

6.0 MORE PRESCRIPTIVE ARCHITECTURAL AND ENGINEERING CRITERIA

Section 13(b)(1) of the Ford Amendment directs the NRC to analyze the following alternative approach to improving quality assurance and quality control in the construction of commercial nuclear power plants:

Alternative (b)(1)

Providing a basis for quality assurance and quality control, inspection, and enforcement actions through the adoption of an approach which is more prescriptive than that currently in practice for defining principal architectural and engineering criteria for the construction of commercial nuclear power plants.

The discussion of the amendment contained in the Congressional Record indicates that some of the amendment's sponsors had in mind an approach similar to NRC's technical specifications for operating plants. The NRC provides guidance for developing technical specifications as part of the process leading up to issuing an operating license; the applicant/licensee develops them for the specific plant; and the NRC reviews and, subject to further review and revision, approves them. Any licensee desiring to continue operating under a condition that does not comply with its technical specifications must receive prior NRC approval. For the construction process, the NRC does not have similar requirements for controlling licensee performance. In particular, design and construction commitments made in the Preliminary Safety Analysis Report (PSAR) are not equivalent to technical specifications in terms of requiring licensee compliance with them.

Under the current regulatory process, the applicant for a construction permit (CP) generally submits required information in the application and makes whatever commitments are necessary to have the CP application accepted and issued. The design description contained in the application (which includes a PSAR) includes the principal architectural and engineering (A&E) criteria. Although not defined in the regulations, these A&E criteria may be thought of as the performance specifications for the safety systems and major components, and for commitments to consensus codes and standards, NRC branch technical positions, and NRC regulatory guides. The applicant then commits to implementing the design and to constructing the plant as described in the application. Under current regulatory procedures, the CP holder can unilaterally modify those portions of the PSAR that are not explicitly stated to be conditions of the CP without notifying the NRC. All changes to the PSAR must be included in the Final Safety Analysis Report (FSAR), which must be submitted as part of the process of applying for an operating license, but the FSAR is submitted after much of the plant construction has already been completed. Under current practice, detailed information and prescriptive commitments, in general, and A&E criteria, in particular, usually are not conditions of the CP.

6.1 SUMMARY, CONCLUSIONS, AND FINDINGS

The NRC's case study analyses of quality assurance and quality control programs at selected sites having had satisfactory programs and at sites that have not

did not show a direct connection between prescriptive criteria (A&E or otherwise) and the achieved level of quality in the design and construction of nuclear power plants. Rather, the analyses have shown that changes in the design basis or the design, for whatever reason, increase the likelihood of reduced quality in construction. Several NRC initiatives (see Section 6.2.2) are under way to systematically reduce opportunities for either the NRC or the licensee to change a design, once completed and approved. These initiatives require a stringent review of the impact of required design changes and encourage a much greater degree of design completion at the time of CP application.

This study concluded that requiring a substantially completed design, including design changes made because of initial procurement activity, before construction begins would significantly enhance the achievement of quality during construction. Such a requirement would significantly reduce the amount of change associated with completing the design after construction has begun, thus enhancing design/construction interfaces, reducing rework, improving the basis for planning and scheduling, and generally making it much easier for the project to cope with and manage change. However, more prescriptive criteria, short of a requirement for a completed design before construction, would have proportionally less effect on controlling the level of change and hence on improving the environment for achieving quality.

Current practice does not provide a strong basis for NRC inspection of PSAR commitments or any resulting enforcement activities during the construction phase. A much improved basis for NRC inspection activity in this regard can be established by adopting an approach that makes a licensee's significant commitments in its PSAR conditions of the CP. This study recommends that staff review practice be changed to provide that, during NRC's review of the licensee's quality assurance program, the licensee's commitments to certain codes, standards and regulatory guide positions in the PSAR would be reviewed for inspectability and enforceability. Selected commitments would be designated as mandatory and made conditions of the CP. The designated commitments would then be binding and readily inspectable and enforceable. It should be noted that any changes to such commitments would require a license amendment and a concomitant notice procedure under Section 189a of the Atomic Energy Act. This would result in a reopened CP hearing under Section 189a if one were requested by an interested party.

