SYSTEM DESCRIPTION

FOR

REACTOR COOLANT GAS VENT SYSTEM

FOR

OMAHA PUBLIC POWER DISTRICT
FORT CALHOUN UNIT NO. 1

8879-PE-SD07

Revision 00

Nuclear Power Systems
COMBUSTION ENGINEERING, INC.
Windsor, Connecticut

Prepared by: Rona Gellob — Cognizant Engineer Date: 2/4/81

Approved by: [signature] — Supervisor Date: 2/10/81

Approved by: R. L. Mills — Project Manager Date: 2/17/81

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00	2/18/81	All	R. B. Gollob	C. A. Worley R. R. Mills

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1.0 PURPOSE

The purpose of this document is to provide a general description of the Reactor Coolant Gas Vent System (RGGVS), including system function, major parameters, and operation.

2.0 SCOPE

This document serves to provide orientation to the system and a summary of its components and their uses. A detailed description of components, process data, and operation is not intended. Process and component data contained herein is of an explanatory nature; it is not to be used for the design of connecting systems or components. Components and process detail will be found in the referenced documents and in subsequent equipment documents, operating guides, etc.

3.0 REFERENCES

3.1 P&ID

1. Reactor Coolant Gas Vent System, E- 8879 -310-107

3.2 Procedural Guidelines for Reactor Coolant Gas Vent System for Fort Calhoun, Unit No. 1, 8879-PE-PR07

4.0 SYSTEM FUNCTIONS

4.1 Remotely Vent Gases From Reactor Vessel Head and Pressurizer Steam Space

The Reactor Coolant Gas Vent System is designed to be used to remotely vent non-condensible gases from the reactor vessel head and pressurizer steam space during post-accident situations when large quantities of non-condensible gases may collect in these high points. The purpose of venting is to prevent possible interference with core cooling. Small amounts of gas can be vented to the quench tank (QT) and thus not enter the containment atmosphere. Larger volumes will require venting directly to the containment where the hydrogen concentration will be controlled by the containment hydrogen purge system. Pressure instrumentation is included in the design to monitor system leakage during normal plant operation.

4.2 Aid in RCS Venting Procedures Following a Maintenance Outage

Although designed for accident conditions, the system may be used to aid in the pre-or post-refueling venting of the reactor coolant system. Venting of the individual CEDMs and RCPs will still be necessary; however, pressurizer and reactor vessel venting can be accomplished with the system if desired. Vent flow would be directed to the QT for this operation to prevent inadvertent release of radioactive fluid to the containment.

5.0 SUMMARY DESCRIPTION

5.1 System Parameters

Flow >100 scfm H_2, dependent upon RCS pressure and temperature

Design Temperature	700°F
Design Pressure	2500 psia
Line Size	1"

5.2 Description Summary

The system is designed to permit the operator to vent the reactor vessel head or pressurizer steam space from the control room under post-accident conditions, and is operable following all design basis events except those requiring evacuation of the control room or a complete loss of all AC power. The vent path from either the pressurizer or reactor vessel head is single active failure proof with active components powered from emergency power sources. Parallel valves powered off alternate power sources are provided at both vent sources to assure a vent path exists in the event of a single failure of either a valve or the power source. The system provides a redundant vent path either to the containment directly or to the QT. The QT route allows removal of the gas from the RCS without the need to release the highly radioactive fluid into containment. Use of the QT provides a discharge location which can be used to store small quantities of gas without influencing containment hydrogen concentration levels. However, venting large quantities of gas to the QT will result in rupture of the QT rupture disc providing a second path to containment for vented gas.

Cooling of gas vented to the QT is provided by introducing the gas below the QT volume. The direct vent path is located to take advantage of mixing and cooling in the containment.

As shown on the P&ID, (Ref. 3.1), non-condensible gases are removed from either the pressurizer or reactor vessel through the flow restricting orifice and one of the parallel isolation valves and delivered to the QT or containment via their isolation valves. Venting under accident conditions would be accomplished using only one source (reactor vessel or pressurizer) and one sink (QT or containment) at a given time.

6.0 COMPONENT DESCRIPTION

There are no major components in the RCGVS.

6.1 Piping and Valves

All piping and valves used in the RCGVS are either type 304 or type 316, austenitic stainless steel or equivalent. Socket welded connections are used throughout except where disassembly for maintenance, particularly refueling operations, is required. The system is designed for 2500 psia and 700°F and is compatible with superheated steam, steam/water mixtures, fission gas, helium, nitrogen and hydrogen. A 7/32 x 1" stainless steel flow restriction orifice is provided in each vent path to limit reactor coolant leakage to less than the capacity of one charging pump in the event of a line break or inadvertent operation. A listing of the major system valves is provided in Table 1.

