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Final
Report

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Positive Isolation Disconnect

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FINAL REPORT

POSITIVE ISOLATION DISCONNECT

December 1975

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FOREWORD

This document presents the results of work performed by the Martin Marietta Corporation's Denver Division for the National Aeronautics and Space Administration, Johnson Space Center. This final report was prepared as partial fulfillment of Contract NAS9-14376, Positive Isolation Disconnect. The NASA Technical Monitors were Mr. James C. Brady and Mr. Frank Collier of the Crew Systems Division, Environmental Control and Life Support Systems Branch.

ABSTRACT

This report describes the effort to develop a positive isolation disconnect for component replacement in serviced liquid and gaseous spacecraft systems for NASA-Johnson Space Center under NASA Contract NAS9-14376. Initially a survey of feasible concepts was made to determine the optimum method for fluid isolation, sealing techniques, coupling concepts and foolproofing techniques. The top concepts were then further evaluated which included the fabrication of a semi-functional model. After all tradeoff analyses were made, a final configuration was designed and fabricated for development testing. This resulted in a 6.35 mm (¼ inch) line and 12.7 mm (½ inch) line positive isolation disconnect, each unit consisting of two coupled disconnect halves, each capable of fluid isolation with essentially zero clearance between them for zero leakage upon disconnect half disengagement. An interlocking foolproofing technique has been incorporated that prevents uncoupling of disconnect halves prior to fluid isolation.

This report also recommends future development efforts and refers to space shuttle subsystems that would benefit from the use of the positive isolation disconnect. Customary units were utilized for principle measurements and calculations with conversion factors being inserted in equations to convert the results to the international system of units.

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ABBREVIATIONS

A	Area
amb	Ambient
C	Compressibility Factor
cc	Cubic Centimeter
cm	Centimeter
Cos	Cosine
CRES	Corrosion Resistance Steel
Cyl	Cylinder
D	Diameter
db	Decibel
defl	Deflection
displ	Displacement
ECLSS	Environment Control and Life Support System
EST	Estimate
F	Force
^{o}F	Degree Fahrenheit
ft	Foot
g	Acceleration of Gravity, 9.8 m/sec^2 (32.2 ft/sec^2)
GN^2	Gaseous Nitrogen
GSE	Ground Support Equipment
H	Height
He	Helium
h	Hour
Hz	Hertz
ID	Inside Diameter
IFM	Inflight Maintenance
in	Inch
k	Resistance Coefficient
^{o}K	Degree Kelvin
kg	Kilogram

ABBREVIATIONS (Cont'd)

lb	Pound
m	Meter
ml	Milliliter
mm	Milimeter
MMC	Martin Marietta Corporation
N	Newton
NASA	National Aeronautics and Space Administration
OD	Outside Diameter
P	Pressure
phm	Parts/Hundred Million
PID	Positive Isolation Disconnect
psi	Pounds per Square Inch
psia	Pound per Square Inch Absolute
psig	Pounds per Square Inch Guage
QAVT	Qualification for Acceptance Verification Testing
RH	Relative Humidity
sec	Second
Sin	Sine
SS	Stainless Steel
TBD	To Be Determined
TDC	Top Dead Center
V	Volume
wt	Weight

I. PROGRAM SUMMARY AND RESULTS

A. PROGRAM SUMMARY

The objective of this contract was to design, fabricate, and test a high reliability developmental positive isolation disconnect (PID) that was of minimum size and weight. The PID's purpose was for component replacement in serviced liquid and gaseous spacecraft systems. These spacecraft systems would consist of high purity water, coolant water, sweat and respiratory condensate, urine, ammonia, and Freon-21.

Maintenance of liquid and gaseous ECLSS components has always presented unique problems throughout past flight programs. Previous techniques proposed for maintenance of fluid systems involved: 1) freezing the fluid and cutting the line at a specific point in the system; 2) draining the fluid from the system and then purging and reservicing the system; and 3) providing a redundant system for those components with low reliability with isolating valves to separate the systems. The first two techniques required considerable time and man power, required additional support equipment and trained personnel, and usually had undesirable effects such as trapped gas. The third technique adds weight and volume to the spacecraft system. All three techniques are costly.

Utilization of existing design quick disconnects also have presented problems in the maintenance of fluid systems. These disconnects have poppets with spring-loaded actuation and closure features. After a period of time with the disconnect in service, the spring becomes corroded or upon separation contamination prevents the spring from closing the internal poppet. Without a positive means of identifying that the poppet was isolated, a spillage could occur under pressure. Other problems are the male-female offset dimension of up to 19.05 mm (3/4 inch) and the opening and closing of the poppets with system pressure applied.

The PID concept that was developed under this contract is designed to eliminate the problems of the previous maintenance techniques and to eliminate the disadvantages of the existing quick disconnects. The program to develop the PID consisted of five tasks as follows:

Task 1 - Development of Preliminary Design - In this task, a tradeoff study on techniques for fluid isolation, sealing, body designs, coupling and foolproofing was performed to determine the best combination of design techniques that would achieve the technical concept restraints. The result of the preliminary design tradeoff study was the selection of two concepts, differing only in the method of fluid isolation. Both would use an integral positive isolation coupling mechanism. The fluid isolation on one was a rotating sphere and the other was individually operated opposing poppets. A preliminary design review was held with NASA-JSC.

Task 2 - Engineering Assessment and Detail Design - During this task the concepts derived from Task 1 were further evaluated. The rotating spheres concept was eliminated due to wear of seals inherent in the design. At this point, the opposing poppet was selected for further development. Detail design drawings were developed to depict the concept. A semi-functional model was fabricated and tested to verify that the conceptual design was functional prior to fabrication of the developmental PID's. A final development design review was held with NASA-JSC.

Task 3 - Development of Disconnect Assemblies - In this task, two units were fabricated, (1) a 6.35 mm (¼ inch) line unit with elastomer seals, and (2) a 12.7 mm (½ inch) line unit with teflon seals for fluids such as Freon-21 and ammonia. The two units fabricated were then subjected to development tests including proof pressure, hydraulic lockup, 5012 life cycles of isolation, separation, and reconnection, internal and external leakage, and pressure drop.

Task 4 - Final Development Design - In this task, the developmental test results were analyzed and required changes were identified. Specific areas of PID usages were preliminarily identified. A design criteria specification was prepared and a recommended future program was prepared. A development design review was held with NASA-JSC.

Task 5 - Documentation - This task prepared the documentation and reports required by the data requirements list (DRL) number T-1028. The conference documentation and hardware delivery was also prepared under this task.

The deliverable end products are a complete set of detail fabrication drawings for the preliminary prototype, a complete test log and summary of the prototype development test, one 6.35 mm (.25 inch) and one 12.7 mm (.50 inch) development test disconnect assemblies, and a recommended future program plan for fabrication and testing of a flight prototype positive isolating disconnect. A disconnect assembly consists of two disconnect halves, each with the necessary operational tools.

B. PROGRAM RESULTS

1. PID Description - One 12.7 mm (.50 inch) and one 6.35 mm (.25 inch) PID was designed and fabricated. The PID consists of two coupled disconnect halves, each capable of fluid isolation with essentially zero clearance between them. Figure I-1 shows the assembled PID with both halves connected. The PID as developed under this contract has the following design features:

- Isolation Feature - Fluid isolation is accomplished through the use of individually operated opposing poppets as shown in Figures I-2 and I-3. The poppet is attached to the poppet shaft with a yoke section near mid-length. The poppet shaft is centered and supported by guide rings that are positioned and located by the internal bore of the valve body. The poppet shaft yoke is sized to allow the insertion of a cam lobed valve stem and a series of leaf springs. The distance between centers of the valve stem shaft and the eccentric is 1.98 mm (0.078 in.) that provides for 3.96 mm (0.156 in.) poppet shaft movement for 3.14 radians (180 degrees) rotation of valve stem. The poppet is adjusted on the poppet shaft so that it mates with the seat when the high point of the cam is 0.52 radians (30 degrees) off TDC. When the cam is rotated to TDC, the leaf springs are deflected 0.355 mm (.014 in.) which provides a loading of 444.8 newtons (100 lbs) on the poppet. With this predetermined loading there is no need for calibrated tooling for valve opening or closure.

  The design provides for .087 radians (5 degrees) over TDC for positive locking of poppet in the closed position. A pin on the valve stem comes in contact with a pin stop to maintain this position. If the pin stop became loose, the cam would come in contact with the side of the yoke limiting the past TDC to .26 radians (15 degrees) as a safety feature. With the 444.8 newtons (100 lbs) load on the poppet and with the low surface area of the elastic seal and metal-to-metal seal, a loading of 2.4×10^7 N/m^2 (3500 psi) exists on the elastic seal (which is 5 times greater than the recommended loading for crushing possible contaminants) and a loading of 8.05×10^6 N/m^2 (1169 psi) exists on the metal-to-metal seal where the recommended loading is 6.89×10^6 N/m^2 (1000 psi). If a contaminant becomes trapped between poppet and its seat and is not crushable, the cam will bottom out on the springs and the springs bottom out on the yoke thereby preventing the operator from

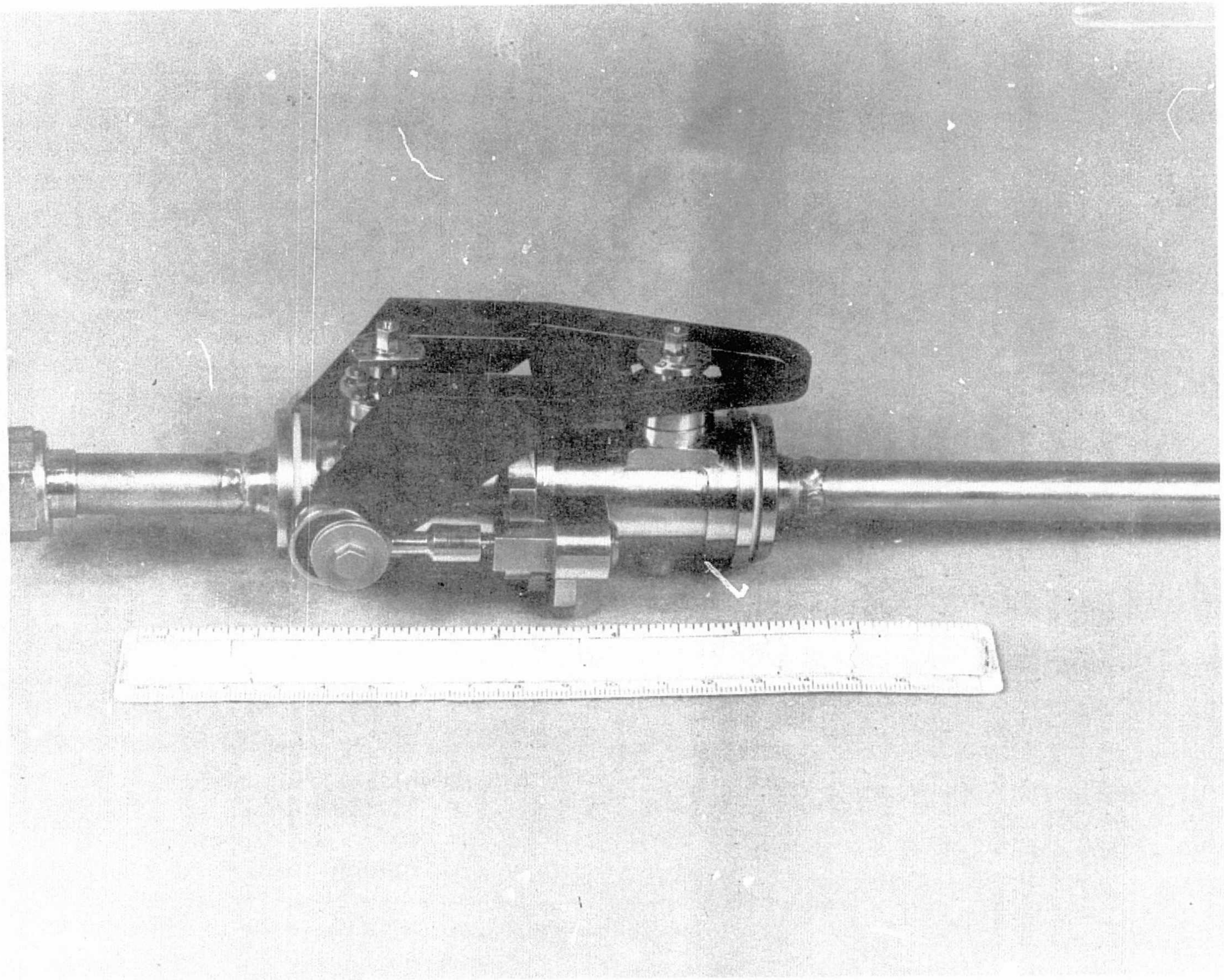

FIGURE I-1 ASSEMBLED PID (SIDE VIEW)

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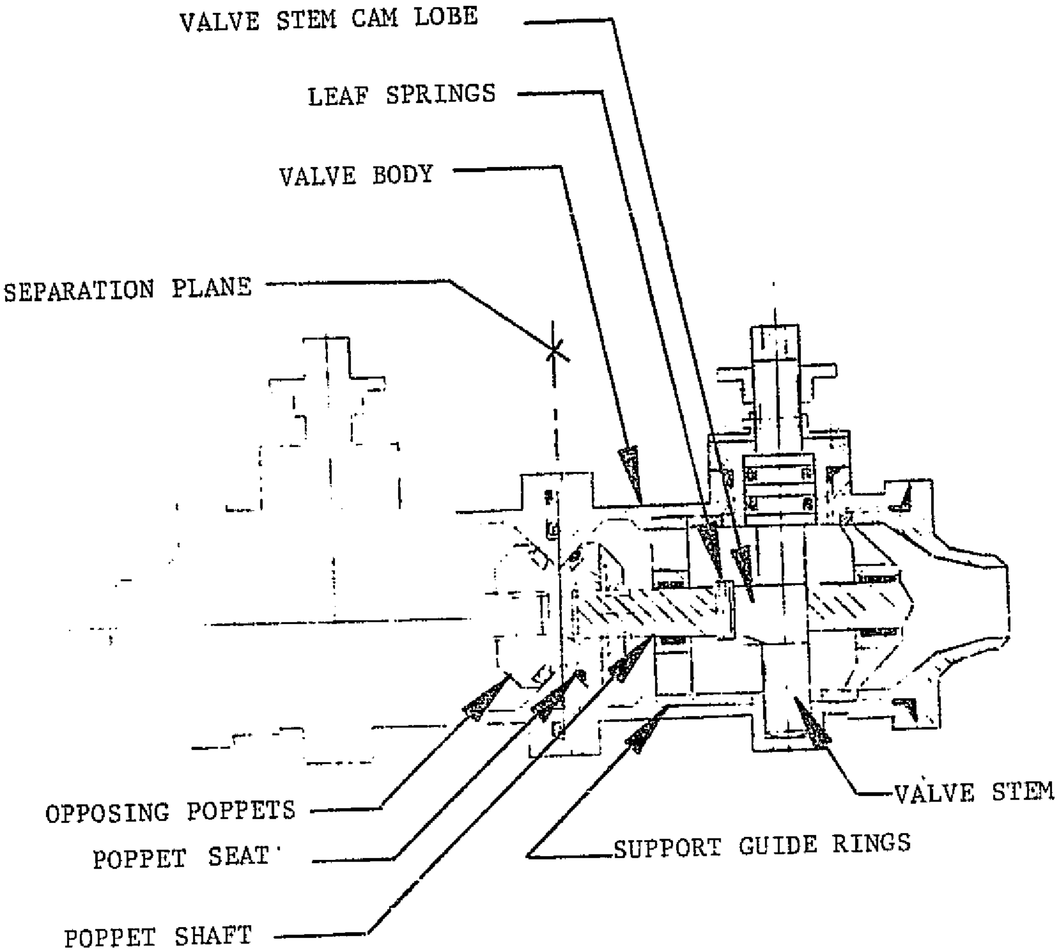


FIGURE I-2 CUTAWAY SIDE VIEW OF PID

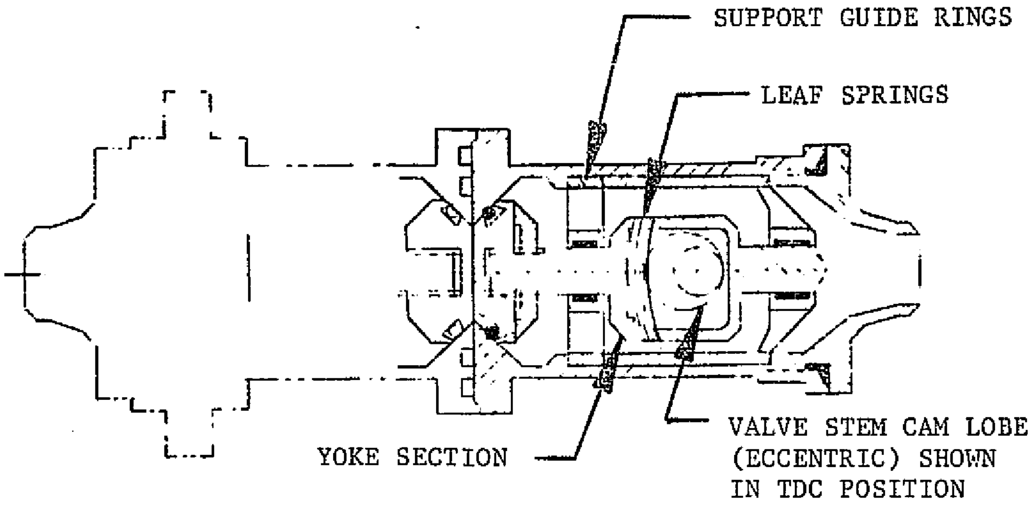


FIGURE I-3 CUTAWAY PLAN VIEW OF PID

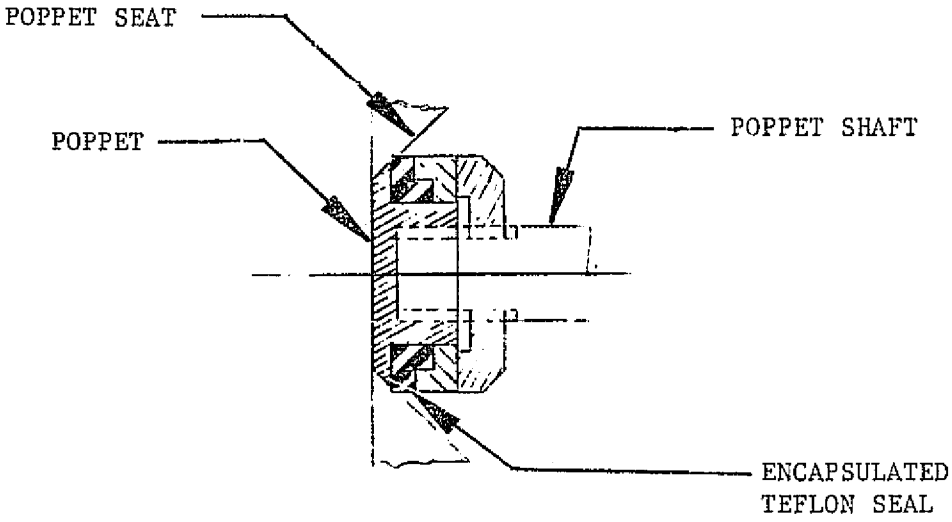


FIGURE I-4 TEFLON ENCAPSULATED POPPET SEAL making the proper complete rotation of the valve stem, and without the valve stem in its proper place the units are incapable of being disengaged. This prevents the uncoupling of the disconnects when the poppets are not completely sealed. The operator would then reopen the poppet thus allowing the contaminate to pass.

- Sealing Features - Since the PID is designed for several different fluid systems, two types of elastic seal material are utilized depending on system usage. Elastomer seal material of ethylene propylene is used on systems flowing high purity water, condensate (sweat and respiratory vapor), urine, coolant water and gaseous systems such as nitrogen. Teflon seal material is utilized on systems flowing Freon-21 and ammonia.

  Redundant seal techniques are incorporated at dynamic sealing locations and single seals are used at static sealing locations, as shown in Figure I-2. The redundant seal locations include the areas of the valve stem, separation plane and poppet. Double seals are used at the valve stem and at the separation plane, but the poppet utilizes metal-to-metal sealing for the redundancy in that area.

  The units using elastomer seals have dovetail grooves for the seal glands on the poppet and on the separation plane. All other areas use the standard elastomer "Rectangular" or MS33649 boss static seal gland.

  The teflon seal units have several different seal configurations. The separation plane seals are of the "Omniseal" type with "Rectangular" gland. The outboard side of the gland has a 0.635 mm (.025 in.) by 0.635 mm (.025 in.) groove. The purpose of the groove is to retain the seals upon separation. Once the seals are pressurized, this design permits cold-flow into the radial groove for retention. The valve stem uses the "Omniseal" type seal with the standard "Rectangular" gland. Static boss seal locations use the teflon O-ring and the poppet uses a captured seal as shown in Figure I-4.

- Coupling Feature - The coupling feature, as shown in Figure I-5, consists of cam actuated clamp fingers that clasp the two disconnect halves together with a force of 2135 newtons (480 lbs). The cam is part of the handle that lays across the top of the disconnect units. The clamp fingers consist of a pivot point at one end and a clamp yoke at the other with the center section made up of an adjustment screw with Belleville washers.

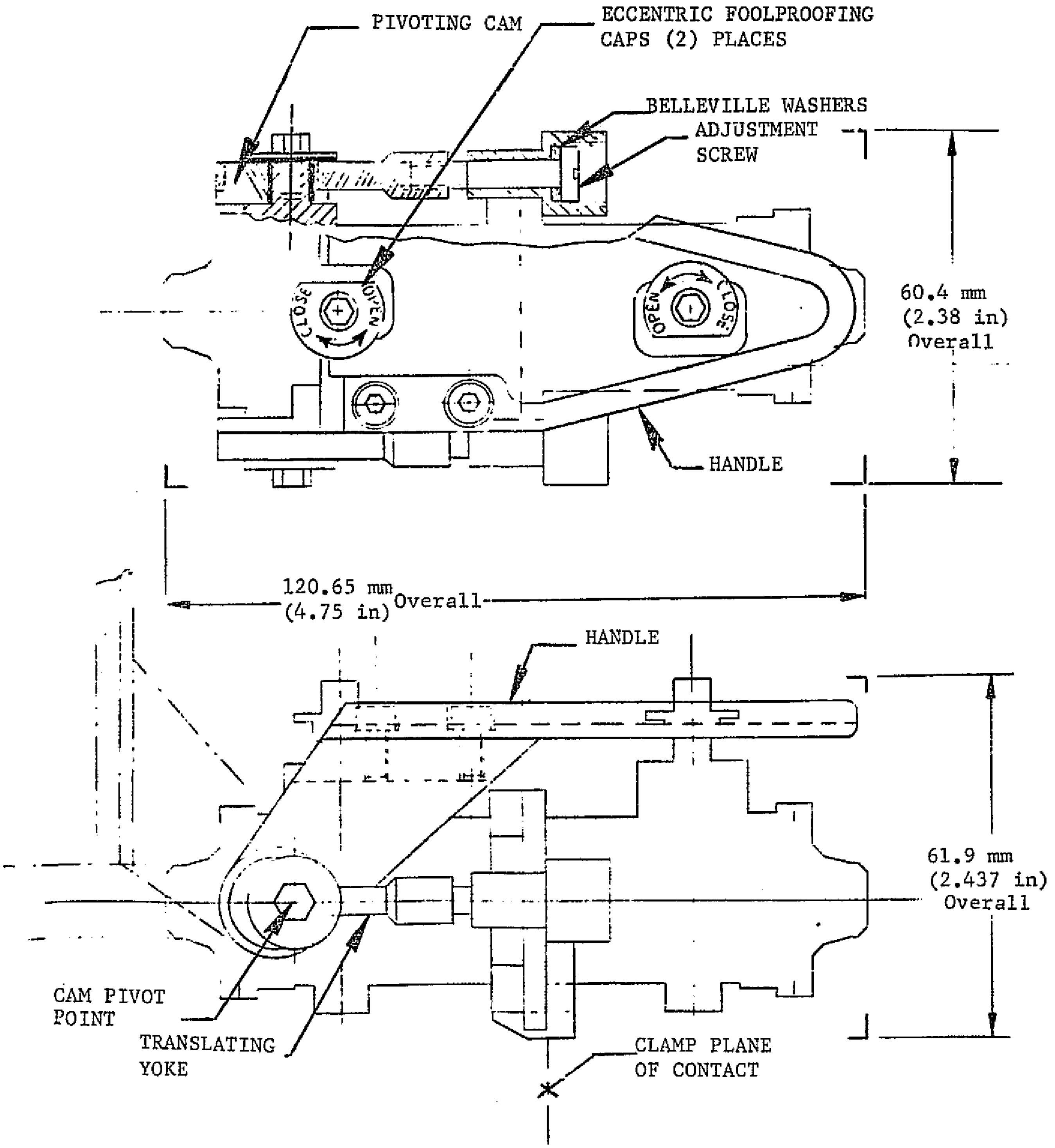


FIGURE I-5 COUPLING ASSEMBLY

The initial setup of the clamp is accomplished by tilting the handle back 0.28 radians (16°) and adjusting the clamp finger until both disconnect halves are in contact with each other. When the handle is positioned flat across the PID, the Belleville washers are deflected 0.127 mm (.005 in.) of a possible .25 mm (.010 in.) resulting in the clamp force of 2135 newtons (480 lbs).

- Foolproofing Technique - To prevent the accidental disengagement of disconnect halves prior to fluid isolation, a foolproofing method is incorporated in the design; see Figure I-5. This consists of eccentric caps attached to the valve stems that coincide with slots in the coupling handle. When the disconnect halves are open, the eccentrics overlap the handle preventing its movement; likewise, when disconnect halves are closed, the handle is allowed to pass by the eccentrics and uncouple the unit.

- Fluid Compression/Expansion - Use of tapered poppets and matching poppet seats prevent fluid compression or expansion as sealing occurs when mating parts are contacted. For the situation where Freon-21 is trapped between the disconnects and a temperature rise takes place, the design incorporates a means of allowing the fluid to expand. For a 44.4°K (80°F) temperature rise, the units must allow for .010 mm (.0004 in.) axial expansion. Since the clamping force is dependent on Belleville washer deflection, the required movement adds that amount to the deflection. Therefore, the clamping force increases from 2135 newtons (480 lbs) to 2579.9 newtons (520 lbs).

- Interface Spillage Volume - The poppet and poppet seat provide a flush surface, thereby minimizing possible leakage to only a wet surface. The thin water film on the separation plane will be retained by surface tension. Tests have shown leakage to be less than 1.26 ml upon disconnect.

- Separation Plane Lateral Movement - The design provides a 1.143 mm (0.045 in.) concentric offset for centering one disconnect half to the other. Therefore, a lateral movement of 1.27 mm (0.050 in.) would be satisfactory for component removal as compared to disconnects requiring lateral movements up to 19 mm (.75 in.) prior to separation.

- Metal-to-Metal Contact - Metal-to-metal contact is prevented by use of teflon bearings on sliding surfaces and a moly-x hard coat lubricant burnished onto the valve stem cam surface.

- Operational Access - All functions can be performed on one side of the unit, thereby limiting access requirements to a side normal to center line of PID and fluid flow.

- Materials - Main body and internal parts are fabricated from 21-6-9 corrosion resistant steel due to its high strength-to-weight ratio and the ability to weld it to 347 stainless steel. To further increase the materials resistance to corrosion, all parts are passivated. The leaf springs are fabricated from 17-7 PH stainless steel and heat treated to RH 950.

  The handle is fabricated out of 6061-T6 aluminum for weight savings. For corrosion resistance and prevention of galling, a hard coat anodize finish is used.

  Weight and Dimensions - The 12.7 mm (.50 inch) prototype disconnect unit with both halves and coupling mechanism weighs .58 kilograms (1.28 lbs). The 12.7 mm (6.50 inch) PID coupled has overall dimensions of 60.4 mm (2.38 in.) wide by 61.9 mm (2.437 in.) in height by 120.7 mm (4.75 in.) in length (see Figure I-5). The 6.35 mm (.25 in.) PID developed during this effort has the same weight and dimensions.

- Fluid Compatibility - The units are compatible with operational fluids of high purity water, Freon-21, sweat and respiratory vapor, urine, coolant water, nitrogen gas, and ammonia for periods up to 10 years.

- Leakage Limitations - The PID has a leakage rate of less than 1 cc/hr disconnected and .02 cc/hr connected with N_2 at operating pressure. There is no visible leakage with water at operating pressure.

- Operational Life Expectancy - The PID is designed for an operational life expectancy of 5000 cycles. Each cycle consists of isolate-disconnect-connect-flow.

- Tool Requirements - For normal PID operation (which includes closing both disconnects, uncoupling, component replacement, coupling disconnects together, open disconnects), only a 4.75 mm (3/16 in.) socket wrench is required. For breakdown of the PID, the required tools include a crescent wrench with an opening of 38.1 mm (1.50 in.), standard blade screw drive, and a set of Allen wrenches.

2. PID Development Test Results

Proof Pressure - The development PID units showed no visible indications of permanent deformation or distortion and no loss of operating capability as a result of being subjected to 4.14×10^6 N/m^2 (600 psig).

Hydraulic Lock Test - Both test units successfully completed this test with no indication of hydraulic lockup and no increase in valve stem torque utilizing pressurized water at pressures of 1.72×10^5 N/m^2 (25 psig) and 2.76×10^6 N/m^2 (400 psig).

Operational Life Cycle Tests - The test units completed 5012 cycles of closing the poppets, disconnecting the halves, reconnecting the halves, and opening the poppets utilizing water at 2.76×10^6 N/m^2 (400 psig) for 2500 cycles, gaseous nitrogen at 2.76×10^6 N/m^2 (400 psig) for 2500 cycles and Freon-21 at 2.76×10^6 N/m^2 (400 psig) for 12 cycles. Table V-10 summarizes the problems during the development tests, the corrective action taken to resolve the problem, and the problem analyses for future design improvements.

Leakage Tests - Both units were subjected to leakage tests at five different pressures between 3.4×10^4 (5 psig) and 2.76×10^6 (400 psig), utilizing water at cycle numbers 451 and 500; gaseous nitrogen at cycle numbers 2500, 3000, 3500, 4000, and 4500; and gaseous helium at cycle numbers 5000 and gaseous helium at cycle numbers 5000 and 5012. In summary, the 6.35 mm (1/4 in.) unit has elastomer seals and had essentially zero leakage until the Freon-21 exposure cycles. The 12.7 mm (1/2 in.) unit had teflon seals and did have leakage problems throughout the test cycles up to cycle number 3735 due to the poppet being loose on the poppet shaft (see Table V-10 for summary discussion on this problem). After rework at cycle 3735, the leak test at later cycles showed essentially zero leakage. It can be concluded that the units are capable of meeting the leakage criteria.

Pressure Drop Tests - For a typical water flowrate of .063 kg/sec (500 lbs/hr) the pressure drop for the PID is 1.32 x 10^4 N/m^2 (1.91 psi). The projected flow coefficient (C_v) was 0.66. Since both the 6.35 mm (1/4 in.) unit and the 12.7 mm (1/2 in.) unit use the same body, a pressure loss penalty is inherent in the 6.35 mm (1/4 in.) unit. The body flow path cross-sectional area is sized for the 12.7 mm (1/2 in.) unit, therefore, creating an expansion/contraction situation in the 6.35 mm (1/4 in.) unit.

3. PID Documentatinn Submittals - Documentation submittals were prepared and submitted in accordance with DRL Number T-1028. The following is a brief description of each submittal.

Monthly Progress Reports - These reports summarized all work accomplished during each month. These reports were submitted as DRL line item 1, Martin Marietta number MCR-74-431.

Program Plan - This document describes the overall plan for the conduct and implementation of the contract. This report was submitted as DRL line item 2, Martin Marietta number MCR-74-355.

Master Test Plan - This document describes the Master Test Plan for the contract. This report was submitted as DRL line item 3, Martin Marietta number MCR 74-361.

Test Procedure - This document provides the detail test procedures to accomplish the Master Test Plan. These procedures were identified as Martin Marietta number H40586.

Test Report - This document contains the test log and summary of prototype development tests. It is identified as Martin Marietta Test Report H40586.

Detail Fabrication Drawings - These drawings consist of detailing the design of the Positive Isolation Disconnect for fabrication purposes. These drawings are identified as NAS9-14376A.

Design Specification - This specification defines the PID as developed under this contract. This specification was submitted as Martin Marietta Number MCR-75-362.

Final Report - This report summarizes the resulte of the contract. It also contains the recommended future program for fabrication and testing of a flight prototype positive isolation disconnect. This report was submitted as DRL line item 4.

4. PID Hardware Delivery - The hardware delivered under this contract consists of the following:

- One 12.7 mm (½ inch) developmental PID cleaned and assembled. One end cap was provided to protect the face seals when the halves were separated.
- One 6.35 mm (¼ inch) developmental PID cleaned and assembled. One end cap was provided to protect the face seals when the halves were separated.
- Two 4.76 mm (3/16 inch) socket torque tools set at 13.83 cm-kg (12 in-lb). This tool is used to open and close the poppets of the PIDs.

II. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

1. The developmental positive isolation disconnects delivered under this contract have demonstrated that they are a highly reliable maintainable concept for component or subsystem module replacement in liquid and gaseous spacecraft systems.

2. The PID concept is suitable for either Shuttle zero-gravity IFM or for ground refurbishment purposes.

3. The developmental PID is currently comparable to other developed disconnects in size and weight for the same line sizes. A complete PID with both halves and coupling mechanism weighs .58 kilograms (1.28 pounds) and has overall dimensions of 60.4 mm (2.38 inches) wide by 61.9 mm (2.437 inches) in height and 120.7 mm (4.75 inches) in length for 12.7 mm (1/2 inch) line size.

4. Elastomer seals should not be utilized with Freon-21 due to the incompatibility between the two.

5. This concept does have commerical application to replace conventional hazardous liquid disconnects utilizing spring loaded valves, with no interlock to prevent disengagement if one or both valves fail to close due to spring corrosion or contamination. The design eliminates operator errors and accidental spills thus increasing the safety in handling hazardous fluids.

B. RECOMMENDATIONS

This program has demonstrated that the PID is a feasible concept for both spacecraft and commercial applications of maintenance. Based upon the results of this program, it is recommended that continued development of the PID be accomplished. The recommended additional effort is as follows:

1. Prototype Flight Article - The following steps should be accomplished to develop a prototype flight article PID:

- Development PID Test Program - Investigate the development PID test results and develop solutions for each problem area.

- Reduction of 6.35 mm (¼ inch) PID Size - Investigate a spool valve concept as alternate design for further diameter and length reduction.

- Man-Machine Interface Testing - Determine both shirt sleeve and pressure suited crewman interface with PID under simulated weightlessness conditions.

- Investigate Vibration/Acceleration PID Effects - Perform limited vibration/acceleration testing of the integral clamping mechanism utilizing the developmental test disconnect assemblies.

- Investigate Adaptability to Larger Sizes and Higher Pressures - Investigate possible uses of PID for sizes up to 50.8 mm (2 inches) and pressures to 3.1×10^7 N/m^2 (4500 psig).

- Develop Prototype Design - A flight article prototype should be developed based upon the above investigations and should consider production type units as well as reducing size and weight.

- Fabricate Prototype Design - Fabricate one 6.35 mm (¼ inch) and one 12.7 mm (½ inch) flight article prototype.

- Perform Prototype Testing - The test program should consider additional life cycle tests and a complete environmental test program per Shuttle MF 0004-014 requirements.

2. Investigate Remote Operation Design - Application of a PID is required when removing modules or performing inflight maintenance with a remote manipulator or free flyer teleoperator. End effector interface and limitations of rotational and push/pull movements must be considered on closing/opening the poppet valves and disconnecting/connecting the two halves. Consideration must also be given to the design for general purpose remote control or a one push/pull operation fully automated. The recommended effort for this task would be to investigate a design for closing both poppets at the same time and the interface end effector design.

3. Investigate Concept Design to Electrical Connector - The integral connecting mechanism should be investigated to determine its applicability to an electrical connector that requires positive pin disengagement prior to separation to prevent electrical shorts. The recommended effort would be to determine if the developed concepts for the PID integral clamping mechanism and the poppet drive mechanism is weight, volume and cost compatible to electrical connectors currently developed.

III. TASK 1 - DEVELOPMENT OF PRELIMINARY DESIGN

A. PURPOSE AND SCOPE

The purpose of Task 1 was to develop candidate techniques for the disconnect on a detail level and to generate candidate concepts for the disconnect assemblies. With the operational requirements as preliminary design criteria, the various isolation, sealing, and body design techniques were developed and compared to ensure that all feasible techniques to accomplish a specific function are explored. The top candidate techniques were then utilized to generate complete disconnect concepts.

B. SIGNIFICANT RESULTS

1. Operational Requirements - Initially, the operational requirements of the disconnect were evaluated so that the detail level design requirements are understood and satisfied. Table III-1 lists the operational requirements.

Table III-1 Operational Requirements

- High Reliability
- Minimum Size, Weight
- No Spring-Loaded Actuation or Closure Features
- Positive Means of Isolation Prior to Separation
- Isolation Functions shall not cause Fluid Compression or Expansion
- Minimize Spillage Volume
- Minimize Lateral Movement for Separation
- Redundant Sealing Techniques
- Preclude Stagnant Areas, Use Single Port Flow Area
- Inlet/Outlet on Common Centerline
- Weldable to 347 SS
- No Metal-to-Metal Contact between Sliding Surfaces
- Single-Side Access
- Design for Maintainability

2. Material Selection - The metallic and nonmetallic materials which could be utilized for the components of the disconnect were identified and evaluated. This material study was aimed at minimizing wear and increasing reliability of the component parts.

Both metallic and nonmetallic materials must not be degraded when exposed to operational fluids for an operational life of ten years. Table III-2 lists the operational fluids.

Table III-2 Operational Fluids

- Ammonia
- High Purity Water
- Freon-21
- Condensate (sweat and respiratory vapor)
- Urine
- Coolant Water

Other selection criteria is shown in Table III-3.

Table III-3 Other Design Factors

Metallics	Non-Metallics
o Compatible with Operational Fluids	o Compatible with Operational Fluids
o Weldable to 347 SS	o Maintain elastic properties
o Resistant to wear during cycling	o Resistant to wear during cycling
o Ease of machining	

The primary design criteria are urine and Freon-21. Most seal materials are degraded by F-21, and many metals are pitted or corroded by urine. There is limited amount of data available on Freon-21, but Freon-21 has a greater effect on elastomers than other Freon fluorocarbons. Table III-4 gives percent linear swelling data for some typical elastomers. Table III-5 gives effect of Freon compounds on plastics.

Tests on metals at $327.6^{\circ}K$ ($130^{\circ}F$) for 5.184×10^6 seconds (60 days) in the presence of free water with "Freon-21" give a penetration rate on 1020 CR steel of 3.2×10^{-3} mm (127×10^{-6} inches) per month. A copper and steel combination was run at $394.26^{\circ}K$ ($250^{\circ}F$) for 5.184×10^6 seconds (60 days) with dry "Freon-21" and the penetration rates were found to be 1.3×10^{-4} mm (5×10^{-6} inches) per month for copper and 2.16×10^{-4} mm (8.5×10^{-6} inches) for 1020 CR steel. Results obtained from published data on corrosion.

Table III-4 Swelling of Elastomers in Fluorocarbons (1 carbon) at Room Temperature

Elastomer	"F-11" CCl_3F	"F-12" CCl_2F_2	"F-13" $CClF_3$	"F-13B1" $CBrF_3$	"F-21" $CHCl_2F$	"F-22" $CHClF_2$	FC-31 CH_2ClF	FC-32 CH_2F_2
Buna N	6	2	1	1	48	26	38	3
Buna S (GR-S)	21	3	1	1	49	4	10	0
Butyl (GR-I)	41	6	0	2	24	1	3	0
"Hypalon" 4C	3	1	1	2	24	3	9	3
Natural Rubber	23	6	1	1	34	6	12	0
Neoprene GN	17	0	0	2	28	2	9	0
Neoprene W	9	- 1	3	0	11	0	4	11
PVA	0	- 8	- 1	1	9	6	2	0
"Thiokol" FA	2	1	0	0	28	4	8	0
"Viton" A	4	10	3	5	26	37	40	21
"Viton B	6	9	4	7	22	28	29	18

Data obtained from E. I. Dupont Co.

The result of the material evaluation was to use 21-6-9 stainless steel for the major disconnect parts (coupling handle was made from aluminum for weight savings). 316L stainless steel meets the design requirements very well, but the higher strength-to-weight characteristic of the 21-6-9 made it the most desirable.

To best meet the sealing material requirements, two sealing materials were selected depending on the system fluid. Ethylene propylene elastomer seals would be used for all fluids except Freon-21, which

TABLE III-5 EFFECT OF "FREON" COMPOUNDS ON PLASTICS AT ROOM TEMPERATURE

	"F-11"		"F-12"		"F-13B1"		"F-21"		"F-22"		"F-112"		"F-113"		"F-114"	
Plastic	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W
"Delrin" acetal resin	0	0	1	2	0	0	-	-	3	2	-	-	0	-1	0	0
Cellulose acetate	0	0	0	13	1	0	D	-	-	-	0	-16	0	0	-	0
Cellulose nitrate	1	-2	0	0	-	-	D	-	-	-	-	-	0	1	-	0
Chlorotrifluoroethylene polymer	0-3	-	2	-	-	-	-	-	1	-	0	0	0	0	-	0
"Lucite" acrylic resin	0	0	0	0	0	0	D	-	D	-	-	-	0	0	1	1-1
"Mylar" polyester film	-	-	-	-	0	-1	-	-	-	-	-	-	-	-	-	-
Nylon ("Zytel" 101)	0	0	0	0	-	-	0	1	1	1	0	0	0	0-5	0	0
Phenol formaldehyde resin	-	-	0	0	-	-	0	0	-	-	0	0	0	0	-	-
Polyethylene	6	1	1	0	3	0	5	1	2	0	-	-	2	1	1	-
Polyethylene, linear	-	-	-	-	1	0	-	-	1	0	4	13	2	9	-	-
Polypropylene	-	-	-	-	1.9	1.4	-	-	-	-	-	-	-	-	-	-
Polystyrene	D	-	0	2	-	-	D	-	-	-	D	-	0	0	-	-
Polyvinyl alcohol	0-3	0	-1	0	1	-5	13	5	-	-	-	-	0	0	-	-
Polyvinyl chloride	0	10	0	0	0	-3	15	10	-	-	-	-	0	0	-	-
Polyvinylidene chloride	0-3	0	0	0	2	0	1	1	4	-	-	-	0	0	-	-
"Teflon" TFE Fluorocarbon resin	0	0	0	3	2	1	0	0	1	0	0	-	0	0	-	-

S = Maximum percent linear swell when submerged in liquid phase
D = disintegrated
W = percent increase in weight after drying in air for about two weeks
- = not tested

Data obtained from E. I. Dupont Co.

would require TFE Teflon seals. The elastomer maintains its elastic properties better than Teflon and therefore should be used where fluid compatibility allows.

3. Fluid Isolation - Four general methods of fluid isolation were selected as being most feasible and subjected to a tradeoff analysis as shown in Table III-6.

a. The first concept is "individually operated conical poppets". This concept utilizes system pressure to add to the sealing force which is beneficial. Since the poppets are operated independently, this fluid isolation method eliminates design complexities and does not require highly critical dimensioning and machining.

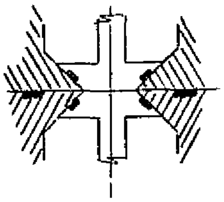
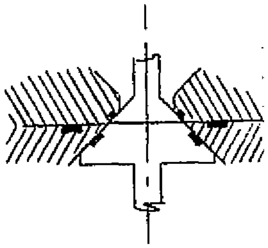
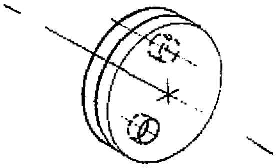
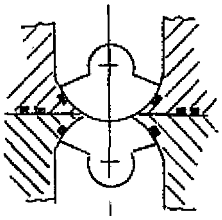
b. The second concept is "conical poppets with tandem drive". This concept requires a tool that operates both poppets simutaneously. With both poppets moving together, a requirement for extremely close tolerances exists adding to fabrication difficulties. Also, one of the tandem poppets will be closing with system pressure and one against.

c. The third method is a pair of "rotating flat discs" with a passage hole offset from the centerline of the disc. As the discs are rotated the passage holes line up and permit system flow, further rotation provides for passage hole misalignment and fluid isolation. Several disadvantages exist with this technique. First, overall size will be comparatively large due to the off-center flow path. Spillage, although minimal, will exist upon disengagement due to the volume of the passage hole in the last disc. Problems are inherent in the indexing of one disc to the other and in fabricating the somewhat critical toleranced parts.

d. The last method is the "rotating spheres" concept. This concept is simply a pair of interconnecting spheres with matching housings. Partial sequential rotation of the spheres opens the fluid lines or closes as desired. For proper operation, critical dimensioning is required.

From Table III-6 it is evident that the "individually operated conical poppets" and the "rotating spheres" concepts are the most promising. The "individually operated conical poppets" for its positive straight forward approach, and the "rotating spheres" concept for its simplicity.

TABLE III-6 FLUID ISOLATION TECHNIQUES

DESIGNATION	SKETCH	DRIVE MECHANISM				TRADEOFF FACTORS						
		GEAR	CAM	BELLOWS	DIRECT	INTERFACE SPILLAGE	FLUID COMPRES-SION	STAGNANT AREAS	SEPARATION LATERAL MOVEMENT	METAL TO METAL CON-TACT	ISOLATION FUNCTIONS LOCATION	WEAR
1. Conical Poppets - Individual Drive (Preliminary Design Selection)		Yes	Yes	Yes	No	Seal Bypass Design	Possible Unless Bypass Design is Used	Behind Poppet	Separation Plane Face Seal	None	One Side	No Effect
2. Conical Poppets - Tandem Drive		Yes	Yes	Yes	No	No Interface Exposure	None, Due to Tandem Action	Behind Poppet	Separation Plane Face Seal	None	One Side	No Effect
3. Rotating Discs		Yes	No	No	No	Thickness of Discs X Hole Dia.	None, Due to Shear Closure	Disc Area	Separation Plane Face Seal	Possible Disc Face Sliding on Seal Failure	One Side Unless Manual -180°	Face Wear When Operating
4. Rotating Spheres (Preliminary Design Selection)		No	No	No	Yes	Residual @ Interface	None, Due to Shear	Behind Poppet	Sphere Interlock Volume	Sliding Spheres	One Side	

FOLDOUT FRAME

ADEOFF FACTORS					
SEPARATION LATERAL MOVEMENT	METAL TO METAL CONTACT	ISOLATION FUNCTIONS LOCATION	WEAR FACTOR	EFFORT TO OPERATE	DESIGN COMMENTS
Separation Plane Face Seal	None	One Side	No Effect	Moderate/Low with CAM	1. Pressure helps seal poppets. 2. Separate drive mechanisms. 3. Poppet seal must provide for fluid bypass on seat closure. 4. Dimensions moderately critical.
Separation Plane Face Seal	None	One Side	No Effect	Moderate/Low with CAM	1. Pressure assists poppet seal on one side only, other side must assure positive seal. 2. Tandem drive mechanism. 3. Dimensioning moderately critical.
Separation Plane Face Seal	Possible Disc Face Sliding on Seal Failure	One Side Unless Manual -180°	Face Wear When Operating @ Pressure	Very High Under High Pressure	1. Disc face seal design complicated. 2. Overall size large due to two ports and 3.14 radians (180°) movement. 3. Drive mechanism becomes gear if operated on one side. 4. Dimensioning very critical.
Sphere Interlock Volume	Sliding Spheres	One Side	Bearing Wear	Moderate Until Bearings Wear	1. Sequential operation. 2. Must provide lateral movement to separate. 3. Dimensioning very critical.

4. Isolation Drive mechanisms - Four techniques for mechanically driving the fluid isolation member of the disconnect were selected as being most feasible and subjected to a tradeoff analysis as shown in Table III-7.

a. Gear - A gear arrangement can provide the driving force in applications where the tool attach point is offset from the sealing member's pivot point. This arrangement could be used for the "rotating spheres" concept with a pair of spur gears; for the "rotating discs" concept with spur and ring gear arrangement; and for the "poppet" concepts with a rack and pinion arrangement. A problem of indexing and inherent backlash plus comparative complexity, are the major drawbacks of this drive method.

b. Cam - An eccentric cam drive can be utilized for the "sliding poppet" concepts. The amount of eccentricity determines the amount of poppet movement.

c. Bellows - This method is unique in that a bellows is used in combination with a threaded coupling sleeve to open and close a series of concentric poppets. The one operation couples disconnect halves and opens poppets.

d. Direct - This method would apply to the "rotating sphere" concept where the valve stem shaft centerline coincides with the point of rotation of the sealing member.

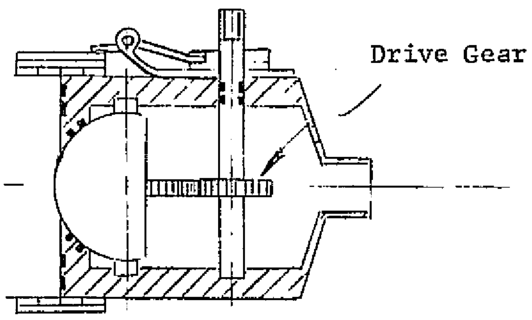
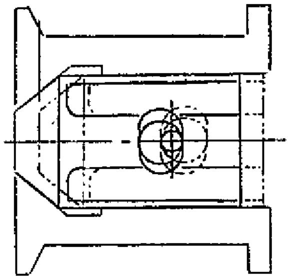
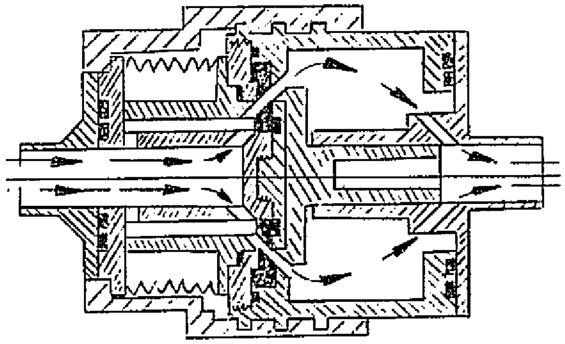
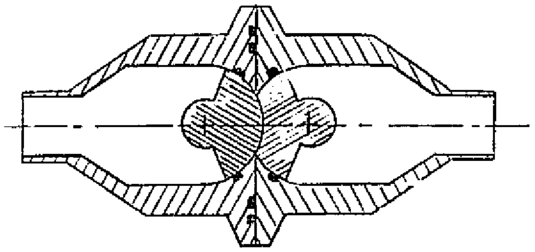
From Table III-7, the two most promising techniques are the "cam" and "direct" method due to their positive and relatively simple arrangement.

5. Sealing Techniques - Four areas in the disconnect requiring seals are examined in Table III-8. Factors such as wear, scuffing during installation, susceptibility to blowout and redundancy methods are evaluated.

a. Shaft Stem - The optimum method of sealing around the shaft stem is to machine a standard gland around the stem and insert an elastomer or Omniseal. Redundancy is accomplished by adding a second seal of the same configuration as the first.

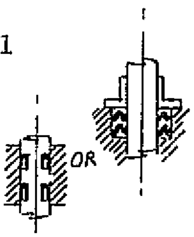
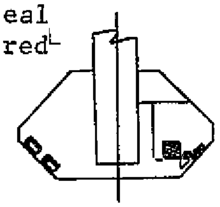
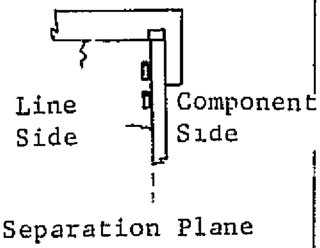
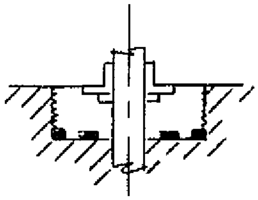
b. Poppet Face - Several seal types can be applied to the poppet. A dovetail groove with an O-ring is one approach, but is susceptible to seal blowout unless vent holes are added to relieve

TABLE III-7 ISOLATION DRIVE MECHANISMS

DESIGNATION	SKETCH	TRADEOFF FACTORS				
		FORCE/ TORQUE APPLICATION	SUSCEPTIBILITY TO WEAR/CONTAMINATION	TRAVEL REQ TO OPEN/ CLOSE DISCONNECT	TOOLS REQ	SUSCEPTIBILITY TO OVER-TORQUE
1. GEAR		Minimal rotation of valve stem	Gear tooth wear, contamination of gears	Gear rotation translates to linear poppet motion, ratios can be designed to minimize rotation req.	No special tool req., shaft rotation only	Possible unless stops are incorporated in design
2. CAM (PRELIMINARY DESIGN SELECTION)		Rotation of valve stem applies force thru eccentric cam	Cam wear	180° cam rotation equates to 4.76 mm (3/16 in.) linear poppet travel	No special tool req., shaft rotation only	Minimal
3. BELLOWS		Torque applied to bellows collar	Collar threads, poppet housing threads	Collar rotation translates to poppet linear motion thru bellows attached to collar sleeve	Wrench to rotate collar	Possible due to moment arm of tool over sleeve
4. DIRECT (PRELIMINARY DESIGN SELECTION)		Valve stem rotation directly transferred to poppet rotation	Wear on poppet faces possible	90° rotation required of both poppets	Shaft rotation only	Possible in open position, poppets/inside disconnect wall interference can occur

EOFF FACTORS				
TOOLS REQ	SUSCEPTIBILITY TO OVER-TORQUE	ACCESS REQ. TO OPERATE	STATUS (OPEN/CLOSED) INDICATOR	DESIGN COMMENTS
No special tool req., shaft rotation only	Possible unless stops are incorporated in design	Access to poppet stem only	Can be incorporated into tool motion (e.g., 90^{o}, 180^{o} or 360^{o})	1. Gears must accommodate required force/torque without slippage, misalignment 2. Useful for sliding poppet or rotating discs concepts
No special tool req., shaft rotation only	Minimal	Access to poppet stem only	Cam displacement of 180^{o} can be used as a guide (tool handle rotation)	1. Design must limit cam travel at each end 2. Can be utilized with any sliding poppet concept
Wrench to rotate collar	Possible due to moment arm of tool over sleeve	Tool access req. in plane perpendicular to flow line	Stops incorporated into bellows travel(?)	1. Collar linear travel must be restricted or marked clearly to prevent poppet over-travel 2. Bellows design must minimize collar travel without poppet travel 3. Can be used with individual or tandem poppets
Shaft rotation only	Possible in open position, poppets/inside disconnect wall interference can occur	Access to poppet stem only or 180^{o} in plane perpendicular to flowline in case of rotating disc	Means to assure proper poppet configuration req.	1. Force/torque required to rotate poppets must be applied at stem 2. Means to identify poppet position must be provided

TABLE III-8 SEALING TECHNIQUES

SEAL LOCATION	TYPE/SKETCH	TRADEOFF FACTORS					
		SCOURING DURING INSTALLATION	WEAR DURING OPERATION	MAINTAIN ELASTICITY	SUSCEPTIBILITY TO BLOW-OUT	RETENTION DURING SEPARATION	REDUNDANCY
1. Shaft Stem	O-Ring* Lip-Seal Packing Seal  	Seals in Stem Allow Easier Installation	Minimum with Stem O-Ring (Omni), Packing Seals Susceptible to Wear	Packing of Chevron Seals Reduces Elasticity, Omniseals Best	Minimal for this Application - All Seals	For Maintenance, Seals on Stem Easier to Replace, Packing Seals are Loosened when Stem is Removed	Seals Should be Separated Vertically
2. Poppet Face	O-Ring* Lip-Seal Captured Seal 	Minimal Since Poppet Face is Accessible	O- Ring sees Shear Forces During Closure, Lip Seal Exposed Only at Edge-elastic Situation	Lip Seal Requires Backing Ring, O- Ring Should use Omni Configuration	Retaining Groove Not Satisfactory for Omni-Seal, Lip Seal Retained by Plate	Retaining Plate Required for Lip Seal, Omniseal Cannot be Retained by Dovetail Groove	Two O- Rings Separated Along Face, Lip Seal with Metallic Seal a
3. Disconnect Separation Plane	O-Ring* Face Seal  	Minimal, Disconnect Face Accessible	Compression Only (Face-to-Face), Wear Minimal, Dog Design Prevents Shear During Separation	Omni Design Aids Elasticity	Groove Design Should Preclude Blowout - Vent Holes Could be Added if Blowout is a Problem	Groove Design Should Assure Seal Retention, Special Omniseal with Retaining Leg Available	Double Ring of Seals Provides Redundancy
4. Internal Mated Surfaces Stem Housing to Disconnect Body Poppet Housing to Disconnect Body	O-Ring "Boss" seal* 	Seals Should be Placed on Removable, Not in Disconnect Body, to Minimize Installation Scouring	None, Assembly/Maintenance Function Only	Static Seal, O- Ring Design, Mat'l Choice Should Optimize Elasticity	None - Surfaces Mated During Disconnect Operation	Groove Design Assures Retention, Easier Access/Visibility if Seals are on Removed Part	Double Seals Utilized for each Application

*Preliminary Design Selection

FOLDOUT FRAME |

OFF FACTORS					
TO BLOW-OUT	RETENTION DURING SEPARATION	REDUNDANCY METHODS	SUSCEPTIBILITY TO CONTAMINATION	SCOURING DURING IN SERVICE MAINTENANCE	DESIGN COMMENTS
Seals	For Maintenance, Seals on Stem Easier to Replace, Packing Seals are Loosened when Stem is Removed	Seals Should be Separated Vertically	Teflon Best for Anticipated Fluids	Minimum with Stem O-Ring	1. Seal groove easier to machine on stem, also allows easier installation. 2. Packing (Chevron) seals must be tightened down to provide seal, thus increasing torque required to turn stem. 3. Packing seals result in bulkier design.
Seal, Lip Seal Retained by Plate	Retaining Plate Required for Lip Seal, Omniseal Cannot be Retained by Dovetail Groove	Two O- Rings Separated Along Face, Lip Seal with Metallic Seal at Edge Provides Redundancy	Teflon Optimum, O-Ring Method Exposes More Seal Surfaces to Contaminating Fluids	Minimal, Face Accessible	1. Seals placed on poppet face rather than on disconnect inner body surfaces to facilitate fabrication and maintenance. 2. Lip seal design incorporates retaining plate over teflon seal/backing ring. Edge of teflon seal follows poppet contour (along side) and allows fluid escape during closure until metallic seal provides final surface contact and positive seal. (Metallic seal extends beyond teflon seal to forward edge of poppet face.)
Holes Could be Added if Blowout is a Problem	Groove Design Should Assure Seal Retention, Special Omniseal with Retaining Leg Available	Double Ring of Seals Provides Redundancy	Choice of Material Should Minimize Problem	Minimal, Disconnect Face Accessible	1. Component-side disconnect flange slips beyond dog on line-side disconnect. Clamping technique pulls dog down on flange, providing seal. 2. Design allows clearance past line-side seals, preventing damaging during separation/connection.
Operation	Groove Design Assures Retention, Easier Access/Visibility if Seals are on Removed Part	Double Seals Utilized for each Application	Minimal, Material Choice Should be Optimized	Minimum for Design Using Seals on Removed Piece, Instead of Within Body	1. Seals should be placed on removable (male) piece, to facilitate fabrication/maintenance.

the pressure differential. A lip-seal can be used as long as a backup spring is incorporated to add elasticity to the seal. To eliminate seal blowout, a captured seal design can be utilized. The recommended methods are the captured seal and the O-ring in the dovetail groove. Due to the limited seal-seat area, the redundant seal in all cases will be the metal-to-metal (poppet against seat).

