July 23, 1986

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Docket No. 50-341
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Docket 50-341

County of Monroe, Michigan
Board of Commissioners
106 East First Street
Monroe, Michigan 48161

Dear Commissioners:

The NRC has been advised by Representative John Dingell that you are interested in the safety of the Mark I containment as is used at the Fermi-2 Plant. In response to Representative Dingell, we have prepared a paper describing the Mark I containment and the ongoing efforts to address concerns regarding that containment's ability to mitigate severe accidents.

We are providing you with a copy of this paper (Enclosure 1) for your use. In addition, I intend to discuss the containment issues at the public meeting on the Fermi site on July 28, 1986. If you wish any further information please call me (301-492-7373) or Ms. Elinor Adensam of my staff (301-492-8180).

Sincerely,
Orinigal Signed by
Elinor G. Adensam for
Robert M. Bernero, Director
Division of BWR Licensing
Office of Nuclear Reactor Regulation

Enclosure:
As stated

cc: See next page

BWD-3:DBL
DLynch/lk/hmc
7/23/86

D:BWD-3:DBL
EAdensam
7/22/86

D:DBL
RBernero
7/23/86

cc:
Mr. Harry H. Voigt, Esq.
LeBoeuf, Lamb, Leiby & MacRae
1333 New Hampshire Avenue, N. W.
Washington, D. C. 20036

John Flynn, Esq.
Senior Attorney
The Detroit Edison Company
2000 Second Avenue
Detroit, Michigan 48226

Mr. Dennis R. Hahn, Chief
Nuclear Facilities and Environmental
Monitoring Section Office
Division of Radiological Health
P. O. Box 30035
Lansing, Michigan 48909

Mr. Robert Woolley
Acting Supervisor-Licensing
The Detroit Edison Company
Fermi Unit 2
6400 No. Dixie Highway
Newport, Michigan 48166

Mr. Walt Rogers
U. S. Nuclear Regulatory Commission
Resident Inspector's Office
6450 W. Dixie Highway
Newport, Michigan 48166

Monroe County Office of Civil
Preparedness
963 South Raisinville
Monroe, Michigan 48161

Mr. B. Ralph Sylvia
Group Vice President
Detroit Edison Company
6400 North Dixie Highway
Newport, Michigan 48166

Ronald C. Callen
Adv. Planning Review Section
Michigan Public Service Commission
6545 Mercantile Way
P. O. Box 30221
Lansing, Michigan 48909

Regional Administrator, Region III
U. S. Nuclear Regulatory Commission
799 Roosevelt Road
Glen Ellyn, Illinois 60137

SEVERE ACCIDENT SAFETY
IN BOILING WATER REACTORS
WITH MARK I CONTAINMENT

As the name indicates, a boiling water reactor (BWR) is a reactor in which the water fed to the reactor core boils right there in the reactor vessel and then passes as steam directly out to the turbine-generator where its energy is converted to electricity. The exhausted steam, after condensation, is returned to the reactor as feedwater. Figure 1 shows a simple schematic of a BWR plant. The reactor is enclosed in a special containment structure. The feedwater enters and the steam leaves this containment structure through multiple, large diameter pipes equipped with redundant valves which can be closed in an emergency. In the pressure suppression containment which is used in all large U.S. BWRs, a very large quantity of water, up to one million gallons, is stored in a special compartment of the containment called the suppression pool. Many auxiliary and emergency cooling systems are provided to pump cooling water into the reactor and to cool the containment atmosphere and its suppression pool. If a pipe breaks by accident, the containment closes to isolate the reactor in the containment and many cooling systems are called into play to cool the reactor and the suppression pool, removing the stored energy and heat generated by radioactive decay.

Thus, the BWR is an open system removing large quantities of energy to nearby equipment which, in emergencies, converts to a closed system, basically relying on external cooling of the containment to remove the bottled-up energy. The most common type of pressure suppression containment in the U.S. is the Mark I type shown in Figure 2, which is used in the 24 U.S. BWRs listed in Table 1. The reactor is contained in the drywell portion of the containment, shaped like an electric light bulb standing upside down. The suppression pool partially fills a toroidal shell around the base of the "bulb" and a series of ducts is installed to guide steam and other releases into the suppression pool which quenches the steam and also absorbs much of the radioactive material (except gases).

