CRBRP-3

HYPOTHETICAL CORE DISRUPTIVE ACCIDENT CONSIDERATIONS IN CRBRP

VOLUME 2:

ASSESSMENT OF THERMAL MARGIN BEYOND THE DESIGN BASE

CLINCH RIVER BREEDER REACTOR PLANT

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REV NO./DATE	CHANGE RELEASE DOCUMENT	PAGES AFFECTED	REMARKS
0/March 80		All	First formal issue of document
Rev 1/5-81		i, 2-4, 2-6, 2-7, 2-10 thru 2-16, 2-24, 2-25, 2-26, 2-32, 2-34, 2-43, 2-44, 2-76	Pages added 2-16A thru 2-16G, 2-34A
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f. There is not a requirement to meet the allowable site boundary or low population zone doses of 10CFR100 or the control room dose of 10CFR50 under TMBDB conditions.

2. Acceptance Criteria

a. The public risk from accidents beyond the design base shall be comparable to that from light water reactors for events beyond the design base with similar probability of occurrence.

b. Containment integrity shall be maintained without venting following initiation of an accident leading to core meltdown for a period of time sufficient to allow evacuation procedures to be implemented. Per NRC guidance, the period is taken as 24 hours.

2.1.2 Feature Requirements

The following requirements are imposed on the specific TMBDB features as well as other systems or components to provide thermal margin beyond the design base in CRBRP.

2.1.2.1 Reactor Cavity-To-Containment Barrier

To insure that the heat capacity of the pipeway cells is employed from 1000 seconds to 50 hours after a HCDA, the total leakage of sodium vapor through the reactor cavity to head access area seals (not through the reactor head or the planned vent path defined in Section 2.2.6) shall not exceed 10000 pounds (for requirements before 1000 seconds see Section 2.2). These leakages shall be based on the pressure differential for the reactor cavity to head access area seals given on Figure 2-1, on the reactor cavity pressures on Figure 2-2, and on the reactor cavity atmosphere temperatures on Figure 2-3.

2.1.2.2 Reactor Cavity Recirculating Gas Cooling System

To insure that the Cell 105 hydrogen concentration does not exceed 6%, the leakage from the reactor cavity through the recirculating gas cooling system to non-inerted cells shall be less than 4000 pounds of sodium from 1000
seconds to 150 hours after HCDA. These leakages shall be based on the 1
reactor cavity pressures and temperatures on Figures 2-2 and 2-3 and on the differential pressure between the reactor cavity and Cell 105 given on Figure 2-4.

2.1.2.3 Guard Vessel Support

To insure that sodium and fuel particulate redistribute in the reactor cavity, a flow area of at least 10 ft^2 shall be provided under the guard vessel skirt bottom flange.

2.1.2.4 Reactor Cavity and Pipeway Cell Liners

To insure that the Reactor Containment Building hydrogen concentration does not exceed 6% (by volume) and to keep from exceeding the containment vent, purge and cleanup system capacities, the reactor cavity wall and pipeway cell liners shall prevent short term (less than 30 hours) sodium-concrete reactions based on the pressure on Figure 2-2 and the temperatures on Figure 2-9 and Figures 2-11 through 2-16. The results of structural analysis will be used to determine the liner failure times assumed in the TMBDB scenario.

To limit the consequences of liner failures, the liner system shall have physical barriers behind the liners between the reactor cavity floor and reactor cavity wall and at 8 feet and 26 feet above the reactor cavity floor. Likewise, the pipeway cells shall have physical barriers behind the liners to separate the vent spaces of the walls, floor, and roof of each cell. Only the spaces of adjacent walls with different liner failure times will be separated.

2.1.2.5 Reactor Cavity and Pipeway Cell Liners Vent System

1. To insure that the pressure buildup, due to the gases released behind the liners, does not impair the ability of the liners to prevent sodium from reacting with concrete, all reactor cavity and pipeway cell liner vent systems shall prevent a pressure buildup behind the liners in excess of 5 psi.

2. To insure that sodium would be prevented from reaching Cell 105 in the event of liner failure, the liner vent system for the reactor cavity floor shall vent the gases released from heated concrete to containment above the operating floor. The floor liner vent system shall have a capacity of 10 $lb/hr\text{-}ft^2$ of water vapor at a density of 0.02 lb/ft^3.

3. The liner vent system for the reactor cavity walls and pipeway cells shall vent the gases released from heated concrete to Cell 105. The liner vent system shall have a capacity of 7 $lb/hr\text{-}ft^2$ of water vapor at a density of 0.02 lb/ft^3.

4. To insure that the Cell 105 hydrogen does not exceed 6%, the sodium leakage from the reactor cavity through the liner vent system to Cell 105 shall be less than 1000 pounds. This leakage shall be based on the reactor cavity pressures and temperatures on Figures 2-2 and 2-3 and on the differential pressure between the reactor cavity and Cell 105 on Figure 2-4.

2.1.2.6 Reactor Cavity Vent System

1. To prevent reactor cavity structural and liner failure by over pressurization, the vent system shall provide redundant flow paths between the reactor cavity and reactor containment building when the pressure differential between the reactor cavity and containment exceeds 11.5 $\pm$ 1.5 psi. After passive initiation, the vent path shall remain open.

2. The vent system shall have a pressure drop of less than 0.1 psi with a flow rate of 4000 lb/hr of gases, a density of 0.03 lb/ft^3, and a viscosity of 0.05 lb/ft-hr. It shall remain functional if up to 1
450 pounds of sodium oxide aerosol enter the vent at a maximum rate of 8000 lb/hr.

3. The vent system shall be capable of performing all of its intended functions for 150 hours in the presence of gases and vapors consisting of Ar, N_2, H_2, Na, fission products, and compounds resulting from fission product reactions.

4. To insure that the heat capacity of the pipeway cells is employed, a minimum of 25% of the mass flow into the pipeway cells shall enter each pipeway cell.

5. To allow sodium that condenses in the pipeway cells to drain back into the reactor cavity, two drain pipes shall be provided between each pipeway cell and the reactor cavity, at the elevation of the pipeway cell floor. Each drain pipe shall be capable of a minimum flow rate of 2000 lb/hr of sodium at its boiling point with a pressure head of 0.2 feet of sodium.

6. To assure that the flame at the vent exit does not approach the containment vessel, the pipeway cell to containment vent line diameter shall not exceed 12 inches.

2.1.2.7 Containment Purge System

1. To insure that the Reactor Containment Building hydrogen concentration does not exceed 6% (by volume), the purge system shall be capable of injecting outside air into containment at a maximum rate of 12,000 scfm at pressures not exceeding atmospheric.

2. To insure containment [illegible] mixing before venting, the purge air shall be injected into [illegible]nment below elevation 840'.

3. The purge system shall prevent backflow from containment to the outside atmosphere.

4. The purge system, in combination with the containment vent and cleanup systems, shall maintain containment at a negative pressure after the containment pressure is reduced by the initial venting after 24 hours.

