Plant-Specific Analysis

for the Dresden Nuclear Power Station, Unit 3, Regarding

Installation of a Hardened Vent

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1.0 Background

In SECY-87-297 (Reference 1), dated December 8, 1987, the Nuclear Regulatory Commission (NRC) staff presented to the Commission its program plan to evaluate generic severe accident containment vulnerabilities in a program entitled the Containment Performance Improvement (CPI) program. The staff began this effort with the premise that there may be generic severe accident challenges to each light water reactor (LWR) containment type that should be assessed to determine whether additional regulatory guidance or requirements concerning needed containment features is warranted. The premise that such assessments are needed is based on the relatively large uncertainty in the ability of some LWR containments (for example, Mark I) to successfully survive some severe accident challenges, as indicated by NUREG-1150, dated June 1989 (Reference 2). This effort is integrated closely with the program for Individual Plant Examination (IPE) and is intended to focus on resolving hardware and procedural issues concerning generic containment challenges. In SECY-89-017 (Reference 3), dated January 23, 1989, the staff presented its findings concerning the Mark I CPI program to the Commission. One of the improvements that the staff recommended was the installation of a hardened vent capability.

The staff concluded that venting, if properly implemented, can significantly reduce plant risk. This vent capability has long been recognized as important in reducing risk caused by loss of long-term decay heat removal events. Controlled venting can prevent the long-term over-pressurization and eventual failure of containment, the failure of Emergency Core Cooling System (ECCS) pumps caused by inadequate net positive suction head, and the re-closure of the valves in the Automatic Depressurization System (ADS). Venting of the containment is currently included in the emergency operating procedures for boiling water reactors (BWRs). A vent path using existing containment penetrations currently exists in all Mark I plants. This vent path generally consists of a system of sheet metal ductwork that has a low design pressure of only a few psi. Venting under high-pressure conditions created either before or after core melt may fail this ductwork, release the containment atmosphere into the reactor building, and potentially contaminate or damage 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 for some accident scenarios. Therefore, venting through a sheet metal ductwork path, as currently implemented at some Mark I plants, is likely to hamper or complicate post-accident recovery activities, and is, therefore, viewed by the staff as reducing the safety benefit. A hardened pipe vent capable of withstanding the anticipated pressure loading of a severe accident would eliminate this disadvantage.

The Commission concurred with the staff's position and directed the staff on July 11, 1989 (Reference 4) to begin imposing a hardened vent capability on a plant-specific basis for each BWR with a Mark I containment. For licensees who, on their own initiative, elect to incorporate this plant improvement, the staff was directed to consider installation of a hardened vent under the provisions of 10 CFR 50.59. For the other licensees who do not intend to install a hardened vent voluntarily, the staff was to perform a plant-specific backfit analysis for each of these Mark I plants to evaluate the efficacy of requiring the installation of hardened vents.

The staff issued Generic Letter (GL) 89-16 dated September 1, 1989 (Reference 5) to BWR licensees with Mark I containments: (1) to inform them of the direction given by the Commission regarding the hardened vent issue, (2) to provide them with a generic cost estimate for the installation of a hardened vent and (3) to request that each licensee provide notification of its plan for addressing resolution of this issue. Moreover, the staff encouraged licensees to implement the design changes to install the hardened vent. For those plants not electing to voluntarily install hardened vents, the staff requested in GL 89-16 that the licensees provide a cost estimate for installation of the hardened vent. In response to the Commission's directives, the staff developed a program to meet the objectives of the Commission's directive. This program plan contains the following five tasks: (1) cost estimation, (2) plant similarity assessment (3) cost-benefit analysis, (4) environmental assessment, and (5) imposition of requirements.

2.0 Discussion

The purpose of this report is to document the results of the plant-specific backfit analysis performed by the staff for the Dresden Nuclear Power Station, Unit 3. This analysis complies with the backfit rule in 10 CFR 50.109 (Reference 6) and includes an assessment of the safety benefits, an estimate of the reduction in core damage frequency and public risk, and a cost-benefit analysis. From the results of this analysis, the staff concludes that the installation of a hardened vent capability will substantially increase public safety and that the results of the cost-benefit analysis support the implementation of the capability.

2.1 Safety Benefits

The major benefit of a hardened vent is the reduction of both the core damage frequency and public risks. Probabilistic Risk Assessment (PRA) studies for BWRs indicate that accidents initiated by transients dominate the total core damage frequency (CDF) in severe accident sequences. The principal accident sequences for BWRs consist of Loss of Long-Term Decay Heat Removal (TW), Station

Blackout (SBO), and Anticipated Transient Without Scram (ATWS). The Reactor Safety Study (WASH-1400) (Reference 7) indicated that TW is the dominant accident sequence causing core damage at the Peach Bottom Atomic Power Station. Further, draft NUREG-1150 (Reference 2) indicates that SBO is the dominant contributor to core damage frequency at Peach Bottom. At Peach Bottom, it was estimated that the TW frequency has been greatly reduced because of the successful implementation of containment venting procedures. This study indicates that venting, if properly implemented, can significantly increase safety.

In SECY 89-017 the staff concluded on a generic basis for Mark I plants that the proposed hardened vent capability would provide enhanced plant capabilities with regard to both accident prevention and mitigation. A core melt, combined with reactor vessel rupture and containment failure, would release significant amounts of fission products to the environment. The addition of a hardened vent (1) prevents the majority of loss of long-term decay heat removal capability sequences (TW) from resulting in core melt, and (2) mitigates the consequences of residual sequences involving core melt where venting through the suppression pool is found necessary. The TW sequences are initiated by transient events and are followed by failure of long-term decay heat removal; the containment fails from overpressurization and causes the subsequent core melt. The installation of a hardened vent will increase the survivability of containment, reduce the likelihood of a core melt from TW sequences, and therefore reduce the risks to the public. For other sequences where core melt occurs before containment failure, venting could be effective in delaying containment failure and in mitigating the release of fission products because venting through the suppression pool would provide significant scrubbing of particulate and volatile releases.

In a BWR, containment venting is currently included in the emergency operating procedures. The existing vent path generally consists of ductwork ranging in pressure capability down to design pressure of only a few psi for most Mark I plants. The low design-pressure ductwork is inadequate for accommodating the high containment pressure following a severe accident. Consequently, venting under severe accident conditions could result in failure of the ductwork and a direct release of radioactivity into the reactor building. The discharge of high-temperature gases over an extended period of time may threaten the availability or performance of safety-related equipment. If substantial fuel damage has occurred, the discharge of hydrogen could cause hydrogen burns (or detonations) inside the reactor building. Electrical cables, motor operators on valves, relays, and control room components may fail under these environmental conditions. Adverse environmental conditions would complicate entry into the reactor building. This environment of high temperature and perhaps radiation could hamper recovery efforts by preventing personnel from entering into the reactor building if systems needed to terminate the accident need repair. As a result, when relying on the existing ductwork, the benefits of containment venting are significantly uncertain. Therefore, hardening the vent path to withstand the anticipated pressure loading during a severe accident would eliminate this disadvantage while retaining all the benefits of containment venting.

