POLICY ISSUE
(Notation Vote)

December 14, 1990

SECY-90-405

For: The Commission

From: James M. Taylor
Executive Director for Operations

Subject: FORMULATION OF A LARGE RELEASE DEFINITION AND SUPPORTING RATIONALE

Purpose: To recommend that a revised definition of a large release be pursued. This revised definition, when it is developed, can then be applied to the third level of the safety goal hierarchy which states that there should be a probability no greater than one in a million per reactor-year of a large release of radioactive materials to the environment from a reactor accident.

Summary: This paper discusses two alternative definitions for a large release that meet criteria suggested previously by the ACRS and the Commission. The staff recommends that the Commission adopt the second alternative definition which will establish a large release with a predetermined magnitude. This value will be determined by calculating that release necessary to cause an offsite early fatality based on a set of pre-established representative site characteristics. This definition differs from the one previously proposed by the staff in SECY-89-102 in that it will be established as a standard which will not be dependent on individual site characteristics, nor will it require the performance of a site specific Level III PRA.

Background: In SECY-89-102 (Ref. 1) the staff proposed an implementation plan for the Safety Goal Policy in which alternatives for a large release definition in support of Level Three were discussed and the following qualitative definition of a large release was proposed:

NOTE: TO BE MADE PUBLICLY AVAILABLE WHEN THE FINAL SRM IS MADE AVAILABLE

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A large release is a release that has a potential for causing an offsite early fatality.

The Commission did not accept this definition. In a staff requirements memorandum (SRM) dated June 15, 1990, the Commission stated that a plant performance objective "... that focuses on accidental releases from the plant and eliminates site characteristics, as suggested by the ACRS, is appropriate." The Commission asked the staff to reexamine this issue and advise them as to whether such an objective is obtainable and useful. Consistent with this approach, the Commission has asked for an alternative definition for a large release to the one previously proposed. In regard to eliminating site characteristics, the staff interprets the Commission's directive to mean that the definition of the large release should not require a Level III PRA or be dependent on plant specific site factors such as meteorology or population distribution.

The Commission's objective as stated in the Safety Goal Policy Statement was to define an acceptable level of radiological risk from nuclear power plant operation. This was done and the quantitative health objectives (QHOs) of 0.1 percent of all other accidental and latent cancer death causes were established to measure achievement of the policy goals. The Commission also stated that by establishing a level of safety considered to be safe enough, public understanding of regulatory criteria and public confidence in the safety of operating plants would be enhanced. As such it is important that the definition chosen for the large release subsidiary objective comport with a realistic and practical assessment of what constitutes such a release. The staff envisions that many current regulatory issues will be tested for conformance with the safety goals. For example, the Commission has recommended that IPE results be compared with the safety goals to enhance understanding of the adequacy of existing regulations. The success of this, as well as other future efforts aimed at gauging the extent to which current regulations are consistent with the safety goals, hinges on how well subsidiary goals, such as the one discussed here, blend with and complement the primary qualitative and quantitative objectives.

Discussion: The ACRS has proposed a five level safety goal hierarchy to facilitate a "top-down" approach to implementation (Ref. 2):

Level One - Qualitative Safety Goals
Level Two - Quantitative Health Objectives
Level Three - Large Release Guideline (A general plant performance objective)
Level Four - Performance Objectives
Level Five - Regulations and Regulatory Practices

Levels Two, Three, and Four of the hierarchy address the quantitative targets of the Safety Goals with the Level Two objectives being the QHOs pertaining to early and latent mortality risks. The ACRS recommended that the large release guideline proposed in the Safety Goal Policy Statement be adopted, as shown above, as a Level Three performance objective.

The ACRS has also suggested guidelines, which have been further developed by the staff, to link the hierarchical levels of the Safety Goal objectives. According to these guidelines each subordinate level:

1. Should be consistent with the level above,
2. Should not be so conservative as to create a de facto new policy,
3. Should represent a simplification of the previous level,
4. Should provide a basis for assuring that the Safety Goal Policy objectives are being met,
5. Should be defined to have broad generic applicability,
6. Should be stated in terms that are understandable to the public, and
7. Should generally comport with current PRA usage and practice.

