TENNESSEE VALLEY AUTHORITY
CHATTANOOGA, TENNESSEE 37401

400 Chestnut Street Tower II

October 26, 1984

U.S. Nuclear Regulatory Commission
Region II
Attn: Mr. James P. O'Reilly, Regional Administrator
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30323

Dear Mr. O'Reilly:

SEQUOYAH NUCLEAR PLANT UNITS 1 AND 2 - IE BULLETIN 84-03 REFUELING CAVITY WATER SEAL - SUPPLEMENTAL RESPONSE

By my letters dated October 2 and 17, 1984, we provided responses to OIE Bulletin 84-03, "Refueling Cavity Water Seal." As a result of a telephone conversation and agreement reached with P. R. Wallace, Sequoyah Plant Manager, enclosed is a supplemental response to OIE Bulletin 84-03.

If there are any questions, please get in touch with R. H. Shell at FTS 858-2688.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

DS Kammer

for L. M. Mills, Manager
Nuclear Licensing

Enclosure

cc: Mr. Richard C. DeYoung, Director (Enclosure)
Office of Inspection and Enforcement
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Records Center (Enclosure)
Institute of Nuclear Power Operations
1100 Circle 75 Parkway, Suite 1500
Atlanta, Georgia 30339

IE11

IE BULLETIN 84-03
REFUELING CAVITY WATER SEAL
SEQUOYAH NUCLEAR PLANT

Description of the Reactor Cavity Annulus Seal at Sequoyah

The opening between the reactor vessel flange and the reactor cavity liner (support ring) is a nominal 2-inch wide annulus. During refueling, the annulus opening is sealed by a passive mechanism using a single reactor cavity seal. The seal (reference figure 1) is a Presray Pneuma-Seal PRS 585. The seal is composed of an inflatable bladder with a wedge/ T-section at the top. The elastomeric portions of the seal are constructed of high strength radiation resistant EPDM compound No. E603 which meets spec ASTM D20804AA620A13B13C12EA14Z1Z2Z3. The seal is constructed of one piece (i.e., no splice joints) and has a layer of reinforcing fabric to provide additional structural integrity and to ensure better resistance to rupture or tear. The reactor vessel flange and support ring which the seal rests on has been hand and machine smoothed, respectively, to accommodate the seal and to prevent sharp edges from damaging the seal (reference figure 2).

The seal is placed in the annulus opening and compressed by hand. The bladder is then inflated to 30 psig (±5). Direct indication of the pressure in the bladder is provided by a pressure gage. Air for this operation is supplied by the service air system with bottled air as a backup. A relief valve, set at 35 psig, is installed to ensure that the seal is not overinflated. The air supply system is provided with two check valves; one at the bottled air supply connection in the event of a loss of plant air supply, and one at the cavity seal connection in the event of a loss of both air supplies.

The main advantages of this passive seal arrangement are its simplicity, ease of installation and removal, and sealing characteristics. As can be seen in figure 2, the compression of the wedge shape portion of the seal into the annulus opening and the inflation of the bladder is designed to ensure that the seal will remain in place. The wedge shape portion of the seal also ensures good sealing characteristics between the seal and the reactor vessel flange/reactor cavity liner.

Comparison of Sequoyah to Haddum Neck

A comparison of the Sequoyah and Haddum Neck reactor cavity seal mechanisms indicates that there are major differences in the seal mechanisms at the two plants. Sequoyah utilizes a passive seal mechanism which requires only that a single seal be placed in a 2-inch wide annulus opening. Haddum Neck utilizes an active seal mechanism which requires the arrangement of two seals and a seal ring to cover an annulus opening of approximately 1'-6" in width (see figure 3). The seal ring and seals must therefore be properly aligned to ensure the integrity of this sytem.

The seal used at Sequoyah has a larger area in the wedge/T-section than the seals used at Haddum Neck (see figure 4). In addition, the wedge/T-section of the Sequoyah seal utilizes a harder material compound (E603 at Sequoyah, E401 at Haddum Neck). These differences result in Sequoyah having a seal which is stronger and stiffer at that portion of the seal which must carry the load and which has been identified as the failure point at the Haddum Neck plant (see "Potential for Seal Failure").