Because of the reduced core melt frequency, reduced fission product releases, and possible reduction or elimination of a significant containment failure mode, the staff concluded that the safety benefits of venting are significant, and further improvement can be achieved by installing hardened vents. In Reference 8, the staff estimated the benefits in the reduction in CDF and in offsite risk, which are discussed in the following sections.

2.2 Reduction in Core Damage Frequency and Public Risk

To estimate the plant-specific reduction in CDF, all Mark I plants were categorized into several groups based on the similarity of the design features that are important to the accident sequences that could be affected by the installation of a hardened vent. In performing the analysis, the staff used existing Mark I PRAs along with the plant similarity assessment to estimate the reduction in CDF for each group of plants. The analysis includes only the change in the core melt frequency for the TW sequence.

2.2.1 Plant Similarity Assessment

In draft NUREG/CR-5225 (Reference 9), the three accident sequences that were identified as being affected by venting are: (1) Loss of Long-Term Decay Heat Removal (TW), (2) Anticipated Transient Without Scram (ATWS), and (3) Station Blackout (SBO). Among these sequences, the addition of a hardened vent was found to produce the greatest reduction in core damage frequency (CDF) through its effect on TW sequences. In the TW sequence, failure to remove decay heat following a transient will cause the gradual pressurization of the containment. The containment may fail from overpressurization and subsequently may lead to a core melt. In this sequence, venting can be used to allow the removal of long-term decay heat from the containment through pool boiling and, therefore, reduce the likelihood of containment failure and subsequent core melt. The design features important to this sequence are the systems used for decay heat removal and containment cooling.

The reduction in CDF for the TW sequence of each Mark I plant resulting from the installation of the hardened vent was estimated by the staff in Reference 8. To account for similarity in design, all Mark I plants were grouped according to the design of their decay heat removal and containment cooling systems - factors important in assessing the frequency of TW sequences. In determining the groups by examining individual plant features in simplified piping and instrument diagrams, the staff studied the differences between the RHR systems, isolation condensers, power conversion system, and service water systems for all Mark I plants. In addition, the staff studied the available PRAs and failure probabilities of related components to identify any major differences and similarities in terms of CDF affected by the hardened vent capability. After careful study of the available PRAs, the staff categorized the Mark I plants into the following four groups:

(1) Plants with a residual heat removal (RHR) system consisting of two trains, with two RHR heat exchangers and two RHR pumps per train,

(2) Plants with an RHR consisting of two trains, with one RHR heat exchanger and two RHR pumps per train,

(3) Plants with an RHR consisting of two trains, with one RHR heat exchanger and one RHR pump per train, and

(4) Plants with isolation condensers.

2.2.2 Reduction in Core Damage Frequency

To estimate the reduction in CDF from the installation of a hardened vent capability, the staff looked into the sequences that require the failure of containment cooling for core damage, and assumed that using hardened vent would reduce 90 percent of these sequences. The estimates of CDF reduction conservatively consider only the TW sequences, and therefore, the benefits on the SBO and ATWS sequences are not included.

For Dresden 3, the reduction in CDF was estimated using the PRA results of a plant with similar design features. The credit of the Isolation Condenser System (ICS) being used as the decay heat removal system was included. To be consistent with the failure frequency assumed in NUREG-1150, the staff incorporated several changes into the referenced PRA. With these changes, the staff calculated that venting would produce a reduction in CDF from TW sequences of 1.4E-5 per reactor year. More detailed information of this analysis is given in Reference 8.

2.2.3 Risk Reduction

Installation of a hardened vent capability will reduce the CDF and will result in reduction in the populsation dose that would be associated with TW sequences. The estimate of the reduction in population dose for Dresden 3 was calculated by multiplying the reduction in CDF estimated for Dresden 3 by a scaling factor to convert the Peach Bottompopulation dose to the Dresden 3 population dose. The scaling factor was obtained from NUREG/CR-2723 (Reference 10) for Dresden 3 plant-specific reactor power and population density. The Peach Bottom population dose from TW sequences was derived using the insights from NUREG-1150. The resulting reduction in the population dose for Dresden 3due to reduction in CDF for TW sequences was estimated to be 3.6E6 man-rem. The averted population dose for Dresden 3 was calculated by multiplying the reduction in CDF by 3.6E6 man-rem to give 50.2 man-rem per reactor year. For the 21 years of operation remaining, the estimated total averted dose is 1055 man-rem. In addition, consideration of a likely 20-year operating life extension will increase the estimated total averted dose to 2060 man-rem.

The averted occupational health risk resulting from the installation of the proposed hardened vent system is discussed and calculated in Section 4.1.2.2 of Appendix A. The estimated occupational risk is approximately one to two percent of the public health risk and is not considered to be a significant contributor. Therefore, the occupational health exposures are not further considered in the cost-benefit analysis.

2.3 Cost-Benefit Analysis

The method used to calculate the cost-benefit ratio is described in NUREG/CR-3568 (Reference 11), and the plant-specific data were considered. The staff obtained plant-specific cost estimates provided by the licensee from the response to Generic Letter (GL) 89-16 and used the risk-reduction data discussed above in Section 2.2.3 to calculate the value-impact ratio in man-rem saved per million dollars.

2.3.1 Cost Estimation

GL 89-16 requested licensees to provide the staff with plant-specific cost estimates for installing a hardened vent. In response to GL 89-16, all Mark I licensees except four (with five plants) indicated that they intend to install the hardened vent under the provisions of 10 CFR 50.59.

Dresden 3 is one of the five Mark I plants. Commonwealth Edison (the licensee) has decided not to voluntarily install the hardened vent capability. By letter dated October 30, 1989 (Reference 12), the licensee of Dresden 3 responded to GL 89-16 with a cost estimate of 1.0 million dollars for the installation of a hardened vent, and incremental costs of $500,000 for an AC-independent power source.

2.3.2 Value-Impact Assessment

The value-impact ratio is calculated in the regulatory analysis (Appendix A) using the method described in NUREG/CR-3568 (Reference 11) to support the backfit decision. The benefits to public risk reduction in man-rem were calculated in Section 2.2.3. The averted population dose for Dresden 3 was calculated in Section 2.2.3 to be 50.2 man-rem per reactor year. For the 21 years of operation remaining, the estimated total averted man-rem is 1055. The cost of installation of the hardened vent capability was estimated in Section 2.3.1 as 1.0 million dollars. The value-impact ratio, not including the averted onsite cost, is calculated to be 1055 man-rem saved per million dollars.