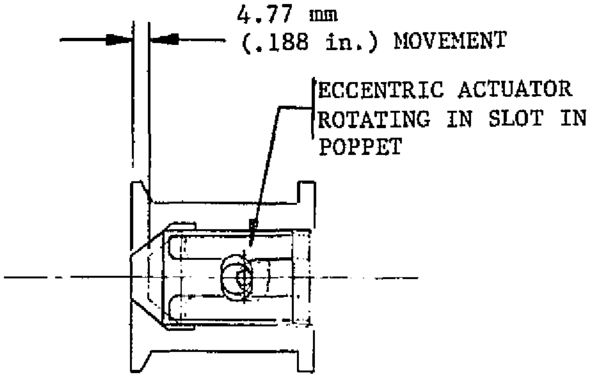
c. Disconnect Separation Plane - Two types of seals can be employed in the separation plane: O-rings and Omniseals. O-rings are retained by the use of dovetail grooves. Omniseals will require a special retention method consisting of a groove on the outer side of the seal gland that allows the Omniseal to deform under pressure to the shape of the groove and retain that shape and position when pressure is released.

d. Internal Mated Surfaces - Standard seal glands will be used where possible with O-rings and Omniseals. To seal mating threaded parts, the boss seal and gland per MS 33649 is used.

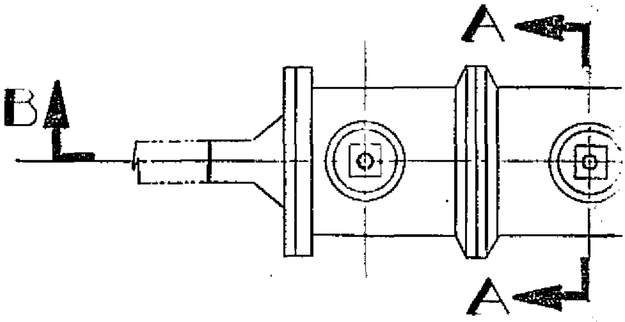
6. Body Design Concepts - Several body designs were evaluated for overall size and weight, lateral movement required during coupling/uncoupling, and access requirements.

a. Individually Operated Opposing Poppet Design Concept - This concept shown in Figure III-1, utilizes cam-driven individually operated poppet disconnects. The poppets utilize the internal bore of the disconnect body as the poppet guide. The poppets have grooves along their outside diameter for fluid passage. The main body of each disconnect half is 53.8 mm (2.12 inches) in length and 57.1 mm (2.25 inches) in diameter with less than 1.27 mm (.050 inches) lateral movement for uncoupling. Opening and closing operations are performed on one side. Coupling/uncoupling mechanism may or may not be operated on the same side as the valve stems depending on type of latching mechanism incorporated.

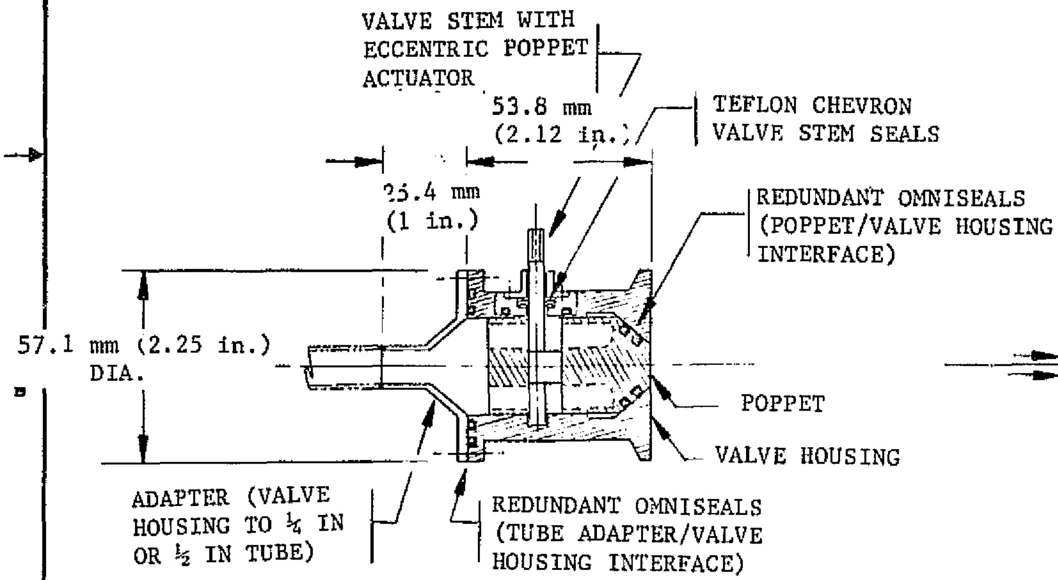
b. Tandem Poppet Concept - This concept, as shown in Figure III-2, requires both poppets to move simultaneously. This type of operation prevents the possibility of hydraulic lockup when poppets come in contact with the seal seats. The configuration shown utilizes the bayonet type coupling mechanism which allows poppet operation and latching operation to be performed on the same access side. The lateral movement required for removal is 1.27 mm (.050 inches). Overall length for a disconnect half of this design is 79.2 mm (3.12 inches) with a height of 57.1 mm (2.25 inches).



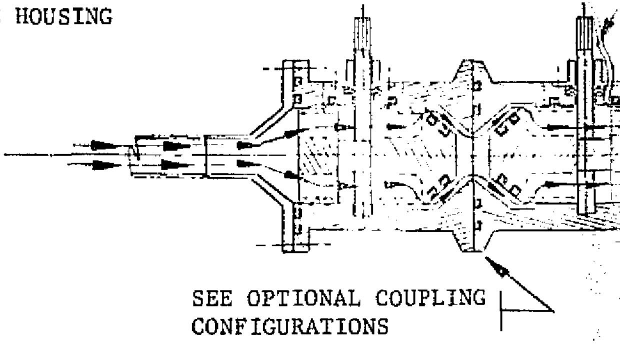
POPPET MOVEMENT



POSITIVE ISOLATION DISCONNECT ASSEMBLY
(COUPLING V-CLAMP NOT SHO



DISCONNECT HALF SEPARATED AND CLOSED

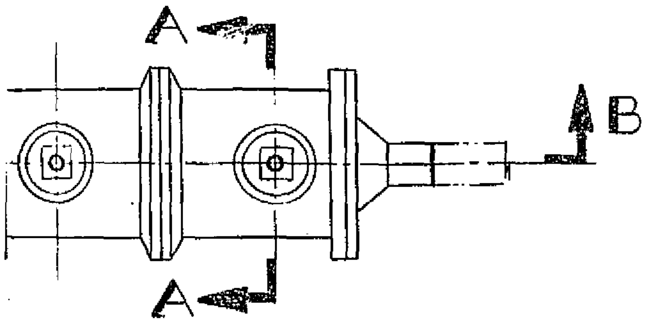


SECTION

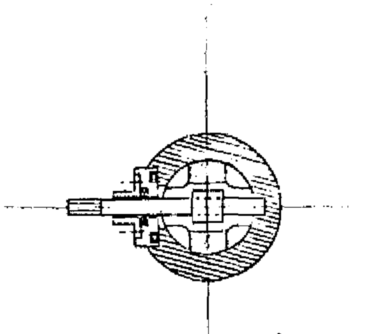
DISCONNECT HALVES CONNE
AND OPEN

FOLDOUT FRAME

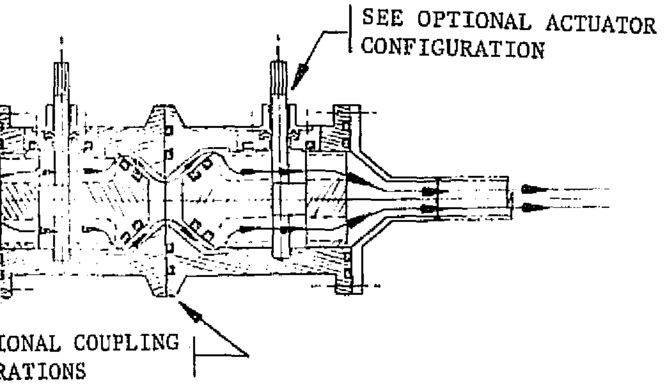
REVISIONS				
SYM.	ZONE	DESCRIPTION	DATE	APPROVED



ITIVE ISOLATION
CONNECT ASSEMBLY
UPLING V-CLAMP NOT SHOWN)

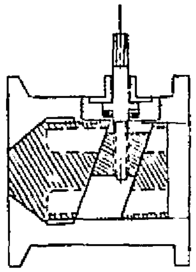


SECTION A-A



SECTION B-B

DISCONNECT HALVES CONNECTED
AND OPEN



THE END OF THE VALVE STEM IS THREADED INTO A PLUG SLIDING IN THE POPPET AND IS OFF-AXIS FROM THE CENTERLINE OF THE VALVE STEM. TURNING OF THE VALVE STEM PULLS OR PUSHES THE PLUG THEREBY PROVIDING THE REQUIRED MOTION FOR OPENING AND CLOSING OF THE POPPET.

OPTIONAL ACTUATOR CONFIGURATION

FIGURE III-1

BASIC POSITIVE ISOLATION

DISCONNECT ASSEMBLY

FOLDOUT FRAME 2

SIZE	CODE IDENT NO	
D	04236	
SCALE		SHEET

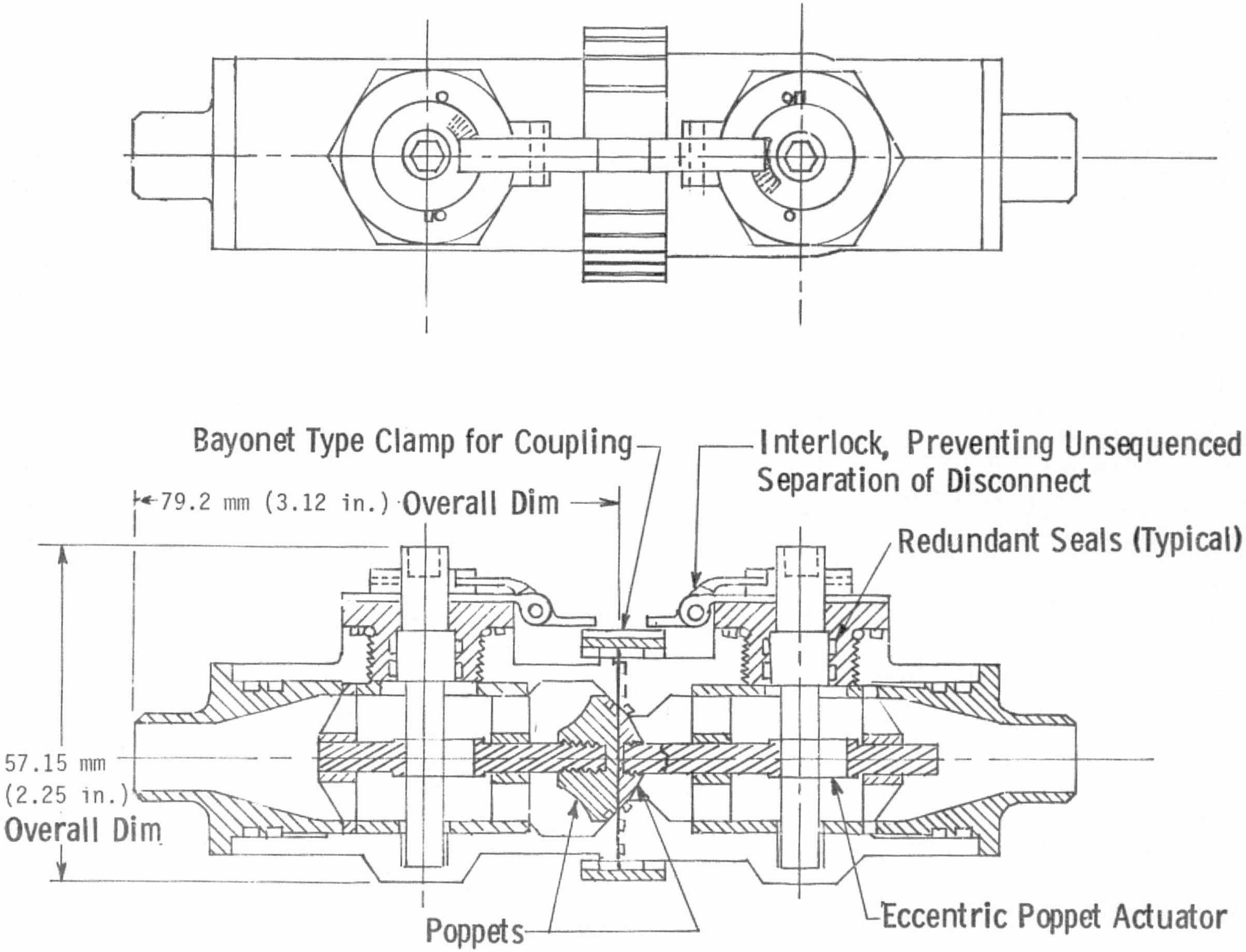


FIGURE III-2 TANDEM CONICAL POPPET CONCEPT

c. Opposing Poppet Concept - This concept, as shown in Figure III-3, is a combination of the designs in Figures III-1 and III-2. This design has individually operated poppets with the internal design and latching techniques of the tandem poppet concept. Overall size and required access are also the same.

d. Interconnecting Spheres Concept - This concept, as shown in Figure III-4, uses a two-ball valve adjacent to each other. Each ball has a shallow spherical indent to facilitate ball rotation and zero leakage upon disengagement. Valve stem shafts are offset .78 radians (45 degrees) with the centerline of the disconnect to allow space for a coupling mechanism. A rotation of 3.14 radians (180 degrees) is required for complete opening or closure of the disconnect to flow. The design provides for minimum pressure loss due to its straight through flow path design. The units are comparatively light with a small envelope volume with an overall length of 82.6 mm (3.25 in.) and a height of 47.8 mm (1.88 in.). Lateral movement required for coupling/uncoupling is 1.9 mm (.075 in.). All operations can be performed on one side, depending on type of coupling mechanism incorporated.

e. Bellows Concept - This concept, shown in Figure III-5, is unique in that a metal bellows is used in the disconnect design. A threaded sleeve couples the two disconnect halves together and the coupling motion also opens the "normally closed" poppets. The overall size of this design is 114.3 mm (4.5 in.) long with a diameter of 69.8 mm (2.75 in.). The lateral movement for coupling/uncoupling is comparatively large at 9.[illegible] mm (.375 in.). Since the unit is operated by rotating the thre[illegible] sleeve, enough access is required for that type of mot[illegible] Also, the design incorporates a spring poppet actuator which is not per the design requirements.

7. Coupling Concepts - Several coupling techniques were evaluated. Tradeoff criteria included crew operations required, ease of operation, access requirements, tools required and wear. A summary of the major concepts and comparisons is shown in Table III-9.

a. V-Band Coupler - There are several commercially available V-band type couplers. Both disconnect halves would require a machined flange to match the V-band. The band is tightened by an adjacent stud-nut at the break of the band. Coupling/uncoupling may be time consuming and require comparatively more access than other concepts.

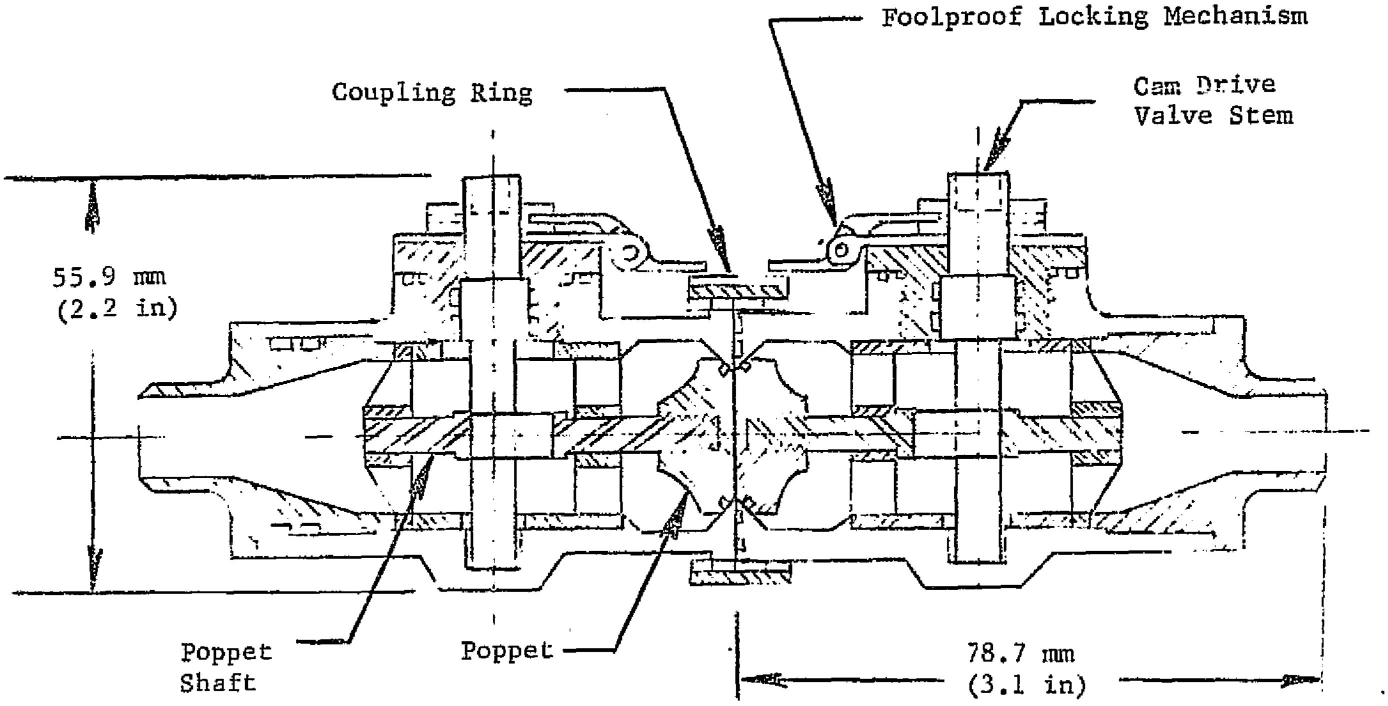


FIGURE III-3 OPPOSING POPPETS CONCEPT
(Preliminary Design Selection)

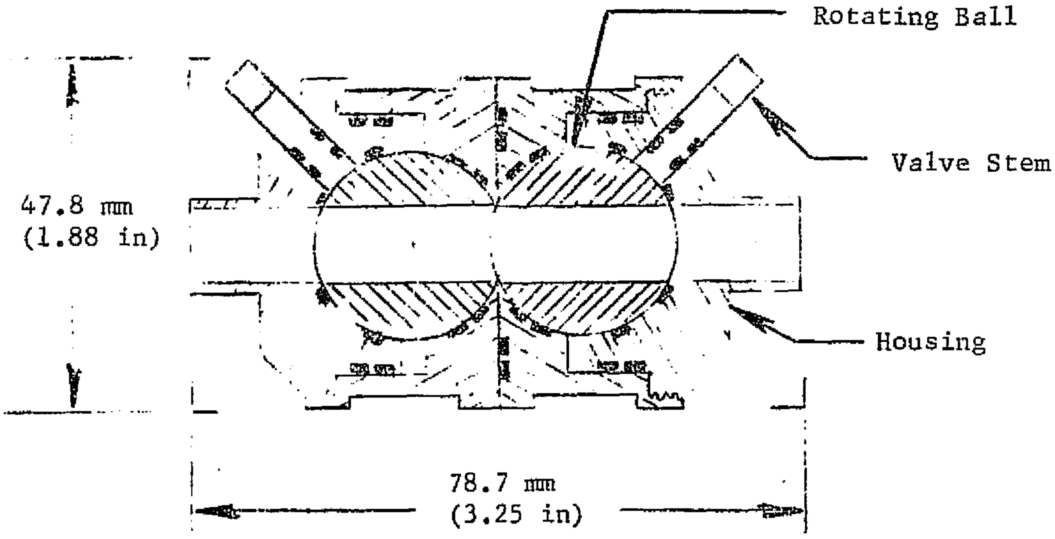
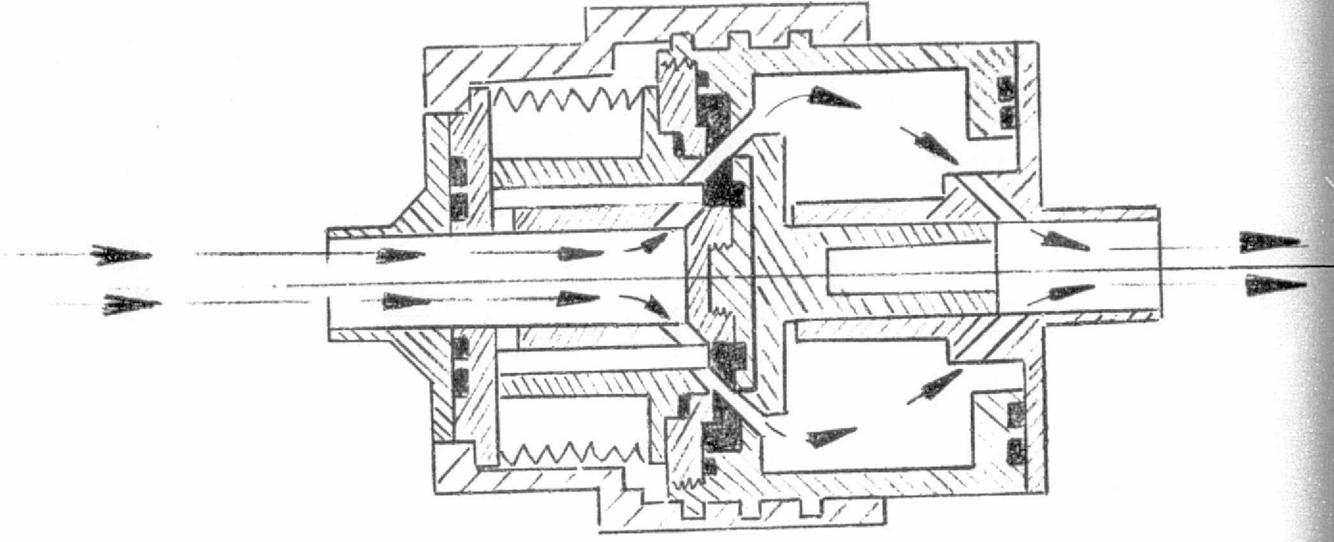
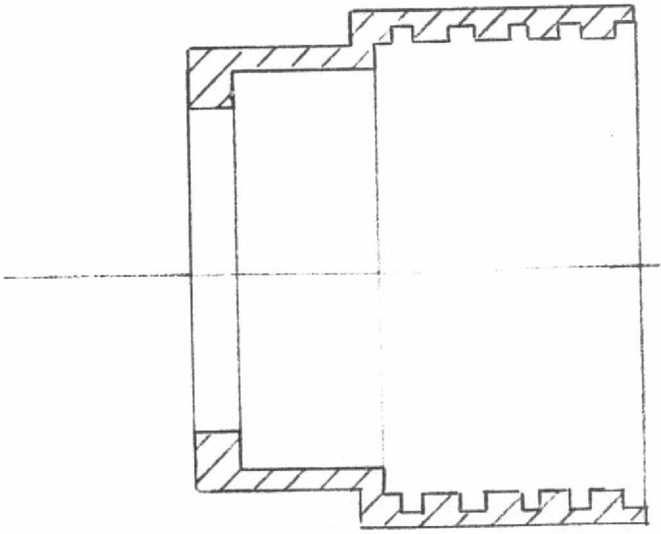


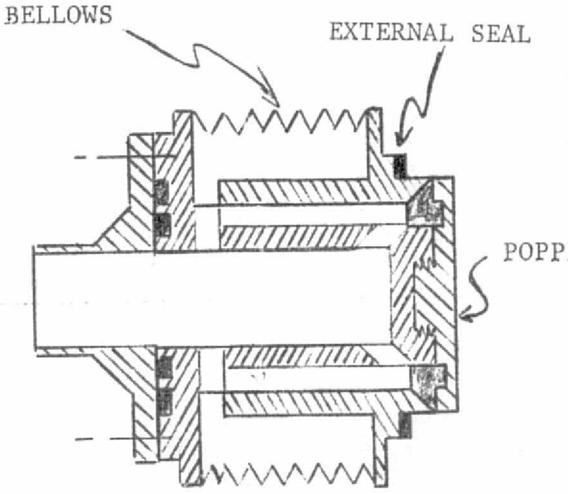
FIGURE III-4 INTERCONNECTING SPHERES CONCEPT
(Preliminary Design Selection)



FLUID FLOW PATH WHEN CONNECTED



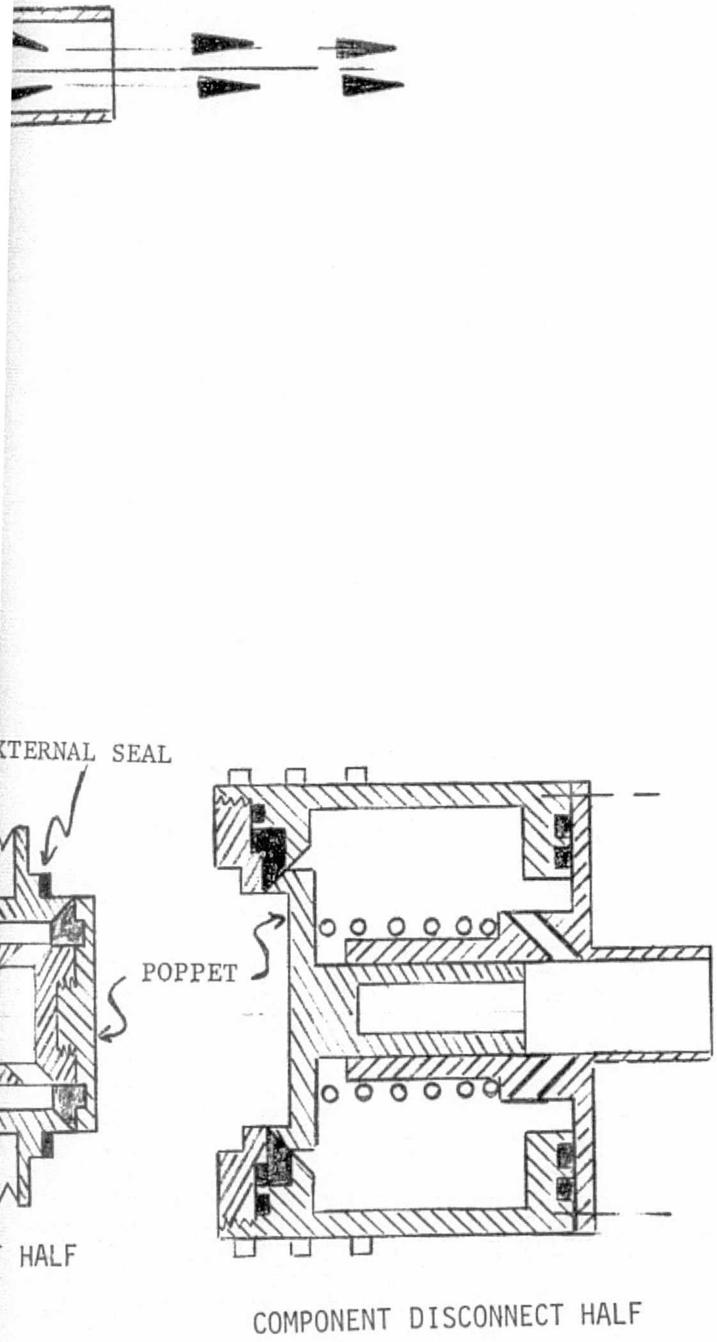
COUPLING SLEEVE



LINE DISCONNECT HALF

CO

FOLDOUT FRAME 1



COUPLING SEQUENCE:

1. COUPLING SLEEVE SLIPS OVER LINE DISC. HALF AND BEGINS BEING THREADED ONTO COMPONENT DISC. HALF.
2. FURTHER THREADING RESULTS IN EXTERNAL SEAL SEATING.
3. STILL FURTHER THREADING RESULTS IN POPPET MOVEMENT AND OPEN FLOW.

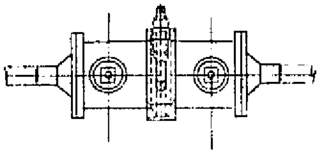
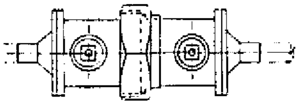
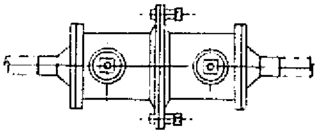
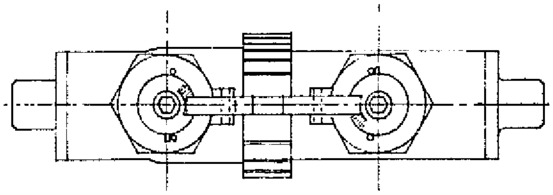
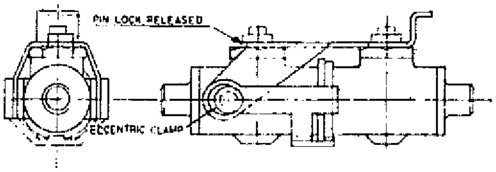
UNCOUPLING SEQUENCE:

OPPOSITE ROTATION SEALS POPPETS AND ISOLATES FLOW, FURTHER ROTATION UNSEATS EXTERNAL SEAL

SINGLE OPERATION CONCEPT THAT CLAMPS DISCONNECT HALVES TOGETHER AND OPENS POPPETS

FIGURE III-5 BELLOWS CONCEPT

TABLE III-9 COUPLING TECHNIQUES

DESIGNATION	CONCEPT SKETCH	TRADEOFF FACTO				
		Effect on Connection Line	Crew Operations Required	Ease of Unlocking/ Locking	Access Required	Tool Required
1. V-BAND COUPLER		No Twist	Minimal, One Operation to Separate	Two-Handed Operation to Lock, Unlocking Simple	Single Side, Tool Access to Clamp Nut	Wrench, Rachet
2. COUPLING NUT		Twisting Torque	Minimal, Single Operation	Alignment to Start Thread may be Critical, Unlocking Simple.	Single Side, Tool Applied Perpendicular to Flow Line	Wrench
3. FLANGE W/CAPTIVE FASTENERS		No Twist	Several Operations, Depending on Number of Fasteners	Simple, Repetitious Functions	Circumference of Disconnect	Wrench, Rachet
4. BAYONET		Twisting Torque	Single Operating, Short Action Coupler	Short Rotational Motion, Thread Engagement Critical	Single Side, Accommodate Small Rotation	Wrench
5. INTEGRAL POSITIVE ISOLATION COUPLING MECHANISM (PRELIMINARY DESIGN SELECTION)		No Twist	Hand-Operated Lever, Single Operation	Simple, Keying can aid Alignment	Clearance for Lever Action	None (for Coupling/ Uncoupling)

	TRADEOFF FACTORS					
	Access Required	Tool Required	Wear During Cycling	Ease of Incorporating Fool-Proofing	Lube Required for Multi-Use	DESIGN COMMENTS
Unlocking Simple	Single Side, Tool Access to Clamp Nut	Wrench, Rachet	V-Band Face	Cover Plate over Coupler	Lube needed on Wedge	1. Disconnect Faces Symmetrical 2. No Unique Machining Required
Critical, Unlocking Simple.	Single Side, Tool Applied Perpendicular to Flow Line	Wrench	Thread Wear, Step Wear	Same as Above	Thread Lube	1. Disconnect Halves Unsymmetrical 2. Machining of Nut Seat and Disconnect-Side Threads Required 3. If Access Restricted, Tool Action may be Limited 4. Threads Poor for Multi-Cycle Use 5. Retaining Nut is Difficult
	Circumference of Disconnect	Wrench, Rachet	Fastener Wear	Same as Above	Replace Bolts Periodically	1. Matching Flanges 2. Overall Flange Size Large to Accommodate Fasteners 3. Rotational Alignment Critical 4. Concept Bulky, Slow 5. Access to Entire Circumference of Disconnect Required
Engagement Critical	Single Side, Accommodate Small Rotation	Wrench	Thread Wear	Lever/Ramp Interlocks with Bayonet Ring	Lube on Dogs	1. Machining of Nut Seat and Disconnect-Side Threads Required 2. Disconnect Halves Unsymmetrical 3. Can Accommodate Limited Access Situations 4. Design to Retain Nut
	Clearance for Lever Action	None (for Coupling/Uncoupling)	Eccentric Cam Wear	Coupler Keyed to Poppet Stems	Self-Lube (Filled Teflon) Bearings	1. Dimensioning Critical for Proper Seat 2. Disconnect Half Slides Out only in one Direction 3. Spring-Loaded Poppet Stem Prevents Turning While Handle is Released (Valve Open) 4. Alignment of Handle over Poppet Stem is Critical - can be keyed

b. Coupling Nut - A coupling nut of the AN 818 type can be used. This would require a flanged disconnect half at the separation plane to retain the nut. The opposite half would be threaded to accept the coupling nut. Several turns of the coupling nut would be required for complete engagement/disengagement thereby resulting in a time consuming task. Also, enough access must be provided for the nut-turning operation.

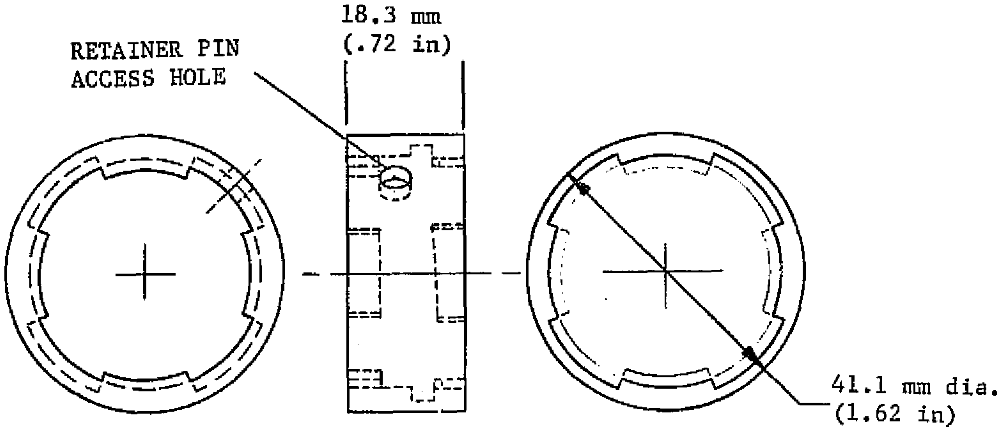
c. Flange with Captive Fasteners - This concept requires access completely around the disconnect (which is against the design requirements) and very time consuming. It would provide a positive clamping force to maintain proper separation plane sealing. One disconnect half separation plane would have captive screws and the other would have mating threaded holes.

d. Bayonet Coupler - This concept, as shown in Figure III-6, utilizes a coupling ring with tapered notches that is retained on the disconnect half. As both disconnect halves are mated, the coupling ring engages a matching set of tapered tabs on the mating disconnect. A rotation of .78 radians (45 degrees) by the coupling ring provides the clamping force to seal the disconnects at the separation plane.

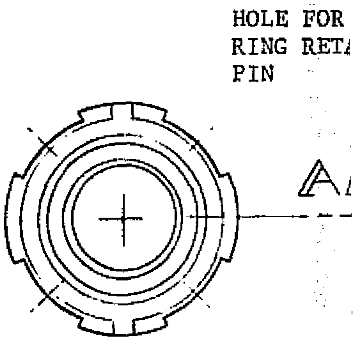
e. Integral Positive Isolation Coupling Mechanism - This concept (shown in Figure III-7) consists of cam actuated clamp fingers that clasp the two disconnect halves together with a force great enough to provide proper sealing between the disconnect halves. The cam is part of the handle that lays across the top of the disconnect units. The clamp fingers consist of a pivot point at one end and a clamp yoke at the other with the center section made up of a tension member. When the handle is positioned flat across the disconnects, the tension member is stretched resulting in the required clamping force. This concept is easy to operate, fast and requires only one-sided access.

8. Tool Concepts - Some of the disconnect concepts require special tools. These tools are evaluated for crew procedures, forces required, and access requirements. A summary of the tools for fluid isolation and coupling and their comparisons are shown in Table III-10.

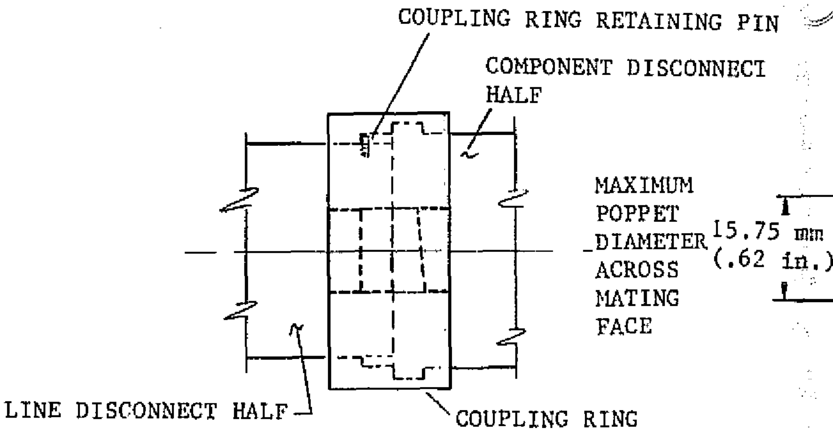
a. Torque Tool with End Adapters - This type of tool (see Figure III-8) can be used to operate the cam-driven poppets and rotating spheres for fluid isolation; and to operate the bolted flange and V-band clamp coupling concepts. Socket and hex head parts will utilize tools of this nature. These tools can be used with limited access and the procedures are straightforward. For development testing an adjustable torque tool would be desirable, while a production unit would be preset.



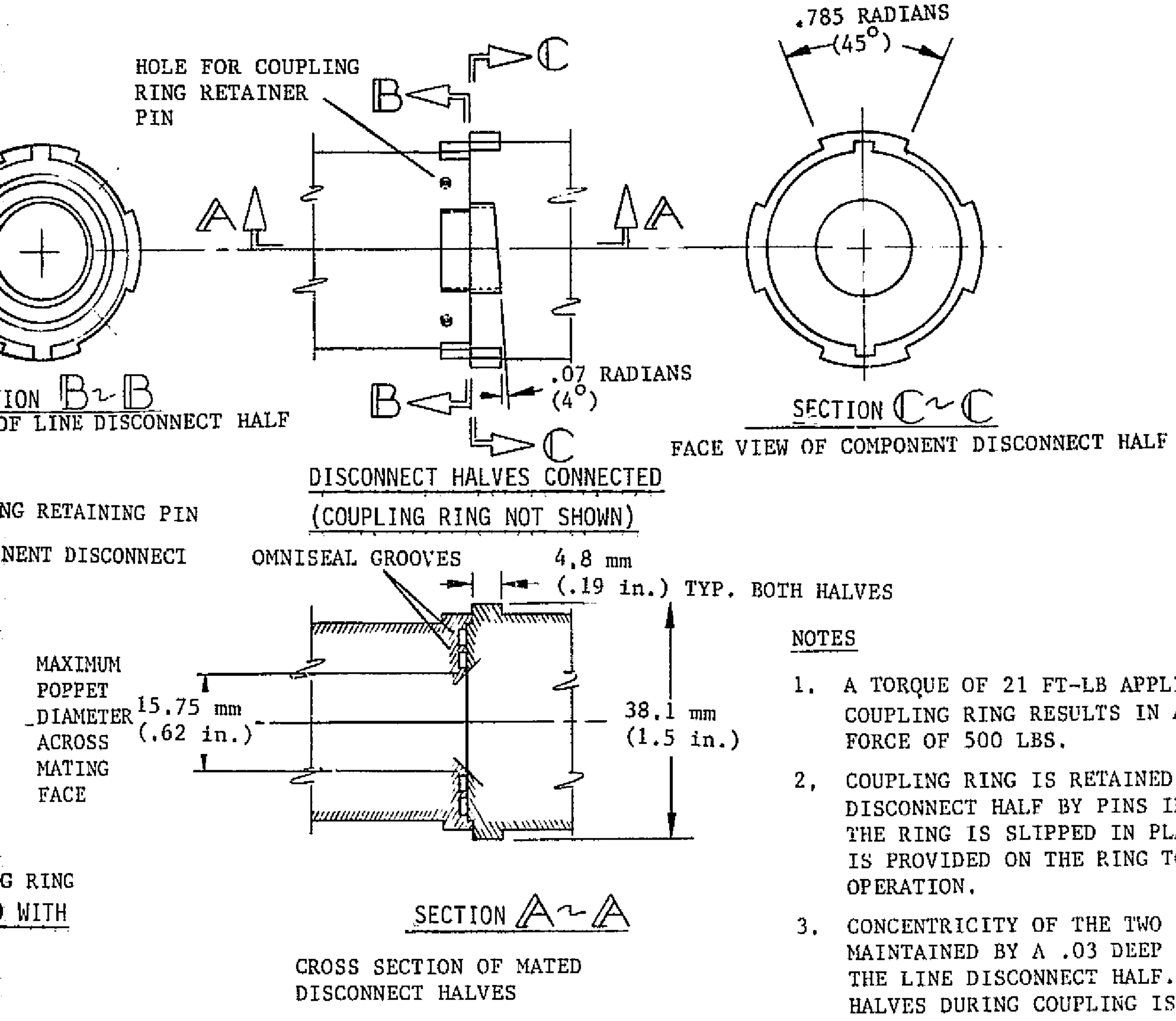
COUPLING RING



SECTION B-B
FACE VIEW OF LINE DISCONNECT H



DISCONNECT HALVES MATED WITH
COUPLING RING IN PLACE



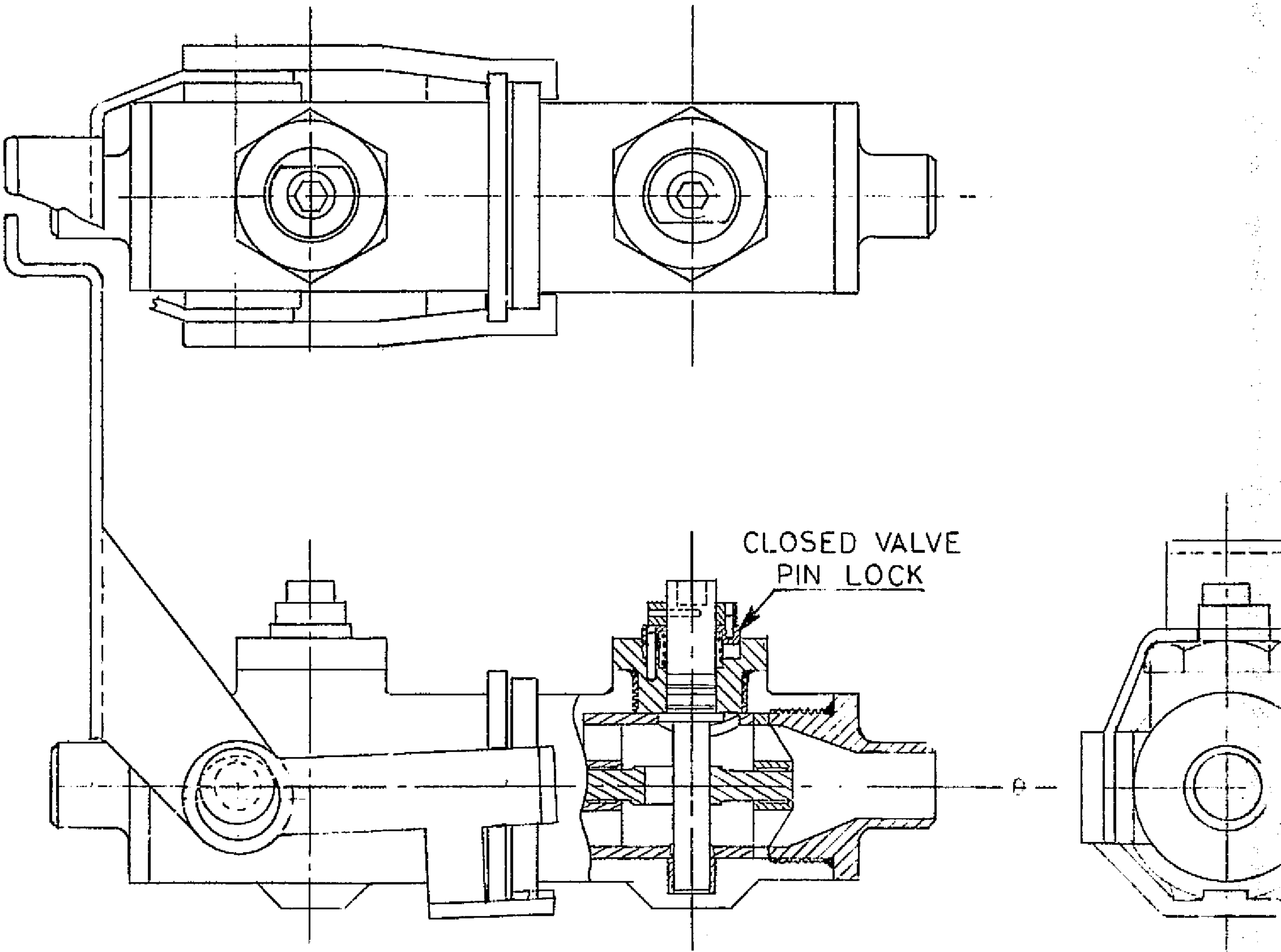
NOTES

1. A TORQUE OF 21 FT-LB APPLIED TO THE COUPLING RING RESULTS IN A CLAMPING FORCE OF 500 LBS.
2. COUPLING RING IS RETAINED ON THE LINE DISCONNECT HALF BY PINS INSTALLED AFTER THE RING IS SLIPPED IN PLACE. AN ACCESS HOLE IS PROVIDED ON THE RING TO FACILITATE THIS OPERATION.
3. CONCENTRICITY OF THE TWO HALVES IS MAINTAINED BY A .03 DEEP COUNTERBORE ON THE LINE DISCONNECT HALF. ROTATION BETWEEN HALVES DURING COUPLING IS PREVENTED BY A COUPLE OF NOTCHES IN THE MATING FACE.

FIGURE III-6

BAYONET COUPLING DETAILS

FOLDOUT FRAME 2



CLOSED VALVES-CLAMP RELEASED

FOLDOUT FRAME

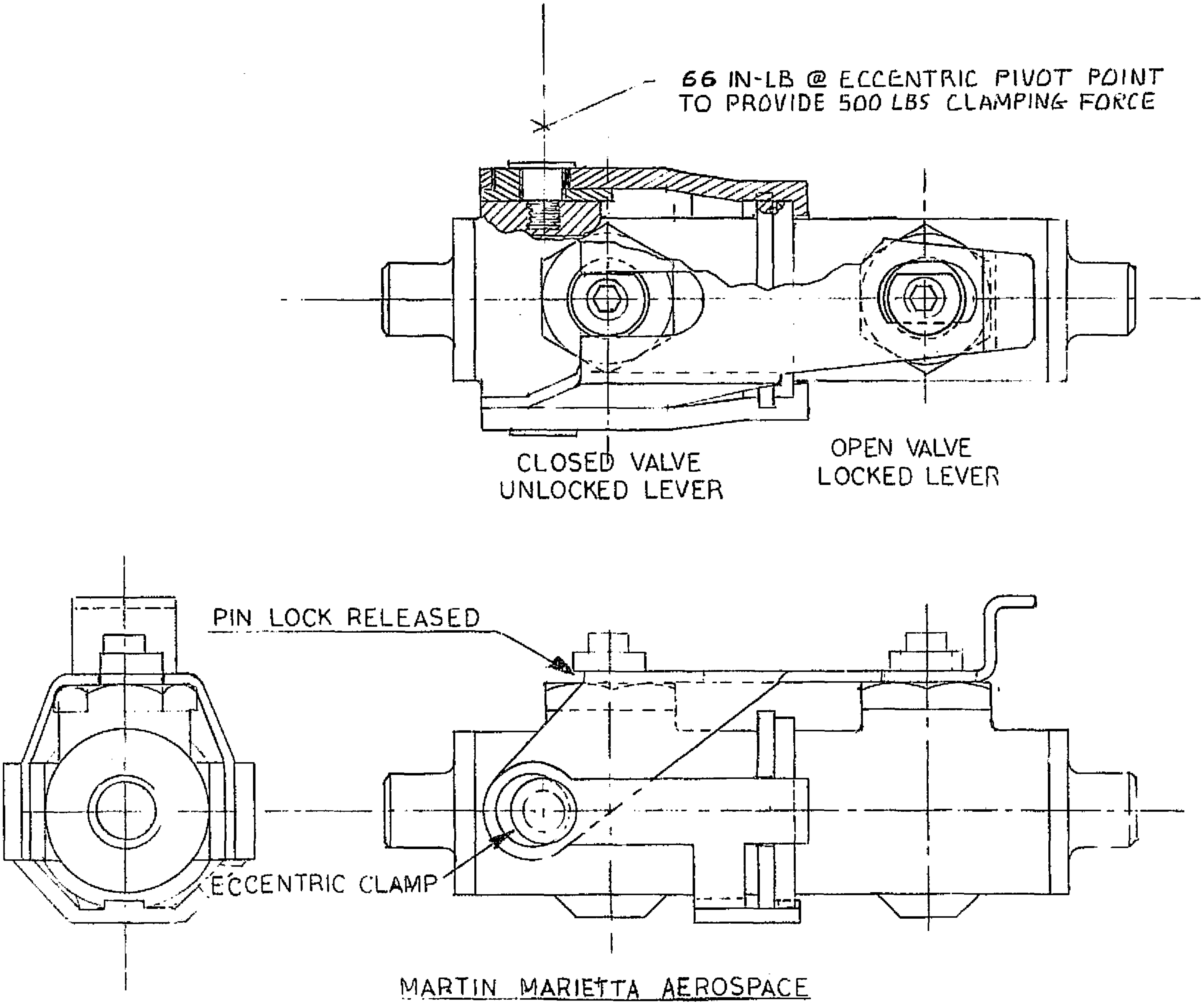
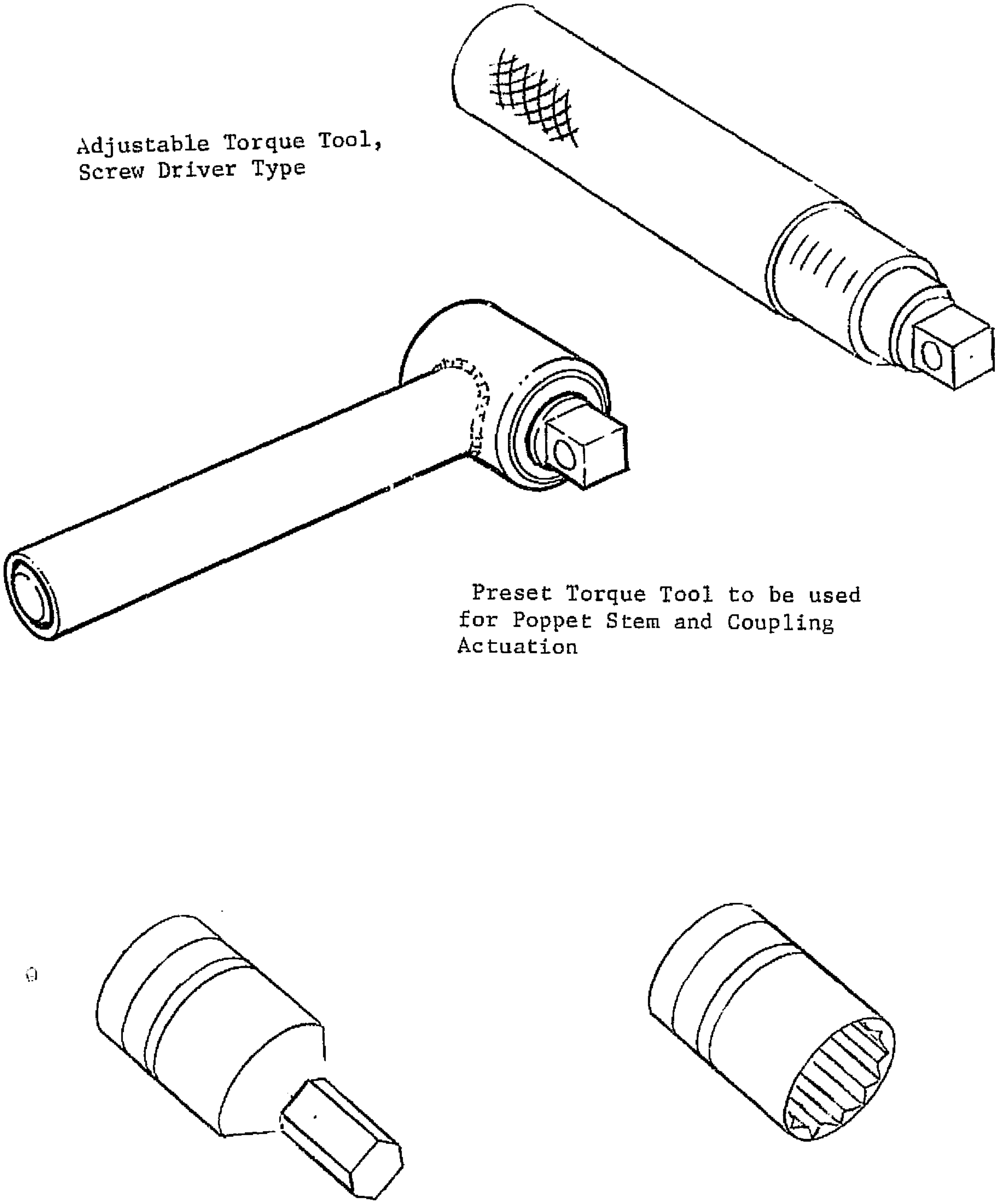


FIGURE III-7 INTEGRAL CLAMPING MECHANISM



Adjustable Torque Tool, Screw Driver Type

Preset Torque Tool to be used for Poppet Stem and Coupling Actuation

End Adapter for Socket Applications

End Adapter for Hex-Type Stems

FIGURE III-8 TORQUE TOOL WITH END ADAPTERS

TABLE III-10 TOOL REQUIREMENTS

TOOL CONCEPT	APPLICABLE TO		TRADEOFF FAC		
	ISOLATION CONCEPT	COUPLING CONCEPT	FORCES/ TORQUES	ACCESS REQUIREMENTS	CREW FUNCTIONS
1. Adjustable Torque Tool (Preliminary Design Selection)	Single Conical Poppet Tandem Conical Poppets Rotating Spheres	Flange/Bolt V-Band Clamp	Applied by Short Handle (e.g., "T"), One-Hand Action Should be Sufficient	Single Hand in Plane Parallel to Flow Line, Except Flange/Bolt-Plane Perpendicular	Conical Poppets-Twist Spheres-Limited Rotation Couplers-Continuous
2. Spanner Wrench	Rotating Discs	Bayonet Nut	Gross Force Application, High Torque Possible	Tool Rotation Plane Perpendicular to Flow Line	Bayonet-Short Action Not-Continuous Rotation
3. Synchronized Poppet Tool	Tandem Poppets		Single-Hand Action Sufficient	Adapter Fits Over Both Poppet Stems, Tool Rotation Above Adapter, Same Plane	Two Piece Tool - Position Adapter, Position Tool in Adapter, Rotate Tool
4. Integrated Coupling Handle		Integral Positive Isolation Coupler	CAM, Action Transfers Force	Handle Rotates to 90^{0} Above Disconnect, in Same Plane as Flow Line	Pivot Handle to Couple/Uncouple Disconnect

FOLDOUT FRAME 1

TRADEOFF FACTORS				
MENTS	CREW FUNC-TIONS	ADAPT-ABLE TO TORQUE LIMIT-ING?	FUNC-TION STATUS INDICA-TION	DESIGN COMMENTS
Except Flange/Bolt-Plane Perpendicular	Conical Poppets-Twist Spheres-Limited Rotation Couplers-Continuous Rotation	Yes	Wrench Position (e.g., 180^0 Rotation), Positive Stop, Direct Visual, or Torque Limiting	1. Forces required for poppet movement may necessitate use of longer handle, i.e., higher torque. 2. For concepts listed, single tool can accomplish both isolation and coupling.
Perpendicular to Flow Line	Bayonet-Short Action Not-Continuous Rotation	Yes	Visual Indication	1. Standard open-ended wrench design. 2. May be two handed operation.
Both Poppet Stems, Tool Rotation Above Adapter, Same Plane	Two Piece Tool - Position Adapter, Position Tool in Adapter, Rotate Tool	Yes	Tool Position Change or Indicator on Adapter Face	1. Design employs small wrench with geared adapter to rotate both stems simultaneously. 2. Design must minimize backlash and maintain synchronization.
90° Above Disconnect, in Same Plane as Flow Line	Pivot Handle to Couple/Uncouple Disconnect	Not Possible	Handle Position	1. Tool is part of coupling design. 2. Poppet stem tool still required for this concept.

