2.0 SUMMARY: STUDY CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the conclusions and recommendations of the Ford Amendment study. Section 2.1 describes the findings and conclusions stemming from NRC's analysis of the underlying questions introduced in Chapter 1. The study conclusions with respect to the five specific alternative approaches to improve quality assurance and quality control described in the Ford Amendment are presented in Section 2.2. Section 2.3 discusses conclusions and recommendations from several consultant studies that were conducted as part of the overall study. Section 2.4 describes administrative actions already undertaken by the NRC or recommended by the study to be undertaken or further analyzed by the NRC as a result of the findings and conclusions in the preceding sections. These actions are summarized in Tables 2.1 and 2.2. Section 2.5 covers actions that the study found to be appropriate for consideration by the nuclear industry. Table 2.3 summarizes the differences among the former (pre-1980), the present (1982-83) and the recommended future NRC and industry programs for the assurance of quality in designing and constructing nuclear power plants. Section 2.6 describes an issue that was identified in the study that requires further analysis before any legislative recommendations can be made.

As with the report as a whole, individual sections of this chapter have been written as stand-alone treatises so that the reader may develop a quick understanding of the study's conclusions or recommendations on a particular topic without reading the whole chapter. This has resulted in some redundancy between sections of the chapter. To the extent possible, the text has been annotated to refer the reader to other similar material in the report.

Most of the actions recommended by this study are directed toward revising NRC's program for the assurance of quality in nuclear power plant design and construction. The recommended actions are intended to improve the capabilities of the NRC and the nuclear industry to better achieve the overall quality assurance (QA) program goals of prevention, detection, and assurance. Although most of the recommended actions are directed at changes in NRC's performance of its QA activities, they will also influence the way the nuclear industry conducts its QA activities. The industry's activities are ultimately the more important of the two, because the actual work activities that result in whether a nuclear power plant is built and operated safely remain where they have always been--with the owner/licensee.

2.1 CONCLUSIONS STEMMING FROM UNDERLYING QUESTIONS

While conducting this study, it became apparent that the root causes of quality assurance breakdowns went well beyond the purview of the formal QA program itself and that the solution of the QA problem went beyond how to devise new or better quality assurance programs. To provide a foundation for the answers to the specific questions asked by the Ford Amendment, there were two underlying questions that needed to be answered first. The answers to these underlying questions also form the foundation for the actions proposed by this study and the conclusions formed concerning the five specific approaches Congress prescribed for study. The following subsections discuss each of these underlying concerns.

2.1.1. Why Have Several Nuclear Construction Projects Experienced Significant Quality-Related Problems While Others Have Not?

The principal conclusion of this study is that nuclear construction projects having significant quality-related problems in their design or construction were characterized by the inability or failure of utility management to effectively implement a management system that ensured adequate control over all aspects of the project. Each of the major quality-related problems cited in Chapter 1 was related to breakdowns or shortcomings in the implementation of the project's quality assurance programs; however, the quality assurance program's deficiencies had as their root cause shortcomings in corporate and project management. At several projects, breakdowns in the quality assurance program were part of larger breakdowns in overall project management, including planning, scheduling, procurement, and oversight of contractors.

There are two major corollary findings associated with management capability and effectiveness. First, in today's environment, prior nuclear design and construction experience of the collective project team (defined as the architect-engineer (A/E), nuclear steam supply system (NSSS) manufacturer, construction manager (CM), constructor, and owner) is essential, and inexperience of some members of the project team must be offset and compensated for by experience of other members of the team. Each member of the project team should assume a project role consistent with its prior nuclear experience and not overstep its capabilities. A false sense of security growing out of prior success in fossil plant construction led several first-time utilities into underestimating the complexity of nuclear design and construction. This miscalculation resulted in the assembly of a project team that lacked the requisite experience, background, and management capability, individually or collectively, to successfully design and construct a commercial nuclear power plant without the development of significant quality problems. Although prior nuclear design construction experience of the collective project team appears necessary for future plants, it is not sufficient to assure the completed construction of a quality nuclear plant.

The second corollary finding is that in the past, the NRC has not adequately assessed the factors of management capability and prior nuclear experience in its pre-construction permit reviews and inspections. The substantial changes the NRC has required of some licensees' projects to bring them up to minimum standards are evidence that some utilities that were not adequately prepared to undertake a nuclear construction project were granted construction permits (CPs). It is clear in retrospect that some utilities granted CPs under previous standards would not, based on the same qualifications, be granted a CP in today's regulatory environment without substantial personnel and organizational improvements in experience levels and management approach. Besides not performing a searching evaluation of licensee management capability before issuing the CP, the NRC also did not foresee that even an otherwise adequate management could be overwhelmed and demoralized by increasingly numerous regulatory, design, and hardware changes mandated during the design and construction process.

Other factors that contributed to major construction quality problems in the past include the changing regulatory, political, and economic environment surrounding nuclear power over the past several years and some licensees' inability to recognize and adjust to the changes as they occurred; the NRC's

and licensees' inability to manage change well; some licensees' failure to treat quality assurance as a management tool, rather than as a paperwork exercise or, conversely, as a substitute for their own management involvement; and NRC's inability to convince some licensees of the necessity for implementing their quality assurance program.

The major quality problems that have arisen in design were related to shortcomings in management oversight of the design process, including failure to implement quality assurance controls over the design process that were adequate to prevent or detect mistakes in an environment of many design changes.

An essential characteristic of a successful nuclear construction project is prior nuclear construction experience of the project team (utility owner, A/E, NSSS manufacturer, CM, and constructor) collectively, with individual team members assuming roles consistent with their prior level of nuclear experience and capabilities. Prior nuclear design and construction experience is necessary for key project personnel for each of the organizations comprising the project team.

Although it is necessary that each team member assume a project role commensurate with its capability and prior experience for project success, it is not sufficient. Prior nuclear construction experience of the utility owner is particularly helpful, although not mandatory if the corporate entities comprising the rest of the project team are sufficiently experienced and if the utility and the other members of the project team assume project roles consistent with their respective levels of nuclear experience. However, the utility is ultimately responsible for the project, and it cannot delegate its management and oversight responsibilities to others. This thought was summarized well by the Deputy Administrator of one of the NRC regional offices:

> It is essential that a utility undertaking the construction and operation of a power reactor facility have strong project management capability within its own organization to enable independent owner direction and assessment of overall management and assurance of quality of the project.

Another essential characteristic of a successful nuclear construction project is an understanding and appreciation of the complexities and difficulties of nuclear construction by top corporate management that manifests itself in a project management approach that includes adequate financial, organizational, and staffing support for the project; good planning and scheduling; and close management oversight of the project and the project contractors. Other factors contributing to project success include strong management commitment to quality and support for the quality program that starts at the top of the corporate structure and flows down through project-level management to first-line supervisors and foremen; involvement of top corporate management in the project; commitment of resources sufficient to complete the project in a quality manner; careful selection of key project staff; an atmosphere that encourages looking for problems and solving them; an openness to ideas for improvements; effective project communications vertically and across project interfaces; an understanding of the symptoms of poor management practices; use of the quality assurance program as a management tool, rather than as a substitute for management; and an understanding of the role, mission, and constraints of the NRC.

Nuclear construction is sufficiently different from and more complex than fossil construction that fundamental changes to a utility's corporate structure and project approach may be necessary to successfully complete the project.

Finally, of several projects studied, there tended to be a direct correlation between the project's success and the utility's view of NRC requirements. More successful utilities tended to view NRC requirements as minimum, not maximum, levels of performance, and they strove to establish and meet increasingly higher, self-imposed goals. This rising standard of excellence theme was an important part of the study's analysis of industry initiatives for self-improvement, such as industry establishment and support of the Institute of Nuclear Power Operations (INPO) (Chapter 5).

The case studies (Chapter 3) of nuclear construction projects having various levels of quality success confirmed, through the analysis of actual cases, several widely held opinions about the cause of major quality-related problems. These opinions include shortcomings in management oversight of the project, lack of management commitment to quality, insufficient prior nuclear experience, and use of a fossil approach to nuclear construction. The case studies also confirmed the phenomenon of top corporate management setting the tone for a project and affecting the emphasis of its subordinates, both managers and workers. In this regard, management's actions have much more influence than their words.

The case studies were also useful in understanding what the principal causes of the quality-related problems were not, e.g., craftsmanship. The case studies found that while poor craftsmanship played a role in some of the major quality-related problems, it was an effect, not the cause, of the underlying problems. The principal underlying cause of poor craftsmanship in constructing nuclear power plants, as well as the quality problem, was found to be poor utility and project management.

This discussion is not meant to minimize the importance of craftsmanship in achieving quality. Clearly, it is craftsmen who build or fail to build quality into a nuclear plant, and quality craftsmanship is necessary for achieving quality in nuclear construction. However, good craftsmanship is not a sufficient condition to achieve quality. Good craftsmanship can be defeated in its attempts to build a quality plant by conditions out of its control. Such conditions include unavailability of tools or materials, rework due to excessive design changes, design completion not sufficiently ahead of construction activity, untimely scheduling of quality of work inspection activities, unqualified or uninformed supervisors and foremen, a project environment that emphasizes production to the detriment of quality, and a project environment that takes away the craftsman's sense of pride and accomplishment in his work. Each of these conditions is within the control of management, not the craftsman, and until project management is improved to minimize these conditions, the effect of improved craft skills alone on nuclear plant quality will be minimal.

For further discussion of these findings and conclusions, refer to Chapter 3 and Appendix A (Case Studies) and Chapter 5 (Audits by Associations of Professionals).

2.1.2. Why Have the NRC and the Utilities Failed or Been Slow To Detect and/or Respond To These Quality-Related Problems?

The utilities, which have primary responsibility for the safe construction and operation of nuclear power plants, have been slow in detecting or responding to quality-related problems for several reasons. The reasons include abdication of project oversight responsibilities to contractors or to subcontractors, inadequate implementation of quality assurance programs, cost and schedule pressures, inadequate QA/QC staffing, and attenuation of vital project information flowing from the working level to top management. Each of these reasons was found to have its roots in shortcomings of project and corporate management; many of these shortcomings were caused or exacerbated by inexperience in constructing nuclear power plants. In some cases, the licensees did not have effective management control of their project as a whole, and the quality problems were symptomatic of a much broader malaise that affected the entire project.

At some projects there was a tacit delegation by management of its responsibility for the achievement of quality to the NRC-required organization (the QA organization) whose mission is the assurance of quality. Inappropriate delegation of responsibility for quality, along with top management not knowing what their quality assurance programs were discovering, either through lack of interest or understanding or through attenuation of information as it passed through layers of intermediate management, contributed in no small part to the untimely detection of and response to some quality problems. Licensee QA managers and their programs have not been without fault, but they can be only as effective as top utility management permits. As with the improvement of craftsmanship, substantial improvements in quality assurance programs must start at the very top of the corporate structures of those organizations involved in the nuclear industry.

