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For: The Commissioners

From: James M. Taylor
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Subject: PROTOTYPE DECISIONS FOR ADVANCED REACTOR DESIGNS

Purpose: To inform the Commission of the staff's procedure for determining the need for a prototype or other demonstration facility for the advanced reactor designs. This paper responds to the staff requirements memorandum of October 2, 1990, in which the Commission asked the staff to continue to evaluate the need for a prototype (9000224).

Background: In the "Statement of Policy on the Regulation of Advanced Nuclear Power Plants" (51 FR 24643) July 8, 1986, the Commission responded to 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?...," as follows:

> 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.

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NOTE: TO BE MADE PUBLICLY AVAILABLE IN 10 WORKING DAYS FROM THE DATE OF THIS PAPER.

In the "Statement of Policy on Nuclear Power Plant Standardization" (52 FR 34884) September 15, 1987, the Commission stated the following:

> The reference system designs, at least initially, are expected to be evolutions of existing proven LWR designs.... For those systems, structures and component designs which represent significant deviations from previously-approved LWR designs, prototype testing and/or empirical information may also be required. Advanced design concepts should be developed according to the guidelines of the Advanced Reactor Policy Statement. When an advanced design concept is sufficiently mature, e.g., through comprehensive, prototypical testing, an application for design certification could be made.

This statement was the basis upon which the staff wrote Part 52 of Title 10 of the Code of Federal Regulations (10 CFR 52), "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Reactors" (54 FR 15372). Part 52 provides the opportunity for certification of both evolutionary and advanced reactor designs. In SECY 88-202, "Standardization of Advanced Reactor Designs," July 15, 1988, the staff proposed criteria that were "...intended to ensure that prior to granting a Design Certification to any design significantly different from one that has been built and operated before, high confidence in the performance of the safety features of that design is demonstrated." These proposed criteria were subsequently incorporated into 10 CFR 52 as part of the certification-by-test approach that is set forth in Section 52.47(b)(2) and are listed in Enclosure 1. This approach will allow reactor designers to perform the necessary tests to demonstrate to the Commission that the proposed design is sufficiently mature to be certified.

<u>Discussion</u>: The procedure for demonstrating that a nuclear power plant design which has not been approved as part of the licensing of a specific nuclear power plant, is ready to be certified is an integral part of the design and licensing process for a new nuclear power plant utilizing that new design. The testing and evaluation of the design continues through the conceptual, preliminary, and final design stages for the new plant. While the staff does not believe that the evolutionary LWRs need a prototype test, they may need separate tests to demonstrate new design features. The staff is currently evaluating the need for control room testing for the ABWR. The advanced reactor designs may need testing ranging from basic research and development (R&D) up to a full-size prototype plant in order to demonstrate that these designs are sufficiently mature to be certified. The advanced

designs differ significantly from the evolutionary LWRs or use simplified, inherent, passive, or other innovative means to accomplish their safety functions.

The staff's process of determining the need for demonstration testing parallels the development of the design. This process begins at the conceptual design stage in which the NRC staff determines research needs. This process concludes near the end of the final design stage in which the staff determines if verification or demonstration of the design is needed. While the research and testing needed to demonstrate the acceptability of a design is principally the designer's responsibility, the NRC will conduct certain research and testing to confirm regulatory conclusions and improve our understanding of particular phenomena or issues.

The NRC staff will review the plant design and the designer's research and development program (including demonstration testing) to confirm the adequacy of the design and to ensure that safety claims can be met. If the staff determines the plant's performance characteristics or safety claims cannot be assured, then the design may require separate effects, integral, or prototype tests to demonstrate these design predictions. Enclosure 2 provides a trial procedure by which either the designer or the NRC staff can determine the need for various types of testing.