The averted cost associated with prevention and mitigation of an accident can be discussed as five separate costs: replacement power, cleanup, onsite occupational health impacts, offsite health impacts, and onsite property damage. The details of each of these items are discussed in Appendix A Section 4.1.2.2. If the savings of $208,414 to Dresden 3 from accident avoidance (cleanup, repair of onsite damages, and replacement power) were included, the overall value-impact ratio would be 1333 man-rem saved per million dollars. Consideration of a likely 20-year operating life extension will increase the value-impact ratio to 2688 man-rem saved per million dollars.

2.4 Alternatives Considered and Impacts on Other Programs

Other alternatives considered and their associated value-impact ratios are discussed in Section 3.0 and 4.0 of the Regulatory Analysis in Appendix A, Regulatory Analysis. The effect of the addition of the hardened vent capability on other requirements including IPE, Improved Plant Operations (IPO), Severe Accident Research Program (SARP), External Events, and Accident Management are discussed in Section 4.2 of Appendix A. A summary of the compliance to the backfit rule (10 CFR 50.109(c)) is also included in Attachment 1 to Appendix A.

2.5 Environmental Assessment

The staff performed a generic environmental assessment (EA) concerning the installation of the hardened vent at Mark I plants. Concurrent with this plant-specific analysis, a draft EA is being sent out for public comments. In the draft EA, the staff concluded that the installation of a hardened vent capability will have no significant radiological or non-radiological impact on the environment.

The installation of the hardened vent capability will prevent and mitigate severe accidents. During normal plant operations or design-basis accidents, the hardened vent will not be used, and therefore, will not result in any changes in amounts of radioactivity released to the atmosphere from the plant. Venting during severe accidents will reduce the CDF and will reduce the radiological environmental risks. For venting sequences, the hardened vent connected to the plant stack could reduce dose consequences more effectively by approximately a factor of two than venting through the ductwork. This reduction is due to a greater effectiveness of atmospheric dispersion resulting from a controlled elevated release compared to an uncontrolled ground level release from ductwork. Furthermore, venting through the suppression pool would provide scrubbing of non-noble-gas fission products with an effective decontamination factor of about 100. The addition of a hardened vent will greatly reduce the occupational doses for personnel that need to enter and work in the reactor building and that could be exposed to the containment environment.

The staff has concluded that this generic EA applies to Dresden 3 and the installation of the hardened vent will, therefore, reduce dose consequences and will not result in an adverse environmental impact. Plant-specific design features will have an effect on the degree of the environmental benefits, but not on the conclusion concerning no significant environmental impact.

3.0 Conclusions and Recommendations

Based on the safety benefits discussed in Sections 2.1, 2.2, and 2.3 for Dresden 3 and in SECY 89-017 for generic Mark I plants and supported by the plant-specific cost-benefit analysis, the staff believes that the installation of a hardened wetwell vent at Dresden 3 is warranted.

3.1 Rationale for the Recommendation

In SECY 89-017, the staff concluded on a generic basis for Mark I plants that the proposed hardened vent capability would provide enhanced plant capabilities with regard to both accident prevention and mitigation. The addition of a hardened vent (1) prevents the majority of TW sequences from resulting in core melt, and (2) mitigates the consequences of residual sequences involving core melt where venting through the suppression pool is found to be necessary. In TW sequences, the containment fails before the core melt occurs; therefore, significant releases could result. A core melt, combined with a reactor vessel and containment failure, would release significant amounts of fission products to the environment. The survivability of the containment, which acts as the last barrier for an uncontrolled release of radiation, would increase with venting. The installation of a hardened vent greatly reduces the likelihood of a core melt from TW sequences and therefore reduces the risks to the public. For other sequences where core melt is predicted, venting could be effective in delaying containment failure and in mitigating the release of fission products. Although venting of the containment is currently included in BWR emergency operating procedures, it generally uses ductwork with a low design pressure. Venting under high-pressure severe accident conditions could fail this ductwork, release the containment atmosphere into the reactor building, and damage equipment, or contaminate equipment needed for accident recovery. Venting through this ductwork will probably hamper or complicate post-accident recovery activities, and is therefore viewed as reducing the safety benefit. The installation of a reliable hardened wetwell vent allows for controlled venting through a path with significant scrubbing of fission products to the plant stack and would prevent damage to equipment needed for accident recovery.

With the installation of the hardened vent capability, the staff estimated that the total plant CDF for Dresden 3 can be reduced by 1.4E-5 per reactor year because of the reduction in the probability of TW sequences. Implementation of the proposed hardened vent modification will significantly reduce the total risk to the health and safety of the public. The averted population dose of 50.2 man-rem per reactor year was calculated for Dresden 3 from the installation of hardened vent capability. For 21 years of remaining operating life the total averted population dose would be 1055 man-rem. If the averted cost associated with an accident is included, the calculated value-impact ratio for Dresden 3 is 1333 man-rem saved per million dollars. In addition, consideration of a likely 20-year operating life extension will increase the total averted population dose to 2060 man-rem and the calculated value-impact ratio to 2688 man-rem saved per million dollars, which demonstrate additional benefits for the installation of the hardened vent capability. Additional benefits of venting, not quantified, include source term reduction and the delay in containment failure for some of the scenarios that lead to core melt.

Based on both the qualitative and quantitative benefits discussed herein and the supporting plant-specific cost-benefit analysis, the staff believes that there will be a substantial increase in the overall protection of the public health and safety by implementing the hardened vent capability for Dresden 3. Therefore, the staff believes that this backfit is justified.

.0 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, Second Draft, 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. U.S. NRC, Generic Letter 89-16, "Installation of a Hardened Wetwell Vent," September 1, 1989.

6. Backfit Rule, Code of Federal Regulation, 10 CFR 50.109.

7. WASH-1400, U.S. NRC "Reactor Safety Study," October 1975.

8. Memorandum from Brian W. Sheron to Ashok C. Thadani, October 19, 1989, "Reduction in Risk From the Addition of Hardened Vents in BWR Mark I Reactors."

9. NUREG/CR-5225, draft, "An Overview of Boiling Water Reactor Mark I Containment Venting Risk Implications," October 1988.

10. NUREG/CR-2723, "Estimates of the Financial Consequences of Nuclear Power Reactor Accidents," September 1982.

11. NUREG/CR-3568, "A Handbook for Value-Impact Assessment," December 1983.

12. Letter from M. H. Richter (Commonwealth Edison) to U.S. NRC, October 30, 1989 "Dresden Station Units 2 and 3 Response to Generic Letter 89-16."

Appendix A

MARK I PLANT-SPECIFIC
ENHANCED VENTING CAPABILITY
REGULATORY ANALYSIS
FOR DRESDEN NUCLEAR POWER STATION, UNIT 3

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Mark I Plant-Specific
Enhanced Venting Capability
Regulatory Analysis

1.0 STATEMENT OF THE PROBLEM

In SECY-89-017 dated January 23, 1989 (Reference 1), the staff presented its findings concerning the Mark I Containment Performance Improvement (CPI) program to the Commission. One of the improvement that the staff recommended was the installation of hardened vent capability. The Commission concurred with the staff's position and directed the staff to proceed with the imposition of a hardened vent capability for each boiling water reactor (BWR) with a Mark I containment where a plant-specific backfit analysis supports such a backfit.

