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LWR Nuclear Power Plant Component Failures

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Abstract

An analysis of the most significant light water reactor (LWR) nuclear power plant component failures, from information in the computerized Nuclear Safety Information Center (NSIC) data bank, shows that for both pressurized water reactor (PWR) and boiling water reactor (BWR) plants the component category most responsible for reactor shutdowns is valves. Next in importance for PWR shutdowns is steam generators followed by seals of all kinds. For BWR plants, seals, and pipes and pipe fittings are the second and third most important component failure categories which lead to reactor shutdown. The data is for records extending from early 1972 through September 1978. A list of the most significant component categories and a breakdown of the number of component citations for both PWR and BWR reactor types is presented.

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LWR NUCLEAR POWER PLANT COMPONENT FAILURES

Introduction

Data relative to the safety aspects of LWR nuclear power plant operation and performance were obtained from the computerized data bank [1,2] at the Nuclear Safety Information Center (NSIC), located at the Oak Ridge National Laboratory, through the Department of Energy on line data link called RECON. By means of "key words" these data were interrogated to obtain information on the number of reports or citations for various categories of equipment in nuclear power plants. Equipment performance is inversely related to the number of citations since the NSIC data is obtained from nuclear power plant Licensee Event Reports (LERs) which are written primarily in response to equipment problems.

The reactor system components which have been considered here are nearly the same as those considered by Scott and Gallaher in "Nuclear Safety" [3] for the operating year 1976. Their data is concerned with the total number of citations or reports relative to particular components (as is part of our data) but does not delineate the number of actual equipment failures and related reactor shutdowns.

The nomenclature and definitions used in nuclear reactor power plant operational and failure records and analyses are not standardized. The words "report", "citation", and "accession", as associated with NSIC files, are synonyms. [4] The word "occurrence" (avoided here) is nearly always associated with a licensee event report (LER). However, starting with the year 1978, the word "occurrence", as used in "Nuclear Safety", [5] pertains only to reportable events which involve reactor shutdown, a condition not previously required. This illustrates how the definition of a word used in the report records can be modified with time.

The key word, "failure", as used in the NSIC files, is associated with a LER pertaining to an abnormal situation which may or may not involve failure of the component to function. The subject component may be involved only indirectly in a reportable event. The problem of word definition in data systems has been pointed out by Boyle in a recent paper. [6]

This report presents data for the total number of citations, as well as for citations related to equipment failure, which pertain to reactor shutdown. With considerations for remedial action in mind, reactor component categories which have relatively large numbers of total citations and large numbers of citations for reactor shutdowns due to component failure are highlighted. The trend of the number and rate of citations and important failures is indicated by a year-by-year breakdown of total citations and equipment failures.

Results

Table I shows the number of data bank citations due to reactor shutdowns because of failure in the various reactor component categories. This table also shows the total number of citations recorded for the various component categories. The total number of citations exceeds the total number of equipment failures and reactor shutdowns due to failures, and is an indicator of problems with components in a given category. The calculated fractions of citations for specific component categories and the order of importance are also given for both PWR and BWR plant types.

Table II presents an overall summary of the number of citations from the NSIC data bank as a function of year from 1972 through 1978 for all failures, shutdowns, and shutdowns due to component failure. These data also imply gross rates of failure as a function of time which apparently reach a maximum for PWRs in the year 1977 and approximately two years earlier for BWRs. This gross rate does not take into account the number of operating reactors, power level, age, etc.

The plant component with the largest number of reports or citations in the data bank is valves and likewise they are the component most responsible for reactor shutdowns. The most significant findings can be summarized as follows:

1. The most important reactor component categories from the standpoint of reactor shutdown due to component failure are in the reactor coolant systems.

   PWR plants:

   valves
   steam generators
   seals

   BWR plants:
   valves
   seals
   pipes and pipe fittings

2. From the standpoint of total citations, the most important component categories are also in the LWR coolant systems.

   valves
   pipes and pipe fittings
   pressure vessels (BWR)
   pumps

3. The gross citation numbers and rates imply continued operational difficulties in both PWR and BWR facilities with only a recent decline from peaks or plateau values.

