

STATUS REPORT  
ON THE  
ENVIRONMENTAL QUALIFICATION  
TASK ACTION PLAN

November 1996

Office of Nuclear Reactor Regulation  
Division of Systems Safety and Analysis

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## Background

In a memorandum dated June 28, 1993, from Samuel J. Chilk of the Office of the Secretary of the Commission to James M. Taylor, Executive Director for Operations, the Commission directed the staff to treat environmental qualification (EQ) of electrical equipment as a potential safety issue within the regulatory process for operating reactors and to periodically inform the Commission of the staff's efforts. On July 1, 1993, the staff responded by submitting the EQ Task Action Plan (EQ-TAP) as Enclosure 3 of the third quarterly report on fire protection issues.

The purpose of the EQ task action plan is to evaluate and resolve existing environmental qualification concerns and to identify and resolve any other EQ issues that may exist. The following paragraphs present a brief history of the development of the EQ-TAP.

As a result of the staff's activities related to license renewal, EQ was identified as an area that required further review. As discussed in SECY-93-049, a major concern related to EQ was whether the EQ requirements for older plants were adequate to support license renewal. Consequently, the staff concluded that differences in EQ requirements between older and newer plants constituted a potential generic issue which should be evaluated for backfit independent of license renewal activities.

In support of the license renewal initiative, EQ testing of electric cables was performed by Sandia National Laboratories (SNL) under contract with the NRC. Some tests were performed to determine the effects of aging on typical electric cable products used in nuclear power plants. In addition, other SNL tests (unrelated to license renewal) were performed to assess the functionality of damaged electric cables during loss-of-coolant accident conditions. After accelerated aging, some of the environmentally qualified cables either failed or exhibited marginal insulation resistance during accident simulation, indicating that qualification of some electric cables may be non-conservative. Depending on the specific application, failure of electric cables during or following design-basis events could compromise the ability of safety-related equipment to function.

While some of the SNL test may have been more severe than required by NRC regulations, the test results raise questions with respect to the environmental qualification and accident performance capability of certain artificially aged equipment. The SNL test results are discussed in NUREG/CR-5772, "Aging, Condition Monitoring, and Loss-of-Coolant Accident (LOCA) Tests of Class 1E Electrical Cables," Volumes 1, 2 and 3; NRC Information Notice (IN) 92-81, "Potential Deficiency of Electrical Cables with Bonded Hypalon Jackets," dated December 11, 1992; and NRC Information Notice 93-33, "Potential Deficiency of Certain Class 1E Instrumentation and Control Cables," dated April 28, 1993. The SNL test results associated with LOCA testing of damaged electric cables (referred to in IN 92-81) were published as a draft NUREG/CR in July 1993.

Independent of the SNL tests, in 1993 the NRC staff performed a preliminary scoping analysis to assess the potential impact of inadequate equipment

qualification on core damage frequency (CDF). The scope of the analysis was limited to core damage prevention, considering internal events only with postulated failures of in-containment electrical equipment, with emphasis on electric cables. The major conclusions of the preliminary scoping analysis were that (1) EQ failures could have significant impact on CDF if electrical component reliabilities are reduced in the presence of a harsh environment, (2) the magnitude of the impact on core damage frequency is plant specific, and (3) the lack of reliability data result in significant uncertainty. Based on the results of the preliminary scoping study, the staff concluded that a more detailed EQ probabilistic risk assessment (PRA) should be completed.

Separate from the license renewal and PRA activities associated with EQ, the staff completed an assessment of the NRC fire protection program in response to issues that were raised by the Office of the Inspector General (OIG) in a report dated August 12, 1992. The staff's assessment of the fire protection program dated February 27, 1993, identified a number of weaknesses and made specific recommendations for programmatic improvements. In view of the weaknesses that were identified relative to the NRC fire protection program, the staff concluded that other programs such as EQ should also be reviewed to identify and correct any programmatic weaknesses that may exist.

