NUREG-1226

Development and Utilization of the NRC Policy Statement on the Regulation of Advanced Nuclear Power Plants

U.S. Nuclear Regulatory Commission

Office of Nuclear Regulatory Research

Peter M. Williams and Thomas L. King

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ABSTRACT

On March 26, 1985, the U.S. Nuclear Regulatory Commission issued for public comment a "Proposed Policy for Regulation of Advanced Nuclear Power Plants" (50 FR 11884). This report presents and discusses the Commission's final version of that policy as titled and published on July 8, 1986 "Regulation of Advanced Nuclear Power Plants, Statement of Policy" (51 FR 24643). It provides an overview of comments received from the public, of the significant changes from the proposed Policy Statement to the final Policy Statement, and of the Commission's response to six questions contained in the proposed Policy Statement The report also discusses the definition for advanced reactors, the establishment of an Advanced Reactors Group, the staff review approach and information needs, and the utilization of the Policy Statement in relation to other NRC programs, including the policies for safety goals, severe accidents and standardization. In addition, guidance for advanced reactors with respect to operating experience, technology development, foreign information and data, and prototype testing is provided. Finally, a discussion on the use of less prescriptive and nonprescriptive design criteria for advanced reactors, which the Policy Statement encourages, is presented.

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EXECUTIVE SUMMARY

Advanced reactors have a long regulatory history, but until recently there has been essentially no explicit policy for their regulation other than case-by-case reviews which included determinations about their licensing requirements, including the extent of their conformance with Light Water Reactor (LWR) criteria. Accordingly the Commission has developed a Statement of Policy for Regulation of Advanced Nuclear Power Plants (Final Statement), published on July 8, 1986 (51 FR 24643) which encourages early interaction between NRC and advanced reactor designers to establish licensing guidance applicable to these designs. This report serves to document the comments on the proposed policy (published in the Federal Register on March 26, 1985, 50 FR 11884), to describe the significant changes made to the policy from that proposed to the final version and to provide guidance about implementation of the final policy, staff information needs and the staff approach to be used in the review of advanced reactor concepts under the Final Policy Statement. It is not the purpose of this document to impose technical design requirements on advanced designs. The staff reviews under the Final Policy Statement would occur before any formal application for authorization of construction or for a standard plant review and certification. However, the review principles and results would be expected to be used in the review of that design after a formal application. The key points contained in this document are summarized below:

(1) The Final Policy Statement is applicable to reactors of innovative design but not to designs for which licensing requirements are essentially covered by the LWR-Standard Review Plan (i.e., evolutions from current generation LWRs). The specific determination of which new designs are considered to fall within the Final Policy Statement will be made case by case. At the present time certain high temperature gas-cooled reactor (HTGR) designs, liquid metal reactor (LMR) designs and innovative LWR designs qualify as advanced reactor designs.

(2) Comments received on the proposed Policy Statement (50 FR 11884) were almost unanimous in the support of its objectives. Most commenters, however, stated that the objectives should not be imposed as requirements.

(3) The Policy Statement established a charter for an Advanced Reactors Group (ARG). The ARG function is in the Office of Nuclear Regulatory Research and is located in the Advanced Reactors and Generic Issues Branch, Division of Regulatory Applications. The ARG serves as a project manager coordinating and scheduling activities both within and outside the NRC, as well as performing a significant portion of the technical review itself. In performing this review, use will be made of the existing licensing guidance for LWRs, where practical, and supplemented, as necessary, with additional criteria to address the unique characteristics of the advanced designs.

(4) While the Final Policy Statement encourages innovative reactor designs and safety criteria, the review of advanced reactor designs will still require satisfactory consideration of the Commission's regulations, regulatory guides and other guidelines, such established and developing criteria as the defense-in-depth philosophy, standardization, the Commission's safety goal and severe accident policies, and applicable industry codes and standards.

(5) The Commission and staff expect the licenseability of advanced reactor designs to be supported by technology through a suitable combination of operating experience, the existing technology base, planned technology development, probabilistic risk assessment, applicable information and data from foreign countries, and plant testing. Prototype testing is encouraged.

(6) The use of less prescriptive, nonprescriptive, or performance related licensing criteria will be considered. Designers are encouraged to propose those criteria they believe are applicable to their designs and to address how such criteria will enhance safety and what changes or benefits in the traditional NRC process of regulation are expected from the use of such criteria.

(7) Requests by advanced reactor designers for reviews of advanced reactor conceptual designs should be addressed to:

    Director, Office of Nuclear Regulatory Research
    USNRC
    Washington, DC 20555

1 INTRODUCTION

On May 1, 1986 the NRC approved the issuance of a document entitled, "Regulation of Advanced Nuclear Power Plants; Statement of Policy." This Policy Statement was published in the Federal Register on July 8, 1986 [51 FR 24643] and forms the overall guidance for the NRC's activities regarding advanced nuclear power plants. The Policy Statement is provided in the Appendix to this document.

The Policy Statement calls for early interaction between the NRC staff and advanced reactor designers; encourages greater safety margins through the use of inherent, passive, or other innovative means for safety design; and establishes an Advanced Reactors Group (ARG) as a focal point for its implementation. The Policy Statement originally established the ARG within the Office of Nuclear Reactor Regulation (NRR), but a subsequent NRC reorganization approved by the Commission on February 11, 1987 transferred the ARG function to the Office of Nuclear Regulatory Research (RES).

The final Policy Statement is based on the development and revision of a proposed Policy Statement, published for comment on March 26, 1985 (50 FR 11884), including assessment of public comments.

The stated primary objectives of the Policy Statement are:

(1) "Encourage earliest possible interactions of applicant, vendors, and government agencies, with the NRC;

(2) Provide all interested parties, including the public, with the Commission's views concerning the desired characteristics of advanced reactor designs; and

(3) Express the Commission's intent to issue timely comment on the implications of such designs for safety and the regulatory process."

The purpose of this document is to (1) summarize the public comments received on the proposed version of the Policy Statement, (2) identify the significant changes made in the Policy Statement from the proposed version to the final version and (3) identify the responsibilities, interfaces and other considerations which must be addressed in the implementation and utilization of the final Policy Statement.

2 HISTORY AND BACKGROUND

The NRC and the Atomic Energy Commission before it, together with the Advisory Committee on Reactor Safeguards (ACRS), have a long history of review and evaluation of advanced reactors. Safety reviews for construction and operation of liquid metal-cooled, gas-cooled, and other types of non-water-cooled power reactors performed in the 1950s and early 1960s were similar to those performed for the early commercial Light Water Reactors (LWRs). The reviews performed by the regulatory staff and the ACRS were highly customized and were generally based on the engineering experience and judgment of participating individuals. The regulatory staff and ACRS members worked closely together in the review and assessment of information supplied by the designers, owners and constructors without the availability of the regulatory guidance and structure established later during the course of LWR commercial development. In more recent advanced reactor reviews, explicit use was made of LWR regulatory guidance where applicable, a practice that continues.

The Advanced Reactor Policy Statement identifies previous experience with the regulation of high temperature gas cooled reactors (HTGRs) and liquid metal reactors (LMRs). Construction permits and operating licenses were granted to the helium cooled Peach Bottom-1 and Fort St. Vrain reactors and to the sodium cooled Fermi-1 and the Southwest Experimental Fast Oxide Reactor (SEFOR) reactors. The design of the Department of Energy's (DOE's) Fast Flux Test Facility (FFTF) was given a safety review by the NRC but a license was not required by law. Reviews were also performed on reactor designs that were not subsequently built. For gas cooled reactors these were the Summit and Fulton applications for large HTGRs, the General Atomic Company's standard large HTGR plant (GASSAR), and a conceptual design for a gas-cooled fast breeder reactor (GCFR). With regard to LMRs, the Clinch River Breeder Reactor (CRBR) was reviewed, and a public hearing held, but the project was terminated by Congress in 1983 before a construction permit was issued and general construction began. It should be noted that since the CRBR was to be a power reactor prototype, it was subject to the same regulatory process as any current commercial nuclear power project.

In addition to the background of individual licensing actions, the Nonproliferation Alternative Systems Assessment Program (NASAP) of 1979 provided both a broad policy study and a review of specific safety concepts on reactor regulation. In the NASAP studies the NRC considered the safety and licensability of a variety of advanced reactor concepts ranging from preliminary conceptual designs to variations on existing LWRs.

Table 2.1, "Advanced Reactor Regulatory Experience" provides in summary format further information on previous advanced reactor safety reviews in the United States.

Until the present Policy Statement, the principal statement on advanced reactor review policy was given in the introduction to Part 50 of Title 10 of the Code of Federal Regulations: Appendix A, "General Design Criteria for Nuclear Power Plants." Specifically, this introduction states:

"These General Design Criteria establish minimum requirements for the principal design criteria for water-cooled nuclear power plants similar in design and location to plants for which construction permits have been issued by the Commission. The General Design Criteria are also considered to be generally applicable to other types of nuclear power units and are intended to provide guidance in establishing the principal design criteria for such other units."

This led to the "comparable level of a safety" philosophy under which HTGRs and LMRs were reviewed for many years; that is, a comparable level of safety would be established for all reactor types, with the recognition that the licensing criteria for advanced reactors could be developed using those for light water reactors to the extent practicable. The implementation of this philosophy took three forms with respect to the existing criteria; direct adoption, suitable adaptation, and recognition of the need for and development of specialized criteria. Direct adoption of the existing criteria was possible in many instances and provided a ready means of ensuring a comparable level of safety.

Examples of direct adoption are numerous and include industry standards for electrical and mechanical equipment and many of the NRC regulatory guides.

For those existing criteria that could not be regarded as unequivocably applicable, suitable adaptations were developed to permit the use of the phrase, "meets the objectives of" or words to this effect. Development of such adaptations was usually a straightforward practice of the applicant identifying and justifying discrepancies from the criteria followed by a staff review of the applicant's approach. An early example of the adaptive approach was the means for conformance of the Fort St. Vrain design to the Commission's General Design Criteria for LWRs.

For those portions of advanced reactor designs that were uniquely different from those of LWR designs (e.g., requirements for handling a sodium coolant or the use of a concrete reactor vessel for HTGRs), adoption or adaptation of existing regulations or standards was not possible or desirable. Such criteria needs were satisfied by engineering judgment and analysis resulting in the development of specialized licensing criteria.

Although the above developments have taken place in the advanced reactor area, they only provide a general background for the scope and intent of the present Advanced Reactor Policy Statement. The first formal development of advanced reactor policy began at a Commission meeting held on November 30, 1983, during which the Commission's responsibilities toward encouraging the development of reactor types of "greater inherent safety" were discussed. NRC's Office of Policy Evaluation (OPE) was asked to prepare an initial draft statement that was to include a discussion of the Commission's role in advanced reactor design in relation to NRC's enabling legislation. This draft was reviewed by the Office of Nuclear Reactor Regulation (NRR) and later discussed with the Commission at a meeting held on February 27, 1984. NRR participated with OPE in the further development of the statement and after substantial Commission and staff review, a statement of "Proposed Policy for the Regulation of Advanced Nuclear Power Plants" was published for comment on March 26, 1985 (50 FR 11884). The proposed Policy Statement included a description of the way the regulation of advanced reactors is guided by the legislative background and noted that the NRC "is precluded from designing, or doing research on, complete new designs for the purpose of establishing or developing their commercial potential." This principle avoids a conflict of interest since the NRC would not be placed "in a position to generate, and then have to defend, basic design data of its own."