6.2 Instrumentation

6.2.1 Pressure indication in the vent line downstream of the reactor vessel head and pressurizer isolation valves is provided to detect leakage past any of these valves during normal power operations and alarm to alert the operator of the leakage. This instrument is not required to function during post-accident conditions and is therefore not provided with emergency power.

6.2.2 Open/close position indication for all remotely operated solenoid valves is provided in the control room.

7.0 OPERATION

7.1 The RCGVS is not used during normal power operations. All remotely operated valves are administratively controlled in the control room to assure the system is used only when necessary under accident conditions or in conjunction with RCS venting procedures associated with maintenance as discussed in Section 4.2. Pressure instrumentation is provided to detect leakage pass the first isolation valves.

7.2 Post-Accident System Operation

In the unlikely event that an accident results in the generation of significant quantities of non-condensible gases within the RCS, the RCGVS is used to remove the gases from the RCS. Prior to operation of the system, the quantity of non-condensible gases that may be present in the RCS must be estimated. This is accomplished through reactor vessel level indication for the case of gas bubbles in reactor vessel and by the response of system pressure control methods or departure from saturation conditions in the pressurizer for the case of gas in the pressurizer. Plant operating guidelines (Ref. 3.2). provides detailed instructions concerning the detection of the presence of non-condensible gas and the approximate volume of the gas.

If it is determined that a gas bubble exists in either the reactor vessel or the pressurizer and administrative approvals to operate the RCGVS are obtained, the system is placed in operation as follows:

A. Administrative controls are removed from control room panels.

B. The vent flow rate will be dependent upon reactor coolant system temperature and pressure. Flow rates for non-condensible gas (hydrogen) from the reactor vessel are provided in Figure 1. With the bubble size estimates and the flow rate, a venting duration can be determined. Figure 2 provides vent durations for various initial conditions. Plant operating guidelines (Ref. 3.2) contains detailed instructions concerning the determination of the duration of venting.

C. The vent system is aligned to vent from the pressurizer or reactor vessel to the containment or pressurizer quench tank. Small quantities of gas may be vented to the QT without rupture of the QT rupture disc. Larger quantities of gas are vented directly to containment; containment H_2 concentration should be monitored and controlled with the hydrogen purge system. Valve position indication is provided to monitor valve operation.

D. Venting is terminated after the previously determined time interval. If necessary, the bubble size is re-estimated and the venting re-established as often as necessary.

After system operation has been completed, adminstrative controls are again implemented to preclude operation.

7.3 System Maintenance and Inspection

7.3.1 Required maintenance is limited to inservice inspection of the Class 2 solenoid valves required by Section XI of the ASME Code. Drains have been provided for this purpose.

7.3.2 The system will have to be partially disassembled each refueling to allow head removal. A removable spool-piece has been included in the design for this purpose.

7.3.3 Operability of each valve should be checked and recorded during each refueling to confirm system operability.

8.0 SAFETY EVALUATION

8.1 Performance

The RCGVS may be required to operate during post-accident situations to remove non-co sible gases from the RCS. To assure operability under those cond ns, the components of the system required to perform venting operations have been designed to operate under post-accident environmental conditions. They are provided with emergency power sources. The system is Safety Class 2, Seismic 1. Parallel valves assure a vent flow path to containment in the event of single active failure. Series isolation is provided in the event that a valve does fail to close.

The RCGVS is not required to operate during normal power operation. To preclude inadvertent operation of the system, valves are subject to administrative controls prior to placing the system in operation. Should inadvertent operation occur, a flow limiting orifice is provided to limit mass loss from the RCS to less than the capacity of a single charging pump.

8.2 Failure Modes and Effects

Appendix B provides the failure modes and effects of those failures upon the RCGVS.

Table 1

Major System Valves

Valve Number	RV-101, 102, 103, 104, 105, 106
Valve Type	Globe
Operator	Solenoid
Design Pressure	2485 psig
Design Temperature	700°F
Operating Environment	Containment: Normal, LOCA, Main Steamline Break
Seismic Class	1
Safety Class	2
Design Code	ASME Code Section III, Class 2
Electrical Class	1E
Active (yes/no)	Yes
Fail Position	Closed
Limit Switch Position Indication	Yes (open, close)
Body Material	Stainless Steel
Leakoff	Packless

FIGURE 1

HYDROGEN (REACTOR)

