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DUANE ARNOLD ENERGY CENTER

REDUCED RHR SERVICE WATER FLOW

AND

SUPPRESSION POOL TEMPERATURE RESPONSE

LICENSING LETTER REPORT

Approved: R. Gridley 7-20-84
R. L. Gridley, Manager
Fuel and Services Licensing

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1. INTRODUCTION

An analysis has been performed to determine the effects of a reduction in the residual heat removal (RHR) service water flow for the Duane Arnold Energy Center (DAEC). Operation of the RHR system in both shutdown cooling and steam condensing modes (the design cases) has been considered.

While not part of the design basis, during certain plant transients the RHR system is also used for pool cooling. NUREG-0783 sets limits on the maximum local suppression pool temperature which may be attained during pool cooling events. Analyses of the suppression pool temperature response have been performed for the DAEC for two values of the RHR service water flow rate: rated flow and 15% flow reduction.

This licensing letter report documents the assumptions and results of the analyses to determine 1) the minimum allowable RHR service water flow and, 2) the suppression pool temperature response. These are discussed below.

2. EVALUATION OF MINIMUM ALLOWABLE RHR SERVICE WATER FLOW

An analysis has been performed to determine the minimum allowable RHR service water flow which will meet the design basis requirements for the RHR system. The analysis considers the following performance requirements for the shutdown cooling and steam condensing modes of operation:

a) The design basis for the shutdown cooling subsystem requires it to be capable of reducing the reactor vessel temperature to 125°F within 20 hours following a reactor scram.

b) The steam condensing mode of operation requires a maximum heat transfer rate of 64.2 x 10^6 Btu/hr per heat exchanger.

2.1 Analysis Results

Operation of the RHR system in both the shutdown cooling and steam condensing modes (the design cases), were considered.

2.1.1 Shutdown Cooling Mode

The analysis utilizes the RHR design basis assumptions with the RHR service water flow being reduced from the rated flow of 4800 gpm for each RHR heat exchanger. Evaluation of the limiting case (normal reactor depressurization from isolation) shows that the service water may be reduced to 338D gpm (a reduction of approximately 30%) and the shutdown cooling function will still meet its performance requirement of cooling the reactor to 125°F within 20 hours following a reactor scram.

2.1.2 Steam Condensing Mode

Evaluation of the steam condensing mode of operation shows that due to the large excess capacity of the RHR heat exchangers, steam condensing is not the limiting mode of operation.

2.2 Conclusion

The results of this portion of the analysis show that, from the standpoint of the functional design requirements of the shutdown cooling and steam condensing modes, a 30% reduction in the RHR service water flow can be tolerated. However, as summarized below, only a 15% reduction in the service water flow rate was incorporated in the suppression pool temperature analysis. In order to qualify the RHR system for operation with a service water flow reduction of more than 15%, it will be necessary to evaluate any additional reduction relative to the suppression pool temperature analysis stated below.

3. SUPPRESSION POOL TEMPERATURE RESPONSE

To satisfy NUREG 0783 requirements for evaluating suppression pool temperature limits for BWR containments, plant unique analyses were also performed for the DAEC utilizing Nuclear Regulatory Commission (NRC) approved methods. These methods included bounding and conservative assumptions and inputs related to initial conditions and operator actions, and analytical modeling. The maximum allowable suppression pool temperature limit for the DAEC is 200.2°F (derived from NUREG 0783 requirements). Seven plant unique events were evaluated for the DAEC. The events analyzed and the corresponding results are shown in Table 1. The results demonstrate that the DAEC meets the maximum suppression pool temperature requirements of NUREG D783.

The two events which produced the highest maximum local pool temperatures (cases 1B and 2A) have been reanalyzed with a 15% reduction in the RHR heat exchanger service flow rate. These two cases are bounding and therefore are expected to result in the highest local pool temperature as analyzed with the reduced heat exchanger flow rate. A 15% reduction in the RHR service water flow rate results in a 3% reduction in the heat exchanger K factor.

3.1 Analysis Results

Table 1 summarizes results for the rated RHR flow rate and the reduced RHR flow rate cases. The maximum local pool temperatures for the reduced RHR flow rate cases are 194°F and 193°F for cases 1B and 2A, respectively. Both of these temperatures are less than the suppression pool temperature limit.

In comparing the results between the full flow rate cases and the reduced flow rate cases, the calculated maximum bulk pool temperatures are unchanged because the difference between the heat exchanger K factors are very small. A dominant effect on maximum local pool temperature is the pool mixing capability of the RHR pumps. Since a 15% decrease in RHR service water flow rate results in a negligible reduction of this capability, the calculated maximum local pool temperatures for the reduced flow rate are nearly identical to those calculated assuming full flow rate.

3.2 Conclusion

The NRC has placed a limit on the suppression pool temperature during transients involving safety/relief valve (SRV) discharges. The results of this analysis demonstrate that the DAEC conforms with the NRC limit even with a 15% reduction in the RHR service water flow rate.

TABLE 1

RESULTS OF DUANE ARNOLD SUPPRESSION POOL TEMPERATURE RESPONSE ANALYSIS

		FULL RHR SERVICE WATER FLOW = 4800 gpm		REDUCED RHR SERVICE WATER FLOW = 4080 gpm	
Case No.	Event	Maximum Bulk Pool Temperature (°F)	Maximum Local Pool Temperature (°F)	Maximum Bulk Pool Temperature (°F)	Maximum Local Pool Temperature (°F)
1A	Stuck Open Relief Valve (SORV) at Power, 1 RHR loop	156	186		
1B	SORV at Power, Spurious Isolation, 2 RHR loops	181	193	181	194
2A	Rapid Depressurization at Isolated Hot Shutdown, 1 RHR loop	173	193	173	193
2B	SORV at Isolated Hot Shutdown, 2 RHR loops	166	175		
2C	Normal Oepressurization at Isolated Hot Shutdown, 2 RHR loops	177	187		
3A	Small Break Accident (SBA) Accident Mode, 1 RHR loop	160	186		
3B	SBA - Failure of Shutdown Cooling Mode, 2 RHR loops	177	186		