MAC 54

REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

ACCESSION NBR:8301180308 DOC.DATE: 83/01/07 NOTARIZED: NO DOCKET #
FACIL:50-261 H. B. Robinson Plant, Unit 2, Carolina Power and Ligh 05000261
AUTH.NAME AUTHOR AFFILIATION
FURR,B.J. Carolina Power & Light Co.
RECIP.NAME RECIPIENT AFFILIATION
VARGA,S.A. Operating Reactors Branch 1

SUBJECT: Responds to NRC request for addl info supporting exemption from 10CFR50 App R.Amount of al consumed in fire,fire duration,temp profiles & essential data used in calculations discussed.Detailed analyses encl.

DISTRIBUTION CODE: A006S COPIES RECEIVED:LTR 1 ENCL 1 SIZE: 10
TITLE: OR Submittal: Fire Protection

NOTES:

	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL
	NRR ORB1 BC 01	3	3			
INTERNAL:	ELD/HDS1	1	0	IE FILE 06	1	1
	NRR FIORAVANT07	2	2	NRR WAMBACH	1	0
	NRR/DE/CEB 09	2	2	NRR/DL DIR	1	1
	REG FILE 04	1	1	RGN2	1	1
EXTERNAL:	ACRS 11	3	3	LPDR 03	1	1
	NRC PDR 02	1	1	NSIC 05	1	1
	NTIS	1	1			

TOTAL NUMBER OF COPIES REQUIRED: LTTR 20 ENCL 18

CP&L
Carolina Power & Light Company

January 7, 1983

Office of Nuclear Reactor Regulation
ATTN: Mr. Steven A. Varga, Chief
Operating Reactors Branch No. 1
United States Nuclear Regulatory Commission
Washington, DC 20555

H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2
DOCKET NO. 50-261
LICENSE NO. DPR-23
REQUESTED INFORMATION TO SUPPORT EXEMPTION
FROM THE REQUIREMENTS OF 10CFR50, APPENDIX R
SECTION III.O

Dear Mr. Varga:

On March 11, 1981, Carolina Power & Light Company (CP&L) filed a request for exemption from the Appendix R (Section III.O) requirement to install a reactor coolant pump (RCP) lube oil collection system. Subsequent to that exemption request, the NRC Staff indicated that technical information to clarify the information already provided would be required in order to grant the exemption. This detailed information needed by the Staff was specifically identified in the Draft Appendix R Safety Evaluation Report (SER) for H. B. Robinson, which CP&L received on December 20, 1982.

This letter, together with the enclosures, responds to the information requested by the NRC Staff to justify the existing Section III.O exemption request. The specific information requested by the NRC Staff on page 19 of the Draft SER is summarized below:

(a) Amount of oil consumed in the fire: The entire inventory of a single reactor coolant pump (200 gallons) was assumed to be combusted. A smaller amount (35 gallons) was also analyzed to be representative of a lube oil leak.

(b) Fire duration: This parameter is not significant because burn time is strictly a function of pool fire diameter. Burn time was on the order of 96 minutes for the 200 gallon case.

(c) Temperature profiles calculated: All safe shutdown equipment experienced temperatures less than that which could occur under LOCA conditions previously analyzed in the FSAR (i.e. less than 290°F).

A006

(d) Essential data/assumptions utilized in the calculations: All significant assumptions and data are contained in the enclosures. In addition to the conservatism of the various assumptions discussed in the enclosures, it was assumed that the recently installed automatic suppression system does not operate. However, for the most severe fire scenario postulated, manual initiation of containment spray was assumed in 35 minutes.

(e) Fire effects on nearby safe shutdown equipment: None.

Several different analyses were performed on the H. B. Robinson containment volume. Based upon the specific analyses summarized in this letter and the clarifying information provided in the enclosures, CP&L believes that a single reactor coolant pump lube oil fire will not endanger public health and safety and that the installation of a lube oil collection system would not provide additional protection to the public health and safety.

Enclosure 1 to this letter, "Containment Temperature Profile Analysis", discusses the results of a simplified fluid flow analysis which was undertaken to verify that the containment volume does not experience excessive temperatures as a result of a postulated reactor coolant pump lube oil fire. For the most severe fire scenario postulated, assuming manual initiation of containment spray after 35 minutes, no safe shutdown equipment would be exposed to an ambient temperature greater than that which could occur as a result of LOCA transients analyzed in the FSAR.

