RULEMAKING ISSUE
NOTATION VOTE

May 13, 2002 SECY-02-0080

FOR: The Commissioners

FROM: William D. Travers
Executive Director for Operations

SUBJECT: PROPOSED RULEMAKING—RISK-INFORMED 10 CFR 50.44, "COMBUSTIBLE GAS CONTROL IN CONTAINMENT" (WITS 20010003)

PURPOSE:

To obtain Commission approval to publish the proposed rule and the draft regulatory guidance implementing the proposed rule.

BACKGROUND:

In SECY-01-0162, "Staff Plans for Proceeding with the Risk-informed Alternative to the Standards for Combustible Gas Control Systems in Light-Water-Cooled Power Reactors in 10 CFR 50.44," dated August 23, 2001, the staff recommended revising the existing regulations rather than developing a voluntary alternative. In an SRM dated December 31, 2001, the Commission approved the staff's recommendation and requested that the staff explain why installing passive autocatalytic recombiners would not pass a cost benefit test.

Mr. Christie, of Performance Technology, Inc., submitted letters, dated October 7 and November 9, 1999, requesting changes to the regulations in § 50.44. The staff has treated Mr. Christie's request as a petition for rulemaking (Docket No. PRM-50-68). The NRC published a notice requesting comment on the petition in the *Federal Register* on January 12, 2000 (65 FR 1829). The staff discussed issues raised by the petitioner in SECY-00-0198, "Status Report on Study of Risk-Informed Changes to the Technical Requirements of 10 CFR Part 50 (Option 3) and Recommendations on Risk-Informed Changes to 10 CFR 50.44 (Combustible Gas Control).

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The Commission also received a petition for rulemaking from the Nuclear Energy Institute. The petition was docketed on April 12, 2000 (Docket No. PRM-50-71). The staff published a notice requesting comment on the petition in the *Federal Register* on May 30, 2000 (65 FR 34599). The petitioner requested that the NRC amend its regulations to allow nuclear power plant licensees to use zirconium-based cladding materials other than zircaloy or ZIRLO, provided the cladding materials meet the requirements for fuel cladding performance and have been approved by the NRC staff. The petitioner believes the proposed amendment would improve the efficiency of the regulatory process by eliminating the need for licensees to obtain individual exemptions to use advanced cladding materials which have already been approved by the NRC.

DISCUSSION:

Since the 1987 revision of 10 CFR 50.44, "Standards for combustible gas control system in light-water-cooled power reactors," there have been significant advances in our understanding of the risk to nuclear power plants, in particular, risk arising from the production and combustion of hydrogen (and other combustible gases) in the spectrum of reactor accidents. These advances are described in SECY-00-0198, "Status Report on Study of Risk-Informed Changes to the Technical Requirements of 10 CFR Part 50 (Option 3) and Recommendations on Risk-Informed Changes to 10 CFR 50.44 (Combustible Gas Control)." This new understanding has led to a reconsideration of the bases for the requirements in 10 CFR 50.44. A portion of this reconsideration is the proposed "rebaselining" of 50.44, as described in SECY-01-0162. This led to the staff recommendation and subsequent Commission approval to update the existing rule which represents the most complete, expeditious, and efficient approach for updating the regulations.

Proposed Rule

The proposed rule, attached herein, retains existing requirements for ensuring a mixed atmosphere, inerting Mark I and II containments, and hydrogen control systems capable of accommodating an amount of hydrogen generated from a metal-water reaction involving 75 percent of the fuel cladding surrounding the active fuel region in Mark III and ice condenser containments[1]. The proposed rule also retains the existing analysis requirements and equipment survivability requirements for Mark III and ice condenser containments. The proposed rule eliminates the design-basis LOCA hydrogen release from § 50.44 and consolidates the requirements for hydrogen and oxygen monitoring into § 50.44 while relaxing safety classifications and licensee commitments to certain design and qualification criteria. The proposed rule also relocates without change the hydrogen control requirements in § 50.34(f) to § 50.44 for future applicants and licensees. The proposed rule also relocates the high point vent requirements from § 50.44 to § 50.46a with a change that eliminates a requirement prohibiting

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[1]The Feasibility Study, in SECY-00-0198, indicated that some mitigative features may need to be enhanced beyond current requirements which was identified as Generic Issue (GI)-189. The resolution of GI-189 will assess whether improvements to safety can be achieved and the costs and benefits of enhancing combustible gas control requirements for Mark III and ice condenser containment designs. The resolution of GI-189 is proceeding independently of this rulemaking. The technical basis for this issue is now under study and will be discussed in June 2002 with the ACRS.

venting the reactor coolant system if it could "aggravate the challenge to containment." The proposed rule addresses Mr. Christie's petition and addresses the § 50.44 portion of the NEI petition. Lastly, the proposed guidance reflects changes in the proposed rule, including related changes that allow removal of oxygen and hydrogen monitors from the technical specifications.

Stakeholder Feedback on Draft Rule Language

On November 14, 2001, the staff published the draft rule language on the NRC Rulemaking Web site, along with an explanation of the intent of the rule and its guidance. The NRC received comments from seven members of the public (including the two petitioners), four utilities, and a law firm that represents the Nuclear Utility Group on Equipment Qualification. The comments supported the draft proposed rule language and praised the staff's efforts to produce "more effective and efficient regulation with respect to combustible gas in containment." Comments that resulted in substantive changes in rule language are addressed in the subject sections of the statement of considerations in the *Federal Register* notice (Attachment 1). The staff also considered information in licensee exemption submittals (discussed below), the two petitions for rulemaking, and the Boiling Water Reactor Owners Group (BWROG) topical report (discussed below).

When the staff published the draft rule language, the staff requested comments on two issues. First, the staff requested comment on the need to maintain the prescriptive ASME Code references versus a more performance-based approach. Based upon stakeholder feedback, the proposed rule eliminates the prescriptive ASME references by incorporating a performanced-based approach with the attached regulatory guide accepting the ASME approach as one way of satisfying the intent of the regulations. The proposed rule, thus, simplifies the regulations.

The staff requested comments on the utility of maintaining post-accident inerting as a means of combustible gas control. No currently licensed facility or new reactor design uses this alternative to control combustible gases. The major concerns with post-accident inerting of containment are its expense and issues associated with its adverse effects and actuation. Stakeholder feedback during public meetings and in the comments received on the draft rule language supported elimination of this option. Based upon staff experience and stakeholder input, the staff decided to revise the draft rule language to eliminate the requirements applicable to the post-accident inerting which further simplifies the regulations.

Implications of Removal of ASME Code References and Post-Accident Inerting

Removal of the ASME Code references[2] would allow a challenge in any licensing proceeding when the licensee or applicant proposes to comply with the rule by complying with the ASME Code. Currently, such challenges would not ordinarily be litigable under 10 CFR 2.758. Likewise, should a future applicant (including for design approval or design certification) choose to use post-accident inerting, criteria for acceptability of the design would have to be developed by the NRC and would be subject to challenge in the licensing or design certification rulemaking

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[2]As regulations become more performanced-based, prescriptive information will be removed from the regulations. This information, previously approved in a public process, rulemaking, would be subject to challenge in a licensing proceeding.

proceedings. Currently, such challenges would not ordinarily be litigable in a licensing hearing or raised in a design certification rulemaking.

Contents of the Proposed-Rulemaking Package

This rulemaking package provides a comprehensive package for Commission consideration. It includes the *Federal Register* notice with the proposed rule (Attachment 1) and the regulatory analysis (Attachment 2). The package also includes the draft regulatory guide (Attachment 3), the draft revision of the standard review plan (Attachment 4), and a model safety evaluation and proposed changes to the standard technical specifications (Attachments 5 and 6). The staff will solicit stakeholder input on these supporting documents at the same time as comments on the proposed rule so that the documents are ready to be issued when the final rule is sent to the Commission.

Exemption and Relief Requests for Hydrogen Control Systems

As discussed in SECY-01-0162, the staff plans to continue processing all licensing requests and requests for exemption or relief consistent with the normal priorities for such actions. The staff will give rulemaking the highest priority since it is the most efficient process for providing the relief consistent with the NRC's strategic and performance goals. The staff received and processed two exemption requests from licensees during the preparation of the proposed rule.

Cost-Benefit Analysis of Passive Autocatalytic Recombiners (PARs)

In the SRM dated December 31, 2001, the Commission directed the staff to provide an explanation why PARs would not pass a cost-benefit test.

The staff prepared a value-impact analysis for updating the existing rule to require PARs for all PWRs with large dry containment buildings (Attachment 7). This action would be considered a backfit since no plants with large dry containments currently use PARs; therefore all licensees of such plants would be required to install PARs and maintain them for the duration of the plant licenses. To determine whether the backfitting of PARs is justified, the analysis assumes maximum benefit, i.e., that the PARs are 100 percent effective in preventing the early and late containment failures resulting from hydrogen combustion for both internal and external events. Thus, the analysis assumes that PARS would potentially eliminate containment failures from the combustion of gases produced during severe accidents.

Even with this assumption of the PARs effectiveness, this analysis indicates PARs backfits would not be cost-beneficial for the fleet of PWRs with large, dry containments. The Value-Impact is approximately -$1,000,000/PWR or about -$70,000,000 for the entire fleet of PWRs. The previous study on hydrogen control for PWRs with large, dry containments ("Hydrogen Combustion, Control, and Value-Impact Analysis for PWR Dry Containments," NUREG/CR-5662, BNL, June 1991) also concluded that a 100 percent effective hydrogen control system (hydrogen ignitor system), a system more effective than PARs, is not beneficial.

The staff concludes that applying PAR technology to the current fleet of PWRs with large, dry containments would provide little safety or risk benefit for a very large expenditure of resources. The staff believes that further consideration of uncertainties would not affect the conclusion.

Unless directed otherwise, the staff will not pursue PAR backfits for large-dry containment designs.

ACRS and CRGR Reviews

The staff met with the Advisory Committee on Reactor Safeguards, on December 6, 2001, and the Committee to Review Generic Requirements, on December 18, 2001. Both committees commented favorably on the proposed rule and provided comments.

RESOURCES:

The resources to complete and implement the proposed rulemaking ($40K and 1.25 FTE for FY 2002 and 0.5 FTE for FY 2003 for NRR and $200K and 0.25 FTE for FY 2002 and 0.1 FTE for FY 2003 for RES) are included in the FY 2002 and FY 2003 budgets. The staff does not expect that additional resources will be needed to complete this effort.

COORDINATION:

The Office of the General Counsel has no legal objection to this paper. The Office of the Chief Financial Officer has reviewed this Commission paper for resource implications and has no objections. The CRGR has reviewed this proposed rule and will review the final rule.

RECOMMENDATIONS:

That the Commission:

1. *Approve* the notice of proposed rulemaking for publication (Attachment 1).

2. *Certify* that this rule, if promulgated, will not have a negative economic impact on a substantial number of small entities in order to satisfy requirements of the Regulatory Flexibility Act, 5 U.S.C. 605(b).3.

Note:

1. The following documents will be published in the *Federal Register* with a 75-day public comment period:

   - Notice of proposed rulemaking including the Environmental Assessment (Attachment 1)
   - Draft regulatory analysis (Attachment 2, also available in Public Document Room and on NRC rulemaking Web site)
   - Draft Regulatory Guide DG-1117, "Control of Combustible Gas Concentrations in Containment" (Attachment 3)
   - Draft revision to Standard Review Plan, Section 6.2.5, "Combustible Gas Control in Containment" (Attachment 4)
   - A model safety evaluation and proposed changes to the standard technical specifications to support the implementation of the proposed rule (Attachments 5 and 6)

2. The Chief Counsel for Advocacy of the Small Business Administration will be informed of the certification regarding economic impact on small entities and the basis for it, as required by the Regulatory Flexibility Act.

3. Copies of the *Federal Register* notice of proposed rulemaking will be distributed to all affected Commission licensees. The notice will be sent to other interested parties upon request.

4. A public announcement will be issued.

5. The appropriate Congressional committees will be informed.

/RA/

William D. Travers
Executive Director
for Operations

Attachments:
1. Federal Register Notice
2. Regulatory Analysis
3. Draft Regulatory Guide (DG-1117)
4. Draft Standard Review Plan (Section 6.2.5)
5. Model Safety Evaluation
6. Draft Proposed Changes to Standard Technical Specifications
7. PAR: Value Impact Assessment

[7590-01-P]

NUCLEAR REGULATORY COMMISSION

10 CFR Parts 50 and 52

RIN 3150 - AG76

Combustible Gas Control in Containment

AGENCY: U. S. Nuclear Regulatory Commission.

ACTION: Proposed rule.

SUMMARY: The U. S. Nuclear Regulatory Commission (NRC) proposes to amend 10 CFR 50.44 by establishing risk-informed, performance-based requirements for combustible gas control systems in power reactors applicable to current licensees, and by setting and consolidating combustible gas control regulations for future applicants and licensees. This action stems from the Commission's ongoing effort to risk-inform its regulations, and is intended to reduce the regulatory burden on present and future power reactor licensees by eliminating the requirements for hydrogen recombiners and hydrogen purge systems and relaxing the requirements for hydrogen and oxygen monitoring equipment to make them commensurate with their risk significance.

In addition to the rulemaking and its associated analyses, the NRC is also proposing a draft regulatory guide, a draft standard review plan revision, and a Consolidated Line Item Improvement Process (CLIIP) for draft technical specifications changes to implement the proposed rule.

DATES: Submit comments by (insert date 75 days after publication in the *Federal Register*). Comments received after this date will be considered if it is practical to do so, but the Commission is able to ensure consideration only for comments received on or before this date.

ADDRESSES: Submit comments to the Secretary, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, Attention: Rulemakings and Adjudications Staff.

Deliver comments to: 11555 Rockville Pike, Rockville, Maryland, between 7:30 AM and 4:15 PM on Federal workdays.

You may also provide comments via the NRC's interactive rulemaking Website at http://ruleforum.llnl.gov. This site provides the capability to upload comments as files (any format) if your Web browser supports that function. For information about the interactive rulemaking Website, contact Ms. Carol Gallagher, (301) 415-5905 (e-mail: CAG@nrc.gov).

Certain documents related to this rulemaking, including comments received, may be examined at the NRC Public Document Room, 11555 Rockville Pike, Rockville, Maryland. Some of these documents may also be viewed and downloaded electronically via the rulemaking Website.

FOR FURTHER INFORMATION CONTACT: Anthony W. Markley, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, telephone (301) 415-3165, e-mail awm@nrc.gov.

SUPPLEMENTARY INFORMATION:

I. Background

On October 27, 1978 (43 FR 50162), the Commission adopted a new rule, 10 CFR 50.44, specifying the standards for combustible gas control systems. The rule requires the applicant or licensee to show that during the time period following a postulated loss-of-coolant accident (LOCA), but prior to effective operation of the combustible gas control system, either: (1) an uncontrolled hydrogen-oxygen recombination would not take place in the containment, or (2) the plant could withstand the consequences of an uncontrolled hydrogen-oxygen recombination without loss of safety function. If neither of these conditions could be shown, the rule required that the containment be provided with an inerted atmosphere to provide protection against hydrogen burning and explosion. The rule defined a release of hydrogen involving up to 5 percent oxidation of the fuel cladding as the amount of hydrogen to be assumed in determining compliance with the rule's provisions. This design-basis hydrogen release was based on the design-basis LOCA postulated by 10 CFR 50.46 and was multiplied by a factor of five for added conservatism to address possible further degradation of emergency core cooling.

The accident at Three Mile Island, Unit 2 involved oxidation of approximately 45 percent of the fuel cladding [NUREG/CR-6197, dated March 1994] with hydrogen generation well in excess of the amounts required to be considered for design purposes by § 50.44. In the aftermath of the Three Mile Island accident, the Commission reevaluated the adequacy of the regulations related to hydrogen control to provide greater protection in the event of accidents more severe than design-basis LOCAs. The Commission reassessed the vulnerability of various containment designs to hydrogen burning, which resulted in additional hydrogen control requirements adopted as amendments to § 50.44. The 1981 amendment, which added paragraphs (c)(3)(i), (c)(3)(ii), and (c)(3)(iii) to the rule, imposed the following requirements:

(1) an inerted atmosphere for boiling water reactor (BWR) Mark I and Mark II containments,
(2) installation of recombiners for light water reactors that rely on a purge or repressurization system as a primary means of controlling combustible gases following a LOCA, and
(3) installation of high point vents to relieve noncondensible gases from the reactor vessel (46 FR 58484, December 2, 1981).

On January 25, 1985 (50 FR 3498), the Commission published another amendment to § 50.44. This amendment, which added paragraph (c)(3)(iv), required a hydrogen control system justified by a suitable program of experiment and analysis for BWRs with Mark III containments and pressurized water reactors (PWRs) with ice condenser containments. In addition, plants with these containment designs must have systems and components to establish and maintain safe shutdown and containment integrity. These systems must be able to function in an environment after burning and detonation of hydrogen unless it is shown that these events are unlikely to occur. The control system must handle an amount of hydrogen equivalent to that generated from a metal-water reaction involving 75 percent of the fuel cladding surrounding the active fuel region.

When § 50.44 was amended in 1985, the NRC recognized that an improved understanding of the behavior of accidents involving severe core damage was needed. During the 1980s and 1990s, the Commission sponsored a severe accident research program to improve the understanding of core melt phenomena, combustible gas generation, transport and combustion, and to develop improved models to predict the progression of severe accidents. The results of this research have been incorporated into various studies (e.g., NUREG-1150 and probabilistic risk assessments performed as part of the Individual Plant Examination (IPE) program) to quantify the risk posed by severe accidents for light water reactors.

The result of these studies has been an improved understanding of combustible gas behavior during severe accidents and confirmation that the hydrogen release postulated from a design-basis LOCA was not risk-significant because it would not lead to containment failure, and that the risk associated with hydrogen combustion was from beyond design-basis (e.g., severe accidents) accidents. These studies also confirmed the assessment of vulnerabilities that went into the 1981 and 1985 amendments which required additional hydrogen control measures for some containment designs.

II. Rulemaking Initiation

In a June 8, 1999, Staff Requirements Memorandum (SRM) on SECY-98-300, Options for Risk-informed Revisions to 10 CFR Part 50 - "Domestic Licensing of Production and Utilization Facilities," the Commission approved proceeding with a study of risk-informing the technical requirements of 10 CFR Part 50. The NRC staff provided its plan and schedule for the study phase of its work to risk-inform the technical requirements of 10 CFR Part 50, in

SECY-99-264, “Proposed Staff Plan for Risk-Informing Technical Requirements in 10 CFR Part 50” dated November 8, 1999. The Commission approved proceeding with the plan for risk-informing the Part 50 technical requirements in a February 3, 2000, SRM. Section 50.44 was selected as a test case for piloting the process of risk-informing 10 CFR Part 50 in SECY-00-0086, “Status Report on Risk-Informing the Technical Requirements of 10 CFR Part 50 (Option 3).”

Mr. Christie of Performance Technology, Inc. submitted letters, dated October 7 and November 9, 1999, that requested changes to the regulations in § 50.44. He requested that the regulations be amended to: reflect that the hydrogen source term be based on realistic calculations for accidents with a high probability of causing severe reactor core damage; eliminate the requirement to monitor hydrogen concentration; eliminate the requirement to control combustible gas concentration resulting from a postulated-LOCA; retain the requirement to inert Mark I and II containments; retain the requirement for high point vents; require licensees with Mark III and ice condenser containments to have hydrogen control systems capable of meeting a specified performance level; and specify that facilities with other types of containments "must demonstrate that the reactor containment (based on realistic calculations) can withstand, without any hydrogen control system, a hydrogen burn for accidents with a high probability of causing severe core damage."

These letters have been treated by the NRC as a petition for rulemaking and assigned the Docket No. PRM-50-68. The NRC published a document requesting comment on the petition in the Federal Register on January 12, 2000 (65 FR 1829). The issues associated with § 50.44 raised by the petitioner were discussed in SECY-00-0198, Status Report on Study of Risk-Informed Changes to the Technical Requirements of 10 CFR Part 50 (Option 3) and Recommendations on Risk-Informed Changes to 10 CFR 50.44 (Combustible Gas Control). The proposed rule and the petition are consistent in most areas, with the following exceptions proposed by the NRC: a functional requirement for hydrogen monitoring, the capability for ensuring a mixed atmosphere, and the expectation that future plants preclude concentrations of hydrogen below limits that may support detonation. The Commission's basis for including these requirements in the proposed rule is addressed in the subsequent sections of this supplementary information.

The Commission also received a petition for rulemaking filed by the Nuclear Energy Institute. The petition was docketed on April 12, 2000, and has been assigned Docket No. PRM-50-71. The petitioner requests that the NRC amend its regulations to allow nuclear power plant licensees to use zirconium-based cladding materials other than zircaloy or ZIRLO, provided the cladding materials meet the requirements for fuel cladding performance and have received approval by the NRC staff. The petitioner believes the proposed amendment would improve the efficiency of the regulatory process by eliminating the need for individual licensees to obtain exemptions to use advanced cladding materials which have already been approved by the NRC. The proposed rule would remove the restrictive language in 10 CFR 50.44 that precludes the use of zirconium-based cladding materials other than zircaloy or ZIRLO. The change requested by the petitioner is unrelated to the risk-informing of 10 CFR 50.44. The Commission is addressing this petition in this rulemaking for effective use of resources. The NRC published a document requesting comment on the petition in the Federal Register on May 30, 2000 (65 FR 34599).

In SECY-00-0198, dated September 14, 2000, the NRC staff proposed a risk-informed voluntary alternative to the current § 50.44. Attachment 2 to that paper, hereafter referred to as the Feasibility Study, used the framework described in Attachment 1 to the paper and risk insights from NUREG-1150 and the IPE programs, to evaluate the requirements in § 50.44. The

Feasibility Study found that combustible gas generated from design-basis accidents was not risk-significant for any containment type, given intrinsic design capabilities or installed mitigative features. The Feasibility Study also concluded that combustible gas generated from severe accidents was not risk significant for (1) Mark I and II containments provided that the required inerted atmosphere was maintained, (2) Mark III and ice condenser containments provided that the required igniter systems were maintained and operational, and (3) large, dry and sub-atmospheric containments because the large volumes, high failure pressures, and likelihood of random ignition help prevent the build-up of hydrogen concentrations.

The Feasibility Study did conclude that the existing requirements for combustible gas mitigative features were risk-significant and must be retained. Additionally, the Feasibility Study also indicated that some mitigative features may need to be enhanced beyond current requirements. This was identified as Generic Issue (GI) 189. The resolution of GI-189 will assess whether improvements to safety can be achieved and the costs and benefits of enhancing combustible gas control requirements for Mark III and ice condenser containment designs. The resolution of GI-189 will proceed independently of this rulemaking.

The staff incorporated Mr. Christie's petition into the effort to risk-inform § 50.44. A comparison of Mr. Christie's petition for rulemaking to the staff's recommended alternative was provided in Attachment 3 to SECY-00-0198. In an SRM dated January 19, 2001, the Commission directed the NRC staff to proceed expeditiously with rulemaking on the risk-informed alternative to § 50.44.

In SECY-01-0162, Staff Plans for Proceeding with the Risk-informed Alternative to the Standards for Combustible Gas Control Systems in Light-water-cooled Power Reactors in 10 CFR 50.44, dated August 23, 2001, the NRC staff recommended a revised approach to the rulemaking effort. This revised approach recognized that risk-informing Part 50, Option 3 was based on a realistic reevaluation of the basis of a regulation and the application of realistic risk analyses to determine the need for and relative value of regulations that address a design-basis issue. The result of this process necessitates a fundamental reevaluation or "rebaselining" of the existing regulation, rather than the development of a voluntary alternative approach to rulemaking. Lastly, upon its own initiative, the staff incorporated the relevant portions of the NEI petition into this rulemaking. On November 14, 2001, in response to Commission direction in an SRM dated August 2, 2001, the staff published draft rule language on the NRC web site for stakeholder review and comment. In an SRM dated December 31, 2001, the Commission directed the staff to proceed with the revision to the existing § 50.44 regulations.

III. Proposed Action

The Commission proposes to retain existing requirements for ensuring a mixed atmosphere, inerting Mark I and II containments, and hydrogen control systems capable of accommodating an amount of hydrogen generated from a metal-water reaction involving 75 percent of the fuel cladding surrounding the active fuel region in Mark III and ice condenser containments. The Commission proposes to eliminate the design-basis LOCA hydrogen release from § 50.44 and to consolidate the requirements for hydrogen and oxygen monitoring into § 50.44 while relaxing safety classifications and licensee commitments to certain design and qualification criteria. The Commission also proposes to relocate without change the hydrogen control requirements in § 50.34(f) to § 50.44. The Commission proposes to relocate the high point vent requirements from § 50.44 to § 50.46a with a change that eliminates a requirement prohibiting venting the reactor coolant system if it could “aggravate” the challenge to containment. The NRC received comments on the draft rule language published on the web site from seven members of the public which included both petitioners, four utilities, and a law firm that represents the Nuclear Utility Group on Equipment Qualification. The comments were overwhelmingly supportive of the draft proposed rule language. The Commission used stakeholder comments on the draft rule language, information provided in licensee exemption submittals, in the petitions for rulemaking, and in the Boiling Water Reactor Owners Group (BWROG) topical report to inform its deliberations and decisions with respect to specific rule language and positions taken.

The Commission also received feedback on several issues for which comments were specifically requested in the draft rule language. The existing rule provides detailed, prescriptive instructions using American Society of Mechanical Engineers (ASME) references for the performance of boiling water reactor (BWR) Mark III and pressurized water reactor (PWR) ice condenser containments. The staff provided an option for a more performance-based approach for stakeholder consideration, which received positive public comment. Based upon stakeholder input, the proposed rule eliminates the existing references to ASME and prescriptive requirements and the proposed regulatory guide, attached to this paper, includes the ASME approach as one in which the intent of the regulations could be satisfied which simplifies the proposed regulations.

The staff also requested feedback on the utility of post-accident inerting as a means of combustible gas control. To date, no current licensee facility has exercised this alternative to address the control of combustible gas nor has any new reactor design opted for this approach. The major concerns involved with post-accident inerting of containment are expense and the issues associated with its adverse effects and actuation. Stakeholder feedback during public meetings and in the comments received on the draft rule language supported elimination of this option. Based upon stakeholder input, the proposed rule eliminates the post-accident inerting option which also simplifies the proposed regulations.

Substantive changes in rule language that resulted from consideration of public comments are addressed in the following subject sections.

A. Retention of Inerting, BWR Mark III and PWR Ice Condenser

Hydrogen Control Systems, Mixed Atmosphere Requirements, And Associated Analysis Requirements

The Commission proposes to retain the existing requirement in § 50.44(c)(3)(i) to inert Mark I and II type containments. Given the relatively small volume and large zirconium inventory, these containments, without inerting, would have a high likelihood of failure from hydrogen combustion due to the potentially large concentration of hydrogen that a severe accident could cause. Retaining the requirement maintains the current level of public protection, as discussed in Section 4.3.2 of the Feasibility Study.

The Commission proposes to retain the existing requirements in § 50.44(c)(3)(iv), (v), and (vi) that BWRs with Mark III containments and PWRs with ice condenser containments provide a hydrogen control system justified by a suitable program of experiment and analysis. The amount of hydrogen to be considered is that generated from a metal-water reaction involving 75 percent of the fuel cladding surrounding the active fuel region (excluding the cladding surrounding the plenum volume). The analyses must demonstrate that the structures, systems and component necessary for safe shutdown and maintaining containment integrity must perform their functions during and after exposure to the conditions created by the burning hydrogen. Environmental conditions caused by local detonations of hydrogen must also be included, unless such detonations can be shown unlikely to occur. A beyond design-basis accident generating significant amounts of hydrogen (on the order of Three Mile Island, Unit 2, accident or a metal water reaction involving 75% of fuel cladding surrounding the active fuel region) would pose a severe threat to the integrity of these containment types in the absence of the installed igniter systems. Section 4.3.3 of the Feasibility Study concluded that hydrogen combustion is not risk-significant, in terms of the framework document's quantitative guidelines, when igniter systems installed to meet § 50.44(c)(3)(iv), (v), and (vi) are available and operable. The Commission proposes to retain these requirements. Previously reviewed and approved licensee analyses to meet the existing regulations constitute compliance with this proposed section. The results of these analyses must continue to be documented in the plant's Updated Final Safety Analysis Report in accordance with § 50.71(e).

The Commission proposes to retain the § 50.44(b)(2) requirement that all containments ensure a mixed atmosphere. A mixed containment atmosphere prevents local accumulation of combustible or detonable gases which could threaten containment integrity or equipment operating in a local compartment. The current regulation ensures that features that promote atmospheric mixing, either active systems and/or containment internal structures that have design features which promote the free circulation of the containment atmosphere, are provided.

B. Elimination of Design-Basis LOCA Hydrogen Release

The proposed rule would remove the existing definition of a design-basis LOCA hydrogen release and eliminate requirements for hydrogen control systems to mitigate such a release. The installation of recombiners and/or vent and purge systems required by § 50.44(b)(3) was intended to address the limited quantity and rate of hydrogen generation that was postulated from a design-basis LOCA. The Commission finds that this hydrogen release is not risk-significant. This finding is based on the Feasibility Study which found that the design-basis LOCA hydrogen release did not contribute to the conditional probability of a large release up to approximately 24 hours after the onset of core damage. The requirements for combustible gas control that were developed after the Three Mile Island Unit 2 accident were intended to minimize potential additional challenges to containment due to long term residual or radiolytically generated hydrogen. The Commission found that containment loadings associated with long term hydrogen concentrations are no worse than those considered in the first 24 hours and are, therefore, not risk-significant. The Commission believes that accumulation of combustible gases beyond 24 hours can be managed by licensee implementation of the severe accident management guidelines (SAMGs) or other ad hoc actions because of the long period of time available to take such action. Therefore, the Commission proposes to eliminate the hydrogen release associated with a design-basis LOCA from § 50.44 and the associated requirements that necessitated the need for the hydrogen recombiners and the backup hydrogen vent and purge systems.

In plants with Mark I and II containments, the containment atmosphere is required to be maintained with a low concentration of oxygen, rendering it inert to combustion. Mark I and II containments can be challenged beyond 24 hours by the long-term generation of oxygen through radiolysis. The regulatory analysis for this proposed rulemaking found the cost of maintaining the recombiners exceeded the benefit of retaining them to prevent containment failure sequences that progress to the very late time frame. The Commission believes that this conclusion would also be true for the backup hydrogen purge system even though the cost of the hydrogen purge system would be much lower because the system is also needed to inert the containment.

The Commission continues to view severe accident management guidelines as an important part of the severe accident closure process. Severe accident management guidelines are part of a voluntary industry initiative to address accidents beyond the design basis and emergency operating instructions. In November 1994, the US nuclear industry committed to implement severe accident management at their plants by December 31, 1998, using the guidance contained in NEI 91-04, Revision 1, “Severe Accident Issue Closure Guidelines.” Generic severe accident management guidelines developed by each nuclear steam system supplier owners group includes either purging and venting or venting the containment to address combustible gas control. On the basis of the industry-wide commitment, the Commission is not proposing to require such capabilities, but continues to view purging and/or controlled venting of all containment types to be an important combustible gas control strategy that should be considered in a plant's severe accident management guidelines.

C. Oxygen Monitoring Requirements

The Commission proposes to amend § 50.44 to codify the existing regulatory practice of monitoring oxygen in containments that use an inerted atmosphere for combustible gas control. Standard technical specifications and licensee technical specifications currently require oxygen monitoring to verify the inerted condition in containment. Combustible gases produced by beyond design-basis accidents involving both fuel-cladding oxidation and core-concrete interaction would be risk-significant for plants with Mark I and II containments if not for the inerted containment atmosphere. If an inerted containment was to become de-inerted during a beyond design-basis accident, then other severe accident management strategies, such as purging and venting, would need to be considered. The oxygen monitoring is needed to implement these severe accident management strategies, in plant emergency operating procedures and is also used as an input in emergency response decision making.

The Commission proposes reclassifying oxygen monitors as not safety-related components. Currently, as recommended by the Commission's Regulatory Guide (RG) 1.97, oxygen monitors are classified as Category 1. Category 1 is defined as applying to instrumentation designed for monitoring variables that most directly indicate the accomplishment of a safety function for design-basis events. By eliminating the design-basis LOCA hydrogen release, the oxygen monitors are no longer required to mitigate design-basis accidents. The Commission finds that Category 2, defined in RG 1.97, as applying to instrumentation designated for indicating system operating status, to be the more appropriate categorization for the oxygen monitors, because the monitors will still continue to be required to verify the status of the inerted containment. Further, the staff concludes that sufficient reliability of oxygen monitoring, commensurate with its risk-significance, will be achieved by the guidance associated with the Category 2 classification. Because of the various regulatory means, such as orders, that were used to implement post-TMI requirements, this proposed relaxation may require a license amendment. Licensees would also need to update their final safety analysis report to reflect the new classification and RG 1.97 categorization of the monitors in accordance with 10 CFR 50.71(e).

