Consideration of Seismic Events in Severe Accidents

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ABSTRACT

In 1985, the U.S. Nuclear Regulatory Commission issued the Severe Accident Policy Statement requiring all licensees to perform a systematic evaluation of their plant to determine plant specific vulnerabilities. At the present time licensees are required to proceed with examinations only for internally initiated events; examinations of externally initiated events will proceed separately on a later schedule. Staff activities concerning how to best proceed with implementing the severe accident policy with respect to externally initiated events are described.

INTRODUCTION

The Severe Accident Policy Statement, issued by the U.S. Nuclear Regulatory Commission (U.S. NRC, 1985) calls for a systematic examination, defined as an Individual Plant Examination (IPE), to determine plant specific vulnerabilities to severe accidents at nuclear power plants. Although the policy does not differentiate between internal and external accident initiators, licensees are required to proceed with examinations only for internally initiated events at the present time. Generic Letter 88-20 (U.S. NRC, 1988) contains NRC guidance concerning the objectives and scope of the internal initiator examination and specifies approved methods of examination. Examination of externally initiated events (e.g., earthquakes, internal fires, high winds) will proceed separately and on a later schedule from that of internal events (1) to permit the identification of which external hazards need a systematic examination, (2) to permit the development of simplified examination procedures, and (3) to integrate other ongoing Commission programs that deal with various aspects of external event evaluations to ensure that there is no duplication of industry efforts.

The NRC has established an External Events Steering Group (EESG) to make recommendations to senior management concerning how best to proceed with implementing the severe accident policy with respect to externally initiated events. The EESG has established three technical subcommittees dealing with seismic, fire and "other" external initiators. Seismic Subcommittee activities related to: defining scope of examinations, acceptable examination methodologies, integrating ongoing seismic issues, and developing seismic related IPE guidance are described in this paper. In addressing these topics, both policy and technical issues need to be examined. This paper also discusses the means of developing the technical bases on which these issues can be decided.

ISSUES RELATED TO SEISMIC IPE METHODOLOGY

Based on the results of several probabilistic risk assessments (PRAs) sum-

marized in an NRC sponsored study (Prassinos, 1988) the seismic event is one of the external events that needs to be included in the review for severe accident vulnerabilities. Two methodologies are being evaluated by the subcommittee to identify seismic vulnerabilities at nuclear power plants. The first, a seismic PRA (The American Nuclear Society, et al., 1983), the second, seismic design margins methodologies as described in Budnitz et al., 1985 and NTS Engineering, et al., 1988.

A seismic design margins methodology provides a potential alternative method to a seismic PRA for consideration of seismic events in the severe accident policy implementation. The margins approach reduces the scope of systems and components to be looked at and seismic hazard curves are not used. However, the margins approach retains the most important features of a seismic PRA; that is, plant walk-downs and an evaluation of an integrated plant response. Margin is demonstrated by showing there is a high confidence of a low probability of failure (HCLPF) for a given earthquake level.

The NRC sponsored seismic design margins methodology (Budnitz, et al., 1985), derived from reviews of past seismic PRAs, aims at establishing HCLPF plant capacity with respect to core damage. HCLPF capacity is reported in terms of a ground acceleration level with reference to a specific spectrum. The NRC methodology uses an event tree/fault tree approach after screening out certain plant systems and components based on PRA insights and fragility considerations. The EPRI sponsored seismic design margins methodology (NTS Engineering, et al., 1988) uses the same definition of HCLPF, however, the demonstration of plant capacity is made through a selection of "success paths" for shutting down the reactor and maintaining core cooling for a specified number of hours.

Some enhancements to the margins approach are needed prior to its general use in severe accident policy implementation. To this end, a meeting was held with experts in this area to discuss the specific enhancements and their feasibility and necessity. Major elements under consideration by the subcommittee with assistance from its contractors, the Lawrence Livermore National Laboratory, Sandia National Laboratories, and various consultants are briefly described below.

