

Environmental Qualification Operating Events Review

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SCIENTECH Report No. SCIE-NRC-223-93

November 29, 1993

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1.0 INTRODUCTION

The licensing bases of older plants with regard to environmental qualification (EQ) differ from more recently commissioned plants. Specifically, the Division of Operating Reactors (DOR) Guidelines, "Guidelines for Evaluating Environmental Qualification of Class 1E Electrical Equipment in Operating Reactors," contained in I&E Bulletin 79-01B, which was applied to older plants, were different from the requirements of NUREG-0588, "Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment" which were applied to newer plants. (Appendix A is a comparison of the DOR and NUREG-0588 requirements; Appendix B shows which requirements apply to which plants.) In 1982, the EQ Rule, 10 CFR 50.49, was published; it applies to plants after February 1983.

There is a generic concern on the part of the NRC Staff that some electrical equipment in use at nuclear power plants in safety-related systems may not be capable of surviving the design basis accident that it was intended to mitigate, because of differences among operating plants' EQ program requirements. For example, some equipment may not have been subjected to appropriate accelerated aging, and its ability to withstand accident environmental conditions is uncertain. As a result of its concern, the NRC Staff has concluded that differences in EQ requirements, as shown in Appendix A, "Comparison of EQ Requirements", constitute a potential generic issue that should be evaluated for backfit.

1.1 Scope of Work

As part of its current support of NRC's Division of Systems Safety and Analysis, SCIENTECH was tasked to assist in the NRC's evaluation of whether existing standards and regulations for EQ are appropriate for all operating reactors. Specifically, SCIENTECH was tasked to review a variety of information on operating events related to EQ and to identify any concerns relating to EQ, especially instances in which environmentally qualified equipment experienced problems prior to the end of its qualified life. Subsequent sections of this report describe how the review was conducted, what was found, the implications of what was found, and recommendations related to the EQ program and related programs.

1.2 EQ Program Structure

The commercial nuclear EQ program consists of two major parts:

- A framework of requirements and guidelines in the form of regulations, guides, and standards.
- Programs established by the commercial nuclear industry to effectively implement EQ requirements and guidelines throughout the entire life cycle of a plant.

In conducting its review of operating events, SCIENTECH looked for specific, as well as programmatic, EQ concerns related to both of these major parts. Important aspects of each part are discussed below.

The fundamental regulatory requirement for EQ is contained in 10CFR50 Appendix A, General Design Criterion #4, Environmental and Dynamic Effects Design Bases, which states that "structures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents." As the understanding and the technology associated with EQ evolved, an infrastructure of further requirements, guidelines, and standards emerged. Examples of this infrastructure are: 10CFR50.49, NUREG documents, Regulatory Guides, I.E. Bulletins/Circulars/Notices, Generic Letters, and certain industry standards (endorsed by the NRC). Although comprehensive and

well-founded, this infrastructure is by no means fixed; it continues to evolve as new insights, issues, and technologies develop. *Carroll*

As with the EQ regulatory infrastructure, programs for implementation of EQ requirements by the nuclear industry are multi-faceted and continue to evolve. Important considerations during various phases of the plant life cycle are as follows:

Design Engineering. Design engineering pertains to the efforts associated with the design of the original plant and with the design of plant modifications for an operating plant. Associated EQ considerations include: proper equipment identification on an EQ Master List; location and testing of electrical equipment and components requiring EQ; specification of appropriate EQ requirements; identification of the normal and post-accident environments for the equipment; maintenance of records and reports to demonstrate EQ; self-assessment of program effectiveness.

Procurement. Like design engineering, procurement efforts occur during initial plant construction and through the life of a plant. Associated EQ considerations include: vendor testing and analyses enveloping the EQ requirements in the purchase specification; comprehensive documentation demonstrating that the equipment meets the specified technical and EQ requirements; instructions delineating the installation and maintenance requirements necessary to preserve the EQ status of the equipment; storage systems and control processes that ensure that the right equipment and material is issued to craft and maintenance personnel.

Installation. Equipment installation occurs during initial plant construction, following equipment removal for repair or refurbishment, and as part of equipment replacement or plant modification. Associated EQ consideration: development of complete work packages for craft personnel to ensure that the equipment is installed, located, and configured consistent with the EQ envelope and configuration for which the equipment was qualified.

Testing and Operation. Following installation, or reinstallation, and periodically throughout the operating life of the plant, a variety of tests and checks are performed to verify that installed equipment is operable. Associated EQ considerations include: test procedures and intervals consistent with vendor recommendations to preserve the EQ status of the equipment; periodic checks to verify that equipment is being operated as intended and that the plant operating environment is actually what was specified for EQ aging purposes; plant operating records and incident reports maintained and analyzed for trends, root causes, and generic lessons learned.

Maintenance. The requirement to perform maintenance on equipment begins, in some cases, as soon as the equipment arrives on site and lasts throughout the life of the plant. Associated EQ considerations include: maintenance intervals, procedures, and materials that meet vendor requirements to ensure that the equipment's EQ status is preserved; storage and analysis of maintenance data for trends, root causes, and generic lessons learned.

1.3 EQ Considerations for Equipment and Components

Equipment and components in the EQ program must perform their intended safety function during and following design basis accidents. In the extreme case, such equipment and components must perform in a post-accident environment, inside and outside containment, that is harsh - that is, significantly more severe than that which is present during normal plant operation. Such *severe* equipment and components contain or comprise transducers, limit switches, seals, seats, electronics, terminal blocks, and wiring. Equipment and components are powered, controlled, and connected throughout the plant by other components subject to the EQ program, such as, cables, splices, and containment penetrations. Conduit and conduit seals also play an important role in EQ by defining and maintaining the EQ boundaries of equipment and components in the EQ program.

Typical EQ concerns for equipment and components are discussed below:

Cables. Conventional cables with rubber or plastic insulation and a protective outer cover are the most common, but coaxial cables and mineral insulated cables are typically used to connect low signal strength outputs to pre-amplifiers. Most of the cables provide their own protection, but coaxial cables generally need to be located inside a metal conduit. High temperatures and radiation fields will prematurely age cable, and too small a bending radius on corners will increase the chance of damage.

Cable Splices. Cable splices provide a way to connect cables and wires without exposing the metal parts to the environment. Bolted or crimped lugs connect the wires, and special heat-shrinkable tubing, or sleeving, with a sealing compound inside is shrunk over the electrical connection and the existing insulation to complete the splice. In some applications, more substantial mechanical protection is required over the sleeves but does not contribute to the seal.

Conduit Seals. Conduit and conduit seals provide a qualified means of protecting the connections between components and cables. Such devices are manufactured by only a handful of vendors and require care to install correctly to avoid damaging the neck-seal on components, such as, transmitters. A brace is sometimes needed to ensure that the body of the component is not allowed to move during the installation of the conduit seal. Lubricant is required on the pipe threads of the conduit seal to avoid galling and lock-up of the threads prior to full engagement, which gives a misleading high torque reading before a true seal is achieved. Orientation and location of conduit weep holes are also important.

Electric Penetrations. Electric penetrations provide a qualified means of connecting the cables inside containment to the cables outside containment. The sealing requirements are much the same as those for conduit. In addition, the penetration must be selected such that the largest fault current in the circuits does not cause overheating and degradation of the penetration.

Sensors, Detectors, and Transmitters. These are the basic components that provide the measurements of the various parameters required to monitor and control the plant. Some are more sensitive than others. Some contain electronic circuits that are very sensitive to radiation, which not only ages semi-conductor materials but changes its performance. Most contain terminal blocks and internal wiring. All of them have to be connected to the plant cabling system while, at the same time, being protected from the effects of temperature, pressure, humidity, and radiation. Access to the electronics and terminal blocks, which is required for calibration and preventative maintenance, is usually accomplished through removable end caps or covers. These are sealed by O-rings, which must be lubricated using a non-petroleum based substance (usually silicone grease), to allow them to deform into the sealed configuration as the end cap or cover is secured to the correct torque. Such devices are typically connected to plant cables using conduits and conduit seals.

Solenoid Operated Valves. Solenoid operated valves (SOVs) are used extensively in harsh environments; consequently, SOV internals must be properly qualified and protected. Conduit seals, cover gaskets, and shaft seals are required. As noted previously, care must be taken when the conduit and SOV are interfaced to ensure a proper seal. Cover gaskets and seals are usually required to be replaced every few years to maintain the EQ of the SOV.

Motor Operated Valves. Motor operated valves (MOVs) are the primary means for controlling flow to most safety-related fluid systems in harsh environments; consequently, their internals must be properly qualified and protected. Conduit seals, cover gaskets, and shaft seals are required. Internal components that must be qualified include terminal blocks, limit switches, motor insulation, and wiring. Limit switches are particularly susceptible to corrosion due to moisture intrusion resulting in open circuits and "welded" contacts.

Limit Switches. Limit switches are used to determine the position of components such as valves and breakers. Their survival through design basis events is essential to the continued operation of vital safety systems by keeping the operations staff up to date on the status of process and safety

systems and on the status of containment boundary integrity. Those located in a harsh environment need conduit seals and cover gaskets, which may have to be replaced on a regular schedule to maintain EQ.

Electric Motors. Electric motors located in harsh areas must have their internals properly qualified and protected. Conduit seals, cover gaskets, and shaft seals are required. Components requiring protection involve internal limit switches, insulation, and wiring. The power leads need special care because of their large size, which is above that sealable by conduit seals. Periodic cleaning of filters in air-intakes is also an EQ consideration because overheating of the windings accelerates aging of electrical insulation.

2.0 APPROACH AND OVERALL RESULTS

SCIENTECH was tasked to gather and review information on operating events related to EQ and to identify any concerns related to EQ, especially instances in which environmentally qualified equipment experienced problems prior to the end of its qualified life. This section describes how the review was conducted and what the overall results of the review were.

2.1 Approach

The task was accomplished by the SCIENTECH EQ Team in three steps:

- Identification and collection of operating event data.
- Review and codification/categorization of operating event data related to EQ.
- Analysis of codified data and development of conclusions and recommendations.

The paragraphs below discuss the three steps further.

2.1.1 Data Collection

Terms such as "equipment qualification" and "environmental qualification" are not used to categorize, and are seldom used as keyword, operating events in the three sources identified for review: Licensee Event Report (LERs), Institute of Nuclear Plant Operations (INPO) reports, and the Nuclear Plant Reliability Data System (NPRDS). Automated searches based on these two terms over the period of interest (1980 through 1993) would have resulted in an incomplete set of operating reports for review. Conversely, gathering and reviewing all LERs, INPO reports, and NPRDS data associated with electrical equipment over the period 1980 through 1993 would have been unnecessarily burdensome. Therefore, SCIENTECH worked with the NRC Plant Systems Branch Staff and information experts for each of the three sources to identify and compile the following plant operating data for the SCIENTECH EQ Team to review:

- Approximately 2000 LERs for electrical, instrumentation, and control equipment in the following LER categories: wrong material, wrong part, seal problems, water spray, high humidity, and high steam conditions (period: 1980-1993).
- Approximately 200 INPO reports for electrical, instrumentation, and control equipment based on a variety of electronic keyword and manual searches (period: 1980-1993).
- Twelve NPRDS reports for Class 1E component failures inside containment (period: 1990-1993).

2.1.2 Data Review

The SCIENTECH EQ Team reviewed the identified reports to eliminate those pertaining to events and failures that were not EQ-related, and to categorize, or codify, those reports that were EQ-related to facilitate further analysis. Over 80% of the reports were determined to be not EQ-related, leaving 395 reports for codification and further analysis. The term "failure" as used throughout this report is applied broadly to:

- Failure of a component or piece of equipment, prior to the end of its qualified life, to perform its function during normal operation or to perform as required during periodic testing.

- Visible degradation or damage to a component or piece of equipment such that it may fail prior to the end of its qualified life or before it completes its post-accident function.
- Administrative or technical breakdowns in the EQ program or its related processes.

It should be noted that, in some cases, EQ-related reports described a number of similar failures in one submittal, for example, a number of common cause valve or instrument failures discovered during a maintenance outage.

The codification process involved the development of a table summarizing relevant information for each EQ-related document: the document number; codes identifying component location, how it failed, when the failure was found, and when the failure was caused; and a brief description of the EQ failure. The codes developed and used by the SCIENTECH EQ Team were as follows:

- W – Where was the component located?
 - IC Inside containment, or both inside and outside containment
 - OH Outside containment, harsh environment
 - OM Outside containment, mild environment
 - US Unsure
- C – What type of failure was it?
 - DE Design error
 - DT Temperature failure
 - IE Installation error
 - LD Lack of documentation to support EQ
 - OL Omission from EQ master list
 - PE Procurement error
 - SF Seal failure or moisture intrusion
 - VA Visible aging
 - US Unsure
- F – When was the failure found?
 - DI During installation, found by utility
 - FO During operation, found by utility
 - IT During testing, found by utility
 - MM During maintenance or modifications, found by utility
 - NR During NRC review or inspection
 - UA During utility assessment
 - UG During utility review or inspection in response to a generic concern
 - US Unsure
- M – When was the error made that led to the failure?
 - DM During manufacture
 - ID During initial design
 - II During initial installation
 - PD During plant modification
 - PM During plant maintenance
 - US Unsure

These codes were selected because they relate to the types of issues and data required by the NRC in its overall evaluation of current EQ requirements and because such information is typically contained in or readily derived from the EQ-related reports reviewed.

A compilation of the results of this step for each of the 395 EQ-related reports is provided in Appendix C. Appendix D provides a count of the EQ-related LERs versus plant docket numbers for the database reviewed by the SCIENTECH EQ Team.

2.1.3 Analysis

Analysis was conducted after the reports were codified and summarized. The structure of the data shown in Appendix C facilitated a variety of analyses. The data was sorted, counted, and plotted vs. time; for example, failures were sorted by type and similar types were analyzed for common causes and trends over time. The SCIENTECH EQ Team looked for linkages among categories and types of equipment. Furthermore, the team looked for generic implications and themes of significance for the EQ program.

The analysis was supplemented, where applicable, by insights and information from the NRC-Industry EQ Workshop, November 15-16, 1993. Once the analysis was complete, the team developed conclusions and, where applicable, recommendations for the EQ program. A summary of the results of the analysis of the 395 EQ-related reports, and related conclusions and recommendations, are contained in Section 3.

2.2 Overall Results

A summary of the overall results of the SCIENTECH EQ Team's review and codification of the EQ-related reports is provided in Table 2-1 and Table 2-2. Table 2-1 shows a breakdown of the 395 reports by evaluation categories, and indicates the total number of, and percentage of, reports in each category and code. Table 2-2 shows a breakdown of EQ-related LERs by EQ program type (i.e., DOR Guidelines, Category I and II). (Table 2-2 is limited to LERs because INPO reports typically applied to numerous plants and because the NPRDS data did not cover the period 1980-1989.)

Significant observations from Table 2-1, which are discussed in further detail in Section 3, are as follows:

- Most equipment failures occurred in areas that would sustain post-accident harsh environments or that experienced high temperature, humidity, and/or radiation during normal operation (codes IC and OH).
- Seal failure/moisture intrusion (SF) was a significant contributor to equipment failures during normal operation when compared to temperature (DT) and aging (VA) effects; however, together, these were small contributors when compared to administrative causes (weaknesses in the design, installation, and procurement processes).

Utility assessments (UA) uncovered more EQ problems than any other method. Components that failed during operation was next highest contributor; these failures are significant because of the potential to disrupt plant operations.

- Most EQ problems were traced back to failures in initial design and installation efforts, but a large number of problems were traced to plant maintenance activities, too.

The most significant observation from Table 2-2 is that there is little difference in the average number of LERs among the older DOR Guidelines plants, the NUREG-0588 Category II plants designed to IEEE 323-71, and the later NUREG-0588 Category I plants designed to IEEE 323-74. A review of the average number of LERs per plant in each EQ program type by year, revealed that Category II plants displayed a slightly higher average than those of the other two types in eight of the fourteen years reviewed.

Table 2-1 Overall Summary

<u>W - Where was component located?</u>	<u>Code</u>	<u>Number</u>	<u>Percent*</u>
Unsure	US	1	0
Outside containment, mild environment	OM	22	6
Outside containment, harsh environment	OH	122	31
Inside containment/ both inside and outside containment	IC	<u>249</u>	<u>63</u>
	TOTAL	395	100

C - What type of failure was it?

Omitted from EQ Master List	OL	14	4
Lack of documentation	LD	16	4
Temperature failure	DT	18	5
Visible aging	VA	23	6
Procurement error	PE	36	9
Seal failure or moisture intrusion	SF	82	21
Installation error	IE	87	22
Design error	DE	<u>119</u>	<u>30</u>
	TOTAL	395	100

F - When was failure found?

During installation, found by utility	DI	0	0
During NRC review or inspection	NR	12	3
During maintenance or modification, found by utility	MM	30	8
During utility inspection or review in response to generic concern	UG	40	10
During testing, found by utility	IT	47	12
During operation, found by utility	FO	95	24
During utility assessment	UA	<u>171</u>	<u>43</u>
	TOTAL	395	100

M - When was error made?

Unsure	US	5	1
During plant modification	PD	12	3
During manufacture	DM	34	9
During initial installation	II	60	15
During plant maintenance	PM	117	30
During initial design	ID	<u>167</u>	<u>42</u>
	TOTAL	395	100

* Note: Percentages may not add to 100% due to rounding.

