LEAKRATE TESTING OF THE
EBR-II REACTOR BUILDING

by

Henry W. Buschman

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ABSTRACT

This report summarizes the results of leakrate testing of the EBR-II reactor building. The existing leakrate criteria are presented and discussed. The report recommends that the leakrate criterion for each individual building penetration be revised. The revised criteria are based on the size of the penetration to a greater extent than before. Although the allowable leakage for many of the penetrations is increased, the revised criteria continue to ensure that the total leakage from the reactor building will not exceed 1000 ft³/day (at reference conditions of 36.2 psia and 32°F) with a differential pressure of 24 psig. (One thousand cubic feet per day was the criterion that had previously been established in the Hazard Summary Report as the total allowable.)

Comparison of the new criteria with leakrate data from past testing shows that there will be little difficulty meeting the new criteria with present testing techniques. This comparison also shows that when a leak exists that can clearly be detected, the criteria are sufficiently restrictive to require identification and subsequent repair of the leak.

I. GENERAL DISCUSSION

A. Introduction

Experimental Breeder Reactor II (EBR-II) is a sodium-cooled reactor with a design power level of 62.5 MWt. The reactor and the primary sodium system are contained within a steel shell, which is referred to hereafter as the reactor building. The building is a cylinder 80 ft in diameter with a hemispherical top closure and a semi-ellipsoidal bottom closure. Total height is 146 ft, 48 ft of which is below grade.^{1,2}

The reactor building was designed so that in the event of a major nuclear accident, the release of radioactive materials to the outside atmosphere would be limited to an acceptable value. To that end, a criterion for total leakage was established, and leakrate tests were performed at the completion of construction; further tests of many of the individual penetrations were performed periodically thereafter. A review of the results of these tests has led to the redefining of individual leakrate criteria for all penetrations of the reactor building. These revised criteria are the main subject of this report.

B. Criterion for Total Leakage from Building

The EBR-II containment system is discussed in detail in the Hazard Summary Report (HSR) and Addendum.^{1,2} The HSR established that, at final acceptance, the total building leakage rate at a differential pressure of 20 psig would not exceed 1000 ft³/day. Two series of tests (see HSR Addendum) verified that leakage from the reactor building did not exceed this value. These tests and their results were as follows:

First Test:

Building Condition: Air locks and freight door installed; no other penetrations. Building shell bare.

Test Conditions: 24 psig for 72 hr.

Test Results: Leak rate less than 560 ft³/day at reference conditions of 36.2 psia and 32 °F.

Second Test:

Building Condition: All penetrations incorporated.

Building painted, insulated, and backfilled.

Test Conditions: 24 psig for 72 hr.

Test Results: Leak rate less than 100 ft³/day at reference conditions of 36.2 psia and 32°F.

Two points must be emphasized with respect to the above tests. First, the leakrate criterion of the HSR was not sufficiently defined. Reference conditions (pressure and temperature) for the allowable 1000 ft³/day were not stated. Second, the actual pressure testing performed on the reactor building was not accomplished at 20 psig, the pressure for which the original leakage criterion was established.

To make them more specific, it is recommended that leak rates and criteria be stated in terms of the following reference conditions: 36.2 psia (24 psig) and 492°R (32°F). These values are selected to be consistent with past practice at EBR-II. Further, they are conservative with respect to the 20-psig test conditions stated in the HSR. It is estimated that if the building leaked at the rate of 1000 ft³/day at 24 psig and 32°F, the leak rate at 20 psig and 32°F would be about 980 ft³/day (about 2% less).

The present methods of leak testing and the practice of stating leakage rates and criteria at the conditions of 36.2 psia and 32°F should be continued. All leakage tests conducted to date have been performed with a differential pressure of 24 psig, and the results have been reported in terms of ft³/day leakage at 36.2-psia and 32°F reference conditions.

Subsequent to the initial testing of building strength and tightness, no further tests of total building pressure were planned; nor it is desirable to conduct such tests. Pressurization of the entire building to a pressure greater than several psi cannot be permitted now because of the pressure sensitivity of much of the equipment and instrumentation.