Conclusion: The staff will follow the procedure described in Enclosure 2 to determine the various types of testing, up to and including a prototype facility, that may be needed to demonstrate that the advanced reactor designs are sufficiently mature to be certified. The staff will inform the designers of our procedure for determining testing needs within 30 days of the date of this paper. During the review process, the staff will work with the designers to refine this procedure and determine the need for prototype or other demonstration facilities.

Coordination: The Office of the General Counsel has reviewed this paper and has no legal objection to its contents.

James M. Taylor
Executive Director
for Operations

Enclosures:
1. Demonstration Testing Criteria
2. Process for Determining Testing Needs

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DEMONSTRATION TESTING CRITERIA

The staff will use the following criteria from 10 CFR 52.47(b)(2) to determine if the designer has sufficiently justified the advanced reactor design, such that a design certification can be awarded:

(i)A1 - The performance of each safety feature of the design has been demonstrated through either analysis, appropriate test programs, experience, or a combination thereof;

(i)A2 - Interdependent effects among the safety features of the design have been found acceptable by analysis, appropriate test programs, experience, or a combination thereof;

(i)A3 - Sufficient data exist on the safety features of the design to assess the analytical tools used for safety analyses over a sufficient range of normal operating conditions, transient conditions, and specified accident sequences, including equilibrium core conditions; and

(i)A4 - The scope of the design is complete except for site-specific elements such as the service water intake structure and the ultimate heat sink; or

(i)B - There has been acceptable testing of an appropriately sited, full-size, prototype of the design over a sufficient range of normal operating conditions, transient conditions, and specified accident sequences, including equilibrium core conditions. If the criterion in...[A4]...is not met, the testing of the prototype must demonstrate that the non-certified portion of the plant cannot significantly affect the safe operation of the plant.

(ii) - The application for final design approval of a standard design of the type described in this subsection must propose the specific testing necessary to support certification of the design, whether the testing be prototype testing or the testing required in the alternative... [in A1-A4].

The Appendix O final design approval of such a design must identify the specific testing required for certification of the design.

ENCLOSURE 2

PROCESS FOR DETERMINING TESTING NEEDS

Introduction

The staff proposes the following process for determining the type of demonstration facilities that may be needed for the certification-by-test approach under Part 52 of Title 10 of the Code of Federal Regulations (10 CFR 52). These facilities will enable the applicant to perform tests in order to justify the performance characteristics and safety claims regarding a new reactor design or design feature not previously licensed by the staff. The process enables the applicant to consider the testing objectives, evaluate those objectives in ascending order of testing complexity and value, combine tests where possible, analyze the results against the regulatory requirements, and determine the acceptability or deficiency of the testing or the new reactor design. The process begins whenever the staff challenges the applicant's bases for the safety claims or performance characteristics of a new reactor design.

The types of possible testing include tests of components, systems, simulators, non-nuclear or nuclear test loops, and comprehensive prototypes for determining proof of principle. The applicant may consider the least burdensome type of testing that provides the safety-related insights required to substantiate the applicant's bases. For instance, the applicant may consider component testing first and only consider the most burdensome type of testing (the testing of a full-scale prototype) as a last resort. The actual item being tested may be prototypical of the item under consideration (e.g., component or system), it may be scaled in size, or it may be limited in the features modeled. For each type of test, the objectives of the test will determine the appropriate degree of test similarity to the matter under consideration. Table 1 briefly relates the types of tests to the item under consideration. "Full-scale prototype" is defined as a full-size plant representing the first-of-a-kind (FOAK) facility in all features and size. The prototype need not include the power production systems, similar to the fast flux test facility (FFTF). The prototype could include additional safety features to protect the public, the plant staff, and the plant itself from the possible consequences of failures during the testing period. An alternative to the construction of a prototype could be the testing of a special feature or system combined with a rigorous and robust start-up testing program at the FOAK plant.

When this process is applied to a component, system, or sub-system and testing requirements are identified, it is important that the testing requirements be evaluated at the overall plant design level. Combinations of tests could provide more representative safety insights and reduce the burden of the overall testing program. More importantly, combining tests may increase assurance that a particular departure from existing technology does not result in unidentified interdependent effects among the safety systems.

