Nuclear Innovation
North America LLC
4000 Avenue F, Suite A
Bay City, Texas 77414

February 28, 2011
U7-C-NINA-NRC-110038

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

South Texas Project
Units 3 and 4
Docket Nos. 52-012 and 52-013
Response to Request for Additional Information

Attached is the Nuclear Innovation North America LLC (NINA) response to Request for Additional Information (RAI) letter numbers 363, 367, and 371 related to Combined License Application (COLA) Part 2, Tier 2, Section 3.9.2. This completes the response to these NRC letters. The attachments address the responses or revised responses to the RAI questions listed below:

03.09.02-27	03.09.02-45	03.09.02-48
03.09.02-31	03.09.02-46	03.09.02-49
03.09.02-44	03.09.02-47	03.09.02-50

Where there are COLA markups, they will be made at the first routine COLA update following NRC acceptance of the RAI response.

There are no commitments in this letter.

If you have any questions, please contact me at (361) 972-7136 or Bill Mookhoek at (361) 972-7274.

D091
NRO

STI 32830027

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 2/28/11

Scott Head
Manager, Regulatory Affairs
South Texas Project Units 3 & 4

jep

Attachments:

1. RAI 03.09.02-27, Revision 1
2. RAI 03.09.02-31, Revision 1
3. RAI 03.09.02-44
4. RAI 03.09.02-45
5. RAI 03.09.02-46
6. RAI 03.09.02-47
7. RAI 03.09.02-48
8. RAI 03.09.02-49
9. RAI 03.09.02-50

cc: w/o attachment except*
(paper copy)

Director, Office of New Reactors
U. S. Nuclear Regulatory Commission
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

Regional Administrator, Region IV
U. S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 400
Arlington, Texas 76011-8064

Kathy C. Perkins, RN, MBA
Assistant Commissioner
Division for Regulatory Services
Texas Department of State Health Services
P. O. Box 149347
Austin, Texas 78714-9347

Alice Hamilton Rogers, P.E.
Inspection Unit Manager
Texas Department of State Health Services
P. O. Box 149347
Austin, Texas 78714-9347

*Steven P. Frantz, Esquire
A. H. Gutterman, Esquire
Morgan, Lewis & Bockius LLP
1111 Pennsylvania Ave. NW
Washington D.C. 20004

*Tom Tai
Two White Flint North
11545 Rockville Pike
Rockville, MD 20852

(electronic copy)

*George F. Wunder
*Tom Tai
Loren R. Plisco
U. S. Nuclear Regulatory Commission

Steve Winn
Joseph Kiwak
Jamey Seely
Eli Smith
Nuclear Innovation North America

Peter G. Nemeth
Crain, Caton and James, P.C.

Richard Peña
Kevin Pollo
L. D. Blaylock
CPS Energy

RAI 03.09.02-27, Revision 1

QUESTION:

In Toshiba Document Number 7B11-D001-3809-02, Revision 0, "Forcing Function Analysis Report for Lower Plenum," the forcing functions on the lower plenum components were determined for different elevations. The applicant is requested to elaborate on the methodology which will be used to correlate the forcing functions at different elevations.

REVISED RESPONSE:

The initial response to this RAI was provided in STPNOC Letter No. U7-C-STP-NRC-100229 dated October 18, 2010. Based on a subsequent change to the forcing functions on the lower plenum components as described below, this response has been revised as follows. Changed portions from the previous response are identified by revision bars in the margin.

For the control rod guide tube (CRGT)/control rod drive housing (CRDH) assembly and the in-core monitor guide tube (ICGT)/in-core monitor housing (ICMH) assembly, the turbulent fluid force is distributed in the longitudinal direction, because the cross flow is not uniform. To reflect this distribution, the representative flow velocity is calculated using computational fluid dynamics (CFD) analysis at 10 mm intervals in the longitudinal direction. The 10 mm length is shorter than the distance between nodes in the finite element model (FEM) of the stress analysis.

