EDO Principal Correspondence Control

FROM: DUE: 02/22/11 EDO CONTROL: G20110047
DOC DT: 01/19/11
FINAL REPLY:

Said Abdel-Khalik, ACRS

TO:

Chairman Jaczko

FOR SIGNATURE OF : ** GRN ** CRC NO: 11-0021

Borchardt, EDO

DESC:

Report on the Safety Aspects of the Aircraft Impact Assessment for the Westinghouse Electric Company AP1000 Design Certification Amendment Application (EDATS: SECY-2011-0029)

ROUTING:

Borchardt
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DATE: 01/21/11

ASSIGNED TO: CONTACT:

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Template: SECY-017

E-RIDS: SECY-01

EDATS

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EDATS Number: SECY-2011-0029 — Source: SECY

General Information

Assigned To: NRO — **OEDO Due Date:** 2/22/2011

Other Assignees: — **SECY Due Date:** NONE

Subject: Report on the Safety Aspects of the Aircraft Impact Assessment for the Westinghouse Electric Company AP1000 Design Certification Amendment Application

Description:

CC Routing: NSIR; RES

ADAMS Accession Numbers - Incoming: NONE — **Response/Package:** NONE

Other Information

Cross Reference Number: G20110047, LTR-11-0021 — **Staff Initiated:** NO

Related Task: — **Recurring Item:** NO

File Routing: EDATS — **Agency Lesson Learned:** NO

OEDO Monthly Report Item: NO

Process Information

Action Type: Letter — **Priority:** Medium

Sensitivity: None

Signature Level: EDO — **Urgency:** NO

Approval Level: No Approval Required

OEDO Concurrence: NO

OCM Concurrence: NO

OCA Concurrence: NO

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Document Information

Originator Name: Said Abdel-Khalik — **Date of Incoming:** 1/19/2011

Originating Organization: ACRS — **Document Received by SECY Date:** 1/21/2011

Addressee: Chairman Jaczko — **Date Response Requested by Originator:** NONE

Incoming Task Received: Letter

OFFICE OF THE SECRETARY
CORRESPONDENCE CONTROL TICKET

Date Printed: Jan 20, 2011 14:29

PAPER NUMBER:	LTR-11-0021	**LOGGING DATE:**	01/20/2011
ACTION OFFICE:	EDO		

AUTHOR: Said Abdel-Khalik

AFFILIATION: ACRS

ADDRESSEE: Gregory Jaczko

SUBJECT: Report on the safety aspects of the aircraft impact assessment for the Westinghouse Electric Company AP1000 design certification amendment application

ACTION: Appropriate

DISTRIBUTION: RF

LETTER DATE: 01/19/2011

ACKNOWLEDGED No

SPECIAL HANDLING:

NOTES:

FILE LOCATION: ADAMS

DATE DUE: **DATE SIGNED:**

EDO --G20110047

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

January 19, 2011

The Honorable Gregory B. Jaczko
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: REPORT ON THE SAFETY ASPECTS OF THE AIRCRAFT IMPACT ASSESSMENT FOR THE WESTINGHOUSE ELECTRIC COMPANY AP1000 DESIGN CERTIFICATION AMENDMENT APPLICATION

Dear Chairman Jaczko:

During the 579th meeting of the Advisory Committee on Reactor Safeguards, January 13-15, 2011, we reviewed the staff's Safety Evaluation Report (SER) on the Aircraft Impact Assessment (AIA), which is part of the Westinghouse Electric Company (WEC or the Applicant) AP1000 Design Certification Amendment (DCA) application. Our AP1000 subcommittee held meetings on November 2-3, November 17-19, and December 15-16, 2010, and reviewed the staff's SER and AIA inspection report. During these meetings, we had the benefit of discussions with representatives of the NRC staff and WEC. The AIA was made available to us by the applicant for review prior to our AP1000 subcommittee meeting of November 2-3, 2010. We also had the benefit of the documents referenced. This letter fulfills the requirement of 10 CFR 52.53 that the ACRS report on those portions of the application which concern safety.

CONCLUSION AND RECOMMENDATION

The WEC AIA for the design described in the AP1000 DCA application, as modified to resolve NRC inspection findings, complies with the requirements of 10 CFR 50.150. Analyses show that the containment remains intact following the impact of a large commercial aircraft. The reactor core remains cooled, and spent fuel pool integrity is maintained.

The staff should evaluate information and analyses presented to the ACRS, but not subjected to staff review or inspection, to determine if there is a need for further revision of the design control document (DCD), or a need for further inspections.

