CONF-8710111-6

CONF-8710111--6

DE88 002534

THE IMPACT OF BWR MK I PRIMARY CONTAINMENT FAILURE DYNAMICS ON SECONDARY CONTAINMENT INTEGRITY

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For presentation at
15th Water Reactor Safety Information Meeting
October 29, 1987

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*Research sponsored by the Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission under Interagency Agreement DOE 0551-0551-A1 with the U.S. Department of Energy under contract DE-AC05-84OR21400 with the Martin Marietta Energy Systems, Inc.

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ABSTRACT

During the past four years, the ORNL BWRSAT Program has developed a series of increasingly sophisticated BWR secondary containment models. These models have been applied in a variety of studies to evaluate the severe accident mitigation capability of BWR secondary containments. This paper describes the results of a recent ORNL study of the impact of BWR MK I primary containment failure dynamics on secondary containment integrity. A 26-cell MELCOR Browns Ferry secondary containment model is described and the predicted thermodynamic response of the secondary containment to a variety of postulated primary containment failure modes is presented. The effects of primary containment failure location, timing, and ultimate hole size on secondary containment response is investigated, and the potential impact of hydrogen deflagrations on secondary containment integrity is explored.

1. INTRODUCTION

The most common boiling water reactor (BWR) plant design in the United States is the BWR-4/MK I primary containment system. These plants employ secondary containments (Exhibit 1) consisting of a reactor building and refueling bay that completely surround the primary containment. Detailed severe accident analyses of MK I containment designs generally indicate that the conditional probability of primary containment failure is quite high in the unlikely event that core debris escapes the reactor vessel.

Should the primary containment pressure boundary fail, the secondary containment becomes the final barrier between the plant's fission product inventory and the environment. Traditional BWR risk studies have, however, de-emphasized the ability of the secondary containment to act as an effective fission product trap. During the past four years, the ORNL BWRSAT Program has developed a series of increasingly sophisticated BWR secondary containment models. These models have been applied in a variety of studies to evaluate the severe accident mitigation capability of BWR secondary containments.

This paper describes the results of a recent ORNL study of the impact of BWR MK I primary containment failure dynamics on secondary containment integrity. The fundamental design characteristics of the Browns Ferry secondary containment are first discussed, followed by a brief description of potential MK I severe accident containment failure modes. A 26-cell MELCOR Browns Ferry secondary containment model is described and the predicted thermodynamic response of the secondary containment to a variety of postulated primary containment failure modes is presented. The effects of primary containment failure location, timing, and ultimate hole size on secondary containment response is investigated, and the potential impact of hydrogen deflagrations on secondary containment integrity is explored.

2. BWR SECONDARY CONTAINMENT DESIGN

Domestic BWRs of the MK I primary containment design employ a secondary containment which is comprised of a multi-floored reactor building and a refueling bay which completely surround and enclose the primary containment. Multi-unit plants employ separate reactor buildings for each unit but may utilize a common refueling bay to service all units. Exhibit 1 is a cross sectional view of the Browns Ferry Unit 1 reactor building and refueling bay (shared with Units 2 and 3). The Browns Ferry reactor building is a massive (1.4 million ft^3 or 40000 m^3), five floored structure with reinforced external concrete walls. The thickness of the walls varies from 6 ft (1.8 m) in the reactor building basement to 2.5 ft (0.76 m) at the junction of the refueling bay siding and the reactor building wall.

Secondary containment above the reactor building is provided by a 2.75 million ft^3 (77700 m^3) refueling bay which is constructed of corrugated sheet metal walls that contain large blowout panels to provide protection from the effects of tornados and steam line breaks. Not shown in Exhibit 1 are details such as stairways, elevator shafts, and internal blowout panels which provide communication pathways between the various floors of the reactor building and between the reactor building and the turbine building.

The Browns Ferry Final Safety Analysis Report[1] indicates that the above grade exterior walls of the reactor building are designed for pressures up to 250 lb/ft^2 (11970 Pa) without structural failure. The tornado design basis is a pressure decrease of 3 psi (20684 Pa) at a rate of 0.6 psi (4137 Pa) per second. The refueling bay siding is designed to withstand internal pressure in excess of 57.6 lb/ft^2 (2758 Pa) without structural failure. Pressures in excess of 50 lb/ft^2 (2394 Pa) will, however, be relieved by blowout panels in the siding.

3. MK I SEVERE ACCIDENT FAILURE MECHANISMS

The design basis accident for existing MK I primary containments is the large break loss of coolant accident in which one of the main re-

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REACTOR BUILDING AND REFUELING BAY PROVIDE BWR SECONDARY CONTAINMENT

