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Engineering Test Results for the Moog Single Line Disconnect

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PREFACE

New and innovative types of disconnects will be required to service, resupply, and maintain future spacecraft subsystems. Efficiently maintaining orbiting scientific instruments, spacecraft support systems, and a manned space station over a long period of time will require the periodic replenishment of consumables and the replacement of components. To accomplish these tasks, fluid disconnects must be designed to connect and separate with minimal hazard to crew and equipment. The capability to simply connect a refueling line or to easily replace a failed component greatly extends the life of a space-based fluid system.

A test program was initiated to evaluate the Moog Single Line Disconnect. The objective of the test program was to demonstrate the operational characteristics of the disconnect and to verify compliance with current safety regulations.

The single line disconnect met or surpassed all the performance characteristics defined by the manufacturer and delineated in the test outline. The motions and actuation forces required to engage the disconnect are within the limitations of a fully suited astronaut. When engaged, the disconnect provides a straight-through, smooth-walled flow passage with minimal pressure loss. However, when disengaged, the current disconnect design is "zero-fault-tolerant" against spillage. All man rated components are required to be "two-fault-tolerant" against spillage. For non-man-rated applications, the single line disconnect offers unique advantages with respect to the actuation sequence and the flow characteristics.

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I. INTRODUCTION

The test program of the Moog Single Line Disconnect (referred to as the single line disconnect or the disconnect in this report) began as a joint agreement between the Goddard Space Flight Center (GSFC), Code 713.2 and the Moog Inc., Space Products Division. The single line disconnect, Figure 1-1, is being produced by Moog Inc. as a development product. The disconnect was loaned to GSFC for test and evaluation.

The testing was conducted at the Goddard Space Flight Center Propulsion Research Facility in Greenbelt, Maryland. The initial phase of the testing was conducted during April, May, and June, 1987. The life cycle test was conducted in September, 1988, and the vibration tests were completed in January, 1989. The test results from each test sequence are presented in this report.

The test article used in this program was the MOOG Single Line Disconnect, model 50E560, serial number 002. The disconnect consists of two halves, male and female, each containing internal mechanisms that interrupt the flow on each side of the interface. The internal sealing mechanism is developed around rotory shut-off technology. This technology incorporates spherical valving elements in each half that are internally rotated open when the two halves of the disconnect are axially engaged and rotated closed when disengaged. The mated disconnect incorporates a straight-through, smooth-walled circular flow path that has nearly the same pressure loss as an equal length of pipe. The spherical valving elements and engagement/disengagement sequence are illustrated in Figure 1-2. The disconnect is fabricated of 304L stainless steel and anodized aluminum. All surfaces in contact with the fluid are fabricated of stainless steel.

II. TEST PROGRAM

The test program for the single line disconnect was conducted in three phases. The three phases were performance evaluation, life cycle testing, and vibration testing. The performance evaluation phase defined the baseline characteristics of the fluid disconnect under the operating conditions specified in Table 2-1. The life cycle testing demonstrated that throughout the required number of operating cycles the disconnect met the baseline characteristics measured during the performance evaluation. The vibration testing verified seal integrity during and after exposure to the STS launch environment.

The GSFC testing was formulated to include general tests to verify the design and to demonstrate operational characteristics. Because one of the possible applications for the disconnect is as a refueling coupling, the specification for the NASA Standardized Refueling Coupling (NSRC), Reference 1, was used as a guideline to define the test requirements. The NSRC specification requires three manually operated flow inhibit devices in series with each inhibit being individually verifiable. The single line disconnect has a single inhibit device that is designed to be operated by the linear engagement sequence. Thus, not all the NSRC requirements could be

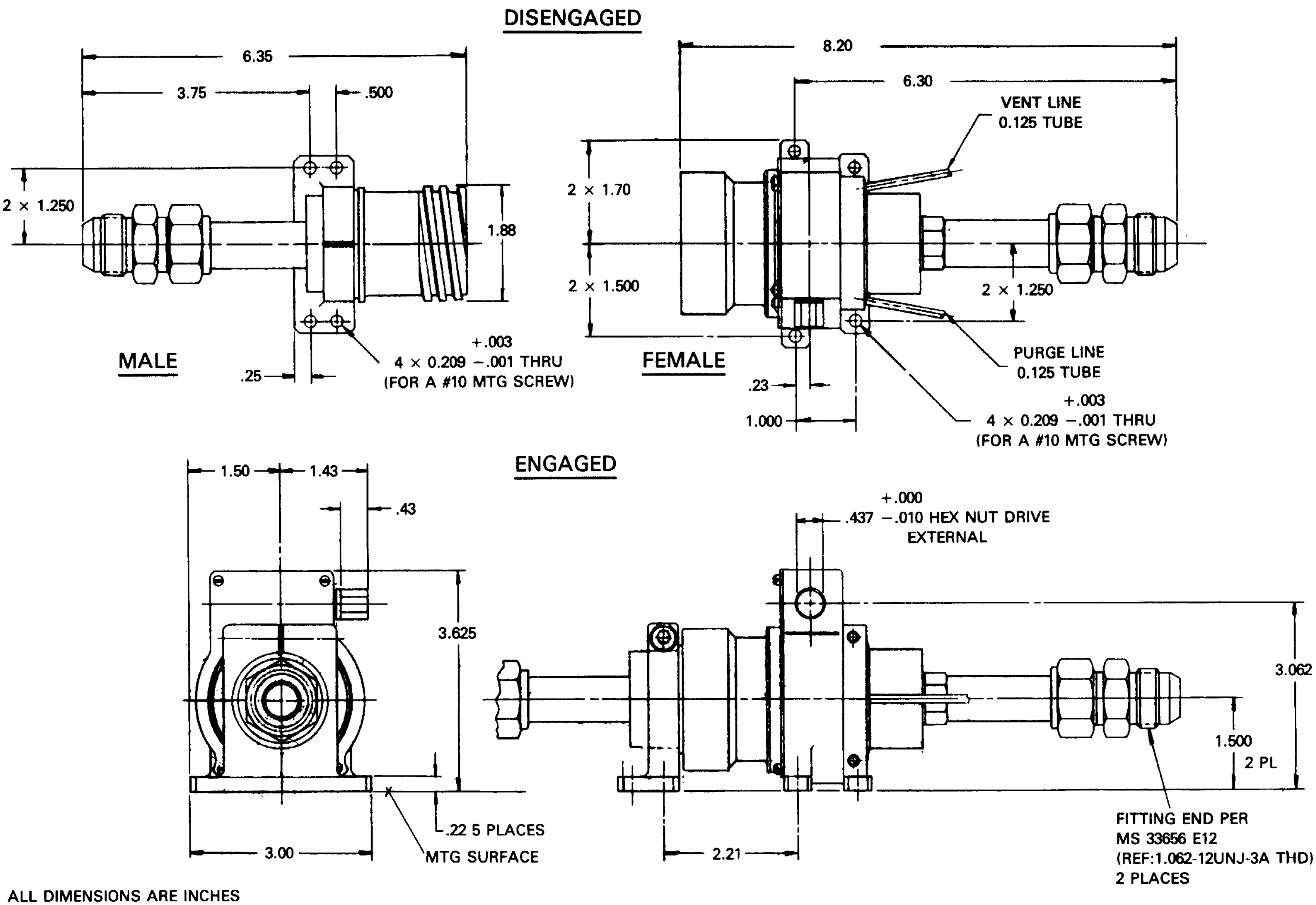

Figure 1-1 Single Line Disconnect

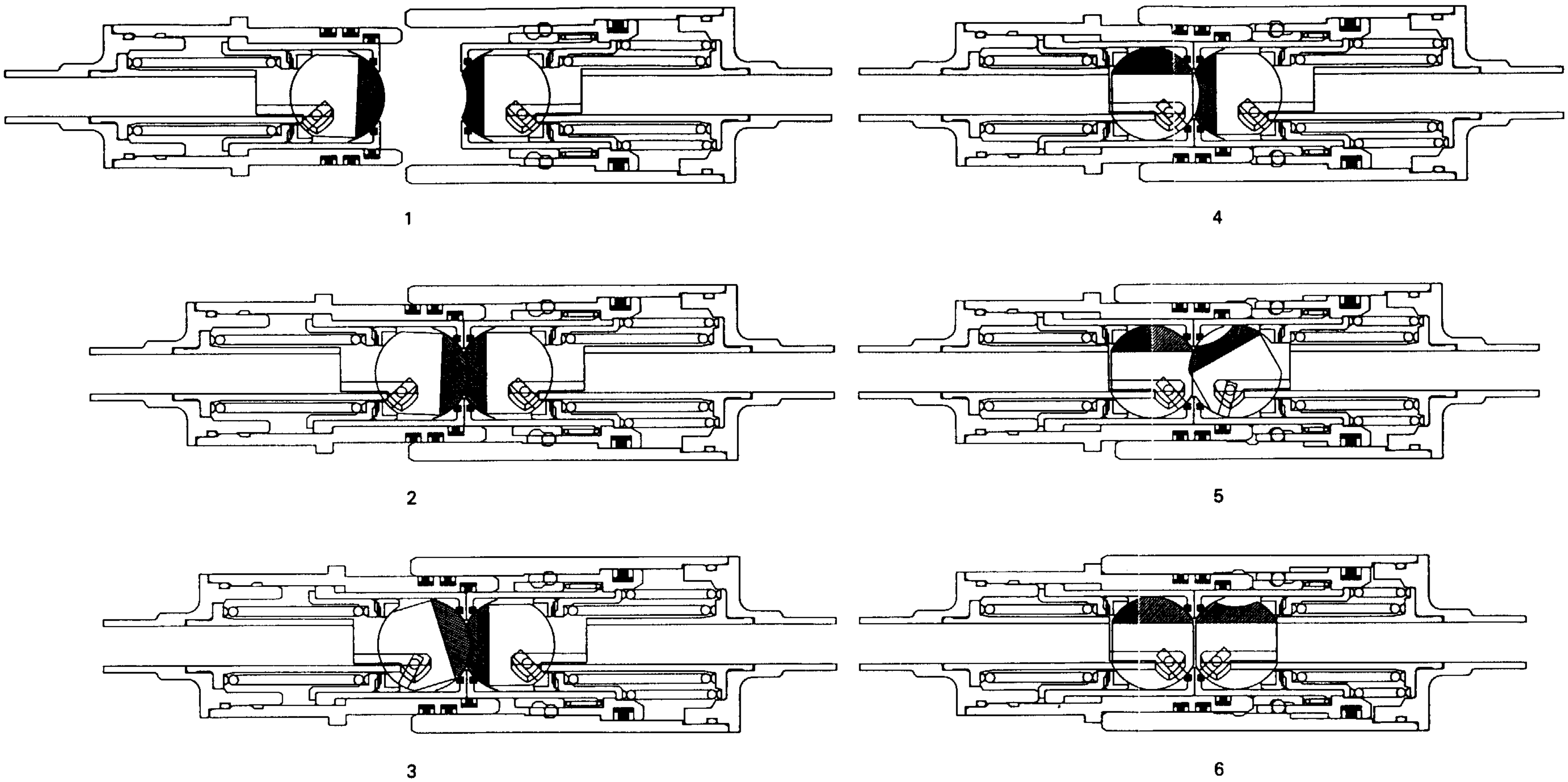

Figure 1-2 Engagement / Disengagement Sequence

applied due to the difference in design philosophies. The baseline NSRC specification, Reference 1, Table 1, was slightly modified to compensate for the single seal feature of the single line disconnect. Table 2-1 provides a comparison of the major GSFC test requirements with the NSRC design specification. Where applicable, the disconnect was tested both fully engaged and disengaged.