BACKGROUND

The results of the AP1000 AIA are a part of the AP1000 DCA application. The AP1000 design was previously certified and the existing AP1000 certification rule references DCD Revision 15. DCD Revision 18 was submitted by WEC in a letter dated December 1, 2010, and it incorporates changes in Revision 16, submitted on May 26, 2007; in Revision 17, submitted on September 22, 2008; as well as those changes made subsequent to the submittal of Revision 17, which are identified in Chapter 23 of the Advanced Final Safety Evaluation Report. We held a series of meetings with the NRC staff and the applicant on the AP1000 DCA application. We wrote a letter, dated December 13, 2010, following our review of the amendment. Our assessment of the AP1000 AIA was not included in the letter.

As required by 10 CFR 50.150, applicants for new nuclear power plants must perform an assessment of the effects of the impact of a large, commercial aircraft. Using realistic analyses, applicants must identify and incorporate into the facility those design features and functional capabilities needed to show that, with reduced use of operator action; (1) the reactor core remains cooled or the containment remains intact, and (2) spent fuel cooling or spent fuel pool integrity is maintained (referred to as the acceptance criteria). Applicants are required to submit a description of the design features and functional capabilities relied upon in the AIA and a description of how these features and capabilities ensure that the acceptance criteria are met. Since the impact of a large, commercial aircraft is a beyond-design-basis event, applicants may use non-safety-related features or capabilities to satisfy the requirements of 10 CFR 50.150.

From September 27, 2010, through October 1, 2010, the staff conducted an inspection of the WEC AP1000 AIA. Based on the results of this inspection, the staff determined that NRC requirements had not been fully met. The inspection revealed that WEC did not use realistic analyses for certain aspects of its AIA and did not fully identify and incorporate into the DCD those design features and functional capabilities credited. WEC responded to the inspection report and proposed corrective actions in its letter to the NRC dated November 12, 2010. The staff issued a letter, dated November 23, 2010, stating that the proposed corrective actions were satisfactory. The staff may review the implementation of the corrective actions during a future inspection to determine that full compliance has been achieved and maintained.

DISCUSSION

The AIA performed by the applicant uses the industry guidance in NEI 07-13, Revision 7, endorsed in Draft Regulatory Guide DG-1176. The results of the AIA show that the modified AP1000 design, described in the application, meets the acceptance criteria of the AIA rule by maintaining containment integrity and spent fuel pool integrity.

The key AP1000 design features identified by WEC to satisfy the requirements of 10 CFR 50.150 include: presenting a small target with a reduced set of safety-related structures, systems, and components (SSCs); a redesigned shield building which protects the steel containment vessel from penetration due to impact[1]; simplified, passive safety equipment for core cooling; no active equipment required for spent fuel pool cooling; and redundancy and defense-in-depth in equipment design. In accordance with 10 CFR 50.150, WEC provided an assessment in the respective technical areas of structures, reactor systems, fire, and shock.

For the structural assessment, WEC used the impulse curve supplied by the NRC and the finite element analysis code LS-DYNA. All of the aircraft strikes analyzed using this code was on the shield building. The redesigned shield building, using a modular, steel concrete composite (SC) structure, reduces passive heat removal air flow. The effects of air flow reduction on containment integrity during accidents were analyzed and shown to be acceptable. Based on the results of the assessment, WEC concluded, and the staff agreed, that both the containment and spent fuel pool remain intact and that core and spent fuel cooling are maintained.

During our November 2-3, 2010 AP1000 subcommittee meeting, we questioned whether the worst-case locations for aircraft impact had been considered. WEC addressed this issue during our November 17-19, 2010, AP1000 subcommittee meeting.

The AP1000 shield building includes a 32 ft. diameter opening in the conical roof which is an essential feature of the passive containment cooling design. This opening is surrounded by the Passive Containment Cooling System water storage tank. During our November 2-3, 2010, subcommittee meeting, issues arose concerning the potential for significant aircraft impact debris to pass through the opening and impact the steel containment vessel. WEC conducted appropriate analyses, which we reviewed during our November 17-19, 2010, subcommittee meeting. Using realistic assumptions for the impact locations of concern, these analyses demonstrated that no significant debris would impact the steel Containment Vessel (CV). In addition, WEC performed a more conservative analysis in which a large mass consisting of debris and the shield plate, was assumed to fall on the steel CV. This impact resulted in only a relatively small amount of plastic deformation and no penetration of the CV.

Our December 13, 2010, letter concerning the AP1000 DCA application describes the SC design, including the addition of tie bars between opposite faceplates of the SC modules. The spacing of these tie bars is smaller in areas of higher, out-of-plane, design basis shear demands - i.e., near discontinuities and connections - than it is in the majority of the shield building wall structure where these demands are lower. Aircraft impacts, unlike design basis events, can impart high out-of-plane shear demands in regions of the shield building wall with greater tie bar spacing. As discussed in our letter of December 13, 2010, these areas can fail in

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[1] The shield building redesign is discussed in our letter dated December, 13, 2010.

a non-ductile manner under such loads. In order to assure acceptable realism in the analyses, it must be demonstrated that the finite element models used in the AIA adequately describe this non-ductile behavior under high out-of-plane shear loads. WEC provided comparisons of the predictions of the LS-DYNA model with an experiment on a beam representing a SC structure with greater tie bar spacing under high out-of-plane shear loads. The load-deformation behavior predicted by the model agreed well with the results of the experiment; the comparison adequately supports the use of the model for these analyses.

