UNITED STATES
NUCLEAR REGULATORY COMMISSION
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FROM: L. G. Hulman, Chief, AEB, DSI, NRR

SUBJECT: COMMISSION PAPER DRAFT: REGULATORY USES OF SOURCE TERM RESEARCH

Bob Bernerno asked that I begin a review process on the subject paper. Accordingly, Enclosure 1 is a draft of a proposed Commission Information Paper on the use of source term research in reactor regulation. The paper is intended to accompany the RES sponsored summary (NUREG-0956 for comment) to the EDO, ACRS and the Commission. To meet the schedule, your comments would be appreciated by May 29. Missing from the draft is Enclosure 1 which is intended to be a description of the IDCOR/NRC review process for assessing severe accident risks at all U. S. reactors. This enclosure is presently being drafted by DST/NRR and is expected to be forwarded to you on about May 22.

The draft incorporates the input and comments of a number of staff members. Those participating are identifed in Enclosure 2.

L. G. Hulman, Chief
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Enclosures:
1) Draft Commission Paper Encl. 1.
2) Contributing Staff Members

See next page for cc's

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cc: w/encl.

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For: The Commissioners

From: William J. Dircks
Executive Director for Operations

Subject: STAFF PLANS FOR THE USE OF NEW SOURCE TERM INFORMATION IN THE PROCESS (DRAFT 2)

Purpose: To inform the Commission of current and forthcoming staff activities to analyze and use new source term information in the regulatory process, to inform the Commission of preparations for Commission actions based upon new source term information, and to enable the Commission to comment on the direction and priorities of staff activities.

Summary: In a companion paper, the staff is presenting to the Commission NUREG-0956, Reassessment of the Technical Basis For Estimating Fission Product Transport In Severe Accidents In Light Water Reactors. That document summarizes and assesses the significance of recent substantial advances in what is called source term research; that is, our ability to estimate how radioactive materials are transported and released in

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reactor accidents. The ability to predict these releases lies at the very heart of the regulatory process. We measure the need for and the extent of protection of the public from undue risk by careful assessment of possible accidents and the releases of radioactive materials they might cause.

Accident release estimates have been used in the regulatory process for more than two decades. The advent of substantial new information on the subject compels us to reevaluate our regulations, standards and practices which are based on such estimates. In particular, we must reexamine the many parts of the process which are based upon the 1962 TID-14844 (see 10 CFR 100) source term estimates, and those which are based upon the more recent 1975 WASH-1400 risk estimates. Examples of uses of TID-14844 include containment performance, environmental qualification, air filtration and other fission product attenuation systems, accident monitoring onsite and offsite, and siting. Examples of uses of WASH-1400 estimates include emergency planning, Price Anderson Act - Insurance and other risk impacts (including Environmental Impact Statements), offsite contamination and recovery, and new regulatory requirements.

The regulatory staff has followed the research on this subject very closely, particularly on watch for evidence which might indicate gaps or weaknesses of safety significance. As the staff informed the Commission on March 14, 1985, we have not found any significant deficiencies in the regulations based upon our knowledge of this new information. We have, however, found a number of areas in which adjustments in regulations, standards and practice are desirable. These areas are summarized below and discussed in detail in the enclosures.

Discussion: 1. Regulatory Uses of Source Term Information - Accident source term information is used in a number of areas. Each is summarized as follows:

a) To assess the risks of severe accidents. Under the Proposed Severe Accident Policy Statement, industry and the staff will search for risk outliers. This activity is to be accomplished through the proposed Industry Degraded Core (IDCOR) reviews. The activities in this area are summarized in enclosure 1.

b) To assure containment performance. This area is presently controlled through the use of TID-14844 source term assumptions, and is implemented through 10 CFR 50, Appendix J, the Standard Review Plan (SRP), and related

Regulatory Guides. A need for modifications involving both potential decreases and increases in regulatory oversight have been identified. The discussion of this area, including staff plans for evaluating potential decreases and increases in regulatory oversight, are discussed in Enclosure 2, Item 1.

c) To assure adequate environmental qualification of electrical equipment. This area is presently controlled through the use of TID-14844 source term assumptions, related Regulatory Guides and the SRP. The present practice in this area, and the staff plans for further study of the margins in present qualifications for the range of source conditions indicated by present and forthcoming research, are discussed in enclosure 2, item 2.

d) To assure adequate emergency planning. This area is presently regulated through 10 CFR 50, Appendix E, and an interagency agreement with FEMA. Bases for regulation include the range of accidents that could occur as assessed primarily using WASH-1400 source term assumptions. The staff proposes to re-evaluate the bases for emergency planning guidance, coordinate with FEMA and affected state and local entities, and potentially propose modification to emergency planning requirements in 10 CFR 50, Appendix E. The bases for change in regulation and the staff plans are summarized in Enclosure 2, Item 3.

e) To assess whether post-accident offsite indemnification is warranted, whether adequate onsite indemnification is available, to advise Congress on the adequacy of and need for continuation of offsite indemnification requirements (Price-Anderson Act), and to evaluate environmental impacts under the National Environmental Policy Act. Regulatory guidance is 10 CFR 140, 10 CFR 50, the Price-Anderson Act, WASH-1400, and a 1980 Commission Interim Policy Statement. This area is discussed in Enclosure 2, Item 4.

f) To assure that accidentally released fission products are adequately attenuated through use of engineered safety features. This area is presently controlled through the use of TID-14844 source term assumptions, 10 CFR 100 guidelines, 10 CFR 50 design criteria, related Regulatory Guides and the SRP. A discussion of present practice, its basis and staff plans for considering potential regulatory relief is presented in Enclosure 2, Item 5. To prevent licensee's from unnecessarily or incorrectly expending valuable resources in implementing approved backfits, a draft Branch Technical Position (BTP) has been prepared explaining the present staff view on the subject. This draft BTP is Enclosure 5.

g) To assure adequate onsite and offsite instrumentation to aid in evaluating the consequences of accidents. This area is regulated via 10 CFR 50, related Regulatory Guides, the SRP, and related practice. The discussion of this area is contained in Enclosure 2, Item 6.

h) To assure that adequate provisions are available for coping with offsite post-accident contamination and recovery. Guidance in this area flows from 10 CFR 50 and general practice. The staff plans to use the new source term information in these areas as discussed in Enclosure 2, Item 7.

i) To evaluate the safety significance of generic issues and whether backfits are necessary. The present methodology for judging the safety significance of newly proposed generic issues has been based upon WASH-1400 source term assumptions. Evaluations of the need for backfitting have included source assumptions based upon both WASH-1400 and the new research. This subject is discussed in Enclosure 2 as Item 8.

j) To assess the adequacy of site and plant characteristics. Present criteria flow from 10 CFR 100, 10 CFR 50, various Regulatory Guides and the SRP. Rulemaking on siting issues, begun but held in abeyance pending source term research results, is again called for in the assessment presented in Enclosure 2, Item 9.

2. Severe Accident Risk Decisions - Prior to the TMI accident in March, 1979, considerations of accidents more severe than used in reactor licensing reviews were limited generic evaluations and assessments of accidents more severe than had been used in licensing evaluations. The primary generic evaluations were those associated with WASH-740 in 1957, those debated in developing 10 CFR 100 that was published in 1962 and WASH-1400 that was published in 1975. Following the TMI accident, an action plan was developed to implement the lessons learned from the event. Directly related were considerations of the evaluations of accidents more severe than those used in licensing evaluations (called severe accidents or Class 9 accidents). Included were activities related to degraded core cooling, the October 2, 1980 Advanced Notice of Proposed Rulemaking on Consideration of Degraded or Melted Cores in Safety Regulation (45FR65474), the hydrogen rules, the severe accident policy (SAP) development, the Interim Policy Statement on Severe Accident Considerations Under NEPA, control room operator protection from severe accidents

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3. Regulatory Uses and Changes. The regulatory uses of source terms can generally be summarized as covering the search for severe accident risk outliers (Enclosure 1) and ten other areas

of regulatory activity identified in Enclosure 2. Changes in regulatory practice are proposed for study or codification. Some of the initiatives are proposed in response to Commission actions others are proposed for initiation by the staff. It should also be noted that the source term research is already being used by the staff; e.g., the search for risk outliers, in cost-benefit assessments of backfit proposals, and in standard plant reviews such as GESSAR II. The applications to the other areas are identified in Enclosure 2.

4. Activities and Interactions - The proposals outlined in the enclosures hereto constitute the staff's current planning agenda for use of source term research in the regulatory process. A fundamental assumption used in the preparation of the agenda is that interactions with the public and industry are necessary for improved understanding of both the research and its application. The interactions will include requests for comments from the public and industry on proposed actions, and peer review of technical assessments in referenced journals. Internal NRC reviews by ACRS and CRGR will also be scheduled.

Finally, the staff offers the agenda in this paper for whatever comment or direction the Commission may wish to offer.

Scheduling: This information paper should be presented to the Commission at the same time that the ASTPO sponsored research culminating in NUREG-0956 is explained. An open session is recommended.

William J. Dircks
Executive Director
for Operations

Enclosures:

1. IDCOR/Staff Interactions
2. Regulatory Areas and Potential Changes
3. Preliminary Cost/Benefit and Schedule for Change
4. Draft Branch Technical Position

REGULATORY AREAS AND POTENTIAL CHANGES

A review of existing licensing or licensing related areas of regulatory practice influenced by accident source term assumptions was used to identify areas where the staff concludes changes may be appropriate. For each of the 9 areas identified, a description of the background and current practice, possibility for and character of possible changes, costs, benefits and schedule follows:

1. CONTAINMENT PERFORMANCE

Background and Current Practice: The current design basis leak rate of containments ranges from 0.1% to 2.0% by volume per day. Licensees are required by technical specification based upon 10 CFR 50, Appendix J, to perform an integrated leak rate test at least once every forty months to demonstrate that the actual leak rate is less than 75% of the design basis value contained in each plant's technical specifications. In addition, the gas and liquid leakage for equipment and components that may handle post-accident contamination outside the containment is also controlled by technical specifications.

The design basis leak rate of a containment is established by calculations which assume that the post accident airborne concentrations of iodine vapor and noble gases originally given by TID-14844 are instantaneously released and uniformly distributed in the containment atmosphere. These calculations either ignore or treat simplisticly the attenuation of iodine by such natural processes as dissolution in water, chemical reactions, and plate-out (adsorption). They also neglect release of other volatile fission products, such as cesium, from the containment.