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

FOLDOUT FRAME 2

b. Zero Torque Wrench - This tool is used to rotate the bayonet type coupling ring (see Figure III-9). The tool consists of two pivoting levers that pick up notches in the coupling ring. As the handles are squeezed together the coupling ring is rotated. An indexing pin on the tool matches indexing holes on the valve body and determines direction of rotation.

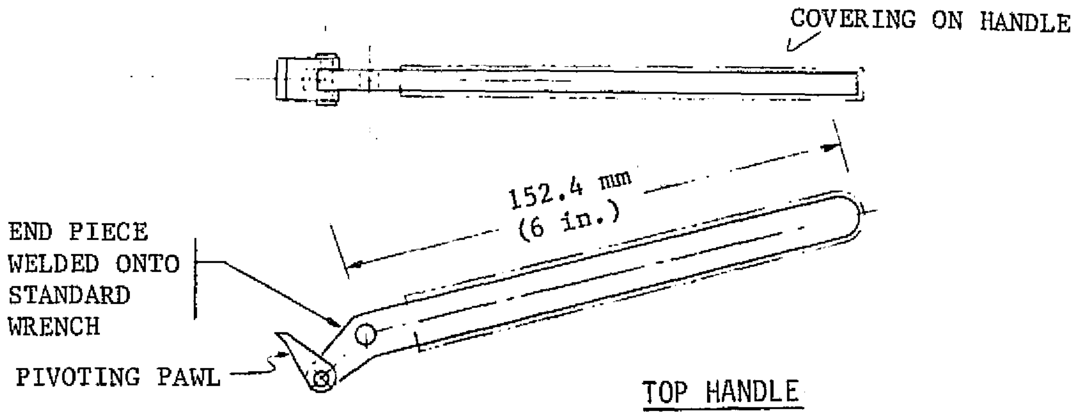
c. Synchronized Poppet Tool - This tool, shown in Figure III-10, would be required for the tandem poppet concept where both poppets must move together. Basically the tool consists of a rack and two gears. The gears are attached to the valve stems through adapters, therefore, the movement of one valve stem results in the same movement in the other. A socket adapter on top of one of the gears provides for the single point operation. This tool can be used with limited access and the procedures are straightforward.

9. Foolproofing Concepts - Table III-11 summarizes the foolproofing techniques that can be applied to disconnect concepts investigated. This evaluation concerns itself with tradeoff factors such as crew functions required, special tools required, and access requirements.

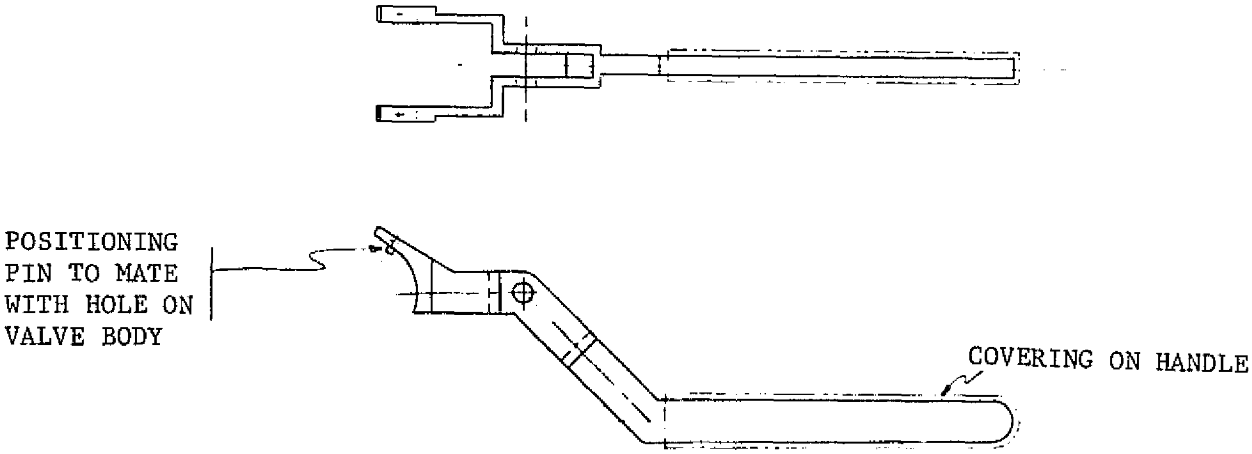
a. Cover Plate - The cover plate technique for foolproofing is shown in Figure III-11. This method covers the uncoupling mechanism (coupling nut in Figure III-11) with a formed plastic cover that also picks up the valve stem locations. The plastic cover has clearance holes for the valve stems and a slot to clear the pins (located on valve stem) when disconnect halves are closed. The plastic type molded cover partially surrounds the coupling, thereby requiring removal of the cover prior to disengagement of the disconnect halves.

b. Integral Positive Isolation Coupling Mechanism - This concept, shown in Figure III-12, uses eccentric caps attached to the valve stems that coincide with slots in the coupling handle. When the disconnect halves are open, the eccentrics overlap the handle preventing its movement; likewise, when disconnect halves are closed, the handle is allowed to pass by the eccentrics and uncouple the unit.

c. Lever Type Interlock - This concept is to be used for coupling ring type clamp mechanisms (see Figure III-13). The concept consists of a pivoting lever controlled by a ramp attached to the valve stem, and grooves along the side of the coupling ring.



TOP HANDLE
MODIFIED PRESET
"CLICK" TORQUE
WRENCH



TOOL NOTES

A SPRING WILL BE INSTALLED THAT OPENS THE HANDLE GRIPS WHEN RELEASED. ALSO A SPRING WILL BE INSTALLED AT THE PAWL PIVOT TO MAINTAIN THE PAWL AGAINST THE COUPLING RING.

STOPS WILL BE PROVIDED TO MAINTAIN PROPER TOOL ACTION.

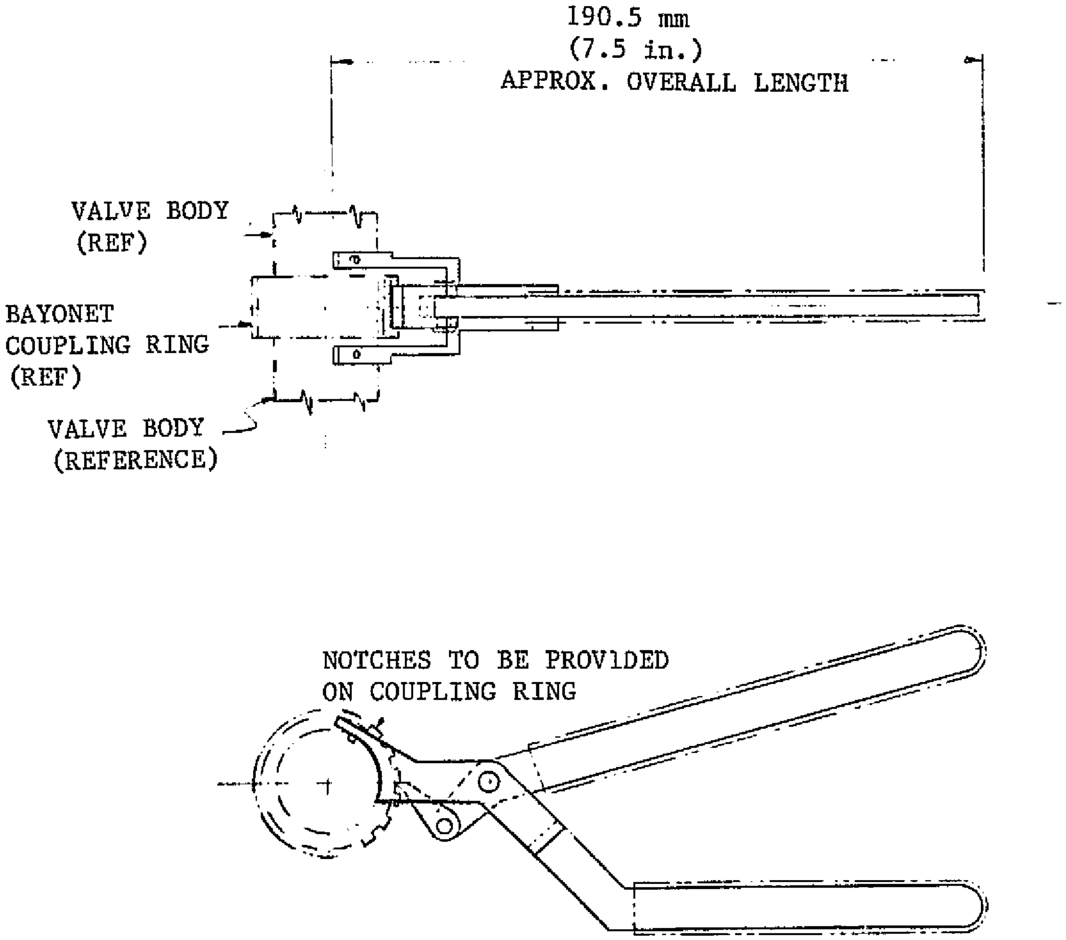
BOTTOM HANDLE
MACHINED TO CONFIGURATION
SHOWN

FOLDOUT FRAME

G ON HANDLE

ING ON HANDLE

JRATION



TOOL OPERATION

TOOL IS PROPERLY POSITIONED ON VALVE BODIES WITH GUIDE PINS. DOWNWARD MOTION OF THE TOP HANDLE PROVIDES LEVERAGE ON THE PAWL THAT ROTATES THE COUPLING RING. THIS MOVEMENT PROVIDES THE NECESSARY CLAMPING FORCE ON THE VALVE BODIES. 2-3 SQUEEZES WITH THE TOOL SHOWN WILL COMPLETELY CONNECT THE VALVE BODIES WHEN A MAXIMUM FORCE OF 50 LBS IS APPLIED. THIS RESULTS IN 500 LBS OF CLAMPING FORCE. OVER TORQUING IS PREVENTED BY INCORPORATING A TORQUE WRENCH IN THE TOP HANDLE.

FIGURE III-9

ZERO-TORQUE-TO-VALVE-BODY COUPLING WRENCH

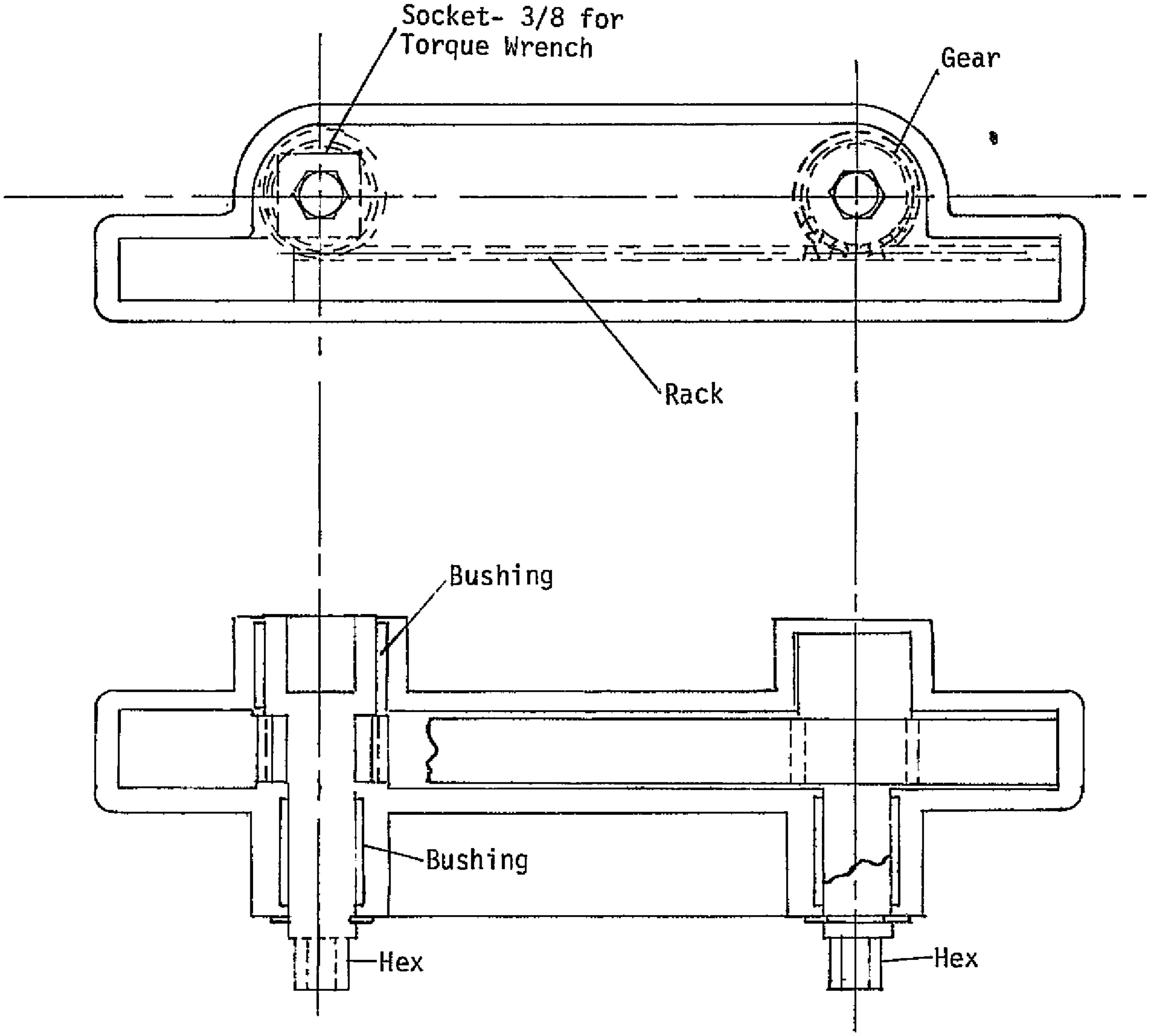
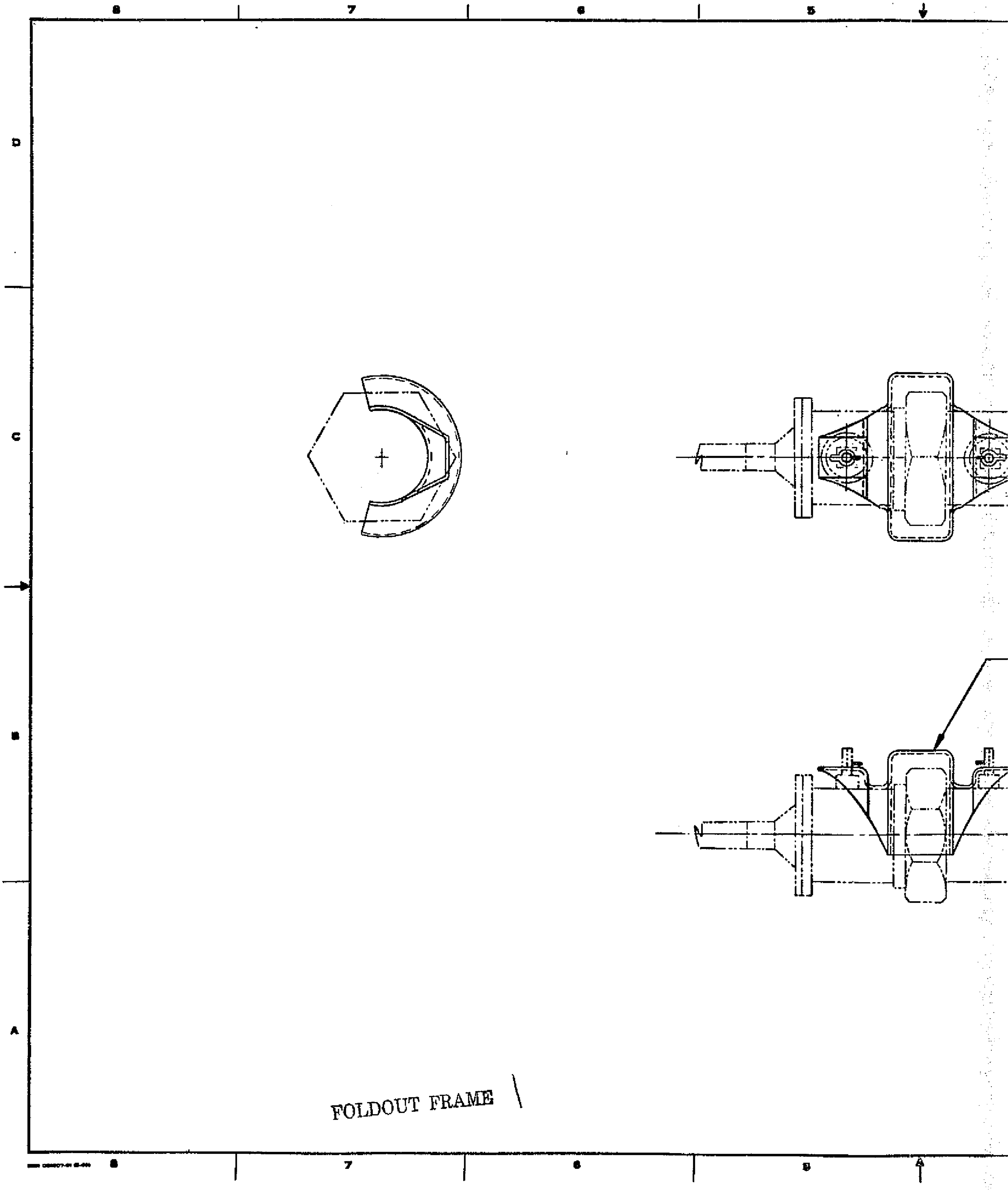
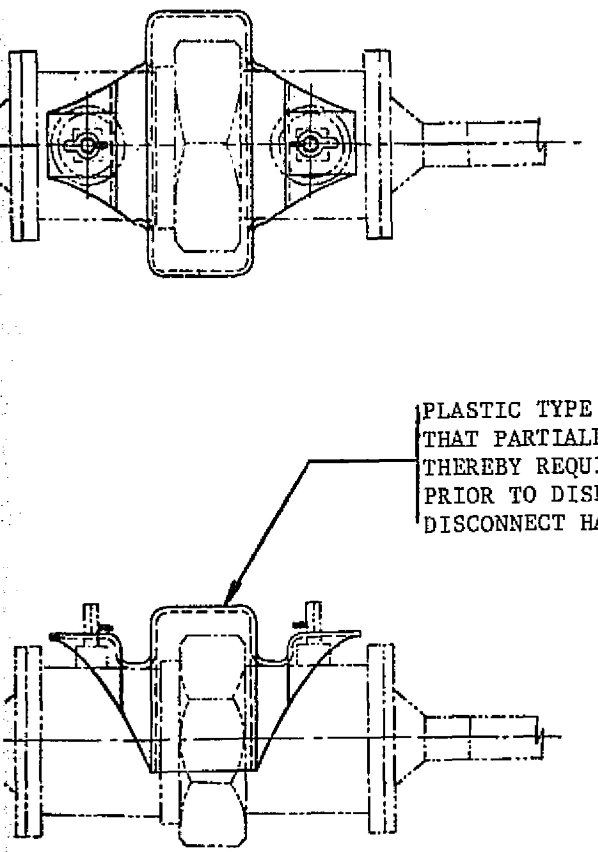


FIGURE III-10 Tooling Concept for Synchronized Poppets Disconnect



FOLDOUT FRAME



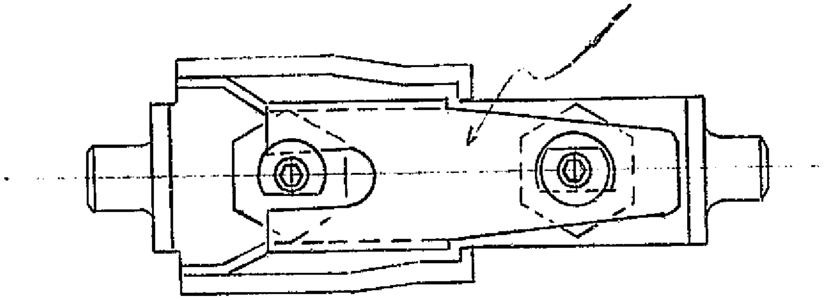
PLASTIC COVER HAS CLEARANCE HOLES FOR VALVE STEMS AND A SLOT TO CLEAR THE PIN ON THE VALVE STEM WHEN DISCONNECT HALVES ARE CLOSED. WHEN VALVES ARE OPEN, THE PINS PREVENT REMOVAL OF THE PLASTIC COVER.

PLASTIC TYPE MOLDED COVER THAT PARTIALLY SURROUNDS COUPLING, THEREBY REQUIRING REMOVAL OF COVER PRIOR TO DISENGAGEMENT OF DISCONNECT HALVES.

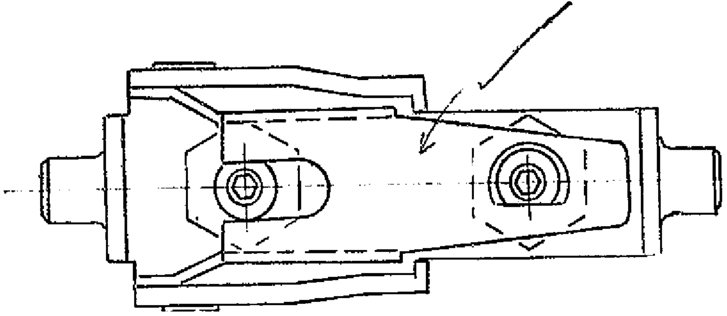
FIGURE III-11

FOOL-PROOFING METHOD FOR BASIC ISOLATION DISCONNECT

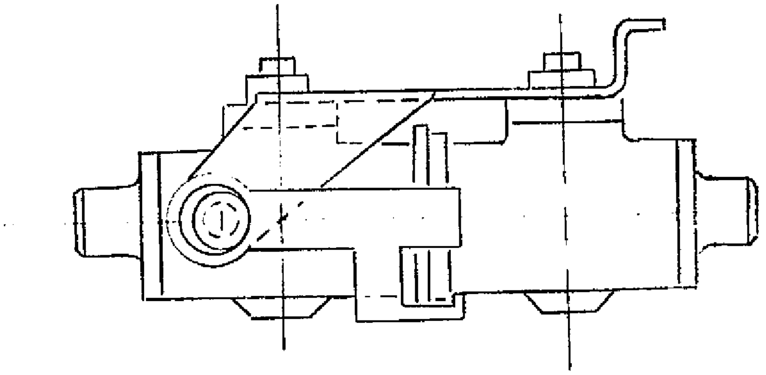
D 04236



Handle Locked in Place

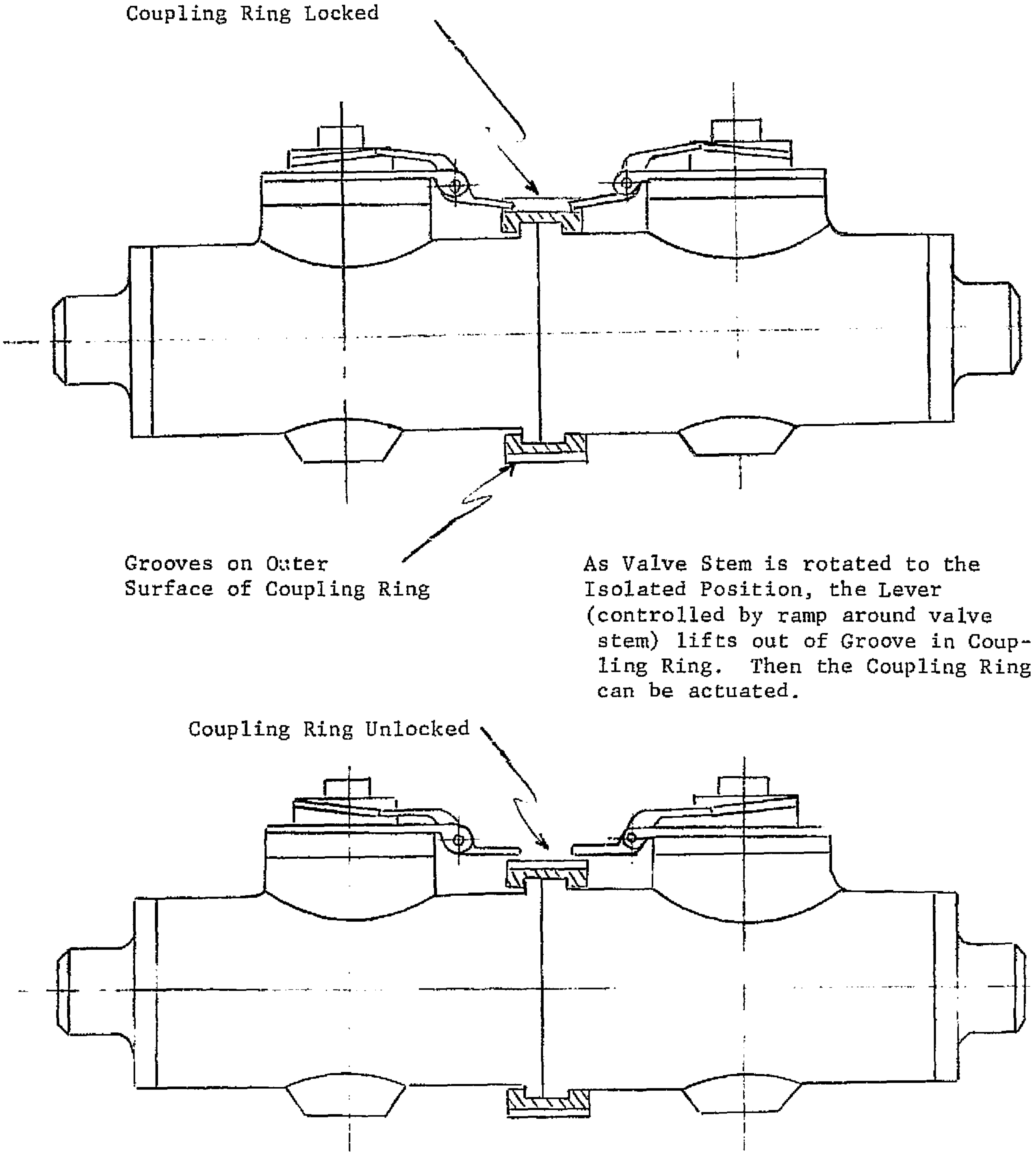


No Flow, Handle can be lifted



This Concept incorporated a Handle with Cutouts that slip over the Valve Stem Assemblies. When the Valves are in the Open Flow Position, the Valve Stem Assembly overlaps the Handle thereby preventing opening of the Disconnect.

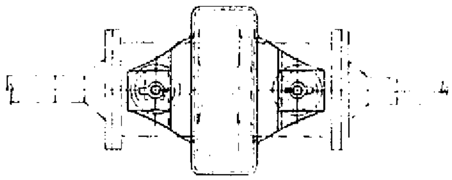
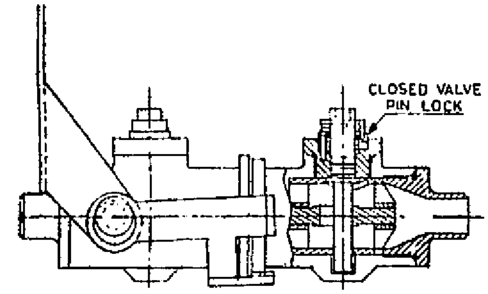
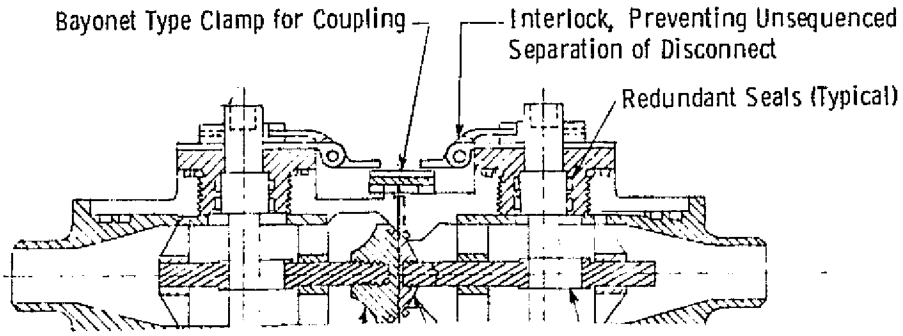
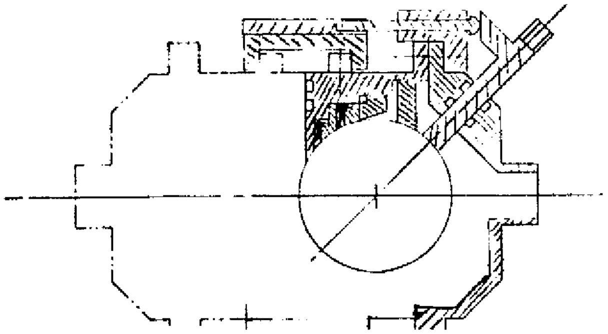
FIGURE III-12 KEYED HANDLE FOOLPROOF METHOD



As Valve Stem is rotated to the Isolated Position, the Lever (controlled by ramp around valve stem) lifts out of Groove in Coupling Ring. Then the Coupling Ring can be actuated.

FIGURE III-13 RAMP/LEVEL FOOLPROOF METHOD

TABLE III - 11 FOOLPROOFING CONCEPTS

DESIGNATION	CONCEPT SKETCH	CREW FUNCTIONS REQUIRED	SPECIAL TOOLS REQUIRED	ACCESS REQUIRED
1. COVER PLATE		Remove or replace cover after valve stems have been properly positioned	None, tool for valve stem (open/close) only	To valve stem only, free volume to remove
2. INTEGRAL POSITIVE ISOLATION COUPLING MECHANISM (PRELIMINARY DESIGN SELECTION)		Turn valve stems to close disconnect, lift handle 90° to release coupling	None, tool for valve stem (open/close) only	Handle must rotate 90° from flow line, dis-
3. LEVER-TYPE INTERLOCK		Rotation of poppet shafts to close valve releases interlocking lever over coupling	None, tool for valve stem (open/close) only	Tool access to stem only
4. SLIDING PIN		Remove pin after poppet shaft has been rotated clear	None	Tool access to stem only

FOLDOUT FRAME \

FOLDOUT FRAME 2

poppet shaft has been rotated clear	shafts to close valve releases interlocking lever over coupling	close disconnect, lift handle 90° to release coupling	after valve stems have been properly positioned	FUNCTIONS REQUIRED	TRADEOFF FACTORS
None	None, tool for valve stem (open/close) only	None, tool for valve stem (open/close) only	None, tool for valve stem (open/close) only	SPECIAL TOOLS REQUIRED	
Tool access to stem only	Tool access to stem only	Handle must rotate 90° from flow line, disconnect can be removed only in direction of handle actuation	To valve stem only, free volume to remove cover from disconnect	ACCESS REQUIRED	
Pin head/stem ramp	Interlock lever wear	Eccentric cam on handle, coupler seats	None	WEAR DURING CYCLING	
Metal-to-Metal contact between pin & ramp	Metal to metal contact between coupling/lever/stem	Handle must accommodate closure forces, wear tendencies must be examined	Cover plate can be non-metallic if compatible	MATERIALS COMPATIBILITY	
Integrated, however, procedure must be followed	Integrated, however, does allow valve opening w/o coupling	Integrated, coupling cannot be released until valve is closed, spring-loaded stems prevent valve opening until coupling is achieved	External, lanyard req. to attach cover to disconnect or fluid line	INTEGRATED VS EXTERNAL	
Mechanical/Procedural	Mechanical/Procedural combination interlock lever restricts tool access to coupler	Mechanical, coupler is integral to isolation	Procedural, however valve can be opened without replacing cover making next sequence not foolproof	FOOL PROOFING RATIONALE	
1. Complicates coupling design 2. Piece part machining required 3. Pin becomes loose part, can be lost	1. Complicates stem design, adds minimal wt., volume 2. Piece part machining required 3. Design of interlock lever must consider coupler geometry, tab locks into clamp surface	1. Design must assure proper positive seating with handle action 2. Spring loaded stem design adds complexity 3. Several small machined parts required	1. Cover plate denies access to coupler until disconnect is fully closed 2. Can be used with many coupling concepts 3. Coupling independent of positive isolation	DESIGN COMMENTS	

As the valve stem is rotated to the closed position, the lever lifts out of the groove in the coupling ring. Then the coupling ring can be actuated.

d. Sliding Pin - This concept, shown in Figure III-14, is similar to the ramp/lever concept except the lever is replaced by a sliding pin. The spring-loaded pin rides against a cam on the valve stem. As the valve is closed, the pin retracts allowing the coupling ring to be unlocked.

C. DISCONNECT CONCEPT COMPARISON DATA

A failure mode and effects analysis was performed on the various disconnect concepts and summarized in Tables III-12 through III-16. These concepts were the tandem conical poppets, individual poppets with the integral positive isolation, individual conical poppets with bayonet coupling, spherical poppets with direct drive, and the bellows concept with integral isolation/coupling. The same concepts are compared quantitatively in Table III-17 where factors such as overall size, envelope volume, poppet movement, pressure drop, and weights are tabulated. Table III-18 compares the concepts with the required design parameters.

D. TOP CANDIDATE CONCEPTS IDENTIFIED

From the preliminary concept comparison data, two concepts were selected for further evaluation. These were the rotating spheres concept and the individual conical poppets with integral positive isolation mechanism. The rotating sphere concept was selected due to its lightweight, small volume, few parts and its low pressure loss due to a straight through flow path. Sealing difficulties exist with this concept which require further evaluation. The individual conical poppets with integral positive isolation provides all functional requirements with reasonable size and weight. This concept will be further evaluated along with the rotating spheres concept for functional reliability and ease of fabrication.

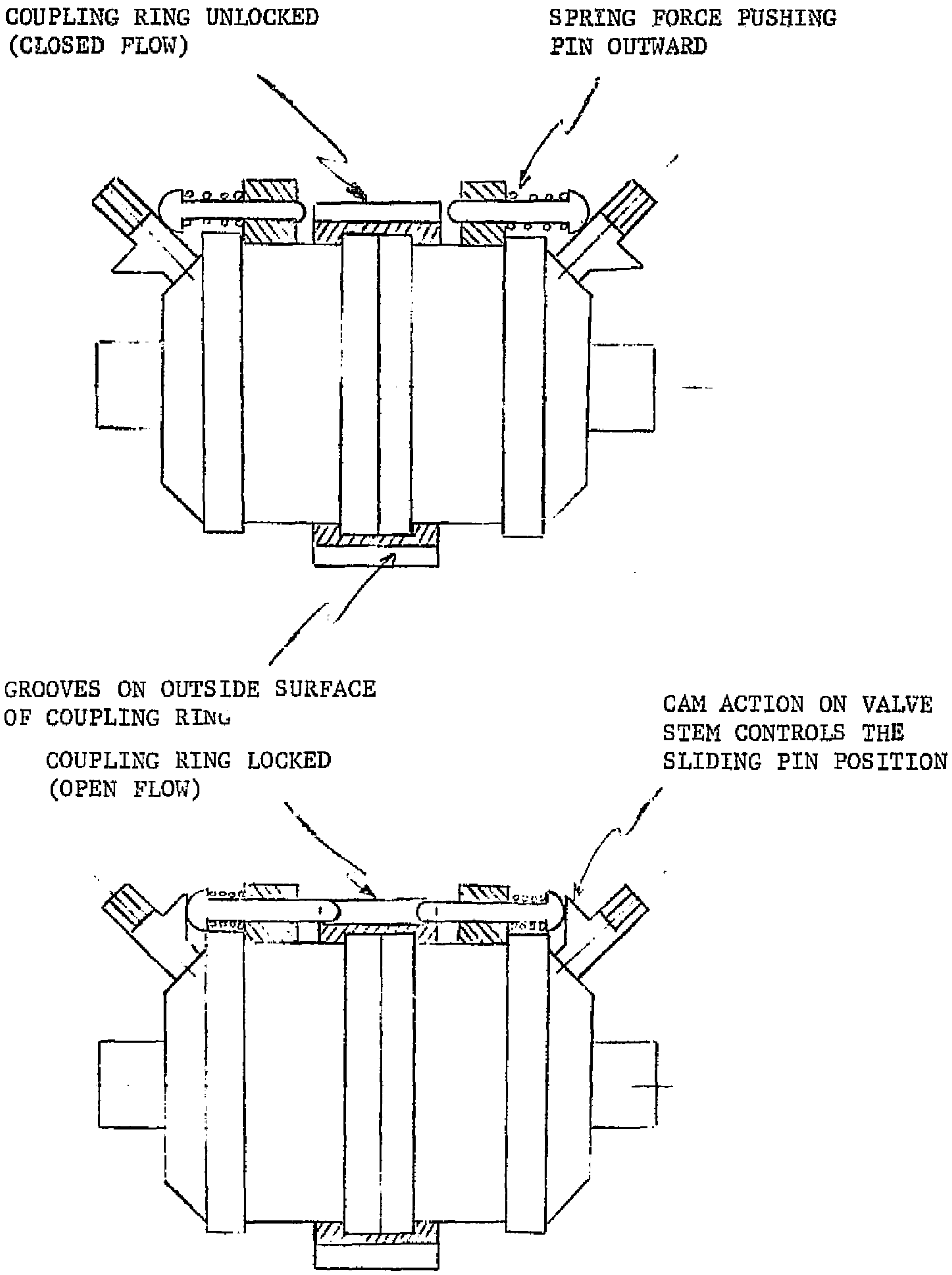


FIGURE III-14 SLIDING PIN FOOLPROOFING CONCEPT

TABLE III-12 TANDEM CONICAL POPPETS

OPERATION	FAILURE MODE	RESULT ON SYSTEM
<u>CONNECT</u>		
Match Disconnect Faces	Strike Face Seals with opposite disconnect half	Seal damage
	Misalignment of faces	Coupling will not operate
Couple Disconnect Halves	Tool failure	Positive coupling not possible
	Misalignment, visible	Coupling not positive, interlock will not allow valves to open
	Incomplete coupling, inadvertent	Interlock will not allow valves to open
	Overtorque	Coupling/coupling seat damage
		Damage at line/disconnect interface
Open Valve to Flow	Interlock misalignment/failure due to stem shaft slippage relative to eccentric actuator	Poppet cannot be opened
	Tool failure	Poppets cannot be opened
	Incomplete poppet movement	Decreased flow, possible reclosure of poppet under pressure
	Overtorque	Poppet Actuator/Poppet Face Wear

FOLDOUT FRAME |

LT ON SYSTEM	DESIGN FEATURE TO PRECLUDE FAILURE	CREW ACTION REQUIRED	SINGLE POINT FAILURE (FAIL OPEN)
mage	Offset engagement flange to protect seals	Perform operation by established procedure	No, Dual Seals
ng will not operate	Alignment pins or faces	Realign/Readjust	No
ve coupling not le	Tool design		No
ng not positive, ock will not allow to open	Coupling position (alignment) must be clearly visible	Readjust coupling	No
ock will not allow to open	Coupling status must be clearly discernible	Recouple	No
ng/coupling seat	Coupling/tool design	Operate tool by established procedure	No
e at line/discon- interface	Tool design, no-torque wrench	Same as above	No
t cannot be opened	Stem shaft keyed to eccentric cam		No
ts cannot be opened	Tool design		No
ased flow, possible sure of poppet under ure	Poppet position must be discernible, use over-center eccentric	Operate tool properly, verify poppet position	No
t Actuator/Poppet Wear	Tool design, spring in actuator eccentric to take up wear, hard surface finish on eccentric	Operate by procedure	No

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TABLE III-12 TANDEM CONICAL POPPETS (Cont'd)

OPERATION	FAILURE MODE	RESULT ON SYSTEM	DESIGN FEATURE PRECLUDE FAILU
<u>DISCONNECT</u>			
Close Valve to Flow	Interlock misalignment/ failure due to stem shaft slippage relative to eccentric actuator	Incomplete closure, leak upon separation	Stem shaft keyed t eccentric cam
		Poppets closed but unit cannot be uncoupled	Interlock design
	Incomplete closure due to contamination behind poppet seal	Leak upon separation if eccentric slippage also occurs	Undercut seal area have eccentric spr force 22.8 kg (50
	Incomplete closure due to hydraulic lock	Leak upon separation if eccentric slippage also occurs	Poppet position ve able
Uncouple Halves	Tool failure	Uncoupling not possible	Tool design
Separate Halves	Strike face seals with opposite disconnect halves	Seal damage	Offset engagement to protect seals

DESIGN FEATURE TO PRECLUDE FAILURE	CREW ACTION REQUIRED	SINGLE POINT FAILURE (FAIL OPEN)
Stem shaft keyed to eccentric cam		Yes
Interlock design	Override interlock if poppet can be verified closed	No
Undercut seal area and have eccentric spring force 22.8 kg (50 lbs)	None	No
Poppet position verifiable	Verify poppet position	No
Tool design		No
Offset engagement flange to protect seals	Perform operation by proper procedure	No, Dual Seals

TABLE III-13 INDIVIDUAL POPPETS W/INTEGRAL POSITIVE ISOLATION

OPERATION	FAILURE MODE	RESULT ON SYSTEM	DES PRE
<u>CONNECT</u>			
Match Disconnect Faces	Strike face seals with opposite disconnect half	Seal damage	Dog le damage
	Misalignment of faces	Coupling will not engage	Alignm
	Face seal missing or misaligned with gland	Possible leak or seal damage	Face s alignm retain
Couple Disconnect Halves (Engage Handle)	Misalignment of dog legs/ disconnect flanges	Coupling not complete	Keyed
	Insufficient coupling force/tool handle failure due to eccentric cam slippage	Coupling incomplete, leak upon separation	Handle eccent
Open Valves to Flow	Interlock misalignment/ failure	Poppet cannot be opened, no flow due to stem shaft slippage relative to eccentric cam	Stem s eccent
	Tool failure	Valves cannot be opened	Tool c
	Incomplete poppet movement	Decreased flow, possible reclosure under pressure	Poppet be dis
	Overtorque	Poppet actuator/poppet face wear	Tool c eccent wear, hard f cam

FOLDOUT FRAME

ION

ESULT ON SYSTEM	DESIGN FEATURE TO PRECLUDE FAILURE	CREW ACTION REQUIRED	SINGLE POINT FAILURE (FAIL OPEN)
damage	Dog leg design prevents damage		No
ling will not engage	Alignment pins	Realign/Readjust	No
ible leak or seal ge	Face seals on line half, alignment pins, gland retaining features		No
ling not complete	Keyed flanges	Readjust	No
ling incomplete, leak separation	Handle design keyed to eccentric		Yes
pet cannot be opened, flow due to stem shaft ppage relative to entric cam	Stem shaft keyed to eccentric cam		No
ves cannot be opened	Tool design		No
reased flow, possible losure under pressure	Poppet position must be discernible	Operate tool properly, verify poppet position	No
pet actuator/poppet e wear	Tool design, spring in eccentric to take up wear, over-center design, hard finish on eccentric cam	Operate by procedure	No

FOLDOUT FRAME 2

TABLE III-13 INDIVIDUAL POPPETS W/INTEGRAL POSITIVE ISOLATION (Cont'd)

OPERATION	FAILURE MODE	RESULT ON SYSTEM	DESIGN FEATURE T PRECLUDE FAILURE
<u>DISCONNECT</u>			
Close Valves to Flow	Interlock misalignment/ failure due to stem shaft slippage relative to eccentric cam	Incomplete closure, leak upon separation	Shaft stem keyed to eccentric cam
		Valves closed but unit cannot be uncoupled	Interlock design
	Incomplete closure due to contamination	Possible leak upon separation if eccentric slippage also occurs	Undercut seal area have eccentric spri force 22.8 kg (50 1
	Incomplete closure due to hydraulic lock	Leak upon separation if eccentric slippage also occurs	Over-center eccentr valves self-sealing under pressure, plu by-pass seal design on poppet
Uncouple Halves (Release Handle)	Handle failure due to slippage of eccentric cam	Uncoupling not possible	Handle design
Separate Halves	Strike face seals with opposite disconnect half	Seal damage	Dog leg design

3

DESIGN FEATURE TO PRECLUDE FAILURE	CREW ACTION REQUIRED	SINGLE POINT FAILURE (FAIL OPEN)
Shaft stem keyed to eccentric cam		Yes
Interlock design	Override interlock if poppet can be verified closed	No
Undercut seal area and have eccentric spring force 22.8 kg (50 lbs)	None	No
Over-center eccentric, valves self-sealing under pressure, plus by-pass seal design on poppet	None	No
Handle design		No
Dog leg design	Separate halves in proper direction	No, Dual Seals

TABLE III-14 INDIVIDUAL CONICAL POPPETS WITH BAYONET COUPLING

OPERATION	FAILURE MODE	RESULT ON SYSTEM
<u>CONNECT</u>		
Match Disconnect Faces	Strike face seals with opposite disconnect half	Seal damage
	Misalignment of faces	Coupling will not operate
	Face seal missing or misaligned with gland	Possible leakage or seal damage
Couple Disconnect Halves	Tool failure	Positive coupling not possible
	Misalignment, visible	Coupling not positive, interlock will not allow valves to open
	Incomplete coupling, inadvertent	Interlock will not allow valves to open
	Overtorque	Coupling/coupling seat damage Damage at line/disconnect interface
Open Valve to Flow	Interlock misalignment/ failure, either side	Poppet cannot be opened, no flow due to stem shaft slippage relative to eccentric cam
	Tool failure	Valves cannot be opened
	Incomplete poppet movement, either side	Decreased flow, possible reclosure of poppet under pressure
	Overtorque	Poppet actuator/poppet face wear

G

LT ON SYSTEM	DESIGN FEATURE TO PRECLUDE FAILURE	CREW ACTION REQUIRED	SINGLE POINT FAILURE (FAIL OPEN)
mage	Offset engagement flange to protect seals	Perform operation by established procedure	No, Dual Seals
g will not operate	Alignment pins on faces	Realign/Readjust	No
le leakage or seal	Face seals on line half, alignment pins, gland retaining features		No
ve coupling not le	Tool design		No
ng not positive, ock will not allow to open	Coupling position (alignment) must be clearly visible	Readjust coupling to design torque	No
ock will not allow to open	Coupling status must be clearly discernible	Recouple	No
ng/coupling seat e	Coupling/tool design includes torque limit	Operate tool by established procedure	No
e at line/discon- interface	Tool design, zero-torque to valve body wrench	Same as above	No
t cannot be opened, ow due to stem slippage relative centric cam	Stem shaft keyed to eccentric cam		No
s cannot be opened	Tool design		No
ased flow, possible sure of poppet pressure	Poppet position must be discernible	Operate tool properly, verify poppet position	No
t actuator/poppet wear	Spring in eccentric to take up wear, over-center design, hard surface finish on eccentric cam	Operate by procedure	No

TABLE III-14 INDIVIDUAL CONICAL POPPETS WITH BAYONET COUPLING (Cont'd)

OPERATION	FAILURE MODE	RESULT ON SYSTEM	DESIGN FEATURE T PRECLUDE FAILURE
<u>DISCONNECT</u>			
Close Valves to Flow	Interlock misalignment/ failure due to stem shaft slippage relative to eccentric cam	Incomplete closure, leak upon separation	Stem shaft keyed to eccentric cam
		Valves closed but unit cannot be uncoupled	Interlock design
	Incomplete closure due to contamination between poppet and poppet seal or behind seal	Possible leakage upon separation if eccentric slippage also occurs	Undercut seal area have eccentric spri force approximately 22.8 kg (50 lbs)
	Incomplete closure due to hydraulic lockup	Leak upon separation if eccentric slippage also occurs	Valves self-sealing plus by-pass seal design on poppet
Uncouple Halves	Tool failure	Uncoupling not possible	Tool design
Separate Halves	Strike face seals with opposite disconnect halves	Seal damage	Offset engagement fl to protect seals

DESIGN FEATURE TO PRECLUDE FAILURE	CREW ACTION REQUIRED	SINGLE POINT FAILURE (FAIL OPEN)
Stem shaft keyed to eccentric cam		Yes
Interlock design	Override interlock if poppet can be verified closed	No
Undercut seal area and have eccentric spring force approximately 22.8 kg (50 lbs)	None	No
Valves self-sealing plus by-pass seal design on poppet	None	No
Tool design		No
Offset engagement flange to protect seals	Perform operation by proper procedure	No, Dual Seals

TABLE III-15 SPHERICAL POPPETS (DIRECT DRIVE)

OPERATION	FAILURE MODE	RESULT ON SYSTEM	DESI PREC
CONNECT			
Match Disconnect Faces	Strike face seals with opposite disconnect half	Seal damage	Protrud require movemen
	Misalignment of faces	Coupling will not engage	Alignme
Couple Disconnect Halves	Tool failure	Positive coupling not possible	Tool de
	Misalignment, visible	Coupling not positive, interlock will not allow valves to open	Couplin ment) m visible
	Incomplete coupling, inadvertent	Interlock will not allow valves to open	Couplin clearly
	Overtorque	Coupling/coupling seat damage	Couplin include
		Damage at line/disconnect interface	Tool de torque wrench
Open Valves to Flow	Improper sequencing of poppets	Poppet galling, seal wear	Procedu sequenc
	Interlock misalignment/failure, either side due to slippage in cam	Poppet cannot be opened, no flow	Shaft s eccentr
	Tool failure	Valves cannot be opened	Tool de
	Incomplete poppet movement, either side	Decreased flow, possible reclosure under pressure	Poppet discern
	Overtorque	Poppet actuator/poppet face wear	Tool de stops

FOLDOUT FRAME

LT ON SYSTEM	DESIGN FEATURE TO PRECLUDE FAILURE	CREW ACTION REQUIRED	SINGLE POINT FAILURE (FAIL OPEN)
amage	Protruding poppet face requires greater lateral movement for separation		No, Dual Seals
ng will not engage	Alignment pins required	Realign/Readjust	
ve coupling not le	Tool design		No
ing not positive, lock will not allow s to open	Coupling position (alignment) must be clearly visible	Readjust coupling	No
lock will not allow s to open	Coupling status must be clearly discernible	Recouple	No
ing/coupling seat e	Coupling/tool design includes torque limit	Operate tool by established procedure	No
e at line/discon- interface	Tool design, zero-torque to valve body wrench	Same as above	No
et galling, seal	Procedural, or design sequencing into unit		No
et cannot be opened, ow	Shaft stem keyed to eccentric cam		No
es cannot be opened	Tool design		No
eased flow, possible osure under pressure	Poppet position must be discernible	Verify poppet position	No
et actuator/poppet wear	Tool design, incorporate stops	Operate by procedure	No

FOLDOUT FRAME 2

TABLE III-15 SPHERICAL POPPETS (DIRECT DRIVE) (Cont'd)

OPERATION	FAILURE MODE	RESULT ON SYSTEM	DESIGN FEATURE TO PRECLUDE FAILURE
<u>DISCONNECT</u>			
Close Valves to Flow	Improper sequencing	Poppet galling, seal wear	Procedural, or desig sequencing into unit
	Interlock misalignment/ failure due to shaft slippage relative to cam	Incomplete closure, leak upon separation	Shaft stem keyed to eccentric cam
		Valves closed but unit cannot be uncoupled	Interlock design
	Incomplete closure (not related to interlock) due to contamination	Leak upon separation if shaft stem also slips	
Uncouple Halves	Tool failure	Uncoupling not possible	Tool design
Separate Halves	Incomplete uncoupling	Separation not possible	Coupling design
	Strike face seals with opposite disconnect half	Seal damage	Protruding poppet fac requires greater late movement for separati

FOLDOUT FRAME 3

DESIGN FEATURE TO PRECLUDE FAILURE	CREW ACTION REQUIRED	SINGLE POINT FAILURE (FAIL OPEN)
Procedural, or design sequencing into unit		No
Shaft stem keyed to eccentric cam		Yes
Interlock design	Override interlock if poppet can be verified closed	No
		No
Tool design		No
Coupling design	Complete uncoupling operation	No
Protruding poppet face requires greater lateral movement for separation		No, Dual Seals

4

FOLDOUT FRAME

TABLE III-16 BELLOWS WITH INTEGRAL ISOLATION/COUPLING

OPERATION	FAILURE MODE	RESULT ON SYSTEM	DES PRE
<u>CONNECT</u>			
Match Disconnect Faces	Strike line disconnect ext. seal with component-side disconnect half	Seal damage, possible leak	Proced positi
	Misalignment of faces	Coupling will not engage	Alignm lize f
Couple Halves/Open Valves	Overtorque	Poppet seal wear	Torque
		Damage at line/disconnect interface	No-tor
	Tool failure	Coupling not possible	Tool de
<u>DISCONNECT</u>			
Close Valves/Uncouple Halves	Bellows failure	External leak, leak at sep. plane	Implies failure
	Tool failure	Uncoupling not possible	Tool de
	Poppet seal failure (either side)		Not suf for dua
	Poppet spring failure, improper seating	Incomplete closure	Pressur poppet
Separate Halves	Strike line disconnect ext. seal with component-side disconnect half	Seal damage, possible leak	Procedu porate protect

ON SYSTEM	DESIGN FEATURE TO PRECLUDE FAILURE	CREW ACTION REQUIRED	SINGLE POINT FAILURE (FAIL OPEN)
ge, possible	Procedural, or incorporate positive seal protection		Yes, Single Seal
will not engage	Alignment pins, or utilize face geometry	Realign/Readjust	No
al wear	Torque-limited tool	Operate by procedure	No
line/dis- interface	No-torque tool design	Operate by procedure	No
not possible	Tool design		No
leak, leak at ne	Implies catastrophic failure		Yes
ng not possible	Tool design		No
	Not sufficient space for dual seals		Yes, Single Seal
te closure	Pressure may close poppet asymmetrically		Yes
age, possible	Procedural, or incorporate positive seal protection		Yes

FOLDOUT FRAME 2

TABLE III-17 CONCEPT COMPARISON VS QUANTITATIVE PARAMETERS

Parameter / Concept	Outside Dim. (Envelope) cm(in)	Envelope Volume cu cm (cu in)	Poppet Movement Req. cm(in) or Deg.	Pressure Drop N/m^2 (psi) @ Water Flowrate of 69.3 gm/sec (550 lb/
Tandem Conical Poppets	15.6L x 4.8 dia. (6.1L x 1.9 dia.) (2.25 dia. w/Poppet Stem)	279 (17)	.20 (.08)	2.55×10^3 (0.37)
Individual Conical Poppets	15.9L x 5.7 dia. (6.3L x 2.3 dia.) (2.8 dia. w/Poppet Stem)	407 (24.8)	.20 (.08)	3.65×10^3 (0.53)
Individual Conical Poppets with Integral Positive Isolation Mechanism (Cam/Doglegs) *	14.9L x 4.8 dia. (5.9L x 1.9 dia.) (2.2 dia. w/Poppet Stem)	273 (16.7)	.20 (.08)	2.34×10^3 (0.34)
Rotating Spheres (Direct Drive) *	18.1L x 7.3 dia. (7.1L x 2.9 dia.) (3.3 dia. w/Poppet Stem)	760 (46.4)	70°	1.38×10^3 (0.20)
Rotating Spheres (Canted Poppet Stem)	8.4L x 4.8 dia. (3.3L x 1.9 dia.)	151 (9.2)	180°	$.14 \times 10^3$ (0.02)
Bellows w/Integral Isolation/Coupling	11.4L x 7.0 dia. (4.5L x 2.8 dia.)	454 (27.7)	.20 (.08)	Estimated 3.5×10^3 (0.5)

* Preliminary Design Selection

Pressure Drop N/m^2 (psi) @ Water Flowrate of 69.3 gm/sec (550 lb/hr)	Body Weight gm (lb)	Possible Coupling Weights gm (lb)	Total (Body & Coupling) Weight gm (lb)
2.55×10^3 (0.37)	720 (1.6)	Bayonet: 55 (.12)	775 (1.7)
		Cam/Doglegs: 120 (.26)	840 (1.9)
3.65×10^3 (0.53)	1180 (2.6)	Nut: 160 (.36)	1340 (3.0)
		Flange/Bolts: 140 (.31)	1320 (2.9)
		Bayonet: 130 (.28)	1310 (2.9)
		Cam/Doglegs: 135 (.30)	1315 (2.9)
2.34×10^3 (0.34)	660 (1.45)	Positive Isolation Mechanism: 120 (.26)	780 (1.7)
1.38×10^3 (0.20)	2060 (4.6)	Bayonet: 105 (.23)	2165 (4.8)
		Cam/Doglegs: 190 (.42)	2250 (5.0)
$.14 \times 10^3$ (0.02)	360 (0.8)	Bayonet: 55 (.12)	415 (0.9)
Estimated 3.5×10^3 (0.5)	Estimated 1500 (3.3)	Coupling Sleeve: Est. 225 (0.5)	1725 (3.8)

TABLE III-18 CONCEPT COMPARISON VS DESIGN PARAMETERS

* Preliminary Design Selection

CONCEPT DESIGN PARAMETER	TANDEM CONICAL POPPETS	INDIVIDUAL CONICAL POPPETS	INDIVIDUAL POPPETS WITH INTEGRAL POSITIVE ISOLATION *	ROTATING SPHERES (DIRECT DRIVE)*	ROTATING (BALL VALVE) W/ CANTED POPPET STEM	BELLOWS W/ INTEGRAL ISOLATION/ COUPLING
Cost, Fabrication	Moderate, Disconnect Halves not fully symmetrical	Moderate, Disconnect halves identical	Moderate, Disconnect halves identical	High, tolerances tight	Moderate, tolerances tight	High, Bellows Fab, Asymmetrical halves
Single Point Failures (Fail Open)	One	One	Two	One	One	Five
Wear During Cycling	Minimum, Shaft Guides, Stem Housing	Minimum, Poppet/Disconnect Body, Stem Housing	Minimum, Shaft Guides, Stem Housing	Seal Wear Under Rotating Spheres	Seal Wear Under Rotating Spheres	Moderate, Poppet Spring Degradation, Seal Wear
Positioning Precision Req.	Poppet Guides Maintain Positioning, Popp. Geometry Aids	Valve Body acts as poppet guide	Guides maintain poppet positioning, poppet geometry aids closure	High, to preclude interference of spheres @ Sep. Plane	High, to preclude interference of spheres, tightening ring aids sphere pos.	Moderate, poppet seating must be symmetrical
Susceptibility to Hydraulic Lock	None, poppets never separate	Minimal, flow past poppet face seals until contact	Minimal, flow past poppet face seals until contact	None, fluid displacement only	None, fluid remains in sphere bore	Minimal, flow past poppet face seals until contact
Lateral Movement for Separation	Minimum, (.08 cm, 1/32 in) removed any direction	Minimum, (.08 cm, 1/32 in) removed any direction	Minimum, (.08 cm, 1/32 in) removed one direction only	Moderate (.24 cm, 3/32 in) to protect face of convex sphere	Moderate (.24 cm, 3/32 in) to protect face of convex sphere	High (.95 cm, .375 in), overlap of coupling halves
Spillage Volume	Minimum, face film only	Minimum, face film only plus spanner holes (0.1 cc)	Minimum, face film only plus spanner holes (0.1 cc)	Possible accumulation (0.5 cc) on concave sphere face, & convex face film	Minimum, face film only	Minimum, face film only
Redundant Sealing	Dual seals along all leak paths	Dual seals along leak paths, teflon & metallic seals on poppet face	Dual seals on leak paths, teflon & metallic seals on poppet face	Dual seals along leak paths	Dual seals, tightening ring for seals on spheres	Single seal [illegible] & exit [illegible], dual seals elsewhere
Single Port Flow Area	Angular flow around poppet, then thru guides	Fluted poppet divides flow (four parts)	Annular flow around poppets, then thru guides	Minimum obstruction to flow in disconnect body	Constant flow area thru body	Annular flow around poppets & near component half outlet
Metal/Metal Contact Between Sliding Surfaces	None	Poppet Valve Body	None	Sphere/Disconnect Body	None	Poppet Guides, Poppet Spring
Single-Side Access (For isolation, separation, connection)	Poppet stems (Disconnect top) and coupling mechanism (TBD)	Poppet stems (Disconnect top) and coupling mechanism (TBD) reqd. access	Access reqd. for handle to actuate cam/doglegs, Access to poppet stem	Access to poppet stems and coupling	Access to poppet stems and coupling	Access to coupling sleeve 6.2 radians (360°)
Tools Types Required	For poppet stems & coupling	For poppet stems & coupling	For poppet stem only	For poppet stems & coupling	For poppet stems & coupling	For coupling sleeve only
Maintain Mode During Vibration	Poppet Cam	Poppet Cam	Poppet Cam & ramp/lever interlock maintain mode	Drive Design Force	Poppet Guides, Flow Geometry	Sleeve (Bellows) Design Force
Vacuum Sealing	External cap required for disconnected operations	External cap required for disconnected operations	External cap required for disconnected operations	External cap required for disconnected operations	External cap required for disconnected operations	External cap required for disconnected operations
Susceptibility to Contamination (Metallic & Non-metallic)	Behind poppet face seal	Spanner holes, behind poppet face seals	Spanner holes, behind poppet face seals	Minimal	In stagnant area behind tightening ring	Bellows inside surface, spring area, at poppet seal
Stagnant Areas	Minimal, behind downstream poppet	Minimal, behind downstream poppet	Minimal, behind downstream poppet	Minimal, behind sphere in open position	Area between tightening ring and remainder of body	Bellows Interior
Positive Isolation/ Foolproofing	Ramp/Lever interlock between poppet stem & coupling	Poppets self-sealing under pressure, several foolproofing tech tech. possible	Poppets self-sealing under pressure, spring loaded poppet stem/handle interlock	Several foolproofing methods possible	Foolproofing method TBD, several possible	Poppets close as sleeve is rotated to uncouple

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

E. PRELIMINARY DESIGN REVIEW (PDR)

A preliminary design review for the Positive Isolation Disconnect (PID) was held on December 3 and 4, 1974, at NASA-JSC. The Task 1 concepts developed for the Positive Isolation Disconnect were summarized in a report, MCR-74-470, and the following is a summary of the PDR.

