Enclosure 1

ZION STATION CONTAINMENT RESPONSE WITH LOSS OF RHR SPRAY DURING LOCA

Document Number RSA-Z-89-03 Revision 1

July 17, 1991

K. B. Ramsden
Reactor Safety Analysis

Nuclear Fuel Services Department
Commonwealth Edison Company
Chicago, Illinois

Prepared by: Kevin B. Ramsden Date: 7/24/91

Reviewed by: Robert W. Tsai Date: 7/24/91

Approved by: Robert W. Tsai Date: 7/24/91

Statement of Disclaimer

"This report was prepared by the Nuclear Fuel Services Department for use internal to the Commonwealth Edison Company as applicable to the Zion Nuclear Generating Station. It is being made available to others upon the express understanding that neither Commonwealth Edison Company nor any of its officers, directors, agents, or employees makes any warranty, representation, or assumes any obligation, responsibility with respect to the contents of this report, or its accuracy or completeness pertaining to any usage other than the originally stated purpose."

Abstract

This report summarizes the analytical work performed in support of Zion Units 1 and 2 regarding the response of the containment to a postulated failure of RHR spray during a design basis LOCA event. The containment pressure and temperature response during the post-LOCA recirculation phase is calculated.

Table of Contents

List of Tables

List of Illustrations

Chapter 1. Introduction

This report documents the analytical work performed to address the postulated loss of RHR spray capability in a post-LOCA event at Zion station. This work was initiated in response to questions raised following a failure of the RHR spray valves during testing. Review of applicable technical specifications and bases as well as the FSAR did not clearly determine the relative safety importance of the RHR spray function. A series of calculations was performed utilizing the CONTEMPT4/MOD5 containment analysis code to provide insight into the post-LOCA recirculation phase containment behavior. This work extends analysis provided in the FSAR to support containment peak pressure response.

Chapter 2. Description of Analytical Models

Description of Model

Analysis of these events was performed with CONTEMPT4 Mod5 as installed on the CECO computer system. This code calculates the time response compartment pressures, temperatures, mass and energy inventories, heat structure temperature distributions, and energy exchange between compartments or to the environment. This code has the ability to describe the effects of engineered safeguard systems such as containment spray, fan coolers, and heat exchangers. This code has been used extensively for containment analysis throughout the nuclear industry.

The model developed for this purpose is depicted in Figure 1. This model consists of a single compartment volume representing the free volume inside the containment building. This volume is a general compartment model consisting of a vapor region and a pool region. Mass and energy additions are modelled as tabular input. The fan coolers are modelled by specifying the heat removal capability versus temperature in tabular format. The containment sprays are modelled as a tabular addition of fluid versus time during the initial phase of the LOCA. During the recirc phase, the spray fluid is modelled as coming from the containment sump and being cooled by the RHR heat exchangers prior to injection via the spray headers. The heat structures are modelled as one-dimensional slabs. The Tagami correlation is used for surface heat transfer up to the end of blowdown, at which point the Uchida correlation is employed for the duration of the event. The surface areas of concrete structures are reduced to 40% of actual values to account for less efficient heat transfer to concrete.

This model is a conversion of the model previously developed for use with the CONTEMPT-LT 026 computer code. Additional description and benchmarking of this model is provided in Reference 2.

Selection of Transient

A review of the FSAR containment integrity calculations, particularly Figure 14.3.4-9 strongly suggests that the heat load on the containment would be well within RCFC capacity during the recirculation phase (2013 seconds into event). Since the interaction of the heat structures was considered to be of concern if RHR spray was disabled, an analysis was performed to provide additional assurance. The case selected was the Case 2 DBA LOCA with reflood effects documented in FSAR section 14.3.4.5. The mass and energy release data for this case are provided in FSAR Tables 14.3.4-9 and 14.3.4-10. These tables provided data to 10,000 seconds, well into the recirculation phase.

Analysis Input Assumptions

The principal input initial conditions and key assumptions are listed in Table 1. These assumptions are consistent with the input utilized in the FSAR analysis.