Table 2-1

Disconnect Test Requirements

PARAMETER	GSFC Test	NSRC Design Spec*
Operating Pressure (maximum), psig	600	600
Proof Pressure, psig	1200	3000
Burst Pressure, psig	2600‡	5000
Flowrate, gpm	20	20
Pressure Drop (@ max flowrate), psid	50	50
Operating Temperature, °F	40 - 120	40 - 120
External Helium Leakage, sccs	$1.4x10^{-4}$	$1.4x10^{-4}$
Internal Helium Leakage, sccs	$1.4x10^{-4}$	$1.4x10^{-4}$

* Reference 1, Table 1

‡ design burst pressure - not verified by test

III. PHASE I

A. PROOF PRESSURE

After being visually inspected for manufacturing defects and shipping damage, a proof pressure test was performed to verify that the disconnect could withstand twice the maximum expected operating pressure (MEOP) of 600 psig prior to conducting other testing. Because the NSRC specified proof pressure is higher than the design burst pressure for the single line disconnect, a proof test to greater than or equal to 1.5 times the MEOP was conducted to demonstrate a positive factor of safety before testing continued. The disconnect was pressurized both engaged and disengaged to a minimum of 1200 psig for greater than 5 minutes. No anomalies or deformations were noted, and the disconnect was determined to be acceptable for continued testing.

B. PRESSURE LOSS *vs*

1. Flowrate

The NSRC specification requires that the disconnect be flow tested to establish accurate pressure drop curves. The NSRC recommended test matrix included flow rates of 0 to 20 gallons per minute (gpm) and system pressures of 0 to 600 psig. However, the test flow equipment was limited to a maximum flow rate of approximately 12 gpm at a maximum system pressure of 100 psig. The GSFC test matrix was modified to accommodate the test flow system limitations.

The pressure loss through any component is proportional to the square of the flow rate and independent of the total system pressure. The measured data is plotted as a function of the flow rate squared, Figure 3-1. Because zero pressure loss for zero flow rate is a required condition, an equation was calculated for a "forced zero intercept," Reference 3; and the resulting equation is plotted along with the measured data in Figure 3-1. Using the derived equation, the equivalent pressure loss at 20 gpm is calculated to be 10.3 psid, which is well below the 50 psid specification.

In addition, the loss coefficient and the flow coefficient of the disconnect were calculated from the actual test data and compared with theoretical analysis. The loss coefficient (K factor) calculated from the test data is 3.5 compared to a theoretical value of 1.82 (see Appendix A and References 4 & 5). The flow coefficient is defined to be the flow of water at 60 ^{o}F in gallons per minute for a 1 psig pressure differential. The flow coefficient calculated from actual test data was 6.23 versus the theoretical value of 8.64 (Appendix A).

2. Valve Position

Since the spherical ball valve rotates into the flow path, interference from incomplete rotation of the valving element could increase the pressure loss. A test was conducted to correlate the flow interference to the spherical ball valve position. The fully engaged position was defined to be 100% of the total motion (Figure 1-2, step 6) while 0% was defined to be the position when one of the two valving elements is closed (Figure 1-2, step 4).

The resulting data is plotted in Figure 3-2. The flow rate is greater than 90% of the total flow when the disconnect has moved through only 50% of the defined motion. If the disconnect is prevented from becoming fully engaged, the pressure loss across the disconnect will not greatly increase. In Figure 3-2, the sharp change in flow rates at less than 1% of the total flow rate is due to test equipment error at the low flow rates.

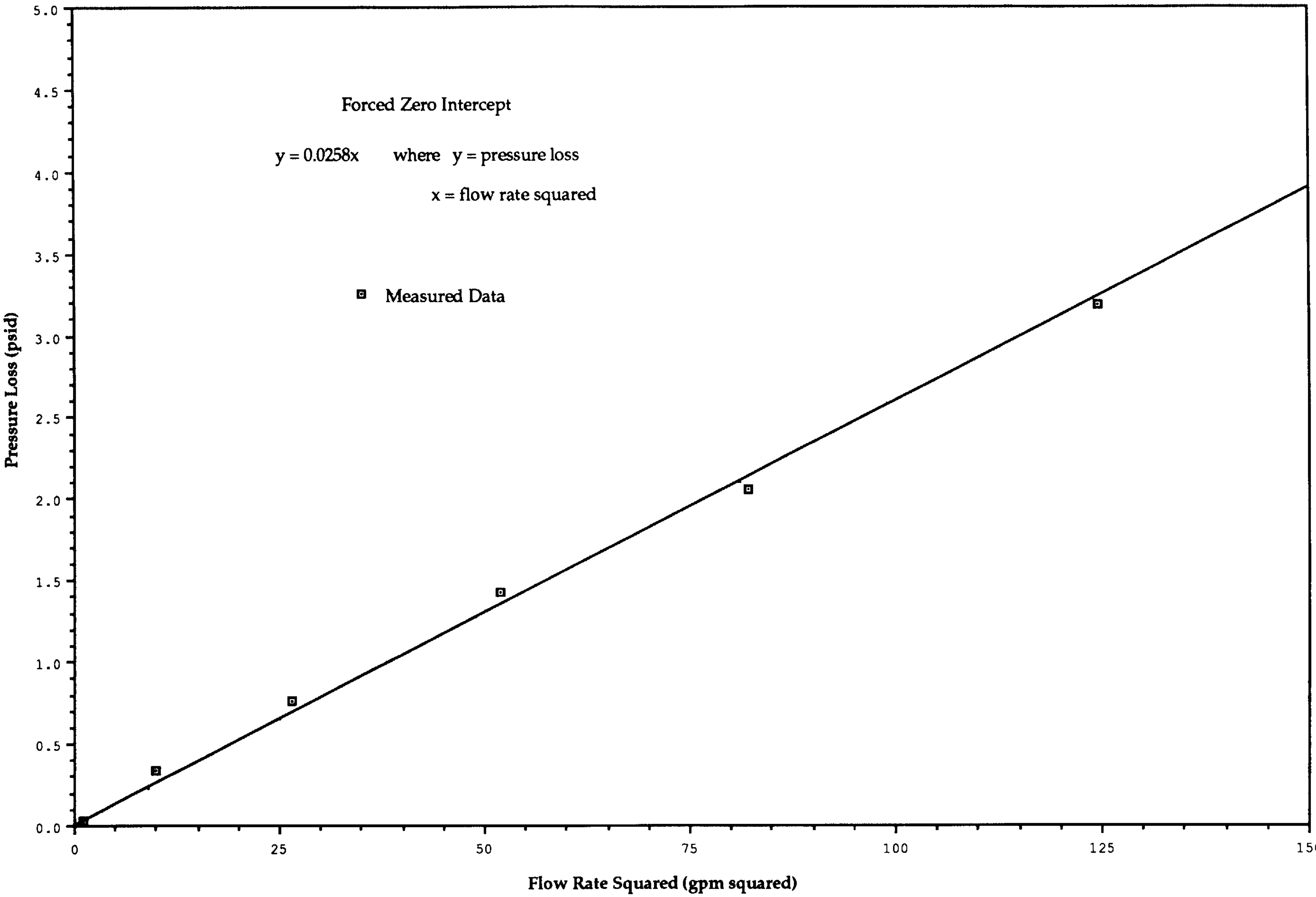

Figure 3-1 Pressure Loss vs Flow Rate Squared

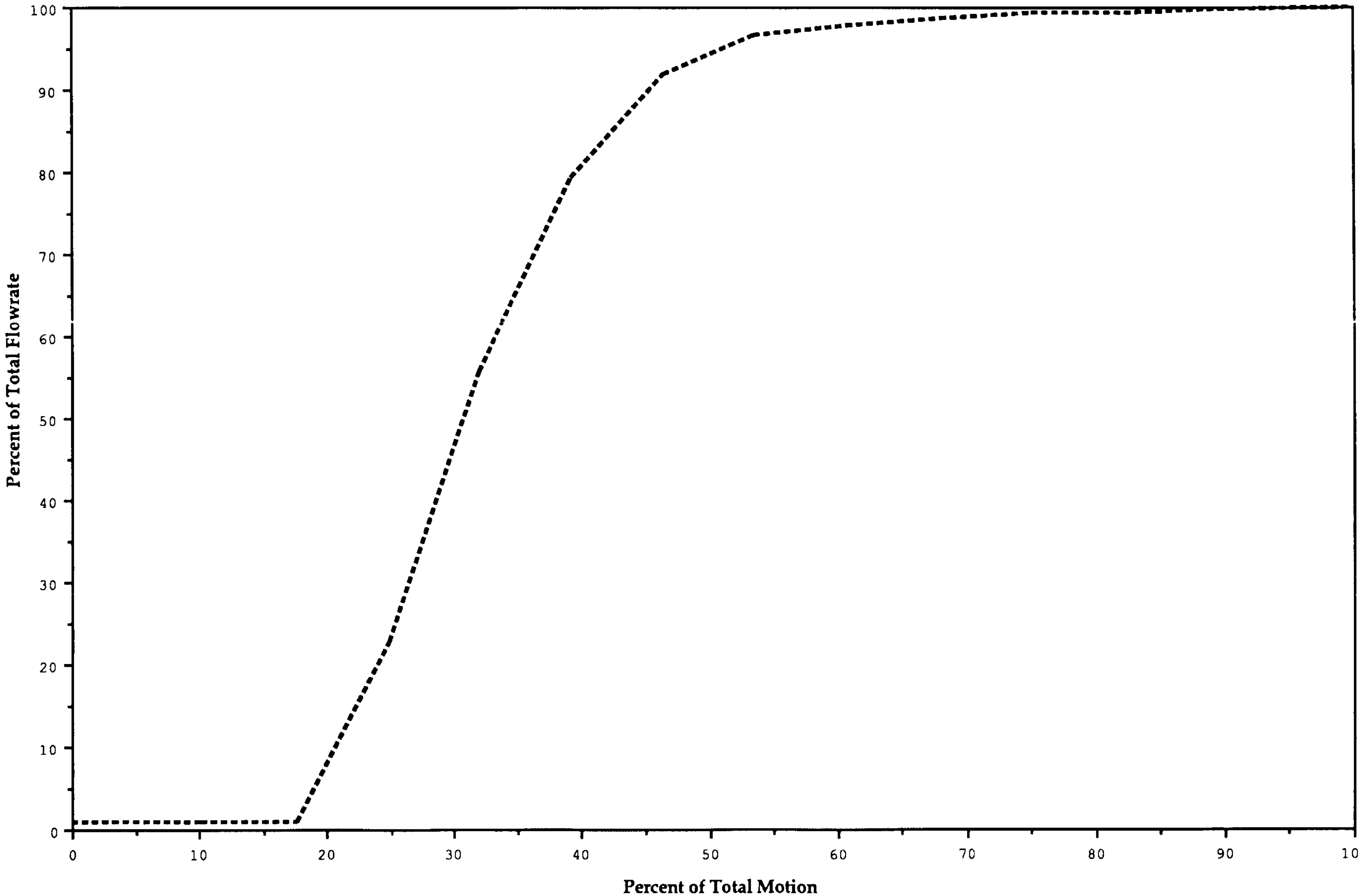

Figure 3-2 Flowrate vs Valve Position

C. LEAKAGE

1. Helium

Gaseous helium leak testing was conducted for comparison against the NSRC specification and used as reference data for subsequent leak testing performed after the completion of other tests. Leakage rates were measured across both the redundant external seals and the single spherical ball valve seal. The leak rate was measured at 0, 25, 150, 300, 450, and 600 psig using gaseous helium. The NSRC specification states a maximum allowable helium leak rate of 1.4×10^{-4} standard cubic centimeters per second (sccs).