The representative flow velocity at each elevation is defined as follows:

- For the CRGT/CRDH assemblies inside the tube bank

  There are a minimum of four gaps around the inside assemblies. For this evaluation, the highest gap mean cross-flow velocity among the four-gap mean cross-flow velocities is conservatively defined as the representative flow velocity at the elevation.

- For the peripheral CRGT/CRDH assemblies

  The assemblies near the opening portion of the shroud support leg are exposed to high flow from the recirculation pumps (RIPs). Therefore, the maximum cross-flow velocity in a horizontal area around the CRGT/CRDH is defined as the representative flow velocity at the elevation to maintain conservatism. The horizontal area is defined as a rectangular area surrounded by tangential lines to the adjacent assemblies.

- For the ICGT/ICMH

  The representative flow velocity is also defined as the maximum cross-flow velocity, but the horizontal area is defined as an almost circular region of a size based on the diameter of the stub tube, because the CFD model does not include the ICGT/ICMH.

In addition, the envelope process of representative flow-velocity distribution in the longitudinal direction is conducted for the CRDH, ICMH, and stub tube regions, because the representative velocity profile in the longitudinal direction is not smooth in these regions.

For the stabilizers, the maximum value of the vertical upflow at the two stabilizer elevations is used as the representative flow velocity to maintain conservatism. The representative flow velocity is defined in inner and outer regions, respectively.

Using these representative flow velocities, fluid force power spectral densities are determined at each elevation. In the stress analysis, these forcing functions are conservatively assumed to have no temporal phase differences (they are coincident) and act in the same direction.

Toshiba Document 7B11-D001-3809-02, "Calculation, Forcing Function Analysis for Lower Plenum" has been revised (Revision 2) to address the updated forcing function.

There are no COLA changes required as a result of this response.

RAI 03.09.02-31, Revision 1

QUESTION:

In Section 6.4 of document XGEN-2010-03, Revision 0, "FIV Evaluation of Option 1 Components for STP Unit 3," it is concluded that the orificed fuel support can be excluded from the FIV test plan. This conclusion is based on extensive operating experience with this design. The applicant is requested to confirm that:

a) there are no design differences between the orificed fuel support planned for STP Unit 3 and those in currently operating plants

b) the flow conditions of the orificed fuel supports in currently operating plants envelope those of STP Unit 3.

REVISED RESPONSE:

This response replaces in its entirety STPNOC's initial response to RAI 03.09.02-31, which was submitted to the NRC by STPNOC Letter U7-C-STP-NRC-100229, dated October 18, 2010. This revision of the RAI response is made to clarify the similarity of the fuel support and the flow conditions for STP Unit 3 and the Reference Japanese ABWR (RJ-ABWR). Changes are indicated with revision bars in the margin.

a) The STP 3 fuel support castings are identical to those used in the RJ-ABWR.

b) Because the design and operating conditions are the same, the hydraulic characteristics and flow conditions for STP 3 will be essentially the same as those for the RJ-ABWR.

No COLA revision is required as a result of this response.

RAI 03.09.02-44

QUESTION:

In the October 18-19, 2010 audit of the subscale model test (SMT) and results, STP proposed to use the pressure measurement on the subscale steam dryer model to estimate the loading function on the full scale dryer. The staff raised concern about the adequacy of confirming the conservatism of the subscale-based dryer load with only one meaningful pressure data point from the K-6 steam dryer dome region. To demonstrate the steam dryer is designed with sufficient margin using the proposed approach, the staff is requesting confirmation that the proposed SMT-based dryer load approach has considered the following:

1. The SMT-based dryer load has met the following provisions:

   a. Sufficient number of pressure transducers on the dryer are used in the SMT.
   b. The scaling of the dryer loading has accounted for the effects of Reynolds number and medium properties. The submission also includes validation of the effects of these parameters.
   c. The frequency content and spectral shape of the pressure measurements on the K-6 dryer reasonably reflect those measured on the SMT dryer.
   d. The design load envelops the K-6 pressure measurements. This means that the design pressure distribution and the design differential pressure distribution on the dryer envelops the K-6 measurements.
   e. No safety relief valve (SRV) resonances are expected within the licensed range of operation.
   f. Conservative bias errors and uncertainties are included in the design.
   g. In the stress analysis of the dryer, the fatigue assessment should be based on ASME fatigue Curve C.