The initial building-pressure tests demonstrated that the building shell was essentially airtight. It was judged probable that any additional leakage would occur at a building penetration, and that it was extremely unlikely that the building shell, which is a totally welded structure, would develop a leak. Hence, the total building integrity could be verified by periodic leak tests of the building penetrations.

C. Building Penetrations

A large number of penetrations through the building shell are required for access of personnel, equipment, freight, electrical conductors, and service fluids. These penetrations are grouped into three broad classifications: large mechanical penetrations; small mechanical penetrations; and electrical penetrations.

Tables I and II give information on the size, type, and function of each penetration. Additional information is presented in Appendix H of Reference 2.

All penetrations employ some sort of mechanical seal that is susceptible to deterioration with time and use. To provide reasonable assurance that the total leak rate of the reactor building remains less than the established criterion of 1000 ft³/day, selected penetrations are leaktested annually. The penetrations tested are:

- (1) all large mechanical penetrations (air locks and freight door);
- (2) all small mechanical penetrations through which leakage could occur and release building air directly to the atmosphere (e.g., all ventilation valves, air-relief valves, and secondary-sodium flexible seals); and
- (3) eleven electrical penetrations selected to provide control tests for each type of seal utilized.

TABLE I. Mechanical Penetrations in Reactor Building

<u>Large Penetrations</u>				
<u>Type</u>	<u>Arrangement</u>	<u>Approx Size of Penetration</u>	<u>Leak Tested</u>	<u>Present Allowable Leak Rate, ft³/day</u>
Personnel air lock	Two doors, interlocked, each with double seal	10 ft dia (79 ft ²)	Yes	20
Emergency air lock	Two doors, interlocked, each with double seal	4 ft dia (13 ft ²)	Yes	15
Equipment air lock	Two doors, interlocked, each with double seal	12-1/2 ft dia (123 ft ²)	Yes	20
Freight door	Two doors, not interlocked one with double seal	7-1/3 x 9-1/3 ft (69 ft ²)	Yes	20

<u>Small Penetrations</u>			
<u>No.</u>	<u>Function</u>	<u>Diameter of Penetration, in.</u>	<u>Pipe Size, in.</u>
1	Spare	8	none
2	Spare	8	none
3	Argon supply	8	3/4
	Nitrogen supply		1/2
	Air supply		3
4	Spare	8	none
5	Ventilating-air inlet	20	20
6	Purge-air exhaust	20	20
9	Ventilating-air exhaust	20	20
11	Primary-sodium fill line	8	2
12	Secondary-sodium vent line	8	2

TABLE I (contd)

Small Penetrations (contd)

<u>No.</u>	<u>Function</u>	<u>Diameter of Penetration, in.</u>	<u>Pipe Size, in.</u>
13L	Freon inlet	6	1-1/4
	Freon outlet		2
	Freon outlet		2
13H	Silicone inlet	6	2-1/2
	Silicone outlet		2-1/2
15L	Freon inlet	6	1-1/2
	Freon outlet		3
	Building DP sensing		1/2
15H	Freon inlet	6	1-1/4
	Instrument air		1-1/2
	Plant air		1-1/2
16	Shutdown cooler, NaK in	8	3
17	Shutdown cooler, NaK out	8	3
18	Shutdown cooler, NaK in	8	3
19	Shutdown cooler, NaK out	8	3
20	Freon inlet	8	1
	Freon outlet		2
21	Freon inlet	8	1
	Freon outlet		2
22	Secondary-system-sodium outlet	20	12
23	Secondary-system-sodium inlet	20	12
none	Manual vacuum relief	8	8
Elect.			
No. 26	Automatic vacuum breaker	6	6

TABLE II. Electrical Penetrations in Reactor Building

<u>No.</u>	<u>Diameter of Penetration, in.</u>	<u>Type of Pressure Connector</u>	<u>Number of Pressure Connectors</u>
1	10	Cannon TBF	7
2	10	Cannon TBF	7
3	10	Cannon TBF	7
4	10	Cannon TBF	7
5	10	Cannon TBF	7
6	10	Cannon TBF	7
7	10	Cannon TBF	7
8	10	Cannon TBF	7
9	10	Cannon TBF	7
10	10	Cannon TBF	7
11	10	Cannon TBF	7
12	10	Cannon TBF	7
13	10	Cannon TBF	7
14	10	Cannon TBF	7
15	10	Cannon TBF	7
16	10	Cannon TBF	7
20	6	Special MI seal	6
21	6	Cannon TBF	1
22	6	Special MI seal	6
23	6	Special MI seal	6