"Severe accidents" is the term most commonly used to describe accidents in which the reactor core is severely damaged. As happened at Three Mile Island, prolonged loss of core cooling can allow the heat of radioactive decay in the

the direct cycle boiling water reactor system

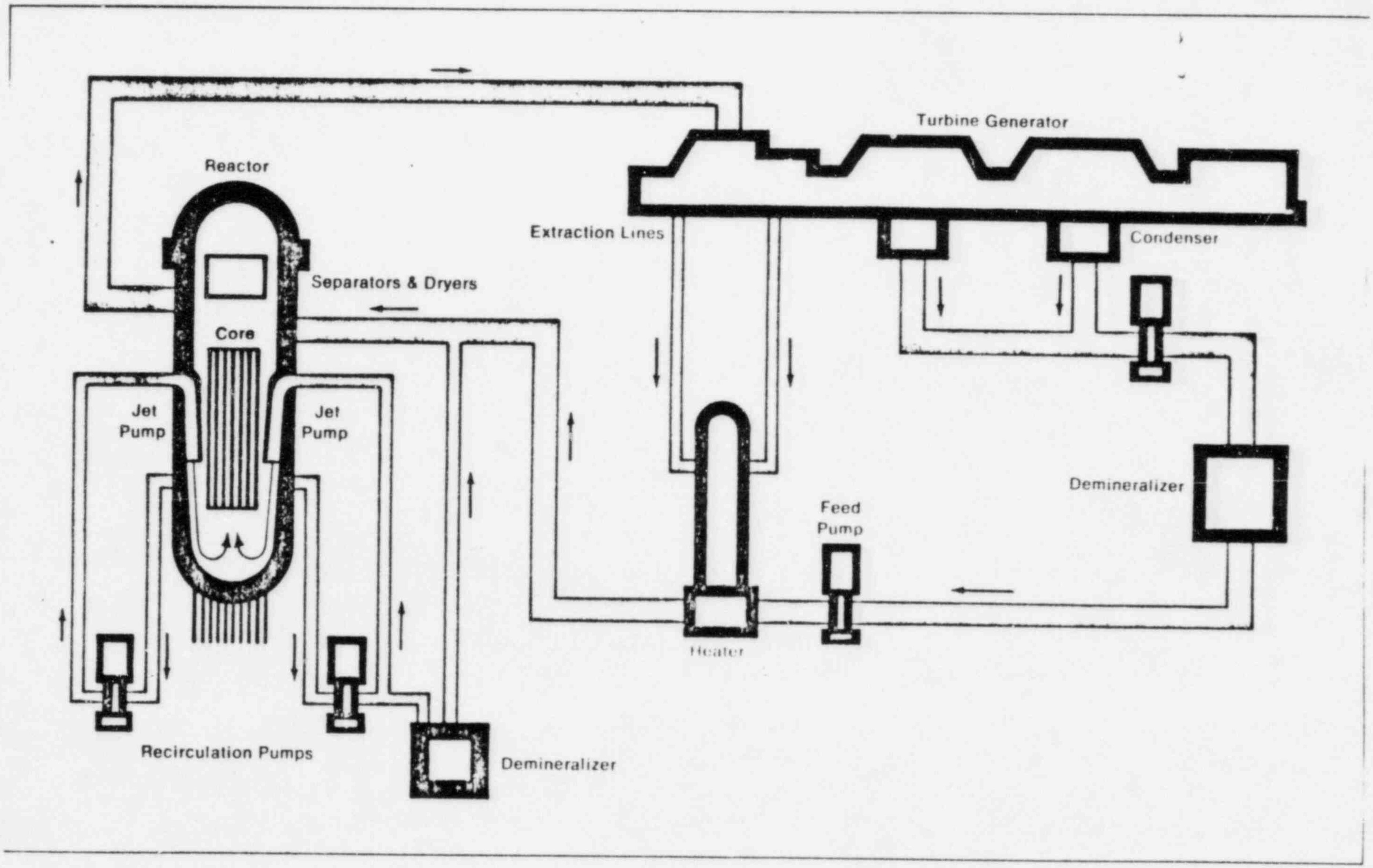

FIGURE 1.

