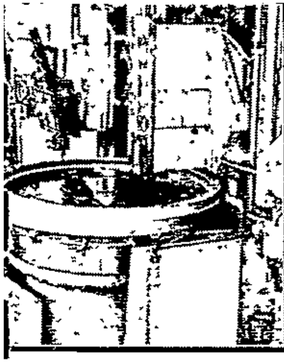

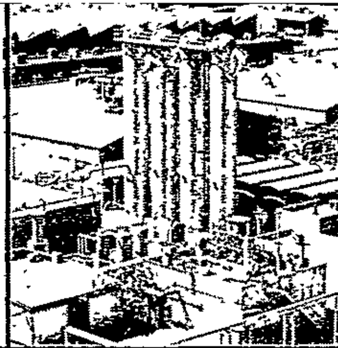

(NASA-CR-158673) BISTABLE (LATCHING) SOLENOID ACTUATED PROPELLANT ISOLATION VALVE Final Report (Marquardt Corp.) 56 p HC A04/MF A01 CSCL 13K

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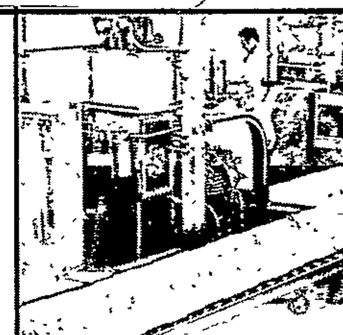
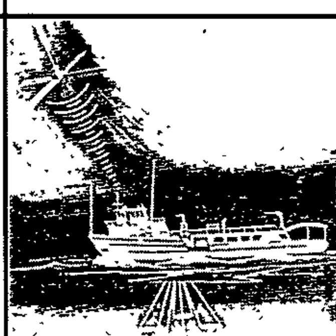
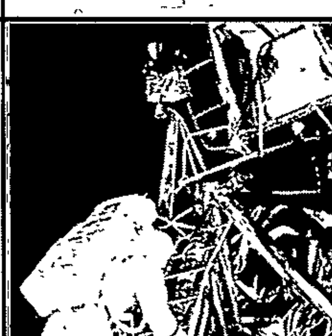






THE Marquardt COMPANY
A CCI Corporation Subsidiary

VAN NUYS, CALIFORNIA

BISTABLE (LATCHING) SOLENOID ACTUATED PROPELLANT ISOLATION VALVE

REPORT NO. S-1480

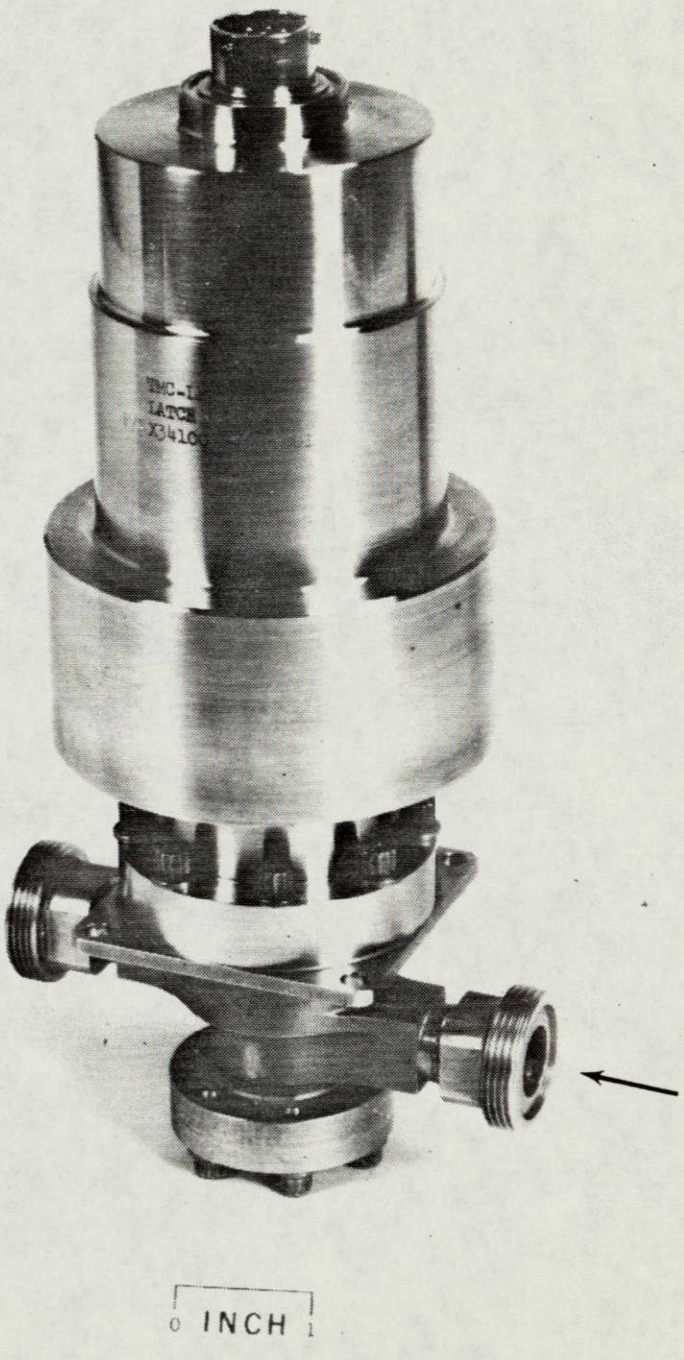
FINAL REPORT

H. Wichmann
H. H. Deboi

JPL Contract No. 954824

THE MARQUARDT COMPANY
16555 Saticoy Street
Van Nuys, California 91409

This work was performed for the Jet Propulsion Laboratory, California Institute of Technology, sponsored by The National Aeronautics and Space Administration, under Contract NAS 7-100.



LF_2 LATCH VALVE ASSEMBLY - P/N X34100

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LIST OF FIGURES

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1.0 INTRODUCTION

This report describes the work performed by TMC under JPL Contract Number 954824 on certain design modifications plus the fabrication, assembly and test of a liquid fluorine Latch Valve. The analysis and original design for this valve was previously reported in TMC Report Number S-1336, "VALVE MODIFICATION FOR A FLUORINATED OXIDIZER PROPULSION SYSTEM".[1]

2.0 DESIGN

Design modifications of the original valve (P/N X31200) are described herein and include an increase in the proof pressure from 675 to 900 psig, an increase in burst pressure from 900 to 1800 psig, an increase in the size of the inlet and outlet (Bobbin type) fittings from 1/2 to 3/4", and an increase in the requirement environmental criteria which are shown in Table Ia and Figure 1. Shown in Table Ib is a reproduction of the contractual Performance & Design Criteria Table. Subsequent to the letting of this contract, other changes authorized by contract modification included the use of an electrical connector in place of pigtails and the addition of a hermetic cover to seal the valve coil cavity. Changes implemented by TMC during the course of fabrication include a modification of the permanent magnet configuration and the method of welding the bellows to the end fittings (both items discussed in the Fabrication section of this report). A cross section drawing and exploded views of the valve components are shown in Figures 2, 3 and 4.

2.1 DESCRIPTION OF DESIGN CHANGES

The increase in burst pressure required a change in the bellows material from 300 series stainless steel to Inconel 718. This change was implemented for all bellows, including the small back-up bellows inside the downstream unit. To meet the higher vibration requirement, the overhanging compression spring design was eliminated and replaced by a belleville spring configuration which was more compact and more favorably located to accommodate the new loads. The design of the coil cover to provide for hermetic sealing included an electrical connector which was EB welded to the cover and a burn-down flange for the cover-to-body weld joint so that this operation could be performed in a helium-filled glovebox.

2.2 DESCRIPTION OF OPERATION

Referring to Figure 2, the Latch Valve can be divided into two basic subassemblies; the actuator assembly consisting of armature, permanent magnet, two coils, two pole pieces, hermetic cover, position indicator switch, and electrical connector. The lower or valve section consists of the poppet and seat, two large pressure balancing bellows, a smaller redundant bellows, the guiding flexure assembly, the belleville spring for control of overtravel forces and the two mid and lower valve body structural members. In this design, all bellows are under compression throughout the operation of the valve. This means that the upstream bellows assembly is acting to open the valve and that the force contributed by this member is offset by the combined forces of the two

Continued on Page 8

TABLE Ia

ENVIRONMENTAL CRITERIA

Environment	Exposure
Vibration, sinusoidal	Sweep from 5 to 2000 Hz and back to 5 Hz at one octave/min with amplitude levels as shown below.
Vibration, random	See Fig. 1a. 300 seconds in each of three mutually perpendicular axes
Shock	See Fig. 1b. Five shocks in each of three mutually perpendicular axes
Acceleration	15 g each direction in each of three mutually perpendicular axes
Vacuum	10^{-9} torr

Frequency (Hz)	Amplitude (g peak)
5 - 30	4.0
30 - 2000	10.0

TABLE Ib : LF_2 LATCH VALVE PERFORMANCE & DESIGN CRITERIA (FROM JPL CONTRACT)

Contract No. 954824
EXHIBIT No. 1
Page 2 of 7

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TABLE IA — LF_2 PROPELLANT ISOLATION VALVE PERFORMANCE AND DESIGN CRITERIA

JPL Spec 77Y02100

	CHARACTERISTIC	DIMENSION	REQUIREMENT
	Operation	---	Bistable (magnetic latching)
	Pressure, operating	psig	450 (maximum)
	proof	psig	900 (maximum)
	burst	psig	1800 (minimum steady-state); 2200 (surge)
1	Leakage, external, He*	scc/sec	10^{-6} (maximum) from zero to 450 psig
	internal, GN_2	scc/hr	10 (maximum) from zero to 450 psig
	Flow rate, LF_2	lb/sec	1.40 (rated flow at -320°F)
1	Differential pressure	psid	30 (maximum) at rated flow
	Temperature, operating	°F	-320 to +160
	Voltage, operating	vdc	20 to 32 (100 msec pulse)
	opening	vdc	17 (maximum) with 450 psig and +160°F
	closing	vdc	17 (maximum) at ambient pressure and +160°F
	Power	watt	75 (maximum) at 30 vdc (+70°F)
1	Response, opening with 20 vdc	msec	30 (maximum) with 450 psig and +160°F
	closing with 20 vdc	msec	30 (maximum) with rated flow at +160°F
	Life	cycles	5,000 (minimum)
	Port, inlet and outlet	inch	3/4 dia x 2 tube (0.020 wall)**
2	Electric connector	pin	To be determined***
	Mounting	--	Optional
	Material, construction	--	CRES, Inconel or Hastelloy B in flow path
	seat (hard)	--	Tungsten Carbide (K96)
	Weight	lb	5.0 (maximum)
	Dielectric strength	microamp	200 (maximum) at 600 VAC RMS (60 cycles)
	Insulation resistance	megohms	100 (Minimum) at 500 vdc
	Envelope	---	To be dtermined
	Flow Media	---	LF_2, GF_2, hydrazine, isopropyl alcohol, water, helium, and nitrogen
	Position Indicator	---	Required (opened and closed)
	Cleanliness	Level D2	JPL Specification SS 80-PD-103

*Leakage shall be measured with a mass spectrometer type leakage detector and the recorded value shall be the largest rate indicated during a test period of at least 30 minutes.

**Prototype will incorporate MS 27854 fittings.

2 ***Prototype may utilize "pigtail".

1 Requirement changed following contract date. See ATP Data Summary, Table II.
2 Changed to hermetic connector & coil cavity.