The helium leak rate test was conducted numerous times throughout the entire test period to confirm the consistency of the test data. For all tests at all pressures, the leak rate was less than 2.0×10^{-6} sccs. Leakage values were typically 2.5×10^{-7} sccs but ranged from 2.0×10^{-6} to 3.0×10^{-8} sccs. When the disconnect was unpressurized, the leakage rates were typically 2.0×10^{-6} sccs. Leakage rates were similar for both the engaged and disengaged configurations.

2. Hydrazine

In addition to the helium leakage tests, hydrazine leakage tests were conducted to confirm the zero liquid leak rate capability of the disconnect. The NSRC specification did not require such a test, but it was desired to check the integrity of the single ball valve seal when exposed to hydrazine. Monopropellant grade hydrazine was used for the leakage test.

The test consisted of filling one half of the disconnect with hydrazine, assembling the disconnect into the test equipment in a vertical position with the ball valve pointing down, and pressurizing the test set-up to 100 psig. The external portion of the ball valve was then placed in a beaker with a known volume of distilled water. The beaker was sealed to prevent contamination from entering. After three weeks exposure time, the concentration of hydrazine in the water was measured. The male half of the disconnect showed no signs of leakage after three weeks exposure to hydrazine. The female half of the disconnect was not tested. The sensitivity of the liquid leak test to measure the concentration of hydrazine is approximately 1 part per million, which is on the order of 10^{-3} cubic centimeters of hydrazine.

D. FORCES

The forces required to operate the disconnect must be within the capability of the suited astronaut. The grip, force, and torque limitations of a fully suited astronaut are defined by the Satellite Services Handbook Interface Guidelines, JSC-19212 (Reference 2). The actuation forces were measured and compared with the Interface Guidelines. The Interface Guidelines states the load limit for a gloved hand, steadystate force application to be 25 lbs for a 5 minute duration. The Interface Guidelines limits the required torque to 90 to 110 inch-lbs using a 7/16" socket and wrench.

1. Axial

The first step in the actuation process is to bring the two halves of the disconnect together. For reference, the female half of the disconnect is assumed to be attached to the spacecraft. As the male half is engaged with the female half, the actuation threads on the male half are "captured" by the female half. The "capture" serves two purposes. First, it holds the two halves together when the astronaut picks up the actuation tool. Second, it acts as a "soft" thread to start the main engagement threads together. The astronaut rotates a hex-nut that is connected to a worm gear to engage the main threads and complete the engagement process.

The average "capture" force is summarized in Table 3-1. The summarized data is divided into three test periods. Each entry in Table 3-1 is the average of all force measurements taken during that time period. The first line of the table summarizes the testing done from the initial performance testing to the verification checks done prior to life cycle testing. The second line is the data collected halfway through the life cycle test. The final line is all testing done after the post life cycle test up to the checks completed after the vibration testing.

Table 3-1

Actuation Forces
Axial Capture Force (lbs)

Test Period	Engage	Disengage
Initial Data - Pre Life Cycle	19.6	19.9
After 500 Cycles	17.7	34.6
After 1000 Cycles - Post Vibration	20.8	39.4

Due to the method by which the male half of the disconnect is "captured" by the female half, the force required to engage the disconnect varied slightly with the orientation between the two halves. The average axial capture force required for all data taken was 19 ± 3 lbs.

A larger variation was measured for the disengagement force. Even though the measured disengagement force is higher than the force limit, the required force could be reduced by continuing to disengage the disconnect. The "capture" mechanism, acting as a "soft" thread, will disengage the two halves until they are completely separated if one continues to rotate the hex-nut.

2. Torque

The engagement sequence is completed by turning a hex-nut, which then draws the two halves of the disconnect together. The relative linear motion between the two halves opens the spherical ball valves inside each half of the disconnect.

The maximum actuation torque required for each test period is summarized in Table 3-2. As noted for the axial force test data, the values listed are the average of all measurements conducted during the given test period. The resulting data is plotted versus internal pressure in Figure 3-3. The torque required increases with internal pressure. Even after 1000 cycles, the required torque is less than the maximum specified in the Interface Guidelines, Reference 2. The reason for the increase in actuation torque from the initial testing data to the post-life cycle data could not be determined. Possible reasons include restrictions in the internal spherical valving elements and binding of the external engagement mechanism.

Table 3-2
Maximum Actuation Torque (in-lbs)

Test Period	Internal Pressure (psig)						
	0	25	50	150	300	450	600
Initial Data - Pre Life Cycle	3.0	6.5	13.0	16.5	27.0	36.0	42.0
After 500 Cycles	4.0	5.0	8.0	17.6	N/A	N/A	N/A
After 1000 Cycles - Post Vibration	3.0	6.3	10.5	24.0	48.0	70.7	88.5

E. APPLIED LOADS

The disconnect may be subjected to external loads as well as internal loads. The disconnect must continue to operate under the external loads without any increased leakage or decrease in performance. The external load limit stated in the NSRC specification is 100 lbs axial load in either direction and a 100 ft-lbs bending moment. The disconnect was fully engaged and loaded with a static weight in increments up to a maximum of 100 lbs in both axial directions. While in the engaged position, a

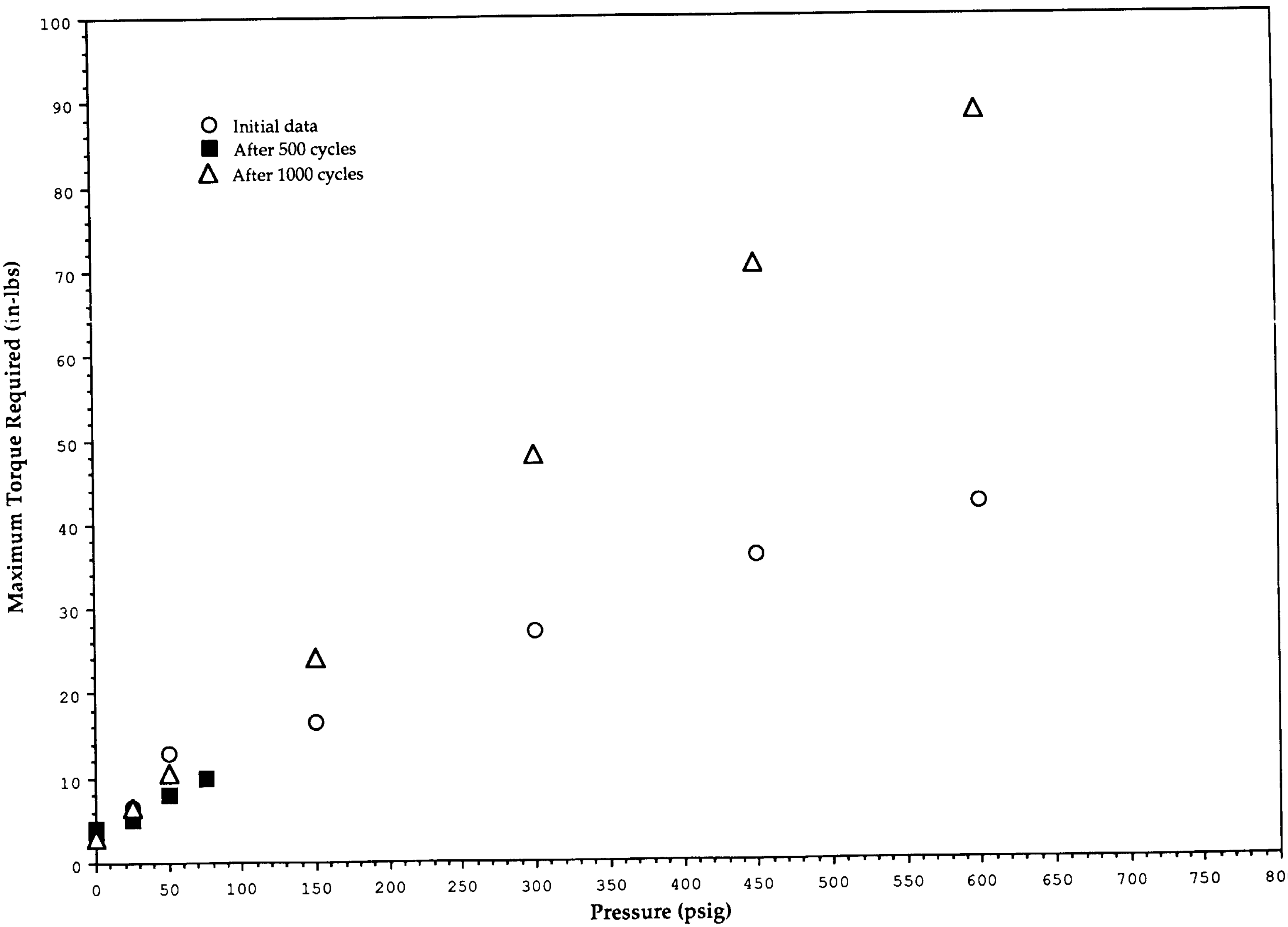

Figure 3-3 Actuation Torque

helium leak check was performed in the same manner as for the baseline leak rate. For all axial loading increments and directions, the disconnect leak rate was not greater than 5.8×10^{-7} sccs helium at 300 psig internal pressure.

After the completion of all testing, a bending load was applied to the engaged disconnect while the disconnect was internally pressurized to 300 psig; and the baseline helium leakage test was conducted. Bending moments of 0, 15, 25, 35 ft-lbs were applied. The bending moment capability of the test equipment was 35 ft-lbs. The maximum leak rate recorded was 2.0×10^{-6} sccs for all loading increments.

IV. PHASE II

A. LIFE CYCLE

Life cycle testing was conducted to verify that the disconnect was capable of meeting all performance requirements after a minimum of 1,000 cycles. One cycle is defined as "capture" of the male half by the female half, engagement to the fully open position, disengagement, and separation of the two halves. The disconnect was unpressurized throughout the testing.

The capture force, actuation torque, and leak rates were measured before testing began, after 500 cycles, and after completion of the test (1000 cycles). The data is summarized in Tables 3-1 and 3-2 as noted previously. The only value that changed substantially was the actuation torque. The data is also plotted in Figure 3-3. The required torque increased but still remained within the limit of 110 in-lbs at the maximum system pressure. As previously mentioned, the cause of the increase could not be determined. Possible causes for the increase in actuation torque include increased resistance in the internal spherical valving elements and binding of the external engagement mechanism. The test set-up is shown in Figure 3-4.