The NRC was slow to detect and/or take strong action in the major quality-related problems cited previously for several reasons. These reasons include, but are not limited to the following. The NRC made a tacit but incorrect assumption that there was a uniform level of industry and licensee competence. NRC inspection presence at construction sites was sporadic (before the NRC resident inspector program was implemented). The NRC inspection program was slow to synthesize scattered quality-related inspection findings coming in over a period of time into a comprehensive picture of a project-wide breakdown. Limited NRC inspection resources were so prioritized to address operations first, construction second, and design last, that inadequate inspection of the design process resulted. The threshold for reacting to construction-related problems was set higher than for operational problems because of (1) no immediate threat to public health and safety posed by construction deficiencies, (2) an attitude that construction problems would be found during an intensive period of startup testing prior to issuance of an operating license, and (3) an attitude that required a project-wide pervasive breakdown to be demonstrated before strong enforcement action would be taken for construction quality problems. The inspection program was oriented to focus heavily on paperwork at the expense of examining either actual work in progress or QA program implementation. The inspection program focused on detail rather than on whether the overall management process for the project was working.

Finally, the NRC was reluctant to address the issue of capability of utility management until the need for a massive remedial program for a particular licensee became evident.

2.2 CONCLUSIONS FROM NRC'S ANALYSES OF FORD AMENDMENT ALTERNATIVES b(1)-b(5)

The following conclusions summarize NRC's analyses of the specific alternatives proposed for study by Congress. Collectively, the study conclusions on these five Ford Amendment alternatives answer study question 3, which was introduced in Section 1.1:

> What changes should be made to the current policies, practices, and procedures governing commercial nuclear power plant design, construction and regulation to prevent major quality problems in the future or to provide more timely detection and correction of problems?

Later parts of this report will provide additional detail on the analyses and on the specific actions that NRC has undertaken or that are recommended. In this section, each alternative is first reprinted and then is followed by the major conclusions resulting from this study's analysis of that alternative.

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 powerplants.

Conclusions:

The study concluded that while more prescriptive architectural and engineering (A&E) (i.e., design) criteria would provide a stronger basis for inspection and enforcement action, neither the degree of prescriptiveness of principal A&E criteria nor the enforcement of such criteria were factors in the major quality-related problems that led to the Congressional mandate to perform this study. None of the five plants having quality-related problems would have found their problems lessened if more prescriptive A&E criteria during the plant's design and construction had been required.

Quality problems in design were directly attributable to changes in the design basis and to inadequate management oversight of the design process, including implementation of quality assurance controls over the design process, rather than to the degree of prescriptiveness of A&E criteria. Historically, neither the industry nor the NRC has done a good job in managing change, whether the changes be technical, regulatory, or procedural. Recent NRC action to control the rate of regulatory change and to prevent unnecessary change by establishing the Committee to Review Generic Requirements has been a positive force in reducing the impact of regulatory change on the industry.

Two other considerations argue against more prescriptive design criteria. First, there is usually more than one satisfactory way to accomplish design activity and more prescription would unnecessarily limit the designer's choices. Second, too much prescription by the NRC tends to shift the licensee's responsibility for safety to the NRC.

The study did find that a more complete design early in the construction process would enhance several project activities, including planning, scheduling, and procurement, and would facilitate readiness reviews (to evaluate readiness to proceed to a new project phase of activity), thereby improving the prospects for greater project quality. Current NRC initiatives concerning standardized designs address this point.

The study also found that current practice does not provide a strong basis for inspection against Preliminary Safety Analysis Report (PSAR) commitments. The study concluded that an effective way of providing a stronger basis for inspection (and subsequent enforcement, if necessary) would be to provide more definitive procedures for management of changes to principal A&E design criteria. One way to accomplish this would be to make licensee commitments to certain A&E design criteria contained in the PSAR conditions of the CP.

No new administrative action is recommended under this alternative other than to revise future staff review practices to accommodate the above conclusions and to further evaluate the impact of changes on the collective NRC-industry regulatory and project management structure in order to develop further guidelines for controlling unnecessary change and for better managing necessary changes. The NRC has several actions currently under way, including a legislative proposal, which address the issue of standardized designs.

Alternative b(2)

> Conditioning the issuance of construction permits for commercial nuclear powerplants on a demonstration by the licensee that the licensee is capable of independently managing the effective performance of all quality assurance and quality control responsibilities for the powerplant.

Conclusions:

The study concluded that this alternative would offer significant advantages over current and past NRC practice. In the past, CPs have been issued to some applicants who would not have met this criterion. Past NRC reviews of CP applicants did not deal substantively with management experience or capability either in an overall sense or in the context of QA program effectiveness. The study found that deficiencies in utility and project management were root causes of the major quality-related problems experienced and that in such projects, problems in the quality program were often accompanied by deficiencies in other management aspects, including planning, scheduling, procurement, and oversight over contractors. The study established a strong correlation between the effectiveness of the QA program and the effectiveness of overall project

management. Therefore, any future assessment of the effectiveness of the licensee's management and oversight of its QA/QC responsibilities should cover other management aspects of the project as well.

This study recommends that future CP applicants be required to meet this criterion. While the licensee could use contractors to manage the project or parts of it, the licensee would retain ultimate responsibility for the effective management of the project, including its quality aspects. Demonstrations of management capability and effectiveness would be required both before CP issuance and throughout the construction process, at about two-year intervals. The CP would be conditioned on the applicant's successful performance on each of these post CP-audits. Poor performance on any single audit would not necessarily result in license suspension but could lead to other enforcement action. Poor performance repeated in a subsequent audit would lead to more extensive enforcement action, including the possibility of license suspension. To perform these audits, NRC staff should develop a better capability to assess, prospectively, project management and quality program management capability.

In addition to this prospective staff review of an applicant's management capability, the NRC should also establish an advisory board that would be similar in function to the Advisory Committee on Reactor Safeguards (ACRS) but whose members would have appropriate background and experience to review the management qualifications, experience, and capability of future CP applicants. This board would advise the NRC of their findings and recommendations regarding the applicant's capability and competence to construct a nuclear power plant.

Comprehensive third-party audits such as those envisioned by alternative b(5) could be used to periodically confirm management and QA/QC program effectiveness after NRC's initial prospective finding of adequacy. Therefore, the third-party audits that were examined in conjunction with alternative b(5) would represent an acceptable method for meeting the post-CP demonstration requirements of this alternative.

Alternative b(3)

> Evaluations, inspections, or audits of commercial nuclear powerplant construction by organizations comprised of professionals having expertise in appropriate fields, which evaluations, inspections, or audits are more effective than those under current practice.

Conclusions:

The study concluded that audits conducted by the American Society of Mechanical Engineers (ASME) for ASME code work and by the National Board of Boiler and Pressure Vessel Inspectors (NB) provide detection capability in certain specific areas beyond that provided by the NRC. Those audits therefore provide a valuable and continuing contribution that complements the NRC inspection program.

The new INPO Construction Project Evaluation (CPE) program fits the alternative b(3) criteria of "evaluations...by organizations comprised of professionals having expertise in appropriate fields, which evaluations... are more effective than those under current practice." INPO implemented its CPE program after Public Law 97-415 was enacted, and this program represents a significant enhancement of efforts by the nuclear industry to improve quality assurance and quality control in design and construction.

Of all audit or evaluation activities by associations of professionals having appropriate expertise, only the CPE is comprehensive enough to be considered as a potential surrogate for NRC inspections. However, the INPO construction evaluations do not attempt to cover all of the areas that a regulatory inspection must cover and do not evaluate the quality of installed hardware to the extent that NRC's Construction Appraisal Team (CAT) inspections do. The study concluded that INPO's current mission of assisting nuclear utilities in raising their levels of performance and standards of excellence will do more to improve industry performance and to prevent future problems than any attempt to transpose INPO's activities into a quasi-regulatory role. Consequently, the study concludes that little change should be sought in INPO's current mission, which is to help the nuclear industry improve itself by establishing standards of industry performance and excellence, and evaluation against those standards.

Although the study concludes that NRC's and INPO's roles presently are separate, INPO's potential is not yet fully realized. Therefore, the NRC should remain alert to future changes in INPO's program that would justify NRC's placing greater reliance on it and that would lessen the combined impact of NRC and INPO evaluation programs on individual licensees. The NRC should find ways to reinforce the INPO concept of improving levels of performance in all areas of nuclear power, including operations, design and construction. The goal should be to ensure that licensees who do not choose to strive for standards of excellence do not find the alternative path any easier.

Currently, none of the designated organizations of professionals have the NRC's technical inspection depth, breadth, and experience. Moreover, no other organization has the statutory strength of the NRC. Effectiveness is not only measured by technical competence, but also by the ability to assure that identified problems are fixed. Only the NRC has the statutory ability to provide such incentives.

Alternative b(4)

> Improvement of the Commission's organization, methods, and programs for quality assurance development, review, and inspection.

Conclusions:

The study found that the NRC shares responsibility with the utilities for the occurrence and magnitude of the major quality-related problems that stimulated this study. The major findings and conclusions relating to NRC's organization, methods, and programs for quality are summarized below. Improvements to NRC's organization, methods and programs for

quality are discussed in Section 2.4 (NRC Administrative Actions) and in Chapters 4 and 7. Each of these conclusions are conclusions of the study and any related recommended regulatory actions are only proposed for implementation at this time. Those recommendations that would result in new regulatory requirements will be subject to the Administrative Procedures Act and established NRC procedures, including review by the Committee to Review Generic Requirements, by public comment, and by the NRC Commissioners before being enacted.

NRC's program for the assurance of quality in design and construction in the nuclear industry has several primary objectives that are achieved through a hierarchy of organizational oversight arrangements involving the licensee, its contractors, independent auditors, the ASME and NB, INPO and the NRC. The three primary objectives of this total program for the assurance of quality are (1) to prevent major quality-related problems such as those cited in the introduction from occurring, (2) to detect, in a timely fashion, developing quality problems and to take corrective action before isolated problems multiply into a programmatic breakdown, and (3) to provide assurance to the NRC, the public, and the Congress that plants that are licensed to operate have met applicable legal requirements and are designed and built in a manner consistent with public safety. The NRC is not primarily responsible for accomplishing any of these three activities, but the NRC is the architect and monitor of the total system for assurance of quality and must share in the blame when the system does not work. This NRC-required system has, on occasion, missed its goals in some or all of the three objectives: prevention, detection, and assurance. The study's conclusions on each of those objectives are discussed below.

Prevention

(1) NRC CP licensing reviews and pre-CP inspections should deal more substantively with prior nuclear construction experience within the project team and the capability of the licensee's management to carry out its intended role within the project team. The NRC should review the aggregate capability, prior nuclear experience, and project roles proposed of each corporate entity within the project team.

    To execute these new reviews, the NRC needs to develop methods to assess project and utility management capability and effectiveness prospectively. The capability for effective management should be a criterion for license issuance and retention. The NRC should develop evaluation criteria or characteristics, based on this study and refined through further research, for the elements of successful and unsuccessful organization and management practices of commercial nuclear power plant construction projects. These criteria should be codified as part of NRC's pre-CP issuance inspection guidelines.

(2) The NRC should revise its quality assurance programmatic requirements to emphasize performance rather than form and to establish QA principles as an integral part of licensee construction management philosophy. As an NRC Regional Administrator observed, NRC quality assurance efforts to date have, unfortunately, succeeded in establishing licensee QA organizations that are short on technical

expertise, long on bureaucratic paperwork and essentially isolated from the safety-related licensee programs they were designed to improve. This has resulted from a licensing process that has emphasized organizational and programmatic form while failing to impress licensees with the need to be effective in the day-to-day management of engineering and construction activities. Similarly, the requirement to establish QA functional independence has, in many cases, convinced construction managers that QA is someone else's job. NRC's failure is in not effectively communicating to licensees that the 18 quality assurance program criteria of 10 CFR 50, Appendix B, describe a comprehensive closed-loop management control system that is worthy of adoption as an overall construction management system. Other knowledgeable officials have suggested that those 18 criteria should probably be given a new name in an effort to take them out of the province of the QA department and establish them as the provenance of the corporate boardroom.

