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Engineering Report No. 3620

Final Report

Contract Title: Design, Fabrication and Testing of a
Destratification Motor-Impeller Unit

Administrator: NASA, Manned Spacecraft Center
General Research Procurement Branch

Contract: NAS9-7770

February 15, 1969

FACILITY FORM 602

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FACILITY FORM 602

Pesco Products

DIVISION OF BORG-WARNER CORPORATION



ENGINEERING REPORT NO. 3620

FINAL REPORT

CONTRACT TITLE: DESIGN, FABRICATION AND TESTING OF A
DESTRATIFICATION MOTOR-IMPELLER UNIT

ADMINISTRATOR: NASA, MANNED SPACECRAFT CENTER
GENERAL RESEARCH PROCUREMENT BRANCH

CONTRACT: NAS9-7770

February 15, 1969

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SECTION 1.0

INTRODUCTION

This document constitutes the final report covering the work accomplished by Pesco Products, division of Borg-Warner Corporation, under contract NAS 9-7770 for the design, fabrication and testing of a destratification motor-impeller unit.

The contract period, which officially began 5 March 1968 and was originally scheduled to extend through 12 August 1968, was modified several times by changes in scope.

The motor-impeller unit is basically an ac induction motor driving a high specific speed impeller. Fluid flow enters the unit axially, and is discharged radially through slotted ports. The synchronous speed of the 8-pole motor is 6000 rpm when operating with an input frequency of 400 Hz and a line-to-line potential of 208 v rms.

Major among the design objectives for the motor-impeller unit are high reliability, long operational life, propellant compatibility, and maximum output flow. Additionally, the unit is required to function satisfactorily in the liquid and gas phases of oxygen, hydrogen and nitrogen.

Design verification and life tests were conducted to demonstrate compliance with the design objectives. These tests were divided into three major groups, each of which was to prove an individual, but not necessarily exclusive, portion of the over-all design concept. First, the oxygen exposure tests were run. This series showed unit compatibility with a 900 psia oxygen gas atmosphere. A calibration test sequence was conducted in oxygen and hydrogen with unit pressure rise and output flow measured in both the gas and liquid phases. Maximum output flow rate achieved was 115% of the 1.3 cfm design objective in liquid oxygen and over 150% of the liquid hydrogen requirement. Life tests to demonstrate high reliability and extended running capability were the final tests conducted. Three units, one each in hydrogen, oxygen, and nitrogen, successfully completed 225 hours of life testing. Included in this test was a start/stop cycle which was timed such that 4500 cycles were accomplished during each 225 hour life test. The test program was completed without incident and all design objectives were satisfied.

SECTION 2.0

SUMMARY AND CONCLUSIONS

2.1 Contract History

During the course of the program, several significant changes in the contract were made. Modification 1 dated 25 March 1968 entailed a slight reduction in motor-impeller outside diameter, relocation of the motor lead-in wires, and relocation of motor mounting holes. This modification required a 3-1/2 week schedule extension.

On 9 April 1968, NASA RFP No. BG721-8-8-477P was received at Pesco. This resulted in a contract change, Modification 2, which increased the total units built from four (4) to nine (9). Contract end date was extended to 5 October 1968.

Modification 3 extended the program end date from 5 October to 25 November 1968, and provided for delivery to the Manned Spacecraft Center of a motor-impeller test unit.

The final contract adjustment, Modification 4, expanded the life testing plan to include an additional specimen run in liquid nitrogen. The contract period was extended to 15 February 1969.

2.2 Test History

Testing on development motor-impeller units was accomplished as follows:

<u>Start Date</u>	<u>End Date</u>	<u>Unit Serial No.</u>	<u>Type Test</u>	<u>Applicable Document</u>
9-26-68	10-4-68	X2132	Oxygen Exposure	TR686
10-14-68	11-26-68	X2132	Calibration Tests	TR686
11-19-68	11-19-68	X2133	Electrical Tests	TR686
12-17-68	1-14-69	X2133	Oxygen Life Tests	TR686
1-6-69	2-11-69	X2139	Hydrogen Life Test	TR686
1-21-69	2-6-69	X2138	Nitrogen Life Test	TR686

2.3 Conclusion

The success of the destratification motor-impeller unit program is best demonstrated in terms of specific objectives accomplished. Oxygen compatibility was demonstrated by the testing conducted in high pressure gas. Data and supporting remarks covering the portion of the program are included in 4.1 of this report. Achievement of a unit output flow exceeding 1.3 cfm in any required pumped fluid was realized, and is shown graphically in Section 4.2. Life testing, the final phase within the scope of the program, was completed without incident. A total of almost 700 hours running and 13,500 start/stop cycles on three identical units, each operating in a different fluid, clearly demonstrate high reliability and extended operational life. Supporting data for the life tests are included in Section 4.3.

Since all of the specified design and test objectives are now satisfactorily accomplished, it is concluded that the destratification motor-impeller unit, Pesco Model 145204-100, is now fully developed and the over-all program under Contract NAS9-7770 was satisfactory.

SECTION 3.0

DESIGN

3.1 Motor

The motor designed and built for this application is a three phase, 8 pole squirrel cage induction machine with a nominal rating of 0.006 horsepower at 5700 rpm - 115/200 volts ac (normal ambient conditions). The materials and assembly techniques used were the result of previous experience in similar applications blended with new innovations developed during a recent study contract for NASA (Ref. Contract No. NAS 9-4923).

The insulation system chosen was based on its thermal integrity at normal ambient conditions and its mechanical stability at cryogenic temperatures. The main ingredient in the system is a polyimide (du Pont ML) insulating varnish whose characteristics have been proven from plus 300° C down to the extreme cryogenic temperatures.

Standard silicone steel laminations (AISI Grade M-19) were optimized around the performance requirement of this application.

The conductors in the stator winding are standard copper wire (IACS-100% conductivity). In order to provide sufficient starting torque at cryogenic temperatures, a material with a higher resistivity than copper must be used in the rotor. A copper alloy per ASTM B-134 (Alloy No. 1 - 95% Cu. -5% ZN) has been successfully used in similar applications and, therefore, became the material designation for both rotor bar and end rings.

The motor performance at room conditions is shown in Section 4.2.

A complete list of the materials used in the motor is contained in Section 3.3.

3.2 Bearings

During February 1968 an Engineering Design Specification, EDS-357 previously submitted, covering the motor-impeller unit ball bearing application was written and sent to approved vendors. The specification defines mounting arrangement, speed, loading, and environmental requirements particular to the subject unit.

Two suppliers responded knowledgeably to this rather unique request and it is not surprising that their design approaches are similar. Both vendors specified an ABEC-7P tolerance ball bearing using 440C stainless steel balls and rings, and a 5813 Duroid ball separator. Additionally, the trade named separator material in both cases was impregnated with moly-disulfide.

Although the majority of our experience with "dry" bearing operation was gained using Barden "Bar-Temp" bearings, the Miniature Precision Bearing Inc. quotation was accepted since it offered some additional features. MPB's bearing, besides using moly-disulfide, employs a modified tungsten-disulfide coating permanently bonded to the balls and rings. This dry film lubricant allows for slightly higher axial preloads and, therefore, increases bearing life since ball sliding at start is minimized. The greater cooling flow through the MPB bearing is another significant factor. MPB's "open cage" concept, which uses no shielding, provides approximately 50% greater flow area through the bearings.

Results of our test program, which was accomplished without incident, clearly demonstrate successful bearing operation.

3.3 Materials

Material selection for all components of the motor-impeller unit was accomplished using the following documents for reference:

Compatibility of Materials with Liquid Oxygen, NASA Technical Memo, NASA TM X-985 dated August 1964.

Compatibility of Materials with Liquid Oxygen, NASA Technical Memo, NASA TM X-53052 dated May 1964.

Compatability of Materials with Liquid Oxygen, III, NASA
 Technical Memo, NASA TM X-53533 dated November 1966.

The following is a complete listing of the materials used in construction of the motor-impeller unit. A unit assembly drawing number 145204-100 is provided as Figure 8. This will serve as a cross reference for the following list.

3.3.1 Material List

<u>Part No.</u>	<u>Name</u>	<u>Material</u>
14-550	Shroud, Impeller	Steel, Cres, per QQ-S-763 Class 304L, Cond. A
14-551	Washer, Flat	Steel, Cres, per QQ-S-763 Class 304L, Cond. A
14-552	Sleeve, Bearing	Steel, Cres, per QQ-S-763 Class 440C, Cond. A
14-553	Sleeve, Bearing	Steel, Cres, per QQ-S-763 Class 440C, Cond. A
14-554	Set Screw	Steel, Cres, per AMS 5735
14-555-02 through 05	Shim	Sheet Aluminum per QQ-A-250/1 (1100) Temper 0
14-557	Spacer, Impeller	Steel, Cres, per QQ-S-763 Class 304L, Cond. A
14-558	Impeller	Steel, Cres, per QQ-S-763 Class 304L, Cond. A
14-559	Cover, Impeller	Steel, Cres, per QQ-S-763 Class 304L, Cond. A
14-560	Sleeve, Thrust Bearing	Steel, Cres, per QQ-S-763 Class 304L, Cond. A

<u>Part No.</u>	<u>Name</u>	<u>Material</u>
21-1215	Lamination, Stator	Steel, Silicon, per AISI type M-19
21-1217	Lamination, Rotor	Steel, Silicon, per AISI type M-19
21-1218	End Ring, Rotor	Copper Alloy, per ASTM B-134, Alloy No. 1
21-1219	Bar, Rotor	Copper Alloy, per ASTM B-134, Alloy No. 1
21-1221	Bearing, Ball	Steel, Cres per QQ-S-763 Class 440C Balls and Rings. Separator Duroid 5813
21-1222	Insulator, Slot	Glass Fabric, Polyimide Impregnated
21-1223	Top Wedge (Flexible)	Glass Fabric, Polyimide Impregnated
21-1224	Top Wedge	Glass Laminate, Teflon Impregnated
21-1227	Shaft, Shouldered	Nickel per MIL-N-8550, Cond. E
22-6404-26	Wire, Lead-in	Copper, Silver Plated, Insulation, Extruded Teflon
22-7020	Brazing Compound	Silfos Powder: 15% silver, 20% 20% copper, 5% phosphorous
22-7-44	Varnish	Polyimide, Pyre ML
22-7053-390	Wire, Magnet	Copper, IACS 100% Conductivity
22-7064	Thinner	duPont T-8585
22-7067-12	Insulation, Sleeving	Teflon, Extruded

<u>Part No.</u>	<u>Name</u>	<u>Material</u>
22-7067-22	Insulation, Sleeving	Polytetrafluorethylene (Modified)
22-7067-30	Insulation, Sleeving	Polytetrafluorethylene (Modified)
22-7069-12	Insulation, Tubing	Polytetrafluorethylene (Modified)
22-7082	Separator, Coil	Teflon, Type H Film (Fused and Treated)
22-7083	Tape, Lacing	Teflon, Type H Film (Fused and Treated)
22-7084	Cord, Banding	Teflon
99-4224-2	Screw, Cap	Steel, Cres, Class A-286
99-4224-4	Screw, Cap	Steel, Cres, Class A-286
99-4326	Grease, Anti-galling	"Krytox" 240AC Fluorinated Grease, Batch Tested for Impact Sensitivity
99-4784	Spring, Bearing Preload	Steel, Cres per QQ-W-423 Class 302, Cond. B
114-467	Cover Assembly, Motor	Steel, Cres per QQ-S-763 Class 304L, Cond. A
114-468	Housing Ass'y., Pump	Steel, Cres per QQ-S-763 Class 304L, Cond. A
114-469	Nut, Assembly	Steel, Cres per QQ-S-763 Class 304L, Cond. A
MS21209C0415	Insert, Screw Thread	Steel, Cres Class 302, Cond. B
NAS1291C06	Nut, Self-locking	Steel, Cres Class A-286 (Silver Plated)

SECTION 4.0

TEST RESULTS AND DISCUSSION

4.1 Oxygen Exposure Tests

Oxygen exposure tests, conducted per TR686, paragraph 5.0, were completed on 4 October 1968. This testing was divided into two parts: operational running first and then locked rotor tests, both of which were run in oxygen gas at 900 psia and 90°F. The test set up for all tests was per Figure 1.

4.1.1 Operational Testing

Using the design verification unit, Serial Number X2132, a series of tests were made at various fixture pressures and in nitrogen as well as oxygen gas. The following test data and curve clearly indicate the unit's ability to operate in the specified fluid conditions.

4.1.2 Locked Rotor Testing

Unit Serial Number X2132 was subjected to a locked rotor test while exposed to oxygen gas at 900 psia and approximately 90°F. Test data and a curve depicting motor winding temperature and current versus time immediately follow this discussion.

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test Oxygen Exposure

Reference Test Request 686

Test Engineer _____ Date 9/27/68
Test Cell B2-3 Run No. 2 Bar. Press. 29.37 " Hg
Test Unit Model No. 145204-100 Serial No. X-2132

Power : 3 phase sine wave
Pump Fluid G-O₂ Aux**Drive
Run Time 2 Hr. 3 Min. 888
min

Test Unit Description Destratification Unit

Purpose To determine compatability of unit in high pressure oxygen.

Comments Phase "A" was run to paragraph 5.1 of T.R. 686. This phase was run with the test fixture pressurized to 10 PSIG with G-O₂. Run time was 34 minutes.

Phase "B" was run with the test fixture pressurized to 435 PSIG with G-O₂. Run time was 31 minutes.

Phase "C" was run with the test fixture pressurized to 885 PSIG with G-O₂. Run time was 28 minutes.

Prior to phase "A" the unit was run with the test fixture pressurized to 750 PSIG with G-N₂. This run was made to check T/C's. Run time was 30 minutes.

G. M. M. M.
10-1-68



27/68

UNIT SER. No. X-2132
MODEL No. 145204-100

~~WELDOUT FRAME~~ 2

LTR No. 686
PARA. 5.0

Page 4.4

A-7	B-1	B-2	B-3	B-4	B-5	B-6	B-7		
5950	5920	5920	5920	5930	5930	5930	5930		
10	433	436	434	433	428	433	429		
163	83	82	82	83	87	92	92		
87	77	75	74	75	80	86	86		
76	6	7	8	8	7	6	6		
91.0	92.0	93.1	93.5	94.0	93.2	93.0	92.8		
90.0	91.5	92.5	93.0	93.0	92.5	92.0	92.0		
90.0	91.5	92.5	93.0	93.2	92.5	92.0	92.0		
5.36	5.03	5.14	5.15	5.17	5.20	5.15	5.15		
5.35	5.00	5.10	5.10	5.15	5.12	5.12	5.10		
5.25	4.97	5.07	5.10	5.12	5.08	5.10	5.08		
120	118	120	120	120	120	120	120		
120	118	120	120	120	120	120	120		
120	118	120	120	120	120	120	120		
400	400	400	400	400	400	400	400		

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test Oxygen Exposure Test

Reference Test Request 686

Test Engineer B.Milota Date 10/1/68
Test Cell B2-3 Run No. 3 Bar. Press. 29.40 "Hg
Test Unit Model No. 145204-100 Serial No. X-2132

Power : 3 phase sine wave
Pump Fluid G-O₂ ~~Aux*Drive~~
Run Time 68 Min. ~~68~~
Min

Test Unit Description Destratification Unit

Purpose To determine compatability of unit in high pressure oxygen.

Comments The gas temperature probe was changed and a T/C was added to the motor skin.

Phase "A" was run to paragraph 5.1 of T.R. 686. This phase was run with the test fixture pressurized to 20 PSIG with G-O₂. Run time was 45 minutes.

Phase "B" was run with the test fixture pressurized to 885 PSIG with G-O₂. Run time was 21 minutes.

Prior to phase "A" a systems check was made to verify unit rotation & speed indication. Run time was 2 minutes.

B. Milota
10-2-68

TEST PHASE		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8
TIME OF DAY		1420	1425	1430	1435	1440	1445	1450	1455
UNIT SPEED	RPM	5960	5960	5960	5960	5960	5950	5950	5950
FIXTURE GAS									
PRESS.	PSIG	22	21	20	20	18	17	16	15
MOTOR WINDING Temp	°F	97	127	143	153	160	166	170	173
FIXTURE GAS Temp	°F	87	88	89	91	92	92	93	93
WINDING TO FIXTURE									
AMBIENT T Temp	°F	10	39	54	62	68	74	77	80
CURRENT									
Phase A	ma	93.5	93.0	92.2	91.9	---	92.0	91.0	90.0
Phase B	ma	92.8	92.0	91.3	91.2	---	91.5	90.2	90.0
Phase C	ma	92.8	92.0	91.3	91.2	---	91.5	90.1	89.0
POWER									
Phase A	Watts	5.18	5.27	5.34	5.36	---	5.47	5.39	5.30
Phase B	Watts	5.14	5.23	5.31	5.33	---	5.43	5.33	5.30
Phase C	Watts	5.15	5.22	5.29	5.34	---	5.41	5.35	5.30
VOLTAGE L-N									
Phase A		120	120	120	121	---	121	120	120
Phase B		118	120	121	122	---	121	120	120
Phase C		120	120	121	122	---	121	120	120
FREQUENCY	CPS	400	400	400	400	400	400	400	400
FOLDOUT FRAME									

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test Oxygen Exposure & L.R.T.

Reference Test Request 686

Test Engineer B. Milota Date 10/4/68
Test Cell B2-3- Run No. 4 Bar. Press. 29.30 "Hg
Test Unit Model No. 145204-100 Serial No. X-2132

Power : 3 phase sine wave
Pump Fluid G-O₂ Aux**Drive*
Run Time 15 Min. *Sec
Min*

Test Unit Description De-stratification Unit

Purpose To determine compatability of unit in high pressure oxygen.

Comments Phase "A" was run to paragraph 5.1 of T.R. 686 with the test fixture pressurized to 200 PSIG with G-O₂. Run time was 15 minutes.

After phase "A" the test fixture was purged with G-N₂ and the locking fixture installed.

The test fixture was then re-assembled, purged with G-N₂ & G-O₂ and pressurized to 885 PSIG. Run time was 6 minutes 25 seconds for the locked rotor test.

B. Milota
10-9-68

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Pesco Products

DIVISION OF BORG WARNER CORPORATION

CRYOGENIC LABORATORY

TEST LOG SH

Senior Tech BERNARD F. MIYOTA F.

DESTRATIFICATION Unit

Test Cell Ambient Temp. 70°F

LTR. No. 686

Baro. Press. 29.20 Hg. 14.34 PSIA

Aux. Drive _____

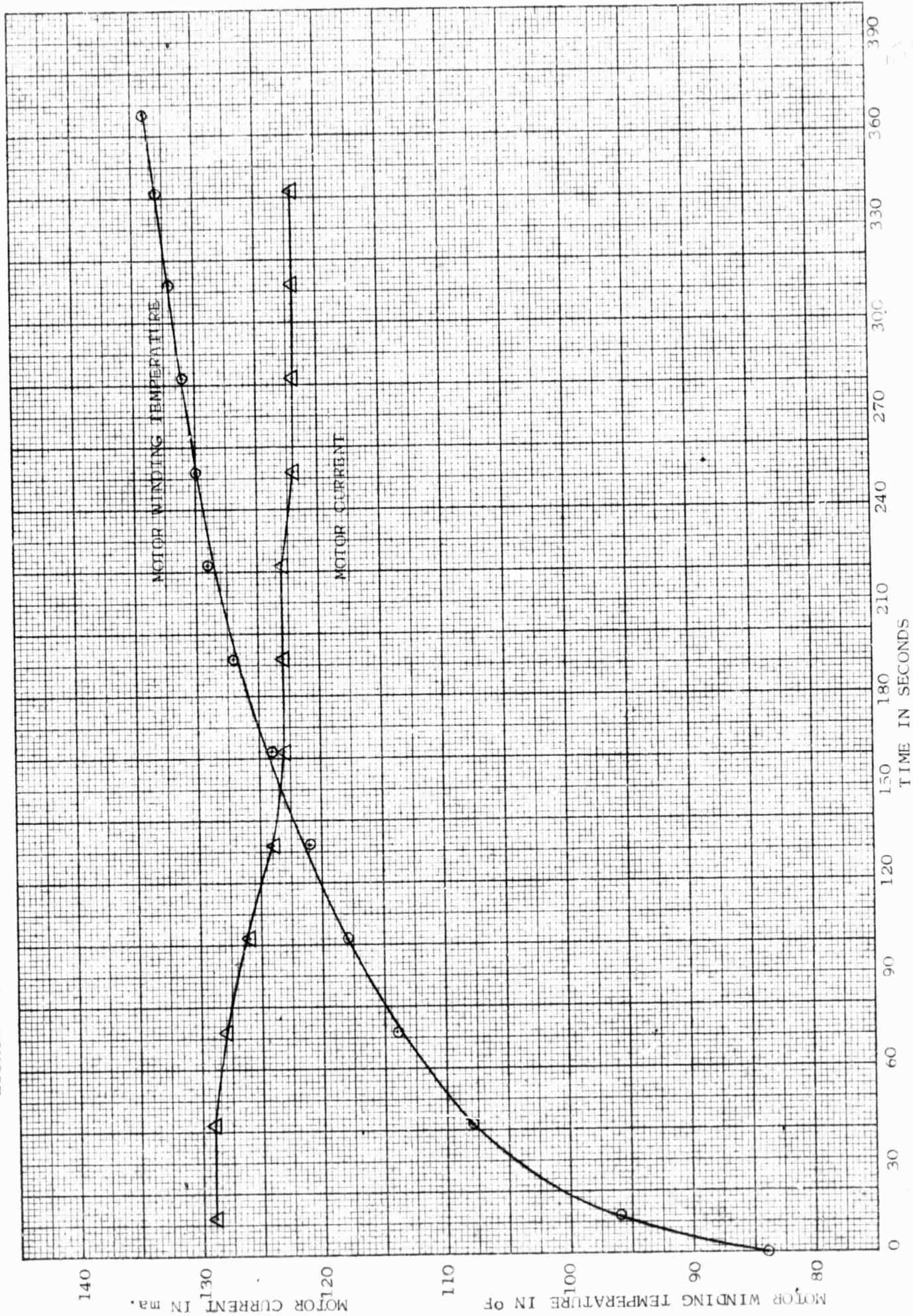
Total Run Time 15 MIN.

Time	Sequence of Events
1412	PURGE HIGH PRESS FIXTURE WITH G-N ₂
1417	PURGE HIGH PRESS FIXTURE WITH G-O ₂
1420	PRESSURIZE TEST FIXTURE TO 200 PSIG WITH G-O ₂
1445	START RUN A
1500	STOP RUN A RUN-TIME 15 MIN.
1501	VENT TEST FIXTURE
1502	PURGE HIGH PRESS FIXTURE WITH G-N ₂
1505	INSTALL LOCKING FIXTURE
1515	RE-ASSEMBLE TEST FIXTURE & PURGE WITH G-N ₂
1520	PURGE TEST FIXTURE WITH G-O ₂ & PRESSURIZE TO 885 PSIG
1544	START LRT
1550	STOP LRT RUN TIME 6 MIN. 25 SEC.
1552	VENT SYSTEM & PURGE WITH G-N ₂
1600	SECURE TEST SYSTEM.

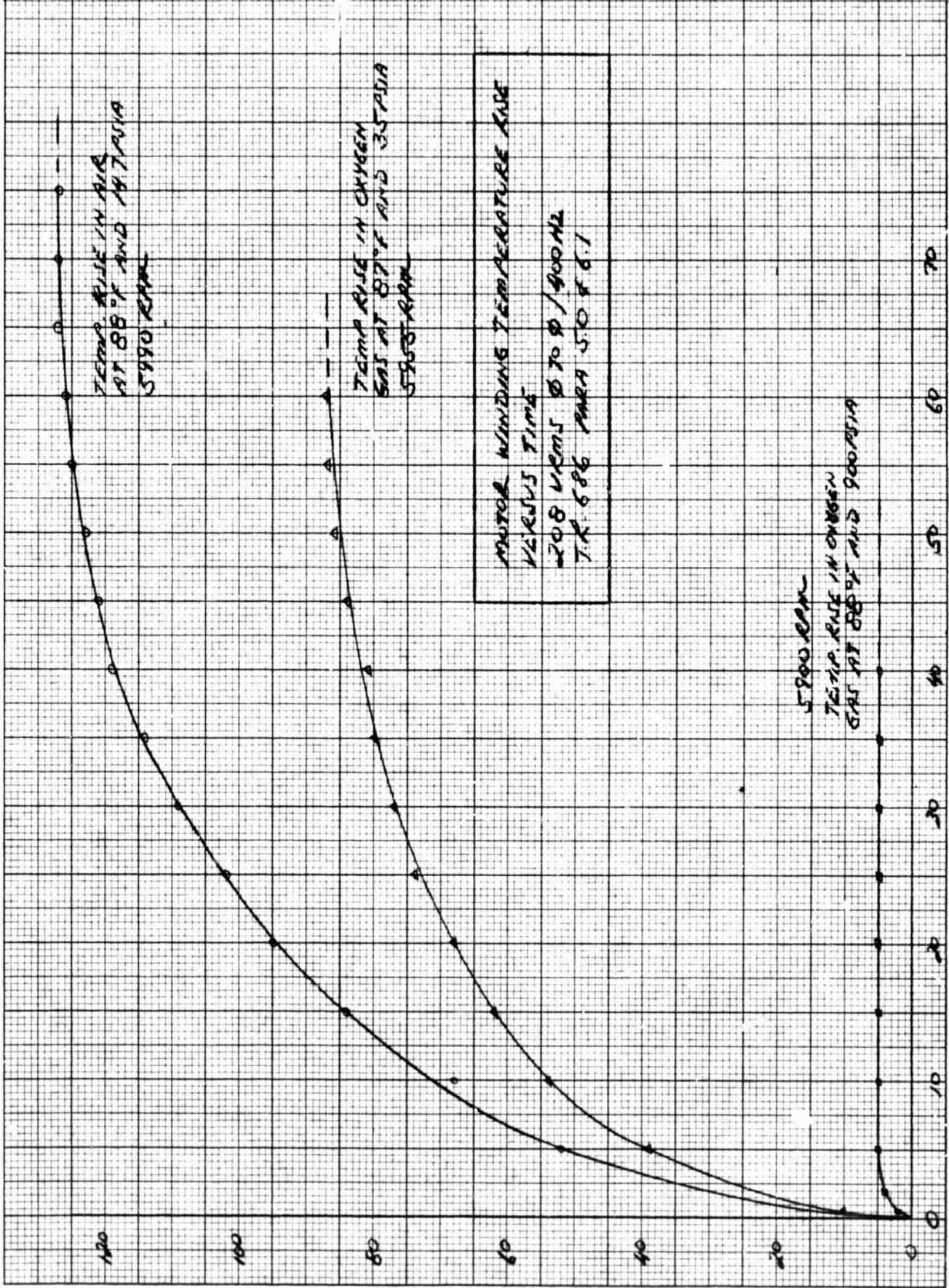
FOLDOUT FRAME /

Total Accu

Locked Rotor Test 22-3-4 Ser. No. X-2132 10/4/68 LTR No. 686 Para. 5.1



ENGINEER **HAMM** **BURG WARNER** Pasco Products DIVISION OF BORG WARNER CORPORATION 14300 N. MILES ROAD, REDDING, OREGON
 TITLE **MOTOR IMPELLER UNIT SN# 21323** MODEL **145204-100**
 DATE OF TEST



MOTOR WINDING TEMP. RISE - °F

TIME AFTER START - MIN.

4.2 Design Verification Tests

Design verification tests were begun on 14 October 1968. These tests are divided into two categories: Motor Test and Calibration Tests. Life testing will be discussed in the next section (4.3) as a separate topic.

4.2.1 Motor Tests

In addition to the insulation resistance, dielectric strength and winding resistance tests, which were run on all units built, unit Serial Number X2133 was subjected to the motor performance and saturation tests described in Section 6.1 of TR686. This document is included in this report as Appendix I. Tabulated test data and the composite curve generated are included at the end of this section.

4.2.2 Calibration Tests

The design verification unit Serial Number X2132 satisfactorily completed all calibration tests outlined in Section 6.2 of the subject test procedure TR686. In all cases, fluid flow was measured using a calibrated venturi. A typical calibration test set up is shown schematically as Figure 2. Photographs of this system are included as Figures 3 and 4. Figure 3 shows the entire test assembly prior to installation in the dewar. An exploded view of this assembly which illustrates unit installation is shown as Figure 4. These calibration tests are best discussed in relation to the fluids used.

During the first liquid oxygen calibration difficulty was experienced in establishing stable data points. The test system was subsequently modified. This change, although not entirely eliminating the problem, substantially reduced instrument line percolation and allowed for more stable test data. Although data point scatter precludes drawing a fixed head versus capacity curve, sufficient extra points were taken to assure accuracy.