INITIAL CONDITIONS AND ASSUMPTIONS	
• Containment Free Volume	2.715E6 cuft
• Pressure	15.0 psia
• Temperature	120F
• RWST Temperature	100F
• Service Water Temperature	80F
• Number of Spray pumps operable	2
• Flow rate per pump	2615 gpm
• Actuation time	45 seconds
• Number of RCFCs available	3
• Actuation time	45 seconds
• RCFC performance basis	Marlo data
• Containment heat sinks	FSAR Tables 14.3.4-2, 14.3.4-8
• Heat transfer coefficients	Tagami/Uchida
• Mass/Energy Release Data	FSAR Tables 14.3.4-9, 14.3.4-10
• RHR Spray Assumptions:	
• Spray Flow Rate	2200 gpm
• RHR Heat Exchanger UA	1.66E6 BTU/hr-F
• RHR HX CCW Flow	5000 gpm
• RHR HX CCW inlet temperature	120 F

Table 1. Input Conditions and Key Assumptions

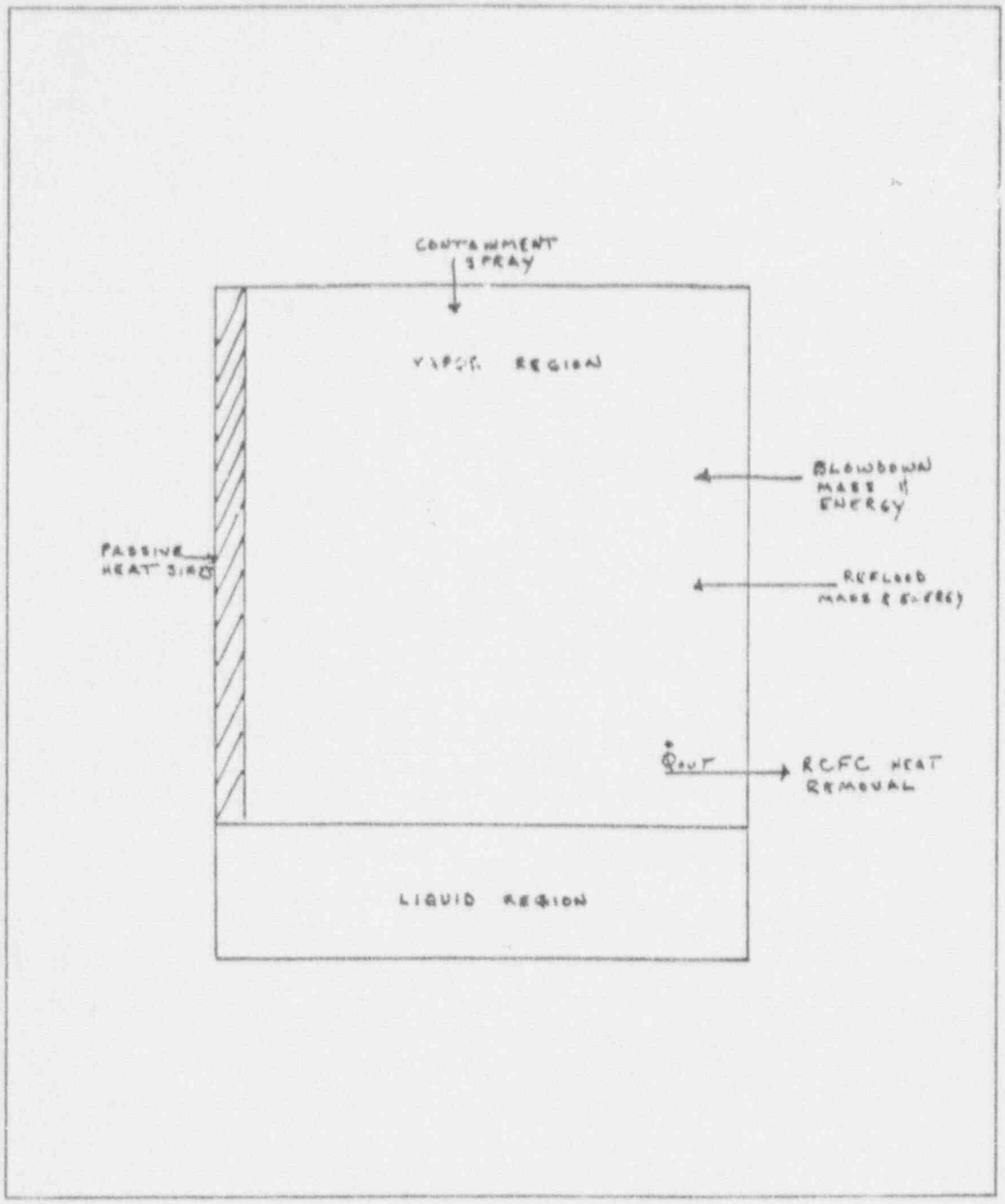

Figure 1. Diagram of CONTEMPT Model

Chapter 3. Discussion of Results

The first calculation performed assumed that the RHR spray was inoperable after entry into the recirc phase at 2013 seconds. The results of this calculation indicate that the RCFCs are indeed able to control the heat load without substantial repressurization. A sequence of events for this transient is provided in Table 2.

Containment pressure is shown in Figure 2 . As can be seen in this figure, the initial peak pressure occurs at the end of the blowdown (29 seconds), a secondary peak occurs at 161 seconds due to the reflood energy addition to the containment. The pressure is reduced significantly by the time the recirc phase is entered at 2013. The effect of the spray up to this point has been to cool the vapor space. At the recirc point, the sump is at a higher temperature and flashing occurs leading to some repressurization.

