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ADVANCED LIGHT WATER REACTOR PLANTS
SYSTEM 80+TM DESIGN CERTIFICATION PROGRAM

SYSTEM 80+

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FY-95 ANNUAL REPORT

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ADVANCED LIGHT WATER REACTOR PLANTS
SYSTEM 80+TM DESIGN CERTIFICATION PROGRAM

ANNUAL PROGRESS REPORT
for period October 1, 1994
through September 30, 1995

Prepared for:

UNITED STATES DEPARTMENT OF ENERGY
OFFICE OF NUCLEAR ENERGY
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A. Purpose

The purpose of this report is to provide the status of the progress that was made towards Design Certification of System 80+™ during the U.S. government's 1995 fiscal year. The System 80+ Advanced Light Water Reactor (ALWR) is a 3931 MW (1350 MWe) Pressurized Water Reactor (PWR). The design covers an essentially complete plant. It is based on EPRI ALWR Utility Requirements Document (URD) improvements to the Standardized System 80 Nuclear Steam Supply System (NSSS) in operation at Palo Verde Units 1, 2, and 3. The NSSS is a traditional two-loop arrangement with two steam generators, two hot legs and four cold legs, each with a reactor coolant pump. The System 80+ standard design houses the NSSS in a spherical steel containment vessel which is enclosed in a concrete shield building, thus providing the safety advantages of a dual barrier to radioactivity release. Other major features include an all-digital, human-factors-engineered control room, an alternate electrical AC power source, an In-Containment Refueling Water Storage Tank (IRWST), and plant arrangements providing complete separation of redundant trains in safety systems.

Some design enhancements incorporated in the System 80+ design are included in the four units currently in operation and under construction in the Republic of Korea. These units and the System 80+ design form the basis of the Korean standardization program. The Nuclear Island portion of the System 80+ standard design has also been offered to the Republic of China (Taiwan), in response to their bid specification for an ALWR.

The ABB-CE Standard Safety Analysis Report (CESSAR-DC) was docketed by the Nuclear Regulatory Commission (NRC) in May 1991 and a Draft Safety Evaluation Report (DSER) was issued in October 1992. The advance Final Safety Evaluation Report (FSER) was issued in February 1994, with no open issues. The NRC's Advisory Committee on Reactor Safeguards (ACRS) completed its review in only five meetings

and issued a strong positive letter in May 1994. The FSER was formally released and the Final Design Approval (FDA) was issued in July 1994.

Major licensing achievements include 1) the resolution of all severe accident issues, including both deterministic and probabilistic analyses showing improved safety by a factor of more than 120, 2) implementation of the new radiological source term, 3) resolution of shutdown risk concerns, 4) approval of an all-digital instrumentation and controls design, 5) approval of major control room features using state-of-the-art human factors engineering principles, and 6) development of a seismic envelope (i.e., standard seismic design). CESSAR-DC also contains the technical basis for compliance with the EPRI URD for reduced emergency planning. The improved safety of the System 80+ design and its implications for revised emergency planning were documented in a letter from the ACRS to the Commission in July 1994.

B. History and Status of Project

Since 1985, ABB-CE and Duke Engineering & Services, Inc. (DESI) have been developing the next generation of the pressurized water reactor plant for worldwide deployment. In 1990, Stone & Webster Engineering Corporation (SWEC) joined this team, thereby adding to the development of System 80+ an Architect Engineering (AE) firm's expertise. The result is an NRC-approved, standard plant design that can satisfy the need for a reliable and economic supply of electricity for residential, commercial, and industrial use. To ensure that such a design is available to meet the utilities' needs, it has been based on proven technology and the most current NRC licensing criteria. These requirements dictate the application of nuclear technology that is advanced, yet evolutionary in nature. This has been achieved with the System 80+ Standard Plant Design.