TABLE 2-2 EQ LER Summary by Plant Category

<u>Category</u>	<u>No. of Plants</u>	<u>No. of EQ LERs</u>	<u>No. of EQ LERs per Plant per Year</u>
DOR	67	234	0.26
Category II	25	88	0.33
Category I	25	54	0.26
Totals/Averages	117	376	0.28

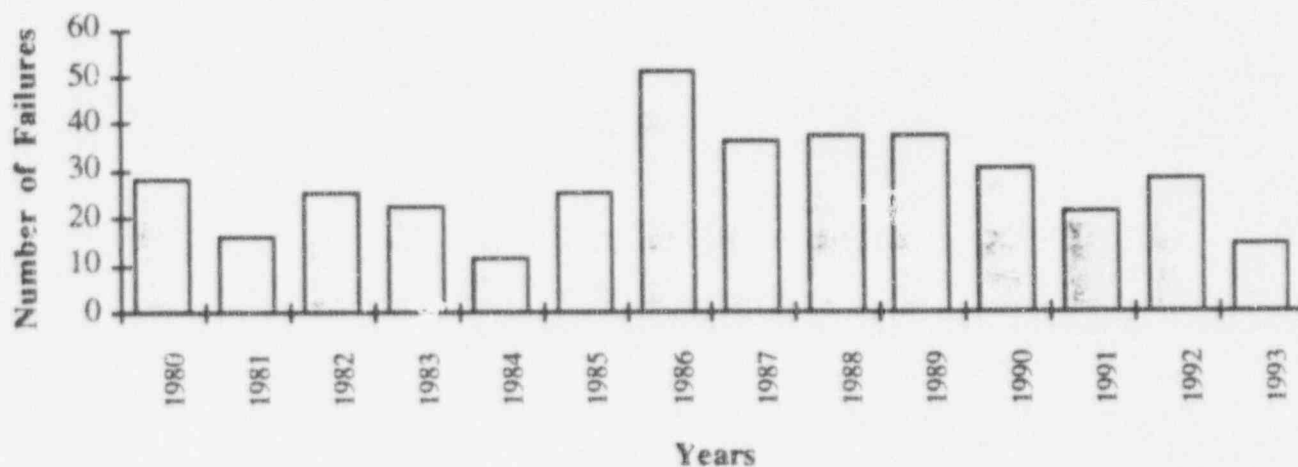
3.0 ANALYSIS AND RECOMMENDATIONS

This section discusses the results of the analysis performed by the SCIENTECH EQ Team on the EQ-related operating reports obtained from the LER, INPO, and NPRDS systems, for the period 1980 through 1993 (year to date). This section also discusses conclusions from the analyses and provides related recommendations.

To aid in the analysis of the data listed in Appendix C and summarized in Table 2-1, these data were arrayed in a histogram, as shown on Figure 3-1, to display the results by year. For the total number of failures, the heaviest year was 1986, when 52 EQ failures were identified. The quietest year was 1984, when there were only 12. After declining since 1986, EQ failures picked up again in 1992. Despite the fact that the SCIENTECH EQ Team had reports for only parts of 1993, there is indication that 1993 may be one of the worst years for EQ failures.

To further aid with the analysis, individual annual breakdowns were created for the various categories. These are reviewed in more detail in the following sections. It should be noted that the distribution of reports written to record EQ failures due to a variety of problems is relatively small and spread over the years. The statistical significance of such a small population could be easily overstated. To avoid placing too much emphasis on the numbers themselves, percentages of the different types of failure by year were also calculated to present a better perspective of performance for that particular year.

Figure 3-1 Total Failures vs. Year



3.1 Location of Component

This evaluation category was used to delineate which components were subjected to a harsh environment and where they were located.

3.1.1 Discussion and Analysis

As stated in Section 1.3, EQ equipment and components inside and outside containment must perform in a post-accident environment. Those components that are located inside containment will most likely be exposed to harsh conditions, while components within secondary containment and other surrounding areas will be subjected to harsh environments if certain types of accidents occur, such as a HELB or LOCA. SCIENITECH felt that it was important to distinguish between the location of these components to determine the focus industry places on EQ requirements with regards to component location.

Mild environment considerations are not within the scope of EQ requirements. However, those mild environment failures that the SCIENITECH EQ Team observed were included to provide examples of a potential weakness or concern that may effect the EQ programs. Table 2-1 shows that 63% of failures related to EQ components were inside containment and 31% were outside containment in a harsh environment.

3.1.2 Conclusions and Recommendations

This ratio, 63:31 or 2:1, is cause for further review. Equipment inside containment is typically subjected to elevated temperatures and radiation exposure during normal operation, and experiences the most sever environmental stresses post-accident. The 2:1 ratio indicates that of all reported EQ failures, equipment and components inside containment fail inspections, tests, or during normal operation twice as frequently as equipment and components outside containment. This supports the NRC's concern over whether or not such equipment and components could function in a post-accident environment, if failures are experienced in normal operating environments.

Specific recommendations in light of this analysis require a further understanding of the types and causes of the failures. Subsequent sections examine types and causes, and provide conclusions and recommendations, accordingly.

3.2 Type of Failure

Table 2-1 shows the types of failures as well as the number found, and failure percentage of each type with respect to the total. Approximately 38% of failures are related to design errors, lack of documentation of component qualification, and components being omitted from the list of EQ components (DE, LD, and OL). Seal failure (SF) and installation errors (IE), which may also be related, were nearly equal and combined for a total of 43%. Nine percent were attributed to procurement errors (PE). Only six percent of the failures reviewed were due to visible aging. Temperature failures accounted for the remainder. (Some of the seal failures could also be due to aging, but most of the failures were stated to be due to moisture intrusion without further elaboration.)

3.2.1 Design Failures

This section discusses the analysis of failures that were assigned to categories DE, OL, and LD. Such failures resulted in the equipment not being qualified for the normal and post-accident environment because of breakdowns in the design engineering process (DE), because the equipment was omitted from the EQ Master List (OL), or because of a lack of EQ documentation (LD). Failures categorized as OL were attributed to errors by the design organization. This is also

true for failures categorized as LD, which were attributable to this design organization's failure to maintain adequate records. Examples of design failures include:

Inadequate flood calculations/failure to consider submergence	LER 237/92-003
Inadequate/non conservative temperature, pressure, and humidity profiles	LER 245/92-005
Failure to qualify equipment in harsh environment (i.e., failure to consider HELBs, LOCAs, MSLBs)	LER 213/90-007
Failure to include component in EQ program	LER 255/92-016
Failure to maintain all necessary documentation to support qualification of component	LER 251/87-007

3.2.1.1 Discussion and Analysis

DE, LD and OL, as a group, constitute the largest part of identified failures, nearly 40% of all EQ failures identified, and it continues to account for a considerable number of failures. As shown in Table 3-1, the worst year was 1980 when these errors represented 66% of all identified failures. The best years were in 1981 and 1982 with 12%. However, they made up 55% of all identified failures in 1992, the last complete year reviewed, and so far in 1993 they represent 55%. The next worst year is 1985, with 54%. It was 32% in both 1989 and 1990, and 46% in 1991. The trend shows a continuing increase in failure codes DE, OL and LD relative to other failure types.

In examining the major contributor in this group, DE, it is important to distinguish between design errors (DE) made during the early 1980s and those made during the late 1980s. In the early 1980s, utilities and design organizations typically formed special EQ groups of EQ specialists to prepare EQ packages in support of the normal utility design team. It may be that current design teams do not have adequate focus on the accident analysis for the plant and, in particular, on the environmental conditions that various equipment is exposed to.

Table 3-1 shows the distribution of reports written to record failures due to a lack of EQ documentation (LD). The two peaks are in 1980 and in 1988. The first peak is most likely the result of failures reported in response to I&E Bulletin 79-01. The 1988 peak is most likely due to failures found by internal and NRC inspections and audits combined with the start up of new plants that had not been involved with the activities in the early 1980s. There was no activity in this area between 1980 and 1985, which suggests that the EQ changes were being implemented and there was nothing new to report. Again, there was no activity in this area after 1990, which suggests that the industry has a good understanding of what kind of documentation should be provided to support the EQ program.

Table 3-1 also shows the distribution of reports written to record failures due to the omission of an EQ component from the EQ Master List. The distribution is limited to 1986 to 1992, and the main peak is in 1988, with secondary peaks in 1986 and 1992. Peaks in the 1980s suggest that EQ omissions took some time to discover, for example, during reviews, audits, or maintenance activities subsequent to the initial completion of EQ program activities. The 1992 peak suggests that the utilities are only recently discovering that there are components that should be qualified, but were not recognized as requiring EQ until recently. Some of the omissions related to undocumented junction boxes along cable runs with non-EQ terminal blocks in them. Omissions from the EQ Master List are a concern because they are a weak link that undermines the work that has been done to qualify the rest of the system.

3.2.1.2 Conclusions and Recommendations

The analysis above raises several issues:

- Errors and weaknesses in the EQ design process are potentially the most detrimental because of the effect on subsequent program steps.

Table 3-1 Analysis of the Type of Failure

	Total	DE	%	DT	%	IE	%	LD	%	OL	%	PE	%	SF	%	VA	%
1980	29	14	48	1	3	1	3	5	17	0	0	0	0	7	24	1	3
1981	17	2	12	0	0	4	24	0	0	0	0	2	12	9	53	0	0
1982	26	3	12	1	4	2	8	0	0	0	0	1	4	19	73	0	0
1983	23	5	22	1	4	1	4	0	0	0	0	3	13	13	57	0	0
1984	12	3	25	3	25	0	0	0	0	0	0	1	8	4	33	1	8
1985	26	12	46	1	4	5	19	2	8	0	0	2	8	3	12	1	4
1986	52	15	29	0	0	13	25	3	6	2	4	9	17	10	19	0	0
1987	37	10	27	0	0	15	41	1	3	1	3	1	3	6	16	3	8
1988	38	8	21	2	5	10	26	4	11	5	13	4	11	4	11	1	3
1989	38	10	26	1	3	17	45	1	3	1	3	4	11	2	5	2	5
1990	31	9	29	0	0	8	26	0	0	1	3	5	16	2	6	6	19
1991	22	9	41	3	14	4	18	0	0	1	5	3	14	1	5	1	5
1992	29	13	45	3	10	5	17	0	0	3	10	1	3	0	0	4	14
1993	15	6	40	2	13	2	13	0	0	0	0	0	0	2	13	3	20
TOTAL	395	119		18		87		16		14		36		82		23	
%	100	30		5		22		4		4		9		21		6	

- Errors and weaknesses in the EQ design process can show up immediately or many years later.

EQ design provides the fundamental framework for the entire EQ program. Therefore, the personnel and processes involved are critical to the success of the program. With regard to personnel, experience, training, and organizational placement, are of utmost importance. In the early 1980s, teams of highly skilled engineers focused on implementing the recently issued requirements, at that time. By the late 1980s, many utilities had reorganized their design teams such that the separate EQ organizations were merged with the design organization. It is not clear, however, what part of the continued high number of design-related failures is attributable to the skills, training, and placement of EQ expertise in the organization.

Recommended areas for focused attention include:

- During the site visits, evaluate the general design engineer's knowledge of EQ requirements, the safety basis and accident analysis for the plant, and in particular, of the conditions that the equipment is exposed to. Also evaluate the organizational residence of EQ expertise in the utility. Specifically, review the following areas:

Does the organizational structure and review process for EQ considerations during the design modification process separate the EQ discipline from broad inter-disciplinary responsibilities?

Does this structure facilitate the interface between design engineering and plant maintenance?

Do all organizations have a consistent understanding of the goals of the EQ program and the design change process?

Does the training of design engineers and design review engineers include sufficient emphasis on EQ concerns and the maintenance of qualification over the useful life of the plant?

- During the site visits, evaluate the design processes used to modify the plant in the following areas:

Does the design process include sufficient consideration of EQ design inputs?

Have adequate reviews been incorporated into the process?

Are qualified EQ reviewers used?

3.2.2 Installation Errors

This section discusses documents that were assigned to failure category IE. Such failures resulted in the equipment not being qualified for the normal and post-accident environment because of breakdowns in the equipment installation process. Examples of installation errors include:

Installed configuration inconsistent with qualified configuration or installation method	LER 327/81-026
Inadequate installation instructions	LER 280/86-035
Failure of personnel to follow approved installation method (and other installation deficiencies related to personnel error)	LER 323/82-028

3.2.2.1 Discussion and Analysis

The worst years for installation errors were 1986 through 1989, as shown in Table 3-1. The peak year was 1989 when they made up 45% of the total. 1987 was also bad with 41% of the total. Since 1989 they have diminished to 13% of the total. The 1986 through 1989 peak is most likely the result of audits and inspections, starting in 1985, after all the EQ packages were installed. There appears to be a definite learning curve since 1989.

3.2.2.2 Conclusions and Recommendations

The analysis above raises the following issues:

- When the installed configuration does not meet the qualified configuration, the following questions arise:
 - Is engineering providing adequate installation and maintenance instructions, procedures, and manuals?
 - Is this a design responsibility?
 - Is there a check to ensure that the latest information is being used during installation?
 - Who is responsible for work packages and other work planning documents?
 - Are the installation crafts receiving adequate training and supervision?
 - Do the crafts need more training in one certain area: for example, is the electrical craft the right discipline to be installing conduit seals?
- Some of the failures attributed to installation could have been caused by inattention to detail in the engineering phase, resulting in seals and splices being installed in a configuration which is not qualified.
- Some failures were likely caused by bad or inadequate information from vendors; such failures did not get specific mention in the failure reports. An example of this is the Raychem splice installation procedure deficiencies that were communicated to the utilities by an I&E Bulletin.

Over the last few years the trend has been steadily downward, which indicates improved training of personnel as well as improved installation methods and instructions. The improving trend could also be due to the fact that initial installation errors are being detected and corrected, with few new errors being made. However, there is still the concern that when an installation error is detected it could be indicative of more failures.

The recommended areas for focused attention are as follows:

- Following the discovery of an installation-related failure, utilities should analyze why the installation was not performed correctly and should determine the generic implications of the failure.
- During the EQ audits, team members should probe the questions listed above.

3.2.3 Seal Failures or Moisture Intrusion Failures

This section discusses documents that were assigned to failure category SF. Such failures resulted in the equipment not being qualified for the normal and post-accident environment because of improper sealing or because of moisture intrusion due to seal or gasket failure. Examples of seal failures include:

Worn and failed seals due to inadequate maintenance LER 219/80-054
 Seal failures due to inadequate installation, bad sealing methodology LER 281/85-004

3.2.3.1 Discussion and Analysis

Reports attributed to seal failures peaked in 1982 with 73% of all identified failures. Since then, such reports have diminished to zero in 1992, but have risen to 13% so far in 1993. Table 3-1 presents the chronological distribution of the data. Concern over seal failures are similar to those due to installation errors. Overt failures related to moisture intrusion are generally found only as a result of critical component failures due to grounding/shorting. In cases where inadequate sealing is attributed to personnel error, it is not apparent from the report whether the root cause was poor seal performance, inadequate training, or inadequate installation instructions. In most reports, the seal failures are either not fully investigated, or the wording does not provide enough information to determine the root cause of the failure. Corrective actions generally include drying the component and replacing the seal. Failures due to degraded seals are often due to inadequate preventive maintenance (i.e., seals were not replaced when they should have been). In most reports related to worn or failed seals, there was no indication that EQ maintenance and surveillance instructions and schedules were reevaluated and/or adjusted.

3.2.3.2 Conclusions and Recommendations

The following ^{observations} issues are raised from the analysis above:

- The rapid drop in the number of reports of seal failures is encouraging and is quite possibly the result of improved training, attention, and methods to correct the multiple seal failure reports in the early and mid-1980s.
- There were many seal failure reports that did not give the reason for the seal failure. These failures may be the result of temperature/aging/other environmental effects or of improper installation or maintenance; this could not be determined from the reports analyzed by SCIENTECH.
- Moisture ingress is actually an accelerated aging mechanism, which is much more rapid than the typical temperature aging process. Moisture ingress has the capability to take a component to the end of its effective life in less than one operating cycle.

Despite a definite trend showing a reduction in the number of seal failures per year, moisture induced failures are more immediate and prevalent than temperature induced failure in operating plants, so continued attention is warranted. The following recommendations should minimize recurrence:

- Once a seal is completely installed, it is hard to verify its efficacy without destroying it. This suggests that craft seal installation qualification tests could be beneficial, similar to welder qualification tests. Continued emphasis by the utility on craft training, qualifications, and methods is important.
- A more thorough analysis by utilities of the root cause and generic implications of seal failures is necessary. Depending on the results of the utilities' analysis, the utilities may

want to change maintenance schedules, or walk down schedules, to catch the seals before they fail. More supervision during seal installation may also be necessary.

- Some utilities have degradation inspection programs. These should be investigated for potential generic application. (Preventing premature seal failure is of economic benefit to the utilities, as well as being important to safety.)

3.2.4 Temperature and Aging Failures

This section discusses documents that were assigned to failure categories VA and DT. Such failures resulted in the equipment not being qualified for the normal and post-accident environment because of failures due to temperature effects (DT) and visible aging (VA). Examples of temperature and aging failures include:

Seal degradation, deterioration, embrittlement of rubber	LER 373/84-094
Degraded wire insulation, cracks in motor lead epoxy interface	LER 412/88-017
Chemicals leached from cable insulation corrodes adjacent components	LER 331/88-019
Hydrogen ignitor cable aged, open access panels caused high drywell temperatures	LER 458/93-019
Components exceed qualified lives due to operating excursion (and resultant excessive temperature)	LER 321/82-076

3.2.4.1 Discussion and Analysis

As shown in Table 3-1, these combined failures peaked in 1984 at 33% of all identified failures, diminished, and then rose in 1992 to 24%. So far in 1993, they are running at 33%, which matches the 1984 peak. The absence of failures due to temperature aging in the peak year ~~for~~ for all EQ-related reports, 1986, could indicate that many of the failures that year were discovered during internal and NRC audit findings that cited other causes. Overt failures related to temperature/aging are generally found only upon failure of a critical component. Other failures may be the result of temperature/aging, but due to the insidious nature of the temperature/aging mechanism, failures cannot always be traced back to them.

