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(2-76)

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TO: Mr. Edson G. Case

FROM: Iowa Electric Light & Power Co.
Cedar Rapids, IA 52406
Ellery L. Hammond

DATE OF DOCUMENT 8/9/77

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DESCRIPTION

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ENCLOSURE

Consists of Local Leak Rate Test report for Type B & C tests conducted at DAEC during refueling outage.

PLANT NAME: Duane Arnold Energy Center (1-P) (32-P)

VT 8/13/77

FOR ACTION/INFORMATION

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(5)

NRC FORM 195 (2-76)

Iowa Electric Light and Power Company

DUANE ARNOLD ENERGY CENTER
P. O. Box 351
Cedar Rapids, Iowa 52406

August 9, 1977
DAEC -77 - 414
Regulatory File Cy.

RECEIVED AUG 12 1977 U.S. NUCLEAR REGULATORY COMMISSION

Mr. Edson G. Case, Acting Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
1717 H Street NW
Washington, D.C. 20545

RE: Duane Arnold Energy Center
SUBJECT: 1977 Local Leak Rate Tests
FILE: A-110

Dear Mr. Case:

In accordance with section 4.7.A.2.f of DAEC Technical Specifications, please find enclosed the Local Leak Rate Test report for Type B and C tests conducted at DAEC during the 1977 refueling outage.

Very truly yours,

Ellery L. Hammond / Bry

Ellery L. Hammond
Chief Engineer
Duane Arnold Energy Center

ELH/JVS/mg
Enclosures

772240309

REACTOR CONTAINMENT BUILDING

LOCAL LEAK RATE TESTS TYPE
B AND C

DUANE ARNOLD ENERGY CENTER
UNIT NO. 1

IOWA ELECTRIC LIGHT AND POWER COMPANY

Issued by: Nuclear Services Corporation
1700 Dell Avenue
Campbell, CA 95008

Prepared by:	Z. Iwashita	Date:	7-11-77	
Reviewed by:	C W Royle	Date:	7-11-77	
Approved by:	[signature]	Date:	7-20-77	

IELP REVIEW AND APPROVAL

Reviewed by:	John H. Gilbert	Date:	8-5-77	Rev. 0
Reviewed by:	Daniel L. Mineck	Date:	8-5-77	Rev. 0
Approved by:	Ellery Hammond	Date:	8-5-77	Rev. 0

IOWA ELECTRIC LIGHT AND POWER COMPANY

DUANE ARNOLD ENERGY CENTER
UNIT NO. 1
PALO, IOWA

Containment Penetration (Type B) and Isolation Valve (Type C) Local Leak Rate Tests

Index

1.0 SUMMARY

The Type B and C Local Leak Rate Test (LLRT) of the Duane Arnold Energy Center Unit No. 1 Containment was completed on May 11, 1977. The testing program was conducted in accordance with the requirements of DAEC Technical Specifications. Nuclear Services Corporation assisted in preparation of the test procedures and the conduct of the individual tests. The method of testing involved the measurement of makeup air or nitrogen through calibrated flow meters for all penetrations except for the inboard main steam isolation valves (MSIV). Outflow leakages were measured for the inboard MSIV's and corrected for unmonitored losses. Leakage was measured at design basis accident pressure of 54 psig, except for the MSIV's at 24 psig as specified in the DAEC Technical Specifications. A bubbler was used to verify results in cases where flow meters indicated zero leakage. In cases where the test volume were filled with water and air was used to pressurize the water, makeup flows were measured and correction applied to obtain equivalent air leakage. All excessive leakages were corrected by valve repairs and penetrations retested satisfactorily. The total leakage or Type B and Type C tests was 50467 SCCM and equal to 23% of the total allowable leakage of 220,609 SCCM equal to 60% of L_A.

2.0 PERIODIC LOCAL LEAK RATE TEST CRITERIA

2.1 REFERENCES

2.1.1 Title 10 CFR 50 Appendix J.

2.1.2 Duane Arnold Technical Specification, Section TS 4.7, Plant Containment Systems.

2.1.3 ANSI N45.4-1972 Leakage-Rate Testing of Containment Structures for Nuclear Reactors.

2.1.4 Manufacturer's Standardization Society, Standard Practice Edition 1961 (MSS-SP-61).

2.2 DEFINITIONS

2.2.1 "Leakage Rate." Reactor Containment Leakage stated in percentage of weight of 1.00 x 10^6 cu-ft of containment air at 54 psig in a 24 hour period.

2.2.2 CLR (SCC/min). The combined leakage rate for all components subject to Type B and C penetration tests. CLR shall not exceed 60% of L_A.

2.2.3 L_A (SCC/min). The maximum allowable leakage rate at pressure P_{LLRT}.

2.2.4 P_{LLRT} (54 psig = 68.7 psia). The absolute pressure used for local leakage rate testing.

2.2.5 P_{STP} (14.7 psia). The absolute pressure at standard conditions.

2.2.6 T_{STP} (530°R). The absolute temperature at standard conditions.

2.2.7 T_{LLRT} (80°F. = 540°R). The absolute temperature used for local leak rate testing.

2.2.8 LLR (SCC/min). The local leak rate.

2.2.9 V_c (Cu. ft). Containment free volume

2.3 ACCEPTANCE CRITERIA

For successful completion of the local leak rate test, the following acceptance criteria as defined in Technical Specification (Section 4.7A.2C (2) and 10 CFR 50, Appendix J, Section III shall be satisfied.

2.3.1 The combined leakage rate (CLR) for all components subject to Type B and C penetration tests shall not exceed 60% of the maximum allowable leakage rate (L_A) for the containment. The CLR is calculated as follows:

$$CLR = \frac{(V_C)(60\%)(L_A)(P_{LLRT})(T_{STP})}{(P_{STP})(T_{LLRT})}$$

Where Vc = Drywell Free volume + Pressure suppression chamber free volume

= $109.40 \times 10^3 + 94.27 \times 10^3$ cu. ft.

60% = Combined leakage fraction of all components subject to Type B and C tests.

L_A = The maximum allowable leakage rate at pressure P_A (2.0% per day at 54 psig).

P_{LLRT} = Absolute pressure used for local leakage rate testing (54 psig = 68.7 psia).

P_{STP} = Absolute pressure at standard conditions (14.7 psia).

T_{STP} = Absolute temperature at standard conditions (530°R).

T_{LLRT} = Absolute temperature used for local leak rate testing (80°F. = 540°R).

$$CLR = \frac{(203.67 \times 10^3 ft^3)(0.60)(0.02/day)(68.7\ psia)(530°R)(19.679\ \frac{cc}{min}\ \frac{day}{ft})}{(14.7\ psia)(540°R)}$$

= 220,609 SCCM

2.3.2 ALLOWED LOCAL LEAKAGE RATE PER PENETRATION

Since the containment isolation valves were procured in accordance with the manufacturer's standardization society, Standard Practice Edition 1961 (MSS-SP-61), which specifies a maximum permissible leakage rate of less than 0.1 SCFH (50 cc/min) per inch of nominal diameter as manufactured, this specification is used as the basis for calculating the allowed leakage rate for each containment isolation valve.

