FOR PDR RELEASE

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

JAN 30 1987

RELEASED TO THE PDR

MEMORANDUM FOR: Robert M. Bernero, NRR
Richard W. Starostecki, IE
Richard E. Cunningham, NMSS
Denwood F. Ross, RES
Clemens J. Heltemes, Jr., AEOD
Joseph Scinto, OGC

FROM: James H. Sniezek, Chairman
Committee to Review Generic Requirements

SUBJECT: CRGR MEETING NO. 109

The Committee to Review Generic Requirements (CRGR) will meet on Monday, February 9, 1987, 1-3 p.m. in Room 6110 MNBB.

T. Speis (NRR) will present for CRGR review the enclosed proposed new Standard Review Plan Section 6.5.5, entitled "Pressure Suppression Pools as Fission Product Cleanup Systems." (Category 2 item.)

If a CRGR member cannot attend the meeting, it is his responsibility to assure that an alternate, who is approved by the CRGR Chairman, attends the meeting.

Persons making presentations to the CRGR are responsible for (1) assuring that the information required for CRGR review is provided to the Committee (CRGR Charter - IV.B), (2) coordinating and presenting views of other offices, (3) as appropriate, assuring that other offices are represented during the presentation, and (4) assuring that agenda modifications are coordinated with the CRGR contact (Walt Schwink, x28639) and others involved with the presentation. Division Directors or higher management should attend meetings addressing agenda items under their purview.

In accordance with the EDO's March 29, 1984 memorandum to the Commission concerning "Forwarding of CRGR Documents to the Public Document Room (PDR)," the enclosure, which contains predecisional information, will not be released to the PDR until the NRC has considered (in a public forum) or decided the matter addressed by the information.

James H. Sniezek

James H. Sniezek, Chairman
Committee to Review Generic Requirements

Enclosure: As stated

cc: (See page 2)

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cc: SECY
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W. Parler
T. Speis

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JC IPP is this O.K. for CRGR review? O.K. Walt S. JO

File CRGR MTG

109

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

DEC 2 2 1986

MEMORANDUM FOR: James H. Sniezek, Deputy Executive Director for Regional Operations and Generic Requirements

FROM: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

SUBJECT: PROPOSED NEW STANDARD REVIEW PLAN SECTION 6.5.5, "PRESSURE SUPPRESSION POOLS AS FISSION PRODUCT CLEANUP SYSTEMS"

The enclosed generic requirements review package contains a proposed new standard review plan section which, if approved, would add a procedure for establishing the fission product retention capabilities of BWR pressure suppression pools. This is a category 2 action.

The proposed item is one of the near-term items discussed and scheduled in an information paper transmitted to the Commission on February 28, 1986 by the EDO entitled "Implementation Plan for the Severe Accident Policy Statement and the Regulatory Use of New Source-Term Information (SECY 86-76). The proposed section does not place any requirement upon licensees, since no credit for fission product retention has previously been allowed in any operating license review. Licensees may opt for such credit, however, by appropriate license amendments. Its acceptance criteria and review procedures contain three features: (1) stated values for pool decontamination factors, such that licensees or applicants claiming minimal credit need not perform computer calculations, (2) technical specification limits on drywell leakage which are reviewed under SRP 6.2.1.1.C are also used to establish pool bypass rates, and (3) when the proposed new section is used to set retention credit, acceptance criterion 5 of SRP 6.5.1 is not to be applied. This last position is needed to prevent the use of SRP 6.5.1 to downgrade an existing standby gas treatment filtration system from being an effective engineered safety feature as defined under the testing guidance of Regulatory Guide 1.52.

The net effect of the proposed new section for existing licensees is a possible relaxation in current staff positions which has no significant detrimental effect on safety, but which provides more flexibility and some potential cost savings to the industry in meeting the regulations. Since fission product cleanup credit for BWR suppression pools was reviewed and approved by the staff for the GESSAR application, the effect of this SRP section will also be to provide uniform and consistent guidance to the staff for the review of this area.

An earlier draft of the attached package has been reviewed by the ACRS, and their comments have been accommodated. After any further changes arising from CRGR considerations, the proposed new section will be published for public comment.

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The proposed new section refers to the SPARC code, which is a part of the source-term code package developed by RES contractors. This code has only recently been updated to treat iodine vapor in addition to aerosols. A Brookhaven National Laboratory report is enclosed as a technical finding document. A reference appearing in the proposed section has not yet been printed, and a preprint has also been enclosed. These enclosures are intended to assist CRGR and ACRS members in their consideration of the general subject of pool retention, and contain no new guidance or criteria. A regulatory analysis, as specified in NUREG/BR-0058, Rev. 1 , is also enclosed. If the proposed section were applied using current Regulatory Guide 1.3 source term assumptions, there would be some net reduction in requirements. On the basis of the assessment of this reduction in the enclosed regulatory analysis, we conclude that public health and safety would be adequately protected if the proposed new section were implemented. The cost savings to an operating plant made possible by this net reduction in requirements, however, would be small.

Committee consideration of this matter by January 15, 1987, is requested.

Harold R. Denton, Director
Office of Nuclear Reactor Regulation

Enclosures:
As stated

DEC 22 1986

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

26 NOV 1986

MEMORANDUM FOR: Zoltan R. Rosztoczy, Chief
Regulatory Improvements Branch
Division of Safety Review & Oversight

FROM: Karl Kniel, Chief
Safety Program Evaluation Branch
Division of Safety Revision & Oversight

SUBJECT: CRGR PACKAGE - PROPOSED NEW SRP SECTION 6.5.5, "PRESSURE SUPPRESSION POOLS AS FISSION PRODUCT CLEANUP SYSTEMS"

In accordance with your requests, we have reviewed a parallel concurrence copy of the proposed CRGR Package. Based on our review, we will concur on the original concurrence package.

Karl Kniel

Karl Kniel, Chief
Safety Program Evaluation Branch
Division of Safety Review & Oversight

cc: L. Soffer
R. Frahm
R. Emrit
J. Read
R. Riggs

~~8612040220~~ 7A 1p.

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Harold R. Denton, Director
Office of Nuclear Reactor Regulation

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The net effect of the proposed new section for existing licensees is a possible relaxation in current staff positions which has no significant detrimental effect on safety, but which provides flexibility and some potential cost savings to the industry in meeting the regulations. Since fission product cleanup credit for BWR suppression pools was reviewed and approved by the staff for the GESSAR application, the effect of this SRP section will also be to provide uniform and consistent guidance to the staff for the review of this area.

An earlier draft of the attached package has been reviewed by the ACRS, and their comments have been accommodated. After any further changes arising from CRGR considerations, the proposed new section will be published for public comment.

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establish whether or not fission product scrubbing of the drywell or reactor compartment atmosphere is claimed or required for mitigation of off-site consequences following a postulated accident.

2.) Design Bases

A comparison is made to establish that the design bases for the suppression pool and the drywell or reactor compartment are consistent with the assumptions made in the accident evaluations of SAR Chapter 15.

3.) System Design

The information concerning the suppression pool is reviewed to familiarize the reviewer with the expected temperature histories, depth of fission product entry expected during postulated accidents and potential leakage paths through drywell penetrations.

4.) Testing and Technical Specifications

The details of the applicant's proposed preoperational tests, and, at the operating license stage, the surveillance requirements, are reviewed under section 6.2.1.1.C. The results of that review are examined to assure that pool depth and amount of leakage bypassing the pool are maintained consistent with the assumptions used in assessing the pool's effectiveness in fission product cleanup.

Proposed New Standard Review Plan Section

6.5.5 PRESSURE SUPPRESSION POOLS AS FISSION PRODUCT CLEAN-UP SYSTEMS

REVIEW RESPONSIBILITIES

Primary - Plant Systems Branch

Secondary - Reactor Systems

I AREAS OF REVIEW

Pressure suppression pools are reviewed under this plan only when the applicant claims credit for fission product scrubbing and retention by the suppression pool. The pressure suppression pool and the drywell, when considered as a barrier to the release of fission products, are reviewed to assess the degree to which fission products released during postulated reactor accidents will be retained in the suppression pool. Leakage paths which allow fission products to bypass the pool are identified and reviewed, and the maximum fractional bypass leakage is obtained, for use in the evaluation of radiological dose consequences.

1.) Fission Product Control Requirement

Sections of the SAR related to accident analysis, dose calculations, and fission product control are reviewed to

2. The bypass leakage assumed for purposes of evaluating fission product retention must be no less than that accepted in the review under section 6.2.1.1.C, and must be demonstrated in periodic tests by the license technical specifications also reviewed under that section.

3. For plants which have already received a construction permit, the iodine retention calculated using this section must not be used to justify removal of the standby gas treatment or other filtered exhaust system from status as engineered safety features. For such reviews, criterion II.5 of SRP 6.5.1 shall not be applied, and the charcoal absorbers must be at least maintained to the minimum level of Table 2 in Regulatory Guide 1.52, Revision 2.

Acceptable methods for computing fission product retention by the suppression pool are given in Subsection III, "Review Procedures."

III Review Procedures

The first step in the review is to determine whether or not the suppression pool is to be used for accident dose mitigation purposes. If no fission product removal credit is claimed in the accident analyses appearing in chapter 15 of the SAR, no further review is required.

II ACCEPTANCE CRITERIA

The acceptance criteria for the fission product clean-up function of the suppression pool are based on the following requirements from Appendix A of 10 CFR 50:

A. General Design Criterion 41 (Ref.1) as related to the control of fission products following potential accidents.

B. General Design Criterion 42 (Ref.1) as related to the periodic inspection of engineered safety features.

C. General Design Criterion 43 (Ref.1) as related to the periodic functional testing of engineered safety features.

Where they can be shown to be in compliance with these criteria, suppression pools may be given appropriate credit for fission product scrubbing and retention (except for noble gases, for which no pool retention is allowed) in the staff's evaluation of the radiological consequences of design basis accidents.

Specific criteria which must be met to receive credit are as follows:

1. The drywell and its penetrations must be designed to assure that, even with a single active failure, all releases from the core must pass into the suppression pool, except for small bypass leakage.

2. Pool bypass fraction

The fraction of the drywell atmosphere bypassing the suppression pool by leaking through drywell penetrations is obtained as a product of the review under section 6.2.1.1.C. If B is the bypass fraction and DF is the time-integrated pool decontamination factor, then the overall decontamination, D, to be reported to the Reactor Systems Branch for use in chapter 15 dose calculations may be taken as:

$$D = \frac{DF}{1 + B(DF-1)}$$

or

$$\frac{1}{D} = B + \frac{1-B}{DF}$$

The reviewer should clearly distinguish that fraction of B which may be further treated by the standby gas treatment system from that fraction of B which also bypasses secondary containment.

3. Other containment atmosphere clean-up systems

Plants having drywell or containment spray systems for which fission product cleanup credit is claimed are reviewed separately under section 6.5.2, and credit for both suppression pool and spray cleanup can be given as a result of the separate reviews.

If the suppression pool is intended as an engineered safety feature for the mitigation of off-site doses, then the reviewer estimates its effectiveness in removing fission products from fluids expelled from the drywell or directly from the pressure vessel through the depressurization system.

1. Pool decontamination factor

The decontamination factor (DF) of the pool is defined as the ratio of the amount of a contaminant entering the pool to the amount leaving. Decontamination factors for each fission product form as functions of time can be calculated by the SPARC code (Ref.2), and this calculation should be performed whenever the pool design is judged by the reviewer to differ significantly from those found acceptable as fission product cleanup systems in past reviews. If, however, the time-integrated DF values claimed by the applicant are 10 or less for particulates and 100 or less for iodine vapor the applicant's values may be accepted without any need to perform calculations (Ref. 3). A DF value of 1 (no retention) should be used for noble gases and, unless the applicant demonstrates otherwise, for organic iodides as well.

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If calculation of fission product decontamination is done using the SPARC code, the review should be coordinated with the Reactor Systems Branch, which is responsible for establishing the accident assumptions needed to assemble the input for the calculations.

function can be accomplished assuming a single failure. The applicant's proposed program for preoperational and surveillance tests will assure a continued state of readiness, and that bypass of the pool is unlikely to exceed the assumptions used in the dose assessments of Chapter 15.

The staff concludes that the suppression pool is acceptable as a fission product cleanup system, and meets the requirements of General Design Criteria 41, 42 and 43.

V IMPLEMENTATION

Except in those cases in which the applicant proposes an acceptable alternative method for complying with the specified portions of the Commission's regulations, the methods described herein are to be used by the staff in its evaluation of conformance with Commissions regulations.

Implementation of the acceptance criteria of subsection II of this plan is as follows:

(a.) Operating plants and OL applicants need not comply with the provision of this review plan section.

(b.) CP applicants will be required to comply with the provisions of this revision.

4. Technical Specifications

The technical specifications are reviewed to assure that they require periodic inspection to confirm suppression pool depth and surveillance tests to confirm drywell leak tightness consistent with the bypass fraction used in computing the overall decontamination. Technical specification review is coordinated with the Facility Operations Branch as provided in NRR Office Letter No. 51.

IV EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided by the applicant and that the review and any calculations support conclusions of the following type, to be included in the staff's Safety Evaluation Report:

> We have reviewed the fission product scrubbing function of the pressure suppression pool and find that the pool will reduce the fission product content of the steam-gas mixture flowing through the pool following accidents which blow down through the suppression pool. We estimate the pool will decontaminate the flow by a factor of _____ for molecular iodine vapor and by a factor of ____ for particulate fission products. No significant pool decontamination from noble gases or organic iodides will occur. The system is largely passive in nature, and the active components are suitably redundant such that its fission product attenuation

VI REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criteria 41, "Containment Atmosphere Clean-up", 42, "Inspection of Containment Atmosphere Cleanup Systems", and 43, "Testing of Containment Atmosphere Cleanup System".

2. P.C. Owczarski, R.I. Shreck and A.K. Postma, "Technical Bases and Users Manual for the Prototype of a Suppression Pool Aerosol Removal Code (SPARC)', NUREG/CR-3317, 1985.

3. P.C. Owczarski and W.K. Winegardner, "Capture of Iodine in Suppression Pools", 19th DOE/NRC Nuclear Air Cleaning Conference, Seattle, 1986.

Standard Review Plan 6.5.3, "Fission Product Control Systems and Structures," contradicts Regulatory Guide 1.3 by stating that suppression pools may be considered as fission product control systems, although no guidance or reference is supplied as to methods to be used in their review. In NUREG-0979, supplement 4, "Safety Evaluation Report related to the final design approval of the GESSAR II BWR/6 Nuclear Island Design," the staff agreed to consider suppression pool retention in any application referencing the approved design. Revisions prompted by new source term information and the replacement of TID-14844 by more realistic accident assumptions will result also in the revision of Regulatory Guide 1.3.

Regardless of whether an accidental release is assumed using the current Regulatory Guide 1.3 or using the most modern methods, it is an undue conservatism to ignore the capability of the suppression pool to mitigate off-site dose consequences, provided that recognition of such capability does not degrade safety.

The effectiveness of suppression pools in retaining gaseous iodine and particulate matter varies markedly with the conditions under which these materials are swept into the pool. While the overall effects of such variation can be calculated for any given postulated accident, this calculation would be uncertain in its predictions of the relevant conditions and would be very expensive to perform. It would be inappropriate to solve the problem of ignoring suppression pool effectiveness by replacing it with a required set of calculations that are

REGULATORY ANALYSIS OF THE REVIEW OF
SUPPRESSION POOLS AS FISSION PRODUCT
CLEANUP SYSTEMS

1. Statement of the Problem

Regulatory Guide 1.3, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors," states, as Regulatory Position C.1.f, that "No credit is given for retention of iodine in the suppression pool." Before the time this guide was first published, November 2, 1970, experiments had demonstrated the efficacy of suppression pools in removing iodine in several chemical forms from air-steam mixtures. The adoption of Regulatory Position C.1.f, therefore, was deliberately conservative. Factors which may have influenced its adoption are:

(1) drywells are generally leaky, permitting significant bypass of the suppression pool.

(2) suppression pool retention of fission products varies markedly with conditions pertaining during the accident, and would have required more complicated models than any being used in 1970.

(3) because of heavy reliance on standby gas treatment systems, suppression pool credit was not needed by boiling water reactors to meet the dose guidelines of 10 CFR 100.

SRP 6.5.3 could be revised to remove the statement allowing pool credit, and the GESSAR II SER could be amended to retract the earlier position. This course would remove the inconsistency between the SRP and Regulatory Guide but, in addition to ignoring the large volume of research data supporting pool credit, would provide an undue degree of conservation to the staff's review and be contrary to commission policy. (Goal 2.4, NUREG-0885, Policy and Planning Guidance, 1986)

The alternative selected is to propose an additional review plan section which would provide a consistent use of the available data without degradation of safety.

In proposing review procedures, two decisions were made concerning the means by which the review could be simplified.

(a) time-averaged decontamination factors (DF) were introduced,

(b) minimum DF values were stated, such that only applications claiming larger DF's would require plant specific computer runs.

These decisions were prompted by practical considerations in conducting reviews; not taking the proposed course would have required great computer expense in any review. If a novel suppression pool feature were proposed, such as, for example, a chemical additive or increased submergence depth of the downcomers or quenchers, the Source Term Code Package computer codes could be run to quantify the effectiveness of the pool. Use of the Source Term Code Package costs about $25,000 per accident sequence.

impractical for use in assessing effectiveness. To avoid this further problem, the present proposal takes a narrow interpretation by replacing the undue conservatism of omitting credit in favor of moderately conservative simplifications.

2. <u>Objectives</u>

The objective of the proposed action is to establish the degree to which suppression pools can be considered as fission product cleanup systems and by revising the Standard Review Plan (SRP) to include procedures and criteria for suppression pool design evaluation.

3. <u>Alternatives</u>

The existing SRP 6.5.3, "Fission Product Control Systems and Structures," in II.5, states that "Fission product retention credit assumed by the applicant for other systems, e.g., pressure suppression pools, may be acceptable provided that justification is supplied by the applicant."

This provision has been applied, so far, only in the review of the GESSAR-II application. The existing SRP, however, contains no procedures for reviewing pressure suppression pools. One alternative to the proposed new section, therefore, would be to continue to review pools on a case-by-case basis. This course would not consistently apply computer code and model validation experiments which have been devised for purposes of developing a means of calculating pool retention of fission products.

Apart from the containment buildings themselves, the most important accident off-site dose mitigation features of boiling water reactor plants under the SRP are the standby gas treatment systems (SGTS). These filtered exhaust systems are designed to have maximum effectiveness against the forms of fission product iodine assumed to be released by TID-14844. When reviewed against the fission product releases predicted by the new source term code package, however, suppression pools are capable of a high degree of retention of fission products. The proposed change will focus attention on suppression pools as dose mitigation features, and as a means of providing defense-in-depth in fission product mitigation capability.

The development of regulatory requirements for suppression pools might lead existing licensees to upgrade the quality of drywell penetrations, as part of measures to minimize pathways bypassing the pools. Drywell penetrations are already subject to leak testing at each refueling under SRP 6.2.1.1.C.

At present, Regulatory Guide 1.3 assumes that 22.75% of the core iodine inventory as molecular iodine, 1.25% as particulate and 1% as organic iodide are available for release from containment. Typical standby gas treatment systems (SGTS) serving BWR secondary containments as filtered exhaust systems are maintained at 99% efficiency against all of these forms, i.e., after one-hundred-fold decontamination 0.25% of the core iodine is exhausted into the environment as the sum of the primary containment and main steam line isolation valve leak rates following a DBA-LOCA.

The minimum DF values chosen are designed to be sufficiently small that no accident sequence is likely to be found to have a smaller time-averaged value, even allowing a margin of safety for uncertainties.

4. Consequences

By resolving the contradiction between Regulatory Guide 1.3 and SRP 6.5.3 in favor of the former, the staff would be denying a large body of evidence proving the efficacy of suppression pools in retaining fission products. This might be defensible on the grounds of being conservative, but would not permit the realistic consideration of core melt accidents as they are currently being modeled to be used in licensing decisions.

By continuing the present situation, i.e., taking no action, the contradiction would remain. Licensees could request suppression pool credit, based on the staff's GESSAR II statement, but the staff would have no consistent guidance for performing the review, and would be reduced to either accepting or rejecting the licensees' submittal, or running the source term code package repeatedly.

The consequences of the proposed new section would be the effect that increased pool credit would have upon the efficiency required of other fission product control systems in order to meet the dose guidelines of 10 CFR Part 100. A licensee could request pool credit to justify a relaxation of the maintenance and surveillance requirements placed on other systems.

Guide 1.3, even if molecular and particulate iodine forms are totally absorbed by the pool.

A 15-fold reduction in SGTS effectiveness, i.e., from a penetration test of 1% or less to one of 15% or less, would reduce its organic iodide absorption efficiency from 99% to 85%. Unfortunately, the SRP section dealing with SGTS review, 6.5.1, states that systems requiring iodine absorption efficiencies of less than 90% may be reviewed under SRP 11.3. Charcoal absorbers reviewed under SRP 11.3 may follow Regulatory Guide 1.140 rather than 1.52, and are not built or maintained to engineered safety feature standards. To prevent use of suppression pool credit to justify not maintaining and testing SGTS absorbers to Regulatory Guide 1.52 criteria, prior to revision of SRP 6.5.1, explicit mention of SGTS surveillance tests has been added as a criterion.

A typical SGTS contains about $20,000 of impregnated charcoal per train, with a comparable additional labor cost for renewing and testing if filter replacement is needed to pass a surveillance test. If the surveillance test criteria of a SGTS were relaxed, charcoal change-out would be required less often, perhaps reducing maintenance by of the order of 10^4 dollars per year.

It is also possible that a licensee might wish both suppression pool and maximum SGTS credits, while requesting an increase in allowable containment leakage. Again, a very large saving in the costs of containment integrated leak rate tests would not be expected, since the large degree of iodine fission product retention would not be associated

Against the same release to containment, the minimum decontamination factors in the proposed SRP 6.5.5 would reduce the 25% of the core iodine inventory available for primary containment leakage to 3.5%, assuming 10% suppression pool bypass leakage. For 1% pool bypass leakage, 1.6% of the core iodine inventory would be computed as available.

Using the assumed release in Regulatory Guide 1.3, and obtaining suppression pool scrubbing credit with 10% bypass, a typical BWR could meet 10 CFR Part 100 thyroid dose guidelines and still reduce the plant SGTS efficiency from 99% to 95%. It should not, however, be assumed that by reducing bypass leakage and claiming suppression pool credit a licensee could greatly reduce the surveillance testing requirements of their SGTS. Other design basis accidents, for example the fuel handling and instrument line break accidents, also require the use of the SGTS to meet the acceptance criteria of SRP 15.6.2, 15.6.5 Appendix B, and 15.7.4.