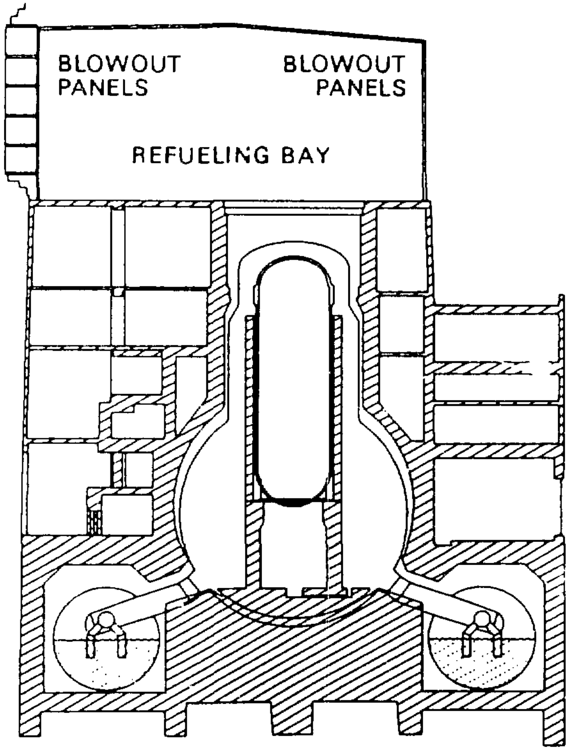

Exhibit 1

circulation pipes is assumed to circumferentially rupture. The purpose of the primary containment is to limit the release of fission products from this accident to levels which will not exceed the limits of 10 CFR 100. This goal is accomplished by designing the containment to withstand the predicted transient pressure and temperature loads induced by the blowdown of steam and hydrogen (produced by cladding oxidation) from the reactor vessel. The design pressure and temperature of the Browns Ferry primary containment are 56 psig (487 kPa) and 281°F (411 K). The primary containment is inerted with nitrogen during reactor operation.

Recent ORNL calculations for an unmitigated short-term station blackout severe accident sequence at Browns Ferry[2] indicate that temperatures as high as 2700°F (1750 K) may be generated in the primary containment if the majority of the core was to be relocated onto the drywell floor. Maximum primary containment pressures for this case appear to be limited primarily by the containment's maximum pressure capability. A recent Chicago Bridge and Iron Company study[3] of the ultimate pressure capability of Peach Bottom's primary containment produced a maximum pressure capability estimate (assuming median gasket resiliency) of 140 psia (965 kPa), with failure predicted to occur via leakage past the drywell head flange assembly. Since the design of the drywell head flange assembly is plant specific, the Peach Bottom results cannot be applied a priori to other plants. It must be noted, of course, that the continued pressure increase associated with the evolution of noncondensible gases from an unmitigated core/concrete reaction would eventually result in over-pressure failure of the primary containment unless precluded by some other failure mechanism.

A second potential mechanism for MK I primary containment failure in an unmitigated severe accident is drywell liner (shell) ablation due to direct attack by molten corium. The ability of molten metals to erode steel structures is well documented.[4] While significant uncertainties surround the behavior of core/concrete reactions and corium spreading in a MK I containment configuration,[2] preliminary analyses indicate failure of the MK I drywell liner is quite likely if core debris does contact the inner liner surface[5].

Should the liner fail near the drywell floor elevation, the most probable sites for blowdown entry into the secondary containment are the reactor building basement torus room and the second floor of the reactor building (Exhibit 2). The transport path for the blowdown is the gap between the drywell shell and the surrounding reactor building concrete, and the annular gaps surrounding the drywell vent pipes and penetrations. These gaps provide a 145 ft^2 (13.5 m^2) flow path into the torus room and a 135 ft^2 (12.6 m^2) flow path into the second floor of the reactor building. Since elevated drywell pressures and temperatures result in swelling of the drywell liner and a reduction in the gap between the liner and the reactor building concrete (Exhibit 3), it appears that the effective flow path area for drywell blowdown would be limited by the actual size of the drywell shell rupture or the available space between the liner and the surrounding concrete. Significant

DRYWELL SHELL MELT-THROUGH WOULD RESULT IN BLOWDOWN TO TORUS ROOM OR SECOND FLOOR OF REACTOR BUILDING

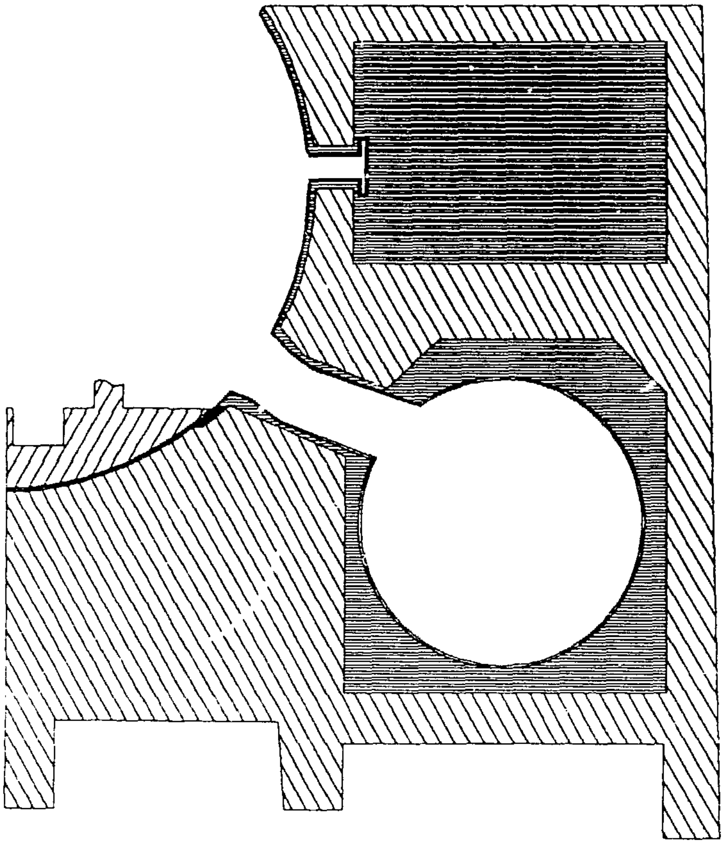

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Exhibit 2

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DRYWELL LINER EXPANSION WILL RESULT IN LOCALIZED BLOWDOWN TO SECONDARY CONTAINMENT