(3) The NRC and industry need to improve their capability to manage change. A key step in improving the management of change is reducing change. The NRC and industry should continue and expand their efforts to control procedural, technical, and regulatory change and to stabilize design requirements.

Detection

(1) The NRC and industry need to focus more on the implementation of quality assurance programs including the quality of completed hardware, and less on the details of the programs (e.g., program description, organization chart, independence of reporting chain, etc.).

(2) The NRC should continue current efforts to match its inspection program to its resources so that areas of greatest safety significance are inspected more heavily. The inspection program should focus more on licensee management performance and effectiveness than it has in the past.

(3) The NRC should continue its newly established integrated design inspections.

(4) The NRC needs to do a better job of synthesizing and analyzing findings from individual inspections and other sources to lower its threshold for taking action on construction quality problems. Team inspections have been found to be one way to address this problem. The NRC should continue and expand current efforts to include more team inspection activity in the inspection program.

(5) Comprehensive third-party inspections are a viable supplement to the NRC inspection program and should be required of future and current CP holders. The third-party audits should assess the effectiveness of both QA program implementation and project management as well as a verification of achieved quality in construction.

Assurance

Assurance exists on at least two levels: the level of the total NRC program and the nuclear industry as a whole and the level of an individual project. Each time some part of the total NRC QA program for the assurance of quality fails to prevent or provide timely detection of a major quality-related problem, such as those cited previously, the level of assurance that the total system provides to the public is lowered, no matter which party (e.g., NRC, licensee, contractor) is primarily to blame. Collectively, the five major quality-related problems cited previously so lowered the level of assurance provided by the total program that Congress directed that this study be conducted to find ways to redesign the system and to restore public confidence in it.

The recent decision by the owners of the Zimmer project to convert their nuclear project to coal underscores the importance of assurance at the individual project level. The NRC had halted safety-related construction on the project because of deficiencies in the system that was intended to provide assurance that the Zimmer project had been constructed in compliance with NRC regulations. It appears that the high cost of a remedial program designed to provide such assurance resulted in termination of the nuclear portions of the project.

Alternative b(5)

> Conditioning the issuance of construction permits for commercial nuclear powerplants on the permittee entering into contracts or other arrangements with an independent inspector to audit the quality assurance program to verify quality assurance performance.

Conclusions:

This study concluded that comprehensive audits of nuclear construction projects by qualified third parties (independent inspectors) can provide significant additional preventive and detection capability as well as enhanced assurance that nuclear plants are built according to their design and licensing commitments. This study found that this alternative, including its provision for conditioning the CP, offers significant benefits over current and past practice. Just as periodic independent audits are conducted of publicly held corporations to determine their financial condition, periodic independent audits of a licensee's construction project would provide the public, regulators and utility stockholders greater assurance that the project's design and construction were of high quality and according to applicable safety requirements. The independent auditor would be required to meet independence criteria to be established by the NRC, and the audits would be reviewed and monitored by the NRC. The NRC also would establish criteria for audit coverage and completeness. An audit frequency of approximately once every two years appears most appropriate. The study concluded that a program of comprehensive periodic audits by qualified third parties should be implemented both for plants currently under construction and for future plants.

2.3. OTHER CONCLUSIONS

While preparing the analyses required by Congress, it became apparent that the study should be expanded beyond Congress' specific questions to the previously described underlying questions that seemed to go to the root of public concerns. Expanding the study revealed several topics that affected the underlying concerns but that required additional study before specific action could be recommended. These topics and the additional study performed on them are summarized below.

2.3.1. The Kist Report on Improvements to NRC's Programs

When it became apparent that NRC's past policies and practices contributed to the development of quality-related problems in design and construction, the NRC arranged for an independent contractor to assess NRC's activities and requirements for quality and quality assurance during design and construction. This assessment was conducted by a management consulting firm, N. C. Kist and Associates, which specializes in nuclear industry QA program audits and reviews. The Kist Report comprises Appendix B of this report. Not all of its conclusions and recommendations have yet been evaluated for adoption. The Kist Report includes the following recommendations:

(1) The regulatory process should be stabilized through more preventive action and planning.

(2) The NRC should make the required elements of control more definitive in guidance documents without specifying how those elements must be implemented.

(3) The NRC should define the applicability of quality program requirements for items considered important to safety.

(4) The NRC should focus QA licensing reviews more on the licensee's QA manual itself and less on pro forma commitments in the PSAR application.

(5) The NRC should evaluate licensees' and contractors' experience, attitude and management capability before authorizations and permits are issued. The NRC should establish acceptance criteria for that evaluation.

(6) The NRC should require the licensee to demonstrate its capability to implement the QA program before authorizations or permits are issued.

(7) The NRC should devote greater attention to design activities.

(8) The NRC should develop programs based on what must be done to assure safety and then obtain necessary resources to implement the programs.

(9) The NRC should require a master Inspection Plan from licensees and contractors, showing planned QA/QC inspection activity.

(10) The NRC should change regulations to permit industry organizations to evaluate vendors instead of requiring individual licensees to evaluate vendors.

(11) The NRC should take stronger, more expeditious enforcement action for quality problems in design or construction, including determining the magnitude of problems and correcting their root causes.

(12) The NRC should perform or require detailed periodic audits of each licensee's implementation of its QA program.

(13) The NRC should increase the training of NRC inspectors in quality assurance, auditing, and implementation of inspection modules.

(14) The NRC should establish an audit program of NRC activities, using qualified personnel not having responsibility in the areas audited.

(15) The NRC should establish a quality assurance program within the NRC.

A number of the Kist Report's recommendations coincide with this study's recommendations. The remainder are being evaluated by the NRC staff for possible followup action.

2.3.2. Battelle Reports on Contractual and Institutional Issues and on QA Programs of Other Industries

This study found that major quality problems were caused by breakdowns or inadequate implementation of quality programs, which invariably stemmed from problems with project management and/or with the project team's inexperience in their assumed roles. Many factors indirectly influence these primary causal factors. Battelle Human Affairs Research Center (HARC) and Pacific Northwest Laboratory (PNL) (operated by Battelle) conducted analyses to identify or better understand some of these less obvious factors. This section describes the results of two special substudies undertaken to develop a broader perspective on which to base study conclusions and recommendations. As with the Kist Report, not all of these conclusions and recommendations have yet been fully evaluated for adoption.

Chapter 8 and Appendix C of this report examine some of the contractual, organizational, and institutional issues associated with designing and constructing nuclear power plants. HARC performed this analysis, with the following results:

(1) Previous nuclear experience appears to provide a significant advantage in a nuclear construction effort. Utilities not possessing such experience initially should consider hiring either a project staff or contractors who can provide such expertise.

(2) A nuclear construction project appears to benefit when its procurement entity is large and experienced enough to exert "marketplace presence". A large procurement entity offers the advantage of market familiarity and commercial leverage as well as the "clout" needed to secure satisfactory performance on procurements.

(3) Without substantially more complete designs before construction is begun and stabilization of technical requirements, fixed-price contracting does not appear to be justified for most aspects of nuclear power plant construction.

(4) Achieving quality objectives includes attention to detail in procurement documents and specifications, careful evaluation of a bidder's capability before a contract is issued, and followup to evaluate contractors' performance after a contract is issued.

(5) The NRC should focus more attention on how a licensee proposes to ensure quality work is performed rather than on written descriptions of QA/QC programs.

(6) Along with the NRC, state Public Utility Commissions (PUCs) provide a major source of regulatory oversight for nuclear construction projects. Historically, state PUCs do not appear to have been active in disallowing construction costs that may have resulted from lapses in quality assurance or project management. Recent developments suggest that this practice is changing with unknown implications for the course of nuclear projects currently under construction.

Chapter 9 and Appendix D describe a second analysis that was undertaken to give this report additional perspective--an analysis of the existing programs for assurance of quality of other U.S. government agencies, other industries, and other countries. The analysis focused on identifying aspects of alternative QA programs that might be transferred to NRC's program and improve it. This analysis was performed in conjunction with NRC staff by PNL. Major insights from this analysis and related work include the following:

(1) Plant designs should be well advanced before construction activities begin.

(2) The NRC should consider establishing a QA system that prioritizes quality efforts commensurate with the relative importance of equipment, components, and systems to safety, reliability and availability.

(3) The NRC should consider adopting "readiness reviews" during nuclear plant construction similar to those used by the Department of Energy (DOE) and the National Aeronautics and Space Administration (NASA). In some industries, readiness reviews are conducted before embarking on a major new phase of a project to ensure that appropriate planning, coordination and design work have been completed and that the project team is "ready" to proceed. These would not be regulatory "hold points" but rather a requirement for licensees to perform a self-assessment at critical points of the construction process.

(4) The NRC should study ways to better integrate NRC inspection functions with system design reviews, test program reviews, and test program evaluations.

(5) The NRC should look at alternative ways of improving its vendor inspection program.

(6) The NRC should emphasize that achieving quality is the responsibility of licensee management, not the QA organization. Several alternative programs studied emphasized the responsibility for quality of line management from top executives down to first-level supervisors and foremen. Several examples demonstrated that if this responsibility is fulfilled, a large contingent of QC inspectors is not needed.

4 NRC ADMINISTRATIVE ACTIONS

This section describes the administrative actions that the NRC has undertaken or that are recommended by this study for improving quality assurance and quality control programs. Each action may address several of the study's findings and conclusions and is grouped according to the QA program objective it most strongly supports: prevention/improved management; detection/lowered threshold; assurance/increased public confidence. For convenience these actions are summarized in tabular form at the end of this section in Tables 2.1 and 2.2. The tables make it easier to understand the actions under way and actions recommended, applying to future plants and to plants currently under construction, and actions requiring more analysis.

Although some of the requirements of the Ford Amendment were futuristic (e.g., two of the five alternatives spoke of conditioning future CPs on certain requirements), several of this study's results are immediately applicable for plants presently under construction. The actions described in the remainder of this chapter collectively define both a framework for future CPs and a framework within which existing plants under construction can be completed safety, according to NRC requirements, and with high assurance of the quality of construction necessary for licensing and safe operation.

2.4.1 NRC Administrative Actions To Support the Prevention Objective and To Improve Management

This section is divided into discussions of actions already undertaken and actions recommended for consideration by the NRC.

Actions Already Undertaken

(1) Systematic Assessment of Licensee Performance

The study found that historically the NRC inspection program has not focused on the quality, capability and effectiveness of licensee management. Following the accident at Three Mile Island, the NRC initiated an effort to better address the issue of management performance through the Systematic Assessment of Licensee Performance (SALP) program. Under the SALP program, the overall performance of each nuclear power plant licensee (both CP and operating license holders) is reviewed periodically (approximately every 9 to 18 months). Evaluation results are discussed with senior licensee management and help prioritize the level of NRC inspection for the coming period for each licensee. The SALP program is discussed in more detail in Chapter 7.