2. STP Unit 3 will operate at the same power level as K-6. The steam dryer of STP Unit 3 will be at least similar to, if not stiffer than the K-6 dryer. The load on STP unit 3 dryer will be smaller than that of K-6 because the SRV resonance will be suppressed.

3. The predictive analysis in the application should be supported by ABWR operating experience.

4. Conservatism on the factor of safety of the dryer outer hood will provide additional assurance of the design adequacy.

5. A license condition not to increase power level beyond approximately 60 percent during initial startup testing unless the limit curves are updated by the pressure measurements on the STP Unit 3 dryer.

RESPONSE:

As noted in this RAI, the audit of October 18-19, 2010 included a discussion of a method of developing steam dryer loads for STP 3 based on use of subscale model test (SMT) results. In a subsequent audit held on December 1-3, 2010, NRC indicated that the use of SMT results for development of full scale dryer loads could not be approved by the staff. This conclusion has been documented in RAI 03.09.02-49. As such, an alternate approach for the steam dryer was discussed at the audit. Some of the items in the specific parts of this RAI are not applicable to this alternate approach and are superseded by the information to be provided in response to RAI 03.09.02-49. The responses to such non-applicable items are marked with footnote (1) below. The responses to the remaining items in this RAI are provided below.

1.
    a. Footnote (1)
    b. Footnote (1)
    c. Footnote (1)
    d. Footnote (1)
    e. The SRV resonances are not applicable to the STP 3&4 design. The resonance onset is estimated not to occur until a power level exceeding well over 100% licensed thermal power. This is documented in WCAP-17256-P, "STP 3 ABWR Prototype Reactor Internals Flow-Induced Vibration Assessment Program."
    f. Footnote (1)
    g. The ABWR DCD, Section 3.9.2.1.1 specifies an endurance limit of 9.95 ksi (68.6 MPa) for allowable vibration displacements/deflections. The calculated stress results due to FIV shall be equal to or lower than this established endurance limit. This limit is lower than the "endurance limit" indicated in ASME fatigue Curve C, which provides an endurance limit of 13.6 ksi. Therefore, the lower value specified in the DCD applies to the STP steam dryer fatigue assessment.

2. STP 3 and the K-6 plant in Japan are identical in power, and the steam dryer for STP 3 is essentially identical to the K-6 dryer. As noted in response to 1e above, the resonance onset occurs outside the licensed power level of STP 3&4.

3. The operating experience of the ABWR steam dryer as demonstrated by the operating experience at Japanese ABWRs, is documented in WCAP-17369-P, "ABWR Dryer Operating Experience for STP Units 3 and 4." The operating experience documented therein demonstrates the success of the improvements in the ABWR dryer design over previous BWR dryers.

4. Footnote (1)

5. Footnote (1)

Note that the two reports referenced in this RAI response, WCAP-17256-P and WCAP-17369-P will be submitted to NRC.

No COLA changes are required as a result of this RAI response.

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(1) The subject of this RAI item is superseded by the change in approach as noted in RAI 03.09.02-49.

RAI 03.09.02-45

QUESTION:

Table 5.4 of FIV Stress Analysis Report of the Control Rod Guide Tube and Control Rod Drive Housing (7B11-D001-3809-08) shows that two predicted strains in load case 4' are less than the actual plant measurement results (ratio of predicted strain/measurement strain of 0.85 and 0.73). Though a safety factor of 1.38 (1/0.73) is applied in the analysis to compensate the difference, the report neither explains why the analysis underestimated the results nor provides any evidence that this factor is not larger for other locations within the reactor. Please explain the difference and provide evidence that the safety factor is not exceeded for other CR Guide Tube and CRD Housing.