For a typical plant, the release of 3000 Ci of ^{131}I would lead to dose consequences in excess of the guidelines of 10 CFR Part 100. This amount is equivalent to only a few parts per million of the core inventory of iodine fission products. For a typical BWR, a million-fold reduction in iodine is mostly achieved by a low leakage containment (0.5% per day in 2 hours leaks $4X10^{-4}$) and to a lesser extent by the SGTS (10^{-2} penetration by iodine). Since suppression pools are virtually useless against organic iodide, and since it is not feasible to eliminate bypass completely, overall decontamination factors of more than about 15 cannot be practically achieved using the current iodine chemistry assumptions in Regulatory

5. Decision Rationale

Strategic goal 2.4 of the NRC Policy and Planning Guidance, 1986, lists as objectives the completion of the reassessment of source terms and the implementation of appropriate revisions in staff practices. The source term revisions will involve many related changes to the SRP and regulatory guidance, and may also include rulemaking and revision of existing regulations. The proposed action is perceived as an early step in this process, since it will put in place the review procedures and criteria necessary for considering the mitigation of new source terms by suppression pools.

The proposed section is equally applicable to the source term assumptions contained in Regulatory Guide 1.3 and to the fission product releases calculated by the Source Term Code Package. For both applications the proposed action offers the following advantages:

1.) Suppression pool fission product retention can be assumed to be described by conservatively chosen decontamination factors. The use of these factors avoids the large expense of computer analysis needed to quantify suppression pool response using the available computer codes. As discussed earlier, very large decontamination factors can be calculated, but the net effective decontamination achievable is limited by the possibility of pool bypass leakage.

with any change in the postulated noble gas releases during a LOCA. Licensees electing this course would be limited by the 10 CFR Part 100 guideline for whole body doses at the low population zone boundary over the course of the accident. For most BWRs, a doubling of the containment leak rate would bring the noble gas release consequences to the guideline, although for some plants having favorable meteorological parameters and large low population zones several-fold increases would still meet the guidelines.

While granting credit for suppression pool scrubbing, as proposed, would allow the deterministic licensing calculations of accident dose to be more easily met, the primary thrust of the change will be to allow greater BWR containment leak rates and more noncondensible accident fission products past SGTS filters. That is, existing BWR containment leak rates of about 0.5 volume percent per day maybe increased to as much as 5 volume percent per day, and 99 percent elemental iodine filter efficiencies maybe reduced to 90 percent. The change, therefore, may result in increases in the quantities of fission products postulated to be released during design basis accidents. However, regulatory guidelines would still be met, and the change in risk is expected to be very small since the bulk of public risk is attributed to accidents in which the containment fails or is bypassed (i.e., severe accidents not design basis accidents).

2.) Existing plants have the possibility of reducing maintenance costs for their charcoal absorbers by being able to retain the absorbent for longer periods of time between changes.

The cost savings of these advantages would vary with the degree to which licensees and aplicants elected to claim suppression pool fission product cleanup credit, and the number and diversity of accident sequences necessary to represent the effectiveness of the pool.

While releases of fission products as assumed in Regulatory Guide 1.3 are effectively reduced by filtered exhaust systems, the releases calculated for many accident sequences by the Source Term Code Package are more effectively reduced by suppression pool scrubbing. By adding guidance for the review of suppression pools as fission product cleanup systems in the form proposed, conservative but appropriately realistic credit would be assessed without significant loss of the safety afforded by existing filtered exhaust systems.

6. Implementation

The proposed action requires no action of existing licensees, except as they might voluntarily elect to reanalyze the accident consequences and submit an FSAR amendment to reduce reported iodine doses. This action would take effect upon publication of the proposed revision.

The SPARC simulation of pool scrubbing first relies on a description of the hydrodynamics of gases entering a water pool at a submerged depth. The hydrodynamics of the vent exit region are very important as are the hydrodynamics of the bubble swarm rise to the pool surface.

Particle Scrubbing

A number of phenomena have been identified as contributors to the particle scrubbing process. These are:

- particle inertia at the vent exit
- bubble inertia at the vent exit
- steam condensation at the vent exit
- temperature gradient at the vent exit
- steam formation during bubble rise
- particle growth
- bubble circulation during swarm rise
- bubble coalescence/redispersion during swarm rise.

The above phenomena are quantitatively modeled in SPARC for their roles in the particle capture mechanisms at the vent exits (centrifugal scrubbing, inertial deposition, steam condensation and thermophoresis) and during swarm rise (centrifugal scrubbing, gravity settling and Brownian diffusion). The centrifugal scrubbing here refers to deposition of particles at curved gas-liquid surfaces caused by the acceleration of particles in the radial direction as a result of tangential surface velocities.

Iodine Behavior

A number of aspects of iodine behavior are related to its capture in suppression pools. These aspects can be identified in three regions of the flow of gases. The first region is the flow of iodine species in the core-melt off gases in the reactor primary system. The second is the vent exit region in the pool and the third is the bubble swarm rise region in the pool.

In the primary system, where gases are hydrogen and steam and iodine species can be I_2, organic iodides, HI, and particulate iodides such as CsI, conditions can exist that favor the complete removal of the volatile inorganic species from the gas phase. These favorable conditions consist of a sufficiently low temperature so that alkaline aerosol particles can exist as a liquid or partially liquid phase. Alkaline hydroxides such as CsOH have this property in the vicinity of $300^{\circ}C$[4]. This liquid phase can be highly reactive with the volatile species HI and I_2. We speculate that solid CsOH can be reactive with these species as well. The SPARC code has a subroutine that allows the user to switch on this iodine absorption process in the primary system. The process is modeled as a continuous plug-flow reactor where spherical aerosol particles absorb elemental iodine at a rate controlled by the diffusion of I_2 in the gas phase around the particles. Although not modeled, HI would behave similarly to I_2, but with a slightly higher diffusion coefficient. The results of using this subroutine are discussed in III. Accident Sequence Results.

19th DOE/NRC NUCLEAR AIR CLEANING CONFERENCE

CAPTURE OF IODINE IN SUPPRESSION POOLS

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Abstract

The effectiveness of suppression pools in capturing airborne iodine species was investigated. A computer code was used to simulate the scrubbing of particulate iodide, vapor elemental iodine, and vapor organic iodides. For a typical postulated severe core damage accident sequence, suppression pools were effective scrubbers of elemental iodine if the pool was alkaline or dilute in iodine and of particles >1.5 μm mass median diameter. Little scrubbing of organic iodide species occurred. An absorption model shows that elemental iodine can be absorbed by wet alkaline droplets before the droplets encounter the suppression pool. Thus, the iodine removal effectiveness of the pools is likely to be controlled by particle scrubbing.

I. Introduction

The estimation of airborne source terms in postulated severe core melt accidents required the evaluation of the responses of nuclear reactor Engineered Safety Features (ESF) under accident conditions. As part of this evaluation, the Pacific Northwest Laboratory (PNL) has been studying the aerosol capture effectiveness of Boiling Water Reactor (BWR) pressure suppression pools.** The initial work assumed that fission product iodine would exist as CsI in the aerosol leaving the reactor primary system. Concern remains that other chemical species of iodine might exist, notably I_2 and organic iodides (represented by CH_3I). Continuing work reported here shows that the scrubbing effectiveness quantified by decontamination factors (DFs)+ of the pool varies dramatically for the three chemical species.

To estimate the pool scrubbing effectiveness on particles, PNL developed the SPARC code(1), which has been partially validated(2) with existing published data(3). The SPARC code was then modified to include I_2 and CH_3I scrubbing. An additional function of SPARC computes the absorption of I_2 by particles containing deliquescent CsOH.

II. Technical Bases Summary

This section summarizes the technical bases for the models in SPARC. The bases for most of the particle scrubbing models have been previously discussed(1) and will be briefly repeated here. Then the bases for iodine scrubbing will be discussed.

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+$DF = \dfrac{\text{mass flow rate of a fission product into pool}}{\text{mass flow rate of that fission product out of pool}}$.

scrubbing. No plans exist to measure volatile iodine scrubbing in large-scale experiments.

Accident Parameters

SPARC can be used to analyze pool scrubbing during the course of an accident scenario. A number of accident parameters must be defined for each time step when pool scrubbing is important. The most important set of parameters is the particle size distribution. The SPARC input parameters are listed below:

Pool

- noncondensable gas flow rate into pool
- noncondensable gas composition
- steam flow rate into pool
- pool depth, temperature
- pool size, configuration
- pressure above pool
- pool composition (surfactants)
- vent exit configuration

Aerosol Particles

- mass flow rate
- size distribution
- density/shape factors
- solubility in water (and fraction of soluble alkaline materials)

Iodine

- mass flow rates of each iodine species
- temperature and pressure of primary system

These parameters are defined for an example accident scenario in the next section.

III. Accident Sequence Results

To examine the behavior of iodine species in the pool, we used a specific postulated accident sequence to establish the pool, flow, and fission product characteristics for this study. The TC sequence[8] for a Mark I BWR was selected as a representative accident. In this accident, a transient event was followed by control rod insertion failure, but emergency core cooling systems operated. However, the reactor power level exceeded the cooling capability of the suppression pool. Overpressure failure of the containment occurred followed by stoppage of reactor vessel coolant flow. The core heated up and melted, releasing fission products into outflowing steam and hydrogen. During this melt release, these gases and fission products flow from the core through the primary system and suppression pool. It is for this period, from 134 to 168 min after the initiating transient, that we have analyzed the pool scrubbing effectiveness of iodine species as

As the gases leave the primary system, they enter the pool at a depth through a specific vent type. In the region of this vent, the gases try to equilibrate with the thermodynamic conditions of the pool at the vent depth. This equilibration process frequently results in steam condensation and scrubbing of particles. In SPARC, this condensation results in some deposition of I_2 and CH_3I, but is limited by the species solubility at the interface.

After the initial gas globules at the vent break up into the rising bubble swarm, the SPARC code assumes that bubble circulation continually renews the bubble interface and that the film theory of mass transfer resistance holds on both sides of the interface. The equilibrium boundary conditions at the interface for the two volatile iodine species are:

$$[TI_2(aq)]_i = H(I_2)[I_2(gas)]_i$$

and

$$[CH_3I(aq)]_i = H(CH_3I)[CH_3I(gas)]_i$$

where $[TI_2(aq)]_i$ = total liquid molar concentration of iodine at the interface as I_2.

$[I_2(gas)]_i$ = interfacial gas molar concentration of I_2

and $H(I_2)$ = iodine partition coefficient.

Similar definitions hold for CH_3I.[5] The aqueous chemistry of iodine is controlled by the fast reactions:

$$I_2(gas) = I_2(aq)$$

$$I_2(aq) + I^- = I_3^-$$

$$I_2(aq) + H_2O = H^+ + I^- + HIO$$

$$I_2(aq) + H_2O = H_2OI^+ + I^-$$

$$H_2O = H^+ + OH^-$$

By using the equilibrium constants for the above five reactions, the partition coefficient is quantitatively defined if mass balances of all iodine species and H+ and OH^- are maintained. The value of $H(CH_3I)$ is obtained in a simpler way using solubility and vapor pressure data.[6]

SPARC Validation

The particle capture models in SPARC have been partially validated with data as they become available.[2] The iodine capture models are validated by small-scale tests. The data of Diffey et al.[7] compare favorably with SPARC calculations for both I_2 and CH_3I

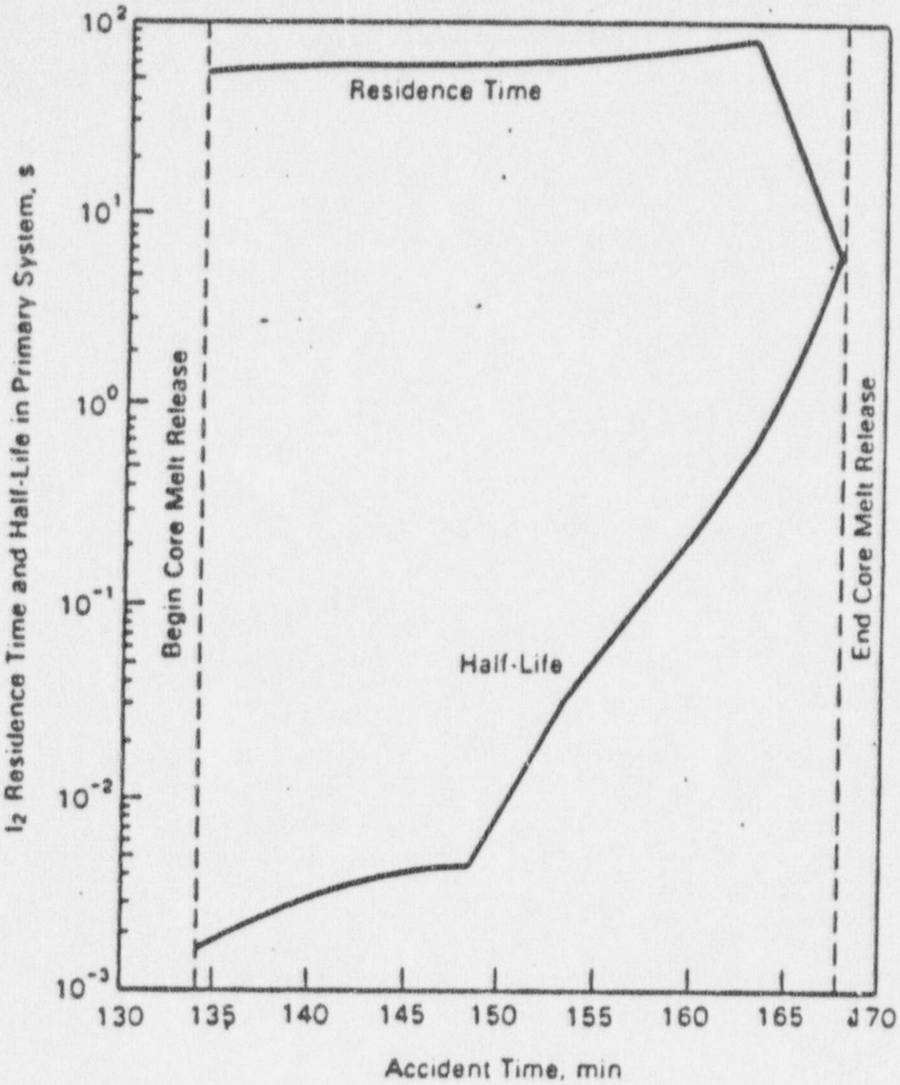

FIGURE 1
COMPARISON OF THE HALF-LIFE OF I_2 EXISTENCE IN THE PRIMARY SYSTEM WITH THE RESIDENCE TIME OF GASES IN THE PRIMARY SYSTEM (CASE 1)

The scrubbing of iodine species is portrayed in Figures 2 and 3. In the first figure, the instantaneous I_2, CsI, and CH_3I DFs are plotted versus time during the melt release. In Case 1, where CsI is the iodine species, the scrubbing of CsI generally increases in time because of the gradually increasing particle size until 154.5 min, where particle size stabilizes until the end of the melt release. However, steam and hydrogen gas flow increase dramatically at this point, and as a result the inertial particle capture mechanism at the vent exit increases the DF. In Case 2, where the iodine is elemental and the pool receives no alkaline particles, the iodine scrubbing is represented by the I_2 curve. Here the I_2 flow rate is fairly high until 148.5 min, then the rate (and incoming I_2 concentration) decreases. These decreases cause the pool scrubbing to become less effective at the iodine concentrations of the pool. However, in Case 3 the pool was allowed to increase in pH from incoming CsOH particles, the time history of iodine DFs was different. Then the instantaneous DFs were never less than 3×10^9 during the accident. The CH_3I curve well as any prior reaction of vapor elemental iodine with alkaline aerosol droplets in the primary system upstream of the pool.

The data pertinent to the SPARC analysis are summarized here: Aerosol flow rates ranged from 110 g/s at the beginning of core melt to less than 1 g/s at the end. CsOH ranged from 60 to 10 wt% of this aerosol. Iodine flow rates ranged from 9 to 1 g/s. Ninety-nine percent of this iodine was examined as either I_2 vapor or as CsI particles and 1% of the iodine was assumed to be as CH_3I. Particle sizes began at 1.5 µm mass median diameter and finished at 2.7 µm. Geometric standard deviations of the aerosol distribution and the aerosol particle density remained constant at 1.7 and 3 g/cm^3, respectively. Gases from the steadily depressurizing primary system (2 to 1.3 atm) maintained a temperature range of 340 to 360°C. Steam flow began at 1300 g/s and ended at 8 g/s. Hydrogen flow began at 170 g/s and ended at 110 g/s. These gas and aerosol flows entered the suppression pool through 13 t-quenchers at 12 ft submergence.

With the above aerosol and flow specifications, the SPARC code was run as three independent cases: Case 1 where the elemental iodine was allowed to be absorbed by alkaline aerosol droplets in the primary system, Case 2 where the alkaline materials were absent in the aerosol, and Case 3 where the CsOH was not allowed to react with the I_2 in the primary system. In Case 1, iodine was present as CsI in the particulate mass. In Case 2, the iodine remained as vapor I_2. Also, the pool did not have the benefit of becoming alkaline from CsOH particles, so I_2 scrubbing was affected by an initially neutral pool (pH = 6.5 at 100°C) that became slightly acidic at the end of core melt (pH = 5.9). In Case 3, the iodine also remained as I_2 vapor, but the pool became alkaline during core melt and reached pH = 8.3.

The first of the SPARC results examined is the behavior of elemental iodine in the primary system in Case 1. Here, I_2 was absorbed by wet alkaline particles in the short, once-through pass of gases through the primary system. The SPARC subroutine for these calculations computes the instantaneous absorption rate for the entire aerosol cloud in terms of the half-life of I_2 existence as the elemental form. The gas residence time in the Mark I primary systems, which splits the flow into two parallel streams, has a value of $2 \times 10^8/Q$ seconds where Q is the total primary system exit volumetric flow rate in cm^3/s. Figure 1 compares the half-life with the residence time for the melt release period of the TC sequence. Here it is evident that sufficient residence time exists from the beginning of the melt to nearly its end to absorb virtually all of the I_2. Only at the end of fuel melt does the residence time equal the half-life of I_2, which indicates that only one half the I_2 vapor is absorbed by droplets at that time. The iodine half-life increased with time because the concentration of particles decreased and particle sizes increased thereby decreasing the area available for absorption. The gas flow rate dramatically increased at 163 min resulting in the insufficient residence time for reaction.

Use of the primary system absorption model, Case 1, was done solely for demonstrating that elemental iodine (or HI) is not likely to exist as a species in the presence of particles containing CsOH in a moist environment.

The integration period starts at the beginning of the core melt. The initial DFs in both Figures 2 and 3 are identical. Cases 1 and 2 are again represented by the CsI curve and the I_2 curve, respectively. The important observation here is that even though the Case 2 pool is slightly acidic, the integrated DF is one order of magnitude greater than the Case 1 integrated DF. The final integrated DF for I_2 in Case 3 (alkaline pool) is 2×10^{11}, which is more than seven orders of magnitude larger than the corresponding Case 2 DF.

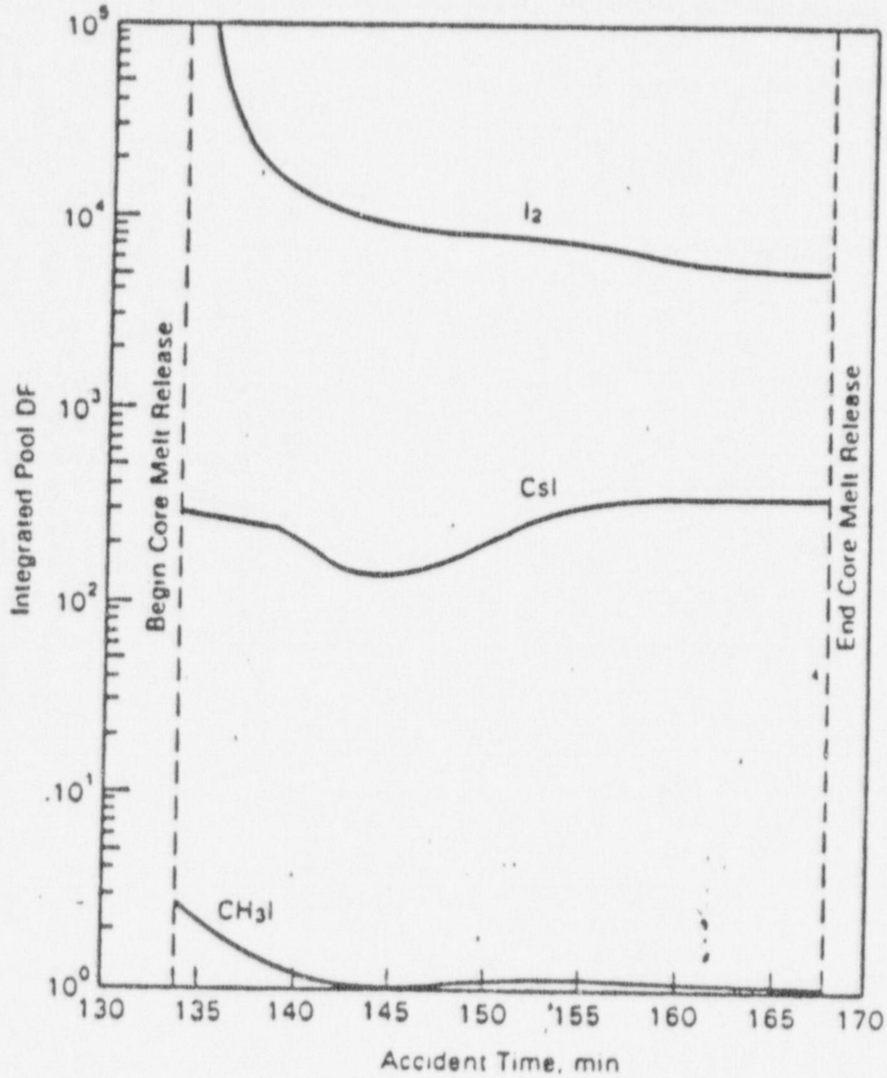

FIGURE 3
DECONTAMINATION FACTORS FOR IODINE SPECIES INTEGRATED OVER THE CORE MELT PERIOD. THE CsI CURVE REPRESENTS CASE 1, THE I_2 CURVE REPRESENTS CASE 2 AND THE CH_3I CURVE IS THE SAME IN ALL CASES

Some general conclusions can be drawn from the results of the core melt sequence above:

- Pool scrubbing of iodine can be very effective when iodine is I_2 vapor if the pool iodine concentration is low or if the pool is alkaline.

shows scrubbing initially and around 148 min, when incoming airborne concentrations are sufficient to drive CH_3I into the pool. Otherwise, the pool is stripped of CH_3I (DFs <1) during periods of low CH_3I concentration in the incoming gas. It should be noted that the 1% assumption does not affect the DFs for CH_3I.