The following describes the individual steps of the process. The step numbers in front of paragraphs correspond to the numbers in the lower part of the symbols (boxes, diamonds, and circles) in the simplified process diagram shown in Figure 1.

Process Description

The process is applied to each performance or safety claim made for the new design. Different claims may indicate the need for different levels of testing. The process for determining the appropriate testing option begins when the staff finds the applicant's bases to be insufficient for substantiating the performance or safety claims made by the designer or implied in the design. This finding would indicate that attempts to use analytical tools, experimental results, operating experience, and expert judgement have failed to provide adequate justification of the design. The staff may determine the justification to be insufficient because of the size of the uncertainties associated with the design or because of the magnitude of the consequences that could result if a safety feature fails to perform its function. To apply the process, the applicant would begin in box 1 and then identify the type(s) of test(s) for each safety claim (circles 3, 5, 7, or 9, as appropriate) for all of the safety claims before proceeding to box 12.

1. Identify and define testing objectives. To select the appropriate type of test(s) or prototype, the applicant must clearly define the objectives. The applicant should select objectives and subordinate objectives to define the results desired from the testing process. The objectives will determine the type of testing to be conducted. Therefore, the applicant should carefully consider the objectives for completeness and clarity. The applicant should identify testing objectives separately for each performance or safety claim. In Figure 1, the applicant would combine tests in decision box 12 of the process diagram, after identifying all testing requirements that may be necessary.

Next, the applicant would evaluate the test objectives identified for each claim to select the appropriate level of testing that is needed. The applicant would begin the process by considering the simpler testing options before considering the more extensive options.

2. Is testing required for component performance, reliability, feasibility, or availability? In this step, the applicant would identify those testing objectives for determining the acceptability of component performance, the reliability of component functions, the feasibility of using a component in the proposed way, the availability of the component to perform its function, the ability of the component to perform in adverse environments (i.e., environmental qualification), and other attributes of the component.

   In the advanced reactor designs under development, designers are reducing the redundancy and diversity of components to simplify the new designs. Consequently, the new designs (especially the SBWR and AP-600) rely on the reliability of components to maintain or exceed the safety levels associated with current plants. If the operating history of a component in current nuclear plants or in similar installations does not support the use of the component in new reactor designs that demand high reliability, the applicant may choose testing to demonstrate that the component meets these demands.

Therefore, in determining the need to conduct component tests, the applicant should carefully consider the reliability demands of the component imposed by the new reactor design. The applicant should assess the component's reliability by considering the operating history of the component in current plants. The applicant could do this by considering the similarity of equipment and operating environments, evaluating the redundancy and diversity of the design, and evaluating any modifications or changes incorporated into the new design.

If the purpose of the test is component performance, reliability, etc., then a component test should be adequate to satisfy the test objective and thereby substantiate the safety claim. Refer to the following discussion for this type of test.

3. Component test(s) or separate effects test(s) are required. The applicant would conduct a component test to verify the performance of a component, such as a valve, a pump, a breaker, or a relay. The test may be required if a component has been significantly redesigned, will be used in a new or innovative way, or has not operated in the past with the reliability needed in the new plant design. The test should generate data to be used to substantiate the performance of the component during both normal and off-normal operating conditions in the plant.

   In developing the advanced reactor designs being considered by the industry, designers are increasing the reliance on component reliability and performance, as redundancy and diversity are reduced (simplification). Because many of the components in the new designs are used in current plants (e.g., motor-operated valves, check valves, breakers, and relays), reliability data exists for their performance in nuclear plant conditions. In some cases, the performance of individual components may not be sufficient for the reliability requirements imposed by the new designs. Designers have achieved reliability in current plants by means of redundancy and diversity. In such cases, the designer may need to test these components to demonstrate that the reliability in the new reactor environment is sufficiently improved from their reliability in the existing plants to allow the component to be used in the new design.