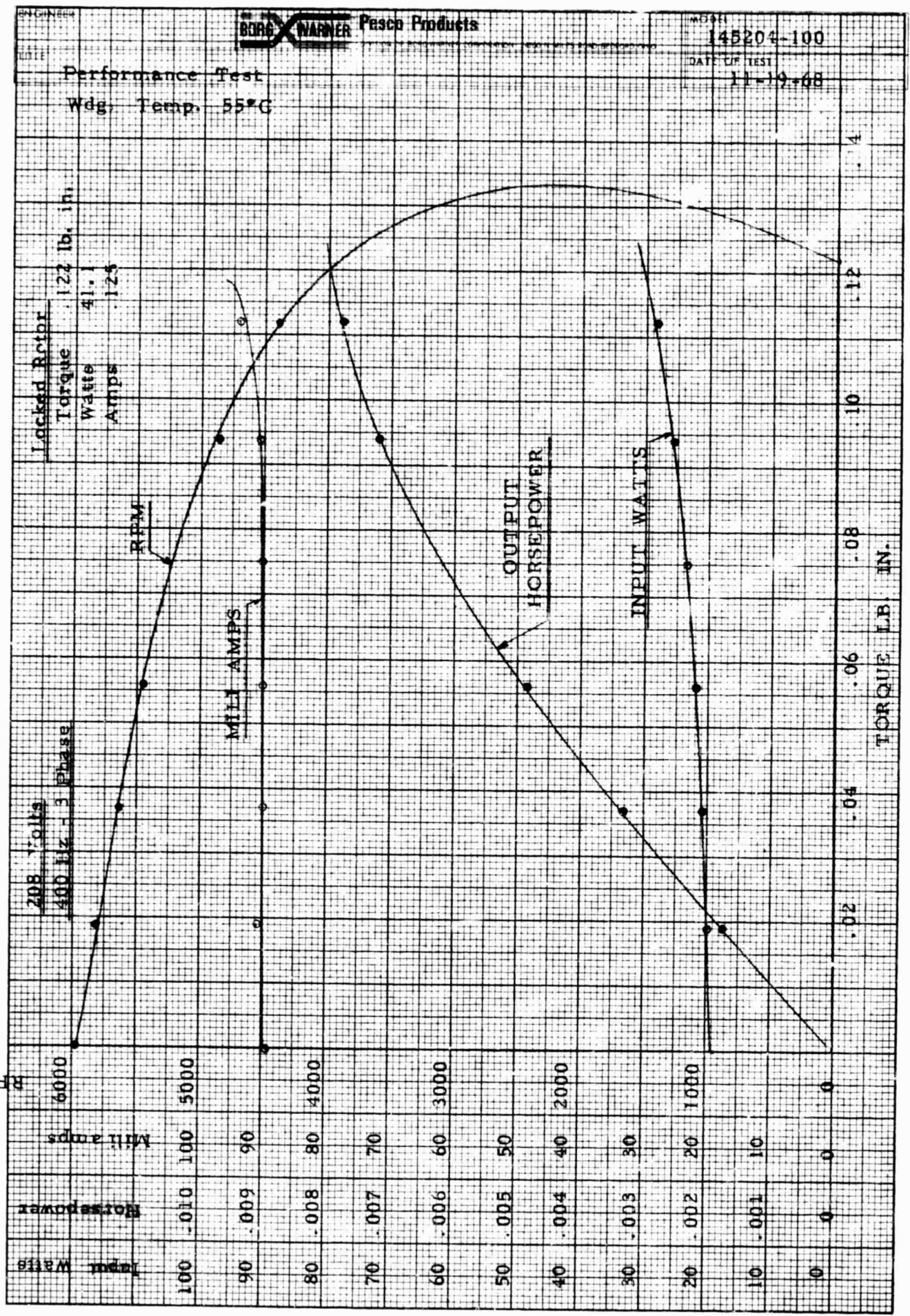
Hydrogen calibrations were conducted in a manner similar to the oxygen tests. Data point scatter noted during these tests

has about the same magnitude as that shown in oxygen.

All gas phase calibrations were conducted using air as a pumped fluid. This method was found to be much more accurate than using either oxygen or hydrogen gas. The micro-manometers used to measure flow and unit differential pressure provided sufficient sensitivity and readability.

Complete calibration data and plots showing unit hydraulic performance are provided at the close of this section. Output flow exceeded 1.3 cfm in all fluids and at all fluid conditions.

K&E 10 X 10 TO 1/2 INCH 46 1322
7 X 10 INCHES
MADE IN U.S.A.
KEUFFEL & ESSER CO.



M-1637

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg Warner Corporation

Sheet ___ of ___

Type of Test Gaseous & Liquid Oxygen

Reference Test Request 686

Test Engineer B. Milota Date 10/23, 24/68
Test Cell B4-3 Run No. 11 & 12 Bar. Press. 29.14 "Hg
Test Unit Model No. 145204-100 Serial No. X-2132

Power : 3 phase sine wave

Pump Fluid G-O₂ & LO₂ ~~AM*** Drive~~
Run Time 73Min.45Sec./11Starts ~~8***~~

Test Unit Description Destratification Motor-Impeller

Purpose To verify design by testing in G-O₂ & LO₂.

Comments 10/23/68
Phase "A" was run in gaseous oxygen to paragraph 6.2.1 Run Time
was two minutes/ one start. No data.
Phase "B" run time was three minutes / one start. No data.

10/24/68
Phase "A" was a systems check. Run time four minutes / 1 start.
Phase "B" was run in gaseous O₂, no data, run time 3 min. / 1 start.
Phase "C" was run in gaseous O₂, no data, run time 5 min. / 1 start.
Phase "D" was run in gaseous O₂, no data, run time 1 min. / 1 start.
Phase "E" was run in gaseous O₂, no data, run time 2 min. / 1 start.
Phase "F" was run in gaseous O₂, no data, run time 1 min. / 1 start.
Phase "G" was a system check, run time 7 min. / 1 start.
Phase "H" was a pump calibration in LO₂, run time 45 min. / 1 start.
Phase "I" was run in gaseous O₂ after dumping LO₂, no data, run
time 10 sec. / 1 start.
Phase "J" , run time 15 sec. / 1 start, no data.
Phase "K" , run time 20 sec. / 1 start, no data.



B. Milota
12-9-68



Pesco Products

DIVISION OF BORG WARNER CORPORATION

CRYOGENIC LABORATORY

Senior Tech. BERNARD F. MUOTA F.

DESTABILIZATION MOTOR IMPEDER Unit S/N X-2132

Test Cell Ambient Temp. 70°F

LTR. No. 686 PARA. 6.2.1

Baro. Press. 29.14 Hg. 14.31 PSIA

GASEOUS & LIQUID OXYGEN TEST

Total Run Time 73 MIN 45 SEC.

DATE: 10-23 & 10-24-68

B4-3-11 & 12

GASEOUS & LIQUID OXYGEN

Time	Sequence of Events
10-23-68	
1452	START RUN A
1455	STOP RUN A RUN TIME 2 MIN. / 1 START
1458	START RUN B
1500	STOP RUN B RUN TIME 3 MIN / 1 START
1515	SECURE SYSTEM
10-24-68	EVACUATE Dewar
0910	PRESSURIZE Dewar TO 5 PSIG & VENT TO ONE ATMOSPHERE.
0917	START RUN A SYSTEM CHECK
0922	STOP RUN A RUN TIME 4 MIN / 1 START
0926	START RUN B IN GASEOUS OXYGEN
0929	STOP RUN B RUN TIME 3 MIN / 1 START (NO DATA)
1111	START RUN C IN GASEOUS OXYGEN
1116	STOP RUN C RUN TIME 5 MIN / 1 START (NO DATA)
1120	START RUN D IN GASEOUS OXYGEN HIGH SIDE OF MANOMETER DISCONNECTED
1121	STOP RUN D RUN TIME 1 MIN / 1 START (NO DATA)
1125	START RUN E IN GASEOUS OXYGEN
1127	STOP RUN E RUN TIME 2 MIN / 1 START
	HIGH SIDE OF 3" INCLINED MANOMETER LOWERED 1/2" (NO DATA)
1137	START RUN F IN GASEOUS OXYGEN (RECONNECT HIGH SIDE OF MANOMETER)
1139	STOP RUN F RUN TIME 1 MIN / 1 START (NO DATA)
1330	LOAD LIQUID OXYGEN
1427	START RUN G SYSTEM CHECK
1434	STOP RUN G RUN TIME 7 MIN / 1 START
1448	START RUN H PUMP CALIBRATION
1534	STOP RUN H RUN TIME 45 MIN / 1 START
1550	DUMP LIQUID OXYGEN
1615	START RUN I COLD OXYGEN GAS WITH MANOMETERS IN THE SYSTEM.
1616	STOP RUN I RUN TIME 10 SEC / 1 START (NO DATA)
1617	START RUN J
1618	STOP RUN J RUN TIME 15 SEC. / 1 START (NO DATA)
1619	START RUN K
1620	STOP RUN K RUN TIME 20 SEC. / 1 START (NO DATA)
1625	SECURE SYSTEM

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test Unit Calibration

Reference Test Request 686 Paragraph 6.2.1.

Test Engineer B. Milota Date 11/15/68
Test Cell B4-3 Run No. 18 Bar. Press. 29.13 "Hg
Test Unit Model No. 145204-100 Serial No. X-2132

Power : 3 phase sine wave

Pump Fluid Liquid Oxygen ~~xxxxxxx~~
Run Time 69 Min./2 starts ~~Sec~~
~~Min~~

Test Unit Description Destratification Motor-Impeller Unit

Purpose To verify design by testing in liquid oxygen

Comments Phase "A" was a unit calibration using 30" H₂O manometers to read venturi Δ P & pump Δ P. Pump Δ P readings were unstable. Run time was 25 minutes in one start.

Phase "B" was a unit calibration using a 30" manometer to read venturi Δ P, transducers were used to read pump Δ P. Run time was 44 minutes in one start.

Secured system at 1605 hours.

(140)

B. Milota
12-3-68

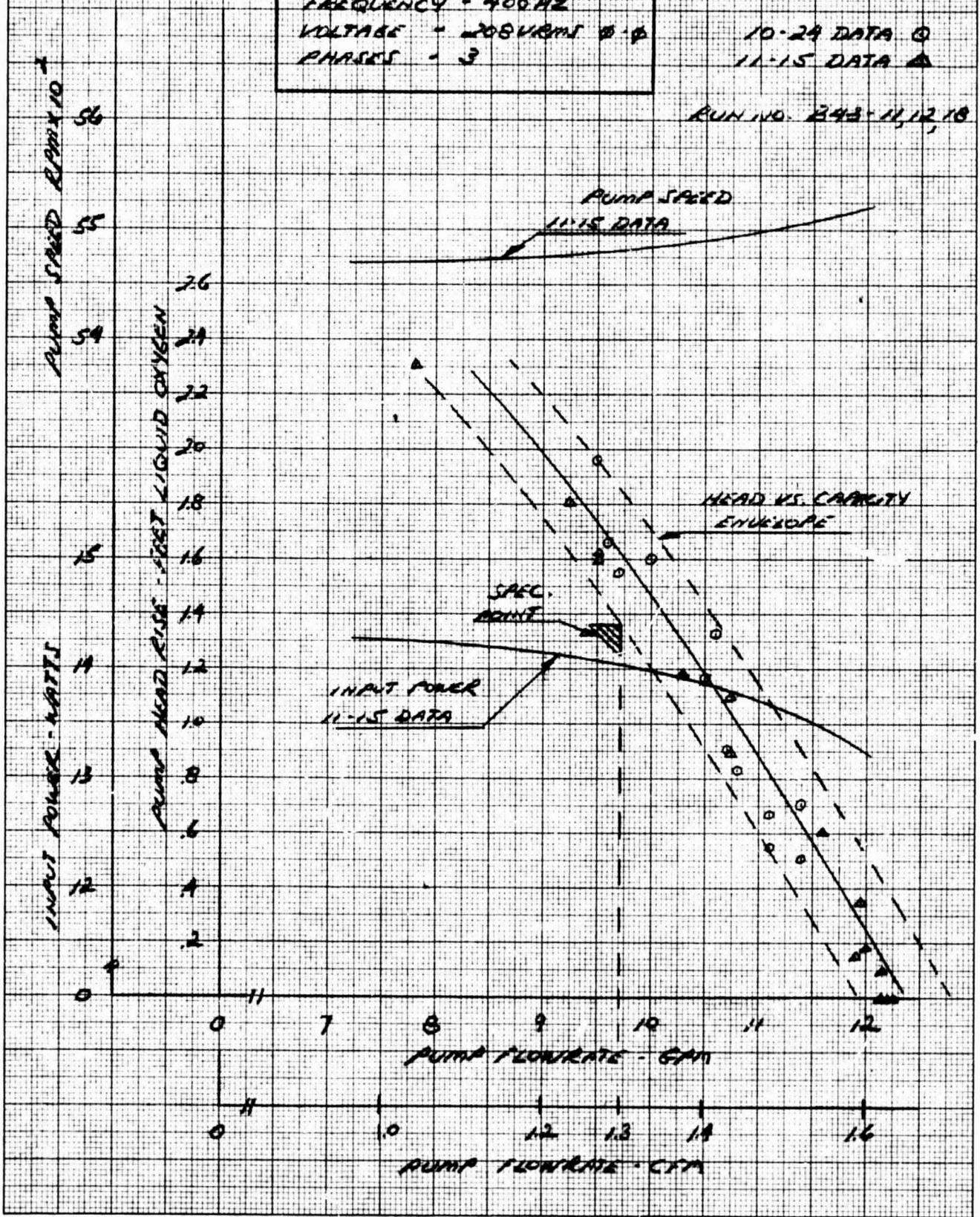
ENGINEER <i>J.R. Hamm</i>	PESCO PRODUCTS DIVISION BORG-WARNER CORP.	BEDFORD, OHIO	MODEL 145204-100
TITLE PUMP CALIBRATION IN LIQUID OXYGEN			DATE OF TEST 10-24-68 11-15-68

ELECTRICAL DATA
 FREQUENCY = 400 HZ
 VOLTAGE = 208 V RMS ϕ - ϕ
 PHASES = 3

UNIT $\frac{1}{2}$ " X 2132

10-24 DATA \odot
 11-15 DATA Δ

RUN NO. 243-11,12,18



TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test To Verify Design by Testing in LH₂

Reference Test Request 686 paragraph 6.2.2

Test Engineer B.Milota Date 11/6,7,11/68
Test Cell B5-4 Run No. 1,2,3 Bar. Press. As Noted "Hg
Test Unit Model No. 145204-100 Serial No. X-2132

Power : 3 phase sine wave

Pump Fluid Liquid Hydrogen ~~****Drive~~
Run Time 53 Min./8 Starts ~~***~~

Test Unit Description De-stratification Motor-Impeller Unit

Purpose To verify design by testing in liquid hydrogen.

Comments Phase "A,B,& C" was run on 11/6/68 and was a systems check with GH_e bubblers in venturi & pump ΔP system. Run time was 15 minutes / 3 starts.

11/7/68 Phase "A" was a systems check, 3 Min./1 Start, Barometer press. 29.14".
Phase "B" was a rotation check, 1 Min./1 Start.
Phase "C" was a pump calibration. Run time was 22 Min./1 Start.

11/11/68 Phases "A & B" were run in GH₂, 12 Min./2 Starts. There was no indicated change in pressure on the micro-manometers for venturi & pump ΔP. Barometer pressure 29.40".
Secured system.

B. Milota
12-6-68



Pesco Products

DIVISION OF BORG-WARNER CORPORATION 24700 N. MILES ROAD, BEDFORD, OHIO

CALIBRATION LIQUID HYDROGEN

TEST No. B5-4-2

11/7/68

TEST PHASE		C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8
UNIT SPEED	RPM	5950	5950	5950	5950	5950	5950	5950	5950
UNIT FLOW	GPM	14.6	14.4	13.9	13.4	12.7	12.0	10.4	15.0
UNIT FLOW	CFM	1.95	1.93	1.86	1.79	1.70	1.60	1.39	2.00
UNIT Δ P	PSI	.033	.034	.037	.039	.045	.048	.055	.030
UNIT Δ H	FT	1.06	1.09	1.19	1.26	1.45	1.56	1.77	1.00
MOTOR WINDING TEMP °F		-416	-415	-414	-413	-413	-412	-411	-410
CURRENT									
PHASE A	ma	105.0	104.8	104.8	104.8	104.8	104.8	104.8	104.8
PHASE B	ma	104.5	104.2	104.2	104.2	104.2	104.2	104.2	104.2
PHASE C	ma	104.8	104.6	104.6	104.6	104.7	104.5	104.2	104.2
POWER									
PHASE A	watts	.70	.73	.73	.70	.70	.70	.73	.73
PHASE B	watts	.65	.65	.65	.65	.65	.65	.65	.65
PHASE C	watts	.73	.73	.73	.73	.73	.73	.73	.73
VOLTAGE L-L									
PHASE A		208	207	207	207	207	207	207	207
PHASE B		208	207	207	207	207	207	207	207
PHASE C		208	207	207	207	207	207	207	207
FREQUENCY	CPS	400	400	400	400	400	400	400	400
FLUID INLET TEMP. °F		-423	-423	-423	-423	-423	-423	-423	-423
DEWAR PRESS.	PSIA	14.31	14.31	14.31	14.31	14.31	14.31	14.31	14.31
LIQUID ABOVE INLET IN.		16.0	15.9	15.8	15.7	15.6	15.4	15.3	15.0
POWER FACTOR									.0
SOLDOUT FRAME									

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test Unit Calibration in LH₂

Reference Test Request 686 Paragraph 6.2.2

Test Engineer B.Milota Date 11/26/68
Test Cell B5-4 Run No. 4 Bar. Press. 29.28 "Hg
Test Unit Model No. 145204-100 Serial No. X-2132

Power : 3 phase sine wave

Pump Fluid Liquid Hydrogen ~~*****Drive~~
Run Time 36 Min./ 4 Starts ~~5**~~
~~Min~~

Test Unit Description Destratification Motor-Impeller Unit

Purpose To verify design by testing unit in LH₂

Comments A system check was made to verify speed & rotation. Run time was 3 min. / 1 start.

A system check was made to set power. Run time was 3 min. / 1 start.

Phase "A" was a unit calibration, run to paragraph 6.2.2 of T.R. 686 using 3" inclined manometer to record pump flow & pump ΔP. Run time Run time was 30 minutes / 1 start.



ENGINEER <i>J.R. Hamm</i>	PESCO PRODUCTS DIVISION BORG-WARNER CORP.	BEDFORD, OHIO	MODEL <i>145200-100</i>
TITLE <i>PUMP CALIBRATION IN LIQUID HYDROGEN</i>			DATE OF TEST <i>11-7-68</i> <i>11-26-68</i>

ELECTRICAL DATA
 FREQUENCY - 400 HZ
 VOLTAGE - 208 V RMS ϕ TO ϕ
 PHASES - 3

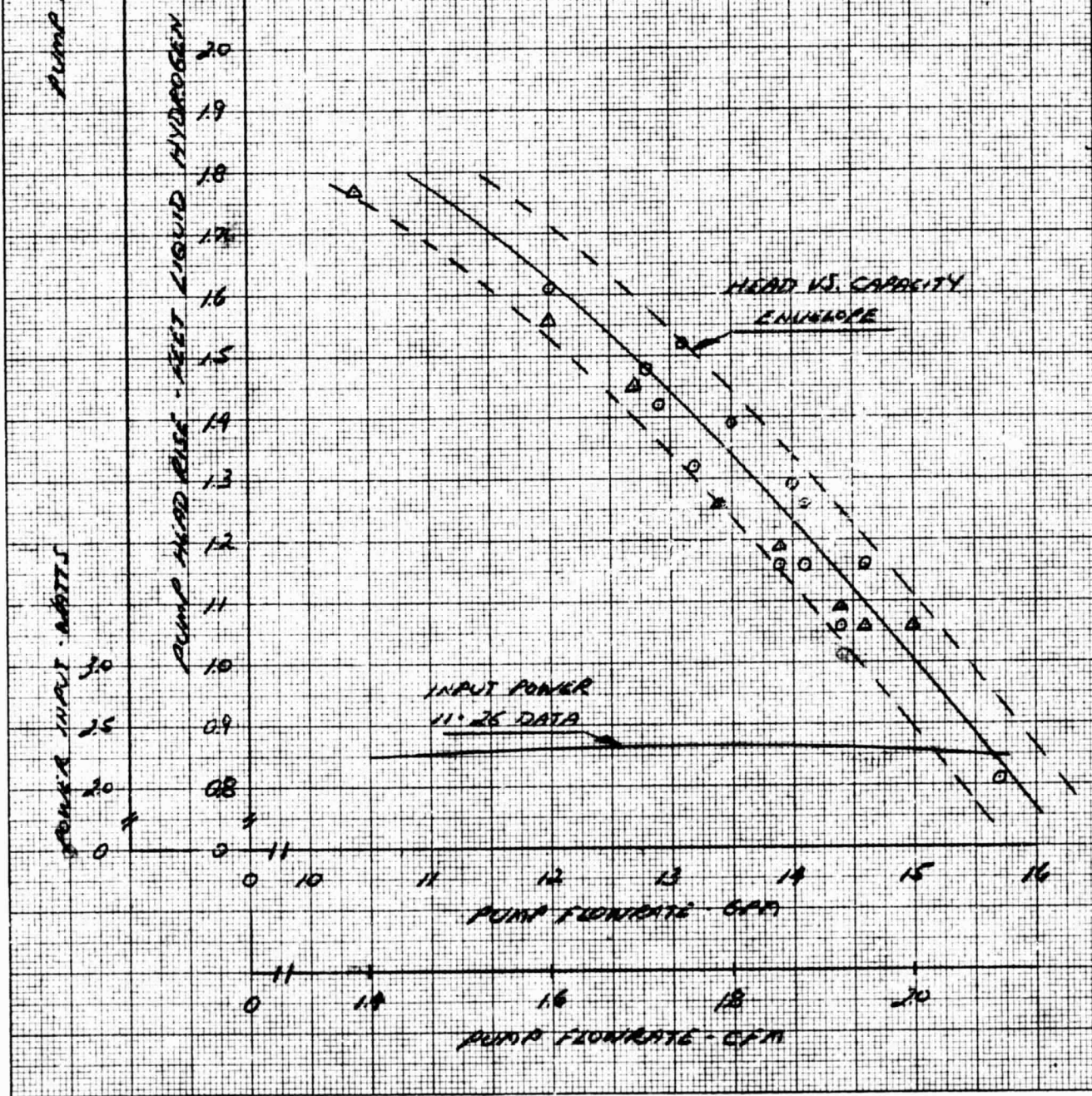
UNIT *5/8" x 2 1/2"*

11-7 DATA : Δ
 11-26 DATA : \circ

RUN NO. *25-4-2, 4*

UNIT SPEED - *5960 RPM*

PUMP SPEED - *5850*



K ϕ S 10 X 10 TO THE CENTIMETER 46 1513
 1 1/2 X 2 1/2 CM
 KEUFFEL & ESSER CO.

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet of

Type of Test Design Verification

Reference Test Request 686

Test Engineer B.Milota Date 11/12,13/68
Test Cell B4-3 Run No. 16 & 17 Bar. Press. 29.14 & 29.45 Hg
Test Unit Model No. 145204-100 Serial No. X-2132

Power : 3 phase sine wave

Pump Fluid G-O₂ & air ~~****~~
Run Time 58 Min. / 5 Starts ~~****~~

Test Unit Description Destratification Motor-Impeller

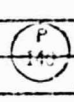
Purpose Design verification per T.R. 686 paragraph 6.2.1

Comments 11/12/68
Phase "A" was run in gaseous O₂, using micromanometers to read pump P & venturi flow, there was no noticable readings on the manometers. Run time was nine min. / 1 start.

The dewar was evacuated and purged with filtered air. The manometric fluid was changed from distilled water to oil with a spsific gravity of 827.

Phase "B" was run with the unit in air & oil in the manometers. No readings were obtained. Run time was 5 min. / 1 start.

11/13/68
Phase "A" was run and readings were obtained. Run time was 15 min. / one start.
Phase "B" was a calibration in air. Run time was 16 min. / 1 start.
Phase "C" was a calibration in air. Run time was 13 min. / 1 start.

 B. Milota
12-9-68



Pesco Products

DIVISION OF BORG WARNER CORPORATION

CRYOGENIC LABORATORY

Senior Tech. BERNARD F. MILOTA F.

DESTABILIZATION MOTOR-IMPELLER Unit SIX X-2132 Test Cell Ambient Temp. 65°F

LTR. No. 686 PARA 6.2.1 Baro. Press. 29.14 Hg. 14.31 PSIA
CALIBRATION IN CO₂ & AIR

Total Run Time 58 MIN / 5 STARTS

DATE: 11-12 & 11-13-68 B4-3-16 & 17 EASEOUS OXYGEN & AIR

Time	Sequence of Events
11-12-68	
1508	START RUN A IN EASEOUS OXYGEN
1517	STOP RUN A RUN TIME 9 MIN / 1 START (NO DATA)
	MICROMANOMETERS WITH DISTILLED H ₂ O WERE USED TO INDICATE VENTURI & PUMP DP.
1525	PURGE SYSTEM WITH FILTERED AMBIENT AIR.
1545	START RUN B
1550	STOP RUN B RUN TIME 5 MIN / 1 START (NO DATA)
	MICROMANOMETERS WITH MERIOM OIL (SPEC. GR. OF 827) WERE USED TO INDICATE VENTURI & PUMP DP.
1600	SECURE SYSTEM
11-13-68	
1125	START RUN A IN AIR
1140	STOP RUN A RUN TIME 15 MIN / 1 START
	MICROMANOMETERS WITH OIL WERE USED TO INDICATE VENTURI & PUMP DP.
1402	START RUN B UNIT CALIBRATION IN AIR
1418	STOP RUN B RUN TIME 16 MIN / 1 START
1500	START RUN C UNIT CALIBRATION IN AIR
1513	STOP RUN C RUN TIME 13 MIN / 1 START
1530	SECURE SYSTEM
11-12-68	BARO. PR. 29.14
11-13-68	29.45

BORG WARNER Pesco Products

DIVISION OF BORG-WARNER CORPORATION 24700 N. MILES ROAD, BEDFORD, OHIO

CALIBRATION AIR
TEST No. B4-3-17
Air Temp. 70°F

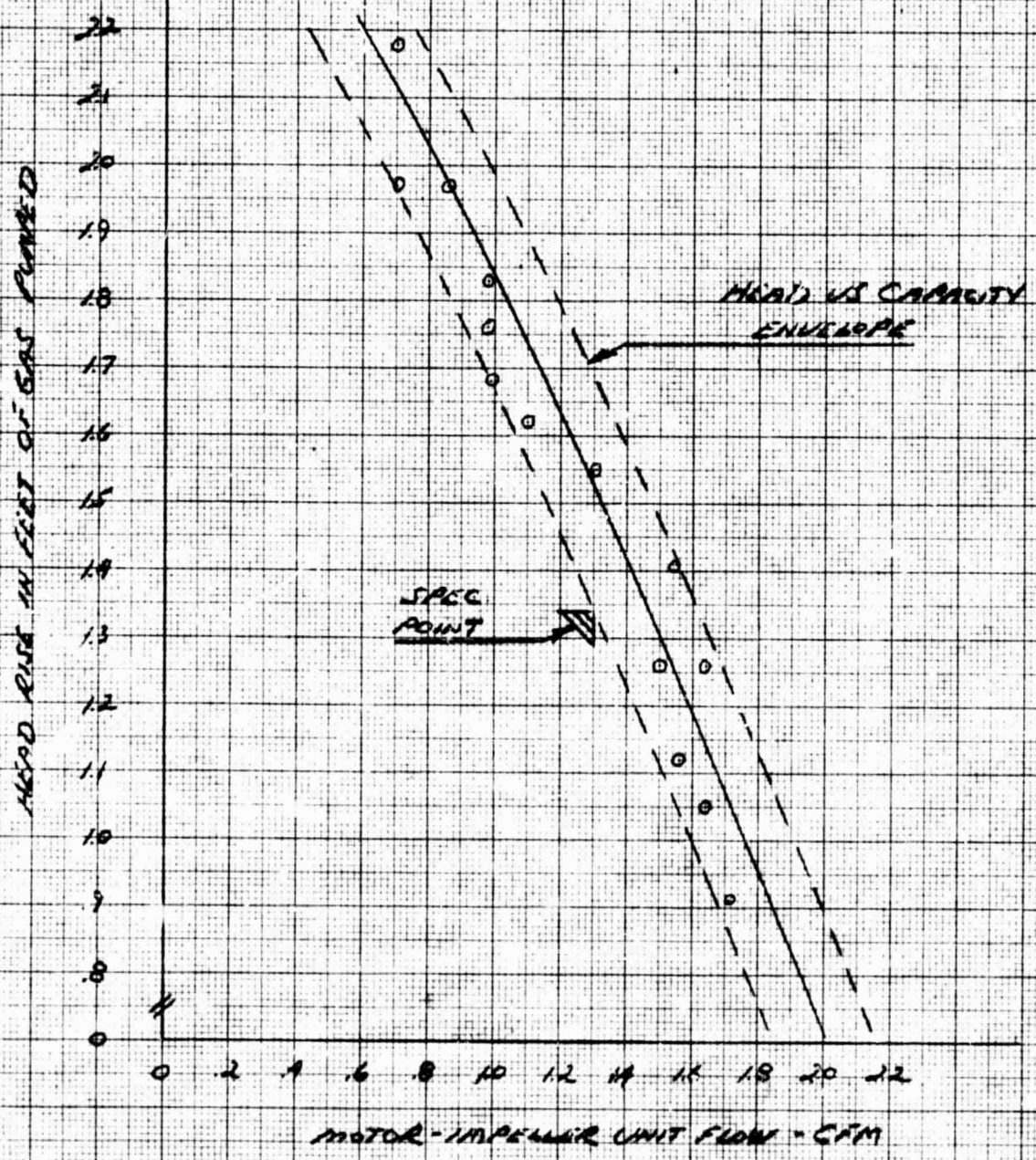
11/13/68

TEST PHASE		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8
UNIT SPEED	RPM	5960	5960	5960	5960	5960	5960	5960	5960
UNIT FLOW	CFM	0.99	1.50	1.62	1.64	1.56	1.71	0.98	0.98
UNIT ΔP	In H2O	.024	.018	.016	.015	.016	.013	.025	.025
MOTOR WINDING TEMP °F		109	112	115	118	122	126	128	128
CURRENT									
PHASE A	ma	95.9	95.8	95.5	95.2	95.0	94.8	95.3	95.3
PHASE B	ma	95.5	95.0	94.7	94.6	94.5	94.2	94.9	94.9
PHASE C	ma	95.8	95.5	95.2	95.0	94.8	94.8	95.0	95.0
POWER									
PHASE A	watts	5.38	5.38	5.42	5.45	5.50	5.52	5.40	5.40
PHASE B	watts	5.40	5.41	5.45	5.50	5.55	5.55	5.45	5.45
PHASE C	watts	5.30	5.30	5.34	5.38	5.40	5.45	5.38	5.38
VOLTAGE L-L									
PHASE A		208	208	208	208	208	208	208	208
PHASE B		208	208	208	208	208	208	208	208
PHASE C		208	208	208	208	208	208	208	208
FREQUENCY	CPS	400	400	400	400	400	400	400	400
FOLDOUT FRAME /									

ENGINEER <i>J. R. Haman</i>	PESCO PRODUCTS DIVISION BORG-WARNER CORP. BEDFORD, OHIO	MODEL 145-209-100
TITLE PUMP CALIBRATION IN AIR @ 0.07428/FT ³		DATE OF TEST 11-13-68

ELECTRICAL DATA
 FREQUENCY 400 Hz
 VOLTAGE 208 VOLTS @ 100
 PHASES - 3
 AVE POWER 18.3 WATTS

UNIT $\frac{5}{8} \times 2132$
 RUN NO. B4-3-17
 SPEED 5960 RPM



4.3 Life Tests

Life tests were conducted on three specimens; one each in oxygen, nitrogen, and hydrogen. All testing followed the typical duty cycle identified in TR686, paragraph 6.3.4. This cycle consists of 3.0 minutes ON and 0.5 minutes OFF. Additionally, the fluid phases, in oxygen and hydrogen, were cycled from liquid to gas as shown in Table I, TR686. The nitrogen unit ran only in the liquid phase. Each of the three units accumulated over 225 hours running time and more than 4500 starts and stops. Tabulated life testing data is included at the end of this section. Testing is summarized as follows:

4.3.1 Life Testing Summary

<u>Unit</u> <u>Serial No.</u>	<u>Fluid</u>	<u>Date</u>	<u>No. of</u> <u>Cycles</u>	<u>Total</u> <u>Cycles</u>	<u>Total</u> <u>Run Time</u> <u>Hours</u>
X2133	LO ₂	12/17/68	36	36	2.55
X2133	LO ₂	12/18-20/68	914	950	48.25
X2133	GO ₂	12/24-28/68	902	1852	93.35
X2133	LO ₂	1/2 - 1/4/69	901	2753	138.45
X2133	GO ₂	1/6 - 1/8/69	918	3671	184.35
X2133	LO ₂	1/9 - 1/10/69	452	4123	206.95
X2133	GO ₂	1/13 - 1/14/69	453	4576	229.55
X2139	LH ₂	1/6 - 1/29/69	908	908	45.5
X2139	GH ₂	1/31 - 2/2/69	910	1818	91.0
X2139	LH ₂	2/2 - 2/5/69	906	2724	136.2
X2139	GH ₂	2/6 - 2/8/69	903	3627	181.4
X2139	LH ₂	2/8 - 2/9/69	452	4079	204.0
X2139	GH ₂	2/10 - 2/11/69	453	4532	226.6
X2138	LN ₂	1/21 - 2/2/69	4433	4433	222.0
X2138	LN ₂	2/6/69	85	4518	225.9

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test Pre-Life Calibration

Reference Test Request 686 Paragraph 6.2.1.5 & 6.3

Test Engineer B.Milota Date 12/17/68
Test Cell B4-3 Run No. 19 Bar. Press. 29.50 "Hg
Test Unit Model No. 145204-100 Serial No. X-2133

Power : 3 phase sine wave
Pump Fluid Liquid & Gaseous O₂ ~~***Drive***~~
Run Time 4 ~~Min~~

Test Unit Description Destratification Motor-Impeller Unit.