The General Electric Company has designed and constructed several BWR configurations with three basic containment designs designated as Mark I, Mark II, and Mark III. Probabilistic Risk Assessment (PRA) studies have been performed for a number of BWRs with Mark I containments. Although these PRA studies do not show the BWR Mark I plants to be risk outliers as a class relative to other plant designs, they do suggest that the Mark I containment could be challenged by a large scale core melt accident, primarily due to its smaller size. However, estimates of the probability of containment failure under such conditions are based on calculations of complex accident conditions that contain significant uncertainty.

Draft NUREG-1150 (Reference 2) evaluated the dominant accident sequences for five plants, one of which was a BWR Mark I. The dominant accident sequences were identified as station blackout (SBO), which includes the loss of all AC and DC power; and anticipated transient without scram (ATWS). This list would have included the loss of long-term decay heat removal (TW) except that, for the particular plant being reviewed, the likelihood of this sequence was considered to be greatly reduced because of assumed successful venting of the containment. While the TW sequence was not considered in NUREG-1150 to be a dominant sequence for the plant reviewed, it can be a significant contributor to overall plant risk for Mark I plants in general. (The June 1989 version of draft NUREG-1150 reported similar results for the Peach Bottom Atomic Power Station as were reported in the February 1987 edition.)

All BWRs with Mark I containments have a capability to vent the containment with various size lines. The largest lines usually are associated with the vent and purge system used to inert and de-inert containment. Venting of containment as an accident mitigative action is permitted in the Emergency Operating Procedures (EOPs). In part, the existing vent path uses sheetmetal ductwork from the containment isolation valves through the standby gas treatment system (SGTS) to the plant stack. The sheetmetal ductwork is usually designed for low pressure and is expected to fail under severe accident pressures. Failure of the ductwork would introduce the containment atmosphere to the reactor building. This could result in harsh environmental conditions that would complicate operator accident recovery actions within the reactor building and could cause failure of equipment within the reactor building.

The hard pipe vent would be designed to withstand severe accident pressures, and, thus, would not fail during a TW event thereby alleviating the harsh environmental concerns in the reactor building. This regulatory analysis studied the costs and benefits of installing a hardened vent capability at BWRs with Mark I containments.

2.0 OBJECTIVES

The staff objective is to reduce the overall risk in BWR Mark I plants by pursuing a balanced approach using accident prevention and accident mitigation. Most recent PRA studies indicate that TW is an important contributor to BWR Mark I risk. The balanced approach includes (1) accident prevention - those features or measures that should reduce the likelihood of an accident occurring or measures that the operating staff can use to control the course of an accident and return the plant to a controlled, safe state, and (2) accident mitigation - those features or measures that can reduce the magnitude of radioactive releases to the environment during an accident. Although the staff considered the quantification aspects of both accident prevention and mitigation, this regulatory analysis only quantified the preventive aspects. The proposed hardened vent capability would provide enhanced plant capabilities and procedures concerning both accident prevention and mitigation.

3.0 ALTERNATIVE RESOLUTIONS

Plant modifications to the containment venting capability are being proposed to reduce the probability of or to mitigate the consequences of a severe core melt accident. The proposed modification consists of installation of a hard pipe from the existing wetwell ventilation penetration, bypassing the ductwork to the standby gas treatment system, and going to the plant stack. The ventilation penetration is the 18- to 24-inch penetration normally used as part of the vent and purge system for deinerting the containment.

For the proposed modifications, the new components need not be safety-grade or safety-related. However, no failure of the modified system or non-safety-related component is to adversely affect any safety-related structure, system, or component required for coping with design-basis accidents.

3.1 Alternative (i)

This alternative is the no-action option, that is, to leave the existing venting capability unaltered.

The existing venting capability vents the containment through the existing ductwork from the suppression pool to the SGTS. The ductwork design pressure is usually a few psid or less (Reference 3). Consequently, venting under severe accident conditions could cause failure of the ductwork and a direct release into the reactor building. The discharge of high-temperature gases over an extended period of time may pose a threat to the availability or performance of safety-related equipment. The discharge of hydrogen could result in hydrogen burns (or detonations) inside the reactor building. Electrical cables, motor operators on valves, relays, and control room components may fail under these environmental conditions. Adverse environmental conditions would complicate entry into the reactor building. Calculations from a venting study during an anticipated transient without scram (ATWS) indicate a severe environment would be present in the reactor building during venting operations (Reference 4). If systems that are needed to terminate the accident need repair, this environment (high temperature and radiation) could hamper recovery efforts by preventing personnel from entering into the reactor building.

3.2 Alternative (ii)

This alternative would involve the installation of a hardened venting capability from the containment wetwell to the plant stack.

The proposed venting improvement would provide a wetwell path to the plant stack capable of withstanding the anticipated environmental conditions of a severe accident. This proposed modification would include the installation of hard pipe from the outlet of an existing wetwell vent outboard containment isolation valve to the base of the plant stack. This pipe would be routed through a new isolation valve that would bypass the existing ductwork and the SGTS. The hard pipe to the stack could contain a rupture disk to prevent inadvertent operation and release of radioactivity. The emergency procedures would need to be modified to provide appropriate instructions for the operator. This alternative would mitigate the consequences of severe accidents by reducing the likelihood of core melt from the TW sequence. All releases through the vent would pass through the suppression pool, and the particulates would be scrubbed.

During a loss of long-term decay heat removal accident, this alternative would prevent failure of the vent path inside the reactor building and would result in an elevated release. The elevated release could reduce the offsite consequences. Since the vent path should not fail inside of the reactor building, personnel could repair equipment and perform other plant recovery activities in the reactor building. Furthermore, there would be no harsh environmental conditions to degrade or fail other equipment. There is the possibility of inadvertent operation of the vent that would release some radioactive material without any holdup time or filtration. This alternative would not affect the releases of radioactive material for those sequences where the drywell fails, such as from corium attack, once the drywell shell has failed.

3.3 Alternative (iii)

This alternative would involve alternative (ii) plus the installation of an external filter system.

The proposed venting improvement includes the hard pipe vent discussed in alternative (ii) plus the installation of an external filter system, such as the Filtra system or the Multi Venturi Scrubbing System (MVSS). This external filter would be installed outside of the existing facilities. A single external filter unit could be constructed to service multiple containments with proper isolation valves. Both the Filtra and the MVSS systems do not rely on AC power to perform their intended functions. Similar to alternative (ii), the emergency procedures would need to be modified to provide appropriate instructions for the operator. This alternative would mitigate the consequences of a severe accident and could reduce the likelihood of core melt if the operator transfers suction of the injection pumps from the suppression pool to an alternate source of water, such as the condensate storage tank, before venting containment. With the external filter, the amount of particulate removal of the external filter would not be sensitive to the conditions in the suppression pool. No significant additional risk reduction was estimated to result from an external filter system in addition to the suppression pool scrubbing. Since all particulate releases through the hardened vent (alternative ii) are scrubbed, the external filter will only provide minimal additional scrubbing. The external filter provides no additional benefit in core melt prevention although it would provide filtration and some holdup time for inadvertent operation of the vent. Similar to alternative (ii), this alternative would not affect the releases of radioactive material for those sequences where the drywell fails, such as from corium attack, once the drywell shell has failed.

