[7590-01]

NUCLEAR REGULATORY COMMISSION

10 CFR Part 50

Modification of General Design Criterion 4 Requirements For Protection Against Dynamic Effects of Postulated Pipe Ruptures

AGENCY: Nuclear Regulatory Commission.

ACTION: Proposed rule.

SUMMARY: The Nuclear Regulatory Commission is proposing to amend its regulations that require the protection of structures, systems and components important to safety against dynamic effects of postulated large pipe ruptures. Specifically, the proposed amendments would modify General Design Criterion 4 (GDC 4) to allow demonstration of piping integrity by analyses to serve as a basis for excluding consideration of dynamic effects associated with certain pipe ruptures. These analyses constitute what commonly is referred to as the "leak-before-break" concept. The modification will permit the selective removal of pipe whip restraints and jet impingement shields from operating plants, plants under construction and future plant designs, but will not impact other design requirements such as emergency core cooling system (ECCS) performance and containment design.

DATE: Comment period expires September 2, 1985. Comments received after this date will be considered if it is practical to do so, but assurance of consideration can only be given to comments received on or before this date.

ADDRESSES: Send comments to: Secretary, U.S. Nuclear Regulatory Commission, Washington, DC 20555, ATTN: Docketing and Service Branch.

Deliver comments to: Room 1121, 1717 H Street, NW, Washington, DC between 8:15am and 5:00pm weekdays.

Copies of the regulatory analysis, documents referenced in this notice and comments received may be examined at: the NRC Public Document Room at 1717 H Street, NW, Washington, DC.

FOR FURTHER INFORMATION CONTACT: John A. O'Brien, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC 20555, telephone (301) 443-7854.

SUPPLEMENTARY INFORMATION:

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BACKGROUND

Recent investigations using both deterministic and probabilistic analyses have demonstrated that for the specific case of the main primary loops of pressurized water reactors, double-ended guillotine or longitudinal ruptures are extremely unlikely. Attempts are currently underway to learn if these findings are applicable tc other high energy piping systems, including piping in boiling water reactors.

These deterministic and probabilistic analyses depend on advanced fracture mechanics techniques, and include investigations of potential indirect failure mechanisms which could lead to pipe rupture. The objective of this approach (hereafter referred to as leak-before-break) is to demonstrate by analysis that the detection of small flaws, either by inservice inspection or by leakage monitoring systems, is assured long before the flaws can grow to critical or unstable sizes and lead to large break areas such as the double-ended guillotine pipe rupture.

General Design Criterion 4 (GDC 4), Appendix A, 10 CFR Part 50, states:

"Criterion 4 - Environmental and missile design bases. Structures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmetnal conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents. These structures, systems, and components shall be appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit." (emphasis added)

The "Definitions and Explanations" section of Appendix A defines a "loss of coolant accident" as follows: "Loss of coolant accidents. Loss of coolant accidents mean those postulated accidents that result from the loss of reactor coolant at a rate in excess of the capability of the reactor coolant makeup system from breaks in the reactor coolant pressure boundary, up to and including a break equivalent in size to the double-ended rupture of the largest pipe of the reactor coolant system." (emphasis added)

GDC 4 and the definition of a "loss of coolant accident" taken together have been conservatively applied to require all nuclear power reactors to employ massive pipe whip restraints and jet impingement shields to mitigate the dynamic effects of a postulated guillotine rupture in the largest pipes of the reactor coolant system. It can now be shown that these protective devices actually degrade overall safety because they reduce the effectiveness of inservice inspection, and because of difficulties and potential errors in installation, or reinstallation, that could actually increase the likelihood of pipe rupture. The past several years have

witnessed the development and experimental validation of analysis methods described above to demonstrate piping integrity in specific situations. This concept is fundamental in deciding whether or not guillotine pipe ruptures should be considered in formulating regulatory requirements.

