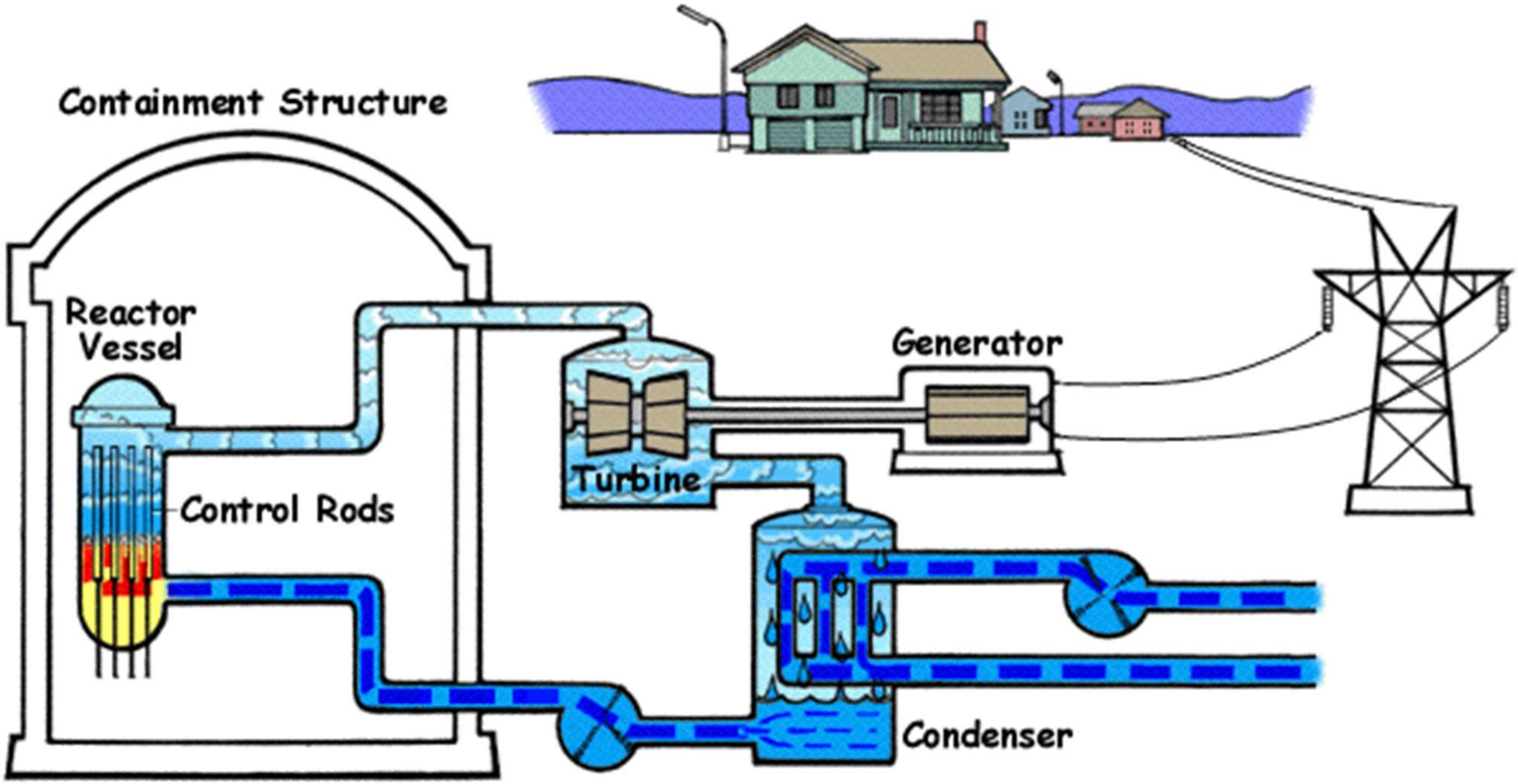
Torus Coating Problem at Fermi Unit 2

July 2019

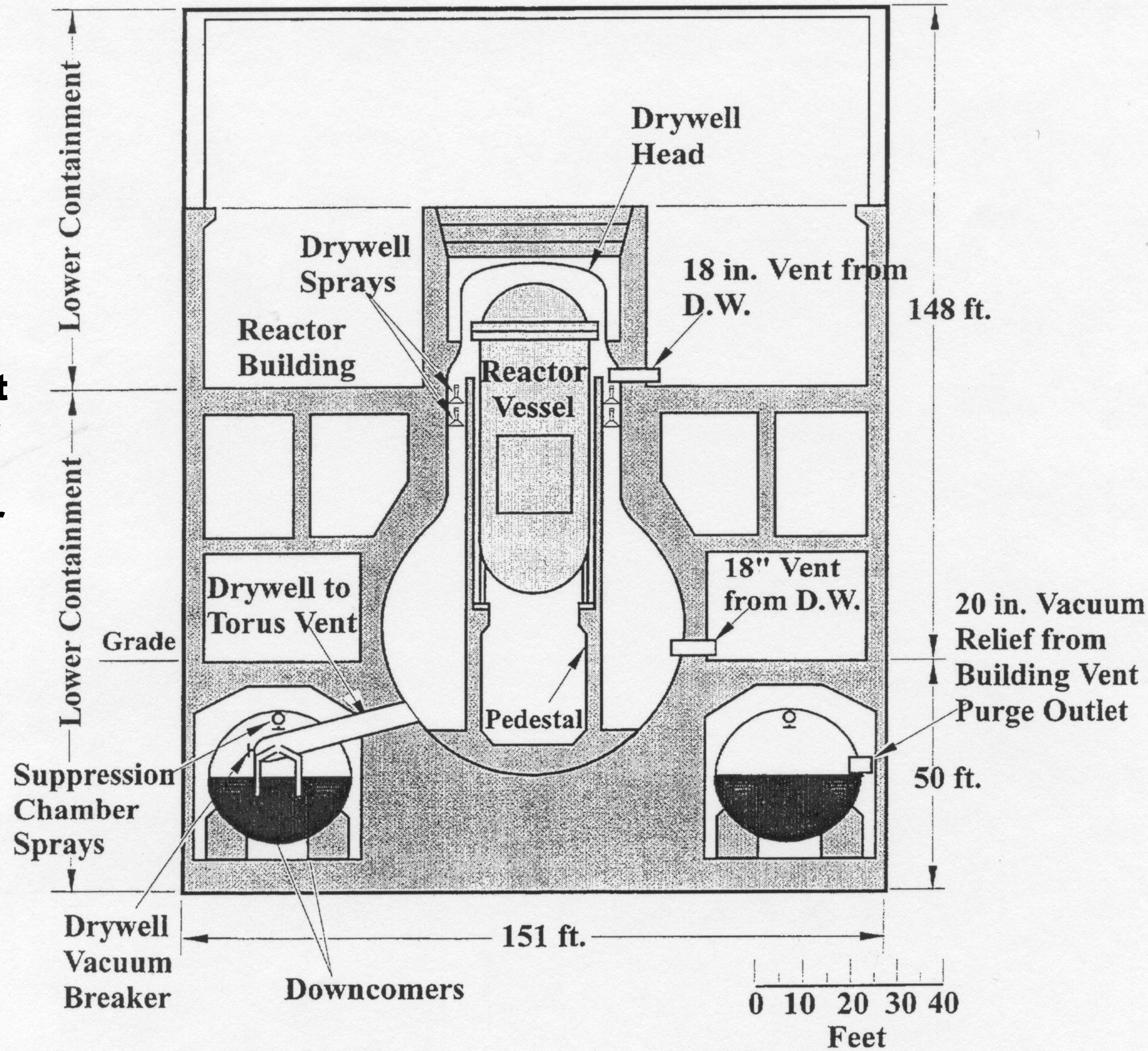
Background



Fermi Unit 2 features a boiling water reactor (BWR). Water flowing past the nuclear fuel inside the reactor vessel is heated to boiling by the thermal energy released by splitting atoms. Steam flows from the reactor vessel to the turbine which spins to generate electricity. The steam is cooled down, converted back into water, and sent back to the reactor vessel to do it all over again.

