NUCLEAR REGULATORY COMMISSION

Installation and Operation of Hardened Vent From Suppression Pool Airspaces of Boiling Water Reactors (BWRs) with Mark I Containments

AGENCY: Nuclear Regulatory Commission

ACTION: Draft Generic Environmental Assessment and Finding of No Significant Impact

SUMMARY: The installation of the hard pipe vent in Mark I plants will reduce the environmental consequences of a severe accident involving loss of long-term decay heat removal capability and provide a significant improvement in safety.

Installation or use of the hard pipe vent will not have any significant environmental impact.

The incremental occupational radiation dose for the proposed operation of the hard pipe vent path is insignificant (unmeasurable) because the vent path would be operated from the control room. The licensees should be able to keep the small radiation doses associated with the installation of the hard pipe vent path within the limits of 10 CFR Part 20, and as low as is reasonably achievable.

Furthermore, the non-radiological impacts of the hard pipe vent path will be insignificant. None of the alternatives is practical or reasonable, and three of the alternatives would produce greater environmental impact than the proposed action. Addition of the external filter would have the same environmental impact as the proposed action, but at an unreasonable cost for minimal increase in benefit.

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Alternative Use of Resources

This action does not involve the use of significant resources beyond the existing resources used for piping and replacement parts at all nuclear plants.

Agencies and Persons Consulted

The NRC staff is initiating this action based on research performed by the Office of Nuclear Regulatory Research. No other agencies or persons were consulted.

DATE: The comment period expires . Comments received after this date will be considered if it is practical to do so, but assurance of consideration cannot be given except to those comments received on or before this date.

ADDRESS: Send comments to the Regulatory Publication Branch, Division of Freedom of Information and Publication Services, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555. Copies of the comments may be inspected and copied for a fee at the NRC Public Document Room, the Gelman Building, 2120 L Street, N.W., Washington, DC.

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SUPPLEMENTARY INFORMATION

Background

In SECY-87-297 (Reference 1), the NRC staff presented to the Commission its plan to evaluate generic severe accident vulnerabilities of containments. The staff's plan included a program for Containment Performance Improvement (CPI). This program was initiated to determine whether there may be generic severe accident challenges to light water reactor (LWR) containments that should be assessed to ascertain whether additional regulatory guidance or requirements concerning containment features are warranted. The staff concluded that such assessments are needed because of the relatively large uncertainty in the ability of some LWR containments (that is, Mark I) to successfully survive some possible severe accident challenges (as indicated by draft NUREG-1150 (Reference 2)). The CPI program is intended to resolve hardware and procedural issues related to generic containment challenges. The staff presented its findings related to the Mark I CPI program to the Commission in SECY-89-017 (Reference 3), dated January 23, 1989. In one of the findings, the staff concluded that properly implemented venting can significantly mitigate potential accident risks.

The capability to vent has long been recognized as important in reducing risk at boiling water reactor (BWR) Mark I facilities for accidents involving loss of ability to remove long-term decay heat (TW). Controlled venting at pressures close to the containment's pressure limits can prevent the long-term overpressurization and failure of containment, the failure of emergency core cooling system (ECCS) pumps from inadequate net-positive suction head, and the failure of the automatic depressurization system (ADS) caused by the failure of

ADS valves to operate. Venting of the containment is permitted in the BWR emergency operating procedures. A vent path from wetwells of the containments exists for some Mark I facilities. However, this vent path includes a ductwork system that has a low design pressure of only a few psi. Venting under high-pressure conditions (as would be required for accidents involving high-pressure challenges, either before or after core melt) could fail this ductwork, releasing the containment atmosphere into the reactor building (with eventual release to the environment), and potentially contaminating or damaging equipment needed for accident recovery.

In addition, with the existing hardware and procedures at some plants, it may not be possible to open or to close the vent valves during certain accident sequences. The inability to operate the vent path valves could result in uncontrolled release of containment atmosphere to the reactor building through the failed sheetmetal ductwork. Therefore, venting through a sheet metal ductwork path, as implemented at some Mark I plants, is likely to greatly hamper or complicate post-accident recovery activities, and is viewed by the NRC staff as inadequate for minimizing the risks to the public health and safety. For high-pressure venting to be effective, the entire vent system must be strengthened to withstand the expected venting pressure. On July 11, 1989 (Reference 4), the Commission endorsed the staff's view that the Mark I design should include a hardened vent from the airspace of the containment wetwell, and directed the staff to require a hardened vent capability for all Mark I plants for which the requisite modifications could be shown to be cost-effective.

