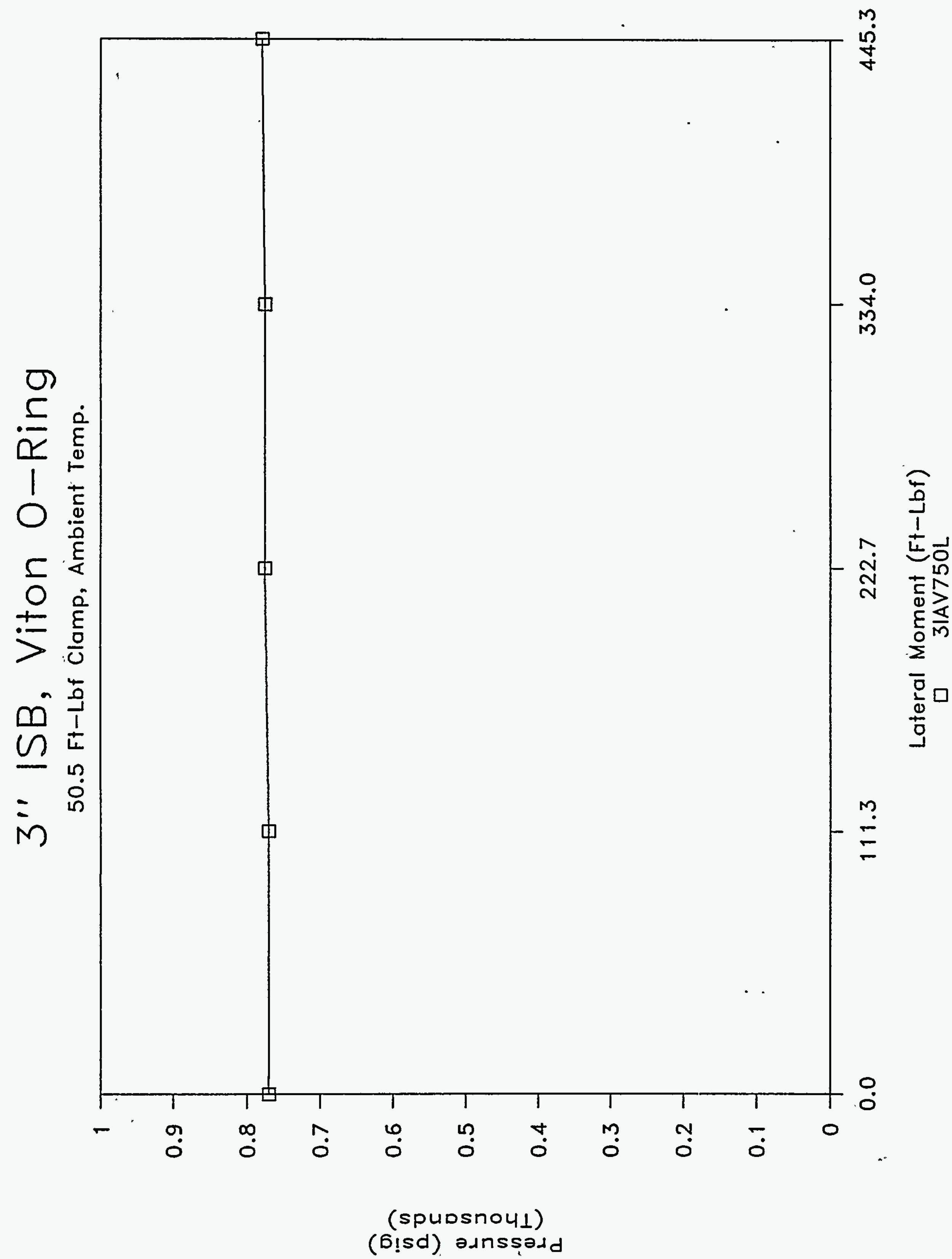


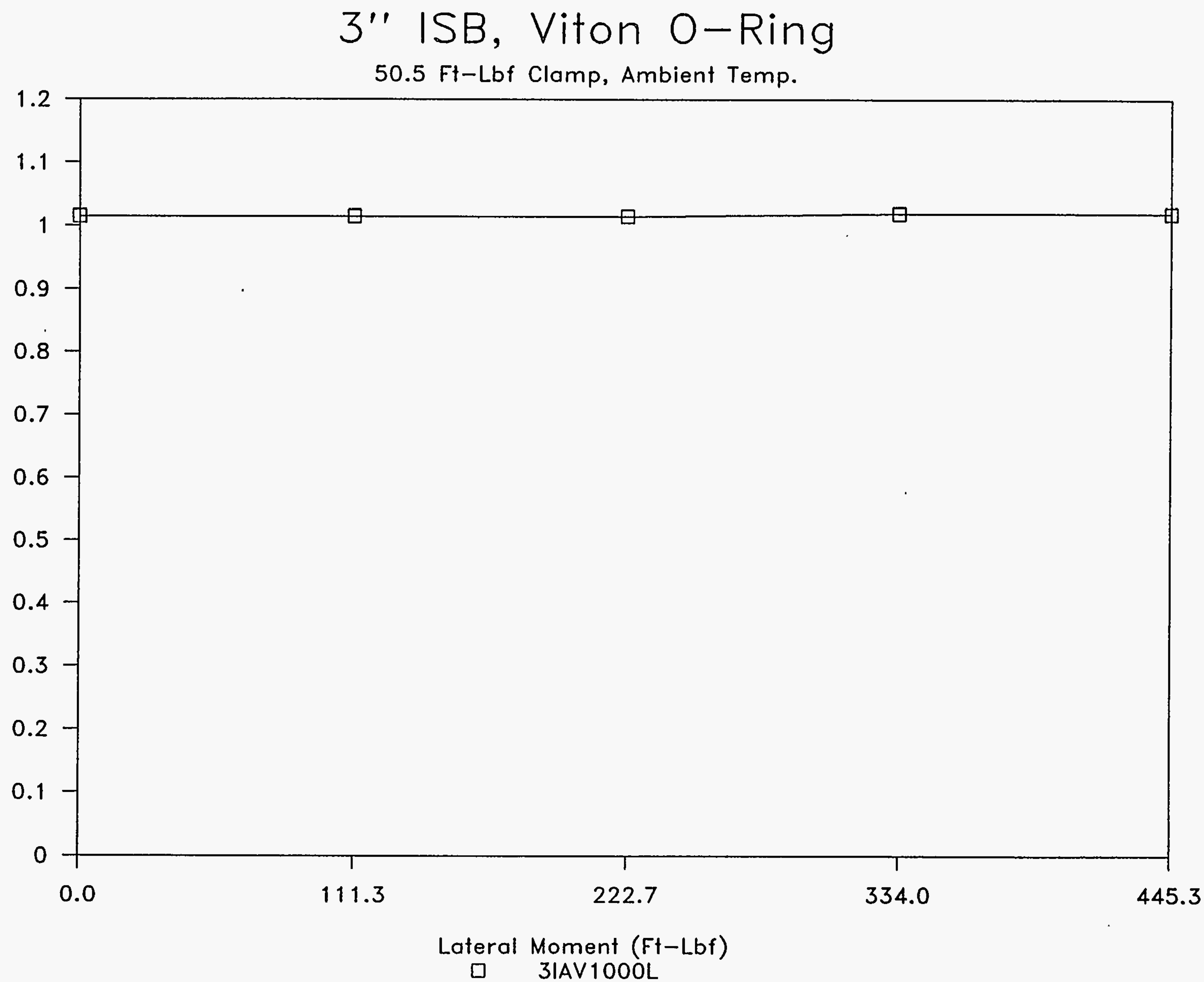
MAY 25, 1994
3" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, AMBIENT TEMP.
STATIC LEAK TEST - NO EXTERNAL MOMENTS
CLAMPING TORQUE = 52.8 FT-LBF GRAPH NAME = 3IAVSTAT
CHARGE PRESSURE = 250 TO 2,500 PSIG

PRESSURE PSIG INPUT	HOLD TIME MIN. INPUT	HOLD TIME SEC. INPUT	ELAPSED MINUTES COMPUTE	ELAPSED SECONDS COMPUTE	ELAPSED DECIMAL ROUNDED MINUTES COMPUTE	MOMENT FORCE LBS INPUT
250	3	4	3	4	3	0
500	3	4	6	8	6	0
750	3	3	9	11	9	0
1000	3	7	12	18	12	0
1250	3	5	15	23	15	0
1500	3	4	18	27	18	0
1750	3	5	21	32	22	0
2000	3	3	24	35	25	0
2250	3	5	27	40	28	0
2500	3	4	30	44	31	0


3" ISB, Viton O-Ring
50.5 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
0
50
100
150
200
250
300
350
400
0.0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
3IAV250L

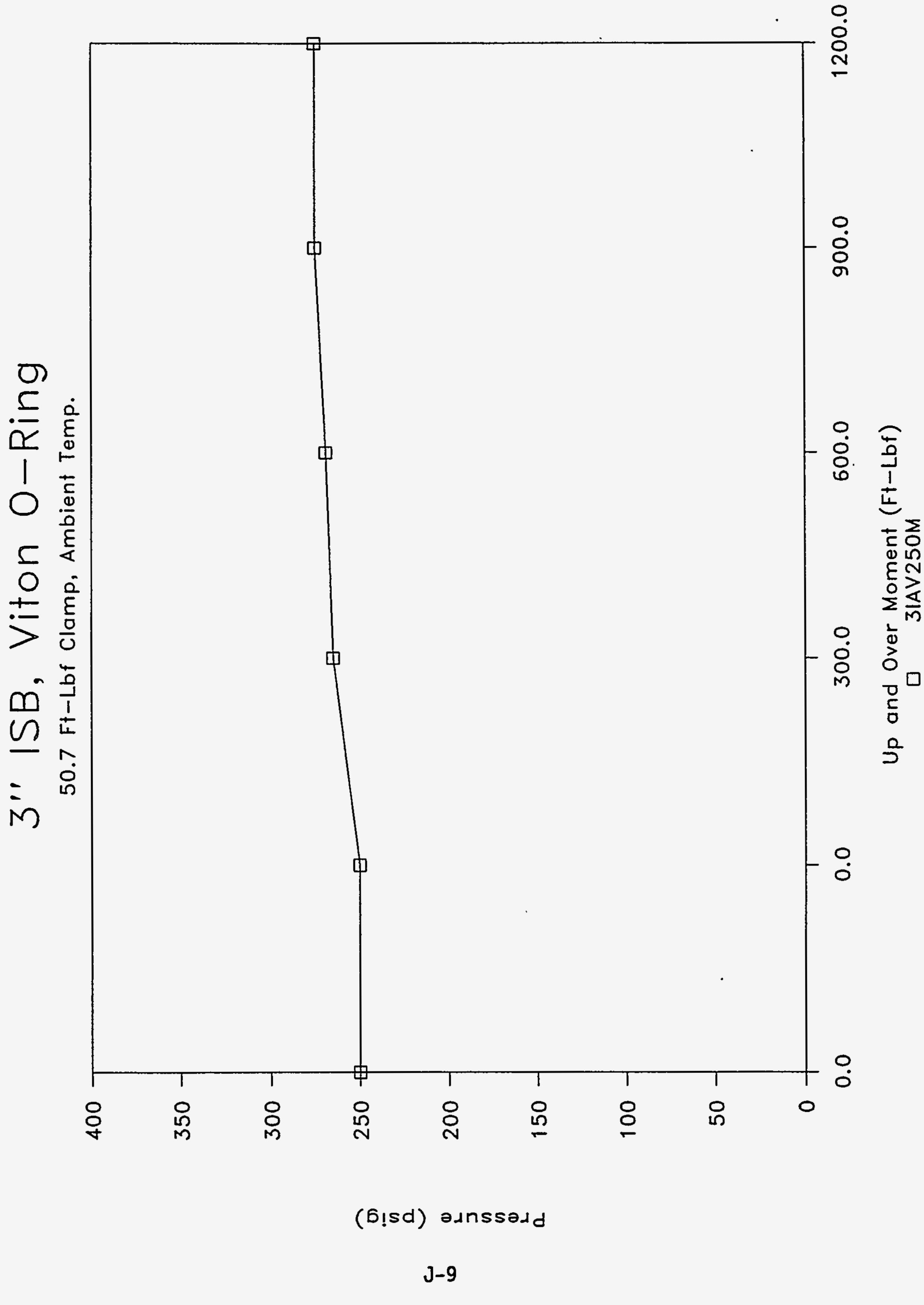

3'' ISB, Viton O-Ring
50.5 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
3IAV500L

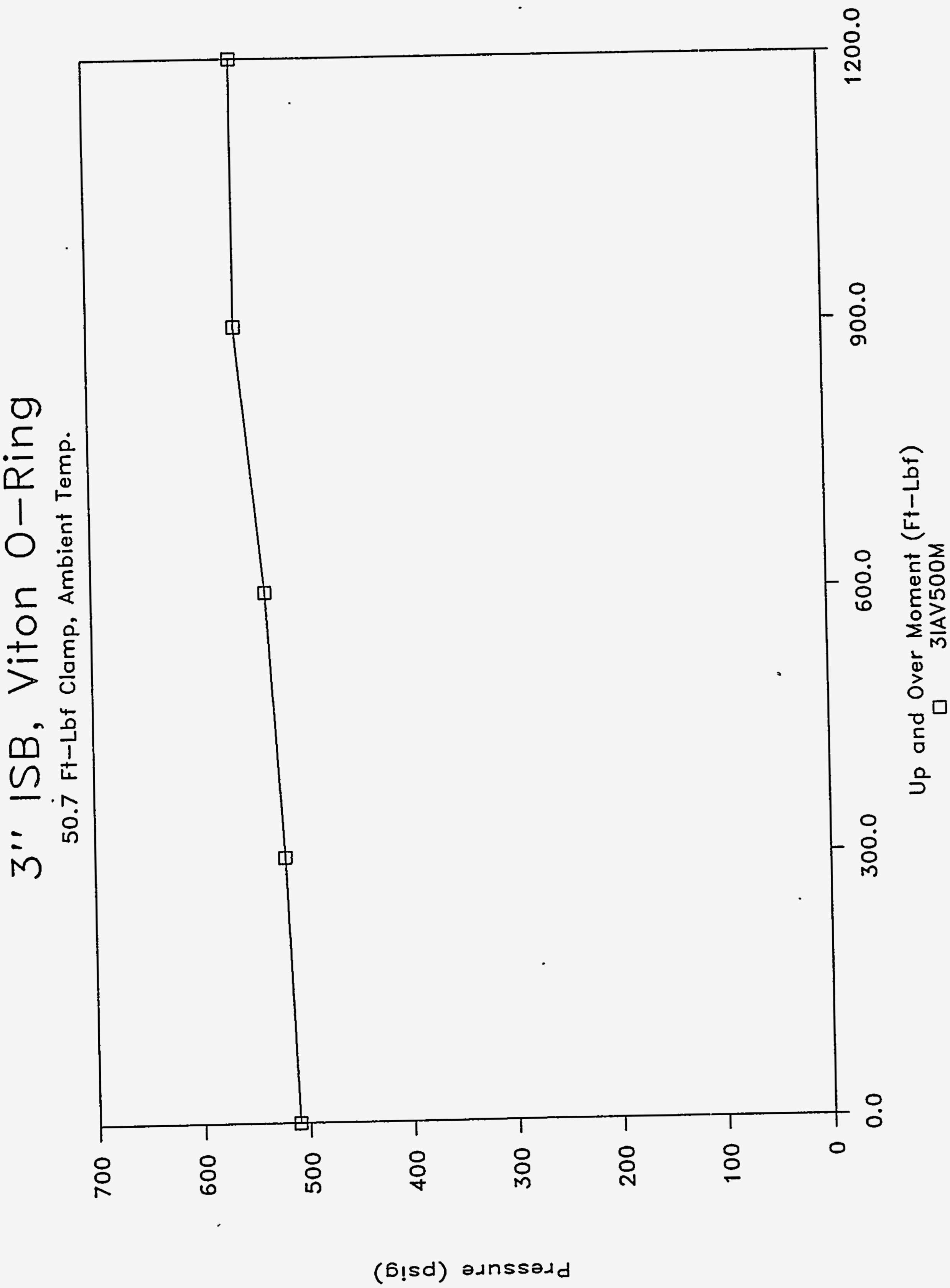

3" ISB, Viton O-Ring
50.5 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
3IAV750L

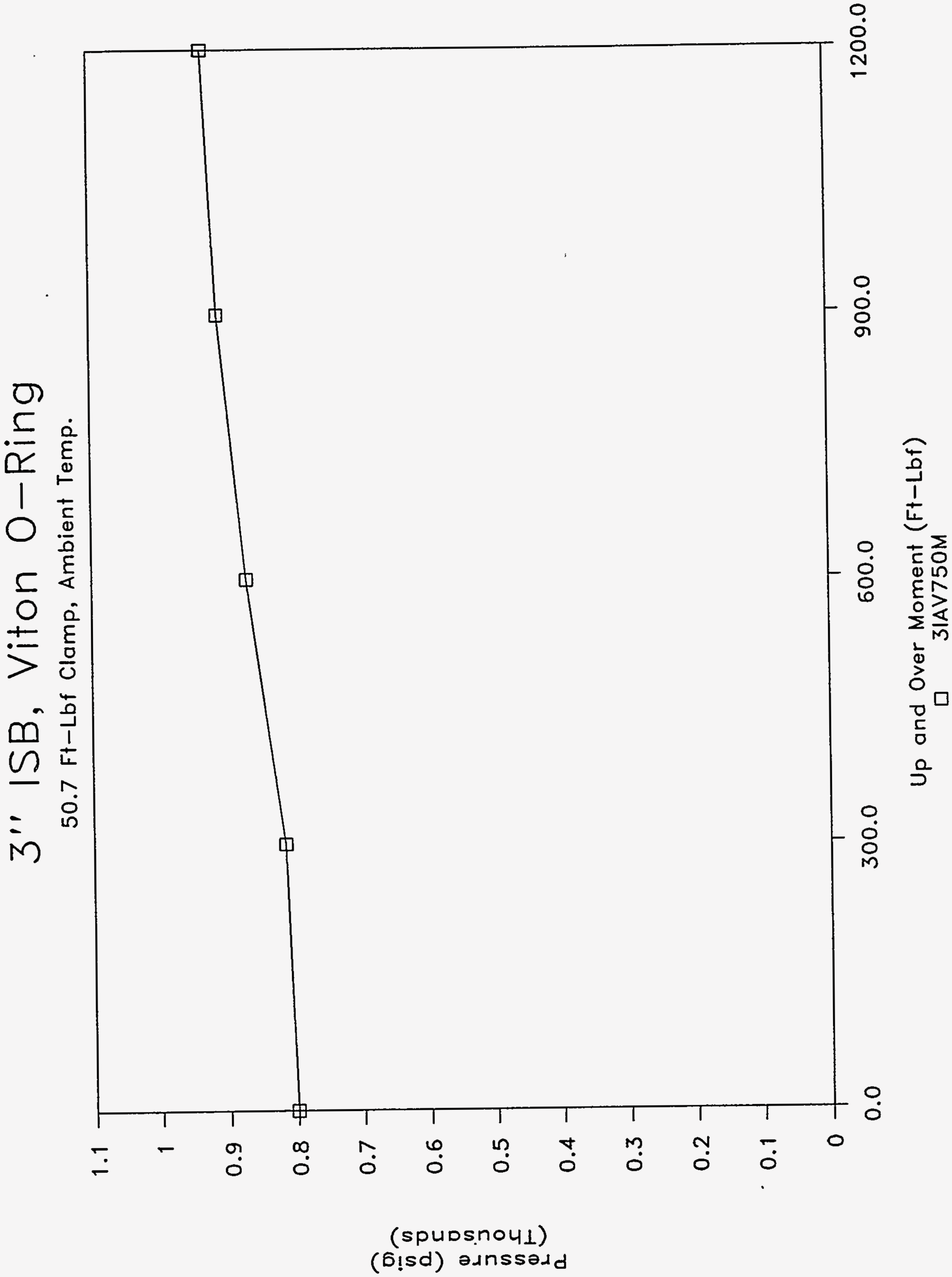

3" ISB, Viton O-Ring
50.5 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
3IAV1000L

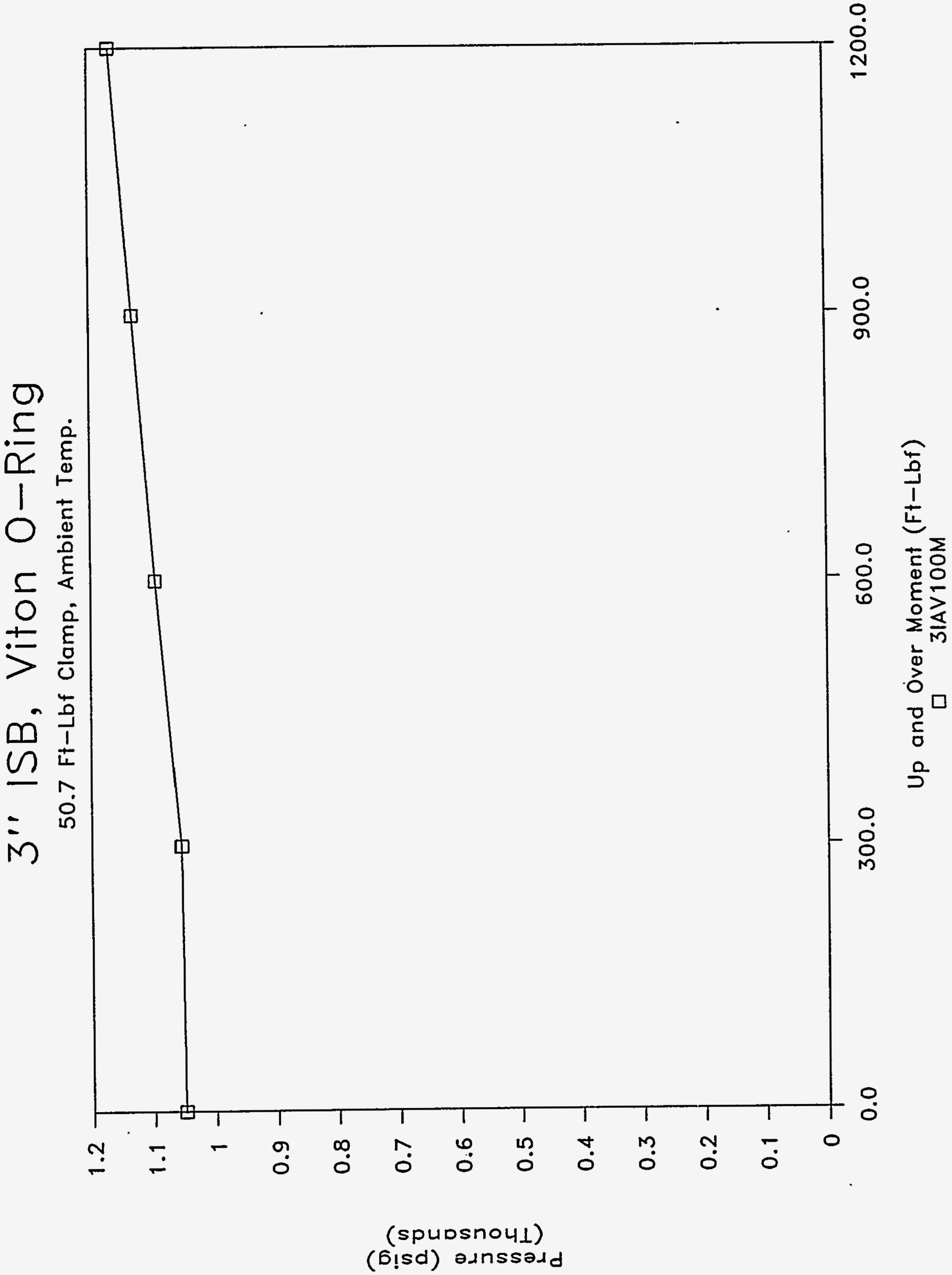
JULY 12, 1994
3" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 50.5 FT-LBF GRAPH NAME = 3IAV250L
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
250	0	0	0.00	0	0.4453	0.0
250	2	1	2.02	0	0.4453	0.0
250	4	2	4.03	250	0.4453	111.3
255	6	8	6.13	500	0.4453	222.7
262	8	7	8.12	750	0.4453	334.0
262	10	4	10.07	1000	0.4453	445.3
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = 3IAV500L		
500	12	6	12.10	0	0.4453	0.0
505	14	5	14.08	250	0.4453	111.3
510	16	4	16.07	500	0.4453	222.7
505	18	3	18.05	750	0.4453	334.0
505	20	8	20.13	1000	0.4453	445.3
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = 3IAV750L		
770	22	2	22.03	0	0.4453	0.0
770	24	3	24.05	250	0.4453	111.3
775	26	7	26.12	500	0.4453	222.7
775	28	4	28.07	750	0.4453	334.0
780	30	15	30.25	1000	0.4453	445.3
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = 3IAV1000L		
1015	32	3	32.05	0	0.4453	0.0
1015	34	4	34.07	250	0.4453	111.3
1015	36	9	36.15	500	0.4453	222.7
1020	38	10	38.17	750	0.4453	334.0
1020	40	8	40.13	1000	0.4453	445.3


3'' ISB, Viton O-Ring
50.7 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
0
50
100
150
200
250
300
350
400
0.0
0.0
300.0
600.0
900.0
1200.0
Up and Over Moment (Ft-Lbf)
3IAV250M

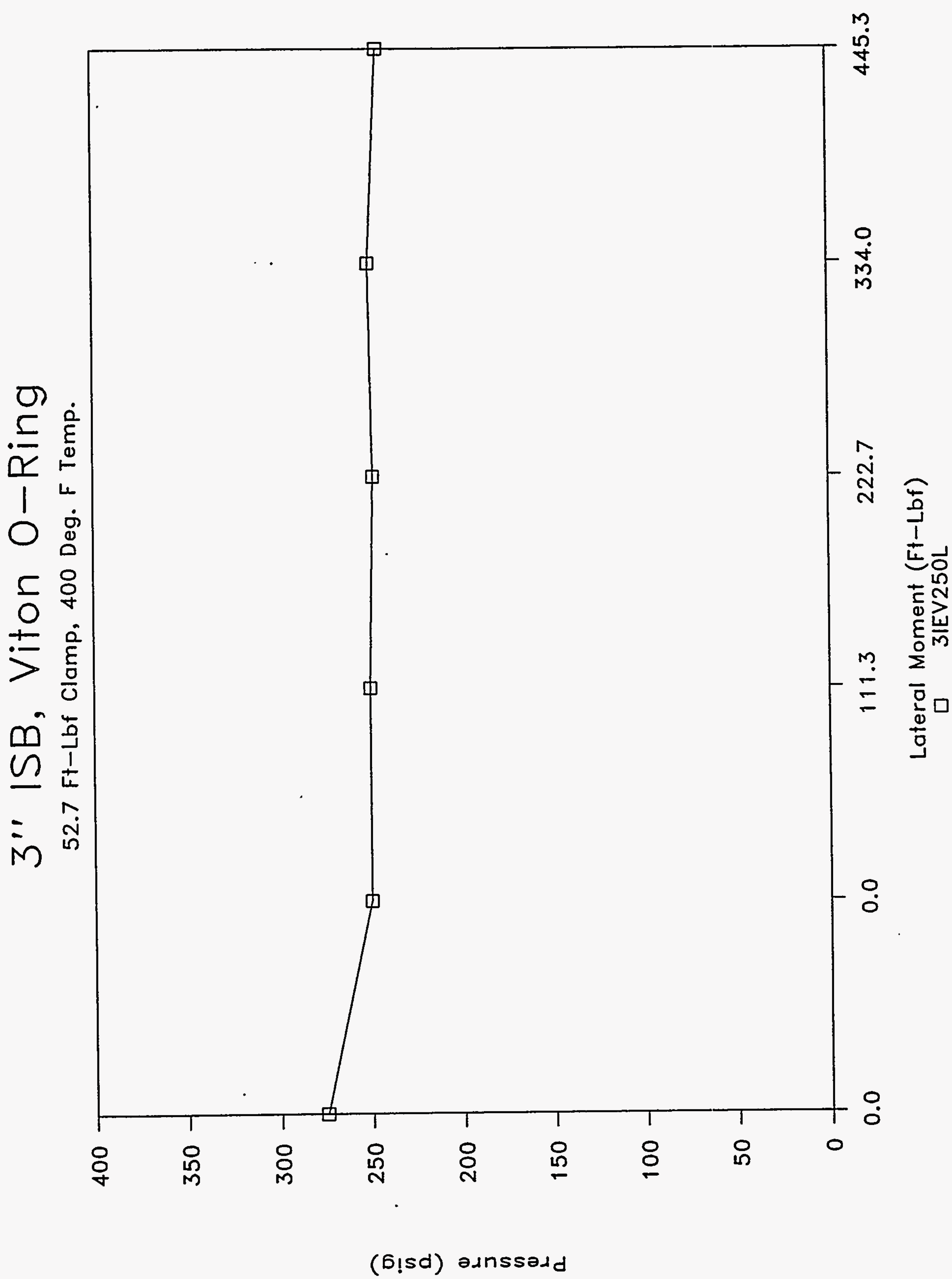

3" ISB, Viton O—Ring
50.7 Ft—Lbf Clamp, Ambient Temp.
Pressure (psig)
0
100
200
300
400
500
600
700
0.0
300.0
600.0
900.0
1200.0
Up and Over Moment (Ft—Lbf)
3IAV500M

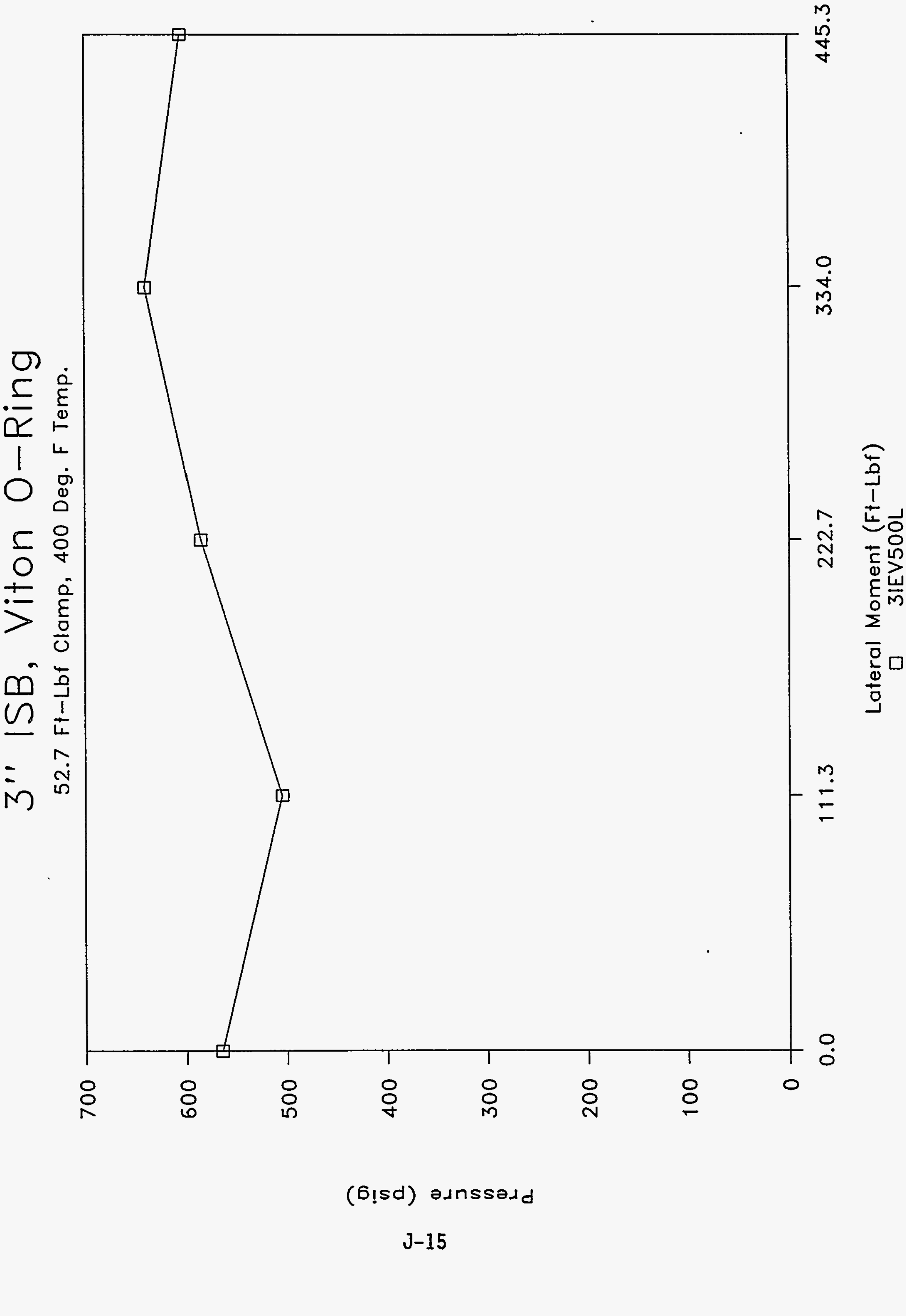

3" ISB, Viton O-Ring
50.7 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
300.0
600.0
900.0
1200.0
Up and Over Moment (Ft-Lbf)
3IAV750M

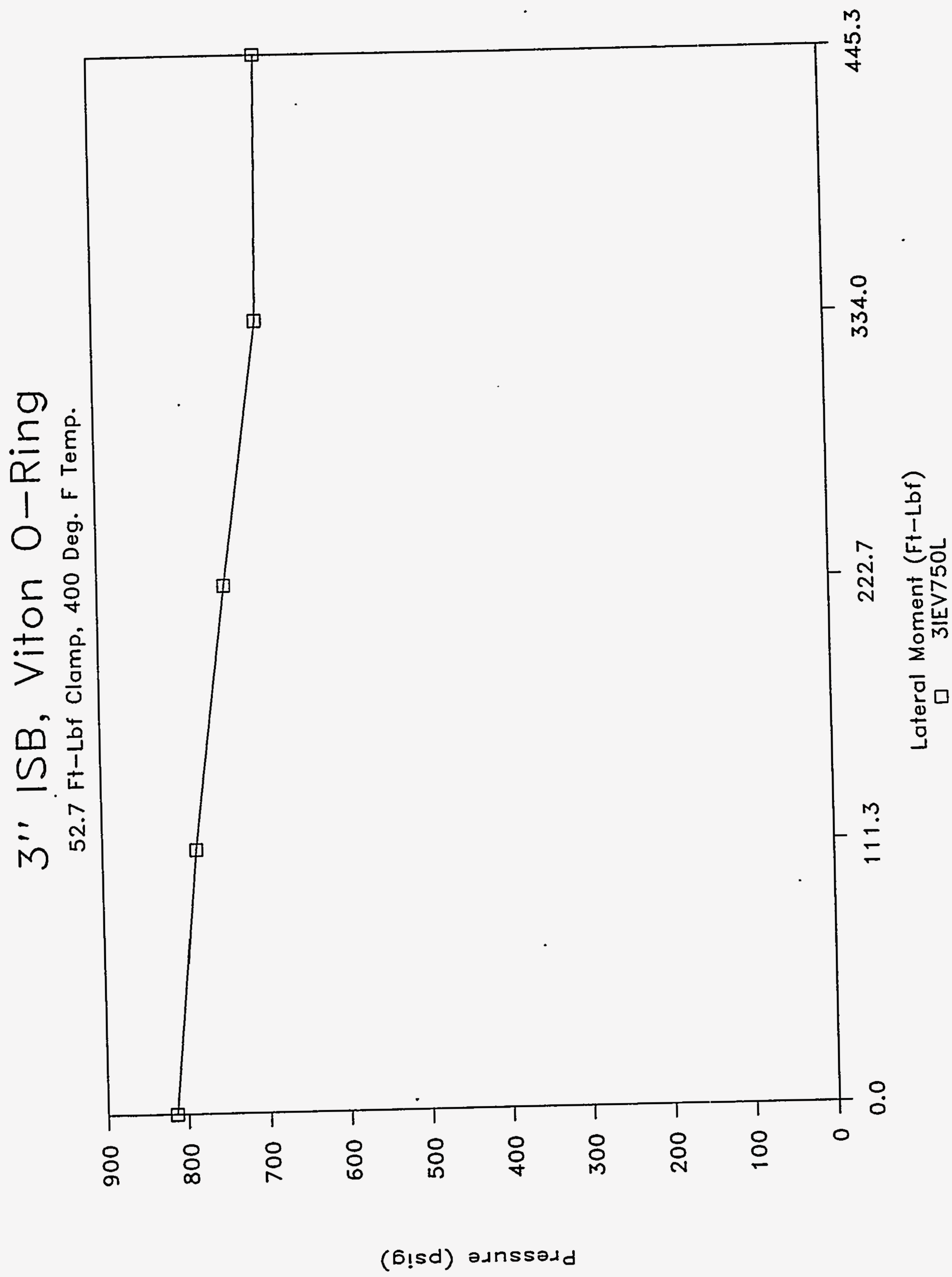

3'' ISB, Viton O-Ring
50.7 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
300.0
600.0
900.0
1200.0
Up and Over Moment (Ft-Lbf)
3IAV100M

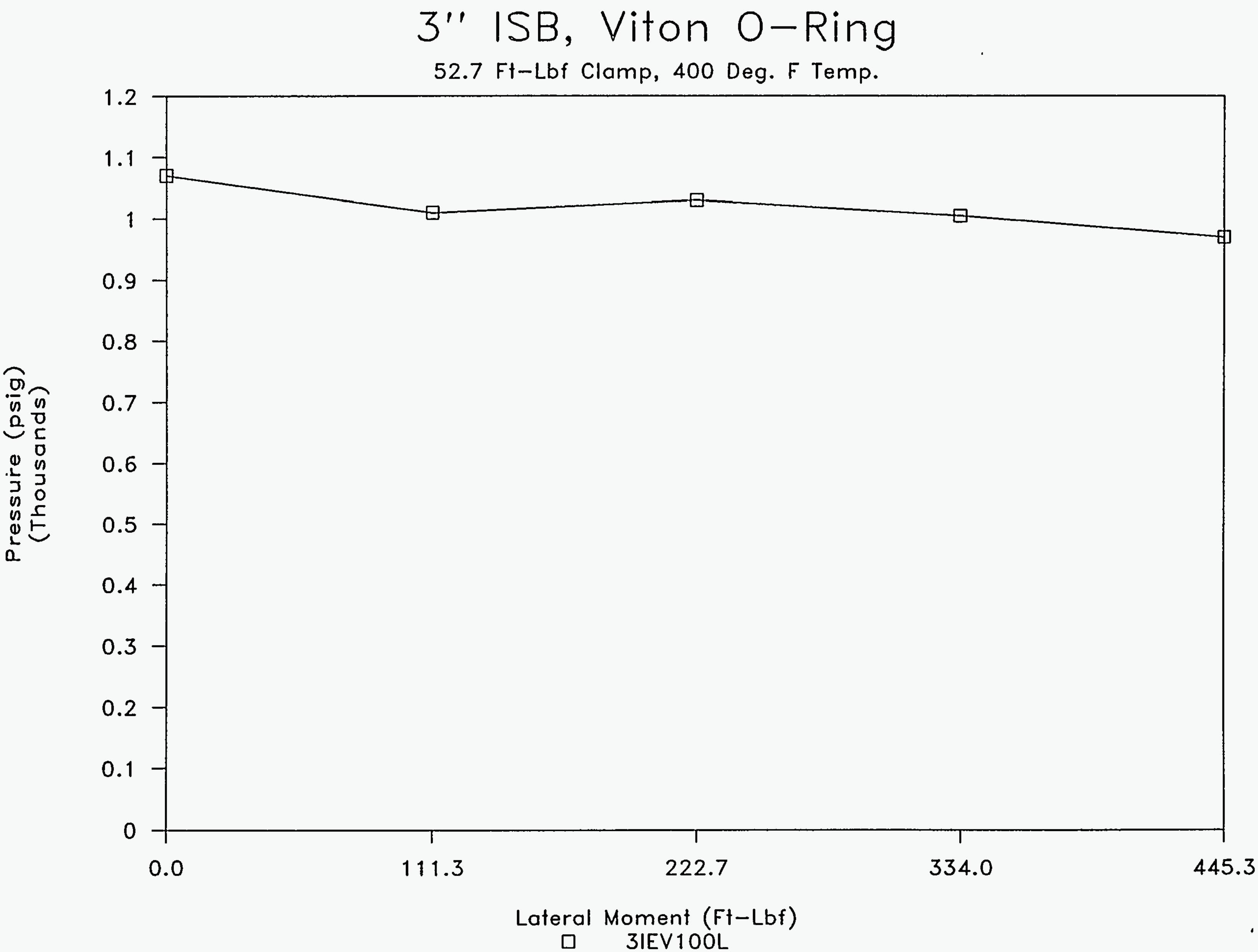
JULY 08, 1994
3" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 50.7 FT-LBF GRAPH NAME = 3IAV250M
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
250	0	0	0.00	0	1.2000	0.0
250	2	1	2.02	0	1.2000	0.0
265	4	3	4.05	250	1.2000	300.0
269	6	2	6.03	500	1.2000	600.0
275	8	2	8.03	750	1.2000	900.0
275	10	44	10.73	1000	1.2000	1200.0
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = 3IAV500M		
510	12	33	12.55	0	1.2000	0.0
520	14	13	14.22	250	1.2000	300.0
535	16	13	16.22	500	1.2000	600.0
560	18	15	18.25	750	1.2000	900.0
560	20	13	20.22	1000	1.2000	1200.0
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = 3IAV750M		
800	21	35	21.58	0	1.2000	0.0
815	23	18	23.30	250	1.2000	300.0
870	25	40	25.67	500	1.2000	600.0
910	27	22	27.37	750	1.2000	900.0
930	29	24	29.40	1000	1.2000	1200.0
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = 3IAV100M		
1050	31	26	31.43	0	1.2000	0.0
1055	33	15	33.25	250	1.2000	300.0
1095	35	22	35.37	500	1.2000	600.0
1130	37	19	37.32	750	1.2000	900.0
1165	39	27	39.45	1000	1.2000	1200.0


3" ISB, Viton O-Ring
52.7 Ft-Lbf Clamp, 400 Deg. F Temp.
Pressure (psig)
0
50
100
150
200
250
300
350
400
0.0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
3IEV250L

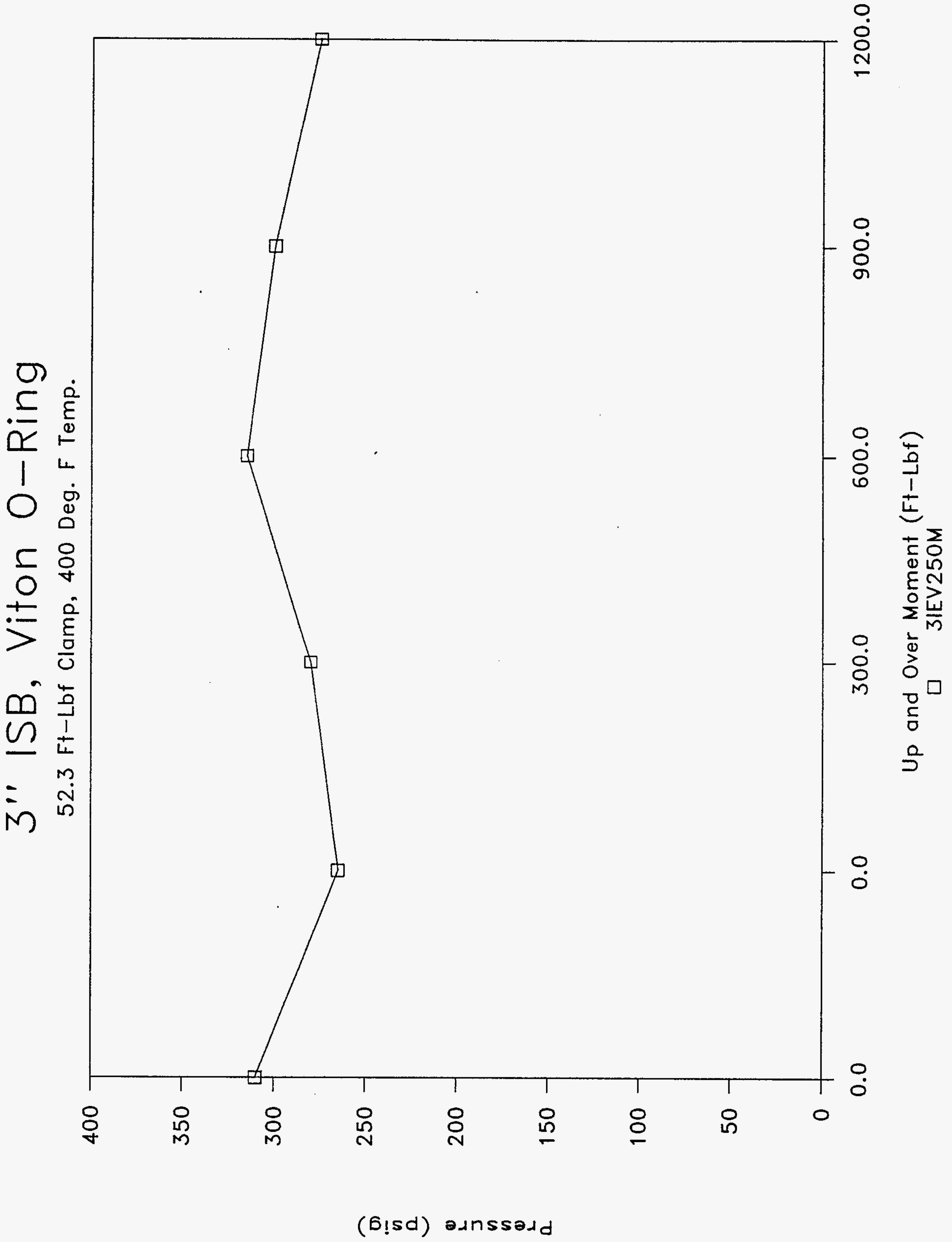

3" ISB, Viton O-Ring
52.7 Ft-Lbf Clamp, 400 Deg. F Temp.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
3IEV500L

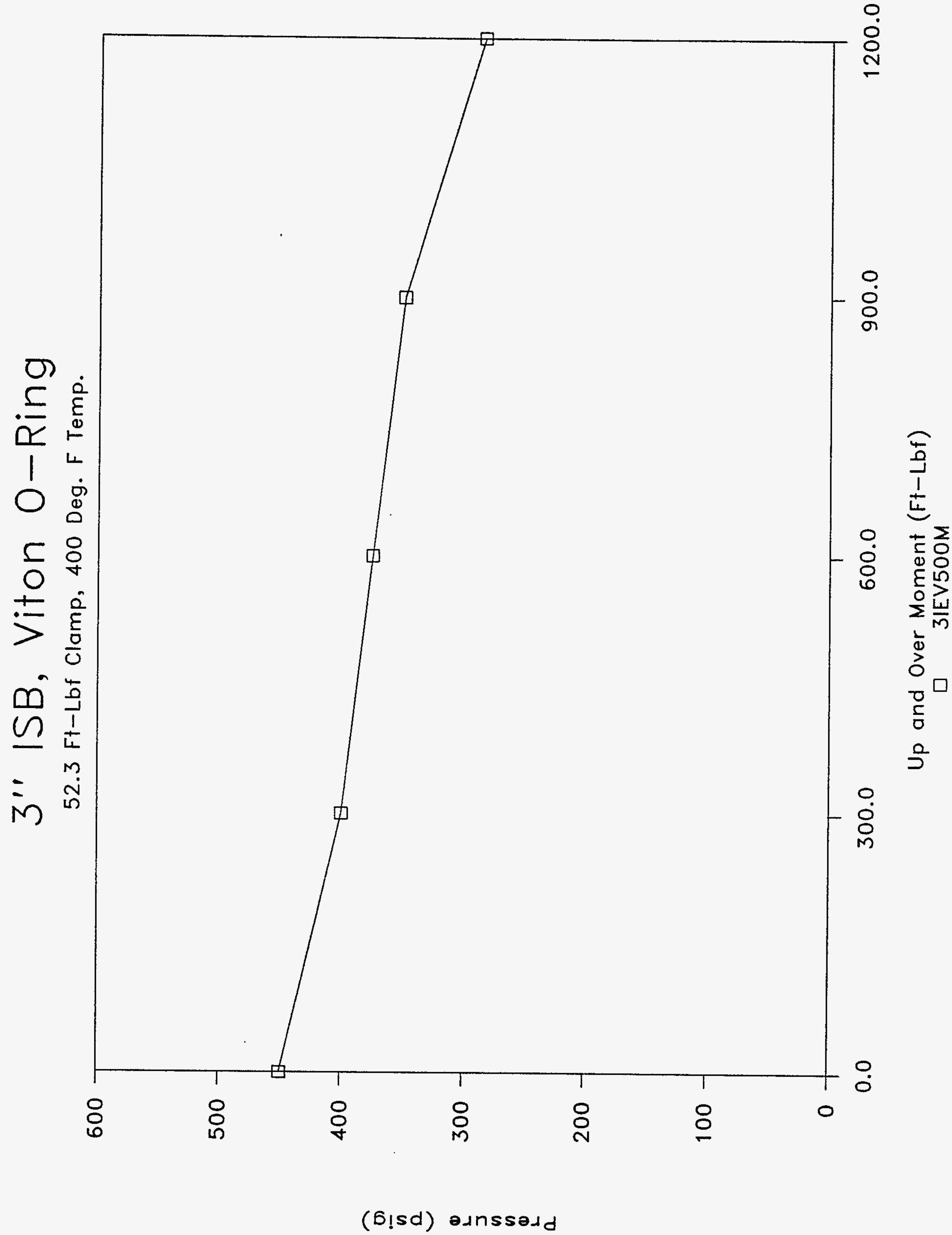

3" ISB, Viton O-Ring
52.7 Ft-Lbf Clamp, 400 Deg. F Temp.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
3IEV750L

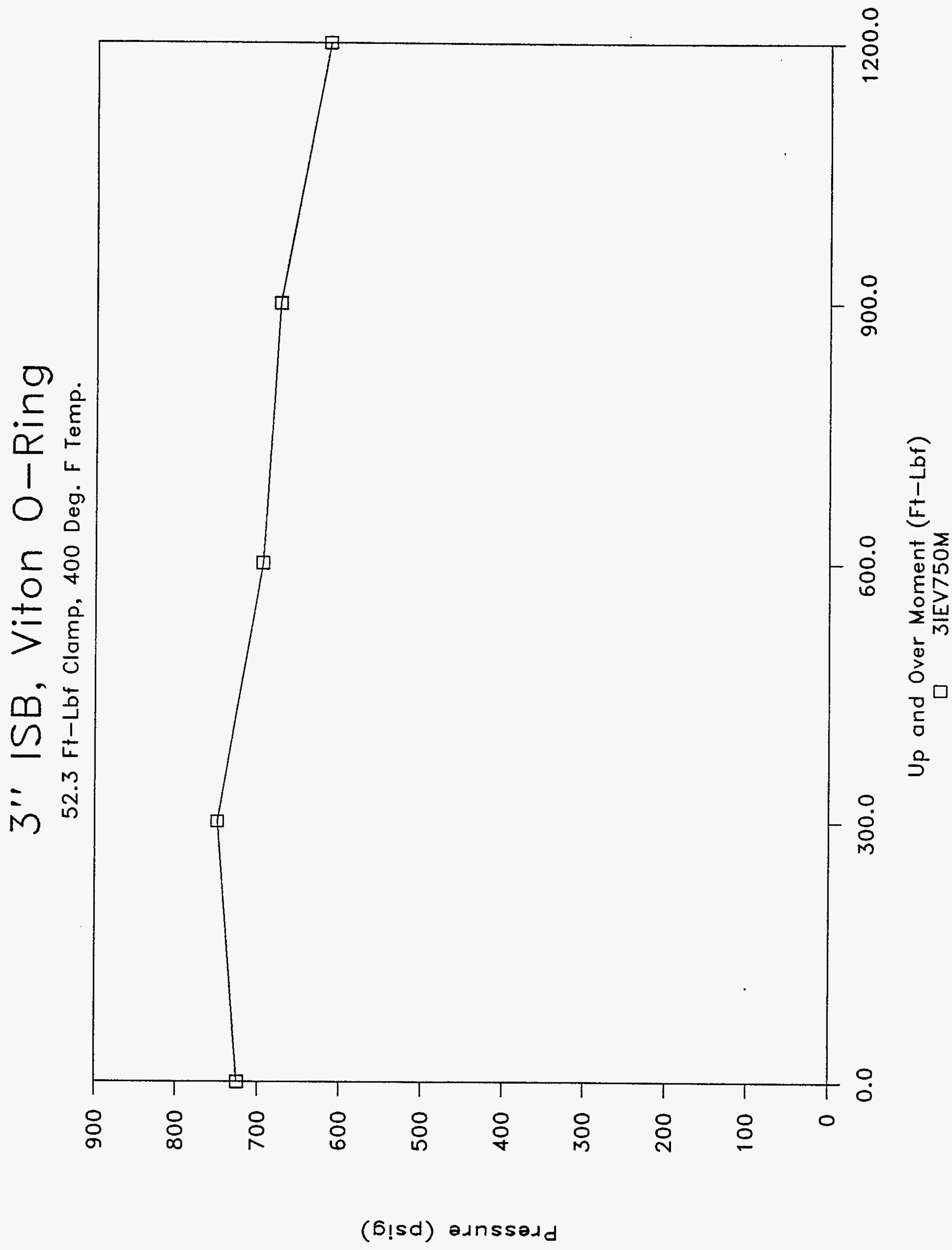

3" ISB, Viton O-Ring
52.7 Ft-Lbf Clamp, 400 Deg. F Temp.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
3IEV100L

JULY 13, 1994
3" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, ELEVATED TEMP.
PRESSURE ASCENSION LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 52.7 FT-LBF GRAPH NAME = 3IEV250L
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
275	0	0	0.00	0	0.4453	0.0
250	2	10	2.17	0	0.4453	0.0
250	4	9	4.15	250	0.4453	111.3
248	6	9	6.15	500	0.4453	222.7
250	8	16	8.27	750	0.4453	334.0
245	10	4	10.07	1000	0.4453	445.3
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = 3IEV500L		
565	12	5	12.08	0	0.4453	0.0
505	14	3	14.05	250	0.4453	111.3
585	16	2	16.03	500	0.4453	222.7
640	18	5	18.08	750	0.4453	334.0
605	20	4	20.07	1000	0.4453	445.3
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = 3IEV750L		
815	22	4	22.07	0	0.4453	0.0
785	24	10	24.17	250	0.4453	111.3
745	26	8	26.13	500	0.4453	222.7
700	28	10	28.17	750	0.4453	334.0
695	30	8	30.13	1000	0.4453	445.3
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = 3IEV1000L		
1070	32	7	32.12	0	0.4453	0.0
1010	34	15	34.25	250	0.4453	111.3
1030	36	3	36.05	500	0.4453	222.7
1005	38	13	38.22	750	0.4453	334.0
970	40	5	40.08	1000	0.4453	445.3

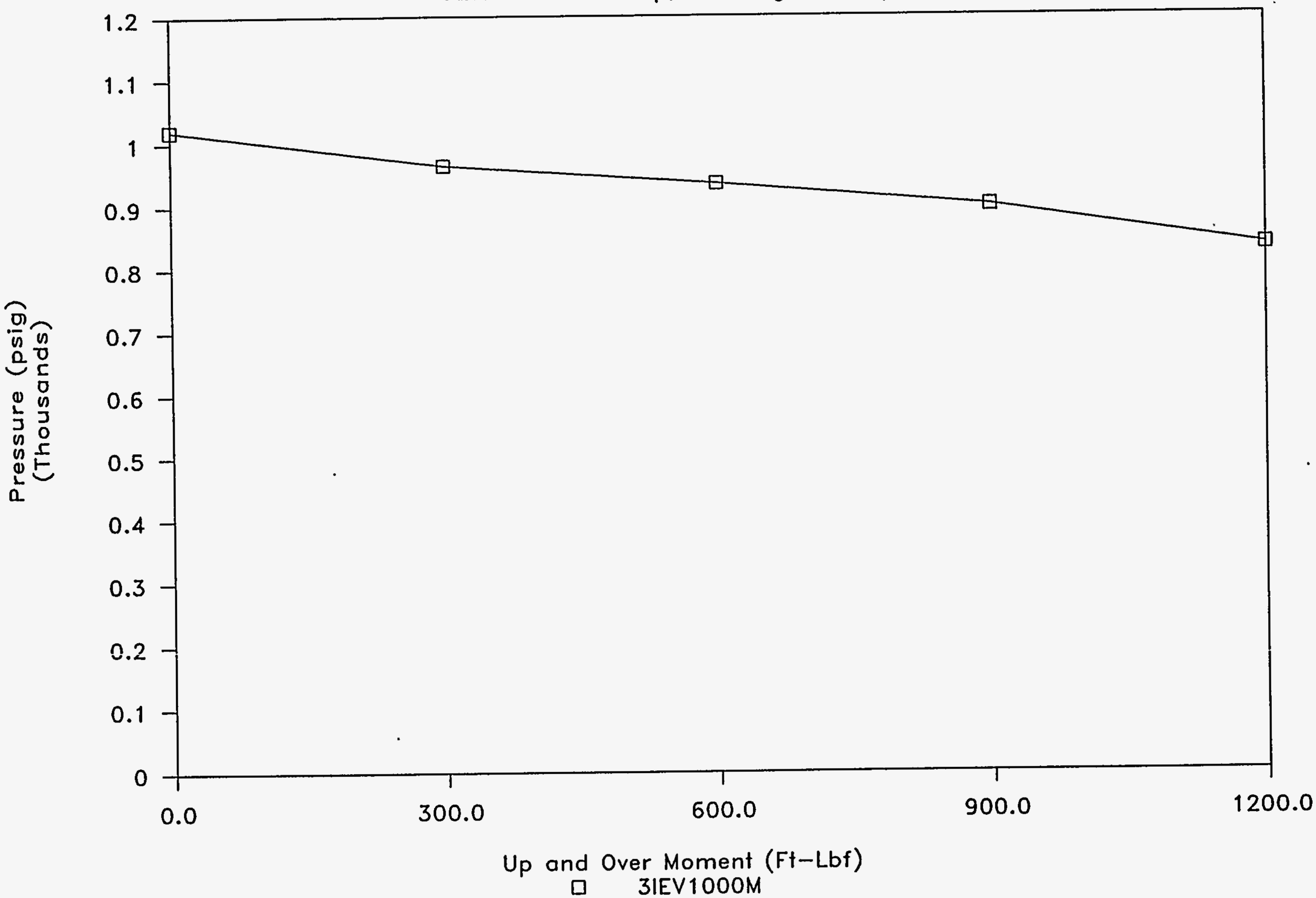

3" ISB, Viton O-Ring
52.3 Ft-Lbf Clamp, 400 Deg. F Temp.
Pressure (psig)
0
50
100
150
200
250
300
350
400
0.0
0.0
300.0
600.0
900.0
1200.0
Up and Over Moment (Ft-Lbf)
3IEV250M


3'' ISB, Viton O-Ring
52.3 Ft-Lbf Clamp, 400 Deg. F Temp.
Pressure (psig)
0
100
200
300
400
500
600
0.0
300.0
600.0
900.0
1200.0
Up and Over Moment (Ft-Lbf)
3IEV500M


3" ISB, Viton O-Ring
52.3 Ft-Lbf Clamp, 400 Deg. F Temp.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
300.0
600.0
900.0
1200.0
Up and Over Moment (Ft-Lbf)
3IEV750M

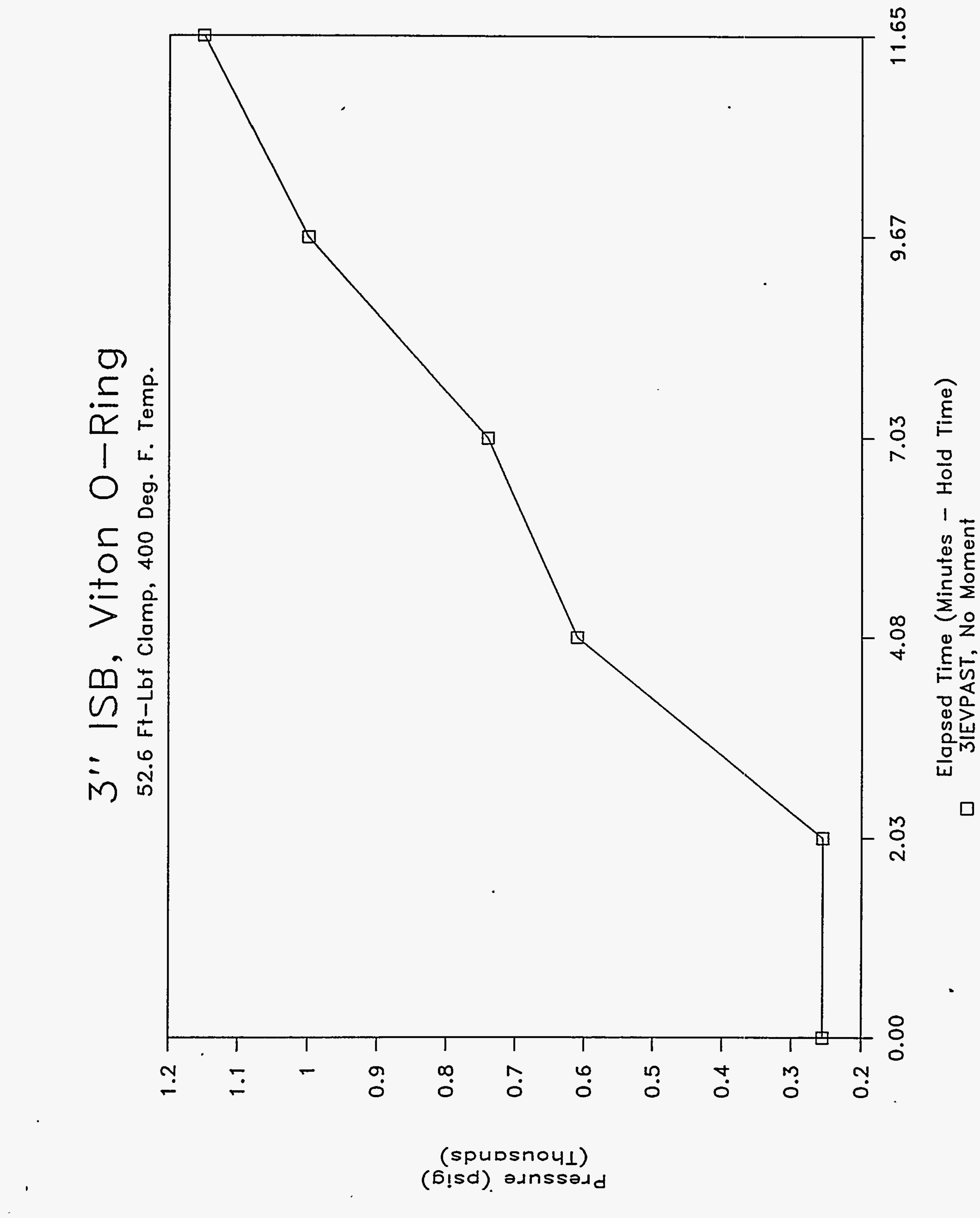
3" ISB, Viton O-Ring

52.3 Ft-Lbf Clamp, 400 Deg. F Temp.



JULY 12, 1994
3" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, ELEVATED TEMP.
PRESSURE ASCENSION LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 52.3 FT-LBF GRAPH NAME = 3IEV250M
CHARGE PRESSURE = 250 PSIG
TEMPERATURE = 400 Deg. F

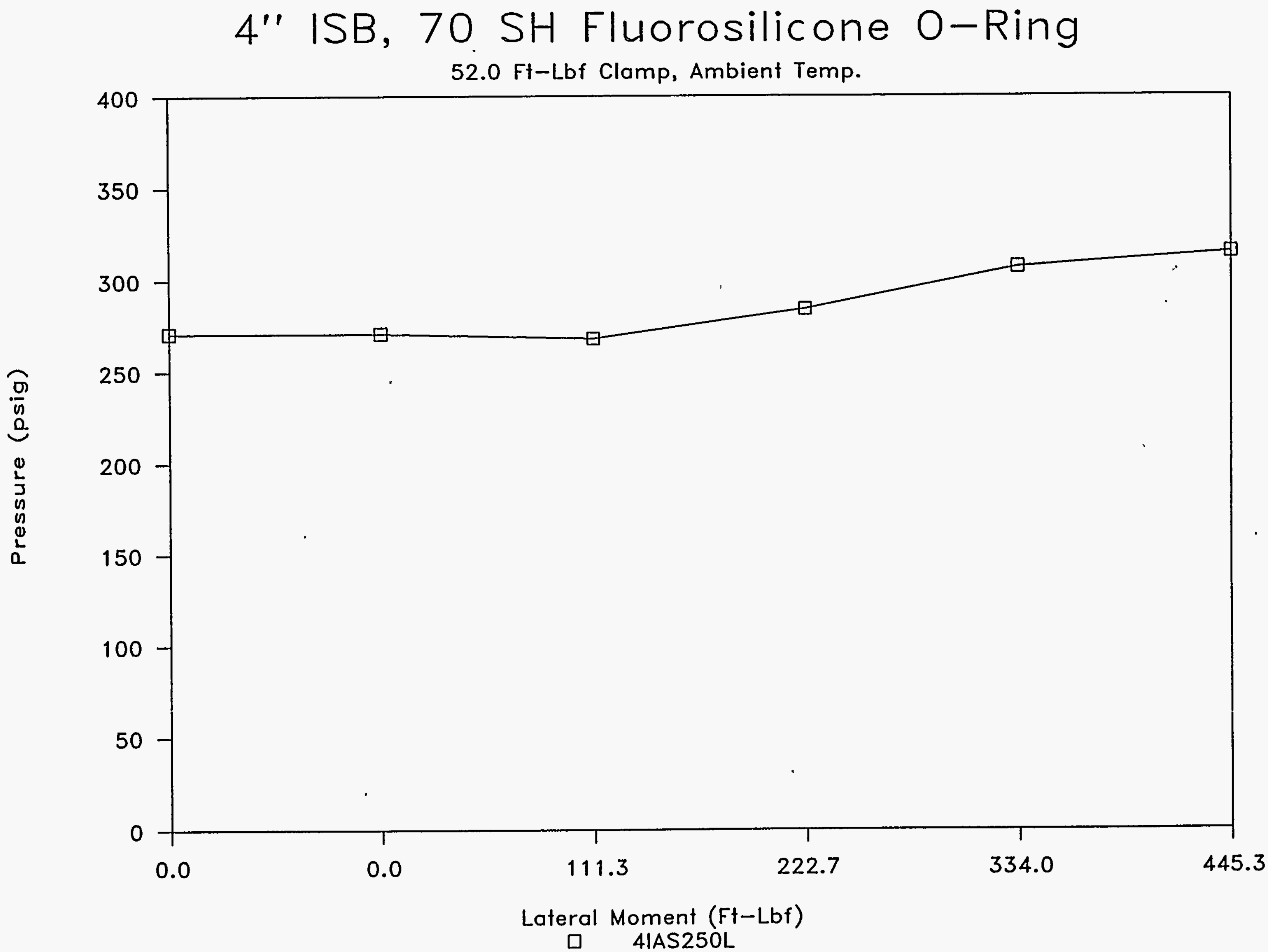
INITIAL PRESSURE PSIG INPUT	HOLD PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
310	310	0	0	0.00	0	1.2000	0.0
265	265	2	3	2.05	0	1.2000	0.0
300	280	4	3	4.05	250	1.2000	300.0
280	315	6	5	6.08	500	1.2000	600.0
290	300	8	3	8.05	750	1.2000	900.0
275	275	10	5	10.08	1000	1.2000	1200.0
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = 3IEV500M			
510	450	12	9	12.15	0	1.2000	0.0
360	400	14	8	14.13	250	1.2000	300.0
400	375	16	2	16.03	500	1.2000	600.0
350	350	18	3	18.05	750	1.2000	900.0
320	285	20	3	20.05	1000	1.2000	1200.0
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = 3IEV750M			
760	725	22	2	22.03	0	1.2000	0.0
735	750	24	1	24.02	250	1.2000	300.0
705	695	26	3	26.05	500	1.2000	600.0
685	675	28	3	28.05	750	1.2000	900.0
690	615	30	3	30.05	1000	1.2000	1200.0
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = 3IEV1000M			
1020	1020	32	5	32.08	0	1.2000	0.0
1020	965	34	4	34.07	250	1.2000	300.0
940	935	36	9	36.15	500	1.2000	600.0
940	900	38	6	38.10	750	1.2000	900.0
855	835	40	4	40.07	1000	1.2000	1200.0

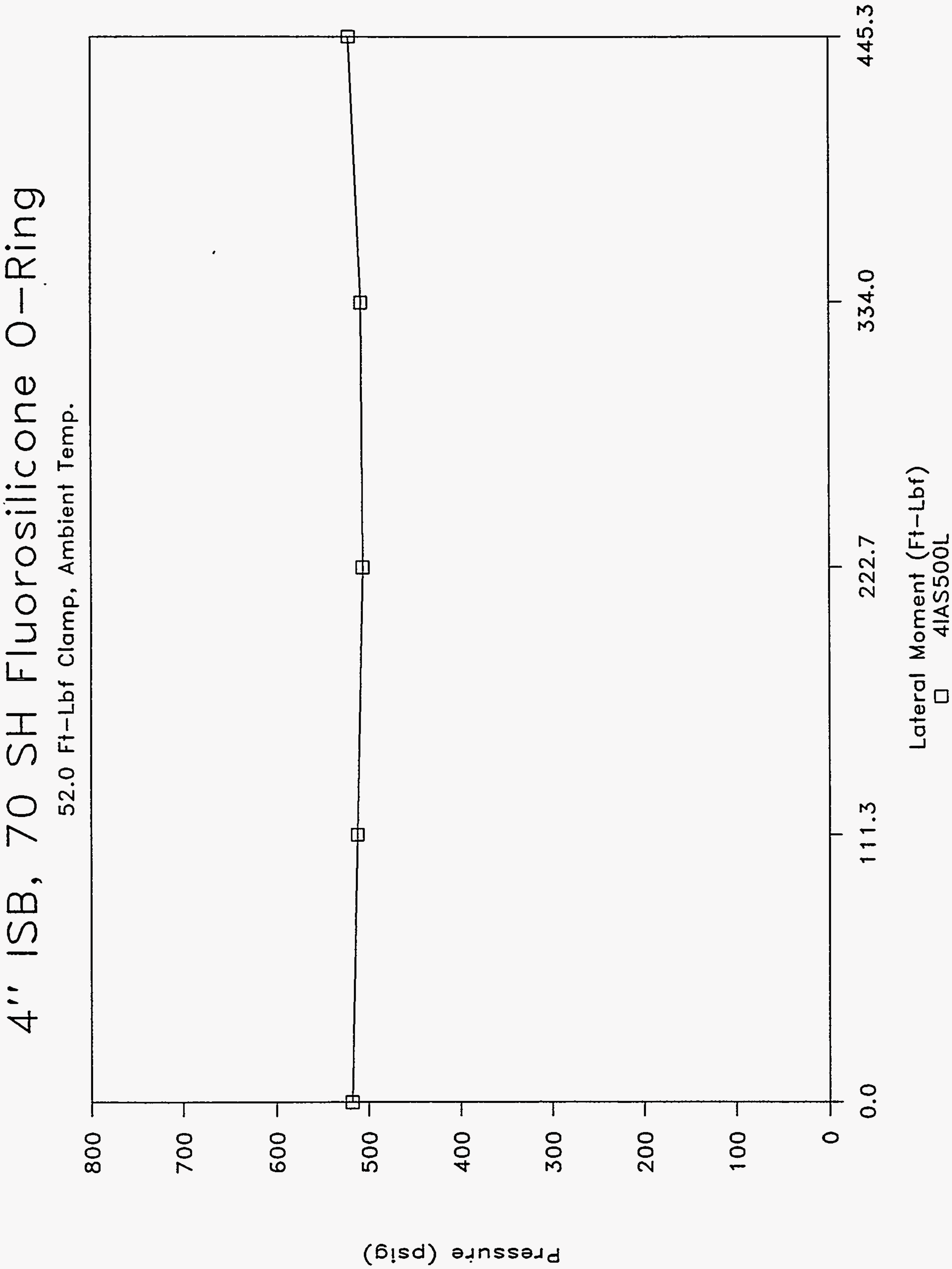

3" ISB, Viton O—Ring
52.6 Ft-Lbf Clamp, 400 Deg. F. Temp.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.00
2.03
4.08
7.03
9.67
11.65
Elapsed Time (Minutes - Hold Time)
3IEVPAST, No Moment

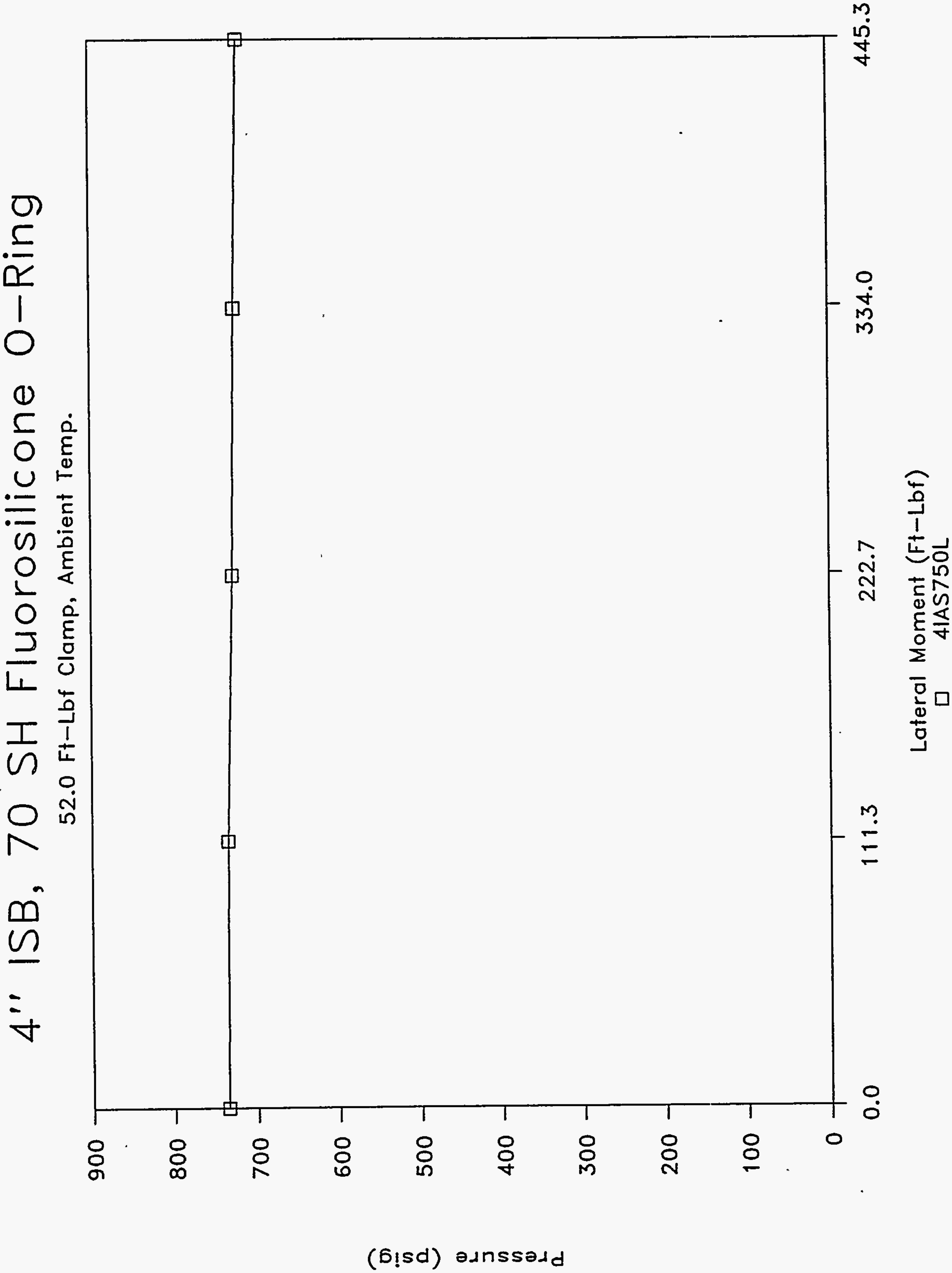
JULY 11, 1994
3" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, ELEVATED TEMP.
PRESSURE ASCENSION LEAK TEST - NO MOMENT APPLIED
CLAMPING TORQUE = 52.6 FT-LBF GRAPH NAME = 3IEVPAST
CHARGE PRESSURE = 250 PSIG TO 1150 PSIG
TEMPERATURE = 400 Deg. F

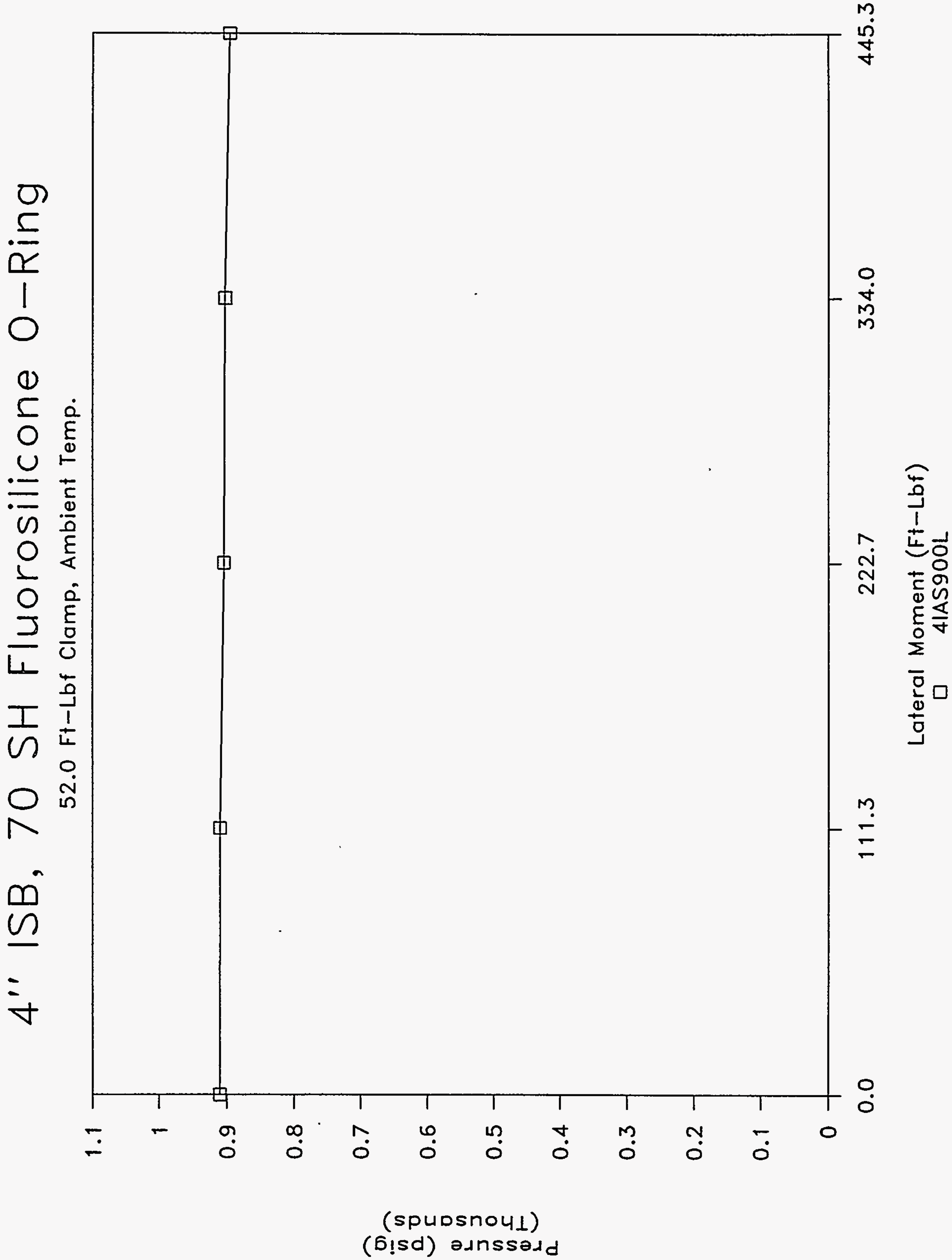
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	APPLIED FORCE LBS INPUT
255	0	0	0.00	0
255	2	2	2.03	0
610	4	5	4.08	0
740	7	2	7.03	0
1000	9	40	9.67	0
1150	11	39	11.65	0

APPENDIX K: GRAPHS OF 4-IN. FLUOROSILICONE TESTS


4" ISB, 70 SH Fluorosilicone O-Ring
52.0 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
400
350
300
250
200
150
100
50
0
0.0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
4IAS250L


4" ISB, 70 SH Fluorosilicone O-Ring
52.0 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
800
700
600
500
400
300
200
100
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
4IAS500L


4" ISB, 70 SH Fluorosilicone O-Ring
52.0 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
4IAS750L


4" ISB, 70 SH Fluorosilicone O-Ring
52.0 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
4IAS900L

JUNE 20, 1994
4" ISB CONNECTOR, 70 SH FLUOROSILICONE O-RING, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 52.0 FT-LBF GRAPH NAME = 4IAS250L
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
271	0	0	0.00	0	0.4453	0.0
271	2	1	2.02	0	0.4453	0.0
268	5	34	5.57	250	0.4453	111.3
284	9	18	9.30	500	0.4453	222.7
307	13	8	13.13	750	0.4453	334.0
315	16	5	16.08	1000	0.4453	445.3

INCREASED CHARGE PRESSURE TO 500 PSIG. GRAPH NAME = 4IAS500L

518	20	50	20.83	0	0.4453	0.0
512	23	3	23.05	250	0.4453	111.3
506	25	31	25.52	500	0.4453	222.7
508	28	4	28.07	750	0.4453	334.0
521	31	5	31.08	1000	0.4453	445.3

INCREASED CHARGE PRESSURE TO 750 PSIG. GRAPH NAME = 4IAS750L

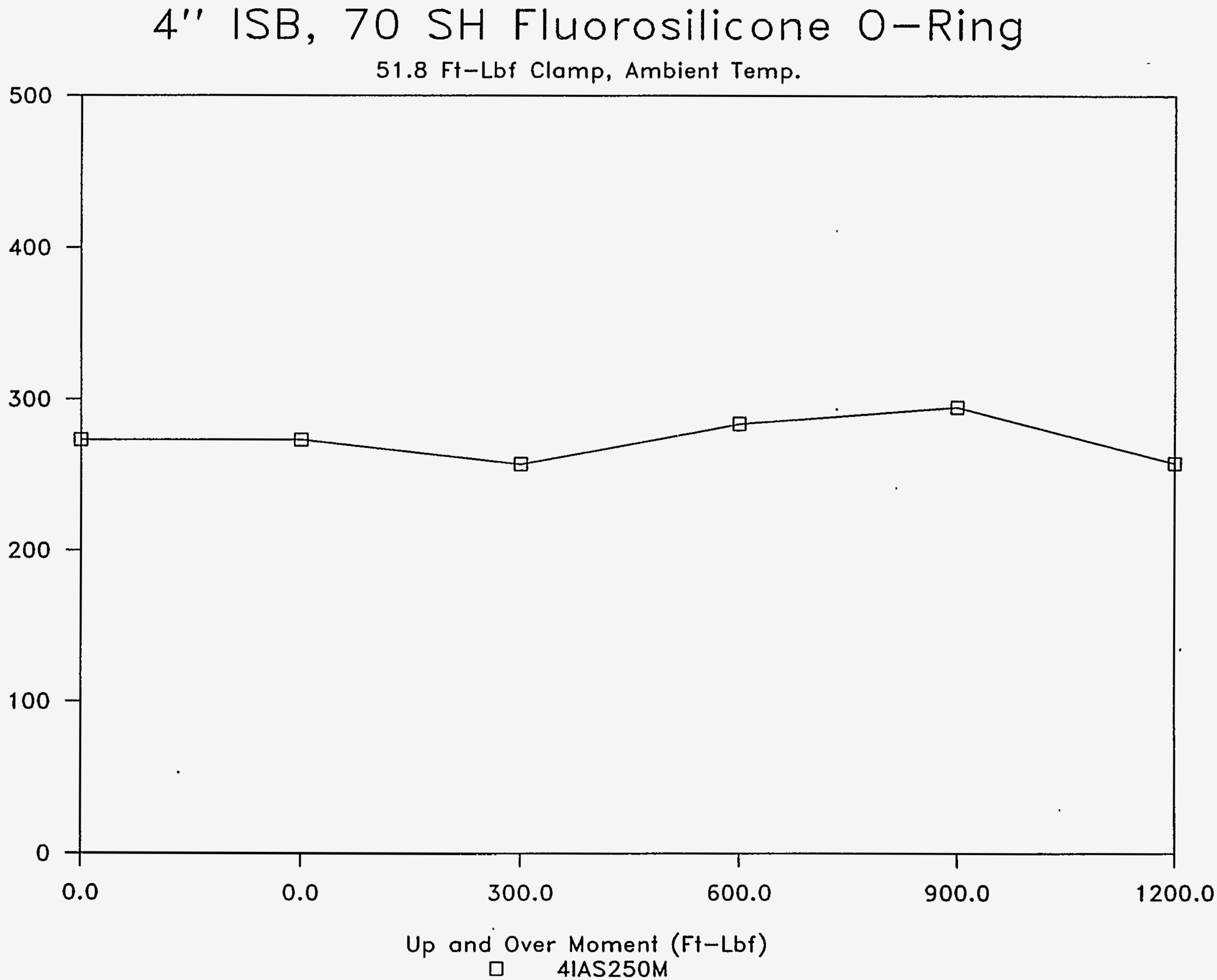
737	36	21	36.35	0	0.4453	0.0

RE-PRESURIZED TO 750 PSIG DUE TO LEAK AT VALVE.