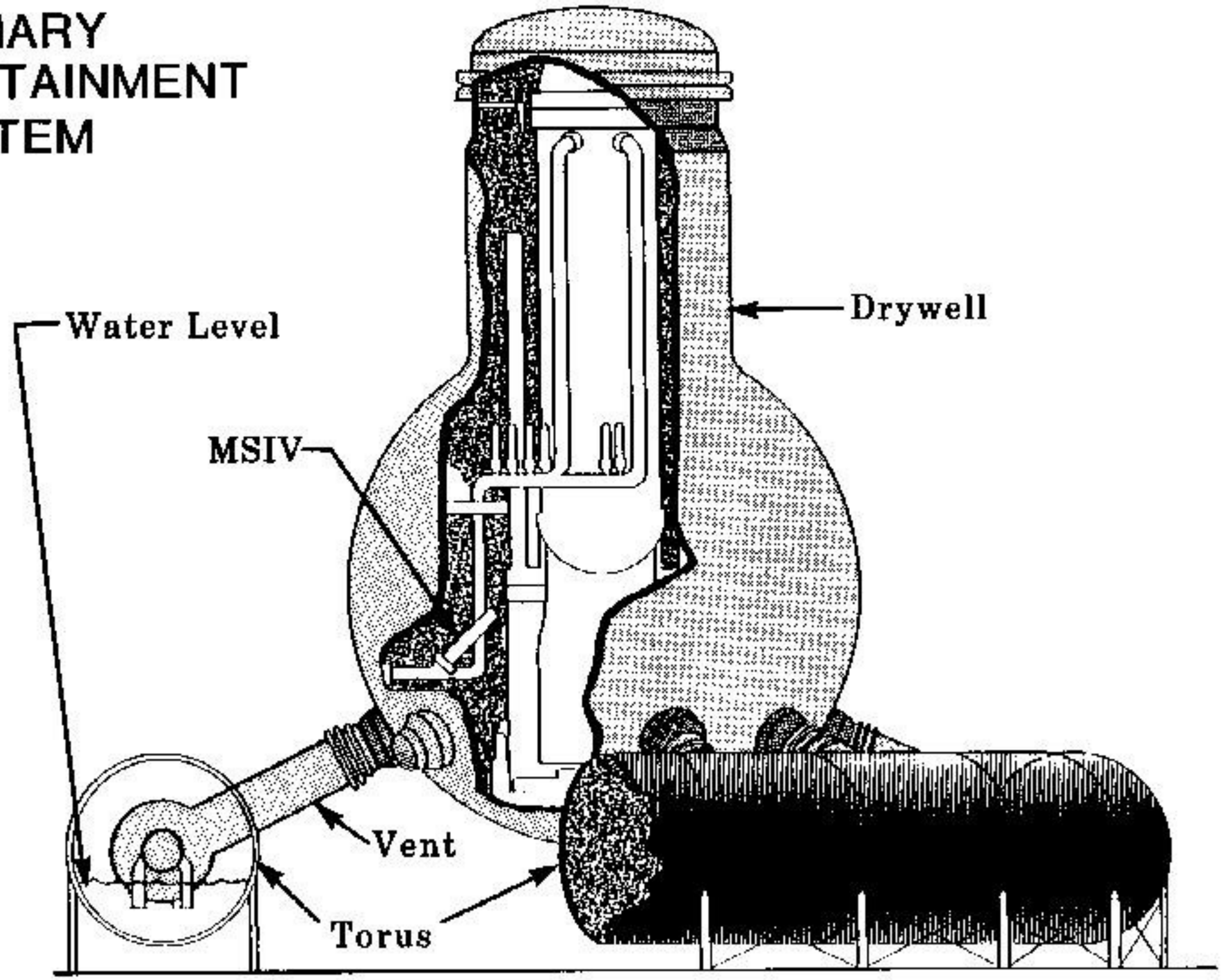
Fermi Unit 2 has a Mark I containment design.

A Mark I containment consists of a primary containment enclosing the reactor vessel and a secondary containment surrounding the primary containment and housing the emergency equipment that cools the nuclear fuel and containment in event of an accident.

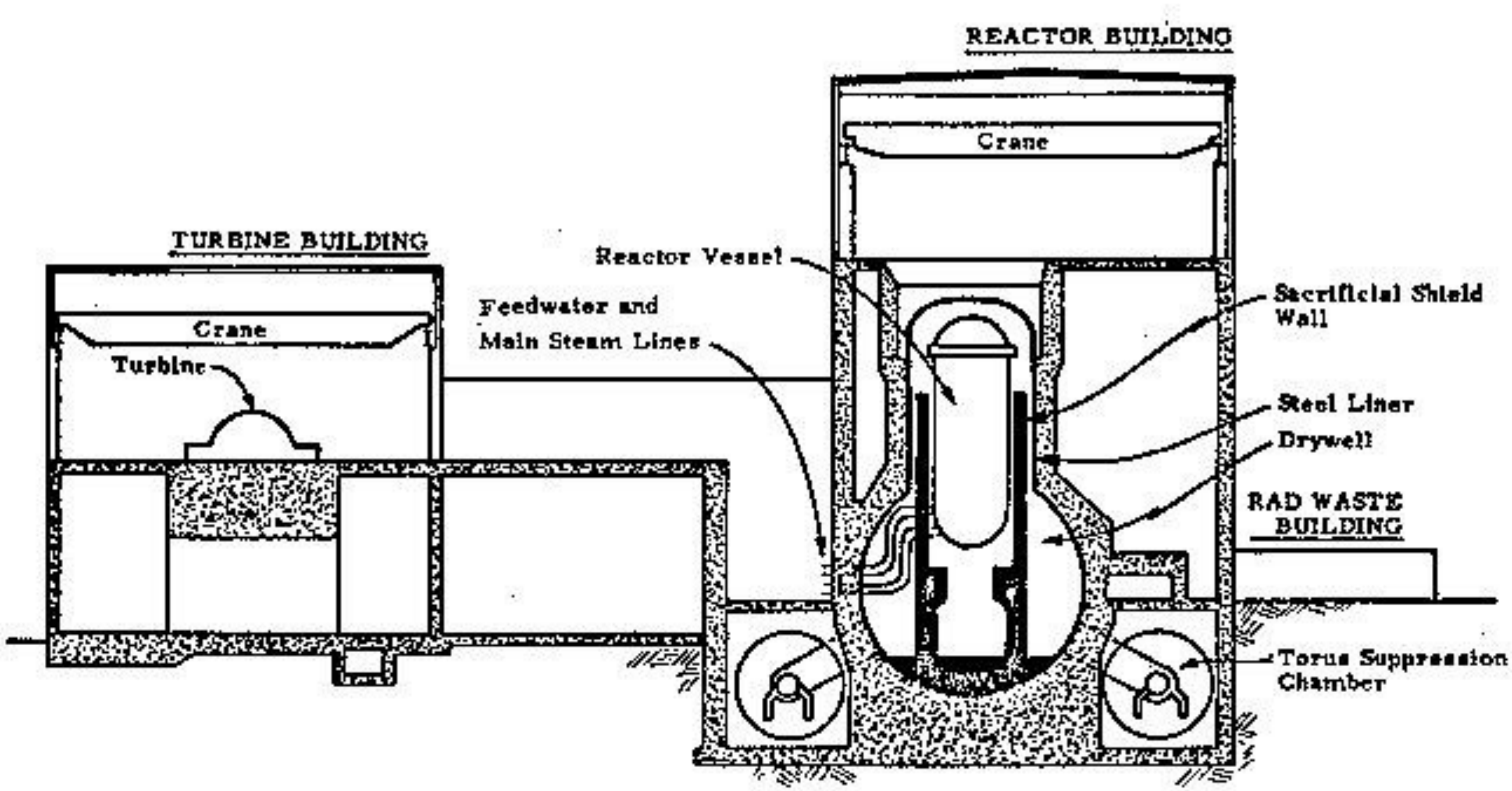


Typical BWR Mark I containment

PRIMARY CONTAINMENT SYSTEM



The Mark I primary containment design is often compared to an inverted lightbulb (drywell) sitting inside a donut (torus or wetwell).