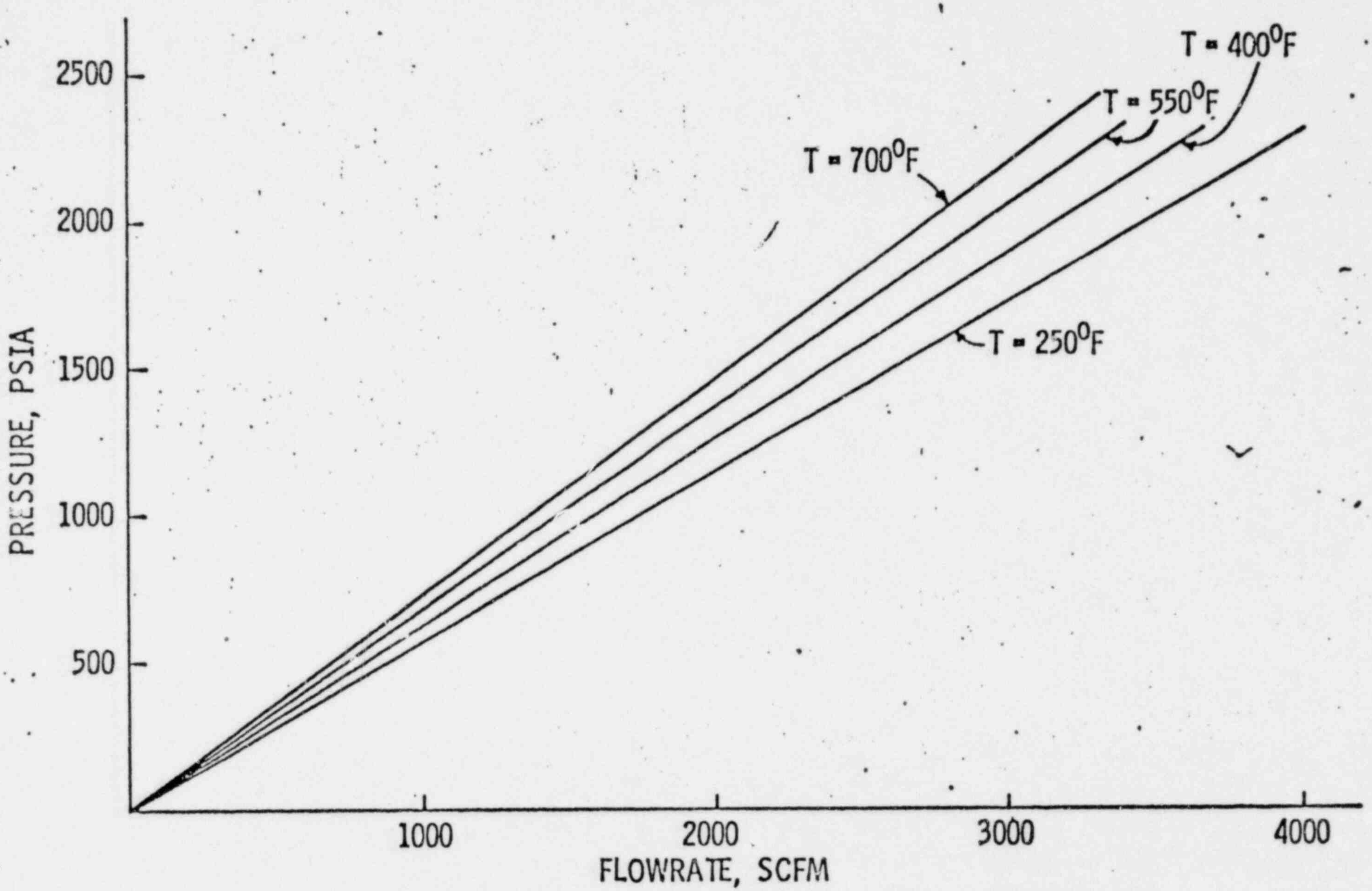