This study also recommends that the NRC further evaluate the impact of changes in general (regulatory, technical, procedural, etc.) on the NRC, industry and project management structure to develop further guidelines for controlling unnecessary changes and for better managing necessary changes. The study also recommends that NRC should further examine the feasibility and benefits of requiring a substantially completed design at the time of CP application. See Chapters 3 and 9 for more discussion of the enhancement to quality available with an advanced design early in the construction process.

6.2 ANALYSIS

The issue of more prescriptive A&E criteria has been approached from two aspects: (1) should the requirements to which licensees are committed during design and construction be more prescriptive? and (2) should the NRC be more prescriptive in its procedures dealing with changes to those commitments?

This section discusses earlier attempts to define "principal A&E criteria", current initiatives concerning prescriptiveness, the relationship of A&E criteria to major quality-related problems, and the industry's management of change. Also discussed are NRC's inspectability and enforceability of changes to design criteria and other licensee commitments, and the amount of prescriptiveness that is appropriate in regulations.

6.2.1 Earlier Attempts to Define "Principal A&E Criteria"

For some time the NRC has been aware of the need for better controls on the licensee's type of design commitment and the extent of changes to design commitments and of NRC's changes to the design basis. The first attempt at improving the situation took place in 1969 as part of an effort to stabilize the licensing process. As part of the proposed rule on backfitting, 10 CFR 50.109, the staff included a more prescriptive definition of principal A&E criteria. However, when the final rule was issued, the more prescriptive definition was not included because the Commission decided that the definition needed further study. As a result of this determination, two studies were conducted to define principal A&E criteria. The results of the first report were published in December 1975 and the results of the second in March 1977. No formal staff action on these studies was taken because of difficulties with implementing the recommended definition and because of other priorities.

While the earlier action did deal with more prescriptive A&E criteria, a December 1979 action addressed the issue of control of design changes. As part of the Commission's decision on the need for a hearing and/or a CP amendment on the Bailey Nuclear Station short pile issue (SECY-A-79-24 and 24A), the staff was requested to prepare a proposal on precisely what design and other changes a CP holder could make without (a) notifying the NRC, (b) securing prior NRC staff approval, and/or (c) obtaining a CP amendment. In response to the Commission's request, the staff developed Commission Paper SECY-80-90, which detailed the historical background (the 1969 proposed rule, the 1975 and the 1977 studies) and proposed five alternatives for addressing the problem:

- (1) Maintain the status quo.
- (2) Borrowing from 10 CFR Part 50.55(e) (dealing with notifications of significant deficiencies having safety significance) and 50.59 (dealing with changes to previously approved designs having safety significance), adopt a rule that establishes general criteria for determining circumstances requiring a CP amendment.
- (3) Adopt a rule defining "principal architectural and engineering criteria" (in effect reviving the 1969 rulemaking on this subject) using information learned to date, including the 1975 and 1977 staff studies.
- (4) Adopt a rule stipulating that all details of the application, including the PSAR, be made conditions of the CP and may not be changed without prior NRC approval.
- (5) Restructure the licensing process to require that complete plant design details be provided in the PSAR (i.e., essentially a final design), which,

upon review and approval, would be made conditions of the CP and could not be changed without prior NRC approval.

The staff then presented the five alternatives to the Commission for publication for public comment as an Advance Notice of Proposed Rulemaking. In approving the publication of the Advance Notice of Proposed Rulemaking, the Commission added the following statement: "The Commission tentatively prefers Alternative 3 now, with a shift to Alternative 5 in three years."

6.2.2 Current Initiatives

The specific rulemaking described above has been subsumed into a series of new initiatives. The initiatives include, in order of occurrence, establishing the Committee to Review Generic Requirements, submitting legislation on one-step licensing, issuing a proposed policy statement on severe accidents, which includes standardization of design, and issuing an Advance Notice of Proposed Rulemaking on the backfitting of new requirements to operating plants and plants under construction. All requirements proposed by the staff for imposition on one or more classes of power reactors is reviewed by the Committee to Review Generic Requirements, which compares the improvement in operational safety to the cost of the change and recommends their approval or disapproval to the Executive Director for Operations.