Potential for Seal Failure

The failure mechanism at the Haddum Neck facility is understood to have been a deformation of the top flange of the seal (see figure 4). The net effect of this deformation was to reduce the effective width of the wedge portion of the seal. This condition resulted in a reduction in the stiffness of the seal and is believed to have led to the failure. (Reference a letter from W. G. Counsil, Connecticut Yankee Atomic Power Company to D. M. Crutchfield, US NRC, dated August 31, 1984.)

TVA does not believe that this type failure is creditable utilizing the Sequoyah Presray Pneuma-Seal PRS 585. To support this position TVA has performed analytical calculations and actual testing on the spare Sequoyah seal.

Analytical Calculation

At TVA's request, Impell's engineering staff has performed simplified calculations concerning the stability of the seal use at Sequoyah. The maximum downward deflection of the head of the pressure seal was computed using a beam model. This model accounts for the properties of rubber as well as the geometry of the seal. The model does not include frictional forces due to the edges supporting the seal and the internal pressure of 35 psi maximum. These assumptions resulted in a conservative value for the deflection of the seal due to the water pressure. Incorporating a safety factor of 1.5 for a water level of 24 feet (24') deep, the maximum deflection of the top of the head of the seal is .22 inches. Results of this calculation indicates that the 24 feet (24') of water with a safety factor of 1.5 could not result in the movement of a properly installed seal through the gap between the reactor pressure vessel and the cavity liner.

Test

An actual test was conducted on the spare Sequoyah seal (see figure 5). A test rig was constructed which simulated a one foot (1') section of the annulus. The seal was installed on the test rig in a deflated configuration. Prior to the test, both the seal and the fixtures on the test rig were wetted down. A total force of 432 lbs was then exerted through a 2- x 12-inch rectangular plate mounted on the upper surface of the seal. The test condition simulated a stress on the seal of 1.5 times the normal stress on the seal during refueling operations (12 psi during refueling, 18 psi test). Total deflection of the seal with 18 psi applied was 0.095 inches. No unusual configuration of the seal was observed during the test which would have rendered the seal unacceptable of performing its design function during refueling operations. The seal surfaces showed no indications of damage upon inspection following the test.

The spare seal and the seal presently in use are required to meet a durometer reading of 60 $\pm$ 10. The spare seal was purchased on August 20, 1981 and had a durometer reading of 61. The test performed on October 20, 1984 showed the spare seal to have a durometer reading of 64. This test data shows that storage does not cause a significant harding of the seals. It can be concluded that the seal presently in use, which was purchased on September 17, 1980, is in an acceptable condition.

The results of these two activities (analytical and testing) provide sufficient data to conclude that a gross failure of the Sequoyah seal is not a creditable event.