Purpose To perform pre-life calibration & to demonstrate 225 hours life.

Comments A dry spin was made prior to installation in the dewar to verify speed and rotation. Run time was 4 minutes.

Phase "A" was a system check run to set power and check speed.

Phase "B" was a unit calibration which was run to paragraph 6.2.1.5 of T.R. 686. Run time was 21 minutes 45 seconds.

Phase "C" was the start of the life testing, which was run to paragraph 6.3 of T.R. 686. Run time was 126 minutes 45 seconds. (36 cycles)

B. Milota
1-7-69

TEST PHASE		B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8	B-9
UNIT SPEED	RPM	5520	5530	5530	5540	5530	5530	5520	5510	5500
UNIT FLOW	GPM	10.9	11.0	11.5	10.4	10.2	9.8	9.6	9.5	9.4
UNIT FLOW	CFM	1.46	1.47	1.54	1.39	1.36	1.31	1.28	1.27	1.26
UNIT ΔP	PSI	.255	.473	.713	.802	.858	.941	.970	1.041	.843
UNIT ΔH	FT	.515	.955	1.440	1.620	1.733	1.901	1.959	2.103	1.70
MOTOR WINDING TEMP. °F		-304	-304	-304	-303	-303	-303	-303	-303	-303
CURRENT										
PHASE A	ma	112.8	112.5	112.5	112.2	112.5	113.0	113.0	113.0	113.
PHASE B	ma	112.5	112.5	112.5	112.2	112.5	113.0	113.0	113.0	113.
PHASE C	ma	112.5	112.2	112.5	112.2	112.5	113.0	113.0	113.2	113.
POWER										
PHASE A	watts	4.15	4.15	4.15	4.13	4.15	4.25	4.30	4.35	4.37
PHASE B	watts	4.30	4.23	4.23	4.20	4.20	4.40	4.40	4.40	4.50
PHASE C	watts	4.15	4.10	4.10	4.05	4.13	4.15	4.35	4.34	4.35
VOLTAGE L-L										
PHASE A		208	208	208	208	208	208	208	208	208
PHASE B		208	208	208	208	208	208	208	208	208
PHASE C		208	208	208	208	208	208	208	208	208
FREQUENCY	CPS	400	400	400	400	400	400	400	400	400
MOTOR CASE TEMP. °F		-294	-294	-294	-294	-294	-294	-294	-294	-294
DEWAR PRESS,	PSI	14.49	14.49	14.49	14.49	14.49	14.49	14.49	14.49	14.4
LIQUIL LEVEL	IN	11.2	11.2	11.1	11.1	11.1	11.1	11.0	11.0	11.0
WELDOUT FRAME /										

Ref: 4.38

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test Life Test (Liquid Phase)

Reference Test Request 686 paragraph 6.3

Test Engineer B. Milota Date 12/18/68
Test Cell B4-3 Run No. 20,21,22 Bar. Press. 29.39 "Hg
Test Unit Model No. 145204-100 Serial No. X2133

Power : 3 phase sine wave
Pump Fluid Liquid Oxygen ~~As***E***~~
Run Time Sec
Min

Test Unit Description Destratification Motor-Impeller Unit

Purpose To demonstrate 225 hours of life testing.

Comments Continued life testing at 0800 Hrs., and secured system at 2345 Hrs.
(270 cycles)

12/19/68 Continued life testing at 0855 Hrs., Unit to run until 900 cycles
have been completed.

12/20/68 Secured system at 2050 Hrs., this completes the first 900 cycles
in liquid oxygen.

Barometric Pressure in Inches Hg	
12/18/68	29.39
12/19/68	29.16
12/20/68	29.13

(11)

B. Milota
1-7-69

CYCLE No.		42	110	178	303		304	380
TIME OF DAY		16:04	12:00	16:00	23:20		08:55	13:30
TOTAL RUN TIME	MIN	126	330	534	909		912	1140
UNIT SPEED	RPM	5560	5560	5570	5650		5540	5560
UNIT FLOW	GPM	10.9	11.0	11.0	0		11.0	11.0
UNIT FLOW	CFM	1.46	1.47	1.47	0		1.47	1.47
UNIT Δ P	PSI	.573	.342	.560	.405		.535	.348
UNIT Δ H	FT	1,157	.691	1,131	.818		1,081	.703
MOTOR WINDING TEMP	°F	-302	-294	-294	-294		-294	-293
CURRENT								
PHASE A	ma	112	112.2	112.0	110.0		113.0	112.0
PHASE B	ma	112	112.2	112.0	110.0		112.8	112.0
PHASE C	ma	112	112.2	112.0	110.0		112.5	112.0
POWER								
PHASE A	watts	4.05	4.15	3.95	3.55		4.20	4.30
PHASE B	watts	4.20	4.20	4.10	3.60		4.15	4.20
PHASE C	watts	4.05	4.15	3.95	3.55		4.15	4.20
VOLTAGE L-L								
PHASE A	V	208	208	208	208		208	208
PHASE B	V	208	208	208	208		208	208
PHASE C	V	208	208	208	208		208	208
FREQUENCY	CPS	400	400	400	400		400	400
MOTOR CASE TEMP	°F	-294	-294	-294	-294		-295	-295
DEWAR PRESS.	PSI	14.49	14.44	14.44	14.44		14.32	14.32
LIQUID LEVEL	IN	7.48	9.42	8.21	3.97		12.81	10.1
FOLDOUT FRAME								

Run No. B4-3-19C
12/17/68 Bar. 29.50 in hg

Run No. B4-3-20
12/18/68 Bar. 29.39 in hg

Run No. b4-3-21
12/19/68 Bar. 29.16 in hg

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet _____ of _____

Type of Test Life Test (Gas Phase)

Reference Test Request 686 paragraph 6.3

Test Engineer B.Milota Date 12/24/68
Test Cell B4-3 Run No. 23,24,25,26 Bar. Press. 29.23 "Hg
Test Unit Model No. 145204-100 Serial No. X2133

Power : 3 phase sine wave

Pump Fluid Gaseous Oxygen *****
Run Time 45 Hours 5**

Test Unit Description Destratification Motor-Impeller Unit

Purpose To demonstrate 225 hours of life testing.

Comments Started life test in G-O₂ at 1058, completed 5-3 minute cycles, secured system at 1115 hours.

12/26/68 Started life test at 0830 B4-3-24, data point at 1600 hours.

12/27/68 Started life test at 0830 B4-3-25, data point taken at 1600hours

12/28/68 Started life test at 0830 B4-3-26 secured system at 1315 Hrs., this completed first 900 cycles in G-O₂.

Barametric Pressure in Inches Hg

12/24/68	29.23
12/26/68	29.23
12/27/68	29.30
12/28/68	29.30

B. Milota
1-7-69

(140)



Pesco Products

DIVISION OF BORG WARNER CORPORATION 24700 N. MILES ROAD BEDFORD, OHIO

LIFE CYCLE TEST (GAS PHASE)

TEST No. B4-3-23, 24; 25, 26

DATE 12/24, 26, 27, 28, /68

CYCLE NO.			1	2	5		6	10	58	
TIME OF DAY			10:58	11:02	11:16		08:30	08:45	11:30	1
TOTAL RUN TIME		MIN	3	6	15		18	30	174	3
UNIT SPEED		RPM	5960	5950	5950		5960	5950	5950	5
MOTOR WINDING TEMP		°F	---	144	163		128	173	208	2
CURRENT										
PHASE A		ma	96.5	95.9	94.6		97.0	95.3	93.7	9
PHASE B		ma	96.2	95.5	94.2		96.0	95.0	93.5	9
PHASE C		ma	96.4	95.8	94.5		97.0	95.0	93.7	9
POWER										
PHASE A		watts	5.35	5.53	5.65		5.35	5.65	5.85	5
PHASE B		watts	5.38	5.58	5.70		5.40	5.70	5.90	5
PHASE C		watts	5.30	5.50	5.65		5.35	5.57	5.85	5
VOLTAGE L-L										
PHASE A			208	208	208		208	208	208	2
PHASE B			208	208	208		208	208	208	2
PHASE C			208	208	208		208	208	208	2
FREQUENCY		CPS	400	400	400		400	400	400	4
MOTOR CASE TEMP		°F	---	91	107		83	112	140	1
DEWAR PRESS.		PSI	14.36	14.36	14.36		14.57	14.57	14.57	1
FOLDOUT FRAME		/								

Run No. B4-3-23
12/24/68 Bar. 29.23 in hg

Run No. B4-3-24
12/26/68 Bar. 29.67 in hg

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test Life Test (Second Liquid Phase)

Reference Test Request 686 Paragraph 6.3.6

Test Engineer B.Milota Date 12/31/68
Test Cell B4-3 Run No. 27,28,29,30 Bar. Press. 29.50 "Hg
Test Unit Model No. 145204-100 Serial No. X-2133

Power : 3 phase sine wave

Pump Fluid Liquid Oxygen ~~*****Drive~~
Run Time 45 Min. / 3 Starts ~~***~~

Test Unit Description Destratification Motor-Impeller Unit

Purpose To demonstrate 225 hours of life testing.

Comments Started second liquid phase at 1010 hours, completed 91 cycles.
Run time was 4 hours 33 minutes.

1/2/69 Continued second liquid phase at 0900 hours, after completing
375 cycles this test day the unit shut down due to electrical problems
with our timers.

1/3/69 Started unit at 0830 hours, 3 data points were taken durring the
8 hour shift, unit to continue running.

1/4/69 Secured system at 1545 hours, this completes the second phase
of 900 cycles in liquid oxygen.



B. Milota
1-13-69

CYCLE No.		1		91		92	143	211	284
TIME OF DAY		10:12		15:19		09:00	12:00	16:00	20:15
TOTAL RUN TIME	MIN	3		273		276	429	633	852
UNIT SPEED	RPM	5530	5550	5550		5520	5540	5560	5550
UNIT FLOW	GPM	10.7	10.6	10.5		10.9	10.8	10.6	10.8
UNIT FLOW	CFM	1.43	1.42	1.40		1.46	1.44	1.42	1.44
UNIT ΔP	PSI	.435	.605	.606		.555	.573	.566	.559
UNIT ΔH	FT	.879	1.222	1.224		1.121	1.157	1.143	1.129
MOTOR WINDING TEMP ^o F		-297	-296	-296		-295	-295	-298	-298
CURRENT									
PHASE A	ma	114.0	114.0	113.0		113.5	114.0	112.5	112.0
PHASE B	ma	114.0	113.5	113.0		113.0	113.5	112.5	112.0
PHASE C	ma	113.0	113.0	113.0		113.0	113.5	112.5	112.5
POWER									
PHASE A	watts	4.35	4.25	4.15		4.25	4.20	4.05	4.05
PHASE B	watts	4.40	4.40	4.30		4.40	4.35	4.10	4.10
PHASE C	watts	4.25	4.25	4.15		4.25	4.20	4.05	4.05
VOLTAGE L-L									
PHASE A		208	208	208		208	208	208	208
PHASE B		208	208	208		208	208	208	208
PHASE C		208	208	208		208	208	208	208
FREQUENCY	CPS	400	400	400		400	400	400	400
MOTOR CASE TEMP ^o F		-293	-293	-293		-294	-294	-294	-294
DEWAR PRESS.	PSI	14.49	14.49	14.49		14.52	14.52	14.52	14.52
LIQUID LEVEL	IN	11.8	8.5	7.3		12.0	9.3	12.6	8.8
FOLDOUT FRAME									

 Run No. B4-3-27
 12/31/68 Bar. 29.50 in hg

 Run No. B4-3-28
 1/2/69 Bar. 29.57 in hg

BORG WARNER Pesco Products

DIVISION OF BORG WARNER CORPORATION 24700 N MILES ROAD, BEDFORD, OHIO

Life Cycle Test (Second Gas Phase)
 Test No. B4-3-23, 24, 25, 26
 Date 12/24, 26, 27, 28/68

Cycle		1	35	106		378	503	522	
Time of Day		0945	1150	1600		0800	1520	1610	
Total Run Time	Min.	3	105	318		1134	1509	1566	
Unit Speed	RPM	5950	5960	5960		5950	5960	5960	
Motor Winding Temp.	°F	130	196	205		210	171	183	
Current									
Phase A	ma	96.0	94.0	93.0		92.5	94.1	94.0	
Phase B	ma	96.0	94.0	93.0		92.5	94.3	94.0	
Phase C	ma	96.0	94.0	93.0		92.5	94.2	94.0	
Power									
Phase A	watts	5.55	5.95	5.85		5.85	5.75	5.80	
Phase B	watts	5.60	6.00	5.90		5.90	5.80	5.80	
Phase C	watts	5.57	5.95	5.85		5.85	5.75	5.75	
Voltages L-L									
Phase A		208	208	208		208	208	208	
Phase B		208	208	208		208	208	208	
Phase C		208	208	208		208	208	208	
Frequency	CPS	400	400	400		400	400	400	
Motor Case Temp.	°F	82	129	137		142	115	118	
Dewar Pressure	PSI	14.27	14.27	14.27		14.20	14.20	14.20	
FOLDOUT FRAME									

Run No. B4-3-31
 1/6/69 Bar. 29.06 in.Hg

Run No. B4-3-32
 1/7/69 Bar. 28.92 in.Hg

Run No. B4-3-33

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test Life Test (Third Liquid Phase)

Reference Test Request 686 Paragraph 6.3

Test Engineer B. Milota Date 1/9, 10/69
Test Cell B4-3 Run No. 34&35 Bar. Press. 28.92 & 29.23" Hg
Test Unit Model No. 145204-100 Serial No. X-2133

Power : 3 phase sine wave

Pump Fluid Liquid Oxygen ~~Acetylene Drive~~
Run Time 22.5 Hr./450 Starts *~~Set~~
~~Min*~~

Test Unit Description Destratification Motor-Impeller Unit

Purpose To demonstrate 225 hours of life testing.

Comments Started third liquid phase at 1010 Hrs. on 1/9/69, unit to run until 450 cycles have been completed, 3 data points were taken this test day.

1/10/69 First data point taken at 0820Hrs, Second data point taken at 1200 Hrs third data point taken at 1530 Hrs.
Completed 450 cycles at 1533 Hrs. test system was secured at 1535 Hrs.



1/10/69
1533-61



Pesco Products

DIVISION OF BORG WARNER CORPORATION 24700 N. MILES ROAD, BEDFORD, OHIO

Life Cycle Test (Third Liquid Ox
Test No. B4-3-34, 35
Date 1/9, 10/69

Cycle		1	32	100		331	393	452
Time of Day		1010	1200	1600		0820	1200	1530
Total Run Time	Min.	3	96	300		993	1179	1356
Unit Speed	RPM	5530	5570	5560		5540	5570	5570
Unit Flow	GPM	10.4	11.0	11.0		11.0	11.1	10.7
Unit Flow	CFM	1.46	1.47	1.47		1.47	1.48	1.43
Unit Δ P	PSI	.619	.570	.858		.455	.422	.424
Unit H	FT	1.250	1.151	1.733		.919	.852	.856
Motor Winding Temp.	°F	-295	-299	-294		-292	-292	-298
Current								
Phase A	ma	113.0	112.0	113.0		113.0	113.0	112.0
Phase B	ma	113.0	112.0	113.0		113.0	113.0	112.0
Phase C	ma	113.0	112.0	113.0		113.0	113.0	112.0
Power								
Phase A	watts	4.35	4.15	4.25		4.25	4.25	4.15
Phase B	watts	4.20	4.00	4.20		4.20	4.20	4.20
Phase C	watts	4.15	4.05	4.15		4.25	4.15	4.05
Voltage L-L								
Phase A		208	208	208		208	208	208
Phase B		208	208	208		208	208	208
Phase C		208	208	208		208	208	208
Frequency	CPS	400	400	400		400	400	400
Motor Case Temp.	°F	-299	-299	-300		-298	-300	-302
Dewar Pressure	PSI	14.20	14.20	14.20		14.36	14.36	14.36
Liquid Level	IN	11.2	11.2	16.4		12.6	13.3	11.7
FOLDOUT FRAME /								

Run No. B4-3-34
1/9/69 Bar. 28.92 in.Hg

Run No. B4-3-35
1/10/69 Bar. 29.23 in.Hg

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TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet of

Type of Test Life Test (Third Gas Phase)

Reference Test Request 686 Paragraph 6.3.6

Test Engineer B. Milota Date 1/13, 14/69
Test Cell B4-3 Run No. 36 & 37 Bar. Press. 29.78 & 29.84 Hg
Test Unit Model No. 145204-100 Serial No. X-2133

Power : 3 phase sine wave

Pump Fluid Gaseous Oxygen ~~***D***~~

Run Time 22.5 Hrs./450 Starts ~~Sec~~
~~Min~~

Test Unit Description Destratification Motor-Impeller Unit

Purpose To demonstrate 225 Hrs. of life testing.

Comments Started third gas phase at 0850 Hrs. on 1/13/69 3 data points were taken this test day, unit to run till 450 cycles have been completed.

1/14/69 Three data points were taken this test day, completed 450 cycles, unit shut down & test system was secured.



B. Milota
1-14-69

Cycle No.		1	51	85		350	396	553
Time of Day		0900	1200	1400		0915	1200	1520
Total Run Time	Min.	3	153	255		1050	1188	1359
Unit Speed	RPM	5950	5960	5960		5960	5960	5960
Motor Winding Temp.	°F	134	202	204		198	213	205
Current								
Phase A	ma	95.3	93.0	92.5		93.5	93.0	93.0
Phase B	ma	95.5	93.5	93.0		93.5	93.0	93.0
Phase C	ma	95.00	93.0	92.5		93.0	92.5	92.5
Power								
Phase A	watts	5.55	5.88	5.95		5.85	5.90	5.75
Phase B	watts	5.60	5.80	5.80		5.90	6.00	5.80
Phase C	watts	5.55	5.80	5.85		5.80	5.85	5.75
Voltage L-L								
Phase A		208	208	208		208	208	208
Phase B		208	208	208		208	208	208
Phase C		208	208	208		208	208	208
Frequency	CPS	400	400	400		400	400	400
Motor Case Temp.	°F	86	137	143		134	146	148
Dewar Pressure	PSI	14.63	14.63	14.63		14.66	14.66	14.66
FOLDOUT FRAME								

 Run No. B4-3-36
 1/13/69 Bar. 29.78 in.Hg

 Run No. B4-3-37
 1/14/69 Bar. 29.84 in.Hg

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test Post Life Test Calibration

Reference Test Request 686 Paragraph 6.3.7

Test Engineer B. Milota Date 1/15/69
Test Cell B4-3 Run No. 38 Bar. Press. 29.86 "Hg
Test Unit Model No. 145204-100 Serial No. X-2133

Power : 3 phase sine wave

Pump Fluid Liquid Oxygen ~~Auxiliary Drive~~
Run Time 28 Min./ 2 Starts ~~Sec~~
~~Min~~

Test Unit Description Destratification Motor-Impeller Unit

Purpose To perform a unit calibration after 225 Hrs. of life testing

Comments Phase "A" was an instrment & system check run. Run time was 13 minute
1 start.

Phase "B" was a unit calibration run consisting of 12 various
flows from minimum to maximum. Run time was 15 min./1 start.



B. Milota
1-15-69



Pesco Products

DIVISION OF BORG WARNER CORPORATION 24700 N MILES ROAD, BEDFORD, OHIO

Calibration Liquid Oxygen
Test No. B4-3-38-B 1/15/69
After Life Cycle

Test Phase		B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8	B-9
Unit Speed	RPM	5590	5600	5590	5580	5590	5540	5550	5520	55
Unit Flow	GPM	.353	.339	.325	.303	.292	.267	.242	.199	.1
Unit Flow	CFM	9.2	9.0	8.8	8.5	8.4	8.07	7.6	6.9	6.
Unit Δ P	PSI	.531	.595	.543	.320	.790	.550	.713	.703	1.
Unit Δ H	FT	1.073	1.202	1.097	.646	1.596	1.111	1.440	1.420	2.
Motor Winding Temp.	°F	304	304	304	304	304	304	304	304	30
Current										
Phase A	ma	111.5	111.5	111.5	112.0	112.0	112.5	113.0	113.5	11
Phase B	ma	112.0	111.5	111.0	112.0	112.0	112.5	113.0	113.5	11
Phase C	ma	111.5	111.0	111.0	112.0	111.5	112.0	112.5	113.0	11
Power										
Phase A	watts	3.95	3.95	3.85	3.95	4.05	4.15	4.15	4.35	4.
Phase B	watts	4.10	4.00	4.00	4.20	4.20	4.30	4.30	4.50	4.
Phase C	watts	3.95	3.95	3.85	3.95	4.15	4.05	4.15	4.35	4.
Voltage L-L										
Phase A		208	208	208	208	208	208	208	208	20
Phase B		208	208	208	208	208	208	208	208	20
Phase C		208	208	208	208	208	208	208	208	20
Frequency	CPS	400	401	400	400	401	399	400	401	40
Motor Case Temp.	°F	-296	-296	-296	-296	-296	-296	-296	-296	-2
Dewar Pressure	PSI	14.67	14.67	14.67	14.67	14.67	14.67	14.67	14.67	14
Liquid Level	IN	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.
SOLDOUT FRAME /										

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test PRE-LIFE CALIBRATION

Reference Test Request 686 Para. 6.2.1.5

Test Engineer B Milota Date 1/3/69
Test Cell B5-4 Run No. 5 Bar. Press. 29.28 "Hg
Test Unit Model No. 145204-100 Serial No. X-2139

Power: 3 Phase sine wave

Pump Fluid Liquid Hydrogen Aux. Drive
Run Time 37 min./4 starts Sec
Min

Test Unit Description Destratification Motor-Impeller Unit

Purpose To perform pre-life calibration in LH₂

Comments A dry spin was made to verify speed and direction of rotation. Run time 1 min /1 start.
Phase A was a power setting run. Run time 2 min./1 start.
Phase B was a unit calibration run. Run time 18 min./1 start.
Phase C was a unit calibration which was run to Para 6.2.1.5 of TR 686. Run time 16 min./1 start.

(P)
140

Handwritten:
Run time 18 min
7-13-69

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test LIFE TEST (1st LIQUID PHASE)

Reference Test Request 686 Para. 6.3.6

Test Engineer B. Milota Date 1,6,13,28,29/69
Test Cell B5-4 Run No. 6,7,8, & 9 Bar. Press. 28.92 "Hg
Test Unit Model No. 145204-100 Serial No. X-2139

Power: 3 Phase Sine Wave

Pump Fluid Liquid Hydrogen Aux. Drive
Run Time 45 hrs./900 starts Sec
Min

Test Unit Description Destratification Motor-Impeller Unit

Purpose To demonstrate 225 hours of life testing.

1/6/69
Comments Started life testing at 1105 hrs. Completed cycles 1 thru 94.

1/13/69 Continued life testing at 1430 hrs. Completed cycles 95 thru 120

1/28/69 Continued life testing at 1508 hrs. Completed cycles 121 thru 908.
Unit ran thru 1/29/69 to complete 1st 900 cycles in Liquid Hydrogen.



Handwritten signature
2-13-69

CYCLE NO.		1	60	89		95	116	120	
TIME OF DAY		11:05	14:15	16:00		14:30	15:45	16:00	
TOTAL RUN TIME	MIN	3	180	267		285	348	360	
UNIT SPEED	RPM	5960	5970	5970		5970	5970	5970	
UNIT FLOW	GPM	15.9	13.7	13.8		13.8	13.8	13.8	
UNIT FLOW	CFM	2.13	1.83	1.84		1.84	1.84	1.84	
UNIT ΔP	PSI	.033	.033	.037		.034	.035	.034	
UNIT ΔH	FT	1.06	1.06	1.19		1.09	1.13	1.09	
MOTOR WINDING TEMP	°F	-403	-403	-403		-403	-403	-403	
CURRENT									
PHASE A	ma	103.4	103.2	103.2		103.0	103.2	103.2	
PHASE B	ma	103.5	103.0	102.5		102.8	103.0	103.0	
PHASE C	ma	103.2	103.0	102.7		102.5	102.8	102.8	
POWER									
PHASE A	watts	.70	.70	.70		.70	.70	.70	
PHASE B	watts	.75	.75	.70		.80	.80	.80	
PHASE C	watts	.75	.75	.75		.75	.73	.73	
VOLTAGE L-L									
PHASE A		208	208	208		208	208	208	
PHASE B		208	208	208		208	208	208	
PHASE C		208	208	208		208	208	208	
FREQUENCY	CPS	400	400	400		400	400	400	
INLET TEMP.	°F	-418	-418	-418		-418	-418	-418	
DEWAR PRESS.	PSI	14.20	14.20	14.20		14.20	14.20	14.20	
WELDOUT FRAME 1									

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test LIFE TEST (1st GAS PHASE)

Reference Test Request 686 Para. 6.3.6

Test Engineer B. Milota

Date 1/31/69
2/1 & 2/2/69

Test Cell B5-4

Run No. 10,11 & 12

Bar. Press. _____ "Hg

Test Unit Model No. 145204-100

Serial No. X-2139

Power: 3 Phase Sine Wave

Pump Fluid Gaseous Hydrogen Aux. Drive

Run Time 45 hrs./900 starts Sec
Min

Test Unit Description Destratification motor-Impeller Unit

Purpose To demonstrate 225 hours of life testing.

Comments 1/31/69 Started 1st Gas Phase at 15:30 hrs.
Unit ran thru 2/2/69. This completes the 1st 900 cycles
in Gaseous Hydrogen.