Possibility for and Character of Changes: The assumed release of iodine vapor during reactor accidents currently dominates the calculations of off-site doses from which technical specifications of containment leak rates are derived. Current research indicates that most accidental iodine released in core-melt accidents will be in chemical and physical forms other than iodine vapor, and that elemental iodine does not dominate off-site risk. It is also now known that aerosols of many other elements may be released following core melt accidents, and that containment by-pass or failure, not diffusive leakage, is of greater importance to public risk. Thus, the basis for specifying containment leak rates should be re-evaluated, and a greater emphasis should be placed on the general integrity of containment.

In the near-term, the staff intends to study the advantages and disadvantages of alternative containment leak rate test requirements and acceptance criteria in terms of accident risk significance as well as operational considerations. Release of noble gases, essentially unchanged by present source term research, will be used to establish an upper limit for containment leak rates and indicates that these might be relaxed by factors ranging from two to ten, depending upon the present value. In addition to assuring low risk following an accident, revised leak rates must also provide assurance of low doses during normal operation as well, consistent with 10 CFR 50, Appendix I.

On the basis of this study, the staff will propose revisions in the Standard Review Plan (SRP) criteria and in the Appendix J test requirements and acceptance criteria. Candidate revisions may include:

1. Specifying a containment leak rate value for each of the major types of containment.

2. Adopting adminstrative controls or penetration design guidelines to aid in precluding an undetected breach of containment integrity.

3. Requiring supplemental testing, without impacting plant operations, to provide additional assurance that an undetected breach of containment integrity does not exist (inherent design/operation features such as the need to maintain a subatmospheric condition or inerted atmosphere may be readily adaptable for this purpose). Licensees will then have the option of utilizing the new criteria in technical specification changes.

For the longer term, the following actions will be considered.

1. Perform mechanistic analyses (plate-out, spray washout, attenuation along release path, etc.) of fission product release from the core

and transport within the containment.

2. Determine threshold levels of containment leakage that begin to be important considerations in risk estimates.

3. Explore the use of containment venting schemes for PWR's (similar to that proposed for BWR's) to reduce public risk by preserving containment integrity.

4. Explore the viability of implementing testing practices that provide a continuous indication of containment integrity.

5. Examine the desirability of certain surveillance/maintenance practices (such as performaning local leak rate tests on containment isolation valves during modes 1 to 4) that might lead to inadvertent safety system lockout, and develop an operability check method for preventing inadvertent safety system lockouts.

6. Provide bases for adjusting Limiting Conditions for Operation and Action Statements, in the Technical Specifications (i.e., to reflect their importance to safety).

<u>Costs and Benefits of Change</u>: Near-term changes exploring the risk significance of the alternative leak rate criteria in light of recent source term research are expected to require moderate staff resources. Longer term

efforts, especially those investigating approaches to enhanced containment integrity may require a greater involvement of staff resources.

Increases in allowable containment leak rate of the order of factors of two to ten are expected to offer direct and significant regulatory relief to many operating licensees, since compliance with the criteria of Appendix J is costly and is incurred regularly. The expense involved in the testing becomes larger as the leak rate to be demonstrated becomes smaller.

Imposition of additional containment integrity requirements would have costs ranging from relatively low for routine administrative controls to high for systems which continously indicate the status of containment integrity.

Tenative Agenda and Schedule: The staff's near-term study and recommendations is expected to be begun in late FY85 and completed in FY86. Longer term studies will commence in FY86 and are expected to be completed in FY88.

2. ENVIRONMENTAL QUALIFICATION:

Background and Current Practice: 10 CFR Part 50.49 requires electrical equipment important to safety to be capable of remaining functional during and following design basis accidents for which that equipment is needed. The radiation doses assessed for this equipment in an accident environment are derived from the TID-14844 assumptions.

Possibilities for and Character of Change: The radiation dose rates and integrated dose values arising from new source term research are likely to differ from those derived from TID-14844. The new information may show equipment to be exposed to lesser quantities of iodine than previously postulated, but exposed to other fission products presently neglected. At the present time, it is not clear whether the source term research will lead to an increase or a decrease in the accident radiation environment for equipment qualification purposes. The staff estimates, however, that the present degree of equipment qualification, derived from TID-14844, provides a very substantial level of protection for many severe accident conditions. A study will be performed to estimate the margins provided by the existing equipment qualification criteria compared to that derived from new source term data. If the study indicates that the new source term data would result in a higher level of radiation for some accident sequences, then the study will also address the risk significance of having equipment qualified only to the lower level. For example, if a piece of equipment is qualified for 30 days post-accident, and the new source term information indicates that qualification to the TID-14844 level assures functionality only for a 20 day radiation dose, the study will address the increase in risk associated with exceeding the qualification at the earlier time. The qualification with respect to temperature and pressure would also have to be examined in a similar manner.

Costs and Benefits of Changes: It is difficult to provide a clear statement of costs and benefits since it is not certain what changes may occur.

The staff estimates a moderate to high effort to be required to evaluate the margins associated with the present criteria, and to address their risk significance, with respect to the new source term research.

If the present criteria prove to be conservative, the staff anticipates no direct relief to the industry, since there would be no great impetus to replace presently qualified equipment. However, at future maintenance outages, equipment qualified to less harsh radiation environments could be used to replace present equipment. It is unlikely that the costs of qualification to moderately lower radiation levels would not be significantly reduced.

If the present criteria are non-conservative in radiation level, but have little risk significance associated with earlier equipment failure, the staff does not anticipate requiring licensees to take any immediate corrective action, such as replacement of equipment or its radiation sensitive components, but might require equipment or components of equipment qualified to higher radiation levels to be installed gradually, during periodic maintenance, as older equipment or components are replaced. This could potentially represent a large cost to the industry, depending on how non-conservative current criteria is and how much equipment and further testing is involved.

If the present criteria are non-conservative in radiation level and there is also a significant increase in risk associated with earlier equipment failure, the expected impact on the industry would be high, since prompt corrective action and/or shutdown might be required. However, equipment qualified to substantially higher radiation levels may not be available. The impact of any increase in radiation levels above current criteria would have to be assessed on an equipment specific basis; i.e., different items of equipment are currently shown to be qualified for different levels of radiation.

Tentative Agenda and Schedule: A staff study to address the margins provided by the existing equipment qualification criteria will be initiated sometime in FY86, and completed in FY88. Although the staff can assess the change in criteria on a generic basis, involvement of industry may be required to assess the impact of a criteria change on specific items of equipment.

It should be noted that changes in qualification to incorporate magnitude or duration of temperatures/pressures associated with severe accidents could have a substantial impact on qualification.

3. EMERGENCY PLANNING

Background and Current Practice: Current emergency planning regulatory practice is based upon consideration of a spectrum of accidents ranging from relatively frequent but low consequence events (including design basis accidents), to low probability severe accidents. The basic document, NUREG-0396, upon which the planning requirements are based, evaluated severe accident consequences and probabilities using WASH-1400 severe accident source terms as the fundamental assumptions. Subsequently, a regulation setting forth a generic approach to onsite and offsite planning and preparedness (10 CFR 50.47 and Appendix E thereto) was promulgated. Generic requirements were set forth for the establishment of a plume exposure emergency planning zone (EPZ) of about 10 miles in radius, and an ingestion exposure EPZ of about 50 miles. The sizes of these zones were considered sufficient for the planning of various possible protective actions at any given nuclear power plant. A companion guidance criteria document (NUREG-0654), prepared jointly by the NRC and FEMA, promulgated guidelines that included both evacuation and sheltering as potential offsite emergency responses. Since the NRC emergency planning requirements include actions by state and local governments, the NRC depends upon FEMA to assist in providing an evaluation of the state and local offsite plans and preparedness around each reactor site.

Possibility for and Character of Change: As a result of the generic approach to EP, misconceptions have arisen that all persons living within the EPZ are at high risk and that those living beyond the 10 mile limit are safe from radiation exposure. In addition, some have interpreted the regulation as virtually always requiring evacuation to 10 miles or even further. The use of WASH-1400 source terms to study emergency planning indicated that the potential for early injuries and fatalities from severe accidents has a large variation within the EPZ; that is, the risks are much greater in the inner portion close to the reactor than at the perimeter of the 10-mile EPZ. The concept of a graded response that would recognize such a risk variation with distance was beginning to gain support at about the time the peer review process for the revised source term research began. Information obtained from the new source term research clearly supports and confirms this concept. Furthermore, the results of the source term work indicates that there may be a reduction in offsite accident impacts that may be specific to plant and site characteristics. Thus, employing generalizations or generic requirements for all plants may not be technically valid. The source term research also strongly indicates that severe accident releases are highly time dependent, a conclusion which affects the timing of any needed emergency actions.

Proposed Actions: A sequence of activities is proposed to implement changes in requirements and practice as follows:

1 Coordinate (IE) with FEMA and solicit their assistance in meetings with appropriate state and local officials to explain the "graded response" approach to emergency planning and the possibility of classifying plants by groups by related accident consequence and

risk estimates.

2 With FEMA's assistance, determine (IE) the impact of a proposed change to emergency planning as discussed above, including appropriate protective action response strategies, on resources and other related factors.

3 RES and IE to draft revisions to 10 CFR 50.47 and Appendix E by devising a change in the emergency preparedness rule taking into consideration the revised source term methodology and using the following alternative approaches: (1) classify plants or groups of plants according to their risk profile, (2) use site specific emergency plans, or (3) use the graded response concept.

4 Using a constituency developed on an alternative, begin a parallel effort to the rulemaking to revise guidance contained in NUREG-0654 in order to have the joint NRC/FEMA guidance document ready to accompany the new rule.

5 Provide (NRR and RES) technical bases for change (NUREG-1082) as a result of the new source term review and validation. This document will form the cornerstone for all the EP changes and, consequently, will contain a detailed technical analysis and rationale for change.

6 (IE) Coordinate with EPA to ensure that any NRC actions do not conflict

with the EPA ongoing effort to revise the Protective Action Guides.

Costs and Benefits of Change: Changes to emergency planning are expected to require a moderate to high effort in staff resources. Significant elements in this effort will include (1) development of the technical bases for change (NUREG-1082) resulting from revised source terms and risk profiles and (2) coordination with other federal agencies, such as FEMA and EPA, and with affected state and local agencies. Rulemaking activities, specifically with an anticipated hearing, will require the moderate expenditure of staff resources.

