INSERVICE TESTING ANO-UNIT 1

CHECK VALVE RELIABILITY ANALYSIS

JUNE 12, 1981

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PLANT MAINTENANCE AND AVAILABILITY

I. Purpose

The purpose of this report is to respond to a request from Performance Engineering for reliability data to support taking exception to an ASME Section XI, Division 1, IWV 3520A requirement.

II. Scope

This analysis covers four valves, specifically as shown below:

Valve	Vendor	Type	Size
CF1A	Velan	Swing Check	14"
CF1B	Velan	Swing Check	14"
BS4A	Anchor	Tilting Disc Check	8"
BS4B	Anchor	Tilting Disc Check	8"

III. Reliability and Maintainability

A. Reliability

BS4A,B

Based upon reliability analysis*, the BS4A,B valves have an inherent reliability of .999 respectively for both calendar and operating hour measurements. This was determined using the component reliability as measured by failures cited in the NPRD report** and the required 90-day testing sequence as per ASME.

Using calendar hours as the measurement criteria, these valves could be tested at period intervals of 13.47 years and still maintain a reliability of .90. The attached calculation sheet shows the reliability probabilities associated with 5-year intervals of testing frequency.

Analysis of reliability of these valves using operating hours as the measurement criteria resulted in a testing frequency interval of 7.05 years would still maintain a .90 reliability factor. The attached calculation sheet, CS-1, shows the probabilities associated with 5-year intervals of testing frequency.

CF1A,B

Based upon reliability analysis*, the CF1A,B valves have an inherent reliability of .999 respectively. This was determined based upon component reliability as measured by failures cited by NPRD** and the required 90-day testing sequence as per ASME.

Changing the testing sequence to the next scheduled refueling outage, 18 months hence, the associated reliability probability is .97 (see attached calculation sheet-2).

Comparison of these two probabilities shows a difference of .029 or a reliability degradation of

3 percent. Therefore, changing the testing frequency would not cause a significant increase in system unavailability.

B. Maintainability

A survey of other nuclear plants was conducted by NUS's Nuclear Operations and Maintenance Information Service. The results are very promising. It not only appears that the operating history is very good, but also shows that several plants have taken exceptions on these valves. The responses are attached.

CALCULATION SHEET

For: BS4A,B (8")

From: NPRDS 1979 Annual Report of Cumulative Component Reliability

Using Calendar Hours

$$\frac{\text{Number of Failures}}{\text{Calendar Hours}} = \text{Failure Rate}$$

$$\frac{31 \text{ Failures}}{34999000 \text{ Hours}} = .00000089 \text{ failures per hour}$$

90-day testing frequency ensures reliability of .999 calculated as follows:

(.00000089 failures per hour)(2160 hours) = .0019 = rt

From Continuous Discount Factor (Table C)***

$$e^{-rt} \approx .999$$

Five-year intervals of testing frequencies ensures the following reliabilities:

Testing Frequency	Reliability (e^{-rt})
5	∿ .961
10	∿ .932
15	∿ .896
20	∿ .861
25	∿ .827

To maintain reliability ≥ 90%:

$$\text{Testing frequency} = \left(\frac{.105}{.00000089}\right)\text{hours} \times \frac{1 \text{ year}}{365 \text{ days}} \times 24 \text{ hours/day}$$

$$= 13.47 \text{ years}$$

Using Operating Hours

$$\frac{31 \text{ Failures}}{18474000 \text{ Hours}} = .0000017 \text{ failures per hour}$$

90-day testing: $\sim .999$ reliability (e^{-rt})

5-year intervals of testing frequencies:

Testing Frequency	Reliability (e^{-rt})
5	$\sim .932$
10	$\sim .869$
15	$\sim .803$
20	$\sim .748$
25	$\sim .705$

To maintain reliability $\geq 90\%$

$$\text{Testing frequency} = \left(\frac{.105}{.0000017}\right)\text{hours}\left(\frac{1 \text{ year}}{(365 \text{ days})(24 \text{ hours})}\right)$$

$$= 7.05 \text{ years}$$

For: CF1A,B (14")

90-day testing interval extended to 18-month testing interval:
(Using Operating Hours)

$$\frac{29 \text{ Failures}}{11608000 \text{ Hours}} = .0000025 \text{ failures per hour}$$