The need and urgency for addressing the issue stem from the widespread acceptance of the analysis results and the research findings pertaining to pipe rupture coupled with increasing confidence in its applicability. Prior to the last few years, there was no sound technical basis for excluding certain pipe ruptures from the design basis. Now it is clear that it is possible to defend the exclusion of pressurized water reactor (PWR) primary loop double-ended guillotine pipe ruptures, and that the scope may be extended to other piping, including piping in boiling water reactors. Rulemaking action will promote investigations to determine which other situations will permit the removal of pipe whip restraints and jet impingement shields. Acceptance criteria for generally applying these results pertaining to leak-before-break have been published by the NRC staff in "Report of the U.S. Nuclear Regulatory Commission Piping Review Committee", NUREG-1061, Volume 3, and are being proposed by the American Nuclear Society in ANS-58.2 entitled "Design Basis for Protection of Light Water Nuclear Power Plants Against Effects of Postulated Pipe Rupture."

In summary, the requirements of GDC 4 as applied in the context of the definition of LOCA have led to a situation where protective devices have been added to nuclear power plants to forestall events which are now

regarded as extremely unlikely. These protective devices reduce safety and increase worker radiation exposures. A need exists to allow exclusion from compliance with GDC 4 requirements of certain pipe ruptures when supported by acceptable analyses.

REGULATORY HISTORY

In 1975, the NRC staff was informed of newly defined asymmetric blowdown loads that result by postulating rapid-opening double-ended ruptures of PWR primary piping at the most adverse location in the piping system, that is, inside the reactor cavity. This problem was later designated as Unresolved Safety Issue A-2 (USI A-2). In June of 1976, the staff requested that the owners of operating PWRs evaluate their primary systems for these asymmetric loads. In response, owner groups submitted probabilistic studies and proposals for augmented inservice inspection. In a letter to the owners of all operating PWRs in January 1978, the staff concluded that the existing data base was not sufficient to support the findings of the probability studies and that inservice inspection alone was not an acceptable resolution.

As a consequence, plant analyses for asymmetric loads were submitted for review during 1980. It became clear after reviewing these analyses that some plants might require extensive modifications. In parallel with the preparation of the plant analyses, Westinghouse undertook a deterministic fracture mechanics evaluation to demonstrate that an assumed double-ended rupture is not a credible design basis event for PWR primary piping. These

efforts eventually led to the submission of two reports: "Mechanistic Fracture Evaluation of Reactor Coolant Pipe Containing a Postulated Circumferential Throughwall Crack," WCAP 9558, Rev 2., May 1981, and "Tensile and Toughness Properties of Primary Piping Weld Metal For Use In Mechanistic Fracture Evaluation," WCAP 9787, May 1981.

Also during 1981, the nine volumes of NUREG/CR-2189 entitled "Probability of Pipe Fracture in the Primary Coolant Loop of a PWR Plant" were published by Lawrence Livermore National Laboratory under contract to the Office of Nuclear Regulatory Research. Using different methodologies, both the Westinghouse and Lawrence Livermore National Laboratory studies supported the conclusion that double-ended pipe ruptures in PWR primary loop piping are extremely low-probability events. The staff reviewed the Westinghouse and Lawrence Livermore National Laboratory documents and accepted the findings presented therein. In the process of resolving USI A-2, both the Westinghouse and Livermore studies were presented to the Advisory Committee on Reactor Safeguards (ACRS) to obtain its concurrence on the staff's evaluation of the results. In a June 14, 1983 letter to the NRC Executive Director for Operations, the ACRS stated:

> "We believe it is now appropriate and fitting to apply [fracture mechanics] to the analysis of Task Action Plan A-2 (USI A-2) dealing with the treatment of Asymmetric Blowdown Loads on Reactor Primary Coolant Systems. Fracture mechanics analysis clearly indicates that in PWR primary piping a substantial range of stable crack sizes exists between those which give detectable leaks, and the much larger size that results in a sudden failure. That is, there is no known mechanism in PWR primary piping material for developing a large break

without going through an extended period during which the crack would leak copiously.

However, any relaxation of requirements to cope with double-ended guillotine break should be preceded by rigorous reexamination of the integrity of heavy component supports under all design conditions."

