AREVA

June 6, 2012
NRC:12:037

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Response to U.S. EPR Design Certification Application RAI No. 507, Supplement 3

Ref. 1: E-mail, Getachew Tesfaye (NRC) to Dennis Williford (AREVA NP Inc.), "U.S. EPR Design Certification Application RAI No. 507 (5964), FSAR Ch. 6," August 26, 2011.

Ref. 2: E-mail, Dennis Williford (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 507 (5964), FSAR Ch. 6," September 26, 2011.

Ref. 3: E-mail, Dennis Williford (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 507 (5964), FSAR Ch. 6, Supplement 1," November 14, 2011.

Ref. 4: E-mail, Dennis Williford (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 507 (5964), FSAR Ch. 6, Supplement 2," January 18, 2012.

In Reference 1, the NRC provided a request for additional information (RAI) regarding the U.S. EPR design certification application. Reference 2 provided a schedule for responding to the four questions in RAI 507. Reference 3 provided technically correct and complete responses to three of the four questions in RAI 507. Reference 4 provided a revised schedule for responding to the remaining question (Question 06.02.02-122).

The enclosure to this letter provides a technically correct and complete final response to the remaining question (Question 06.02.02-122). AREVA NP Inc. (AREVA NP) considers some of the material contained in the enclosed response to Question 06.02.02-122 to be proprietary. As required by 10 CFR 2.390(b), an affidavit is enclosed to support the withholding of the information from public disclosure. Proprietary and non-proprietary versions of the enclosure to this letter are provided.

The following table indicates the respective pages in the enclosure that contain AREVA NP's final response to the subject question.

Question #	Start Page	End Page
RAI 507 — 06.02.02-122	2	15

This concludes the formal AREVA NP response to RAI 507, and there are no questions from this RAI for which AREVA NP has not provided responses.

D077
NRO

AREVA INC.
3315 Old Forest Road, P.O. Box 10935, Lynchburg, VA 24506-0935
Tel.: 434 832 3000 www.areva.com

If you have any questions related to this submittal, please contact Mr. Darrell Gardner by telephone at 704-805-2355, or by e-mail to darrell.gardner@areva.com.

Sincerely,

Pedro Salas, Director
Regulatory Affairs
AREVA NP Inc.

Enclosures

cc: G. Tesfaye
Docket No. 52-020

AFFIDAVIT

COMMONWEALTH OF VIRGINIA)
) ss.
COUNTY OF CAMPBELL)

1. My name is Gayle F. Elliott. I am Manager, Product Licensing, for AREVA NP Inc. (AREVA NP) and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by AREVA NP to determine whether certain AREVA NP information is proprietary. I am familiar with the policies established by AREVA NP to ensure the proper application of these criteria.

3. I am familiar with the AREVA NP information contained in letter NRC:12:037, "Response to U.S. EPR Design Certification Application RAI No. 507, Supplement 3," and referred to herein as "Document." Information contained in this Document has been classified by AREVA NP as proprietary in accordance with the policies established by AREVA NP for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by AREVA NP and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure. The request for withholding of proprietary information is made in accordance with 10 CFR 2.390. The information for which withholding from disclosure is

requested qualifies under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information":

6. The following criteria are customarily applied by AREVA NP to determine whether information should be classified as proprietary:

(a) The information reveals details of AREVA NP's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for AREVA NP.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA NP in product optimization or marketability.

(e) The information is vital to a competitive advantage held by AREVA NP, would be helpful to competitors to AREVA NP, and would likely cause substantial harm to the competitive position of AREVA NP.

The information in the Document is considered proprietary for the reasons set forth in paragraphs 6(b) and 6(c) above.

7. In accordance with AREVA NP's policies governing the protection and control of information, proprietary information contained in this Document has been made available, on a limited basis, to others outside AREVA NP only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA NP policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

SUBSCRIBED before me this 6th

day of June 2012.