- NASA requested that MMC consider adding ammonia to the fluid compatibility list and revising the operational pressure to 2.76 x 10^6 N/m^2 (400 psig) to be compatible with Shuttle launch loads.
- NASA requested that MMC consider the use of 21-6-9 stainless steel for the metallic material of the PID.
- Two PID concepts were selected for continued engineering assessment during Task 2. The first concept was the individual conical poppets with an integral positive isolation mechanism for the connector and foolproofing techniques. The second concept was the interconnecting spheres with the integral positive isolation mechanism. The ball stems were to be vertical rather than canted to provide support for a fixed ball.
- On each of the two concepts, it was decided to investigate two different sealing concepts. The first concept would be for fluids other than Freon-21 and ammonia which would permit consideration of some elastomers. The second concept would consider the Freon-21 and ammonia fluids where only teflon or compatible filled teflon is acceptable.
- NASA requested that an aluminum model be fabricated for the concept selected. One-half of the PID could be operational with the other half being a simulated dummy. Exact sealing requirements such as dual seals did not have to be duplicated.
- NASA requested that a protective cap be designed to cover the PID face when disconnected and separated to protect the face seals and surfaces.
- The following were miscellaneous NASA design comments relative to the PID:

a) Poppet seat load should be at least 4.83×10^6 N/m^2 (700 psi) for contamination crushing.

b) Prevent lip-seal from reversing under high delta pressure and contamination from being trapped behind seal.

c) Provide positive lock for stem in "open" position to prevent flow pressure closure.

d) Provide a positive location identification for ball valve rotational position to prevent interference of the opposite ball upon rotation.

e) Investigate a design for a two-piece poppet rather than three.

f) Prevent rotation between PID face halves with detent pins or other positive means when connected.

g) Utilize no adhesives in the design for seal retainment, etc.

h) Prevent hydraulic lockup.

i) Investigate face surface seals' reliability by placement of one seal on each face with a recess on on opposite face.

o The following concepts were eliminated from further consideration:

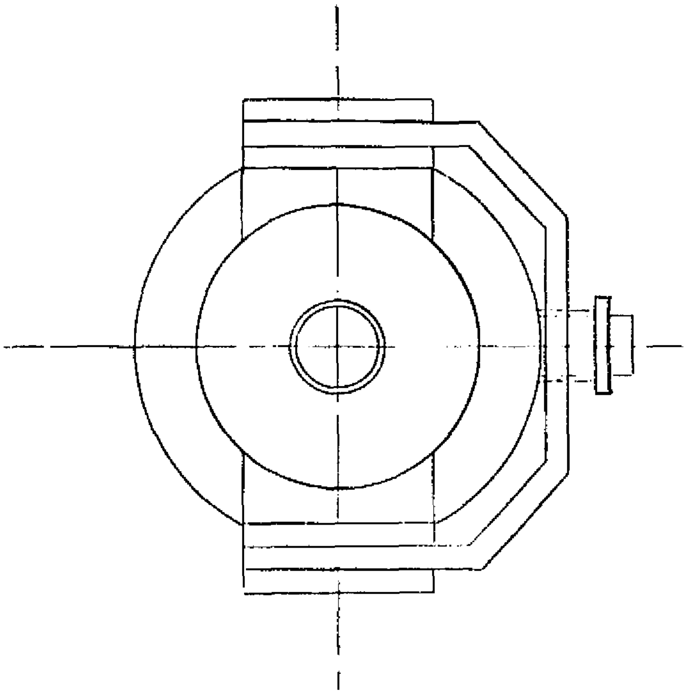
a) Tandem conical poppets - major deficiency concern is that one side of the poppet has no pressure assist for sealing. The pressure behind the poppet is working against the sealing.

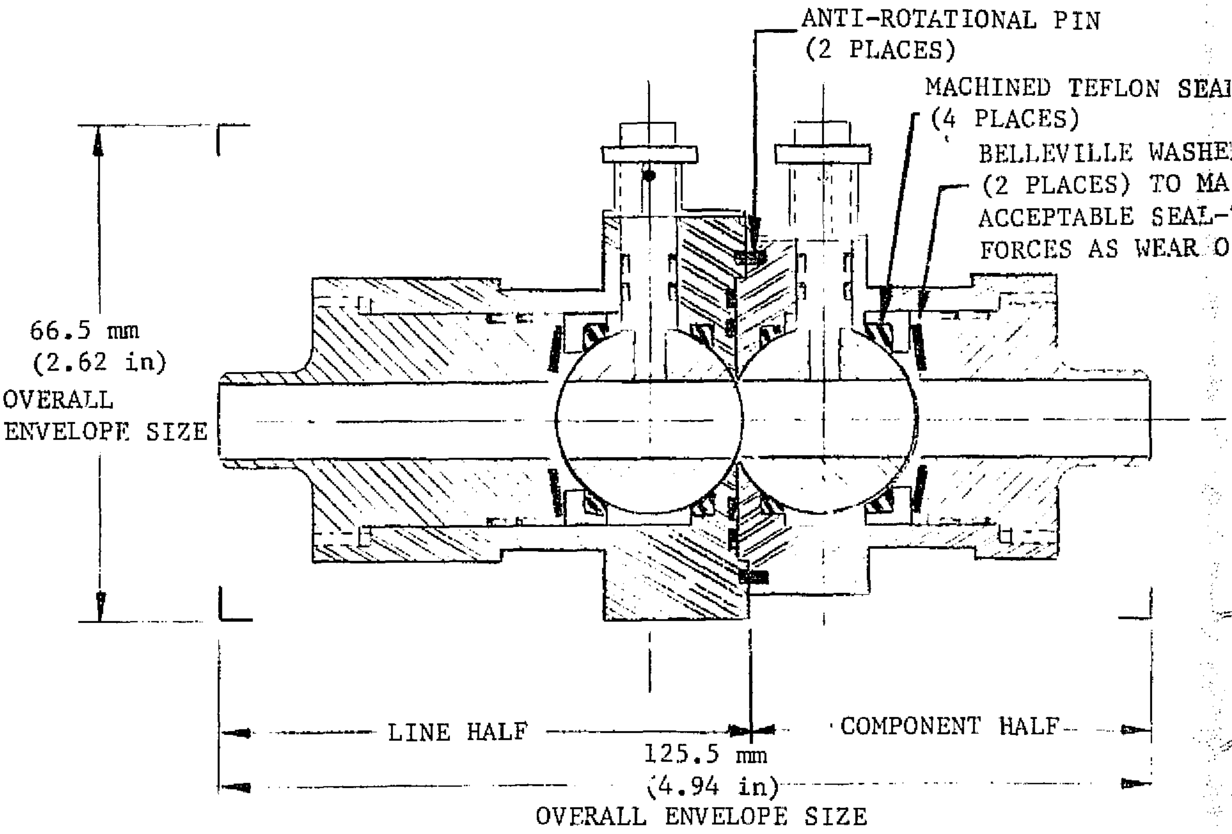
b) Rotating spheres with direct drive - major deficiency concern is the large volume and weight due to the increase in diameter of the sphere. Offset drives with gears are subject to contamination and lockup.

c) Bellow's single operation concept - major deficiency concerns included cost and the use of an internal spring for poppet operation.

d) Coupling techniques eliminated included V-band, nut and fasteners due to loose items upon uncoupling and bayonet due to wear and galling between ramps.

e) Concepts for positive isolation methods (foolproofing) and tools were related closely with the connectors. Therefore, these concepts were eliminated except those associated with the integral positive isolation coupling mechanism.




ANTI-ROTATIONAL PIN
(2 PLACES)
MACHINED TEFLON SEA
(4 PLACES)
BELLEVILLE WASHE
(2 PLACES) TO MA
ACCEPTABLE SEAL-
FORCES AS WEAR O
66.5 mm
(2.62 in)
OVERALL
ENVELOPE SIZE
LINE HALF
COMPONENT HALF
125.5 mm
(4.94 in)
OVERALL ENVELOPE SIZE

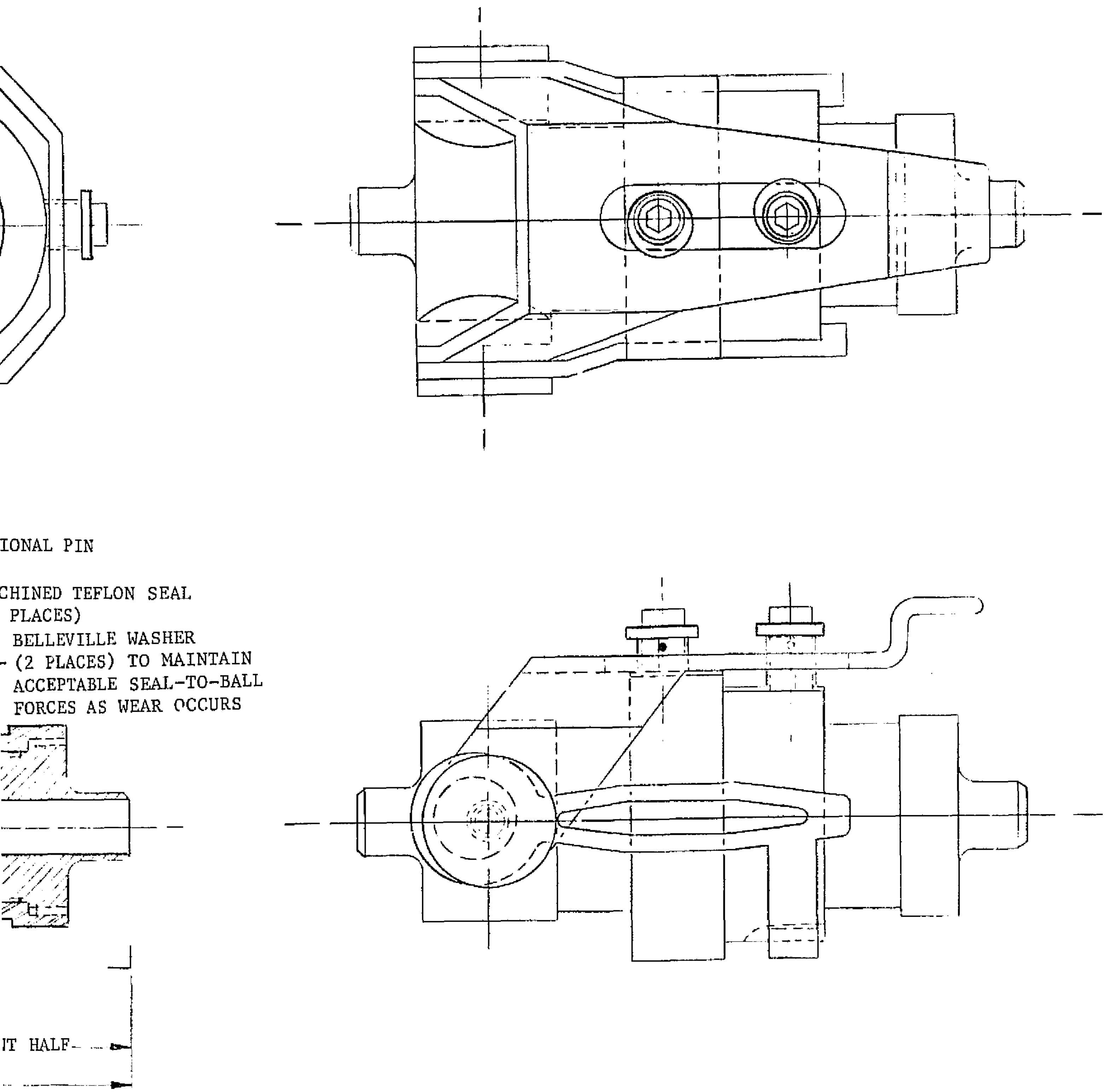


FIGURE IV-1

FLOATING BALL CONCEPT
POSITIVE ISOLATION DISCONNECT
INTEGRAL CAM-LEG COUPLING

Table IV-1 Deficiencies in Floating Ball Concept

1. Design restricted to one seal (no redundancy) due to space limitation. Redundant seals would require a ball approximately 50.8 mm (2") in dia, resulting in a unit twice as bulky and heavy.

2. It is possible for metal-to-metal contact between the ball and the spherical housing depending on amount of wear. A load of 1.58×10^{6} N/m^{2} (1100 psi) on the seal (comprised of preload and fluid pressure) results in 3% compression of the seal. For the design shown, the initial clearance of .25 mm (.010 in) between ball and socket is reduced to .178 mm (.007 in). Wear of .170 mm (.007 in) on the seal will result in metal-to-metal contact.

3. Metal-to-metal scuffing of balls can result in inaccurate ball positioning with .25 mm (.010 in) clearance between balls, positioning must be within .017 radians (1°). Tolerances are critical between valve stem and keyed ball for ball positioning.

4. Critical tolerances also exist between valve stem guide and ball socket. Interference between valve stem and stem guide will result in improper ball-to-seal pressures and wobbling of ball during rotation.

5. Halves are not symmetrical, due to length required on integral cam-leg coupling design.

6. Stagnant areas exist that allow contamination buildup.

7. Fabrication is difficult with spherical surfaces and critical tolerances throughout the design.

8. Contamination is generated from cycling the ball orifice edge across the teflon seal.

9. Trapped pressure exists from seal to separation plane. With .25 mm (.010 in) clearance between ball and socket and ball and ball, the trapped volume under pressure is approximately .1 cc (.006 in^{3}).

10. An increase in fluid pressure results in a proportional increase in actuation torque.

b. Fixed Ball Concept (with Omniseal) - This concept (see Figure IV-2) differs from the floating ball concept in that the ball shaft axis is fixed with the use of close fitting bearings. Sealing around the ball is accomplished with the use of an Omniseal. Overall weight is estimated to be 1.54 kg (3.4 lbs). This concept maintains no metal-to-metal contact between the ball and ball socket. As in the floating ball concept the design provides low pressure drop and is generally insensitive to contamination resulting from the self wiping action. Undesirable features are listed in Table IV-2.

Table IV-2 Deficiencies in Fixed Ball with Omniseal Concept

1. Difficult to control ball-to-seal pressure upon cycling and wear. Leakage path will occur.
2. Design restricted to one seal (no redundancy) due to space limitation. Redundant seals would require a ball approximately 50.0 mm (2") in dia, resulting in a unit twice as bulky and heavy.
3. Metal-to-metal scuffing of balls can result in inaccurate ball positioning. With .25 mm (.010 in) clearance between balls, positioning must be within .017 radians (1°). Tolerances are critical between valve stem and keyed ball for ball positioning.
4. Critical tolerances also exist between valve stem guide and ball socket. Interference between valve stem and stem guide will result in improper ball-to-seal pressures and wobbling of ball during rotation.
5. Halves are not symmetrical, due to length required on integral cam-leg coupling design.
6. Stagnant areas exist that allow contamination buildup.
7. Fabrication is difficult with spherical surfaces and critical tolerances throughout the design.
8. Contamination is generated from cycling the ball orifice edge across the teflon seal.

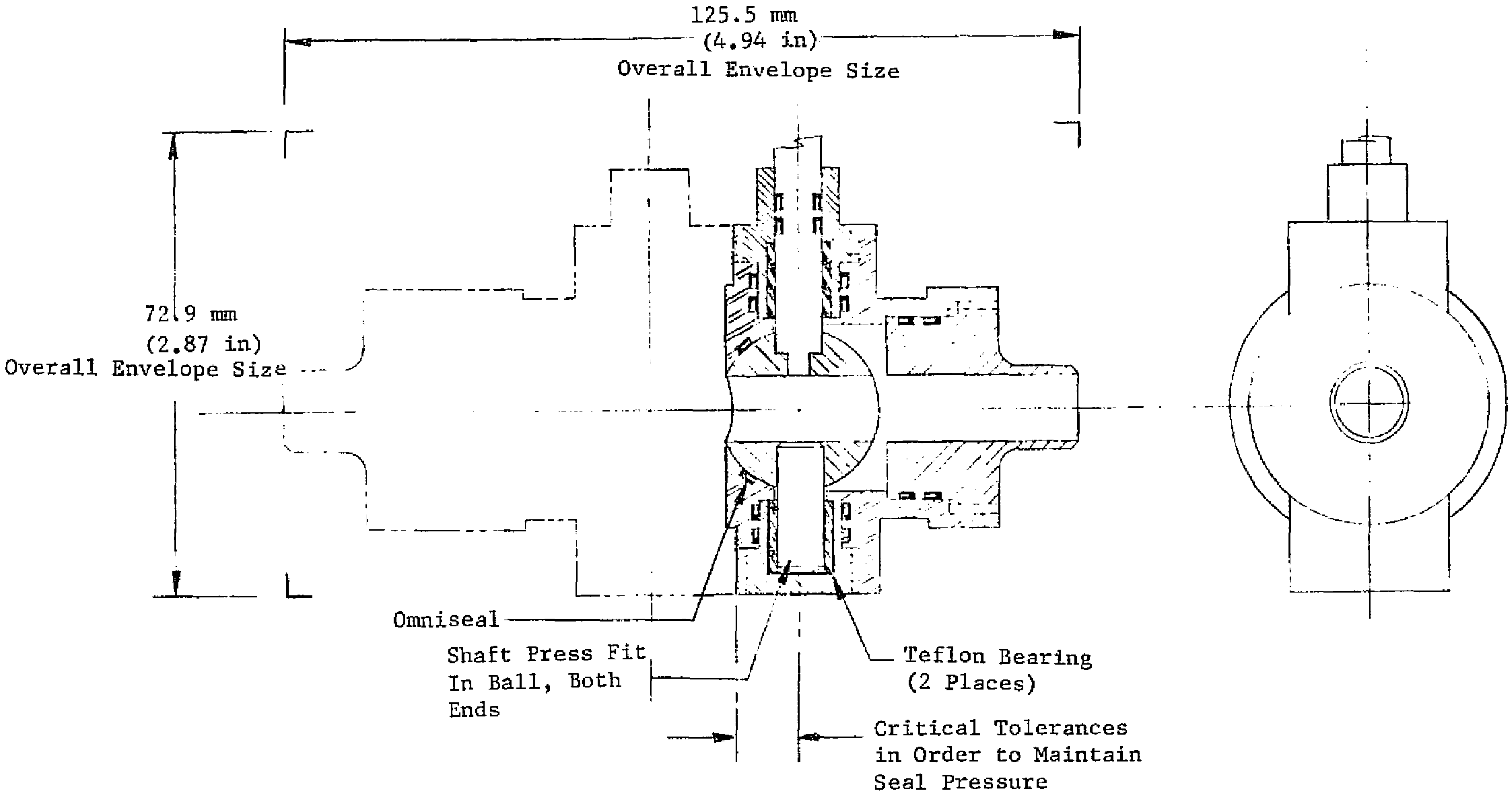


FIGURE IV-2 OMNISEAL FIXED BALL CONCEPT
POSITIVE ISOLATION DISCONNECT

c-2

Table IV-2 continued

9. Trapped pressure exists from seal to separation plane. With .25 mm (.010 in) clearance between ball and socket and ball and ball, the trapped volume under pressure is approximately .1 cc (.006 in^3).

10. An increase in fluid pressure results in a proportional increase in actuation torque.

11. Press fit of bearing shafts to ball add to the difficult assembly.

12. Additional seals required due to added leak paths from bearing caps.

c. <u>Fixed Ball Concept (with Lip-Seal)</u> - This concept (see Figure IV-3) is identical to the fixed ball concept with the Omniseal except the lip-seal is used in place of the Omniseal. The lip-seal is teflon with a stainless spring steel backup ring to provide seal pressure against the ball at all times. Total weight of the unit is calculated at 1.54 kg (3.4 lbs). This concept also maintains no metal-to-metal contact between the ball and ball socket. The design provides low pressure drop and is generally insensitive to contamination. Undesirable features are listed in Table IV-3.

Table IV-3 Deficiencies in Fixed Ball with Lip Seal Concept

1. Difficult to retain seal assembly in proper location without increasing dia. of ball to provide surface area for a threaded retaining ring, thus overall volume and weight would approximately double.

2. Press fit of bearing shafts to ball add to the difficult assembly.

3. Additional seals required due to added leak paths from bearing caps.

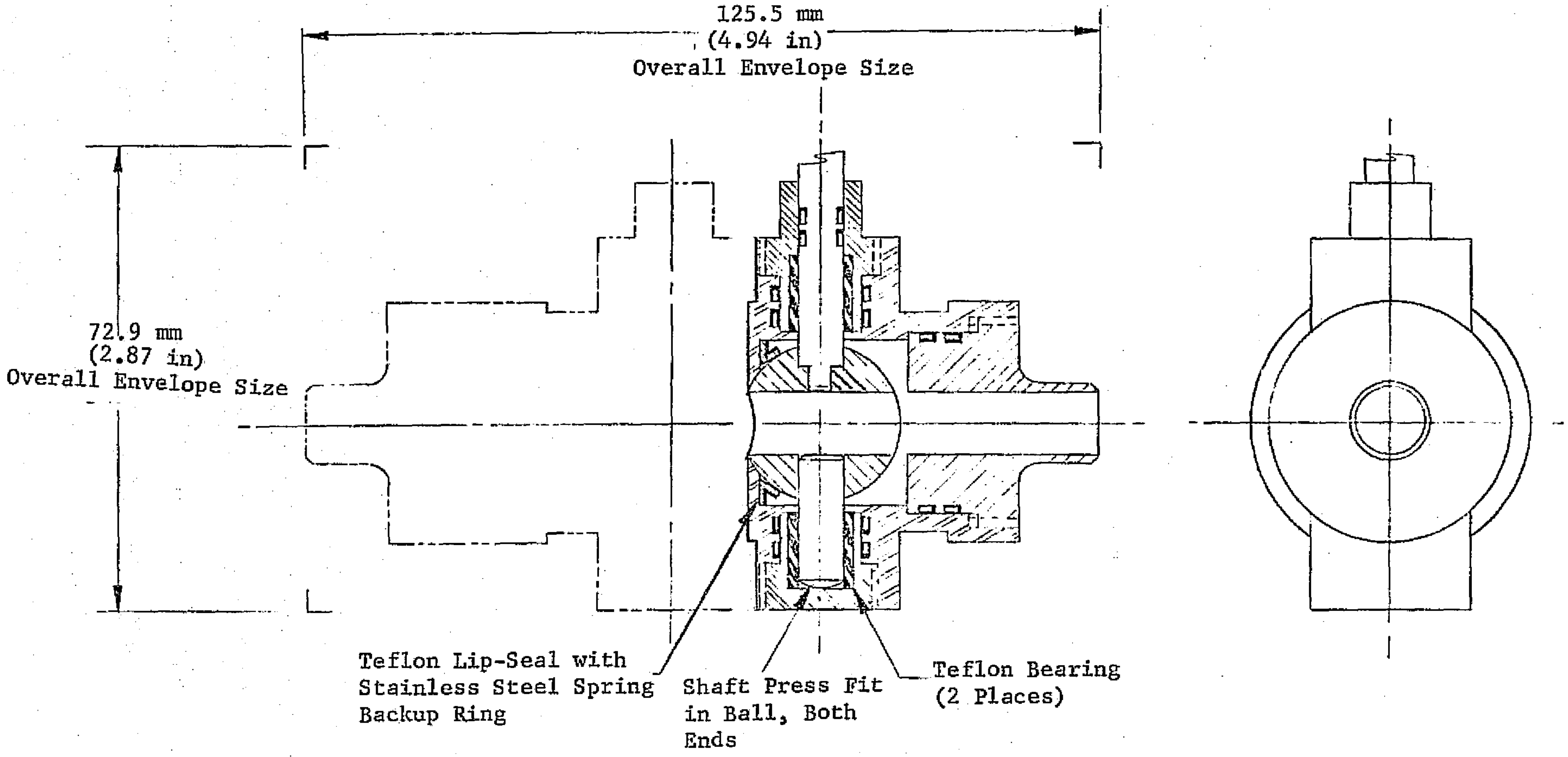


FIGURE IV-3 LIP-SEAL, FIXED BALL CONCEPT POSITIVE ISOLATION DISCONNECT

Table IV-3 continued

4. Design restricted to one seal (no redundancy) due to space limitation. Redundant seals would require a ball approximately 50.0 mm (2") in dia, resulting in a unit twice as bulky and heavy.

5. Metal-to-metal scuffing of balls can result in inaccurate ball positioning. With .25 mm (0.10 in) clearance between balls, positioning must be within .017 radians (1^{o}). Tolerances are critical between valve stem and keyed ball for ball positioning.

6. Critical tolerances also exist between valve stem guide and ball socket. Interference between valve stem and stem guide will result in improper ball-to-seal pressures and wobbling of ball during rotation.

7. Halves are not symmetrical, due to length required on integral cam-leg coupling design.

8. Stagnant areas exist that allow contamination buildup.

9. Fabrication is difficult with spherical surfaces and critical tolerances throughout the design.

10. Contamination is generated from cycling the ball orifice edge across the teflon seal.

11. Trapped pressure exists from seal to separation plane. With .25 mm (0.10 in) clearance between ball and socket and ball and ball, the trapped volume under pressure is approximately .1 cc (.006 in^3).

12. An increase in fluid pressure results in a proportional increase in actuation torque.

<u>2. Opposing Poppet Concept</u> - The opposing poppet concept (see Figure IV-4) as described in Task 1 is a simple straight forward concept that meets all the design requirements. This concept also uses the integral coupling mechanism. Overall size is 177.8 mm (7.0 inches) in length with a height of 76.2 mm (3.0

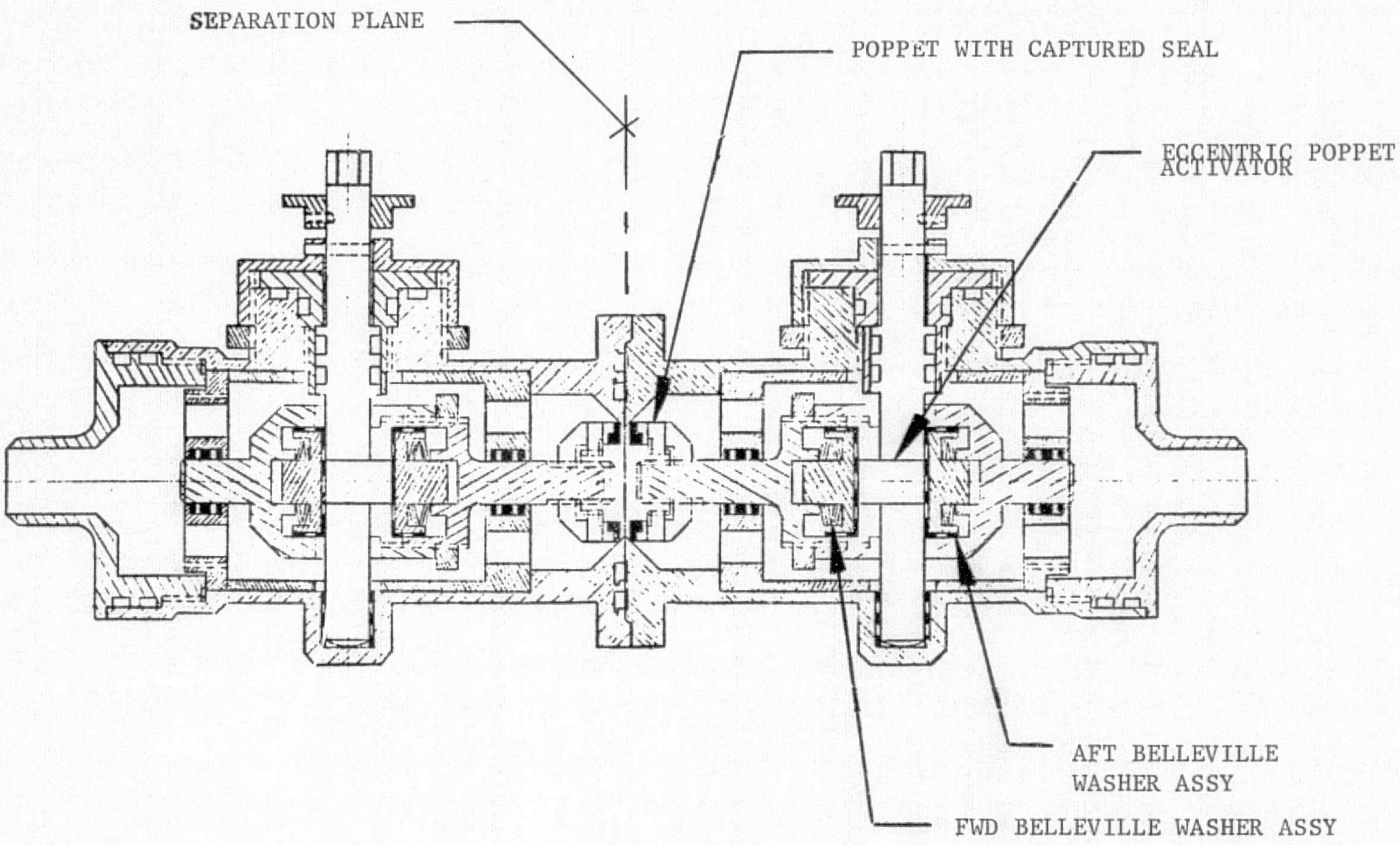


FIGURE IV-4 OPPOSING POPPET CONCEPT

inches). Weight is calculated to be .862 kg (1.9 lbs). This design uses Belleville washers to provide the loading on the poppets. The design is highly reliable and easy to operate. The isolation technique is positive and can maintain this mode during vibration. The design tolerances on this concept are met easier than on the rotating sphere concepts.

3. Selected Concept - It was Martin Marietta's opinion that the ball concept has many more deficiencies than the individual conical poppets concept. When performing the 5000 cycle test, it is doubtful that the ball concept could meet the design requirements. In addition, the weight of 1.54 kg (3.4 lbs) is greater than that of the poppet concept, which is .862 kg (1.9 lbs), while overall size is approximately equal.

In summary, the ball concept was deleted from further consideration and the poppet concept was selected for continued development toward meeting the design requirements for the positive Isolation Disconnect.

C. SEMI-FUNCTIONAL MODEL OF SELECTED CONCEPT

To further evaluate the opposing poppet concept, a semi-functional model was fabricated and tested. The model incorporated the integral clamping mechanism as shown in Figure IV-5 and IV-6. Figure IV-7 shows the separation plane faces where the poppet and interface seal can be seen. Figure IV-8 illustrates the detail parts of the semi-functional model which include the poppet, poppet shaft, poppet shaft guides, valve stem (with cam) and the housing.

Pressurized gas and water was used as test fluids for checking leak rates at the poppet and interface seal. Table IV-4 summarizes the test conditions and the corresponding results. The results were excellent and verified the functional characteristics of the opposing poppet concept.

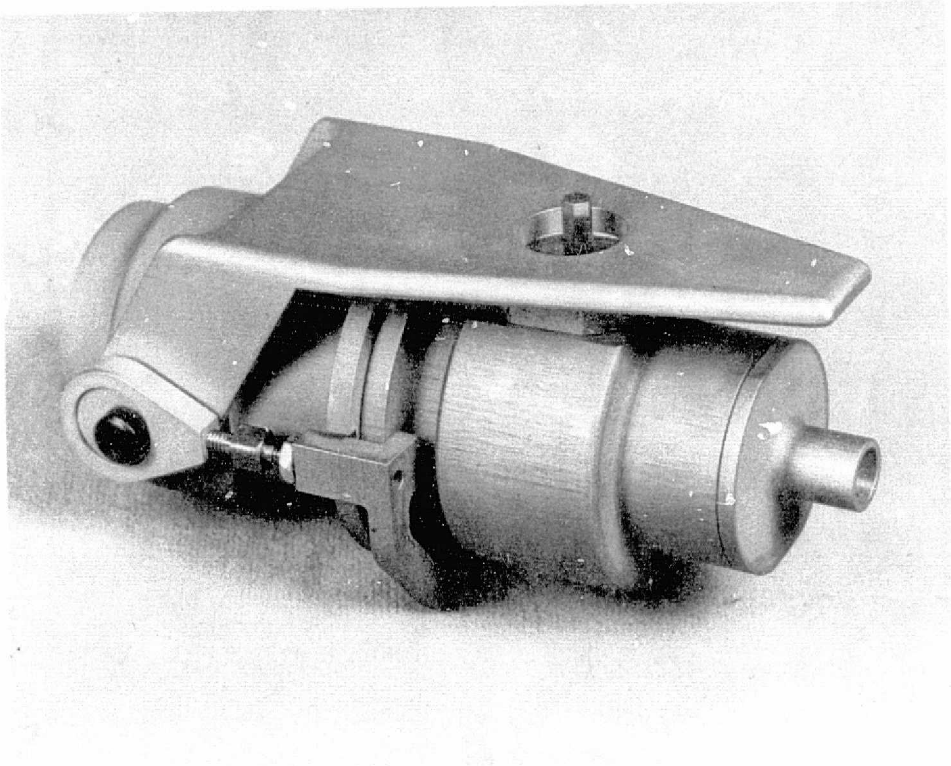


FIGURE IV-5 COUPLING MECHANISM FULLY CLAMPED

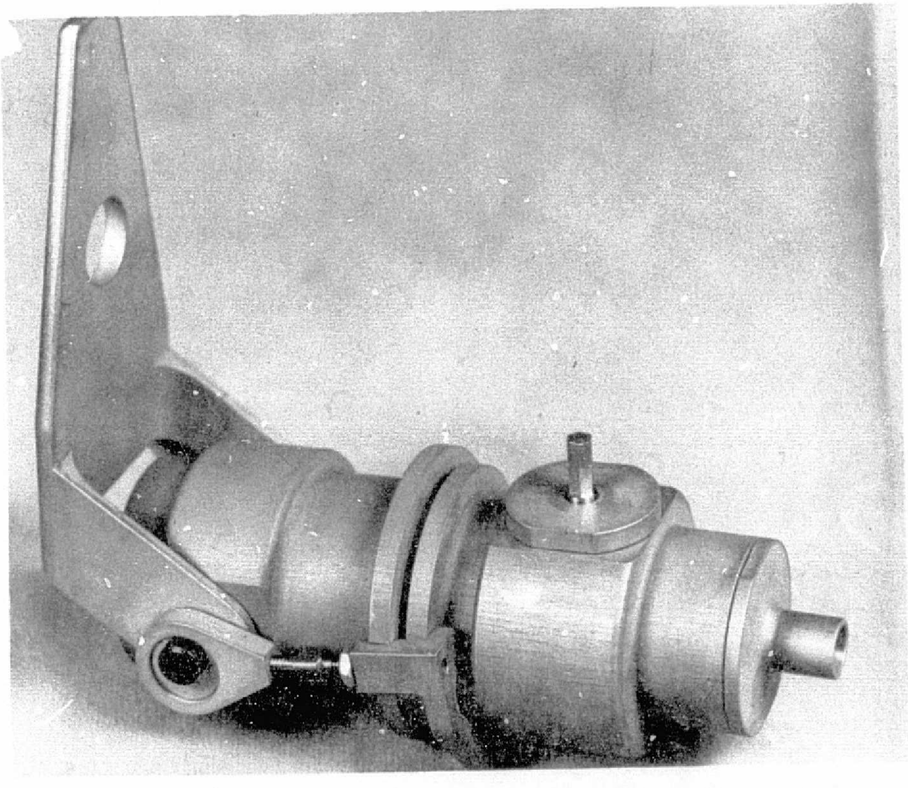


FIGURE IV-6 COUPLING MECHANISM COMPLETELY RELEASED

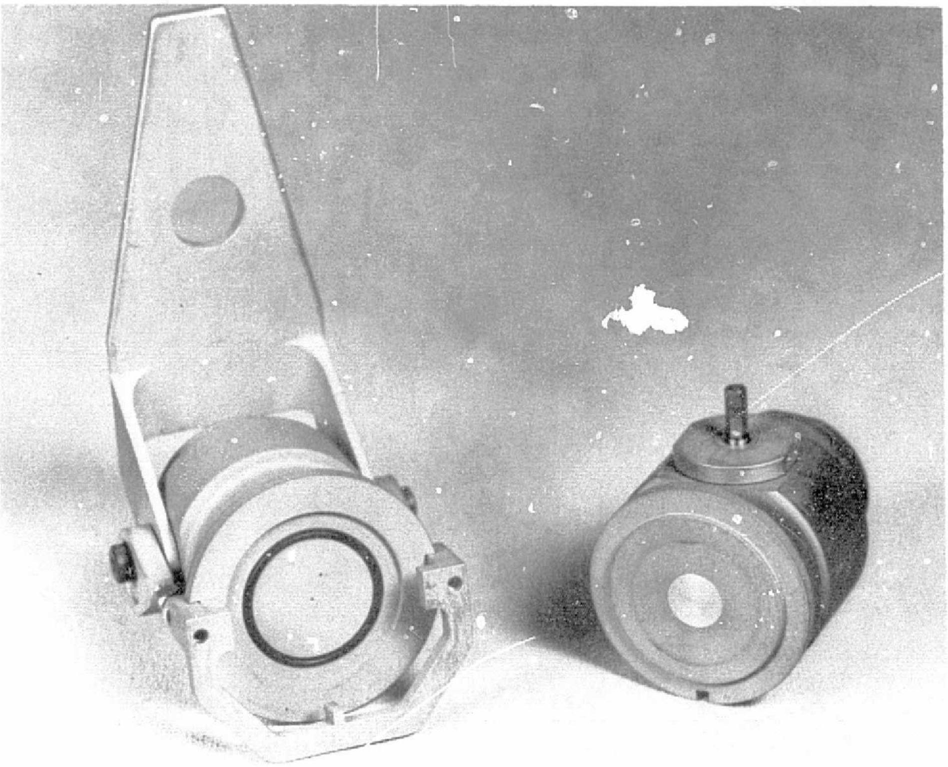


FIGURE IV-7 SEMI-FUNCTIONAL MODEL DISCONNECTED

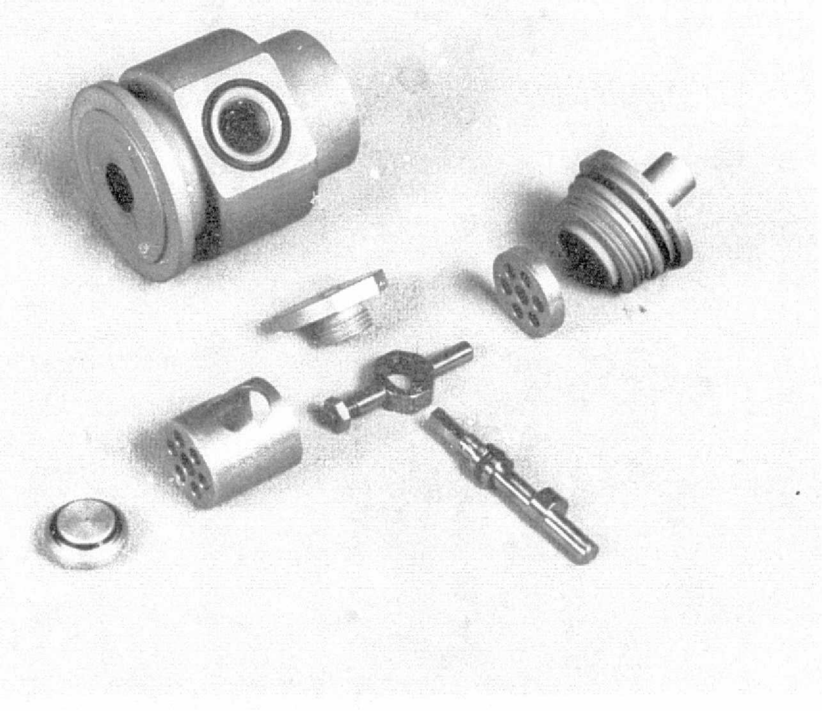


FIGURE IV-8 SEMI-FUNCTIONAL MODEL PARTS

Table IV-4 Semi-Functional Model Tests

I. Nitrogen Gas: 34.46 x 10^3 and 51.71 x 10^4 N/m^2 (5 and 75 psig)

Test Condition:	Results:
Leakage: Unit Submerged in H_2O	
a.) Disconnected, Poppet Closed	Bubble Formed at Valve Stem Gland and at Poppet Seal, But Did Not Release
b.) Connected, Poppet Opened	No Bubbles Formed or Released
c.) Connected, Poppet Opened and Then Closed, Disconnected	Three Bubbles Observed
d.) Poppet Closed, Connected Disconnected	Three Bubbles Observed (Same as C above)
Gas Expansion:	
a.) Connected, Poppet Opened and Then Closed, Disconnected	No Noticeable Gas Expansion

II. Water: 20.69 x 10^4 - 34.46 x 10^4 N/m^2 (30 - 50 psig)

Test Condition:	Results:
Leakage:	
a.) Disconnected, Poppet Closed	No Leakage or Drop Formation
b.) Connected, Poppet Opened	No Leakage or Drop Formation
Hydraulic Lockup:	
a.) Connected, Poppet Opened, Then Closed, Disconnected	Stem Operation Positive, No Bubbles Formed or Released
Fluid Loss:	
a.) Connected, Poppet Opened, Then Closed, Disconnected	Wet Surface Observed Within Seal Area, No Formation or Release of Drops

D. FINAL CONFIGURATION

The final configuration is a result of all previous evaluations and testing. The final design drawings are shown in Figure IV-9. The PID consists of two coupled disconnect halves, each capable of fluid isolation with essentially zero clearance between them providing for zero leakage upon disconnect half disengagement.

1. Isolation Technique - Fluid isolation is accomplished through the use of individually operated opposing poppets as shown in Figures IV-10 and IV-11. The poppets are 12.7 mm (.50 in.) in diameter with a taper of 0.785 radians (45 degrees) and the seats are machined at the same angle. The poppet is attached to the poppet shaft which is 6.35 mm (0.25 in.) in diameter and 38.1 mm (1.5 in.) long with a yoke section near mid-length. The poppet shaft is centered and supported by guide rings that are positioned and located by the internal bore of the valve body. The poppet shaft yoke is sized to allow the insertion of a cam lobed valve stem and a series of leaf springs. The valve stem is 6.35 mm (.25 in.) in diameter and the cam eccentric is 10.29 mm (0.405 in.) in diameter. The distance between centers of the valve stem shaft and the eccentric is 1.98 mm (0.078 in.) that provides for 3.96 mm (0.156 in.) poppet shaft movement for 3.14 radians (180 degrees) rotation of valve stem. The poppet is adjusted on the poppet shaft so that it mates with the seat when the high point of the cam is 0.52 radians (30 degrees) off TDC. When the cam is rotated to TDC, the leaf springs are deflected 0.355 mm (.014 in.) which provides a loading of 444.8 newtons (100 lbs) on the poppet. With this predetermined loading there is no need for calibrated tooling for valve opening or closure.

The design provides for .087 radians (5 degrees) over TDC for positive locking of poppet in the closed position. A pin on the valve stem comes in contact with a pin stop to maintain this position. If the pin stop became loose, the cam would come in contact with the side of the yoke limiting the past TDC to .26 radians (15 degrees) as a safety feature. The .087 radians (5 degrees) movement past TDC reduces the spring deflection by .0127 mm (.0005 in.). With the 444.8 newtons (100 lbs) load on the poppet and with the low surface area of the elastic seal and metal-to-metal seal, a loading of 2.4×10^7 N/m^2 (3500 psi) exists on the elastic seal (which is 5 times greater than the recommended loading for crushing possible contaminants) and a loading of

TOOL REQUIREMENT

OPERATION: 3/16 SOCKET WRENCH

MAINTENCE: CRESCENT WRENCH WITH OPENING TO 1.50"
STANDARD SCREW DRIVER
SET OF ALLEN WRENCHES

SET-UP INSTRUCTIONS

DISCONNECT HALF:

1. DIMENSION FROM SEPARATION PLANE TO HIGH POINT OF CAM AT 30' OFF CENTER TO BE IDENTICAL TO THE DIMENSION FROM THE AFT SURFACE OF BACK SPRING (UNDEFLECTED) TO FWD SURFACE OF POPPET.
2. -014 PIN STOP TO BE INSTALLED WITH STOP SURFACES 5° OFF-CENTERLINE BOTH FWD AND AFT.

COUPLER: WITH HANDLE TILTED BACK 25°; TIGHTEN -042 ADJUSTMENT SCREW UNTIL A SLIGHT COMPRESSION OF THE BELLEVILLE WASHERS IS OBSERVED AND CLAMP IS IN CONTACT WITH FLANGE. MAINTAINING THIS SETTING, INSTALL -095 END CAP SCREWS.

FLAGNOTES

1▷ POPPET AND VALVE BODY SEAT TO BE MATCHED SETS AND MACHINED ACCORDINGLY FOR A FLUSH SURFACE WHEN MATED.

2▷ MOLY-X HARD COAT (DRY LUBRICANT) ON EXTERIOR SURFACE

3▷ CLEAR ANODIZE HARD COAT ON ALUMINUM SURFACES

4▷ PASSIVATE STAINLESS STEEL SURFACES

GENERAL NOTES

1. BREAK ALL SHARP CORNERS
2. LUBRICATE THREADS (TO PREVENT GALLING) WITH A DRY LUBRICANT. APPLY TEFLON SPRAY, CONTACT ENGINEERING FOR ACCEPTABLE SUBSTITUTES.
5. LUBRICATE O-RINGS AND METAL PARTS IN CONTACT WITH THE O-RING. APPLY SILICONE GREASE (DO NOT USE PETROLEUM BASE LUBRICANTS).

A	M/L	CHANGED QTY AND MTL ON DET-005; REPLACED TYPE OF SEAL ON DET-006 AND -030; CHANGED SIZE OF DETAILS -021, -023 AND -047	6-18-75	CHG BY - T. TONCONIEC
	F-6	IN SET-UP INSTRUCTIONS - 30° WAS 40°		
	B-6	IN GENERAL NOTES - LUBRICANTS SPECIFIED		
	M/L	SEAL MATERIAL SPECIFIED	6-18-75	G. Roman

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NING TO 1.50°

SEPARATION PLANE TO HIGH POINT
OFF CENTER TO BE IDENTICAL TO THE
THE AFT SURFACE OF BACK SPRING
TO FWD SURFACE OF POPPET.

TO BE INSTALLED WITH STOP SURFACES
LINE BOTH FWD AND AFT.

TIGHTEN -042 ADJUSTMENT SCREW
OF THE BELLEVILLE WASHERS IS OBSERVED
TH FLANGE. MAINTAINING THIS SETTING,
S.

MATCHED SETS AND MACHINED
EN MATED.

EXTERIOR SURFACE

MINUM SURFACES

WITH A DRY LUBRICANT.
FOR ACCEPTABLE SUBSTITUTES.