5. The purge system operations shall be by remote manual actuation from the control room.

2.1.2.8 Containment Vent System

1. To prevent containment failure by excessive pressure, the vent system shall have a capacity between 24,000 and 26,400 acfm with a containment pressure of 30 psia, a containment atmosphere density of 0.07 lb/ft^3 and a viscosity of 0.06 lb/ft-hr. It shall remain functional if up to 300,000 pounds of aerosol enter the system at a maximum rate of 5,600 lb/hr.

2. The vent system shall exhaust the containment atmosphere from the top of containment into the containment cleanup system.

3. The containment vent system shall be compatible with the following gases, vapors and aerosols: Ar, N_2, H_2, H_2O, CO, CO_2, O_2, Na_2O, Na_2O_2, NaOH, Na_2CO_3, fission products, and compounds resulting from fission product reactions. The system must remain functional for inlet gas temperatures and pressures given on Figures 2-5 and 2-6.

4. The vent system operations shall be by remote manual actuation from the control room.

2.1.2.9 TMBDB Containment Cleanup System

1. The containment cleanup system efficiency shall be a minimum of 99% for vented materials in the solid or liquid state, 97% for vapors (NaI, SeO_2, and Sb_2O_3) subject to condensation in the cleanup system, and 0% for noble gases. These efficiencies shall apply when subjected to the vent rates on Figure 2-7 and containment atmosphere temperatures on Figure 2-5 with a containment atmosphere density of 0.07 lb/ft^3. It shall be capable of performing all of its intended functions in the presence of Ar, N_2, H_2, H_2O, CO, CO_2, O_2, Na_2O, Na_2O_2, NaOH, Na_2CO_3, fission products, and compounds resulting from fission product reactions.

2. The containment cleanup system shall remain functional at an aerosol mass flow rate of up to 5,600 lb/hr and a total mass of 300,000 pounds of aerosol entering the cleanup system. The principal constitutents of the aerosol are NaOH and Na_2O, the proportions of which can vary from 0 to 100% of the aerosol, and Na_2CO_3 which can vary from 0 to 8% of the aerosol.

The aerosol particle properties are:

Mass Mean Radius (microns):	$5 < r_{50} < 10$
Aerodynamic Equivalent Radius (microns):	$2.3 < AER < 4.7$
Density (g/cc):	$2.1 < \rho < 2.5$
Mass Geometric Standard Deviation:	$3.0 < \sigma < 3.5$

Aerodynamic equivalent radius is based on $AER = r_{50} (\rho\alpha)^{0.5}$

where $\rho = 2.21$ and $\alpha = 0.1$

3. The containment cleanup system shall remain functional at fission products power levels in the accumulated filter aerosol of:

Time (hours)	Fission Product Power (MW)
0	0
24	3.1×10^{-5}
48	0.16*
96	0.16*
240	0.11
720	0.05

4. The containment cleanup system design shall be capable of performing all its intended functions with the following chemical and physical states of the 10 most radiologically significant fission products in the containment atmosphere:

*Maximum value.

MAXIMUM PERCENTAGE OF THE FISSION PRODUCTS BY CHEMICAL AND PHYSICAL FORM

	Elemental		Oxide	
Element	Vapor	Liquid or Solid	Vapor	Liquid or Solid
Se	1%	1%	100%	100%
Rb	1	1	1	100
Sr	1	1	1	100
Zr	1	1	1	100
Sb	1	1	100	100
Te	1	1	1	100
Cs	1	1	1	100
Ba	1	1	1	100
Ce	1	1	1	100
			NaI	
I	1	1	33	100

5. The exhaust from the containment cleanup system shall have a temperature compatible with operation of the TMBDB Exhaust-Plant Effluent Radiation Monitoring System.

6. The containment cleanup system operations shall be by remote manual actuation from the control room. 1

2.1.2.10 Annulus Cooling System

1. To insure containment and confinement do not fail from excessive temperatures, the annulus cooling system shall remove the heat load into the containment steel shell on Figure 2-8.

2. Steel containment temperatures shall be below those that cause structural failure or excessive containment leakage.

3. Concrete confinement temperatures shall be below those that cause structural failure.

4. The annulus cooling system operations shall be by remote manual actuation from the control room. 1

2.1.2.11 Containment System Leakage Barrier

At any given time, containment leakage shall not exceed the greater of:

1. The design leakrate (0.1 volume percent per day).

2. The design leakrate adjusted for pressures above the containment design pressure of 10 psig. Leakrate = Design Leakrate x (Actual Pressure $(psig))^{.5}/3.2$.

3. One percent of the mass leaving the containment through the containment vent system.

2.1.2.12 TMBDB Instrumentation System

Operator action to initiate TMBDB systems operation is required only for events beyond the design base. However, mis-operation of TMBDB systems, because of incorrect instrument readings in the control room, could defeat 1
Engineered Safety Features (ESFs) required to mitigate design basis accidents. In accordance with this importance to maintain ESF capability, plant instrumentation has been designated "TMBDB Instrumentation", shall be designed, manufactured and qualified to all standards applied to Class 1E instrumentation. Specifically the following subsystems of the Reactor Containment Instrumentation System (RCIS) and of the Radiation Monitoring System (RMS) shall be considered TMBDB instrumentation:

(1) Containment Pressure (RCIS)
(2) Containment Atmosphere Temperature (RCIS)
(3) Containment Hydrogen Concentration (RCIS)
(4) Containment Vessel Temperature (RCIS)
(5) TMBDB Exhaust-Plant Effluent Radiation Monitoring (RMS)
(6) High-Range Containment Area Radiation (RMS)

Note that subsystems (5), and (6) are not in the category of instrumentation which could be used to defeat ESFs; however, because of their importance in assessing releases from the plant during a TMBDB scenario they are included 1
in the TMBDB instrumentation.

1. The TMBDB instrument ranges shall be:

	Minimum	Maximum	
Containment Atmosphere Temperature (degrees F)	60	1100	
Containment Steel Dome Temperature (degrees F)	40	700	
Containment Atmosphere Pressure (psia)	14.7	55	1
Containment Hydrogen Concentration (Volume %)	0	8	

	Minimum	Maximum
High-Range Containment Area Radiation (R/hr) (60 Kev to 3 Mev photons. This range applies inside the RCB. If the detectors are located outside the RCB, appropriate adjustments in conditions shall be made.)	1	10^7
Radioactivity of Released Products (ci/sec)*		
Particulates	0	7
Radioiodines	0	30
Radiogases	0	6000
Fuels and Transuranics	0	0.01

1

2. Instrument accuracy shall be:

Temperature	(Percent of Maximum Value)	±5
Pressure	(Percent of Maximum Value)	±5
Hydrogen Concentration	(Percent of Maximum Value)	±5
Radioactivity of Released Products at 95% SCL	(Percent of Maximum Value)	+100, -50
High-Range Containment Area Radiation	(Percent of reading)	±20**

1

3. Instrument response time shall be:

Temperature	Less than 5 minutes
Pressure	Less than 5 minutes

*These are based on total amounts released. Instrument ranges will depend on the sampling rate.