736	39	52	39.87	0	0.4453	0.0
735	42	3	42.05	250	0.4453	111.3
728	45	10	45.17	500	0.4453	222.7
725	48	8	48.13	750	0.4453	334.0
720	51	2	51.03	1000	0.4453	445.3

INCREASED CHARGE PRESSURE TO 900 PSIG. GRAPH NAME = 4IAS900L

911	55	50	55.83	0	0.4453	0.0
910	58	32	58.53	250	0.4453	111.3
905	61	10	61.17	500	0.4453	222.7
903	64	8	64.13	750	0.4453	334.0
896	67	39	67.65	1000	0.4453	445.3

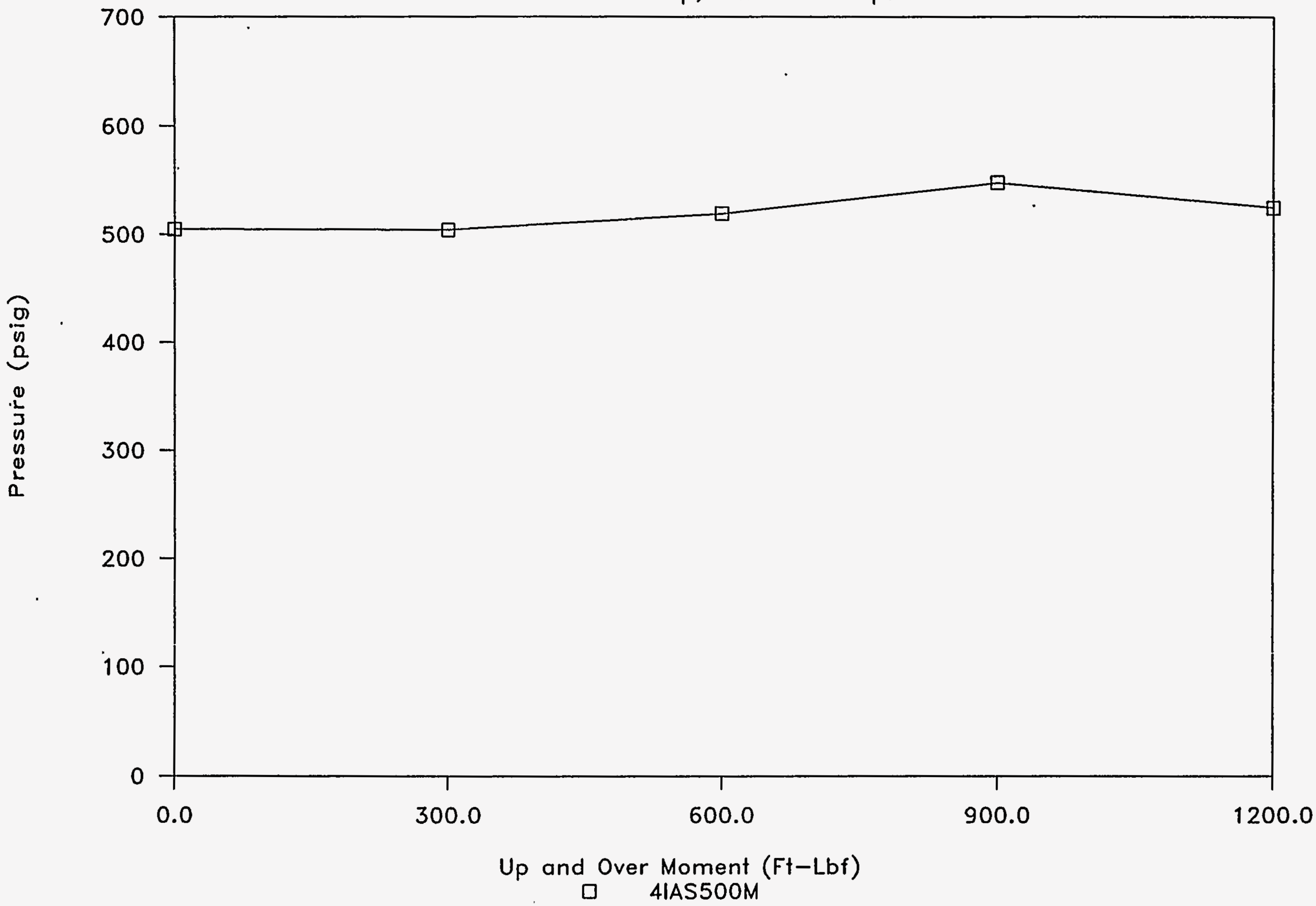


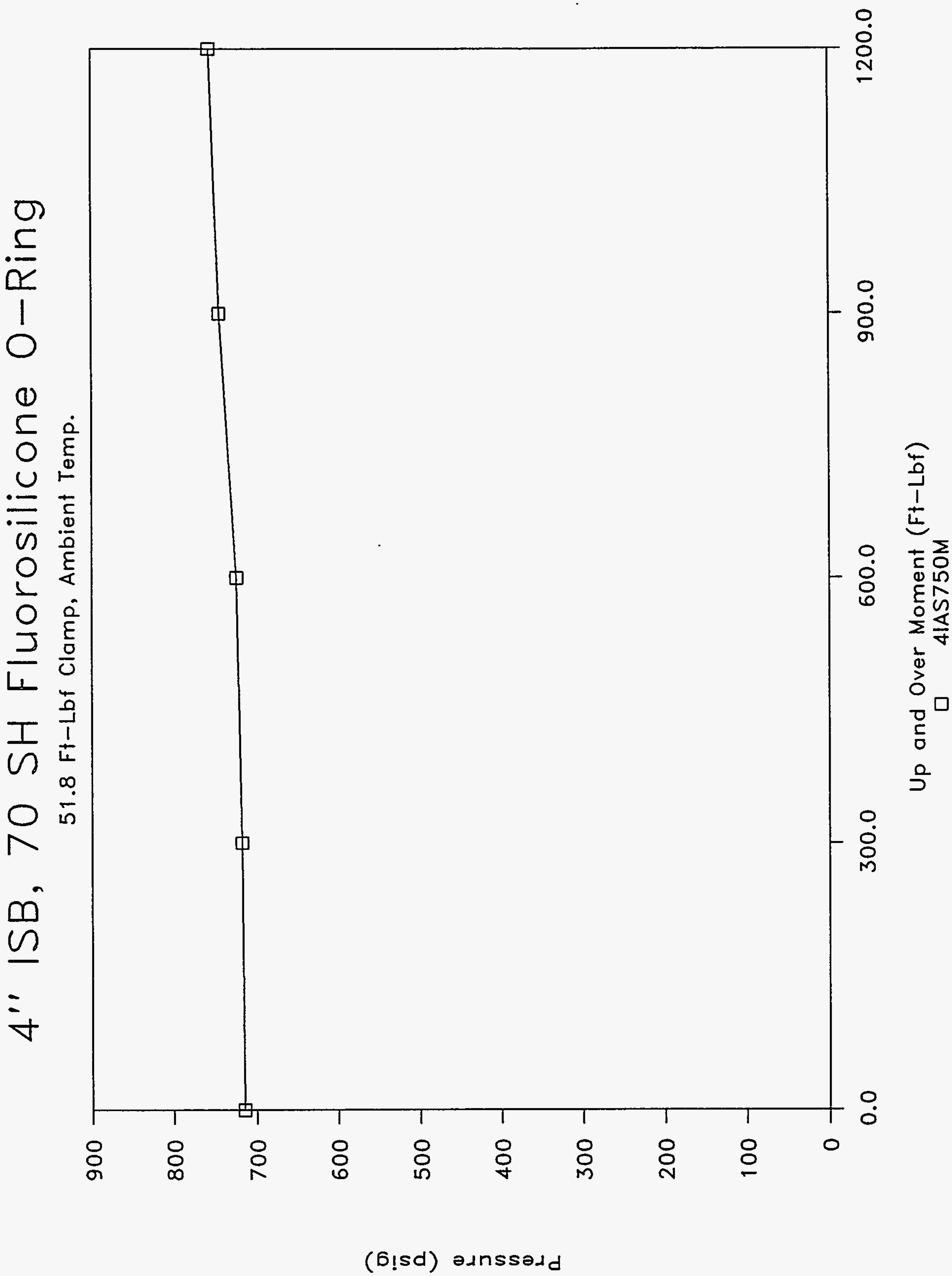
K-7

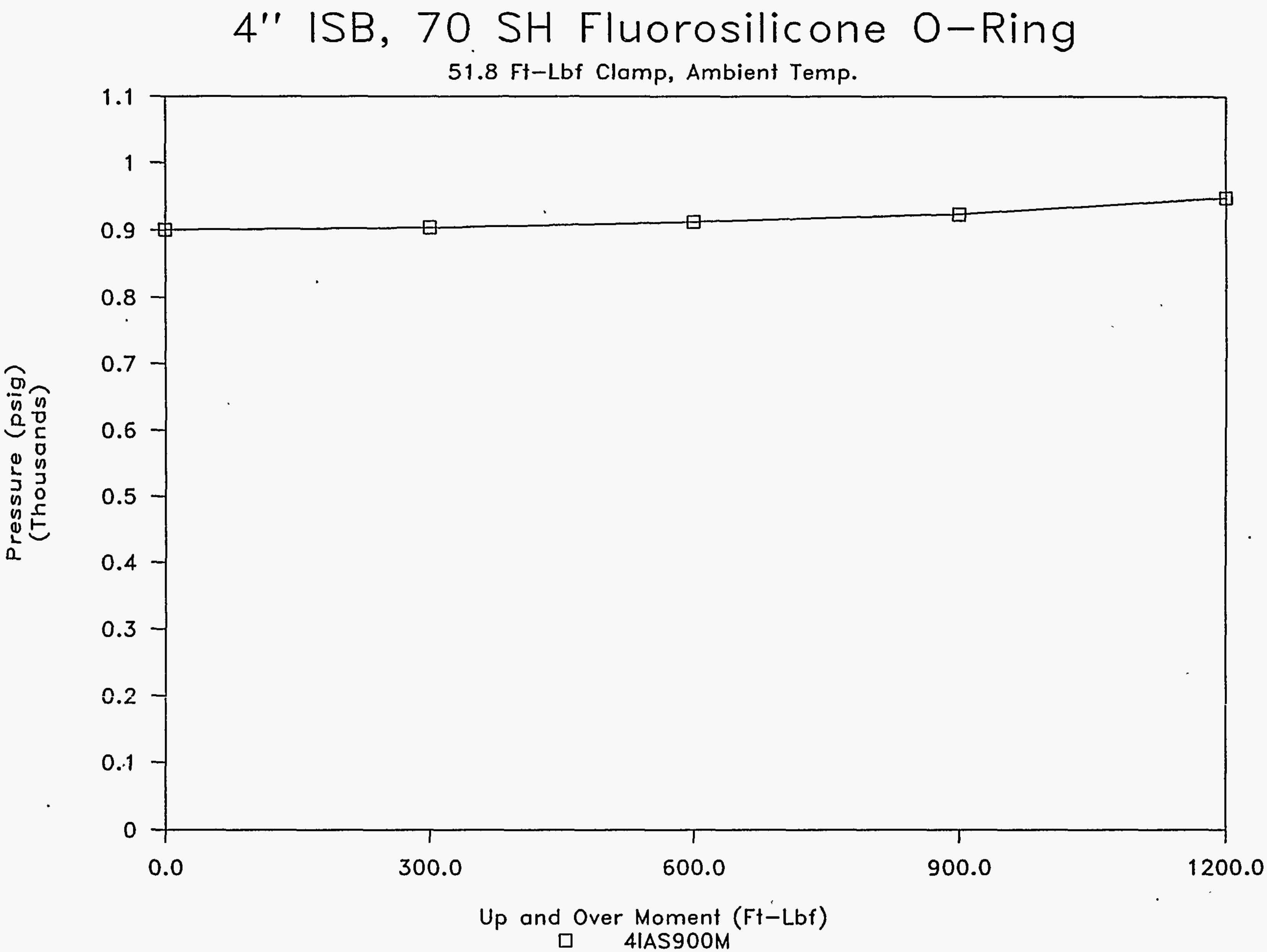
WHC-SD-WM-TRP-223
Rev. 0

4" ISB, 70 SH Fluorosilicone O-Ring

51.8 Ft-Lbf Clamp, Ambient Temp.




4'' ISB, 70 SH Fluorosilicone O-Ring
51.8 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
0
100
200
300
400
500
600
700
800
900
0.0
300.0
600.0
900.0
1200.0
Up and Over Moment (Ft-Lbf)
4IAS750M

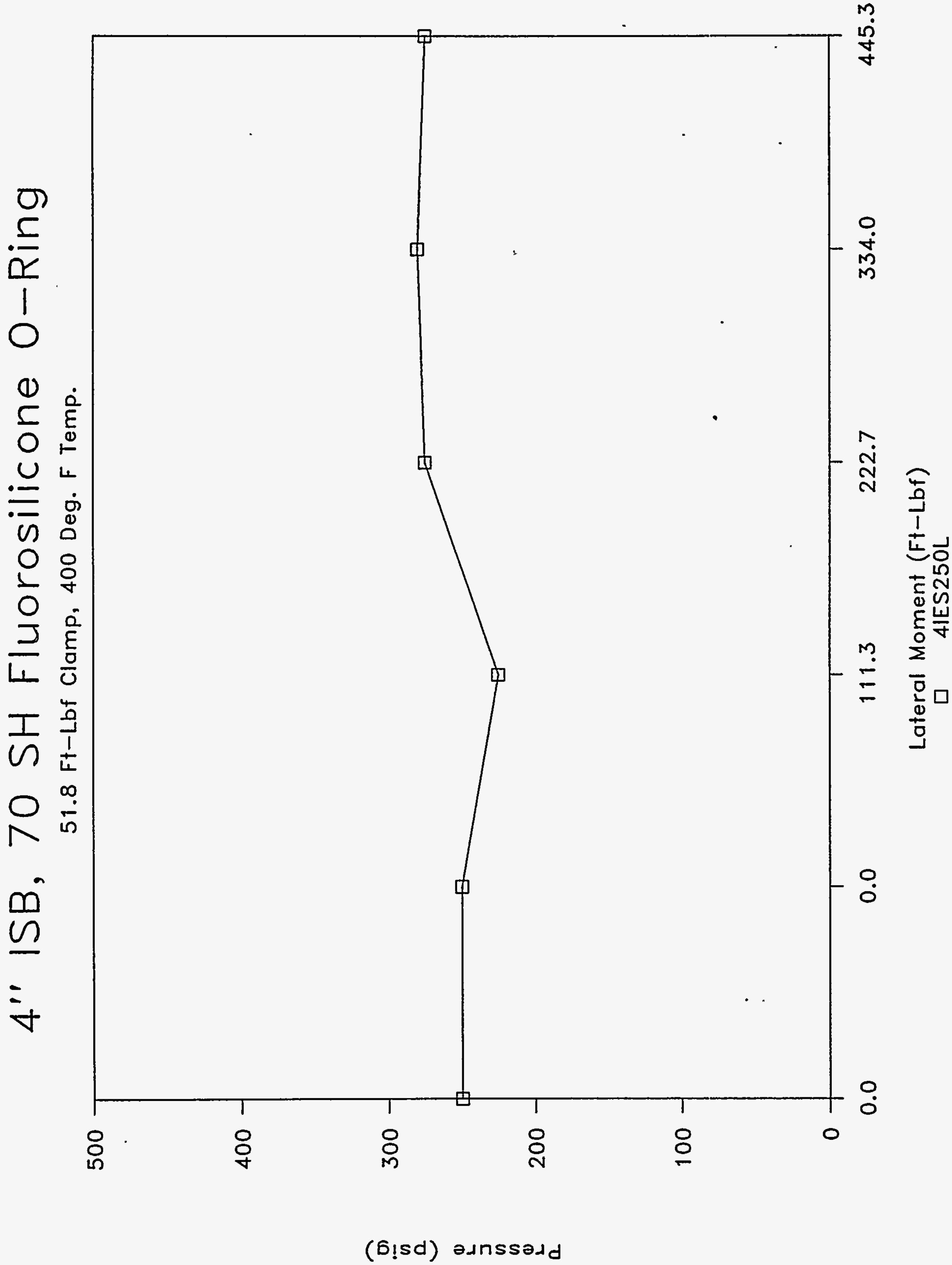


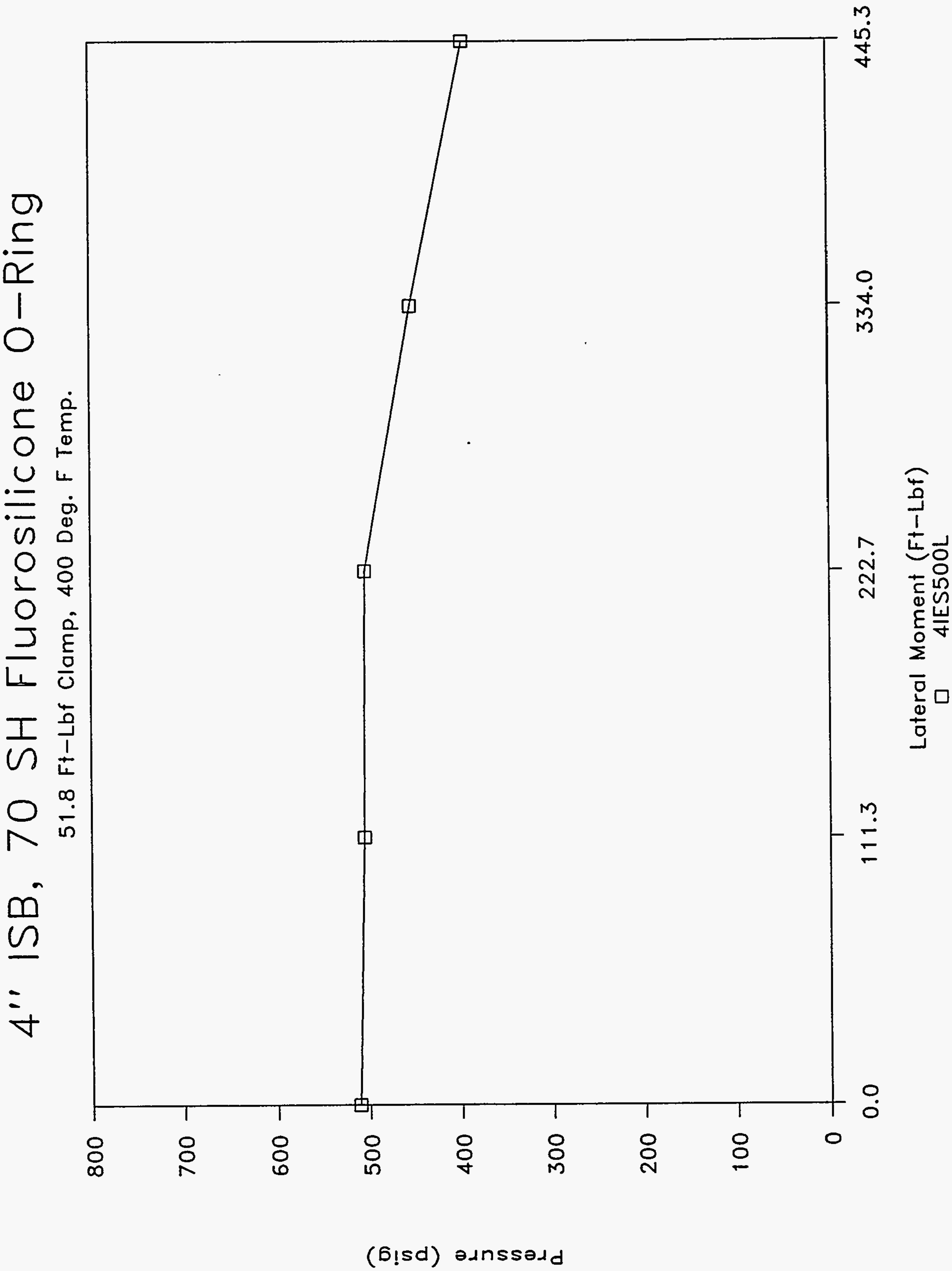
4" ISB, 70 SH Fluorosilicone O-Ring
51.8 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
300.0
600.0
900.0
1200.0
Up and Over Moment (Ft-Lbf)
4IAS900M

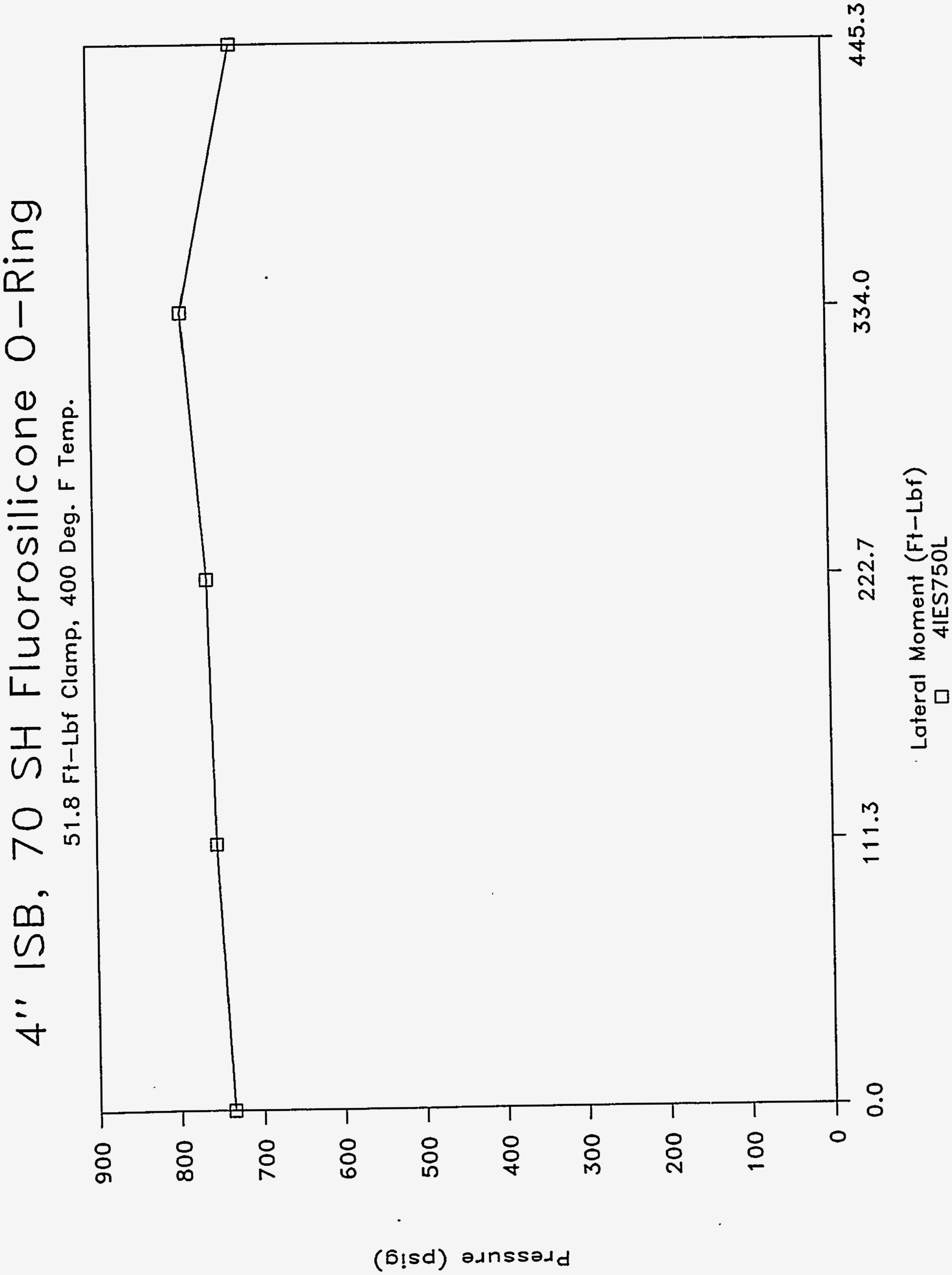
K-10

JUNE 16, 1994
4" ISB CONNECTOR, 70 SH FLUOROSILICONE O-RING, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 51.8 FT-LBF GRAPH NAME = 4IAS250M
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
273	0	0	0.00	0	1.2000	0.0
273	2	1	2.02	0	1.2000	0.0
257	5	20	5.33	250	1.2000	300.0
284	8	31	8.52	500	1.2000	600.0
295	11	51	11.85	750	1.2000	900.0
258	15	2	15.03	1000	1.2000	1200.0
INCREASED CHARGE PRESSURE TO 500 PSIG.				GRAPH NAME = 4IAS500M		
505	22	3	22.05	0	1.2000	0.0
504	25	21	25.35	250	1.2000	300.0
519	29	23	29.38	500	1.2000	600.0
548	33	3	33.05	750	1.2000	900.0
525	35	45	35.75	1000	1.2000	1200.0
INCREASED CHARGE PRESSURE TO 750 PSIG.				GRAPH NAME = 4IAS750M		
715	43	39	43.65	0	1.2000	0.0
718	46	12	46.20	250	1.2000	300.0
724	49	5	49.08	500	1.2000	600.0
745	52	45	52.75	750	1.2000	900.0
757	56	30	56.50	1000	1.2000	1200.0
INCREASED CHARGE PRESSURE TO 900 PSIG.				GRAPH NAME = 4IAS900M		
901	64	3	64.05	0	1.2000	0.0
904	68	2	68.03	250	1.2000	300.0
912	71	5	71.08	500	1.2000	600.0
924	74	20	74.33	750	1.2000	900.0
949	78	4	78.07	1000	1.2000	1200.0


4" ISB, 70 SH Fluorosilicone O-Ring
51.8 Ft-Lbf Clamp, 400 Deg. F Temp.
Pressure (psig)
0
100
200
300
400
500
0.0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
4IES250L


4" ISB, 70 SH Fluorosilicone O-Ring
51.8 Ft-Lbf Clamp, 400 Deg. F Temp.
Pressure (psig)
0
100
200
300
400
500
600
700
800
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
4IES500L


4" ISB, 70 SH Fluorosilicone O-Ring
51.8 Ft-Lbf Clamp, 400 Deg. F Temp.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
4IES750L

JUNE 20, 1994
4" ISB CONNECTOR, 70 SH FLUOROSILICONE O-RING, ELEVATED TEMP.
PRESSURE ASCENSION LEAK TEST - LATERAL MOMENT.
CLAMPING TORQUE = 51.8 FT-LBF GRAPH NAME = 4IES250L

CHARGE PRESSURE = 250 PSIG
TEMPERATURE : 400 Deg. F

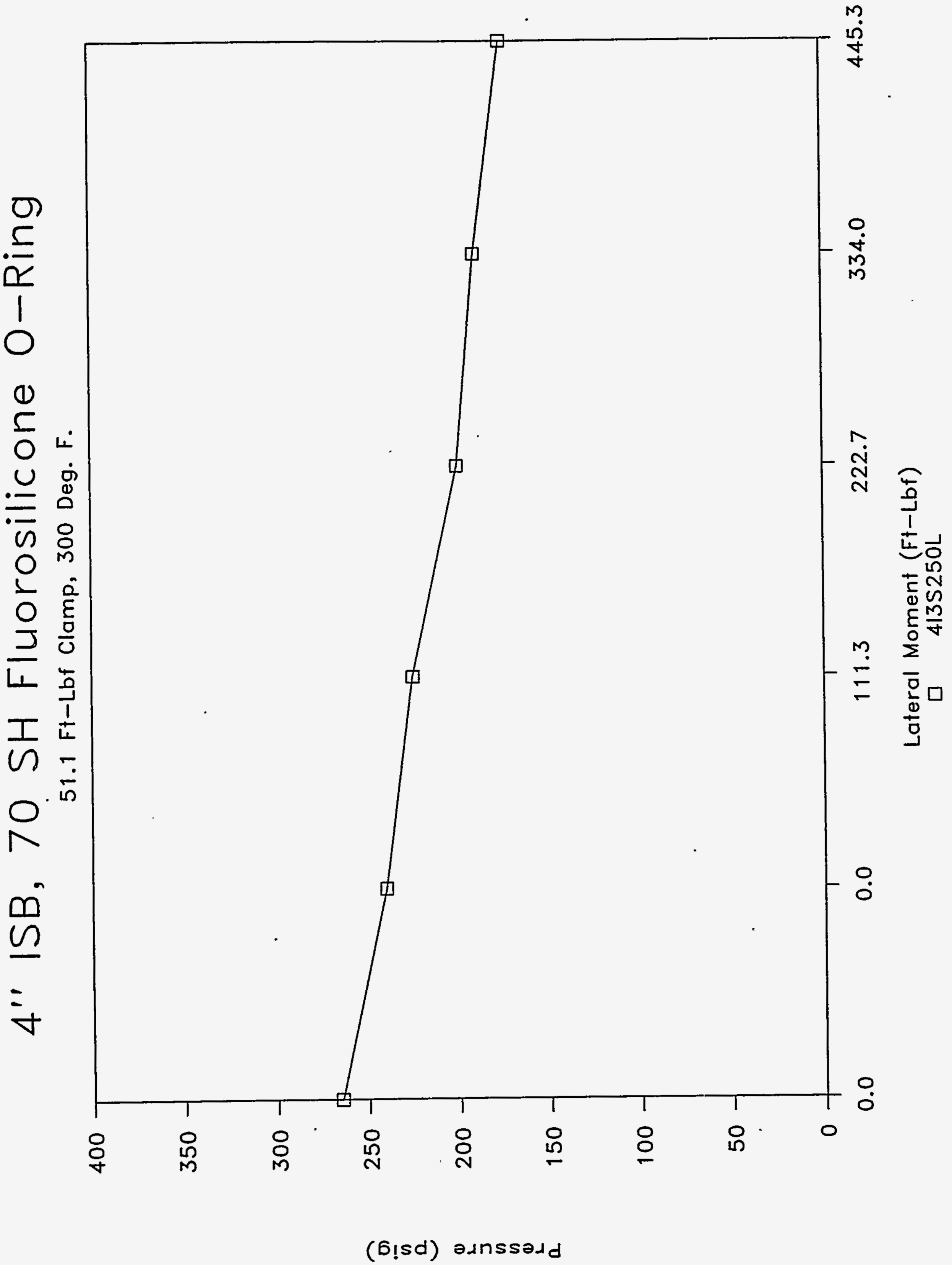
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
250	0	0	0.00	0	0.4453	0.0
250	2	0	2.00	0	0.4453	0.0
225	5	21	5.35	250	0.4453	111.3
275	8	35	8.58	500	0.4453	222.7
280	12	7	12.12	750	0.4453	334.0
275	16	45	16.75	1000	0.4453	445.3

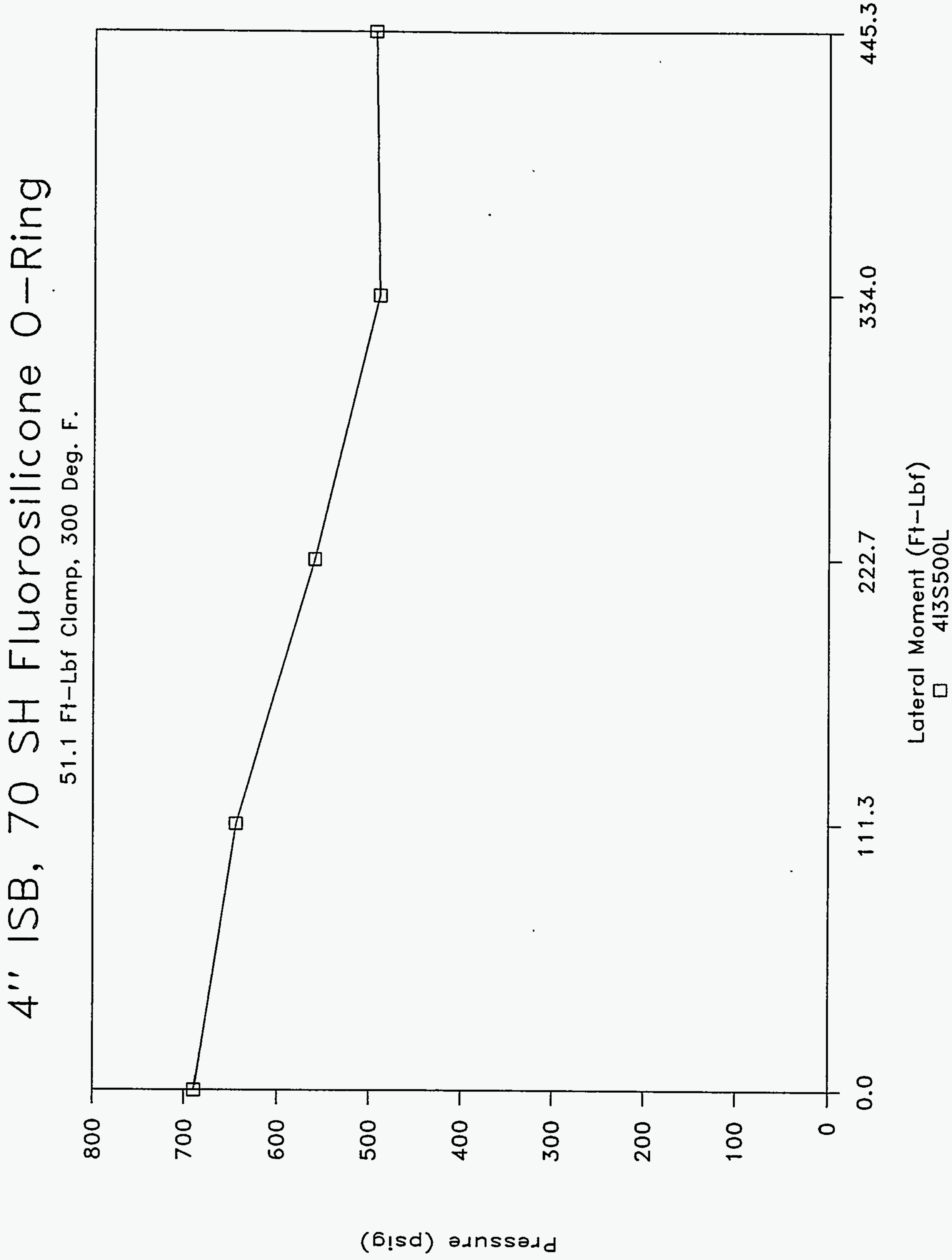
INCREASED CHARGE PRESSURE TO 500 PSIG. GRAPH NAME = 4IES500L

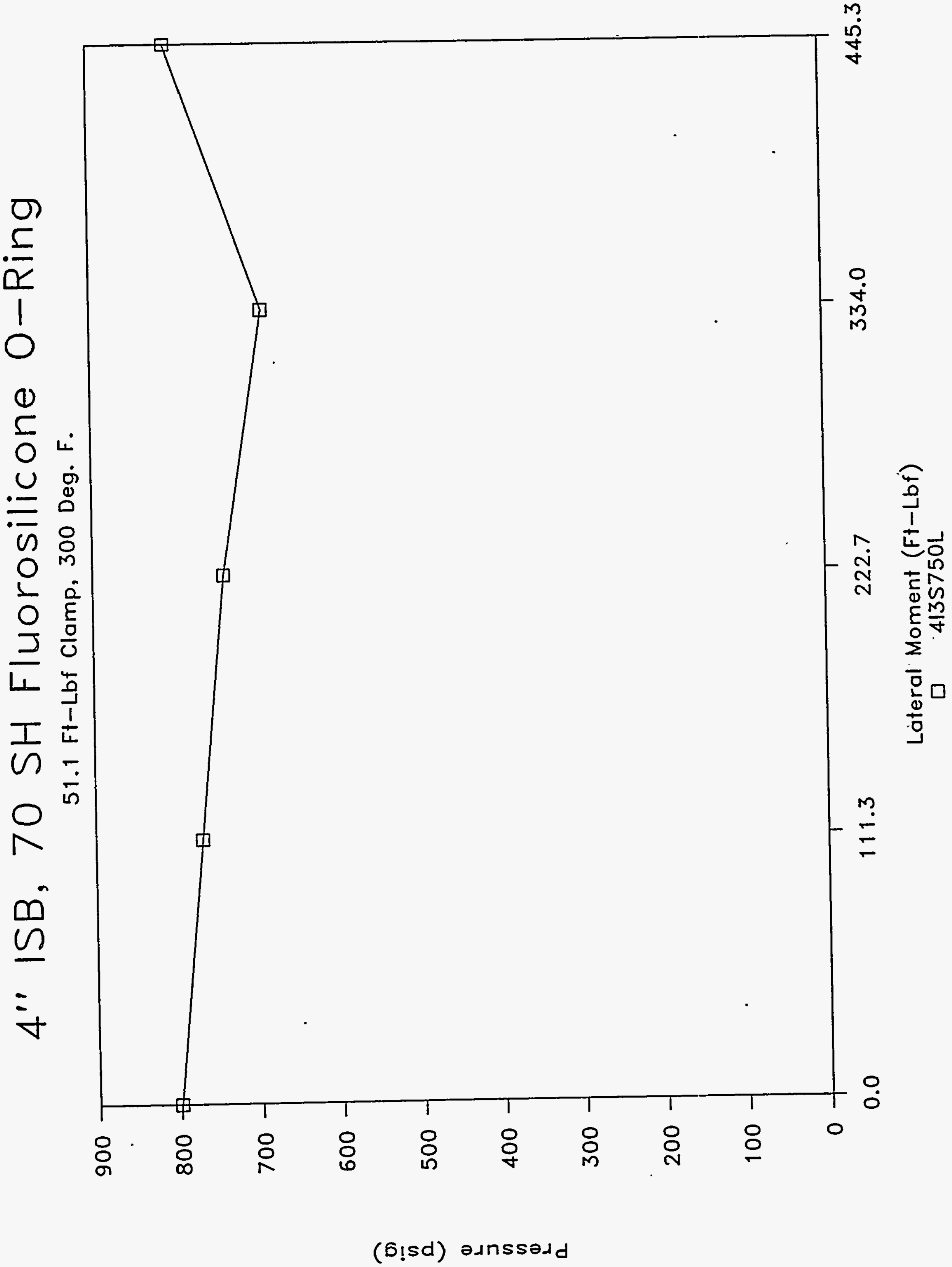
511	24	47	24.78	0	0.4453	0.0
505	27	2	27.03	250	0.4453	111.3
504	29	15	29.25	500	0.4453	222.7
453	32	39	32.65	750	0.4453	334.0
395	36	3	36.05	1000	0.4453	445.3

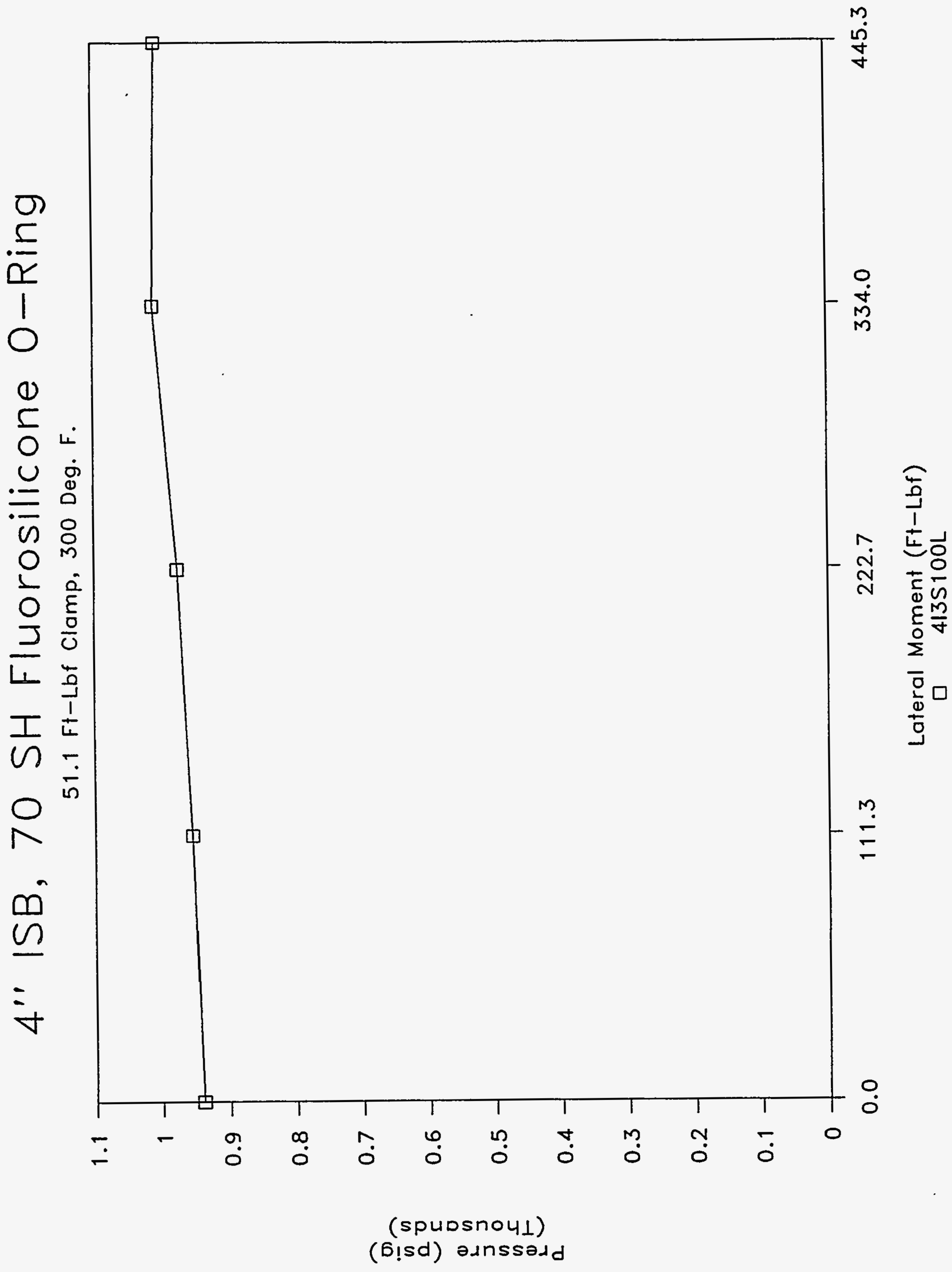
INCREASED CHARGE PRESSURE TO 750 PSIG. GRAPH NAME = 4IES750L

736	41	3	41.05	0	0.4453	0.0
754	45	37	45.62	250	0.4453	111.3
762	48	27	48.45	500	0.4453	222.7
790	51	6	51.10	750	0.4453	334.0
725	55	13	55.22	1000	0.4453	445.3


4" ISB, 70 SH Fluorosilicone O-Ring
51.1 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
0
50
100
150
200
250
300
350
400
0.0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
413S250L


4" ISB, 70 SH Fluorosilicone O-Ring
51.1 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
800
700
600
500
400
300
200
100
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
413S500L


4" ISB, 70 SH Fluorosilicone O-Ring
51.1 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
0
100
200
300
400
500
600
700
800
900
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
413S750L


4" ISB, 70 SH Fluorosilicone O-Ring
51.1 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
(Thousands)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
4I3S100L

OCTOBER 17, 1994
4" ISB CONNECTOR, 70 SH FLUOROSILICONE O-RING, ELEVATED TEMP.(300 DEG. F
LEAK TEST - LATERAL MOMENT (SIDEWAYS)
CLAMPING TORQUE = 51.1 FT-LBF GRAPH NAME = 4I3S250L
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
265	0	0	0.00	0	0.4453	0.0
240	2	1	2.02	0	0.4453	0.0
225	4	2	4.03	250	0.4453	111.3
200	6	1	6.02	500	0.4453	222.7
190	8	7	8.12	750	0.4453	334.0
175	10	3	10.05	1000	0.4453	445.3

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = 4I3S500L

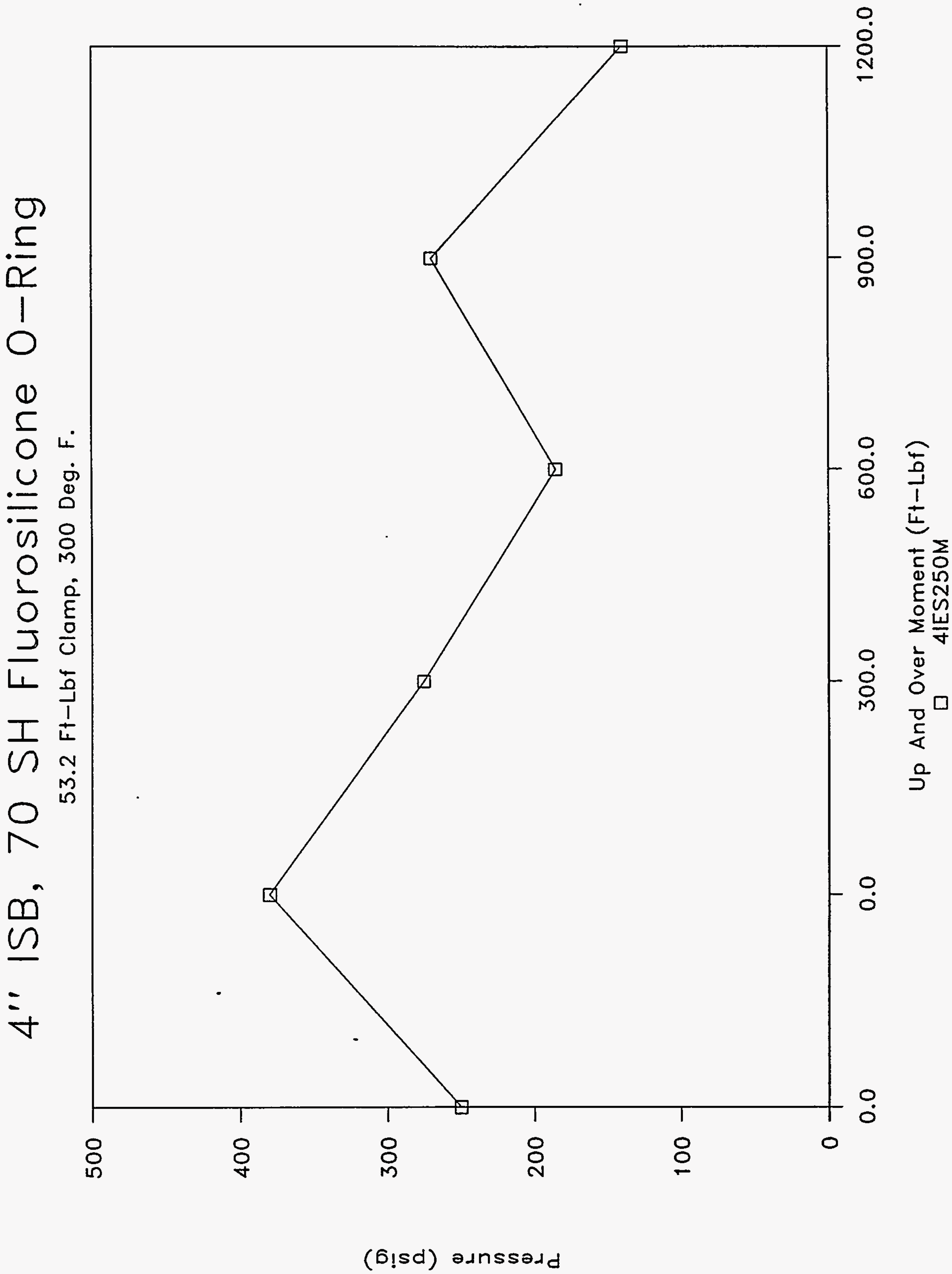
690	12	4	12.07	0	0.4453	0.0
645	14	1	14.02	250	0.4453	111.3
560	16	1	16.02	500	0.4453	222.7
490	18	1	18.02	750	0.4453	334.0
495	20	2	20.03	1000	0.4453	445.3

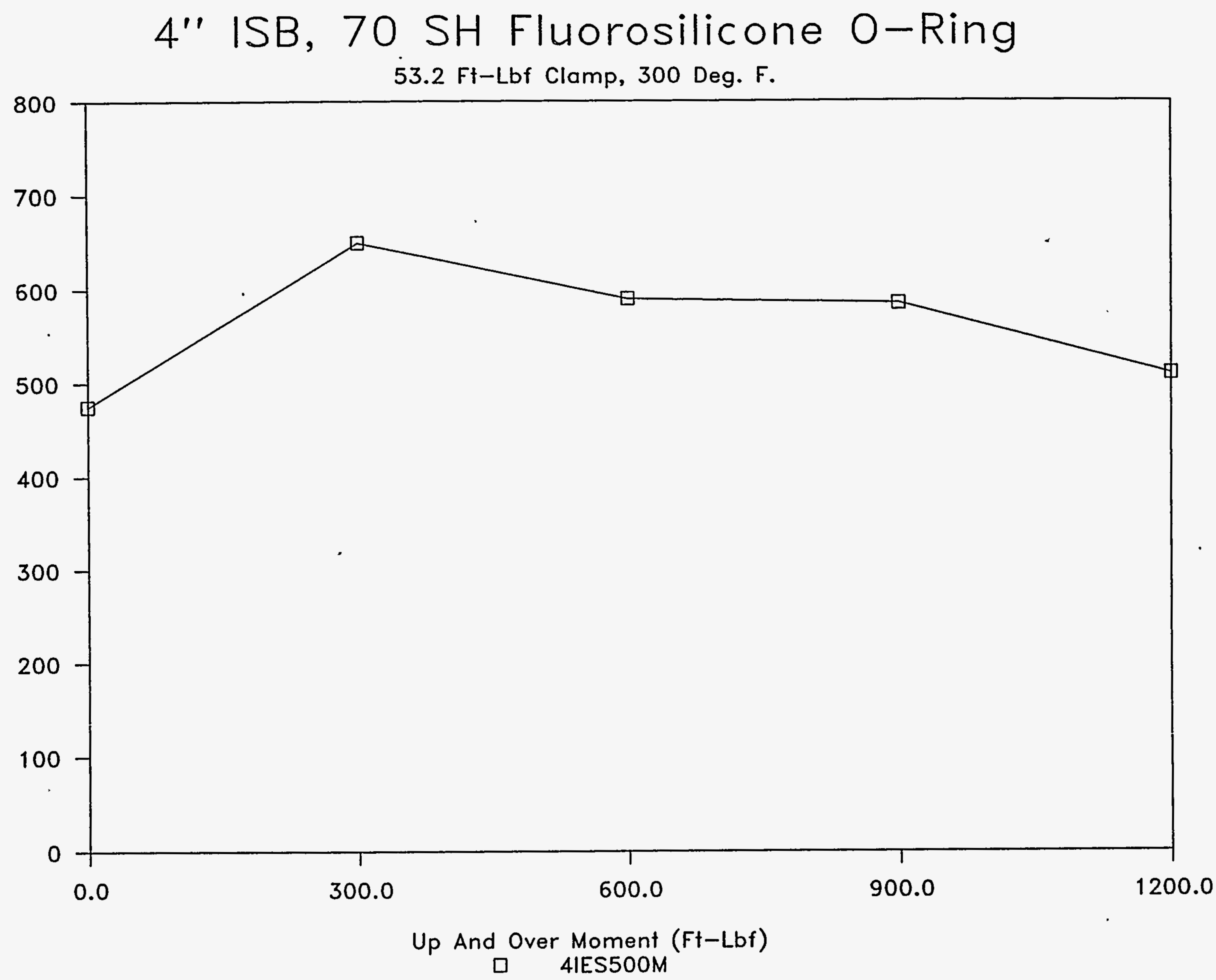
INCREASED PRESSURE TO 750 PSIG GRAPH NAME = 4I3S750L

800	22	1	22.02	0	0.4453	0.0
770	24	3	24.05	250	0.4453	111.3
740	26	2	26.03	500	0.4453	222.7
690	28	4	28.07	750	0.4453	334.0
805	30	3	30.05	1000	0.4453	445.3

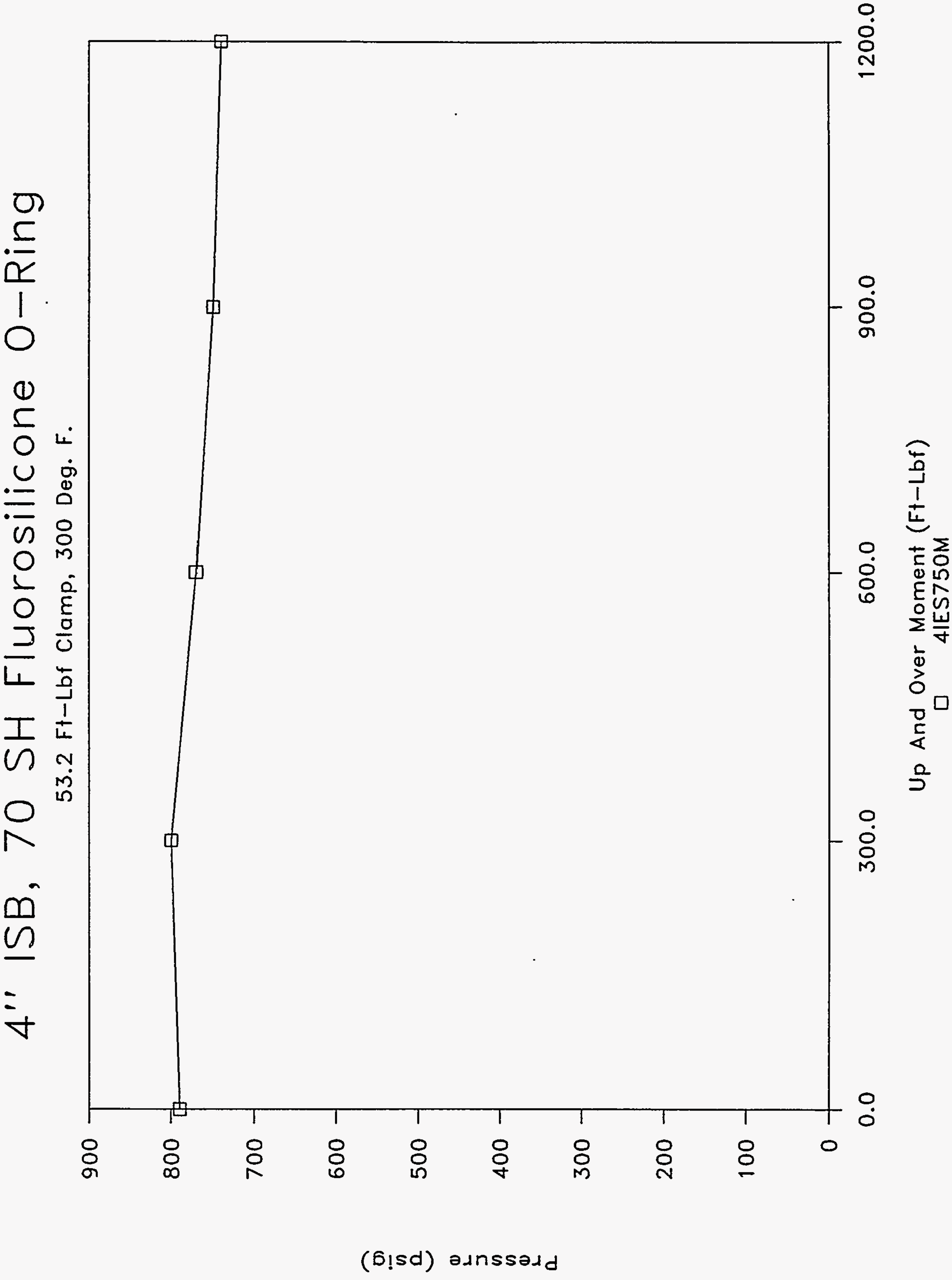
INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = 4I3S100L

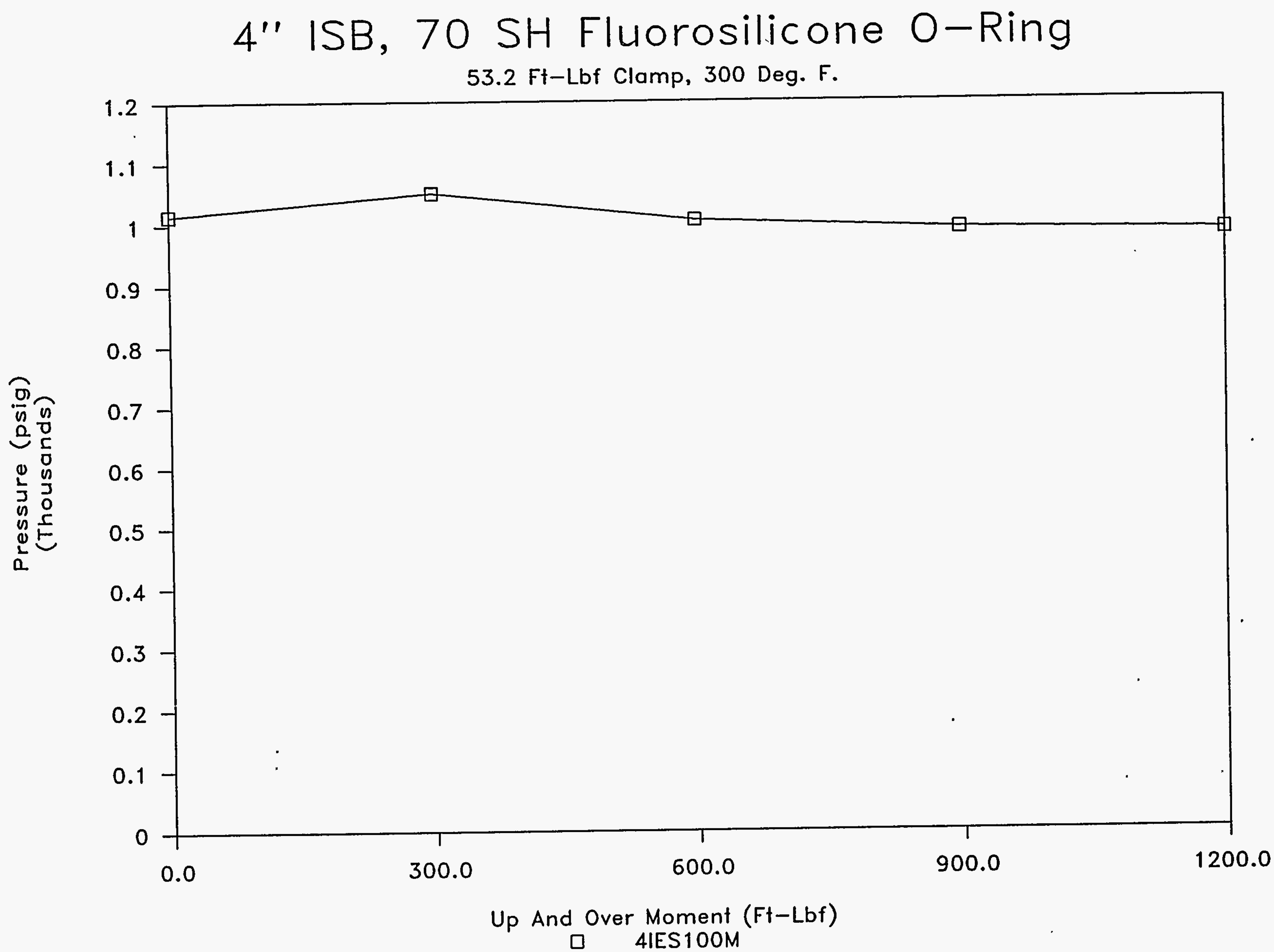
940	32	2	32.03	0	0.4453	0.0
955	34	2	34.03	250	0.4453	111.3
975	36	2	36.03	500	0.4453	222.7
1010	38	1	38.02	750	0.4453	334.0
1005	40	2	40.03	1000	0.4453	445.3


4" ISB, 70 SH Fluorosilicone O-Ring
53.2 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
0
100
200
300
400
500
0.0
0.0
300.0
600.0
900.0
1200.0
Up And Over Moment (Ft-Lbf)
4IES250M



4" ISB, 70 SH Fluorosilicone O-Ring
53.2 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
800
700
600
500
400
300
200
100
0
0.0
300.0
600.0
900.0
1200.0
Up And Over Moment (Ft-Lbf)
4IES500M


4" ISB, 70 SH Fluorosilicone O-Ring
53.2 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
0
100
200
300
400
500
600
700
800
900
0.0
300.0
600.0
900.0
1200.0
Up And Over Moment (Ft-Lbf)
4IES750M


4" ISB, 70 SH Fluorosilicone O-Ring
53.2 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig) (Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
300.0
600.0
900.0
1200.0
Up And Over Moment (Ft-Lbf)
4IES100M

OCTOBER 12, 1994
4" ISB CONNECTOR, 70 SH FLUOROSILICONE O-RING, ELEVATED TEMP.(300 DEG. F
LEAK TEST - UP AND OVER MOMENT (UPWARD)
CLAMPING TORQUE = 53.2 FT-LBF GRAPH NAME = 4IES250M
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
250	0	0	0.00	0	1.2000	0.0
380	2	1	2.02	0	1.2000	0.0
275	4	2	4.03	250	1.2000	300.0
185	6	1	6.02	500	1.2000	600.0
270	8	3	8.05	750	1.2000	900.0
140	10	2	10.03	1000	1.2000	1200.0

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = 4IES500M

475	12	3	12.05	0	1.2000	0.0
650	14	4	14.07	250	1.2000	300.0
590	16	2	16.03	500	1.2000	600.0
585	18	2	18.03	750	1.2000	900.0
510	20	1	20.02	1000	1.2000	1200.0

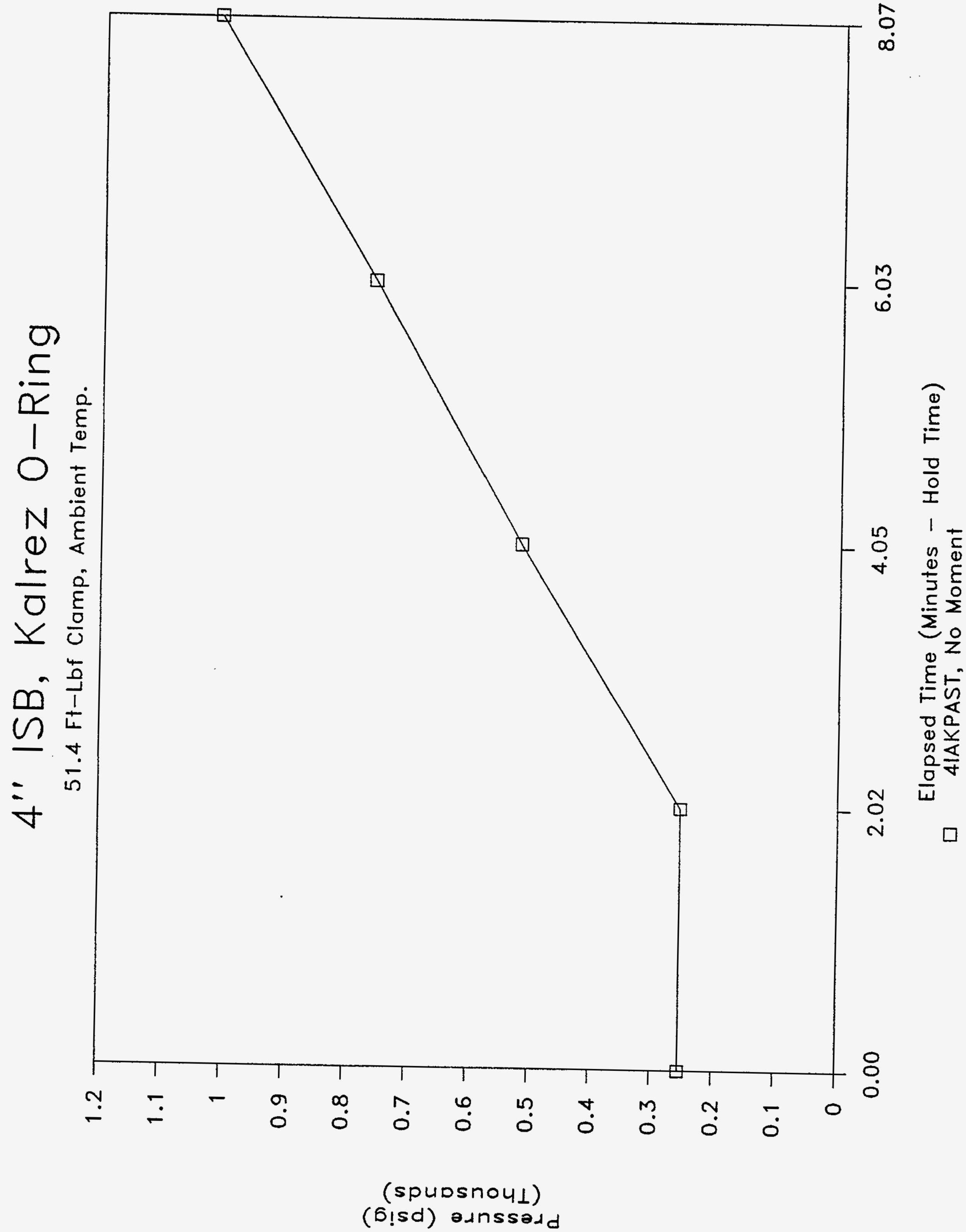
INCREASED PRESSURE TO 750 PSIG GRAPH NAME = 4IES750M

790	22	2	22.03	0	1.2000	0.0
800	24	1	24.02	250	1.2000	300.0
770	26	2	26.03	500	1.2000	600.0
750	28	1	28.02	750	1.2000	900.0
740	30	3	30.05	1000	1.2000	1200.0

INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = 4IES100M

1015	32	1	32.02	0	1.2000	0.0
1050	34	2	34.03	250	1.2000	300.0
1005	36	2	36.03	500	1.2000	600.0
990	38	3	38.05	750	1.2000	900.0
985	40	1	40.02	1000	1.2000	1200.0

APPENDIX L: GRAPHS OF 4-IN. KALREZ TESTS

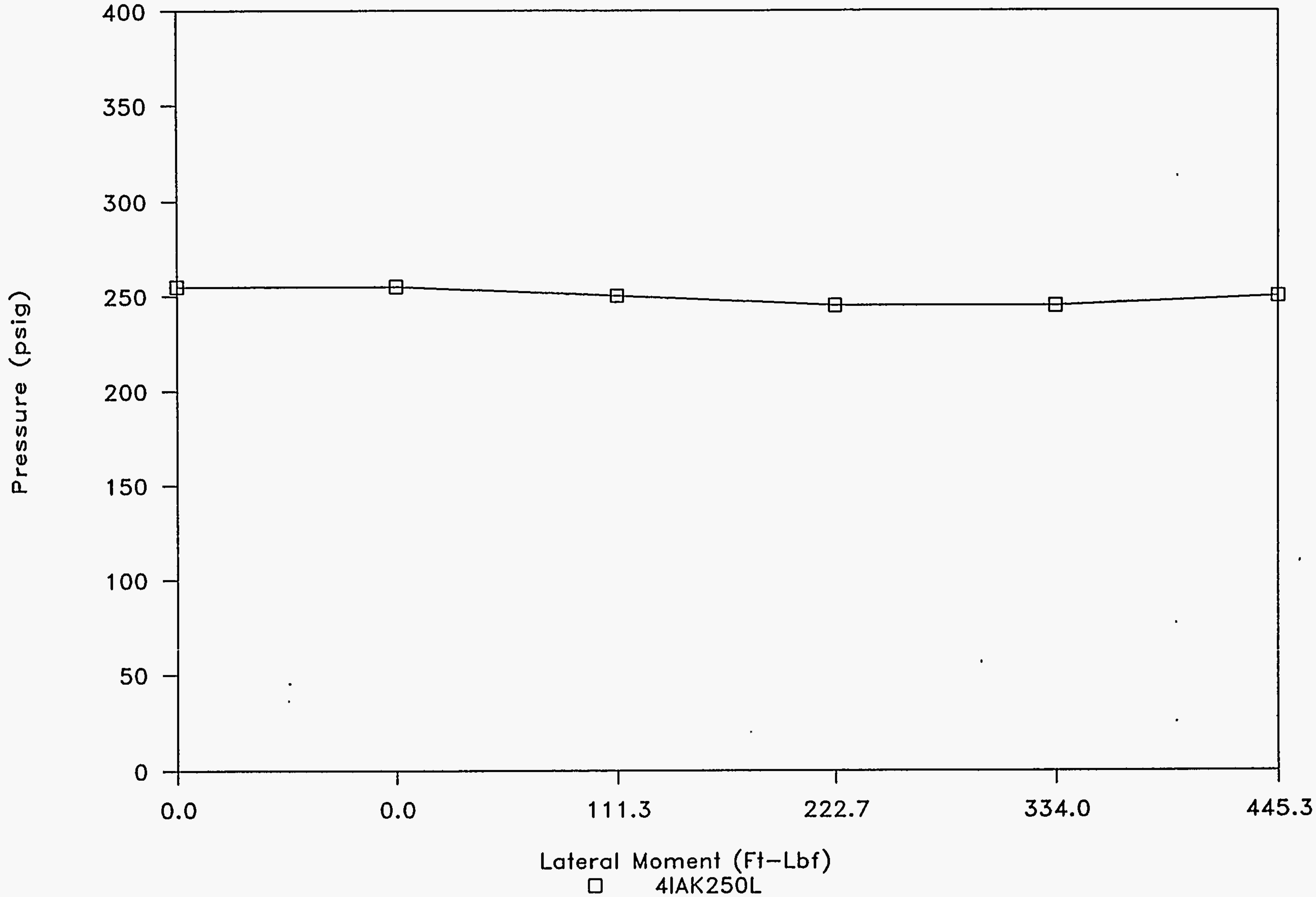

4" ISB, Kalrez O-Ring
51.4 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.00
2.02
4.05
6.03
8.07
Elapsed Time (Minutes - Hold Time)
4IAKPAST, No Moment

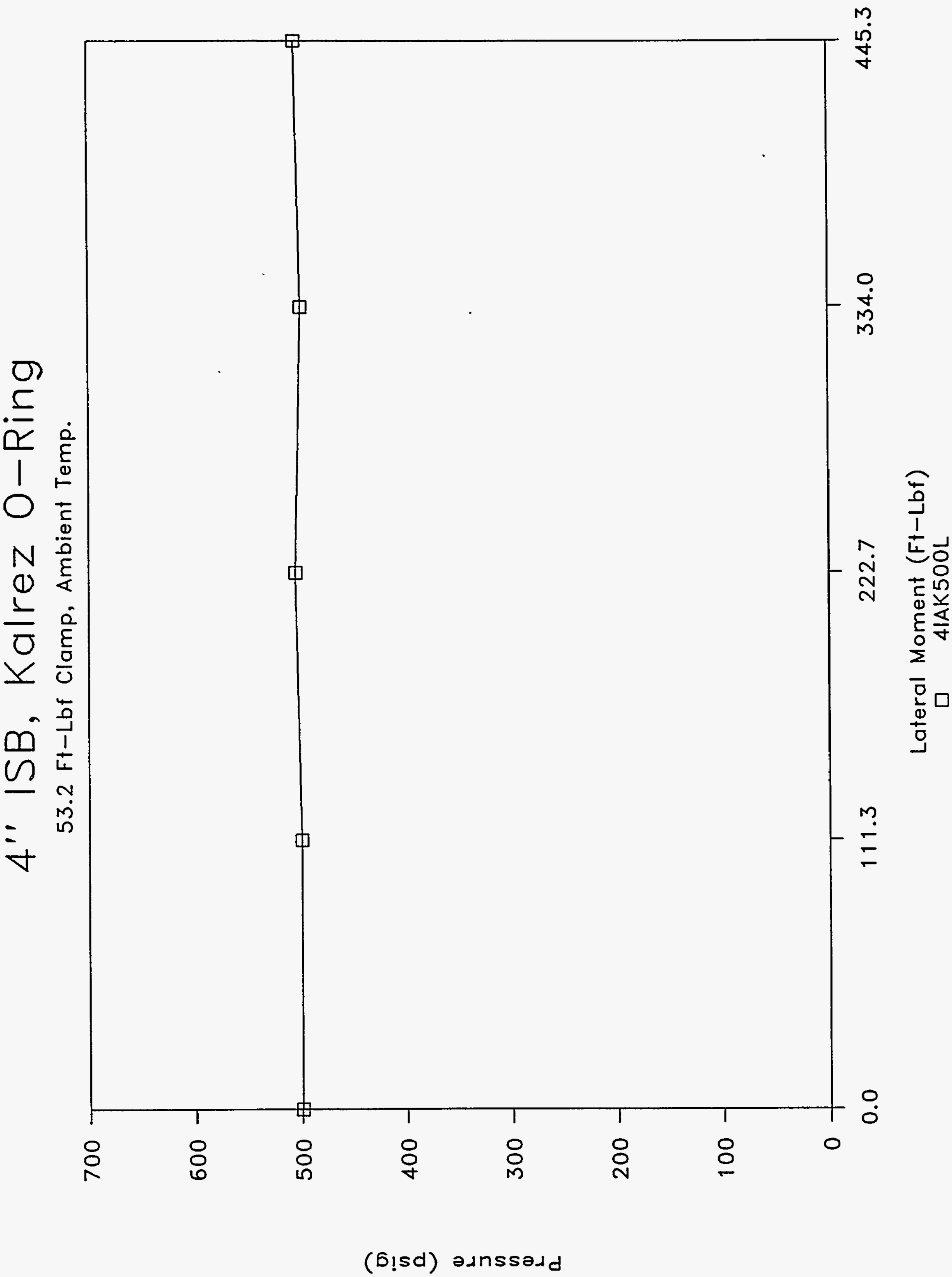
OCTOBER 06, 1994
4" ISB CONNECTOR, KALREZ O-RING, 70 DUROMETER, AMBIENT TEMP.
PRESSURE ASCENSION LEAK TEST - NO MOMENTS
CLAMPING TORQUE = 51.4 FT-LBF GRAPH NAME = 4IAKPAST
CHARGE PRESSURE = GRADUALLY INCREMENTED HIGHER

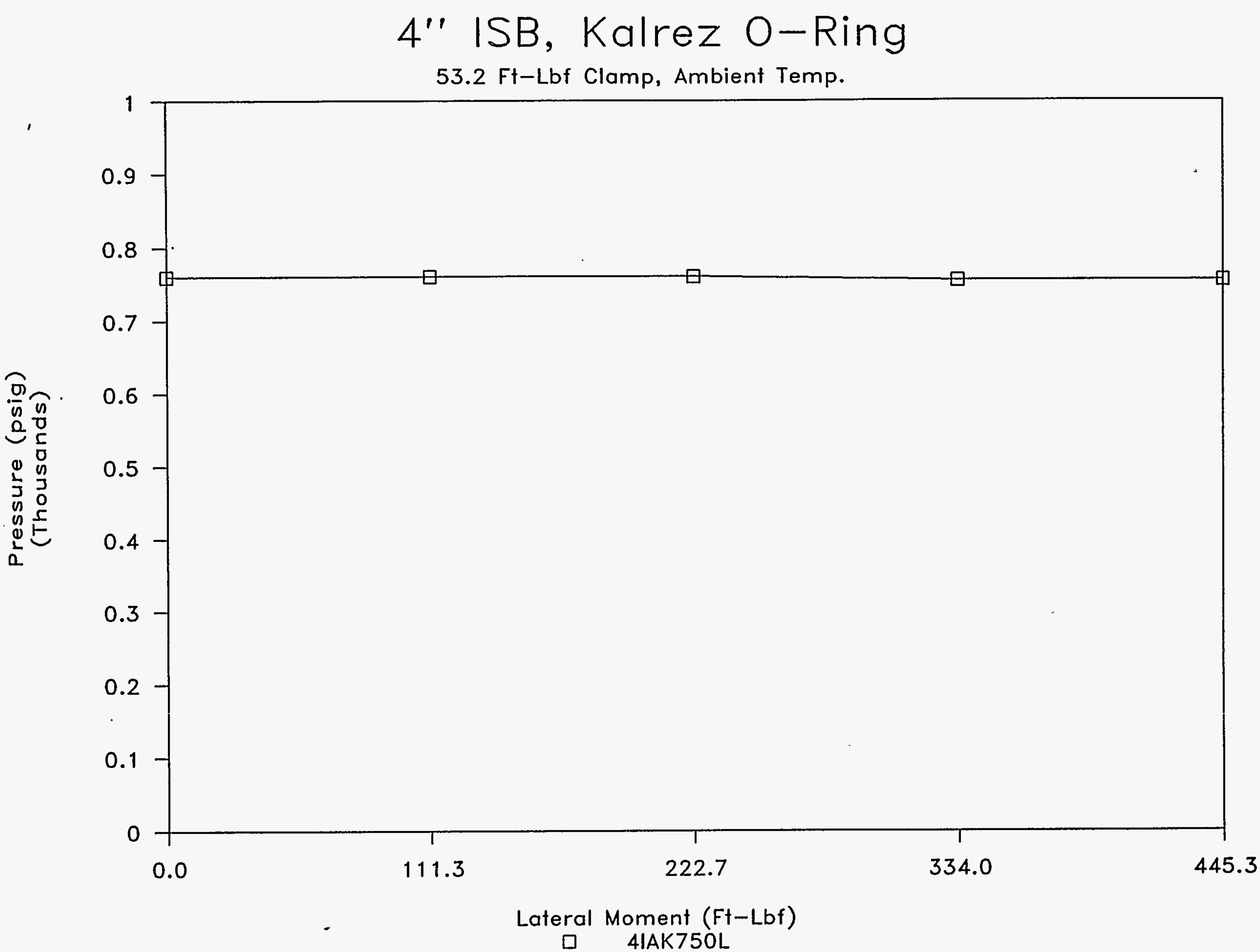
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	APPLIED FORCE LBS INPUT
255	0	0	0.00	0
255	2	1	2.02	0
518	4	3	4.05	0
760	6	2	6.03	0
1015	8	4	8.07	0

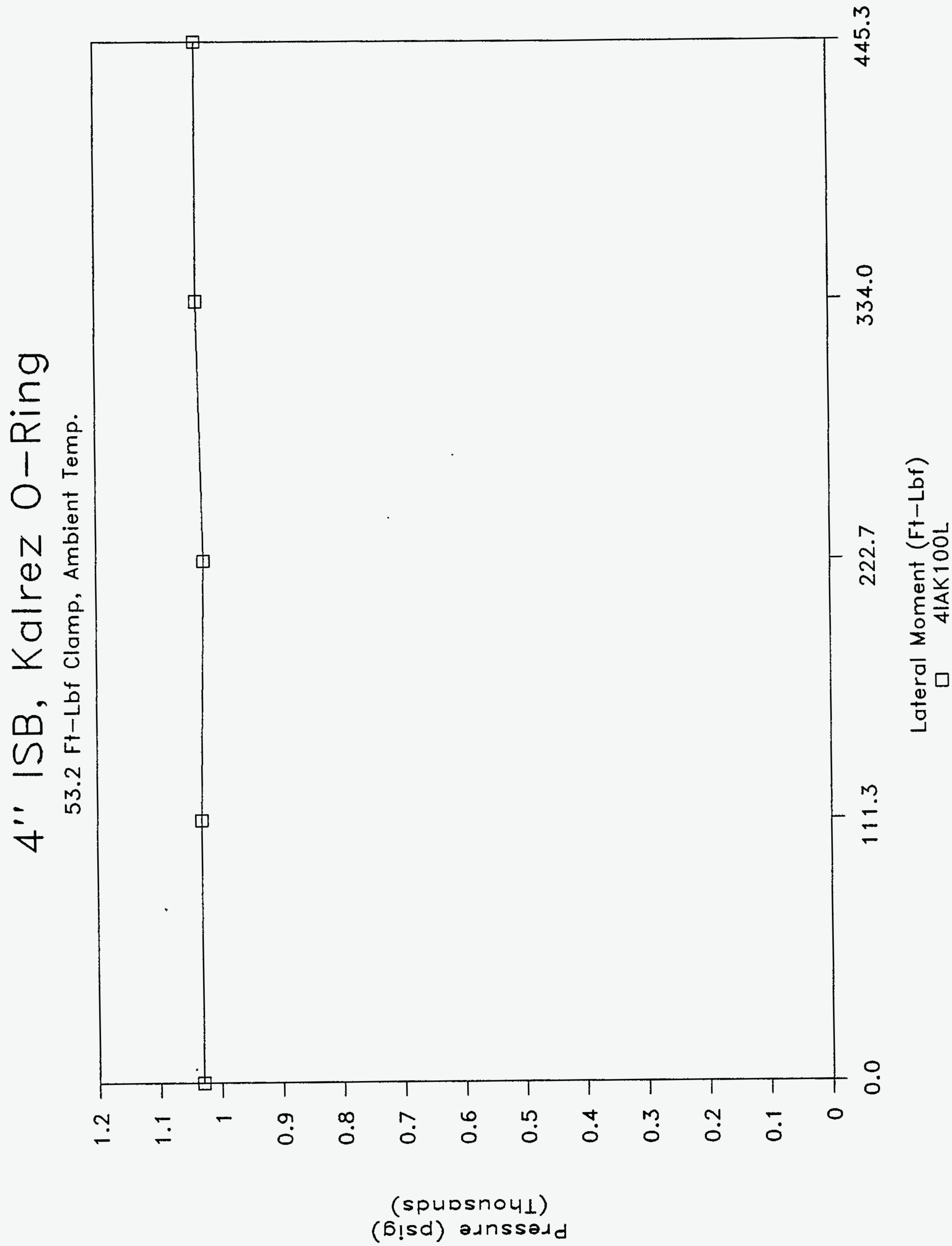
4" ISB, Kalrez O-Ring

53.2 Ft-Lbf Clamp, Ambient Temperature




4" ISB, Kalrez O-Ring
53.2 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
0
100
200
300
400
500
600
700
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
4IAK500L


4" ISB, Kalrez O—Ring
53.2 Ft—Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft—Lbf)
4IAK750L


4" ISB, Kalrez O-Ring
53.2 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
4IAK100L

OCTOBER 06, 1994
4" ISB CONNECTOR, KALREZ O-RING, 70 DUROMETER, AMBIENT TEMP.
LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 53.2 FT-LBF GRAPH NAME = 4IAK250L
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
255	0	0	0.00	0	0.4453	0.0
255	2	2	2.03	0	0.4453	0.0
250	4	1	4.02	250	0.4453	111.3
245	6	3	6.05	500	0.4453	222.7
245	8	1	8.02	750	0.4453	334.0
250	10	2	10.03	1000	0.4453	445.3

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = 4IAK500L

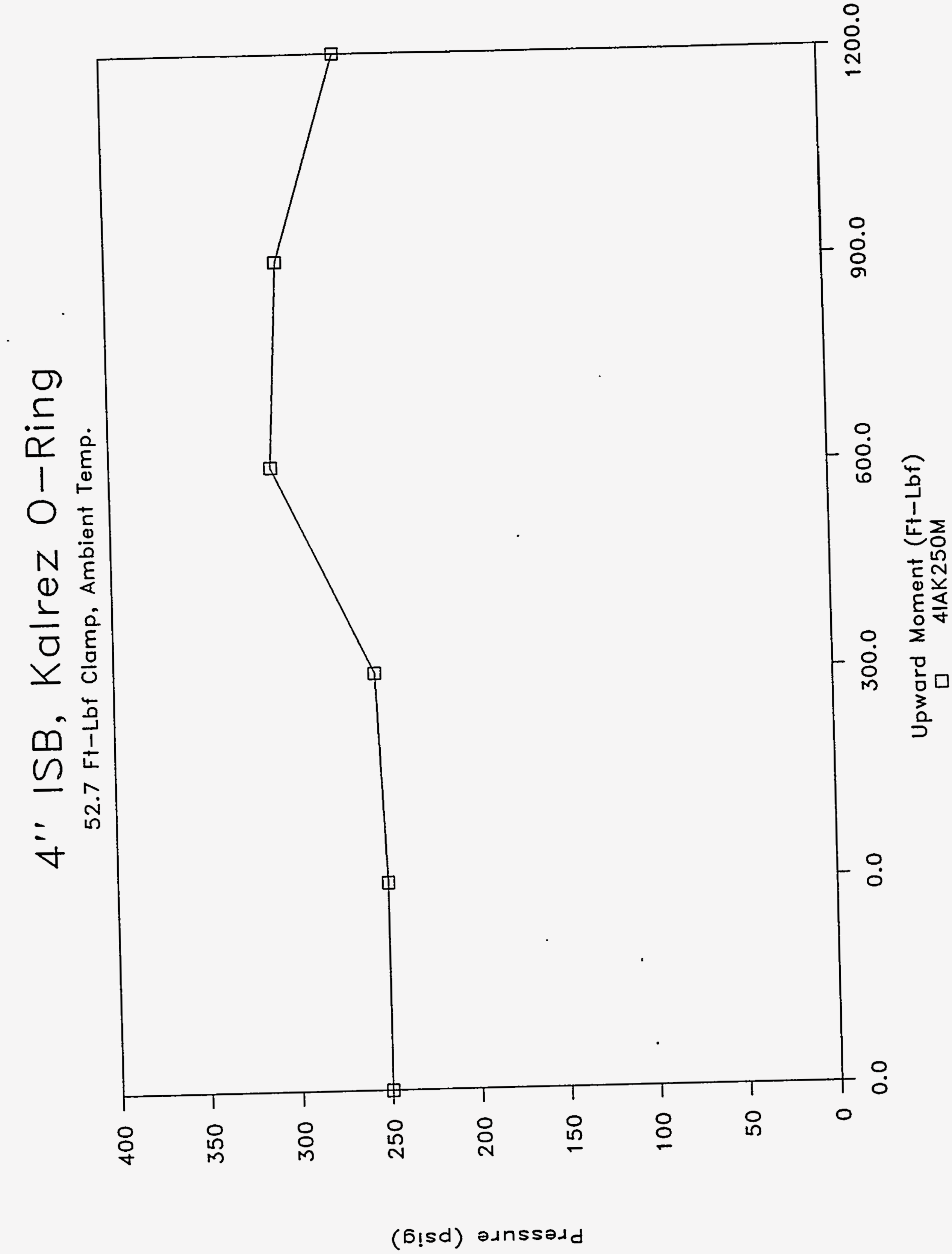
500	12	3	12.05	0	0.4453	0.0
500	14	1	14.02	250	0.4453	111.3
505	16	1	16.02	500	0.4453	222.7
500	18	2	18.03	750	0.4453	334.0
505	20	1	20.02	1000	0.4453	445.3

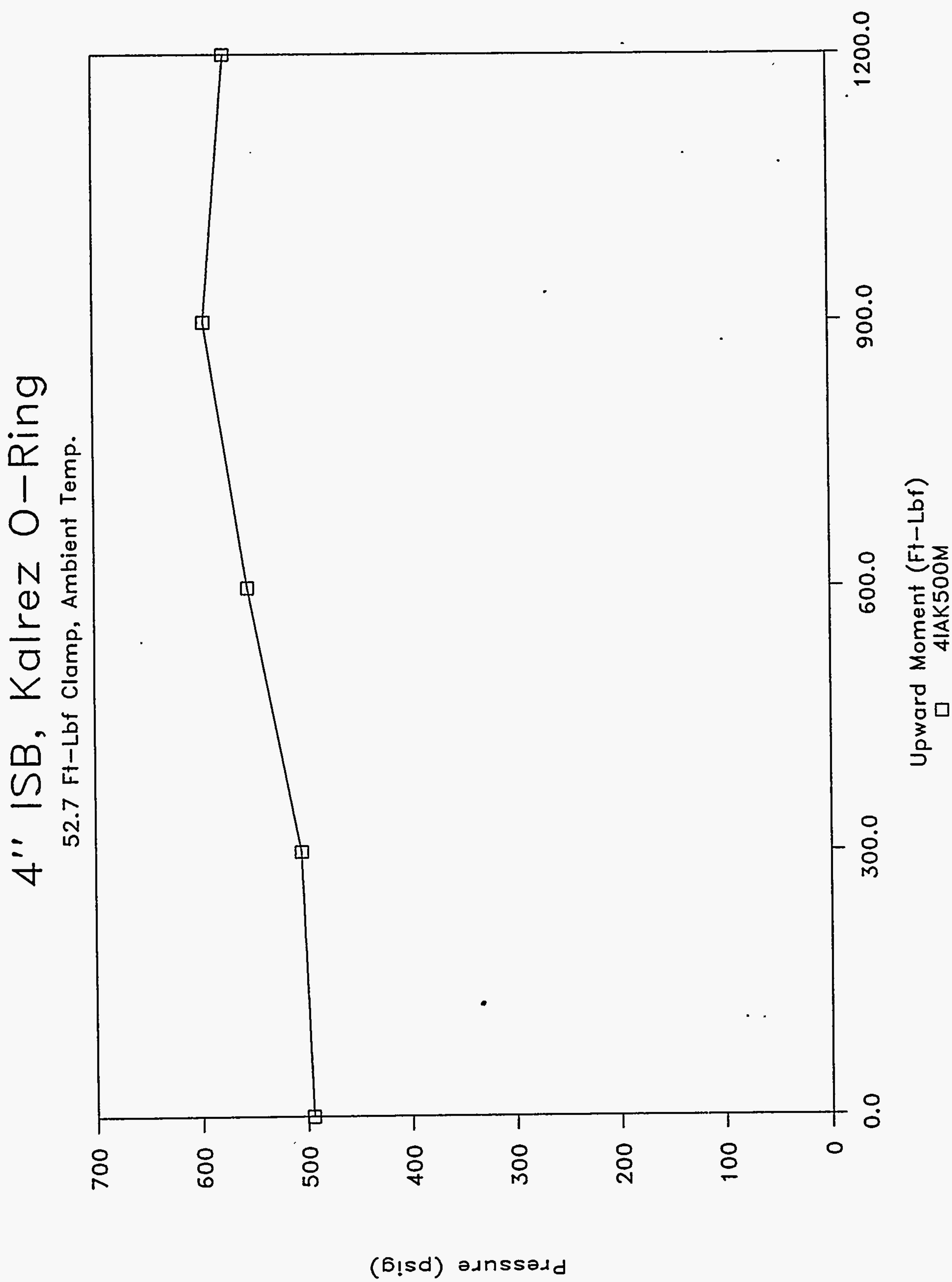
INCREASED PRESSURE TO 750 PSIG GRAPH NAME = 4IAK750L

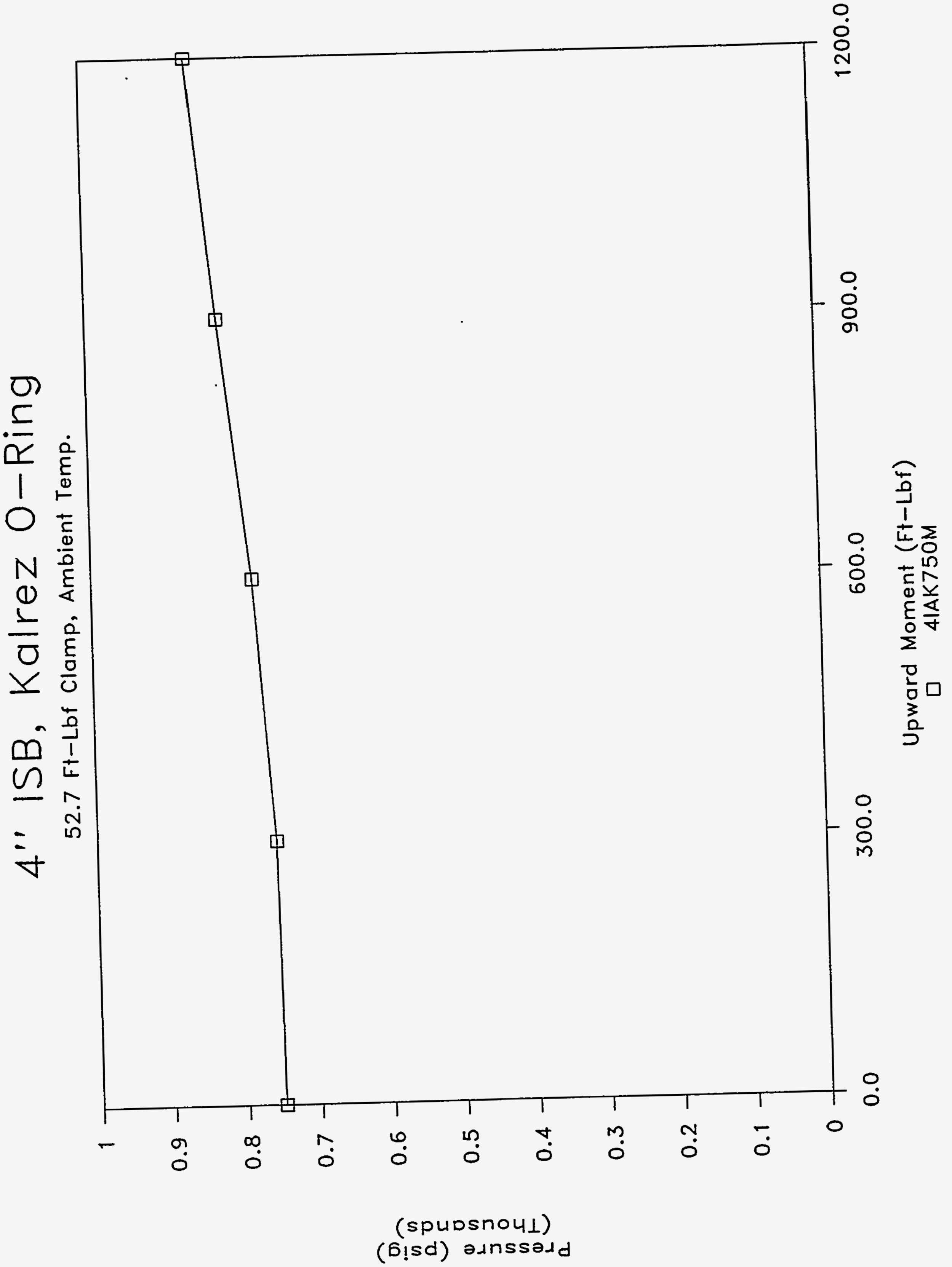
760	22	1	22.02	0	0.4453	0.0
760	24	3	24.05	250	0.4453	111.3
760	26	1	26.02	500	0.4453	222.7
755	28	2	28.03	750	0.4453	334.0
755	30	1	30.02	1000	0.4453	445.3

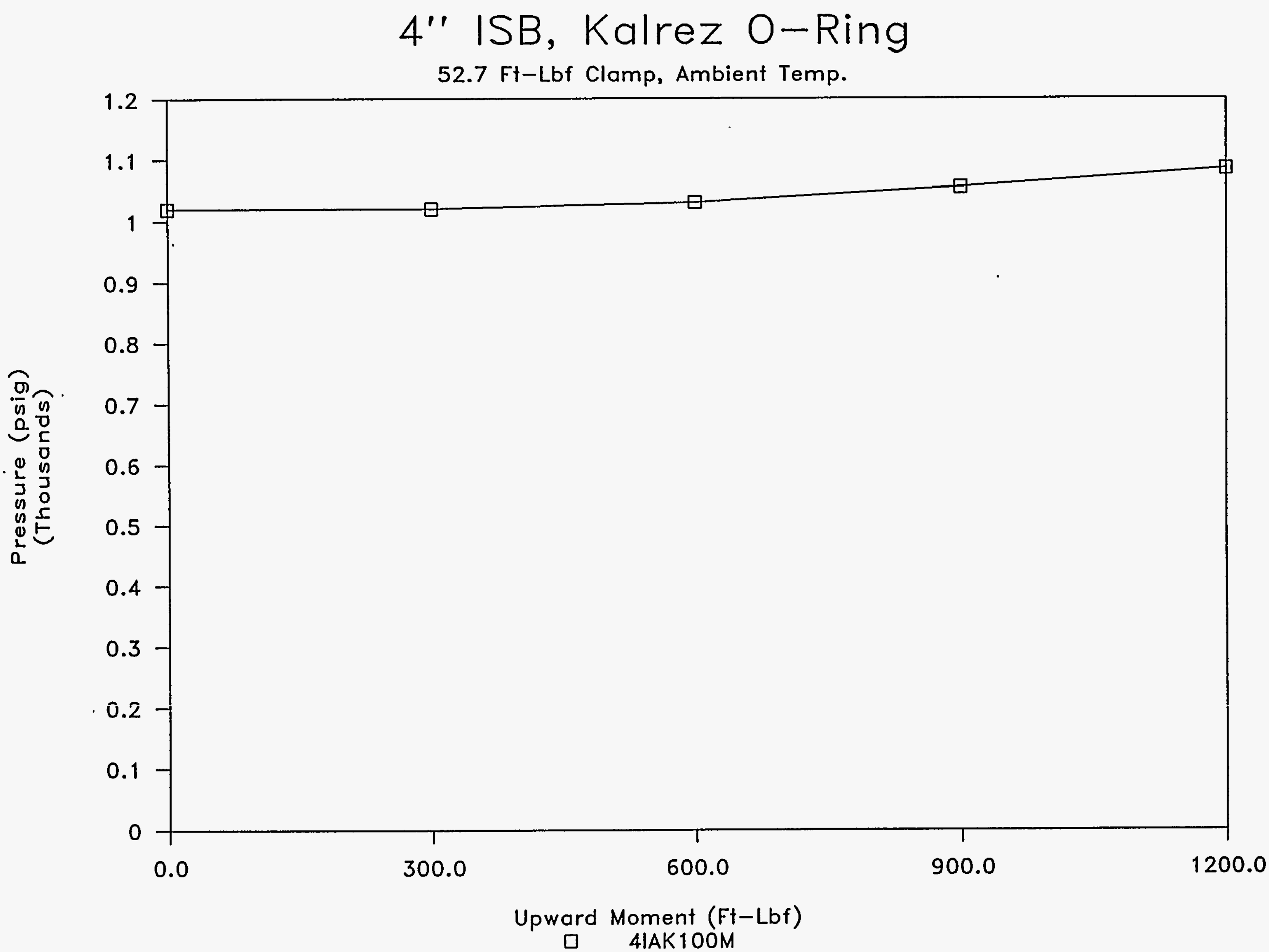
INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = 4IAK100L

1030	32	2	32.03	0	0.4453	0.0
1030	34	1	34.02	250	0.4453	111.3
1025	36	3	36.05	500	0.4453	222.7
1035	38	1	38.02	750	0.4453	334.0
1035	40	1	40.02	1000	0.4453	445.3


4'' ISB, Kalrez O-Ring
52.7 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
0
50
100
150
200
250
300
350
400
0.0
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft-Lbf)
4IAK250M


4" ISB, Kalrez O-Ring
52.7 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
0
100
200
300
400
500
600
700
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft-Lbf)
4IAK500M


4" ISB, Kalrez O-Ring
52.7 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft-Lbf)
4IAK750M


4" ISB, Kalrez O-Ring
52.7 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft-Lbf)
4IAK100M

OCTOBER 06, 1994
4" ISB CONNECTOR, KALREZ O-RING, 70 DUROMETER, AMBIENT TEMP.
LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 52.7 FT-LBF GRAPH NAME = 4IAK250M
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
250	0	0	0.00	0	1.2000	0.0
250	2	1	2.02	0	1.2000	0.0
255	4	3	4.05	250	1.2000	300.0
310	6	1	6.02	500	1.2000	600.0
305	8	2	8.03	750	1.2000	900.0
270	10	2	10.03	1000	1.2000	1200.0