SECY-89-102 provided a comprehensive discussion of the attributes of candidate definitions of a large release that have been considered to date. Definitions previously considered include a wide range of options:

1. The definition provided above and previously recommended by the staff.
2. The idea of a conservative individual dose to a member of the public at the site boundary, such as the 25 REM whole body guideline value in 10 CFR Part 100 or alternatively, an

individual dose of a much greater magnitude which would result in a fatality.

3. A release definition in terms of a source term magnitude, for example, a percentage of the core inventory of the radionuclides present at the time of reactor shutdown, weighted by their biological contribution to health effects.
4. A definition encompassing any release from accidents that involve severe core damage, reactor coolant system pressure boundary failure, and early containment failure.

The first two definitions listed above do not eliminate site characteristics as directed by the Commission and, thus, will not be considered further.

By virtue of the above, coupled with the Commission's directive, two alternative definitions for a large release have been developed and are presented. These alternative definitions represent extensions of those previously discussed in Enclosure 1 to SECY-89-102, "Options for Defining a Large Release and Plant Performance Objectives." Regardless of the alternative selected, the staff believes that the definition of a large release from a severe accident should be based upon early conditions of the plant (containment failure or bypass) or early consequences (fatalities) that result from such early failure conditions at the plant. It is these early conditions that would control conformance to the 0.1 percent health effects objective, thus the staff believes that a close connection must be retained here in the large release definition. Consideration of early containment failure or early fatalities places attention on the most risk significant aspect of severe accidents associated with potentially large releases from containment failure.

Alternative Definitions

The first alternative definition considered by the staff is:

> A large release is any release from an event involving severe core damage, reactor coolant system pressure boundary failure, and early failure or significant bypass of the containment.

This definition would not require detailed calculations of fission product release. However, it is limited in its application to reactors having conventional containments. In effect, it states that the mean probability of early containment failure or significant bypass from severe accidents should not exceed 1 in 1,000,000 per reactor year.

While conceptually easy to understand, practical application of this definition for regulatory purposes would require much additional guidance and interpretation. For example, in using the term "early failure" the staff recognizes that a real challenge exists in arriving at a consensus as to what timing is implied by use of the term "early." Is it early in relation to accident initiation, core degradation, vessel breach, or core concrete interaction? In addition, how long does the early failure interval last? It could vary depending on the sequence. There is an associated problem in defining containment failure. Is it a specific leakage significantly in excess of the design leakage rate, for example, 100 percent per day, or is it at the time at which a theoretical containment building maximum strain level is achieved? Also, how would variations in power level be included?

Of particular importance in "significant bypass" of the containment is whether the bypass path allows for water pool scrubbing of the release before it reaches the environment, for instance, via the suppression pool in a BWR containment. It is generally accepted that, although limited containment bypass did occur at TMI-2, it was through a water-filled pathway and was not significant in magnitude, and so should not be considered a large release under this definition. Another mitigating effect on the release magnitude might be "plate-out" effects which would come into play if the release path outside containment involved long piping runs, such as via an interfacing systems LOCA event.

Some insight on the application of such a definition can be gained by looking at NUREG-1150 results. For example, the second draft of NUREG-1150 indicates that, for the Surry nuclear plant which is well within the QHO guidelines, the mean frequency of containment bypass accident with

core melt was 5 in one million, while the mean frequency of early containment failure coincident with core damage was 3 in ten million. Thus determining whether or not the proposed definition is met would be highly dependent upon what is considered "significant," "early," and "containment failure." For instance, in NUREG-1150 "early" was defined for PWRs as within a few minutes of vessel breach.