In 1985, ABB-CE and DESI joined forces under the aegis of the EPRI ALWR Program to develop, with utility oversight, the design requirements for the next generation of

nuclear power plants. The final version of the EPRI ALWR URD was submitted to the NRC in September 1990, and in May 1991 CESSAR-DC was docketed by NRC. CESSAR-DC, initially consisting of 18 volumes, was expanded to 26 volumes in response to NRC questions. A DSER was issued by NRC on October 1, 1992. In 1993, after working on several commercial projects related to System 80+ development, SWEC became an approved subcontractor for Design Certification, taking on selected aspects of BOP design and licensing for the System 80+ Standard Plant Design. Other organizations involved in the technical development of System 80+ include Bechtel Power Corporation, Impell Corporation, RPK Structural Mechanics Consulting, United Engineers and Constructors, and ABB-Atom. All technical issues raised by the NRC in the DSER were resolved, and the FSER and FDA were issued on schedule in July 1994.

C. Design Certification Overview

Licensing in the United States has been facilitated by a new process called Design Certification, described in Title 10, Part 52, of the Code of Federal Regulations (CFR). This part of the U.S. nuclear program is characterized by one-step licensing, where only a single license is required to both build and operate the plant. Further, only complete, standardized plant designs can be licensed, and all safety issues must be resolved before construction begins, rather than after, as in the past. Two opportunities for public participation are provided, but their timing and scope should reduce the potential for licensing delays while preserving the opportunity to address relevant technical issues.

The first phase of Design Certification, technical review by NRC staff, was completed upon issuance of the FSER and FDA. As part of the Design Certification process, ABB-CE has received 4,951 Requests for Additional Information (RAIs) and follow-on questions from the NRC during their review of System 80+ over the past three years. This includes 1,590 RAIs before the DSER, 939 DSER open items, and 802 questions

on System 80+ Inspections, Tests, Analyses and Acceptance Criteria (ITAAC), and 1620 "follow-on" questions, including NRC independent review of the Technical Specifications and ITAAC.

In 1995, NRC issued the System 80+ Notice of Proposed Rule (NOPR) and a nearly identical NOPR for General Electric's ABWR design. ABB-CE provided extensive comments to the NRC on the proposed rule in addition to providing input to the Nuclear Energy Institute (NEI) and the U. S. Department of Energy for their comment packages. The next phase of the DC process involves resolution of public comments, and issuance of the final rule by the Commission. The final rule should be published by the NRC in the Federal Register in 1996.

D. Progress in FY 1995

The intensive interactions with the NRC were initiated in 1991 and continued until the System 80+ FDA was issued in July 1994. In the first quarter of FY 1995, the Design Control Document (DCD) was completed and submitted to the NRC. NRC review was completed and the DCD was revised in the second quarter of FY 1995. NRC then issued the NOPR in April 1995, and industry participants provided comments by the August 7 deadline. Followup comments were submitted in September 1995. These efforts culminated in the transmittal of the following documentation in FY 1995:

1	LD-94-063, Revised SAMDA Tech Support Document	10/10/94
2	LD-94-064, ITAAC and Tier 2* ISSUES	10/13/94
3	LD-94-065, Proposed Language for Design Cert. Rule Related to Tier 2*	10/28/94
4	LD-94-069, DCD Design Change for Seal Cooler Removal	12/8/94
5	LD-94-071, DCD Category 2 Changes	12/15/94
6	LD-94-072, Tier 2* Expiration Dates	12/16/94
7	LD-94-073, Draft DCD	12/16/94
8	LD-95-001, Revised SAMDA Tech Support Document	1/6/95

9	LD-95-003, Seal Cooler Removal Justification	3/3/95
10	LD-95-005, System 80+ Proprietary Info for RELAP Deck	2/10/95
11	LD-95-006, DCD Revisions (Markups)	2/16/95
12	LD-95-007, Formal Submittal of DCD Revisions	2/22/95
13	LD-95-011, DCD Revisions (Draft Markups)	3/17/95
14	LD-95-013, Official Submittal of DCD Revisions	3/24/95
15	LD-95-015, Errata Page to DCD Revisions	3/27/95
16	LD-95-026, Request Clarification of PRA Issue	5/19/95
17	LD-95-030, Submittal of DCD on Compact Disk	7/6/95
18	LD-95-040, Proposed Rule	9/5/95

During FY 1995 a great deal of effort has been expended by ABB-CE and its subcontractors to complete the DCD and comment on NRC's NOPR. As a result, the eventual Design Certification of System 80+ in the United States represents major technical and licensing advances. The following subsections addressing completion of the Design Control Document (DCD), resolution of NRC comments on the DCD, and generation of comments on NRC's proposed DC rule for System 80+ describe the most significant FY 1995 work items completed in pursuit of certification.

