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HUMAN ERROR RATES - QUANTIFICATION METHOD FROM NUCLEAR EXPERIENCE AND DATA*

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This paper reports on a practical method of quantifying human errors made in conjunction with testing, maintaining, and operating select important components in reactor safety systems of licensed nuclear power plants. This quantification of human error is measured in terms of human error rate (HER) namely the ratio of the number of human errors (of a specified type) to the number of opportunities for those particular errors. The human error rates generated in this work provide a very useful broad basis of comparison for appropriate derived and/or best judgement human error rate estimates which have been used in WASH-1400,(1) and also can provide input to bounding type risk assessments.

The number of human errors have been extracted from a computer-based data file of one-line description summary interpretations of Licensee Event Reports (LER) for interfacing with manual and remotely operated valves and pumps over a three (3) year period ending in 1978. The systems evaluated are the reactor safety systems for the 23 BWRs - the CoS, HPCI, and LPCI including Drywell and Suppression Chamber Spray systems; and for the 41 PWRs - the AFW, CtS, HPSI including safety related charging pumps and LPSI systems. Table 1 provides the results of the one-line summary human error interpretation.

The uniqueness of this approach lies in the denominator. The number of opportunities for human errors while interfacing with manual and remotely operated valves and pumps in the reactor safety systems during the three (3)

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year period for all 64 licensed plants considered has been estimated using assumptions made based on licensed senior operator experience with safety systems. A detailed in-depth evaluation of the reactor safety systems was conducted on five (5) PWRs - one B&W, one CE, and three Westinghouse plants and two (2) BWRs - both GE plants. Using the safety system Piping and Instrumentation Diagrams (or equivalent) for each of the seven (7) plants, the average number (#) of remotely operated valves (ROV), manual valves (XV), and pumps cycled per year per plant has been calculated and tabulated in Table 2. When the total number of plant years (based on initial criticality of each plant) for each reactor vendor was determined for the three (3) year period of interest, the total weighted human - selected reactor safety system component (ROV, XV, and pumps) interface estimates were established (see Table 2). This represents the number of opportunities for human error.

Table 3 summarizes the HERs obtained by dividing the appropriate errors in Table 1 by the corresponding opportunities in Table 2. These broad classes of HERs provide a comparison to indicate that WASH-1400[1] estimates appear to be reasonable. This paper has indicated a practical method for actually determining the opportunities for human errors with safety systems which is far more accurate than determining the actual number of human errors.

References

1. "Reactor Safety Study," U.S. Nuclear Regulatory Commission, WASH-1400 (NUREG-75/014), Appendix III, Section 6.1, Table III 6-1, "General Error Rate Estimates" (1975).

2. Sullivan, W.H. and Poloski, J.P., "Data Summaries of Licensee Event Reports of Pumps at U.S. Commercial Nuclear Power Plants," NUREG/CR-1205 (1980).

3. Hubble, W.H. and Miller, C.F., "Data Summaries of Licensee Event Reports of Valves at U.S. Commercial Nuclear Power Plants," NUREG/CR-1363, (1980).

TABLE 1

Summary of Number of Reported Human Errors
Associated with Selected Reactor Safety System
Interfacing Components Over a Specific Three-Year Period*

Reactor Safety System Interfacing Component	Reactor Type PWR	BWR
Remotely Operated Valves (ROV)	17	13
Manual Valves (XV)	16	8
Total Valves (ROV + XV)	33	21
Total Pumps	18	9

*January 1, 1976 through December 31, 1978 for valves.
May 1, 1975 through April 30, 1978 for pumps.

TABLE 2

Human - Selected Reactor Safety System Component
Total Interface Estimates Over a
Specific Three-Year Period*

Reactor Vendor	# Plant Years 1976-1978 (5/75-4/78)	Average # ROV Cycled Per Year Per Plant	Total # ROV Cycled 1976-1978	Average # XV Cycled Per Year Per Plant	Total # XV Cycled 1976-1978	Average # Pump Cycled Per Year Per Plant	Total # Pump Cycled (5/75-4-78)
B&W	22.0 (20.0)	213	4,686	89	1,958	90	1,800
CE	19.7 (18.0)	357	7,033	23	453	100	1,800
WX	67.2 (62.7)	267	17,942	76	5,107	93	5,831
All PWR	108.9 (100.7)	274	29,661	68	7,518	94	9,431
GE BWR	65.0 (63.2)	221	14,365	22	1,430	80	5,056
All	173.9 (163.9)	Totals	44,026		8,948		14,487

ROV - Remotely Operated Valve
XV - Manual Valve

* January 1, 1976 through December 31, 1978 for valves.
May 1, 1975 through April 30, 1978 for pumps.

TABLE 3

Human Error Rate (HER) Calculation

Summary

Reactor Safety System Interfacing Component	Reactor Type PWR	BWR	Both
Remotely Operated Valves (ROV)	0.57×10^{-3}	0.91×10^{-3}	0.68×10^{-3}
Manual Valves (XV)	2.1×10^{-3}	5.6×10^{-3}	2.7×10^{-3}
Pumps	1.9×10^{-3}	1.8×10^{-3}	1.9×10^{-3}