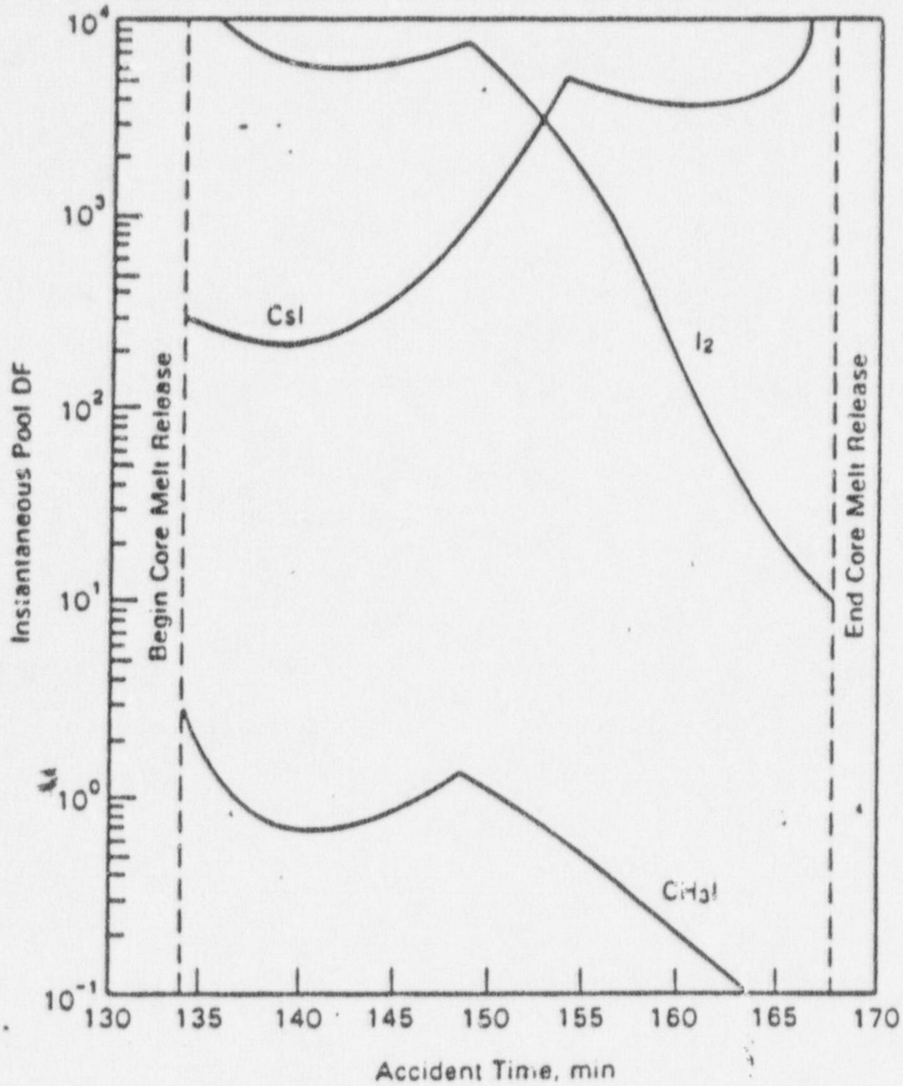

FIGURE 2
INSTANTANEOUS POOL DECONTAMINATION FACTORS FOR IODINE SPECIES DURING CORE MELT IN TC ACCIDENT SEQUENCE. CsI CURVE REPRESENTS CASE 1, I_2 CURVE REPRESENTS CASE 2 AND THE CH_3I CURVE IS THE SAME IN ALL CASES

Another representation of pool scrubbing is portrayed in Figure 3. Here, the time-integrated DF is portrayed over the core-melt period. This DF is defined (over the time period Δt) as

$$DF(\text{time-integrated})_i = \frac{\text{total mass of species i entering the pool in } \Delta t}{\text{total mass of species i leaving the pool in } \Delta t}$$

- Pool scrubbing of CH_3I is poor.
- Pool scrubbing of iodine as particulate CsI can be fairly effective for large particles (>1.5 μm mass median diameter)
- I_2 vapor cannot exist long in the presence of large numbers of wet alkaline droplets
- The limiting pool DF would be that of particulate CsI unless significant core iodine (>0.1%) is converted to CH_3I.

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TECHNICAL REPORT
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EFFECTIVENESS OF BWR PRESSURE SUPPRESSION POOLS IN RETAINING FISSION PRODUCTS

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ABSTRACT

The effectiveness of BWR suppression pools in retaining fission products released during severe accidents is assessed. Scrubbing models are reviewed and sensitivities to input parameters of SPARC Computer Code used in Source Term Code Package (STCP) are also discussed. An assessment of the effective decontamination factors for the suppression pools based on the results of recent STCP calculations performed by BNL and BCL is also presented.

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1. INTRODUCTION

The radiological source terms resulting from postulated severe reactor accidents have important implications regarding health and public risk. To assess the radiological consequences of reactor accidents, an evaluation must be made of the quantities and characteristics of releases of radionuclides from the fuel pins to the environment.

The fission product release and transport is strongly influenced among other things by reactor type, containment design and the engineered safety features.

In a boiling water reactor (BWR), the pressure suppression pool is designed to serve as a passive heat sink. In most accident sequences involving severe core damage, soluble gases and aerosol-laden gases vent through the suppression pool prior to escape to the outer containment building. The passage of these materials (gases, vapors, and particulate materials) through the water in the pool results in the removal of certain fission products.

This report presents information for the mitigative potential of pressure suppression pools in order to develop a technical basis for changes in regulatory requirements for such engineered safety features.

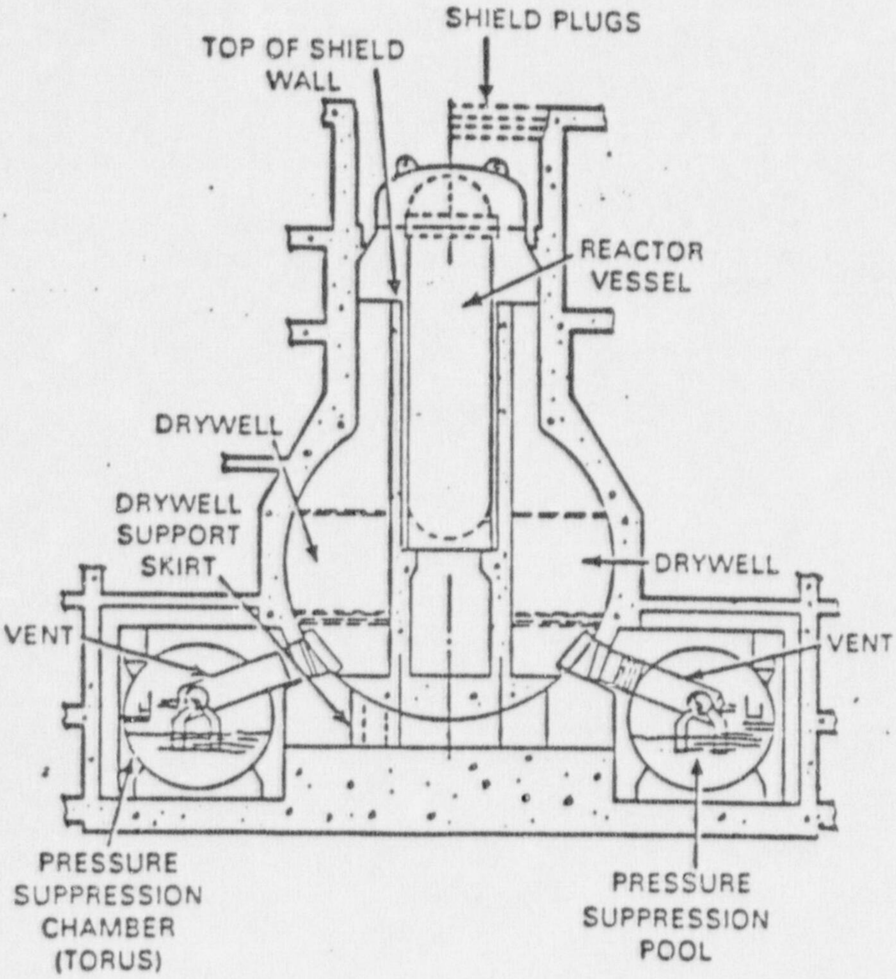

Figure 1 BWR Mark I containment system.

2. DESCRIPTION OF PRESSURE SUPPRESSION POOLS

The pressure suppression pool is primarily designed to reduce the primary containment pressure following a design basis accident. The three basic BWR containment designs (Mark I, II, and III) are illustrated in Figures 1 through 3. These three types of designs are similar in concept.

The Mark I design has a separate toroidal pool (wetwell) that is connected to the main part of containment (drywell) by large vent pipes. Typically, the suppression pools contain approximately 120,000 ft^3 of water. The torus containing the water has a major diameter of about 110 feet and a minor diameter of 30 ft. Ducts several feet in diameter connect the drywell to the wetwell torus. The large ducts branch through a vent header into multiple (typically 2-ft-diameter) downcomers that have their open lower ends submerged in the water. Steam can also be directed into the pool by separate lines from the safety/relief valves on the reactor's primary system.

The Mark II design is called the "over-under" design because the drywell is located directly above the wetwell. Steam released during an accident to the drywell is conveyed into the suppression pool by multiple vertical steel downcomer pipes. The downcomers penetrate the diaphragm floor separating the drywell and the wetwell. Vent valves in the floor allow free flow from the top of the wetwell back into the drywell.

In the Mark III design the wetwell is an annular region at the periphery of the containment. Water is retained by the weir wall (height approximately 20 ft) and steam discharges into the pool from the drywell through submerged, horizontal vents in the lower drywell wall in the event of a steam system rupture in the drywell. The safety relief valves on the primary reactor system discharge directly into large pipe headers that terminate at spargers submerged in the suppression pool. The suppression pool volume is typically about 160,000 ft^3, similar to a Mark II plant.

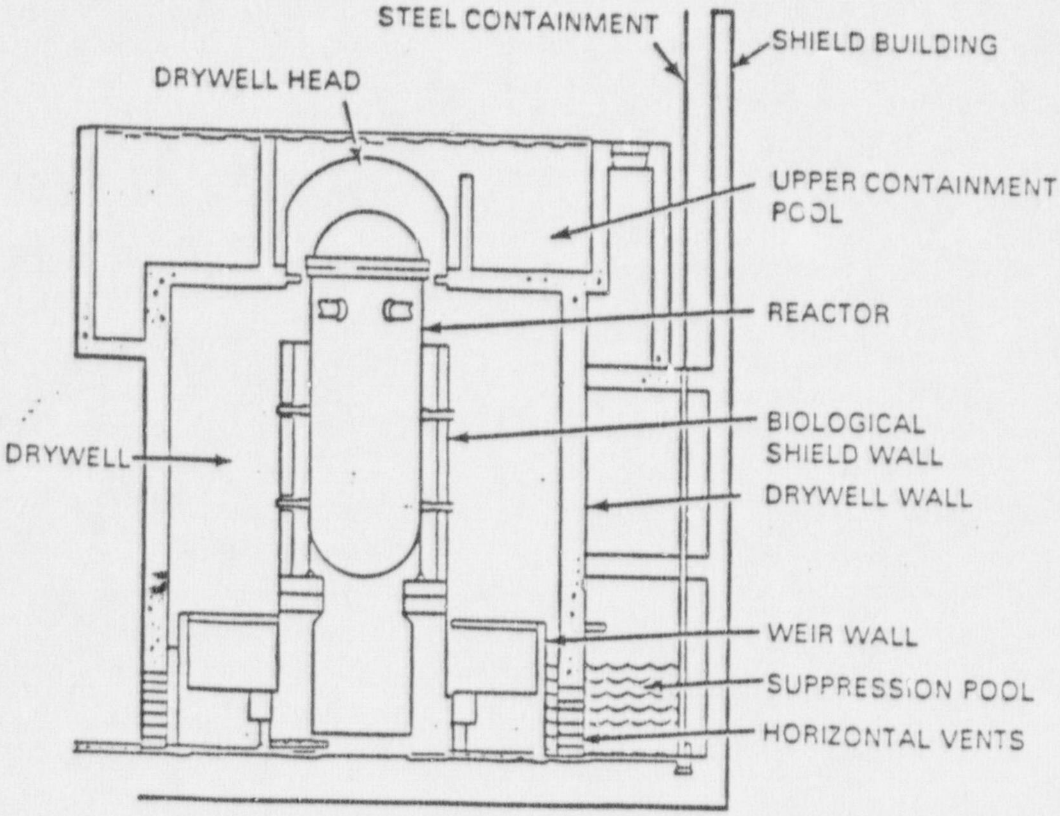

Figure 3 BWR Mark III containment system.

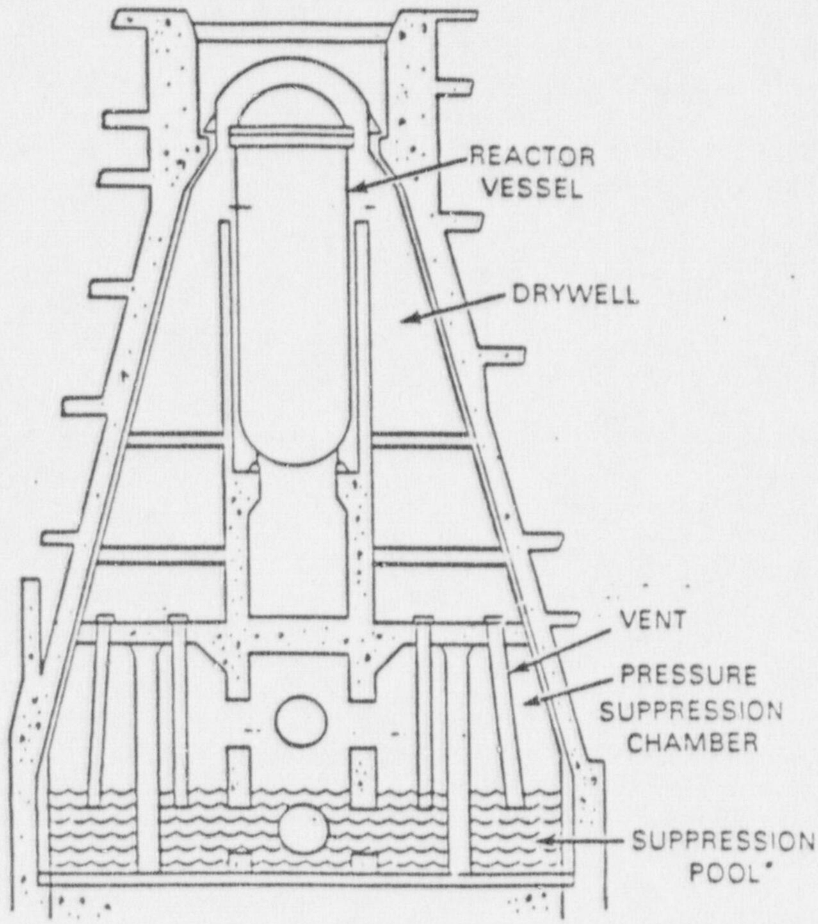

Figure 2 BWR Mark II containment system.

In addition to the three removal mechanisms modeled by Fuchs, the SPARC code considers the following additional mechanism.

- Steam condensations (no particle size dependence assumed).

- Convection caused by vapor flux to or from the bubble walls. The convection velocity is added algebraically to the deposition velocities calculated for other deposition mechanisms.

- Inlet impaction during gas injection into the pool.

- Particle growth in the bubble from water acquisition by deliquescing material in the particles. This is not specifically a removal mechanism, but it will enhance removal of larger particles by larger particle dominant mechanisms and degrade removal of smaller particles by small particle dominant mechanisms.

3.2 Experimental Validation of the SPARC Code

The phenomenological models included in the SPARC code are well supported by separate effects testing as found in the extensive literature on bubble dynamics and mass transfer between rising bubbles and liquid media.

Experimental studies of pool scrubbing have been conducted at Battelle Columbus Laboratories. The available data base consists of particle scrubbing measurements taken in a pool using a 0.5 in diameter horizontal injector.[9] The following conditions were varied during 56 different experiments: inert gas composition (air or helium), steam composition, gas flow rate, injector depth, pool temperature (ambient or near boiling), and aerosol (CsI, TeO_2, or Sn), size, solubility, density, and aerosol concentration.

Decontamination factor (DF) measurements for each experiment consist of the time-integrated particle mass flow rate into the pool divided by time-integrated particle mass flow rate out of the pool. Figure 4 presents a comparison of experimental values and calculations by the SPARC code as used in the STCP. These comparisons correspond to an underprediction by SPARC by an average factor of 6.2.[9]

3.3 SPARC Sensitivity Analyses

The sensitivity study of the SPARC code involves variations in the following important input parameters:

- Particle size of aerosols borne through the pool by gases

- The size of gas bubbles passing through the pool (DIAM)

- The aspect ratio of the gas bubbles (RATIO)

- The swarm rise velocity of the gas bubbles (VSWARM)

- The volume fraction of steam in inlet gas

3. PREDICTIVE METHODS

Several models have been developed for predicting aerosol scrubbing efficiencies in BWR suppression pools. The Fuchs' model of particle removal from single spherical bubbles[2] is the basis of all particle scrubbing models and codes currently in use for nuclear reactor analysis. These models include; (1) SPARC,[3] developed under NRC sponsorship by Battelle Pacific Northwest Laboratory, (2) SUPRA,[4] developed under EPRI sponsorship by SAIC and (3) a model developed by General Electric.[5]

Several models have also been developed for scrubbing efficiency of soluble gases. Diffey et al.[6] proposed a model for scrubbing efficiency of elemental iodine based on the assumption that iodine in the gases leaving the pool is in equilibrium with iodine in the water pool. The experimental measurement reported by Diffey et al. seems to support the plausibility of their model. DeVell et al.[7] carried out experiments with I_2 in water at 100°C and concluded that iodine in gas bubbles did not necessarily reach equilibrium with iodine in the liquid and thus, extended the Diffey et al. model to account for the degree of saturation. SUPRA also includes models for scrubbing gaseous fission products. More recently, models for elemental and organic iodine scrubbing have also been added to the SPARC code.[8]

In the following sections, the SPARC (as used in the STCP) aerosol scrubbing model will be discussed and the code results will be used to illustrate the variation in scrubbing decontamination factors over a range of input parameters selected to reflect the current uncertainty in their values.

3.1 SPARC (Suppression Pool Aerosol Removal Code)

The SPARC computer code[2] has been developed to calculate the behavior of aerosol particles in the pressure suppression pool under conditions that may be predicted to result from a postulated accident. The code calculates the scrubbing of the aerosol particles from the gas mixture bubbling through the pressure suppression pool. This calculation is handled in terms of a decontamination factor (DF) per particle size.

Fuchs' model of particle removal from single, spherical bubbles is the basis of particle scrubbing models used in the SPARC code. In the Fuchs' model, the dominant scrubbing processes take place inside rising bubbles. This model identifies three mechanisms of particle removal. They are:

1. Brownian diffusion of particles to the bubble wall (dominant for smaller particles).

2. Gravitational settling of particles to the lower bubble wall (dominant for larger particles).

3. Inertial deposition of particles on the bubble wall driven by the centrifugal acceleration produced in the internal circulation of the gas in the bubble (dominant for larger particles).

There are other less important input parameters to SPARC such as pool temperature, pool depth and percent of soluble material in particles.

Aerosol particle size is a parameter obtained from the result of calculations with the VANESA and TRAPMERGE models of Source Term Code Package (STCP). The sensitivity of the SPARC analyses to this parameter is reduced as the breadth of the particle size distribution is increased.[10] The volume fraction of steam in inlet gas is a sequence-dependent quantity calculated by the MARCH code. In this section decontamination curves calculated by SPARC will be presented to illustrate the importance of the user input parameters, namely, the bubble size, the bubble shape, and the bubble rise velocity. The parameter ranges for these variables that are chosen reflect a reasonable range of uncertainty.

Experimental studies of gas liquid hydrodynamics have been conducted at BCL.[11] Tests have been conducted using mixtures of condensable (superheated steam) and noncondensable (air, helium, or hydrogen) gases injected into water pools through single hole and multihole configurations typical of those found in BWR quencher pipes. In an actual accident situation, swarms of bubbles rather than single bubbles will be encountered. The bubble size in these swarms is a distribution. The bubble size distribution has been found to be independent of the injection-flow rate and injection angle. There is, however, a dependence on condensable steam fraction. The distribution is well described by a lognormal distribution with mean diameters of 0.55 cm and 0.35 cm for low and high steam volume fraction respectively, and with a constant standard deviation of 1.5. The bubble diameters selected for the sensitivity study are 0.3 to 0.9 cm to reflect the range of uncertainty associated with this parameter.

Aspect ratio and bubble diameter are related, the larger bubble being more elliptical. This relationship also depends on water purity. Figure 5 shows the aspect ratio of bubbles as a function of their equivalent spherical diameter. Two correlations from Clift et al.[12] are given. One is for pure water and the other for contaminated water. Impurity levels of parts per million range are sufficient to produce more nearly spherical bubbles. Figure 5 also shows a correlation developed by BCL based on their experimental results. The aspect ratio selected is based on the Clift correlation for contaminated systems.

The resulting SPARC sensitivity to bubble diameter and aspect ratio is presented in Fig. 6. The important input parameters for these cases are presented in Table 1. The input parameters to SPARC which are calculated by preceding codes in the STCP are taken from a recent BNL calculation for a typical time frame in the Peach Bottom TC2 sequence (TIME = 90 min).