A recent temperature/aging LER dealt with a hydrogen ignitor cable that was overheated because insulation panels in the ventilation system were inadvertently left off at the start of a cycle. While conducting informal drywell temperature research on his own initiative, a utility HVAC engineer discovered several improperly located reactor vessel skirt insulation access panels and an open vessel insulation door. The engineer was investigating problems with the recirculating pump seals and conducting daily monitoring of drywell temperature. He observed that drywell temperature was increasing and arranged to walkdown the drywell to determine the reason. It is thought that missing panels admitted air flow into the vessel area and that abnormal air flow pushed open the access door, allowing hot air to escape, causing high drywell temperatures in two spots in the vicinity of the hydrogen ignitor cable. The cable was originally qualified for forty years at an average conductor temperature of 194°F. The LER estimated that the cable had been exposed to approximately 248°F for eighteen months; in a presentation during the November 1993 EQ Workshop, the utility said it had actually been exposed to 300°F for about six months. The ignitor passed all surveillance tests satisfactorily, but was still declared inoperable and its cable replaced. As the cable was being withdrawn from the conduit it was carefully marked before being subjected to indenter tests. The results of these tests of aging confirmed the location of two hot spots as indicated by the air flow analysis.

3.2.4.2 Conclusions and Recommendations

There were not many failures directly attributed to aging or high temperatures (overall the figure is about 8%), but failure rates are increasing. If the average failure rates continue to increase with

age, it could mean that the equipment is not being replaced in a timely manner, when compared to actual aging performance in the given plant environment. Temperature/aging failures may require that EQ evaluations be performed for eighteen and twenty-four month cycles versus the twelve month refueling cycles previously assumed. Components subjected to accelerated aging because of a local overheating problem, such as an insulation panel to a piece of electrical equipment which has been inadvertently left off for a cycle, may not survive the cycle, much less a design basis accident. The Arrhenius Equation gives the following approximations:

- 10°C decreases component life by 2
- 20°C decreases component life by 4
- 30°C decreases component life by 8
- 40°C decreases component life by 16

A 40 year life cable would last only two-and-a-half years if the ambient temperature were raised 40°C (72°F).

Failures in categories VA and DT were generally localized. This fact emphasizes the need for continued walkdowns and inspections by utility staff to look for localized problems. Also, utilities should reinforce among its staff the need to be vigilant in maintaining thermal barriers to protect equipment. Temperature monitoring data should be preserved and analyzed to demonstrate aging history. Such data will be invaluable in the plant-life extension process to show that components have not aged as much as was assumed in the EQ programs.

3.2.5 Procurement Errors

This section discusses documents that were assigned to failure category PE. Such failures resulted from the equipment not being qualified for the normal and post-accident environment because of breakdowns in the procurement process. Reports for two types of problems were categorized as PE: equipment vendors did not fully qualify the component or equipment in accordance with the purchase specification; equipment vendors did not provide adequate instructions or parts. Examples of procurement errors include:

Failure to provide or maintain documentation to support component testing	LER 410/90-026
Inadequate installation instructions or kits (with wrong or missing parts) to utility	LER 261/89-013
Failure to meet procurement specifications, or false component performance claims (i.e., defective components supplied by manufacturer)	LER 259/85-017

3.2.5.1 Discussion and Analysis

Table 3-1 presents the chronological distribution of the data. The peak year for reports attributed to this category was 1986, which was the peak year for all EQ-related reports. There was a resurgence of reports attributed to this category in the late eighties, peaking in 1990, decreasing in 1991 and 1992, and zero in 1993. This almost certainly means that the remaining supplies of safety-related equipment are fully aware of their responsibilities and are meeting such responsibilities.

3.2.5.2 Conclusions and Recommendations

This is not now considered a problem area based on the review of this limited data set. Nevertheless, during the EQ site visits, the team should confirm that there is enough information provided to vendors in procurement specifications, and that the utilities have established a process by which EQ qualification documentation received with a component is reviewed for adequacy before the new component is installed in the plant.

3.3 When Found

This section discusses how failures in EQ equipment and components and in the EQ programs themselves were identified.

3.3.1 Discussion and Analysis

As shown in Table 3-2, nearly half of all EQ failures were found by the utility during assessments, reviews, walkdowns, and inspections (UA). However, information in these reports did not provide sufficient detail to allow the SCIENTECH EQ Team to determine what prompted the assessment, review, etc. That is, was the failure discovered as a result of: a self-initiated EQ program assessment; information obtained from INPO communications; or routine maintenance and testing activities?

Equipment and component failures during plant operation (FO) accounted for a quarter of all EQ failures, 95 out of 395. Considering the number of plants in commercial operation, the number of safety-related components in those plants, and the time period of interest (14 years), this number is small.

An analysis of codes by year revealed that the fraction of equipment and component failures during operation (FO) and testing (IT) generally dropped off over time, when compared to total failures, until 1992 and 1993. By comparison, failures discovered by the utility during assessments and reviews (UA) became a larger fraction of the total over time. This last point is especially important in light of the fact that failures found by the NRC (NR) or found by the utility as a result of a review mandated by the NRC (UG) represented a small portion of the total failures found, especially in the later years.

3.3.2 Conclusions and Recommendations

The analysis indicates that the utility and its staff are the first line of defense in discovering and correcting its own EQ program and equipment problems. However, it could not be determined whether the utility efforts were self-initiated or whether problems were "discovered" as an outcome of other efforts and events. Furthermore, the EQ-related reports reviewed by the team usually provided no indication that root cause analysis and generic implementation of failures were analyzed. Therefore, utilities should be encouraged to either implement or continue periodic EQ program self-assessments. As part of such self-assessments, utilities should make it a practice to determine the root cause and generic implications of the programmatic and technical EQ failures thus found.

The number of EQ-related equipment and component failures found during normal operation, although small, is cause for concern, nevertheless. These are failures that, in some cases, caused transients or placed the plant in an abnormal configuration. What's more, these are failures that could have been prevented, for the most part, by more attention to good practices (i.e., proper installation and maintenance of the equipment). The recommendations in Section 3.4 apply here, too.

3.4 When Made

This section discusses the codification of EQ-related operating reports under the "when made" category. This codification was an attempt by the SCIENTECH EQ Team, based on information in the EQ-related operating reports, to identify when the error or event took place that eventually led to the EQ failure.

Table 3-2 Analysis of When the Failure was Found

	Total	FO	%	IT	%	UA	%	UG	%	NR	%	MM	%	DI	%
1980	29	7	24	2	7	8	28	11	38	0	0	1	3	0	0
1981	17	5	29	7	41	4	24	0	0	0	0	0	0	0	0
1982	26	10	38	9	35	4	15	0	0	0	0	3	12	0	0
1983	23	11	48	8	35	4	17	0	0	0	0	0	0	0	0
1984	12	6	50	1	8	5	42	0	0	0	0	0	0	0	0
1985	26	6	23	3	12	13	50	1	4	0	0	3	12	0	0
1986	52	10	19	4	8	24	46	10	19	1	2	3	6	0	0
1987	37	7	19	2	5	12	32	8	22	3	8	5	14	0	0
1988	38	5	13	1	3	23	61	2	5	4	11	3	8	0	0
1989	38	6	16	0	0	23	61	4	11	3	8	2	5	0	0
1990	31	10	32	2	6	16	52	0	0	0	0	3	10	0	0
1991	22	3	14	2	9	12	55	2	9	0	0	3	14	0	0
1992	29	3	10	4	14	17	59	1	3	1	3	3	10	0	0
1993	15	6	40	2	13	6	40	1	7	0	0	0	0	0	0
TOTAL	395	95.0		47.0		171.0		40.0		12.0		29.0		0.0	
%	100	24		12		43		10		3		7		0	

3.4.1 Discussion and Analysis

As shown in Table 3-3, nearly half of all EQ failures were traceable to errors or events that occurred during the initial design (ID) efforts related to each plant's EQ program. 1980 saw the most reports for this code; 1981 and 1993 saw the least. Over time, the number of reports coded as ID increased from 1981 until 1986, then remained generally high through 1992. The large number of ID reports in 1980 is most likely due to the increased efforts by all nuclear utilities to implement DOR Guidelines and NUREG-0588 requirements; EQ errors and failures in 1980, and in the early years, can be attributed to a lack of familiarity and understanding of the full scope of the then new EQ requirements. The slow increase in ID reports through 1986 and the generally high number of reports thereafter is explained by the fact that errors during the initial design take time to manifest themselves. For example, aging and moisture effects typically do not manifest themselves until several years have elapsed; likewise, evidence of pre-failure damage is not detectable by inspection or maintenance until time has elapsed.

Over a quarter of all EQ failures were traceable to errors occurring during plant maintenance (PM); nearly three quarters of such errors resulted in equipment failing during normal plant operation or during periodic testing due to seal failures, moisture intrusion, or general aging (SF and VA). In fact, errors during plant maintenance resulted in more operational and testing failures than did errors during initial design or installation, together. The significance of plant maintenance errors as a contributor to EQ failures is somewhat reduced, however, by the fact that failures attributable to such errors peaked in 1986 and 1987, and have been declining since then.

Failures traceable to installation errors (II) are the third most significant group in this category and have remained relatively constant since 1986. This is most likely attributable to two effects: (1) the time delay before the actual failure appears; (2) some continued installation errors in older plants as equipment is replaced, refurbished, or added (due to plant modifications).

Failures resulting from the manufacturing process (DM), have generally declined since 1986.

3.4.2 Conclusions and Recommendations

The analysis above raises several issues:

- Errors and omissions early in the EQ program are systemic and do not manifest themselves until years later.
- Errors during maintenance, although a declining driver in recent years, result in the most significant EQ failures.
- Installation errors continue to be an important cause of EQ failures.

As noted in Section 3.3, the utility's staff, especially the plant staff, is the first line of defense in preventing and finding EQ problems before they result in operational failures or in conditions that could result in post-accident failures. Recommended areas for focused attention are:

- EQ program periodic self-assessment by utility staff.
- Review of plant maintenance procedures; specialized training for maintenance staff.
- Review of equipment installation instructions; training of craft personnel who do installation.

Table 3-3 Analysis of When The Error Was Made

① 11. Error ...
 ② Data ...

	TOTAL	ID	%	PM	%	II	%	DM	%	US	%	PD	%
1980	29	20	69	7	24	1	3	0	0	1	3	0	0
1981	17	2	12	8	47	5	29	2	12	0	0	0	0
1982	26	6	23	17	65	1	4	1	4	1	4	0	0
1983	23	7	30	9	39	2	9	3	13	1	4	1	4
1984	12	7	58	3	25	1	8	1	8	0	0	0	0
1985	26	14	54	7	27	3	12	2	8	0	0	0	0
1986	52	18	35	11	21	12	23	10	19	0	0	1	2
1987	37	14	38	9	24	11	30	1	3	0	0	2	5
1988	38	18	47	9	24	6	16	3	8	1	3	1	3
1989	38	14	37	9	24	8	21	3	8	1	3	3	8
1990	31	13	42	11	35	3	10	4	13	0	0	0	0
1991	22	12	55	3	14	4	18	3	14	0	0	0	0
1992	29	18	62	9	31	1	3	1	3	0	0	0	0
1993	15	4	27	5	33	2	13	0	0	0	0	4	27
TOTAL	395	167		117		60		34		5		12	
%	100	42		30		15		9		1		3	

4.0 OVERALL CONCLUSIONS AND RECOMMENDATIONS

As part of its current support of NRC's Division of Systems Safety and Analysis, SCIENTECH was tasked to assist in the NRC's evaluation of whether existing standards and regulations for EQ are appropriate for all operating reactors. Specifically, SCIENTECH was tasked to review a variety of information on operating events related to EQ and to identify any concerns relating to EQ, especially instances in which environmentally qualified equipment experienced problems prior to the end of its qualified life. To accomplish this task, SCIENTECH analyzed 395 EQ-related operating events in detail. The overall results of the effort are presented in Section 2.0, and detailed results and recommendations are presented in Section 3.0. This section discusses the most important conclusions and recommendations resulting from SCIENTECH's analysis. As such, this section is not an enveloping summary of Section 3.0; it is an addition to and a reinforcement of the significant points in Section 3.0.

A very encouraging conclusion is that there is little difference in the average number of LERs between the older DOR Guidelines plants, the Category II plants designed to IEEE 323-71, and the later Category I plants designed to IEEE 323-74. The data reviewed to date do not support the concern that the DOR Guideline plants are experiencing more problems than the Category II plants, or even the Category I plants.

Actual equipment and component degradation and failure was reported in 123 of the 395 reports. A closer analysis revealed that 104 of the 123 were attributable to poor installation and maintenance practices. The remainder, 19 of the 123, were the result of a variety of causes occurring during the initial design or manufacturing processes; none of the reports in this group of 19 gave any indication of common, generic programmatic EQ deficiencies.

The remaining 272 reports generally pertained to equipment and components not being qualified for the intended service (but not yet degraded) for a variety of reasons, such as, improper in-situ configuration, lack of documentation, non-conservative testing, or unqualified materials. Such problems were the result of weaknesses in the design, engineering, procurement, and installation processes of the utilities and vendors. This conclusion, coupled with the conclusion above that poor installation and maintenance practices was the major cause of degraded and failed equipment, suggests that utilities should, as applicable:

- Assess the training, staffing, and organizational placement of the EQ function.
- Assess and improve the training and methods for its craft and maintenance personnel.
- Implement EQ self-assessment and continuous improvement (e.g., TQM) programs.
- Improve root cause analysis and examine generic implications of failures.

One final conclusion deals with the databases reviewed during this effort. Existing codes in the three sources - LER, INPO, and NPRDS - do not facilitate automatic selection of the subset of reports dealing with EQ issues. What's more, the construction of the NPRDS system rendered it unable to provide more than a few examples of reports within the time frame of this effort. These three data sources represent a potential wealth of EQ-related information. Therefore, we recommend that NRC investigate the feasibility of enhancing the LER and NPRDS databases to facilitate retrieval of such information. Likewise, we recommend that INPO investigate the feasibility of enhancing its database.

5.0 REFERENCES

In addition to the EQ-related operating reports reviewed in detail as noted in Section 2, the SCIENTECH EQ Team consulted the following referenced in developing this report.

1. Generic Letter 88-07
April 7, 1988 Modified Enforcement Policy relating to 10CFR50.49
"Environmental Qualification of Electrical Equipment Important to Safety for Nuclear Power Plants"
2. NUREG/CR-5181
May 1990 "Nuclear Plant Aging Research: The 1E Power System" EG&G Idaho, Inc.
3. NUREG/CR-5461
July 1990 "Aging of Cables, Connections, and Electrical Penetration Assemblies used in Nuclear Power Plants" Sandia National Laboratories.
4. NUMARC 90-08
July, 1990 "The Low Voltage In-Containment, Environmentally Qualified Cable License Renewal Industry Report", developed by USDOE and Sandia NL, under the direction of the NUMARC * NUPLEX Working Group.
5. NUREG/CR-5772
August 1992 "Aging, Condition Monitoring, and Loss-of-Coolant Accident (LOCA) Tests of Class 1E Electrical Cables" Sandia National Laboratories.
 - a. Volume 1 Crosslinked Polyolefin Cables
 - b. Volume 2 Ethylene Propylene Rubber Cables
 - c. Volume 3 Miscellaneous Cable Types
6. NUREG 1377, R 3
September 1992 "NRC Research Program on Plant Aging: Listing and summaries of reports issued through July 1992"
7. SECY-93-049
March 1, 1993 Implementation of 10 CFR Part 54, "Requirements for renewal of Operating Licenses for Nuclear Power Plants"
8. Risk Assessment
March 30, 1993 "Risk Impact of Environmental Qualification Requirements for Electrical Equipment at Operating Nuclear Power Plants", Nicholas T. Saltos, NRC Probabilistic Risk Assessment Branch, Office of NRR.
9. 10 CFR 50.49 TAP
June 16, 1993 Environmental Qualification (EQ) 10 CFR 50.49 Task Action Plan, Office of Nuclear Reactor Regulation (NRR), Division of Systems Safety and Analysis, Plant Systems Branch, Balance of Plant Systems Section.
10. NUREG/CR-6095
August 1993 Draft to NUMARC of "Aging, and Loss-of-Coolant Accident (LOCA) and High Potential Testing of Damaged Cables" Sandia NL.
11. Vesely Slides
August 12, 1993 "Evaluations of the Risk Effects of Aging" Dr. W.E. Vesely, SAIC, who reviewed the Nuclear Plant Aging Research (NPAR) project.
12. EQ Survey
August 1993 Environmental Qualification Survey sent to NRC & Industry, Industry version.

13. 10 CFR 50.49 TAP
August 25, 1993 Environmental Qualification of Electric Equipment Task Action Plan, George Hubbard, Chief, Balance of Plant Systems Section, Division of Systems Safety and Analysis. (plus schedule and responsibilities chart)
14. ORNL/NOAC-
231/V2
December, 1985 Sequence Coding and Search System for Licensee Event Reports. Code Listings, Volume 2. (Coding Manual for Keyword explanations for LER matrices, Dale Yielding in AEOD has complete set of seven volumes.)
15. 10 CFR 50, App. A GDC 4, "Environmental and Missile Design Bases."
16. 10 CFR 50.49 "Environmental Qualification of Electrical Equipment Important to Safety for Nuclear Power Plants"
17. Generic Letter 84-24
December 27, 1984 Certification of Compliance to 10 CFR 50.49, "Environmental Qualification of Electrical Equipment Important to Safety for Nuclear Power Plants"
18. Generic Letter 85-15
August 6, 1985 Information relating to the deadlines for compliance with 10 CFR 50.49, "Environmental Qualification of Electrical Equipment Important to Safety for Nuclear Power Plants"
19. Generic Letter 86-15
September 22, 1986 Information relating to compliance with 10 CFR 50.49, "Environmental Qualification of Electrical Equipment Important to Safety for Nuclear Power Plants"
20. IE Bulletin 79-01B
January 14, 1980 "Environmental Qualification of Class 1E Equipment". The DOR (Division of Regulation) Guidelines, "Guidelines for Evaluating Environmental Qualification of Class 1E Electrical Equipment in Operating Reactors", is contained as Enclosure 4.
21. IEEE Std 323-1971
1974
1983 "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers.
22. NUREG-0588
Rev. 1, July 1981 "Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment."
23. NUREG-0800
Rev. 2 - July 1981 Standard Review Plan, Section 3.11 "Environmental Qualification of Mechanical and Electrical Equipment"
24. NUREG/CR-5313
January 1989 "Equipment Qualification (EQ) Risk Scoping Study," Sandia NL.
25. Reg. Guide 1.70
Rev. 3, Nov. 1978 Format & Content Guide, Section 3.11, "Environmental Design of Mechanical and Electrical Equipment."
26. Reg. Guide 1.89
June 1984, Rev. 1 "Environmental Qualification of Certain Electric Equipment Systems Important to Safety for Nuclear Power Plants"(this guide supplements IEEE Std 323).
27. Reg. Guide 1.97
Rev. 3, May 1983 "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environmental Conditions During and Following an Accident."