TABLE II (contd)

<u>No.</u>	<u>Diameter of Penetration, in.</u>	<u>Type of Pressure Connector</u>	<u>Number of Pressure Connectors</u>
24	6	None	0 (flanged)
25	6	None	0 (flanged)
26	6	See Table I	-
27	6	None	0 (flanged)
28	6	Cannon TBF	1
29	6	Cannon TBF	1
30	16	Cannon TBF	12
33	16	Cannon TBF	12
34	16	Amphenol 100X (coaxial)	24
35	16	Amphenol 100X (coaxial)	24
31	8	Cannon TBF	5
32	8	Cannon TBF	5
36	8	Cannon TBF	5
37	8	Cannon TBF	5

II. RESULTS OF LEAKRATE TESTS OF BUILDING PENETRATIONS

Tables III, IV, and V present the results of the annual leakrate tests which have been conducted on the building penetrations. These results are discussed below.

A. Large Mechanical Penetrations

Table III presents the results of leakrate testing of the air locks and freight door. The measured leak rate for each of these penetrations has always been much less than the allowable with one exception: the outer door of the equipment air lock. There are two reasons for the greater measured leak rate of this door. First, several electrical penetrations in the shell of the equipment air lock were known to leak considerably. (These penetrations were repaired and leak tested independently of the air lock. It was not considered necessary to retest the air lock after tightness of these penetrations was demonstrated.) Second, the inherent accuracy of the measured leak rate for this door is much lower than that for the other penetrations. This is due to the relatively large test volume involved. An estimate of the possible error of the measured leak rate may be obtained from the equation

$$\frac{dV}{dt} = V \left[\frac{1}{T} \frac{dT}{dt} - \frac{1}{P} \frac{dP}{dt} \right],$$

where

$\frac{dV}{dt}$ = possible error in the measured leak rate,

V = test volume,

T = mean temperature of gas,

P = gas pressure,

dT = temperature-measurement error of the test
volume of gas in the interval of time dt ,

dP = pressure-measurement error of the test volume
of gas in the interval of time dt , and

dt = time interval in which dT and/or dP occurs.

TABLE III. Results of Annual Leakrate Tests of Large Mechanical Penetrations ^a

Personnel Air Lock

I. Outer Door (No. 1) Test volume = 930 ft³
Allowable leakrate = 20 ft³/day

<u>Date</u>	<u>Leakrate, ft³/day</u>
6/2/63	6.7
3/18/64	5.1
5/5/66	13.0
6/17/67	12.0
8/4/68	8.4

II. Inner Door (No. 2) Test volume = 170 ft³
Allowable leakrate = 20 ft³/day

<u>Date</u>	<u>Leakrate, ft³/day</u>
5/31/63	16.0
5/13/64	0.5
5/18/64 ^b	1.0
10/17/65	1.7
5/4/66	7.5
6/14/67	2.0
8/3/68	3.0

Equipment Air Lock

I. Outer Door (No. 1) Test volume = 3545 ft³
Allowable leakrate = 20 ft³/day

<u>Date</u>	<u>Leakrate, ft³/day</u>
10/15/63	70.0
10/13/64	19.7
10/27/65	21.4
1/7/66	52.4
1/15/67	6.9
1/13/68	16.5
2/8/69	19.0

^a Tests were conducted at 24 psig; all leakrates are referenced to 36.2-psia and 32°F conditions.

^b Retested after replacement of inflatable seal.