**For photons of 0.1 to 3 Mev.

1

Hydrogen Concentration	Less than 10 minutes	
Radioactivity of Released Products	Less than 5 minutes	
High-Range Containment Area Radiation	Less than 5 minutes	1

4. Measurement capability after initiation of the TMBDB condition shall be provided for:

Temperature	500 hours	
Pressure	500 hours	
Hydrogen Concentration	8,000 hours	
Radioactivity of Released Products	8,000 hours	
High-Range Containment Area Radiation	8,000 hours	1

5. The instrument sensor/sampling elevations inside of containment shall be:

Hydrogen Concentration	Above 970'	
Containment Atmosphere Temperature	Above 955'	
Containment Atmosphere Pressure	Above 823'	
Containment Steel Dome Temperature	At 817', 823', 833', 854', 875', 902', 964', and 974'	1

6. TMBDB sensors inside containment shall be functional with a maximum containment atmosphere temperature of 1100°F and pressure of 55 psia. 1

7. TMBDB sensors inside containment shall be functional with containment atmosphere maximum constituent concentrations of:

Oxygen	21% (volume)
Nitrogen	90% (volume)
Water Vapor	10% (volume)
Hydrogen	8%

Carbon Dioxide	6%
$NaOH + Na_2O$ (any proportion of the two from 0 to 100%)	6×10^{-3} lb/ft^3*
Na_2CO_3	5×10^{-4} lb/ft^3*

8. TMBDB sensors inside containment shall be functional with the following masses of settled and plated aerosols ($NaOH$, Na_2O, and Na_2CO_3) on any unprotected horizontal or vertical surfaces in containment.

Horizontal Surface	80 lb/ft^2
Vertical Surface	0.5 lb/ft^2

9. TMBDB sensors inside containment shall be functional with radiation levels of:

Peak radiation level (High-Range Containment Area Radiation)	1×10^8 R/hr
Peak radiation level (other sensors)	1×10^6 R/hr
Average radiation level over 30 days	1×10^5 R/hr
Total accumulated dose	1×10^8 R

1

The above doses are the sum of β and γ releases, which are estimated to be of equal magnitude. The High-Range Containment Area Radiation Sensors may be located outside containment. 1

10. The instruments monitoring radioactivity of products leaving the cleanup system shall provide count rates for particulate (including Pu), radioiodine and gaseous release.

*For 0-500 hours.

11. The TMBDB Exhaust-Plant Effluent Radiation monitoring sensors shall be functional with atmosphere maximum constituent concentrations of: 1

Oxygen	21%
Nitrogen	90%
Water Vapor	Saturated
Hydrogen	8% (volume)
Carbon Dioxide	6% (volume)
$NaOH + Na_2O$ (any proportion of the two from 0-100%)	6×10^{-5} lb/ft^3
Na_2CO_3	5×10^{-6} lb/ft^3

12. The TMBDB instrumentation systems shall be capable of remote manual actuation from the control room. The indicators shall be located in the control room. 1

2.1.2.13 Electrical Power System

1. Class 1E electrical power shall be provided to all TMBDB systems and components that require electrical power to perform their post accident functions.

2. Electrical loads for TMBDB features shall be remote manually actuated from the control room except for the TMBDB instrumentation which shall be normally connected to Class 1E electrical power. 1

2.1.2.14 Containment Structures

1. The reactor cavity and pipeway structures shall not collapse prior to sodium boildry. Structural conditions at boildry for the various scenarios are enveloped by the temperatures on Figures 2-9 through 2-18.

2. The reactor containment building and confinement structure shall retain
their integrity above the basemat as long as the containment structural
integrity is important in limiting the risk to the health and safety of
the public based on the limiting temperatures on Figures 2-19 through
2-31. This time is taken to be 8000 hours. 1

2.1.2.15 Control Room Habitability 1

The exposure to the control room operators following a TMBDB condition shall 1
not exceed the following limits in 30 days:

Organ	Dose (rem)
Whole Body*	25
Thyroid	300
Lung	75
Bone	150
Skin (beta)	150

*The whole body gamma dose consists of
contributions from airborne radioactivity
inside and outside the control room, as well 1
as direct shine from fission products inside
the RCB.

(Because the postulated occurrence of the TMBDB scenario is of such a low
probability as to be excluded from the category of a design basis accident,
exposure limits intended for design basis accidents should not apply. The
25 rem whole body dose limit for the control room operators corresponds to 1
the once in a lifetime accidental occupation exposure limit recommended in
Reference 2-1. The thyroid limit is based on the 10CFR100 equivalent of a
25 rem whole body dose. The corresponding bone and lung limits are the
accepted equivalents to the 25 rem whole body dose (Reference 2-2).)

2.1.3 Maintenance and Testing Requirements for TMBDB Features

To assure the TMBDB features will be fully functional and available on demand during normal reactor operation, testing shall be periodically performed to demonstrate that the TMBDB systems/components satisfy the required functional levels. Maintenance on the TMBDB features shall be performed based on this testing and the necessary preventive maintenance program. The following requirements define the Maintenance Testing for the CRBRP TMBDB features.

2.1.3.1 General

2.1.3.1.1 General Requirements

1. The Maintenance and Testing of the TMBDB features shall not adversely impact the overall safety, availability, maintainability, reliability, and operability of the total plant.

2. Maintenance of the TMBDB features shall be performed based on the results of the shutdown testing program and vendor specifications. Preventive maintenance shall be scheduled if possible during reactor shutdown; however, if maintenance of the TMBDB features is required during reactor power operation, one TMBDB feature train shall be continuously available.

3. The full functional test to be performed periodically shall be performed for all of the specific active components of each TMBDB features train in a given test sequence, since they interface with each other. The specific active TMBDB features are the isolation valves of the Reactor Cavity Vent System, Containment Purge System, Containment Vent System, Containment Cleanup System, Annulus Cooling System, and the isolation valves of the RC-Recirculating Gas Cooling System. 1

2.1.3.1.2 Precautions and Limitations

1. To minimize the risk of an accidental radiation release, minimize the impact on availability, and achieve a full functional test, the periodic full functional testing of the TMBDB features shall be performed during refueling or other reactor shutdown after the radioactive cover gas has been processed/decayed, while the refueling hatch is closed, inerted cells have not been deinerted for maintenance, and maintenance is not being performed on auxiliary systems/components containing radioactivity in the RCB. 2

2. During the TMBDB full functional tests, maintenance shall not be performed on the systems/components in the RCB containing radioactive material that could, as a result of a single failure, be released to containment and cause site boundary dose limits to be exceeded.