Although the original issue involved whether the EQ requirements for older plants were adequate for license renewal, the issue has evolved into whether existing EQ standards and regulations are adequate for all operating reactors. With the preliminary scoping assessment indicating that inadequate EQ could be a significant contributor to core damage frequency, the staff determined that focused staff and management attention were necessary to fully address EQ concerns.

The staff developed the EQ task action plan to direct the review of EQ-related information and to perform EQ-related research so that the staff would be able to (1) evaluate differences that currently exist in EQ requirements between older and newer plants, (2) assess the adequacy of accelerated aging practices that are currently used for demonstrating equipment qualification, and (3) perform a programmatic review of EQ requirements to identify and resolve any other EQ issues that may exist.

Although the EQ-TAP describes planned actions, it should be recognized that this issue has been evolving and the actions, as described, may be modified as additional information is obtained through further research and review of industry operating experience. For example, Sandia National Laboratory recently submitted a report detailing the results of tests of electrical connectors performed to support license renewal. The connectors were artificially aged to simulate a 60-year service life and subjected to tests similar to, but perhaps not representative of, those used to qualify EQ equipment at nuclear power plants. Even though half of all the connectors failed, the staff does not consider the results a significant concern at this time due to the type of tests that were performed. The staff is currently performing a thorough review of the test results.

The EQ-TAP describes present and future activities of the offices of Nuclear Reactor Regulation (NRR) and Nuclear Regulatory Research (RES). Activities

include meetings with the industry, a program review of EQ, data collection and analysis, a refined PRA, research on aging and condition monitoring (CM), and options for resolving EQ concerns.

Following is a summary of the program's accomplishments, continuing actions, and past or planned schedular changes.

#### Summary of EQ-TAP Action Items

1. Informing the Commission, Senior Nuclear Regulatory Commission (NRC) Managers, and the Nuclear Industry of the Emerging EQ Issue.

Scope - NRR will prepare NRC information notices, submit a memorandum to the Commission, submit a user need request to RES, and make a presentation at the NRR Regulatory Information Conference to inform the appropriate people of the emerging EQ issue.

Completion Date - 5/28/93

Status - Completed. NRR issued two information notices on EQ and sent a memorandum to the Commission. The NRR staff presented a paper on EQ at the 1993 NRC Regulatory Information Conference. NRR made a presentation on EQ to staff members of the House Subcommittee on Mining and Energy. The staff will continue to periodically update the Commission on the status of the EQ-TAP.

2. Encouraging Nuclear Industry Participation in Identifying and Resolving Specific EQ Concerns.

Scope - NRR and RES will openly exchange information with industry groups. NRR and RES will meet with the Nuclear Energy Institute (NEI), the Nuclear Utility Group on EQ (NUGEQ), and the Electric Power Research Institute (EPRI) to apprise them of EQ review activities and to exchange information. The Plant Systems Branch (SPLB) and the Electrical, Materials and Mechanical Engineering Branch (EMMEB/RES) will coordinate activities with these industry groups.

Projected Completion Date - Ongoing

Status - On August 6-7, 1996 the staff held open meetings with the industry to discuss the findings from the Brookhaven National Laboratory's (BNL's) report NUREG/CR-6384, "Literature Review of Environmental Qualification of Safety-Related Electric Cables," Vols. 1 and 2. During the meeting, industry representatives committed to provide additional data and industry reports that they believe will resolve several of the 19 outstanding technical issues that the staff currently has under investigation as part of the EQ-TAP cable research program. RES is working with industry to obtain the additional data and reports so that they can be evaluated.

NRC staff members have also been active in communicating with the public. Staff members from RES and NRR participated in a NUQE public meeting in October 1996. Staff members from RES are scheduled to participate in the annual NUS EQ Database meeting scheduled for November 1996 and will participate in an upcoming Institute of Electrical and Electronics Engineers (IEEE) meeting on EQ in November 1996.

### 3. Programmatic Review

#### a. Review license renewal background information.

Scope - SPLB will collect and evaluate information that has been developed on EQ during the past few years from the NRR License Renewal Project Directorate. SPLB will review and evaluate the differences in the EQ requirements and the bases for the differences.