Kathleen A. Bennett
NOTARY PUBLIC, COMMONWEALTH OF VIRGINIA
MY COMMISSION EXPIRES: 8/31/2015
Reg. #110864

KATHLEEN ANN BENNETT
Notary Public
Commonwealth of Virginia
110864
My Commission Expires Aug 31, 2015

Response to

Request for Additional Information No. 507, Supplement 3

8/26/2011

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 06.02.02 - Containment Heat Removal Systems
Application Section: 6.3

QUESTIONS for Containment and Ventilation Branch 1 (AP1000/EPR Projects) (SPCV)

Question 06.02.02-122:

In RAI 416, Question 06.02.01-94, the staff requested demonstration testing of the CONVECT system. In a November 2010 response the applicant indicated that vendor-specific testing was not possible because the vendor had not been selected. In RAI 468, Question 06.02.02-83 the staff again requested demonstration testing of the CONVECT system. The staff noted that vendor-specific testing was not necessary but proof-of-concept testing was necessary for the first-of-a-kind application. In July of 2011 the applicant responded and did not include proof of concept testing in the response. The response provided a general description of "behaviors that are based on simple physics." The response is not sufficient for the staff to make a finding that the foils and dampers used in CONVECT system are capable of accomplishing the safety function as described in FSAR. Since the staff is unaware of any testing or operating experiences associated with the foils and dampers as described in FSAR, proof of concept testing is needed for the foils and dampers in this first-of-a-kind application. Specifically, the staff requests testing to demonstrate the capability of the foils and dampers.

Response to Question 06.02.02-122:

The two-room convection and pressure equalization system CONVECT consists of the following three components:

- Convection Foils (CF).
- Rupture Foils (RF).
- Hydrogen Mixing Dampers (HMD).

The purpose of the CONVECT system is the separation of the equipment rooms from the operating rooms during normal plant operation.

The safety-related functions of the CONVECT system are pressure equalization and gas mixture during a design basis accident (DBA). If the DBA transitions into a beyond design basis event (BDBE), the CONVECT system has to maintain integrity.

Because of the importance of proper functioning of the CONVECT system, the components CF, RF and MD were subjected to a comprehensive component testing program. The objective was to prove their functionality under several demanding conditions to demonstrate adequacy in all relevant design cases.

1. Testing of Convection and Rupture Foils

The CF components were extensively tested under a general testing program. Because the RFs are the burst elements of the CFs, the CF testing includes the testing of the RFs.

The component CF consists of a RF, steel framework, gaskets, and a thermo-lock containing fusible links.

The objective of the testing program was to verify that the CF and RF:

- Remain close and tight during normal operating conditions (NOC).
- Open in case of a DBA—depending on the differential pressure or ambient temperature.

The qualification testing was subdivided into analytical and experimental parts. The analytical part covered strength analysis and evaluation of reliability, aging, and influence of radiation.

The RFs and fusible links are commercial grade items with well-proven industrial applications and experience. The fusible links are derived from a standard product installed in fire protection dampers. The RFs are based on those installed in German KONVOI nuclear power plants for more than 30 years.

The diverse design of the CFs (i.e., pressure and temperature actuation) is combined in a steel framework. Except for the gaskets, the component consists mainly of metallic parts. The expected accumulated dose rate, based on the equipment location above the steam generator towers, is less than [ ] over the design lifetime of 60 years. This expected material dose allows for the use of a wide range of gasket materials. Also, any influence on general physical and chemical characteristics of metallic materials can be excluded because the relevant activation energy for expected material degradation is orders of magnitude higher. Nevertheless, experimental tests were performed to show radiation and thermal aging resistance (see Sections A and B below)

The strength analysis verified operability, including stability/integrity after loads due to internal or external hazards. Based on a mathematical model of the CFs, the analysis verified that the CF withstands earthquake loads during normal operating conditions and remains operable in case of a DBA or BDBE. The allowable stresses were not exceeded in any of the simulated scenarios.

The following table summarizes the test objectives and test type of the performed experimental phase.