3. After each full functional test, access to TMBDB equipment, or any TMBDB panel activity, the status of the TMBDB components shall be checked to verify the proper status.

4. The reactor shall not be operated at power following pre-service or periodic full functional testing of TMBDB features until the Acceptance Criteria of Section 2.1.3.1.3 are satisifed.

2.1.3.1.3 Acceptance Criteria

1. The pre-service testing and inspection of the TMBDB features shall assure that the TMBDB features would be capable of performing their full functions on demand.

2. The periodic full functional testing of TMBDB features shall assure that both redundant trains of specific active TMBDB features are capable of performing their full functions on demand. 1

2.1.3.2 Specific Features Maintenance and Testing Requirements

Throughout this section the term "design base surveillance requirements" means the inspection and/or testing that will be specified (for each system) to assure that the CRBRP systems and components are capable of performing 2
their functions within the design base envelope.

2.1.3.2.1 Reactor Cavity-to-Containment Barrier

The Reactor Cavity to Head Access Area seals will have surveillance performed as part of the design base. The design base surveillance requirements shall be specified so as to assure, in conjunction with design 2
and analyses, that the augmented (TMBDB) requirements of Section 2.1.2.1 will be met.

2.1.3.2.2 Reactor Cavity Recirculating Gas Cooling System

The Reactor Cavity Recirculating Gas Cooling System will have surveillance performed as part of the design base. The design base surveillance requirements shall be specified so as to assure, in conjunction with design 2
and analyses, that the augmented (TMBDB) requirements of Section 2.1.2.2 will be met. In addition, the isolation valves shall be tested as part of the periodic full functional test.

2.1.3.2.3 Guard Vessel Support

The Guard Vessel Support requirement of Section 2.1.2.3 is not testable, but will be assured by design and the normal construction surveillance.

2.1.3.2.4 Reactor Cavity and Pipeway Cell Liners

The Reactor Cavity and Pipeway Cell Liner requirements of Section 2.1.2.4 are not testable, but will be assured by analysis and the normal construction surveillance. 1

2.1.3.2.5 Reactor Cavity and Pipeway Cell Liners Vent System

The Liners Vent System requirements of Section 2.1.2.5 are not testable, but will be assured by analysis and the normal construction surveillance.

2.1.3.2.6 Reactor Cavity Vent System

1. The Reactor Cavity Vent System requirements of Section 2.1.2.6 are not testable, but will be assured by analysis and the normal construction surveillance.

2. After construction, a pre-service full functional test of the rupture disk isolation valves shall be performed using diesel power (to verify that the valves can actually be operated on emergency power).

3. During plant lifetime the rupture disk isolation valves shall be tested approximately once a year during a refueling shutdown (or other shutdown that meets the Precautions and Limitations of Section 2.1.3.1.2). This testing shall be a full functional test of each valve using normal power.

4. The reactor cavity vent system rupture disks shall be inspected at the end of each refueling or other extended reactor shutdown to ensure the disks have not been accidentally penetrated.

2.1.3.2.7 Containment Purge System

1. After construction a pre-service full functional test of the containment purge system shall be performed using diesel power (to verify that the valves can actually be operated on emergency power). 1

2. During plant lifetime the containment purge system shall be tested approximately once a year during a refueling shutdown (or other shutdown that meets the Precautions and Limitations of Section 2.1.3.1.2). The test shall be a full functional test of each redundant train of active components using normal power.

2.1.3.2.8 Containment Vent System

1. After construction a pre-service full functional test of the containment vent system shall be performed using diesel power (to verify that the system can actually be operated on emergency power).

2. During plant lifetime the containment vent system shall be tested approximately once a year during a refueling shutdown (or other shutdown that meets the Precautions and Limitations of Section 2.1.3.1.2). The test shall be a full functional test of each redundant train of active components using normal power.

2.1.3.2.9 TMBDB Containment Cleanup System

1. After construction a pre-service full functional test of the containment cleanup system shall be performed using diesel power (to verify that the system can actually be operated on emergency power).

2. During plant lifetime the containment cleanup system shall be tested approximately once a year during a refueling shutdown (or other shutdown that meets the Precautions and Limitations of Section 2.1.3.1.2). The test shall be a full functional test of each redundant train of active components using normal power. 1

2.1.3.2.10 Annulus Cooling System

1. After construction a pre-service full functional test of the Annulus Cooling System shall be performed using diesel power (to verify that the system can actually be operated on emergency power).

2. During plant lifetime the Annulus Cooling System shall be tested approximately once a year during a refueling shutdown (or other shutdown that meets the Precautions and Limitations of Section 2.1.3.1.2). The test shall be a full functional test of each redundant train of active components using normal power.

2.1.3.2.11 Containment System Leakage Barrier

The Containment System Leakage Barrier will have surveillance performed as part of the design base. The design base surveillance requirements shall be 2
specified so as to assure, in conjunction with design and analyses, that the augmented (TMBDB) requirements of Section 2.1.2.11 will be met.

2.1.3.2.12 TMBDB Instrumentation System

The TMBDB Instrumentation System will have surveillance performed as part of the design base. The design base surveillance requirements shall be 2
specified so as to assure, in conjunction with design and analyses, that the augmented (TMBDB) requirements of Section 2.1.2.12 will be met.

2.1.3.2.13 Electrical Power System

The Class 1E Electrical Power System will have surveillance performed as part of the design base. The design base surveillance requirements shall be 2
specified so as to envelop the augmented (TMBDB) requirements of Section 2.1.2.13 and to demonstrate the capability of the Class 1E power system to 1
energize the TMBDB Equipment.

2.1.3.2.14 Containment Structures

The containment structures requirements of Section 2.1.2.14 are not testable, but will be assured by analysis and the normal construction surveillance.

2.1.3.2.15 Control Room Habitability

The Dual Control Room Air Intakes will have surveillance performed as part
of the design base. The design base surveillance requirements shall be 2
specified so as to assure, in conjunction with design and analyses, that the
augmented (TMBDB) requirements of Section 2.1.2.15 will be met. 1

The arrangement of the system reflects these functions as follows. The gases and vapors from the Reactor Cavity are vented thru the pipeway cells, which are isolated from the PHTS cells by flexible, low leakage bellows. The venting to the operating floor is accomplished from the North (No. 2) pipeway cell through shielding labyrinths and straight upward pipes, to minimize reactor cavity back pressure due to head losses and to promote local flaring of the vented hydrogen. Up to 50% of the vented gases enters the North (No. 2) PHTS pipeway cell directly and the remaining gases are first vented through the East and West (No. 1 & 3) pipeway cells ($\geq$25% each), then through the North (No. 2) pipeway cell. To assure this flow distribution a gas flow labyrinth is provided in the North pipeway cell, to balance the flow and pressure thru the different vent paths. In this way, maximum heat exchange between the gases and the building structures is facilitated. This will reduce the maximum internal building pressure in the containment before venting. In addition, this arrangement ensures that if only one rupture disk breaks, flow through all pipeway cells occurs, whereas, if a rupture disk were provided for each pipeway, the rupture of one disk could lower the pressure in the cavity below the setpoints of the other two without providing heat exchange between all of the pipeway cells and the vented gases.