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = 4IAK500M

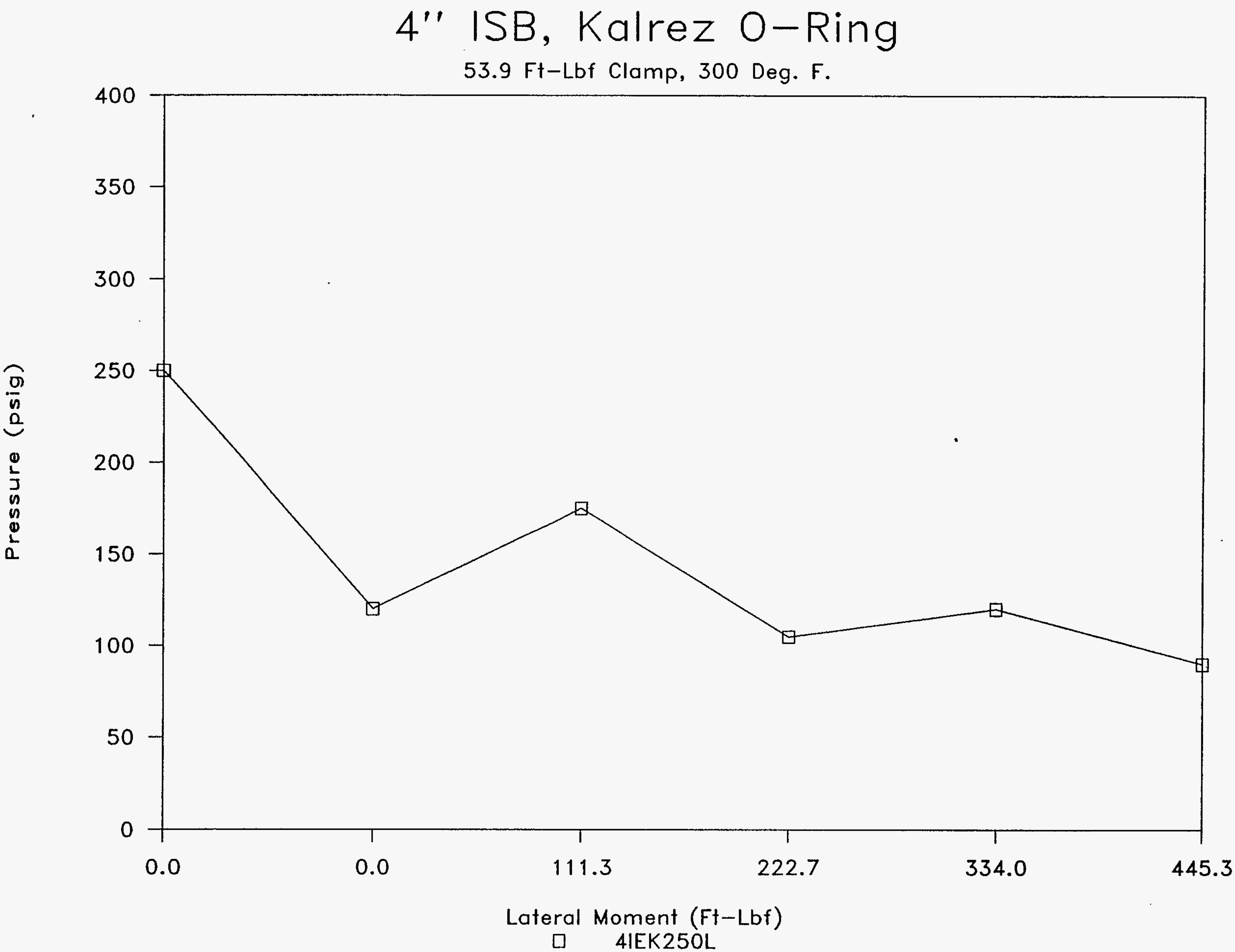
495	12	2	12.03	0	1.2000	0.0
505	14	6	14.10	250	1.2000	300.0
555	16	2	16.03	500	1.2000	600.0
595	18	3	18.05	750	1.2000	900.0
575	20	10	20.17	1000	1.2000	1200.0

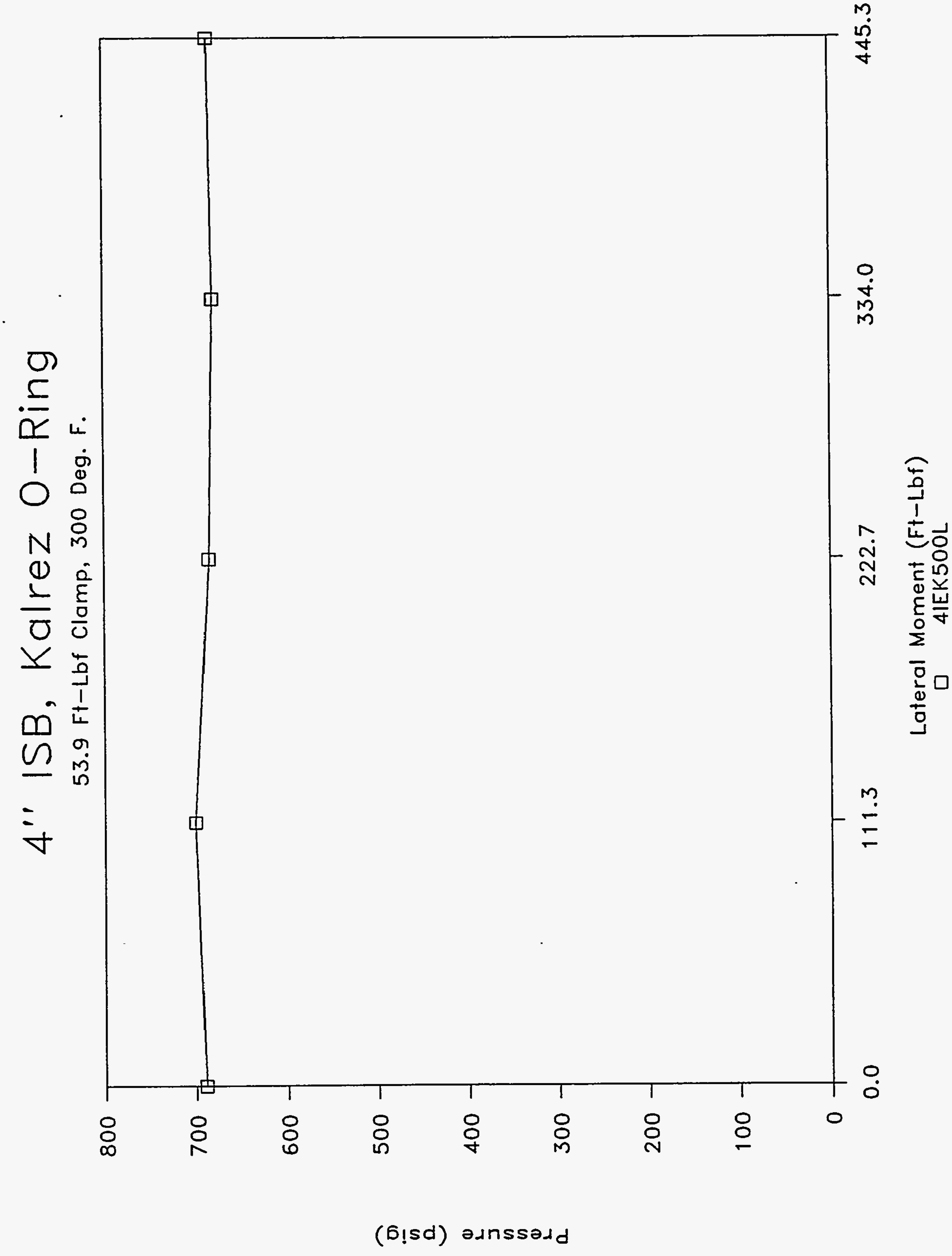
INCREASED PRESSURE TO 750 PSIG GRAPH NAME = 4IAK750M

750	22	2	22.03	0	1.2000	0.0
755	24	2	24.03	250	1.2000	300.0
780	26	6	26.10	500	1.2000	600.0
820	28	1	28.02	750	1.2000	900.0
855	30	1	30.02	1000	1.2000	1200.0

INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = 4IAK100M

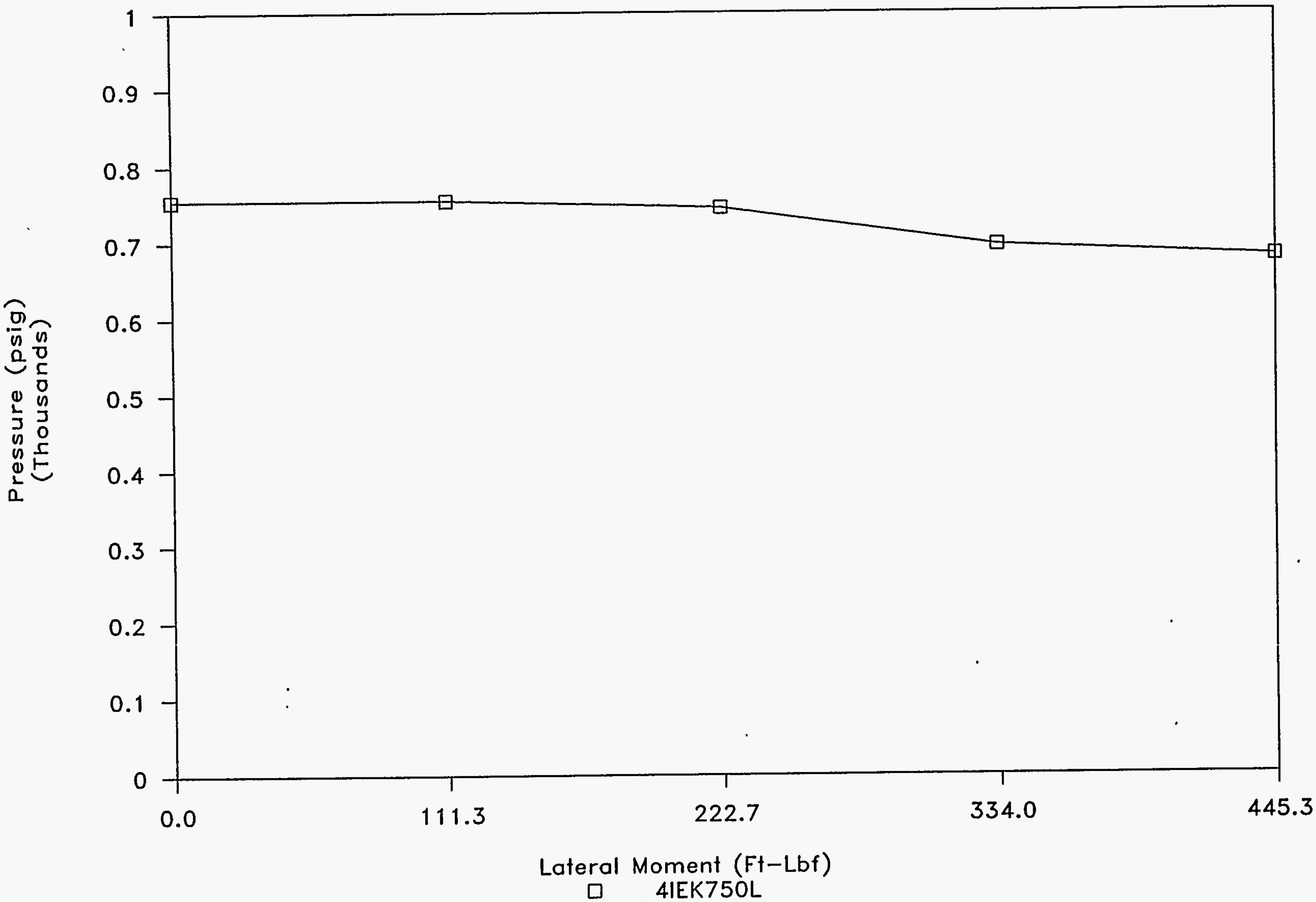
1020	32	2	32.03	0	1.2000	0.0
1020	34	2	34.03	250	1.2000	300.0
1030	36	3	36.05	500	1.2000	600.0
1055	38	2	38.03	750	1.2000	900.0
1085	40	1	40.02	1000	1.2000	1200.0

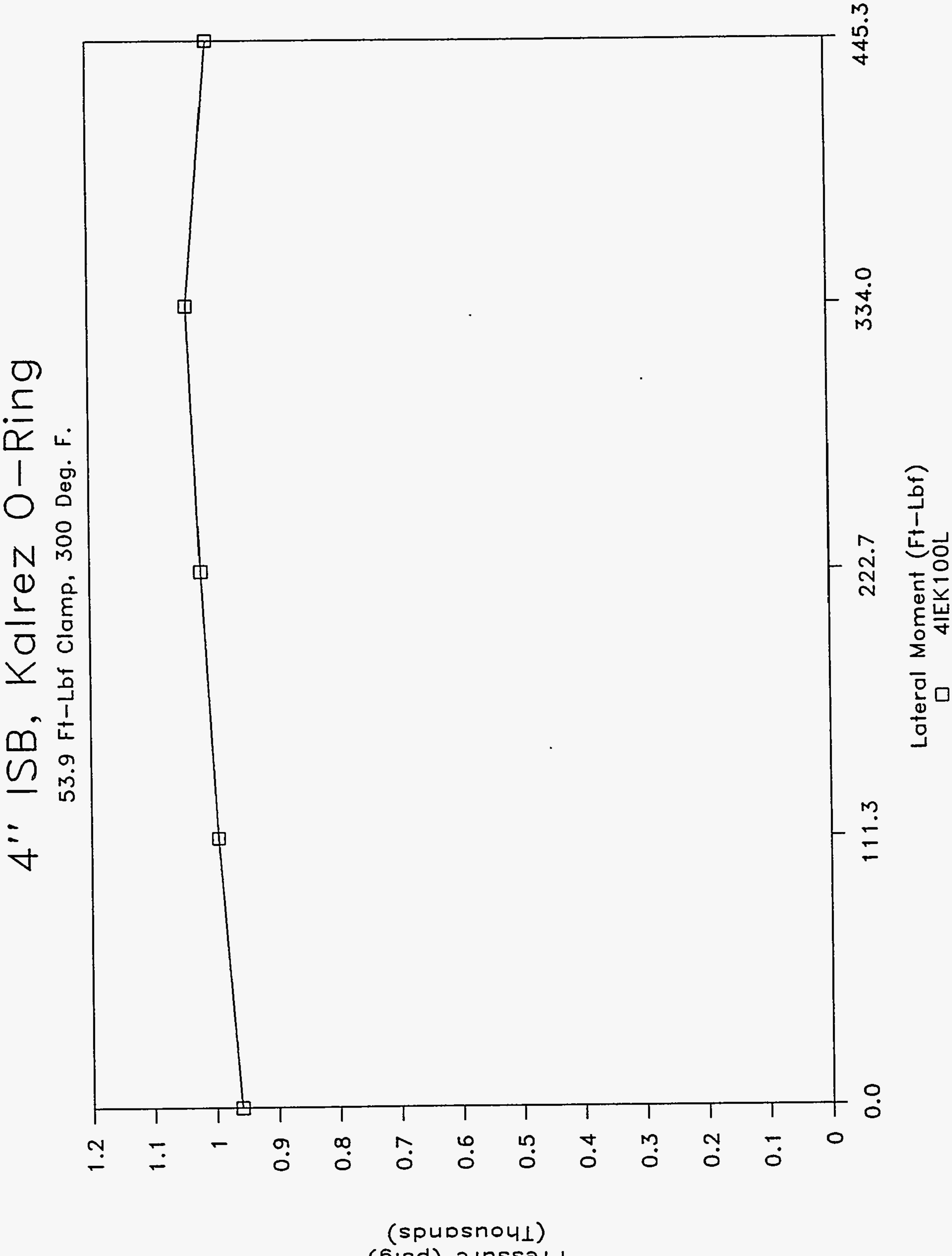

4" ISB, Kalrez O-Ring
53.9 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
0
50
100
150
200
250
300
350
400
0.0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
4IEK250L


4" ISB, Kalrez O-Ring
53.9 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
800
700
600
500
400
300
200
100
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
4IEK500L

4" ISB, Kalrez O-Ring

53.9 Ft-Lbf Clamp, 300 Deg. F.




4'' ISB, Kalrez O-Ring
53.9 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
4IEK100L

OCTOBER 07, 1994
4" ISB CONNECTOR, KALREZ O-RING, 70 DUROMETER, ELEVATED TEMP.(300 DEG. F
LEAK TEST - LATERAL MOMENT (SIDEWAYS)
CLAMPING TORQUE = 53.9 FT-LBF GRAPH NAME = 4IEK250L
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
250	0	0	0.00	0	0.4453	0.0
120	2	1	2.02	0	0.4453	0.0
175	4	2	4.03	250	0.4453	111.3
105	9	43	9.72	500	0.4453	222.7
120	12	0	12.00	750	0.4453	334.0
90	14	1	14.02	1000	0.4453	445.3

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = 4IEK500L

690	16	1	16.02	0	0.4453	0.0
700	18	2	18.03	250	0.4453	111.3
685	20	2	20.03	500	0.4453	222.7
680	22	8	22.13	750	0.4453	334.0
685	24	13	24.22	1000	0.4453	445.3

INCREASED PRESSURE TO 750 PSIG GRAPH NAME = 4IEK750L

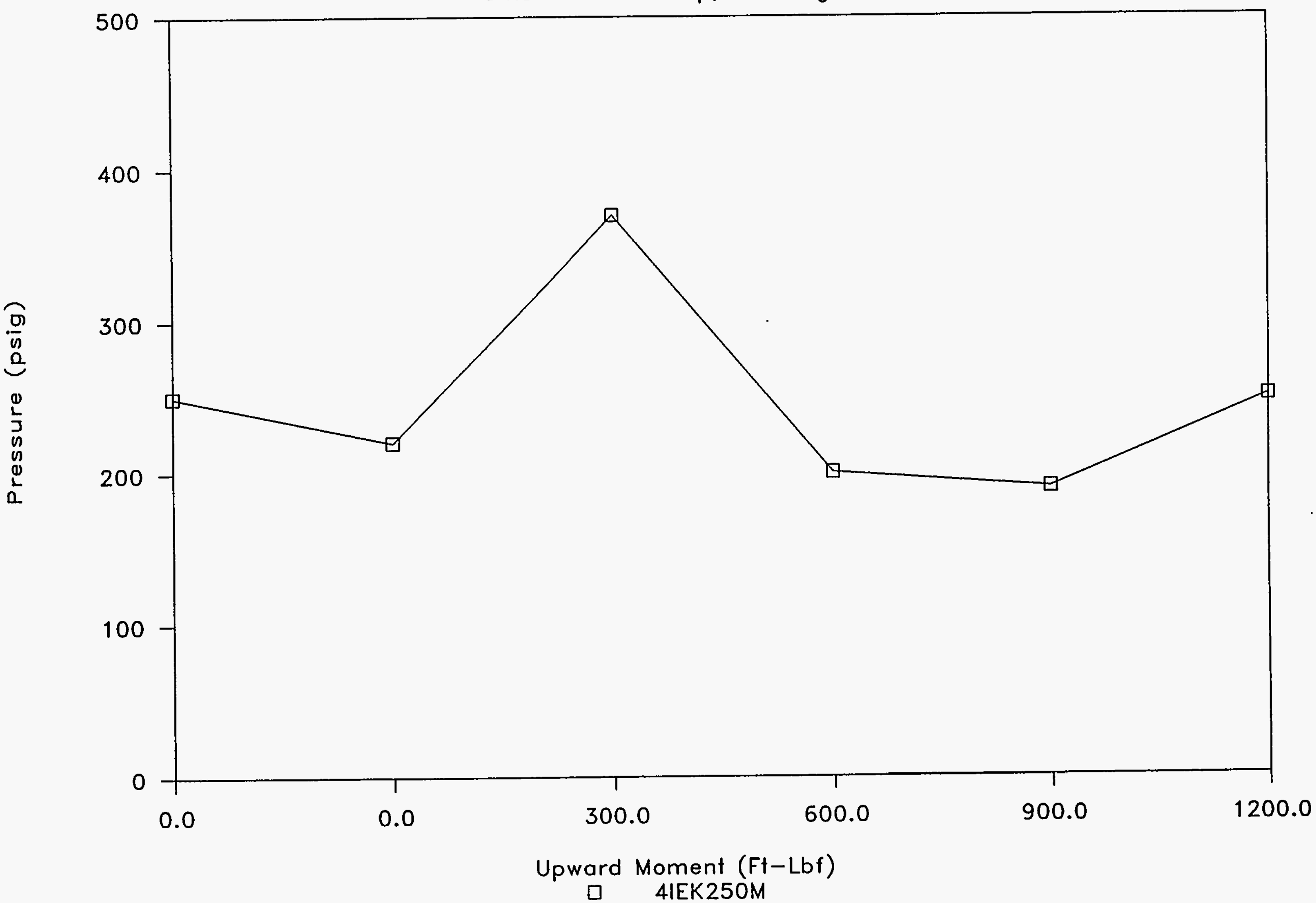
755	26	8	26.13	0	0.4453	0.0
755	28	5	28.08	250	0.4453	111.3
745	30	3	30.05	500	0.4453	222.7
695	32	2	32.03	750	0.4453	334.0
680	34	1	34.02	1000	0.4453	445.3

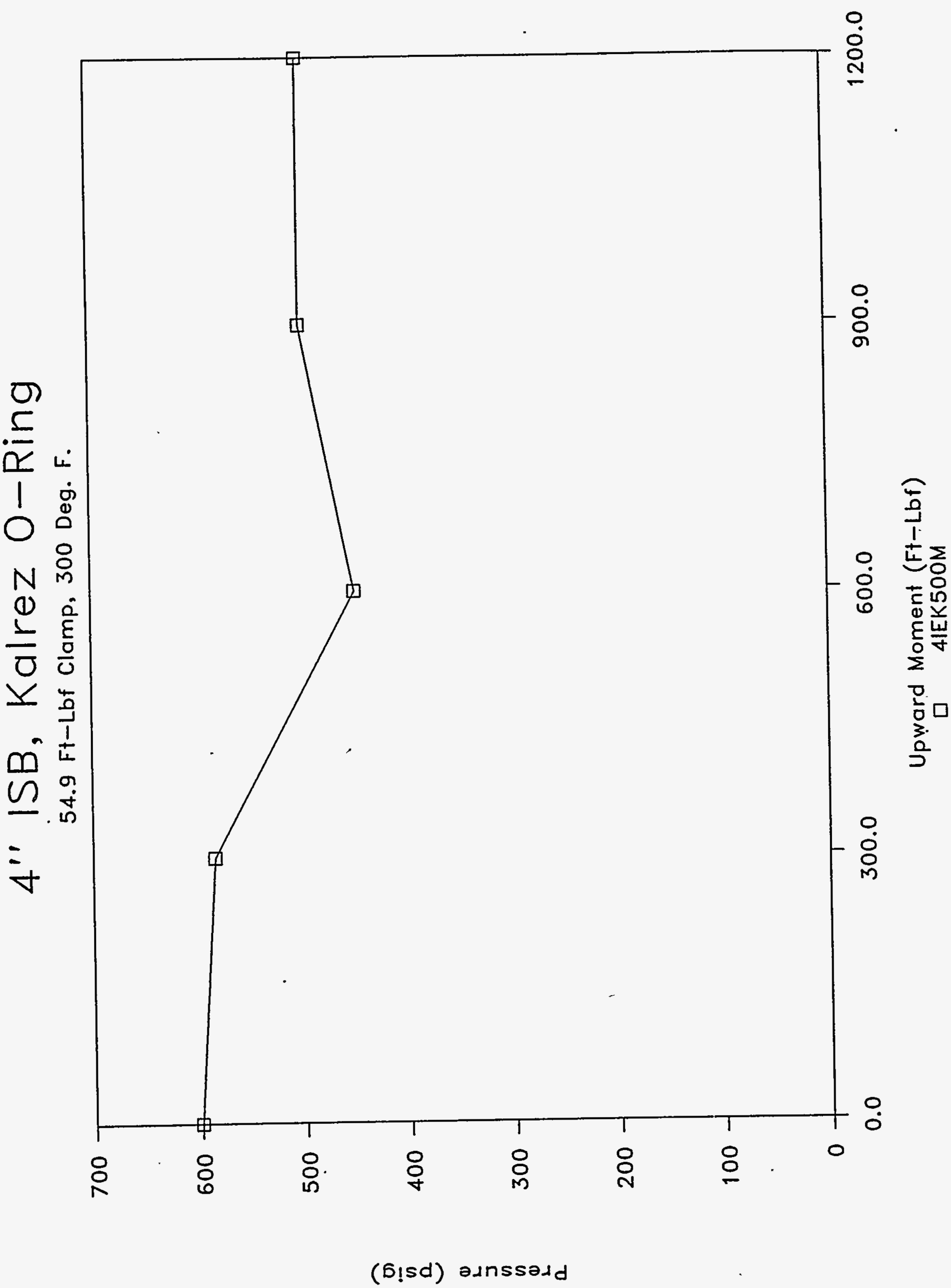
INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = 4IEK100L

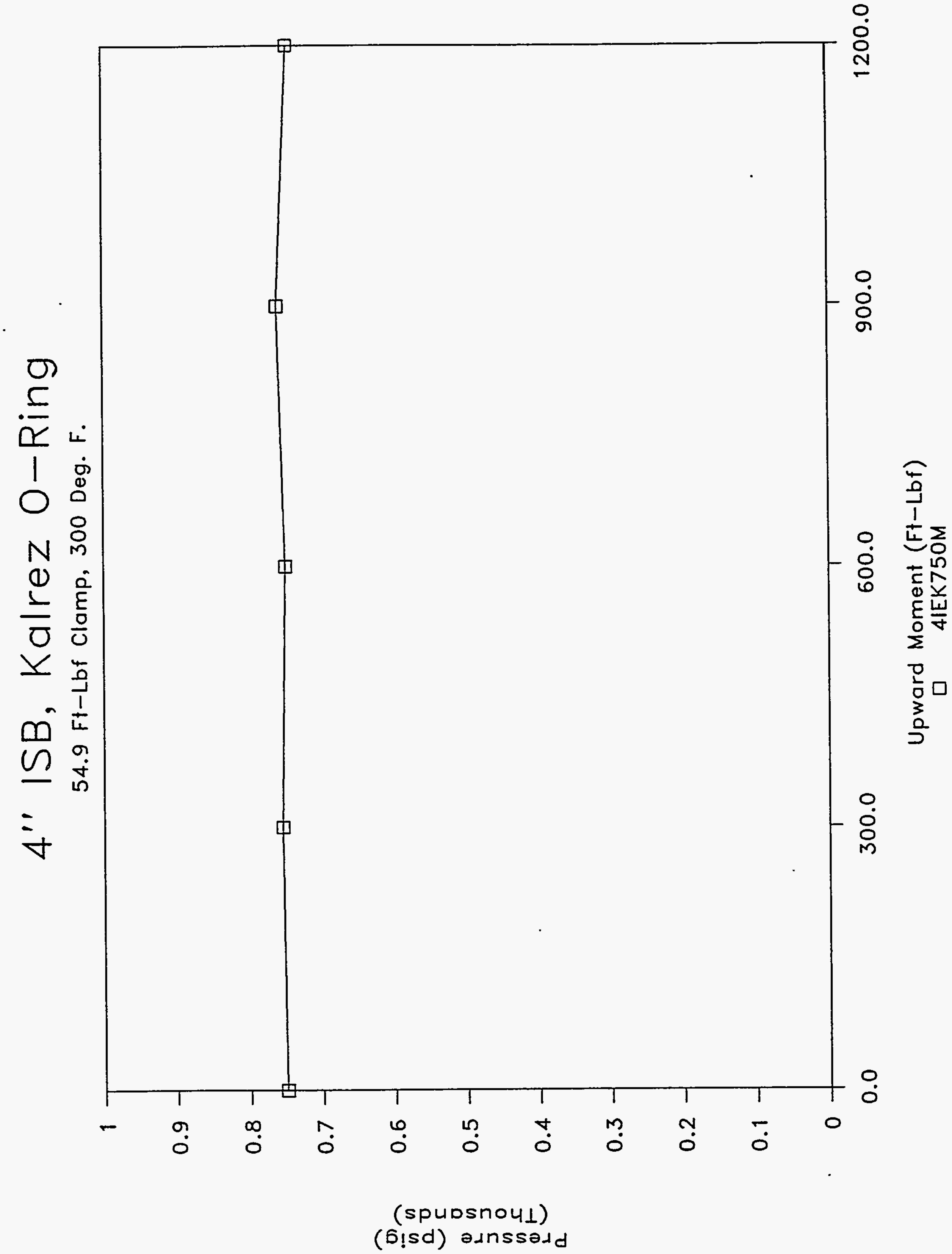
960	36	2	36.03	0	0.4453	0.0
995	38	1	38.02	250	0.4453	111.3
1020	40	1	40.02	500	0.4453	222.7
1040	42	3	42.05	750	0.4453	334.0
1005	44	3	44.05	1000	0.4453	445.3

4'' ISB, Kalrez O-Ring

54.9 Ft-Lbf Clamp, 300 Deg. F.

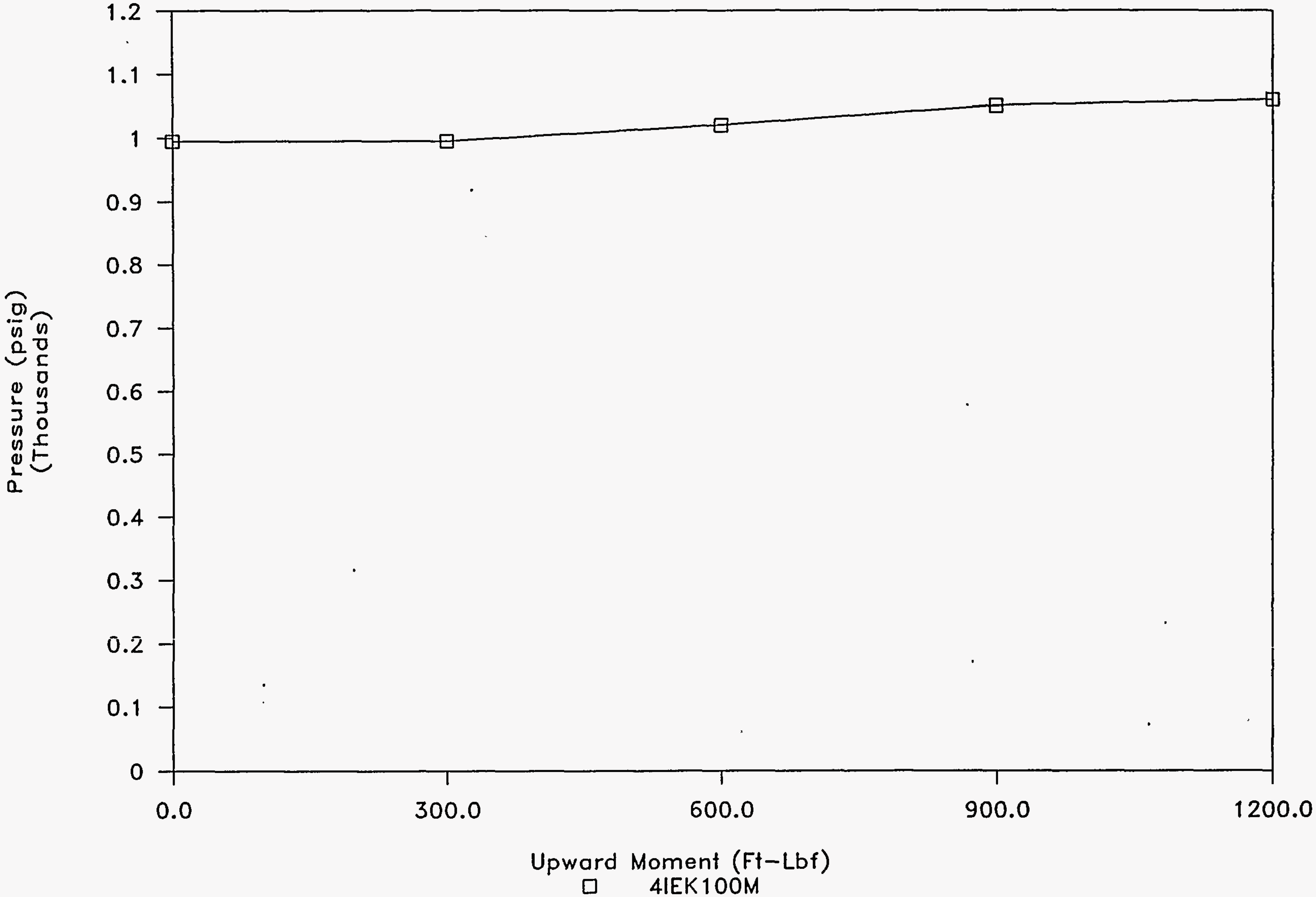



4" ISB, Kalrez O-Ring
54.9 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
0
100
200
300
400
500
600
700
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft-Lbf)
41EK500M


4" ISB, Kalrez O-Ring
54.9 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
(Thousands)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft-Lbf)
4IEK750M

4'' ISB, Kalrez O-Ring

54.9 Ft-Lbf Clamp, 300 Deg. F.



OCTOBER 07, 1994
4" ISB CONNECTOR, KALREZ O-RING, 70 DUROMETER, ELEVATED TEMP.(300 DEG. F
LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 54.9 FT-LBF GRAPH NAME = 4IEK250M
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
250	0	0	0.00	0	1.2000	0.0
220	2	7	2.12	0	1.2000	0.0
370	4	3	4.05	250	1.2000	300.0
200	6	2	6.03	500	1.2000	600.0
190	8	2	8.03	750	1.2000	900.0
250	10	2	10.03	1000	1.2000	1200.0

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = 4IEK500M

600	12	4	12.07	0	1.2000	0.0
585	14	1	14.02	250	1.2000	300.0
450	16	1	16.02	500	1.2000	600.0
500	18	2	18.03	750	1.2000	900.0
500	20	7	20.12	1000	1.2000	1200.0

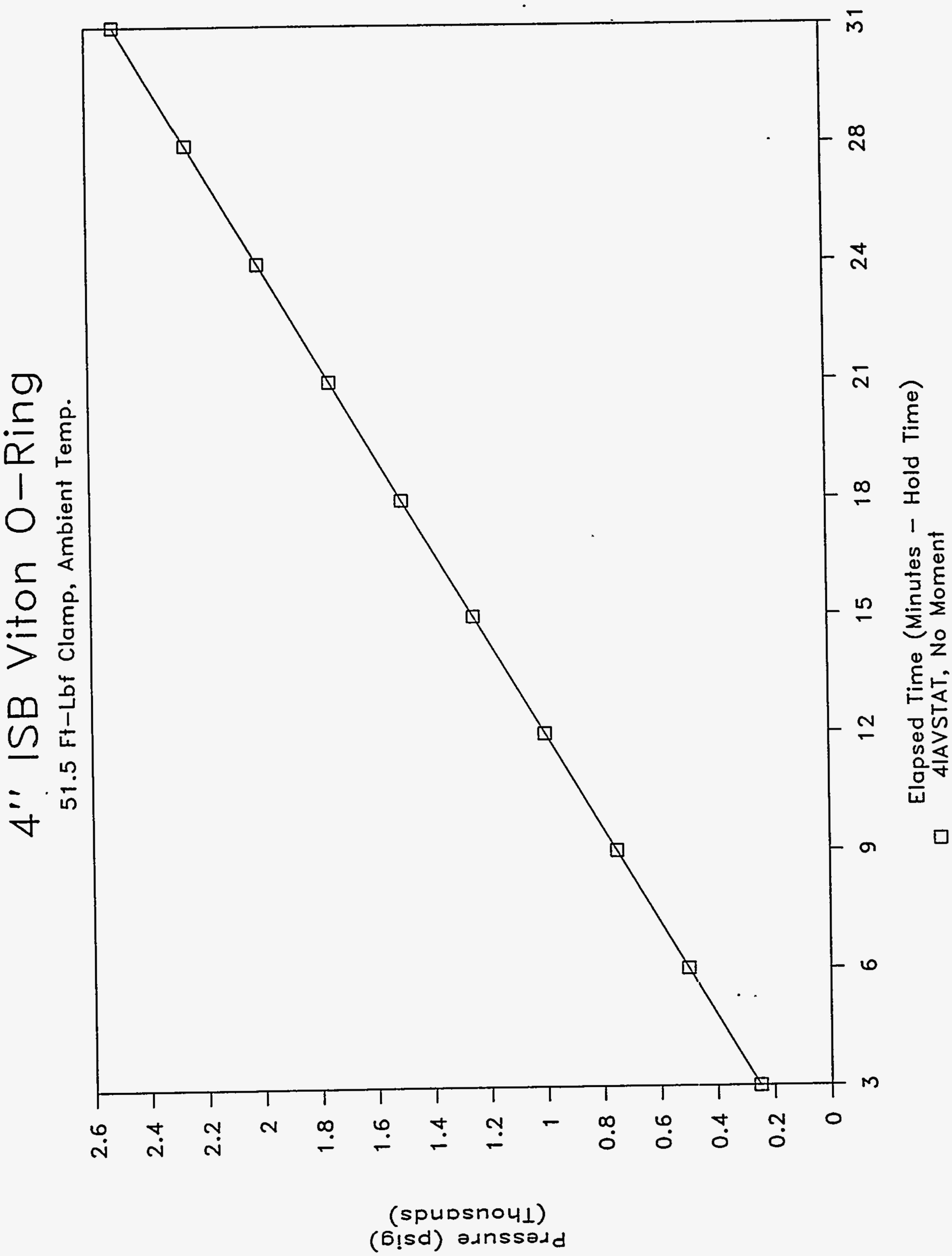
INCREASED PRESSURE TO 750 PSIG GRAPH NAME = 4IEK750M

750	22	3	22.05	0	1.2000	0.0
755	24	1	24.02	250	1.2000	300.0
750	26	1	26.02	500	1.2000	600.0
760	28	3	28.05	750	1.2000	900.0
745	30	2	30.03	1000	1.2000	1200.0

INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = 4IEK100M

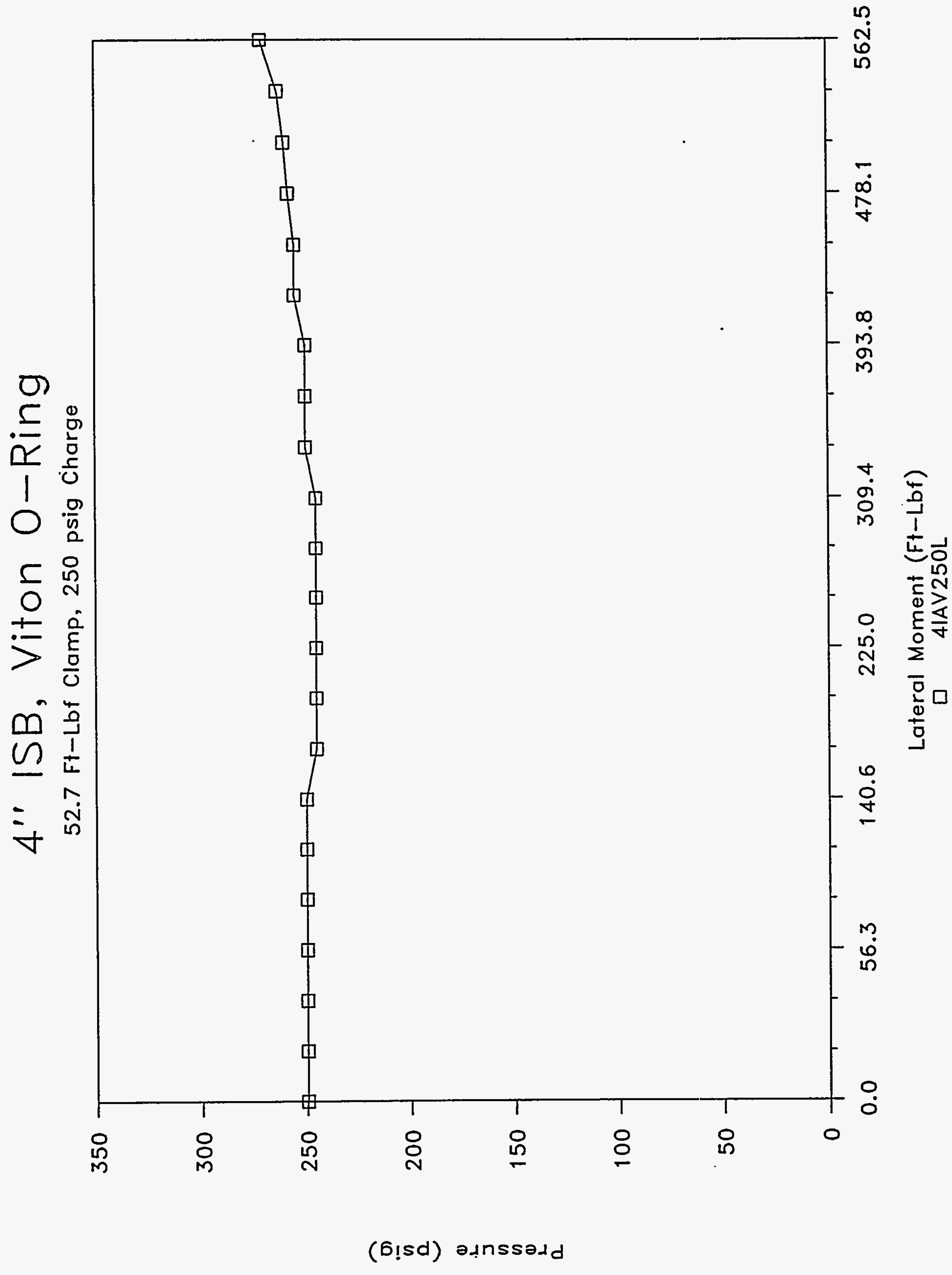
995	32	1	32.02	0	1.2000	0.0
995	34	2	34.03	250	1.2000	300.0
1020	36	1	36.02	500	1.2000	600.0
1050	38	1	38.02	750	1.2000	900.0
1060	40	2	40.03	1000	1.2000	1200.0

APPENDIX M: GRAPHS OF 4-IN. VITON TESTS


4" ISB Viton O-Ring
51.5 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
3
6
9
12
15
18
21
24
28
31
Elapsed Time (Minutes - Hold Time)
4IAVSTAT, No Moment

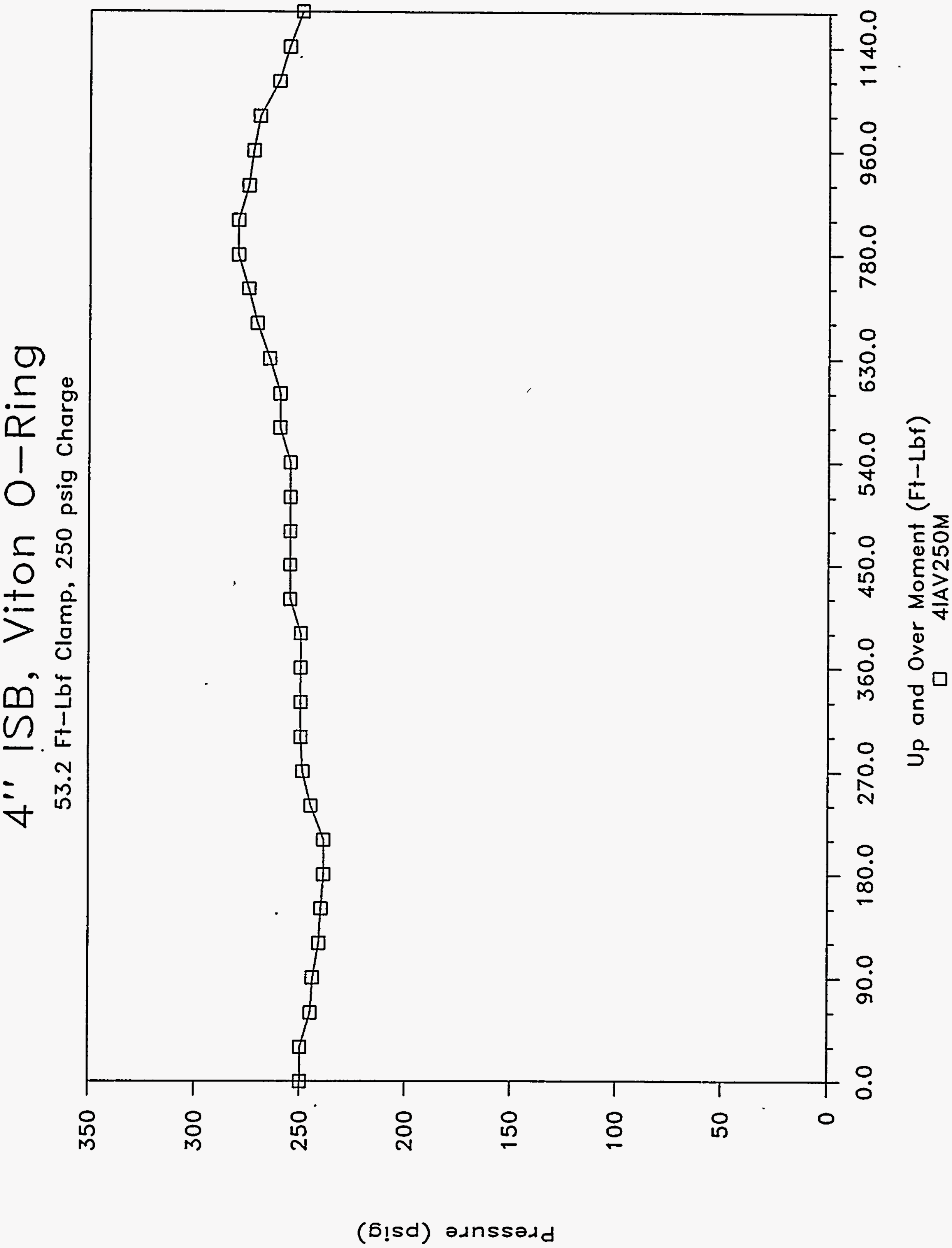
MAY 26, 1994
4" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, AMBIENT TEMP.
STATIC LEAK TEST - NO EXTERNAL MOMENTS
CLAMPING TORQUE = 51.5 FT-LBF GRAPH NAME = 4IAVSTAT
CHARGE PRESSURE = 250 TO 2,500 PSIG

PRESSURE PSIG INPUT	HOLD TIME MIN. INPUT	HOLD TIME SEC. INPUT	ELAPSED MINUTES COMPUTE	ELAPSED SECONDS COMPUTE	ELAPSED DECIMAL ROUNDED MINUTES COMPUTE	MOMENT FORCE LBS INPUT
250	3	4	3	4	3	0
500	3	5	6	9	6	0
750	3	3	9	12	9	0
1000	3	2	12	14	12	0
1250	3	3	15	17	15	0
1500	3	2	18	19	18	0
1750	3	4	21	23	21	0
2000	3	2	24	25	24	0
2250	3	5	27	30	28	0
2500	3	7	30	37	31	0


4" ISB, Viton O-Ring
52.7 Ft-Lbf Clamp, 250 psig Charge
Pressure (psig)
350
300
250
200
150
100
50
0
0.0
56.3
140.6
225.0
309.4
393.8
478.1
562.5
Lateral Moment (Ft-Lbf)
4IAV250L

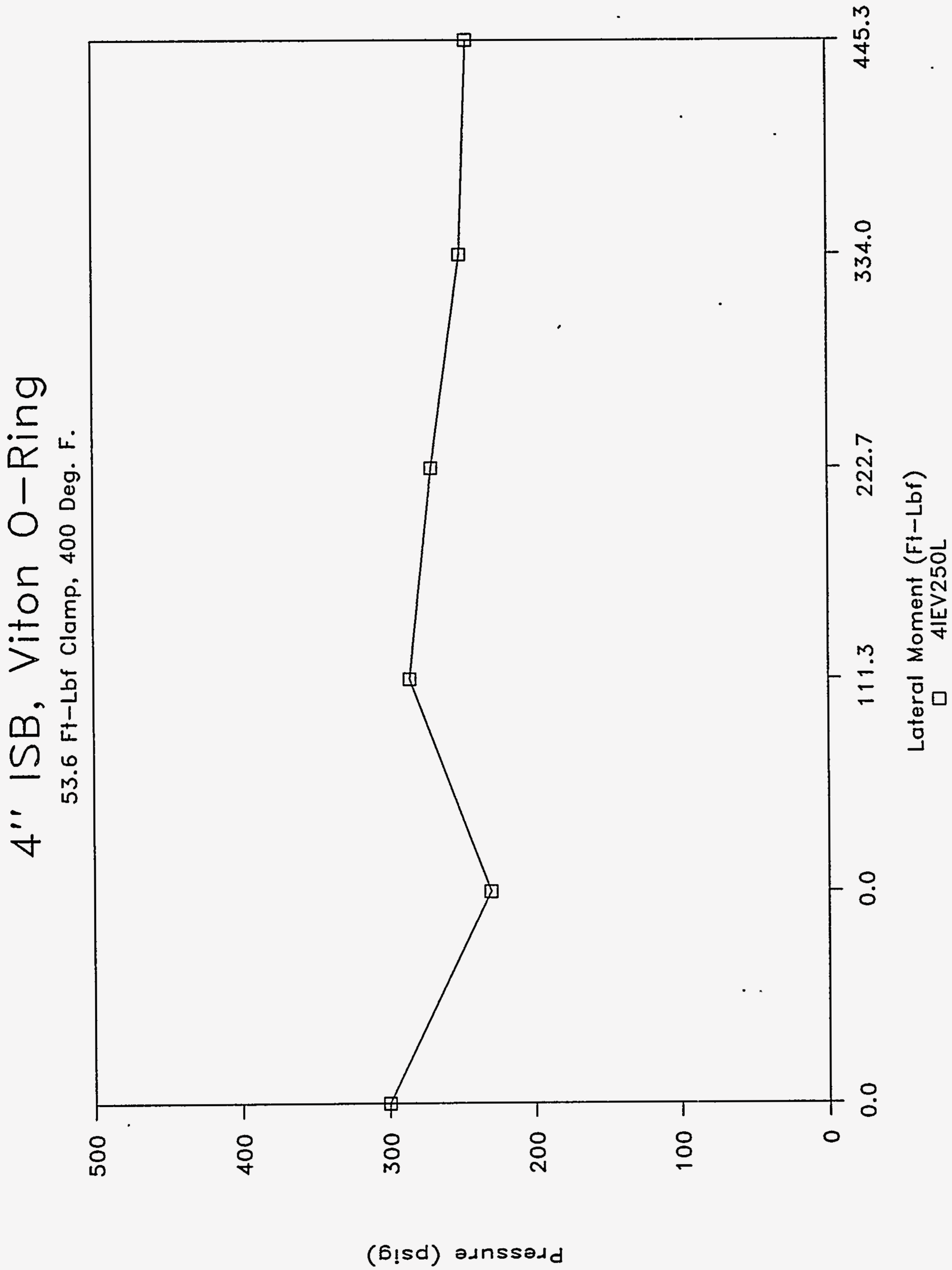
JUNE 01, 1994
4" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, AMBIENT TEMP.
LEAK TEST - LATERAL MOMENTS APPLIED (SIDEWAYS ROTATION)
CLAMPING TORQUE = 52.7 FT-LBF GRAPH NAME = 4IAV250L
CHARGE PRESSURE = 250 PSIG

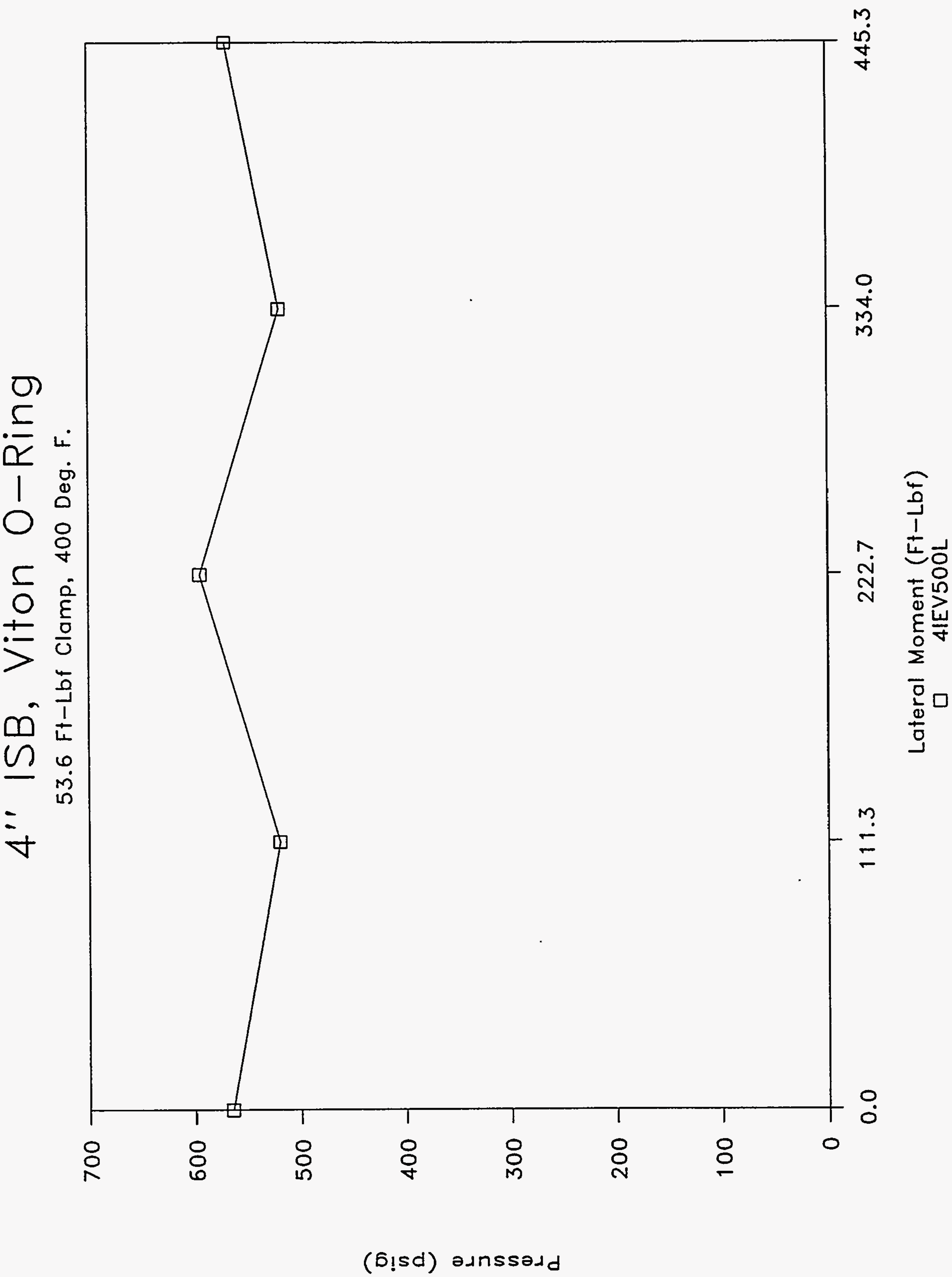
PRESSURE PSIG INPUT	HOLD TIME MIN. INPUT	HOLD TIME SEC. INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	MOMENT FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE	LATERAL DEFLECTIO (CHORDAL) INCHES INPUT
250	0	0	0	0	0.00	0	0.5625	0.0	0.000
250	2	4	2	4	2.07	0	0.5625	0.0	0.000
250	2	3	4	7	4.12	50	0.5625	28.1	0.006
250	2	5	6	12	6.20	100	0.5625	56.3	0.025
250	1	1	7	13	7.22	150	0.5625	84.4	0.06
250	1	2	8	15	8.25	200	0.5625	112.5	0.092
250	1	1	9	16	9.27	250	0.5625	140.6	0.125
245	1	1	10	17	10.28	300	0.5625	168.8	0.166
245	1	2	11	19	11.32	350	0.5625	196.9	0.202
245	1	5	12	24	12.40	400	0.5625	225.0	0.244
245	1	1	13	25	13.42	450	0.5625	253.1	0.293
245	1	3	14	28	14.47	500	0.5625	281.3	0.335
245	1	2	15	30	15.50	550	0.5625	309.4	0.381
250	1	3	16	33	16.55	600	0.5625	337.5	0.455
250	1	4	17	37	17.62	650	0.5625	365.6	0.492
250	1	3	18	40	18.67	700	0.5625	393.8	0.528
255	1	2	19	42	19.70	750	0.5625	421.9	0.573
255	1	6	20	48	20.80	800	0.5625	450.0	0.626
258	1	1	21	49	21.82	850	0.5625	478.1	0.663
260	1	2	22	51	22.85	900	0.5625	506.3	0.698
263	1	1	23	52	23.87	950	0.5625	534.4	0.726
271	1	5	24	57	24.95	1000	0.5625	562.5	0.761

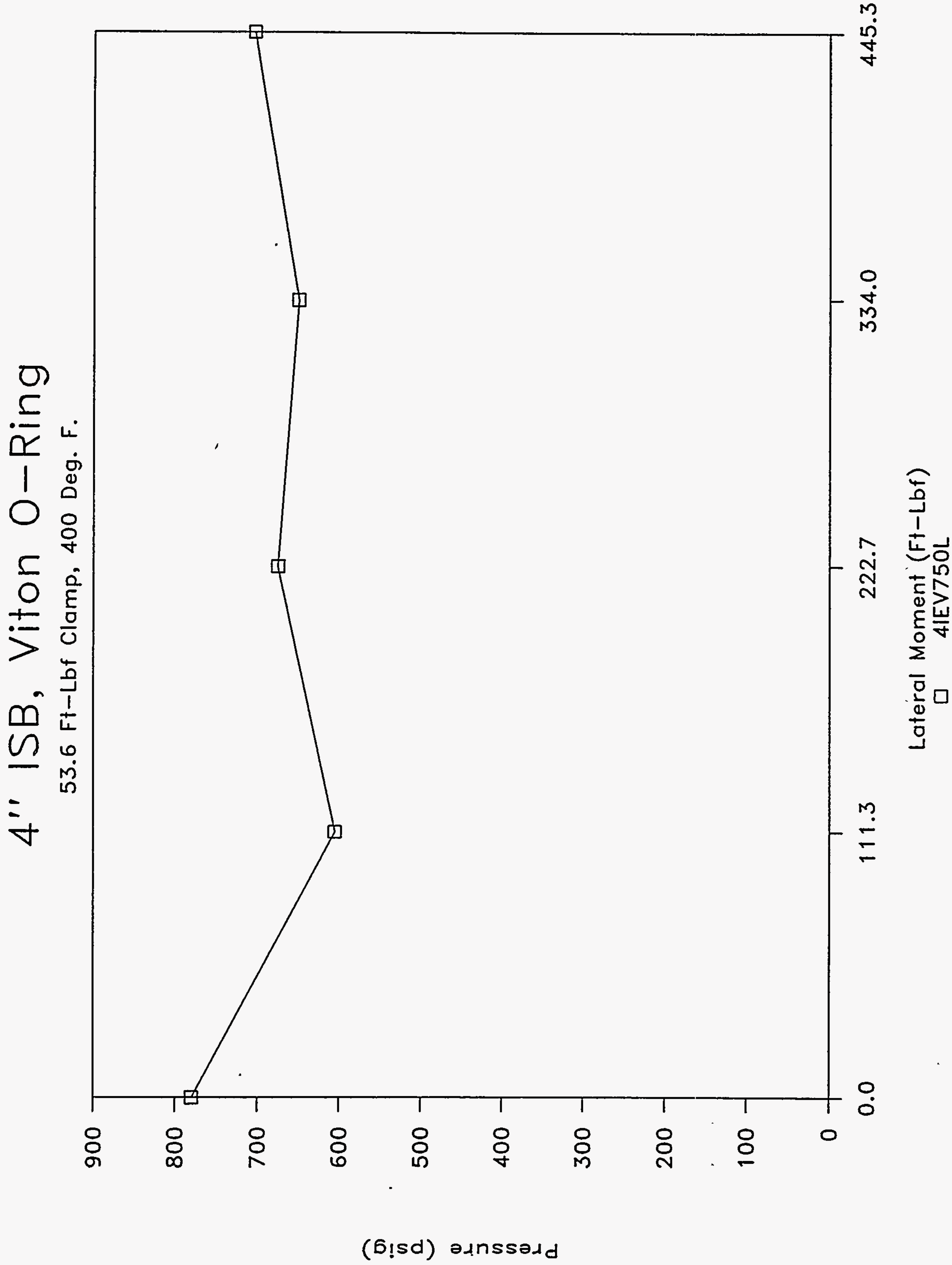

4'' ISB, Viton O-Ring
53.2 Ft-Lbf Clamp, 250 psig Charge
Pressure (psig)
0
50
100
150
200
250
300
350
0.0
90.0
180.0
270.0
360.0
450.0
540.0
630.0
780.0
960.0
1140.0
Up and Over Moment (Ft-Lbf)
4IAV250M

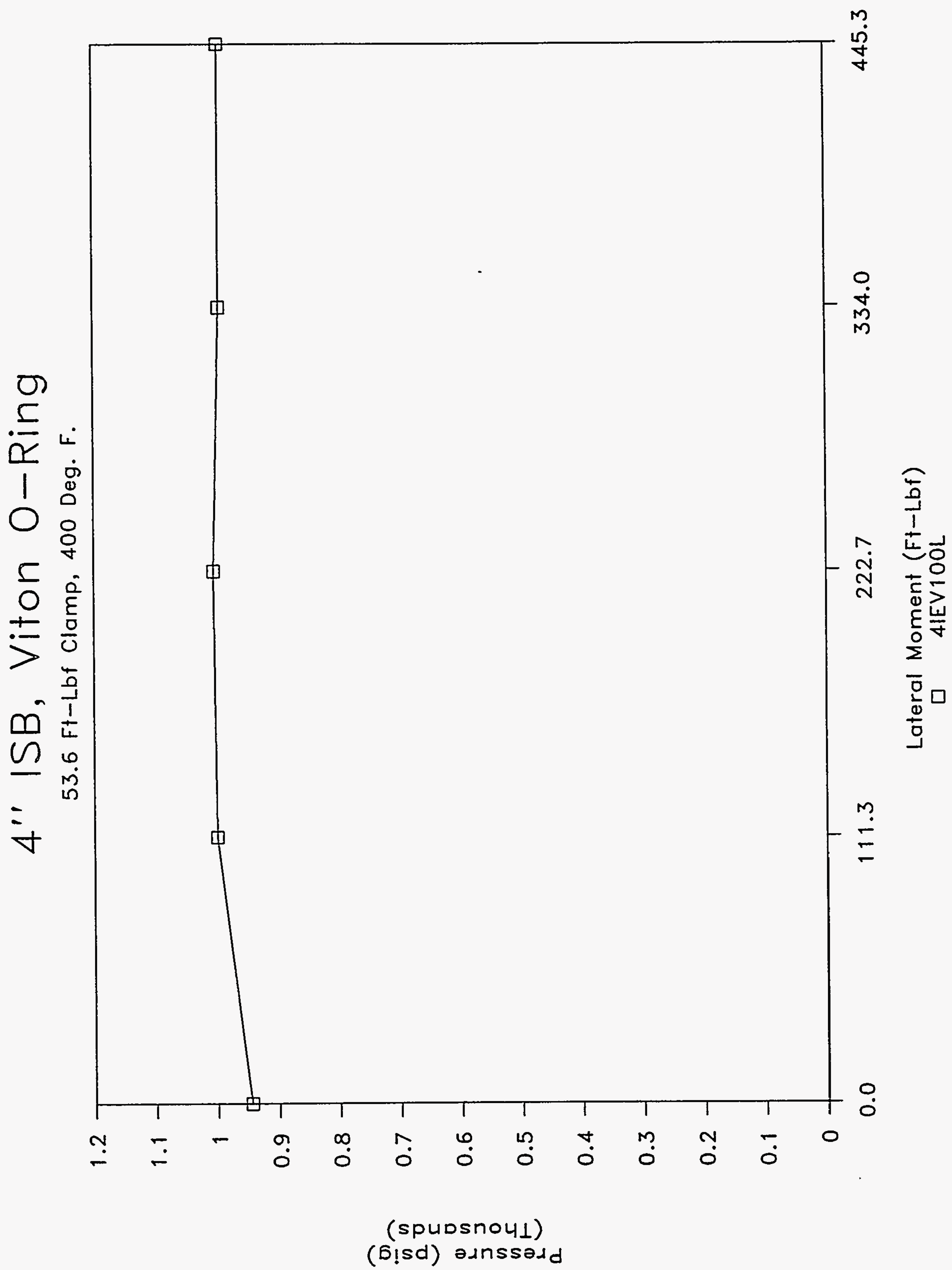
JUNE 06, 1994
4" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, AMBIENT TEMP.
LEAK TEST - UP AND OVER MOMENT APPLIED (UPWARD ROTATION)
CLAMPING TORQUE = 53.2 FT-LBF GRAPH NAME = 4IAV250M
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	HOLD TIME MIN. INPUT	HOLD TIME SEC. INPUT	ELAPSED MINUTES COMPUTE	ELAPSED SECONDS COMPUTE	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE	UPWARD DEFLECTIO (CHORDAL) INCHES INPUT
250	0	0	0	0	0.00	0	1.2	0.0	0.000
250	2	1	2	1	2.02	0	1.2	0.0	0.000
245	2	4	4	5	4.08	50	1.2	60.0	0.009
244	2	2	6	7	6.12	75	1.2	90.0	0.012
241	2	3	8	10	8.17	100	1.2	120.0	0.016
240	2	5	10	15	10.25	125	1.2	150.0	0.020
239	2	4	12	19	12.32	150	1.2	180.0	0.025
239	2	2	14	21	14.35	175	1.2	210.0	0.030
245	2	3	16	24	16.40	200	1.2	240.0	0.039
249	2	4	18	28	18.47	225	1.2	270.0	0.044
250	2	2	20	30	20.50	250	1.2	300.0	0.049
250	2	1	22	31	22.52	275	1.2	330.0	0.053
250	2	2	24	33	24.55	300	1.2	360.0	0.058
250	2	3	26	36	26.60	325	1.2	390.0	0.062
255	2	2	28	38	28.63	350	1.2	420.0	0.070
255	2	4	30	42	30.70	375	1.2	450.0	0.075
255	2	1	32	43	32.72	400	1.2	480.0	0.082
255	2	3	34	46	34.77	425	1.2	510.0	0.087
255	2	4	36	50	36.83	450	1.2	540.0	0.094
260	2	2	38	52	38.87	475	1.2	570.0	0.098
260	2	5	40	57	40.95	500	1.2	600.0	0.102
265	1	1	41	58	41.97	525	1.2	630.0	0.106
271	1	5	42	63	43.05	550	1.2	660.0	0.111
275	1	2	43	65	44.08	600	1.2	720.0	0.119
280	1	3	44	68	45.13	650	1.2	780.0	0.128
280	1	2	45	70	46.17	700	1.2	840.0	0.131
275	1	9	46	79	47.32	750	1.2	900.0	0.134
273	1	5	47	84	48.40	800	1.2	960.0	0.136
270	1	4	48	88	49.47	850	1.2	1020.0	0.139
261	1	2	49	90	50.50	900	1.2	1080.0	0.142
256	1	3	50	93	51.55	950	1.2	1140.0	0.145
250	1	2	51	95	52.58	1000	1.2	1200.0	0.147


4" ISB, Viton O-Ring
53.6 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
0
100
200
300
400
500
0.0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
4IEV250L


4" ISB, Viton O-Ring
53.6 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
4IEV500L


4" ISB, Viton O—Ring
53.6 Ft—Lbf Clamp, 400 Deg. F.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft—Lbf)
4IEV750L


4" ISB, Viton O-Ring
53.6 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
111.3
222.7
334.0
445.3
Lateral Moment (Ft-Lbf)
4IEV100L

OCTOBER 11, 1994
4" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, ELEVATED TEMP.(400 DEG. F)
LEAK TEST - LATERAL MOMENT (SIDEWAYS)
CLAMPING TORQUE = 53.6 FT-LBF GRAPH NAME = 4IEV250L
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
300	0	0	0.00	0	0.4453	0.0
230	2	0	2.00	0	0.4453	0.0
285	4	9	4.15	250	0.4453	111.3
270	6	5	6.08	500	0.4453	222.7
250	8	0	8.00	750	0.4453	334.0
245	10	2	10.03	1000	0.4453	445.3

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = 4IEV500L

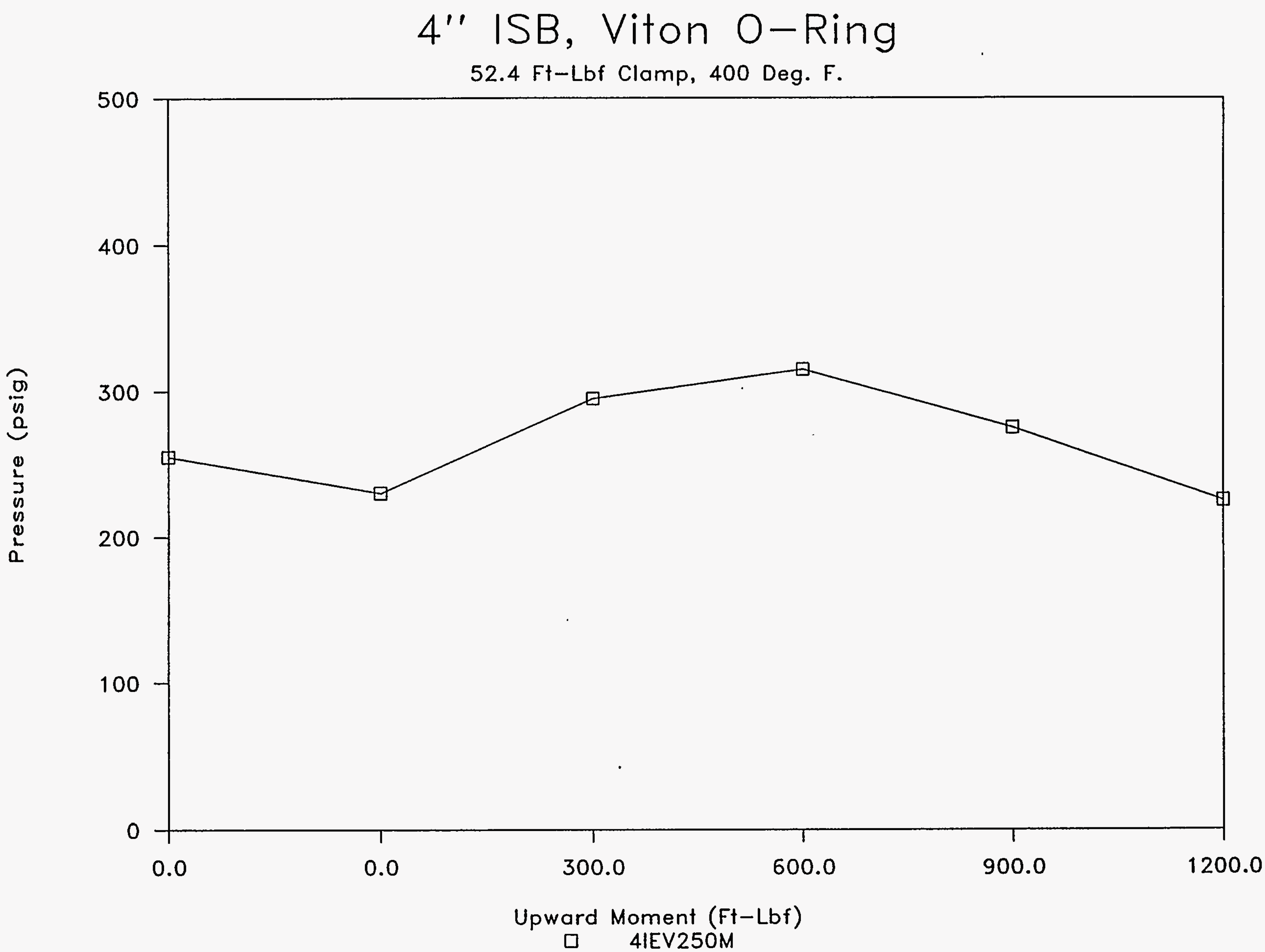
565	12	1	12.02	0	0.4453	0.0
520	14	1	14.02	250	0.4453	111.3
595	16	7	16.12	500	0.4453	222.7
520	18	10	18.17	750	0.4453	334.0
570	20	4	20.07	1000	0.4453	445.3

INCREASED PRESSURE TO 750 PSIG GRAPH NAME = 4IEV750L

780	22	1	22.02	0	0.4453	0.0
605	24	2	24.03	250	0.4453	111.3
675	26	3	26.05	500	0.4453	222.7
650	28	2	28.03	750	0.4453	334.0
705	30	1	30.02	1000	0.4453	445.3

INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = 4IEV100L

945	32	6	32.10	0	0.4453	0.0
1000	34	4	34.07	250	0.4453	111.3
1005	36	2	36.03	500	0.4453	222.7
995	38	1	38.02	750	0.4453	334.0
995	40	2	40.03	1000	0.4453	445.3



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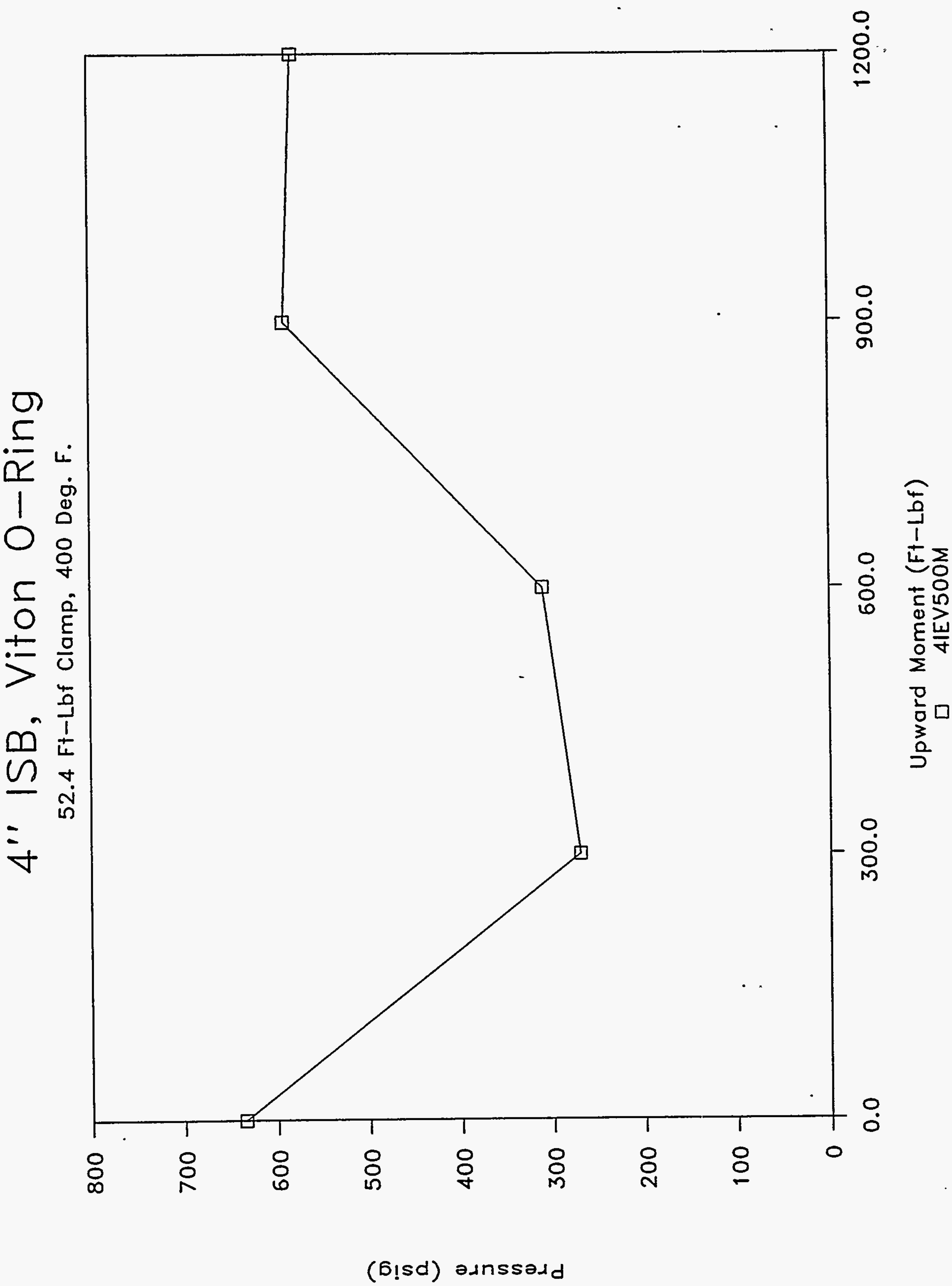
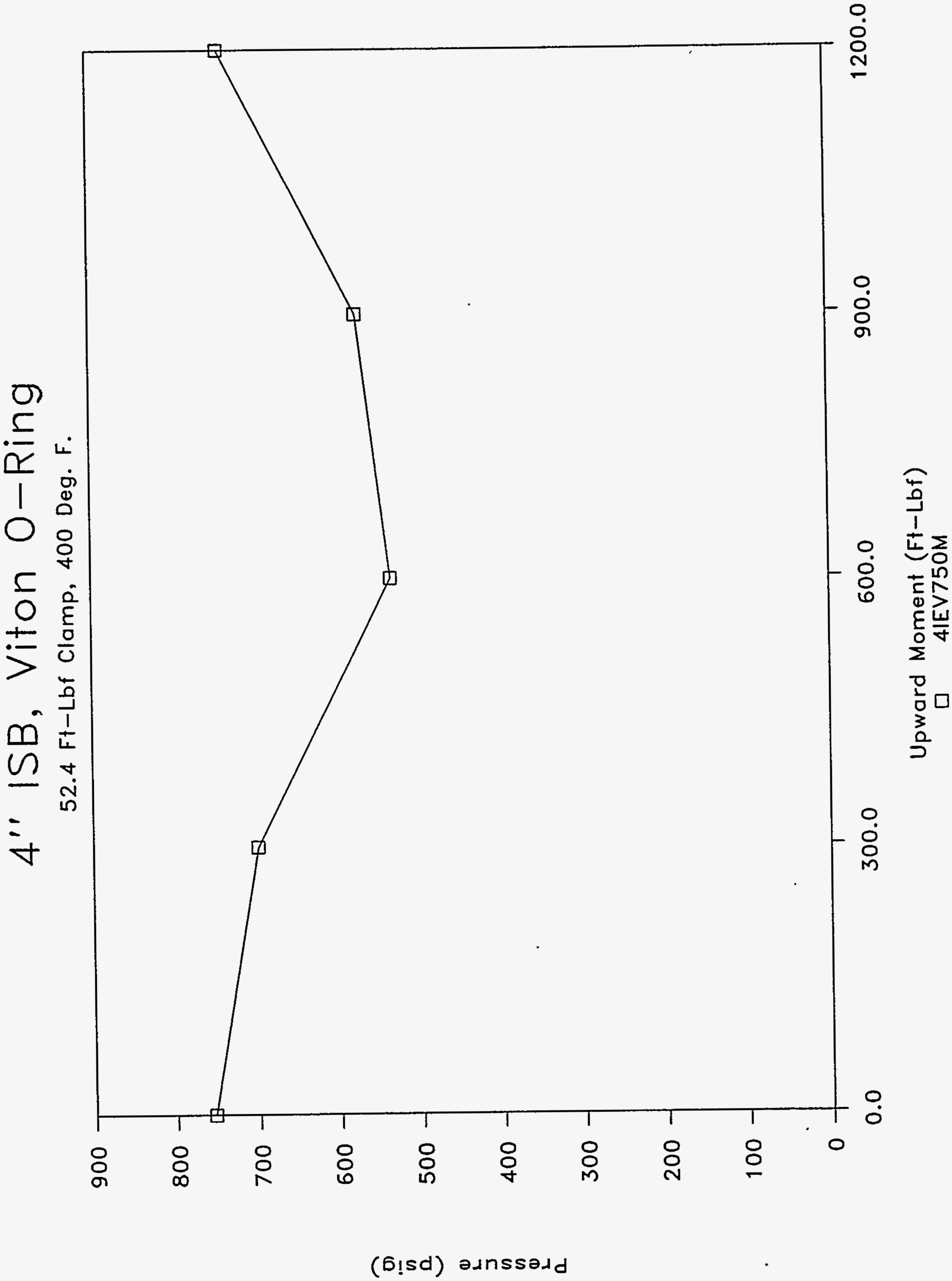
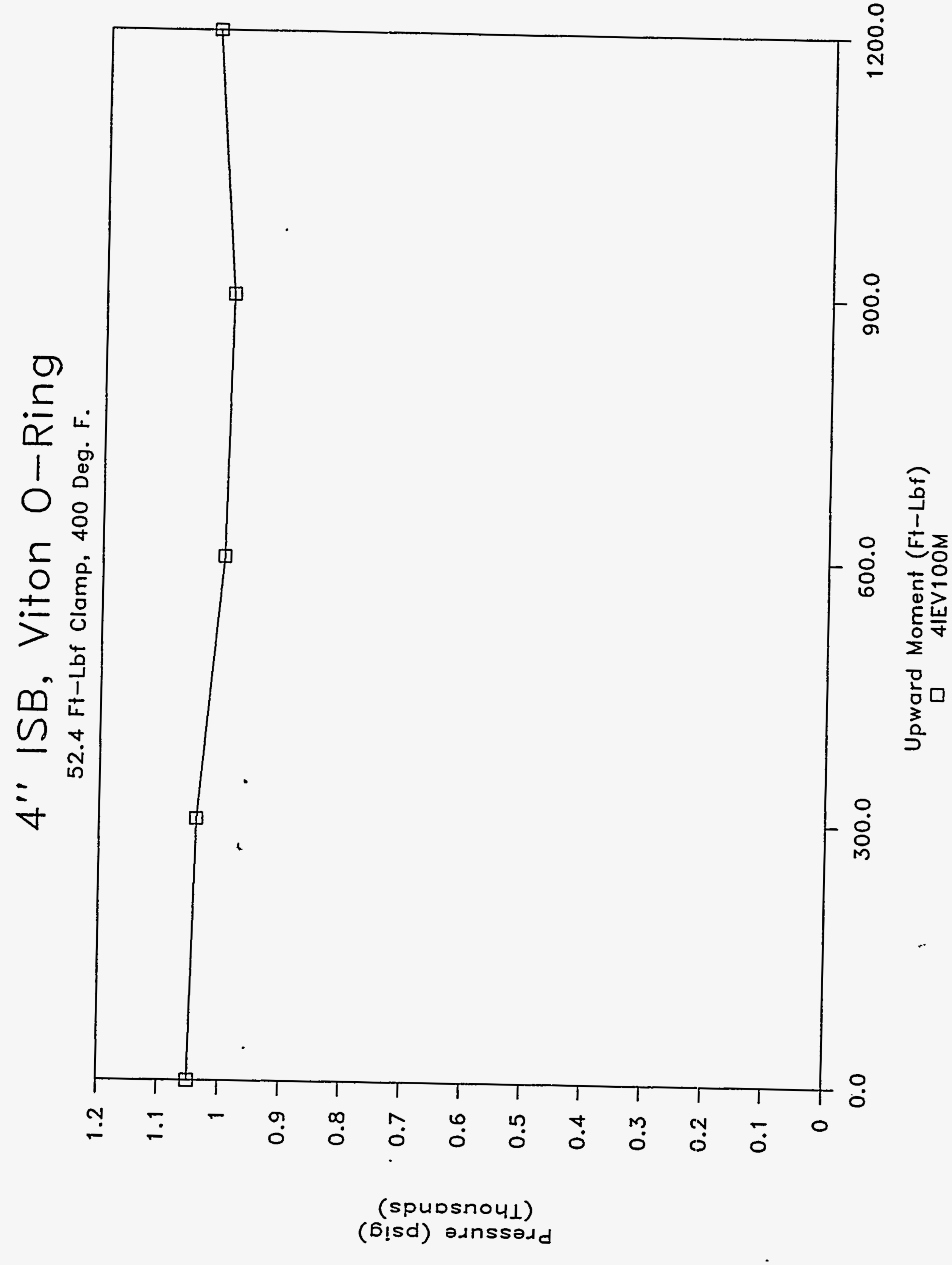
WHC-SD-WM-TRP-223
Rev. 0

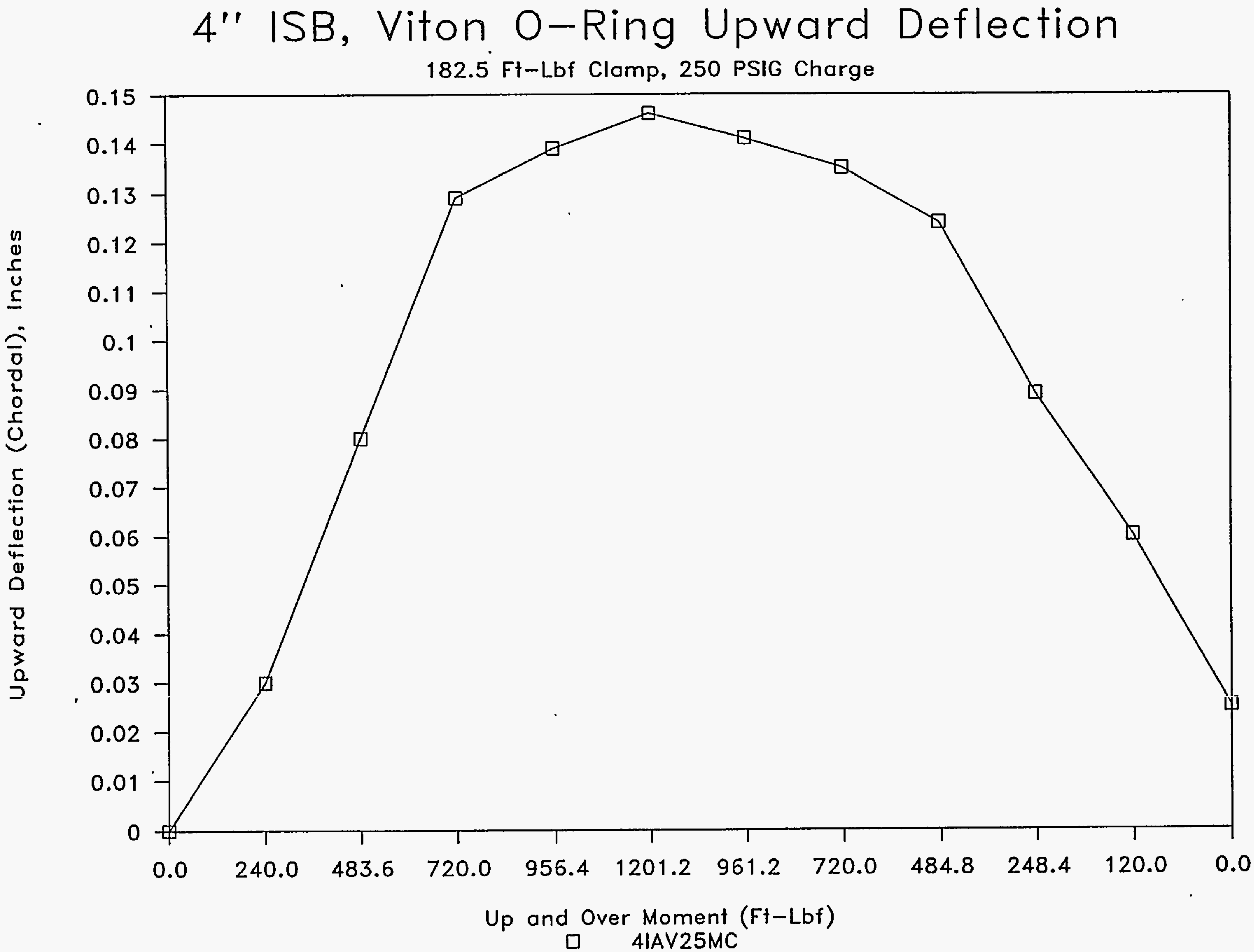

4" ISB, Viton O—Ring
52.4 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
0
100
200
300
400
500
600
700
800
Upward Moment (Ft-Lbf)
0.0
300.0
600.0
900.0
1200.0
4IEV500M


4" ISB, Viton O-Ring
52.4 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
0
100
200
300
400
500
600
700
800
900
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft-Lbf)
4IEV750M


4'' ISB, Viton O—Ring
52.4 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft-Lbf)
4IEV100M

OCTOBER 10, 1994
4" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, ELEVATED TEMP.(400 DEG. F)
LEAK TEST - UP AND OVER MOMENT (UPWARD)
CLAMPING TORQUE = 52.4 FT-LBF GRAPH NAME = 4IEV250M
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
255	0	0	0.00	0	1.2000	0.0
230	2	1	2.02	0	1.2000	0.0
295	4	0	4.00	250	1.2000	300.0
315	6	3	6.05	500	1.2000	600.0
275	8	5	8.08	750	1.2000	900.0
225	10	1	10.02	1000	1.2000	1200.0
INCREASED PRESSURE TO 500 PSIG			GRAPH NAME = 4IEV500M			
635	12	1	12.02	0	1.2000	0.0
270	14	1	14.02	250	1.2000	300.0
310	16	5	16.08	500	1.2000	600.0
590	18	4	18.07	750	1.2000	900.0
580	20	2	20.03	1000	1.2000	1200.0
RELEASED MOMENT LOAD AND ALLOWED TEST FIXTURE TO SET FOR AN EXTENDED PERIOD OF TIME.						
550	59	12	59.20	0	1.2000	0.0
INCREASED PRESSURE TO 750 PSIG			GRAPH NAME = 4IEV750M			
755	61	2	61.03	0	1.2000	0.0
700	63	5	63.08	250	1.2000	300.0
535	65	2	65.03	500	1.2000	600.0
575	67	3	67.05	750	1.2000	900.0
740	69	2	69.03	1000	1.2000	1200.0
INCREASED PRESSURE TO 1000 PSIG			GRAPH NAME = 4IEV100M			
1050	71	3	71.05	0	1.2000	0.0
1040	73	15	73.25	250	1.2000	300.0
1000	75	18	75.30	500	1.2000	600.0
990	77	10	77.17	750	1.2000	900.0
1020	79	3	79.05	1000	1.2000	1200.0



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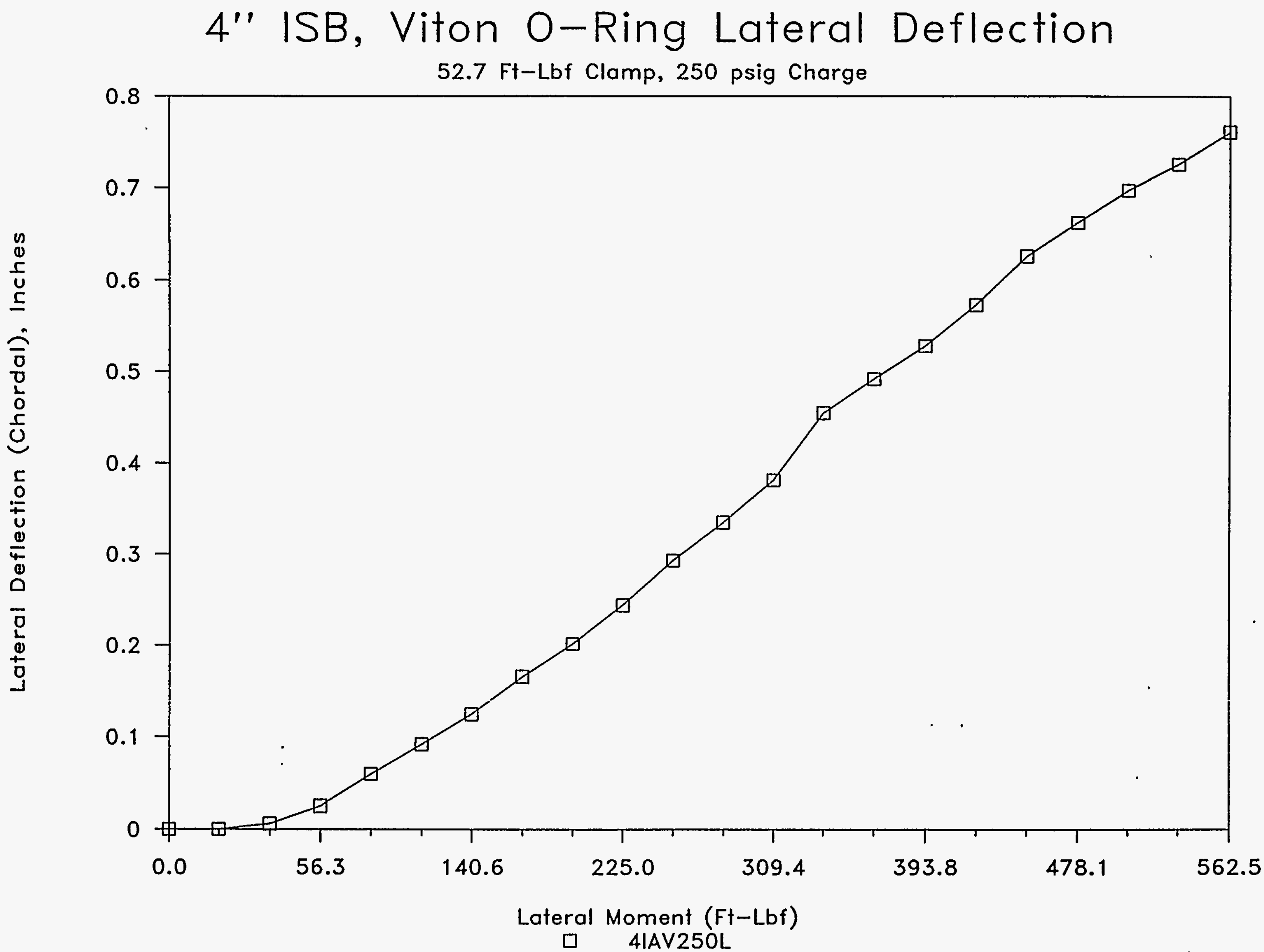
WHC-SD-WM-TRP-223
Rev. 0