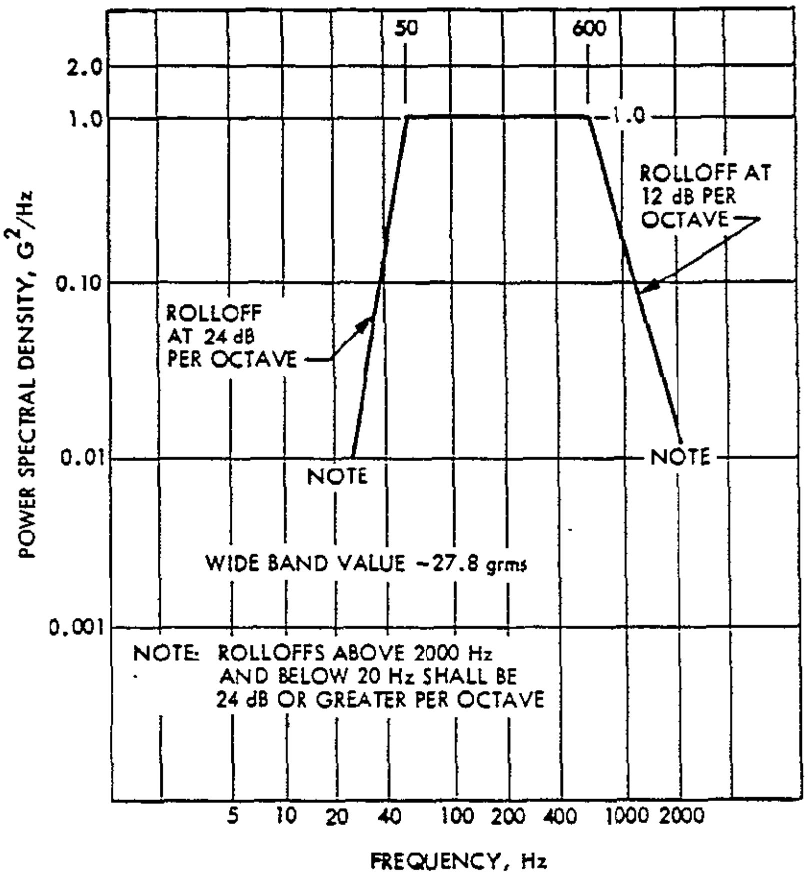

FIGURE 1a: RANDOM VIBRATION SPECTRUM

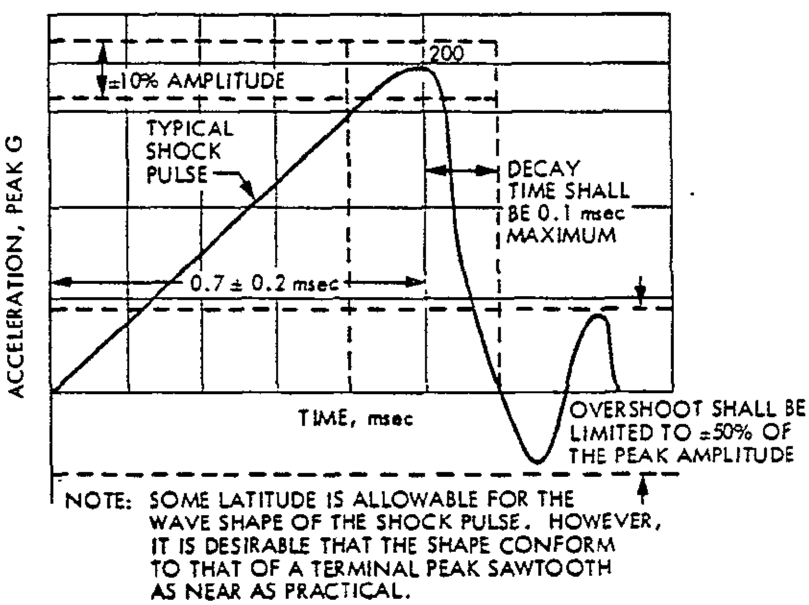

FIGURE 1b: SHOCK PULSE

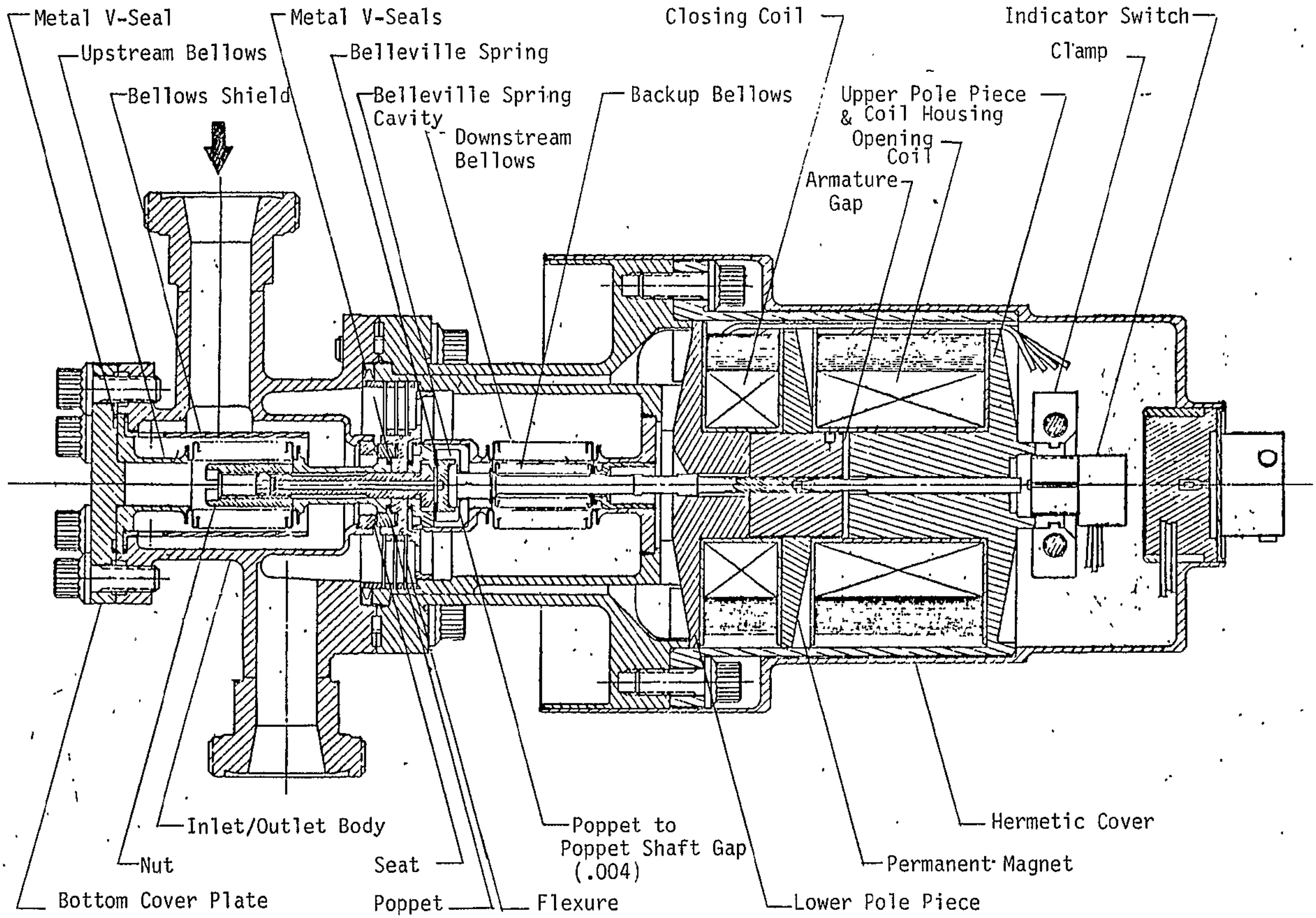

FIGURE 2: X34100 LF_2 LATCH VALVE CROSS SECTION (VALVE CLOSED)

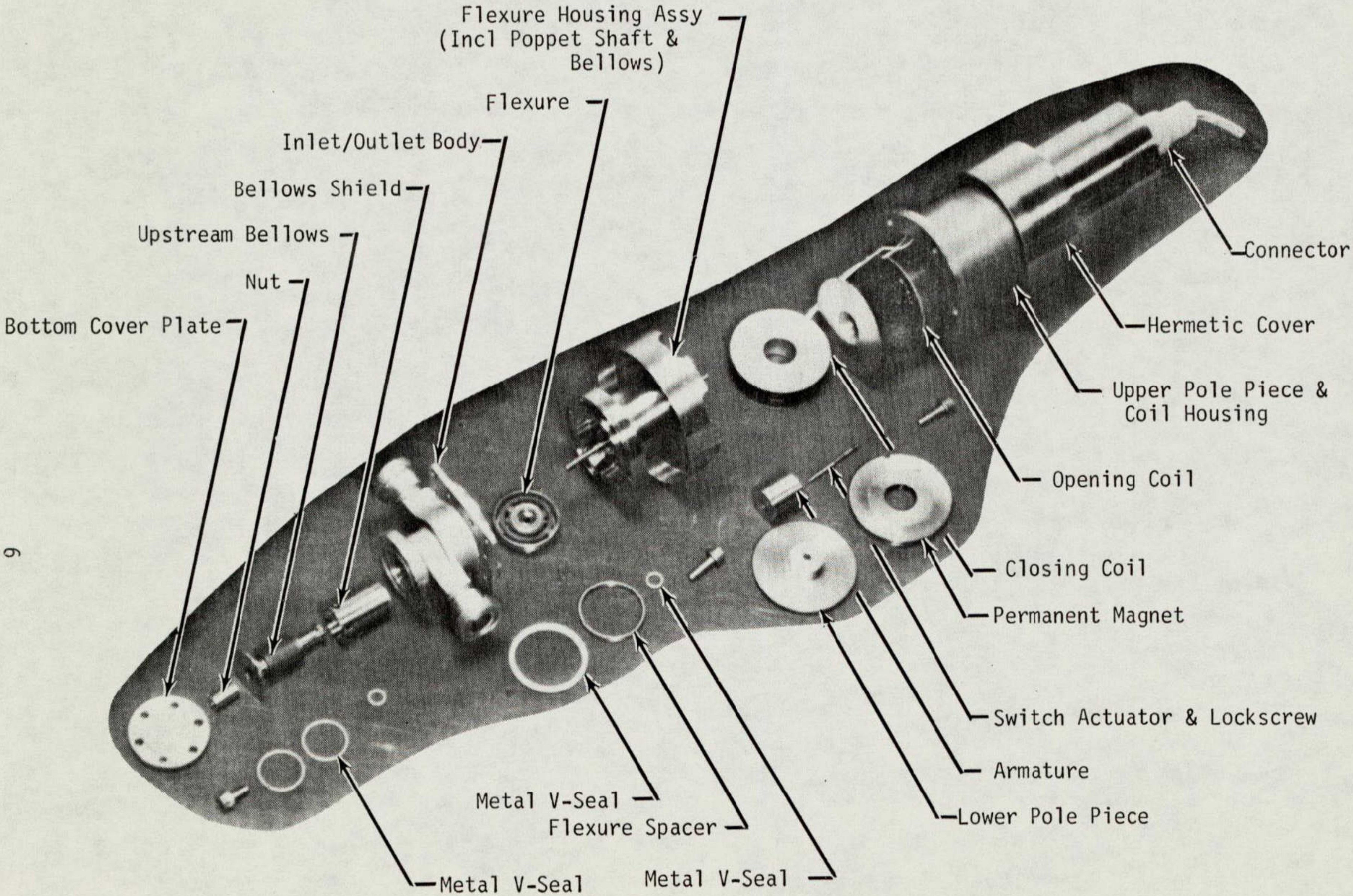

FIGURE 3: X34100 LF_2 LATCH VALVE ASSEMBLY - EXPLODED VIEW

Neg. 78-408-1

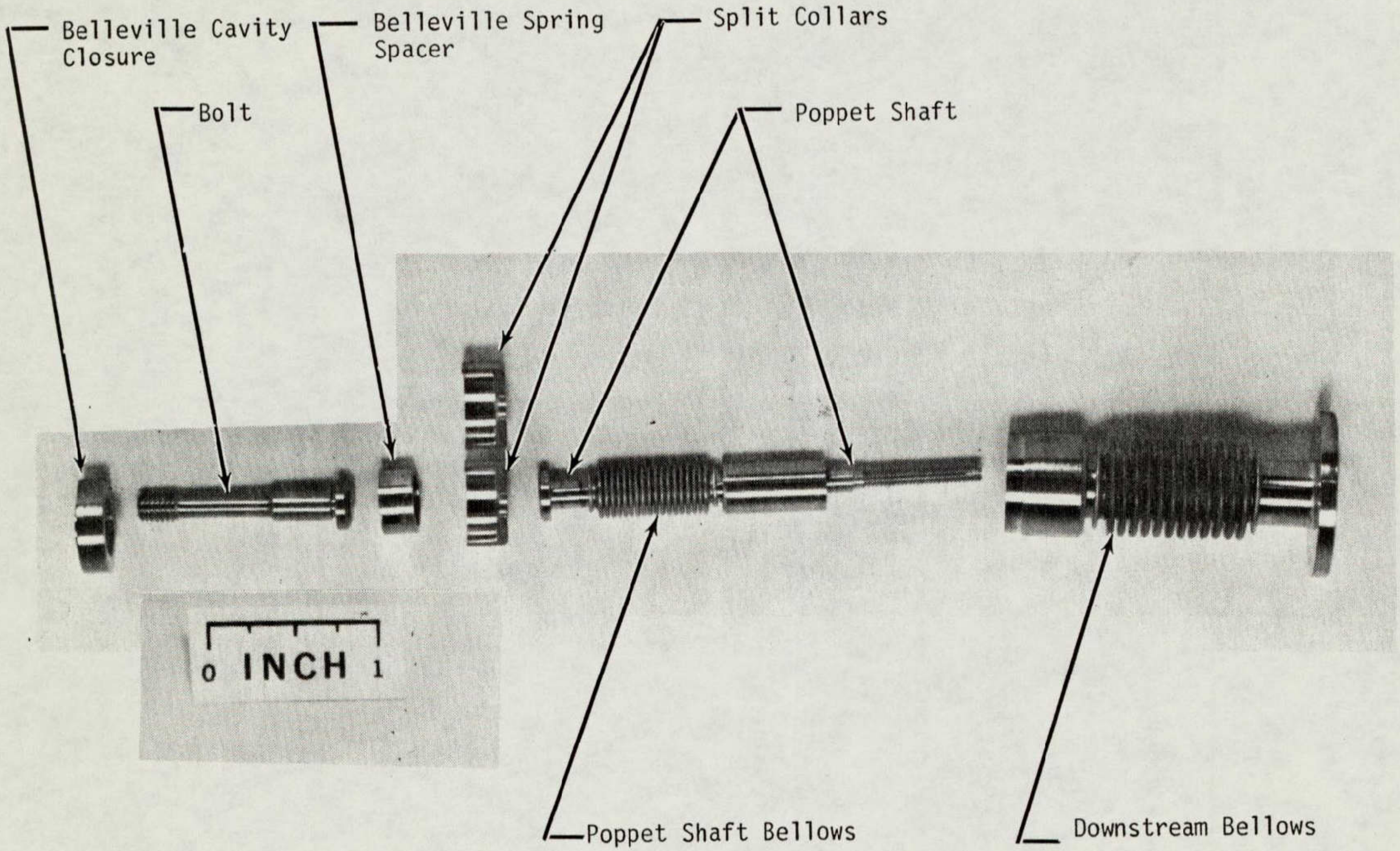

FIGURE 4: DOWNSTREAM BELLOWS & SPRING ASSEMBLY - EXPLODED VIEW

THE Marquardt COMPANY VAN NUYS, CALIFORNIA

S-1480

Only a limited number of spares were ordered or fabricated for this valve. Spares ordered were:

(a) Large Bellows weldment
(b) Permanent magnet elements
(c) Position indicator switch
(d) Electrical connector
(e) Metal seals
(f) Flexure elements
(g) Screws
(h) Belleville springs

Of these items, the spare bellows weldment, position indicator switch and seals were used.

3.1 FABRICATION OF DETAIL PARTS AND SUBASSEMBLIES

Pertinent facts regarding the fabrication of major details, the subassemblies and the final valve assembly, follow.

3.1.1 Belleville Spring

The function of the belleville spring is to permit a small amount of armature overtravel after the poppet has bottomed, without significantly increasing the seat load. The intent is to permit both the poppet and the armature to fully bottom independently of the other. In the previous valve design, this was accomplished with an overhanging compression spring in the area of the upstream bellows. Due to the constraints imposed by the higher vibration requirements, the compression spring was eliminated and the belleville substituted. For the belleville to work successfully in this capacity, it is necessary to use that portion of the force deflection curve near the "hump", or point at which, over a short deflection, the belleville spring rate is essentially zero. The location of this "Hump" and its shape are extremely sensitive to the tolerance of the sheet stock from which the spring is stamped. For this reason, a number of extra belleville springs were ordered. The results of measurements on several of these springs are shown in Figure 5a. From these curves, the belleville having the appropriate "Hump" was selected. Also, from this curve, the required installation deflection was determined for the calculation of the belleville spring spacer height. Figure 5b presents the force deflection curve of the downstream bellows and belleville spring assembly following the welding of that unit. The measurement is taken across the large flange and the belleville cavity closure fitting.

3.1.2 Permanent Magnet

Efforts to obtain a permanent magnet of the configuration shown in Figure 6a were unsuccessful, both in terms of schedule and of practical cost. The magnet size and field orientation both presented obstacles which could be solved only by a special foundry run and which included the design and fabrication of special heat treating fixtures for the casting. An alternate to the original configuration, and which was fabricated, is shown in Figure 6b. No difficulties in the operation of the valve were experienced and the measured latch forces were satisfactory. As shown in Figure 6b, no attempt was made to taper the magnet in view of its design and the development nature of the valve.