Review Level Earthquake

The review level earthquake used in conjunction with seismic design margins review is specified "a priori" and should be sufficiently high to uncover vulnerabilities but such that the number of systems and components to be examined are minimized. Plant HCLPF capacities are determined by comparing structure and component HCLPF capacitities to the review level earthquake. Structures or components having HCLPF capacities higher than the review level are screened out from further consideration. As such, a number of issues are tied to the selection of the review level earthquake. For example, implicit in the selection of the review level is the judgment that a plant with HCLPF greater than the review level earthquake has no seismic vulnerabilities from the severe accident point of view. Conversely, when the plant HCLPF is less than the review level questions may arise as to whether further action is warranted.

The subcommittee is currently considering a generic review level for central and eastern U.S. plant sites and site specific review levels for western U.S. plants. Before making a final decision, and to develop a rational basis for such a decision, the subcommittee is reviewing past PRAs to estimate the relationship between seismic hazard, plant HCLPFs, and core damage frequencies. Several studies have suggested that one can in a generic sense, define correlation between annual probabilities of exceeding the review level earthquake and seismic induced core-damage frequency. In determining the review level earthquake, the subcommittee is also assessing the impact of the two sets of hazard curves (Bernreuter, et al., 1989 and Risk Engineering, Inc, et al., 1986)

currently available for central and eastern U.S. plant sites.

Earthquake Magnitude/Duration

The screening table developed as part of the NRC seismic design margins method (Budnitz, et al., 1985) is stated to be valid for up to a magnitude 6.5 earthquake. The EPRI sponsored methodology which adopted this table stated it could be used for up to a magnitude 7.0 earthquake. The subcommittee is evaluating the applicability of earthquake magnitude and duration on screening table use.

The fragility screening tables and systems insights used in the seismic design margins methodology are based on ground motion records and observations from the 1971 San Fernando, 1979 Imperial Valley and 1983 Coalinga earthquakes. The subcommittee is comparing the range of durations recorded during those earthquakes at near-source (damaging) distances with existing estimates of duration for eastern and western U.S. earthquakes. This will enable the subcommittee to determine at what magnitude (mb, MS, ML or MW) and distance strong motion duration significantly exceeds that assumed in the seismic design margins methodology. It is expected that this will not significantly limit the applicability of the seismic design margins methodology.

High Frequency Ground Motion

The spectra from new ground motion models gaining acceptance by the earth science community have identified higher ground motions at higher frequencies and lower ground motion at lower frequencies than used in the past. The assumptions and philosophy used in the development of the NRC seismic design margins methodology will be revisited to determine if the method accommodates (or can be modified to accommodate) increased high frequency motions. In particular, it will be determined if the fragility data base used in the margins methodology is applicable when high frequency motions are considered. As part of this effort, a recent EPRI sponsored study (Benjamin, 1988) which addresses the impact of high frequency motion is being reviewed by the NRC. It will be determined whether modifications to the spectral shape of the review level earthquake should limit use of the screening tables (Budnitz et al., 1985).

Risk Insights

Margin methodologies in their current form do not provide insights on plant damage states or quantitative results in terms of core damage frequencies or other risk measures. Risk insights may be needed in some cases for the severe accident policy implementation if questions arise regarding the effectiveness of resource allocation. The subcommittee is developing guidance to extend the NRC methodology (Budnitz, et al., 1985) to obtain plant damage state insights.

Suggested enhancements will be evaluated using the Maine Yankee, Catawba and Hatch plants margins studies. In addition, the subcommittee is developing guidelines to obtain risk insights from the NRC margins methodology. The guidance will address the methodological aspects as well as the usefulness of these insights in decision making. The EPRI margins methodology (NTS Engineering, et al., 1988) will also be examined to determine if it can be extended to obtain risk insights with reasonable effort.

Containment Performance

As stated in the Severe Accident Policy Statement (U.S. NRC, 1985), the systematic examination of the plant needs to include specific attention to containment performance relative to accident prevention and consequence mitigation. For large dry PWR containments, and BWR Mark II and Mark III containments, the effect of containment systems on core damage has already been