INCREASED TORQUE TO 182.5 FT-LBF. PRESSURE INCREASED TO 335 PSIG AS TORQUE LOAD INCREASED. GRAPH NAME = 4IAV25MC

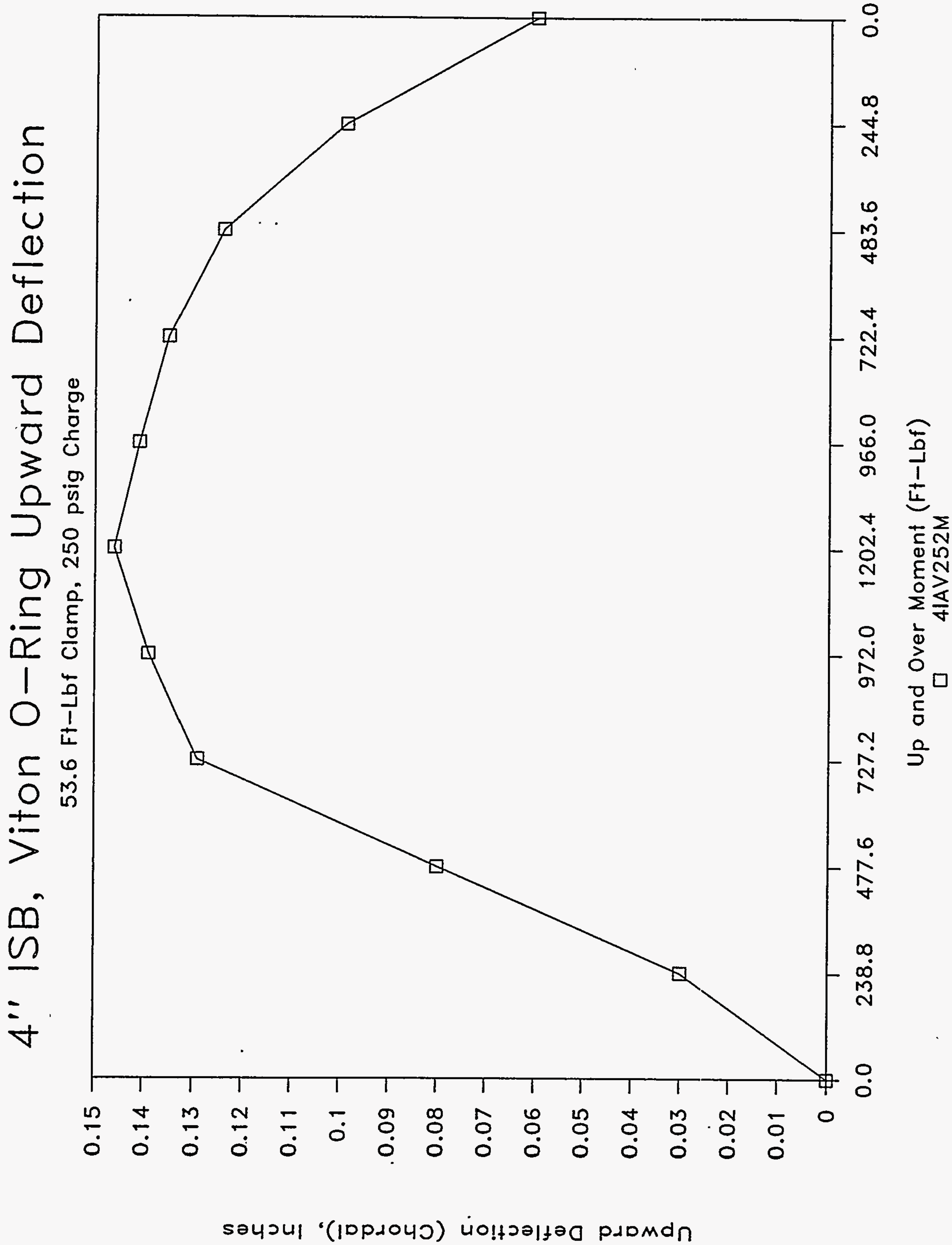
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE	UPWARD DEFLECTIO (CHORDAL) INCHES INPUT
335	0	0	0.00	0	1.2000	0.0	0.000
335	1	10	1.17	200	1.2000	240.0	0.030
335	2	10	2.17	403	1.2000	483.6	0.080
335	3	15	3.25	600	1.2000	720.0	0.129
335	4	15	4.25	797	1.2000	956.4	0.139
337	5	15	5.25	1001	1.2000	1201.2	0.146
340	6	14	6.23	801	1.2000	961.2	0.141
340	7	0	7.00	600	1.2000	720.0	0.135
339	8	0	8.00	404	1.2000	484.8	0.124
335	9	5	9.08	207	1.2000	248.4	0.089
340	12	10	12.17	100	1.2000	120.0	0.060
340	12	50	12.83	0	1.2000	0.0	0.025



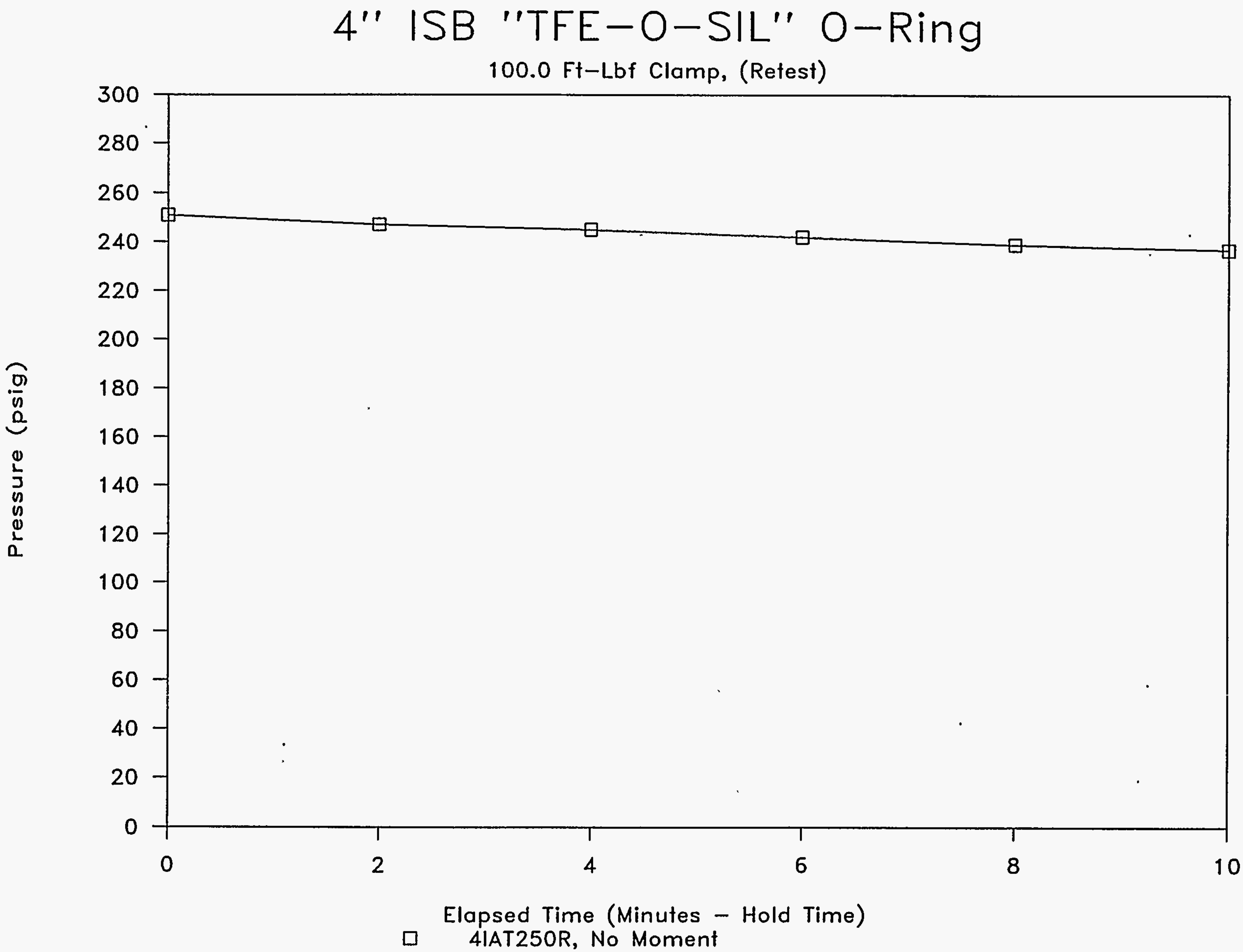
4" ISB, Viton O-Ring Lateral Deflection
52.7 Ft-Lbf Clamp, 250 psig Charge
Lateral Deflection (Chordal), Inches
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
56.3
140.6
225.0
309.4
393.8
478.1
562.5
Lateral Moment (Ft-Lbf)
4IAV250L

JUNE 08, 1994
4" ISB CONNECTOR, VITON O-RING, 70 DUROMETER, AMBIENT TEMP.
LEAK TEST - UP AND OVER MOMENT APPLIED (UPWARD ROTATION)
CLAMPING TORQUE = 53.6 FT-LBF GRAPH NAME = 4IAV252M
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE	UPWARD DEFLECTIO (CHORDAL) INCHES INPUT
250	0	0	0.00	0	1.2000	0.0	0.000
235	2	0	2.00	199	1.2000	238.8	0.030
235	4	0	4.00	398	1.2000	477.6	0.080
260	5	45	5.75	606	1.2000	727.2	0.129
241	7	7	7.12	810	1.2000	972.0	0.139
223	8	22	8.37	1002	1.2000	1202.4	0.146
230	10	35	10.58	805	1.2000	966.0	0.141
245	11	33	11.55	602	1.2000	722.4	0.135
255	12	28	12.47	403	1.2000	483.6	0.124
240	13	33	13.55	204	1.2000	244.8	0.099
220	14	39	14.65	0	1.2000	0.0	0.060


4" ISB, Viton O-Ring Upward Deflection
53.6 Ft-Lbf Clamp, 250 psig Charge
Upward Deflection (Chordal), Inches
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0
238.8
477.6
727.2
972.0
1202.4
966.0
722.4
483.6
244.8
0.0
Up and Over Moment (Ft-Lbf)
4IAV252M

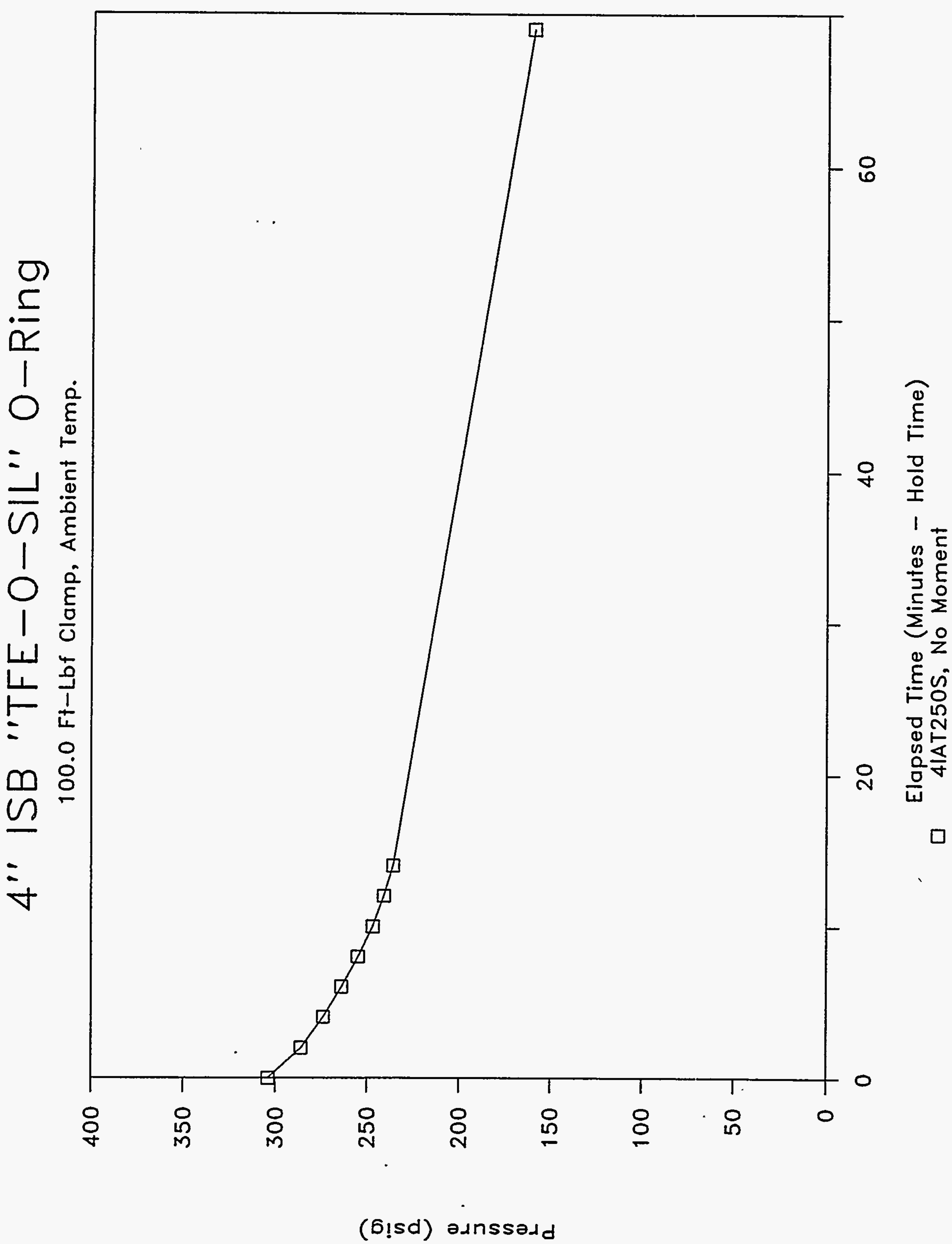
APPENDIX N: GRAPHS OF 4-IN. TFE-O-SIL TESTS



4" ISB "TFE-O-SIL" O-Ring
100.0 Ft-Lbf Clamp, (Retest)
Pressure (psig)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
0
2
4
6
8
10
Elapsed Time (Minutes - Hold Time)
4IAT250R, No Moment

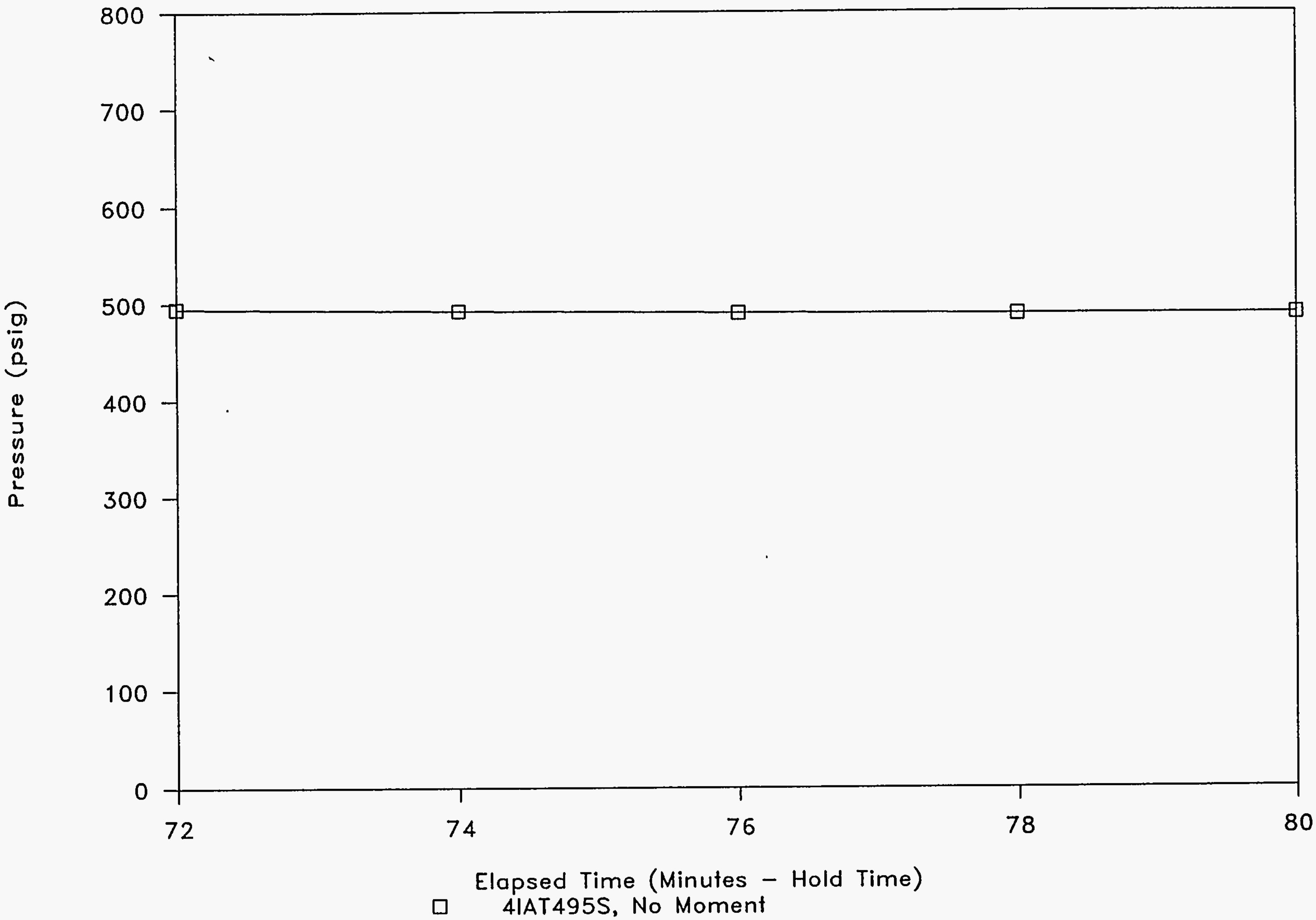
JUNE 22, 1994
4" ISB CONNECTOR, "TFE-O-SIL" TEFLON COATED O-RING, AMBIENT TEMP.
LOW PRESSURE LEAK TEST (RETEST) - NO MOMENT.
CLAMPING TORQUE = 100.0 FT-LBF GRAPH NAME = 4IAT250R
CHARGE PRESSURE = 250 PSIG

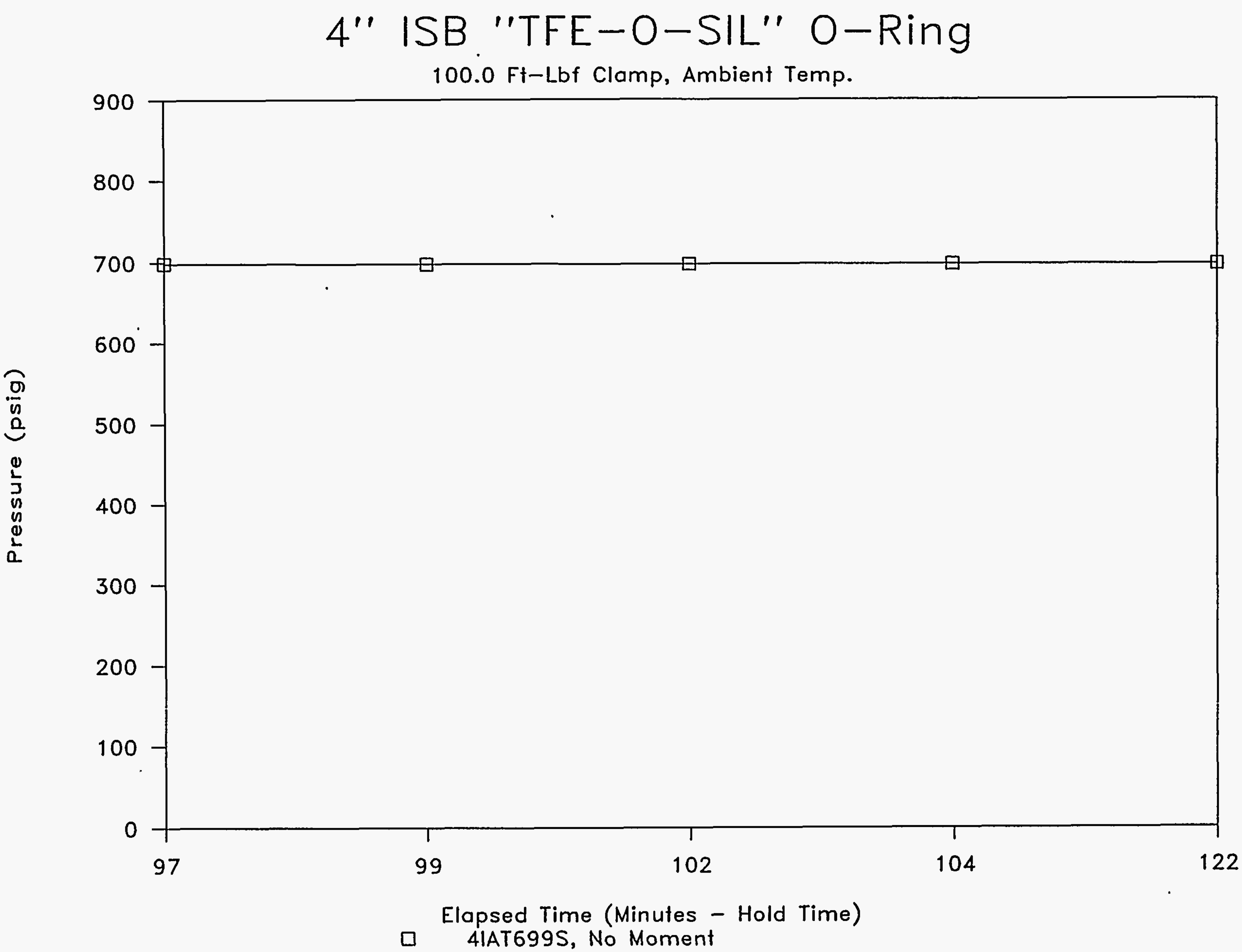
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	MOMENT FORCE LBS INPUT
251	0	0	0.00	0
247	2	18	2.30	0
245	4	4	4.07	0
242	6	4	6.07	0
239	8	6	8.10	0
237	10	5	10.08	0

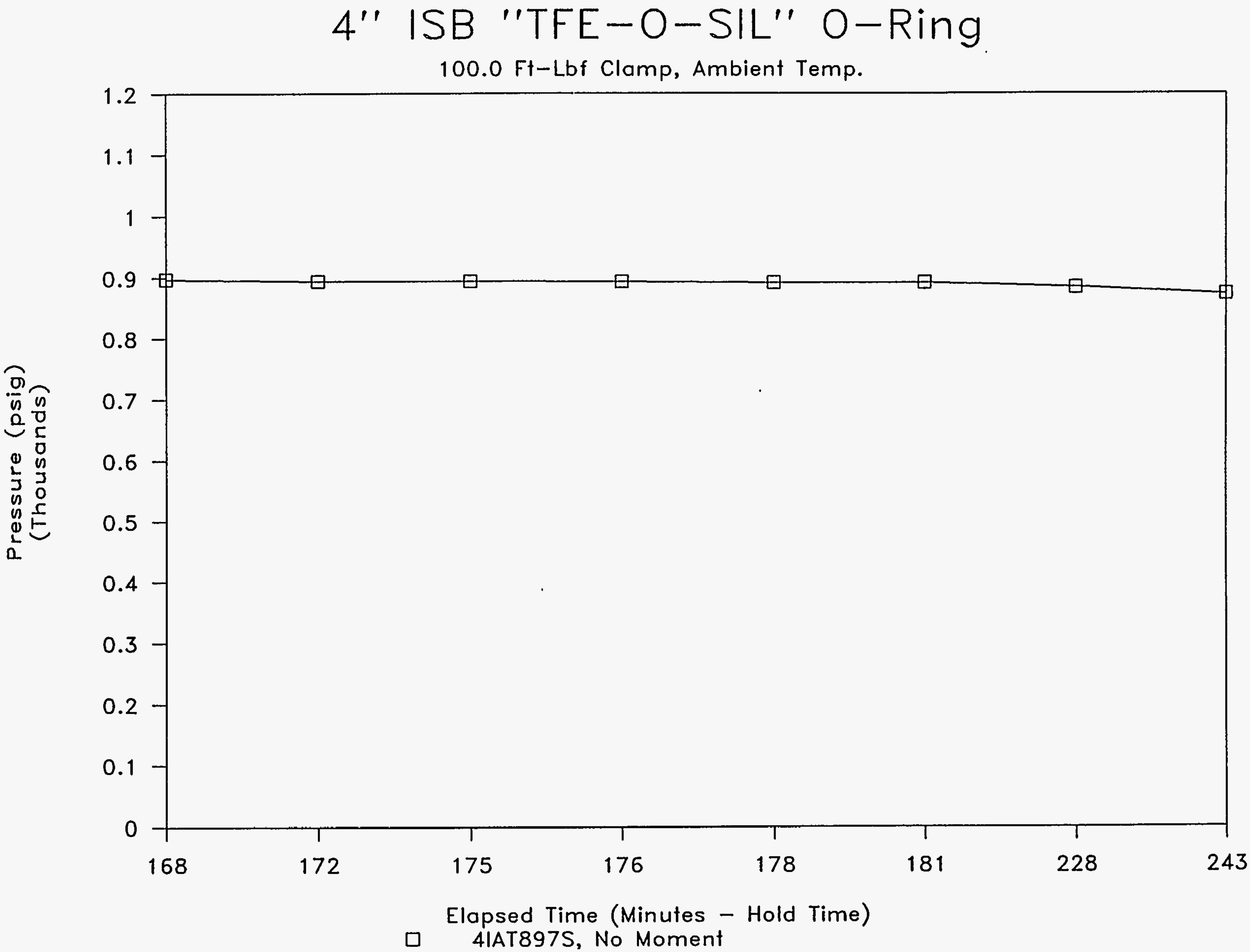

4" ISB "TFE-O-SIL" O-Ring
100.0 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
400
350
300
250
200
150
100
50
0
0
20
40
60
Elapsed Time (Minutes - Hold Time)
4IAT250S, No Moment

4" ISB "TFE-O-SIL" O-Ring

100.0 Ft-Lbf Clamp, Ambient Temp.




4" ISB "TFE-O-SIL" O-Ring
100.0 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
97
99
102
104
122
Elapsed Time (Minutes - Hold Time)
4IAT699S, No Moment


4" ISB "TFE-O-SIL" O-Ring
100.0 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig) (Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
168
172
175
176
178
181
228
243
Elapsed Time (Minutes - Hold Time)
4IAT897S, No Moment

JUNE 21, 1994
4" ISB CONNECTOR, TEFLON COATED SILICONE "TFE-O-SIL" O-RING.
AMBIENT TEMP. / PRESSURE ASCENSION LEAK TEST - NO MOMENT
CLAMPING TORQUE = 100.0 FT-LBF GRAPH NAME = 4IAT250S
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	MOMENT FORCE LBS INPUT
304	0	0	0.00	0
286	2	7	2.12	0
274	4	10	4.17	0
264	6	7	6.12	0
255	8	4	8.07	0
247	10	21	10.35	0
241	12	23	12.38	0
236	14	25	14.42	0
160	69	48	69.80	0

INCREASED CHARGE PRESSURE TO 495 PSIG. GRAPH NAME = 4IAT495S

495	72	42	72.70	0
492	74	21	74.35	0
490	76	0	76.00	0
489	78	51	78.85	0
489	80	53	80.88	0

INCREASED CHARGE PRESSURE TO 699 PSIG. GRAPH NAME = 4IAT699S

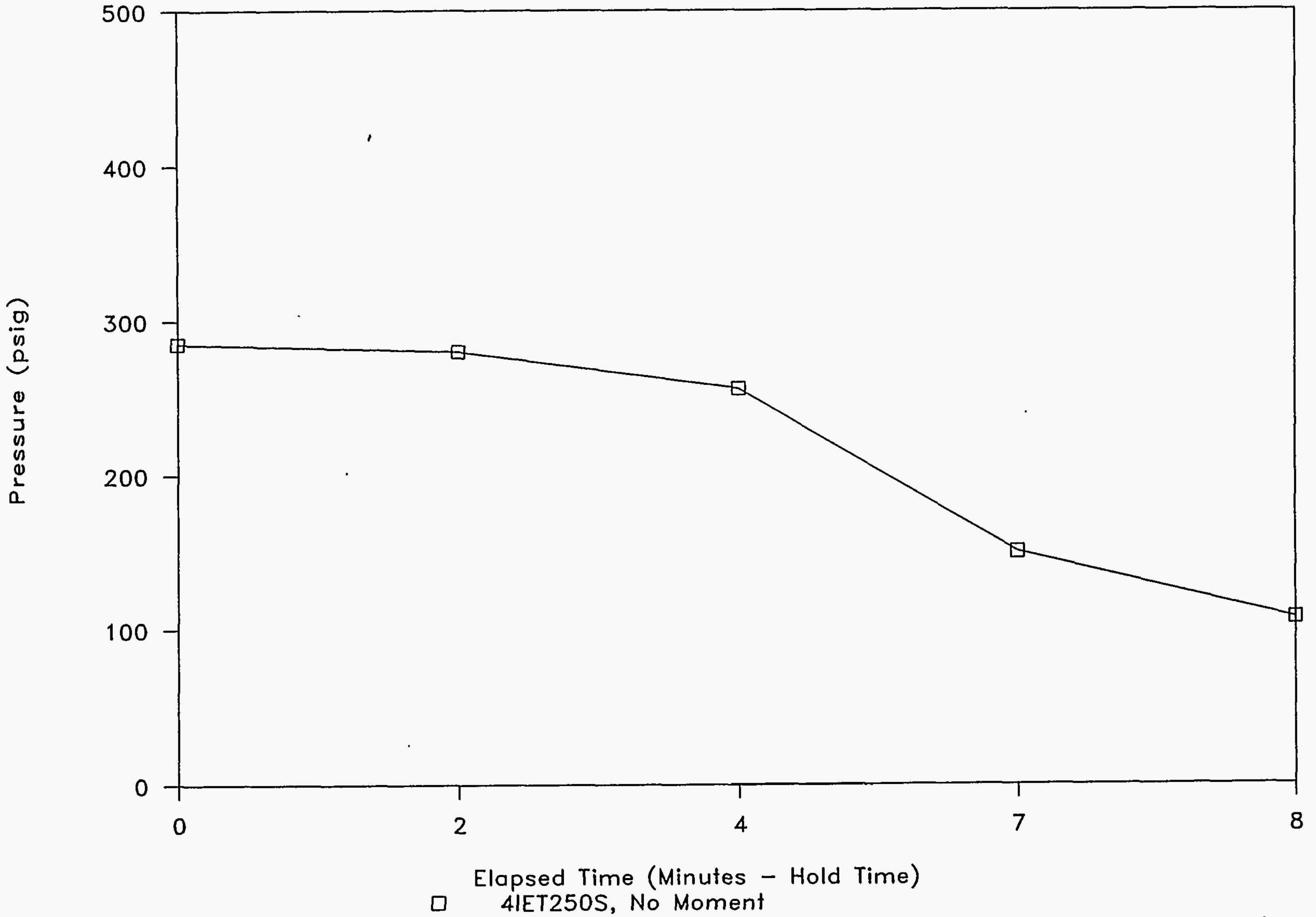
699	97	30	97.50	0
698	99	31	99.52	0
697	102	33	102.55	0
697	104	45	104.75	0
697	122	46	122.77	0

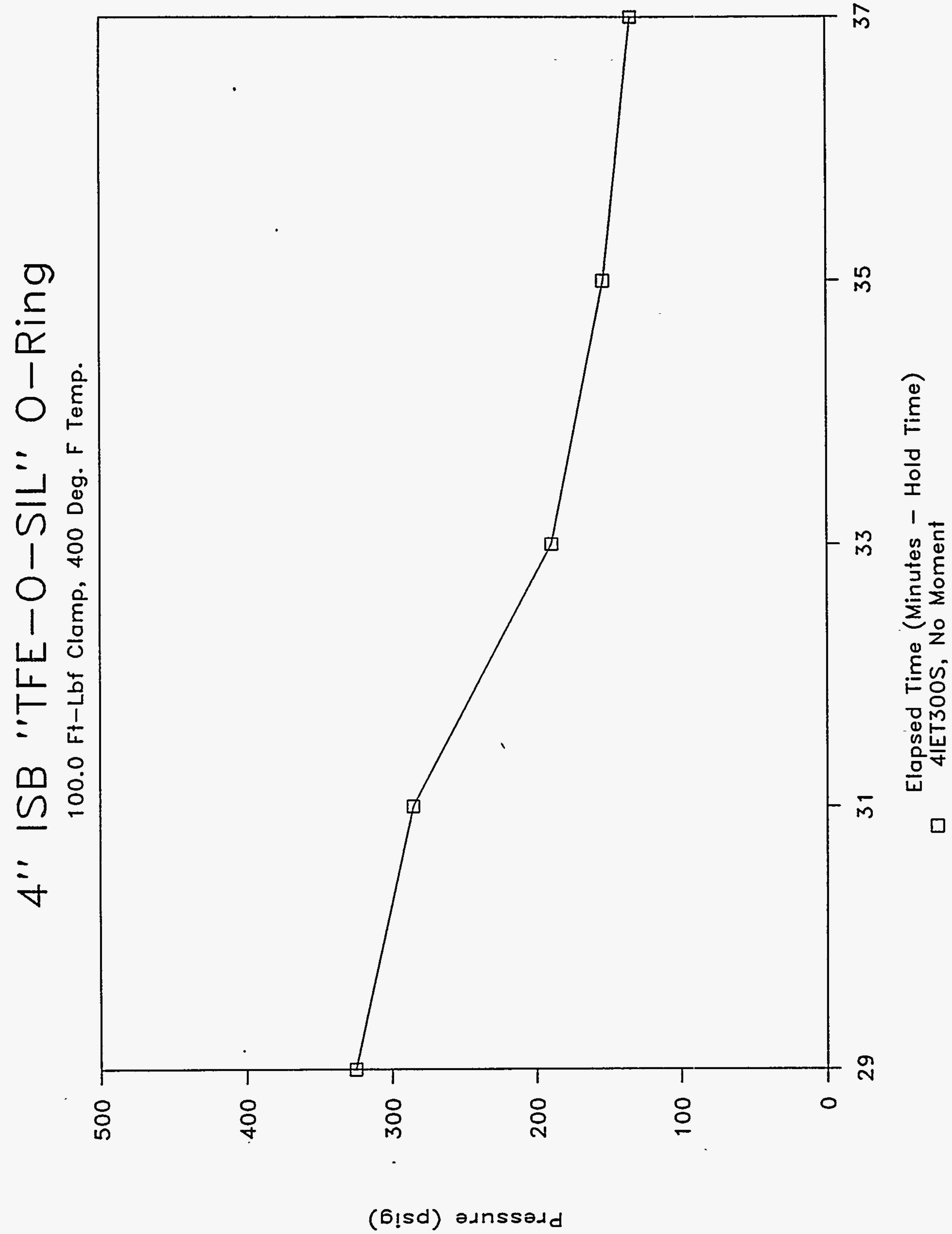
INCREASED CHARGE PRESSURE TO 897 PSIG. GRAPH NAME = 4IAT897S

897	168	50	168.83	0
894	172	1	172.02	0
894	175	29	175.48	0
893	176	52	176.87	0
891	178	59	178.98	0
891	181	7	181.12	0
884	228	43	228.72	0
873	243	50	243.83	0

4" ISB "TFE-O-SIL" O-Ring

100.0 Ft-Lbf Clamp, 400 Deg. F Temp.




4" ISB "TFE-O-SIL" O-Ring
100.0 Ft-Lbf Clamp, 400 Deg. F Temp.
Pressure (psig)
0
100
200
300
400
500
29
31
33
35
37
Elapsed Time (Minutes - Hold Time)
4IET300S, No Moment

JUNE 22, 1994
4" ISB CONNECTOR, TEFLON COATED SILICONE "TFE-O-SIL" O-RING.
ELEVATED TEMP. / LOW PRESSURE LEAK TEST - NO MOMENT
CLAMPING TORQUE = 100.0 FT-LBF GRAPH NAME = 4IET250S
CHARGE PRESSURE = 250 PSIG
INITIAL TEMP. SETTING: 212 Deg. F

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	MOMENT FORCE LBS INPUT
285	0	0	0.00	0
280	2	8	2.13	0
256	4	27	4.45	0
150	7	4	7.07	0
107	8	31	8.52	0

INCREASED TEMP. TO 300 Deg. F; RE-ADJUSTED PRESSURE TO 300 PSIG.

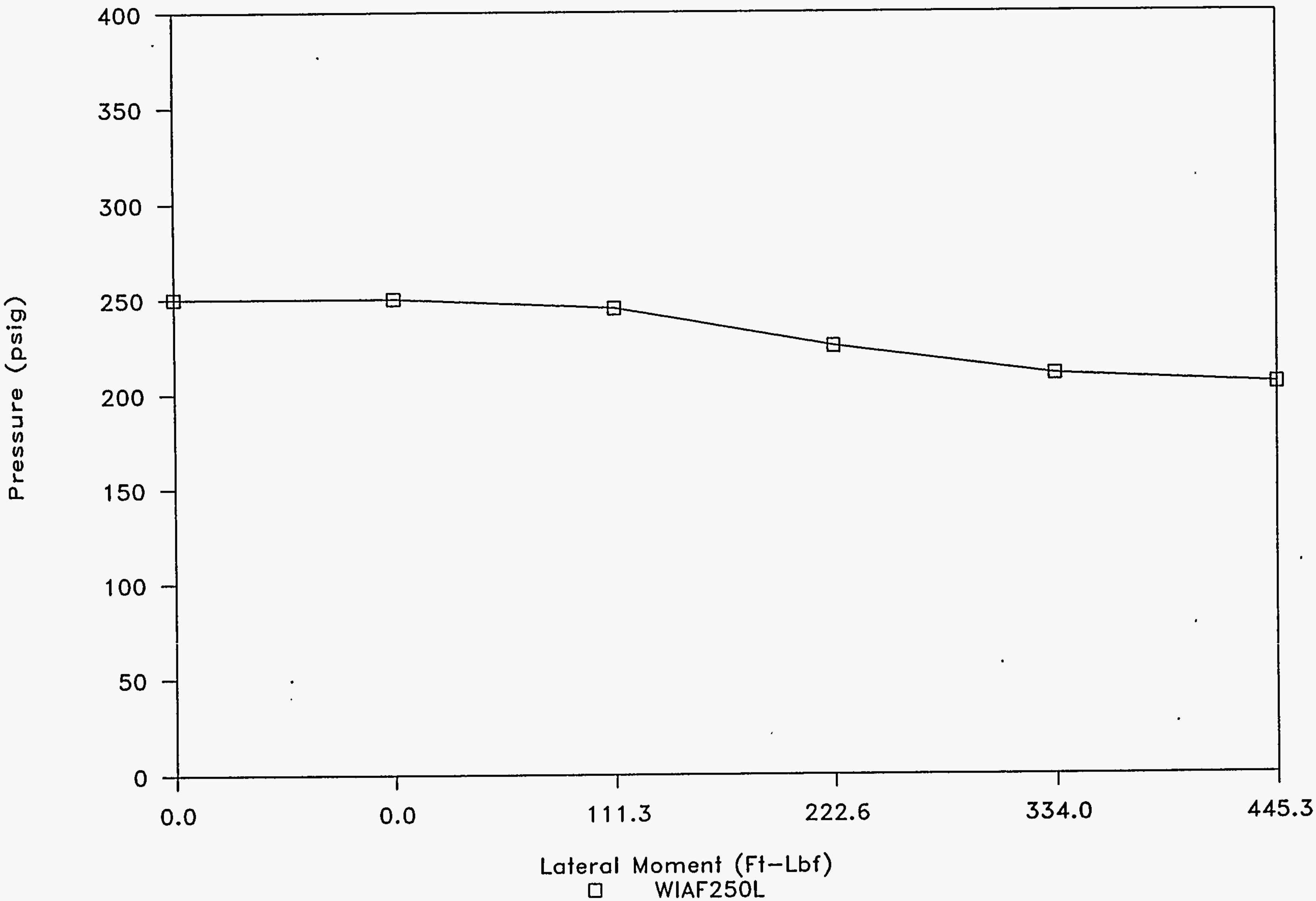
GRAPH NAME = 4IET300S

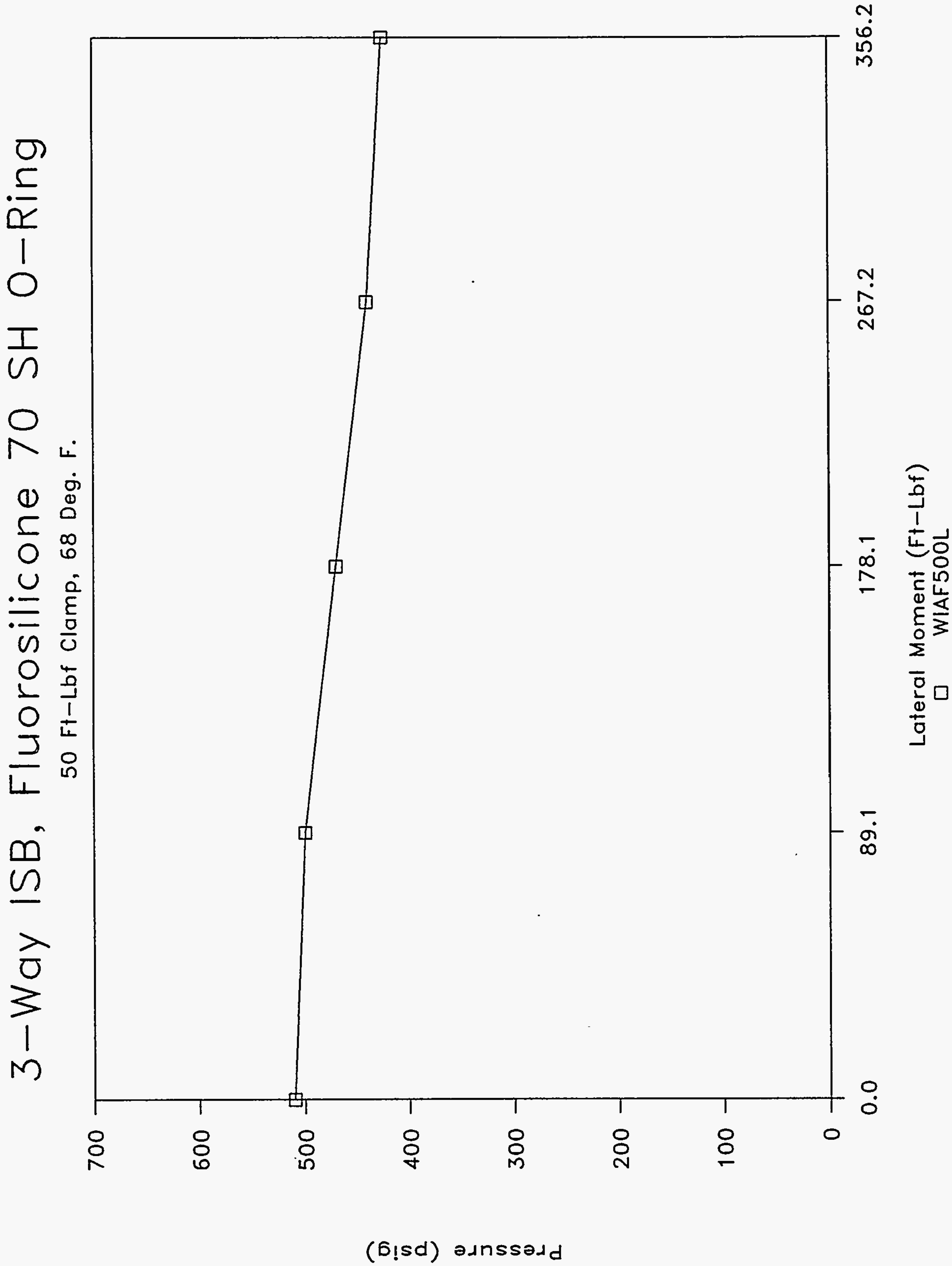
325	29	20	29.33	0
285	31	29	31.48	0
189	33	29	33.48	0
153	35	20	35.33	0
134	37	19	37.32	0

APPENDIX O: GRAPHS OF THREE-WAY FLUOROSILICONE TESTS

3-Way ISB, Fluorosilicone 70 SH O-Ring

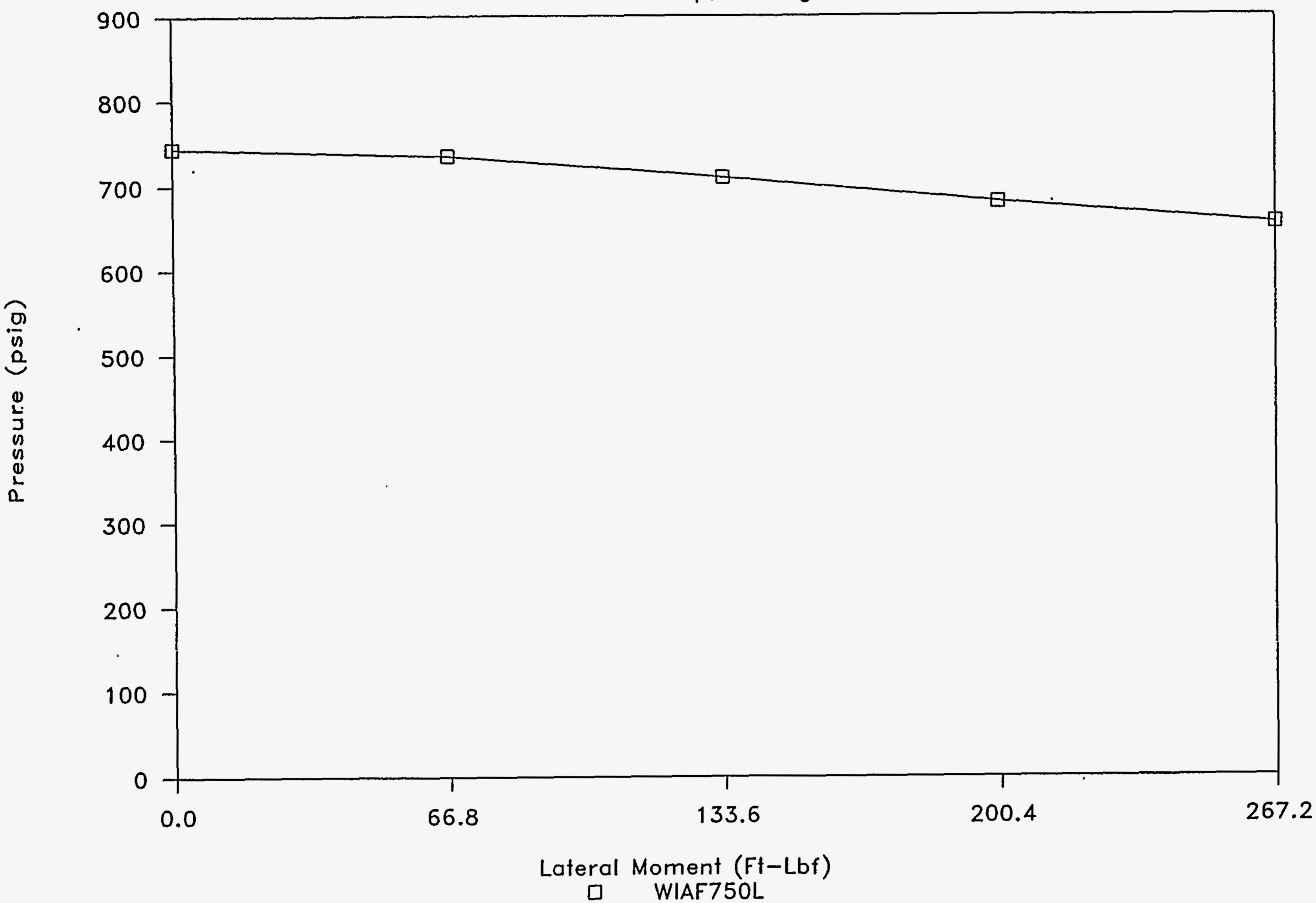
50 Ft-Lbf Clamp, 68 Deg. F.

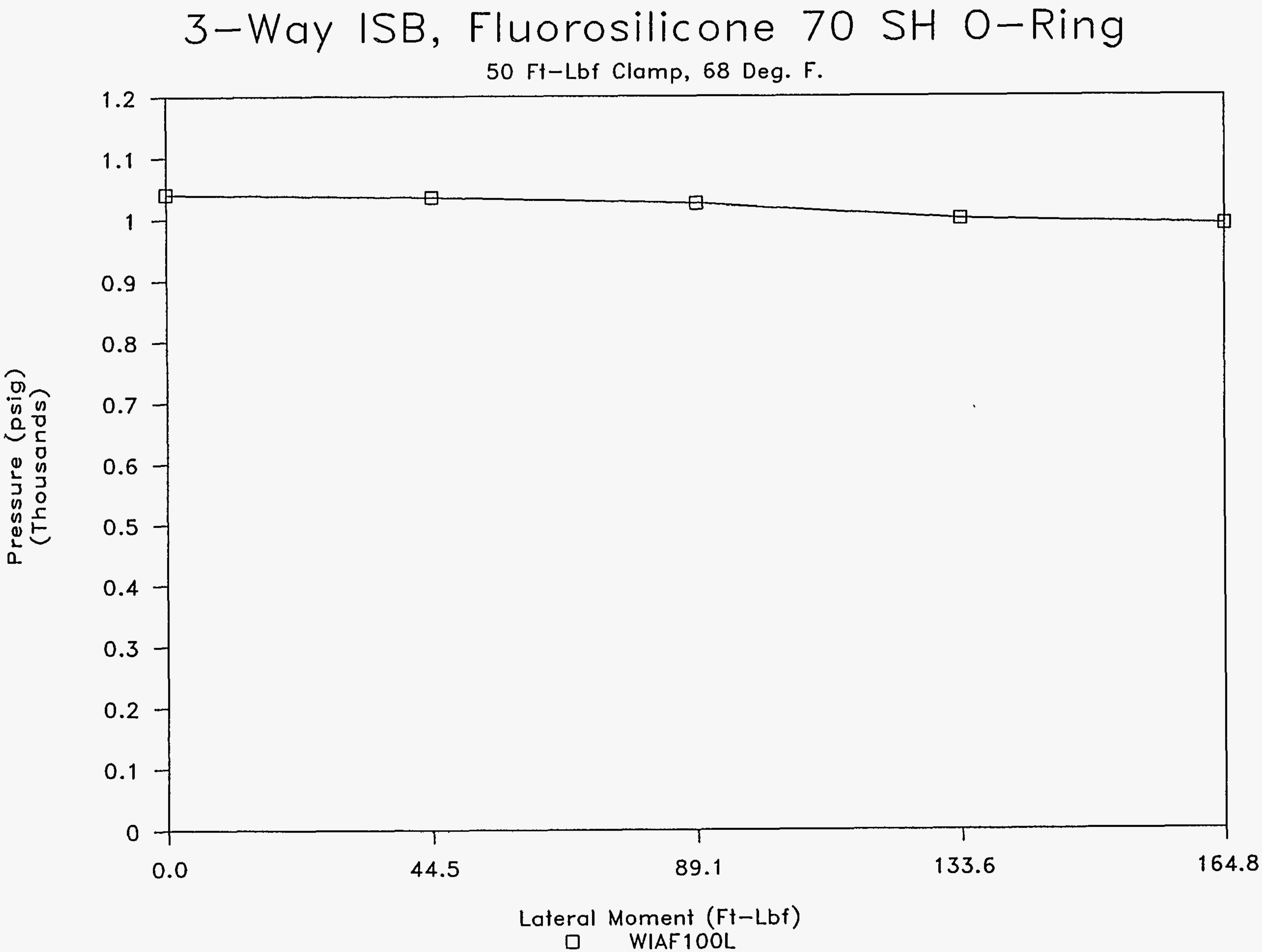



3-Way ISB, Fluorosilicone 70 SH O-Ring
50 Ft-Lbf Clamp, 68 Deg. F.
Pressure (psig)
0
100
200
300
400
500
600
700
Lateral Moment (Ft-Lbf)
0.0
89.1
178.1
267.2
356.2
WIAF500L

3-Way ISB, Fluorosilicone 70 SH O-Ring

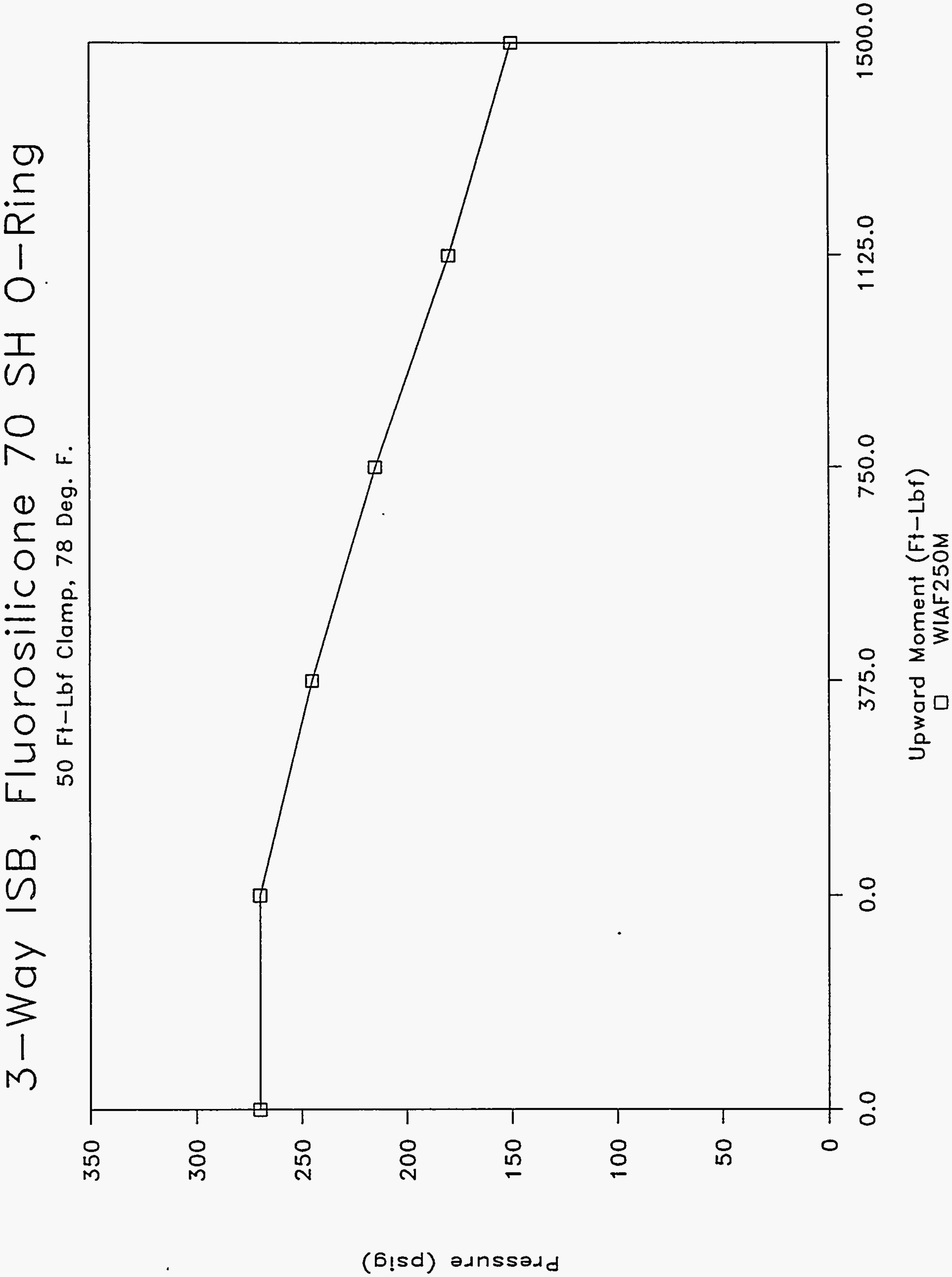
50 Ft-Lbf Clamp, 68 Deg. F.

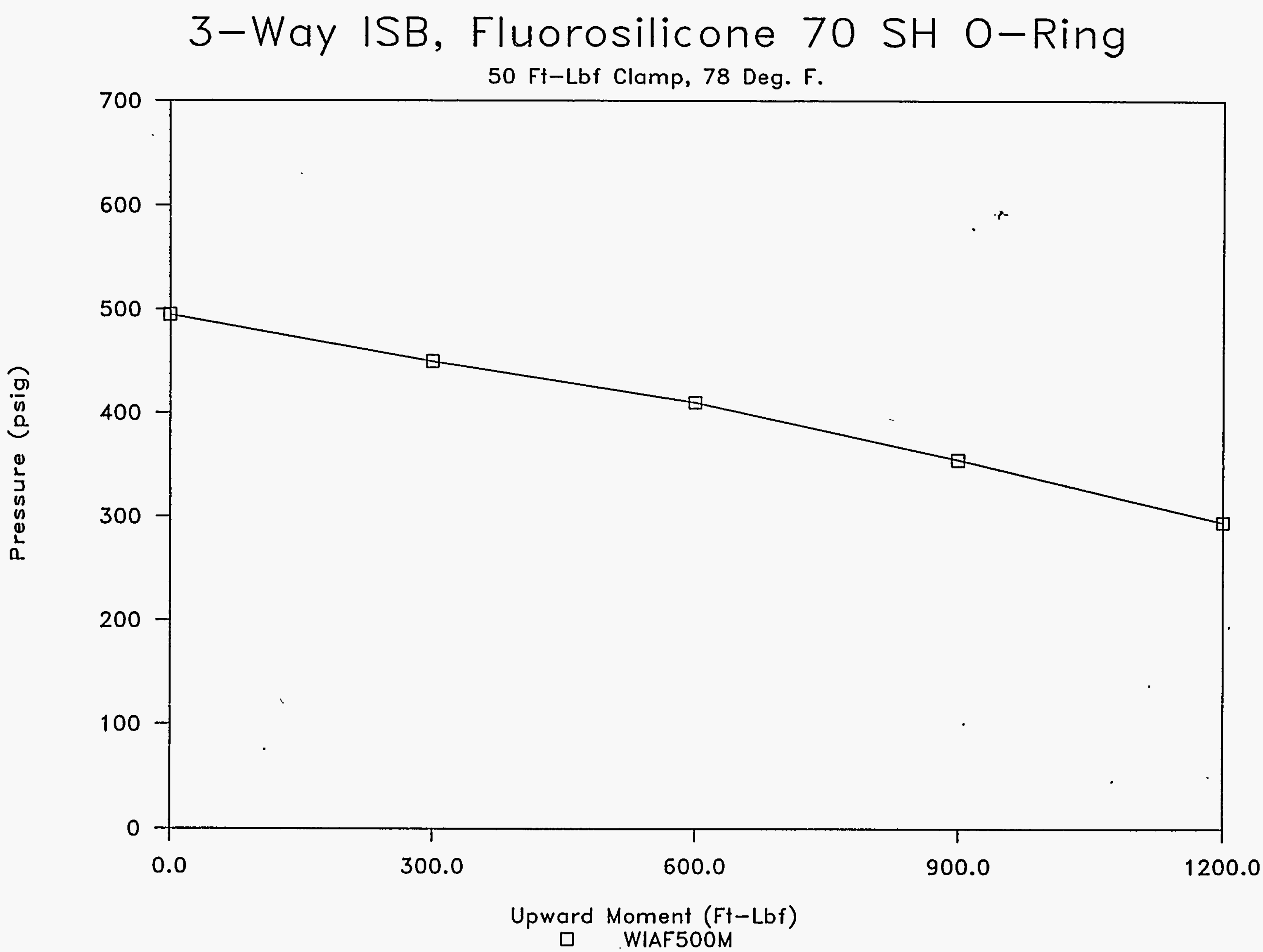


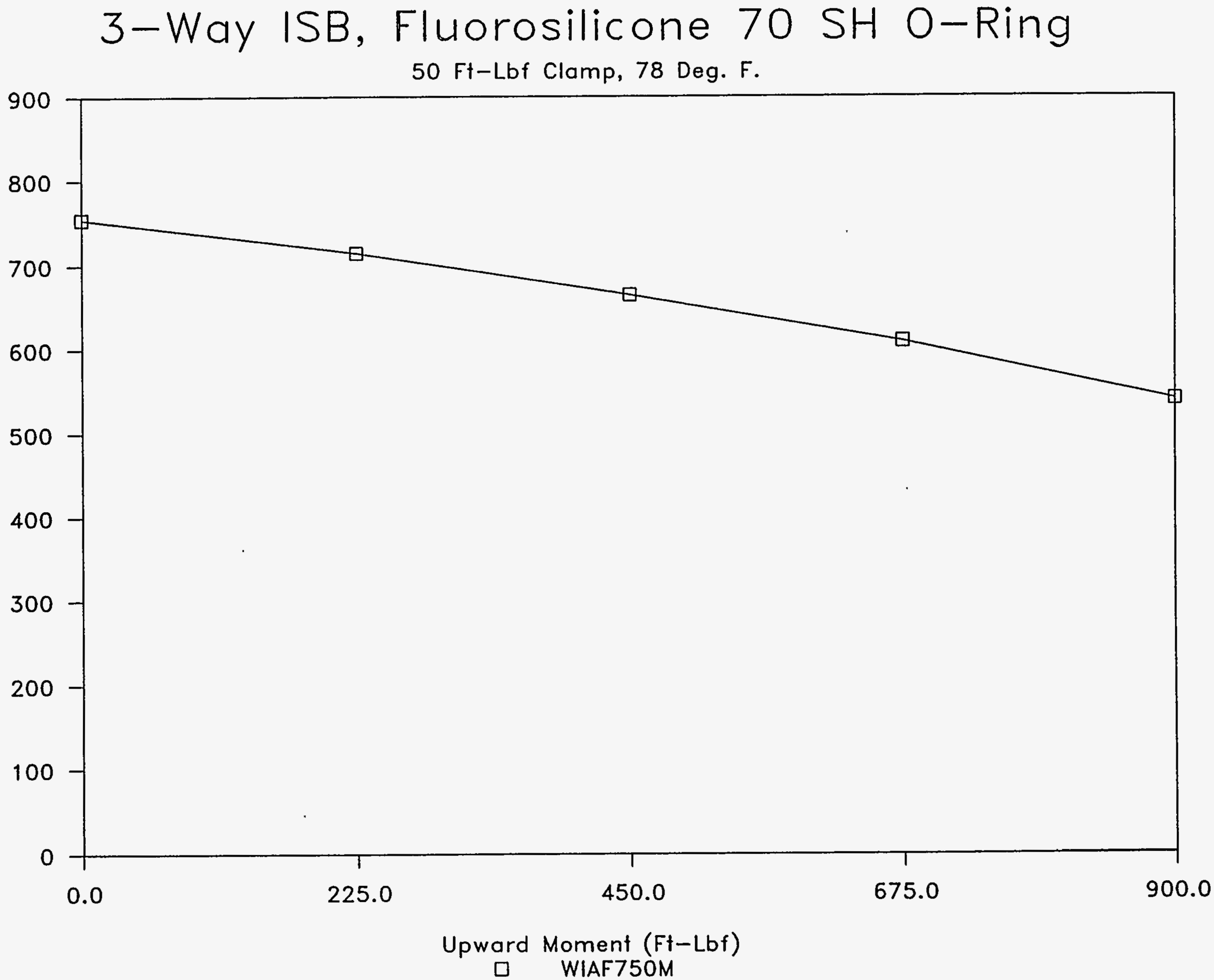

3-Way ISB, Fluorosilicone 70 SH O-Ring
50 Ft-Lbf Clamp, 68 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
44.5
89.1
133.6
164.8
Lateral Moment (Ft-Lbf)
WIAF100L

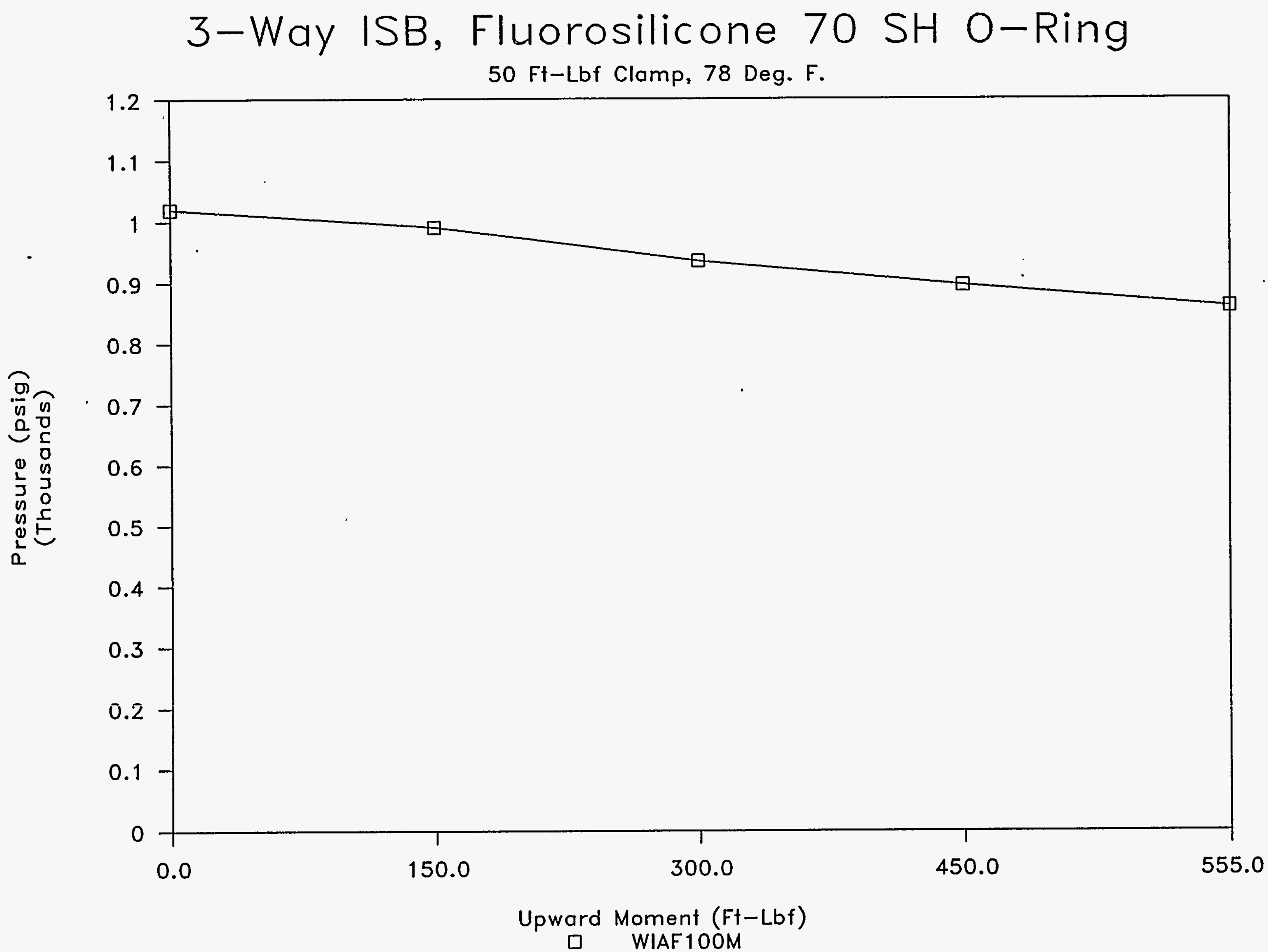
DECEMBER 09, 1994
2" 3-WAY ISB CONNECTOR, FLUOROSILICONE O-RING, 70 DUROMETER, AMBIENT TEM
PART # 2-119 L1120-70, CONQUEST SEAL CO., BATCH 70011, CURE DATE 4Q89
LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIAF250L
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 68 DEG. F.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
250	0	0	0.00	0	0.4453	0.0
250	2	0	2.00	0	0.4453	0.0
245	4	0	4.00	250	0.4453	111.3
225	6	0	6.00	500	0.4453	222.7
210	8	0	8.00	750	0.4453	334.0
205	10	0	10.00	1000	0.4453	445.3
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = WIAF500L		
510	12	0	12.00	0	0.4453	0.0
500	14	0	14.00	200	0.4453	89.1
470	16	0	16.00	400	0.4453	178.1
440	18	0	18.00	600	0.4453	267.2
425	20	0	20.00	800	0.4453	356.2
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = WIAF750L		
745	22	0	22.00	0	0.4453	0.0
735	24	0	24.00	150	0.4453	66.8
710	26	0	26.00	300	0.4453	133.6
680	28	0	28.00	450	0.4453	200.4
655	30	0	30.00	600	0.4453	267.2
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = WIAF100L		
1040	32	0	32.00	0	0.4453	0.0
1035	34	0	34.00	100	0.4453	44.5
1025	36	0	36.00	200	0.4453	89.1
1000	38	0	38.00	300	0.4453	133.6
990	40	0	40.00	370	0.4453	164.8


3-Way ISB, Fluorosilicone 70 SH O-Ring
50 Ft-Lbf Clamp, 78 Deg. F.
Pressure (psig)
350
300
250
200
150
100
50
0
0.0
0.0
375.0
750.0
1125.0
1500.0
Upward Moment (Ft-Lbf)
WIAF250M

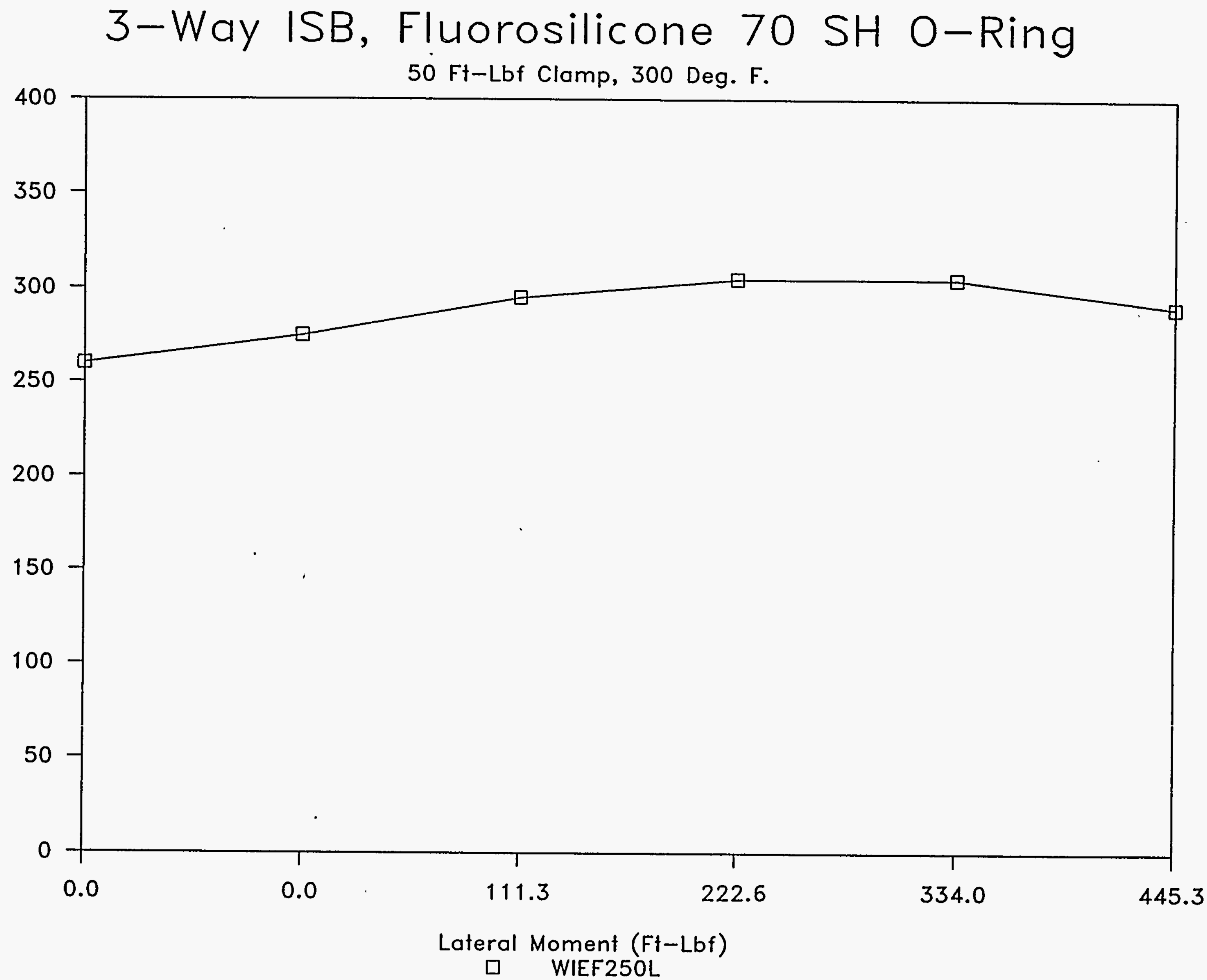

3-Way ISB, Fluorosilicone 70 SH O-Ring
50 Ft-Lbf Clamp, 78 Deg. F.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft-Lbf)
WIAF500M

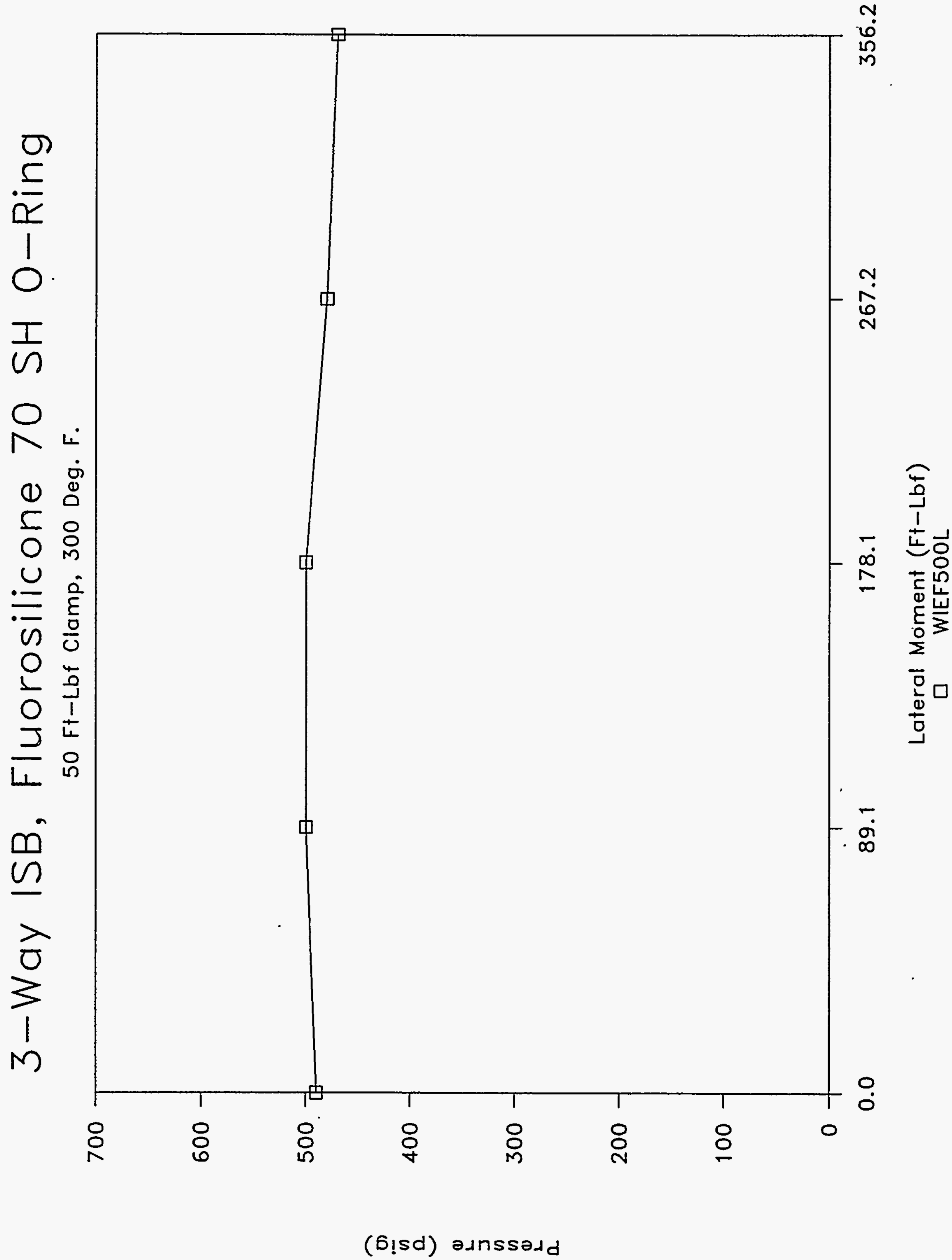

3-Way ISB, Fluorosilicone 70 SH O-Ring
50 Ft-Lbf Clamp, 78 Deg. F.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
225.0
450.0
675.0
900.0
Upward Moment (Ft-Lbf)
WIAF750M

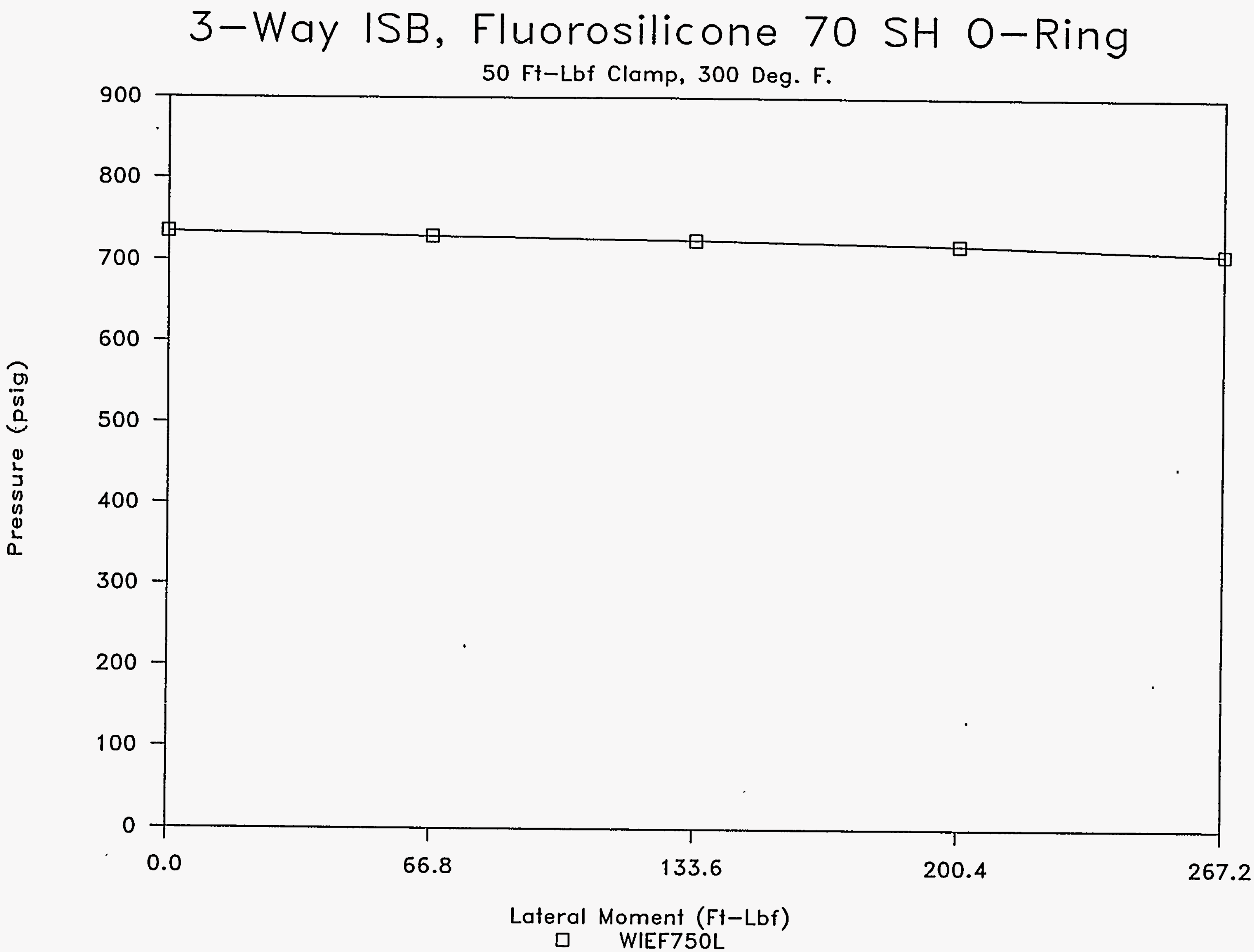

3-Way ISB, Fluorosilicone 70 SH O-Ring
50 Ft-Lbf Clamp, 78 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
150.0
300.0
450.0
555.0
Upward Moment (Ft-Lbf)
WIAF100M

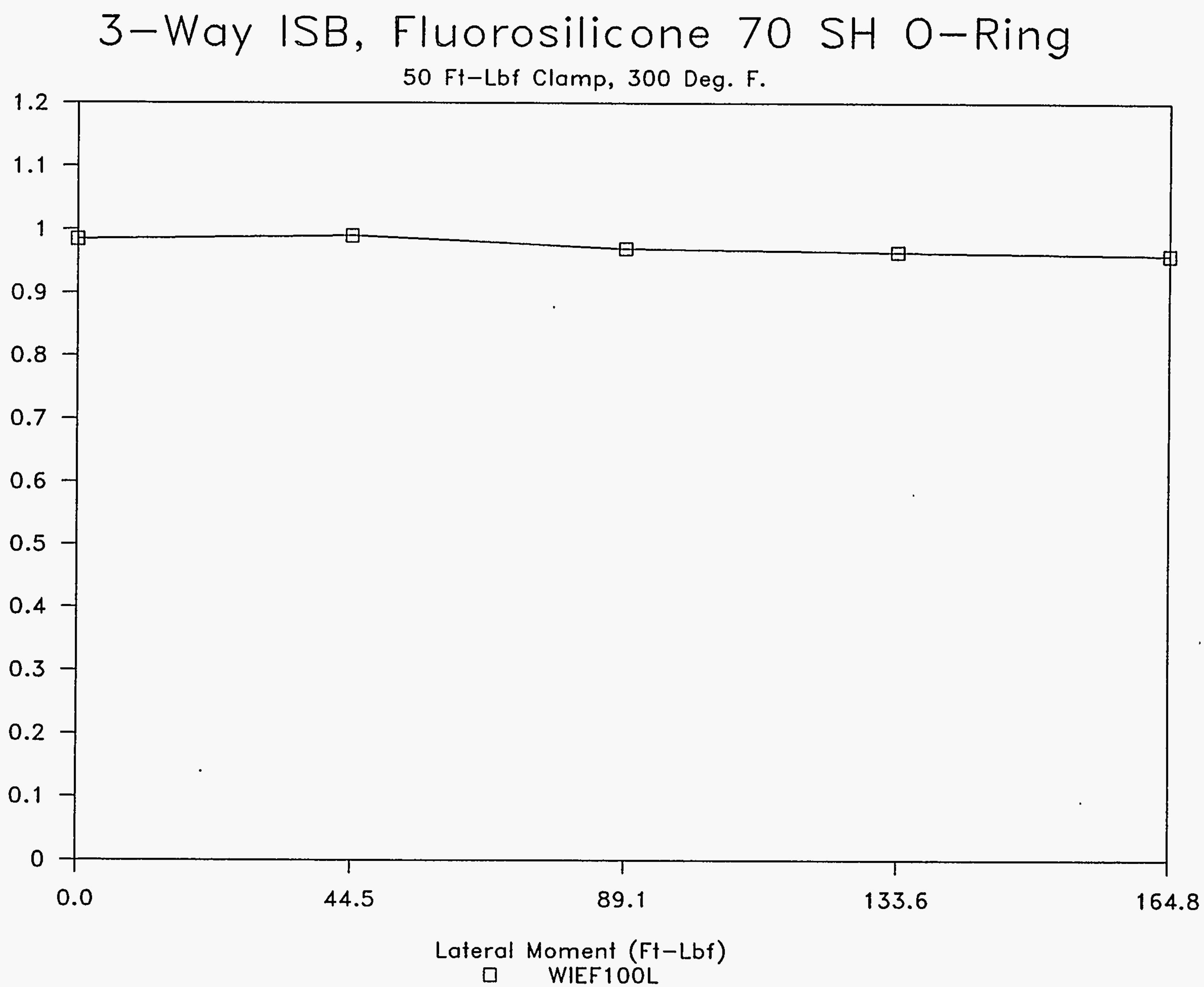
NOVEMBER 29, 1994
2" 3-WAY ISB CONNECTOR, FLUOROSILICONE O-RING, 70 DUROMETER, AMBIENT TEM
PART # 2-119 L1120-70, CONQUEST SEAL CO., BATCH 70011, CURE DATE 4Q89
LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIAF250M
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 78 DEG. F.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
270	0	0	0.00	0	1.5000	0.0
270	2	0	2.00	0	1.5000	0.0
245	4	0	4.00	250	1.5000	375.0
215	6	0	6.00	500	1.5000	750.0
180	8	0	8.00	750	1.5000	1125.0
150	10	0	10.00	1000	1.5000	1500.0
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = WIAF500M		
495	12	0	12.00	0	1.5000	0.0
450	14	0	14.00	200	1.5000	300.0
410	16	0	16.00	400	1.5000	600.0
355	18	0	18.00	600	1.5000	900.0
295	20	0	20.00	800	1.5000	1200.0
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = WIAF750M		
755	22	0	22.00	0	1.5000	0.0
715	24	0	24.00	150	1.5000	225.0
665	26	0	26.00	300	1.5000	450.0
610	28	0	28.00	450	1.5000	675.0
540	30	0	30.00	600	1.5000	900.0
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = WIAF100M		
1020	32	1	32.02	0	1.5000	0.0
990	34	0	34.00	100	1.5000	150.0
935	36	0	36.00	200	1.5000	300.0
895	38	2	38.03	300	1.5000	450.0
860	40	0	40.00	370	1.5000	555.0


3-Way ISB, Fluorosilicone 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
400
350
300
250
200
150
100
50
0
Pressure (psig)
0.0
0.0
111.3
222.6
334.0
445.3
Lateral Moment (Ft-Lbf)
WIEF250L


3-Way ISB, Fluorosilicone 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
89.1
178.1
267.2
356.2
Lateral Moment (Ft-Lbf)
WIEF500L


3-Way ISB, Fluorosilicone 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
66.8
133.6
200.4
267.2
Lateral Moment (Ft-Lbf)
WIEF750L



3-Way ISB, Fluorosilicone 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig) (Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
44.5
89.1
133.6
164.8
Lateral Moment (Ft-Lbf)
WIEF100L

DECEMBER 09, 1994
2" 3-WAY ISB CONNECTOR, FLUOROSILICONE O-RING, 70 DUROMETER, ELEVATED TE
PART # 2-119 L1120-70, CONQUEST SEAL CO., BATCH 70011, CURE DATE 4Q89
LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIEF250L
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 300 DEG. F.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
260	0	0	0.00	0	0.4453	0.0
275	2	0	2.00	0	0.4453	0.0
295	4	0	4.00	250	0.4453	111.3
305	6	0	6.00	500	0.4453	222.7
305	8	0	8.00	750	0.4453	334.0
290	10	0	10.00	1000	0.4453	445.3

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = WIEF500L

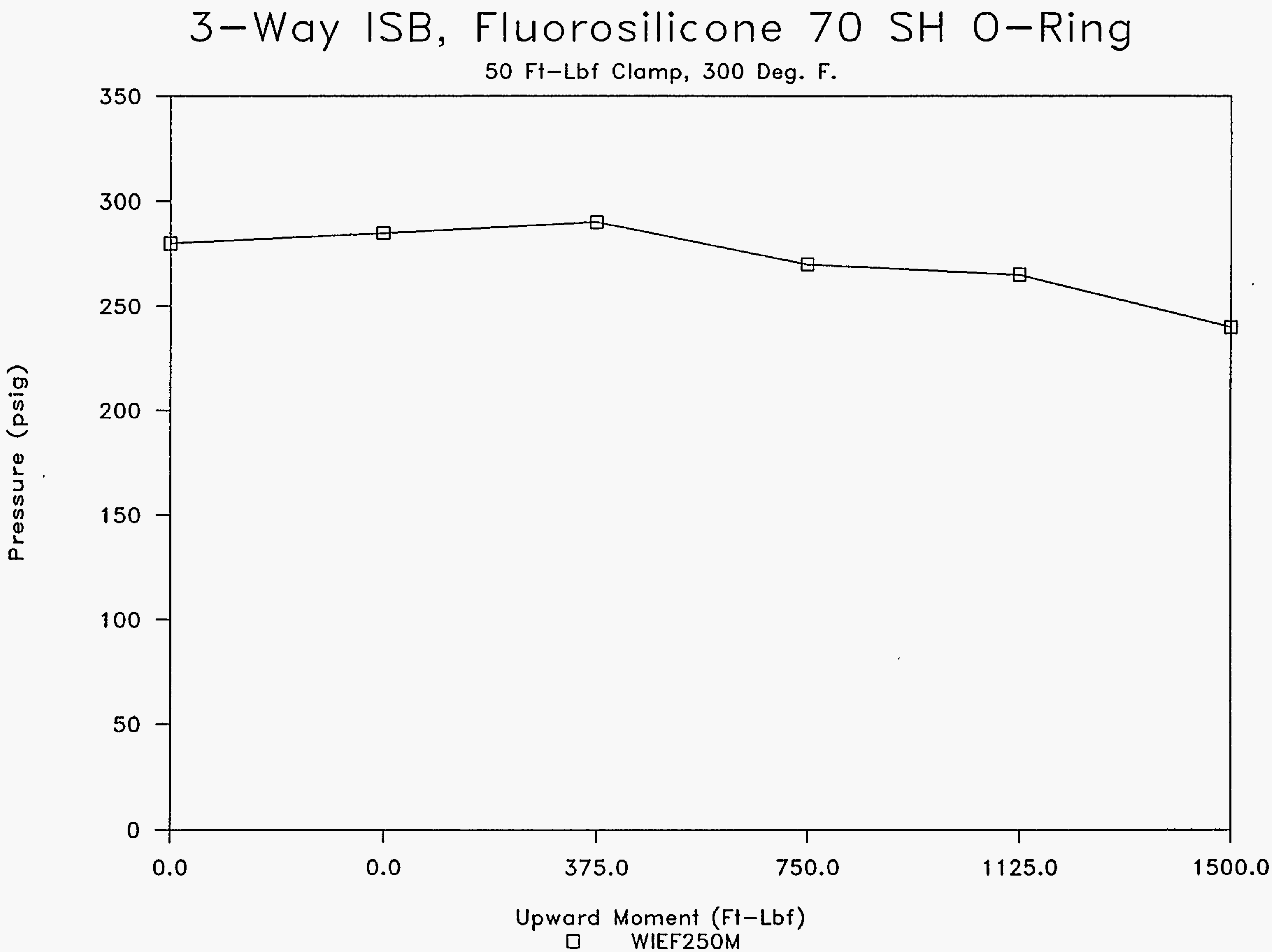
490	12	0	12.00	0	0.4453	0.0
500	14	0	14.00	200	0.4453	89.1
500	16	0	16.00	400	0.4453	178.1
480	18	0	18.00	600	0.4453	267.2
470	20	0	20.00	800	0.4453	356.2

INCREASED PRESSURE TO 750 PSIG GRAPH NAME = WIEF750L

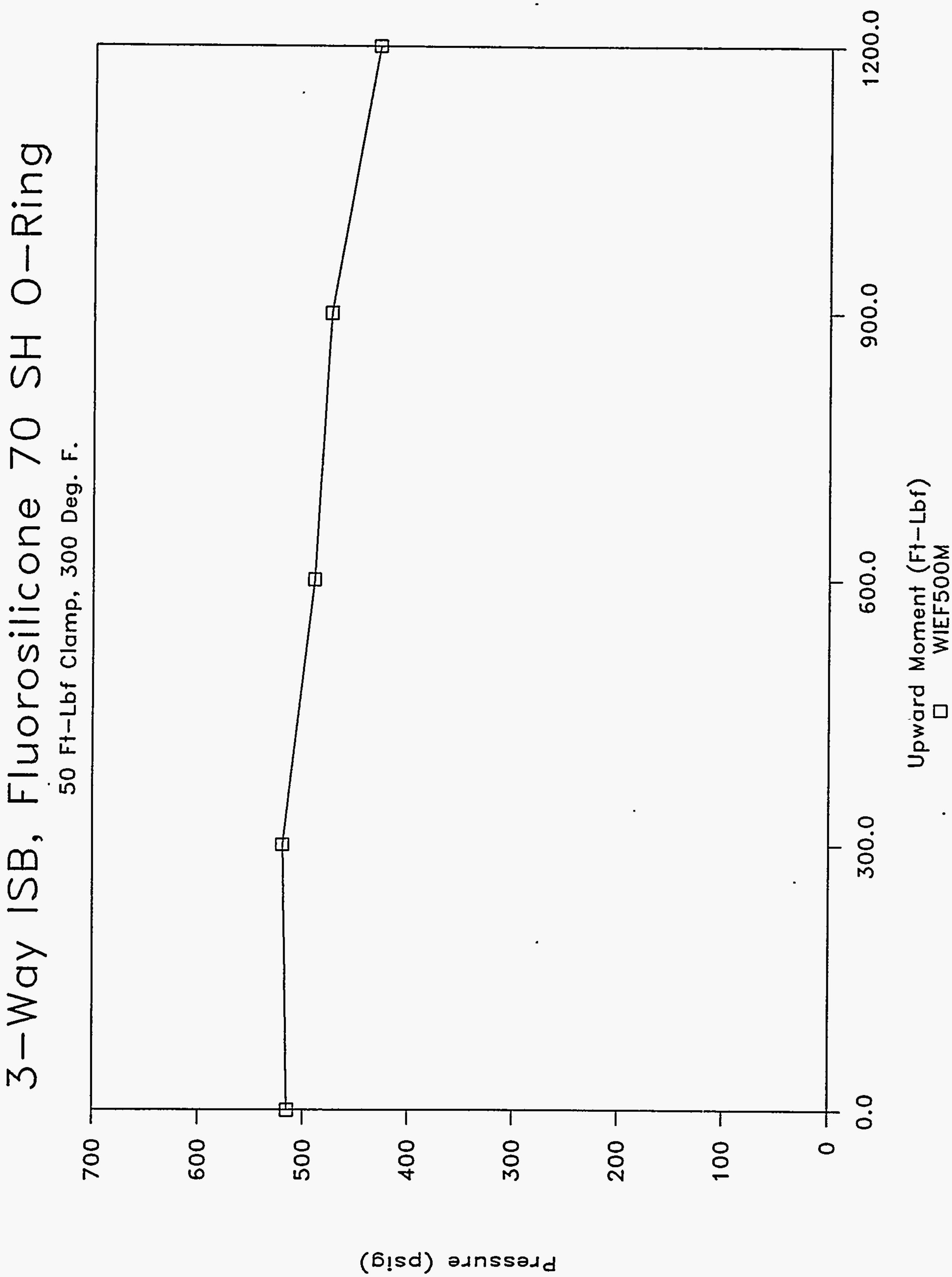
735	22	0	22.00	0	0.4453	0.0
730	24	0	24.00	150	0.4453	66.8
725	26	0	26.00	300	0.4453	133.6
720	28	0	28.00	450	0.4453	200.4
710	30	0	30.00	600	0.4453	267.2