D. Hydrogen Monitoring Requirements

The Commission proposes to maintain the existing requirement in § 50.44(b)(1) for monitoring hydrogen in the containment atmosphere for all plant designs. Section 50.44(b)(1), standard technical specifications and licensee technical specifications currently contain requirements for monitoring hydrogen, including operability and surveillance requirements for the monitoring systems. Licensees have also made commitments to design and qualification criteria for hydrogen monitors in NUREG-0737, Item II.F.1, Attachment 6 and in RG 1.97. The hydrogen monitors are required to assess the degree of core damage during a beyond design-basis accident and confirm that random or deliberate ignition has taken place. Hydrogen monitors are also used, in conjunction with oxygen monitors in inerted containments, to guide response to emergency operating procedures. Hydrogen monitors are also used in emergency operating procedures of BWR Mark III facilities. If an explosive mixture that could threaten containment integrity exists, then other severe accident management strategies, such as purging and/or venting, would need to be considered. The hydrogen monitors are needed to implement these severe accident management strategies.

The Commission proposes to reclassify the hydrogen monitors as not safety-related components. With the proposed elimination of the design-basis LOCA hydrogen release (see Item B. earlier), the hydrogen monitors are no longer required to mitigate design-basis accidents and, therefore, the hydrogen monitors do not meet the definition of a safety-related component as defined in § 50.2. This is consistent with the Commission's proposal that oxygen monitors that are used for beyond-design basis accidents need not be safety grade.

Currently, RG 1.97 recommends classifying the hydrogen monitors in Category 1, defined as applying to instrumentation designed for monitoring key variables that most directly indicate the accomplishment of a safety function for design-basis accident events. The hydrogen monitors no longer meet the definition of Category 1 in RG 1.97 and, therefore, the Commission believes that licensees' current commitments are unnecessarily burdensome. The Commission believes that Category 3, as defined in RG 1.97, is an appropriate categorization for the hydrogen monitors because the monitors are required to diagnose the course of beyond design-basis accidents. Category 3 applies to high-quality, off-the-shelf backup and diagnostic instrumentation. As with the revision to oxygen monitoring, this proposed relaxation may require a license amendment. Licensees would also need to update their final safety analysis report to reflect the new classification and RG 1.97 categorization of the monitors in accordance with 10 CFR 50.71(e).

E. Combustible Gas Control Requirements for Future Applicants

The Commission proposes to set forth combustible gas control requirements for all future applicants for or holders of a construction permit or an operating license under Part 50, and to all future applicants for design approval, design certification, or a combined license under Part 52. These requirements would consolidate combustible gas requirements for existing and future light water reactors in § 50.44. Section 52.47(a)(ii) requires demonstration of compliance with the technically relevant portions of the Three Mile Island requirements in § 50.34(f). Section 50.34(f)(2)(ix) requires a system for hydrogen control that can safely accommodate hydrogen generated by the equivalent of a 100 percent fuel-clad metal-water reaction. In addition, the regulation requires this system to be capable of precluding uniform concentrations of hydrogen from exceeding 10 percent (by volume), or providing an inerted atmosphere within the containment. The Commission is proposing requirements for future light water reactors that are consistent with the criteria currently contained in § 50.34(f)(2)(ix) to preclude local concentrations of hydrogen collecting in areas where unintended combustion or detonation could cause loss of containment integrity or loss of appropriate mitigating features. These requirements are in keeping with the Commission's expectation that future designs will achieve a higher standard of severe accident performance (50 FR 32138; August 8, 1985). Additional advantages of providing hydrogen control mitigation features (rather than reliance on random ignition of richer mixtures) include the lessening of pressure and temperature loadings on the containment and essential equipment.

F. Clarification and Relocation of High Point Vent Requirements From 10 CFR 50.44 to 10 CFR 50.46a

The Commission proposes to remove the current requirements for high point vents from § 50.44 and to transfer them to a new § 50.46a. The Commission proposes relocating these requirements because high point vents are relevant to emergency core cooling system (ECCS) performance during severe accidents, and § 50.44 does not address ECCS performance. The requirement to install high point vents was imposed by the 1981 amendment to § 50.44. This requirement permitted venting of noncondensible gases which may interfere with the natural circulation pattern in the reactor coolant system. This process is regarded as an important safety feature in accident sequences that credit natural circulation of the reactor coolant system. In other sequences, the pockets of noncondensible gases may interfere with pump operation. The high point vents could be instrumental for terminating a core damage accident if ECCS operation is restored. Under these circumstances, venting noncondensible gases from the vessel allows emergency core cooling flow to reach the damaged reactor core and thus prevents further accident progression.

The Commission proposes to amend the language in current § 50.44(c)(3)(iii) by deleting the statement, “the use of these vents during and following an accident must not aggravate the challenge to the containment or the course of the accident.” For certain severe accident sequences, the use of reactor coolant system high point vents is intended to reduce the amount of core damage by providing an opportunity to restore reactor core cooling. While the release of noncondensible and combustible gases from the reactor coolant system will, in the short term, “aggravate” the challenge to containment, the use of these vents will positively affect the overall course of the accident. The release of any combustible gases from the reactor coolant system has been considered in the containment design and mitigative features that are required for combustible gas control. Any venting is highly unlikely to affect containment integrity; however, such venting will reduce the likelihood of further core damage. Inasmuch as the overall safety is increased by venting through high point vents, the Commission proposes elimination of this statement in § 50.46a.

G. Elimination of Post-Accident Inerting

The proposed rule would no longer provide an option to use post-accident inerting as a means of combustible gas control. Although post-accident inerting systems were permitted as a possible alternative for mitigating combustible gas concerns after the accident at Three Mile Island, Unit 2, these systems have never been implemented to date. Concerns with a post-accident inerting system include: corrosion (if halon gas is used as the inerting agent), increase in containment pressure with use, limitations on emergency response personnel access, and cost. Sections 50.44(c)(3)(iv)(D) and 50.34(f)(ix)(D) were promulgated to address these concerns. On November 14, 2001, draft rule language was made available to elicit comment from interested stakeholders. The draft rule language recommended eliminating the option to use post-accident inerting as a means of combustible gas control and asked stakeholders if there was a need to retain these requirements. Stakeholder feedback supported the staff recommendation to eliminate the post-accident inerting option and indicated that licensees do not intend to convert existing plants to use post-accident inerting. Because there is no need for the regulations to support an approach that is unlikely to be used, post-accident inerting requirements are being eliminated.

IV. Section-by-Section Analysis of Substantive Changes

Section 50.44 - Combustible gas control in containment.

Paragraph (a) [*Definitions*]. Paragraph (a) adds definitions for two previously undefined terms, “mixed atmosphere,” and “inerted atmosphere.”

Paragraph (b) [*Requirements for currently-licensed reactors*]. This paragraph would set forth the requirements for control of combustible gas in containment for currently-licensed reactors. All BWRs with Mark I and II type containments will be required to have an inerted containment atmosphere, and all BWR Mark III type containments and PWR s with ice condenser type containments would be required to include a capability for controlling combustible gas generated from a metal water reaction involving 75% of the fuel cladding surrounding the active fuel region (excluding the cladding surrounding the plenum volume) so that there is no loss of containment integrity. Current requirements in § 50.44(c)(i), (iv), (v), and (vi) would be incorporated in to the proposed amended regulation without substantial change. Previously reviewed and installed combustible gas control mitigation features to meet the existing regulations are considered in compliance with this proposed section. Because these proposed requirements address beyond design-basis combustible gas control, it is acceptable for structures, systems, and components provided to meet these requirements to not be safety-related and may be procured as commercial grade items.

Proposed paragraph (b)(1) [*Mixed atmosphere*]. The requirement for capability ensuring a mixed atmosphere in all containments is consistent with the current requirement in § 50.44(b)(2) and would not require further analysis or modifications by current licensees. The intent of this requirement is to maintain those plant design features (e.g., availability of active mixing systems or open compartments) that promote atmospheric mixing. The requirement could be met with active or passive systems. Active systems could include a fan, a fan cooler or containment spray. Passive capability could be demonstrated by evaluating the containment for susceptibility to local hydrogen concentration. These evaluations have been conducted for currently licensed reactors as part of the IPE program.

Proposed paragraph (b)(3) retains the existing requirements for BWR Mark III and PWR ice condenser facilities that do not use inerting to establish and maintain safe shutdown and containment structural integrity to use structures, systems, and components capable of performing their functions during and after exposure to hydrogen combustion.

Proposed paragraph (b)(4)(i) would codify the existing regulatory practice of monitoring oxygen in containments that use an inerted atmosphere for combustible gas control. The proposed rule would not require further analysis or modifications by current licensees but certain design and qualification criteria would be relaxed. The proposed rule requires that equipment for monitoring oxygen be functional, reliable and capable of continuously measuring the concentration of oxygen in the containment atmosphere following a beyond design-basis accident. Equipment for monitoring oxygen is expected to perform in the environment anticipated in the severe accident management guidance. The oxygen monitors are expected to be of high-quality and may be procured as commercial grade items. Existing oxygen monitoring commitments for currently licensed plants are sufficient to meet the intent of this rule.

Proposed paragraph (b)(4)(ii) would retain the requirement in § 50.44(b)(1) for measuring the hydrogen concentration in the containment. The proposed rule would not require further analysis or modifications by current licensees but certain design and qualification criteria would be relaxed. The proposed rule requires that equipment for monitoring hydrogen be functional, reliable and capable of continuously measuring the concentration of hydrogen in the containment atmosphere following a beyond design-basis accident. Equipment for monitoring hydrogen is expected to perform in the environment anticipated in the severe accident management guidance. The hydrogen monitors may be procured as commercial grade items. Existing hydrogen monitoring commitments for currently licensed plants are sufficient to meet the intent of this rule.

Paragraph (c) [*Requirements for future applicants and licensees*]. Proposed paragraph (c) would promulgate requirements for combustible gas in containment control for all future construction permits or operating licenses under Part 50 and to all design approvals, design certifications, combined licenses or manufacturing licenses under Part 52. The current requirements in § 50.34(f)(2)(ix) and (f)(3)(v) would be retained. Proposed paragraph (c)(2) would require all containments to have an inerted atmosphere or limit hydrogen concentrations in containment during and following an accident that releases an equivalent amount of hydrogen as would be generated from a 100 percent fuel-clad coolant reaction, uniformly distributed, to less than 10 percent and maintain containment structural integrityand appropriate mitigating features. Structures, systems, and components (SSCs) provided to meet this requirement must be designed to provide reasonable assurance that they will operate in the severe accident environment for which they are intended and over the time span for which they are needed. Equipment survivability expectations under severe accident conditions should consider the circumstances of applicable initiating events (such as station blackout or earthquakes) and the environment (including pressure, temperature, and radiation) in which the equipment is relied upon to function. The required system performance criteria will be based on the results of design-specific reviews which include probabilistic risk-assessment as required by 10 CFR 52.47(a)(v). Because these requirements address beyond design-basis combustible gas control, SSCs provided to meet these requirements need not be subject to the environmental qualification requirements of 10 CFR Section 50.49; quality assurance requirements of 10 CFR Part 50, Appendix B; and redundancy/diversity requirements of 10 CFR Part 50, Appendix A. Guidance such as that found in Appendices A and B of RG 1.155, "Station Blackout," is appropriate for equipment used to mitigate the consequences of severe accidents. Proposed paragraph (c) would also promulgate requirements for ensuring a mixed atmosphere and monitoring oxygen and hydrogen in containment, consistent with the requirements for current plants set forth in proposed paragraphs (b)(1), and (b)(4)(i) and (ii).

Section 50.46a - Acceptance criteria for reactor coolant system venting systems.

Proposed § 50.46a would be a new section which relocates the requirements for high point vents currently contained in § 50.44. The amendment includes a change that eliminates a requirement prohibiting venting the reactor coolant system if it could “aggravate” the challenge to containment. Any venting is highly unlikely to affect containment integrity; however, such venting will reduce the likelihood of further core damage. Commission continues to view use of the high point vents to be an important strategy that should be considered in a plant’s severe accident management guidelines.

Section 52.47 - Contents of applications.

§ 52.47 would be amended to eliminate the reference to subsections within § 50.34(f) for technically relevant requirements for combustible gas control in containment for future design approval, design certification, or license applicants. These applicants would reference § 50.44 for technical requirements for combustible gas control in containment.

V. Plain Language

The Presidential memorandum dated June 1, 1998, entitled “Plain Language in Government Writing” directed that the Government’s writing be in plain language. This memorandum was published on June 10, 1998 (63 FR 31883). In complying with this directive, editorial changes have been made in these proposed revisions to improve the organization and readability of the existing language of the paragraphs being revised. These types of changes are not discussed further in this document. The NRC requests comments on the proposed rule specifically with respect to the clarity and reflectiveness of the language used. Comments should be sent to the address listed under the ADDRESSES caption of the preamble.

VI. Voluntary Consensus Standards

The National Technology Transfer and Advancement Act of 1995, Pub. L. 104-113, requires that Federal agencies use technical standards that are developed or adopted by voluntary consensus standards bodies unless using such a standard is inconsistent with applicable law or is otherwise impractical. In this proposed rule, the NRC proposes to use the following Government-unique standard: 10 CFR 50.44, U.S. Nuclear Regulatory Commission, October 27, 1978 (43 FR 50163), as amended. The NRC is not aware of any voluntary consensus standard that could be used instead of the proposed Government-unique standard. The NRC will consider a voluntary consensus standard if an appropriate standard is identified. If a voluntary standard is identified for consideration, the submittal should explain how the voluntary consensus standard is comparable and why it should be used instead of the proposed Government-unique standard.

VII. Finding of No Significant Environmental Impact: Environmental Assessment

The Commission has determined under the National Environmental Policy Act of 1969, as amended, and the Commission's regulations in Subpart A of 10 CFR Part 51, that this rule, if adopted, would not be a major Federal action significantly affecting the quality of the human environment and, therefore, an environmental impact statement is not required. The basis for this determination reads as follows:

This action endorses existing requirements and establishes regulations that reduce regulatory burdens for current and future licensees and consolidates combustible gas control regulations for future applicants and licensees. This action stems from the Commission's ongoing effort to risk-inform its regulations. The proposed rule would reduce the regulatory burdens on present and future power reactor licensees by eliminating the LOCA design-basis accident as a combustible gas control concern. This change eliminates the requirements for hydrogen recombiners and hydrogen purge systems and relaxes the requirements for hydrogen and oxygen monitoring equipment to make them commensurate with their safety and risk significance.

The proposed action would not significantly increase the probability or consequences of an accident. No changes are being made in the types or quantities of radiological effluents that may be released off site, and there is no significant increase in public radiation exposure since there is no change to facility operations that could create a new or affect a previously analyzed accident or release path. There may be a reduction of occupational radiation exposure since personnel will no longer be required to maintain or operate, if necessary, the hydrogen recombiner systems which are located in or near radiologically controlled areas.

With regard to non-radiological impacts, no changes are being made to non-radiological plant effluents and there are no changes in activities that would adversely affect the environment. Therefore, there are no significant non-radiological impacts associated with the proposed action.

The primary alternative to this action would be the no action alternative. The no action alternative would continue to impose unwarranted regulatory burdens for which there would be little or no safety, risk, or environmental benefit.

The determination of this environmental assessment is that there will be no significant offsite impact to the public from this action. However, the general public should note that the NRC is seeking public participation. Comments on any aspect of the environmental assessment may be submitted to the NRC as indicated under the ADDRESSES heading.

The NRC has sent a copy of this proposed rule to every State Liaison Officer and requested their comments on the environmental assessment.

VIII. Paperwork Reduction Act Statement

This proposed rule decreases the burden on new applicants to complete the hydrogen control analysis required to be submitted in a license application, as required by sections 50.34 or 52.47. The public burden reduction for this information collection is estimated to average 720 hours per request. Because the burden for this information collection is insignificant, Office of Management and Budget (OMB) clearance is not required. Existing requirements were approved by the Office of Management and Budget, approval numbers 3150-0011 and 3150-0151.

Public Protection Notification

The NRC may not conduct or sponsor, and a person is not required to respond to, a request for information or an information collection requirement unless the requesting document displays a currently valid OMB control number.

IX. Regulatory Analysis

The Commission has prepared a draft regulatory analysis on this proposed regulation. The analysis examines the costs and benefits of Commission alternatives for updating the existing rule to accommodate technological advances while addressing regulatory relaxation issues. From an overall safety and value impact perspective, the analysis recommends removing hydrogen recombiner requirements and relaxing hydrogen and oxygen monitoring requirements.

The Commission requests public comment on the draft regulatory analysis. The regulatory analysis may be viewed and downloaded, and comments may be submitted at the NRC Rulemaking Web site. Single copies of the analysis are also available from Anthony Markley, Office of Nuclear Reactor Regulation, (301) 415-3165, e-mail awm@nrc.gov. Comments on the draft analysis may be submitted to the NRC as indicated under the ADDRESSES heading.

X. Regulatory Flexibility Certification

As required by the Regulatory Flexibility Act, as amended, 5 U.S.C. 605(b), the Commission certifies that this proposed rule, if adopted, would not have a significant economic impact on a substantial number of small entities. This proposed rule would affect only licensees authorized to operate nuclear power reactors. These licensees do not fall within the scope of the definition of "small entities" set forth in the Regulatory Flexibility Act, or the Size Standards established by the Nuclear Regulatory Commission (10 CFR 2.810).

XI. Backfit Analysis

The NRC has determined that the backfit rule does not apply to this proposed rule; therefore, a backfit analysis is not required for this proposed rule because these amendments do not impose more stringent safety requirements on 10 CFR Part 50 licensees. For current licensees, the proposed amendments either maintain without substantive change existing requirements or reduce current regulatory requirements. For future applicants and future licensees, the proposed requirements do not involve backfitting as defined in 10 CFR 50.109(a)(1). This is because any changes will have only a prospective effect on future design certification applicants and future applicants for licensees under 10 CFR Part 50 and 52. As the Commission has indicated in other rulemakings, sec., e.g., 54 FR 15372, April 18, 1989 (Final Part 52 Rule), the expectations of future applicants are not protected by the Backfit Rule. Therefore, the NRC has not prepared a backfit analysis for this rulemaking.

List of Subjects

10 CFR Part 50

Antitrust, Classified information, Criminal penalties, Fire protection, Intergovernmental relations, Nuclear power plants and reactors, Radiation protection, Reactor siting criteria, Reporting and record keeping requirements.

10 CFR Part 52

Administrative practice and procedure, Antitrust, Backfitting, Combined license, Early site permit, Emergency planning, Fees, Inspection, Limited work authorization, Nuclear power plants and reactors, Probabilistic risk assessment, Prototype, Reactor siting criteria, Redress of site, Reporting and record keeping requirements, Standard design, Standard design certification.

For the reasons set out in the preamble and under the authority of the Atomic Energy Act of 1954, as amended; the Energy Reorganization Act of 1974, as amended; and 5 U.S.C. 553, the NRC is proposing to adopt the following amendments to 10 CFR Parts 50 and 52.

PART 50 -- DOMESTIC LICENSING OF PRODUCTION AND UTILIZATION FACILITIES

1. The authority citation for Part 50 continues to read as follows:

AUTHORITY: Secs. 102, 103, 104, 105, 161, 182, 183, 186, 189, 68 Stat. 936, 938, 948, 953, 954, 955, 956, as amended, sec. 234, 83 Stat. 444, as amended (42 U.S.C. 2132, 2133, 2134, 2135, 2201, 2232, 2233, 2239, 2282); secs. 201, as amended, 202, 206, 88 Stat. 1242, as amended, 1244, 1246 (42 U.S.C. 5841, 5842, 5846).

Section 50.7 also issued under Pub. L. 95-601, sec. 10, 92 Stat. 2951, as amended by Pub. L. 102-486, sec. 2902, 106 Stat. 3123 (42 U.S.C. 5851). Section 50.10 also issued under secs. 101, 185, 68 Stat. 936, 955, as amended (42 U.S.C. 2131, 2235); sec. 102, Pub. L. 91-190, 83 Stat. 853 (42 U.S.C. 4332). Sections 50.13, 50.54(dd), and 50.103 also issued under sec. 108, 68 Stat. 939, as amended (42 U.S.C. 2138). Sections 50.23, 50.35, 50.55, and 50.56 also issued under sec. 185, 68 Stat. 955 (42 U.S.C. 2235). Sections 50.33a, 50.55a and Appendix Q also issued under sec. 102, Pub. L. 91-190, 83 Stat. 853 (42 U.S.C. 4332). Sections 50.34 and 50.54 also issued under Pub. L. 97-415, 96 Stat. 2073 (42 U.S.C. 2239). Section 50.78 also issued under sec. 122, 68 Stat. 939 (42 U.S.C. 2152). Sections 50.80 - 50.81 also issued under sec. 184, 68 Stat. 954, as amended (42 U.S.C. 2234). Appendix F also issued under sec. 187, 68 Stat. 955 (42 U.S.C. 2237).

2. In § 50.34, paragraph (a)(4) is revised, paragraph (g) is redesignated as paragraph (h), and a new paragraph (g) is added to read as follows:

§ 50.34 Contents of applications; technical information.

(a) * * *

(4) A preliminary analysis and evaluation of the design and performance of structures, systems, and components of the facility with the objective of assessing the risk to public health and safety resulting from operation of the facility and including determination of the margins of safety during normal operations and transient conditions anticipated during the life of the facility, and the adequacy of structures, systems, and components provided for the prevention of accidents and the mitigation of the consequences of accidents. Analysis and evaluation of ECCS cooling performance and the need for high point vents following postulated loss-of-coolant accidents must be performed in accordance with the requirements of § 50.46 and § 50.46a of this part for facilities for which construction permits may be issued after December 28, 1974.

* * * * *

(g) *Combustible gas control*. All applicants for a construction permit or operating license under Part 50 of this chapter, and all applicants for design approval, design certification, or license under part 52 of this chapter, whose application was submitted after [EFFECTIVE DATE OF

RULE], shall include the descriptions of the equipment, systems, and analyses required by § 50.44 as a part of their application.

*   *   *   *   *

3. Section 50.44 is revised to read as follows:

§ 50.44 Combustible gas control in containment.

(a) *Definitions*.

(1) *Inerted atmosphere* means a containment atmosphere with less than 4 percent oxygen by volume.

(2) *Mixed atmosphere* means that the concentration of combustible gases in any part of the containment is below a level that supports combustion or detonation that could cause loss of containment integrity.

(b) *Requirements for currently-licensed reactors*. Each boiling or pressurized light-water nuclear power reactor with an operating license on [EFFECTIVE DATE] must comply with the following requirements, as applicable:

(1) *Mixed atmosphere*. All containments must have a capability for ensuring a mixed atmosphere.

(2) *Combustible gas control*.

(i) All boiling water reactors with Mark I or Mark II type containments must have an inerted atmosphere.

(ii) All boiling water reactors with Mark III type containments and all pressurized water reactors with ice condenser containments must have the capability for controlling combustible gas generated from a metal-water reaction involving 75 percent of the fuel cladding surrounding the active fuel region (excluding the cladding surrounding the plenum volume) so that there is no loss of containment structural integrity.

(3) *Equipment Survivability.* All boiling water reactors with Mark III containments and all pressurized water reactors with ice condenser containments that do not rely upon an inerted atmosphere inside containment to control combustible gases must be able to establish and maintain safe shutdown and containment structural integrity with systems and components capable of performing their functions during and after exposure to the environmental conditions created by the burning of hydrogen. Environmental conditions caused by local detonations of hydrogen must also be included, unless such detonations can be shown unlikely to occur. The amount of hydrogen to be considered must be equivalent to that generated from a metal-water reaction involving 75 percent of the fuel cladding surrounding the active fuel region (excluding the cladding surrounding the plenum volume).

(4) *Monitoring*.

(i) Equipment must be provided for monitoring oxygen in containments that use an inerted atmosphere for combustible gas control. Equipment for monitoring oxygen must be functional, reliable, and capable of continuously measuring the concentration of oxygen in the containment atmosphere following a beyond design-basis accident for combustible gas control and accident management, including emergency planning.

(ii) Equipment must be provided for monitoring hydrogen in the containment. Equipment for monitoring hydrogen must be functional, reliable, and capable of continuously measuring the concentration of hydrogen in the containment atmosphere following a beyond design-basis accident for accident management, including emergency planning.

(5) *Analyses*. Each holder of an operating license for a boiling water reactor with a

Mark III type of containment or for a pressurized water reactor with an ice condenser type of containment, shall perform an analysis that:

(i) Provides an evaluation of the consequences of large amounts of hydrogen generated after the start of an accident (hydrogen resulting from the metal-water reaction of up to and including 75 percent of the fuel cladding surrounding the active fuel region, excluding the cladding surrounding the plenum volume) and include consideration of hydrogen control measures as appropriate;

(ii) Includes the period of recovery from the degraded condition;

(iii) Uses accident scenarios that are accepted by the NRC staff. These scenarios must be accompanied by sufficient supporting justification to show that they describe the behavior of the reactor system during and following an accident resulting in a degraded core.

(iv) Supports the design of the hydrogen control system selected to meet the requirements of this section; and,

(v) Demonstrates, for those reactors that do not rely upon an inerted atmosphere to comply with paragraph (b)(2)(ii) of this section, that:

(A) Containment structural integrity is maintained. Containment structural integrity must be demonstrated by use of an analytical technique that is accepted by the NRC staff in accordance with § 50.90. This demonstration must include sufficient supporting justification to show that the technique describes the containment response to the structural loads involved. This method could include the use of actual material properties with suitable margins to account for uncertainties in modeling, in material properties, in construction tolerances, and so on; and

(B) Systems and components necessary to establish and maintain safe shutdown and to maintain containment integrity will be capable of performing their functions during and after exposure to the environmental conditions created by the burning of hydrogen, including local detonations, unless such detonations can be shown unlikely to occur.

(c) *Requirements for future applicants and licensees*. The requirements in this paragraph apply to all construction permits or operating licenses under this part, and to all design approvals, design certifications, combined licenses or manufacturing licenses under part 52 of this chapter, any of which are issued after [EFFECTIVE DATE].

(1) *Mixed atmosphere*. All containments must have a capability for ensuring a mixed atmosphere.

(2) *Combustible gas control*. All containments must have an inerted atmosphere or limit hydrogen concentrations in containment during and following an accident that releases an equivalent amount of hydrogen as would be generated from a 100 percent fuel clad-coolant reaction, uniformly distributed, to less than 10 percent and maintain containment structural integrity and appropriate mitigating features.

(3) *Equipment Survivability*. Containments that do not rely upon an inerted atmosphere to control combustible gases must be able to establish and maintain safe shutdown and containment structural integrity with systems and components capable of performing their functions during and after exposure to the environmental conditions created by the burning of hydrogen. Environmental conditions caused by local detonations of hydrogen must also be included, unless such detonations can be shown unlikely to occur. The amount of hydrogen to be considered must be equivalent to that generated from a fuel clad-coolant reaction involving 100 percent of the fuel cladding surrounding the active fuel region.

(4) *Monitoring*.

(i) Equipment must be provided for monitoring oxygen in containments that use an inerted atmosphere for combustible gas control. Equipment for monitoring oxygen must be functional, reliable, and capable of continuously measuring the concentration of oxygen in the containment atmosphere following a beyond design-basis accident for combustible gas control and accident management, including emergency planning.

(ii) Equipment must be provided for monitoring hydrogen in the containment. Equipment for monitoring hydrogen must be functional, reliable, and capable of continuously measuring the concentration of hydrogen in the containment atmosphere following a beyond design-basis accident for accident management, including emergency planning.

(5) *Analyses*. An applicant shall perform an analysis that demonstrates containment structural integrity. This demonstration must use an analytical technique that is accepted by the NRC staff and include sufficient supporting justification to show that the technique describes the containment response to the structural loads involved. The analysis must address an accident that releases hydrogen generated from 100 percent fuel clad-coolant reaction accompanied by hydrogen burning. Systems necessary to ensure containment integrity must also be demonstrated to perform their function under these conditions.

4. Section 50.46a is added to read as follows:

§ 50.46a Acceptance criteria for reactor coolant system venting systems.

Each nuclear power reactor must be provided with high point vents for the reactor coolant system, for the reactor vessel head, and for other systems required to maintain adequate core cooling if the accumulation of noncondensible gases would cause the loss of function of these systems. High point vents are not required for the tubes in U-tube steam generators. Acceptable venting systems must meet the following criteria:

(a) The high point vents must be remotely operated from the control room.

(b) The design of the vents and associated controls, instruments and power sources must conform to Appendix A and Appendix B of this part.

(c) The vent system must be designed to ensure that:

(1) The vents will perform their safety functions, and

(2) There would not be inadvertent or irreversible actuation of a vent.

PART 52-EARLY SITE PERMITS; STANDARD DESIGN CERTIFICATIONS; AND COMBINED LICENSES FOR NUCLEAR POWER PLANTS

5. The authority citation for Part 52 continues to read as follows:

AUTHORITY: Secs. 103, 104, 161, 182, 183, 186, 189, 68 Stat.936, 948, 953, 954, 955, 956, as amended, sec. 234, 83 Stat. 444, as amended (42 U.S.C. 2133, 2201, 2232, 2233, 2236, 2239, 2282); secs. 201, 202, 206, 88 Stat. 1242, 1244, 1246, as amended
(42 U.S.C. 5841, 5842, 5846).

6. In § 52.47, paragraph (a)(1)(ii) is revised to read as follows:

§ 52.47 Contents of applications

(a) * * *

(1) * * *

(ii) Demonstration of compliance with any technically relevant portions of the Three Mile Island requirements set forth in 10 CFR 50.34(f) except paragraphs (f)(1)(xii), (f)(2)(ix) and (f)(3)(v);

* * * * *

Dated at Rockville, Maryland, this ___ day of ________, 2002.

For the Nuclear Regulatory Commission.

Annette Vietti-Cook
Secretary of the Commission

Attachment 2
Regulatory Analysis for 50.44

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Tables

1. Statement of the Problem and Objective

Since the 1987 revision of 10 CFR 50.44, "Standards for combustible gas control system in light-water-cooled power reactors," there have been significant advances in our understanding of the risk from nuclear power plants, in particular risk arising from the production and combustion of hydrogen (and other combustible gases) during reactor accidents. These advances are described in SECY-00-0198, "Status Report on Study of Risk-Informed Changes to the Technical Requirements of 10 CFR Part 50 (Option 3) and Recommendations on Risk-Informed Changes to 10 CFR 50.44 (Combustible Gas Control)" [1]. This new understanding has led to a reconsideration of the bases for the requirements in 10 CFR 50.44. A portion of this reconsideration is the proposed "rebaselining" of 50.44, as described in SECY-01-0162 [2]. This risk-informed, performance-based rulemaking is the subject of the regulatory analysis.

The objective of this regulatory analysis is to address the regulatory relaxation issues associated with the proposed rebaselining action described in [2], consistent with the regulatory analysis guidance documents [3, 4].

Two options are presented in [2]:

Option 1

Update the existing rule and delete the hydrogen recombiner requirements for all containment types. As a part of this rulemaking, additional changes to the regulations may be necessary to retain hydrogen monitoring requirements for accident assessment purposes. In addition, complete the resolution of GI-189.

Option 2

Update the existing rule and delete the hydrogen recombiner requirements for all facilities except those with BWR Mark III and PWR ice condenser containments. As a part of this rulemaking, additional changes to the regulations may be necessary to retain hydrogen monitoring requirements for accident assessment purposes. In addition, for the BWR Mark III and PWR ice condenser facilities, defer any rule changes until the staff completes its resolution of GI-189.

(Note that Generic Issue 189 (GI-189) will assess the costs and benefits of possible additional hydrogen control requirements for PWR ice condenser and BWR Mark III containment designs. Analyses indicate these containments are more susceptible to failure during station blackout sequences where the AC powered igniters are not available. Therefore, removing the dependence on AC power for the combustible gas control systems could be of value for risk-significant accidents.)

The first option was recommended because it presents the most complete, expeditious, and efficient method of updating the regulations, and therefore will be the subject of this regulatory analysis. As such, the regulatory analysis will focus on the recommended removal of hydrogen recombiner requirements and the relaxation of hydrogen monitoring requirements, as well as the relaxation of oxygen monitoring requirements for BWRs with Mark I and Mark II containments. The issue of resolution of GI-189 is separate from the "rebaselining" of 50.44 and will be considered under a separate regulatory analysis.