28. OTA-E-575
September 1993

"Aging Nuclear Power Plants: Managing Plant Life and
Decommissioning," US Congress, Office of Technology
Assessment.

Appendix A

Comparison of EQ Requirements

COMPARISON OF EQ REQUIREMENTS

<u>Qualification Element</u>	<u>DOR Guidelines</u>	<u>IEEE 323-71 and NUREG-0588 Cat. II</u>	<u>IEEE 323-74 and NUREG-0588 Cat. I</u>
1 SCOPE	Class IE equipment; includes emergency shutdown systems used to bring the plant to a cold shutdown condition.	Class IE equipment, including equipment required for accident mitigation, post-incident monitoring, and safe shutdown, and interfaces (i.e., a junction or junctions between Class IE equipment and another equipment or device). Though not explicitly stated, non-Class IE equipment whose failure can impact Class IE equipment is also included.	Same as Cat. II
2 EQUIPMENT SPECIFICATION REQUIREMENTS	Not addressed.	Specific requirements, including system safety function, environmental envelope as a function of time, time required for equipment to fulfill safety function, and basis for classification.	Same as Cat. II, plus: performance and electrical characteristics, installation requirements, preventive maintenance schedules, design life, auxiliary devices needed for proper operation, number of operating cycles, environmental conditions, and qualified life.
3 LOCA SERVICE CONDITIONS			
a. Temperature and Pressure (LOCA)	Based on FSAR, except for pressure suppression type containments: • 6 hours at 340°F for BWR drywells, and • 3 hours at 340°F for PWR ice condenser lower compartments.	Specific guidance provided for calculating the temperature and pressure response. Also, a generic envelope was defined for use on BWR and ice-condenser type plants. Cat. II plants are allowed to assume partial reevaporation in PWR dry containments, and other assumptions that could result in a reduced containment temperature response are also possible.	Same as Cat. II, except as noted.
b. Radiation (LOCA)	Normal operating dose plus accident dose. Equipment located directly above containment sump, in the vicinity of filters, or submerged in contaminated liquids evaluated on a case-by-case basis. Total assumed gamma dose of 2E7 RADS for general areas in PWR dry containment is acceptable; otherwise, evaluation required (guidance provided for PWR dry containment applications).	Normal operating dose plus accident dose; specific guidance provided for calculating the accident dose, including margin considerations. Unlike DOR Guideline plants, no conservative gamma dose estimates and no exceptions for beta doses are given.	Same as Cat. II, plus IEEE 278-87 referenced for calculating the service dose and consideration required for oxidation gas diffusion effects.

COMPARISON OF EQ REQUIREMENTS (cont.)

<u>Qualification Element</u>	<u>DOR Guidelines</u>	<u>IEEE 323-71 and NUREG-0588 Cat. II</u>	<u>IEEE 323-74 and NUREG-0588 Cat. I</u>
b. Radiation (LOCA) (cont.)	Specific guidance for beta dose included; if less than 10% of the gamma dose, no further consideration required.	See previous page.	See previous page.
c. Miscellaneous (LOCA)	Must include submergence and spray when applicable.	The type test data must contain the special conditions to be applied, such as fire, water, seismic, chemical sprays, dust and submergence effects. Some specific guidance provided for chemical spray effects.	Conditions to be simulated include (for example) humidity, dust, chemical solutions, vibrations, jet forces, chemical composition of the ambient environment, submergence, seismic effects, and expected mechanical wear and electrical contact degradation. Some specific guidance provided for chemical spray effects.
4 MSLB SERVICE CONDITIONS INSIDE CONTAINMENT			
a. Temperature and Pressure (MSLB)	<p>Equipment qualified for LOCA also qualified for MSLB in plants with automatic spray systems that are not subject to single failure (acceptability of this approach pending completion of Task Action Plan A-21).</p> <p>Otherwise, plant specific analysis required (NUREG-0588 Cat. II referenced for methodology).</p>	<p>Where qualification has not been completed, environmental parameters should be calculated using a plant-specific model based on staff-approved assumptions contained in the NUREG (acceptable models are referenced as an alternative to plant-specific models). The case where qualification was previously completed was not addressed.</p> <p>BWR and ice-condenser plants can opt to use the generic profile provided in the NUREG.</p> <p>If only LOCA conditions were considered during initial qualification, MSLB qualification is based on peak component surface temperature. If the qualification temperature is exceeded:</p> <ul style="list-style-type: none"> • additional justification is required, or • requalification testing is required, or • qualified physical protection for the component is required. 	<p>Specific guidance provided for calculating environmental parameters; a plant-specific model approved by the staff must be used.</p> <p>BWR and ice-condenser plants can opt to use the generic profile provided.</p> <p>If only LOCA conditions were considered during initial qualification, MSLB qualification is based on peak surface temperature of the component. If the qualification temperature is exceeded:</p> <ul style="list-style-type: none"> • requalification testing is required, or • qualified physical protection for the component is required. <p>Note: Providing additional justification is not an option for Cat. I plants.</p>
b. Radiation (MSLB)	Same as for LOCA, except a conservative gamma dose of 2E5 RADS is acceptable.	Similar to LOCA.	Similar to LOCA.

COMPARISON OF EQ REQUIREMENTS (cont.)

<u>Qualification Element</u>	<u>DOR Guidelines</u>	<u>IEEE 323-71 and NUREG-0588 Cat. II</u>	<u>IEEE 323-74 and NUREG-0588 Cat. I</u>
c. Miscellaneous (MSLB)	Same as LOCA.	Same as LOCA.	Same as LOCA.
5 SERVICE CONDITIONS OUTSIDE CONTAINMENT			
a. MELB	Credit was given to the staff's 12/72 review that was initiated to evaluate the effects of MELB on a plant-specific basis. Equipment required to mitigate the event must be qualified.	Temperature and pressure should be determined using the same techniques that were used for LOCA; dust environments should be addressed.	Same as Cat. II.
b. Post-Accident Recirculation	<p>100% relative humidity assumed for confined spaces where fluids are recirculated from inside containment during long-term cooling. Temperature and pressure as a function of time should be based on the FSAR analysis.</p> <p>Radiation service conditions must be evaluated on a case-by-case basis. A dose of at least 4E6 RADS is expected. Submergence and chemical sprays are not applicable.</p>	Components of the ECCS located outside containment should be qualified to withstand the radiation that penetrates containment plus exposure from the sump fluid, in addition to the normal lifetime radiation dose. Dust environments should be addressed.	Same as Cat. II.
c. Areas Normally at "Room Conditions"	No special consideration required provided that aging requirements are satisfied, and the areas are maintained at room conditions by redundant air conditioning or ventilation systems served by the on-site emergency electrical power system. Otherwise, a plant-specific analysis is required.	<p>Equipment should be qualified for the range of environmental conditions postulated to occur; dust environments should be addressed.</p> <p>Equipment not served by Class IE support systems, or served by Class IE support systems that may be secured, should be qualified to the limiting conditions that could occur assuming a loss of the support systems. Cat. II plants are given the option of installing monitoring devices to alert the operators to adverse conditions so that corrective actions can be taken.</p>	Same as Cat. II, except Cat. I plants are not given the option of installing monitoring devices to alert the operators to adverse conditions.
6 QUALIFICATION METHODS	The qualification method used is largely a matter of technical judgement. Type testing is the preferred method of qualification for Class IE equipment located inside containment. As a minimum, the qualification for severe	In general, analysis in lieu of test data will not be accepted unless testing is impractical due to size limitations, and partial test data is provided to support the analytical assumptions and conclusions.	Same as Cat. II.

COMPARISON OF EQ REQUIREMENTS (cont.)

<u>Qualification Element</u>	<u>DOR Guidelines</u>	<u>IEEE 323-71 and NUREG-0588 Cat. II</u>	<u>IEEE 323-74 and NUREG-0588 Cat. I</u>
6 QUALIFICATION METHODS (cont.)	temperature, pressure, and steam service conditions should be based on type testing. Qualification for other service conditions such as radiation and chemical spray may be by analysis supported by test data.	Equipment that must function to mitigate an accident, or equipment (safety-related or non-safety-related) that need not function but must not fail in a detrimental manner when exposed to the DBA, should be qualified by test. For qualification of equipment subject to events other than a DBA, which result in abnormal environmental conditions, actual type testing is preferred but other methods may be acceptable when justified.	See previous page.
a. Type Test	The test environment should envelope the postulated service conditions; the duration should be at least as long as the period until the temperature and pressure return to essentially the same levels that existed before the postulated accident.	The bases should be provided for the time interval required for equipment operability, and a single profile encompassing the conditions that are postulated for accidents inside containment (i.e., LOCA and MSLB) is preferred. A "double-peak" profile is not specifically required for Cat. II plants. The temperature to which equipment is qualified should be determined by analysis if no thermocouples were conveniently located for this purpose during testing.	Same as Cat. II plants, plus additional guidance that the type test shall consist of a planned sequence of test conditions that meet or exceed the expected or specified service conditions, including performance margin, and shall take account of both normal and abnormal operation. The test plan should provide an auditable link between the specifications and the test results. Specific information to be included in the test plan is listed. The temperature to which equipment is qualified should be determined by thermocouple readings (Cat. II plants are allowed to use analysis). Also, a "double-peak" profile is required for Cat. I plants.
Test Specimen Requirements	The test specimen should be the same model and identical to the equipment being qualified.	Not addressed other than a requirement that the test data contain the equipment specifications and any specific features to be demonstrated.	Not addressed other than a listing of test plan requirements and a stipulation that the test plan provide an auditable link between the specifications and the test results.
Test Monitoring Requirements	Not addressed.	Included in the listing of test data requirements are the variables to be measured (including accuracy), and the number, type, and location of test monitoring sensors for each variable.	The test equipment should provide resolution for detecting meaningful changes and must be calibrated against auditable calibration standards. The time interval between measurements

COMPARISON OF EQ REQUIREMENTS (cont.)

<u>Qualification Element</u>	<u>DOR Guidelines</u>	<u>IEEE 323-71 and NUREG-0588 Cat. II</u>	<u>IEEE 323-74 and NUREG-0588 Cat. I</u>
Test Monitoring Requirements (cont.)	See previous page.	The temperature to which equipment is qualified should be defined by thermocouple readings; performance characteristics should be verified before, after, and periodically during testing throughout the required range of operability, and the operability status should be monitored continuously during testing (discrete intervals may be justified for long-term testing).	shall provide the time dependence of each variable. The test plan should contain performance and environmental variables to be measured, test equipment requirements including accuracies, and the measurement sequence in step-by-step detail. The temperature to which equipment is qualified should be defined by thermocouple readings; performance characteristics should be verified before, after, and periodically during testing throughout the required range of operability, and the operability status should be monitored continuously during testing (discrete intervals may be justified for long-term testing).
Test Sequence Requirements	The sequence defined for the service conditions and postulated accident should be used. Radiation due to service conditions can be applied at any time during the test sequence provided the component only contains materials that are known not to be susceptible to significant radiation damage at the service condition levels. Otherwise, radiation exposure must be applied prior to or concurrent with exposure to the elevated temperature and pressure steam/air environment.	The test should simulate as closely as practicable the postulated environment. The test sequence selected should be justified. Caustic spray should be incorporated during simulated event testing at the maximum pressure and temperature conditions that would occur when the spray systems actuate. Separate effects testing (not an option for Cat. I plants) is not acceptable for vital electrical equipment such as penetrations, connectors, cables, valves and motors, and transmitters located inside containment or exposed to hostile steam environments outside containment.	The test should simulate as closely as practicable the postulated environment. The suggested test sequence includes initial inspection, normal operation for baseline data, operation to the extremes of the specifications, artificially age specimen, expose to normal mechanical and seismic vibrations, operate during design basis event, operate post accident, disassemble, inspect, and record findings. Caustic spray should be incorporated during simulated event testing at the maximum pressure and temperature conditions that would occur when the onsite spray systems actuate. The test procedure should ensure that the same piece of equipment is used throughout the test sequence (not specifically required for Cat. II plants).
Functional Testing Requirements	Operational modes tested should represent the actual application of the component (i.e., components that operate normally energized in the plant should be energized during the test, etc.).	Performance characteristics of equipment should be verified before, after, and during testing throughout its range of required operability.	Same as Cat. II, plus additional guidance states that the type test should include operation to the extremes of the specifications, exposing the artificially aged specimen to normal mech-

COMPARISON OF EQ REQUIREMENTS (cont.)

<u>Qualification Element</u>	<u>DOR Guidelines</u>	<u>IEEE 323-71 and NUREG-0588 Cat. II</u>	<u>IEEE 323-74 and NUREG-0389 Cat. I</u>
Functional Testing Requirements (cont.)	See previous page.	The operability status of equipment should be monitored continuously during testing. For long-term testing, monitoring at discrete intervals may be justified.	mechanical and seismic vibrations, operation during the design basis event, and operation post-accident.
Interface Considerations	Equipment mounting, electrical and mechanical seals should be representative of the installed configuration. As-built inspection should be included in the equipment qualification program. Particular emphasis should be placed on common problems, such as drain holes not properly located and unsealed electrical connections.	The test data should identify the equipment mountings relevant to performance and the cable connections and other required appurtenances. No amplifying instructions are provided.	Equipment mountings and mechanical and electrical connections to be used during testing should be representative of the actual installed condition.
Aging Requirements	Tests that were successful using specimens that were not preaged may be considered acceptable provided the component does not contain materials that are known to be susceptible to significant degradation due to thermal and radiation aging. Otherwise, a qualified life for the component must be established on a case-by-case basis. Arrhenius techniques are generally considered acceptable for thermal aging.	Unless required by ancillary standards that were committed to, materials that are subject to aging effects should be identified and a schedule should be established to periodically replace the affected components and/or materials.	Aging effects on all equipment, including synergistic effects, should be considered (not required for Cat. II plants). The test plan should contain the aging simulation procedure. Radiation must be added to other known degrading influences, such as temperature and vibration, where appropriate. Electro-mechanical equipment shall be operated to simulate wear. The Arrhenius methodology is acceptable for defining accelerated aging. However, the acceleration rate should be described and justified (not required for Cat. II plants). For insulating materials, a regression line may be used as a basis for selecting the aging time and temperature. Sample aging times less than 100 hours shall not be used. Known material phase changes and reactions should be defined

COMPARISON OF EQ REQUIREMENTS (cont.)

<u>Qualification Element</u>	<u>DOR Guidelines</u>	<u>IEEE 323-71 and NUREG-0588 Cat. II</u>	<u>IEEE 323-74 and NUREG-0588 Cat. I</u>
Aging Requirements (cont.)	See previous page.	See previous page.	to ensure that changes do not occur within extrapolation limits (not required for Cat. II plants). The effects of relative humidity need not be considered in the aging of electrical cable insulation.
Test Margin Requirements	Conservatism is included in the service conditions that are imposed which assure adequate margins between the service conditions specified and the actual conditions which could realistically be expected in a design basis event. Therefore, if the Guidelines are followed, no additional margins need to be imposed.	The margins provided in the design will be evaluated on a case-by-case basis. Equipment that is exposed to accident conditions and required to perform its function within a very short period of time (i.e., within seconds or minutes), should be qualified to operate for a minimum of one hour in the accident environment (same for Cat. I and Cat. II plants).	Same as Cat. II, except that type testing must include provisions to verify that adequate margins exist. Specific margins are listed for temperature, pressure, radiation, voltage, frequency, time, transient conditions, and vibration. With regard to aging, margins over that expected in the qualified life must be provided in the application of each aging influence.
Post-Test Inspection Requirements	Not addressed.	Not addressed.	Upon completion of type testing, the equipment shall be dismantled to permit all parts to be appropriately tested and visually inspected. The condition of electrical insulation, mechanical parts, bearings, lubricants, electrical contacts, wiring, gear drive trains, linkages, and other related components shall be recorded.
Failure Criteria	Failure criteria should include instrument accuracy requirements. If a component should fail at any time during the test, even in the fail-safe condition, the test should be considered inconclusive.	The failure criteria should be established prior to testing. The test results should demonstrate that the equipment can perform its required function for all service conditions postulated (with margin) during its installed life.	Same as Cat. II plants, with the additional guidance that in the evaluation of the test results, a failure has occurred when the equipment does not perform the Class IE functions required by the equipment specifications.
Documentation of Test Results	Not addressed.	A summary of the test results that demonstrates the adequacy of the qualification program is required. The type test data must contain the test results for each test, including the objective, equipment tested, test facility and	Same as Cat. II.

COMPARISON OF EQ REQUIREMENTS (cont.)