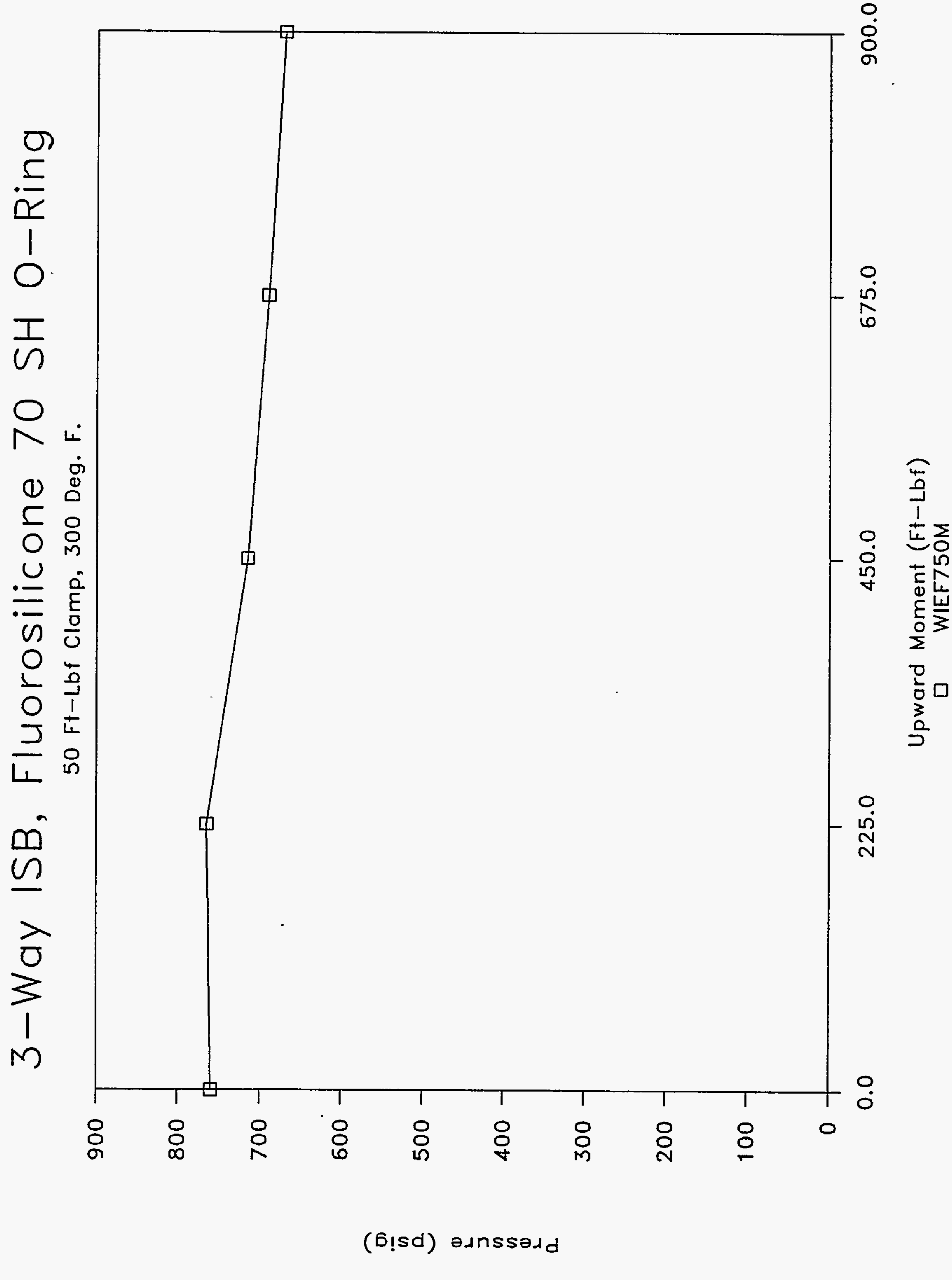
INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = WIEF100L

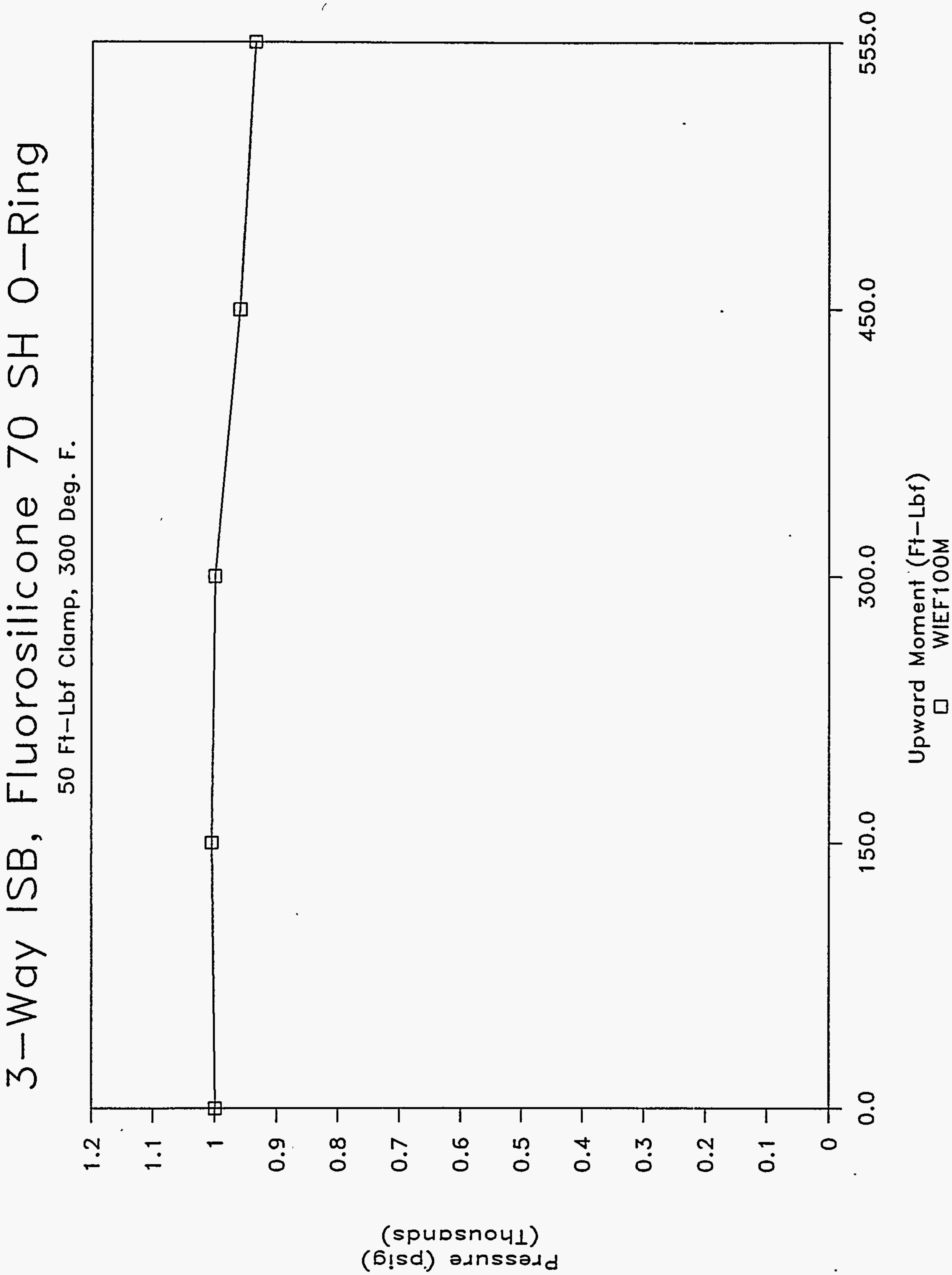
985	32	0	32.00	0	0.4453	0.0
990	34	0	34.00	100	0.4453	44.5
970	36	0	36.00	200	0.4453	89.1
965	38	0	38.00	300	0.4453	133.6
960	40	0	40.00	370	0.4453	164.8



3-Way ISB, Fluorosilicone 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
350
300
250
200
150
100
50
0
0.0
0.0
375.0
750.0
1125.0
1500.0
Upward Moment (Ft-Lbf)
WIEF250M


3-Way ISB, Fluorosilicone 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
0
100
200
300
400
500
600
700
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft-Lbf)
WIEF500M


3-Way ISB, Fluorosilicone 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
225.0
450.0
675.0
900.0
Upward Moment (Ft-Lbf)
WIEF750M


3—Way ISB, Fluorosilicone 70 SH O—Ring
50 Ft—Lbf Clamp, 300 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
150.0
300.0
450.0
555.0
Upward Moment (Ft—Lbf)
WIEF100M

NOVEMBER 29, 1994
2" 3-WAY ISB CONNECTOR, FLUOROSILICONE O-RING, 70 DUROMETER, ELEVATED TE
PART # 2-119 L1120-70, CONQUEST SEAL CO., BATCH 70011, CURE DATE 4Q89
LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIEF250M
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 300 DEG. F.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
280	0	0	0.00	0	1.5000	0.0
285	2	0	2.00	0	1.5000	0.0
290	4	0	4.00	250	1.5000	375.0
270	6	0	6.00	500	1.5000	750.0
265	8	0	8.00	750	1.5000	1125.0
240	10	0	10.00	1000	1.5000	1500.0

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = WIEF500M

515	12	0	12.00	0	1.5000	0.0
520	14	0	14.00	200	1.5000	300.0
490	16	0	16.00	400	1.5000	600.0
475	18	0	18.00	600	1.5000	900.0
430	20	1	20.02	800	1.5000	1200.0

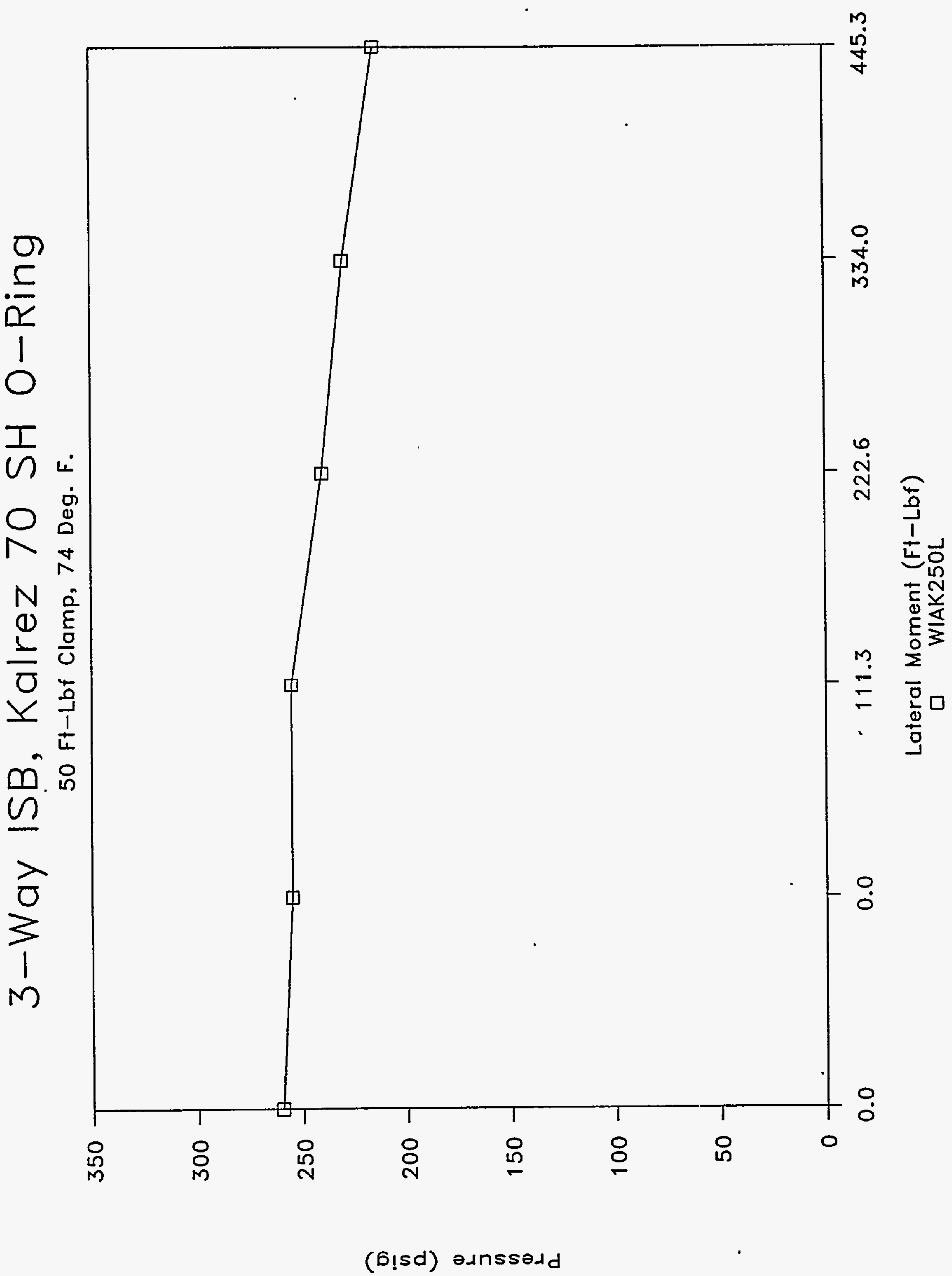
INCREASED PRESSURE TO 750 PSIG GRAPH NAME = WIEF750M

760	22	0	22.00	0	1.5000	0.0
765	24	0	24.00	150	1.5000	225.0
715	26	0	26.00	300	1.5000	450.0
690	28	0	28.00	450	1.5000	675.0
670	30	1	30.02	600	1.5000	900.0

INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = WIEF100M

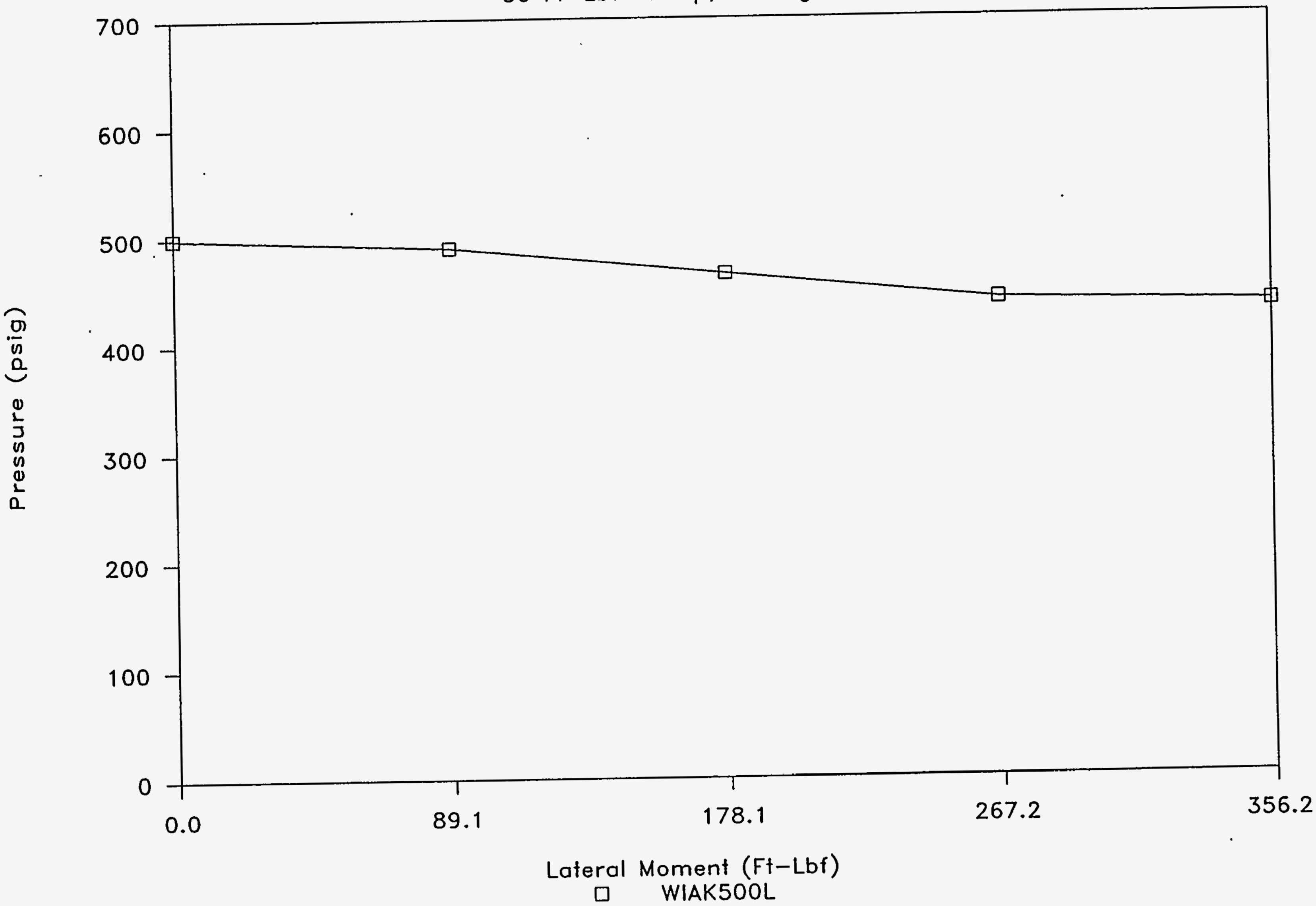
1000	32	0	32.00	0	1.5000	0.0
1005	34	0	34.00	100	1.5000	150.0
1000	36	0	36.00	200	1.5000	300.0
960	38	1	38.02	300	1.5000	450.0
935	40	0	40.00	370	1.5000	555.0

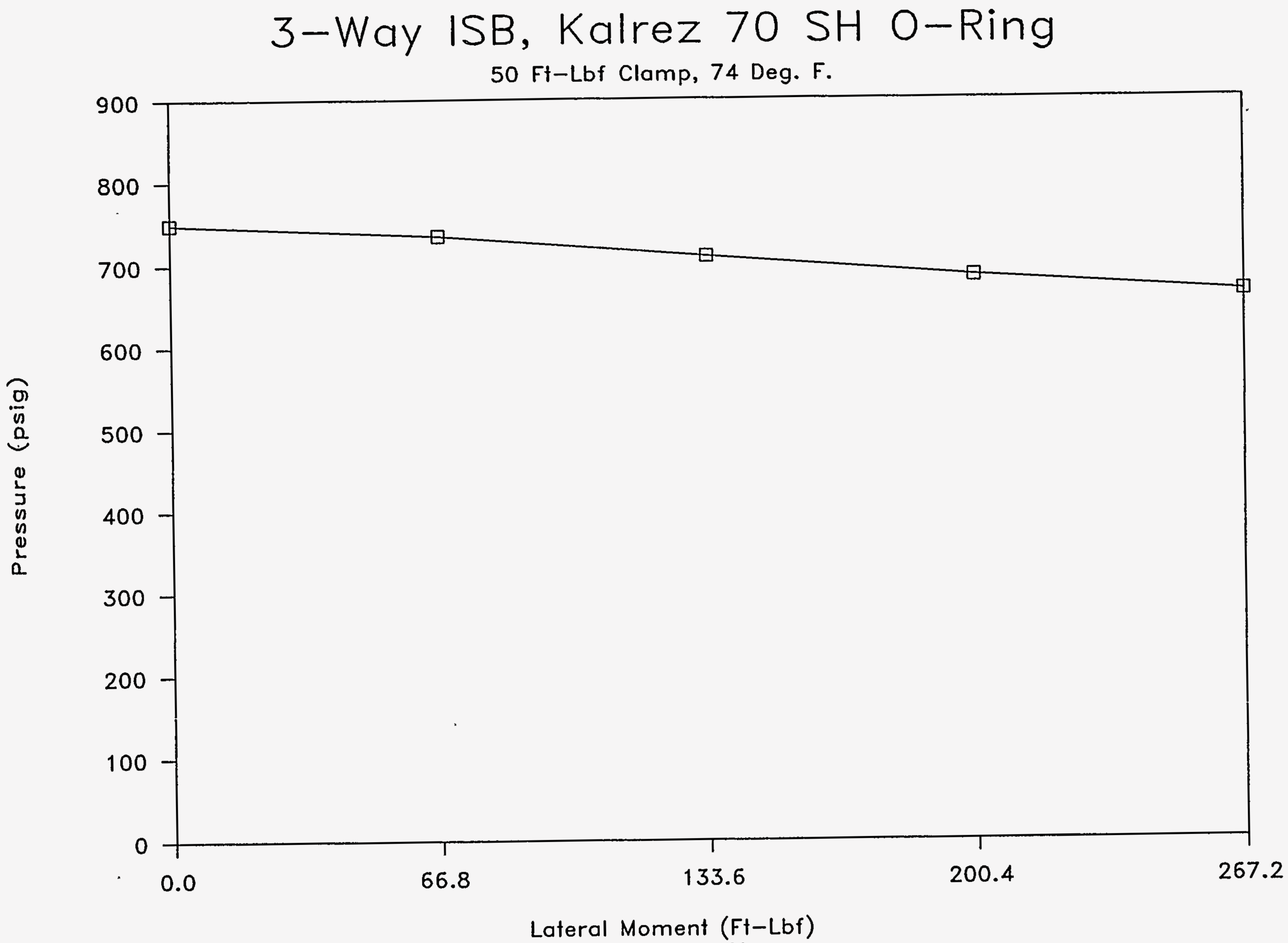
APPENDIX P: GRAPHS OF THREE-WAY KALREZ TESTS


3-Way ISB, Kalrez 70 SH O-Ring
50 Ft-Lbf Clamp, 74 Deg. F.
Pressure (psig)
350
300
250
200
150
100
50
0
0.0
0.0
111.3
222.6
334.0
445.3
Lateral Moment (Ft-Lbf)
WIAK250L

3-Way ISB, Kalrez 70 SH O-Ring

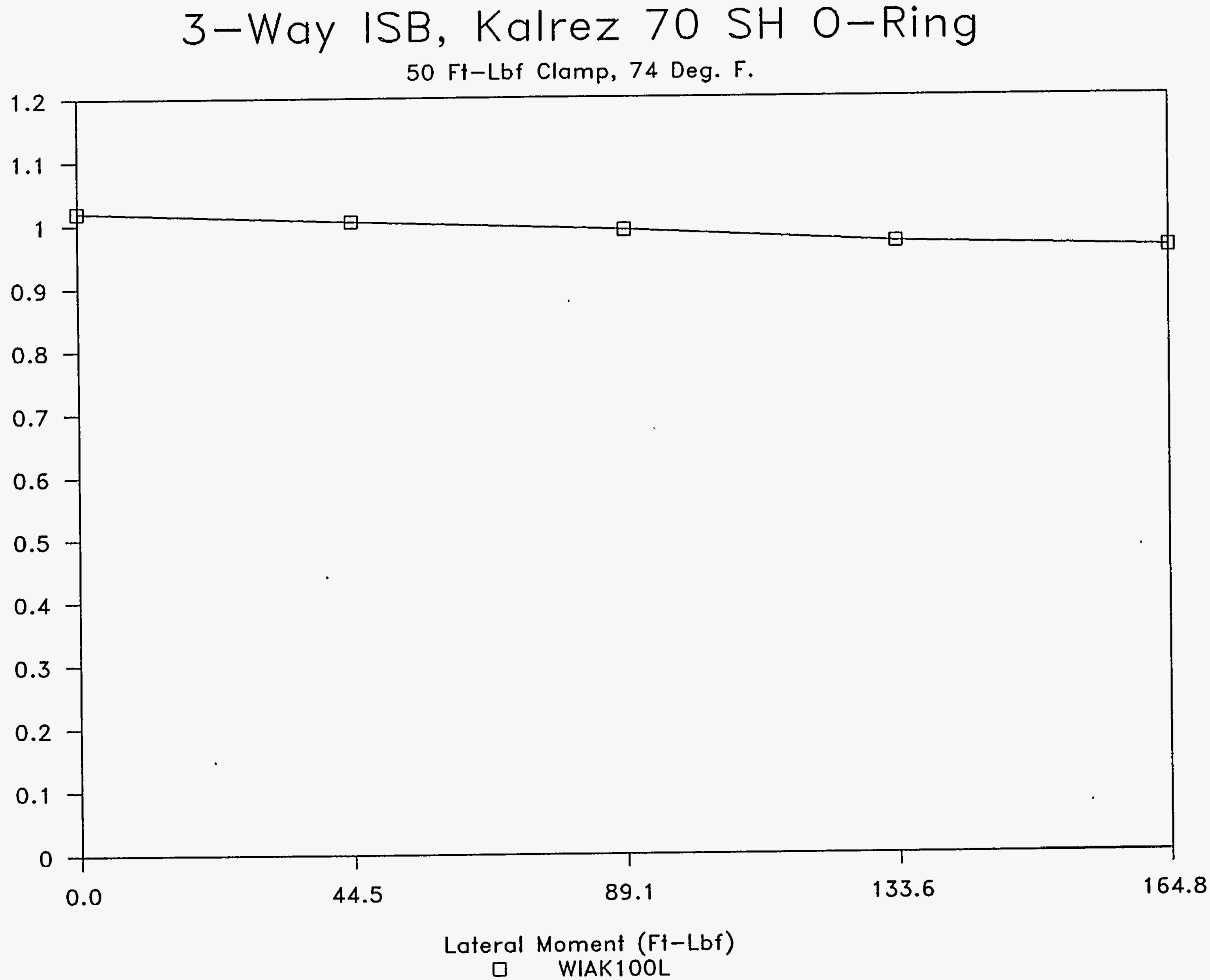
50 Ft-Lbf Clamp, 74 Deg. F.





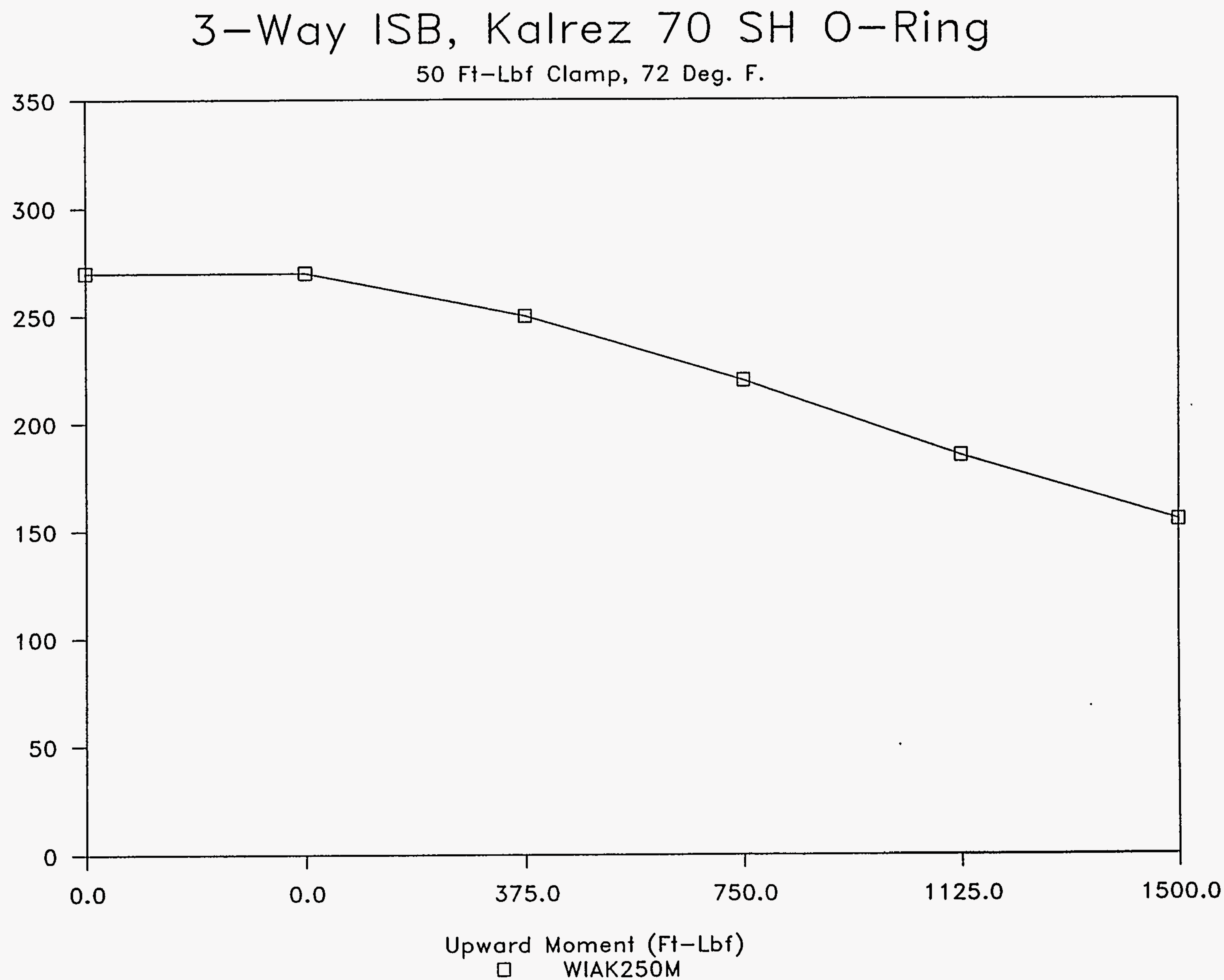
P-4

WHC-SD-WM-TRP-223
Rev. 0

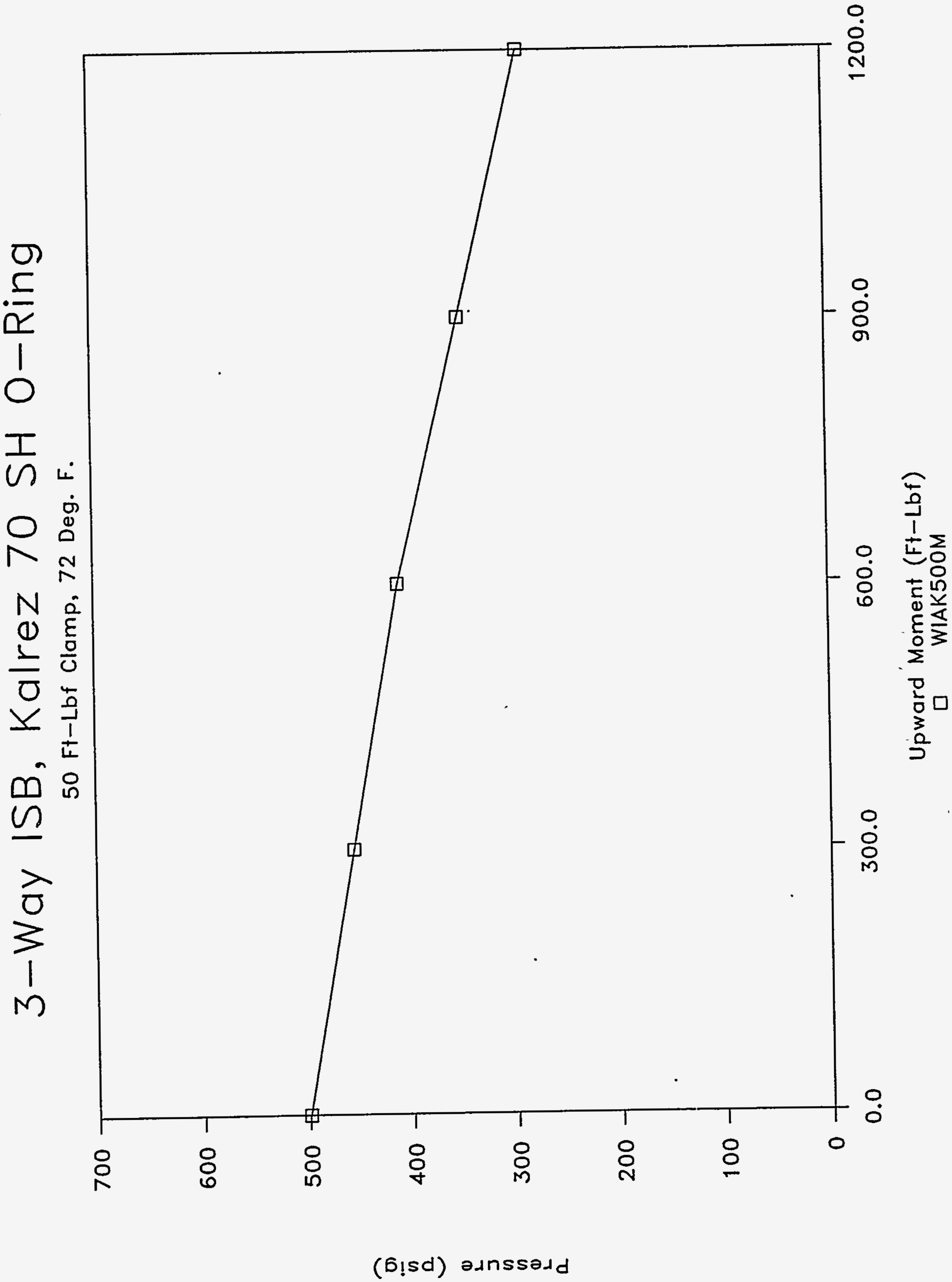

3-Way ISB, Kalrez 70 SH O-Ring
50 Ft-Lbf Clamp, 74 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
44.5
89.1
133.6
164.8
Lateral Moment (Ft-Lbf)
WIAK100L

DECEMBER 07, 1994
2" 3-WAY ISB CONNECTOR, KALREZ O-RING, 70 DUROMETER, AMBIENT TEMP.
PART # AS-568A K# 119, DuPONT CO., CURE DATE 04/18/94
LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIAK250L
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 74 DEG. F.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
260	0	0	0.00	0	0.4453	0.0
255	2	0	2.00	0	0.4453	0.0
255	4	0	4.00	250	0.4453	111.3
240	6	0	6.00	500	0.4453	222.7
230	8	0	8.00	750	0.4453	334.0
215	10	0	10.00	1000	0.4453	445.3
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = WIAK500L		
500	12	0	12.00	0	0.4453	0.0
490	14	0	14.00	200	0.4453	89.1
465	16	0	16.00	400	0.4453	178.1
440	18	0	18.00	600	0.4453	267.2
435	20	0	20.00	800	0.4453	356.2
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = WIAK750L		
750	22	0	22.00	0	0.4453	0.0
735	24	0	24.00	150	0.4453	66.8
710	26	0	26.00	300	0.4453	133.6
685	28	0	28.00	450	0.4453	200.4
665	30	0	30.00	600	0.4453	267.2
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = WIAK100L		
1020	32	0	32.00	0	0.4453	0.0
1005	34	0	34.00	100	0.4453	44.5
990	36	0	36.00	200	0.4453	89.1
970	38	0	38.00	300	0.4453	133.6
960	40	0	40.00	370	0.4453	164.8

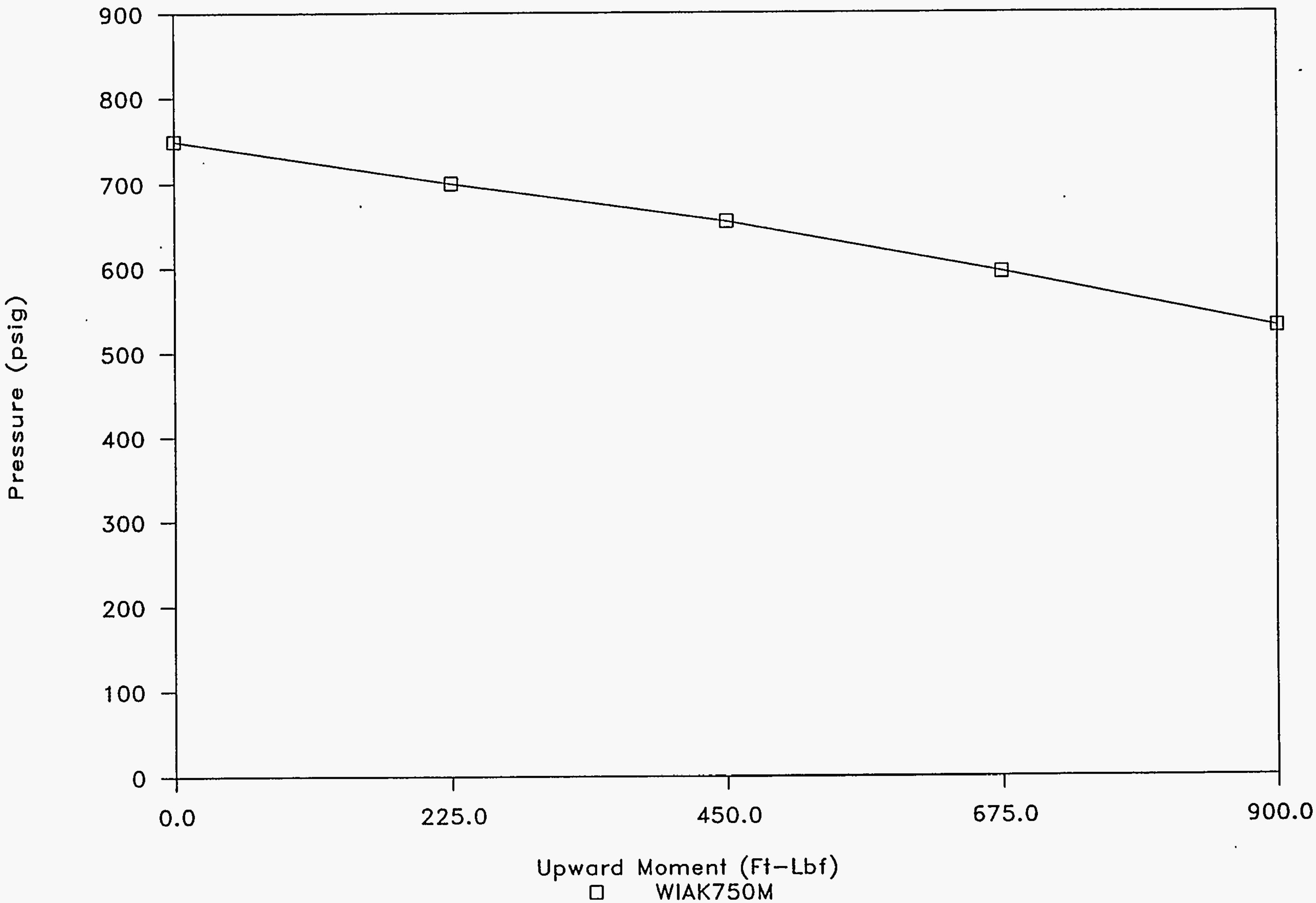


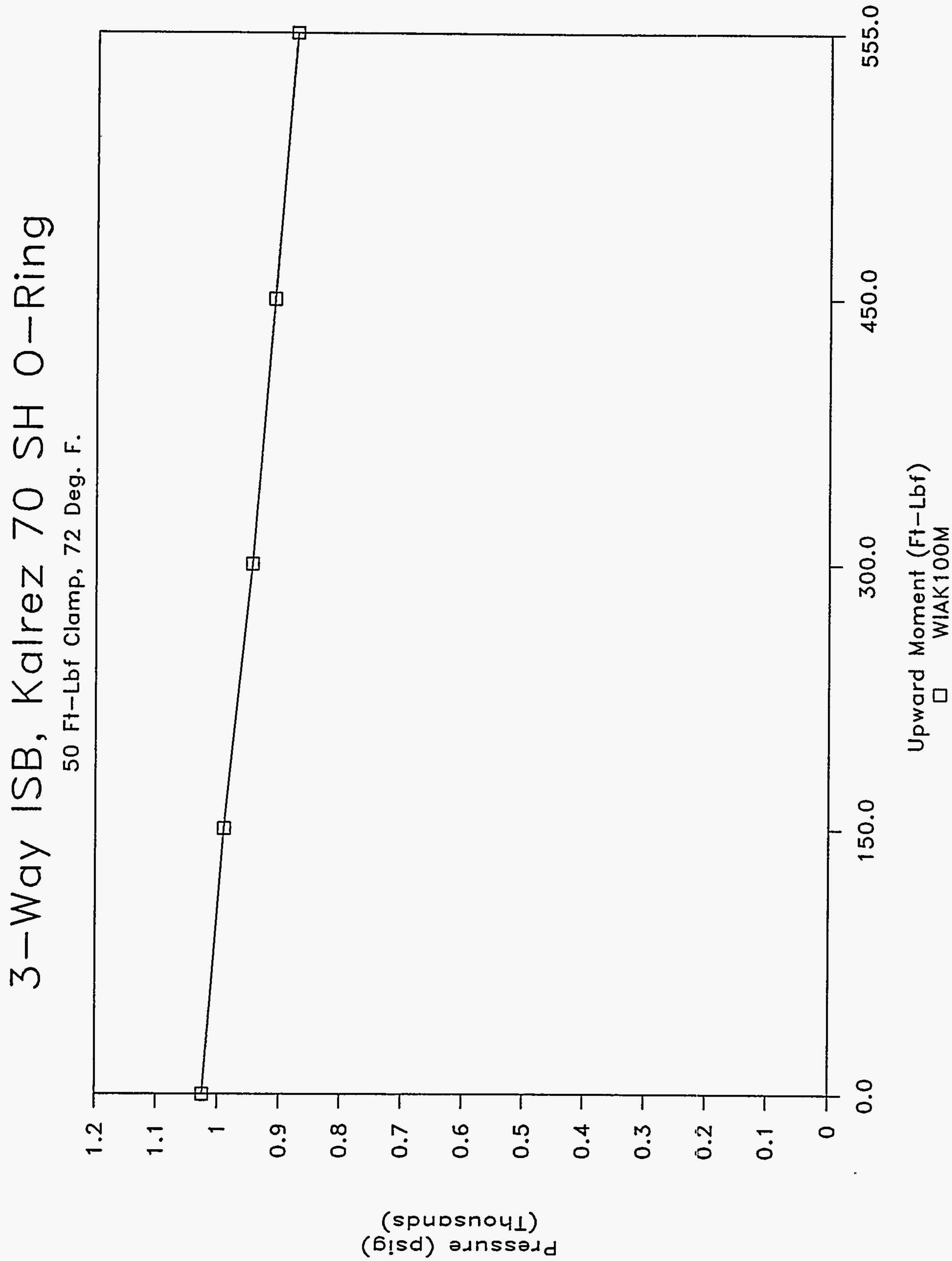
3-Way ISB, Kalrez 70 SH O-Ring
50 Ft-Lbf Clamp, 72 Deg. F.
Pressure (psig)
350
300
250
200
150
100
50
0
0.0
0.0
375.0
750.0
1125.0
1500.0
Upward Moment (Ft-Lbf)
WIAK250M


3-Way ISB, Kalrez 70 SH O-Ring
50 Ft-Lbf Clamp, 72 Deg. F.
Pressure (psig)
0
100
200
300
400
500
600
700
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft-Lbf)
WIAK500M

3-Way ISB, Kalrez 70 SH O-Ring

50 Ft-Lbf Clamp, 72 Deg. F.




3—Way ISB, Kalrez 70 SH O—Ring
50 Ft—Lbf Clamp, 72 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
150.0
300.0
450.0
555.0
Upward Moment (Ft—Lbf)
WIAK100M

DECEMBER 02, 1994
2" 3-WAY ISB CONNECTOR, KALREZ O-RING, 70 DUROMETER, AMBIENT TEMP.
PART # AS-568A K# 119, DuPONT CO., CURE DATE 04/18/94
LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIAK250M
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 72 DEG. F.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
270	0	0	0.00	0	1.5000	0.0
270	2	0	2.00	0	1.5000	0.0
250	4	1	4.02	250	1.5000	375.0
220	6	0	6.00	500	1.5000	750.0
185	8	0	8.00	750	1.5000	1125.0
155	10	0	10.00	1000	1.5000	1500.0

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = WIAK500M

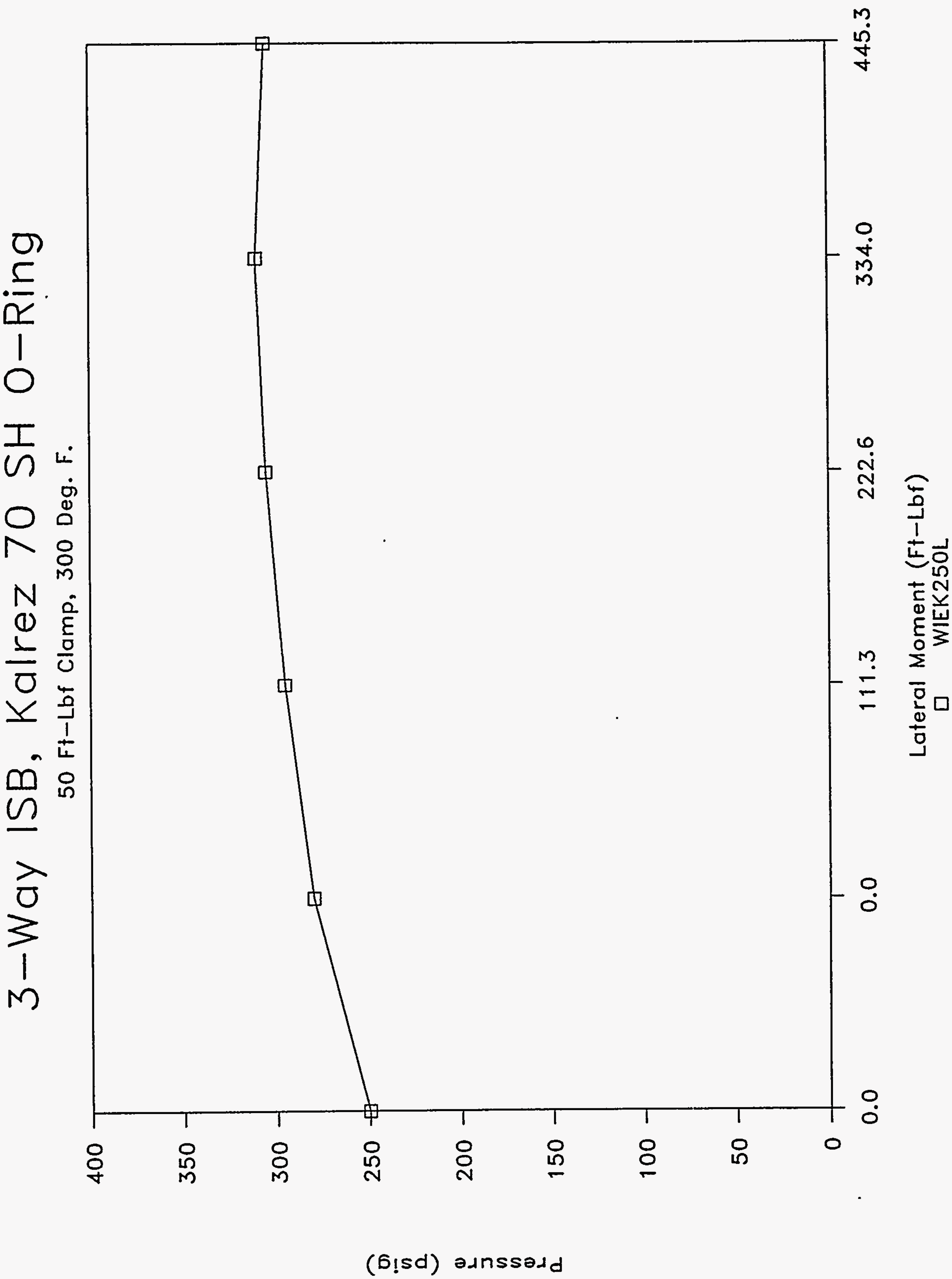
500	12	0	12.00	0	1.5000	0.0
455	14	0	14.00	200	1.5000	300.0
410	16	0	16.00	400	1.5000	600.0
350	18	0	18.00	600	1.5000	900.0
290	20	0	20.00	800	1.5000	1200.0

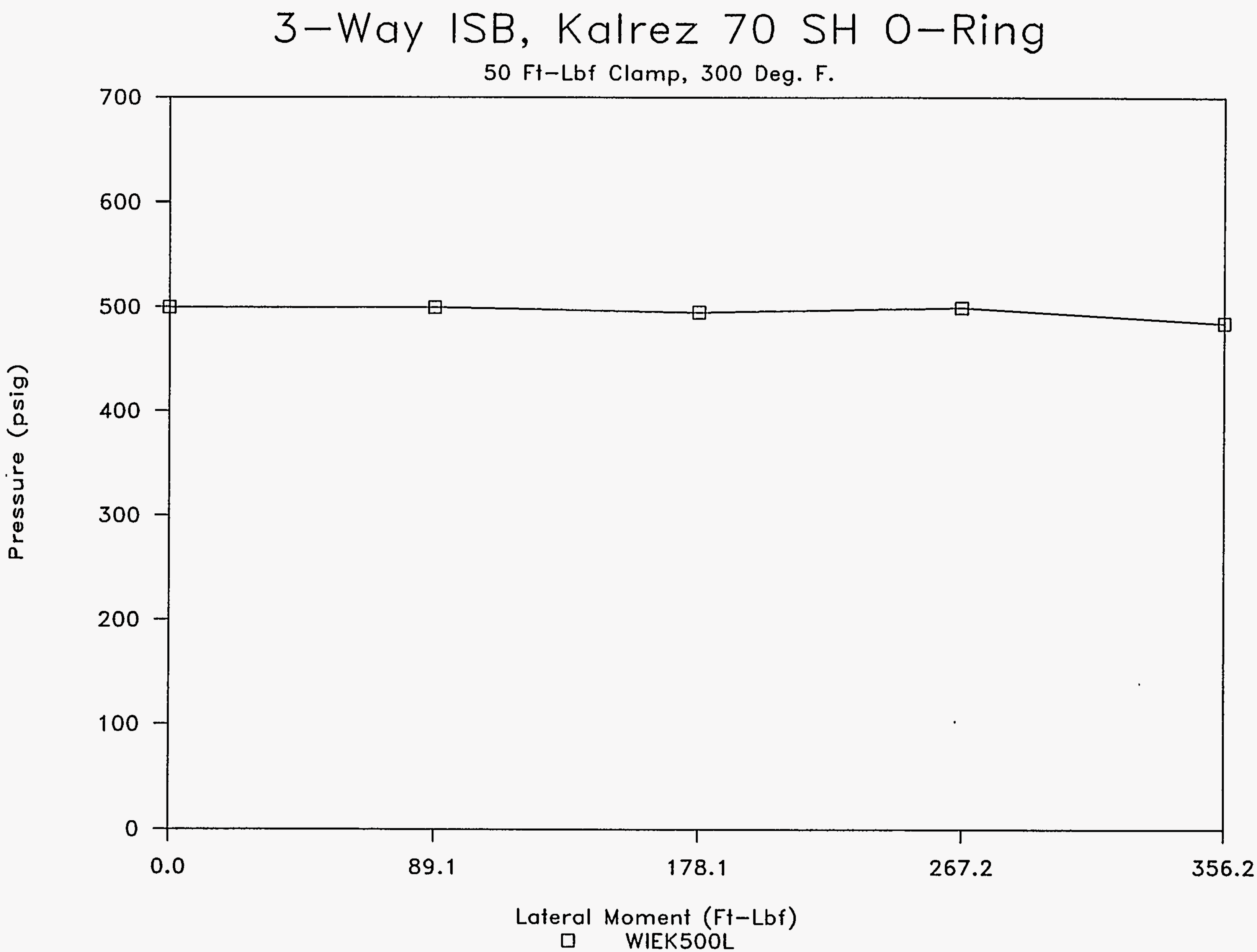
INCREASED PRESSURE TO 750 PSIG GRAPH NAME = WIAK750M

750	22	0	22.00	0	1.5000	0.0
700	24	0	24.00	150	1.5000	225.0
655	26	0	26.00	300	1.5000	450.0
595	28	0	28.00	450	1.5000	675.0
530	30	0	30.00	600	1.5000	900.0

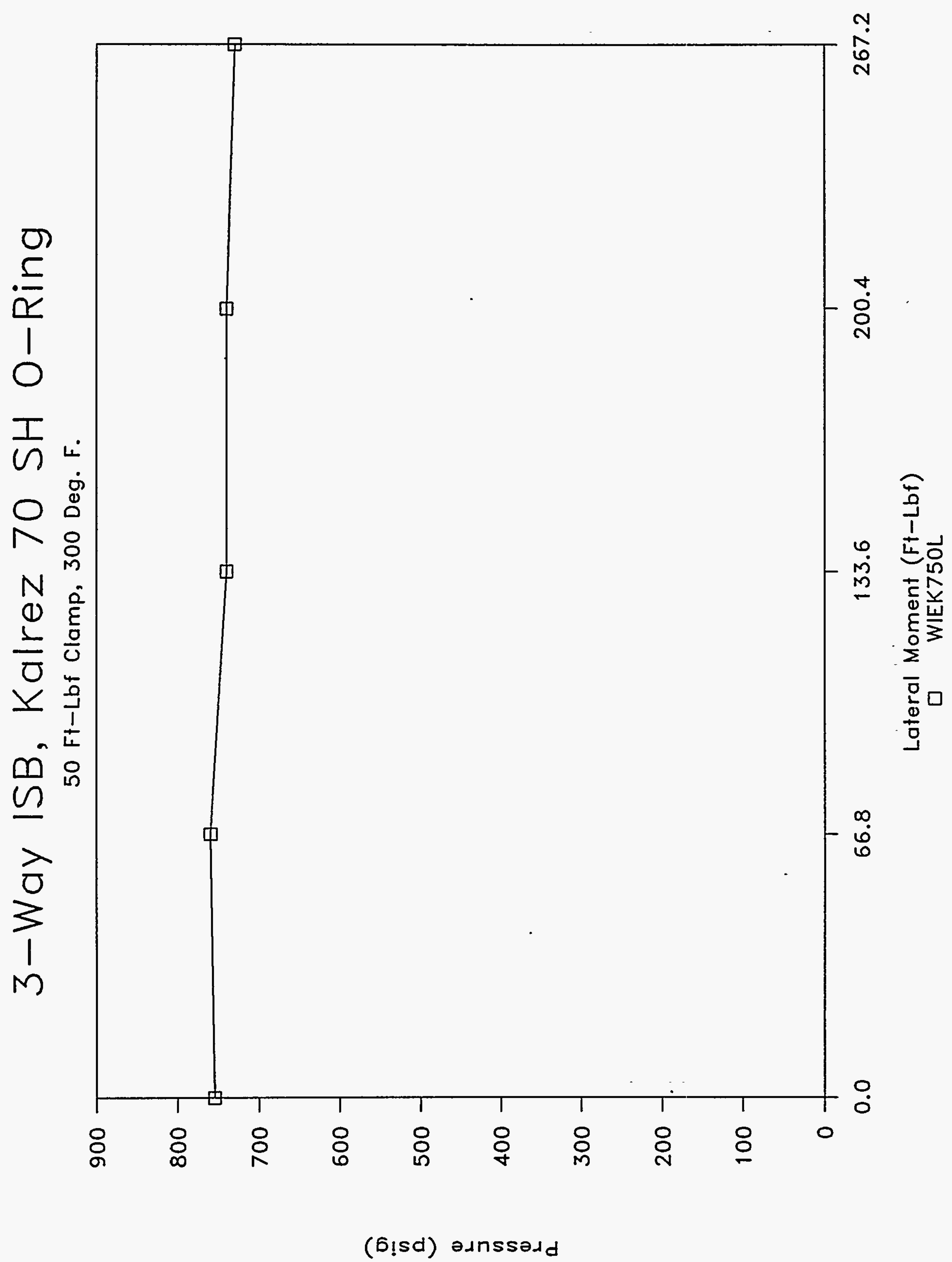
INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = WIAK100M

1025	32	0	32.00	0	1.5000	0.0
990	34	1	34.02	100	1.5000	150.0
945	36	1	36.02	200	1.5000	300.0
910	38	0	38.00	300	1.5000	450.0
875	40	2	40.03	370	1.5000	555.0


3-Way ISB, Kalrez 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
400
350
300
250
200
150
100
50
0
0.0
0.0
111.3
222.6
334.0
445.3
Lateral Moment (Ft-Lbf)
WIEK250L

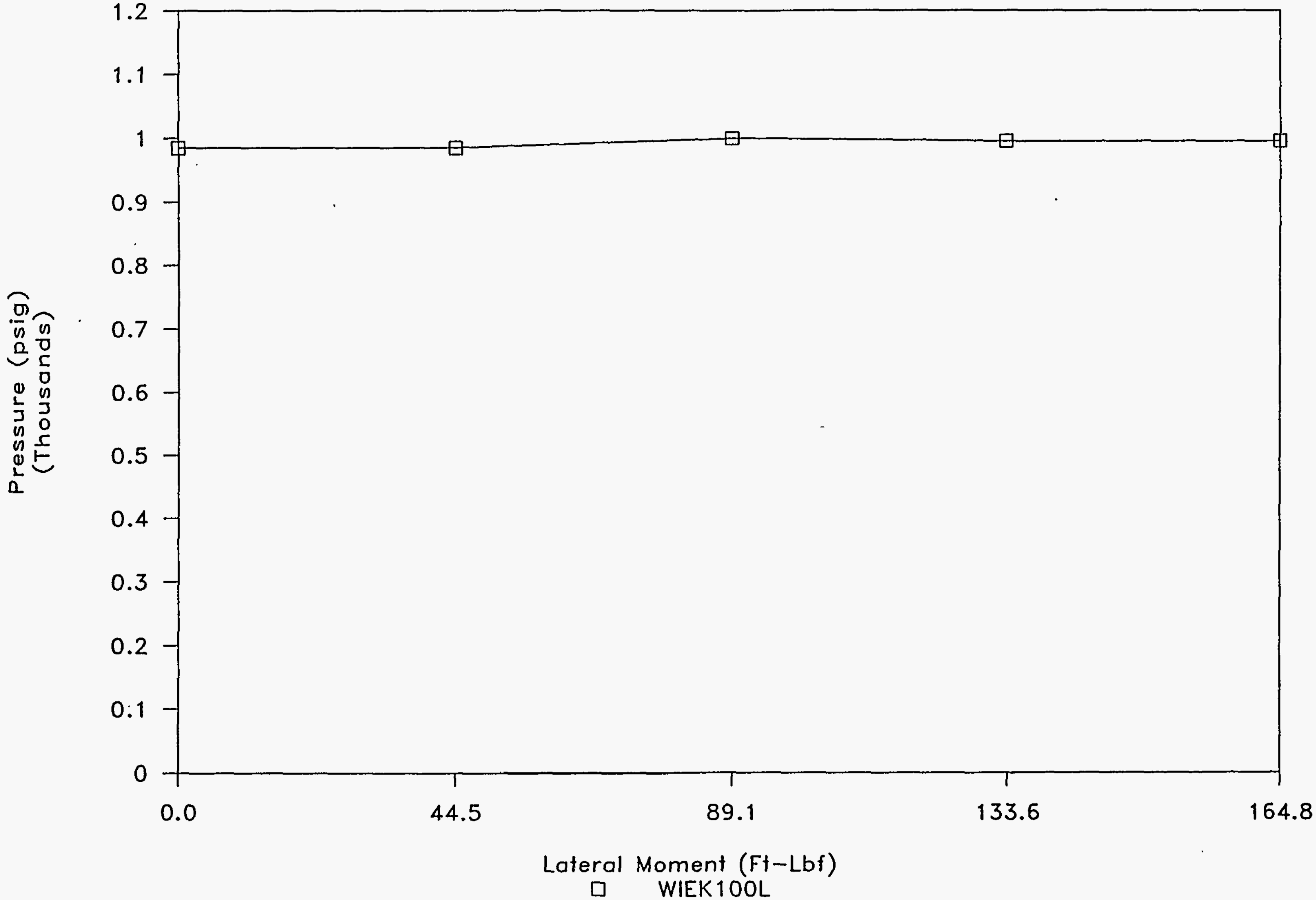


3-Way ISB, Kalrez 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
89.1
178.1
267.2
356.2
Lateral Moment (Ft-Lbf)
WIEK500L


3-Way ISB, Kalrez 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
66.8
133.6
200.4
267.2
Lateral Moment (Ft-Lbf)
WIEK750L

3-Way ISB, Kalrez 70 SH O-Ring

50 Ft-Lbf Clamp, 300 Deg. F.



DECEMBER 12, 1994
2" 3-WAY ISB CONNECTOR, KALREZ O-RING, 70 DUROMETER, ELEVATED TEMP.
PART # AS-568A K# 119, DuPONT CO., CURE DATE 04/18/94
LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIEK250L
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 300 DEG. F.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
250	0	0	0.00	0	0.4453	0.0
280	2	0	2.00	0	0.4453	0.0
295	4	0	4.00	250	0.4453	111.3
305	6	0	6.00	500	0.4453	222.7
310	8	0	8.00	750	0.4453	334.0
305	10	0	10.00	1000	0.4453	445.3

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = WIEK500L

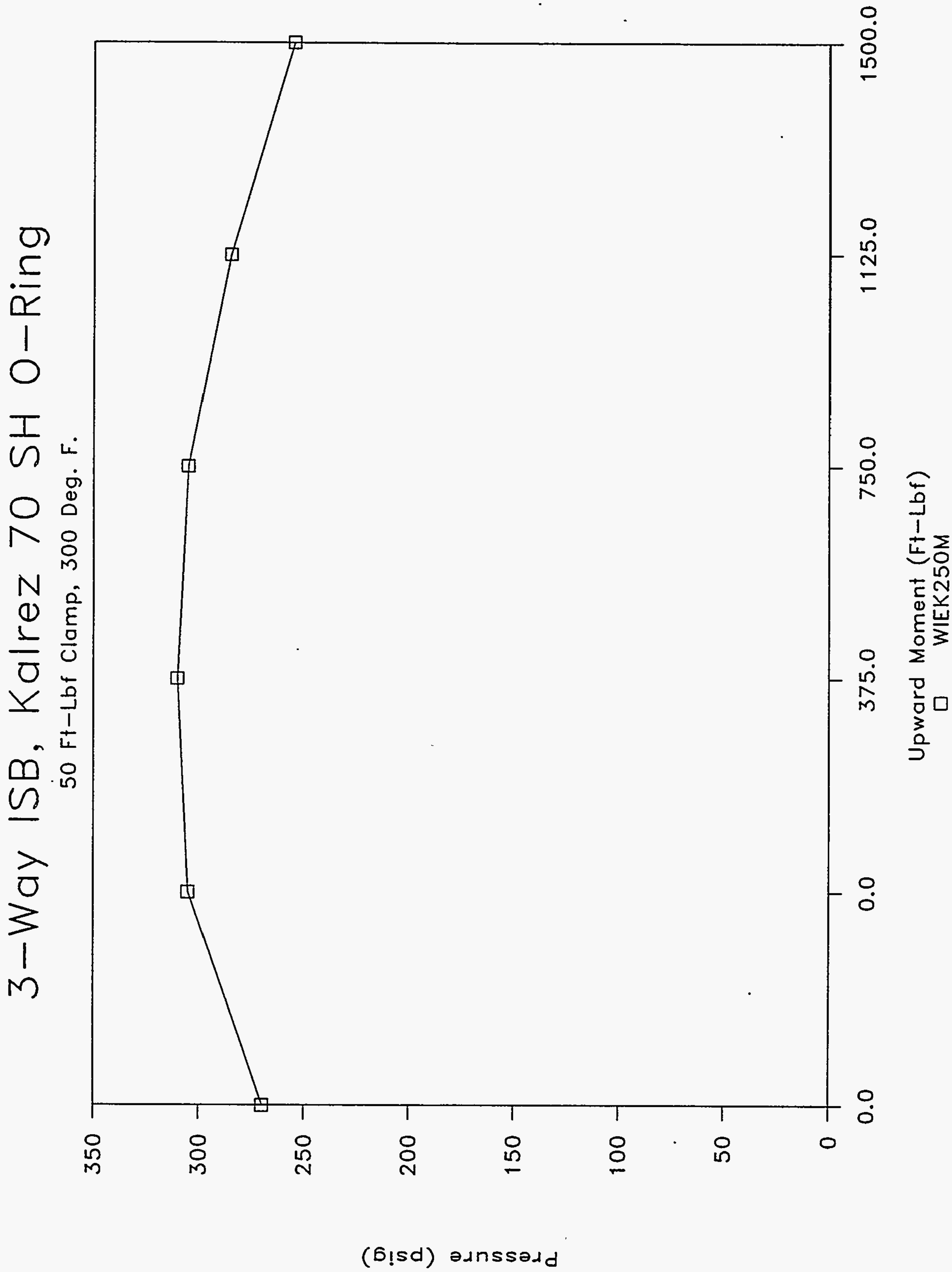
500	12	0	12.00	0	0.4453	0.0
500	14	0	14.00	200	0.4453	89.1
495	16	0	16.00	400	0.4453	178.1
500	18	0	18.00	600	0.4453	267.2
485	20	0	20.00	800	0.4453	356.2

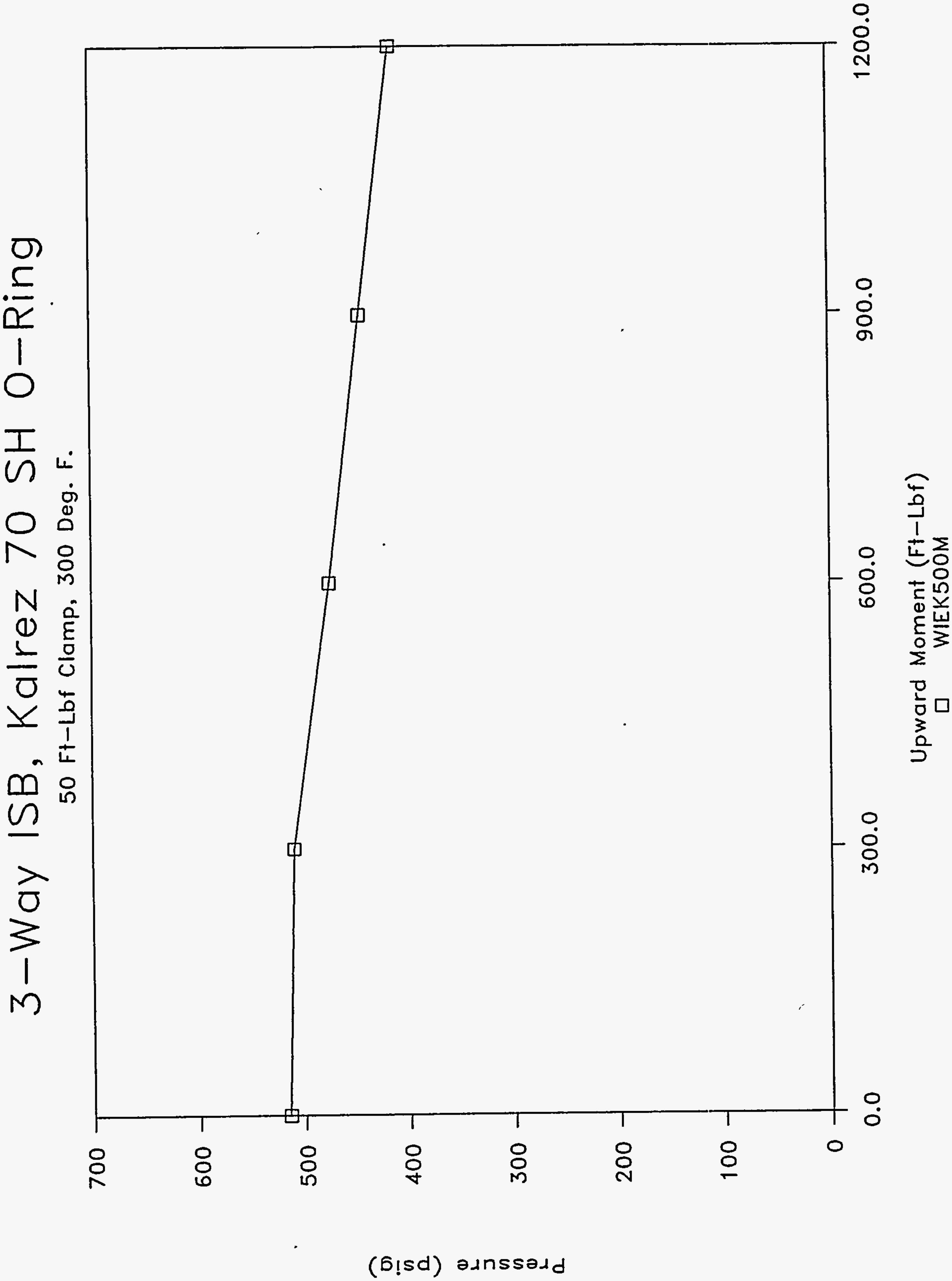
INCREASED PRESSURE TO 750 PSIG GRAPH NAME = WIEK750L

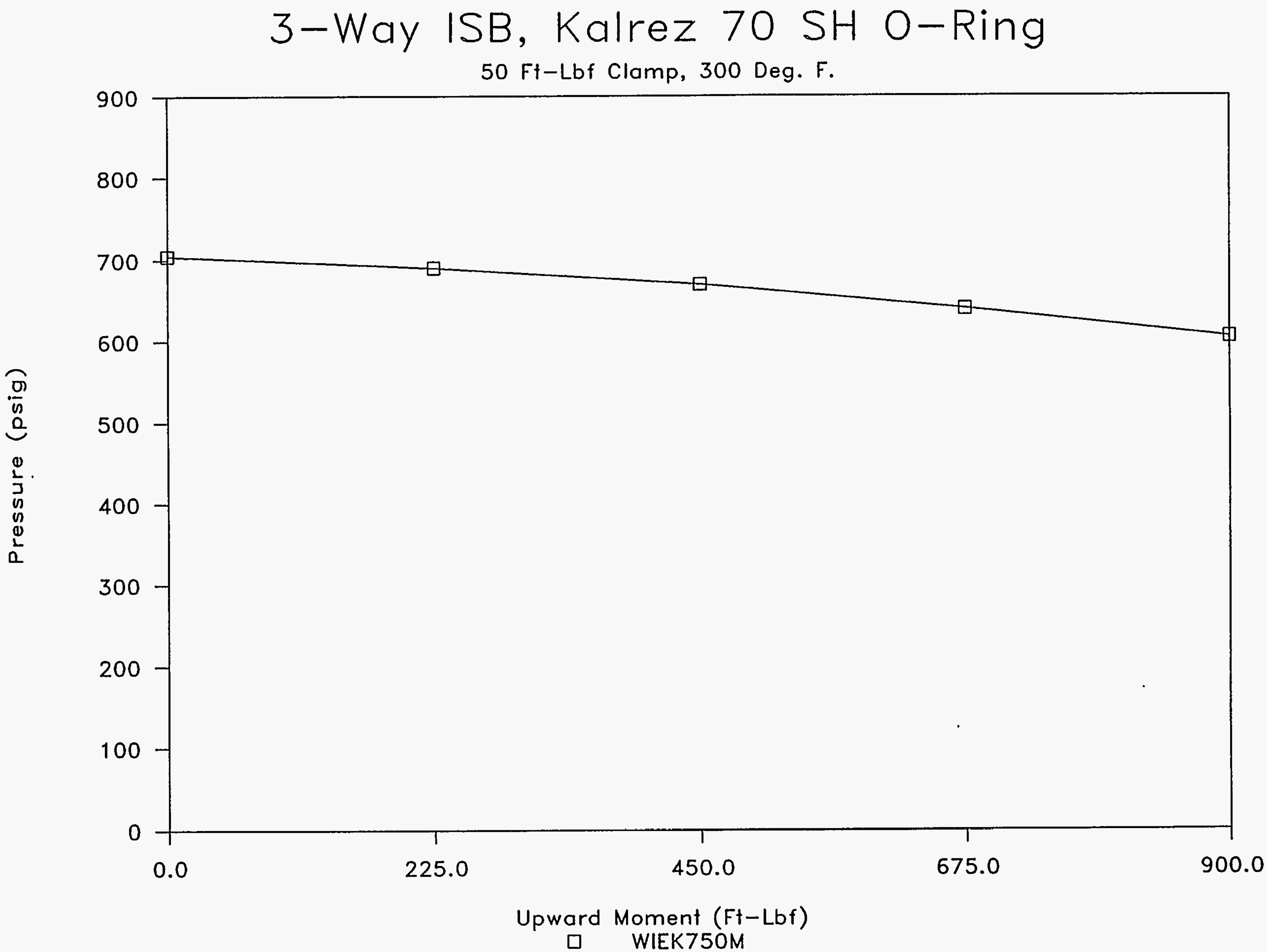
755	22	0	22.00	0	0.4453	0.0
760	24	0	24.00	150	0.4453	66.8
740	26	0	26.00	300	0.4453	133.6
740	28	0	28.00	450	0.4453	200.4
730	30	0	30.00	600	0.4453	267.2

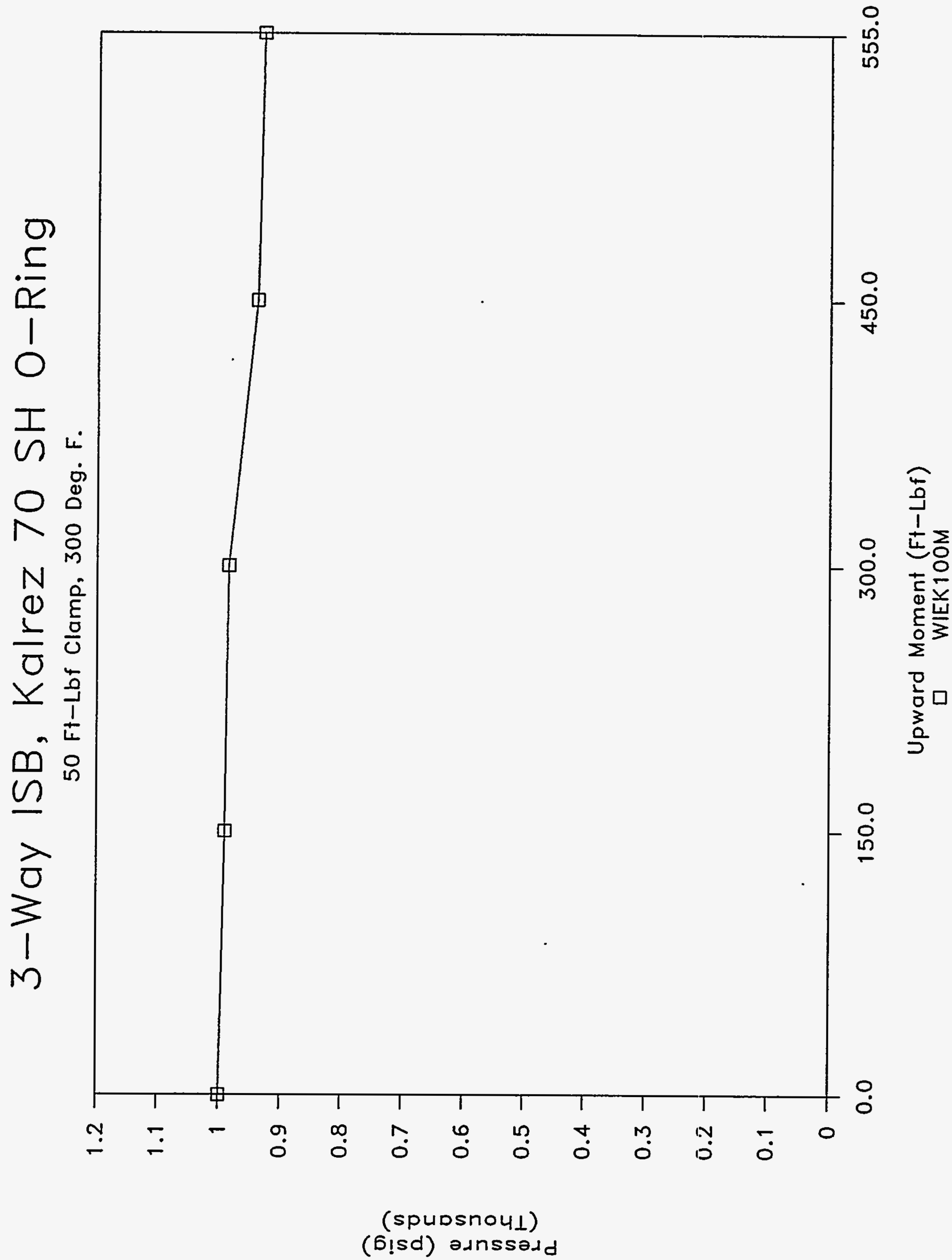
INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = WIEK100L

985	32	0	32.00	0	0.4453	0.0
985	34	0	34.00	100	0.4453	44.5
1000	36	0	36.00	200	0.4453	89.1
995	38	0	38.00	300	0.4453	133.6
995	40	0	40.00	370	0.4453	164.8


3-Way ISB, Kalrez 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
0
50
100
150
200
250
300
350
0.0
0.0
375.0
750.0
1125.0
1500.0
Upward Moment (Ft-Lbf)
WIEK250M


3-Way ISB, Kalrez 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft-Lbf)
WIEK500M


3-Way ISB, Kalrez 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
900
800
700
600
500
400
300
200
100
0
Pressure (psig)
0.0
225.0
450.0
675.0
900.0
Upward Moment (Ft-Lbf)
WIEK750M


3-Way ISB, Kalrez 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
150.0
300.0
450.0
555.0
Upward Moment (Ft-Lbf)
WIEK100M

DECEMBER 02, 1994
2" 3-WAY ISB CONNECTOR, KALREZ O-RING, 70 DUROMETER, ELEVATED TEMP.
PART # AS-568A K# 119, DuPONT CO., CURE DATE 04/18/94
LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIEK250M
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 300 DEG. F.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
270	0	0	0.00	0	1.5000	0.0
305	2	0	2.00	0	1.5000	0.0
310	4	0	4.00	250	1.5000	375.0
305	6	0	6.00	500	1.5000	750.0
285	8	0	8.00	750	1.5000	1125.0
255	10	0	10.00	1000	1.5000	1500.0

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = WIEK500M

515	12	0	12.00	0	1.5000	0.0
510	14	0	14.00	200	1.5000	300.0
475	16	0	16.00	400	1.5000	600.0
445	18	0	18.00	600	1.5000	900.0
415	20	0	20.00	800	1.5000	1200.0

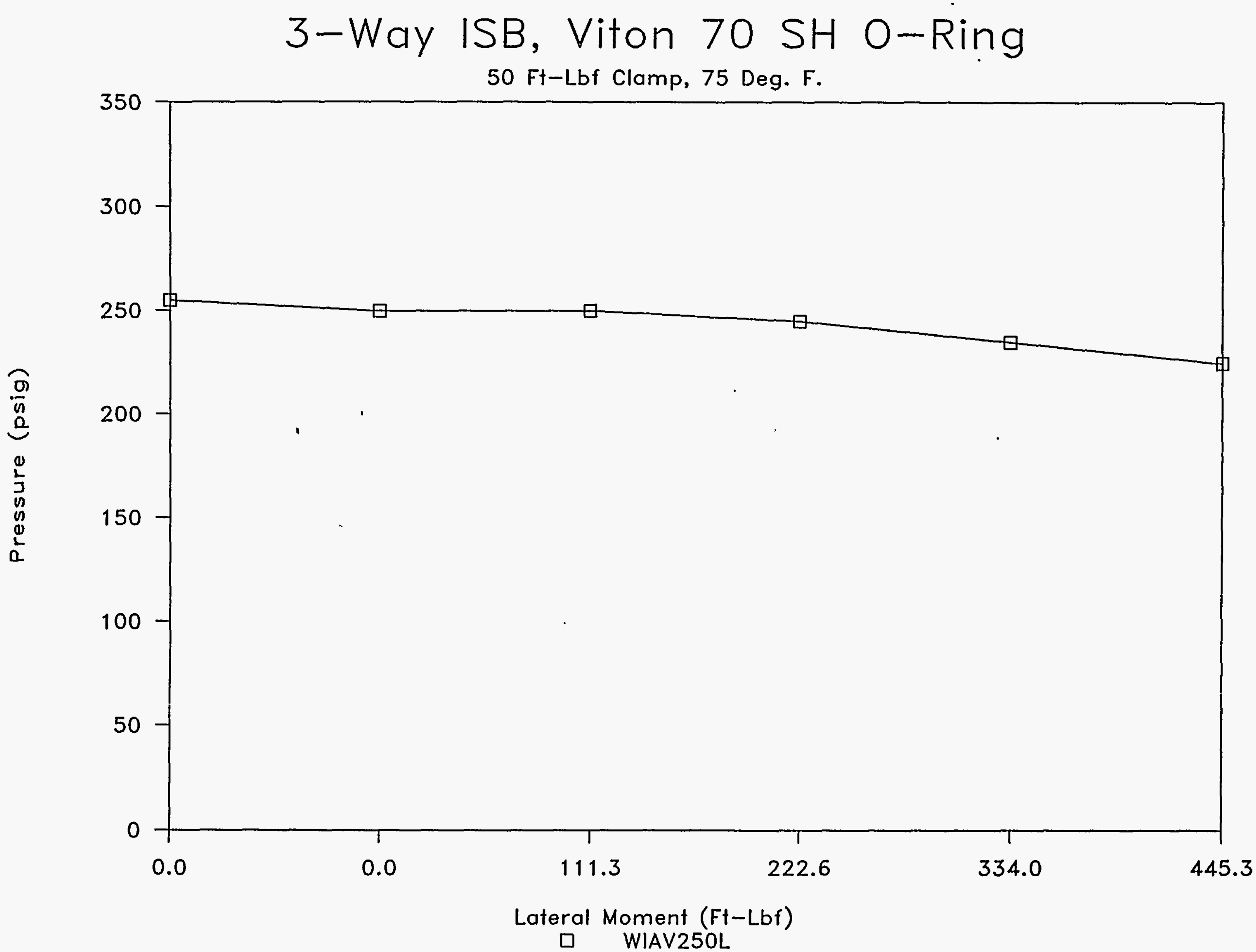
INCREASED PRESSURE TO 750 PSIG GRAPH NAME = WIEK750M

705	22	0	22.00	0	1.5000	0.0
690	24	0	24.00	150	1.5000	225.0
670	26	0	26.00	300	1.5000	450.0
640	28	0	28.00	450	1.5000	675.0
605	30	0	30.00	600	1.5000	900.0

INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = WIEK100M

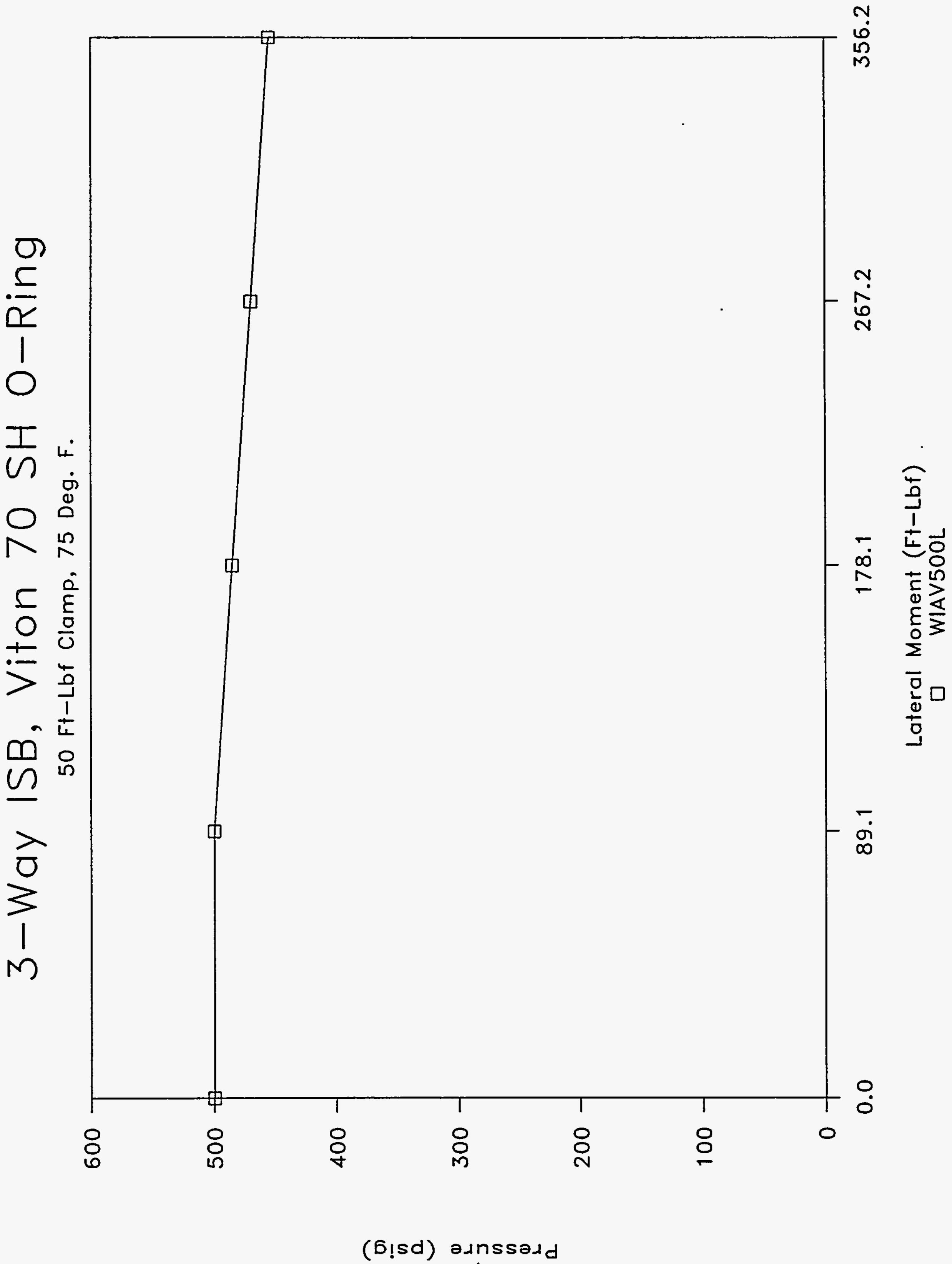
1000	32	0	32.00	0	1.5000	0.0
990	34	0	34.00	100	1.5000	150.0
985	36	0	36.00	200	1.5000	300.0
940	38	0	38.00	300	1.5000	450.0
930	40	0	40.00	370	1.5000	555.0

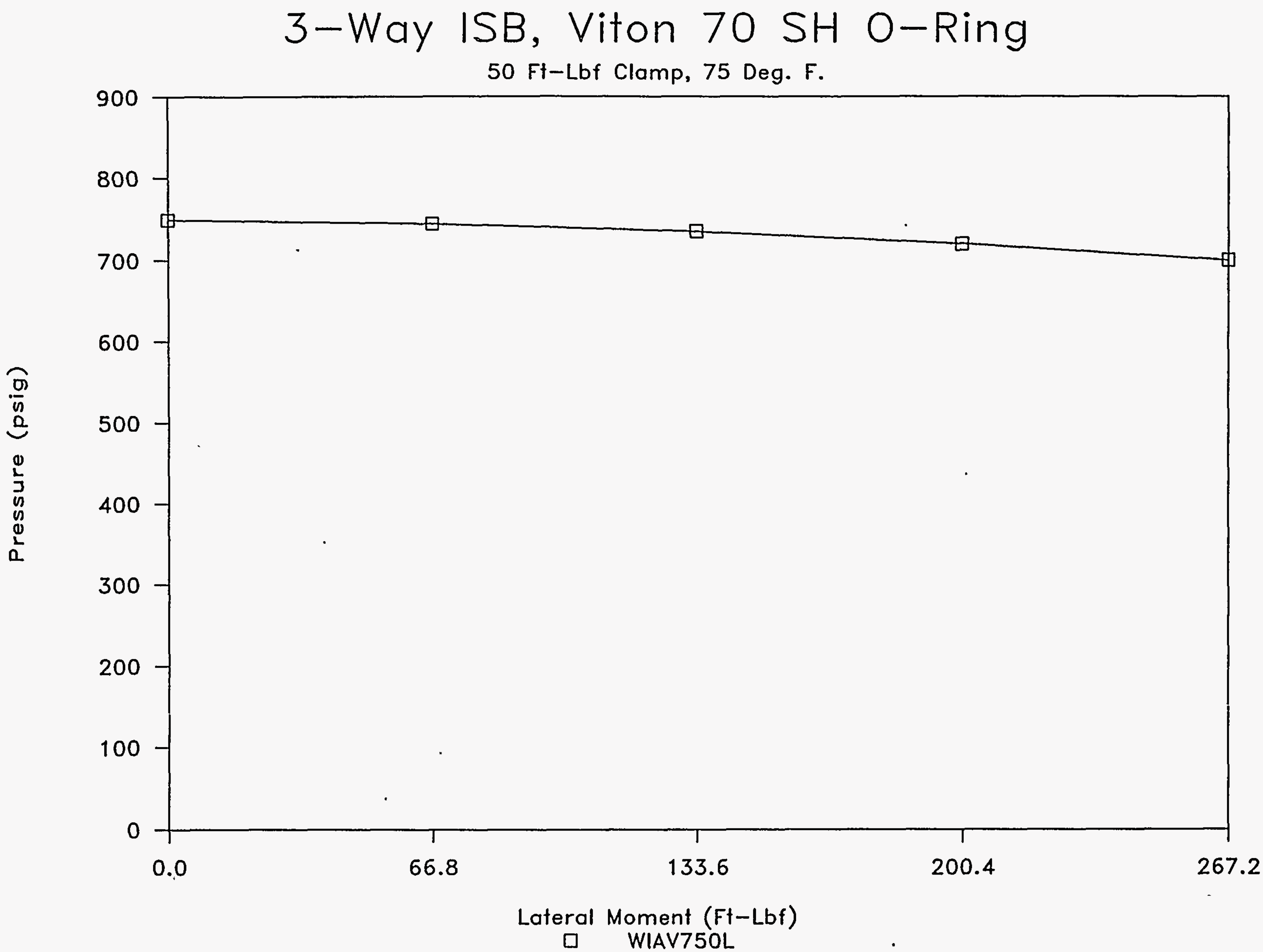
APPENDIX Q: GRAPHS OF THREE-WAY VITON TESTS

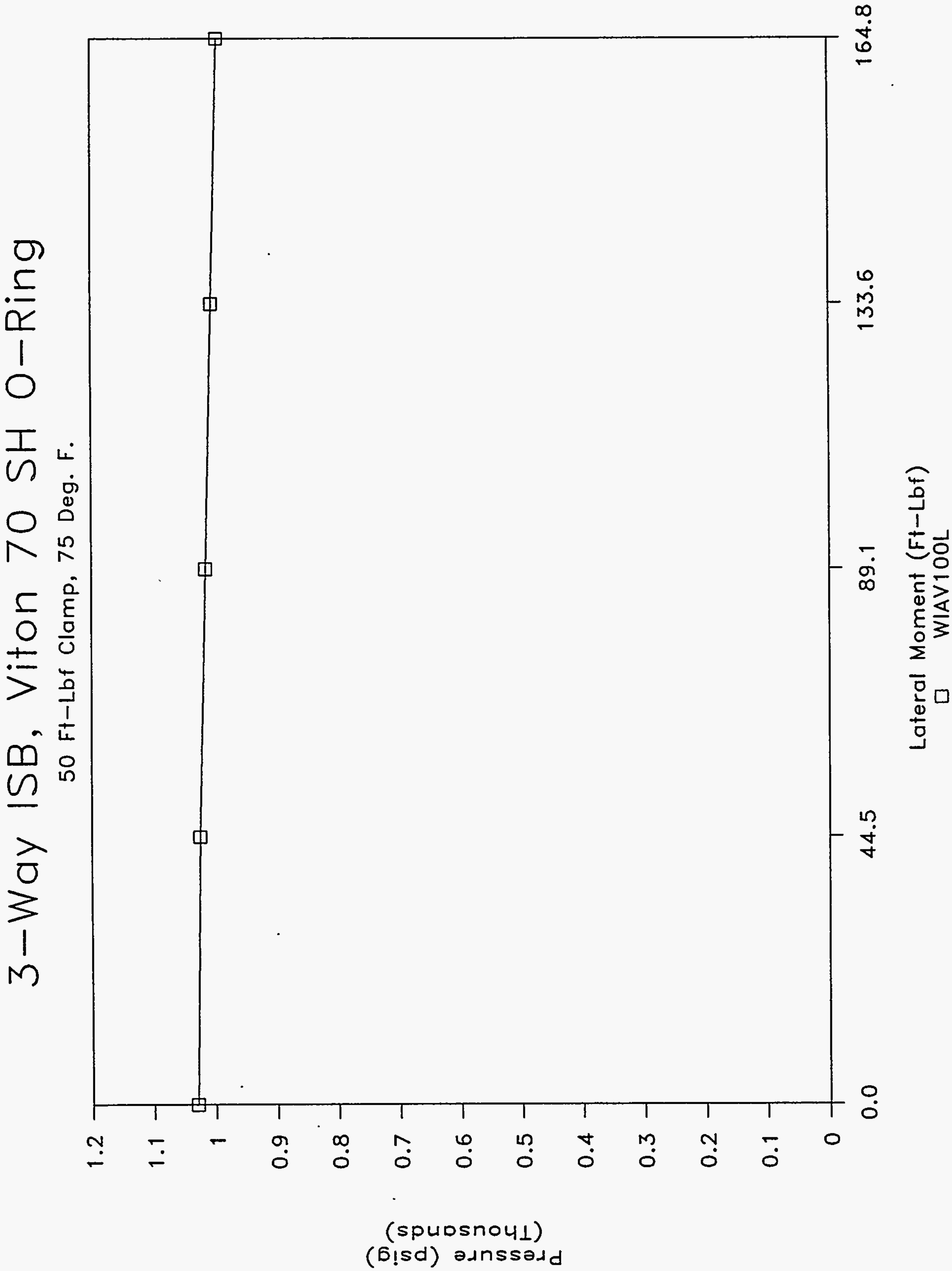


3-Way ISB, Viton 70 SH O-Ring
50 Ft-Lbf Clamp, 75 Deg. F.
Pressure (psig)
350
300
250
200
150
100
50
0
0.0
0.0
111.3
222.6
334.0
445.3
Lateral Moment (Ft-Lbf)
WIAV250L

