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Opening Remarks by
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Chairman, U.S. Nuclear Regulatory Commission
at the
Fifth Workshop on Containment Integrity
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Good morning, ladies and gentlemen. I am pleased to welcome you to the Fifth Workshop on Containment Integrity. It is gratifying to see such a large turnout of representatives from the U.S. nuclear industry and the international community. This workshop provides an important opportunity for enhancing our common understanding of containment performance under severe accident conditions, both for current and advanced light water reactor designs.

As most of you know, since Three Mile Island the NRC has increasingly emphasized the need to understand the variety of containment challenges that could occur as a result of a severe core damage accident. The focus of this effort has been on those containment challenges where the resultant pressure and temperature conditions could threaten the integrity of the containment building.

Numerous containment integrity initiatives have been completed over the past several years. As a result, the NRC has concluded that the design basis criteria used to license nuclear power plants provide a considerable margin of safety. In turn, this safety margin provides reasonable assurance that the public is protected from significant radiation releases even under the core damage conditions that occurred at Three Mile Island. However, we all recognize that accident scenarios resulting in even greater core damage than that which occurred at TMI are physically possible. Thankfully, they are very unlikely.

Such scenarios could present even greater challenges to containment integrity and justify the continued interest and research in containment performance. Accidents which lead to containment failure are the major source of the residual risk to the public. Since the containment is the last barrier between fission products and the environment, its performance across a wide spectrum of potential accidents is of critical importance.

One can more fully appreciate the importance of containment performance to public safety by contrasting the TMI and Chernobyl accidents. The TMI accident showed that robust containments can protect against a variety of core damage conditions and challenges. In spite of a loss of fuel integrity, the public was not exposed to an uncontrolled release of fission products. Such was not the case at Chernobyl. While the Chernobyl accident was due to a combination of design inadequacies and human failures, the lack of a containment capability was a major factor in the devastation visited upon the surrounding populace. The contrasting experiences at Chernobyl and Three Mile Island Unit 2 showed how important containment survival is in minimizing the release of radioactivity to the environment in the event of a core melt accident.

The nuclear industry's reliance on defense-in-depth requires the integration of preventive and mitigative efforts. Containment is, primarily, mitigative in its design. It is called upon should other barriers be overcome. Evaluation of the effectiveness of containment performance, therefore, must consider plausible but low likelihood scenarios. Containment designs must also be robust and tolerant of beyond design basis events.

The NRC has a high degree of confidence that the containments of the current light water reactors can perform the functions for which they were designed. Our research is, therefore, focused largely on understanding containment capabilities and the margins in performance that go beyond design loads and severe core damage threats. The consequences of core damage accidents depend very strongly on whether and when containment failures occur in the course of the accident. Consequently, we need to better understand what occurs in containment during the latter stages of an accident. This knowledge will enhance accident management strategies and emergency planning.

The goal of the NRC Containment Integrity Program is to develop general methods to estimate containment performance. This goal is being accomplished through the combined use of analytical and experimental programs. In complex areas, where numerical solutions have not yet evolved, testing is being used to empirically predict the behavior of some components of the containment pressure boundary.

Ultimately, predicting a containment's behavior requires information in five specific areas: (1) the combinations of pressure and temperature that could lead to the failure of the containment pressure boundary, (2) the timing of containment failure (early or late) in the accident sequence, (3) the failure mode, (4) the leak area and the associated leak rate, and (5) the location of the failure.

NRC's containment integrity research focuses directly on the phenomena considered most likely to produce combinations of high pressures and temperatures that might cause the containment to fail. These include scenarios such as the high-pressure ejection from the reactor vessel of finely divided particles of molten core debris; the generation of noncondensible and flammable gases from the decomposition of concrete by hot core debris; direct thermal and chemical attack on structures and engineered safety features; and, the burning or detonation of hydrogen and other gases produced in the course of the accident. At this point, I need to acknowledge the expertise of yourselves and members of the NRC staff. My understanding of these phenomena is at best, superficial. Fortunately, Dr. Speis, Deputy Director of the Office of Nuclear Regulatory Research, will address these topics in much greater detail in his presentation.

The NRC's experimental and analytical research has included the testing of large models of actual containment structures as well as large and full-scale testing of penetration assemblies. These research results are being used to predict failure thresholds and modes, and their related leak rates. When loads anticipated from severe accidents are included, estimates of plant releases and off-site consequences can be made.