2.3.3 ALLOWED LOCAL LEAK RATE FOR MAIN STEAM ISOLATION VALVE (MSIV)

Allowed leakage from any one main steam isolation valve shall not exceed 11.5 SCF/hr (5427 SCCM) at an initial pressure of 24 psig.

2.3.4 Leakage rates for equipment hatch and airlock doors are arbitrarily assigned 1cc/min/lineal inch of resilient seal.

2.3.5 Leakage rate for hot pipe and electrical penetrations are assigned 0 cc/min.

3.0 DESIGN INFORMATION

3.1 CONTAINMENT SYSTEM

Allowable Leakage Rate	2%/day @ 54 psig and 70°F.
Codes and Standards	IEEE proposed guides for electrical penetration ANS 45.4 proposed standard for leak testing
Drywell Free Volume	109.40×10^3 ft^3
Pressure Suppression Free Volume	94.27×10^3 ft^3

3.2 LOCAL LEAKAGE TESTING UNIT

3.2.1 Two local leakage rate testing units were used. These portable units are constructed of 3/8" stainless steel piping and fitted with a pressure regulator, pressure gage, two flow instruments, a bubbler and ball-valves. In use, the unit is supplied with either dry instrument air or nitrogen and connected to the volume to be tested. Leakage rates are determined by measuring the amount of makeup air required to maintain the test pressure. The leakage is read directly in cc/min which is converted to scc/min by using the calibration curve for the flowmeter.

3.2.2 TESTING UNIT COMPONENTS

3.2.2.1 Back Pressure Regulator; provides 54 or 24 psig test pressure to the local test volume.

3.2.2.2 0-100 psia pressure gage; monitors the back pressure regulator operation and the test volume pressure.

3.2.2.3 Rotameter; two of three flowmeters are mounted to the testing unit to measure makeup air to the test volume. The ranges of the meters are from 0-250 cc/min, 0-2100 cc/min. and 0-5200 cc/min. Meters were calibrated to compensate for test volume pressures. A conversion chart was used to correct the reading for the test pressure and normalize the reading to SCCM.

3.2.2.4 Bubbler; verifies low leakage rates from the test volume. Each bubble displaces approximately 0.2 cc of air.

3.2.2.5 Air Filter; insures a clean source of air to the test volume.

3.2.2.6 Flowmeter; two meters to measure outflow of air leaking through the seat of the main steam isolation valve.

3.3 INSTRUMENT CALIBRATION AND ACCURACY

3.3.1 The local leak rate testing unit is designed to provide measurement of test volume leakage at a high level of accuracy. Instruments were calibrated and checked for accuracy immediately prior to the conduct of the tests.

3.3.1.1 PRESSURE GAGES

Instrument Nos.	P-131 and P-130
Manufacturer	Heise
Model	CMM
Range	0-100 psia

3.3.1.2 FLOW INDICATORS

Instrument No.	P-133	P-134
Manufacturer	Brooks	Brooks
Model	7212-41122/2	7212-41122/1
Calibration;		
SCCM	200 - 2100	200-2100
PSIG	24 and 54	24 and 54
Temperature	70°F.	70°F.
Accuracy (full scale)	± 1%	± 1%

Instrument No.	P-135	P-138
Manufacturer	Brooks	Brooks
Model	7212-41123/1	7301-41381/2
Calibration:		
SCCM	500 - 5200	20 - 200
PSIG	24 - 54	54
Temperature	70°F.	70°F.
Accuracy (full scale)	± 1%	± 1%

Instrument No.	P-139
Manufacturer	Brooks
Model	7301-41381/1
Calibration:	
SCCM	20 - 200
PSIG	54
Temperature	70°F.
Accuracy (full scale)	± 1%

Instrument No.	A	B
Manufacturer	Fischer & Porter	Fischer & Porter
Model	10A1460	10A1460
Calibration:		
MM	1 - 26	1 - 26
PSIG	14.7	54
Temperature	70°F.	70°F.
Accuracy (full scale)	$\pm$ 1%	$\pm$ 1%

3.4 TEST MEDIUM

3.4.1 Type B tests were performed using dry instrument air for testable gaskets and flange "0" rings. Dry nitrogen was used to test expansion bellows and electrical penetrations.

3.4.2 Type C tests were performed using dry instrument air and with dry instrument air in combination with water (known as Type "H" tests). Measured leakage rate obtained by using water as a test fluid are in terms of equivalent air leakage.

3.4.3 The Manufacturer's Standardization Society, Standard Practice Edition 1961 (MSS-SP61) provides the relationship that 10 cc per hour per inch of diameter water leakage equals to 0.1 SCF per hour per inch of diameter air leakage. Accordingly, when air is used to pressurize the water to 54 psig and the volume of air required to replace the leaked water is measured.

1 SCCM of measured air = 60.5 SCCM or equivalent air leakage

3.5 PROCEDURES

3.5.1 Leak Test Unit Procedure - Detailed written procedure was used for the operation of the local leak test equipment. This procedure was approved for use by Iowa Electric Light and Power Company and reviewed by Iowa Light and Power Company, Nuclear Regulatory Commission - Region III, and Nuclear Services Corporation prior to its implementation.

3.5.2 Leak Rate Test - Type B penetrations test and containment isolation valve leak tightness test - Type C penetrations test procedures were prepared by Nuclear Services Corporation and approved by the Duane Arnold Operations Committee. These procedures provide the proper authorization for the test crew to perform the test, details of the pretest valve lineup, details of the individual tests, and the post-test valve lineup returning the system to normal on completion of the test. In general, the procedure provides for valve lineups, isolation of the test volume, opening vents or drains necessary to obtain maximum differential across the valve seats and measuring the leakage rate.

3.5.3 Local Leak Rate Test - LLRT of MSIV Leakage Control System bleed valves was prepared on site to demonstrate the leak tight integrity of the leak control system motor operated bleed valves. This test was coordinated with the Type C test to facilitate ease of determining leakage rate of valves using the test set up for the main steam isolation valve seat leak rate tests.

4.0 CONDUCT OF TEST PROGRAM

4.1 REACTOR CONTAINMENT LOCAL TEST SURVEILLANCE REQUIREMENTS

4.1.1 The retest scheduled for Local tests will be in accordance with Technical Specification TS4.7.A.2.d.

4.1.2 Inspection and reporting of Local tests will be in accordance with Technical Specification TS4.7.A.2.f.

4.1.3 Type B and C tests of the penetrations (Table TS.3.7.2 of the Technical Specification) shall be performed at a pressure of 54 psig (Pa) in accordance with TS4.7.A.2.c.

4.1.4 Type B and C tests shall be performed by local pressurization. The pressure shall be applied in the same direction as that when the valve would be required to perform its safety function unless testing in the opposite direction would provide the equivalent or more conservative results.