A 60-day comment period for the Policy Statement followed its publication and 20 responses were received. These responses are identified and discussed in Section 3, "Abstract of Comments." After consideration of the comments and further review by the Commission and the staff, the final Policy Statement was issued. One of the features of the proposed Policy Statement was the inclusion of six questions on advanced reactor policy. The final Policy Statement restates these questions together with the Commission's own responses. The commenters' responses to the questions are discussed in Subsection 3.5, "Response to Questions." A discussion of the major changes in formulating final Commission advanced reactor policy from that proposed in 1985 is given in Section 4, "Formulation of Final Policy."

Table 2.1 Advanced Reactor Regulatory Experience

Part A - High Temperature Gas-Cooled Reactors
(The General Atomic Company and its successors were responsible for all HTGR designs)

Project Identification	Operational and/or Regulatory Experience	Comments and Remarks
Peach Bottom I - 40MWe, Philadelphia Electric Company, Peach Bottom, Penn.	Construction initiated in 1962. OL granted in 1967. Highly successful operation between 1967 and 1974.	First HTGR in U.S. Demonstrated cermanic (graphite) core design and ceramic fuel. Fuel concept differed from later HTGRs as design provided for fission product release and clean-up. Reactor project terminated for economic reasons.
Fort St. Vrain - 330MWe, Public Service Company of Colorado, Weld County, Colo.	Constructed between 1968 and 1974. OL granted in 1974. Operation sporadic, mainly caused by water ingress from helium circulator bearings.	Provided basis for modern, large HTGR concept through introduction of PCRV, integrated primary coolant system, improved fission product retention in fuel particles through use of silicon carbide layer. Fuel and steam generator performance excellent.
1000 MWe HTGR Study	A 1969 study involving both the staff and ACRS to upgrade HTGR power level. Favorable ACRS letter issued.	LWR type large containment vessel determined to be necessary for an HTGR of this size.
Summit and Fulton Plants, Sited in Delaware and Pennsylvania, but never built, 700-1000 MWe.	Licensing activities 1973 to 1975. Favorable SERs and ACRS letters issued but plants cancelled for economic reasons prior to public hearings and CP issuance.	Design based on 1000 MWe study. Substantial component development program planned.

Table 2.1 (Cont'd)

Part A - High Temperature Gas-Cooled Reactors

Project Identification	Operational and/or Regulatory Experience	Comments and Remarks
Gas Cooled Fast Breeder Reactor - GCFR	Concept reviewed by staff and ACRS between 1971 and 1975. Staff concluded that a demonstration plant, subject to the conditions of its SER, could be built.	Some SER concerns about ECCS were later addressed by use of a natural convection design for decay heat removal when pressurized.
GASSAR - a standard plant review based on Fulton Reactor Design	Staff review initiated 1974, terminated in 1977 with an interim SER.	Detailed review of fission product release from fuel experiments published as NUREG-0111.
Severe Accident Source Term Study - PRA study performed by RES Contractors on 2240MW(t) concept.	Study performed between 1982 and 1984. Inconclusive quantitative results but valuable insights into HTGR severe accidents developed.	Forms a basic starting point for continued HTGR severe accident analysis. Did not consider air and water ingress events.

Table 2.1 (cont'd)

Part B - Liquid Metal Reactors
(Fast Reactors Unless Otherwise Noted)

Project Identification	Operational and/or Regulatory Experience	Comments and Remarks	Designer
EBR-I (Experimental Breeder Reactor) INEL Site, Idaho 1.4 MWt	Plant not reviewed or licensed by NRC. Startup 1951, Shutdown in 1964	NaK cooled, first commercial power generation	Argonne National Laboratory
EBR-II Idaho 62.5 MWt INEL: Site (Experimental Breeder Reactor)	Plant not reviewed or licensed by NRC. Startup 1963, Continues in operation	Has operated successfully for 24 years. Demonstrated inherent safety characteristics of liquid metal reactors and metal fuel	Principal Nuclear Contractor Argonne National Laboratory
SRE Sodium Reactor Experiment Santa Susana, Calif., 20 MWt	Startup 1957, Shutdown 1964	Sodium Graphite Reactor (Thermal Reactor)	Atomics International
Hallam Nuclear Power Facility - Hallam, Nebr. 240 Mwe	Startup in 1962, Shutdown 1964	Sodium Graphite Reactor (Thermal Reactor)	Atomics International
Fermi-I Lagoona Beach, Mich. 200 MWt	Startup 1963, Shutdown 1963	Experienced fuel melting from partial core flow blockage. Returned to service but shutdown for economic reasons.	Power Reactor Development Corp.
SEFOR (Southwest Experimental Fast Oxide Reactor) Strickler, Ark. 20 MWt	Startup in 1969, Shutdown in 1972	Operated successfully until shutdown due to completion of its mission. Demonstrated inherent negative reactivity feedback in oxide fuel.	General Electric
ETEC Facilities - Santa Susana, Calif. (Non-Nuclear)	Sodium equipment test facility	Demonstrated liquid metal component performance.	Atomics International
FFTF (Fast flux Test Facility), Hanford, Wash 400 MWt	Constructed 1971-1980, NRC performed a safety review of the design and issued an SER (NUREG-0365) in 1978.	Plant has operated successfully for 6 years. Has demonstrated oxide fuel system.	Westinghouse
Clinch River Breeder Reactor - Oak Ridge, Tenn. 975 MWt	NRC completed the SER (NUREG-0968) and public hearing for CP in 1983.	Plant never built due to lack of funding. Much R&D done in support of design.	Westinghouse

3 COMMENTS ON PROPOSED POLICY

This section consists of abstracts and discussions of the public comments that were submitted on the Commission's proposed Policy Statement on advanced reactors published on March 26, 1985 (50 FR 11884). The abstracts were prepared from the 20 sets of comments from the organizations listed in Table 3.1. These organizations, which are indicated parenthetically, can be categorized according to the following groups: nuclear utilities (4, 6, 12, 16, 19); nuclear industry, (1, 3, 8, 9, 10, 11, 13, 15, 18, 20); national laboratories (2, 7); academic institution (17); government agency (5); and public interest group (14). The general reactions of the commenters and their responses to the six Commission questions are discussed in the following sections.

The abstracts are intended as accurate as possible representations of the oral and written comments that were received. In the interest of brevity, however, the commenters' reasons for their views are not given in detail; therefore, the abstracts may not be totally accurate. The reader who finds an abstract unclear and wishes to know exactly what the commenter said should consult the original comments; these are available for inspection at the Commission's Public Document Room, 1717 H Street, N.W., Washington, DC 20555.

3.1 Overall Reaction

The commenters unanimously supported the issuance of a policy statement. All except one (14) endorsed the desirability of simplifying and stabilizing the regulatory process and called for less specificity in the NRC's regulations, although they differed somewhat in the specific details of the process they would endorse. These commenters generally supported NRC's use of top-level public risk objectives, with most explicitly referencing safety goals. Although generally endorsing the Commission's objectives for advanced reactors that were stated in the proposed Policy Statement, all but two (13, 14) felt that they should not be considered as NRC requirements. Most believed that the baseline for acceptability should be the level of safety required of current light water reactors.

Most commenters were supportive of an Advanced Reactors Group and continuing interactions between the industry and the NRC during the development process. However, there were some differences in their views. In addition, there was confusion among the commenters about the type of reactor to which the policy statement was applicable and the extent of the difference from current reactors before a reactor could qualify as an "advanced" reactor; some explicitly suggested that the Commission clarify this point. Summarized below are the comments received on the individual sections of the proposed Policy Statement, including the six questions.

Table 3.1 Table of Commenters

Reference Number	Name	Affiliation
1.	Doan L. Phung	Professional Analysis, Inc.
2.	J. O. Zane	EG&G Idaho, Inc.
3.	John J. Taylor	Electric Power Research Institute
4.	D. W. Edwards	Yankee Atomic Electric Company
5.	James W. Vaughan, Jr.	Department of Energy
6.	H. L. Brey	Public Service Company of Colordao
7.	Herman Postma	Oak Ridge National Laboratory
8.	T. E. Northup	GA Technologies, Inc.
9.	L. D. Mears	Gas-Cooled Reactor Associates
10.	A. E. Scherer	Combustion Engineering, Inc.
11.	R. B. Bradbury	Stone & Webster Engineering Corp.
12.	L. Bernath	San Diego Gas & Electric
13.	John C. Young	International Energy Associates Limited
14.	E. Nemethy	Ecology/Alert
15.	Glenn G. Sherwood	General Electric Company
16.	Hal B. Tucker	Duke Power Company
17.	M. Golay, D. Lanning and L. Lidsky	Department of Nuclear Engineering, Massachusetts Institute of Technology
18.	E. P. Rahe, Jr.	Westinghouse Electric Corporation
19.	J. R. Thorpe	GPU Nuclear
20.	R. P. Schmitz	Bechtel Power Corporation

3.2 Scope

The proposed Policy Statement defined advanced reactors as "reactor designs which are significantly different from the present generation light water reactors." Most commenters (1, 2, 6, 7, 9, 10, 11, 12, 13, 14, 16, 17, 20) either accepted or did not mention the Commission's definition. Some (5, 8) explicitly supported the definition. The Electric Power Research Institute (EPRI) (3) believed that the statement was applicable to both advanced reactor designs based on "evolutionary improvements demonstrated by current light water reactor technology" and to those based on "substantial changes or radical departures from current technologies" and criticized the statement for not defining criteria that distinguished between the two. Similarly, Westinghouse (18) stated that "the policy statement should recognize that future designs do not necessarily require different features to be viable and licensable." Others (4, 15) believed that the scope of the Policy Statement was unclear and needed revision.

3.3 Interaction with NRC

Many commenters (2, 3, 5, 8, 11, 13) supported the earliest possible interaction between the industry and the NRC during the development process, with the NRC Advanced Reactors Group responsible for this interaction. Others (1, 4, 6, 7, 10, 14, 15, 17, 19) did not explicitly discuss this issue. Duke Power Company (16) expressed the opinion that the NRC should be cautious so as not to unduly influence, either positively or negatively, the selection of alternative concepts at the conceptual design stage and should deal with industry in a cooperative but independent manner.

San Diego Gas and Electric (12) was negative in its reaction to the concept of early interaction with the Commission and disclosure of the Commission's safety judgements to the public throughout the process. This commenter stated: "These 'motherhood' statements are antithetical, since premature disclosure of design details, before being fully analyzed and verified, raises expectations, which subsequently may require substantial modification to be viewed by the regulators and the anti-nuclear activists as equivocation. Also, early interaction invites critical assessment before all design features are fully coordinated into a defensible, validated whole. The NRC should take care to minimize opportunities for demagoguery and the fostering of misconceptions."