(143)

Handwritten notes:
by Milota
2-13-69

CYCLE NO.		1	3	9		391	395	400	
TIME OF DAY		15:30	15:40	16:00		14:30	14:45	15:00	
TOTAL RUN TIME	MIN	3	9	27		1173	1185	1200	
UNIT SPEED	RPM	5970	5970	5970		5960	5970	5970	
UNIT FLOW	GPM								
UNIT FLOW	CFM								
MOTOR WINDING TEMP	°F	57	83	118		131	139	142	
CURRENT									
PHASE A	ma	99.0	98.0	98.0		96.0	96.5	96.0	
PHASE B	ma	99.0	98.0	98.0		96.5	96.5	96.5	
PHASE C	ma	99.0	98.0	97.8		96.5	96.5	96.0	
POWER									
PHASE A	watts	5.15	5.15	5.15		5.55	5.60	5.65	
PHASE B	watts	5.20	5.20	5.20		5.65	5.70	5.70	
PHASE C	watts	5.15	5.13	5.15		5.55	5.55	5.55	
VOLTAGE L-L									
PHASE A		208	208	208		208	208	208	
PHASE B		208	208	208		208	208	208	
PHASE C		208	208	208		208	208	208	
FREQUENCY	CPS	400	400	400		400	400	400	
DEWAR PRESS.	PSI	14.67	14.67	14.67		14.6	14.6	14.6	
FOLDOUT FRAME									

1/31/69
B5-4-10

2/1/69
B5-4-11

2/2/69
B5-4-12

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TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet of

Type of Test LIFE TEST (2nd LIQUID PHASE)

Reference Test Request 686 Para. 6.3.6

Test Engineer B. Milota

Date 2/2, 2/3, 2/4, and 2/5/69

Test Cell B5-4 Run No. 13, 14, & 15 Bar. Press. 29.05 "Hg

Test Unit Model No. 145204-100 Serial No.

Power: 3 Phase Sine Wave.

Pump Fluid Liquid Hydrogen Aux.-Drive

Run Time 45 hrs./900 starts See-
Min

Test Unit Description Destratification Motor-Impeller Unit

Purpose To Demonstrate 225 hrs of Life Testing

Comments 2/2/69 Started 2nd Liquid Phase at 23:15 hrs.
Unit ran until 2/5/69 This completes 900 cycles
in Liquid Hydrogen. Test ran to Para. 6.3.6 of TR 686

(P
140)

Handwritten notes:
2/2/69
2/3/69
2/4/69
2/5/69



Pesco Products

DIVISION OF BORG WARNER CORPORATION 24700 N. MILES ROAD BEDFORD, OHIO

LIFE CYCLE TEST (2ND LIQUID PHASE)

TEST No. B5-4-12,13,14,15

DATE 2/2,3,4,5/69

CYCLE NO.		1		170	221	255	374	
TIME OF DAY		23:15		11:05	14:00	16:00	23:30	
TOTAL RUN TIME	MIN	3		510	663	765	1122	
UNIT SPEED	RPM	5970		5960	5960	5960	5960	
UNIT FLOW	GPM	13.9		14.7	13.5	13.5	14.3	
UNIT FLOW	CFM	1.86		1.97	1.80	1.80	1.91	
UNIT ΔP	PSI	.033		.034	.029	.029	.032	
UNIT ΔH	FT	1.06		1.09	0.93	0.93	1.03	
MOTOR WINDING TEMP °F		-416	2/2/69	-416	-416	-416	-416	2/4/69
CURRENT								
PHASE A	ma	104.0		104.0	104.0	104.0	103.5	
PHASE B	ma	104.0	B5-4-12	103.6	103.5	103.0	104.0	B5-4-14
PHASE C	ma	103.5		103.2	103.2	103.5	103.0	
POWER								
PHASE A	watts	.85		.85	.85	.85	.85	
PHASE B	watts	.80		.90	.90	.90	.90	
PHASE C	watts	.85		.85	.85	.85	.85	
VOLTAGE L-L								
PHASE A		208		208	208	208	208	
PHASE B		208		208	208	208	208	
PHASE C		208		208	208	208	208	
FREQUENCY	CPS	400		400	400	400	400	
INLET TEMP.	°F	-422		-422	-422	-422	-422	
DEWAR PRESS.	PSI	14.7		14.7	14.7	14.7	14.7	
MOLDOUT FRAME /								

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test LIFE TEST (2nd GAS PHASE)

Reference Test Request 686 Para. 6.3.6

Test Engineer B. Milota Date 2,6,7,8/69
Test Cell B5-4 Run No. 16,17 & 18 Bar. Press. 29.36 "Hg
Test Unit Model No. 154204-100 Serial No. X-2139

Power: 3 Phase Sine Wave
Pump Fluid Gaseous Hydrogen Aux. Drive
Run Time 45 hrs/903 starts Sec-
Min

Test Unit Description Destratification Motor-Impeller Unit

Purpose To demonstrate 225 hours of Life Testing

Comments 2/6/69 The 2nd Gas Phase was started at 08:30 hrs, and
ran thru 2/8/69 to complete 900 cycles in the 2nd
Gas Phase. Test was done to TR 686 Para. 6.3.6

(P 110)
B. Milota
2/11/69



Pesco Products

DIVISION OF BORG WARNER CORPORATION 24700 N MILES ROAD, BEDFORD, OHIO

LIFE CYCLE TEST (2ND GAS PHASE)

TEST No. B5-4-16, 17, 18

DATE 2/6, 7, 8/69

CYCLE NO.		1	77	128		400	485	519
TIME OF DAY		08:30	13:00	16:00		08:00	13:00	15:00
TOTAL RUN TIME	MIN	3	231	384		1200	1455	1557
UNIT SPEED	RPM	5970	5960	5960		5970	5970	5970
MOTOR WINDING TEMP	°F	86	132	137		144	142	142
CURRENT								
PHASE A	ma	99.0	97.0	97.0		99.0	97.0	97.0
PHASE B	ma	99.0	97.0	97.0		99.0	97.0	97.0
PHASE C	ma	98.0	96.3	96.2		99.0	96.0	96.0
POWER								
PHASE A	watts	5.25	5.57	5.60		5.37	5.75	5.75
PHASE B	watts	5.30	5.70	5.70		5.45	5.80	5.80
PHASE C	watts	5.17	5.55	5.55		5.35	5.65	5.65
VOLTAGE L-L								
PHASE A		208	208	208		208	208	208
PHASE B		208	208	208		208	208	208
PHASE C		208	208	208		208	208	208
FREQUENCY	CPS	400	400	400		400	400	400
INLET TEMP.	°F	38	56	57		61	61	61
DEWAR PRESS.	PSI	14.4	14.4	14.4		14.4	14.4	14.4
FOLDOUT FRAME								

2/6/69
B5-4-16

2/7/69
B5-4-17

17

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test LIFE TEST (3rd LIQUID PHASE)

Reference Test Request 686 Para. 6.3.6

Test Engineer B. Milota Date 2,8,9/69
Test Cell B-5-4 Run No. 19 & 20 Bar. Press. 29.46 "Hg
Test Unit Model No. 145204-100 Serial No. X-2139

Power: 3 Phase Sine Wave

Pump Fluid Liquid Hydrogen Aux.-Drive

Run Time 22.5 hrs./450 starts Sec
Min

Test Unit Description Destratification Motor-Impeller Unit

Purpose To demonstrate 225 hours of Life Testing

Comments 2/8/69 Started 3rd Liquid Phase at 1900 hrs, and ran
thru 2/9/69 to complete 450 cycles, and 22.5 hrs in
Liquid Hydrogen. Test run to TR 686 Para. 6.3.6

140

Handwritten notes:
2-8-69
2-9-69
2

Rec: 4.64

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test LIFE TEST (3rd GAS PHASE)

Reference Test Request 686 Para. 6.3.6

Test Engineer B. Milota Date 2, 10, 11/69
Test Cell B5-4 Run No. 21 & 22 Bar. Press. 29.58 "Hg
Test Unit Model No. 145204-100 Serial No. X-2139

Power: 3 Phase Sine Wave

Pump Fluid Gaseous Hydrogen Aux.-Drive
Run Time 22.5 hrs./450 starts Sec
Min

Test Unit Description De-stratification Motor-Impeller Unit

Purpose To demonstrate 225 hrs of Life Testing.

Comments 2/10/69 Started 3rd Gas Phase at 11:15 hrs, and ran thru
2/11/69 to complete 450 cycles and 22.5 hours of Life Testing.
Test run to TR 686 Para. 6.3.6

P
143

Handwritten notes:
11. 11/11/69
A - 4 - 2 - 1
J - 1



Pesco Products

DIVISION OF BORG WARNER CORPORATION 24700 N MILES ROAD, BEDFORD, OHIO

LIFE CYCLE TEST (3RD GAS PHASE)
TEST No. B5-4-21, 22
DATE 2/10, 11/69

CYCLE NO,		1	8	73		362	379	396	4
TIME OF DAY		11:15	11:40	15:30		09:30	10:30	11:30	14
TOTAL RUN TIME	MIN	3	24	219		1086	1137	1188	13
UNIT SPEED	RPM	5960	5960	5960		5950	5960	5960	59
MOTOR WINDING TEMP °F		---	---	---		139	139	139	14
CURRENT									
PHASE A	ma	99.0	96.2	98.0		97.0	97.0	97.0	97
PHASE B	ma	99.0	96.2	95.8		97.0	97.0	97.0	97
PHASE C	ma	98.5	95.8	97.5		96.5	96.5	96.5	96
POWER									
PHASE A	watts	5.55	5.45	5.38		5.75	5.75	5.75	5.
PHASE B	watts	5.60	5.50	5.40		5.80	5.80	5.80	5.
PHASE C	watts	5.55	5.45	5.45		5.65	5.75	5.75	5.
VOLTAGE L-L									
PHASE A		208	208	208		208	208	208	20
PHASE B		208	208	208		208	208	208	20
PHASE C		208	208	208		208	208	208	20
FREQUENCY	CPS	400	400	400		400	400	400	40
INLET TEMP.	°F	52	52	59		57	57	57	58
DEWAR PRESS.	PSI	14.5	14.5	14.5		14.3	14.3	14.3	14
HOLDOUT FRAME!									

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test POST LIFE - CALIBRATION

Reference Test Request 686 Para. 6.3.7

Test Engineer B. Milota Date 2/12/69
Test Cell B5-4 Run No. 23 Bar. Press. 29.06 "Hg
Test Unit Model No. 145204-100 Serial No. X-2139

Power: 3 Phase Sine Wave
Pump Fluid Liquid Hydrogen Aux. Drive
Run Time 59 min./2 starts Sec
Min

Test Unit Description Destratification Motor-Impeller Unit

Purpose To perform a unit calibration after 225 hrs. of Life Testing.

Comments Phase "A" was a unit calibration run consisting of
14 various flows from minimum to maximum run time. 53 min./1 start.
Phase "B" was run to check the maximum flow point,
run time 7 min/1 start



Handwritten notes:
4.11.66
7-69
7



Pesco Products

DIVISION OF BORG WARNER CORPORATION 24700 N MILES ROAD, BEDFORD, OHIO

CALIBRATION LIQUID HYDROGEN

TEST No. B5-4-23

DATE 2/12/69

(AFTER L

TEST PHASE		A-1	A-2	A-3	A-4	A-5	A-6	A-7
UNIT SPEED	RPM	5950	5960	5950	5950	5950	5950	5950
UNIT FLOW	GPM	11.6	11.8	12.6	13.0	13.5	13.8	13.9
UNIT FLOW	CFM	1.55	1.58	1.68	1.74	1.80	1.84	1.86
UNIT ΔP	PSI	.041	.046	.041	.037	.033	.035	.033
UNIT ΔH	FT	1.32	1.48	1.32	1.19	1.06	1.13	1.06
MOTOR WINDING TEMP	$^{\circ}F$	-402	-402	-402	-402	-402	-402	-402
CURRENT								
PHASE A	ma	103.0	103.8	103.8	103.6	103.5	103.4	103.
PHASE B	ma	102.9	103.5	103.4	103.3	103.0	103.0	103.
PHASE C	ma	102.5	103.2	102.9	103.0	103.0	102.9	102.
POWER								
PHASE A	watts	.75	.75	.75	.75	.75	.75	.75
PHASE B	watts	.80	.80	.80	.80	.80	.80	.79
PHASE C	watts	.75	.80	.75	.75	.75	.75	.74
VOLTAGE L-L								
PHASE A		208	208	208	208	208	208	208
PHASE B		208	208	208	208	208	208	208
PHASE C		208	208	208	208	208	208	208
FREQUENCY	CPS	400	400	400	400	400	400	400
INLET TEMP.	$^{\circ}F$	-408	-408	-408	-408	-408	-408	-408
DEWAR PRESS.	PSI	14.3	14.3	14.3	14.3	14.3	14.3	14.3
LIQUID LEVEL	IN	27.4	27.4	27.3	27.2	27.1	27.0	26.9
FOLDOUT FRAME /								

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test LIFE TEST IN LN₂

Reference Test Request 686 Para. 6.3

Test Engineer B. Milota Date 1/21/69 to 2/2/69
Test Cell B4-3 Run No. 39 to 51 Bar. Press. 29.44 "Hg
Test Unit Model No. 145204-100 Serial No. X 2138

Power 3 phase sine wave

Pump Fluid Liquid nitrogen Aux. Drive

Run Time 22165 hrs./4433 starts See Min

Test Unit Description Destratification Motor-Impeller Unit

Purpose To demonstrate 225 hrs. of life testing in Liquid Nitrogen.
Per. -Mil-P-27401-A

Comments Started life testing at 1120 hrs. on 1/21/69. Unit ran thru
2/2/69, at which time the unit was shut down.
A total of 4440 cycles have been made as of this date.
Shut down was due to a late LN₂ delivery.



Bernard A. Milota
2-13-69

TEST RECORD

CRYOGENIC LABORATORY
PESCO PRODUCTS DIVISION
Borg-Warner Corporation

Sheet ___ of ___

Type of Test LIFE TEST IN LN₂

Reference Test Request 686 Para. 6.3

Test Engineer B. Milota Date 2/6/69
Test Cell B4-3 Run No. 52 Bar. Press. 29.26 "Hg
Test Unit Model No. 145204-100 Serial No. X 2138

Power: 3 phase sine wave

Pump Fluid Liquid Nitrogen ~~Aux. Drive~~
Run Time 4.25 hrs./85 starts ~~Sec~~
Min

Test Unit Description Destratification Motor-Impeller Unit

Purpose To complete 225 hrs. of life testing in LN₂

Comments Started unit at 1500 hrs. Unit shut down at 2000 hrs.
This completes 225 hrs. of life testing in LN₂



B. Milota
2-13-69

CYCLE NO.		1	47	79		313	381	440	
TIME OF DAY		11:22	14:05	16:00		08:00	12:00	15:30	
TOTAL RUN TIME	MIN	3	141	237		939	1143	1320	
UNIT SPEED	RPM	5660	5680	5680		5710	5710	5710	
CURRENT									
PHASE A	ma	109.5	109.4	109.5		109.0	109.0	108.0	
PHASE B	ma	109.0	109.4	109.4		109.0	109.0	108.5	
PHASE C	ma	108.5	108.8	108.5		108.5	108.5	107.5	
POWER									
PHASE A	watts	3.25	3.30	3.25		3.15	3.15	2.95	
PHASE B	watts	3.40	3.40	3.40		3.25	3.20	3.10	
PHASE C	watts	3.35	3.33	3.25		3.17	3.15	3.05	
VOLTAGE L-L									
PHASE A		208	208	208		208	208	208	
PHASE B		208	208	208		208	208	208	
PHASE C		208	208	208		208	208	208	
FREQUENCY	CPS	400	400	400		400	400	400	
DEWAR PRESS.	PSI	14.5	14.5	14.5		14.5	14.5	14.5	
NOTE: MINIMUM LIQUID LEVEL WAS 14.5 IN ABOVE INLET									
FOLDOUT FRAME /									

1/21/69
 B4-3-39
 BARO. 29.44 in hg

1/22/69
 B4-3-40
 BARO. 29.48 in hg

1/23/69
 B4-3-41
 BARO. 29.32 in hg



Pesco Products

DIVISION OF BORG WARNER CORPORATION 24700 N. MILES ROAD, BEDFORD, OHIO

LIFE CYCLE TEST (LN₂)

TEST No. B4-3-44, 45, 46, 47, 48

DATE 1/26, 27, 28, 29, 30/69

CYCLE NO.		1900		2197	2290	2298		2558	
TIME OF DAY		14:30		08:00	13:30	14:00		08:00	1
TOTAL RUN TIME	MIN	5700		6537	6870	6894		7674	7
UNIT SPEED	RPM	5670		5700	5710	5660		5660	5
CURRENT									
PHASE A	ma	112.0		109.0	109.2	109.2		109.0	1
PHASE B	ma	111.5		108.8	109.0	109.0		108.8	1
PHASE C	ma	111.0	1/26/69	108.2	108.5	108.5	1/27/69	108.5	1
POWER									
PHASE A	watts	3.35		3.15	3.10	3.25		3.15	3
PHASE B	watts	3.40		3.20	3.15	3.30		3.20	3
PHASE C	watts	3.30	B4-3-44	3.15	3.10	3.25	1/28/69	3.18	3
VOLTAGE L-L									
PHASE A		208		208	208	208		208	2
PHASE B		208		208	208	208		208	2
PHASE C		208		208	208	208		208	2
FREQUENCY	CPS	400		400	400	400		400	4
DEWAR PRESS.	PSI	14.5		14.7	14.7	14.7		14.6	1
NOTE: MINIMUM LIQUID LEVEL WAS 14.5 IN. ABOVE INLET									
FOLDOUT FRAME /									

CYCLE NO,		3667	3735	3786		4160	4164	4168	
TIME OF DAY		08:00	12:00	15:00		15:15	15:30	15:45	
TOTAL RUN TIME	MIN	11001	11205	11358		12480	12492	12504	
UNIT SPEED	RPM	5710	5670	5670		5670	5670	5670	
CURRENT									
PHASE A	ma	108.0	110.0	109.0		109.0	109.0	109.0	
PHASE B	ma	108.0	110.0	108.5		109.0	109.0	109.0	
PHASE C	ma	108.0	109.5	108.0		109.0	108.5	109.0	
POWER									
PHASE A	watts	3.15	3.35	3.31		3.25	3.25	3.25	
PHASE B	watts	3.00	3.30	3.30		3.30	3.30	3.30	
PHASE C	watts	3.05	3.35	3.25		3.25	3.25	3.25	
VOLTAGE L-L									
PHASE A		208	208	208		208	208	208	
PHASE B		208	208	208		208	208	208	
PHASE C		208	208	208		208	208	208	
FREQUENCY	CPS	400	400	400		400	400	400	
DEWAR PRESS	PSI	14.6	14.6	14.6		14.5	14.5	14.5	
NOTE: MINIMUM LIQUID LEVEL WAS 14.5 IN ABOVE INLET									
FOLDOUT FRAME									

1/31/69
 B4-3-49
 BARO. 29.68

2/1/69
 B4-3-50

2/2/69
 B4-3-51

UNIT SER.No. X-2138
 MODEL No. 145204-100

LTR 686 / Acc 4.72
 PARA. 6.10

68		4302	4306	4310	4433		4434	4442	4518
:45		14:30	14:45	15:00	22:00		15:00	15:30	20:00
504		12906	12918	12930	13299		13302	13326	13554
70		5710	5710	5710			5650	5650	5650
					Unit stopped low on LN ₂				
9.0		108.5	108.0	108.5			110.0	110.0	110.0
9.0		108.0	108.0	108.0			110.0	110.2	110.1
9.0	2/2/69	107.5	107.5	108.0		2/6/69	110.0	110.2	110.2
25	B4-3-51	3.05	3.03	3.05		B4-3-52	3.40	3.45	3.45
30		3.10	3.10	3.10		BARO. 29.26	3.50	3.50	3.50
25		3.05	3.01	3.05			3.35	3.37	3.35
8		208	208	208			208	208	208
8		208	208	208			208	208	208
8		208	208	208			208	208	208
0		400	400	400			400	400	400
.5		14.5	14.5	14.5			14.4	14.4	14.4
NLET							NOTE: TOTAL RUNNING		
							TIME WAS 225.9 HOURS		
							W/OUT FRAM 2		

4.4 Acceptance Tests

Acceptance tests were conducted on all shipper units except Serial Number X2132 which was shipped cleaned but in "as is" condition after development testing. Shipper units were tested in liquid nitrogen only. Testing proceeded according to Pesco Test Procedure TR693. This test procedure is included as Appendix II. All of the shipper units successfully passed all paragraphs of this test document.

SECTION 5.0
QUALITY ASSURANCE

The quality control function at Pesco has participated in all phases of the de-stratification motor-impeller program, from the initial contract review through delivery of completed units.

During the design phase of the program, Quality Control and Design Engineering coordinated their activities closely.

Later, Quality Control participated in the preliminary design review which was held at Pesco, March 29, 1968. The results of this design review were published in Technical Memorandum No. 2740.

Cleaning procedures, Number QC-110-6 and QC110-8, were prepared, based on NASA specification MSFC-SPEC-164, and submitted as part of monthly progress report Number 1.

A Quality Control program inspection plan was prepared and submitted to NASA. This document outlined Quality Control Procedures and Controls for each manufacturing, inspection and test area.

As drawings were released, Quality Control coordinated with Manufacturing-Engineering in the preparation of the work order and routing forms (Process and Planning) to be utilized on this program.

Pesco Reliability and Quality Control conducted a critical characteristic review. The results were published in monthly progress report Number 4.

In general, it is felt that all the Pesco departments involved worked closely together on this program, thereby making the effort a success.

SECTION 6.0

RELIABILITY

Since the initiation of the project, on March 5, 1968, Pesco Reliability Department was involved in the following activities on the destratification motor-impeller unit, Pesco Model No. 145204-100:

March 19, 1968

Preliminary reliability mathematical model, in accordance with exhibit "B", paragraph 2.3 of Contract NAS9-7770. The inherent reliability of the motor-impeller unit was estimated to be 49,600 hours MTBF. (Pesco Engineering Report No. 5279 dated March 19, 1968)

March 29, 1968

Preliminary design review was held prior to the detailing of parts and sub-assemblies. The meeting was attended by Engineering, Design, Metallurgy, Quality Control, and Reliability. (Pesco Technical Memorandum No. 2740 dated April 9, 1968)

May 22, 1968

Failure Mode and Effects Analysis was completed in accordance with exhibit "B" paragraph 3.4 of Contract NAS9-7770. This deals with all the components and subassemblies of the unit; their failure modes, effects of these failure modes at the unit level and the design features which should compensate for the above failure modes and effects. (Pesco Engineering Report No. 5299 dated May 22, 1968)

June 24, 1968

Critical dimensions analysis was conducted by Reliability in association with Quality Control. (Progress Report No. 4 dated June 24, 1968)

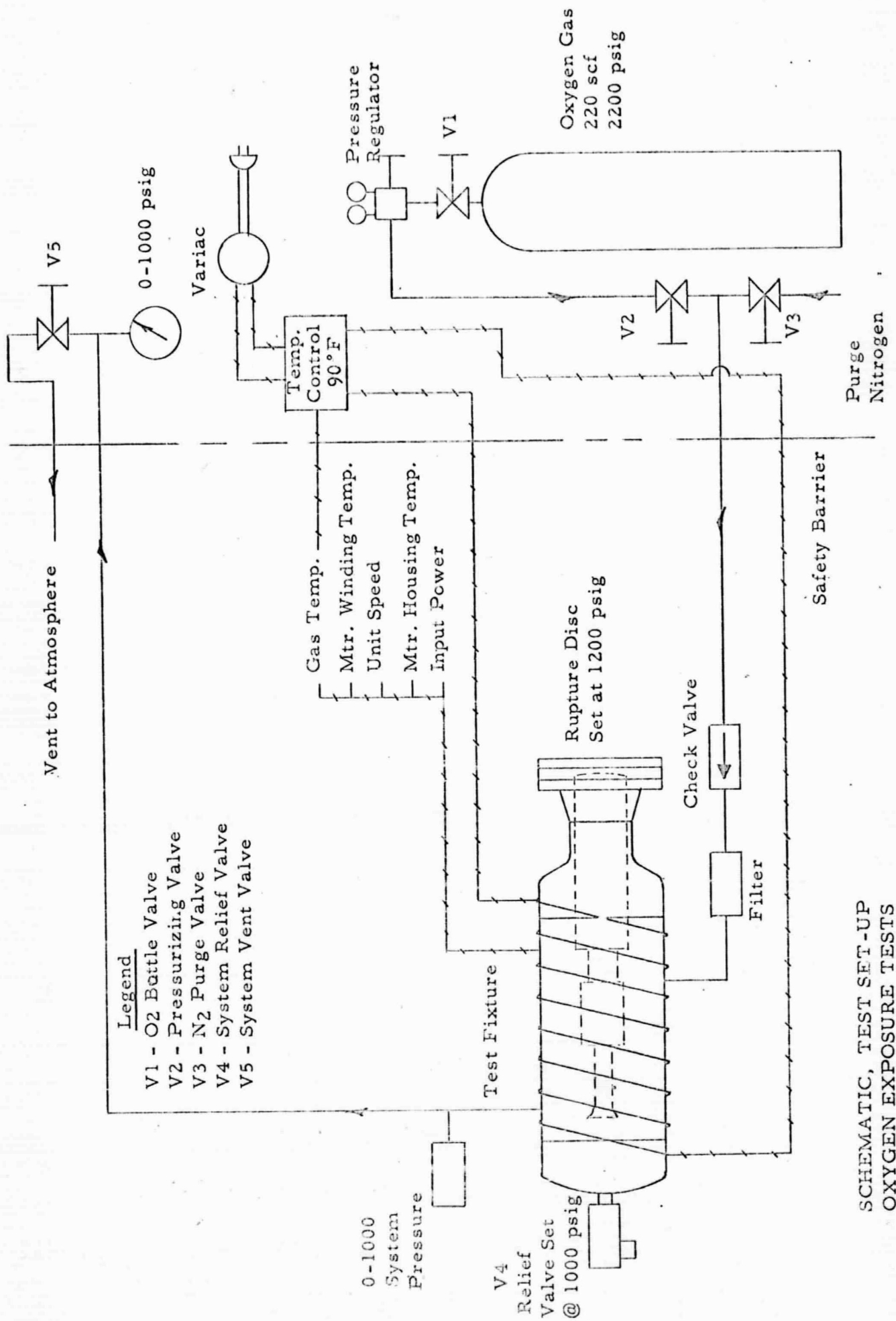
December 2, 1968

Final Failure Rate, and Failure Modes and Effects Analysis was prepared in accordance with exhibit "B" paragraph 2.3 of Contract NAS9-7770. The inherent reliability of the unit was estimated to be 59,170 hours MTBF. The critical items according to the analysis are listed as follows:

<u>Subassembly Part</u>	<u>Failure Mode</u>
Ball Bearings	Bearing Seizure
Shaft	Fracture
Impeller	Gall and Seizure
Stator Assembly	Shorted or Grounded Windings

Pesco has recorded a total run time of about 700 hours and 13,765 starts on nine centrifugal pumps, and has recorded no failures on any components of the units. Three of these units have recorded a total run time of 230 hours each. The tests consisted of all possible fluid media of hydrogen, nitrogen and oxygen. The temperature cycling was about 600°F in magnitude, and none of the critical items listed above showed any signs of deterioration.

Pesco intends to update the failure rates of the above mentioned critical items if any field data is made available to them.