Regarding the recombiners and their associated vent/purge systems, the staff has applied the risk-informed process described in Attachment 2 [5] to SECY-00-0198 [1] to each of the generic containment design types. The staff found that the outcome for PWR large dry and subatmospheric containment designs and for BWR Mark I and II containment designs was always the same. That is, for these containment types, the outcomes were that hydrogen recombiners could be eliminated from the design basis and no additional hydrogen control requirements would be needed. The outcome of the SECY-00-0198 process is less clear for PWR ice condenser and BWR Mark III containment designs. With respect to the need for recombiners however, the outcome was similar to that for other containment designs. That is, recombiners could be eliminated from the design basis of facilities with these containment designs with no significant risk impact. Other issues associated with the control of combustible gases for core melt accidents for these containment types are being deferred to the GI-189. A remaining issue for Mark I and Mark II type plants with inerted containments, is the potential for the production of oxygen by radiolysis during severe accidents to form combustible mixtures with hydrogen that has evolved from radiolysis and zirconium/water reactions. Although analysis indicates that it will take days for these combustible mixtures to develop, there is a concern with removing recombiners that could prevent combustion events that lead to containment failure. This concern is addressed in the regulatory analysis.

Regarding hydrogen monitoring, the analyses from SECY-00-0198 [1, 5] further concluded that hydrogen monitors at some facilities are not necessary for combustible gas control. However, these monitors, depending on plant type, may be needed to support emergency operating procedures, severe accident guidelines, and accident assessment functions that facilitate emergency response decision making. If these monitors are determined to be necessary only for accident assessment purposes, then this equipment would no longer be required to be safety grade. Therefore, updating hydrogen monitoring requirements could result in a reduction in unnecessary burdens in the areas of procurement, upgrading, and maintenance of hydrogen monitoring systems by reclassifying the monitors from an indication that most directly indicates the accomplishment of a safety function to backup and diagnostic instrumentation. Guidance on design specifications is delineated in Regulatory Guide 1.97 [6]. The guide specifies that safety-grade (Category 1) instrumentation provides for full qualification, redundancy, and continuous real-time display and requires onsite (standby) power.

1.1 Background of Problem

1.1.1 History

In a June 8, 1999 Staff Requirements Memorandum (SRM) on SECY-98-300, "Options for Risk-Informed Revisions to 10 CFR Part 50," the Commission approved proceeding with a study of risk-informing the technical requirements of 10 CFR Part 50.

The staff provided its plan and schedule for the study phase of its work to risk-inform the technical requirements of 10 CFR Part 50 in SECY-99-264, "Proposed Staff Plan for Risk-Informing

Technical Requirements in 10 CFR Part 50," dated November 8, 1999. The plan consists of two phases: an initial study phase (Phase 1), in which an evaluation of the feasibility of risk-informed changes along with recommendations to the Commission on proposed changes will be made; and an implementation phase (Phase 2), in which changes recommended from Phase 1, and approved by the Commission, will be made. SECY-99-264 discussed Phase 1 of the plan. In Phase 1, the staff is studying the ensemble of technical requirements contained in 10 CFR Part 50 to (1) identify candidate changes to requirements and design basis accidents (DBAs), (2) prioritize candidate changes to requirements and DBAs, and (3) establish the feasibility of and identify recommended changes to requirements.

The Commission approved proceeding with the proposed staff plan in an SRM dated February 3, 2000. In addition, the Commission directed the staff to highlight any policy issues for Commission resolution as early as possible during the process, particularly those related to the concept of defense-in-depth, Staff has been directed to develop a communication plan that facilitates greater stakeholder involvement and actively seeks stakeholder participation.

Revision of combustible gas control requirements following a postulated LOCA was requested in conjunction with Task Zero of the Risk-Informed, Performance-Based Regulation Pilot Program. This program was an initiative undertaken by the NRC and the Nuclear Energy Institute to improve the incorporation of risk-informed and performance-based insights into the regulation of nuclear power plants. Task Zero resulted in an exemption from combustible gas control requirements from the San Onofre nuclear generating station's design basis as documented in a letter to the licensee, dated September 3, 1999.

On April 12, 2000, the staff provided its first status report on Phase 1 in SECY-00-0086 ("Status Report on Risk-Informing the Technical Requirements of 10 CFR Part 50 (Option 3)") and also indicated its intention to expedite recommendations for risk-informed changes to 10 CFR 50.44 ("Standards for Combustible Gas Control System in Light-Water-Cooled Power Reactors").

On September 14, 2000, the staff provided its second status report on Phase 1 in SECY-00-0198 [1]. This SECY included a "Framework for Risk-Informed Changes to the Technical Requirements of 10 CFR 50" as Attachment 1 [7] and "Feasibility Study for a Risk-Informed Alternative to 10 CFR 50.44" as Attachment 2 [5]. In SECY-00-0198, the staff proposed a risk-informed voluntary alternative to the current 10 CFR 50.44. Attachment 2 [5] to that SECY described a process by which licensees could determine which of a number of possible regulatory requirements would apply to their facility, if they chose the voluntary alternative.

Since it completed SECY-00-0198, the staff has taken three actions that affect its approach and schedule for risk informing 10 CFR 50.44. First, the staff has continued the technical work described in the paper to develop hydrogen source terms and to assess the significance of seismically-initiated and fire-initiated accidents. Second, it established Generic Issue 189 (GI-189) to assess the costs and benefits of possible additional hydrogen control requirements for PWR ice condenser and BWR Mark III containment designs. (The issue raised in SECY-00-0198 was that analyses indicate these containments have a high conditional containment failure probability associated with station blackout sequences during which the AC powered igniters are not available. Therefore, removing the dependence on AC power for the combustible gas control systems could be of value for risk-significant accidents.) Third, the staff has applied the process described in Attachment 2 to SECY-00-0198 to each of the generic containment design types and concluded that hydrogen recombiners could be eliminated from the design basis for all LWRs and no additional hydrogen control requirements would be needed for any LWR, except those with ice condenser or MARK-III containments. SECY-01-0162 recommended removing this issue of additional hydrogen control measures for plants with ice condenser or Mark III containments from the rulemaking and assigning it to GI-189. With the removal of this issue from the rulemaking, the staff concluded that, for all containment types, a more efficient regulatory approach than that proposed in SECY-00-0198 would be to modify (rebaseline) the current 50.44 to eliminate the requirement for recombiners rather than offering a voluntary alternative that would, upon licensee evaluation, lead to the same result. Adopting this simplified approach could also help expedite the schedule for this rulemaking.

The analyses from SECY-00-0198 further concluded that hydrogen monitors are not risk-significant for combustible gas control. However, these monitors, depending on plant type, are needed to support emergency operating procedures, severe accident guidelines, and accident assessment functions that facilitate emergency response decision making. If these monitors are determined to be necessary only for these purposes, then this equipment would no longer be required to be safety grade. Therefore, unnecessary burden reduction benefits of updating hydrogen monitoring requirements could be realized in the areas of procurement, upgrading, and maintenance of these systems.

SECY-01-0162 [2] requests Commission approval of the staff's plans for proceeding with rulemaking to risk-inform 10 CFR 50.44, as requested in the SRM to SECY-00-0198, dated January 19, 2001. The SRM directed the staff to proceed expeditiously with rulemaking on the risk-informed alternative to 10 CFR 50.44, including completing outstanding technical work and necessary regulatory analyses. The Commission requested that the staff avoid overly prescriptive requirements and develop sufficiently flexible requirements to permit improvements in the methodology if better models become available. The Commission also directed the staff to provide recommendations for actions that could shorten the time for developing the proposed rule.

From these staff assessments, it was decided to proceed with the rebaselining of 10 CFR 50.44 with Option 1, described in Section 1, being the recommended option.

1.1.2 Contributions of Existing Requirements to the Problem

Recombiners are required to accommodate the amount of hydrogen associated with design basis events. Risk studies have shown that the risk is from beyond design basis events, not from the design basis events postulated in 10 CFR 50.44. For beyond design basis events, recombiners have little to no effect on mitigating the consequences of these events. The requirements for maintaining recombiners and hydrogen monitors as design-basis structures, systems and components (SSCs) have been burdensome to the nuclear power industry. Both the BWR Owners Group report [8] and Mr. R. Christie's Petition for Rulemaking [9] attest to this burden. This regulatory analysis takes into full account this burden in the Value-Impact portion of the analysis.

1.1.3 Immediate Problem as Part of Larger Issue and Ongoing Programs

This proposed regulatory action is the attempt to apply the staff's framework for risk-informing

10 CFR 50 and performance-basing any regulatory enhancements that might result. Next anticipated steps are to resolve GI-189 and to attempt to risk-inform 10 CFR 50.46.

1.1.4 Relationship of the Objectives of this Rulemaking to the Commission's Safety Goals

Since this action is a relaxation of requirements, it is neither a backfit nor subject to the safety goal requirements [3, page 9] normally imposed on regulatory actions. However, a level of assessment should be provided that demonstrates that the public health and safety and the common defense and security would continue to be adequately protected if the proposed reduction in requirements were implemented [3, page 6]. This demonstration is provided as part of Section 3 of this regulatory analysis. The risk analysis (described further in [5]) shows that these rulemaking actions either do not increase risk or only increase risk slightly, such that there is virtually no change in the conditions for assuring that the public health and safety is adequately protected.

In addition, a level of assessment should be provided that demonstrates that the cost savings attributed to the action would be substantial enough to justify taking action [3, page 6]. The assessment in Section 3 provides this demonstration.

1.1.5 Relationship to Formal Positions Adopted by National and International Standards Organization or Foreign Regulators

In a letter dated June 28, 2001, the French Nuclear Installations Safety Directorate directed Electricite de France to install passive autocatalytic recombiners (PARs) for severe accident hydrogen control in all PWR reactors by the end of 2007. This approach requires approximately 40 PARs per plant to achieve a capacity appropriate for severe accidents.

PARs will not be considered for US PWRs with large-dry containments or sub-atmospheric containments. This conclusion was drawn after applying the framework for risk-informed changes to the technical requirements of 10 CFR 50 [7]. The staff concluded that hydrogen combustion is not a significant threat to the integrity of these containment types, when compared to the 0.1 conditional large release probability of the framework document [7]. The staff further concluded that additional combustible gas control requirements for currently licensed large-dry and sub-atmospheric containments were unwarranted.

Based on available information, the staff concludes that the different position adopted by the French regulatory authority on severe accident hydrogen control stems from fundamental differences in their analysis and criteria for hydrogen sources and allowable buildup, treatment of random ignition of leaner mixtures, and different acceptance criteria for containment performance.

1.2 Backfit Rule

Since this regulatory analysis addresses only relaxations to the current rule, no backfit evaluation is required. Voluntary relaxations (i.e., relaxations that are not mandatory) do not fall within the scope of the backfit rule (10 CFR 50.109). As mandated on page 6 of NUREG/BR-0058, Revision 3, requirements associated with relaxations will be addressed, as described in Section 1.1.4 and in Section 3 of this regulatory analysis.

2. Identification and Preliminary Analysis of Alternative Approaches

The alternative approaches considered here are all based on variants of Option 1 of SECY-01-162, namely,

Update the existing rule and delete the hydrogen recombiner requirements for all containment types. As a part of this rulemaking, additional changes to the regulations may be necessary to retain hydrogen monitoring requirements for accident assessment purposes.

2.1 Approach 1: Option 1 of SECY-01-0162, With Relaxation for Hydrogen and Oxygen Monitoring

This approach would eliminate the requirement for recombiners and associated vent/purge systems for all containment types and would relax the requirements for hydrogen (& oxygen) monitoring from meeting Category 1 requirements, as defined in Regulatory Guide 1.97, "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident," to meeting Category 3 for hydrogen, and Category 2 for oxygen.

The current special treatment requirements associated with the hydrogen and oxygen monitors are overly burdensome. Special treatment requirements associated with the hydrogen and oxygen monitors have been invoked by either order or commitments to NUREG-0737, "Clarification of TMI Action Plan Requirements," Item II.F.1, Attachment 6 which endorses RG 1.97 or RG 1.97 itself [6]. RG 1.97 recommends that the hydrogen and oxygen monitors be Category 1, which includes environmental qualification, seismic qualification, redundancy, being energized from station standby power sources, and being backed up by batteries where momentary interruption is not tolerable. Category 1 provides the most stringent requirements and is intended for key variables that most directly indicate the accomplishment of a safety function for design basis accident events. As discussed in SECY-00-198 [1], combustible gas control is not needed for a design-basis LOCA. Therefore, the hydrogen monitors no longer meet the definition of Category 1 in RG 1.97. RG 1.97 states that Category 3 is intended to provide requirements that will ensure that high-quality off-the-shelf instrumentation is obtained and applies to backup and diagnostic instrumentation. Hydrogen monitors can be back instrumentation to support operator actions in the emergency operating procedures. Hydrogen monitors are used as diagnostic instrumentation to assess the degree of core damage, support severe accident guidelines, emergency operating procedures, and accident assessment functions that facilitate emergency response decision making. Therefore, Category 3 is a more appropriate categorization for hydrogen monitors.

The oxygen monitors also no longer meet the definition of Category 1 in RG 1.97. As discussed in SECY-00-198 [1, 5], oxygen monitoring is not needed to control combustible gas resulting from a LOCA. RG 1.97 states that Category 2 provides less stringent requirements and generally applies to instrumentation designated for indicating system operating status. Category 2 is a more appropriate categorization for the oxygen monitors because the oxygen monitors are used to indicate the status of the inerted containment environment, support severe accident guidelines, emergency operating procedures, and accident assessment functions that facilitate emergency response decision making.

Regarding recombiners, this rulemaking action would eliminate the requirement for combustible gas control systems following a postulated LOCA from §50.44 by the following means:

- Remove §50.44(c)(1) and §50.44(c)(2) — requires plants to demonstrate no uncontrolled hydrogen combustion following postulated LOCA but before operation of control system

- Remove §50.44(c)(3)(ii) including §50.44(c)(3)(ii)(A) and §50.44(c)(3)(ii)(B) — requires internal or external recombiners and imposes requirements on external recombiner containment penetrations

- Remove §50.44(d)(1) and §50.44(d)(2) — specifies the post-LOCA hydrogen amounts evolved in the accident.

- Remove §50.44(e), §50.44(f) and §50.44(g) — impose requirements relative to recombiners and purge-repressurization systems as means of hydrogen control following postulated LOCA

- Remove §50.44(h) — as all of the definitions it contains refer to text in earlier portions of the regulation that are already proposed to be deleted.

Some key implications of Approach 1 for NRC are summarized in Table 2.1 while some implications for industry are listed in Table 2.2. The tables present a screening assessment. Implications for both the industry and the NRC are evaluated in Section 3 in detail.

Table 2.1 Approach 1, NRC Implications

Item	**Yes/No**	**Description/Comments**
Rule change	Yes	10 CFR 50.44 would be revised by making the changes summarized above to physical requirement contained in the current rule.
Impact on other regulations	Yes	NUREG-0737 would be revised to allow commercial grade monitors.
Revise/modify implementing documents	Yes	Existing regulatory guidance on safety grade monitors in Regulatory Guide 1.97 would be revised. Regulatory guidance on recombiners will need elimination.
Create implementing documents	Yes	New regulatory guides would be needed on providing acceptable methods for compliance with the risk-informed rule.
Analysis	No	No new analysis will be needed.
Review	Yes	Licensee submittals on hydrogen monitoring will need to be reviewed to verify compliance. License amendment requests associated with tech spec removal will be needed.
Inspection	Maybe	Depends on way in which compliance is achieved.

Table 2.2 Approach 1, Licensee Implications

Item	Yes/No	Description/Comments
Equipment	Maybe	Relaxation of special treatment requirements would allow for commercial grade monitors (Category 3 for hydrogen and Category 2 for oxygen). Changes would allow removal of recombiners, and purge/vent systems.
Analysis	No	No new analysis will be needed.
Maintenance/Inspection	Maybe	Will depend on the way compliance is achieved.
Tech Specs	Maybe	Remove hydrogen and oxygen monitors, recombiners, and vent/purge systems from technical specifications.
Procedures/Training	Maybe	Will depend on the way compliance is achieved.

2.2 Approach 2: Eliminate Requirement for Both Recombiners and Hydrogen Monitors

This second approach would then read as:

"Update the existing rule and delete the hydrogen recombiner requirements and hydrogen monitoring requirements for all containment types."

Under this approach, additional burden would be removed from the licensee by not having to install and maintain a (Category 3) hydrogen monitoring capability. However, then the hydrogen monitoring function would be lost for emergency planning and accident assessment functions.

2.3 Approach 3: Option 1 of SECY-01-0162, but Recombiner Requirements for BWRs with Mark I and Mark II Would Remain in Force

This third approach would then read as:

"Update the existing rule and delete the hydrogen recombiner requirements for all containment types, except Mark Is and Mark IIs. As a part of this rulemaking, additional changes to the regulations may be necessary to retain hydrogen monitoring requirements for accident assessment purposes."

Under this approach, continued burden (relative to Approach 1) would be required of licensees with plants that have Mark I or Mark II containments in that they would have to retain their recombiner capability. However, this approach would provide some control over the potential for very late containment failure that would otherwise result from combustion of gases produced from radiolysis following a severe accident (a de-inerting of the containment due to oxygen produced from radiolysis of water; a de-inerting that could be prevented by recombiners).

A variation on Approach 3 is to relax the current requirements for recombiners for plants with Mark I and Mark II containments, but still retain the recombiner function. Thus, for these plants, recombiners would be required, but they would no longer be safety-grade systems. The system design, operation and maintenance specifications would be relaxed, but would be sufficiently robust to meet reliability and availability guidelines. The values and the impacts associated with this variation on Approach 3 are intermediate between Approach 3–retain current recombiner requirements for plants with Mark I and Mark II containments, and Approach 1–remove recombiner requirements for plants with Mark I and Mark II containments. The "value" that this variation would provide is some control over the potential for very late containment failure by preventing late, large containment hydrogen burn events due to radiolysis, but with a cost (or impact) commensurate with maintaining the recombiner function. This is discussed in more detail in Section 4.

2.4 Approach 4: Base Reference Approach – No Change to Current Requirements

This approach allows for a baseline from which other approaches can be compared.

2.5 Discussion of Approaches

All of these approaches are variations on regulatory relaxations. All must pass the adequacy test which requires that the public health and safety and the common defense and security must continue to be adequately protected if the proposed reduction in requirements are implemented [3, page 6]. Approach 1 has been extensively evaluated, as summarized in [5].

Retaining Recombiners for Inerted Containments (Approach 3)

For the first 24 hours following initiation of core damage, the recombiners are ineffective -- either there is so much hydrogen present in containment that the recombiners are incapable of accommodating the hydrogen or the containment atmosphere is inert. The only question is whether there would be some use for the recombiners for containments in the long term recovery from an accident. Inerted containments could become de-inerted due to radiolysis under severe accident conditions occurring over a few days. PWR containments could use recombiners to remove residual hydrogen in the long term to prevent further hydrogen combustion. Consideration of these issues did not reveal any risk-significance. It is expected that accumulations of combustible gases beyond 24 hours can be managed by licensee implementation of SAMGs or other ad hoc actions because of the time available to take such action. This question is considered further in Section 3 of this regulatory analysis.

Comment on Retaining Purge/Vent or Venting Capabilities

In November 1994, the US nuclear industry committed to implement severe accident management at their plants by December 31, 1998, using the guidance contained in NEI 91-04, Revision 1, "Severe Accident Issue Closure Guidelines." Generic severe accident management guidelines developed by each nuclear steam system supplier owners group include either purging and venting (for BWRs) or venting (for PWRs) the containment to address combustible gas control. The Commission continues to view purging and/or controlled venting of the containment to be important severe accident management strategies. This regulatory analysis does not evaluate such capabilities but assumes that licensees address purging and/or controlled venting of all containment types as a part of their severe accident management guidelines.

Approach 1 in this regulatory analysis concludes that the cost of maintaining the recombiners greatly exceeds the benefit of retaining them to prevent containment failure in sequences that progress to beyond 24 hours. The issue of eliminating the requirement for safety-grade purge/vent systems is not specifically analyzed in this regulatory analysis because the staff believes that the above conclusion would also be true for the backup hydrogen purge system. The cost is expected to exceed the estimated benefit of $21,320 as calculated in Appendix A of this document. In addition, the benefit would not be as great because the hydrogen purge system does not prevent a release. The hydrogen purge system would allow for a controlled release without containment failure as opposed to an uncontrolled release due to containment failure.

Eliminating Hydrogen Monitoring (Approach 2)

Combustible gas generation and combustion from beyond design basis accidents involving both fuel-cladding oxidation and core-concrete interaction has not been shown to be risk-significant when using the framework document's quantitative guidelines. The risk of early containment failure from hydrogen combustion is limited by the following mitigative features: (1) inerting in Mark I and II containments, (2) igniters in Mark III and ice condenser containments, and (3) the large volumes and likelihood of random ignition in large dry and sub-atmospheric containments that help prevent the build-up of detonable concentrations. Hydrogen monitoring is not needed to initiate or activate any of these measures, hence hydrogen monitors have a limited significance in mitigating the threat to containment in the early stages of a core melt accident.

Hydrogen monitors are needed to assess the degree of core damage and confirm that random or deliberate ignition has taken place and that containment integrity is not threatened by an explosive mixture. If an explosive mixture that could threaten containment integrity exists during a beyond design basis accident, then other severe accident management strategies, such as purging and/or venting, would need to be considered. For Mark I, II and III containments, the monitoring of hydrogen is used extensively in the emergency procedure guidelines/severe accident guidelines. On these bases, the Commission proposes to require hydrogen monitoring for beyond design basis severe accident management in all containment designs. Hydrogen monitoring will be evaluated as part of this regulatory analysis. However, the staff notes that there have been arguments made that hydrogen monitors are not needed for these emergency planning purposes [9].

Both the industry and the NRC staff have determined the need for hydrogen monitoring for Severe Accident Management Guidelines (SAMGs) and emergency planning. For example, NEI 99-01, "Methodology for Development of Emergency Action Levels," recommends declaring a General Emergency when a radiation monitor reading corresponding to 20 percent fuel clad damage is registered. This corresponds to a hydrogen concentration inside containment of approximately 3-4 percent. The NRC Response Technical Manual, RTM-96, which is used for incident response, indicates that the concentration of containment hydrogen is more accurate than the containment radiation monitors whose ability to predict the degree of core damage is affected by fission product decay, shielding, and spray actuation. The GE, Westinghouse, and CE core damage assessment methodologies all include hydrogen monitoring. Hydrogen monitors are needed to confirm that random ignition has taken place and that containment venting does not need to be considered. Currently, severe accident management guidance includes consideration of venting based on containment pressure, hydrogen concentration, and radiation. This is a greater concern for Mark I and II plants that rely more heavily on hydrogen and oxygen monitoring to support actions such as RCS depressurization, spray initiation, and containment venting. Thus, removal of hydrogen monitoring will compromise emergency planning and severe accident management. Therefore, Approach 2 will be screened out as an option and not considered further in this regulatory analysis.

By retaining the requirement for hydrogen monitoring capability while at the same time relaxing the special treatment requirements, Approach 1 allows for more effective emergency planning capability and severe accident management, but also provides relief from regulatory burden.

2.6 Summary of the Preliminary Analysis of Alternative Approaches

Three approaches have been considered with reference to a no action baseline (Approach 4). The proposed rule as described in SECY-01-0162 is Approach 1. Approach 2 allows for removal of all hydrogen monitor requirements, not just a relaxation of requirements from Safety Grade (Category 1- Special Treatment) to Category 3. Approach 3 is the same as Approach 1 except it would not allow for the removal of recombiners for plants with Mark I or Mark II containments. There is a sufficient argument to screen out Approach 2, based on the utility of hydrogen monitoring for accident assessment functions that facilitate emergency response decision making and severe accident management, as supported by both the NRC and the industry. Relaxing the requirements for hydrogen monitoring should not compromise the utility of this monitoring capability as part of SAMGs. The subject of the following Value-Impact assessment then will be an analysis of Approaches 1 and 3, relative to taking no action (Approach 4).

3. Value-Impact Assessment

This section provides an assessment of the Values and the Impacts of the approaches discussed in Section 2, following the Regulatory Analysis guidance in [3, 4]. The two key issues, namely hydrogen monitoring and recombiners, are addressed separately. In Section 3.1, a summary of the Value-Impact assessment is provided. This is followed in Section 3.2 with comments on the assessment methodology and the assumptions used in the analysis. The required statement regarding the Safety Goal comprises Section 3.3. In Section 3.4, the Value-Impact analysis is presented.

3.1 Summary of Value-Impact Assessment

Section 3.4 provides an assessment of the values and impacts of the approaches discussed in Section 2. In Section 4, the results are presented. Tables 3.1, 3.2 and 3.3 summarize these results.

Table 3.1 Summary of the Value-Impact Assessment for Hydrogen Monitor Relaxation: Approach 1 compared to Baseline (Approach 4)

	per plant (average)	for Industry: 103 plants
Value	approximately zero	approximately zero
Impact	-$517,000	-$53,000,000
Value-Impact	$517,000	$53,000,000

Table 3.2 Summary of the Value-Impact Assessment for Recombiner Removal: Approach 1 compared to Baseline (Approach 4) for All PWRs and Mark III BWRs

	per plant (average)	for Industry: 69 PWRs, 4 BWRs
Value	$12,000	$876,000
Impact	-$438,000	-$31,974,000
Value-Impact	$450,000	$32,850,000

Table 3.3 Summary of the Value-Impact Assessment for Recombiner Removal: Approach 1 compared to Baseline (Approach 4) for Mark I and Mark II BWRs

	per plant (average)	for Industry (30 BWRs)
Value	$400	$12,000
Impact	-$437,500	-$13,125,000
Value-Impact	$438,000	$13,137,000

For both the monitors and the recombiners, the Value-Impact results are positive, indicating that this rulemaking action is supported by the Value-Impact assessment. Consideration of uncertainties in the assessment and consideration of the impact of Approach 3 – allowing recombiner removal only for PWRs and the BWRs with Mark III containments – does not alter the conclusion that the rulemaking action is justified. These matters are considered further in Sections 3.4 and 4.

3.2 Introduction to Value-Impact Assessment

This Value-Impact assessment follows the guidelines in [3, 4]. Consistent with these guidelines, the following assumptions are made in the assessment:

- The year chosen as a basis is 2002 and all costs are adjusted to reflect 2002 dollars
- The discount rate used is 7 percent, as recommended in [4]
- The remaining life of the average plant is assumed to be 35 years. This value was determined by adding 20 years (assuming license renewal) to 15 years remaining on the plant's current license [4]
- Using the 7 percent discount rate and 35-year lifetime, the multiplier used for determining the 2002 cost equivalent for yearly costs over the remaining life of the plant is 13.053 [4].

The "Values" considered in the quantitative assessment are:

- Public Health – Accident
- Public Health – Routine
- Occupational Health – Accident
- Occupational Health – Routine
- Property – Offsite
- Property – Onsite

The “Impacts” considered in the quantitative assessment are:

- Industry Implementation
- Industry Operation
- NRC Implementation
- NRC Operation

The sign convention, consistent with [4], is that increased public and occupational health (e.g., decreased risk to the public) and increased property values are “positive,” while reduced public and occupational health (e.g., increased risk to the public) and reduced property values are “negative.” Likewise, increased implementation and operation costs for the industry and NRC are “positive” while reduced implementation and operation costs (e.g., reductions in regulatory burden) for the industry and NRC are “negative.”

The equation for determining the Value-Impact is then:

Value-Impact = {sum of all Values} - {sum of all Impacts} =

{(Public Health_Accident) + (Public Health_Routine) + (Occupational Health_Accident) + (Occupational Health_Routine) + (Property_Offsite) + (Property_Onsite)} – {(Industry Implementation) + (Industry Operation) + (NRC Implementation) + (NRC Operation)}

Thus, a positive Value-Impact will support a rulemaking action while a negative Value-Impact will not, independent of whether the rulemaking action is a relaxation or an enhancement.

3.3 Safety Goal Evaluation

As stated in Section 1.1.4, relaxations of requirements are not subject to the safety goal evaluation requirements.

3.4 Estimation and Evaluation of Values and Impacts for the Selected Alternatives

The Value-Impact assessment comprises two parts: 1) consideration of hydrogen monitoring, and 2) consideration of recombiners.

3.4.1 Hydrogen Monitoring

Regulatory actions that reduce current requirements (remove special treatment requirements) must be based on the determination that two conditions are satisfied:

- The public health and safety and the common defense and security would continue to be adequately protected if the proposed reduction in requirements or positions were implemented.
- The cost savings attributed to the action would be substantial enough to justify taking the action.

It has been determined that hydrogen monitoring is not needed to actuate the primary means for combustible gas control. Rather, its utility is for support of alternative EOP actions, emergency planning, and emergency decision making. The intent of the present approach is to allocate some performance to hydrogen monitoring as part of accident management. Accordingly, this regulatory analysis has already screened out Approach 2, which completely eliminates monitoring.

Approach 1 proposes that the current requirements on hydrogen monitoring be relaxed. The special treatment requirements on hydrogen monitoring currently in force can be relaxed if there is assurance that commercial-grade monitors can adequately meet the above-stated needs, and thereby provide assurance that the public health and safety and the common defense and security would continue to be protected. The high-level guidelines for performance-based regulatory activities show how to assess whether commercial-grade monitors can meet the present needs. Based on the low challenge frequency of this function (the frequency at which the hydrogen monitoring function is expected to be challenged), periodic verification of the functional capability of the hydrogen monitoring system is adequate, provided that the verification protocol tests the appropriate range of atmospheric conditions and that licensee corrective action programs include addressing issues in hydrogen monitoring performance if such issues arise. These detailed aspects are addressed in the regulatory guidance.

The cost savings per plant for this relaxation are estimated by the BWR Owners' Group [8] to be in the range of $40K to $150K per year for monitor maintenance, testing and calibration costs. If these costs represent typical costs across the industry, yearly industry savings would range from $4M to $15M per year. If monitoring systems are replaced, the additional savings would be $400K to $900K per monitoring system replacement. However, there will be costs (impacts) associated with implementation of this rule change, as listed in Tables 2.1 and 2.2. All these costs (impacts) and cost savings (negative impacts) are described in more detail in Section 3.4.1.1 below.

3.4.1.1 Identification of Attributes

In the determination of the values and impacts of this proposed action, it should be noted that since this is a proposed relaxation, most attributes as defined in [4] will normally be "negative," since the risk will actually increase (most times only slightly) for items 1 through 4, and the impacts (items 7 through 10) will normally be negative (although there will be "positive" impact elements). The remaining attributes are presented qualitatively in Section 3.4.1.1.11. These attributes will be summarized and compared in Section 4. Below is a discussion of the Value-Impact attributes for hydrogen monitoring relaxation:

3.4.1.1.1 Public Health (Accident)

Consideration of the possible increase (or possible decrease) in risk to the public from relaxing the requirements for hydrogen monitoring is not subject to quantitative analysis. One aspect, however, can be discussed from a qualitative point of view.

By going from Category 1 requirements to Category 3, the monitors will not be subject to the Category 1 quality assurance requirements, redundancy requirements, Class 1E requirements or seismic requirements. Thus, for the purposes intended, namely, to assess the degree of core damage and confirm that random or deliberate ignition has taken place and that containment integrity is not threatened by an explosive mixture, the monitors might not be as reliable or available. This could complicate emergency decision making. In general, less information or misleading information would be expected to incur costs to the public in the form of the consequences of false-positive or false-negative evacuation decisions. Actual quantification of the value of degraded information depends on the details of procedures and guidelines, and the availability of alternative sources of information to support evacuation decisions, in addition to depending on the low frequency at which this information is needed. Any actual difference in the availability of the hydrogen monitoring function caused by a change in special treatment requirements would be difficult to establish, and its impact, most probably, would be negligible. Although not as stringent as Category 1, Category 3 is intended to ensure that high-quality off-the-shelf instrumentation is obtained and provides for servicing, testing and calibration.

3.4.1.1.2 Public Health (Routine)

There is no change in the Public Health (Routine), when comparing Approach 1 to the base case (Approach 4) since this approach does not involve any change to normal operational (routine) releases from the plant.

3.4.1.1.3 Occupational Health (Accident)

There is no change in the Occupational Health, when comparing Approach 1 to the base case (Approach 4) since the onsite damage from the accident and the resultant health effects would have occurred in any event.

