

---

**Evaluation of Candidate LSSC Check Valves for Risk Based IST Extension  
at Comanche Peak Units 1,2**

---

**K. L. McElhane**

**Oak Ridge National Laboratory  
Oak Ridge, Tennessee**

**January 6, 1997**

**NRC Job Code W6324**

9703030045-1A



## Background

Comanche Peak Steam Electric Station has recently submitted to the NRC a request for relief from the Inservice Test (IST) intervals currently required by the ASME Code for certain check valves based on a probabilistic analysis of the valves' importance to safety. In theory, this analysis methodology results in the ranking of components into two basic categories, those of high safety significance and those with low safety significance. The goal is to ensure that the components more important to plant safety are to be tested in a manner that provides a high level of assurance of their operability. Another goal of the Risk Based approach (RBIST) is to show that IST intervals may be extended beyond the current requirements without resulting in significantly increased safety risks. One consideration in this type of analysis is component performance history, both from the specific plant as well as from an industry perspective.

Comanche Peak has requested IST extension from their current Code requirements (usually quarterly) to an interval of 6 years on approximately 380 "low safety significant" (LSSC) check valves. In an effort to provide information needed to evaluate potential candidate check valves at Comanche Peak for extended IST intervals, Oak Ridge National Laboratory (ORNL) has done a brief review of the available performance data for the valves in question. The following is a summary report on that analysis.

## Analysis Results

An analysis was done on check valve failure data obtained from NPRDS for Comanche Peak Units 1 and 2 from 1990 through 1995. Unit 1 began commercial service in 1990, while Unit 2 began commercial operation in 1993. "Raw" NPRDS failure narratives were reviewed and characterized according to the criteria used in development of the ORNL check valve performance database. The ORNL database itself was not used for this analysis since it covers only the time period 1984 through 1992, which would have failed to incorporate most of the Comanche Peak operating experience. Comanche Peak check valve failure experience was reviewed according to several parameters, including severity of degradation (to the valve itself), system, failure cause, and component repeat failures. A comparison of valves with failure records in NPRDS with the deferral candidate valves was also made. Only 33 failure records were included in the NPRDS database (as of November 1996) for failures occurring from 1990 through 1995. Therefore, due to the small failure population, all records were included in the analysis (i.e., external leakage type failures were included). Also due to the limited failure data available, a detailed comparison to overall industry performance experience was not made at this time.

### *Comanche Peak check valve failure experience—1990-1995*

Of the 33 NPRDS check valve failure records available for 1990-1995, the failure distribution according to extent of degradation is shown in Table 1:

Table 1 All Comanche Peak Check Valve Failures by Extent of Degradation

Extent of Degradation	No. Failures
Moderate	11
Significant	16
External Leakage	6



"Extent of degradation" refers to the effect of the failure on the ability of the component to perform one or more of its design functions, not to any resultant effect on train, system, or plant operation. For a check valve, therefore, a *significant* failure would be one in which the valve either stuck open or stuck closed, exhibited mechanical binding, or had loose or detached internal parts. External leakage (e.g., bonnet or flange leakage) type failures were not originally included in the ORNL check valve database, but were identified for this analysis for the purpose of providing an overall representation of check valve performance at Comanche Peak.

If only moderate and significant failures are considered, then for Comanche Peak during the study period of interest, 59% of the check valve failures were significant. This compares with an industry average of approximately 35% significant failures for 1991-1992 (excluding external leakage type failures).<sup>1,2</sup> Further examination of the Comanche Peak failures indicates that many of the significant failures were of the type to be expected in a new plant, however. Table 2 shows the failure distribution by extent of degradation and failure cause.

**Table 2**  
**Comanche Peak Check Valve Failure Distribution by Extent of Degradation and Failure Cause**

Failure Cause	No. Moderate Failures	No. Significant Failures
Abnormal wear	1	
Abnormal wear; design problem		1
Abnormal wear; procedure problem		1
Foreign material	5	
Foreign material; design problem	2	
Foreign material; procedure problem		5
Maintenance problem		1
Procedure problem; improper installation		1
Manufacturing defect		4
Unknown	3	2
Normal wear		1

From Table 2 it is apparent that of the 27 failures involving internal degradation (i.e., excluding external leakage failures), 9 were related to "infant" type problems, including manufacturing defects or maintenance, installation, or design errors. Seven of the sixteen significant failures were related to these causes. Also, in consideration of the length of the IST interval extension requested, it is important to note that of the 27 internal-related failures, 16 involved some type of age-related failure mechanism such as debris accumulation or wear. Of the 16 significant failures, 8 were age-related.