<u>Qualification Element</u>	<u>DOR Guidelines</u>	<u>IEEE 323-71 and NUREG-0588 Cat. II</u>	<u>IEEE 323-74 and NUREG-0588 Cat. I</u>
Documentation of Test Results (cont.)	See previous page.	Instrumentation with traceability records, test procedures, test data and accuracy, summary, conclusions, recommendations, approval signature, and date.	See previous page.
b. Operating Experience			
General Guidance	Not addressed.	This method is most suitable for equipment where testing is precluded by the physical size of the equipment being qualified. When operating experience is credited, partial type tests on vital components of the equipment should be completed in support of this method.	Same as Cat. II, with additional guidance that operating experience is a method of limited use as a sole means of qualification but of great use for supplementing type testing; it is most useful for qualification of equipment that is located outside of the containment.
Qualification Determination	Not addressed.	Qualification will be based on operating experience data, consisting of the equipment specifications for both the equipment to be qualified and the equipment for which operating experience is available, identification of features being addressed by this method, comparison of the equipment information, summary and source of operating experience, and the basis on which the data have been determined to be suitable.	Qualification shall consist of correlating operating service conditions with design service conditions, and proving that the Class IE performance characteristics of the equipment will meet or exceed the equipment specification under design service conditions. Partial type testing may be necessary to address conditions that are not covered by operating experience, such as seismic capability (specific guidance given by IEEE 323-74).
c. Analysis			
General Guidance	An item of Class IE equipment may be shown to be qualified to a complete spectrum of service conditions even though it was only type tested for high temperature, pressure, and steam. The qualification for service conditions such as radiation and chemical sprays may be demonstrated by analysis.	This method is most suitable for equipment where testing is precluded by the physical size of the equipment being qualified. When analysis is used, partial type tests on vital components of the equipment should be completed in support of this method.	Same as Cat. II, plus additional guidance stated that in general, electric equipment is too complex to be qualified by analysis alone. However, it may be effective in the extrapolation of test data and determination of the effects of minor design changes on equipment that was previously tested.
Qualification Determination	Examples of radiation and chemical spray qualifications are provided, but no specific guidelines are established.	Qualification will be based on data which contains the equipment specifications, interface or boundary conditions, specific features to be analyzed, assumptions, derived values, and mathematical models used with appro-	Qualification shall consist of a mathematical or logical proof that the Class IE equipment performance to be qualified meets or exceeds the specifications when subjected to its normal and DBA environments. In general, this

COMPARISON OF EQ REQUIREMENTS (cont.)

Qualification Element	DOR Guidelines	IEEE 323-71 and NUREG-0588 Cat. II	IEEE 323-74 and NUREG-0588 Cat. I
Qualification Determination (cont.)	See previous page.	appropriate justification, a description of analytical methods and/or computer programs, and a summary of analytically established performance characteristics.	proof must be based on established principles, operating experience data, partial type test data, or a combination of these. All assumptions must be justified. Specific guidance with regard to mathematical modeling and extrapolation of data is given in IEEE 323-74.
7 QUALIFIED LIFE	The incremental improvement in safety by arbitrarily requiring that a specific qualified life be demonstrated for all Class IE equipment is not sufficient to justify the expense for plants already constructed and operating. If the component contains materials that are known to be susceptible to significant degradation due to thermal and radiation aging, a qualified life for the component must be established on a case-by-case basis.	Similar to DOR Guidelines (also see periodic maintenance and/or surveillance requirements).	Qualified life is one of the equipment performance specifications that must be determined to support equipment qualification. Qualified life should be established based on the severity of the testing that was performed, the conservatism used in the extrapolation of data, the operating history, and by other methods that may be reasonably assumed, coupled with good engineering judgment.
8 PERIODIC MAINTENANCE AND/OR SURVEILLANCE REQUIREMENTS	On-going programs should exist at the plant to review surveillance and maintenance records to assure that equipment which is exhibiting age-related degradation will be identified and replaced as necessary.	Equipment that is composed of materials that are susceptible to aging effects should be identified, and a schedule for periodically replacing the equipment and/or materials should be established.	A preventive maintenance schedule for the installed life of the equipment must be established in support of equipment qualification. Periodic surveillance testing under normal service conditions is not considered an acceptable method for on-going qualification, unless the periodic testing subjects the equipment to the limiting service environment conditions.
9 MODIFICATIONS	Not addressed.	Each modification to the equipment or equipment specification made subsequent to the start of the type test or beginning of the operating experience reporting period shall be evaluated to determine its effect on the equipment qualification.	Same as Cat. II.
10 DOCUMENTATION	Complete and auditable records must be available in sufficient detail to demonstrate that the	Sufficient qualification documentation, including equipment identification, categorization, speci-	Qualification files containing the information required by IEEE 323-74 must be maintained demon-

COMPARISON OF EQ REQUIREMENTS (cont.)

<u>Qualification Element</u>	<u>DOR Guidelines</u>	<u>IEEE 323-71 and NUREG-0588 Cat. II</u>	<u>IEEE 323-74 and NUREG-0588 Cat. I</u>
10 DOCUMENTATION (cont.)	Guidelines have been satisfied.	Documentation (including application requirements), test details (including test data), test results, and references to any supporting information, should be established to permit an independent evaluation.	stating that equipment is qualified and meets the performance requirements. Qualification documentation should include equipment identification, categorization, specification, test details, test results, references to any supporting information, etc.
11 MISCELLANEOUS COMMENTS	The DOR Guidelines were used to perform an initial screening of operating plants. Plants that did not satisfy the screening criteria were further reviewed by the staff on a plant-specific basis to determine acceptability. Specific criteria for performing the plant-specific reviews were not referenced.	IEEE 323-71 is essentially a listing of the data and information needed to support equipment qualification, with very little amplifying instruction. NUREG-0588, for Cat. II plants, supplements the guidance contained in IEEE 323-71, and provides clarification regarding the data and information needed to support equipment qualification.	IEEE 323-74 is a listing of data and information that is needed to support equipment qualification, including substantial clarifying information. NUREG-0588, for Cat. I plants, supplements the guidance contained in IEEE 323-74, and further clarifies the data and information needed to support equipment qualification.

Appendix B

List of Plants by Docket Number and Type of EQ Program

Appendix B

Docket	Plant	Type	Utility
29	Yankee Rowe	D	YA
155	Big Rock Point	D	Consumer's Power
206	San Onofre 1	D	Southern Calif. Edison
213	Connecticut Yankee	D	YA
219	Oyster Creek	D	GPU
220	Nine Mile Point	D	Niagara Mohawk
237	Dresden 2	D	Commonwealth Edison
244	RE Ginna	D	BG&E
245	Millstone 1	D	NBU
247	Indian Point 2	D	Consolidated Edison
249	Dresden 3	D	Commonwealth Edison
250	Turkey Point 3	D	Florida Power & Light
251	Turkey Point 4	D	Florida Power & Light
254	Quad Cities 1	D	Commonwealth Edison
255	Palisades	D	Consumer's Power
259	Brown's Ferry 1	D	TVA
260	Brown's Ferry 2	D	TVA
261	Robinson 2	D	CP&L
263	Monticello	D	Northern States Power
265	Quad Cities 2	D	Commonwealth Edison
266	Point Beach 1	D	Wisc. Electric Power
267	Fort St. Vrain	D	PS of Colorado
269	Oconee 1	D	Duke Power
270	Oconee 2	D	Duke Power
271	Vermont Yankee	D	NY Nuclear
272	Salem 1	D	PSE&G
275	Diablo Canyon	II	PG&E
277	Peach Bottom 2	D	PECo
278	Peach Bottom 3	D	PECo
280	Surry 1	D	Virginia Power
281	Surry 2	D	Virginia Power
282	Prairie Island 1	D	Northern States Power
285	Pt. Calhoun 1	D	Omaha Public Power Dist.
286	Indian Point 3	D	NYPA
287	Oconee 3	D	Duke Power
289	TMI 1	D	GPU
293	Pilgrim 1	D	Boston Edison
295	Zion 1	D	Commonwealth Edison
296	Brown's Ferry 3	D	TVA

D - DOR Guidelines

Docket	Plant	Type	Utility
298	Cooper	D	Nebraska PF District
301	Point Beach 2	D	Wisc. Electric Power
302	Crystal River 3	D	Florida Power Corporation
304	Zion 2	D	Commonwealth Edison
305	Kewaunee	D	Wisconsin Electric Power
306	Prairie Island 2	D	Northern States Power
309	Maine Yankee	D	MY Nuclear
311	Salem 2	II	PSE&G
312	Rancho Seco	D	SMUD
313	Ark Nuclear One #1	D	AP&L/Entergy
315	DC Cook 1	D	AEP (B&M&C)
316	DC Cook 2	D	AEP (B&M&C)
317	Calvert Cliffs 1	D	BG&E
318	Calvert Cliffs 2	D	BG&E
320	TMI 2	D	GPU
321	Hatch 1	D	Georgia Power
322	Shoreham	II	LILCo
323	Diablo Canyon 2	II	PG&E
324	Brunswick 2	D	CP&L
325	Brunswick 1	D	CP&L
327	Sequoyah 1	II	TVA
328	Sequoyah 2	II	TVA
331	Duane Arnold	D	Iowa Electric
333	JA Fitzpatrick	D	NYPA
334	Beaver Valley 1	D	Duquesne Light
335	St. Lucie 1	D	Florida Power & Light
336	Millstone 2	D	NBU
338	North Anna 1	D	Virginia Power
339	North Anna 2	II	Virginia Power
341	Fermi 2	II	Detroit Edison
344	Trojan	D	Portland Gas & Electric
346	Davis-Besse 1	D	Toledo Edison
348	Ferley 1	D	Alabama Power
352	Limerick 1	II	PECo
353	Limerick 2	II	PECo
354	Hope Creek 1	I	PSE&G
361	San Onofre 2	II	Southern Calif. Edison
362	San Onofre 3	II	Southern Calif. Edison
364	Ferley 2	II	Alabama Power

II - NUREG-0588, Cat. II

Docket	Plant	Type	Utility
366	Hatch 2	D	Georgia Power
368	Ark Nuclear One #2	D	AP&L/Entergy
369	McGuire 1	II	Duke Power
370	McGuire 2	II	Duke Power
375	La Salle 1	II	Commonwealth Edison
374	La Salle 2	II	Commonwealth Edison
382	Waterford 3	I	AP&L/Entergy
387	Susquehanna 1	II	PP&L
388	Susquehanna 2	II	PP&L
389	St. Lucie 2	I	Florida Power & Light
395	VC Summer 1	II	SC&EG
397	WNP #2	II	WPPSS
400	Shearon Harris 1	I	CP&L
409	LaCrosse	D	Dairyland Power
410	Nine Mile Point 2	II	Niagara Mohawk
412	Beaver Valley 2	II	Duquesne Light
413	Catawba 1	I	Duke Power
414	Catawba 2	I	Duke Power
416	Grand Gulf 1	I	MP&L/Entergy
423	Millstone 3	I	NBU
424	Vogtle 1	II	Georgia Power
425	Vogtle 2	II	Georgia Power
440	Perry 1	I	Cleveland Electric
443	Seabrook 1	I	PSNH
445	Comanche Peak 1	I	TUGCo
446	Comanche Peak 2	I	TUGCo
454	Byron 1	I	Commonwealth Edison
455	Byron 2	I	Commonwealth Edison
456	Braidwood 1	I	Commonwealth Edison
457	Braidwood 2	I	Commonwealth Edison
458	River Bend 1	I	GSU/Entergy
461	Clinton 1	I	Illinois Power
482	Wolf Creek 1	I	BG&E
483	Callaway 1	I	Union Electric
498	South Texas 1	I	HL&P
499	South Texas 2	I	HL&P
528	Palo Verde 1	I	APS
529	Palo Verde 2	I	APS
530	Palo Verde 3	I	APS

I - NUREG-0588, Cat. I

117

Appendix C

Report #	W	C	F	M	Description	Year
155/80-048	IC	DE	UA	ID	EQ inspection found non-qualified splices dating back to plant construction.	80
219/80-044	OH	DE	MM	ID	During unrelated maintenance, utility discovered connections never sealed, which resulted in motor winding for core spray booster pumps to become wet.	80
219/80-054	OH	SF	FO	PM	Worn gaskets allowed water to leak into core spray pump motor.	80
220/80-013	IC	SF	IT	PM	SCRAM solenoid failed during SCRAM test due to moisture and corrosion during.	80
259/80-082	IC	DE	UA	ID	Drywell pressure transmitters not qualified for LOCA.	80
260/80-048	IC	DE	UG	ID	Drywell pressure transmitter not qualified for post-LOCA environment as noted in IE Bulletin.	80
261/80-014	IC	LD	UG	ID	No certification of qualification was available for PVC electric cable "pigtailed" used on eight penetrations, as required by IEB 79-01B.	80
263/80-015	IC	IE	UG	II	During inspection required by IE Bulletin, unqualified splices found in inboard MSIV solenoid valve cables.	80
265/80-030	IC	SF	FO	PM	Worn O-rings in solenoid of Standby Gas suction vent valve.	80
269/80-008	IC	DE	UA	ID	A valve operator was determined to be unqualified for in-containment use.	80
285/80-006	IC	LD	UG	ID	Inspection per IE Bulletin found lead splices on flow and pressure transmitters lacking sufficient EQ documentation.	80
285/80-007	IC	LD	UG	ID	Inspection per IE Bulletin found penetration cable splices lacking sufficient EQ documentation.	80
296/80-044	IC	DE	UG	ID	Drywell pressure transmitter not qualified for radiation environment per IE Bulletin 79-01B.	80
305/80-041	IC	DE	UG	ID	Review requested by IE Bulletin found unsealed switches might become submerged during LOCA.	80
311/80-025	IC	DE	UA	ID	During a review of qualification records it was discovered that several POVs were not EQ because of a design error.	80
312/80-004	OH	LD	UG	ID	IE Bulletin review found no qualification documentation for main steam system pressure switches.	80
312/80-045	IC	DE	UG	ID	IE Bulletin review found that a containment isolation valve limit switch did not meet EQ criteria for post LOCA radiation.	80
312/80-047	IC	LD	UG	ID	IE Bulletin review found no qualification documentation for flow transmitter utilized during long-term cooling following a LOCA.	80
327/80-018	IC	DE	UA	ID	Reevaluated post LOCA radiation levels caused cables in containment to no longer be qualified.	80
327/80-028	OH	DE	UA	ID	Main steam header pressure transmitters lack EQ at proper temperatures.	80

Report #	W	C	F	M	Description	Year
327/80-085	IC	DE	UA	ID	EQ review found valves rated for lower temperature than may be encountered.	80
327/80-151	OH	VA	FO	PM	A torque switch failed to function properly causing an MOV to short and thermal overloads to melt, caused by wear/age/end of life.	80
327/80-157	IC	DE	UG	ID	Notification received that several valve operators are not qualified for accident environment.	80
331/80-037	OH	SF	FO	PM	During testing, the CB air intake monitor failed a source check due to water in radiation monitor.	80
335/80-029	IC	SF	FO	PM	CIV failed to close due to moisture passing down conduit into terminal box and grounding the terminal.	80
346/80-034	IC	DT	FO	ID	Control Rod Absolute Position Indication Reed switch assemblies (i.e., switch and cable) failed due to high temperatures.	80
366/80-081	OP	SF	FO	PM	Outboard MSIV failed due to failed O-ring in solenoid.	80
409/80-001	IC	SF	IT	US	Periodic leak rate testing revealed cracked containment penetration glands.	80
SER 80-27	IC	DE	UA	ID	S.G. level transmitter not qualified to post-accident temperature.	80
219/81-052	IC	SF	IT	PM	During a trip trace, a limit switch failed due to moisture intrusion and graphite build-up around the operating arm.	81
255/81-049	IC	IE	UA	PM	Improperly installed gasket on CRDM resulted in PCS Leakage.	81
285/81-002	IC	PE	IT	DM	Foxboro Co. notified utility of pressure transmitter defects negating EQ rating.	81
324/81-051	OM	SF	IT	PM	Moisture buildup in the diesel run control solenoid valve prevented diesel generator from operating.	81
324/81-091	OH	IE	FO	II	Power fuse blown due to failure to seal electrical leads penetration in operator motor housing of RHR pump torus valve.	81
324/81-108	OH	SF	FO	PM	Corrosion of switch internals of permissive of RHR pump discharge ADS initiation log pressure switch due to moisture intrusion.	81
324/81-109	OH	SF	FO	PM	Moisture accumulation in switch housing caused corrosion, resulting in a ground of HPCI temperature switch.	81
324/81-136	OH	SF	IT	PM	During a functional test of ECCS LPCI Pump Discharge Pressure Interlock, corrosion in the switch internals prevented core spray or RHR pumps running annunciator from initiating.	81
324/81-139	OH	SF	IT	PM	During an RCIC System Turbine Exhaust Diaphragm High Pressure Channel Functional Test, corrosion in the switch internals prevented diaphragm instrument from initiating.	81
325/81-052	OH	IE	UA	II	Corrosion buildup in RHR pump torus suction valve motor operator due to improperly installed cover.	81
327/81-026	IC	DE	UA	ID	Design failed to evaluate the sealing material for containment electrical penetrations during accident conditions.	81
327/81-067	IC	PE	IT	DM	Foxboro notified licensee of incorrect insulating sleeving used on SG level transmitters.	81

Report #	W	C	F	M	Description	Year
333/81-015	IC	SF	UA	II	Water entered CIV motor MCC from electrical conduit.	81
336/81-039	IC	SF	FO	PM	RPS TC failed due to moisture accumulating on leads in a terminal box which had been left open.	81
368/81-017	OH	IE	IT	II	RTD response time surveillance data led to discovery that a liquid used in RTD wells dried out during operation because of poor installation procedures.	81
369/81-142	IC	DE	FO	II	Barton transmitters failed because operating in higher temperature environment than installation conditions causing bellows to expand against walls.	81
O&MR-93 (1982)	IC	SF	DM	ID	O ring seals of ethylene propylene failed due to use of improper sealing compound.	81
219/82-054	IC	SF	IT	PM	During a trip trace, a limit switch failed due to moisture intrusion and graphite build-up around operating arm.	82
237/82-009	OH	SF	IT	PM	While performing the refuel hi-rad surveillance, utility found SGTS failure due to blown gasket in Foxboro controller.	82
245/82-008	OH	SF	FO	PM	Failed environmental enclosure penetration seal allowed moisture into breakers that operate the main steam line drain valve, inboard torus spray stop valve, and inboard drywell stop valve.	82
260/82-020	OH	SF	MM	PM	During surveillance, failed main steam tunnel temperature switch due to water intrusion into junction box.	82
293/82-024	OH	SF	FO	PM	HPCI gland seal condenser gasket failure caused moisture to penetrate HPCI control circuitry.	82
296/82-019	OH	SF	IT	ID	During a test on the H/O Analyzer system isolation valves, the utility found Valcor solenoid failure due to moisture buildup from improper seal.	82
296/82-020	IC	IE	IT	PM	CRD failed to scram due to an extra O-ring installed, a reversed diaphragm and incorrectly rebuilt scram pilot valves.	82
302/82-017	IC	SF	UA	PM	Water found in junction box and flex cable of Reactor Building Pressure Indicator.	82
315/82-099	IC	SF	FO	PM	Water collected in transmitter junction box and corroded the terminal block.	82
321/82-076	OH	DE	MM	ID	Two relative humidity controllers for SBT failed due to corrosion attributed to high temperature and humidity.	82
324/82-031	IC	IE	FO	PM	Water leak into equipment cabinet of primary containment atmospheric monitor resulting in a loss of power to the motor.	82
324/82-086	IC	SF	UA	PM	During surveillance, SRM Monitor connectors experienced moisture intrusion due to a guide tube sealing gland leak.	82
325/82-077	IC	SF	FO	PM	Suspected moisture in LPRM resulted in inoperable APRM cable.	82
325/82-102	IC	SF	IT	PM	While preparing SRM Channel Functional Test, moisture accumulation on SRM cable prevented proper indication.	82
325/82-122	IC	SF	FO	PM	ATWS reactor pressure instrument terminal boxes contained moisture, resulting in Recirculation pump trip.	82

