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## Item B-58: Passive Mechanical Failures (Rev. 1)

### DESCRIPTION

#### *Historical Background*

This NUREG-0471<sup>1</sup> task involves a review of valve failure data in a systematic manner to verify the staff's present judgment regarding the likelihood of passive mechanical valve failures, to categorize these and other valve failures as to expected frequency, to specify acceptance criteria, and to determine if and how the results of this effort should be applied in licensing reviews. The issue is related to a number of other issues dealing with valve reliability: Item C-11, "Assessment of Failure and Reliability of Pumps and Valves"; Item II.D.2, "Research on Relief and Safety Valve Test Requirements"; and Item II.E.6.1, "In-Situ Testing of Valves - Test Adequacy Test Study." Item C-11, in particular, is aimed at active failure of pumps and valves. Valve failure data collected at the Nuclear Safety Information Center were studied to identify failure frequency for active failure mechanisms.<sup>2</sup> These same data are examined here to identify passive failure mechanisms. The distinction is made here that active failures typically occur during valve operation while passive failures occur over a period of time, going unnoticed as the valve is rendered inoperable. Detection of failure then occurs after valve operation is demanded.

#### *Safety Significance*

In view of the fact that safety-related systems contain about 500 valves, passive failures present a potentially significant safety concern because the effects on safety-related systems can be so widespread.

#### *Possible Solution*

The solution to this safety issue is a program to investigate these valve failures and the operation of a valve maintenance program, including the replacement of valves as necessary over the life of the plant.

### PRIORITY DETERMINATION

#### *Frequency/Consequence Estimate*

In an evaluation of this issue by PNL,<sup>3</sup> passive valve failure was noted to be due primarily to crud and corrosion which caused deterioration of valve function over a period of time. Based on the available data,<sup>4</sup> it was noted that the average number of hardware-related failures for BWRs and PWRs were 17% and 18%, respectively, of all valve failures. Over the life of existing plants, the average hardware-related passive failures represent about 12% of all valve failures. These data<sup>5</sup> also indicate that the failure rates

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<sup>1</sup> NUREG-0471, "Generic Task Problem Descriptions (Categories B, C, and D)," U.S. Nuclear Regulatory Commission, June 1978.

<sup>2</sup> NUREG/CR-0848, "Summary and Bibliography of Operating Experience with Valves in Light-Water-Reactor Nuclear Power Plants for the Period 1965– 1978," U.S. Nuclear Regulatory Commission, August 1979.

<sup>3</sup> NUREG/CR-2800, "Guidelines for Nuclear Power Plant Safety Issue Prioritization Information Development," U.S. Nuclear Regulatory Commission, February 1983, (Supplement 1) May 1983, (Supplement 2) December 1983, (Supplement 3) September 1985, (Supplement 4) July 1986, (Supplement 5) July 1996.

<sup>4</sup> NUREG/CR-0848, "Summary and Bibliography of Operating Experience with Valves in Light-Water-Reactor Nuclear Power Plants for the Period 1965– 1978," U.S. Nuclear Regulatory Commission, August 1979.

<sup>5</sup> NUREG/CR-0848, "Summary and Bibliography of Operating Experience with Valves in Light-Water-Reactor Nuclear Power Plants for the Period 1965– 1978," U.S. Nuclear Regulatory Commission, August

for passive mechanical failures is 1.3/RY and 0.36/RY for BWRs and PWRs, respectively.

It is assumed that a 50% reduction in passive mechanical failures can be achieved by the resolution of this issue. This would result in a reduction in the average of hardware-related failures of 6% and a reduction in the failure rate of 0.65/RY and 0.18/RY for BWRs and PWRs, respectively.

Risk reduction is calculated for a representative PWR (Oconee 3) in which the affected parameters in the accident sequences are those which contain valves with hardware failure modes.<sup>6</sup> The base case public risk reduction was estimated by PNL to be less than 1 man-rem/RY for BWRs and PWRs. Therefore, the total public risk reduction is estimated to be less than 4,000 man-rem.<sup>7</sup> The occupational risk is increased by virtue of the implementation of this issue (+300 man-rem) but the exposure during operation and maintenance is reduced because of improved valve performance (-1,140 man-rem). The net change in occupational dose due to the resolution of this issue is -840 man-rem.