3.4.1.1.4 Occupational Health (Routine)

This attribute is a value which accounts for radiological exposures to workers during normal facility operations. The proposed change seeks to relax the requirements for hydrogen and oxygen monitors. Typically, the hydrogen and oxygen monitors are located outside containment. Based on this, there would be very little change, if any, in the routine occupational health of the workers. In the event that a plant may have monitors located inside containment, the savings associated with no longer being required to perform certain surveillance would be minimal, but contribute to the overall benefits of the proposed change.

3.4.1.1.5 Offsite Property

As with consideration of risk to the public, consideration of the possible increase (or possible decrease) in offsite property costs resulting from relaxing the requirements for hydrogen monitoring is not subject to quantitative analysis. However, from a qualitative point of view, the arguments here for offsite property would be similar to those discussed in Section 3.4.1.1.1. Studies [10] have shown that the dollar equivalents for offsite property and public health (public risk impact) are the same order of magnitude. Thus, since the impact on public health is small, the impact on offsite property will also be small.

3.4.1.1.6 Onsite Property

There is no change in the Onsite Costs, when comparing Approach 1 to the base case (Approach 4) since the onsite damage from the accident would have occurred in any event.

3.4.1.1.7 Industry Implementation

This attribute is an impact which accounts for the projected net economic effect on the affected licensees to install or implement mandated changes. Approach 1 would relax the requirements for the hydrogen and oxygen monitors. As part of the relaxation, a new regulatory guide would be developed, or Regulatory Guides 1.7 and 1.97 would be revised, no longer requiring the monitors to be safety grade. Effectively, licensees could replace their Category 1 systems with Category 3 systems for hydrogen monitors and Category 2 systems for oxygen monitors. Although licensees would be able to meet the revised guidance with their current systems, it is likely that most licensees will replace their current monitors with more modern commercial grade models. Replacement costs would include modification package development, commercial grade monitors, removal and installation, and disposal. For recent severe accident mitigation alternative analysis, one PWR estimated [11] the cost to develop and implement an integrated hardware modification package, including post-implementation costs such as training, to be $70,000. The cost of commercial grade hydrogen monitors is estimated to be between $3,000 and $5,000 per sensing location. Using an example of 10 locations, this cost averages to be $40,000 per plant. Since the monitors are located outside containment, it is not certain whether any radioactive waste would be generated from the replacement of the monitors. Therefore, it is assumed to be small and costs for disposal are not estimated for this analysis.

Because the existing systems would satisfy the proposed regulation, it is expected that licensees would perform the modification during a regularly scheduled outage. Additionally, the monitoring systems are located outside containment (for most plants), so licensees could replace the systems while the plant is on-line, thus not necessitating an outage. At an estimated cost of $500K to $1M per day each day a plant is not operating, it is unlikely that any plant would extend an outage to perform this modification. Therefore, costs associated with shutdown and replacement power are not included.

The relaxation in Approach 1 would most likely precipitate a technical specification change. It would be to licensees' advantage to amend their technical specifications; therefore, licensees would incur a cost for preparing and submitting a license amendment request. According to NUREG/CR-4627 [12], it costs approximately $28,000 (adjusted to 2002 dollars) to prepare a typical uncomplicated technical specification amendment request. Since it is likely that licensees will submit one license amendment request that will cover both the monitors and the recombiners, only half of the cost ($14,000) for the amendment is considered in this portion of the Value-Impact analysis. See Section 3.4.2.2.7 for inclusion of the remaining half of this cost.

3.4.1.1.8 Industry Operation

This attribute is an impact which measures the projected net economic effect due to routine and recurring activities required by the proposed action on all affected licensees. According to industry estimates [8], it costs between $80,000 and $150,000 per year per reactor to operate and maintain hydrogen/oxygen monitors. Although this estimate is for a BWR, it is expected that costs for PWRs are similar. A relaxation of the requirement as recommended in Approach 1 is expected to reduce such costs by approximately 50 percent [8]. Assuming an annual cost of $100,000, a typical plant could realize "costs" of -$50,000 per year, or -$650,000 over the remaining life assumed by this analysis. (Because this attribute is an impact, the dollar amounts are expressed as negative numbers.)

3.4.1.1.9 NRC Implementation

Approach 1 would necessitate a rulemaking as well as revision to or development of regulatory guidance. Whether or not the Commission chooses to proceed with the rulemaking, the costs associated with the development of the rulemaking and associated guidance are sunk costs, and not considered by this regulatory analysis.

Approach 1 involves the relaxation of a requirement which will result in the subsequent deletion of technical specifications. Therefore, license amendments are expected on the part of the licensees, i.e., licensees will request an amendment to delete requirements associated with operation and surveillance of the monitors. Therefore, the NRC will incur costs associated with review and approval of the amendment requests. According to NUREG/CR-4627 [12], it costs approximately $17,000 (adjusted to 2002 dollars) to review a typical uncomplicated technical specification amendment request. This cost includes preparation of a generic communication and model technical specification change. However, it should be noted that the technical specification amendment request for monitors is likely to be combined with the amendment request for the recombiners. Therefore, $8,500 is assumed for the hydrogen monitor portion of the Value-Impact.

3.4.1.1.10 NRC Operation

This attribute is an impact which measures the projected net economic effect on the NRC after the proposed action is implemented. As a result of the proposed action, there will be a reduced effort during inspections. This reduction is expected to be small, and not quantified for the purposes of this analysis.

3.4.1.1.11 Other Attribute Considerations

For completeness, the remaining attributes that make up the full set [4] are addressed here. Several – Safeguards and Security, Antitrust, Environmental, General Public, Improvement in Knowledge, and Other Government – have no bearing on this regulatory analysis and therefore are not discussed further. A discussion follows for the issue of Regulatory Efficiency.

One of the major motivations for this rulemaking is to reduce unnecessary regulatory burden on both the industry and the NRC. This is reflected in the preceding sections in reductions in the impacts, primarily for industry operations.

With relatively small industry and NRC implementation costs, savings to the industry in "Operation" drives the equation and allows for the conclusion that the benefits of the relaxation far outweigh the costs envisioned. Safety is not compromised because the monitors will be available when needed for severe accident management, with a functionality commensurate with the consequences and probability of severe accident events. Defense in depth is assured through other means of managing these accidents.

3.4.2 Recombiner Removal

This section focuses on the issue of removal of recombiners and associated vent/purge systems. The staff analysis, as presented in Attachment 2 to SECY-00-0198 [5], demonstrates that recombiners serve little or no safety function in plants with large dry, ice-condenser, or Mark III containments. They may have utility for plants with Mark I or Mark II containments a number of days after a severe accident as a means to accommodate oxygen generated by radiolysis. Approach 3 addresses the values and impacts of retaining recombiners for these plants. Table 3.4 summarizes the staff position.

Table 3.4 Staff Position on Means of Hydrogen Control

Containment Type	Means of Hydrogen Control	Comments
Large-Dry	No active means	Volume/strength sufficient to accommodate hydrogen threat
Ice Condenser	Hydrogen Igniters	Ignitors sufficient to accommodate hydrogen threat, except during station blackout–deferred to GI-189
Mark III	Hydrogen Igniters	Igniters sufficient to accommodate hydrogen threat, except during station blackout–deferred to GI-189
Mark I	Inerted Containment	Inerted containment sufficient to accommodate hydrogen threat, except possibly for long-term radiolysis
Mark II	Inerted Containment	Inerted containment sufficient to accommodate hydrogen threat, except possibly for long-term radiolysis

As noted in Section 3.4.1, regulatory actions that reduce current requirements must be based on the determination that two conditions are satisfied:

1. The public health and safety and the common defense and security would continue to be adequately protected if the proposed reduction in requirements or positions were implemented.
2. The cost savings attributed to the action would be substantial enough to justify taking the action.

The following value-impact assessment addresses both of these requirements. The assessment focuses on Approach 1. By separating out the assessment into two parts – (1) all PWR containments and all BWR Mark III containments and (2) all BWR Mark I & II containments, the value and impacts for Approach 3 can be more easily compared. This is because Approaches 1 and 3 are the same for all PWR containments and all BWR Mark III containments.

For Approach 1, the only increase in risk would come from not being able to accommodate combustible mixtures of oxygen and hydrogen in the long term for the Mark I and Mark II containments, if the recombiners were removed. In order to determine the magnitude of this risk increase, a baseline analysis was performed, as described in Section 3.4.2.1. This is followed by an assessment of the Value-Impact attributes that make up the Value-Impact determination, as described in Section 3.4.2.2.

3.4.2.1 Baseline Risk for the Mark I and Mark II Plants

Methodology

For the Mark I and Mark II analysis, Peach Bottom was selected as a representative plant. Relevant data on sequence frequencies and characterization, containment failure probabilities, radiological source terms to the environment, and risk consequences were obtained for Peach Bottom from a number of sources that were readily available and deemed best suited to the task, including plant-specific IPEs, IPEEEs, and a number of NUREG studies. For this plant type, the main challenge is posed by long-term generation of hydrogen and oxygen through radiolysis, and therefore risk-significant sequences are made up of all sequences that progress to the very late phase without containment failure or bypass.

A baseline risk was estimated for the risk-significant sequences using the available data, under the assumption that combustible gas control is unavailable for these sequences. Using the same sources of data, sensitivity case risk estimates were calculated assuming that some means of combustible gas control is available and 100 percent effective. These two calculations were the basis for obtaining a maximum achievable risk-benefit from their difference. Note that these calculations treat only the increased risk from offsite dose; offsite economic costs are addressed separately in Section 3.4.2.2.5. For a more detailed presentation of the methodology and data employed in performing these calculations, see Appendix A (BWR Mark I).

Results

Results of the risk-benefit calculations are described in detail in Appendix A. A summary of these results is shown below in Table 3.5. For BWRs with Mark I containments, the maximum risk-benefit from controlling the possible threat posed by radiolysis is estimated at $21,300. This figure includes both internal and external events (the latter made up mainly of fires).

Table 3.5 Summary of Risk-Benefit Results for Combustible Gas Control

Result	**BWR Mark I (Peach Bottom)**
CDF for Risk-Significant Events (events/reactor-year)	7.26e-6
Offsite Health Risk (whole-body person-rem per year within 50 miles)	
Baseline (without provision for combustible gas control)	0.82
Sensitivity (with provision for combustible gas control)	<0.001
Difference	0.82
Risk-Benefit ($)	
Baseline (without provision for combustible gas control)	$21,300
Sensitivity (with provision for combustible gas control)	very small
Difference	-$21,300[1]

1. Includes both internal and external events.

3.4.2.2 Identification of Attributes

Below is a discussion of the Value-Impact attributes for recombiner relaxation (considering both Approaches 1 and 3). These attributes will be summarized and compared in Section 4:

3.4.2.2.1 Public Health (Accident)

The decrease in public health due to this relaxation results in a numerical value of -$21,300 per plant for Approach 1 for BWRs with Mark I and Mark II containments, as described in Section 3.4.2.1. The value was determined by using the methodology described in Section 5.7.1 of [4]. It is the product of the person-rem/year (0.82), the monetary value of public health ($2,000/person rem), and the multiplier for present worth (13.05). This multiplier was calculated assuming a 7 percent discount rate and an average plant remaining lifetime of 35 years (starting in 2002). This lifetime was determined by subtracting 9 years from the 1993 data presented in Table B.1 of [4] -- remaining lifetime of 24 years -- and adding 20 years to account for license renewal.

There have been arguments posed by [9] that this “relaxation’ will improve safety. Basically the argument is that mandated hydrogen control activities (e.g., putting recombiners into operation during an accident and then monitoring them) could distract operators from more important tasks in the early phases of accident mitigation and could have a negative impact on the higher priority critical operator actions. The staff agreed that removal of recombiner requirements could have this safety benefit [13]. This benefit can not be quantified but should be considered in the uncertainty associated with -$21,300/plant.

Since Approach 3 does not alter the recombiner requirements for BWRs with Mark I and Mark II containments, the numerical value for decrease in public health is zero.

3.4.2.2.2 Public Health (Routine)

There is no change in the Public Health (Routine), when comparing Approach 1 or Approach 3 to the base case (Approach 4) since neither of these approaches involve any changes to normal operational (routine) releases from the plant.

3.4.2.2.3 Occupational Health (Accident)

There is no change in the Occupational Health, when comparing Approach 1 to the base case (Approach 4) since the onsite damage from the accident and the resultant health effects would have occurred in any event. This is also the case for Approach 3.

3.2.2.2.4 Occupational Health (Routine)

This attribute accounts for radiological exposures to workers during normal facility operations. Currently, surveillance is required by technical specifications for the hydrogen recombiners. For some plants, the recombiners are located inside containment. For such plants, during required surveillance and routine maintenance, workers who are in close proximity to the recombiners are exposed at an average rate of 10 mrem/hr (PWRs) and 20 mrem/hr (BWRs) [4]. A relaxation or deletion of the requirement would result in a dose savings to licensees.

According to industry estimates [8], it costs approximately $36,000 per year per reactor to operate and maintain a typical post-LOCA hydrogen recombiner system. Although this estimate is for a BWR, it is expected that costs for PWRs are similar. Of the $36,000, $14,000 is attributed to surveillance and maintenance. Assuming that one-fourth of this cost is directly attributed to time and labor spent in proximity to the recombiners, an estimate of dose savings can be derived. Using a cost of $3,500 for maintenance and surveillance, and an average industry labor rate of $80/hour, the resultant yearly exposure time is 44 hours. Thus, the dose per PWR is estimated to be 0.44 person-rem, and 0.88 person-rem for BWRs. The dose savings over 35 years, using the dollar per person-rem conversion factor of $2,000, would be $11,500 for each PWR and $23,000 for each BWR.

3.4.2.2.5 Offsite Property

The Offsite Property cost due to this relaxation was calculated consistent with the methodology described in Section 5.7.5 of [4]. From NUREG/CR-6349 [10], the offsite property consequences are about 6 percent of the magnitude of the public health costs for late containment failure for Peach Bottom. Thus, the Offsite Property cost savings is estimated to be -$1,300 per plant for Approach 1.

Since Approach 3 does not alter the recombiner requirements for BWRs with Mark I and Mark II containments, the numerical value for Offsite Property costs is zero.

3.4.2.2.6 Onsite Property

There is no change in the Onsite Costs, when comparing Approach 1 to the base case (Approach 4) since the onsite damage from the accident would have occurred in any event. This is also the case for Approach 3.

3.4.2.2.7 Industry Implementation

This attribute is an impact which accounts for the projected net economic effect on the affected licensees to install or implement mandated changes. Approach 1 would eliminate the requirement to maintain hydrogen recombiners. Since the recombiners would no longer be required, licensees would be able to remove them permanently from service. Licensees could abandon the equipment in place, or permanently remove it. If licensees chose to remove the equipment, they would incur costs associated with the removal and radioactive waste disposal. However, if licensees choose to abandon the equipment in place, there would be some costs associated with instrumentation changes or deletions. For the purposes of this regulatory analysis it is assumed that an average of $10,000 per plant would be spent for the above implementation.

The relaxation in Approach 1 would lead to a technical specification change. It would be to licensees' advantage to amend their technical specifications (remove the technical specification associated with recombiners); therefore, licensees would incur a cost for preparing and submitting a license amendment request. According to NUREG/CR-4627 [12], it costs approximately $28,000 (adjusted to 2002 dollars) to prepare a typical uncomplicated technical specification amendment request. Since it is likely that licensees will submit one license amendment request that will cover both the monitors and the recombiners, only half of the cost ($14,000) for the amendment is considered in this portion of the Value-Impact analysis. See Section 3.4.1.1.7 for inclusion of the remaining half of this cost.

3.4.2.2.8 Industry Operation

This attribute is an impact which measures the projected net economic effect due to routine and recurring activities required by the proposed action on all affected licensees. According to industry estimates [8], it costs approximately $36,000 per year per reactor to operate and maintain a typical post-LOCA hydrogen recombiner system. Although this estimate is for a BWR, it is expected that costs for PWRs are similar. Approach 1 would eliminate the requirement to maintain hydrogen recombiners. Therefore, a plant could expect annual savings of $36,000, or $470,000 over the remaining life assumed by this analysis. Because this attribute is an impact, the dollar amounts are expressed as negative numbers.

3.4.2.2.9 NRC Implementation

Approach 1 would necessitate a rulemaking as well as revision to or development of regulatory guidance. Whether or not the Commission chooses to proceed with the rulemaking, the costs associated with the development of the rulemaking and associated guidance are sunk costs, and not considered by this regulatory analysis.

Because Approach 1 involves a deletion of a requirement, license amendments are expected on the part of the licensees, i.e., licensees will request an amendment to delete requirements associated with operation and surveillance of the recombiners. Therefore, the NRC will incur costs associated with review and approval of the amendment requests. According to NUREG/CR-4627 [12], it costs approximately $17,000 (adjusted to 2002 dollars) to review a typical uncomplicated technical specification amendment request. This cost includes preparation of a generic communication and model technical specification change. As was indicated in Section 3.4.1.1.9, the technical specification amendment request for recombiners is likely to be combined with the amendment request for the monitors. Therefore, $8,500 is assumed for this portion of the Value-Impact.

3.4.2.2.10 NRC Operation

This attribute is an impact which measures the projected net economic effect on the NRC after the proposed action is implemented. As a result of the proposed action, there will be a slight reduction in the effort during inspections. This reduction is expected to be small, and therefore will not be quantified for the purposes of this analysis.

3.4.2.2.11 Other Attribute Considerations

For completeness, the remaining attributes that make up the full set [4] are addressed here. Several – Safeguards and Security, Antitrust, Environmental, General Public, Improvement in Knowledge, and Other Government – have no bearing on this regulatory analysis and therefore are not discussed further. A discussion follows for the remaining one, Regulatory Efficiency. One of the major motivations for this rulemaking is to reduce unnecessary regulatory burden on both the industry and the NRC. This reduction in unnecessary regulatory burden results in a more efficient regulatory framework and refocuses resources on more risk significant SSCs.

4. Presentation of Results

4.1 Results for Monitors

Table 4.1 presents the “hydrogen monitor” results comparing Approach 1 (Option 1 from SECY-01-0162 [2]) to Approach 4 (the “No Change to Current Requirements, baseline Approach”) *for all BWRs and PWRs*. The Value-Impact indicates that Approach 1 is cost-beneficial, even when considering uncertainties. The Industry Value-Impact – the “per unit” Value-Impact times 103 units – is about $53M. There would be a slight adjustment to these numbers for BWRs with Mark I and Mark II containments in that the relaxation requirements for oxygen monitors should be taken into account. This impact is considered small and well within the uncertainties of the analysis.

Table 4.1 Results for Monitors in Approach 1 for All Plants

Quantitative Attribute			Present Value Estimate ($)
Health (value)	Public	Accident	0
		Routine	0
	Occupational	Accident	0
		Routine	0
Property (value)	Offsite		0
	Onsite		0
Industry (impact)	Implementation		70,000 + 40,000 + 14,000
	Operation		-650,000
NRC (impact)	Implementation		8,500
	Operation		0
NET Value (Sum)			517,000

From Table 4.1, the Value-Impact is calculated to be {(0)- (70,000+40,000+14,000+8,500-650,000)}= $517,500/plant, or about $520,000/plant.

The uncertainties for this evaluation are driven by the uncertainty in the result for Industry Operation. Only those uncertainties that would significantly reduce the magnitude of the result given, namely $650,000/plant, could have an impact on the conclusion for Approach 1. Elements of this uncertainty include: (1) the assumption that plant will obtain a life-extension of 20 years and (2) the assumption that the typical number used for operational savings per year provided in reference [8] is too large. If the assumption is made that there will be no license renewal and that the smallest magnitude number for operations savings is used (15 years of remaining life vs. 35 years or $40,000 per year vs. $50,000 per year) then the Industry Operation amount is $371,000. Even this number is large relative to other numbers in Table 4.1.

Another uncertainty relates to Approach 4, the no action reference case. The Value-Impact assessment described above does not consider the equipment replacement costs associated over 35 years of maintaining the status quo. It is assumed here that, if the Commission took no action, licensees would request exemptions, as was the case for Oconee [13]. This would be the less costly alternative to doing nothing and thus incurring the higher multimillion-dollar costs associated equipment replacement. Industry costs for an exemption are about $30,000, while NRC review of the exemption would run about $10,000. While these costs are not insignificant, they do not alter the conclusions of this regulatory analysis. Additionally, current Commission practice is to address generic issues through the rulemaking process. The rulemaking process vs. individual exemption process allows for greater public involvement, thereby increasing public confidence. Also, the rulemaking option would eliminate a non risk-significant requirement, and at the same time, would provide relief from unnecessary regulatory burden.

Thus, while there is some uncertainty in this analysis, it does not adversely affect the overall conclusion that Approach 1 is viable for all plants.

4.2 Results for Recombiners

Table 4.2 presents the "recombiner" results comparing Approach 1 (Option 1 from SECY-01-0162 [2]) compared to Approach 4 (the "No Change to Current Requirements, baseline "Approach") *for all BWRs with Mark I or Mark II containments.* The Value-Impact indicates that Approach 1 is cost-beneficial, even when considering uncertainties. The Industry Value-Impact – the "per unit" Value-Impact times 30 units – is about $13M.

Table 4.2 Results for Recombiners in Approach 1 for Mark I and II Containments

Quantitative Attribute			Present Value Estimate ($)
Health (value)	Public	Accident	-21,300
		Routine	0
	Occupational	Accident	0
		Routine	23,000
Property (value)	Offsite		-1,300
	Onsite		0
Industry (impact)	Implementation		10,000 + 14,000
	Operation		-470,000
NRC (impact)	Implementation		8,500
	Operation		0
NET Value (Sum)			438,000

From Table 4.2, the Value-Impact is calculated to be {(-21,320+23,000 –1,300)-(10,000+14,000+8,500-470,000)} = $437,900/plant, or about $438,000/plant.

The uncertainties for this evaluation can be considered in two parts: uncertainties associated with the Values (Public and Occupational Health) and with the Impacts (NRC and Industry).

As was discussed in Section 3.4.2.1, value for the increased risk due to the relaxation is conservative, that is, the magnitude of the value is expected to be less. Using a less conservative value for Public-Accident, would make the "Value" portion of the equation even more positive, thereby further supporting Approach 1. Even if the Occupational-Routine contribution was zero, the total "Value" would be a relatively small, although a negative number. Thus, considering the uncertainties associated with the "Value" portion – that portion of the Value-Impact that focuses on protecting health and safety – the staff concludes that the result is either positive or negative but small, both in an absolute sense and relative to the results for the Impacts.

If the uncertainties for the "Impacts" are large and positive in sign, these uncertainties might challenge the conclusion that Approach 1 is cost-beneficial. Only if the uncertainties in the (positive) costs for NRC and Industry implementation are large can this happen (the result for Industry Operation is a best-estimate). If the amounts for NRC and Industry Implementation are doubled, the total Impact is still relatively large and negative, thus yielding an overall positive Value-Impact for Approach 1.

Even if the uncertainties are large, they do not adversely affect the overall conclusion that Approach 1 is viable for BWRs with Mark I or Mark II containments.

Approach 3, discussed in Section 2.3, also addresses recombiners, but is limited to plants with Mark I or Mark II containments. For these plants, Approach 3 would leave the recombiner requirements intact. Considering the recombiner issue for these plants then, the Value-Impact would be no different from doing nothing (Approach 4) while the Value-Impact from Approach 1 is sizable and positive. Thus, Approach 3 is not an attractive option from a Value-Impact perspective.

In Section 2.3, a variation of Approach 3 was addressed which retained the recombiners but relaxed the requirements for maintaining and operating them. The BWR Owners' Group estimates [8] that the annual cost savings of at least $25K could be expected if the recombiners were reclassified as non-safety. This equates to -$326K "Impact" over the life of the plant. Comparing this number to the equivalent for Approach 1, namely -$470K (note "Public-Accident" Value in Table 4.2), yields the conclusion that, while this variation on Approach 3 might be attractive, its Value-Impact is less than that of Approach 1 (The absolute values of the other attributes in the Value-Impact equation are smaller by at least an order of magnitude.)

Table 4.3 Results for Recombiners in Approach 1 for PWRs and Mark III Containments

Quantitative Attribute			Present Value Estimate ($)
Health (value)	Public	Accident	0
		Routine	0
	Occupational	Accident	0
		Routine	12,100[1]
Property (value)	Offsite		0
	Onsite		0
Industry (impact)	Implementation		10,000 + 14,000
	Operation		-470,000
NRC (impact)	Implementation		8,500
	Operation		0
NET Value (Sum)			449,600

[1]The value $12,100 was calculated based on 69 PWRs x $11,500 + 4 Mark III's x $23,000, then averaged over 73 plants.

Table 4.3 presents the "recombiner" results comparing Approach 1 (Option 1 from SECY-01-0162 [2]) compared to Approach 4 (the "No Change to Current Requirements, baseline "Approach") *for all BWRs with Mark III containments and all PWRs*. The Value-Impact indicates that Approach 1 is cost-beneficial, even when considering uncertainties. The Industry Value-Impact – the "per unit" Value-Impact times 73 units – is about $33M. From Table 4.3, the Value-Impact is calculated to be {(12,100)- (10,000+14,000+8,500-470,000)}= $449,600/plant, or about $450,000/plant.

The uncertainties for this evaluation can also be considered in two parts: uncertainties associated with the Values (Public and Occupational Health) and with the Impacts (NRC and Industry).

The only way that uncertainties in the Value portion can adversely impact the position that Approach 1 is viable is for the benefit of reducing the occupational routine value be reevaluated as zero. Thus, considering this uncertainty associated with the "Value" portion – that portion of the

Value-Impact that focuses on protecting health and safety – the staff concludes that the result is positive but small, both in an absolute sense and relative to the results for the Impacts.

If the uncertainties for the "Impacts" are large and positive in sign, these uncertainties might challenge the conclusion that Approach 1 is cost-beneficial. Only if the uncertainties in the (positive) costs for NRC and Industry implementation are large can this happen (the result for Industry Operation is a best-estimate). If the amounts for NRC and Industry Implementation are doubled, the total Impact is still relatively large and negative, thus yielding an overall positive Value-Impact for Approach 1.

While the uncertainties might be large, they do not adversely affect the overall conclusion that Approach 1 is viable for BWRs with Mark III containments and all PWRs.

5. Decision Rationale

The conclusion drawn from this regulatory analysis is that the regulatory relaxation proposed as Approach 1 (Option 1 of SECY-01-0162) is appropriate from an overall safety and a Value-Impact perspective. The basic criteria for this determination is that the relaxation meets two specific conditions:

- the public health and safety and the common defense and security would continue to be adequately protected
- the cost savings attributed to the action would be substantial enough to justify taking action.

The risk and regulatory insights described in this regulatory analysis show that these rulemaking actions either do not increase risk or only increase risk slightly, such that there is virtually no change in the conditions for assuring that the public health and safety is adequately protected.

In addition, this analysis shows that the savings to the NRC and industry far outweigh the costs inherent in the action itself.

The Value-Impact demonstrates that the benefits, mainly in terms of relief from regulatory burden, far outweigh the small increase in risk for BWRs with Mark I and Mark II containments and far outweigh the essentially zero increase in risk for the PWRs and the BWRs with Mark III containments.

6. Implementation

The implementation of this action will be consistent with the schedule for the rulemaking provided in SECY-01-0162.

7. References

1. SECY-00-198, "Status Report on Study of Risk-Informed Changes to the Technical Requirements of 10 CFR Part 50 (Option 3) and Recommendations on Risk-Informed Changes to 10 CFR 50.44 (Combustible Gas Control)," September 2000.

2. SECY-01-162, "Staff Plans for Proceeding with the Risk-Informed Alternative to the Standards for Combustible Gas Control Systems in Light-Water-Cooled Power Reactors in 10 CFR 50.44," August 2001.

3. "Regulatory Analysis Guidelines of the U.S. NRC," NUREG/BR-0058, Rev. 3, July 2000.

4. "Regulatory Analysis Technical Evaluation Handbook," NUREG/BR-0184, January 1997.

5. Attachment 2 to SECY-00-0198, "Feasibility Study for a Risk-Informed Alternative to 10 CFR 50.44," August 2000.

6. "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions during and following an Accident," Regulatory Guide 1.97, Revision 3, May 1983.

7. Attachment 1 to SECY-00-0198, "Framework For Risk-Informed Changes to the Technical Requirements of 10 CFR 50, Draft, Revision 2," August 2000.

8. "Regulatory Relaxation For the H_2/O_2 Monitors and Combustible Gas Control System," BWR Owner's Group, July 2001.

9. PRM-50-68, 10 CFR Part 50, Bob Christie; Receipt of Petition for Rulemaking. 65 FR 1829. January 12, 2000.

10. Mubayi, V. et al., "Cost-Benefit Considerations in Regulatory Analysis," NUREG/CR-6349, BNL, October 1995.

11. *Applicant's Environmental Report - Operating License Renewal Stage, Turkey Point Units 3 & 4*. Florida City, FL, September 2000.

12. "Generic Cost Estimates, Abstracts from Generic Studies for Use in Preparing Regulatory Impact Analyses," NUREG/CR-4627, including Revs. 1 and 2, February 1992.

13. "Oconee Nuclear Station, Units 1, 2, and 3 RE: Exemption from the Requirements of Hydrogen Control Requirements of 10 CFR 50.44 .....," Letter to Mr. W.R. McCollum, Jr., Duke Energy Corporation, from Mr. David E. LaBarge, US NRC, dated July 17, 2001.

Appendix A

RISK-BENEFIT ANALYSIS OF COMBUSTIBLE GAS CONTROL FOR BWRS WITH MARK I CONTAINMENT

APPENDIX A

RISK-BENEFIT ANALYSIS OF COMBUSTIBLE GAS CONTROL FOR BWRS WITH MARK I CONTAINMENT

A.1 Introduction

In BWRs with Mark I containment, the containment atmosphere is normally maintained by nitrogen at a low concentration of oxygen, rendering it inert to combustion under most circumstances. Therefore, the only credible pathway leading to combustion in the containment is the long-term generation of hydrogen and oxygen by radiolysis in the suppression pool. After sufficient radiolysis has taken place, the concentration of oxygen in the containment may rise to a sufficiently high level (5 percent or greater) to de-inert the atmosphere, thus making combustion events possible. The radiolysis process is sensitive to such factors as accident timing; amount of liquid-phase iodine in the suppression pool; and the concentration of hydrogen in the containment atmosphere. De-inerting of containment is calculated in [A.1] to occur in about 3.6 days for conditions in which liquid-phase iodine represents 30 percent of the total core inventory, and would shorten for postulated conditions in which liquid-phase iodine approaches 75-100 percent of initial core inventory. However, the analysis did not take credit for the concentration of hydrogen in the containment atmosphere, which has been shown to have a strong effect on lengthening the time to de-inerting [A.6].

A.2 Basic Methodology

The risk-benefit associated with combustible gas control may be calculated using the formula:

$$\Delta R = C\,Z\,f_{CD}\sum_{i}\left(p_{i,base} - p_{i,sens}\right)D_i \qquad \text{(A.1)}$$

where

ΔR	=	net risk-benefit associated with combustible gas control ($);
C	=	effective number of years from the present over which to calculate the risk-benefit (years) (e.g., 13.05 years for a 35-year period calculated at a 7 percent discount rate, the average remaining lifetime of all U. S. reactors of General Electric design (including 20-year license extension) according to [A.2]);
Z	=	valuation factor for offsite dose consequence ($/person-rem) (a value of $2000/person-rem calculated within a 50-mile radius is recommended by [A.2]);
f_{CD}	=	total core damage frequency for risk-significant sequences (events/reactor-year);

$p_{i,base}$ = conditional probability of containment failure mode or release class *i* in the baseline case without combustible gas control;

$p_{i,sens}$ = conditional probability of containment failure mode or release class *i* in the sensitivity case with combustible gas control; and

D_i = offsite dose consequence associated with containment failure mode or release class *i* (person-rem/event).

The three main elements of data required are thus the frequency of risk-significant core damage events; the conditional probabilities of containment failure; and the offsite health consequences of containment failure. For this study, Peach Bottom Unit 2 is used as a reference plant, since it was used as the reference for NUREG/CR-4551 [A.3] and therefore has the most available data. Where possible, data from the Peach Bottom IPE [A.4] was used as well.

A.3 Risk-Significant Event Frequency

Risk-significant sequences for this study are represented by all sequences in which the accident progresses past the late time frame (1-3 days) with an intact containment. In case of a pre-existing, early, or late containment failure by other means, the radiolysis issue is rendered irrelevant. Moreover, sequences leading to controlled containment venting are not included, since it is assumed that the releases and consequences resulting from the earlier venting will themselves be much greater than those resulting from the very late containment rupture induced by combustion of gases produced by radiolysis.