(2) Committee to Review Generic Requirements

The study found that historically neither the NRC nor the industry had managed changes well, whether they were technical, procedural, or regulatory. The most direct way to improve management's capability to handle change is to reduce the rate of change itself. In 1981, the NRC established the Committee to Review Generic Requirements (CRGR) for the NRC to exercise better management control over the flow of new regulatory requirements and to carefully examine the feasibility and benefits of proposed NRC staff actions having generic implications. The CRGR is

generally credited with bringing order to the promulgation of new regulatory requirements and thereby giving more stability to the regulatory process.

Recommended Actions

(1) Enhanced Pre-CP Review of Applicants' Experience and Managerial Qualifications

Past NRC reviews of CP applications have not dealt substantively with management experience and capability or prior nuclear experience. The Commission has no CP applications at this time nor does it expect any in the near future. This hiatus presents an excellent opportunity to review and revise Commission practice in this area without impacting any current applications. This study has concluded that this issue should be addressed in two ways: (1) enhancing NRC staff review, and (2) establishing an advisory board.

As a result of this study, the NRC staff has improved its understanding of the management factors that have resulted in both satisfactory and less than satisfactory quality in construction. Based on this improved understanding and further analysis in this area, the study recommends that the NRC staff revise portions of the Standard Review Plan (SRP) and the inspection program to greater emphasize reviews of the applicant's management capability, quality assurance program, project team experience and management's prior nuclear experience before CP issuance. The revised SRP and inspection program are intended to provide substantial additional guidance to the staff for its review of the applicant's ability to effectively implement a quality program and manage a nuclear construction project. The staff's efforts are anticipated to be augmented with expert consultants in conducting these management reviews.

In addition to this enhanced staff review of management capability, the study has concluded that independent advice on this subject is needed from persons having expert knowledge of and experience in various aspects of the management of a commercial nuclear power plant construction project. One alternative is to establish an advisory board that is similar in some regards to the Advisory Committee on Reactor Safeguards (ACRS) but whose charter is to address management, organizational, experience, and qualification issues associated with constructing a commercial nuclear power plant. In particular, the board would independently advise the NRC on the applicant's capability to effectively manage all aspects of a nuclear construction project, including its quality assurance program. The duties of this board might also be expanded later to include advice on the applicant's capability to manage the plant's operation.

The Commission is authorized to establish advisory boards by Section 161a. of the Atomic Energy Act. The creation and operation of such boards and committees are subject to the requirements of the Federal Advisory Committee Act and 10 CFR 7 of the Commission's regulations. The proposed board would be a balanced body of persons having direct experience and knowledge of managing the design and construction of a large commercial nuclear power plant. Board membership would be formed on

an ad-hoc basis from a slate of experienced persons from such organizations as other nuclear utilities, investment banking firms that arrange financing for nuclear projects, state PUCs, nuclear insurance firms, nuclear-experienced A/E firms, NSSS manufacturers, legal firms with an extensive nuclear practice, and perhaps management consulting firms. In creating such a board (whose membership would be voluntary), procedural safeguards would have to be carefully structured to avoid conflicts of interest.

An alternative to the proposed construction advisory panel would be to expand the duties of the ACRS to advise the NRC on the managerial qualification of CP applicants. Such an expansion in scope of ACRS purview would represent a significant change from the highly technical reviews ACRS now performs. Moreover, the type of background and experience envisioned for the proposed advisory board historically has not been available on the ACRS. This proposed administrative action directly addresses Congressional Alternative b(2).

(2) Post-CP Demonstration of Managerial Competence and Effectiveness

The study concluded that future CPs for commercial nuclear power plants should be conditioned on a licensee's post-CP demonstration that it is capable of managing or providing effective management oversight over the construction project. This would include a demonstration that the licensee is capable of independently managing or overseeing the management of the effective performance of all quality assurance and quality control responsibilities for the power plant. Although the licensee could delegate some project responsibility, it would retain responsibility for the effectiveness of project management, including the effectiveness of the quality program.

In some cases in the past, the NRC has been slow to conclude that a major breakdown has occurred in a licensee's quality assurance program, although the symptoms of and practices leading to the breakdown were, in hindsight, evident early in the project. In such cases, neither the interests of the public nor the licensee have been well served by the delays inherent in the NRC accumulating sufficient foundation for a Show Cause Order or other enforcement action.

The study has concluded that a post-CP demonstration of management capability and effectiveness, as a condition of the license, is the most effective way to impress upon an applicant the importance the Congress and the Commission attach to proper implemention of the applicant's QA program. Such a requirement would provide a substantial incentive for the licensee, its reactor manufacturer, its A/E, and all its contractors to demonstrate that the QA program committed to in the licensing process has been implemented and is being effectively managed. Public confidence in the quality of the project's design and construction would also be enhanced. The system of independent third-party audits proposed by Congressional Alternative b(5) could be one method for verifying such demonstration.

The first of the periodic independent third-party audits, proposed by Congressional Alternative b(5) and recommended by this study in Section 2.4.2, could appropriately evaluate this demonstration and could assure the NRC and the public that the licensee is properly implementing its QA/QC program and building a high-quality plant. If the performance in this first audit were unsuccessful, the CP could be suspended or other enforcement action could be taken.

NRC's past practice has not been to comprehensively assess, at an early stage, a licensee's implementation of the QA/QC program. The Commission's adoption of the requirement to demonstrate such implementation as a condition of the CP would correct that shortcoming. A regulatory analysis should be performed to assess the feasibility and benefits of alternative approaches for implementing this proposed action. Alternatives include promulgating a new rule requiring that the CP be conditioned on a post-CP demonstration of management capability. This proposed administrative action directly addresses Congressional Alternatives b(2) and b(5). See Chapter 4 for further discussion of this recommendation.

(3) Performance Objectives for QA Programs

The study found that the regulatory basis for QA in the nuclear industry, i.e., 10 CFR 50, Appendix B, was sound. The only significant change the study envisions is that Appendix B should be viewed by the NRC and industry as a "comprehensive, closed-loop management system", not just a program for the assurance of quality. While the study found the management practices advocated by Appendix B to be sound and not needing improvement, NRC's methods for implementing Appendix B emphasize form and paper at the expense of substance, and program implementation and effectiveness. As one member of the ACRS noted, any new QA initiatives will not have the effect of improving quality unless steps are taken to motivate people, both in design, construction and vendor operations. The current methods of quality assurance alienate professional and technically oriented people, as well as craftsmen and foremen. He said a way must be found to make these people feel that they can make an important contribution to design, construction and safe operation.

The study concluded that NRC's methods to get licensees to implement the management practices of Appendix B need to be changed so that licensees and their employees are motivated to achieve results rather than merely comply with regulations. The study recommends that this be done by re-examination of NRC's method of ensuring that Appendix B is implemented. Both Appendix B and NQA-1-1983, the voluntary consensus code and the standard, describe performance standards. The NRC must translate these performance standards into performance objectives; implementing Appendix B by establishing performance objectives would define what a licensee's QA program is expected to accomplish. NRC inspections would then measure the effectiveness of licensee management and the QA program in meeting the performance objectives.

The study recognizes that successfully achieving this fundamental shift in program emphasis from compliance to performance will not be easy. However, such a shift in NRC (and industry) emphasis is necessary if substantial improvements in quality and quality assurance are going to be made. The following paragraphs describe how such a program could be structured.

NRC currently establishes very prescriptive requirements for a "QA program" in Chapter 17 of NRC's Standard Review Plan. Once NRC has approved a QA program, the licensee develops a set of detailed implementing procedures in the form of a "QA manual". The licensee's employees use the QA manual to guide their actions.

The "QA program" reviews conducted by the NRC have emphasized description of the QA program and provide reasonable certainty that any NRC-approved QA program will have met all of the requirements of the Standard Review Plan Chapter 17 guidelines. However, major difficulties have arisen at some projects in implementing the written QA programs approved by the NRC. NRC inspection experience suggests, and this study has confirmed, that the major problems with QA programs are in their implementation, not in their description.

The study concluded that an alternative to the current approach should be developed in which performance objectives or criteria govern a licensee QA program rather than its written description. These performance objectives would establish what the NRC wants the licensee's QA activities to actually accomplish. The licensee would then develop a QA manual that establishes detailed procedures designed to meet NRC's performance objectives. The intermediate step of a "QA Program Description", which is currently reviewed and approved by NRC, would be eliminated. The performance objectives would be based upon 10 CFR 50, Appendix B, and would be a substitute for the current Chapter 17 guidelines. A licensee could elect to establish procedures that exceed NRC's minimums. However, a licensee's actual performance would be evaluated against NRC's minimum performance criteria rather than the procedures described in the licensee's QA manual, which could exceed NRC's minimums.

To implement this study conclusion on a trial basis, the NRC staff should begin developing a set of performance objectives for an operations QA program and implement it on a voluntary trial basis with one or more licensees who are currently constructing a plant and approaching the operating license stage. Currently, no CP applicants are pending, so the program would have to be tested on an operating license applicant. Because all CP licensees are required to prepare a new QA program for the operating phase of their project, this approach should allow an opportunity to test performance QA objectives in parallel with the existing program. If the proposed program is successful, the NRC should consider adopting performance objectives for all QA activities and should evaluate the benefits and costs of backfit of these performance objectives to all licensees. Although staff action to test the approach in a limited way has begun, this action cannot be considered to be a short-term action in terms of its effect on the assurance of quality. This proposed administrative action directly addresses Congressional Alternative b(4).

(4) Management Appraisals as an Adjunct to the CAT Inspections

The case studies conducted for this study produced a set of project and management characteristics evidenced by more successful projects, as well as a set of characteristics that tended to be shared by projects experiencing major quality-related problems. The empirical lessons learned

about the quality, capability, and effectiveness of management should be applied in future Construction Appraisal Team (CAT) inspections. (See Section 2.4.2 for a discussion of the CAT program.) Current CAT methodology emphasizes hardware inspection and indirectly draws inferences about the quality and effectiveness of project and quality management by assessing the finished project's quality. Management problems are thus identified indirectly and inferentially. The proposed adjunct to the CAT methodology would complement the existing methodology by viewing project and quality performance from the top down as well as from the bottom up. It is believed that potential or actual problems in the management of the project will be more quickly identified and better characterized through this augmentation of the CAT inspection approach.

This recommendation differs from the previously described recommended activities in that it can be implemented immediately and applied to plants currently under construction. This activity, coupled with the recommended interim expansion of the CAT program to cover plants currently under construction pending action on a third-party audit rule (see description of interim expanded CAT program in the next section) would provide a significant near-term enhancement in NRC's oversight of utility and project management. As one Regional Administrator noted, "The solution of the short-term effective management problem must be based on observed results and proper use of governmental authority." This proposed administrative action directly addresses Congressional Alternative b(4).

(5) Application of Ford Study Lessons to Plants Currently Under Construction/Inspection Prioritization

The NRC should apply lessons learned from this study regarding the elements of successful and unsuccessful commercial nuclear power plant construction experience, project organization, and management to projects currently under construction. This retrospective look would be used to identify any plants that might be more susceptible than others to problems during design and construction. An enhanced inspection effort should be undertaken to ensure that any such problems are detected as early as possible. This administrative action directly addresses Congressional Alternative b(4). This recommendation is discussed in more detail in Chapter 7.

(6) Improved Diagnostic Capability Including Trend Analysis

NRC inspection program management recognizes and this study confirms the need for NRC management and staff to recognize and treat NRC inspection findings and licensee event reports as symptoms of potential utility management shortcomings and to pursue them accordingly. In several of the major construction quality problems, the NRC was slow to diagnose the programmatic illnesses underlying the symptomatic information trickling into the NRC via the inspection program and licensee reports.