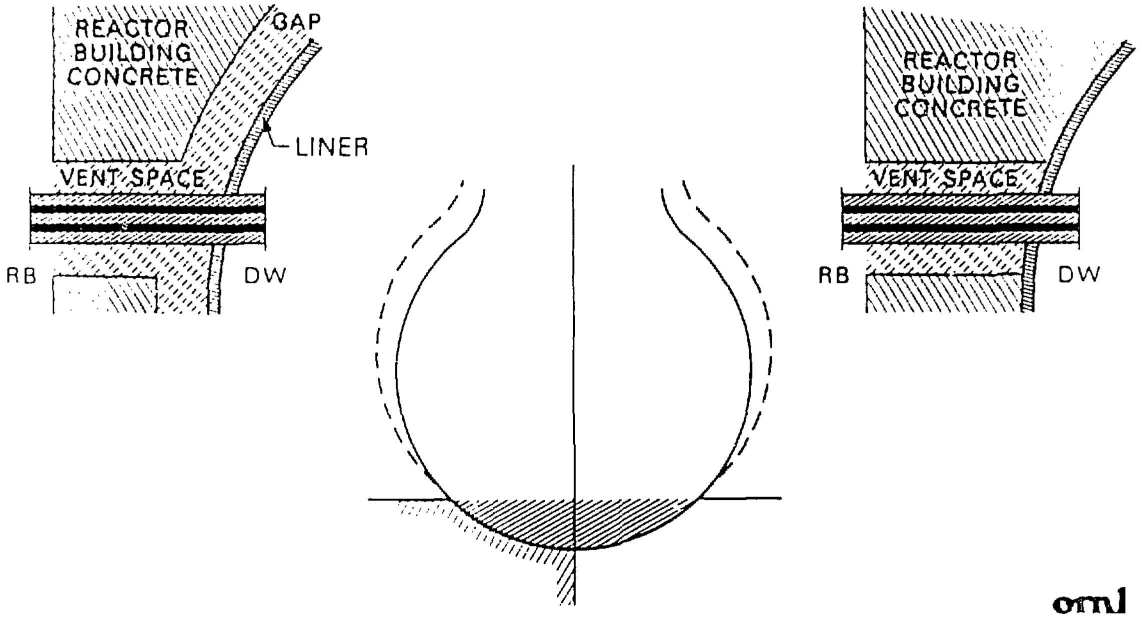

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Exhibit 3

uncertainty therefore surrounds both the ultimate hole size and the ablation time associated with opening of the hole for this drywell failure mechanism.

Given the uncertainties surrounding the dynamics of MK I primary containment failure, it appears prudent to investigate the impact of a range of failure mode assumptions on secondary containment hydrogen deflagration phenomena and building survivability. Such an investigation is possible only via detailed computer simulations of secondary containment behavior. During the past two years ORNL has developed an extremely detailed computer model of the Browns Ferry Unit 1 secondary containment. That model is described in the following section.

4. DESCRIPTION OF ORNL 26 CELL BROWNS FERRY SECONDARY CONTAINMENT MODEL

Exhibit 4 is a schematic representation of the ORNL MELCOR[6] Browns Ferry secondary containment model utilized in this study. The model employs 26 computation cells (control volumes) and 51 flow paths to represent the Browns Ferry reactor building, refueling bay, the turbine building, and the interconnections between these compartments and the outside environment. The outside environment is represented by a single control volume yielding a total of 27 computational cells. The overall model topology is dictated by the actual reactor building architecture (Exhibit 5). Each distinct room in the reactor building is represented by a separate cell, while stairwells and open doorways are characterized as flow paths. The floors, ceilings, walls, and steel structures within the reactor building, refueling bay, and turbine building are represented by 126 distinct structures. Table 1 presents a summary of the physical characteristics of each of the 26 cells. The model structure and the parameters employed in the model are based on a detailed review of drawings and on measurements made at the plant by ORNL personnel.

The basement of the reactor building (Exhibit 5) is modeled with six cells representing the torus room, the four corner rooms, and the HPCI pump room (Cell 6). The 565 ft elevation of the reactor building (immediately above the basement) is simulated with five cells representing the north, west, south, and east quadrants of the building and the drywell personnel access room. Each floor of the reactor building above the 565 ft elevation (i.e., elevations 593, 621, and 639 ft) is modeled by four cells representing the north, west, south, and east quadrants of that floor. Additionally, the large refueling cask hatchway which provides the vent path from the blowout panels (at the 565, 593, and 621 ft elevations) to the refueling bay is represented by a single cell. The refueling bay and turbine building are each modeled with single cell representations.