The vapor space temperature is shown in Figure 3, and clearly illustrates the impact of the RHR spray failure. After the loss of normal spray, the temperature rises to a peak value of 231.4 degrees F as the thinner structures return heat to the cooled vapor region. Note that the temperature remains well below the equipment qualification temperature of 271 F.

An additional calculation was performed for comparison showing the effect of an active RHR spray system. The containment pressure response is shown in Figure 4, and shows that very little difference in repressurization occur. Figure 5 shows the vapor space temperature response. In this figure it can be clearly seen that the principal effect of the RHR spray would be to continue the temperature reduction started by the containment spray.

A benchmarking comparison was performed to confirm that the CONTEMPT4 Mod5 model exhibits reasonable comparison to the original FSAR case and the previous CONTEMPT-LT-026 model developed at CECo. The results of this comparison (pressure only) are shown in Figure 6, and clearly demonstrate that the CONTEMPT4 Mod5 model is performing in a consistent and conservative manner. The principal differences between the models are due to the manner in which the structure heat transfer coefficients are applied, CONTEMPT4 tending to underpredict the coefficients relative to the FSAR case.

EVENT	TIME (sec)
• Rupture occurs	0
• Ena of blowdown	28.7
• Reflood steaming begins	30.6
• RCFCs, Spray initiate	45
• Peak pressure occurs	161
• RWST Empties, Recirc begins	2013