90 days - $\sim$.99 reliability (e^{-rt})
(rt = .005)

18 months - $\sim$.970 reliability
(rt = .03)

BIBLIOGRAPHY

*Power Plant Availability Engineering
Basic Techniques in Availability Engineering
Prepared by Pickard, Howe and Garick, Inc. for
Electric Research Institute
Part 2. Reliability Analysis
Page 2-7

**NPRD Report A03 (Part 2)
Annual Report of Cumulative Component
Reliability/Nuclear Plant Reliability Data System
Report Period: 7/74 - 12/79

***Table C - Continuous Discount Factor - e^{-rt}
Quantitative Analysis for Business Decisions
Bierman
Bonini
Housman
Third Edition, 1969
(see copy attached)

DUE DATE: 5/11/81
INI: RHL

PLANT: ANO/ARKANSAS PSI
REQUESTER: Patti Campbell
REACTOR: B&W
TURBINE: W
SYSTEM: Operations/Maintenance
COMPONENT: Check Valve

PROBLEM DESCRIPTION: ISI Requirements on Check Valves

81-5-102 - (A.) What plants have taken exception to ASME Section XI, Division 1, IWV-3520A which requires exercising check valves in three month intervals or during cold shutdowns; specifically, for the swing check pressure isolation valves in the Containment Spray and L.P. Safety Injection (Core Flood) Systems? (B.) What is the surveillance testing period for these valves in your plant? (C.) If your plant has either Anchor Darling or Velan check valves in these locations, what has been your 'a' failure rate and maintenance experience? Arkansas Nuclear One

PLANT RESPONSES:

BEAVER VALLEY - has had significant problems with the Velan check valves. Contact Ralph Hansen, 412/643-4429 for further information. Mainly 3" and 6" - not problems we would expect.

BIG ROCK POINT - will either exercise the check valves or take them apart. Their valves have an isolation valve on either side of the check valve, and a drain tap to allow testing the checks. If a safety signal is received during testing, the safety signal will override the isolation valves and open them so that the safety function can be performed.

COOK - took exception to the Section XI requirements to exercise these valves as it cannot be done. They have a lot of both of these type of valves and have not experienced any major problems with them. These valves are inspected during refueling.

DAVIS BESSE - has taken exception to the requirements for exercising of the 14" Core Flood check valves, the same ones that lost their locking plates and bolts last fall. They verify these valves as operable via leak rate after each refueling outage, if in cold shutdown more than 72 hours and not tested in the last nine months, or following any maintenance repair or replacement. In 1976 one valve failed but passed after relapping and then problems were again encountered as mentioned last fall.

DRESDEN - has six to eight valves which fit in this category. They test remote operators for testable check valves at each refueling outage. Some valves could not be tested, and they sought relief from the NRC and received it. This was several years ago. Contact Rob Coen, ext. 483 at the plant for more information.

FERMI - (pre-op) has taken exception to ASME Section XI, Division 1, IWV 3520A. Presently they are in cold shutdown and they exercise the Anchor/Darling valves once every three months. Their IST pump and valve program has not been submitted to the NRC yet.

FITZPATRICK - does not test these valves at present.

FT. CALHOUN - does surveillance on these particular check valves each refueling outage. They don't have Anchor/Darling or Velan valves; however, they have not had any failures with the valves they have. They are presently working on tests to verify that the valves close and are leak tight.

GINNA - has had problems with Velan check valves. This 4-inch valve is in the Closed Cooling Water system.

INDIAN POINT 2 - has a general program to test their Main Steam isolation valves each shutdown or whenever possible and do all other valves every 18 months (refueling). Check valves are primarily Anchor Darling, Atwood, and Westinghouse and have about the same problems as everyone else has are encountered.

INDIAN POINT 3 - has not taken exception to the ASME Section XI requirement and exercises their check valves during cold shutdowns. The plant has Anchor Darling check valves and the test failure rate has been zero with the maintenance history experience being very good.

Note 19 From NOMIS (Staff) <Organizer> To and (er%1) 10-Jun-81 6:14 AM
81-5-102

MIDLAND - (pre-OL) has not made a firm decision but will probably do these valves during each refueling.