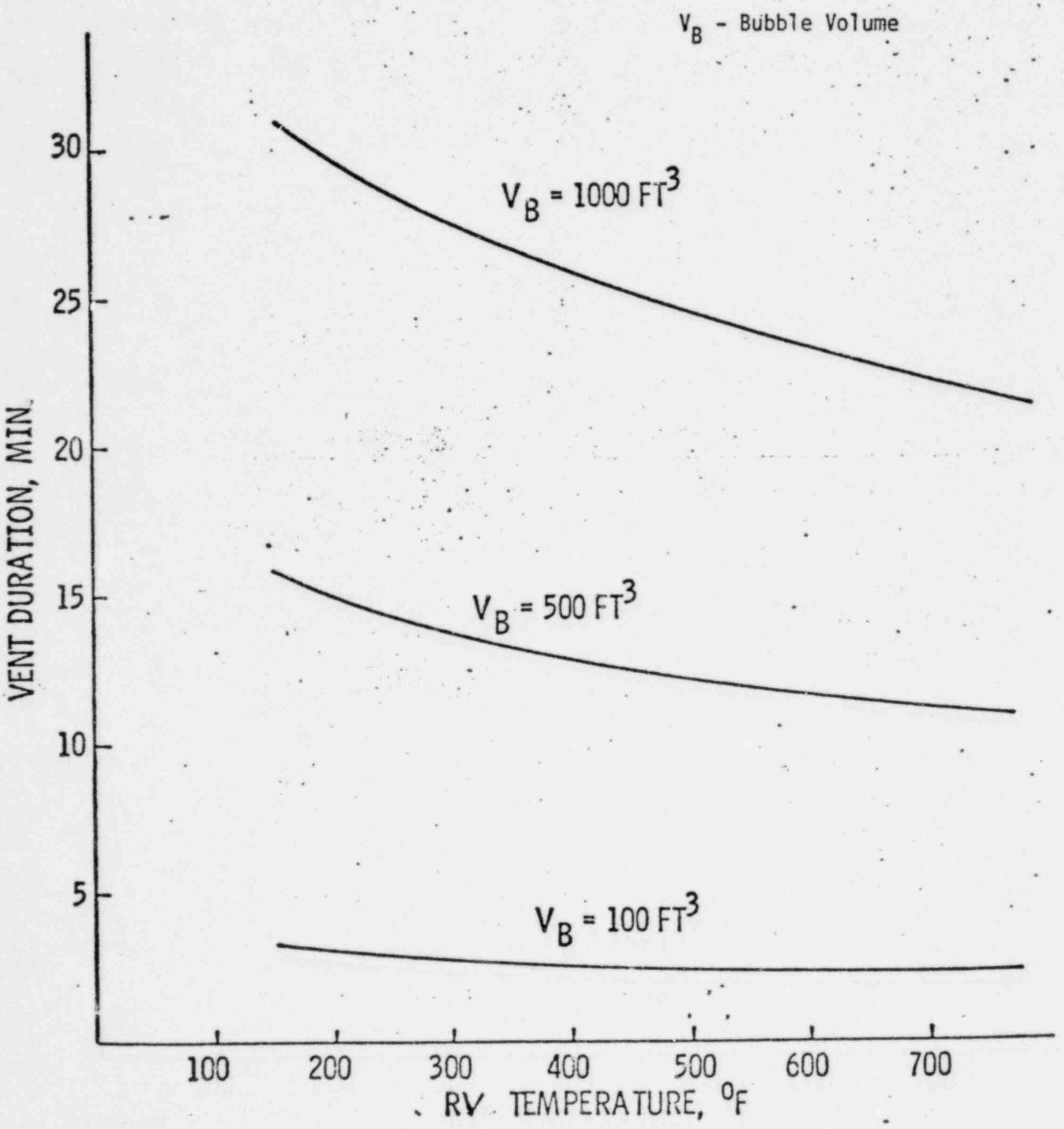