Report #	W	C	F	M	Description	Year
334/82-023	IC	SF	UA	PM	N-41 excore spikes as a result of water found in cable and connector of N-41 detector due to leakage through seal.	82
338/82-020	IC	SF	UA	PM	Improper sealing of canister that encloses containment gas and particulate monitor.	82
339/82-004	IC	SF	FO	PM	Containment Isolation Steam Generator Blowdown Valve failed due to moisture in limit switch housing.	82
366/82-100	OH	DE	IT	ID	During performance of a RCIC Turbine exhaust pressure instruction FT&C, corroded switches due to moisture intrusion caused failure of the RCIC system were found.	82
369/82-006	IC	SF	IT	ID	Periodic testing found the electronic housing of differential pressure transmitter full of water, which caused a no flow reading on the remote auxiliary shutdown control panel flow gauge.	82
395/82-006	IC	SF	FO	PM	Several high range monitors experienced moisture accumulation in pre-amp connectors.	82
409/82-011	IC	SF	IT	US	Periodic leak rate testing revealed cracked containment penetration glands.	82
O&MR-49 (1981)	OH	SF	MM	II	Core spray motor lead junction boxes contained moisture due to worn cover gaskets and poor conduit seals (Oyster Creek LER 219/80-054).	82
O&MR-75 (1982)	OM	DT	FO	ID	RCP undercurrent relay failed due to overheating due to normally energized condition (Yankee-Rowe LER 29/81-029).	82
SER 82-07	IC	PE	IT	DM	Rockbestos coaxial cables failed above 230°F during environmental testing.	82
SER 82-74	IC	DE	FO	ID	Victoreen area radiation monitors failed due to high gamma at TMI-2.	82
251/83-018	OH	SF	FO	PM	Water in motor lead connection box rendered RHR pump inoperable.	83
269/83-017	IC	DE	UA	ID	Potential EQ deficiency with limit switch moisture intrusion. They were never tested in their installed configuration.	83
270/83-008	OH	SF	FO	PM	MDEFDW Pressure Switch developed small hole which let water in.	83
277/83-001	OH	DE	IT	ID	Switch used in ECCS room coolers failed during EQ radiation testing.	83
295/83-025	IC	DE	FO	ID	Steam penetrated the leak-tight junction box of MSIV Safeguards Solenoid. As a result, all junction boxes were moved to areas free from steam leaks.	83
324/83-001	OH	SF	FO	PM	Moisture accumulation in PCIS switch housing and rendered RCIC inoperable.	83
325/83-020	IC	SF	FO	PM	Moisture accumulation in IRM cable undervessel connector resulted in inaccurate indication.	83
325/83-054	OH	SF	IT	PM	Routine surveillance revealed worn seals in H/O Analyzer sample pump resulted in erroneous sample.	83

Report #	W	C	F	M	Description	Year
331/83-022	OH	SF	IT	PM	During routine surveillance testing, it was found that HPCI pump experienced moisture intrusion and corrosion, and failed to operate.	83
339/83-016	IC	DE	FO	ID	Chemical feed line sprayed liquid onto the containment isolation, which shorted the limit switches, and resulted in inaccurate indications.	83
366/83-050	OH	IE	UA	PD	Investigation of unrelated event found unspecified RCIC temperature indicator installed during modifications.	83
368/83-002	IC	SF	FO	ID	Grounded motor power cable failed for intake structure exhaust fan. It showed signs of internal pressure that could have been caused by moisture intrusion.	83
369/83-085	OH	PE	FO	DM	Crouse-Hinds conduit coupling sealing method may be susceptible to moisture intrusion. This conclusion is a result of a limit switch failure on the Steam Generator Blowdown Recycle System Valve.	83
370/83-050	IC	PE	UA	DM	Equipment/cable interfaces using a Crouse-Hinds conduit coupling may be susceptible to moisture intrusion. (See LER 369/83-085.)	83
370/83-078	IC	DT	IT	ID	During a Unit 2 Airlock Operability Test, adverse operation of the RCU due to the microprocessor excitation due to the environmental conditions(high humidity, and temperature and poor ventilation).	83
373/83-001	IC	SF	UA	PM	LPCI injection valve leak due to failure of seal inside pressure switch due to lack of resiliency.	83
373/83-021	OH	PE	IT	DM	EQ testing of hydrogen recombiner circuit breakers by Rockwell Int. found that breakers were not qualified for post-LOCA.	83
373/83-074	IC	SF	FO	PM	Water accumulation in level switch instrument block on the HCU over a number of years made it inoperable.	83
373/83-101	IC	SF	FC	PM	Reactor Water Cleanup limit switch housing gasket leakage caused limit switch and torque switch damage.	83
409/83-002	IC	SF	IT	US	Periodic leak rate testing revealed cracked containment penetration glands.	83
O&MR-127 (1983)	IC	SF	FO	II	TMI-2 pressure transmitters failed due to moisture intrusion due to improper conduit seals.	83
O&MR-147 (1983)	IC	DE	IT	ID	Solenoid valves using ethylene propylene components failed after exposure to hi-temp/hi-radiation environments (IEN 81-29).	83
SER 83-09	IC	SF	IT	II	Pressure and temperature detector-to-conduit interface not properly sealed, causing failure during surveillance testing.	83
213/84-017	OM	VA	UA	ID	On routine surveillance, degraded cables of the Foxboro RPS found in control room.	84
250/84-011	IC	SF	FO	ID	Water entered containment penetration canister, causing an inner to outershield short in a cable, which conducts the signal to the detector cabinet..	84

Report #	W	C	F	M	Description	Year
312/84-018	IC	DE	FO	ID	Water accumulated in pressure switches and shorted them out. Caused by bourdon tube leaks.	84
320/84-008	IC	SF	UA	ID	Leakage of water into Bailey Level transmitter housing by the way of electrical conduits caused significant internal corrosion.	84
338/84-014	IC	PE	UA	DM	Fisher Controls failed to provide environmentally qualified actuators as required by specifications.	84
366/84-021	IC	SF	FO	PM	Leak on pneumatic system solenoid valve for inboard MSIV.	84
373/84-094	OH	DT	IT	PM	Turbine Control Valve limit switch degradation due to heat and moisture.	84
409/84-002	IC	SF	FO	PM	O-ring in accumulator transducer on CRDM failed.	84
O&MR-212 (1984)	IC	DT	FO	II	Cable insulation failed due to overheating due to poor ventilation and fire barriers (LER 255/84-010).	84
O&MR-219 (1984)	IC	DE	UA	ID	Same as SER 84-67.	84
SER 84-36	IC	DT	FO	ID	ASCO solenoid valve failures due to : heating from being energized, improper assembly, and improper refurbishment.	84
SER 84-67	IC	DE	UA	ID	Miscellaneous deficiencies with Limitorque MOVs such as : damaged terminal blocks, loose wires, unqualified limit switches and splices, damaged gaskets, no drain holes, wrong grease, and improper conduit seals.	84
213/85-017	IC	DE	UA	ID	During a review of previous plant modifications, it was determined that MOVs in containment were not qualified.	85
250/85-010	IC	DE	UA	ID	RCS temperature elements found not to meet EQ criteria.	85
255/85-017	OM	LD	UA	ID	EQ review determined that control switches did not meet EQ schedule requirements for operational testing.	85
255/85-025	IC	LD	UA	ID	Various components were not environmentally qualified by the deadline.	85
255/85-027	IC	DE	UA	ID	Unqualified terminal block in PCS circuit with respect to MSLB or LOCA.	85
259/85-012	OH	DE	MM	ID	Non-qualified cables used to route SGTS cables through pressure seal found by modification engineers.	85
259/85-017	OH	PE	UA	DM	Accident radiation levels determined to exceed Teflon failure threshold because vendor did not meet procurement specifications for H/O Analyzer.	85
261/85-011	OH	DE	FO	ID	SG Blowdown valve sprayed water into limit switch causing an electrical ground.	85
265/85-007	IC	VA	IT	PM	Leak rates for valves and penetrations were in excess specifications allowed due to aging of the seat materials. EQ discrepancies were also found.	85
281/85-004	US	IE	MM	PM	Overtorquing of hollow terminal screws in Rosemount transmitters; improper installation of Conax connectors.	85
304/85-018	OH	IE	UA	II	Inspection of EQ MOV found MOV operators had different wires from ones tested in EQ program.	85

Report #	W	C	F	M	Description	Year
316/85-004	IC	PE	UG	DM	Plant notified that connection on replacement RTD not EQ.	85
323/85-028	IC	IE	MM	PM	Only one O-ring seal installed in calibrating pressure transmitter instead of two required for qualified configuration.	85
324/85-008	IC	DE	IT	ID	During surveillance testing, MSIVs failed to fast close due to disc-to-seat sticking of ASCO solenoids resulting from deterioration of sealing materials.	85
327/85-032	OH	DE	UA	ID	Increased radiation levels not considered in EQ of pressure transmitters.	85
331/85-047	OM	DE	FU	ID	CB air intake radiation monitor has not been tested to determine exact effects of environmental conditions on the monitor's electronics.	85
341/85-002	OH	SF	FO	II	RWCU isolation due to ground fault at breaker; water entered switchgear cabinet through defective seal.	85
370/85-018	OH	IE	FO	PM	Solenoid valve failure due to incorrect installation of electrical cover, in which water spray from broken pipe caused a short circuit of the SG FW isolation.	85
409/85-019	IC	SF	FO	PM	Worn mechanical seal on CRDM allowed moisture intrusion, causing partial scram.	85
416/85-045	IC	DE	UA	II	Unqualified Namco limit switches on isolation valves were installed during construction.	85
454/85-086	IC	DE	UA	ID	Environmentally unqualified terminal strips found in junction boxes on MSIVs.	85
458/85-033	IC	IE	UA	PM	36 electrical junction boxes not sealed per EQ.	85
528/85-052	OH	DE	UA	ID	A confirmatory engineering review of the Post-accident Sampling System found a potential for breakdown of insulation in solenoid valves due to inadequate design for radiation environment.	85
O&MR-255 (1985)	OH	DT	IT	ID	Terry Turbine failed surveillance test; trip solenoid valve diaphragm deteriorated before end of qualified life.	85
O&MR-267 (1985)	IC	DE	UA	ID	Containment penetrations containing teflon found to deteriorate in high radiation environment.	85
206/86-014	OH	SF	FO	II	DC bus ground deenergized power to FW valves for safety injection as a result of moisture in junction box of solenoid valves.	86
213/86-009	OM	DE	UA	ID	Flood protection barriers around SW pumps inadequate. 3 unanalyzed flowpaths.	86
219/86-001	IC	SF	IT	PM	During a monthly surveillance, low-level SCRAM sensors found out-of-specification due to leak past O-ring.	86
247/86-005	IC	LD	UG	II	Inspection of Limitorque MOVs, following receipt of IE IN 86-03, found wiring and switches in configuration not addressed by EQ documentation.	86
247/86-006	IC	LD	UA	ID	Documentation unavailable to substantiate EQ of thermocouple in Hydrogen Recombiner system.	86
247/86-007	OH	IE	UA	PM	Main steam flow transmitters seal restoration required because not resealed after maintenance before heating above 200F.	86

Report #	W	C	F	M	Description	Year
247/86-013	IC	DE	UA	ID	Containment penetration unqualified for submergence during a LOCA.	86
249/86-024	IC	PE	UA	DM	Qualification of cable splices located in three primary containment electrical penetrations not supported by Amp Industries Testing.	86
254/86-037	IC	PE	IT	DM	Unqualified drywell penetration butt splices were identified by Wyle Laboratories in testing.	86
259/86-014	IC	DE	IT	ID	ESF Actuation caused by short from moisture in 2 high drywell pressure switches.	86
265/86-004	OH	SF	FO	PM	Corroded seals in turbine exhaust pressure switch due to moisture intrusion, which created a short.	86
271/86-002	OH	DE	UA	ID	Error in calculations found by engineering review rendered parts of the Hydrogen/Oxygen analyzer unqualified.	86
272/86-007	IC	IE	UA	II	Walkdown of EQ components found several MOVs inside containment without T-drains installed and thus not qualified.	86
280/86-020	IC	PE	UG	DM	EQ verification could not be completed for Limitorque motor operated (MOV) valve wiring, in response to IEN 86-03. Wiring was unqualified and undocumented.	86
280/86-035	IC	IE	UG	II	Inspection in response to IE Notice 86-53 found Raychem heatshrink tubing improperly installed in splices per Raychem guidelines.	86
281/86-018	IC	IE	UG	II	In response to IEN 86-53, inspection revealed improper installation of Raychem heat shrink, per Raychem guidelines.	86
282/86-007	IC	IE	UG	II	In response to IEN 86-53, inspection revealed improper installation of Raychem heat shrink, per Raychem guidelines.	86
286/86-008	IC	IE	UG	II	In response to IEN 86-53, an inspection revealed various EQ deficiencies due to insufficient procedural instructions and improper work practices.	86
289/86-009	IC	OL	UA	ID	EQ Re-verification Program walkdown found cable not on the master list whose qualification of could not be verified.	86
295/86-026	IC	IE	UA	II	Incorrect installation of Raychem splices.	86
295/86-040	OH	DE	UA	ID	Inspection of EQ splices found leads on post accident monitoring equipment landed on terminal blocks in environmentally harsh area.	86
302/86-007	IC	PE	UG	DM	In response to IEN 86-03, all wiring was replaced on Limitorque MOVs, due to lack of documentation.	86
322/86-028	IC	PE	UG	DM	Investigation initiated by IE Notice 86-03 found wiring not qualified in 218 MOVs throughout the plant.	86
325/86-021	OH	DE	FO	ID	Flange gasket steam leak on a half inch steam leak-off line near limit switch resulted in grounding of DC Power Supply to switch of MS Bypass Valve.	86
327/86-026	OM	SF	FO	PM	Microswitch had shorted in the CSST relay housing due to moisture on contacts of switch.	86

Report #	W	C	F	M	Description	Year
331/86-024	OH	SF	FO	PM	Moisture in HPCI Steamline High Flow Pressure Indicating switch compartment, which shorted the terminals and resulted in HPCI isolation.	86
333/86-007	OH	LD	UG	DM	Inspections per IE Notice found Limitorque valve actuators containing insulation not qualified for containment use even though a qualification report said it was qualified.	86
341/86-044	IC	DE	UA	ID	During a self initiated EQ program review, a design deficiency in drywell vacuum breaker valves was found that would cause the failure of a limit switch under harsh conditions.	86
344/86-010	OH	DE	UA	ID	Safety-related equipment was found unqualified for harsh conditions.	86
346/86-006	IC	IE	UA	PM	EQ review revealed EQ maintenance program problems resulting in equipment not installed per EQ requirements, poor EQ documentation, and EQ maintenance backlogs.	86
346/86-021	IC	IE	UA	II	During training session on Raychem splices, it was determined that improper splices may be present in the field, which would provide inadequate insulation.	86
346/86-022	IC	DE	UG	ID	During a Reg. Guide 1.97 review, it was found that because of a design error SG level transmitters were not qualified for submerged conditions.	86
354/86-06*	IC	PE	MM	DM	Incorrect installation of Raychem shrink sleeves due to deficiency in vendor's manual.	86
368/86-013	IC	DE	MM	PD	EQ discrepancy concerning installation of conduit containing electrical cables for wide range containment building pressure transmitters.	86
368/86-018	OH	DE	UA	ID	Incorrect HELB analysis. Distance between SG Blowdown pipe and SG water level and pressure instrumentation were too close.	86
370/86-013	IC	PE	UA	DM	During a Limitorque MOV inspection, an unidentified type of internal control jumper wire was discovered, due to a manufacturing deficiency of Limitorque Corporation QA program to identify wiring.	86
374/86-012	IC	IE	UA	II	Various limit switches and solenoids were not installed to meet EQ requirements.	86
374/86-013	IC	IE	UA	II	Electrical terminations at ASCO solenoid valves not in configuration tested for EQ.	86
374/86-014	IC	IE	UA	II	Electrical terminations at SRV limit switches and Rosemount/Conax seal assemblies insulated with Okonite tape and Kapton insulated wire, which is inconsistent with EQ documentation.	86
397/86-019	IC	PE	UA	DM	During a Limitorque MOV inspection, 27 valves were found with EQ discrepancies: nonqualified lubricants, wiring, and wiring splices.	86
397/86-037	IC	IE	UA	PM	Replacement of original with unqualified part; original EQ Amphenol connector was unavailable, so modification request package included substitute.	86