Description of the Proposed Action: Installation of a Hardened Vent

The NRC staff's safety evaluation report (Reference 5) approved Revision 4 of the Emergency Procedure Guidelines (EPGs) that included the staff's approval for venting BWR Mark I containments. This approval indicated that venting with the existing systems could reduce the likelihood of core melt and, in extremely rare cases, could help avoid uncontrolled releases of radioactive materials during severe core damage accidents. Since the issuance of Revision 4 of the EPGs, additional insights indicate that a venting strategy that has a potential to breach the vent path inside the reactor building could have significant detrimental effects on (1) radiation exposure impact on personnel, (2) potential plant recovery actions, and (3) public risk. A hard pipe vent capable of withstanding the anticipated severe accident pressure loadings would eliminate these disadvantages of using a vent path containing sheetmetal ductwork.

The use of the containment vent to prevent a core melt accident, by reducing containment pressure, would result in the release of very low levels of radioactivity associated with the reactor coolant. The reactor coolant steam would be released to the suppression pool that would retain most of the fission products. In the unlikely event of a core melt accident, venting of the wetwell airspace would provide a scrubbed venting path to significantly reduce the release of particulate and volatile fission products (radioactive materials) to the environment. Only the noble gases would escape to the environment without any attenuation. Venting would reduce the likelihood of a late overpressure failure of the containment and would reduce offsite consequences for severe accidents provided that the containment shell does not fail.

If the shell fails because of a core debris attack (shell melt through by core melt released to the containment floor), venting will provide little benefit because fission products would be released directly into the reactor building. However, if shell failure was delayed for a period of a few hours (for example, by the addition of containment spray water over the molten core debris released to the containment floor), significant scrubbing of radioactive material would still take place. A recent analysis has been performed on the effects of water on core debris in the drywell (Draft NUREG/CR-5423, "The Probability of Liner Failure in a Mark I Containment" currently released for peer review). Preliminary results indicate that the presence of substantial quantities of water in the containment floor area on top of any molten core debris that would result from injection of water from available sources, will very likely prevent containment shell melt through and failure as a result of a core debris attack. The overlying pool of water will also provide scrubbing of fission products released in the aerosols generated by core melt and concrete interactions.

As proposed in SECY-87-297 (Reference 1), the installation of a hard pipe to bypass the ductwork from the wetwell airspace to the plant stack could include (1) additional isolation valves to isolate the ductwork path from the hard pipe vent path, and (2) radiation monitor(s) to monitor any offsite releases of radioactive materials, in case of venting. The proposed action would prevent failure of the vent path inside the reactor building and, in the unlikely event of core melt, would result in release only of residual fission products (not scrubbed by the suppression pool) through the stack. Because the vent path is not expected to fail inside the reactor building, personnel would be able to repair equipment and perform other plant-recovery activities, provided the levels of radiation in the containment are not excessive. Furthermore, because the environmental conditions in the reactor building would not be harsh, important equipment would not be expected to degrade or fail.

In the proposed action, all potential releases through the hard pipe vent will be scrubbed by the suppression pool water that will reduce the radioactive material released to the environment, but will not decrease the release of the noble gases. The effectiveness of the scrubbing is affected by the temperature of the suppression pool water. Depending upon the temperature, the decontamination factors could vary from three orders of magnitude to one order of magnitude, but over the course of the accident, the effective decontamination factor would be about two orders of magnitude (100). However, as long as water is present, all releases to the vent will first pass through the water that will retain substantial fractions of radioactive material. Additionally, the use of the hard pipe vent could prevent or delay core degradation for those accidents where containment failure results in core degradation, as previously explained.

The estimated reductions in the values of the total core damage frequency per reactor-year are shown in Table 1 for each Mark I plant. The risk reduction in man-rems per reactor year is also shown in Table 1 (the bases and assumptions for the staff analyses are presented in Reference 6). The hard vent path would also provide additional risk reduction for those accidents where core melt has occurred, because the suppression pool would scrub the radioactive material released by molten core.

The NRC staff estimated the costs for installation of the hard pipe vent path to be about $750,000 (Reference 7). Costs were also provided by the licensees for the Dresden, FitzPatrick, Millstone, and Oyster Creek facilities.