4.1.5 Each valve to be tested shall be closed by normal operation and without any preliminary exercising or adjustments.

4.1.6 Any major modification or replacement of a component of the containment boundary will be followed by either an ILRT or Local Leak Test, as applicable for the area affected by the modification.

4.2 PREREQUISITES FOR THE TEST PROGRAM

4.2.1 Local Leak Test instruments recently calibrated and checked out for proper operation. See Appendix D.

4.2.2 All written procedures were reviewed and approved by the Duane Arnold Operations Committee.

4.2.3 All test personnel were properly trained and qualified to perform their specific functions. See Appendix E.

4.2.4 Radiation protection instruction was provided to all test personnel.

4.2.5 Test personnel reviewed each procedure prior to testing.

4.2.6 Radiation protection personnel were alerted for each test.

4.3 ORGANIZATION AND ADMINISTRATIVE CONTROLS DURING TESTING

4.3.1 Maintenance Superintendent scheduled specific tests with Shift Supervisor and alerted Radiation Protection.

4.3.2 The Shift Supervisor reviewed procedures and released the line for testing.

4.3.3 The Test Leadman coordinated the efforts of the test crew as directed by the Maintenance Superintendent.

4.3.4 The test crew performed checkout of Local Leak Tester instrumentation to assure its performance during test conditions.

4.3.5 The test crew conducted the test using the detailed procedure, communicating with the operating crew as necessary for valve lineup.

4.3.6 The Leak Test unit was connected to the test connection.

4.3.7 The vent or drain as appropriate was connected to tubing directed to a floor drain.

4.3.8 The test volume was pressurized and the leakage measured on the first isolation valve.

4.3.9 The control room was contacted for necessary valve operations and the leakage measured on the second isolation valve.

4.3.10 Vent and drains were closed and drain hoses removed and test unit disconnected.

4.3.11 The Shift Supervisor was notified that the test was complete by returning the partially completed procedure to him for completion of post test valve lineup.

4.3.12 If leakage was excessive, the leak was measured on a high range meter and an attempt to identify the location was made (seat, bonnet, gasket, packing).

4.3.13 The incomplete procedure was directed to the Maintenance Superintendent who issued a work request for repairs.

4.3.14 When repairs were complete the penetration was scheduled for retesting.

4.3.15 The completed procedures were returned by the Shift Supervisor to the Maintenance Superintendent for review and documentation.

4.4 PRETEST SAFETY PRECAUTIONS

4.4.1 The test was conducted using normal plant safety practices.

4.4.2 Radiation protection instruction was provided to all test personnel.

4.4.3 Test personnel reviewed each procedure for personal and plant safety prior to testing.

4.4.4 Dry instrument air, reactor grade water and dry nitrogen was checked out prior to testing.

4.5 LOCAL LEAK RATE TESTING

4.5.1 SCHEDULE

4.5.1.1 Type C local leak rate testing commenced by pressurizing the inboard main steam isolation valves on March 13, 1977 in accordance with the approved containment isolation valve leak test procedure. Testing of the outboard valves began on March 14, 1977.

4.5.1.2 The local leak rate test of MSIV leakage control system bleed valves commenced on March 17, 1977.

4.5.1.3 Type B local leak rate testing commenced on penetrations with flanged "O" Rings on April 2, 1977.

4.5.1.4 Retest of penetrations selected for repair as a result of the leak rate testing were accomplished immediately after repair on a priority basis.

4.5.1.5 Six Type B penetrations with testable gaskets were performed by Iowa Electric Light and Power Company personnel between May 9 and 11, 1977. These tests were scheduled to be performed during the final phase of the refueling outage.

4.5.1.6 One Type C retest was performed by Iowa Electric Light and Power Company personnel. This was on the HPCI condensate return isolation valves (Penetration 11).

4.6 PROBLEMS ENCOUNTERED

4.6.1 MAIN STEAM ISOLATION VALVES (MSIV)

The test procedure for the inboard MSIVs specified pressurizing the reactor side with compressed air to 24 psig. Outflow leakage from the inboard valve was then monitored. A test flow meter (calibrated to atmospheric pressure) was connected, through approximately 50 feet of 3/8 inch tygon hose, to the drain of outboard MSIV. The MSIV leak control system bleed line is additionally connected at a tee at this point. The measured maximum outflow leakage for any one MSIV at the meter was 1/3 of the allowable leakage of 5427 SCCM. Therefore the inboard valves were considered acceptable.

Following the inboard testing, the outboard MSIVs were tested by pressurizing the volume between the inboard and outboard MSIV to 24 psig via the same drain connection. The inflow leakage to each of steam lines A, C and D was seen to be at least 4 times, and as much as 15 times, the allowable leakage for any one valve. Since the pressure was equalized across the inboard valve for this test, this leakage was considered the total leakage from the stem and seat of the outboard MSIV and the MSIV leakage control system valve seats. This gross leakage required verification of the inboard leak rate tests with respect to the magnitude of leakage not monitored across the stem and seat of the outboard MSIV and across the seat of the leak control system bleed valves. Investigation confirmed that the leakage was from the stem packing. Detailed calculations to determine the acceptability of the inboard MSIV leak rate tests were then conducted. The inboard and the outboard MSIV test data, results of the corrective action to tighten the stem packing, and the local leak rate test of the MSIV Leak Control System bleed valves were input to the calculations. The calculations are included in this report.

4.6.2 MSIV LEAKAGE CONTROL SYSTEM BLEED VALVES

Main steam isolation valve leak control system (LCS), local leak rate tests were performed. The system comprised four pairs of LCS bleed valves branching off from the main steam lines A, B, C and D drain lines. Three of the four pairs of valves showed leak rates greater than the allowable rate which necessitated repairs.

The test data obtained from the initial tests of the LCS bleed valves is considered relevant in establishing the leak rates of the inboard main steam isolation valves. Therefore, the test data is included in this report.

4.6.3 TORUS PURGE OUTLET-PENETRATION N-205

The test procedure specified simultaneous pressurizing both of the torus purge outlet 18" butterfly valves (installed in series) and the 2" bypass line valve, CV-4309. The test volume is between the two butterfly valves and the 2" bypass branch line between the butterflies up to the bypass valve. Initial test indicated a gross leakage of 1599 SCCM. To identify which particular valve or valves contributed the leakage, the 2" bypass valve was isolated for test. This required isolating the two butterfly valves at the orifice flange connection on the 2" line immediately upstream from the 18" branch connection. A blank plate was found installed in place of orifice plate, FO-4309B. The initial test gross leakage was then identified to the 2" bypass valve. Retest of all three valves simultaneously, with the blank plate removed, showed a total leakage of 2005 SCCM, which necessitated the repair of CV-4309. An isolated retest of CV-4309 following repair showed minimal leakage of 1.6 SCCM.

Subsequently, the proper orifice was installed and the installation witnessed.