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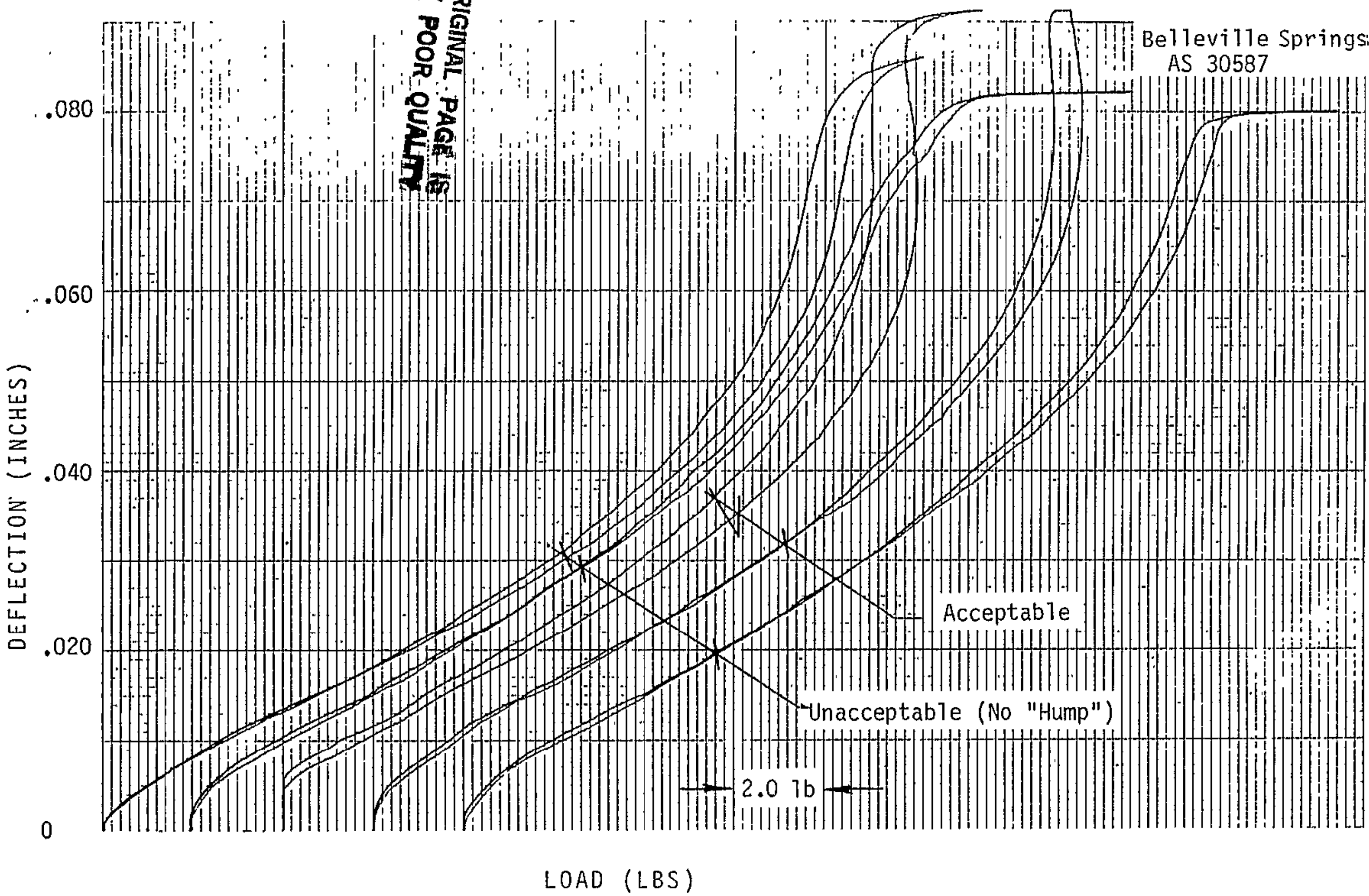

FIGURE 5a: FORCE DEFLECTION CURVES FOR BELLEVILLE SPRINGS

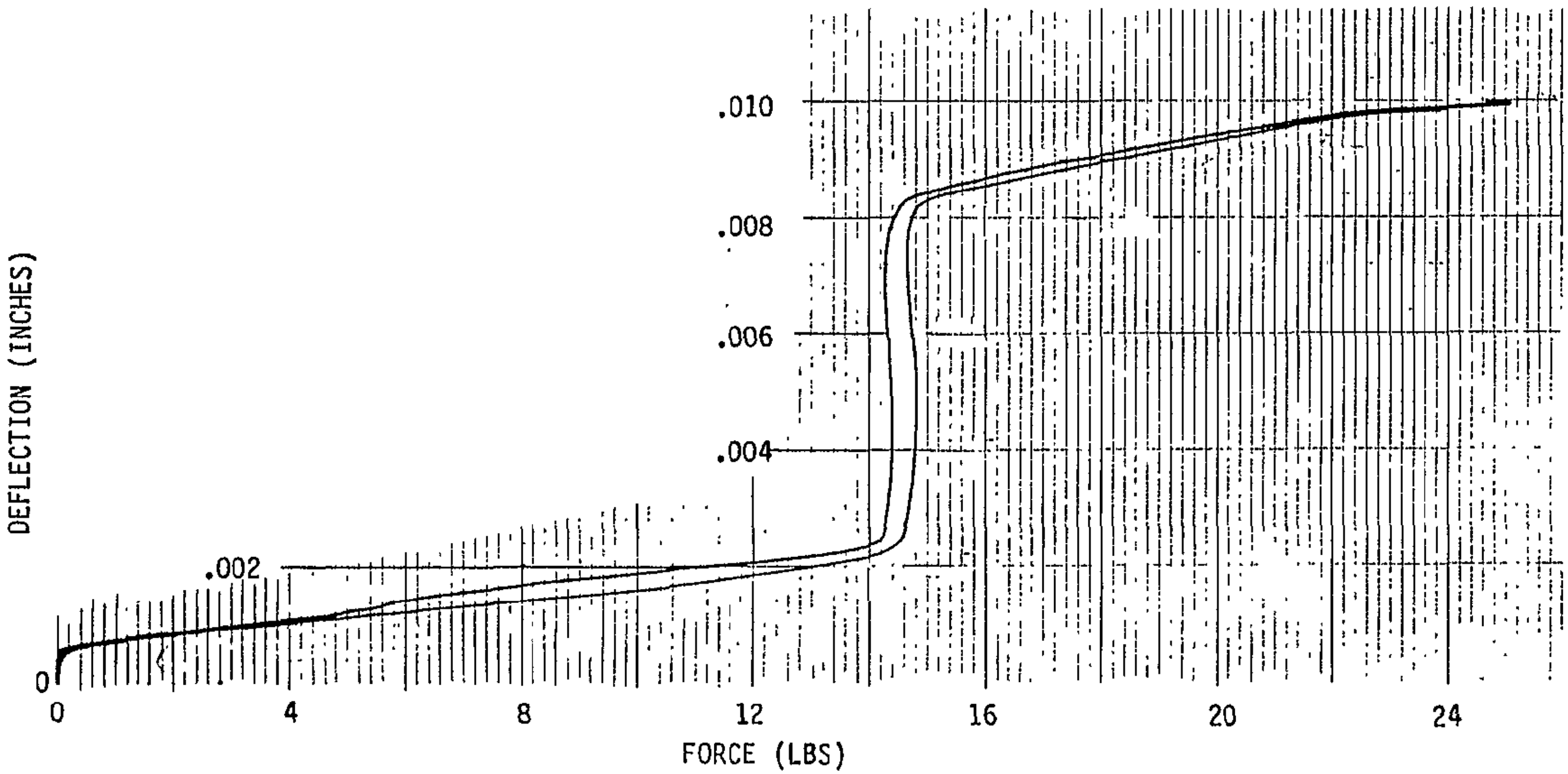

FIGURE 5b: FORCE DEFLECTION CURVE FOR DOWNSTREAM BELLOWS & BELLEVILLE SPRING ASSEMBLY

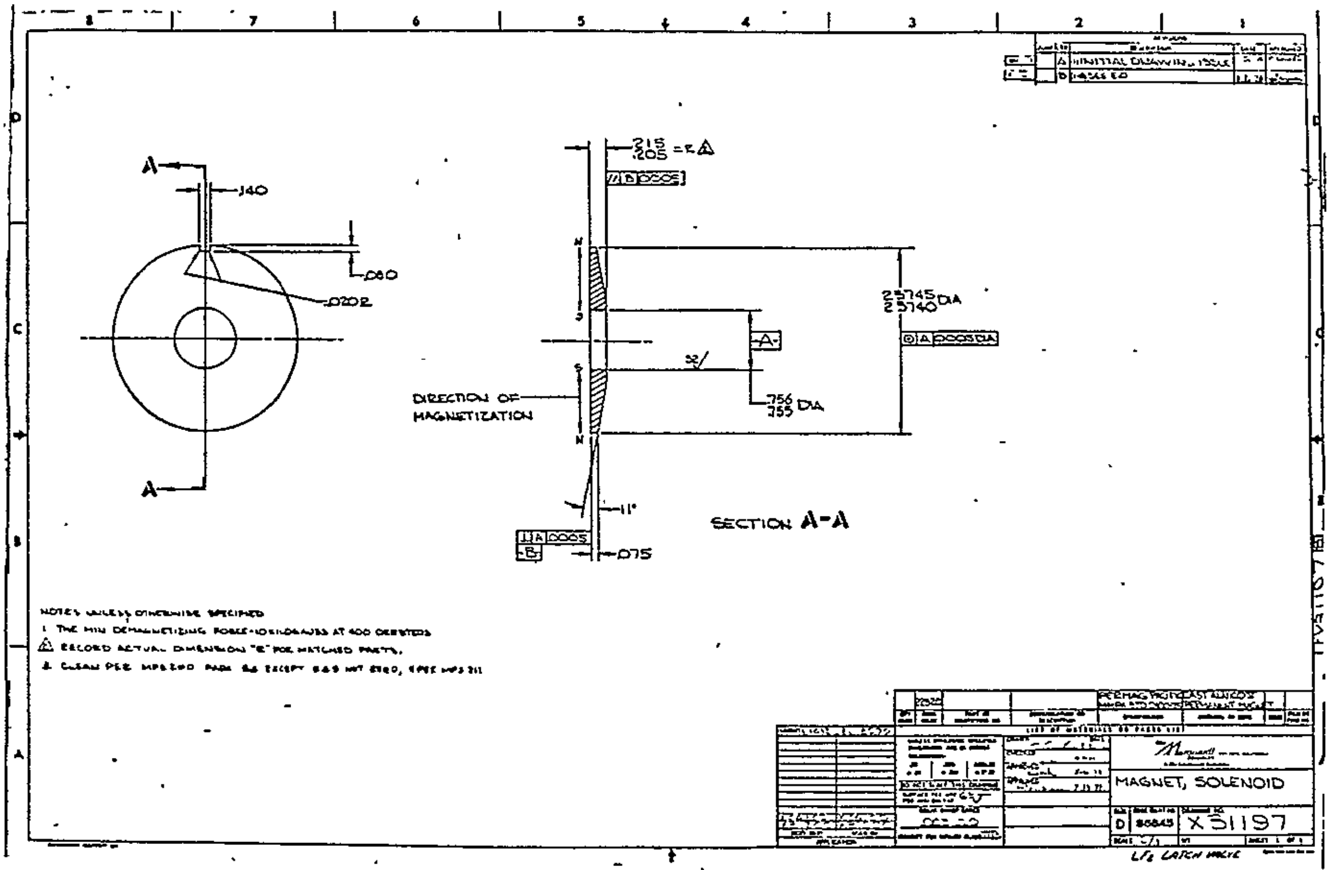

FIGURE 6a: SINGLE PIECE PERMANENT MAGNET

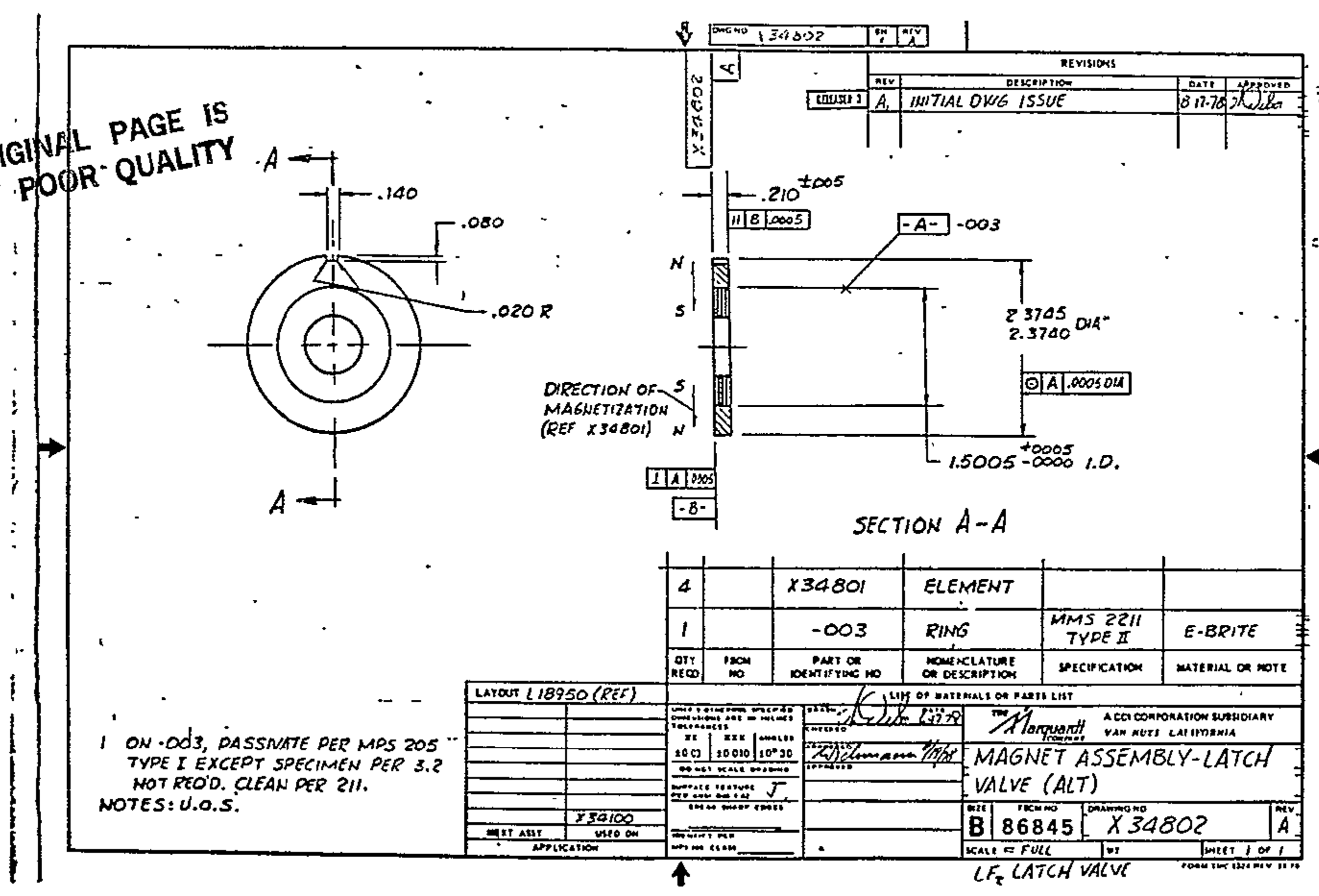

FIGURE 6b: BUILT UP PERMANENT MAGNET ASSEMBLY

3.1.3 Bellows Weld Assemblies

Attempts by the bellows manufacturer to complete the weldment of the end fittings to the bellows, using TIG welding techniques, were unsuccessful and E.B. welding was then explored. While a cylindrical joint between the bellows and end fittings is preferred for E.B. welding, the requirement to keep that weld joint unloaded during operation of the bellows dictated the upright flange shown in Figure 7. Ultimately, this joint presented no significant problems and the weld was successfully completed.

3.1.4 Position Indicator Switch

Figure 8 is the force deflection curve for the indicator switch and indicates the switch pretravel, closed position, overtravel, switch open position and mechanical differential. Data from this curve was used to determine the exact position of the switch trip point relative to its overtravel which was critical since the overtravel for this switch was very small.

