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November 22, 1996

Jerry E. Jackson
U. S. Nuclear Regulatory Commission
MS T10 E10
Washington, D.C. 20555

Dear Mr. Jackson:

On October 31, 1996 we provided a DRAFT of Letter Report ORNL/NRC/LTR-96-32, "A Characterization Update of Pump and Related Equipment Failure Experience in the Nuclear Power Industry (1994-1995)." The purpose of this letter is to expand upon some of the data developed in the Letter Report. The observations discussed below are consistent with ones evaluated in ORNL's previous pump study that covered the years 1990-1993. Thus, these trends cover a total period of 6 years.

Figure 1 shows the failure rate breakdown for safety related pumps and related equipment. This distribution also evaluates failure rates for PWR and BWR applications. The basic summary of significant failure observations are as follows:

- The failure rate for pumps and related equipment is significantly higher at PWRs than BWRs with the exception of electric motors.
- Electric-driven pumps at PWRs have a 40% larger failure rate than at BWRs and turbine-driven pumps at PWRs have a 86% larger failure rate than at BWRs.
- Circuit breaker failure is a major contributor to the loss of safety-related pumps at both PWRs and BWRs (>40% of total failure rate).
- Required Regulatory/Code inspections only found approximately 1/3 of the significant failures of pumps and related equipment.
- Required Regulatory/Code inspections only found 2% of electric motor failures and 3% of circuit breaker failures.

Figure 2 shows the distribution of failures by pump age group for both PWRs and BWRs. The trends for significant failures from Figure 2 can be used to estimate a relative aging rate (α) for pumps. This estimate shows some significant trends for pur[illegible]5 years of age at PWR plants.

ATTACHMENT 1

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During the first 10 years of pump operation, both PWRs and BWRs are on a similar wear-in trend that reaches a minimum failure rate of about 2.60 E-05 failures/hr at 10 years. Between 10 years and 15 years, both PWR and BWR pumps are aging at a linear rate of approximately 7% increase per year. Beyond 15 years the BWR pump trend continues at a linear rate of 7% increase per year. However, the PWR pump trend shows a failure rate increase beyond 15 years to a new linear aging rate (α) of approximately 25% increase per year.

These increased aging rates for older PWR pumps certainly indicate the need for consideration of special IST intervals for this portion of the pump population. Unless specific plant maintenance records can support a lower aging trend, the unavailability of PWR pumps $\geq$15 years in age should be evaluated using a value of $\alpha = 0.25$.

Figure 3 shows the distribution of pump failures by system for both PWRs and BWRs. Any system with a relative failure rate above 1.00 has failures larger than the average of the total population. The essential service water (ESW) systems at both PWRs and BWRs have pump failures about 70% above the average. This is also true for the high pressure safety injection (HPSI) systems at PWRs.

The failure distribution of circuit breakers has been evaluated relative to the breaker voltage requirements. Circuit breakers in the 4160 volt class had 55% of the total failures. The next highest percentage was 32% for circuit breakers in the 480 volt class. The remaining classes of circuit breakers had approximately equal numbers of failures (1 each) except for the 600 volt class which had 6% of the total failures.

The most important finding concerning circuit breakers is that, for significant failures, their failure count is highest (i.e., exceeding that of pumps, turbine drives and electric motors). The circuit breakers are complex in terms of the total number of electrical and mechanical parts and many of the failures of these parts led to serious symptoms (e.g., failure to close, spurious trips, failure to charge springs) and 70% of the failures were classified as serious failures. It is also noteworthy that Regulatory/Code inspections only found 3% of the failures. These findings indicate that safety-related pump unavailability is significantly effected by circuit breaker failures.

Oak Ridge National Laboratory (ORNL) and the Y-12 plant maintenance group have collaborated for numerous years on circuit breaker testing and maintenance studies at Y-12. This has led to the establishment of a major circuit breaker testing facility at Y-12. This testing facility can easily accommodate 480 volt, 600 volt, 4160 volt and larger circuit breakers.

In consideration of the recent NRC Strategic Assessment Issue, it is suggested that a joint DOE/NRC program could use this existing Y-12 facility to conduct both confirmatory and exploratory research on circuit breakers. The NRC could conduct research as needed to respond to the new information, that is, confirm that prior regulatory decisions continue to provide an adequate level of safety and independently confirm industry's technical positions. The NRC could also conduct exploratory research to develop information that could be used to respond to issues that might arise in the future, (e.g., aging effects and safety impact of circuit breaker failures). The NRC could also conduct research in support of its rulemaking activities and its risk-informed performance-based regulations.

We hope that this information will be useful to you. Should you need additional information we would be glad to provide further assistance.