   With the component testing program, the applicant should demonstrate that the performance of the component fulfills the safety claims directly related to the component's performance. This program could include environmental qualification, seismic qualification, and quality class. Applicants should conduct such tests where high operating cycles can be achieved in short periods of time. To address the issue of age-related degradation in developing the testing plan, the applicant must carefully consider the advantages and disadvantages of conducting accelerated aging tests in relation to testing naturally aged components. The applicant should include in this decision process the results of the NRC's Nuclear Plant Aging Research Program.

4. Is testing required for man-machine interface, instrumentation information transfer, plant automation, or operator actions? In this step, the applicant would identify those testing objectives that focus on the human performance element in the design that might be the basis for safety claims about the new reactor design. If, for example, the design depends heavily on operator actions (or inactions) that reactor operating experience has shown to be unreliable, then the applicant may need to perform tests to determine the level of human performance that is needed. In this step, the applicant would also identify the testing required to substantiate safety claims concerning plant automation features that have not been confirmed in existing reactor experience or by testing.

   The new reactor designs use much more automation for processing information, displaying the status of systems, and controlling plant operation. In some cases, applicants have proposed major changes in the control room design, that involve computer display and manipulation of data for the operators. In such cases, the ability of operators to control the new automated plants cannot be demonstrated from current plant operating history. Therefore, applicants may need to test the manner in which operators interact with automated plant systems for monitoring and control (including related computer systems and software).

   The applicant should base the decision to conduct simulator tests, construct mock-ups or otherwise test the interaction of humans with the automated plant on the considerations of design differences between the new and current plants, the current philosophy of procedures and practices, and the consequences of operator inaction and erroneous intervention.

   If the objective to be tested meets these qualifications, then the applicant may need a simulator or mock-up in order to satisfy the testing objective. Refer to the following discussion for this type of test.

5. Simulator or mock-up test(s) are required. A simulator or mock-up test is (1) a computer model of the plant or a part of the plant that is used to test operator performance or (2) a model of a portion of the plant that is used to test the reliability of the operators to perform in that area. The applicant could perform these tests using a full operations simulator, mock-ups and simulations of control panels, or mock-ups of plant areas to test accessibility, maintenance reliability, or other factors.

   In developing the new reactor designs, applicants have proposed different control and instrumentation features. These features are not familiar to operators in current light water reactors, and very little performance and reliability data may be available for evaluating the ability of the systems to meet performance specifications and reliability goals.

   Applicants should design tests in these areas so as to evaluate both the human and the equipment elements associated with the proposed designs. For such a test, the applicant may need to develop procedures for operators to follow. These procedures might become part of the certified design, depending on the amount of operator action and interaction required. In these types of tests involving human interactions, it is very difficult to completely model all of the factors that affect plant operators in normal and other-than-normal situations. The applicant should evaluate the uncertainties associated with operator performance in these simulated tests to determine the acceptability of the design.

6. Is testing required to determine the performance, reliability, availability, or feasibility of systems? In this step, the applicant would identify those testing objectives for determining the acceptability of system performance, the reliability of system performance, the feasibility of using a system in the proposed way, the degree of availability of the system to perform its function, or other attributes of the system.

   In the simplified reactor designs, passive systems would perform many safety functions that active systems perform in current plants. These passive systems rely on the natural circulation of coolant, gravity-driven flows, and the injection of coolant by pressurized gas. These systems would depart from the design philosophy of current plants by replacing diverse, redundant, active systems with passive designs that need high reliability rather than redundancy and diversity.

   In determining to test such systems, the applicant must, therefore, consider the very high demands for reliability placed on these systems and their contribution to overall safety and reliability of the plant. The applicant should provide significant assurance that the passive systems can be initiated from any plant operating condition, including off-normal conditions, and that these passive systems can function as claimed in the new design. The designer should assess the uncertainty associated with the ability to operate the system as designed (system feasibility), system reliability, and system availability.