To address this problem, the study concluded that NRC inspection staff and management should (1) make a conscious effort to analyze each inspection finding to determine its root cause, (2) based on inspection experience, the results of this study, and other information, develop a set of con-

struction performance indicators to be monitored, trended and evaluated by each licensee for his own performance and by the NRC. These activities are discussed in more detail in Chapter 7. Such indicators should be oriented toward measuring the effectiveness of activities that contribute to, control, and verify construction quality. The trending program would be an extension of some present SALP activities and would provide input for future SALP evaluations. A goal of this "trending" program would be for the licensee and NRC to more quickly detect and correct quality problems. QA problems at any one site should be clearly and accurately identified, including root causes, and that information should be provided to all sites immediately. Strong results-oriented management of this activity is needed to ensure adequate followup and problem resolution.

As a corollary to developing this trending program, the NRC should revise its training program to instruct inspectors, supervisors, and managers in the use of the system and followup of findings. Also, as the inspection program is further revised from a compliance-based orientation to a performance-based orientation, inspector, supervisor, and management training must be revised to reflect the change in emphasis and to help develop the skills needed for effective evaluation of performance. This proposed administrative action directly addresses Congressional Alternative b(4).

(7) NRC/Utility Senior Management Meetings

The NRC should expand the existing practice of conducting senior-level meetings between NRC and utility management to discuss the status, progress, and problems of ongoing construction activities, particularly those relating to quality and quality assurance. In such meetings both top NRC and utility management have to focus on the problems of construction, including its quality. Such meetings require that top management of both the regulator and regulatee become personally aware of specific details of construction projects, including quality problems, and help to combat the attenuation of information that contributed to the quality-related problems at some projects and that is inherent to some degree in most organizational structures. This concept is strongly supported by one NRC Regional Administrator, who writes:

> Frequent planned meetings must be held between Regional Administrators, cognizant Office Directors, and high level licensee management for projects under construction. In addition, periodic meetings with the Commission that involve both a licensee and the staff should be held to assure Commission support, advice and project familiarity. Such meetings will serve to ensure direct involvement at the highest levels of licensee and NRC management in QA-related matters such as the adequacy of resources; the clear recognition of significant problems at licensee and other sites; and the acceptance (or non-acceptance) of corrective measures, including root causes and timeliness, by the NRC.

This administrative action directly addresses Congressional Alternative b(4).

(8) Enhanced Vendor and Supplier Inspection Program

The NRC is in the process of modifying its vendor and supplier inspection program to better prioritize its effort according to the significance of safety concerns. However, this NRC inspection program, like the construction inspection program, fulfills an oversight role only. The responsibility for the quality of a vendor's or supplier's product, like the construction quality of a nuclear power plant, lies with the licensee. With the decline in nuclear plant orders, the entire supplier/vendor/licensee infrastructure is changing, with unknown implications for safety and quality in the future. While this issue needs more study, within the present structure enhanced NRC enforcement is clearly appropriate against some licensees for failing to provide effective quality assurance oversight over their vendors, including in some cases failure to audit vendors and/or to detect work of unacceptable quality.

Although not the focus of this study, there are many examples of poor quality products supplied by vendors for use at nuclear power plants, which makes the vendor issue of considerable importance to the NRC. Three of the five NRC Regional Administrators provided comments on the vendor issue:

> I think the NRC should take a strong stand on unacceptable vendor performance, including enforcement action and "blackballing", as appropriate.
>
> I agree with (the above) comment concerning the role of the vendors. We need to take a much stronger stand on unacceptable vendor performance. As I have stated many times over the past 3 years, we need to have a strong enforcement policy for vendors, including AEs, NSSS and component suppliers, and equipment qualification facilities. In addition, we need to review our inspection programs to address the utilities vendor surveillance programs. Too many utilities sit back and expect the NRC to do their work with regard to vendors. We need to reverse this role and place the responsibility directly on the shoulders of the utility.
>
> Heavy emphasis must be placed on the identification of generic and QA weaknesses in the following organizations: Nuclear Steam Supply System Manufacturers, Architect Engineers, and Vendors supplying safety equipment. The recommendations relating to High Level Meetings with licensees are directly applicable to meetings with these organizations - including the Commission. This area must be aggressively pursued by the NRC to assure formal and prompt feedback to licensees.

The NRC vendor program is in the process of being restructured, reoriented, reprioritized, and relocated. While it is too early to characterize all effects of this transformation, the following is clear for the near-term:

- The licensee will continue to be held responsible for the quality of work performed for it by vendors.

- The NRC vendor inspection program in no way substitutes for or relieves the licensee of its responsibility for vendor oversight; the NRC vendor inspection program is NRC's QA check of the effectiveness of licensee oversight programs.

- Stronger enforcement action than in the past can be expected against licensees whose vendor and supplier oversight is demonstrably inadequate.

Special note should be taken here about the first bullet above. Many comments have been received on the desirability of licensing vendors, and in particular, the major vendors such as the A/E and NSSS manufacturers. This study has concluded that the current organizational environment that requires that the utility take all or most of the price risk for the nuclear power plant virtually demands that only the utility be licensed. The licensing of vendors would inevitably reduce some of the control utilities currently have over licensing-driven actions while still requiring the utility to pay for those actions. However, there are circumstances under which it may be desirable to license vendors, and this is discussed in Section 2.4.5 under the heading, "Project Ownership and Management Arrangements". This administrative action directly addresses Congressional Alternative b(4).

2.4.2 NRC Administrative Actions To Support the Detection Objective and To Lower the Threshold for Taking Action for Construction Quality Problems

This section is divided into discussion of actions already undertaken and actions recommended for consideration by the NRC.

Actions Already Under Way

(1) Resident Inspector Program

As directed by the Ford Amendment [Section 13(a)], the NRC has assigned at least one resident inspector to all sites under active construction where construction is more than 15% complete. The study found that the resident inspector program is the backbone of the present NRC inspection program and provides the NRC with a better awareness and understanding of the status of a construction project as well as a more continuous inspection presence than previously. Each of the five major quality-related problems that stimulated this study began or occurred before the resident inspector program was implemented. The day-to-day presence of the resident at a site allows him to better understand the project and improves the NRC's capability to determine the extent and magnitude of quality or quality assurance problems and to require corrective action in a more timely fashion.

While it cannot be conclusively demonstrated that major quality-related problems in construction would not have occurred if the resident program been in place earlier, the study found that several of the major quality-related problems would have been detected sooner and would not have been as serious if the program been implemented sooner. For future applicants,

the study concluded that the NRC should assign resident inspectors to the construction site as early as CP issuance and possibly as early as the start of any construction begun under a Limited Work Authorization before CP issuance. The exact timing would be determined on a case-by-case basis and such factors as prior nuclear construction experience would be considered. This administrative action directly addresses Congressional Alternative b(4).

(2) Team Inspections

One reason that NRC was slow to detect or realize the extent of some of the quality problems in design and construction is the difficulty in integrating and synthesizing, into a comprehensive picture, site-specific inspection results determined at different times by different inspectors in different disciplines. For several of the projects having significant quality-related problems, the extent and magnitude of the problem was eventually established by a comprehensive team inspection involving several inspectors in different disciplines and several weeks of concurrent field work. With such comprehensive team inspections, information can be interchanged frequently and quickly among inspectors looking at different areas, and synthesizing and integrating findings and developing project-wide conclusions are made easier.

Team inspections have also been shown to effectively overcome the problem of reaching the "threshold" for taking action in response to quality problems in construction. The NRC is establishing a pilot program in one of its five regional offices to test the feasibility and benefits of reorienting the present routine inspection program. The present inspection program generally supplements the resident program with inspections by individual specialists from the regional office and uses few team inspections. The reoriented program would (1) provide for more residents at each site where special circumstances apply, and (2) use team inspections as the primary inspection activity of the regional office. This trial program is consistent with this report's findings, and pending the results of the pilot inspection program, the NRC inspection program for all regions may be reoriented to place more residents at sites and place region-based inspection emphasis on team inspections. This administrative action directly addresses Congressional Alternative b(4).

(3) Construction Appraisal Team (CAT) Inspections

The team inspection approach for reactor construction projects has been tested by the NRC regions and instituted by NRC headquarters. A regional trial Construction Appraisal Team (CAT) inspection program was conducted in 1981, with eight trial inspections being performed by region-based inspectors. These inspections were effective in identifying hardware and construction quality problems not identified by the routine inspection program. However, the manpower demand of these team inspections caused the Regional Administrators to defer routine performance of this type of inspection. Although some regions have conducted subsequent CAT-type inspections on an as-needed basis (the inspection program encourages the regions to perform CAT-type inspections), they are not mandatory. The previously described pilot program was a test of whether they should be

made mandatory. A headquarters CAT program was instituted by the NRC Headquarters Office of Inspection and Enforcement (IE) in 1982. These headquarters-based CAT inspections serve as both an audit of the licensee's performance and the NRC's resident and regional-based inspection program. The primary emphasis of the CAT is to concentrate on examining safety-related hardware after installation and after the licensee's own quality control inspection process has been completed. The study recommends that future CAT inspections be modified to more directly address management issues through the addition of a management appraisal. See Section 2.4.1.

Each CAT inspection involves about ten professionals in various specialties who spend four to five weeks and 1,600 to 2,000 manhours on site. Counting preparation time, analysis, and report writing, each CAT inspection takes about three months to complete. As of February 1984, six headquarters-based CAT inspections had been conducted and further CAT inspections had been planned at a frequency of four per year. This frequency is not sufficient to provide CAT inspection coverage of the current population of plants under construction. Consequently, this study recommends an expansion of the CAT program to ensure that plants presently under construction are subject to either a CAT inspection or a comprehensive third-party audit. This recommendation is discussed later in this chapter. The CAT program is discussed also in Chapter 7. This administrative action directly addresses Congressional Alternative b(4).

(4) Integrated Design Inspection (IDI)

The NRC has also developed a special design inspection program whose object is to assess the quality of design activities. The design area received little inspection attention in the past, and recent experience, including some of the major quality-related problems that stimulated this study, indicated that NRC should increase its design inspection efforts. Like the CAT program, the Integrated Design Inspection (IDI) program uses the team approach and is conducted by the NRC Headquarters Office of Inspection and Enforcement.

The IDI inspection supplements a core group of NRC staff members with contractors or consultants having specific design expertise and experience. This design inspection program encompasses the total design process on a selected plant system, from formulating design and A&E criteria through developing and translating the design and its reviews to actual site construction. The inspection staff evaluates and confirms certain basic design information previously submitted in connection with license applications. Inspections are conducted at the A/E design organization and the site to verify that proper design control programs are in place. This program examines the adequacy and consistency of the integration of all the design details within a selected sample area. It is believed that conclusions about the adequacy of the overall design process can be drawn from this very detailed audit of a selected sample.

Each IDI requires about twelve persons and four months to complete. As of December 1983, three IDIs had been performed and current plans are to conduct three IDIs per year. This frequency is based on staffing limitations and is not sufficient to provide coverage of every plant under

construction. For the forseeable future, IDI inspections will concentrate on plants nearing completion of the construction process and for which the design is essentially complete. Among this group of plants, candidates for the IDI inspection are selected based on a review of all pertinent data, including such things as whether any other form of independent design review has been performed (such as an Independent Design Verification Program, see Section 2.4.3), the nuclear experience of the licensee and the A-E, results of other inspections, and advice from the NRC Regional Administrator. This administrative action directly addresses Congressional Alternative b(4). The IDI program is discussed further in Chapter 7.