The second alternative definition presented is based on offsite consequences. However, rather than comparing plant specific offsite consequences, the staff proposes that a spectrum of sites be considered to establish representative site characteristics. These site characteristics would take into account factors such as meteorology and population distribution. From these site characteristics, the staff will determine a value for an accidental radioactive release to the environment that would have the potential for causing doses high enough that one or more early fatalities are probable at the representative site. In other words, Safety Goal Objective Level Three would define a large release to be a release of predetermined magnitude, as follows:

> A large release is a release of radioactivity from the containment to the environment of a magnitude equal to or greater than: (An amount, to be determined by the staff, expressed in curies or fraction of the core inventory, which has the potential, based on representative site characteristics, for causing one or more offsite early fatalities.)

In this definition, the magnitude of the source term release may be expressed as curies (or "equivalent curies") or fraction of the core inventory of chemical elements that represent the radionuclides present at full power operation. Appropriate provision will need to be made to address significant variations in power levels, if the definition is stated in terms of fraction of core inventory released.

This definition would be based upon the same calculational tools and practices used in NUREG-1150, including the offsite consequence

calculational techniques employed in the MELCOR Accident Consequence Code System (MACCS) which considers the effects of various accident sequences, source terms, and siting. Use of the NUREG-1150 methodology would ensure that the large release definition so obtained would be reasonably consistent with the 0.1 percent QHOs and would not exceed the order of magnitude conservatism that the Commission recognized to exist with the prior SECY-89-102 large release proposal.

The effort to determine the release magnitude would focus on highly exposed individuals to determine the release required for an early fatality in a fashion identical to that used in NUREG-1150. That is, the weighted probability of an early fatality over the exposed population, given site and source term factors, would be determined. The source term factors include the timing of the release, its path to the environment and energy content, and the biological effectiveness of the various radionuclides. The site factors include population distribution and meteorology. It is expected that the early offsite fatalities will be dominated by events involving early containment failure or bypass. Therefore, it is expected that the assumptions used for emergency planning early in the accident sequence will not be critical and that the magnitude selected for a large release will be independent of emergency planning assumptions early in the accident sequences. The staff intends to confirm this by evaluating the effect of various emergency planning assumptions as part of the analysis.

The large release magnitude obtained would be valid for current and future light water reactors (LWRs). If the definition of a large release is cast in the form of release magnitudes or fractions of each of the radionuclide groups, it is not likely to be valid for non-LWRs such as liquid metal or high temperature gas cooled reactors because the relative releases of various radionuclides are expected to be very different from LWR values. On the other hand, if the large release were to be cast in the form of a number of equivalent curies, it might remain reasonably valid for future non-LWRs. In either case, the differing nature of radionuclide release for non-LWRs would have to be addressed.

The second draft of NUREG-1150 found that, using the definition of a large release as one which results in one or more offsite early fatalities with a probability of one in a million per reactor-year, all five plants successfully met (or met with margin) this standard for internal events. For Sequoyah, a plant whose mean response comes relatively close to the standard, the radionuclide release fractions (at the 10^{-6} probability level) included approximately all the noble gases, 20 percent each of the iodine and cesium, and less than one percent each of the other radionuclide groups. Based on preliminary estimates, the Chernobyl release exceeded these levels (Ref. 3). Note, however, that Sequoyah was influenced primarily by the bypass mode of containment failure and that release fractions and timing based on other sequences or plants may consist of significantly different relative source term fractions. Accordingly, in developing the large release magnitude the staff would evaluate the variations in the makeup of source terms conforming to this definition of a large release by considering different accident sequences and different nuclear plant site characteristics to cover a range of important parameters. The intent of this evaluation would be to consider a wide variation of potential accident sequences and site characteristics prior to recommending a value for a large release.

Adoption of this definition retains the advantages put forth in support of the original staff proposal, and it addresses the concerns raised by the Commission and the ACRS. For example, it would explicitly focus on the magnitude of an accidental release and not site characteristics. This would facilitate understanding by the general public as well as plant designers and it would clearly imply a release much larger than that at TMI-2, but potentially smaller than the Chernobyl release. Because it would have been derived through an examination of a spectrum of representative sites, it would eliminate plant specific site considerations from entering into its application, including the need to rely on a Level III PRA, since the magnitude of the release would have already been established.