Report #	W	C	F	M	Description	Year
409/86-020	IC	SF	FO	PM	CRD SCRAM solenoid failed. Not determined if it was due to moisture intrusion or random failure.	86
409/86-036	IC	SF	FO	PM	CRD SCRAM solenoid failed. Not determined if it was due to moisture intrusion or random failure.	86
410/86-026	OH	DE	UA	ID	Conduit seals inside manhole did not meet flooding criteria, and could result in the flooding of safety related equipment.	86
416/86-020	OH	OL	UA	ID	A contact in the SGTS located in a unqualified fire detection cabinet could cause a failure of the SGTS system and therefore should be EQ.	86
440/86-021	OM	SF	FO	IL	Recirculation damper actuators in DG ventilation system failed; seal failures due to seal life expiration, improper storage and maintenance, or excessive temperature exposure.	86
440/86-057	IC	DE	UA	ID	Limitorque valve operators could not be EQ verified due to an inadequacy in the non-conformance program to identify potential EQ discrepancies.	86
454/86-003	OH	SF	FO	PM	Degradation of limit switch gasket on MSIV due to exposure to hydraulic fluid.	86
458/86-068	OH	SF	FO	PM	RCIC High Steam Supply line flow transmitter failed due to moisture accumulation.	86
482/86-043	IC	PE	NR	DM	During an NRC EQ inspection, discrepancies in internal wiring and terminal blocks in safety related motor operated valve actuators were identified, which were attributed to a manufacturing problem.	86
483/86-002	IC	DE	MM	ID	During modifications, it was determined that deferred installation of Conax conduit connectors led to qualification of head vent valves not being implemented prior to startup.	86
528/86-023	OH	DE	IT	ID	During design verification testing the containment atmospheric sample recirculation pumps were determined to be unqualified for the recirculation condition following an accident.	86
155/87-008	OH	OL	UA	ID	Walkdowns of EQ circuits found splices not identified as needing to be upgraded to EQ.	87
206/87-006	IC	DE	UG	ID	Non-EQ configuration for butt-splices in containment level instrumentation.	87
206/87-08	IC	IE	MM	II	Kapton connector insulation was damaged on Conax containment electrical penetration "pig tails."	87
220/87-010	OM	VA	FO	PM	Stack gas sample pump failed due to deteriorated components.	87
247/87-017	OH	DE	UG	ID	In response to IEN 86-53, inspection found unqualified splices which could be subjected to a harsh environment.	87
247/87-020	IC	PE	MM	DM	In replacing an RTD, it was noticed that the manufacturer's vapor tight requirement was not met on the new RTD leads due to insufficient length supplied with RTD.	87
261/87-003	IC	IE	UA	II	Heatshrink tubing splice connecting containment EPA to CIV motor lead was found to be unqualified.	87

Report #	W	C	F	M	Description	Year
261/87-007	IC	LD	NR	ID	NRC EQ inspection found insufficient EQ documentation on various plant components.	87
261/87-020	OH	SF	FO	PM	Water trapped in solenoid conduit from unknown source, caused an electrical short resulting in failure at main FW regulating valve.	87
272/87-016	IC	VA	UA	ID	Cabling for pressurizer valves found degraded because it was qualified for 40 years at 120°F and experienced 160°F.	87
272/87-017	OH	DE	NR	ID	An NRC inspector identified that the AFW turbine driven pump compartment contained 7 unsealed openings.	87
286/87-011	IC	IE	UG	II	Inspection revealed several discrepancies related to EQ equipment within containment.	87
305/87-002	IC	DE	FO	ID	Seepage of borated water into source range detector. O-ring has been installed to prevent reoccurrence.	87
309/87-003	IC	IE	UA	ID	Splice sleeves not properly installed on lead wire splices to EQ thermocouples and RTDs.	87
309/87-005	IC	DE	MM	ID	Maintenance workers found an unqualified brand of cable connected to hot and cold leg RTDs that did not have documentation of its environmental qualification.	87
312/87-006	IC	DE	UG	ID	Test program in response to IE Bulletin found MOVs containing unqualified operator grease and valve internals damage.	87
317/87-007	IC	IE	NR	PM	NRC inspection of EQ program found unqualified splices installed by maintenance.	87
322/87-032	IC	IE	UG	II	Investigation prompted by IE Notice found heat shrink tubing installed in an unqualified configuration.	87
323/87-003	OH	SF	FO	PM	Water entered switch housing, shorted contacts, and MSIV valve closure position switch failed.	87
325/87-007	OM	SF	FO	PM	CB HVAC autoisolated due to spurious actuation of chlorine detector attributed to momentary resistance created by leakage past O-ring.	87
338/87-021	IC	IE	MM	PM	Broken seals on sensor necks of safety injector accumulator pressure transmitters due to installation deficiencies.	87
341/87-030	IC	DE	IT	ID	Tests of HPCI system found a suction line that experienced higher pressures than previously thought, thus negating its EQ.	87
341/87-046	IC	IE	UG	II	Walkdown in response to IE Notice 86-53 identified improper installation of heat shrink tubing in safety related equipment caused by inadequate training and inspection.	87
344/87-006	OM	DE	UA	ID	Flood relief louvers in turbine building not adequately designed to prevent flooding of AFW pump, EDG, and remote shutdown rooms.	87
344/87-009	IC	IE	UA	II	Improperly installed Raychem splices on electrical connections to pressurizer PORVs.	87

Repo #	W	C	F	M	Description	Year
344/87-	IC	VA	IT	PM	Leakage past electrical penetration conductor seals as a result of a permanent compressed displacement of the seals due to age.	87
348/87-012	IC	DE	UG	ID	In reviewing EQ discrepancies found at another plant concerning solenoid valve splices and terminations, the utility found that improper installation of splices and termination's due to possible incomplete design evaluation could exist.	87
361/87-031	OH	SF	FO	PM	Threaded solenoid conduit connector loose; cable penetration area not sealed on FW isolation valve.	87
373/87-026	OH	IE	UA	PD	EQ surveillance found RHR motor terminations reworked during modifications in an unqualified manner.	87
373/87-027	OH	IE	UA	PD	RHR motor terminations rework using a termination kit instead of the required splice kit. Same issue as LER 373/87-026 above.	87
395/87-025	IC	IE	UG	II	EQ findings at another plant prompted review that found splices installed in configuration not tested for EQ.	87
413/87-015	OH	SF	FO	II	Moisture in MFTV terminal box caused failure.	87
413/87-043	OH	DE	UA	ID	Cable termination junction boxes were not sealed. Unqualified for HELB.	87
424/87-074	IC	SF	MM	PM	Incorrect installation of O-rings and junction box covers for the core exit thermocouple junction boxes.	87
461/87-066	IC	IE	UA	II	An inspection of junction boxes revealed that they did not contain weep holes to allow the box to breath and drain accumulated water under harsh conditions, due to incorrect installation in various buildings.	87
482/87-052	IC	IE	UA	II	Splices in EQ instrumentation circuits in multiple systems and redundant safety trains not installed with proper size heat shrink tubing according to vendor and EQ requirements due to improper work instructions.	87
482/87-058	IC	IE	UA	II	During a review, it was determined that detector cables were not installed using a qualified configuration.	87
206/88-001	IC	OL	UA	ID	A review determined that there were several components not included on EQ list.	88
206/88-020	IC	OL	UA	ID	SGWRL Indication System components unqualified in containment building.	88
213/88-006	IC	DE	UG	ID	During an engineering inspection, utility discovered unqualified terminal blocks due to a design oversight in identifying all flood protection leak paths.	88
237/88-022	IC	DT	MM	PM	Cable and splices in drywell exceeded qualified lives due to excessive temperature experienced during previous operating cycle.	88
254/88-010	IC	IE	UA	II	Drywell penetration butt splices found without Raychem Heat Shrink tubing applied.	88
261/88-015	OH	LD	UA	ID	Licensee found deficiencies in EQ documentation on Safety Injection System & Containment Spray Pumps.	88

Report #	W	C	F	M	Description	Year
261/88-020	IC	OL	UA	ID	Reactor Head Vent Target Rock valves not qualified due to failure to include on Master EQ list.	88
261/88-022	IC	DE	UA	ID	Error in containment Flood level calculation resulted in incomplete qualification of components which could be subjected to immersion.	88
261/88-024	IC	DE	UA	ID	Licensee determined that pigtail-to-penetration motor lead splice configurations inside containment are not qualified nor qualifiable.	88
275/88-028	IC	LD	UA	ID	Qualification of surge suppressers not in EQ documentation.	88
302/88-015	OH	OL	UA	ID	Incorrect design input led engineers to erroneously assume that main feedwater startup blocks don't need to be EQ.	88
302/88-016	OH	DE	UA	PD	HELB not considered when modifying safety-related systems.	88
302/88-027	IC	DE	UA	ID	Crack found in AS line could cause environmental condition that exceeded qualification rating of some equipment.	88
309/88-005	IC	OL	UA	ID	Four HPSI SOVs were not found on the EQ master list.	88
315/88-010	IC	IE	UA	II	Electrical cables of the reactor head vent valves and pressurizer steam space vent valves unconfigured per current design drawings.	88
328/88-022	IC	DE	UA	ID	Unqualified pre-insulated butt splices found on steam generator narrow-range level transmitter.	88
331/88-013	IC	SF	IT	PM	Spurious actuation of Yarway level switch due to moisture intrusion resulted in inadvertent Core Spray injection.	88
331/88-019	IC	VA	MM	PM	Visible aging and leaching of chlorides from cable insulation corroded CRD piping.	88
369/88-007	OM	PE	FO	DM	Initiated analysis of limit switch valve failure and implications to other EQ equipment due to an unknown fault on controller card (related to the steam generator feedwater regulating valve in the control cabinet).	88
369/88-017	IC	IE	UG	PM	During inspection of all EQ limit switches, utility found pinched limit switch gasket on Containment Ventilation Unit Supply containment Isolation Valve due to defective maintenance/replacement procedure.	88
382/88-004	IC	IE	UA	PM	EQ of CIV Valve Position Indicator invalidated due to missing seal.	88
382/88-027	IC	PE	NR	DM	Okonite company provided information of indeterminate qualification of some taped splice configurations.	88
395/88-008	IC	DE	UA	ID	Potential for steam propagation path (2 paths were noted) which could affect safe shutdown equipment.	88
395/88-012	IC	DE	NR	ID	Potential existed for spurious operation of solenoid valves of the 125VDC Distribution System due to possible multiple ground paths occurring in a harsh environment.	88
410/88-021	OH	PE	UA	ID	A pre-audit review discovered temporary HPCS system relays not qualified and scheduled to be replaced by qualified relays.	88

Report #	W	C	F	M	Description	Year
412/88-017	IC	DT	FO	ID	Degraded wire insulation and switch cover gaskets resulted in the PORV position indication inoperable. They were exposed to higher temperatures than those for which they had been environmentally qualified.	88
413/88-003	IC	IE	UA	II	RTD cables discovered in incorrect configuration. It was later determined that the sealed bellows hose was cut during installation invalidating EQ of the RTD cables.	88
416/88-006	OM	SF	FO	US	Manway cover leaked (rubber gasket slipped from groove) and sprayed water into hotwell low level switch, causing a low hotwell level signal.	88
424/88-036	IC	IE	NR	II	NRC inspection walkdown found a splice with heatshrink tubing that had not been heated to complete the splice during construction.	88
424/88-037	OH	IE	MM	II	O-rings missing from Conax T-8 Head Junction Boxes for Post Accident Sampling System.	88
440/88-027	OH	SF	FO	PM	HPCI line break transmitter failed due to water intrusion.	88
457/88-011	IC	LD	UA	ID	During a review of open Westinghouse Field Deviation Reports, environmental qualification reports could not be found for MOVs on the RHR to the RCS.	88
458/88-006	OH	SF	FO	PM	Reactor recirculation pump motor trip due to moisture intrusion from leaking SW valve through motor's unsealed power conduit into termination cabinet.	88
461/88-012	OH	LD	UA	PM	EQ program was not complete in ensuring that cycling for the standby gas treatment system damper actuators was completed as stated in the EQ requirements.	88
482/88-027	IC	IE	NR	PM	The Post Accident Excure Neutron Flux Monitoring System was not installed using an EQ configuration.	88
483/88-003	IC	PE	UA	DM	Heat shrink moisture seals were not installed correctly due to lack of guidance from vendor during construction.	88
483/88-013	IC	IE	UA	ID	Raychem heatshrink terminations for S/G FW level transmitter not installed in EQ configuration; terminations on multiple system circuits not installed per configuration.	88
498/88-008	OH	IE	UA	II	Installation procedure not followed, resulting in incorrectly installed splices in safety-related electrical cables.	88
206/89-021	IC	VA	FO	II	Loss of insulation resistance of flow transmitter cable from time-temperature-radiation exposure of insulation.	89
220/89-009	IC	IE	UA	II	Cable connecting plug to EQ penetration plug assembly X-E2000 was incorrectly installed, therefore making temperature element connected to it unqualified.	89
220/89-019	OM	OL	UA	ID	Unqualified thermal overload heaters installed on EDG Room door motors, EQ temperature of safety related components could be exceeded. Basis for omission from Q-List determination not documented.	89

Report #	W	C	F	M	Description	Year
245/89-001	IC	DE	UA	ID	It was determined that the Reactor Clean-up Water System may not isolate under a LOCA, due to the questionable equipment qualification of two motor valve operators.	89
249/89-005	OH	DE	UA	ID	Two non-EQ cable terminal blocks, instead of qualified splices, were found in HPCI cable pull box for outboard steam supply isolation MOV due to partial initial EQ circuit walkdown.	89
261/89-013	IC	PE	UG	ID	Moisture intrusion path existed through safety related cable entrance conduit seals in containment due to inadequate vendor installation instructions permitting wrong size of grommet for the size of wire used in application.	89
270/89-005	IC	IE	MM	ID	Cable sealing not leaktight between the electrical entrance fitting of the valve and the point at which cable was potted, and therefore was susceptible to submergence.	89
277/89-020	OH	IE	UA	II	4kV EQ motor lead to field cable splice insulating boots were found to be attached with non-conforming tie-wrap/tape due to inadequate installation procedures used in initial construction.	89
277/89-028	IC	DE	UA	ID	Following a review of safety related relay applications it was found that the SGBT heater control relays were not qualified for the LOCA radiation environment due to lack of procedural guidance in EQ design modification process.	89
280/89-020	IC	DE	UG	ID	Continental cable leakage current was determined to be excessive during loop accuracy review prompted by NRC EQ finding at a sister plant.	89
298/89-021	OH	IE	MM	II	Non-documented splices on pigtails to internal rack wiring.	89
302/89-010	OH	IE	UA	PM	Non-EQ cable splices found on MFWP suction valves due to an inadequate installation procedure that did not require check of wire sizes and allowed smaller spliced leads than application guidelines.	89
302/89-012	IC	IE	UA	PM	Eight CIV solenoid valves were found with coils that had ratings lower than the EQ design temperature, and were different from those specified in the vendor drawings.	89
302/89-013	IC	IE	NR	PM	NRC review resulted in several EQ deficiencies including improper cables and splices, improper silicon oil level in junction boxes, and valve motor operators.	89
302/89-016	IC	DE	NR	ID	NRC Inspectors found many EQ deficiencies including cables, splices, JBs, MOVs due to deficiencies in detailed development and implementation of EQ program.	89
309/89-002	IC	PE	UA	DM	Fifty-one connectors with improper cable heatshrink tubing that did not conform to vendor usage range recommendations. Vendor supplied incorrectly sized heatshrink tubing and unqualified potting compound seals.	89
311/89-017	IC	DT	FO	PD	Wire insulation damage due to energized space heaters in limit switch compartments of MOV operators. (LER references earlier EQ walkdown as cause.)	89

Report #	W	C	F	M	Description	Year
312/89-003	IC	LD	UG	ID	Melamine switch casings and Micro Switch contacts which lack EQ documentation were found in Limitorque SMB-00/000 torque switches following a second 10CFR21 notification.	89
312/89-005	OH	IE	UA	PM	Unqualified configuration (plastic instead of metal plugs) of flow transmitters in AFW system due to installation deficiencies.	89
313/89-049	OH	PE	UA	DM	Two MFW Containment Isolation Valves did not meet EQ because leads had been insulated with Scotch 33, instead of Okonite T-95 tape, by vendor during rework.	89
316/89-011	IC	IE	UA	II	EQ discrepancies in installation of RVLIS.	89
317/89-010	OH	DE	UA	ID	HELB temperature profile for 5' E piping penetration room incorrectly prepared, affecting EQ of all components in room.	89
317/89-016	IC	IE	UA	II	Improperly installed seal on RCS RTDs, which invalidated EQ requirements.	89
327/89-033	OM	DE	FO	PD	RWST level transmitters failed because of freezing of sense lines from extreme cold weather because of calculational error during design change that lead to removal of heaters and thermostats from enclosures.	89
328/89-004	IC	SF	FO	US	RPI channel connector failed due to "moisture deterioration."	89
331/89-008	IC	IE	FO	PM	Failed MSIV solenoid due to moisture intrusion as a result of overtorqueing during maintenance.	89
333/89-001	OH	VA	UA	PM	Loose terminal box on RHR/LPCI due to gasket aging or inadequate bolt threads.	89
352/89-017	IC	IE	UA	ID	Unqualified configuration of drywell Hydrogen Mixing System low flow element covers.	89
352/89-019	OH	DE	UG	ID	In response to IEB 81-7, equipment in the HELB compartment was found that might not perform its safety function, as a result of a HELB.	89
352/89-034	IC	DE	UA	ID	Excess flow check valve test valves would not remain leak tight during post DBAs. Seals were made from unqualified material (Teflon coated viton seals), and would break down causing loss of pressure boundary and instrumentation.	89
354/89-016	IC	IE	UA	PM	Limit switch assembly on PCIG valve didn't meet EQ requirements due to installation deficiencies.	89
361/89-012	IC	IE	UA	PD	Five of the six Foxboro transmitters inside containment were mounted with the conduit entry not inclined downwards as they had been during tests. This combined with absence of required weep holes in conduit could lead to accumulation of moisture in termi	89
369/89-017	IC	PE	UA	DM	Design engineering personnel found a manufacturing deficiency of teflon wiring in annulus preheater during materials evaluation. It will not withstand post-LOCA radiation levels.	89