Completion Date - 4/94

Status - Completed. Report issued March 22, 1994. The staff found no issues requiring its immediate action and will address potential issues and concerns in the final report under EQ-TAP Action Item 3.g.

#### b. Review Fire Protection Reassessment Report.

Scope - SPLB will review recommendations from the NRC staff's February 27, 1993, reassessment of the fire protection program to discover specific issues that could relate to EQ.

Completion Date - 5/94

Status - Completed. Report issued May 10, 1994. The staff found no issues requiring its immediate action and will address potential issues and concerns in the final report under EQ-TAP Action Item 3.g.

#### c. Elicit opinions from others (regions, EQ experts).

Scope - SPLB will survey NRC regional offices, NRC Headquarters, and industry experts for potential problems with EQ and evaluate the results of the survey.

Completion Date - 5/94

Status - Completed. Report issued June 12, 1994. The staff considered information from the survey in developing the site visit plan and has used the information in preparing the RES EQ Program Plan. The staff found no issues requiring its immediate action and will address potential issues in the final report under EQ-TAP Action Item 3.g.

#### d. Review existing EQ program requirements.

Scope - SPLB will review EQ program requirements to discover any new EQ issues and will determine whether they need to be addressed. SPLB will

review 10 CFR 50.49, NUREG-0588, Division of Operating Reactors (DOR) Guidelines, Regulatory Guide 1.89, IEEE 323-1971, IEEE 323-1974, and so on, to determine whether potential programmatic problems exist.

Completion Date - 12/94

Status - Completed. Report issued December 21, 1994. The staff found no issues requiring its immediate action and will address potential issues and concerns in the final report under EQ-TAP Action Item 3.g.

e. Review audit and inspection practices of the NRC.

Scope - SPLB will review EQ inspection guidance and a sample of reports from licensee EQ inspections and vendor EQ inspections to discover programmatic problems. SPLB will review inspection findings, enforcement policy (Generic Letter 88-07), enforcement actions, and enforcement history.

Completion Date - 4/95

Status - Completed. Report issued April 14, 1995. The staff found no issues requiring its immediate action and will address potential issues and concerns in the final report under EQ-TAP Action Item 3.g.

f. Review EQ implementation practices of licensees.

Scope - SPLB will review and evaluate EQ implementation by visiting the sites of selected licensees to look for any problems.

Completion Date - 10/94

Status - Completed. Report issued October 7, 1994. The staff completed four of the five scheduled site visits, reviewed EQ program information from the licensee for the fifth site, and included this information in the report. The staff found no issues requiring its immediate action and will address potential issues in the final report under EQ-TAP Action Item 3.g.

g. Finalize review results.

Scope - The staff will document the results of the programmatic review in a final report and make recommendations for further action, as appropriate.

Projected Completion Date - 1/97

Status - The staff issued the first draft of this report in early 1995. Management review of the report resulted in a significant number of comments and subsequent revision. The staff widely disseminated a second draft report for comment in April 1996 to managers within the NRC (e.g., NRR, RES, Office for Analysis and Evaluation of Operational



Data). Comments and recommendations have been incorporated into the report, which is currently under review by NRR managers.

#### 4. Data Collection and Analysis

##### a. Review published documents and industry reports pertaining to EQ.

Scope - SPLB and RES will evaluate information about aging to assess the validity of qualification methods. The information to be reviewed includes approximately 300 documents. SPLB and RES will evaluate vendor and licensee qualification test reports to determine the test conditions and results.