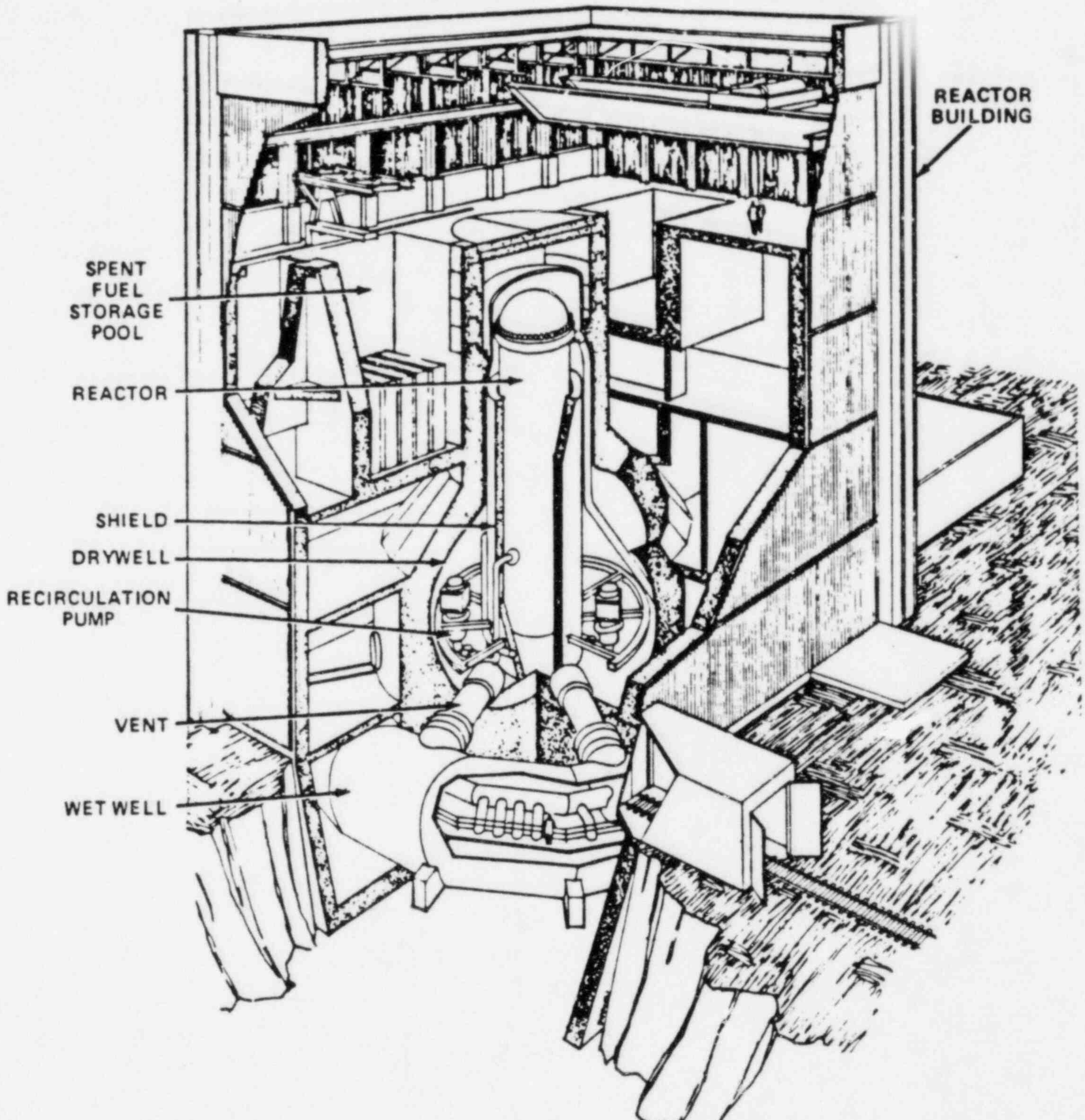

Figure 2 Fermi 2 Containment System

TABLE 1
BOILING WATER REACTORS WITH MARK I CONTAINMENTS

PLANT NAME	LICENSED POWER LEVEL	OPERATING LICENSE DATE	COUNTY	STATE	UTILITY
BROWNS FERRY 1	3293	12/20/73	LIMESTONE COUNTY	AL	TVA
BROWNS FERRY 2	3293	08/02/74	LIMESTONE COUNTY	AL	TVA
BROWNS FERRY 3	3293	08/18/76	LIMESTONE COUNTY	AL	TVA
BRUNSWICK 1	2436	11/12/76	BRUNSWICK COUNTY	NC	CAROLINA POWER & LIGHT
BRUNSWICK 2	2436	12/27/74	BRUNSWICK COUNTY	NC	CAROLINA POWER & LIGHT
COOPER	2381	01/18/74	NEMEHA COUNTY	NE	NEBRASKA PUBLIC POWER DISTRICT
DRESDEN 2	2527	12/22/69	GRUNDY COUNTY	IL	COMMONWEALTH EDISON
DRESDEN 3	2527	03/02/71	GRUNDY COUNTY	IL	COMMONWEALTH EDISON
DUANE ARNOLD	1658	02/22/74	LINN COUNTY	IA	IOWA ELECTRIC POWER & LIGHT
FERMI 2	3292	07/15/85	MONROE COUNTY	MI	DETROIT EDISON
FITZPATRICK	2436	10/17/74	OSWEGO COUNTY	NY	POWER AUTHORITY OF STATE OF NY
HATCH 1	2436	10/13/74	APPLING COUNTY	GA	GEORGIA POWER
HATCH 2	2436	06/13/78	APPLING COUNTY	GA	GEORGIA POWER
HOPE CREEK 1	3293	04/11/86	SALEM COUNTY	NJ	PUBLIC SERVICE ELECTRIC & GAS
MILLSTONE 1	2011	10/16/70	NEW LONDON	CT	NORTHEAST NUCLEAR ENERGY