The costs are minimal when compared to the operating expenses of the plants and are not excessive when compared to the significant enhancement of safety achieved by the proposed action. The NRC and the licensees' costs are summarized in Table 1.

Environmental Impacts of Installation and Operation of a Hard Vent

Radiological Impacts

The radiological impacts of installation of a hard pipe vent system should not be significantly different from other operational modifications that occur at facilities such as reactors with Mark I containments. For example, a conceptual analysis of radiation exposures for installation of a filtered vent at the Limerick Generating Station indicates that annual radiation exposures (assuming 20 years of remaining plant life) would not exceed 2 man-rems per reactor-year. The small radiation dose associated with this proposed plant modification will not affect the licensee's ability to maintain individual occupational doses within the limits of 10 CFR Part 20, and is expected to meet the criteria for the requirements of as low as is reasonably achievable (ALARA).

Each plant contains radioactive waste treatment systems that are designed to collect and process the gaseous, liquid, and solid waste that might contain radioactive material. The proposed installation of a hard pipe vent will not affect any waste treatment systems or their effluents under normal plant conditions or under design basis accident conditions.

Installation of the hard pipe vent path should not significantly increase the radiation dose to operating personnel or the public. Any increased doses associated with the testing of the additional isolation valves should be minimal and, in most cases, insignificant.

Thus, we have concluded that the proposed installation of the hard pipe vent will not result in any significant increase in radiological impacts to workers or the public.

Because the operation of the wetwell vent system is postulated for extremely rare severe accidents, the impacts of the use of the wetwell vent system are discussed in terms of environmental risks. As stated previously, the venting from the wetwell airspace is intended to (1) reduce the risk of over-pressure failure of the containment and subsequent damage to the reactor core, and (2) provide a scrubbed pathway (to decontaminate effluents) for containment pressure relief for rare situations involving core damage. Table 1 shows a listing of reduction of potential risks for all Mark I facilities caused by venting prior to core damage. The reductions in potential risk are calculated to range from 15.3 to 281.9 man-rems per reactor year. For rare situations where core damage could occur, venting could prevent containment failure and unmitigated release of fission products to the environment. Venting through the suppression pool will ensure that most of the radioactive materials, excluding noble gases, would be trapped in the suppression pool and would not be released to the environment. Therefore, the use of the vent system would reduce the radiological risks posed by severe accidents involving core damage. These additional benefits of venting have not been included in Table 1 results.

Based on the preceding discussion, we conclude that there will be no incremental environmental risks posed by operation of the wetwell vent system.

Non-radiological Impacts

The non-radiological impacts of installation of hard pipe vent system are not expected to be different from other operational modifications that occur at facilities such as reactors with Mark I containments during routine plant outages.

No non-radiological effluents are expected to be affected by the installation or use of the hard pipe vent. The proposed plant modification and use of hard pipe vent will not require any change to the national pollution discharge elimination system (NPDES) permit.

Therefore, the staff concludes that the non-radiological environmental impacts of installing a hard pipe vent will be insignificant.

Alternatives Considered

To prevent or delay containment failure caused by overpressurization, the NRC staff considered the following alternatives to the proposed action:

1. The containment pressure could be relieved using the existing ductwork vent path (the "No Action" option).

2. A hard pipe path to an external filter could be installed.

3. An alternate means of removing the decay heat either from the reactor or from containment could be installed.

4. Venting of containment could be prohibited.

Each of these alternatives to the proposed action is discussed in the following paragraphs..

Existing Ductwork Vent Path (No Action Option)

This alternative consists of no action and continued venting of the containment through the existing ductwork. However, the existing ductworks are designed to withstand a pressure of a few psig (Reference 8). The venting pressures expected during some accidents will be substantially higher than the ductwork design pressure. Consequently, venting could result in failure of the ductwork and a direct release of reactor coolant steam into the reactor building. The discharge of this high-temperature steam and other gases over an extended period of time could pose a threat to the availability or performance of safety-related equipment. In the event of core melt, the threat would be even greater, because substantially large amounts of radioactive materials will be released with the steam to the reactor building. Electrical cables, motor operators on valves, and relays could fail under these environmental conditions.