4.0 CONSEQUENCES

4.1 Costs and Benefits of Alternative Resolutions

The staff used available PRAs to estimate the incremental benefit of the three alternatives discussed in the following paragraphs. The only accident sequence that is being considered for this analysis is the TW. This is considered to be conservative since the alternatives could have a beneficial but small effect on other sequences (Reference 5). The staff estimated the change in the CDF, but not the total CDF from internal events (Reference 6).

4.1.1 Alternative (i)

This alternative would be to take no action. Since it is expected that the ductwork would fail if the containment were vented at high pressure, this approach would not only jeopardize personnel, but also the ability to regain control of the facility during the accident. Furthermore, based on a generic regulatory analysis (Reference 1) the Commission instructed the staff to require hardened vent capability for plants for which it could be shown to be cost effective. Therefore, based on the discussion below the no-action alternative is not recommended.

4.1.2 Alternative (ii)

4.1.2.1 Value: Risk Reduction Estimates

For those accident scenarios where containment failure results in core degradation and a severe accident, the approach using a hard pipe vent path could reduce or delay core degradation. This is estimated to reduce the total core damage frequency per reactor year by 1.4E-5. Corresponding to a release of 3.6E6 man-rem, this represents a risk reduction in man-rem per reactor year of 50.2.

4.1.2.2 Impacts: Cost Estimates

The estimated cost for installation of the hard pipe vent path is 1.0 million dollars (Reference 7).

The averted cost associated with prevention and mitigation of an accident can be discussed as five separate costs: replacement power, cleanup, onsite occupational health impacts, offsite health impacts, and onsite property damage. To estimate the costs of averting plant damage and cleanup, the reduction in accident frequency was multiplied by the discounted costs of onsite property. The following equations from NUREG/CR-3568 (Reference 8) were used to make this calculation:

$$V_{op} = NdFU$$

$$U = (C/m)[(e^{-rt(i)})/r^2]\ [1-e^{-r(t(f)-t(i))}]\ (1-e^{-rm})$$

where: (cited values are from Table 2)

V_{op} = value of avoided onsite property damage ($)
N = number of affected facilities = 1
dF = reduction in accident frequency = 1.4E-5 /RY
U = present value of onsite property damage ($)
C = cleanup and repair costs = $1.0 billion
t(f) = years remaining until end of plant life = 21
t(i) = years before reactor begins operation = 0
r = discount rate = 10%
m = period of time over which damage costs are paid out (recovery period in years) = 10

Using these values, the present value of avoided onsite property damage is estimated to be $77,660.

Replacement power costs can be estimated using NUREG/CR-4012 (Reference 9), which lists the replacement power costs for each nuclear power reactor by season. Using this information for only Mark I reactors averaged over the four years of projected data and escalated by six percent for 1989 dollars, the generic replacement power cost is $400,666 per day. (The plant-specific replacement power cost is shown in Table 3. NUREG-1109 (Reference 10) used a generic cost of $500,000 per day and compares favorably with NUREG/CR-4012.)

The change in public health risk associated with the installation of the proposed hardened vent system is expressed as total man-rem of avoided exposure. The following equations from NUREG/CR-3568 were used to make this calculation:

$$V_{PH} = NT\ (D_P \times R)$$

where:

V_{PH} = value of public health risk avoided for net-benefit method ($)
N = number of affected reactors = 1
T = average remaining lifetime of affected facilities (years) = 21
D_P = avoided public dose per reactor-year (man-rem/RY) = 50.2
R = monetary equivalent of unit dose ($/man-rem) = $1000

Using these values, the avoided public health exposure of 1.055 million dollars is obtained for Dresden 3. Considering a possible 20-year operating life extension, the value of avoided public health exposure is 2.06 million dollars.

The occupational health risk avoided because of the installation of the proposed hardened vent system is expressed as man-rem of avoided exposure. The following equations from NUREG/CR-3568 were used to make this calculation:

$$V_{OHA} = NT(D_{OA} \times R)$$

where:

V_{OHA} = value of occupational health risk due to accidents avoided ($)
N = number of affected reactors (reactors) = 1
T = average remaining lifetime of affected facilities (years)
D_{OA} = avoided occupational dose per reactor year (Man-Rem/Reactor-Year)
R = monetary value of unit dose ($/Man-Rem)=$1000/Man-rem

There are two types of occupational exposure related to accidents, immediate and long-term. The first occurs at the time of the accident and during the immediate management of the emergency. The second is a long-term exposure, presumably at significantly lower individual rates, associated with the cleanup and refurbishment of the damaged facility. The best estimate of the immediate occupational exposure as specified in NUREG/CR-3568 is 1000 man-rem. The best estimate of the long-term occupational exposure as specified in NUREG/CR-3568 is 20,000 man-rem. This results in occupational exposure of 21,000 man-rem. The multiplication of 21,000 man-rem by the reduction in CDF, 1.4E-5 per reactor year, produces the avoided occupational dose per reactor year, D_{OA}.

Using these values, the present value of avoided occupational health exposure was calculated to be $6,174, approximately one to two percent of the public health risk, and is not considered to be a significant contributor. Therefore, the occupational health exposures will not be considered further.

4.1.2.3 Value-Impact Ratio

The value-impact ratio, not including the costs of onsite accident avoidance, is 1055 man-rem averted per million dollars. If the savings to industry from accident avoidance (cleanup and repair of onsite damages and replacement power) were included, the overall value-impact ratio would be 1333 man-rem averted per million dollars. Considering a likely 20-year operating life extension, the overall value-impact ratio would be 2688 man-rem averted per million dollars.

4.1.3 Alternative (iii)

4.1.3.1 Value: Risk Reduction Estimates

This alternative would provide minor additional particulate scrubbing for the hard vent. However, because all particulate releases will have been scrubbed by the suppression pool, the improvement over alternative (ii) could be minimal.

4.1.3.2 Impacts: Cost Estimates

External filters were estimated to cost $10 million to $50 million for the Filtra design and about $5 million for the Multi-Venturi Scrubber System design.

Using the same equations given in alternative (ii), the present value of the estimated avoided onsite damage to property is $77,660. Similarly, the estimated replacement power cost is $168 million per year. Thus, the estimated avoided damage to onsite property and the replacement power is $208,414.

The present value of the change in the estimated public health risk associated with the installation of the hard vent and the external filter is $1.055 million.