TABLE III (contd)

II. <u>Inner Door (No. 2)</u>		Test volume = 48.4 ft ³ Allowable leakrate = 20 ft ³ /day
<u>Date</u>	<u>Leakrate, ft³/day</u>	
7/14/63	2.2	
9/27/64	2.8	
10/26/65	3.6	
4/29/66	1.2	
1/12/67	2.0	
1/11/68	7.0	
2/7/69	8.7	

Emergency Air Lock

I. <u>Outer Door (No. 1)</u>		Test volume = 114.3 ft ³ Allowable leakrate = 15 ft ³ /day
<u>Date</u>	<u>Leakrate, ft³/day</u>	
5/16/63	2.6	
7/5/64	6.8	
7/12/65	7.0	
7/15/66	31.9	
7/19/66 ^c	4.2	
11/11/67	4.3	
11/21/68	4.2	

II. <u>Inner Door (No. 2)</u>		Test volume = 13.8 ft ³ Allowable leakrate = 15 ft ³ /day
<u>Date</u>	<u>Leakrate, ft³/day</u>	
5/11/63	1.6	
6/29/64	2.7	
7/1/65	1.9	
7/14/66	2.9	
11/10/67	2.9	
11/19/68	3.1	

^c Retested after repair of leak.

TABLE III (contd)

Freight Door

Test volume = 100 ft³
Allowable leakrate = 20 ft³/day

<u>Date</u>	<u>Leakrate, ft³/day</u>
10/1/63	1.0
4/24/64	1.8
4/26/65	0.4
3/19/66	~0
5/3/68	1.8
2/18/69	9.8

TABLE IV. Results of Annual Leakrate Tests of Small Mechanical Penetrations ^a

Penetration No.	Identification	Diameter, in.	Test Volume, ft ³	Criterion, ft ³ /day	Measured Leakage, ft ³ /day			
					1964-65	1966	1967	1968
5	Outside-air-intake dampers	20	23.2	4	29.8	7.34	1.83	0.75
---	Pressure-test line (manual pressure-equalizing valves)	8	1.157	4	0.45	0.76	1.38	1.02
9	Suspect exhaust valve	20	22.4	4	5.52	1.40	0.80	0.30
6	Purge exhaust valve	20	6.74	4	1.6	0.84	1.84	0.33
26 (elect.)	Vacuum breaker	6	1.374	4	0.0	0.08	0.00	0.00
22	Secondary-system-sodium outlet	20	5	0.6	0.1	0.6	0.7 (1st test) 0.1 (2nd test)	0.0
23	Secondary-system-sodium inlet	20	5	0.6	0.1	0.1	0.2	0.2

^a Tests were conducted at 24 psig; reported leakrates are referenced to 36.2-psia and 32°F conditions.

TABLE V. Results of Annual Leakrate Tests of Electrical Penetrations ^a

Penetration No.	Number and Type of Pressure Connector	Diameter, in.	Test Volume, ft ³	Criterion, ft ³ /day	Measured Leakage, ft ³ /day			
					1965	1966	1967	1968
9	7-Cannon	10	0.685	2.5	0.01	0.003	0.001	0.0
10	7-Cannon	10	0.685	2.5	0.0	0.003	0.001	0.0
13	7-Cannon	10	0.685	2.5	0.004	0.003	0.001	0.0
24	Blind flange	6	0.234	2.5	0.0	0.003	0.000	0.0
25	Blind flange	6	0.234	2.5	0.0	0.003	0.018	0.0
27	Blind flange	6	0.234	2.5	0.0	0.003	0.011	0.0
29	1-Cannon	6	0.234	2.5	0.0	0.003	0.000	0.0
31	5-Cannon	8	0.55	2.5	0.007	0.003	0.000	0.003
36	5-Cannon	8	0.55	2.5	0.004	0.003	0.000	0.024
23	6-MI	6	0.234	2.5	0.002	0.012	0.000	0.00
35	24-Coaxial	16	1.53	2.5	0.32	0.22	0.042	0.20
26	Vacuum breaker	See TABLE IV		---	---	---	---	---

^a Tests were conducted at 24 psig; reported leakrates are referenced to 36.2-psia and 32°F conditions.