NRC's "Committee to Review Generic Requirements" (CRGR) has the responsibility to review and recommend to the Executive Director for Operations approval or disapproval of requirements to be imposed by the staff on power reactors. Because the application of leak-before-break technology in lieu of postulated large pipe ruptures is at variance with current NRC regulations, the proposed staff actions regarding USI A-2 were presented to the CRGR.

The CRGR views on the leak-before-break concept were reported in the minutes of CRGR meeting number 47, dated October 14, 1983, as indicated below:

"The CRGR observed that the staff findings concerning leak before break have broad implications that go beyond resolution of the A-2 issue affecting 13 (sic) PWR licensees. These findings and the technical justifications in support of the findings could extend to other break locations and to assumptions previously made for piping loops and components of the reactor coolant systems, for piping connected to the coolant system and perhaps to the piping of other systems in the plant. This broader applicability of the

leak-before-break criteria could have potentially large positive benefits in terms of the degree to which unneeded and potentially counter-productive hardware (e.g., piping restraints, jet impingment barriers etc.) continues to be required in plant construction. In this regard, the CRGR was advised by staff that the leak-before-break criteria could be more broadly extended to apply to the large size piping and components in the PWR reactor coolant system."

Generic letter 84-04, dated February 1, 1984, entitled "Safety Evaluation of Westinghouse Topical Reports Dealing With Elimination of Postulated Pipe Breaks In PWR Primary Main Loops" allowed licensees to request exemptions from the requirements of GDC 4 with respect to asymmetric blowdown loads resulting from discrete breaks in the primary main coolant loop (USI A-2). This use of exemptions, however, is limited and indicates a need to address the issue in rulemaking. This rulemaking is being initiated to permit this new approach to piping behavior and to obtain public comment on the proposed course of action.

SCOPE OF RULEMAKING

The direct dynamic effects of pipe rupture are missile generation, pipe whipping, pipe break reaction forces and discharging fluids. The influence of discharging fluids includes jet impingement forces, decompression waves within the intact portion of the piping system and pressurization in cavities, subcompartments and compartments.

There are two reasons for the decision to treat only dynamic effects in this rulemaking as opposed to other related requirements which could be interpreted to involve postulated pipe ruptures. First, loss-of-coolant accidents that place requirements on safety systems and structures include breaches in the reactor coolant pressure boundary other than the double-ended pipe rupture. Second, studies completed to date indicate that the only adverse safety implications associated with postulating pipe rupture are those resulting from consideration of the dynamic effects associated with pipe rupture. The placement of pipe whip restraints and jet impingement shields degrades plant safety, reduces the accessibility for and effectiveness of inservice inspection, increases inservice inspection radiation dosages and adversely affects construction and maintenance economics. Thus, significant safety benefits accrue when more realistic assumptions are made concerning the dynamic effects associated with postulated pipe ruptures. Current design margins in the primary loop heavy component supports are to be maintained. Existing heavy component supports designed for the dynamic effects of pipe rupture and seismic events are not affected. New plants will be designed with supports which have margins comparable and equivalent to those margins now present.

PROPOSED RULE

The language of the proposed amendment to the rule specifies "conditions consistent with the design basis for piping." The design basis for the

piping includes the Code of Federal Regulations, that is, applicable general design criteria, applicable sections of NUREG-0800 (Standard Review Plan), applicable Regulatory Guides and applicable industry standards (Section III of the ASME Boiler and Pressure Vessel Code). The proposed rule consists of added text at the end of GDC 4 which permits the use of analyses to exclude dynamic effects of certain pipe ruptures.

The amendment would permit the demonstration of piping integrity by analyses such as a fracture mechanics evaluation including the effects of fatigue and, if relevant, stress corrosion, in addition to an investigation of potential indirect failure mechanisms which could lead to pipe rupture.

Modification of the licensed configuration of operating plants by the removal of pipe whip restraints and jet impingement shields involves an unreviewed safety question under 10 CFR 50.59. Licensees of operating plants desiring to make modifications beyond the scope of this amendment will be required to submit a license amendment for NRC approval in accordance with revised General Design Criterion 4. The license amendment shall also include provisions for an augmented leakage detection system or other license conditions developed during the rulemaking action.