Both the legislation on one-step licensing submitted to Congress and the policy statement on standardization contained in the proposed severe accident policy statement would require that a much more complete design be submitted for approval at the CP application stage. However, both would stop short of requiring that the design be complete to the point that it incorporate changes made to the initial design as a result of feedback from the procurement process. (To accommodate available equipment that may not satisfy initial design assumptions and to provide an acceptable level of safety, the design may have to be changed.) The most prescriptive A&E criterion, of course, would be requiring a complete design including the characteristics of specific components to be submitted as part of the CP application. The design approval granted under the one-step licensing proposal would be for 10 years, and the design could not be changed in that time frame by either the licensee or the NRC without going through the hearing process again. The Advance Notice of Proposed Rulemaking on backfitting would require the NRC staff to justify any change in requirements they wish to impose on operating plants. The incremental improvement to operating safety would have to be weighed against the cost of the change in terms of dollars and exposure.

6.2.3 Relationship of A&E Criteria to Major Quality-Related Problems

Previous NRC efforts in the area of more prescriptive A&E criteria have been directed towards stabilizing the licensing process rather than towards improving the basis for quality control, quality assurance, inspection and enforcement actions. While more prescriptive A&E criteria may be the answer to the licensing issue, this study did not show them to be an answer to quality problems. NRC's case studies and regional inspections have shown that the welding and masonry construction problems at Zimmer, the soil compaction problems at Midland, and the voids in the concrete at Marble Hill were not related to either the prescriptiveness or the enforceability of the principal A&E criteria. In these three cases, the problems were caused by inadequate

management of the construction process to assure that the design criteria were met. See Chapter 3 and Appendix A for more discussion of this point.

South Texas had both design and construction problems. The design problems resulted from failure to effectively manage the design process and to keep the design sufficiently ahead of construction to avoid redesign and rework due to physical interferences. The problem was not so much that the design did not meet the NRC's criteria, but that design changes coupled with an improperly managed design/construction interface made construction problems almost a certainty.

The errors identified in the seismic analysis at Diablo Canyon are generally considered to be an example of design errors. However, those errors occurred mainly in areas that had to be redesigned after a previously unknown geologic fault was discovered. The errors occurred because of needed design changes, coupled with deficiencies in management oversight of the design process, rather than from a lack of prescriptiveness in A&E criteria.

6.2.4 Management of Change

As the South Texas and Diablo Canyon cases illustrate, the difficulties inherent in managing complex projects are exacerbated by having to deal also with a rapidly changing project environment. Besides design changes, management of a nuclear power plant construction project must also cope with technical, regulatory, and procedural changes. The following excerpt from a letter written by a member of the study's special review group, Dr. George Coulbourn, expresses the author's viewpoint on the analyses leading to this report (see Section 10.4 for the text of entire letter):

There is a level of change action (technical, regulatory, and procedural) beyond which any program management structure can no longer prosecute its program. Utility management has consistently been faulted for quality assurance breakdowns. In some instances, the charge is well founded. However, in most instances, I believe the root cause is found in the circumstances which produced rampant, uncontrolled change. I submit that most of the utility management structures assembled to build the nuclear power plants of the past decade could have performed adequately in a more stable design and construction environment.

While not endorsing Dr. Coulbourn's position in total, the study has concluded that historically neither the industry nor the Atomic Energy Commission (AEC)/NRC have done a good job in managing change. The nuclear industry grew rapidly and was subject to rapid changes in technology and sizing of reactors. Also having to make these changes were several established industries comfortable with their routine methods of operation and not always amenable to the changes to their way of doing business required by the new and developing technology. These industries include the utilities, A/E firms, construction firms, and power plant equipment suppliers (see Section 9.2 for more discussion of this point).

The quality problems of several licensees can be directly attributed to their inability to foresee and adapt to changes to their traditional methods of power plant construction and project management required for nuclear construction (see Chapter 3 for more discussion of this point). The AEC's understanding of

safety issues grew along with the industry, and new requirements were provided at an increasing rate as the nuclear power "state of the art" developed, increasing the difficulty for either licensees or regulators to stay current. During study interviews, licensee management and staff most frequently mentioned stabilizing the process that had produced the constantly changing (and increasing) level of requirements as being an area in which NRC programs and policies could be improved. Issuance of new requirements reached a peak after the 1979 accident at Three Mile Island. To control the flow of requirements and to examine them for benefits and feasibility, the Commission established the Committee to Review Generic Requirements, discussed earlier. That committee is generally credited with providing a rigorous analysis of new requirements over the past two years and with bringing a much greater degree of stability to the regulatory process. In so doing, it has reduced the impact of change on both the industry and regulators, making it somewhat easier for both to manage and to cope with the level of remaining change.