The bubble swarm rise velocity determines the residence time for scrubbing. For a single bubble rising in an infinite pool, terminal velocity measurements for a large number of gas - liquid systems have been performed.[13] For an air bubble rising in a stagnant water pool, the experimental data reported by Haberman and Morton[14] shows that the terminal rise velocity is nearly constant at about 0.24 m/s for bubbles with equivalent diameters between 2 and 20 mm. For a swarm of bubbles the drag force between the bubbles and the surrounding liquid will create significant circulation current in the liquid. Inside the bubble column the rising gas bubbles pump liquid from

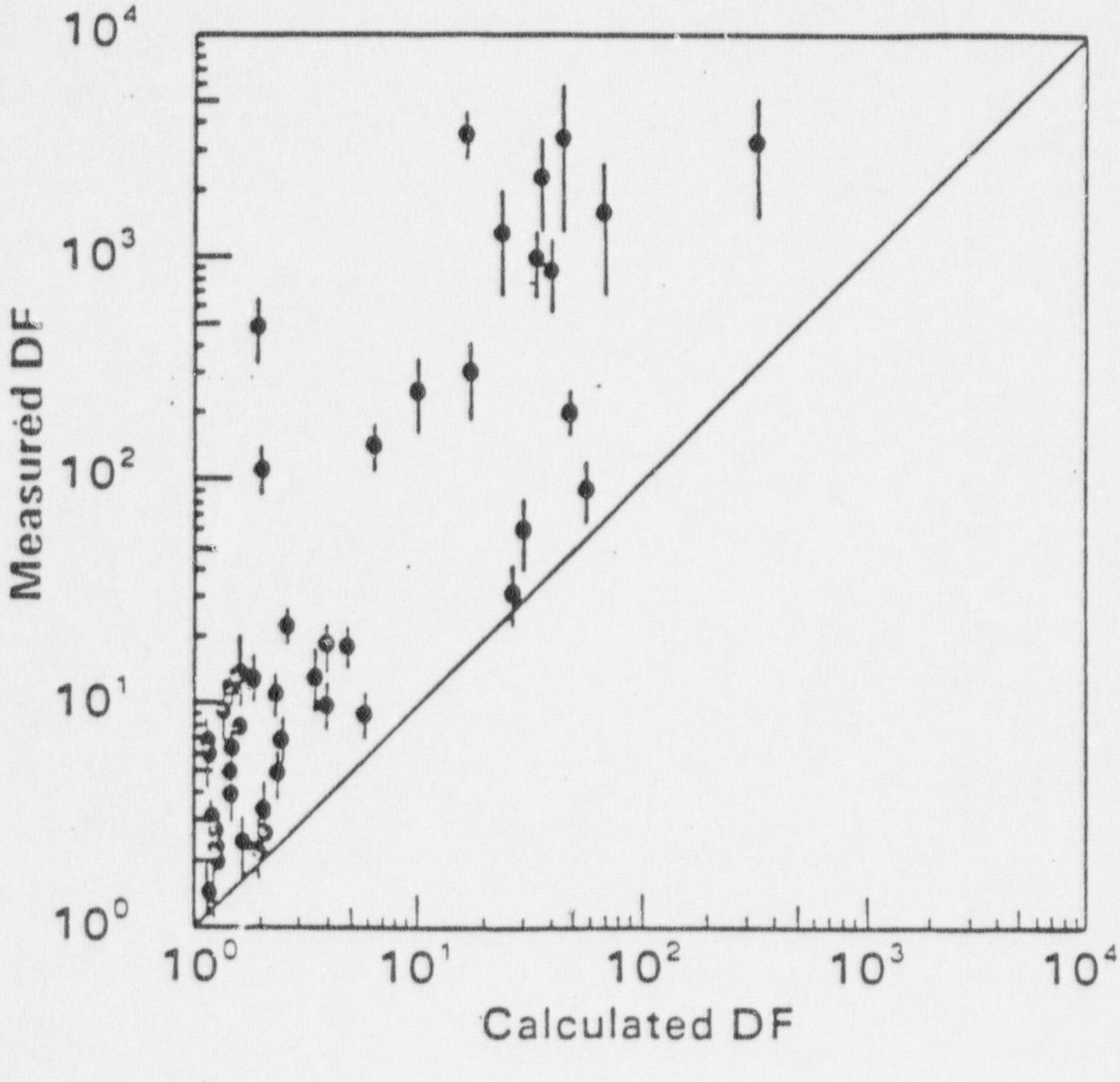

Figure 4 Comparison of SPARC calculated decontamination factors with BCL experimental values for 1/2 in diameter horizontal injector.

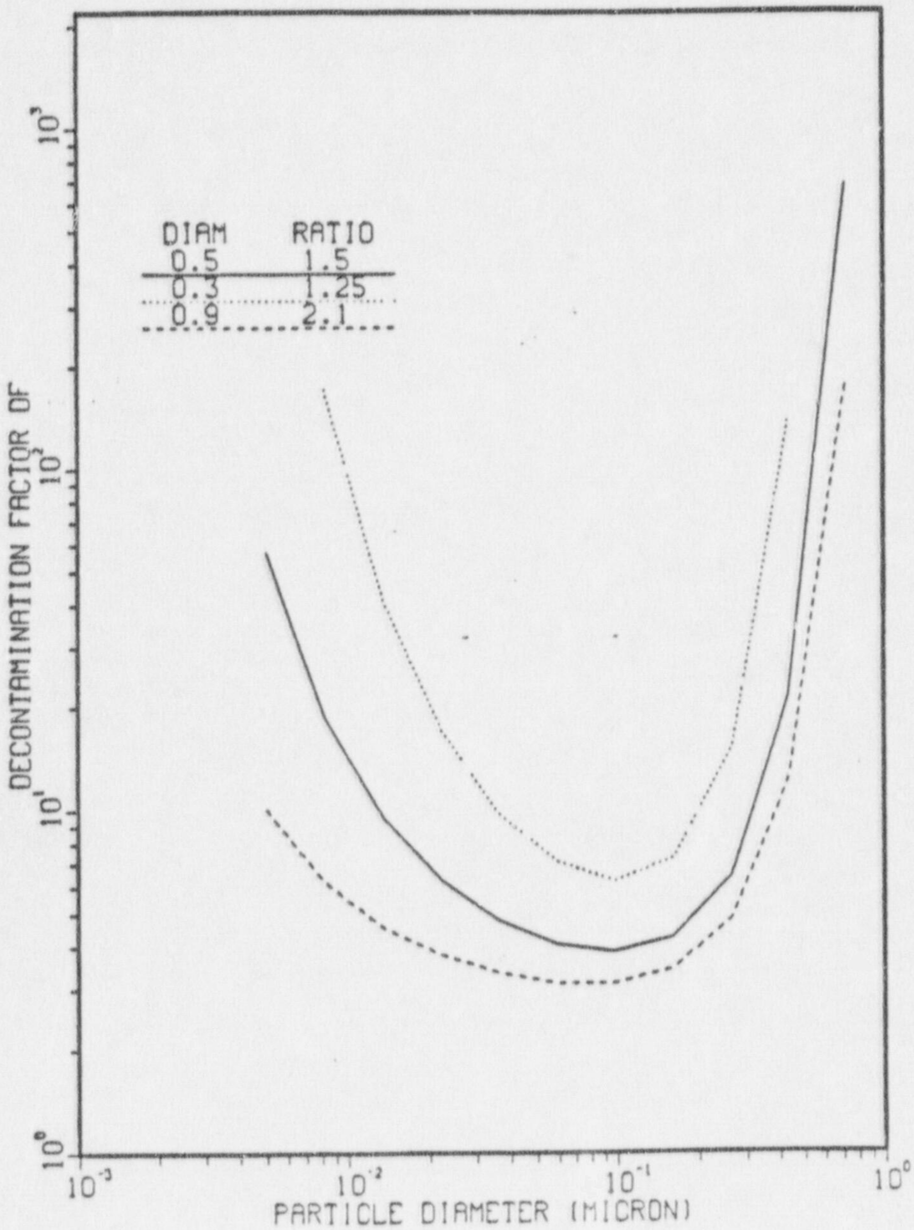

Figure 6 Effect of bubble diameter and aspect ratio on DF.

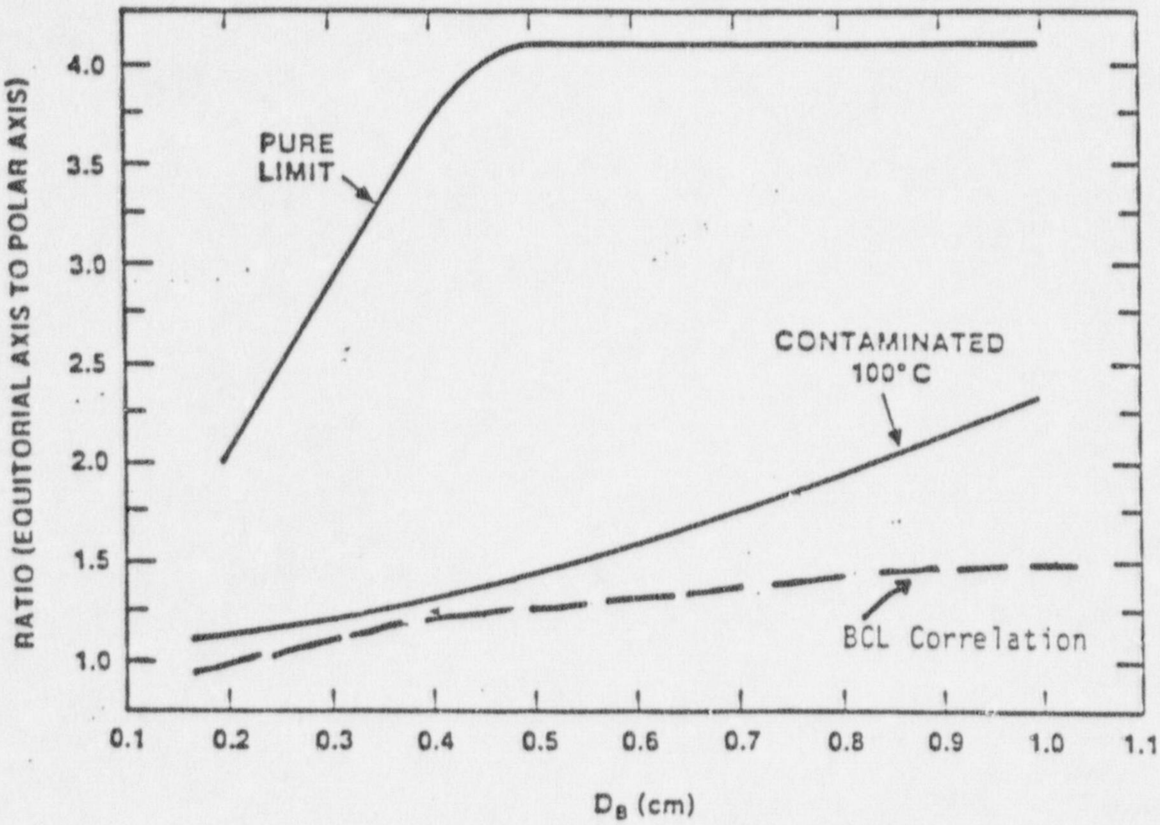

Figure 5 Variation in bubble aspect ratio with mean bubble diameter.

the bottom of the pool to the surface. The local liquid velocity inside the bubble column increases the bubble rise velocity relative to a stationary observer outside the pool. In the BCL experiments,[11] the bubble rise velocities have been measured relative to a stationary observer outside the tank for different gas injection rates. The typical spatial distribution of bubble rise velocities in the bubble column varies between 20 cm/sec at the outer edge of the bubble column to 100 cm/sec at the centerline of the bubble column. The values ranging from 20 to 116 cm have been chosen for the purpose of the present analyses. The higher value of 116 cm/sec was chosen because it corresponds to the value used in the BNL and the BCL STCP calculations.[16-18]

The result of sensitivity of SPARC with respect to bubble swarm rise velocity is presented in Fig. 7. The important input parameters for these cases are also presented in Table 1 and are based on BNL STCP calculations of Peach Bottom TC2 Sequence (TIME = 116 min).

The various uncertainties identified in the sensitivity study of the SPARC model are estimated to lead to an order of magnitude uncertainty in the pool decontamination. This conclusion is consistent with the QUEST study for the Grand Gulf TC sequence performed by Sandia National Laboratory.[10] It should be noted that the SPARC underpredicts the DF values due to both unmodeled phenomena such as fragmentation and coalescence of bubbles as well as uncertainties associated with the code input parameters. As indicated earlier, the DF values in the BNL and BCL recent STCP calculations are similar to the lower bound estimates of the present sensitivity study.

3.4 Soluble Gas Scrubbing

Mechanistic models for elemental and organic iodine scrubbing have been added recently to the SPARC computer code. A good comparison between available experimental data and the SPARC prediction has been observed.[8] An integral decontamination factor of the order of 7000 for elemental iodine (I_2) has been calculated for the Peach Bottom TC1 sequence.[8,15] Due to high solubility of HI in water (relative to I_2), a higher integral decontamination factor for hydrogen iodide is expected. An exact quantification of pool scrubbing efficiency for various soluble gases requires detailed calculations using any of the available models discussed previously.

Table 1 The Input Parameter Values to SPARC (Calculated by Preceding Codes in the STCP)

	TIME = 90 min	TIME = 116 min
Pool Temperature (°C)	113.	115
Pressure Above Pool (ATM)	4.75	5.58
Inlet Gas Flow Rate (G/SEC)		
H_2O	1.27E+4	4.03E+4
H_2	5.12E+2	1.06E+2
CO_2	0.	0.
CO	0.	0.
Air	0.	0.
Inlet Gas Temperature (°C)	517	451
Inlet Gas Pressure (PSIG)	49.5	61.
Particle Material Density (G/CC)	3.	3.
Percent Soluble Material	0.35	0.37

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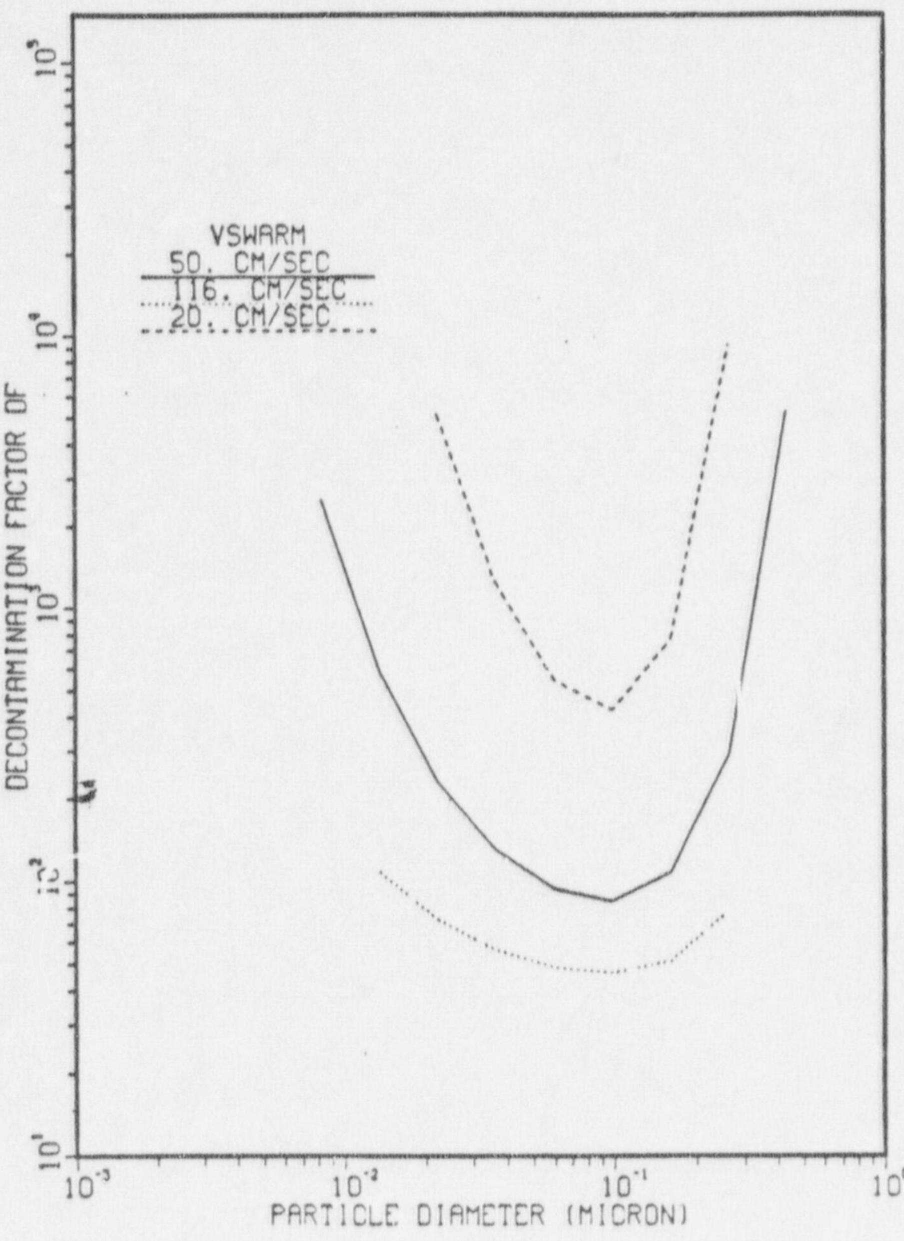

Figure 7 Effect of bubble swarm rise velocity on DF.

Table 2 Effective (Time Averaged) In-Vessel Release Decontamination Factors for the Suppression Pool (Peach Bottom Mark I)

Fission Product Group	In-Vessel DF	
	TC2 Sequence	TB1 Sequence
CSI	200	Large*
CSOH	300	Large
Te	250	Large

*Due to inconsistencies in the reported values, an exact quantification is not possible.

4. EFFECTIVE DECONTAMINATION FACTORS FOR THE SUPPRESSION POOL

One of the major considerations in predicting the scrubbing effectiveness of suppression pools is the definition of the environment and conditions that could conceivably challenge the pool. This section of the report presents a sequence-based assessment of the effective decontamination factors for the BWR suppression pools. The information is based on the results of Source Term Code Package (STCP) calculations performed by BNL[16] and BCL[17,18] for Peach Bottom (Mark I) and Grand Gulf (Mark III) plant subject to a postulated severe accident condition.

4.1 Peach Bottom (Mark I)

Peach Bottom Unit 2 Power Plant was included in the BCL and BNL STCP radionuclide release calculations. Peach Bottom, which is a General Electric BWR 4/Mark I design, has been in operation since early 1970. The accident sequences selected for BCL detailed source term analysis includes of (1) TC, an anticipated transient without scram, (2) TB, a station blackout scenario, and (3) V, an interfacing system LOCA sequence. These sequences were selected on the basis of preliminary ASEP results on accident sequence probabilities as well as preliminary SARRP containment event tree quantification. In this section, the results of Source Term Code Package Calculations for one variation of TC (TC2) sequence and one variation of TB (TB1) sequence ~~is~~ are used to assess the effective decontamination factors for the BWR/Mark I suppression pools.

In the TC2 sequence the failure to scram is accompanied by the failure to achieve early power reduction as well as the failure to achieve emergency depressurization. The primary coolant inventory is maintained by the combination of the HPCI, RCIC, and the CRD systems. As the suppression pool heats up due to the continuing large steam input through the safety/relief valves, failure of the safety systems could take place due to loss of lubrication oil cooling, seal overheating, etc. In the present analysis the HPCI was assumed to fail at a suppression pool temperature of 200°F, and the RCIC was assumed to fail at a containment pressure of 25 psia, due to high turbine exhaust back pressure. The CRD system, which takes its suction from the condensate storage tank, would continue to operate as long as the water in the latter was available. The CRD flow is insufficient to keep the core covered and cooled, and eventual core melting would take place. The containment would be intact during the initial core melting in this sequence, but would fail shortly after the reactor vessel failure.

For the TB1 scenario loss of all off-site and on-site AC power leads to the loss of all active engineered safety features except the steam powered emergency core cooling systems. The latter, however, require DC power for operation and would fail when the station batteries are depleted; the latter has been estimated at six hours after the start of the accident. In such an event, core uncovery and melting takes place with the containment initially intact; containment ~~failure~~ is assumed to fail late in the accident sequence.

In both sequences considered, the in-vessel fission product release due to core degradation and melting which consists primarily of CsI, CsOH, and Te are free to pass down the safety relief lines and into the suppression pool through the quenchers, and these are subject to pool scrubbing. Table 2 presents the implied decontamination factor (DF) for the in-vessel phase, for

Containment failure in this case would be expected due to the buildup of non-condensables during the attack of the concrete foundation by the core debris. For the early containment failure variation of the station blackout scenario, containment failure was assumed to occur immediately after reactor vessel failure due to a large hydrogen burn. The expulsion of the hot core debris from the primary system is the obvious ignition source. In the analysis of this scenario, a large leakage between the drywell and the outer containment was assumed after vessel and containment failure; this implies some degradation of the boundary between the drywell and containment due to the events associated with primary system failure or the hydrogen burn.

In all three sequences considered, the in-vessel fission product release due to core degradation and melting, primarily of CsI, CsOH, and Te, are subject to pool scrubbing. Table 3 presents the implied decontamination factor (DF) for the in-vessel release phase for the three calculated sequences.

In the TC and TB2 sequence, the fission product released during core/concrete interactions can bypass the suppression pool. However, in TB1 sequence it is assumed that most of the Te and refractory fission products during the ex-vessel release phase pass through the suppression pool. These fission products consist primarily of Ba, Sr, La, and Ce with lesser quantities of Te (a proportionately larger fraction of Puff release at the time of pressure vessel failure is Te due to its later release time, during the melt release phase). Table 4 presents the effective ex-vessel release decontamination factors for TB1 sequence.

The DFs corresponding to the ex-vessel release phase are smaller than the DFs for the in-vessel release phase because:

1) The gases evolved ex-vessel contains less condensable gas (steam)

2) The pool temperature is higher later in the accident sequence

3) The ex-vessel aerosol particle sizes are smaller

4) The depth of the suppression pool during the release under water is smaller for the ex-vessel release.

The values for in-vessel release decontamination factors for the TC sequence shown in Table 3 are of the same order of magnitude as the lower bound estimates in the QUEST study[10] for the Grand Gulf TC sequence performed by Sandia National Laboratories. (In-vessel release DF values for Cesium, Iodine and Tellurium reported in the QUEST study is 111). The lower bound ex-vessel release DF value for Tellurium reported in the QUEST study is 5 compared to 10 obtained in the present study.

both BNL TC2 and BCL TB1 calculated sequences. The variation of DF with fission product species is due to the fact that the various species are released at different times and thus experience different conditions in the pool.

In the TC2 sequence, the containment was assumed to fail at the time of pressure vessel failure. This ensures that the fission products released during core/concrete interactions can bypass the suppression pool. However, in the TB1 sequence, it is assumed that the containment failure occurs late and therefore most of the Te and refractory fission products released ex-vessel are passed through the suppression pool. These fission products consist primarily of Ba, Sr, La, and Ce with lesser quantities of Te (a proportionately larger fraction of the puff release at the time of pressure vessel failure is Te). In this case, the DFs corresponding to the ex-vessel release phase were found to be negligible as compared with DFs for the in-vessel release phase.

The BCL STCP results for another variation of TC, TC3, which is identical to TC2 except for inclusion of containment venting, was also studied. With venting all the releases pass through the suppression pool but due to inconsistencies in the reported values, no quantification of ex-vessel release decontamination factors was possible at this time.

4.2 Grand Gulf (Mark III)

Selected severe accident scenarios for the Grand Gulf Unit 1 Power Plant were included in the BCL STCP radionuclide release calculations. Grand Gulf Unit 1, which is a General Electric BWR 6 with Mark III containment, began operations in June 1982. The accident sequences selected for BCL detailed source term analysis consists of (1) TC, an anticipated transient with scram, and (2) TB, a station blackout scenario. These sequences were selected on the basis of preliminary ASEP results on accident sequence probabilities as well as preliminary SARRP containment event tree quantification.

For the TC sequence, the containment was assumed to fail by overpressurization prior to core melting due to the elevated power input to the suppression pool associated with the failure to scram; containment failure was assumed to lead to failure of the emergency core cooling system pumps. It was also assumed that the Automatic Depressurization System (ADS) would be activated prior to containment failure and subsequent core uncovery. In the analysis of the containment response, nominal leakage between the drywell and the outer containment bypassing the suppression pool was assumed.