SCHEMATIC, TEST SET-UP
OXYGEN EXPOSURE TESTS

FIGURE I

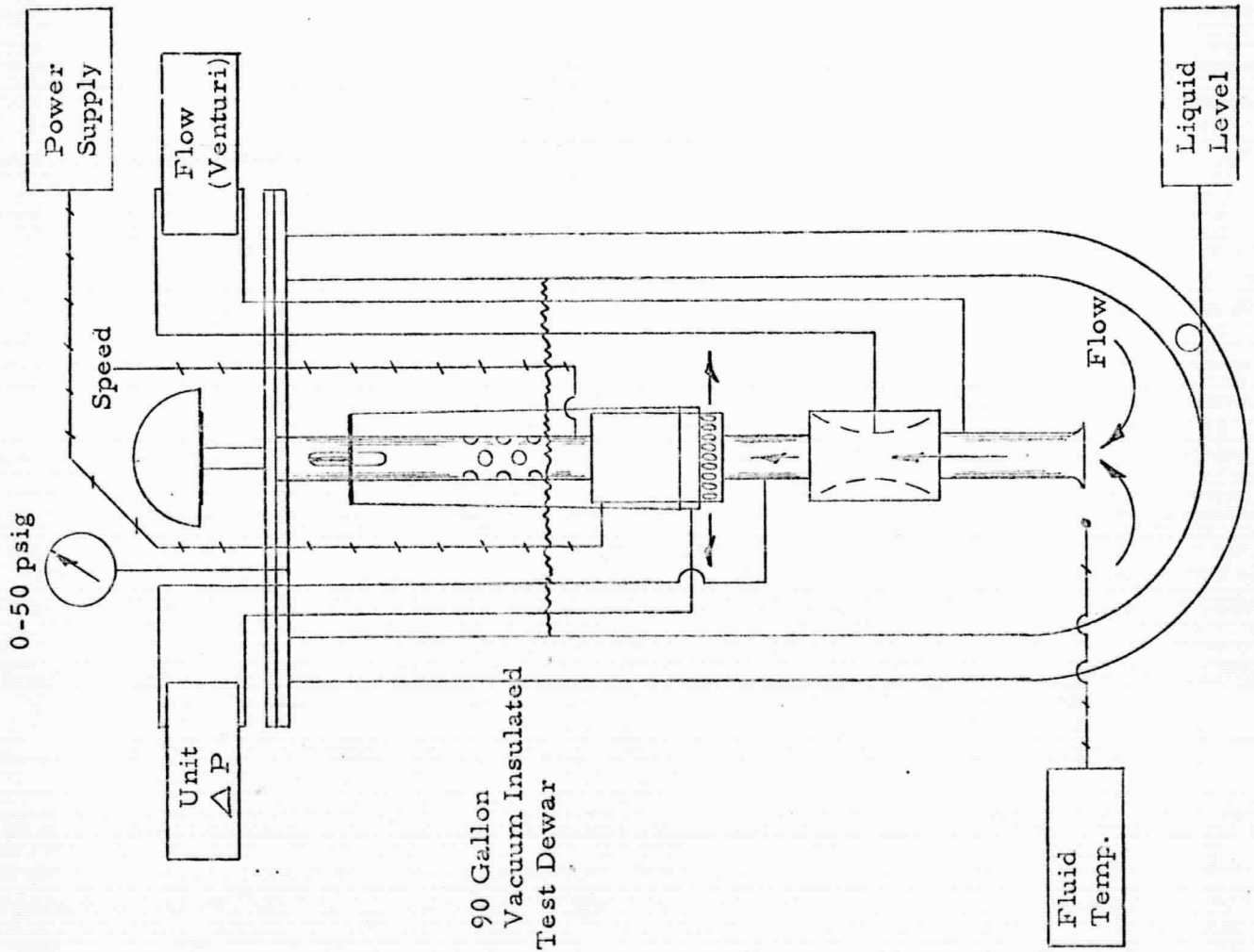
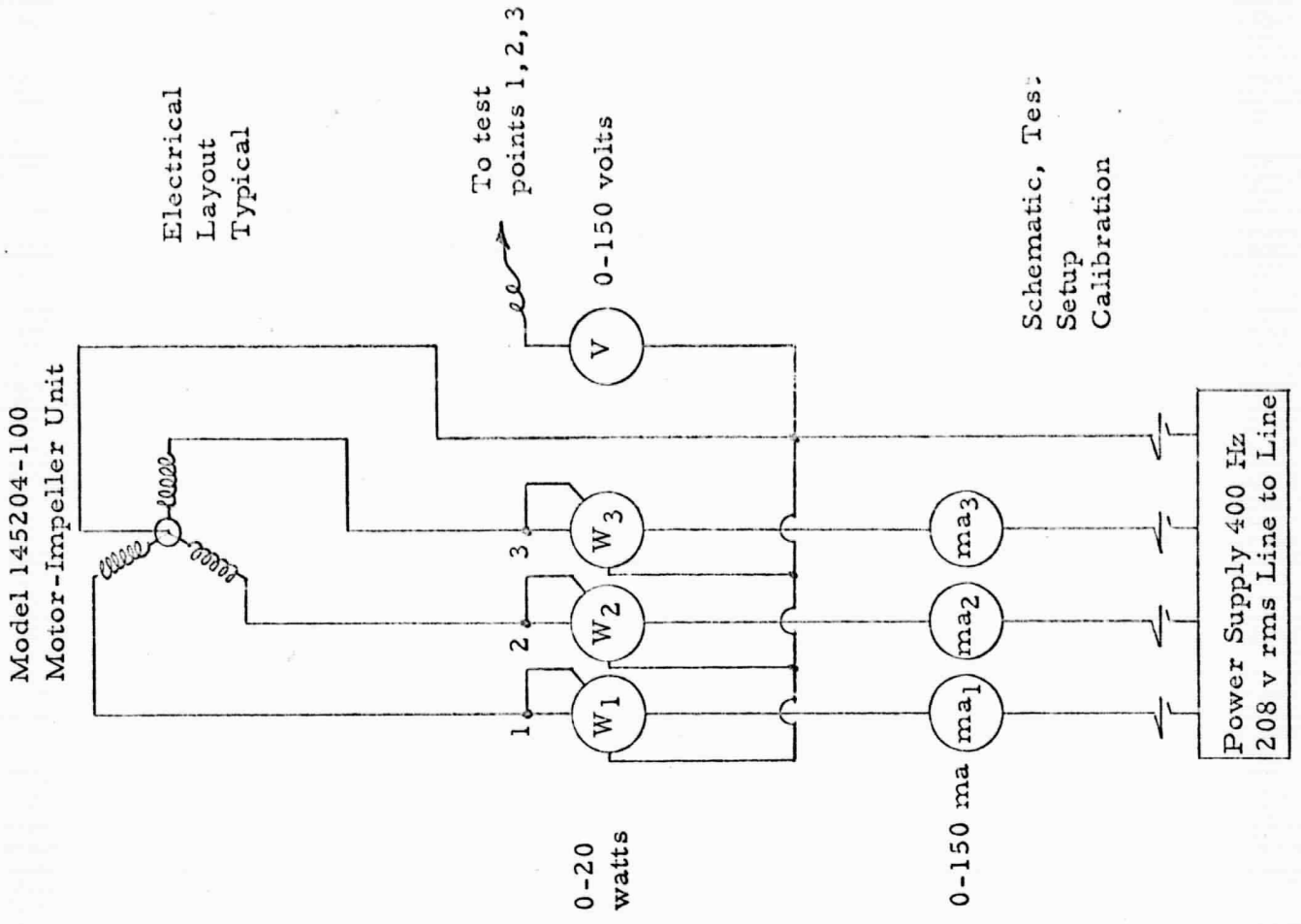
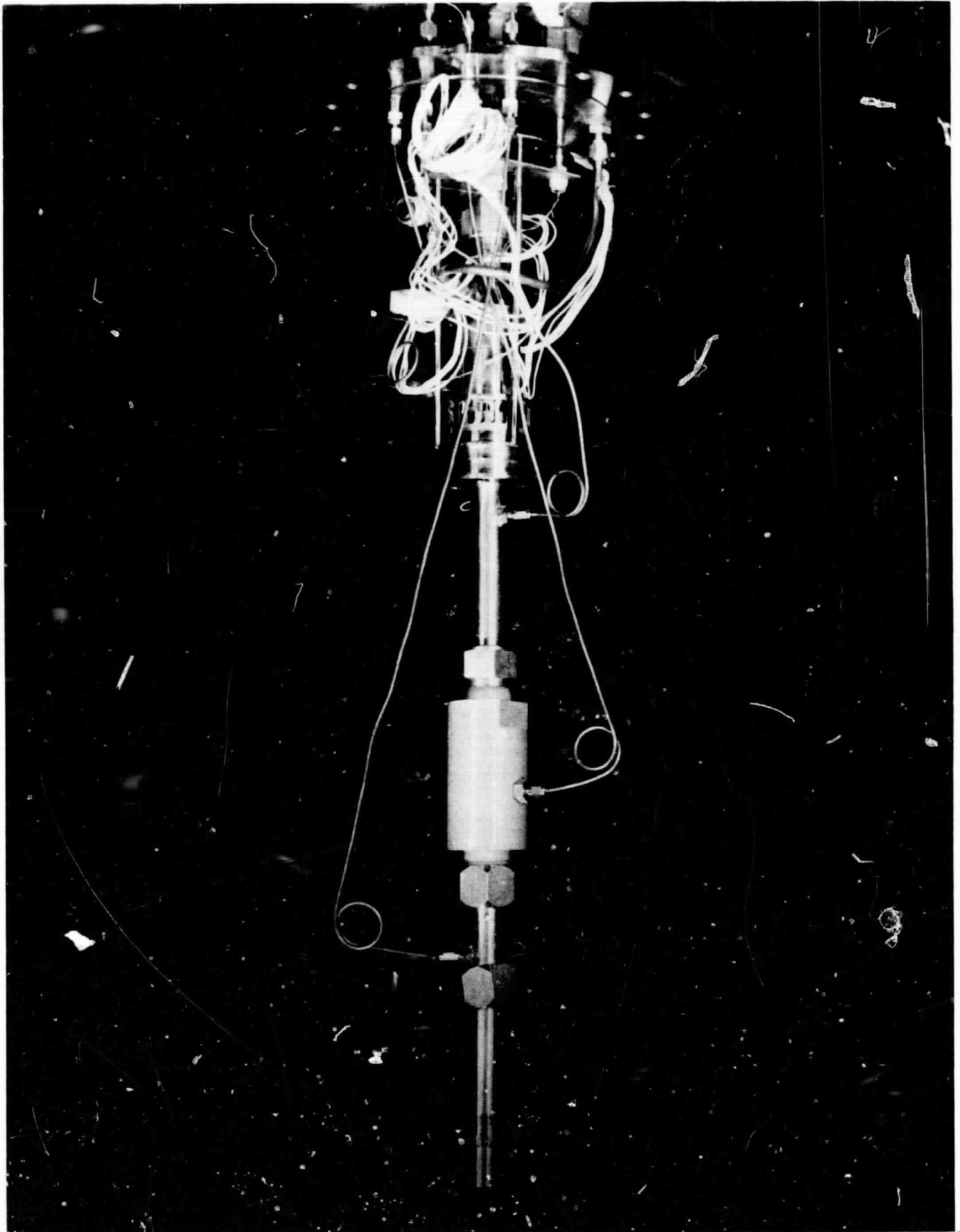
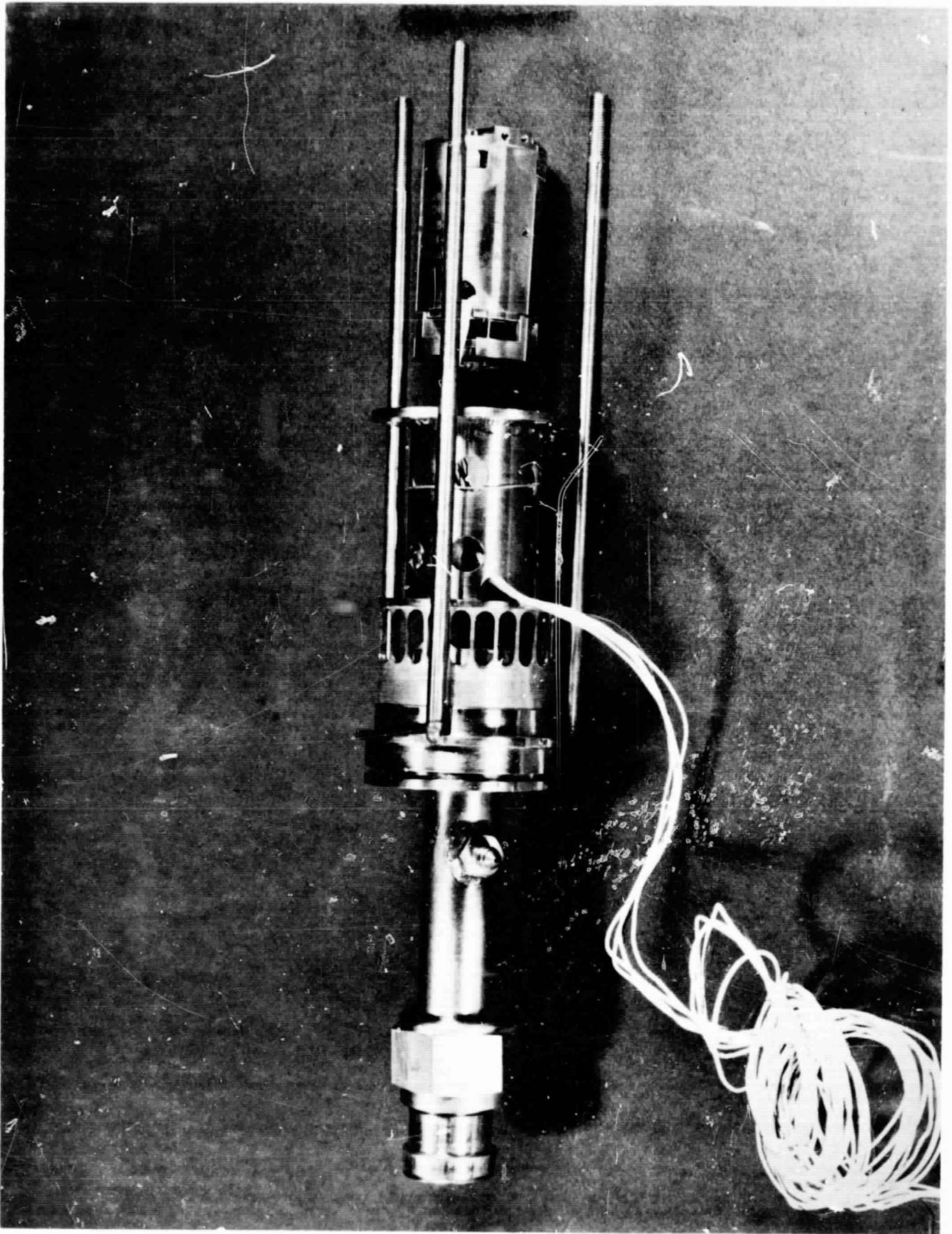


FIGURE 2



Photograph, Test Set-up, Calibration



Photograph, Test Set-up, Calibration, Exploded

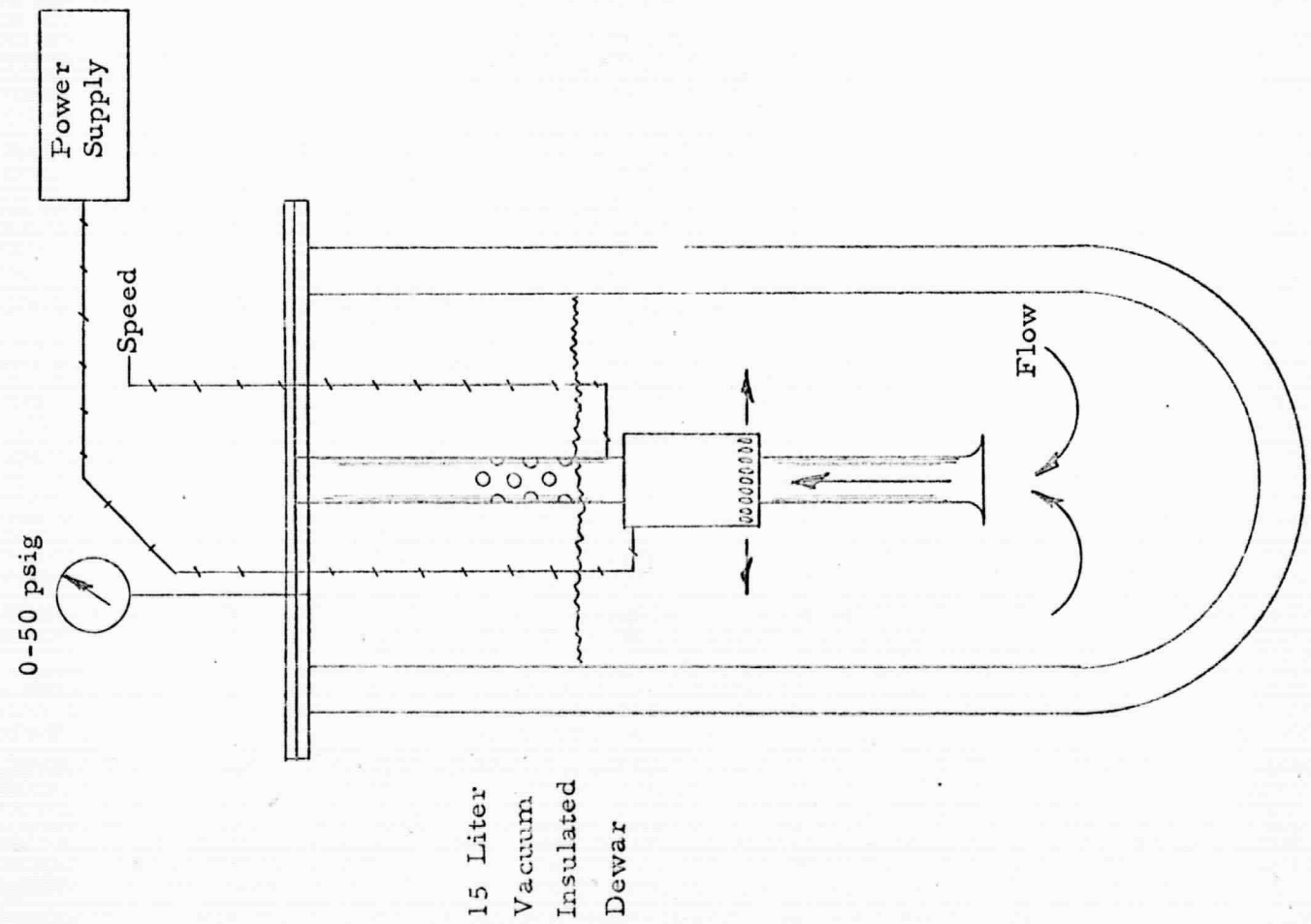
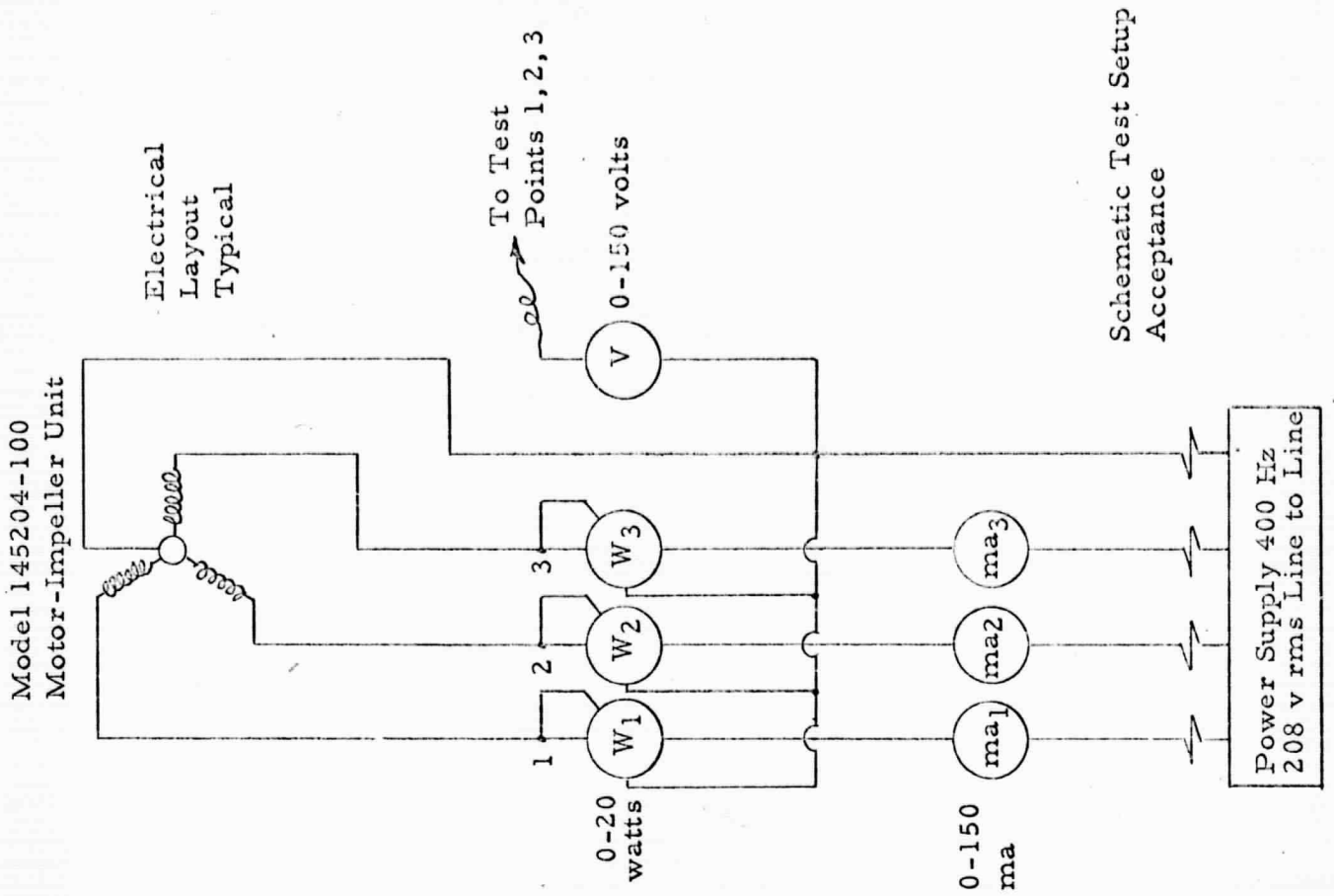
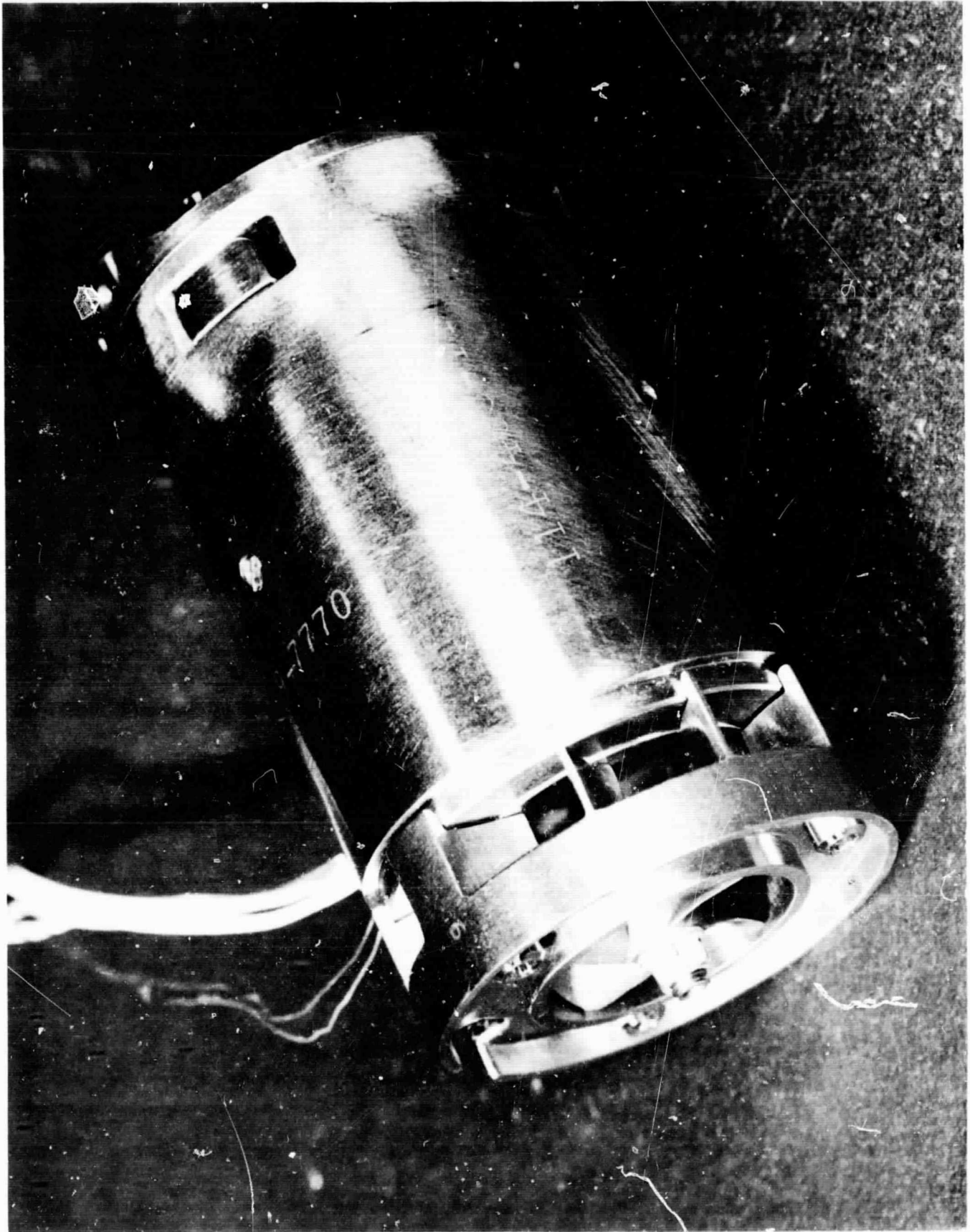


FIGURE 5



Photograph. Destratification Motor-Impeller Unit 145204-100

Engineering Report 3620

APPENDIX I

TEST REQUEST TR686

No. TR 686
Original Issued 4/17/68
Date Revised 12/16/68
Revision A
Page 1 of 18

COMPOSITE TEST PROCEDURE

PESCO MODEL 145204-100

DESTRATIFICATION MOTOR-IMPELLER UNIT

Prepared by J.R. Hamm Title Sr. Development Engineer
J.R. Hamm

Approved by L. J. Schafer Title Manager - Cryogenics and Pneumatics
L. J. Schafer

Approved by John F. DiStefano Title Director of Engineering
John F. DiStefano JFS

Approved by J.A. Moffitt
Pesco Quality Control

Coordinated with Earl Lynn
DCASR Resident



No. TR 686
Original Issued 4/17/68
Date Revised 12/16/68
Revision A
Page 2 of 18

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2.0	APPLICABLE DOCUMENTS	3
3.0	REFERENCE DOCUMENTS	3
4.0	GENERAL INSTRUCTIONS	4
5.0	OXYGEN EXPOSURE TESTS	5
	5.1 Operational Test	5
	5.2 Locked Rotor Test	6
6.0	DESIGN VERIFICATION TESTS	8
	6.1 Motor Tests (Electrical Tests)	8
	6.2 Calibration Tests	8
	6.3 Life Tests	11
7.0	ACCEPTANCE TESTS	13
8.0	PREPARATION FOR DELIVERY	14

FIGURES

- Figure 1 System, test, oxygen gas, high pressure
- Figure 2 Calibration Test Fixture
- Figure 3 Test setup, calibration, oxygen and hydrogen, typical
- Figure 4 List, Instrumentation, composite

REVISION SHEET

<u>Rev.</u>	<u>Date</u>	<u>Page</u>	<u>Para.</u>	<u>Revision</u>	<u>Reason</u>
A	12/16/68	2	-	Correct list of figures	Eliminate redundant figures
		6	5.1.12	Reduce motor winding temperatures to one	To comply with actual test method
		8	6.1	Add ambient condition note	Customer request for clarity
		9	6.2.1	Add note permitting air test	Improved accuracy in calibration
		10	6.2.2	Add note permitting air test	Improved accuracy in calibration
		12	6.3.9	Added data required for life test	Improved clarity
		13	6.3.10	Add test requirement for third life unit	Modification 4 to contract
		13	-	Eliminate section 7.0 Dealing with acceptance test	Modification 4 to contract

No. TR 686
Original Issued 4/17/68
Date Revised 12/16/68
Revision A
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1.0 SCOPE

This document specifies the testing and test methods to be used in determining compliance of Pesco Model 145204 Destratification Motor-Impeller unit with the requirements of NASA Contract NAS 9-7770.

2.0 APPLICABLE DOCUMENTS

2.1 National Aeronautics and Space Administration Negotiated Contract No. NAS 9-7770, Exhibits A and B.

2.2 Pesco Products Division of Borg-Warner Corporation Proposal for Design, Fabrication and Design Verification Testing of a Destratification Motor-Impeller Model 145204-100.

2.3 Pesco Products, Division of Borg-Warner Corporation Drawing Number 145204-100, unit outline and assembly destratification motor-impeller.

3.0 REFERENCE DOCUMENTS

3.1 Pesco Products, Division of Borg-Warner Corporation, Quality Control Measuring Device Manual No. 1002.

3.2 Pesco Products, Division of Borg-Warner Corporation, Quality Control Procedure for Precision Cleaning of Liquid Oxygen, Liquid Hydrogen and Liquid Helium Components for Space Vehicles and Ground Support Equipment, QC-110-6.

3.3 Pesco Products, Division of Borg-Warner Corporation, Quality Control Specification, Packaging of Precision Cleaned Liquid Hydrogen and Liquid Oxygen Pump Units for Space Vehicles, QC-110-14.



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3.4 Pesco Products, Division of Borg-Warner Corporation, Quality Control Procedure, Packaging Procedure for Liquid Hydrogen and Liquid Oxygen Pumps, QC 110-15.

4.0 GENERAL INSTRUCTIONS

4.1 Prior to start of testing, provide visual inspection of the unit. Note any discrepancies of unit on test report.

4.2 Evacuate test systems to less than 2 mm Hg for 30 minutes minimum prior to propellant filling.

4.3 Start all recorders prior to starting unit.

4.4 All instrumentation shall be maintained in calibration according to MIL-C-45662A, Military Specification, Calibration System Requirements, and Pesco Document Measuring Device Manual 1002.

4.5 All test runs shall be included and suitably identified in the test report.

4.6 Notify NASA resident representative and Pesco quality control engineering at least four (4) hours prior to start of testing.

4.7 Notify Bedford engineering prior to discontinuing any test.

4.8 Re-run of any questionable test sequence is permissible at the discretion of the test engineer with prior approval of the project engineer.

4.9 Failure Discrepancy Reports shall be initiated by the Perry Laboratory as required.

4.10 Units shall be stored in shipping containers when not installed in test systems.



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4.11 Approved lint-free gloves shall be worn at all times when installing or handling test units.

4.12 Electrical input to unit for all test phases to be as follows:

Current-sinusoidal alternating	Power 35 watts maximum
Frequency 400 ± 15 Hz	Phase to phase voltage 208 ± 2 v ac
Number of Phases 3	Phase to neutral voltage 120 ± 1 v ac

5.0 OXYGEN EXPOSURE TESTS

5.1 Operational Testing

5.1.1 Mount the unit in the 500 in³ high pressure test fixture, Figure 1, This operation to be performed in the Perry Laboratory controlled environment bench.

5.1.2 Pressurize the sealed test fixture to approximately 5 psig using filtered nitrogen gas per MIL-P-27401, Type 1.

5.1.3 With the unit installed in the high pressure test fixture, connect the fixture to system as shown in Figure 2.

5.1.4 With unit installed and instrumented per Figure 1, pressurize the fixture to 100 psig using nitrogen gas as in 5.1.2.

5.1.5 When it has been determined that the test system is free from leaks, vent fixture internal pressure to atmospheric.

5.1.6 Using high purity oxygen gas per MIL-P-25508C purge the test fixture and system for 5 minutes at a low gas flow rate.

5.1.7 Close system vent and slowly raise fixture internal pressure to approximately 800 psig while continuously monitoring fixture temperature.



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5.1.8 Stabilize fixture internal temperature at $90 \pm 5^\circ\text{F}$ using the electric heater coil and automatic temperature control.

5.1.9 Bring system to test equilibrium conditions of $90 \pm 5^\circ\text{F}$ and 885 ± 5 psig (900 ± 5 psia).

5.1.10 Apply input power to the unit per Para. 4.12, and operate until motor winding temperatures stabilize or until 60 minutes running time is accumulated.