Completion Date - 4/96

Status - RES through BNL completed its review of foreign and domestic test reports on EQ and the EPRI\NUS EQ database, focusing on published qualification and research reports on low-voltage instrumentation and control cables. The final report on the findings from the BNL literature survey was published as NUREG/CR-6384, Vols. 1 and 2, in April 1996. Of the 43 EQ-related topics considered for resolution under the EQ-TAP, 24 were either resolved as a result of the review of existing literature or left unresolved, with no further research recommended. BNL recommended the remaining 19 issues be resolved by conducting the cable condition monitoring research and test program (See EQ-TAP Item 7). RES held an open meeting with the industry in August 1996 to discuss the results of this report (See EQ-TAP Item 2). During the meeting, industry representatives committed to provide additional data and industry reports that they believe will resolve several of the 19 outstanding technical issues that the staff currently has under investigation as part of the EQ-TAP cable research program. RES is working with industry to obtain the reports so that they can be evaluated.

##### b. Gather equipment replacement experience.

Scope - SPLB, with contractor assistance, will make site visits to a sample of plants to review qualification tests, EQ binders, and maintenance and replacement records of EQ components. SPLB will review and evaluate equipment replacement schedules to determine where NRC should focus its resources in performing EQ aging reviews.

Completion Date - 9/94

Status - Completed. On September 15, 1994, the staff issued a final report, which included information from the site visits made under Task 3.f. The staff assessed plant replacement data and additional EQ measures taken at the plants visited, the impact on CDF of each category of equipment, and the contractor's experience; the staff then recommended retaining cables, connectors, and penetrations in NRC's EQ aging reviews.

c. Review operating experience data.

Scope - SPLB, with contractor assistance, will review licensee event reports (LERs) and the Nuclear Plant Reliability Data System (NPRDS) database for instances of age-related degradation of environmentally qualified equipment.

Completion Date - 6/94

Status - Completed. The review included LERs, Institute of Nuclear Power Operations (INPO) reports, and the NPRDS database. The staff issued the final report on June 30, 1994.

d. Review information on equipment failures at Three Mile Island (TMI) via the Department of Energy.

Scope - RES and SPLB will use contractor assistance to obtain and evaluate information on equipment failures during the TMI accident.

Completion Date - 4/96

Status - RES through BNL has completed its review of the relevant information regarding equipment failures at TMI. BNL has included the results of the review in the final report for Task 4.a (NUREG/CR-6384).

e. Develop an EQ database.

Scope - An RES contractor, with SPLB and RES guidance, will develop an integrated database of EQ test reports, research tests, and other test activities for EQ equipment.

Completion Date - 12/95

Status - BNL has finished developing an integrated EQ database. BNL's software selection and database format were accepted by the staff. Information reviewed for this program in Task 4.a was categorized and loaded into the database. Additional EQ information will be added to the database in the future, as appropriate.

5. Risk Assessment

a. Perform preliminary scoping study.

Scope - The Probabilistic Safety Assessment Branch (SPSB) of NRR will perform a preliminary scoping analysis to quantify the impact on CDF of environmentally qualified electrical equipment.

Completion Date - 4/93

Status - Completed. In a memorandum to T. Murley, A. Thadani detailed the results of the preliminary scoping study. The results indicated that EQ equipment failures in a harsh environment could significantly



affect core damage frequency, which prompted the staff to recommend a more detailed EQ PRA.

b. Perform final PRA.

Scope - SPLB, with SPSB and contractor assistance, will perform a more detailed assessment of the impact on CDF associated with EQ issues. SPSB will provide technical assistance to SPLB to interpret the SPSB contractor's assessment activities and to incorporate the results of other tasks into the final PRA.

Projected Completion Date - 1/97

Status - The staff initially assessed the impact on CDF of EQ issues in EQ-TAP Items 5.a and b. to support a potential backfit of plants with older EQ requirements, should the findings of the EQ-TAP conclude older requirements were inadequate. The results of the scoping study indicated that if the reliability of EQ components was reduced by the presence of harsh environments, the probability of CDF estimates could significantly increase, though the magnitude of the CDF impact was plant specific. The study also concluded, however, that the lack of reliability data bases resulted in significant uncertainty in the results. Further work (i.e., a final PRA) was recommended to determine whether data existed that could be used to perform a more accurate PRA.