In order to provide a more detailed review, Table 3 lists all failures by component ID and extent of degradation. Repeat failures are also identified. A summary of the significant and repeat failure records is provided (see notes).



Table 3 Comanche Peak Check Valve Failures by Component ID

Component ID	Valve Type	System	No. failures/Extent of degradation*	Repeat failures (both units)?	Valve on RBIST candidate deferral list?	Notes
1AF-0086		AFW	1E		Yes	
1AF-0093		AFW	1S		Yes	1
1AF-0098		AFW	1M		Yes	
1AF-0101	Swing	AFW	1S		Yes	2
1CA-0016		Containment Isolation	2M	Yes	Yes	3
1CC-0657	Stop	CCW	1S		Yes	4
1CC-0831	Lift	CCW	2M	Yes	Yes	9
1CC-1075	Stop	CCW	1S		Yes	4
1CC-1076	Stop	CCW	1S		Yes	4
1CC-1077	Stop	CCW	1S		Yes	4
1CC-1078	Stop	CCW	1S		Yes	4
1CS-8443	Lift	CVCS	1M			
1CT-0013		Containment Spray	1E		Yes	
1CT-0047		Containment Spray	1E		Yes	
1CT-0063		Containment Spray	1E		Yes	
1CT-0077		Containment Spray	1E		Yes	
1CT-0094		Containment Spray	1E		Yes	
1DO-0258		Diesel Fuel Oil	1S	Yes	Yes	5
1FW-0076	Tilting disc	Feedwater	1S		Yes	6
1FW-0088	Tilting disc	Feedwater	1S		Yes	7
1SI-8968	Lift	Containment Isolation	2M	Yes	Yes	9
2CA-0016		Containment Isolation	1M	Yes	Yes	3
2CC-0831	Lift	CCW	1S	Yes	Yes	11
2CS-8368C	Lift	CVCS	1M		Yes	
2DO-0258		Diesel Lube Oil	2S	Yes	Yes	8
2FW-0013	Tilting disc	Feedwater	2S	Yes		12
2SI-8968	Lift	Containment Isolation	1M, 1S	Yes	Yes	10

\* E-External leakage, M-Moderate, S-Significant



Table 3 notes (taken from NPRDS failure narratives):

- 1 Valve disc held off its seat due to mechanical interference between disc counterweight and valve body. Manufacturing defect.
- 2 Crack in valve seat circumferential seal weld. Manufacturing defect.
- 3 Repeat failures due to debris buildup on valve seat resulting from moisture in the system.
- 4 Stop check valve failed open due to corrosion product accumulation between plug and bore during long periods of inactivity. Periodic stroking of valve was less than adequate. Quarterly stroking of valve had to be initiated to prevent recurrence.
- 5 Valve disc detached from hinged connection at valve body due to combination of repeated cycling and high reseating pressure. (Clow Corp. "FIG 53").
- 6 Vendor supplied valve with incorrect angle clearance, causing disc to bind on side supports prior to fully closing.
- 7 Inadequate assembly procedure resulted in improper installation of torsion springs. Disc would not fully contact the seat.
- 8 Repeat failures due to wear and slamming of viton valve seat/gasket on metal sealing surface resulting in tearing of (soft) viton seat material. "Valve inadequately designed for application." (Clow Corp. "FIG 53").
- 9 Repeat internal leakage failures.
- 10 Repeat failures due to galling, seat cocking.
- 11 Stuck open due to "bad seat and disc." Failure cause unknown.
- 12 Repeat stuck open failures. (1) Disc lodged against seat with pivot and retaining pins missing. Interference weld securing the retaining pin inadequate. Maintenance error. (2) Binding at disc stop contact area prevented closure. Manufacturing defect.

The 33 check valve failures were distributed across 8 systems as shown in Table 4. Figure 1 illustrates the failure distribution by failure cause and system.