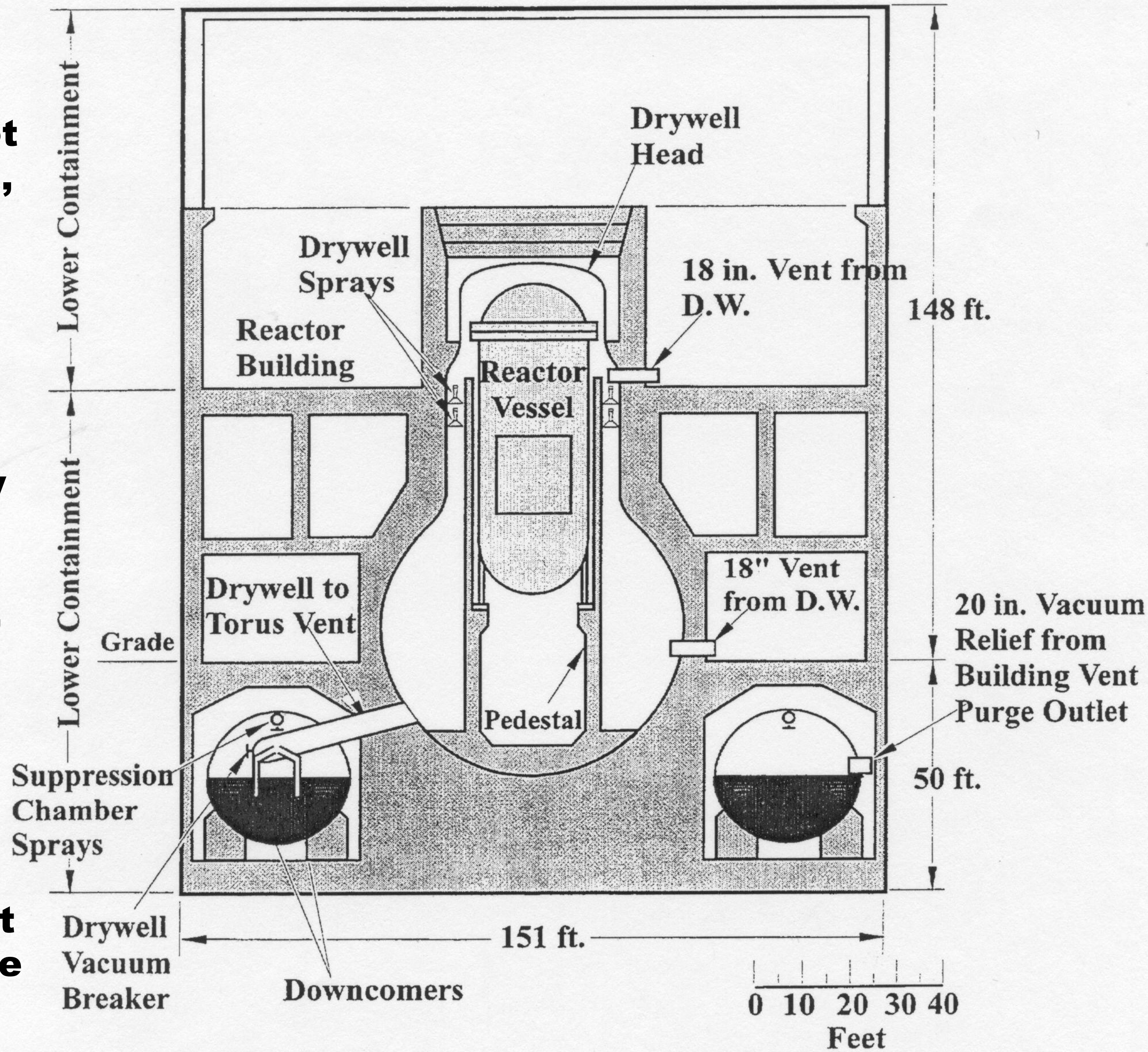
Drywell-Torus Containment Arrangement for BWR Systems

Collectively, the primary and secondary containments have three nuclear safety objectives during an accident: (1) contain radioactivity to protect workers and the public from excessive radiation exposures, (2) provide a heat sink for energy released, and (3) supply water to emergency systems that cool the nuclear fuel and containment.

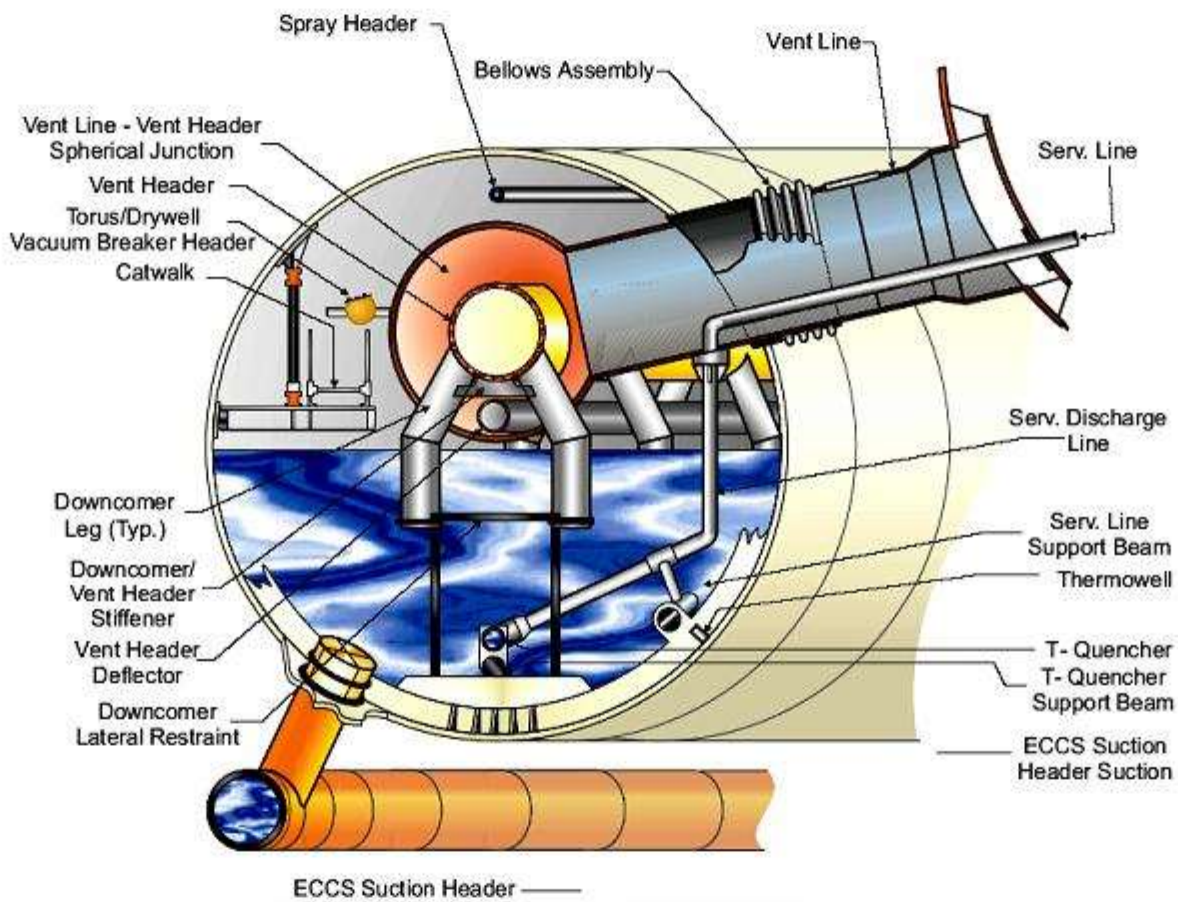
The primary and secondary containments are not leak-tight structures, but minimize the amount of leakage.