FIGURE 2

VENT DURATION OF HYDROGEN vs RV TEMP. AT P = 2250 PSIA



Appendix A

Summary of Definitions & Abbreviations

1.C DEFINITIONS

COMPONENT CLASSIFICATIONS

Safety Class: As defined in ANSI N18.2 except for Safety Class 4 which is defined as Quality Group D in Reg. Guide 1.26.

Mechanical Code Class: ASME pressure vessel code or other

Seismic Category: As defined in NRC Reg. Guide 1.29

Active/Non-Active Component: As defined in Reg. Guide 1.48.

Class I Electrical: As defined in IEEE 308

2.0 ABBREVIATIONS

1. SYSTEMS:
   - RCS - Reactor Coolant System
   - RCGVS - Reactor Coolant Gas Vent System

2. EQUIPMENT:
   - CRDM - Control Rod Drive Mechanism
   - RCP - Reactor Coolant Pump
   - QT - Quench Tank

Appendix B

RCGVS Failure Modes Effects Analysis

Failure Modes Effects Analysis for the Reactor Coolant Gas Vent System

No.	Name	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remark and other Effects
7	Position Indicator for RV-101, 102	False indication of valve position	Electro-mechanical failure.	Loss of ability to detect valve psoition in reactor vessel vent line.	Pressure gauge (P-138) indication shows valve is opened.	None	
8	Position Indicator for RV-103, 104	False indication of valve position	Electro-mechanical failure.	Loss of ability to detect valve position in pressurizer vent line.	Pressure gauge (P-138), indication shows valve is opened.	None	
9	Position Indicator for RV-105	False indication of valve position	Electro-mechanical failure	Loss of ability to detect valve position in quench tank vent line.	Quench Tank temperature and pressure verify value position. Pressure gauge (P-138).	None	
10	Position Indicator for RV-106	False indication of valve position	Electro-mechanical failure	Loss of ability to detect valve position in containment vent line.	Containment pressure/humidity/radiation levels verify containment valve position. Pressure gauge (P-138).	None	
11	Drain Valves RV-200, 203, 204	a. Seat Leakage	Contamination, Mechanical damage	No impact on system operation.	None	Drain lines are blind flanged.	
		b. Fails Closed	Mechanical Binding	No impact on normal operations. Inability to drain affected line section.	Operator	None	

Failure Modes Effects Analysis for the Reactor Coolant Gas Vent System

No.	Name	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and other Effects
		b. Fails Closed	Mechanical Failure, Loss of Power to the Valve	No impact on normal operation. Inability to vent pressurizer or reactor to containment.	Valve position indication in the control room. Operator.	None	Venting to the quench tank if possible if necessary.
5	Pressurizer Vent Isolation Valve RV-103, 104	a. Fails Open	Mechanical Binding, Seat Leakage	No impact on normal operation. Inability to vent the reactor vessel without also venting pressurizer. This is satisfactory and will not impact natural circulation.	Valve position indication in control room. P-138 high pressure indication.	None	Redundant isolation values to containment (RV-105), and quench tank (RV-10[illegible]) precludes uncontrolled venting of the pressurizer.
		b. Fails Closed	Mechanical Failure, Loss of Power	Inability to vent the pressurizer.	Valve position in the control room. Isolation valve. Operator.	Parallel redundant isolation valve.	Parallel isolation valve allows venting of the pressurizer.
6	Reactor Vessel Vent Isolation Valve RV-101, 102	a. Fails Open	Mechanical Binding, Seat Leakage	No impact on normal operation. Unable to vent pressurizer without also venting the Reactor Vessel. This is satisfactory and will not impact natural circulation.	Valve position indication in the control room. P-138 high pressure indication.	None	Redundant isolation values to containment (RV-106) and (RV-105) precludes uncontrolled venting of the reactor vessel.
		b. Fails Closed	Mechanical Failure, Loss of Power	Inability to vent the reactor vessel.	Valve position in the control room. Operator.	Parallel redundant isolation valve.	Parallel isolation valve allows venting of the reactor vessel.

Failure Modes Effects Analysis for the Reactor Coolant Gas Vent System

No.	Name	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and other Effects
1	Pressure Indicator P-138	a. spurious high pressure indication/alarm	Electro-mechanical failure, set-point drift	No impact on normal operation. Loss of ability to detect leakage into the vent system piping.	Valve position indication in the control room.	None	Post-Accident venting is not affected
		b. spurious low pressure indication	Electro-mechanical failure, set-point drift	No impact on normal operation. Loss of ability to detect leakage into the vent system piping.	Valve position indication in the control room.	None	Post-Accident venting is not affected
2	Quench Tank Isolation Valve RV-105	a. Fails Open	Mechanical Binding, Seat Leakage	Inability to isolate quench tank from the reactor coolant gas vent system.	Valve position indication in the control room.	None	Redundant isolation valves to the reactor vessel and pressurizer preclude uncontrolled venting to the quench tank.
		b. Fails Closed	Mechanical Failure, Loss of Power	No impact on normal operation. Inability to vent pressurizer or reactor to quench tank.	Valve position indication in the control room. Operator.	None	Venting to the containment is possible, if necessary.
3	Pressure Instrument Isolation Valves RV-201, 202	a. Fails Open	Mechanical Binding, Seat Leakage	None	Operator	Redundant Valves	
		b. Fails Closed	Mechanical Failure	Loss of ability to detect seat leakage from the pressurizer and reactor isolation valves into the reactor coolant gas vent system piping.	Operator	None	Unlikely event since valve is normally open and has only a manual operator
4	Containment Isolation Valve RV-106	a. Fails Open	Mechanical Binding, Seat Leakage	Inability to isolate reactor coolant vent system from containment.	High containment pressure and humidity if venting is in progress. Valve position indication in the control	None	Redundant isolation valves to the reactor vessel and pressurizer preclude uncontrolled venting to the containment.