5.0 LOCAL LEAK RATE CALCULATIONS AND RESULTS

The results of the type B and Type C local leak rate tests are summarized in Table 1. The total leakage rate (CLR) is within the allowable limits in Technical Specification.

TABLE I

TEST	DESCRIPTION	LEAKAGE-SCCM	REMARKS
	TESTABLE GASKETS	0	
TYPE	ELECTRICAL CANISTERS	0	
B	FLANGE "O" RINGS	3	
	EXPANSION BELLOWS	9	
	CONTAINMENT ISOL. VLVS:		
	TYPE "C" (AIR TESTS)	2633	FROM TEST DATA
TYPE	TYPE "H" (WATER TESTS)	35091	CORRECTED-WATER VS AIR
C	MN. STM. ISOL. VLVS:		
	PENETRATION 7A	3243	INB'D VLV-CALCULATED
	PENETRATION 7B	2375	OUTB'D VLV-TEST DATA
	PENETRATION 7C	3183	INB'D VLV-CALCULATED
	PENETRATION 7D	3930	OUTB'D VLV-TEST DATA
	TOTAL	50467	

CLR = 220,609 SCCM

Leakage in % of CLR = $\frac{50467}{220609}$ = 23%

5.1.1 WATER VERSUS AIR LEAKAGE TESTS

For Type "H" designated test, air is used to pressurize the water to 54 psig and the volume of air required to replace the leaked water is measured.

The relationship for conversion is 10cc per hour per inch of diameter water leakage equals to 0.1 SCF per hour per inch of diameter air leakage.

Therefore:

10CCM of water leakage = 0.1 SCFH of equivalent air leakage

$$1\text{CCM of water leakage} = \frac{0.1}{10} \times (12 \times 2.54)^3 \text{ SCCM of equiv. air leakage}$$

$$= 283 \text{ SCCM of equiv. air leakage}$$

When air is used to pressurize the water to 54 psig:

1CCM of measured air = 1CCM water leakage

$$1 \times \frac{68.7}{14.7} \text{ SCCM of measured air} = 1\text{CCM water leakage}$$

$$= 283 \text{ SCCM of equiv. air leakage}$$

$$\text{or } 1 \text{ SCCM of measured air} = 283 \times \frac{14.7}{68.7} \text{ SCCM of equiv. air leakage}$$

$$= 60.5 \text{ SCCM}$$

so: Measured Equivalent Air

Leakage in SCCM = (flowmeter reading in SCCM) x 60.5

The Following Penetration Received
Type "H" Tests:

PENETRATION	VALVE	MEASURED AIR	EQUIVALENT AIR LEAKAGE
9-A	CV-2313/Mo. 4441	135 SCC/M	8168 SCC/M
9-B	V-14-1	68 SCC/M	4114 SCC/M
10	CV-2410/2411	35 SCC/M	2118 SCC/M
126	MO-1908/1909	206 SCC/M	12463 SCC/M
16A	MO-2117/2115	110 SCC/M	6655 SCC/M
16B	MO-2135/2137	6 SCC/M	363 SCC/M
36	V-17-73	20 SCC/M	1210 SCC/M

5.1.2 REPAIRED AND RETESTED VALVES

The following Type C penetrations were retested after valve repair:

PENETRATION	VALVE	AS FOUND LEAKAGE	RETEST LEAKAGE
9-B	V-14-1	4.2 Liters/M	68 SCC/M
11	CV-2211/2212	9378 SCC/M	200 SCC/M
25	CV-4302/4303/4310	27,277 SCC/M	31 SCC/M
32D	CV-4378 A/4378B	2100 SCC/M	14 SCC/M
32F	CV-1804A	359 SCC/M	30 SCC/M
205N	CV-4300/4301/4309	2005 SCC/M	408 SCC/M

5.1.3 LEAKAGE OF INBOARD MSIVs

MAIN STEAM LINE	A	B	C	D
OUTB'D MSIV LEAKAGE TEST DATA 24 PSIG-SCCM	35,000*	7,000*	84,000*	19,000*
INB'D MSIV LEAKAGE-TEST DATA-SCCM	1850	0	0.1	1200
DIFF. PRESS. ACROSS STEM PACKING-IN H_2O	2.65**	2.3**	2.40**	2.62**
CORR. TO ΔP FOR 50' TYGON HOSE-IN H_2O	.10	.10	.10	.10
DIFF. PRESS.-CORRECTED-IN H_2O	2.75	2.40	2.50	2.72
CALC. STEM LEAKAGE CORRECTION	1393	263	3183	750
TOTAL INBOARD VALVE LEAKAGE-SCCM	3243	263	3183	1950

* Leakage identified across valve stem packing prior to tightening packing gland nut.

**Values from Figure 4-Flowmeter Reading (CM) vs ΔP in. H_2O

Allowed leakage from any MSIV $\leqq$ 5427 SCCM at 24 psig.

5.1.4 LEAKAGE OF OUTBOARD MSIVs

MAIN STEAM LINE	A	B	C	D
OUTB'D VALVE LEAKAGE-AS FOUND-SCCM	2,000	2,375	450	3,930

CLIENT I.E.L.P.

PROJECT LOCAL LEAK RATE TEST

SUBJECT LEAKAGE CORRECTION TO INBOARD MSIV TEST RESULTS

COMPUTED BY T.T. IWASHITA

CHECKED BY [signature]

REFERENCE: CRANE TECH. PAPER 410; PG 1-8 & 1-9

FLOW DIAGRAM:

GIVEN:

$Q_{1A} = 35000\ cc/M = \frac{35000\ cc \times FT^3}{28322\ cc \times M \times 60\ SEC} = .0206\ FT^3/SEC$

$Q_{1B} = 7000\ cc/M = .0041\ FT^3/SEC$

$Q_{1C} = 84000\ cc/M = .0494\ FT^3/SEC$

$Q_{1D} = 19000\ cc/M = .0112\ FT^3/SEC$

FIND:

Q_{2A} @ $\Delta P_{2A} = 2.75''\ H_2O$; $P_{2A} = \frac{2.75 \times 62.4}{1728} + 14.7 = 14.7993$ PSIA

Q_{2B} @ $\Delta P_{2B} = 2.40''\ H_2O$; $P_{2B} = 2.40 \times .0361 + 14.7 = 14.7886$ PSIA

Q_{2C} @ $\Delta P_{2C} = 2.50''\ H_2O$; $P_{2C} = 2.50 \times .0361 + 14.7 = 14.7903$ PSIA

Q_{2D} @ $\Delta P_{2D} = 2.72''\ H_2O$; $P_{2D} = 2.72 \times .0361 + 14.7 = 14.7982$ PSIA

ASSUMPTION: STEM PACKING PROVIDES A TORTUROUS PATH SUCH THAT $R_e \leq 2000$ & FLOW LAMINAR W/LOW VELOCITY.