*Cost Estimate*

Based on the judgment of the PNL staff,<sup>8</sup> it is assumed that 13 valves will be replaced in BWRs and 4 valves replaced in PWRs during the implementation of the solution to this issue. (It is noted here that the final priority ranking of this issue is relatively insensitive to this assumption). Assuming that 24 man-hr/valve replacement is required, a total of 313 man-hrs and 96 man-hrs for the work of implementation in a radiation zone is calculated for BWRs and PWRs, respectively.

For backfit plants, it is assumed that the work time spent in radiation zones represents 20% of the total utility staff commitment to this issue. With administrative and engineering support, the total labor estimated is:

BWR:	$\text{Labor} = \frac{1}{20\%} \times \frac{312 \text{ man-hrs / plant}}{40 \text{ man-hrs / man-wk}}$	=39 man-wk/plant
PWR:	$\text{Labor} = \frac{1}{20\%} \times \frac{90 \text{ man-hrs / plant}}{40 \text{ man-hrs / man-wk}}$	=12 man-wk/plant

Backfit equipment is assumed to consist of 13 valves/BWR and 4 valves/PWR at a cost of \$30,000/valve. Work will presumably be conducted during normal outages so that no additional downtime is foreseen.

It is also assumed that the nuclear industry will fund research totaling \$500,000, a cost spread over all 134 plants. The intention of this program is to identify those elements that contribute significantly to

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<sup>6</sup> NUREG/CR-2800, "Guidelines for Nuclear Power Plant Safety Issue Prioritization Information Development," U.S. Nuclear Regulatory Commission, February 1983, (Supplement 1) May 1983, (Supplement 2) December 1983, (Supplement 3) September 1985, (Supplement 4) July 1986, (Supplement 5) July 1996.

<sup>7</sup> NUREG/CR-2800, "Guidelines for Nuclear Power Plant Safety Issue Prioritization Information Development," U.S. Nuclear Regulatory Commission, February 1983, (Supplement 1) May 1983, (Supplement 2) December 1983, (Supplement 3) September 1985, (Supplement 4) July 1986, (Supplement 5) July 1996.

<sup>8</sup> NUREG/CR-2800, "Guidelines for Nuclear Power Plant Safety Issue Prioritization Information Development," U.S. Nuclear Regulatory Commission, February 1983, (Supplement 1) May 1983, (Supplement 2) December 1983, (Supplement 3) September 1985, (Supplement 4) July 1986, (Supplement 5) July 1996.

passive valve failures so that they can be better controlled in the future.

The total costs per plant for implementation of the solution to the issue is:

Item	Cost (\$/Plant)			
	BWR		PWR	
	Backfit	Forward-Fit	Backfit	Forward-Fit
Labor	88,500	-	27,200	-
Equipment	390,000	-	120,000	-
Research	<b>3,700</b>	<b>3,700</b>	<b>3,700</b>	<b>3,700</b>
	<b>482,000</b>	<b>3,700</b>	<b>150,900</b>	<b>3,700</b>

For 24 backfit and 20 forward-fit BWRs and 47 backfit and 43 forward-fit PWRs, the total industry implementation cost is \$19M, based on a labor rate of \$2,270/man-wk.

For operation and maintenance, the resolution of the safety issue is assumed to reduce the labor, equipment, and outage time attributable to passive valve failures. The labor and equipment requirements prior to resolution of the safety issue are as follows (note that the labor estimate of 24 man-hr/failure is increased by a factor of 5 to 120 man-hr/failure to include support labor, such as engineering and administration):

<b>Labor</b>	
	BWRs: $(1.3 \text{ failures/RY})(120 \text{ man-hr/failure}) = 3.9 \text{ man-wk/RY}$
	PWRs: $(0.36 \text{ failures/RY})(120 \text{ man-hr/failure}) = 1.1 \text{ man-wk/RY}$
<b>Equipment</b>	
	BWRs: 1.3 valve replacements/RY at \$30,000/valve
	PWRs: 0.36 valve replacements/RY at \$30,000/valve