Enclosure 2, "RCP Bay Separation Analysis", describes the analyses which were performed to verify that a fire in any one reactor coolant pump bay would not adversely affect the safe shutdown equipment in the adjacent bay. The existing containment geometry assures at least one reactor coolant loop will always be available to the operator regardless of fire location. The conservatisms inherent in the methodology used for this analysis, combined with the unrealistically large fire postulated, conclusively demonstrate that the plant could be safely shutdown.

Based upon the information contained in this letter, CP&L believes that an exemption from the requirements of 10CFR50 Appendix R Section III.O should be granted for H. B. Robinson Unit 2. Carolina Power & Light Company understands that this information, which clarifies the existing exemption request, will be considered by the Staff under the exemption provisions of 10CFR50.48 and be factored into the Staff's evaluation of the existing exemption requests and final SER.

If you have any additional questions regarding this exemption request or analysis effort, please do not hesitate to contact us.

Yours very truly,

B. J. Furr
Vice President
Nuclear Operations

DLB/kjr (5974C12T5)
Enclosures (2)

cc: Mr. J. P. O'Reilly (NRC-RII)
Mr. G. Requa (NRC)
Mr. Steve Weise (NRC-HBR)

Enclosure 1

CONTAINMENT TEMPERATURE PROFILE ANALYSIS

Introduction

This enclosure summarizes the analysis completed to examine the effect on containment of a single reactor coolant pump lubricating oil fire in response to NRC Staff questions. The analysis is based upon a detailed fluid flow analysis utilizing a one-dimensional time-dependent hydrothermal computer simulation. The results of this analysis indicate that a single reactor coolant pump fire under worst-case conditions will not result in unacceptable containment temperatures, thereby ensuring that safe shutdown equipment would remain free of fire damage.

Methodology

The containment atmosphere heating due to a large oil fire is modeled using a one-dimensional integral fire plume model coupled to a one-dimensional stratification model. This simulation models the important aspects of fire plume dynamics including the effects of variable fluid density, entrainment of air into the plume, and pressurization of containment.

The fire plume model is based on the assumption that plume velocity, density and temperature are uniform across any horizontal section and only vary along the vertical axis. The fire plume radius is assumed to be a well-defined demarcation between the plume and surrounding air giving the modeled fire a characteristic top hat profile. The steady state plume equations were solved in a stepwise manner starting with the initial conditions at the base of the plume and then propagating the solution vertically along the plume. The nonlinear model equations were solved at each vertical step using an iterative Newton-Ralphson algorithm. The plume solution is validated by comparison with Test 1 of Stavrianidis1/ The computer solution was found to be nearly identical to experimental data.

A fire within a confined volume will cause the formation of a hot gas layer at ceiling level. The cold air originally occupying this region will be displaced by the combustion gases and forced downward. This layering of hot gas over cold air is

---

1/ P. Stavrianidis, "The Behavior of Plumes above Pool Fires", A Thesis Presented to the Department of Mechanical Engineering, Northeastern University, Boston MA, August 1980.

stabilized by buoyancy forces. The growth of this stratification model reflects this phenomenon in a manner very similar to the plume model. The containment volume is divided into several horizontal sections with uniform densities and velocities defined for each section. The stratification model is a dynamic model in that the transient terms are retained in all equations allowing for growth of the stratification layer with time. The time derivatives were approximated using a Crank-Nickolson approximation.

The combined plume-stratification model is solved in a two-step process. First, the stratification model is advanced one time step with the nonlinear equations solved using a Newton-Ralphson algorithm. After the stratification time step is completed the stratification densities and pressures are used to define ambient conditions for the steady state plume model. This solution implies that the plume is always in equilibrium with the surrounding stratification layer.

Assumptions

The critical parameter for this analysis is the energy input to the containment volume, which is a function of assumed fuel quantity, fire size and combustion efficiency. Of these three variables, fire size and combustion efficiency impact heat release rate while fuel quantity only determines burn time.

Lubricating oil cannot be ignited unless it is contacting a hot surface with a temperature above the oil's fire point. The size of the fire is therefore determined by the surface area of hot components in the vicinity of the reactor coolant pump. For this analysis a pool fire 8 feet in diameter is postulated as the heat source even though a fire of this magnitude is virtually precluded by the existing integral lube oil system design.