Adverse environmental conditions would also complicate personnel entry into the reactor building. Calculations from a study that examined venting during an anticipated transient without scram (ATWS) sequence indicated that a severe environment (high temperature and radiation) would be present in the reactor building during venting (Reference 9). The discharge of hydrogen under core melt conditions could result in hydrogen burns or detonations inside the reactor building. This environment could hamper recovery efforts by preventing personnel access to the reactor building and preventing repair of systems needed to terminate the accident. For these reasons, the existing Mark I designs do not ensure an adequate reactor building environment after a severe accident to permit personnel entry to regain control of the facility and do not maximize the potential reduction in environmental risk. Thus, the staff has concluded that the no-action alternative is unacceptable.

Installation of Hard Pipe Vent to External Filter System

This alternative is the same as the proposed action with addition of an external filter. However, the external filter would not significantly increase removal of radioactive material because the suppression pool would remove nearly all material that could be removed by filtration. Consequently, the additional reduction in risk caused by an external filter system is expected to be small. Moreover, an external filter would not yield an incremental reduction in the core damage frequency beyond the reduction obtained with the hard pipe vent alone. In both cases, there would be no retention of noble gases. External filters have been estimated to cost $20 million (1982 dollars) (Reference 10) to $65 million (1987 dollars) (Reference 11) for the Filtra design. Because the incremental benefit is very small compared to the proposed action and the incremental cost is very high, this alternative is not considered practical or reasonable.

Installation of Other Means of Decay Heat Removal

In lieu of venting containment, an additional decay heat removal system could be provided to remove the heat from either the reactor or the containment, or a system that has not been previously accounted for could be used on an ad hoc basis, such as the reactor water cleanup system. Installation of a new system was considered in NUREG-1289 (Reference 12), which is associated with Unresolved Safety Issue A-45, "Shutdown Decay Heat Removal Requirements." The instal-lation of a new decay heat removal system was not found to be cost beneficial in NUREG-1289. The use of another, previously unaccounted-for system was estimated to require unusual or unplanned system piping line-ups, which, if performed incorrectly or inappropriately, could reduce the likelihood of accident recovery with normal systems or create a new and unanalyzed accident sequence (Reference 13). Therefore, this alternative is not considered practical or reasonable.

No Venting of Containment

This alternative would remove the guidance in Revision 4 of the Emergency Procedure Guidelines (EPGs) that instructs the operator to vent the containment under certain conditions. In the event of the loss of long-term decay heat removal capability without drywell failure, the containment drywell will probably fail because of overpressurization. The drywell failure could have a significant effect on the ability to return the plant to a safe and controlled condition and would result in an increase in risk to plant personnel and to the public (Reference 14). Therefore, this alternative is not considered practical or reasonable.

Finding of No Significant Impact

The staff reviewed the plant-specific features in conjunction with the proposed hard pipe vent path modification relative to the requirements set forth in 10 CFR Part 51. From the environmental assessment, the staff concluded that there are no significant radiological or non-radiological impacts associated with the proposed action and that the proposed modification will not have significant adverse effects on the quality of the human environment. Therefore, the Commission has determined, pursuant to 10 CFR 51.31, not to prepare an environmental impact statement for the proposed plant modifications.

Table 1

Plant Name	TW*** Frequency (per reactor-year)**	Potential Risk Reduction (man-rems/ry*)**	Installation Costs (million)**
Browns Ferry 1	2.3 E-05	32.7	0.75
Browns Ferry 2	2.3 E-05	32.7	0.75
Browns Ferry 3	2.3 E-05	32.7	0.75
Brunswick 1	4.5 E-05	44.0	0.75
Brunswick 2	4.5 E-05	44.0	0.75
Cooper	4.5 E-05	45.6	0.75
Dresden 2	1.4 E-05	50.2	1.00
Dresden 3	1.4 E-05	50.2	1.00
Duane Arnold	4.5 E-05	55.0	0.75
Fermi 2	4.5 E-05	192.4	0.75
Fitzpatrick	4.5 E-05	65.5	0.68
Hatch 1	4.5 E-05	39.2	0.75
Hatch 2	4.5 E-05	39.2	0.75
Hope Creek	6.3 E-05	281.9	0.75
Millstone 1	1.4 E-05	35.1	1.10
Monticello	4.5 E-05	33.9	0.75
Nine Mile Point 1	1.4 E-05	15.3	0.75
Oyster Creek	1.4 E-05	55.4	1.50
Peach Bottom 2	3.6 E-06	15.5	0.75
Peach Bottom 3	3.6 E-06	15.5	0.75
Pilgrim	2.3 E-05	31.2	0.75
Quad Cities 1	4.5 E-05	94.1	0.75
Quad Cities 2	4.5 E-05	94.1	0.75
Vermont Yankee	2.3 E-05	28.9	0.75

* reactor year
** Reference 15
*** Accident sequences involving the loss of long-term decay heat removal capability

REFERENCES

1. SECY-87-297, U.S. NRC, "Mark I Containment Performance Program Plan," V. Stello to NRC Commissioners, December 8, 1987.