FROM WHICH:

$f = 64/R_e = 64\mu/124 dv\rho$ & $\Delta P = .000668 \mu L v/d^2$

(VALID FOR COMPRESSIBLE FLUID IN LAMINAR REGION)

HOWEVER, FOR COMPRESSIBLE FLOW WHERE ΔP = >40% OF P_1

$$W^2 = \left[\frac{144 g D A^2}{\bar{V} f L}\right]\left[\frac{(P_1')^2 - (P_2')^2}{P_1'}\right]$$

WHERE:

- W = #/SEC
- g = 32 FT/SEC/SEC
- D = FT (PIPE DIA.)
- A = FT^2 (FLOW AREA)
- $\bar{V}$ = FT^3/#
- $f = 64\mu\bar{V}/124 dv$
- L = FT
- $P_1' = 38.7$ PSIA
- $P_2' = 14.7$ PSIA

$\frac{38.7 - 14.7}{38.7} = 62\%$

FOR 24 PSIG: $\frac{(P_1')^2 - (P_2')^2}{P_1'} = \frac{38.7^2 - 14.7^2}{38.7} = 33.12$

FOR 2.75" H_2O: $\frac{14.7993^2 - 14.7^2}{14.7993} = .1979$

FOR 2.40" H_2O: $\frac{14.7886^2 - 14.7^2}{14.7886} = .1767$

FOR 2.50" H_2O: $\frac{14.7903^2 - 14.7^2}{14.7903} = .1800$

FOR 2.72" H_2O: $\frac{14.7982^2 - 14.7^2}{14.7982} = .1957$

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FOR Q_{1A}: $W_{1A} = \frac{.0206 FT^3}{SEC} \times \frac{.075 \#}{FT^3} \times \frac{38.7}{14.7} = .0041 \#/SEC$

FOR Q_{1B}: $W_{1B} = \frac{.0041 \times .075 \times 38.7}{14.7} = .0008 \#/SEC$

FOR Q_{1C}: $W_{1C} = \frac{.0494 \times .075 \times 38.7}{14.7} = .0098 \#/SEC$

FOR Q_{1D}: $W_{1D} = \frac{.0112 \times .075 \times 38.7}{14.7} = .0022 \#/SEC$

THEN: $W_{2A} = .0041\left[\frac{.1919}{33.12}\right]^{1/2} = 3.16 \times 10^{-4} \#/SEC$ IF f & $\bar{V}$ ARE CONSTANT

$W_{2B} = .0008\left[\frac{.1767}{33.12}\right]^{1/2} = .58 \times 10^{-4} \#/SEC$

$W_{2C} = .0098\left[\frac{.1800}{33.12}\right]^{1/2} = 7.22 \times 10^{-4} \#/SEC$

$W_{2D} = .0022\left[\frac{.1957}{33.12}\right]^{1/2} = 1.69 \times 10^{-4} \#/SEC$

HOWEVER;

$f = 64\mu/124 d v \rho$ WHERE: μ, d and 64/124 ARE CONSTANTS

THEREFORE:

$f \cong 1/v\rho$ AND $v = Q/A$; $\rho_2/\rho_1 = C\frac{P_2}{P_1}$; $W \cong (1/f)^{1/2} = \left(\frac{1}{1/\rho}\right)^{1/2} = (1/\rho)^{1/2}$

THEN: $CP_{2A}/P_{1A} = 14.7993/38.7 = .38$

$CP_{2B}/P_{1A} = 14.7886/38.7 = .38$

$CP_{2C}/P_{1A} = 14.7903/38.7 = .38$

$CP_{2D}/P_{1A} = 14.7982/38.7 = .38$

HENCE CORRECTING FOR ρ; $W_{2A} = 3.16 \times 10^{-4}(.38)^{1/2} = 1.95 \times 10^{-4} \#/SEC$

$W_{2B} = .58 \times 10^{-4}(.38)^{1/2} = .36 \times 10^{-4} \#/SEC$

$W_{2C} = 7.22 \times 10^{-4}(.38)^{1/2} = 4.45 \times 10^{-4} \#/SEC$

$W_{2D} = 1.69 \times 10^{-4}(.38)^{1/2} = 1.04 \times 10^{-4} \#/SEC$

FROM WHICH:

$Q_{2A} = 1.95 \times 10^{-4} \#/SEC \times FT^3/.075 = 2.60 \times 10^{-3} FT^3/SEC$

$Q_{2B} = .36 \times 10^{-4} \#/SEC \times FT^3/.075 = .48 \times 10^{-3} FT^3/SEC$

$Q_{2C} = 4.45 \times 10^{-4} \#/SEC \times FT^3/.075 = 5.93 \times 10^{-3} FT^3/SEC$

$Q_{2D} = 1.04 \times 10^{-4} \#/SEC \times FT^3/.075 = 1.39 \times 10^{-3} FT^3/SEC$

THEN CORRECTING FOR v: $W_{2A} = 1.95 \times 10^{-4}\left(\frac{.00260}{.0206} \times \frac{FT^3}{SEC}\right)^{1/2} = .69 \times 10^{-4} \#/SEC$

$W_{2B} = .36 \times 10^{-4}\left(\frac{.00048}{.0041} \times \frac{FT^3}{SEC}\right)^{1/2} = .12 \times 10^{-4} \#/SEC$

$W_{2C} = 4.45 \times 10^{-4}\left(\frac{.00593}{.0494} \times \frac{FT^3}{SEC}\right)^{1/2} = 1.54 \times 10^{-4} \#/SEC$

$W_{2D} = 1.04 \times 10^{-4}\left(\frac{.00139}{.0112} \times \frac{FT^3}{SEC}\right)^{1/2} = .37 \times 10^{-4} \#/SEC$

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AND CORRECTING FOR $\bar{V}$ WHERE: $\bar{V} = 1/\rho_1 = \frac{1}{.075 \times P_1/P_2} = \frac{1}{.075 \times 38.7/14.7} = 5.06\ FT^3/\#$

$W \cong \left[\frac{1}{\bar{V}}\right]^{1/2}$ SO IF $\bar{V}$ GOES UP, W DECREASES BY $\left(\frac{\bar{V}_1}{\bar{V}_2}\right)^{1/2}$

THEN:

$$\bar{V}_{2A} = \frac{1}{.075 \times P_{2A}/P_2} = \frac{1}{.075 \times 14.7993/14.7} = 13.24\ FT^3/\#$$

$$\bar{V}_{2B} = \frac{1}{.075 \times P_{2B}/P_2} = \frac{1}{.075 \times 14.7886/14.7} = 13.25\ FT^3/\#$$

$$\bar{V}_{2C} = \frac{1}{.075 \times P_{2C}/P_2} = \frac{1}{.075 \times 14.7903/14.7} = 13.25\ FT^3/\#$$

$$\bar{V}_{2D} = \frac{1}{.075 \times P_{2D}/P_2} = \frac{1}{.075 \times 14.7982/14.7} = 13.24\ FT^3/\#$$