Gas Cooled Reactor Associates (GCRA) (9) felt that the Policy Statement needed to be revised to "include a statement to the effect that the NRC will actively pursue the development of mechanisms for the timely and effective incorporation of data from other countries into the licensing process." Westinghouse (18) voiced opposition to the aspect of NRC interaction with foreign sources by stating: "We strongly question the USNRC's stated willingness in this policy statement to review designs proposed by foreign vendors. The Atomic Energy Act of 1954, as amended, provides no extraterritorial jurisdiction to the NRC in the review of designs which may neither be manufactured or licensed in the United States. Improper exercise of USNRC jurisdiction could give rise to legal challenges." Westinghouse also felt that technical review responsibilities should rest with the current staff technical organization and not with a new staff group.

3.4 Standardization

Only two comments were received with respect to standardization. The Department of Energy (DOE) (5) stated:

> "The Department considers that it is critically important to improve the efficiency of the nuclear licensing and regulatory process and has had introduced into both Houses of Congress the "Nuclear Facility Standardization Act of 1985" to accomplish that objective. Any policy statement on the regulation of advanced reactors should be supplementary and complementary to that prime objective."

In contrast, the Public Service Company of Colorado (6) stated:

> "As a general comment, PSC supports the Commission's 1985 Policy and Planning Guidance statement that encourages industry to pursue standardization of the current generation of nuclear power reactors. However, the immediate application of this policy to advanced nuclear reactors may be inappropriate, since advanced reactors, by definition, are reactor designs which are significantly different from the present generation of light water reactors and the various advanced reactor concepts ordinarily differ in many ways from one another. Until a particular advanced reactor develops into a proven design that is capable of giving rise to a new family of nuclear power plants, it would be premature to think in terms of standardization for such units."

3.5 Responses to Questions

Question 1 - Regulatory Approach

> "Should NRC's regulatory approach be revised to reduce dependance on prescriptive regulations and instead establish less prescriptive design objectives, such as performance standards? If so, in what aspects of nuclear power plant design (for example, reactor core power density, reactor core heat removal, containment, and siting) might the performance standards approach be applied most effectively? How could implementation of these performance standards be verified?"

All commenters agreed that a less prescriptive approach to regulation (than the current one) is desirable, with the exception of the commenter from Ecology Alert (14), who did not address the issue. Almost all of these expressed the view that advanced reactors should be subject to top-level risk objectives or safety goals concerned with public health and safety and that any subsidiary performance standards should be closely related to showing compliance with these goals: in other words, they did not want regulation to otherwise restrict the design of advanced reactors. Most commenters felt that any design objectives should be broad enough to permit or encourage innovation. EPRI (3) differentiated between designs evolving from current reactors, which it feels should be regulated under an improved version of the current process, and reactors based on radical design approaches, for which it deems performance standards practical. DOE (5) emphasized the importance of a predictable, well-defined licensing process which identified information required and methodology used by NRC to judge compliance with the top-level criteria. Duke Power Company (16) contended that use of performance standards rather than design-oriented regulations is not enough to avoid prescriptive regulation. It also argued that the management structures of NRC and industry, and the interactions between them, must be changed. Oak Ridge National Laboratory (ORNL) (7) suggested establishing performance standards for essentially all aspects of the nuclear steam supply system and all systems which determine the safety of the public. Several commenters (5, 7, 18) stated that, to the extent that more detailed standards are needed, general NRC regulations should be supplemented as necessary by industry standards and codes. Several commenters (4, 7, 10, 15) believed that standardization will reduce the need for prescriptive regulation. Several others (2, 7, 9, 13, 15, 16) discussed the need for standards which permit simple verification and give designers considerable latitude and responsibility for demonstrating compliance.

Question 2 - Inherent Safety

"Should the regulations for advanced reactors require more inherent safety margin in their design? If so, should the emphasis be on providing features that permit more time for operator response to off-normal conditions, or should the emphasis be on providing systems that are capable of functioning under conditions that exceed the design basis."

Commenters were divided in their opinions on whether advanced reactors should be more inherently safe but generally believed that the regulations should not require a degree of supplemental safety (beyond the top-level safety goals). Two (13, 14) believed that regulations should require more inherent safety. Four (3, 7, 8, 15) considered greater safety margins appropriate for advanced reactors and thought that NRC should encourage or give credit for margins incorporated by designers rather than require them. General Electric (15) stated that it would be more appropriate to reduce uncertainty in safety assessments. A number of others (2, 4, 5, 6, 9, 11, 12, 16, 18, 20) believed that a safety margin is not necessary because it would be redundant to a well-conceived design objective, would undermine the objective and lead to additional, unnecessary standards, and would not recognize the adequacy of the current level of safety. Two commenters (16, 19) suggested that a clear definition of design objectives would incorporate safety margins to the extent necessary and that separate margins would not be necessary.

No commenters advocated requirements for systems capable of functioning under conditions that exceed the design basis. Ecology/Alert (14) recommended requiring passive measures. A number of commenters (1, 2, 5, 6, 7) did not express a view as to which safety approach should be emphasized, but advocated leaving the choice to designers. A number of others (3, 8, 9, 10, 13, 14, 15, 16) suggested that designs should incorporate passive features which permit more time for operator response, but none stated a preference for requiring this.

Question 3 - Simplified Designs

"Should licensing regulations for advanced reactors mandate simplified designs which require the fewest operator actions, and the minimum number of components needed for achieving and maintaining safe shutdown conditions, thereby facilitating operator comprehension and reliable system function for off-normal conditions?"

While all commenters (except Ecology/Alert (14), who did not comment on Question 3) expressed the view that simplicity of design should not be a regulatory criterion, there was strong support for encouragement of simplicity in design (7, 8, 15). International Energy Associates Limited (IEAL) (13) stated that it is unnecessary for NRC to require simplicity; rather, inherent safety will yield simplicity. ORNL (7) believed that simpler designs are likely to make safety more predictable and verifiable and reduce burdens on both the operator and the regulator.

ORNL (7) gave further support to this concept by stating that facilities to enhance operator comprehension and understanding and to achieve reliable system functions should be required for both normal and off-normal conditions. It noted that these may be achieved by simplification of design to require fewer operator actions e.g., by providing the operator with automated assistance, improved information display and more extensive analytical systems.

Some commenters (2, 5, 8, 18) stated that the designer must be free to balance safety and ease of operation with plant availability, to balance greater time for operator action against plant economics, or to balance the extent of operator action against the degree of design complexity. DOE (5) further stated that regulatory policy should encourage flexibility.

Other views included the statement of GCRA (9) that additional hardware complexity should be avoided where increased operator understanding can achieve a net gain in safety. Westinghouse (18) stated that reducing the number of operator actions results in more system complexity because it requires more automatic functions. IEAL (13) said that NRC should consider a goal for advanced reactors of "walk away" safety--that is, the reactor system will shut itself down to a safe condition without any operator action. In summary, commenters generally were opposed to any regulation of simplicity in design, but believed that the regulatory policy should encourage it. They further believed that once the top-level safety criteria had been achieved, it is the responsibility of the designer to trade off or balance design simplicity and increased safety margin with economics of the plant operation.

<u>Question 4 - Design Criteria</u>

"Should the NRC develop general design criteria for advanced reactors by modifying the existing regulations, which were developed for the current generation of light water reactors, or by developing a new set of general design criteria applicable to specific concepts which are brought before the Commission?"

All but two commenters (18, 19) believed that a new set of design criteria should be developed. Westinghouse (18) believed that the current General Design Criteria are nonprescriptive and have proven to be "remarkably durable", and that a new set of criteria would not be consistent with stability and certainty in the licensing process. On the other hand, GPU Nuclear (19) felt that the existing General Design Criteria did need to be modified to be "less prescriptive and more criteria-oriented." EPRI (3) believed that the current criteria should be employed for evolutionary reactors, unless they could be shown to be excessively conservative, and that new criteria may need to be developed for advanced reactors based on radical design changes. The remainder of the commenters (except for four who did not comment on this question), felt that a new set of General Design Criteria should be developed. Two commenters (1, 11) felt that a unified set of criteria was necessary, with specific implementation being reactor type specific. Four commenters (1, 8, 9, 17) specifically stated that these should be developed and traceable to a safety goal based on acceptable risk to the public health and safety. Eight (4, 5, 6, 7, 9, 13, 15, 20) stated that they believed the criteria should be reactor type specific. Four (4, 6, 12, 13) felt that the industry and NRC should develop the criteria cooperatively. DOE (5) believed the criteria should be developed as part of the interactions between the NRC staff and each of the Department's advanced reactor programs during the development of the individual concepts.

<u>Question 5 - Encouragement of Simplified and High Reliability Systems</u>

> "Should the NRC favor advanced reactor designs that concentrate the primary safety functions in very few large systems (rather than in multiple subsystems), thereby minimizing the need for complex benefit and cost balancing in the engineering of safe reactors?"

The 18 commenters that responded to the question supported the concept of design simplification. Fourteen commenters (1, 2, 3, 4, 5, 6, 8, 9, 11, 12, 15, 18, 19, 20) stated that they were opposed to the NRC favoring any particular design. Generally, they believed that it was up to industry to balance among concepts to arrive at a final design without the NRC being prescriptive in defining design requirements. One commenter (14) felt that the NRC should change emphasis from "defense-in-depth" to "simplifying reactor design, placing the core at least 10 feet underground, and doubling the thickness of the containment since the concept of 'defense in depth,' with multiple safety systems, simply adds to the number of buttons, levers and blinking lights." The remainder did not address this latter point.

<u>Question 6 - Degree of Proof</u>

> "What degree of proof would be sufficient for the NRC to find that a new design is based on technology which is either proven or can be demonstrated by a satisfactory technology development program? For example, is it necessary or advisable to require a prototypical demonstration of an advanced reactor concept prior to final licensing of a commerical facility?"

Of the 20 commenters, 19 responded to this question. Nine of these (3, 4, 6, 11, 13, 15, 16, 18, 20) commented that whether or not a prototype of a facility would be required would be a function of the degree of departure from existing proven technology, the degree of uncertainty in the technology and any specific concerns with the technology. They stated that these factors would determine the need for prototype testing of either the facility or subsystems. Six (5, 6, 8, 9, 10, 15) believed that prototype testing should not be a requirement but an acceptable alternative to traditional methods for demonstrating compliance with the NRC's regulations. Four commenters (2, 7, 14, 19) felt that prototype testing for advanced reactors should be required. ORNL (7) cautioned that prototype testing would not be able to simulate such events as natural disasters, fire, sabotage, or aircraft impact. San Diego Gas and Electric (12) felt that the term "proof" was "totally inappropriate." Professional Analysis, Inc. (1) believed that a prototype facility is not sufficient to prove a concept due to the low probability of accidents of safety concern and that a concept could only be demonstrated through component prototype testing combined with risk analysis.