This alternative has the additional advantage that it could be more straightforwardly applied to existing as well as future LWR plants than the

first alternative presented above. Application of this portion of the Safety Goals to future plants, which may not possess the conventional high strength containment structures, would be the same, in principal, as for conventional plants, in contrast to the case of a large release definition based on early containment failure.

Consistent with the staff's original recommendation for a large release in SECY-89-102, this proposed definition would result in a Level Three criterion that is somewhat more conservative, based on NUREG-1150 Second Draft results, than the Level Two QHOs. At an overall mean frequency of less than 1 in 1,000,000 per year, nearly any plausible large release definition, including the largest "SST-1" release class developed for earlier siting study efforts (circa 1983) by the Sandia National Laboratory would result in average individual risks of exposure which are less than those implicit in the QHOs.

Other Considerations

As part of the effort to define the release magnitude for the second proposed definition, the staff would also investigate latent mortalities and the offsite costs associated with this release. The issue of land interdiction is frequently raised as one of the primary, yet largely misunderstood, long term costs associated with large releases to the environment. These costs are a component of the overall impact on the health and safety of the public from a large release. This information will provide the Commission with a more complete estimate of costs associated with the large release definition. For example, based on calculations for the Limerick Final Environmental Statement (Ref. 4), for a release of the order of that required for an early fatality, these other impacts are: about a thousand latent fatalities, a billion dollars for offsite mitigation measures, and ten square miles of land subject to long-term interdiction.

In a separate but related effort, the staff is working concurrently on a new radionuclide release definition as a replacement for TID-14844, the current licensing standard which prescribes the magnitude of the release into the containment. These efforts will be coordinated and both will

use information developed for NUREG-1150 to ensure consistency.

The staff believes that either definition discussed above could accomplish the objectives required of it in the safety goal hierarchy. The first alternative definition (early containment failure or significant bypass) would not require detailed calculations of fission product release, would be independent of site characteristics, and would be conceptually easy to understand. However, it would require much interpretation and, to maintain its simplicity, would likely cover a range of release magnitudes and offsite fatalities. The second alternative definition is potentially more precise since it would include an explicit statement of the release magnitude itself. It would not depend upon plant power level nor the existence of a containment structure. Finally, it would not require designers to perform a Level III PRA to implement, but rather would be based upon the methodology and precedent established by NUREG-1150. In the staff's view, it also would be subject to less interpretation than the first alternative definition. Accordingly, the staff believes that the second alternative definition is the more practical alternative.

Coordination: The Office of the General Counsel has reviewed this paper and has no legal objections.

Recommendation: The staff recommends that the second proposed definition for a large release be pursued. The staff has outlined the elements of the proposed definition which it believes will best function as the third level in the safety goal hierarchy. Additional effort is needed to convert them into a useable form. This effort is included in the Five Year Plan and funding to accomplish it is included in our FY-1991 budget. The staff believes that this effort can be completed within 6 months from Commission approval.

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for Operations

References:

1. SECY-89-102, March 30, 1989, Subject: Implementation of Safety Goal Policy.

2. Memorandum, May 13, 1987, Dr. William Kerr, Chairman, ACRS; to the Honorable Lando W. Zech, Jr., Chairman, U.S.N.R.C.; Subject: ACRS Comments on an Implementation Plan for the Safety Goal Policy.

3. "First International Workshop - Severe Accidents and Their Consequences", Preliminary (unofficial) Proceedings of the First International Workshop on Severe Accidents and Their Consequences, Sochi, USSR, October 30-November 3, 1989, produced through the U.S. Department of Energy, 1990.

4. NUREG-0974, Final Environmental Statement Related to the Operation of Limerick Generating Station, Units 1 and 2, April 1984.

Commissioners' comments or consent should be provided directly to the Office of the Secretary by COB Monday, December 31, 1990.

Commission Staff Office comments, if any, should be submitted to the Commissioners NLT Monday, December 24, 1990, with an information copy to the Office of the Secretary. If the paper is of such a nature that it requires additional time for analytical review and comment, the Commissioners and the Secretariat should be apprised of when comments may be expected.

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