Table 2. Sequence of Events

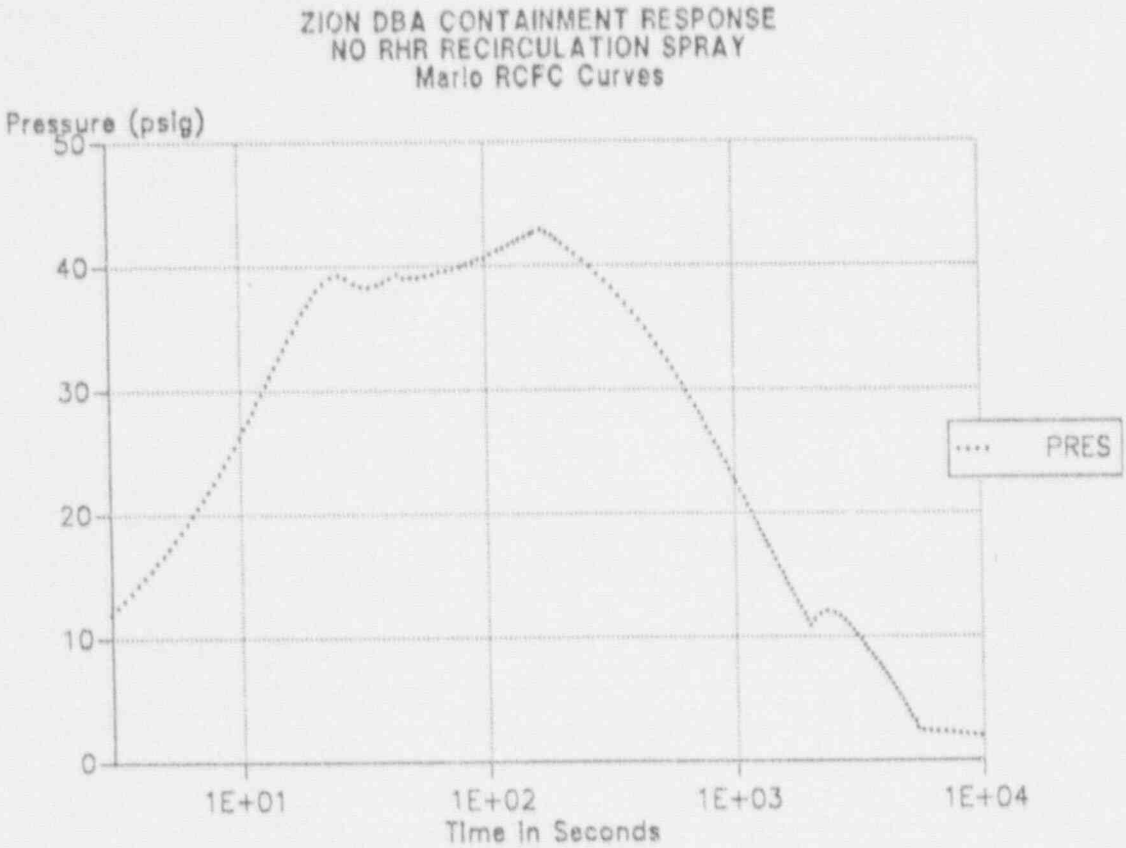

Figure 2. Containment Pressure (No RHR Spray)

Figure 3. Containment Vapor Temperature (No RHR Spray)