Prior to primary containment pressure boundary failure, the major interaction between the primary and secondary containments is heating of the torus room atmosphere due to heat transfer from the outer surface of

BROWNS FERRY UNIT 1 SECONDARY CONTAINMENT MODEL

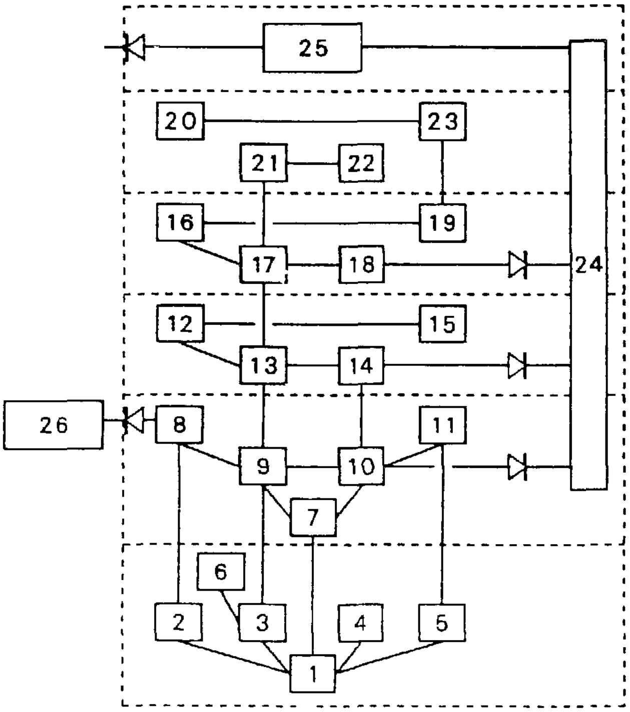

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Exhibit 4

Table 1. ORNL 26 Cell Browns Ferry Secondary Containment Model Characteristics

Cell No.	Name	Volume (m^3)	Total area (m^2)		
			Floor	Ceiling	Walls
1	Torus room	5848	1172	1185	2535
2	North corner	775	71	69	346
3	West corner	2784	71	55	340
4	South corner	555	46	46	346
5	East corner	775	71	64	346
6	HPCI Pump rm	1147	144	144	238
7	565 P/A rm	198	58	58	118
8	565 north	2438	342	342	514
9	565 west	2240	276	284	584
10	565 south	1571	197	197	595
11	565 east	1698	235	242	565
12	593 north	1187	121	172	400
13	593 west	2934	321	318	566
14	593 south	1292	133	133	580
15	593 east	1022	117	117	608
16	621 north	526	123	123	226
17	621 west	1556	350	350	363
18	621 south	982	229	229	277
19	621 east	522	110	110	225
20	639 north	3660	158	158	452
21	639 west	3030	423	423	559
22	639 south	1711	239	239	505
23	639 east	525	73	73	402
24	Hatchway	1001	—	—	327
Reactor building total		39977	5080	5131	12017
25	Refueling bay	77730	4202	4756	5709
26	Turbine building	161567	8279	8279	7596

MODEL TOPOLOGY IS DICTATED BY REACTOR BUILDING ARCHITECTURE

REACTOR BUILDING BASEMENT

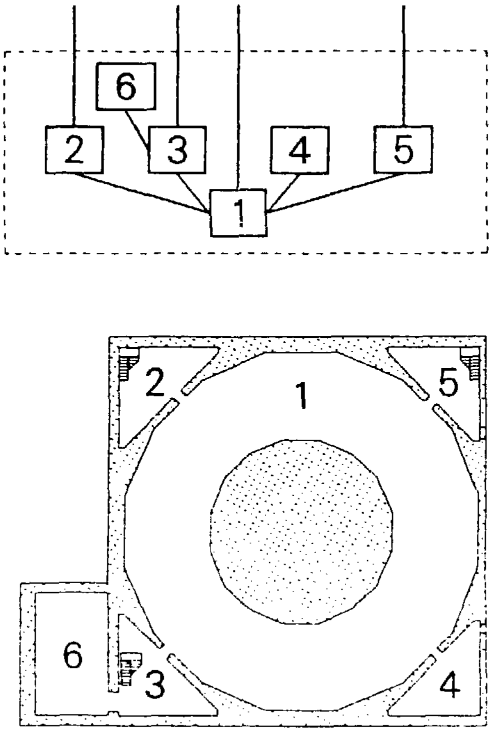

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Exhibit 5

the torus. This effect is captured by representing the torus wall as a steel slab with an appropriate surface area. A time-dependent surface temperature boundary condition is specified on the "inner" surface of the slab, while the outer surface is allowed to convect and radiate energy to the surrounding torus room atmosphere. The inner surface temperature history is taken from the appropriate BWRSAR[7] (prior to reactor vessel failure) and CONTAIN[8] (after reactor vessel failure) calculation results.

All blowout panels are modeled as pressure dependent flow areas. The panels are assumed to begin leaking with an area equivalent to 10% of the total panel area, at a pressure differential equivalent to 90% of the design basis pressure differential for the blowout panel. Eighty percent of the total panel area is assumed to be open at the design pressure differential, and all of the blowout panel is assumed to be open at 110% of the design actuation pressure. This modeling approach reflects the results of laboratory tests which indicate that the blowout panel retaining bolts may fail at pressure differentials equivalent to plus or minus 10% of the design value.[9]

Some BWR secondary containments incorporate comprehensive fire protection systems which utilize fused-link water sprinklers for fire suppression. The Browns Ferry plant utilizes fused-link sprinklers which are designed to actuate at 165°F (347 K). The system consists of two 10000 gallon (37.9 m^3) raw service water (RSW) storage tanks (located atop the reactor building), four RSW pumps (which maintain the tank inventory during normal operation), four fire system pumps (one of which is driven by a dedicated diesel), and the sprinkler system. The RSW storage tanks provide a 20000 gallon (75.7 m^3), gravity-fed sprinkler supply reservoir, and no power is required for actuation of the fused-link sprinklers. Additionally, and very importantly, the one diesel-driven pump provides a highly reliable supply of water to sprinklers located in the first two levels of the reactor building.