OCONEE - has taken exception to the Building Spray check valve and tests it every five years. The Core Flood check valves are partially tested during each heat up by opening the isolation valve when the Reactor Coolant pressure is slightly below the core flood tank pressure. They have Crane check valves in these applications.

PILGRIM - has taken exceptions to Section XI, Division 1, IWV 3520A. They will send a copy of their list of exceptions to NOMIS and it will be forwarded upon receipt. (Requested)

PRAIRIE ISLAND - test some checks during refueling. In particular, they test the Containment Spray check valves using compressed air. They test Low Head Safety Injection check valves by realigning the Safety Injection system during refueling and run a flow test. They took exception to this section and have submitted it. They will send copies of this submittal to NOMIS and it will be available upon request. (Requested)

QUAD CITIES - is doing their ISI update now. They have some testable check valves and are examining these requirements very closely for other valves in the plant.

ROBINSON - tests these valves for full flow every refueling but not at cold shutdown due to highly borated water. They have had no problems with these valves and no leakage has been detected. They have Anchor/Darling and Velan valves with an excellent maintenance history. The Steam system valves have given some problems and they are checked on a quarterly basis during cold shutdown.

SALEM - has taken exception to this and does not exercise their Containment Spray check valves. They test their Low Pressure Safety Injection valves every refueling. They do not have either Anchor/Darling or Velan check valves.

ST. LUCIE - has Velan valves and the maintenance history has been very good with only one valve having to have a gasket repaired early during startup/construction. Contact Neil Roos, 305/465-3550, ext. 220 for further information.

SUMMER - (pre-op) has taken exception to the ASME Section XI requirement by submitting a relief request to the NRC. They have not received their return reply yet. The surveillance testing period for these valves is requested to be changed to each refueling shutdown. Summer is pre-op and does not have any experience with their check valves in these areas.

SURRY - asked for an exemption and did get relief. They exercise these valves during each refueling outage. They must test every cold shutdown for leak tightness, however. They will send NUMIS a copy of their submittal and it will be forwarded upon request. (Requested)

TROJAN - has not taken exception to the ASME code and their testing interval is 92 days or during the next cold shutdown (greater than a 72 hour duration). The majority of these valves in service are Copes Vulcan and they have had trouble with two of the valves in the past not meeting acceptance criteria. Other problems with the valves are that they do not seat properly and they have major body to bonnet leaks. Jerry Stein has performed a Plant study on valve repairs and has found that Copes Vulcan has supplied 2.6% of the total valves in the Plant, constituting 18% of the repairs in the Plant. Velan valves have contributed 1.5% to the total valve package in the Plant of which 4% comprises the total valve maintenance. Anchor/Darling has 1.4% of the valves in the Plant and comprises about 5% of the total valve maintenance. Copes Vulcan supposedly will not discuss their problems any further with Trojan.

TVA - Contact Gary Paley, 615/755-8681.

WATERFORD - (pre-op) has not addressed this problem yet since they are in pre-op stage.

TABLE C

Continuous Discount Factor—e^{-rt}

rt	e^{-rt}	rt	e^{-rt}	rt	e^{-rt}
.00	1.000	.55	.577	3.40	.033
.01	.990	.60	.549	3.60	.027
.02	.980	.65	.522	3.80	.022
.03	.970	.70	.497	4.00	.018
.04	.961	.75	.472	4.20	.015
.05	.951	.80	.449	4.40	.012
.06	.942	.85	.427	4.60	.010
.07	.932	.90	.407	4.80	.008
.08	.923	.95	.387	5.00	.007
.09	.914	1.00	.368	5.50	.004
.10	.905	1.05	.350	6.00	.002
.11	.896	1.10	.333		
.12	.887	1.15	.317		
.13	.878	1.20	.301		
.14	.869	1.25	.287		
.15	.861	1.30	.273		
.16	.852	1.40	.247		
.17	.844	1.50	.223		
.18	.835	1.60	.202		
.19	.827	1.70	.183		
.20	.819	1.80	.165		
.21	.811	1.90	.150		
.22	.803	2.00	.135		
.23	.795	2.10	.122		
.24	.787	2.20	.111		
.25	.779	2.30	.100		
.26	.771	2.40	.091		
.27	.763	2.50	.082		
.28	.756	2.60	.074		
.29	.748	2.70	.067		
.30	.741	2.80	.061		
.35	.705	2.90	.055		
.40	.670	3.00	.050		
.45	.638	3.10	.045		
.50	.607	3.20	.041		