V. PHASE III

A. VIBRATION

The vibration tests were conducted to simulate the random vibration and acceleration loads of the STS launch environment. Random vibration reproduces the dynamic accelerations; the sine burst simulates the static g loading encountered during launch. The NSRC specification requires shock testing, but the GSFC vibration facility did not have the capability to produce the specified conditions. The sine burst test was substituted for the shock testing because it replicated similar static g loadings to those required by the shock testing. The disconnect was tested both engaged and disengaged. The engaged configuration is shown in Figure 3-5 while the male half and the female half are shown in Figures 3-6 and 3-7, respectively. The disconnect was instrumented with two triaxial accelerometers, one on each half of the disconnect. Data from both accelerometers was recorded for all engaged configurations. In addition to the pre-test leakage measurements, the leak rate was

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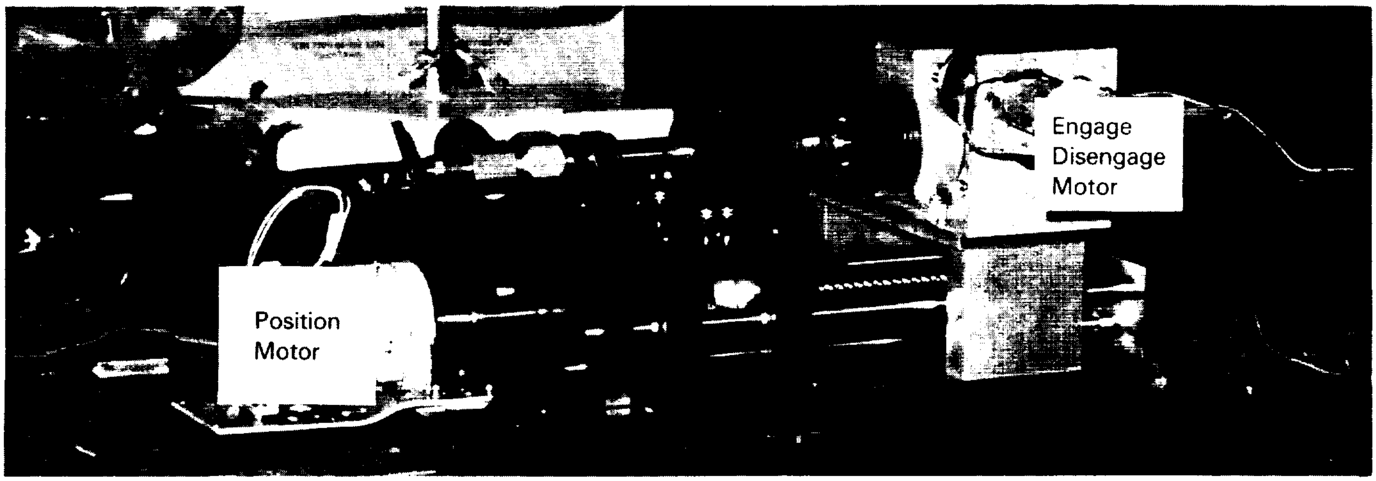

Figure 3-4 Life Cycle Test Set-up

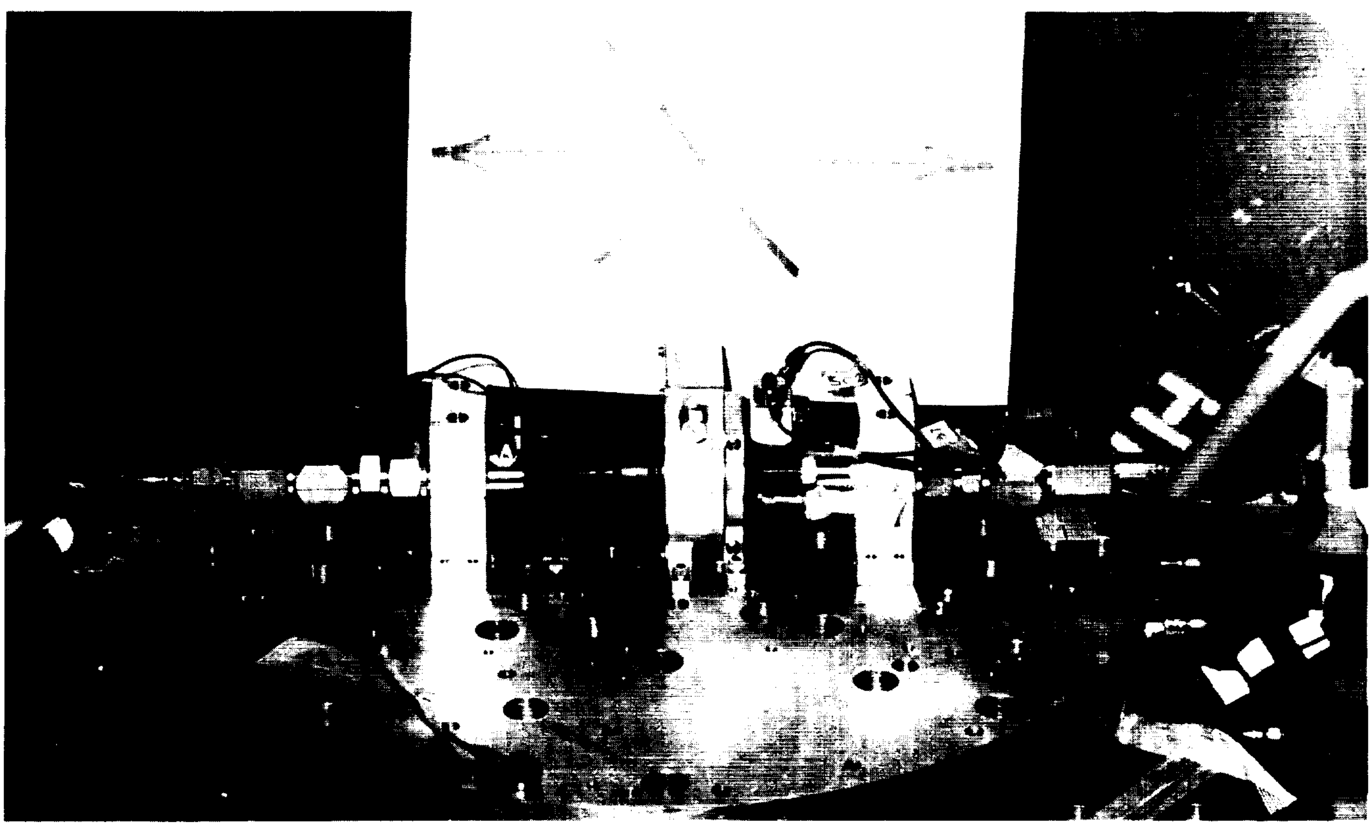

Figure 3-5 Vibration Test - Engaged Configuration

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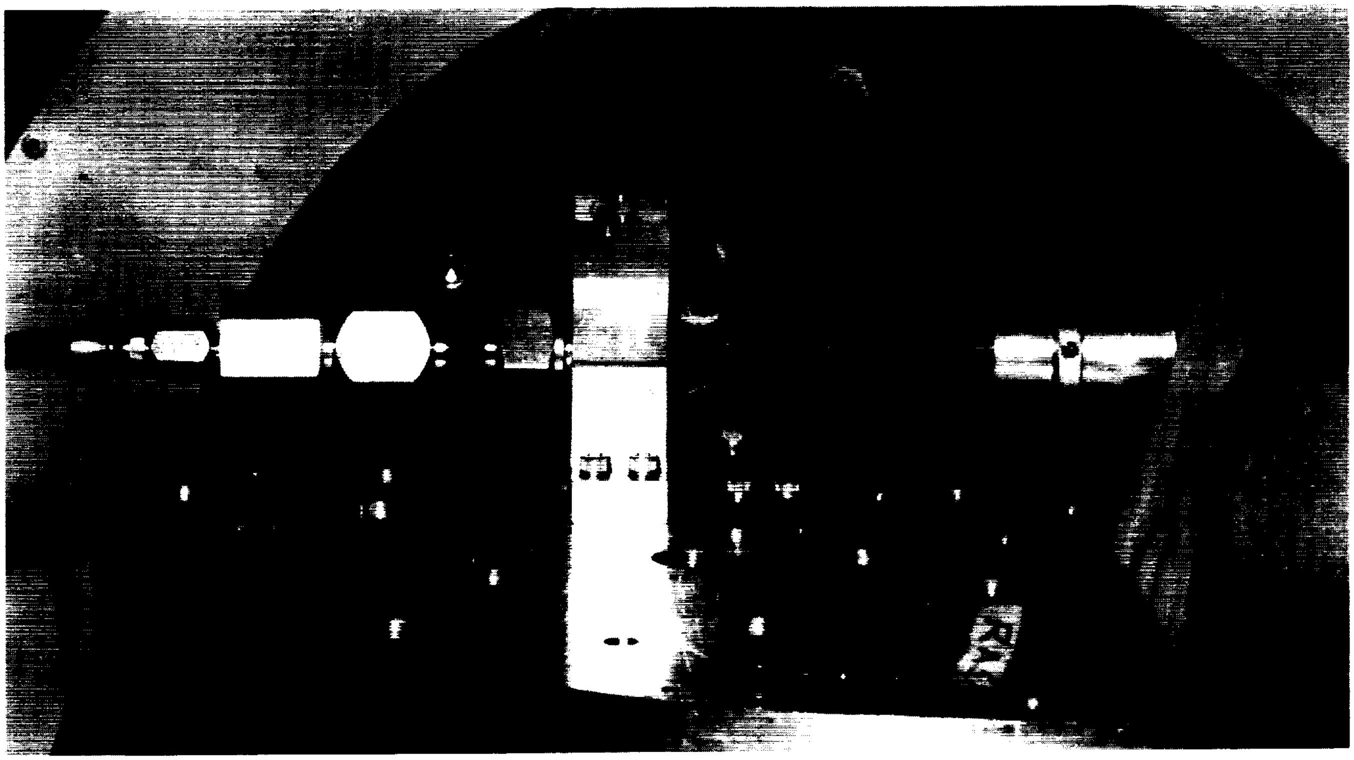

Figure 3-6 Vibration Test - Disengaged Configuration - Male Half

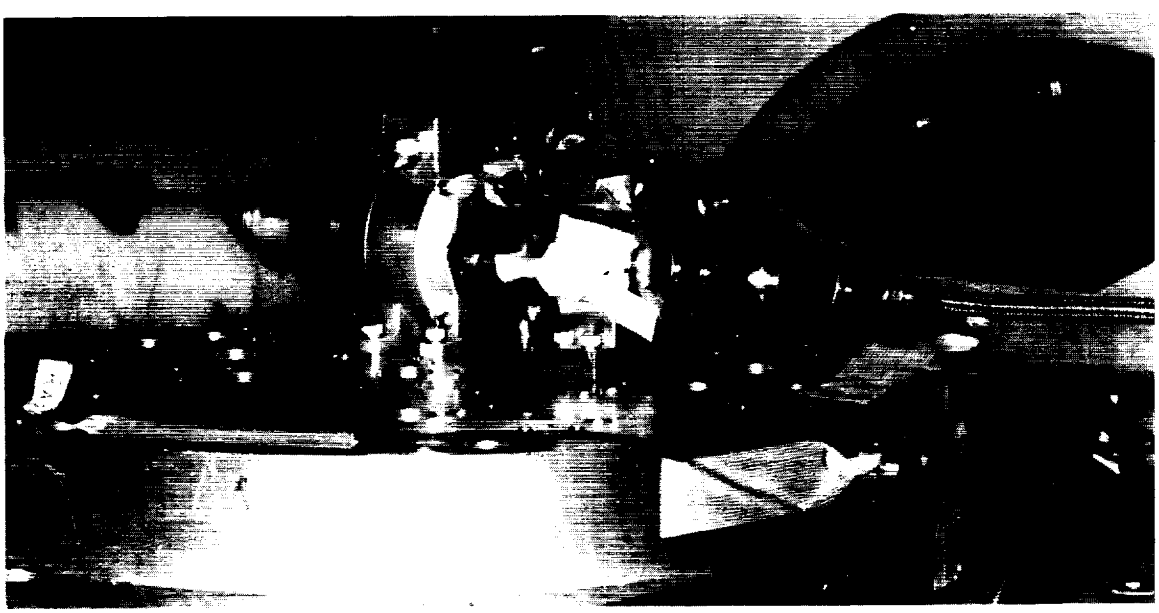

Figure 3-7 Vibration Test - Disengaged Configuration - Female Half

monitored throughout the test sequences to verify that the leakage did not increase due to the vibration environment. Indications of short duration, large leak rates such as sudden spikes in the leakage reading were not observed. The leak rates remained constant throughout each of the test runs for all configurations. The leak rate was monitored for a few minutes after the completion of each test run to confirm that the leak rate did not change.