4.1.3.3 Value-Impact Ratio

The overall value-impact ratio of this alternative is in terms of man-rem averted per million dollars. If the savings to industry from accident avoidance (cleanup and repair of onsite damages and replacement power) were included, the overall value-impact ratio would be 182 man-rem averted per million dollars. This is calculated from the value in Column G of Table 2 divided by the installation cost in Column H of Table 2 and added 5 million dollars for the MVSS design minus the value in Column N of Table 2. This alternative is not recommended because it does not provide substantial additional safety benefit over alternative (ii) and is not cost effective.

Table 1 - Cost Benefits of Alternatives (i)-(iii)
(man-rem averted per million dollars)

Alternative (i)	- do nothing	0
Alternative (ii)	- hard pipe venting	
	for the remaining life	1333
	with 20-year life extension	2688
Alternative (iii)	- hard pipe venting + MVSS external filter	182

Table 2 - Backfit Analysis for Proposed Hardened Vent Capability for Dresden 3

Plant Group No.	Plant Name	Date of Commercial Operation1	(A) Years of Operation Remaining	(B) Population (0-50 miles) (1970)2	(C) TW CMF 3	(D) "Strip" Factor (SST1)4	(E) Gross Dose (PB2*D)3	(F) Man-Rem per RY (C*E)	(G) Man-Rem Saved (A*F)	(H) Install Costs ($M)5&6	(I) Value-Impact (G/H)	(J) * Vop 7	(K) Vph 7	(L) Voha 7	(M) Repl Pwr ($ per Year)	(N) * Vop & Repl Pwr	(O) Val-Imp w/Vop&RP (G/H-N)
4	Dresden 3	1971	21	6,305,000	1.40E-05	0.8346304	3.59E+06	50.2	1055.1	1.00	1055	$77,660	$1,055,140	$6,174	$168,367,200	$208,414	1333
4	Dresden 3	1971	41	6,305,000	1.40E-05	0.8346304	3.59E+06	50.2	2060.0	1.00	2060	$87,030	$2,060,035	$12,054	$168,367,200	$233,561	2688

* Discount rate: 10 %

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1) Source: USNRC NUREG-1350, dated March 1989
2) Source: USNRC NUREG-0348
3) Source: Memorandum from B.W. Sheron, dated October 19, 1989, to A.C. Thadani, "Reduction in Risk from the Addition of Hardened Vents in BWR Mark I Reactors"
4) Source: USNRC NUREG/CR-2723, dated September 1982 (except: Hope Creek = (Salem1/PBAPS)*(MWth-hc/MWth-s1))
5) Source: Generic Letter #89-16, dated September 1, 1989, "Installation of Hard Wetwell Vent"
6) Source: Installation costs from memorandum from J.G. Partlow to T.E. Murley, dated November 9, 1989, "Licensees' Responses to Generic Letter 89-16 Related to Installation of Hardened Wetwell Vent"
7) Source: USNRC NUREG/CR-3568, dated December 1983, pages 3.11-3.12, 3.29-3.31, 3.16-3.18
8) The numbers in the column titles refer to source of information number above.
9) The letter in brackets, (A), are the column identifiers and the letters in brackets, (C*E), are the equations using the column identifiers for references. The "Strip" Factor is the scaled man-rem SST1 number from the Strip Report divided by the similar number for Peach Bottom Unit 2 to account for the site differences.
10) Negative numbers in Column (O) indicate that the onsite costs exceed the installation costs. Therefore the proposed modification exceeds the $1000/man-rem criteria and may be imposed.
11) Vop = value of avoided onsite property damage ($)
    Vph = value of public health risk avoided for net-benefit method ($)
    Voha = value of occupational health risk due to accident avoided ($)

Table 3 - Estimated Replacement Power Costs
(in dollars per day)

Reactor Name	MWe	Year Licensed	Est. Cost 1985$	Est. Cost 1989$	Est. Cost (per year)
Dresden 3	794	1971	$372,000	$461,280	$168,367,200

Notes: 1:NUREG/CR-4012 (Table S.1) provides replacement power costs for all plants on per plant/season basis for 1987-1991.

2:The inflation rate used is 6 percent/year, and the discount rate used is 10 percent/year.

4.2 Impacts on Other Requirements

There are six programs related to severe accidents: Individual Plant Examination (IPE), Containment Performance Improvement (the topic of this regulatory analysis), Improved Plant Operations, Severe Accident Research Program, External Events, and Accident Management. Each of the five programs related to Containment Performance Improvement (CPI) will be discussed briefly in Item 3 of Attachment 1, Backfit Rule Analysis.

4.3 Constraints

The plant-specific imposition of a hardened vent is constrained by the guidelines of U.S. NRC Manual Chapter 0514, "NRC Program for Management of Plant-Specific Backfitting of Nuclear Power Plants", which is based on the backfit rule (10 CFR 50.109), as published by the Commission on September 20, 1985, and the provisions of 10 CFR 50 Appendix O, 10 CFR 50.54(f), and 10 CFR 2.204.

No other constraints have been identified that affect this program.

5.0 DECISION RATIONALE

The evaluation of the CPI program included deterministic and probabilistic analyses. Calculations to estimate the CDF and the consequences of the TW sequence were performed using information available from the NUREG-1150 program and from existing PRAs.

The best estimate of the contribution of TW to the total plant CDF expressed in events per reactor year for Dresden 3 is 1.4E-5. Implementation of the proposed hardened venting capability will cause TW to be a minor contributor to the total CDF and will significantly reduce the total risk to the health and safety to the public.

5.1 Commission's Safety Goal

On August 4, 1986, the Commission published in the Federal Register a policy statement on "Safety Goals for the Operations of Nuclear Power Plants" (51 FR 28044). This policy statement focuses on the risks to the public from nuclear power plant operation and establishes goals that broadly define an acceptable level of radiological risk. The discussion in the Regulatory Analysis of SECY 89-017 addressed the CPI program recommendation in light of these goals.

6.0 IMPLEMENTATION

6.1 Schedule for Implementation

The licensee may reconsider its position on the installation of the hardened vent under the provisions of 10 CFR 50.59. Without the licensee's commitment, the staff intends to pursue an order after 30 days of its receipt of this analysis, requiring this backfit under the provision of 10 CFR 50.109. Within 60 days after issuance of the backfit order, the licensee will be required to submit to the NRC a schedule for implementing any necessary equipment and procedural modifications to meet the performance goals and to provide adequate defense-in-depth. All plant modifications are to be installed, procedures (including the decision making process for venting) revised, and operators trained not later than January 1993.

Other schedules were considered; however, the staff believes the proposed implementation of the hard pipe vent capability can be largely performed with minimum interfacing with containment and engineered safety feature systems and thus with the plant online. Therefore, the licensee can install the proposed modification without unnecessary financial burden for plant shutdown. The schedule allows reasonable time for the implementation of necessary hardware to achieve a reduction in the risk from TW. Shorter or less flexible schedules would be unnecessarily burdensome.