From the IPE, the total core damage frequency due to internal events is about 5.53e-6 per reactor-year, of which 46.4 percent (page 4.6-30 of [A.4]) result in a late intact containment. Therefore, the frequency of risk-significant sequences for internal initiators is 2.57e-6 per reactor-year.

NUREG/CR-4551 [A.3] is used at present as having the most usable data for Peach Bottom on external event initiators. From Figure 2.5-9 in that document, the frequency of core damage due to fires that result in a late intact containment is 4.69e-6 per reactor-year (i.e., about 24 percent of the total fire CDF of 1.98e-5 per reactor-year). Figures 2.5-11(a, b) in [A.3] show that there is zero probability of seismic core damage sequences resulting in a late intact containment.

These frequencies are summarized in Table A.1.

A.4 Containment Failure Probabilities

The sequences in the baseline case, by definition, all have late intact containment. For the sensitivity case, it is assumed that the lack of combustible gas control will in all of the same circumstances result in a very late, catastrophic failure of the drywell. The resulting containment response matrix is shown in Table A.2.

A.5 Consequences

From NUREG/CR-4551, representative source terms are available for core damage sequences leading to an intact containment, for both internally and externally initiated sequences. These source terms are shown in Table A.3. Comparing to Tables 3.4-4 and 3.4-8 in [A.3], it can be seen that these correspond most closely to release classes PB-17-1 (for internally initiated events) and PBF-19-1 (for fires). The resulting consequences, from Tables 4.3-1 and 4.3-2 in [A.3], are 52.2 person-rem/event and 62.9 person-rem/event, respectively. Consequences are summarized in Table A.4.

Source terms corresponding to a very late catastrophic rupture of the containment are unavailable in NUREG/CR-4551; all containment failures considered there occur within about 40,000 seconds (11 hours) of scram. Instead, it is proposed for now to use the source terms for late containment failure, typical values of which are shown in Table A.3 (taken from, e.g., Figure 3.3-15 in [A.3]). These source terms are approximately represented by release classes PB-1-1 (for internal events) and PBF-1-1 (for fires), with consequences of 1.82e5 person-rem/event and 7.45e4 person-rem/event, respectively.

A.6 Results

Using Equation (A.1), the risk-benefit associated with combustible gas control for Peach Bottom can now be calculated as:

$$\begin{aligned}\Delta R_{\text{int}\,ernal} &= (2.57\times 10^{-6})(13.05)(\$2000)\left[(1.0)(1.82\times 10^{5} - 52.2)\right] \\ &= (13.05)\ (\$2000)\ (0.468) \\ &= \$12{,}210. \end{aligned} \qquad \text{(A.2)}$$

$$\begin{aligned}\Delta R_{fires} &= (4.69\times 10^{-6})(13.05)(\$2000)\left[(1.0)(7.45\times 10^{4} - 62.9)\right] \\ &= (13.05)(\$2000)(0.349) \\ &= \$9110. \end{aligned} \qquad \text{(A.3)}$$

$$\Delta R_{seismic} = 0. \qquad \textbf{(A.4)}$$

$$\begin{aligned}\Delta R_{total} &= \Delta R_{\text{int}} + \Delta R_{fires} + \Delta R_{seismic} \\ &\boxed{= \$21{,}320.} \end{aligned} \qquad \text{(A.5)}$$

These results are also summarized in Table A.5.

A.7 Conclusions

Using available information from the Peach Bottom IPE and NUREG/CR-1150, a bounding risk-benefit of about $21,320 has been found for control of combustible gases and oxygen produced during radiolysis. This is a conservative estimate, given that the actual source term and consequences for very late containment failure (several days after scram) are likely to be significantly lower than those for late containment failure (less than 12 hours after scram), which were used in the calculation. Nevertheless, the resulting benefit is relatively small. This is largely attributable to the fact that consequences for such late failure times are relatively small.

Note that this analysis has not included offsite economic consequences of the proposed action. In view of past consequence calculations, the offsite economic consequences are generally of similar magnitude to the offsite health consequences. In [A.5] (Table 4-6), it is in fact seen that the conditional offsite health and property consequences for late containment failure (PB-01-1) are 2.05e5 person-rem and $2.40e7, respectively. Using a conversion factor of $2000/person-rem, it is seen that property costs are only about 6 percent of the health costs. If the result of the present analysis were to be increased by the same proportion to include property costs, then the total benefit would become $22,600.

A.8 References

A.1. BWR Owners' Group, "Licensing Topical Report: Regulatory Relaxations for the H_2/O_2 Monitors and Combustible Gas Control Systems", NEDO-33003, General Electric Company, July 2001.

A.2. U. S. NRC Office of Regulatory Research, "Regulatory Analysis Technical Evaluation Handbook", NUREG/BR-0184, U. S. Nuclear Regulatory Commission, January 1997.

A.3. A. C. Payne, R. J. Breeding, et al., "Evaluation of Severe Accident Risks: Peach Bottom, Unit 2 – Main Report", Vol. 4, Rev. 1, Part 1, NUREG/CR-4551, December 1990.

A.4. G. J. Beck et al., "Individual Plant Examination, Peach Bottom Atomic Power Station Units 2 & 3", Philadelphia Electric Co., August 1992.

A.5. V. Mubayi, V. Sailor, et al., "Cost-Benefit Considerations in Regulatory Analysis", NUREG/CR-6349, Brookhaven National Laboratory, October 1995.

A.6. K. I. Parczewski and V. Benarroya, "Generation of Hydrogen and Oxygen by Radiolytic Decomposition of Water in Some BWRs", presented at Joint ASME/ANS Nuclear Engineering Conference, Portland, Oregon, August 5-8, 1984.

Table A.1 Event Frequencies for Peach Bottom Unit 2

Initiator Category	Total CDF (events/year)	CDF with Late Intact Containment (events/year)	Conditional Probability of Late Intact Containment
Internal Events[1]	5.53e-6	2.57e-6	0.46
Fires[2]	1.98e-5	4.69e-6	0.24
Seismic Events[2]	7.52e-5	0	0
Total	1.01e-4	7.26e-6	

[1] Source: IPE [A.4].
[2] Source: NUREG/CR-4551 [A.3].

Table A.2 Containment Matrix for Peach Bottom Unit 2 (Sequences with Late Intact Containment in Baseline Case)

Case	Conditional Probability of No Containment Failure	Conditional Probability of Very Late Catastrophic Containment Rupture
Baseline (without combustible gas control)	0.0	1.0
Sensitivity (with combustible gas control)	1.0	0.0

Table A.3 Source Terms for Peach Bottom Unit 2 (from NUREG/CR-4551 [A.3])

Containment Failure Mode or Release Class	Xe	I	Cs	Te	Ba	Sr	La
No CF	2e-3	1e-4	1e-8	1e-9	1e-9		1e-10
PB-17-1	4e-3	3e-6	6e-9	2e-9	2e-9	2e-9	1e-10
PBF-19-1	3e-3	5e-6	4e-9	2e-9	7e-10	8e-10	6e-11
Late CF	1.0	1e-2	5e-4			5e-5	5e-6
PB-1-1	0.95	1e-2	7e-4	4e-4	6e-5	6e-5	6e-6
PBF-1-1	0.95	1e-2	1e-4	6e-5	3e-5	3e-5	2e-6

Table A.4 Consequences for Peach Bottom Unit 2 Release Classes (from NUREG/CR-4551 [A.3])

Release Class	Description	Conditional Offsite Health Consequence (person-rem/event, 50-mile radius)
PB-17-1	No CF (Internal Events)	5.22e1
PBF-19-1	No CF (Fires)	6.29e1
PB-1-1	Late CF (Internal Events)	1.82e5
PBF-1-1	Late CF (Fires)	7.45e4

Table A.5 Summary of Risk-Benefit Results for Combustible Gas Control at Peach Bottom Unit 2

Initiator Category	Net Change in Consequence (person-rem/year)	Net Risk-Benefit ($)
Internal Events	0.468	$12,210
Fires	0.349	$9110
Seismic Events	0	$0
Total	**0.817**	**$21,320**

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DRAFT REGULATORY GUIDE

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CONTROL OF COMBUSTIBLE GAS CONCENTRATIONS IN CONTAINMENT

A. INTRODUCTION

The NRC has issued a proposed revision to Section 50.44, “Standards for Combustible Gas Control System in Light-Water-Cooled Power Reactors,” which will become an amendment to 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities.” This proposed regulation will be applicable to all construction permits or operating licenses under this part, and to all design approvals, design certifications, combined licenses or manufacturing licenses under part 52 of this chapter, any of which are issued after the effective date of the rule. This regulatory guide is being developed to describe methods that would be acceptable to the NRC staff for implementing the proposed Section 50.44.

Regulatory guides are issued to describe to the public methods acceptable to the NRC staff for implementing specific parts of the NRC's regulations, to explain techniques used by the staff in evaluating specific problems or postulated accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations, and compliance with regulatory guides is not required. Regulatory guides are issued in draft form for public comment to involve the public in developing the regulatory positions. Draft regulatory guides have not received complete staff review; they therefore do not represent official NRC staff positions.

The information collections contained in this draft regulatory guide are covered by the requirements of 10 CFR Part 50, which were approved by the Office of Management and Budget, approval number 3150-0011. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

B. DISCUSSION

The proposed Section 50.44 provides requirements for the mitigation of combustible gas generated by a beyond-design-basis accident. In an accident more severe than the design-basis loss-of-coolant accident (LOCA), combustible gas is predominately generated within the containment as a result of :

1. Fuel clad-coolant reaction between the fuel cladding and the reactor coolant, and
2. Molten core-concrete interaction in a severe core melt sequence with a failed reactor vessel.

If a sufficient amount of hydrogen is generated, it may react with oxygen present in the containment at a rate rapid enough to lead to the breaching of the containment or a leakage rate in excess of technical specification limits. Additionally, damage to systems and components essential to continued control of the post-accident conditions could occur.

In SECY-00-0198, "Status Report on Study of Risk-Informed Changes to the Technical Requirements of 10 CFR Part 50 (Option 3) And Recommendations on Risk-informed Changes to 10 CFR 50.44 (Combustible Gas Control)," dated September 14, 2000 (Ref. 1), the NRC staff recommended changes to 10 CFR 50.44 that reflect the position that only combustible gas generated by a beyond-design-basis accident is a risk-significant threat to containment integrity. Based on those recommendations, the proposed revision to 10 CFR 50.44 eliminates requirements that pertain to only design-basis LOCAs.

Attachment 2 to SECY-00-198 (Ref. 1) used the framework described in Attachment 1 to the paper with risk insights from NUREG-1150 (Ref. 2) and the integrated plant evaluation programs to evaluate the proposed requirements in 10 CFR 50.44. It was noted in Attachment 2 that containment types that rely on pressure suppression concepts (i.e., ice baskets or water pools) to condense the steam from a design-basis LOCA have smaller containment volumes, and in some cases lower design pressures, than pressurized water reactor (PWR) large-volume or subatmospheric containments. Consequently, the smaller volumes and lower design pressures associated with pressure suppression containment designs make them more vulnerable to hydrogen deflagrations during degraded core accidents because the pressure loads could cause structural failure of the containment. Also, because of the smaller volume of these containments, detonable mixtures could be formed. A detonation would impose a dynamic pressure load on the containment structure that could be more severe than the static load from an equivalent deflagration. However, the staff noted in SECY-00-0198 that the risk of early containment failure from hydrogen combustion in these types of containments can be limited by the use of mitigative features: (1) inerting in Mark I and II containments and (2) using igniter systems in Mark III and ice condenser containments. As a result, the proposed Section 50.44 has the following requirements:

1. All boiling water reactor (BWR) Mark I and II type containments must be inerted. By maintaining an oxygen-deficient atmosphere, hydrogen combustion that could threaten containment integrity is prevented.

2. All BWRs with Mark III type containments and all PWRs with ice condenser type containments must have the capability to control combustible gas generated from a metal-water reaction involving 75% of the fuel cladding surrounding the active fuel region (excluding the cladding surrounding the plenum volume) so that there is no loss of containment structural integrity. The deliberate ignition systems provided to meet this existing hydrogen source term are capable of safely accommodating even greater amounts of hydrogen associated with even more severe core melt sequences that fail the reactor vessel and involve molten core-concrete interaction. Deliberate ignition systems, if available, generally consume the hydrogen before it reaches concentrations that can be detrimental to containment integrity.

3. For all applicants for and holders of a construction permit or operating license under 10 CFR Part 50, and all applicants for a design approval, design certification, or combined license under 10 CFR Part 52 that are docketed after the effective date of the rule, the following requirement applies. All containments must have an inerted atmosphere or limit hydrogen concentrations in containment during and following an accident that releases an equivalent amount of hydrogen as would be generated from a 100% fuel-clad coolant reaction, uniformly distributed, to less than 10% and must maintain containment structural integrity.

The combustible gas control systems, the atmosphere mixing systems, and the provisions for measuring and sampling that would be required by Section 50.44 are risk-significant as they have the ability to mitigate the risk associated with combustible gas generation caused by beyond-design-basis accidents. The recommended treatments for those systems are delineated in the Regulatory Position.

C. REGULATORY POSITION

1. COMBUSTIBLE GAS CONTROL SYSTEMS

For all construction permits or operating licenses under this Part 50, and to all design approvals, design certifications, combined licenses or manufacturing licenses under Part 52 of this chapter, any of which are issued after [EFFECTIVE DATE OF RULE], SECY-93-087, "Policy, Technical, And Licensing Issues Pertaining to Evolutionary And Advanced Light-water Reactor (ALWR) Designs," dated April 2, 1993 (Ref. 3), provides the following design guidance applicable to combustible gas control systems installed to mitigate the risk associated with combustible gas generation due to beyond design basis accidents. Structures, systems, and components (SSCs) installed to mitigate the hazard from the generation of combustible gas in containment should be designed to provide reasonable assurance that they will operate in the severe accident environment for which they are intended and over the time span for which they are needed. Equipment survivability expectations under severe accident conditions should consider the circumstances of applicable initiating events (such as station blackout or earthquakes) and the environment (including pressure, temperature, and radiation) in which the equipment is relied upon to function. The required system performance criteria will be based on the results of design-specific reviews which include probabilistic risk-assessment as required by 10 CFR 52.47(a)(v). Because these requirements address beyond design-basis combustible gas control, SSCs provided to meet these requirements need not be subject to the environmental qualification requirements of 10 CFR Section 50.49; quality assurance requirements of 10 CFR Part 50, Appendix B; and redundancy/diversity requirements of 10 CFR Part 50, Appendix A. Guidance such as that found in Appendices A and B of Regulatory Guide 1.155 (Ref. 4), is appropriate for equipment used to mitigate the consequences of severe accidents. This guidance was used to review the design of evolutionary and passive plant designs as documented in NUREG –1462 (Ref. 5), NUREG-1503 (Ref. 6), and NUREG-1512 (Ref. 7).

The combustible gas control systems in all BWRs with Mark III type containments and all PWRs with ice condenser type containments must meet the requirements in the Proposed Section 50.44   The staff considers that the combustible gas control systems installed and approved by the NRC as of [EFFECTIVE DATE OF THE RULE], are acceptable without modification.

2. OXYGEN AND HYDROGEN MONITORS

2.1 Hydrogen Monitors

The Proposed Section 50.44 would require that equipment be provided for monitoring hydrogen in the containment. The equipment for monitoring hydrogen must be functional, reliable, and capable of continuously measuring the concentration of hydrogen in the containment atmosphere following a beyond design-basis accident for accident management, including emergency planning. Safety-related hydrogen monitoring systems installed and approved by the NRC prior to the effective date of the rule are sufficient to meet these criteria. Non-safety-related commercial grade hydrogen monitors can also be used to meet these criteria if they:

1. Comply with the Category 3 design and qualification criteria of Regulatory Guide 1.97 (Ref. 8) for monitors used as diagnostic or backup indicators.

2. Comply with the Category 2 power source design and qualification criteria as specified in Table 1 of Regulatory Guide 1.97 (Ref. 8).

The above provisions can be met with a program based on compliance with a pre-specified, structured program of testing and calibration; alternatively, these items can be met with a less-prescriptive, performance-based approach to assurance of the hydrogen monitoring function. Such an approach is consistent with SECY-00-191, "High-Level Guidelines for Performance-Based Activities" (Ref. 9). Specifically, assurance of the reliability, availability, and capability of the hydrogen monitoring function can be derived through tracking actual reliability performance (including calibration) against targets established by the licensee based on the significance of this function, which is determined on a plant-specific basis. Thus, for hydrogen monitoring, it is acceptable to accomplish the functions of servicing, testing, and calibration within the maintenance rule program provided that applicable targets are established based on the functions of the hydrogen monitors delineated above.

Section 50.44 also requires that hydrogen monitors be functional. Functional requirements can be found in TMI Action Item II.F.1, Attachment 6, in NUREG-0737 (Ref. 10), which states that hydrogen monitors are to be functioning within 30 minutes of the initiation of safety injection. This requirements was imposed by confirmatory orders following the Three Mile Island Unit 2 accident. Since that requirement was issued, the staff has determined that 30 minutes can be overly burdensome. Through the “Confirmatory Order Modifying Post-TMI Requirements Pertaining to

Containment Hydrogen Monitors for Arkansas Nuclear One, Units 1 and 2" (Ref. 11), dated September 28, 1998, the staff developed a method for licensees to adopt a risk-informed functional requirement in lieu of the 30-minute requirement. As described in the confirmatory order, an acceptable functional requirement would meet these requirements:

i. Procedures shall be established for ensuring that indication of hydrogen concentration in the containment atmosphere is available in a sufficient timely manner to support the role of information in the Emergency Plan (and related procedures) and related activities such as guidance for the severe accident management plan.

ii. Hydrogen monitoring will be initiated on the basis of:

   (1) The appropriate priority for establishing indication of hydrogen concentration within containment in relation to other activities in the control room.

   (2) The use of the indication of hydrogen concentration by decision makers for severe accident management and emergency response.

   (3) Insights from experience or evaluation pertaining to possible scenarios that result in significant generation of hydrogen that would be indicative of core damage or a potential threat to the integrity of the containment building.

The NRC staff has found that adoption of this functional requirement by licensees results in the hydrogen monitors being functional within 90 minutes after the initiation of safety injection. This period of time includes equipment warm-up but not equipment calibration.

2.2 Oxygen Monitors

Proposed Section 50.44 would require that equipment be provided for monitoring oxygen in containments that use an inerted atmosphere for combustible gas control. The proposed rule requires the equipment for monitoring oxygen to be functional, reliable, and capable of continuously measuring the concentration of oxygen in the containment atmosphere following a beyond design-basis accident for combustible gas control and accident management, including emergency planning. Safety-related oxygen monitoring systems installed and approved by the NRC prior to the effective date of the rule are sufficient to meet this criterion. Non-safety-related oxygen monitors would also meet these criteria if they meet the Category 2 design and qualification criteria of Regulatory Guide 1.97 (Ref. 8) for monitors designated for indicating system operating status.

3. ATMOSPHERE MIXING SYSTEMS

The Proposed Section 50.44 would require that all containments have a capability for ensuring a mixed atmosphere. This capability may be provided by an active, passive, or combination system. Active systems may consist of a fan, a fan cooler, or containment spray. For passive or combination systems that use convective mixing to mix the combustible gases, the containment internal structures should have design features that promote the free circulation of the atmosphere. All containment types should have an analysis of the effectiveness of the method used for providing a mixed atmosphere. This analysis should demonstrate that combustible gases will not accumulate within a compartment or cubicle to form a combustible or detonable mixture that could cause loss of containment integrity.

Atmosphere mixing systems prevent local accumulation of combustible or detonable gases that could threaten containment integrity or equipment operating in a local compartment.   Active systems installed to mitigate this threat should be reliable, redundant, single-failure proof, able to be tested and inspected, and remain operable with a loss of onsite or offsite power. The NRC staff considers atmosphere mixing systems installed and approved by the NRC as of the effective date of the rule to be acceptable without modification.

4. HYDROGEN GAS PRODUCTION

Materials within the containment that would yield hydrogen gas by corrosion from the emergency cooling or containment spray solutions should be identified, and their use should be limited as much as practicable.

5. CONTAINMENT STRUCTURAL INTEGRITY

Proposed Section 50.44 would require that containment structural integrity be demonstrated by use of an analytical technique that is accepted by the NRC staff. This demonstration must include sufficient supporting justification to show that the technique describes the containment response to the structural loads involved. The analysis must address an accident that releases hydrogen generated from 100 percent fuel clad-coolant reaction accompanied by hydrogen burning. Systems necessary to ensure containment integrity must also be demonstrated to perform their function under these conditions. The following criteria of the ASME Boiler and Pressure Vessel Code provides an acceptable method for demonstrating that the requirements are met.

i. That steel containments meet the requirements of the ASME Boiler and Pressure Vessel Code (Edition and Addenda as incorporated by reference in 10 CFR 50.55a(b)(1)), Section III, Division 1, Subsubarticle NE - 3220, Service Level C Limits, considering pressure and dead load alone (evaluation of instability is not required); and

ii. That concrete containments meet the requirements of the ASME Boiler and Pressure Vessel Code, Section III, Division 2, Subsubarticle CC - 3720, Factored Load Category, considering pressure and dead load alone.

These criteria, while being removed from the existing regulations, are acceptable to meet the proposed regulations. The acceptability of licensee analyses using the ASME Code criteria remains unaffected by this rulemaking.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this draft regulatory guide.

This draft guide has been released to encourage public participation in its development. Except in those cases in which an applicant or licensee proposes an acceptable alternative method for complying with the specified portions of the NRC's regulations, the methods to be described in the active guide reflecting public comments will be used in the evaluation of submittals in connection with combustible gas concentrations in containment.

REFERENCES

1. SECY-00-0198, “Status Report on Study of Risk-Informed Changes to The technical Requirements of 10 CFR Part 50 (Option 3) and Recommendations on Risk-Informed Changes to 10 CFR 50.44 (Combustible Gas Control),” September 14, 2000.[1]

2. USNRC, “Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants,” NUREG-1150, December 1990.[2]

3. SECY-93-087, “Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-water Reactor (ALWR) Designs,” USNRC, April 2, 1993.[1]

4. USNRC, “Station Blackout,” Regulatory Guide 1.155, August 1988.[3]

5. USNRC, “Final Safety Evaluation Report Related to the Certification of the Advance Boiling Reactor Design,” NUREG-1462, August 1994.[2]

6. USNRC, “Final Safety Evaluation Report Related to the Certification of the System 80+ Design, Docket No. 52-002,” NUREG-1503, July 1994.[2]

7. USNRC, “Final Safety Evaluation Report Related to the Certification of the AP600 Standard Design, Docket No. 52-003,” NUREG-1512, September 1998.[2]

8. USNRC, “Instrumentation for Light-Water-Cooled Nuclear Power Plants To Assess Plant and Environs Conditions During and Following an Accident,” Regulatory Guide 1.97, Revision 3, May 1983.[3]

9. USNRC, "High-Level Guidelines for Performance-Based Activities," SECY-00-0191, September 1, 2000.[1]

10. USNRC, "Clarification of TMI Action Plan Requirements," NUREG-0737, November 1980.[2]

11. USNRC, “Confirmatory Order Modifying Post-TMI Requirements Pertaining to Containment Hydrogen Monitors for Arkansas Nuclear One, Units 1 and 2,” September 28, 1998.[1]

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[1] Copies are available for inspection or copying for a fee from the NRC Public Document Room at 11555 Rockville Pike (first floor), Rockville, MD; the PDR’s mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or 1-(800)397-4209; fax (301)415-3548; e-mail <PDR@NRC.GOV>.

[2] Copies are available at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone (202)512-1800); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161; <http://www.ntis.gov/ordernow>, telephone (703)487-4650; . Copies are available for inspection or copying for a fee from the NRC Public Document Room at 11555 Rockville Pike, Rockville, MD; the PDR’s mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or (800)397-4209; fax (301)415-3548; email is PDR@NRC.GOV.

[3] Single copies of regulatory guides, both active and draft, and draft NUREG documents may be obtained free of charge by writing the Reproduction and Distribution Services Section, OCIO, USNRC, Washington, DC 20555-0001, or by fax to (301)415-2289, or by email to <DISTRIBUTION@NRC.GOV>. Active guides may also be purchased from the National Technical Information Service on a standing order basis. Details on this service may be obtained by writing NTIS, 5285 Port Royal Road, Springfield, VA 22161; telephone (703)487-4650; online <http://www.ntis.gov/ordernow>. Copies of active and draft guides are available for inspection or copying for a fee from the NRC Public Document Room at 11555 Rockville Pike, Rockville, MD; the PDR’s mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or (800)397-4209; fax (301)415-3548; email <PDR@NRC.GOV>.

REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this guide. The draft regulatory analysis prepared for the revision to 10 CFR 50.44, "Standards for Combustible Gas Control System in Light-water-Cooled Power Reactors," provides the regulatory basis for this guide and examines the costs and benefits for the rule as implemented by the guide. A copy of this regulatory analysis is available for inspection or copying for a fee in the NRC Public Document Room, located at 11555 Rockville Pike (first floor), Rockville, Maryland. This regulatory analysis is also available in the NRC's Electronic Reading Room under Accession Number ML021080807.

BACKFIT ANALYSIS

This regulatory guide is being developed to describe a voluntary method that is acceptable to the NRC staff for complying with the requirements of 10 CFR 50.44, "Standards for Combustible Gas Control System in Light-water-Cooled Power Reactors." Compliance with this regulatory guide is not a requirement, and a licensee may chose this or another way to achieve compliance with these rules. This regulatory guide does not require a backfit analysis as described in 10 CFR 50.109(c) because it does not impose a new or amended provision in the NRC's rules or a regulatory staff position interpreting the NRC's rules that is either new or different from a previous staff position; nor does it require the modification of or addition to systems, structures, components, or design of a facility, or the procedures or organization required to design, construct, or operate a facility.

DRAFT REVISION TO
STANDARD REVIEW PLAN - NUREG-0800
IN CONJUNCTION WITH RISK-INFORMED REVISION TO 50.44

SECTION 6.2.5 COMBUSTIBLE GAS CONTROL IN CONTAINMENT

REVIEW RESPONSIBILITIES

Primary - Plant Systems Branch (SPLB)

Secondary - None

I. AREAS OF REVIEW

10 CFR 50.44, "Combustible Gas in Containment," is applicable to each boiling or pressurized water nuclear power reactor with an operating license on [EFFECTIVE DATE] and all construction permits or operating licenses under this part, and to all design approvals, design certifications, combined licenses or manufacturing licenses under part 52 of this chapter, any of which are issued after [EFFECTIVE DATE]. Draft Regulatory Guide DG-1117, "Control of Combustible Gas Concentrations in Containment" (Ref. 1), describes methods that are acceptable to the NRC staff for implementing 10 CFR 50.44.

Note: This SRP is primarily intended to cover new plant applications. Guidance for a plant which had already received its operating license as of [EFFECTIVE DATE] may be found in Draft Regulatory Guide DG-1117.

SPLB reviews the information presented in the applicant's safety analysis report (SAR) or design control document (DCD) concerning the control of combustible gases in the containment following a beyond-design-basis accident involving 100% fuel clad-coolant reaction or postulated accident to ensure conformance with the requirements of General Design Criteria 5, 41, 42, and 43, and 10 CFR 50.44. Following an accident, hydrogen and oxygen may accumulate inside the containment.

After an accident, combustible gas is predominantly generated within the containment as a result of:

a. Fuel clad-coolant reaction between the fuel cladding and the reactor coolant.

b. Molten core-concrete interaction in a severe core melt sequence with a failed reactor vessel.

If a sufficient amount of combustible gas is generated, it may react with the oxygen present in the containment at a rate rapid enough to breach the containment or cause a leakage rate in excess of Technical Specification limits. Additionally, the associated pressure and temperature increase could damage systems and components essential to continued control of the post-accident conditions.

The SPLB review includes the following general areas:

1. The production and accumulation of combustible gases within the containment following a beyond design-basis accident.

2. The capability to mix the combustible gases with the containment atmosphere and prevent high concentrations of combustible gases in local areas.

3. The capability to monitor combustible gas concentrations within containment, and, for inerted containments, oxygen concentrations within containment.

4. The capability to reduce combustible gas concentrations within containment by suitable means, such as igniters.

The SPLB review specifically covers the following analyses and aspects of combustible gas control system designs:

1. Analysis of combustible gas (e.g., hydrogen, carbon monoxide, oxygen) production and accumulation within the containment following a beyond-design-basis accident.

2. Analysis of the functional capability of the systems or passive design features provided to mix the combustible gas within the containment.

3. Analysis of the functional capability of the systems provided to reduce combustible gas concentrations within the containment.

4. Analyses of the capability of systems or system components to withstand dynamic effects, such as transient differential pressures that would occur early in the blowdown phase of an accident.

5. Analyses of the consequences of single active component malfunctions, to meet GDC 41.

6. The quality classification of each system.

7. The seismic design classification of each system.

8. The results of qualification tests performed on system components to demonstrate functional capability.

9. The design provisions and proposed program (including Technical Specifications at the operating license (OL) or combined license (COL) stage of review) for periodic inservice inspection, operability testing, and leakage rate testing of each system or component.

10. The functional aspects of instrumentation provided to monitor system or system component performance.

At the construction permit (CP) or early site permit stage of review, the design of the systems provided for monitoring and controlling combustible gases within the containment may not be completely determined. In such cases, SPLB reviews the applicant's preliminary designs and statements of intent to comply with the acceptance criteria for such systems. At the OL or COL stage, SPLB reviews the final designs of these systems to verify that they meet the acceptance criteria detailed in subsection II of this SRP section. For design approvals and certifications, SPLB reviews the applicant's preliminary designs and statements of intent to comply with the acceptance criteria for such systems.

Review Interfaces

SPLB will coordinate other branch evaluations that interface with the overall review of combustible gas control as follows:

1. The Mechanical and Civil Engineering Branch (EMEB) will review seismic design and quality group classifications as part of its primary review responsibility for SRP Section 3.2.1 and SRP Section 3.2.2, respectively.

2. The Electrical and Instrumentation and Controls Branch (EEIB), as part of its primary review responsibility for SRP Section 7.5, will evaluate the actuation and control features of active components, including the hydrogen and oxygen monitors.

3. The EEIB, as part of its primary review responsibility for SRP Section 3.11, will evaluate the qualification test program for electric valve operators, fans, hydrogen/oxygen sampling or analyzing equipment, igniters, and sensing and actuation instrumentation of the plant protection system, located both inside and outside the reactor containment.

4. The Probabilistic Safety Assessment Branch (SPSB), as part of its primary review responsibility for SRP Section 12.3, will evaluate the accessibility of combustible gas control systems equipment under postulated accident conditions.

5. The Operating Reactor Improvements Program (RORP), as part of its primary review responsibility for SRP Section 16.0, will review, at the OL or COL stage of review, proposed Technical Specifications pertaining to the operability and leakage rate testing of systems and components.

For those areas of review identified above that are being reviewed as part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

SPLB acceptance criteria for the design of the systems provided for combustible gas control are the relevant requirements of 10 CFR Part 50, § 50.44, and General Design Criteria 5, 41, 42, and 43. The requirements are as follows:

1. 10 CFR Part 50, § 50.44, as it relates to BWR and PWR plants being designed to:

    a. accommodate hydrogen generation equivalent to a 100% fuel clad-coolant reaction,

    b. limit containment hydrogen concentration to no greater than 10%,

    c. have a capability for ensuring a mixed atmosphere,

    d. provide containment-wide hydrogen control (such as igniters or inerting) for severe accidents. Post-accident conditions should be such that an uncontrolled hydrogen/oxygen recombination would not take place in the containment, or the plant should withstand the consequences of uncontrolled hydrogen/oxygen recombination without loss of safety function or containment structural integrity.

2. General Design Criterion 5 as it relates to providing assurance that sharing of structures, systems and components important to safety among nuclear power units will not significantly impair their ability to perform their safety functions.

3. General Design Criterion 41 as it relates to systems being provided to control the concentration of hydrogen or oxygen that may be released into the reactor containment following postulated accidents to ensure that containment integrity is maintained; systems being designed to suitable requirements, i.e., that there be suitable redundancy in components and features, and suitable interconnections to ensure that for either a loss of onsite or a loss of offsite power the system safety function can be accomplished, assuming a single failure; and systems being provided with suitable leak detection, isolation, and containment capability to ensure that system safety function can be accomplished.