Two variations of the station blackout (TB) scenario were considered. In the first, late containment failure was considered and in the second, the containment was assumed to fail at the time of reactor vessel failure. With the complete loss of electric power in this sequence, all the active engineered safety systems, with the exception of the steam turbine driven emergency core cooling systems, would be unavailable. The turbine driven pumps would operate as long as the station batteries were available. The latter were assumed to be depleted at six hours after the start of the accident. Also, in the absence of electric power, the ADS, upper pool dump, and the hydrogen igniters would not be able to perform their functions. Thus, core overheating and melting would take place with the primary system at elevated pressure. For the late containment failure variation of the station blackout sequence, nominal leakage between the drywell and the outer containment was assumed.

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Table 3 Effective (Time Averaged) In-Vessel Release Decontamination Factors for the Suppression Pool (Grand Gulf Mark III)

Fission Product Group	TC Sequence	TB1 Sequence	TB2 Sequence
CsI	85	50	60
CsOH	80	55	65
Te	40	40	50

Table 4 Effective (Time Averaged) Ex-Vessel Release Decontamination Factors for the Suppression Pool (Grand Gulf Mark III)

Fission Product Group	Ex-Vessel DF
Sr	25
Ba	20
La	15
Ce	30
Te	10

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5. SUMMARY AND CONCLUSIONS

The scrubbing models and sensitivity to input parameters of SPARC computer code used in Source Term Code Package (STCP) have been discussed. The various uncertainties identified in the sensitivity study of SPARC model were estimated to lead to an order of magnitude uncertainty in the decontamination factor by the suppression pool.

An assessment of the effective decontamination factors for the suppression pools based on the results of Source Term Code Package (STCP) calculations performed by BNL and BCL has also been presented. The DF values in these calculations correspond to the lower bound estimates of the sensitivity study. It is seen that variation in pool decontamination factors are a functions of sequence and system being considered and the DFs corresponding to the ex-vessel release phase are smaller than the DFs for the in-vessel release phase.

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17. R. S. Denning et al., "Radionuclide Release Calculations for Selected Severe Accident Scenarios, Vol. 1 BWR, Mark I Design," Battelle Columbus Laboratories, Draft, November 1985.

18. R. S. Denning et al., "Radionuclide Release Calculations for Selected Severe Accident Scenarios, Vol. IV, BWR, Mark III Design," Battelle Columbus Laboratories, Draft, February 1986.

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15. P. C. Owczarski and W. K. Winegardner, "Capture of Iodine in Suppression Pools," To be presented at the 19th DOE/NRC Nuclear Air Cleaning Conference, Seattle, Washington, August 19, 1986.

SAFETY ISSUE MANAGEMENT SYSTEM

SAFETY ISSUE LEVEL INFORMATION

ISSUE NUMBER: SRP 6.5.5   TITLE: PRESSURE SUPPRESSION POOLS AS FISSION PRODUCT CLEANUP SYSTEMS

1. ISSUE APPROVAL & PLANNING

- ISSUE APPROVAL (DATE) 02/86C

2. TECHNICAL RESOLUTION

- LEAD OFFICE ....
- SUPPORTING OFFICE(S) .... NRR
- INITIATION DATE .... /85C
- INTER OFFICE REVIEW/COORD. COMPLETION (DATE) ... ******
- PROPOSED SOLUTIONS/REQUIREMENTS APPROVAL BY OFFICE DIRECTOR (DATE) .... ******

3. REQUIREMENTS REVIEW AND APPROVAL

- INITIAL CRGR REVIEW (DATE) 12/86

	A. RULE MAKING			B. OTHER (SPECIFY)
	ANPR	PROPOSED	FINAL	SRP
- FORM	NONE	NONE	NONE	SRP
- OFFICE RESPONSIBLE				NRR
- EDO APPROVAL TO PROCEED (YES/NO)				
- CRGR REVIEW (DATE)				12/86
- ACRS REVIEW (DATE)				09/86C
- EDO REVIEW (DATE)				******
APPROVAL (YES/NO)				NO
- COMMISSION REVIEW (DATE)				******
APPROVAL (YES/NO)				NO
- PUBLIC COMMENT (DATE)				02/87
- FINAL APPROVAL AND ISSUANCE (DATE)				04/87

4. REQUIREMENTS IMPOSITION NEEDED FOR VERIFICATION

A. IMPOSITION - LICENSED PLANTS

- MULTIPLANT ACTION (CODE & TITLE) ....

CODE: - TITLE:

- OTHER ....
- APPROVAL OF LICENSEE PROPOSAL NEEDED (YES/NO) .. YES

SAFETY ISSUE MANAGEMENT SYSTEM

SAFETY ISSUE LEVEL INFORMATION

ISSUE NUMBER: SRP 6.5.5   TITLE: PRESSURE SUPPRESSION POOLS AS FISSION PRODUCT CLEANUP SYSTEMS

TYPE: NEW SRP   PRIORITY: STATUS: IDENT. ORG: NRR   SPON. OFFICE: NRR   CONTACT: JBJREAD

DESCRIPTION

THERE IS AT PRESENT NO GUIDANCE BY WHICH TO REVIEW BWR PRESSURE SUPPRESSION POOLS AS FISSION CLEANUP SYSTEMS. A NEW SRP SECTION CONTAINS ACCEPTANCE CRITERIA AND REVIEW PROCEDURES FOR ASSESSING TIME-AVERAGED DECONTAMINATION FACTORS FOR POOLS.

SOLUTION (NEAR AND LONG TERM)

TYPE OF REACTORS AFFECTED: OTHER:

DEPENDENT ISSUES:

NET CHANGE IN DOLLAR COST	POINT ESTIMATE	RANGE LOW	RANGE HIGH
NRC DEVELOPMENT		0	N/A
NRC (IMPLEMENTATION/IMPOSITION)		0	0.4M
NRC (ASSURE CONTINUE COMPLIANCE)		0	0
PUBLIC/INDUSTRY/OTHER (IMPLEMENTATION)		0	0.4M
PUBLIC/INDUSTRY/OTHER (CONTINUED COMPLIANCE)		0	0.4M

NET CHANGE IN BENEFITS	POINT ESTIMATE	RANGE LOW	RANGE HIGH
PUBLIC EXPOSURE		0	0
OCUPATIONAL EXPOSURE		0	0
CORE MELT FREQUENCY		0	0

S A F E T Y   I S S U E   M A N A G E M E N T   S Y S T E M

SAFETY ISSUE LEVEL INFORMATION

ISSUE NUMBER: SRP 6.5.5   TITLE: PRESSURE SUPPRESSION POOLS AS FISSION PRODUCT CLEANUP SYSTEMS

B. IMPOSITION - PLANTS NOT LICENSED

- SRP REVIEW PROCESS................YES
- OTHER (SPECIFY)................

C. IMPOSITION - ALL PLANTS

- OFFICE RESPONSIBLE...............NRR
- IMPOSITION COMPLETION STATUS.....
- LAST PLANT (DATE)................

D. NEED FOR VERIFICATION/POST IMPLEMENTATION REVIEW

- VERIFICATION NEEDED (YES/NO).....NO
- OFFICE RESPONSIBLE................
- POST IMPLEMENTATION
  REVIEW NEEDED (YES/NO).........NO
- OFFICE RESPONSIBLE................

5. REQUIREMENTS IMPLEMENTATION BY LICENSEE &-VERIFICATION BY NRC

- IMPLEMENTATION COMPLETION STATUS....
- LAST PLANT (DATE)...................
- VERIFICATION COMPLETION STATUS......
- LAST PLANT (DATE)...................
- POST IMPL. REV. COMPLETION STATUS...
- LAST PLANT (DATE)...................

6. REQUIREMENTS IMPLEMENTATION BY STAFF

A. STAFF REQUIREMENTS

- REQUIREMENT (SPECIFY)............
- OFFICE(S) RESPONSIBLE............
- COMPLETION DATE..................

B. ROUTINE INSPECTION PROGRAM MODIFICATIONS

- MODIFICATION NEEDED..............NO

FEB 12 1987

RELEASED TO THE PDR

MEMORANDUM FOR: Victor Stello, Jr.
Executive Director for Operations

FROM: James H. Sniezek, Chairman
Committee to Review Generic Requirements

SUBJECT: MINUTES OF CRGR MEETING NUMBER 109

The Committee to Review Generic Requirements (CRGR) met on Monday, February 9, 1987 from 1-3 p.m. A list of attendees for this meeting is enclosed (Enclosure 1).

B. Sheron (NRR) and L. Soffer (DSRO) presented for CRGR review the proposed new Standard Review Plan 6.5.5, "Pressure Suppression Pools as Fission Product Cleanup Systems." Enclosure 2 summarizes the meeting. The vugraphs used for the presentation are attached to enclosure 2.

Enclosure 2 contains predecisional information and, therefore, will not be released to the Public Document Room until the NRC has considered (in a public forum) or decided the matter addressed by the information.

In accordance with the EDO's July 18, 1983, directive concerning "Feedback and Closure on CRGR Reviews," a written response is required from the cognizant office to report agreement or disagreement with CRGR recommendations in these minutes. The response, which is required within 5 working days after receipt of these meeting minutes, is to be forwarded to the CRGR Chairman and if there is disagreement with the CRGR recommendations, to the EDO for decisionmaking.

Questions concerning these meeting minutes should be referred to Walt Schwink (492-8639).

Original signed by
James H. Sniezek

8702270239 2pp

James H. Sniezek, Chairman
Committee to Review Generic
Requirements

Enclosures: As stated

cc: Commission (5)
SECY
Office Directors
Regional Administrators
CRGR Members
W. Parler
B. Sheron
L. Soffer

Distribution:
JSniezek
JZerbe
JClifford
FHebdon
PErickson
EFox
PDR (NRG/CRGR)
WOlmstead
BZalcman
JRoe
PRabideau
GZwetzig
WLittle
MLesar
DEDROGR cf
Central File
ROGR Staff
WMcDonald

OFC	:ROGR	:ROGR/D	:DEDROGR	:	:	:	:
NAME	:PPolk	:JZerbe	:JSniezek	:	:	:	:
DATE	:2/11/87	:2/11/87	:2/12/87	:	:	:	:

OFFICIAL RECORD COPY

Enclosure 1
LIST OF ATTENDEES
CRGR MEETING NO. 109

February 9, 1987

CRGR MEMBERS

J.H. Sniezek
D. Ross
R.E. Cunningham
R.M. Bernero
R.W. Starostecki
S. Rubin (for C. Heltemes)
J. Scinto

OTHERS

W. Schwink
J. Zerbe
J. Conran
P. Polk
B. Sheron
Z. Rosztoczy
J. Mitchell
L. Soffer
J. Read
M. Miller
T. Cox
W. Shields
J. Clifford

Enclosure 2 to the Minutes of CRGR Meeting No. 109
Review of the Proposed New SRP 6.5.5

B. Sheron (NRR) and L. Soffer (DSRO) presented for CRGR review the proposed new Standard Review Plan (SRP) 6.5.5. The vugraphs used for this presentation, as well as a revised SRP 6.5.5., are attached.

In essence, SRP 6.5.5. allows credit in the 10 CFR 100 dose calculation for suppression pools as fission product cleanup systems. Such credit is a recognition of the present state of knowledge regarding fission product retention in water.

Allowing credit for suppression pool retention is not intended to reduce plant safety. However, the proposed SRP did envision SGTS filtration system efficiencies as low as 90 percent or containment allowable leakages as high as 5 percent.

Other than plants applying for a new Construction Permit (CP), of which there presently are none, compliance with the SRP is voluntary. Furthermore, if a licensee uses conservative decontamination factors (DFs), then an analysis is not required. Conservative DFs for Mark I designs are equal to or less than DFs for Mark II/III designs due to Mark I smaller pool inventory and smaller downcomer submergence.

ACRS did not object to issuance of SRP 6.5.5. for comment. However, ACRS advised that they wanted to re-look at the revised SRP after comments have been received and evaluated.

The CRGR recommended that the following issues be addressed:

(1) If increased fission product concentrations in the suppression pool are acknowledged, then the effect on the environmental qualification of equipment and access to equipment during an accident should be addressed.

(2) SRP 6.5.5. and R.G. 1.3 are inconsistent. They should both be revised in final form at the same time and, by so doing, be made consistent. This correlation should be indicated when the SRP is issued for comment.

(3) ALARA considerations vs. system safety requirements should be balanced. As a minimum, there should be a recognition of ALARA concerns.

(4) It should be made clear that the burden of proof should be on the applicant if DFs above the conservative allowables are used.

(5) Revisions to allowable containment leakage rates should be handled separately as part of the siting, source term or containment performance criteria efforts.

CRGR recommends that the staff issue the proposed SRP for comment after appropriate revision to reflect issues 2 through 5. Issue 1 may be addressed subsequent to issuing the SRP for comment.

OVERVIEW

PROPOSED NEW SRP 6.5.5

BACKGROUND:

o ONE OF THE SHORT-TERM CHANGES DISCUSSED IN SECY 86-76.

MAJOR ASPECTS

o PERMITS CREDIT FOR SUPPRESSION POOLS AS FISSION PRODUCT CLEANUP SYSTEMS. CONSERVATIVE DECONTAMINATION FACTORS (DF) ALLOWED WITH NO APPLICANT ANALYSIS.

o SUPPRESSION POOL BYPASS LEAKAGE TO BE ACCOUNTED FOR IN DOSE CALCULATIONS.

o EXISTING ESF FILTRATION SYSTEMS NOT TO BE DEGRADED BELOW MINIMUM VALUE (90%) OF REG. GUIDE 1.52 (REV. 2).

OTHER ASPECTS

o NOT DEPENDENT ON PARTICULAR SOURCE TERM INSIDE CONTAINMENT CAN BE USED WITH TID-14844 OR POTENTIAL REVISION.

o NO LICENSEE ACTION REQUIRED.

SUMMARY - REPRESENTS RELAXATION WITH NO SIGNIFICANT DETRIMENT TO SAFETY.

STANDARD REVIEW PLANS INVOKED BY DBA LOCA DOSE EVALUATION

- o 6.5.2 CONTAINMENT SPRAY AS A FISSION PRODUCT CLEANUP SYSTEM.
- o 6.5.3 FISSION PRODUCT CONTROL SYSTEMS AND STRUCTURES.
- o 6.5.4 ICE CONDENSER AS A FISSION PRODUCT CLEANUP SYSTEM.

PROPOSED

- o 6.5.5 PRESSURE SUPPRESSION POOLS AS FISSION PRODUCT CLEANUP SYSTEMS.
- o 15.6.5A RADIOLOGICAL CONSEQUENCES OF A DBA-LOCA FROM CONTAINMENT LEAKAGE.
- o 15.6.5B LEAKAGE FROM ENGINEERED SAFETY COMPONENTS OUTSIDE CONTAINMENT.
- o 15.5.5D LEAKAGE FROM MAIN STEAM LINE ISOLATION VALVE LEAKAGE CONTROL SYSTEM (BWR)

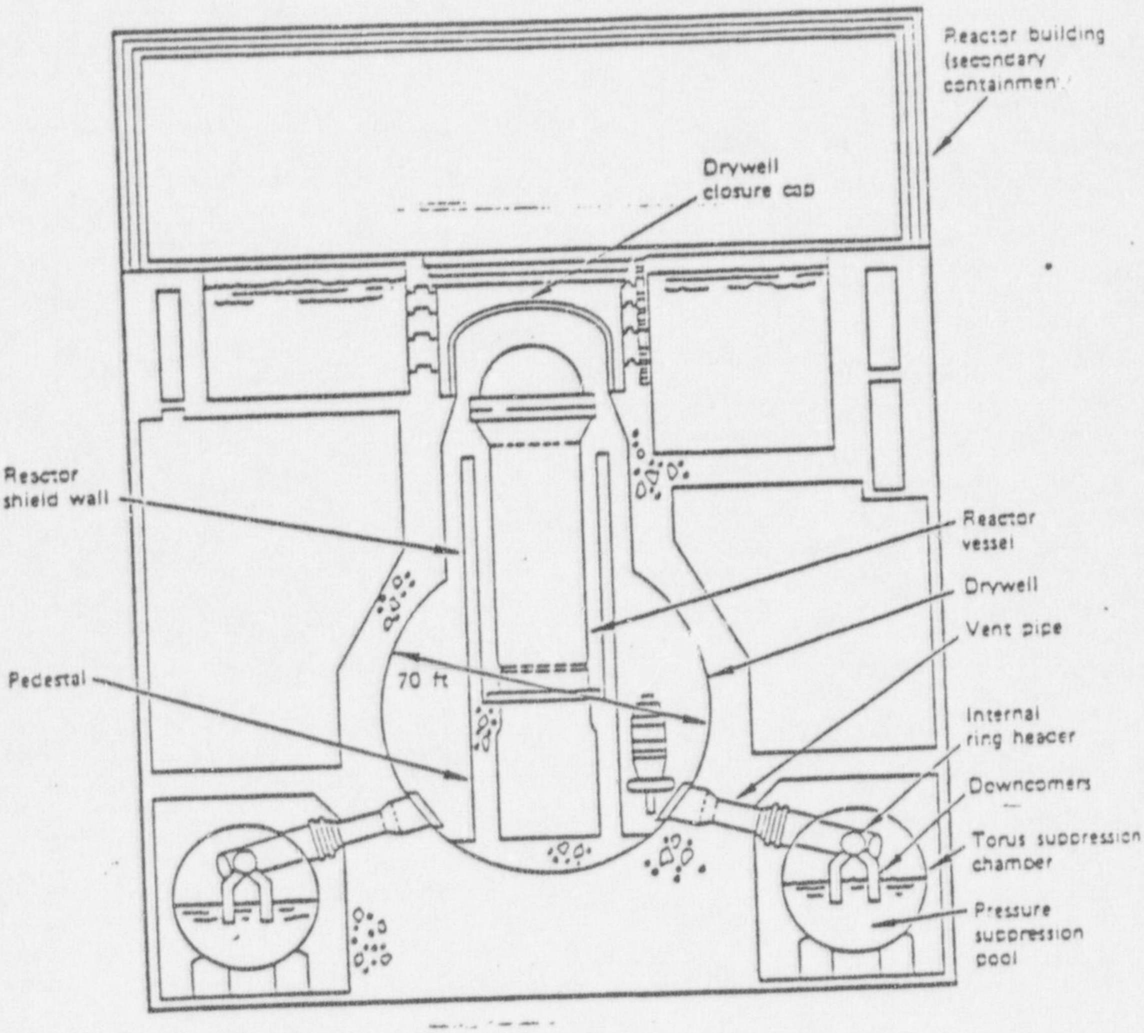


Figure 4.3 BWR Mark I Containment

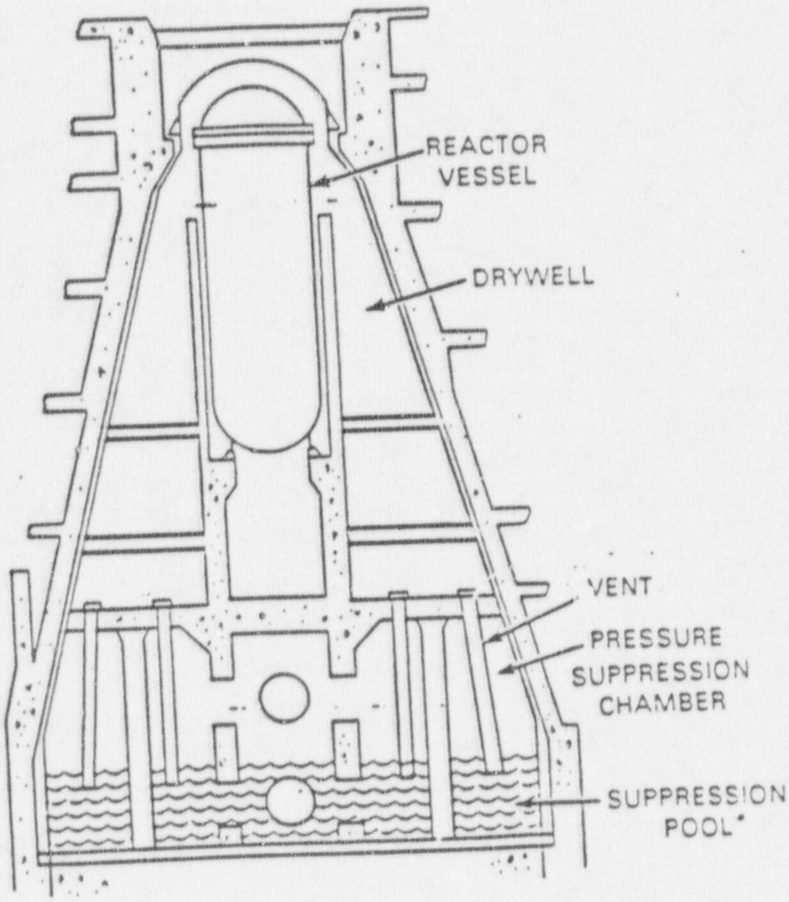


Figure 2 BWR Mark II containment system.

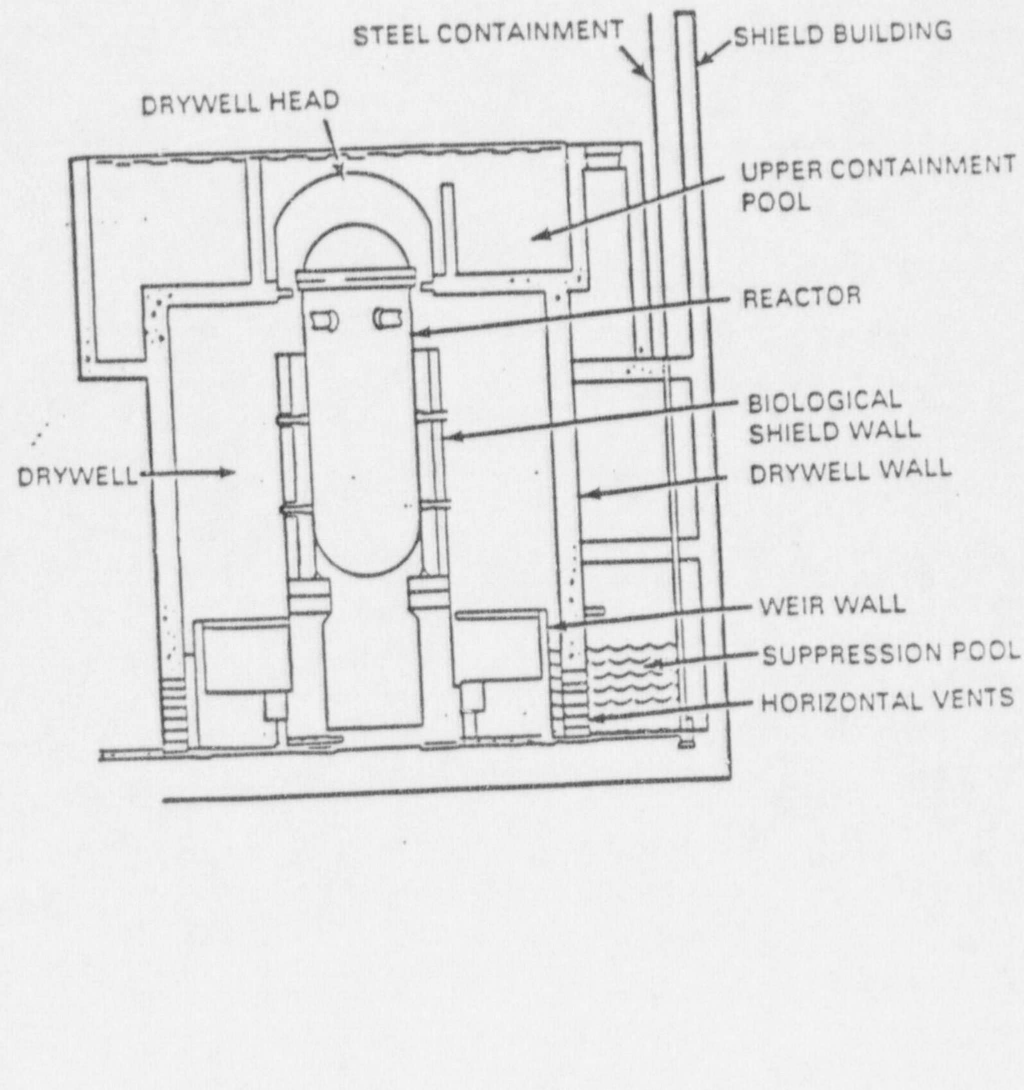


Figure 3 BWR Mark III containment system.