Similarly, applicants for an operating license seeking design modifications beyond those approved in Generic Letter 84-04 will be required to submit an amendment to the application for NRC approval in accordance with 10 CFR 50.35(c). The amendment to the application shall also include provisions for any license conditions developed during the rulemaking action.

The supporting safety analysis must demonstrate from the results of a fracture mechanics analysis that a substantial range of stable pipe crack sizes exist for an extended period which provide detectable leaks, and that the fluid systems piping will not rupture under these conditions consistent with the design basis for the piping.

It is estimated that this rulemaking action will reduce total occupational radiation exposure by amounts measured in tens of thousands of man-rem and that total cost savings will exceed $100 million.

FUTURE RULEMAKING

The amendment proposed below is limited to the primary coolant loop piping in pressurized water reactors. It is therefore equivalent in scope to the staff actions taken in Generic Letter 84-04 regarding USI A-2 and to the exemptions to GDC 4 which were authorized in that connection. The Commission will, in the near future, propose a broader amendment to GDC 4 which would allow application of the new technical approach outlined above to all reactor piping in all reactor types providing adequate technical justification can be supplied for each new application.

AVAILABILITY OF DOCUMENTS

1. Copies of NUREG/CR-1061, Volume 3, may be purchased by calling (202) 275-2060 or (202) 275-2171 or by writing to the Superintendent of Documents, U.S. Government Printing Office, Post Office Box 37082,

Washington, D.C., 20013-7082, or purchased from the National Technical Information Service, Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

2. ANS-58.2, "Design Basis for Protection of Light Water Nuclear Power Plants Against Effects of Postulated Pipe Rupture," is available from The American Nuclear Society, 555 North Kensington Avenue, La Grange Park, Illinois 60525.

3. A nonproprietary version of the Westinghouse report, "Mechanistic Fracture Evaluation of Reactor Coolant Piping Containing a Postulated Circumferential Throughwall Crack," WCAP 9558, Rev. 2, May 1981, is available in the NRC Public Document Room, 1717 H Street NW, Washington, D.C.

4. A nonproprietary version of the Westinghouse report, "Tensile and Toughness Properties of Primary Piping Weld Metal For Use In Mechanistic Fracture Evaluation," WCAP 9787, May 1981, is available in the NRC Public Document Room.

5. Copies of NUREG/CR-2189, Volumes 1-9 , may be purchased by calling (202) 275-2060 or (202) 275-2171 or by writing to the Superintendent of Documents, U.S. Government Printing Office, Post Office Box 37082, Washington, D.C., 20013-7082, or purchased from the National Technical Information Service, Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

6. ACRS Letter to William J. Dircks, NRC Executive Director of Operations, dated June 14, 1983, dealing with fracture mechanics, is available in the NRC Public Document Room.

7. Minutes of CRGR Meeting Number 47, dated October 14, 1983, are available in the NRC Public Document Room.

8. Generic Letter 84-04, dated February 1, 1984, is available in the NRC Public Document Room.

FINDING OF NO SIGNIFICANT ENVIRONMENTAL IMPACT

The Commission has determined under the National Environment Policy Act of 1969, as amended, and the Commission's regulations in Subpart A of 10 CFR Part 51, that this rule, if adopted, would not be a major Federal action significantly affecting the quality of the human environment and therefore an environmental impact statement is not required. Although certain plant hardware may not be reinstalled after removal for inspections, this will not alter the environmental impact of the licensed activities. It is anticipated that removed hardware would be stored at the plant site to be available for any potential future needs. The environmental assessment and finding of no significant impact on which this determination is based are available for inspection at the NRC Public Document Room, 1717 H Street, NW, Washington, DC. Single copies of the environmental assessment and the finding of no significant impact are available from John A. O'Brien, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC 20555, Telephone (301) 443-7854.

PAPERWORK REDUCTION ACT STATEMENT

This proposed rule does not contain a new or amended information collection requirement subject to the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). Existing requirements were approved by the Office of Management and Budget approval number 3150-0011.