The Browns Ferry secondary containment fire protection system sprays would be expected to actuate following primary containment blowdown as a result of rising reactor building temperatures. The MELCOR secondary containment model incorporates a detailed representation of the reactor building fire protection system sprays. The model utilizes ten separate spray systems to simulate the spray heads installed in the west and south basement corner rooms, and the four quadrants of the 565 and 593 ft elevations. The spray flow rate characteristics of each of the ten systems were developed from an analysis of the expected performance characteristics for the situation in which (a) only the diesel-driven pump is available, and (b) all spray heads are open on all systems. The results of that analysis indicate that (for the assumed conditions) the 593 ft elevation sprays would function only until the RSW tank inventory is exhausted.

5. THE PARAMETRIC STUDY

The model described in Section 4 was employed to investigate the impact of MK I primary containment failure dynamics on the Browns Ferry secondary containment's response to the initial (first 5 min) drywell blowdown phase of the short-term station blackout severe accident sequence. A test matrix of 15 cases was defined as described in Table 2. The size of the drywell rupture was varied from 0.5 m^2 (775 in^2) down to 0.0005 m^2 (0.78 in^2), while the time for ablation of the hole was varied from 1 s to 60 s. Additionally, various assumptions were made regarding the hydrogen concentration necessary for deflagration (1, 8, and 12 mole %) and the location at which the blowdown enters the secondary containment (torus room, one corner of reactor building second floor, or all zones of reactor building second floor).

The Browns Ferry secondary containment model described in Section 4 was augmented for this study by the addition of a single cell to represent the entire primary containment (drywell and wetwell). The initial primary containment conditions for the analyses were based on Browns Ferry short-term station blackout CONTAIN calculations performed by C. R. Hyman at ORNL.[2] The drywell pressure boundary is assumed to fail at 9.6 h into the accident due to erosion of the drywell shell by molten corium. This failure is modeled by opening a flow path between the primary containment cell and the appropriate cell or cells of the secondary containment model. The drywell conditions at the time of failure are as noted in Table 2, and the secondary containment is assumed to be at 14.7 psia (101 kPa), 80°F (300 K), and 80 % relative humidity at the start of the accident. The MELCOR calculations for each case were conducted for the period from accident initiation until 5 minutes after drywell failure.

6. RESULTS OF THE ANALYSIS

The results of the various case studies are summarized in Table 3. Cases 1, 2, and 3 (0.5 m^2 cases) all result in hydrogen burn-induced secondary containment pressures well in excess of the design value of 17.7 psia. Case 7 produced the lowest pressure response of any of the cases, because no hydrogen deflagrations were predicted to occur during the first 5 minutes after primary containment failure.

Exhibit 6 depicts the results of Cases 3, 4, 5, 8, and 6, in which a 60 s ablation time was assumed, and hole sizes of 0.5, 0.05, 0.005, 0.0018, and 0.0005 m^2 were employed. The abscissa of Exhibit 6 is reactor building elevation, where RB1 is the reactor building basement, PA-RM is the drywell personnel access room (an interior room) on the second floor (565 ft elevation) of the reactor building, RB2 is the remainder of the second floor of the reactor building, RB3, RB4 and RB5 are the third, fourth, and fifth floors of the reactor building, and RF is the refueling bay. The ordinate of Exhibit 6 is the maximum observed

Table 2. Secondary Containment Study Cases[1]

Case	Description
1	0.5 m^2 hole, 1 s ablation time
2	0.5 m^2 hole, 30 s ablation time
3	0.5 m^2 hole, 60 s ablation time
4	0.05 m^2 hole, 60 s ablation time
5	0.005 m^2 hole, 60 s ablation time
6	0.0005 m^2 hole, 60 s ablation time
7	0.0005 m^2 hole, 1 s ablation time
8	0.0028 m^2 hole, 60 s ablation time
9	Case 5 except 1/2 primary containment H_2
10	Case 5 except no burn propagation allowed
11	Case 5 except flame speed fixed at 3.0 m/s
12	Case 5 except blowdown to one corner of second floor of reactor building
13	Case 5 except blowdown into all of second floor of reactor building
14	Case 5 except burn triggers at 1 mole % H_2
15	Case 5 except burn triggers at 12 mole % H_2

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[1] Except as noted, all cases assume:

(a) blowdown to torus room,
(b) deflagration trigger at 8 mole % H_2,
(c) 4.1 mole % H_2 for upward flame propagation,
(d) 6 mole % H_2 for horizontal flame propagation,
(e) 9 mole % H_2 for downward flame propagation,
(f) drywell failure at 9.6 h,
(g) primary containment conditions at failure — 81 psia (559 kPa), 381°F (467 K), 53 mole % hydrogen, 1 mole % oxygen, 25 mole % nitrogen, 1 mole % carbon dioxide, and 20 mole % steam

Table 3. Results of Case Studies — Reactor Building Response

Case No.	Peak Basement		Peak Reactor Building[1]	
	Pressure (psia)	Temperature (°F)	Pressure (psia)	Temperature (°F)
1	37.7	3683	27.2	2397
2	32.3	3288	28.9	2286
3	32.1	3445	26.8	2225
4	24.6	3362	18.1	1978
5	20.8	1452	16.5	337
6	22.1	1340	19.6	946
7	14.8	101	14.7	88
8	20.8	137	16.5	783
9	20.7	1352	16.5	330
10	20.9	4404	16.4	662
11	18.0	1275	17.2	895
12	15.6	125	15.7	1292
13	16.3	189	16.8	1295
14	15.3	4756	15.0	836
15	25.9	1929	18.4	659

[1] Excluding basement compartments.