Active failures of pumps and valves are estimated to account for 10% of the average 60 days/RY of routine downtime at a plant, or 6 days/RY. Dividing this equally between pump and valve failures, one can attribute 3 days/RY of downtime to active valve failures. Active valve failures were reported at rates of 639 failures in 140 RY (BWRs), or 4.6/RY, and 678 failures in 190 RY (PWRs), or 3.6/RY.<sup>9</sup> If the amount of downtime attributable to active valve failures is assumed proportional to their failure rates, then it follows that the amount of downtime attributable to passive valve failures will be proportional to the ratio of passive to active valve failure rates, or  $(1.3/4.6) = 0.28$  for BWRs and  $(0.36/3.6) = 0.10$  for PWRs. Thus, prior to safety issue implementation, the downtime attributable to passive valve failures is assumed to be as follows:

<sup>9</sup> NUREG/CR-0848, "Summary and Bibliography of Operating Experience with Valves in Light-Water-Reactor Nuclear Power Plants for the Period 1965– 1978," U.S. Nuclear Regulatory Commission, August 1979.

BWRs:  $(0.28)(3 \text{ days/Ry}) = 0.84 \text{ day/Ry}$

PWRs:  $(0.10)(3 \text{ days/Ry}) = 0.30 \text{ day/Ry}$

Assuming that the resolution of the safety issue reduces the passive valve failure rate by 50%, the following **reductions** in labor, equipment and down-time for operation and maintenance result:

	BWR	PWR
Labor (man-wk/Ry)	2.0	0.55
Equipment (valve replacements/ Ry)	0.65	0.18
Downtime (days/Ry)	0.42	0.15

The reductions in the per plant industry costs (indicated by the negative sign) for operation and maintenance is as follows:

	BWR	PWR
Labor (at \$2,270/man-wk)	-\$4,500/Ry	-\$1,200/Ry
Equipment (at \$30,000/valve)	-\$19,500/Ry	-\$5,400/Ry
Downtime (at \$300,000/day)	<b>-\$126,000/Ry</b>	<b>-\$45,000/Ry</b>
	<b>-\$150,000/Ry</b>	<b>-\$51,600/Ry</b>

Based on average plant lifetimes of 28.8 yrs and 27.4 yrs for BWRs and PWRs, respectively, the total industry cost for operation and maintenance of this program is a fairly large estimated savings of \$315M resulting principally from the reduction in reactor downtime.

The direct costs for the implementation and development of this safety issue are as follows:

Industry Implementation Cost	=\$19,000,000
NRC Development Cost	= \$50,000
Total	<b>=\$19,050,000</b>

*Value/Impact Assessment*

Based on the estimated risk reduction of less than 4,000 man-rem, the value/ impact score is given by:

$$S \left( \frac{4,000 \text{ man - rem}}{\$19.05\text{M}} \right)$$

$$\left( 210 \text{ man - rem} / \$\text{M} \right)$$

## CONCLUSION

Based on the value/impact score of less than 210 man-rem/\$M and a public risk reduction of less than 4,000 man-rem, this issue would have warranted a low to medium priority ranking. However, in view of the potentially large industry savings of approximately \$300M that could accrue from reduced maintenance and reduced downtime, the issue was judged to be medium priority.

In pursuing a resolution to this issue, NRR recognized the existence of the Nuclear Plant Aging Research (NPAR) program that was being conducted by RES. Systematic studies under this program were to be performed to: (1) identify aging and service wear effects associated with mechanical components that could impair plant safety, and (2) identify techniques that will be effective in determining aging and service wear effects, prior to loss of safety function, so that proper maintenance and timely repair or replacement can be implemented. Although the NPAR program is intended to encompass many component types, it is envisioned to include various safety-related valve types and pump components. RES intends to evaluate LWR operating experience and identify aging trends. One of the specific benefits cited is improved reliability and availability.

NRR evaluated the NPAR program and concluded that it generally encompasses the scope of the program inferred by Items B-58 and C-11. When this program is completed, it is expected that recommendations will be made by RES for maintenance, repair, or replacement according to component type. At that time, these recommendations will be grouped into manageable tasks and considered by NRR for possible changes to regulatory requirements. Thus, this issue was RESOLVED and no new requirements were established.<sup>10</sup>

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<sup>10</sup> Memorandum for T. Speis from H. Denton, "Closeout of Generic Issues B-58 and C-11," July 9, 1985. [8507180530]