Q-2

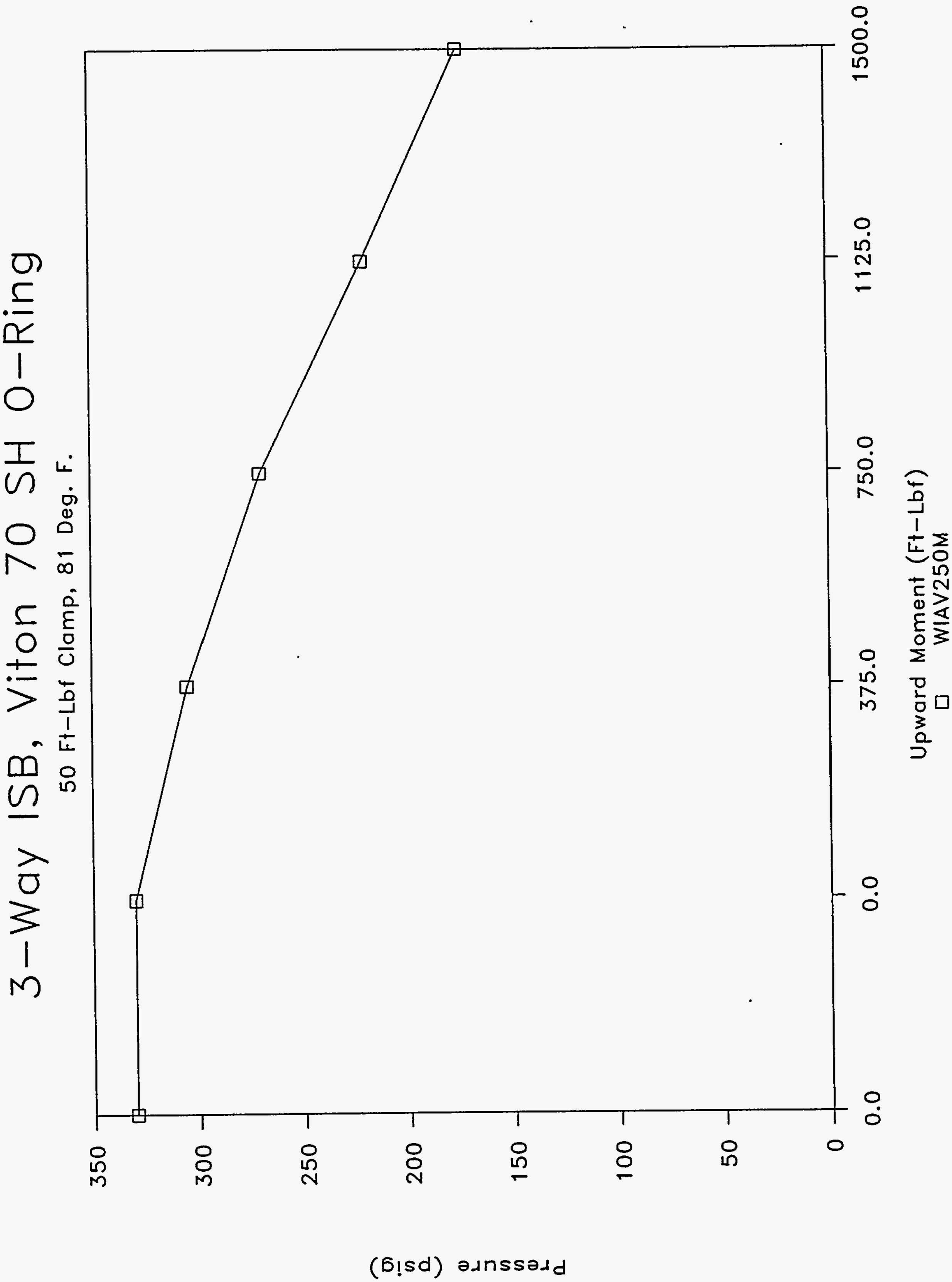

3-Way ISB, Viton 70 SH O-Ring
50 Ft-Lbf Clamp, 75 Deg. F.
Pressure (psig)
0
100
200
300
400
500
600
Lateral Moment (Ft-Lbf)
0.0
89.1
178.1
267.2
356.2
WIAV500L

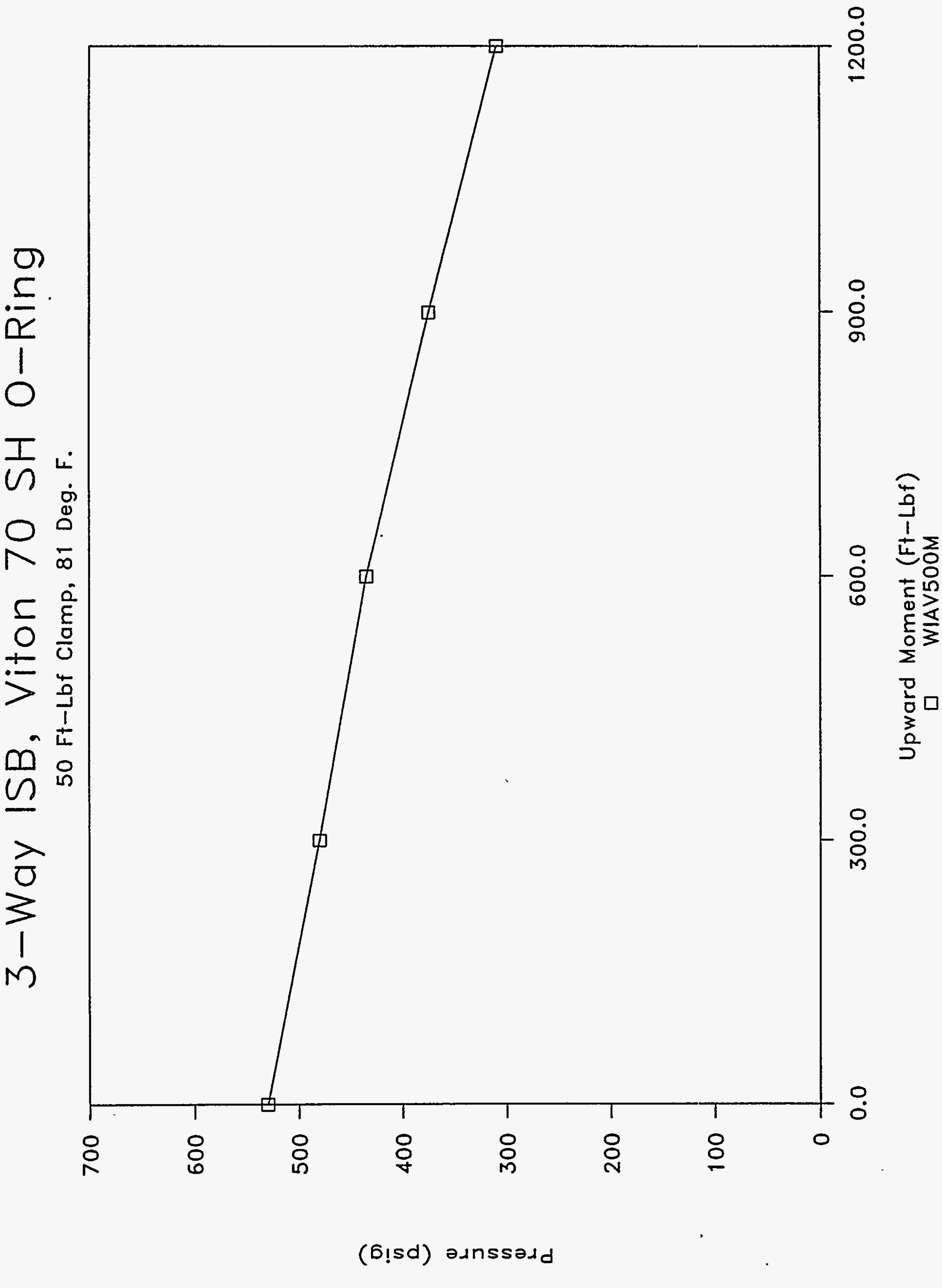

3-Way ISB, Viton 70 SH O-Ring
50 Ft-Lbf Clamp, 75 Deg. F.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
66.8
133.6
200.4
267.2
Lateral Moment (Ft-Lbf)
WIAV750L

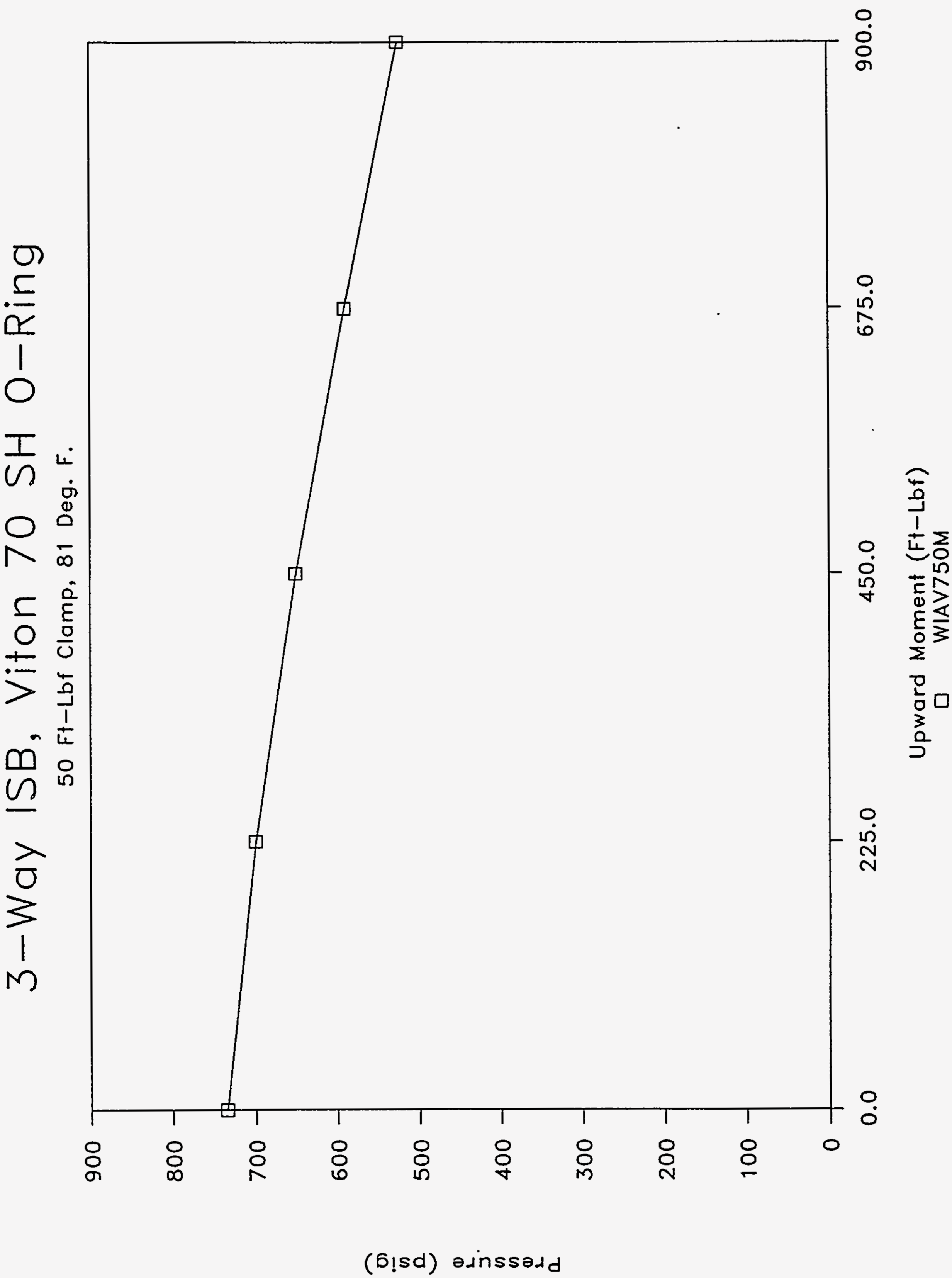

3-Way ISB, Viton 70 SH O-Ring
50 Ft-Lbf Clamp, 75 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
44.5
89.1
133.6
164.8
Lateral Moment (Ft-Lbf)
WIAV100L

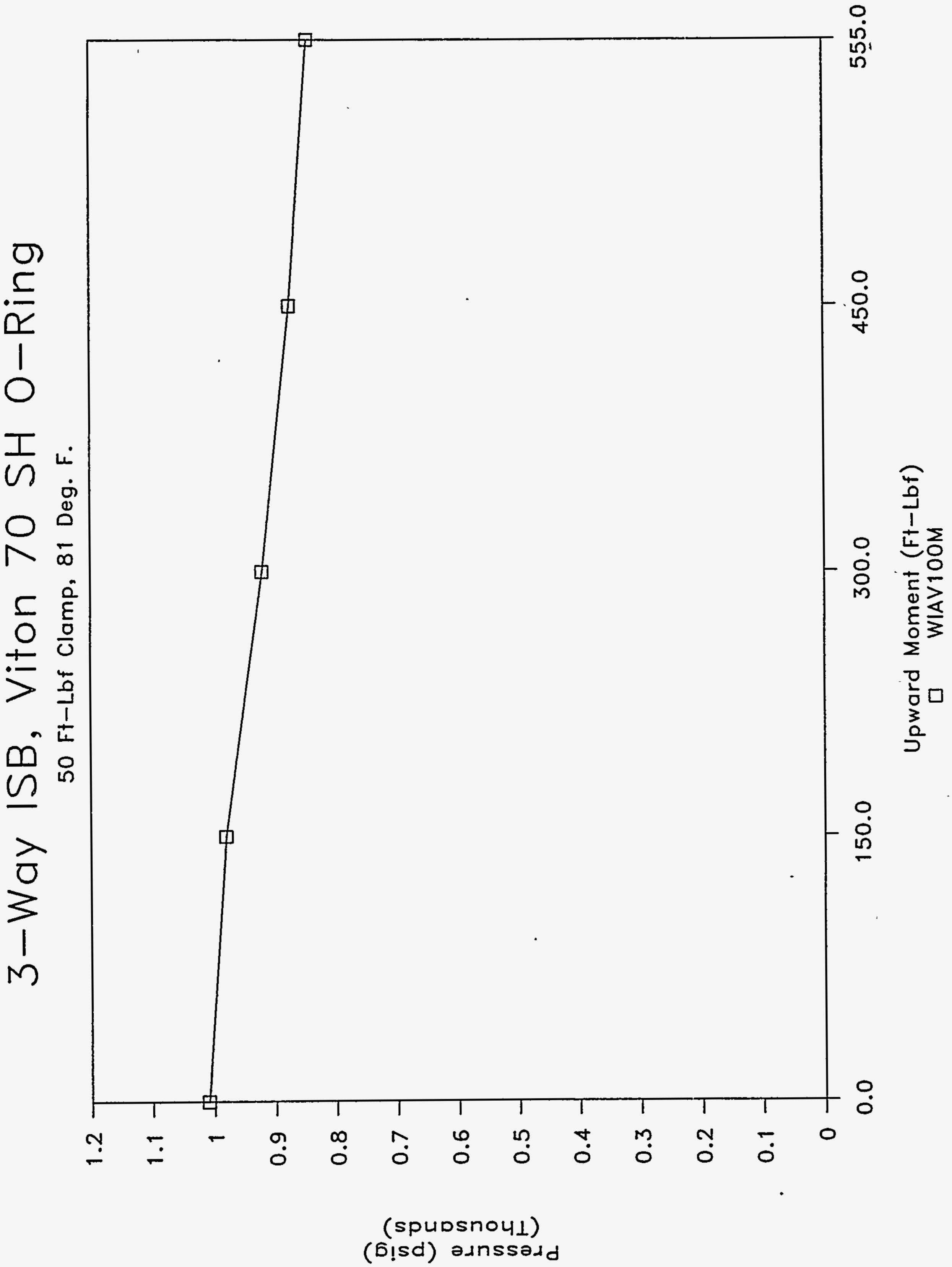
DECEMBER 06, 1994
2" 3-WAY ISB CONNECTOR, VITON O-RING, 70 DUROMETER, AMBIENT TEMP.
PART # 2-142 V884-75, PARKER SEAL CO., BATCH 311986, CURE DATE 3Q93
LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIAV250L
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 75 DEG. F.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
255	0	0	0.00	0	0.4453	0.0
250	2	0	2.00	0	0.4453	0.0
250	4	0	4.00	250	0.4453	111.3
245	6	0	6.00	500	0.4453	222.7
235	8	0	8.00	750	0.4453	334.0
225	10	0	10.00	1000	0.4453	445.3
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = WIAV500L		
500	12	0	12.00	0	0.4453	0.0
500	14	0	14.00	200	0.4453	89.1
485	16	0	16.00	400	0.4453	178.1
470	18	0	18.00	600	0.4453	267.2
455	20	0	20.00	800	0.4453	356.2
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = WIAV750L		
750	22	0	22.00	0	0.4453	0.0
745	24	0	24.00	150	0.4453	66.8
735	26	0	26.00	300	0.4453	133.6
720	28	0	28.00	450	0.4453	200.4
700	30	0	30.00	600	0.4453	267.2
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = WIAV100L		
1030	32	0	32.00	0	0.4453	0.0
1025	34	0	34.00	100	0.4453	44.5
1015	36	0	36.00	200	0.4453	89.1
1005	38	0	38.00	300	0.4453	133.6
995	40	0	40.00	370	0.4453	164.8


3-Way ISB, Viton 70 SH O-Ring
50 Ft-Lbf Clamp, 81 Deg. F.
Pressure (psig)
350
300
250
200
150
100
50
0
0.0
0.0
375.0
750.0
1125.0
1500.0
Upward Moment (Ft-Lbf)
WIAV250M


3-Way ISB, Viton 70 SH O-Ring
50 Ft-Lbf Clamp, 81 Deg. F.
Pressure (psig)
0
100
200
300
400
500
600
700
Upward Moment (Ft-Lbf)
0.0
300.0
600.0
900.0
1200.0
WIAV500M


3-Way ISB, Viton 70 SH O-Ring
50 Ft-Lbf Clamp, 81 Deg. F.
Pressure (psig)
0
100
200
300
400
500
600
700
800
900
Upward Moment (Ft-Lbf)
0.0
225.0
450.0
675.0
900.0
WIAV750M


3-Way ISB, Viton 70 SH O-Ring
50 Ft-Lbf Clamp, 81 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
150.0
300.0
450.0
555.0
Upward Moment (Ft-Lbf)
WIAV100M

NOVEMBER 28, 1994
2" 3-WAY ISB CONNECTOR, VITON O-RING, 70 DUROMETER, AMBIENT TEMP.
PART # 2-142 V884-75, PARKER SEAL CO., BATCH 311986, CURE DATE 3Q93
LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIAV250M
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 81 DEG. F.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
330	0	0	0.00	0	1.5000	0.0
330	2	1	2.02	0	1.5000	0.0
305	4	0	4.00	250	1.5000	375.0
270	6	0	6.00	500	1.5000	750.0
221	8	1	8.02	750	1.5000	1125.0
175	10	1	10.02	1000	1.5000	1500.0

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = WIAV500M

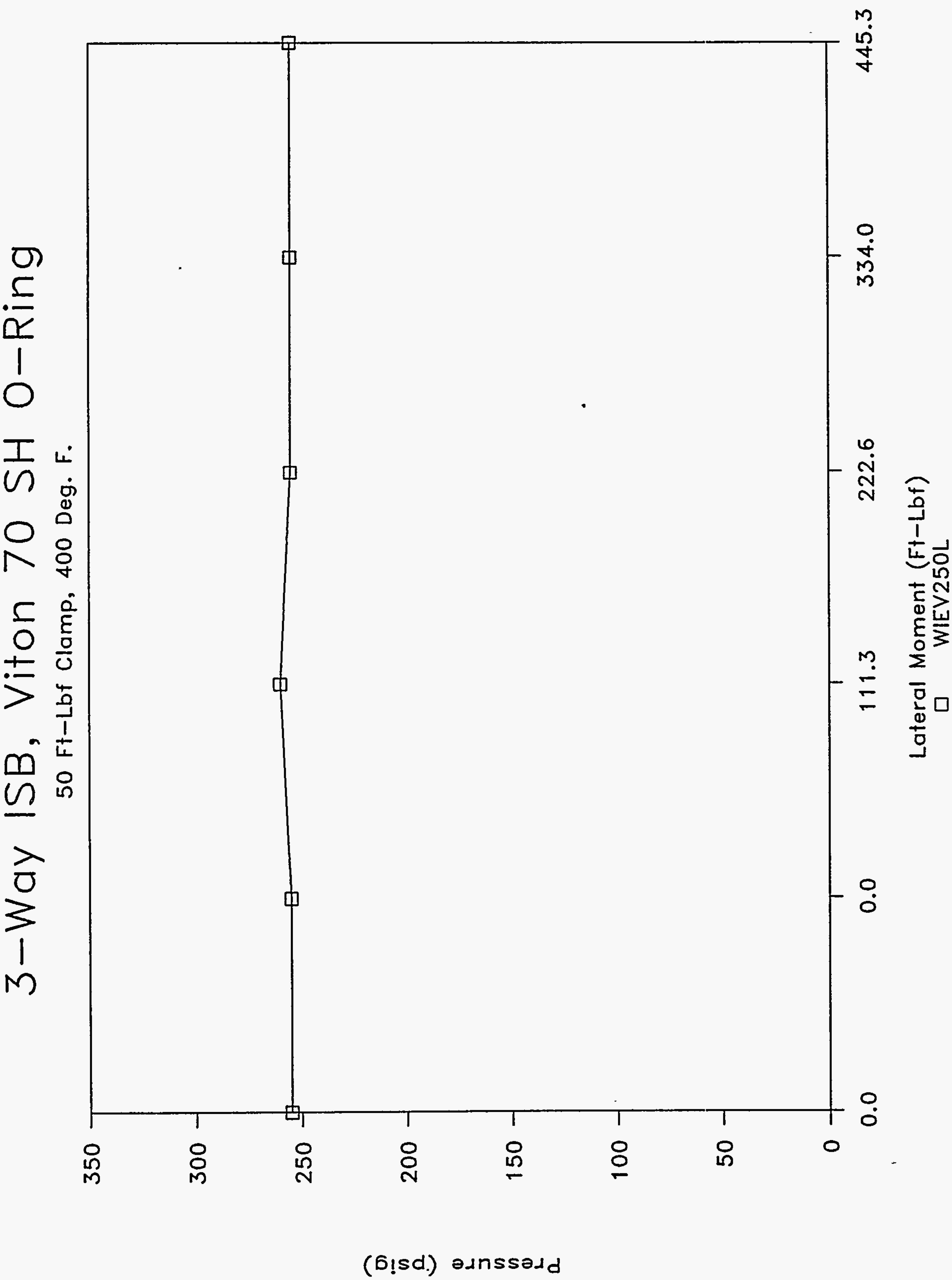
530	12	1	12.02	0	1.5000	0.0
480	14	0	14.00	200	1.5000	300.0
435	16	0	16.00	400	1.5000	600.0
375	18	0	18.00	600	1.5000	900.0
310	20	0	20.00	800	1.5000	1200.0

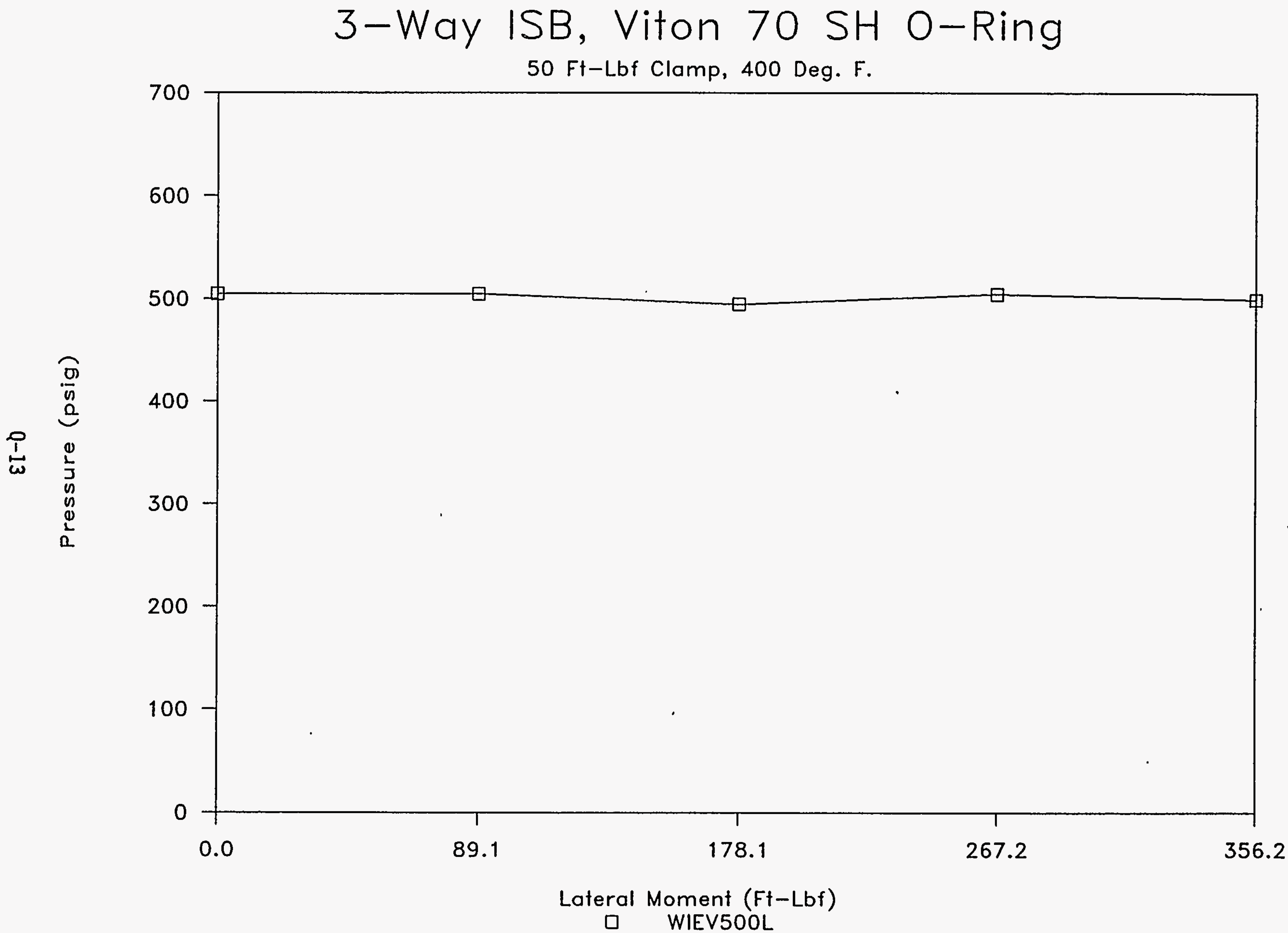
INCREASED PRESSURE TO 750 PSIG GRAPH NAME = WIAV750M

735	22	0	22.00	0	1.5000	0.0
700	24	0	24.00	150	1.5000	225.0
650	26	0	26.00	300	1.5000	450.0
590	28	0	28.00	450	1.5000	675.0
525	30	1	30.02	600	1.5000	900.0

INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = WIAV100M

1010	32	0	32.00	0	1.5000	0.0
980	34	0	34.00	100	1.5000	150.0
920	36	0	36.00	200	1.5000	300.0
875	38	0	38.00	300	1.5000	450.0
845	40	0	40.00	370	1.5000	555.0

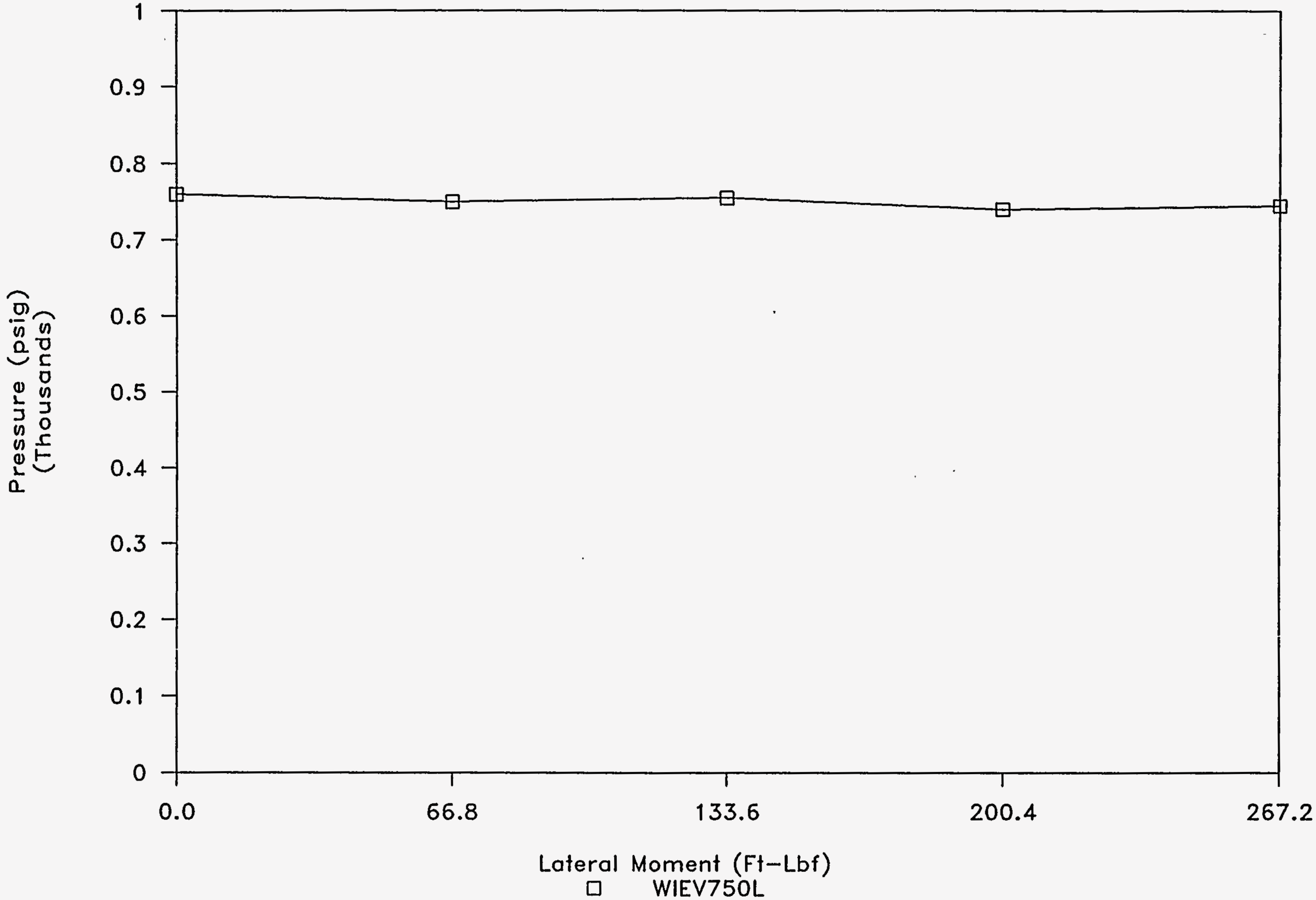

3-Way ISB, Viton 70 SH O-Ring
50 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
350
300
250
200
150
100
50
0
0.0
0.0
111.3
222.6
334.0
445.3
Lateral Moment (Ft-Lbf)
WIEV250L

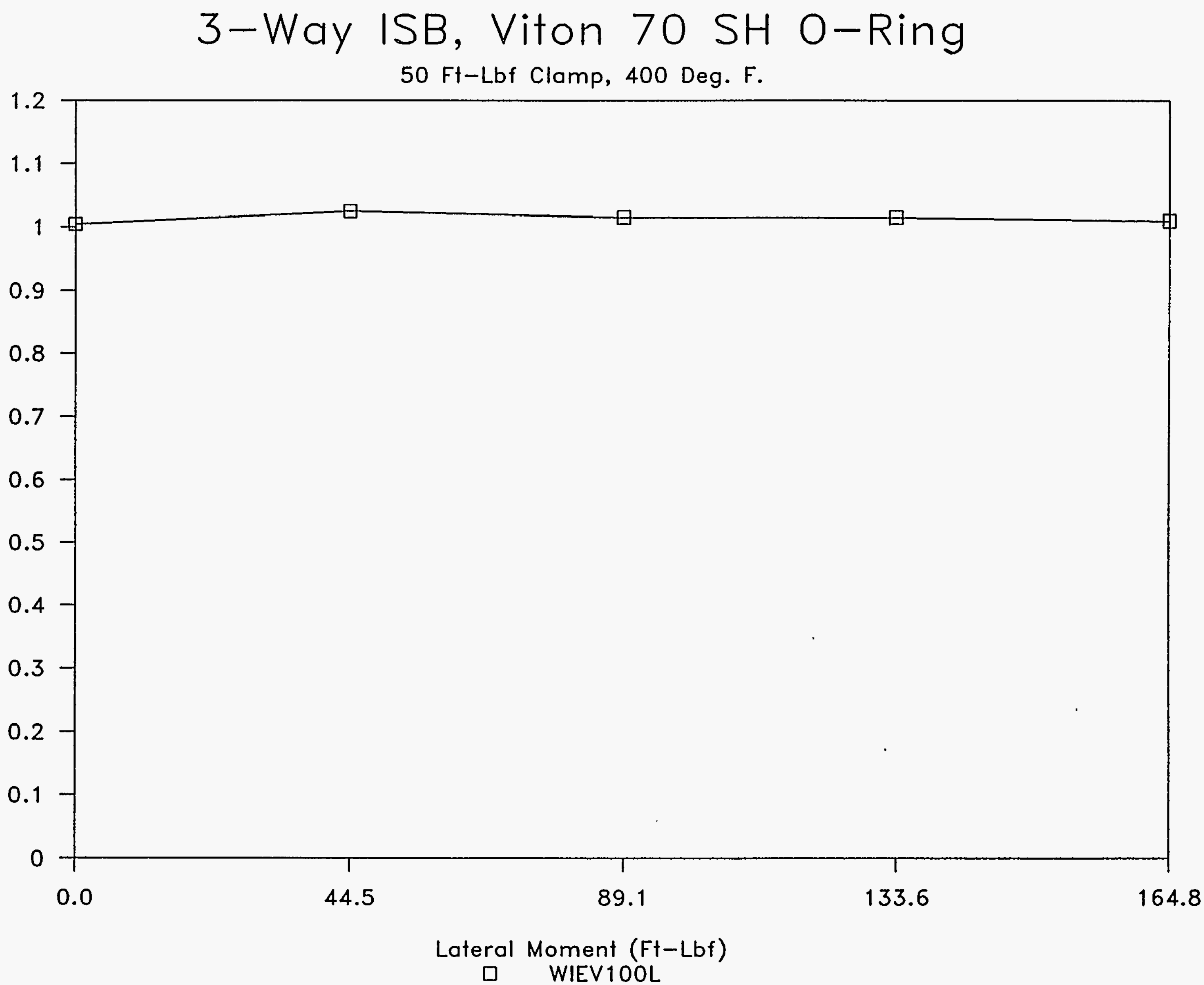


3-Way ISB, Viton 70 SH O-Ring
50 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
89.1
178.1
267.2
356.2
Lateral Moment (Ft-Lbf)
WIEV500L

3-Way ISB, Viton 70 SH O-Ring

50 Ft-Lbf Clamp, 400 Deg. F.




3-Way ISB, Viton 70 SH O-Ring
50 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig) (Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
44.5
89.1
133.6
164.8
Lateral Moment (Ft-Lbf)
WIEV100L

NOVEMBER 23, 1994
2" 3-WAY ISB CONNECTOR, VITON O-RING, 70 DUROMETER, ELEVATED TEMP.
PART # 2-142 V884-75, PARKER SEAL CO., BATCH 311986, CURE DATE 3Q93
LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIEV250L
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 400 DEG. F.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
255	0	0	0.00	0	0.4453	0.0
255	2	1	2.02	0	0.4453	0.0
260	4	2	4.03	250	0.4453	111.3
255	6	1	6.02	500	0.4453	222.7
255	8	1	8.02	750	0.4453	334.0
255	10	2	10.03	1000	0.4453	445.3

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = WIEV500L

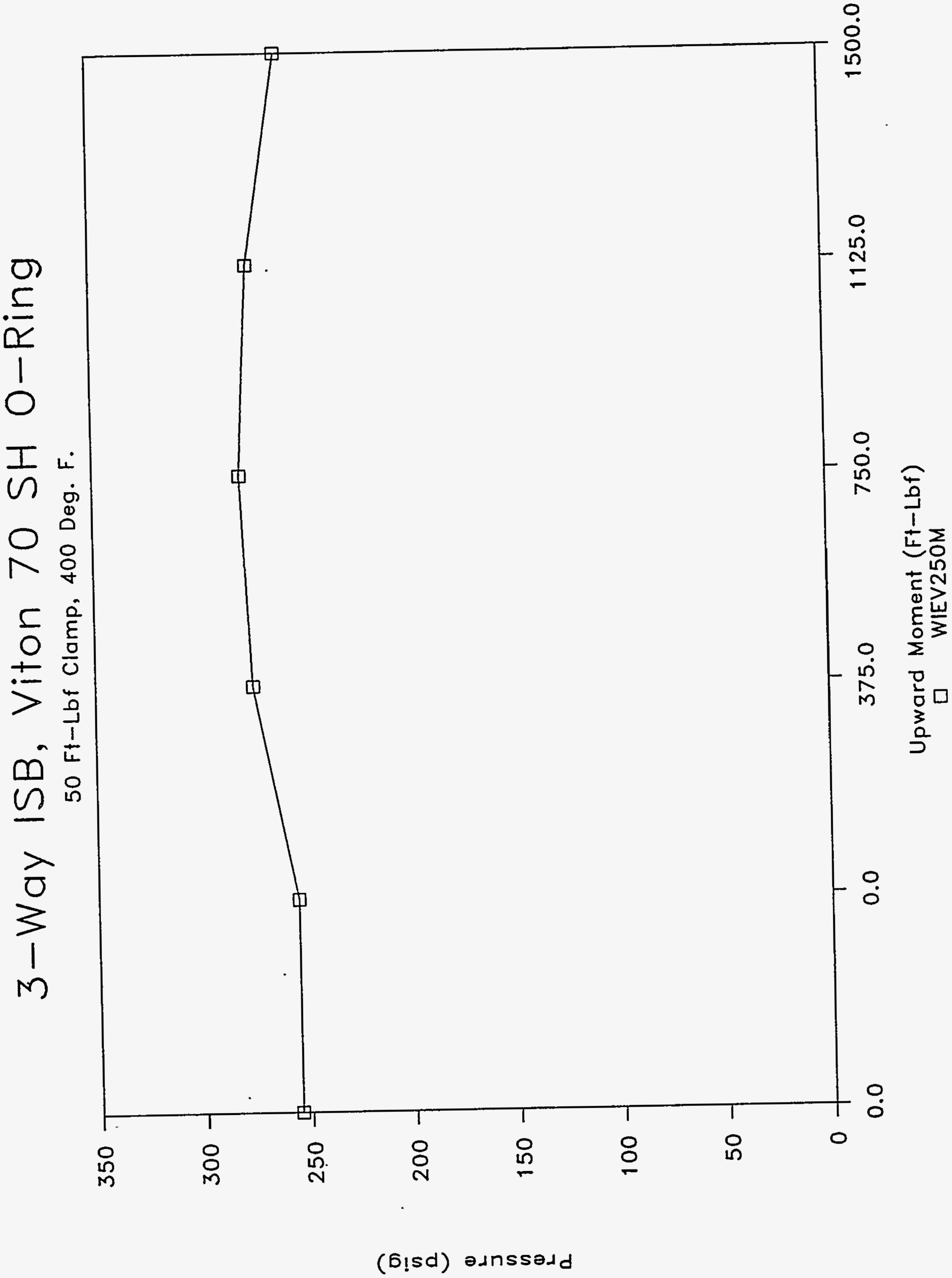
505	12	2	12.03	0	0.4453	0.0
505	14	1	14.02	200	0.4453	89.1
495	16	2	16.03	400	0.4453	178.1
505	18	3	18.05	600	0.4453	267.2
500	20	2	20.03	800	0.4453	356.2

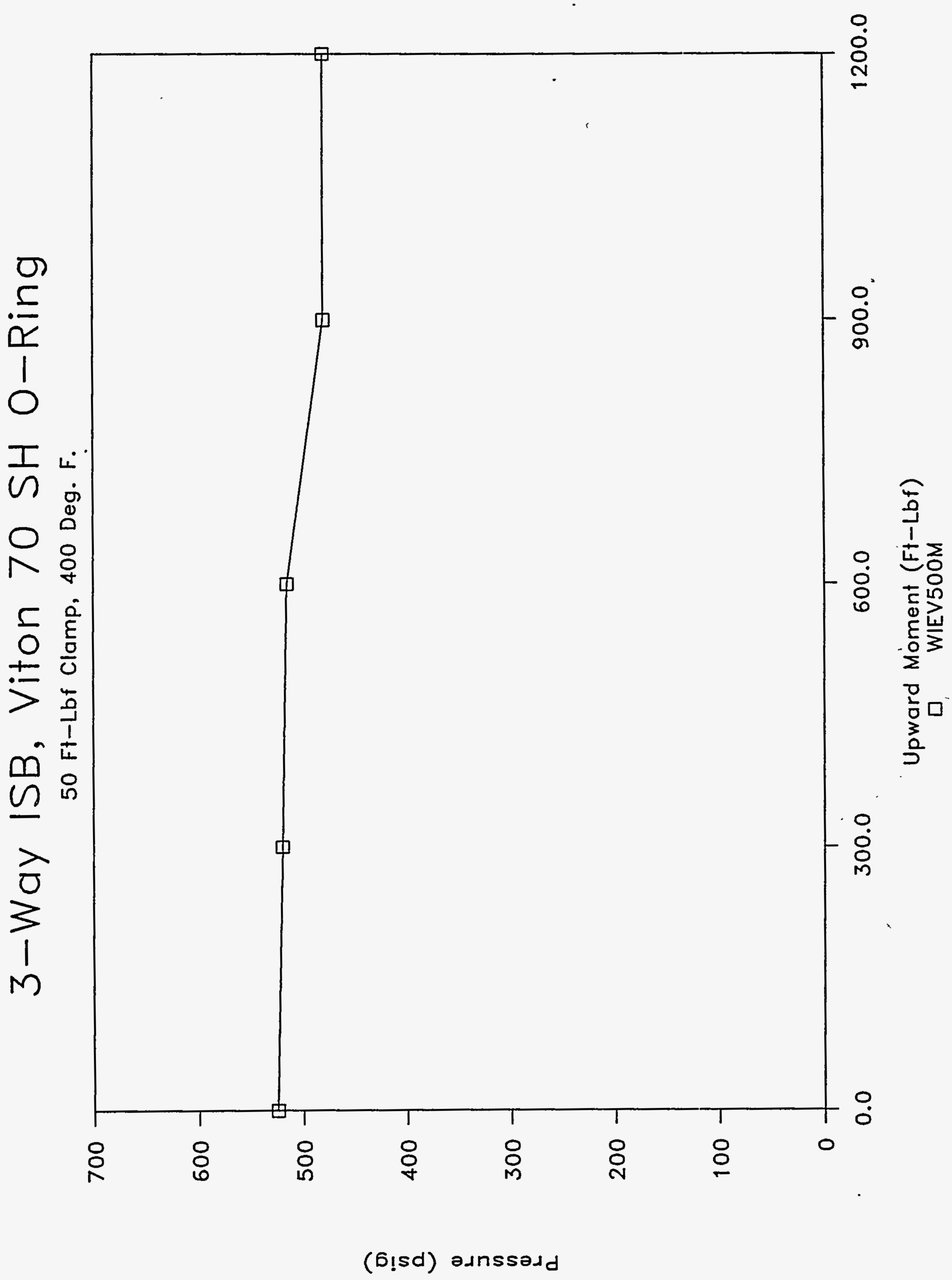
INCREASED PRESSURE TO 750 PSIG GRAPH NAME = WIEV750L

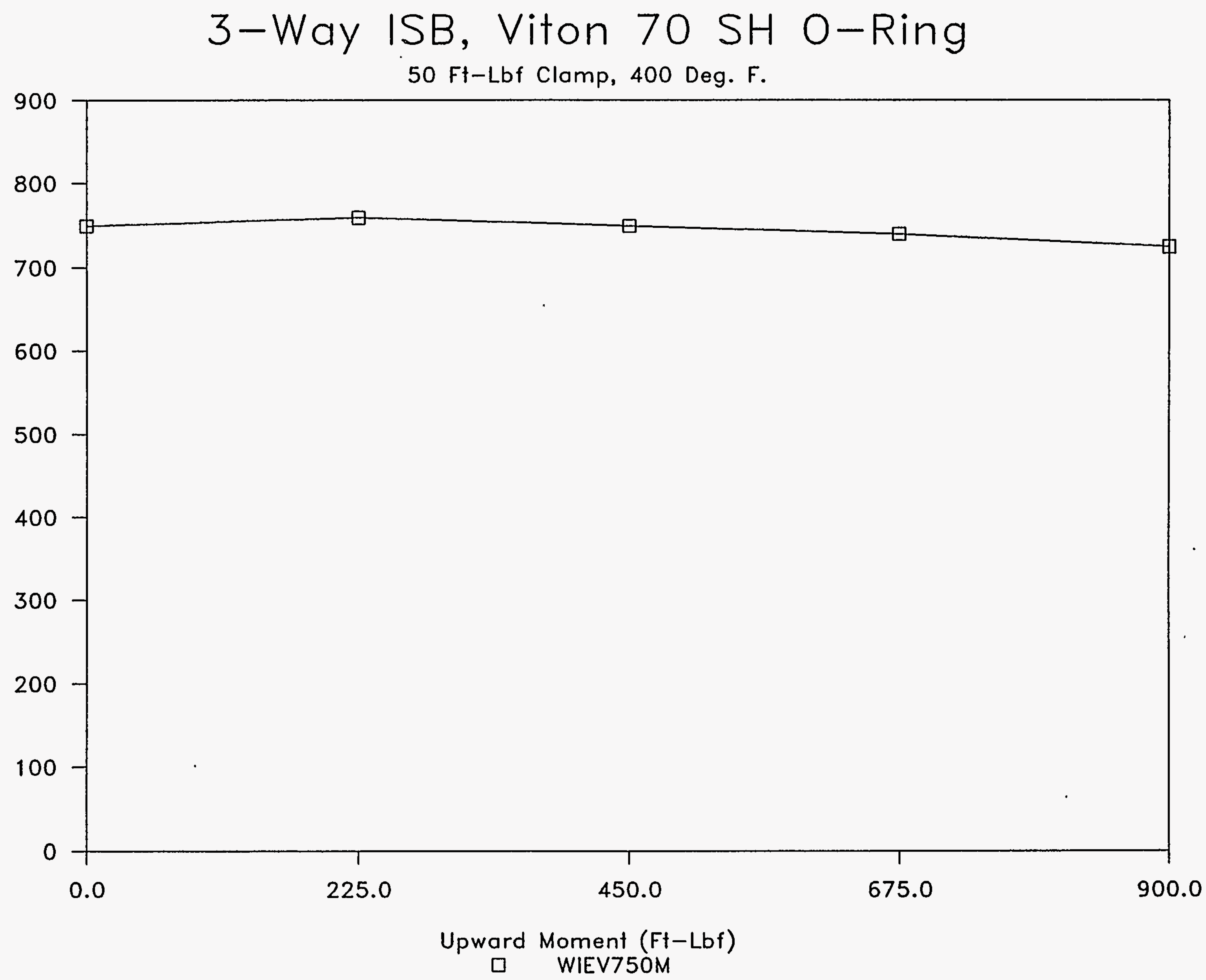
760	22	1	22.02	0	0.4453	0.0
750	24	1	24.02	150	0.4453	66.8
755	26	4	26.07	300	0.4453	133.6
740	28	2	28.03	450	0.4453	200.4
745	30	1	30.02	600	0.4453	267.2

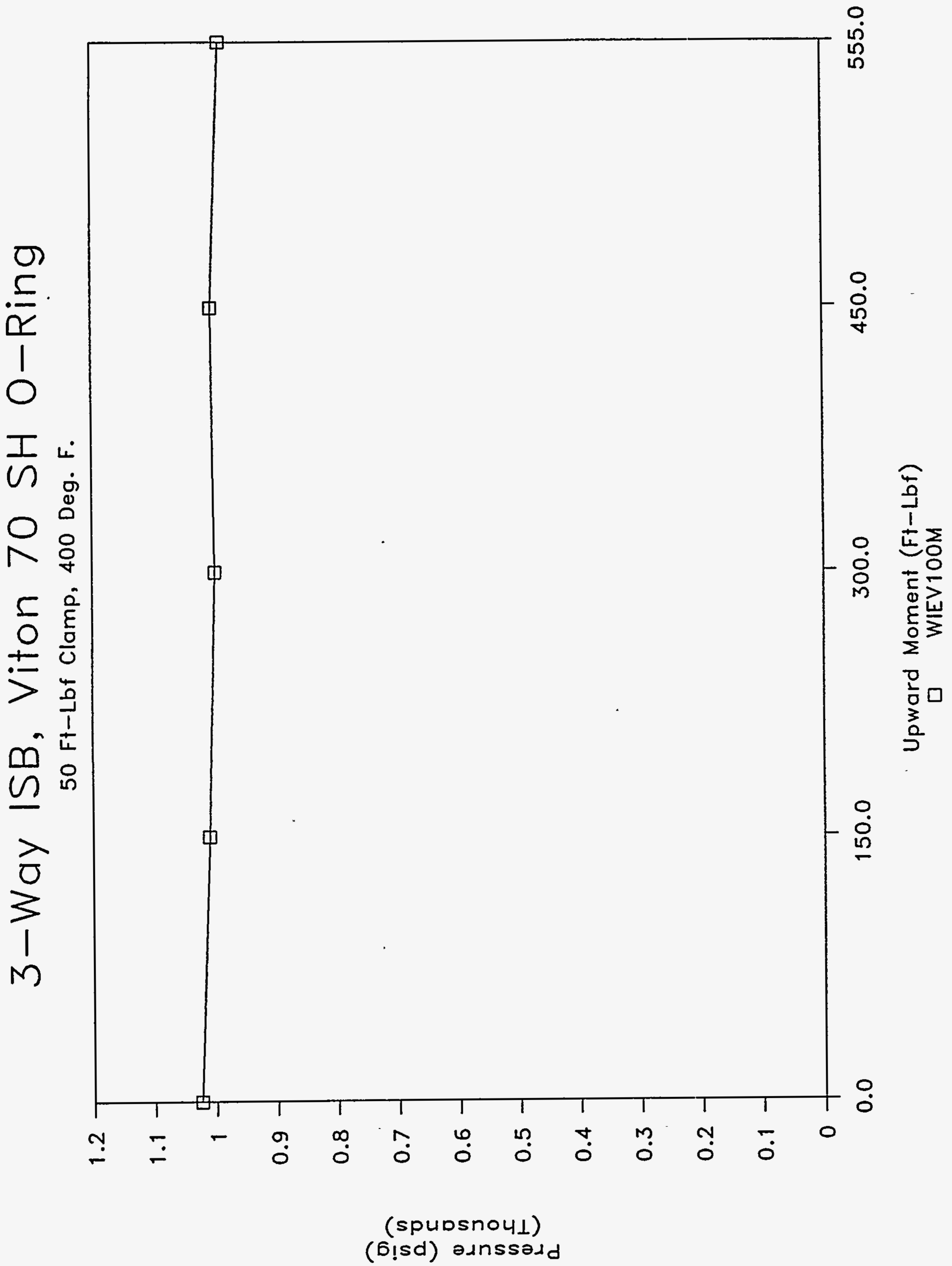
INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = WIEV100L

1005	32	2	32.03	0	0.4453	0.0
1025	34	1	34.02	100	0.4453	44.5
1015	36	1	36.02	200	0.4453	89.1
1015	38	7	38.12	300	0.4453	133.6
1010	40	2	40.03	370	0.4453	164.8


3-Way ISB, Viton 70 SH O-Ring
50 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
350
300
250
200
150
100
50
0
0.0
0.0
375.0
750.0
1125.0
1500.0
Upward Moment (Ft-Lbf)
WIEV250M


3-Way ISB, Viton 70 SH O-Ring
50 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft-Lbf)
WIEV500M


3-Way ISB, Viton 70 SH O-Ring
50 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
225.0
450.0
675.0
900.0
Upward Moment (Ft-Lbf)
WIEV750M


3-Way ISB, Viton 70 SH O-Ring
50 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
150.0
300.0
450.0
555.0
Upward Moment (Ft-Lbf)
WIEV100M

NOVEMBER 28, 1994
2" 3-WAY ISB CONNECTOR, VITON O-RING, 70 DUROMETER, ELEVATED TEMP.
PART # 2-142 V884-75, PARKER SEAL CO., BATCH 311986, CURE DATE 3Q93
LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIEV250M
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 400 DEG. F.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
255	0	0	0.00	0	1.5000	0.0
255	2	1	2.02	0	1.5000	0.0
275	4	2	4.03	250	1.5000	375.0
280	6	5	6.08	500	1.5000	750.0
275	8	4	8.07	750	1.5000	1125.0
260	10	6	10.10	1000	1.5000	1500.0

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = WIEV500M

525	12	1	12.02	0	1.5000	0.0
520	14	1	14.02	200	1.5000	300.0
515	16	1	16.02	400	1.5000	600.0
480	18	2	18.03	600	1.5000	900.0
480	20	1	20.02	800	1.5000	1200.0

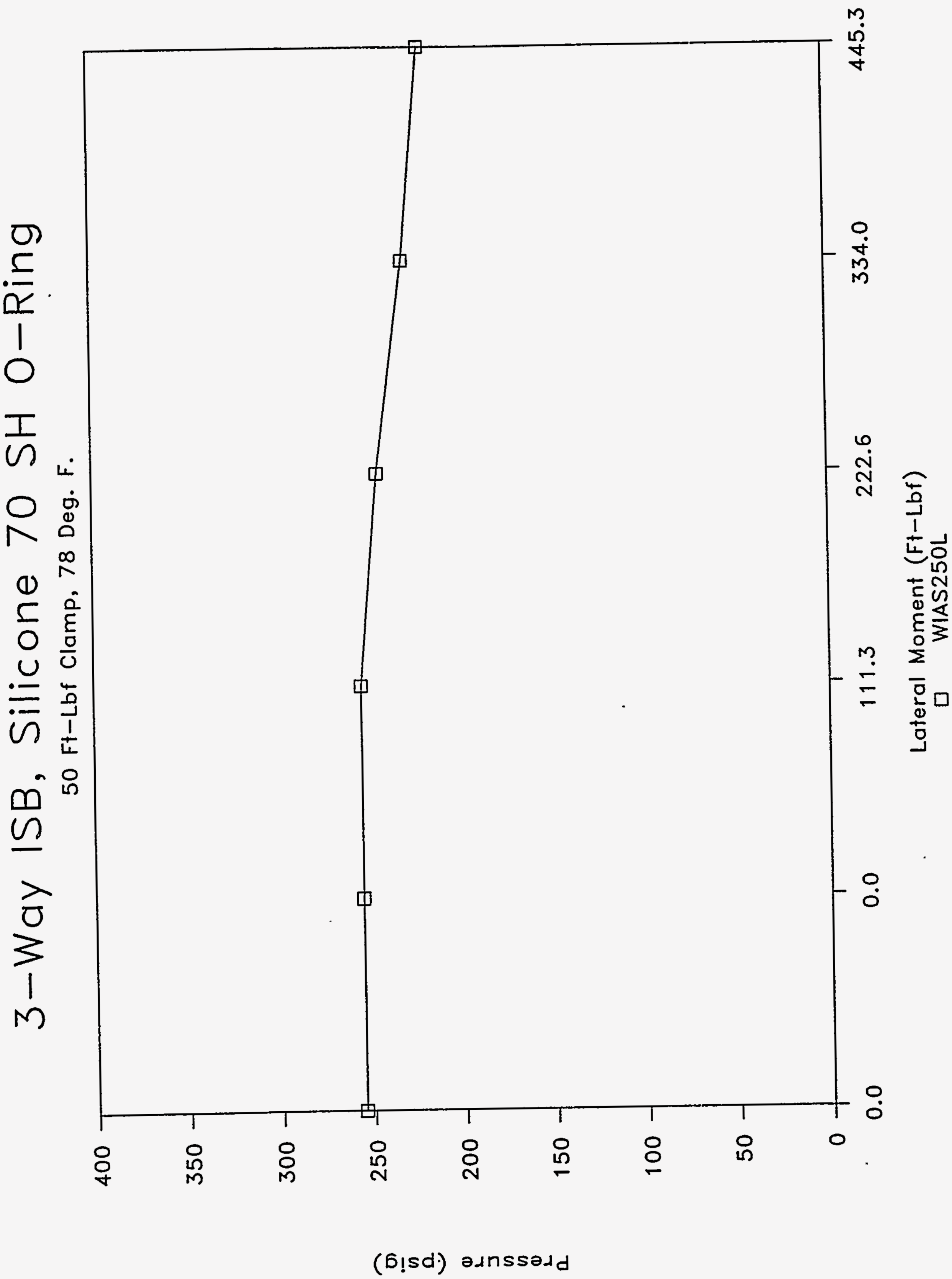
INCREASED PRESSURE TO 750 PSIG GRAPH NAME = WIEV750M

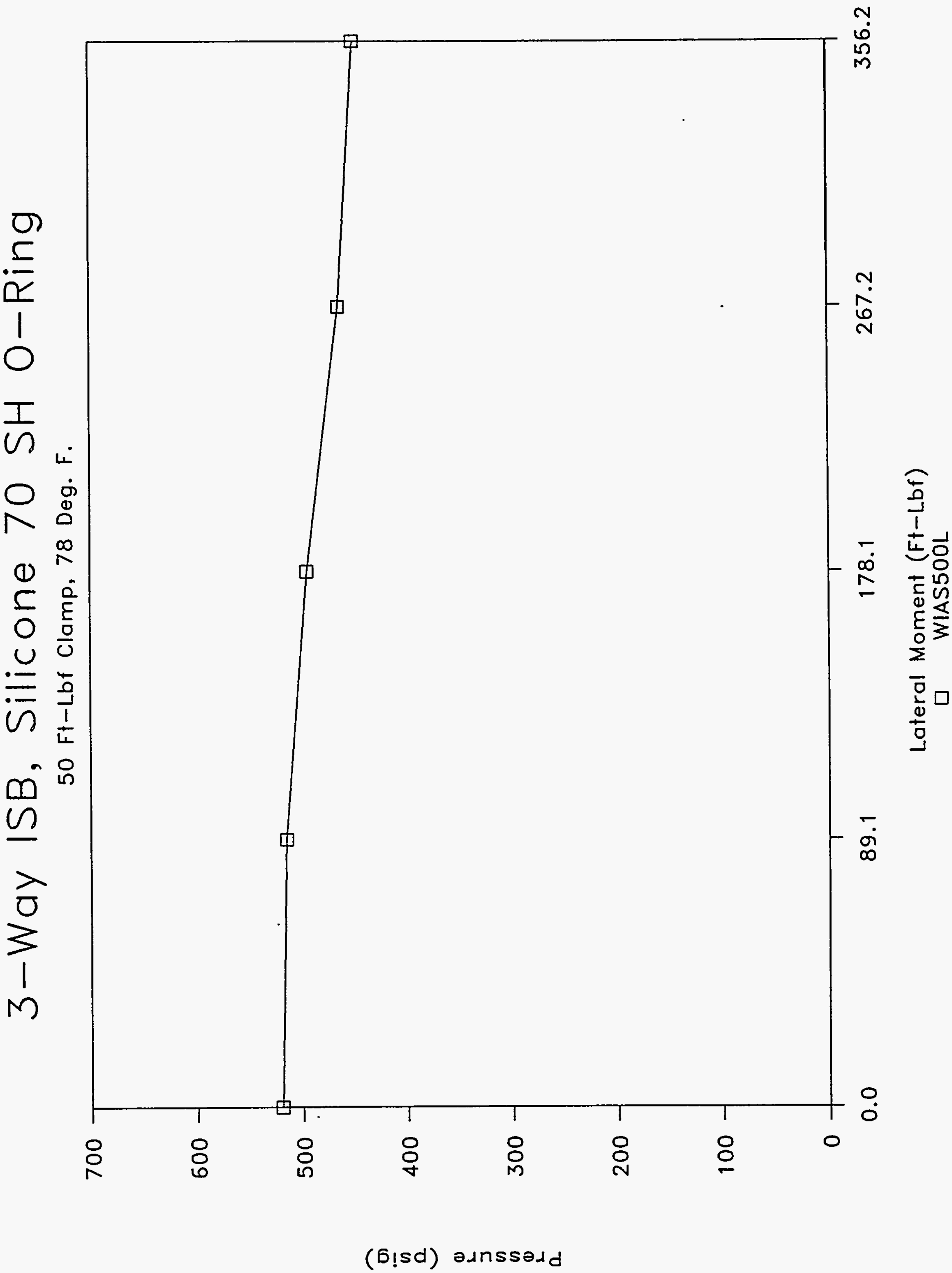
750	22	3	22.05	0	1.5000	0.0
760	24	1	24.02	150	1.5000	225.0
750	26	1	26.02	300	1.5000	450.0
740	28	1	28.02	450	1.5000	675.0
725	30	1	30.02	600	1.5000	900.0

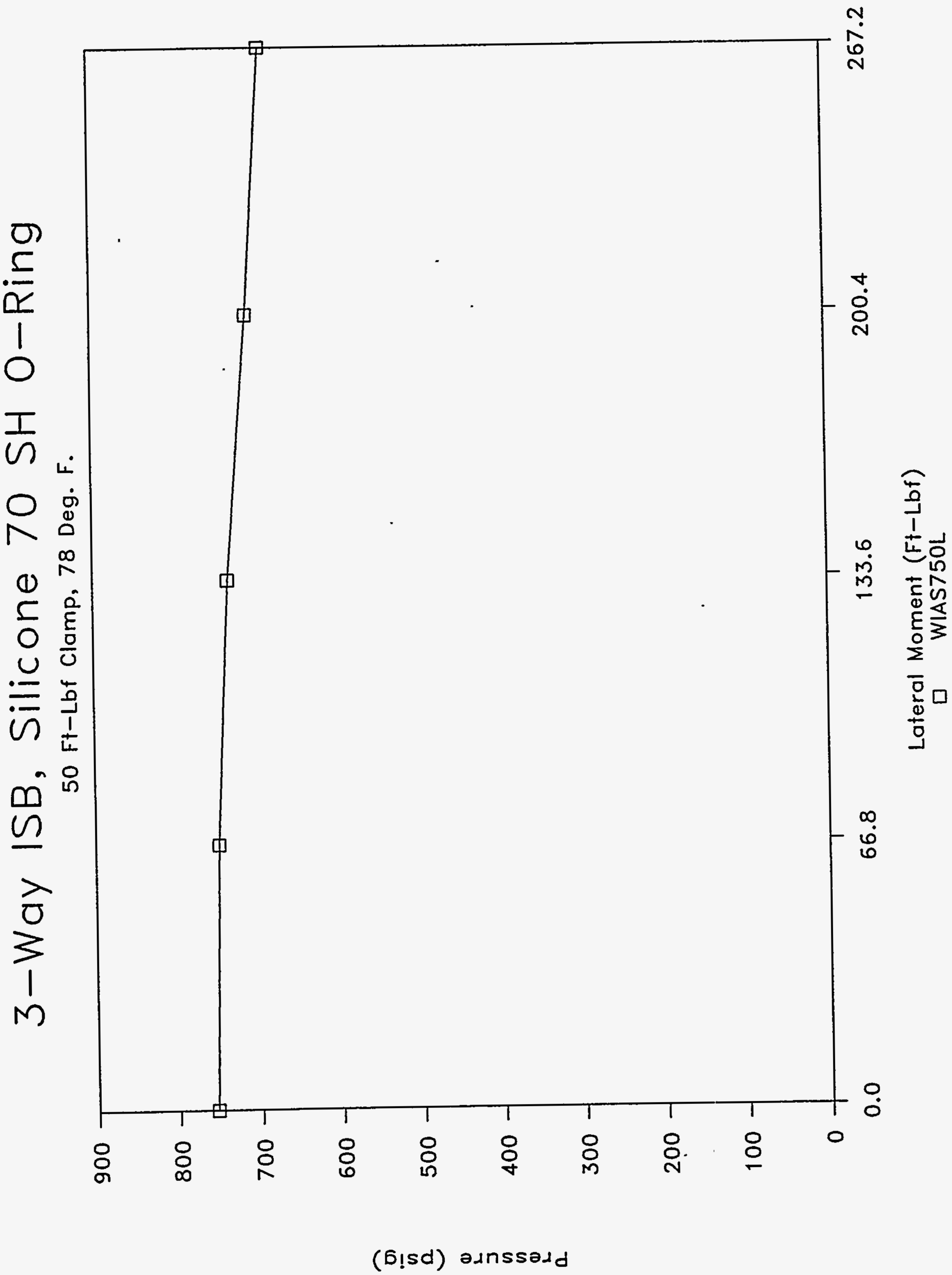
INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = WIEV100M

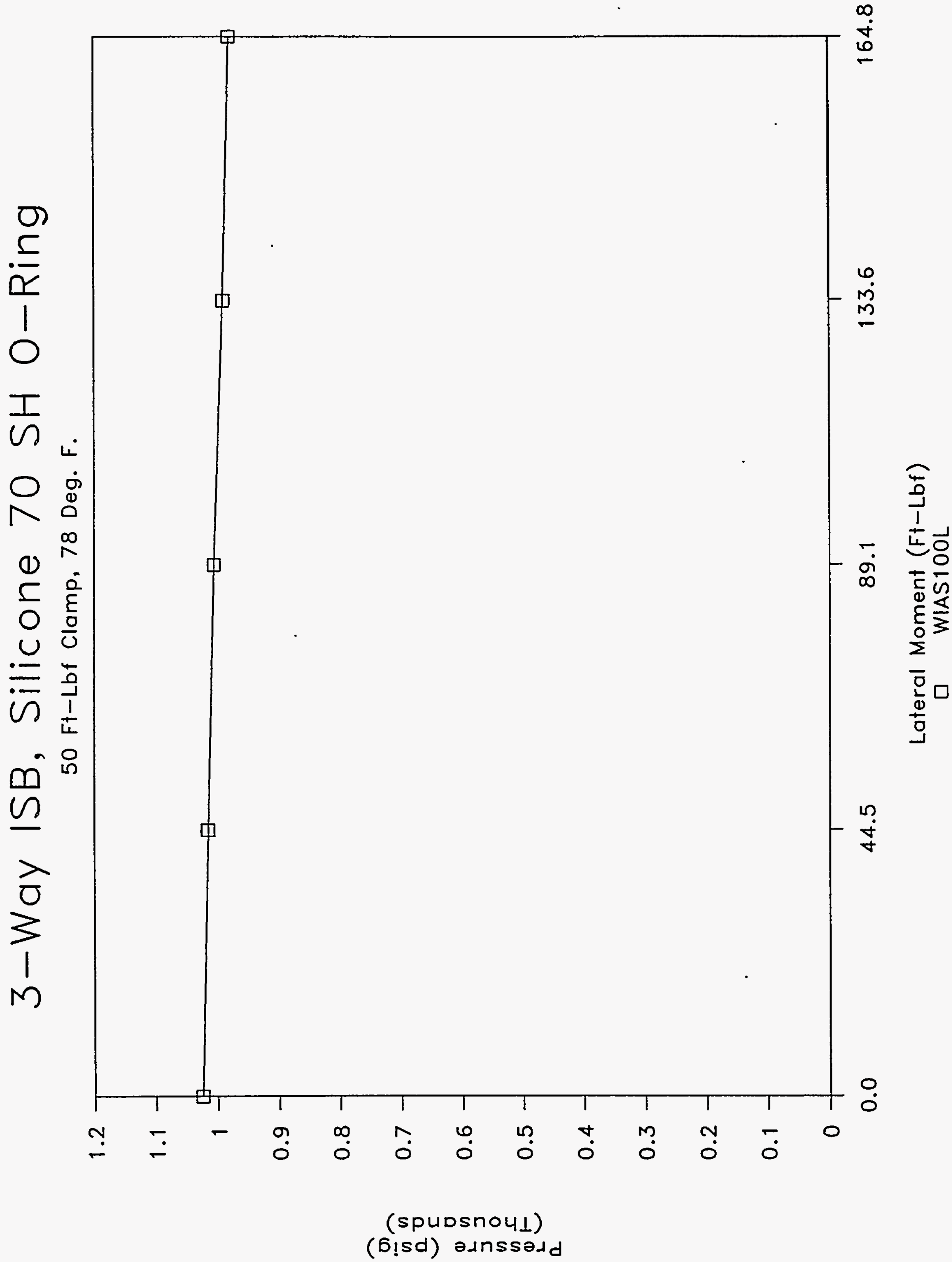
1025	32	1	32.02	0	1.5000	0.0
1010	34	2	34.03	100	1.5000	150.0
1000	36	1	36.02	200	1.5000	300.0
1005	38	2	38.03	300	1.5000	450.0
990	40	1	40.02	370	1.5000	555.0

APPENDIX R: GRAPHS OF THREE-WAY SILICONE TESTS


3-Way ISB, Silicone 70 SH O-Ring
50 Ft-Lbf Clamp, 78 Deg. F.
Pressure (psig)
0
50
100
150
200
250
300
350
400
0.0
0.0
111.3
222.6
334.0
445.3
Lateral Moment (Ft-Lbf)
WIAS250L


3-Way ISB, Silicone 70 SH O-Ring
50 Ft-Lbf Clamp, 78 Deg. F.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
89.1
178.1
267.2
356.2
Lateral Moment (Ft-Lbf)
WIAS500L


3-Way ISB, Silicone 70 SH O-Ring
50 Ft-Lbf Clamp, 78 Deg. F.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
66.8
133.6
200.4
267.2
Lateral Moment (Ft-Lbf)
WIAS750L


3-Way ISB, Silicone 70 SH O-Ring
50 Ft-Lbf Clamp, 78 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
44.5
89.1
133.6
164.8
Lateral Moment (Ft-Lbf)
WIAS100L

DECEMBER 12, 1994
2" 3-WAY ISB CONNECTOR, SILICONE O-RING, 70 DUROMETER, AMBIENT TEMP.
PART # 2-119 5604, PARKER SEAL CO., BATCH # 75561, CURE DATE 3Q93
LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIAS250L
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 78 DEG. F.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
255	0	0	0.00	0	0.4453	0.0
255	2	0	2.00	0	0.4453	0.0
255	4	0	4.00	250	0.4453	111.3
245	6	0	6.00	500	0.4453	222.7
230	8	0	8.00	750	0.4453	334.0
220	10	0	10.00	1000	0.4453	445.3

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = WIAS500L

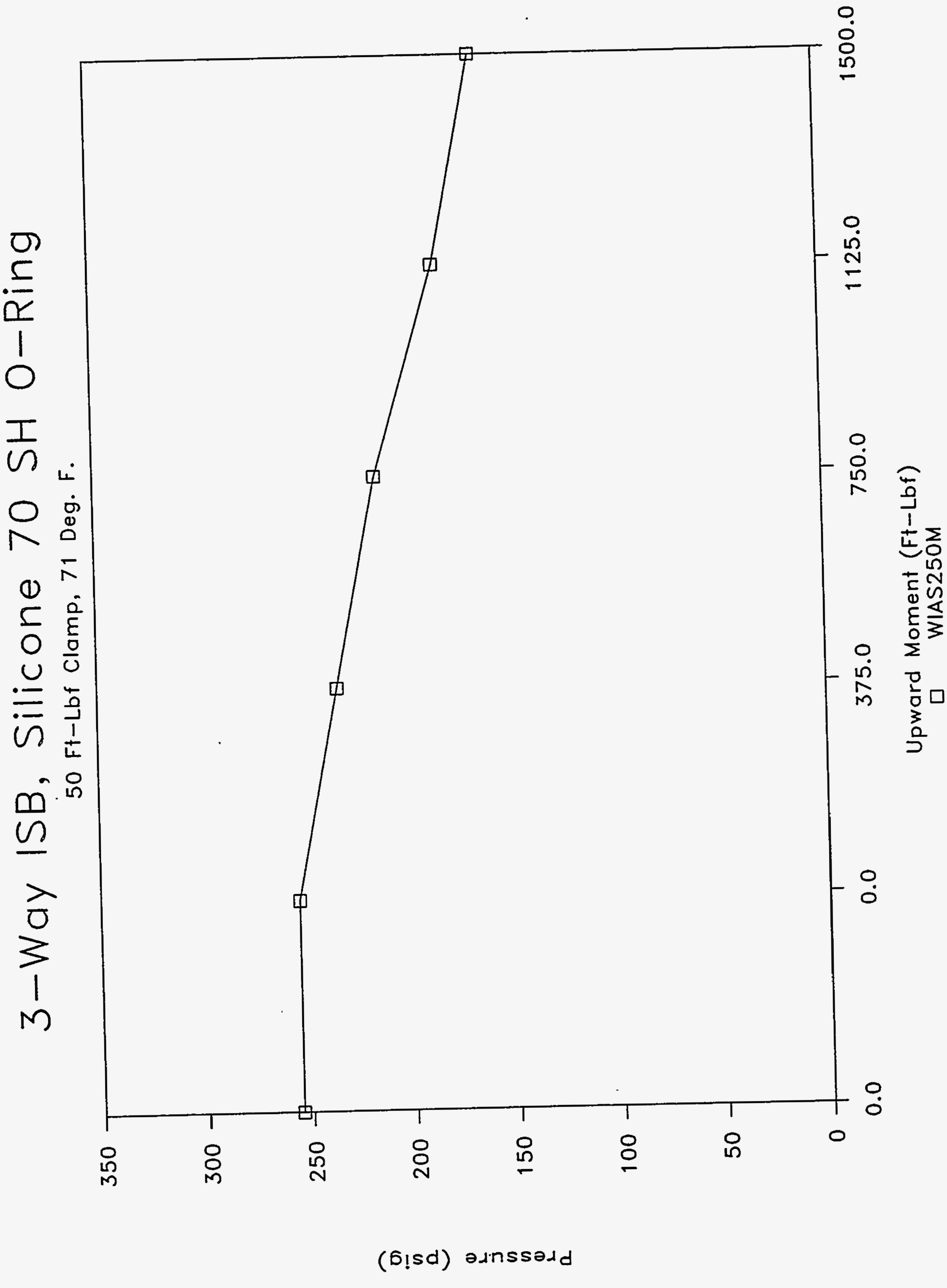
520	12	0	12.00	0	0.4453	0.0
515	14	0	14.00	200	0.4453	89.1
495	16	0	16.00	400	0.4453	178.1
465	19	24	19.40	600	0.4453	267.2
450	21	0	21.00	800	0.4453	356.2

INCREASED PRESSURE TO 750 PSIG GRAPH NAME = WIAS750L

755	23	0	23.00	0	0.4453	0.0
750	25	0	25.00	150	0.4453	66.8
735	27	0	27.00	300	0.4453	133.6
710	29	0	29.00	450	0.4453	200.4
690	31	0	31.00	600	0.4453	267.2

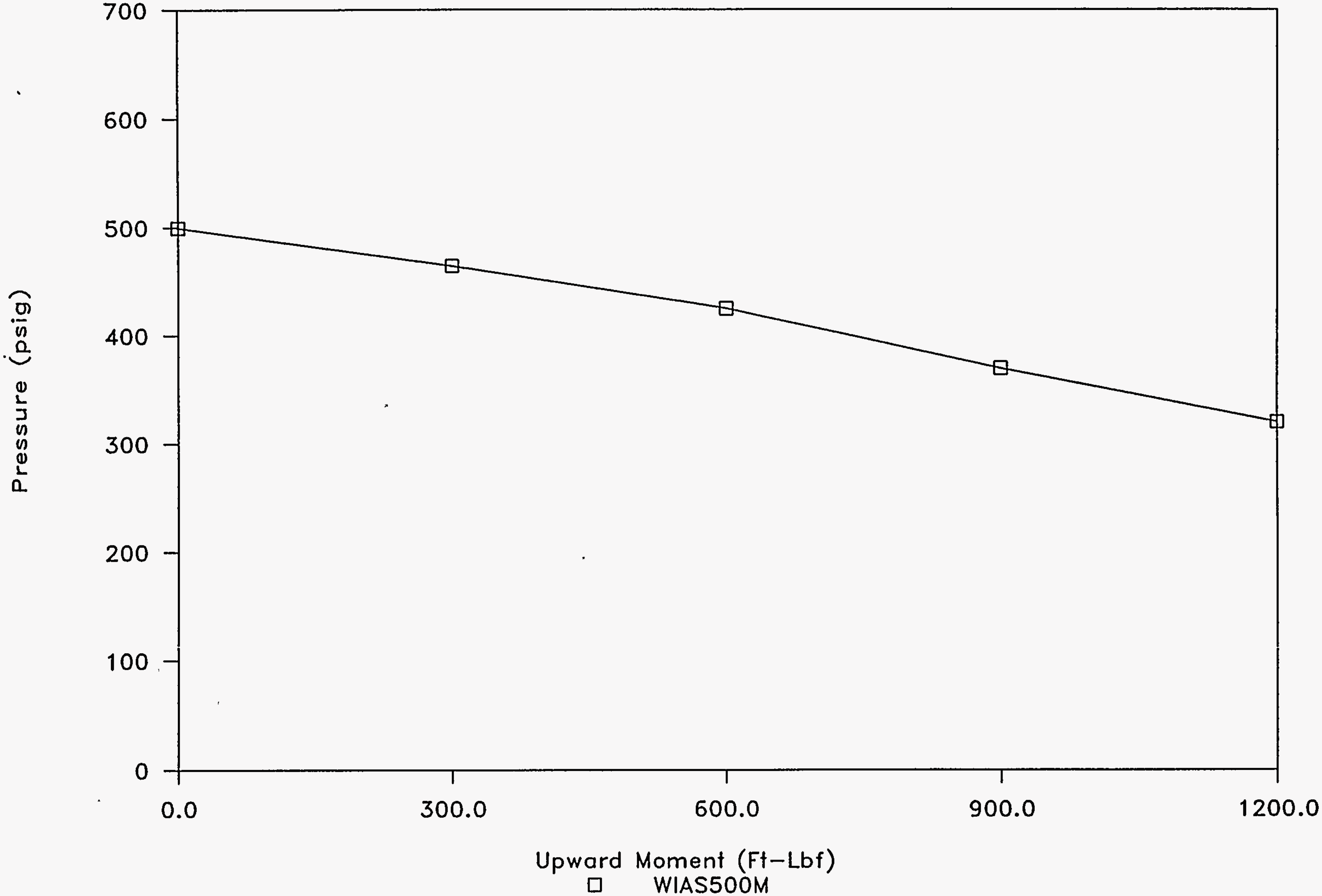
INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = WIAS100L

1025	33	0	33.00	0	0.4453	0.0
1015	35	0	35.00	100	0.4453	44.5
1005	37	0	37.00	200	0.4453	89.1
990	39	0	39.00	300	0.4453	133.6
980	41	0	41.00	370	0.4453	164.8


3—Way ISB, Silicone 70 SH O—Ring
50 Ft—Lbf Clamp, 71 Deg. F.
Pressure (psig)
350
300
250
200
150
100
50
0
0.0
0.0
375.0
750.0
1125.0
1500.0
Upward Moment (Ft—Lbf)
WIAS250M

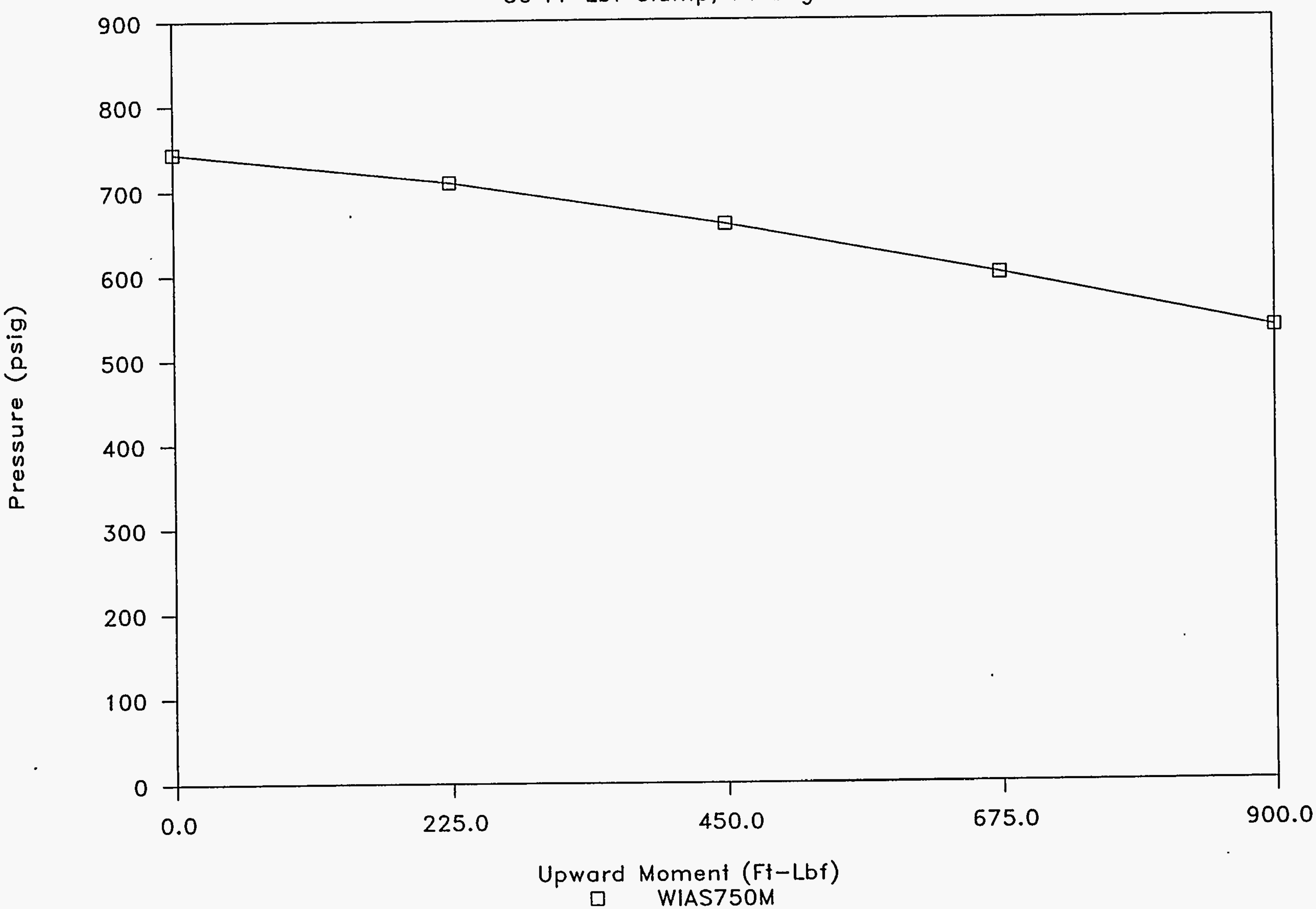
3-Way ISB, Silicone 70 SH O-Ring

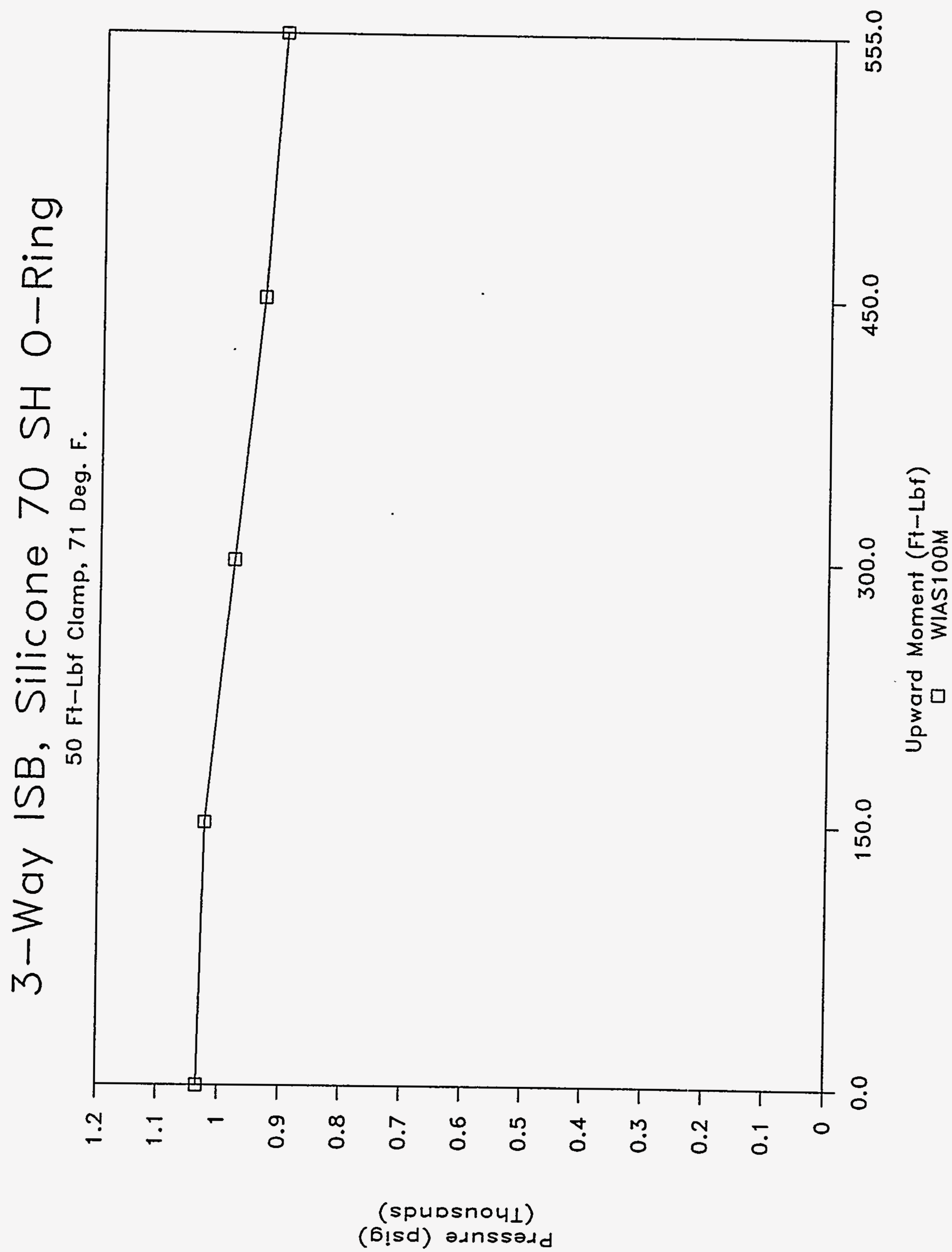
50 Ft-Lbf Clamp, 71 Deg. F.



