UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

FEB 19 1987

TO: All Holders of Operating Licenses Not Reviewed to Current Licensing Criteria on Seismic Qualification of Equipment

GENTLEMEN:

SUBJECT: VERIFICATION OF SEISMIC ADEQUACY OF MECHANICAL AND ELECTRICAL EQUIPMENT IN OPERATING REACTORS, UNRESOLVED SAFETY ISSUE (USI) A-46 (Generic Letter 87-02)

As a result of the technical resolution of USI A-46, "Seismic Qualification of Equipment in Operating Plants," the NRC has concluded that the seismic adequacy of certain equipment in operating nuclear power plants must be reviewed against seismic criteria not in use when these plants were licensed. The technical basis for this conclusion is set forth in References 1 and 2.

Direct application of current seismic criteria to older plants could require extensive, and probably impracticable, modification of these facilities. An alternative resolution of this problem is set out in the enclosure to this letter. This approach makes use of earthquake experience data supplemented by test results to verify the seismic capability of equipment below specified earthquake motion bounds. In the staff's judgment, this approach is the most reasonable and cost-effective means of ensuring that the purpose of General Design Criterion 2 (10 CFR Part 50 Appendix A) is met for these plants.

Because affected plants are being asked to carry out this evaluation against criteria not used to establish the design basis of the facility, this resolution is a backfit under 10 CFR 50.109. The backfit analysis and findings may be found in the Regulatory Analysis (Reference 2) at pp. 31.

Seismic verification may be accomplished generically, as described in the enclosure. Utilities participating in a generic program should so state in their reply to this letter, identifying the utility group and the schedule established for completion of the effort. The implementation schedule will be negotiated with utility groups or individual utilities in accordance with the NRC policy on integrated schedules for plant modifications. See Generic Letter 83-20, May 9, 1983. Utilities not participating in a generic review may be allowed some additional time to complete the review.



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INFO LTR

We therefore request* that you provide within 60 days of receipt of this letter a schedule for implementation of the seismic verification program at your facility.

Sincerely,

Harold R. Denton, Director
Office of Nuclear Reactor Regulation

Enclosure:
Seismic Adequacy Verification
Procedure

References: (1) NUREG-1030, "Seismic Qualification of Equipment in Operating Nuclear Power Plants (USI A-46)," February 1987

(2) NUREG-1211, "Regulatory Analysis for Resolution of Unresolved Safety Issue A-46, Seismic Qualification of Equipment in Operating Plants," February 1987

Computer Printout: See Jacket

* This request is covered by Office of Management and Budget Clearance Number 3150-0011 which expires September 30, 1989. Comments on burden and duplication may be directed to the Office of Management and Budget, Room 3208, New Executive Office Building, Washington, DC 20503.

ENCLOSURE

SEISMIC ADEQUACY VERIFICATION PROCEDURE

The proposed procedure for verifying seismic adequacy of equipment is addressed in the following paragraphs. Each licensee will be required to perform the verification steps and submit a report to the NRC including an affidavit that the verification has been completed and all equipment within the scope defined below has been found to be acceptable. A generic resolution will be accepted in lieu of a plant-specific verification review subject to the guidance presented herein.

1. <u>Scope of Seismic Adequacy Review</u>

Each licensee will determine the systems, subsystems, components, instrumentation, and controls required during and following a design-basis seismic event using the following assumptions:

(1) The seismic event does not cause a loss-of-coolant accident (LOCA), a steam-line-break accident (SLBA), or a high-energy-line-break (HELB), and a LOCA, SLBA, or HELB does not occur simultaneously with or during a seismic event. However, the effects of transients that may result from ground shaking should be considered.

(2) Offsite power may be lost during or following a seismic event.

(3) The plant must be capable of being brought to a safe shutdown condition following a design-basis seismic event.

The equipment to be included is generally limited to active mechanical and electrical components and cable trays. Piping, tanks, and heat exchangers are not included except that those tanks and heat exchangers that are required to achieve and maintain safe shutdown must be reviewed for adequate anchorage.

Seismic system interaction is included in the scope of review to the extent that equipment within the scope must be protected from seismically induced physical interaction with all structures, piping, or equipment located nearby. Lessons learned from studies of nuclear and nonnuclear facilities under earthquake loading indicate that the effect of failure of certain items--such as suspended ceilings and lighting fixtures--could influence the operability of equipment within the scope of reviews. Instrument air lines and electrical and instrumentation cabling must be verified to have sufficient flexibility from the connection to equipment so that relative movement of anchor points will not jeopardize their integrity. Air lines and electrical and instrument cabling are not included in the scope of review except for that portion from the equipment item to the first anchor point. The failure of masonry walls that could affect the operability of nearby safety-related equipment is of concern. However, this concern has been addressed by IE Bulletin 80-11, which requires that all such masonry walls be identified and re-evaluated to confirm their design adequacy under postulated loads and load combinations. This concern is, therefore, not considered as part of A-46 implementation. The required seismic interaction reviews will be based on, and consistent with, observations made in the seismic experience data base augmented by expert judgement of

SQUG/SSRAP. The review procedures will be reviewed by the NRC staff and SSRAP prior to plant specific implementation.

For some pressurized water reactor plants, the seismic adequacy of auxiliary feedwater (AFW) systems has been verified by licensee actions taken in response to Generic Letter 81-14, dated February 10, 1981. Review of the AFW systems may be deleted from consideration under USI A-46 if staff acceptance has been documented in a Safety Evaluation Report or if the licensee has committed to meet the requirements of the generic letter.

For the purpose of seismic adequacy verification, the following guidance is given. Each licensee must identify equipment necessary to bring the plant to a hot shutdown condition and maintain it there for a minimum of 72 hours. The 72-hour period is sufficient for inspection of equipment and minor repairs, if necessary, following a safe-shutdown earthquake (SSE) or to provide additional source(s) of water for decay heat removal, if needed, to extend the time at hot shutdown.

Equipment required includes that necessary to maintain the supporting functions required for safe shutdown. For all equipment within the defined scope, the verification must closely follow the procedure outlined in paragraph 2 below.

Each licensee must show practical means of staying at hot shutdown for a minimum of 72 hours. If maintaining safe shutdown is dependent on a single (not redundant) component whose failure, either due to seismic loads or random failure, would preclude decay heat removal by the identified means, the licensee must show that at least one practical alternative for achieving and maintaining safe shutdown exists that is not dependent on that component.

Each licensee must develop an equipment list. This list will include all equipment within the required scope.

The equipment to be considered depends on the functions required to be performed. Typical plant functions would include:

(1) Bring the plant to a hot shutdown condition and establish heat removal.