Test Objective	**Function**	**Functional Tests**
Aging Effects	—	Radiological aging (A) Thermal aging (B)
Functional Tests I	Availability	Leak tightness after aging (C) Functional tests during NOC conditions (D) Functional tests during increased NOC conditions (E)
Load Capacity	Reliability	Burst pressure (F) Thermal opening (G) Integral High Flow Burst (H) Vibration/Seismic load (I)
Functional Tests II		Post vibration functional check (J)
Clamping Force		Clamping force test (K)

Each test is described in the following sections.

A. Radiological Aging of the CF components

Radiological aging of the CF components was performed at the ISOTRON Deutschland GmbH, Germany.

To prove their function after irradiation, RFs, gaskets and fusible links were irradiated during the test program. The goal was to simulate an accumulated material dose of approximately [ ] covering a normal plant life time of 60 years in the reactor building plus the dose of a subsequent accident.

Test conditions

The irradiation chamber contained a [ ] source at a radiation energy of [ ] The dose rate of the gamma radiation source is dependent on the distance to the test specimen. In this case, the average dose rate was approximately [ ] The dose of the components was measured by dosimeters. To provide a uniform radiation level, the irradiated components were rotated 180° after the first half of the total irradiation time. The components were exposed to a dose of [ ], which exceeded the planned dose of [ ]

Test results

A subsequent visual inspection was performed after the radiological aging process. No mechanical changes in terms of embrittlement were detected.

B. Thermal Aging of CF components

Thermal aging of CF components was performed in the thermal test facility of AREVA NP in Karlstein, Germany.

The purpose of the test program was to verify that thermal aging has no negative influence on the leak tightness of an assembled CF. Therefore, the components were stressed by a steam/air mixture at a temperature of [ ] before leak tightness was assessed.

Test conditions

The complete assembled CF test device was installed on the rear side of a cover plate in the thermal test facility. Additional test components were arranged inside the thermal test facility. Heating was performed either by a controlled fan heater or by steam generated by an electrical steam generator. The hot air/steam entered the test facility from the bottom and lateral ventilation slots.

The set temperature of [ ] was achieved by the fan heater, and steam was injected into the test facility leading to conservative test conditions.

Test results

A visual inspection was performed to detect potential damages. No damages were detected after thermal aging.

C. Leak tightness tests after aging

The testing was performed at AREVA NP's test facility Karlstein, Germany.

The aim of the test program was to verify the required leak tightness after thermal and radiological aging. Therefore, components that were already irradiated and thermally aged were used.

Three different test series were performed to verify the required leak tightness of the CF components (i.e., gaskets, steel frame, RF, and thermo-lock):

- Verification of leak tightness after thermal and radiological aging.
- Determination of required torque to achieve tightness.
- Verification of leak tightness after the pressure load cycle tests A1-NOC (Normal Operating Condition) and A2-DBC (Design Basis Condition) 1/2 (elevated NOC).

Test conditions

Three different gasket types were used during the tests— [ ]

The thermal test facility was used for the leak tightness tests. The CF was bolted at the upper lid of the thermal test facility. A displacer reduced the inside volume to [ ]

The CF leak tightness was tested by measuring the pressure drop over a certain period of time. Each leak tightness test was performed at the following two delta pressures across the inside and outside of the CF [ ]

In addition to the leak tightness test, determination of the required torque where the silicone gaskets still fulfill the tightness requirement was part of the test. Three different nut torques were applied during the tests: [ ] The tightness was measured again by the pressure loss over a certain time period.

The leak tightness test verification performed after the pressure load cycle tests A1-NOC (see Section D) for details) and A2-DBC 1/2 (see Section E) for details) was conducted in the same way as the previous leak tightness test.

Three temperature gauges measured the temperature inside and outside the test facility.

All tests were documented by calibrated recorders and testing protocols.

The table below lists the test conditions of the leak tightness tests.