5.1.11 At conclusion of test slowly vent fixture to atmospheric pressure and purge with nitrogen gas for 5 minutes.

5.1.12 Record and/or tabulate the following data at start, shut-down and at 5 minute intervals during test:

- a) Unit speed rpm
- b) Motor winding temperatures $^\circ\text{F}$
- c) Fixture internal gas temperature $^\circ\text{F}$
- d) Input voltage (3 phases) v ac rms
- e) Input current (3 phases) amps rms
- f) Input power (3 phases) watts
- g) Power supply frequency cps

5.1.13 Data package to be supplied by Perry Lab

- a) Technician log and test record sheets
- b) Tabulation of all parametric measurements in 5.1.12
- c) Plot of winding temperatures and current versus time
- d) Calculate power factor at one typical data point

5.2 Locked Rotor Testing

5.2.1 With the unit shaft locked to prevent rotation, assemble the high pressure test fixture and prepare the test system as in paragraph 5.1.1 through 5.1.9.



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5.2.2 Apply input power to unit as per paragraph 4.12, and monitor motor winding temperatures continuously until either temperature indication reaches 225°F.

CAUTION: Provisions must be made to automatically interrupt input power if either winding temperature exceeds 250°F.

5.2.3 At conclusion of test, vent fixture to atmospheric pressure and purge with nitrogen gas for 5 minutes.

5.2.4 Continuously record the following parameters:

- a) Motor winding temperatures °F
- b) Fixture internal gas temperature (1) °F

5.2.5 Read and tabulate the following parameters at 30 second intervals:

- a) Input voltage (1 phase) vac rms
- b) Input current (1 phase) amps rms
- c) Input power (1 phase) watts

5.2.6 Data to be supplied by Perry Lab -

- a) Technician log and test record sheet
- b) Tabulation of all parametric measurements in paragraphs 5.2.4 and 5.2.5 at 30 second intervals.
- c) Plot of winding temperatures and current versus time.



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6.0 DESIGN VERIFICATION TESTS

6.1 Motor Tests (Electrical Laboratory - Bedford) (These tests to be performed at standard laboratory conditions)

6.1.1 Insulation Resistance - Apply 500 ± 50 v dc between all motor windings and ground. Insulation resistance shall be greater than 100 megohms. Record results on data sheet.

6.1.2 Dielectric Strength - Apply 1000 ± 100 v dc between all motor windings and ground for 1 minute then apply 500 ± 50 v ac at 60 Hz between all motor windings and ground for 1 minute. Current leakage shall not exceed 1.0 ma. Record results on data sheet.

6.1.3 Winding Resistance - Measure and record the DC resistance of all motor windings at room temperature. Individual winding resistance shall not exceed 750 ohms when measured to neutral.

6.1.4 Performance Test - With the unit at room temperature measure output and input and record results on test data sheet.

6.1.5 Saturation Test - Perform saturation tests per directions of electrical engineering.

6.2 Calibration Tests

6.2.1 Gaseous and Liquid Oxygen Tests

6.2.1.1 Mount the test unit in a suitable oxygen test system per Figure 3.

6.2.1.2 Evacuate the assembled test system to less than 2 mm Hg for approximately 30 minutes to eliminate air and moisture.

6.2.1.3 Raise system internal pressure with oxygen gas, per MIL-P-25508C, to 5 psig, and then vent to one atmosphere.



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6.2.1.4 With the system throttling device full open, apply power to the unit as per paragraph 4.12.

6.2.1.5 Perform a calibration test by varying throttle position in approximately 10 increments from full flow to zero flow. Add additional calibration points as required to obtain sufficient data to produce a smooth head versus capacity curve. Head and flow rate will be measured with water inclined manometers.

6.2.1.6 At conclusion of gaseous oxygen test, fill test system with liquid oxygen per MIL-P-25508C to a level of 12 inches above the unit inlet tube.

6.2.1.7 Repeat calibration per paragraphs 6.2.1.4 through 6.2.1.5.

6.2.1.8 Secure test system according to Perry Laboratory standard operating procedures.

6.2.1.9 Exercise caution when removing unit from test system to assure unit temperature is approximately equal to test cell ambient.

NOTE: It is permissible to repeat gas phase calibration in ambient air to obtain more accurate head versus capacity curves.

6.2.2 Gaseous and Liquid Hydrogen Tests

6.2.2.1 Mount the test unit in a suitable hydrogen test system per Figure 3.

6.2.2.2 Evacuate the assembled test system to less than 2 mm Hg for approximately 30 minutes to eliminate air and moisture.

6.2.2.3 Raise system internal pressure with hydrogen gas, per MIL-P-27201, to 5 psig, and then vent to one atmosphere.

6.2.2.4 With the system throttling device full open, apply power to unit as per paragraph 4.12.

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6.2.2.5 Perform a calibration test by varying throttle position in approximately 10 increments from full flow to zero flow. Add additional calibration points as required to obtain sufficient data to produce a smooth head versus capacity curve. Head and flow rate will be measured with inclined water manometers.

6.2.2.6 At conclusion of gaseous hydrogen test, fill test system with liquid hydrogen per MIL-P-27201C to a level of 12 inches above the unit inlet tube.

6.2.2.7 Repeat calibration per paragraph 6.2.1.4 through 6.2.1.5.

6.2.2.8 Secure test system according to Perry Laboratory standard operating procedures.

6.2.2.9 Exercise caution when removing unit from test system to assure unit temperature is approximately equal to test cell ambient.

NOTE: It is permissible to repeat gas phase calibration in ambient air to obtain more accurate head versus capacity curves.

6.2.3 Record and/or tabulate the following data at start, shut-down, and at each stabilized calibration point in paragraphs 6.2.1 and 6.2.2:

- a) Unit Speed rpm
- b) Motor winding temperature °F
- c) Unit fluid inlet temperature °F
- d) Input voltage (3 phases) v ac rms
- e) Input current (3 phases) amps rms
- f) Power supply frequency cps
- g) Input power (3 phases) watts
- h) Motor starting current (1 phase) amps pk
- i) Unit flow rate gpm/cfm
- j) Unit head rise ft
- k) Dewar pressure psig
- l) Liquid level above unit (liquid tests only) inches

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6.2.4 Data Package to be Supplied by Perry Laboratory

- a) Technician log and test record sheet
- b) Tabulation of all parametric measurements recorded during calibration tests
- c) Plot of heat-capacity for each calibration test
- d) Plot of motor winding temperature and current versus time
- e) Power factor, calculated at design flow point in each fluid

CAUTION: Provisions must be made to automatically interrupt input power motor winding temperature exceeds 250°F.

6.3 Life Tests

6.3.1 Mount two units, one in the oxygen test system, the other in the hydrogen system. Test setup to be per Figure 3 for both systems.

6.3.2 Life testing shall be performed on two units simultaneously, one in oxygen, the other in hydrogen. Fluid phase will be alternated during test per Table I, so as to provide equal accumulated test time in gas and liquid.

6.3.3 The life test shall consist of 225 hours total operating time and 4500 start-stops on each unit.

6.3.4 A duty cycle of 3.0 minutes ON and 0.5 minutes OFF shall be maintained semi-automatically during all life testing.

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6.3.5 Provide a unit calibration, in the liquid phase only, per applicable sections of paragraph 6.2, prior to start of life tests.

6.3.6 Following the pre-life test calibration, and with the test systems throttling valves in the full open position, perform a life test per Table I.

TABLE I

<u>Fluid Phase</u>	<u>Number of Duty Cycles</u>	<u>Hours Running</u>	<u>Hours at Rest</u>
Liquid	900	45.0	7.5
Gas	900	45.0	7.5
Liquid	900	45.0	7.5
Gas	900	45.0	7.5
Liquid	450	22.5	3.75
Gas	450	22.5	3.75
Totals	4500	225	37.5

6.3.7 At the conclusion of life testing, perform a post-life test calibration, in liquid phase only, on each unit per applicable sections of paragraph 6.2.

6.3.8 Due to the extent of life testing, an absolute minimum of data points are to be recorded. Record and tabulate three data points per test day for all parameters listed in paragraph 6.2.3.

6.3.9 Data package to be supplied by Perry Lab for each life test unit.

- a) Technician Log
- b) Test record sheet
- c) Tabulation of all measurements recorded during life tests.



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6.3.10 Mount a third unit in a suitable test system for liquid nitrogen testing.

6.3.11 The life test shall consist of 225 hours total operating time while submerged at all times in liquid nitrogen.

6.3.12 The duty cycle specified in 5.3.4 shall be maintained until 4500 start-stops are accumulated.

6.3.13 Data for this unit shall be the same as that taken for the oxygen and hydrogen units except no measurement of unit output flow or head rise is required.

**TEST SCHEMATIC
HIGH PRESSURE OXYGEN
EXPOSURE TESTS**

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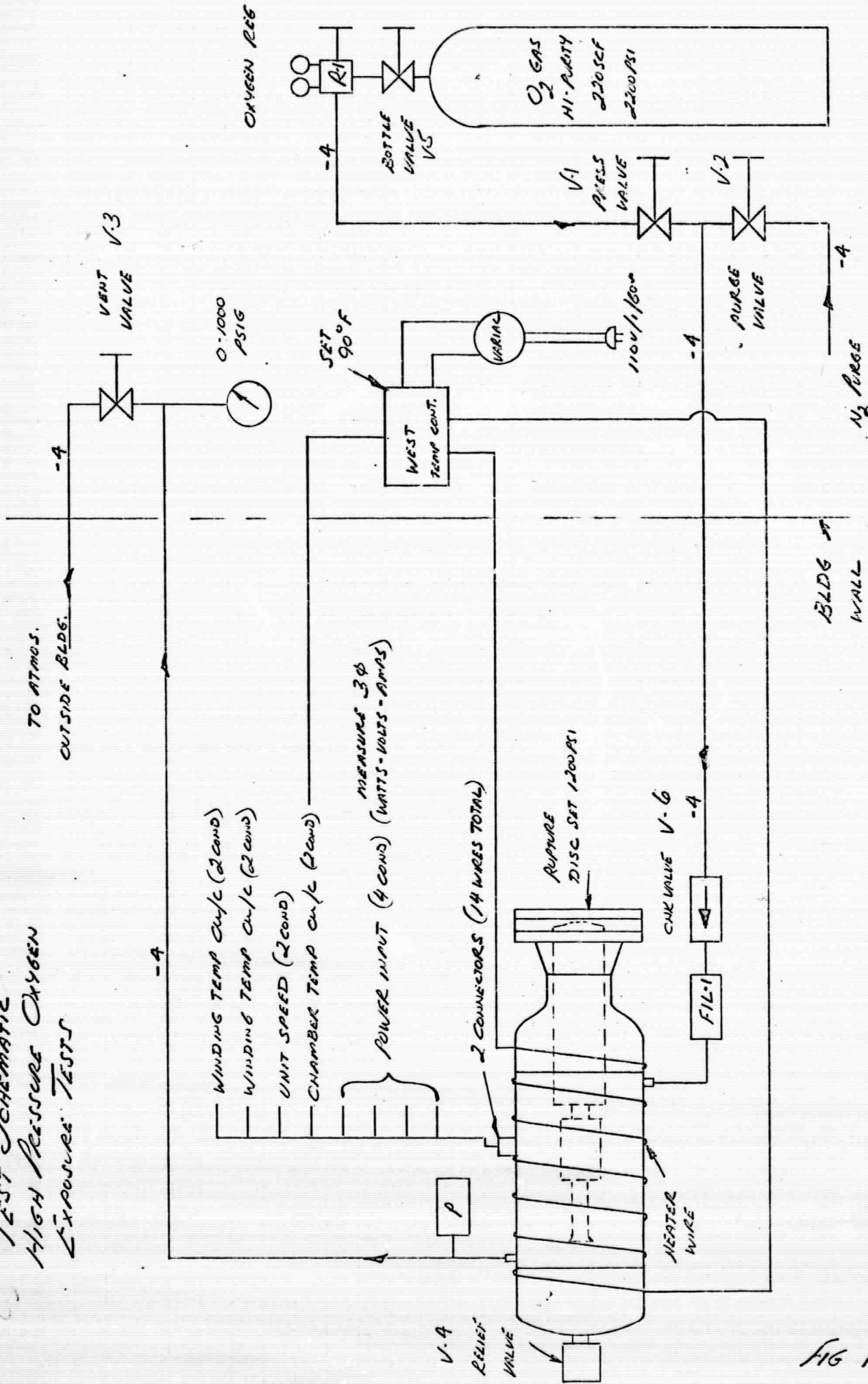
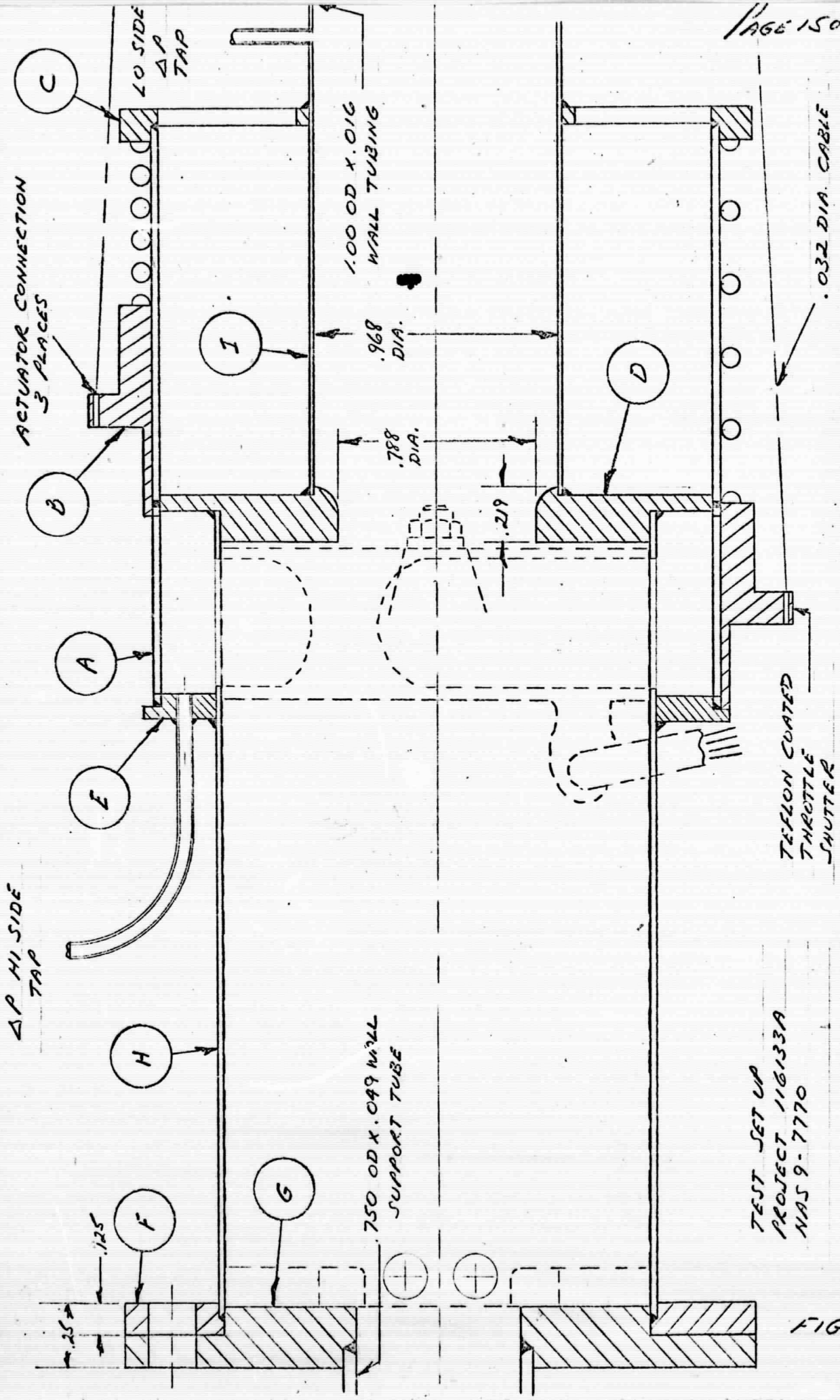


FIG 1



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TEST SET UP
PROJECT 116133A
NAS 9-7770

FIG 2

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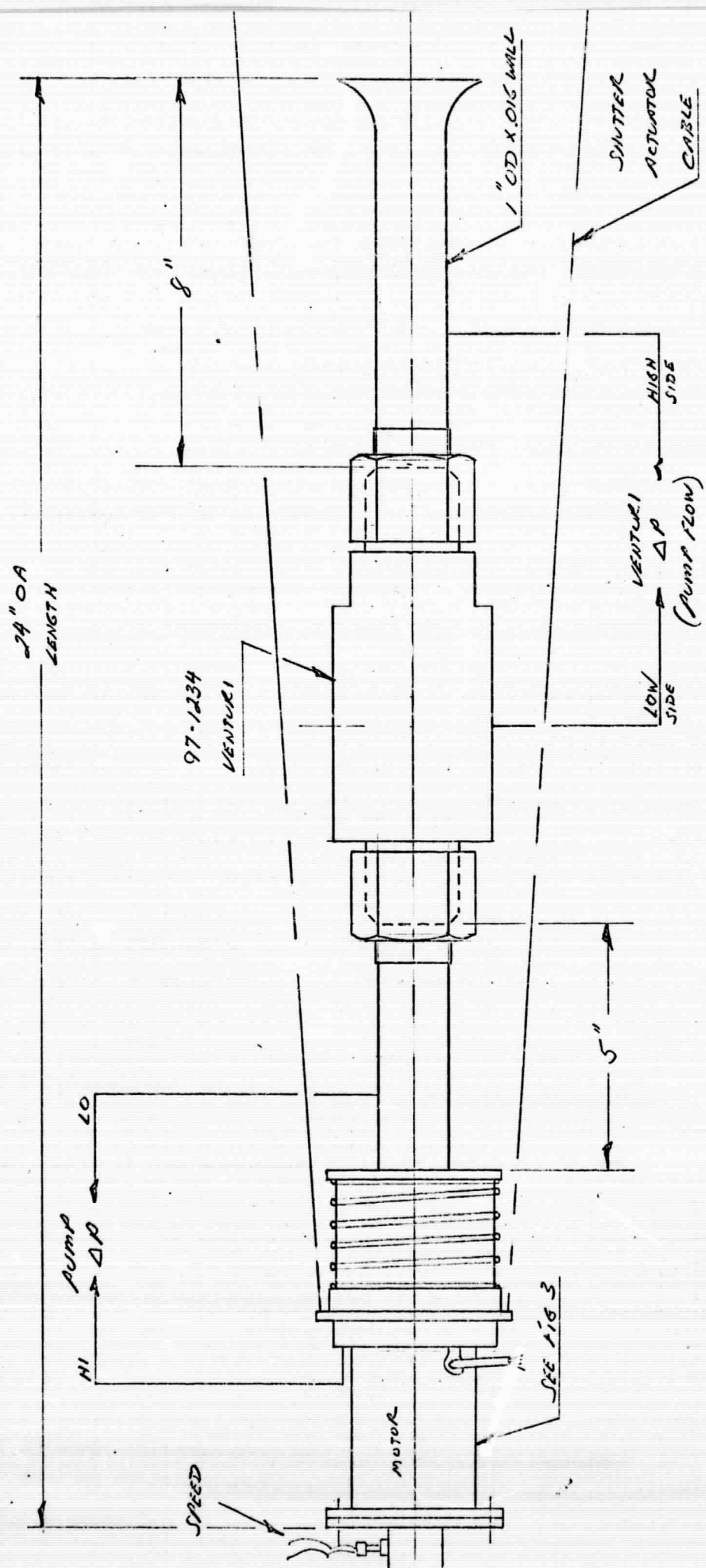


FIG 3
TYPICAL TEST SETUP
PROJECT 116133A

LIST, INSTRUMENTATION, COMPOSITE

<u>Parameter Measured</u>	<u>Instrument Make & Model</u>	<u>Range</u>	<u>System Accuracy</u>	<u>Re-corder Type</u>
Unit Speed	Electro Products 721915A	0-6000 rpm	±0.3%FS	SMX
Oxygen Liquid Level	Satham Model PM280TC	±2.5 psid	±0.6%FS	SMX
Hydrogen Liquid Level	Satham Model PM5TC	±0.33 psid	±0.6%FS	SMX
Oxygen Unit ΔP (liquid)	Satham Model PM280TC	±3.0 psid	±0.6%	SMX
Hydrogen Unit ΔP (liquid)	Satham Model PM96TC	±0.5 psid	±0.6%FS	SMX
Dewar Pressures	Ashcroft	-30"Hg to 30 psig	±5.0% FS	Visual
Oxygen Flowrate (Orifice ΔP) (liquid)	Satham Model PM280TC	±2.5 psid	±0.6%FS	SMX
Hydrogen Flowrate (Orifice ΔP) (liquid)	Satham Model PM283TC	±0.15 psid	±0.6%FS	SMX
Input Voltage (3 phases)	Weston-Model 433 (25-1000 cps)	0-150 v ac	±0.75%FS	Visual
Input Current (3 phases)	Weston-Model 433 (25-500 cps)	0-300/150 ma	±0.75%FS	Visual
Input Power (3 phases)	Weston-Model 432 (25-1000 cps)	0-20/10 watts	±0.5%FS	Visual
Power Supply Frequency	Vidar Model 904 500 Hz	350 to 450 Hz	±0.3%FS	SMX
Oxygen Unit Inlet Temp. Ambient Tests	Cu/C thermocouple Probe	-75 to +200°F	±1.5°F	SMX
Oxygen Unit Inlet Temp Liquid Tests	Rosemont Model 152T21A	-290 to -310°F	±0.3%FS	SMX

FIGURE 4



<u>Parameter Measured</u>	<u>Instrument Make & Model</u>	<u>Range</u>	<u>System Accuracy</u>	<u>Re-corder Type</u>
Hydrogen Unit Inlet Temp. -Ambient Tests	Cu/C Thermo-couple Probe	-75 to +200°F	±1.5°F	SMX
Hydrogen Unit Inlet Temp. -Liquid Tests	Rosemont Model 152T21A	-415 to -425°F	±0.3%FS	SMX
Motor Winding Temp. (2 on each motor)	Cu/C Thermo-couple Probe	-75 to +200°F	±1.5°F	SMX
Oxygen Gas Fixture Internal Temp.	Cu/C Thermo-couple Probe	-75 to +200°F	±1.5°F	SMX
Oxygen Gas Fixture Internal Pressure	Taber Model 176	0-1000 psig	±0.6%FS	SMX
Oxygen Unit ΔP (Gas)	Meriam Model 40GE4	0-1 in water	±1%FS	Visual
Hydrogen Unit ΔP (Gas)	Meriam Model 40GE4	0-1 in water	±1%FS	Visual
Oxygen Flowrate (Orifice ΔP)(gas)	Meriam Model 40GE4	0-1 in water	±1%FS	Visual
Hydrogen Flowrate (Orifice ΔP)(gas)	Meriam Model 40GE4	0-1 in water	±1%FS	Visual

FIGURE 4



Pesco Products DIVISION OF BORG-WARNER CORPORATION

Engineering Report 3620

APPENDIX II

TEST REQUEST TR693

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Revision _____ New
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• ACCEPTANCE TEST PROCEDURE

PESCO MODEL 145204-100

DESTRATIFICATION MOTOR-IMPELLER UNIT

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R. Hamm

Approved by *L.J. Schafer* Title Manager-Cryogenics
L. J. Schafer and Pneumatics

Approved by *John F. DiStefano* Title Director of Engineering
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Pesco Quality Control

Coordinated with *Earl Lyman*
DCASR Resident

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3.0	REFERENCE DOCUMENTS	3
4.0	GENERAL INSTRUCTIONS	4
5.0	ACCEPTANCE TESTS	5
6.0	PREPARATION FOR DELIVERY	6

FIGURES

- Figure 1 - Acceptance Test Setup
- Figure 2 - Instrumentation List



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1.0 SCOPE

This document specifies the testing and test methods to be used in determining low temperature operation and electrical characteristics of Pesco Model 145204-100 Destratification Motor-Impeller Unit. This procedure applies to additional units not covered in original Composite Procedure TR 686.

2.0 APPLICABLE DOCUMENTS

2.1 National Aeronautics and Space Administration Negotiated Contract No. NAS 9-7770, Exhibits A and B, and as amended by supplemental agreement.

2.2 Pesco Products, Division of Borg-Warner Corporation Drawing Number 145204-100, unit outline and assembly destratification motor-impeller.

3.0 REFERENCE DOCUMENTS

3.1 Pesco Products, Division of Borg-Warner Corporation Quality Control Measuring Device Manual No. 1002.

3.2 Pesco Products, Division of Borg-Warner Corporation, Quality Control Procedure for Precision Cleaning of Liquid Oxygen, Liquid Hydrogen and Liquid Helium Components for Space Vehicles and Ground Support Equipment, QC-110-6.

3.3 Pesco Products, Division of Borg-Warner Corporation, Quality Control Specification, Packaging of Precision Cleaned Liquid Hydrogen and Liquid Oxygen Pump Units for Space Vehicles, QC-110-14.



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3.4 Pesco Products, Division of Borg-Warner Corporation, Quality Control Procedure, Packaging Procedure for Liquid Hydrogen and Liquid Oxygen Pumps, QC 110-15.

4.0 GENERAL INSTRUCTIONS

4.1 Prior to start of testing, provide visual inspection of the unit. Note any discrepancies of unit on test report.

4.2 All instrumentation shall be maintained in calibration according to MIL-C-45662A, Military Specification, Calibration System Requirements, and Pesco Document Measuring Device Manual 1002.

4.3 All test runs shall be included and suitably identified in the test report.

4.4 Notify NASA resident representative and Pesco quality control engineering prior to start of testing.

4.5 Notify Bedford engineering prior to discontinuing any test.

4.6 Failure Discrepancy Reports shall be initiated as required.

4.7 Units shall be stored in shipping containers when not installed in test systems.

4.8 Total running time on any unit shall not exceed four (4) hours.

4.9 Approved lint-free gloves shall be worn at all times when installing or handling test units.

4.10 Electrical input to unit for all test phases to be as follows:

Current-sinusoidal alternating
Frequency 400 ± 15 Hz
Number of Phases 3

Power 35 watts maximum
Phase to phase voltage 208 ± 2 v ac
Phase to neutral voltage 120 ± 1 vac



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5.0 ACCEPTANCE TEST

5.1 Electrical Tests (To be performed at room temperature and ambient pressure conditions.)

5.1.1 Insulation Resistance - Apply 500 ± 50 v dc between all motor windings and ground. Insulation resistance shall be greater than 100 megohms. Record results on data sheet.

5.1.2 Dielectric Strength - Apply 1000 ± 100 v dc between all motor windings and ground for 1 minute, then apply 500 ± 50 v ac at 60 Hz between all motor windings and ground for 1 minute. Current leakage shall not exceed 1.0 ma. Record results on data sheet.

5.1.3 Winding Resistance - Measure and record the resistance of all motor windings. Individual winding resistance shall not exceed 750 ohms when measured to neutral.

5.1.4 Performance Test - Measure output and input and record results on test data sheet.

5.2 Cold Shock and Low Temperature Operation

5.2.1 Mount the unit in an acceptance test fixture and provide test setup per Figure I.

5.2.2 With the unit submerged and stabilized in liquid nitrogen per MIL-P-27401A, apply power per Paragraph 4.10.

5.2.3 Tabulate the following data immediately after start, after ten minutes running time, and prior to shutdown after twenty minutes total running time.

NOTE: Maintain liquid nitrogen height above unit by periodically filling Dewar to vent standpipe level. Liquid height shall be verified prior to low temperature operational test.



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- a) Unit Speed rpm
- b) Input Voltage (3 phases) v ac rms
- c) Running Current (3 phases) . . . amps rms
- d) Input power (3 phases) watts
- e) Power supply frequency cps
- f) Unit running time minutes

5.2.4 Following the liquid nitrogen test, warm unit to ambient temperature while maintaining a nitrogen atmosphere sufficient to prevent moisture contamination.

5.2.5 Data Package

- a) Technician Log and Test Record Sheet
- b) Tabulation of all parametric measurements taken in Paragraph 5.2.3.

NOTE: Maximum running time shall not exceed 4 hours on any unit.