4 FORMULATION OF FINAL POLICY

4.1 Changes From Proposed Statement

Changes in the proposed Policy Statement that were incorporated in the final Policy Statement reflect review and consideration of the public comments and input provided by the staff to the Commissioners on August 21, 1985 (SECY-85-279) "Revised Advanced Reactor Policy Statement". In many cases the changes are for the purposes of clarification. The changes judged significant are described below in the order that they appear in the final Policy Statement:

(1) For clarification, an explicit list of three primary objectives has been added.

(2) For clarification, the definition for an advanced reactor has been added to differentiate between reactors of innovative design and reactors that represent evolutionary improvement over current generation light water reactors. This definition is discussed further in Section 5.1.

(3) The final policy statement explicitly deals with the question of enhanced margins of safety and safety goals with the added statement:

"Regarding advanced reactors, the Commission expects, as a minimum, at least the same degree of protection of the public and the environment that is required for current generation LWRs. Furthermore, the Commission expects that advanced reactors will provide enhanced margins of safety and/or utilize simplified, inherent, passive, or other innovative means to accomplish their safety functions. The Commission also expects that advanced reactor designs will comply with the Commission's forthcoming Safety Goal Policy Statement."

This was added to make it clear that the Commission expects but does not require enhanced safety margins other than those that may be required by the safety goal policy.

(4) The listed desirable attributes that could assist in establishing the acceptability or licenseability of a proposed advanced reactor design has been increased from five to nine. These attributes are essentially the same as stated in the proposed Policy Statement except that they have been expanded for clarity. A proposed paragraph and attribute relating to increased standardization and shop fabrication was not carried over to the final Policy Statement since this is not unique to advanced reactors.

(5) A paragraph requesting early identification of plans for the use of proven technology and/or technology development programs was added in order to provide for early identification of issues which could impact standard plant approval and certification.

(6) The charter of the Advanced Reactors Group was expanded to "maintain knowledge of advanced reactor designs, developments and operating experience in other countries" and to "provide guidance regarding the timing and format of submittals for review." The implication that the NRC would review applications directly from foreign designers was removed.

4.2 Responses to Questions

The Commission's response to the six questions contained in the proposed Policy Statement are included in the final Policy Statement. These responses were developed considering the public comments received and the staff input provided in SECY-85-279. The questions and the Commission's response to each are contained on pages 14 through 19 in the Appendix. The questions and responses address the following topics: (1) Regulatory Approach, (2) Inherent Safety, (3) Simplified Designs, (4) Design Criteria, (5) Encouragement of Simplified and High Reliability Systems, (6) Degree of Proof.

5 GUIDELINES FOR UTILIZATION

The purpose of this section is to discuss the staff's plans for utilization and implementation of the guidance contained in the Advanced Reactor Policy Statement, including staff information needs and the approach to be used in the review of advanced reactor concepts. These plans are based both on the provisions of the Policy Statement and on certain related policies and regulations. It is not the purpose of this section to impose technical design requirements on advanced designs.

The following paragraphs reflect the staff's plans at this time which may be subject to evolutionary changes based on progress in the reviews of advanced reactor concepts and further developments in the LWR licensing structure. These plans are described here in order to provide guidance on the staff's information needs and the staff's approach to be used in the review of advanced reactor concepts. The staff reviews performed under the charter of the Policy Statement would occur before any formal application for review of either a one-of-a-kind plant or a standard plant, including design certification. In that sense they are the first of a multi-step process, leading toward construction and operation of an advanced nuclear power plant. However, this first step is not mandatory but reactor designers are encouraged to take advantage of it to obtain feedback early in the design process on licensing requirements. The review principles and results of the review discussed in this document would be expected to be used in subsequent reviews of that design, if and when a formal application for either a specific plant or a standard plant, including design certification, is filed.

5.1 Definition of Advanced Reactors

Advanced reactors are defined broadly in the Policy Statement as "those reactors that are significantly different from current generation light water reactors under construction or in operation and to include reactors that provide enhanced margins of safety or utilize simplified inherent or other innovative means to accomplish their safety functions." The staff considers that in this frame work the term "current generation reactors" refers also to the most recent evolutionary LWR designs (such as the General Electric-Advanced Boiling Water Reactor and the Westinghouse and Combustion Engineering Advanced Pressurized Water Reactors) which have improved safety features. The attributes listed in the Policy Statement for advanced reactor designs provide further definition. Also, in general, reactor designs that utilize inherent or passive safety features (features that perform their function without dependence on or influence by electric power, actuation of mechanical devices, or operator action) to perform their safety functions will be considered advanced reactors in the context of the Policy Statement. For each design submitted to the Commission for review, a determination will be made case by case about whether it should be classified as an advanced reactor and treated under the Policy Statement. In addition to the above, reactor designs that are classified as "advanced" and are reviewed as part of the staff's activities under the Advanced Reactor

Policy Statement, should have licensing requirements significantly different than those contained in the LWR Standard Review Plan (SRP), NUREG-0800. Accordingly, their review as an advanced reactor is intended to help ensure that appropriate regulatory requirements addressing the unique characteristics of these designs are developed in a timely fashion. At the present time certain high temperature gas-cooled reactor (HTGR) designs, liquid metal reactor (LMR) designs and innovative LWR designs* qualify as advanced reactor designs.

5.2 Advanced Reactors Group-Contacts and Information Needs

The Policy Statement sets out a charter for an Advanced Reactors Group (ARG) as follows:

"This group will be the focal point for NRC interaction with the Department of Energy, reactor designers and potential applicants, and will coordinate the development of regulatory criteria and guidance for proposed advanced reactors. In addition, the group will maintain knowledge of and expertise on advanced reactor designs, knowledge of developments and operating experience in other countries, and will provide guidance on an NRC-funded advanced reactor safety research program to ensure that it supports, and is consistent with, the Commission's advanced reactor policy. The Advanced Reactors Group will also provide guidance regarding the timing and format of submittals for review."

At the present time, the ARG functions as part of the Advanced Reactors and Generic Issues Branch, Division of Regulatory Applications, RES. The main function of the ARG is to serve as the focal point for NRC review of advanced reactors at the conceptual design stage. In general, the staff will implement the Policy Statement by reviewing designs at the conceptual stage (before any formal application), developing guidance on the licensing criteria applicable to that design and making a preliminary assessment of the potential of that design to meet those criteria. This review will be done primarily by the staff (under the coordination and direction of the ARG) and will include the involvement of the ACRS. Commission review will also be requested on those matters considered to have policy or other major implications.

Once a design has reached the point at which a formal application for review is submitted (either a plant specific license application or an application for standard plant review), its review will use and build on the initial reviews done by the ARG at the conceptual design stage.

Reactor designers proposing to initiate interactions with NRC on the review of an advanced reactor conceptual design should contact the Director, Office of Nuclear Regulatory Research, USNRC, Washington, DC 20555 prior to submitting design information for review.

Because of resource limitations, the NRC staff will have to determine case by case a priority for review of the proposed advanced concept considering such factors as:

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*Those LWR designs that are consistent with the EPRI Advanced Light Water Reactor Design Requirements and/or contain significant safety advances beyond current licensing requirements may be reviewed under the guidelines of the Advanced Reactor Policy Statement.

(1) the potential of the design to result in an improvement in safety;

(2) level of support behind the design (industrial involvement, utility involvement);

(3) congressional or executive branch mandate; and

(4) utility interest.

In general, it is desired that the scope of review of an advanced concept include review of the entire plant (see Section 5.3.4 for further description). To enable the staff to perform a meaningful review, the following information is desired:

- Description of the plant design and its proposed design, safety and licensing criteria, including analysis of major accident scenarios demonstrating acceptable plant response.

- Probabilistic risk analysis (see Section 5.3.3 for further description).

- Description of those applicant sponsored R&D programs considered necessary to support development and licensing of the design.

The results of the staff review of this information would then be documented in a Safety Evaluation Report. This Safety Evaluation Report will identify the key safety issues associated with the design, provide guidance on the licensing criteria applicable to that design, provide an assessment of the adequacy of the applicant sponsored research and development programs proposed in support of the design and, in consideration of the above, assess whether any obvious impediments exist to licensing the advanced reactor design.

The following sections provide additional information regarding the staff review and information needs.

5.3 Review Approach and Related Policies, Practices and Regulations

As stated in the Advanced Reactor Policy Statement an advanced reactor must, as a minimum, have the same degree of protection of the public and environment as is required for current generation LWRs. However, enhanced margins of safety over current generation LWRs are expected. The degree of the enhanced margin of safety will be based on a judgment of the designs involving:

- the extent to which the designs incorporate those attributes listed as desirable in the Policy Statement,

- the uncertainties associated with the safety analysis and supporting base technology for the designs,

- the extent to which margins and defense-in-depth are employed to account for these uncertainties,

- the capability and margin included in the design to prevent and mitigate severe accidents, including compliance with the Commission's severe accident and safety goal policies,

- the previous operating experience, existing technology and proposed R&D supporting the design.

In consideration of the above, the staff will consider giving credit for enhanced safety characteristics incorporated into the design. This credit may be in the form of changed design criteria or administrative requirements. This section provides additional description of the key factors to be considered in the staff's review of an advanced design.

The existing regulatory structure for advanced reactors, of which the Policy Statement is now a part, ranges from top-level nonprescriptive criteria, such as the safety goal policy, to very detailed industry codes and standards. In reviewing an advanced reactor design at the conceptual design stage use will be made of the following NRC policies, practices, and regulations: (1) defense-in-depth philosophy, (2) safety goal policy, (3) severe accident policy (4) standardization policy, (5) existing LWR regulations and guidelines, where applicable, and (6) industry codes and standards.

How each of these items will be utilized by the staff in the review of advanced reactors is discussed below.

5.3.1 Defense-in-Depth Philosophy

There has been much discussion over the past several years about using less prescriptive or performance based licensing criteria and, it is noted, that novel design approaches could reduce the need for some types of safety equipment traditionally required on LWRs. Alternatives ranging from probabilistic based criteria to descriptive goal based criteria have been suggested. The use of such criteria is being explored and will be considered for advanced reactors (see Section 5.5). It is the staff's opinion that such criteria should be consistent with or the defense-in-depth philosophy. This is especially true when considering reactor types for which there is significantly less design, construction and operating experience as compared to LWRs. Accordingly, the staff believes that it is still essential and intends to employ engineering judgment and the defense-in-depth philosophy in the review of advanced reactors to account for uncertainties in the design. Such uncertainties may be in the areas of component/system performance, reliability, analytical tools or supporting technology. The application of defense-in-depth may take various forms, such as:

- requirements to prevent accidents, such as high reliability, redundancy and/or diversity in systems, structures and components,

- requirements to mitigate accidents, such as long response times, multiple barriers, or safety systems,

- requirements to contain radioactive materials.

The exact nature and extent of defense in depth to be required on an advanced design will be determined case by case on the merits of the design under review considering factors such as:

- reliability of safety systems
- supporting technology
- uncertainties in analytical tools, reliability, supporting data base
- margin in design for accidents beyond the design basis

5.3.2 Safety Goal Policy

On August 4, 1986, the Commission published a policy statement on "Safety Goals for the Operation of Nuclear Power Plants" (51 FR 28044). This policy statement focused on the radiological risks to the public from nuclear power plant operation and established goals that broadly define an acceptable level of such risks. Specific guidelines are being developed to establish a consistent level of safety between licensing criteria for advanced reactors and the safety goal policy. For advanced reactors these guidelines will be used, wherever appropriate.