   If the purpose of the test is as discussed, then a system test should be adequate to satisfy the test objective and substantiate the safety claim. Refer to the following discussion for this type of test.

7. Systems test(s) or non-nuclear integral loop test(s) are required. The applicant would use a system test to verify the performance of a system that includes new, untested features, eliminates levels of diversity and redundancy used in current plants, or claims to have high reliability not substantiated by operating history in existing plants. The test should generate data to be used to substantiate the performance of the system during plant normal and off-normal operating conditions. Depending on the objectives, the test may be a partial scale or a full-size system loop.

   The advanced light water reactor (ALWR) designs use systems that operate differently from the technology associated with current LWRs. In many of the systems, after initial actuation of the system (which is mostly an active function), the systems function passively by natural circulation, gravity flow, or pressurized gas. The need for the high reliability of these systems may require testing to demonstrate the reliability or to reduce the uncertainties of performance to acceptable levels.

The applicant should develop these tests to evaluate the performance, the feasibility, and the reliability of the systems. These tests should demonstrate the availability and reliability of the system to function in all operating modes, including off-normal conditions as designed.

8. Is testing required for determining nuclear performance, physics coefficients, reactivity control, or stability? In this step, the applicant would identify those testing objectives that could validate or substantiate the acceptability of reactor physics performance and could demonstrate the performance of the core in normal and off-normal operating conditions. Such tests could validate the reactor coefficients and their stability over the range of known operating conditions, including off-normal and severe accident conditions, from the conditions at the initial core load up to and including the equilibrium core.

   The new reactor core designs differ in varying degrees from the current LWR core designs. The applicant should carefully consider the basic characteristics of the core design, including its stability and control margins for reactivity, and the stability of any neutronic and thermal-hydraulic interactions, as they may affect the stability and control margins of the reactor. The core performance should be predictable and should exhibit favorable (negative) reactivity coefficients (void, temperature, moderator, doppler, pressure, and power) in normal and other-than-normal operating conditions.

   Many analytical models are available to evaluate the behavior of existing core designs. However, the applicant should carefully consider the application of a particular model to a specific new core design in terms of applicability of the model, the completeness of the analytical results (have all normal and off-normal operating conditions been considered), and the uncertainties associated with the model. The applicant should consider this type of test if analytic models reveal that the design would diverge from the safety envelop generally associated with current reactor operating philosophy or if the analytical models yield unacceptable uncertainty levels.

   If the purpose of the test is as discussed, then the applicant may need to perform a critical facility test in order to satisfy the test objective and thereby substantiate the safety claims associated with the physics and performance characteristics of the reactor core. Refer to the following discussion for this type of test.

9. Critical testing facility is required. The applicant would construct a critical testing facility to verify the reactor physics and performance characteristics of the reactor core. Using this facility, the applicant would perform tests to verify all reactor coefficients and their stability during all normal and off-normal conditions. Such a test should model the thermal-hydraulics of the core so as to reveal changes that may occur in the reactivity coefficients. These types of tests can range from individual assemblies in test reactors to independent loops designed to model sections of the reactor core.

These tests should be designed to reduce any uncertainties associated with the design and performance of the core. The testing program should model and test all conceivable operating conditions and environments to establish the safety of the core design. This testing program may actually require a series of tests beginning with fuel tests in a test reactor followed by tests of bundles or a partial core in a test facility. Finally, the applicant may test a section of the core for overall performance, reactivity coefficients, and shutdown mechanisms.

10. Is testing required for systems interactions, interdependencies, overall feasibility, integrated system performance, or reliability? In this step, the applicant would identify those testing objectives for validating or substantiating that interacting and interdependent systems in the plant perform acceptably and for demonstrating the performance of these systems in normal and off-normal operating conditions. The objectives could be directed at assuring that failures of ancillary systems do not cause failures in safety systems, which could result in unacceptable behavior or consequences during operation, including off-normal and severe accident conditions.