REGULATORY ANALYSIS

The Commission has prepared a draft regulatory analysis on this proposed regulation. The analysis examines the costs and benefits of the alternatives considered by the Commission. The draft analysis is available for inspection in the NRC Public Document Room, 1717 H Street NW, Washington, DC. Single copies of the analysis may be obtained from John A. O'Brien, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC 20555, Telephone (301) 443-7854.

REGULATORY FLEXIBILITY ACT CERTIFICATION

As required by the Regulatory Flexibility Act of 1980, (5 U.S.C. 605(b)), the Commission certifies that this rule, if adopted, will not have a significant economic impact on a substantial number of small entities. This rule affects only the licensing and operation of nuclear power plants. The companies that own these plants do not fall within the scope of the definitions of "small entities" set forth in the Regulatory Flexibility Act or the Small Business Size Standards set out in regulations issued by the Small Business Administration at 13 CFR Part 121.

LIST OF SUBJECTS IN 10 CFR PART 50

Antitrust, Classified information, Fire prevention, Incorporation by reference, Intergovernmental relations, Nuclear power plants and reactors, Penalty, Radiation protection, Reactor siting criteria, Reporting and recordkeeping requirements.

For reasons set out in the preamble and under the authority of the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974, as amended, and 5 U.S.C. 553, the NRC is proposing to adopt the following amendments to 10 CFR Part 50.

PART 50 - DOMESTIC LICENSING OF PRODUCTION AND UTILIZATION FACILITIES

1. The authority citation for Part 50 continues to read as follows:

AUTHORITY: Secs. 103, 104, 161, 182, 183, 186, 189, 68 Stat. 936, 937, 948, 953, 954, 955, 956, as amended, sec. 234, 83 Stat. 1244, as amended (42 U.S.C. 2133, 2134, 2201, 2232, 2233, 2236, 2239, 2282); secs. 201, 202, 206, 88 Stat. 1242, 1244, 1246, as amended (42 U.S.C. 5841, 5842, 5846), unless otherwise noted.

Section 50.7 also issued under Pub. L. 95-601, sec. 10, 92 Stat. 2951 (42 U.S.C. 5851). Sections 50.57(d), 50.58, 50.91, and 50.92 also issued under Pub. L. 97-415, 96 Stat. 2071, 2073 (42 U.S.C. 2133, 2239). Section 50.78 also issued under sec. 122, 68 Stat. 939 (42 U.S.C. 2152). Sections

50.80-50.81 also issued under sec. 184, 68 Stat. 954, as amended (42 U.S.C. 2234). Sections 50.100 - 50.102 also issued under sec. 186, 68 Stat. 955 (42 U.S.C. 2236).

For the purposes of sec. 223, 68 Stat. 958, as amended (42 U.S.C. 2273), §§ 50.10(a), (b), and (c), 50.44, 50.46, 50.48, 50.54, and 50.80(a) are issued under sec. 161b, 68 Stat. 948, as amended (42 U.S.C. 2201(b)); §§ 50.10(b) and (c) and 50.54 are issued under sec. 161i, 68 Stat. 949, as amended (42 U.S.C. 2201(i)); and §§ 50.55(e), 50.59(b), 50.70, 50.71, 50.72, 50.73, and 50.78 are issued under sec. 161o, 68 Stat. 950, as amended (42 U.S.C. 2201(o)).

2. In Appendix A, General Design Criterion 4 is revised to read as follows:

APPENDIX A - GENERAL DESIGN CRITERIA FOR NUCLEAR POWER PLANTS

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CRITERIA

I. Overall Requirements

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Criterion 4 - Environmental and missile design bases. 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. These structures, systems, and components shall be appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit. However, the dynamic effects associated with postulated pipe ruptures of primary coolant loop piping in pressurized water reactors may be excluded from the design basis when analyses demonstrate the probability of rupturing such piping is extremely low under design basis conditions.

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Dated at Washington, D.C. this 25th day of June 1985.

For the Nuclear Regulatory Commission.

Samuel J. Chilk,
Secretary of the Commission.