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REACTOR BUILDING STRUCTURAL INTEGRITY MAY BE THREATENED BY EVEN SMALL RUPTURES OF PRIMARY CONTAINMENT BOUNDARY

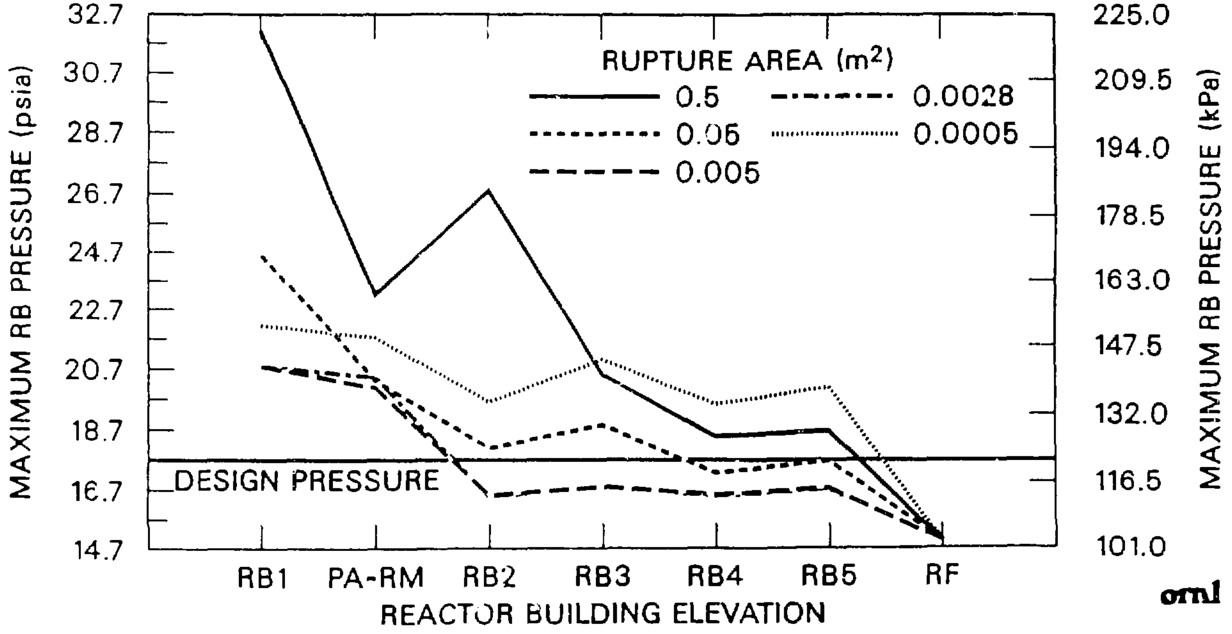

Exhibit 6

pressure on each respective floor of the reactor building during the duration of the 5 minute analysis period. (It should be noted that the pressures plotted in Exhibit 6 and the exhibits to follow may not have occurred at the same instant in time.)

A review of Exhibit 6 reveals that peak reactor building pressures in excess of the design pressure may be produced by a wide range of primary containment hole sizes (0.5, 0.05, and 0.0005 m^2). Interestingly, Exhibit 6 suggests that there may be an optimal hole size which minimizes the deflagration-induced secondary containment pressures. This inference is of little utility, however, since there is currently no available method for predicting the hole size resulting from corium ablation of the drywell liner.

The results of this evaluation indicate that reactor building survivability may be a function of the hydrogen concentration at which deflagrations initiate. This behavior is demonstrated by Exhibit 7, which depicts the results of Cases 5, 14, and 15. Case 5 is a default case in which a 0.005 m^2 hole is assumed to open over 60 s. Deflagration is allowed to occur at hydrogen concentrations of 8 mole %. Case 14 is identical to Case 5, except that deflagrations are allowed to occur at hydrogen concentrations of only 1 mole %. This case is a crude approximation of a situation in which the hydrogen is assumed to burn in a continuous fashion as it enters the torus room. Case 15 is a case in which hydrogen deflagration is delayed until 12 mole % concentrations are reached (as might occur in the absence of auto-ignition or ignition sources). Exhibit 7 demonstrates that, for a given primary containment hole size and ablation time, the survivability of the reactor building may depend on avoidance of delayed hydrogen deflagrations.

Not shown in Exhibit 7, but illustrated by Table 3, is the effect of continuous hydrogen burning (Case 14) on reactor building basement atmosphere temperatures. While continuous burning does reduce the magnitude of deflagration-induced reactor building pressure spikes, this reduction in pressure is coupled with a tremendous increase in thermal loading in the zone in which the burn is occurring. The maximum observed reactor building temperature (4756°F or 2898 K) occurs in conjunction with the continuous burning case. If maintained, temperatures of this magnitude would challenge the integrity of the pressure suppression pool torus and produce degassing of the structural concrete. Neither of these effects were considered in the present analysis.