Tangible benefits in terms of direct regulatory relief to operating plant licensees are expected to be low, since the staff anticipates no major changes in licensees emergency response capabilities or facilities. Intangible benefits in terms of reduced risk perceptions are anticipated to be high. Benefits to state and local agencies involved in emergency planning and response are expected to be high, since it is anticipated that a significant portion of the planning efforts devoted to the peripheral region of the EPZ may be eased. Revised emergency planning criteria more closely linked to our best understanding of accident risk can be expected to significantly enhance public confidence and lead to a more stable and efficient licensing procedure, as well.

Tentative Agenda and Schedule: The technical basis for change is expected to be initiated in FY 1986 and rulemaking could be completed in late FY 1987.

4. PRICE-ANDERSON ACT, INSURANCE, AND OTHER RISK IMPACTS

Background and Current Practice: Nuclear power plant licensees are required by 10 CFR 50.54(w) to obtain the maximum on-site property damage insurance reasonably available, and by the Price-Anderson Act of 1957, as amended, are required to obtain the maximum liability insurance coverage available. Should an accident at any U.S. plant incur liabilities in excess of that coverage, a retrospective premium would be paid by all licensees to create a fund to discharge this excess. At present, these two layers of insurance provide $630 million of coverage, an amount that increases by $5 million as each new nuclear power plant is licensed. The effective liability insurance limit and the retrospective premiums are set by Congress, and do not directly reflect an actuarial value of the indemnification provided. The Commission does, however, periodically provide recommendations and information concerning accident consequences, probabilities and liability limits to Congress. An example of such a report to Congress is NUREG-0957.

In the event of an accident, the Commission must make a determination of whether or not that accident was an "extraordinary nuclear occurrence" using criteria contained in 10 CFR 140. The radiological criteria in 10 CFR 140 correspond to much lower severity levels than the dose guidelines of 10 CFR 100, and could, in theory, be exceeded by accidents not involving core damage. The accident at TMI-2 was, by 10 CFR 140 criteria, not an extraordinary nuclear occurrence. The Commission is considering revisions to the definition of an "extraordinary nuclear occurrence."

Off-site risks of both human injuries and property damage are computed by the staff for each plant for purposes of implementing the National Environmental Policy Act, and are reported in Draft and Final Environmental Statements.

Possibility for and Character of Changes: Amendments to the on-site property insurance provisions of 10 CFR Part 50 are being considered, and the current Price-Anderson act expires on August 1, 1987. The Commission has recommended that Congress extend the act and amend it to remove the liability limit. This last would be done by providing for retrospective premiums to be paid every year following an accident until all claims are settled, and by doubling the premium to $10 million per operating power reactor per year. It is possible that the future availability of the results of a thorough re-examination of the risks of severe accidents, using the new methodology, may affect the outcome of Congressional deliberations of this matter; perhaps suggesting different treatment of certain reactor/containment types, or a decreased need for or a reduced cost of indemnification.

The improved source terms will be used to compute more realistic off-site consequences in future NEPA reviews.

Benefits and Costs of Changes: Impacts on staff resources are expected to be minimal. Since the risks of nuclear power are small, the expected costs and benefits to individual utilities governed by the Price-Anderson Act are also small, actuarially. In the event of an accident, however, the difference between limited and unlimited indemnification could be immense to the affected utility. Impacts on public confidence are unknown.

Tentative Agenda and Schedule: The staff will prepare a report to the Congress providing an assessment of the impact of revised source terms on the Price-Anderson limit of liability. The report will be completed in late FY86 or early FY87, well before the expiration of the present act.

The new source term information will be used in preparing Draft Environmental Statements beginning in FY86.

5. AIR FILTRATION AND OTHER FISSION PRODUCT ATTENUATION SYSTEMS:

Background and Current Practice: Engineered safety features provided to mitigate accidental radioactive releases are reviewed and tested primarily for effectiveness against iodine. Such systems include (1) containment spray systems, (2) recirculating air filters within containments, (3) control room habitability system air filters, and (4) filtered building exhausts. Since accidentally released iodine is presently assumed to be predominately in the form of molecular vapor, such mitigative features contain either a spray additive or charcoal impregnant intended to optimize the retention of molecular iodine. Some control room and building exhaust filter systems are also used to mitigate the radiological consequences of normal releases covered by 10 CFR 50, Appendix I. Such releases also include radioactive iodine for which charcoal filters are known to be effective for removal. These systems are assumed basically ineffective in the mitigation of noble gas releases.

PWR spray systems employ additives, such as hydrazine or sodium hydroxide, to enhance removal of elemental iodine. These systems are credited with such removal during safety reviews. BWR suppression pools and BWR containment sprays, which do not employ additive systems, presently are not credited with fission product removal or retention during safety reviews.

As an inducement for the design of rapidly acting systems, accidentally released iodine is assumed to occur simultaneously with accident initiation and to leak into the environment untreated for the duration of any time necessary for the filters or sprays to achieve full capacity. Often, large fractions of the estimated off-site thyroid doses are due to the iodine releases postulated during the first few minutes of the assumed accident.

Possibility for and Character of Change: Present fission product mitigation systems, as discussed above, are optimized for the removal or retention of iodine, largely in elemental form. Source term research indicates that iodine accidentally released in core melt accidents does not appear for a number of minutes after accident initiation and is likely to be present primarily in aerosol form along with aerosols of other volatile fission products, as well. Thus, both the timing and nature of fission product releases are in error. The effectiveness of present spray and filter systems against aerosols is believed to be high. ESF filter systems contain several stages of particulate filters specifically designed to remove aerosols, while spray systems are known to be effective in removal of such contaminants. The use of additives in the spray system add little to the already high removal of aerosols by spray systems. Such additives are potentially important, however, in post-accident pH control. At present there also exists a plant operational disincentive to have the spray system automatically actuated, lest a corrosive additive harm equipment or personnel in the event of an inadvertent spray actuation. The staff concludes, on the basis of the above factors, that automatic injection of spray additives should be eliminated. Use of spray additives should be retained for PWR's, however, as an option to be factored into the emergency operating procedures, as well as for post-accident chemistry control. Credit should also be extended to BWR sprays and suppression pools for fission product removal or retention.

While the effectiveness of present filter systems against aerosols is believed to be very high, no short-term changes with regard to existing filter systems are anticipated. Changes in filter system criteria are to be incorporated in Reg. Guide 1.52 along with other changes since the last revision of the Guide. Backfitting for elemental iodine removal is not to be required.

Cost and Benefits of Change: A large indirect benefit to most PWR licensees is anticipated as a result of discontinuance of automatic injection of the spray additives. This is due primarily to reduced concern regarding the adverse effects of an inadvertent spray system actuation. A moderate, indirect benefit to BWR licensees is anticipated as a result of the granting of fission product removal credit for BWR suppression pools and sprays.

Tentative Agenda and Schedule: These changes are expected to be initiated in FY85 and completed in FY86.

6. ACCIDENT MONITORING ONSITE AND OFFSITE INSTRUMENTATION:

Background and Current Practice: All plants are required to provide instrumentation to monitor plant variables and systems during and following an accident. This instrumentation is qualified to be capable of operating under conditions estimated from the fission product assumptions of TID-14844 and the peak accident temperature and pressure profiles. Under Regulatory Guide 1.97, some instruments considered necessary to follow reactor accidents are qualified to a much harsher radiation environment.

Instrumentation is also required for off-site monitoring of both routine and accidental releases. Off-site instrumentation generally includes fixed thermo-luminescent detectors (TLD) at an array of locations surrounding the site, portable radiation measuring equipment, and portable air samplers.

Possibility for and Character of Change: The qualification of the instrumentation required to assess plant conditions during and following an accident is to an environment consisting of the non-mechanistic radiation doses in TID-14844 (except for a small number, as indicated above, which are qualified to a more stringent environment) combined with temperature and pressure profiles calculated for pipe break accidents not involving a core melt.

The minimum number of variables that could enable an operator to follow and potentially prevent or mitigate releases during the course of any accident, up to and including severe accidents, should be identified. Given this identification, it would be possible to evaluate the risk significance and benefits for instrumentation needed to measure the identified variables and their capability of surviving the environment to which they might be subjected for the period of time for which they must operate.

The radiological criteria in 10 CFR Part 140 by which an extraordinary nuclear occurrence is to be determined are given in terms of human organ doses and surface contamination densities by specific classes of radioisotopes. These measurements, however, are not simply and unambiguously made by the TLD's and portable equipment presently available. This difficulty is exacerbated by the new source term information for many kinds of accidents, which decreases the likely off-site dose contributions expected from noble gases (by virtue of potential delayed containment failure) and iodine vapor. Off-site monitoring requirements should be re-evaluated using new source terms to assure adequate diagnostic capability. It may prove necessary either to recast the radiological criteria of 10 CFR Part 140 in terms more directly related to measurable quantities, or to require specific radio-assay equipment in the off-site monitoring program.

Costs and Benefits of Change: The expense of requalifying instruments and their supporting electrical equipment could be large, and would only be justified in those instances in which the assured operation of particular instruments could be shown to signficantly reduce the likelihood of accident progression.

Off-site portable equipment is not a major expense, but a large intangible benefit exists in adequately quantifying radioactive releases, both routine and accidental, in order to demonstrate compliance and to adequately evaluate estimated health effects.

Tentative Agenda and Schedule: The identification of reactor variables that are of risk significance in preventing accidents from progressing in severity or in mitigating them that are not presently adequately covered by the guidance in Regulatory Guide 1.97 is expected to be complete by the end of FY 1986.

Offsite monitoring will also be re-assessed by the close of FY86, and any necessary revisions to Regulatory Guide 1.101 proposed.

7. OFFSITE CONTAMINATION AND RECOVERY

Background and Current Practice: Considerations of offsite contamination and recovery resulting from an accident is applied in a number of areas of regulatory oversight.

As part of its assessment of standard plant risks, the staff routinely analyzes the off-site effects of severe accidents, including health effects, costs of contaminated real property, crop interdiction, evacuation and decontamination costs. The GESSAR II review of severe accidents has already utilized the new source term information. These assessments are currently performed usually using source terms derived from WASH-1400. WASH-1400 source terms have also been the basis of risk judgments on activities such as predistribution of potassium iodide (KI) to be used as a thyroid blocking agent, and possible use of severe accident mitigation features, (e.g., filtered-vented containments) to reduce the impact of offsite contamination. In addition, while not directly applied in the regulatory arena, the judgments made using WASH-1400 source terms regarding offsite contamination have had a significant influence upon public attitudes toward nuclear power.