MONTICELLO	1670	01/19/71	WRIGHT COUNTY	MN	NORTHERN STATES POWER
NINE MILE POINT 1	1850	08/22/69	OSWEGO COUNTY	NY	NIAGARA MOHAWK POWER
OYSTER CREEK 1	1930	08/01/69	OCEAN COUNTY	NJ	GPU NUCLEAR CORP
PEACH BOTTOM 2	3293	12/14/73	YORK COUNTY	PA	PHILADELPHIA ELECTRIC
PEACH BOTTOM 3	3293	07/02/74	YORK COUNTY	PA	PHILADELPHIA ELECTRIC
PILGRIM	1998	06/08/72	PLYMOUTH COUNTY	MA	BOSTON EDISON
QUAD CITIES 1	2511	12/14/72	ROCK ISLAND COUNTY	IL	COMMONWEALTH EDISON
QUAD CITIES 2	2511	12/14/72	ROCK ISLAND COUNTY	IL	COMMONWEALTH EDISON
VERMONT YANKEE	1593	02/02/73	WINDHAM COUNTY	VT	VERMONT YANKEE NUCLEAR POWER

core to build up to the point that the fuel begins to disintegrate, the zirconium metal cladding melts or reacts with residual steam to form combustible hydrogen, and even the ceramic uranium oxide fuel pellets can melt. A great deal of attention is being given to understanding the behavior of reactors and their containments in severe accidents, especially since the Three Mile Island accident. The objectives are to ensure that the likelihood of core melt accidents is very low and that, should one occur, there is substantial assurance that the containment will mitigate its consequences.