Discussion

A comparison of the present total citation data with the 1976 data of Scott and Gallaher shows that for PWRs the three highest component categories are still valves, pipes and pipe fittings, and pumps, respectively. For BWRs, however, the present data shows that the order of importance is not the same as for PWRs, as indicated by Scott and Gallaher, but pumps have moved to fourth place, and third place is now occupied by the pressure vessel citations. The reason for the increase in pressure vessel citations has not been investigated but suggests the importance of closely following citation rates for individual components in order to affect timely remedial action.

This general survey of reactor component citations is brief and far from complete in that many parameters on which component performance depends, such as age, reactor power level, operational history, etc., have not been considered. However, the importance of both shutdown failure citations and total citations as criteria for highlighting the effect of significant component problems on reactor operation is indicated. Also, the importance of categorizing by reactor types in order to properly illuminate troublesome components is indicated.

The consistently large number of incidences of component failure in essentially the same categories, from at least 1976 through September 1978, indicates a need for routine component failure analysis in order to encourage timely and effective remedial action.

Table I

LWR COMPONENT FAILURE DATA

From Nuclear Safety Information Center Files

1972 Through September 1978

Component	Total Citations						Reactor Shutdown Citations					
	PWR	Fract	Order	BWR	Fract	Order	PWR	Fract	Order	BWR	Fract	Order
Valves	2567	.175	1	2361	.234	1	49	.192	1	89	.423	1
Pipes & Pipe Fittings	1805	.123	2	1414	.142	2	18	.071		17	.081	3
Pumps	1681	.115	3	779	.077	4	27	.106	4	11	.052	6
Steam Generator	1176	.080	4	48	.005	20	33	.129	2	0	.0	18
Storage Container	957	.065	7	361	.036	10	3	.012	13	0	.0	19
Breaker	340	.023	14	203	.020	14	4	.016	11	4	.019	9
Cables & Connectors	546	.037	8	426	.042	9	10	.039	9	15	.071	4
Seal	519	.035	9	468	.046	7	31	.122	3	27	.129	2
Support Structure	1034	.070	5	690	.068	5	2	.008	16	2	.010	13
Tubing	334	.023	15	88	.009	18	25	.098	5	5	.024	8
Valve Operators	246	.017	16	254	.026	12	3	.012	14	9	.043	7
Shock Absorbers	191	.013	18	195	.019	15	1	.004	18	0	.0	20
Accumulators	170	.012	19	42	.004	21	2	.008	17	0	.0	21
Control Rods	455	.031	10	343	.034	11	13	.051	8	4	.019	10
Heat Exchangers	226	.015	17	163	.016	16	1	.004	19	2	.010	14
Bearing	103	.007	20	83	.008	19	4	.016	12	1	.005	17
Control Rod & Drives	413	.028	12	460	.046	8	19	.075	6	3	.014	12
Turbine	443	.030	11	508	.050	6	6	.024	10	13	.062	5
Solenoid	102	.007	21	119	.012	17	1	.004	20	4	.019	11
Fastener	355	.024	13	254	.025	13	3	.012	15	2	.010	15
Pressure Vessels	99	.068	6	79	.079	3	0	.0	21	2	.010	16
Total	14662	.998		10083	.998		255	1.003		210	1.001	

Table II

REACTOR OPERATION CITATION NUMBERS BY YEAR

From Nuclear Safety Information Center Data Files

Category	Year 72	73	74	75	76	77	78*	Total	All Time Total Thru 1978
All Reactor Types									
Failures	802	1405	2143	2621	2832	3142	1726	14671	16657
Shutdowns	36	42	38	150	130	184	80	660	722
Shutdowns, failure	10	16	18	109	94	139	61	447	464
PWR's									
Failures	250	535	842	1135	1288	1783	1040	6873	7365
Shutdowns	11	14	17	56	55	100	45	298	319
Shutdowns, failure	3	4	7	40	41	83	37	215	221
BWR's									
Failures	411	685	926	1206	1271	1217	687	6403	7007
Shutdowns	18	18	14	68	53	63	24	248	262
Shutdowns, failure	6	11	9	59	48	44	20	197	200

*Through September 1978

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