Report #	W	C	F	M	Description	Year
424/89-018	OH	SF	FO	PM	Limit switch failure associated with the 125VDC control power distribution panel due to moisture intrusion and arcing.	89
461/89-019	IC	DE	NR	ID	As a result of reviews performed by the utility and NRC, 13 issues related to EQ were identified.	89
498/89-018	IC	IE	UA	II	Installation procedure did not include details to assure qualification.	89
528/89-002	OH	IE	UA	II	Engineering personnel found non-EQ pressure gauges on ADV positioners. They should have been removed per vendor instructions provided with valves.	89
528/89-013	IC	IE	UA	PM	It was determined that containment power purge access valves were not installed in the configuration specified in the EQ report.	89
206/90-001	IC	VA	FO	II	Ground on DC feeder breakers to SI components due to water in conduit from degraded cable insulation, ineffective conduit sealing, and underground conduit corrosion.	90
206/90-012	IC	DE	FO	ID	Ground alarm because junction box contained water, due to moisture intrusion along electrical conduit located on top of box.	90
206/90-017	IC	DE	UA	ID	EQ discrepancies in various plant systems, programmatic problem involving construction and maintenance activities discovered during corrective action for LER 361/89-012/1.	90
213/90-007	OH	DE	UA	ID	Failure to evaluate equipment in room subject to harsh environment.	90
213/90-025	OH	OL	UA	ID	AFW flow transmitter not included in EQ program.	90
220/90	IC	VA	IT	PM	Degraded insulation on Limitorque valves.	90
277/90-007	OH	DE	UA	ID	HPCI equipment not included in EQ program.	90
277/90-023	IC	IE	UA	PM	Unqualified temporary seal in a SBT system conduit that could result in inoperability during flooding.	90
293/90-010	OH	VA	FO	PM	A recirculation loop became inoperable due to a voltage oscillation caused by a degraded voltage adjust potentiometer in the voltage regulator.	90
295/90-015	OH	DE	UA	ID	Inaccurate calculation of containment flood level. EQ components (terminal blocks, level and temperature transmitters, RTDs) could be submerged.	90
302/90-005	IC	DE	MM	ID	Nonconservative Reactor Building flood level calculation.	90
309/90-001	IC	IE	FO	II	EQ limit switch for position indication of isolation valve for Primary Sampling System failed due to inadequate sealing of conduit.	90
309/90-008	IC	IE	FO	II	Moisture entered EQ limit switch for indication of isolation valve for Containment Sump Pump Discharge lines due to inadequate sealing of conduit.	90
313/90-006	OH	DE	UA	ID	MOV's not qualified for submergence.	90
322/90-005	IC	DE	UA	ID	Lost operability of conductors in 6 primary containment electrical penetration assemblies due to loss or reduction of insulation resistance.	90
324/90-012	OH	IE	FO	PM	The Start Up Level Control Valve failed to close due to a worn O-Ring.	90

Report #	W	C	F	M	Description	Year
334/90-014	OH	SF	FO	ID	AFW switch failed as a result of moisture-induced corrosion in circuitry.	90
344/90-011	IC	DE	MM	ID	Originally installed seals and lubricant materials for electrical penetration assembly seals were inappropriate.	90
352/90-003	OH	PE	IT	DM	HPCI inboard isolation valve isolated as a result of failed Rosemount trip unit due to degradation of transistor.	90
352/90-018	OH	SF	UA	ID	Degraded water/steam barriers, which serve as barriers for HELB or MELB.	90
354/90-021	IC	PE	UA	PM	SRM and IRM connectors were replaced during maintenance by non-EQ connectors with w/for., instead of rexolite, bushings.	90
362/90-007	IC	IE	UA	PM	Construction and maintenance errors such as non-EQ pressure transmitter and non-conforming heat-shrink sleeving on pressurizer safety valve position sensors discovered during corrective action for LER 361/89-012/1.	90
397/90-002	IC	IE	UA	PM	Installation on an unqualified power connector on MS solenoid pilot valves.	90
410/90-026	IC	PE	UA	DM	Environmental seals on temperature elements in Containment Atmosphere Monitoring System did not meet R.G. 1.89 criterion and alternate approach in FSAR. Qualification testing by vendor had not been performed to NMP-2 specification requirements.	90
414/90	IC	VA	FO	PM	SGBD Isolation Valve failed to open due to an insulation breakdown.	90
461/90	IC	VA	FO	PM	Dirty contacts on the Limit Switch.	90
461/90-003	IC	IE	UA	PM	13 transmitters failed to meet EQ requirements (e.g., low torque values, broken neck seal).	90
498/90-012	IC	IE	MM	ID	Total of 22 missing O-rings in Conax T-8 junction boxes associated with the RCS RTDs.	90
528/90-002	OH	PE	UA	DM	Engineering personnel found non-EQ air regulators on ADV manual remote control air system. The vendor should have supplied components that met procurement specifications.	90
530/90-005	IC	PE	UA	DM	FWIV 4-way valve rebuild kits contained unqualified material (non-viton backup rings.)	90
O&MR-372 (1990)	IC	VA	FO	PM	Level switches failed when not changed out within manufacturer's recommended replacement interval.	90
213/91-029	OH	DE	UA	ID	Engineering analysis determined environmental conditions in Terry Turbine building would render SLB detection portion of RPS inoperable.	91
245/91-010	IC	DE	UA	ID	Kerite control cable in drywell non-EQ. It could not withstand post-LOCA high drywell temperature, insulation resistance could degrade to give dual indication, causing CR operator confusion during course of accident.	91
247/91-009	OH	IE	MM	II	Incorrect installation of Conax connectors. Note: all outside containment, but could have generic implications.	91
255/91-002	IC	IE	UA	II	Improperly installed Raychem cable splice on containment penetration connector discovered during troubleshooting reactor head vent valve ground fault. 9 of 127 pigtailed found to have same out-of-specification splices.	91

Report #	W	C	F	M	Description	Year
271/91-008	OH	DE	UG	ID	In response to IEN 90-053, the utility found House Heating Steam Lines not addressed previously in HELB analyses.	91
277/91-001	OH	DE	UA	ID	During a review of procurement documents two non-EQ relays were found to be installed in HPCI controls due to inadequate EQ review of components in rooms required to be EQ.	91
277/91-017	OH	DE	IT	ID	Non-EQ relays installed in HPCI room cooler fan logic due to inadequate installation procedures used in initial construction, EQ design review, and subsequent system reviews.	91
285/91-010	OH	DE	UA	ID	Failure to assess Upper Electrical Penetration Room environment as harsh.	91
285/91-022	OH	DE	MM	ID	Neutron flux monitoring channels did not meet single failure criteria and EQ.	91
293/91-001	OH	DT	IT	II	Failed transistor in Woodward Governor and degraded cable.	91
333/91-027	IC	DE	UA	ID	Determination of post-LOCA EQ problem with lack of two independent power supplies for LPCI valves caused plant shutdown. All cables ran in one tray so only one was Class 1E.	91
333/91-030	IC	PE	UA	DM	Vendor inadvertently left undocumented test equipment in primary containment radiation monitors. They could not withstand post-LOCA high drywell temperature and radiation levels, and were susceptible to EMI in normal operation.	91
334/91-008	OH	IE	UA	PM	During PM underrated motor termination for 1 kV, instead of 4 kV, was found to have been installed after a repair.	91
334/91-009	OM	DE	UA	ID	ASCO solenoid valves had insufficient documentation for low-temperature operation due to inadequate specification of low-temperature requirements in design basis.	91
341/91-003	IC	PE	UG	DM	Vendor used teflon, instead of tefzel, insulation in exo-sensor flow switch. Inadequate repair attempted, heat-shrink sleeving did not cover entire length of lead wire.	91
344/91-011	IC	PE	UA	DM	Lubricants used to install electric penetration assembly seals per vendor recommendations may degrade seals.	91
458/91-007	IC	IE	UA	II	EQ Status of Pyco RTDs installed in SGTS indeterminate due to non-qualified configuration since initial installation.	91
458/91-022	OH	OL	UA	ID	RTDs in fuel building heater trains were not qualified.	91
498/91-023	OH	VA	MM	ID	Cracks found on RHR Motor lead epoxy interface.	91
530/91-006	OH	SF	FO	PM	Degraded seal of plant multiplexer cabinet resulted in moisture intrusion.	91
SEN 82 (1991)	OM	DT	FO	ID	UPS system control batteries failed due to high temperature in UPS cabinet.	91
SER 91-21	OM	DT	FO	PM	Transformer insulation failed due to overheating caused by incomplete cleaning during maintenance.	91
237/92-003	OM	DE	NR	ID	Incorrect flood calculations. An unsealed power transfer switch junction box for the diesel generator cooling water pump was found below design basis flood level.	92

Report #	W	C	F	M	Description	Year
245/92-005	OH	DE	UA	ID	Non-conservative temperature profile for Rx. Building impacted qualification of safe shutdown components.	92
245/92-010	OH	IE	UA	PM	Unqualified Molded Case Circuit Breaker installed by maintenance in safety related application, could lose 480v Motor Control Center feeding LPCI, CS, and CIS safety related valves.	92
255/92-007	OH	DE	UA	ID	Determined that MSIV actuator solenoid valves could be rendered inoperable by MSL break.	92
255/92-012	OH	OL	UA	ID	Elements in MSL radiation monitors not EQ as required by RG 1.97 Cat 2, & 10CFR50.49, due to errors in RG 1.97 list and modification package.	92
255/92-013	OH	OL	UA	ID	Plant stack gas flow transmitter not EQ as required by RG 1.97 Cat 2, & 10CFR50.49 due to lack of controls and design reviews in development of RG 1.97 list.	92
255/92-016	OH	OL	UA	ID	Components (solenoid valves, position switches) for CVs which control SW flow from CCW Heat Exchanger not included on EQ list.	92
255/92-019	IC	DE	UA	ID	39 position switches were found to have been installed with wire nuts instead of qualified EQ splices due to inadequate review when switches were added to EQ list.	92
255/92-023	IC	DE	UA	ID	Non-EQ cable terminal blocks, instead of qualified splices, were found in previously unidentified Hot Leg Injection SV cable pull box due to failure of design authority to assure that procurement & installation of equipment met 10CFR50.49 requirements.	92
255/92-028	OM	DE	UA	ID	Inadequate cooling capacity in EDG Rooms to maintain EQ temperature of 104° F with only one of two fans powered from a Class 1E power source. It was caused by an original design and construction error because of a conflict with Appendix R separation crit	92
255/92-038	OM	IE	FO	PM	Accelerated aging of transformer coils due to maintenance making wrong connections. It failed two transformers + inverter and resulted in a reactor trip due to loss of the preferred ac bus..	92
272/92-004	IC	PE	UA	PM	Non-1E replacement detectors were installed in MSL Radmonitors, instead of 1E detectors as required by RG 1.97 Cat 2 in initial design due to personnel error in procurement process.	92
272/92-011	IC	VA	UA	ID	Rubber grommet holding GM tube detector pins embrittled and caused slipping.	92
272/92-015	IC	DE	MM	ID	EQ valve limit switches and control solenoids share breaker with non-EQ pressure switches in PORVs.	92
275/92-026	OH	DE	UA	ID	Surge suppression diodes in electrical control circuitry for PASS not adequate for operation in harsh environment.	92
323/92-005	OH	DE	UA	ID	ABVS control circuit surge suppression diodes did not meet radiation qualification requirements due to incomplete FMEA.	92
344/92-013	IC	DE	UA	ID	Drawing update process identified four potentially inappropriate SG level drain valve applications that may not meet design temperature requirements.	92

Report #	W	C	F	M	Description	Year
346/92	IC	DE	FO	ID	Broken Torque Switch due to faulty material.	92
354/25756	OH	DT	UA	DM	Epoxy insulation in Comsip microswitch is damaged by overheating and could potentially cause a short-to-ground. They are located in 16 safety related control panels. Analysis shows a 7.7 year life expectancy in a harsh environment. 10CFR21 submitted on	92
361/92-001	OH	DE	UA	ID	Potential for harsh environment in a location (e.g., AFW Building) not previously recognized.	92
362/92	IC	VA	IT	PM	Dirty contacts on the Limit Switch.	92
364/92	IC	IE	MM	PM	O-Ring hanging out of an MOV.	92
368/92	IC	VA	IT	PM	Torque Switch contacts stuck.	92
382/92-014	IC	DE	UA	ID	RCS Sample Isolation Valve erroneously not required for post-accident operability.	92
387/92-014	IC	IE	UG	PM	In response to GL 91-15, O-rings on the circle valve seal solenoids were found susceptible to failure due to incorrect installation procedures.	92
414/92	IC	VA	IT	PM	Torque Switch contacts were open due to aging of the switch.	92
456/92	IC	DT	IT	II	RTD cable splice resistance change due to sudden temperature change because splice was not prepared well by maintenance/ modification..	92
498/92	IC	IE	MM	PM	Closed Limit Switch stops were out of adjustment.	92
SEN 86 (1992)	OM	DT	FO	ID	ITE/Gould relays in MCCs failed due to shorting due to thermal aging of insulation (not qualified for normally-energized condition).	92
213/93-005	IC	SF	FO	PM	Moisture intrusion resulted in corrosion of solenoid for CIV.	93
245/26083	OH	DE	UA	ID	Fuel Pool Cooling System cannot maintain the Fuel Pool below the 150° F design temperature without augmentation from Shutdown Cooling System because local area coolers are not supplied by fully qualified QA Power Supplies.	93
249/93-005	IC	VA	FO	PM	Degradation of O-ring on the Fail Safe Accumulator system, caused by aging and fatigue, led to leakage out of a weep hole of a two way Versa valve.	93
269/93-006	IC	DE	UG	ID	Vendor analysis of MSLB accident did not consider an MSLB inside containment. Recent analysis per IEB 80-04 shows that containment design pressure could now be exceeded. Utility does not discuss pressure implications on existing EQ, only temperature eff	93
275/93-005	OM	SF	FO	PD	Three 4 kV and two 12 kV cables failed in underground duct bank conduits. All are Okonite, EPR insulation, with neoprene jackets. 12 kV cables failed due to chemical attack. Chloride and/or fatty acid contaminants in 12 kV cable jackets and shields wer	93
282/93-008	IC	DT	FO	II	Failure of solenoid in pilot valve of Instrument Air Containment Isolation Valve caused main valve to close.	93

Report #	W	C	F	M	Description	Year
315/93-002	OH	DE	UA	PD	HELB analysis of TDAPP rooms assumed that doors would be open to prevent pressurization. However, doors are fitted with fusible thermal links to automatically close the doors in the event of a fire. The links could be melted by the HELB temperatures all	93
333/93-003	IC	DE	UA	ID	Engineering review identified non-safety related components connected to safety-related drywell Nitrogen header. Buna-N parts could not withstand post-LOCA radiation levels.	93
369/93-005	IC	DT	FO	II	Field cable from control rod to bulkhead failed during zero power physics tests.	93
369/93A	IC	VA	IT	PM	O-Rings and Oil Seals were worn and brittle from normal aging.	93
369/93B	IC	VA	IT	PM	O-Rings and Oil Seals were worn and brittle from normal aging.	93
397/93-027	IC	IE	FO	PD	Non-EQ. Dual-solenoid pilot-operated valve on inboard MSIV failed causing full isolation of MSIVs and reactor shutdown. Original stem re-used instead on new stem in vendor supplied kit during refurbishment in an inadequate work area. Craft had not bee	93
443/93-007	IC	DE	UA	ID	Non-Class 1E circuit protection devices provided to isolate non-Class 1E to ensure Class 1E circuits in same trays are not degraded were not qualified for the post-LOCA environment in which they are expected to function.	93
458/93-019	IC	IE	UA	PM	Hydrogen igniter cable exceeded EQ lifetime due to localized high drywell temperature caused by reactor vessel insulation access door/panels having been left open during power cycle. Normal reactor vessel skirt cooling flow paths disrupted exposing cable	93
498/93-017	OH	DE	UA	PD	A/E memo lead to erroneous downgrading of FWIBV positioners to non-safety related so the EQ maintenance requirements were removed and life extended to 40 years. The internals should have been replaced after 4 years and so qualified lifetime was exceeded.	93

Note: See Section 2.1 for a description of codes used in columns 2 through 5.

Appendix D

EQ Related LER Count by Docket Number

Number of LERS for Plants by Docket Number and EO Type

Docket #	Type	LERs	Docket #	Type	LERs	Docket #	Type	LERs		
29	*	D	0	298	D	1	366	D	4	
155		D	2	301	D	0	368	D	5	
206	*	D	9	302	D	10	369	II	9	
213		D	8	304	D	1	370	II	4	
219		D	5	305	D	2	373	II	7	
220		D	5	306	D	0	374	II	3	
237		D	3	309	D	6	382	I	3	
244		D	0	311	II	2	387	II	1	
245		D	6	312	*	D	7	388	II	0
247		D	7	313	D	2	389	I	0	
249		D	3	315	D	3	395	II	4	
250		D	2	316	D	3	397	II	4	
251		D	1	317	D	3	400	I	0	
254		D	2	318	D	0	409	*	D	7
255		D	13	320	*	D	1	410	II	3
259		D	4	321	D	1	412	II	1	
260		D	2	322	*	II	3	413	I	3
261		D	10	323	II	3	414	I	2	
263		D	1	324	D	11	416	I	3	
265		D	3	325	D	8	423	I	0	
266		D	0	327	II	10	424	II	4	
267	*	D	0	328	II	2	425	II	0	
269		D	3	331	D	7	440	I	3	
270		D	2	333	D	6	443	I	1	
271		D	2	334	D	4	445	I	0	
272		D	6	335	D	1	446	I	0	
275		II	3	336	D	1	454	I	2	
277		D	7	338	D	3	455	I	0	
278		D	0	339	II	2	456	I	1	
280		D	3	341	II	5	457	I	1	
281		D	2	344	*	D	7	458	I	6
282		D	2	346	D	5	461	I	5	
285		D	5	348	D	1	482	I	4	
286		D	2	352	II	5	483	I	3	
287		D	0	353	II	0	498	I	6	
289		D	1	354	I	4	499	I	0	
293		D	3	361	II	3	528	I	5	
295		D	4	362	II	2	529	I	0	
296		D	3	364	II	1	530	I	2	

Total number considered = 117

67 DOR plants (7 were shut down early)

25 Category II plants (1 was shut down early)

25 Category I plants

* means that the plant was shut down early, but did hold an operating license between 1980 and 1993