Preventive Maintenances

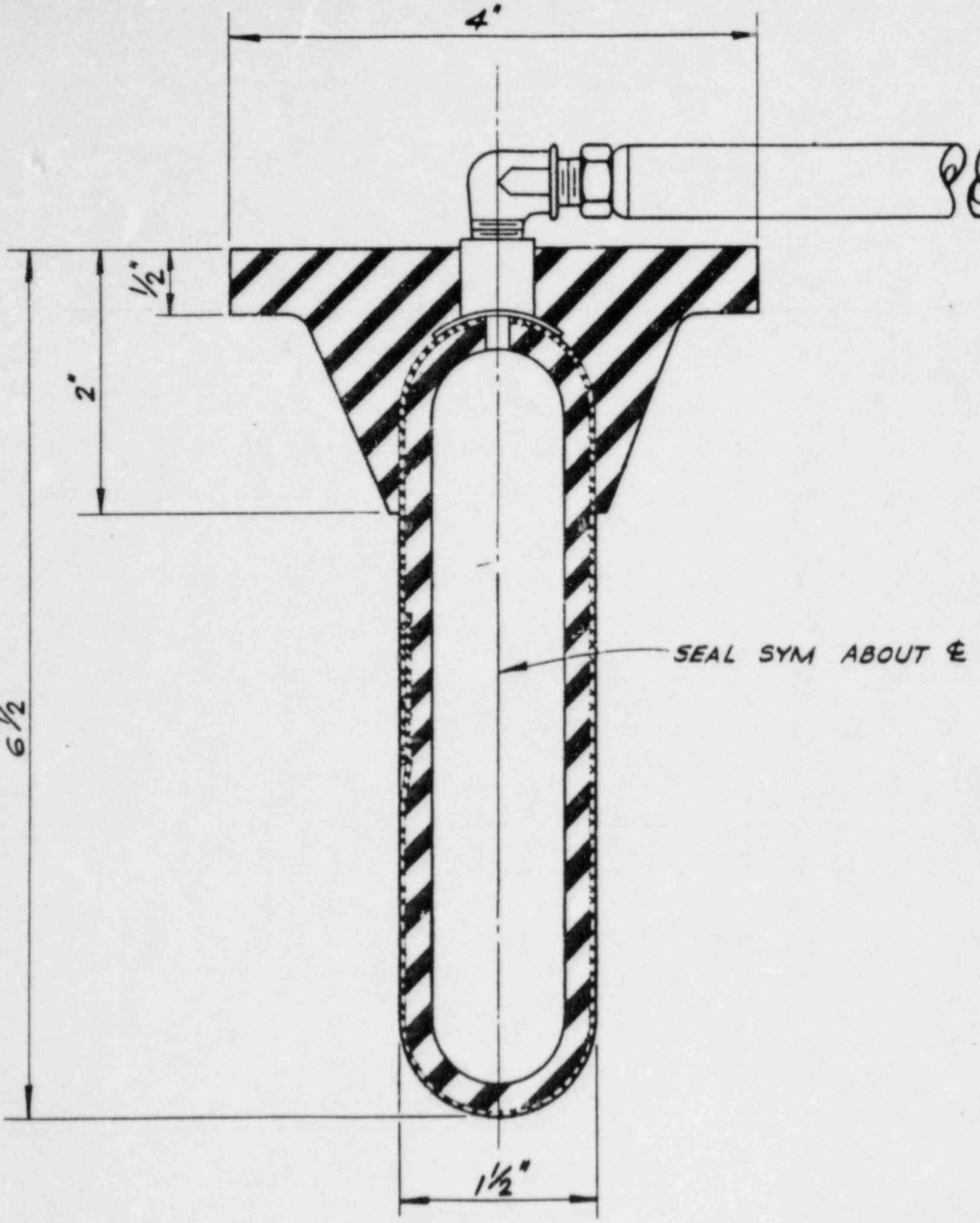
To ensure that the properties of the seal are not degraded during storage, handling, and use, a preventive maintenance program will be implemented for storage and inspection of the seal. Maintenance Instruction 1.2 "Removal and Replacement of RPV Head and Attachments," will be revised to require visual inspection and durometer readings of the seal prior to use.

Additional Precautions

The abnormal operating instructions (AOIs) have been revised to assist the reactor operator in diagnosing the symptoms of a potential reactor cavity seal leakage during refueling and the corrective actions needed to mitigate the event.

Conclusion

TVA has demonstrated, utilizing analytical calculations, actual test, and engineering judgment, that a gross seal failure of the type experienced at the Haddum Neck Nuclear Plant is not a creditable event at Sequoyah Nuclear Plant.



B3 - B3
12" = 1'-0"