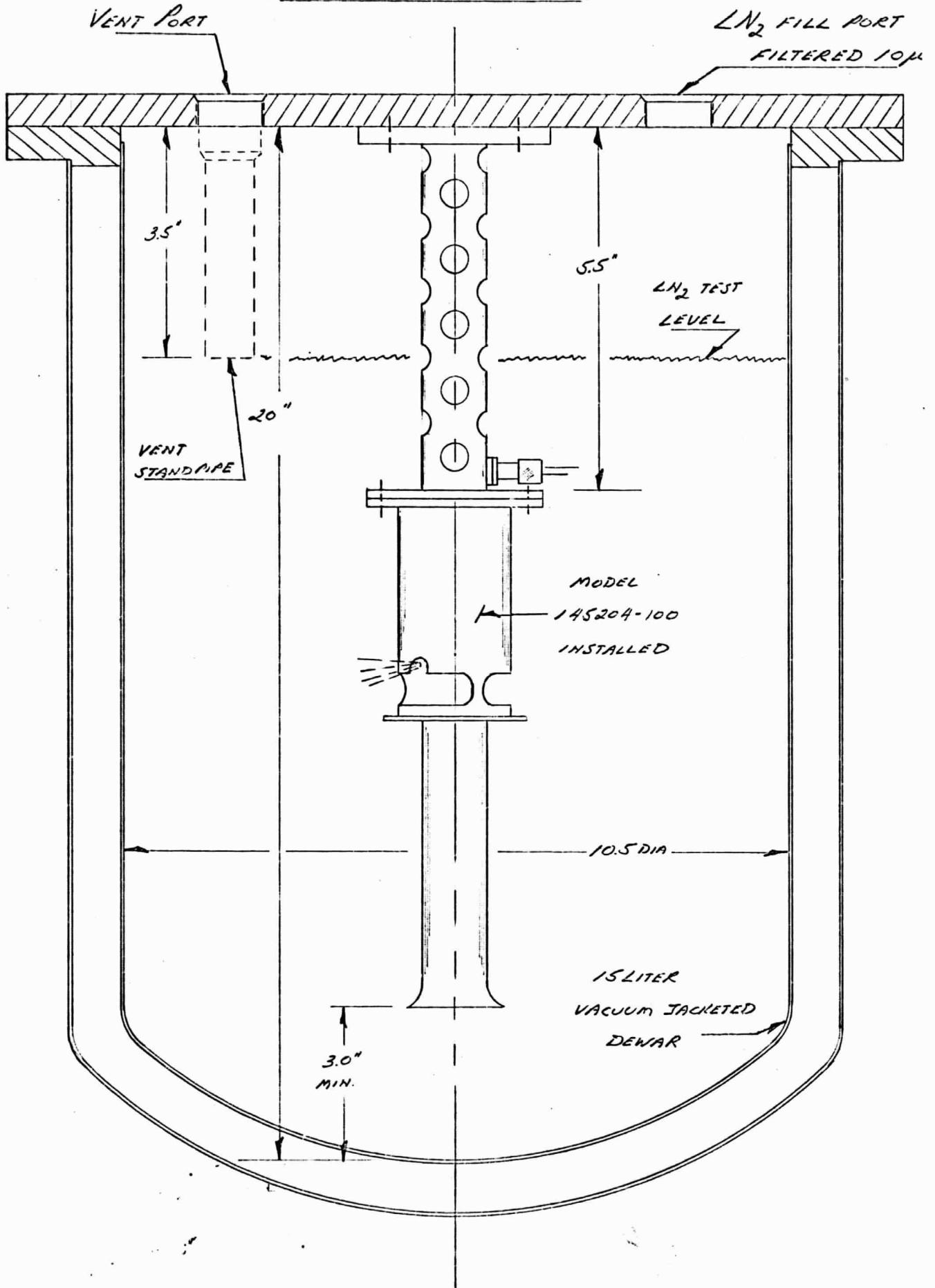
6.0 PREPARATION FOR END ITEM DELIVERY

6.1 Clean unit per Pesco Quality Control Procedure QC 110-8.

6.2 Package unit per Pesco Quality Control Procedure QC 110-15 and Quality Control Specification QC 110-14.



ACCEPTANCE TEST SETUP



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INSTRUMENTATION LIST

<u>Parameter Measured</u>	<u>Instrument Make & Model</u>	<u>Range</u>	<u>System Accuracy</u>	<u>Recorder Type</u>
Unit Speed	Electro Products 721915A-Hewlett Packard 5512-A	0-6000 rpm	± 1 rpm	Visual
Input Voltage (3 phases)	Weston-Model 433 (25-1000 cps)	0-150 v ac	±0.75% FS	Visual
Input Current (3 phases)	Weston-Model 433 (25-500 cps)	0-300/150 ma	±0.75% FS	Visual
Input Power (3 phases)	Weston-Model 432 (25-1000 cps)	0-20/10 watts	±0.5% FS	Visual
Power Supply Frequency	Hewlett-Packard 5512-A or equiv.	0-1000 cps	± 1 cps	Visual

FIGURE 2



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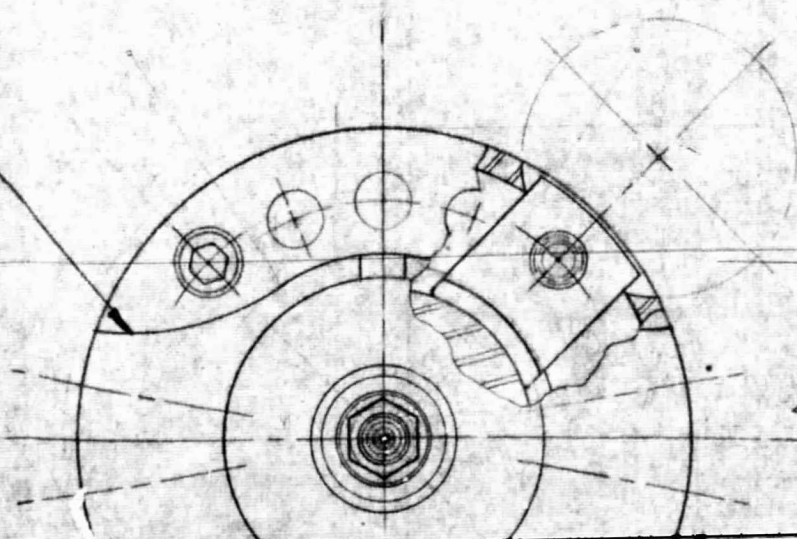
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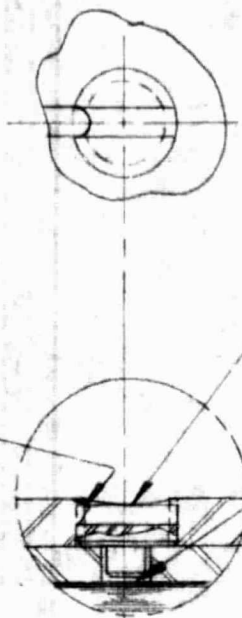


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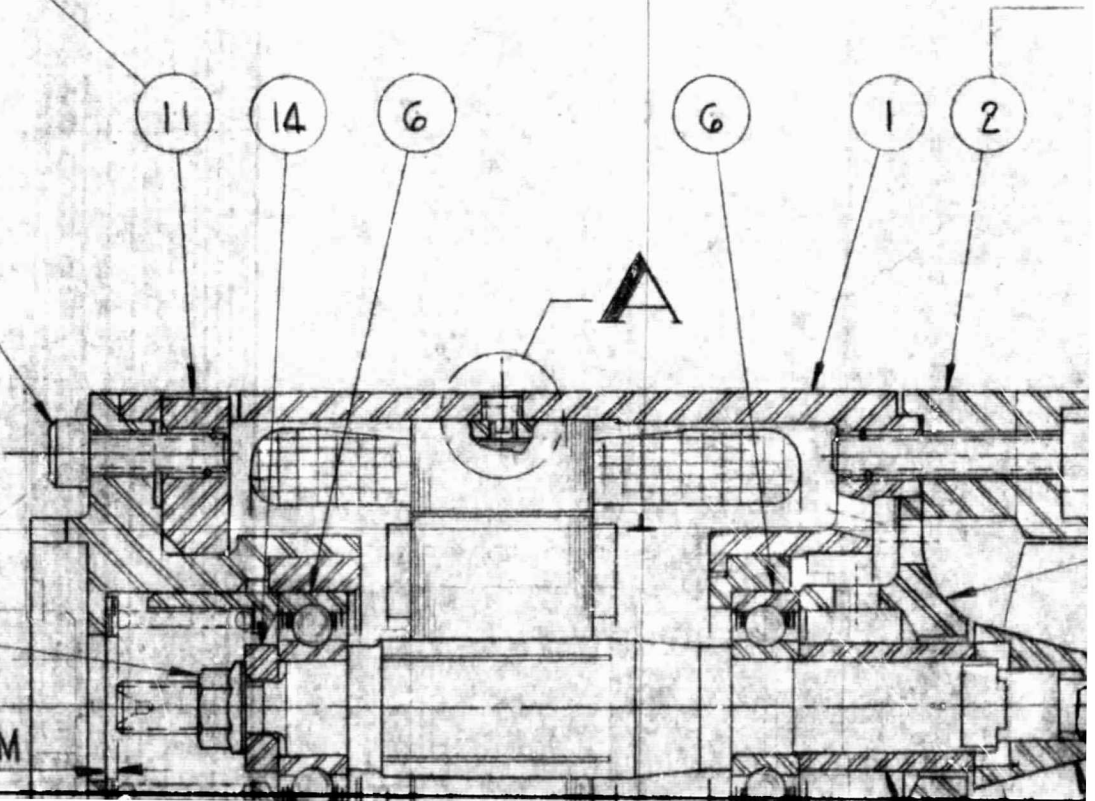
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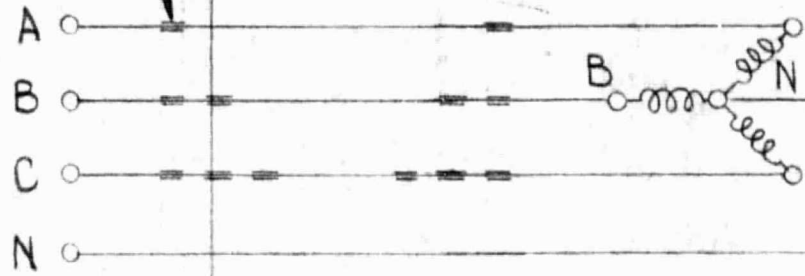


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IDENTIFICATION SLEEVING :
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ACES

MOTOR SCHEMATIC

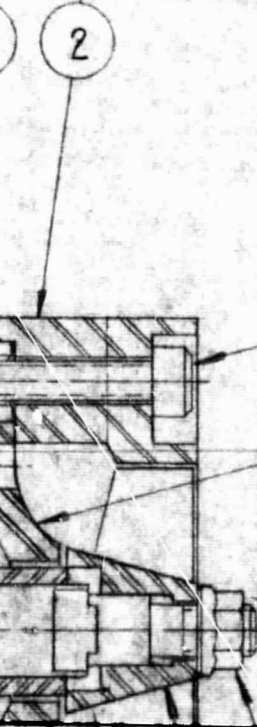
NOTE : A-B-C PHASE SEQU
ROTATION VIEWING IM

WINDINGS MUST NOT
GED DURING ASSEMBLY

LEAD WIRE IDENTIFICATION CODE

- LEAD "A" — ONE SLEEVE
 - LEAD "B" — TWO SLEEVES
 - LEAD "C" — THREE SLEEVES
 - LEAD "N" — PLAIN (NO SLEEVES)
- } TYP. 2 PLACES
(APPROX
EXIT &
END OF

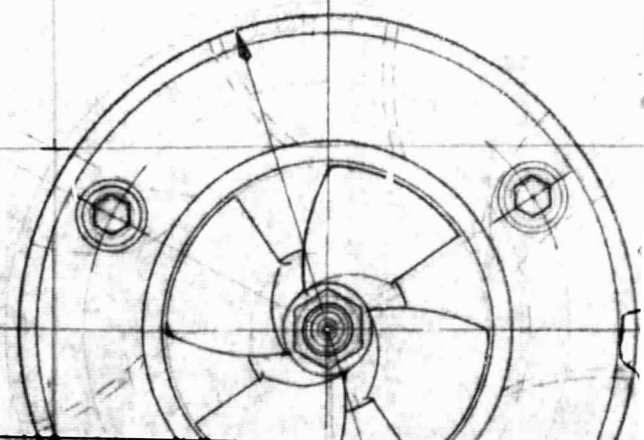
ASSEMBLE WITH SLOT
POSITIONED AS SHOWN



TORQUE TO 5-7 IN. LBS

APPLY PER PESCO EDI 103

ROTATION
←

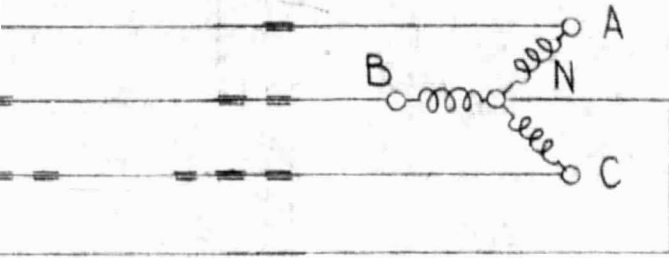


FOLDOUT FRAME 4

ZONE LTR

RE
DESCR

IDENTIFICATION SLEEVING :
APPROX .38 LONG & .38 APART



MOTOR SCHEMATIC

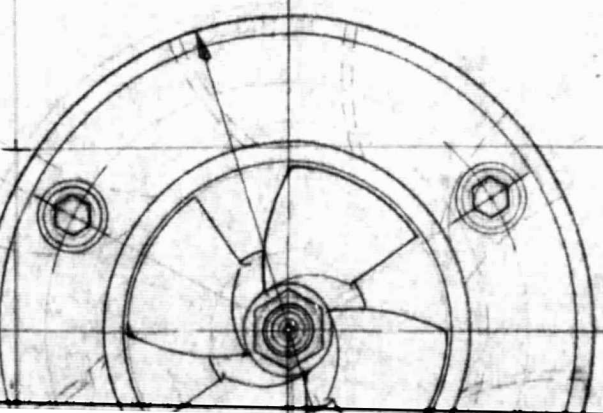
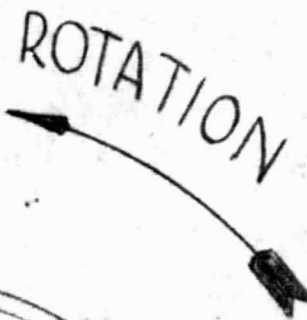
NOTE : A-B-C PHASE SEQUENCE FOR CCW
ROTATION VIEWING IMPELLER END

IDENTIFICATION CODE :

ONE SLEEVE
 TWO SLEEVES
 THREE SLEEVES
 MAIN (NO SLEEVES)

TYP. 2 PLACES EACH LEAD WIRE
 (APPROX 18 IN. FROM LEAD
 EXIT & APPROX 6 IN. FROM
 END OF LEADS)

LBS
EDI 103



REVISIONS

DESCRIPTION

DATE

APPROVED

FOLDOUT FRAME

5

D

C



-05

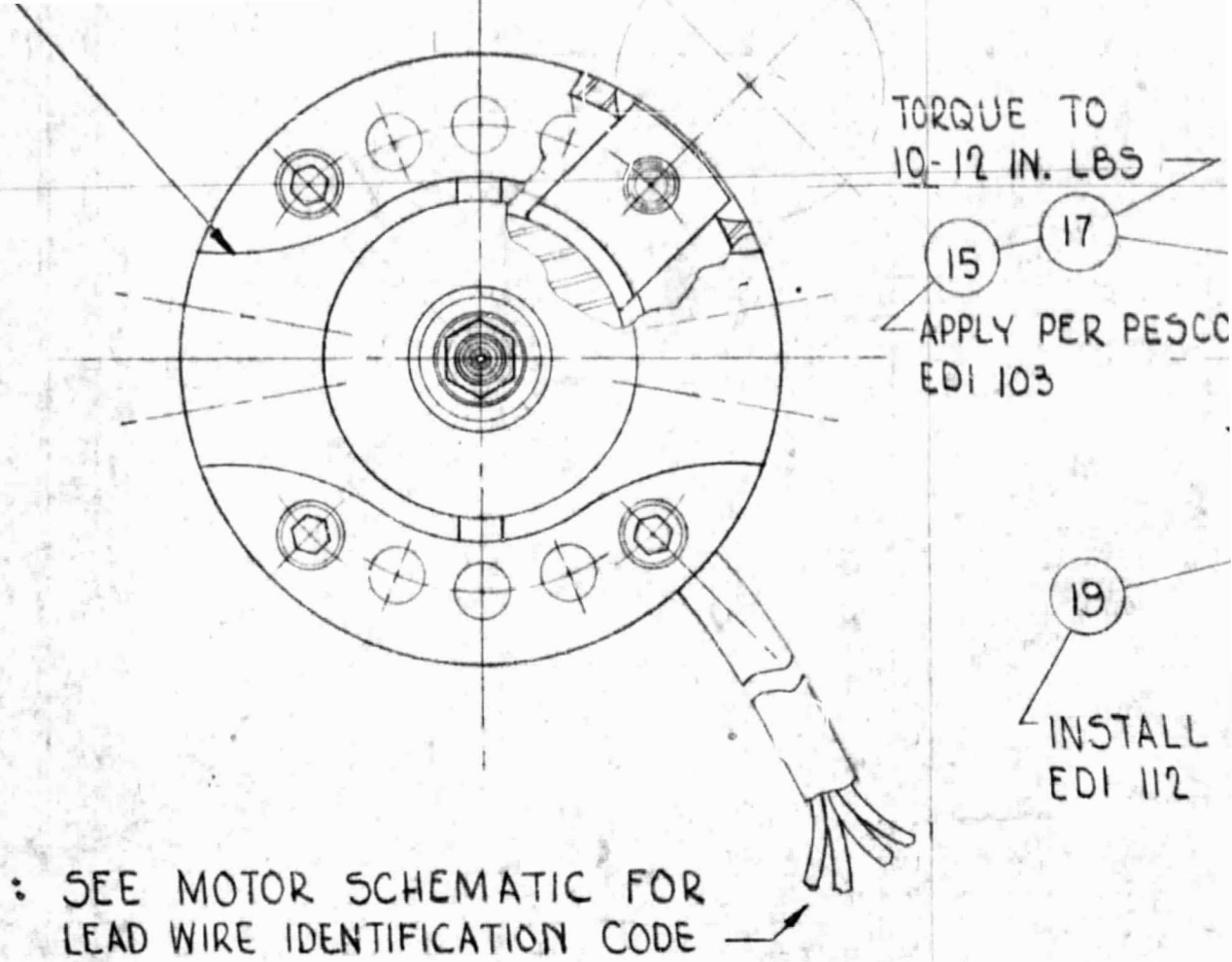
SHIM (.032)

04

SHIM (.015)

B

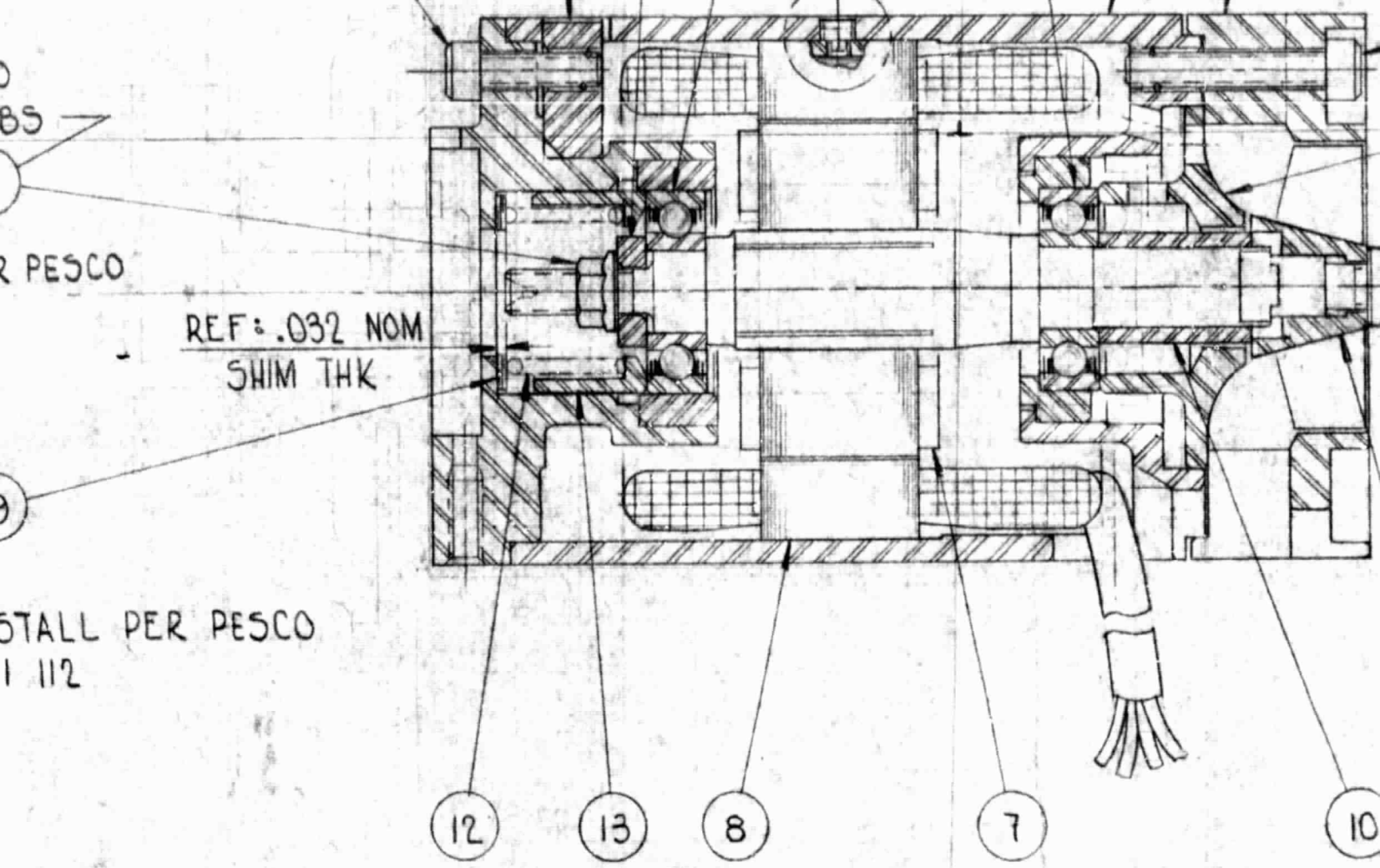
A



4. AFTER TEST & PRIOR TO SHIPMENT CLEAN COMPLETED PESCO PROCEDURE QC-110-8
3. UPON COMPLETION OF ASSEMBLY, INSERT UNIT IN A CLEAN BAG, REMOVE AIR & HERMETICALLY SEAL
2. DURING ASSEMBLY, CONTAMINATION OF PARTS WITH OILS, HYDROCARBONS INCLUDING BODY OILS IS PROHIBITED. PRECAUTIONS:
 - A) ASSEMBLE IN A DUST FREE ROOM
 - B) ASSEMBLER SHALL WEAR A CLEAN, (INCLUDING GLOVES & CAP)
 - C) ALL TOOLS USED FOR ASSEMBLY PER PESCO SPEC P-144 OR EQ
1. ALL COMPONENTS INCLUDING ALL MS, AN, & NAT AT TIME OF ASSEMBLY PER PESCO PROCEDURE QC

FOLDOUT FRAME

6



ETED ASSEMBLY PER
 A CLEAN PLASTIC

OILS, GREASES, AND OTHER
 BITED. MAINTAIN THE FOLLOWING
 ROOM
 CLEAN, LINT FREE UNIFORM

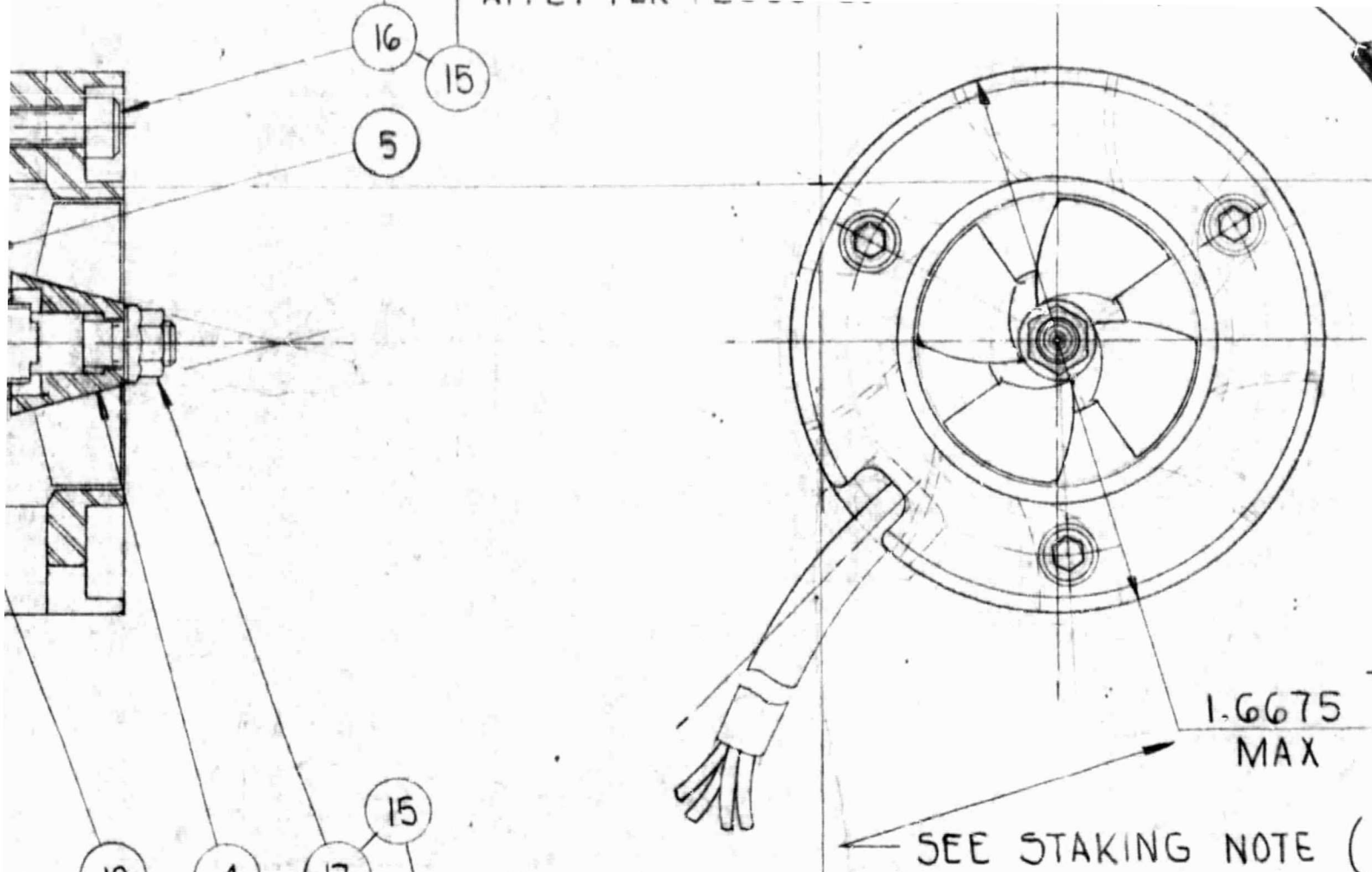
MBLY SHALL BE CLEAN
 OR EQUIVALENT

NAS PARTS MUST BE CLEAN
 QC-110-6

FOLDOUT FRAME 7

6

5

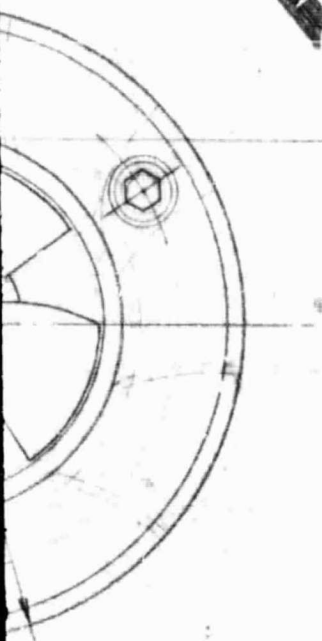


APPLY PER EDI 103
 TORQUE TO 10-12 IN. LBS

NOTE: ASSEMBLE AFTER INSTALLING SHIMS
 (ITEM NO. 19)

* FOR PROCUREMENT OR VENDOR PART NO. SEE
 SOURCE OR SPECIFICATION CONTROL DRAWING
 SEE SHEET 2 OF 2 FOR ENVELOPE DRAWING

UNLESS OTHERWISE SPECIFIED	
ALL DIMS ARE IN INCHES . . . TOL ON DRILLED HOLES $\pm .01$. . . REMOVE ALL BURRS & BREAK SHARP EDGES .005-.015 . . . DIMS ARE AFTER PLATING . . . THREADS PER MIL-S-7742 . . . MACHINING CENTERS OPTIONAL . . . TRUE POSITION TOLERANCES ARE FOR MAX MATERIAL CONDITION . . . MACHINED DIAS ON COMMON CENTER LINE TO BE CONC WITHIN .005 FIR. . . MACHINED PARALLEL SURFACES TO BE PAR. WITHIN .003 PER IN. . . MACHINED PERP SURFACES TO BE SQ WITHIN .003 PER IN. . . MACHINED FILLET RADII .005-.015 . . . MACHINED SURFACES 150V . . . REM FINS & SPRUES . . . CAST RADII & FILLETS . . . SURFACE ROUGHNESS PER MIL-STD-10	TOLERANCE ON D 1 PLACE .X 2 PLACES .XX 3 PLACES .XX. TOLERANCE ON A MATERIAL: FOLDOUT FRAME



1.6675 **Y**
MAX DIA

NG NOTE (VIEW **A**)

NO. SEE
L DRAWING
OPE DRAWING

AS REQD	14-555-05	SHIM (.032)
	14-555-04	SHIM (.015)
	14-555-03	SHIM (.010)
	14-555-02	SHIM (.005)
	14-555-01	SHIM (.002)
4	99-4224-2	SCREW-CAP, SOCKET HEAD
2	NAS1291C06	NUT, SELF-LOCKING, HEX
3	99-4224-4	SCREW-CAP, SOCKET HEAD
As Req	99-4326	GREASE, ANTI-GALLING
1	14-551	WASHER, FLAT
1	14-560	SLEEVE, THRUST-BEAR
1	99-4784	SPRING, HELICAL, COMPRESSION
4	114-469	NUT ASSEMBLY, SELF LOC
1	14-557	SPACER
3	14-554	SET SCREW, SLOTTED
1	121-1226	STATOR, MOTOR
1	121-1228	ROTOR, MOTOR, COMP
2	21-1221	BEARING, BALL
1	14-550	SHROUD, IMPELLER
1	14-558	IMPELLER
1	114-467	COVER ASSY, MOTOR
1	14-559	COVER, IMPELLER
1	114-468	HOUSING ASSY, PUMP
QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DES

PARTS LIST

TOLERANCE ON DIMENSIONS
 1 PLACE .X = ±.06
 2 PLACES .XX = ±.03
 3 PLACES .XXX = ±.01
 TOLERANCE ON ANGLES ± 1°

MATERIAL:

DR	E. CONAWAY	3/28/68
CHK	<i>Ed C</i>	4/30/68
APPD	<i>Feb</i>	4-30-68
APPD	<i>Mr. Fair</i>	4/30/68
EXP REL	PROD. REL	
XE 3003-5		

PESCO PRODUCTS
DIVISION

PUMP, CENTRI
ASSEMBLY 0

SIZE CODE IDENT NO.
D 77200 14520

SCALE 2/1

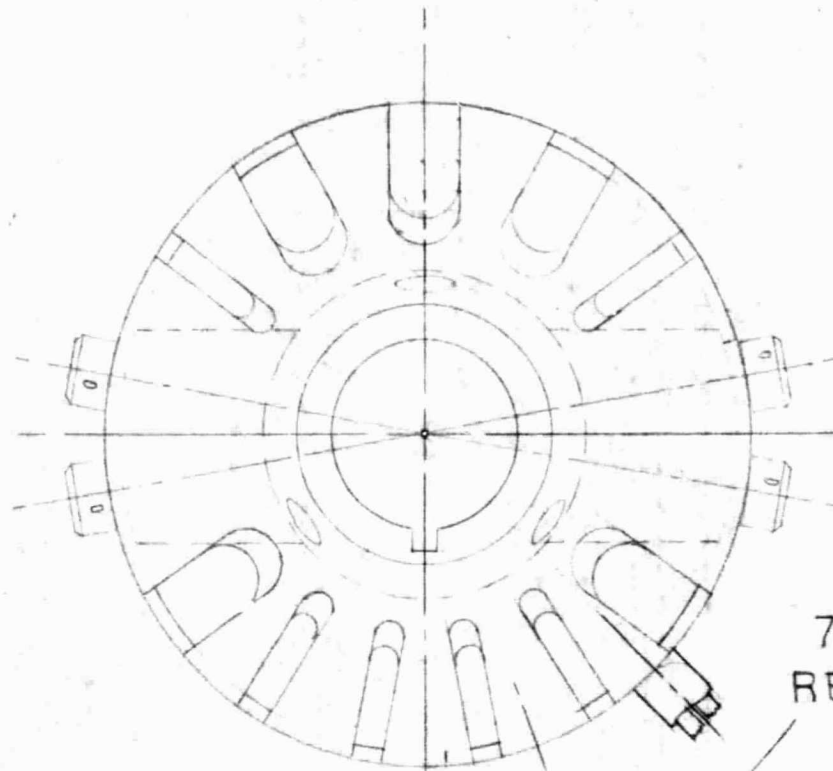
FOLDOUT FRAME **9**

3

2

THIS PRINT IS THE PROPERTY OF PESCO PRODUCTS DIVISION, BORG-WARNER CORPORATION, AND REPRESENTS PROPRIETARY ARTICLES IN WHICH PESCO PRODUCTS DIVISION AND BORG-WARNER CORPORATION RETAIN ANY AND ALL PATENT AND OTHER RIGHTS, INCLUDING EXCLUSIVE RIGHTS OF USE AND/OR MANUFACTURE AND/OR POSSESSION OF THIS PRINT DOES NOT CONVEY ANY PERMISSION TO REPRODUCE PRINT OR MANUFACTURE ARTICLE OR ARTICLES SHOWN THEREIN, SUCH PERMISSION TO BE GRANTED ONLY BY SPECIFIC AUTHORIZATION IN WRITING SIGNED BY AN OFFICER OR OTHER AUTHORIZED AGENT OF BORG-WARNER CORPORATION OF PESCO DIVISION THEREOF.