SUPPRESSION POOL PARAMETERS

TYPE	VOLUME (FT^3)	SUBMERGENCE OF DOWNCOMERS, FT
MARK I	120,000	3 - 4
MARK II	160,000	10 - 15
MARK III	160,000	8.5 - 13

SUPPRESSION POOLS AS FISSION PRODUCT CLEANUP SYSTEMS - PRESENT STATUS

- REGULATORY GUIDE 1.3 - NO POOL CREDIT TO BE GIVEN.

- SRP 6.5.3 STATES THAT POOL CREDIT MAY BE GIVEN, BUT GIVES NO PROCEDURES OR CRITERIA FOR DOING SO.

- SRP 6.5.1, CRITERION V, PERMITS CHARCOAL FILTRATION UNITS TO BE NON-ESF IF $<$ 90% IODINE EFFICIENCY.

- GESSAR-II REVIEW ALLOWED POOL CREDIT FOR SEVERE ACCIDENT RISK EVALUATION.

BASES FOR PROPOSED SRP

- SPARC CODE TIME-AVERAGED DECONTAMINATION FACTOR CALCULATIONS FOR NUREG-1150.

- PNL EXPERIMENTS ON I_2 POOL SCRUBBING.

- KNOWN CHEMISTRY OF HYDROGEN IODIDE.

DEFAULT DF VALUES IN
PROPOSED SRP 6.5.5

DF = 1 FOR NOBLE GASES, ORGANIC IODIDES

(XE, KR, CH_3I)

DF = 10 FOR PARTICULATE IODINE, OTHER AEROSOLS (MARK II AND III)
= 5 FOR PARTICULATE IODINE, OTHER AEROSOLS (MARK I)
(CsI, TE, SR, ETC.)

DF = 10 FOR ELEMENTAL IODINE (I_2) (MARK II AND III)
= 5 FOR ELEMENTAL IODINE (I_2) (MARK I)

Effective (Time Averaged) In-Vessel Release Decontamination Factors for the Suppression Pool (Peach Bottom Mark I)

Fission Product Group	In-Vessel DF	
	TC2 Sequence	TB1 Sequence
CSI	200	Large*
CSOH	300	Large
Te	250	Large

*Due to inconsistencies in the reported values, an exact quantification is not possible.

Effective (Time Averaged) Ex-Vessel Release Decontamination Factors for the Suppression Pool (Grand Gulf Mark III)

Fission Product Group	TC Sequence	TB1 Sequence	TB2 Sequence
CsI	85	50	60
CsOH	80	55	65
Te	40	40	50

Fission Product Group	Ex-Vessel DF
Sr	25
Ba	20
La	15
Ce	30
Te	10

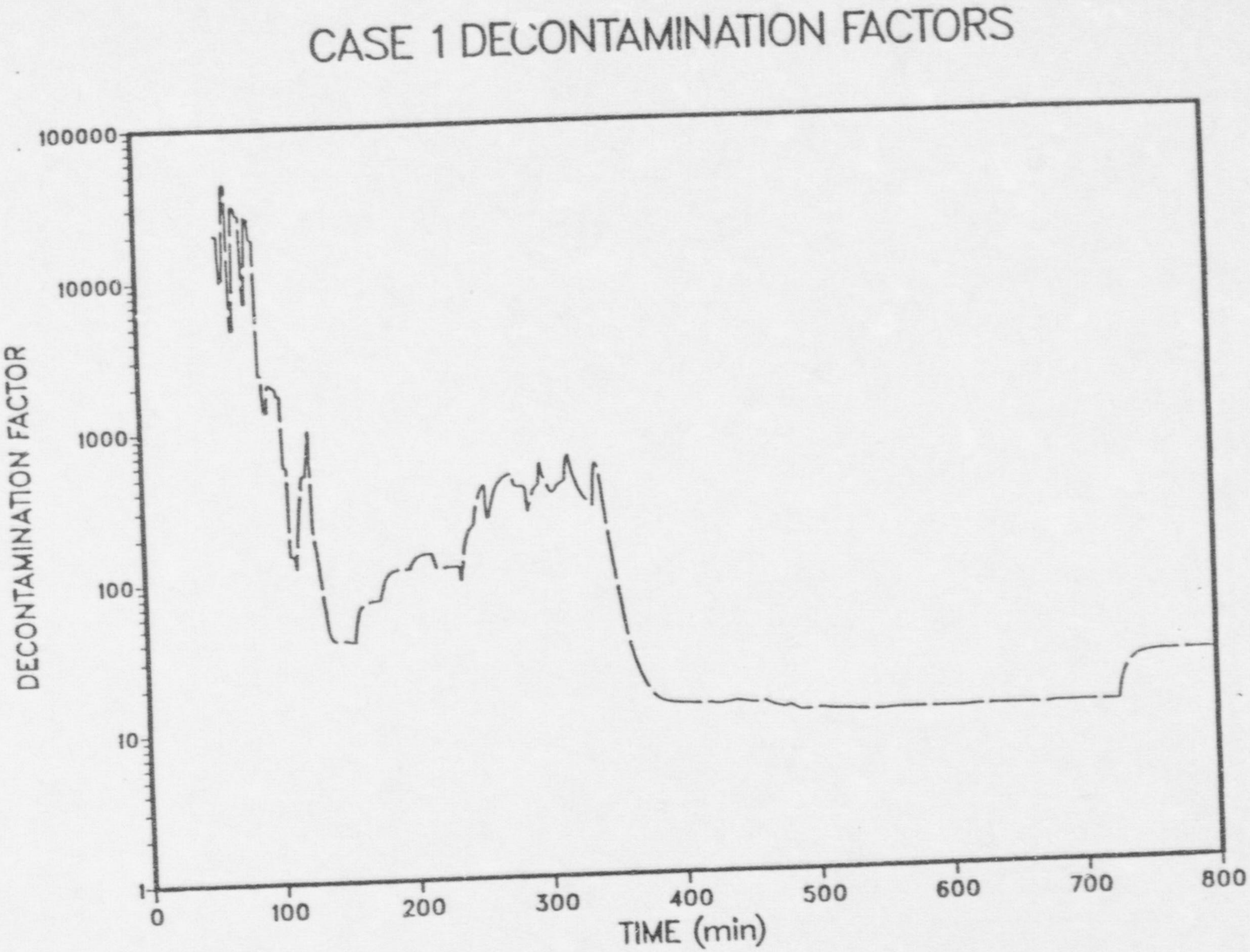


FIGURE 6.3. BASE CASE DECONTAMINATION FACTORS

CASE 4A DECONTAMINATION FACTORS

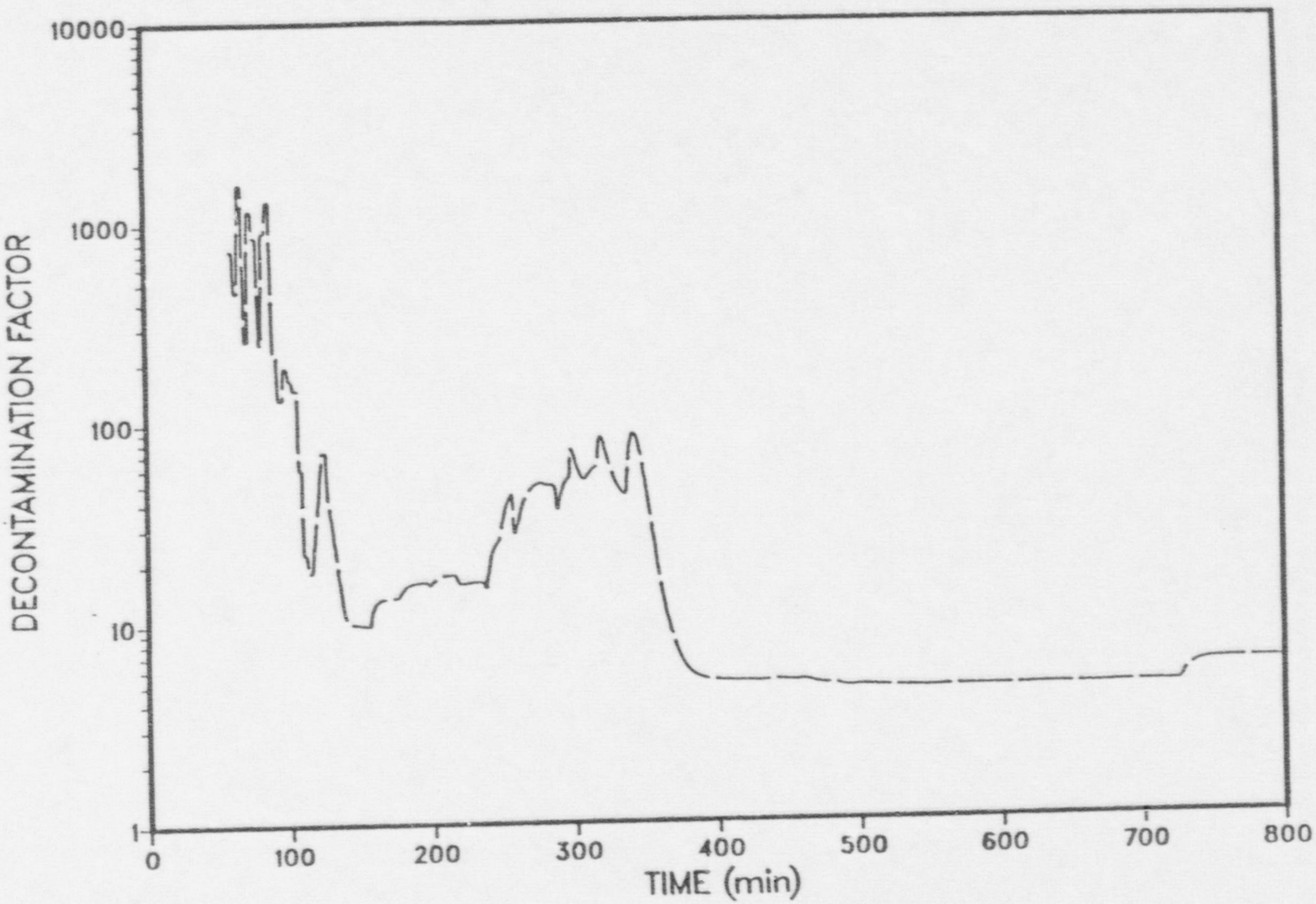


FIGURE 6.8. DECONTAMINATION FACTORS FOR LARGE ELLIPTICAL BUBBLES

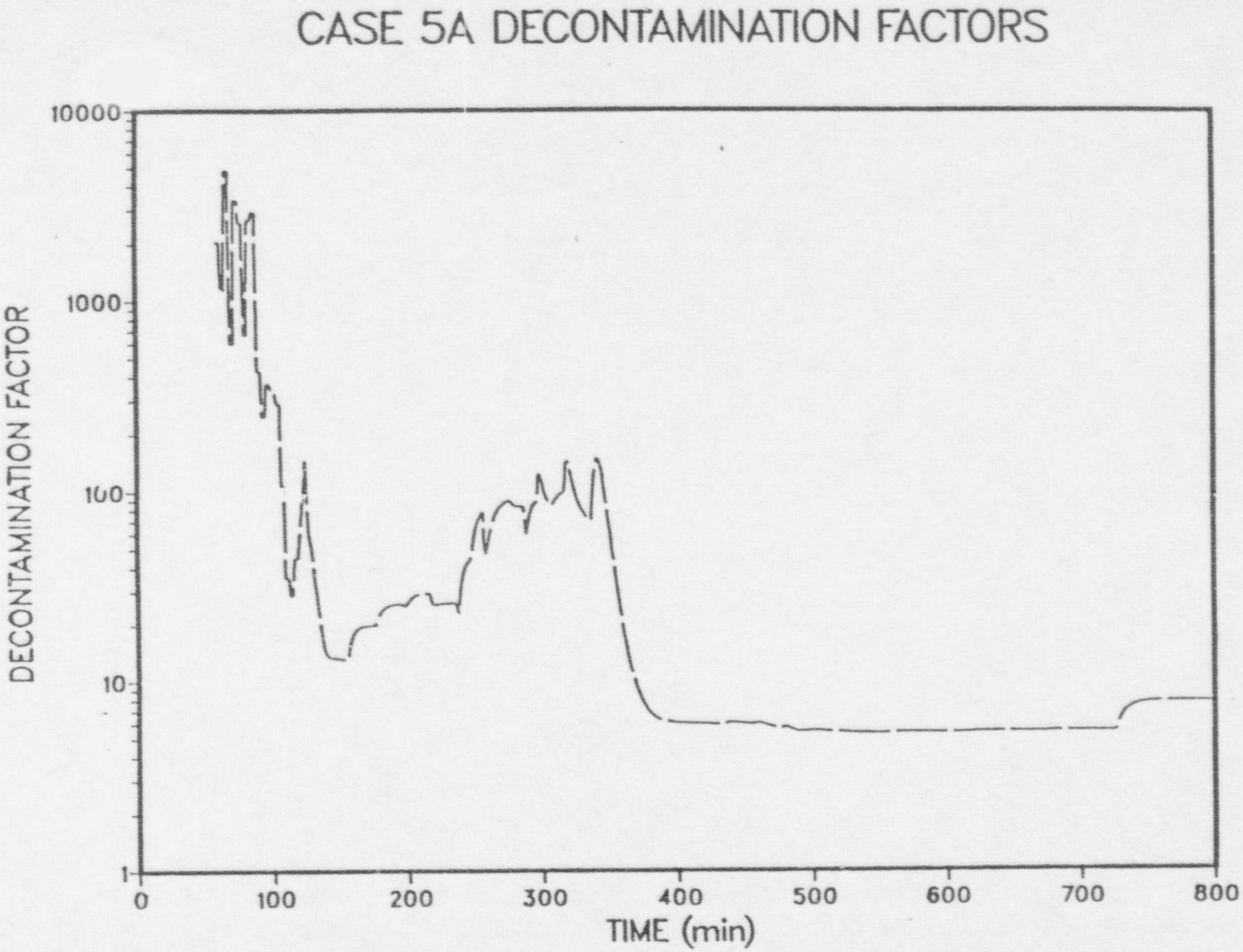
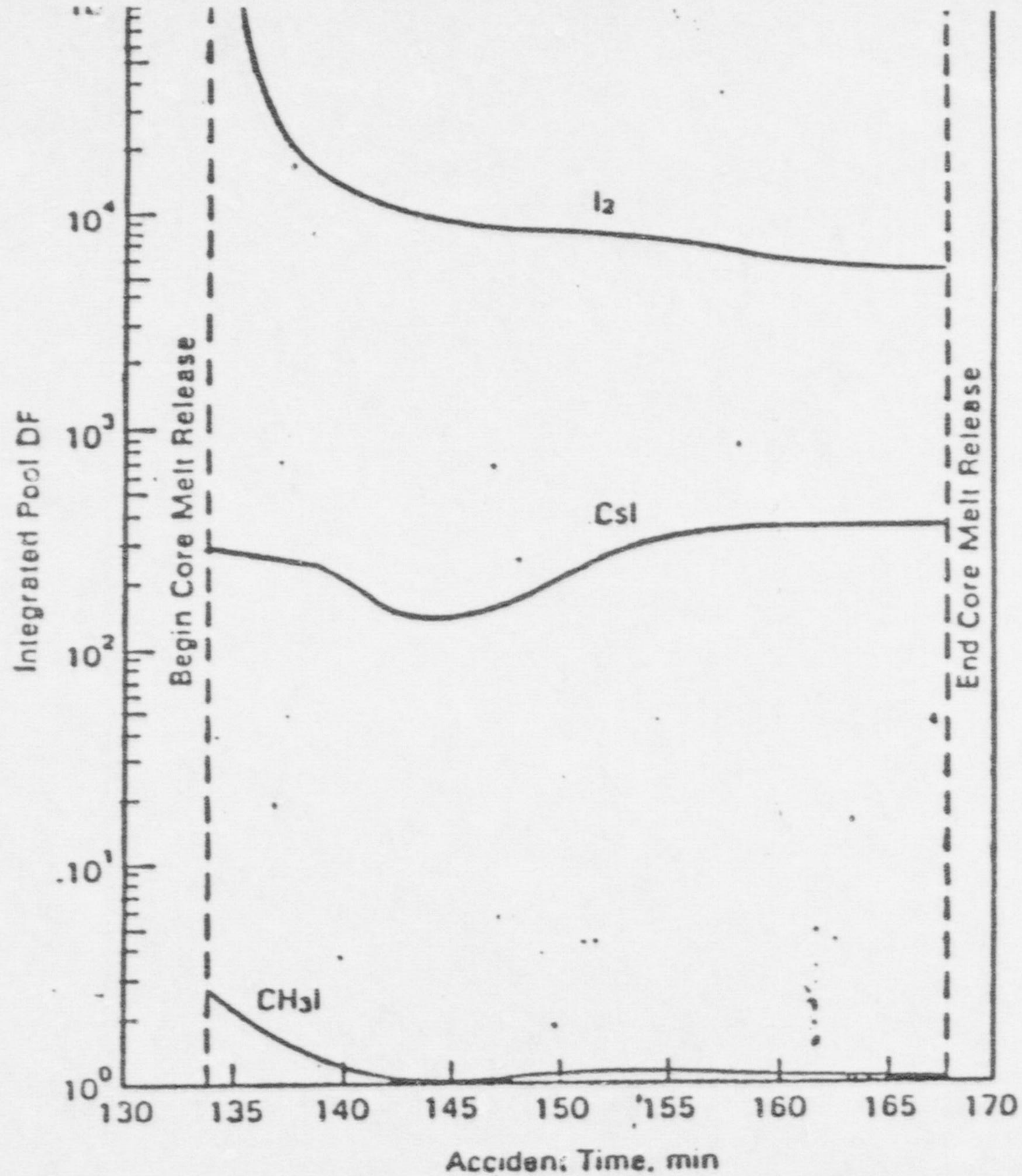


FIGURE 6.10. DECONTAMINATION FACTORS FOR INTERMEDIATE ELLIPTICAL BUBBLES INCLUDING CIRCULATION AND SOLUBLE PARTICLES



DECONTAMINATION FACTORS FOR IODINE SPECIES INTEGRATED OVER THE CORE MELT PERIOD. THE CsI CURVE REPRESENTS CASE 1, THE I_2 CURVE REPRESENTS CASE 2 AND THE CH_3I CURVE IS THE SAME IN ALL CASES

SUPPRESSION POOL BYPASS

- NOT ALL FISSION PRODUCTS GO FROM DRYWELL THRU SUPPRESSION POOL. SMALL FRACTION (TYPICALLY, FEW PERCENT) BYPASSES POOL.

- FRACTION THAT BYPASSES POOL IS UNSCRUBBED.

- NEED TO ACCOUNT FOR POOL BYPASS IN STAFF ASSESSMENT OF CONSEQUENCES.

POTENTIAL IMPACT OF

SUPPRESSION POOL CREDIT

ON OTHER ESF"S

o SINCE SUPPRESSION POOLS AND ESF FILTERS BOTH ATTENUATE IODINE, CREDIT FOR POOL SCRUBBING MIGHT BE TRADED OFF FOR FILTER REQUIREMENTS

o STAFF AND ACRS CONSENSUS NOT TO PERMIT CREDIT FOR SUPPRESSION POOLS TO ALLOW LARGE RELAXATION OF FILTERS (REMOVAL OR CHANGE IN STATUS TO NON-ESF), SINCE BOTH SYSTEMS YIELD DIVERSITY IN FISSION PRODUCT MITIGATION AND MINIMIZE BYPASS CONDITIONS.

o THEREFORE, STAFF POSITION THAT EXISTING ESF"S CAN BE RELAXED SOMEWHAT, BUT NOT BELOW MINIMUM VALUE OF R.G. 1.52.

Proposed New Standard Review Plan Section

6.5.5 PRESSURE SUPPRESSION POOLS AS FISSION PRODUCT CLEAN-UP SYSTEMS

REVIEW RESPONSIBILITIES

Primary - Plant Systems Branch

Secondary - Reactor Systems

I AREAS OF REVIEW

Pressure suppression pools are reviewed under this plan only when the applicant claims credit for fission product scrubbing and retention by the suppression pool. The pressure suppression pool and the drywell, when considered as a barrier to the release of fission products, are reviewed to assess the degree to which fission products released during postulated reactor accidents will be retained in the suppression pool. Leakage paths which allow fission products to bypass the pool are identified and reviewed, and the maximum fractional bypass leakage is obtained, for use in the evaluation of radiological dose consequences.

1.) Fission Product Control Requirement

Sections of the SAR related to accident analysis, dose calculations, and fission product control are reviewed to

establish whether or not fission product scrubbing of the drywell or reactor compartment atmosphere is claimed or required for mitigation of off-site consequences following a postulated accident.

2.) Design Bases

A comparison is made to establish that the design bases for the suppression pool and the drywell or reactor compartment are consistent with the assumptions made in the accident evaluations of SAR Chapter 15.

3.) System Design

The information concerning the suppression pool is reviewed to familiarize the reviewer with the expected temperature histories, depth of fission product entry expected during postulated accidents and potential leakage paths through drywell penetrations.

4.) Testing and Technical Specifications

The details of the applicant's proposed preoperational tests, and, at the operating license stage, the surveillance requirements, are reviewed under section 6.2.1.1.C. The results of that review are examined to assure that pool depth and amount of leakage bypassing the pool are maintained consistent with the assumptions used in assessing the pool's effectiveness in fission product cleanup.