4. General Design Criterion 42 as it relates to the design of the systems to permit appropriate periodic inspection of components to ensure the integrity and capability of the systems.

5. General Design Criterion 43 as it relates to the systems being designed to permit periodic testing to ensure system integrity, and the operability of the systems and active components.

Specific criteria necessary to meet the requirements of 10 CFR Part 50, § 50.44, and GDC 5, 41, 42 and 43, are as follows:

1. In meeting the requirements of 10 CFR Part 50, § 50.44, and GDC 41 to provide systems to control the concentration of hydrogen in the containment atmosphere, materials within the containment that would yield hydrogen gas due to corrosion from the emergency cooling or containment spray solutions should be identified, and their use should be limited as much as practicable.

2. In meeting the requirements of 10 CFR Part 50, § 50.44, and GDC 41 to provide systems to control the concentration of hydrogen or oxygen in the containment atmosphere, the applicant should demonstrate by analysis, for non-inerted containments, that the design can safely accommodate hydrogen generated by an equivalent of a 100% fuel clad-coolant reaction, while limiting containment hydrogen concentration, with the hydrogen uniformly distributed, to less than 10%, and while maintaining containment structural integrity.

3. In meeting the requirements of 10 CFR Part 50, § 50.44(c)(3), regarding equipment survivability, equipment necessary for achieving and maintaining safe shutdown of the plant and maintaining containment structural integrity should perform its safety function during and after being exposed to the environmental conditions attendant with the release of hydrogen generated by the equivalent of a 100 percent fuel clad-coolant reaction including the environmental conditions created by activation of the combustible gas control system.

4. In meeting the requirements of 10 CFR Part 50, § 50.44, to provide the capability for ensuring a mixed atmosphere in the containment, and of GDC 41 to provide systems as necessary to ensure that containment integrity is maintained, this capability may be provided by an active, passive, or combination system. Active systems may consist of a fan, a fan cooler, or containment spray. For passive or combination systems that use convective mixing to mix the combustible gases, the containment internal structures should have design features which promote the free circulation of the atmosphere. For all containment types, an analysis of the effectiveness of the method used for providing a mixed atmosphere should be provided. This analysis is acceptable if it shows that combustible gases will not accumulate within a compartment or cubicle to form a combustible or detonable mixture that could cause loss of containment integrity.

   Atmosphere mixing systems prevent local accumulation of combustible or detonable gases which could threaten containment integrity or equipment operating in a local compartment. Active systems installed to mitigate this threat should be reliable, redundant, single failure proof, able to be tested and inspected, and remain operable with a loss of onsite or offsite power.

5. In meeting the requirements of 10 CFR Part 50, § 50.44, and GDC 41 regarding the functional capability of the combustible gas control systems to ensure that containment integrity is maintained, the design should meet the provisions of Draft Regulatory Guide DG-1117, section C.1.

6. To satisfy the design requirements of GDC 41:

   a. Performance tests should be performed on system components, such as hydrogen igniters and combustible gas monitors. The tests should support the analyses of the functional capability of the equipment.

   b. Combustible gas control system designs should include instrumentation needed to monitor system or component performance under normal and accident conditions. The instrumentation should be capable of determining that a system is performing its intended function, or that a system train or component is malfunctioning and should be isolated. The instrumentation should have readout and alarm capability in the control room. The containment hydrogen and oxygen monitors should meet the provisions of Draft Regulatory Guide DG-1117, section C.2.

7. To satisfy the inspection and test requirements of GDC 41, 42 and 43, combustible gas control systems should be designed with provisions for periodic inservice inspection, operability testing, and leak rate testing of the systems or components.

8. In meeting the requirements of 10 CFR Part 50, § 50.44(c)(5), regarding containment structural integrity, an analysis must demonstrate containment structural integrity, using an analytical technique that is accepted by the NRC staff and including sufficient supporting justification to show that the technique describes the containment response to the structural loads involved. The analysis must address an accident that releases hydrogen generated from 100% fuel clad-coolant reaction accompanied by combustible gas burning. Systems necessary to ensure containment integrity must also demonstrate the capability to perform their functions under these conditions. One acceptable analytical technique is a demonstration that the following specific criteria of the ASME Boiler and Pressure Vessel Code as described in Draft Regulatory Guide DG-1117, section C.5.

   As a minimum, the specific code requirements set forth for each type of containment will be met for a combination of dead load and an internal pressure of 45 psig. Modest deviations from these criteria will be considered by the staff, if good cause is shown by an applicant.

9. In meeting the requirements of 10 CFR Part 50, § 50.44(c), and GDC 41 for the design and functional capability of the combustible gas control systems, preliminary system designs and statements of intent in the SAR are acceptable at the CP or early site

permit stage of review if the guidelines of Draft Regulatory Guide DG-1117 are endorsed.

III. REVIEW PROCEDURES

The procedures described below provide guidance for the detailed review of the combustible gas control systems. The reviewer selects and emphasizes material from this SRP section, as may be appropriate for a particular case. Portions of the review may be done on a generic basis for aspects of combustible gas control systems design common to a class of plants or by adopting the results of previous reviews of similar plants.

Upon request from the primary reviewer, other review branches will provide input for the areas of review stated in subsection I, above. The primary reviewer obtains and uses such input as required to ensure that this review procedure is complete.

The combustible gas control systems include systems for mixing the combustible gases, monitoring combustible gas concentrations, and reducing the combustible gas concentrations. In general, all of the combustible gas control systems should meet the design requirements outlined in subsection II. The system description and schematic drawings presented in the safety analysis report should be sufficiently detailed to permit judgments to be made regarding system acceptability.

1. SPLB determines that all potential, active mechanical failures and passive electrical failures have been identified and that no single failure would incapacitate an entire system.

2. SPLB compares the quality standards applied to the systems to the provisions of draft Regulatory Guide DG-1117.

3. SPLB compares the seismic design classifications of the systems to the provisions of draft Regulatory Guide DG-1117.

4. SPLB reviews the qualification testing of systems and components, to establish the functional capability of the equipment.

5. SPLB reviews the provisions made in the design of the systems and the program for periodic inservice inspection and operability testing of the systems or components. The inspections are reviewed with regard to the purpose of each inspection. The operability tests that will be conducted are reviewed with regard to what each test is intended to accomplish. Judgment and experience from previous reviews are used to determine the acceptability of the inspection and test program.

6. SPLB reviews the proposed technical specifications, for plants at the OL or COL stage of review, for the systems used to control and monitor combustible gas and oxygen concentrations in the containment to ensure that the requirements of 10 CFR 50.44 and General Design Criteria 5, 41, 42, and 43 are met.

7. SPLB reviews the capability to monitor system performance and control active components to be sure that control can be exercised over a system and that a malfunctioning system

train or component can be isolated. The instrumentation provided for this purpose should be redundant and should enable the operator to identify the malfunctioning system train or component.

8. SPLB reviews analyses of the functional capability of the systems, or passive design features provided to mix combustible gases within the containment. SPLB reviews the supporting information in the safety analysis report which should include elevation drawings of the containment showing the routing of ductwork and the circulation patterns caused by fans, sprays, or thermal convection. Special attention is paid to interior compartments to ensure that combustible gases cannot collect in them without mixing with the bulk containment atmosphere. SPLB ensures that interior compartments are identified in the safety analysis report and the provisions made to ensure circulation within them are discussed.

   Systems provided to mix the combustible gases within the containment may also be used for containment heat removal, e.g., the fan cooler and spray systems. The acceptability of the design of these systems is considered in the review of the containment heat removal systems in SRP Section 6.2.2.

9. SPLB reviews the manner in which the systems provided to reduce combustible gas concentrations will be operated. The point at which the system is actuated (the control point) will be determined from the safety analysis report. For deliberate ignition systems, the control point is typically core exit temperature exceeding 1200 degrees Fahrenheit.

For standard design certification reviews under 10 CFR Part 52, the procedures above should be followed, as modified by the procedures in SRP Section 14.3 (proposed), to verify that the design set forth in the standard safety analysis report, including inspections, tests, analysis, and acceptance criteria (ITAAC), site interface requirements and combined license action items, meet the acceptance criteria given in subsection II. SRP Section 14.3 (proposed) contains procedures for the review of certified design material (CDM) for the standard design, including the site parameters, interface criteria, and ITAAC.

IV. <u>EVALUATION FINDINGS</u>

The reviewer verifies that sufficient information has been provided and that his evaluation supports conclusions of the following type, to be included in the staff's safety evaluation report:

The staff concludes that the design and expected performance of the combustible gas control systems are acceptable and meet the requirements of 10 CFR Part 50, § 50.44, and Criteria 5, 41, 42, and 43. This conclusion is based on the following: [The reviewer should discuss each item of the regulations or related set of regulations as indicated.]

1. The applicant has met the requirements of (cite regulation) with respect to (state limits of review in relation to regulation) by (for each item that is applicable to the review state how it was met and why acceptable with respect to the regulation being discussed):

   a. meeting the regulatory positions in Regulatory Guide(s) ________;

b. providing and meeting an alternative method to regulatory positions in Regulatory Guide _____, that the staff has reviewed and found to be acceptable;

c. meeting the regulatory position in BTP ___;

d. using calculational methods for (state what was evaluated) that have been previously reviewed by the staff and found acceptable; the staff has reviewed the impact parameters in this case and found them to be suitably conservative or performed independent calculations to verify acceptability of their analysis; and/or

e. meeting the provisions of (industry standard number and title) that have been reviewed by the staff and determined to be appropriate for this application.

2. Repeat discussion for each regulation cited above.

For design certification reviews, the findings will also summarize, to the extent that the review is not discussed in other safety evaluation report sections, the staff's evaluation of inspections, tests, analyses, and acceptance criteria (ITAAC), including site interface requirements and combined license action items that are relevant to this SRP section.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding NRC staff plans for using this SRP section.

This SRP section will be used by the staff when performing safety evaluations of license applications submitted by applicants pursuant to 10 CFR 50 or 10 CFR 52. Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

The provisions of this SRP section apply to reviews of applications docketed six months or more after the date of issuance of this SRP section.

VI. REFERENCES

1. Draft Regulatory Guide DG-1117, “Control of Combustible Gas Concentrations in Containment,” dated [DATE OF RULE?].

2. SECY-00-0198, “Status Report on Study of Risk-informed Changes to The Technical Requirements of 10 CFR Part 50 (Option 3) And Recommendations on Risk-informed Changes to 10 CFR 50.44 (Combustible Gas Control),” dated September 14, 2000.

3. SECY-93-087, “Policy, Technical, And Licensing Issues Pertaining to Evolutionary And Advanced Light-water Reactor (ALWR) Designs,” dated April 2, 1993.

4. USNRC, “Station Blackout,” Regulatory Guide 1.155, Revision 0, August 1988.

5. USNRC, “Final Safety Evaluation Report Related to the Certification of the System 80+ Design, Docket No. 52-002,” NUREG-1503, July 1994.

6. USNRC, “Final Safety Evaluation Report Related to the Certification of the Advance Boiling Reactor Design,” NUREG-1462, August 1994.

7. USNRC, “Final Safety Evaluation Report Related to the Certification of the AP600 Standard Design, Docket No. 52-003,” NUREG-1512, September 1998.

8. USNRC, “Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident,” Regulatory Guide 1.97, Revision 3, May 1983.

9. 10 CFR Part 50, § 50.44, "Combustible Gas Control in Containment."

10. 10 CFR Part 50, § 50.46, “Acceptance Criteria for Emergency Core Cooling Systems for Light Water Cooled Reactors."

11. 10 CFR Part 50, Appendix A, General Design Criterion 5, "Sharing of Structures, Systems and Components."

12. 10 CFR Part 50, Appendix A, General Design Criterion 41, "Containment Atmosphere Cleanup."

13. 10 CFR Part 50, Appendix A, General Design Criterion 42, "Inspection of Containment Cleanup System."

14. 10 CFR Part 50, Appendix A, General Design Criterion 43, "Testing of Containment Atmosphere Cleanup System."

15. Branch Technical Position ASB 9-2, "Residual Decay Energy for Light Water Reactors for Long-Term Cooling," attached to SRP Section 9.2.5.

16. NUREG/CR-4905, "Detonability of H -Air-Diluent Mixtures," Sandia National Laboratory, June 1987.

17. NUREG/CR-4961, "A Summary of Hydrogen-Air Detonation Experiments," Sandia National Laboratory, June 1987.

18. NUREG/CR-5275, "Flame Facility" (The Effect of Obstacles and Transverse Venting on Flame Acceleration and Transition to Detonation of Hydrogen-Air Mixtures at Large Scale), Sandia National Laboratory, April 1989.

19. NUREG/CR-5525, "Hydrogen-Air-Diluent Detonation Study of Nuclear Reactor Safety Analyses," Sandia National Laboratory, December 1990.

Proposed Safety Evaluation

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

Consolidated Line Item Improvement

Technical Specification Task Force (TSTF) Change TSTF-XXX

Elimination of Requirements for Hydrogen Recombiners and Change of Requirements for Hydrogen and Oxygen Monitors

1.0 Introduction

On [EFFECTIVE DATE OF RULE], the Nuclear Regulatory Commission (NRC) adopted a revised rule, 10 CFR 50.44, which amended its standards for combustible gas control in light-water-cooled power reactors. The amended standards eliminated the requirements for hydrogen recombiners and relaxed the requirements for hydrogen and oxygen monitoring. In a letter dated XXXXX XX, 2002, the Nuclear Energy Institute (NEI) Technical Specification Task Force (TSTF) proposed to remove requirements for hydrogen recombiners and hydrogen and oxygen monitors from the standard technical specifications (STS) (NUREGs 1430 - 1434) on behalf of the industry to incorporate the amended standards. This proposed change is designated TSTF-XXX.

TSTF-XXX can be viewed on the NRC's web page at http://www.nrc.gov/NRR/sts/sts.htm.

The NRC staff prepared this model safety evaluation (SE) relating to the elimination of requirements regarding containment hydrogen recombiners and the removal of requirements from technical specifications for containment hydrogen and oxygen monitors and solicited public comment [FR] in accordance with the Consolidated Line Item Improvement Process (CLIIP). The use of the CLIIP in this matter is intended to help the NRC to efficiently process amendments that propose to remove the hydrogen recombiner and hydrogen and oxygen monitor requirements from TS. Licensees of nuclear power reactors to which this model applies were informed [FR] that they could request amendments conforming to the model, and, in such requests, should confirm the applicability of the SE to their reactors and provide the requested plant-specific verifications and commitments.

2.0 Background

Regulatory Issue Summary 2000-06, "Consolidated Line Item Improvement Process for Adopting Standard Technical Specification Changes for Power Reactors," was issued on March 20, 2000. The CLIIP is intended to improve the efficiency of NRC licensing processes. This is accomplished by processing proposed changes to the standard technical specifications (STS) in a manner that supports subsequent license amendment applications. The CLIIP includes an opportunity for the public to comment on proposed changes to the STS following a preliminary assessment by the NRC staff and finding that the change will likely be offered for adoption by licensees. The CLIIP directs the NRC staff to evaluate any comments received for a proposed change to the STS and to either reconsider the change or proceed with announcing the availability of the change for proposed adoption by licensees. Those licensees opting to apply for the subject change to technical specifications are responsible for reviewing the staff's evaluation, referencing the applicable technical justifications, and providing any necessary plant-specific information. Each amendment application made in response to the notice of availability would be processed and noticed in accordance with applicable rules and NRC procedures.

The Commission's regulatory requirements related to the content of Technical Specifications are set forth in § 50.36. This regulation requires that the TSs include items in five specific categories. These categories include 1) safety limits, limiting safety system settings and limiting control settings, 2) limiting conditions for operation, 3) surveillance requirements, 4) design features, and 5) administrative controls. However, the regulation does not specify the particular TSs to be included in a plant's license.

Additionally, § 50.36(c)(2)(ii) sets forth four criteria to be used in determining whether a limiting condition for operation (LCO) is required to be included in the TS. These criteria are as follows:

1 Installed instrumentation that is used to detect, and indicate in the control room, a significant abnormal degradation of the reactor coolant pressure boundary.

2. A process variable, design feature, or operating restriction that is an initial condition of a design-basis accident or transient analysis that assumes either the failure of or presents a challenge to the integrity of a fission product barrier.

3. A structure, system, or component that is part of the primary success path and which functions or actuates to mitigate a design-basis accident or transient that either assumes the failure of or presents a challenge to the integrity of a fission product barrier.

4. A structure, system or component which operating experience or probabilistic risk assessment has shown to be significant to public health and safety.

Existing LCOs and related surveillances included as TS requirements which satisfy any of the criteria stated above must be retained in the TSs. Those TS requirements which do not satisfy these criteria may be relocated to other, licensee-controlled documents.

On [EFFECTIVE DATE OF RULE], the Nuclear Regulatory Commission (NRC) adopted a revised § 50.44. In the revised rule, the Commission retained requirements for ensuring a mixed atmosphere, inerting Mark I and II containments, and providing hydrogen control systems capable of accommodating an amount of hydrogen generated from a metal-water reaction involving 75 percent of the fuel cladding surrounding the active fuel region in Mark III and ice condenser containments. The Commission eliminated the design-basis LOCA hydrogen release from § 50.44 and consolidated the requirements for hydrogen and oxygen monitoring to § 50.44 while relaxing safety classifications and licensee commitments to certain design and qualification criteria. The Commission also relocated without change the hydrogen control requirements in § 50.34(f) to § 50.44 and the high point vent requirements from § 50.44 to § 50.46a.

3.0 Evaluation

The ways in which the requirements and recommendations for combustible gas control were incorporated into the licensing bases of commercial nuclear power plants varied as a function of when plants were licensed. Plants that were operating at the time of the TMI accident are likely to have been the subject of confirmatory orders that imposed the combustible gas control functions described in NUREG-0737 as obligations. The issuance of plant specific amendments to adopt these changes, which would remove hydrogen recombiner and hydrogen and oxygen monitoring controls from TS, supersede the combustible gas control specific requirements imposed by post-TMI confirmatory orders.

3.1 Hydrogen Recombiners

The revised § 50.44 no longer defines a design-basis LOCA hydrogen release, and eliminates requirements for hydrogen control systems to mitigate such a release. The installation of hydrogen recombiners and/or vent and purge systems required by § 50.44(b)(3) was intended to address the limited quantity and rate of hydrogen generation that was postulated from a design-basis LOCA. The Commission has found that this hydrogen release is not risk-significant because the design-basis LOCA hydrogen release does not contribute to the conditional probability of a large release up to approximately 24 hours after the onset of core damage. In addition, these systems were ineffective at mitigating hydrogen releases from risk-significant accident sequences that could threaten containment integrity. Therefore, the staff finds that requirements related to hydrogen recombiners currently in TS no longer meet the criteria of § 50.36(c)(2)(ii) for retention in TS and may be removed from TS for all plants.

3.2 Hydrogen Monitoring Equipment

§ 50.44(b)(1), standard technical specifications and licensee technical specifications currently contain requirements for monitoring hydrogen. Licensees have also made commitments to design and qualification criteria for hydrogen monitors in NUREG-0737, Item II.F.1, Attachment 6 and RG 1.97. The hydrogen monitors are required to assess the degree of core damage and confirm that random or deliberate ignition has taken place and that containment integrity is not threatened by an explosive mixture. If an explosive mixture that could threaten containment integrity exists during a beyond design-basis accident, then other severe accident management strategies, such as purging and/or venting, would need to be considered.

With the elimination of the design-basis LOCA hydrogen release, hydrogen monitors are no longer required to mitigate design-basis accidents and, therefore, the hydrogen monitors do not meet the definition of a safety-related component as defined in § 50.2. RG 1.97 Category 1, is intended for key variables that most directly indicate the accomplishment of a safety function for design-basis accident events. The hydrogen monitors no longer meet the definition of Category 1 in RG 1.97. As part of the rulemaking to revise § 50.44 the Commission found that Category 3, as defined in RG 1.97, is an appropriate categorization for the hydrogen monitors because the monitors are required to diagnose the course of beyond design-basis accidents. Hydrogen monitoring is not the primary means of indicating a significant abnormal degradation of the reactor coolant pressure boundary. Section 4 of Attachment 2 to

SECY-00-0198 found that hydrogen monitor was not risk-significant. Therefore, the staff finds that hydrogen monitoring equipment requirements no longer meet the criteria of § 50.36(c)(2)(ii) for retention in TS and, therefore, may be removed from TS.

[Note: The CLIIP for elimination of Post-Accident Sampling System requirements for Westinghouse and Combustion Engineering designs indicated that during the early phases of an accident, safety-grade hydrogen monitors provide an adequate capability for monitoring containment hydrogen concentration. The staff has subsequently concluded that Category 3 hydrogen monitors also provide an adequate capability for monitoring containment hydrogen concentration during the early phases of an accident.]

However, because the monitors are required to diagnose the course of beyond design-basis accidents, each licensee should verify that it has, and make a regulatory commitment to maintain, a hydrogen monitoring system capable of diagnosing beyond design-basis accidents.

3.3 Oxygen Monitoring Equipment

Standard technical specifications and licensee technical specifications currently contain requirements for monitoring oxygen. The oxygen monitors are required to verify the status of the inert containment. Combustible gases produced by beyond design-basis accidents involving both fuel-cladding oxidation and core-concrete interaction would be risk-significant for plants with Mark I and II containments if not for the inerted containment atmospheres. If an inerted containment was to become de-inerted during a beyond design-basis accident, then other severe accident management strategies, such as purging and venting, would need to be considered. The oxygen monitors are needed to implement these severe accident management strategies. Oxygen concentration also appears extensively in the emergency procedure guidelines/severe accident guidelines of plants with inerted containment atmospheres.

With the elimination of the design-basis LOCA hydrogen release, the oxygen monitors are no longer required to mitigate design-basis accidents and, therefore, the oxygen monitors do not meet the definition of a safety-related component as defined in § 50.2. RG 1.97 recommends that, for inerted containment plants, the oxygen monitors be Category 1 which is intended for key variables that most directly indicate the accomplishment of a safety function for design-basis accident events. The oxygen monitors no longer meet the definition of Category 1 in RG 1.97. As part of the rulemaking to revise § 50.44 the Commission found that Category 2, as defined in RG 1.97, is an appropriate categorization for the oxygen monitors, because the monitors are required to verify the status of the inert containment. Oxygen monitoring is not the primary means of indicating a significant abnormal degradation of the reactor coolant pressure boundary. Oxygen monitors have not been shown by a probabilistic risk assessment to be risk-significant. Therefore, the staff finds that oxygen monitoring equipment requirements no longer meet the criteria of § 50.36(c)(2)(ii) for retention in TS and, therefore, may be removed from TS.

However, for plant designs with an inerted containment, because the monitors are required to verify the status of the inert containment, each licensee should verify that it has, and make a regulatory commitment to maintain, an oxygen monitoring system capable of verifying the status of the inert containment. In addition, for plant designs with an inerted containment, the requirement for primary containment oxygen concentration will be retained in TS; however, the basis for retention of this requirement in TS is that it meets Criterion 4 of 10 CFR 50.36(c)(2)(ii) in that it is a structure, system or component which operating experience or probabilistic risk assessment has shown to be significant to public health and safety.

4.0 Verifications and Commitments

As requested by the staff in the notice of availability for this TS improvement, the licensee has addressed the following plant-specific verifications and commitment.

4.1 Each licensee should verify that it has, and make a regulatory commitment to maintain, a hydrogen monitoring system capable of diagnosing beyond design-basis accidents.

The licensee has verified that it has a hydrogen monitoring system capable of diagnosing beyond design-basis accidents. The licensee has committed to maintain the hydrogen monitors within its [specified document or program]. The licensee has [implemented this commitment or will implement this commitment by (specific date)].

4.2 For plant designs with an inerted containment, each licensee should verify that it has, and make a regulatory commitment to maintain, an oxygen monitoring system capable of verifying the status of the inert containment.

The licensee has verified that it has an oxygen monitoring system capable of verifying the status of the inert containment. The licensee has committed to maintain the oxygen monitors within its [specified document or program]. The licensee has [implemented this commitment or will implement this commitment by (specific date)].

The NRC staff finds that reasonable controls for the implementation and for subsequent evaluation of proposed changes pertaining to the above regulatory commitments are provided by the licensee's administrative processes, including its commitment management program. Should the licensee choose to incorporate a regulatory commitment into the emergency plan, final safety analysis report, or other document with established regulatory controls, the associated regulations would define the appropriate change-control and reporting requirements. The staff has determined

that the commitments do not warrant the creation of regulatory requirements which would require prior NRC approval of subsequent changes. The NRC staff has agreed that NEI 99-04, Revision 0, "Guidelines for Managing NRC Commitment Changes," provides reasonable guidance for the control of regulatory commitments made to the NRC staff. (See Regulatory Issue Summary 2000-17, Managing Regulatory Commitments Made by Power Reactor Licensees to the NRC Staff, dated September 21, 2000.) The commitments should be controlled in accordance with the industry guidance or comparable criteria employed by a
specific licensee. The staff may choose to verify the implementation and maintenance of these commitments in a future inspection or audit.

5.0 State Consultation

In accordance with the Commission's regulations, the [ ] State official was notified of the proposed issuance of the amendment. The State official had [(1) no comments or (2) the following comments - with subsequent disposition by the staff].

6.0 Environmental Consideration

The amendments change a requirement with respect to the installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20 and change surveillance requirements. The NRC staff has determined that the amendments involve no significant increase in the amounts and no significant change in the types of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendments involve no significant hazards consideration, and there has been no public comment on such finding (FR). Accordingly, the amendments meet the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b) no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendments.

7.0 Conclusion

The Commission has concluded, based on the considerations discussed above, that (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendments will not be inimical to the common defense and security or to the health and safety of the public.

MODEL NO SIGNIFICANT HAZARDS CONSIDERATION DETERMINATION

Description of Amendment Request: The proposed amendment deletes requirements from the Technical Specifications to maintain hydrogen recombiners and hydrogen and oxygen monitors. Licensees were generally required to implement upgrades as described in NUREG-0737, “Clarification of TMI [Three Mile Island] Action Plan Requirements,” and Regulatory Guide 1.97, “Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident.” Implementation of these upgrades was an outcome of the lessons learned from the accident that occurred at TMI, Unit 2. Requirements related to combustible gas control were imposed by Order for many facilities and were added to or included in the technical specifications (TS) for nuclear power reactors currently licensed to operate. The revised § 50.44 eliminated the requirements for hydrogen recombiners and relaxed safety classifications and licensee commitments to certain design and qualification criteria for hydrogen and oxygen monitors.

Basis for proposed no significant hazards consideration determination: As required by 10 CFR 50.91(a), an analysis of the issue of no significant hazards consideration is presented below:

Criterion 1 - The Proposed Change Does Not Involve a Significant Increase in the Probability or Consequences of an Accident Previously Evaluated.

The revised § 50.44 no longer defines a design-basis LOCA hydrogen release, and eliminates requirements for hydrogen control systems to mitigate such a release. The installation of hydrogen recombiners and/or vent and purge systems required by § 50.44(b)(3) was intended to address the limited quantity and rate of hydrogen generation that was postulated from a design-basis LOCA. The Commission has found that this hydrogen release is not risk-significant because the design-basis LOCA hydrogen release does not contribute to the conditional probability of a large release up to approximately 24 hours after the onset of core damage. In addition, these systems were ineffective at mitigating hydrogen releases from risk-significant accident sequences that could threaten containment integrity.

With the elimination of the design-basis LOCA hydrogen release, hydrogen and oxygen monitors are no longer required to mitigate design-basis accidents and, therefore, the hydrogen monitors do not meet the definition of a safety-related component as defined in § 50.2. RG 1.97 Category 1, is intended for key variables that most directly indicate the accomplishment of a safety function for design-basis accident events. The hydrogen and oxygen monitors no longer meet the definition of Category 1 in RG 1.97. As part of the rulemaking to revise § 50.44 the Commission found that Category 3, as defined in RG 1.97, is an appropriate categorization for the hydrogen monitors because the monitors are required to diagnose the course of beyond design-basis accidents. Also as part of the rulemaking to revise § 50.44 the Commission found that Category 2, as defined in RG 1.97, is an appropriate categorization for the oxygen monitors, because the monitors are required to verify the status of the inert containment.

The regulatory requirements for the hydrogen and oxygen monitors can be relaxed without degrading the plant emergency response. The emergency response, in this sense, refers to the methodologies used in ascertaining the condition of the reactor core, mitigating the consequences of an accident, assessing and projecting offsite releases of radioactivity, and establishing protective action recommendations to be communicated to offsite authorities. Classification of the hydrogen monitors as Category 3, classification of the oxygen monitors as Category 2 and removal of the hydrogen and oxygen monitors from Technical Specifications (TS) will not prevent an accident management strategy through the use of the SAMGs, the emergency plan (EP), the emergency operating procedures (EOP), and site survey monitoring that support modification of emergency plan protective action recommendations (PARs).

Therefore, the elimination of the hydrogen recombiner requirements and relaxation of the hydrogen and oxygen monitor requirements, including removal of these requirements from TS, does not involve a significant increase in the probability or the consequences of any accident previously evaluated.

Criterion 2 - The Proposed Change Does Not Create the Possibility of a New or Different Kind of Accident from any Previously Evaluated.

The elimination of the hydrogen recombiner requirements and relaxation of the hydrogen and oxygen monitor requirements, including removal of these requirements from TS, will not result in any failure mode not previously analyzed. The hydrogen recombiner and hydrogen and oxygen monitor equipment was intended to mitigate a design-basis hydrogen release. The hydrogen recombiner and hydrogen and oxygen monitor equipment are not considered accident precursors, nor does their existence or elimination have any adverse impact on the pre-accident state of the reactor core or post accident confinement of radionuclides within the containment building.

Therefore, this change does not create the possibility of a new or different kind of accident from any previously evaluated.

Criterion 3 - The Proposed Change Does Not Involve a Significant Reduction in the Margin of Safety.

The elimination of the hydrogen recombiner requirements and relaxation of the hydrogen and oxygen monitor requirements, including removal of these requirements from TS, in light of existing plant equipment, instrumentation, procedures, and programs that provide effective mitigation of and recovery from reactor accidents, results in a neutral impact to the margin of safety.

The installation of hydrogen recombiners and/or vent and purge systems required by § 50.44(b)(3) was intended to address the limited quantity and rate of hydrogen generation that was postulated from a design-basis LOCA. The Commission has found that this hydrogen release is not risk-significant because the design-basis LOCA hydrogen release does not contribute to the conditional probability of a large release up to approximately 24 hours after the onset of core damage. In addition, these systems were ineffective at mitigating hydrogen releases from risk-significant accident sequences that could threaten containment integrity.

Category 3 hydrogen monitors are adequate to provide rapid assessment of current reactor core conditions and the direction of degradation while effectively responding to the event in order to mitigate the consequences of the accident. The intent of the requirements established as a result of the TMI-2 accident can be adequately met without reliance on safety-related hydrogen monitors.

Category 2 oxygen monitors are adequate to verify the status of an inerted containment.

Therefore, this change does not involve a significant reduction in the margin of safety. The intent of the requirements established as a result of the TMI-2 accident can be adequately met without reliance on safety-related oxygen monitors. Removal of hydrogen and oxygen monitoring from technical specifications will not result in a significant reduction in their functionality, reliability, and availability.

Based upon the reasoning presented above and the previous discussion of the amendment request, the requested change does not involve a significant hazards consideration.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

February 27, 2002

MEMORANDUM TO: William D. Beckner, Program Director
Operating Reactor Improvements Program
Division of Regulatory Improvement Programs, NRR

FROM: Eric J. Benner, Reactor System Engineer
Technical Specification Section
Operating Reactor Improvements Program
Division of Regulatory Improvement Programs, NRR

SUBJECT: DRAFT PROPOSED CHANGES TO STANDARD TECHNICAL SPECIFICATIONS BASED ON DRAFT RULEMAKING FOR RISK-INFORMED 10 CFR 50.44, COMBUSTIBLE GAS CONTROL (TAC NO. MB1080)

The NRC is proposing to amend 10 CFR 40.44 to eliminate the requirement for hydrogen recombiners and to allow hydrogen and oxygen monitors to be commercial grade instead of safety grade. These changes stem from the Commission's ongoing effort to risk-inform its regulations. The staff will issue the proposed rule for public comment in the near future and intends to issue a model safety evaluation including proposed changes to the to the Improved Standard Technical Specification NUREGs (1430, 1431, 1432, 1433 and 1434) for public comment at the same time. The proposed changes to NUREGs 1430, 1431, 1432, 1433 and 1434 are attached.