Probability for and Character of Change: Revised source term research is likely to change estimates of both the absolute as well as the relative amounts of fission products released. Although research is incomplete, the results appear to be generally lower in absolute quantities, and highly dependent upon the plant as well as the sequences examined. Changes in several areas may be anticipated. For example, a recent policy statement by the Federal Radiation Planning Coordinating

Committee (FRPCC) recommended against the pre-distribution of potassium iodide (KI) to the general public. This recommendation was based upon iodine releases as predicted by WASH-1400. Since the new source term information indicates that iodine releases will be substantially lower for some reactor types, and most likely in a less volatile form, it is anticipated that this provides additional basis against the pre-distribution of KI.

The staff expects in forthcoming standard plant evaluations to examine accident risks as well as offsite contamination and recovery costs utilizing both the new information and WASH-1400 assumptions. It is anticipated that the new source term results will generally show a lower degree of offsite contamination. These evaluations are directly related to the cost-effectiveness of a number of engineered safety features that have been proposed to mitigate the consequences of a severe accident, such as filtered-vented containments. Although the cost/benefit ratios are expected to vary significantly, depending upon the plant design, expensive mitigation features are not expected to prove cost-beneficial.

Costs and Benefits of Change: Little additional staff effort is anticipated in regard to actions regarding KI. There have been a number of staff analyses prepared and presented in the past. A moderate staff effort is anticipated in utilizing revised source term information for forthcoming standard plant reviews. This will be principally in the area of obtaining revised source terms that are appropriately categorized and binned so as to provide an adequate risk perspective. A moderate staff effort is expected in the area of assessment of prospective engineered saf cy features in light of revised source term information. Some research studies have been performed in the past. Work on standardized plants, such as RESSAR-90, are expected to demonstrate this conclusion.

Operating licensees are not expected to benefit directly from the anticipated changes in this area. Actions regarding KI are expected to ease the costs for state and local governments involved in emergency planning. Similarly, research studies on proposed engineered safety features for severe accident mitigation are not expected to result in any direct cost reductions to licensees and applicants, but will likely build confidence in existing designs.

Overall, the benefits in this area are expected to be primarily intangible ones, largely in the area of increased public confidence.

<u>Tentative Agenda and Schedule</u>: The revised FRPCC policy statement on KI is expected to be considered within the very near future. Assessment of proposed ESF's is being pursued as part of the Severe Accident Research Program and standard plant reviews. Together with staff interaction with the industry group (IDCOR), evaluations expected in FY 86 and FY 87 are expected to demonstrate reduced risks and lowered requirements for additional ESF's for standard plants.

8. NEW REGULATORY REQUIREMENTS

Background and Current Practice: Each newly raised generic safety issue is assessed by the staff in a two-step process. In the first step, the staff establishes the potential importance of the new safety issue relative to all others, in order to assign it a priority in the competition for limited resources. This prioritization is a systematic application of PRA methods to estimate two indices of safety importance:

(a) Risk Importance - an assessment of the increase in societal risk posed by the generic issue as indicated by the estimated dose to the surrounding population out to 50 miles from the plant; and

(b) Value/Impact - a measure of the cost effectiveness of resolving the safety issue, i.e., the ratio of the risk reduction to the total cost (to industry and the NRC) involved in developing and implementing the mode of resolution.

The indices are currently evaluated using source terms derived from WASH-1400.

As generic safety issues achieve priority in the use of staff resources, they enter the second step of the process. A more detailed evaluation is performed, comparing risks under existing conditions with what they are estimated to be under improved conditions brought about by increased regulatory requirements addressing the generic safety issue. Among the factors considered in this second step are the potential reduction in risk to the public and the potential impact on the radiological exposure to plant personnel associated with the proposed new requirements or backfit. Currently, the probabilistic estimate of public risk uses source terms derived from WASH-1400. On the other hand, occupational exposures are estimated in a relatively direct manner based on measured onsite radiation levels and expected times of exposure.

Possibility for and Character of Change: Depending upon accident sequence and type of plant, the new source term methodology can estimate lower accident consequences and risks than those derived from WASH-1400. In many cases, the assessed value/impact could be changed, yielding changed priorities, and differing results in the assessment of the justification for backfitting. The staff anticipates revising the indices by which the safety importance of generic issues are evaluated to agree with the insights gained from the recent source term research. These may be more complete than presently envisioned, and may be different for different plant types or groups.

Costs and Benefits of Change: Moderate staff effort is expected to revise the evaluation of generic safety issues using new source term information. Benefits are expected to be high since the risk categorization of an issue will be in keeping with the latest research data and emphasize areas of risk significance.
This change is expected to result in a general risk reduction for many generic issues.

Tentative Agenda and Schedule: Revision of the methodology for evaluating generic safety issues is scheduled to begin in FY 85 and to be completed in late FY 85 or early FY 86.

9. SITING

Background and Current Practice: Siting criteria in 10 CFR Part 100 include several tests in which it must be demonstrated that (a) the site possesses certain characteristics; (b) the plant-site combination meets certain criteria; and (c) that the site is located sufficiently far from population centers (remote siting). Each site must have an exclusion area within which an applicant has authority to determine all activities. Beyond the exclusion area lies the low population zone (LPZ) which may contain residents, the total number and density of which are such that there is a reasonable probability that protective measures could be taken in their behalf in the event of an accident. Finally, Part 100 requires that the distance from the reactor to the nearest population center (of about 25,000 or more residents) must be at least one and one-third times the distance to the outer boundary of the LPZ. The distances to the exclusion area boundary, the LPZ outer boundary and the population center are not numerically fixed, but depend upon the plant characteristics, including its maximum full power fission product inventory, and the complement and performance of certain engineered safety features.

To test whether the plant-site combination meets the requirements of Part 100, a hypothetical core melt accident (TID-14844) is postulated involving the instantaneous release of 100% of the core inventory of noble gases and 50% of the iodines into the containment. Half the iodines released are assumed to plate-out upon interior surfaces, while the remaining 25% is available for leakage. The containment is assumed to remain intact, but is presumed to leak at its design basis leak rate. The performance of fission product mitigating features (e.g., sprays, filters) are assessed in a stylized fashion to estimate thyroid and whole body doses unlikely to be exceeded in hypothetical individuals located at the exclusion area boundary and the LPZ outer boundary for specified time periods. The plant-site combination is determined to be acceptable if the calculated doses do not exceed the guideline values given in Part 100. It is clear that current siting practice involves a close coupling of the site and the reactor design. Also, the thyroid dose calculation, driven by assumptions of release of elemental iodine, is usually the limiting dose in determining the acceptability of the exclusion area boundary, the low population zone, and performance requirements of certain fission product mitigating features.

No dose calculation is performed for individuals located at the population center. However, in the statement of considerations accompanying the issue of Part 100, it was noted that the population center distance requirement was added to provide for protection against excessive accidental exposure doses to people in large centers, since accidents greater than the hypothetical accident postulated for siting purposes was considered conceivable (core melt with containment failure), although highly improbable. This statement was recognition of the possibility of accidents involving containment failure and of their importance in siting considerations. Since publication of the Reactor Safety Study (WASH-1400) in 1975, there has been a general recognition that although probably small, public risks are dominated by such accident considerations.

These siting criteria, promulgated in 1962, led to a significant improvement in fission product mitigating engineered safety features in the late 1960's and early 1970's. In 1975, the staff in response to objections that 10 CFR Part 100 did not preclude sites with very small exclusion area boundaries or in relatively densely populated regions, proposed (Regulatory Guide 4.7) that exclusion area distances should be about 0.4 miles or greater and that the average population density for the circular region surrounding a site should have no more than about 500 people per square mile within a distance of 30 miles. The effect of this Guide is to suggest a minimum stand-off distance from reactor sites to large population centers (for example, a reactor should be located about 25 miles away from a city of 1,000,000 people). Sites where these values are exceeded are not forbidden, but should be shown to possess superior features in other respects to offset the disadvantage of high population. About 90 percent of the 75 U. S. power reactor sites meet the density criteria of the Guide; those that do not were reviewed and approved prior to 1975. The criteria of Regulatory Guide 4.7 were intended to provide a reasonable degree of separation from large population centers while maintaining a good availability of land area for potential future sites. However, no explicit consideration of severe accidents was employed.

In 1979, a staff evaluation of siting policy and practice (NUREG-0625) recommended, among other things, an explicit consideration of severe accidents in siting and separation, and a decoupling between plant design and siting requirements. The Commission initiated rulemaking in this area in 1980, but suspended it about a year later, pending a re-evaluation of accident source terms as well as an evaluation of the proposed safety goal.

Possibility for and Character of Changes: Changes in siting could come about primarily in two areas. These are in (1) evaluation of certain design basis accidents used in licensing evaluations and technical specifications, and (2) consideration of accidents more severe than the design basis.

(1) The present design basis accident postulated for testing combinations of ESF and site characteristics, including the evaluation of the performance of containment and other engineered safety features, may contain significant errors when examined in light of our present understanding. Among these are an undue attention to iodine, particularly in the elemental form, and neglect of other fission products of importance, such as cesium. The possibilities for change with regard to design basis accidents are as follows:

a) Develop revised design basis accident assumptions for siting and evaluation procedures for engineered safety feature performance that are in accord with the evolving understanding of fission product behavior under degraded core conditions.

b) Eliminate design basis accident radiological evaluations related to site/plant adequacy entirely by specifying a minimum set of required engineered safety features together with their performance criteria, plus a minimum set of site characteristics (e.g., distances to exclusion area boundary, LPZ and population center).

(2) With regard to accidents beyond the design basis, siting criteria presently contain no explicit considerations of severe accidents, as noted above. Commission policy, 10 CFR Part 100, and present staff practice (via Regulatory Guide 4.7) does encourage siting away from densely populated centers, but the present population density criteria have no clear link to severe accident risk. It should be noted, however, that more than 20 site-specific Environmental Impact Statements (EIS) have been performed by the staff which have included an explicit discussion of severe accident risks. These have shown the risks to be low for all the sites analyzed. In addition, the Commission special proceeding for the Indian Point site, the highest population density reactor site, also explicitly considered severe accident risks and concluded these to be low. Based upon evaluations of low accidental risks for present sites using WASH-1400 source terms, together with the fact that there appears to be little incentive for siting in more populous areas, the staff anticipates that a revision of siting criteria employing new source terms would represent no major changes from present staff practice with respect to accident considerations.