Isolation of the rupture disks is provided by remote manually operated gate valves located between the cavity and the rupture disk assembly. These valves are provided to allow periodic replacement of the rupture disks and to provide isolation of the reactor cavity atmosphere should a disk be ruptured under other than TMBDB conditions. To prevent inadvertant operation of these valves, no local operators will be provided, valve position indication will be displayed in the Control Room, and appropriate physical restraints and warning plates will be used for the valve actuation switches. These valves are normally open.

Uncertainties in rupture disk performance were considered in the reactor cavity venting system. The overall scenario analysis results are not sensitive to the exact pressure at which the rupture disk breaks because the rate of pressure increase is large enough so that the rupture disk will break at about the same point in time regardless of the exact reactor cavity pressure. Commercially available rupture disks are usually guaranteed to break within 10% of set pressure. In addition, it was assumed in the TMBDB analysis that only one of the rupture disks breaks.

Analysis has shown that clogging of the piping by sodium reaction products should not be a problem because of the small quantity of aerosol expected and because of the large surface areas available for deposit in reactor and pipeway cells as compared to the small surface areas of the vent system piping. Appendix G.3 shows that margin exists to accommodate a wide range of postulated vent malfunctions.

The system piping material will be suitable for high temperature service. The piping is sloped toward the cavity to provide drainage of condensed sodium. Cell liner penetrations will utilize a combination of bellows sleeves and flued heads in order to reduce pipe stress to a minimum value for the non-embedded portions of the piping. For the embedded piping, anchorage will be provided to prevent piping failure due to thermal expansion and degradation of the supporting concrete.

2.2.7 Containment Purge Capability

The containment purge cabability is provided by the containment cleanup system exhaust blowers which draw a negative pressure in the containment building and by the opening of the redundant containment purge penetrations. The system is shown on Figure 2-34 and has total active redundant capability.

The two purge pipes penetrating the containment are 24 inches in diameter 1
and are designed to the requirements of the ASME Boiler and Pressure Vessel Code, Section III, Division I, Class 2. Each purge line is provided with redundant normally closed isolation valves outside of the steel containment vessel (see Section 2.2.11).

Should a purge of the RCB be required, it would be necessary to vent the RCB first. The venting, along with operation of the containment cleanup system exhaust blowers, decreases the RCB pressure below atmospheric pressure. Operation of the purge requires the opening of the purge line isolation valves from a remote-manual station in the main control room. Flow direction sensing instrumentation is provided to automatically close the purge isolation valves in the event a backflow condition occurs. To prevent inadvertent operation of the purge, the switches for the valve operators are located on a control room panel; no local operators are provided at the valve locations. Valve position indication will be displayed in the Control Room and appropriate physical restraints and warning plates will be used for the valve switches.

2.2.8 Containment Vent Capability

The RCB vent capability is provided by the vent line connected to the Containment Cleanup System. The connected system is shown in Figure 2-34. This vent capability allows the blowdown of the RCB after some time period to reduce the internal pressure and to subsequently reduce the hydrogen concentration through purging. Prior to venting complete isolation of the RCB would be maintained. The vent line is connected to the TMBDB cleanup system through two redundant 24-inch diameter pipes which penetrate the RCB with isolation valves located outside the steel containment vessel (see section 2.2.11). The vent line and pipes penetrating the RCB are designed to the requirements of the ASME Boiler and Pressure Vessel Code, Section III, Division 1, Class 2. The pipes penetrating the RCB which are used for TMBDB have their valves in the normally closed position. 1

At the time of venting (estimated to be approximately 36 hours), the isolation valves would be opened to allow the depressurization of the RCB at a maximum rate of 24,000 cfm. The effluent of the depressurization is processed through the Containment Cleanup System.

To prevent inadvertent operation of the valves, no local operators would be provided and the valve actuation system would be equipped with appropriate physical restraints and warning plates.

2.2.9 Containment Cleanup System

The Containment Cleanup System is shown in Figure 2-34 and is provided for filtering of the Reactor Containment Building (RCB) atmosphere prior to release to the environment. The RCB atmosphere exhausted by the Containment Vent System is treated by a wet scrubber filtration system. The discharge from the filters is then directed through an exhaust pipe for release at the top of the confinement structure. In addition, the effluent stream is continuously monitored for the levels of particulates, radioiodine, radiogases, and plutonium.

The exhaust filter train is comprised of a jet venturi scrubber in series with a high efficiency wetted fiber bed scrubber unit and redundant blowers. An air washer is located upstream to ensure that virtually all of the sodium oxide is reacted to sodium hydroxide prior to reaching the scrubbers. Additionally, the air washer effectively reduces the air stream temperature from a maximum of $1100^{o}F$ to approximately $160^{o}F$ during system operation. The filter train is rated for 24,000 acfm at an air density of 0.06 lbs/ft^3 and will provide a minimum overall filtration system efficiency of 99 percent for all vented solids and liquids and 97% for all vented vapors (excluding noble gases).

The wet scrubber filter system is designed such that the temperature of the aerosol leaving the scrubbers would be maintained below $160^{o}F$ during the course of the accident. The 150,000 gallon storage capacity of the scrubbing system would accommodate the design level of 300,000 lbs. of containment reaction products.

The wet scrubber filter system requires protected water storage on the order of 150,000 gallons. The recirculation pumps supply approximately 1500 gpm of continuous water flow from the storage tanks to the sodium scrubbers and air washer. Discharge water is then returned to the water supply system. A maximum concentration of sodium hydroxide of 30 percent (by weight) with a corresponding pH of 13 will result from this recirculation in the storage temperature and hydrogen levels. Each of these measurements will be redundant, designed to remain functional following a Safe Shutdown Earthquake, and qualified to assure operability under the environmental conditions in Section 2.1.2.12. The locations of the various detectors are shown schematically in Figure 2-35.

2.2.12.1.1 Reactor Containment Pressure

The Reactor Containment Building pressure is measured at two widely separated locations. The instrumentation penetrations are at 108° and 285° (0° is plant north). The design will be such that the pressure element and transmitter are located outside of the Reactor Containment Building and will sense pressure with an impulse or capillary line. This arrangement will allow sensing of containment pressure at temperature up to 1100°F. Each transmitter will send a signal to the main control room. The channels will be completely independent and physically separated in accordance with Regulatory Guide 1.75. Each channel will be powered from the Class 1E power system.

2.2.12.1.2 Reactor Containment Atmosphere Temperature

The Reactor Containment atmosphere temperature is measured near the top of the RCB. The measurement will be redundant so that any single failure will not preclude the operator from receiving temperature data. The channel will be designed to operate 500 hours to a maximum temperature of 1100°F.