CONTACT WITH THE O-RING.
EUM BASE LUBRICANTS)

FIGURE IV-9 PID DETAIL DESIGN DRAWINGS

	2									-053	6D	3	JAMB NUT	3/4 RD x 1/4 L	21-6-9 CRES	AMS 5656	4
	2									-052	6D	3	RETAINER RING	3/4 RD x 1/4 L	21-6-9 CRES	AMS 5656	4
	2									-051	8B	3	POPPET SEAL	3/4 RD x 1/4 L	TEFLON		
	2									-050	7D	3	POPPET	1" RD x 1/2 L	21-6-9 CRES	AMS 5656	4
		2								-048	4E	3	JAMB NUT	1" RD x 1/2 L	21-6-9 CRES	AMS 5656	4
		2								-047	4C	3	POPPET SEAL	PARKER O-RING # 2-014 (.489 I.D.) ETHYLENE PROPYLENE			
			2							-046	6A	5	HANDLE	1/4 x 2 x 4	6061-T6 AL	QQ-A-250/11	3
			4							-045	7G	4	JAMB SCREW	3/4 RD x 1/2 L	21-6-9 CRES	AMS 5656	4
			8							-044	4H	2	BELLEVILLE WASHER	.190 I.D. x .375 O.D.			
			2							-04	3E	5	SLIDE CLAMP	1 x 1 1/4 x 2 1/2	21-6-9 CRES	AMS 5595	4
			4							-042	7F	4	ADJUSTMENT SCREW	1/2 RD x 1 1/2 L	21-6-9 CRES	AMS 5656	4
			4							-041		4	COLLAR	1/2 x 1 x 2	21-6-9 CRES	AMS 5595	4
			4							-040	3G	4	RETAINER SCREW	1" RD x 3/4 L	21-6-9 CRES	AMS 5656	4
			4							-038	2G	4	WASHER	1/32 SH x 1 x 1	TEFLON		
			4							-037	1E	4	BEARING STRIP	1/32 SH x 1/2 x 1	TEFLON		
			2							-036	3B	5	PIVOT LEG (OPP -035)	3/4 x 2 x 3	6061-T6 AL	QQ-A-250/11	3
			2							-035	3B	5	PIVOT LEG	3/4 x 2 x 3	6061-T6 AL	QQ-A-250/11	3
			8							-034	5F	2	SOCKET HD CAP SCREW	8-32 THD x 5/16 LONG			
				1	1	1	1			-033	7F	3	YOKE	3/8 x 3/4 x 6	21-6-9 CRES	AMS 5595	4
				1	1					-032	8E	4	TUBE ADAPTER	1 1/2 RD x 3/4 L	21-6-9 CRES	AMS 5656	4
						1	1			-031	8E	4	TUBE ADAPTER	1 1/2 RD x 3/4 L	21-6-9 CRES	AMS 5656	4
Ⓐ						1	1			-030	4B	2	BOSS SEAL	SSD3-12	MARTIN STANDARD		
				1	1					-028	4B	2	BOSS SEAL	PARKER O-RING # S-912 (.924 I.D.) VITON			
				1	1	1	1			-027	3F	3	AFT POPPET GUIDE	1 1/4 RD x 1 1/4 L	21-6-9 CRES	AMS 5656	4
				1	1	1	1			-026	5F	3	FWD POPPET GUIDE	1 1/4 RD x 1/2 L	21-6-9 CRES	AMS 5656	4
				1		1				-025	3B	6	VALVE BODY	2 1/4 RD x 2 1/4 L	21-6-9 CRES	AMS 5656	4
							1			-024	4B	2	FACE SEAL	OMNISEAL # AR10204-025A10 (1.312 O.D.)			
Ⓐ					1					-023	4B	2	FACE SEAL	PARKER O-RING # 2-024 (1.114 I.D.) ETHYLENE PROPYLENE			
							1			-022	4B	2	FACE SEAL	OMNISEAL # 10204-020A10 (1.00 O.D.)			
Ⓐ					1					-021	4B	2	FACE SEAL	PARKER O-RING # 2-0[illegible] (.801 I.D.) ETHYLENE PROPYLENE			
				1	1	1	1			-020	6H	3	AFT POPPET SHAFT BEARING	1/32 SH x 1 1/2 x 1	TEFLON		
				1	1	1	1			-018	3B	4	VALVE STEM	1/2 RD x 2 1/4 L	21-6-9 CRES	AMS 5656	2
				2	2					-017	3C	2	SHAFT SEAL	PARKER O-RING # 2-010 (.239 I.D.) VITON			
						2	2			-016	3C	2	SHAFT SEAL	OMNISEAL # AR 10105-010A10 (.284 I.D.)			
				1	1	1	1			-015	7E	4	STEM RETAINER	1" RD x 1" L	21-6-9 CRES	AMS 5656	4
				1	1	1	1			-014	5E	4	PIN STOP	1" RD x 1/2 L	21-6-9 CRES	AMS 5656	4
				4	4	4	4			-013	3C	2	FILLISTER HD SCREW	2-56 THD x 1/4 L			
				1	1	1	1			-012	3E	4	FOOLPROOF CAP	3/4 RD x 1/2 L	6061-T6 AL	QQ-A-225/8	3
		2								-011	4B	3	POPPET	1" RD x 1/2 L	21-6-9 CRES	AMS 5656	4
				1	1	1	1			-010	C4	2	DOWEL PIN	1/16 DIA x 3/8 L			
				1	1	1	1			-008	C4	2	SET SCREW	2-56 THD x 1/4 L	SOCKET HEAD		
				1	1					-007	2A	2	BOSS SEAL	PARKER O-RING # 3-906 (.568 I.D.) ETHYLENE PROPYLENE			
Ⓐ						1	1			-006	2A	2	BOSS SEAL	SSD3-6	MARTIN STANDARD		
Ⓐ				5	5	5	5			-005	H3	3	LEAF SPRING	.016 x 1/2 x 1	17-7 PH STAINLESS HEAT TREAT TO RH950		
				1	1	1	1			-004	6A	3	FWD POPPET SHAFT BEARING	1/32 SH x 3/4 x 1	TEFLON		
					1					-003	7B	6	VALVE BODY	2 1/2 RD x 2 1/4 L	21-6-9 CRES	AMS 5656	4
							1			-002	7B	6	VALVE BODY	2 1/4 RD x 2 1/4 L	21-6-9 CRES	AMS 5656	4
								1	1	-001	7E	5	END CAP	1 5/8 RD x 1 1/2 L	6061-T651 AL	QQ-A-225/8	3
						1	1			-089			POPPET ASSY				
				1	1					-079			POPPET ASSY				
					1		1			-069			COUPLING ASSY				
								1		-059			COMPONENT HALF ASSY				
								1		-049			LINE HALF ASSY				
									1	-039			COMPONENT HALF ASSY				
									1	-029			LINE HALF ASSY				
										-019			PID ASSY FOR 1/4" LINE (ELASTOMER SEALS)				
										-009			PID ASSY FOR 1/2" LINE (TEFLON SEALS)				

SH

T. TONCONIEC

G.G. Roman 7/18/75

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MARTIN MARIETTA CORPORATION

POSITIVE ISOLATION
DISCONNECT

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1 OF 6

FOLDOUT FRAME 2

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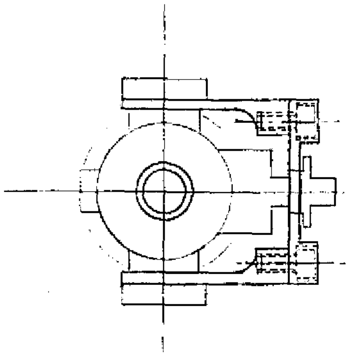

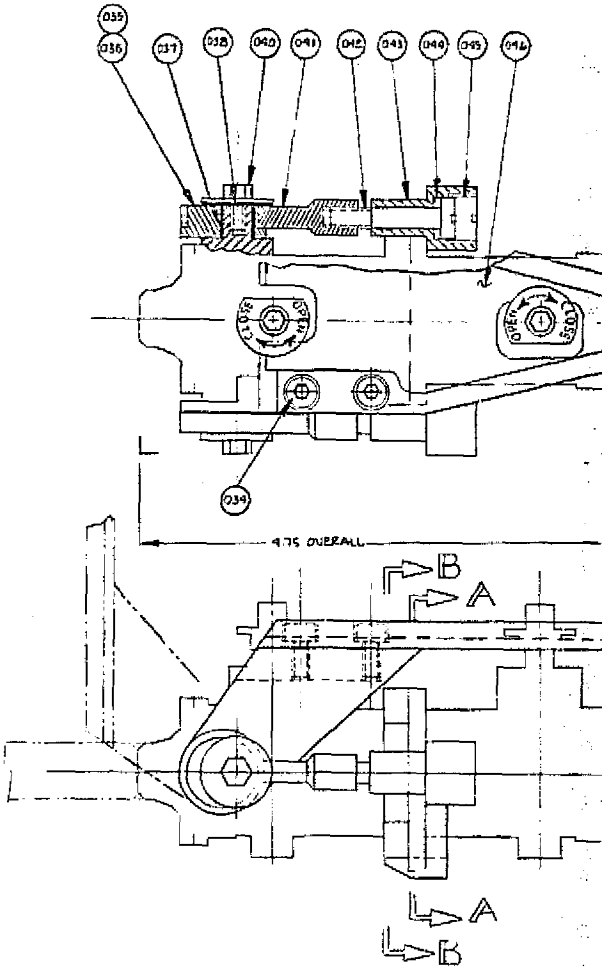

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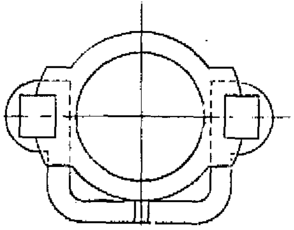
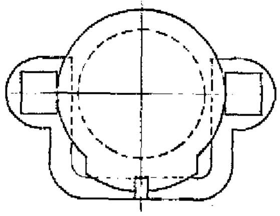


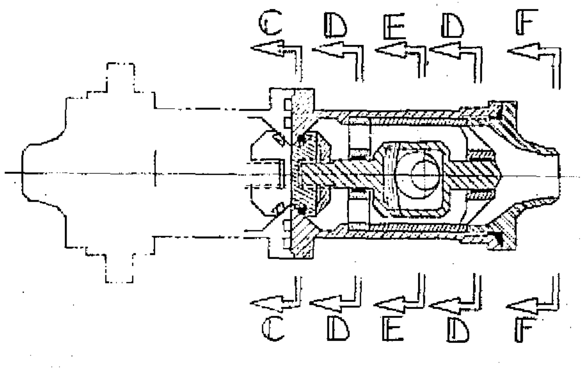
SECTION B-B

FLANGE ON -029, 049

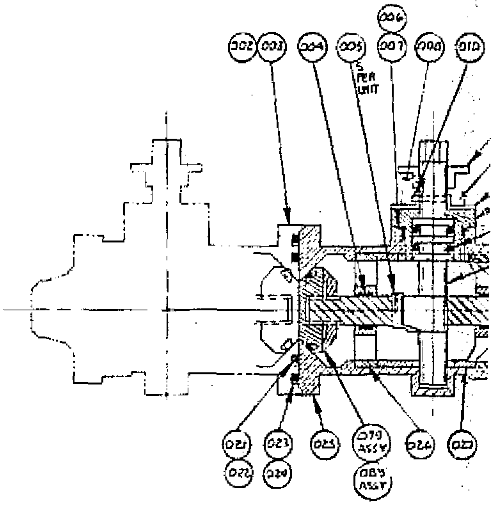


SECTION A-A

FLANGE ON -039, 059



PLAN VIEW OF DISCONNECT



-029 LINE HALF ASSY
(-049)

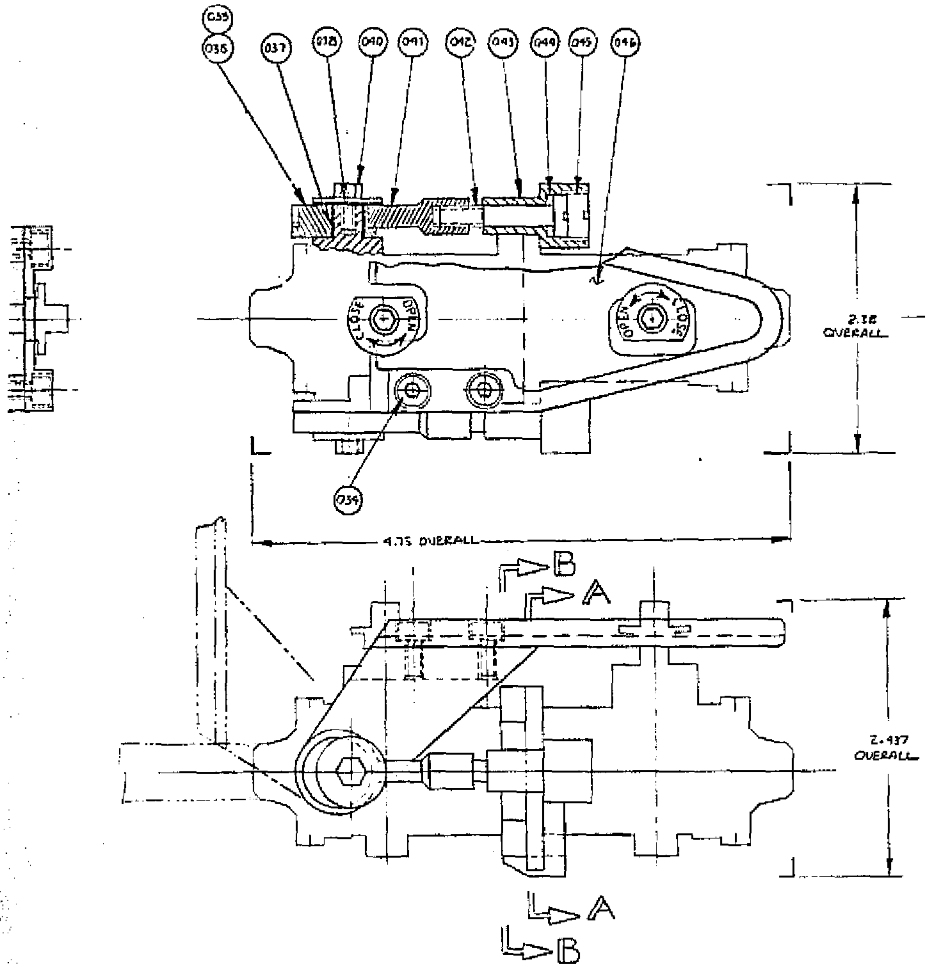
-039 COMPON
(-059)

-009 POSITIVE ISOLATION DISCON
(-019)

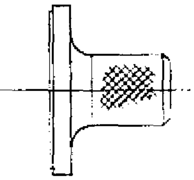
FOLDOUT FRAME

REVISIONS

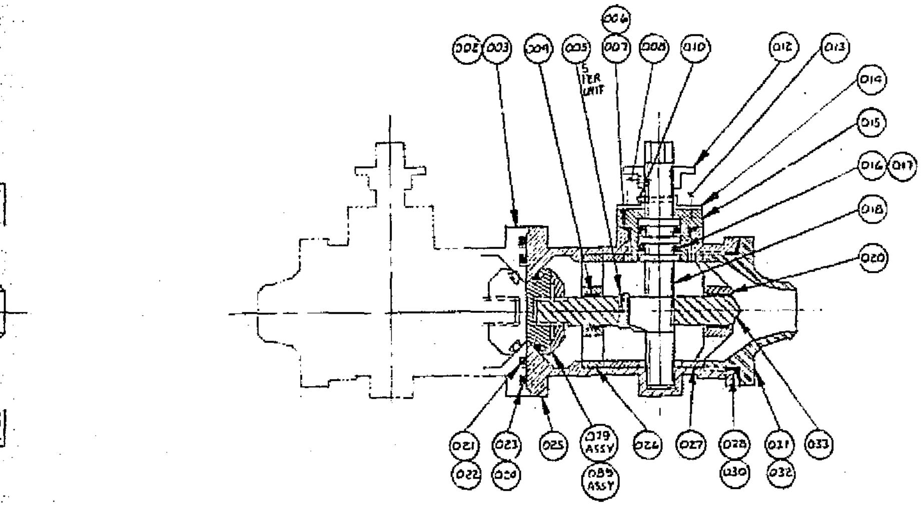
A	F/D	CHANGED NUMBER OF -005 SPRINGS FROM 4 TO 5	[illegible] [illegible]	[illegible] [illegible]



- 069 COUPLING ASSY



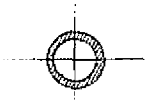
-001 END CAP



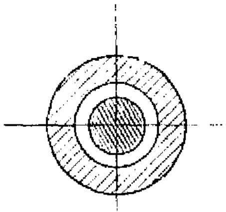
-029 LINE HALF ASSY
(-049)

-039 COMPONENT HALF ASSY
(-059)

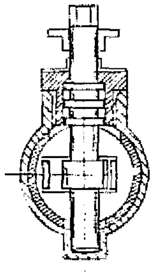
-009 POSITIVE ISOLATION DISCONNECT ASSEMBLY
(-019)



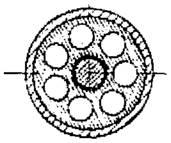
SECTION F ~ F
FLOW AREA ≈ .145 IN²



SECTION C ~ C
FLOW AREA ≈ .193 IN²



SECTION E ~ E
FLOW AREA ≈ .365 IN²

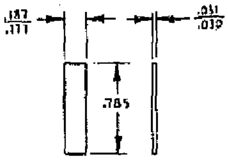


SECTION D ~ D
FLOW AREA ≈ .264 IN²

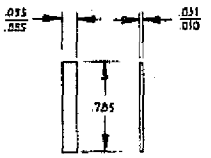
FIGURE IV-9 (Con't)

A	E	04236	NAS9-14376-A
	2:1		2

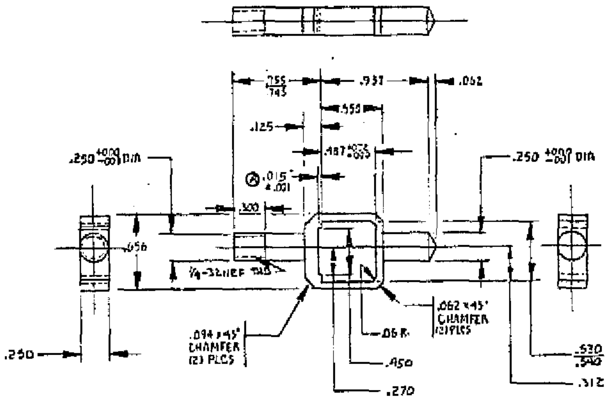
FOLDOUT FRAME 2



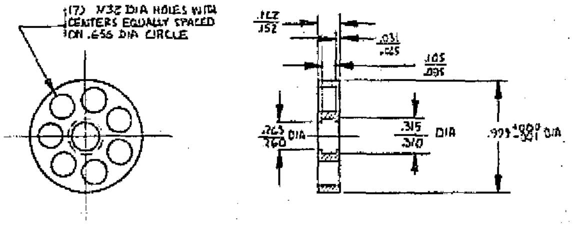
-020 AFT POPPET SHAFT BEARING



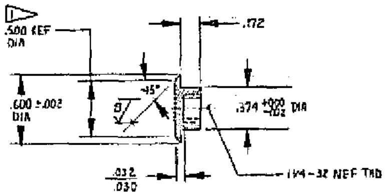
-004 FWD POPPET SHAFT B



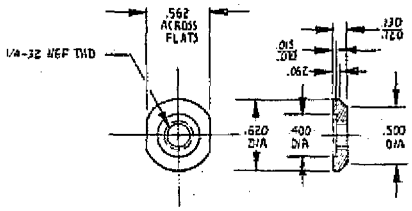
-033 YOKE



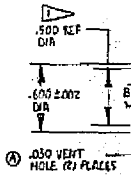
-026 FWD POPPET GUIDE

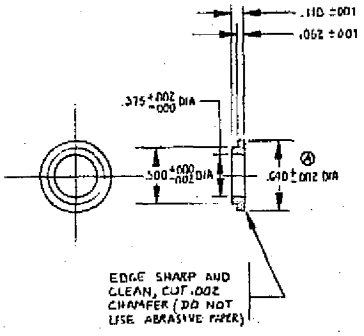


-050 POPPET

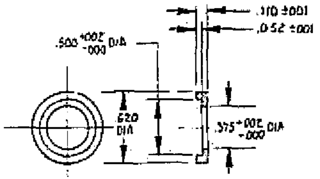


-053 JAMB NUT

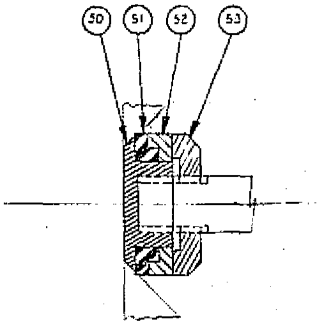




-051 SEAL

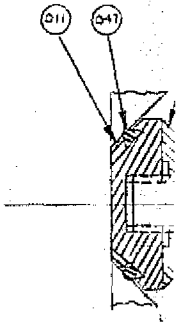


-052 RETAINER RING



-089 POPPET ASSY

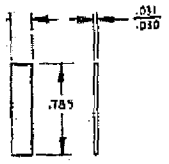
(SCALE 4:1)



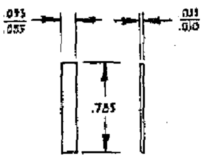
-079 POPPE

FOLDOUT FRAME

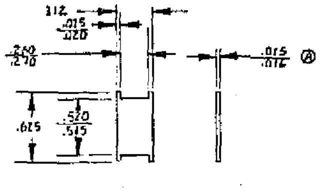
A	7-G	DIM .015 WAS .010	5 1975	ENG OT T CONCORD
	1-H	DIM .017/.016 WAS .021/.020		
	7-G	DIM .640 WAS .630		
	7/D	.030 VENT HOLES ADDED TO -011 DETAIL	3-5-75	G. Rossm



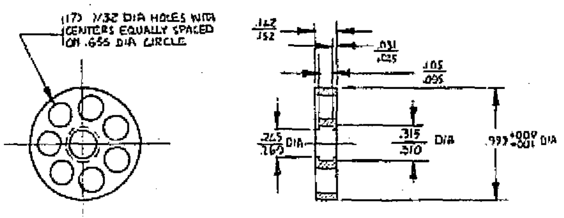
0 AFT POPPET
AFT BEARING



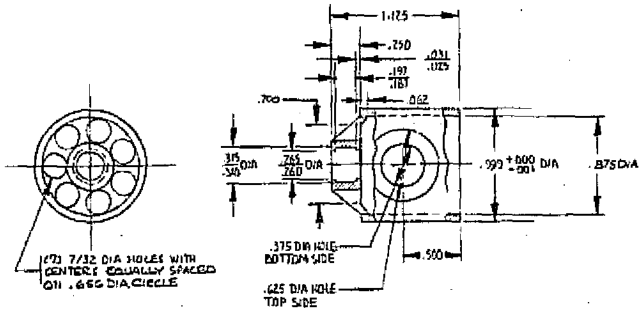
-004 FWD POPPET SHAFT BEARING



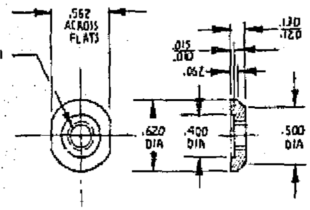
-005 LEAF SPRING



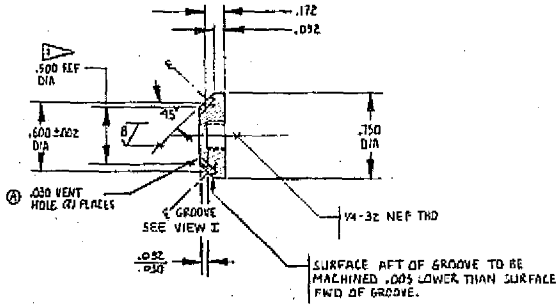
-026 FWD POPPET GUIDE



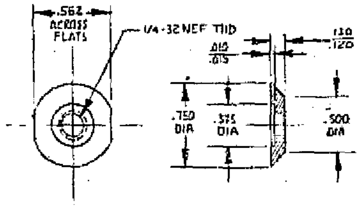
-027 AFT POPPET GUIDE



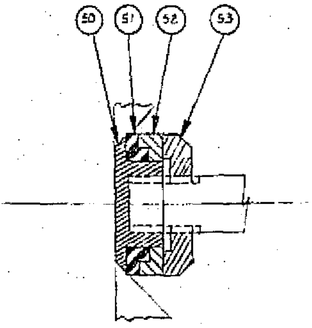
-053 JAMB NUT



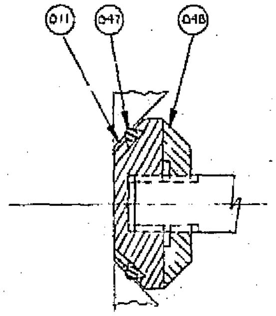
-011 POPPET



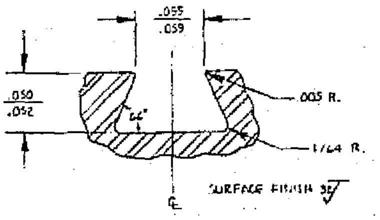
-048 JAMB NUT



-089 POPPET ASSY
(SCALE 4:1)



-079 POPPET ASSY
(SCALE 4:1)

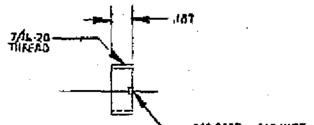


VIEW I
BASIC DOVETAIL GROOVE

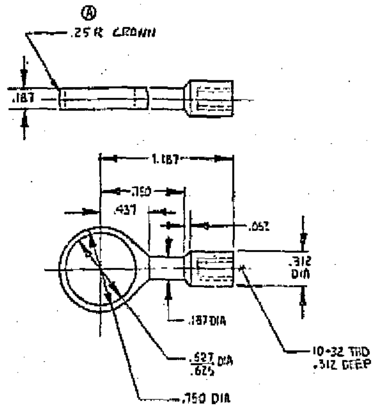
FIGURE IV-9 (Con't)

A	E	04236
	NAS9-14376-A	
	2	3

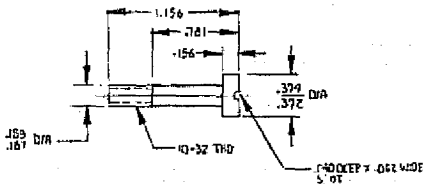
EPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR



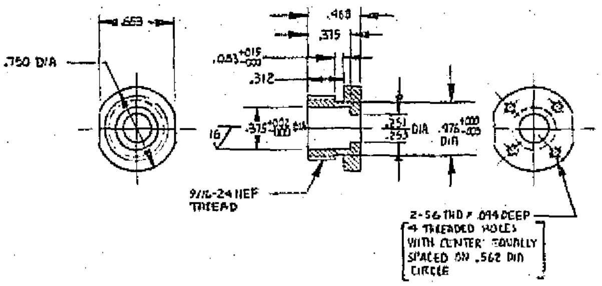
-045 JAMB SCREW



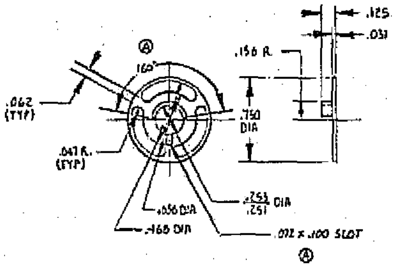
-041 COLLAR



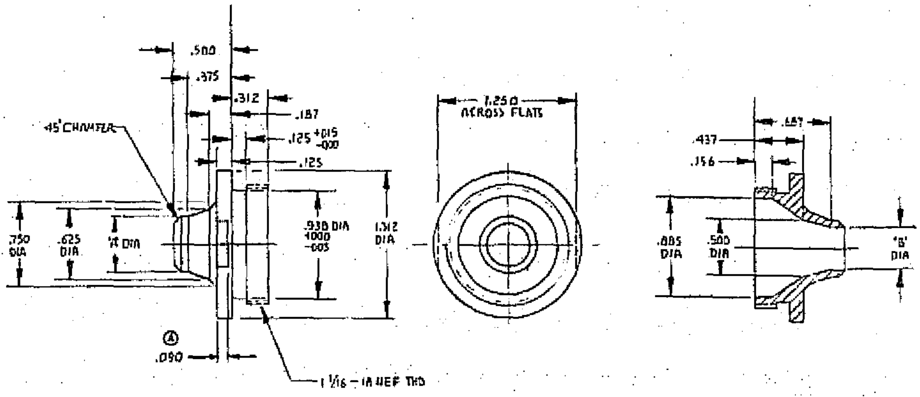
-042 ADJUSTMENT SCREW



-015 STEM RETAINER



-014 PIN STOP

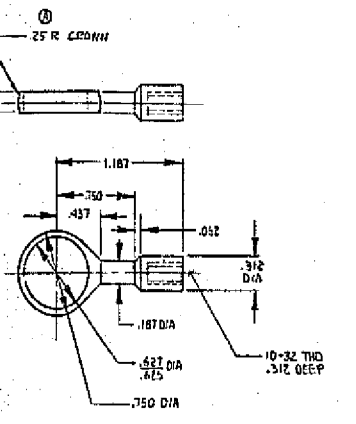


DETAIL	DIM "B"	DIM "A"
031	.391 ± .004	.500 ±.005
032	.172 ±.003	.250 ±.005

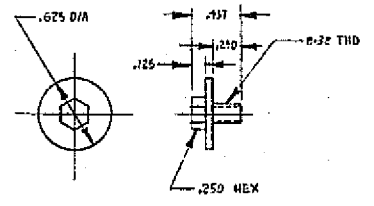
-031 TUBE ADAPTER
(-032)

FOLDOUT FRAME

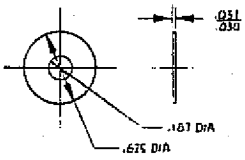
REVISIONS				
A	7-D	REVISED FLATS ON DETAIL -031(032)	6-1975	CHG BY T. [illegible]
	5-H	ADDED CROWN TO -041 DETAIL		
	3-B	DIM .249/.248 WAS .250/.248		
	5-E	REVISED DETAIL -014	8-1975	[illegible]



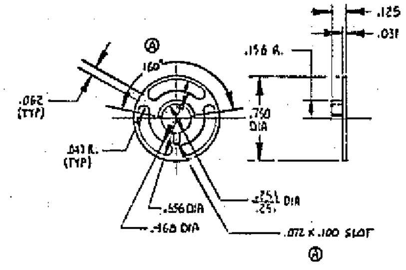
-C41 COLLAR



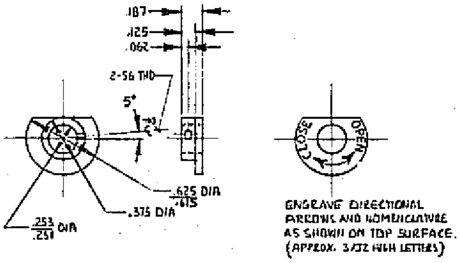
-040 RETAINER



-038 WASHER

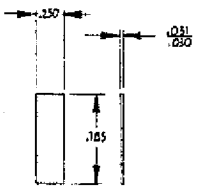


-014 PIN STOP

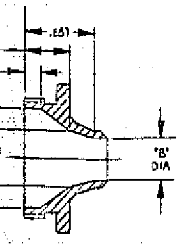


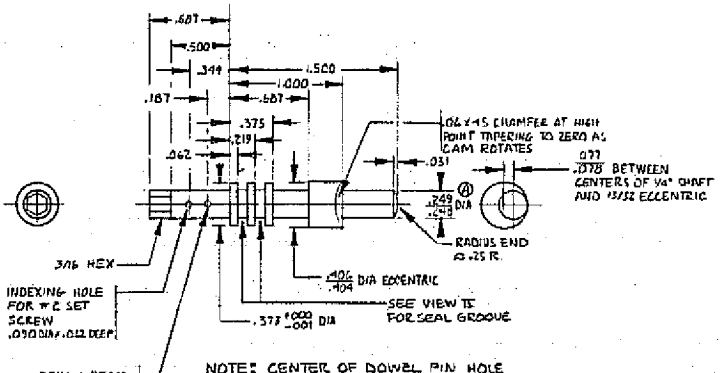
ENGRAVE DIRECTIONAL ARROWS AND NOMENCLATURE AS SHOWN ON TOP SURFACE. (APPROX. 3/32 HIGH LETTERS)

-012 FOOLPROOF CAP



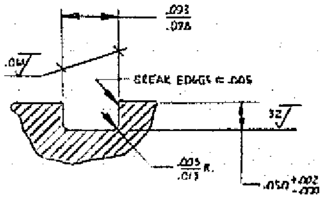
-037 BEARING STRIP





NOTE: CENTER OF DOWEL PIN HOLE AND SET SCREW INDEXING HOLE TO BE IN SAME PLANE AS HIGH POINT ON ECCENTRIC.

-018 VALVE STEM ◁2

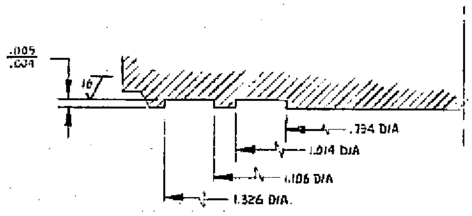


VIEW II SEAL GROOVE

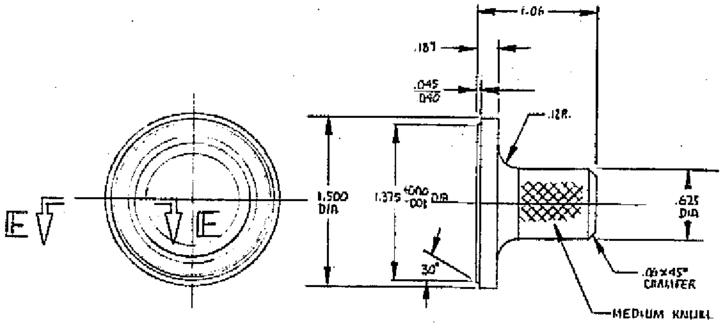
FIGURE IV-9 (Cont'd)

A	E	04236	NAS9-14376-A
	2:1		4

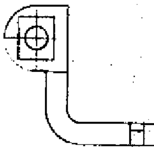
FOLDOUT FRAME 2

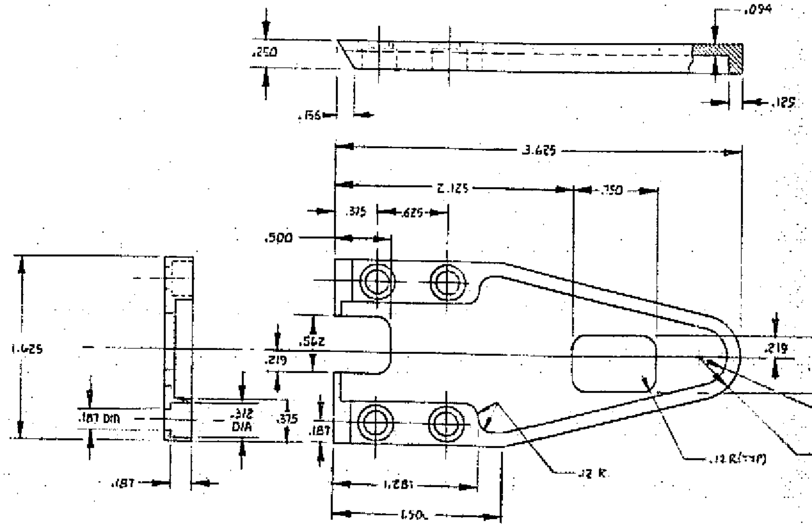


SECTION E~E
(ENLARGED, NO SCALE)



-001 END CAP





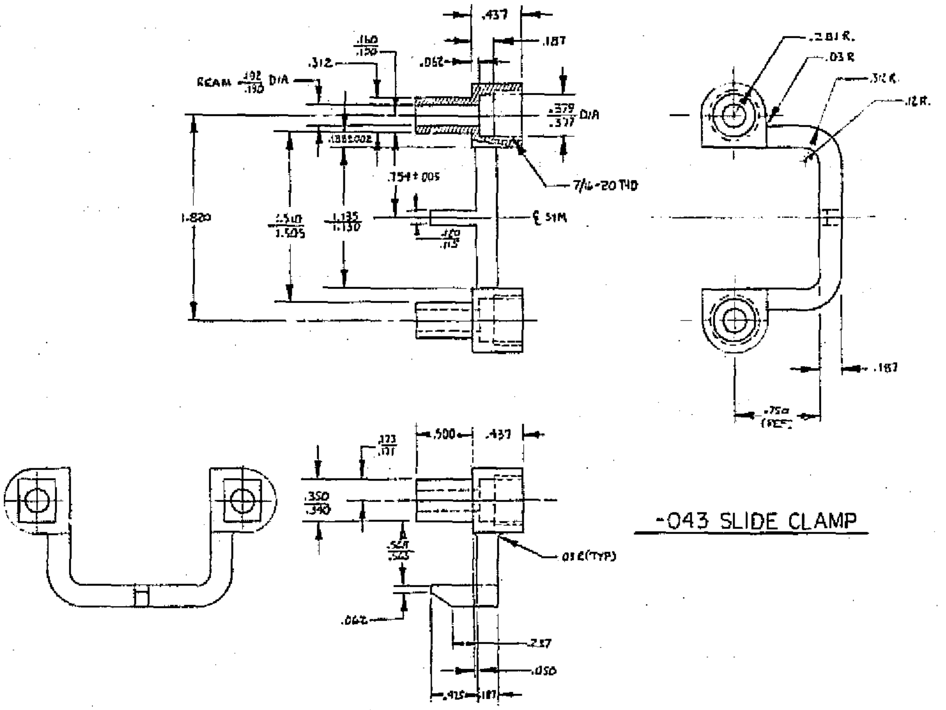
-046 HANDLE

REPRO
ORIGIN

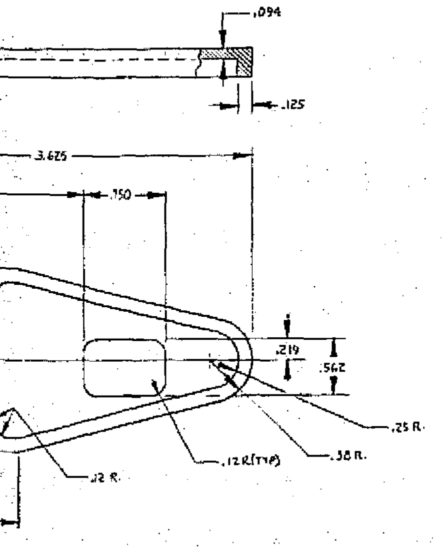
FOLDOUT FRAME 1

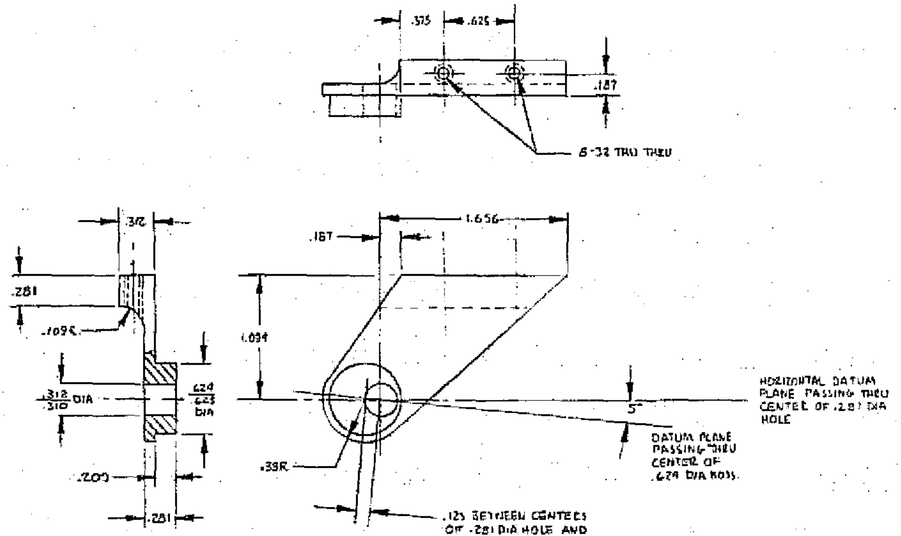
REVISIONS

A	6-F	DIM 1.375 $^{+.010}_{-.001}$ WAS 1.376 $^{+.001}_{.000}$	8-15-75 1-9-75	CH BY T. [illegible] G. Bein



-043 SLIDE CLAMP





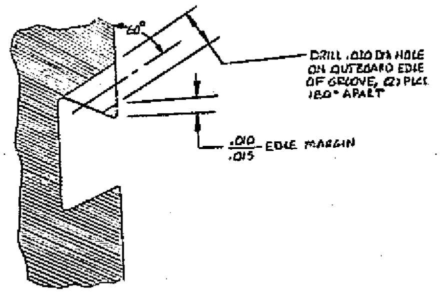
-035 PIVOT LEG
(-036 OPPOSITE)

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

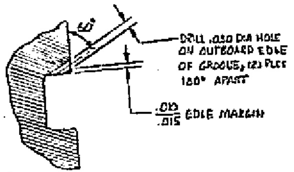
FIGURE IV-9 (Con't)

A
E
04220
NAS9-14376-A
2:1
6

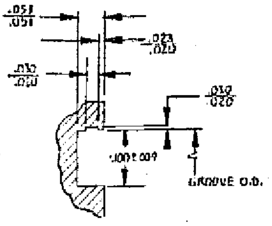
FOLDOUT FRAME 2



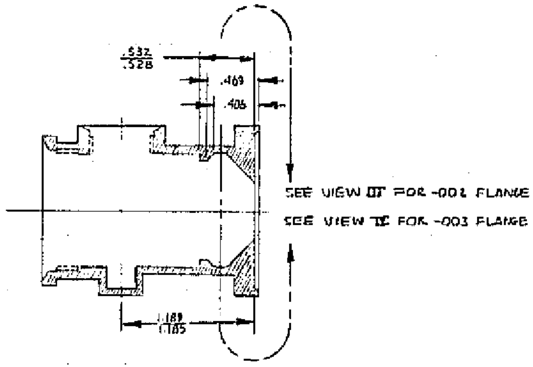
Ⓐ VIEW VI
VENT HOLE INSTALLATION



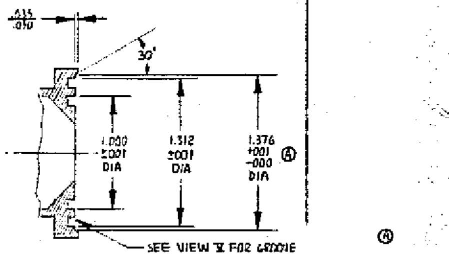
Ⓐ VIEW VII
VENT HOLE INSTALLATION



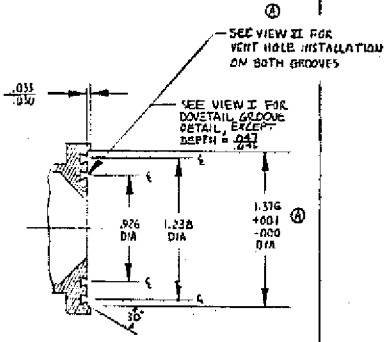
VIEW V



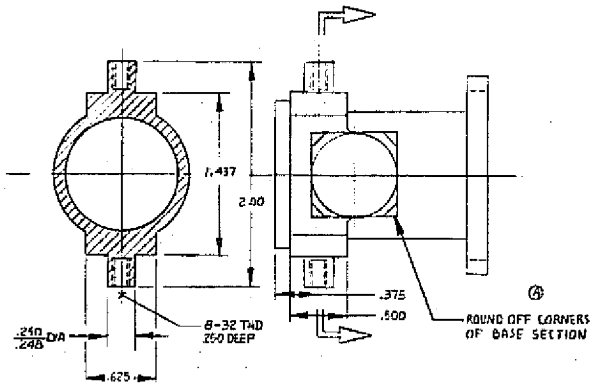
NOTE: INTERNAL DIMENSIONING
IDENTICAL TO -025
EXCEPT AS SHOWN

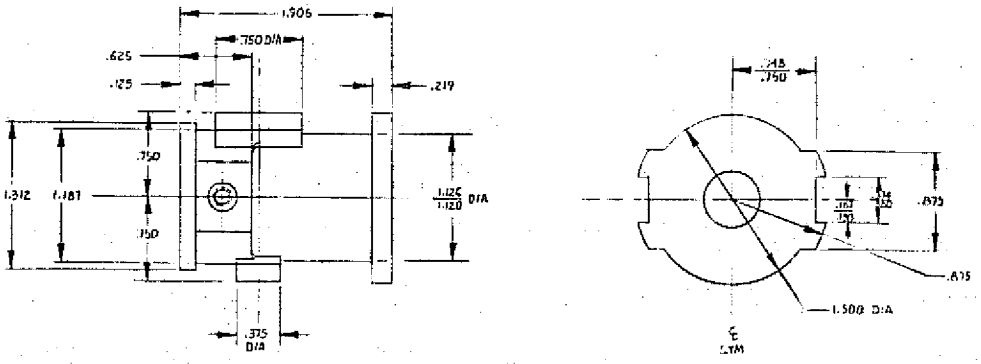


VIEW III -002 FLANGE



VIEW IV -003 FLANGE





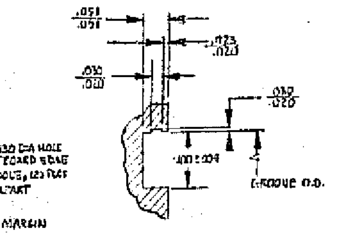
-002 VALVE BODY
(-003)

1.50

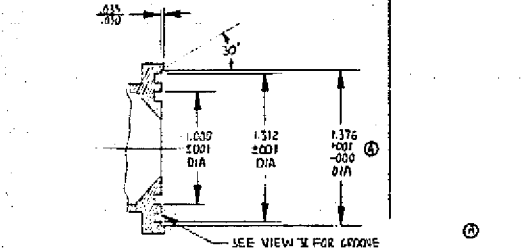
SEE
SECTI
E 2

FOLDOUT FRAME 1

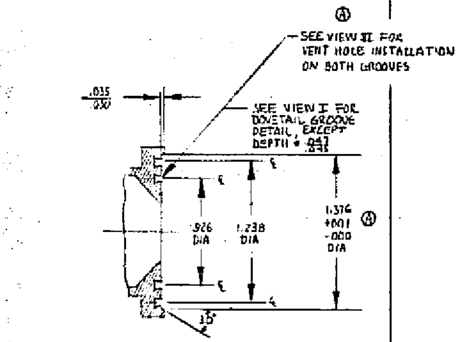
REVISIONS				
A	F/D	ADDED VIEWS III & VII. REVISED DETAIL -002 (-003) & -025	8/8/75 1-1-75	CHG BY T. G.



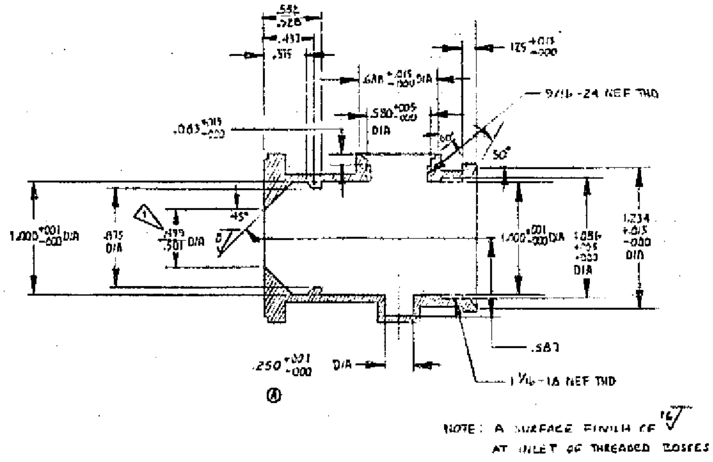
VIEW V



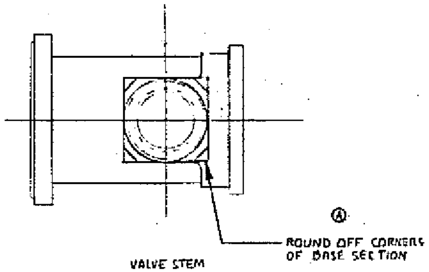
VIEW III -002 FLANGE

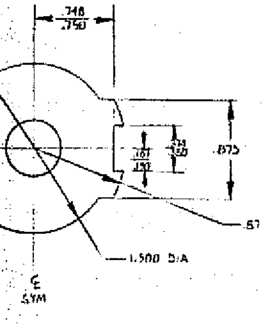


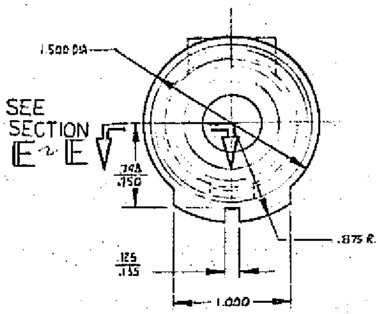
VIEW IV-003 FLANGE

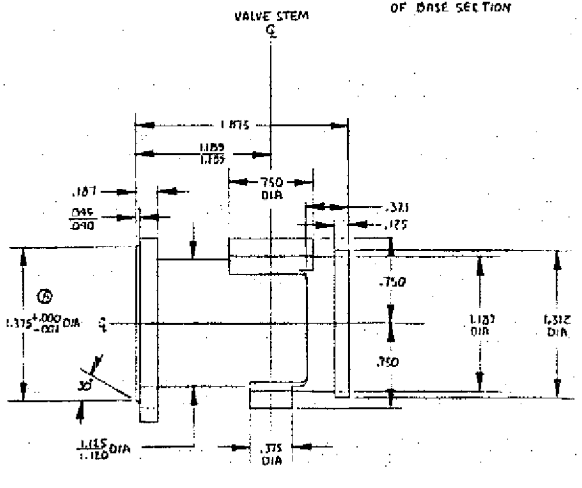


NOTE: A SURFACE FINISH OF 16√ AT INLET OF THREADED BOSSES









-025 VALVE BODY

FIGURE IV-9 (Con't)

A	E 04235	NAS9-14376-A
	2:1	6

FOLDOUT FRAME 2

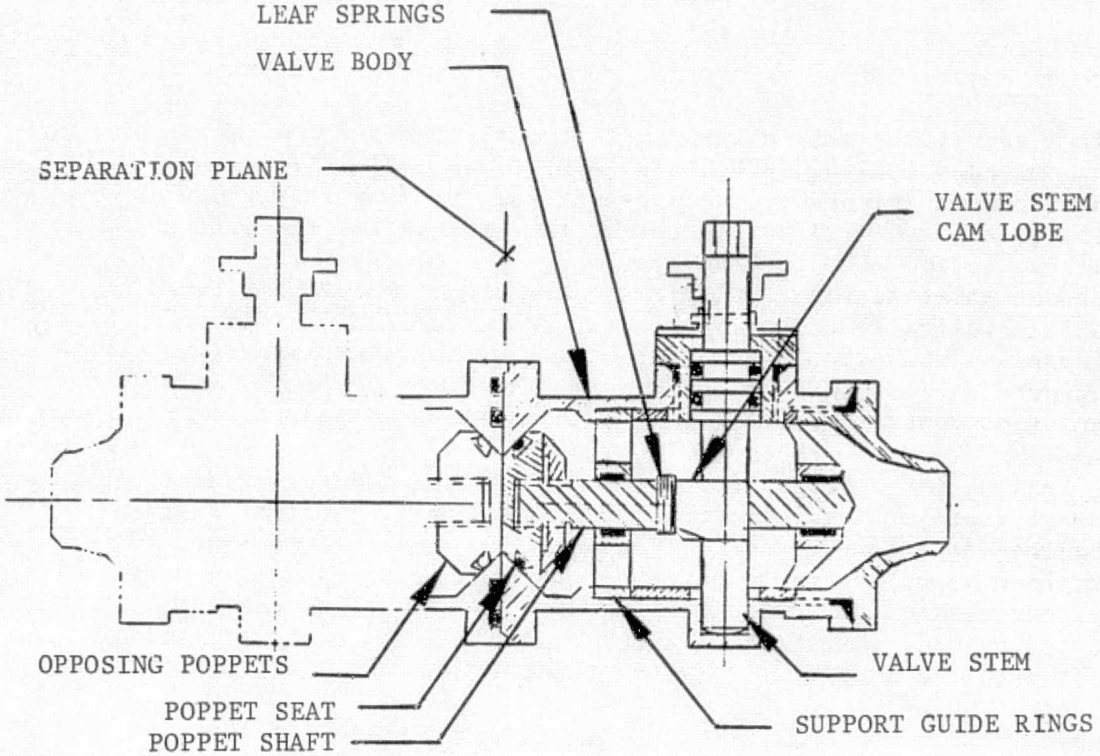


FIGURE IV-10 CUTAWAY SIDE VIEW OF PID

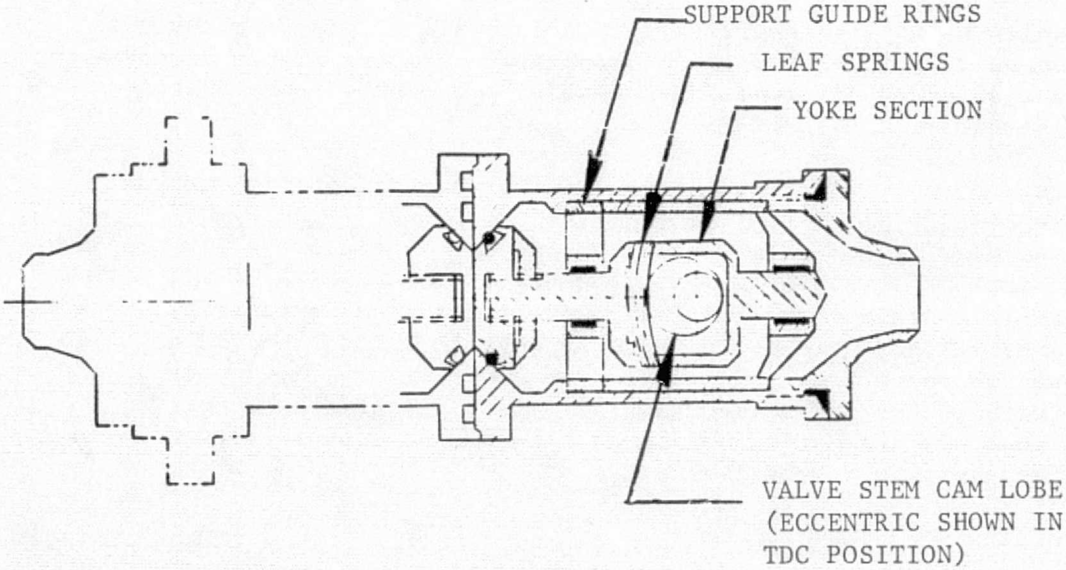


FIGURE IV-11 CUTAWAY PLAN VIEW OF PID

8.06×10^6 N/m^2 (1169 psi) exists on the metal-to-metal seal where the recommended loading is 6.89×10^6 N/m^2 (1000 psi). If a contaminant becomes trapped between poppet and its seat and is not crushable, the cam will bottom out on the springs and the springs bottom out on the yoke thereby preventing the operator from making the proper complete rotation of the valve stem, and without the valve stem in its proper place the units are incapable of being disengaged. This prevents the uncoupling of the disconnects when the poppets are not completely sealed. The operator would then re-open the poppet thus allowing the contaminate to pass.

2. Sealing Techniques - Since the PID is designed for several different fluid systems, two types of elastic seal material will be required depending on system usage. Elastomer seal material of ethylene propylene is to be used on systems flowing high purity water, condensate (sweat and respiratory vapor), urine, coolant water and gaseous systems such as nitrogen. Teflon seal material will be required on systems flowing Freon-21 and ammonia.

Redundant seal techniques are incorporated at dynamic sealing locations and single seals are used at static sealing locations, as shown in Figure IV-10. The redundant seal locations include the areas of the valve stem, separation plane and poppet. Double seals are used at the valve stem and at the separation plane, but the poppet utilizes metal-to-metal sealing for the redundancy in that area.

The units using elastomer seals have dovetail grooves for the seal glands on the poppet and on the separation plane. All other areas use the standard elastomer "Rectangular" or MS33649 boss static seal gland.

The teflon seal units have several different seal configurations. The separation plane seals are of the Omniseal type with "Rectangular" gland. The outboard side of the gland has a 0.635 mm (.025 in.) by 0.635 mm (.025 in.) groove. The purpose of the groove is to retain the seals upon separation. Once the seals are pressurized, this design permits cold-flow into the radial groove for retention. The valve stem uses the Omniseal type seal with the standard "Rectangular" gland. Static boss seal locations use the teflon O-ring and the poppet uses a captured seal as shown in Figure IV-12.

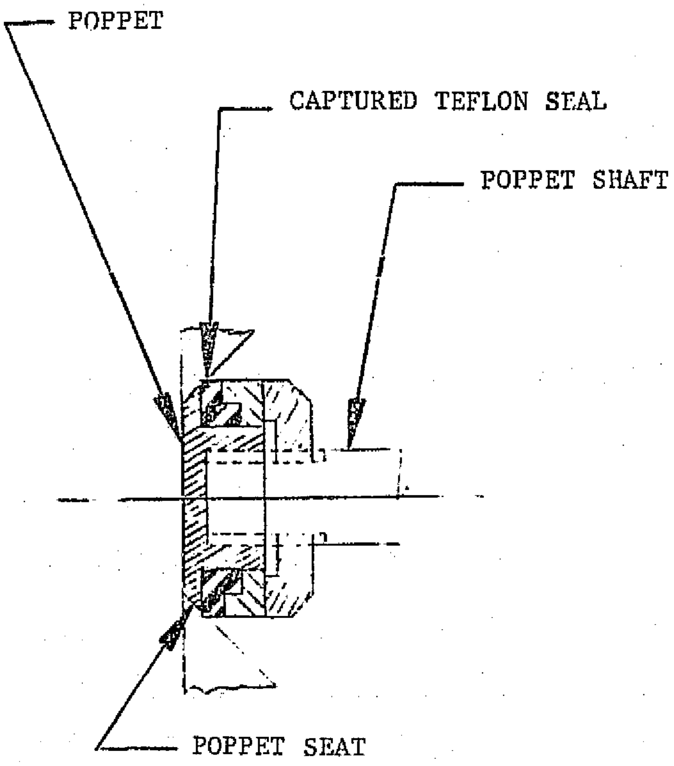


FIGURE IV-12 TEFLON ENCAPSULATED POPPET SEAL

3. Coupling Technique - The coupling technique, as shown in Figure IV-13, consists of cam actuated clamp fingers that clasp the two disconnect halves together with a force of 2135 newtons (480 lbs). The cam is part of the handle that lays across the top of the disconnect units. The clamp fingers consist of a pivot point at one end and a clamp yoke at the other with the center section made up of an adjustment screw with Belleville washers.

The initial setup of the clamp is accomplished by tilting the handle back 0.28 radians (16°) and adjusting the clamp finger until both disconnect halves are in contact with each other. When the handle is positioned flat across the PID, the Belleville washers are deflected 0.127 mm (.005 in.) of a possible .25 mm (.010 in.) resulting in the clamp force of 2135 newtons (480 lbs).

4. Foolproofing Technique - To prevent the accidental disengagement of disconnect halves prior to fluid isolation, a foolproofing method is incorporated in the design; see Figure IV-13. This consists of eccentric caps attached to the valve stems that coincide with slots in the coupling handle. When the disconnect halves are open, the eccentrics overlap the handle preventing its movement; likewise, when disconnect halves are closed, the handle is allowed to pass by the eccentrics and uncouple the unit.

5. Separation Plan Lateral Movement - The design provides a 1.143 mm (0.045 in.) concentric offset for centering one disconnect half to the other. Therefore, a lateral movement of 1.27 mm (0.050 in.) would be satisfactory for component removal as compared to disconnects requiring lateral movements up to 19 mm (.75 in.) prior to separation.

6. Metal-to-Metal Contact - Metal-to-metal contact is prevented by use of teflon bearings on sliding surfaces and a moly-x hard coat lubricant burnished onto the valve stem cam surface.

7. Operational Access - All functions can be performed on one side of the unit, thereby limiting access requirements to a side normal to center line of PID and fluid flow.