During the setup of the valve assembly and adjustment of the position indicator switch, the leadwire end of the switch, which is in the form of a molded potting resin turret, was cracked. This switch was subsequently removed from the wiring harness and the spare switch installed. The splices for the three leadwires was accomplished through the use of ¼" long Stakon sleeves in which the appropriate leadwire ends were installed and mechanically compressed. The joints were staggered to avoid creating a lump in the wiring harness and black shrink tubing over each joint completed the splice.

3.1.5 Flexure Assembly

The flexure elements for this assembly were gold-plated to provide braze material for the joints between the elements and the inside and outside diameter flexure spacer rings. The joint between the tungsten carbide poppet and the flexure assembly was brazed with Palniro 7 braze alloy. This assembly was brazed in a vacuum furnace at 5×10^{-9} torr. However, the brazing fixture had been designed in such a way that all of the air inside the fixture was not free to vent off in the furnace and furnace vacuum times were insufficient to remove the air via the small cracks remaining in the fixture assembly. As a result, the Inco 718 flexure elements oxidized during the brazing operation. The JPL Project Manager was advised of this condition and following his inspection of the assembly, agreed that the valve buildup could continue without corrective action.

3.1.6 Seat and Poppet

Following the brazing of the K-96 tungsten carbide seat and poppet rings in the body and flexure assemblies, respectively, these surfaces were ground; the poppet to a flat surface and the seat to a double-ringed surface as shown in Figure 2. Both surfaces were then

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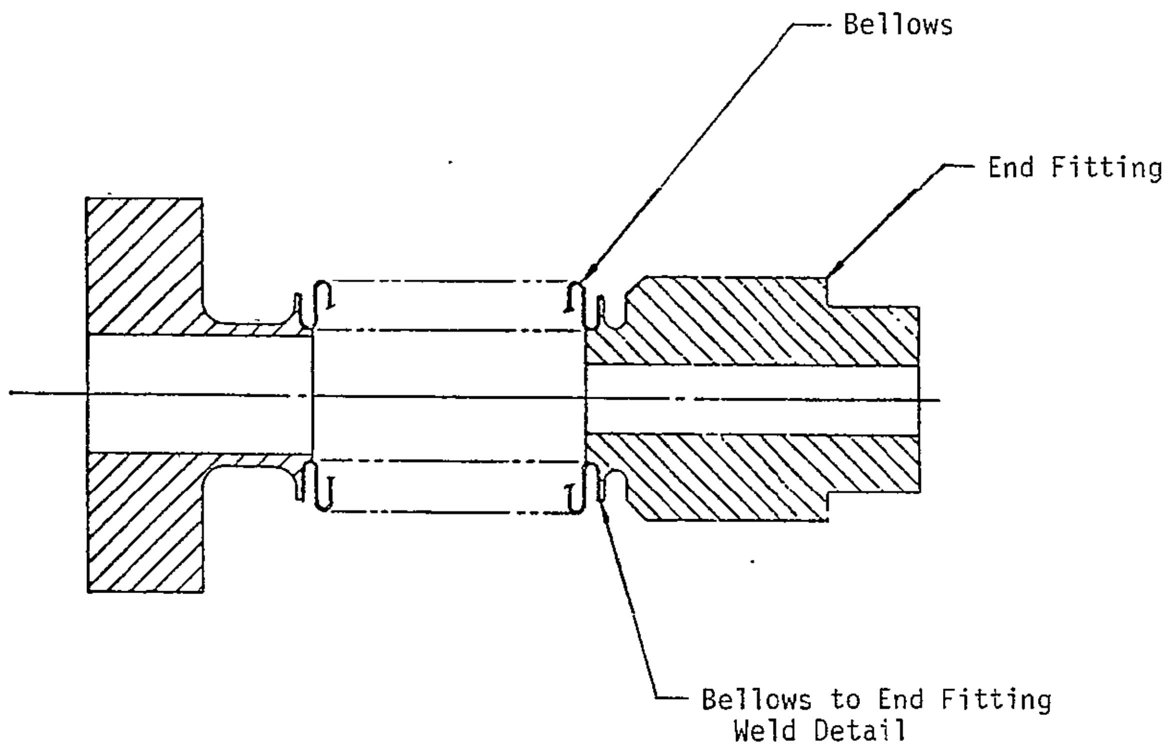

FIGURE 7: BELLOWS WELDMENT

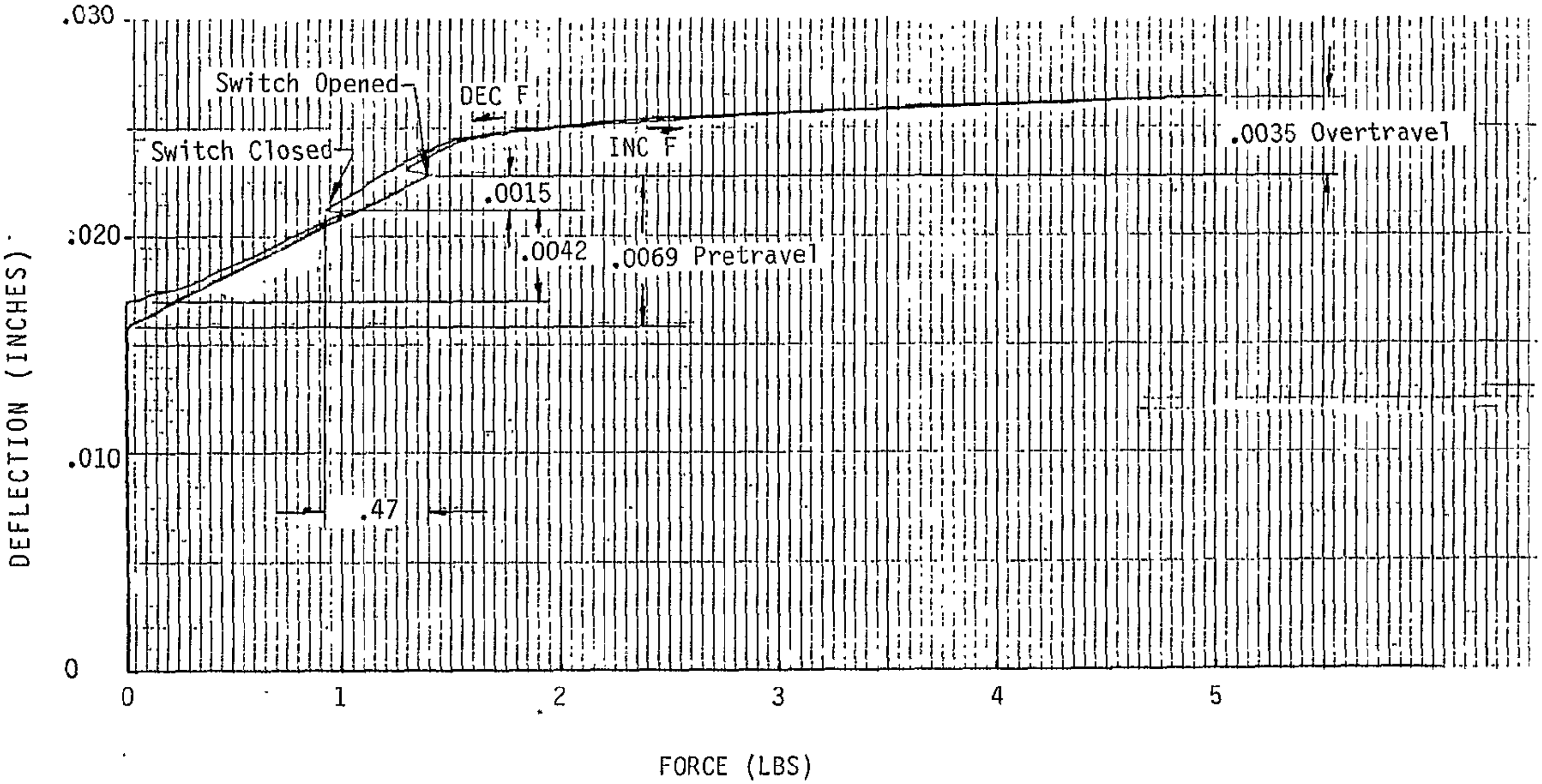

FIGURE 8: INDICATOR SWITCH FORCE DEFLECTION CURVE

lapped to a flatness of ½ helium lightband, measured across the sealing diameter, after which the outer, or seat bumper, ring was given an additional lap to provide between .000020 and .000080 inch axial gap below the plane of the inner or seat sealing ring. (The outer ring of the valve seat is intended to take the initial contact load of the closing poppet to provide alignment of the poppet with the seat sealing ring. Only the inner ring of the seat affects sealing upon valve closure.) As with the flexure assembly, the K-96 ring was brazed into valve body with Palniro 7 braze alloy.

3.1.7 Coil Assemblies

The coil assemblies were potted with Emerson Cuming 2850 FT Black Stycast potting resin by immersing them in a vessel of resin which had been previously heated to 165°F and outgassed at less than 1 torr pressure. Immersion of the coil assemblies was accomplished in a vacuum chamber, again at ½ torr or better, after which the pressure was returned to atmosphere to completely and intimately fill all voids between the wires or elsewhere in the coil assemblies. The assemblies were then removed from the resin, drained and cured to achieve initial set. Following the conventional cure, the coil assemblies then received a post-cure bake of 4 hours at 300°F for further enhancement of electrical properties.

3.1.8 Hermetic Cover

The hermetic cover features a small encapsulation turret around the rear of the electrical connector. The purpose of the turret is to provide a volume in which the solder joints, connecting the lead-wires to the connector, may be encapsulated. The same potting resin was used for this encapsulation as for the coil assemblies. The intent of this potting design was to ensure the integrity of the lead-wire-to-pin joint throughout the low temperatures anticipated in that area of the valve. The hermetic cover was installed on the valve in a 100% gaseous He filled glovebox, and the skirt heli-arc welded to the valve to achieve the desirable seal.

3.1.9 Valve Assembly

Upon completion of the valve assembly, a shaft was threaded into the nut through the bottom closure plate (with the AN fitting) and the assembly placed in the force-deflection fixture for seat load, stroke and spring constant measurements. Figure 9 is a curve generated for this assembly and was made of the valve assembly prior to energizing the permanent magnet. The opening and closing forces, with the permanent magnet energized, were measured with a push-pull scale and were 39 and 20 pounds, respectively.

3.2 SPECIAL FIXTURES

A total of fifteen special fixtures and items of tooling required for assembly of the valve were designed and fabricated. These included fixtures for brazing, effective area measurement of the large bellows, pressure test fixtures for major subassemblies and assembly tools. A major existing fixture currently in use at TMC for assembly of the Shuttle RCS Propellant Valves was a force/deflection fixture which was used during the assembly of the Latch Valve to confirm proper seat

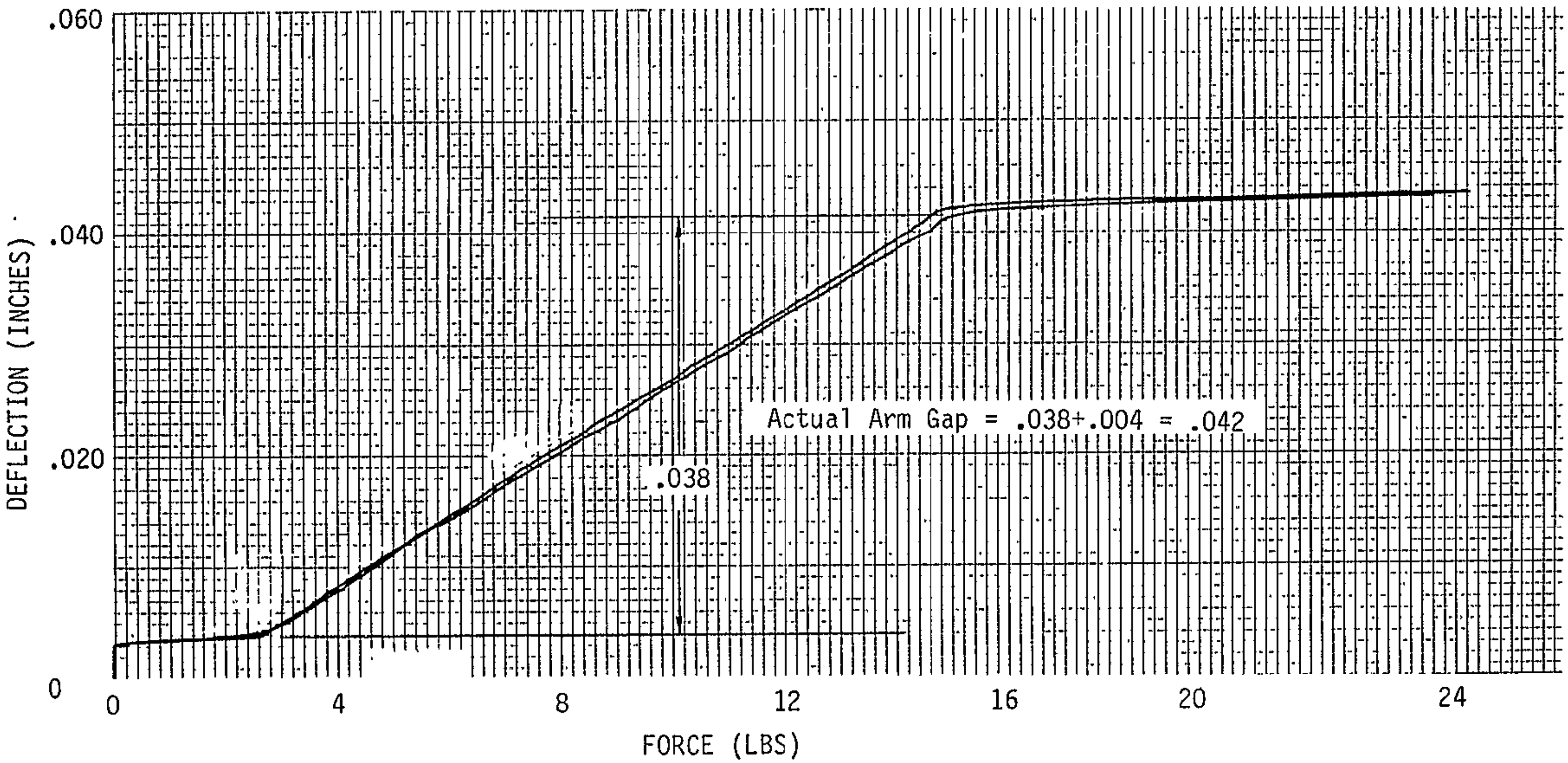

FIGURE 9: VALVE SEAT LOAD & STROKE

loads, strokes and spring rates. It is important in reading the force/deflection curves in this report to recognize that the force scale is along the abscissa of the curve while the deflection scale is along the ordinant. Since this is the reverse of conventional force/deflection curves, care should be exercised in interpreting the data. Also, the curves shown in this report show a rise on the deflection axes for 0 force. This was deliberately done to insure that the 0 point of the curve, as generated on the force/deflection fixture, was not inadvertently suppressed. For this reason, displacement dimensions drawn on these curves start a short distance up the deflection axes. All forces are in compression.

Included in the special fixtures was the Cover Stroke Test Fixture originally intended to permit direct measurement of the valve seat load and spring rates during buildup. This Cover, which is the same as the plate in Figure 2 but with an AN fitting, was used in the final assembly of the valve, to permit monitoring for any leakage past the poppet seals during tests at ETS.