Costs and Benefits of Change: Revision of siting criteria is expected to require a low to moderate effort in regard to staff resources. Most of this would be in evaluating the risks associated with the proposed criteria and alternative approaches, including an evaluation with regard to the Safety Goal criteria.

Benefits in terms of direct regulatory relief are expected to be low, since, as mentioned earlier, the staff anticipates no major departures from present staff practice and there is little incentive for more populous siting. Intangible benefits in terms of contributing to the Commission's policy on preapproval of plant sites and enhancement of public confidence are expected to be high, however. The benefits also include the potential for a more stable and efficient licensing process.

Tentative Agenda and Schedule: Since rulemaking in this area had been initiated in 1980 and suspended about a year later, some of the technical work, especially in the area of land availability, is considered to be still applicable. It is estimated that rulemaking could be reactivated in FY 1986 and completed in late FY 1986 or early FY 1987.

ENCLOSURE 3

PRELIMINARY BENEFIT-COST SUMMARY OF AREAS TARGETED FOR SOURCE TERM RELATED CHANGES

REGULATORY AREA	COSTS	BENEFITS	CHANGE IN REGULATORY REQUIREMENTS*	IMPLEMENTATION TARGET
1 IDCOR-NRC Staff Search For Risk Outliers		TO BE DETERMINED		
2 Containment Performance				
Near Term	Low	High	D	FY86
Future	Unknown	Unknown	Unknown	Unknown
3 Equipment Qualification	Moderate to High	Moderate to High	U	FY88
4 Emergency Planning	Moderate	High	D	FY86
5 Price Anderson Act Insurance, And Other Risk Impacts	Unknown**	Unknown**	U	FY86
6 Air Filtration & Other Fission Product Attenuation Methods	Low	High	D	FY86
7 Instrumentation	High	High	U	FY86
8 Offsite Contamination & Recovery	Low	High	D	FY87
9 New Regulatory Requirements	Moderate	High	U	FY86
10 Siting	Moderate	High	D	FY87

* Increase (I), Decrease (D), Unknown (U)
**Depends on Congress

DRAFT
BRANCH TECHNICAL POSITION AEB 6-4
CONTROL ROOM HABITABILITY

A. BACKGROUND

Control room habitabilty requirements historically have been dominated by considerations of thyroid doses that result from assumed accidental exposure to gaseous iodine. Assumed releases of gaseous iodine have resulted in control room habitability system designs which incorporate such items as charcoal adsorbers in control room pressurization and recirculation systems.

Recent source term research activities indicate that the accidental release of gaseous iodine as given in TID-14844* may be considerably overstated. That is, iodine releases from core melt accidents will primarily be in the form of cesium iodide as an aerosol mixed with aerosols of other fission products. As a result the guidance for iodine protection as given in Standard Review Plan Section 6.4 may be unduly conservative with respect to iodine releases. Therefore, pending further decisions on the fission product mix and physical and chemical characteristics used in design basis accident assessments, the staff is suspending use of the thyroid criteria set forth in the Standard Review Plan. In the interim the staff will utilize the whole body and beta skin dose guidelines of the Standard Review Plan in determining the acceptability of control room habitability systems.

Control rooms provide protection to the operators by limiting the amount

* See Footnote 1 to 10 CFR 100. TID-14844 is Technical Information Document-14844, "Calculation of Distance Factors for Power and Test Reactor Sites"; by DiNunno et al.; March, 1962.

of inleakage to the control room envelope. The staff concludes the concept of a tight control room is still valid because the tighter the control room is, the more control there is over the amount of fission products that reach the control room. Protection of the control rooms against aerosols, in tern, could be provided by designs that minimize inleakage and/or incorporate HEPA filters on pressurization systems. Most current control room habitability systems incorporate HEPA filters and, therefore, have some capability for removal of aerosols and operator protection.

B. BRANCH TECHNICAL POSITION

Control room habitability systems will be evaluated on the basis of estimated whole body and beta skin doses until additional performance requirements are stated. These doses will be evaluated considering a TID 14844 release of 100% of the core noble gas inventory to the containment.

Control room designs should utilize low leakage design considerations such as bubble tight damper construction, etc. Pressurization systems should be installed with the capability of pressurizing the control room to 1/8" water gauge with a minimum amount of flow. Any pressurization or recirculation system backfitting should provide for (but not necessarily include) the potential for future use of HEPA filters designed to remove aerosols.

Lecture at Harvard
"Planning for Nuclear Emergencies"
June 1985

RECENT DEVELOPMENTS IN NRC EMERGENCY PREPAREDNESS

RESEARCH AND REGULATIONS

LEONARD SOFFER

U. S. NUCLEAR REGULATORY COMMISSION

WASHINGTON D. C.

JUNE 14, 1985

B-14

OUTLINE

- BASIS FOR PRESENT EMERGENCY PLANNING REGULATIONS
- SOURCE TERM RESEARCH SINCE WASH-1400 AND PRESENT STATUS
- CONCEPT OF "GRADED RESPONSE"

REVISION TO EMERGENCY PLANNING REGULATION

(AUGUST 1980)

- PREVIOUS REGULATION ESTABLISHED EMERGENCY PLANNING ONLY IN LOW POPULATION ZONE (TYPICALLY, 2 TO 3 MILES) - BASED ON DBA-LOCA ANALYSIS.
- REVISED REGULATION BASED ON WASH-1400 SOURCE TERMS AND PROPOSED PROTECTIVE ACTION GUIDES (PAG) OF 1-5 REM WHOLE BODY, 5-25 REM THYROID ESTABLISHED
  - PLUME EXPOSURE EMERGENCY PLANNING ZONE (EPZ) OF ABOUT 10 MILES
  - INGESTION PATHWAY EPZ OF ABOUT 50 MILES
- RATIONALE
  - APPROPRIATE TO PLAN FOR A SPECTRUM OF ACCIDENTS, NOT SINGLE ONE
  - FOR MOST CORE-MELT ACCIDENTS - UPPER LEVEL PAG'S NOT EXCEEDED BEYOND ABOUT 10 MILES
  - FOR SEVERE CORE-MELT ACCIDENTS - LIFE THREATENING DOSES NOT EXCEEDED BEYOND ABOUT 10 MILES
  - ESTABLISHMENT OF 10 MILES FOR PLANNING PURPOSES PROVIDES BASE FOR EXPANSION, IF NECESSARY

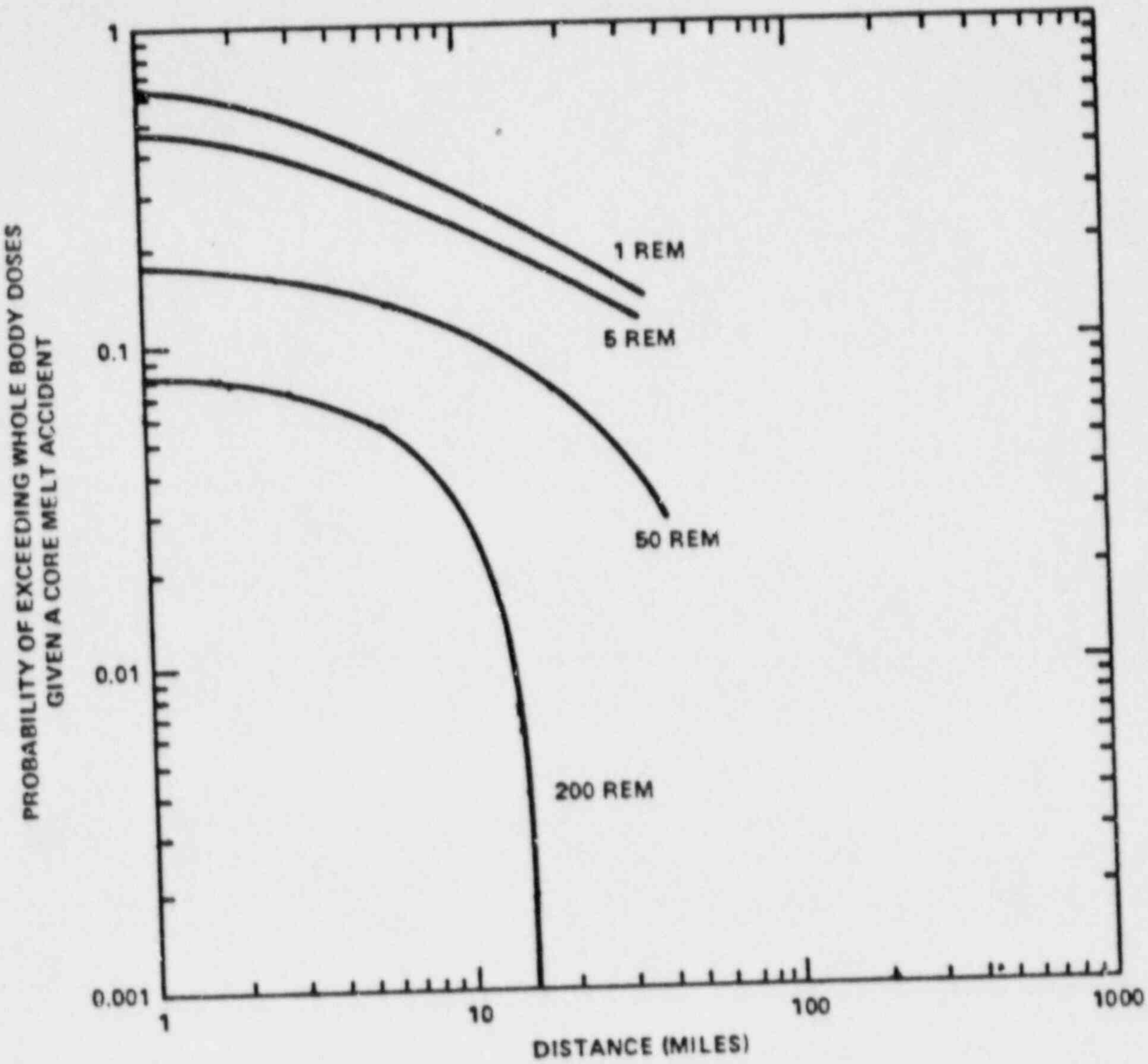

Figure I-11. Conditional Probability of Exceeding Whole Body Dose Versus Distance. Probabilities are Conditional on a Core Melt Accident (5×10^{-5}).