The severe accident behavior of a BWR with a Mark I containment, the Peach Bottom plant, was assessed in the Reactor Safety Study (WASH-1400 or NUREG-75/014) which was published in 1975. That study indicated a relatively low overall risk for the BWR, principally due to its ability to prevent core melt. The containment was estimated to provide very little mitigation of core melt consequences because the buildup of pressure under accident conditions would be a direct cause of containment failure unless adequate cooling was preserved. Consistent with operating procedures in place in 1975, the Study assumed little effort by the reactor operators which might effectively preserve the containment's integrity.

The situation, more than ten years later, is different and still changing for the better. It is recognized today that molten core material melting into the ground through the thick containment base is not the principal threat; rather, it is an atmospheric release of radioactive material which is the principal threat. The principal factors which can cause containment failure with atmospheric release are hydrogen ignition, gas overpressure buildup to rupture, and direct attack of the drywell by core melt debris. The general situation for each of these is summarized as follows:

Hydrogen Ignition

Recognizing that combustible hydrogen can be generated and released in severe accidents, all Mark I containments now are purged and filled with inert nitrogen gas during operation so that even if hydrogen gas is formed it has insufficient oxygen available to support combustion. Remaining questions in this area relate to how long the containment may be without this inert atmosphere in order to permit inspections, and how air might leak in or hydrogen leak out to nearby rooms under accident conditions

Overpressure Failure

Careful analysis indicates that a typical Mark I containment can withstand pressures of more than twice the design pressure without rupture. Nevertheless, severe accidents in the extreme can generate such pressures and cause containment rupture. Overpressure damage control procedures have been developed for pressure suppression containments and are already in place for operator use. With these procedures the containment remains closed for most accident conditions; but, if overpressure failure threatens, large vent valves above the suppression pool chamber are opened so that the excess pressure is released gradually by bubbling the releases through the pool, forming a filtered vent containment system. With this path assured, virtually nothing but the noble gases are released. The radioactive noble gases pose a modest exposure threat offsite only in the area very close to the plant. A number of questions are being pursued in this area. All the plants have suitably large vent valves and ducts but they vary one to another in the ability to open these valves under accident conditions. The valves are designed for highly reliable closure, not opening. Consideration is being given to modifying valve controls. In addition, the vent ductwork downstream of the valves may warrant modification. In most plants it is fairly light gauge ductwork and might be breached in accident venting. If so, consideration is being given to the effects of secondary release of radioactive gas, hydrogen, and perhaps steam into the reactor building.

Direct Attack

The core melt debris, since it has melted through the reactor vessel into the drywell may, by direct radiation of heat, cause failure of connections in the drywell shell; or the debris, if sufficiently fluid, may flow out to the wall and melt through the steel. The Mark I containments have one or more spray systems in the drywell which are able to spray water along the walls and onto the floor of the drywell inhibiting direct attack. Concerns in this area are in three general areas: core debris modeling, shell and concrete attack modeling, and spray reliability. In the first area, it is recognized that a molten reactor core, to melt through the bottom of a BWR, must dissolve a very large amount of inert metal in the lower reactor vessel, probably diluting the core melt. The key question is whether the melt would come out moving sluggishly like Hawaiian volcano lava or as a hot free flowing liquid. The latter is the more threatening condition.

If core melt debris reaches the concrete floor and steel shell of the wall, it is important to understand that the path to the outside that might be opened bypasses the beneficial scrubbing of radioactive material passing through the pool.

As noted earlier all these plants have drywell spray systems, but they are designed as a secondary mode of operation for a reactor safety system. Strong consideration is being given to enabling hookup of these systems to fire protection systems so that spray capability is almost always available.

Substantially different emergency operating procedures and training were put in place at all reactors after the Three Mile Island accident; further improvements in these procedures are still being made. For the Mark I containments both industry and NRC studies are being used to identify the best combined strategy for procedures and perhaps some changes in equipment such as alternate vent paths, or improved valve operability. The Mark I studies are being given highest priority by the NRC staff and the industry. The expectation is that, with modest improvements of this type, one can achieve substantial assurance of core melt consequences mitigation by a Mark I containment.