(2) Maintain support systems necessary to establish and maintain hot shutdown.

(3) Maintain control room functions and instrumentation and controls necessary to monitor hot shutdown.

(4) Provide alternating current (ac) and/or direct current (dc) emergency power as needed on a plant-specific basis to meet the above three functions.

2. <u>General Verification Procedure for Plant-Specific Review</u>

The licensee will be required to conduct a plant walk-through and visual inspection of all identified equipment items necessary to perform the functions related to plant shutdown. The inspection team must consist of as a minimum,

(1) an experienced structural engineer familiar with seismic anchorage requirements

(2) an experienced mechanical engineer familiar with plant mechanical equipment

(3) an experienced electrical engineer familiar with plant electrical equipment

Furthermore, an operations supervisor or a licensed Senior Reactor Operator must be available for consultation before and during the walk-through process. Not all members of the inspection team are required to participate in all parts of the walk-through; however, appropriate technical expertise must be included for each review area, and a person with proper structural background must always be present to inspect the anchorage for all equipment.

As an alternative, licensees may use consultants instead of their staff for (1), (2), and (3) above.

Before the walk-through inspection, the licensee will be required to verify that the appropriate data base spectra envelope the site free-field spectra at the ground surface defined for the plant. There are a number of nuclear plants whose free field SSE spectra are defined at the foundation level. For these plants, an estimate of the free field spectra at the ground surface must be made for comparison with the data base bounding spectra. The licensee must identify all equipment on the plant's equipment list that is located at an elevation higher than 40 feet above grade level.* For equipment above 40 feet, one-and-one-half times the appropriate data base bounding spectrum (defined in paragraph 6 below) must envelope the floor response spectra for the equipment. For those cases where floor response spectra are needed, NUREG/CR-3266, "Seismic and Dynamic Qualification of Safety-Related Equipment in Operating Nuclear Power Plants: The Development of a Method to Generate Generic Floor Response Spectra," may be used as one alternative to develop the necessary floor response spectra on a case-specific basis. The appropriate bounding spectra for equipment belonging to the original eight types in the data base are defined in paragraph 6 below. For equipment types that are not included in the eight types in the data base but that exist in the data base plants, and for equipment unique to nuclear plants, the appropriate bounding spectra are defined in paragraph 7 below.

The walk-through inspection must cover anchorage review and identification of potential "deficiencies" and "outliers." "Deficiency" in this context means equipment, components, and their anchorages/supports that are identified as obviously inadequate by the A-46 criteria during plant-specific walk-through reviews and confirmed as inadequate by further engineering studies. "Outlier" in this context means equipment items that are subject to the caveats and exclusions defined in this generic letter, or that are otherwise not covered by the experience data. The treatment of deficiencies is further described in paragraphs 4 and 5 below. The walk-through inspection must cover the following:

(1) For equipment within scope, verify equipment anchorage (including required cable trays, tanks, and heat exchangers) using the guidance provided in paragraph 3 below, and identify potential deficiencies. Utilities participating in a generic implementation may use the walk-through procedures being developed by SQUG/EPRI when these are approved by SSRAP and NRC.

*"Grade level" is the top of the ground surrounding the building.

(2) For equipment belonging to the initial eight types in the data base, identify data base exclusions and caveats (outliers) from the guidance provided in paragraph 6 below.

(3) For equipment types that exist in the data base plants but that are not included in the eight types in the data base, the guidelines provided in paragraph 7 below and the guidelines being developed by SQUG (to be approved by SSRAP and NRC prior to implementation) must be used for identification and review of "outliers" and "caveats" during the walk-through inspection for this equipment.

The licensee must specify all equipment items that are required to function during the period of strong shaking. The licensee must demonstrate the operability of these items by means other than comparison with the experience data base; otherwise, the licensee must determine that any change of state will not compromise plant safety. The period of strong shaking is defined to be the first 30 seconds of the seismic event and should be considered in conjunction with the loss of offsite power. On the basis of the seismic experience data gathered to date, the only concern remaining on equipment functional capability is the concern regarding relays. Contactors and switches are considered as relays in this context. In addition, mercury switches are known to malfunction during testing and should be replaced by other types of qualified switches. Unless the test data being collected by the Electric Power Research Institute (EPRI) and the NRC Office of Research (RES) reveal otherwise, certain types of relays are the only equipment whose functional capability will need to be verified.

The essential plant functions that are required to achieve and maintain hot shutdown during and after an SSE must be identified. The associated systems and electrical circuits required to provide these functions must then be identified. Next, these functions must be evaluated and the essential relays must be identified. Essential relays are relays that must remain functional without chatter during an SSE.

These essential relays must be qualified by test, in a manner consistent with current licensing requirements (Section 3.10 of the Standard Review Plan (NUREG-0800), NRC Regulatory Guide 1.100/IEEE Standard 344-1975), verified by comparison with the test data base being developed by EPRI/RES, or replaced by relays qualified to current licensing requirements. As an alternative, the redesign of circuitry, strengthening of relay supports/cabinets to reduce seismic demand, or relocation of relays to reduce demand can be used.

The licensee must identify all relays that could potentially change state during an SSE as a result of contact chatter and preclude use of equipment needed after the SSE to place the plant in safe shutdown. The redesign of circuitry, strengthening of relay supports/cabinets to reduce demand, or relocation of relays to reduce demand can also be used. As an alternative, the licensee may show that chattering or change of state of the relays does not affect system performance or preclude subsequent equipment or system functions. In addition, credit can be taken for timely operator action to reset the relays in case change of state occurs during an SSE, provided detailed relay resetting procedures are developed and there is sufficient time for resetting the relays.

For components included in the data base by type but outside the limits of experience data or test data , or of a type not included in the data base, as a general guideline the seismic verification can be deferred until additional test data is developed, endorsed by SSRAP, and approved by the NRC staff, provided that the seismic verification is completed no later than about 36 months from the date of issuance of the USI A-46 final resolution. Actual schedule dates will be based on negotiations with the generic group or with individual utilities. The proper integration of the proposed work scope into each plant's schedule for plant modifications will be considered.

If a utility replaces components for any reason, each replacement (assembly, subassembly, device) must be verified for seismic adequacy either by using A-46 criteria and methods or, as an option, qualifying by current licensing criteria. This provision also applies to future modification or replacements. "Component" in this context means equipment and assemblies (including anchorages and supports)--such as pumps and motor control centers--and subassemblies and devices--such as motors and relays that are part of assemblies.