The staff reviewed the findings from the initial scoping study (EQ-TAP Item 5.a), a follow-up study by Argonne National Laboratory to search the existing literature for reliability data for electrical components in harsh environments, and BNL's Literature Review (EQ-TAP 4.a), and issued a draft final report in April 1996 on PRA issues regarding EQ equipment. The draft report concluded that the information and data that is available cannot adequately support a more detailed PRA of EQ issues.

The staff considered further work, but is recommending against it for the following reason. Attachment 2 of this report describes the staff conclusions on the differences between older and newer EQ requirements. The staff concluded that the differences between older and newer EQ requirements do not constitute a significant safety issue, and that adequate margin exists in the qualification process for both older and newer plants to ensure public health and safety. Therefore, backfitting of plants with older EQ requirements will not be pursued on this basis, and further work to assess the impact on CDF of EQ equipment is not recommended.

The draft report is currently under management review.

c. Incorporate probabilistic risk assessment insights.

Scope - SPLB will coordinate with SP3B to incorporate insights from PRA into the other tasks in the action plan. The staff will review the results of the final PRA and determine the impact on CDF of the differences in EQ requirements.

Projected Completion Date - Ongoing

Status - The staff considered the results of the preliminary scoping study tasks during the preparation of the action plan. The staff will continue to use insights from the preliminary scoping study as implementation of the task action plan continues. NRR management is currently reviewing the Task 5.b summary report and will incorporate insights from that report, as appropriate.

6. Review and Evaluation of the Status of the EQ-TAP

Scope - SPLB, with RES assistance, will review the results of the initial tasks of the EQ-TAP (Items 2-5) to determine which issues can be resolved with available information and which issues will require further research. The results of this assessment will be used to refocus the RES EQ research program (EQ-TAP Item 7), if necessary. The final completion date for EQ-TAP Items 7.a and b. may be revised on the basis of the results of this review.

Projected Completion Date - 12/96

Status - The staff has been reviewing the results of the Literature Review (EQ-TAP Item 4.a) and the draft Program Review final report (EQ-TAP Item 3.g) and refocusing the scope of the cable research test program, as appropriate.

7. Technical Issues

a. Evaluate uncertainties associated with accelerated aging methodology.

Scope - RES, with SPLB assistance, will develop and implement a test program to evaluate the use of accelerated aging in the qualification of safety-related equipment within the scope of 10 CFR 50.49.

Projected Completion Date - 10/98

Status - Since the issuance of the third status report dated June 27, 1995, RES has issued the following documents:

- "Acquisition Plan for Non-Aged and Naturally Aged Cable Samples from Nuclear Facilities,"
- "Condition Monitoring Research Plan for Low-Voltage Electrical Cables," and

- "Preaging and LOCA Test Plan for Low-Voltage Electrical Cables."

These documents are now available at the Public Document Room (PDR). RES and NRR staff identified 43 EQ-related technical issues. In the two-volume NUREG/CR-6384 report issued by EMMEB/RES in April 1996, it was concluded that 18 of these issues have been resolved and that an additional 6 issues do not warrant further research.

An open meeting with the industry was held in August 1996 to discuss the results of the literature review (See EQ-TAP Item 2). During the meeting, industry representatives committed to provide additional data and industry reports that they believe will resolve several of the 19 outstanding technical issues that the staff currently has under investigation as part of the EQ-TAP cable research program. RES is working with industry to obtain the reports so that they can be evaluated. The results of this evaluation may further reduce the number of unresolved technical issues being considered.

The first set of cables were delivered to Wyle Labs on October 24, 1996 for preaging and LOCA testing. These cables are Rockbestos Firewall III with cross-linked polyethylene (XLPE) insulation and neoprene jacket. Test procedures have been developed by Wyle and are now being reviewed. Thermal preaging will be started in early November and will continue for approximately 3 weeks. Radiation aging will be performed at Georgia Tech University. Test cables will also be subjected to accident radiation exposure. LOCA testing of the cables is expected to begin in January 1997. The preaging and LOCA test parameters used for the first set of cable samples are consistent with those used for the original qualification tests for these cables. Other cable samples will be tested at a later date.