Completion of the Design Control Document

General

Preparation of the DCD included extensive discussion of policy issues with NRC as well as incorporation of a design change after issuance of the System 80+ Final Safety Evaluation Report (FSER) and Final Design Approval (FDA).

Concerning policy issues, considerable discussion centered on the purpose and use of the Site Parameters which are part of the Certified Design Material. ABB-CE believed that the Site Parameters were solely for the evaluation of site acceptability and that

their basis in the design process should not be discussed. NRC prevailed, however, in their view that since the Site Parameters were developed in the design process, the relationship between design and Site Parameters should be stated. As a result, ABB-CE added qualifiers to the seismic envelopes to make it clear that:

- For soil (vs. rock) sites, it is not required that all piping and equipment be designed to the bounding seismic envelope. A subset of that envelope may be used provided that analyses are performed.
- Site-specific information comes from an "evaluation" which can be either a soil analysis or actual seismic data measured at the site.

It was agreed that COL Action Items would be identified in the DCD text with brackets and footnotes.

The industry prevailed in its position that a requirement for a living PRA should be deleted from the DCD. Such a requirement was considered to be a plant operation issue and its use should properly be discussed with utilities as part of a separate rulemaking process.

Considerable discussion centered on when the Tier 2* items should expire. ABB-CE contended that all Tier 2* items should expire when a plant incorporating the System 80+ design reaches full power for the first time. NRC contended that four items (piping Design Acceptance Criteria (DAC), Human Factors Engineering, seismic qualification, and motor-operated valve testing) should have no expiration dates. Resolution was as follows:

- For the seismic qualification and motor-operated valve testing items, ABB-CE emphasized that existing regulations and NRC enforcement procedures adequately addressed NRC's concerns and provided

adequate assurance of plant safety. The NRC agreed that these Tier 2* items would expire at first full power for a particular Combined License (COL) holder.

- In support of its position on the piping DAC, NRC pointed to the safety impact of piping and support systems and to "mis-use" of the 10 CFR 50.59 change process. ABB-CE did not agree, but the NRC did not alter its judgments on this issue.
- The NRC also decided that the Tier 2* restriction on Human Factors Engineering (HFE) should exist for the life of the plant. They contended that regulatory experience in the HFE area is sparse, and that lack of complete control room design detail prevents their understanding the overall impact of HFE on plant safety. ABB-CE contended that the 10 CFR 50.59 regulation adequately covers the change process for all design changes whether safety-related or not. Further, ABB-CE contended that any perceived mis-use of the 10 CFR 50.59 process by a utility should be the subject of normal NRC inspection and enforcement programs. The NRC has not revised their position on this item.

In November, 1994, NRC orally agreed that ABB-CE could remove the RCP auxiliary seal coolers without affecting the System 80+ FSER or the FDA. NRC asked numerous detailed questions, however, when DCD revisions were formally submitted. They also requested documentation on the basis for the change to be used in an eventual supplement to the FSER. To limit the scope of the review, ABB-CE determined the level of detail that would satisfy the NRC reviewer and, ultimately, obtained approval of the design change.

DCD Production

Production of the DCD was a major effort that began in FY 1994 and culminated with the approval of the DCD on March 13, 1995. Approximately 15,000 pages of material were involved in the DCD preparation process.

The DCD was structured in three basic sections: 1) Tier 1 Certified Design Material which includes Design Descriptions and ITAAC; 2) Tier 2 Approved Design Material which came primarily from a reprint of CESSAR-DC without Probabilistic Safety Assessment (PSA) methods and probabilistic results; and 3) Tier 2 Approved Design Material consisting of the System 80+ Emergency Operations Guidelines (EOGs).

Conversion of CESSAR-DC text to the DCD font and format was challenging and required close control and oversight to ensure a quality product. The conversion was required to produce a document having a uniform format. CESSAR-DC was produced over a period of eight years using two different word processing systems. In addition, custom formatting of CESSAR-DC was required in some cases to control printing costs and to speed production of amendments to maintain licensing review schedules.

Various text changes during the preparation process resulted from negotiations with the NRC staff on the contents of CESSAR-DC Chapter 19 (PSA) and other editorial and minor technical inconsistency changes discovered during the proofreading process. It was also necessary to identify conceptual design information, COL items, and Tier 2* material.