3. Verification of Anchorage

To verify acceptable seismic performance, adequate engineered anchorage must be provided. There are numerous examples of equipment sliding or overturning under seismic loading because anchorage was absent or inadequate. Inadequate anchorage can include short, loose, weak, or poorly installed bolts or expansion anchors; inadequate torque on bolts; and improper welding or bending of sheet metal frames at anchors. Torque on bolts can normally be ensured by a preventive maintenance and inspection program.

In general, checking of equipment anchorages requires the estimation of equipment weight and its approximate center of gravity. Also, one must either estimate the fundamental frequency of the equipment to obtain the spectral acceleration at this frequency or else use the highest spectral acceleration for all frequencies. When horizontal floor spectra exist, these spectra may be used to obtain the equipment spectral acceleration. Alternatively, for equipment mounted less than about 40 feet above grade, one-and-a-half times the free-field horizontal design ground spectrum may be used to conservatively estimate the equipment spectral acceleration. For equipment mounted more than about 40 feet above grade, floor spectra must be used. This restriction may be modified if additional data become available to justify raising the 40-foot-limit.

Equipment anchorage must not only be strong enough to resist the anticipated forces but must also be stiff enough to prevent excessive movement of the equipment and potential resonant response with the supporting structure. The review of anchorages should include consideration of both strength and stiffness of the anchorage and its component parts.

Additional discussions on seismic motion bounds and equipment supports and anchorage for each of the original eight classes of equipment in the experience data base are included in paragraph 6 below. This guidance supplements the general guidance above.

During the walk-through inspection, anchors and supports of equipment within the scope of review will be carefully inspected. The detailed guidance developed is the preferred method for review of anchorages. The detailed guidance has been developed jointly by SQUG and EPRI. It was approved by SSRAP and is being reviewed by the NRC staff. It will be approved by the NRC staff before implementation. If the adequacy of supports and anchors cannot be determined by inspection, an engineering review of the anchorage or support will be conducted. This engineering review will include a review of design calculations or the performance of new calculations and/or verification of fundamental frequency of equipment to ensure adequate restraint and stiffness. Physical modifications may be necessary if engineering review determined the anchorage or support to be inadequate.

4. Generic Resolution

The NRC will endorse and encourage a generic resolution of USI A-46 provided the guidelines presented below are followed:

(1) All member utilities of the SQUG would be eligible to participate.

(2) The generic group must be responsible (a) for developing procedures to identify relays to be evaluated, (b) for defining functionality requirements, and (c) for developing evaluation procedures for relays. This procedure must be reviewed and endorsed by SSRAP and the NRC staff.

(3) The generic group must submit to the NRC a generic schedule for the development of implementation procedures and for workshops/training seminars for participating utilities. A pilot walk-through must be conducted on a few selected plants to test the procedure. Afterwards, the generic group must hold workshops/training seminars for participating utilities to ensure uniformity in approach. Each individual utility must submit an implementation schedule to the NRC within 60 days of receipt of the A-46 generic letter. Individual utilities must then perform the plant-specific implementation reviews.

(4) Each utility must submit to the NRC an inspection report that must include: certification of completion of the review, identification of deficiencies and outliers, justification for continued operation (JCO) for identified deficiencies if these deficiencies are not corrected within 30 days, modifications and replacements of equipment/anchorages (and supports) made as a result of the reviews, and proposed schedule for future modifications and replacements.

    The objective of the requirement to submit a JCO is to provide assurance that the plant can continue to be operated without endangering the health and safety of the public during the time required to correct the identified deficiency.

    The JCO may consider arguments such as imposition of administrative controls or limiting conditions for operation (LCOs) or consideration of the importance of the safety function involved and/or identification of alternate means to perform that function.

(5) Consultants to the generic group must perform audits of plant-specific reviews. All plants must be audited. The NRC staff will participate in plant audits on a selective basis. The generic group must submit a report of audits performed and results of these audits to the NRC. This report covers all participating utilities, and must also include the results of any reviews and/or audits performed by the SSRAP.

(6) The SSRAP and the NRC staff must perform a limited review of the generic group audit process to evaluate effectiveness.

(7) Final approval of the implementation will be made by the NRC in the form of a plant-specific Safety Evaluation Report for each affected plant after NRC receives a final report from the utility involved certifying completion of implementation reviews and equipment/anchorage modifications and replacements.

(8) The generic group must provide for the continuation of the SSRAP as an independent review body. The SSRAP must be consulted during the development of the generic program and walk-through procedure, and must audit the implementation.

(9) NRC staff members must be invited to participate in all meetings between the generic group and the SSRAP.

5. Provisions for Resolution for Individual Utilities

The generic resolution described in paragraph 4 above, Generic Resolution, is the method preferred by the NRC for the resolution of A-46. This paragraph offers provisions for resolution of A-46 for individual utilities not participating in the generic group.

Each utility must develop a detailed review procedure that must be submitted to the NRC staff for review. This procedure must reflect the guidance given in paragraph 2 above. The data and procedures developed by the SQUG will not, in general, be available to non-participating utilities. All information that has been made publicly available by SQUG or the staff can be used.

Each utility must perform plant-specific verification reviews according to guidance in paragraphs 2 and must also maintain an auditable record of implementation of USI A-46.

Within 60 days of receipt of the A-46 generic letter, each utility must submit to the NRC a schedule for implementation of the A-46 requirements. Utilities who may not have access to SQUG implementation procedures or data base may have difficulty in establishing implementation schedules within 60 days. For these utilities the NRC will negotiate time extensions on a case by case basis. The utility must submit an inspection report to the NRC after the plant-specific walk-through inspection. It should consist of the following:

(1) Certification of completion of the walk-through inspection and a description of the procedures used.

(2) A list of the equipment included in the review scope. Equipment required to function during the strong shaking period should be identified.

(3) Identified deficiencies.

(4) Identified outliers.

(5) Modifications and replacements of equipment/anchorages (and supports) made as a result of the inspection.

(6) The proposed schedule for future modifications and replacements.

(7) A JCO for identified deficiencies if these deficiencies are not corrected within 30 days.

Following the completion of implementation reviews and all necessary modifications and replacements of equipment/anchorages, the utility must submit a final report to the NRC. A description of the procedures used for the implementation reviews and the modifications and replacements must be included.

The NRC will review the inspection procedure, inspection report, and the final report and will audit all plant-specific reviews before granting final NRC approval. The final NRC approval will be in the form of plant-specific SERS.