1. Random

Random vibration testing was conducted to the levels specified by the NSRC specification to verify seal integrity during launch. The disconnect was vibrated in all three axes, both engaged and disengaged, while internally pressurized to 25 psig. Leakage measurements were taken throughout each of the test runs. For all three axes and all three configurations, the leak rate did not increase above the pre-test value. The power spectral density, transfer function, and phase angle plots for one selected configuration for each vibration axis is given in Appendix B. The plots show that the first resonance is above 1900 Hz for all configurations and axes. The first resonance frequency for either disengaged configuration is only slightly lower than that for the engaged configuration.

2. Sine Burst

The sine burst test simulates the static loading experienced during lift-off. A sine burst test was conducted for each axis with the disconnect engaged and repeated for all three axes with the disconnect disengaged. The test was conducted at 20 Hz to a level of 12 g's for a duration of 5 cycles at maximum loading and maximum frequency for each configuration. A plot of the acceleration loading vs time is shown in Figure 3-8. Again, the leakage measurements revealed no anomalies.

VI. CONCLUSIONS

In general, the disconnect satisfied the expected performance defined by the manufacturer and specified in the test outline. The disconnect incorporates many new features that will enhance the current fluid disconnect designs needed to support future program requirements. The significant merits of the single line disconnect are summarized in the following paragraphs.

The predominate feature of the disconnect is the low pressure loss at flow rates of up to 20 gpm. Even though most fluid transfer applications require a flow rate of less than 20 gpm, the low pressure loss reduces the required work of the fluid transfer system. The resulting fluid system would be smaller and lighter.

The actuation forces and motions required to engage the disconnect remained within the capabilities of a fully suited astronaut. However, the actuation forces required to engage the disconnect are directly related to the external drive mechanism that translates the actuation forces into the required linear motion. A

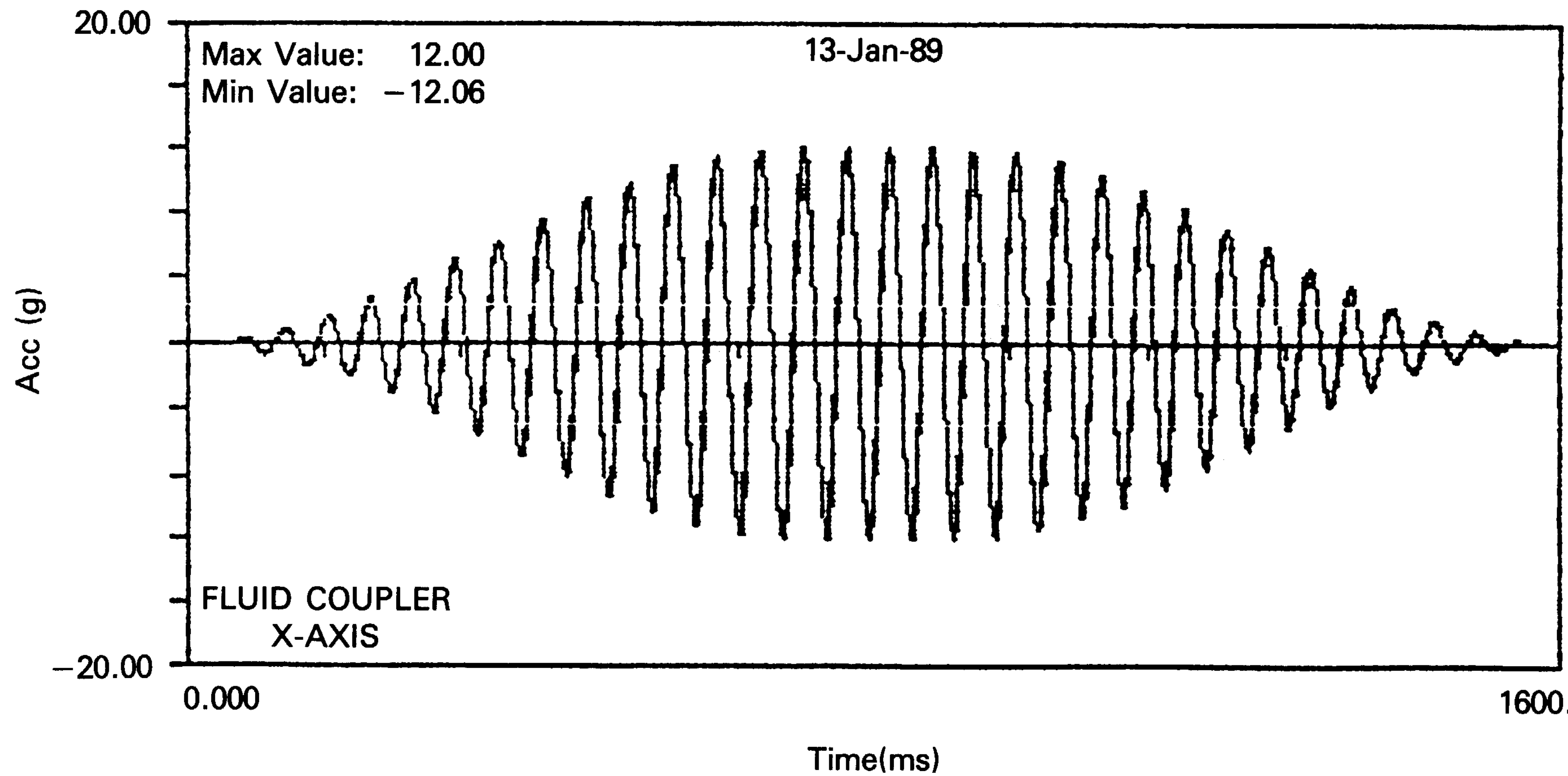

Figure 3- 8 Sine Burst Trace

different external drive configuration requires a different actuation forces. Nevertheless, this basic design demonstrates that the actuation forces can be kept within the limits of a fully suited astronaut.

The disconnect met the helium leak requirements when engaged and disengaged. While engaged, the disconnect has three external seals against leakage. Tests verified that the leakage rates are within the acceptable limits, even when an external load is applied to the disconnect. However, the external seals are dynamic. During every engagement cycle, the external seals slide across the opposite sealing surface. If the surface becomes damaged or scratched, the effectiveness of the seals may be decreased. Damage to a single surface has the potential of degrading two of the three external seals.

The area of greatest concern is the single internal ball valve seals. While disengaged, each half of the disconnect has only a single seal (inhibit) against leakage i.e. "zero-fault-tolerant." The NSRC specification also required verification of seals before disengagement. Currently, the seal integrity cannot be directly verified before disengagement. Additional fault isolation devices need to be considered to satisfy the STS "two-fault-tolerant" safety requirement of man-rated components.

The basic design concept of the disconnect offers some distinct advantages over previous fluid disconnect designs. The deficiencies in the sealing requirements may be overcome by considering other seal concepts. Since this test program was initiated, the manufacturer has already begun developing follow-on designs that address the seal requirements.

REFERENCES

1. End Item Specification for NASA Standardized Refueling Coupling.

2. JSC-19212, 23 December 1983, Satellite Servicing Handbook Interface Guidelines.

3. Robert G. Mortimer, Mathematics for Physical Chemistry (New York, Macmillian Publishing Company, Inc., 1981), pp. 305-306.

4. Robert W. Fox and Alan T. McDonald, Introduction to Fluid Mechanics, 3rd Edition (New York, John Willey & Sons, Inc., 1985), pp. 357-369.

5. Frank M. White, Fluid Mechanics (New York, McGraw-Hill Book Company, 1979), pp. 330-337.

ACRONYMS

GSFC	Goddard Space Flight Center
MEOP	Maximum Expected Operating Pressure
NSRC	NASA Standardized Refueling Coupling
STS	Space Transportation System

APPENDIX A

Coefficient Calculations

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Coefficient Calculations

Pressure Loss Coefficient Calculations

Assuming incompressible fluid flow through a level passage with minor head loss (h_L):

$$\frac{P_1}{\rho g} = \frac{P_2}{\rho g} + \frac{V_2{}^2}{2g} + h_L$$

where
P_1 = upstream pressure [lbs / ft^2]
P_2 = downstream pressure [lbs / ft^2]
ρ = density [slugs / ft^3]
g = Gravity = 32.174 ft / sec^2
h_L = minor head loss [ft] = $K\frac{V^2}{2g}$ by definition
K = pressure loss coefficient

therefore

$$\Delta P = P_1 - P_2 = h_L \rho g = K \rho \frac{V^2}{2}$$

but

$$V = \frac{Q}{A}$$

where
Q = volume flowrate [ft^3/sec]
A = Area [ft^2]

then

$$\frac{\Delta P}{Q^2} = \frac{K\rho}{2\,A^2}$$

Converting ΔP from psfd to psid and Q to gpm with $A = \frac{\pi D^2}{4}$ where D= 0.052083 ft

$$\frac{\Delta P}{Q^2} = 7.367 \times 10^{-3} \times K = \text{slope of Figure 3-1}$$

Therefore

$$K = \frac{135.75 \times \Delta P\,[\text{psid}]}{Q^2\,[\text{gpm}^2]} = 135.75 \times \{\text{slope of Figure 3-1}\}$$

From Figure 3-1, slope = 0.0258

$$K_{measured} = 3.50$$

Theoretical Head Loss Calculations

For any measured total head loss h_L,

$$h_L = h_f + \Sigma h_m$$

where h_f = frictional head loss
h_m = minor head loss

Recall that

$$h_m = \frac{K_m V^2}{2g}$$

$$h_f = f \frac{l}{d} \frac{V^2}{2g}$$

where
K_m = minor head loss coefficient
V = velocity
g = gravity
f = friction factor
l = length of component
d = diameter

then

$$h_L = \frac{V^2}{2g} \{f \frac{l}{d} + \Sigma K_m\} = K \frac{V^2}{2g}$$

Equating coefficients

$$K = f \frac{l}{d} + \Sigma K_m$$

The minor head losses are to the gradual inlet and outlet of the disconnect design. The worse case values for a gradual contraction and gradual expansion were chosen to calculate the largest pressure loss. From References 5 and 6:

$f = 0.044$ $\quad$ $K_c = 0.05$ $\quad$ $K_e = 0.30$

where subscripts indicate contraction (c) or expansion (e) The dimensions of the test article were measured to be the following:

$l = 10.5"$ $\quad$ $d = 0.3125"$

Therefore

$$K_{\text{theoretical}} = 1.82$$

Flow Coefficient Calculations

The flow coefficient is defined as the flow of water at 60 °F in gallons per minute for a 1 psi pressure differential.