HENCE THE CORRECTION:

$$W_{2A} = .69 \times 10^{-4}\left[\frac{5.06}{13.24}\right]^{1/2} = 4.266 \times 10^{-5}\ \#/SEC$$

$$W_{2B} = .12 \times 10^{-4}\left[\frac{5.06}{13.25}\right]^{1/2} = .742 \times 10^{-5}\ \#/SEC$$

$$W_{2C} = 1.54 \times 10^{-4}\left[\frac{5.06}{13.25}\right]^{1/2} = 9.517 \times 10^{-5}\ \#/SEC$$

$$W_{2D} = .37 \times 10^{-4}\left[\frac{5.06}{13.24}\right]^{1/2} = 2.379 \times 10^{-5}\ \#/SEC$$

FINALLY:

$$Q_{2A} = \frac{4.266 \times 10^{-5} \times 60}{.075 \times 14.7993/14.7} = .03390\ FT^3/MIN = 58.6\ \frac{IN^3}{MIN} = 960\ SCC/M$$

$$Q_{2B} = \frac{.742 \times 10^{-5} \times 60}{.075 \times 14.7886/14.7} = .00590\ FT^3/MIN = 10.2\ \frac{IN^3}{MIN} = 167\ SCC/M$$

$$Q_{2C} = \frac{9.517 \times 10^{-5} \times 60}{.075 \times 14.7903/14.7} = .07567\ FT^3/MIN = 130.8\ \frac{IN^3}{MIN} = 2143\ SCC/MIN$$

$$Q_{2D} = \frac{2.379 \times 10^{-5} \times 60}{.075 \times 14.7982/14.7} = .01890\ FT^3/MIN = 32.7\ \frac{IN^3}{MIN} = 536\ SCC/MIN$$

NOTE: THE ABOVE VALUES ARE CALCULATED FOR $\Delta P > 40\%$ OF P_1. FOR $\Delta P < 40\%$ OF P_1, DARCY'S FORMULA CAN BE APPLIED.

NUCLEAR SERVICES CORPORATION

FILE NO. ____
SHEET 4 OF 4
DATE JUNE 20 197[illegible]
JOB NO. 10W-0165
COMPUTED BY T.T. IWASHITA
CHECKED BY [illegible]

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SINCE: $\Delta P/P_1 = .0993/14.7993 = 0.67\%$

DARCY'S FORMULA CAN BE APPLIED.

$$W = .525 Y d^2 \left[\frac{\Delta P \rho}{K}\right]^{1/2} \text{ OR } \frac{W_1}{W_2} = \left[\frac{\Delta P_1 \rho_1}{\Delta P_2 \rho_2}\right]^{1/2}$$

THEN: $W_2 = W_1 \left[\frac{\Delta P_2 \rho_2}{\Delta P_1 \rho_1}\right]^{1/2}$

$$Q_{2A} = 35000\left[\frac{.0993(.075 \times \frac{14.7993}{14.7})}{24(.075 \times \frac{38.7}{14.7})}\right]^{1/2} = 35000(.0398) = 1393 \text{ scc/m}$$

$$Q_{2B} = 7000\left[\frac{.0886(.075 \times \frac{14.7886}{14.7})}{24(.075 \times \frac{38.7}{14.7})}\right]^{1/2} = 7000(.0376) = 263 \text{ scc/m}$$

$$Q_{2C} = 84000\left[\frac{.0903(.075 \times \frac{14.7903}{14.7})}{24(.075 \times \frac{38.7}{14.7})}\right]^{1/2} = 84000(.0379) = 3183 \text{ scc/m}$$

$$Q_{2D} = 19000\left[\frac{.0982(.075 \times \frac{14.7982}{14.7})}{24(.075 \times \frac{38.7}{14.7})}\right]^{1/2} = 19000(.0395) = 750 \text{ scc/m}$$

THEREFORE; TRUE VALUES ARE BETWEEN:

Q_{2A} = 960 scc/m (MINIMUM) = 1393 (MAXIMUM)

Q_{2B} = 167 scc/m (MINIMUM) = 263 (MAXIMUM)

Q_{2C} = 2143 scc/m (MINIMUM) = 3183 (MAXIMUM)

Q_{2D} = 536 scc/m (MINIMUM) = 750 (MAXIMUM)