**b. Investigate CM methods.**

Scope - RES, with SPLB assistance, will develop and implement a test program to investigate methods of monitoring the condition or performing inservice inspection, of environmentally qualified cables to determine the degree of degradation.

Projected Completion Date - 10/98

Status - Several promising cable condition monitoring techniques are being evaluated. These techniques include indenter testing, oxygen induction time/temperature, Fourier transform infrared spectroscopy, time domain reflectometry, and ac impedance measurements. These CM techniques will be used periodically during preaging and LOCA testing of artificially and naturally aged cable samples. The results will be compared to elongation measurements to evaluate the effectiveness of the various CM methods being studied. Baseline testing of the first set of cable samples was completed on October 17, 1996.

c. Evaluate the impact of the new source term on EQ.

Scope - NRR and RES will develop a staff position on the use of the new source term for operating reactors. SPLB and RES will monitor this continuing activity to analyze its affect on EQ issues.

Interim Completion Date - 1/95

Status - The staff performed an interim study on the effects of the new source term on plant equipment and reported the results in a report issued on December 30, 1994. The staff will continue to monitor the work being conducted by NRR and RES regarding the use of the new source term and how it will affect EQ.

## 8. Options for Resolution

Scope - NRR and RES will develop options for resolving EQ concerns, such as issuing a generic letter, changing the rule, or documenting the acceptability of the current EQ rule and standards.

In developing options, the staff must consider the effect of changes on license renewal because the regulatory initiative will continue into the renewal term. The staff should also consider the possibility of including EQ CM and upgrades in the maintenance rule. The resolution must address all environmentally qualified components and should not be restricted to cables. It may be necessary to develop new acceptance criteria for EQ testing, elongation testing, indenter testing, and other issues.

Projected Completion Date - To be determined (TBD)

Status - Not applicable (N/A)

## 9. Implementation

a. Plan the NRC regulatory initiative.

Scope - NRR and RES will decide on appropriate regulatory action, plan and take the action, and document the basis for the action. NRR and RES may consider issuing an information notice or a generic letter or initiating rulemaking.

Projected Completion Date - TBD

Status - N/A

b. Review and verify nuclear industry actions

Scope - NRR will monitor licensee actions in response to the NRC staff's initiative on EQ. NRR and NRC regional offices will verify that licensees have taken appropriate action to correct any EQ problems.

Projected Completion Date - TBD

Status - N/A

Differences Between EQ Requirements  
for  
Older and Newer Plants

The staff has reviewed the information gathered to date under the Environmental Qualification Task Action Plan (EQ-TAP) and prepared this paper to address the differences that exist in the EQ requirements between older and newer plants. The conclusions and recommendations stated herein are based on a review of the staff's actions to date regarding the development of EQ regulations and requirements, and the information gathered specifically to resolve the issues identified in the EQ-TAP. The EQ-TAP was started in 1993 to evaluate and resolve existing EQ concerns. The major elements of the action plan include meetings with industry, a review of the EQ program, data collection and analysis (including a review of the existing literature regarding EQ), and research on aging and condition monitoring.

Problem Origin

Fundamental to NRC regulation of nuclear power reactors is the principle that safety systems must perform their intended function in spite of the environment which may result from postulated accidents. Confirmation that these systems will remain functional under postulated accident conditions constitutes environmental qualification. The NRC has used a variety of methods over the years to ensure that the EQ requirements are met for electrical safety-related equipment. For the oldest plants, qualification was based on the fact that electrical components were of high industrial quality. For newer plants constructed after 1971, qualification was judged on the basis of Institute of Electrical and Electronics Engineers (IEEE) 323-1971, "IEEE Trial-Use Standard: General Guide for Qualifying Class I Electrical Equipment for Nuclear Power Generating Stations." For the newest plants, those with NRC construction permit (CP) Safety Evaluation Reports (SERs) dated July 1, 1974 or later, the Commission adopted the version of IEEE 323 released in 1974. At the time of its release, the NRC considered backfitting IEEE 323-1974 to older plants, but recommended against it because the incremental improvements provided by the new standard were not considered safety significant and full implementation of IEEE 323-1974 required further development of other ancillary standards. Public comments and a review by the Advisory Committee on Reactor Safeguards (ACRS) did not alter the recommendation concerning backfitting the standard.