The signal conditioning for the temperature sensors will be located in the Steam Generator Building. Each transmitter will send a signal to the main control room. Each channel will be physically separated in accordance with IEEE 384-1974 and will be powered from the Class 1E power system.

2.2.12.1.3 Reactor Containment Vessel Temperature

The Reactor Containment Vessel temperatures will be measured at selected locations on the inside of the steel shell.

2.2.12.1.4 Hydrogen Measurement System

The containment atmosphere hydrogen concentration measurement system consists of redundant, independent and continuous hydrogen analyzers located in the Intermediate Bay of the Steam Generator Building. These are connected to the containment atmosphere through redundant and independent sampling lines. The inlet to the sampling lines is located at the top of containment to prudently protect against hydrogen stratification even though stratification would not occur (Section 3.2.1). Sample transport time and sample plate out will be considered in establishing the exact location of these sampling stations. Each sampling station will include a hydrogen analyzer which will transmit a signal to the main control room. The channels will be physically separated and powered from the Class 1E power system.

The hydrogen measurement system involves severe environmental conditions arising from high temperature and aerosol contamination which may limit instrument lifetime. In view of this, early procurement of this equipment will be initiated. It is anticipated that the procurement process will provide confirmation as to whether this equipment can be obtained from existing sources or whether additional development or design verification requirements are necessary.

2.2.12.2 Radiation Monitoring

2.2.12.2.1 TMBDB Exhaust Plant Effluent Radiation 1

Since containment could be vented beyond 24 hours (although such venting is not needed for 36 hours) and therefore most of the radiological release would be through the vent and filter systems, radiation monitors are provided downstream of the filter system where the releases to the atmosphere would occur.

The redundant filter train monitors provide for determination of the radioactivity being released from the filter train. Monitoring will be accomplished using isokinetic sampling nozzles and associated three channel continuous air monitors (CAMs) which provide one channel each for particulates, radioiodines, and radiogases. The detectors and associated electronics are shielded to reduce the accident induced radiation background to levels suitable for system operation.

The three channel CAMs will provide gross count rates for each channel. The predicted radioisotopic inventories within the RCB coupled with gross count rate data will allow estimates of off-site doses to be made and will provide early identification of rapid and/or significant changes in release concentrations.

In addition, a suitably shielded plutonium air particulate monitor (PAPM) specifically designed to measure very low concentration of the long half-life alpha emitters, such as Pu-239, will be provided and will also continuously isokinetically sample the common exhaust. The PAPM provides capability for identifying the plutonium releases at the point where such releases would be the most concentrated and in this way maximizes the sensitivity of the measurement.

Redundancy is provided for the CAMs by the common exhaust monitor and is required due to the inaccessibility of the channels under accident conditions. Redundant PAPMs are not required due to the inherent redundancy of a typical PAPM which is provided as a means of accounting for the natural radon-thoron background (switching collection between dual channels allows the radon-thoron on the "idle" channel to decay (leaving behind the longer lived isotopes)).

The power requirements for the plant radiation monitoring system are supplied by the 1E power distribution system.

Provisions for off-site monitoring are described in the TVA Radiological Emergency Plan, as discussed in Section 13.3.11 of the PSAR.

2.2.12.2.2 High-Range Containment Area Radiation

Three High-Range Containment Area Radiation Monitors are provided to indicate the radiation levels within containment to assist in determining actions to protect the public. These monitors have a seven decade range to 10^7 R/Hr gamma. The detectors are located approximately 120 degrees apart around the Reactor Containment Building periphery in the annulus space, to take advantage of the relatively benign environment. The monitors are classified as Safety Class 1E and powered from three independent divisions of power. All three monitors have continuous display in the Control Room and one channel is recorded. 1

2.2.13 Electrical Power System

The electrical power requirements for motors, controls, and instruments will be distributed as part of the Class 1E electric power system using the appropriate standards of quality assurance, structural support, and physical separation.

These loads will, however, be remote manually connected to the 1E power source from the control room after removing other loads which are not essential during TMBDB conditions.

2.2.14 Containment Structures

As a result of the structural analysis of the containment building, a few changes in the design have been made to provide increased thermal margins. These include:

1. Modifications of the typical cell liner design have been made in the Reactor Cavity and the pipeway cells. Specifically the modifications are in the wall studs anchor size, spacing, and length, and in the size of the supporting beams in the pipeway floor.

2. Additional reinforcing bars and stirrups are provided in the reactor cavity wall to resist shear, compressive forces, and bending moments at the base, near the top and in the regions restrained by vertical walls.