In addition, an emergency ventilation system keeps the secondary containment pressure below the outside air pressure, causing clean air to leak in rather than allow radioactively contaminated air to leak out.

This enables the first safety objective to be met.

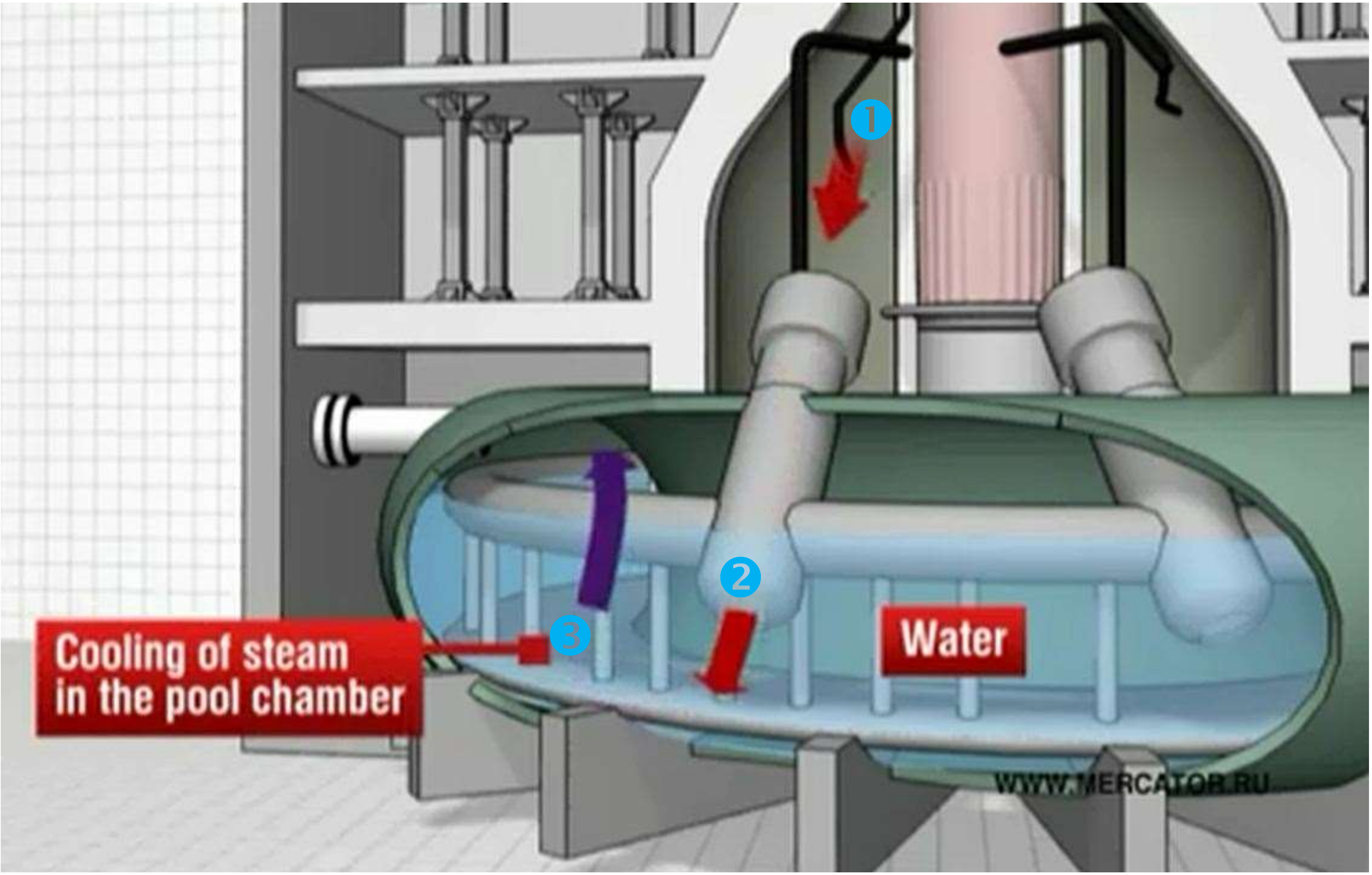


Typical BWR Mark I containment

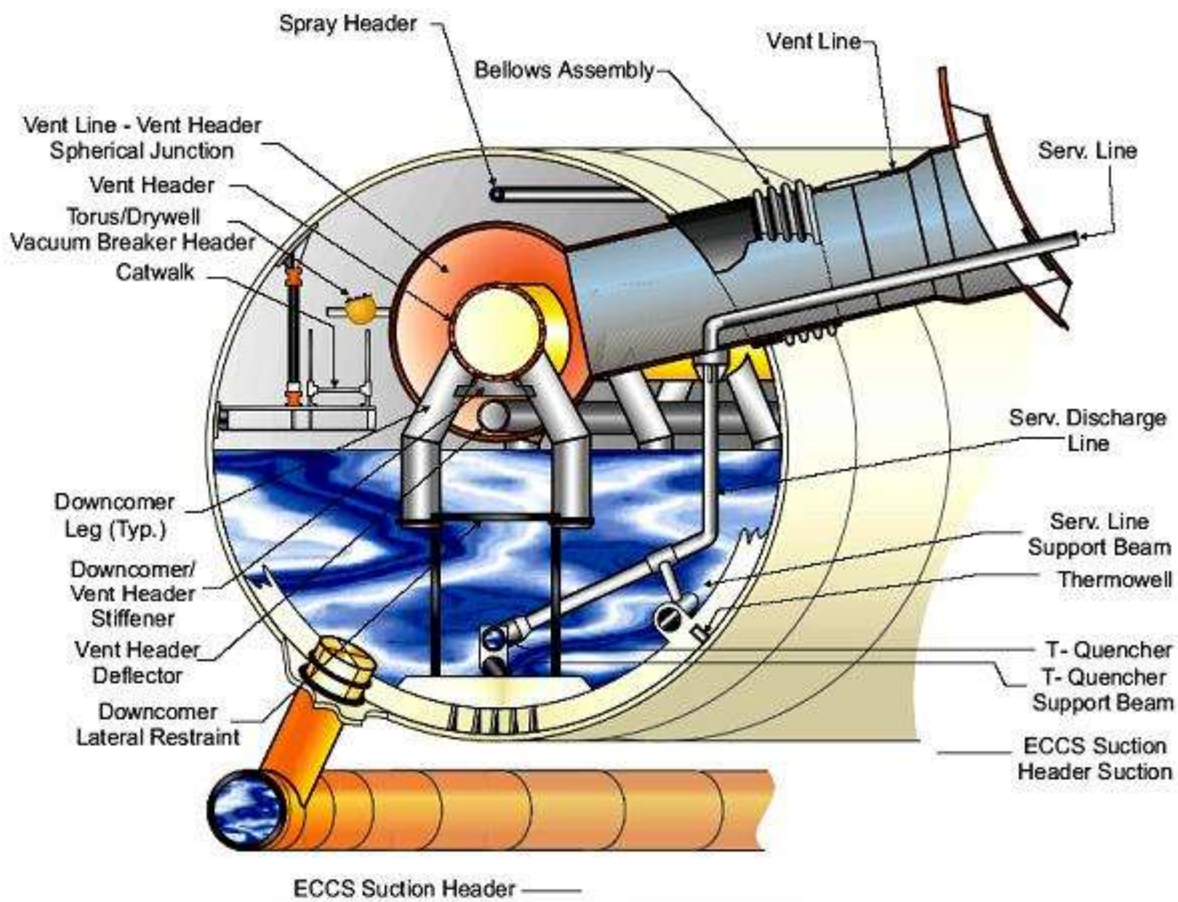


This cross-section of a torus shows one of the eight vent pipes connecting the drywell to the wetwell (torus). The torus is partially filled with water. Energy released from the nuclear fuel during an accident is absorbed by the torus water to cool the core and minimize the pressure rise inside the drywell.