Exhibit 8 displays the impact that the primary containment blowdown entrance site into the secondary containment has on peak deflagration-induced reactor building pressures. Each of the three cases depicted in Exhibit 8 assumes a 0.005 m^2 primary containment failure hole size and a 60 s ablation time. The lowest peak pressures are seen to result from the case in which the blowdown is assumed to enter the south quadrant of the second floor of the reactor building. Intermediate pressures are generated by the case in which the blowdown is assumed to enter all quadrants of the second floor of the reactor building. The highest pressures are produced by the case in which the primary containment

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DEFLAGRATION TRIGGER MECHANISM DOMINATES SECONDARY CONTAINMENT RESPONSE UNCERTAINTIES

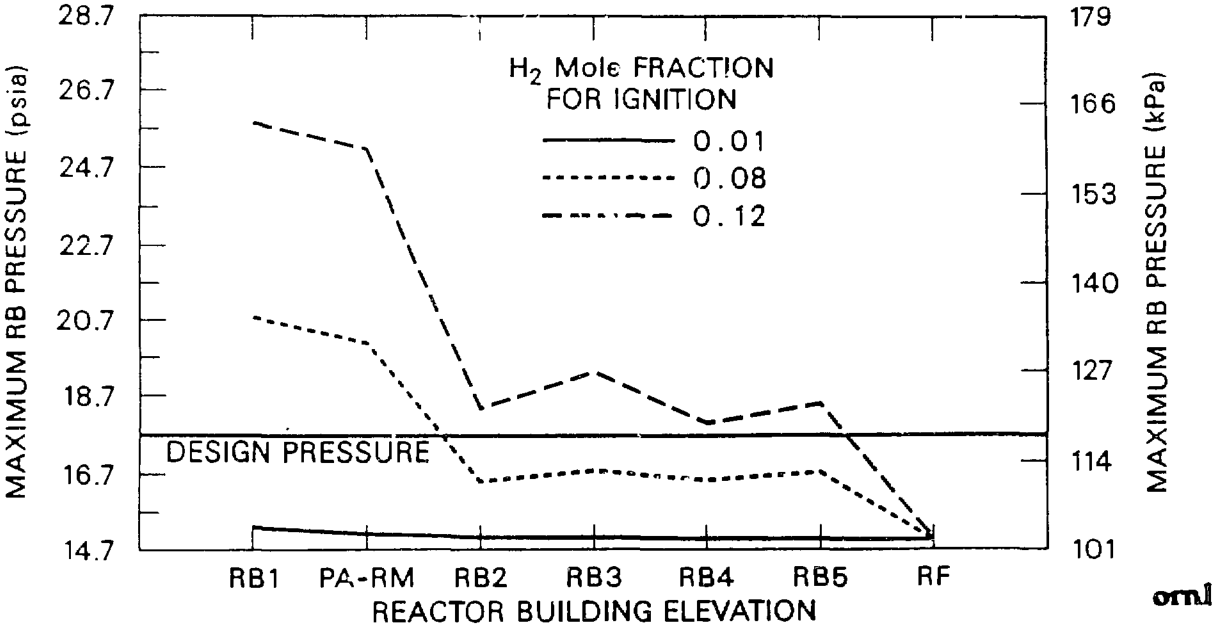

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Exhibit 7

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LOCATION OF BLOWDOWN ENTRANCE INTO SECONDARY CONTAINMENT INFLUENCES PEAK PRESSURES