The postulated fire releases energy in the form of thermal radiation and convective gases. The thermal radiation is assumed to be directly absorbed by the structure and equipment within the reactor coolant bay so that the radiative fraction is retained in the bay until fire extinguishment, at which time it is released to containment primarily through natural convection. The convective heat was assumed to be carried directly into the main containment volume via the steam generator penetration. A convective heat release rate of 534 kW/m^2 is used, which is typical of large-scale pool oil fires. The actual reactor coolant pump bay and containment geometry is too complex to directly model using the simplified one-dimensional plume and stratification models described. Instead, the containment is treated as a single enclosed volume with a postulated fire occurring at its base. To account for the volume occupied by walls, floors and equipment in the actual containment, the base of the model containment is artificially raised 20.5 feet to provide free volume of both the assumed and actual containment volumes of $1.95 \times 10^6 ft^3$. The containment building is nearly empty above the operating floor and was well approximated by this model which includes the variation of containment radius with elevation.

The equipment with the highest elevation will be the first to enter the stratification layer as it descends from the ceiling. This equipment has been identified to be the containment ventilation coolers which are mounted on the operating floor and have been qualified to LOCA temperatures. The failure criterion for this analysis effort was therefore defined as a gas temperature at the elevation of the operating floor as measured from the ceiling equivalent to the worst-case LOCA temperature (290°F).

Containment Spray

A separate analysis was performed to determine the effectiveness of containment spray in cooling combustion gases in the stratified layer near the containment ceiling. It was assumed that the initial droplet size was 1,000 microns, that water concentration in the air corresponded to 100% relative humidity at the initial containment temperature of 100°F, and, finally, that the minimum droplet flight was 80 ft.

Under these conditions, it was found that at least 56.6% of the droplet mass would evaporate prior to the droplet reaching the operating floor. For smaller droplets, a much higher mass fraction would evaporate. Assuming only one of the two redundant containment spray headers was operational, this would result in an initial heat removal rate by evaporation of 113,000 kW compared with the 2,494 kW released by the fire. The initial cooling rate of the containment gas was calculated to be -1.65°K/sec (-2.97°F/sec). Although these cooling rates could be expected to decrease as gas temperature is reduced and relative humidity increases, there is obviously adequate cooling supplied by the containment spray system.

Results

Utilizing the methodology and assumptions previously described, the effects of two different fuel quantities are examined. The first fire size was selected as being representative of the upper bound of possible lube oil fires is 35 gallons. The second fire simulated involves the complete combustion of 200 gallons of oil, which is the entire inventory of a reactor coolant pump lube oil system.

For a 35-gallon lube oil fire, no operator action is required at any time during the event to mitigate the effects of the fire. No safe shutdown equipment would experience temperatures in excess of worst-case LOCA temperature (290^{o}F).

The postulated 200-gallon fire, while potentially a much more severe transient, allows sufficient time for the operator to reduce the thermal transient. The operator would have, as a minimum, 35 minutes to initiate a single train of containment spray which would rapidly cool the hot gas layer as previously described. During this period the Control Room operator would have sufficient indication to:

(1) Detect the existence of a fire of this magnitude;

(2) Note the gradual rise in containment temperature; and,

(3) Initiate containment spray prior to threat to any safe shutdown equipment.

<u>Conclusions</u>

This containment analysis demonstrates that a worst-case reactor coolant pump lube oil fire will not endanger public health and safety. For a fuel quantity equivalent to a lube oil leak, no operator action is required. For a postulated fire size involving 200 gallons, a minimum of 35 minutes is available for manual initiation of containment spray. The analysis is bounding for all size fires because of the following conservatisms:

(1) A fire diameter of 8 ft was assumed even though this size fire could not actually occur.

(2) No credit was taken for ambient heat losses or heat removal via containment fan coolers.

(3) No credit was taken for manual suppression of the lube oil fire.

(4) No credit was taken for the installed automatic suppression system.

RCP BAY SEPARATION ANALYSIS

Introduction

This enclosure summarizes the analysis efforts which were completed to verify that the existing reactor coolant pump bay separation is adequate. The Staff's concern was that a catastrophic failure of a single reactor coolant pump lube oil system could cause a fire of sufficient magnitude to affect nearby safe shutdown equipment in the adjacent bay.

It is evident that, after examining the existing containment configuration, one steam generator loop with all associated instrumentation and control would remain completely unaffected from fire in any bay. While "A" and "B" reactor coolant pump bays share a common ceiling, the "C" reactor coolant bay is isolated to the north by the floor-to-ceiling wall which is the boundary wall for the refueling canal. In addition, the "C" bay is isolated to the south by a wall which extends down from the ceiling level approximately 28 feet. This partial wall prevents the migration of combustion gases to an adjacent bay as they build up at ceiling level. Consequently, it is assured that at least one reactor coolant loop with all associated instrumentation would remain unaffected due to a fire in any reactor coolant bay.