The Effective Area Fixture shown in Figure 10 permitted the pressurization of the large bellows weldment assemblies while the entire Fixture-Bellows Assembly was installed in the force/deflection fixture. Measurement of the pressure and resultant force permitted the calculation of the effective diameter of the bellows, and thereby the diameter of the valve seat for the balanced poppet feature of the valve. (The diameter of the inner or sealing land of the seat is .0264 inch less than the effective diameter of the bellows and has the effect of increasing the valve seat load with increasing inlet pressure.

4.0 VALVE TEST

Following the initial assembly of the valve, tests, flowing water and GN_2, were performed. These tests were followed with the disassembly and inspection of the valve, final cleaning, reassembly and then repeat response tests flowing GN_2. A comparison of response tests flowing GN_2 before and after the disassembly, inspection and final cleaning operations would confirm that reassembly of the valve was satisfactory. Fluids used in the test of the valve complied with the NASA requirements for Shuttle Component tests, specifically NASA Specification SE-S-0073, "Space Shuttle Fluid Procurement Use Control". In addition, all fluids passing into the valve were filtered through 5-15 micron filters located immediately upstream of the valve inlet. Bobbin seals were not used in the valve inlet and outlet fittings for these tests. JPL supplied fittings, modified per TMC drawing, Figure 11, and utilizing silicone O-rings, were captured in the valve inlet and outlet with Bobbin coupling to MS threaded adapters. This permitted connecting the valve to conventional in-house plumbing.

An Acceptance Test Procedure, MTS 1332, is attached as Appendix 1. This ATP delineates the requirements specified in the JPL contract and includes the examination, weighing, pressuring testing, internal and external leakage measurements, electrical measurements, response measurements, pressure drop, disassembly and inspection, final cleaning, and certain concluding tests to verify satisfactory reassembly and maintenance of internal and external leakage minimums.

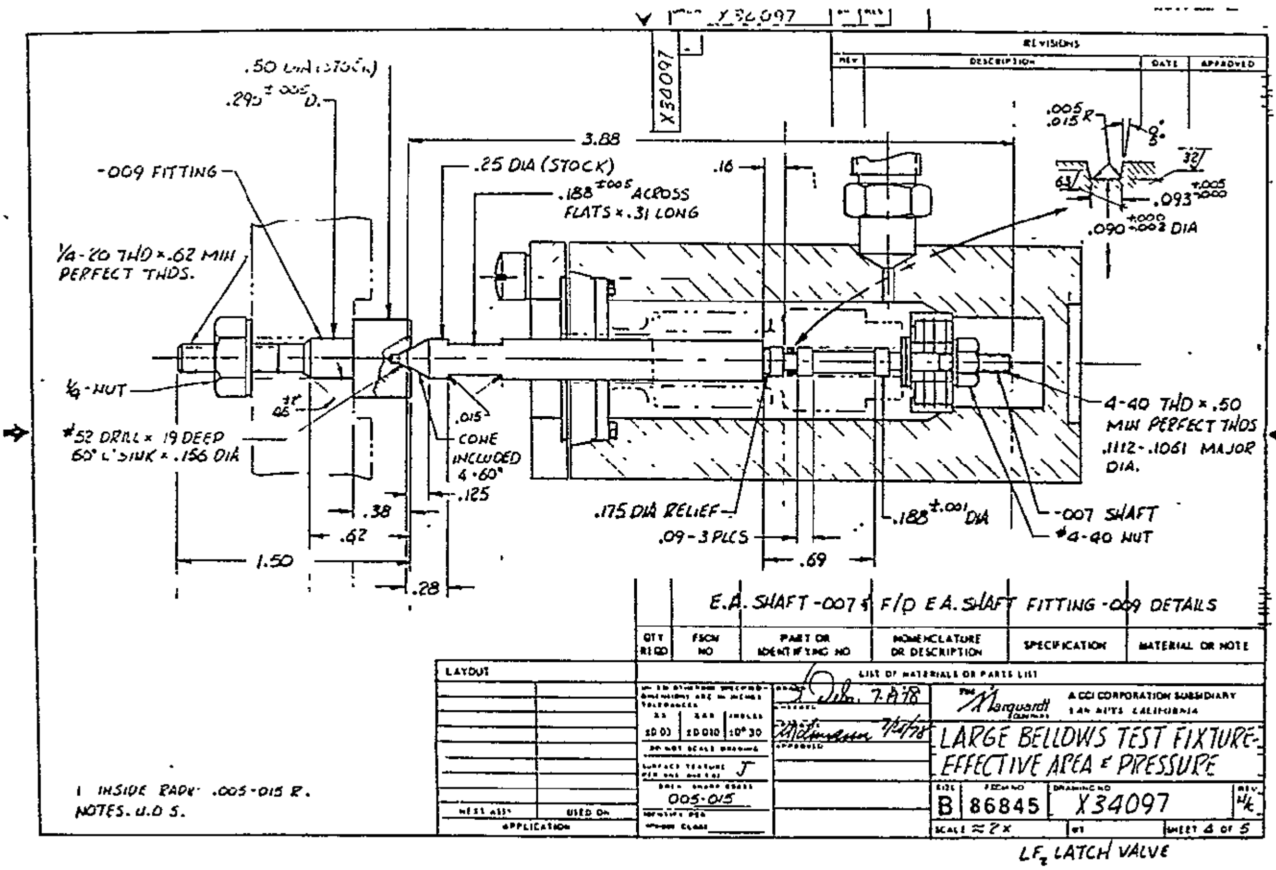

FIGURE 10: BELLOWS EFFECTIVE AREA TEST FIXTURE

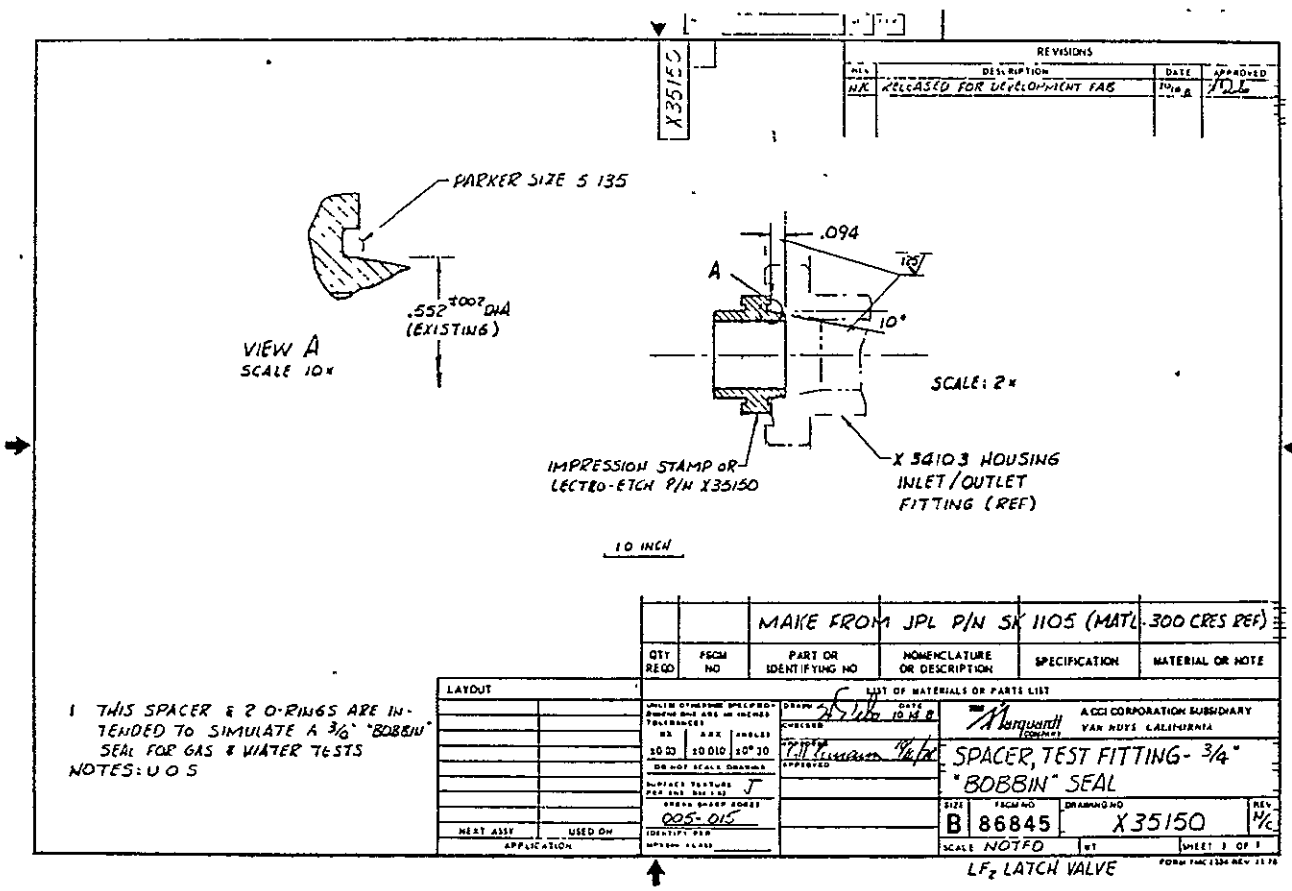

FIGURE 11: BOBBIN SEAL SUBSTITUTE FITTING

Figure 12 presents Polaroid pictures of oscilloscope response traces made during tests. The upper photo, of the voltage applied to the actuating coil and induced voltage of the non-actuated coil, represents the type of photo taken for most of the response tests. The lower picture is the oscilloscope presentation of valve operating coil amperage and again, the non-operating coil induced voltage trace. The latter photo was taken to corroborate the interpretation given the first photo; specifically, that the second deep glitch in the induced voltage trace was the valve opening time. The small glitch preceeding the opening response glitch in the induced voltage trace is the time at which the poppet shaft gap in the belleville cavity has closed and motion of the poppet started.

4.1 DATA SUMMARY

The following Tables from MTS 1332 present the data summary. The "Required" values specified in the tables reflect the waivers provided by JPL as described in the MTS 1332 "B" change EO. A copy of that EO is included in Appendix A with the ATP.

Based on final contractual requirements, all performance parameters were met. The required and measured values for the complete MTS 1332 test program are summarized in Table II. Highlights from this data include:

1. Internal leakages of only 1.0 cc/hr at 450 psig and 0 at 5 psig GN_2 inlet pressures.
2. External leakages of 1.0×10^{-6} scc/sec or better for 2 metal seal joints and 3.3×10^{-5} scc/sec for the third at 450 psig GHe inlet pressure.
3. Minimum operating voltages of 6.6 and 5.8 Vdc for opening and closing at 450 psig non-flowing water inlet pressure, and 1.8 pps flowing.
4. Valve opening and closing response times of 31 and 14 msecs at 450 psig non-flowing water inlet pressure and 1.5 pps flowing.
5. Pressure drop of 36 psid at 1.12 pps water.

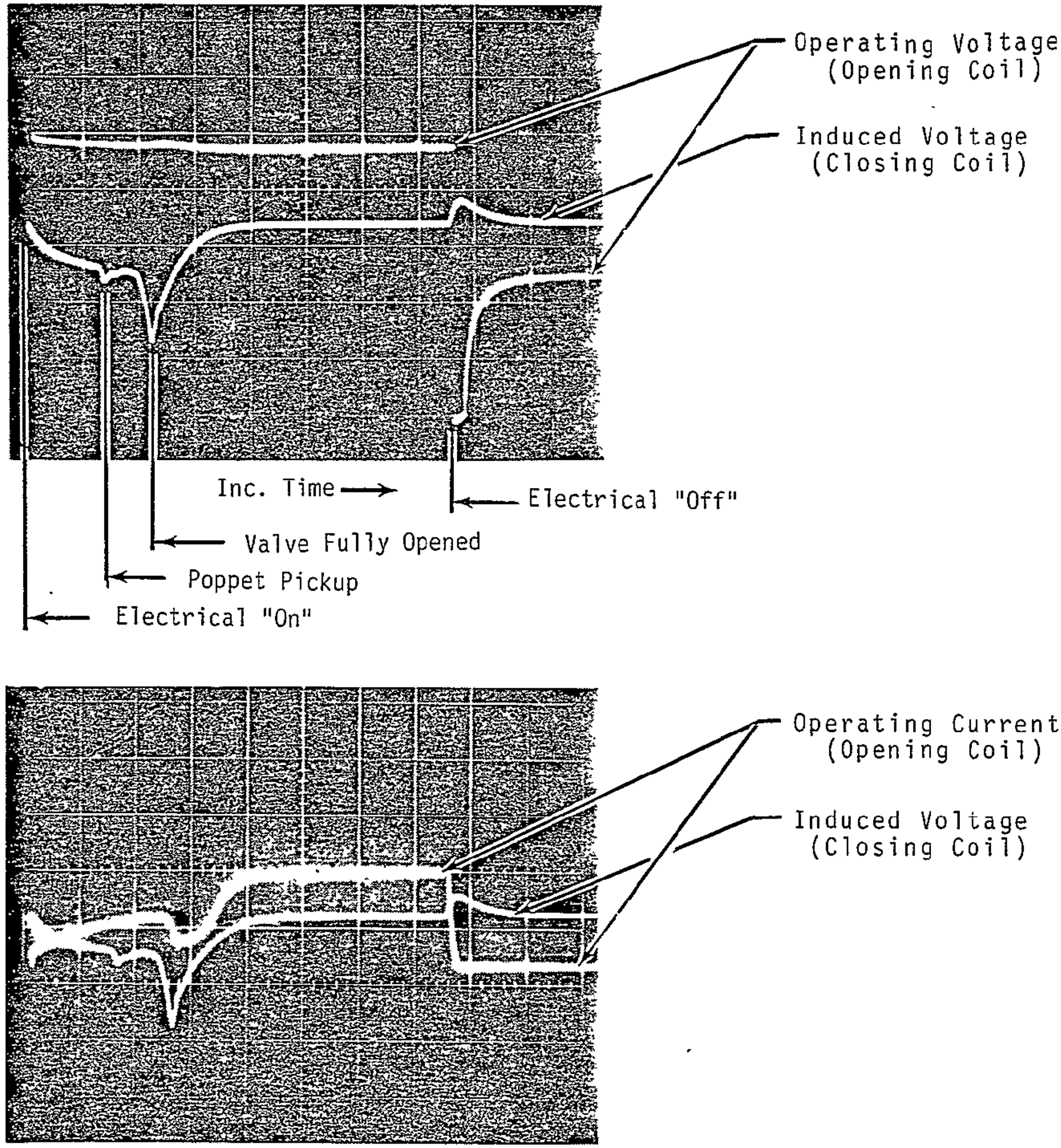

FIGURE 12: LF_2 LATCH VALVE RESPONSE PHOTOS

TABLE II

ATP DATA SUMMARY

TABLE III
LF_2 LATCH VALVE ACCEPTANCE TEST
DATA SHEET

Valve P/N X34100 Tested Per MTS 1332B

S/N 0001 Total Actuations, this page 3

Engr DEBOI Tech ______ Date ______

Test Para (Ref)	Test Parameter	Units	Required	Measured
4.1	Visual Examination			
	1. Workmanship	N.A.	Acceptable	ACCEPTABLE
	2. Nameplate	N.A.	Complete	COMPLETE
4.2	Weight	pounds	6.0 Max	5.67
4.3.1	Proof Pressure 900 psig ~~H_2O~~ GN_2 for 5 seconds	N.A.	No physical degradation	SEE DISASSY & INSP PER TEST PARA 5.0
4.3.2	External Leakage 450 psig GHe			
A	1. Mid Body to Inlet/Outlet Body Flange	scc/sec	$1x10^{-6}$ max	①
	2. Cover Plate Port	scc/sec	$1x10^{-3}$ max	①
	3. Cover Plate Flange	scc/sec	$1x10^{-6}$ max	①
4.3.3	Internal Leakage 450 psig GN_2 for 6 minutes	cc/hr	20 max	14
	5 psig GN_2 for 6 minutes	cc/hr	20 max	0
	-15 psig GN_2	cc/hr	Info Only	0
	-500	cc/hr	Info Only	300
	-600	cc/hr	Info Only	7080
4.3.4	Dielectric Strength 600 ± 60 Vac @ 60 Hz across the following leads:			
	a) Closing coil to body	microamps	<200	1.0
	b) Opening coil to body	microamps	<200	1.5
	c) Switch to body	microamps	<200	<1
	d) Closing coil to opening coil	microamps	<200	<1
	e) Closing coil to switch	microamps	<200	<1
	f) Opening coil to switch	microamps	<200	<1