Recall

$$\Delta P = \frac{K\,Q^2\,\rho}{2\,A^2} = 7.367 \times 10^{-3} \times \{K\,Q^2\}$$

then

$$Q = \sqrt{\frac{2A^2\,\Delta P}{K\,\rho}} = \sqrt{\frac{135.75 \times \Delta P}{K}}$$

from above

$K_{measured} = 3.50$

$K_{theoretical} = 1.82$

Given

$\Delta P = 1$ psid

then

$Q_{measured} = 6.23$ gpm

$Q_{theoretical} = 8.64$ gpm

APPENDIX B

Vibration Plots

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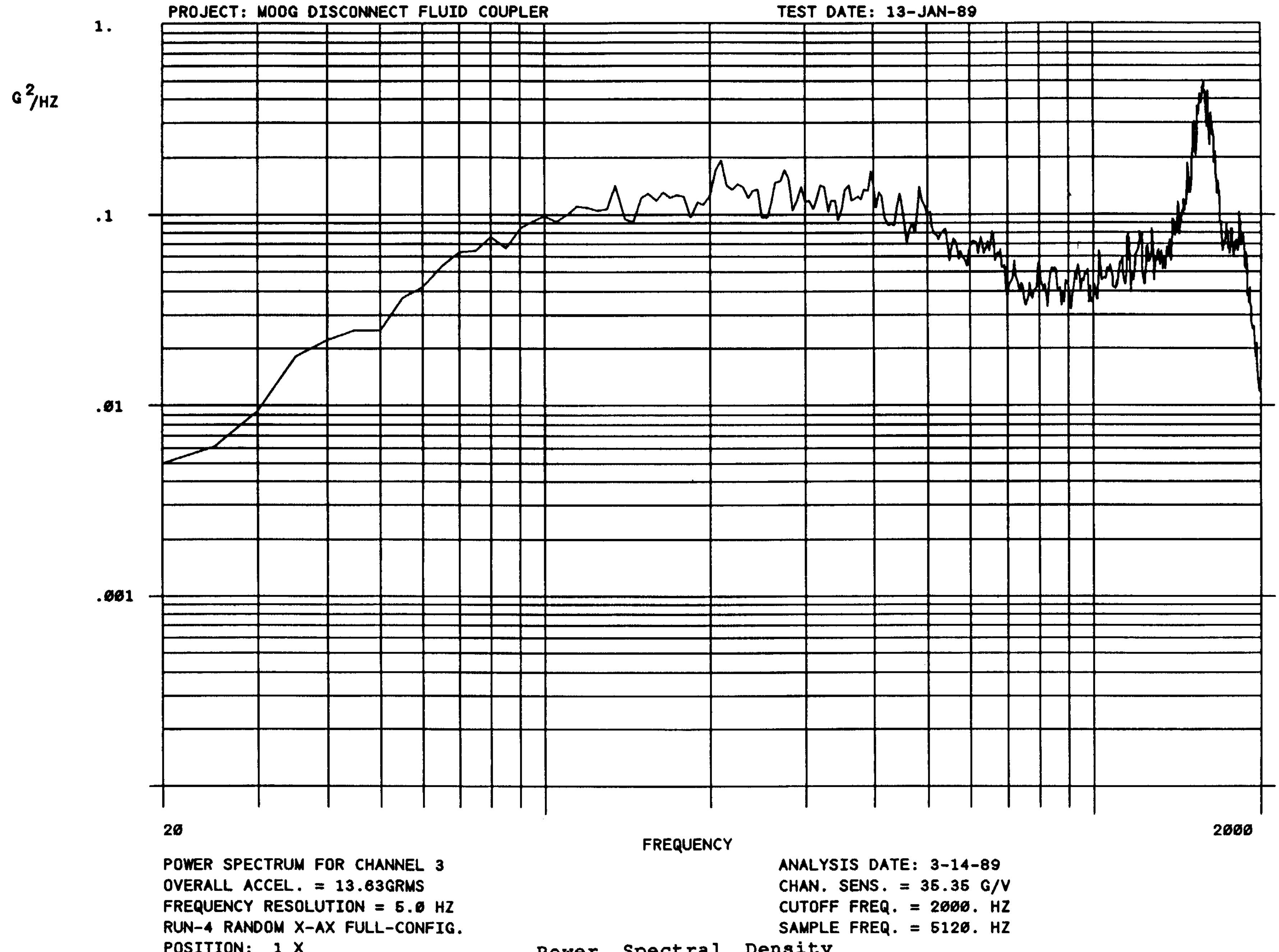
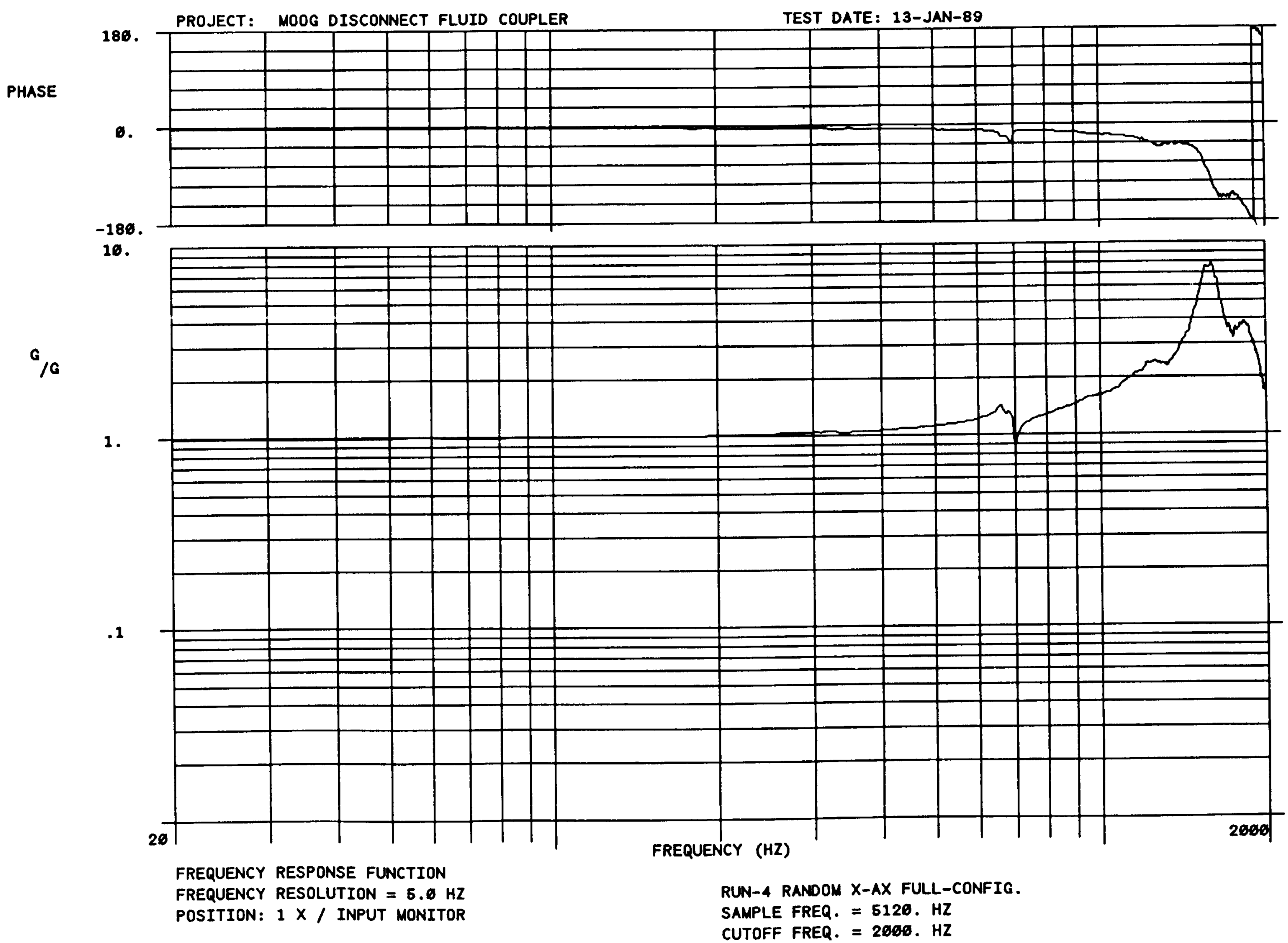
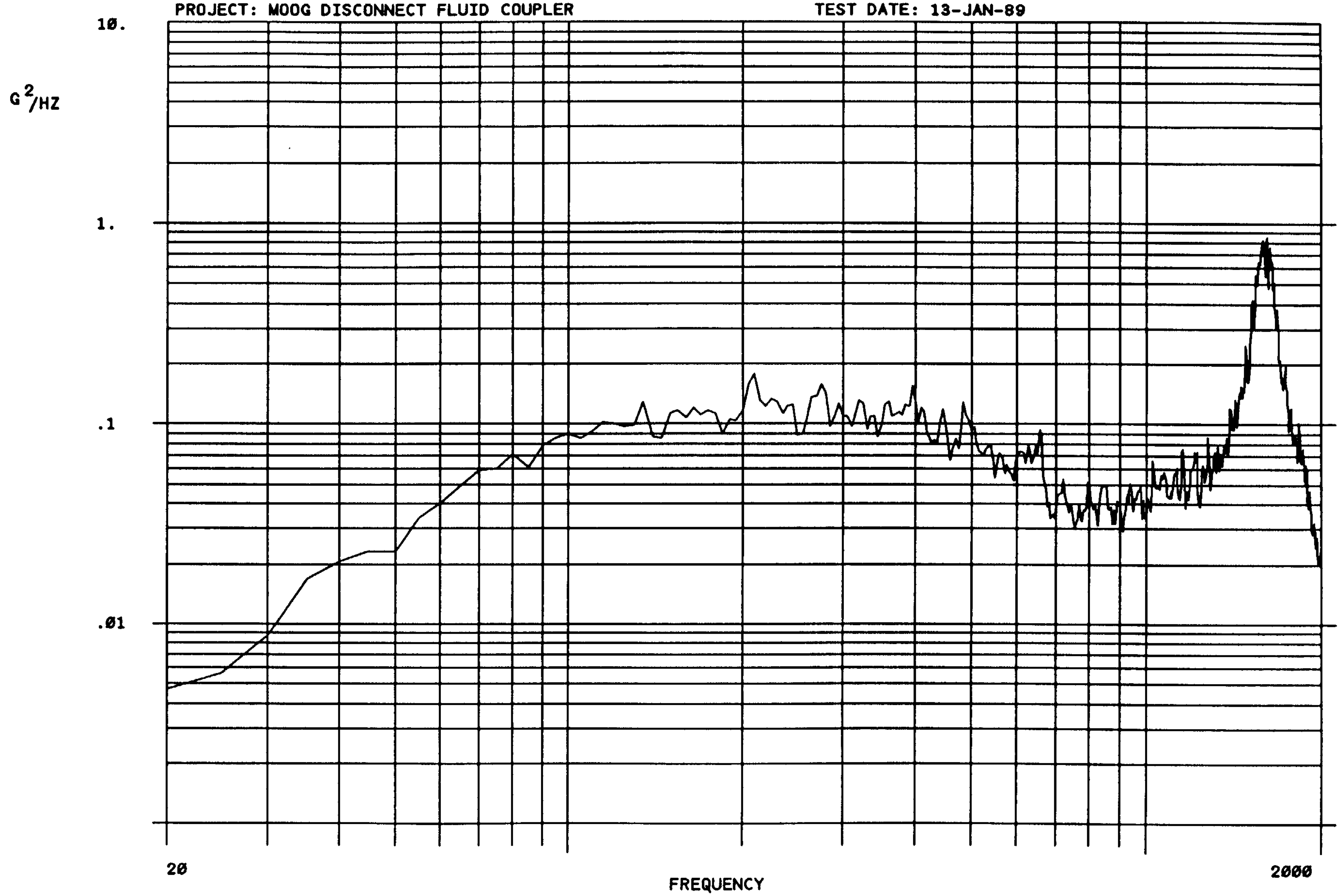