This analysis addressed the issue of a fire in either "A" or "B" reactor coolant pump bays causing unacceptable temperatures for equipment in the adjacent bay. For the purpose of this analysis, a fire in "B" bay is arbitrarily assumed to occur and the affects of this fire on "A" reactor coolant pump bay examined. Due to similar bay configurations, the results are considered to be applicable to a fire in the "A" bay as well.

Methodology

The analysis effort which was undertaken to examine the effects of a fire in "B" reactor coolant pump bay was based upon the simulation of the Navier-Stokes equation of motion for fluids. This fluid flow simulation was actually performed using TEMPEST (Transient Energy, Momentum and Pressure Equation Solution in Three Dimensions)1/, a three-dimensional hydrothermal

---

1/ D.S. Trent, M.J. Budden and L.L. Eyler, "TEMPEST: A Three-Dimensional Time-Dependent Computer Program for Hydrothermal Analysis", Report No. FATE-80-114, Battelle Pacific Northwest Laboratory, Richland, WA, 1981.

computer code developed by the Pacific Northwest Laboratory on behalf of the U.S. Department of Energy.

Prior to performing any detailed analysis of the containment, a validation program was completed for the TEMPEST computer code to predict the thermal conditions which were noted during several fire studies.2,3/ With the exception of regions extremely close to the flame front, which is not significant in this analysis, TEMPEST predicted higher gas temperatures and velocities than were experimentally determined. In all regions critical to this analysis program, the TEMPEST computer code was demonstrated to give consistently conservative results.

The basic modeling approach used simulates a lubricating oil fire by a volumetric heat source with a constant heat release rate. Air entrained in this volume is heated and rises as a fire plume until ceiling impingement occurs. The gases then move as a horizontal jet along the ceiling until they reach one of the steam generator vents where they are drawn out into the main containment volume by buoyancy forces.

Assumptions

The fire size for analysis purposes is assumed to be equivalent to the heat release rate of a burning pool of lubricating oil with a diameter of 8 feet. As described in Enclosure 1, this size fire is precluded by the existing lubricating oil system design and piping layout; however, it will provide results which will bound all credible fires.

The postulated fire is assumed to achieve steady-state conditions immediately upon ignition. After ignition, the fire was assumed to release energy at a constant rate into the reactor coolant pump bay. A convective heat release rate of 534 kW/m^2, typical of a large fire involving a high temperature hydrocarbon, was used.

2/ P. Stavrianidis, "The Behavior of Plumes above Pool Fires", A Thesis Presented to the Department of Mechanical Engineering, Northeastern University, Boston, MA, August 1980.

3/ J.S. Newman and J.P. Hill, "Assessment of Exposure Fire Hazards to Cable Trays", EPRI-NP-1675, Electric Power Research Institute, Palo Alto, CA, June 1980.

Results

The TEMPEST program was then used to predict the gas temperatures and velocities throughout the two adjacent reactor coolant pump bays. The program was allowed to run until gas temperatures and velocities reached steady-state conditions to allow for general applicability of the simulation regardless of the total volume of lube oil burned.

This analysis demonstrates for a fire in "B" bay that conditions in the adjacent "A" reactor coolant pump bay do not threaten safe shutdown equipment. The steady-state gas flow velocity and temperature patterns which were obtained show that equipment greater than 3.1 feet from ceiling level is not at rist due to the postulated fire. The information available indicates that no safe shutdown components exist in this threatened zone within 3.1 feet of the bay ceiling. This will be verified by a visual inspection the first time the bay is available for access.

The conservative nature of this analysis has demonstrated that permanent loss of safe shutdown equipment in the adjacent "A" reactor coolant pump bay will not occur as a result of a lubricating oil fire in "B" reactor coolant pump bay. Because hazardous temperature conditions exist only in a zone 3.1 feet below the ceiling, no permanent loss of safe shutdown equipment function is postulated. The only impact on the "A" reactor coolant pump bay which could affect its continued operation during the fire would be the loss of steam generator level indication due to heating of the external reference leg. However, once the fire was extinguished in "B" reactor coolant pump bay and ambient conditions returned to normal, the "A" steam generator reference leg would cool and the steam generator would be returned to service. (Note - the "C" reactor coolant loop would be totally unaffected by this transient).

Conclusion

This analysis effort demonstrates that for a worst-case fire the necessary safe shutdown equipment in the adjacent bay would not be permanently impaired, and in all probability even during the fire safe shutdown system function would not be lost. In addition, Bay "C" is completely independent of the postulated fire in either "A" or "B" bay. It has also been clearly demonstrated that once the fire has been extinguished the adjacent bay could be returned to service with no repair necessary and with all necessary instrumentation available to the control room operator for safe shutdown.