FIG-1

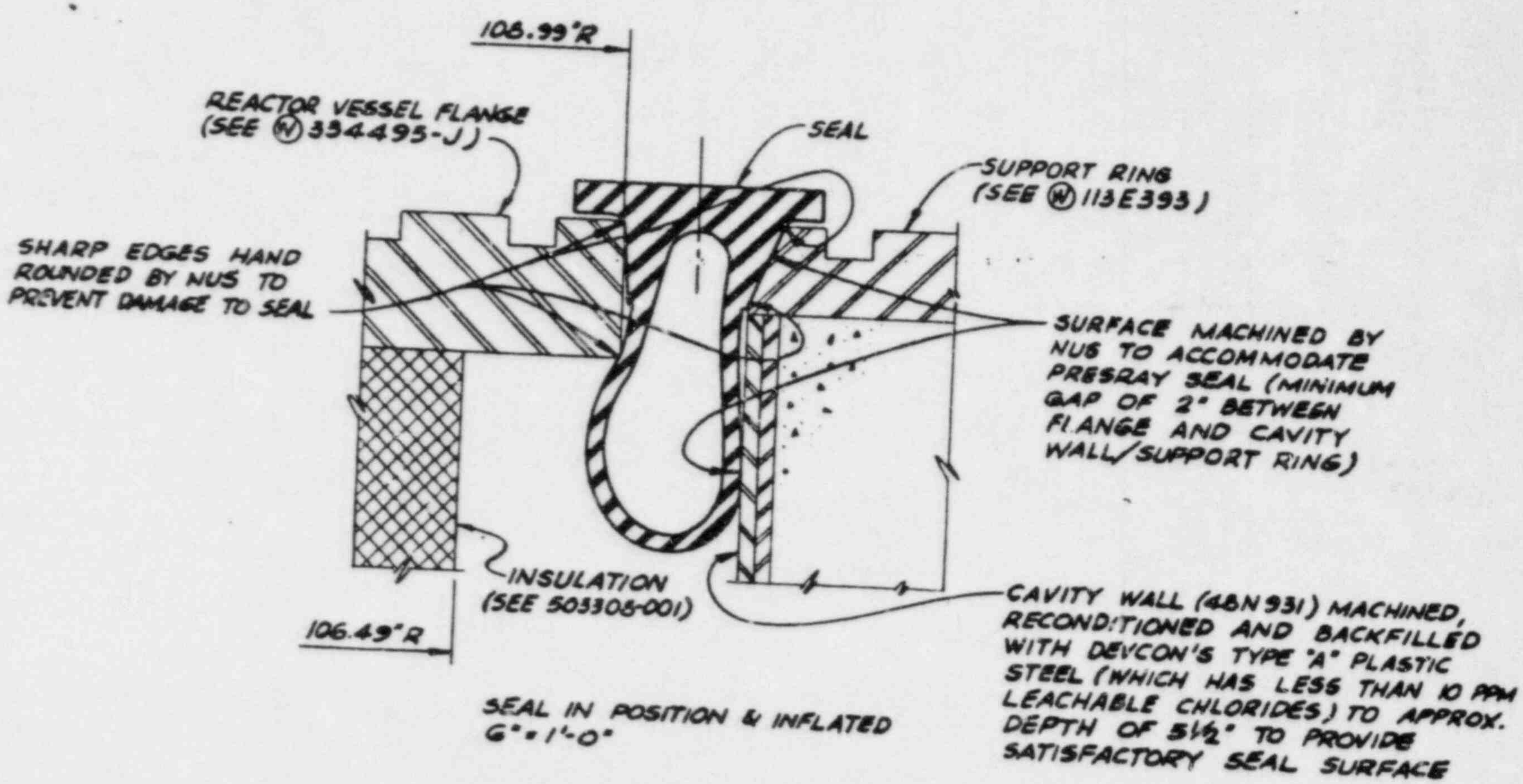

108.99"R
REACTOR VESSEL FLANGE
(SEE Ⓦ 334495-J)
SEAL
SUPPORT RING
(SEE Ⓦ 113E393)
SHARP EDGES HAND
ROUNDED BY NUS TO
PREVENT DAMAGE TO SEAL
SURFACE MACHINED BY
NUS TO ACCOMMODATE
PRESRAY SEAL (MINIMUM
GAP OF 2" BETWEEN
FLANGE AND CAVITY
WALL/SUPPORT RING)
INSULATION
(SEE 503308-001)
106.49"R
CAVITY WALL (48N931) MACHINED,
RECONDITIONED AND BACKFILLED
WITH DEVCON'S TYPE "A" PLASTIC
STEEL (WHICH HAS LESS THAN 10 PPM
LEACHABLE CHLORIDES) TO APPROX.
DEPTH OF 5½" TO PROVIDE
SATISFACTORY SEAL SURFACE
SEAL IN POSITION & INFLATED
6" = 1'-0"