(5) Contractor Support to the NRC Inspection Program

An increase in direct NRC inspection of licensee-sponsored design and construction would increase confidence that licensee commitments are being met. This is particularly true when special circumstances require added inspection attention (e.g., oversight of a project with a remedial program under way or one with many allegations of safety-related deficiencies).

On a trial basis, the CAT and IDI inspections have used substantial contractor support as one method for increasing the expert technical resources available to the NRC for carrying out its inspection responsibilities. Such contractor augmentations have proven to be extremely helpful for these headquarters-based inspection efforts. Like all NRC team inspections, contractor-supported team inspections are led by an NRC team leader having inspection authority and responsibility. There is no delegation of NRC inspection authority or responsibilities to a contractor. The use of contractor assistance for NRC inspections is being expanded in both headquarters and the region-based inspection programs, including regional team inspections. Other appropriate uses for contractor support are being sought. This administrative action directly addresses Congressional Alternative b(4).

(6) Revised Construction Inspection Program

The construction inspection program was recently revised for two reasons: (1) a recognition that procedures in NRC's inspection program manual exceeded inspection manpower resources; and (2) review of the licensee's written QA program and QA program documentation was being emphasized at the expense of observing work and inspecting hardware. The NRC staff is presently revising the individual inspection procedures in the construction inspection manual to better match the budgeted resources and to better focus the inspection effort to improve effectiveness.

The main goals of the revisions are as follows: (1) to shift emphasis of inspection from reviewing records to observing work; (2) to facilitate performance of certain procedures by resident inspectors; (3) to re-examine the scope and frequency of some inspections based on limitations of inspector resources; and (4) to eliminate redundancies in the procedures. Current plans will substantially consolidate procedures. It is too early to determine the full effect of these revisions of the written inspection program on the effectiveness of the implementation of the NRC inspection program. This administrative action directly addresses Congressional Alternative b(4) and is discussed further in Chapter 7.

A word of caution: Improvements resulting from the revised procedures are limited, as are any other improvements to the inspection program, by the following two considerations. First, NRC's inspection program is an oversight program only. It does not perform direct first-line QC inspection. It is not sufficiently staffed to perform a 100% oversight function and performs direct inspections of at most 1-2% of the safety-related work at a construction site, on a sampling basis. Second, only about 1.5 manyears per year of direct NRC inspection effort are budgeted for each reactor under construction.

Recommended Actions

(1) Independent Third-Party Audits

As indicated in Section 2.2, this study found that a program of periodic independent third-party evaluations, inspections, or audits of commercial nuclear power plant construction by qualified individuals would represent a significant improvement over current practice and would complement the Commission's own inspection program. Such independent audits would bring an additional measure of confidence that licensing commitments are being met and increase the probability that any major systematic quality deficiencies will be identified earlier than in the past. Current NRC direct inspection resources of about 1.5 staff years per reactor under construction per year have not been adequate to provide timely detection of all major problems. The added use of qualified, independent auditors would increase the probability of more timely detection of major problems.

The study recommends that for future CP applicants, CP issuance be conditioned on the applicant's entering into contracts or other arrangements with independent inspectors to periodically verify the adequacy of its achieved construction quality, quality assurance program performance, and ability to independently manage the effective performance of all QA and QC responsibilities. That is, the study recommends that the proposed third-party audit program meet the performance criteria implicit in both Congressional Alternatives b(2) and b(5).

The study recommends that current CP holders also be subject to a program of periodic independent third-party audits. Until the third-party audit program is established as a requirement, the NRC should continue with the current voluntary Independent Design Verification Program (IDVP) on a case-by-case basis and implement an expanded CAT program. These recommended actions are discussed below.

The recommended independent audits would be conducted for each plant under construction about every two years, with the scope and nature of the audit being adjusted to the construction schedule and level of completion. For example, the first audit should occur within the first 12 to 20 months of construction and would concentrate on civil and structural work and the design control process in addition to its primary objective of verifying management capability to successfully implement an effective QA program. Later audits would cover electrical work, piping, instrumentation and control, etc. The last audit would cover completed design verification as well as review proposed technical specifications against the plant design

and serve the purpose, among others, of the current voluntary IDVP program. Each audit would be designed to meet the requirements of Congressional Alternatives b(2) and b(5), i.e., to verify that the licensee had demonstrated the capability to independently manage or oversee the management of the effective performance of all QA and QC responsibilities for the project over the previous two years.

Criteria for the third-party audits, including independence criteria similar to those now used in the IDVP efforts, should be developed by the NRC staff in consultation with appropriate professionals and other interested groups. Those criteria should incorporate lessons learned from the NRC's evaluation of the third-party audits reviewed as part of the pilot program (Chapter 4), the case studies (Chapter 3), and the current IDVP, CAT, and IDI programs.

A regulatory analysis will have to be performed before this proposed action can be implemented as a new regulatory requirement. This proposed administrative action is also discussed in Chapter 4. This action directly addresses Congressional Alternatives b(2), b(4), and b(5).

(2) Interim Expanded CAT Program

Implementing a program for third-party audits for plants under construction would probably take two years or more from the date of initiation of action before it could become effective, if it were approved by the Commission. This time delay stems from the procedural safeguards that are a part of the rulemaking process. According to current estimates, many of the plants currently under construction will be completed within this time frame, and the third-party audit requirement would not apply to over half of the plants presently being constructed. Therefore, in the interim, pending the approval and implementation of a third-party audit rule, the study recommends that the NRC expand its CAT program to ensure that as many plants under construction as possible are subjected to either an intensive audit by a qualified third party or an NRC CAT inspection. Thereafter, CATs would be required on a sampling basis (to check third-party audit effectiveness). The management appraisal recommended in the preceding section as an adjunct to the CAT program should apply to the expanded CAT program as well. This proposed administrative action directly addresses Congressional Alternative b(4) and indirectly addresses Alternative b(5).

(3) Regional Team Inspections

The use of contractor support to assist headquarters-based team inspections has been successful. The study recommends that the regional inspection program be supplemented with additional use of contractor support for the routine regional inspection program. This will allow more NRC staff time for reactive inspections such as allegation followup, remedial

program inspections, and regional team inspections. As indicated previously, increased use of regional team inspections is being tested in one NRC regional office. Depending on its results, the NRC inspection program in all regions may be reoriented to emphasize team inspections. This administrative action addresses Congressional Alternative b(4) and is also discussed in Chapter 7.

(4) Resident Inspectors

The study found that for new applicants or for the restart of construction at projects presently in suspension, resident inspectors should be assigned to the site as early as possible, preferably before CP issuance and the start of safety-related construction activities. This study recommends that this finding become part of NRC's future policy on placing residents at construction sites. As indicated previously, the NRC is also establishing a pilot program in one of its regional offices which will place more resident inspectors at plant sites where special circumstances dictate. Depending on the outcome of this trial program, the NRC inspection program may be reoriented to an even heavier emphasis on resident inspectors. This proposed administrative action directly addresses Congressional Alternative b(4) and is discussed further in Chapter 7.

(5) Improved Licensee Detection Capability

In licensee QA programs, additional emphasis must be placed on identifying problems and trends, including the processing of nonconformance reports and design changes. The NRC should develop more definitive guidance to be followed by utilities for determining root causes of nonconformances, timeliness of corrective action, and evaluation of generic implications of nonconformances found both in the design and construction process. While the NRC needs to improve its own capability in these areas, the NRC sees, on a nation-wide basis, both good and bad practices and is in the most logical position to develop and share such information and generic guidance with the utilities. This proposed administrative action addresses Congressional Alternative b(4).

2.4.3 NRC Administrative Actions To Support the Assurance Objective and To Increase Public Confidence

This section is divided into discussions of actions already undertaken and recommended actions for consideration by the NRC.

Actions Already Under Way

(1) Independent Design Verification Program (IDVP)

On a case-by-case basis, the NRC staff has requested an applicant for an operating license to provide additional assurance that the design process used in constructing the plant has fully complied with NRC regulations and licensing commitments.

Many licensees have responded to this request by initiating a design review through an independent third-party contractor. This review has been termed the Independent Design Verification Program (IDVP). This program has been mentioned several times previously in conjunction with other actions under way or proposed, and is also discussed in Chapter 7. Reviews conducted under this program have provided an evaluation of the quality of design based on a detailed examination of a small sample. The independent review has also addressed programmatic areas, e.g., classification of systems and components, design and verification records, interface control and interdisciplinary review, consistency with the Final Safety Analysis Report (FSAR), nonconformances and corrective actions, and audit findings and resolutions. The review includes verifying specific design features by independent calculations and comparing installations against as-built drawings. The NRC staff reviews the selection of the independent review organization and the audit plan before they are implemented, reviews the completed report, and assesses the applicant's response to the audit findings. In all cases to date, the NRC staff has concluded that the applicant has complied with NRC regulations and licensing commitments.

The usefulness of these audits has varied from site to site because of the variability between each audit's scope and methodology. With the recent transfer of IDVP responsibility to the same NRC program office (IE) responsible for the IDI program, future IDVPs will be modeled somewhat like an IDI, and the degree of variability should decrease.

Recommended Actions

(1) Interim IDVP/Third-Party Audit

This study has concluded that a series of comprehensive third-party audits required by regulation with a clearly established set of audit criteria will better enable the NRC to meet its responsibilities than the current IDVP practice. Until this requirement has been established, however, the NRC should continue to encourage licensees to perform independent design reviews on a case-by-case basis.

The recommended third-party audit program was listed in Section 2.4.2 under the detection objective. However, it also strongly supports the assurance objective. The independent oversight brought to the nuclear construction process by the third-party audit concept should increase public confidence in the construction process. This administrative action directly addresses Congressional Alternatives b(4) and b(5).

(2) Audit Program for the NRC

One of the findings of the Kist Report was that the NRC should have a QA program for its own activities. While the CAT, IDI, and PAT (Performance Appraisal Team inspections) programs, as well as NRC Headquarters audits of regional performance, provide some degree of quality assurance over NRC regional activities, there is no formal NRC program for QA of NRC QA activities. In view of the study findings that shortcomings in the NRC QA program contributed partly to the quality problems that led to this study,

both the overall assurance of quality for nuclear power and the public's confidence in NRC's oversight of it would be enhanced if NRC had a formal QA program covering its own QA activites. The study recommends that such a program be established and that it include an audit program for NRC QA activities that provides for periodic independent audits.

2.4.4 Summary of NRC Actions Under Way and Actions To Be Taken

Table 2.1 summarizes the NRC actions under way and proposed actions to be taken.

Note: The NRC actions that have been identified and recommended by the study are extremely comprehensive, and several of them could consume all of NRC's current budget and manpower allocated to development of the quality assurance program. It will be necessary to prioritize the quality assurance issues within the other issues faced by the NRC and make resource allocations. As a result, some of the recommended actions may necessarily be deferred until the higher priority actions are completed.