FOLDOUT FRAME



3-CU

70° REF

2-RADIAL 6-HOLES FOR BE

SURFA

REF-VIEW **A-A**

(CUSTOMERS SUPPORT TUBE ASSY)

.875 DIA, .151-.161 DEEP
.03 MAX FILLET R
AT BOTTOM

1.6675
1.6625

Z DIA FOR THIS LEN

1.00 DIA

.75 R TYP
4 PLACES

.300
.270

10° 20°
BASIC

D

C



ON. AND REPRESENTS A
RATION RETAIN ANY AND
FACTURE AND/OR SALE.
OR MANUFACTURE THE
SPECIFIC AUTHORIZATION
CORPORATION OF THE

FOLDOUT FRAME **2**

FOLDOUT

3-SLOTS EQ SPACED IN
CUSTOMERS SUPPORT TUBE

2-RADIAL SLOTS (.12 WIDE X .09 DEEP) &
6-HOLES (.156 DIA - LOCATED APPROX AS SHOWN)
FOR BEARING COOLING FLOW THRU UNIT

SURFACE **Y**

DIA
OR THIS LENGTH

2.943
MAX

2.410
MIN

.220
MIN

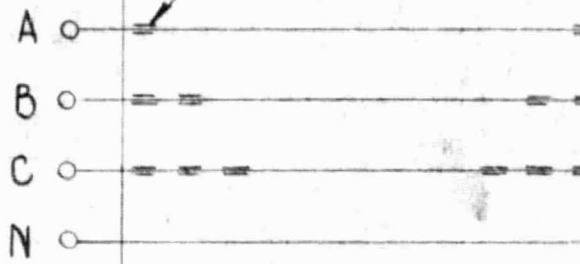
2.14
APPROX

A

20°
BASIC

FOLDOUT FRAME **3**

IDENTIFICATION



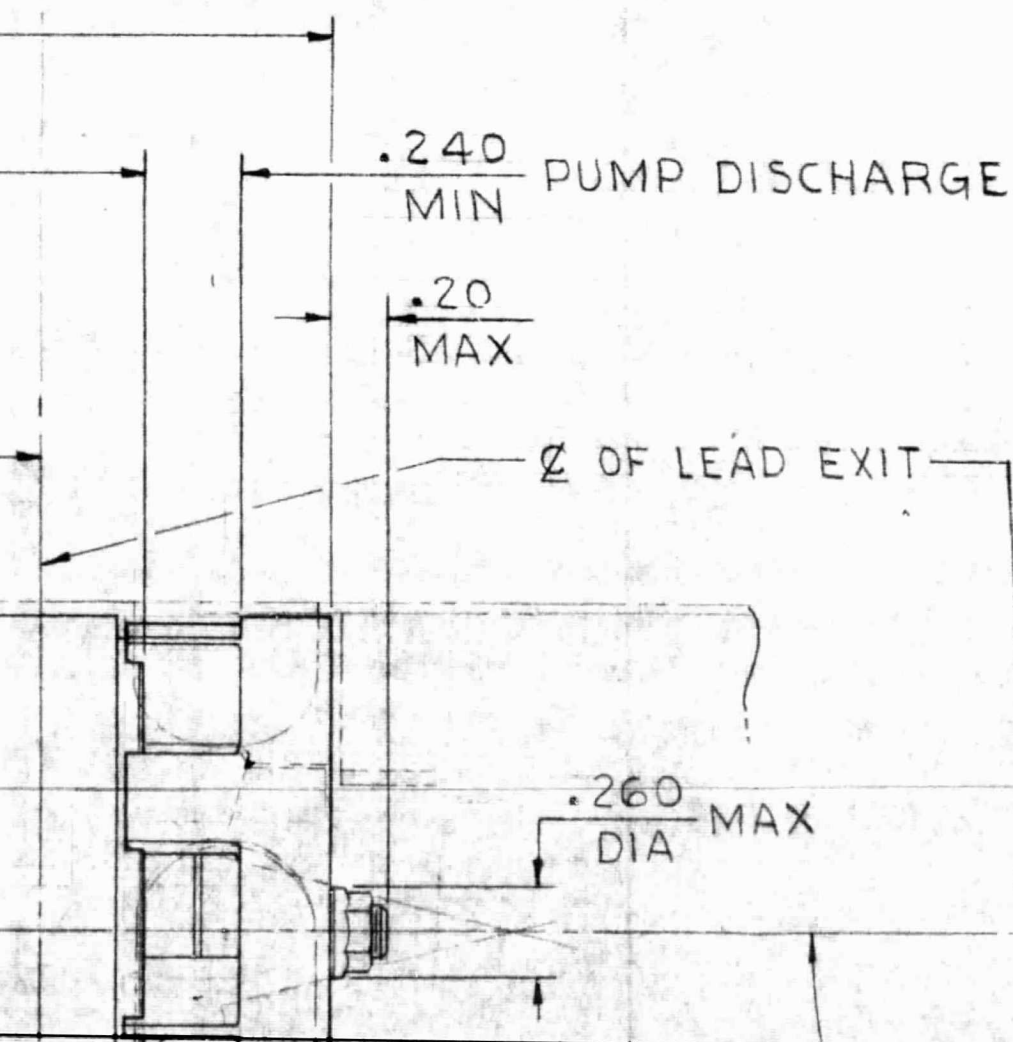
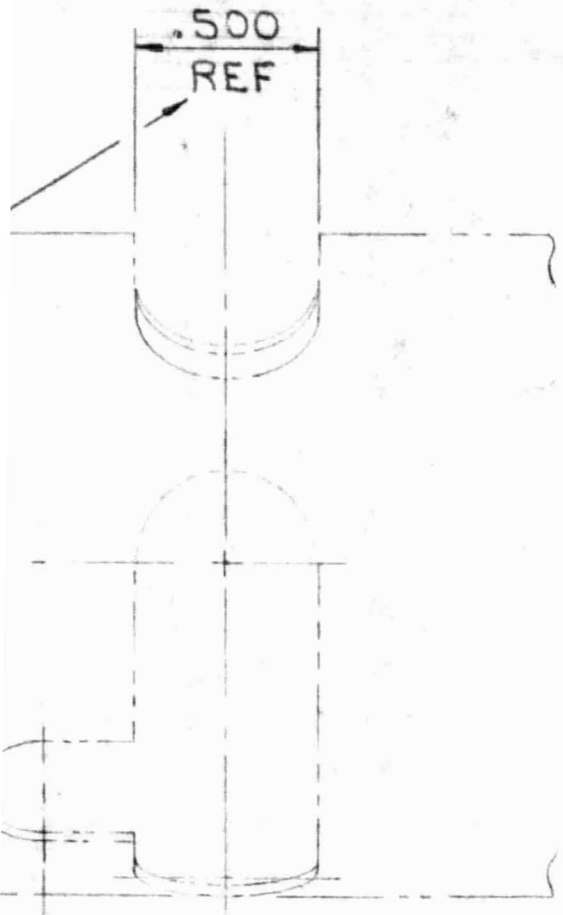
MOTOR SCHEMA

A-B-C PHASE SEQUENCE
ROTATION VIEWING IMP

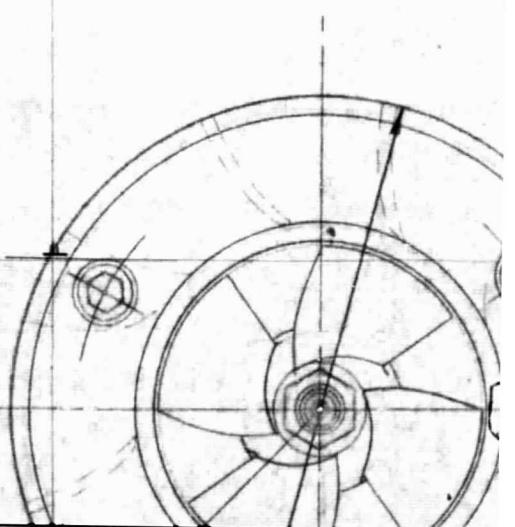
LEAD WIRE IDENTIFICATION

- LEAD "A" — ONE SLEEVE.
- LEAD "B" — TWO SLEEVES
- LEAD "C" — THREE SLEEVES
- LEAD "N" — PLAIN (NO SLEEVES)

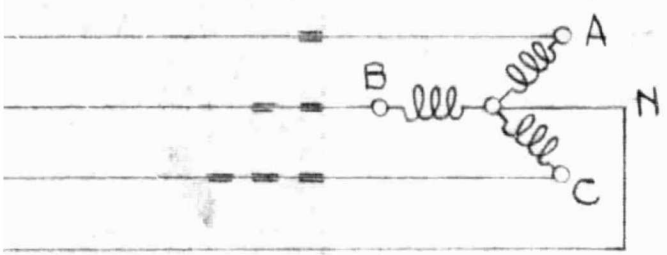
TYP 2-PLA
APPROX L
APPROX G
(EACH SLE
\$.38 AF



ROTATION



IDENTIFICATION SLEEVING



FOLDOUT FRAME

4

OR SCHEMATIC

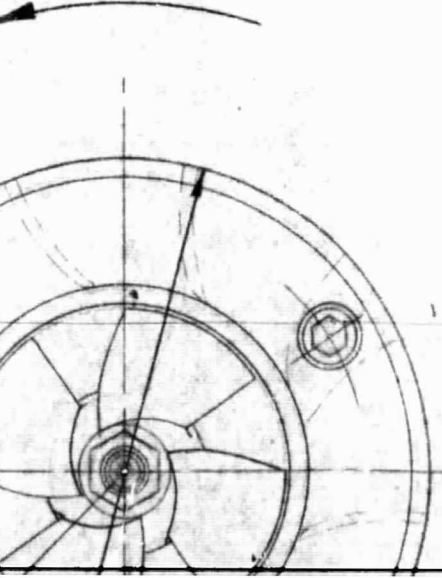
USE SEQUENCE FOR CCW VIEWING IMPELLER END

IDENTIFICATION CODE

SLEEVE.
 SLEEVES
 SLEEVES
 (NO SLEEVES)

-TYP 2-PLACES (EACH LEAD WIRE)
 APPROX 18" FROM LEAD EXIT &
 APPROX 6" FROM END OF LEADS
 (EACH SLEEVE-APPROX .38 LONG
 & .38 APART)

ROTATION



REVISION

ZONE	LTR	DESCRIPTION
~	C	REVISED & REDRAWN TO CUSTOMER'S NEW LEAD EX
~	D	ADDED GENERAL NOTES i ADDED IDENTIFICATION SLEE OUTS TO SCHEMATIC (ENG RE
5A	E	1) ADDED UNIT IDENTIFIC APPLICATION NOTE (ENG REL XE 3003-

FOLDOUT FR

REVISIONS

DESCRIPTION	DATE	APPROVED
DRAWN TO CONFORM TO W LEAD EXIT SPEC	3/29/68	ELC
NOTES 1 THRU 4 TION SLEEVING & CALL- ATIC (ENG REL XE3003-5)	4/30/68	ELC
IDENTIFICATION AND NOTE (XE 3003-11)	9/12/68	<i>J. Mott</i>

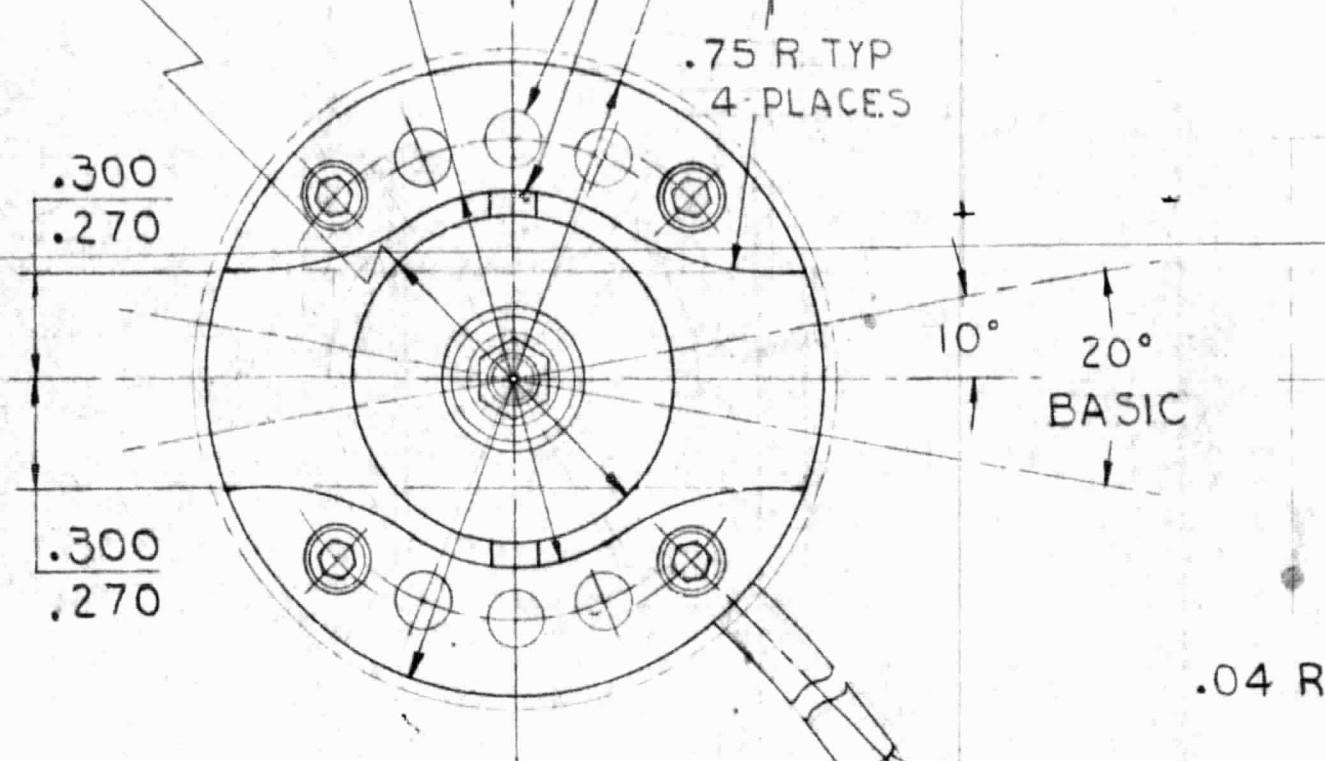
D

FOLDOUT FRAME

5

C





4-LEAD WIRES PER MIL-W-16878 TYPE "E", TEFLON COATED, NICKEL PLATED COPPER CONDUCTORS NO. 26 AWG, 75 INCHES LG- EXPOSED (TEFLON TUBING TO COVER 4-LEAD WIRES APPROX 12" LG FROM MTR EXIT)

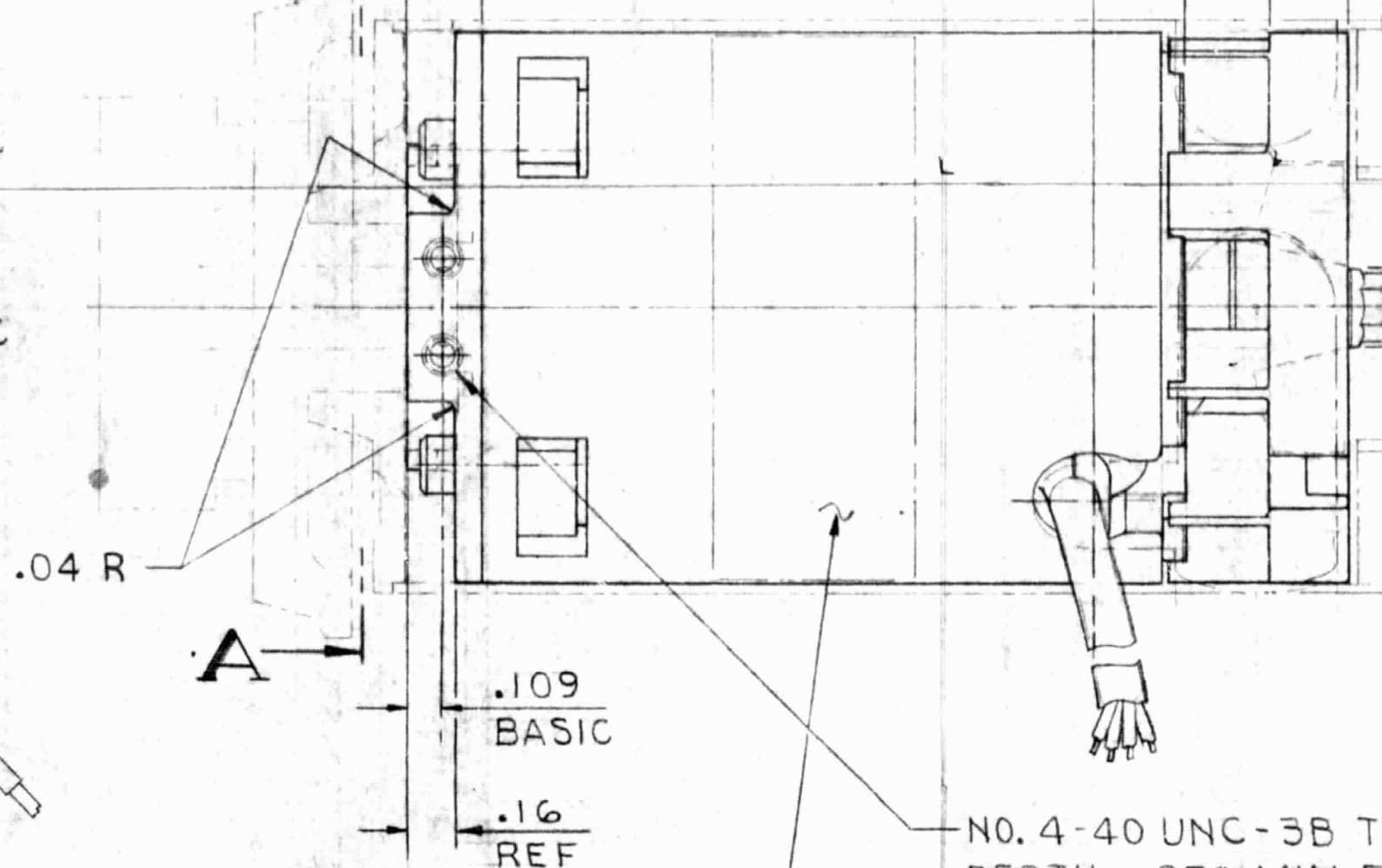
.04 R

NOTE

ELECTROLY
FIGURES.06
THIS APPROX L
CONTRACT NO.
DIRECTED BY P
PURCHASE OR

4. OUTPUT: 1.3 CFM MINIMUM AT NORMAL BOILING POINTS OF LIQUID OXYGEN AND LIQUID HYDROGEN
3. POWER: LESS THAN 35 WATTS AT DESIGN OUTPUT
2. VOLTAGE: 208 VAC LINE TO LINE ; 120 VAC LINE NEUTRAL (NOMINAL)
1. TYPE : 3 PHASE , 400 CYCLE, SINO^USOIDAL ALTERNATING

FOLDOUT FRAME **6**



NOTE: SEE SCHEMATIC FOR LEAD WIRE IDENTIFICATION CODE
 TROLYTIC ETCH IN
 ES.06 HIGH. THIS INFORMATION IN
 PROX LOCATION. MARK SERIAL NO. &
 CT NO. IN APPLICABLE SPACES AS
 D BY PESCO SALES DEPT. & CUSTOMER'S
 SE ORDER

NO. 4-40 UNC-3B T
 DEPTH-.250 MIN F
 4-HOLES LOCATED
 .005 R OF TRUE PO
 RELATION TO SURF

(E1)

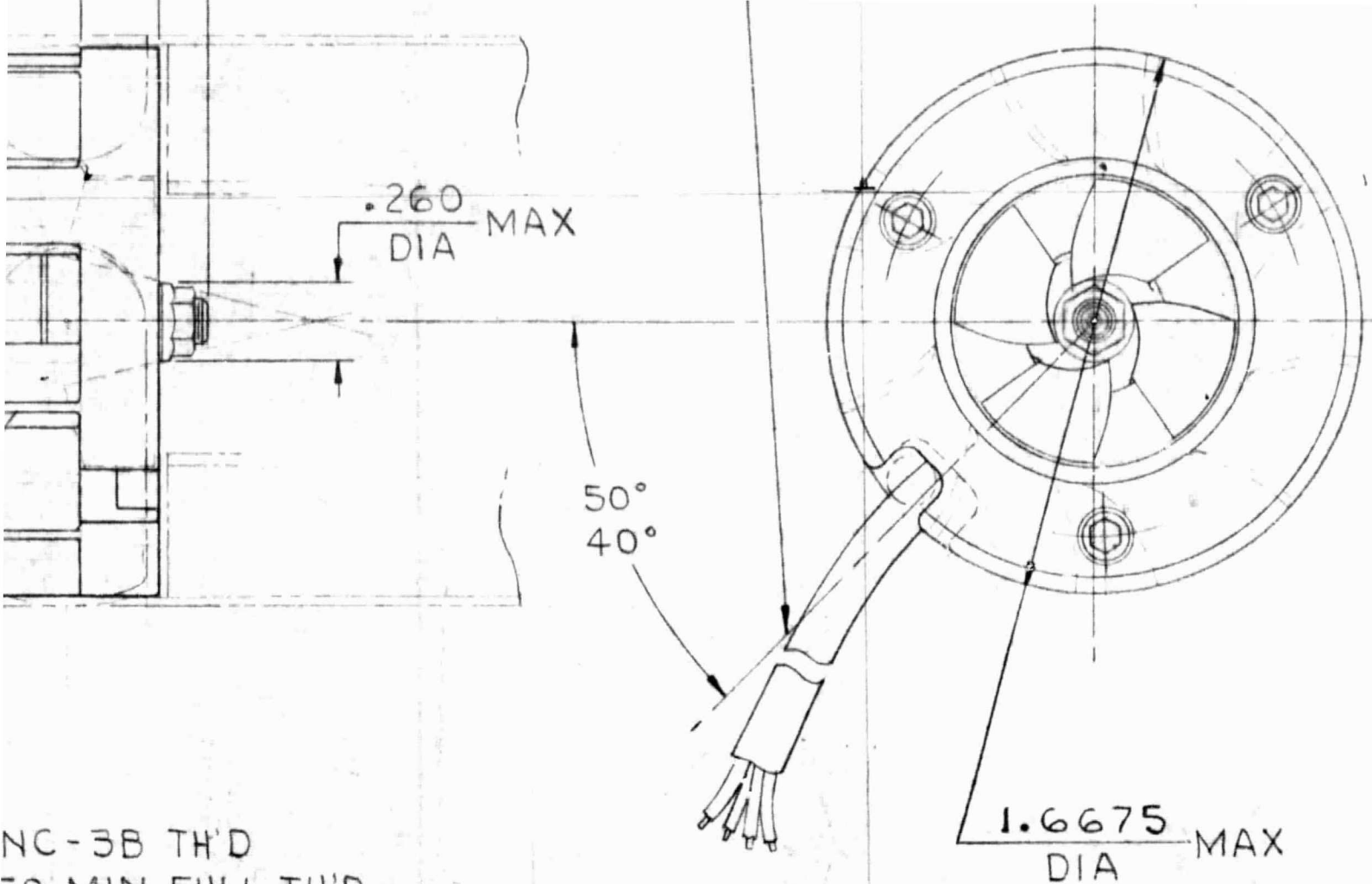
PUMP, CENTRIFUGAL
 PESCO PRODUCTS DIVISION
 BORG-WARNER CORP, BEDFORD, OHIO
 MDEL NO. 45204-100
 SERIAL NO. CONTR NO. NAS 9-7770
 NASA HOUSTON U.S.

INTS OF
 LINE TO
 NATING CURRENT

FOLDOUT FRAME 7

6

5



NC-3B TH'D
 .50 MIN FULL TH'D
 LOCATED WITHIN
 TRUE POSITION IN
 TO SURFACE **Y** & **Z** DIA

~~WELDOUT FRAME~~ **8**

~~WELDOUT FRAME~~

~~OF UNIT (REF)~~

UNLESS OTHERWISE SPECIFIED		TOLERANCE OF
ALL DIMS ARE IN INCHES . . . TOL ON DRILLED HOLES $\pm .01$. . . REMOVE ALL BURRS & BREAK SHARP EDGES .005-.015 . . . DIMS ARE AFTER PLATING . . . THREADS PER MIL-S-7742 . . . MACHINING CENTERS OPTIONAL . . . TRUE POSITION TOLERANCES ARE FOR MAX MATERIAL CONDITION . . . MACHINED DIAS ON COMMON CENTER LINE TO BE CONC WITHIN .005 FIR . . . MACHINED PARALLEL SURFACES TO BE PAR. WITHIN .003 PER IN. . . MACHINED PERP SURFACES TO BE SQ WITHIN .003 PER IN. . . MACHINED FILLET RADII .005-.015 . . . MACHINED SURFACES 150V . . . REM FINS & SPRUES . . . CAST RADII & FILLETS . . . SURFACE ROUGHNESS PER MIL-STD-10		1 PLACE . . .
		2 PLACES . . .
		3 PLACES . . .
		TOLERANCE OF MATERIAL:



4

3



MAX

W/OUT FRAME 9

SEE SHEET 1 FOR ASSEMBLY DRAWING

TOLERANCE ON DIMENSIONS
 1 PLACE .X = ±.06
 2 PLACES .XX = ±.03
 3 PLACES .XXX = ±.01
 TOLERANCE ON ANGLES ± 1°

MATERIAL:

DR	E. CONAWAY	3/29/68
CHK	<i>ELC</i>	4/30/68
APPD	<i>F.W. Burt</i>	3-29-68
APPD	<i>W. J. ...</i>	4/30/68
EXP	REL	PROD. REL
XE3003-5		

PESCO PRODUCTS DIVISION

PUMP, CENTRIFUGAL ENVELOPE OF

SIZE	CODE IDENT NO.
D 77200	14520
SCALE 2/1	

3

2



B
[145204-100]

FEB 11 1969

~~WITHOUT~~ FRAME 10

TS BORG-WARNER
CORPORATION
BEDFORD, OHIO

A

TRIFUGAL -
OF

5204-100

SHEET 2 OF 2