7.0 REFERENCES

1. SECY-89-017, "Mark I Containment Performance Improvement Program," January 23, 1989.

2. NUREG-1150, (Draft), "Reactor Risk Reference Document," February 1987.

3. NUREG/CR-5225, "An Overview of Boiling Water Reactor Mark I Containment Venting Risk Implications," October 1988.

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

5. NUREG/CR-5225, Addendum 1, "An Overview of Boiling Water Reactor Mark I Containment Venting Risk Implications, An Evaluation of Potential Mark I Containment Improvements," June 1989.

6. Sheron, B.W., Memorandum to Thadani, A.C., "Reduction in Risk from the Addition of Hardened Vents in BWR Mark I Reactors," October 19, 1989.

7. Letter from M. H. Richter (Commonwealth Edison) to U.S. NRC, October 30, "Dresden Station Units 2 and 3 Response to Generic Letter 89-16."

8. NUREG/CR-3568, "A Handbook for Value-Impact Assessment," December 1983.

9. NUREG/CR-4012, "Replacement Energy Costs for Nuclear Electricity-Generating Units in the United States: 1987-1991," January 1987.

10. NUREG-1109, "Regulatory/Backfit Analysis for the Resolution of Unresolved Safety Issue A-44, Station Blackout," June 1988.

11. SECY-88-147, "Integration Plan for Closure of Severe Accident Issues," May 25, 1988.

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

ATTACHMENT 1 TO APPENDIX A

BACKFIT RULE ANALYSIS

Analysis and Determination That the Recommended Hard Pipe Vent Capability for Containment Performance Improvement Complies with the Backfit Rule 10 CFR 50.109

The Commission's regulations establish requirements for the design and testing of containment and containment cooling systems (10 CFR 50, Appendix A, General Design Criteria 50, 52, 53, 54, 55, 56, and 57) with respect to design basis accident conditions. As evidenced by the accident at TMI Unit 2, accidents could progress beyond design basis considerations and result in a severe accident. Such an accident could challenge the integrity of containment. Existing regulations do not explicitly require that nuclear power plant containments be designed to withstand severe accident conditions.

The staff and our consultants studied this issue as part of the severe accident program for the General Electric Company boiling water reactors (BWRs) with Mark I containments. BWRs with Mark I containments were reviewed first because of the perceived susceptibility of the Mark I containments to failure based, in part, on the small containment volume of the Mark I containment design. Both deterministic and probabilistic analyses were performed to evaluate the loss of long-term decay heat removal (TW) in challenging containment integrity and potential failure modes affecting the likelihood of core melt, reactor vessel failure, containment failure, and risk to the public health and safety. The risk analysis shows that the risks from plants with Mark I containments are generally similar to the risks from plants with containments of other types. In addition, the hardened pipe vent capability is not needed to provide adequate protection of the public health and safety. Rather, the proposed plant improvement will provide substantial cost-effective enhancement to Mark I plant safety.

The estimated benefit from implementing the proposed hard pipe vent is a reduction in the frequency of core melt caused by TW and the associated reduction in risk of offsite radioactive releases. The estimated risk reduction in terms of man-rem is 1055 and supports the conclusion of the Commission that implementation of the proposed improvement provides a substantial improvement in the level of protection of the public health and safety.

The estimated cost to the licensee to implement the proposed safety enhancement is 1.0 million dollars. This cost would be primarily for the licensee to 1) assess the plant's capability, 2) install equipment to provide additional pressure relieving capability, 3) revise the emergency operating procedures, and 4) provide operator training concerning mitigating the TW sequence.

The estimated value-impact ratio, not including accident avoidance costs, in terms of man-rems averted per million dollars is 1055. If the net cost, which includes the cost savings from accident avoidance (i.e. cleanup and repair of onsite damages and replacement power following an accident), was included, the estimated overall value-impact in terms of man-rems averted per million dollars would be 1333. If 20 years of life extension were included, the estimated overall value-impact in terms of man-rems averted per million dollars would be 2688. These values support proceeding with the proposed hard pipe vent capability improvement.

Although the preceding quantitative value-impact analysis was one of the factors considered in evaluating the proposed improvements, other factors were considered as a part in the decision-making process. PRA studies performed for this issue have shown that the loss of long-term decay heat removal (TW) events can be a significant contributor to core melt frequency. With consideration of the conditional containment failure probability, TW events can provide an important contribution to reactor risk.

Although there are licensing requirements and guidance for providing a containment and support systems to contain any release of material from the reactor vessel, containment integrity may be significantly challenged under severe accident conditions. In general, active systems required for reactor and containment heat removal are unavailable during the TW event. Therefore, the offsite risk is higher from a TW event than it is from many other types of accidents. The containment integrity is primarily challenged by over-pressure for the TW events. Under certain conditions, failure of the containment can also initiate core degradation.

The estimated frequency of core melt from TW events is directly proportional to the frequency of the initiating events. The estimate of the TW frequency for Dresden 3 was partly based on information provided in draft NUREG-1150, "Severe Accident Risks: An Assessment for Five US Nuclear Power Plants," for the Peach Bottom Atomic Power Station, Unit 2, and other available PRAs. This is assumed to be a realistic estimate of the core melt frequency when compliance with 10 CFR 50.63, the Station Blackout Rule, has been achieved.

The factors discussed in the previous paragraphs support the determination that the additional defense-in-depth provided by the ability to cope with a TW event would substantially increase the overall protection of the public health and safety. Also, this increased protection will justify the direct and indirect costs of implementation.

<u>Analysis of 10 CFR 50.109(c) Factors</u>

(1) <u>Statement of the specific objectives that the backfit is designed to achieve</u>

The objective of the proposed hard-pipe vent capability is to reduce the risk from TW events by reducing the likelihood of core melt and to mitigate releases given a TW or other similar events leading to core melt.

(2) <u>General description of the activity required by the licensee or applicant in order to complete the backfit</u>

To comply with the proposed improvement in containment venting, the licensee will be required to:

* Evaluate the actual capability of the existing containment vent system to withstand the anticipated containment temperatures and pressures without failing any portion of the vent path to the plant stack.

* Evaluate the actual capability of the existing containment vent isolation valves to be opened and closed under anticipated containment pressures and vent flow rates during severe accidents involving TW sequences.

* Determine the necessary plant modifications to ensure a hard-pipe vent path will be available under TW events, develop a schedule for plant modification, and submit the schedule to the NRC within 60 days from the issuance of the backfit order.

* Complete the necessary modifications by January, 1993.

The licensee will be required to have the decision making process, the procedures and training to cope with and recover from a TW severe accident. These procedures should conform to the Emergency Procedure Guidelines of the Boiling Water Reactor Owner's Group.