In the design of any complex process, particularly in a power generating facility fueled by a nuclear core, the systems are highly interdependent both in their ability to function successfully and to propagate failures. Many systems must operate according to design to ensure the plant produces power safely. The failure of a system may affect the ability of a related system to function properly, which could significantly increase the consequences of the failure.

Therefore, the applicant should base the decision to consider multiple system tests on the degree of interdependency of systems in the proposed design, the redundancy and diversity of the systems that may reduce the consequences of individual system failures, the possibility of synergistic effects from the interactions of various phenomena or systems, and the susceptibility of the design to failures that propagate through one or more systems. As with other testing options, multiple systems test decisions must consider the reliability of the multiple systems compared to the demands placed on the systems by the safety analysis. In addition, the applicant must consider the level of uncertainty associated with the performance and interdependencies of the systems, and the consequences to the plant and the public if one system fails and limits the ability or inhibits the function of other systems to protect the plant and the public.

If the purpose of the test is as discussed, then the applicant should determine whether the testing objectives can be combined with other tests or met with a test of a scale model or a partial plant. Refer to the discussion in boxes 12 and 13 for this decision.

11. Is testing required for other objectives? In this step, the applicant would identify those testing objectives that have not already been covered in decision boxes 2, 4, 6, 8, and 10. Once the applicant has identified the purpose of the test, the applicant should determine whether the testing objectives can be combined with those of other tests or met with a test of a scale model or partial plant. Refer to the following discussion for this decision.

In this section of the process, the applicant should combine, where appropriate, one or more of the testing options identified in the evaluation of the entire plant design.

12. Is combined testing possible? In this step, the applicant should consider possible combinations of tests. In evaluating each performance or safety claim against the criteria in the previous decision boxes, the applicant had identified testing requirements. Once all of these tests are identified, the applicant should consider the combinations of tests that can improve the overall confidence of testing results and can achieve economic savings in the testing program. Where tests involve phenomena related to each other, common sense suggests that the combined testing would give higher confidence to the results and may identify synergistic effects. In this step, the applicant would compare the objectives and features of the tests indicated to identify opportunities to combine tests.

    Where combinations are possible, the applicant would move to boxes 15 or 16 to develop the integrated test plans. If combinations are not feasible, then the applicant would move to box 14 to consider separate test(s).

13. Can test(s) objective(s) be demonstrated with scale test(s)? The applicant would use this decision point to determine whether the test objectives can be satisfied by tests of scale models or partial plants. The appliant may perform such tests to demonstrate new phenomenon in the design that have not been justified in currently licensed plants. The applicant may conduct the test to determine seismic responses to input spectrum or other attributes of the design. Testing may range in size and scope from small phenomena tests to larger component or systems interactions tests.

14. Conduct separate test(s). If a certain test(s) cannot be combined with other tests and scale testing is not possible, then the designer would conduct the separate tests. The NRC staff may review the testing plan and observe the conduct of the tests.

15. Conduct partial scale test(s). The applicant may test scale models to substantiate safety claims associated with limited interactions of systems, structures, and components. This type of test depends significantly on the validity of the scaling factors. Therefore, the appliant should consider the need to carefully and thoroughly analyze these relationships to the full-size design.

When combined testing is possible, the applicant can perform tests of partial-scale systems or loops, where the scaling factors can be justified. With these tests, the applicant can establish performance parameters and basic design proof-of-principle. The applicant must take care in using the results of scale model tests because some phenomena can only be evaluated in full-scale tests.

16. Conduct full-scale integrated test(s) or prototype test. The designer can now develop the integrated test(s) that satisfies the objectives of each of the contributing test(s). The designer can perform these test(s) to justify claims where the testing objectives cannot be satisfied by scale model tests (from box 13 in Figure 1). The designer or the NRC staff may decide that a test of a full-scale prototype is required.