Figures were generated directly from the CESSAR-DC figure set. Approximately 3,500 figures were involved, of which about 225 were of the fold-out type. Because only a fraction of the figures had been originally generated using a CAD program, creating a complete electronic file of DCD figures was a substantial undertaking. Special

arrangements were implemented to store the estimated 250 megabytes of scanned image data on ABB-CE's network.

Because of the conversion to a new font and format, every page of the DCD was proofread and individually checked for consistency with the CESSAR-DC text and for legibility. A comprehensive proofreading procedure was instituted to focus the required degree of attention on the process. Review groundrules were developed, and reviewers were required to sign an affidavit attesting to the thoroughness of their review. Numerous minor editorial and technical revisions were required. Most were so minor that NRC declined the opportunity to review them. The NRC agreed in all cases with the changes proposed by ABB-CE.

The DCD was submitted to the NRC on December 16, 1994, one week ahead of schedule.

Resolution of NRC Comments on the DCD

Approximately 100 pages of NRC review comments were received via an NRC letter dated January 27, 1995. Although the comments were numerous, they were not difficult to address. Many of the revisions to the DCD were format changes to the Technical Specifications. NRC management was very complementary on the quality of the DCD, and they opined that ABB-CE's production quality control system was a principal reason that their review could be completed without any significant findings.

DCD changes incorporating the comment resolutions were submitted to NRC on February 16, 1995. The DCD was approved on March 13, 1995.

Generation of Comments on NRC's Proposed DC Rule for System 80+

On February 3, 1995, the NRC staff forwarded to the Commission SECY-95-023 which included the draft proposed design certification rules for System 80+ and for the ABWR. The proposed design certification rule for System 80+ was published in the Federal Register on April 7, 1995. A number of provisions of the Notice of Proposed Rulemaking (NOPR) depart from the fundamental objectives and principles of design certification, threatening to render the design certification process unusable. The same shortcomings exist in the NOPR for the ABWR. ABB-CE participated in the preparation of industry comments on the NOPR and on a set of its own comments to supplement those of the industry. The issues of concern to ABB-CE and the industry in general are discussed below.

Finality Issues

Relative to ABB-CE's System 80 design, the System 80+ Standard Plant possesses many new severe accident mitigation features and represents an overall improvement in safety of more than two orders of magnitude in terms of risk. Ironically, System 80+ will be subjected by the rule, as proposed, to substantially greater regulatory burdens in some areas, and will be afforded less flexibility, than existing designs attempting to accomplish the same ends.

For example, as now proposed, every Section 50.59-like change made to Tier 2 of the System 80+ design will cause a loss of design finality and subject System 80+ to a potential hearing. Existing plants, meanwhile, can make 50.59 changes with no such impediments. This, and other similarly inflexible approaches in the NOPR to design changes made in accordance with the rule's stringent change criteria are not only counterintuitive, but constitute a regulatory penalty for designs which ought to be given more, not less, latitude given their enhanced safety features.

Standardization Issues

The NOPR denies finality to certain key aspects and provisions of Tier 2, and falls short of granting the requisite finality for certain aspects of Tier 1.

Tier 1 was intended by the Commission and industry to encompass only the most important safety and design features and to fix and standardize those features in both scope and time. Accordingly, changes to Tier 1 were intended to involve a high threshold of difficulty and, thus, cannot occur without a rule change or an exemption. Likewise, the burden on NRC staff to impose backfits on Tier 1 was to involve a high degree of difficulty, necessitating either a nonconformance with regulations or questions of adequate protection.

Tier 2, on the other hand, was recognized to involve a lesser level of safety significance and substantially greater design detail. Accordingly, a Section 50.59-like change process was deemed adequate and desirable. Tier 2 was created precisely because both the Commission and the industry recognized that it was not possible or workable to fix the entire design in the same manner as was appropriate for Tier 1. The standardization threshold was deliberately and appropriately lowered for Tier 2.