This enables the second safety objective to be met.

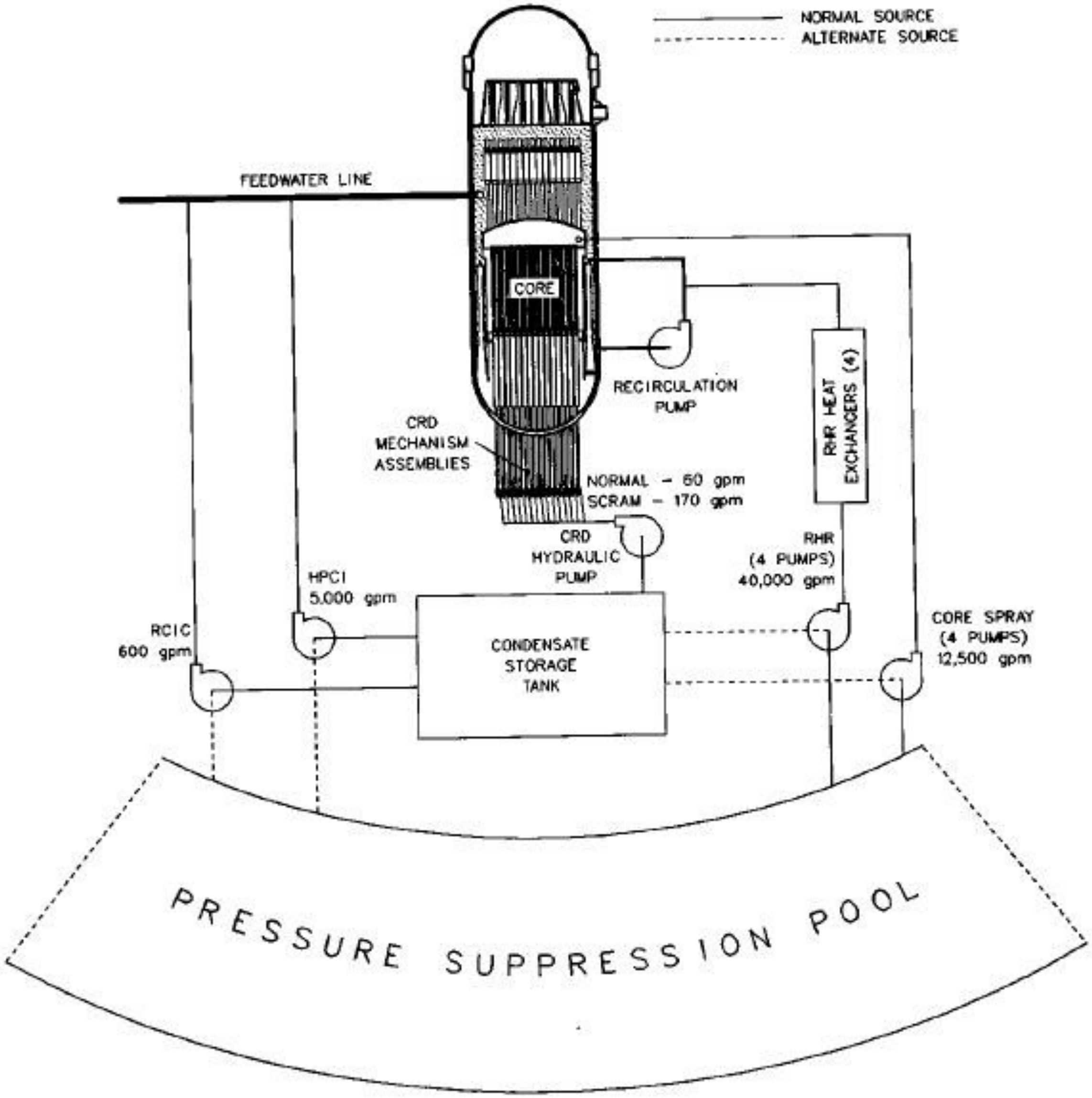


This graphic shows a pipe connected to the reactor vessel that has broken (1), releasing steam into the drywell. The steam is pushed through the vent pipes into the torus (2). The steam flows out of the downcomers below the torus water surface (3). The water converts the steam back into water.



This cross-section of a torus shows a second, smaller "donut" called the ECCS suction header. The emergency pumps draw water from this header to cool the nuclear fuel, containment, and other essential plant components. In some BWRs, each emergency pump penetrates the torus wall to get water rather than drawing it from a shared header.

Either way, this enables the third safety objective to be met.