**Table 4**  
**Distribution of Comanche Peak Check Valve Failures by System and Extent of Degradation**

System	External leakage	Moderate	Significant
AFW	1	1	2
CCW		2	6
Containment Isolation		6	1
Containment Spray	5		
CVCS		2	
Diesel Fuel Oil			1
Diesel Lube Oil			2
Feedwater			4



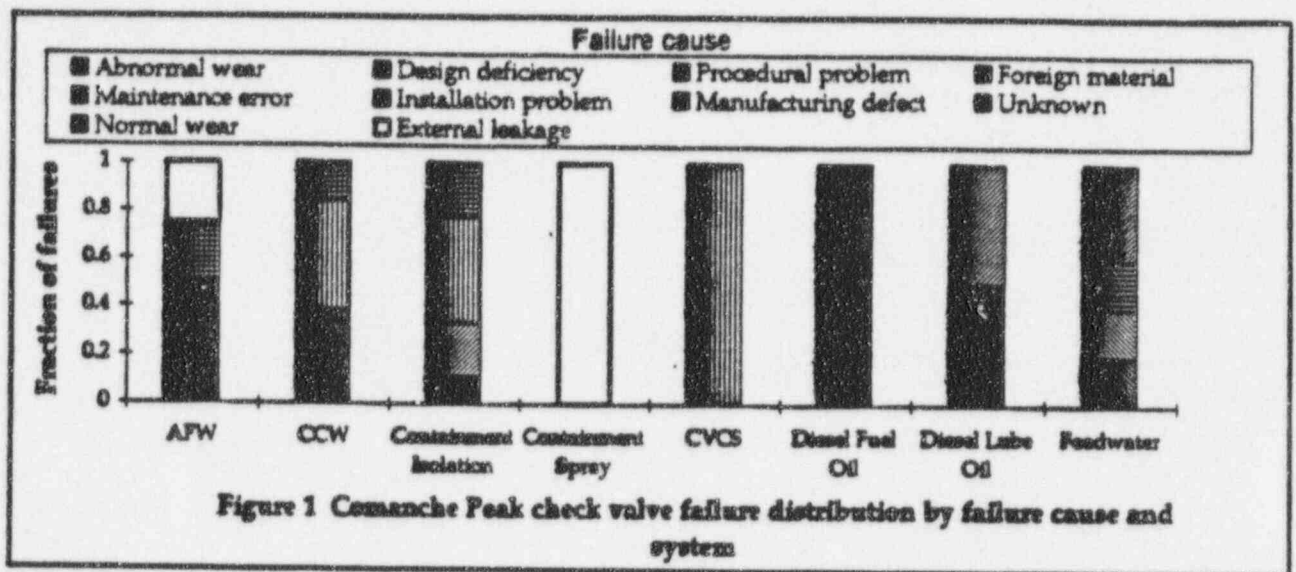


Figure 1 Comanche Peak check valve failure distribution by failure cause and system

## Conclusions

Of the 33 failure records recorded in NPRDS for Comanche Peak check valves from 1990-1995, all but 2 of the failed valves are included in the list of IST deferral candidates. (Table A-1 in the Appendix lists all the deferral candidate check valves by unit and system.) Nine of the thirty-three failures involved repeat failures (considering both units). Two individual components (2FW-0013 and 2DO-0258) had repeat significant failures. Diesel Lube Oil valve DO-0258 had a total of three significant failures, considering both units.

It is important to understand that due to the small number of failure records available for Comanche Peak check valves during the relatively short analysis period, few statistically meaningful results can be derived. The data does not, however, at this point suggest any abnormal failure patterns or causes. By the same argument, little data is currently available to validate IST interval extension or to evaluate the effect of interval extension on check valve performance. Further collection and analysis of performance data over an extended operating period would be necessary to more accurately evaluate the effects of changes in the IST program.

In the review of current relief requests for Comanche Peak check valves, it might be prudent to question both the nature of (and corrective measures taken with regard to) the failures which have occurred as well as the source(s) of data that were used as input to risk-based calculations. For example, it might be reasonable to question the failure experience of five CCW stop check valves that involved the valves' sticking closed due to ... "corrosion product accumulation between plug and bore during long periods of inactivity. Periodic stroking of valve(s) was less than adequate. Quarterly stroking of (the) valve(s) had to be initiated to prevent recurrence." Additionally, considering the limited nature of Comanche Peak operating experience and data, the sources of component failure rates and other analysis inputs might be questioned.