6. Guidance on Use of Seismic Experience Data for the Eight Equipment Types in the Experience Data Base*

(1) Seismic Motion Bounds

To compare the potential performance of equipment at a given nuclear power plant with the actual performance of similar equipment in the data base plants in recorded earthquakes, SSRAP has developed seismic motion bounding spectra to facilitate comparison. The purpose of these bounding spectra is to compare the potential seismic exposure of equipment in a nuclear power plant with the estimated ground motion that similar equipment actually resisted in earthquakes described in the data base. For convenience, the bounding spectra are expressed in terms of ground response at the nuclear site rather than floor response or equipment response. These bounding spectra represent approximately two-thirds of the free-field ground motion to which the data base equipment was actually exposed.

Three different seismic motion bounds (types A, B, and C) are used. Different bounding spectra were developed, not to infer different ruggedness of equipment, but to represent the actual exposure of significant numbers of each class of equipment within the data base to ground motion. These bounds are defined in terms of the 5% damped horizontal ground response spectra shown in Figure A-1. The seismic motion bounds may be used for the equipment class as defined below.

| Equipment Class | Bound |
|---|---|
| Motor control centers<br>Low-voltage (480-V) switchgear<br>Metal-clad (2.4 to 4-kV) switchgear<br>Unit substation transformers | Type B |

*Guidance in this paragraph is based on the SSRAP report dated January 1985. The SQUG is in the process of expanding the data base to include more recent earthquake experience and 20 classes of equipment which cover all the equipment needed for plant hot shutdown. The SSRAP report also is being revised accordingly. The final guidance in the SSRAP report may differ from that mentioned here. The revised SSRAP report should be followed for implementation guidance.

| Equipment Class | Bound |
|---|---|
| Motor-operated valves with large eccentric-operator-lengths-to-pipe-diameter ratios | Type C |
| Motor-operated valves (exclusive of those with large eccentric-operator-lengths-to-pipe-diameter ratios)<br>Air-operated valves<br>Horizontal pumps and their motors<br>Vertical pumps and their motors | Type A |

These spectrum bounds are intended for comparison with the 5% damped design horizontal ground response spectrum at a given nuclear power plant. In other words, if the horizontal ground response spectrum for the nuclear plant site is less than a bounding spectrum at the approximate frequency of vibration of the equipment and at all greater frequencies (also referred to as the frequency range of interest), then the equipment class associated with that spectrum is considered to be included within the scope of this method. Alternately, one may compare 1.5 times these spectra with a given 5% damped horizontal floor spectrum in the nuclear plant.

The comparison of these seismic bounds with the design horizontal ground response spectrum is judged to be acceptable for equipment mounted less than about 40 feet* above grade (the top of the ground surrounding the building) and for moderately stiff structures. For equipment mounted more than about 40 feet above grade, comparisons of 1.5 times these spectra with the horizontal floor spectrum is necessary. In all cases such a comparison with floor spectra is also acceptable. The vertical component will not be any more significant relative to the horizontal components for nuclear plants than it was for the data base plants. Therefore, it was decided that seismic bounds could be defined purely in terms of horizontal motion levels.

The criteria are met so long as the 5% damped horizontal design spectrum lies below the appropriate bounding spectrum at frequencies greater than or equal to the fundamental frequency range of the equipment. This estimate can be made judgmentally by experienced engineers without the need for analysis or testing.

The recommendation that the seismic bounding spectrum can be compared with the horizontal design ground response spectrum for equipment mounted less than about 40 feet above grade is based upon various judgments concerning how structures respond in earthquakes. However, this 40-foot above grade criterion must be applied with some judgment because some structures may respond in a different manner.

(2) Motor Control Centers

Motor control centers contain motor starters (contactors) and disconnect switches. They also provide over-current relays to protect the system from

*In most cases where numerical values are given in this section they should be considered as either "approximate" or "about," and a tolerance about the stated value is implied.

overheating. In addition, some units will contain small transformers and distribution panels for lighting and 120 V utility service.

Motor control centers of the 600-V class (actual voltage is 480-V) are considered. The general configuration of the cabinets must be similar to those specified in the Standards of the National Electrical Manufacturers Association (NEMA). This requirement is imposed to preclude unusual designs not covered in the data base. Cabinets that are configured similarly to NEMA standards will perform well if they are properly anchored. Cabinet dimensions and material gauges need not exactly match NEMA standards.

On the basis of a review of the data base and anticipated variations in conditions, it appears that the motor control centers are sufficiently rugged to survive a seismic event and remain operational thereafter provided the following conditions exist in the nuclear facility:

(a) The spectrum for the nuclear facility is less than the type B bounding spectrum described in Figure A.1 for frequencies above the estimated fundamental frequency of the cabinet, and the motor control center is located less than 40 feet above exterior grade and has stiff anchorage, as discussed below. If the motor control center is located higher than 40 feet above exterior grade or does not have stiff anchorage, the floor spectrum shall be compared to 1.5 times the type B bounding spectrum. In all cases a comparison with floor spectra is also acceptable.

(b) The cabinets have stiff engineered anchorage. Both the strength and stiffness of the anchorage and its component parts must be considered. Stiffness can be evaluated by engineering judgment based on the cabinet construction and the location and type of anchorage, giving special attention to the potential flexibility between the tiedown anchorage and the walls of the cabinet. One concern is with the potential flexibility associated with bending of a sheet metal flange between the anchor and the cabinet wall. Stiffly anchored cabinets will have a fundamental frequency greater than about 8 Hz under significant shaking.

    The intent of this recommendation is to prevent excessive movement of the cabinet and to ensure that under earthquake excitations the natural frequency of the installed cabinet will not be in resonance with both the frequency content of the earthquake and the fundamental frequency of the structure, thereby allowing comparison of the ground response spectra with the type B bounding spectrum.

(c) Cabinets with sufficiently strong anchorage that do not have the stiff anchorage as recommended above are still considered in the data base; however, the floor response spectrum must be compared to 1.5 times the type B bounding spectrum.

(d) Cutouts in the cabinet sheathing are less than about 6 inches wide and 12 inches high including side sheathing between multi-bay cabinets.

(e) All internal subassemblies are securely attached to the motor control cabinets that contain them.