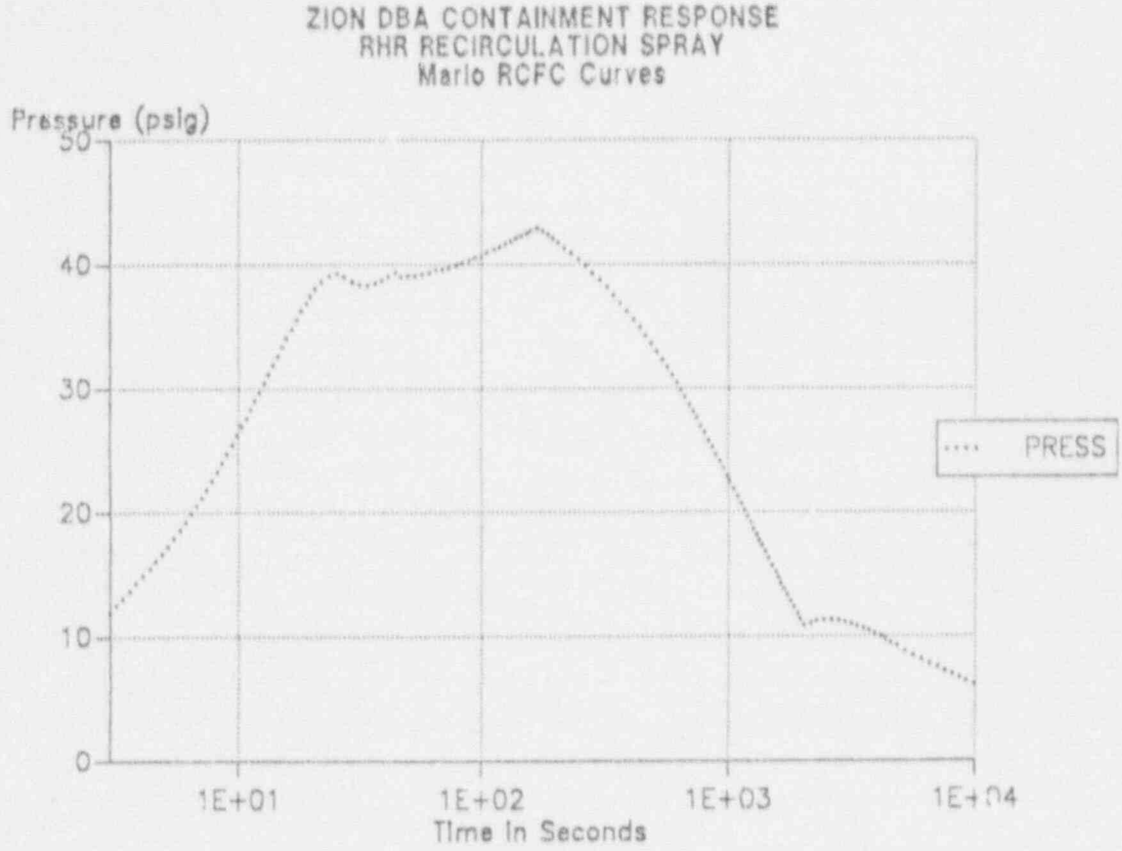

Figure 4. Containment Pressure (RHR Spray)

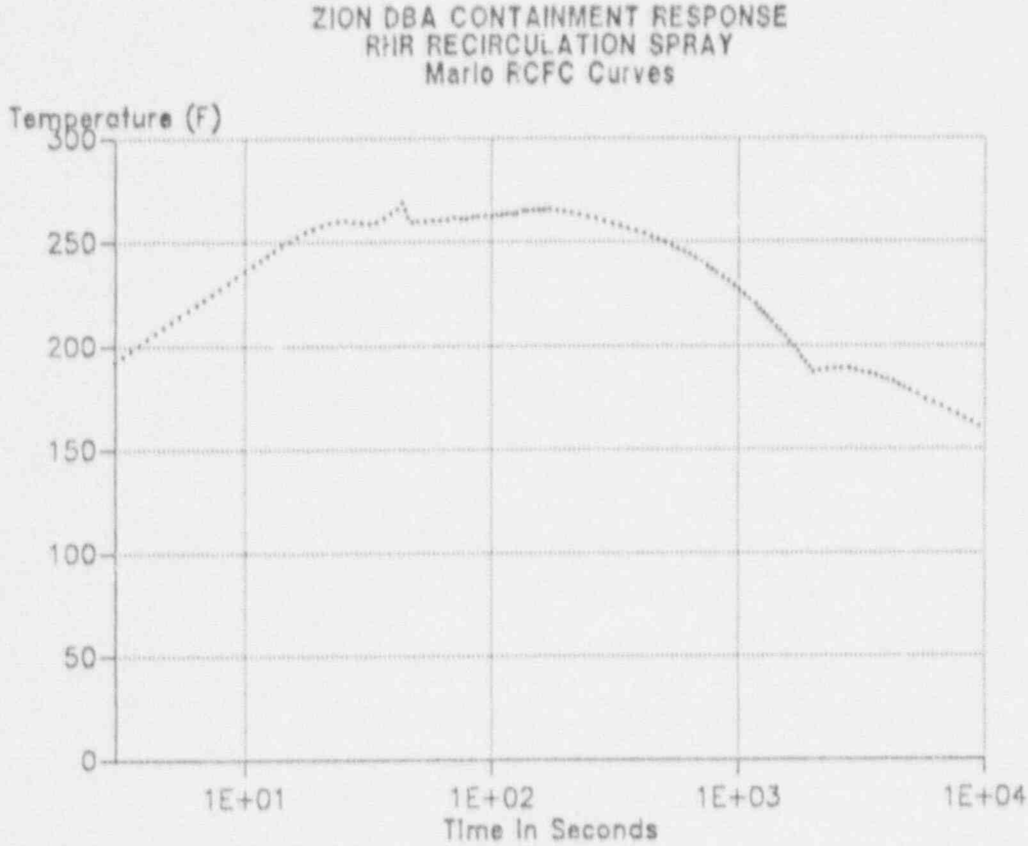

Figure 5. Containment Temperature (RHR Spray)