Dr. Coulbourn's thoughts on the management of change conclude with the following recommendation, which the study endorses:

Accordingly, I recommend that NRC commission an examination of the change management process itself, both within NRC and in the other parts of the industry. This examination should focus on both the management of change as a discipline (elsewhere called configuration management) and upon the reduction of the volume of change. The latter can have numerous constituents; for example, higher percent design completion prior to start of construction, more restraint regarding in-process change, standardization, etc. All of these constituents require disciplined and consistent management.

6.2.5 Inspectability and Enforceability

When considering the use of criteria that are more prescriptive to improve inspection and enforcement, it becomes apparent that existing procedures for handling changes to design criteria and other licensee commitments do not provide a strong basis for inspections and enforcement against PSAR commitments during the construction phase. The NRC's enforcement policy contained in 10 CFR 2, Appendix C - "General Policy and Procedures for NRC enforcement actions," paragraph IV.E(3) states:

Notices of Deviation are written notices describing a licensee's or vendor's failure to satisfy a commitment. The commitment involved has not been made a legally binding requirement. The notice of deviation requests the licensee or vendor to provide a written explanation or statement describing corrective steps taken (or planned), the results achieved, and the date when corrective action will be completed.

Because the licensee can unilaterally modify the PSAR commitments that are not conditions of the CP and therefore not legally binding, a licensee's answer to a Notice of Deviation may be nothing but a change in the commitment. Changes in commitments should be based on factors other than a desire to legitimize

nonconforming work. The basis for NRC inspection and resulting enforcement action can be improved by adopting an approach that makes significant licensee PSAR commitments conditions of the CP.

6.2.6 Prescriptiveness

One of the difficulties faced by regulators is determining the amount of prescriptiveness appropriate in regulations. In recent years, the NRC has favored performance-oriented regulations that state the level of performance to be achieved but not the way to achieve that level. To provide supplementary guidance, NRC regulatory guides are also issued to describe acceptable ways the performance objective may be met, but those guides do not require any one method to be used. Maintaining this separation between saying what must be achieved and how it is to be done is fundamental to preserving the existing statutory roles of NRC and the industry. The industry is primarily responsible for the safety of nuclear power (e.g., reactor operators are employees of a utility, not the NRC), and the NRC is responsible for regulating the use of nuclear power in a manner consistent with maintaining public health and safety.

In this context, the NRC has two strong reasons to be careful about being more prescriptive in its regulations for design criteria. First, there is usually more than one satisfactory way to perform most design activities, and prescription would unreasonably limit the designer's choices. Second, too much prescription tends to put the NRC into an industry management role, where it does not belong, and tends to shift some of the licensee's responsibility for safety to the NRC.

These arguments against prescriptiveness apply to areas other than design also, e.g., quality assurance. Although the study concluded that the NRC could provide better guidance to licensees on acceptable ways to meet NRC QA requirements, the study did not find that the QA requirements should be made more prescriptive. The study recommends the opposite: rather than more prescriptive requirements that say "how" something should be done, the study concluded that present QA programs should be reoriented to meet performance objectives based on Appendix B, which say what is to be achieved but do not specify how it should be done. See Section 2.3.1.

6.2.7 Summary

The study has concluded that increased quality in the construction of nuclear power plants will result from a more careful coordination of changes in design criteria and design during construction rather than from more prescriptive criteria. Several initiatives are under way to systematically reduce opportunities for either the NRC or the licensee to change a design, once completed and approved.

The study has also concluded that the basis for inspection and enforcement during construction would be improved by including certain licensee commitments contained in the PSAR as conditions of the CP and that staff review practice should be revised to provide such conditioning. Such procedures should only apply to new CP applicants. The study concluded that this condition does not need to be applied to plants currently under construction because they will have passed the point where changes to principal A&E criteria are likely to occur by the time implementing regulations could be made effective.

The study also concluded that the NRC should examine the change management process itself, both within the NRC and the nuclear industry, to evaluate the impact of changes on the collective NRC-industry regulatory and project management structure. The goal of this examination would be to develop further guidelines for controlling excessive change and for better management of necessary change. The aerospace industry's apparently successful approach to configuration management should be a principal focus of study in this area (see Chapter 9 and Appendix D). Moreover, the study concluded that NRC should further analyze the feasibility and benefits resulting from requiring that plant design of future CP applicants be substantially complete before construction activities begin.