5.3.3 Severe Accident and Source Term Policies

The Commission's "Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants" was issued on August 8, 1985 (50 FR 32138). Advanced reactors are expected to comply with the provisions of this policy that pertain to new plant applications. The staff is currently developing more detailed guidance regarding implementation of this policy statement. In addition, the regulatory procedures and criteria are being developed that will use the improved information from extensive research on radioactive material releases (i.e., source terms) under severe accident conditions. While some of the details of these severe accident and source term regulatory provisions may not be applicable to specific types of advanced reactors, advanced reactors are, in general, expected to conform to the relevant guidance they provide. Thus advanced reactor designers, when considering severe accidents and source terms at the conceptual design stage, are expected to show that the applicable portions of their designs meet "the intent of" or "the objectives of" the following:

(1) Demonstration of or commitment to compliance with the procedural requirements and criteria of the current Commission regulations, including the Three Mile Island requirements for new plants as reflected in the construction permit rule, 10 CFR 50.34(f)

(2) Demonstration of or commitment to technical resolution of all applicable unresolved safety issues and the medium-priority and high-priority generic safety issues, including a special focus on ensuring the reliability of decay heat removal systems and the reliability of both ac and dc electrical supply systems;

(3) Completion of a probabilistic risk assessment (PRA) at the conceptual design stage and consideration of the severe accident vulnerabilities that the PRA exposes, along with the insights that it may add to the assurance that there is no undue risk to public health and safety.

Advanced reactor designers when addressing the above criteria are expected to take notice that the Policy Statement lists among the desirable attributes for proposed advanced reactor designs "designs that minimize the potential for severe accidents and their consequences by providing sufficient inherent safety, reliability, redundancy, diversity and independence in safety systems." Potentially, an advanced reactor could be proposed that would meet these preventative requirements with such sufficiency that relief could be justified in the type of source terms and severe accident mitigative features from that traditionally employed on LWRs. However, advanced designs are expected to consider a balance between prevention and mitigation consistent with the uncertainty associated with their analysis and to provide sufficient information to justify their design choices.

PRAs performed for the advanced reactor concepts should cover the whole plant, should address internal and external events as well as various plant operating states (full power, low power, refueling, etc.) and should confirm the bases for component and system selections, confirm the adequacy of overall plant design, be used to identify and correct any areas of high risk, and confirm the adequacy of plant response to severe accidents and mitigation measures. In addition, the PRA should be used to improve knowledge of component and structural reliability requirements and inservice inspection and testing needs. Any PRA must also estimate and factor in the uncertainties associated with it. These uncertainties must be factored into decisions which utilize PRA results.

In addition, analysis should be presented at the conceptual design stage to show the margin available in the design to accommodate events of low probability and to maintain protection of the public and environment.

5.3.4 Standardization Policy

On September 15, 1987, the Commission published a policy statement on "Nuclear Power Plant Standardization" (52 FR 34884). The development of advanced concepts should be consistent with the Commission's standardization goals and policy from the project's inception. Attention to the principles of standardization on advanced designs is not intended to discourage innovation but, rather, is intended to ensure that the end product is amenable to being standardized. Therefore, it is expected that advanced reactor designers should have as an ultimate goal the development of a standard plant design. Specific items regarding standardization which should be considered on advanced designs at the conceptual design stage are:

(1) The use of standardized practices in design, manufacture, construction, operation, and maintenance, to the extent possible;

(2) The use of standard components, structures, systems, and human engineering practices;

(3) The use of proven state-of-the-art technology, to the maximum extent possible, in the conception, design, and construction of any advanced reactor. Where the design deviates from state-of-the-art technology, a comprehensive research, development, and testing program will be necessary to demonstrate that the component or design feature being proposed performs with known characteristics and sufficient reliability to warrant standardization. To this end, the Commission stated in its Advanced Reactor

Policy Statement that it "favors the use of prototypical demonstration facilities as an acceptable way of resolving many safety related issues" (Section 5.4.4 provides additional information on prototype testing).

(4) As a minimum, at the conceptual design stage, the designer should present an essentially complete nuclear plant design for review rather than just the nuclear island or the safety-related components. Although the formal application for design approval[1] and design certification[2] may request design approval and certification of only interface criteria for certain systems, structures and components, a representative design for the complete plant should be presented at the conceptual design stage to allow the staff to assess the adequacy of the interface criteria and to aid in the review.

To ensure that each of the above considerations is adequately addressed, designers should provide more information at the conceptual design stage than a simple commitment to meet standardization goals. Information should be provided that describes their plans for achieving standardization.

5.3.5 Existing Regulations and Guidelines

The Standard Review Plan (SRP) Rule (10 CFR 50.34(g)) requires that applications for light-water-cooled nuclear power plant construction permits, operating licenses, preliminary design approvals and final design approvals docketed after May 17, 1982, include an evaluation of the facility against the SRP in effect on May 17, 1982, or the SRP in effect 6 months before the docket date of the application, whichever is later. The staff believes that advanced reactor designers should also review the SRP for applicability to their designs at the conceptual design stage. For those SRP sections identified as applicable, the advanced reactor design should be consistent with those requirements. Where advanced designs are different, designers should propose alternatives to the SRP requirements to account for the unique characteristics of their design.

In general, the staff will develop licensing criteria for advanced reactors by utilizing LWR criteria, where applicable, and by modifying existing criteria or developing new criteria to account for the unique characteristics of the design. The use of less or nonprescriptive criteria will be considered as discussed in Section 5.5.

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[1]Design approval is addressed in 10 CFR 50, Appendix O, whereby a standard reactor design, or a major portion thereof, is reviewed and approved by the NRC staff and ACRS. The approved design would then be relied upon by the staff and ACRS in their review of individual license applications that reference the design. Design approval is a prerequisite to design certification.

[2]Certification through rulemaking is addressed in 10 CFR 50, Appendix O, whereby a standard reactor design, or a major portion thereof, is reviewed and approved by the NRC staff and then certified by the Commission for use through a formal rulemaking process. That portion of the design approved in a rulemaking proceeding would not be subject to review by the staff or challenge in individual license applications that reference the certified design.

5.3.6 Industry Codes and Standards

The use of industry codes and standards for the technical details of reactor and support systems designs has been a fundamental part of reactor licensing for many years. Over the years a large body of such codes and standards has been developed by experts in conjunction with the NRC and provide in most cases the essential details of how higher level criteria, policies, guides, rules, and regulations may be met. Like the use of appropriate operational experience, the use of these existing codes and standards, wherever practicable, is encouraged in advanced designs rather than proposing specialized unique approaches.

One of the reasons for the successful use of industry codes and standards in licensing LWRs is that the standards committees consist of a combination of members representing different interests and experiences such as reactor vendors, utilities, equipment manufacturers, and government and sometimes foreign representatives. The output of these committees represents a consensus on the important characteristics to be controlled in the areas covered by the standards. The staff encourages that committees such as the American Nuclear Society's ANS-53, "HTGR Management Committee" and ANS-54, "Committee on LMFBR Standards" be continued and used by advanced reactor designers.

5.3.7 Treatment of Sabotage

As indicated by the quote below from the Commission's Policy Statement on Severe Accidents, the importance of sabotage as a contributor to severe accident risk is recognized:

> "The issues of both insider and outsider sabotage threats will be carefully analyzed and, to the extent practicable, will be emphasized as special considerations in the design and in the operating procedures developed for new plants."

In addition, Generic Issue A-29, "Nuclear Power Plant Design for the Reduction of Vulnerability to Industrial Sabotage," is one of the medium-priority Generic Safety Issues for which that policy expects new designs to demonstrate technical resolution.

The Advanced Reactor Policy Statement, in response to question number 1, indicated that in the area of sabotage the Commission intends to make use of existing and future regulations in reviewing advanced reactors. As such, the vulnerability of advanced reactors to sabotage is an important consideration and advanced reactors will be required to meet the same regulations regarding physical protection as LWRs. It is expected that, in many cases, advanced reactors, due to their inherent safety characteristics and simplified safety systems, will be less reliant upon physical security systems and procedures for protection against sabotage than current generation plants. Accordingly, at the conceptual design stage, advanced reactor designers should submit a short description of the advantages and disadvantages their design provides in protection from insider and outsider sabotage as compared to a current generation LWR.

5.4 Supporting Technology

The Policy Statement addresses the role of supporting technology several times as quoted below:

> "The Commission expects that these designs [for advanced reactors] will reflect the benefits of significant research and development work and include experience gained in operating the many power and development reactors both in the United States and throughout the world."

> "Among the attributes ...which, therefore, should be considered in advanced design are:... Design features that can be proven by citation of existing technology or which can be satisfactorily established by commitment to a suitable technology development program."

> "During the initial phase of advanced reactor development, the Commission particularly encourages design innovations which enhance safety and reliability... and which are either proven or can be demonstrated by a straight-forward technology development program."

In the subsections below are brief discussions on the use of supporting technology in the areas of operating experience, technology development, foreign information and data and use of prototype testing. Advanced reactor designers are expected to provide information on the application of each of these areas to their designs.

5.4.1 Operating Experience

The staff believes that the use of technology proven through operating experience is the most direct, least expensive and preferred means for the demonstration of licensability of reactor concepts. The available sources of operating experience should be used wherever possible. It is emphasized that sources of useful operating experience are not limited to reactors. For example, other industries provide valuable experience with water systems, testing and inspection procedures, control systems, and electrical and mechanical systems and components.

5.4.2 Technology Documentation and Development

Each submittal for review of an advanced design at the conceptual design stage should include a "technology development plan" or equivalent documentation. The technology development plan should document the scientific and engineering data that will be developed to support the design and safety analysis of the advanced reactor concept. This scientific and engineering data could include laboratory research, component development and testing, verifications during plant preoperational testing or startup, periodic testing and/or inspection during plant operation, and the use of a reactor prototype test. At the conceptual design stage the staff review will provide a preliminary assessment of the adequacy of the technology development plan for the design, utilizing engineering judgment, experience and insights gained from its review of the design.

5.4.3 Foreign Information and Data

Foreign programs can provide valuable design information, operating experience and basic data about advanced reactors. Regardless of the reliance to be placed on the information from foreign sources, each advanced reactor applicant submitting its design to the NRC for review should provide a summary of any applicable foreign reactor experience. This should include a discussion of major design differences and similarities, performance related experience and applicable research and development. How this information was factored into the advanced design should also be discussed. This is considered important because, in general, the experience base associated with advanced concepts is less than that for LWRs and the consideration of other experience is essential. The use of foreign data to support a U.S. advanced reactor design is acceptable provided the staff has sufficient access to the design, analysis and experimental data being used.