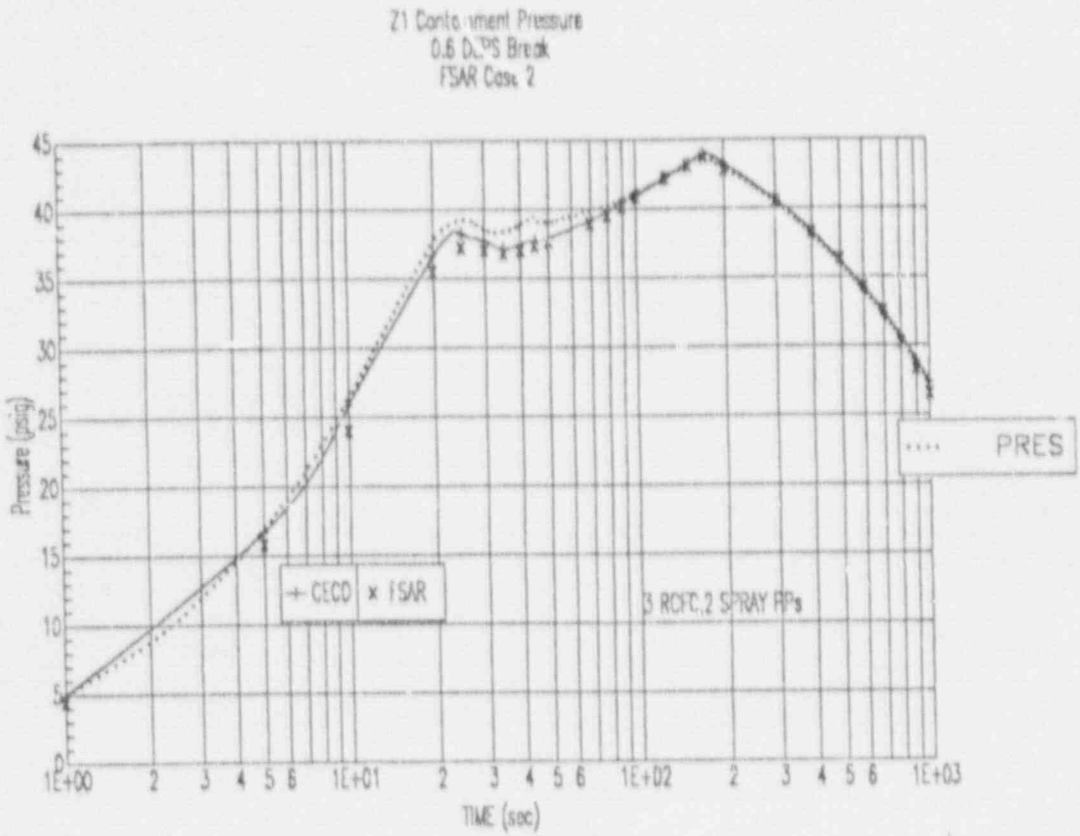

Figure 6. Benchmark Comparison Case (Contempt4M5 = dotted line)

Chapter 4. Conclusions

The results of the calculations clearly demonstrate the effects of the RHR spray system on containment response. The assumption that the RCFCs can handle the post recirculation heat loads is valid. The loss of the RHR spray function causes a temperature rise in the containment vapor space, but does not result in the violation of the design basis equipment qualification envelopes. Therefore, the safety significance of the RHR spray function is considered minimal.

References

1. "Zion UFSAR Chapter 14".

2. "Zion Containment Analysis with CONTEMPT LT-026 Code", NFSR-0025, K. B. Ramsden.

3. "CONTEMPT4/MOD5: AN Improvement to CONTEMPT4/MOD4 Multicompartment Containment System Analysis Program for ICE Containment Analysis", NUREG/CR-4001, C. C. Lin.