    A full-scale prototype is defined as a full-size nuclear plant, which represents the FOAK plant, and is prototypical of the new design in all features, size, and performance. Such a prototype would include the reactor core, the nuclear steam supply system (NSSS), the balance-of-plant systems, and the ancillary systems as they would be built in the "production" model plants. The prototype may not include the power production systems, similar to the fast flux test facility (FFTF). The prototype could include additional safety features to protect the public, the plant staff, and the plant itself from the consequences of unanticipated failures during the testing period. The function of each system in the prototype must accurately represent the function specified in the final design in order to justify the design for certification under 10 CFR Part 52.

    In addition to physically constructing the prototype, the applicant must design the testing program to test the full range of design features and safety claims associated with the plant. Some features may not be testable in the prototype without damaging and possibly destroying the plant, resulting in consequences that are unacceptable. For these features and design functions, the prototype test must be performed at partial power levels or be supplemented with other types of tests (e.g., special features tests or component tests) to validate the behavior of the design without the extreme consequences that could result if the feature were tested in the full-size plant. The applicant would need a comprehensive testing program and a program for ensuring safety while the uncertainties of the plant are being tested.

    The prototype for an advanced reactor design may need some additional safety features to compensate for the uncertainties in the design that the prototype is intended to test. However, the applicant would have to insure that the additional safety features would not affect the test program. For example, if a design is proposed without a containment, the ability of such a plant to protect the public would be very uncertain if the safety systems failed and a release occurred. Therefore, the prototype might be built at an isolated site that would minimize the threat of exposure to the public from atmospheric dispersion of accidental releases, or the prototype could be built inside a containment designed to capture any release from the plant under all postulated conditions. New designs with less diversity and redundancy in safety systems or with boundaries that rely on highly reliable equipment, may require extra trains or components that can be used if the reliability of the system or component is not as high as expected. The backup system or component, which is only intended for the prototype, could be used to perform the function if the primary equipment were to fail. In such tests, if the backup equipment were used, it would indicate a failure of the plant design, the assumptions, or the reliability of the equipment. Therefore, the safety claim and the design would not be sufficient for the NRC staff to certify the new design under 10 CFR Part 52.

The applicant would conduct the tests identified herein and prepare a report of the results to support its request for certification. The NRC staff could review the testing plan and observe the conduct of the tests.

17. Did the testing successfully justify the safety claims? The designer and ultimately the NRC must determine the acceptability of the test results of both integrated and separate tests. The data must be reviewed to determine whether they support the performance and safety claims.

18. The safety claims are justified. If the data successfully substantiates the performance and safety claims, then this certification-by-test approach has demonstrated that the advanced reactor design can be certified under 10 CFR 52. The process for determining necessary testing is now complete.

    If the testing results fail to substantiate the performance and safety claims or fail to reduce the uncertainty levels sufficiently, then either the testing program has failed or the design cannot perform acceptably. The applicant would move to box 19.

19. Redefine testing objective(s) or redesign plant. In this step, the applicant would revise the testing objectives if the results have failed to substantiate the performance and safety claims. If, during this evaluation, the applicant identifies weaknesses in the testing methods or the objectives, the applicant would return to box 1 to redefine the objectives and redesign or modify the testing program to achieve positive results. If the proposed design cannot meet the performance and safety claims, then the applicant would revise the final design and perform the necessary testing to support certification of the revised final design.

TABLE 1

Type of Test	Feature to be Tested
special feature(s) test (e.g., control room simulator)	man-machine effects, human error rates
separate effects test (e.g., counter-current flow heat transfer)	heat transfer coefficients
non-nuclear integral loop test (e.g., Semi-scale, FIST, ROSA-4)	thermal-hydraulics, efficacy of ECCS
critical facility	basic physics characteristics, dynamic reactivity characteristics
partial scale reactor test	engineering feasibility of reactor systems, systems interactions
full-scale reactor test	engineering feasibility of entire reactor plant, extensive systems interactions, synergistic effects

Figure 1
Process Diagram