During promulgation of the EQ rule in 1983, the staff again had the opportunity to require that older plants meet the latest standards. When the rule was finalized, the staff deemed older qualification methods acceptable (i.e., grandfathered them) without providing a technical justification. At the time of rulemaking, the Commission stated that the new rule was based on the requirements in the Division of Operating Reactor (DOR) Guidelines (a set of guidelines issued November 13, 1979, that was used to review plants licensed to older EQ requirements) and NUREG-0588 Category II. The Commission also recognized that the industry had just invested significant human resources and billions of dollars conforming plants to the requirements of the DOR Guidelines and NUREG-0588 Category II. Requiring the older plants to meet



the newer EQ requirements (i.e., Category I) would invalidate the industry's efforts to comply with the staff's previous directions (i.e., meeting the requirement of the DOR Guidelines and NUREG-0588 Category II). Nonetheless, without requiring the older plants to upgrade to the latest EQ requirements, the staff, in effect, sanctioned the use of three different sets of EQ requirements.

### Staff Actions

Over the past 3 years, the staff collected information regarding the differences between older and newer EQ requirements. The staff found that older EQ requirements (DOR Guidelines and NUREG 0588 Category II) are not as rigorous as, and therefore not technically equivalent to, new EQ requirements (NUREG-0588 Category I). However, a preponderance of evidence supports the staff's decision not to backfit the requirements of IEEE 323-1974 on older plants and suggests that existing standards and regulations, even though not equivalent, are acceptable for all operating reactors. Due to the complex history of the EQ issue, the technical basis for the staff's decision not to backfit older plants was not well documented. However, the following paragraphs provide insight for the staff's conclusions.

Under Item 3 of the EQ-TAP, the staff undertook a comprehensive look at the history and development of the EQ regulations. The staff reviewed NRC EQ program requirements, audit and inspection practices, and licensee implementation of the EQ rule. From these reviews, the staff gained the following insights concerning the different EQ requirements found at reactor sites:

- Between 1979 and 1988, all plants were subject to comprehensive inspections of their EQ programs. The staff developed guidelines for reviewing documentation associated with older plants (DOR Guidelines for the oldest plants, NUREG-0588 Category II for those plants committed to meet the requirements of IEEE 323-1971). Although not as rigorous as the requirements for the newest plants, these guidelines identified acceptable methods for the environmental qualification of electrical equipment in operating reactors, and were generally based on IEEE 323-1974. The guidelines were intended to ensure even the oldest plants met minimum safety criteria. The staff followed up the documentation review with on-site inspections at each licensee to ensure the equipment described in the EQ documentation matched the equipment installed in the plant.
- During the site visits conducted as part of the task action plan (EQ-TAP Item 3.f), the staff found that at older sites most of the EQ cable used in containment was aged as part of the qualification process, even though the qualification requirements did not require aging unless the equipment was known to be susceptible to some form of aging. At one site, all qualified equipment met NUREG-0588 Category I requirements even though the reactor was licensed under NUREG 0588 Category II. These findings were supported by a survey sponsored by the Nuclear Management and Resources Council (NUMARC) in cooperation with the Nuclear Utility Group on Environmental Qualification. The survey found



that a majority of the cables and components in older reactor plants met NUREG-0588 Category I requirements or had been aged as part of the qualification process. The survey results were forwarded to the Commission by NUMARC in a letter dated December 21, 1993. Likewise, a review of the Idaho National Engineering Laboratory EQ Database assembled during the initial review of licensee EQ programs showed that 80% of all qualified equipment at older sites had been preaged.