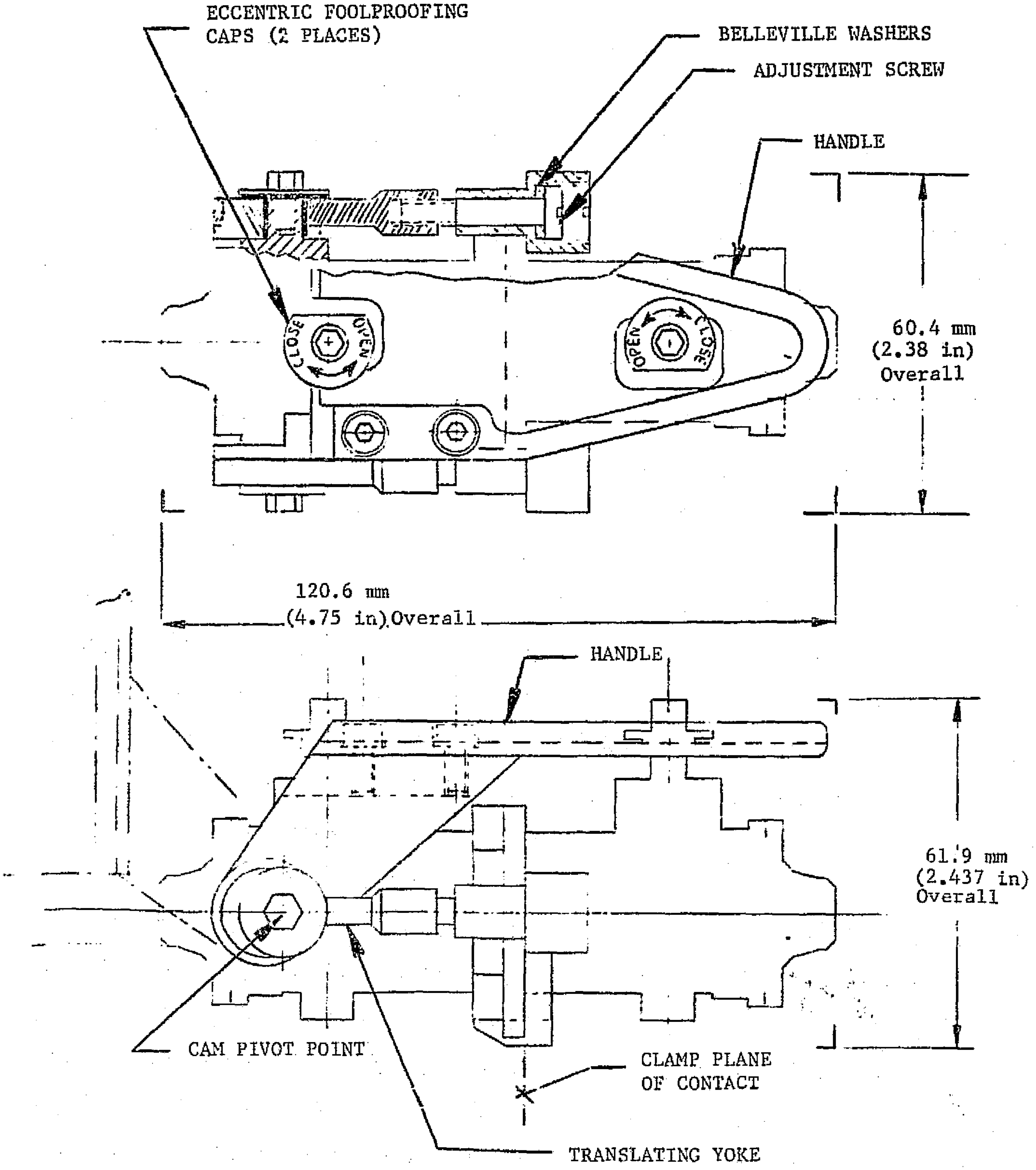


FIGURE IV-13 COUPLING ASSEMBLY

8. Materials - Main body and internal parts are fabricated from 21-6-9 corrosion resistant steel due to its high strength-to-weight ratio and the ability to weld it to 347 stainless steel. To further increase the materials resistance to corrosion, all parts are passivated. The leaf springs are fabricated from 17-7 PH stainless steel and heat treated to RH 950.

The handle is designed to be fabricated out of 6061-T6 aluminum for weight savings. For corrosion resistance and prevention of galling, a hard coat anodize finish is used.

9. Tool Requirements - For normal PID operation (which includes closing both disconnects, uncoupling, component replacement, coupling disconnects together, open disconnects), a 4.75 mm (3/16 in.) socket torque .14 m-kg (12 in-lb) wrench is required. For breakdown of the PID, the required tools include a crescent wrench with an opening of 38.1 mm (1.50 in.), standard blade screw driver, and a set of Allen wrenches.

E. ENGINEERING CALCULATIONS

Calculations that support the final design are in the following paragraphs.

1. Disconnect Comparisons - Table IV-5 compares features of the PID to that of commercially available self-sealing disconnects. The conclusion made is that the PID is within the state-of-the-art for size and weight even though added restrictions are required of the PID which are not imposed on other disconnects.

2. Calculated Weight - The calculated weight for the 12.7 mm (1/2 in) disconnect unit including both halves and coupling mechanism is tabulated in Table IV-6.

3. Maximum Fluid Spillage - The separation plane should be metal-to-metal, but a gap of 0.127 mm (.005 in.) will be assumed for the worst case.

$$\text{Volume} = \frac{\pi (1.125)^2}{4} (.005)(16.4) = .08 \text{ cc } (.00497 \text{ in}^3)$$

TABLE IV-5 SUMMARY AND COMPARISON CHART

	SHUTTLE TECHNOLOGY		COMMERCIAL	
MODEL SPECIFICATION	NAS9-14376*	SEATON-WILSON	SNAP TITE 25 SERIES	ADEL
Line Size	12.7 mm (1/2")	15.9 mm (5/8")	12.7 mm (1/2")	12.7 mm (1/2")
Material:				
Body	21-6-9 SS	300 CRES	316 SS	300 CRES
Seals	Teflon	Teflon	Teflon	Teflon
Closure/Actuation Technique	Stem/cam	Spring	Spring	Spring
Length mm (in.)	120.6 (4.75)	86.4 (3.4)	98.4 (3.875)	147.3 (5.8)
Height mm (in.)	60.4 (2.437)	50.8 (2) OD	35.1 (1.38) OD	54.6 (2.15) OD
Width mm (in.)	60.5 (2.38)	-	-	-
Weight kg (lb.)	.64 (1.4)	.54 (1.2)	.28 (.625)	1.36 (3.0) EST
Lateral Disengagement Length mm (in.)	.76 (.03)	19.1 (.75)	25.4 (1.0)	12.7 (.5)
ΔP @ 2500 #/Hr H_2O psig	.015 @ 550 #/Hr, .299 @ 2500 #/Hr	.580 @ 2500 #/Hr	.3	Straight Pipe
Spillage, Fluid	.11 CC	.003 CC	5.2 CC	4.1 CC (.25 In^3)
Air Inclusion	.11 CC	.009 CC	4.6 CC	4.1 CC (.25 In^3)
Closure Fool Proofing	Integral Mechanism & Stem/cam	None	None	None
Closure Under Press	Yes	Yes	No 10.34×10^4 N/m^2 (15 psi)	Yes
Coupling Technique	Compression by cam	Threaded	Knurled Sleeve & Balls	Sleeve & Guide Pins
Seat Type	Poppet	Poppet	Poppet	Ball

*NOTE: Key criteria specified by Contract NAS9-14376 and not imposed on other disconnects are:

a) No spring-loaded actuation or closure features.
b) Minimum lateral prior to shear separation of two halves.
c) Positive means of isolation of flow prior to separation of disconnect halves.
d) Redundant Seals

TABLE IV-6 PID ESTIMATED WEIGHT

DETAIL NO.	QTY REQ'D FOR (1) ASSY	DETAIL WEIGHT kg (lb)	TOTAL WEIGHT kg (lb)	DETAIL NO.	QTY REQ'D FOR (1) ASSY	DETAIL WEIGHT kg (lb)	TOTAL WEIGHT kg (lb)
-001		.026 (.058)		-032		.03 (.067)	
-002	1	.18 (.396)	.18 (.396)	-033	2	.01 (.022)	.02 (.044)
-003		.18 (.396)		-034	4	*	*
-004	2	*	*	-035	1	.0113(.025)	.0113 (.025)
-005	8	.0005(.001)	.0036 (.008)	-036	1	.0113(.025)	.0113 (.025)
-006	2	*	*	-037	2	*	*
-007		*		-038	2	*	*
-008	2	*	*	-040	2	.0027(.006)	.0054 (.012)
-010	2	*	*	-041	2	.0054(.012)	.0109 (.024)
-011		.009 (.019)		-042	2	.0059(.013)	.0118 (.026)
-012	2	.0018(.004)	.0036 (.008)	-043	1	.0218(.048)	.0218 (.048)
-013	8	*	*	-044	4	*	*
-014	2	.0013(.003)	.0027 (.006)	-045	2	.0036(.008)	.0073 (.016)
-015	2	.0104(.023)	.021 (.046)	-046	1	.021 (.046)	.021 (.046)
-016	4	*	*	-047		*	
-017		*		-048		.0041(.009)	
-018	2	.019 (.042)	.038 (.084)	-050	2	.0027(.006)	.0054 (.012)
-020	2	*	*	-051	2	*	*
-021		*		-052	2	.0018(.004)	.0036 (.008)
-022	1	*	*	-053	2	.0032(.007)	.0064 (.014)
-023		*					
-024	1	*	*				
-025	1	.16 (.353)	.16 (.353)				
-026	2	.01 (.022)	.02 (.044)				
-027	2	.022 (.049)	.0445 (.098)				
-028		*					
-030	2	*	*				
-031	2	.03 (.067)	.061 (.134)				

* Individual Weight Negligble
Combined Weight Assumed

SUBTOTAL	1.296
*WEIGHT	.150
0.65 kg	(1.446 lbs)

The poppet forward surface should be flush with housing separation, but for a worst case, an off-set of .127 mm (.010) is assumed.

$$\text{Volume} = \frac{(2)\ (\pi)\ (.500)^2}{4}\ (.005)(16.39) = .032\ \text{cc}\ (.00196\ \text{in}^3)$$

$$\text{Maximum Spillage} < .00497 + .00196$$

$$< \underline{\underline{.11\ \text{cm}^3\ (.0069\ \text{in}^3)}}$$

4. Temperature Variation on Trapped Freon-21

GIVEN:

- o Trapped fluid is solid disc shaped with a height of .127 mm (.005") (Design Tolerances) and a diameter of 21.9 mm (.864") (inside dia. of face seal)
- o Initial temperature assumed to be 277.6°K (40°F)
- o Final temperature assumed to be 322.04°K (120°F)
- o Fluid densities per the following chart:

LIQUID DENSITY OF "FREON-21" AT VARIOUS TEMPERATURES

TEMP		DENSITY		
°F	°K	g/cc	lb/cu ft	lb/gal
-40	233.15	1.514	94.52	12.64
-20	244.26	1.490	93.04	12.44
0	255.37	1.466	91.52	12.23
20	266.48	1.441	89.96	12.03
40	277.59	1.415	88.35	11.81
60	288.71	1.389	86.71	11.59
80	299.82	1.362	85.03	11.37
100	310.93	1.335	83.31	11.14
120	322.04	1.306	81.54	10.90

DETERMINE: Effects on disconnect unit due to desire of fluid to expand with a lower density at the higher temperature.

ANALYSIS: The first step is to determine the magnitude of pressure involved with this temperature change on a confined volume.

STEP 1

From a Physics Handbook, the following expression for "compressibility" was found:

$$C = \frac{V_1 \quad \Delta V}{\Delta P}$$

C = Compressibility Factor
V = Specific Volume
P = Pressure

$$\therefore \quad \Delta P = \frac{V_1 \quad \Delta V}{C}$$

Where "C" is estimated to be $10^{-9} \frac{m^2}{N}$,

$$V_1 = \frac{1}{1.415}, \quad V_2 = \frac{1}{1.306}, \Delta V = .05899$$

$$P = \frac{(1)}{(1.415)(.05899)(10^{-9})} = 11.98 \times 10^{14} \frac{N}{m^2} \quad (\underline{17.3 \times 10^{10} \text{ psi}})$$

This conclusion made from the above calculation is that the disconnect unit must have provisions to allow liquid expansion, since pressure buildup is beyond material strength limits.

STEP 2

Step 2 is to determine the amount of expansion with the given conditions.

Since liquid is solid disc shaped, V = (height)(area)

$$= (.005)\frac{(\pi)(.864)^2}{4}(16.4)$$

$$= .048 \text{ cc @ } 277.6^{\circ}\text{K}$$

$$(\underline{.00293 \text{ in}^3} \text{ @ } 40^{\circ}\text{F})$$

Since final volume is inversely proportional to density,

$$V = \frac{(88.35)}{(81.54)}(.00293)(16.4)$$

$$= .052 \text{ cc @ } 322.04^{\circ}\text{K}$$

$$(\underline{.00317 \text{ in}^3} \text{ @ } 120^{\circ}\text{F})$$

Assuming all volume increase takes place in height of disc,

$$H = \frac{(4)\Delta V}{D^2} = \frac{(4)(.00024)(25.4)}{\pi(.864)^2} = .01 \text{ mm } (\underline{.00042 \text{ in}})$$

Therefore, the disconnect assembly must allow .01 mm (.00042) in axial expansion.

STEP 3

Determining points of expansion in disconnect assembly.

The disconnect halves are clamped together with the use of (8) Belleville washers preloaded. With an initial system pressure of 2.76 x 10^6 N/m^2 (400 psi) and an interface area of 221.5 mm^2 (.586 in^2), the (8) washers have an applied force of 1040.8 N (234 lbs) or 266.9 N (60 lbs) per washer. The following is individual Belleville washer data:

Total Possible Deflection = .25 mm (.010 in)

Spring Rate - 53.4 N (12 lbs) per .025 mm (.001 in)
(up to .127 mm (.005 in) def)
44.5 N (10 lbs) per .025 mm (.001 in)
(.127 mm to .25 mm (.005 to .01 in) def)

Therefore, initial system pressure corresponds to .127 mm (.005 in) deflection of washer, but as system is heated to 322.04°K (120°F) an additional .01 mm (.0004 in) deflection must take place (from Step 2 calculation) which is easily handled by the Belleville washer making the total deflection approximately equal to .137 mm (.0054 in).

STEP 4

System pressure @ 322.04°K (120°F) with liquid expansion. The .137 mm (.0054) washer deflection corresponds to 289.1 N (65 lbs) load per washer of 2313 N (520 lbs) total.

$$\text{Press.} = \frac{\text{Force}}{\text{Area}} = (6.895 \times 10^3)\frac{(520)}{.586} = 6.1 \times 10^6 \text{ N/m}^2 \ (\underline{887 \text{ psi}})$$

5. Axial Force to Load Seal to 4.83 x 10^6 N/m^2 (700 psi)

- Maximum seal width against seat = .53 mm (.021 in)

- Neglecting fluid pressure behind poppet

F_1 = Force normal to seal; F_2 = Axial force

Seal Area = $(.021)(\pi)(.63) = .27 \times 10^{-4}$ m^2 (.042 in^2)

$F_1 = \phi A = (700)(.042)(4.448)$

$= 130.8$ N (29.4 lbs)

$F_2 = (.707)(F_1) = (.707)(29.4)(4.448)$

$= 92.4$ N (20.78 lbs) NOTE: Unit utilizes an applied force of 444.8 N (100 lbs)

6. Metal-to-Metal Seal Loading

- Seal width = 1.78 mm (.070 in)

- Seal diameter = 13.97 mm (.550 in to mid-point)

- Applied force = 444.8 N (100 lbs)

Seal Area = (width)(circ)

$= (.070)(\pi)(.55)(6.45 \times 10^{-4})$

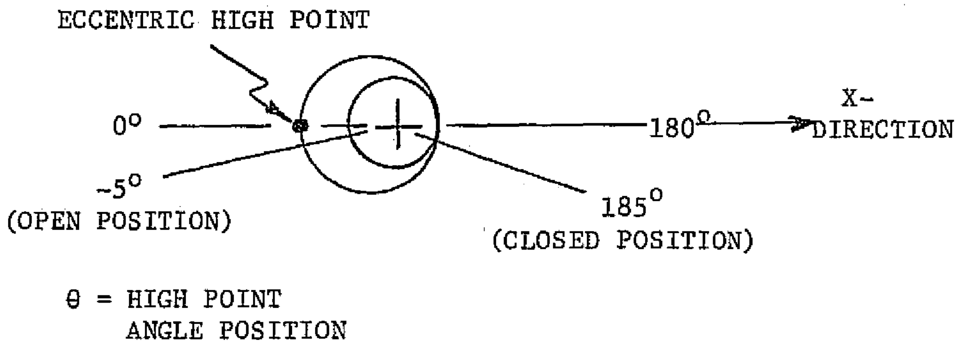
$= .78 \times 10^{-4}$ m^2 (.121 in^2)

Normal force to seat $= \frac{(100)}{.707}(4.448) = 629.13$ N (141.44 lbs)

Seat Loading $= \frac{F}{A} = (6.895 \times 10^3)\frac{(141.44)}{.121} = 8.06 \times 10^6$ N/m^2 (1169 psi)

Where 6.89×10^6 N/m^2 (1000 psi) is adequate for metal-to-metal seal loading

7. Poppet Actuator Data and Curves



Cam lobe displacement = .078 - (.078)(COSθ)

Poppet Travel = (Cam lobe displacement) - (Leaf spring deflection)

Poppet Load = (Leaf spring rate)(Leaf spring deflection)

Torque around ℄ of Valve Stem = (Load)(.078)(SIN θ)

Table IV-7 tabulates values for the above equations for a θ range from -.087 to +3.24 radians (-5° to $+185^{\circ}$). Fig. IV-14 plots poppet cam lobe displacement against cam high point angle. Fig. IV-15 plots poppet displacement against cam high point angle. Figure IV-16 plots poppet load against cam high point angle. Figure IV-17 plots valve stem torque against cam high point angle.

8. Coupling Data & Curves

- Belleville Washer: 4.83 mm (.190 in.) I.D.
  9.53 mm (.375 in.) O.D.
  Single Washer, 266.9 N (60 lbs) @ .127 mm (.005 in) Def.
- With (4) washers stacked parallel on both sides of the clamp, the clamping force equals 2135.1 N (480 lbs.).

TABLE IV-7 POPPET ACTUATOR DATA

ECCENTRIC HIGH POINT ANGLE RADIANS (DEGREES)	CAM LOBE DISPLACEMENT IN X-DIRECTION mm(in)	POPPET DISPLACEMENT IN X-DIRECTION mm(in)	POPPET LOAD kg(lbs)	TORQUE AROUND VALVE STEM cm-kg(in-lb)
-.087(-5)	.008(.0003)	.008(.0003)	0(0)	(0)
-.053(-3)	.003(.0001)	.003(.0001)	0(0)	(0)
0(0)	0(0)	0(0)	0(0)	(0)
+.035(+2)	.0013(.00005)	.0013(.00005)	0(0)	(0)
+.07(+4)	.005(.0002)	.005(.0002)	0(0)	(0)
+.088(+5)	.008(.0003)	.008(.0003)	0(0)	(0)
+.105(+6)	.010(.0004)	.010(.0004)	0(0)	(0)
+.14(+8)	.018(.0007)	.018(.0007)	0(0)	(0)
+.175(+10)	.028(.0011)	.028(.0011)	0(0)	(0)
+.21(+12)	.043(.0017)	.043(.0017)	0(0)	(0)
+.245(+14)	.058(.0023)	.058(.0023)	0(0)	(0)
+.35(+20)	.119(.0047)	.119(.0047)	0(0)	(0)
+.525(+30)	.254(.0100)	.254(.0100)	0(0)	(0)
+.70(+40)	.462(.0182)	.462(.0182)	0(0)	(0)
+.875(+50)	.709(.0279)	.709(.0279)	0(0)	(0)
+1.05(+60)	.991(.0390)	.991(.0390)	0(0)	(0)
+1.225(+70)	1.303(.0513)	1.303(.0513)	0(0)	(0)
+1.4(+80)	1.638(.0645)	1.638(.0645)	0(0)	(0)
+1.575(+90)	1.981(.0780)	1.981(.0780)	0(0)	(0)
+1.75(+100)	2.324(.0915)	2.324(.0915)	0(0)	(0)
+1.925(+110)	2.659(.1047)	2.659(.1047)	0(0)	(0)
+2.10(+120)	2.972(.1170)	2.972(.1170)	0(0)	(0)
+2.275(+130)	3.254(.1281)	3.254(.1281)	0(0)	(0)
+2.45(+140)	3.500(.1378)	3.500(.1378)	0(0)	(0)
+2.538(+145)	3.607(.1420)	3.607(.1420)	0(0)	(0)
+2.625(+150)	3.696(.1455)	3.607(.1420)	11.34(25.0)	+1.12(+.97)
+2.80(+160)	3.843(.1513)	3.607(.1420)	30.12(66.4)	+2.04(+1.77)
+2.975(+170)	3.932(.1548)	3.607(.1420)	41.46(91.4)	+1.43(+1.24)
+3.063(+175)	3.955(.1557)	3.607(.1420)	44.36(97.8)	+.76(+0.66)
+3.15(+180)	3.962(.1560)	3.607(.1420)	45.36(100.0)	0(0)
+3.203(+183)	3.957(.1558)	3.607(.1420)	44.68(98.5)	-4.61(-4.0)
+3.238(+185)	3.955(.1557)	3.607(.1420)	44.36(97.8)	-.76(-.66)

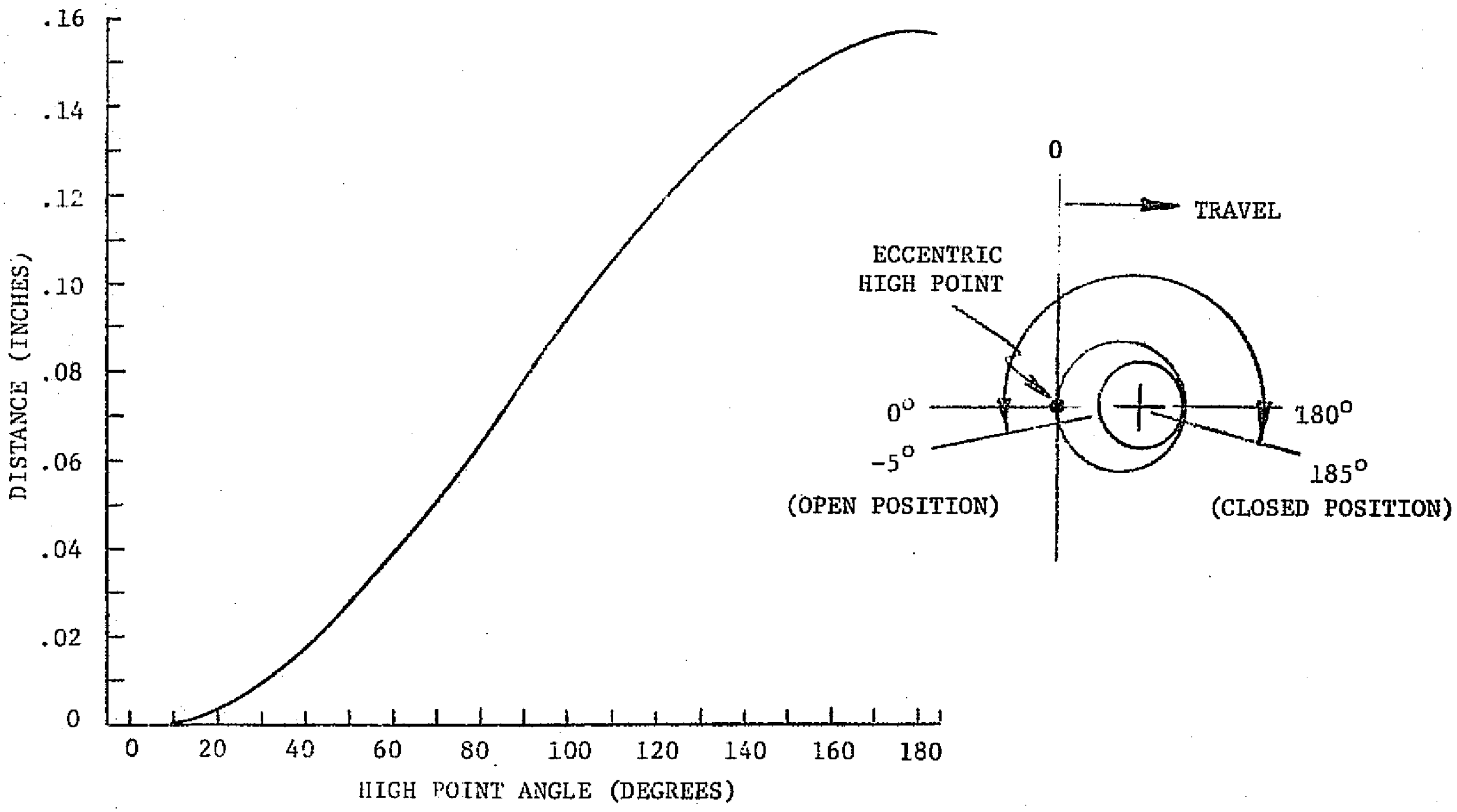


FIGURE IV-14 POPPET CAM LOBE DISPLACEMENT

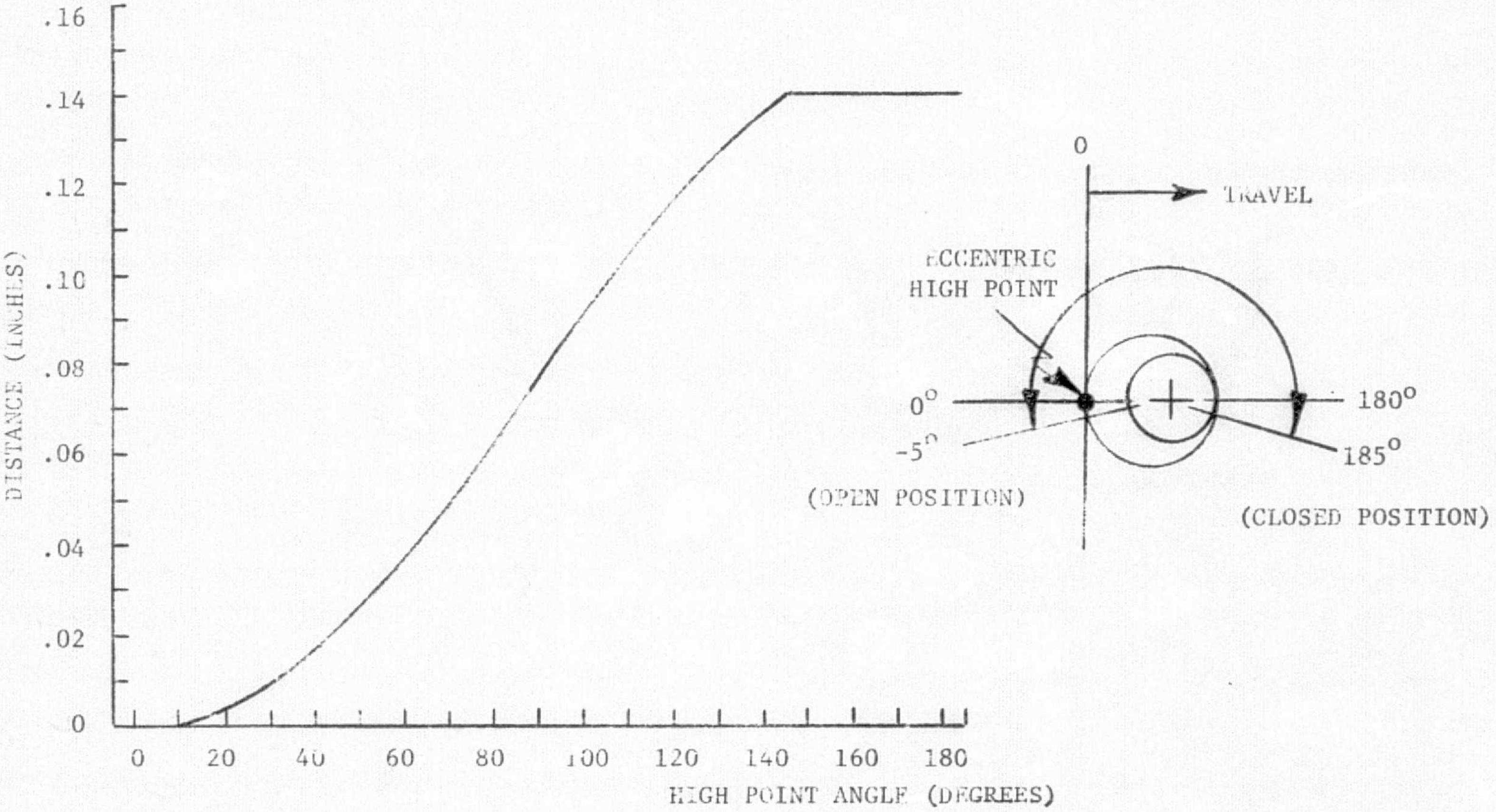


FIGURE IV-15 POPPET DISPLACEMENT

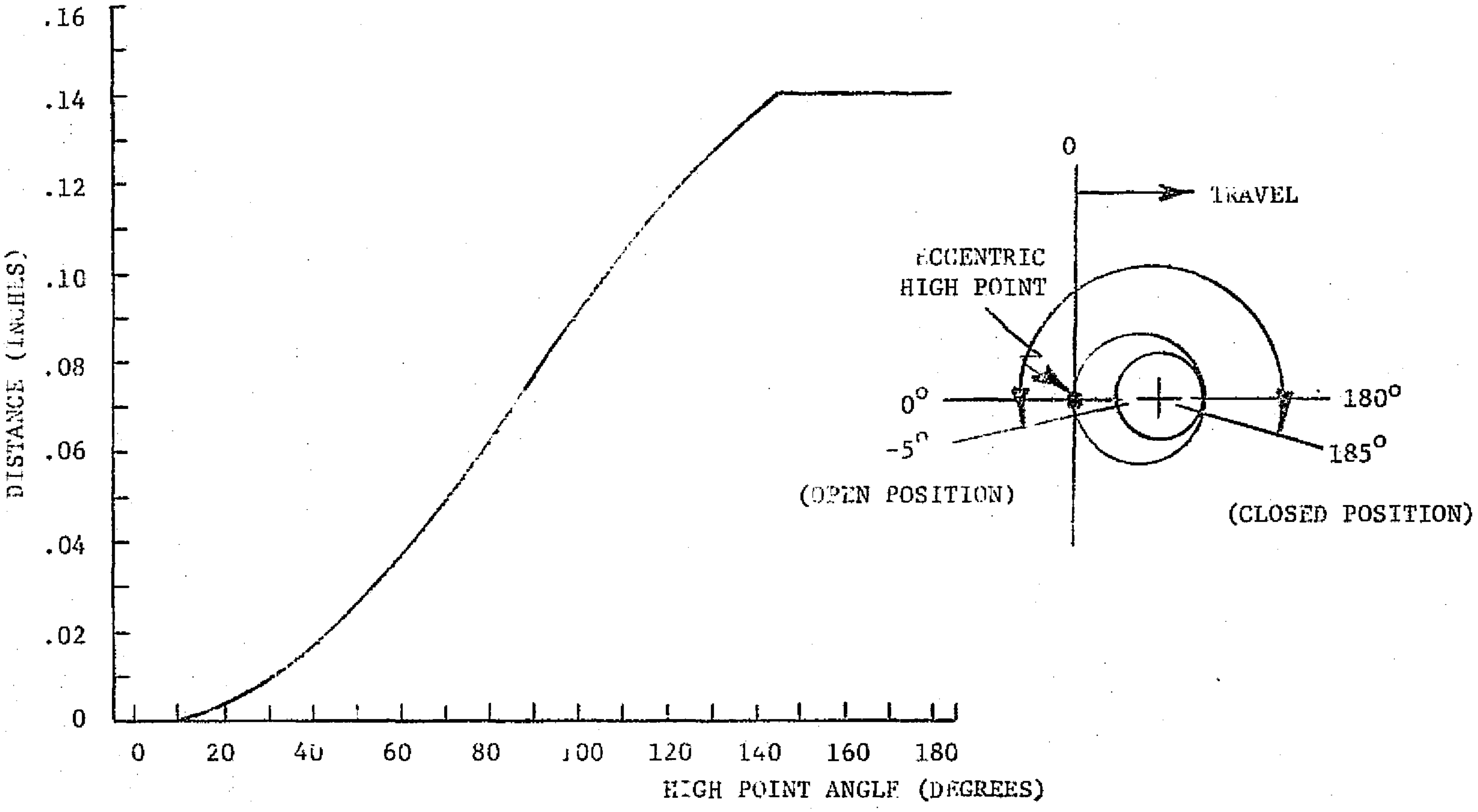


FIGURE IV-15 POPPET DISPLACEMENT

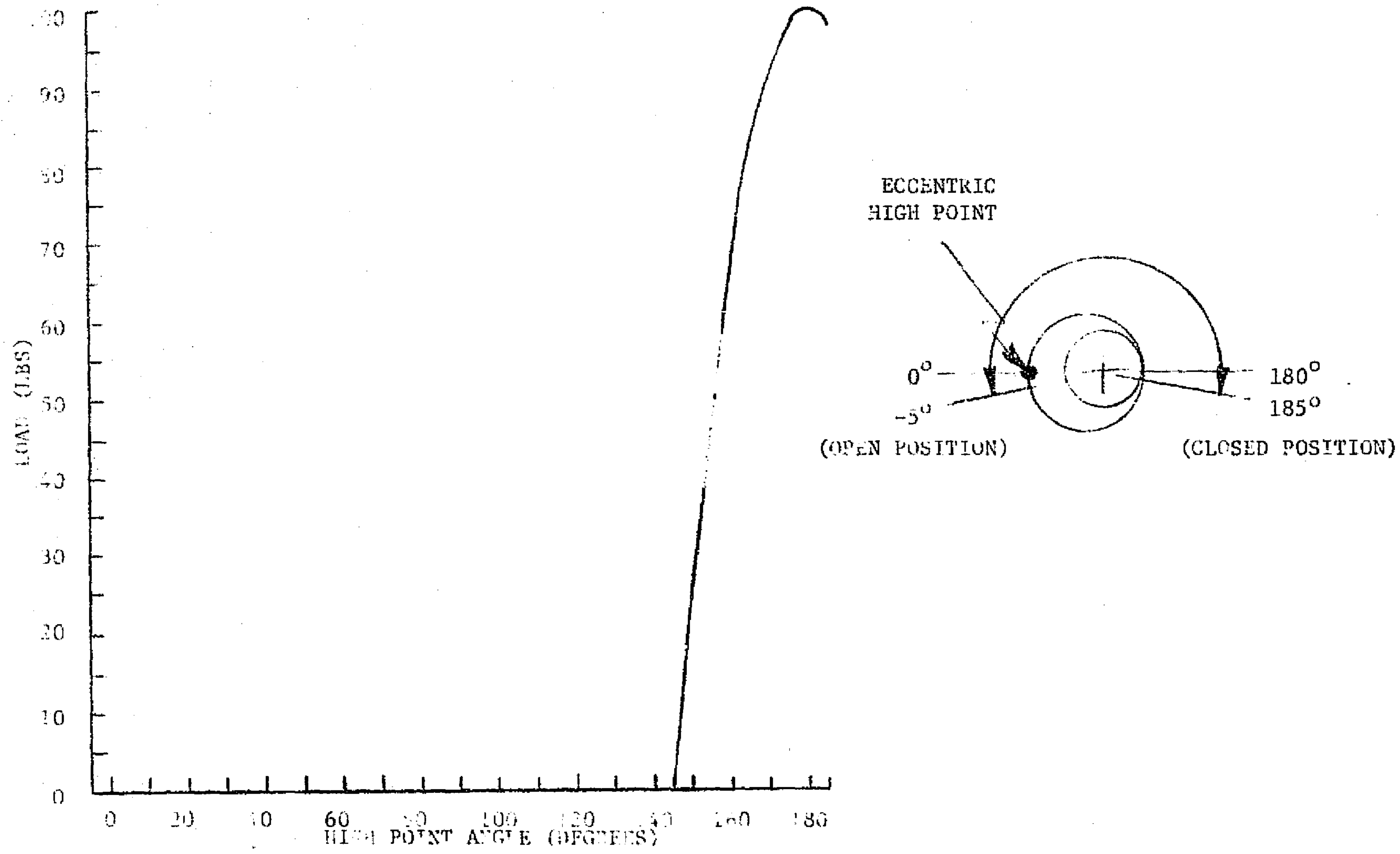


FIGURE IV-16 POPPET LOAD

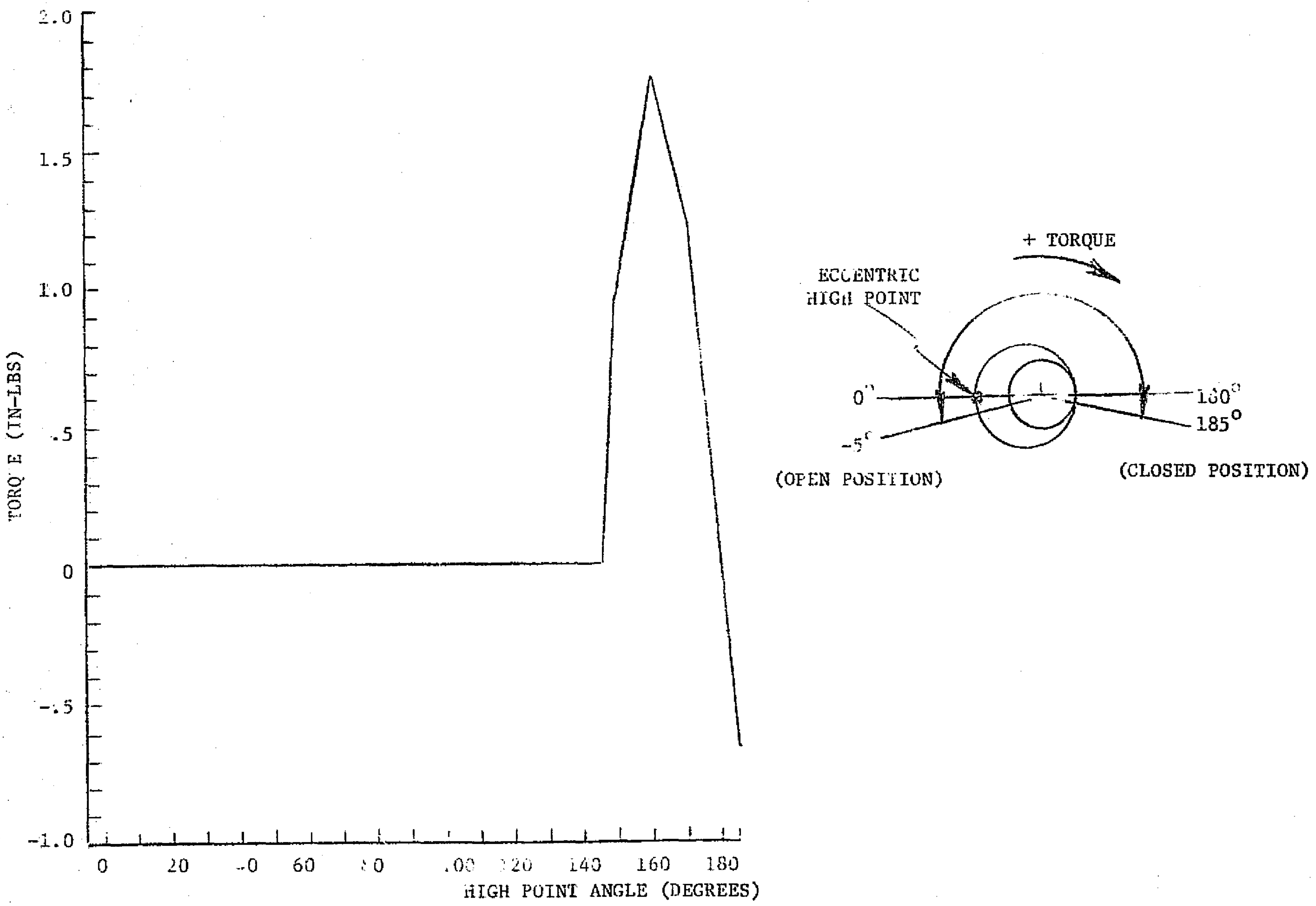


FIGURE IV-17 VALVE STEM TORQUE

Equations Related to Coupling Data Curves:

Cam Lobe Displacement = .125 - (.125)(COS θ)

Clamp Travel = (Cam lobe displ) - (washer defl)

Clamp Load = (Washer spring rate)(washer defl)

Torque at Clamp Pivot = (Load)(.125)(Sinθ)

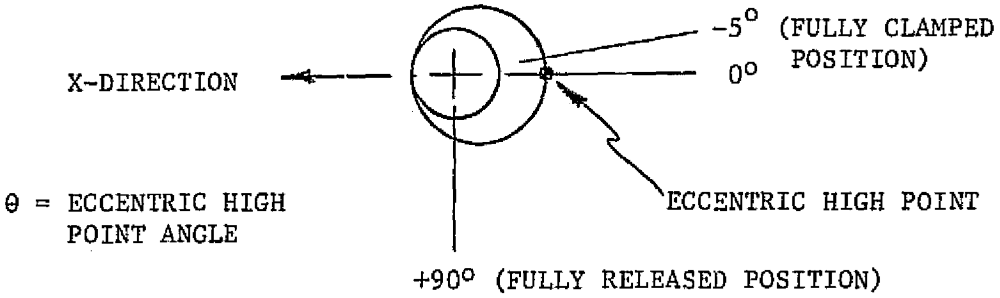


Table IV-8 tabulates values for the above equations for a θ range of -.087 to 1.53 radians (-5 to $+90^{\circ}$). Figure IV-18 plots clamp cam lobe displacement against cam high point angle. Figure IV-19 plots clamp displacement against cam high point angle. Figure IV-20 plots clamp load against cam high point angle. Figure IV-21 plots clamp torque against cam high point angle.

9. Flow Area

Inlet: 12.7 mm (1/2") tube with wall thk of .89 mm (.035 in)

$$\text{Area} = \frac{\pi D^2}{4} = (6.45)\ \pi \frac{(.430)^2}{4} = 0.935\ \text{cm}^2\ \underline{(.145\ \text{in}^2)}$$

Around Poppet: Axial Movement = 3.71 mm (.146 in)

Pheripheral Clearance = (.707)(.146)
= 2.62 mm (.103 in)

Area = (Width)(Length of Annulus)

TABLE IV-8 COUPLING DATA

ECCENTRIC HIGH POINT ANGLE RADIANS (DEGREES)	CAM LOBE DISPLACEMENT IN X-DIRECTION mm(in)	CLAMP DISPLACEMENT IN X-DIRECTION mm(in)	CLAMP LOAD kg (lbs)	CLAMP TORQUE AROUND PIVOT POINT cm-kg (in-lb)
-.087(-5)	.013(.0005)	0(0)	195.96(432)	-5.42(-4.7)
-.053(-3)	.005(.0002)	0(0)	209.11(461)	-3.46(-3.0)
0(0)	0(0)	0(0)	217.73(480)	0(0)
+.035(+2)	.003(.0001)	0(0)	213.19(470)	2.42(2.1)
+.07(+4)	.008(.0003)	0(0)	204.57(451)	4.49(3.9)
+.105(+6)	.018(.0007)	0(0)	187.34(413)	6.22(5.4)
+.14(+8)	.031(.0012)	0(0)	165.56(365)	7.26(6.3)
+175(+10)	.048(.0019)	0(0)	135.17(298)	7.49(6.5)
+.280(+16)	.130(.0050)	0(0)	0(0)	0(0)
+.350(+20)	.191(.0075)	.064(.0025)	0(0)	0(0)
+.525(+30)	.432(.0170)	.310(.0120)	0(0)	0(0)
+.70(+40)	.742(.0292)	.615(.0242)	0(0)	0(0)
+.875(+50)	1.133(.0446)	1.006(.0396)	0(0)	0(0)
+1.05(+60)	1.586(.0625)	1.461(.0575)	0(0)	0(0)
+1.225(+70)	2.088(.0822)	1.961(.0772)	0(0)	0(0)
+1.40(+80)	2.616(.1030)	2.489(.0980)	0(0)	0(0)
+1.575(+90)	3.175(.1250)	3.10(.1200)	0(0)	0(0)

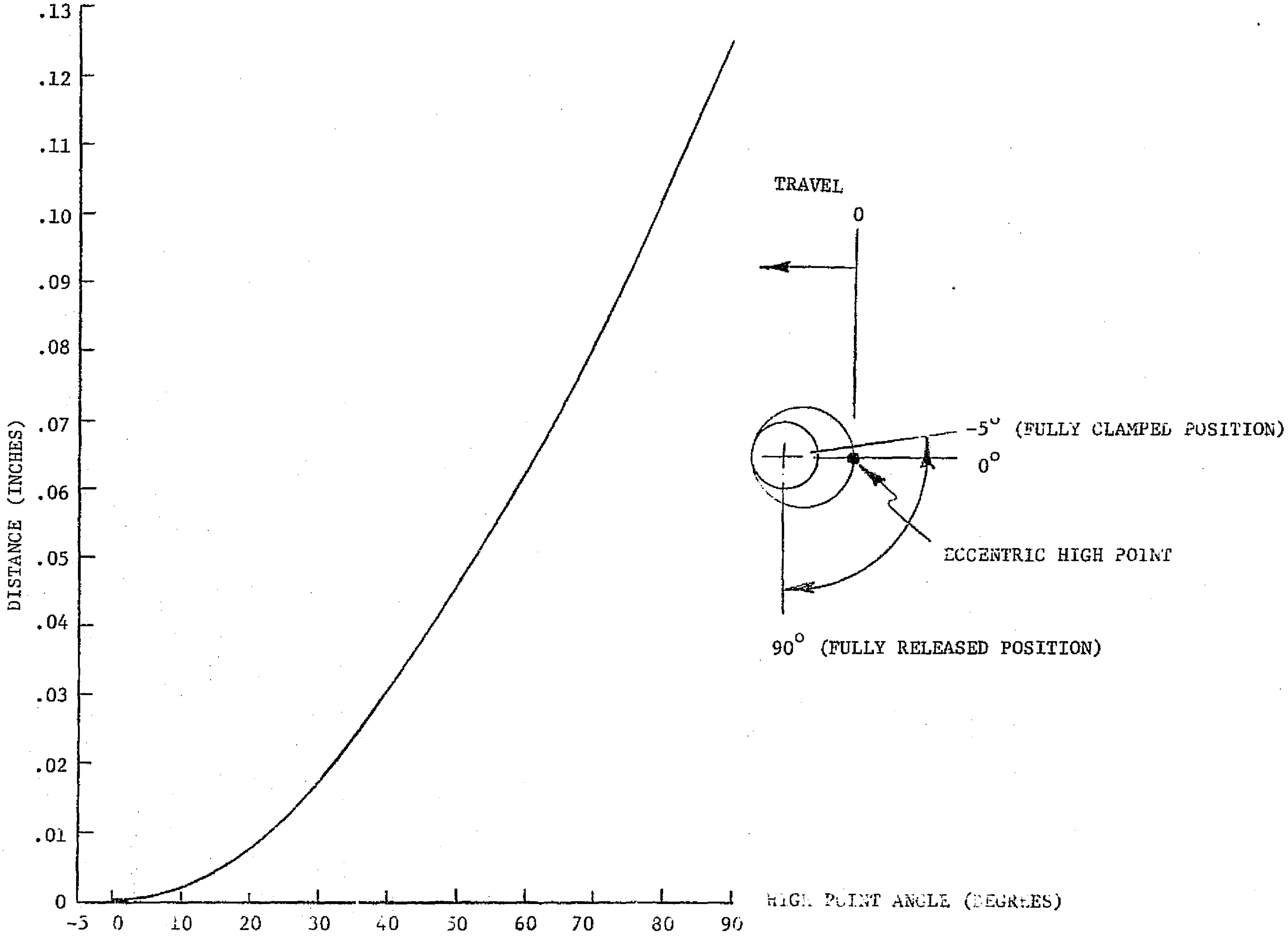


FIGURE IV-18 CLAMP CAM LOBE DISPLACEMENT

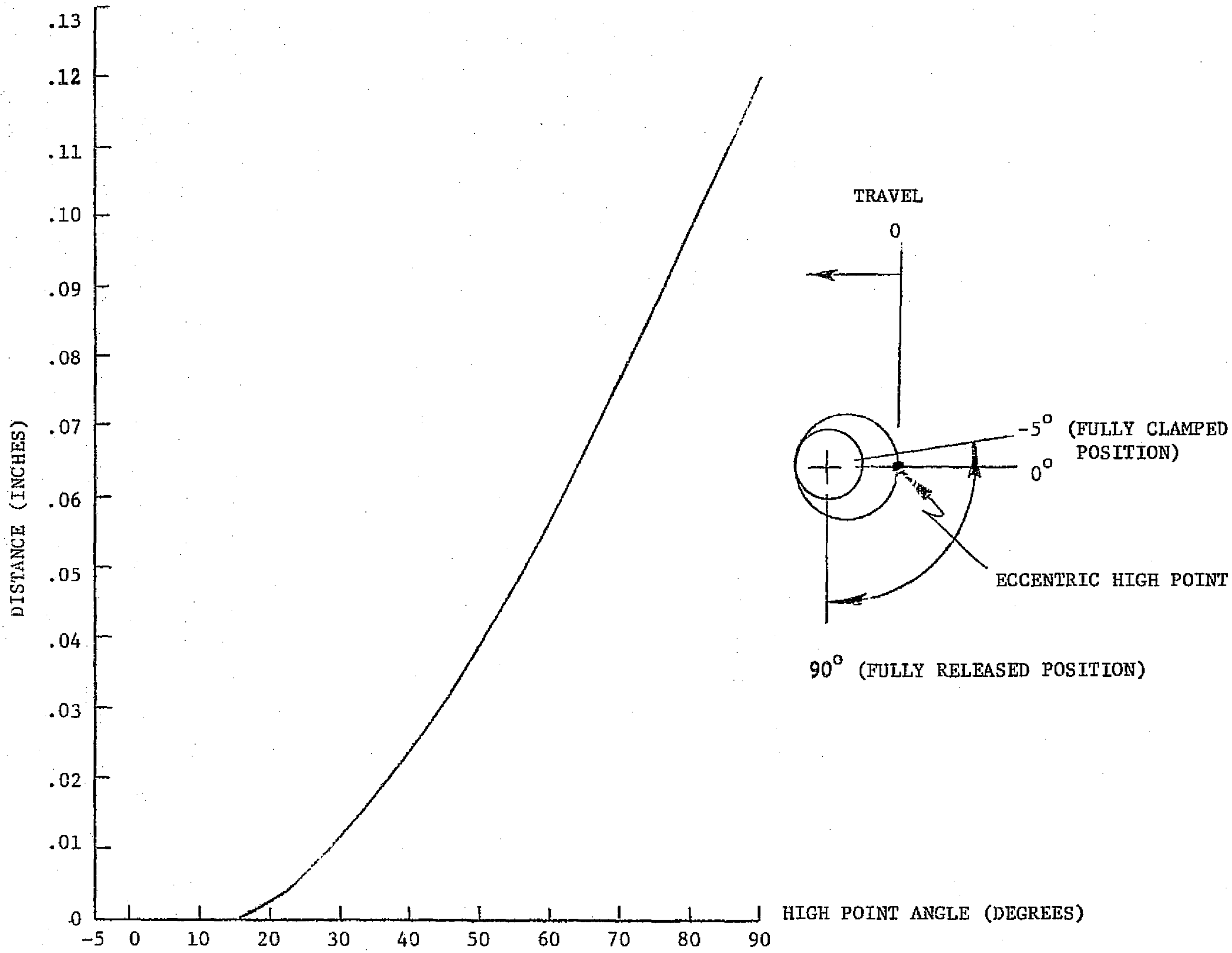


FIGURE IV-19 CLAMP DISPLACEMENT

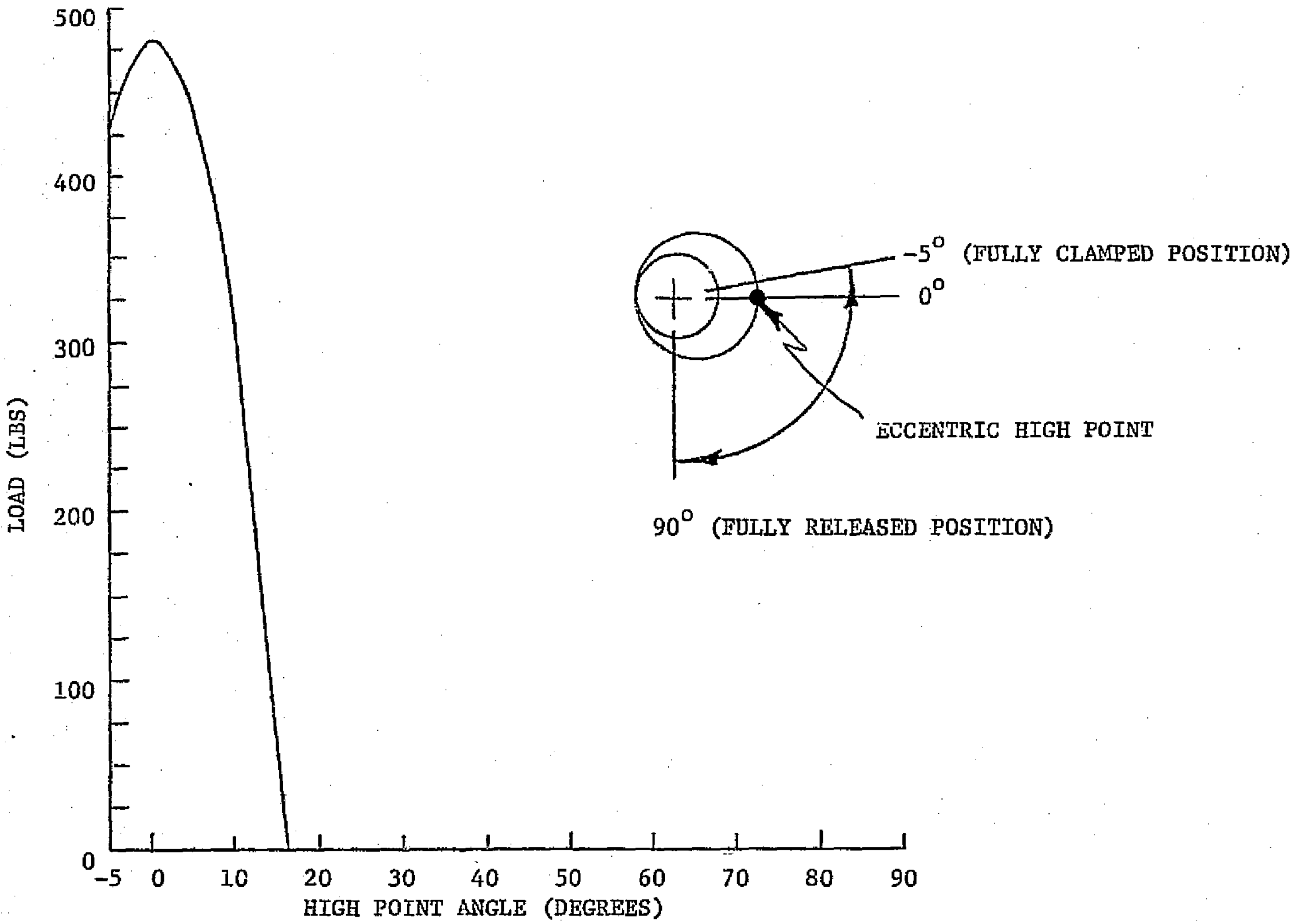


FIGURE IV-20 CLAMP LOAD

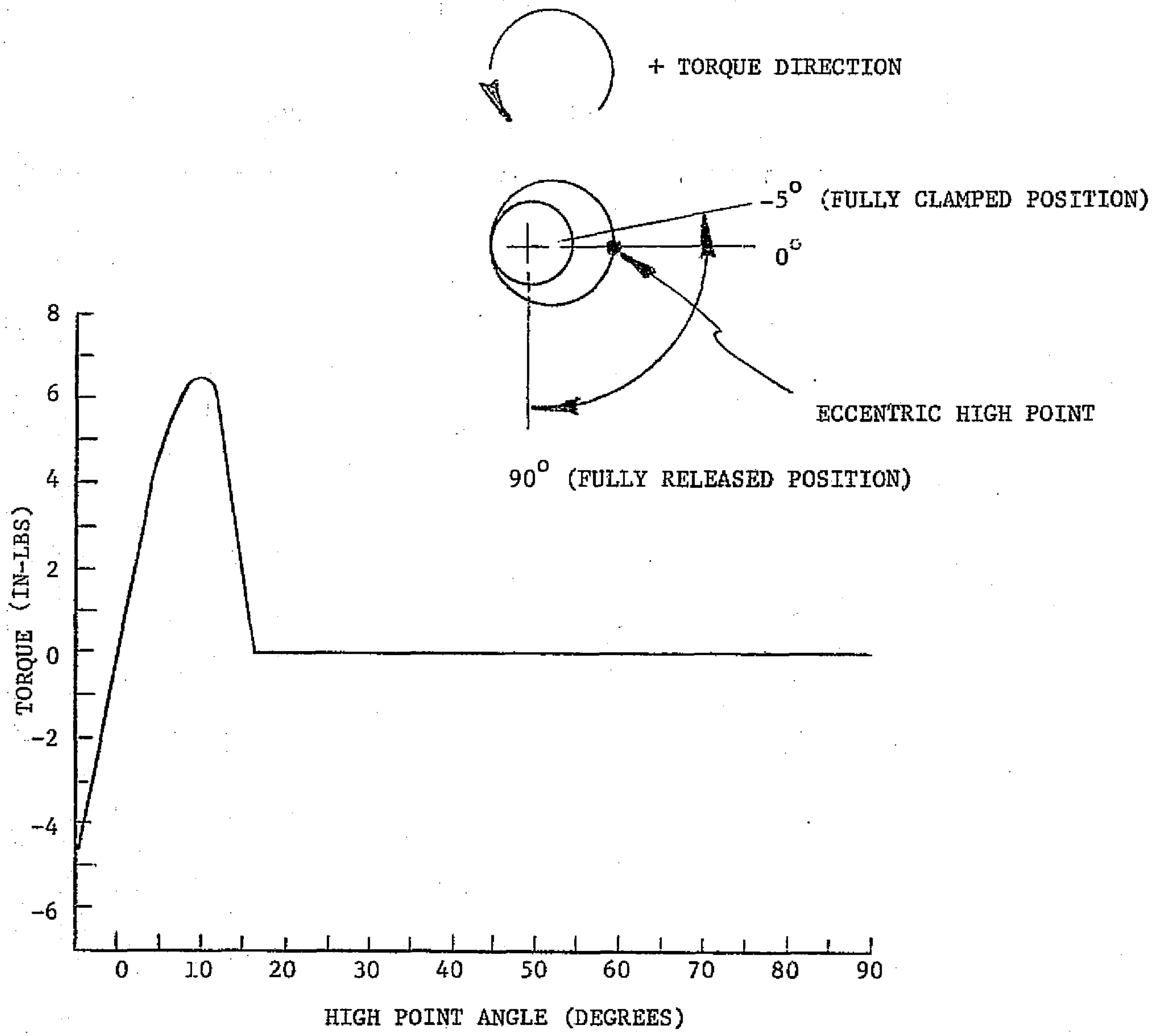


FIGURE IV-21 CLAMP TORQUE

$$\text{Area} = (.103)\ (\pi)\ (.50 + .103)$$

$$= (.103)\ (\pi)\ (.603)(6.4516)$$

$$= 1.26 \text{ cm}^2\ (.195 \text{ in}^2) > .935 \text{ cm}^2\ (.145 \text{ in}^2)$$

which is equal to
12.7 mm (1/2") tube

Through Poppet Guides:

$$\text{Area} = \frac{\pi(.219)^2}{4}\ 6.45\ (7) = 1.7 \text{ cm}^2\ (.264 \text{ in}^2) > .935 \text{ cm}^2\ (.145 \text{ in}^2)$$