[ ]

Test results

The CF achieved the required leak tightness according to DIN 1751 Class C (DIN 1751—Ventilation for buildings—Air terminal devices—Aerodynamic testing of damper and valves).

The ratio of the achieved to the allowed leak rate was in the range of per mil (≈factor of 1000 between allowed and achieved leak rate). The test series further demonstrated that a nut torque of [ ] is sufficient to fulfill the leak tightness requirements.

D. Functional tests during NOC conditions

The tests were performed in the test facility at the AREVA NP, Karlstein, Germany.

The objective of this test was to verify the mechanical strength of the RF and the tightness of the CF including the gasket. Therefore, the CF was stressed by mechanical loads in the form of pressure cycles at increased temperatures. This test arrangement simulated delta pressure fluctuations across the foils during normal operation (e.g., that caused by the plant HVAC system). The tests were performed with thermal and radiological pre-aged components.

After the load cycles, the CF was tested with regard to its leak tightness per the process described in Section C above.

Test conditions

The CF was attached to the rear side of the cover lid of the heated chamber. To reduce the inner free volume, a displacer was installed. The remaining free volume was connected to the pulse generation unit (PGU), which consisted of a 1.3 gal compressed air accumulator, a three way valve, and a pulse generator. To prevent the inside pressure exceeding the specified test values, a U-tube filled with demineralized water was installed between the three-way valve and the CF.

The chamber was heated either by a controlled air heater or by steam. Within this test program, the chamber was heated by hot air. The hot air entered the chamber at the bottom and lateral ventilation slots. The chamber was heated to [ ] by the fan heater first. To start the load cycles, the pulse generator, which controlled the solenoid valve and the three way valve, was turned on. One pressure load cycle consisted of the following 4 steps:

1) Charging of the accumulator with compressed air by opening the solenoid valve (RF unloaded).
2) Charging of the accumulator at closed solenoid valve.
3) Stressing the RF with a pressure load from the charged accumulator.
4) Unloading the RF and recharging of accumulator (cycle completed).

At the beginning of the test program the maximum pressure of the load cycle was adjusted to [ ] After approximately 850 load cycles, the maximum pressure was reduced to [ ] This caused a change in the water column in the U-tube from [ ]

All pressure and temperature signals were documented by a recorder.

The table below lists the test conditions during the leak tightness tests after NOC conditions.

[ ]

The table below summarizes the test environmental conditions and pressure cycles.

[ ]

Test results

With the adjusted maximum pressure [ ] of the first part of the test, the RF showed a slight buckling in conjunction. The initial test pressure was based on very conservative engineering judgment and was close to the minimum burst pressure of [ ] During NOC, the expected differential pressure across the CF is [ ] only, which covers fluctuation of the HVAC system by reactor startup and shut down.

The reduced test requirement of [ ] load pressure was set for the part of the test, which is conservative by having a factor of [ ] between the expected and tested differential pressure.

After the test, the RF was visually inspected. No damage was detected.

To summarize the results, the test verified that the RF withstands approximately [ ]

The CF fulfilled, during a subsequent leak tightness test series, the leak tightness requirements of DIN 1751 Class C. The ratio of the achieved to the allowed leak rate is in the range of [ ] between allowed and achieved leak rate).

E. Functional tests during increased NOC conditions (DBC 1/2)

The tests have been performed in the test facility at the AREVA NP, Karlstein, Germany.

The objective of this test was to verify the mechanical strength of the RF and the tightness of the CF including the gasket during increases in NOC conditions. Therefore, the CF was stressed by mechanical loads in the form of pressure cycles at increased temperatures. The test was performed with thermal and radiological pre-aged components. Additionally, the CF was already stressed by the previous NOC test with [ ] cycles at the elevated temperature. After the load cycle tests, the CF was tested for leak tightness according to C above.

Test conditions

The same test setup as described above was used for the NOC tests. Differing from the previous NOC tests, the chamber was heated up to [ ] The test conditions for the DBC are given in the table below.