5.4.4 Use of Prototype Test

The Advanced Reactor Policy Statement does not require a priori that a prototype test reactor be constructed and operated; however, it does state that "The Commission favors the use of prototypical demonstration facilities as an acceptable way of resolving many safety related issues." The staff will, however, have to be satisfied for the design being reviewed that there is a basis for each claim regarding system and equipment performance and reliability. For reactor designs that depart significantly from proven technology, the staff favors the use of a prototype full-scale test facility to demonstrate those features of the design which are fundamental to its safety performance. This alternative has the potential for reducing or removing uncertainties because it will represent an integrated test of all plant systems under prototypical conditions, including the effects of construction, maintenance and operation. As part of the review of the conceptual design, the staff will make a case-by-case judgment about the need for a prototype test to resolve safety issues considering such factors as:

(1) Departure from proven technology,
(2) Uncertainties in performance and how they could be reduced,
(3) Degree of defense-in-depth, and
(4) Other R&D programs planned in support of the design.

It must be kept in mind that prototype tests cannot impact many of the uncertainties associated with certain types of events such as earthquakes, sabotage, and degraded core accidents. Risks from these types of events must be evaluated using engineering judgment and where applicable, probabilistic methods.

Regarding the need for a protypical demonstration facility to support design certification, the Commission stated in its Policy Statement on Nuclear Power Plant Standardization that "When an advanced design concept is sufficiently mature, e.g., through comprehensive, prototypical testing, an application for design certification could be made." Accordingly, advanced reactor designers should, at the conceptual design stage, describe their plans for the construction, testing and operation of a prototype plant to support design certification.

5.5 The Use of Less or Nonprescriptive Design Criteria

The Commission's guidance on and encouragement of the use of less prescriptive or nonprescriptive criteria in the regulatory process is given in its responses to two of the six questions contained in the proposed Advanced Reactor Policy Statement. These responses are included in the final Policy Statement, attached as an appendix to this document and are excerpted below:

Response to Question 1 (Regulatory Approach)

> "In developing additional criteria and guidance to address those characteristics which differ from LWRs less prescriptive criteria will be considered. The use of less prescriptive criteria will depend upon the design in question and the ability to verify compliance with the criteria. Advanced reactor designers are encouraged as part of their design submittals to propose specific review criteria or novel regulatory approaches which NRC might apply to their designs."

Response to Question 4 (Design Criteria)

> "In following this approach, it is the Commission's intent to establish, for each design reviewed, the licensing criteria that apply to that design. As stated in the response to Question No. 1, these criteria will be a combination of applicable LWR criteria and criteria developed to address the unique characteristics of that design. Reactor designers are encouraged to propose specific criteria and novel regulatory approaches which might apply to their design."

The Policy Statement does not include a definition for nonprescriptive criteria but does observe that "Many of the Commission's existing regulations, criteria, and guidelines are of a nonprescriptive nature..." and cites the safety goal policy as an example. The development of less prescriptive regulatory requirements is also a goal in "NRC Policy and Planning Guidance," NUREG-0885, Issue 5, 1986.

The role of and the justification for the use of less or nonprescriptive licensing criteria in those areas where existing LWR criteria do not apply is an area which will receive considerable emphasis in the review of advanced reactors. While the use of less or nonprescriptive criteria may be desirable in many cases, certain information and study is needed to assure that, in the event they are used, an acceptable level of safety is attained. To illustrate the information and considerations which need to be addressed in this area, a list of items follows that designers should be prepared to address during the course of an advanced reactor review if they propose to use less or nonprescriptive criteria for their designs. This list serves to illustrate the way newly proposed criteria will be examined by the staff. The fact that the staff will carefully evaluate any proposed new criteria is not intended to discourage their development. On the contrary, the staff encourages the development of improved regulatory approaches and will give high priority to reviews of new criteria to support the development of advanced reactors. In general, the staff expects advanced reactor designers to propose those criteria which, in their judgment, apply to their design, including any less or nonprescriptive criteria. Where such criteria depart from the traditional level of specificity employed on LWRs regarding design configuration and plant performance, the following information should be provided to justify and clarify the use of the less or nonprescriptive criteria and to assist the NRC in making the requisite assessment:

(1) A description of why such criteria are being proposed and what changes in the scope or type of NRC regulation are desired or implied by the use of the new criteria. For example, if probabilistic based criteria are proposed, will NRC be required to regulate data bases, reliability assurance programs or maintenance programs to help ensure reliability goals are met?

(2) A description of the way the proposed criteria will lead to a safer plant design and not detract from safety. For example, would the use of the proposed criteria lead to the use of components, systems or structures of superior reliability than would be required by the traditional regulatory structure?

(3) A description of the extent to which less or nonprescriptive criteria are to be employed in the regulation of the proposed design, including the proper mix between nonprescriptive and deterministic criteria, and considering the need to preserve the defense-in-depth philosophy to account for uncertainties and unknowns.

(4) Standardization of design has long been encouraged by the Commission. It is possible that the adoption of less or nonprescriptive regulations could work against standardization. Although a less or nonprescriptive approach may seem attractive for new and innovative designs it should be noted that in the past this flexibility has produced instead a multiplicity of designs with no clear advantage among them. Therefore, a description would be useful of the compatibility of the proposed regulatory approach with the Commission's standardization goals, along with a description of how the nonprescriptive regulation should be implemented to ensure there is no detrimental effect on the Commission's standardization efforts.

(5) The scope of the analyses to be used to justify and implement the proposed criteria should be discussed. This should include discussion of the way analyses are to be maintained over the life of the plant. For example, to implement reliability based criteria, should the reliability analysis be updated over the life of the plant to reflect both plant specific and industry wide operating experience?

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APPENDIX

NUCLEAR REGULATORY COMMISSION

10 CFR PART 50

REGULATION OF ADVANCED NUCLEAR POWER PLANTS;
STATEMENT OF POLICY

AGENCY: Nuclear Regulatory Commission.

ACTION: Final Policy Statement.

SUMMARY: The Nuclear Regulatory Commission intends to improve the licensing environment for advanced nuclear power reactors to minimize complexity and uncertainty in the regulatory process. This statement gives the Commission's policy regarding the review of, and desired characteristics associated with, advanced reactors. This policy statement is a revision of the "Proposed Policy for Regulation of Advanced Nuclear Power Plants" that was published for comment on March 26, 1985 (50 FR 11884).

EFFECTIVE DATE:

FOR FURTHER INFORMATION CONTACT: Ken Herring and Dennis Rathbun, Office of Policy Evaluation, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Telephone: 202-634-3295.

SUPPLEMENTARY INFORMATION:

BACKGROUND

The Commission's primary objectives in issuing an advanced reactor policy statement are threefold:

- First, to encourage the earliest possible interaction of applicant, vendors, and government agencies, with the NRC;
- Second, to provide all interested parties, including the public, with the Commission's views concerning the desired characteristics of advanced reactor designs; and
- Third, to express the Commission's intent to issue timely comment on the implications of such designs for safety and the regulatory process.

Such interaction and guidance early in the design process should enhance stability and predictability in the licensing and regulation of advanced reactors.

Advanced reactors are considered here to be those reactors that are significantly different from current generation light water reactors under construction or in operation.

The Commission expects that these designs will reflect the benefits of significant research and development work, and include the experience gained in operating the many power and development reactors both in the United States and throughout the world. The Commission expects that advanced reactors would provide more margin prior to exceeding safety limits and/or utilize simplified, inherent, passive, or other innovative means to reliably accomplish their safety functions. The Commission expects, as a minimum, at least the same degree of protection of the public and the environment that is required for current generation LWRs. For the longer term, the Commission expects designs to provide enhanced margins of safety. To provide regulatory guidance during the development phase of advanced reactor design, the Commission wishes to encourage the earliest possible interaction between the NRC and other government agencies, reactor designers, and potential licensees.

This advanced reactor policy statement sets forth the general characteristics of advanced reactor design, which the Commission believes advanced reactors should exhibit, to increase assurance of safety, to improve public understanding, and to promote more effective regulation. As the agency responsible for assuring the protection of the public from the potential hazards of nuclear power plants, the Commission will keep the public informed of its judgment on the safety aspects of advanced reactor designs as such designs come before the Commission.

A report which discusses the revisions to the Policy Statement will be published shortly as NUREG-XXX "TITLE." A copy of NUREG-XXX will be available for inspection at the Commission's Public Document Room, 1717 H Street, N.W., Washington, D.C.

REGULATORY POLICY FOR ADVANCED REACTORS

The Commission intends to improve the licensing environment for advanced nuclear power reactors and to minimize complexity and uncertainty in the regulatory process. This is a statement of the Commission's policy regarding the review of, and desired characteristics associated with, advanced reactors. This policy statement is a revision of the "Proposed Policy for Regulation of Advanced Nuclear Power Plants" that was published for comment on March 26, 1985 (50 FR 11884).

The Commission's primary objectives in issuing an advanced reactor policy staetment are threefold:

- First, to encourage the earliest possible interaction of applicant, vendors, and government agencies, with the NRC;

- Second, to provide all interested parties, including the public, with the Commission's views concerning the desired characteristics of advanced reactor designs; and

- Third, to express the Commission's intent to issue timely comment on the implications of such designs for safety and the regulatory process.

Such interaction and guidance early in the design process should enhance stability and predictability in the licensing and regulation of advanced reactors.

The Commission considers the term "Advanced" to apply to reactors that are significantly different from current generation light water reactors (LWRs) now under construction, or in operation and to include reactors that provide enhanced margins of safety or utilize simplified inherent or other innovative means to accomplish their safety functions.

Currently, certain high temperature gas-cooled reactors (HTGRs), liquid metal reactors (LMRs), and light-water reactors (LWRs) of innovative design are considered advanced designs.

LEGISLATIVE BACKGROUND

The Commission's policy with respect to regulation of advanced reactors is guided by the legislative background. The Energy Reorganization Act of 1974, which established the Nuclear Regulatory Commission, specifically delegated to NRC "licensing and related regulatory authority" for demonstration nuclear reactors other than those already in existence "...when operated as part of the power generation facilities of an electric utility system, or when operating in any other manner for the purpose of demonstrating the suitability for commercial application of such a reactor..." The Energy Research and Development Administration (now the Department of Energy) was charged with "...encouraging and conducting research and development, including demonstration of commercial feasibility and practical applications of the extraction, conversion, storage, transmission, and utilization phases related to the development and use of energy from...nuclear...sources."

Under Section 205 of the Energy Reorganization Act, the NRC must provide a "Long-term plan for projects for the development of new or improved safety systems for nuclear power plants." The NRC is precluded from designing, or doing research on, complete new designs for the purpose of establishing or developing their commercial potential. 1/

PREVIOUS EXPERIENCE

The Commission has had experience in the regulation of HTGRs and LMRs as well as in the regulation of LWRs. The NRC has reviewed several applications for HTGR construction permits, and a conceptual design for a gas-cooled breeder reactor, and has granted an operating license to Peach Bottom-1 and to Fort St. Vrain. The NRC also expended substantial effort from 1975 to 1979 in reviewing General Atomic's Standard high-temperature, gas-cooled nuclear reactor steam supply system (GASSAR). In addition, the NRC has supported a modest program of safety research on gas-cooled reactors every year since the agency's inception.