Around Poppet Shaft:

Area = Cyl. Area - Obstructions

$$= \frac{\pi(.874)^2}{4} - (.25)\ (.875) - (.030)\ (.25)\ (4)$$

$$= (.601 - .219 - .030)(6.4516)$$

$$= 2.27 \text{ cm}^2\ (\underline{.352 \text{ in}^2}) > .935 \text{ cm}^2\ (.145 \text{ in}^2)$$

10. Pressure Drop Calculation

a. Assumptions for Case 1

- Values calculated for 12.7 mm (1/2 in) SS tubing 10.9 mm (.430 in) I.D.
- Water flow rate assumed to be .07 kg/sec (550 lb/hr) or .07 m^3/sec $(2.45 \times 10^{-3} \frac{ft^3}{sec})$
- Turbulent flow is assumed
- Basic equation $\Delta P = K\ (1 - \frac{A_1}{A_2})^2 \frac{V_1}{2g} \frac{e}{144}$ for enlargement losses
- Basic equation $\Delta P = \frac{K\ v^2\ p}{2g\ (144)}$ for contraction losses

Where ΔP = Pressure drop psi

K = Resistance coefficient (from handbook)

V = Fluid velocity, ft/sec

p = Fluid density, lb/ft^3

g = Acceleration of gravity 9.8 m/sec^2 (32.2 ft/sec^2)

o Conversion 1 psi = $6.89 \times 10^{-3} \frac{N}{m^2}$

1. Inlet (Gradual Enlargement) to aft poppet guide $\frac{D_2}{D_1} = (25.4)\frac{(.67)}{(.430)}$ = 38.1 mm (1.5 in) θ 1.02 radians (60°)

$\therefore$ From graph, $K_1 = \underline{1.2}$

$$\Delta P_1 = K_1 \left(1 - \frac{A_1}{A_2}\right)^2 \frac{V_1^2}{2g} \frac{(62.4)}{144} (6.895 \times 10^3) = (1.2)\left(1 - \frac{.145}{.264}\right) \frac{(2.43)^2}{(2)(32.2)} \frac{(62.4)}{(144)} (6.895 \times 10^3)$$

$$= (6.895 \times 10^3)(1.2)(.451)^2 \frac{(2.43)^2}{(64.4)} \frac{(62.4)}{(144)} = 69 \text{ N/m}^2$$

(<u>.010 psi</u>)

2. Poppet Guide to Center Cavity (Sudden Enlargement) $\frac{D_1}{D_2} = 25.4 \frac{(.58)}{(.67)}$ = 22 mm (.866 in)

V_1 = .41 m/sec (1.336) From graph, K_2 = .06

$$\Delta P_2 = K_2 (6.895 \times 10^3) \left(1 - \frac{A_1}{A_2}\right)^2 \frac{V_1^2}{2g} \frac{(62.4)}{144}$$

$$= \frac{(.06)(.25)^2 (1.336)^2 (62.4) (6.895 \times 10^3)}{9274}$$

$$= .3 \text{ N/m}^2$$ (<u>.00005 psi</u>)

3. Center Cavity to Fwd Poppet Guide (Sudden Contraction) $\frac{D_1}{D_2} = 25.4 \frac{(.58)}{(.67)} = 22$ mm (.866 in)

$V_2 = .31$ m/sec (1.002) From graph, $K_3 = .06$

$$\Delta P_3 = \frac{K_3 V_2^2}{2g} \frac{(62.4)}{144} (6.895 \times 10^3) = \frac{(.06)(1.002)^2(6.895 \times 10^3(62.4)}{9274}$$

$$= 2.8 \text{ N/m}^2 \ \underline{(.0004 \text{ psi})}$$

4. Fwd Poppet Guide to Open Cavity (Sudden Enlargement)

$$\Delta P_4 = \Delta P_2 = 3 \text{ N/m}^2 \ \underline{(.00005 \text{ psi})}$$

5. Open Cavity Through Poppet (Gradual Contraction) $K_5 = .04$

$$\Delta P_5 = 6.895 \times 10^3 \ (.04) \ \frac{V_2^2}{2g} \ \frac{62.4}{144} = \frac{(.04)(1.002)^2(62.4)(6.895 \times 10^3)}{9274}$$

$$= 1.9 \text{ N/m}^2 \ \underline{(.00027 \text{ psi})}$$

6. Second Poppet to Open Cavity (Gradual Enlargement) $\frac{D_2}{D_1} = (25.4)\frac{(.67)}{(.495)} = 34.3$ mm (1.35 in)

$V_1 = .55$ m/sec (1.808) $\theta \simeq 45^\circ$

From graph, $K_6 = 1.1$

$$\Delta P_6 = K_6 \ 6.895 \times 10^3 \ \left(1 - \frac{A_1}{A_2}{}^2\right) \frac{V_1^2}{2g} \ \frac{62.4}{144}$$

$$= \frac{(1.1)(.262)^2(1.808)^2(62.4)(6.895 \times 10^3)}{9274}$$

$$= 11.4 \text{ N/m}^2 \ \underline{(.00166 \text{ psi})}$$

7. Open Cavity to Poppet Guide (Sudden Contraction) $\frac{D_1}{D_2} = (25.4)\frac{(.495)}{(.67)} = 18.8$ mm (.74 in)

$V_2 = .31$ m/sec (1.002) $K = .18$

$$\Delta P_7 = \frac{(.18)(1.002)^2(6.895 \times 10^3)(62.4)}{9274} = 8.4 \text{ N/m}^2 \ \underline{(.00122 \text{ psi})}$$

8. Poppet Guide to Center Gravity
(Sudden Enlargement)

$\Delta P_8 = \quad P_2 = .3 \text{ N/m}^2$ $\underline{(.00005 \text{ psi})}$

9. Center Cavity to Poppet Guide

$\Delta P_9 = \quad P_3 = 2.8 \text{ N/m}^2$ $\underline{(.0004 \text{ psi})}$

10. Poppet Guide to Outlet
(Gradual Contraction)

$$\Delta P_{10} = .04 \, \frac{(1.808)^2}{2g} \, \frac{(62.4)}{144}(6.895 \times 10^3)$$

$$= \frac{.04 \, (1.808)^2 \, (62.4)}{9274}(6.895 \times 10^3)$$

$$= 6.1 \text{ N/m}^2 \ \underline{(.00088 \text{ psi})}$$

$\underline{\text{Total } \Delta P = 103.4 \text{ N/m}^2 \ (.015 \text{ psi})}$

b. Case 2 - Pressure Drop Calculation for .315 kg/sec (2500 lb/hr) H_2O

Point 1 $\Delta P_1 = \dfrac{(1.2)(.451)^2 \, (11.04)^2 \, (6.895 \times 10^3)(62.4)}{9274}$

$= 1379 \text{ N/m}^2$ (.200 psi)

Point 2 $\Delta P_2 = \dfrac{(.06)(.25)^2 \, (6.073)^2 \, (6.895 \times 10^3)(62.4)}{9274}$

$= 6.2 \text{ N/m}^2$ (.0009 psi)

Point 3 $\Delta P_3 = \dfrac{(.06)(4.555)^2 \, (6.895 \times 10^3)(62.4)}{9274}$

$= 55.2 \text{ N/m}^2$ (.008 psi)

Point 4 $\Delta P_4 = \quad P_2 = 6.2 \text{ N/m}^2$ (.0009 psi)

Point 5 $\Delta P_5 = \dfrac{(.04)(4.555)^2 \, (6.895 \times 10^3)(62.4)}{9274}$

$= 41.4 \text{ N/m}^2$ (.006 psi)

Point 6 $\Delta P_6 = \frac{1.1(.262)^2 \ (6.895 \times 10^3)(8.218)^2(62.4)}{9274}$

$= 234.4 \text{ N/m}^2$ (.034 psi)

Point 7 $\Delta P_7 = \frac{(.18)(4.555)^2 \ (6.895 \times 10^3)(62.4)}{9274}$

$= 172.4 \text{ N/m}^2$ (.025 psi)

Point 8 $\Delta P_8 = \quad P_2 = 6.2 \text{ N/m}^2$ (.0009 psi)

Point 9 $\Delta P_9 = \quad P_3 = 55.2 \text{ N/m}^2$ (.008 psi)

Point 10 $\Delta P_{10} = \frac{(.04)(8.218)^2 \ (6.895 \times 10^3)(62.4)}{9274}$

$= 124.1 \text{ N/m}^2$ (.018 psi)

Total $\Delta P = 2080 \text{ N/m}^2$ (.3017 psi)

c. Case 3

ΔP for .315 kg/sec (2500 #/hr) F-21 @ 255.4°K (0°F)

$\Delta p = 1464.3 \text{ kg/m}^3$ (91.52 #/ft^3)

$= .299 \times \frac{91.5}{62.4} \times (6.895 \times 10^3) = 3020 \text{ N/m}^2$ (.438 psi)

11. Stress Analysis

a. For Valve Body with Internal Pressure:

MAT'L:
21-6-9 SS
$5.2 \times 10^8 \text{ N/m}^2$
(75K psi)
YIELD

Hoop Stress $= \frac{Pr}{t}$

$P = 4.14 \times 10^6 \text{ N/m}^2$ (600 psi)
$r = .5$
$t = .062$

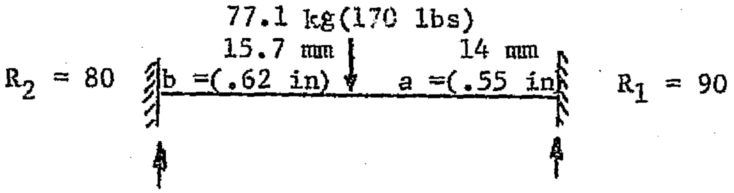
Longitudian Stress $= \frac{Pr}{2t}$

$= \frac{Pr}{t} = \frac{(600)(.5)(6.895 \times 10^3)}{.062} = 333.65 \times 10^5 \text{ N/m}^2$ (4839 psi)

$<$ Allowable $5.2 \times 10^8 \text{ N/m}^2$ (75K)

b. **Stress in Valve Stem Due to Bending:**

MAT'L:
21-6-9 SS
5.2×10^8 N/m^2
(75K psi)
YIELD



$$M_{max} = W \frac{ab^2}{2} + R_1 a$$

$$M_{max} = \frac{-(170)(.55)(.62)^2}{(1.17)^2} + \frac{(90)(.55)}{(1.15)}$$

$$M_{max} = 28 \text{ cm-kg } \underline{(24.3 \text{ in-lb})}$$

$$I = .05\ d^4 = .05(.25)^4\ (41.6 \times 10^{-8}) = 8.4 \times 10^{11}\ m^4\ \underline{(.000195\ in^4)}$$

$$C = .125$$

$$\sigma = \frac{MC}{I} = \frac{(24.3)(6.895 \times 10^3)(.125)}{.000195} = 10.7 \times 10^7\ N/m^2\ \underline{(15{,}500\ psi)}$$

$<$ Allowable 5.2×10^8 N/m^2 (75K)

Deflection = .005 mm (.0002 in)

c. **Shear Stress on Flange**

Assume Clamp Force at one side = 181.44 kg (400 lbs)

Shear Area

$$A = (.187)(.500)(6.4516 \times 10^{-4})$$

$$= 6.1 \times 10^{-5}\ m^2\ \underline{(.094\ in^2)}$$

MAT'L:
21-6-9 SS
5.2×10^8 N/m^2
(75K psi)
YIELD

$$\sigma = \frac{F}{A} = (6.895 \times 10^3)\ \frac{(400)}{(.094)} = 2.94 \times 10^7\ N/m^2\ \underline{(4260\ psi)}$$

$<$ Allowable 5.2×10^8 N/m^2 (75K)

d. **Clamp Pivot Boss Shear**

MAT'L:
21-6-9 SS
5.2×10^8 N/m^2
(75K psi)
YIELD

$$\text{Cross-Sectional Area} = \frac{\pi(.25)^2}{4} - \frac{\pi(.16)^2}{4} \quad (6.4516 \times 10^{-4})$$

$$= 1.87 \times 10^{-5}\ \text{m}^2 \quad (.029\ \text{in}^2)$$

$$\sigma = \frac{F}{A} = (6.895 \times 10^3)\ \frac{(400)}{(.029)} = 9.5 \times 10^7\ \text{N/m}^2\ (13{,}793\ \text{psi})$$

$< \text{Allowable } 5.2 \times 10^8\ \text{N/m}^2\ (75\text{K})$

e. **Tensile Strength of 10-32 Thd in Clamp Rods**

MAT'L:
21-6-9
5.2×10^8 N/m^2
(75K psi)
YIELD

$$A = \frac{(6.4516 \times 10^{-4})\ \pi\ d^2}{4} = \frac{(6.4516 \times 10^{-4})\ \pi(.140)^2}{4}$$

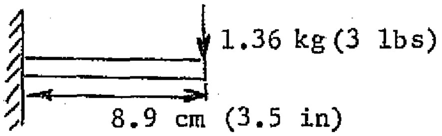
$$= 9.7 \times 10^{-6}\ \text{m}^2 \quad (.015\ \text{in}^2)$$

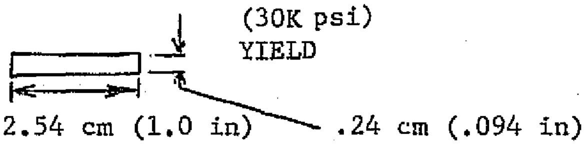
$$\sigma = \frac{F}{A} = (6.895 \times 10^3)\ \frac{(400)}{(.015)} = 1.84 \times 10^8\ \text{N/m}^2\ \underline{(26{,}666\ \text{psi})}$$

$< \text{Allowable } 5.2 \times 10^8\ \text{N/m}^2\ (75\text{K})$

f. **Handle Bending**

MAT'L
6061-T6
2.07×10^5 N/m^2
(30K psi)
YIELD





$$I = \frac{41.6 \times 10^{-8}\ (bh^3)}{12} = \frac{(1.0)(.094)(41.6 \times 10^{-8})}{}$$

$$= 2.9 \times 10^{-11}\ \text{m}^4 \quad (.0000692\ \text{in}^4)$$

$$M = 12.1 \text{ cm/kg } \underline{(10.5 \text{ in-lb})}$$

$$= \frac{MC}{I} = \frac{(10.5(.047)(6.895 \times 10^3)}{6.92 \times 10^{-5}} = 4.69 \times 10^7 \text{ N/m}^2 \ \underline{(6800 \text{ psi})}$$

$< \text{Allowable}$

g. <u>Axial Force Loading of Poppet</u>

Leaf Spring MAT'L: 17-7 PH SS 1.4×10^9 N/m^2 (200K psi yield)

Size: .41 mm x 9.5 mm x 12.7 mm (.016 in x .375 in x .500 in)

for 45.6 kg (100 lb) or 9.1 kg (20 lb/spring)

$$M = \frac{WL}{4} = \frac{(20)(.5)(1.15)}{4} = 2.9 \text{ cm-kg } (2.5 \text{ in-lb})$$

$$I = \frac{bh^3}{12} = \frac{(41.6 \times 10^{-8})\ (.375)(.016)^3}{12} = 5.35 \times 10^{-14} \text{ m}^4$$

$$(1.285 \times 10^{-7} \text{ in}^4)$$

$$\sigma = \frac{MC}{I} = \frac{(6.895 \times 10^3)(2.5)(.008)}{1.285 \times 10^{-7}} = 1.08 \times 10^9 \text{ N/m}^2 \ (156{,}250 \text{ psi})$$

Allowable 1.4×10^9 N/m^2 (200K)

$$f = \frac{WL^3}{EI\ 48} = \frac{(20)(.5)^3\ (2.54)}{(2.9 \times 10^7)(1.285 \times 10^{-7})48} = .035 \text{ cm } \underline{(.0139 \text{ in})}$$

$\therefore$ (5) springs .41 mm (.016 in) thk with .36 mm (.014 in) deflection equals 45.6 kg (100 lbs) load.

F. FINAL DEVELOPMENT DESIGN REVIEW

The final design review for the positive isolation disconnect was held February 4, 1975, at NASA-JSC. Final design drawings and related engineering calculations were submitted and discussed by Martin Marietta. The proposed design is shown in Figure IV-4, and after the recommended action item changes were incorporated the final design was in the form shown in Figure IV-9. The action items investigated and the corrective actions taken were as follows:

1. NASA requested that vent holes be added to relieve entrapped fluid volumes in the Belleville washer region. Martin Marietta revised that portion of the design by using a series of flat springs in a yoke which is an open design that eliminates areas of entrapped fluid.

2. NASA requested positive means, such as a directive arrow, for indicating direction of valve stem rotation for valve opening and closure. Martin Marietta incorporated directive arrows and nomenclature on the design to indicate operational directions.

3. NASA requested a positive operation indicator that would alert operator to a condition of incomplete poppet closure due to trapped uncrushable contaminants between seal and seat. Martin Marietta's revised design provides a clearance between leaf springs and poppet shaft drive yoke of .38 mm (.015 in.) when springs are in relaxed position. Normal closing of the poppet takes up all that clearance with spring deflection. If solid material is lodged between poppet and its seat as valve stem is torqued for closure, the stem cam will bottom out the leaf springs against the poppet shaft drive yoke before the stem cam reaches top dead center. The resulting applied torque of valve stem will increase rapidly and valve stem position pin will not be against the pin stop indicating incomplete poppet closure.

4. NASA requested further investigation into design alternatives of the poppet shaft yoke assembly to accomplish minimum volume and length, resulting in a smaller disconnect unit. Martin Marietta revised the design by using a series of leaf springs in the yoke that resulted in a more compact design.

5. NASA requested that the integral latching mechanism be redesigned considering fabrication from aluminum for a weight advantage. Martin Marietta revised the latch handle to a smaller aluminum configuration.

6. NASA requested that the flow path through the disconnect body be contoured to reduce the pressure drop. Martin Marietta modified the design to provide gradual expansion and contraction of the flow path.

7. NASA requested that the overall weight and volume be reduced to a figure in accordance with the preliminary design report. Martin Marietta revised the design with weight and envelope volume to be within the PDR values.

V. DEVELOPMENT OF DISCONNECT ASSEMBLY

The objective of this task was to fabricate one 6.35 mm (¼ inch) PID assembly and one 12.7 mm (½ inch) PID assembly and to perform developmental testing.

A. FABRICATION OF PID ASSEMBLIES

The PID assemblies were fabricated in Martin Marietta's Engineering Model Shop from the NAS9-14376A detail design drawings shown in Figure IV-9. Program personnel prepared and released procurement requirements for commercial components and material per the drawing bill of materials. An assembled PID with both halves and coupling mechanism weighed .58 kilograms (1.28 pounds). The complete PID had overall dimensions of 60.4 mm (2.38 inches) wide, 61.9 mm (2.437 inches) in height, and 120.7 mm (4.75 inches) in length.

Figure V-1 is the assembled PID with both halves coupled together by the coupling mechanism. The tubing attached to each end is not a part of the PID, but was utilized in the developmental testing. Figure V-2 is a top view of the PID with the poppet stem foolproofing cams aligned with the coupling mechanism handle slots. In this condition, the internal poppets are closed and the handle can be lifted to uncouple the two halves as shown in Figure V-3.

Figure V-4 shows the two halves separated. The half with the coupling mechanism is considered the line half and the other half is considered the component half. The dual face seals in the line half and the recessed mating partial glands in the component face are visible in this figure. Figure V-5 shows the line half PID with the internal poppet opened. The outer flange is notched as shown at the bottom of this figure for quick alignment purposes between the two halves. The poppet is opened by turning the poppet valve stem 3.14 radians (180°) in the direction of the arrow marked "open".

Figure V-6 shows the line half PID with the protection end cap. The cap protects the face seals during periods when the component half is removed with the component to be maintained during maintenance functions. The cap is slipped inside the coupling mechanism and the handle is pulled down to clamp the cap against the seals as shown in Figure V-7.

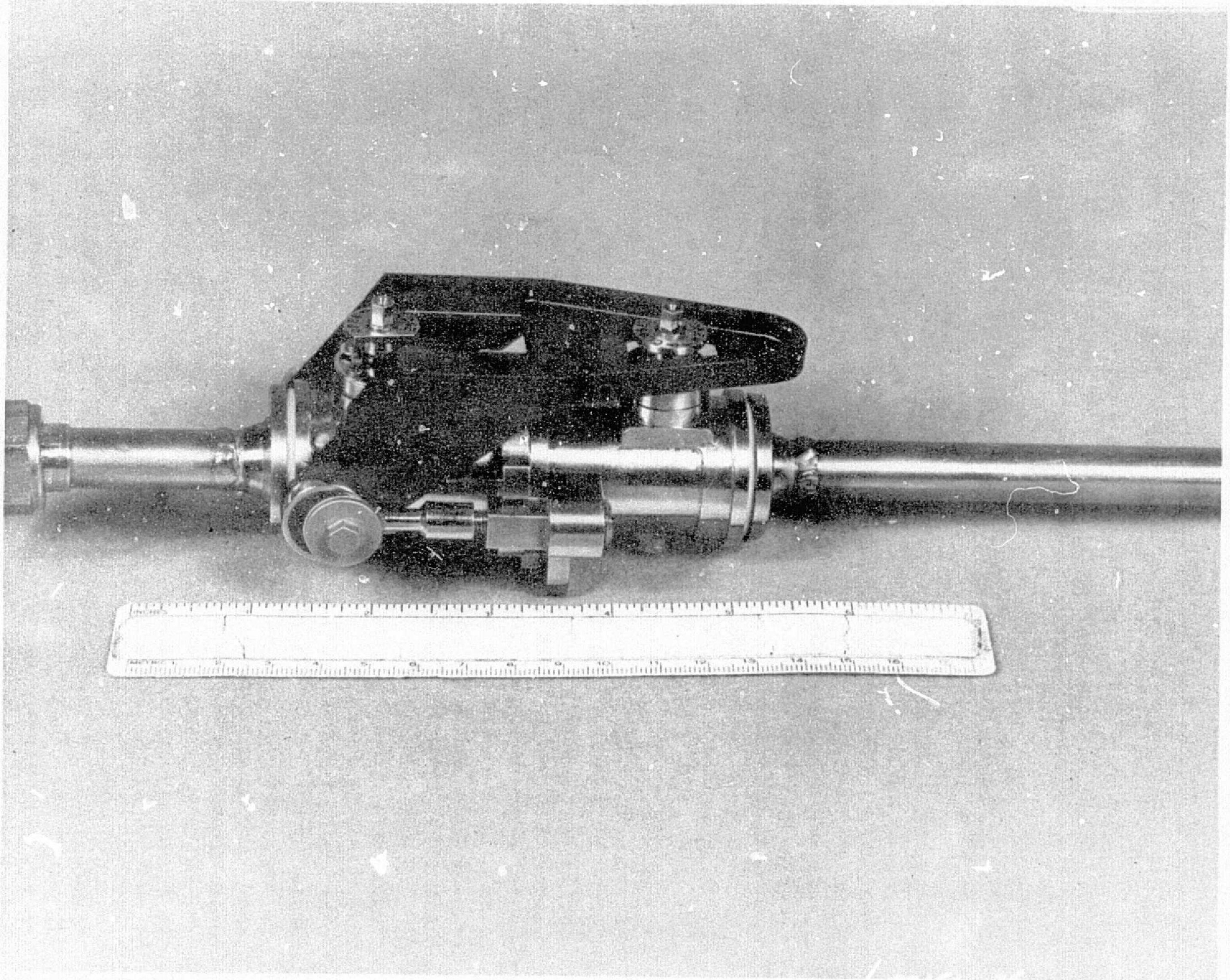


FIGURE V-1 ASSEMBLED PID (SIDE VIEW)

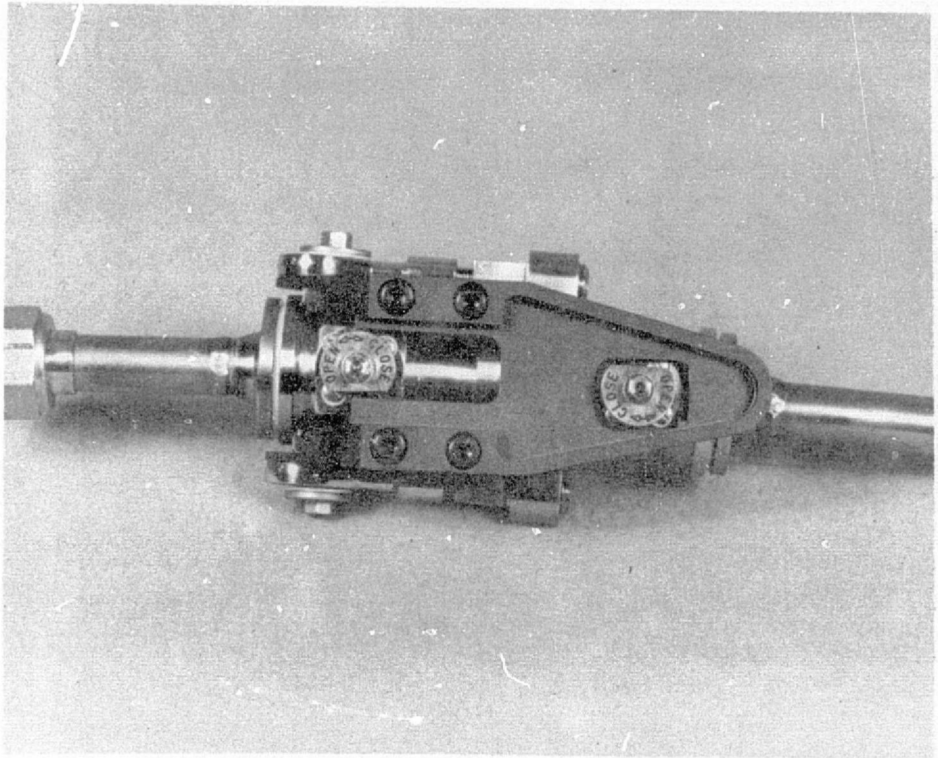


FIGURE V-2 ASSEMBLED PID (TOP VIEW)

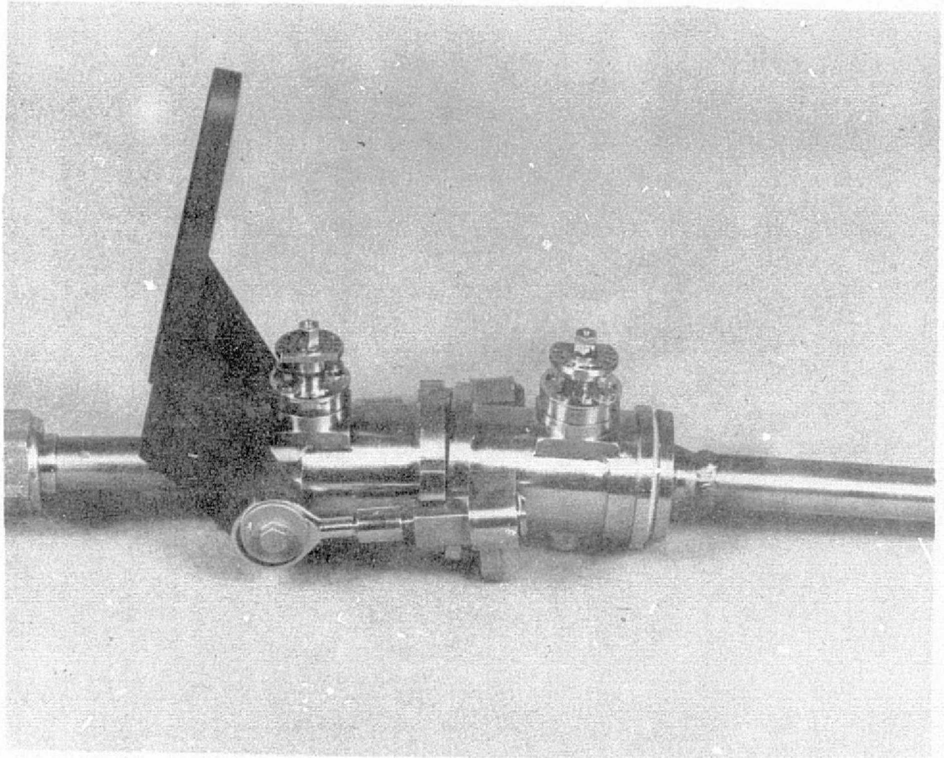


FIGURE V-3 PID COUPLING MECHANISM IN RELEASED POSITION

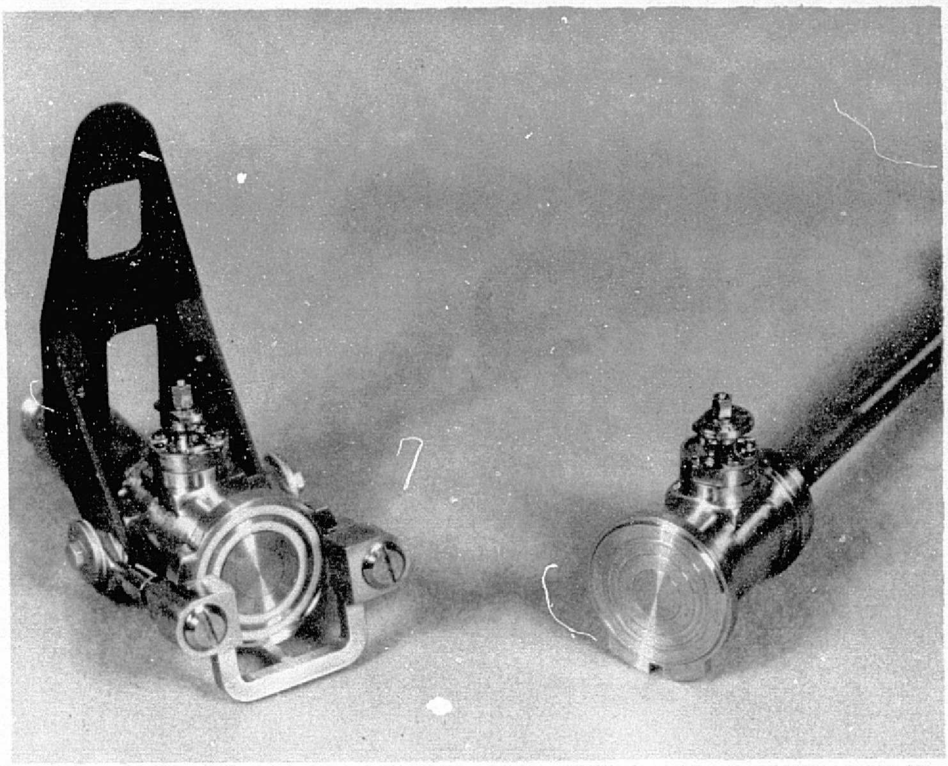


FIGURE V-4 PID HALVES SEPARATED

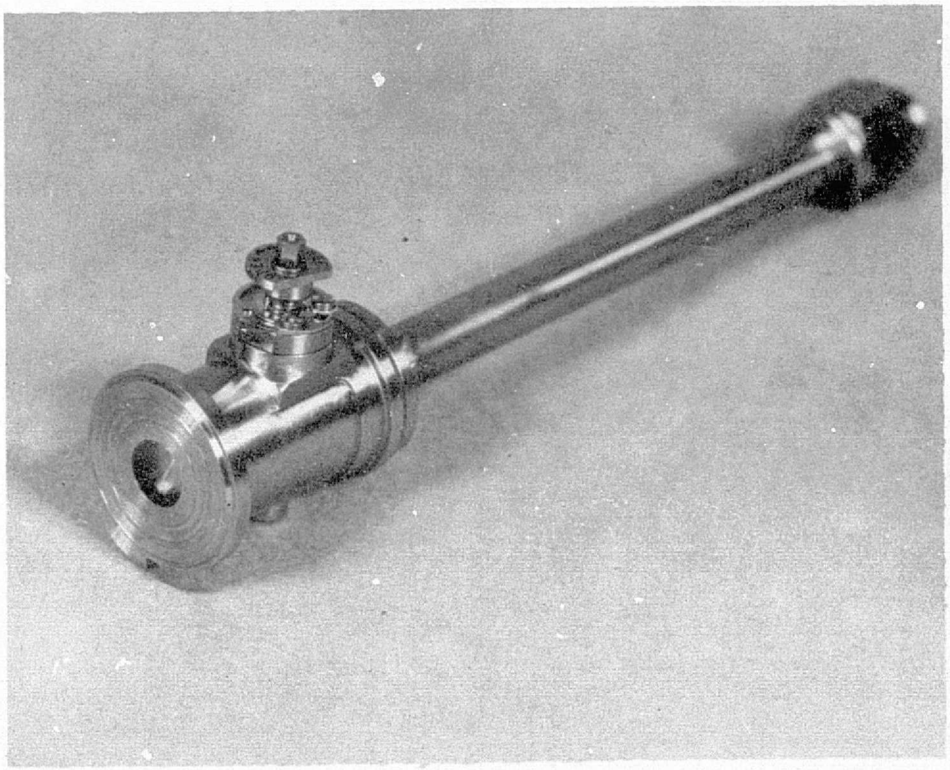


FIGURE V-5 COMPONENT HALF PID WITH MATERIAL POPPET OPENED

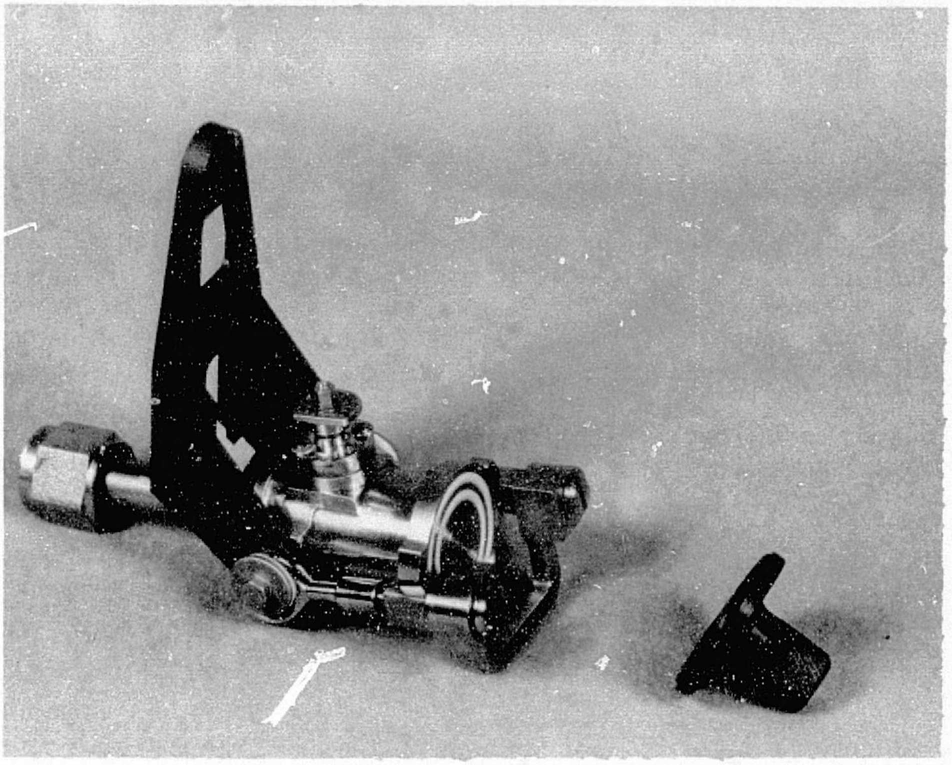


FIGURE V-6 LINE HALF PID WITH END CAP

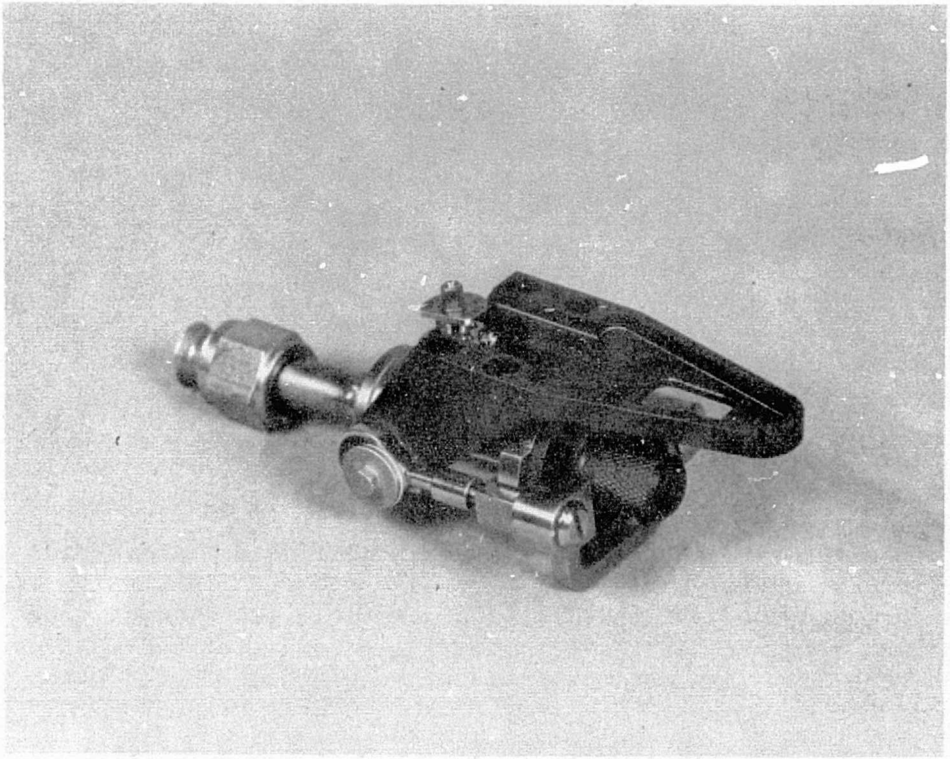


FIGURE V-7 END CAP INSTALLED ON LINE HALF PID

B. DEVELOPMENT TEST PROGRAM

This task was to provide a test program for developmental design criteria to evaluate the PIDs designed and fabricated under this contract. The primary purpose of the test program was to verify that the desired design life and leakage characteristics of the PIDs could be attained using operational fluids at specified temperatures and pressures.

A Master Test Plan, DRL Number T-1028, DRL line item 3, was prepared and submitted. From this test plan, a test procedure identified as Procedure H40586 was prepared. The testing was performed in Martin Marietta's Engineering Propulsion Laboratory. The test articles were the 6.35 mm (¼ inch) PID and the 12.7 mm (½ inch) PID fabricated in paragraph VA. Figure V-8 shows the two PIDs installed in the test fixture.

Test Description

The test program on the disconnect assemblies consisted of proof pressure, internal leakage, external leakage and operational life cycle testing. The compatibility of the disconnect assembly with water and Freon-21 was also evaluated during the test program.

The proof pressure test was performed to demonstrate the structural integrity of the disconnect assemblies prior to performing any other testing. For this test the unit was pressurized to 4.14×10^6 plus 0 minus 4.14×10^4 N/m^2 (600 plus 0 minus 6 psig) (1.5 times the design operating pressure) for 300 seconds (5 minutes) with GN_2 at ambient temperature. At the end of the 300 second (5 minute) period the pressure was decreased to 0 N/m^2 (0 psig) and the unit was inspected for any signs of permanent deformation or degradation in its operational capability. This test was performed with the isolation valves open and the unit connected and repeated on each half of the disconnected unit with the isolation valves closed (see Figures V-9 and V-10).

Internal and external leak tests were performed at intervals during the operational life cycle testing as an indication of performance degradation. For the internal leak checks, water and GN_2 were used as the test fluids. When water was used as the test fluid, the unit was disconnected while filled with

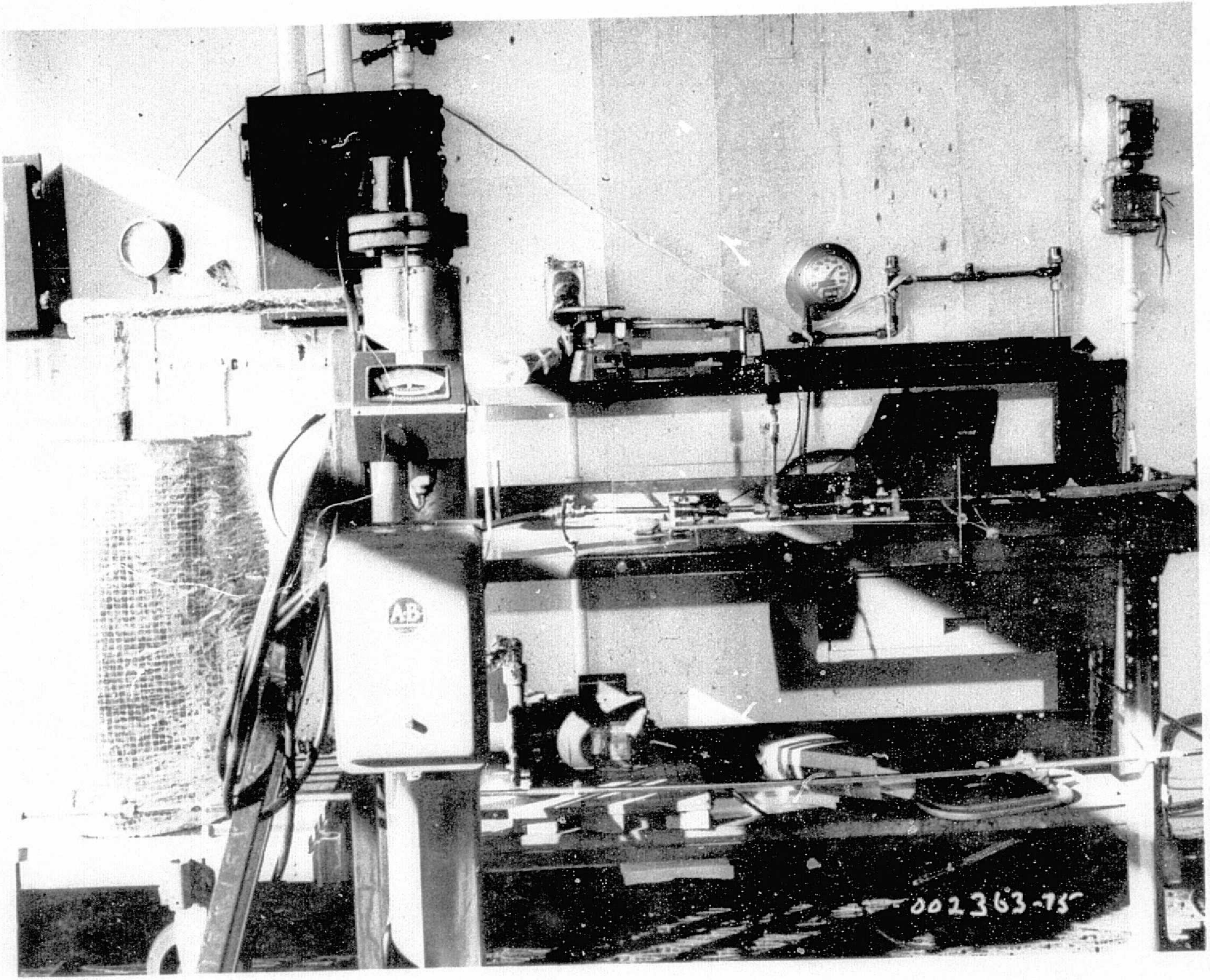


FIGURE V-8 PID'S INSTALLED IN TEST FIXTURE

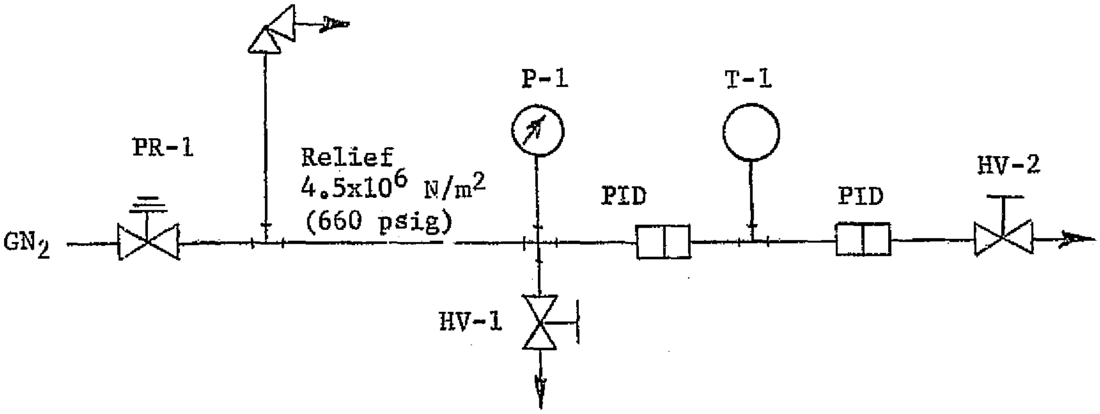


FIGURE V-9 PROOF TEST - INTERNALLY OPEN

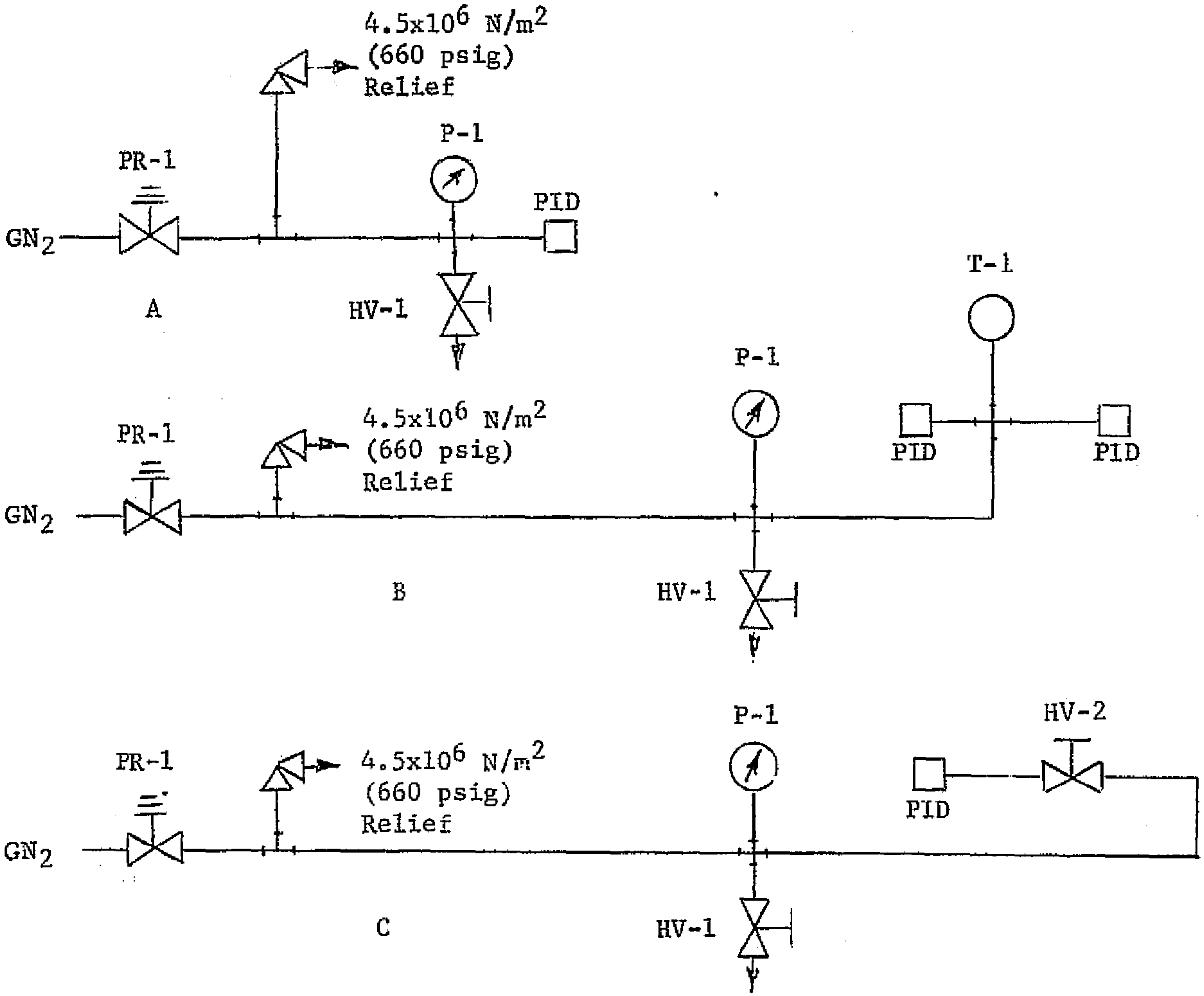


FIGURE V-10 PROOF TEST - INTERNALLY CLOSED water at the desired pressure. The water left at th interface was collected and measured and the mating faces were purged dry. The mating faces were then observed for a 3600 second (one hour) period to verify the absence of a liquid leak. When GN_2 was used as the test fluid, each half of the unit was pressurized and submerged in water (see Figure V-11). Leakage was collected in an inverted graduated beaker and the rate was determined by timing the displacement. Water and helium were used as the test fluids for the external leak tests. These tests were performed with the unit in a connected mode and with the internal poppets open. When water was used as the test fluid, the unit was filled and pressurized with water. The external surfaces of the unit were then purged dry and observed for a period of 3600 seconds (one hour) to verify the absence of leakage. When helium was used as the test medium, the connector was encased in a polyethylene bag and pressurized to the desired pressure with helium (Figure V-12). The leakage rate was determined by inserting the probe from a helium mass spectrometer into a bag and allowing the mass spectrometer output to stabilize.

The operational life cycle tests were performed using Freon-21 (see Figure V-13), water and GN_2 (as shown in Figures V-14 and V-15) as the test fluids. A cycle consisted of circulating the test fluid through the connector assembly at a pressure of 2.758×10^6 N/m^2 (400 psig) and a temperature of 274.8 or 355.4°K (35 or 180°F). The isolation valves were then closed and the connector was disconnected. The connector was then reconnected and the isolation valves were opened. This cycle was repeated for a total of 2500 cycles using water as a test fluid and 2500 cycles using GN_2 as the test fluid. An additional 12 cycles were performed using Freon-21 as the test fluid in order to assure that the operation of the disconnect would not be degraded when exposed to Freon-21 as an operational fluid.