3. Additional reinforcing bars and stirrups are provided in the pipeway cells to resist the thermal forces and moments.

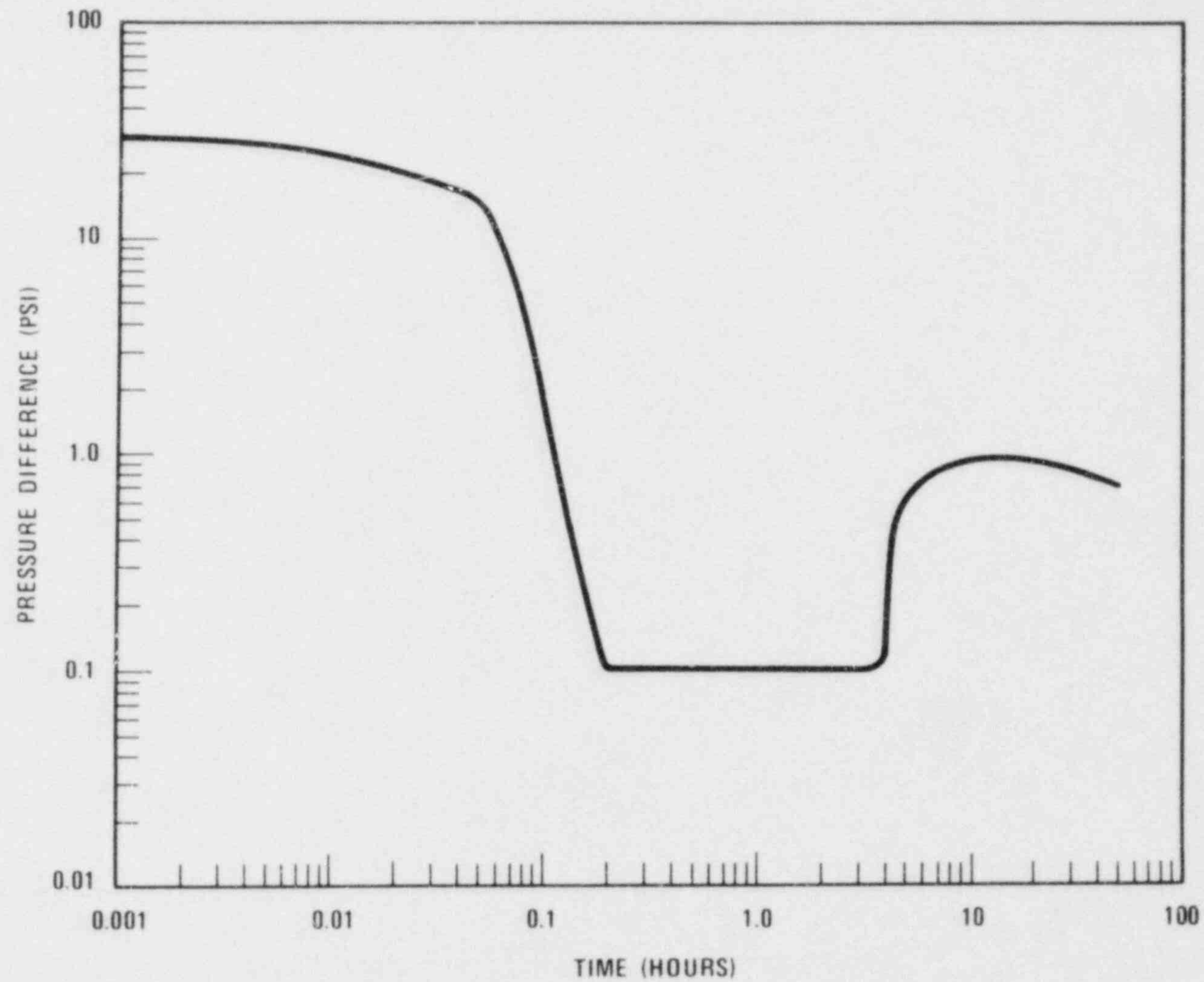

Figure 2-1 Maximum Pressure Differential Between the Reactor Cavity and Head Access Area