Whole body dose calculated includes: external dose to the whole body due to the passing cloud, exposure to radionuclides on ground, and the dose to the whole body from inhaled radionuclides.

Dose calculations assumed no protective actions taken, and straight line plume trajectory.

SOURCE TERM DEVELOPMENT*
POST WASH-1400

- o ELIMINATION OF SMOOTHING IN RELEASE CATEGORIES
- o REEVALUATION ("REBASELINING") OF KEY ACCIDENT SEQUENCES
- o STEAM EXPLOSION CONTAINMENT FAILURE PROBABILITY MUCH REDUCED
- o ANALYSIS OF ADDITIONAL PLANTS (OCONEE, SEQUOYAH, CRYSTAL RIVER, INDIAN PT., CALVERT CLIFFS)
- o DEVELOPMENT OF GENERIC SOURCE TERMS (KNOWN AS SITING SOURCE TERMS, OR "SST")

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* REFERENCE, NUREG-0773

TABLE 2 - Source Terms for Siting Analysis

Release Category	Time of Release (hr)	Release Duration (hr)	Warning Time (hr)	Release Height (meters)	Release Energy
SST 1	1.5	2	0.5	10	0
SST 2	3	2	1	10	0
SST 3	1	4	0.5	10	0
SST 4	0.5	1	-	10	0
SST 5	0.5	1	-	10	0

Core Inventory Release Fractions (to atmosphere)
(for Release Categories SST1 to SST5)

Xe-Kr	I	Cs-Rb	Te-Sb	Ba-Sr	Ru	La
1.0	.45	.67	.64	.07	.05	9×10^{-3}
0.9	3×10^{-3}	9×10^{-3}	3×10^{-2}	1×10^{-3}	2×10^{-3}	3×10^{-4}
6×10^{-3}	2×10^{-4}	1×10^{-5}	2×10^{-5}	1×10^{-6}	2×10^{-6}	1×10^{-6}
3×10^{-6}	1×10^{-7}	6×10^{-7}	1×10^{-9}	1×10^{-11}	0	0
3×10^{-7}	1×10^{-8}	6×10^{-8}	1×10^{-10}	1×10^{-12}	0	0

	Accident Type	Nature of Containment Leakage
SST 1	Core Melt	Large, Overpressure Failure
SST 2	Core Melt	Large, H_2 Explosion or Loss of Isolation
SST 3	Core Melt	~1%/day
SST 4	Gap Release	~1%/day
SST 5	Gap Release	~0.1%/day

Note: SST stands for Siting Source Term

RE-EXAMINATION OF ACCIDENT SOURCE TERMS

- O AS A RESULT OF TMI, MUCH DOUBT CAST ON IODINE RELEASES UNDER ACCIDENT CONDITIONS. INDUSTRY GROUPS HAVE ALSO STATED THAT ACCIDENT CONSEQUENCES HAVE BEEN GREATLY OVER-ESTIMATED

- O NRC STAFF REVIEWED AVAILABLE TECHNOLOGY

  - PUBLISHED NUREG-0772, TECHNICAL BASES FOR ESTIMATING FISSION PRODUCT BEHAVIOR DURING LWR ACCIDENTS, JUNE 1981

  - GENERAL CONCLUSION: RELEASE ESTIMATES OF WASH-1400 PROBABLY CONSERVATIVE, BUT DIFFICULT TO QUANTIFY WITHOUT ADDITIONAL RESEARCH

- O ACCIDENT SOURCE TERM PROGRAM OFFICE (ASTPO) FORMED WITHIN NRC IN JANUARY 1983 TO ASSESS ACCIDENT SOURCE TERMS MORE REALISTICALLY

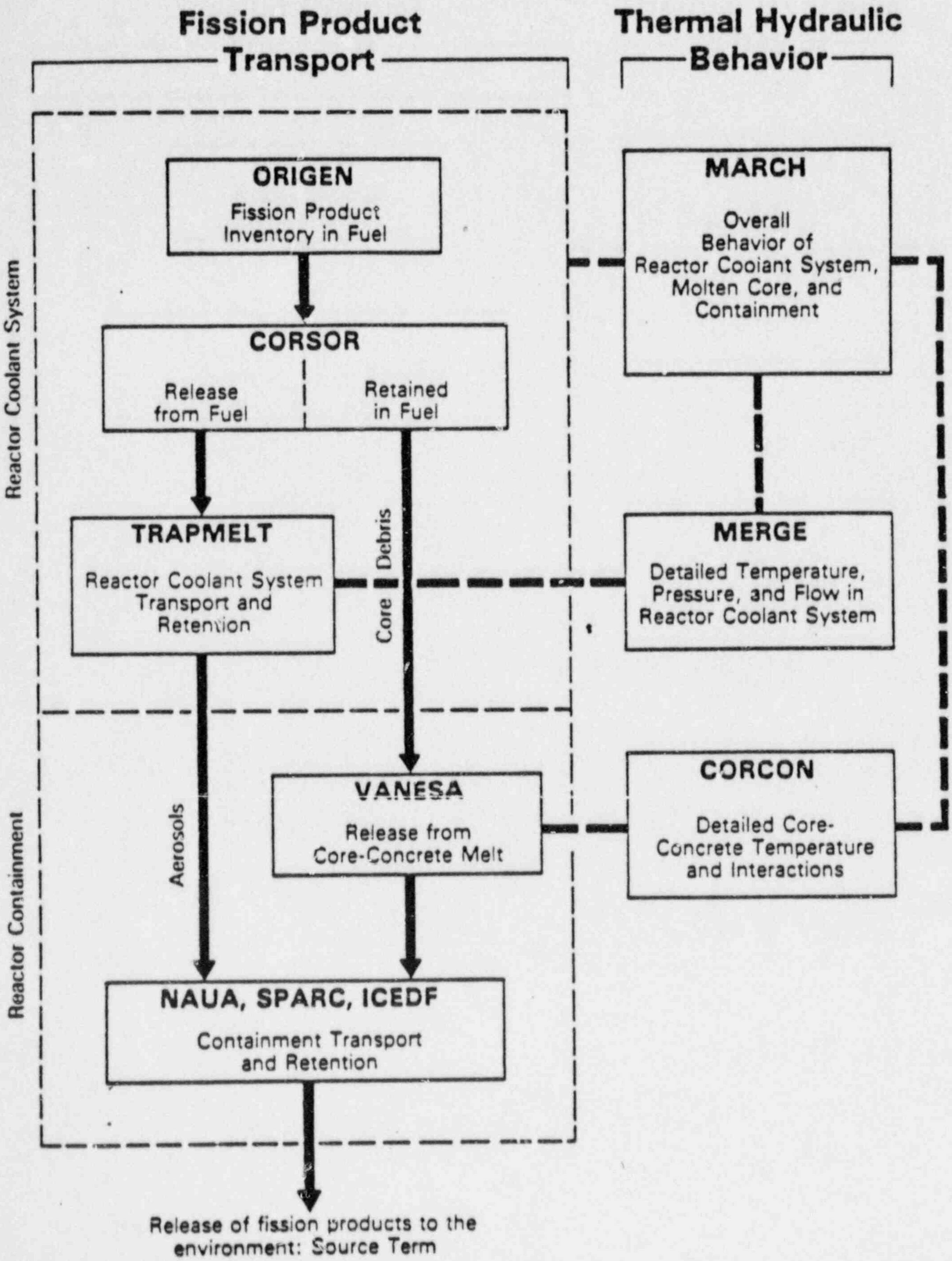
ASTPO BASIC AGENDA

- o DOCUMENT CURRENT DATA BASE FOR SEVERE ACCIDENT BEHAVIOR PREDICTION
- o APPLY LATEST BEST ESTIMATE MODELS FOR SEVERE ACCIDENT SOURCE TERMS
- o OBTAIN SUBSTANTIAL AND BROAD PEER REVIEW OF PRINCIPAL WORK
- o SYSTEMATIC EVALUATION OF EMERGENCY PLANNING EXPERIENCE
- o APPLY IMPROVED SOURCE TERM INFORMATION TO REGULATORY PROGRAMS
  - EMERGENCY RESPONSE
  - OTHER

SELECTED PLANTS FOR SOURCE TERM STUDY

PLANT	GENERAL CHARACTERISTICS
1. SURRY	o PRESSURIZED WATER REACTOR (PWR) o LARGE DRY CONTAINMENT o REFERENCE PLANT IN WASH-1400
2. PEACH BOTTOM	o BOILING WATER REACTOR (BWR) o MARK I CONTAINMENT o REFERENCE PLANT IN WASH-1400
3. GRAND GULF	o BWR o MARK III CONTAINMENT o TYPICAL OF RECENT BWR DESIGNS
4. SEQUOYAH	o PWR o LOW PRESSURE ICE CONDENSER CONTAINMENT
5. ZION	o PWR o LARGE DRY CONTAINMENT o TYPICAL OF RECENT PWR DESIGNS

Source Term Code Suite



PWR - LARGE, DRY CONTAINMENT (SURRY)

FRACTION OF CORE INVENTORY

SEQUENCE	SPECIES	RCS	CONTAINMENT	ENVIRONMENT	WASH 1400
TMLB'-δ	CsI	0.85	0.11	0.046	0.7
	CsOH	0.86	0.10	0.039	0.5
	Te	0.30	0.16	0.11	0.3
TMLB'-ϵ	CsI	0.85	0.15	2.8×10^{-3}	8×10^{-4}
	CsOH	0.86	0.14	1.7×10^{-4}	8×10^{-4}
	Te	0.30	0.19	8.1×10^{-2}	1×10^{-3}

Battelle
Columbus Laboratories

PWR - LARGE, DRY CONTAINMENT (SURRY)

FRACTION OF CORE INVENTORY

SEQUENCE	SPECIES	RCS	CONTAINMENT	SAFEGUARDS BUILDING	ENVIRONMENT	WASH 1400
V WITH WATER	CsI	0.50	0.018	0.40	0.079	0.7
	CsOH	0.51	0.017	0.40	0.073	0.5
	TE	0.13	0.71	0.14	0.025	0.3
V NO WATER	CsI	0.50	0.018	0.069	0.41	0.7
	CsOH	0.51	0.017	0.071	0.40	0.5
	TE	0.13	0.71	0.044	0.12	0.3

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BWR, MARK I (PEACH BOTTOM)
Fraction of Core Inventory