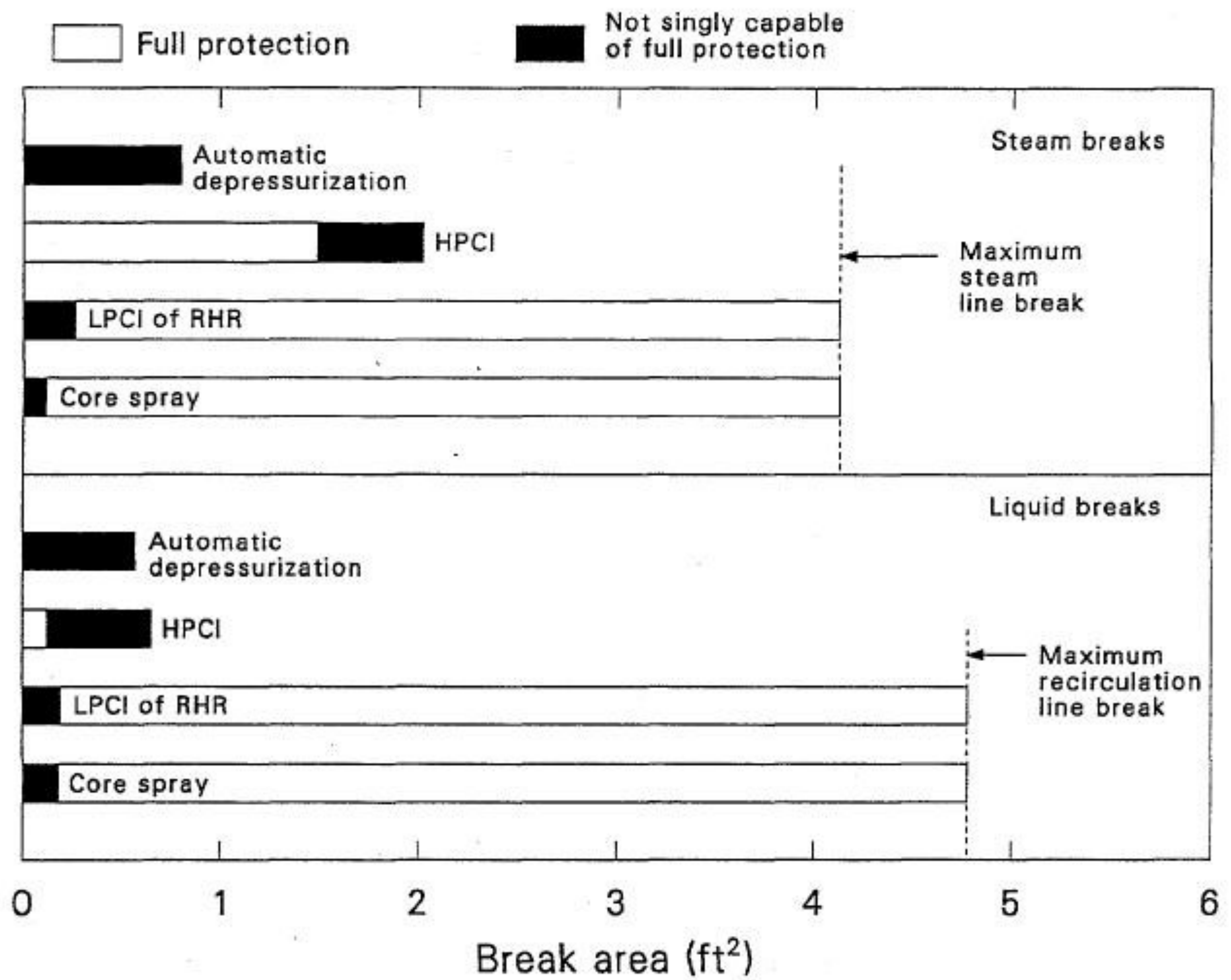


Simplified diagram of reactor vessel injection systems

ALL the emergency core cooling system pumps draw water from the pressure suppression pool (torus).

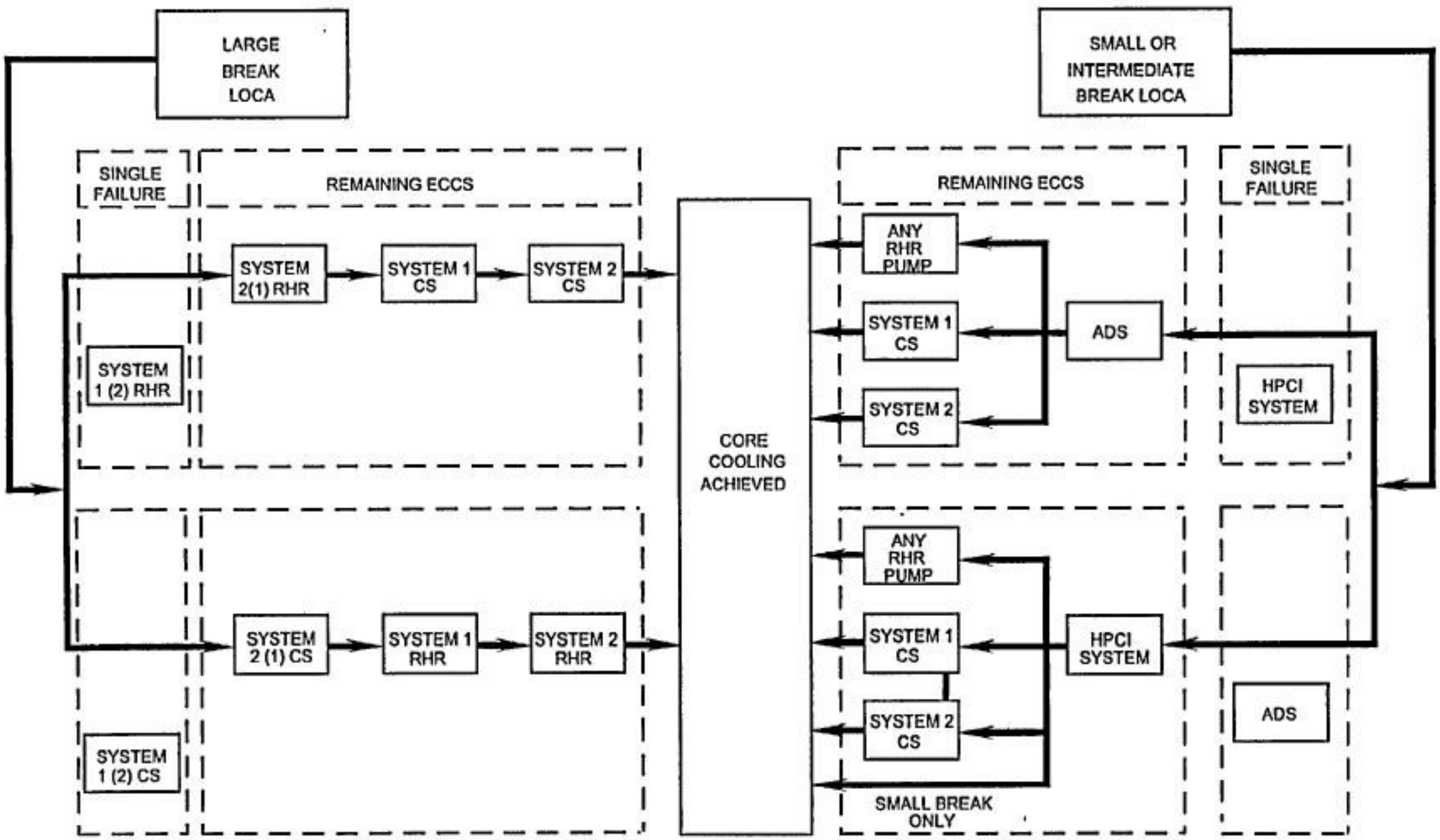
The Reactor Core Isolation Cooling (RCIC) and High Pressure Coolant Injection (HPCI) are pumps driven by steam turbines that enable high pressure makeup to the reactor vessel.

The Residual Heat Removal (RHR), Core Spray, and Control Rod Drive (CRD) pumps are motor-driven pumps.



Emergency core cooling system performance for two worst-case scenarios.

The array of emergency core cooling systems features both high pressure and low pressure pumps to mitigate accidents caused by the rupture of a large-diameter pipe or the rupture of a small-diameter steam-filled or water-filled pipe.

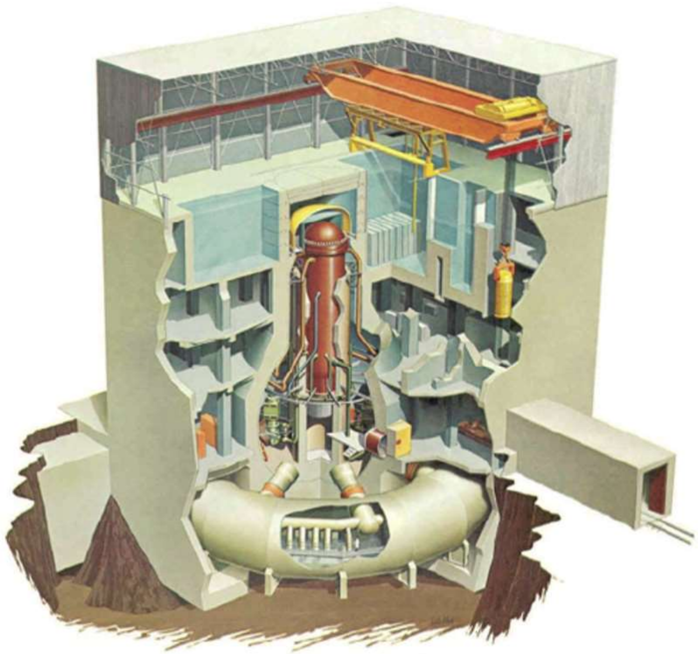


The array of emergency core cooling systems has redundancy to mitigate an accident even if a single pump or system were to fail. As long as failure is limited to one pump or system, adequate core cooling is assured.