1966-2

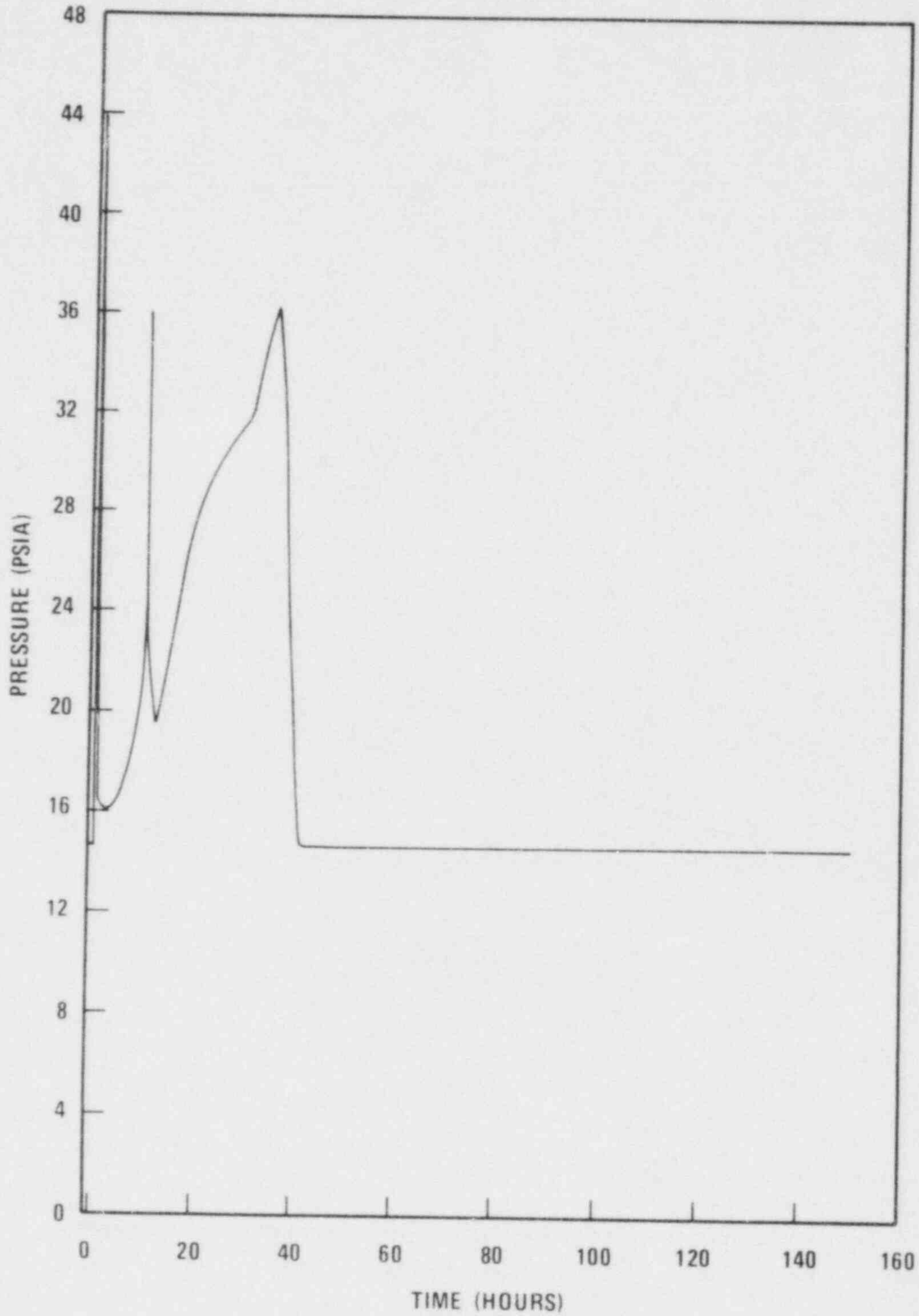

Figure 2-2 Maximum Reactor Cavity Atmosphere Pressure

1966-3

1966-33

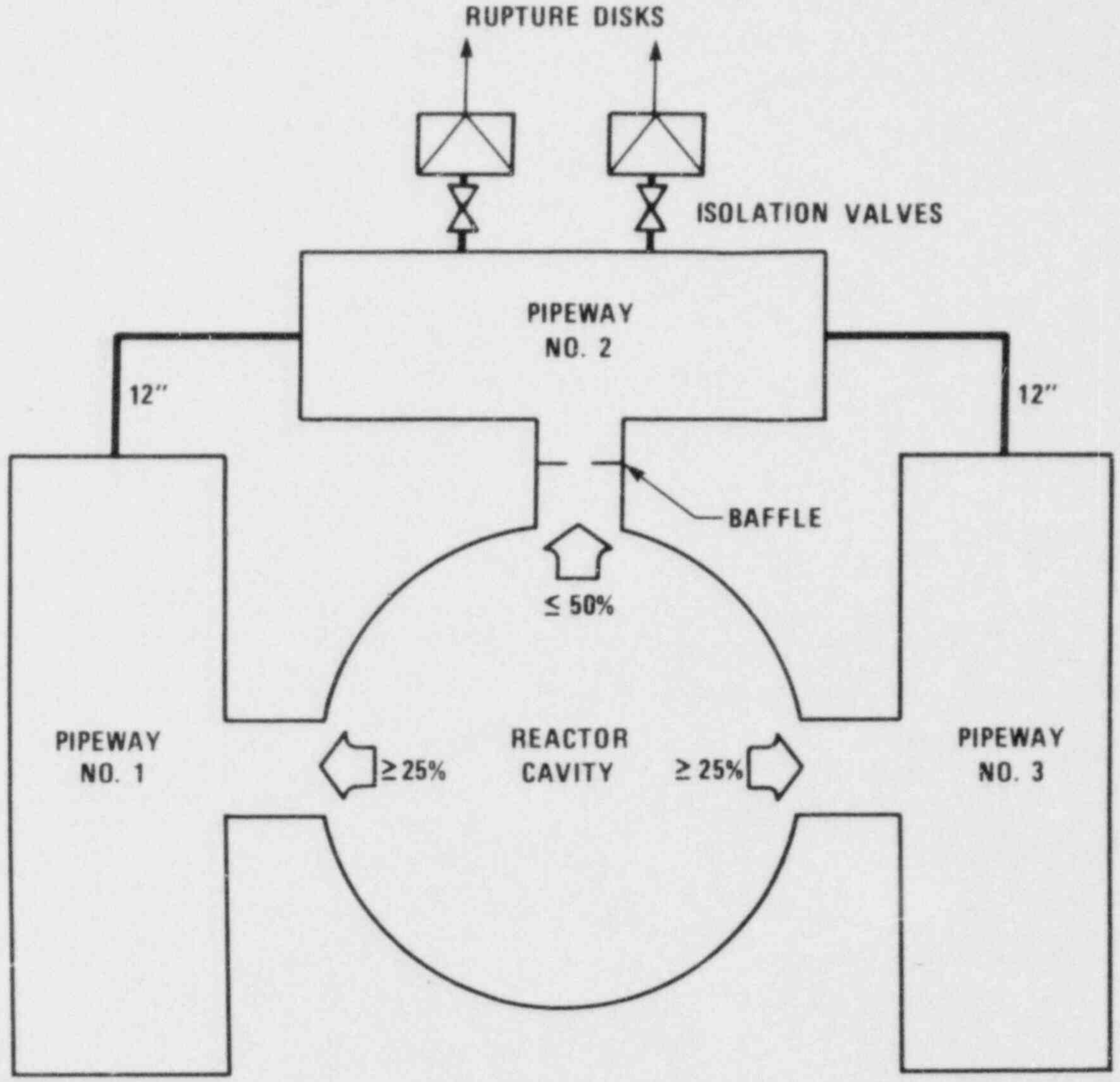

Figure 2-33 Reactor Cavity Vent System

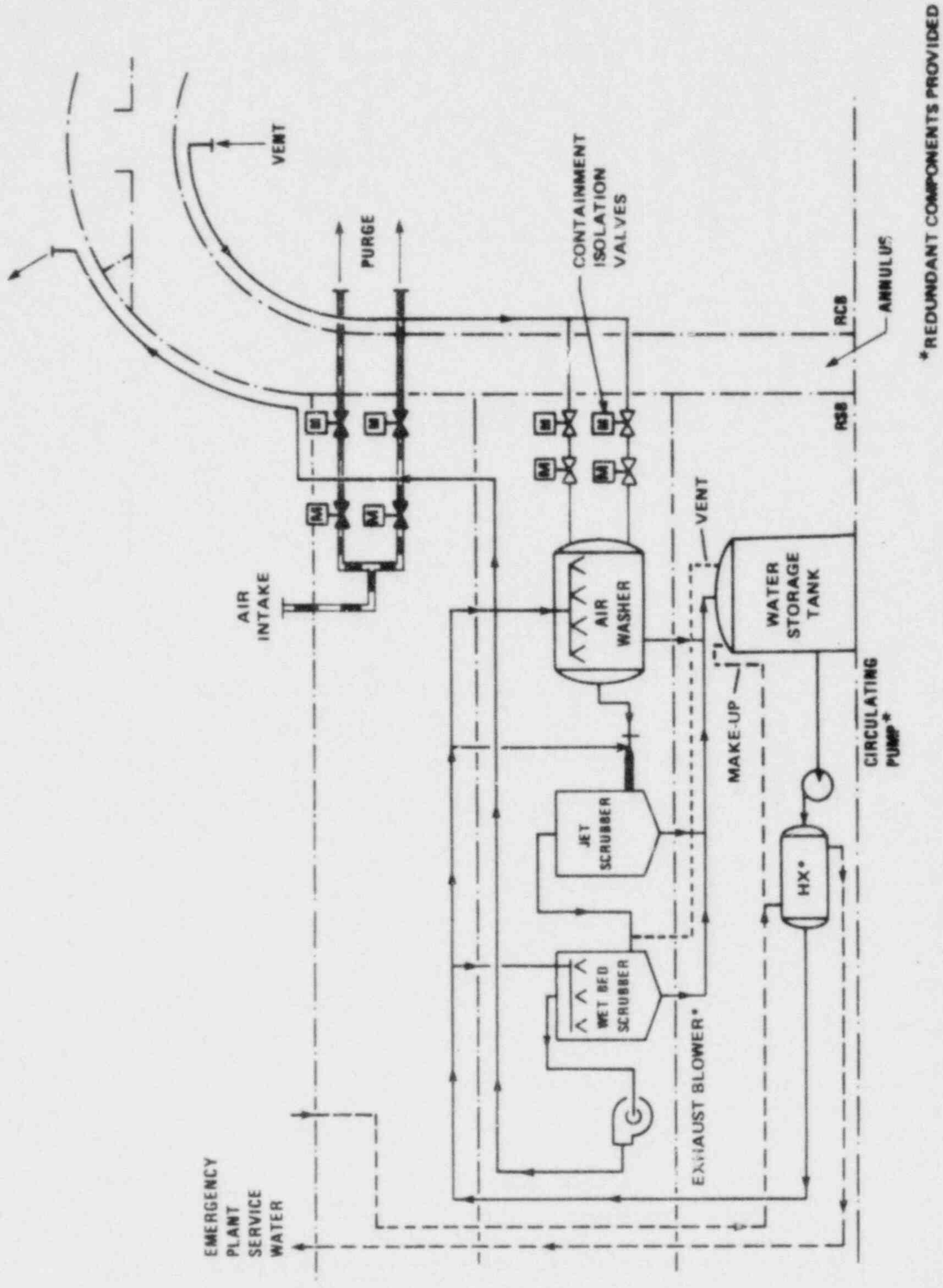

Figure 2-34 Containment Vent, Purge and Cleanup Systems