2. NUREG-1150, U.S. NRC, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants," June 1989.

3. SECY-89-017, U.S. NRC, "Mark I Containment Performance Improvement Program," V. Stello to NRC Commissioners, January 23, 1989.

4. Memorandum from S. J. Chilk to V Stello, "SECY-89-017 - Mark I Containment Performance Improvement Program," July 11, 1989.

5. Letter from A. C. Thadani to D. Grace, Chairman, BWROG, "Safety Evaluation of BWR Owner's Group - Emergency Procedure Guidelines, Revision 4, NEDO-31331, March 1987," September 12, 1988.

6. Memorandum from M. Cunningham to W. D. Beckner, "Reduction in Risk from the Addition of Hardened Vents in BWR Mark I Reactors," October 19, 1989.

7. Memorandum J. G. Partlow to T. E. Murley, "Licensees' Responses to Generic Letter 89-16 Related to Installation of Hardened Vent," November 9, 1989.

8. NUREG/CR-5225, U.S NRC, "An Overview of BWR Mark I Containment Venting Risk Implications, November 1988.

9. Harring, R.M., "Containment Venting as a Mitigation Technique for BWR Mark I Plant ATWS," 1986 Water Reactor Safety Meeting, Gaithersburg, Maryland, October 1986.

10. K. Johansson, L. Nilsson, and A. Persson, "Design Considerations for Implementing a Vent-Filter System at the BARSEBACK Nuclear Power Plant," International Meeting on the Thermal Nuclear Safety, Chicago, August 29 - September 2, 1982.

11. Long Island Lighting Company Presentation, "Shoreham Supplemental Containment System," April 1987.

12. NUREG-1289, U.S. NRC, "Regulatory and Backfit Analysis: Unresolved Safety Issue A-45, Shutdown Decay Heat Removal Requirements," November 1988.

13. Letter from J. Dallman to J. Ridgely, "A Preliminary Assessment of BWR Mark II Containment Challenges, Failure Modes, and Potential Improvements in Performance," May 10, 1989.

14. NUREG/CR-5225, Addendum 1, "An Overview of BWR Mark I Containment Venting Risk Implications, an Evaluation of Potential Mark I Containment Improvements," June 1989.

15. Memorandum from Warren Minners to Ashok C. Thadani, January 8, 1990.

Dated at Rockville, Maryland this 15th day of June , 1990.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Thomas E. Murley, Director
Office of Nuclear Reactor Regulation

NOTE: All referenced documents are available for public inspection and copying for a fee in the Commission's Public Document Room at 2120 L Street, N.W., Washington, DC 20555.

14. NUREG/CR-5225, Addendum 1, "An Overview of BWR Mark I Containment Venting Risk Implications, an Evaluation of Potential Mark I Containment Improvements," June 1989.

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Original signed by

Thomas E. Murley, Director
Office of Nuclear Reactor Regulation

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*Previously concurred [MARK I EA]

PDI-2/LA*	PDI-2/PM*	PDI-2/D*	ADRI*	DRSP*	OGC*
MO'Brien	MThadani:mj	WButler	WB for BBoger	GHolahan	LChandler
[illegible]	05/09/90	05/09/90	05/09/90	05/10/90	05/25/90

[illegible]	DRP*	DST/D*	DREP/D*	ADT*	[illegible]	OGC
JMain	SVarga	AThadani	FCongel	WRussell	JPartlow	FMiraglia
05/29/90	05/30/90	06/07/90	06/08/90	06/13/90	6/15/90	6/15/90

ONRR/D
TMurley
6/15/90

Dist./w/encl
Central File → PDR
PDI-2 Reading File
MThadani
WButler
[redacted]

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

June 18, 1990

DOCKET NO.

MEMORANDUM FOR: Regulatory Publications Branch
Division of Freedom of Information and Publications Services
Office of Administration and Resources Management

FROM: Office of Nuclear Reactor Regulation

SUBJECT: Installation and Operation of Hardened Vent From Suppression Pool Airspaces of Boiling Water Reactors (BWRs) with Mark I Containment

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