The NOPR negates these distinctions. For example, the NOPR states that Tier 2 changes should lose finality to maintain the benefits of standardization. The NOPR also states, however, that NRC should be able to impose changes to Tier 2 by plant-specific order without considering the impacts on loss of standardization because Tier 2 information is not as safety significant as Tier 1 information. Yet, where information is clearly safety significant and, therefore, loss of standardization ought to weigh heavily (as in the case of Tier 1 severe accident features), the NRC staff has informed the industry that Staff's primary objective in imposing the concept of the proposed "applicable regulations" is to enhance NRC's ability to enforce compliance backfits to Tier 1, presumably irrespective of standardization.

ABB-CE believes the approaches to standardization and finality suggested in the NOPR, unless corrected to reflect the goals and objectives of design certification and the two-tiered implementation process, will significantly diminish the achievements embodied in the System 80+ Standard Design and will compromise the substantial licensing benefits that were envisioned by industry, NRC, and Congress to be embodied in Part 52.

Term of Tier 2* Applicability

The NOPR provides that Tier 2* information may not be changed without prior NRC approval. This restriction expires for each referencing plant when that plant first achieves full power except for the following Tier 2* items: Control Room Human Factors Engineering (HFE) and Piping DAC.

Extending the Tier 2* restriction for these items beyond first full power impairs licensing stability and creates another unnecessary level of regulatory oversight and expense to licensees with no identifiable safety benefit. Any control room or piping changes significant enough to affect safe plant operation would unquestionably result in an unreviewed safety question under the 50.59-like change process, and NRC's current inspection and enforcement authority provides more than adequate protection against abuse. In addition, the industry's plan for self-policing the standardization of each family of plants, and the strong economic motivation to maintain a standard design, provide further oversight of design changes and assurance against inappropriate changes.

Indeed, the NOPR's approach could actually impede design changes intended to improve plant safety and performance. An example in the HFE area is that of control room video display units. Those units currently use a touch screen feature for the operator to initiate an action. The utility owner should be able to switch to a mouse-cursor or a track ball-cursor method, possibly to be consistent with standard methods

already in place at the utility, without having to secure prior NRC approval. With respect to piping, Section 3.9.1.2.1 of the DCD requires that computer codes used for dynamic analysis be benchmarked in accordance with NUREG/CR-6128. While such a requirement may be reasonable during the initial design of the piping systems, it would be overly restrictive when selecting a method for analysis of a minor design change.

The extension of Tier 2* beyond first full power is an unnecessary burden on both the COL holder and the NRC staff and should be eliminated.

"Applicable Regulations"

NRC staff has made a determination, as articulated in the NOPR, that additional "applicable regulations" are needed to: (1) ensure that the NRC has not required ABB-CE to adhere to design requirements for which there are no regulatory requirements; and (2) to ensure the staff's ability to backfit the design by rule or plant-specific order. ABB-CE strongly opposes the NOPR's application of the concept of "applicable regulations" as well as the extremely imprecise and overreaching language proposed by the staff for those regulations.

On the first point, ABB-CE and the industry collectively have already agreed and committed to design features intended to be encompassed by the NOPR's "applicable regulations." Upon certification, those design features will become regulatory requirements in their own right by virtue of this rulemaking. The staff's concern on this point is, therefore, misplaced.

On the second point, ABB-CE strongly objects to the staff's attempt to preserve for itself a compliance backfit prerogative that: (1) could not be accomplished in the case of existing plants even to backfit the features now present in System 80+, let alone to accommodate changes to those features; (2) would apply only to features that enhance

the level of safety beyond that of existing designs; and (3) could be accomplished by the NRC in any event if a genuine issue of adequate protection were involved.

Compounding the problem is the use of language for the "applicable regulations" that is needlessly vague and expansive and that was expunged from the Tier 1 certified design descriptions and ITAAC because it was viewed as destabilizing. Examples are phrases such as "must be minimized," "to the extent practical," "advanced techniques," "adequate defense," "best estimate," "reliable means," "the time period needed," and "more likely."

ABB-CE believes the staff's proposed "applicable regulations" for System 80+ undercut the regulatory stability sought to be achieved by Part 52.

ITAAC Requirement for Part 50

The NOPR proposes that if the System 80+ Standard Plant design is referenced under Part 50 instead of under Part 52, the ITAAC should nevertheless be requirements for Part 50 licensing. This proposal, if adopted, would render the System 80+ Standard Plant Design essentially unlicensable under Part 50 because no potential licensee would ever desire to subject itself to the risks of a second hearing under Part 50 and yet be forced to meet the ITAAC acceptance criteria as additional prerequisites for fuel load.