References

- 1 Oak Ridge National Laboratory, NUREG/CR-5944, Vol. 2, "A Characterization of Check Valve Degradation and Failure Experience in the Nuclear Power Industry — 1991 Failures," July 1995.
- 2 Oak Ridge National Laboratory, ORNL/NRC/LTR-96/11, "A Characterization of Check Valve Degradation and Failure Experience in the Nuclear Power Industry — 1992 Failures," June 1996.



## APPENDIX

Table A-1 Comanche Peak Risk Based RBIST Deferral Candidate Check Valves

Comanche Peak RBIST Deferral Candidate Check Valves	Unit(s)	System	Failures in NPRDS (1990-1995)
1,2AF-0014	1,2	AFW	
1,2AF-0024	1,2	AFW	
1,2AF-0032	1,2	AFW	
1,2AF-0038	1,2	AFW	
1,2AF-0051	1,2	AFW	
1,2AF-0065	1,2	AFW	
1,2AF-0075	1,2	AFW	
1,2AF-0078	1,2	AFW	
1,2AF-0083	1,2	AFW	
1,2AF-0086	1,2	AFW	Unit 1 (1E)
1,2AF-0093	1,2	AFW	Unit 1 (1S)
1,2AF-0098	1,2	AFW	Unit 1 (1M)
1,2AF-0101	1,2	AFW	Unit 1 (1M)
1,2AF-0106	1,2	AFW	
1AF-0215	1	AFW	
1AF-0216	1	AFW	
1AF-0217	1	AFW	
1AF-0218	1	AFW	
1AF-0219	1	AFW	
1AF-0220	1	AFW	
1,2AF-0221	1,2	AFW	
1,2AF-0222	1,2	AFW	
1AF-0223	1	AFW	
2AF-0224	2	AFW	
1AF-0224	1	AFW	
2AF-0223	2	AFW	
1AF-0226	1	AFW	
2AF-0227	2	AFW	
1AF-0227	1	AFW	
2AF-0226	2	AFW	
1,2AF-0228	1,2	AFW	
1,2AF-0229	1,2	AFW	
1AF-0230	1	AFW	
2AF-0231	2	AFW	
1AF-0231	1	AFW	
2AF-0230	2	AFW	
1,2AF-0232	1,2	AFW	
1,2AF-0233	1,2	AFW	
1,2AF-0234	1,2	AFW	
1,2AF-0235	1,2	AFW	



## Comanche Peak Units 1,2

Comanche Peak RBIST Deferral Candidate Check Valves	Unit(s)	System	Failures in NPRDS (1990-1995)
1,2CC-0003	1,2	CCW	
1,2CC-0004	1,2	CCW	
1,2CC-0031	1,2	CCW	
1,2CC-0061	1,2	CCW	
2CC-0371	2	CCW	
2CC-0372	2	CCW	
2CC-0373	2	CCW	
2CC-0374	2	CCW	
1,2CC-0629	1,2	CCW	
1,2CC-0646	1,2	CCW	
1,2CC-0657	1,2	CCW	Unit 1 (1S)
1,2CC-0687	1,2	CCW	
1,2CC-0694	1,2	CCW	
1,2CC-0713	1,2	CCW	
1,2CC-0831	1,2	CCW	Unit 1 (2M); Unit 2 (1S)
1CC-1075	1	CCW	Unit 1 (1S)
1CC-1076	1	CCW	Unit 1 (1S)
1CC-1077	1	CCW	Unit 1 (1S)
1CC-1078	1	CCW	Unit 1 (1S)
1CC-1079	1	CCW	
1CC-1080	1	CCW	
1CC-1081	1	CCW	
1CC-1082	1	CCW	
2CC-1091	2	CCW	
2CC-1092	2	CCW	
2CC-1093	2	CCW	
2CC-1094	2	CCW	
1,2CH-0300	1,2	Containment Isolation	
1,2CH-0301	1,2	Containment Isolation	
XCS-0037	Common	CVCS	
XCS-0039	Common	CVCS	
XCS-0041	Common	CVCS	
XCS-0044	Common	CVCS	
1,2CS-8180	1,2	CVCS	
1,2CS-8350A	1,2	CVCS	
1,2CS-8350B	1,2	CVCS	
1,2CS-8350C	1,2	CVCS	
1,2CS-8350D	1,2	CVCS	
1,2CS-8367A	1,2	CVCS	
1,2CS-8367B	1,2	CVCS	
1,2CS-8367C	1,2	CVCS	
1,2CS-8367D	1,2	CVCS	
1,2CS-8368A	1,2	CVCS	
1,2CS-8368B	1,2	CVCS	
1,2CS-8368C	1,2	CVCS	Unit 2 (1M)