Assuming that

$$V = 3545 \text{ ft}^3 \text{ (volume of the air lock),}$$

$$T = (460 + 60) = 520^\circ\text{R},$$

$$P = (24 + 12.2) = 36.2 \text{ psia},$$

$$\frac{dT}{dt} = \pm 1^\circ\text{R/day, and}$$

$$\frac{dP}{dt} = \pm 0.1 \text{ psi/day,}$$

then

$$\frac{dV}{dt} = \pm 3545 \left[\frac{1}{520} + \frac{0.1}{36.2} \right] = \pm (6.8 + 9.8) = \pm 16.6 \text{ ft}^3/\text{day}.$$

The above calculation shows that the measurement error is of the same magnitude as the allowable leak rate. It is not surprising, therefore, that the measured leak rate of the outer door of the equipment air lock has approached and several times exceeded the allowable leak rate. This situation is not desirable, because an unnecessary effort may be expended in trying to meet a criterion when, in fact, the actual leak rate might be very low. The opposite appears to be true for penetrations which have small test volumes. For example, each of the inner doors of the air locks has almost always had a measured leak rate much less than the allowable.

Despite the inherent error in leakrate measurements involving large test volumes, the actual total leakage from the reactor building has always been less than the allowable $1000 \text{ ft}^3/\text{day}$. The revised allowable leakrate criteria which have been recommended for each penetration (see Section III) will ensure that the total building leak rate continues to be less than $1000 \text{ ft}^3/\text{day}$. At the same time, they will reduce if not eliminate the expending of unnecessary effort to meet an unrealistic criterion.

B. Small Mechanical Penetrations

Table IV presents the results of the annual leakrate tests of the small mechanical penetrations. These penetration tests (except those of penetration Nos. 22 and 23, the secondary-sodium piping penetrations) are in reality seat-tightness tests of valves. Seat leakage through these valves would result in the release of reactor-building air directly to the atmosphere. The penetrations (valves) tested are those utilized for ventilation and building-pressure control. At present, no other mechanical penetrations are routinely tested. Table IV shows that several of the reported leakage rates are greater than the allowable. The large ventilation valves which are tested have composition seats which provide reasonable assurance of a gastight seal. These seats are normally replaced whenever leakage is abnormally high. Replacement is usually scheduled so that the work will not interfere with reactor operation. Hence, larger-than-normal leakage has been permitted for reasonable periods of time so long as the total building leakage is less than 1000 ft³/day.

C. Electrical Penetrations

Table V lists the electrical penetrations which are leak tested and gives the results of the annual tests. The leak rates for these penetrations have always been very low, much less than the allowable. However, these measurements should not be construed to be more accurate than those for the mechanical penetrations. In fact, the accuracy of temperature and pressure measurements required to be sure of meeting the existing leakage criteria for electrical penetrations is much less than that required for the large mechanical penetrations. For example, comparing electrical penetration No. 35 with the outer door of the equipment airlock, pressure and temperature measurements can be

$$\frac{\frac{dV}{V} \text{ for penetration No. 35}}{\frac{dV}{V} \text{ for air lock}} = \frac{2.5}{1.53} \bigg/ \frac{20}{3545} \approx 300 \text{ times less accurate to meet the}$$

existing criterion with the same testing methods.

Another comparison can be made by calculating what criterion would be

required for penetration No. 35 to make it consistent with criterion used for the outer door of the equipment air lock. In this calculation,

$$\frac{dV}{V} \text{ for air lock } \bigg/ \frac{dV}{V} \text{ for penetration No. 35} = 1 \text{ (assumes}$$

equal error in the temperature and pressure measurements).

$$\text{Thus } \frac{20}{3545} \bigg/ \frac{dV}{1.53} = 1,$$

$$\text{and } dV = \frac{20(1.53)}{3545} = 0.0086 \text{ ft}^3/\text{day}.$$

On this basis, 0.0086 ft³/day instead of 2.5 ft³/day would be used as the criterion for penetration No. 35. As Table V shows, a measured leak rate of 0.0086 ft³/day has never been observed.

On the basis of the test data and the previous discussion, it became apparent that more-realistic leakrate criteria could and should be established. These new criteria would be consistent with the capabilities of current testing techniques. They would not require measurements that would strain the techniques in some cases while tolerating measurements less accurate than necessary in others.