(3) <u>The potential safety impact of changes in plant or operational complexity, including the relationship to proposed and existing regulatory requirements</u>

The hardened vent capability to cope with the TW event should not add to plant or operational complexity, because the vent is normally closed and not operated during normal power operation. Although this system does add some additional hardware to the plant, it is a simple system. The containment performance improvement (CPI) program is related to implementation of the Commission's Severe Accident Policy Statement as defined in SECY-88-147 (Reference 11). In SECY-88-147 the staff described the various programs underway related to closure of severe accident issues. Included among these was the CPI program. Other programs described in SECY-88-147 are related to the CPI program as the following discussion indicates.

* Individual Plant Examination (IPE)

The IPE involves the formulation of an integrated and systematic approach to an examination of each nuclear power plant in operation or under construction for possible significant plant-specific risk contributors that might be missed without a systematic search. Supplement 1 to Generic Letter 88-20 requested that Mark I licensees include in their IPEs the proposed plant improvements identified in SECY-89-017, other than the hardened vent, namely operation of the enhanced automatic depressurization system, and alternative low-pressure water supply for injection into the reactor vessel and for containment sprays. The examination will carefully examine containment performance in striking a balance between accident prevention and consequence mitigation. The IPE program may require three to four years until the last plant has performed the IPE.

* Improved Plant Operations (IPO)

The IPO includes consideration of continued improvements in the following areas: Systematic Assessment of Licensee Performance (SALP) program; regular reviews by senior NRC staff managers to identify and evaluate those plants that may not be meeting NRC and industry standards of operating performance; diagnostic team inspections; improved plant Technical Specifications; improved operating procedures; expansion of the Emergency Operating Procedures (EOPs) to include guidance on severe accident management strategies; industry's programs to reduce transient and other challenges to engineered safety feature systems; feedback from the IPE program of experience and improvements in operational areas, such as maintenance and training; and continued research to evaluate the sensitivity of risk to human errors, and the effectiveness of operational reliability methods to help identify potential problems early and prevent their occurrence. The IPO is related to the CPI program's recommendation since we recommend improved procedures and operator training to use the proposed hard vent system.

* Severe Accident Research Program (SARP)

The SARP was begun after the Three Mile Island, Unit 2, (TMI-2) accident in March 1979 to provide the Commission and the NRC staff with the technical data and analytical methodology needed to address severe accident issues. This program has provided input to the NUREG-1150 program and to the CPI program. Additional research is being carried out to evaluate the need for and feasibility of core debris controls. Research will also confirm and quantify the benefits of having water in the containment to either scrub fission products or to prevent or delay shell melt by core debris.

* Accident Management

The accident management program addresses certain preparatory and recovery measures that plant operating and technical staff can perform to prevent or significantly mitigate the consequences of a severe accident. This program includes the following measures to be performed by the plant staff: 1) prevent core damage, 2) terminate the progress of core damage if it begins and retain the core within the reactor vessel, 3) failing that, maintain containment integrity as long as possible, and 4) minimize the consequences of offsite releases. The plant enhancement recommended by the CPI program would provide the accident management program with additional capability to achieve their goals by providing improved hardware with which to deal with a severe accident. The procedures for using the vent should be re-examined under the Accident Management program.

(4) Whether the backfit is interim or final and, if interim, the justification for imposing the backfit on an interim basis

The proposed hardened-vent capability is not an interim measure.

(5) Potential change in the risk to the public from the accidental offsite release of radioactive material

Implementation of the proposed hardened-vent capability is expected to result in an estimated risk reduction to the public of 1055 man-rem over the remaining plant life.

(6) Potential impact on radiological exposure of facility employees

Although the reduction in occupational exposure caused by reduced CDF and associated post-accident cleanup and repair activities has not been quantified, it could be substantial if the hardened vent prevents contamination of the reactor building. The estimated total occupational exposure for installation of the hardened-vent path should be negligible. No increase in occupational exposure is expected from operation and maintenance of the hardened-vent system. In fact, if the vent is ever used, it should decrease the risk to employees because of the reduced potential for vent path failure and the resulting reactor building contamination.

(7) Installation and continuing costs associated with the backfit, including the cost of facility downtime or the cost of construction delay

Because the plant can be operating during installation, there are no costs associated with construction delays. The hardened-vent path can be installed with the plant operating or during normal plant outages. Thus, there are no costs associated with additional plant downtime.

The estimated cost of the hardened vent system is 1.0 million dollars.

(8) <u>The estimated burden on the NRC associated with the backfit and the availability of such resources</u>

With an estimated expenditure of 200 man-hours for review of the submittals, the estimated total cost for NRC review of industry submittals is $17,000. The staff will concentrate on the review of design criteria and the method to incorporate the venting into emergency operating procedures.

(9) <u>Consideration of important qualitative factors bearing on the need for the backfit at the particular facility</u>

The installation of the hardened vent will provide greater flexibility in managing accidents other than the TW events, and will provide defense in depth.

(10) <u>Statement affirming appropriate interoffice coordination related to the proposed backfit and the plan for implementation</u>

The licensee may reconsider its position on the installation of the hardened vent under the provisions of 10 CFR 50.59. Without the licensee's commitment, the staff intends to pursue an order after 30 days, requiring this backfit under the provision of 10 CFR 50.109. The proposed backfit was developed as a cooperative effort between the Offices of Nuclear Regulatory Research (RES) and Nuclear Reactor Regulation (NRR) with consultation with the Office of General Counsel. The implementation is being handled within the NRR. The staff considered implementation schedules consistent with the guidelines provided by the Commission (Reference 12). Within 60 days after issuance of the backfit order, the licensee is to provide to the NRC a schedule for implementing any equipment and procedural modifications necessary to meet the performance goals and to provide adequate defense-in-depth. All plant modifications are to be installed, procedures revised, and operators trained not later than January 1993.

(11) <u>Basis for requiring or permitting implementation on a particular schedule</u>

Although other schedules were considered, the staff believes the proposed implementation of the hard pipe vent capability can be performed with minimum interfacing with containment and engineered safety feature systems and either with the plant online or during a normal refueling outage. Therefore, the staff believes the schedule is achievable without incurring unnecessary financial burden on the licensee for plant shutdown. The schedule allows reasonable time for the implementation of necessary hardware to reduce the risk from TW and allows appropriate coordination with IPE program. Shorter or less flexible schedules would be unnecessarily burdensome.

(12) Schedule for staff actions involved in implementation and verification of implementation of the backfit, as appropriate

The proposed backfit is to be installed under 10 CFR 50.59 for most of plants and, thus, will require minimal staff effort. Therefore, timely staff review will be expected. However, for those plants that choose not to implement the modifications under 10 CFR 50.59, more staff time and efforts will be involved.

(13) Importance of the proposed backfit considered in light of other safety-related activities underway at the affected facility

The proposed backfit should not directly involve any other safety-related activities that may be underway at the affected facility.

(14) Statement of the consideration of the proposed plant-specific backfit as a potential generic backfit

Initially, the staff proposed the installation of hardened vent as a generic backfit. The Commission directed the staff to implement it as a plant-specific backfit considering the plant differences in risk reduction and benefits to be gained from a generic backfit.