Sincerely,

A. B. Poole

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ABP:jkc

Attachments

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PWR

All pump hardware:

PWR	Signif fail.	Years	Hours	Rate f/hr
Pumps	56	2812	24633120	2.273E-06
Motors	14	2403	21050280	6.651E-07
Turbine drives	25	146	1278960	1.955E-05
Circuit breakers	62	2403	21050280	2.945E-06
	Overall for pump systems:			2.543E-05

Purely electric-driven system:

PWR	Signif fail.	Years	Hours	Rate f/hr
Pumps	53	2677	23450520	2.26E-06
Motors	14	2403	21050280	6.651E-07
Circuit breakers	62	2403	21050280	2.945E-06
	Overall for electric-driven pumps:			5.87E-06

All pump hardware:		2.543E-05
Electric pump system:	(-)	5.87E-06
Turbine-driven system:		1.956E-05

BWR

All pump hardware:

BWR	Signif fail.	Years	Hours	Rate f/hr
Pumps	19	1537	13464120	1.41E-06
Motors	10	1203	10538280	9.49E-07
Turbine drives	10	108	946080	1.06E-05
Circuit breaker	19	1203	10538280	1.8E-06
	Overall for pump systems:			1.47E-05

Purely electric-driven system:

BWR	Signif fail.	Years	Hours	Rate f/hr
Pumps	18	1431	12535560	1.44E-06
Motors	10	1203	10538280	9.49E-07
Circuit breaker	19	1203	10538280	1.8E-06
	Overall for electric-driven pumps:			4.19E-06

All pump hardware:		1.47E-05
Electric pump system:	(-)	4.19E-06
Turbine-driven system:		1.05E-05

Figure 1 - Failure Rate Breakdown for Safety-Related Pumps and Related Equipment (1994-1995)