RESPONSE:

The structural analysis report for the control rod guide tube (CRGT) and control rod drive (CRD) housing has been revised (see Reference 1) to incorporate an update in the forcing function based on comments received at an NRC audit in December, 2010. This updated forcing function provides a new enveloping velocity profile, which is shown in Figures 4.3 to 4.8 of Reference 2. This new velocity profile envelopes the uncertainty bands in the original velocity profiles that were used in Revision 0 and Revision 1 of Reference 2 and results in higher calculated stresses in Reference 1 (compared to Revision 0 of that reference). As a result, all of the calculated stresses for Cases 1 and 4' are now greater than the K-6 measured data.

The updated stress report in Reference 1 is available for NRC review.

There is no COLA change required as a result of this response.

References

1. 7B11-D001-3809-08, "Structural Analysis Report – FIV Stress Analysis (CR Guide Tube and CRD Housing)", Revision 1.

2. 7B11-D001-3809-02, "Calculation, Forcing Function Analysis for Lower Plenum", Revision 2.

RAI 03.09.02-46

QUESTION:

Tables 5.11 and 5.13 of FIV Stress Analysis Report of the High Pressure Core Flood Sparger and Coupling (7B11-D001-3809-10) shows that several predicted strains under turbulent buffeting and pump pulsation loads are less than the actual plant measurement results (ratio of predicted strain/measurement strain of 0.28, 0.35, and 0.74). Please provide the explanation why the analysis underestimated the results. Also provide explanation why there is no safety factor applied in the analysis to compensate the difference.

RESPONSE:

The calculated stresses for the high pressure core flooder (HPCF) sparger and coupling have been revised based on updated load input which has been provided per Reference 1. This report revision was required in order to address several NRC requests for additional information. The revised calculated stresses are reported in Reference 2. These revised results show that, at location S13 for Case 4', which demonstrated the minimum ratio of predicted strain to measured strain, the ratio has increased from 0.28 (as reported in the Revision 0 version of Reference 2) to 0.59. Thus, the revised report shows better agreement with the measured test results, although some underprediction from the analysis still occurs. The most likely reason for the underprediction is that the measured strain includes some effects other than flow induced vibration (FIV) effects, which would have had a large percentage impact on the reading because the measured strains were so low.

The underprediction of the HPCF sparger and coupling strains relative to the measured data in the locations identified in Reference 2 is not a significant issue, because the calculated and measured stresses are low and only a small fraction of the allowable design limit. For example, the calculated highest stress from all cases and locations, which also exceeds all measured values, is 11.9 MPa. This is only 17% of the maximum allowable fatigue limit of 68.6 MPa. This is deemed to be sufficient margin to the limit to preclude application of any safety factors as a result of underprediction of measured data in these locations. Note that the stress calculation includes several conservative assumptions, such as a damping factor of 0.2% and a fatigue factor of 4.0. Consequently, the HPCF sparger and coupling designs are structurally qualified for flow induced vibration loads.

The updated stress analysis report in Reference 2 is available for NRC review.

There is no COLA change required as a result of this response.

References

1. CN-SEE-II-10-15, "STP Unit 3 Flow Induced Vibration Analysis", Revision 1.
2. 7B11-D001-3809-10, "Structural Analysis Report – FIV Stress Analysis (HPCF Sparger and Coupling), Revision 1.

RAI 03.09.02-47

QUESTION:

An open item in Section 2.2 of the FIV Stress Analysis Report of the Shroud (7B11-D001-3809-11) states that the calculation is based on the load definitions in the CN-SEE-II-10-15, Rev. 0. During the audit, the applicant stated that the load definitions of the shroud have been updated. Please provide the impact or the results based on the new load on the fatigue usage of the shroud.

RESPONSE:

The analyses using the updated input loads provided in Reference 1 have been completed and are documented in Reference 2. The revised calculated stresses as a result of application of these updated input loads are shown in Table 5.4 of Reference 2. Table 5.3 of Reference 2 provides a comparison of the strains between the analyses and the measured K-6 data. These tables show that the calculated strain values are all larger than the measured results at K-6 and below the fatigue limit. This demonstrates that the analyses are conservative and that the shroud is adequately designed to withstand the stresses due to flow induced vibration.