Sequence	Species	RCS	Pool	Drywell	Wetwell	Reactor Building	SGTS	Environment	WASH-1400
	CsI	0.19	0.35	0.12	0	---	---	0.34	0.9
AE-γ'	CsOH	0.19	0.34	0.14	0	---	---	0.33	0.5
	Te	2.9×10^{-2}	3.2×10^{-3}	0.32	0	---	---	0.65	0.3
	CsI	0.14	0.80	5.4×10^{-3}	0	---	---	4.8×10^{-2}	0.9
TW-γ'	CsOH	0.15	0.79	5.0×10^{-3}	0	---	---	4.5×10^{-2}	0.5
	Te	0.40	8.6×10^{-3}	0.2	0	---	---	0.19	0.3

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Table 4

Final Distribution of Fission Products
in Grand Gulf TC Sequence - BMI-2104 Base Case

Species	Fraction of Core Inventory				
	RCS	Drywell	Pool	Containment	Environment
CsI	0.19	3.6×10^{-2}	0.77	1.4×10^{-4}	6.8×10^{-3}
CsOH	0.51	1.4×10^{-3}	0.49	9.2×10^{-6}	3.5×10^{-4}
Te	0.22	0.32	0.45	4.3×10^{-4}	8.8×10^{-3}

Table 5

Final Distribution of Fission Products
in Grand Gulf TC Sequence - Low Case

Species	Fraction of Core Inventory				
	RCS	Drywell	Pool	Containment	Environment
CsI	0.90	0.004	0.096	3×10^{-6}	9.7×10^{-5}
CsOH	0.90	0.0003	0.099	2×10^{-7}	7.1×10^{-6}
Te	0.90	0.008	0.092	1×10^{-5}	1.9×10^{-4}

Table 6

Final Distribution of Fission Products
in Grand Gulf TC Sequence - High Case

Species	Fraction of Core Inventory				
	RCS	Drywell	Pool	Containment	Environment
CsI	0.1	0.04	0.78	2×10^{-3}	7.6×10^{-2}
CsOH	0.1	0.0025	0.89	2×10^{-4}	6.4×10^{-3}
Te	0.1	0.069	0.65	1×10^{-2}	1.7×10^{-1}

From SAND84-0410
Vol 1.

PRESENT SOURCE TERM STATUS

(AS OF JUNE 1985)

O PUBLICATION OF DRAFT BMI-2104 (JULY 1984)

- o RESULTS VERY SEQUENCE AND PLANT-SPECIFIC
- o TIMING OF CONTAINMENT FAILURE VERY IMPORTANT
- o RELEASES LOWER THAN WASH-1400 FOR MOST PLANTS
- o RELEASES (ESP. FROM CORE-CONCRETE REACTIONS) LARGER THAN WASH-1400 FOR SOME PLANTS

O AMERICAN NUCLEAR SOCIETY (ANS) REPORT (SEPT. 1984)

- o NOBLE GAS RELEASES ESSENTIALLY SAME AS PREDICTED BY WASH-1400
- o OTHER SOURCE TERMS CAN BE REDUCED BY A FACTOR OF 10 OR MORE
- o SOME UNCERTAINTY WITH REGARD TO BWR - MARK I's

O IDCOR STUDIES (NOV. 1984)

- o ACCIDENT SEQUENCES GENERALLY SLOWER TO DEVELOP THAN PREVIOUSLY THOUGHT
- o ASSUMING REASONABLE EMERGENCY RESPONSE, NO EARLY FATALITIES PREDICTED
- o EARLY FATALITIES PREDICTED ONLY FOR ASSUMED FRACTION OF POPULATION NOT PARTICIPATING IN EVACUATION

PRESENT SOURCE TERM STATUS

(CONTINUED)

- O AMERICAN PHYSICAL SOCIETY (APS) - FEB. 1985

  - o ACCIDENT RELEASES LOWER THAN WASH-1400 FOR MANY SEQUENCES BECAUSE OF

    - STRONGER CONTAINMENTS
    - CHEMICAL PHENOMENA PREVIOUSLY NEGLECTED (CsI RATHER THAN ELEMENTAL IODINE)
    - ADDITIONAL SITES TO TRAP AND RETAIN ACTIVITY

  - o ACCIDENT RELEASES PREDICTED TO BE HIGHER FOR SOME SEQUENCES (NON-VOLATILES FROM CORE-CONCRETE INTERACTIONS)

  - o CANNOT MAKE SWEEPING GENERALIZATION THAT SOURCE TERM FOR ANY SEQUENCE AND ANY PLANT IS ALWAYS A SMALL FRACTION OF CORE INVENTORY

  - o SOURCE TERM RESEARCH NOT YET ADEQUATE

- O NUREG-0956

  DRAFT SCHEDULED FOR JULY 1985. WILL PRESENT NRC STAFF VIEW AND SUMMARY OF RECENT RESEARCH. COMMISSION PAPER MAY ACCOMPANY NUREG-0956 AND PRESENT PLAN FOR REGULATORY USES OF NEW RESEARCH.

WHAT IS THE SIGNIFICANCE OF CURRENT RESULTS?

- CONSIDERABLE PROGRESS HAS BEEN MADE SINCE THE REACTOR SAFETY STUDY BUT SEVERE ACCIDENT RELEASE ESTIMATION IS NOT AN EXACT SCIENCE

- CAREFUL CONSIDERATION OF UNCERTAINTIES IS MANDATORY

- QUANTITATIVE RELEASE, CONSEQUENCE, OR RISK RESULTS VARY WITH DIFFERENT NUCLIDES, SEQUENCES, PLANTS AND CONTAINMENTS

- THE METHODOLOGY COULD LEAD TO A BASIS FOR DECREASED EMPHASIS ON CERTAIN REGULATORY REQUIREMENTS (E.G., MOLECULAR IODINE) AS WELL AS POSSIBLE INCREASED EMPHASIS IN OTHER REQUIREMENTS (E.G., NON-VOLATILE NUCLIDES, CONTAINMENT CAPABILITY)

- IN GENERAL, THE REVISED METHODOLOGY YIELDS VARIABLY LOWER RELEASES THAN CURRENT REGULATORY ASSUMPTIONS FOR MOST ACCIDENTS

- PRESENT EMERGENCY PLANNING ZONES (EPZ) NOT WELL UNDERSTOOD IN TERMS OF ACTUAL RISK
  - MISPERCEPTION OF UNIFORM RISK IN 10-MILE EPZ
  - MISPERCEPTION THAT EVACUATION ONLY EFFECTIVE PROTECTIVE ACTION

CONCEPT OF "GRADED RESPONSE"

- O MANY STUDIES HAVE SHOWN SIGNIFICANT VARIATION IN RISK VS. DISTANCE. THIS IMPLIES THAT ACTIONS PHASED OR GRADED BOTH IN DISTANCE AND TIME, MANY COMPORT WITH ACTUAL RISK. THIS HAS BEEN REFERRED TO AS "GRADED RESPONSE"

- O GRADED OR PHASED RESPONSES IMPLICITLY RECOGNIZED IN PRESENT PLANNING DOCUMENTS

OBJECTIVES AND APPROACHES

OBJECTIVE - ASSESS HOW GRADED RESPONSE FITS IN WITH ACTUAL RISK AND DEVISE A PROTECTIVE ACTION STRATEGY CAPABLE OF DEALING WITH A WIDE SPECTRUM OF ACCIDENTS

- O STRATEGY SHOULD BE FLEXIBLE
- O SHOULD PROVIDE A PRIORITY OF DESIRED ACTIONS
  PRIORITIES SHOULD BE, IN ORDER
  - o AVOID EARLY FATALITIES
  - o REDUCE EARLY INJURIES
  - o REDUCE OTHER HEALTH EFFECTS

APPROACH -

- O STUDY MADE USE OF WASH-1400 ACCIDENT SOURCE TERMS, USING THE SST1, SST2 AND SST3 GROUPING
- O STUDY LOOKED AT
  - o TIME FROM INITIATING EVENT TO RELEASE
  - o TIME FOR AN INDIVIDUAL AT A GIVEN DISTANCE TO RECEIVE A GIVEN DOSE
    (TIME - DOSE - DISTANCE RELATION)

TIME FROM INITIATING EVENT TO START OF RELEASE

- PRINCIPALLY AFFECTS "WARNING TIME"
- NUREG-0396 INDICATED WARNING TIME RANGES FROM "0.5 HOURS TO ONE DAY" WITHOUT ELABORATION
- TIME OF RELEASE FOR SEVERE SEQUENCES AT FOUR PLANTS (GRAND GULF, SEQUOYAH, OCONEE, CALVERT CLIFFS) TAKEN FROM RSSMAP STUDY.

EXAMPLES FOR SEQUOYAH

SEQUENCE	PROB.	TIME OF RELEASE (MINUTES)
V	5×10^{-6}	38.
$S_2H-\delta$	2×10^{-5}	110.
$S_2HF-\delta$	5×10^{-6}	197
$S_1HF-\delta$	3×10^{-6}	219
$TML-\delta$	3×10^{-6}	238

CONCLUSION - FOR FOUR PLANTS EXAMINED, MOST (ABOUT 85%) OF SEVERE ACCIDENTS WOULD TAKE LONGER THAN ABOUT 2 HOURS FROM ACCIDENT INITIATION TO RELEASE