In addition to the possibility of global structural failure, there is also a potential for local failure due to penetration by hard objects such as an engine or landing gear. The AIA analysis included comparisons of the predictions of the LS-DYNA model with penetration tests conducted in Japan on SC structures. The predictions show adequate agreement with the tests. Although the geometry of the specimens in these tests differs from that of the shield building, the comparisons support the use of the model to predict local failures associated with aircraft impact.

WEC demonstrated that AIA requirements with respect to core and spent fuel cooling are met. This is because the systems required for design basis core cooling are located inside containment, which is protected by the redesigned shield building, and there are no active systems required for cooling of spent fuel. In addition, WEC demonstrated that at least one backup water source is always available for cooling.

Similarly, for the fire aspect of AIA, based on the limited systems required for core cooling in the AP1000, and their location within the intact containment, WEC demonstrated that the requirements of 10 CFR 50.150 are met.

Finally, with regard to the effects of shock associated with aircraft impact, WEC demonstrated that these shock loadings are less than those resulting from a design basis seismic event.

The AP1000 AIA was reviewed in parallel with the development of DCD Revision 18, which was submitted on December 1, 2010. Also, the staff conducted an inspection of the AIA and resolved their findings with WEC, as described in a letter dated November 23, 2010. In parallel with these activities, we conducted subcommittee meetings to review the AIA during which WEC responded with information and analyses, some of which may not be reflected in the DCD, as revised, or within the scope of the staff's inspection. In view of these parallel activities, the staff should evaluate information and analyses presented to the ACRS, but not subjected to staff review or inspection, to determine if there is a need for further revision of the DCD, or a need for further inspections.

The AIA for the design described in the AP1000 DCA application, as modified to resolve the staff's inspection findings, complies with the requirements of 10 CFR 50.150. Following the impact of a large commercial aircraft, the containment remains intact, the reactor core remains cooled, and spent fuel pool integrity is maintained.

Sincerely,

/RA/

Said Abdel-Khalik
Chairman

REFERENCES

1. U.S. Nuclear Regulatory Commission, "Advanced Copy of the Final Safety Evaluation Report Related to Certification of the AP1000 Standard Design" various dates 2010 (ML103260072)
2. Letter to U.S. Nuclear Regulatory Commission, "Westinghouse Application to Amend the AP1000 Design Certification," APP-GW-GL-700, Revision 16, May 26, 2007 (ML071580757)
3. Letter to U.S. Nuclear Regulatory Commission, "Update to Westinghouse's Application to Amend the AP1000 Design Certification Rule," APP-GW-GL-700, Revision 17, September 22, 2008 (ML083220482)
4. Westinghouse Electric Company, AP1000 Design Control Document (DCD), APP-GW-GL-700, Revision 18, December 1, 2010 (ML103480059 and ML103480572)
5. NUREG-1793, "Final Safety Evaluation Report Related to Certification of the AP1000 Standard Design (NUREG-1793)" September 2004 (ML043450344, ML043450354, ML043450284, ML043450290, and ML043450274)
6. NUREG-1793, Supplement 1, "Final Safety Evaluation Report Related to Certification of the AP1000 Standard Design," December 2005 (ML060330557)
7. ACRS letter to the NRC Chairman on the AP1000 DCD amendment review, December 13, 2010 (ML103410351)
8. NRC Letter to WEC on "Ap1000 Pressurized Water Reactor Design Aircraft Impact Assessment Inspection, NRC Inspection Report No. 05200006/2010-203 and Notice of Violation," October 28, 2010 (ML10298058311)
9. WEC response to NRC on "Reply to Notice of Violation Cited in NRC Inspection Report No.: 05200006/2010-203 dated October 28, 2010, " November 12, 2010 (ML1032104091)
10. NRC closure letter on "Westinghouse Electric Company Response To U.S. Nuclear Regulatory Commission (NRC) Inspection Report [05200006/2010-203] and Notice of Violation, " November 23, 2010 (ML1032604471)

11. NRC Letter, "Aircraft Impact Assessment for New Reactor Designs," May 17, 2007 (ML071360212)
12. NRC Letter, "Issuance of Order Imposing Safeguards Information Protection Requirements and Fingerprinting and Criminal History Records Check Requirements for Access to Safeguards Information," September 12, 2007 (ML072220401)