The updated stress analysis report in Reference 2 is available for NRC review upon request.

There is no COLA change required as a result of this response.

References

1. CN-SEE-II-10-15, "STP Unit 3 Flow Induced Vibration Analysis", Revision 1.
2. 7B11-D001-3809-11, "Structural Analysis Report – FIV Stress Analysis (Shroud)", Revision 1.

RAI 03.09.02-48

QUESTION:

In Calculation Note CN-A&SA-10-48, the STP steam dryer modal analysis is compared with the Japanese hammer test results. In general, the calculated natural frequencies of the key dryer components agree well (within 10 percent) with the Japanese hammer test, except the lowest mode of the outer hood which differs by 21 percent compared to the Japanese results (64.7 Hz of modal analysis vs. 82 Hz of Japanese results). During the audit, the applicant re-examined the frequency spectra obtained from the hammer tests of the dryer and found a frequency close to the analytical result of 64.7 Hz. Therefore, STP is requested to:

(a) review the frequency spectra obtained from the hammer tests of all other components of the dryer to ensure that no other resonance frequencies are overlooked from the hammer tests of the dryer.

(b) update the STP modal analysis report CN-A&SA-10-38.

RESPONSE:

All frequency spectra from the K6 hammer test were reviewed. No additional frequencies, besides the frequency close to the lowest mode of the outer hood, were found for any of the dryer components tested for K6. Calculation note CN-A&SA-10-48 Revision 1 has been issued to reflect the 70 Hz outer hood frequency from the hammer test results. (Note that the modal analysis report referred to in Item (b) of this RAI should be CN-A&SA-10-48 and not CN-A&SA-10-38.) The outer hood frequencies from the modal analysis now agree with the K6 hammer test results within 10%.

There is no COLA change required as a result of this response.

RAI 03.09.02-49

QUESTION:

During the audit, STP presented sample pressure spectra measured on the sub-scale steam dryer. STP suggested that these pressure measurements can be scaled up to the full scale reactor size and operating conditions and then used to estimate the design dynamic loading on the dryer. After reviewing these sample pressure spectra, the NRC staff concluded that most of the pressure spectra measured on the sub-scale dryer do not exemplify the spectral characteristics of the pressure fluctuations measured on the Japanese dryer. Therefore, the staff advised STP that the use of pressure measurements from the sub-scale tests to estimate the STP dryer design load at full power level cannot be approved by the staff. STP was further advised to propose an alternative approach to demonstrate that the steam dryer can be operated safely at the planned maximum power level. In response, STP suggested the following alternative approach:

1. Comprehensive industrial experiences on ABWR dryers will be collected and submitted to NRC for review. The industrial experiences will be compiled for the reactors in Japan because these reactors are "identical" to the STP dryer and have been in operation for several years at conditions similar to those of the STP dryer.

2. A "best estimate" design load for the STP dryer will be developed from compilation of the results obtained from:
   - 15 pressure transducers on the sub-scale dryer
   - 3 pressure transducers on the Japanese dryer
   - 7 strain gages on the Japanese dryer
   - 4 accelerometers on the Japanese dryer.

3. The "best estimate" design load will be used to design the dryer, but the dryer will be instrumented with pressure transducers, strain gages and accelerometers to monitor the alternating stresses during the start-up measuring program.

4. During the start-up measurement program, the reactor load will not be increased beyond an approved power level (around 60% CLTP) until pressure measurements on the actual dryer are obtained and used to update the dryer load, stress margins and limit curves. Further power increases would proceed only if the updated stress margins allow.

5. STP will provide a comprehensive report explaining the methodology which will be used to estimate the dynamic dryer load from pressure measurements on the dryer during the start-up test program. The report will include validation tests together with expected bias errors and uncertainties. The SMT will be used to validate the methodology of load definition.

6. STP will also submit a comprehensive report documenting the FE dynamic model of the dryer and the method which will be used to estimate the minimum alternating stress ratio of the dryer at CLTP operating conditions. The report will include expected bias errors and

uncertainties. In this report, the best estimate design load will be used to estimate the stress level of the dryer.