Foreground

NRC Launches Special Inspection at Fermi Nuclear Power Plant

The Nuclear Regulatory Commission has launched a special inspection at the Fermi nuclear power plant to determine if degraded paint inside a portion of the reactor containment could impact certain safety systems in accident conditions.



DRYWELL TORUS

During a recent engineering inspection, the NRC noted a degradation in the paint inside the torus, a donut-shaped component of the reactor containment located below the reactor vessel. Filled with water, the torus is designed to absorb energy from the reactor or supply water to safety systems during an accident. Loose paint chips from the torus could potentially impede the flow of water to safety-related equipment.

NRC's five-person inspection team will focus on establishing a sequence of events related to degraded paint in the torus; reviewing the plant's maintenance practices; and assessing the overall response since the discovery of the condition.

On July 11, 2019, the Nuclear Regulatory Commission (NRC) announced it was sending a Special Inspection Team to investigate degradation of a coating applied to the interior surface of the torus.

TABLE 6.2-8 PRIMARY AND SECONDARY CONTAINMENTS SURFACE COATING SCHEDULE PRIMARY CONTAINMENT

Type of Coating	Location	Average DFT[a] (mils)	Total Surface (ft^2)	Approx. Dry Film Density (lb/ft^3)	Total Volume (ft^3)	Total Mass (lb)
Carbo Zinc 11	Drywell interior steel Interior structural steel hangers and supports	7	125,000	217	73	15,841
Plasite 7155[bc]	Torus interior	12	67,000	150	66.9	10,035
Ameron 66 and Surfacer[b]	RPV support pedestal Drywell concrete floors Drywell concrete walls	1/16 in. plus10 mils	7,380	125	44.6	5,575
Galvanox I or Galvanox V	Weld joints on galvanized ductwork	5	775	202	0.36	73
Mill Scale and Varnish	Uninsulated carbon steel piping, structural steel	3.4	89,000	350	25.22	8,827
Unqualified Paints[e]	Miscellaneous equipment	0.7 to 2.5	972	90 to 150	0.128	15
Unqualified Paints[e]	Drywell Fan Enclosures	7	801	123	0.47	58
Unqualified Paints[e]	Reactor Recirculation Pump "B" Stator Housing	7	168.6	108.7	0.098	11
Carboguard 890N	Drywell floor Dado	6	[illegible]	[illegible]	[illegible]	[illegible]
Keeler Long KLE1-7475	Reactor Recirc Pump Motor "A"	13.5	[illegible]	[illegible]	[illegible]	[illegible]

The inner surface of the torus is coated with over 10 thousand pounds of material to protect the torus metal from rusting and other degradation

Requested Actions

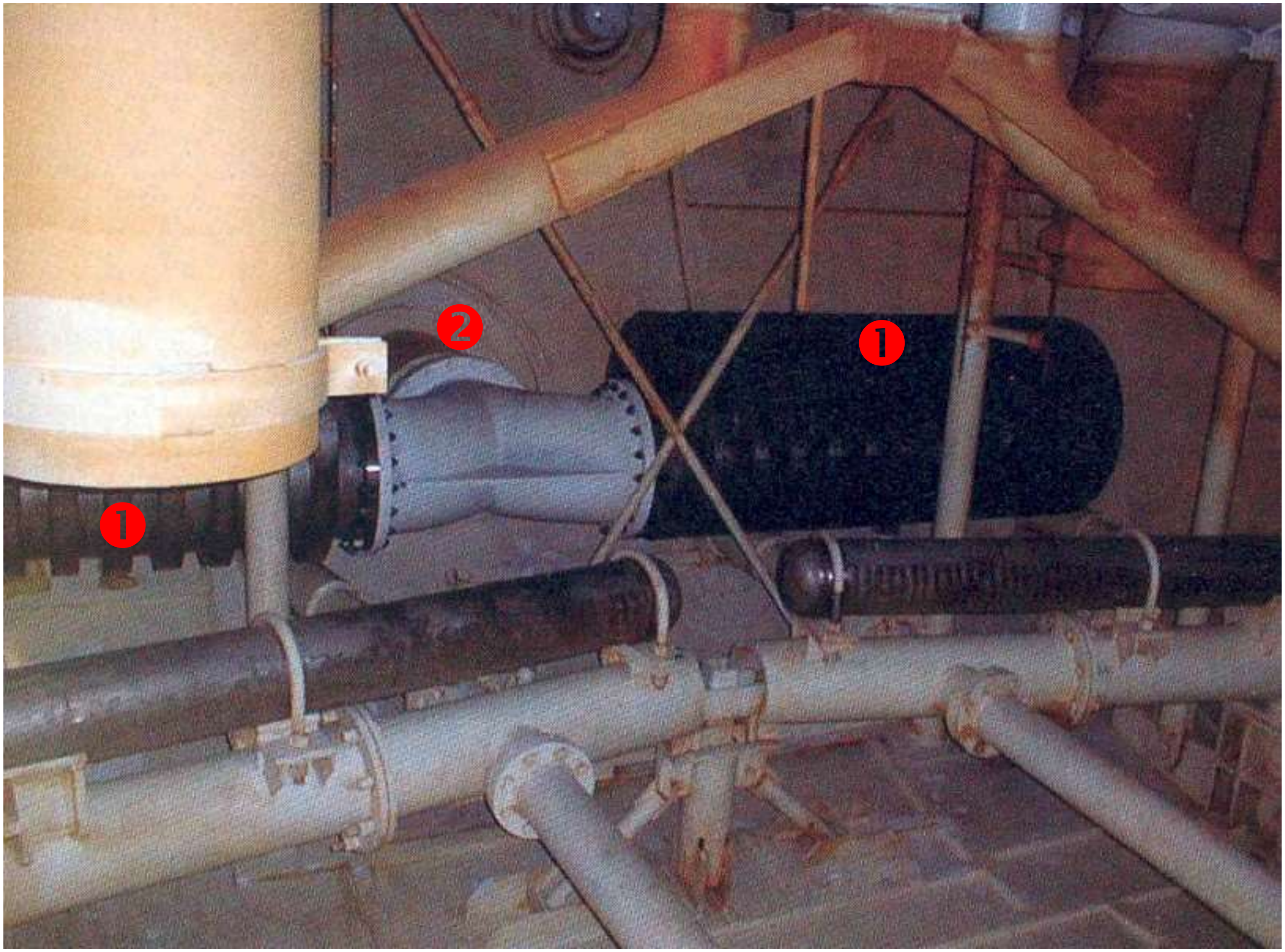
All BWR licensees are requested to implement appropriate measures to ensure the capability of the ECCS to perform its safety function following a LOCA. The staff has identified three potential resolution options; however, licensees may propose others which provide an equivalent level of assurance that the ECCS will be able to perform its safety function following a LOCA. The three options identified by the staff are as follows:

Option 1: Installation of a large capacity passive strainer design.