3-Way ISB, Silicone 70 SH O-Ring

50 Ft-Lbf Clamp, 71 Deg. F.




3-Way ISB, Silicone 70 SH O-Ring
50 Ft-Lbf Clamp, 71 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
150.0
300.0
450.0
555.0
Upward Moment (Ft-Lbf)
WIAS100M

DECEMBER 05, 1994
2" 3-WAY ISB CONNECTOR, SILICONE O-RING, 70 DUROMETER, AMBIENT TEMP.
PART # 2-119 5604, PARKER SEAL CO., BATCH # 75561, CURE DATE 3Q93
LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIAS250M
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 71 DEG. F.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
255	0	0	0.00	0	1.5000	0.0
255	2	0	2.00	0	1.5000	0.0
235	4	0	4.00	250	1.5000	375.0
215	6	0	6.00	500	1.5000	750.0
185	8	0	8.00	750	1.5000	1125.0
165	10	0	10.00	1000	1.5000	1500.0

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = WIAS500M

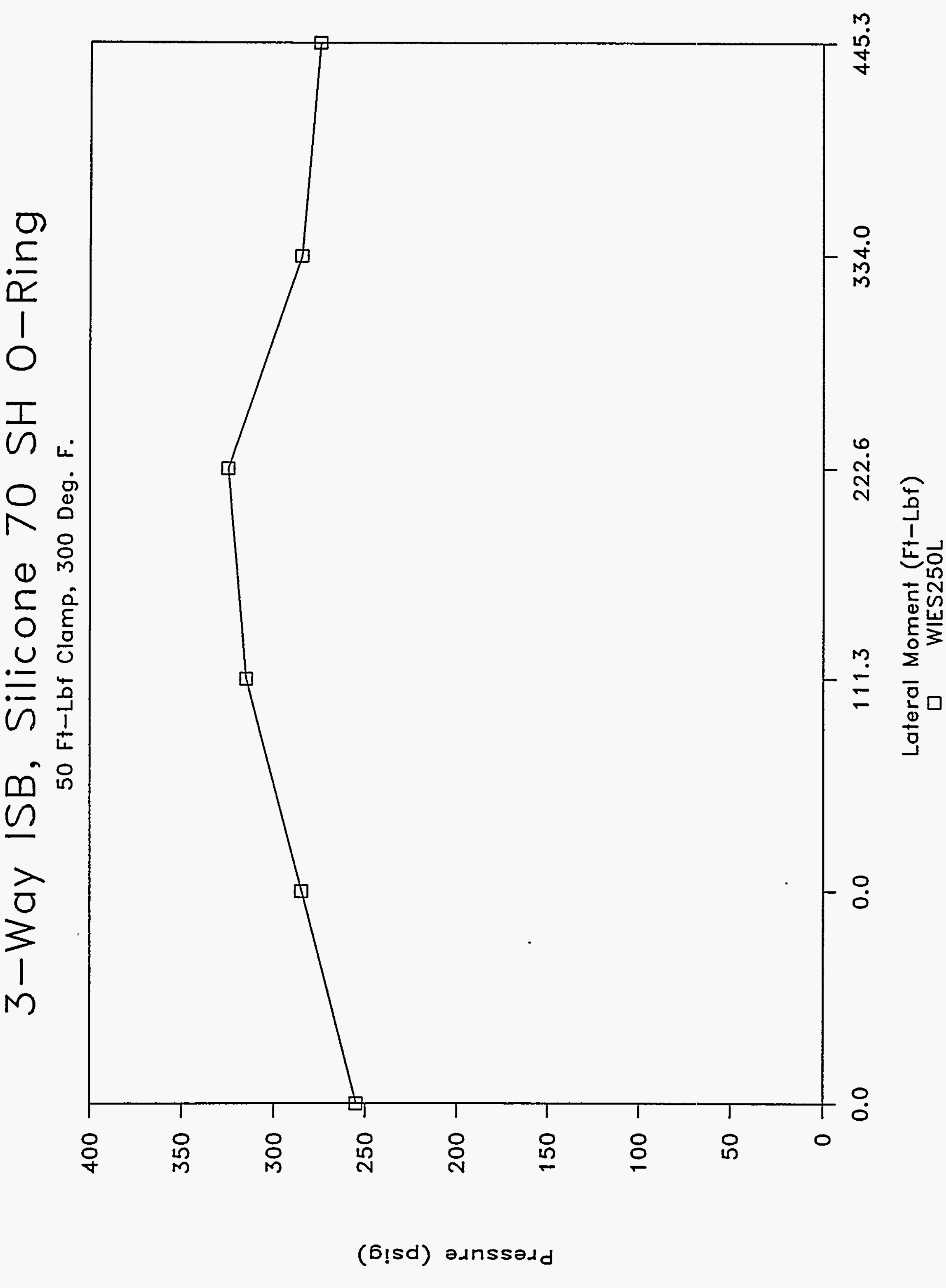
500	12	0	12.00	0	1.5000	0.0
465	14	0	14.00	200	1.5000	300.0
425	16	0	16.00	400	1.5000	600.0
370	18	0	18.00	600	1.5000	900.0
320	20	0	20.00	800	1.5000	1200.0

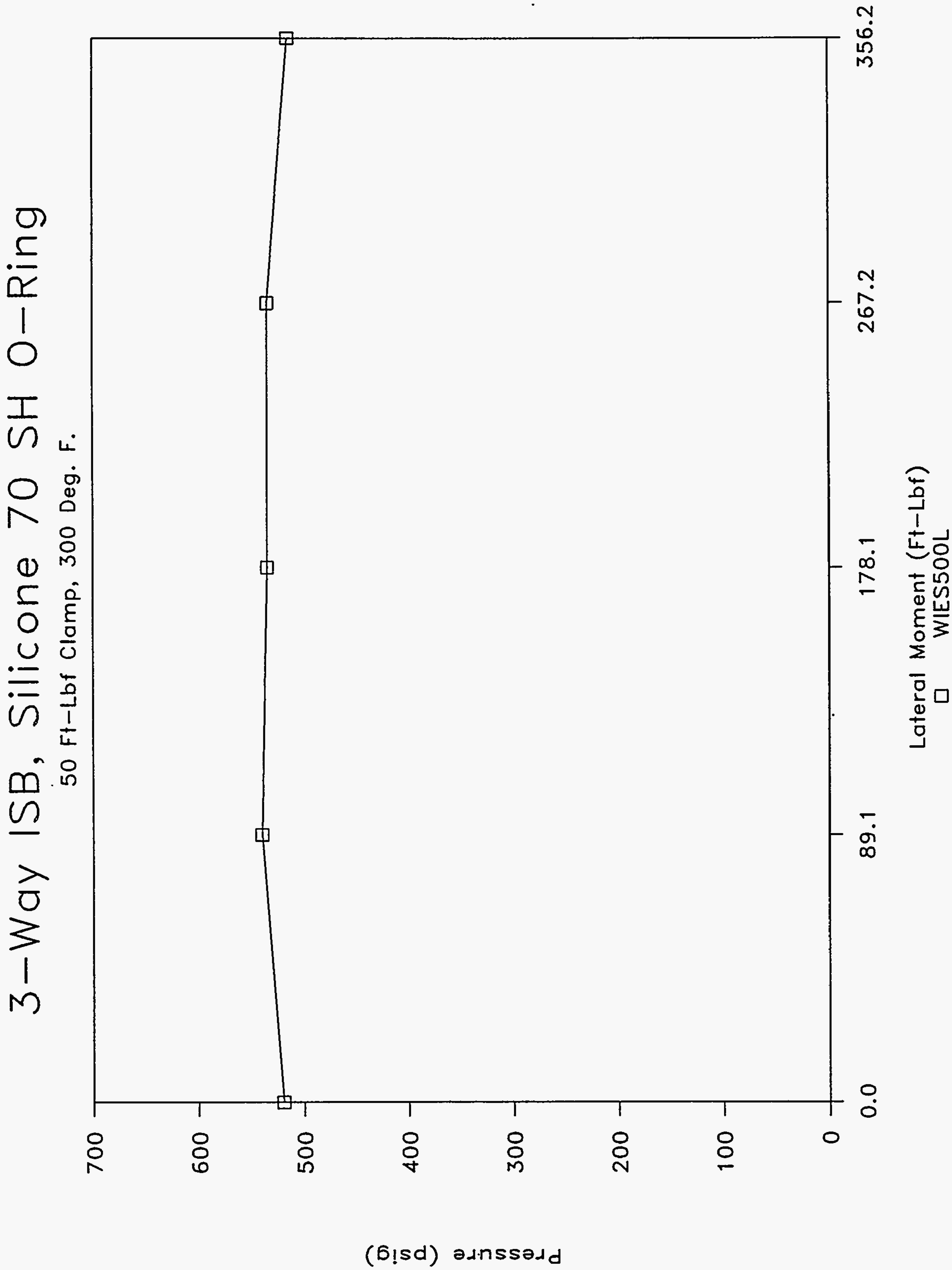
INCREASED PRESSURE TO 750 PSIG GRAPH NAME = WIAS750M

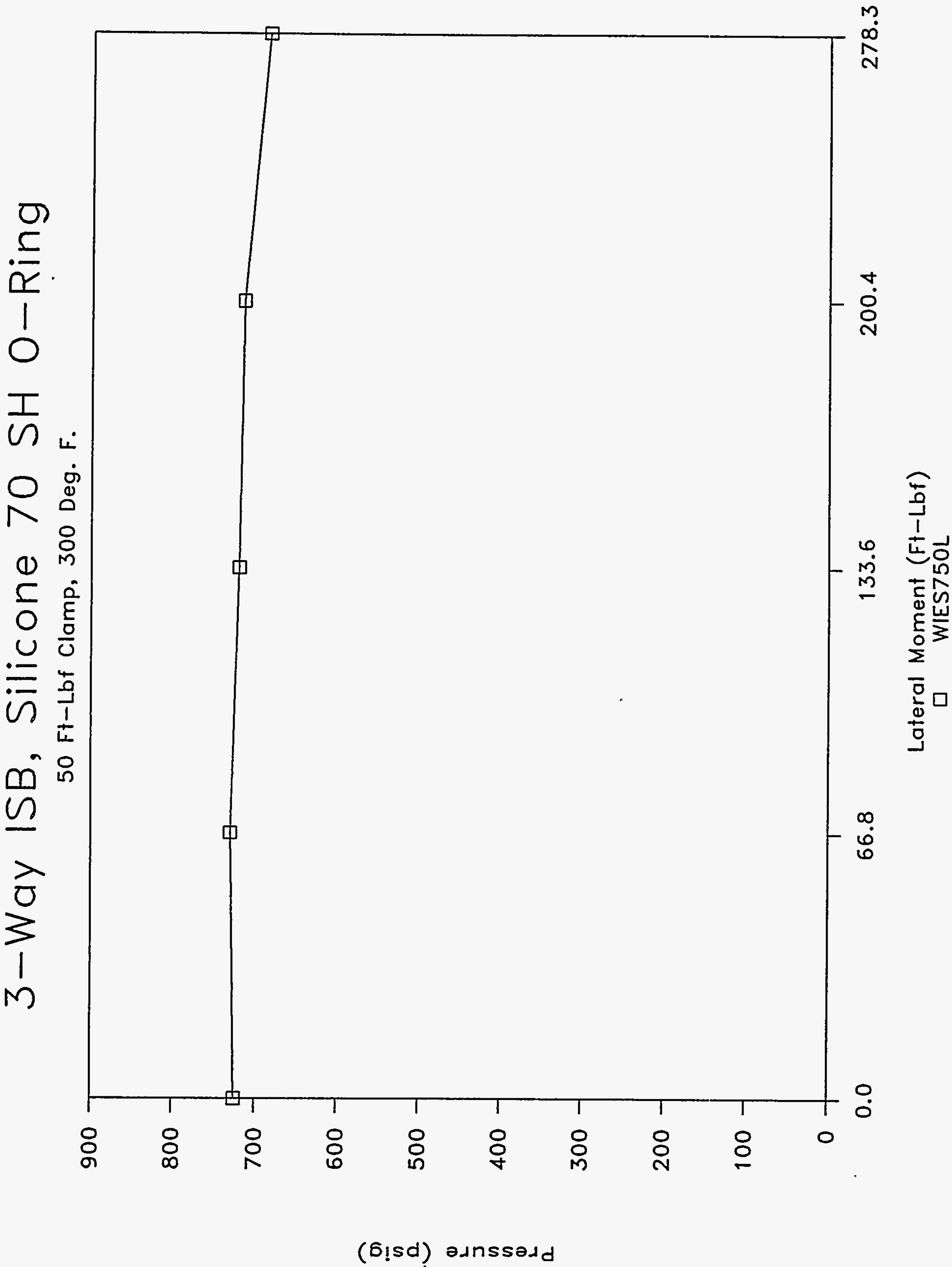
745	22	0	22.00	0	1.5000	0.0
710	24	0	24.00	150	1.5000	225.0
660	26	0	26.00	300	1.5000	450.0
600	28	0	28.00	450	1.5000	675.0
535	30	0	30.00	600	1.5000	900.0

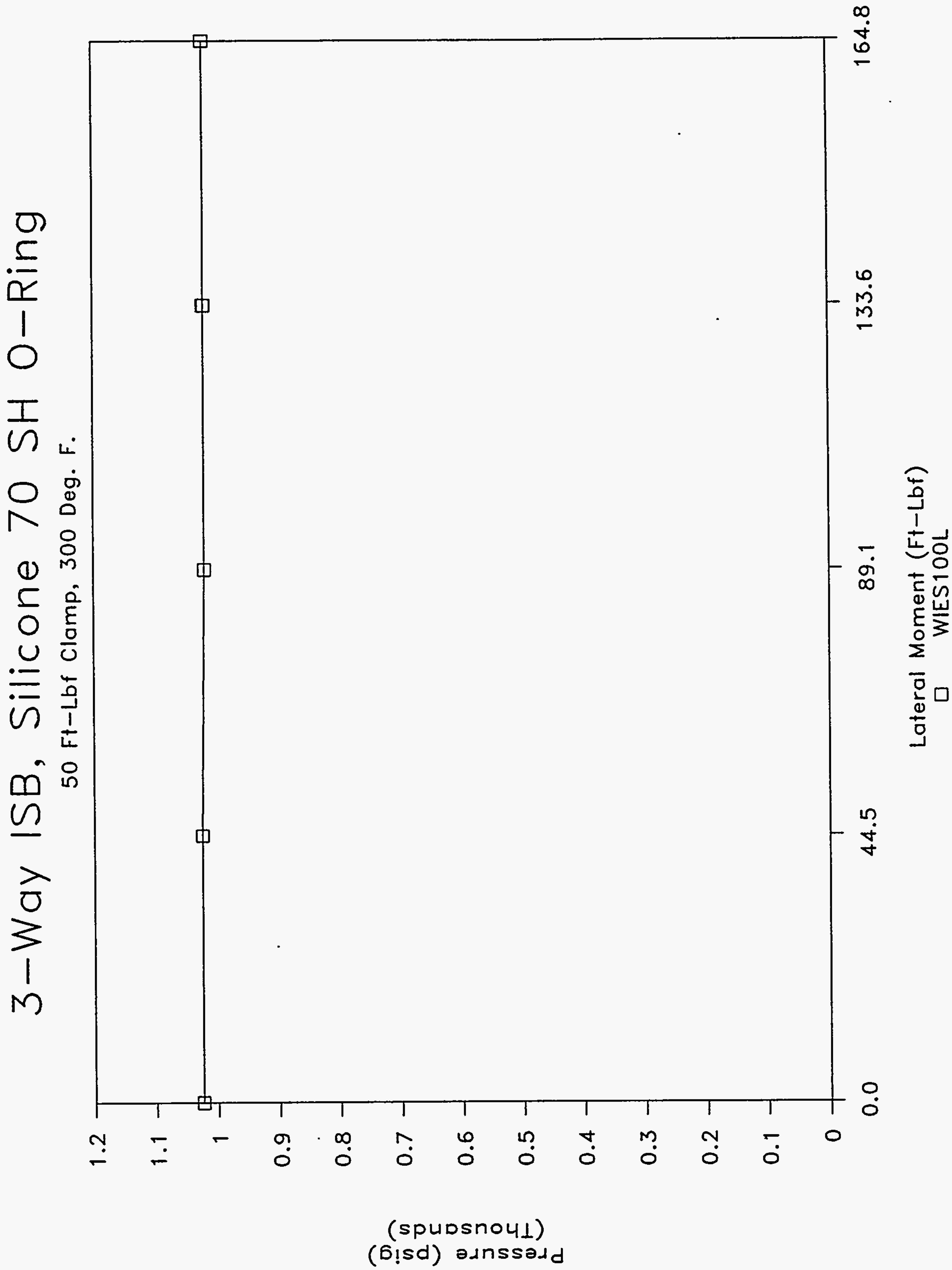
INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = WIAS100M

1035	32	0	32.00	0	1.5000	0.0
1025	34	0	34.00	100	1.5000	150.0
980	36	0	36.00	200	1.5000	300.0
935	38	0	38.00	300	1.5000	450.0
905	40	0	40.00	370	1.5000	555.0


3-Way ISB, Silicone 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
400
350
300
250
200
150
100
50
0
0.0
0.0
111.3
222.6
334.0
445.3
Lateral Moment (Ft-Lbf)
WIES250L


3-Way ISB, Silicone 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
0
100
200
300
400
500
600
700
0.0
89.1
178.1
267.2
356.2
Lateral Moment (Ft-Lbf)
WIES500L


3-Way ISB, Silicone 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
66.8
133.6
200.4
278.3
Lateral Moment (Ft-Lbf)
WIES750L


3-Way ISB, Silicone 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
44.5
89.1
133.6
164.8
Lateral Moment (Ft-Lbf)
WIES100L

DECEMBER 12, 1994
2" 3-WAY ISB CONNECTOR, SILICONE O-RING, 70 DUROMETER, ELEVATED TEMP.
PART # 2-119 5604, PARKER SEAL CO., BATCH # 75561, CURE DATE 3Q93
LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIES250L
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 300 DEG. F.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
255	0	0	0.00	0	0.4453	0.0
285	2	0	2.00	0	0.4453	0.0
315	4	0	4.00	250	0.4453	111.3
325	6	0	6.00	500	0.4453	222.7
285	8	0	8.00	750	0.4453	334.0
275	10	0	10.00	1000	0.4453	445.3

INCREASED PRESSURE TO 500 PSIG GRAPH NAME = WIES500L

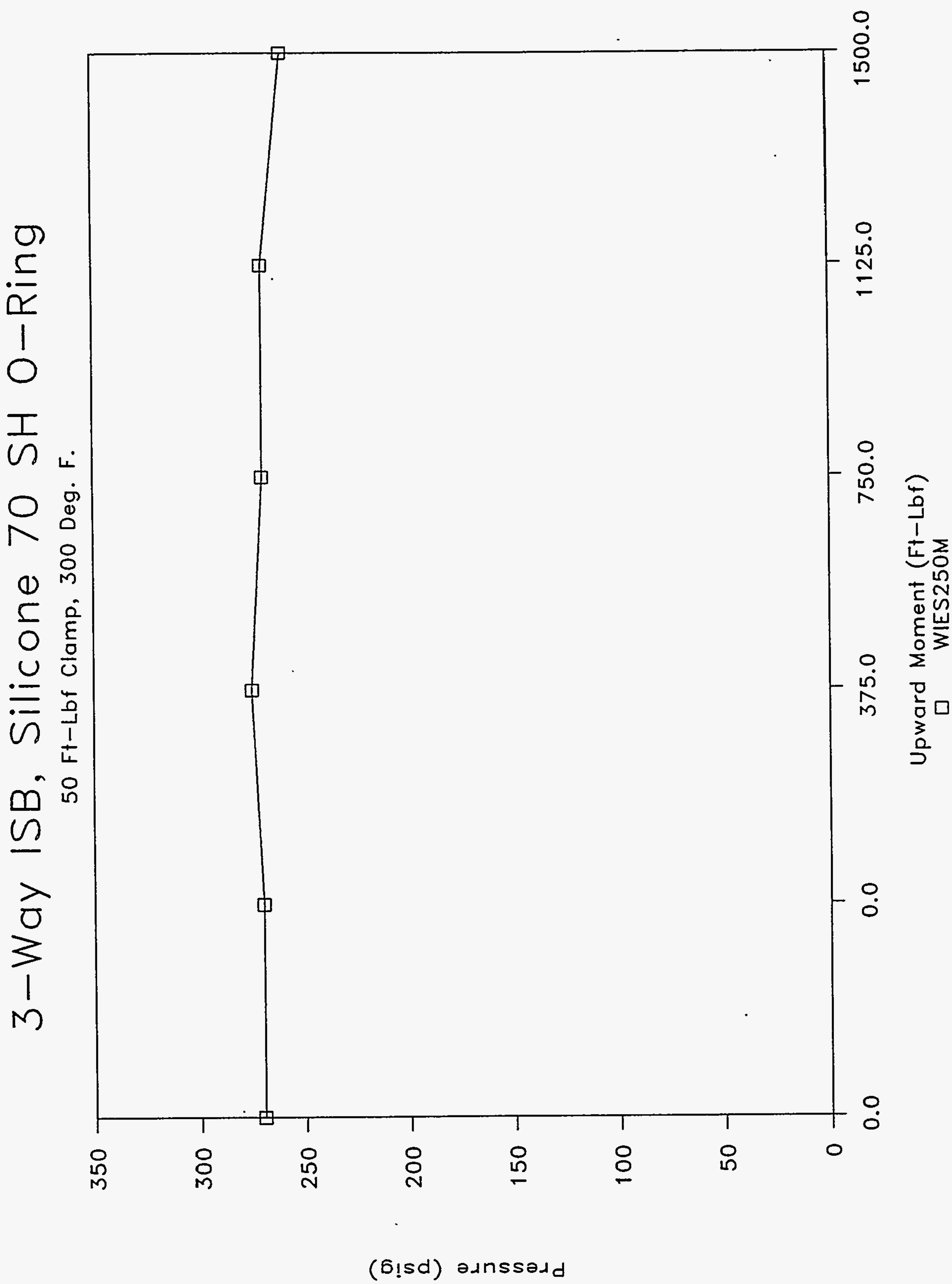
520	12	0	12.00	0	0.4453	0.0
540	14	0	14.00	200	0.4453	89.1
535	16	0	16.00	400	0.4453	178.1
535	18	0	18.00	600	0.4453	267.2
515	20	0	20.00	800	0.4453	356.2

INCREASED PRESSURE TO 750 PSIG GRAPH NAME = WIES750L

725	22	0	22.00	0	0.4453	0.0
730	24	0	24.00	150	0.4453	66.8
720	26	0	26.00	300	0.4453	133.6
715	28	0	28.00	450	0.4453	200.4
685	30	0	30.00	625	0.4453	278.3

INCREASED PRESSURE TO 1000 PSIG GRAPH NAME = WIES100L

1025	32	0	32.00	0	0.4453	0.0
1025	34	0	34.00	100	0.4453	44.5
1020	36	0	36.00	200	0.4453	89.1
1020	38	0	38.00	300	0.4453	133.6
1020	40	0	40.00	370	0.4453	164.8



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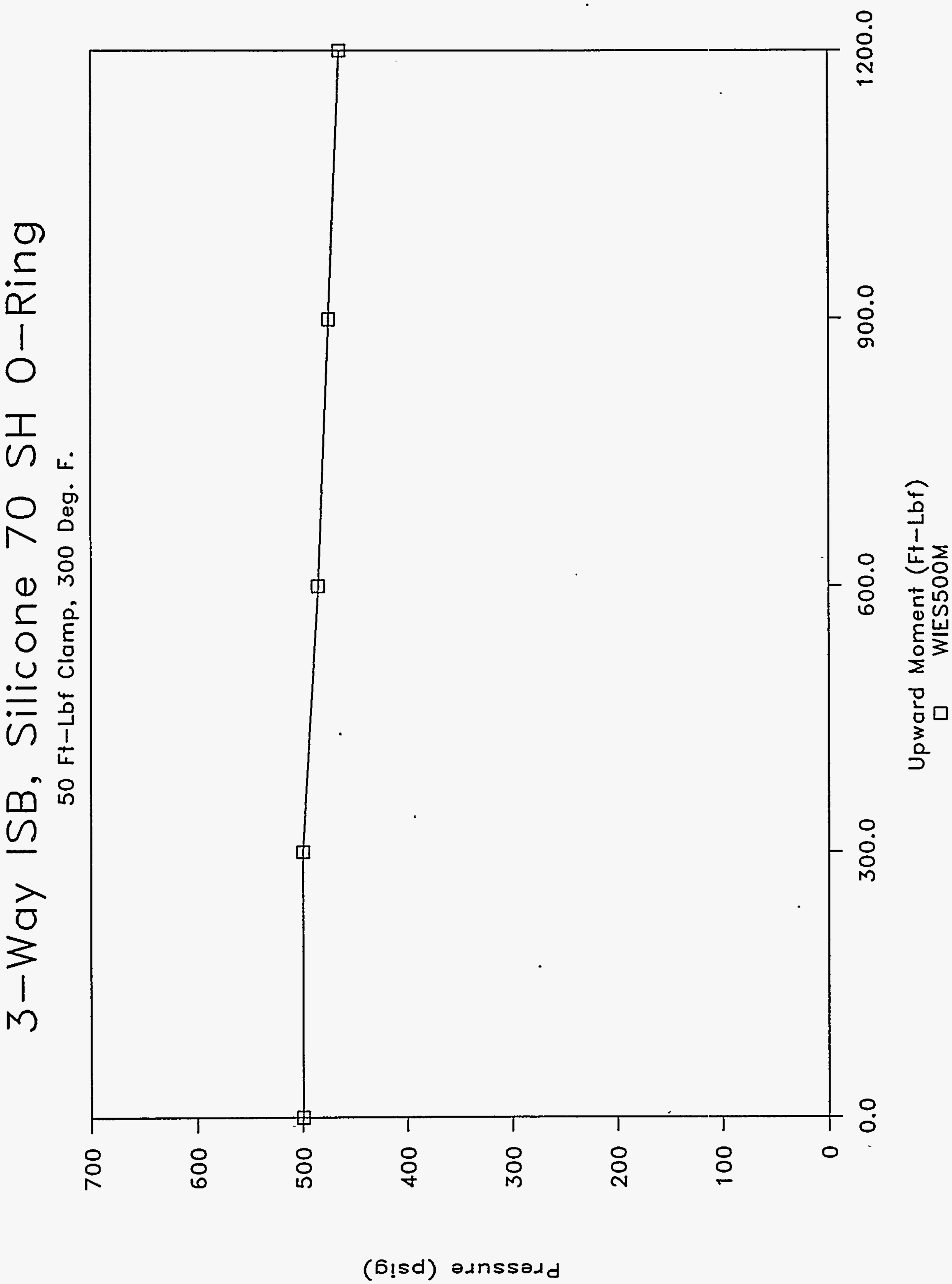
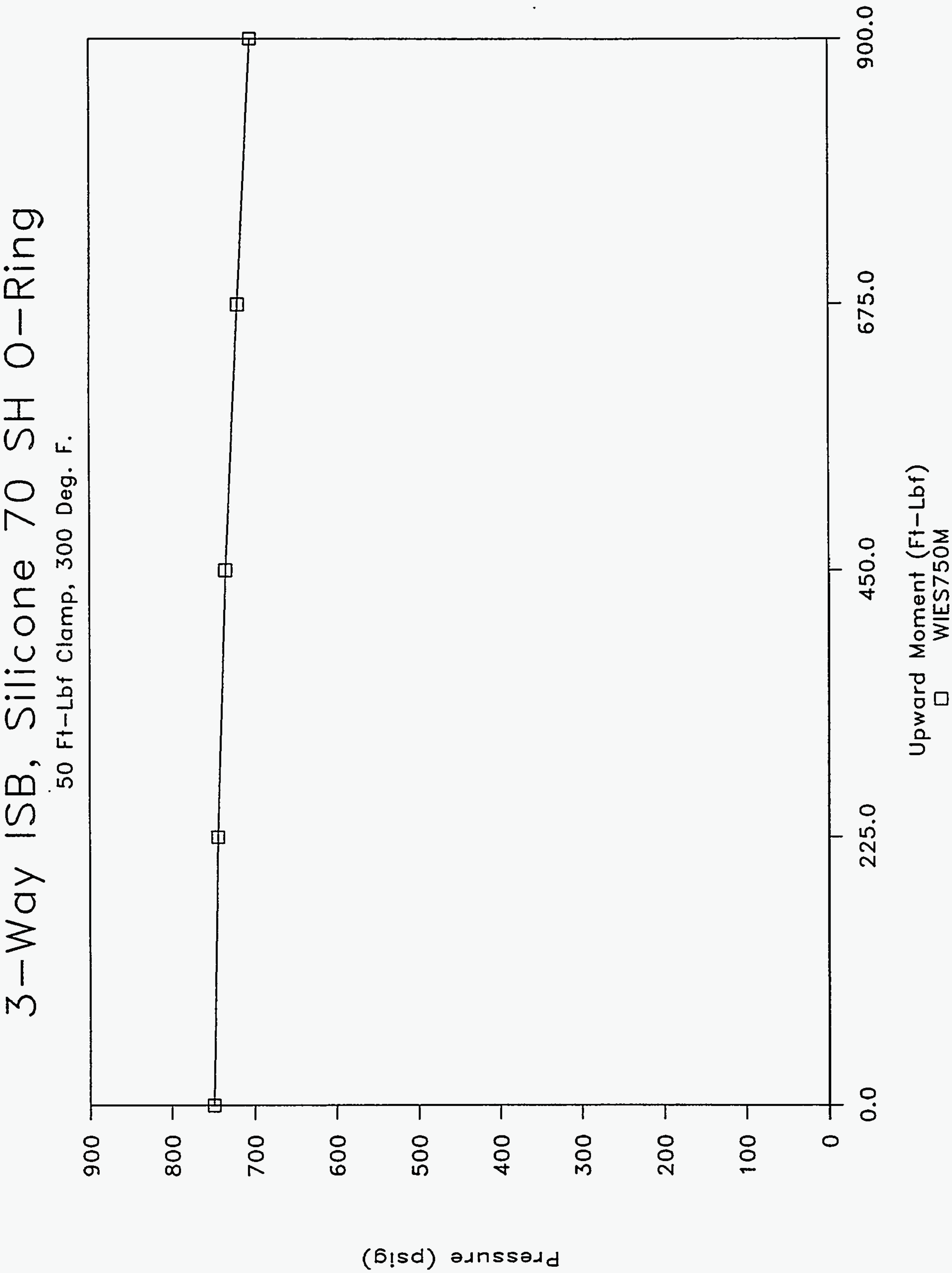
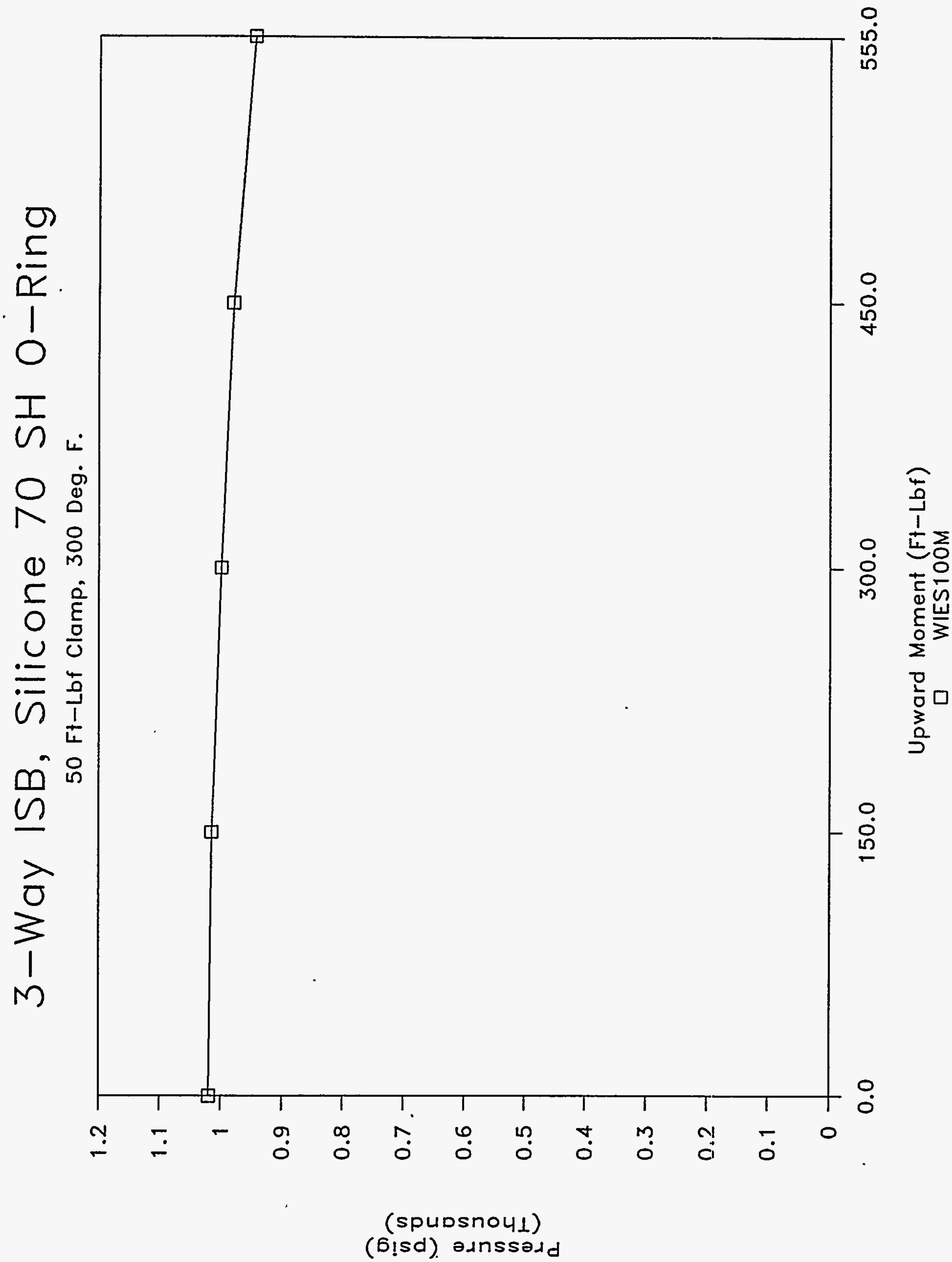
per telecon ER.

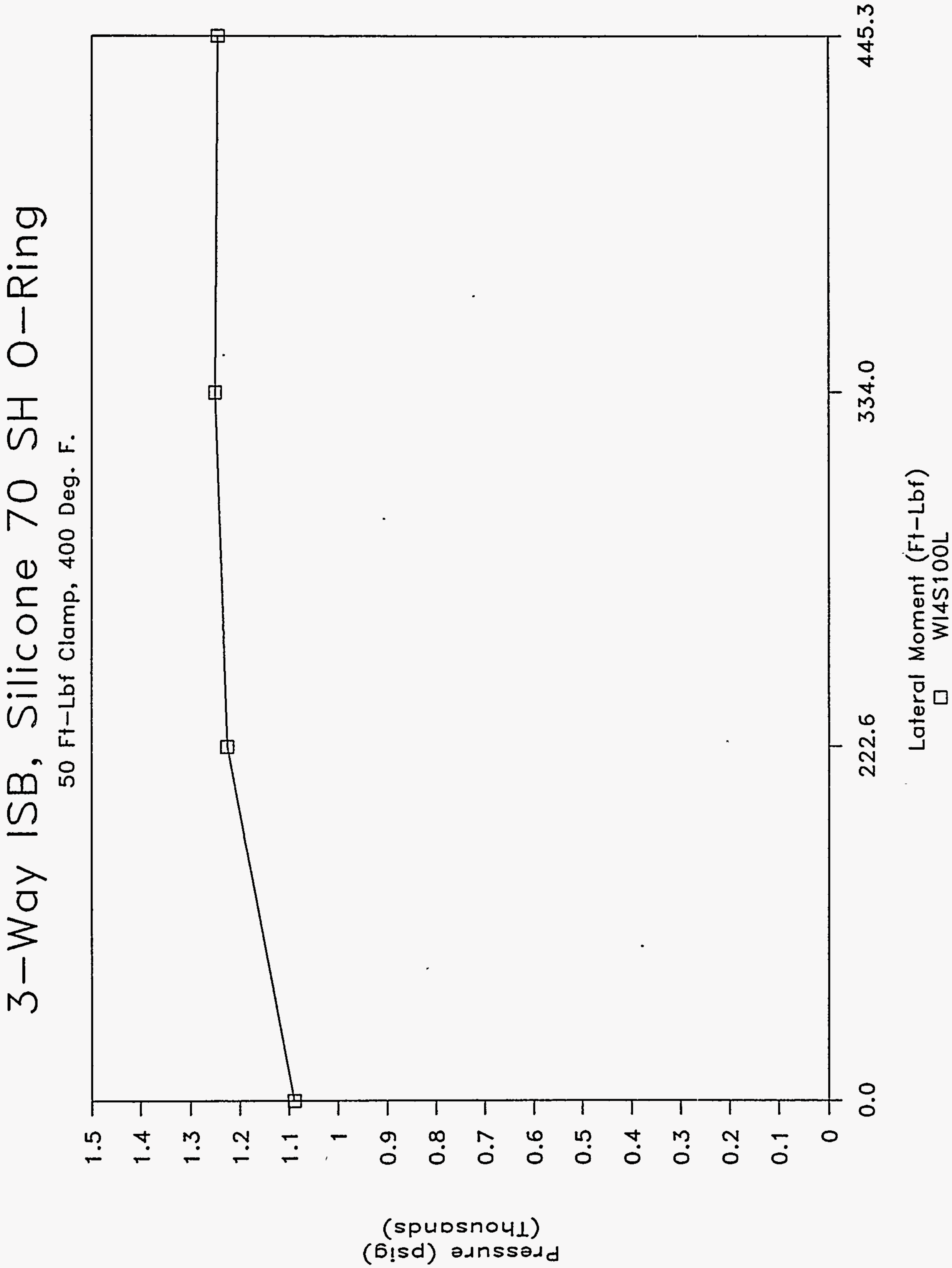

3—Way ISB, Silicone 70 SH O—Ring
50 Ft—Lbf Clamp, 300 Deg. F.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft—Lbf)
WIES500M

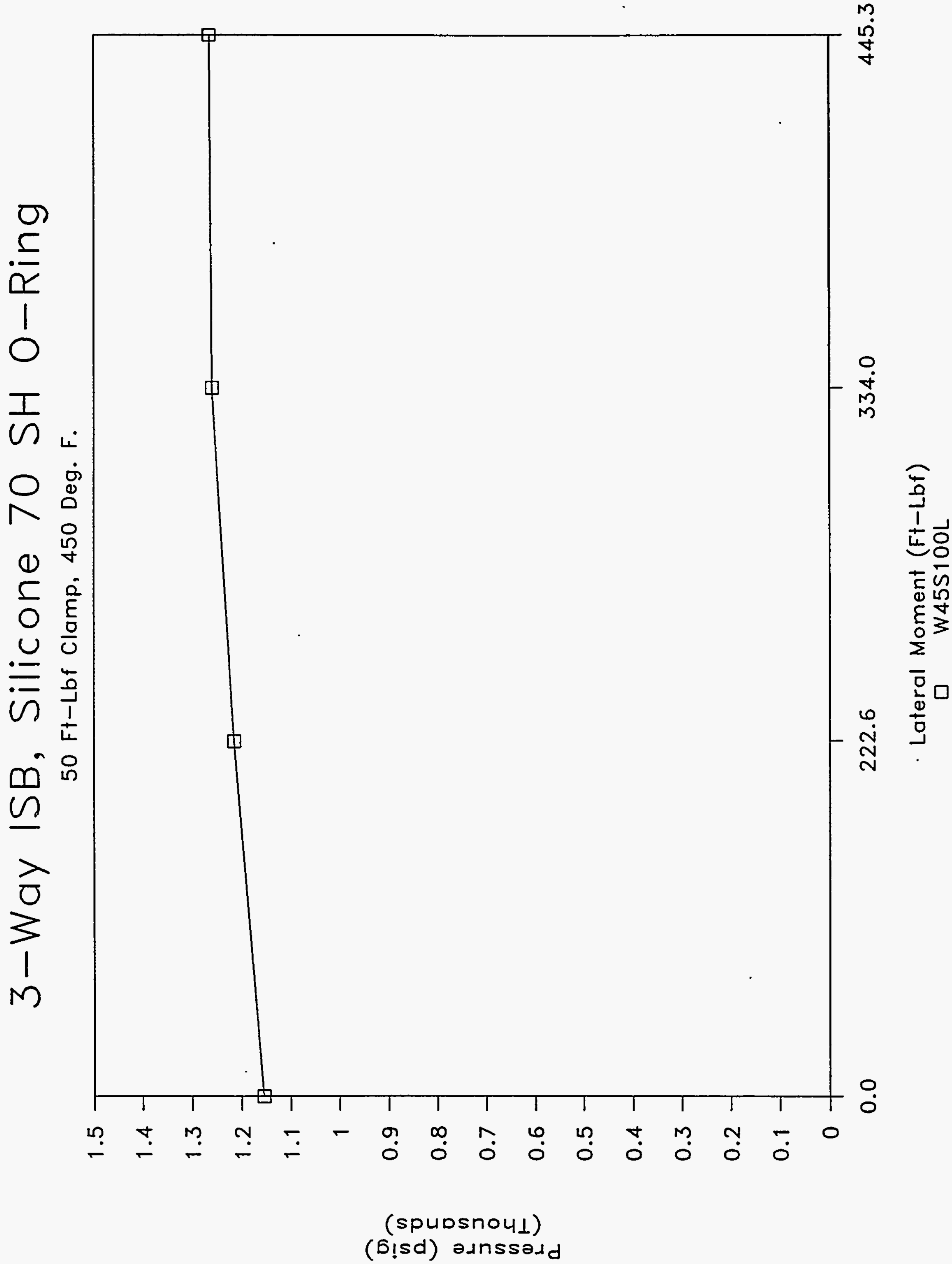

3-Way ISB, Silicone 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
225.0
450.0
675.0
900.0
Upward Moment (Ft-Lbf)
WIES750M

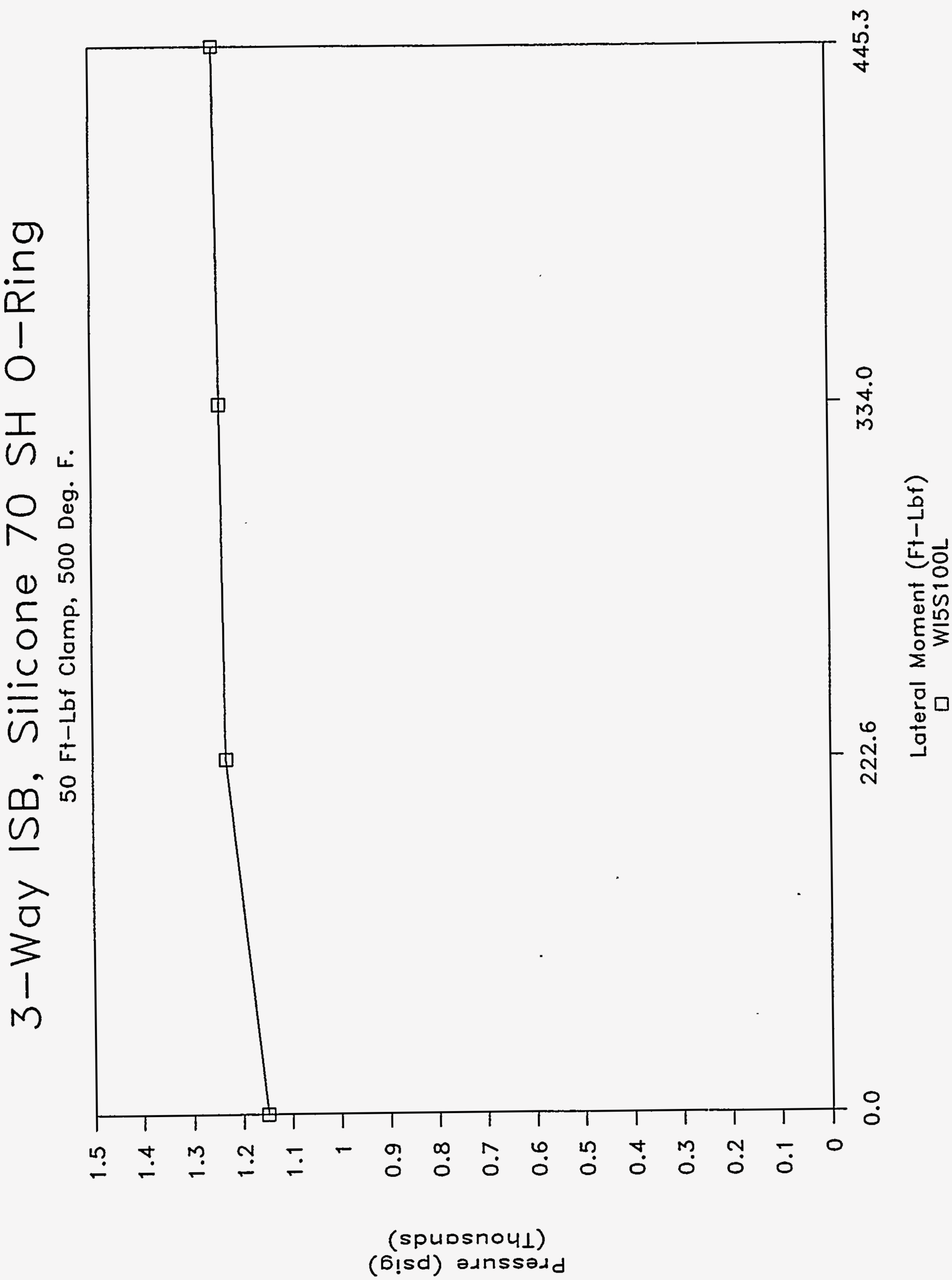

3-Way ISB, Silicone 70 SH O-Ring
50 Ft-Lbf Clamp, 300 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
150.0
300.0
450.0
555.0
Upward Moment (Ft-Lbf)
WIES100M

DECEMBER 06, 1994
2" 3-WAY ISB CONNECTOR, SILICONE O-RING, 70 DUROMETER, ELEVATED TEMP.
PART # 2-119 5604, PARKER SEAL CO., BATCH # 75561, CURE DATE 3Q93
LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIES250M
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 300 DEG. F.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
270	0	0	0.00	0	1.5000	0.0
270	2	0	2.00	0	1.5000	0.0
275	4	2	4.03	250	1.5000	375.0
270	6	0	6.00	500	1.5000	750.0
270	8	0	8.00	750	1.5000	1125.0
260	10	0	10.00	1000	1.5000	1500.0
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = WIES500M		
500	12	0	12.00	0	1.5000	0.0
500	14	0	14.00	200	1.5000	300.0
485	16	0	16.00	400	1.5000	600.0
475	18	0	18.00	600	1.5000	900.0
465	20	0	20.00	800	1.5000	1200.0
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = WIES750M		
750	22	0	22.00	0	1.5000	0.0
745	24	0	24.00	150	1.5000	225.0
735	26	0	26.00	300	1.5000	450.0
720	28	0	28.00	450	1.5000	675.0
705	30	0	30.00	600	1.5000	900.0
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = WIES100M		
1020	32	0	32.00	0	1.5000	0.0
1015	34	0	34.00	100	1.5000	150.0
1000	36	2	36.03	200	1.5000	300.0
980	38	0	38.00	300	1.5000	450.0
945	40	0	40.00	370	1.5000	555.0


3-Way ISB, Silicone 70 SH O-Ring
50 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
(Thousands)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
222.6
334.0
445.3
Lateral Moment (Ft-Lbf)
WI4S100L


3-Way ISB, Silicone 70 SH O-Ring
50 Ft-Lbf Clamp, 450 Deg. F.
Pressure (psig)
(Thousands)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
222.6
334.0
445.3
Lateral Moment (Ft-Lbf)
W45S100L


3–Way ISB, Silicone 70 SH O–Ring
50 Ft–Lbf Clamp, 500 Deg. F.
Pressure (psig)
(Thousands)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
222.6
334.0
445.3
Lateral Moment (Ft–Lbf)
WI5S100L

DECEMBER 12, 1994
2" 3-WAY ISB CONNECTOR, SILICONE O-RING, 70 DUROMETER, ELEVATED TEMP.
PART # 2-119 5604, PARKER SEAL CO., BATCH # 75561, CURE DATE 3Q93
LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL

Note: Following comments added on Dec. 15, 1994 by Ed S. Ruff:

The following series of tests was performed at the end of the official" test program sequence. A deliberate attempt was made to cause an o-ring failure, and subsequent leak, in the 3-way ISB connector that was on the stand from the previous test.

The lateral moment load was increased to the max. test stand capacity of 1,000 lbf. Ultimately, the pressure was increased to approx. 1,250 psig and the temperature was elevated to 500 deg. F.

In spite of all this, the 3-way ISB connector, with silicone o-rings installed, did not leak or lose pressure.

MOMENT LOAD INCREASED TO 1000 LBS. NO GRAPH

960	42	0	42.00	1000	0.4453	445.3

INCREASED TEMP. TO 400 DEG. F; PRESSURE AT 1000 PSIG.

GRAPH NAME = WI4S100L

1090	44	0	44.00	0	0.4453	0.0
1225	46	0	46.00	500	0.4453	222.7
1250	48	0	48.00	750	0.4453	334.0
1245	50	0	50.00	1000	0.4453	445.3

INCREASED TEMP. TO 450 DEG. F; PRESSURE AT 1000 PSIG.

GRAPH NAME = W45S100L

1155	52	0	52.00	0	0.4453	0.0
1215	54	0	54.00	500	0.4453	222.7
1260	56	0	56.00	750	0.4453	334.0
1265	58	0	58.00	1000	0.4453	445.3

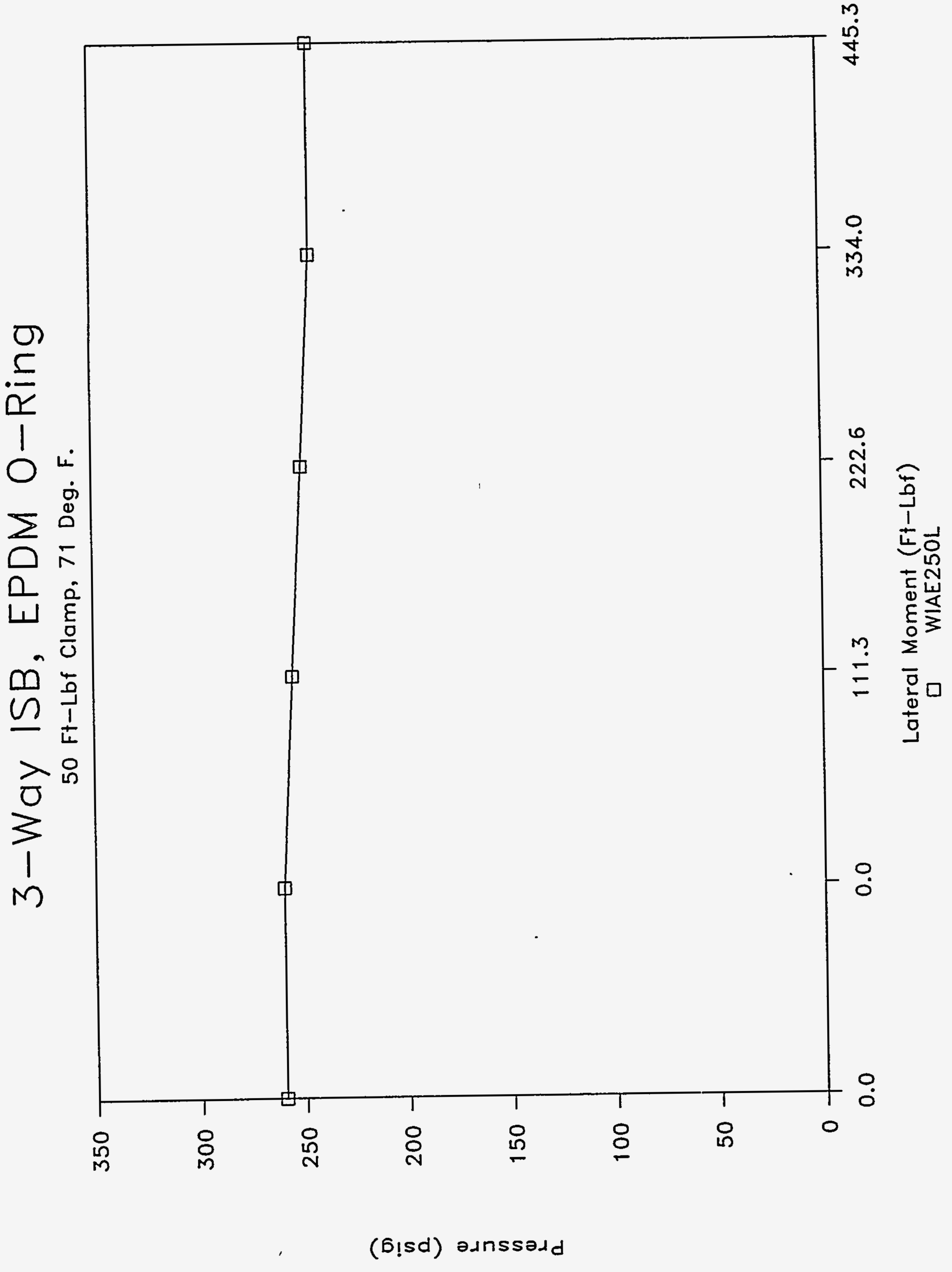
INCREASED TEMP. TO 500 DEG. F; PRESSURE AT 1000 PSIG.

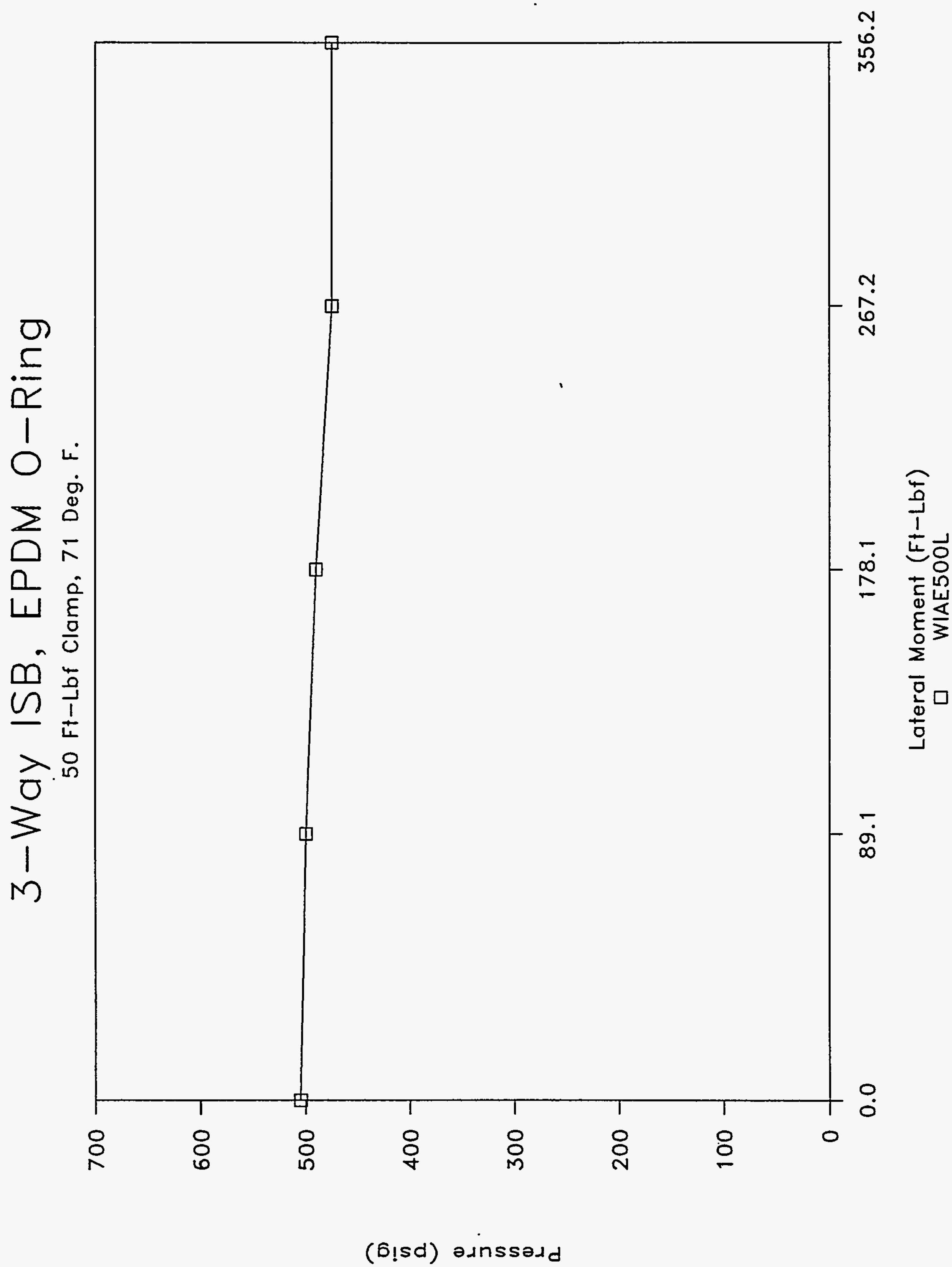
GRAPH NAME = WI5S100L

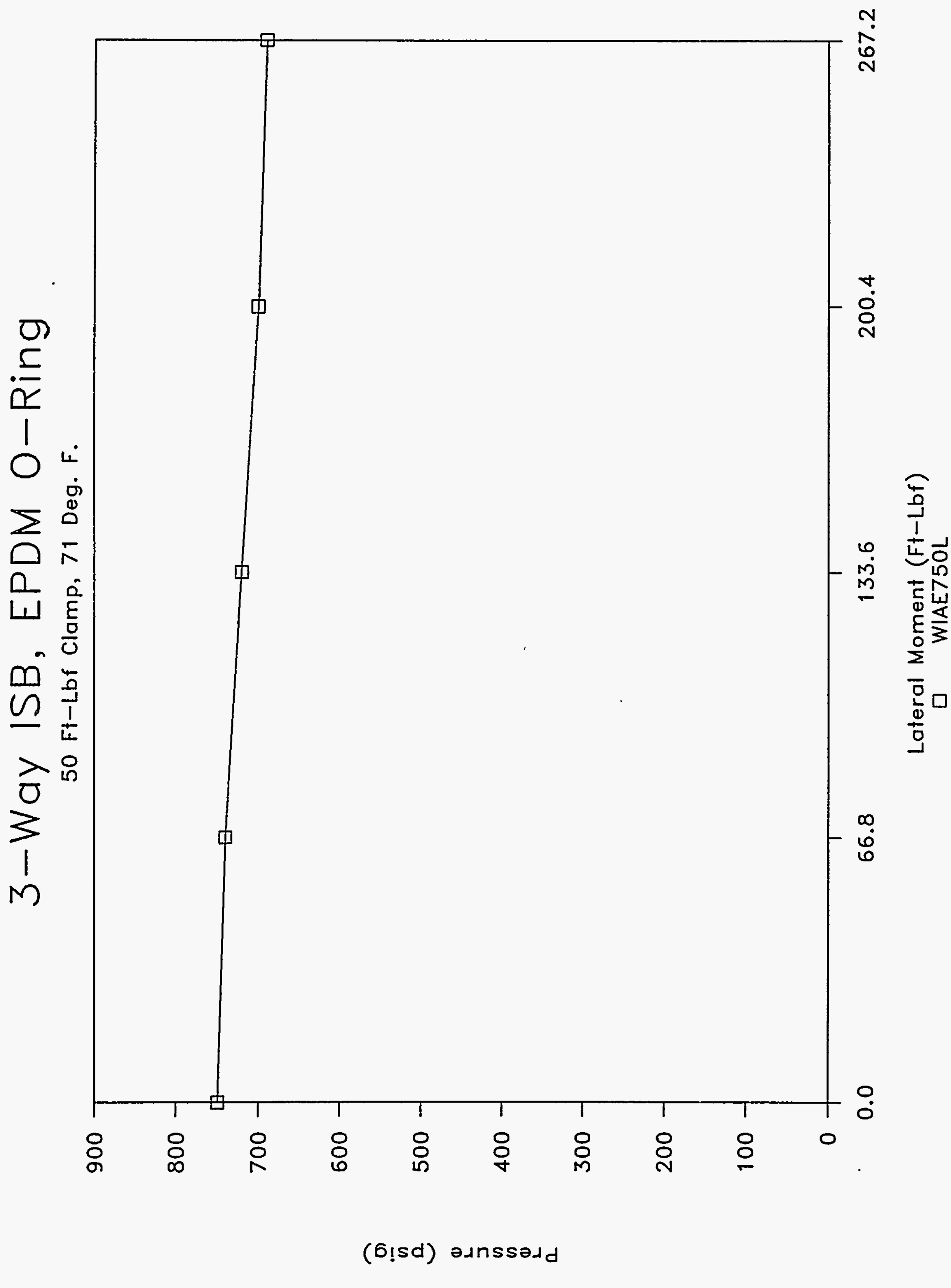
1150	59	0	59.00	0	0.4453	0.0

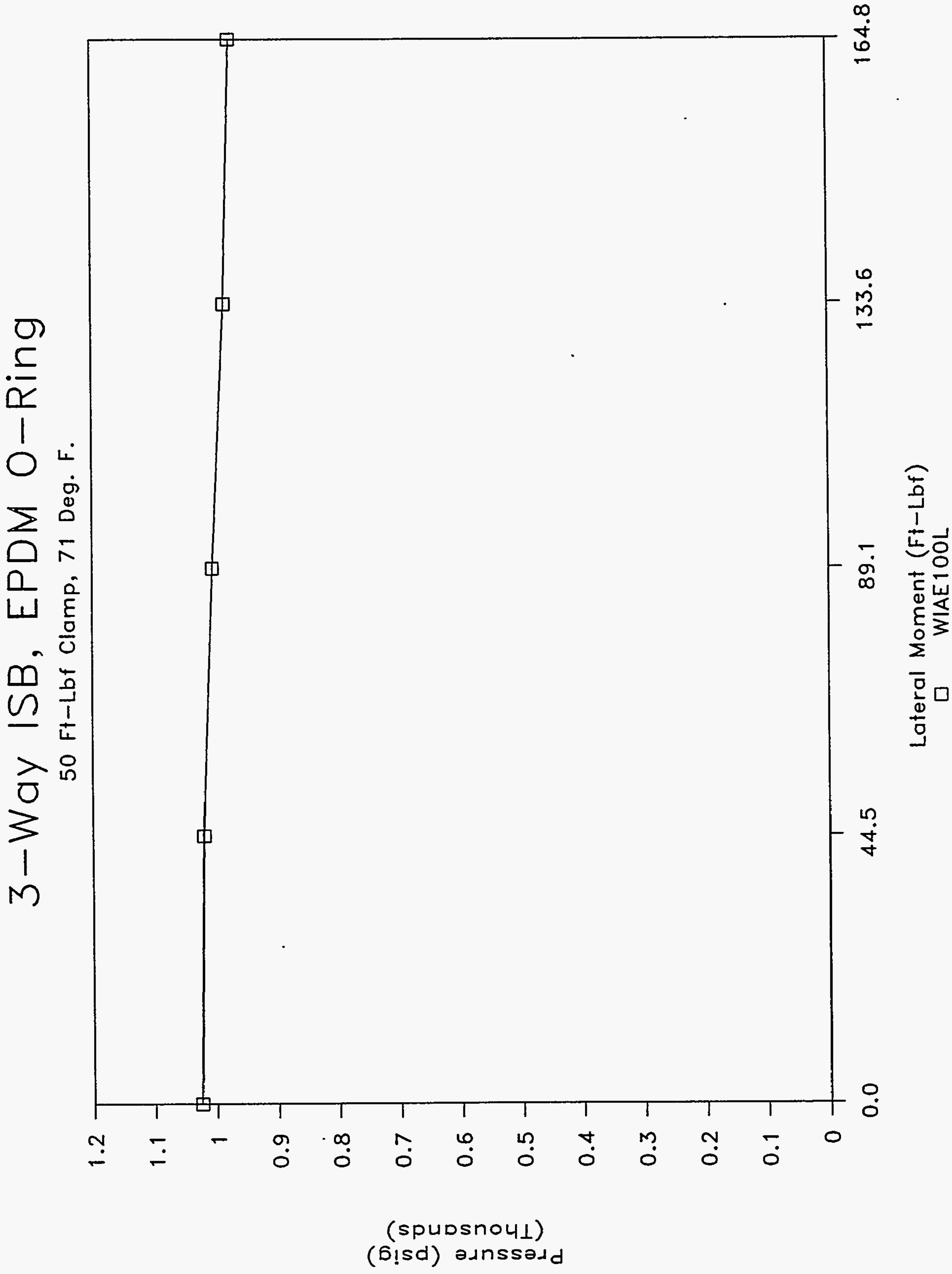
1230	61	0	61.00	500	0.4453	222.7
1240	63	0	63.00	750	0.4453	334.0
1250	65	0	65.00	1000	0.4453	445.3

APPENDIX S: GRAPHS OF THREE-WAY EPDM TESTS


3-Way ISB, EPDM O-Ring
50 Ft-Lbf Clamp, 71 Deg. F.
Pressure (psig)
0
50
100
150
200
250
300
350
0.0
0.0
111.3
222.6
334.0
445.3
Lateral Moment (Ft-Lbf)
WIAE250L

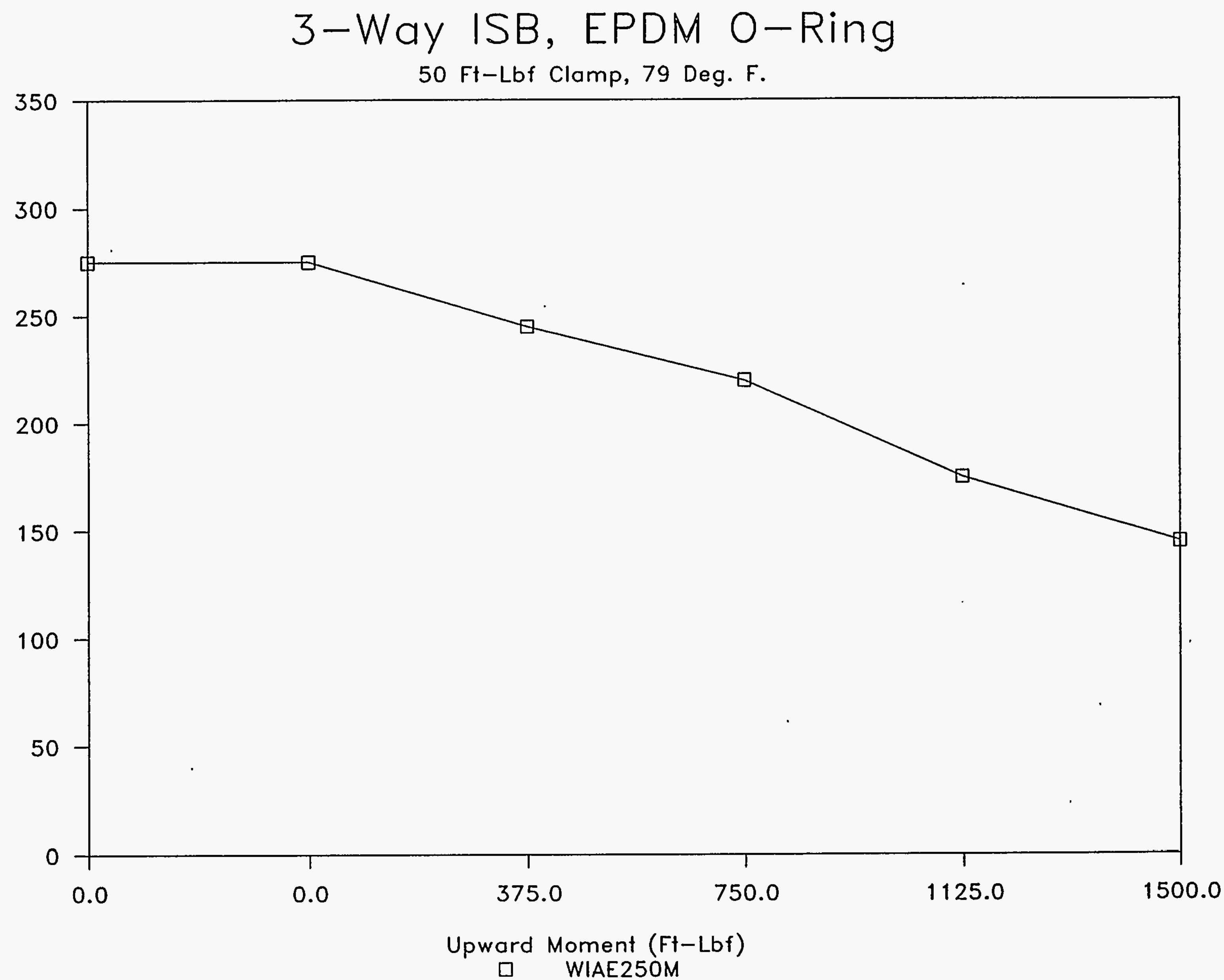

3-Way ISB, EPDM O-Ring
50 Ft-Lbf Clamp, 71 Deg. F.
Pressure (psig)
0
100
200
300
400
500
600
700
0.0
89.1
178.1
267.2
356.2
Lateral Moment (Ft-Lbf)
WIAE500L


3-Way ISB, EPDM O-Ring
50 Ft-Lbf Clamp, 71 Deg. F.
Pressure (psig)
900
800
700
600
500
400
300
200
100
0
0.0
66.8
133.6
200.4
267.2
Lateral Moment (Ft-Lbf)
WIAE750L

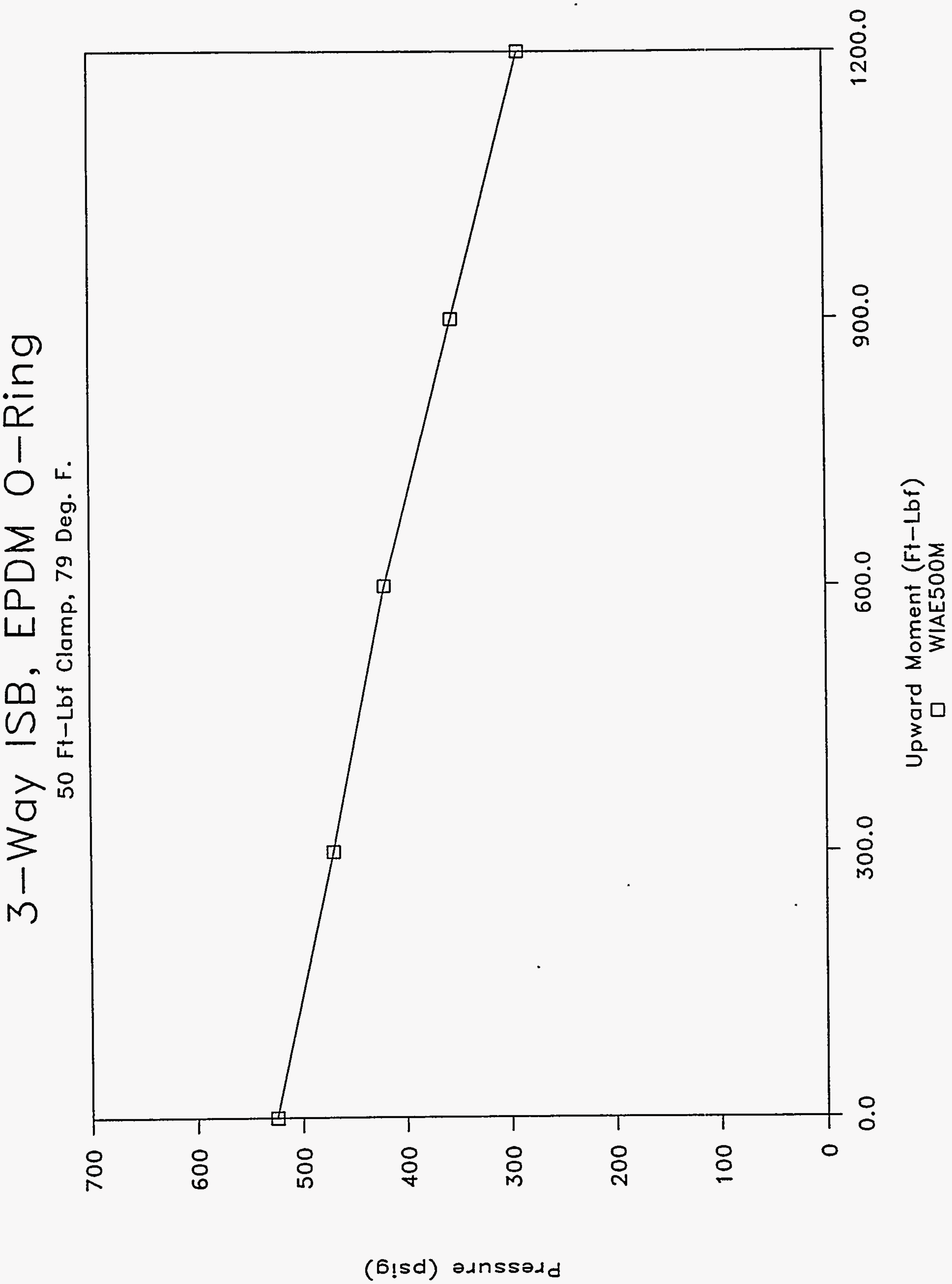

3-Way ISB, EPDM O-Ring
50 Ft-Lbf Clamp, 71 Deg. F.
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
44.5
89.1
133.6
164.8
Lateral Moment (Ft-Lbf)
WIAE100L
Pressure (psig)
(Thousands)

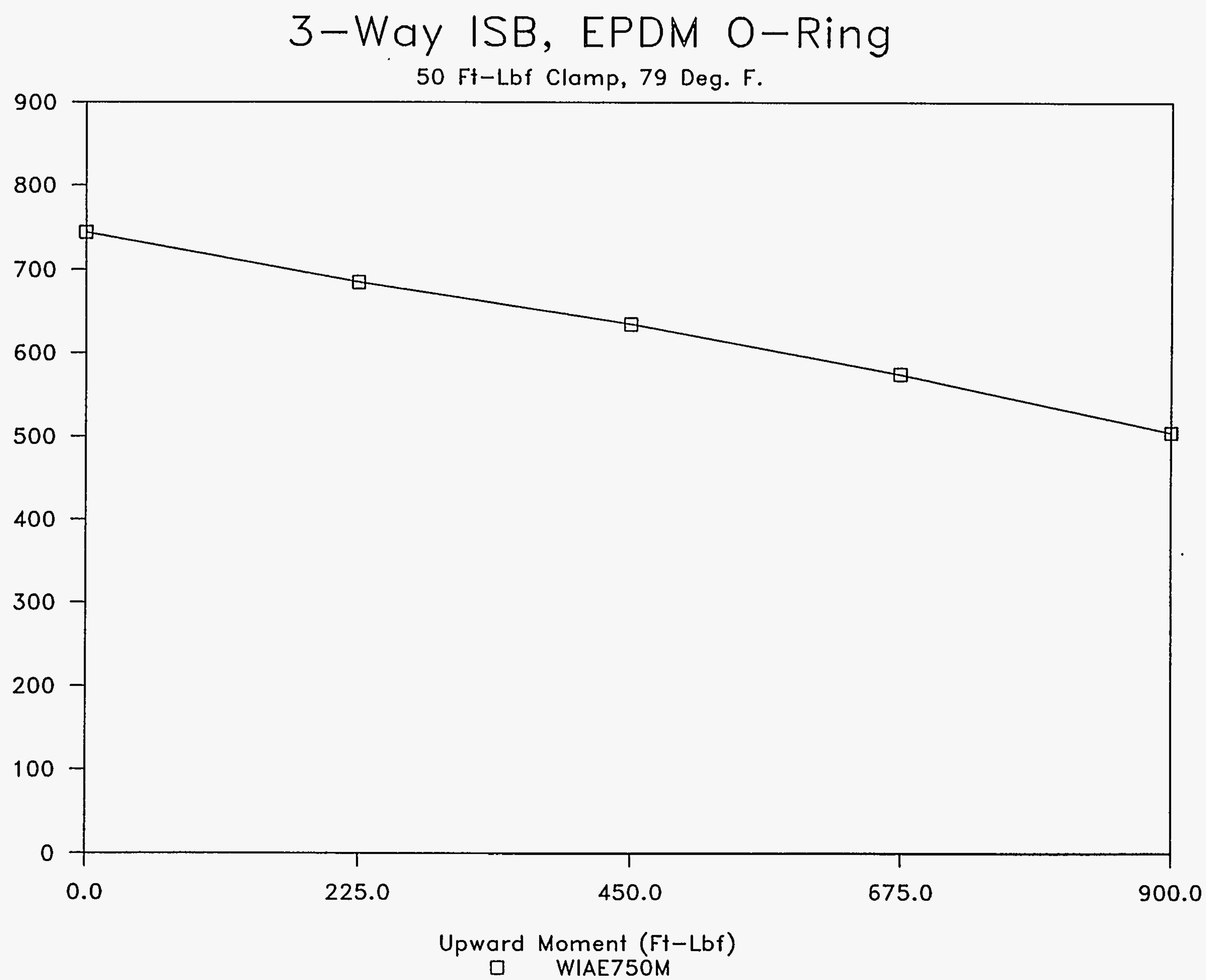
DECEMBER 07, 1994
2" 3-WAY ISB CONNECTOR, EPDM O-RING, 70 DUROMETER, AMBIENT TEMP.
PART # 2-119 E893-80, PARKER SEAL CO., BATCH # 315989, CURE DATE 3Q94
LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIAE250L
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 71 DEG. F.

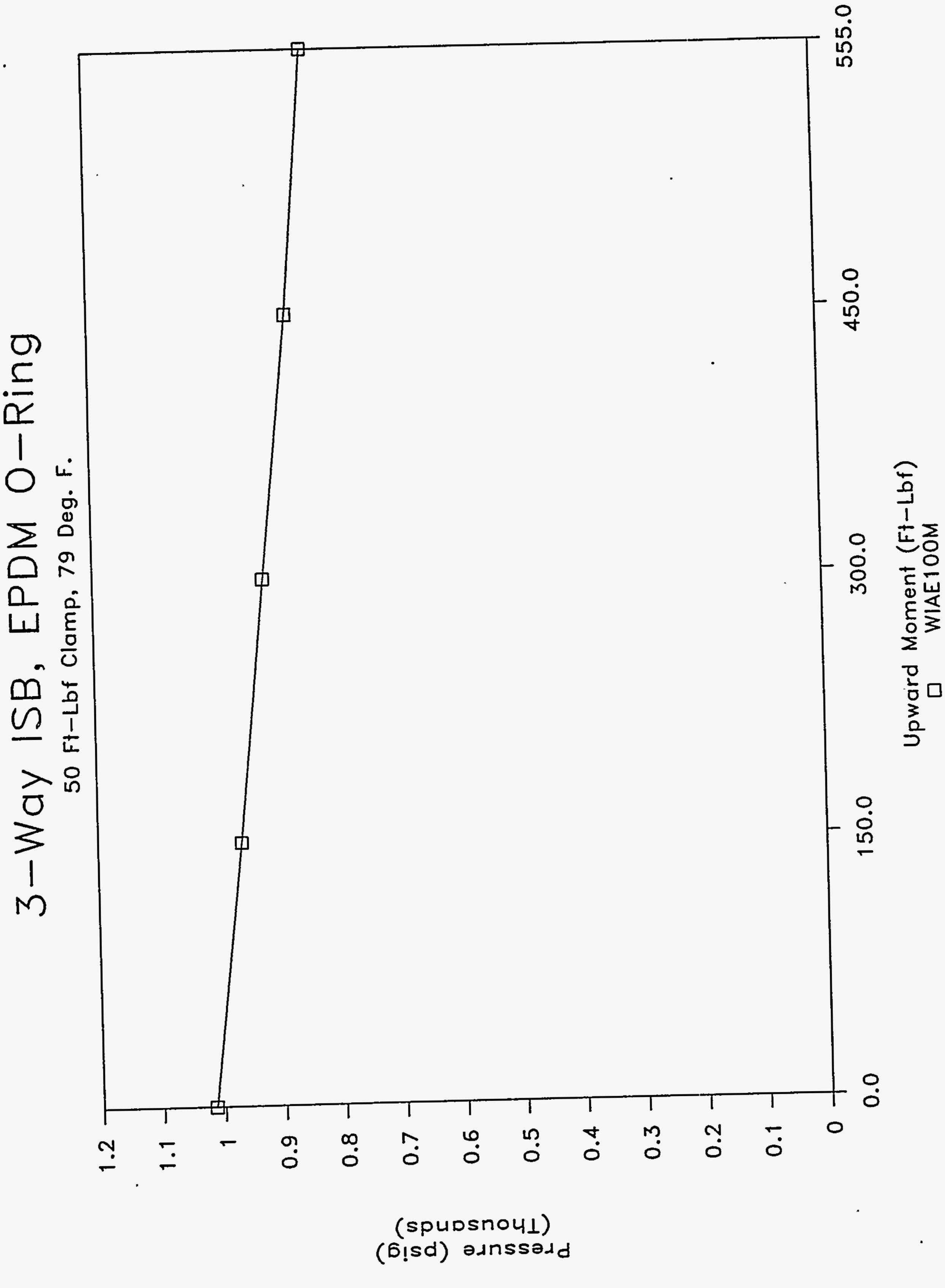
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
260	0	0	0.00	0	0.4453	0.0
260	2	0	2.00	0	0.4453	0.0
255	4	0	4.00	250	0.4453	111.3
250	6	0	6.00	500	0.4453	222.7
245	8	0	8.00	750	0.4453	334.0
245	10	0	10.00	1000	0.4453	445.3
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = WIAE500L		
505	12	0	12.00	0	0.4453	0.0
500	14	0	14.00	200	0.4453	89.1
490	16	0	16.00	400	0.4453	178.1
475	18	0	18.00	600	0.4453	267.2
475	20	0	20.00	800	0.4453	356.2
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = WIAE750L		
750	22	0	22.00	0	0.4453	0.0
740	24	0	24.00	150	0.4453	66.8
720	26	0	26.00	300	0.4453	133.6
700	28	0	28.00	450	0.4453	200.4
690	30	0	30.00	600	0.4453	267.2
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = WIAE100L		
1025	32	0	32.00	0	0.4453	0.0
1020	34	0	34.00	100	0.4453	44.5
1005	36	0	36.00	200	0.4453	89.1
985	38	0	38.00	300	0.4453	133.6
975	40	0	40.00	370	0.4453	164.8


3-Way ISB, EPDM O-Ring
50 Ft-Lbf Clamp, 79 Deg. F.
Pressure (psig)
350
300
250
200
150
100
50
0
0.0
0.0
375.0
750.0
1125.0
1500.0
Upward Moment (Ft-Lbf)
WIAE250M

S-7

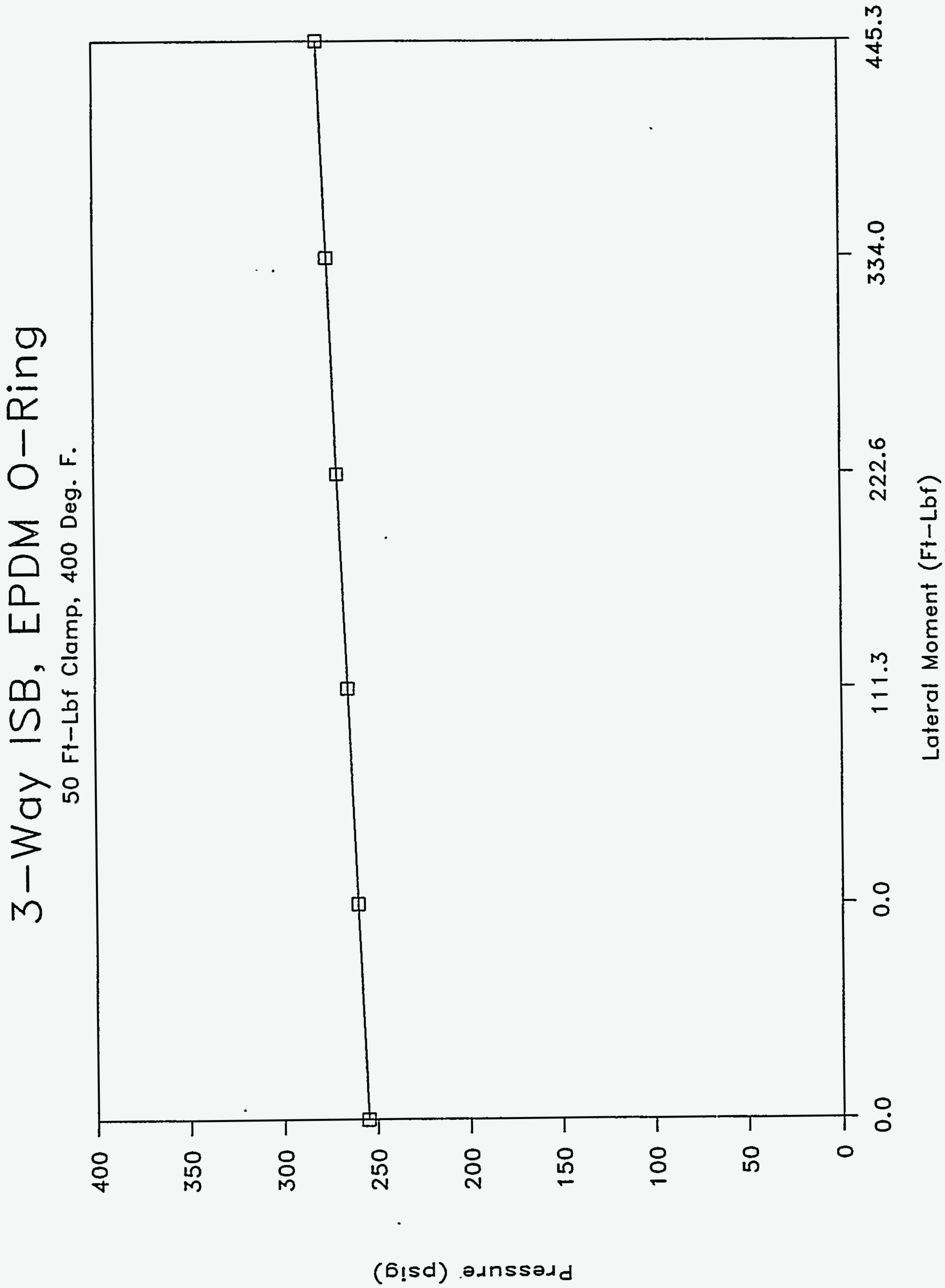

3-Way ISB, EPDM O-Ring
50 Ft-Lbf Clamp, 79 Deg. F.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft-Lbf)
WIAE500M


3-Way ISB, EPDM O-Ring
50 Ft-Lbf Clamp, 79 Deg. F.
900
800
700
600
500
400
300
200
100
0
Pressure (psig)
0.0
225.0
450.0
675.0
900.0
Upward Moment (Ft-Lbf)
WIAE750M


3—Way ISB, EPDM O—Ring
50 Ft—Lbf Clamp, 79 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
150.0
300.0
450.0
555.0
Upward Moment (Ft—Lbf)
WIAE100M

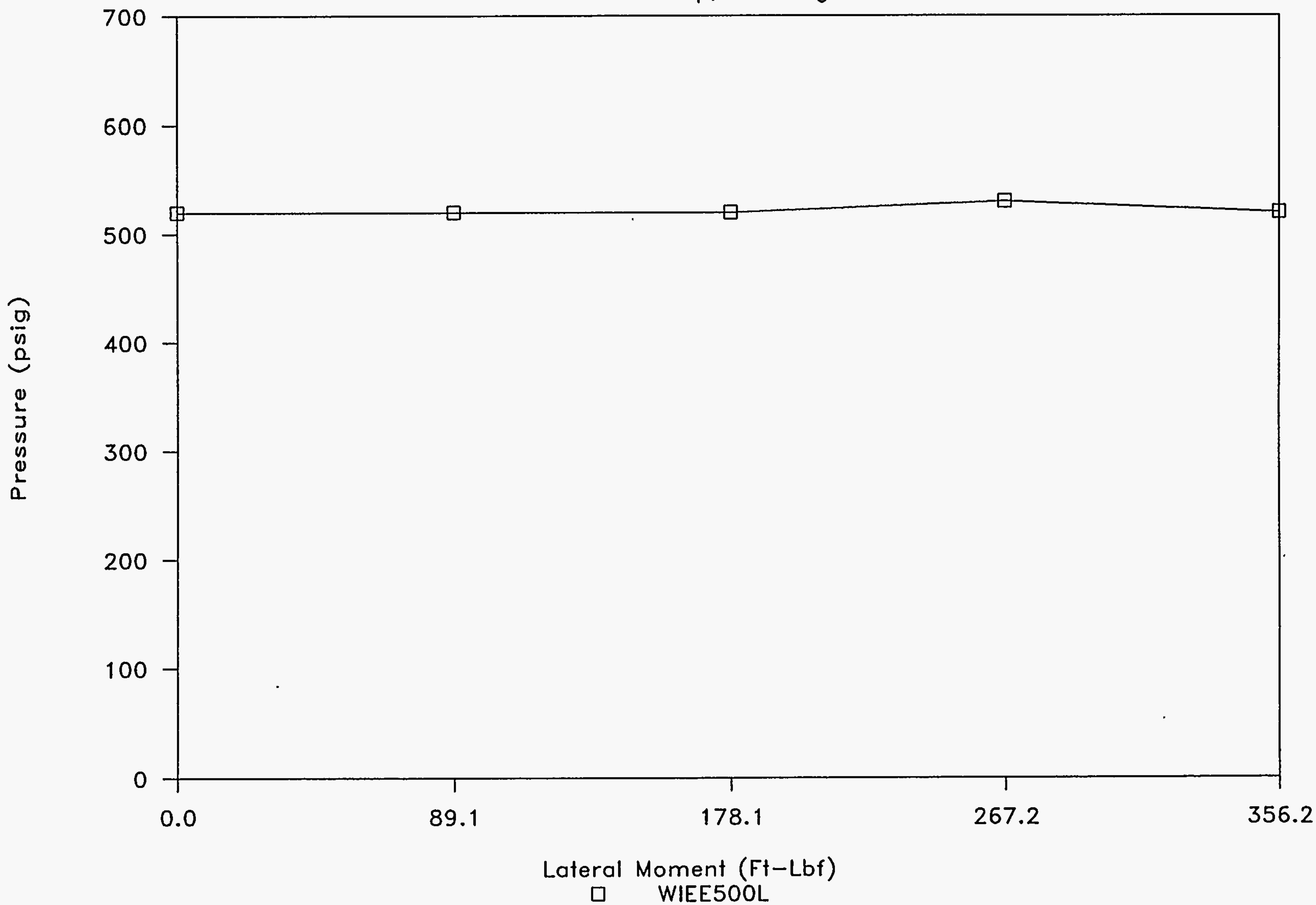
DECEMBER 02, 1994
2" 3-WAY ISB CONNECTOR, EPDM O-RING, 70 DUROMETER, AMBIENT TEMP.
PART # 2-119 E893-80, PARKER SEAL CO., BATCH # 315989, CURE DATE 3Q94
LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIAE250M
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 79 DEG. F.

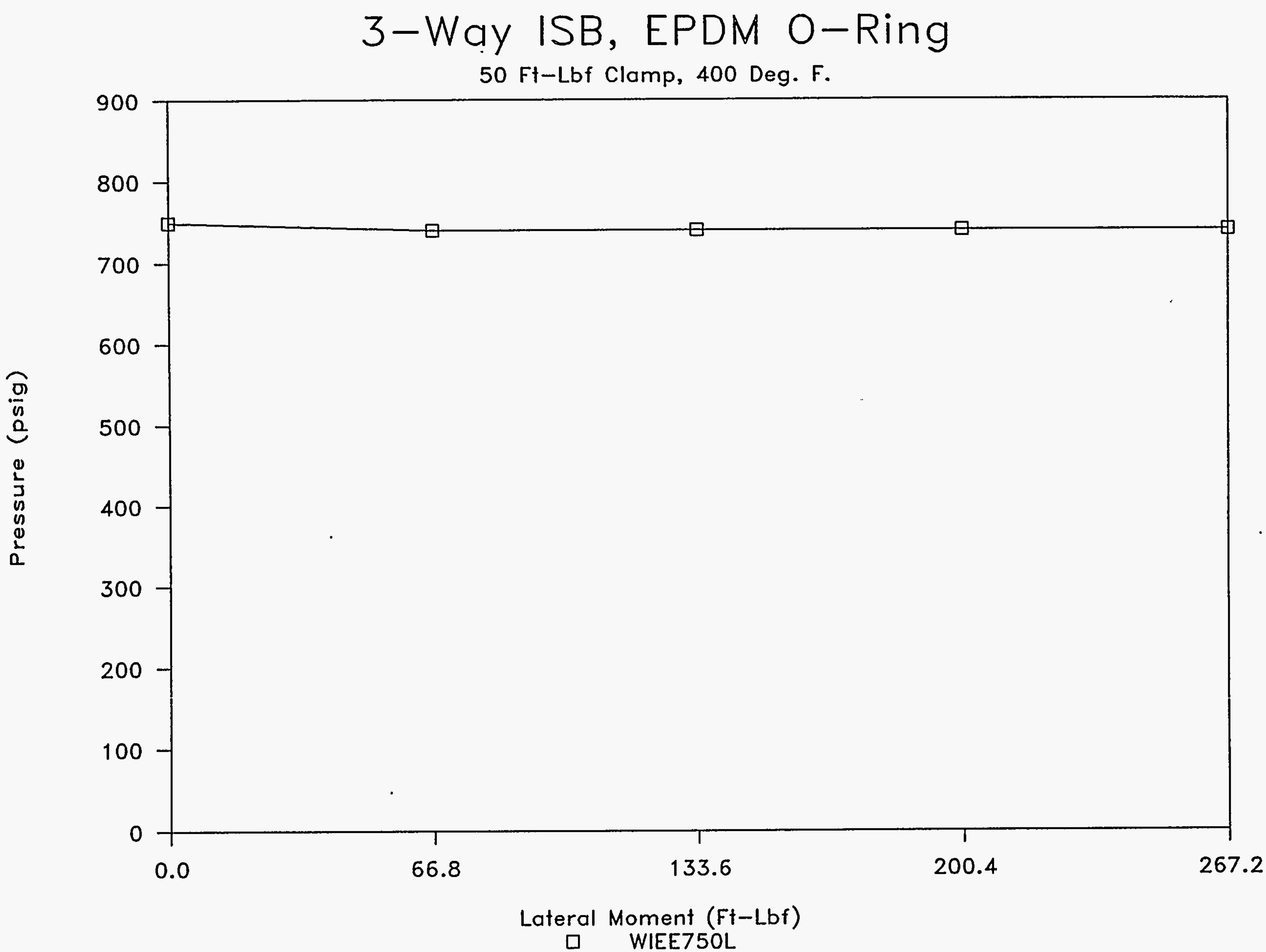
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
275	0	0	0.00	0	1.5000	0.0
275	2	0	2.00	0	1.5000	0.0
245	4	0	4.00	250	1.5000	375.0
220	6	0	6.00	500	1.5000	750.0
175	8	0	8.00	750	1.5000	1125.0
145	10	0	10.00	1000	1.5000	1500.0
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = WIAE500M		
525	12	0	12.00	0	1.5000	0.0
470	14	0	14.00	200	1.5000	300.0
420	16	0	16.00	400	1.5000	600.0
355	18	0	18.00	600	1.5000	900.0
290	20	0	20.00	800	1.5000	1200.0
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = WIAE750M		
745	22	0	22.00	0	1.5000	0.0
685	24	0	24.00	150	1.5000	225.0
635	26	0	26.00	300	1.5000	450.0
575	28	0	28.00	450	1.5000	675.0
505	30	0	30.00	600	1.5000	900.0
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = WIAE100M		
1015	32	0	32.00	0	1.5000	0.0
965	34	0	34.00	100	1.5000	150.0
920	36	0	36.00	200	1.5000	300.0
875	38	0	38.00	300	1.5000	450.0
840	40	0	40.00	370	1.5000	555.0


3—Way ISB, EPDM O—Ring
50 Ft—Lbf Clamp, 400 Deg. F.
Pressure (psig)
0
50
100
150
200
250
300
350
400
0.0
0.0
111.3
222.6
334.0
445.3
Lateral Moment (Ft—Lbf)
WIEE250L

3-Way ISB, EPDM O-Ring

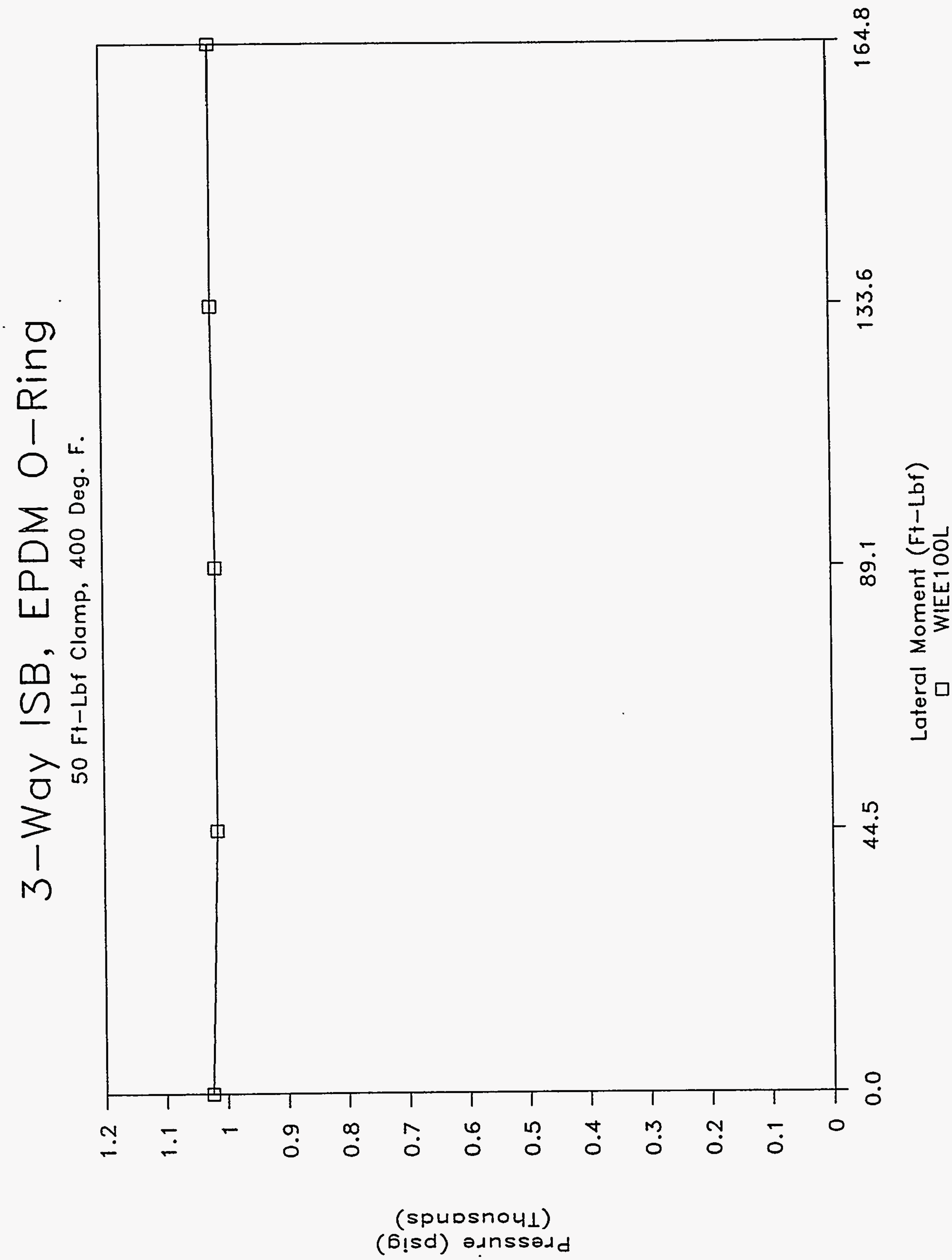
50 Ft-Lbf Clamp, 400 Deg. F.