NPRD REPORT A03 (PART 2)
REPORT PERIOD: 7/74 -- 12/79

ANNUAL REPORT OF CUMULATIVE COMPONENT RELIABILITY
NUCLEAR PLANT RELIABILITY DATA SYSTEM

VALVES

THIS REPORT CONTAINS STATISTICS ON ALL COMPONENTS IN THE NPRDS ACCUMULATED BETWEEN 7/01/74 AND 12/31/79

COMPONENT CLASSIFICATION / FAILURE MODES	NO. FAILURES	NO. UNITS	FAILURES PER MILLION CALENDAR HOURS * 25 TH MINIMUM PERCENTILE	MEDIAN	75 TH PERCENTILE	MAXIMUM	** AVERAGE RESTORATION HOURS	OUT-OF-SERVICE HOURS HIGHEST	AVERAGE	LOWEST
CHECK										
NONE										
4 TO 11.99 IN.					903		18,474	31	195	48
							34,999			
LEAK	29	11	.00	.00	.00	.00	17.53	1047	4236	1166
WON'T CLOSE	1	1	.00	.00	.00	.00	5.84	1032	1032	1032
WON'T HOLD	1	1	.00	.00	.00	.00	1.48	205	205	205
TOTAL	31	11	.00	.00	.00	.00	23.38	1019	4236	1131
CHECK										
NONE										
12 TO 19.99 IN					455		11,608	29	105	39
							17,703			
LEAK	22	8	.00	.00	.00	.00	17.53	1046	4200	1047
PHYSICAL DISTORTION	1	1	.00	.00	.00	.00	.48	12	12	12
WON'T CLOSE	2	2	.00	.00	.00	.00	1.38	122	242	122
WON'T OPEN	1	1	.00	.00	.00	.00	1.44	1147	1147	1147
OUT OF ADJUSTMENT	3	1	.00	.00	.00	.00	3.66	3	3	3
TOTAL	29	11	.00	.00	.00	1.38	17.53	842	4200	843
CHECK										
NONE										
20 TO 39.99 IN					66		1.120	0	21	15
							2.179			
CHECK										
NONE										
40 TO 59.99 IN					3		.111	0	2	2
							.111			

* LOWEST CALCULATED FAILURE RATE FROM AN INDIVIDUAL UNIT
** HIGHEST CALCULATED FAILURE RATE FROM AN INDIVIDUAL UNIT

6.5.3 This submittal shall include a listing of all additions, deletions and revisions to the existing programs that have been implemented since the last submittal to the NRC. This submittal shall also include justification for any relief requests from specific requirements of the Section XI of the ASME Code.

6.5.4 The submittal shall be issued by the Plant Analysis Superintendent after approval by the PSC.

6.6 IST Program Records

The IST Coordinator(s) shall maintain a working file of Inservice Test Program records which include:

6.6.1 Pump and valve test data. This file should include selected data from the current and the previous year.

6.6.2 All request for additions, deletions and revisions to the IST Program.

6.6.3 Baseline test data for each re-run of baseline data as required following maintenance or modifications.

6.6.4 All NRC submittals and correspondence involving the IST program.

6.7 Valve testing in accordance with the ASME Code, Section XI, shall commence within two hours after a cold shutdown condition is achieved but not later than 48 hours after shutdown and continue until complete or the plant is ready to return to power. Completion of all valve testing is not a prerequisite to return to power. Any testing not completed at one cold shutdown will be performed during any subsequent cold shutdowns that may occur before refueling to meet the Code specified testing frequency.

Exceptions to the 48 hour start time will be taken for planned cold shutdowns where all valve testing in Cold Shutdown mode identified in our Inservice Testing Program will be completed.

7.0 FORMS AND ATTACHMENTS

Form 1015.06A, IST Program - Revision Control

Attachment 1 - Unit One IST Program

Attachment 2 - Unit Two IST Program

Attachment 3 - Guidance for ASME Section XI category classification of pumps and valves.