Power Spectral Density
Engaged Configuration - X axis



Phase Angle and Transfer Function
Engaged Configuration - X axis

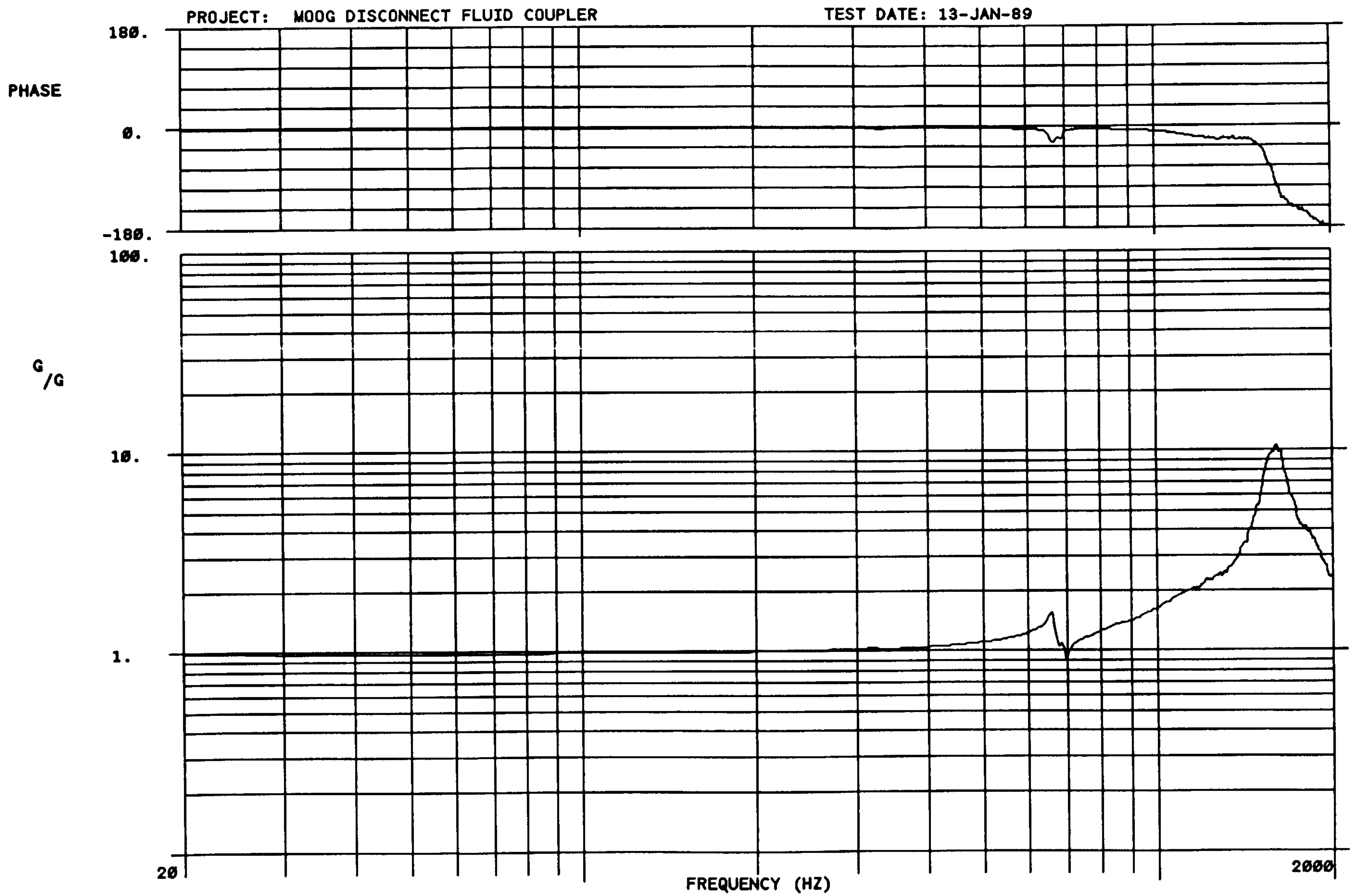
PROJECT: MOOG DISCONNECT FLUID COUPLER TEST DATE: 13-JAN-89



POWER SPECTRUM FOR CHANNEL 0
OVERALL ACCEL. = 15.42GRMS
FREQUENCY RESOLUTION = 5.0 HZ
RUN-4 RANDOM X-AX FULL-CONFIG.
POSITION: 2 X

ANALYSIS DATE: 3-14-89
CHAN. SENS. = 35.35 G/V
CUTOFF FREQ. = 2000. HZ
SAMPLE FREQ. = 5120. HZ

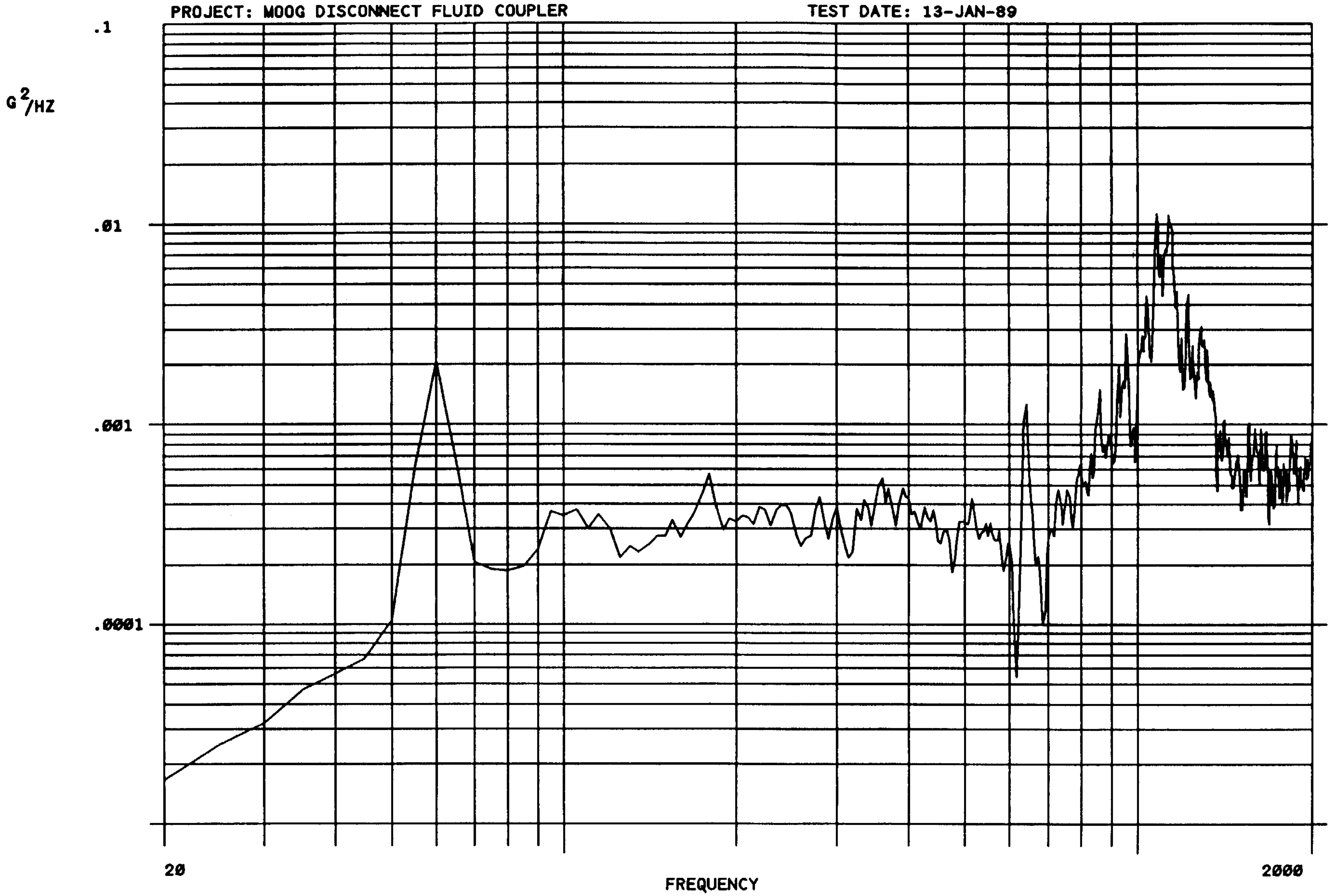
Power Spectral Density
Engaged Configuration - X axis



FREQUENCY RESPONSE FUNCTION
FREQUENCY RESOLUTION = 5.0 HZ
POSITION: 2 X / INPUT MONITOR

RUN-4 RANDOM X-AX FULL-CONFIG.
SAMPLE FREQ. = 5120. HZ
CUTOFF FREQ. = 2000. HZ

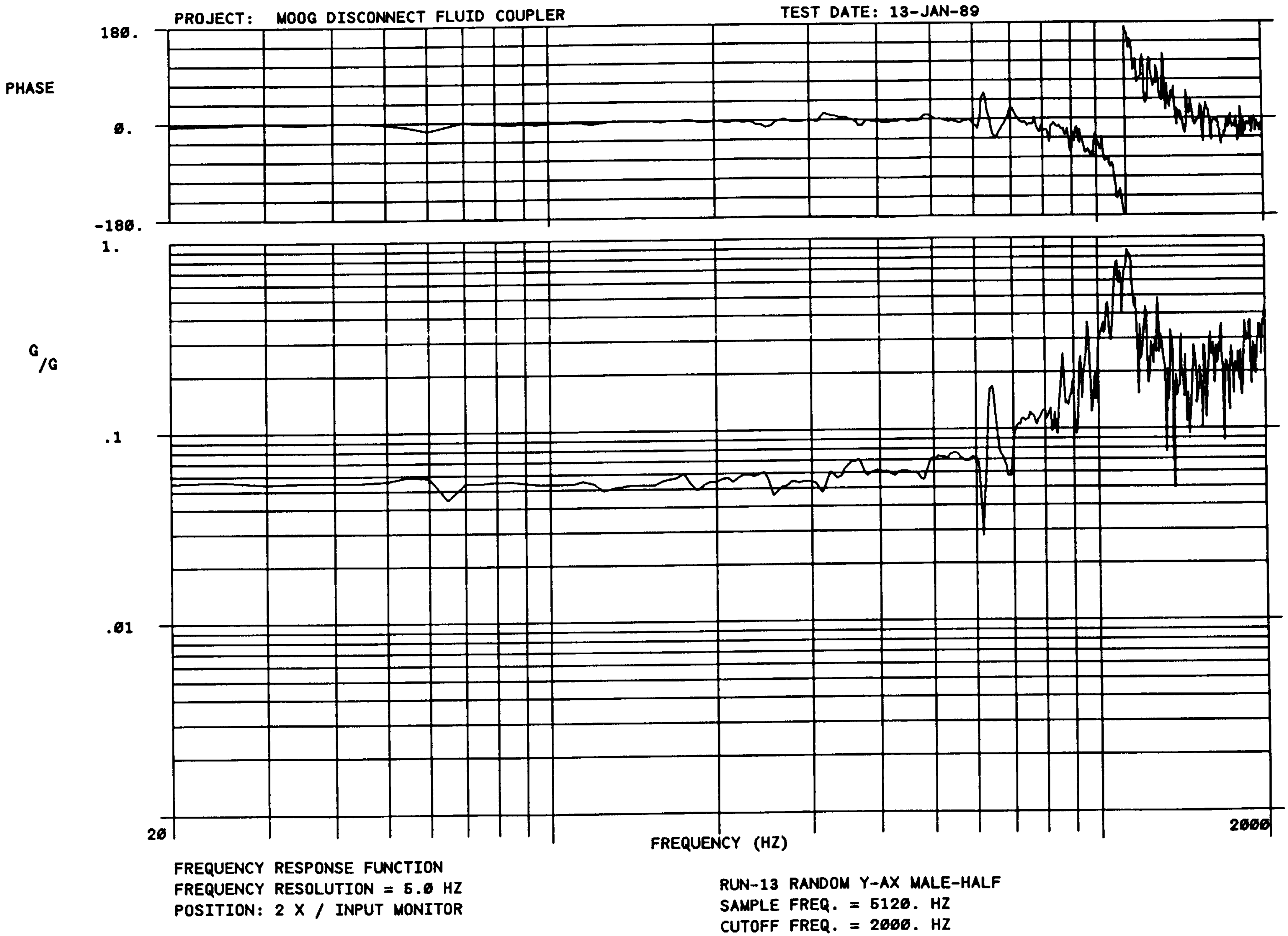
Phase Angle and Transfer Function
Engaged Configuration - X axis