## Comanche Peak Units 1,2

Comanche Peak RBIST Deferral Candidate Check Valves	Unit(s)	System	Failures in NPRDS (1990-1995)
1,2CS-8368D	1,2	CVCS	
1,2CS-8377	1,2	CVCS	
1,2-8378A	1,2	CVCS	
1,2-8378B	1,2	CVCS	
1,2-8379A	1,2	CVCS	
1,2-8379B	1,2	CVCS	
1,2-8381	1,2	CVCS	
1,2CS-8442	1,2	CVCS	
1,2CS-8473	1,2	CVCS	
1,2CS-8480A	1,2	CVCS	
1,2CS-8480B	1,2	CVCS	
1,2-8481A	1,2	CVCS	
1,2-8481B	1,2	CVCS	
1,2CS-8487	1,2	CVCS	
1,2-8497	1,2	CVCS	
1,2CT-0013	1,2	Containment Spray	Unit 1 (1E)
1,2CT-0020	1,2	Containment Spray	
1,2CT-0025	1,2	Containment Spray	
1,2CT-0031	1,2	Containment Spray	
1,2CT-0042	1,2	Containment Spray	
1,2CT-0047	1,2	Containment Spray	Unit 1 (1E)
1,2CT-0048	1,2	Containment Spray	
1,2CT-0063	1,2	Containment Spray	Unit 1 (1E)
1,2CT-0064	1,2	Containment Spray	
1,2CT-0065	1,2	Containment Spray	
1,2CT-0072	1,2	Containment Spray	
1,2CT-0077	1,2	Containment Spray	Unit 1 (1E)
1,2CT-0082	1,2	Containment Spray	
1,2CT-0094	1,2	Containment Spray	Unit 1 (1E)
1,2CT-0142	1,2	Containment Spray	
1,2CT-0145	1,2	Containment Spray	
1,2CT-0148	1,2	Containment Spray	
1,2CT-0149	1,2	Containment Spray	
2DD-0002	2	Demineralized and Reactor Makeup Water	
1,2DD-0006	1,2	Demineralized and Reactor Makeup Water	
2DD-0008	2	Demineralized and Reactor Makeup Water	
2DD-0009	2	Demineralized and Reactor Makeup Water	



Comanche Peak RBIST Deferral Candidate Check Valves	Unit(s)	System	Failures in NFRDS (1990-1995)
1,2DD-0016	1,2	Demineralized and Reactor Makeup Water	
1,2DD-0018	1,2	Demineralized and Reactor Makeup Water	
XDD-0044	Common	Demineralized and Reactor Makeup Water	
XDD-0048	Common	Demineralized and Reactor Makeup Water	
IDD-0064	1	Demineralized and Reactor Makeup Water	
IDD-0065	1	Demineralized and Reactor Makeup Water	
IDD-0066	1	Demineralized and Reactor Makeup Water	
1,2DO-0004	1,2	Diesel Fuel Oil	
1,2DO-0005	1,2	Diesel Fuel Oil	
1,2DO-0016	1,2	Diesel Fuel Oil	
1,2DO-0017	1,2	Diesel Fuel Oil	
1,2DO-0049	1,2	Diesel Fuel Oil	
1DO-0050	1	Diesel Fuel Oil	
2DO-0052	2	Diesel Fuel Oil	
1,2DO-0058	1,2	Diesel Fuel Oil	
1,2DO-0059	1,2	Diesel Fuel Oil	
1,2DO-0060	1,2	Diesel Fuel Oil	
1,2DO-0061	1,2	Diesel Fuel Oil	
1,2DO-0062	1,2	Diesel Fuel Oil	
1,2DO-0063	1,2	Diesel Fuel Oil	
1,2DO-0064	1,2	Diesel Fuel Oil	
1,2DO-0065	1,2	Diesel Fuel Oil	
2DO-0074	2	Diesel Fuel Oil	
2DO-0075	2	Diesel Fuel Oil	
2DO-0076	2	Diesel Fuel Oil	
2DO-0077	2	Diesel Fuel Oil	
1,2DO-0104	1,2	Diesel Fuel Oil	
1,2DO-0157	1,2	Diesel Fuel Oil	
1,2DO-0158	1,2	Diesel Fuel Oil	
1,2DO-0204	1,2	Diesel Fuel Oil	
1,2DO-0257	1,2	Diesel Fuel Oil	
1,2DO-0258	1,2	Diesel Fuel Oil	Unit 1 (1S); Unit 2 (2S)