II ACCEPTANCE CRITERIA

The acceptance criteria for the fission product clean-up function of the suppression pool are based on the following requirements from Appendix A of 10 CFR 50:

A. General Design Criterion 41 (Ref.1) as related to the control of fission products following potential accidents.

B. General Design Criterion 42 (Ref.1) as related to the periodic inspection of engineered safety features.

C. General Design Criterion 43 (Ref.1) as related to the periodic functional testing of engineered safety features.

Where they can be shown to be in compliance with these criteria, suppression pools may be given appropriate credit for fission product scrubbing and retention (except for noble gases, for which no pool retention is allowed) in the staff's evaluation of the radiological consequences of design basis accidents. Other assumptions concerning the release of radioactivity are to be taken from Regulatory Guide 1.3, except for Position C.1.f, which this section replaces.

Specific criteria which must be met to receive credit are as follows:

1. The drywell and its penetrations must be designed to assure that, even with a single active failure, all releases from the core must pass into the suppression pool, except for small bypass leakage.

2. The bypass leakage assumed for purposes of evaluating fission product retention must be no less than that accepted in the review under section 6.2.1.1.C, and must be demonstrated in periodic tests by the license technical specifications also reviewed under that section.

3. For plants which have already received a construction permit, the iodine retention calculated using this section must not be used to justify removal of the standby gas treatment or other filtered exhaust system from status as engineered safety features. For such reviews, criterion II.5 of SRP 6.5.1 shall not be applied, and the charcoal absorbers must be at least maintained to the minimum level of Table 2 in Regulatory Guide 1.52, Revision 2.

Acceptable methods for computing fission product retention by the suppression pool are given in Subsection III, "Review Procedures."

III Review Procedures

The first step in the review is to determine whether or not the suppression pool is to be used for accident dose mitigation purposes. If no fission product removal credit is claimed in the accident analyses appearing in chapter 15 of the SAR, no further review is required.

If the suppression pool is intended as an engineered safety feature for the mitigation of off-site doses, then the reviewer estimates its effectiveness in removing fission products from fluids expelled from the drywell or directly from the pressure vessel through the depressurization system.

1. Pool decontamination factor

The decontamination factor (DF) of the pool is defined as the ratio of the amount of a contaminant entering the pool to the amount leaving. Decontamination factors for each fission product form as functions of time can be calculated by the SPARC code (Ref.2), and this calculation should be performed whenever the pool design is judged by the reviewer to differ significantly from those found acceptable as fission product cleanup systems in past reviews. If, however, the time-integrated DF values claimed by the applicant for removal of particulates and elemental iodine are 10 or less for a Mark II or a Mark III BWR; and are 5 or less for a Mark I BWR, the applicants values may be accepted without any need to perform calculations (Refs 3,4). (Ref. 3). A DF value of 1 (no retention) should be used for noble gases and, unless the applicant demonstrates otherwise, for organic iodides as well.

If calculation of fission product decontamination is done using the SPARC code, the review should be coordinated with the Reactor Systems Branch, which is responsible for establishing the accident assumptions needed to assemble the input for the calculations.

2. Pool bypass fraction

The fraction of the drywell atmosphere bypassing the suppression pool by leaking through drywell penetrations is obtained as a product of the review under section 6.2.1.1.C. If B is the bypass fraction and DF is the time-integrated pool decontamination factor, then the overall decontamination, D, to be reported to the Reactor Systems Branch for use in chapter 15 dose calculations may be taken as:

$$D = \frac{DF}{1 + B(DF-1)}$$

or

$$\frac{1}{D} = B + \frac{1-B}{DF}$$

The reviewer should clearly distinguish that fraction of B which may be further treated by the standby gas treatment system from that fraction of B which also bypasses secondary containment.

3. Other containment atmosphere clean-up systems

Plants having drywell or containment spray systems for which fission product cleanup credit is claimed are reviewed separately under section 6.5.2, and credit for both suppression pool and spray cleanup can be given as a result of the separate reviews.

4. Technical Specifications

The technical specifications are reviewed to assure that they require periodic inspection to confirm suppression pool depth and surveillance tests to confirm drywell leak tightness consistent with the bypass fraction used in computing the overall decontamination. Technical specification review is coordinated with the Facility Operations Branch as provided in NRR Office Letter No. 51.

IV EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided by the applicant and that the review and any calculations support conclusions of the following type, to be included in the staff's Safety Evaluation Report:

> We have reviewed the fission product scrubbing function of the pressure suppression pool and find that the pool will reduce the fission product content of the steam-gas mixture flowing through the pool following accidents which blow down through the suppression pool. We estimate the pool will decontaminate the flow by a factor of _____ for molecular iodine vapor and by a factor of ____ for particulate fission products. No significant pool decontamination from noble gases or organic iodides will occur. The system is largely passive in nature, and the active components are suitably redundant such that its fission product attenuation

function can be accomplished assuming a single failure. The applicant's proposed program for preoperational and surveillance tests will assure a continued state of readiness, and that bypass of the pool is unlikely to exceed the assumptions used in the dose assessments of Chapter 15.

The staff concludes that the suppression pool is acceptable as a fission product cleanup system, and meets the requirements of General Design Criteria 41, 42 and 43.

V IMPLEMENTATION

Except in those cases in which the applicant proposes an acceptable alternative method for complying with the specified portions of the Commission's regulations, the methods described here in are to be used by the staff in its evaluation of conformance with Commissions regulations.

Implementation of the acceptance criteria of subsection II of this plan is as follows:

(a.) Operating plants and OL applicants need not comply with the provision of this review plan section.

(b.) CP applicants will be required to comply with the provisions of this revision.

VI REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criteria 41, "Containment Atmosphere Clean-up", 42, "Inspection of Containment Atmosphere Cleanup Systems", and 43, "Testing of Containment Atmosphere Cleanup System".

2. P.C. Owczarski, R.I. Shreck and A.K. Postma, "Technical Bases and Users Manual for the Prototype of a Suppression Pool Aerosol Removal Code (SPARC)', NUREG/CR-3317, 1985.

3. P.C. Owczarski and W.K. Winegardner, "Capture of Iodine in Suppression Pools", 19th DOE/NRC Nuclear Air Cleaning Conference, Seattle, 1986.

4. R.S. Denning et al, "Radionuclide Release Calcuations for Selected Severe Accident Scenarios", NUREG/CR-4524, Vol. 1

FEB 12 1987

MEMORANDUM FOR: Victor Stello, Jr.
Executive Director for Operations

FROM: James H. Sniezek, Chairman
Committee to Review Generic Requirements

SUBJECT: MINUTES OF CRGR MEETING NUMBER 109

The Committee to Review Generic Requirements (CRGR) met on Monday, February 9, 1987 from 1-3 p.m. A list of attendees for this meeting is enclosed (Enclosure 1).

B. Sheron (NRR) and L. Soffer (DSRO) presented for CRGR review the proposed new Standard Review Plan 6.5.5, "Pressure Suppression Pools as Fission Product Cleanup Systems." Enclosure 2 summarizes the meeting. The vugraphs used for the presentation are attached to enclosure 2.

Enclosure 2 contains predecisional information and, therefore, will not be released to the Public Document Room until the NRC has considered (in a public forum) or decided the matter addressed by the information.

In accordance with the EDO's July 18, 1983, directive concerning "Feedback and Closure on CRGR Reviews," a written response is required from the cognizant office to report agreement or disagreement with CRGR recommendations in these minutes. The response, which is required within 5 working days after receipt of these meeting minutes, is to be forwarded to the CRGR Chairman and if there is disagreement with the CRGR recommendations, to the EDO for decisionmaking.

Questions concerning these meeting minutes should be referred to Walt Schwink (492-8639).

Original signed by
James H. Sniezek

James H. Sniezek, Chairman
Committee to Review Generic
Requirements

8702270259 ZPP

Enclosures: As stated

cc: Commission (5)
SECY
Office Directors
Regional Administrators
CRGR Members
W. Parler
B. Sheron
L. Soffer

Distribution:

JSniezek	JRoe
JZerbe	PRabideau
JClifford	GZwetzig
FHebdon	WLittle
PErickson	MLesar
EFox	DEDROGR cf
PDR (NRG/CRGR)	Central File
WOlmstead	ROGR Staff
BZalcman	WMcDonald

OFC	:ROGR	:ROGR/D	:DEDROGR	:	:	:	:
NAME	:PPolk	:JZerbe	:JSniezek	:	:	:	:
DATE	:2/ 11 /87	:2/ 11 /87	:2/ 11 /87	:	:	:	:

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Enclosure 1
LIST OF ATTENDEES
CRGR MEETING NO. 109

February 9, 1987

CRGR MEMBERS

J.H. Sniezek
D. Ross
R.E. Cunningham
R.M. Bernero
R.W. Starostecki
S. Rubin (for C. Heltemes)
J. Scinto

OTHERS

W. Schwink
J. Zerbe
J. Conran
P. Polk
B. Sheron
Z. Rosztoczy
J. Mitchell
L. Soffer
J. Read
M. Miller
T. Cox
W. Shields
J. Clifford

Enclosure 2 to the Minutes of CRGR Meeting No. 109
Review of the Proposed New SRP 6.5.5

B. Sheron (NRR) and L. Soffer (DSRO) presented for CRGR review the proposed new Standard Review Plan (SRP) 6.5.5. The vugraphs used for this presentation, as well as a revised SRP 6.5.5., are attached.

In essence, SRP 6.5.5. allows credit in the 10 CFR 100 dose calculation for suppression pools as fission product cleanup systems. Such credit is a recognition of the present state of knowledge regarding fission product retention in water.

Allowing credit for suppression pool retention is not intended to reduce plant safety. However, the proposed SRP did envision SGTS filtration system efficiencies as low as 90 percent or containment allowable leakages as high as 5 percent.

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ACRS did not object to issuance of SRP 6.5.5. for comment. However, ACRS advised that they wanted to re-look at the revised SRP after comments have been received and evaluated.

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CRGR recommends that the staff issue the proposed SRP for comment after appropriate revision to reflect issues 2 through 5. Issue 1 may be addressed subsequent to issuing the SRP for comment.

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OTHER ASPECTS

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SUMMARY - REPRESENTS RELAXATION WITH NO SIGNIFICANT DETRIMENT TO SAFETY.

STANDARD REVIEW PLANS INVOKED BY DBA LOCA DOSE EVALUATION

- 6.5.2 CONTAINMENT SPRAY AS A FISSION PRODUCT CLEANUP SYSTEM.
- 6.5.3 FISSION PRODUCT CONTROL SYSTEMS AND STRUCTURES.
- 6.5.4 ICE CONDENSER AS A FISSION PRODUCT CLEANUP SYSTEM.

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- 15.6.5A RADIOLOGICAL CONSEQUENCES OF A DBA-LOCA FROM CONTAINMENT LEAKAGE.
- 15.6.5B LEAKAGE FROM ENGINEERED SAFETY COMPONENTS OUTSIDE CONTAINMENT.
- 15.5.5D LEAKAGE FROM MAIN STEAM LINE ISOLATION VALVE LEAKAGE CONTROL SYSTEM (BWR)

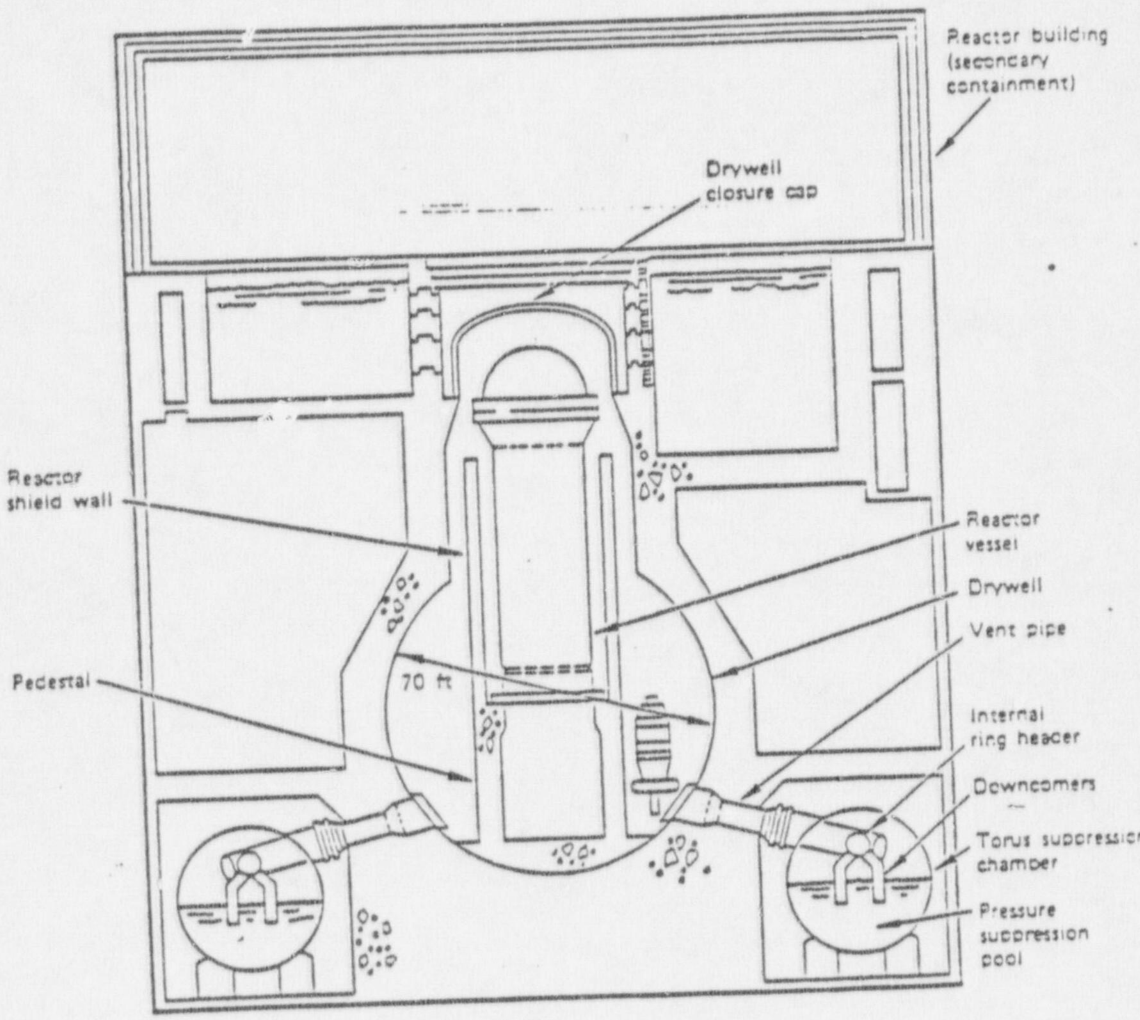

Figure 4.3 BWR Mark I Containment

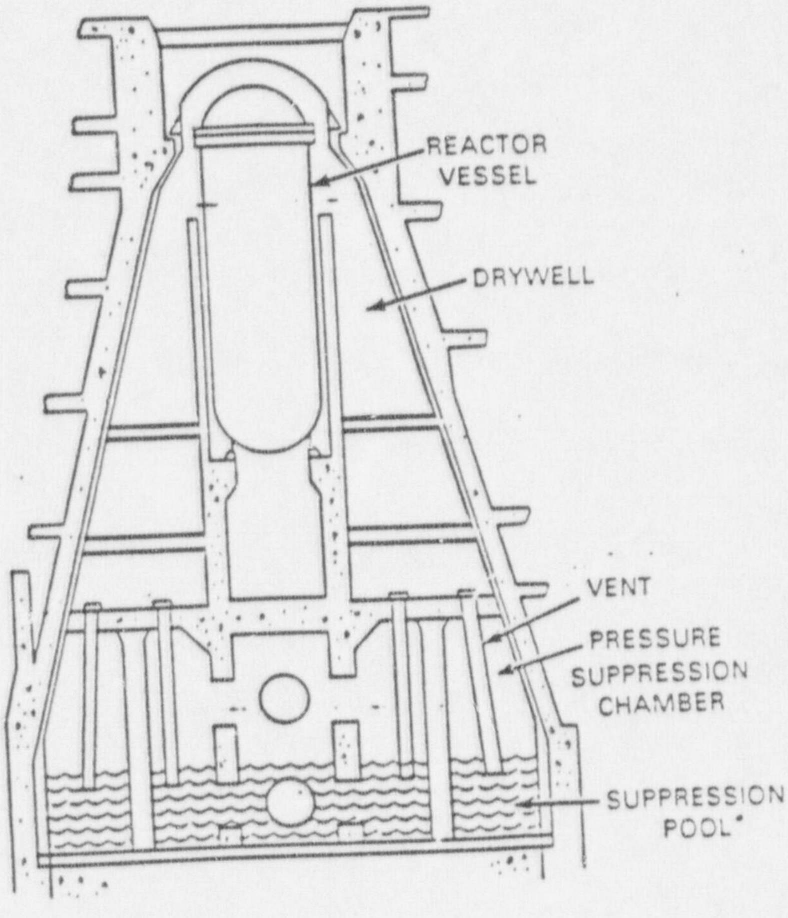

Figure 2 BWR Mark II containment system.

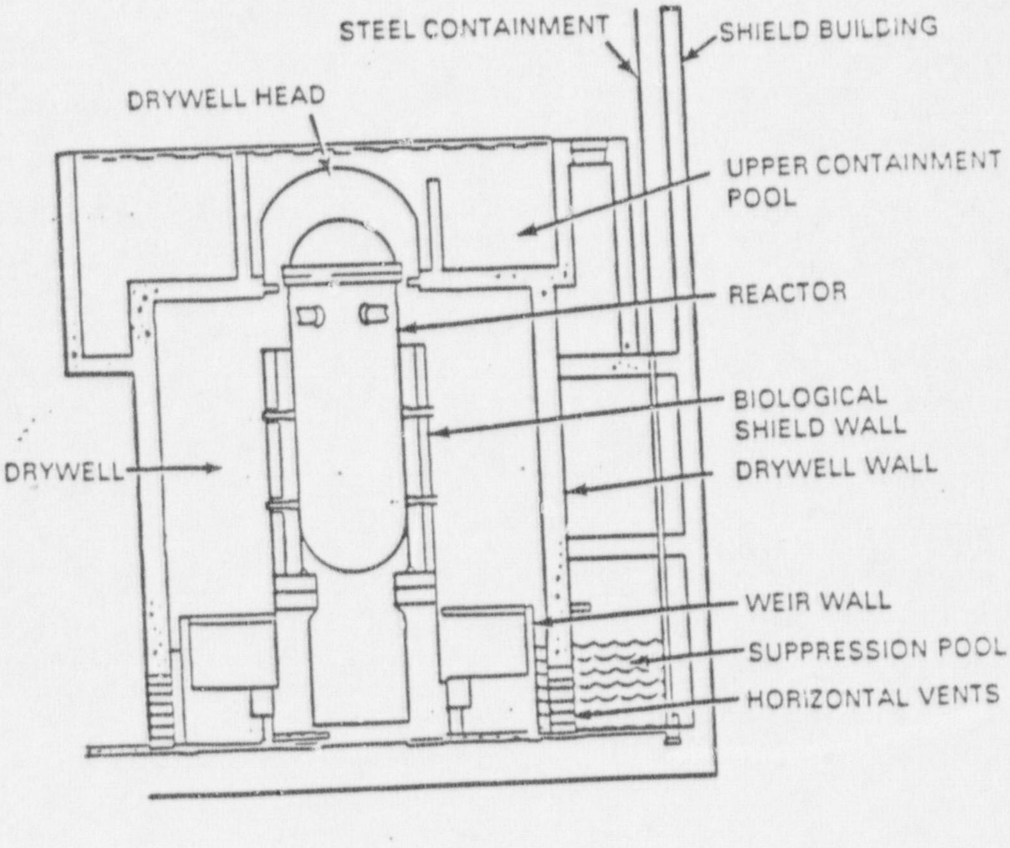

Figure 3 BWR Mark III containment system.

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- PRESENT STATUS

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- KNOWN CHEMISTRY OF HYDROGEN IODIDE.

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PROPOSED SRP 6.5.5

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(XE, KR, CH_3I)

DF = 10 FOR PARTICULATE IODINE, OTHER AEROSOLS (MARK II AND III)
= 5 FOR PARTICULATE IODINE, OTHER AEROSOLS (MARK 1)
(CsI, TE. SR, ETC.)

DF = 10 FOR ELEMENTAL IODINE (I_2) (MARK II AND III)
= 5 FOR ELEMENTAL IODINE (I_2) (MARK I)

Effective (Time Averaged) In-Vessel Release Decontamination Factors for the Suppression Pool (Peach Bottom Mark I)

Fission Product Group	In-Vessel DF	
	TC2 Sequence	TB1 Sequence
CSI	200	Large*
CSOH	300	Large
Te	250	Large

*Due to inconsistencies in the reported values, an exact quantification is not possible.