[ ]

Test results

The RF was stressed with [ ] load cycles at increased temperature conditions of [ ] After the test, the RF was visually inspected. No damage was detected.

The tests verified that the RF withstands [

]

The CF fulfilled, during a subsequent leak tightness test series, the leak tightness requirements of DIN 1751 Class C. The ratio of the achieved to the allowed leak rate is in the range of [ ] between allowed and achieved leak rate).

F. Burst Pressure Test

The burst pressure tests were performed in the test facility at AREVA NP in Karlstein, Germany.

The aim of the test program was to verify the proper opening (burst) function of the RFs, which are part of the CFs. The nominal bursting pressure of the RF is [

]

Two different test setups were performed.

Test conditions

The test facility has a volume of [ ] It was extended with a transparent plexiglas cube, which was mounted at the flange connection beneath the test vessel. This transparent cube allowed observing the burst process.

The vessel was charged with compressed air. The pressure inside the vessel was measured by a pressure transducer and the burst pressure was documented.

The RFs were tested in both directions: convex and concave.

Test #1: RF was pre-stressed by:

- Radiological aging.
- Thermal aging.
- Load cycle test NOC condition.
- Load cycle test increased NOC condition.

Test #2: New RF (not pre-stressed)

Test results

The burst pressure of the RFs was in the specified range of [ ] for both tests. For these tests, no difference could be detected in the burst pressure of pre-stressed and new RFs. Aging of the RFs had no influence on the bursting behavior.

G. Fast Thermal Opening Test

The tests were performed in the thermal test facility at AREVA NP Karlstein, Germany.

For this test program the solder melt temperature of [ ] of the fusible link, as part of the thermo-lock, was verified. For these tests, both radiological pre-aged and new fusible links were used.

Test conditions

The CF was attached to the rear side of the cover lid of the thermal test facility. Heating was accomplished solely by steam, which entered the test facility from the bottom and exited through lateral ventilation slots.

For the test, pre-stressed and new fusible links were used.

Test #1: Fusible links already pre-stressed by radiological aging and load cycles NOC and increased NOC.

Test #2: New fusible links.

Test results

Fast thermal opening was successfully tested for both pairs of fusible links. Both the radiological and mechanical pre-stressed and the new fusible links opened at a temperature of [ ] which is in the required, specified temperature range of [ ] As the opening temperature was the same for both tests, no influence of the pre-stress by load cycles was detected.

H. Integral High Flow Burst Tests

The tests were performed in a test facility at Aerodynamische Ingenieurgesellschaft mbH Aachen (AIA), Germany.

The objective of the tests was to confirm proper burst function under high pressure plant conditions (accident scenario).

Test condition

The test facility mainly consisted of a pressure vessel [( ] with a flow channel leading to the installed CF/RF. After achieving the pressure of about [ ] in the vessel, the vessel isolation valve was opened, and the high pressure burst the CF/RF burst element. Beside the vessel pressure, the flow rate in the pipe and the differential pressure between duct and outlet were measured. Two high speed cameras recorded the opening process.

Test results

Pictures of the opening behavior were taken by a high speed camera to determine the opening cross-section. The result was an opening cross-section between [ ] For the CFs, no missiles were detected by reviewing the high speed filming of the opening process.

I. Vibration/Seismic Test

The tests were performed in a test facility at AREVA NP in Erlangen (Germany).

The test goal was to prove seismic stability of the CF. Within this test program, the integrity of the CF after operating basis earthquake (OBE) and safe shutdown earthquake (SSE) was demonstrated.

Test conditions

Servo hydraulic shaking tables were used to simulate uniaxial dynamic loads in horizontal and vertical directions. During the tests, the CFs were mounted on a fixation frame, which was rigidly assembled on the shaker table. According to its normal installation situation, the CF was mounted on the shaker table in hanging position on the original fixation points.

[ ]

Test results

The CF withstood the induced loads regarding mechanical functionality. No mechanical damage could be detected visually at the specimen. The integrity of the specimen could be seen during all tests. Afterwards, a dye penetrant test was performed at the Karlstein test facility later. See Section J for details.