Comanche Peak RBIST Deferral Candidate Check Valves	Unit(s)	System	Failures in NPRDS (1990-1995)
1,2FW-0070	1,2	Feedwater	
1,2FW-0076	1,2	Feedwater	Unit 1 (1S)
1,2FW-0082	1,2	Feedwater	
1,2FW-0088	1,2	Feedwater	Unit 1 (1S)
1,2FW-0191	1,2	Feedwater	
1,2FW-0192	1,2	Feedwater	
1,2FW-0193	1,2	Feedwater	
1,2FW-0194	1,2	Feedwater	
1,2FW-0195	1,2	Feedwater	
1,2FW-0196	1,2	Feedwater	
1,2FW-0197	1,2	Feedwater	
1,2FW-0198	1,2	Feedwater	
1,2FW-0199	1,2	Feedwater	
1,2FW-0200	1,2	Feedwater	
1,2FW-0201	1,2	Feedwater	
1,2FW-0202	1,2	Feedwater	
1,2MS-0142	1,2	Main Steam	
1,2MS-0143	1,2	Main Steam	
2MS-0663	2	Main Steam	
2MS-0664	2	Main Steam	
2MS-0665	2	Main Steam	
2MS-0666	2	Main Steam	
2MS-0667	2	Main Steam	
2MS-0668	2	Main Steam	
2MS-0669	2	Main Steam	
2MS-0670	2	Main Steam	
1MS-0680	1	Main Steam	
1MS-0681	1	Main Steam	
1MS-0682	1	Main Steam	
1MS-0683	1	Main Steam	
1MS-0684	1	Main Steam	
1MS-0685	1	Main Steam	
1MS-0686	1	Main Steam	
1MS-0687	1	Main Steam	
1,2-8730A	1,2	RHR	
1,2-8730B	1,2	RHR	
XSF-0003	Common	Spent Fuel Pool Cooling System	
XSF-0004	Common	Spent Fuel Pool Cooling System	
XSF-0160	Common	Spent Fuel Pool Cooling System	
XSF-0180	Common	Spent Fuel Pool Cooling System	
1,2-8841A	1,2	RHR	
1,2-8841B	1,2	RHR	



**Evaluation of Candidate LSS: Check Valves for Risk Based IST Extension at  
Comanche Peak Units 1,2**

<b>Comanche Peak RBIST Deferral Candidate Check Valves</b>	<b>Unit(s)</b>	<b>System</b>	<b>Failures in NPRDS (1990-1995)</b>
1,2-8890A	1,2		
1,2-8890B	1,2		
1,2SI-8900A	1,2	HPSI	
1,2SI-8900B	1,2	HPSI	
1,2SI-8900C	1,2	HPSI	
1,2SI-8900D	1,2	HPSI	
1,2SI-8905A	1,2	HPSI	
1,2SI-8905B	1,2	HPSI	
1,2SI-8905C	1,2	HPSI	
1,2SI-8905D	1,2	HPSI	
1,2SI-8919A	1,2	HPSI	
1,2SI-8919B	1,2	HPSI	
1,2-8922A	1,2	HPSI	
1,2-8922B	1,2	HPSI	
1,2-8949A	1,2	HPSI	
1,2-8949B	1,2	HPSI	
1,2-8949C	1,2	HPSI	
1,2-8949D	1,2	HPSI	
1,2-8958A	1,2	RHR	
1,2-8958B	1,2	RHR	
1,2SI-8968	1,2	Containment Isolation	Unit 1 (2M); Unit 2 (1M,1S)
1,2-8969A	1,2	HPSI	
1,2-8969B	1,2	HPSI	
1,2VD-0003	1,2	Vents and Drains	
1,2VD-0004	1,2	Vents and Drains	
1,2VD-0011	1,2	Vents and Drains	
1,2VD-0012	1,2	Vents and Drains	
1,2CA-0016	1,2	Containment Isolation	Unit 1 (2M); Unit 2 (1M)
1,2CH-0024	1,2	Containment Isolation	
1,2CI-0030	1,2	Containment Isolation	

E-External leakage  
M-Moderate  
S-Significant