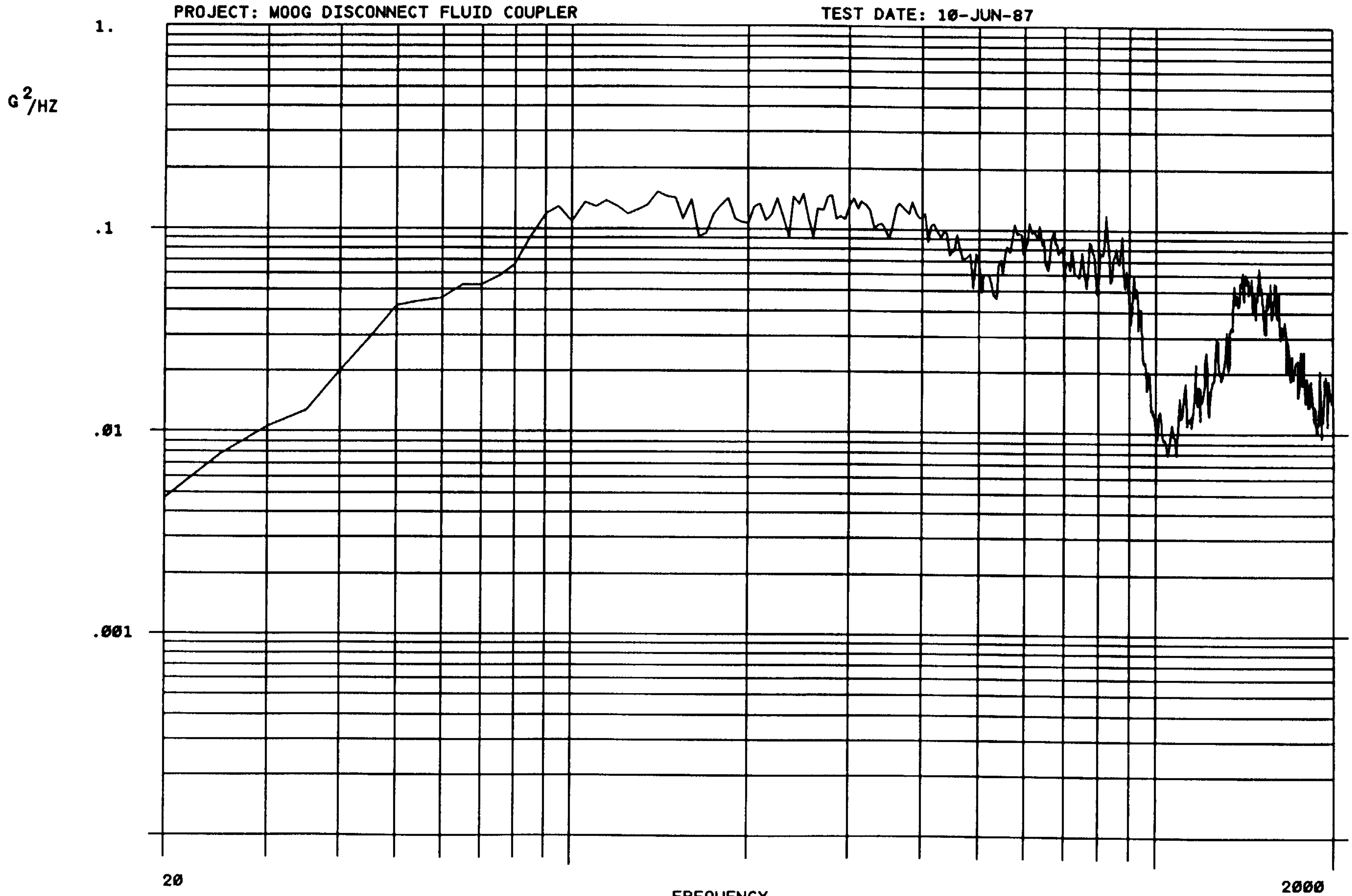
POWER SPECTRUM FOR CHANNEL 0
OVERALL ACCEL. = 1.493GRMS
FREQUENCY RESOLUTION = 5.0 HZ
RUN-13 RANDOM Y-AX MALE-HALF
POSITION: 2 X

ANALYSIS DATE: 3-15-89
CHAN. SENS. = 35.35 G/V
CUTOFF FREQ. = 2000. HZ
SAMPLE FREQ. = 5120. HZ

Power Spectral Density
Male Half - Y axis



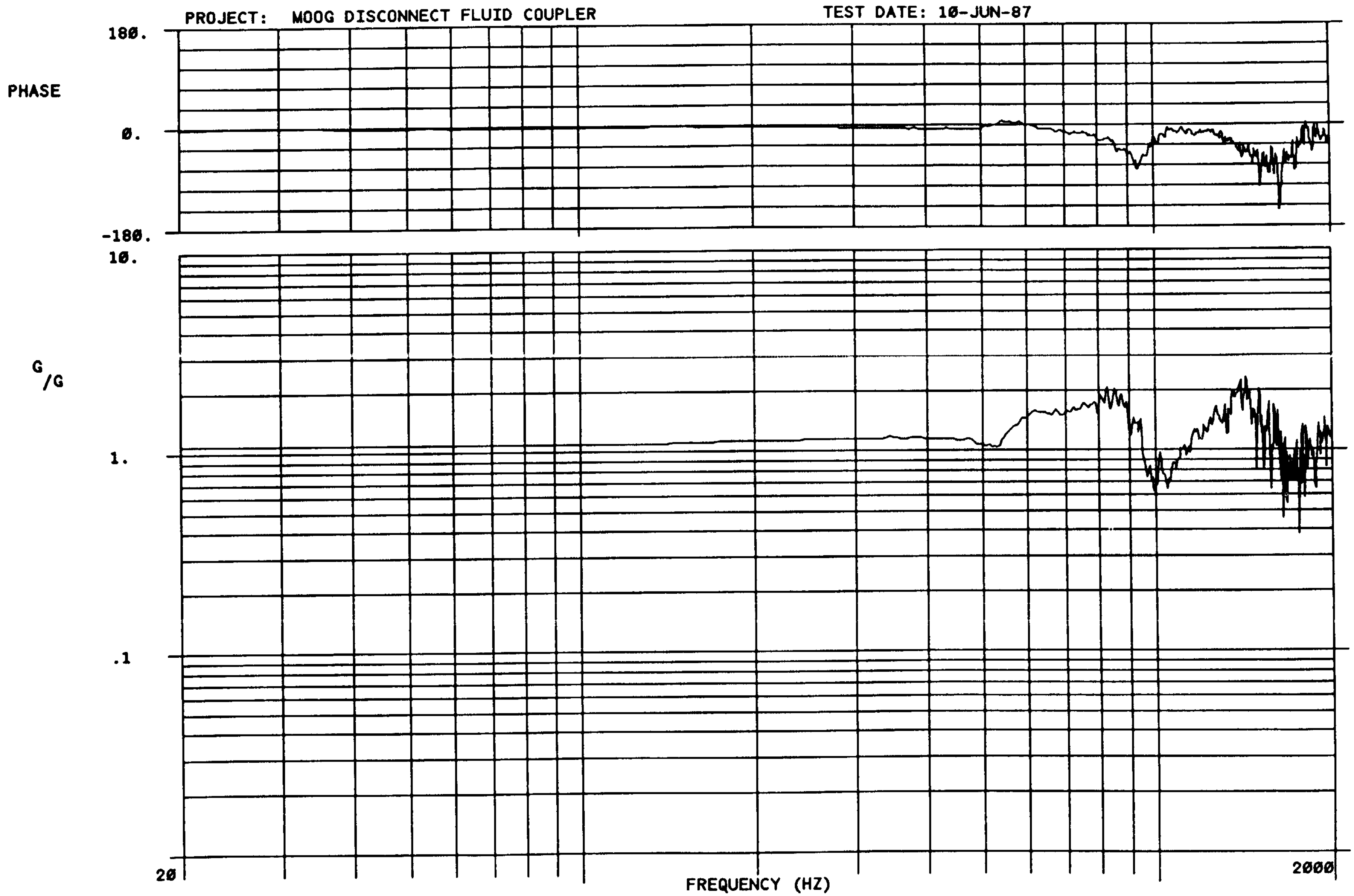
Phase Angle and Transfer Function
Male Half - Y axis



POWER SPECTRUM FOR CHANNEL 2
OVERALL ACCEL. = 10.44GRMS
FREQUENCY RESOLUTION = 5.0 HZ
RUN-7 RANDOM Z-AX FEMALE-HALF
POSITION: 2 Z

ANALYSIS DATE: 3-13-89
CHAN. SENS. = 35.35 G/V
CUTOFF FREQ. = 2000. HZ
SAMPLE FREQ. = 5120. HZ

Power Spectral Density
Female Half - Z axis



FREQUENCY RESPONSE FUNCTION
FREQUENCY RESOLUTION = 5.0 HZ
POSITION: 2 Z / INPUT MONITOR

RUN-7 RANDOM Z-AX FEMALE-HALF
SAMPLE FREQ. = 5120. HZ
CUTOFF FREQ. = 2000. HZ

Phase Angle and Transfer Function
Female Half - Z axis

Report Documentation Page

National Aeronautics and Space Administration

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15. Supplementary Notes

16. Abstract

New and innovative types of disconnects will be required to service, resupply, and maintain future spacecraft subsystems. Efficiently maintaining orbiting scientific instruments, spacecraft support systems, and a manned space station over a long period of time will require the periodic replenishment of consumables and the replacement of components. To accomplish these tasks, the fluid disconnect must be designed to allow the connection and separation of fluid lines and components with minimal hazard to crew and equipment. The capability to simply connect a refueling line or to easily replace a failed component greatly extends the life of a space-based fluid system.

A test program was initiated to evaluate the Moog Single Line Disconnect. The objective of the test program was to demonstrate the operational characteristics of the disconnect and to verify compliance with current safety regulations. The results of the program are summarized in the referenced document.

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