In order to confirm mutual understanding of the new approach being pursued by STP, the applicant is requested to:

(a) confirm that the above detailed approach will be followed, or update the NRC staff if any deviations from this approach are expected.

(b) submit comprehensive reports on: the industrial experiences of ABWRs; determination of the best estimate dryer load; validation of the procedure of load definition from pressure measurements on the dryer during start up tests; and FE stress analysis of the dryer based on the best estimate design load.

RESPONSE:

a) The referenced audit of the STP 3&4 flow-induced vibration (FIV) documentation was conducted by NRC on December 1-3, 2010. At a subsequent audit conducted on January 24-26, 2011 and a phone call with NRC staff on February16, 2011, additional discussions were held that resulted in a re-direction to the approach as outlined in this RAI. Therefore this response provides a modified approach from that described in the RAI to demonstrate steam dryer FIV qualification for the STP Unit 3 prototype.

Background:

Regulatory Guide (RG) 1.20 provides guidance for the comprehensive vibration assessment program (CVAP) for nuclear power plants including preoperational and initial startup testing. The program is intended to demonstrate that the reactor internals are adequately designed to withstand flow-induced vibration (FIV) forces at normal and transient plant operating conditions for the design life of the plant. The ABWR was designed and certified under RG 1.20 Revision 2. This same design is employed in multiple ABWR plants in Japan. One of those Japanese ABWRs, as described in Reference 1 and referred to as the reference Japanese ABWR (RJ-ABWR), commenced commercial operation in 1996 after going through extensive preoperational and start-up testing to confirm that the reactor internals are adequately designed to withstand FIV loads. The RJ-ABWR steam dryer has an excellent operating history as demonstrated by tests and inspections. The latest revision (Revision 3, March 2007) of RG 1.20 contains additional requirements based on recent BWR experiences on steam dryers. Based on the need to address the current guidance, STPNOC (now NINA) decided that STP Unit 3 reactor internals will be designated as the US ABWR prototype.

Approach for Qualification of STP Unit 3 Steam Dryers:

As stated above, the steam dryer design in the ABWR certified design was developed to satisfy the guidance of RG 1.20 Revision 2. The Final Safety Evaluation Report (FSER) for the ABWR (Reference 2) states that the response of the dryer to FIV must be predicted before final design approval, discusses the analyses that were done by the DC applicant which were reviewed by the NRC staff, and concludes that the combination of predictive analysis, pre-test inspections, tests, and post-test inspections provides reasonable assurance that the reactor internals will perform without loss of structural integrity. The ABWR DCD specifies a peak stress amplitude limit that is significantly lower than the ASME Code allowable value (the ASME allowable is approximately 37% higher than the DCD allowable value). Thus the certified dryer design has a predictive analysis that is adequate for this lower allowable stress. This has been confirmed by pre-operational testing at the RJ-ABWR, which confirmed the peak and alternating stresses in the steam dryer meet the allowable limit, and that the maximum stresses are less that this conservative allowable limit.

As discussed in Reference 2, it was anticipated that the data results from the RJ-ABWR, including the information specified in Regulatory Positions C.2.1, C.2.2, C.2.3, and C.2.4 of RG 1.20, would be provided in the response to COL License Information Item 3.9.7.1. However, it was determined in a meeting between STPNOC and the NRC staff in December 2009 that the predictive analyses that were available to STPNOC for submittal in the STP 3&4 COLA were not adequate to meet the guidance as described in Regulatory Position C.2.1 of RG 1.20. However, the FSER was written to anticipate the possibility of this, as it states that if the data from the RJ-ABWR proves insufficient, the COL applicant will develop a test plan to ensure that any additional data is obtained and submitted to the staff. The approach described herein includes an approach to obtain this additional data.