The Commission has also had experience in the review and licensing of LMRs. In the past the FERMI-1 and SEFOR reactors were reviewed and licensed. DOE's Fast Flux Test Facility (FFTF) was reviewed and approved but not licensed, and a formal construction permit licensing proceeding was

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1/ The general principal defining the scope of NRC's research can be described as avoiding a conflict of interest-- "[NRC] should never be placed in a position to generate , and then have to defend, basic design data of its own" as expressed in the Conference Report to the Energy Reorganization Act of 1974.

conducted for the Clinch River Breeder Reactor (CRBR). The CRBR was subject to the same regulatory process as any current commerical nuclear power project.

Finally, the Commission notes that the precedent for the broad policy approach to advanced reactor regulation, as proposed here, is firmly established in the 1979 Nonproliferation Alternative Systems Assessment Program (NASAP), wherein the NRC considered the safety and licensability of a variety of advanced reactor concepts within the context of nonproliferation objectives. The concepts considered and reported on by the NRC in the 1979 study ranged from preliminary conceptual designs to variations of existing (LWR) power plants designs.

COMMISSION POLICY

Consistent with its legislative mandate, the Commission's policy with respect to regulating nuclear power reactors is to assure adequate protection of the public health and safety and the environment. Regarding advanced reactors, the Commission expects, as a minimum, at least the same degree of protection of the public and the environment that is required for current generation LWRs. Furthermore, the Commission expects that advanced reactors will provide enhanced margins of safety and/or utilize simplified, inherent, passive, or other innovative means to accomplish their safety functions. The Commission also expects that advanced reactor designs will comply with the Commission's forthcoming safety goal policy statement.

Among the attributes which could assist in establishing the acceptability or licensability of a proposed advanced reactor design, and which therefore should be considered in advanced designed are:

° Highly reliable and less complex shutdown and decay heat removal systems. The use of inherent or passive means to accomplish this objective is encouraged (negative temperature coefficient, natural circulation).

° Longer time constants and sufficient instrumentation to allow for more diagnosis and management prior to reaching safety systems challenge and/or exposure of vital equipment to adverse conditions.

° Simplified safety systems which, were possible, reduce required operator actions, equipment subjected to severe environmental conditions, and components needed for maintaining safe shutdown conditions. Such simplified systems should facilitate operator comprehension, reliable system function, and more straight-forward engineering analysis.

- Designs that minimize the potential for severe accidents and their consequences by providing sufficient inherent safety, reliability, redundancy, diversity and independence in safety systems.

- Designs that provide reliable equipment in the balance of plant, (or safety-system independence from balance of plant) to reduce the number of challenges to safety systems.

- Designs that provide easily maintainable equipment and components.

- Designs that reduce potential radiation exposures to plant personnel.

- Designs that incorporate defense-in-depth philosophy by maintaining multiple barriers against radiation release, and by reducing the potential for an consequences of severe accidents.

- Design features that can be proven by citation of existing technology or which can be satisfactorily established by commitment to a suitable technology development program.

If specific advanced reactor designs with some of all of the above of the foregoing attributes are brought to the NRC for comment and/or evaluation, the Commission can develop preliminary design safety evaluation and licensing criteria for their safety related aspects. Combination of some or all of the above attributes may help obtain early licensing approval with minimum regulatory burden. Designs with some or all of these attributes are also likely to be more readily understood by the general public. Indeed, the number and nature of the regulatory requirements may depend on the extent to which an individual advanced reactor design incorporates general attributes such as listed above. However, until such time as conceptual designs are submitted, the Commission believes that regulatory guidance must be sufficiently general to avoid placing unnecessary constraints on the development of new design concepts.

To provide for more timely and effective regulation of advanced reactors, the Commission encourages the earliest possible interaction of applicants, vendors, other government agencies, and the NRC to provide for early identification of regulatory requirements for advanced reactors, and to provide all interested parties, including the public, with a timely, independent assessment of the safety characteristics of advanced reactor designs. Such licensing interaction and guidance early in the design process, will contribute toward minimizing complexity and adding stability and predictability in the licensing and regulation of advanced reactors.

While the NRC itself does not develop new designs, the Commission intends to develop the capability for timely assessment and response to innovative and advanced designs that might be presented for NRC review. Prior experience has shown that new reactor designs -- even variations of established designs -- may involve technical problems that must be solved in order to assure adequate protection of the public health and safety. The earlier such design problems are identified, the earlier satisfactory resolution can be achieved. Prospective applicants are reminded that, while the NRC will undertake to review and comment on new design concepts, the applicants are responsinle for documentation and research necessary to support any specific license application. (NRC research is conducted to provide the technical bases for rulemaking and regulatory decisions; to support licensing and inspection activities; and to increase NRC's understanding of phenomena for which analytical methods are needed in regulatory activities).

During the initial phase of advanced reactor development, the Commission particularly encourages design innovations which enhance safety and reliability (such as those described above) and which generally depend on technology which is either proven or can be demonstrated by a straight-forward technology development program. In the absence of a significant history of operating experience on an advanced concept reactor, plans for innovative use of proven technology and/or new technology development programs should be presented to the NRC for review as early as possible, so that the NRC can assess how the proposed program might influence regulatory requirements. To achieve these borad objectives, an Advanced Reactors Group has been established in the Office of Nuclear Reactor Regulation. This group will be the focal point for NRC interaction with the Department of Energy, reactor designers and potential applicants, and will coordinate the development of regulatory criteria and guidance for proposed advanced reactors. In addition, the group will maintain knowledge of advanced reactor designs, developments and operating experience in other countries, and will provide guidance on an NRC-funded advanced reactor safety research program to ensure that it supports, and is consistent with, the Commission's advanced reactor policy. The Advanced Reactors Group will also provide guidance regarding the timing and format of submittals for review. The Advisory Committee on Reactor Safeguards (ACRS) will play a significant role in reviewing proposed advanced reactor design concepts and supporting activities.

COMMISSION POSITION REGARDING POLICY STATEMENT QUESTIONS

Six questions pertaining to the proposed policy for advanced reactors were included for comment in the original policy statement. The public responses to these questions are summarized in the "Abstract of Comments" section. After careful consideration of the public comments, the Commission response to the issues raised in each question is as follows:

Question 1. Should NRC's regulatory approach be revised to reduce dependence on prescriptive regulations and, instead, establish less prescriptive design objectives, such as performance standards? If so, in what aspects of nuclear power plant design (For Example, reactor core power density, reactor core heat removal, containment, and siting) might the performance standards approach be applied most effectively? How could implementation of these performance standards be verified?

COMMISSION RESPONSE

Many of the Commission's existing regulations, criteria, and guidelines are of a nonprescriptive nature, and the extent to which the Commission's proposed safety goals, (which are also of a nonprescriptive nature) will be used in the regulation of nuclear reactors is currently being evaluated. In the review and regulation of advanced reactors the Commission intends to make use of existing and future regulations where they are applicable to advanced reactors. Many such regulations are expected to be of a nonprescriptive nature. The areas where existing regulations and guidelines would be used include: quality assurance, equipment qualification, external events, sabotage, fire protection, radiation protection, and operator training and qualification. In developing additional criteria and guidance to address those characteristics which differ from LWRs less prescriptive criteria will be considered. The use of less prescriptive criteria will depend upon the design in question and the ability to verify compliance with the criteria. Advanced reactor designers are encouraged as part of their design submittals to propose specific review criteria or novel regulatory approaches which NRC might apply to their designs.

Question 2. Should the regulations for advanced reactors require more inherent safety margin for their design? If so, should the emphasis be on providing features that permit more time for operator response to off-normal conditions, or should the emphasis be on providing systems that are capablle of functioning under conditions that exceed the design basis?

Commission Response

The Commission encourages the incorporation of enhanced margins of safety in advanced designs and will encourage the use of designs that accomplish their safety functions in as reliable and simplified a fashion as practical. The Commission considers inherent or passive safety systems to have the potential for high reliability and encourages the consideration of such means (in lieu of active systems) in advanced designs.

To encourage such action the Commission, in its review of these advanced designs, will look favorably on designs with greater safety margin and/or highly reliable safety systems. Such desirable features can be design-related or can take the form of reduced administrative requirements.

Question 3. Should licensing regulations for advanced reactors mandate simplified designs which require the fewest operator actions, and the minimum number of components needed for achieving and maintaining safe shutdown conditions, thereby facilitating operator comprehension and reliable system function for off-normal conditions?

Commission Response

The Commission will encourage designs which are simpler and more reliable in accomplishing their safety functions. While current generation nuclear power plants, in operation or under construction represent no undue risk to either the public or the environment, the Commission believes that reactors with improved safety characteristics can and will be developed. Such improved safety characteristics support the Commission's Long-range Goal of minimizing the risk to the public and the environment through the "ALARA" approach.

Question 4. Should the NRC develop general design criteria for advanced reactors by modifying the existing regulations, which were developed for the current generation of light water reactors, or by developing a new set of general design criteria applicable to specific concepts which are brought before the Commission?

Commission Response

In developing licensing criteria for advanced reactors, the Commission intends to build upon existing regulations wherever practical, as discussed in the response to Question No. 1. In following this approach, it is the Commission's intent to establish, for each design reviewed, the licensing criteria that apply to that design. As stated in the response to Question No. 1, these criteria will be a combination of applicable LWR criteria and criteria developed to address the unique characteristics of that design. Reactor designers are encouraged to propose specific criteria and novel regulatory approaches which might apply to their design.

Question 5. Should the NRC favor advanced reactor designs that concentrate the primary safety functions in very few large systems (rather than in multiple subsystems), thereby minimizing the need for complex benefit and cost balancing in the engineering of safe reactors?

Commission Response

While the NRC will not necessarily favor one design approach over another in regard to the number of safety systems, the NRC will encourage the use of simplified systems and systems of high reliability for the accomplishment of safety functions.

Question 6. What degree of proof would be sufficient for the NRC to find that a new design is based on technology which is either proven or can be demonstrated by a satisfactory technology development program? For example, is it necessary or advisable to require a prototypical demonstration of an advanced reactor concept prior to final liensing of a commercial facility?

Commission Response

The Commission requires proof of performance of certain safety-related components, systems or structures prior to issuing a license on a design. For LWR's this proof has traditionally been in the form of analysis, testing, and research development sufficient to demonstrate the performance of the item in question. Similar proof of performance for certain components, systems or structures for advanced reactors will also be required. The requisite proof will be design dependent. Therefore, the Commission's specific assessment of a safety technology development program for an advanced reactor design, or of the possible need for a prototypical demonstration of that design can be determined only by review of a specific design. However, the Commission favors the use of prototypical demonstration facilities as an acceptable way of resolving many safety related issues.

The dissenting views of Commissioner Asselstine and the additional views of Commissioner Bernthal are attached.

FOR THE NUCLEAR REGULATORY COMMISSION

Samuel J. Chilk
Secretary of the Commission

Dated at Washington, D.C.
This 1st day of July, 1986

Additional Views of Commissioner Bernthal on Advanced Reactor Policy Statement

Less than three years ago, the Commission began to consider seriously its responsibility (and the mandate of Congress) to become more deeply involved with early review and comment on new and advanced reactor design concepts. Such early design review has long been a commonplace within the Federal Aviation Administration, for example, where timely FAA review and comment on new airframe design proposals is longstanding tradition.