During the life cycle testing when water was being used as the test fluid, a specific cycle was performed to evaluate the hydraulic lock and valve torque characteristics of the unit (see Figure V-16). For this test, the connector and associated plumbing were verified filled with water and both sides of the disconnect were closed in sequence. The absence of a hydraulic lock was verified by observation. The isolation valves were closed using a torque wrench to verify that the required torque did not exceed the design limits. The disconnect halves were

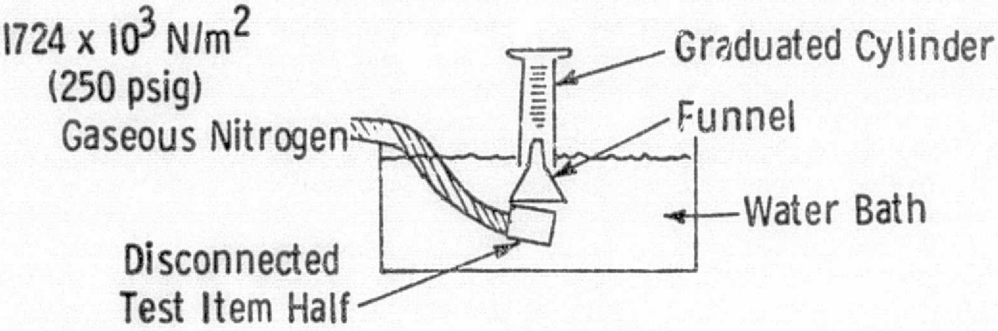


FIGURE V-11 INTERNAL LEAKAGE TEST SCHEMATIC (DISCONNECTED MODE)

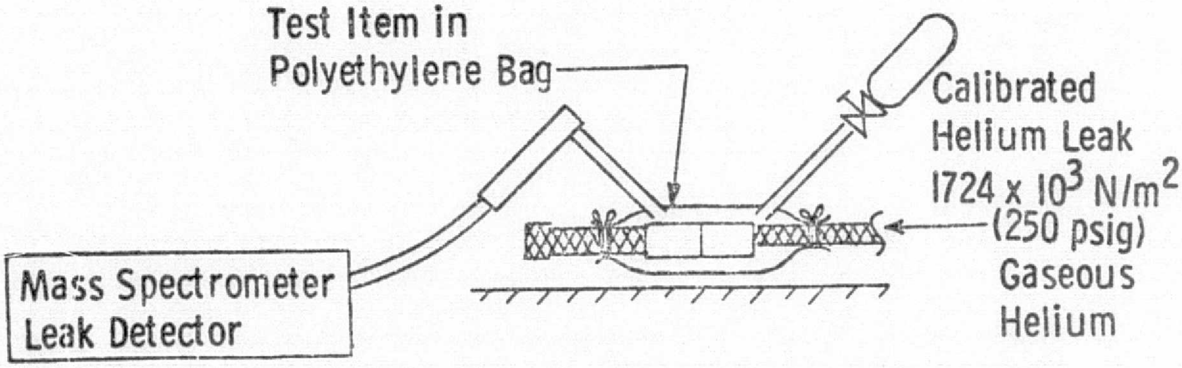


FIGURE V-12 EXTERNAL LEAKAGE TEST SCHEMATIC (CONNECTED MODE)

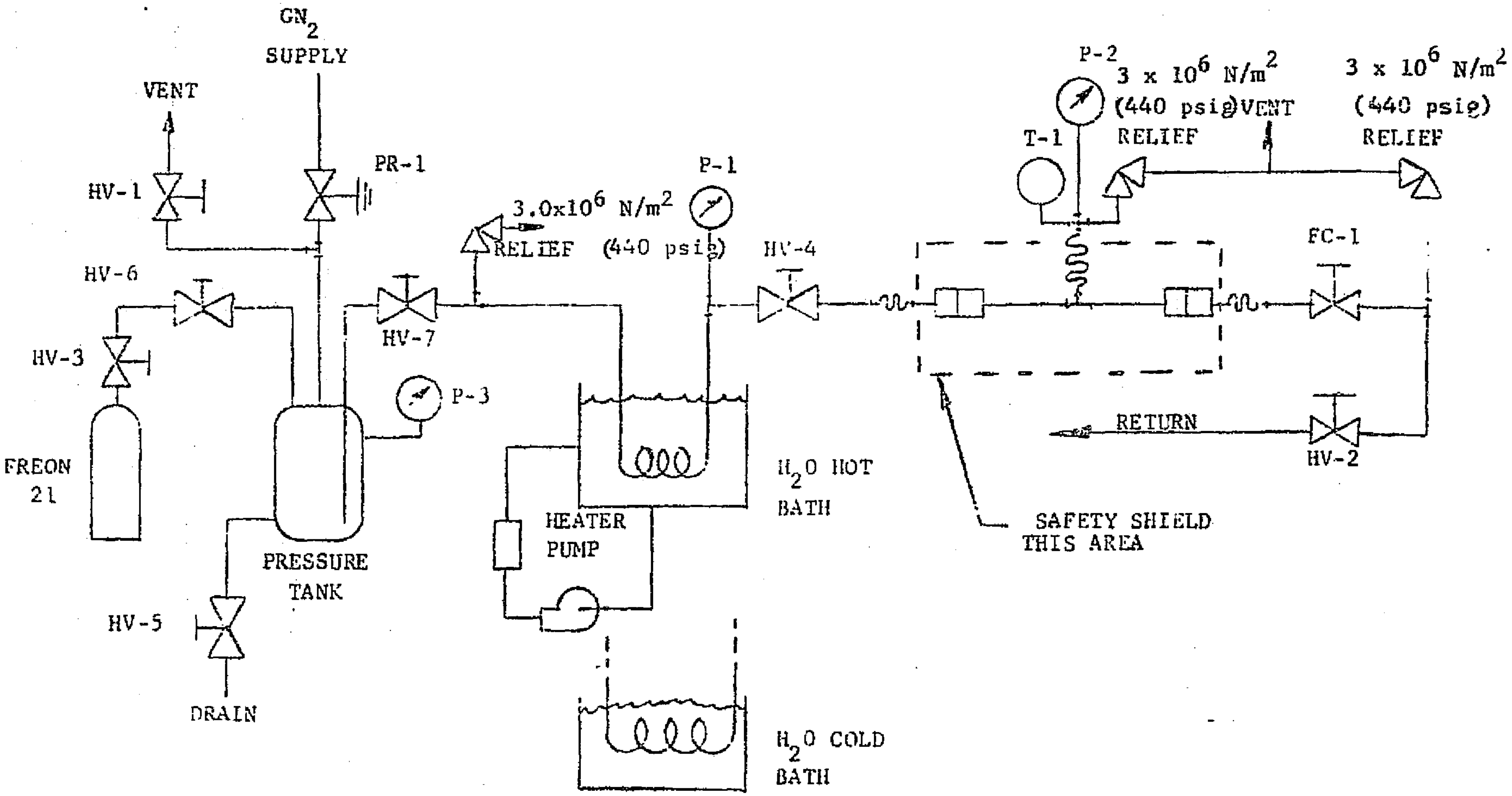


FIGURE V-13 FREON-21 EXPOSURE AND CYCLE

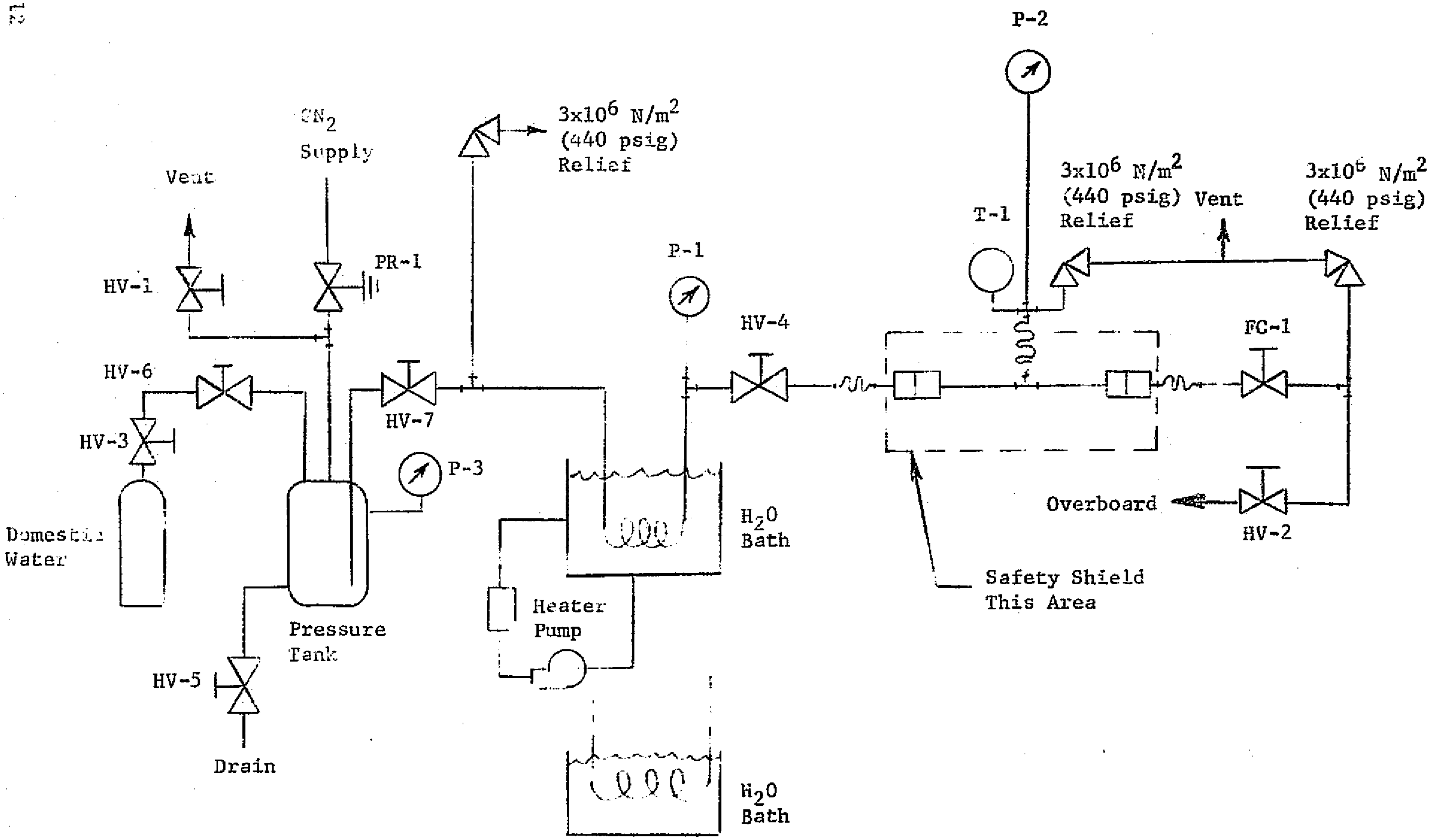


FIGURE V-14 H_2O OPERATIONAL LIFE CYCLE

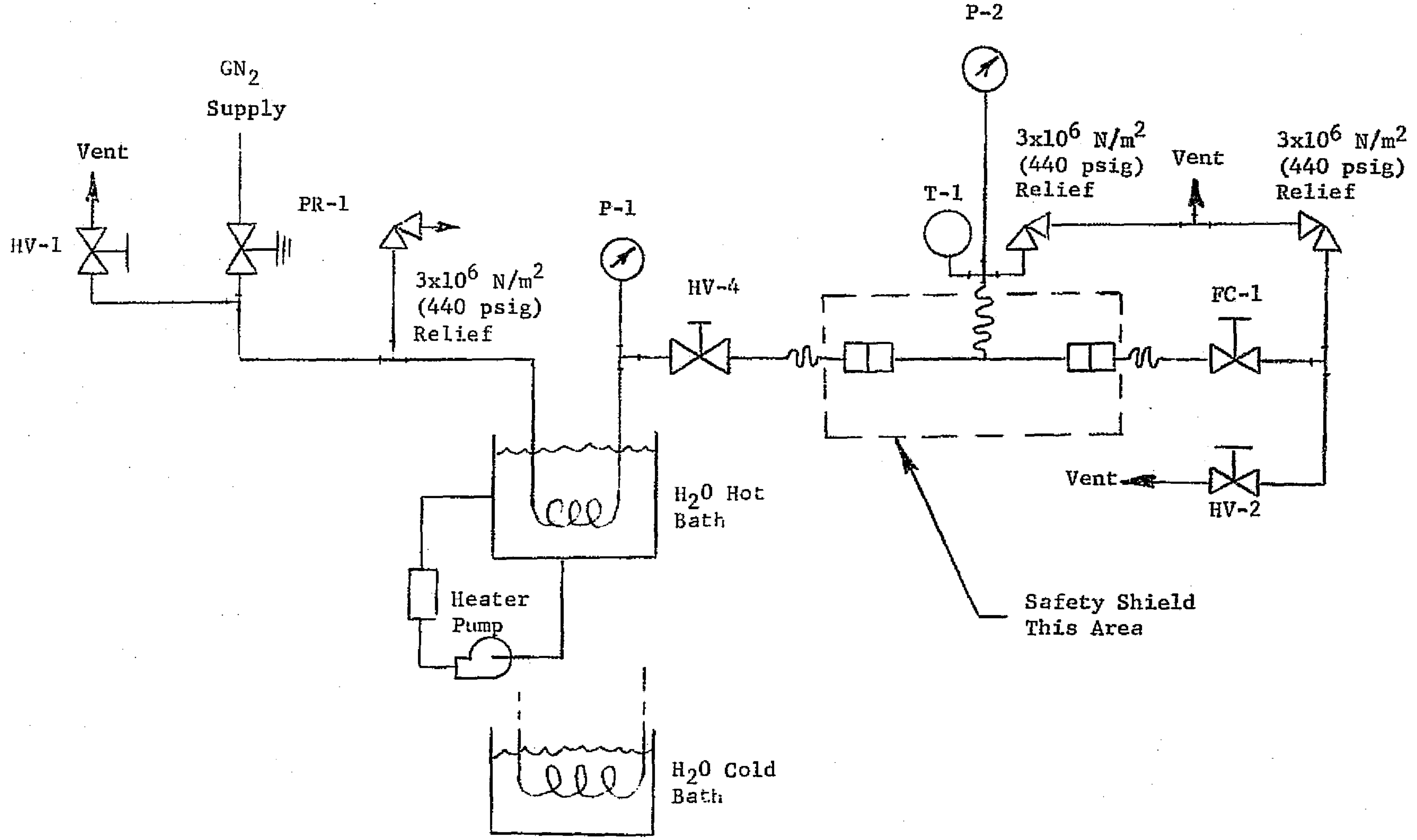


FIGURE V-15 GN_2 OPERATIONAL LIFE CYCLE

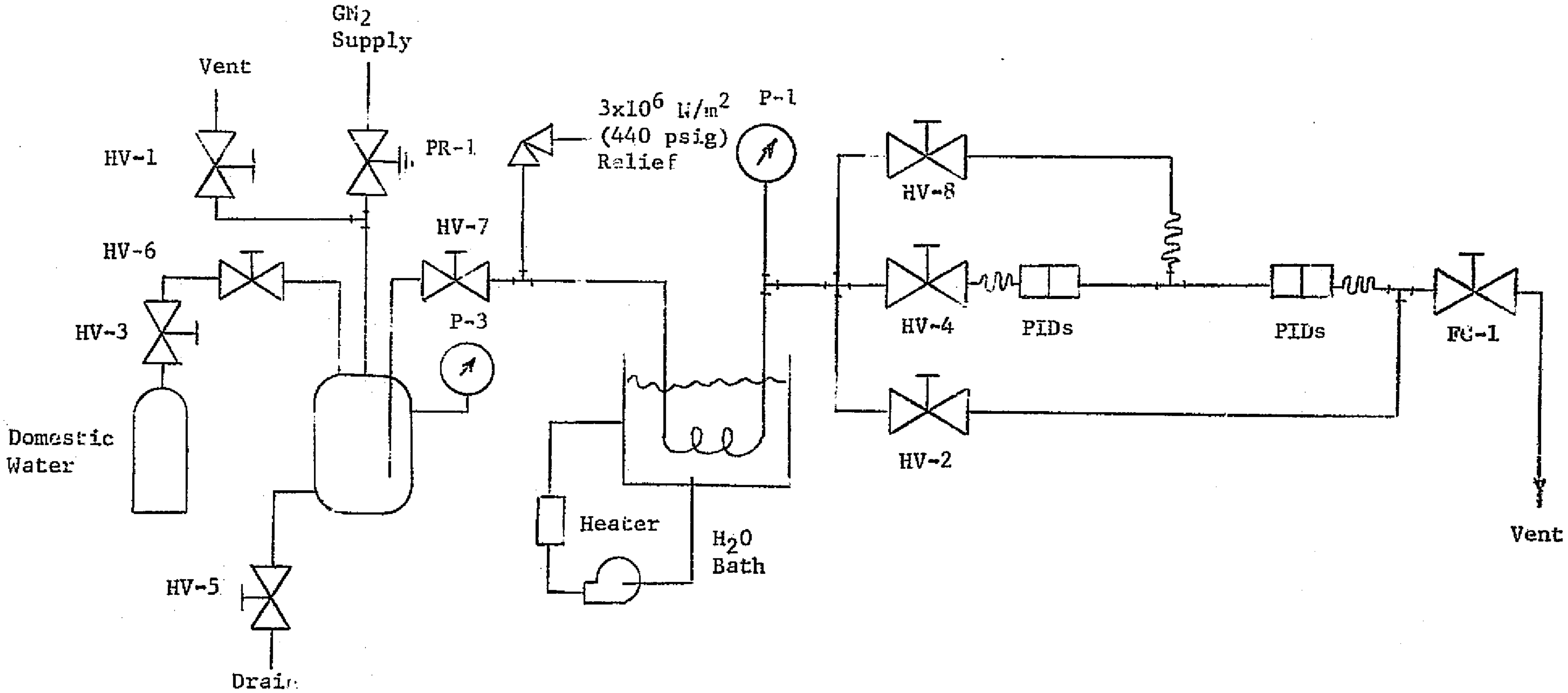


FIGURE V-16 HYDRAULIC LOCK-UP

then separated to verify that the poppets were fully closed and to measure any fluid remaining at the interface.

Test History and Results

The sequence of testing and the test results are presented in the following paragraphs. A description of the test methods is included in the Test Description section of this report. All testing was performed in accordance with EPL Procedure Number H40586.

Proof Test - For this test the disconnect assemblies were installed in the test fixtures as shown in Figures V-9 and V-10. The 12.7 mm (1/2 inch) unit successfully completed the proof test on the first attempt. The 6.35 mm (1/4 inch) unit leaked excessively when pressurized from the line side between the adapter tube and the boss seal. The proof test was repeated. The 6.35 mm (1/4 inch) unit successfully completed the test on the second attempt.

A .38 mm (.015 inch) gap was measured between the adapter tube (-032) and the PID bodies (-002 and -025). This did not allow a complete capture of the boss seal (-028) in its gland. This was due to a tolerance build up in the assembly of the internal mechanisms of the PID. The dimension 7.92 mm (.312 inch) was reduced by .38 mm (.015 inch) on both end adapters which allowed the adapter flange to physically interface with the PID body.

The test units showed no visible indications of permanent deformation or distortion and no loss of operating capability as a result of the proof pressure test.

Hydraulic Lock Test - This test was performed with the disconnect assemblies installed in the test fixture as shown in Figure V-16. The test was performed at a pressure of 1.72×10^5 N/m^2 (25 psig) and repeated at a pressure of 2.76×10^6 N/m^2 (400 psig) using water at a temperature of 283.7°K (51°F) as the test fluid. Both units completed this test with no indication of hydraulic lockup and no increase in the torque required to open and close the isolation valves. Operational torques were all less than 5.76 cm-kg (5 in-lbs).

Operational Life Cycle and Leakage Tests - The test history for the life cycle testing is presented with respect to the number of cycles completed. The first cycles on the disconnect assemblies were performed using water at 355.4°K (180°F) as the test fluid. A schematic of the test fixture for these cycles is shown in Figures V-14 and V-15.

050: During these initial cycles, the poppet O-ring on the line side of the 6.35 mm (1/4 inch) connector blew out several times. When the connector was reversed in the fixture, the O-ring on the component side was blown out. This problem was resolved by drilling two .75 mm (.030 inch) relief holes in the seal glands. The O-rings on the face of the 6.35 mm (1/4 inch) unit also came off and leaked during the initial cycles. Two .76 mm (.030 inch) relief holes in the seal glands also resolved the problems with these O-rings.

90: The isolation valve on the component side of the 12.7 mm (1/2 inch) unit would no longer close all the way against the stop. There was no leakage as a result of this condition.

280: The isolation valve on the line side of the 12.7 mm (1/2 inch) unit would no longer close all the way against the stop. There was no leakage as a result of this condition.

405: Interface seal on 12.7 mm (1/2 inch) unit slightly twisted. No leakage.

426: Poppet seal on 6.35 mm (1/4 inch) unit pinched in mechanism. PID was disassembled and vent holes were inspected. No contamination was found. O-ring replaced and PID was reassembled.

451: Measured interface leakage. See Table V-1 for Test Results.

455: Handle mechanism on 12.7 mm (1/2 inch) unit squeak during opening and closing.

500: Performed internal leak test. See Table V-2 for test results. Tightened adjustment on 6.35 mm (1/4 inch) unit to stop leak.

501: Changed test fluid to water at ambient temperature.

816: Face O-rings on 12.7 mm (1/2 inch) unit started leaking.

902: Poppet O-rings on line side of 6.35 mm (1/4 inch) unit blew out. Face O-ring on 12.7 mm (1/2 inch) unit still leaking.

925: Both stem packings on the 12.7 mm (1/2 inch) unit show slight intermittent leak.

1501: Changed test fluid to water at 355.35°K (180°F). Action of handle mechanism on the 6.35 mm (1/4 inch) unit became extremely stiff.

TABLE V-1 LEAKAGE TEST DATA FOR CYCLE 451

Leak Test Type	Cycle No.	Test Fluid	Temp. °K (°F)	Pressure N/m^2 (psig)	12.7 mm (½ Inch) Unit Line Side	6.35 mm (¼ Inch) Unit Line Side
Fluid Separation	451	Water	AMB	3.4 x 10^4 (5)	.003 ml/sec	.009 ml/sec
				1.72 x 10^5 (25)	.009 ml/sec	.012 ml/sec
				6.89 x 10^5 (100)	.009 ml/sec	.021 ml/sec
				1.72 x 10^6 (250)	.015 ml/sec	.018 ml/sec
				2.75 x 10^6 (400)	.018 ml/sec	.015 ml/sec

TABLE V-2 LEAKAGE TEST DATA FOP CYCLE 500

Leak Test Type	Cycle No.	Test Fluid	Temp. °K (°F)	Pressure N/m^2 (psig)	12.7 mm (½ Inch) Unit		6.35 mm (¼ Inch) Unit	
					Line Side	Component Side	Line Side	Component Side
Internal	500	Water	355.37 (180)	3.4 x 10^4 (5)	0 ml/sec	0 ml/sec	0 ml/sec	0 ml/sec
				1.72 x 10^5 (25)	0 ml/sec	0 ml/sec	0 ml/sec	0 ml/sec
				6.89 x 10^5 (100)	0(1)ml/sec	0 ml/sec	0 ml/sec	0 ml/sec
				1.72 x 10^6 (250)	0 ml/sec	0 ml/sec	0 ml/sec	0 ml/sec
				2.75 x 10^6 (400)	0 ml/sec	0 ml/sec	0 ml/sec	0(2) ml/sec

NOTES: 1. Leak of .0006 ml/sec @ 6.89 x 10^5 N/m^2 (100 psig) from stem packing on line side.

2. Leak of .18 ml/sec @ 2.75 x 10^6 N/m^2 (400 psig) between faces when connected.

1575: Face O-rings on 12.7 mm (1/2 inch) unit stopped leaking.

1670: Lubricated the handle mechanism on the 6.35 mm (1/4 inch) unit.

1690: All four 4.75 mm (3/16 inch) hex heads on the isolation valves are showing wear.

2001: Changed test fluid to water at ambient temperature. Tightened adjustment on 6.35 mm (1/2 inch) unit to stop leakage.

2035: Hex heads on the isolation valves were worn until they were no longer workable. Removed both units for rework. Valve stem hex modified with the installation of a larger hex head with a distance across the flats of 7.92 mm (.312 inches).

2500: Performed internal leak test with GN_2. See Table V-3 for test results.

2838: The amount of GN_2 escaping from the 12.7 mm (1/2 inch) unit when the two halves are separated was increasing. Popping noise noted during separation.

2885: The excess pressure escaping from the 12.7 mm (1/2 inch) was occasionally blowing the face O-rings out.

2897: Poppet O-ring on the component side of the 6.35 mm (1/4 inch) unit blew out. Removed 6.35 mm (1/4 inch) unit for rework. The seal blew out as if the vent holes were not working properly (possibly plugged with contamination). Unit was dismantled and cleaned, O-ring replaced and PID was reassembled.

3000: Performed internal leak test with GN_2. See Table V-4 for test results.

3150: Handle mechanism on 12.7 mm (1/2 inch) unit squeaking and becoming hard to operate.

3500: Performed internal leak test with GN_2. See Table V-5 for test results.

3506: Lubricated handle mechanism on 12.7 mm (1/2 inch) unit.

3615: The popping noise noted when the two halves of the 12.7 mm (1/2 inch) unit were separated (reference cycle 2838) was increasing. It is apparently caused by the GN_2 escaping from

TABLE V-3 LEAKAGE TEST DATA FOR CYCLE 2500

Leak Test Type	Cycle No.	Test Fluid	Temp. °K (°F)	Pressure N/m^2 (psig)	12.7 mm (½ Inch) Unit		6.35 mm (¼ Inch) Unit	
					Line Side	Component Side	Line Side	Component Side
Internal	2500	GN_2	AMB	3.4×10^4 (5)	.097 ml/sec	0 ml/sec	0 ml/sec	0 ml/sec
				1.72×10^5 (25)	.5 ml/sec	.0067 ml/sec	0 ml/sec	0 ml/sec
				6.89×10^5 (100)	.12 ml/sec	.09 ml/sec	0 ml/sec	0 ml/sec
				1.72×10^6 (250)	.077 ml/sec	.25 ml/sec	0 ml/sec	0 ml/sec
				2.75×10^6 (400)	.13 ml/sec	.37 ml/sec	0 ml/sec	0 ml/sec

TABLE V-4 LEAKAGE TEST DATA FOR CYCLE 3000

Leak Test Type	Cycle No.	Test Fluid	Temp. °K (°F)	Pressure N/m^2 (psig)	12.7 mm (½ Inch) Unit		6.35 mm (¼ Inch) Unit	
					Line Side	Component Side	Line Side	Component Side
Internal	3000	GN_2	AMB	3.4×10^4 (5)	.003 ml/sec	.025 ml/sec	0 ml/sec	0 ml/sec
				1.72×10^5 (25)	.008 ml/sec	.017 ml/sec	0 ml/sec	0 ml/sec
				6.89×10^5 (100)	.035 ml/sec	.097 ml/sec	0 ml/sec	0 ml/sec
				1.72×10^6 (250)	.113 ml/sec	.23 ml/sec	0 ml/sec	0 ml/sec
				2.75×10^6 (400)	.15 ml/sec	.22 ml/sec	0 ml/sec	0 ml/sec

TABLE V-5 LEAKAGE TEST DATA FOR CYCLE 3500

Leak Test Type	Cycle No.	Test Fluid	Temp. °K (°F)	Pressure N/m^2 (psig)	12.7 mm (½ Inch) Unit		6.35 mm (¼ Inch) Unit	
					Line Side	Component Side	Line Side	Component Side
Internal	3500	GN_2	AMB	3.4×10^4 (5)	.03 ml/sec	.022 ml/sec	0 ml/sec	0 ml/sec
				1.72×10^5 (25)	.063 ml/sec	.04 ml/sec	0 ml/sec	0 ml/sec
				6.89×10^5 (100)	.098 ml/sec	.11 ml/sec	0 ml/sec	0 ml/sec
				1.72×10^6 (250)	.05 ml/sec	.17 ml/sec	0 ml/sec	0 ml/sec
				2.75×10^6 (400)	.125 ml/sec	.397 ml/sec	0 ml/sec	0 ml/sec

TABLE V-6 LEAKAGE TEST DATA FOR CYCLE 4000

Leak Test Type	Cycle No.	Test Fluid	Temp. °K (°F)	Pressure N/m^2 (psig)	12.7 mm (½ Inch) Unit		6.35 mm (¼ Inch) Unit	
					Line Side	Component Side	Line Side	Component Side
Internal	4000	GN_2	AMB	3.4×10^4 (5)	0 ml/sec	0 ml/sec	0 ml/sec	0 ml/sec
				1.72×10^5 (25)	0 ml/sec	0 ml/sec	0 ml/sec	0 ml/sec
				6.89×10^5 (100)	0 ml/sec	0 ml/sec	0 ml/sec	0 ml/sec
				1.72×10^6 (250)	0 ml/sec	0 ml/sec	0 ml/sec	0 ml/sec
				2.75×10^6 (400)	0 ml/sec	0 ml/sec	0 ml/sec	0 ml/sec

the component side seating the poppet seal during separation. Face O-ring still being blown out occasionally.

3625: Lubricated handle mechanism on the 6.35 mm (1/4 inch) unit.

3728: Had a high pressure leak from the component side of the 12.7 mm (1/2 inch) unit during separation. While trying to contain the leak the outside face O-ring was slightly pinched. Leak stopped when poppet seal seated after a delay.

3735: High pressure leak from component side of 12.7 mm (1/2 inch) unit repeated and the outside face O-ring again was pinched. Leak did not stop until all pressure had bled off. Unit was removed for rework. Unit was dismantled and a loose poppet was discovered. This accounted for the previous problems since cycle 2500. Poppet was properly adjusted and secured.

3780: Started getting the high pressure leak from the component side of the 12.7 mm (1/2 inch) unit. During the next cycles it was noted that there seems to be an "over-center" condition when the isolation valve is turned all the way to the stop. When the rotation of the stem is stopped at the apparent TDC the component side does not leak.

3950: Isolation valve on the line side of the 12.7 mm (1/2 inch) unit became hard to turn.

4000: Performed internal leak test with GN_2. See Table V-6 for test results.

4010: Popping sound and high pressure leak returned on the 12.7 mm (1/2 inch) unit. The inside face O-ring was blown out. Reinstalled O-ring.

4020: The inside face O-ring on the 12.7 mm (1/2 inch) unit blew out again. Reinstalled O-ring.

4066: The inside face O-ring on the 12.7 mm (1/2 inch) unit blew out again. Installed new O-ring.

4074: The inside face O-ring on the 12.7 mm (1/2 inch) unit leaking excessively. Installed another O-ring.

4119: The inside face O-ring on the 12.7 mm (1/2 inch) unit blew out again. Installed new O-ring.

4250: Had a high pressure leak on the component side of the 12.7 mm (1/2 inch) unit. Blew the inside face O-ring out. Reinstalled O-ring.

4500: Performed internal leak test using GN_2. See Table V-7 for test results.

4728: Had a high pressure leak on the component side of the 12.7 mm (1/2 inch) unit. The escaping gas blew a piece out of the inside face O-ring.

4830: The isolation valve on the line side of the 12.7 mm (1/2 inch) unit turning "rough" compared to the other isolation valves.

4967: Had high pressure leak on the component side of the 12.7 mm (1/2 inch) unit. Blew out the inside face O-ring. Installed new O-ring.

5000: Performed external leak test using helium. See Table V-8 for test results. Removed both test units for refurbishment prior to testing with Freon-21 as the test fluid. Units were dismantled with new seals inserted at dynamic sealing locations.

5001: Changed to Freon-21 at ambient temperature as the test fluid. The stem on the isolation valve on line side of the 12.7 mm (1/2 inch) unit leaked when opened. The poppets on both sides of the 6.35 mm (1/4 inch) unit appeared not to seat properly as they were recessed approximately 1.57 mm (1/16 inch) back into the valve body.

5002: The 6.35 mm (1/4 inch) unit could not be separated because the poppets were not seated in either half of the unit. The stem on the isolation valve on the line side of the 12.7 mm (1/2 inch) unit stopped leaking. Continued test on the 12.7 mm (1/2 inch) unit only as the 6.35 mm (1/4 inch) unit is unworkable due to swelling of elastomer poppet seal.

5007: Changed to Freon-21 at 355.35°K (180°F) as the test fluid.

5012: Testing completed. Performed external leak test on the 12.7 mm (1/2 inch) unit using helium. See Table V-9 for test results.

Pressure Drop Test - The 6.35 mm (1/4 inch) unit was selected for the pressure drop test. Since the 6.35 mm (1/4 inch) unit

TABLE V-7 LEAKAGE TEST DATA FOR CYCLE 4500

Leak Test Type	Cycle No.	Test Fluid	Temp. °K (°F)	Pressure N/m^2 (psig)	12.7 mm (½ Inch) Unit		6.35 mm (¼ Inch) Unit	
					Line Side	Component Side	Line Side	Component Side
Internal	4500	GN_2	AMB	3.4×10^4 (5)	0 ml/sec	0 ml/sec	0 ml/sec	0 ml/sec
				1.72×10^5 (25)	.0043 ml/sec	0 ml/sec	0 ml/sec	0 ml/sec
				6.89×10^5 (100)	.01 ml/sec	0 ml/sec	0 ml/sec	0 ml/sec
				1.72×10^6 (250)	0 ml/sec	0 ml/sec	0 ml/sec	0 ml/sec
				2.75×10^6 (400)				

TABLE V-8 LEAKAGE TEST DATA FOR CYCLE 5000

Leak Test Type	Cycle No.	Test Fluid	Temp. °K (°F)	Pressure N/m^2 (psig)	12.7 mm (½ Inch) Unit	6.35 mm (¼ Inch) Unit
External	5000	He	AMB	3.4×10^4	0 ml/sec	0 ml/sec
				1.72×10^5 (25)	0 ml/sec	0 ml/sec
				6.89×10^5 (100)	Off Scale on x 1000	0 ml/sec
				1.72×10^6 (250)	Off Scale on x 1000	1.2×10^{-8} ml/sec
				2.75×10^6 (400)	9.6×10^{-6} ml/sec	8×10^{-9} ml/sec

TABLE V-9 LEAKAGE TEST DATA FOR CYCLE 5012

Leak Test Type	Cycle No.	Test Fluid	Temp. $^{\circ}$K ($^{\circ}$F)	Pressure N/m^2 (psig)	12.7 mm (½ Inch) Unit
External	5012	He	AMB	3.4×10^4 (5)	0 ml/sec
				1.72×10^5 (25)	3.3×10^{-8} ml/sec
				6.89×10^5 (100)	1.4×10^{-6} ml/sec
				1.72×10^6 (250)	Off Scale on x 1000
				2.75×10^6 (400)	Off Scale on x 1000

has a total of 241.3 mm (9.5 inches) of tubing welded to inlet and outlet ports a section of 6.35 mm (1/4 inch) tubing 362 mm (14.25 inches) in length was also tested to determine the net pressure loss for the PID. Also, since the 6.35 mm (1/4 inch) and 12.7 mm (1/2 inch) PID use a common body, a test piece consisting of a 25.4 mm (1.0 inch) diameter tube 120.6 mm (4.75 inches) long with 6.35 mm (1/4 inch) end pieces making a total length of 362 mm (14.25 inches) was also tested to determine the effect of rapid expansion/contraction of the test fluid. Figure V-17 shows the results of these tests, which were the following cases:

- 6.35 mm (1/4 inch) PID with 241.3 mm (9.5 inches) of 1/4 inch tubing
- 362 mm (14.25 inches) of 6.35 mm (1/4 inch) tubing
- 6.35 mm (1/4 inch) PID (derived from the above cases)
- 25.4 mm (1.0 inch) diameter expander 120.6 mm (4.75 inches) long with 241.3 mm (9.5 inches) of 6.35 mm (1/4 inch) tubing

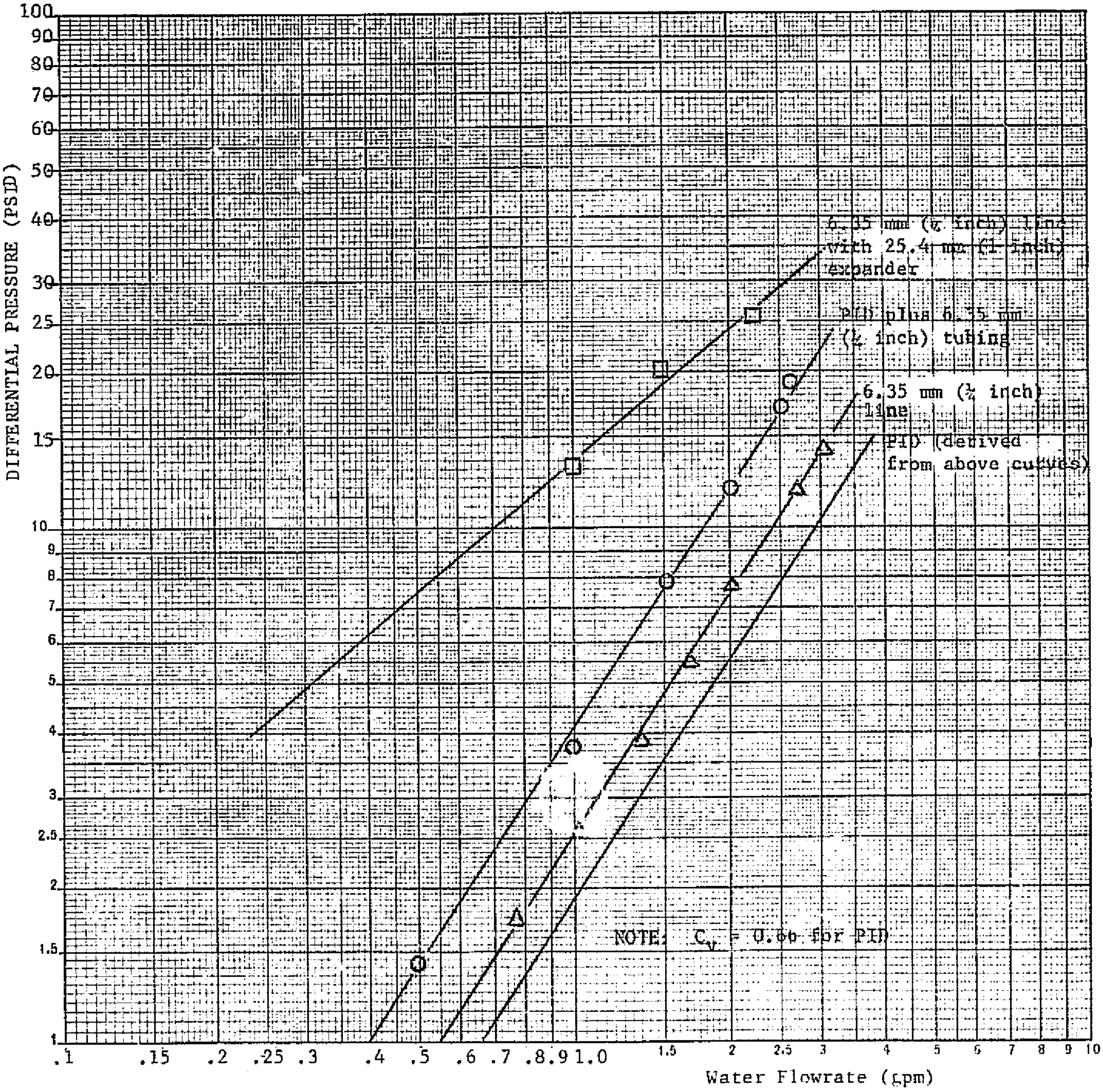
Development Test Summary

Proof Pressure - The test units showed no visible indications of permanent deformation or distortion and no loss of operating capability as a result of being subjected to 4.14×10^6 N/m^2 (600 psig).

Hydraulic Lock Test - Both test units successfully completed this test with no indication of hydraulic lockup and no increase in valve stem torque utilizing pressurized water at pressures of 1.72×10^5 N/m^2 (25 psig) and 2.76×10^6 N/m^2 (400 psig).

Operational Life Cycle Tests - The test units completed 5012 cycles of closing the poppets, disconnecting the halves, reconnecting the halves, and opening the poppets utilizing water at 2.76×10^6 N/m^2 (400 psig) for 2500 cycles, gaseous nitrogen at 2.76×10^6 N/m^2 (400 psig) for 2500 cycles, and Freon-21 at 2.76×10^6 N/m^2 (400 psig) for 12 cycles. Table V-10 summarizes the problems during the development tests, the corrective action taken to resolve the problem, and the problem analyses for future design improvements.

Leakage Tests - Both units were subjected to leakage tests at five different pressures between 3.4×10^4 N/m^2 (5 psig) and 2.75×10^6 N/m^2 (400 psig), utilizing water at cycle numbers 451 and 500;



NOTE: C_v = 0.66 for PID

FIGURE V-17 PRESSURE DROP TEST RESULTS

TABLE V-10 PROBLEM SUMMARY FROM PID DEVELOPMENT TEST PROGRAM

Problem	Cycle	6.35 mm (¼") Comp Half	6.35 mm (¼") Line Half	12.7 mm (½") Comp Half	12.7 mm (½") Line Half	Comment
Poppet O-Ring Blowout	0-50	X	X			Addition of vent holes were very beneficial. To eliminate poppet seal blowout entirely, a captive seal similar to 12.7 mm (½") unit would be required. Apparent clogging of vent holes caused blowouts later.
	426		X			
	902		X			
	2897	X				
Discrepancy in Stop Position	90			X		This problem can result from two conditions: 1) the pin stop can be loose thereby indicating an erroneous position, and 2) the poppet must be positioned on poppet shaft correctly and locked in place. Present configuration has a jamb nut that squeezes Teflon seal that can cold-flow resulting in a loose poppet.
	280				X	
	3780			X		
Poppet Seal Leaking and Producing a Popping Sound	2838[1]			X		[1] Poppet was loose on the poppet shaft and unthreaded enough to leak; and seal under high back pressure causing a popping sound when it becomes seated. [2] Over-the-counter action of the stem shaft cam and permanent deformation of the leaf springs allows poppet to float.
	2885[1]			X		
	3615[1]			X		
	3728[1]			X		
	3735[1]			X		
	3780[2]			X		
	4010[2]			X		
	4250[2]			X		
	4728[2]			X		
	4967[2]			X		
Interface Seal Blowout	405				X	This condition was caused by two problems: 1) the seal retention method is inadequate, and 2) in most cases the poppet seal in the component half was leaking allowing high pressure gas to unseat the seal.
	2885				X	
	3615				X	
	4010				X	
	4020				X	
	4066				X	
	7074				X	
	4115				X	
	4250				X	
	4967				X	
Handle Mechanism Tightness/ Looseness	455				X	This condition occurred when a rapid temperature variation in flowing fluid took place, ΔT of 55.6°K (100°F). This caused the main body of the unit to expand/contract at a faster rate than the clamp legs.
	1501	X				
	1670	X				
	3150				X	
	3506				X	
	3625	X				
Interface Seal Leakage	816				X	This problem is directly related to the looseness of handle mechanism.
	902				X	
	2001		X			
Valve Stem Seal Leakage	925			X	X	Seals should be pressurized to expand to seal properly.
Deterioration of 4.75 mm (3/16") Hex on Valve Stems	1690	X	X	X	X	The act of installing tool and indexing tool to Hex will have a tendency to wear off the corners.
	2035	X	X	X	X	
Valve Stem Hard to Turn	3950				X	Apparently the bearing spring became permanently deformed, thereby allowing it to slip out of its position.
	4830				X	

gaseous nitrogen at cycle numbers 2500, 3000, 3500, 4000, and 4500; and gaseous helium at cycles numbers 5000 and 5012. In summary, the 6.35 mm (1/4 inch) unit has elastomer seals and had essentially 0 leakage utilizing the test method specified until the Freon-21 exposure cycles. The 12.7 mm (1/2 inch) unit had teflon seals and did have leakage problems throughout the test cycles up to cycle number 3735 due to the poppet being loose on the poppet shaft (see Table V-10 for summary discussion on this problem). After rework at cycle 3735, the leak test at later cycles showed essentially 0 leakage utilizing the test method specified. It can be concluded that the units are capable of meeting the leakage criteria.

Pressure Drop Tests - For a typical water flowrate of .063 kg/sec (500 lbs/hr) the pressure drop for the PID is 1.32 x 10^4 N/m^2 (1.91 psi). Also, from figure V-17, the projected flow coefficient (C_v) was 0.66. Since both the 6.35 mm (1/4 inch) unit and the 12.7 mm (1/2 inch) unit use the same body, it can be seen from the graph that a pressure loss penalty is inherent in the 6.35 mm (1/4 inch) unit. The body flow path cross-sectional area is sized for the 12.7 mm (1/2 inch) unit, therefore, creating an expansion/contraction situation in the 6.35 mm (1/4 inch) unit. The graph shows the expansion/contraction condition to be the main factor in total pressure loss for the 362 mm (14.25 inches) of fluid length in question.

VI. FINAL DEVELOPMENT DESIGN

The purpose of this task was to establish the final development design baseline for the PID and to develop a future recommended program plan for fabrication of a prototype unit and a flight environment test program. This involved reviewing the development test program to update the development design drawings (NAS9-14376A) to reflect modifications to the PIDs during the test, developing further recommended design changes based upon the test results, determining potential usages in the Shuttle EC/LSS system and GSE potential requirements, and providing a recommended future program plan that includes a flight environment test program.

A. FINAL DEVELOPMENT DESIGN BASELINE

The development test log and report was reviewed and changes were added to the NAS9-14376A design drawings as revision "A" to reflect the "as-built" condition and modifications incorporated as a result of the testing. The following is a summary of the modifications to the PID as a result of the development testing:

- Vent holes were added to the 6.35 mm (.25 in.) poppet O-ring glands to relieve pressure build up under the O-ring and prevent blowing the seal.
- Vent holes were added to the face seal O-ring glands of both the 6.37 mm (.25 in.) and 12.7 mm (.50 in.) PIDs to relieve pressure build up under the O-ring and prevent blowing the seal upon uncoupling the disconnect halves.
- The 12.7 mm (.50 in.) poppet seal diameter was increased from 16.0 mm (.630 in.) to 16.26 mm (.640 in.) to allow for cold-flowing when the teflon seal is loaded.

During the period of development testing, a number of areas in need of design improvement were noticed. The following items recapitulate the problems encountered and provide recommended solutions.

- Clamp tightness and looseness were observed during periods of temperature changes of 55.6°K (100°F) of the flowing fluid. This indicates an uneven thermal expansion between the disconnect body and the coupling mechanism. The addition of more Belleville washers in series would increase the total deflection available and thereby provide a clamping force even during periods of thermal expansion/contraction.

- At times, a squeaking sound was prevalent during coupling operations along with an occasional rough action. The addition of teflon thrust washers in areas of metal-to-metal contact in region of handle mechanism pivot point would eliminate any binding condition. Also, a dry lube between cam and coupling collar would be beneficial.
- A loose poppet on the poppet shaft was observed that possibly indicates that the jamb nut was engaging only the teflon seal which cold-flowed under the jambing pressure resulting in looseness. The design should insure that the jamb nut on the poppet shaft fully engages the metal side of poppet and not only compress the teflon seal.
- During disassembly of the disconnect units after development testing, it was noticed that the leaf springs were permanently deformed. Leaf spring material should be re-evaluated to insure that the deflective loads are within the elastic limit of the material.
- Face seal blowout on the teflon seals was frequent and new methods of face seal retention should be researched. Possibly a special configuration seal with an extended outboard lip that would match a groove in the seal gland; or eliminate the recessed mating face.
- Effort should be undertaken to streamline the handle configuration for size and weight reduction.
- End adapter fittings should be positively secured to prevent rotational torques from loosening fittings resulting in a possible leak path.
- During development testing the poppet with the dovetail groove and elastomer seal had a problem with seal blowout. An alternate design for seal retention such as the captured teflon seal in the 12.7 mm (1/2 in.) PID should be incorporated.

Based upon the development testing, a design specification was prepared and identified as Martin Marietta Document MCR-75-362 This specification specified the design techniques for isolation, sealing, coupling, foolproofing, fluid compression/expansion, interface spillage volume, separation plane lateral movement, and operational access. Additional criteria is specified for the materials, weight and dimensional criteria, fluid compatibility, leakage, life expectancy, and tool requirements.

B. POTENTIAL SHUTTLE APPLICATIONS

The Space Shuttle Orbiter Environmental Control and Life Support System has several areas of possible PID maintenance applications. These systems include the following:

- Cabin Air
- Freon Loop
- Oxygen
- Potable H_2O
- Nitrogen
- Coolant H_2O
- LCG H_2O
- Ammonia
- Waste Water
- O_2/N_2 Vent

Within each system, the following specific usages are identified:

- Disconnects at system interfaces
- Pressure, temperature, humidity, flow transducers
- Maintainable filters

- Pumps

- Low reliability fluid components

An additional usage of the PID could be for the GSE interface with the Shuttle Orbiter. This would allow such services as filling systems with fluids and gases, flushing systems for cleaning purposes, and draining systems during ground refurbishment.

C. FUTURE PROGRAM PLAN

The recommended future PID program plan for a prototype unit and flight environment test program is outlined in the following paragraphs:

1. Investigate Development Test Design Improvements - The development testing identified a number of possible design improvements as outlined in paragraph VI. A. above. These areas of design improvements should be individually investigated and a resolution provided as a first step in developing a flight prototype PID.

2. Reduction of 6.35 mm (1/4 in.) PID Size - The development program utilized the same basic body concept for both 6.35 mm (1/4) and 12.7 mm (1/2 in.) PID with end adapter fittings for the 6.35 mm (1/4 in.) PID. To reduce the pressure drop loss through the 6.35 mm (1/4 in.) PID, the body OD and size should be reduced to eliminate the contraction/expansion type losses through the PID. The test summary pressure drop loss for the 6.35 mm (1/4 in.) diameter tubing with expander is shown in Figure V-17. The future program plan should investigate a possible spool valve concept as alternate design for further diameter and length reduction.

3. Man-Machine Interface Testing - Determine both shirt sleeve and pressure suited crewman interface with PID under simulated weightlessness conditions. Determine ease of closing poppets, lifting integral clamping mechanism, separating two halves, reconnecting halves, closing clamping mechanism and opening poppets. Suggest performance under neutral buoyancy and KC-135 parabolic flight conditions in a closed loop pressurized water system.

4. Investigate Vibration/Acceleration PID Effects - Perform limited vibration/acceleration testing of integral clamping mechanism. This should be performed utilizing the developmental test

disconnect assemblies. KC-135 testing could verify acceleration testing and possible leakage when unit is pressurized with water and poppets are open. Small shake table could check random and transient vibration with units pressurized with water to determine integrity of integral clamping mechanism.

5. Investigate Adaptability to Larger Sizes and Higher Pressures - Possible uses of PID for both spacecraft systems and industrial applications would necessitate sizes up to 50.8 mm (2 in.) and pressures to 3.1×10^7 N/m^2 (4500 psig). Increase in size poses nominal design problems but higher pressures may require a modification in the design of the poppet seal to prevent blowout during opening of the poppet.

6. Develop Prototype Design - A flight article prototype should be developed based upon items 1 through 4 findings. The design should consider production type units and reduce size and weight. Based upon number of units required, the design should consider use of castings. If castings are not feasible, the production should as a minimum, consider limitations of the machine tools to create an optimized design to achieve a minimum cost PID.

7. Fabricate Prototype Design - Fabricate one 6.35 mm (1/4 in.) and one 12.7 mm (1/2 in.) flight article prototype.

8. Perform Prototype Testing - The test program should consider additional life cycle tests and a complete environmental test program per Shuttle MF 0004-004 requirements as outlined in Table VI-1.

9. Investigate Remote Operation Design - Application of a PID is required when removing modules or performing inflight maintenance with a remote manipulator or free flyer teleoperator. End effector interface and limitations of rotational and push/pull movements must be considered on closing/opening the poppet valves and disconnecting/connecting the two halves. Consideration must also be given to the design for general purpose remote or a one push/pull operation fully automated. The effort for this task would be to investigate a design for closing both poppets at the same time and the interface and effector design.

10. Investigate Concept Design to Electrical Connector - The integral connecting mechanism should be investigated to determine its applicability to an electrical connector that requires positive pin disengagement prior to separation to prevent electrical shorts.

11. Investigate Adaptability as Interface Between Airborne and Ground Support - PID could be used as an interface disconnect with one half being airborne and the other half being part of the ground support equipment. In addition to the existing design, would be a requirement to provide protective face caps to both halves when separated to prevent damage to seals or sealing surfaces.

Table VI-1 Positive Isolation Disconnect - Natural and Induced Environment (Design and Test)

ENVIRONMENT	LAUNCH & BOOST	ORBITAL PHASE	RE ENTRY & LANDING
Fungus	Design: Temperature above 293.15°K (68°F) and humidity above 297.04°K (75°F) are conductive to high growth rates and bacteria Test: Not required if shown that no fungus nutrient materials are used or that such materials have been adequately treated or are hermetically sealed	NA	Same as Column 2
Humidity	Design: Non-Operational: 8 to 100% RH Operational: 22% RH Minimum at 299.82°K (80°F) Dry Bulb: 85% RH Maximum at 65% Dry Bulb Salinity - 1% by Wt Maximum	85% Maximum RH at 291.48°K (65°F) Dry Bulb: 17% Minimum RH at 305.37°K (90°F) Dry Bulb	Same as Column 2, Operational
	Test: (Salt Fog Only) o Perform to MIL-STD-810, Method 509, Procedure 1 for one hour o With Chamber at 85% RH Thermally Cycle four Times	Same as Column 2	Same as Column 2
Lighting	Design and Test: Per MF 004-002	NA	Same as Column 2
Ozone	Design: 3-6 Parts/Hundred Million: 60 phm per 3600 to 10800 seconds (1 to 3 hrs) per 86400 seconds (24 hrs). Levels increase with altitude from 100 phm at 10668 meters (35000 ft) to 1100 phm near 29870.4 meters (98000 ft). Test: Only if materials are susceptible to Ozone	Same as Column 2	Same as Column 2
Salt Fog	Design: 1.0% by Weight Salt (NaCl) Solution for 30 Days Test: Run in Conjunction with Humidity Tests. For Electrical/Electronic Equipment Test per MIL-STD-810, Method 507, Procedure IV.	Same as Column 2	Same as Column 2
Random Vibration	Design: Equipment must be designed to meet the Qualification for Acceptance Vibration Testing (QAVT) Test: Run in Accordance with MF 004-23 o QAVT Level 20 Hz to 80 Hz Increasing 3 db/Octave 80 Hz to 350 Hz Constant 0.067 g^2/Hz 350 Hz to 2000 Hz Decreasing 3 db/Octave o Functional/Continuity Tests to be Conducted During the QAVT o Run 5 Times the Normal AVT Duration o Vibration Environments are to be applied in each of Three Orthogonal axis for Duration Specified		
Sinusoidal Vibration Shock (Transient Vibration)	Design: ± 0.25g Peak From 5 to 35 Hz Test: Bench Handling: In Accordance with MIL-STD-810, Method 516.1, Procedure V, Basic Design: In Accordance with MIL-STD-810, Method 516.1, Procedure I. Pyro Shock: TBD	From 5 to 35 F	

Table VI-I (cont'd)

ENVIRONMENT	LAUNCH & BOOST	ORBITAL PHASE	RE-ENTRY & LANDING
Sinusoidal Vibration Shock (Transient Vibration) (Cont'd)	Test: (cont'd) Landing Shock: Analyze the Landing Shock Environment in Lieu of Test since the "G" Levels are Low in Comparison to Bench Handling Shock.		
Acceleration	Design: ± 5g in Each Axis. Duration 300 seconds (5 minutes). Test: No Normally Required.	Zero g to 3.3 g Test only as Necessary using Free Fall or Aircraft to Simulate Zero g	Same as Column 2
Shock	Design: NA	NA	Design: ± 20g Terminal Saw Tooth Shock Pulse of 10 Millisecond Duration in each of 6 Axes. Test: In Accordance with MIL-STD-810, Method 516, Procedure 1.
Crash Safety Shock	NA	NA	Design: 20g AFT 3g FWD ± 3.3g YAW 10g UP 4.4g DOWN Test: In Accordance with MIL-STD-810, Method 516.1, Procedure 3.
Pressure	Design: Structural Integrity Check: 4.14×10^6 N/m^2 (600 psig) Operational Leak Check: 2.75×10^6 N/m^2 (400 psig) Test: o Proof test at 1½-times the operational pressure. o Functional test at maximum operating pressure of 2.75×10^6 N/m^2 (400 psig)	Range: 3.4×10^4 N/m^2 (5 psig) to 1.72 $\times 10^6$ N/m^2 (250 psig) Same as Column 2	Range: 3.4×10^4 N/m^2 (5 psig) to 2.75×10^6 N/m^2 (400 psig) Same as Column 2
Temperature	Fluid: Ambient to 355.4°K (180°F) External: Cabin Ambient Test: Vary fluid temperature while performing functional test	Same as Column 2 Same as Column 2 Same as Column 2	Same as Column 2 Same as Column 2

NOTE: No design nor test requirements for hail, rain, snow, radiation (thermal and nuclear), sand, dust, explosive and corrosive atmosphere.

VII. QUALITY ASSURANCE, RELIABILITY AND SAFETY SUMMARY

A. QUALITY ASSURANCE

Quality assurance effort was involved in the design, procurement, receiving, fabrication, testing, shipping and final inspection of the deliverable end items. In the design phase, system analysis was performed and the following items were identified and incorporated into the design to assure the quality of the hardware:

- Notes were added to the NAS9-14376A design drawings that specified tool requirements for operations and maintenance, assembly set-up instructions for the disconnect and coupler, and general notes pertaining to lubrication requirements for installation of O-rings and lubrication of threads.
- Dimensional buildup tolerances were analyzed to determine fit interferences and design tolerances on detailed parts. These tolerance dimensions are incorporated in the design drawings.
- Wear and contamination areas of metal-to-metal contact were identified. Teflon was specified for areas of bearing loads. A moly-x hard coat (dry lubricant) was specified on the cam lobe to prevent wear of the lobe on the leaf springs.
- Finish callouts were added to the design drawings for passivating the stainless steel parts and anodizing the aluminum parts for added resistance to corrosion. Surface finish was specified for seal glands and seat surfaces.
- All load carrying parts were stress analyzed to preclude material failure. All sharp corners were eliminated.
- A design analysis was prepared to assure that the operational functions could be successfully achieved.

During the development task, quality assurance was active in the procurement cycle by being responsible for specification of the inspection processes and supplier qualification. All of the raw materials, parts, and components were inspected in receiving.

During the fabrication and build of the end item, in-process and final inspections were made to assure the proper level of workmanship and quality of the end item. To insure proper mating of parts, critically dimensioned detail parts were machined and fitted to individual disconnect halves. This resulted in proper flatness, slip, flushness and fit of parts.

The test set-up was inspected for structural integrity and setup per the test procedures. During all testing, the test conductor was monitored at the start of each test sequence and periodically throughout the test for conformance with the test procedure. All instrumentation was inspected for calibration time certification requirements. The test engineer recorded data from the test conductor with the design engineer in observance.

Finally, quality assurance was also responsible for monitoring the packaging and shipment of the end items. This included both documentation and hardware.

B. RELIABILITY

A Failure Mode and Effect Analysis (FMEA) tradeoff was performed on all concepts during the preliminary design. Information derived included: failure mode, result on system, design feature to preclude failure, crew action required and single point failures. From this information, areas of critical weaknesses were searched out and corrective measures were incorporated in the final design. These included the following:

- The elimination of spring-loaded actuation or closure features for poppet closure.
- Incorporation of a positive means to identify poppet closure prior to separation of disconnect halves.
- Incorporation of redundant sealing techniques in all dynamic areas.
- The elimination of threaded connections to prevent contamination during disconnect.

- Recessed grove on flange face to match face O-ring on mating face to prevent O-ring damage.

- Tapered mating flanges and clamping mechanism keyed leg for alignment of two disconnect halves.

- All functions for PID operation are located on a single side such that all required actions can be performed by access at a single plane perpendicular to the centerline of the fluid parts.

C. SAFETY

Safety concerns were considered and appropriate corrective measures were provided in each task of the program. During the conceptual and final designs, a stress analysis was performed on all detail parts and assemblies of the PID. The detail parts were designed in accordance with the stress analysis and materials were selected to meet the stress and environmental requirements.

The design of the PID incorporates the following additional safety features:

- The integral clamping mechanism cannot be opened unless the internal poppets are closed to prevent spraying the operator with high pressure liquid or gas upon disconnection.

- If contamination is trapped between the poppet and its seat, the stem shaft (for poppet closure) cannot be rotated 3.14 radians (180°) against its pin stop for visual indication that the poppet is not closed.

- Redundant sealing is provided at dynamic seal locations to prevent high pressure liquid or gas spray on operator in both the connected or disconnected modes.

- The design allows for a volume expansion of trapped Freon-21 between the disconnect's halves when connected and with the poppets of each half closed. This prevents overstressing the structural integrity of the PID's materials.

During the fabrication of the developmental PID assemblies, Martin Marietta machine shop safety standards were followed at all times. A test procedure was prepared for the test program and it was reviewed and signed by the safety engineer assigned to the program. The test support hardware design drawings were reviewed and approved by the safety representative. After the test hardware and PID assemblies were installed, the safety representative reviewed the setup and required the following two additional safety precautions that can be observed in Figure VI.

1) The test setup must include a transparent shield that protects the test personnel from an inadvertent release of high pressure test fluid upon PID separation.

2) The test disconnects must be "safety wired" to the test fixture to retain them in the event the fluid connections separate under pressure.

After installation of these additional safety features to the test setup, the PID assemblies were proof measured to 4.14×10^6 N/m^2 (600 psig) (1.5 times the maximum operational pressure). Throughout the test program, Martin Marietta safety standards were followed.