RG 1.20, Revision 3, Part D – Implementation, states, "Except in those cases in which a licensee proposes or has previously established an acceptable alternative method for complying with specified portions of the NRC's regulations, the NRC staff will use the methods described in this guide…" Because the certified ABWR steam dryer design was not designed specifically to meet the guidance of RG 1.20 Revision 3 (as portions of this guidance were not available at the time), but was designed to satisfy the earlier guidance of RG 1.20 Revision 2, NINA proposes to use a combination of the previously established qualification of the dryer along with a proposed alternative to provide a means to demonstrate that the reactor internals will perform without loss of structural integrity, as discussed in the FSER. The alternative approach consists of the activities as described in the following paragraphs:

- *Operating Experience:* As described in Reference 1, the ABWR dryer incorporates improvements in the dryer design that result in greater structural capability and better performance than earlier dryer designs. The ABWR dryers are in use at multiple ABWR reactors in Japan. The STP 3&4 dryers are essentially identical in both configuration and plant operating conditions to the RJ-ABWR and another Japanese ABWR (J-ABWR). The RJ-ABWR has operated for over twelve years and the J-ABWR has operated since 2005. The dryers for both operating plants have undergone inspections and no indications were found. The RJ-ABWR is inspected during each outage, and underwent an extensive examination following the July 2007 earthquake near the site. This successful operating experience, as documented in Reference 1, supports the conclusion of the predictive analysis as described in the DCD and the FSER that the ABWR steam dryer is adequate to meet the DCD stress limits.

- *Confirmatory Predictive Analysis using K-6 Strain Data:* Reference 2 cites a letter that documents an audit of the reactor internals (Reference 3) by the NRC staff. Reference 3 summarizes that the predictive analyses performed in support of the design certification provided reasonable assurance that the ABWR reactor internals are adequately designed to withstand FIV. In Reference 3 it is also stated that the staff agreed that the analytically predicted values may be upgraded when future test data become available, such as data from preoperational and startup tests of the RJ-ABWR. A confirmatory predictive analysis will be performed following this approach, using the recorded strains from the RJ-ABWR applied to the STP 3&4 analytical model. Stresses in the dryer will be developed and used as a baseline for establishing the design margin. This analysis uses the same finite element model (FEM) that will be used for the power ascension as described below. This predictive analysis will be prepared and provided in a revision to Reference 5. This revision is currently planned to be submitted to NRC by April 15, 2011.

- *Design Modifications to Avoid Acoustic Resonance:* Testing of the RJ-ABWR indicated resonance at a power level less than 100%. As part of the detailed design effort for STP 3&4, subscale testing of the dryer and main steam lines was performed to identify the potential for acoustic resonance for power levels up to 100%. The initial subscale tests confirmed an acoustic resonance occurs below 100% power, similar to that noted for the RJ-ABWR. While the operating experience and inspection results prove that this acoustic resonance does not result in dryer cracking, the STP 3&4 safety relief valve (SRV) standpipe configuration has been redesigned to eliminate the possibility of acoustic resonance. Additional subscale testing was then performed to confirm that the modified standpipe configuration eliminates the acoustic resonance. This subscale testing, standpipe redesign, and confirmatory subscale testing is documented in Reference 4. This design improvement will enhance the overall ability of the STP 3&4 steam dryers to maintain structural integrity for FIV type loads.

- *Instrumentation and Detailed Analysis during Startup:* The STP Unit 3 steam dryer will be instrumented and monitored during initial plant startup with pressure transducers, strain gages, and accelerometers as discussed in Reference 5. To determine the instrument locations for the STP Unit 3 dryer measurement program, a unit loads analysis approach is used to calculate the high stress locations, important acceleration / displacement locations, and important pressure locations that are used to best locate the instrumentation.

  At approximately 60% power, pressure, strain, and accelerometer data will be collected. A methodology being submitted as part of Reference 4, which is based on preceding approaches presented to and/or approved by the NRC, describes in detail how the STP Unit 3 pressure loading will be developed from the full scale pressure transducer data, which includes application of bias and uncertainties, and frequency shifting for significant modes as applicable. This methodology will be used to perform a stress analysis for the dryer. Limit curves (Level 1 corresponding to 100% of the allowable stress fatigue limit and Level 2 corresponding to 80% of the allowable stress fatigue limit) will be generated. Power will be increased in increments of about10% power, from approximately 60% power up to 100% power. At each new power level, data will be obtained and compared to the limit curves to ensure that the loads and resulting dryer stresses are below the fatigue limit. The limit curves will be redone using the actual pressure data at each new power level before ascending power to the next level. Actions are defined to address the circumstance of a limit curve being exceeded, as described in Reference 5.