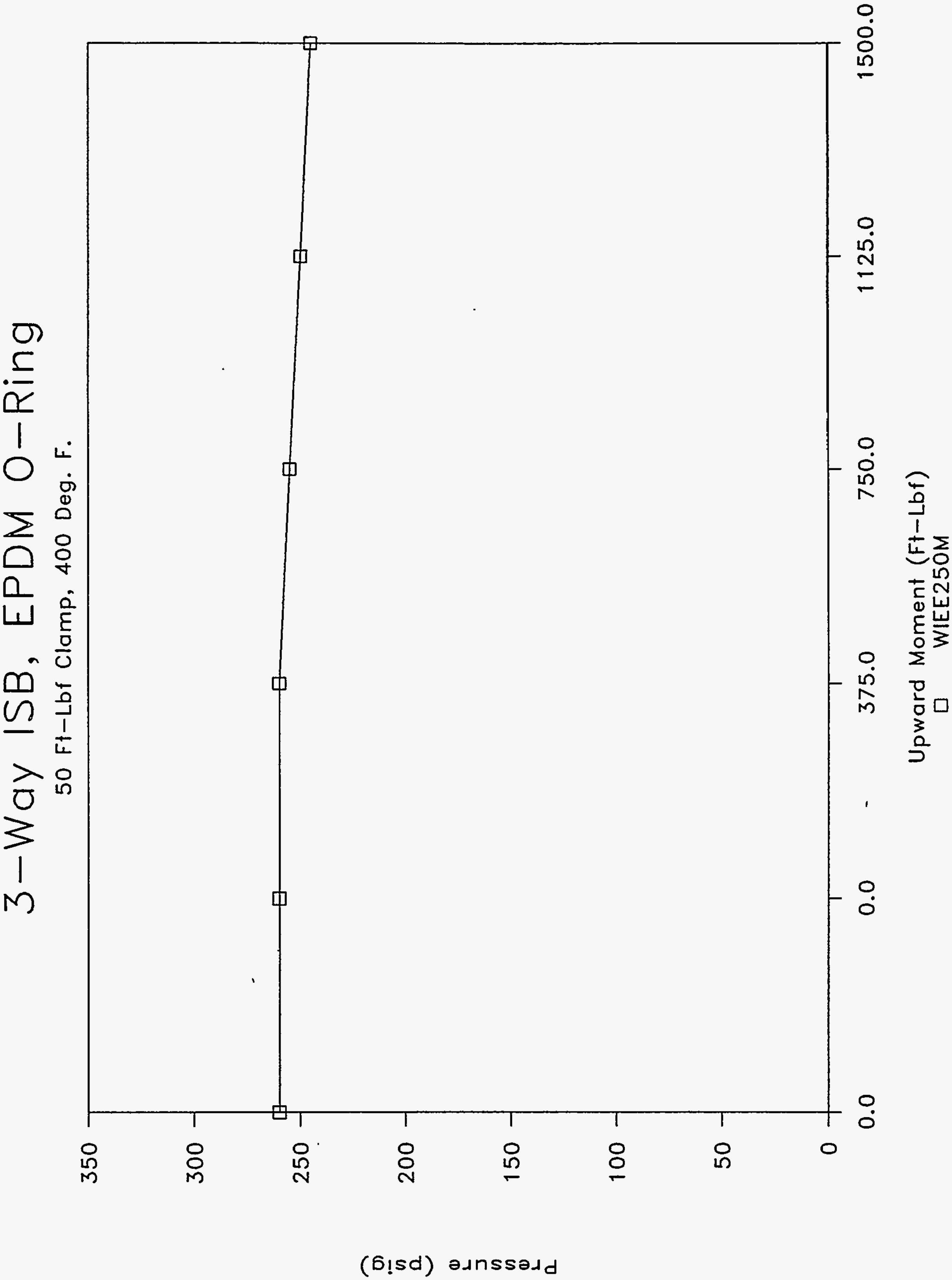
S-14

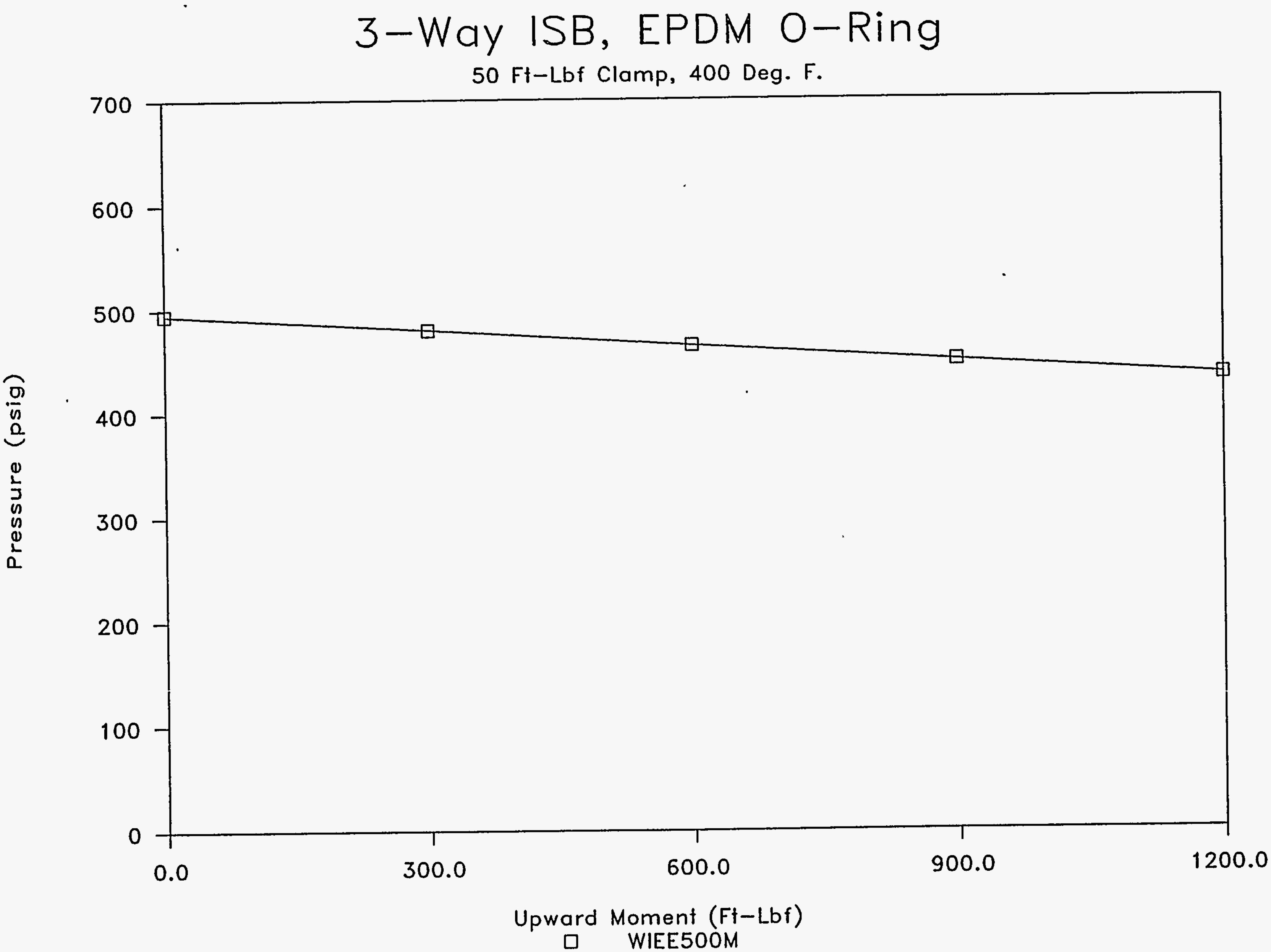
WHC-SD-WM-TRP-223
Rev. 0

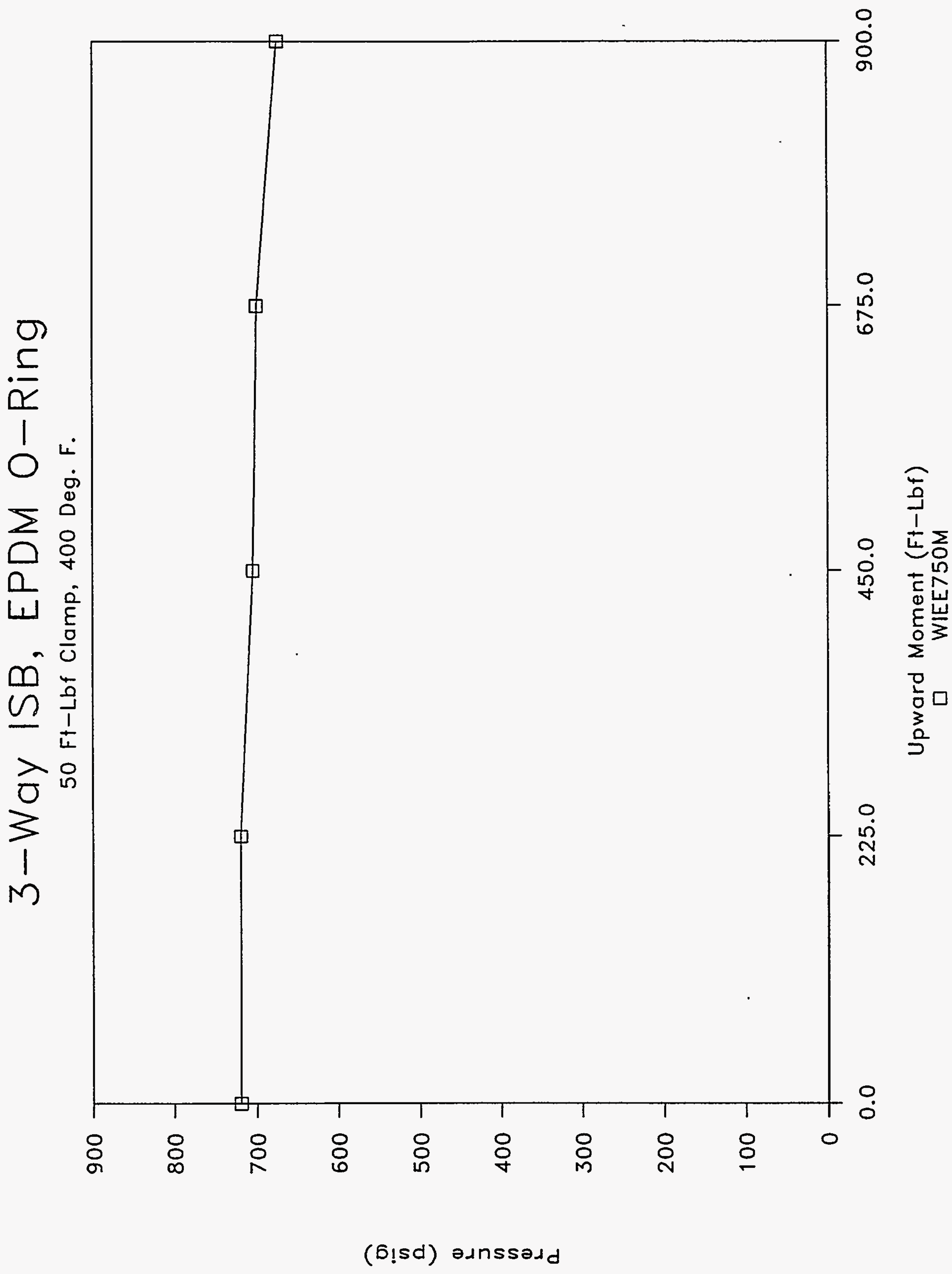

3-Way ISB, EPDM O-Ring
50 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
44.5
89.1
133.6
164.8
Lateral Moment (Ft-Lbf)
WIEE100L

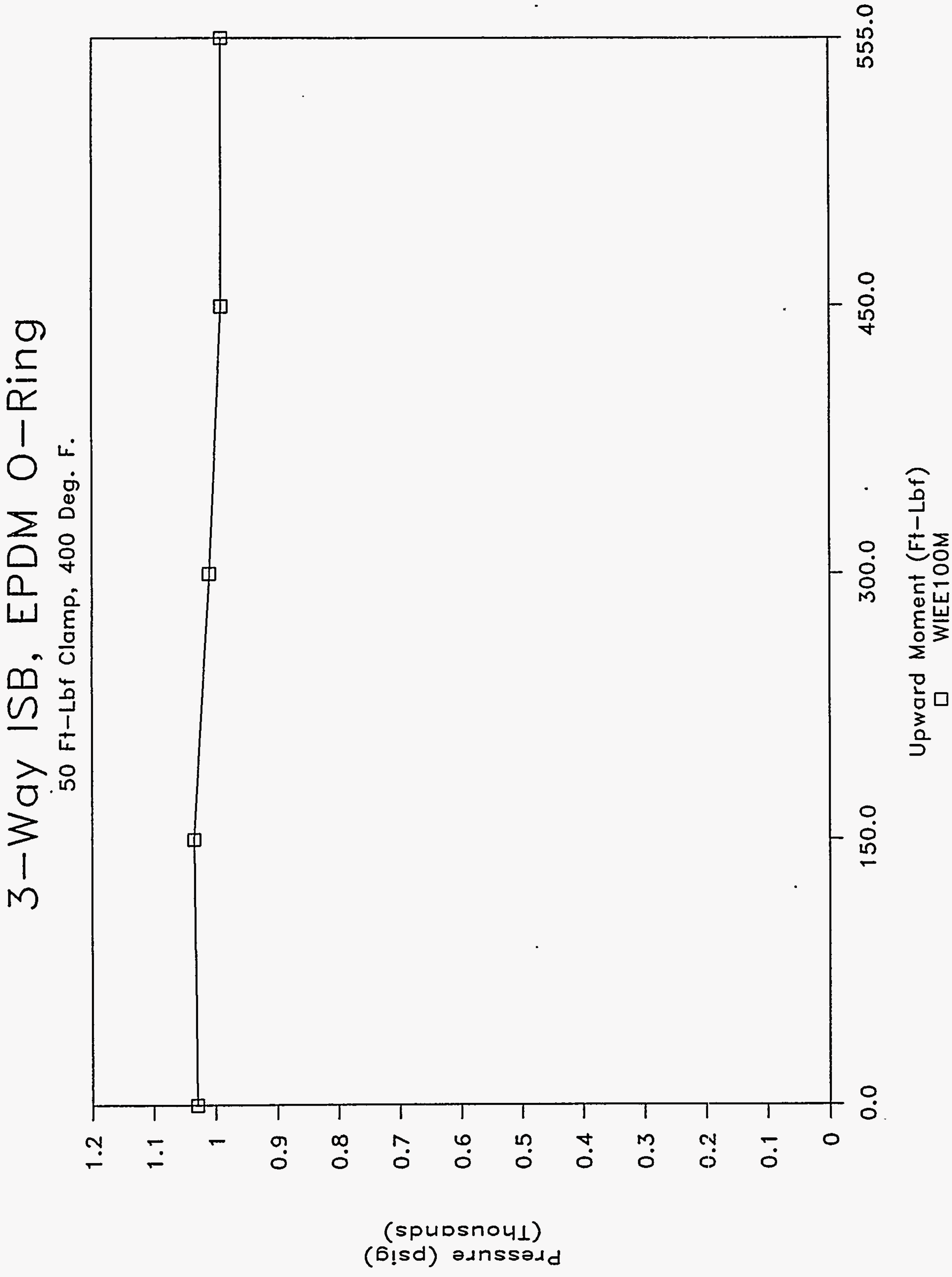
DECEMBER 07, 1994
2" 3-WAY ISB CONNECTOR, EPDM O-RING, 70 DUROMETER, ELEVATED TEMP.
PART # 2-119 E893-80, PARKER SEAL CO., BATCH # 315989, CURE DATE 3Q94
LEAK TEST - LATERAL MOMENT (SIDEWAYS ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIEE250L
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 400 DEG. F.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	LATERAL MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE
255	0	0	0.00	0	0.4453	0.0
260	2	0	2.00	0	0.4453	0.0
265	4	0	4.00	250	0.4453	111.3
270	6	0	6.00	500	0.4453	222.7
275	8	0	8.00	750	0.4453	334.0
280	10	0	10.00	1000	0.4453	445.3
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = WIEE500L		
520	12	0	12.00	0	0.4453	0.0
520	14	0	14.00	200	0.4453	89.1
520	16	0	16.00	400	0.4453	178.1
530	18	0	18.00	600	0.4453	267.2
520	20	0	20.00	800	0.4453	356.2
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = WIEE750L		
750	22	0	22.00	0	0.4453	0.0
740	24	0	24.00	150	0.4453	66.8
740	26	0	26.00	300	0.4453	133.6
740	28	0	28.00	450	0.4453	200.4
740	30	0	30.00	600	0.4453	267.2
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = WIEE100L		
1025	32	0	32.00	0	0.4453	0.0
1015	34	0	34.00	100	0.4453	44.5
1015	36	0	36.00	200	0.4453	89.1
1020	38	0	38.00	300	0.4453	133.6
1020	40	0	40.00	370	0.4453	164.8


3-Way ISB, EPDM O-Ring
50 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
350
300
250
200
150
100
50
0
0.0
0.0
375.0
750.0
1125.0
1500.0
Upward Moment (Ft-Lbf)
WIEE250M


3-Way ISB, EPDM O-Ring
50 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
700
600
500
400
300
200
100
0
0.0
300.0
600.0
900.0
1200.0
Upward Moment (Ft-Lbf)
WIEE500M

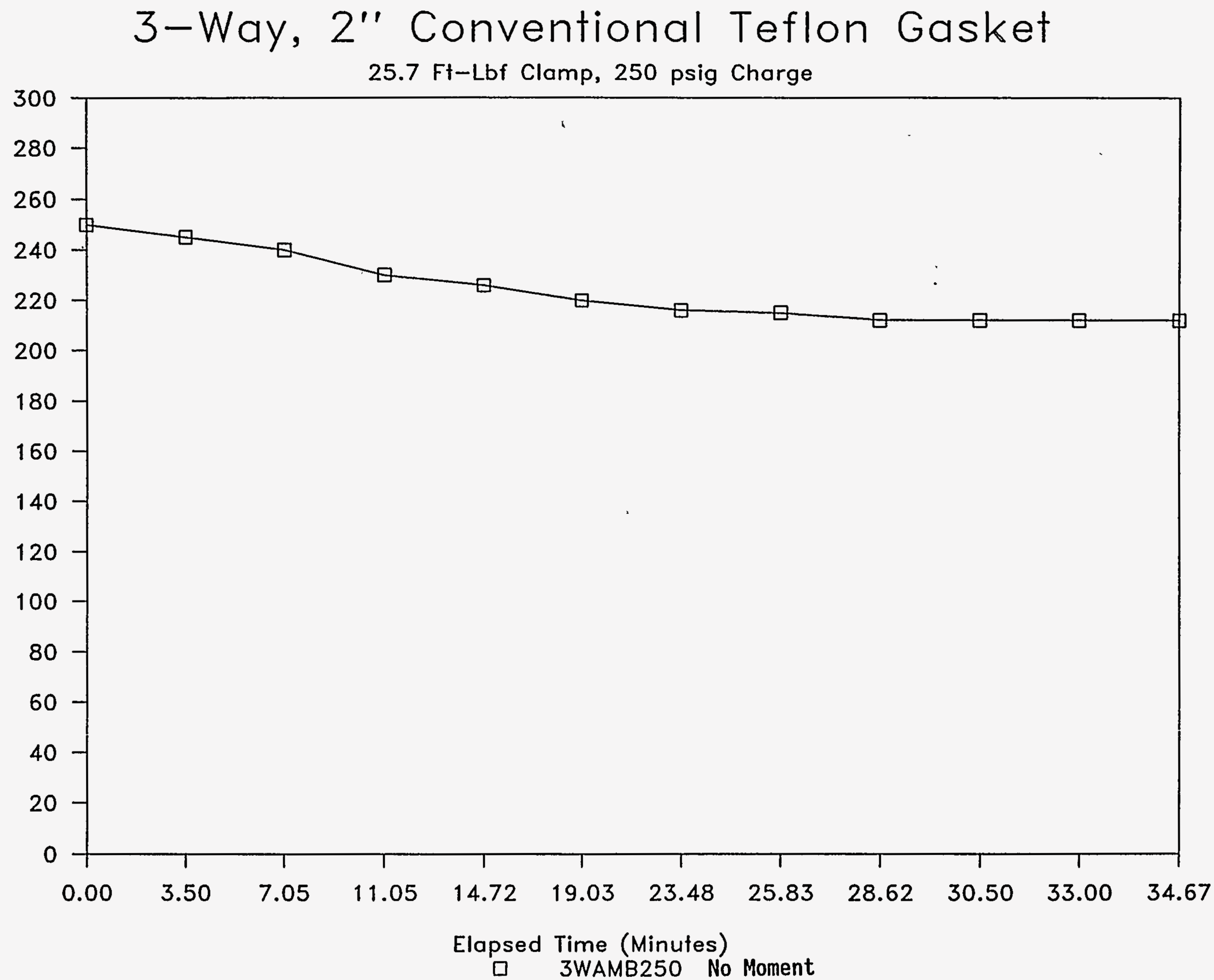

3-Way ISB, EPDM O-Ring
50 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
0
100
200
300
400
500
600
700
800
900
Upward Moment (Ft-Lbf)
0.0
225.0
450.0
675.0
900.0
WIEE750M


3-Way ISB, EPDM O-Ring
50 Ft-Lbf Clamp, 400 Deg. F.
Pressure (psig)
(Thousands)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
150.0
300.0
450.0
555.0
Upward Moment (Ft-Lbf)
WIEE100M

DECEMBER 05, 1994
2" 3-WAY ISB CONNECTOR, EPDM O-RING, 70 DUROMETER, ELEVATED TEMP.
PART # 2-119 E893-80, PARKER SEAL CO., BATCH # 315989, CURE DATE 3Q94
LEAK TEST - UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 50 FT-LBF NOMINAL GRAPH NAME = WIEE250M
CHARGE PRESSURE = 250 PSIG TEMPERATURE: 400 DEG. F.

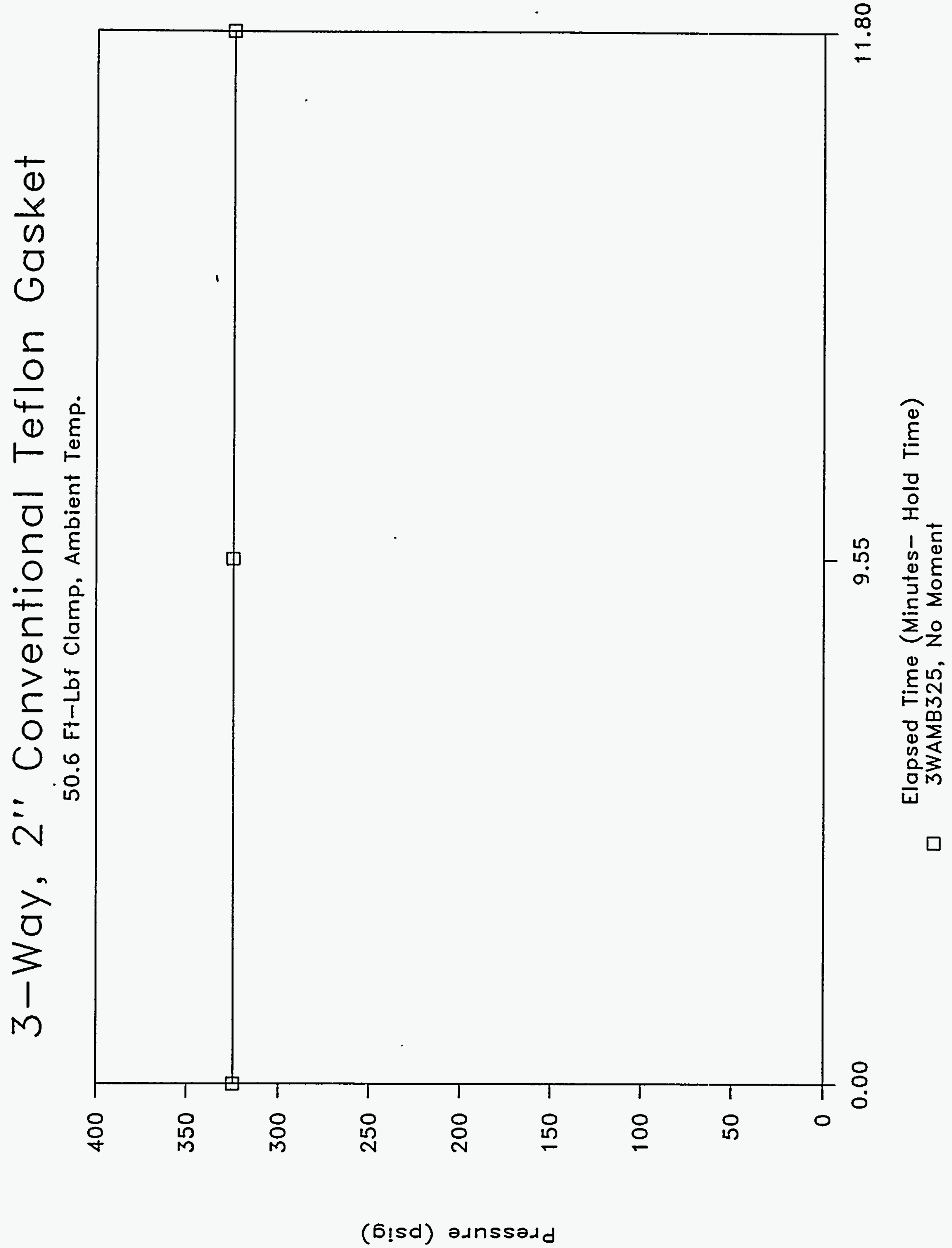
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	UPWARD FORCE LBS INPUT	UPWARD MOMENT ARM FT. INPUT	UPWARD MOMENT FT-LBF. COMPUTE
260	0	0	0.00	0	1.5000	0.0
260	2	0	2.00	0	1.5000	0.0
260	4	0	4.00	250	1.5000	375.0
255	6	0	6.00	500	1.5000	750.0
250	8	0	8.00	750	1.5000	1125.0
245	10	0	10.00	1000	1.5000	1500.0
INCREASED PRESSURE TO 500 PSIG				GRAPH NAME = WIEE500M		
495	12	0	12.00	0	1.5000	0.0
480	14	0	14.00	200	1.5000	300.0
465	16	0	16.00	400	1.5000	600.0
450	18	0	18.00	600	1.5000	900.0
435	20	0	20.00	800	1.5000	1200.0
INCREASED PRESSURE TO 750 PSIG				GRAPH NAME = WIEE750M		
720	22	0	22.00	0	1.5000	0.0
720	24	0	24.00	150	1.5000	225.0
705	26	0	26.00	300	1.5000	450.0
700	28	0	28.00	450	1.5000	675.0
675	30	0	30.00	600	1.5000	900.0
INCREASED PRESSURE TO 1000 PSIG				GRAPH NAME = WIEE100M		
1030	32	0	32.00	0	1.5000	0.0
1035	34	0	34.00	100	1.5000	150.0
1010	36	0	36.00	200	1.5000	300.0
990	38	0	38.00	300	1.5000	450.0
990	40	0	40.00	370	1.5000	555.0

APPENDIX T: GRAPHS OF THREE-WAY CONVENTIONAL TEFLON GASKET TESTS


3-Way, 2" Conventional Teflon Gasket
25.7 Ft-Lbf Clamp, 250 psig Charge
Pressure (psig)
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
0.00
3.50
7.05
11.05
14.72
19.03
23.48
25.83
28.62
30.50
33.00
34.67
Elapsed Time (Minutes)
3WAMB250 No Moment

MAY 03, 1994
3-WAY, 2" CONVENTIONAL TEFLON BLOCK
AMBIENT TEMP.
STATIC LEAK TEST - NO EXTERNAL MOMENTS
CLAMPING TORQUE = 25.7 FT-LBF GRAPH NAME = 3WAMB250
CHARGE PRESSURE = 250 PSIG.

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE
250	0	0	0.00
245	3	30	3.50
240	7	3	7.05
230	11	3	11.05
226	14	43	14.72
220	19	2	19.03
216	23	29	23.48
215	25	50	25.83
212	28	37	28.62
212	30	30	30.50
212	33	0	33.00
212	34	40	34.67

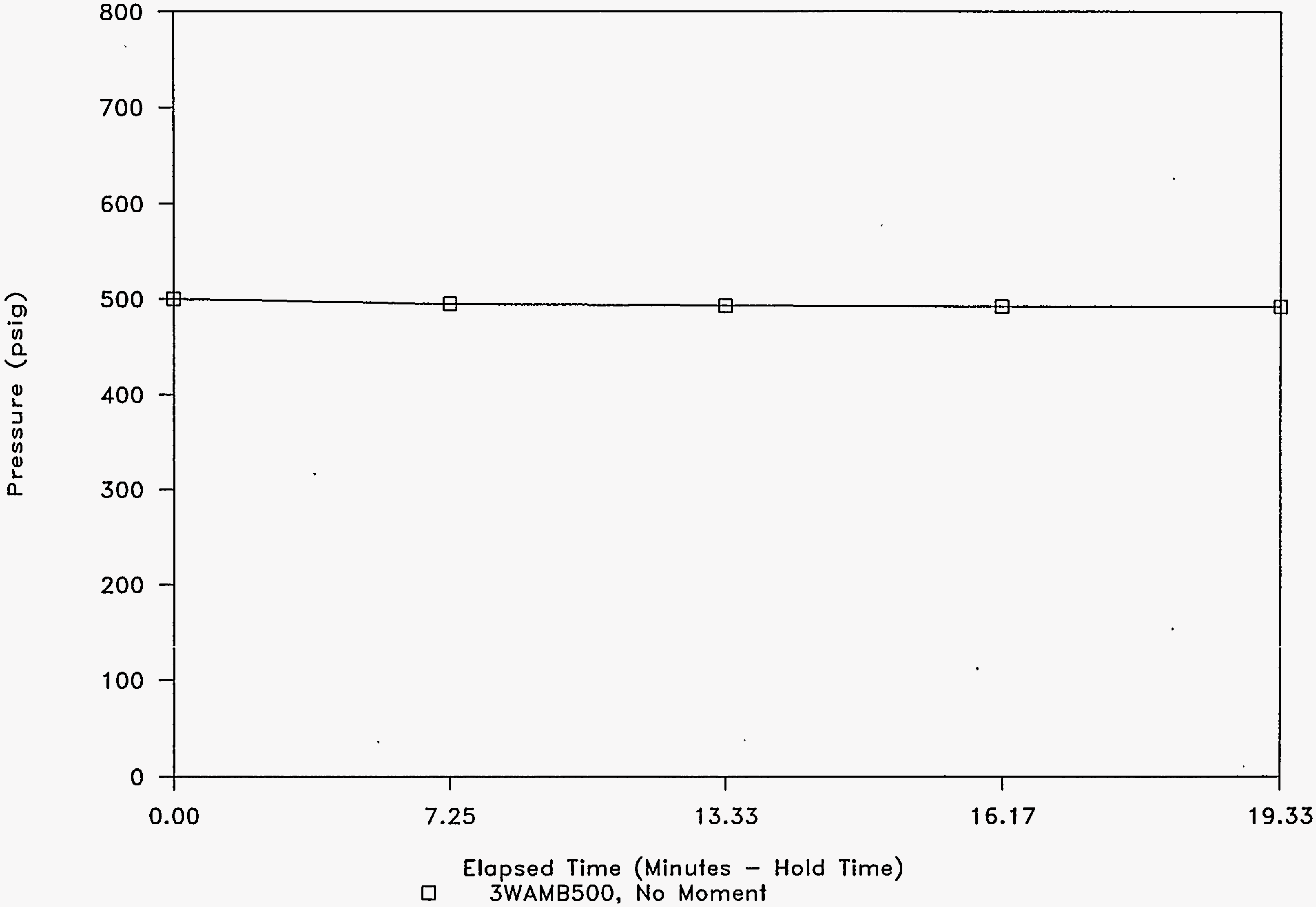

3-Way, 2" Conventional Teflon Gasket
50.6 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
400
350
300
250
200
150
100
50
0
0.00
9.55
11.80
Elapsed Time (Minutes- Hold Time)
3WAMB325, No Moment

MAY 03, 1994
3-WAY, 2" CONVENTIONAL TEFLON BLOCK
AMBIENT TEMP.
STATIC LEAK TEST - NO EXTERNAL MOMENTS
CLAMPING TORQUE = 50.6 FT-LBF
CHARGE PRESSURE = 325 PSIG. GRAPH NAME = 3WAMB325

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE
325	0	0	0.00
325	9	33	9.55
325	11	48	11.80

3-Way, 2" Conventional Teflon Gasket

50.6 Ft-Lbf Clamp, Ambient Temp.

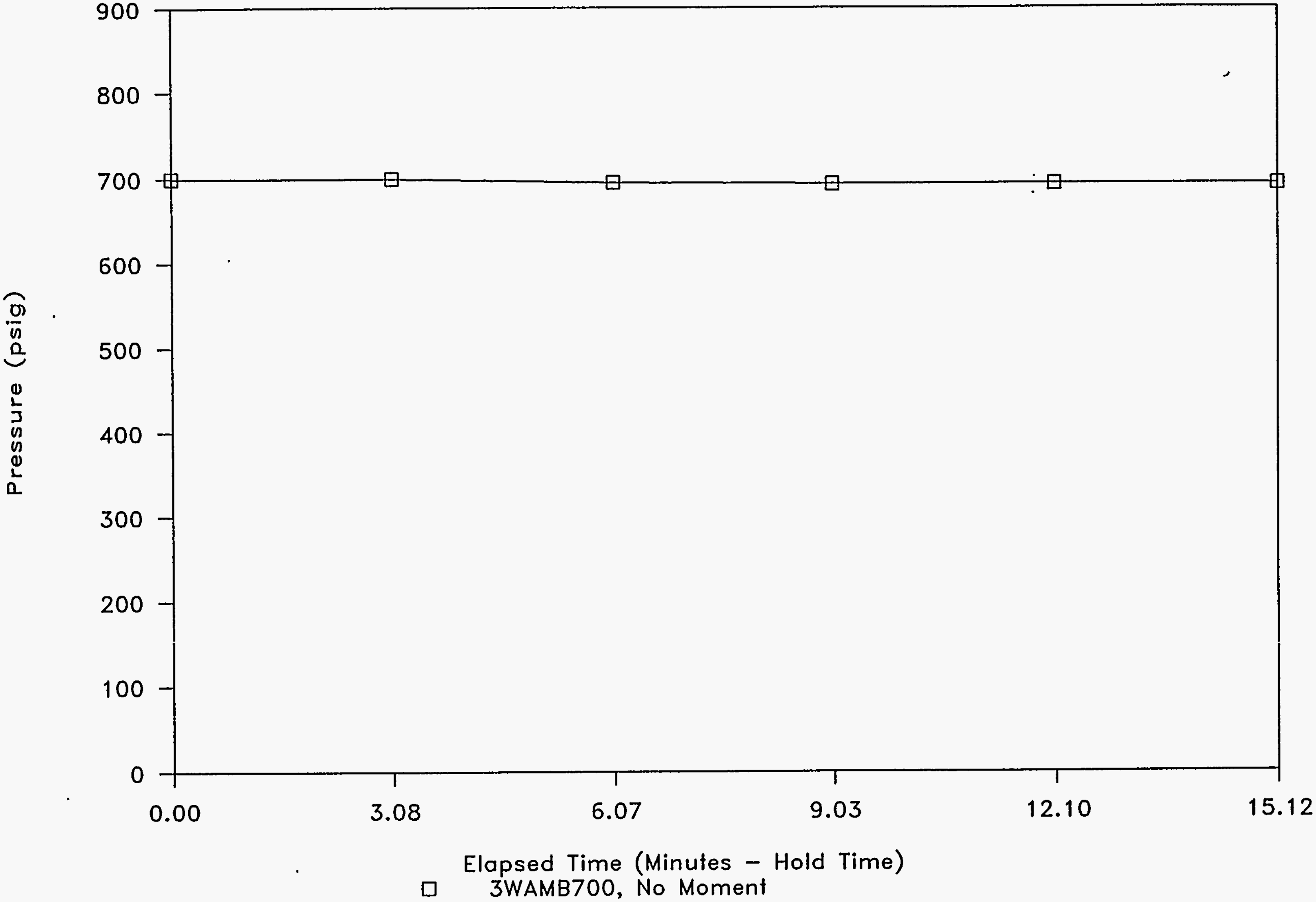


MAY 03, 1994
3-WAY, 2" CONVENTIONAL TEFLON BLOCK
AMBIENT TEMP.
STATIC LEAK TEST - NO EXTERNAL MOMENTS
CLAMPING TORQUE = 50.6 FT-LBF
CHARGE PRESSURE = 500 PSIG. GRAPH NAME = 3WAMB500

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE
500	0	0	0.00
495	7	15	7.25
493	13	20	13.33
492	16	10	16.17
492	19	20	19.33

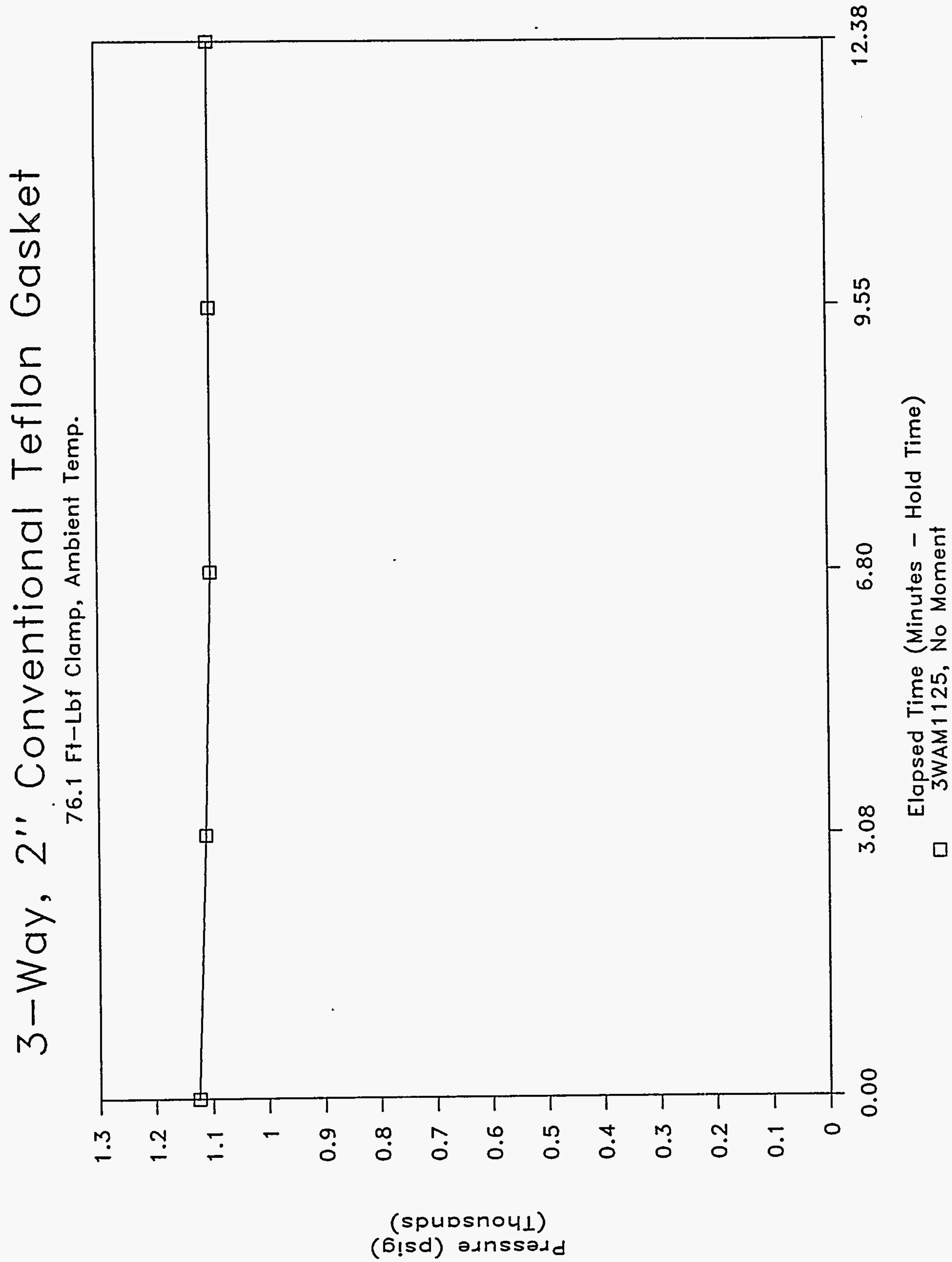
3-Way, 2" Conventional Teflon Gasket

76.1 Ft-Lbf Clamp, Ambient Temp.



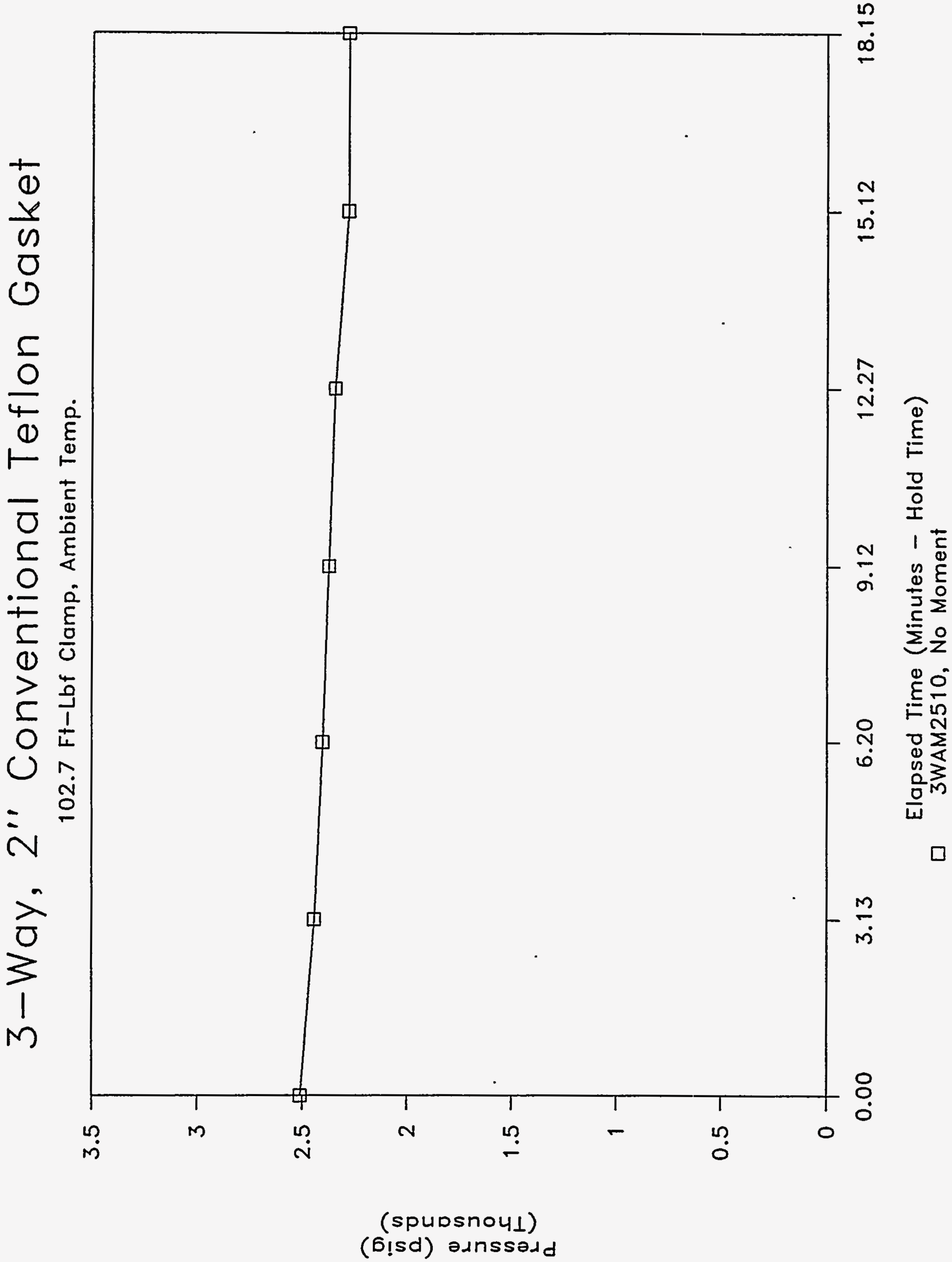
MAY 03, 1994
3-WAY, 2" CONVENTIONAL TEFLON BLOCK
AMBIENT TEMP.
STATIC LEAK TEST - NO EXTERNAL MOMENTS
CLAMPING TORQUE = 76.1 FT-LBF
CHARGE PRESSURE = 700 PSIG. GRAPH NAME = 3WAMB700

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE
700	0	0	0.00
700	3	5	3.08
695	6	4	6.07
693	9	2	9.03
693	12	6	12.10
693	15	7	15.12


3-Way, 2" Conventional Teflon Gasket
76.1 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.00
3.08
6.80
9.55
12.38
Elapsed Time (Minutes - Hold Time)
3WAM1125, No Moment

MAY 03, 1994
3-WAY, 2" CONVENTIONAL TEFLON BLOCK
AMBIENT TEMP.
STATIC LEAK TEST - NO EXTERNAL MOMENTS
CLAMPING TORQUE = 76.1 FT-LBF
CHARGE PRESSURE = 1125 PSIG. GRAPH NAME = 3WAM1125

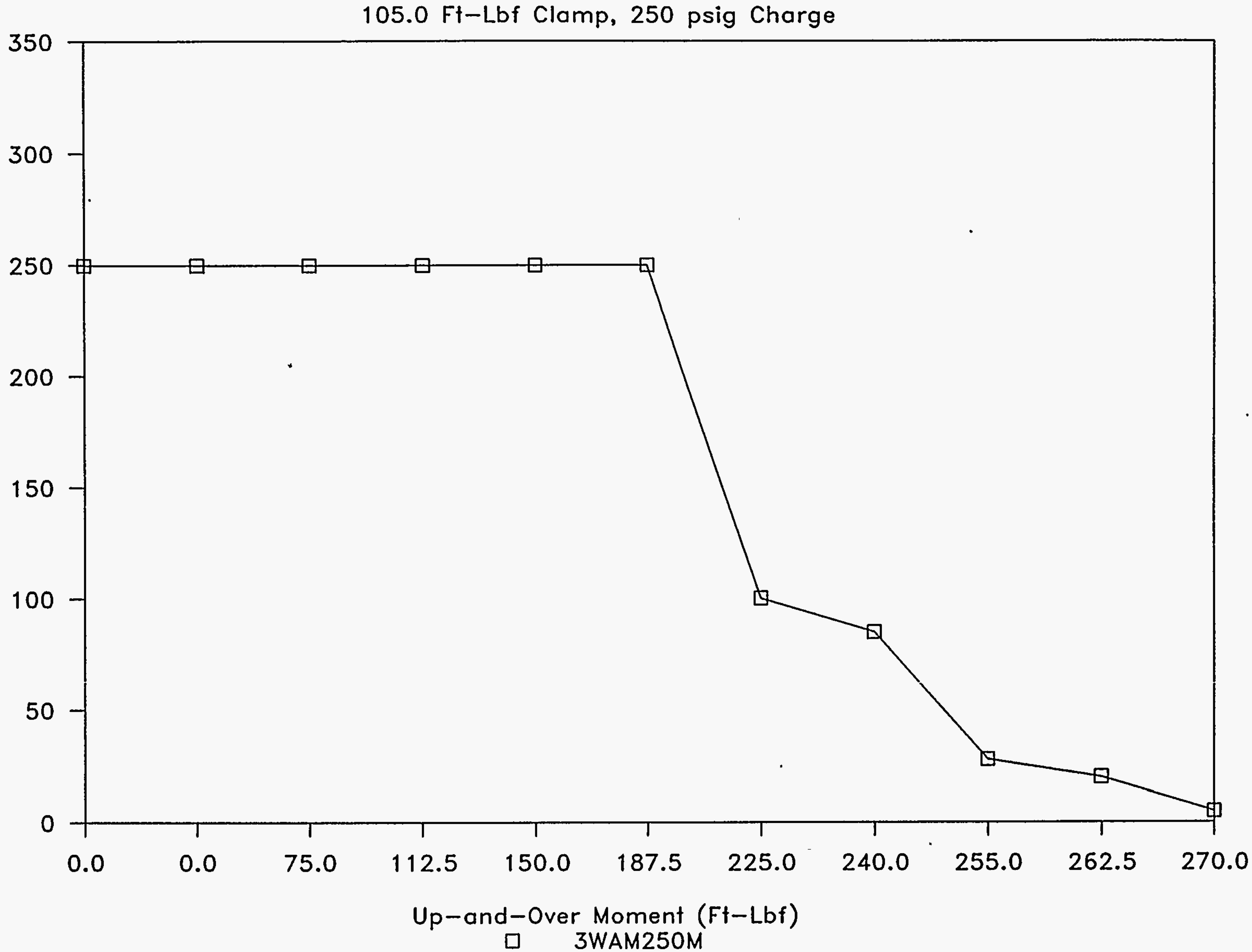
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE
1125	0	0	0.00
1110	3	5	3.08
1100	6	48	6.80
1100	9	33	9.55
1100	12	23	12.38


3-Way, 2" Conventional Teflon Gasket
102.7 Ft-Lbf Clamp, Ambient Temp.
Pressure (psig)
(Thousands)
3.5
3
2.5
2
1.5
1
0.5
0
0.00
3.13
6.20
9.12
12.27
15.12
18.15
Elapsed Time (Minutes - Hold Time)
3WAM2510, No Moment

MAY 03, 1994
3-WAY, 2" CONVENTIONAL TEFLON BLOCK
AMBIENT TEMP.
STATIC LEAK TEST - NO EXTERNAL MOMENTS
CLAMPING TORQUE = 102.7 FT-LBF
CHARGE PRESSURE = 2510 PSIG. GRAPH NAME = 3WAM2510

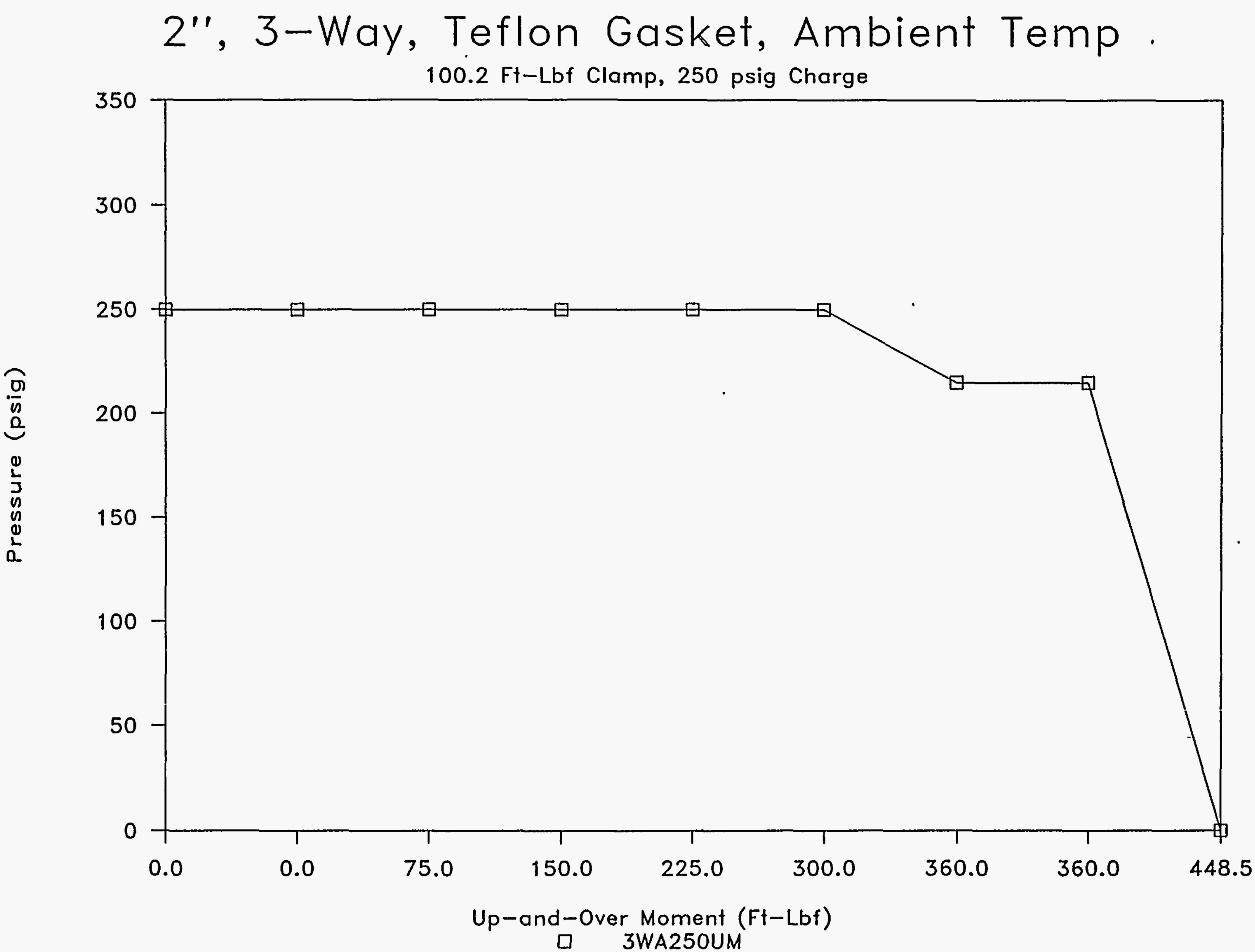
PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE
2510	0	0	0.00
2445	3	8	3.13
2405	6	12	6.20
2375	9	7	9.12
2345	12	16	12.27
2285	15	7	15.12
2285	18	9	18.15

3-Way, Teflon Gasket



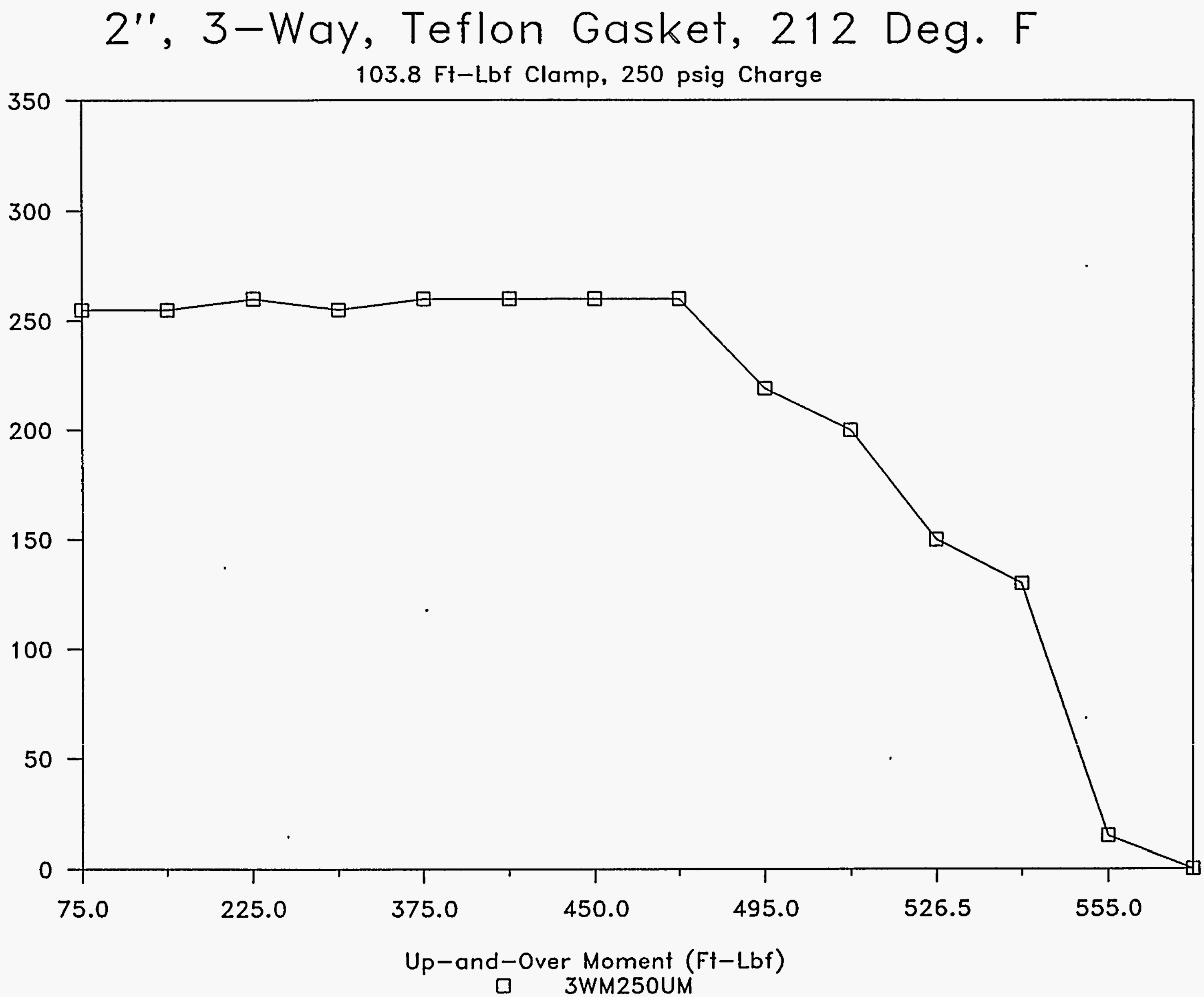
MAY 24, 1994
3-WAY CONNECTOR, CONVENTIONAL, 100% TEFLON GASKET, AMBIENT TEMP.
LEAK TEST - UP AND OVER MOMENTS APPLIED
CLAMPING TORQUE = 105.0 FT-LBF GRAPH NAME = 3WAM250M
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	MOMENT FORCE LBS INPUT	MOMENT ARM FT. INPUT	UP&OVR MOMENT FT-LBF. COMPUTE	UPWARD DEFLECTIO (CHORDAL) INCHES INPUT
250	0	0	0.00	0	1.5	0.0	0.000
250	2	3	2.05	0	1.5	0.0	0.000
250	4	20	4.33	50	1.5	75.0	0.006
250	6	16	6.27	75	1.5	112.5	0.010
250	8	18	8.30	100	1.5	150.0	0.015
250	10	20	10.33	125	1.5	187.5	0.021
100	13	18	13.30	150	1.5	225.0	0.029
85	16	15	16.25	160	1.5	240.0	0.032
28	19	16	19.27	170	1.5	255.0	0.035
20	22	13	22.22	175	1.5	262.5	0.037
5	25	15	25.25	180	1.5	270.0	0.039


2", 3-Way, Teflon Gasket, Ambient Temp
100.2 Ft-Lbf Clamp, 250 psig Charge
350
300
250
200
150
100
50
0
Pressure (psig)
0.0
0.0
75.0
150.0
225.0
300.0
360.0
360.0
448.5
Up-and-Over Moment (Ft-Lbf)
3WA250UM

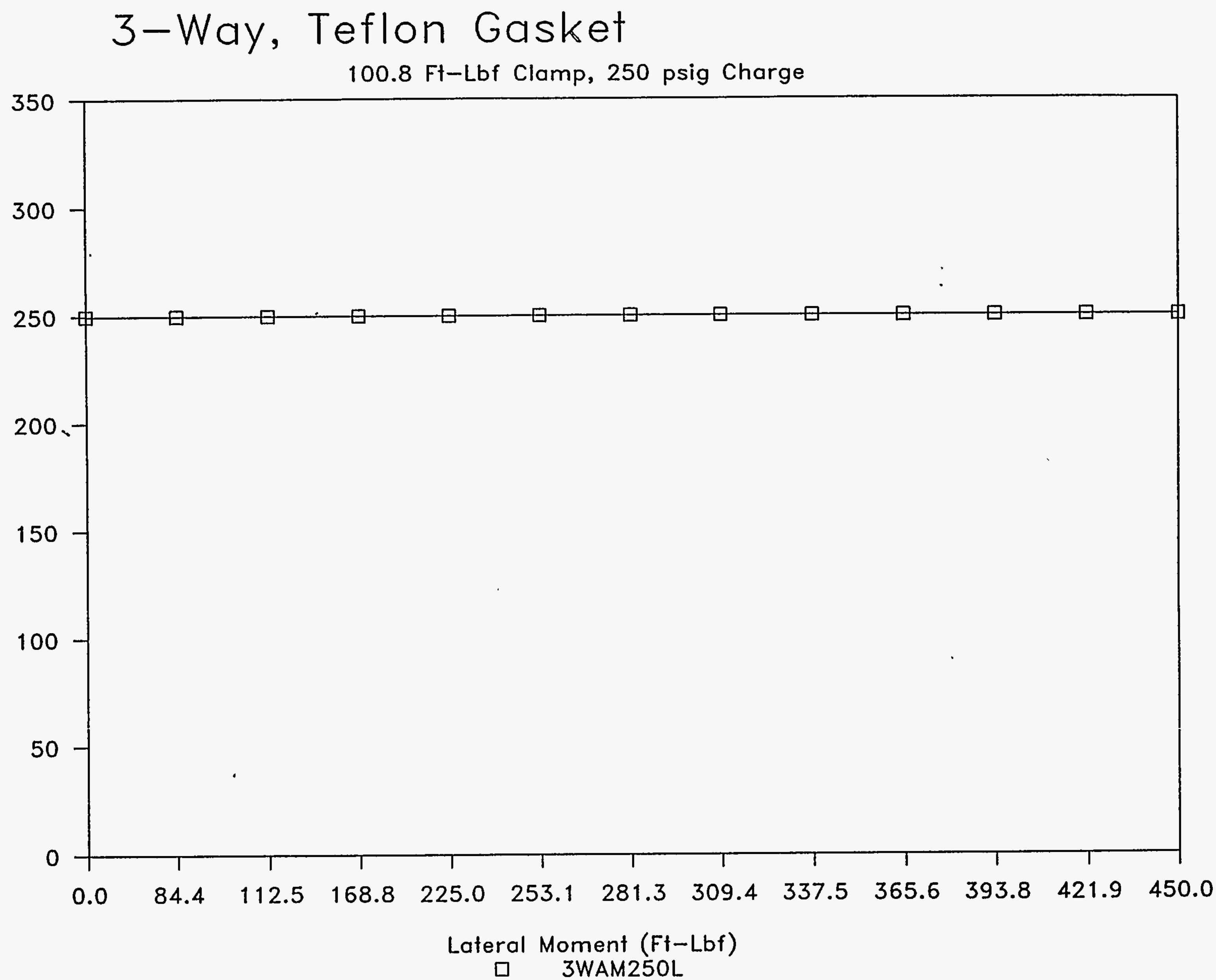
MAY 10, 1994
2", 3-WAY CONNECTOR, 100% TEFLON GASKET, AMBIENT TEMP.
UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 100.2 FT-LBF GRAPH NAME = 3WA250UM
CHARGE PRESSURE = 250 PSIG

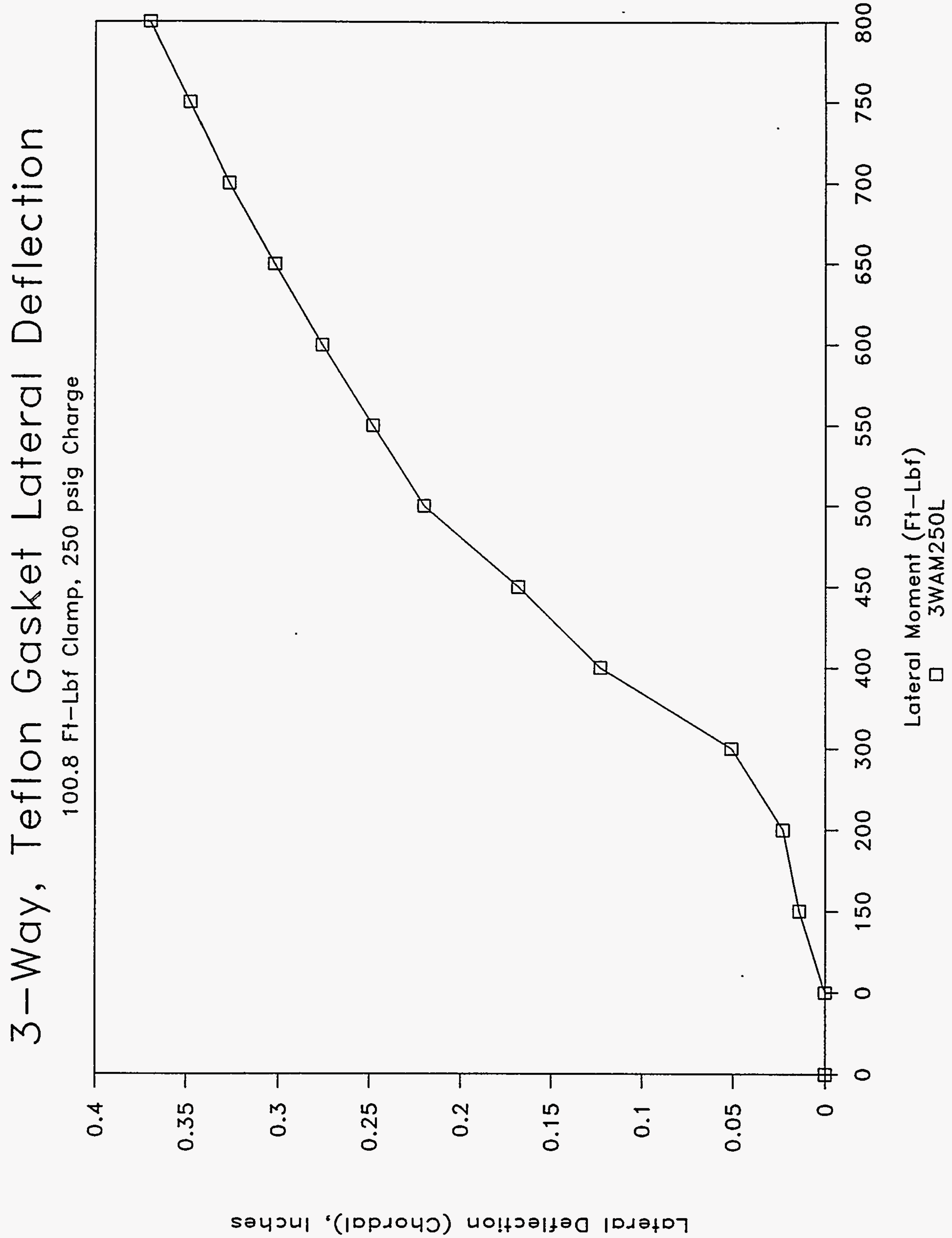
PRESSURE PSIG INPUT	HOLD TIME MINUTES INPUT	HOLD TIME SECONDS INPUT	HOLD TIME DECIMAL MINUTES COMPUTE	MOMENT FORCE LBS. INPUT	MOMENT ARM FT. INPUT	UP&OVR MOMENT FT-LBF. COMPUTE
250	0	0	0.00	0	1.5	0.0
250	2	3	2.05	0	1.5	0.0
250	2	2	2.03	50	1.5	75.0
250	2	3	2.05	100	1.5	150.0
250	2	5	2.08	150	1.5	225.0
250	2	5	2.08	200	1.5	300.0
215	0	0	0.00	240	1.5	360.0
215	2	4	2.07	240	1.5	360.0
0	0	0	0.00	299	1.5	448.5


2", 3–Way, Teflon Gasket, 212 Deg. F
103.8 Ft–Lbf Clamp, 250 psig Charge
Pressure (psig)
350
300
250
200
150
100
50
0
75.0
225.0
375.0
450.0
495.0
526.5
555.0
Up–and–Over Moment (Ft–Lbf)
3WM250UM

MAY 12, 1994
2", 3-WAY CONNECTOR, 100% TEFLON GASKET, 212 DEG. F TEMP.
UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 103.8 FT-LBF GRAPH NAME = 3WM250UM
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	HOLD TIME MINUTES INPUT	HOLD TIME SECONDS INPUT	HOLD TIME DECIMAL MINUTES COMPUTE	MOMENT FORCE LBS. INPUT	MOMENT ARM FT. INPUT	UP&OVR MOMENT FT-LBF. COMPUTE
255	2	2	2.03	50	1.5	75.0
255	2	3	2.05	100	1.5	150.0
260	2	2	2.03	150	1.5	225.0
255	2	1	2.02	200	1.5	300.0
260	2	2	2.03	250	1.5	375.0
260	2	1	2.02	275	1.5	412.5
260	2	2	2.03	300	1.5	450.0
260	2	5	2.08	325	1.5	487.5
219	2	2	2.03	330	1.5	495.0
200	2	1	2.02	345	1.5	517.5
150	2	4	2.07	351	1.5	526.5
130	2	1	2.02	357	1.5	535.5
15	0	0	0.00	370	1.5	555.0
0	0	0	0.00	370	1.5	555.0


3-Way, Teflon Gasket
100.8 Ft-Lbf Clamp, 250 psig Charge
Pressure (psig)
350
300
250
200
150
100
50
0
0.0
84.4
112.5
168.8
225.0
253.1
281.3
309.4
337.5
365.6
393.8
421.9
450.0
Lateral Moment (Ft-Lbf)
3WAM250L

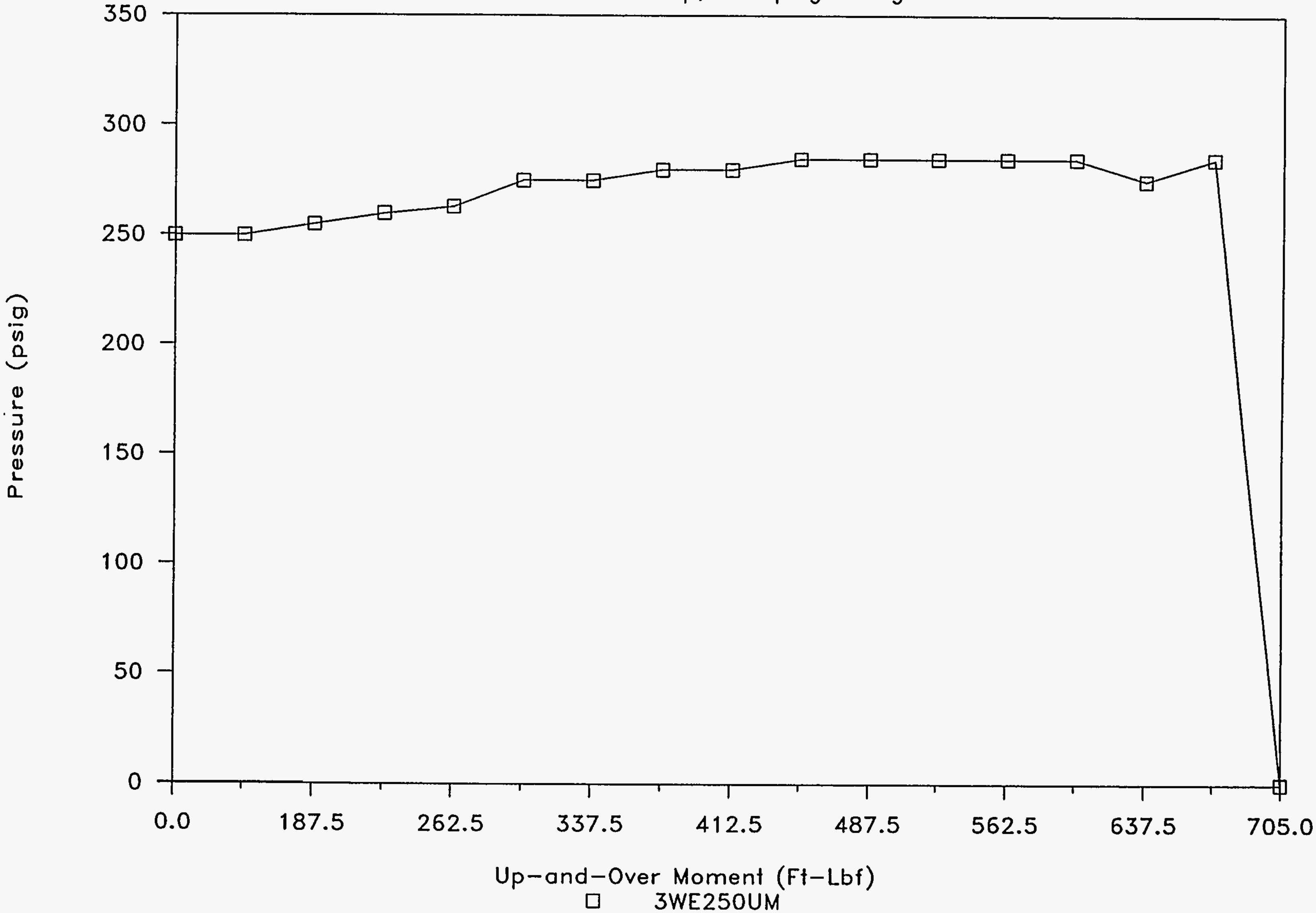

3-Way, Teflon Gasket Lateral Deflection
100.8 Ft-Lbf Clamp, 250 psig Charge
Lateral Deflection (Chordal), Inches
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
Lateral Moment (Ft-Lbf)
0
0
150
200
300
400
450
500
550
600
650
700
750
800
3WAM250L

MAY 20, 1994
3-WAY CONNECTOR, CONVENTIONAL, 100% TEFLON GASKET, AMBIENT TEMP.
LEAK TEST - LATERAL EXTERNAL MOMENTS APPLIED
CLAMPING TORQUE = 100.8 FT-LBF GRAPH NAME = 3WAM250L
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE	LATERAL FORCE LBS INPUT	MOMENT ARM FT. INPUT	LATERAL MOMENT FT-LBF. COMPUTE	LATERAL DEFLECTIO (CHORDAL) INCHES INPUT
250	0	0	0.00	0	0.5625	0.0	0.000
250	2	7	2.12	0	0.5625	0.0	0.000
250	4	50	4.83	150	0.5625	84.4	0.014
250	6	56	6.93	200	0.5625	112.5	0.023
250	10	26	10.43	300	0.5625	168.8	0.051
250	11	56	11.93	400	0.5625	225.0	0.123
244	16	0	16.00	450	0.5625	253.1	0.168
244	21	0	21.00	500	0.5625	281.3	0.220
244	26	45	26.75	550	0.5625	309.4	0.248
241	34	0	34.00	600	0.5625	337.5	0.276
241	41	50	41.83	650	0.5625	365.6	0.302
240	49	0	49.00	700	0.5625	393.8	0.327
240	53	30	53.50	750	0.5625	421.9	0.348
240	57	0	57.00	800	0.5625	450.0	0.370

2", 3-Way, Teflon Gasket, 400 Deg. F

100.2 Ft-Lbf Clamp, 250 psig Charge



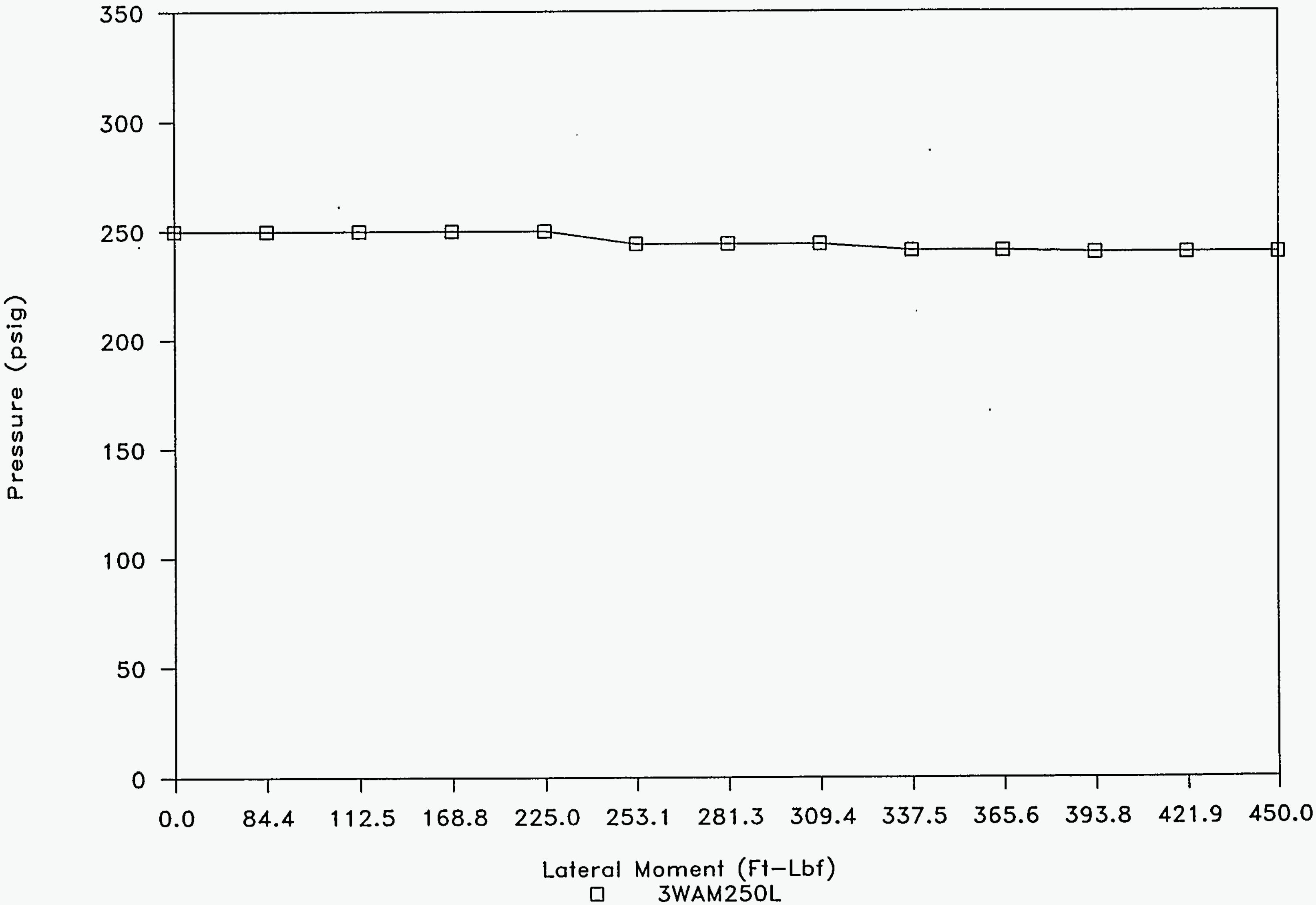
MAY 12, 1994
2", 3-WAY CONNECTOR, 100% TEFLON GASKET, 400 DEG. F TEMP.
UP AND OVER MOMENT (UPWARD ROTATION)
CLAMPING TORQUE = 102.3 FT-LBF GRAPH NAME = 3WE250UM
CHARGE PRESSURE = 250 PSIG

PRESSURE PSIG INPUT	HOLD TIME MINUTES INPUT	HOLD TIME SECONDS INPUT	HOLD TIME DECIMAL MINUTES COMPUTE	MOMENT FORCE LBS. INPUT	MOMENT ARM FT. INPUT	UP&OVR MOMENT FT-LBF. COMPUTE
250	2	4	2.07	0	1.5	0.0
250	2	5	2.08	100	1.5	150.0
255	2	3	2.05	125	1.5	187.5
260	2	9	2.15	150	1.5	225.0
263	2	7	2.12	175	1.5	262.5
275	2	5	2.08	200	1.5	300.0
275	2	3	2.05	225	1.5	337.5
280	2	2	2.03	250	1.5	375.0
280	2	11	2.18	275	1.5	412.5
285	2	10	2.17	300	1.5	450.0
285	2	3	2.05	325	1.5	487.5
285	2	11	2.18	350	1.5	525.0
285	2	1	2.02	375	1.5	562.5
285	42	58	42.97	400	1.5	600.0
275	2	2	2.03	425	1.5	637.5
285	2	15	2.25	450	1.5	675.0
0	0	0	0.00	470	1.5	705.0

NOTE: THE LAST READING OF "0" WAS ACTUALLY THE POINT WHERE THE TEFLON SEAL TOTALLY FAILED. PRESSURE LOSS WAS SUDDEN AND COMPLETE.

3-Way, Teflon Gasket Lateral Deflection

100.8 Ft-Lbf Clamp, 250 psig Charge



MAY 05, 1994
3-WAY, 2" CONVENTIONAL TEFLON BLOCK
AMBIENT TEMP. THERMAL CYCLE
STATIC LEAK TEST - NO EXTERNAL MOMENTS
CLAMPING TORQUE = 100.7 FT-LBF
CHARGE PRESSURE = 250 PSIG.   GRAPH NAME = 3WA250-1

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE
255	0	0	0.00
250	2	6	2.10
250	4	5	4.08
250	6	6	6.10
250	8	6	8.10

MAY 05, 1994
3-WAY, 2" CONVENTIONAL TEFLON BLOCK
ELEVATED TEMP. THERMAL CYCLE
STATIC LEAK TEST - NO EXTERNAL MOMENTS
CLAMPING TORQUE = 100.7 FT-LBF
CHARGE PRESSURE = 250 PSIG. GRAPH NAME = 3WE250-2
TEMPERATURE = 400 DEG. F

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE
250	0	0	0.00
240	2	54	2.90
240	5	55	5.92

MAY 06, 1994
3-WAY, 2" CONVENTIONAL TEFLON BLOCK
ELEVATED TEMP. THERMAL CYCLE
STATIC LEAK TEST - NO EXTERNAL MOMENTS
CLAMPING TORQUE = 100.7 FT-LBF
CHARGE PRESSURE = 250 PSIG. GRAPH NAME = 3WE250-3
TEMPERATURE = 400 DEG. F

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE
255	0	0	0.00
260	3	4	3.07
260	6	3	6.05

MAY 09, 1994
3-WAY, 2" CONVENTIONAL TEFLON BLOCK
ELEVATED TEMP. THERMAL CYCLE
STATIC LEAK TEST - NO EXTERNAL MOMENTS
CLAMPING TORQUE = 100.7 FT-LBF
CHARGE PRESSURE = 250 PSIG. GRAPH NAME = 3WE250-4
TEMPERATURE = 400 DEG. F

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE
250	0	0	0.00
245	3	5	3.08
245	6	2	6.03

MAY 10, 1994
3-WAY, 2" CONVENTIONAL TEFLON BLOCK
ELEVATED TEMP. THERMAL CYCLE
STATIC LEAK TEST - NO EXTERNAL MOMENTS
CLAMPING TORQUE = 100.7 FT-LBF
CHARGE PRESSURE = 260 PSIG. GRAPH NAME = 3WE260-5
TEMPERATURE = 400 DEG. F

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE
250	0	0	0.00
250	2	11	2.18
250	4	21	4.35

MAY 10, 1994
3-WAY, 2" CONVENTIONAL TEFLON BLOCK
ELEVATED TEMP. THERMAL CYCLE
STATIC LEAK TEST - NO EXTERNAL MOMENTS
CLAMPING TORQUE = 100.7 FT-LBF
CHARGE PRESSURE = 275 PSIG. GRAPH NAME = 3WE275-6
TEMPERATURE = 400 DEG. F

PRESSURE PSIG INPUT	ELAPSED MINUTES INPUT	ELAPSED SECONDS INPUT	ELAPSED DECIMAL MINUTES COMPUTE
300	0	0	0.00
300	2	9	2.15
300	4	27	4.45

APPENDIX U: STATEMENT ATTESTING TO TEST PROCEDURES USED AND DATA CHECKS PERFORMED

STATEMENT ATTESTING TO TEST PROCEDURES USED AND DATA CHECKS PERFORMED

PERFORMANCE OF TESTS: Tests for this report were conducted during the period April 27, 1994 to December 13, 1994. All of these tests were conducted in such a manner to meet the requirements of WHC-SD-TP-256 Rev. 0, "Jumper Connector Integral Seal Block Test Plan and Procedure," Westinghouse Hanford Company, Richland, Washington, according to the procedure on pages 10-12 therein. Official issue date of the procedure was July 18, 1994. Tests conducted during the period April 27, 1994 to July 17, 1994 were performed under the auspices of the draft version of that procedure. To verify quality of data obtained during that period, it is hereby attested that there were no differences between the draft procedure and the final approved procedure that affected test methods or data collection. All tests were performed in the same laboratory, by the same personnel, using the same equipment, and the same method. All instruments used to collect data were in current calibration, traceable to the National Institute of Standards. Tests were performed by Test Technician Steven R. Jordan, assisted at various times by Senior Principal Engineer Edward S. Ruff.

QC WITNESS: WHC Quality Control Engineer Ernest N. Wegener witnessed testing performed on the 3-way ISB jumper connectors. He verified that instruments used to collect data were in current calibration, and that testing was performed in accordance with procedure. Testing performed on 2-in, 3-in, and 4-in single port ISB's was not witnessed by Mr. Wegener. For these tests, QC review of data was performed as described below.

DATA RECORD REVIEW: QC Engineer E.N. Wegener reviewed all laboratory notebook data entries for 2-in, 3-in, 4-in, and 3-way ISB's, and verified that it matched the data entered in spreadsheets used to graph results presented in the data appendices of this test report. Original data, as recorded during testing, is archived in the following documents:

Jordan, Steven R., 1994a, *Laboratory Notebook #WHC-N-817* (Hard Bound and Paginated), pp. 44-142, Westinghouse Hanford Company, Richland, Washington.

Jordan, Steven R., 1994b, *Laboratory Notebook #WHC-N-1088* (Hard Bound and Paginated), "3-Way Integral Seal Block Jumper Connector," Westinghouse Hanford Company, Richland, Washington.

Jordan, Steven R., 1994c, *PUREX Jumper Connector Integral Seal Block Leak Test Data*, WHC-SD-WM-DP-118, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Edward Ruff 2/9/95 | Steven R. Jordan 2-9-95

Edward S. Ruff, Sr. Principal Engineer
Materials Engineering

Steven R. Jordan, Test Technician
Equipment Testing Laboratory

APPENDIX V: SOURCE REFERENCES FOR TEST CRITERIA

**Westinghouse
Hanford Company**

**Internal
Memo**

From: Structural Margin Assessments 93:MAR:064
Phone: 372-2277
Date: December 6, 1993
Subject: QUALIFICATION OF MECHANICAL JUMPERS AND ELECTRICAL CONNECTIONS

To:	V. J. Cruz	B4-08
	J. M. Light	B4-08
cc:	T. J. Conrads	H5-55
	S. K. Farnworth	H5-55
	M. T. Husain	E6-37
	J. L. Julyk	H5-57
	D. S. Leach	H4-64
	M. R. Lindquist	H5-57
	J. R. Nicholson	E6-37
	E. C. Ocoma	H5-55
	E. S. Ruff	H5-67
	T. B. Salzano	E6-37
	File/LB	

The qualification of the jumpers is in progress. So far, the effort has been directed in retrieving the historical work carried out by WHC, KEH, and PNL as well as other DOE sites on similar components. A summary of the findings with recommendations are presented herein.

The next step is to start the finite-element modelling and perform the analysis and evaluation. The experimental work on leakage test has also been initiated with the preparation of a test specification. Ed Ruff (from Materials and Welding Engineering group) is overseeing this phase of the project.

The findings of the review are itemized below with applicable recommendations, if any.

1. General Review Comments

   The jumper qualifications carried out in the past, mainly concentrated on the jumper connector heads. No work has been found on qualifying the jumpers as a whole unit. Traditionally, AUTOPIPE has been used to calculate the reactions of the jumpers on the jumper connected head. Naturally, the seismic analysis would yield the resulting forces and moments from the jumper piping to the connector head. This approach assumes the connection of the jumper heads as rigid connectors for the piping. The qualification looks at the structural integrity of the connector head from these loads, applied torque to seal, pressure loads, and thermal loads.

   The possibility of the seal failure, resulting in leakage, of the jumpers has not been addressed in the past. It needs to be determined if seal leakage during a seismic event is an issue. **Action: D. Leach ________ (date)**

2. Proposed Work on MWTF Jumpers

The FDC Rev. 1 classifies the jumpers as safety class 2. The design pressure and temperature (for the 2- and 3-inch waste transfer piping) is specified to be 400 psig and 250°F, respectively. It is assumed that the 4-inch and 3-way 1/2 inch jumpers are under the same design conditions. The chemical compositions are listed in the FDC, Rev. 1, and will be used for seal selection. The seal material selection will be addressed under leakage test section.

Notes: The piping loads transferred to the connector heads are not specified yet. Worst case values used for PUREX and HWVP will be used for the analysis.

3. PUREX Jumpers

Structural analysis and evaluation was carried out for 2-inch jumpers for PUREX (WHC-SD-W028-DA-001). The analysis used ANSYS and was a rigorous analysis. The design pressure was 400 psig and the design temperature was 240°F. The seal used was Teflon. the evaluation used AISC and ASME allowables. The seal was not evaluated for integrity as only testing can qualify such a component.

4. HWVP Jumpers

Structural analysis and evaluation was carried out for 2-, 3-, and 4-inch jumpers for HWVP. The report is not issued yet. It has been checked and independently reviewed. The analysis considered the critical components as identified in PUREX report. The operating pressure was 220 psig and the design temperature was 390°F. A series of leakage tests were also performed to find the minimum required torque to seal. The evaluation used AISC and ASME allowables. The seal material and its function were not addressed for seismic events. The connector head only was considered for seismic evaluation as one unit.

5. Leakage Test for HWVP Jumpers

A series of tests were run to bind the relationship between the applied torque, to the screw to seal the connector head, and the force on the block of the connector head. Furthermore, tests were run to find the torque valve to guarantee seal for 2-, 3-, and 4-inch connector heads under 250 psig pressure. The seal of choice was Teflon and original design of gasket retainers were used.

[3] From: Edward G III Allen at ~WHC116 4/14/94 12:20PM (2794 bytes: 47 ln)
To: Edward S (Ed) Ruff at ~WHC208
cc: John W Bailey at ~WHC20, Thomas H (Tom) May at ~WHC82, Kenneth G Squires at
~WHC14
Subject: Project W320 Connector Needs
------------------------------- Message Contents -------------------------------

Ed,

This is in response to your last transmittal.

Safety Class: The current classification for these items of the Project is SC-3. If a higher level of "leak tightness" is certifyable, we may want to upgrade in order to take the emphasis off of the containment value of the Tank Farm pits.

Nozzle Material: The project requires 300 series stainless, which is pretty standard.

Block Material: Same as above.

Cast or Machined Hooks: Either should be adequate. In researching the available components to build 4" connectors, I found that we'll be short 108 hooks for the Project needs. We may be in a bit of a jackpot with regard to casting houses anyway, so there is a strong chance we'll be going with machined hooks for the 4" assemblies.

Temperature: The FDC requirements call for a 180 degree F limit on temperature for purposes of structural design. The limit for routine operation is 120 degrees F. I wouldn't let this set the limit for overall testing.

Pressure: The pressure will be up about 350-400 psig. Everything is calculated right now and we're still kind of waiting to see what the pump vendors come back with based on our head and flow requirements.

Connector Sizes: We'll be using 1" through 4" vertical and horizontal assemblies. The 1" head is a blank.

As far as filling out the data chart, I think we'll need to hold off on some of the items like "moment". KEH is doing an analysis to see what kind of thermally and mechanically induced loads will be on the nozzles and pit walls.

In talking with Tom, it seems that we need a meeting to really look at what testing is relevant, how it will be documented, and to what extremes it will be taken (e.g., ultimate destructive testing, etc.). If you folks set something up, give a call beforehand and I'll try to help you with whom to invite. Thanks. EGA

[4] From: Thomas B Salzano at ~KEH14 2/7/94 8:54AM (708 bytes: 11 ln)
To: M A Rezvani-Bafrouyeh at ~WHC240, Edward S (Ed) Ruff at ~WHC208
cc: Thomas J Conrads at ~WHC74, Susan K Farnworth at ~WHC208, Victor J Cruz at ~WHC231
Subject: JUMPER QUALIFICATION
------------------------------- Message Contents -------------------------------

The 4-in jumpers are for the Pit Exhaust System. The design temperature and pressure for this system are 120 F and -10" of water, respectively.

The 2-in three way jumpers are for the Instrument Air System. The design temperature and pressure for this system are 125 F and 125 psig, respectively.

T. Salzano
372-2267