- A survey was conducted of NRC and industry EQ experts on a wide variety of EQ-related topics (EQ-TAP Item 3.c). Because of the diverse backgrounds of the survey participants, consensus could not be achieved on many issues. However, the following insights were obtained from reviewing the responses to certain survey questions related to older EQ requirements:

(a) Most respondents believed the current requirements at both older and newer plants were adequate to ensure safety. The respondents based their views on experience of utility EQ experts (practitioners), experience with IEEE standards committees, national laboratory studies, 20 years of qualification test experience, 15 years of research testing at Sandia National Laboratory, the significant environmental and operating time conservatisms inherent in the qualification process, and hundreds of years of operating experience at nuclear power plants.

(b) Respondents agreed that operating experience indicates that equipment is not aging as fast as predicted. Most plants currently employ some form of environmental monitoring to ensure local temperatures do not exceed those predicted in qualification calculations. The licensees have found that actual operating environments have been consistently less severe than predicted.

(c) Most respondents agreed that equipment (both older and newer) currently installed in plants is not routinely failing due to aging effects. Analyses of past age-related failures indicate that improper manufacturing and the influence of thermal or radiation "hotspots" have been the primary causes of these failures.

Under EQ-TAP Item 4, "Data Collection and Evaluation," the staff performed reviews of (a) replacement experience for EQ components, (b) operating experience through licensee event reports and the Nuclear Plant Reliability Data System, and (c) EQ-related literature (EQ test reports, research reports, and other EQ-related literature). From these reviews, the staff gained the following insights concerning the different EQ requirements found at reactor sites:

- At a sample of four reactor sites with differing EQ requirements, cables and connectors known to be in high temperature or radiation environments were inspected and changed out on a periodic basis at each site. All sites in the sample employed some form of radiation or temperature monitoring in selected locations in the plant.

- Many sites have procedures that require workers to document the condition of EQ equipment when performing an inspection or maintenance activity on the equipment. This type of condition monitoring allows the licensee to trend age-related degradation.
- The literature review (EQ-TAP Item 4.a) performed by Brookhaven National Laboratory (BNL) included hundreds of EQ-related documents. BNL observed that according to past research, a number of cables previously qualified to DOR Guidelines and NUREG-0588 Category II requirements passed Category I qualification requirements. In addition, test cables have operated in environments 180 °C over DOR Guidelines, indicating significant temperature margin. Differences in test sequence were also investigated and found not to affect the acceptability of past qualification results. BNL also found that a sample of cables qualified to the oldest requirements have passed accident profiles which meet the latest requirements. Although not a comprehensive accounting of all equipment qualified to older standards, these results indicated that equipment qualified to older standards has margin.
- The staff found that EQ equipment other than cables, connectors and penetrations is refurbished or replaced. Surveillances, tests, and calibrations are also performed on a regular basis to give operators information about the performance of EQ equipment.
- Some EQ equipment (cables and components) qualified to older requirements and installed in harsh environments was not preaged prior to EQ testing. However, this equipment represents only a small fraction of all safety-related equipment and each piece has been reviewed to ensure the equipment does not contain any materials that are known to be sensitive to thermal or radiation environments. In addition, the EQ rule (10 CFR 50.49) requires that when qualified equipment is replaced, it must be replaced with equipment qualified to the newest standards. Thus, over time, the percentage of equipment in licensee EQ programs qualified to older EQ requirements has diminished.

### Conclusions

EQ-related literature and on-site EQ documentation is replete with examples supporting the position that older qualification requirements are adequate. The staff, therefore, has reasonable assurance that its decision not to backfit older plants to the newest EQ requirements was not flawed and remains valid.

Even though the staff has concluded that the differences between older and newer EQ requirements do not constitute a significant safety issue, and that adequate margin exists in the qualification process for both older and newer plants to ensure public health and safety, uncertainties associated with the methodologies used to predict the effects of age-related degradation and LOCA survivability indicate that it would be prudent to have some form of condition monitoring during the current and the license renewal period. The staff is currently sponsoring research to investigate whether certain condition monitoring techniques can be used successfully to predict the condition of nuclear power plant cables that are within the scope of 10 CFR 50.49.