FIG-2

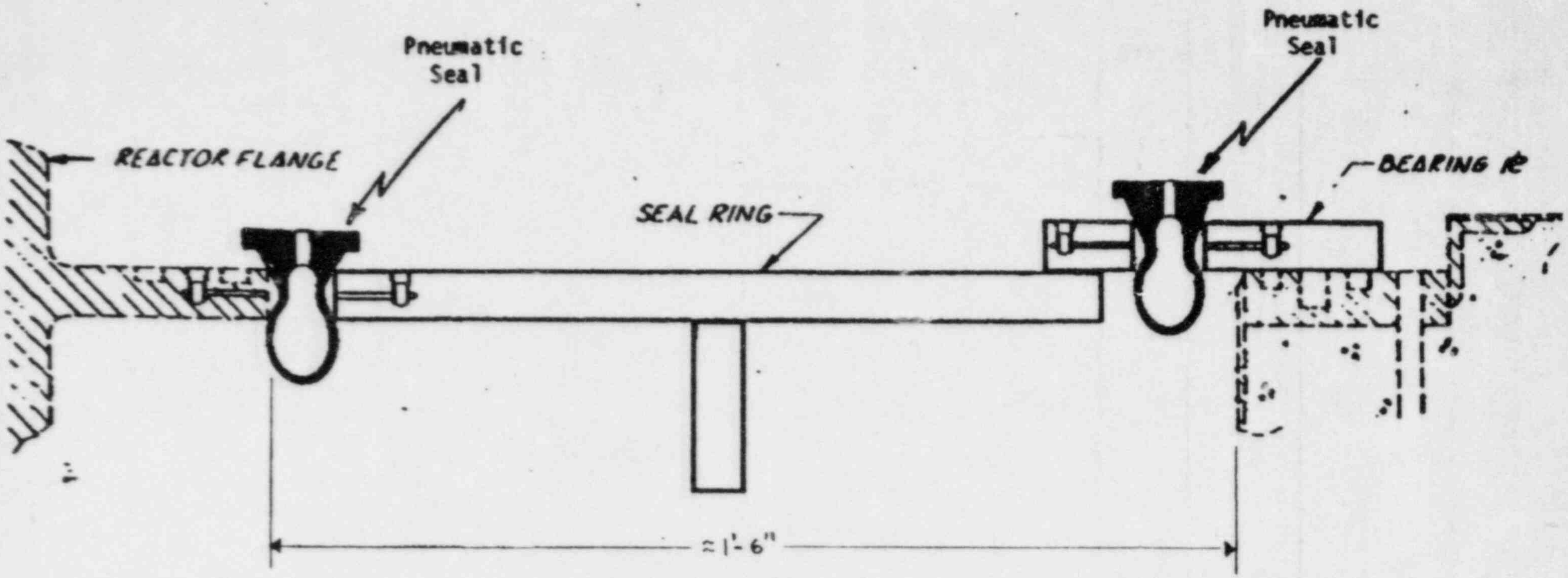


Figure 3 - Haddam Neck Refueling Cavity Water Seal

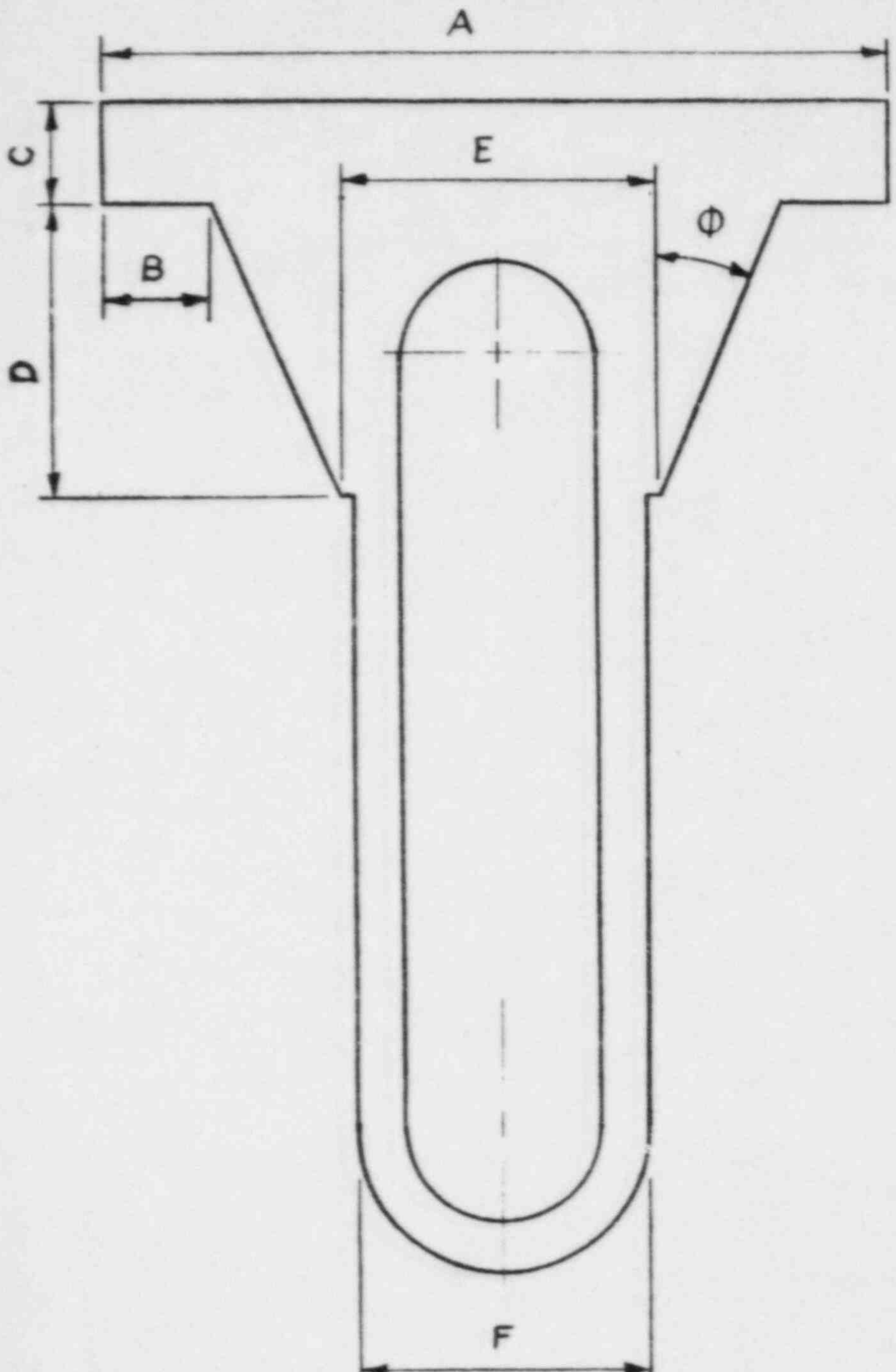


FIG - 4

DIMENSIONS	
HADDAM NECK	SEQUOYAH
A 3.5"	A 4"
B 0.350"	B 0.5625
C 0.5"	C 0.5"
D 1.125"	D 1.5
E 1.5"	E 1.6875
F 1.5"	F 1.5"
Φ 30°	Φ 20°
CAVITY GAP ≈ 1'-6"	CAVITY GAP 2"
EPDM T/WEDGE E 401 EPDM BLADDER E 603	EPDM T/WEDGE E 603 EPDM BLADDER E 603