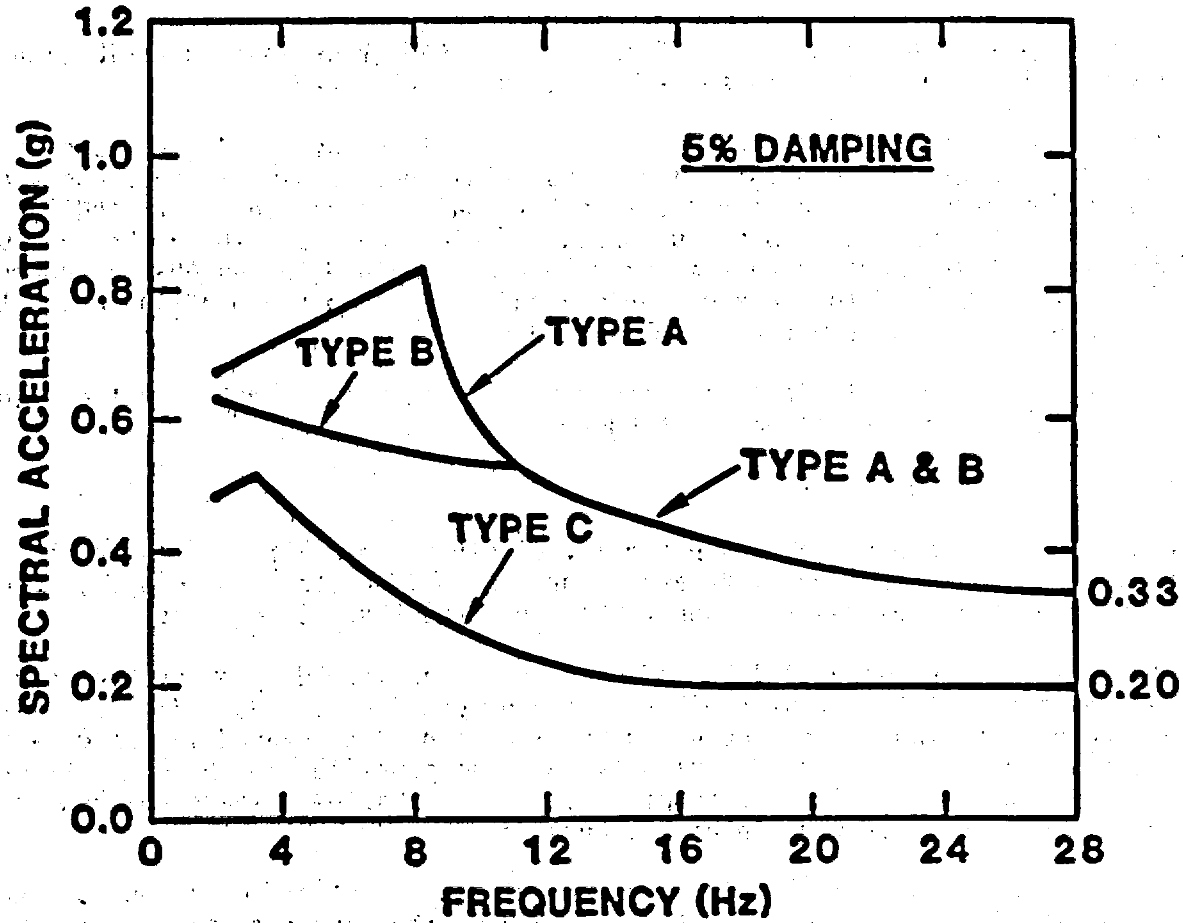


Figure A.1 Seismic motion bounding spectra, horizontal ground motion

(f) Adjacent sections of multi-bay cabinet assemblies are bolted together.

(g) Equipment and their enclosures mounted externally to motor control center cabinets and supported by them have a total weight of less than 100 pounds.

Functional capability (that is, inadvertent change of state or failure to change state on command of relays during an earthquake) is not considered here. Functional capability must be established by other means. The structural integrity of relays contained in the motor control centers and their ability to function properly after earthquakes, as defined in Figure A.1, has been demonstrated.

(3) Low-Voltage Switchgear

Low-voltage switchgear consists of low voltage (600 V or less) distribution busses, circuit breakers, fuses, and disconnect switches.

Low-voltage switchgear of the 600-V class (actual voltage is 480-V) is considered. The general configuration of cabinets must be similar to those specified in Standard C37.20 of the American National Standard Institute (ANSI). This requirement is imposed to preclude unusual designs not covered in the data base. Cabinets that are configured similarly to those defined in the ANSI standards will perform well if they are properly anchored. Cabinet dimensions and material gauge need not exactly match the ANSI standard.

All the conclusions, limitations, and bounding spectra for motor control centers are applicable to low-voltage switchgear.

(4) Metal-Clad Switchgear

Metal-clad switchgear consists primarily of circuit breakers and associated relays (such as over-current relays or ground fault protection relays), interlocks, and other devices to protect the equipment that it services.

Metal-clad switchgear of 2.4 kV and 4.16 kV is considered. The general configuration of cabinets must be similar to those specified in ANSI C37.20. This requirement is imposed to preclude unusual designs not covered in the data base. Cabinets that are configured similarly to those specified in the ANSI standards will perform well if they are properly anchored. Cabinet dimensions and material gauges need not exactly match ANSI standards.

All the conclusions, limitations, and bounding spectra for motor control centers are applicable to metal-clad switchgear, except that the cutouts in the cabinet sheathing shall be less than about 12 inches by 12 inches.

(5) Motor-Operated Valves

Motor-operated valves consist of an electric motor and gear box cantilevered from the valve body by a yoke and interconnected by a drive shaft. The motor and gear box serve as an actuator to operate the valve.

On the basis of a review of the data base and anticipated variations in conditions, it appears that motor-operated valves are sufficiently rugged to survive a seismic event and remain operational thereafter provided the following conditions exist in the nuclear facility:

(a) The spectra for the nuclear facility are less than the appropriate bounding spectrum described in Figure A.1 for frequencies above the estimated fundamental frequency of the piping-valve system.

(b) The valve is located less than 40 feet above exterior grade. If the valve is located higher than 40 feet above exterior grade, the floor spectra shall be compared with 1.5 times the appropriate bounding spectrum.

(c) The valve body and yoke construction is not of cast iron.

(d) The valve is mounted on a pipe at least 2 inches in diameter.

(e) The actuator is supported by the pipe and not independently braced to or supported by the structure unless the pipe is also braced immediately adjacent to the valve to a common structure.

The following limitations on operator weight and eccentric length relative to pipe diameter are derived from the data base for motor-operated valves that was provided by SQUG.*

(a) A type A bounding spectrum shall be used for the following cases: (see Figure A.2):

Valves mounted on 12-inch diameter or larger pipes with a 60-inch or smaller distance from the pipe centerline to the top of the motor actuator, and the approximate actuator weight is less than 400 pounds.

Valves mounted on 24-inch diameter or larger pipes with a 100-inch or smaller distance from the pipe centerline to the top of the motor actuator, and the approximate actuator weight is less than 300 pounds.