TABLE 2.1. NRC Administrative Actions Under Way and Recommended for Nuclear Plants Under Construction to Support the NRC QA Program Objectives of Prevention, Detection, and Assurance

	Objective	Applies To Current Plants	Applies To Future Plants
I.	**Prevention/Improved Management**		
	Under Way		
1.	Systematic Assessment of Licensee Peformance	X	X
2.	Committee to Review Generic Requirements	X	X
	Recommended		
1.	Enhanced Pre-CP Review of Experience and Managerial Qualif./Advisory Board		X
2.	Post-CP Demonstration of Management Effectiveness		X
3.	QA Program Performance Objectives*	X	X
4.	Management Appraisals/CAT Adjunct*	X	X
5.	Inspection Prioritization of Plants Currently Under Construction*	X	X
6.	Improved Diagnostic Capability/Trend Analysis	X	X
7.	Senior Management Meetings	X	X
8.	Enhanced Vendor Program*	X	X
II.	**Detection/Lowered Threshold**		
	Under Way		
1.	Resident Inspector Program	X	X
2.	Team Inspections	X	X
3.	CAT Program	X	X
4.	IDI Program	X	X
5.	Contractor Support to the NRC Inspection Program	X	X
6.	Revised Inspection Program	X	X
	Recommended		
1.	Third-Party Audit/Interim CAT*/Interim IDVP*	X	X
2.	Regional Team Inspections*	X	X
3.	Expanded Resident Program*	X	X
4.	Improved Licensee Detection Capability	X	X
III.	**Assurance/Public Confidence**		
	Under Way		
1.	IDVP	X	
	Recommended		
1.	Interim IDVP*/Third-Party Audit	X	X
2.	QA of NRC	X	X

* Action on recommendation already begun.

2.4.5 Actions Requiring Further Analysis

During the course of this study, several possible actions were identified that unfortunately could not be sufficiently analyzed in the time frame of this report to be included as study recommendations. These possible actions are described below. In some cases further study is needed to determine the feasibility and benefits of further changes to NRC's programs. In other cases, further study is required to better understand certain issues that may have an impact on quality and the assurance of quality in the nuclear industry.

(1) Ford Amendment Study to Improve QA for Plants in Operation

The Ford Amendment directed the NRC to conduct a study designed to improve quality and the assurance of quality in the design and construction of nuclear power plants. An effort of similar magnitude and scope should be undertaken for plants in operation. Many more nuclear plants are in operation today in the U.S. (about 80) than are under active construction (about 40), and operating plants represent a more immediate threat to public health and safety than do plants under construction. The 1983 ATWS (anticipated transient without scram) event at the Salem nuclear station is a recent example of the importance of quality and quality assurance in nuclear power plant operations and maintenance. The near-term future focus of U.S. nuclear power will be in operations and maintenance, not design and construction and serious, though less publicized, operational problems with safety implications have occurred because of poor QA.

(2) Prioritization of QA Measures

The NRC needs to establish more detailed guidance for QA systems that prioritize quality-related efforts. Such a QA system is currently required by NRC regulations, but it has been unevenly implemented, partly because of a lack of appropriate NRC guidance. In some prioritized approaches, quality assurance measures are prioritized based on the safety, reliability and availability analyses such as discussed under (7), "Quality Engineering" below. The usefulness of this approach is suggested by findings of the study on the DOE, NASA and shipbuilding programs. The goal of new NRC guidance in this area would be to provide a logical foundation for applying quality measures to plant structures, systems, and components commensurate with their relative importance to achieving some system objective such as safety or reliability. This guidance should also reduce the application of deterministic engineering judgment to the lowest possible level. Although such guidance is expected to extend beyond the current "safety-related" class, it may also reduce quality program requirements for some equipment, systems or components that are presently considered to be "safety-related". This topic is discussed also in Chapters 7 and 9 and Appendices B and D.

(3) Measuring Effectiveness of QA Programs

As indicated in Chapter 1, this study did not attempt to quantify the relationships among quality, quality assurance, and safety, nor did it attempt to quantify the relationship between risk and quality assurance. It became increasingly clear during the study that clearly defined measures need to be developed to assess QA program effectiveness.

Developing such measures is crucial to meaningfully address the above unanswered questions. Moreover, without such measures, it is virtually impossible to evaluate the benefits that would accrue from adopting an alternative approach to QA (such as that of NASA, the Federal Aviation Administration (FAA), or DOE).

The NRC should set as top QA research priorities development of ways to measure QA program effectiveness and analyses to quantify the quality, quality assurance and safety relationship, and the relationship of risk to quality assurance. In particular, the effect of a QA program on plant safety should be evaluated through probabilistic and other risk analyses.

(4) Essentially Complete Design at CP Stage

The NRC should further analyze the feasibility and benefits of requiring that plant designs of future CP applicants be well advanced before construction activities begin. This analysis should also consider whether future applicants should be required to have scale models of their plants and computer-assisted drawings. (See public comment (3) in Section 10.2.1.) This research is suggested by the findings from the case studies (Chapter 3 and Appendix A), the review of outside programs (Chapter 9 and Appendix D), the study of contracts (Chapter 8 and Appendix C), and other study activities.

(5) Configuration Control/Management of Change

The NRC needs to further analyze the feasibility of applying the techniques of the aerospace industry's apparently successful configuration management approach to the nuclear industry's need for improved management of change. Change and the difficulty in managing change were found to have significant impacts on design and construction quality. This research is suggested by the results of the case studies (Chapter 3 and Appendix A), the study of outside QA programs (Chapter 9 and Appendix D), and comments from the study's special review group (Chapter 10).

As part of this effort, NRC should determine how best to revise staff review practices to provide more definitive procedures for managing changes to principal A&E design criteria. This analysis would include consideration of including licensee commitments to certain A&E design criteria contained in the PSAR as conditions of the CP. See the study conclusion on Alternative b(1) in Section 2.2.

(6) Feasibility of Readiness Reviews

The NRC should analyze the feasibility and benefits of requiring formal assessments by licensees of their readiness to proceed to the next critical phase of a project (i.e., planning to construction, construction to pre-operational testing, testing to operations). In such "readiness reviews" plant designers, construction managers, owner/operators, and (possibly) NRC staff would participate. The reviews could be required at key points in the project beginning with "design ready for construction" and could be repeated at selected key milestone points. The usefulness of this approach is suggested by the findings from the DOE, NASA and shipbuilding programs (see Chapter 9 and Appendix D).

(7) Quality Engineering

The NRC should analyze the degree to which NRC design requirements should include the completion of safety, reliability, and availability analyses, including failure modes and effects analyses, and fault tree and hazard or safety analyses. The usefulness of this approach is suggested by the findings from the DOE, NASA, FAA, foreign nuclear, and shipbuilding programs and the movement of the NRC toward expanded use of Probabilistic Risk Assessment. See Chapter 9 and Appendix D.

(8) Project Ownership and Management Arrangements/PUC Interface

Projects under construction appear to benefit significantly when the owners and members of the project team possess strong management experience and a strong financial position (see Chapter 8 and Appendix C). The advantage of these circumstances appears great enough to warrant NRC's examination of ways in which beneficial ownership and management arrangements can be stimulated and fostered. The specific advantages/disadvantages of various ownership and management arrangements for assuring safe and successful nuclear projects need careful study. Such a study should include determining which desirable changes are possible within the present statutory framework and which would require legislation.

Recent events affecting the nuclear industry suggest that financial considerations will be the principal determinant of any new CP applications and that a possible form of a new construction project may be the presentation to a utility of an essentially "turnkey" proposal by an NSSS manufacturer and A&E joint venture. One essential component of this proposal is likely to be assumption of a significant portion of the price risk by the joint venture. Consistent with the previous discussion (see Section 2.4.1, "Enhanced Vendor and Supplier Inspection Program") concerning the necessity for the entity having control of the funding also having responsibility for licensing, the appropriate CP licensee in this case might be the joint venture, not the utility. Further analysis must be undertaken to understand the potential implications of such "dual licensing" where the CP holder may be different from the operating licensee. For example, this process would be much simplified by using pre-approved sites whose licensing was separate from the CP process. It would also require a careful scrutiny of whether an operating license could reasonably be granted to a utility with no prior nuclear operating experience.

Further study of the NRC/PUC interaction must also be undertaken. There are indications that certain major preventive maintenance actions, such as replacing the recirculation piping in a boiling water reactor or replacing a steam generator in a pressurized water reactor, may be deferred by utilities because of concern over PUC policies. In cases like these, good engineering judgment and safety concerns indicate that the work should go forward, but it might be deferred because of a lack of confidence that PUCs will consider the "non-essential" maintenance expenses to have been prudently incurred, absent an NRC order to perform the maintenance. Other lessor examples of utilities deferring or postponing important maintenance activities because of concern over PUC policies exist. The NRC must develop a clearer understanding of its options and possible actions when faced by a new regulatory activism by state PUCs.

(9) Feasibility of Designated Representatives

One possible way to increase the resources available to carry out NRC inspections is the use of a "designated representative" (DR) program analogous to that employed by the FAA. Under the FAA's DR program, employees of an aircraft designer or manufacturer are deputized by the FAA to perform examinations, inspections, and tests on behalf of the FAA. If an analogous NRC program were established, it would place some NRC inspection responsibility and authority in the hands of employees of the licensee. This is a potentially controversial program whose advantages and disadvantages have not been fully assessed. Further analysis of this issue is needed before any conclusion can be reached. This topic is also discussed in Chapter 7 and was the subject of several NRC staff papers to the Commission (SECY 83-26 and SECY 83-499).

(10) Limiting Construction Permits

Many of the problems experienced by the nuclear industry recently were exacerbated by the surge of reactor orders and CP applications that occurred in the early and mid-1970s. This surge caused utilities to assemble project teams having key members with little or no prior nuclear experience. (See discussion in Chapter 3 and Appendix A.) Extraordinary demands were also placed on component suppliers and subcontractors, with many entities competing for increasingly scarce nuclear experienced personnel. The inevitable result was that performance declined--to sometimes unacceptable levels.

The NRC was also faced with problems caused by the earlier rapid growth of the nuclear industry: increased CP applications to be reviewed, safety evaluation reports to be prepared with practically every reactor design different from the last one reviewed, more and more construction projects to be inspected, competition with the industry for a limited pool of experienced personnel.

Consideration should be given to establishing limits on the rate of growth of any future resumption in nuclear power plant construction. Depending on when a resumption might begin and the circumstances causing such a resumption, the U.S. could be faced with problems similar to those that ocurred with the last rapid buildup. Many factors could influence a decision on the number of construction permits issued in a year. Such factors include the degree of standardization of design; the experience of the potential operators; industry capacity and residual experience, including major vendors, subcontractors and suppliers; NRC staffing levels and ability to respond to workload fluctuations; and the availability of sites.

Further analysis should be performed to identify the rapid-expansion-related problems that previously occurred and to develop guidelines for assessing whether and what future limits should be placed on issuing CPs by the NRC. These efforts should not be directed to establish such limits at this time but rather to identify the key parameters that could be used to establish such limits in the future.

Table 2.2 lists all the the actions discussed in 2.4.5 requiring further analysis.

TABLE 2.2. Actions Requiring Further Analysis

(1) Ford Amendment Study for Plants in Operation

(2) Prioritization of QA Measures:

Guidance on "Safety-Related" vs. "Important to Safety"

(3) Measuring Effectiveness of QA Programs

(4) Essentially Complete Design at CP Stage

(5) Feasibility of Aerospace Industry's Configuration Management Approach

(6) Feasibility of Readiness Reviews

(7) Quality Engineering

(8) Alternative Project Ownership and Management Arrangements/PUC Interface

(9) Feasibility of Designated Representatives

(10) Limiting Construction Permits

Note: The NRC actions that have been identified and recommended by the study are extremely comprehensive, and several of them could consume all of NRC's current budget and manpower allocated to development of the quality assurance program. It will be necessary to prioritize the quality assurance issues within the other issues faced by the NRC and to make resource allocations. As a result, some of the recommended actions may necessarily be deferred until the higher priority actions are completed.