The complexity and costs of such large scale tests provide a strong incentive for engaging in jointly sponsored research programs. The NRC research program on containment integrity has been enhanced by significant international cooperation. Research organizations from the United Kingdom, France, Germany, and Italy have worked with us, particularly with respect to "testing to failure" various models of steel and reinforced concrete PWR containments. In Japan, the Ministry of International Trade and Industry (MITI) is sponsoring a research program on containment performance under severe accident conditions. Discussions between Japan and the U.S. have led to the conclusion that it would be mutually advantageous to engage in a jointly sponsored research program. This research program would use, as its principal element, tests-to-failure of various models of a prestressed concrete PWR containment and a steel BWR containment. Models of these containment types have not been tested in the NRC research effort. This joint testing program should, therefore, fill voids in our understanding of containment failure under severe accident conditions.

In the area of severe accident phenomena and containment challenges, the NRC and 16 countries have signed research agreements under the Cooperative Severe Accident Research Program. The partners in this program have a mutual interest in realizing the safety benefits that can be obtained from integrated severe accident research and a sharing of research data and results.

During the course of the severe accident research performed by the NRC over the past 13 years, significant progress has been made in the development of computer codes to analyze nuclear power plant responses to severe accidents. All of this information is available to the Co-op participants. In return, the participants share their technical reports and experimental data. Joint programs, using facilities owned by the other parties and under specific commercial agreements are also being pursued. The severe accident research specified in the signed agreements cover a wide gamut of research areas. I do not need to detail them here today.

Several of the Co-op countries have participated for five to ten years, and have developed significant severe accident programs of their own. Thus, they now conduct insightful peer reviews and provide increasingly valuable data and reports. Finally, the program fosters a wide-scale testing of the major computer codes as participants apply them in their own programs. This has uncovered various code errors and deficiencies and has allowed the codes to be greatly improved. Moreover, the application of the codes to numerous experiments tests the various failure models. All of these interactions improve the overall quality assurance of the overall severe accident program.

Advanced Reactors

The programs I have described so far have emphasized the current generation of light water reactors. We are also devoting considerable effort to the containment issues of the next generation of reactor designs. In this regard, we expect to build as much as possible on the existing base of research.

For all advanced reactor containment designs submitted for certification, the NRC will evaluate containment performance under severe accident conditions. These evaluations will include the likelihood of, and uncertainties associated with, severe accidents involving potential containment failure, containment bypass leakage, and inadvertent containment openings. The NRC will also assess overall containment performance to ensure that systems designed to contain radioactive materials, when combined with other mitigation systems, provide an acceptably low probability of a large release of radioactive materials.

Containments for some of the advanced light water reactors are significantly different from current designs. For example, the containment for ABB's System 80+ reactor is a large volume, spherical steel shell, similar to some existing ones located in

Germany. Westinghouse's AP600 containment is a return to simplicity inasmuch as it uses a largely passive heat removal system, requiring few active components. For these containments, the NRC is addressing a number of issues that have arisen from our prior LWR safety assessments. These issues include hydrogen control, core concrete interaction, high pressure core melt ejection, and debris cooling.

Other future designs are also being considered by the NRC in its pre-application interactions with prospective applicants. These reactors also have certain novel or unique containment design features. The advanced liquid metal reactor (ALMR), the modular high temperature gas reactor (MHTGR), the Swedish designed, PIUS (Process Inherent Ultimate Safety), and the Canadian heavy water reactor design (CANDU) will all generate their own specific sets of questions. The NRC will need to be assured in the adequacy and accuracy of the design assumptions and operational capabilities. Only then will certification be possible. In all of these cases, the intent is to ensure the robustness of the containment design against severe accident phenomena that could lead to early containment failure. I would also note that as a measure of containment performance and as a basis for regulatory guidance, the Commission has approved the use of a 0.1 conditional containment failure probability for the evolutionary light water reactors. The Commission, however, directed that this containment performance objective should not be imposed as a requirement. Also, the use of the conditional containment failure probability should not discourage accident prevention. To help in this matter, the staff was directed to investigate suitable alternative, deterministically-established, containment performance objectives which could be submitted by the applicants.

<u>Summary</u>

In summary, the NRC has made considerable progress in recent years in understanding what happens during severe accidents. Such information is essential for assessing potential safety improvements and for making decisions on whether or not particular improvements are warranted. This program is what we have to offer to our international partners in safety research.

I hope this brief overview of containment integrity issues and initiatives gives you an appreciation of the great deal of effort that has been and continues to be invested in this area. We must continue to ensure that the results of our research efforts are applied effectively, on a timely basis, where they are most needed, and that effective initiatives are not allowed to wane.

Let me close my remarks by again expressing my appreciation for your willingness to join us today and invite your active participation in this important workshop.