III. REVISED LEAKRATE CRITERIA

A. General Recommendations

Based on the results of this study, it is recommended that:

- (1) The existing leakrate criteria for individual building penetrations be revised.
- (2) Leakrate criteria be established for all building penetrations regardless of whether the penetration is tested or not.
- (3) Leakrate criteria be established on the basis of some consistent technique that will not tax our present methods of testing and that will not be overly restrictive when compared with the results of past leakage tests. The technique must provide assurance,

however, that the total leakage from the containment building does not exceed 1000 ft³/day (at reference conditions of 36.2 psia and 32°F) with a differential pressure of 24 psig.

B. Proposed Allotment of Leakage

The following proposal is made to accomplish the above objectives.

- (1) Allotment of the allowable 1000 ft³/day should be approximately as follows:
 - (a) 200 ft³/day for large mechanical penetrations,
 - (b) 190 ft³/day for small mechanical penetrations,
 - (c) 30 ft³/day for electrical penetrations,
 - (d) 500 ft³/day for building shell and safety factor, and
 - (e) 80 ft³/day contingency.
- (2) Establishment of the criterion for each penetration within a class shall be approximately according to the size (area) of the penetration.

The above procedure takes into account the result of past testing and attempts to take into account the facts that (a) leakage is probably proportional to possible crack length, and (b) the ability to obtain a leakfree penetration is related to the size of the penetration.

The procedure does not directly take into account the differences in the accuracy of leakrate measurements which result from the differences in test volumes. This was not desirable or possible to do, since (a) this would result in different criteria for the inner and outer doors of all the air locks, and (b) the test volumes for penetrations not being tested at present are not established.

Leakrate criteria based on the above procedure have been calculated for all building penetrations. The calculated values were rounded off. As a result, the actual leakage allotments for some classes of penetrations are different from the allotments listed in item (1) above. The actual allotment of the total allowable 1000 ft³/day is:

- (a) 200 ft³/day for large mechanical penetrations,
- (b) 187 ft³/day for small mechanical penetrations,
- (c) 28-1/4 ft³/day for electrical penetrations,
- (d) 500 ft³/day for building shell and safety factor, and

(e) $84\text{-}3/4\text{ ft}^3/\text{day}$ for contingency, which add up to a total of $1000\text{ ft}^3/\text{day}$.

This technique of rounding off yields whole numbers or fractions that are easy to remember and work with. In addition, it does not lead the reader to the undesirable conclusion that some sophisticated technique was used in establishing individual leakrate criteria.

The allotment of $84\text{-}3/4\text{ ft}^3/\text{day}$ for "contingency" warrants some discussion. The reasons for establishing this contingency are:

- (1) In the unlikely event that additional penetrations were made in the reactor-building shell, part or all of this $84\text{-}3/4\text{ ft}^3/\text{day}$ could be established as the allowable leakrate criterion for that penetration. This could be done without revising any of the other established criteria.
- (2) If the annual leakrate test of a penetration reveals leakage above the acceptance criterion, the provision of some grace time for repair without restricting operations is desirable. This grace time may be required, for example, to procure a valve component, lap a valve seat, or obtain an inflatable seal. It is proposed to allow leakage from a penetration up to its allowable criterion plus the contingency ($84\text{-}3/4\text{ ft}^3/\text{day}$) for short periods of time. This will provide the necessary grace period often necessary to effect repair, without unnecessarily restricting reactor operation. This technique will still ensure that the total building leakage does not exceed the allowable $1000\text{ ft}^3/\text{day}$.

C. Discussion of Revised Criteria

Tables VI, VII, and VIII list the new proposed leakrate criteria for all building penetrations. The old criteria also are listed for comparison. For most penetrations, the new criteria represent a relaxation in the tightness required; at the same time, however, compliance with these criteria ensures that the total building leak rate will not exceed $1000\text{ ft}^3/\text{day}$.