(b) A type C bounding spectrum shall be used for the following cases: (see Figure A.3):

Valves mounted on a pipe diameter of at least 2 inches but less than 6 inches, with a 30-inch or smaller distance from the pipe centerline to the top of the motor actuator, and the approximate actuator weight is less than 100 pounds.

Valves mounted on a pipe diameter of at least 6 inches but less than 8 inches, with a 40-inch or smaller distance from the pipe centerline to the top of the motor actuator, and the approximate actuator weight is less than 300 pounds.

*The data base contains relatively few heavy operators and small pipe diameters subjected to severe ground shaking. These limitations could be less restrictive if more motor-operated valves had been located and documented in the areas of higher shaking. Additional data, either from other earthquake experience or seismic qualification tests, could expand the scope of these recommendations.

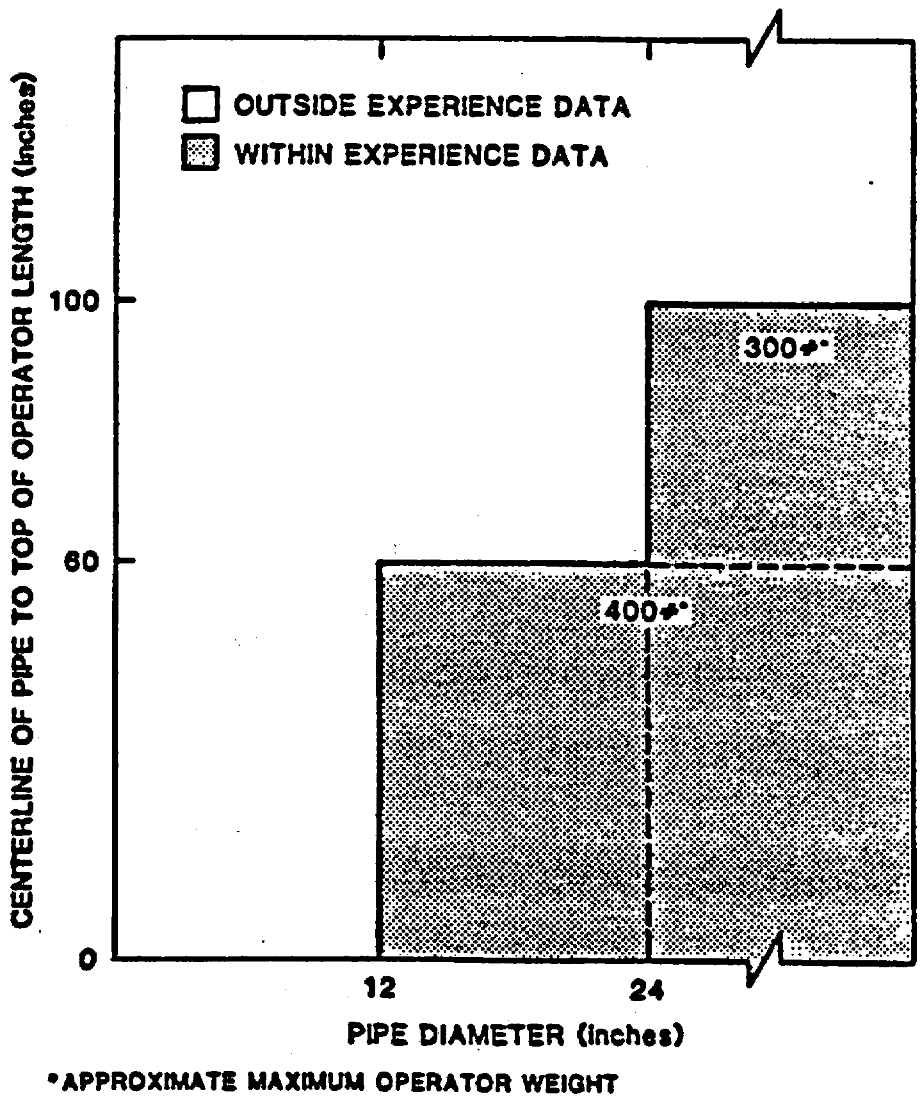


Figure A.2 Motor-operated valves for which type A spectrum is to be used

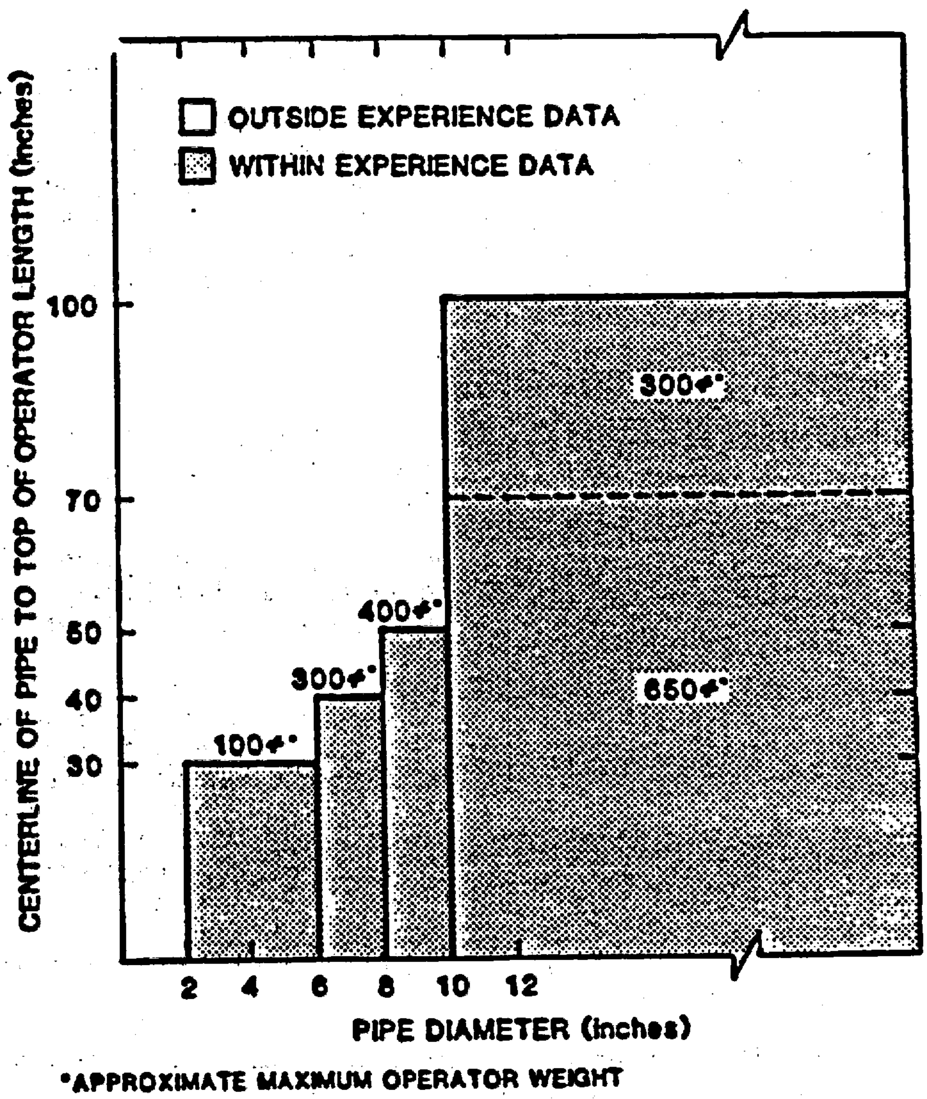


Figure A.3 Motor-operated valves for which type C spectrum is to be used

Valves mounted on a pipe diameter of at least 8 inches but less than 10 inches, with a 50-inch or smaller distance from the pipe centerline to the top of the motor actuator, and the approximate actuator weight is less than 400 pounds.

Valves mounted on a pipe diameter of at least 10 inches with a 70-inch or smaller distance from the centerline of the pipe to the top of the motor actuator, and the approximate actuator weight is less than 640 pounds; or the weight is more than 300 pounds for cases where the distance from the centerline of the pipe to the top of the motor actuator is not greater than 100 inches.

For motor-operated valves not complying with the above limitations, the seismic ruggedness for ground motion not exceeding the type A bounding spectrum may be demonstrated by static tests. In these tests, a static force equal to three times the approximate operator weight shall be applied non-concurrently in each of the three orthogonal principal axes of the yoke. Such tests should include a demonstration of operability following the application of the static load. The limitations other than those related to the operator weight and distance from the top of the operator to the centerline of the pipe, given above shall remain in effect.

(6) Unit Substation Transformers

Unit substation transformers convert the distribution voltage to low voltage. In this discussion, unit substation transformers that convert 2.4-kV or 4.16-kV distribution voltages to 480 V are considered.

On the basis of a review of the data base and anticipated variations, it appears that unit substation transformers are sufficiently rugged to survive a seismic event and remain operational thereafter provided the following conditions exist in the nuclear facility:

(a) The spectrum for the nuclear facility is less than the type B bounding spectrum described in Figure A.1 for frequencies above the estimated fundamental frequency of this equipment, and the unit substation transformer is located less than 40 feet above exterior grade. If the unit substation transformer is located higher than 40 feet above exterior grade, the floor spectrum shall be compared with 1.5 times the bounding spectrum. In all cases a comparison with floor spectra is also acceptable.