① DATA QUESTIONABLE. SEE RESULTS ON DATA SHEET PARA 4.6.2

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TABLE II
ATP DATA SUMMARY (CONT)

TABLE III
LF_2 LATCH VALVE ACCEPTANCE TEST
DATA SHEET

Valve P/N X 34100 | Tested Per MTS 1332 B

S/N 0001 | Total Actuations, this page ≈ 200

Engr W. Coi | Tech ______ | Date ______

Test Para (Ref)	Test Parameter	Units	Required	Measured
4.3.5	Insulation Resistance 500±50 Vdc across following leads:			
	a) Closing coil to body	ohms	$<100 \times 10^6$	200×10^9
	b) Opening coil to body	ohms	$<100 \times 10^6$	200×10^9
	c) Switch to body	ohms	$<100 \times 10^6$	$>200 \times 10^9$
	d) Closing coil to opening coil	ohms	$<100 \times 10^6$	$>200 \times 10^9$
	e) Closing coil to switch	ohms	$<100 \times 10^6$	$>200 \times 10^9$
	f) Opening coil to switch	ohms	$<100 \times 10^6$	$>200 \times 10^9$
4.3.6	Minimum Operating Voltages Flowing GN_2			
	Opening @ 450 psig	Vdc	Info Only	4.4
	Closing @ 450 psig	Vdc	Info Only	4.2
4.3.7	Valve Response Flowing GN_2 @ 20 Vdc			
	Opening @ 450 psig	msecs	Info Only	26
	Closing @ 450 psig (.015 DIA ORIFICE ON OUTLET)	msecs	Info Only	19
	@ ~~28 Vdc~~ 24 Vdc ①			
	Opening @ 450 psig	msecs	Info Only	23
	Closing @ 450 psig (.015 DIA ORIFICE ON OUTLET)	msecs	Info Only	15
4.3.8	Minimum Operating Voltages Flowing Water			
	Opening @ 450 psig	Vdc	17 Max	6.6
	Closing @ ~~1.12 pps~~ 1.87 pps ACTUAL	Vdc	17 Max	5.5
4.3.9	Valve Response Flowing Water @ 20 Vdc			
	Opening @ 450 psig	msec	35 Max	31
	Closing @ ~~1.12 pps~~ 1.45 pps ACTUAL	msec	30 Max	14
	@ ~~28 Vdc~~ 24 Vdc ①			
	Opening @ 450 psig	msec	~~30 Max~~	24
	Closing @ 1.12 pps	msec	~~30 Max~~	12

① VOLTAGE LIMITED BY PULSER USED FOR THIS TEST

TABLE II
ATP DATA SUMMARY (CONT)

TABLE II

LF_2 LATCH VALVE ACCEPTANCE TEST

DATA SHEET

Valve P/N X 34100 Tested Per MTS 1332 B

S/N 0001 Total Actuations, this page ≈ 20

Engr DEE 31 Tech ____ Date ____

Test Para (Ref)	Test Parameter	Units	Required	Measured
4.3.10	Coil Resistances			
	Opening Coil @ 68°F	Ohms	12.5 ± 0.5	12.14
	Closing Coil @ 68°F	Ohms	12.5 ± 0.5	12.67
4.3.11	Pressure Drop			
	@ 0.84 pps water	psid	Info Only	20 ①
	@ 1.12 pps water	psid	40 Max	36 ①
	@ 1.40 pps water	psid	Info Only	55 ①
5.0	Disassembly and Inspection	N.A.	Per Para. 5.0	Results attached (Rpt para 4.1.1)
6.0	Final Cleaning Performed by GARWOOD LABS INC on 1-18-79	N.A.	Per TMC MPS 210	Results attached (Rpt para 4.1.2) (DATED 1-22-79)
4.6.2	External Leakage @ 450 psig GHe			
	1. Mid Body to Inlet/Outlet Body Flange Valve Configuration II	scc/sec	$1x10^{-6}$ max	0.5×10^{-6}
	2. Cover Plate Port Valve Configuration II	scc/sec	$1x10^{-3}$ max	3.3×10^{-5}
	3. Cover Plate Flange Valve Configuration III	scc/sec	$1x10^{-6}$ max	1.0×10^{-6}
	Final Test Flowing GN_2			
4.3.6	Minimum Operating Voltages Flowing GN_2			
	Opening @ 450 psig	vdc	Info Only	5.7
	Closing @ 450 psig (.015 DIA OUTLET ORIFICE)	vdc	Info Only	8.5

① MEASUREMENTS MADE WITH 2ND UPSTREAM BELLOWS ASSEMBLY

TABLE II
ATP DATA SUMMARY (CONT)

TABLE III

LF_2 LATCH VALVE ACCEPTANCE TEST

DATA SHEET

Valve P/N X34100 Tested Per MTS 1332B

S/N 0001 Total Actuations, this page ______

Engr OEB01 Tech ______ Date ≈50

Test Para (Ref)	Test Parameter	Units	Required	Measured
4.3.7	Valve Response Flowing GN_2			
	@ 20 Vdc			
	Opening @ 450 psig	msec	Info Only	32
A	Closing @ 450 psig (.015 DIA OUTLET ORIFICE)	msec	Info Only	18
	@ ~~28 Vdc~~ 24 Vdc ①			
	Opening @ 450 psig	msecs	Info Only	24
A	Closing @ 450 psig (.015 DIA OUTLET ORIFICE)	msecs		16
4.3.3	Internal Leakage			
	450 psig GN_2 for 6 minutes	cc/hr	20. max.	1.0
A	5 psig GN_2 for 6 minutes	cc/hr	20. max.	0
A				
4.0.	Total valve actuations this test	cycles	Info Only	≈ 273

① VOLTAGE REDUCED TO REPEAT EARLIER TEST CONDITIONS

MAC A1844-1

4.1.1 Disassembly & Inspection Per ATP Paragraph 5.0

Following the initial assembly of the valve, external leakages in excess of permissible levels were measured. Disassembly of the valve and inspection of the seals and sealing surfaces revealed both the seal and valve surfaces to be deficient in several joints. Microscopic examination showed the metal seals to have nodule-like imperfections in the plating. Small pits and diagonal scratches were observed. Surface finishes on several valve components were rougher than RMS 8 and in need of touch-up.

The bellows convolutions on the upstream bellows assembly were distorted and unevenly compressed. No signs of cracks could be seen in any of the convolution radii at 40x microscopic examination, but some were fairly sharp. Both sealing surfaces on the end fittings appeared satisfactory, but were out of parallel as a result of the bellows distortion.

The sealing surfaces of the tungsten carbide poppet and seat appeared free of scratches or distortion. Occasional circumferential scratches were noted in the seat, but were too narrow to measure with the interference microscope. Overall flatness of both seat and poppet carbide surfaces was better than ½ lightband. A slight discoloration noted on these surfaces cleaned off easily with Freon.

In addition to cleaning the tungsten carbide seats with Freon, the sealing surfaces on all valve component parts, found to be less than RMS 8, were relapped. Also performed at this time was a special lapping operation on the metal seal sealing surfaces to obtain a burnish zone by which the suitability of the seal could be confirmed in terms of having a well defined, single plane, continuous burnish line around the entire diameteral sealing surfaces on both sides of the seal. This technique permitted an evaluation of the nodules noted previously in terms of potential discontinuity. The combined effect of this burnishing operation plus the resurfacing of the valve component sealing surfaces was effective insofar as leakages past the valve mid-body joint and lower cover plate dropped dramatically. The success of this operation was marginal for the two small seals since leakage past these was greatly reduced but still in excess of the original requirements.

4.1.2 Final Cleaning Particulate Count Per ATP Paragraph 6.0

Final cleaning results are reproduced below. JPL requirements from SS80-PD-103A, Level 2 Class D for the 4 particulate groups shown are 140, 20, 5 and 1 max.

GARWOOD LABORATORIES, INC.
708 SOUTH VAIL AVE.
MONTEBELLO, CALIF. 90640
TELEPHONE: 723-0011

CONTAMINATION RECORD

GLI Job No. Marquardt

Customer The Marquardt Company
Customer P.O. # 825185 Date 1-22-79
Customer P/N See Below

MICRON COUNT (100/ml.)

S/N	6-10	11-25	26-50	51-100			
Seals & Internal parts	96	10	3	1			
Body	85	12	2	0			
Assembly & Bellows	104	14	4	1			

FORM G-121 3M 6-69

GLI 1 INSP

Shirley Frettwell
INSPECTOR - GLI

INSPECTOR - CUSTOMER

5.0 CONCLUSIONS AND RECOMMENDATIONS

A development configuration Latch Valve suitable for the control of liquid fluorine and hydrazine was successfully fabricated, assembled and tested in GN_2 and H_2O. Based on the experience gained in this program, the following conclusions may be drawn:

1. Very low internal leakage rates of less than 5.0 cc/hr at 5 to 450 psig GN_2 inlet pressure may be maintained through the use of properly fabricated hard poppets and seats. (A leakage rate of 1.0 cc/hr was demonstrated following final assembly of the Latch Valve.)

2. The propellant cavity of the valve can be kept free of self-generated metal particles and proper and consistent alignment of poppet and seat elements maintained through the use of flexures and bellows.

The following recommendations are made:

1. Fabrication techniques to more easily obtain suitable sealing surfaces on valve components, as well as to ensure proper fabrication and plating of small metal seals, bear investigation.

2. Coincident with the above, alternatives to the metal V-seal configuration or alternative methods for plating the seal should be explored.

3. Inherent in a development valve fabrication, assembly and test program is the need for close liaison between personnel involved in the fabrication and testing phases of the program. For analysis, interpretation of test results and incorporation of conclusions in the final valve configuration, a one-to-one relationship between these personnel is mandatory.

4. It is recommended that the ATP be revised to specify proof pressure tests with GN_2 after final assembly of the valve.

6.0 NEW TECHNOLOGY

No new technological items were developed at TMC during the performance of this contract.

REFERENCES

1. Valve Modification for a Fluorinated Oxidizer Propulsion System by Wichmann, Deboi & Kelly.

   TMC Report No. S-1336, July 18, 1978

APPENDIX A

MTS 1332

"ATP - LF_2 VALVE, P/N X34100"

THE MARQUARDT COMPANY
CCI CORPORATION
FORM TMC 604 REVISED 11-74

ENGINEERING ORDER

SHEET 1 OF 1 | DWG NO. MTS 1332

NEW ☐ INFORMATION/INSTRUCTIONS ☐ MEMO ☐

E.O. ISSUE NO. 2 | PRESERVE LTR B1-6

SALVAGE NO.

TITLE: ATP-LF_2 LATCH VALVE, P/N X34100

CHANGE	CHANGE IDENTIFICATION (CIN)
CLASS II	PROGRAM NO. 5153
CATEGORY	CHANGE SEQ NO. –
TYPE	CONFIGURED ITEM (C.I.) –

CHANGE DESIG. | PROPOSED BY: Component Engineering

REASON

To incorporate changes specified by the customer.

Page #	Para #	Statement of Change
13	4.2	Weight (IS) 6.0 max (WAS) 5.0 max
13	4.3.2	Cover plate port leakage (IS) 1×10^{-3} max (WAS) 1×10^{-6} max
13	4.3.3	Internal leakage @ 450 psig GN_2 for 6 minutes (IS) 20 max (WAS) 10 max
15	4.3.11	Pressure drop @ 1.12 pps water (IS) 40 max (WAS) 30 max
15	4.6.2	External leakage @ 450 psig GH_2 at cover plate port valve configuration II (IS) 1×10^{-3} max (WAS) 1×10^{-6} max
16	4.3.3	Internal leakage @ 450 psi GN_2 for 6 minutes (IS) 20 max (WAS) 10 max

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PART NO./MODEL	SERIAL NUMBER EFFECTIVITY	ENGINEERING TASK NO.
	S/N 0001 and subsequent (previous parts comply)	N86810-30

DISPOSITION

ORIGINATING SECTION	LF_2 Latch Valve	DATE
PREPARED BY		
CHECK		
DESIGN ENGINEER		
PROCESS ENGINEER		
PRODUCT ENGINEER		
MATERIAL ENGINEER		
FUNCTIONAL ENGINEER	[signature]	3/2/79
PROJECT ENGINEER	[signature]	3/2/79
RELEASE	[signature]	3/6/79

SPARES EFFECTIVITY: INCORP. MANDATORY ☐ INCORP. OPTIONAL ☐ NO EFFECT ☐

		DATE
PRODUCT SUPPORT	[signature]	3-2-79
MFG ENGINEER		
QUALITY ENGINEER	[signature]	3-5-79
RELIABILITY ENGINEER	[signature]	3-2-79
CUSTOMER APPROVAL		

SEND COPIES TO DE801

THE MARQUARDT COMPANY
CCI CORPORATION
FORM TMC 664. REVISED 11-74

ENGINEERING ORDER

SHEET 1 OF 2	DWG NO. MTS 1332
NEW ☐ / INFORMATION/INSTRUCTIONS ☐ / MEMO ☐	E.O. ISSUE NO. 2 — DWG CHANGE LTR A
	SALVAGE NO.
CHANGE	CHANGE IDENTIFICATION (CIN)
CLASS II	PROGRAM NO. 5153
CATEGORY	CHANGE SEC NO —
TYPE	CONFIGURED ITEM (C I) —

TITLE: ATP - LF_2 LATCH VALVE, P/N X34100

CHANGE DESIG.

PROPOSED BY: Component Engineering

REASON

Noted.

See N/C Release for previous configuration.

	Paragraph No.	Statement of Change	Reason
1.	3.7	Deleted entire paragraph, "Test Sequence"	Requirements are specified in paragraph 4.0.
2.	4.0	Specified External Leakage be performed after Final Cleaning and before Final Test-Flowing GN_2. Renumbered test sequence 7 and 8 and clarified valve configuration.	Customer request.
3.	4.0 Footnote 4	Revised note and added seal 5.	Clarify footnote.
4.	Page 5	Added Figure of X34094 cover.	To clarify valve configurations I and II.
5.	4.3.3.2	Added "Note Reverse leakage..."	To avoid backflow through clean valve.
6.	4.3.6.1	Gry was R/W & Grn was G/W.	To make callouts agree with Figure 1.