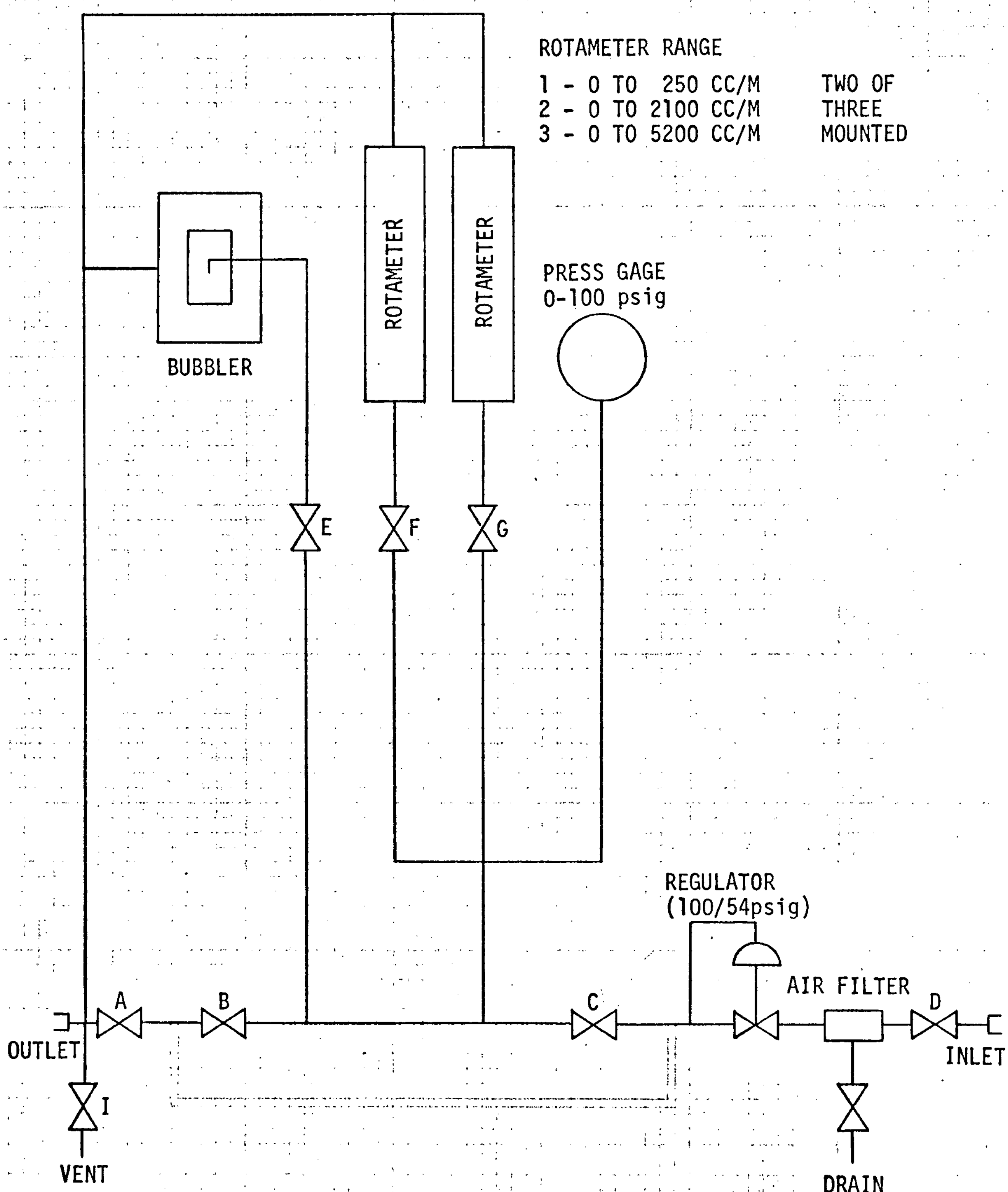


Figure 1. Local Leak Rate Tester

FIGURE 2

Electrical Canister Test Connection

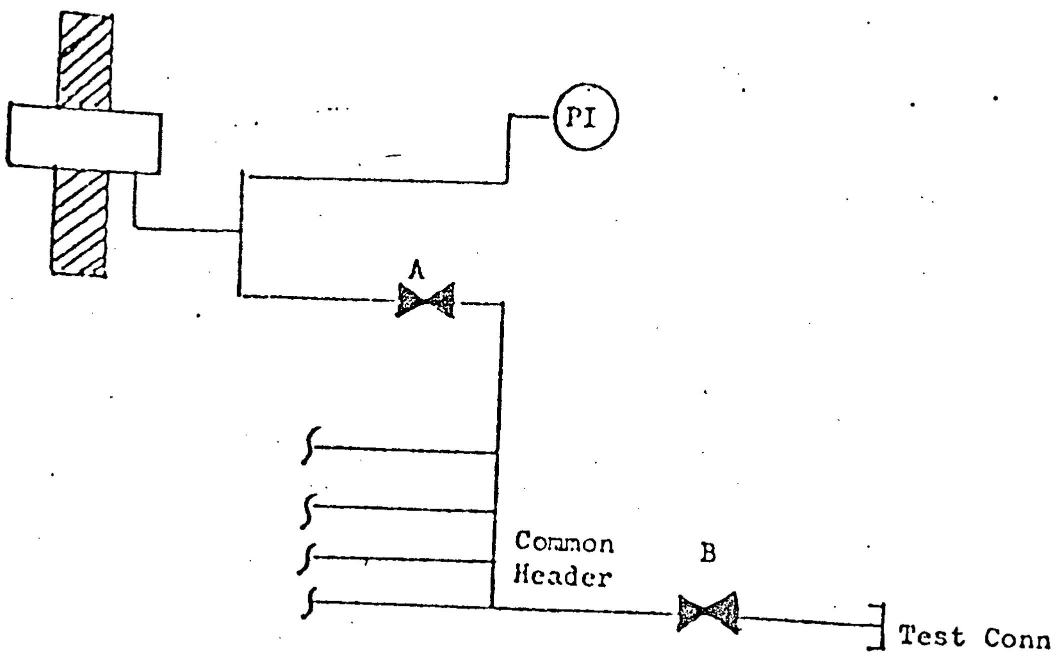
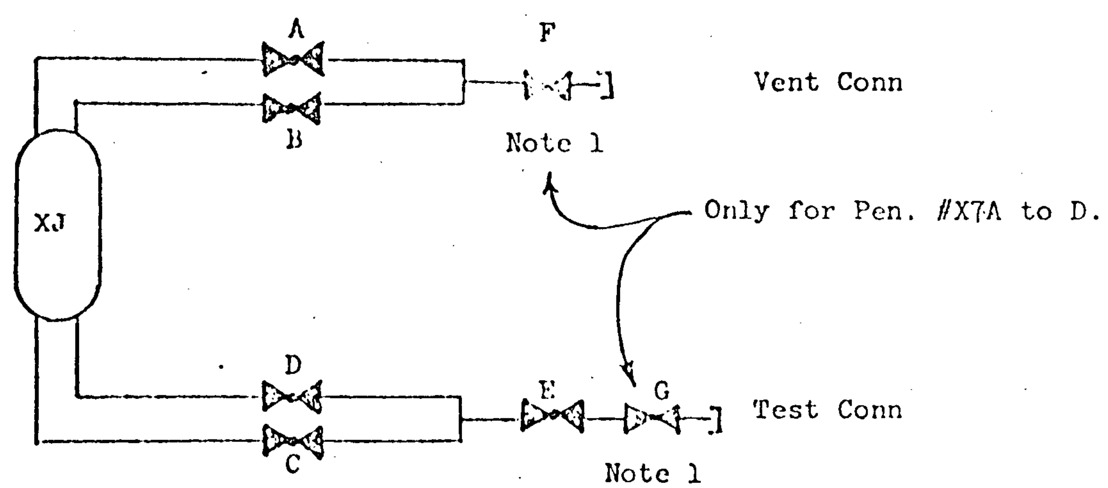


FIGURE 3

EXPANSION BELLOWS

Penetration Number	XJ	MANIFOLD VALVES					
		A	B	C	D	E	F/G
X7A	4413	V-14-64	V-14-65	V-14-66	V-14-67	V-14-68	Note 1
X7B	4416	V-14-69	V-14-70	V-14-71	V-14-72	V-14-73	Note 1
X7C	4419	V-14-74	V-14-75	V-14-76	V-14-77	V-14-78	Note 1
X7D	4421	V-14-79	V-14-80	V-14-81	V-14-82	V-14-83	Note 1
X9A	4441	V-14-84	V-14-85	V-14-86	V-14-87	V-14-88	---
X9B	4442	V-14-89	V-14-90	V-14-91	V-14-92	V-14-93	---
X10	2400	V-24-34	V-24-35	V-24-36	V-24-37	V-24-38	---
X11	2238	V-22-46	V-22-47	V-22-48	V-22-49	V-22-50	---
X12	1908	V-19-113	V-19-114	V-19-115	V-19-116	V-19-117	---
X13A	2002	V-20-64	V-20-65	V-20-66	V-20-67	V-20-68	---
X13B	1906	V-19-108	V-19-109	V-19-110	V-19-111	V-19-112	---
X15	2701	V-27-100	V-27-101	V-27-102	V-27-103	V-27-104	---
X16A	2118	V-21-48	V-21-49	V-21-50	V-21-51	V-21-52	---
X16B	2138	V-21-53	V-21-54	V-21-55	V-21-56	V-21-57	---
X17	1900	V-19-103	V-19-104	V-19-105	V-106	V-19-107	---

Typical Expansion Joint Test Connection



<u>Note 1</u> Vent lines and test lines for XJ 4413, 4416, 4419, 4421 form a common header with single isolation valves (F,G) located at the test connection and vent connection. (F-isolation valve for vent header; G-isolation valve for test header).