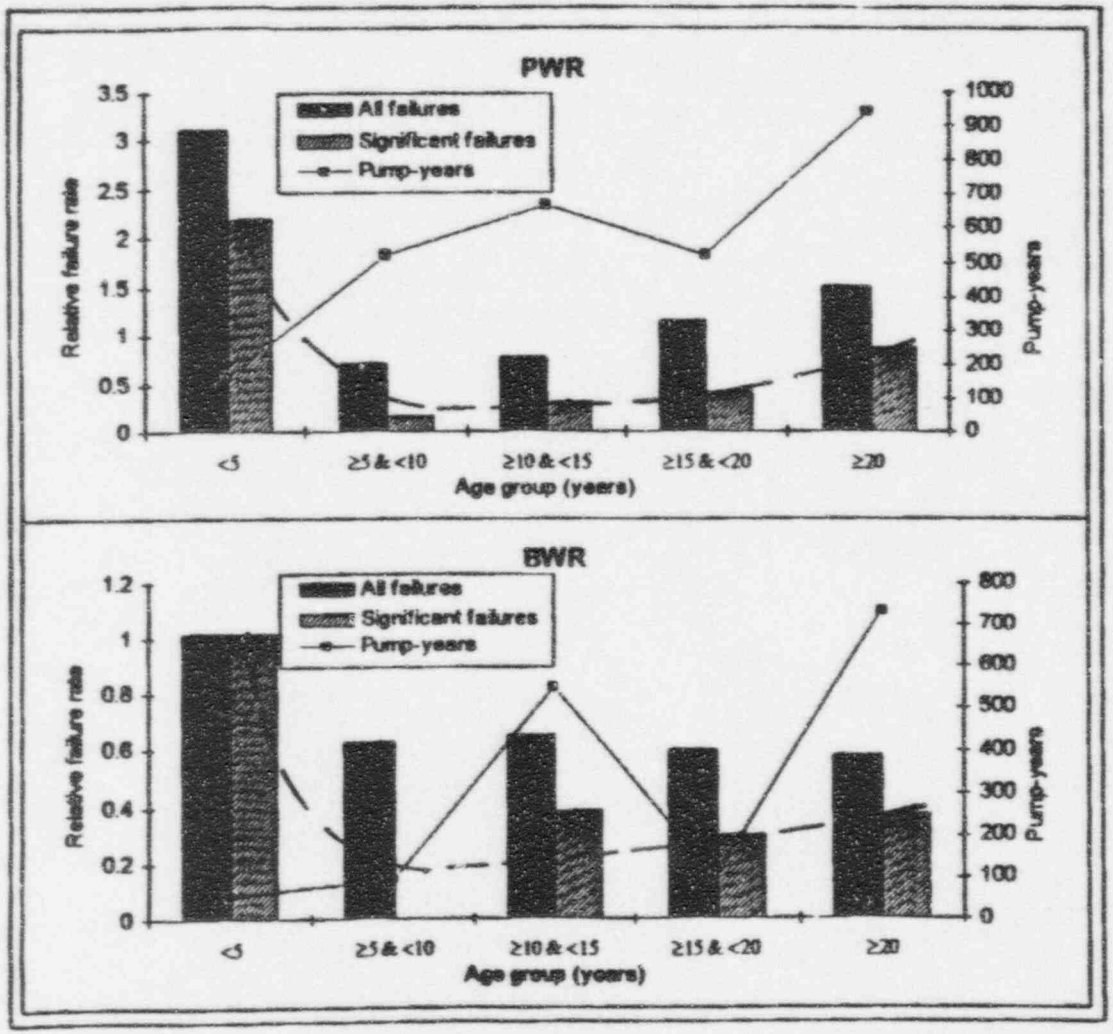

Figure 2 - Distribution of PWR and BWR pump failures by age group and significance (1994-1995)

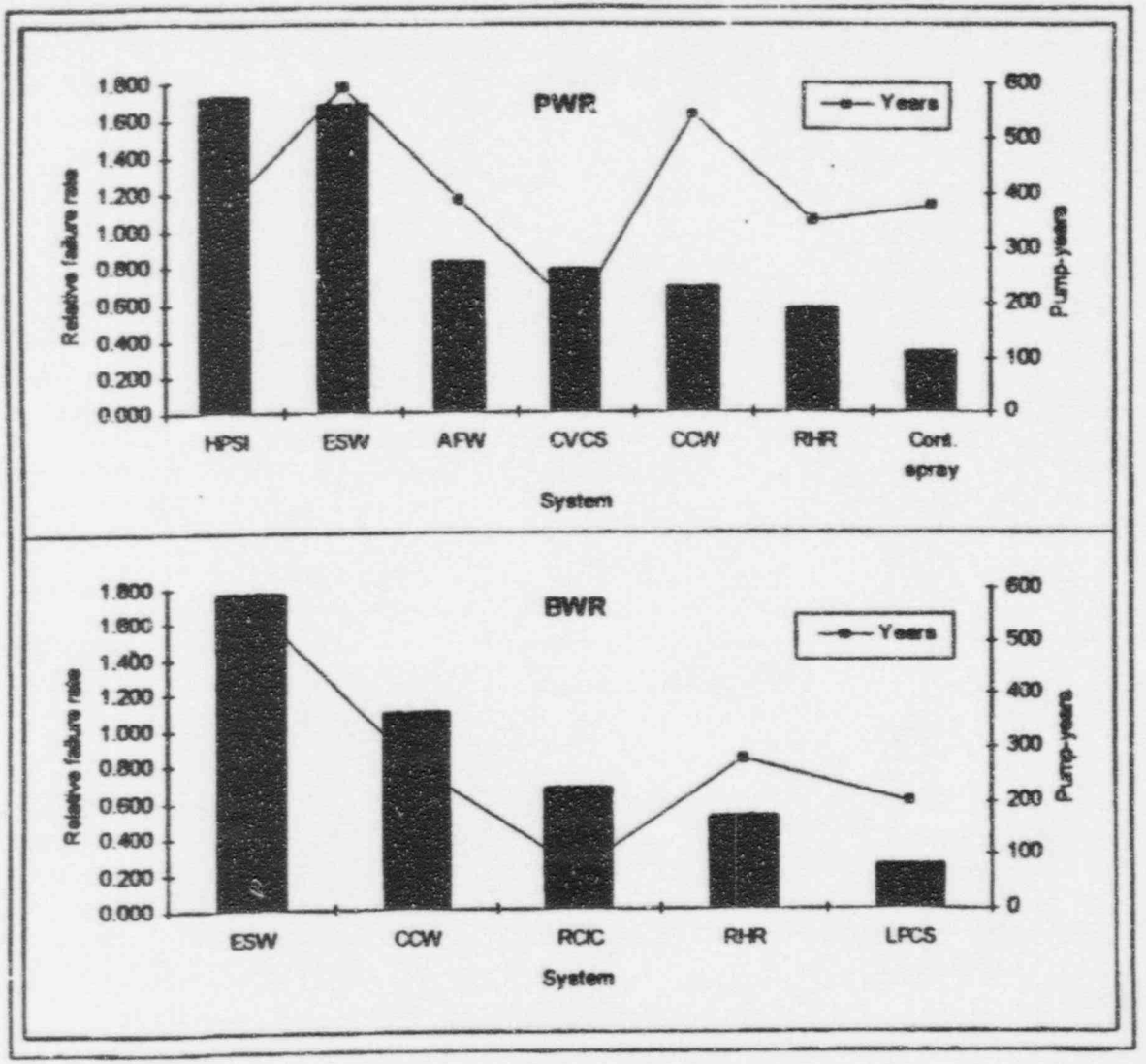

Figure 3 - Distribution of PWR and BWR pump failures by system (1994-1995)