J. Post Vibration Functional Check

The tests were performed in the test facility at AREVA NP Karlstein, Germany.

The objective of the test program was to perform a final functional check of the pre-stressed CF and RF after vibration/seismic induced loads and pre-stressing by thermal and radiological aging and by a burst test load.

Test conditions:

Test set-up for leak tightness test

The CF was installed at the lower side of a cover plate. The inner free volume of the CF was connected to compressed air. Using pressure transducers, an initial pressure difference of [ ] was applied on the CF at constant ambient temperature. Every 5 minutes, the differential pressure was documented. The test lasted for [ ]

The following table lists the test conditions during the leak tightness tests after vibration induced loads.

[ ]

Test set-up of the thermal opening test

The assembled CF test module was installed at the rear side of a cover lid of the thermal test facility. The heating of the test facility was done by steam. The hot steam entered the test facility from the bottom and exited through lateral ventilation slots.

Visual inspection of the welding seams

Subsequent to the leak tightness test and the thermal opening test, a visual inspection (dye penetrant test) of the welding seams and a visual check of the straightness and flatness of the CF frame was performed.

Test Results:

Test results of the leak tightness test

The leak rates did not exceed the allowed limit according to DIN EN 1751 class C.

Test results of the thermal opening test

At the beginning of the test, the temperature at the fusible link increased immediately. The temperature inside the CF increased much slower than the temperature at the fusible link. When the temperature at the fusible link reached [ ] the CF opened and the steam entered the CF. The temperature inside the CF increased immediately.

Results of the visual inspection of the welding seams

Following the leak tightness test and the thermal opening test, a visual inspection (NDT) of the welding seams was carried out. No cracks or other damage were detected. Furthermore, no changes to the straightness and flatness of the CF frame were detected.

K. Clamping Force Test

The clamping force tests were performed in the test facility at AREVA NP Karlstein, Germany.

The objective of the test program was to determine the required clamping force for the CF. Therefore, the force the thermo-lock has to withstand was assessed. The measured forces provided a basis to define the applied loads to the thermo-lock during inservice inspection.

Test conditions

The clamping force was determined at [ ] Three clamping force tests were performed for each test type (DT1a, DT1b and DT1c).

The tests were performed in the test facility which has a volume of [ ]

The test vessel was charged with compressed air. The pressure inside the test vessel was measured by a pressure transducer. The RF was replaced by a solid steel plate to perform the tests at pressure differences that are greater than the design pressure of the RF. To measure the clamping force of the CF, a hydraulic jack and a load cell was mounted beneath the test vessel.

The following table lists the test conditions of the clamping force test.

[ ]

Test Type DT1a

The pressure vessel was at [ ] . Using the hydraulic jack, force was applied to the CF until the pre-stressed thermo-lock tension was released. The applied force was measured by the load cell and represents the clamping force of the CF. The applied force was documented in test records.

Test Type DT1b

The pressure vessel was charged by a pressure of [ ] Using the hydraulic jack, force was applied to the CF until the pre-stressed thermo-lock tension was released. The applied force was measured by the load cell and represents the clamping force of the CF. The applied force was documented in test records.

Test Type DT1c

The pressure vessel was charged by a pressure of [ ] Using the hydraulic jack, force was applied to the CF until the pre-stressed thermo-lock tension was released. The applied force was measured by the load cell and represents the clamping force of the CF. The applied force was documented in test records.

Test results

The test showed that the thermo-lock withstands loads of up to [ ] the highest test pressure achieved, without any damage. This exceeds the [ ] design pressure of the RF, which would result in an intended bursting (opening) at such high pressure. Therefore, the tested thermo-lock load is bounding for the CF application.

The qualification report of the CF device is available for audit by the NRC staff.

2. Testing of Hydrogen Mixing Dampers

Test results of Hydrogen Mixing Damper testing will be made available for NRC audit by October 15, 2012.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.