It is unfortunate and unacceptable, particularly given the present defects in the NOPR that would make Part 52 licensing substantially more risky than originally envisioned, for the NOPR to simultaneously vitiate the only available alternative licensing regime for System 80+, i.e., Part 50, by requiring ITAAC adherence for Part 50 licensing of System 80+. This result is contrary to the obvious intent of Part 52 which repeatedly attempts to preserve the ability of potential licensees to seek licensing under Part 50. Moreover, there is no legal or technical justification for the result proposed by the NOPR.

E. Summary

The U.S. NRC has completed its review of the System 80+ Standard Plant Design, approving advanced design features and closing severe accident licensing issues, and has issued the proposed Design Certification rule for the System 80+ design. The System 80+ design is an evolutionary ALWR plant, producing 3931 MWt, or 1350 MWe, whose development was sponsored by the U.S. DOE. The NRC released the System 80+ advance FSER in February 1994 with no open technical issues. It was then approved by the NRC Commissioners and the System 80+ FDA was issued in July 1994. The NRC review required written responses to 4951 questions. Not only were all regulatory concerns resolved, but the review process was flexible and efficient. This was due to NRC and ABB-CE management commitments to schedule and technical correctness. The task was formidable for both ABB-CE and the NRC. Design features to address improved plant safety had to be evaluated and explained to NRC.

The System 80+ design was developed and supported during NRC review by a single, closely-coordinated design team. This made it easier to ensure that structures and systems which interface with each other and licensing issues which cross boundaries of multiple structures and systems were addressed in an integrated manner. ABB-CE assigned a "Chapter Champion" to each of the chapters in CESSAR-DC. These Chapter Champions were authorized to resolve all outstanding questions with their counterpart reviewers at the NRC.

Plant safety was evaluated using a "defense-in-depth" analytical approach. Design basis accidents were analyzed with the historic conservative methods. Severe accidents were analyzed deterministically using best-estimate methods, as well as probabilistically using a detailed three-level PSA. These analyses demonstrated the importance of consistently analyzing design features, since changing a characteristic or component in one structure or system was found to impact design features or safety analyses in other structures or systems. Examples of such integrated structures,

systems and analyses are: 1) structural design, soil properties analysis, and seismic margins assessment; 2) equipment qualification, radiological source term dose analysis, ventilation system design, water chemistry control, and plant emergency evacuation; 3) reactor cavity floor design, wall design, and containment ultimate strength; and 4) electrical distribution system, emergency and standby power sources, and hydrogen control systems.

An integrated approach to the design and analysis of the System 80+ advanced design features has resulted in not only a safer plant design, but also a balanced allocation of safety functions. A comprehensive PSA was used to select the most effective design features and allocate risk among plant structures, systems, and components. The PSA was also used to demonstrate that plant safety has been improved by more than two orders of magnitude relative to the current generation of nuclear power plants.

The Design Control Document which is required as the main reference for the Design Certification rule was submitted to and approved by NRC in FY 1995. ABB-CE and other industry participants provided comments on NRC's proposed DC rules. These comments will be resolved and the NRC is expected to issue the final rule in FY 1996.

F. Complete Bibliography of System 80+ and Related Publications

For information purposes, a complete bibliography of System 80+ publications is provided below. This list covers all public information provided on System 80+ since February 1985, when development began, through September 1995 including papers to be presented. Together, papers marked with an asterisk (*) give a fairly comprehensive and up-to-date picture of the System 80+ design, including the status of licensing and commercial efforts. These are recommended for anyone wishing to obtain a basic understanding, without having to digest the entire collection of publications.

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10. Status of Advanced Technology and Design for Water Cooled Reactors: Light Water Reactors, IAEA-TECDOC-479, International Atomic Energy Agency, October 1988.
11. Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants, Code of Federal Regulations, Title 10, Part 52, Federal Register, 54 (73): 15386 (April 18, 1989).
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19. Advanced Water-Cooled Reactor Technologies: Rationale, State of Progress and Outlook, OECD-44953, Organization for Economic Cooperation and Development (Nuclear Energy Agency), November 1989.
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