(b) Both unit substation transformer enclosures and the transformer itself must have engineered anchorage.

The functional capability of properly anchored unit substation transformers during and after earthquakes, as defined above, has been demonstrated.

(7) Air-Operated Valves

Air-operated valves consist of a valve (controlled by a solenoid valve) operated by a rod actuated by air pressure against a diaphragm attached to the rod. The actuator is supported by the valve body through a cantilevered yoke.

On the basis of a review of the data base and anticipated variations in conditions, it appears that air-operated valves are sufficiently rugged to survive a seismic event and remain operational thereafter provided the following conditions exist in the nuclear facility:

(a) The ground motion spectra for the nuclear facility are less than the type A bounding spectrum for frequencies above the estimated fundamental frequency of the piping-valve system.

(b) The valve body is not of cast iron.

(c) The valve is mounted on a pipe of 1-inch diameter or greater.

(d) If the valve is mounted on a pipe less than 4 inches in diameter, the distance from the centerline of the pipe to the top of the operator shall not exceed 45 inches. If the valve is mounted on a pipe 4 inches in diameter or larger, the distance from the centerline of the pipe to the top of the operator shall not exceed 60 inches (see Figure A.4).

(e) The actuator and yoke are supported by the pipe, and neither is independently braced to the structure or supported by the structure unless the pipe is also braced immediately adjacent to the valve to a common structure.

The air supply line is not included in this assessment.

For air-operated valves not complying with the above limitations, the seismic ruggedness for ground motion not exceeding the type A bounding spectrum may be demonstrated by static tests. In these tests, a static force equal to three times the approximate operator weight shall be applied non-concurrently in each of the three orthogonal principal axes of the yoke. Such tests should include demonstration of operability following the application of the static load. The limitations other than those related to the distance of the top of the operator to the centerline of the pipe given above shall remain in effect.

(8) Horizontal and Vertical Pumps

Horizontal pumps in their entirety and vertical pumps above their flange are relatively stiff and very rugged devices as a result of their inherent design and operating requirements. Motors for these pumps are also included. Subject to the limitations set forth below, all pumps meet the criteria for the type A bounding spectrum.

For horizontal pumps, the driver (electric motor, turbine, etc.) and pump must be rigidly connected through their bases to prevent damaging relative motion. Of concern are intermediate flexible bases, which must be evaluated separately. Thrust restraint of the shaft must also be ensured in both axial directions. The data base covers pumps up to 2500 hp; however, the conclusions appear to be equally valid for horizontal pumps of greater horsepower.

For vertical pumps, the data base has many entries up to 700 hp and several up to 6000 hp. However, vertical pumps, above the flange, of any size at nuclear plants appear to be sufficiently rugged to meet the type A bounding spectrum.