Effective (Time Averaged) Ex-Vessel Release Decontamination Factors for the Suppression Pool (Grand Gulf Mark III)

Fission Product Group	TC Sequence	TB1 Sequence	TB2 Sequence
CsI	85	50	60
CsOH	80	55	65
Te	40	40	50

Fission Product Group	Ex-Vessel DF
Sr	25
Ba	20
La	15
Ce	30
Te	10

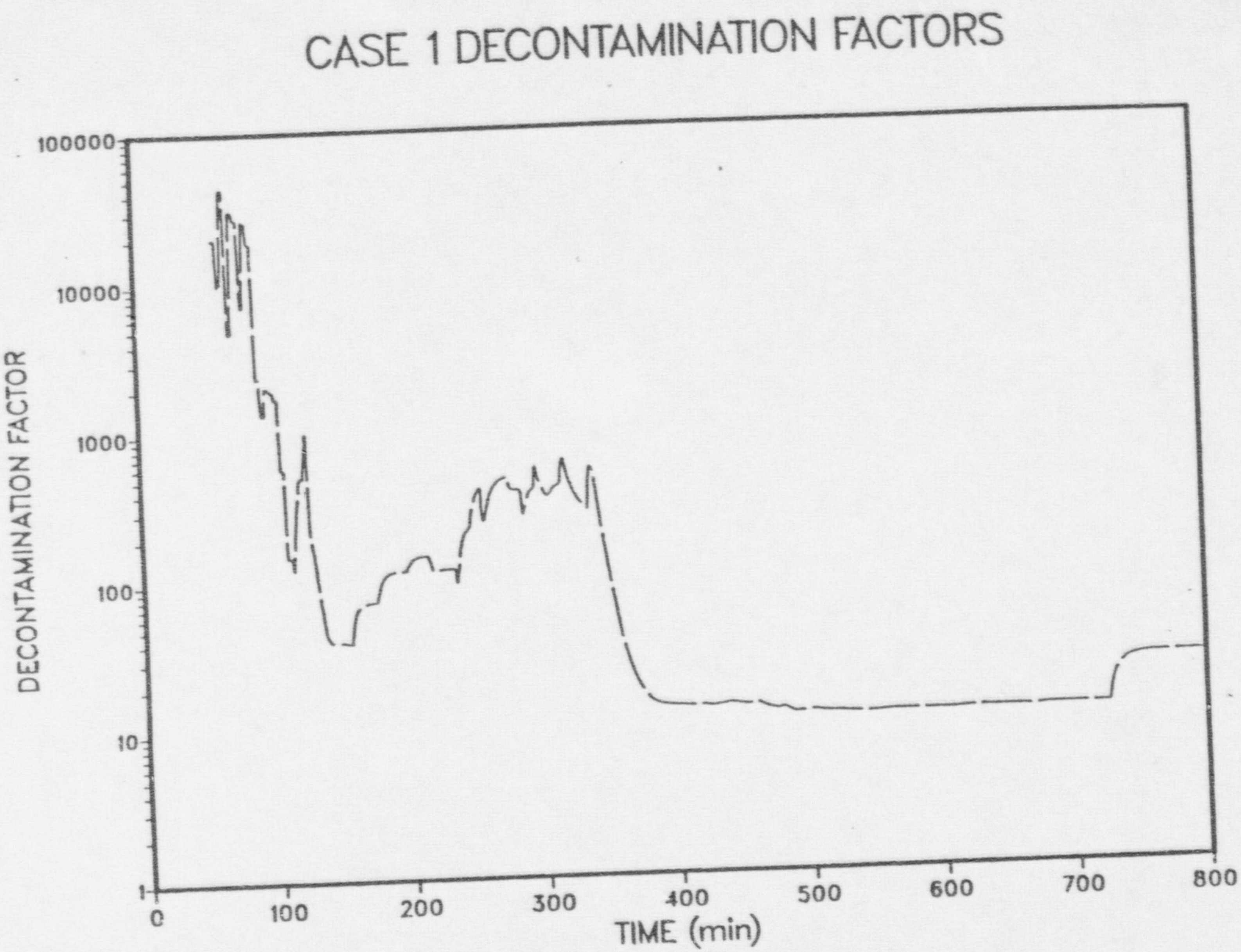


FIGURE 6.3. BASE CASE DECONTAMINATION FACTORS

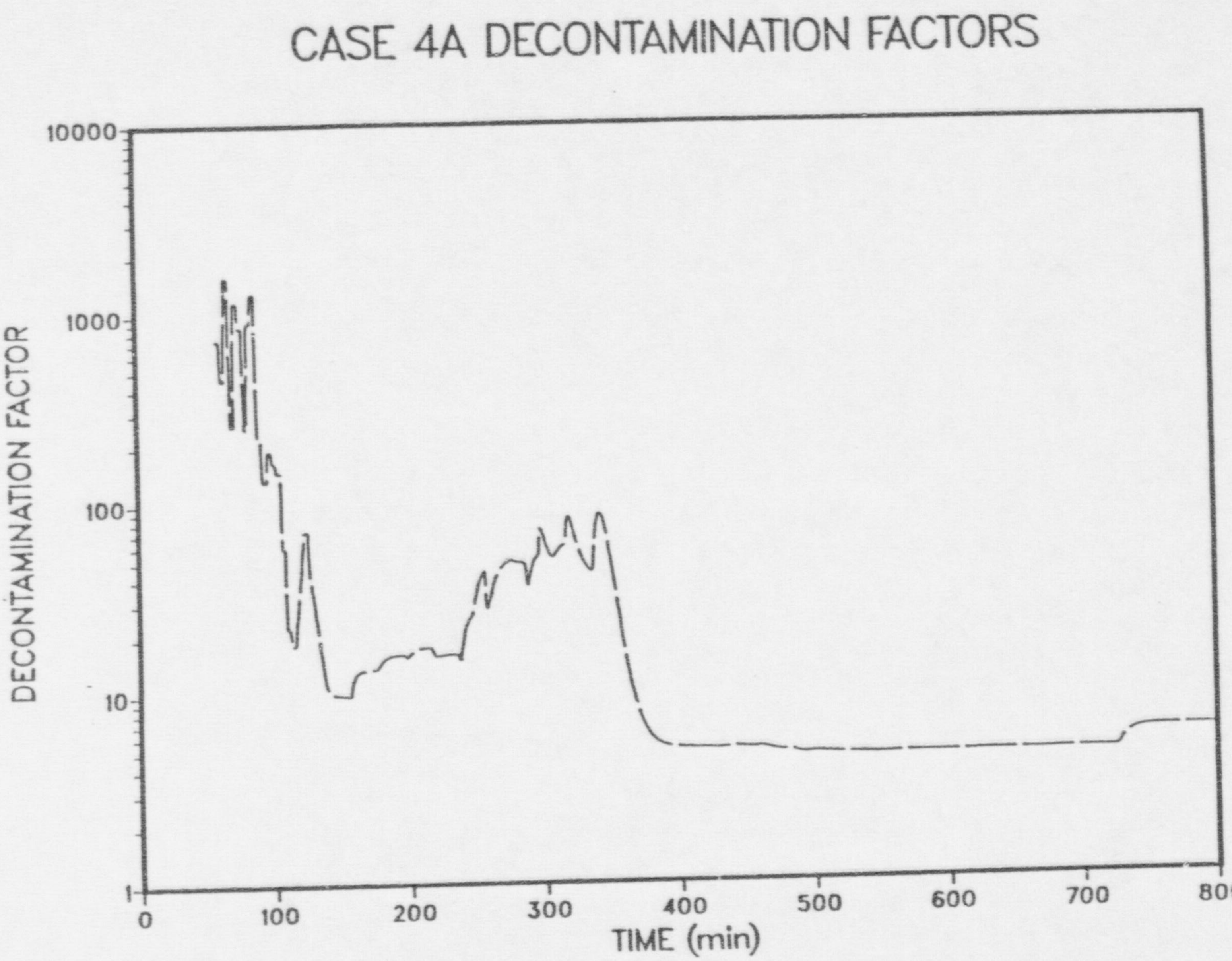


FIGURE 6.8. DECONTAMINATION FACTORS FOR LARGE ELLIPTICAL BUBBLES

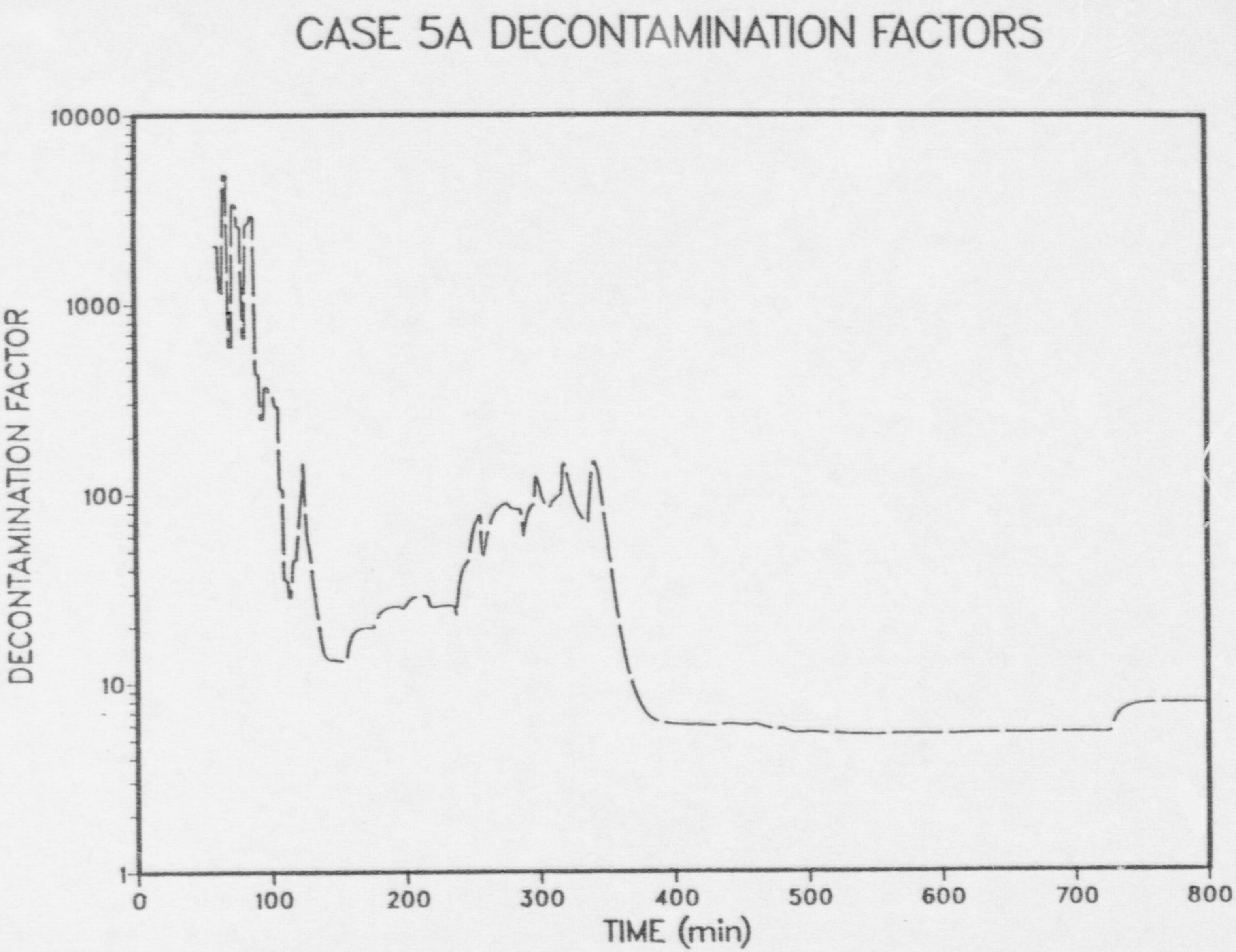
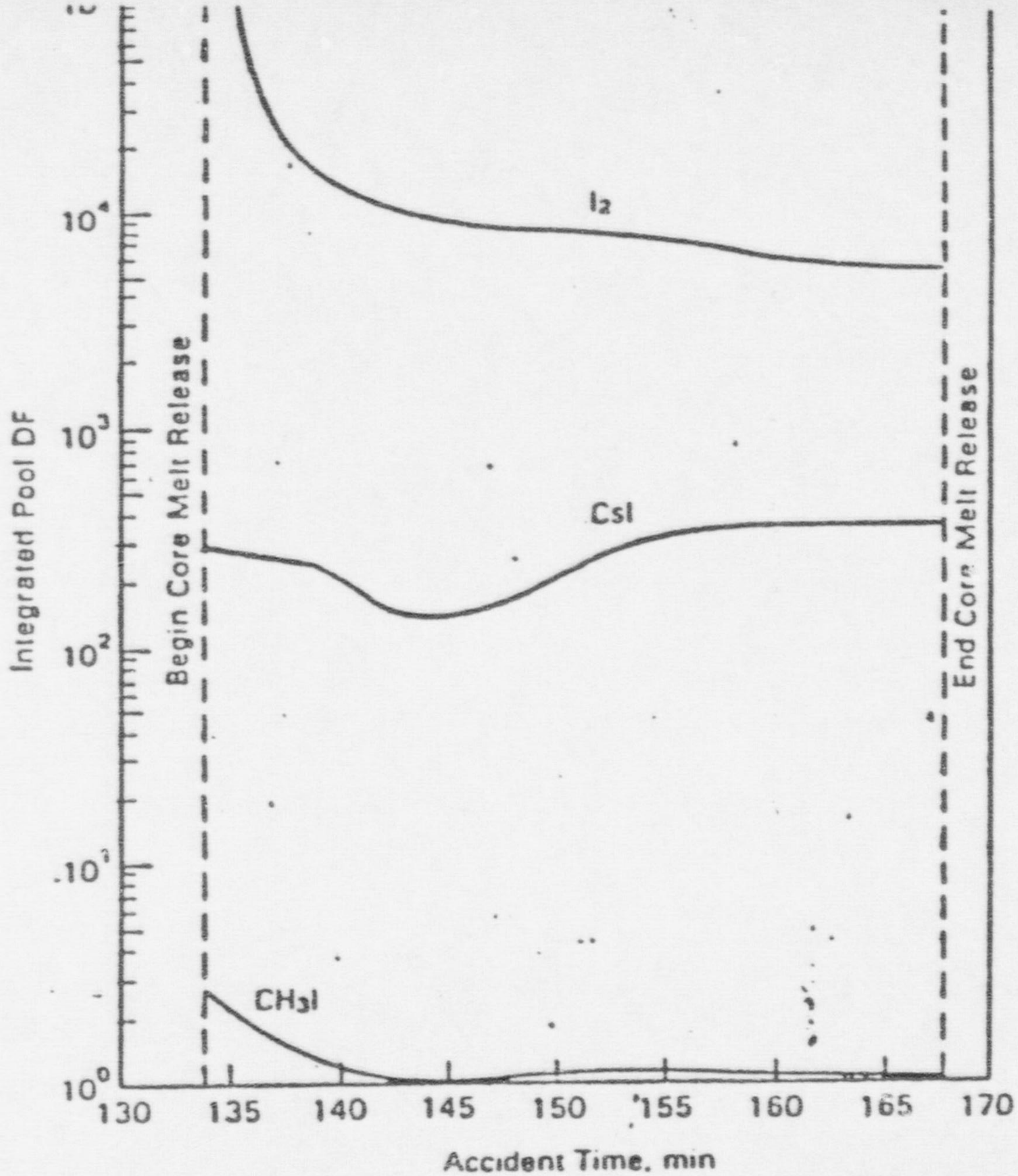


FIGURE 6.10. DECONTAMINATION FACTORS FOR INTERMEDIATE ELLIPTICAL BUBBLES INCLUDING CIRCULATION AND SOLUBLE PARTICLES



DECONTAMINATION FACTORS FOR IODINE SPECIES INTEGRATED OVER THE CORE MELT PERIOD. THE CsI CURVE REPRESENTS CASE 1, THE I_2 CURVE REPRESENTS CASE 2 AND THE CH_3I CURVE IS THE SAME IN ALL CASES

SUPPRESSION POOL BYPASS

- NOT ALL FISSION PRODUCTS GO FROM DRYWELL THRU SUPPRESSION POOL. SMALL FRACTION (TYPICALLY, FEW PERCENT) BYPASSES POOL.

- FRACTION THAT BYPASSES POOL IS UNSCRUBBED.

- NEED TO ACCOUNT FOR POOL BYPASS IN STAFF ASSESSMENT OF CONSEQUENCES.

POTENTIAL IMPACT OF

SUPPRESSION POOL CREDIT

ON OTHER ESF"S

- o SINCE SUPPRESSION POOLS AND ESF FILTERS BOTH ATTENUATE IODINE, CREDIT FOR POOL SCRUBBING MIGHT BE TRADED OFF FOR FILTER REQUIREMENTS

- o STAFF AND ACRS CONSENSUS NOT TO PERMIT CREDIT FOR SUPPRESSION POOLS TO ALLOW LARGE RELAXATION OF FILTERS (REMOVAL OR CHANGE IN STATUS TO NON-ESF), SINCE BOTH SYSTEMS YIELD DIVERSITY IN FISSION PRODUCT MITIGATION AND MINIMIZE BYPASS CONDITIONS.

- o THEREFORE, STAFF POSITION THAT EXISTING ESF"S CAN BE RELAXED SOMEWHAT, BUT NOT BELOW MINIMUM VALUE OF R.G. 1.52.

Proposed New Standard Review Plan Section

6.5.5 PRESSURE SUPPRESSION POOLS AS FISSION PRODUCT CLEAN-UP SYSTEMS

REVIEW RESPONSIBILITIES

Primary - Plant Systems Branch

Secondary - Reactor Systems

I AREAS OF REVIEW

Pressure suppression pools are reviewed under this plan only when the applicant claims credit for fission product scrubbing and retention by the suppression pool. The pressure suppression pool and the drywell, when considered as a barrier to the release of fission products, are reviewed to assess the degree to which fission products released during postulated reactor accidents will be retained in the suppression pool. Leakage paths which allow fission products to bypass the pool are identified and reviewed, and the maximum fractional bypass leakage is obtained, for use in the evaluation of radiological dose consequences.

1.) Fission Product Control Requirement

Sections of the SAR related to accident analysis, dose calculations, and fission product control are reviewed to

establish whether or not fission product scrubbing of the drywell or reactor compartment atmosphere is claimed or required for mitigation of off-site consequences following a postulated accident.

2.) Design Bases

A comparison is made to establish that the design bases for the suppression pool and the drywell or reactor compartment are consistent with the assumptions made in the accident evaluations of SAR Chapter 15.

3.) System Design

The information concerning the suppression pool is reviewed to familiarize the reviewer with the expected temperature histories, depth of fission product entry expected during postulated accidents and potential leakage paths through drywell penetrations.

4.) Testing and Technical Specifications

The details of the applicant's proposed preoperational tests, and, at the operating license stage, the surveillance requirements, are reviewed under section 6.2.1.1.C. The results of that review are examined to assure that pool depth and amount of leakage bypassing the pool are maintained consistent with the assumptions used in assessing the pool's effectiveness in fission product cleanup.

II ACCEPTANCE CRITERIA

The acceptance criteria for the fission product clean-up function of the suppression pool are based on the following requirements from Appendix A of 10 CFR 50:

A. General Design Criterion 41 (Ref.1) as related to the control of fission products following potential accidents.

B. General Design Criterion 42 (Ref.1) as related to the periodic inspection of engineered safety features.

C. General Design Criterion 43 (Ref.1) as related to the periodic functional testing of engineered safety features.

Where they can be shown to be in compliance with these criteria, suppression pools may be given appropriate credit for fission product scrubbing and retention (except for noble gases, for which no pool retention is allowed) in the staff's evaluation of the radiological consequences of design basis accidents. Other assumptions concerning the release of radioactivity are to be taken from Regulatory Guide 1.3, except for Position C.1.f, which this section replaces.

Specific criteria which must be met to receive credit are as follows:

1. The drywell and its penetrations must be designed to assure that, even with a single active failure, all releases from the core must pass into the suppression pool, except for small bypass leakage.

2. The bypass leakage assumed for purposes of evaluating fission product retention must be no less than that accepted in the review under section 6.2.1.1.C, and must be demonstrated in periodic tests by the license technical specifications also reviewed under that section.

3. For plants which have already received a construction permit, the iodine retention calculated using this section must not be used to justify removal of the standby gas treatment or other filtered exhaust system from status as engineered safety features. For such reviews, criterion II.5 of SRP 6.5.1 shall not be applied, and the charcoal absorbers must be at least maintained to the minimum level of Table 2 in Regulatory Guide 1.52, Revision 2.

Acceptable methods for computing fission product retention by the suppression pool are given in Subsection III, "Review Procedures."

III <u>Review Procedures</u>

The first step in the review is to determine whether or not the suppression pool is to be used for accident dose mitigation purposes. If no fission product removal credit is claimed in the accident analyses appearing in chapter 15 of the SAR, no further review is required.

If the suppression pool is intended as an engineered safety feature for the mitigation of off-site doses, then the reviewer estimates its effectiveness in removing fission products from fluids expelled from the drywell or directly from the pressure vessel through the depressurization system.

1. Pool decontamination factor

The decontamination factor (DF) of the pool is defined as the ratio of the amount of a contaminant entering the pool to the amount leaving. Decontamination factors for each fission product form as functions of time can be calculated by the SPARC code (Ref.2), and this calculation should be performed whenever the pool design is judged by the reviewer to differ significantly from those found acceptable as fission product cleanup systems in past reviews. If, however, the time-integrated DF values claimed by the applicant for removal of particulates and elemental iodine are 10 or less for a Mark II or a Mark III BWR; and are 5 or less for a Mark I BWR, the applicants values may be accepted without any need to perform calculations (R-: 3,4). (Ref. 3). A DF value of 1 (no retention) should be used for noble gases and, unless the applicant demonstrates otherwise, for organic iodides as well.

If calculation of fission product decontamination is done using the SPARC code, the review should be coordinated with the Reactor Systems Branch, which is responsible for establishing the accident assumptions needed to assemble the input for the calculations.

2. Pool bypass fraction

The fraction of the drywell atmosphere bypassing the suppression pool by leaking through drywell penetrations is obtained as a product of the review under section 6.2.1.1.C. If B is the bypass fraction and DF is the time-integrated pool decontamination factor, then the overall decontamination, D, to be reported to the Reactor Systems Branch for use in chapter 15 dose calculations may be taken as:

$$D = \frac{DF}{1 + B(DF-1)}$$

or

$$\frac{1}{D} = B + \frac{1-B}{DF}$$

The reviewer should clearly distinguish that fraction of B which may be further treated by the standby gas treatment system from that fraction of B which also bypasses secondary containment.

3. Other containment atmosphere clean-up systems

Plants having drywell or containment spray systems for which fission product cleanup credit is claimed are reviewed separately under section 6.5.2, and credit for both suppression pool and spray cleanup can be given as a result of the separate reviews.

4. Technical Specifications

The technical specifications are reviewed to assure that they require periodic inspection to confirm suppression pool depth and surveillance tests to confirm drywell leak tightness consistent with the bypass fraction used in computing the overall decontamination. Technical specification review is coordinated with the Facility Operations Branch as provided in NRR Office Letter No. 51.

IV EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided by the applicant and that the review and any calculations support conclusions of the following type, to be included in the staff's Safety Evaluation Report:

> We have reviewed the fission product scrubbing function of the pressure suppression pool and find that the pool will reduce the fission product content of the steam-gas mixture flowing through the pool following accidents which blow down through the suppression pool. We estimate the pool will decontaminate the flow by a factor of _____ for molecular iodine vapor and by a factor of ____ for particulate fission products. No significant pool decontamination from noble gases or organic iodides will occur. The system is largely passive in nature, and the active components are suitably redundant such that its fission product attenuation

function can be accomplished assuming a single failure. The applicant's proposed program for preoperational and surveillance tests will assure a continued state of readiness, and that bypass of the pool is unlikely to exceed the assumptions used in the dose assessments of Chapter 15.

The staff concludes that the suppression pool is acceptable as a fission product cleanup system, and meets the requirements of General Design Criteria 41, 42 and 43.

V IMPLEMENTATION

Except in those cases in which the applicant proposes an acceptable alternative method for complying with the specified portions of the Commission's regulations, the methods described here in are to be used by the staff in its evaluation of conformance with Commissions regulations.

Implementation of the acceptance criteria of subsection II of this plan is as follows:

(a.) Operating plants and OL applicants need not comply with the provision of this review plan section.

(b.) CP applicants will be required to comply with the provisions of this revision.

VI REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criteria 41, "Containment Atmosphere Clean-up", 42, "Inspection of Containment Atmosphere Cleanup Systems", and 43, "Testing of Containment Atmosphere Cleanup System".

2. P.C. Owczarski, R.I. Shreck and A.K. Postma, "Technical Bases and Users Manual for the Prototype of a Suppression Pool Aerosol Removal Code (SPARC)', NUREG/CR-3317, 1985.

3. P.C. Owczarski and W.K. Winegardner, "Capture of Iodine in Suppression Pools", 19th DOE/NRC Nuclear Air Cleaning Conference, Seattle, 1986.

4. R.S. Denning et al, "Radionuclide Release Calcuations for Selected Severe Accident Scenarios", NUREG/CR-4524, Vol. 1