Attachment: As stated

CONTACT:
E. Benner, NRR/RORP/DRIP
301-415-1171

February 27, 2002

MEMORANDUM TO: William D. Beckner, Program Director
Operating Reactor Improvements Program
Division of Regulatory Improvement Programs, NRR

FROM: Eric J. Benner, Reactor System Engineer /RA/
Technical Specification Section
Operating Reactor Improvements Program
Division of Regulatory Improvement Programs, NRR

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Attachment: As stated

CONTACT:
E. Benner, NRR/RORP/DRIP
301-415-1171

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DATE	02/27/02	02/27/02	02/27/02

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3.6 CONTAINMENT SYSTEMS

3.6.8 Hydrogen Recombiners (Atmospheric, Subatmospheric, Ice Condenser, and Dual) (if permanently installed)

LCO 3.6.8 Two hydrogen recombiners shall be OPERABLE.

APPLICABILITY: MODES 1 and 2.

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. One hydrogen recombiner inoperable.	A.1	- NOTE - LCO 3.0.4 is not applicable. Restore hydrogen recombiner to OPERABLE status.	30 days
B. [Two hydrogen recombiners inoperable.	B.1	Verify by administrative means that the hydrogen control function is maintained.	1 hour AND Once per 12 hours thereafter
	AND		
	B.2	Restore one hydrogen recombiner to OPERABLE status.	7 days]
C. Required Action and associated Completion Time not met.	C.1	Be in MODE 3.	6 hours

Attachment

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SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
SR 3.6.8.1	Perform a system functional test for each hydrogen recombiner.	[18] months
SR 3.6.8.2	Visually examine each hydrogen recombiner enclosure and verify there is no evidence of abnormal conditions.	[18] months
SR 3.6.8.3	Perform a resistance to ground test for each heater phase.	[18] months

delete

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3.3 INSTRUMENTATION

3.3.3 Post Accident Monitoring (PAM) Instrumentation

LCO 3.3.3 The PAM instrumentation for each Function in Table 3.3.3-1 shall be OPERABLE.

APPLICABILITY: MODES 1, 2, and 3.

ACTIONS

- NOTES -

1. LCO 3.0.4 is not applicable.
2. Separate Condition entry is allowed for each Function.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One or more Functions with one required channel inoperable.	A.1 Restore required channel to OPERABLE status.	30 days
B. Required Action and associated Completion Time of Condition A not met.	B.1 Initiate action in accordance with Specification 5.6.7.	Immediately
C. - NOTE - Not applicable to hydrogen monitor channels. (delete) One or more Functions with two required channels inoperable.	C.1 Restore one channel to OPERABLE status.	7 days
(delete) D. Two hydrogen monitor channels inoperable.	D.1 Restore one hydrogen monitor channel to OPERABLE status.	72 hours

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Table 3.3.3-1 (page 1 of 1)
Post Accident Monitoring Instrumentation

FUNCTION	REQUIRED CHANNELS	CONDITION REFERENCED FROM REQUIRED ACTION E.1
1. Power Range Neutron Flux	2	F
2. Source Range Neutron Flux	2	F
3. Reactor Coolant System (RCS) Hot Leg Temperature	2 per loop	F
4. RCS Cold Leg Temperature	2 per loop	F
5. RCS Pressure (Wide Range)	2	F
6. Reactor Vessel Water Level	2	G
7. Containment Sump Water Level (Wide Range)	2	F
8. Containment Pressure (Wide Range)	2	F
9. Penetration Flow Path Containment Isolation Valve Position	2 per penetration flow path(a)(b)	F
10. Containment Area Radiation (High Range)	2	G
~~11. Hydrogen Monitors~~	~~2~~	~~F~~ delete
12. Pressurizer Level	2	F
13. Steam Generator Water Level (Wide Range)	2 per steam generator	F
14. Condensate Storage Tank Level	2	F
15. Core Exit Temperature - Quadrant [1]	2(c)	F
16. Core Exit Temperature - Quadrant [2]	2(c)	F
17. Core Exit Temperature - Quadrant [3]	2(c)	F
18. Core Exit Temperature - Quadrant [4]	2(c)	F
19. Auxiliary Feedwater Flow	2	F

(a) Not required for isolation valves whose associated penetration is isolated by at least one closed and deactivated automatic valve, closed manual valve, blind flange, or check valve with flow through the valve secured.

(b) Only one position indication channel is required for penetration flow paths with only one installed control room indication channel.

(c) A channel consists of two core exit thermocouples (CETs).

- REVIEWER'S NOTE -

Table 3.3.3-1 shall be amended for each unit as necessary to list:
1. All Regulatory Guide 1.97, Type A instruments and
2. All Regulatory Guide 1.97, Category I, non-Type A instruments in accordance with the unit's Regulatory Guide 1.97, Safety Evaluation Report.

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BASES

LCO (continued)

for use by operators in determining the need to invoke site emergency plans. Containment radiation level is used to determine if a high energy line break (HELB) has occurred, and whether the event is inside or outside of containment.

delete

11. Hydrogen Monitors

    Hydrogen Monitors are provided to detect high hydrogen concentration conditions that represent a potential for containment breach from a hydrogen explosion. This variable is also important in verifying the adequacy of mitigating actions.

12. Pressurizer Level

    Pressurizer Level is used to determine whether to terminate SI, if still in progress, or to reinitiate SI if it has been stopped. Knowledge of pressurizer water level is also used to verify the unit conditions necessary to establish natural circulation in the RCS and to verify that the unit is maintained in a safe shutdown condition.

13. Steam Generator Water Level (Wide Range)

    SG Water Level is provided to monitor operation of decay heat removal via the SGs. The Category I indication of SG level is the extended startup range level instrumentation. The extended startup range level covers a span of ≥ 6 inches to ≤ 394 inches above the lower tubesheet. The measured differential pressure is displayed in inches of water at 68°F.

    Temperature compensation of this indication is performed manually by the operator. Redundant monitoring capability is provided by two trains of instrumentation. The uncompensated level signal is input to the unit computer, a control room indicator, and the Emergency Feedwater Control System.

    SG Water Level (Wide Range) is used to:

    - identify the faulted SG following a tube rupture,
    - verify that the intact SGs are an adequate heat sink for the reactor,

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BASES

ACTIONS (continued)

applied to the PAM instrumentation. Therefore, requiring restoration of one inoperable channel of the Function limits the risk that the PAM Function will be in a degraded condition should an accident occur. Condition C is modified by a Note that excludes hydrogen monitor channels.

delete -

D.1

- REVIEWER'S NOTE -
Implementation of WCAP-14986, Rev 1, "Post Accident Sampling System Requirements: A Technical Basis," and the associated NRC Safety Evaluation dated June 14, 2000, allows other core damage assessment capabilities in lieu of the Post Accident Sampling System.

Condition D applies when two hydrogen monitor channels are inoperable. Required Action D.1 requires restoring one hydrogen monitor channel to OPERABLE status within 72 hours. The 72 hour Completion Time is reasonable based on [the backup capability of the Post Accident Sampling System to monitor the hydrogen concentration for evaluation of core damage or other core damage assessment capabilities available and] to provide information for operator decisions. Also, it is unlikely that a LOCA (which would cause core damage) would occur during this time.

E.1

Condition E applies when the Required Action and associated Completion Time of Condition C or D are not met. Required Action E.1 requires entering the appropriate Condition referenced in Table 3.3.3-1 for the channel immediately. The applicable Condition referenced in the Table is Function dependent. Each time an inoperable channel has not met any Required Action of Condition C or D, and the associated Completion Time has expired, Condition E is entered for that channel and provides for transfer to the appropriate subsequent Condition.

F.1 and F.2

If the Required Action and associated Completion Time of Conditions C or D are not met and Table 3.3.3-1 directs entry into Condition F, the unit must be brought to a MODE where the requirements of this LCO do not apply. To achieve this status, the unit must be brought to at least MODE 3 within 6 hours and MODE 4 within 12 hours.

DRAFT - DELETE SPEC & ASSOCIATED BASES

3.6 CONTAINMENT SYSTEMS

3.6.3.1 Primary Containment Hydrogen Recombiners (if permanently installed)

LCO 3.6.3.1 Two primary containment hydrogen recombiners shall be OPERABLE.

APPLICABILITY: MODES 1 and 2.

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. One primary containment hydrogen recombiner inoperable.	A.1	- NOTE - LCO 3.0.4 is not applicable. Restore primary containment hydrogen recombiner to OPERABLE status.	30 days
B. [Two primary containment hydrogen recombiners inoperable.	B.1	Verify by administrative means that the hydrogen control function is maintained.	1 hour AND One per 12 hours thereafter
	AND		
	B.2	Restore one primary containment hydrogen recombiner to OPERABLE status.	7 days]
C. Required Action and associated Completion Time not met.	C.1	Be in MODE 3.	12 hours

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SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
SR 3.6.3.1.1	Perform a system functional test for each primary containment hydrogen recombiner.	[18] months
SR 3.6.3.1.2	Visually examine each primary containment hydrogen recombiner enclosure and verify there is no evidence of abnormal conditions.	[18] months
SR 3.6.3.1.3	Perform a resistance to ground test for each heater phase.	[18] months

delete

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3.3 INSTRUMENTATION

3.3.3.1 Post Accident Monitoring (PAM) Instrumentation

LCO 3.3.3.1 The PAM instrumentation for each Function in Table 3.3.3.1-1 shall be OPERABLE.

APPLICABILITY: MODES 1 and 2.

ACTIONS

- NOTES -

1. LCO 3.0.4 is not applicable.
2. Separate Condition entry is allowed for each Function.

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. One or more Functions with one required channel inoperable.	A.1	Restore required channel to OPERABLE status.	30 days
B. Required Action and associated Completion Time of Condition A not met.	B.1	Initiate action in accordance with Specification 5.6.7.	Immediately
C. - NOTE - Not applicable to [hydrogen monitor] channels. (delete) One or more Functions with two required channels inoperable.	C.1	Restore one required channel to OPERABLE status.	7 days
D. Two [required hydrogen monitor] channels inoperable. (delete)	D.1	Restore one [required hydrogen monitor] channel to OPERABLE status.	72 hours

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Table 3.3.3.1-1 (page 1 of 1)
Post Accident Monitoring Instrumentation

FUNCTION	REQUIRED CHANNELS	CONDITIONS REFERENCED FROM REQUIRED ACTION E.1
1. Reactor Steam Dome Pressure	2	F
2. Reactor Vessel Water Level	2	F
3. Suppression Pool Water Level	2	F
4. Drywell Pressure	2	F
5. Primary Containment Area Radiation	2	[G]
[6. Drywell Sump Level	2	F]
[7. Drywell Drain Sump Level	2	F]
8. Penetration Flow Path PCIV Position	2 per penetration flow path[a] [c]	F
9. Wide Range Neutron Flux	2	F
10. Drywell H_2 & O_2 Analyzer	2	F
11. Containment H_2 & O_2 Analyzer	2	F
12. Primary Containment Pressure	2	F
13. [Relief Valve Discharge Location] Suppression Pool Water Temperature	2[c]	F

delete

(a) Not required for isolation valves whose associated penetration flow path is isolated by at least one closed and de-activated automatic valve, closed manual valve, blind flange, or check valve with flow through the valve secured.

(b) Only one position indication channel is required for penetration flow paths with only one installed control room indication channel.

(c) Monitoring each [relief valve discharge location].

- REVIEWER'S NOTE -

Table 3.3.3.1-1 shall be amended for each plant as necessary to list:
1. All Regulatory Guide 1.97, Type A instruments and
2. All Regulatory Guide 1.97, Category 1, non-Type A instruments specified in the plant's Regulatory Guide 1.97, Safety Evaluation Report.

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BASES

LCO (continued)

position indication in the control room to be OPERABLE for each active PCIV in a containment penetration flow path, i.e., two total channels of PCIV position indication for a penetration flow path with two active valves. For containment penetrations with only one active PCIV having control room indication, Note (b) requires a single channel of valve position indication to be OPERABLE. This is sufficient to verify redundantly the isolation status of each isolable penetration via indicated status of the active valve, as applicable, and prior knowledge of passive valve or system boundary status. If a penetration is isolated, position indication for the PCIV(s) in the associated penetration flow path is not needed to determine status. Therefore, the position indication for valves in an isolated penetration is not required to be OPERABLE. Each penetration is treated separately and each penetration flow path is considered a separate function. Therefore, separate Condition entry is allowed for each inoperable penetration flow path.

[For this plant, the PCIV position PAM instrumentation consists of the following:]

9. Wide Range Neutron Flux

Wide range neutron flux is a Category I variable provided to verify reactor shutdown.

[For this plant, wide range neutron flux PAM instrumentation consists of the following:]

delete –

~~10, 11. Drywell and Containment Hydrogen and Oxygen Analyzer~~

~~Drywell and containment hydrogen and oxygen analyzers are Category I instruments provided to detect high hydrogen or oxygen concentration conditions that represent a potential for containment breach. This variable is also important in verifying the adequacy of mitigating actions.~~

~~[For this plant, the drywell and containment hydrogen and oxygen analyzers PAM instrumentation consists of the following:]~~

12. Primary Containment Pressure

Primary containment pressure is a Category I variable provided to verify RCS and containment integrity and to verify the effectiveness of ECCS actions taken to prevent containment breach. Two wide range primary containment pressure signals are transmitted from separate pressure

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BASES

ACTIONS (continued)

C.1

When one or more Functions have two required channels that are inoperable (i.e., two channels inoperable in the same Function), one channel in the Function should be restored to OPERABLE status within 7 days. The Completion Time of 7 days is based on the relatively low probability of an event requiring PAM instrument operation and the availability of alternate means to obtain the required information. Continuous operation with two required channels inoperable in a Function is not acceptable because the alternate indications may not fully meet all performance qualification requirements applied to the PAM instrumentation. Therefore, requiring restoration of one inoperable channel of the Function limits the risk that the PAM Function will be in a degraded condition should an accident occur. Condition C is modified by a Note that excludes hydrogen monitor channels. Condition D provides appropriate Required Actions for two inoperable hydrogen monitor channels.

delete

D.1

When two hydrogen monitor channels are inoperable, one hydrogen monitor channel must be restored to OPERABLE status within 72 hours. The 72 hour Completion Time is reasonable, based on the backup capability of the Post Accident Sampling System to monitor the hydrogen concentration for evaluation of core damage and to provide information for operator decisions. Also, it is unlikely that a LOCA that would cause core damage would occur during this time.

E.1

This Required Action directs entry into the appropriate Condition referenced in Table 3.3.3.1-1. The applicable Condition referenced in the Table is Function dependent. Each time an inoperable channel has not met any Required Action of Condition C or D, as applicable, and the associated Completion Time has expired, Condition E is entered for that channel and provides for transfer to the appropriate subsequent Condition.

F.1

For the majority of Functions in Table 3.3.3.1-1, if any Required Action and associated Completion Time of Condition C or D is not met, the plant

DRAFT - DELETE SPEC & ASSOCIATED BASES

3.6 CONTAINMENT SYSTEMS

3.6.3.1 Primary Containment Hydrogen Recombiners (if permanently installed)

LCO 3.6.3.1 Two primary containment hydrogen recombiners shall be OPERABLE.

APPLICABILITY: MODES 1 and 2.

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. One primary containment hydrogen recombiner inoperable.	A.1	- NOTE - LCO 3.0.4 is not applicable. Restore primary containment hydrogen recombiner to OPERABLE status.	30 days
B. [Two primary containment hydrogen recombiners inoperable.	B.1	Verify by administrative means that the hydrogen control function is maintained.	1 hour AND Once per 12 hours thereafter
	AND		
	B.2	Restore one primary containment hydrogen recombiner to OPERABLE status.	7 days]
C. Required Action and associated Completion Time not met.	C.1	Be in MODE 3.	12 hours

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SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
SR 3.6.3.1.1	Perform a system functional test for each primary containment hydrogen recombiner.	[18] months
SR 3.6.3.1.2	Visually examine each primary containment hydrogen recombiner enclosure and verify there is no evidence of abnormal conditions.	[18] months
SR 3.6.3.1.3	Perform a resistance to ground test for each heater phase.	[18] months

delete

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3.3 INSTRUMENTATION

3.3.3.1 Post Accident Monitoring (PAM) Instrumentation

LCO 3.3.3.1 The PAM instrumentation for each Function in Table 3.3.3.1-1 shall be OPERABLE.

APPLICABILITY: MODES 1 and 2.

ACTIONS

- NOTES -

1. LCO 3.0.4 is not applicable.
2. Separate Condition entry is allowed for each Function.

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. One or more Functions with one required channel inoperable.	A.1	Restore required channel to OPERABLE status.	30 days
B. Required Action and associated Completion Time of Condition A not met.	B.1	Initiate action in accordance with Specification 5.6.7.	Immediately
C. - NOTE - Not applicable to [hydrogen monitor] channels. (delete) One or more Functions with two required channels inoperable.	C.1	Restore one required channel to OPERABLE status.	7 days
D. Two [required hydrogen monitor] channels inoperable. (delete)	D.1	Restore one [required hydrogen monitor] channel to OPERABLE status.	72 hours

DRAFT

Table 3.3.3.1-1 (page 1 of 1)
Post Accident Monitoring Instrumentation

FUNCTION	REQUIRED CHANNELS	CONDITIONS REFERENCED FROM REQUIRED ACTION E.1
1. Reactor Steam Dome Pressure	2	F
2. Reactor Vessel Water Level	2	F
3. Suppression Pool Water Level	2	F
4. Drywell Pressure	2	F
5. Primary Containment Area Radiation	2	[G]
[6. Drywell Sump Level	2	F]
[7. Drywell Drain Sump Level	2	F]
8. Penetration Flow Path PCIV Position	2 per penetration flow path[a] [b]	F
9. Wide Range Neutron Flux	2	F
10. Drywell H_2 & O_2 Analyzer	2	F
11. Containment H_2 & O_2 Analyzer	2	F
12. Primary Containment Pressure	2	F
13. [Relief Valve Discharge Location] Suppression Pool Water Temperature	2[c]	F

-delete

(a) Not required for isolation valves whose associated penetration flow path is isolated by at least one closed and deactivated automatic valve, closed manual valve, blind flange, or check valve with flow through the valve secured.

(b) Only one position indication channel is required for penetration flow paths with only one installed control room indication channel.

(c) Monitoring each [relief valve discharge location].

- REVIEWER'S NOTE -

Table 3.3.3.1-1 shall be amended for each plant as necessary to list:
1. All Regulatory Guide 1.97, Type A instruments and
2. All Regulatory Guide 1.97, Category 1, non-Type A instruments specified in the plant's Regulatory Guide 1.97, Safety Evaluation Report.

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BASES

LCO (continued)

indication to be OPERABLE. This is sufficient to redundantly verify the isolation status of each isolable penetration via indicated status of the active valve, as applicable, and prior knowledge of passive valve or system boundary status. If a penetration flow path is isolated, position indication for the PCIV(s) in the associated penetration flow path is not needed to determine status. Therefore, the position indication for valves in an isolated penetration flow path is not required to be OPERABLE. Each penetration is treated separately and each penetration flow path is considered a separate function. Therefore, separate Condition entry is allowed for each inoperable penetration flow path.

[For this plant, the PCIV position PAM instrumentation consists of the following:]

9. Wide Range Neutron Flux

Wide range neutron flux is a Category I variable provided to verify reactor shutdown. [For this plant, the wide range neutron flux PAM instrumentation consists of the following:]

10, 11. Drywell and Containment Hydrogen and Oxygen Analyzers

Drywell and containment hydrogen and oxygen analyzers are Category I instruments provided to detect high hydrogen or oxygen concentration conditions that represent a potential for containment breach. This variable is also important in verifying the adequacy of mitigating actions. [For this plant, the drywell and containment hydrogen and oxygen analyzers PAM instrumentation consists of the following:]

12. Primary Containment Pressure

Primary containment pressure is a Category I variable provided to verify RCS and containment integrity and to verify the effectiveness of ECCS actions taken to prevent containment breach. Two wide range primary containment pressure signals are transmitted from separate pressure transmitters and are continuously recorded and displayed on two control room recorders. These recorders are the primary indication used by the operator during an accident. Therefore, the PAM Specification deals specifically with this portion of the instrument channel.

DRAFT

BASES

ACTIONS (continued)

C.1

When one or more Functions have two required channels that are inoperable (i.e., two channels inoperable in the same Function), one channel in the Function should be restored to OPERABLE status within 7 days. The Completion Time of 7 days is based on the relatively low probability of an event requiring PAM instrument operation and the availability of alternate means to obtain the required information. Continuous operation with two required channels inoperable in a Function is not acceptable because the alternate indications may not fully meet all performance qualification requirements applied to the PAM instrumentation. Therefore, requiring restoration of one inoperable channel of the Function limits the risk that the PAM Function will be in a degraded condition should an accident occur. Condition C is modified by a Note that excludes hydrogen monitor channels. Condition D provides appropriate Required Actions for two inoperable hydrogen monitor channels.

delete

D.1

When two hydrogen monitor channels are inoperable, one hydrogen monitor channel must be restored to OPERABLE status within 72 hours. The 72 hour Completion Time is based on the low probability of the occurrence of a LOCA that would generate hydrogen in amounts capable of exceeding the flammability limit; the length of time after the event that operator action would be required to prevent hydrogen accumulation from exceeding this limit; and the availability of the hydrogen recombiners, the Hydrogen Purge System, and the Post Accident Sampling System.

E.1

This Required Action directs entry into the appropriate Condition referenced in Table 3.3.3.1-1. The applicable Condition referenced in the Table is Function dependent. Each time an inoperable channel has not met any Required Action of Condition C or D, as applicable, and the associated Completion Time has expired, Condition E is entered for that channel and provides for transfer to the appropriate subsequent Condition.

F.1

For the majority of Functions in Table 3.3.3.1-1, if any Required Action and associated Completion Time of Condition C or D are not met, the

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B 3.6 CONTAINMENT SYSTEMS

B 3.6.3.3 Primary Containment Oxygen Concentration

BASES

BACKGROUND

All nuclear reactors must be designed to withstand events that generate hydrogen either due to the zirconium metal water reaction in the core or due to radiolysis. The primary method to control hydrogen is to inert the primary containment. With the primary containment inert, that is, oxygen concentration < 4.0 volume percent (v/o), a combustible mixture cannot be present in the primary containment for any hydrogen concentration. The capability to inert the primary containment and maintain oxygen < 4.0 v/o works together with the Hydrogen Recombiner System (LCO 3.6.3.1, "Primary Containment Hydrogen Recombiners") and the [Drywell Cooling System fans] (LCO 3.6.3.2, "[Drywell Cooling System Fans]") to provide redundant and diverse methods to mitigate events that produce hydrogen. For example, an event that rapidly generates hydrogen from zirconium metal water reaction will result in excessive hydrogen in primary containment, but oxygen concentration will remain < 4.0 v/o and no combustion can occur. Long term generation of both hydrogen and oxygen from radiolytic decomposition of water may eventually result in a combustible mixture in primary containment, except that the hydrogen recombiners remove hydrogen and oxygen gases faster than they can be produced from radiolysis and again no combustion can occur. This LCO ensures that oxygen concentration does not exceed 4.0 v/o during operation in the applicable conditions.

APPLICABLE SAFETY ANALYSES

The Reference 1 calculations assume that the primary containment is inerted when a Design Basis Accident loss of coolant accident occurs. Thus, the hydrogen assumed to be released to the primary containment as a result of metal water reaction in the reactor core will not produce combustible gas mixtures in the primary containment. Oxygen, which is subsequently generated by radiolytic decomposition of water, is recombined by the hydrogen recombiners (LCO 3.6.3.1) more rapidly than it is produced.

4 insert

Primary containment oxygen concentration satisfies Criterion 2 of 10 CFR 50.36(c)(2)(ii). delete

---

LCO

The primary containment oxygen concentration is maintained < 4.0 v/o to ensure that an event that produces any amount of hydrogen does not result in a combustible mixture inside primary containment.

DRAFT - DELETE SPEC & ASSOCIATED BASES

3.6 CONTAINMENT SYSTEMS

3.6.8 Hydrogen Recombiners (Atmospheric and Dual) (if permanently installed)

LCO 3.6.8 [Two] hydrogen recombiners shall be OPERABLE.

APPLICABILITY: MODES 1 and 2.

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. One hydrogen recombiner inoperable.	A.1	- NOTE - LCO 3.0.4 is not applicable. Restore hydrogen recombiner to OPERABLE status.	30 days
B. [Two hydrogen recombiners inoperable.	B.1	Verify by administrative means that the hydrogen control function is maintained.	1 hour AND Once every 12 hours thereafter
	AND		
	B.2	Restore one hydrogen recombiner to OPERABLE status.	7 days]
C. Required Action and associated Completion Time not met.	C.1	Be in MODE 3.	6 hours

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SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
SR 3.6.8.1	Perform a system functional test for each hydrogen recombiner.	[18] months
SR 3.6.8.2	Visually examine each hydrogen recombiner enclosure and verify there is no evidence of abnormal conditions.	[18] months
SR 3.6.8.3	Perform a resistance to ground test for each heater phase.	[18] months

delete

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3.3 INSTRUMENTATION

3.3.11 Post Accident Monitoring (PAM) Instrumentation (Analog)

LCO 3.3.11 The PAM instrumentation for each Function in Table 3.3.11-1 shall be OPERABLE.

APPLICABILITY: MODES 1, 2, and 3.

ACTIONS

- NOTES -

1. LCO 3.0.4 is not applicable.
2. Separate Condition entry is allowed for each Function.

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. One or more Functions with one required channel inoperable.	A.1	Restore required channel to OPERABLE status.	30 days
B. Required Action and associated Completion Time of Condition A not met.	B.1	Initiate action in accordance with Specification 5.6.7.	Immediately
C. - NOTE - Not applicable to hydrogen monitor channels. (delete) One or more Functions with two required channels inoperable.	C.1	Restore one channel to OPERABLE status.	7 days
D. Two hydrogen monitor channels inoperable. (delete)	D.1	Restore one hydrogen monitor channel to OPERABLE status.	72 hours

DRAFT

Table 3.3.11-1 (page 1 of 1)
Post Accident Monitoring Instrumentation

FUNCTION	REQUIRED CHANNELS	CONDITIONS REFERENCED FROM REQUIRED ACTION E.1
1. [Logarithmic] Neutron Flux	2	F
2. Reactor Coolant System Hot Leg Temperature	2 per loop	F
3. Reactor Coolant System Cold Leg Temperature	2 per loop	F
4. Reactor Coolant System Pressure (wide range)	2	F
5. Reactor Vessel Water Level	2	[G]
6. Containment Sump Water Level (wide range)	2	F
7. Containment Pressure (wide range)	2	F
8. Penetration Flow Path Containment Isolation Valve Position	2 per penetration flow path(a)(b)	F
9. Containment Area Radiation (high range)	2	[G]
~~10. Containment Hydrogen Monitors~~	~~2~~	~~F~~ delete
11. Pressurizer Level	2	F
12. Steam Generator Water Level (wide range)	2 per steam generator	F
13. Condensate Storage Tank Level	2	F
14. Core Exit Temperature - Quadrant [1]	2(c)	F
15. Core Exit Temperature - Quadrant [2]	2(c)	F
16. Core Exit Temperature - Quadrant [3]	2(c)	F
17. Core Exit Temperature - Quadrant [4]	2(c)	F
18. Auxiliary Feedwater Flow	2	F

(a) Not required for isolation valves whose associated penetration is isolated by at least one closed and de-activated automatic valve, closed manual valve, blind flange, or check valve with flow through the valve secured.

(b) Only one position indication channel is required for penetration flow paths with only one installed control room indication channel.

(c) A channel consists of two or more core exit thermocouples.

- REVIEWER'S NOTE -

Table 3.3.11-1 shall be amended for each unit as necessary to list:
1. All Regulatory Guide 1.97, Type A instruments and
2. All Regulatory Guide 1.97, Category I, non-Type A instruments specified in the unit's Regulatory Guide 1.97, Safety Evaluation Report.

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3.3 INSTRUMENTATION

3.3.11 Post Accident Monitoring (PAM) Instrumentation (Digital)

LCO 3.3.11 The PAM instrumentation for each Function in Table 3.3.11-1 shall be OPERABLE.

APPLICABILITY: MODES 1, 2, and 3.
During movement of [recently] irradiated fuel assemblies.

ACTIONS

- NOTES -

1. LCO 3.0.4 not applicable.
2. Separate Condition entry is allowed for each Function.

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. One or more Functions with one required channel inoperable.	A.1	Restore required channel to OPERABLE status.	30 days
B. Required Action and associated Completion Time of Condition A not met.	B.1	Initiate action in accordance with Specification 5.6.7.	Immediately
C. - NOTE - Not applicable to hydrogen monitor channels. (delete) One or more Functions with two required channels inoperable.	C.1	Restore one channel to OPERABLE status.	7 days
D. Two hydrogen monitor channels inoperable. (delete)	D.1	Restore one hydrogen monitor channel to OPERABLE status.	72 hours

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Table 3.3.11-1 (page 1 of 1)
Post Accident Monitoring Instrumentation

FUNCTION	REQUIRED CHANNELS	CONDITIONS REFERENCED FROM REQUIRED ACTION E.1
1. [Wide Range] Neutron Flux	2	F
2. Reactor Coolant System Hot Leg Temperature	2 per loop	F
3. Reactor Coolant System Cold Leg Temperature	2 per loop	F
4. Reactor Coolant System Pressure (wide range)	2	F
5. Reactor Vessel Water Level	2	[G]
6. Containment Sump Water Level (wide range)	2	F
7. Containment Pressure (wide range)	2	F
8. Penetration Flow Path Containment Isolation Valve Position	2 per penetration flow path[(a)(b)]	F
9. Containment Area Radiation (high range)	2	[G]
~~10. Containment Hydrogen Monitors~~	~~2~~	~~F~~ delete
11. Pressurizer Level	2	F
12. Steam Generator Water Level (wide range)	2 per steam generator	F
13. Condensate Storage Tank Level	2	F
14. Core Exit Temperature - Quadrant [1]	2[(c)]	F
15. Core Exit Temperature - Quadrant [2]	2[(c)]	F
16. Core Exit Temperature - Quadrant [3]	2[(c)]	F
17. Core Exit Temperature - Quadrant [4]	2[(c)]	F
18. Emergency Feedwater Flow	2	F

(a) Not required for isolation valves whose associated penetration is isolated by at least one closed and de-activated automatic valve, closed manual valve, blind flange, or check valve with flow through the valve secured.

(b) Only one position indication channel is required for penetration flow paths with only one installed control room indication channel.

(c) A channel consists of two or more core exit thermocouples.

- REVIEWER'S NOTE -

Table 3.3.11-1 shall be amended for each unit as necessary to list:
1. All Regulatory Guide 1.97, Type A instruments and
2. All Regulatory Guide 1.97, Category I, non-Type A instruments specified in the unit's Regulatory Guide 1.97, Safety Evaluation Report.

DRAFT

BASES

LCO (continued)

8. Containment Isolation Valve Position

Containment Isolation Valve Position is provided for verification of containment OPERABILITY.

PCIV position is provided for verification of containment integrity. In the case of PCIV position, the important information is the isolation status of the containment penetration. The LCO requires one channel of valve position indication in the control room to be OPERABLE for each active PCIV in a containment penetration flow path, i.e., two total channels of PCIV position indication for a penetration flow path with two active valves. For containment penetrations with only one active PCIV having control room indication, Note (b) requires a single channel of valve position indication to be OPERABLE. This is sufficient to redundantly verify the isolation status of each isolable penetration via indicated status of the active valve, as applicable, and prior knowledge of passive valve or system boundary status. If a penetration flow path is isolated, position indication for the PCIV(s) in the associated penetration flow path is not needed to determine status. Therefore, the position indication for valves in an isolated penetration flow path is not required to be OPERABLE. Each penetration is treated separately and each penetration flow path is considered a separate function. Therefore, separate Condition entry is allowed for each inoperable penetration flow path.

[For this unit, the PCIV position PAM instrumentation consists of the following:]

9. Containment Area Radiation (high range)

Containment Area Radiation is provided to monitor for the potential of significant radiation releases and to provide release assessment for use by operators in determining the need to invoke site emergency plans.

[For this unit, Containment Area Radiation instrumentation consists of the following:]

10. Containment Hydrogen Monitors

Containment Hydrogen Monitors are provided to detect high hydrogen concentration conditions that represent a potential for

delete

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BASES

LCO (continued)

containment breach. This variable is also important in verifying the adequacy of mitigating actions.