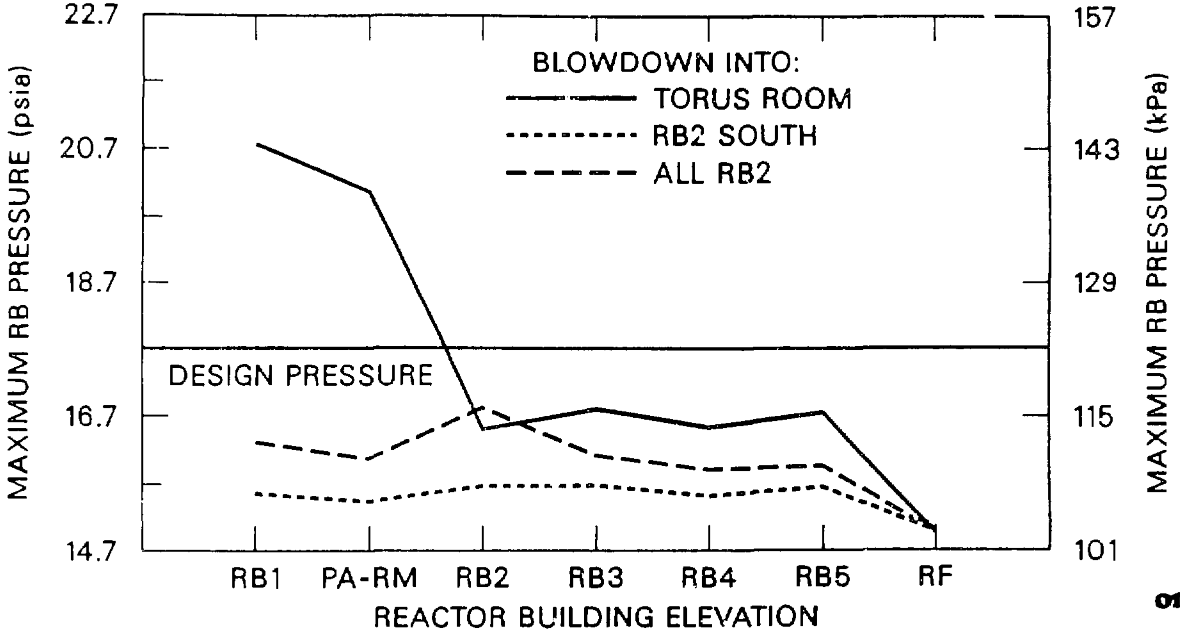

Exhibit 8

blowdown enters the torus room. Maximum pressures in the regions of the reactor building above ground level are below the design dynamic pressure of the concrete walls for all three cases.

7. SECONDARY CONTAINMENT SURVIVABILITY — UNCERTAINTIES

The results of the analysis presented here do not constitute a definitive assessment of reactor building survivability due to a host of unresolved phenomenological and modeling uncertainties. From the phenomenological standpoint, the major uncertainty is probably the characterization of the primary containment failure opening (hole size and ablation time). It must be noted, however, that a wide range of hole sizes result in peak deflagration-induced reactor building pressures significantly in excess of design values.

Secondly, the peak induced reactor building pressures are very sensitive to the assumed minimum hydrogen concentrations necessary for ignition. In the case of primary containment boundary failure due to corium attack of the drywell shell, the gases leaving the drywell would flow over hot core debris and might be heated to auto-ignition conditions (approximately 1000°F or 800 K). A spark source would be required for ignition of the resulting hydrogen mixtures for cases in which auto-ignition does not occur. While power would not be available during the station blackout scenario, the abundance of batteries and capacitive and inductive devices in the secondary containment should provide the necessary spark source. The length of the delay prior to ignition is an important unknown, since long delays would result in hydrogen-rich secondary containment gas concentrations and higher peak pressures when deflagrations do occur.

Modeling uncertainties which have the potential to significantly impact the results of this analysis include model topology issues and uncertainties in MELCOR's deflagration physics models. Previous ORNL secondary containment studies[10] have demonstrated the importance of detailed, architectural-based secondary containment models. The model employed in this study, while more detailed than any previous model employed by ORNL, does treat the reactor building torus room as a single, well mixed cell. The torus cell is the largest cell (volume) in the reactor building model, and approximately 83 lb (37.7 kg) of hydrogen are required to bring the torus room atmosphere up to default (8 mole % hydrogen) deflagration conditions. The intricacies of the communication between the torus room and the basement corner rooms are also not completely captured by this model. Sub-nodalization of this cell would result in more accurate representation of torus room and corner room interaction, and (perhaps) impact peak building pressures due to ignition of smaller quantities of hydrogen.

The second major area of modeling uncertainty which has the capacity to impact the results of this study is associated with MELCOR's hydrogen deflagration physics models. MELCOR employs the basic deflagration models developed for HECTR[11] and CONTAIN, with the exception that MELCOR's flame speed correlation does not include a term which reduces flame speeds for steam-rich atmospheres. Most of the experimental data upon which the deflagration models are based was generated by small and intermediate scale experiments (less than 10 m^3 compartments). The scaling of flame speed and burn completeness correlations, burn-induced heat flux partitioning fractions (convective versus radiative), and hydrogen concentration ignition thresholds from these small experiments to compartments with volumes of 1000 to 6000 m^3 is subject to many uncertainties.

Finally, the results of this study suggest that primary containment venting might be employed as a solution to the secondary containment survivability issue. One can envision scenarios in which hydrogen would be vented via a "hard" (special purpose) wetwell vent, thereby reducing the amount of hydrogen available for combustion in the secondary containment should the primary containment boundary fail. The vent could (in theory) be closed prior to drywell liner failure to insure that subsequent hydrogen deflagrations in the reactor building basement would not result in torus or vent ducting failure and the opening of a direct vent path from the primary containment to the outside atmosphere. Although we intend to investigate this concept further, it should be noted that (a) corium attack of the drywell shell would not be precluded by containment venting, and (b) recent ORNL studies[2,7] indicate that significant hydrogen might be generated by the core/concrete reaction after the drywell liner is failed.

8. CONCLUSIONS

The impact of BWR MK I primary containment boundary failure dynamics on Browns Ferry's secondary containment integrity has been explored via a parametric study approach. The results of the study indicate that peak hydrogen deflagration-induced reactor building pressures exceed design pressures for a wide range of primary containment hole sizes and ablation times, but that reactor building survivability appears probable for some scenarios. The major uncertainty in the analysis is the assumption regarding the minimum hydrogen concentration necessary for deflagration. Low minimum hydrogen concentrations (an approximation to continuous burning) result in low reactor building peak pressures but extremely high temperatures. The location at which the primary containment blowdown enters the secondary containment influences the peak deflagration-induced reactor building pressures. Primary containment venting for the purpose of reducing the hydrogen inventory available for deflagration in the secondary containment may improve the probability of secondary containment survivability for some scenarios. Additional analysis is underway to explore the potential benefits of this procedure. Finally, existing hydrogen deflagration physics models incorporated in present codes are based on small and intermediate scale experiments. Significant uncertainties are implicit in the application of these models to the simulation of deflagrations in large compartments.

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