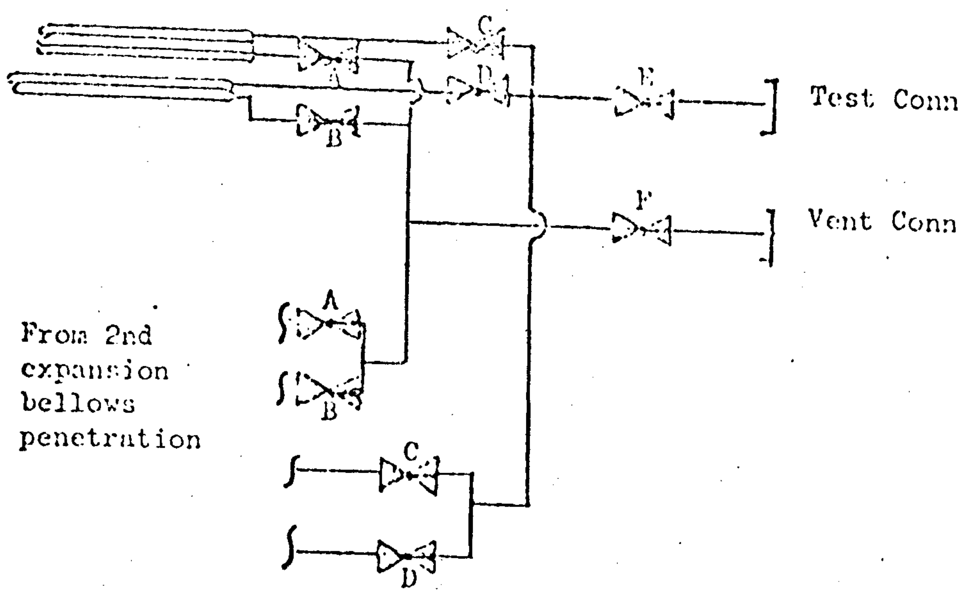
FIGURE 4

Drywell/Suppression Chamber Vent Line
Penetrations with Expansion Bellows

Penetration Number	Manifold Valves					
	A	B	C	D	E	F
N201D					V-43-92	V-43-96
N201B						
N201C					V-43-93	V-43-97
N201A						
N201E		SEE SKETCH BELOW			V-43-94	V-43-98
N201G						
N201F					V-43-95	V-43-99
N201H						

NOTE: Penetrations N201A - N201C, N201B - N201D, N201E - N201G, and N201F N201H have common test and vent connections.

Expansion Bellows Arrangement



FISHER & PORTER DATA (R. BEAN)

FOR 10" FLOWMETER TUBE

25 CM = 7.6"
20 CM = 6.0"
15 CM = 4.4"
10 CM = 3.6"
5 CM = 2.8"
1 CM = 2.4"

$0.1 \frac{CC}{MIN} = 0.1$ CM

$1850 \frac{CC}{MIN} = 3.4$ CM

$1200 \frac{CC}{MIN} = 2.2$ CM

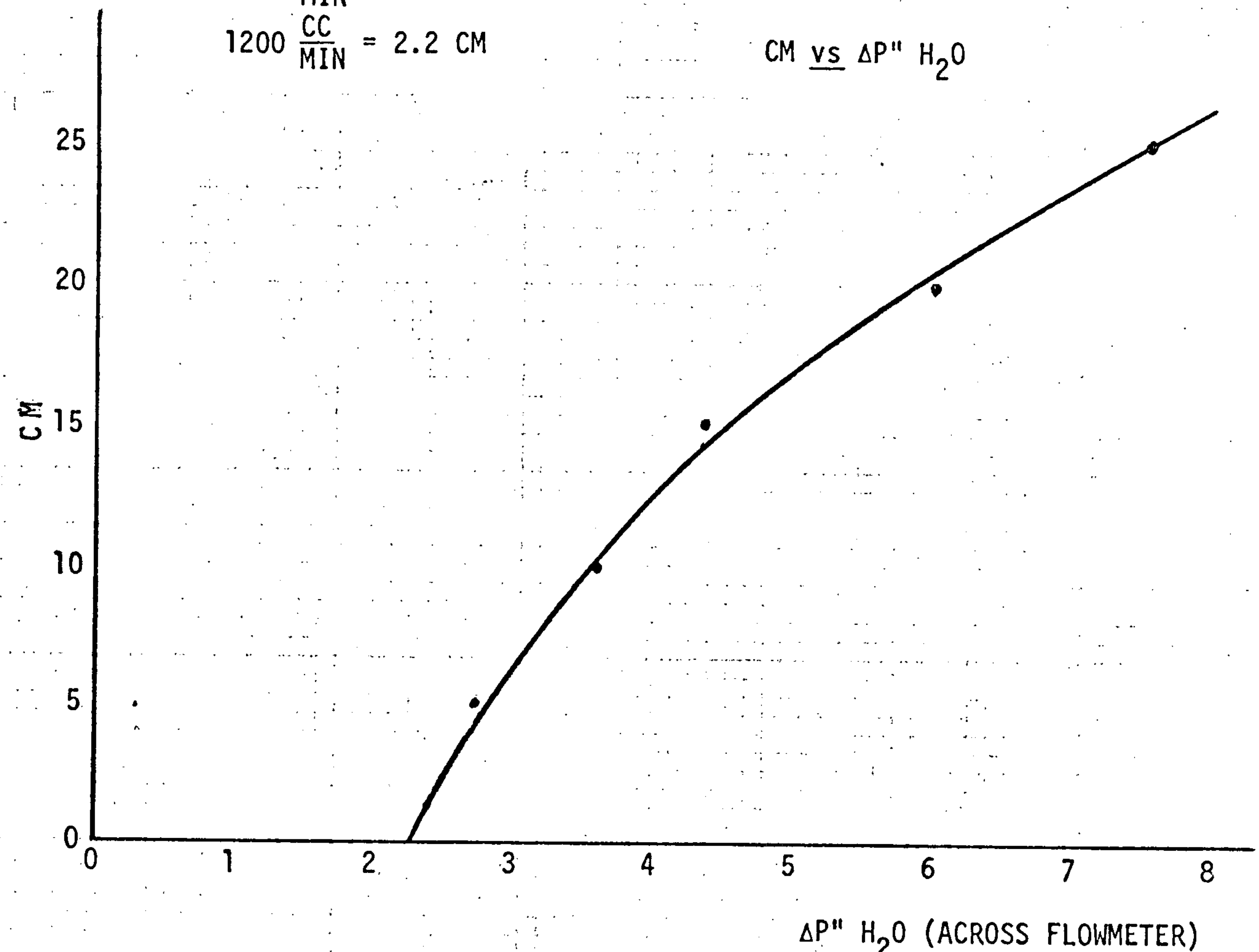


FIGURE 5