ORIGINAL PAGE IS OF POOR QUALITY

PART NO./MODEL	SERIAL NUMBER EFFECTIVITY	ENGINEERING TASK NO.
	S/N 0001 & subs. (No parts tested)	N86810-30

DISPOSITION

ORIGINATING SECTION	LF_2 Latch Valve	DATE	SPARES EFFECTIVITY: INCORP. MANDATORY ☐ INCORP. OPTIONAL ☐ NO EFFECT ☐		DATE
PREPARED BY					
CHECK			PRODUCT SUPPORT	[signature]	11-27-78
DESIGN ENGINEER	[signature]	11-27-78	MFG ENGINEER		
STRESS ENGINEER			QUALITY ENGINEER	[signature]	11-29-78
PRODUCT ENGINEER			RELIABILITY ENGINEER	[signature]	11-27-78
MATERIAL ENGINEER			CUSTOMER APPROVAL		
FUNCTIONAL ENGINEER					
PROJECT ENGINEER	M. Wildmann	11/27/78	SEND COPIES TO DE801 (7)		
RELEASE	Coral Strong	11-29-78			

	Paragraph No.	Statement of Change	Reason
7.	4.3.6.2	Grn was G/W and Brn was Blk/W.	To make callouts agree with Figure 1.
8.	4.3.7.1	Added: Tolerance to 450±10 callout.	Writing omission.
9.	6.0	TMC Cleaning Spec........ was JPL Cleaning Spec	Comply with contract requirements.
10.	Page 13	Added External Leak Check Points 1, 2 and 3.	To clarify leakage measurement locations.
11.	Page 15 Test Para. 4.3.10	Revised coil resistance requirements.	To make test requirements compatible with drawings X31194 & X31196.
12.	Page 15 Test Para. 6.0	Per TMC MPS 210 was Per JPL SS80-PD-103 Level D-2.	Comply with contract requirements.
13.	Page 15 Test Para. 4.6.2	Added External Leakage Requirement following final cleaning.	Customer request.
14.	Page 16 Test Para. 4.3.7	Changed Valve Response Units to msec.	Writing error.
15.	Page 16 Test Para. 4.3.7	28 Vdc was 20 Vdc.	Writing error.
16.	Page 16 Test Para. 4.3.3	Added "Max" to internal leakage requirements	To clarify acceptable leak rates.
17.	Page 16 Test Para. 4.3.3	Deleted reverse leakage measurements.	To avoid reverse flow through clean valve.

1.0 SCOPE

This specification establishes the Acceptance Test requirements for the LF_2 Latch Valve, P/N X34100.

2.0 APPLICABILITY

The following documents, of latest issue, form a part of this specification. In case of conflict between these documents and this specification, this specification shall take precedence.

NASA Documents

SE-S-0073	Space Shuttle Fluid Procurement & Control Specification

JPL Documents

SS80-PD-103	General Cleaning Requirements for Fluorine Service

Marquardt Company Documents

MPS 210	Cleanliness Requirements for Reaction Control System Engine
MPS 1500	Proof Pressure and Leakage Testing

3.0 GENERAL REQUIREMENTS

3.1 TEST ENVIRONMENT

Unless otherwise specified, tests of this MTS will be conducted under local ambient pressure and temperature conditions. Fluid temperature and alternate ambient pressure and temperature conditions will be specified where required.

3.2 FLUID CLEANLINESS & HANDLING

3.2.1 Fluids

All test fluids are to be passed through filters between the storage tanks ond the test valves. One filter shall bé located within 12 inches of the valve inlet and shall have a rating of 15μ absolute or better.

3.2.2 Bagging

3.2.2.1 Upon completion of the Area 1 Clean Room tests of this MTS and in preparation for removal from the Area 1, the Valve Assembly shall be dried and double-bagged per MPS 210.

3.2.2.2 In the event the valve or components will not be removed from the Clean Room prior to additional handling, it shall be single-bagged per MPS 210.

3.2.3 Purging

3.2.3.1 Purging shall be accomplished with GN_2 at a static inlet pressure of 100 psig ± 10 psi. A minimum of 2 cycles of at least 5 seconds open, with valve closed time as required for the recovery of the inlet pressure, shall be completed to purge the valve of residual test fluids.

3.2.4 Drying

Within 12.0 hours after draining or purging, the valves shall either be returned to test or shall be dried by a vacuum bake of 1-1/2 to 24 hours (accumulated) at 170 ± 30°F and 0.3 psia or lower.

3.2.5 Test Site

The response and cleanliness verification tests of this MTS shall be performed in an Area 1 Clean Room or equivalent as defined by MPS 210.

3.2.6 Supply Plumbing

All plumbing through which the valve test fluids pass, and the mounting fixture for the valve, shall be constructed of 300 series stainless steel or other metals compatible with fluorine.

3.3 TEST RECORDS

3.3.1 Data Package

A Data Package shall be prepared for each Valve Assembly tested per this MTS. Each package shall be organized in a manner to facilitate its inclusion in the valve log book.

3.4 DRIVER CIRCUITRY

For the response tests of this MTS, a TMC Model 9 pulse generator equipped with an SSRCS arc suppression circuit shall be used. For nonresponse tests, any electrical switching circuit may be used at the valve voltages specified herein.

3.5 LIMITS OF OPERATION

Operation of the Valve Assembly in excess of the following limits shall be cause for rejection:

Valve Voltage	33 vdc
Power ON Time (Flowing)	No limit
Power ON Time (Nonflowing)	5 minutes maximum in any 60 minute period

3.6 PARAMETER MEASURED ACCURACY

Test instrumentation and equipment shall be in accordance with the following:

Measured Parameter	Fluid	Instrument	Range	Accuracy (% of Full Scale)
Inlet Pressure	H_2O	Pressure Gage	0-500 psig	±1
Inlet Pressure	GN_2	Pressure Gage	0-500 psig	±1
Inlet Pressure	GN_2	Pressure Gage	0-20 psig	±1
Pressure Drop	H_2O	ΔP Gage	0-50 psid	±1
Oven Pressure	Air	Pressure Gage	0-15 psia	±1
Temperature	H_2O	Thermocouple & Indicator	30-130° F	±1
Leakage, Forward	GN_2	Burette	0-10 cc	±.25
Leakage, Reverse	GN_2	Burette	0-10 cc	±.25
Voltage		Voltmeter	0-40 vdc	±.5
Current		Differential Voltmeter	0-2 amps	±2
Response Time		Oscilloscope & Camera	0-100 ms	5
Valve - Cycles		Pulser Counter	0-999,999	±5 cycles
Time		Timer	0-60 min.	±1
Flow Rate	H_2O	Flowmeter	0.5-1.4 pps	±1
Flow Rate	H_2O	Graduate Cylinder	0-50 cc	±.25
Oven Temperature	Air	Thermocouple & Meter	40-250° F	±5
Flow		Electronic Counter	0-99,999 cps	±2
Valve Cover Temp		Digital Thermometer	60-120°F	±2
Coil Resistance		Wheatstone Bridge	0-25 ohms	±0.2

A 3.7

4.0 VALVE EXAMINATION, MEASUREMENT & PROCEDURES

These procedures will be performed in the following sequence, with exceptions as noted, and according to the requirements of the indicated paragraph:

Sequence	Examination/Measurement/Test	Valve Configuration (from Table I)	Paragraph
1. ①	Examination of valve	III	4.1
2. ①	Weight	III	4.2
3.	Tests		4.3
	1 Proof Pressure	I	4.3.1
	2 ② External Leakage	I	4.3.2
	3 ② Internal Leakage	I	4.3.3
	4 ② Dielectric Strength	I	4.3.4
	5 ② Insulation Resistance	I	4.3.5
	6 Minimum Operating Voltages Flowing GN_2	I	4.3.6
	7 Valve Response Flowing GN2	I	4.3.7
	8 ③ Minimum Operating Voltages Flowing H_2O	I	4.3.8
	9 ③ Valve Response Flowing H_2O	I	4.3.9
	10 ③ Coil Resistance	I	4.3.10
	11 ③ Pressure Drop	I	4.3.11
4.	Disassembly & Inspection		5.0
5.	Final Cleaning		6.0
A 6.	External Leakage	II & III ④	4.3.2
7.	Final Test-Flowing GN_2		
	1 Minimum Operating Voltage	II	4.3.6
	2 Valve Response	II	4.3.7
	3 Internal Leakage	III	4.3.3
8.	Preparation for Shipment	III	7.0

Notes:

① ② ③ These tests may be performed in any order, within the group number shown inside the circle, to best utilize the test setup.

A ④ This sequence is intended to provide an external leakage test of final configuration seals 3, 4, and 5 (valve configuration II) after which seal 1 will be replaced with the final configuration seal (valve configuration III) and the external leakage test completed.

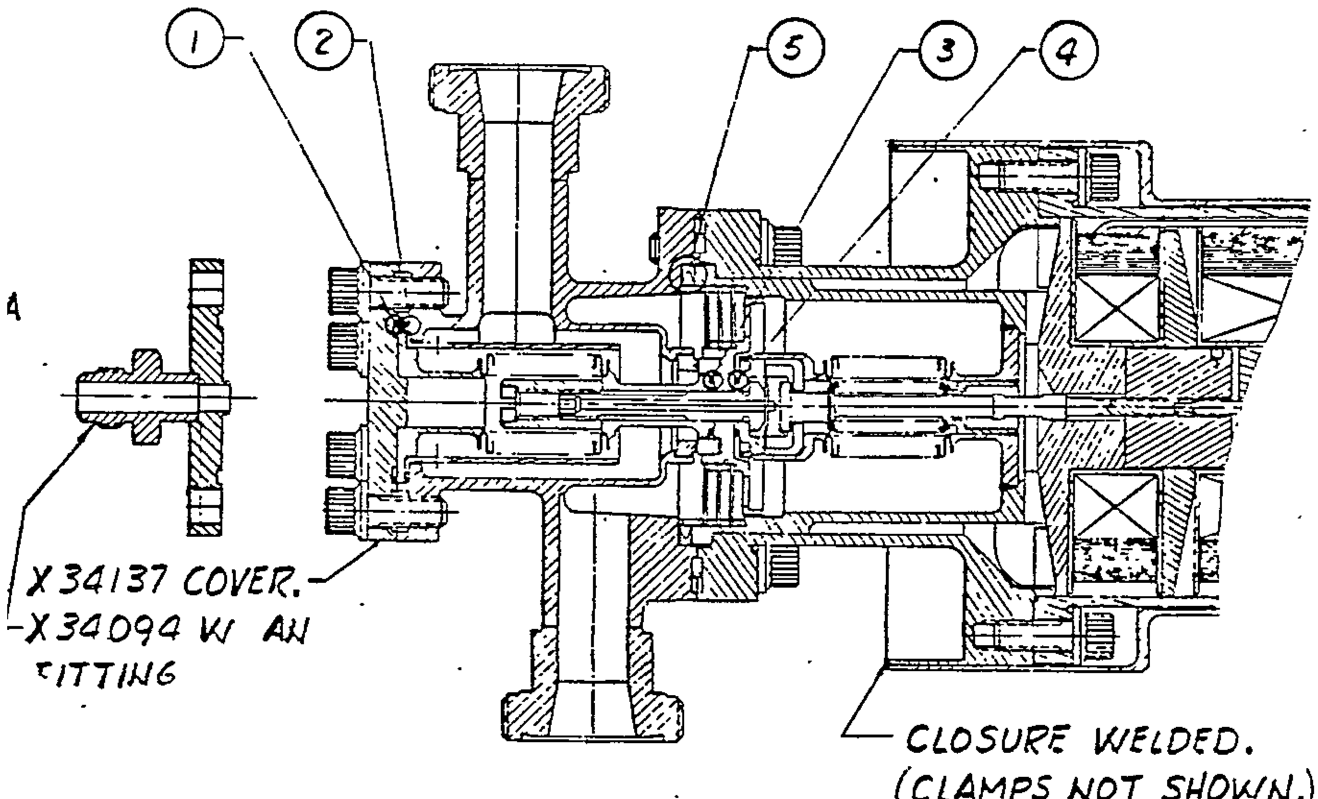
The total number of valve actuations performed during the tests of this MTS shall be recorded in Table III. One actuation shall consist of a valve opening and closing operation which produces a poppet to seat impact force.

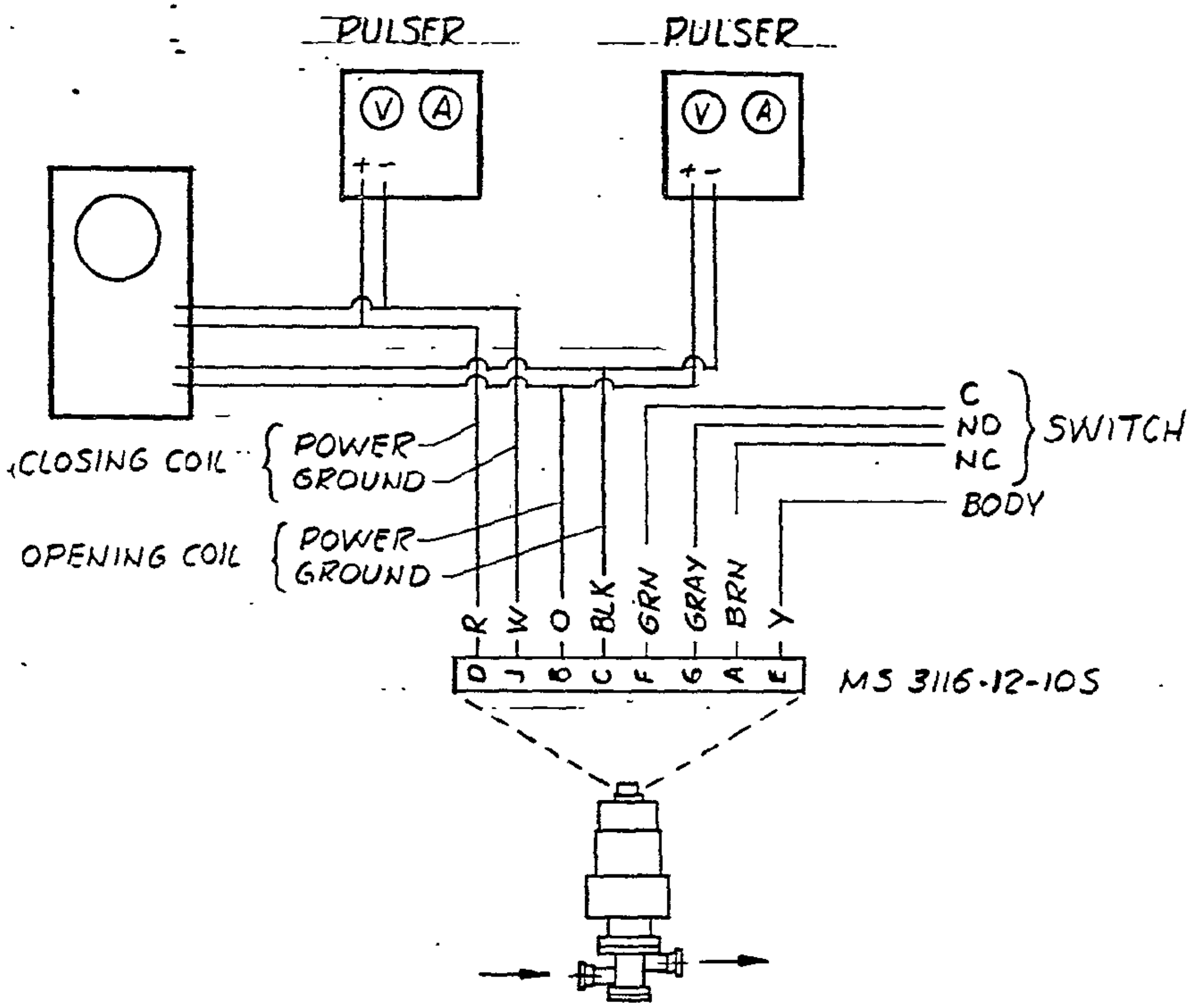
A wiring schematic for the valve appears in Figure 1.