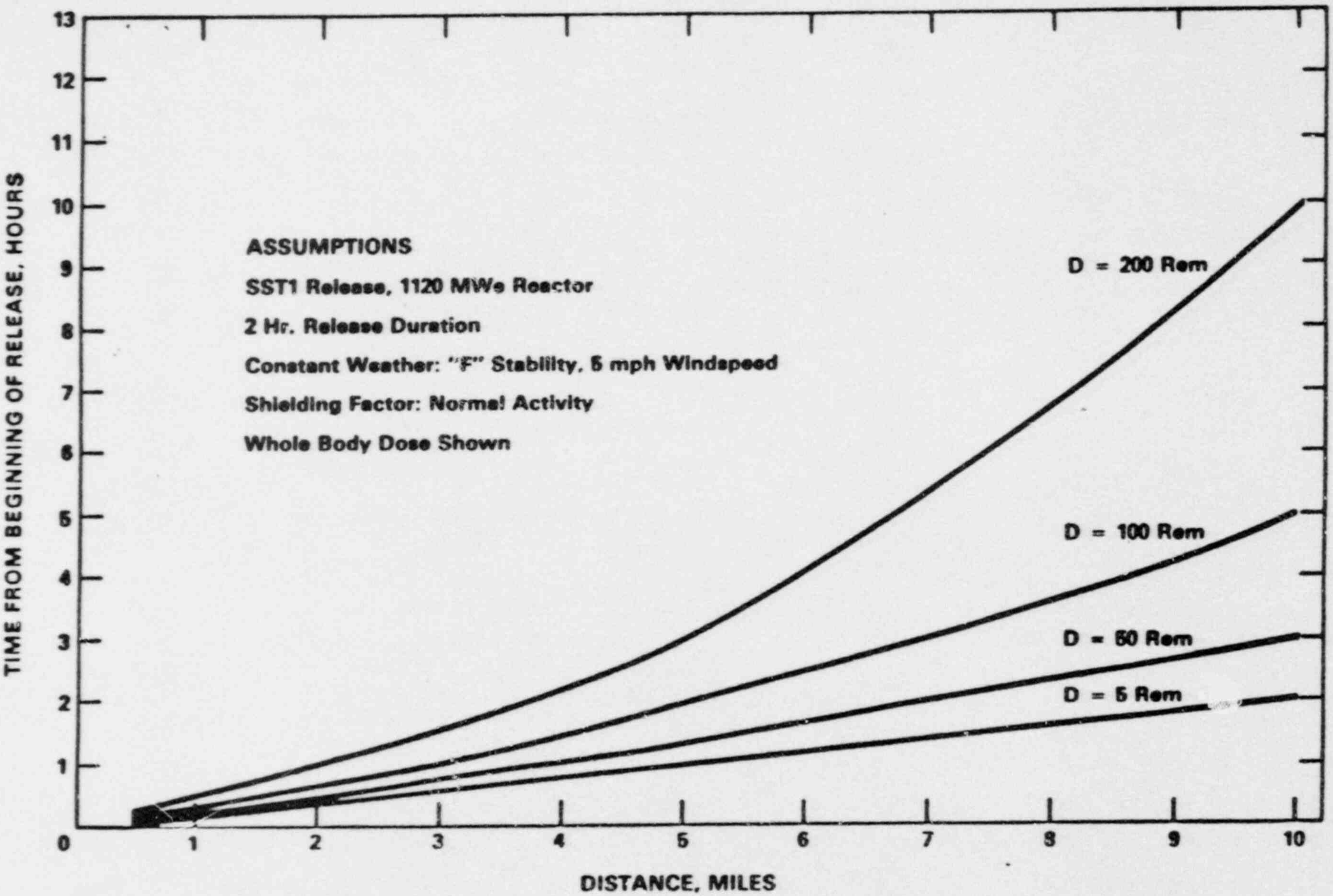

Figure 3.3-2 TIME-DOSE-DISTANCE RELATIONSHIP

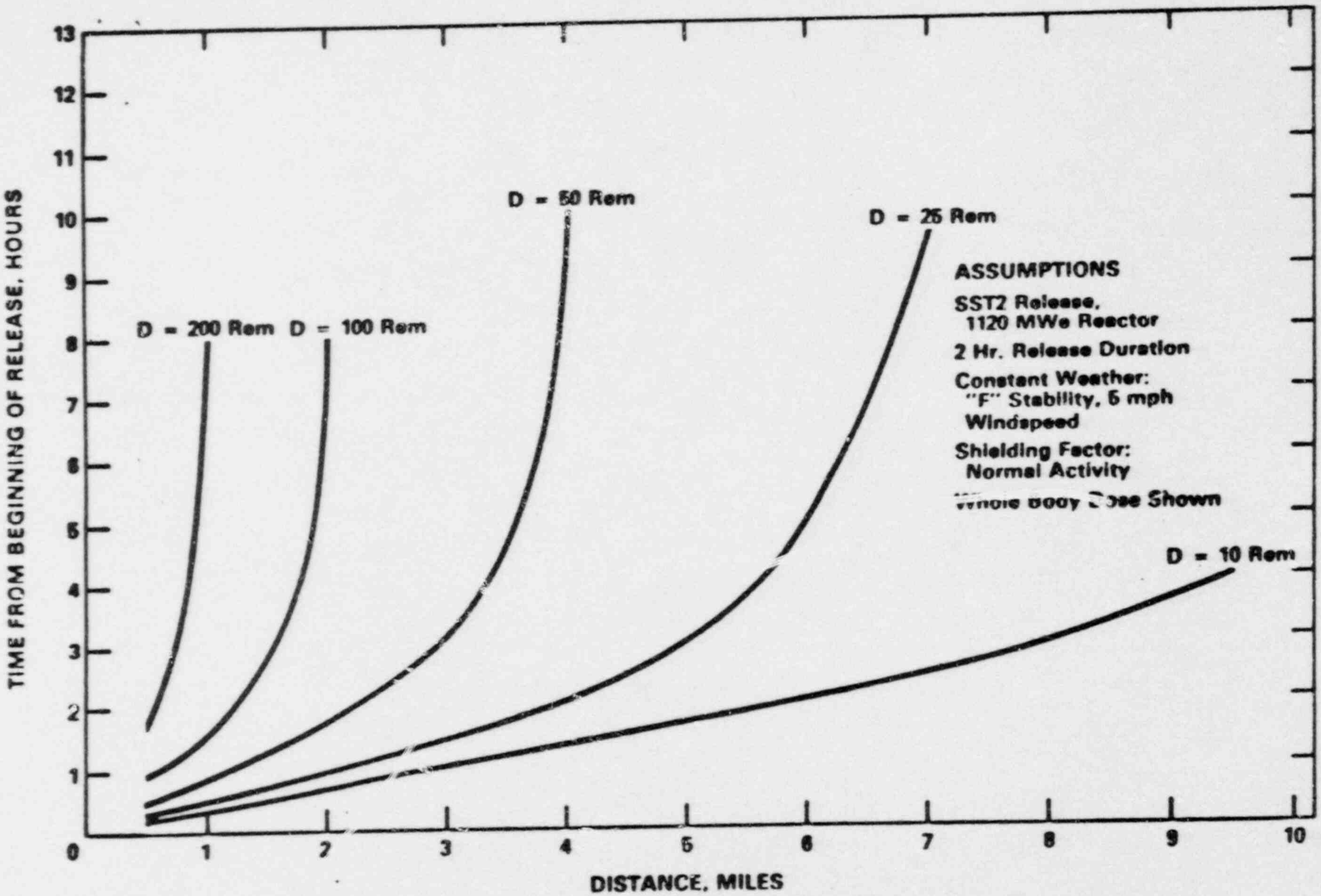

Figure 3.3-4 TIME-DOSE-DISTANCE RELATIONSHIP

RISK INSIGHTS

- O WITHIN 10-MILE EPZ, RISK NOT ONLY VARIES SIGNIFICANTLY WITH DISTANCE, BUT PROTECTIVE ACTIONS HAVE GREATER DEGREE OF URGENCY AT CLOSE-IN DISTANCES.

- O REGION WITHIN ABOUT TWO MILES, AND TIME FRAME OF ABOUT TWO HOURS HAS SOME SIGNIFICANCE

  - o FOR MOST CORE-MELT RELEASES, PROJECTED DOSES UNLIKELY TO RESULT IN EARLY HEALTH EFFECTS BEYOND ABOUT TWO MILES

  - o FOR MOST CORE-MELT RELEASES, TIME FROM ACCIDENT INITIATION TO RELEASE GREATER THAN TWO HOURS.

- O TWO MILE EVACUATION INSUFFICIENT FOR WORST (SST1) RELEASES UNDER ADVERSE METEOROLOGICAL CONDITIONS.

PROPOSED PROTECTIVE ACTION STRATEGY

FIRST, UPON DECLARATION OF GENERAL EMERGENCY, RECOMMEND IMMEDIATE EVACUATION OF EVERYONE (LOCAL WEATHER AND INSTITITIONAL CONCERNS PERMITTING) WITHIN TWO MILES, WITH OBJECTIVE OF BEING ACCOMPLISHED WITHIN TWO HOURS. ALL OTHERS IN EPZ SHOULD TAKE SHELTER AND AWAIT FUTHER INSTURCTIONS.

NEXT, CONTINUE ACCIDENT ASSESSMENT OF BOTH PLANT AND FIELD CONDITIONS. ADDITIONAL ACTIONS, INCLUDING EVACUATION AND/OR RELOCATION, RECOMMENDED AS NECESSARY.

O STRATEGY EMPHASIZES PROMPT ACTIONS IN HIGHEST RISK PART OF EPZ, WHILE MAINTAINING PLANNING AND FLEXIBILITY TO CARRY OUT ACTIONS IN REMAINDER OF EPZ.

EVALUATION AND CONCLUSIONS

- O DOSES CALCULATED TO ASSESS STRATEGY
  - o FOR MOST RELEASES, EARLY EVACUATION TO 2 MILES, THEN SHELTER AND RELOCATION AFTER 4 TO 12 HOURS FOR THOSE BEYOND, RESULTS IN NO EARLY FATALITIES, LOW RISK OF INJURIES
  - o FOR WORST RELEASES, EVACUATION TO 2 MILES INSUFFICENT TO PRECLUDE EARLY FATALITIES, BUT EVACUATION TO ABOUT 5 MILES (DOWNWIND ONLY) WITH SHELTER AND RELOCATION AFTER 4 HOURS WOULD DO SO.

CONCLUSIONS

- o GRADED RESPONSE STRATEGY TAKES SUITABLE ACCOUNT OF SPATIAL AND TEMPORAL RISK VARIATION WITHIN EPZ
- o RESULTS SHOWN FOR WASH - 1400 SOURCE TERMS, BUT METHOD APPLICABLE FOR ANY REVISED SOURCE TERMS, CONCEPT UNDER SERIOUS CONSIDERATION WITHIN NRC.

SUMMARY

- O WASH-1400 SOURCE TERMS WERE IMPORTANT IN THE DEVELOPMENT OF THE PRESENT REGULATIONS

- O RECENT RESEARCH SUGGESTS THAT SEVERE ACCIDENT RELEASES ARE GENERALLY LOWER THAN PREVIOUSLY THOUGHT, BUT RESULTS ARE COMPLEX AND STRONGLY AFFECTED BY PLANT-SPECIFIC FACTORS. SOME RELEASES MAY BE HIGHER. IMPACT ON EMERGENCY PREPAREDNESS NOT YET CLEAR.

- O CONCEPT OF GRADED RESPONSE APPLICABLE FOR WASH-1400 OR REVISED SOURCE TERMS.