2.5 ACTIONS OF THE NUCLEAR INDUSTRY

This section discusses actions already undertaken and future actions by the nuclear industry to improve quality and the assurance of quality in the industry. The preceding section discussed in detail the framework of NRC actions under way to improve quality and the assurance of quality in the nuclear industry. NRC actions were emphasized because the Ford Amendment specified that NRC actions be highlighted. While improvements to NRC's programs, methods, and organization are necessary for improving quality in the nuclear industry, they are not sufficient. The study concluded that the primary cause of the quality-related problems in the nuclear industry was shortcomings in utility management.

Real improvements to address this root cause must come from the industry itself. The NRC cannot write a regulation that will achieve good utility management. Better utility management must come from the utilities themselves, from the boards of directors, from the stockholders, and from the ratepayers. The NRC and the PUCs can provide penalties for poor utility management, but these negative incentives are of limited value without the utilities' conscious commitment to raise their own performance standards. Quality must be built into a plant by the builder, it cannot be inspected in by QA. Similarly, achieving quality in nuclear design, construction, and operation is the responsibility of the utility and utility management, and it must be achieved by them. The NRC cannot inspect quality into a plant.

Given that the sine qua non to improved quality in the nuclear industry is improved, informed, capabable utility management, this section discusses industry actions already taken or recommended by the study to improve quality.

2.5.1 Actions Already Undertaken

In 1979, in response to the accident at Three Mile Island, the nuclear industry created the Institute of Nuclear Power Operations (INPO). INPO's chartered mission is to promote the highest level of safety and reliability in operating nuclear power plants. In carrying out this mission, INPO strives to encourage excellence in all phases of design, construction, and operation. This study performed a thorough review of INPO's new program for construction evaluation and concluded that the program was consistent with INPO's stated mission of promoting excellence in construction and design (See Chapter 5.).

Another INPO activity that bears directly on improving utility management has been the sponsorship of several management workshops for utility chief executive officers, plant managers, and others to stress the importance of quality and management responsibility for quality and to strengthen management awareness, understanding and commitment to safe operation and quality construction of nuclear facilities. NRC Commissioners and senior managers have participated in these workshops to the mutual benefit of both the industry and the NRC. The study endorses the INPO program of management workshops, which is consistent with the belief that any significant improvements in the nuclear industry must start at the top.

2.5.2 Future Action

The already undertaken and proposed NRC actions described in Section 2.4 should result in many improvements on the part of the nuclear industry in the design and construction of nuclear power plants. Many of those actions were modifications to improve the NRC inspection program. It is important to understand the limitations of any NRC inspection program, no matter how many improvements are made to it.

The NRC inspection program is a sampling program that covers at most 1% to 2% of the safety-related construction activities at a site. Presently, only 1.5 staff years/year/reactor is budgeted for direct inspection of reactors under construction. Even if the NRC spent four or five times that inspection effort, it could not keep pace with all of the activities of the several thousand workers at a nuclear construction site. Although reshaping the NRC inspection programs along the lines indicated in earlier discussion will improve the programs and the overall assurance of quality, NRC actions alone will not be enough to stop future quality problems of the type that stimulated this report. As one NRC Regional Administrator noted, "While I endorse reshaping our inspections along the line described, if the licensee doesn't do the job properly, I don't believe we can ever count on our limited inspection program alone to provide timely identification of the scope of the problems. We have to achieve the principle of the licensee building quality in from the beginning."

The study confirmed the intuitively obvious observation that quality has to be put into a product or project by the producer or builder, not by the inspector. Because the NRC does not build nuclear plants, but only inspects them, no matter how much NRC inspection effort is devoted to plants under construction, the builder (i.e., the nuclear industry: utility-owners, A/E, CM, reactor supplier and other vendors) must ultimately achieve quality in the construction. If the nuclear industry does not take positive action, this report's recommendations will do little more than assure that poorly or questionably built plants do not operate. The recommendations will not assure that plants, once started, are not stopped in mid-construction due to quality problems. Such positive industry action cannot be successfully elicited through regulation; it must come because the nuclear industry wants it to. It must come because the nuclear industry, and each of its members, believes it is the right and necessary, but not the obligatory thing to do. In this regard, three conclusions of this study require voluntary industry action to be accomplished:

(1) Industry should view NRC requirements as minimum levels of performance, not absolute goals, and should capitalize on and expand on the practice of some utilities that continually seek to improve their level of performance and seek excellence in their operations. Industry establishment and support of INPO is a positive step in this direction.

The overriding, predominant conclusion of this report is that the common cause of poor quality in nuclear power plant construction is poor management by the responsible licensees--the utilities. It follows that the solution to the problem must also lie with utility management. To the extent the utilities use INPO, their performance can be aided measurably by the programs, reviews,

common knowledge, experience and peer pressure provided by INPO as an integral part of utility management. The NRC is farther removed and does not have responsibility for managing the utilities. In pursuing its statutory responsibilities for ensuring the health and safety of the public, the regulations, inspections, and penalties NRC imposes can motivate utility management, including INPO, to strive toward high quality in construction and operations through excellence in their management. However, since the problem and the ultimate solution lie with the utilities, NRC must recognize, encourage, support and nurture the efforts of utility management, including INPO, to improve their performance through their self-improvement, self-inspection, and self-developed programs and peer pressure. Their programs and practices are no substitute for NRC practices because the NRC has different responsibilities with the same goal. The NRC cannot and must not manage for them and they cannot fulfill NRC's statutory responsibilities to the public. This requires a rather critical balance: if NRC over-prescribes and over-regulates, it can stifle the efforts of utility management through INPO to do their job themselves. If this should happen, the net result would be the opposite of what was intended.

The study found that of the utilities studied, there was a strong correlation between project success in design and construction and embracement of the "rising standard of excellence" concept by the owner utility (see Section 3.4.3). INPO efforts in this direction will improve quality and safety in the nuclear industry and should contribute to increased public confidence in and acceptance of nuclear power. However, INPO alone cannot accomplish this goal. The active support and commitment of each nuclear power plant licensee to achieving excellence are needed. No regulation can achieve its full potential effect unless the regulatees comply with it because they believe in it, not just because they have to.

(2) The nuclear industry needs to treat quality assurance as a management tool, not as just another regulatory requirement, or as a substitute for active management oversight of a project.

The words of one NRC Regional Administrator are particularly appropriate on this point and merit repeating. He wrote:

> NRC's failure is in not effectively communicating to licensees that 10 CFR 50, Appendix B, describes a comprehensive closed loop management control system that is worthy of adoption as an overall construction management system. Consequently, managers often rely on inspecting quality into a plant rather than doing it right the first time. We believe additional NRC effort is warranted in establishing QA principles as an integral part of licensee construction management philosophy.

Quality assurance as a discipline cannot achieve or assure quality. In some organizations, management views QA as being responsible for quality and fires the QA manager if quality is not achieved. This study concluded that too often top utility management assessed blame in the wrong place and fired the wrong person(s). Top management, and through them, intermediate management and the workers, are primarily responsible for quality. Quality assurance is a management tool to provide feedback on how well quality objectives are being attained. Achieving quality requires effective management of the design and

construction process and placing quality as a high priority. The 18 criteria of Appendix B could just as easily be entitled "elements for effective management of a project" as "quality assurance criteria." Because they really are elements of effective management, they must be implemented; similarly, they will not serve as substitutes for active line management involvement in their implementation.

(3) Additional emphasis must be placed on aspects of licensee QA programs that identify problems and trends, including the processing of noncompliance reports and design changes.

In the past, neither the utilities nor the NRC have done well in analyzing trends and recognizing the root causes of quality problems. Several activities to improve NRC's capability in this regard are described in Section 2.2 and Chapter 7. Management of ongoing construction projects should develop trend analysis capabilities of their own, improve their ability to determine the root causes of identified problems, and do both of these in a more timely manner. The NRC should share the results of its industry-wide and generic analyses described in Section 2.4 with licensees so that both can enhance their programs.

Table 2.3 summarizes NRC and industry actions under way and actions proposed to be taken as well as the NRC/industry program for the assurance of quality in place when the major quality-related problems occurred (pre-1980).

TABLE 2.3. Comparison of Major Features of Former, Present and Proposed NRC and Industry Programs for Assurance of Quality in the Design and Construction of Nuclear Power Plants

Former Program (Pre 1980)	Present Program (1982-83)	Future Program	Application to Current or Future CP Holders
		NRC ACTIVITY	
°Appendix B Rqmts.	°Appendix B Rqmts.	°Appendix B Rqmts.	Both
°Licensing Review	°Licensing Review	°Performance Objectives for QA Programs	Both
°Regional-Based Insp.	°Regional-Based Insp.	°Revised Regional-Based Inspection	Both
	°Resident Insp. Prog.	°Expanded Resident Insp. Program	Both
	°CAT Inspections-4/yr	°Interim Expanded CAT Inspection Program	Both
	°IDI Inspections-3/yr	°IDI Inspections-3/yr	Both
		°Enhanced Pre-CP Rev. (Mgmt & Adv. Board)	Future Only
		°Post-CP Demonstrations as Condition of License	Future Only
		°NRC Mgmt Assessments/ CAT Adjunct	Both
		°Periodic Third-Party Audits	Both
		INDUSTRY ACTIVITY	
°Licensee QA Program	°Licensee QA Program	°Licensee QA Program	Both
°ASME Audits	°ASME Audits	°ASME Audits	Both
°NB Audits	°NB Audits	°NB Audits	Both
	°INPO Constr. Eval.	°INPO Audits	Both
	°IDVP Program	°Interim IDVP Program Pending Third-Party Audit Rule	Current

Note: The NRC actions that have been identified and recommended by the study are extremely comprehensive, and several of them could consume all of NRC's current budget and manpower allocated to development of the quality assurance program. It will be necessary to prioritize the quality assurance issues within the other issues faced by the NRC and to make resource allocations. As a result, some of the recommended actions may necessarily be deferred until the higher priority actions are completed.

2.6 POSSIBLE LEGISLATIVE INITIATIVES

Many knowledgeable people believe that any long-term solution to the problems of nuclear power in the U.S. involve major institutional changes to the structure of the nuclear industry itself. The institutional changes may require substantial legislative changes. This study confined itself only to the question of what changes, legislative or otherwise, should be made to improve quality and the assurance of quality in the commercial nuclear industry. Given this narrow scope, the study does not make any legislative recommendations at this time. However, further analysis of the impact of state Public Utility Commission decisions on construction quality and the issue of project ownership and management arrangements may require that legislation be proposed in the future. The relationship of state PUC actions to construction quality must be better understood before the need for a legislative proposal can be determined. Also, if further research indicates that public health and safety interests would be significantly better served if the owning, building, and operation of nuclear power plants were consolidated in the hands of fewer and stronger institutions, then legislation removing barriers to consolidating such interests might be proposed. Consolidation has long been widely discussed as a way of improving the quality of planning, financing, managing, designing, building and operating nuclear plants, but little concrete action has been taken in this area. Further analysis is clearly required and is proceeding.