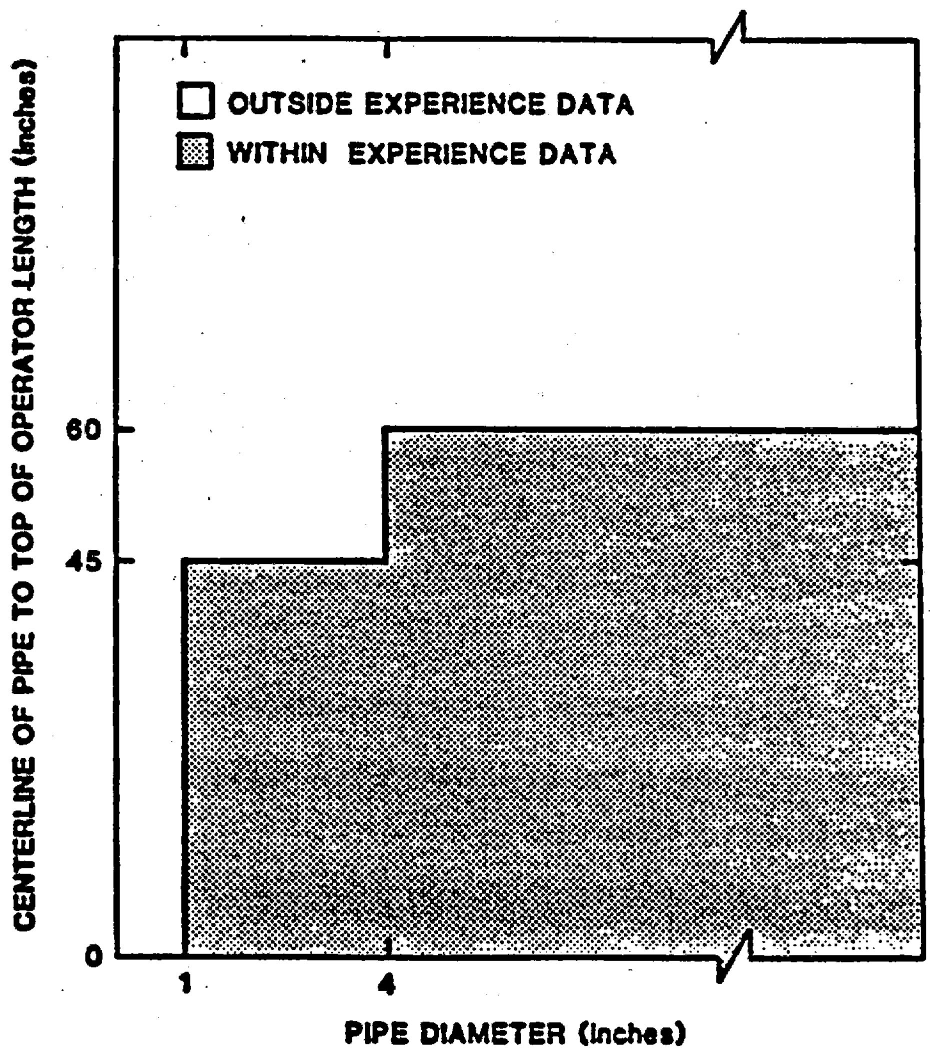


Figure A.4 Air-operated valves for which type A spectrum is to be used

The variety of vertical pump configurations and shaft lengths, below the flange, and the relatively small number of data base points in several categories preclude the use of the data base to screen all vertical pumps. Vertical turbine pumps (deep well submerged pumps with cantilevered casings up to 20 feet in length and with bottom bearing support of the shaft to the casing) are well enough represented to meet the bounding criteria below the flange as well. Either individual analysis or use of another method should be considered as a means of evaluating other vertical pumps below the flange. The chief concerns would be damage to bearings as a result of excessive loads, damage to the impeller as a result of excessive displacement, and damage as a result of interfloor displacement on multi-floor supported pumps.

7. Guidance on Review of Equipment that Exists in the Experience Data Base Plants but that Is Not Included in the Eight Types in the Data Base

On the basis of the above experience, reviews conducted by the staff in the SEP Program and licensing activities (SQRT audits), and the observation of the behavior of equipment beyond the original eight classes found in the data base plants, the staff concludes that the seismic adequacy of equipment other than the eight types can be achieved by (1) anchorage verification; (2) a careful review of caveats, outliers, and exclusions observed; and (3) documentation by SQUG of the basis for seismic adequacy of each equipment type.

The SQUG is in the process of broadening the data base to include more recent earthquake experience (notably the 1985 earthquakes of Chile and Mexico). The equipment covered by the experience data base will be expanded from the original eight to twenty which will encompass all equipment needed for plant hot shutdown. The SSRAP report is also being revised accordingly. The guidance in the final revised SSRAP report may differ from that mentioned in the January 1985 SSRAP report. The revised SSRAP report should be followed for implementation guidance.

For individual utilities not participating in the generic group, the detailed procedures used to review the seismic adequacy of all equipment should be submitted to the NRC for review. Items such as equipment caveats and exclusions, bounding spectra to be used, and the like should be included in the submittal.

LIST OF RECENTLY ISSUED GENERIC LETTERS

| Generic Letter No. | Subject | Date of Issuance | Issued To |
|---|---|---|---|
| GL 87-01 | PUBLIC AVAILABILITY OF THE NRC OPERATOR LICENSING EXAMINATION QUESTION BANK | 01/08/87 | ALL POWER REACTOR LICENSEES AND APPLICANTS FOR AN OPERATING LICENSE |
| GL 86-17 | AVAILABILITY OF NUREG-1169, "TECHNICAL FINDINGS RELATED TO GENERIC ISSUE C-8 BWR MSIC LEAKAGE AND LEAKAGE CONTROL SYSTEM | 10/17/86 | ALL LICENSEES OF BOILING WATER REACTORS |
| GL 86-16 | WESTINGHOUSE ECCS EVALUATION MODELS | 10/22/86 | ALL PRESSURIZED WATER REACTOR APPLICANTS AND LICENSEES |
| GL 86-15 | INFORMATION RELATING TO COMPLIANCE WITH 10 CFR 50.49, "EQ OF ELECTRICAL EQUIPMENT IMPORTANT TO SAFETY" | 09/22/86 | ALL LICENSEES AND HOLDERS OF AN APPLICATION FOR AN OPERATING LICENSE |
| GL 86-14 | OPERATOR LICENSING EXAMINATIONS | 08/20/86 | ALL POWER REACTOR LICENSEES AND APPLICANTS |
| GL 86-13 | POTENTIAL INCONSISTENCY BETWEEN PLANT SAFETY ANALYSES AND TECHNICAL SPECIFICATIONS | 07/23/86 | ALL POWER REACTOR LICENSEES WITH CE AND B&W PRESSURIZED WATER REACTORS |
| GL 86-12 | CRITERIA FOR UNIQUE PURPOSE EXEMPTION FROM CONVERSION FROM THE USE OF HEU FUEL | 07/03/86 | ALL NON-POWER REACTOR LICENSEES AUTHORIZED TO USE HEU FUEL |
| GL 86-11 | DISTRIBUTION OF PRODUCTS IRRADIATED IN RESEARCH REACTORS | 06/25/86 | ALL NON-POWER REACTOR LICENSEES |
| GL 86-10 | IMPLEMENTATION OF FIRE PROTECTION REQUIREMENTS | 04/28/86 | ALL POWER REACTOR LICENSEES AND APPLICANTS |
| GL 86-09 | TECHNICAL RESOLUTION OF GENERIC ISSUE NO. B-59 (N-1) LOOP OPERATION IN BWRS AND PWRS | 03/31/86 | ALL BWR AND PWR LICENSEES AND APPLICANTS |