Comparison of the new criteria with the leakrate data from past testing shows that there should be little difficulty in meeting the new criteria with present testing methods. This comparison also shows that when a leak exists that can clearly be detected, the new criteria are

TABLE VI. Comparison of Present and Proposed Leakrate Criteria for Large Mechanical Penetrations^a

Penetration	Approximate Size	Present Criterion, ft ³ /day	Proposed Criterion, ft ³ /day
Personnel air lock	10 ft dia (79 ft ²)	20	55
Emergency air lock	4 ft dia (13 ft ²)	15	10
Equipment air lock	12-1/2 ft dia (123 ft ²)	20	85
Freight door	<u>7-1/2 x 9-1/3 ft (69 ft²)</u>	20	<u>50</u>
	Total area = 284 ft ²		Total 200

^a Leakage measured with a differential pressure of 24 psig and corrected to 36.2-psia and 32°F conditions.

TABLE VII. Comparison of Present and Proposed Leakrate Criteria
for Small Mechanical Penetrations^a

<u>Penetration</u>	<u>Diameter, in.</u>	<u>Present Criterion,^b ft³/day</u>	<u>Proposed Criterion, ft³/day</u>
1	8	-	4
2	8	-	4
3	8	-	4
4	8	-	4
5	20	4	25
6	20	4	25
9	20	4	25
11	8	-	4
12	8	-	4
13L	6	-	2
13H	6	-	2
15L	6	-	2
15H	6	-	2
16	8	-	2
17	8	-	4
18	8	-	4
19	8	-	4
20	8	-	4
21	8	-	4
22	20	0.6	25
23	20	0.6	25
Manual vacuum relief	8	4	4
Elect. No. 26	<u>6</u>	4	<u>2</u>
Sum of squares = 3012			Total 187

^a Leakage measured with a differential pressure of 24 psig and corrected to 36.2-psia and 32°F conditions.

^b Blanks indicate that no criterion was set and that the leakrate through the penetration has not been measured regularly.

TABLE VIII. Comparison of Present and Proposed Leakrate Criteria for Electrical Penetrations^a

Penetration	Diameter, in.	Present Criterion, ^b ft ³ /day	Proposed Criterion, ft ³ /day
1	10	-	1
2	10	-	1
3	10	-	1
4	10	-	1
5	10	-	1
6	10	-	1
7	10	-	1
8	10	-	1
9	10	2.5	1
10	10	2.5	1
11	10	-	1
12	10	-	1
13	10	2.5	1
14	10	-	1
15	10	-	1
16	10	-	1
20	6	-	1/4
21	6	-	1/4
22	6	-	1/4
23	6	2.5	1/4
24	6	2.5	1/4
25	6	2.5	1/4
26	6	See Table VII	---
27	6	2.5	1/4
28	6	-	1/4
29	6	2.5	1/4
30	16	-	2
31	8	2.5	1/2
32	8	-	1/2
33	16	-	2
34	16	-	2
35	16	2.5	2
36	8	2.5	1/2
37	8	-	1/2
Sum of squares = 3204		Total 28-1/4	

^aLeakage measured with a differential pressure of 24 psig and corrected to 36.2-psia and 32°F conditions.

^bBlanks indicate that no criterion was set and that the leakrate through the penetration has not been measured regularly.

sufficiently tight to require identification and subsequent repair of the leak.

Acceptance of the criteria recommended by this report will not invalidate the present cumulative leakrate criterion now included in the EBR-II Operating Limits. The sum of the recommended criteria for the individual penetrations is less than the acceptable cumulative value listed in the Operating Limits.

To provide some "feel" for the size of the defect (hole) which could be tolerated in the containment barrier, a calculation was made to determine the diameter of a sharp-edged orifice that would pass 1000 ft³/day of air (at 36.2 psia and 32°F) with a differential pressure of 24 psig. The calculated diameter was approximately 1/16 in. This indicates the measure of the care that must be exercised when working on, maintaining, or testing any part of the building shell or penetration in order to maintain acceptable reactor-building containment.

REFERENCES

1. Koch, L. J., et al., Hazard Summary Report, Experimental Breeder Reactor II (EBR-II), ANL-5719 (May 1957).
2. Koch, L. J., et al., Addendum to Hazard Summary Report, Experimental Breeder Reactor II (EBR-II), ANL-5719 (Addendum), (June 1962).