Results shall be recorded in and meet the requirements of the Data Summary Tabulation of Table III.

TABLE I: Valve Configuration

Config. No.	End Cover	Seal Set Seal Position Number 1	2	3	4	5	Closure Attachment
I	X34094 w AN fitting	1st set	→	→	→	→	Clamped
II	X34094 w AN fitting	1st set	2nd set	→	→	→	Clamped
III	X34137 w/o AN fitting	2nd set	→	→	→	→	Welded per X24100





CAUTION!

THE VALVE LEAD WIRE ORIENTATION MUST BE AS SHOWN, FOR ACTUATION OF THE VALVE OR DEMAGNETIZATION OF THE PERMANENT MAGNET WILL RESULT

FIGURE 1: LF_2 LATCH VALVE WIRING DIAGRAM

4.1 EXAMINATION OF PRODUCT

The valve shall be examined to insure the following:

1. A high level of workmanship; smooth external surfaces with no nicks, scratches or similar blemishes.

2. Complete identification on the valve including part number, serialization and flow direction arrow.

4.2 WEIGHT

The valve shall be weighed and the weight, to two decimal places, recorded in the data sheet.

4.3 TESTS

4.3.1 Proof Pressure

4.3.1.1 Pressure & Duration

The valve will be proof pressure tested to 900±30 psig per MPS 1500 Type I, with the following additional provisions and exceptions:

1. The pressurizing fluid shall be distilled water.
2. No "method" of MPS 1500 shall apply (viz; no attempt to detect leakage shall be made).
3. Duration of test shall be 5 seconds at the full test pressure.

4.3.1.2 Plumbing

The valve will be plumbed such that the pressure, delivered to the valve inlet and the downstream face of the valve seat, occurs simultaneously.

4.3.1.3 Pressurization & Venting

Both pressurization and venting will be done in a manner to insure the pressure at the valve outlet does not exceed the pressure at the valve inlet by more than 5 psi, to guard against reverse flow through the valve.

4.3.1.4 Post Test Inspection

Following depressurization, the valve shall be visually inspected for signs of physical degradation. This visual inspection may be performed after the External Leakage test.

4.3.2 External Leakage

4.3.2.1 The valve shall be plumbed per 4.3.1.2 above and pressurized to 450^{+10}_{-15} psig GHe for a period of at least 3 minutes. Leakage at all external joints shall be detected using a sniffer probe. For Valve Configuration I & II of paragraph 4.0 this will include the AN fitting port on End Cover X34094. Pressurization and venting shall be per 4.3.1.3 above.

4.3.3 Internal Leakage

4.3.3.1 Forward Leakage

4.3.3.1.1 Apply a pressure of 450±10 psig GN_2 to the valve inlet and monitor leakage at the outlet for a minimum of 6.0 minutes.

4.3.3.1.2 Decrease the inlet pressure to 5.0±2.0 psig GN_2. Monitor and record leakage for a minimum of 3.0 minutes.

4.3.3.2 Reverse Leakage

Apply a pressure of 15.0±1.0 psig GN_2 to the valve outlet. Monitor leakage for a minimum of 6.0 minutes (less if burette range is exceeded) and record the results, in cc/min.

Repeat reverse leakage measurements at pressures as requested by the cognizant engineer.

A NOTE: Reverse leakage shall not be performed after final cleaning.

4.3.4 Dielectric Strength

Using a Hipot, apply 600 ± 60 volts AC at 60 Hz across the test points of Table II. Duration shall be 60 seconds for each test setup.

4.3.5 Insulation Resistance

Using a megger, apply 500±50 volts DC across the test points of Table II until resistance stabilizes or 2 minutes, whichever occurs first.

TABLE II

DIELECTRIC STRENGTH & INSULATION RESISTANCE TEST COMBINATIONS

Setup	Component to Component		Pin Letter to Pin Letter		Lead Color to Lead Color	
a	Closing Coil	Body	D & J	E	R & W ①	Y
b	Opening Coil	Body	B & C	E	O & Blk	Y
c	Switch	Body	A & F & G	E	Brn & Grn & Gry	Y
d	Closing Coil	Opening Coil	D & J	B & C	R & W	O & Blk
e	Closing Coil	Switch	D & J	A & F & G	R & W	Brn & Grn & Gry
f	Opening Coil	Switch	B & C	A & F & G	O & Blk	Brn & Grn & Gry

NOTES: ① & denotes joined or twisted leads

4.3.6 Minimum Operating Voltages Flowing GN_2

Valve actuations, flowing GN_2, shall be minimized.

4.3.6.1 Opening Voltage

The valve outlet shall be closed off with a cap having an 0.015 diameter hole. The nonflowing inlet pressure shall be set at 450±10 psig GN_2. Starting at 10 vdc, voltage to the opening coil will be slowly increased and the coil amperage, to two decimal places, at the moment of valve opening, recorded. Switch valve voltage off. Check continuity between leads Gry & Grn to confirm that position switch is signaling valve open. Calculate the opening voltage at room temperature from,

A

Opening Voltage = Opening Current (measured) x Coil Resistance (at 68°F).

4.3.6.2 Closing Voltage

The GN_2 inlet pressure shall be set at 0 psig. Valve voltage to the closing coil will be slowly increased from 10 vdc, and coil amperage, to two decimal places, at the moment of valve closing, recorded. Switch valve voltage off. Check continuity between leads Grn & Brn to confirm that position switch is signaling valve closed. Calculate the equivalent closing voltage at room temperature from,

A

Closing Voltage = Closing Current (measured) x Coil Resistance (at 68°F).

4.3.7 Valve Response Flowing GN_2

Valve actuations, flowing GN_2, shall be minimized.

4.3.7.1 Opening Response

The valve outlet shall be capped per 4.3.6.1. With the nonflowing inlet pressure set at 450±10 psig, the valve opening coil shall be sequentially energized for 100 msec at 20 ± 0.5 vdc and 28 ± 0.5 vdc. Valve opening response for each voltage, shall be measured from the Polaroid photos taken of the oscilloscope traces.

A

4.3.7.2 Closing Response

With the valve opened per 4.3.7.1, the inlet pressure shall be recorded. The valve shall be closed by energizing the closing coil for 100 msec at 20±0.5 and 28 ±0.5 vdc Valve closing responses for each voltage shall be measured from Polaroid photos taken of the oscilloscope traces.

4.3.8 Minimum Operating Voltages Flowing Water

4.3.8.1 Opening Voltage

Procedures for measuring opening voltage flowing water shall be the same as those for paragraph 4.3.6.1, except that the inlet water pressure shall be set at 450±10 psig water and a throttling valve shall be installed at the valve outlet in place of the cap. This throttling valve shall be set for a flow rate of 1.12 lbs/sec.

4.3.8.2 Closing Voltage

This test shall be performed using the procedures of paragraph 4.3.6.2, except that the water flow rate shall be adjusted to 1.12 pps H_2O.

4.3.9 Valve Response Flowing H_2O

4.3.9.1 Opening Response

This test shall be performed in the same manner as that for paragraph 4.3.7.1, except inlet pressure shall be set at 450±10 psig H_2O and the flow rate through the valve shall be set to 1.12 lbs/sec.

4.3.9.2 Closing Response

This test shall be performed using the same setup as paragraph 4.3.7.2, except that the water flow rate shall be adjusted to 1.12 pps.

4.3.10 COIL RESISTANCES

A tape-on or similar surface type thermocouple shall be attached to the outside of the coil cover. The valve shall be permitted to temperature stabilize on a thermally insulated surface and in a temperature controlled area for at least 1.0 hour.

The coil resistances shall be measured to two decimal places corrected to an equivalent resistance at 68°F by the expression:

$$R_{68} = \frac{R_T}{[1 + .00218\ (T - 68)]}$$

where R_{68} = resistance at 68°F (calculated)

R_T = resistance at stabilized temperature (measured)

T = coil temperature from surface thermocouple (measured)

4.3.11 Pressure Drop

Pressure drop shall be measured across the valve at H_2O flow rates of .84, 1.12 and 1.40 pps.

5.0 DISASSEMBLY AND INSPECTION

The valve shall be disassembled and inspected for signs of damage, corrosion or evidence of any characteristics which would preclude proper operation of the valve. Of particular interest will be the hard seat and poppet surfaces which will be microscopically examined. Photographic documentation will be made as requested by the cognizant Development Engineer.

6.0 FINAL CLEANING

A Final cleaning of the valve components will be performed by an outside cleaning source to meet the requirements of TMC Cleaning Specification MPS 210.

7.0 PREPARATION FOR SHIPMENT

The valve shall be prepared for shipment per the requirements of JPL Specification SS80-PD-103.

TABLE III

LF_2 LATCH VALVE ACCEPTANCE TEST

DATA SHEET

Valve P/N ____________________ Tested Per MTS ____________________

S/N ____________________ Total Actuations, this page ____________

Engr ____________________ Tech ____________________ Date ____________

Test Para (Ref)	Test Parameter	Units	Required	Measured
4.1	Visual Examination			
	1. Workmanship	N.A.	Acceptable	______
	2. Nameplate	N.A.	Complete	______
4.2	Weight	pounds	5.0 Max	______
4.3.1	Proof Pressure 900 psig H_2O for 5 seconds	N.A.	No physical degradation	______
4.3.2	External Leakage 450 psig GHe			
A	1. Mid Body to Inlet/Outlet Body Flange	scc/sec	$1x10^{-6}$ max	______
	2. Cover Plate Port	scc/sec	$1 x10^{-6}$ max	______
	3. Cover Plate Flange	scc/sec	$1x10^{-6}$ max	______
4.3.3	Internal Leakage 450 psig GN_2 for 6 minutes	cc/hr	10 max	______
	5 psig GN_2 for 6 minutes	cc/hr	10 max	______
	-15 psig GN_2	cc/hr	Info Only	______
	-______	cc/hr		______
	-______	cc/hr		______
4.3.4	Dielectric Strength 600 ± 60 Vac @ 60 Hz across the following leads:			
	a) Closing coil to body	microamps	<200	______
	b) Opening coil to body	microamps	<200	______
	c) Switch to body	microamps	<200	______
	d) Closing coil to opening coil	microamps	<200	______
	e) Closing coil to switch	microamps	<200	______
	f) Opening coil to switch	microamps	<200	______

TABLE III

LF_2 LATCH VALVE ACCEPTANCE TEST

DATA SHEET

Valve P/N ______________ Tested Per MTS ______________

S/N ______________ Total Actuations, this page ______________

Engr ______________ Tech ______________ Date ______________

Test Para (Ref)	Test Parameter	Units	Required	Measured
4.3.5	Insulation Resistance 500±50 Vdc across following leads:			
	a) Closing coil to body	ohms	$<100 \times 10^6$	______
	b) Opening coil to body	ohms	$<100 \times 10^6$	______
	c) Switch to body	ohms	$<100 \times 10^6$	______
	d) Closing coil to opening coil	ohms	$<100 \times 10^6$	______
	e) Closing coil to switch	ohms	$<100 \times 10^6$	______
	f) Opening coil to switch	ohms	$<100 \times 10^6$	______
4.3.6	Minimum Operating Voltages Flowing GN_2			
	Opening @ 450 psig	Vdc	Info Only	______
	Closing @ ___ psig	Vdc		______
4.3.7	Valve Response Flowing GN_2			
	@ 20 Vdc			
	Opening @ 450 psig	msecs	Info Only	______
	Closing @ ___ psig	msecs		______
	@ 28 Vdc			
	Opening @ 450 psig	msecs	Info Only	______
	Closing @ ___ psig	msecs		______
4.3.8	Minimum Operating Voltages Flowing Water			
	Opening @ 450 psig	Vdc	17 Max	______
	Closing @ 1.12 pps	Vdc	17 Max	______
4.3.9	Valve Response Flowing Water			
	@ 20 Vdc			
	Opening @ 450 psig	msec	30 Max	______
	Closing @ 1.12 pps	msec	30 Max	______
	@ 28 Vdc			
	Opening @ 450 psig	msec	30 Max	______
	Closing @ 1.12 pps	msec	30 Max	______

TABLE II

LF_2 LATCH VALVE ACCEPTANCE TEST

DATA SHEET

Valve P/N ____________________ Tested Per MTS ____________________

S/N ____________________ Total Actuations, this page ____________

Engr ____________________ Tech ________________ Date __________

	Test Para (Ref)	Test Parameter	Units	Required	Measured
	4.3.10	Coil Resistances			
A		Opening Coil @ 68°F	Ohms	12.5 ± 0.5	________
A		Closing Coil @ 68°F	Ohms	12.5 ± 0.5	________
	4.3.11	Pressure Drop			
		@ 0.84 pps water	psid	Info Only	________
		@ 1.12 pps water	psid	30 Max	________
		@ 1.40 pps water	psid	Info Only	________
	5.0	Disassembly and Inspection	N.A.	Per Para. 5.0	Results attached
A	6.0	Final Cleaning Performed by ________________	N.A.	Per TMC MPS 210	Results attached
A	4.6.2	External Leakage @ 450 psig GHe			
		1. Mid Body to Inlet/Outlet Body Flange Valve Configuration II	scc/sec	1×10^{-6} max	________
		2. Cover Plate Port Valve Configuration II	scc/sec	1×10^{-6} max	________
		3. Cover Plate Flange Valve Configuration III	scc/sec	1×10^{-6} max	________
		Final Test Flowing GN_2			
	4.3.6	Minimum Operating Voltages Flowing GN_2			
		Opening @ 450 psig	vdc	Info Only	________
		Closing @ ____ psig	vdc	Info Only	________

TABLE III

LF_2 LATCH VALVE ACCEPTANCE TEST

DATA SHEET

Valve P/N ____________________ Tested Per MTS ____________________

S/N ____________________ Total Actuations, this page ____________

Engr ____________________ Tech ____________________ Date ____________

Test Para (Ref)	Test Parameter	Units	Required	Measured
4.3.7	Valve Response Flowing GN_2			
	@ 20 Vdc			
A	Opening @ 450 psig	msec	Info Only	______
	Closing @ ______psig	msec	Info Only	______
	@ 28 Vdc			
	Opening @ 450 psig	msecs	Info Only	______
	Closing @ ___ psig	msecs		______
4.3.3	Internal Leakage			
	450 psig GN_2 for 6 minutes	cc/hr	10. max.	______
A	5 psig GN_2 for 6 minutes	cc/hr	10. max.	______
A				
4.0	Total valve actuations this test	cycles	Info Only	______