CAVITY SEAL TEST

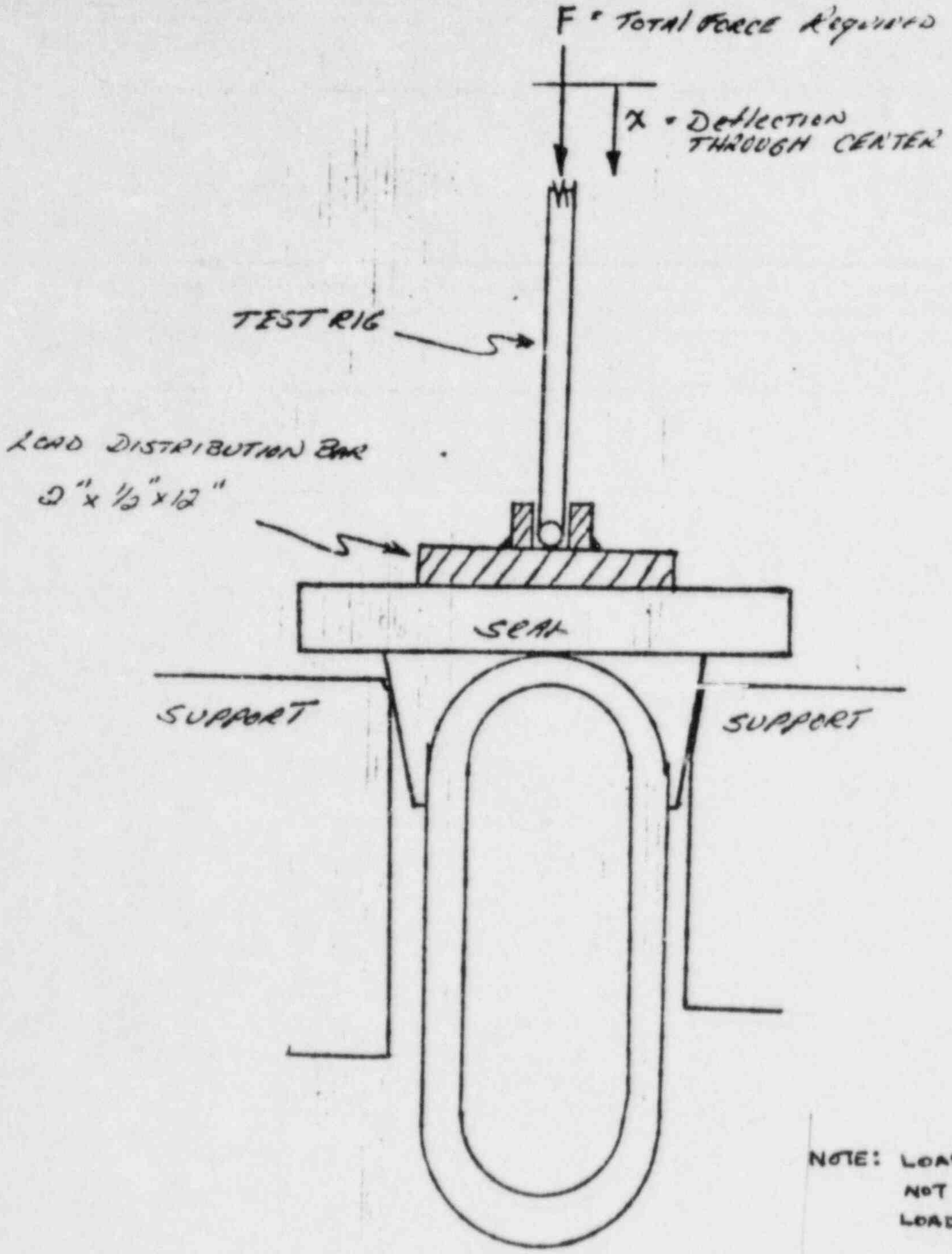


FIG-5

NOTE: LOAD BEAM WEIGHT WAS NOT CONSIDERED IN THE LOAD CONNECTIONS.

Calculations:

$$F = (\text{SAFETY FACTOR})(\text{HEAD PRESSURE}_{H_2O})(\text{AREA of DIST. BAR})$$

$$= (1.5)(12\ lb/in^2)(24\ in^2)$$

$$= 432\ lb.$$

where: Head Pressure$_{H_2O}$ = 26' of H_2O over Seal Surface

F = total Force Required to exert 18 psi or 1.5 (12 psi) on seal surface.