[For this unit, Containment Hydrogen instrumentation consists of the following:]

delete

11. Pressurizer Level

Pressurizer Level is used to determine whether to terminate safety injection (SI), if still in progress, or to reinitiate SI if it has been stopped. Knowledge of pressurizer water level is also used to verify the plant conditions necessary to establish natural circulation in the RCS and to verify that the plant is maintained in a safe shutdown condition.

[For this unit, Pressurizer Level instrumentation consists of the following:]

12. Steam Generator Water Level

Steam Generator Water Level is provided to monitor operation of decay heat removal via the steam generators. The Category I indication of steam generator level is the extended startup range level instrumentation. The extended startup range level covers a span of 6 inches to 394 inches above the lower tubesheet. The measured differential pressure is displayed in inches of water at 68°F. Temperature compensation of this indication is performed manually by the operator. Redundant monitoring capability is provided by two trains of instrumentation. The uncompensated level signal is input to the plant computer, a control room indicator, and the [Auxiliary Feedwater (AFW)] Control System.

At some plants, operator action is based on the control room indication of Steam Generator Water Level. The RCS response during a design basis small break LOCA is dependent on the break size. For a certain range of break sizes, the boiler condenser mode of heat transfer is necessary to remove decay heat. At these plants, extended startup range level is a Type A variable because the operator must manually raise and control the steam generator level to establish boiler condenser heat transfer. Operator action is initiated on a loss of subcooled margin. Feedwater flow is increased until the indicated extended startup range level reaches the boiler condenser setpoint.

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ACTIONS (continued)

Completion Time of 7 days is based on the relatively low probability of an event requiring PAM instrumentation operation and the availability of alternate means to obtain the required information. Continuous operation with two required channels inoperable in a Function is not acceptable because the alternate indications may not fully meet all performance qualification requirements applied to the PAM instrumentation. Therefore, requiring restoration of one inoperable channel of the Function limits the risk that the PAM Function will be in a degraded condition should an accident occur.

D.1

When two required hydrogen monitor channels are inoperable, Required Action D.1 requires one channel to be restored to OPERABLE status. This Required Action restores the monitoring capability of the hydrogen monitor. The 72 hour Completion Time is based on the relatively low probability of an event requiring hydrogen monitoring and the availability of alternative means to obtain the required information. Continuous operation with two required channels inoperable is not acceptable because alternate indications are not available.

delete

E.1

This Required Action directs entry into the appropriate Condition referenced in Table 3.3.11-1. The applicable Condition referenced in the Table is Function dependent. Each time Required Action C.1 or D.1 is not met, and the associated Completion Time has expired, Condition E is entered for that channel and provides for transfer to the appropriate subsequent Condition.

F.1 and F.2

If the Required Action and associated Completion Time of Condition C are not met, and Table 3.3.11-1 directs entry into Condition F, the plant must be brought to a MODE in which the requirements of this LCO do not apply. To achieve this status, the plant must be brought to at least MODE 3 within 6 hours and to MODE 4 within 12 hours.

The allowed Completion Times are reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner and without challenging plant systems.

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BASES

LCO (continued)

PCIV position is provided for verification of containment integrity. In the case of PCIV position, the important information is the isolation status of the containment penetration. The LCO requires one channel of valve position indication in the control room to be OPERABLE for each active PCIV in a containment penetration flow path, i.e., two total channels of PCIV position indication for a penetration flow path with two active valves. For containment penetrations with only one active PCIV having control room indication, Note (b) requires a single channel of valve position indication to be OPERABLE. This is sufficient to redundantly verify the isolation status of each isolable penetration via indicated status of the active valve, as applicable, and prior knowledge of passive valve or system boundary status. If a penetration flow path is isolated, position indication for the PCIV(s) in the associated penetration flow path is not needed to determine status. Therefore, the position indication for valves in an isolated penetration flow path is not required to be OPERABLE. Each penetration is treated separately and each penetration flow path is considered a separate function. Therefore, separate condition entry is allowed for each inoperable penetration flow path.

[For this unit, the PCIV position PAM instrumentation consists of the following:]

9. Containment Area Radiation (high range)

Containment Area Radiation is provided to monitor for the potential of significant radiation releases and to provide release assessment for use by operators in determining the need to invoke site emergency plans.

[For this unit, Containment Area Radiation instrumentation consists of the following:]

delete

10. Containment Hydrogen Monitors

Containment Hydrogen Monitors are provided to detect high hydrogen concentration conditions that represent a potential for containment breach. This variable is also important in verifying the adequacy of mitigating actions.

[For this unit, Containment Hydrogen instrumentation consists of the following:]

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ACTIONS (continued)

limits the risk that the PAM Function will be in a degraded condition should an accident occur.

D.1

When two required hydrogen monitor channels are inoperable, Required Action D.1 requires one channel to be restored to OPERABLE status. This Required Action restores the monitoring capability of the hydrogen monitor. The 72 hour Completion Time is based on the relatively low probability of an event requiring hydrogen monitoring and the availability of alternative means to obtain the required information. Continuous operation with two required channels inoperable is not acceptable because alternate indications are not available.

delete

E.1

This Required Action directs entry into the appropriate Condition referenced in Table 3.3.11-1. The applicable Condition referenced in the Table is Function dependent. Each time Required Action C.1 or D.1 is not met, and the associated Completion Time has expired, Condition E is entered for that channel and provides for transfer to the appropriate subsequent Condition.

F.1 and F.2

If the Required Action and associated Completion Time of Condition C are not met and Table 3.3.11-1 directs entry into Condition F, the plant must be brought to a MODE in which the LCO does not apply. To achieve this status, the plant must be brought to at least MODE 3 within 6 hours and to MODE 4 within 12 hours. The allowed Completion Times are reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner and without challenging plant systems.

[G.1

At this plant, alternate means of monitoring Reactor Vessel Water Level and Containment Area Radiation have been developed and tested. These alternate means may be temporarily installed if the normal PAM channel cannot be restored to OPERABLE status within the allotted time. If these alternate means are used, the Required Action is not to shut down the plant, but rather to follow the directions of Specification 5.6.7. The report provided to the NRC should discuss whether the alternate

DRAFT - DELETE SPEC & ASSOCIATED BASES

3.6 CONTAINMENT SYSTEMS

3.6.8 Hydrogen Recombiners (if permanently installed)

LCO 3.6.8 Two hydrogen recombiners shall be OPERABLE.

APPLICABILITY: MODES 1 and 2.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One hydrogen recombiner inoperable.	A.1 - NOTE - LCO 3.0.4 is not applicable. Restore hydrogen recombiner to OPERABLE status.	30 days
B. [Two hydrogen recombiners inoperable.	B.1 Verify by administrative means that the hydrogen control function is maintained. AND B.2 Restore one hydrogen recombiner to OPERABLE status.	1 hour AND Every 12 hours thereafter 7 days]
C. Required Action and associated Completion Time not met.	C.1 Be in MODE 3.	6 hours

DRAFT

SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
SR 3.6.8.1	Perform a system functional test for each hydrogen recombiner.	[18] months
SR 3.6.8.2	Visually examine each hydrogen recombiner enclosure and verify there is no evidence of abnormal conditions.	[18] months
SR 3.6.8.3	Perform a resistance to ground test for each heater phase.	[18] months

delete

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3.3 INSTRUMENTATION

3.3.17 Post Accident Monitoring (PAM) Instrumentation

LCO 3.3.17 The PAM instrumentation for each Function in Table 3.3.17-1 shall be OPERABLE.

APPLICABILITY: MODES 1, 2, and 3.

ACTIONS

- NOTES -

1. LCO 3.0.4 is not applicable.
2. Separate Condition entry is allowed for each Function.

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. One or more Functions with one required channel inoperable.	A.1	Restore required channel to OPERABLE status.	30 days
B. Required Action and associated Completion Time of Condition A not met.	B.1	Initiate action in accordance with Specification 5.6.7.	Immediately
C. ~~- NOTE - Not applicable to hydrogen monitor channels.~~ (delete) One or more Functions with two required channels inoperable.	C.1	Restore one channel to OPERABLE status.	7 days
D. Two required hydrogen monitor channels inoperable. (delete)	D.1	Restore one required hydrogen monitor channel to OPERABLE status.	72 hours

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Table 3.3.17-1 (page 1 of 1)
Post Accident Monitoring Instrumentation

FUNCTION	REQUIRED CHANNELS	CONDITIONS REFERENCED FROM REQUIRED ACTION C.1
1. Wide Range Neutron Flux	2	F
2. RCS Hot Leg Temperature	2 per loop	F
3. RCS Cold Leg Temperature	2 per loop	F
4. RCS Pressure (Wide Range)	2	F
5. Reactor Vessel Water Level	2	G
6. Containment Sump Water Level (Wide Range)	2	F
7. Containment Pressure (Wide Range)	2	F
8. Penetration Flow Path Containment Isolation Valve Position	2 per penetration flow path[a][b]	F
9. Containment Area Radiation (High Range)	2	G
10. Containment Hydrogen Concentration	2	F
11. Pressurizer Level	2	F
12. Steam Generator Water Level	2 per SG	F
13. Condensate Storage Tank Level	2	F
14. Core Exit Temperature	2 independent sets of 5[c]	F
15. Emergency Feedwater Flow	2	F

delete

- REVIEWER'S NOTE -
Table 3.3.17-1 shall be amended for each unit as necessary to list all U.S. NRC Regulatory Guide 1.97, Type A instruments and all U.S. NRC Regulatory Guide 1.97, Category I, non-Type A instruments in accordance with the unit's U.S. NRC Regulatory Guide 1.97, Safety Evaluation Report.

(a) Not required for isolation valves whose associated penetration is isolated by at least one closed and deactivated automatic valve, closed manual valve, blind flange, or check valve with flow through the valve secured.

(b) Only one position indication channel is required for penetration flow paths with only one installed control room indication channel.

(c) The subcooling margin monitor takes the average of the five highest CETs for each of the ICCM trains.

DRAFT

BASES

LCO (continued)

8. Containment Isolation Valve Position

PCIV position is provided for verification of containment integrity. In the case of PCIV position, the important information is the isolation status of the containment penetration. The LCO requires one channel of valve position indication in the control room to be OPERABLE for each active PCIV in a containment penetration flow path, i.e., two total channels of PCIV position indication for a penetration flow path with two active valves. For containment penetrations with only one active PCIV having control room indication, Note (b) requires a single channel of valve position indication to be OPERABLE. This is sufficient to redundantly verify the isolation status of each isolable penetration via indicated status of the active valve, as applicable, and prior knowledge of passive valve or system boundary status. If a penetration flow path is isolated, position indication for the PCIV(s) in the associated penetration flow path is not needed to determine status. Therefore, the position indication for valves in an isolated penetration flow path is not required to be OPERABLE. Each penetration is treated separately and each penetration flow path is considered a separate function. Therefore, separate Condition entry is allowed for each inoperable penetration flow path.

[For this plant, the PCIV position PAM instrumentation consists of the following:]

9. Containment Area Radiation (High Range)

Containment Area Radiation (High Range) instrumentation is provided to monitor the potential for significant radiation releases and to provide release assessment for use by operators in determining the need to invoke site emergency plans. [For this unit, the Containment Area Radiation instrumentation consists of the following:]

delete

10. Containment Hydrogen Concentration

Containment Hydrogen Concentration instrumentation is provided to detect high hydrogen concentration conditions that represent a potential for containment breach. This variable is also important in verifying the adequacy of mitigating actions. [For this unit, the Containment Hydrogen Concentration instrumentation consists of the following:]

DRAFT

BASES

ACTIONS (continued)

B.1

Required Action B.1 specifies initiation of action described in Specification 5.6.7, that requires a written report to be submitted to the NRC. This report discusses the results of the root cause evaluation of the inoperability and identifies proposed restorative actions. This action is appropriate in lieu of a shutdown requirement since alternative actions are identified before loss of functional capability and given the likelihood of unit conditions that would require information provided by this instrumentation. The Completion Time of "Immediately" for Required Action B.1 ensures the requirements of Specification 5.6.7 are initiated.

C.1

When one or more Functions have two required channels inoperable (i.e., two channels inoperable in the same Function), one channel in the Function should be restored to OPERABLE status within 7 days. This Condition does not apply to the hydrogen monitor channels. The Completion Time of 7 days is based on the relatively low probability of an event requiring PAM instrumentation action operation and the availability of alternative means to obtain the required information. Continuous operation with two required channels inoperable in a Function is not acceptable because the alternate indications may not fully meet all performance of qualification requirements applied to the PAM instrumentation. Therefore, requiring restoration of one inoperable channel of the Function limits the risk that the PAM Function will be in a degraded condition should an accident occur.

delete

D.1

When two required hydrogen monitor channels are inoperable, Required Action D.1 requires one channel to be restored to OPERABLE status. This action restores the monitoring capability of the hydrogen monitor. The 72 hour Completion Time is based on the relatively low probability of an event requiring hydrogen monitoring and the availability of alternative means to obtain the required information. Continuous operation with two required channels inoperable is not acceptable because alternate indications are not available.

E.1

Required Action E.1 directs entry into the appropriate Condition referenced in Table 3.3.17-1. The applicable Condition referenced in the

Passive Autocatalytic Recombiner (PAR) Requirements for PWRs: Value Impact Assessment

Objective:

Determine whether it is cost-effective to update the existing § 50.44 requirements on combustible gas control to require passive autocatalytic recombiners for all PWRs with large-dry containment buildings.

Under this approach, a backfit would be required of licensees with plants that have large dry containments in that they would have to install PARs and maintain them for the duration of the plant license. This approach would provide control over the potential for containment failure that would otherwise result from combustion of gases produced during severe (core-damage) accidents.

Introduction to Value-Impact Assessment

This Value-Impact assessment follows the guidelines in [1, 2]. Consistent with these guidelines, the following assumptions are made in the assessment:

- The year chosen as a base is 2002 and all costs are adjusted to reflect 2002 dollars.

- The discount rate used is 7 percent, as recommended in [2].

- The remaining life of the average plant is assumed to be 35 years. This value was determined by adding 20 years (assumption of license renewal) to 15 years remaining on the plant's current license [2].

- Using the 7 percent discount rate and 35-year lifetime, the multiplier used for determining the 2002 cost equivalent for yearly costs over the remaining life of the plant is 13.053 [2].

The "Values" considered in the assessment are:

- Public Health – Accident
- Public Health – Routine
- Occupational Health – Accident
- Occupational Health – Routine
- Property – Offsite
- Property – Onsite

The "Impacts" considered in the assessment are:

- Industry Implementation
- Industry Operation
- NRC Implementation
- NRC Operation

The Base Case for this analysis is a typical PWR with no severe-accident hydrogen control in the containment, The sign convention, consistent with [4], is that -- relative to the Base Case -- increased public and occupational health (e.g., decreased risk to the public, as is the case here) and increased property values are "positive" while reduced public and occupational health (e.g., increased risk to the public) and reduced property values are "negative." Likewise, increased implementation and operation costs for the industry and NRC are "positive" while reduced implementation and operation costs (e.g., reductions in regulatory burdens) for the industry and NRC are "negative."

The equation for determining the Value-Impact is then:

Value-Impact = {sum of all Values} - {sum of all Impacts} =

{(Public Health_Accident) + (Public Health_Routine) + (Occupational Health_Accident) + (Occupational Health_Routine) + (Property_Offsite) + (Property_Onsite)} – {(Industry Implementation) + (Industry Operation) + (NRC Implementation) + (NRC Operation)}

Thus, a positive Value-Impact will support a rulemaking action while a negative Value-Impact will not, independent of whether the rulemaking action is a relaxation or an enhancement.

Estimation and Evaluation of Values and Impacts for the Action

Identification of Attributes

Below is a discussion of the Value-Impact attributes for installation and maintenance of PARs in PWRs with large-dry containments. The Base Case for this analysis is a large-dry PWR with no hydrogen control in containment (no recombiners, no hydrogen ignitors).

Public Health (Accident)

The approach taken here is to take assess the potential risk reduction and compare the dollar equivalent of that risk reduction to the costs described elsewhere in this cost-benefit assessment. The risk reduction assessment can be considered in two parts:

- An estimate of the consequences of those accidents that would be eliminated if PARs were installed. This is usually expressed in person-rem dose out to 50 miles from the plant. Suggested consequences, resulting from various containment failure modes are listed in [2] and repeated here in Table 1. These are used as representative of consequences resulting from containment failures caused by hydrogen burns, consequences that would be eliminated by the backfit.

- An estimate of the reduction in frequency of the occurrence of those consequences, due to the PAR backfit.

Table 1 first shows the consequences, frequency, associated risk and dollar equivalent for early containment failures and late containment failures for typical PWRs with large-dry containments. The second part of the table shows the estimated contribution to containment failures from hydrogen burns, as reflected in the frequency. A 10% contribution to the "Total" from hydrogen burns is assumed. This is based on results from Individual Plant Examination Program (IPE).

Table 1: Elements for Determining Averted Risk

	Consequences (person-rem)[1]	Frequency (1/year)[2]	Risk (person-rem/yr)	2002 Dollar Equivalent
Early Failures: Total	6×10^6	5×10^{-6}	30	$783,000
Late Failures: Total	8×10^5	3×10^{-5}	24	$627,000
Early Failures: Hydrogen Contribution	6×10^6	5×10^{-7}	3	$78,000
Late Failures: Hydrogen Contribution	8×10^5	3×10^{-6}	2.4	$63,000

1 Data from [2], Table 5.3 for "Total" and "Hydrogen Contribution" values
2 Data from [6], Table 12.16 for "Total" values; for "Hydrogen Contribution" values, 10% of the "Total" was assumed based on [7], page 105.

A rough estimate of the contribution from external events is to double the values for internal events [13]. Thus, the total dollar equivalent risk reduction from eliminating containment failure due to hydrogen burns is 2 x ($78,000 + $63,000) or $282,000. This, of course, assumes that the PARs are 100% effective at mitigating the early and late containment failures assumed to be from hydrogen combustion for both internal and external events.

Public Health (Routine)

There is no change in the Public Health (Routine), when comparing this proposed backfit to the base case (no hydrogen control) since this backfit does not involve any change to normal operational (routine) releases from the plant.

Occupational Health (Accident)

This attribute is a value and is estimated consistent with the methodology described in Section 5.7.3 of [2]. The approach here was to estimate the positive value of the reduced risk of the proposed backfit compared to the base case (no hydrogen control). The risk reduction is a result of the backfit case preventing early and late containment failure due to hydrogen combustion. The frequency, of which, was estimated in Table 1. The reduction is due to lower dose consequences from Accident Scenario 2 as compared to Accident Scenario 3. These accident scenarios are described in Section 5.7.3.1 of [2]. The immediate dose for the base case was estimated to be 1.2×10^{-2} person-rem/yr and 3.5×10^{-3} person-rem/yr for the backfit case. The long-term dose for the base case was estimated to be 6.9 x 10^{-2} person-rem/yr and 2.7 x 10^{-2} person-rem/yr for the backfit case. The monetary value of occupational health (accident) risk avoided per facility due to immediate doses, after discounting was $220. The monetary value of occupational health (accident) risk avoided per facility due to long-term doses, after discounting was $790.

Thus the total cost for occupational health (accident) is $0.001M.

Occupational Health (Routine)

This attribute is a value which accounts for radiological exposures to workers during normal facility operations (i.e., non-accident situations). Assuming that the PARs will be maintained as commercial grade type components, periodic testing and maintenance would be conducted to ensure proper functioning of the PARs. This would involve the removal of a catalyst bed, placing it in an enclosure, passing a known concentration of hydrogen over the bed, and measuring the temperature difference. This work is assumed to be conducted outside containment; however, a portion of time would be required inside containment to remove, then reinstall the catalyst bed, as well as to clean the unit.

Workers who are in close proximity to the hydrogen recombiners are exposed at an average rate of 10 mrem/hour (PWRs) [2]. Although this value is based on the existing hydrogen recombiners, it is assumed that the value would be similar for PARs. Each containment (plant) would contain, on the average, 40 half-size PARs. It is assumed that testing would occur during refueling outages only, and that only a portion of the PARs would be tested during each outage. It is estimated that approximately 30 minutes would be spent inside containment for each PAR, and that at least two workers would be involved. If one-fourth of the PARs are tested during an outage, the exposure time would equate to five hours/worker, or ten person-hours. The total anticipated exposure per outage would be 100 mrem, or 66 mrem/year, assuming an 18-month refueling cycle. This equates to an impact of approximately $1,700 over 35 years, using the $2,000/person-rem conversion factor. This amount does not account for exposure time in containment due to the erection of scaffolding or other such equipment for the purposes of accessing the PARs. Additionally, the amount does not account for additional exposure from other components that might be in close proximity to the PARs. The location and accessibility of the PARs are plant-specific, and therefore, exposure related to accessing the PARs cannot be easily derived. Therefore, it is expected that actual worker exposures would be greater which makes it less likely that PARs could be justified.

Offsite Property

The Offsite Property benefit (cost reduction) due to this backfit is estimated consistent with the methodology described in Section 5.7.5 of [2]. From NUREG/CR-6349 [5], the offsite property consequences are typically of the same magnitude as health consequences for early containment failures and are typically less than half the health consequences for late failures. Thus, referring to Table 1, the dollar equivalent reduction in offsite property risk (including external events) is:

$78,000 (internal) + $78,000 (external) + 0.5 x $63,000 (internal) + 0.5 x $63,000 (external) = $219,000

Onsite Property

There would be a slight positive value in the Onsite Costs, if the approach taken for occupational health (accident) were used. This value is a result of the backfit case preventing early and late containment failure due to hydrogen combustion. Based on the results of occupational health (accident) and because the cleanup, decontamination, and long-term replacement power costs are so similar for the two cases, onsite property costs were not calculated for the purpose of this value impact assessment.

Industry Implementation

This attribute is an impact which accounts for the projected net economic effect on the affected licensees to install or implement mandated changes. It is estimated that an average of 40 half-sized PARs would be installed in each large, dry (PWR) containment. The average purchase price per half-sized PAR is estimated to be $24,000 [11]. Although the ability exists to produce PARs domestically, currently, PARs are imported from Europe. The amount above is based on the cost of an imported PAR. Thus, the purchase cost equates to $960,000. Should a catalyst bed need to be replaced (due to test failure), a replacement bed would cost approximately $350 [11]. A few beds are likely to be purchased at the time the PARs are purchased. Therefore, an additional cost of $1,000/plant is likely.

The engineering associated with installation of the PARs will vary depending on the intended location of the PARs and whether extensive modifications will be necessary to accommodate the PARs. Based on information provided in past SAMA evaluations, a recent response to a Request for Additional Information related to SAMA evaluations, and information obtained from Indian Point 2, engineering costs ranged from $35,000 to $400,000 [11, 12]. The projected likely cost for engineering and qualification (2-over-1) of the PARs is $150,000/plant.

Installation costs will also vary depending on the area of the country (differing labor rates) in which the plant is located. At Indian Point 2, it cost approximately $100,000 to install two full-sized PARs [11]. Although the cost for installation is not expected to increase by 20 times, it is expected to increase by a factor of five (based on economy of scale). Thus, total labor costs are expected to be $500,000 per plant.

The PARs, most probably, will be maintained as commercial grade components. It is assumed that testing and surveillance would be conducted to ensure proper functioning of the PARs. A testing/surveillance procedure would need to be developed. Industry estimates for development of a procedure and its implementation (i.e., training) are a minimum of $30,000 [4]. However, the procedure for testing the PARs is not as complex as other procedures (such as emergency operating procedures), and has already been developed for Indian Point 2. The effort at Indian Point 2 cost approximately $2,000 [11]. However, this included the training of only two individuals. Since for the purposes of this analysis 40 PARs are going to be installed, it is likely that more than two individuals would be trained. Therefore, the estimated cost for developing and implementing the testing procedure at a typical large, dry PWR is estimated to cost $3,000.

The catalyst beds need to be tested in a testing enclosure complete with sensing instrumentation and a computer. The current cost for such a testing apparatus is $10,000. Each plant would require a testing apparatus.

Thus the total cost for industry implementation is $1.624 M.

Industry Operation

This attribute is an impact which measures the projected net economic effect due to routine and recurring activities required by the proposed action on all affected licensees.

The only expected operation costs associated with the PARs after installation will be due to testing. One catalyst bed per PAR should be tested periodically. It is estimated that it will take a technician 0.5 hour to remove a catalyst bed, observe the PAR for any fouling (accumulation of dirt, debris, dusts), then reinstall it after testing [11]. The total time estimated for performing the test, including transportation time, paper work, etc., is one hour per PAR [11]. This process involves two persons. Therefore, the total labor cost involved with testing is estimated to be $200/PAR. This equates to approximately $1,300 per year per plant based on an 18-month refueling cycle. Using the multiplier of 13.053 to determine the year 2002 cost equivalent, the cost is $17,000.

The testing involves the passing of a known concentration of hydrogen gas across the catalyst bed. A cylinder of hydrogen would be required to perform the testing. At Indian Point 2, it cost approximately $100/PAR for the hydrogen [11]. Therefore, at a PWR considered by this analysis, the cost for hydrogen per year is estimated to be $700. Again, using the multiplier of 13.053 to determine the year 2002 cost equivalent, the cost is $9,000.

The last expected cost associated with operation of the PARs is a calibration of the testing unit once every six years. This cost is expected to be approximately $1,000 per calibration. If this calibration took place once every year over the remaining life of the plant the year 2002 cost equivalent would be $13,053. Using a remaining life of 35 years, approximately six calibrations will be necessary for a year 2002 cost equivalent of $2,000.

Thus the total cost for industry operation is $0.028 M.

NRC Implementation

This attribute is an impact which measures the projected net economic effect on the NRC to place the proposed action into operation.

The proposed action (installation of PARs) would necessitate a rulemaking as well as revision to or development of regulatory guidance. The cost for a simple rulemaking is estimated to be $300,000. More complex rules can cost upwards of $1,000,000. It is likely that this rulemaking would generate many comments, thus, necessitating staff review and response to the comments. Therefore, a cost of $500,000 is estimated for the rulemaking or $8,000 per reactor assuming 60 units.

NRC Operation

This attribute is an impact which measures the projected net economic effect on the NRC after the proposed action is implemented. As a result of the proposed action, there will be an increased effort during inspections. This Increase is expected to be small, and not quantified in detail for the purposes of this analysis. An additional inspection cost of about $1,000/year is not unreasonable. Thus, the 2002 cost equivalent is $13,000.

Presentation of Results

Results for PARs

For PWRs with large dry containments, a requirement would be added to install and operate PARs.

Table 2: Results for PARs for PWRs with Large Dry Containments

Quantitative Attribute			Present Value Estimate ($M)/reactor (rounded to nearest $K)
Health (value)	Public	Accident	0.282
		Routine	0.000
	Occupational	Accident	0.001
		Routine	-0.002
Property (value)	Offsite		0.219
	Onsite		0.000
Industry (impact)	Implementation		1.624
	Operation		0.028
NRC (impact)	Implementation		0.008
	Operation		0.013
NET Value (Values minus Impacts)			**-1.173**

The Industry Value-Impact – the "per unit" Value-Impact times 60 units – is about -$70M. From Table 2, the Value-Impact is calculated to be:

$500K (Value) - $1,673K (Impact) or -$1.173M/plant.

<u>Thus the net value is negative, suggesting that the proposed action is not cost-beneficial.</u>

Consideration of uncertainties

The important uncertainties are those which would adversely affect the preliminary results of this Value-Impact assessment. Thus the uncertainties discussed here are those that would increase the magnitude of the "Values," listed in Table 2 or decrease the magnitude of the "Impacts" listed in Table 2.

- A suggested sensitivity analysis [2] is to change the discount rate from 7% to 3%. This affects the operational impacts and the public-accident and offsite-property values and is summarized in Table 3. The new Value-Impact is -$0.869M.

Table 3:Results for PARs for PWRs with Large Dry Containments: Discount Rate Sensitivity

<table>
<tr><td colspan="3">Quantitative Attribute</td><td>Present Value Estimate ($M)/reactor
(rounded to nearest $K)
3% Discount Rate assumed</td></tr>
<tr><td rowspan="4">Health
(value)</td><td rowspan="2">Public</td><td>Accident</td><td>0.468</td></tr>
<tr><td>Routine</td><td>0.000</td></tr>
<tr><td rowspan="2">Occupational</td><td>Accident</td><td>0.002</td></tr>
<tr><td>Routine</td><td>-0.003</td></tr>
<tr><td rowspan="2">Property
(value)</td><td colspan="2">Offsite</td><td>0.364</td></tr>
<tr><td colspan="2">Onsite</td><td>0.000</td></tr>
<tr><td rowspan="2">Industry
(impact)</td><td colspan="2">Implementation</td><td>1.624</td></tr>
<tr><td colspan="2">Operation</td><td>0.046</td></tr>
<tr><td rowspan="2">NRC
(impact)</td><td colspan="2">Implementation</td><td>0.008</td></tr>
<tr><td colspan="2">Operation</td><td>0.022</td></tr>
<tr><td colspan="3">NET Value (Values minus Impacts)</td><td>-0.869</td></tr>
</table>

- The key components of the public accident health value are (taken from Table 1):

	Consequences (person-rem)	Frequency (1/year)
Early Failures: Hydrogen Contribution	6×10^6	5×10^{-7}
Late Failures: Hydrogen Contribution	8×10^5	3×10^{-6}

The consequences listed are average values. They will be larger for some high-population sites and lower for low-population sites. As an example, for Zion (high population site) the consequences of an early hydrogen burn failure are estimated to be 1.8×10^7 person-rem [7], or three times larger than the value used in the analysis. (Other plants, of course, have values lower than the values used in the analysis.) Even if the high Zion values were used (a factor of three increase in consequences), the Value-Impact for PARs would still be negative, i.e., about -$600K. The frequencies shown are 10% of the average frequencies for early and late containment failures for PWRs with large-dry containments (average of all the IPE results). As discussed in the section on “Public Health (Accident),” frequencies given for hydrogen-related failures are considered conservative. Uncertainties would, for the most part, reduce the values further.

An uncertainty that would drive the Value-Impact to even larger negative values is the consideration of time added to an outage for the installation of the 40 PRAs. The analysis above assumes that the installation can be done with no impact on an outage. One day of added outage due to the backfit would add between $500K and $1,000K to the industry implementation costs.

Summary

In summary, the analysis indicates that the fleet of PWRs with large-dry containments would not benefit from a PAR backfit. The Value-Impact equals -$1,173,000/PWR or about -$70,000,000 for the fleet of PWRs. The previous study on hydrogen control for PWRs with large-dry containments [7] also concluded that a 100% effective hydrogen control system (Hydrogen Ignitor System), a system more effective in mitigating accidents than PARs (with the exception of accommodating loss of all electric power), is not beneficial.

References

1. "Regulatory Analysis Guidelines of the U.S. NRC," NUREG/BR-0058, Rev. 3, U.S. NRC, July 2000.
2. "Regulatory Analysis Technical Evaluation Handbook," NUREG/BR-0184, U.S. NRC, January 1997.
3. "Instrumentation for Light-Water-Cooled Nuclear power plants to Assess Plant and Environs Conditions during and following an Accident," Regulatory Guide 1.97, Revision 3, May 1983
4. *Applicant's Environmental Report - Operating License Renewal Stage, Turkey Point Units 3 & 4*. Florida City, FL, September 2000.
5. Mubayi, V. et al., "Cost-Benefit Considerations in Regulatory Analysis," NUREG/CR-6349, BNL, October 1995.
6. "Individual Plant Examination Program: Perspectives on Reactor Safety and Plant Performance, Vol. 2, Final Report, NUREG-1560, U.S. NRC, December 1997.
7. "Hydrogen Combustion, Control, and Value-Impact Analysis for PWR Dry Containments," NUREG/CR-5662, BNL, June 1991.
8. "Evaluation of Severe Accident Risks: Zion, Unit 1, NUREG/CR-4551," Vol. 7, Rev. 1, Part 2A, Brookhaven National Laboratory, March 1993.
9. "Performance Testing of Passive Autocatalytic Recombiners," NUREG/CR-6580, Sandia National Laboratory, June 1998.
10. B. Eckardt, et al., "Containment Hydrogen Control and Filtered Venting Design and Implementation," Framatome ANP, Offenbach, Germany, Date
11. Green, Kim. <kgreen@islinc.com> "Cost Information from Indian Point 2" 31 January 2002.
12. Henig, Michael. <Michael_Henig@dom.com> "SAMA Questions Final Response" 22 January 2002.
13. "Generic Environmental Impact Statement for License Renewal of Nuclear Plants Regarding the Arkansas Nuclear One, Unit 1," NUREG-1437, Supplement 3, Final Report, U.S. NRC, April 2001.