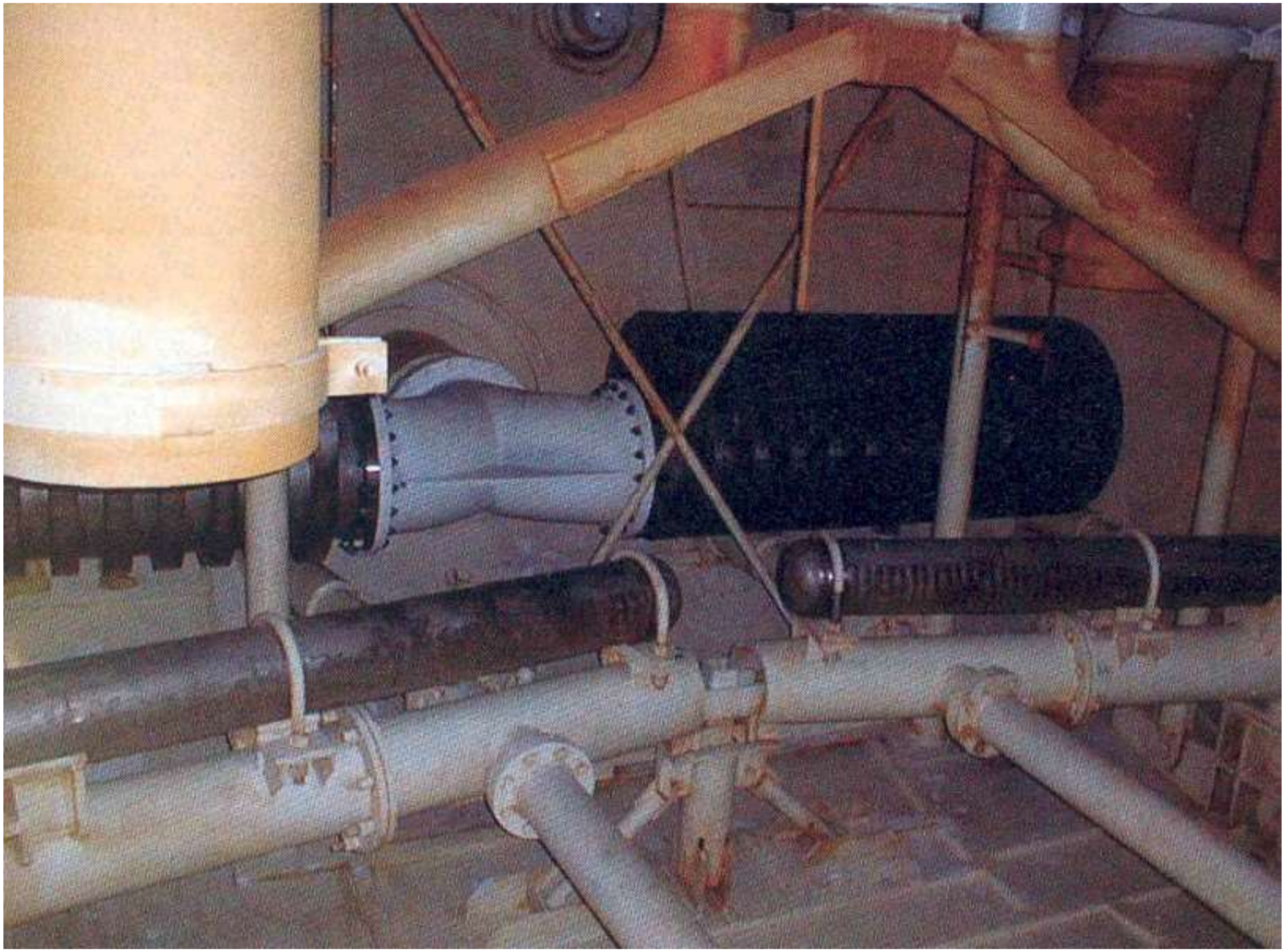
If this option is selected by a licensee, the strainer design used should have sufficient capacity to ensure that debris loadings equivalent to a scenario calculated in accordance with Section C.2.2 of RG 1.82, Revision 2, do not cause a loss of NPSH for the ECCS. This option has two main advantages. First, it is completely passive and, therefore, requires no operator intervention. Second, it does not require an interruption of ECCS flow. While this is the most advantageous of the options identified, the staff recognizes that it may be difficult for some licensees to implement this option owing to the difficulty in providing sufficient structural support for the strainers to handle LOCA-induced hydrodynamic loads. However, the staff notes that licensees may take appropriate measures in combination with this option to reduce the potential debris sources in containment and the suppression pool, which would, in turn, reduce the required capacity and physical size of the strainer, and therefore, assist in reducing the structural burden of the strainer installation. Licensees choosing this option for resolution should establish new or modify existing programs, as necessary, to ensure that the potential for debris to be generated and transported to the strainer surface does not at any time exceed the assumptions used in estimating the amounts of debris for sizing of the strainers in accordance with RG 1.82, Revision 2.

In May 1996, the NRC warned BWR owners that coatings scoured off surfaces, insulation torn off piping, and other debris created by the high velocity water jetting from a broken pipe inside containment could block the emergency pumps drawing water from the torus (and actually had blocked pumps at BWRs in Ohio and Sweden.)

The NRC required owners to lessen the vulnerability to pump blockage by either of three options, the first option being installing larger strainers capable of handling the amount of debris estimated to be created in an accident.



This picture taken inside a torus drained of water shows larger strainers (1) attached to a pipe penetrating the torus wall (2) to supply water to emergency pump(s).



Strainers prevent debris in water from being carried to the pumps and causing them to be disabled or degraded.

A.1.82 REGULATORY GUIDE 1.82 (May, 1996, Revision 2), WATER SOURCES FOR LONG TERM RECIRCULATION COOLING FOLLOWING A LOSS-OF-COOLANT ACCIDENT

Consistent with Section D, the Detroit Edison response to NRC Bulletin 96-03 committed to replace the original RHR and CS suction strainers with new, larger passive strainers designed to meet the sizing criteria of Revision 2 of this regulatory guide. The new strainers, which were designed and installed in RF06, are of the GE optimized stacked-disk [OSD] design. Whereas the original design sizing was predicated on the deterministic assumption of 50% plugging, the new OSD strainers were designed under the commitment to satisfy the mechanistic design methodology described in Revision 2 of the Regulatory Guide. In their closure of the Fermi response to Bulletin 96-03, the NRC expressed their understanding that the design of the Fermi OSD strainers was performed in accordance with the method provided in NEDO-32686, BWROG Utility Resolution Guidance. The NRC SER that approved the URGs did not accept its proposed analytical methodology for calculating debris head loss and instead stipulated that the calculation of debris head loss were based on vendor supplied analytical correlations developed from tested performance. This requirement is satisfied by utilizing the debris head loss methodology in the NRC-approved GE Licensing Topical Report NEDO-32721P-A, except as modified to correct elements of the method affected by errors identified in GE Safety Communication 08-02.

The owners of Fermi 2 went with the first NRC option and installed larger strainers for the plant's emergency pumps. The new strainers were backed by analyses of how much debris might be created during an accident and transported to accumulate on the strainers.

Larger strainers were installed at Fermi 2, but (and it's a large BUT) the design of the replacement strainers assumed several factors including potential sources of debris that could accumulate on the strainers.

If the degradation of the torus coating is extensive, the strainers could be loaded with more debris than they are designed to handle.

If that were to occur, one or all of the containment's three safety objectives could be compromised/

So what?

3.6 CONTAINMENT SYSTEMS

3.6.2.2 Suppression Pool Water Level

LCO 3.6.2.2 Suppression pool water level shall be ≥ −2 inches and ≤ +2 inches.

APPLICABILITY: MODES 1, 2, and 3.

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. Suppression pool water level not within limits.	A.1	Restore suppression pool water level to within limits.	2 hours
B. Required Action and associated Completion Time not met.	B.1	Be in MODE 3.	12 hours
	AND		
	B.2	Be in MODE 4.	36 hours

At Fermi 2, the minimum amount of water in the torus for continued operation of the reactor is 905,738.94 gallons. If too much or too little water is in the torus, workers must restore the proper amount within 2 hours or shut down the reactor within the next 12 hours.

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	B.2 Be in MODE 4.	36 hours

The torus coating in question could result in the torus having sufficient water, but none of the emergency pumps being able to use it. How many hours, nay months, will it take the NRC to determine whether Fermi 2 is safe, or not? It's already taken more than 14 hours.


(un)Fairground
People might be protected from an accident
at Fermi 2, unless an accident happens.