The Commission has since undergone considerable progressive evolution in its thinking on this subject, and in this document the Commission, for the first time, has gone on record as supporting such timely, anticipatory safety review of new design concepts. In addition, the Commission has plainly stated its expectation that next-generation reactors will exhibit enhanced and simplified safety characteristics, and has set down broad and diverse guidelines for how it believes such characteristics might be achieved.

There is little doubt that this policy statement as it stands fails to conform in some respect with each Commissioner's ideal of what such a statement should be. But I find the statement to be a major step forward; it commits the Commission to exactly the kind of "proactive" planning that Commissioner Asselstine still seems to find absent.

Many of the specific objections raised by my colleague are puzzling. His sweeping statement that "containment capabilities are minimized to reduce costs" and "core power densities have been driven to the limits of materials capabilities and our understanding of decay heat removal phenomena" are scientifically insupportable and inconsistent with the facts as generally understood. The fact is that containment capabilities were in general designed to cope with well-known accident scenarios, and core power limits were conservatively derived.

Nor <u>should</u> the Commission insist on "specific requirements" for advanced reactor designs -- indeed, such insistence would go far beyond our mandate (and our capability). Such specificity was never the intent of this policy statement. Detailed specification of systems such as containment, for example, was never contemplated as an objective of the "advanced reactor" policy; indeed, one can imagine advanced reactor designs that might demand <u>less</u> containment capability than current generation LWR plants.

In sum, it was never intended that this statement promulgate "a set of safety requirements". As the statement notes, broad safety requirements are to be addressed in the Commission's forthcoming Safety Goal Policy Statement (to the extent they are not already addressed in the Severe Accident Policy Statement and elsewhere). Furthermore, The Commission's response to Question 6 makes clear its encouragement of plant designs firmly grounded in prototypical plants -- just as Commissioner Asselstine desires.

Nor does this policy "accept the next generation of U.S. power plants if [they] provide a level of safety equivalent to that achieved in the U.S. designs that were completed 10 years ago." There is necessarily room for interpretation in the Commission's pronouncement, but whether or not the Commission might ever issue (or be asked to issue) new construction permits replicating "current generation plants, plants whose designs were largely frozen more than 10 years ago" is not the question. It is amply clear from this policy statement that "the Commission expects that advanced [emphasis added] reactors will provide enhanced margins of safety...", and the Commission has broadly defined "advanced" to include reactors that lie beyond current generation designs.

Finally, Commissioner Asselstine's comment that the "next generation of plants should be more reliable, more forgiving, simpler, easier to construct, easier to operate, and easier to maintain than the current generation" is a nice synopsis of the broad guidelines clearly set forth in this policy statement. I am pleased that he concurs in the desirability of those traits.

Dissenting Views of Commissioner Asselstine

I do not believe that this advanced reactor policy statement provides the sound regulatory basis needed to support a new generation of nuclear power plants in this country. This policy statement encourages, but does not require, safety improvements in advanced reactor design, and expresses a willingness on NRC's part to conduct safety reviews of advanced reactor design concepts so that NRC will be in a position to act on any future plant or design license application. The primary decision made in developing this policy is the commitment to maintain a small advanced reactor group within the Agency that would serve as the focal point for interaction with reactor design groups. However it appears that even this commitment may be in jeopardy given current budgetary constraints.

I believe that more is needed to articulate an effective regulatory policy and to ensure a successful program for future nuclear power plants in this country, whether those plants are of a type similar to current light water reactors or whether they are of more fundamentally different design. Such a policy should reconsider the Commission's regulatory practices of the past thirty years. Those past practices can be characterized as primarily a reactive regulatory regime to what the designers propose. It leaves resolution of issues to what one industry executive has called the rough, tough, surly competitive elements. Safety systems are limited because of cost considerations. Containment capabilities are minimized to reduce costs. 1/ Core power densities have been driven to the limits of materials capabilities and our understanding of decay heat removal phenomena. 2/ And the balance of plant is designed to lower standards than the reactor systems to minimize costs. These competitive forces are what led to the level of safety achieved in the current generation of nuclear power plants and are in part responsible for the poor performance of some of our plants.

The NRC and AEC before it have often avoided developing stringent specifications or design requirements because of a fear that if the Commission were to be too specific in its requirements, the emerging industry might be slowed in its growth and innovation might be discouraged. That argument might have had some validity in the 1960's and 1970's when the current generation of reactors was being designed without the benefit of signifi-

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1/ For example, to keep the containment size down, crucial pumps, heat exchangers, and emergency water supplies have been located outside the containment, which results in flow paths for highly contaminated water that effectively bypass the containment. In addition, containment volumes and design pressures have been traded-off for pressure suppression schemes that substantially complicate safety analyses and that add additional vulnerabilities to the public health and safety. Initially containments were intended to be an independent barrier to substantial releases given a core meltdown. Some of that defense-in-depth was given up for the sake of costs, when large power reactors came on the scene in the mid-1960's and it became known that the decay heat and the core meltdown phenomena could fail the containment.

2/ For example, in the event of a loss of coolant accident, external water supplies must be rapidly injected into the core to keep it from melting. While some relatively small-scale integral experiments on loss of coolant phenomena have been completed, there are still multinational supported research programs underway to further examine thermal hydraulic phenomena during accidents. Further, we are just beginning expensive, integral effects tests on thermal hydraulic phenomena associated with a class of pressurized water reactors.

cant operating experience or data. However, now that we have considerable worldwide experience with a large variety of nuclear reactor designs, I believe it is time for NRC to become more proactive in what it will require of future generations of reactors.

Following the TMI-2 accident, the notion of a demarcation between the current generation of plants and a future generation of plants was raised, with the distinction that the latter would be designed based on a reformulation of the Siting Criteria and General Design Criteria to reflect all that had been learned over the years, including the broader lessons of TMI-2. Thus, the TMI Action Plan was developed with the current generation of plants in mind, leaving open the question of possible broader changes for a future generation of plants. One such broad change could be to go beyond the so-called single failure criterion which experience shows may not be serving us well. The June 9, 1985 accident at Davis-Besse is a case in point where 14 separate failures occurred.

Many foreign countries are requiring four independent trains of safety systems whereas NRC requires only two. When NRC reviews advanced designs such as the one being jointly developed by a U.S. vendor and a foreign country, the NRC staff does not require as prudent additional safety features being required by the foreign country. Rather, Commission practices and procedures require a cost-benefit analysis to justify any additional safety feature. This analysis is typically incomplete and often crude. Furthermore, the Commission gives little consideration to the enormous uncertainties in reactor risks in its decisionmaking process. This approach to reactor safety needs improvement.

There has been insufficient thought and effort in developing a map for the future. The Advanced Reactor Policy Statement provides no guidance on what containment capabilities will be required; on whether the single failure criterion is adequate for the future; on acceptable core power densities (an issue which has significant bearing on the core meltdown risks to the public); and on the root causes of the core meltdown risks that might be addressed by design improvements in a future generation of reactors. Nor is there guidance on what standards the balance of plant must meet. Nothing is said about the fuel cycle and the process for licensing the fuel cycle associated with some of the advanced designs currently being examined. For example, one problem area presented by some designs is the proliferation potential of the reactor's fuel cycle. This fuel cycle could present the need for the Commission to reopen the aborted proceeding on plutonium recycle. And, finally the Commission gives essentially no guidance on whether a prototypical plant will be required before allowing widespread use of that design. This policy statement encourages much, just like the Commission encourages excellence in operations. However, the Commission too often accepts far less. I would have expected that NRC would approach a future generation of nuclear power plants with an attitude of correcting past weaknesses. Unfortunately, the Advanced Reactor Policy Statement does not reflect that kind of attitude.

Other countries with extensive nuclear power programs appear to be designing, constructing, operating and maintaining better nuclear power plants than those of this country. Foreign countries are demanding more safety and reliability in their current generation of plants than the NRC is requiring of the U.S. plants. Yet, this Advanced Reactor Policy Statement accepts the next generation of U.S. power plants if such a design provides a level of safety equivalent to that achieved in the U.S. designs that were completed over 10 years ago. I do not think such a policy serves the country well. My concern is not merely that we should keep up with others. Rather, my concern is that the current generation of plants is still surprising us in their performance. As the Commission has recently acknowledged to the Congress, the current generation of nuclear power plants in this country can best be characterized as a complex technology that is not fully mature. There remain great uncertainties in the level of risk they pose to the public. In such circumstances, I believe prudent decisionmaking should come down on the side of improved safety, not only for the current generation of plants but for the next generation as well.

If there is to be a future generation of nuclear power plants and if the nuclear option is to be an important element of the nation's future energy mix, then the NRC, the vendors, the utilities, and the Congress must ensure that the next generation of power plants is substantially better than the current generation. The next generation of plants should be more reliable, more forgiving, simpler, easier to construct, easier to operate, and easier to maintain than the current generation. Any design that does not accomplish this is not acceptable in my view. I say this for a straightforward reason. We cannot afford to will to the future reactor designs that have a fifty percent chance of a core meltdown every ten to twenty years in a population of 100 reactors. We should not will to the future the great uncertainties in safety levels that exist today. Nor should we will to the future consumer reactor designs that have a 50 to 60 percent capacity factor.

We must step back and examine the strengths and weaknesses of past and current designs and the approaches taken in getting where we are today. Only then, in my view, can we intelligently map a course for the future. I am encouraged that there is a segment within the industry that is undertaking a fresh look at the nuclear technology. The forward-looking members of the industry are attempting to generate a set of requirements that, from the standpoint of the utilities, must be met before utilities will consider placing new orders. I find it disappointing that the NRC is unwilling to generate a set of safety requirements for the next generation of power plants.

NRC FORM 335 (2-84) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

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On March 26, 1985, the U.S. Nuclear Regulatory Commission issued for public comment a "Proposed Policy for Regulation of Advanced Nuclear Power Plants" (50 FR 11884). This report presents and discusses the Commission's final version of that policy as titled and published on July 8, 1986 "Regulation of Advanced Nuclear Power Plants, Statement of Policy" (51 FR 24643). It provides an overview of comments received from the public, of the significant changes from the proposed Policy Statement to the final Policy Statement, and of the Commission's response to six questions contained in the proposed Policy Statement The report also discusses the definition for advanced reactors, the establishment of an Advanced Reactors Group, the staff review approach and information needs, and the utilization of the Policy Statement in relation to other NRC programs, including the policies for safety goals, severe accidents and standardization. In addition, guidance for advanced reactors with respect to operating experience, technology development, foreign information and data, and prototype testing is provided. Finally, a discussion on the use of less prescriptive and nonprescriptive design criteria for advanced reactors, which the Policy Statement encourages, is presented.

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DEVELOPMENT AND UTILIZATION OF THE NRC POLICY STATEMENT ON THE REGULATION OF ADVANCED NUCLEAR POWER PLANTS

JUNE 1988