NINA will agree to a COL license condition stating this approach. The proposed license condition is included at the end of this RAI response.

Summary:

The structural adequacy of the STP 3&4 steam dryer for FIV loads is demonstrated by the predictive analysis reviewed by the NRC as part of initial design certification and the successful operating experience verified by inspections. In addition, the FEM to be used for the steam dryer analysis is used to perform a confirmatory analysis of the original predictive analysis, using the actual strain data obtained from the RJ-ABWR tests. To further assure minimization of acoustic excitation for STP 3&4, design modifications have been made to eliminate acoustic resonance, thereby improving the dryer margin for peak and alternating stresses, and the power ascension plan during initial startup with a hold at 60% power to generate limit curves, further ensure the structural adequacy of the STP 3&4 steam dryer for FIV loads.

The STP 3&4 COLA is to be revised to be consistent with this revised approach for steam dryer qualification. Proposed changes to the COLA are provided below. Changes are highlighted by gray shading.

b) Comprehensive reports that provide the necessary information for qualification of the STP 3&4 steam dryers, including the industrial experiences of ABWRs (Reference 1), and the minimization of acoustic excitation and the use of start-up test data for stress analyses and development of limit curves (Reference 5) are being submitted to the Staff for review.

References

1. Westinghouse Report, WCAP-17369-P, "ABWR Dryer Operating Experience for STP Units 3 and 4," February 2011.
2. NUREG-1503, "Final Safety Evaluation Report Related to the Certification of the Advanced Boiling Water Reactor Design," US Nuclear Regulatory Commission, July 1994.
3. NRC Document, "Audit Summary - Advanced Boiling Water Reactor (ABWR) Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) on Reactor Vessel Internals," May 10, 1992.
4. Westinghouse Report, WCAP-17256-P (Draft), "STP 3 ABWR Prototype Reactor Internals Flow-Induced Vibrations Assessment Program," February 2011.
5. Westinghouse Report, WCAP-17385-P, "STP Unit 3 Steam Dryer Flow-Induced Vibration Assessment," February 2011.

Proposed License Condition

During power ascension of STP Unit 3, power will be held at approximately 60% of licensed thermal power and data collected from instrumentation on the steam dryer. That data shall be used to predict the pressure loading definition on the steam dryer, and this loading will be used to perform dynamic finite element analysis of the dryer to predict stresses. Limit curves will be generated for the power ascension from the hold power up to 100% power, based on the methodology in report WCAP-17385-P. During power ascension from the hold power, data from the dryer instrumentation will be taken and compared to the limit curves at approximately 70%, 80%, 90%, and 100% licensed thermal power. At each power level, if the measured values are within the limit curves, then power may be increased to the next power level without prior NRC approval. If the Level 1 limit curve is exceeded, then the power will be reduced to a previous power level where the Level 1 limit curve was not exceeded. Evaluations will be performed to resolve the uncertainties in the steam dryer analysis and evaluate the continued structural integrity of the steam dryer, including evaluation of the steam dryer strain data at the power level at which the Level 1 limit curve was exceeded, and that evaluation will be submitted to the NRC staff.

Proposed COLA Changes

3.9.2.4 Preoperational Flow-Induced Vibration Testing of Reactor Internals

The following standard supplement addresses Regulatory Guide (R.G.) 1.206, Rev. 0:

As discussed in Subsection 3.9.2.3, STP 3 reactor internals are classified as Prototype, and the STP 4 reactor internals are classified as non-prototype, Category I. In accordance with the requirement of Regulatory Guide 1.206 Section C.I.3.9.2.4 for prototype, Section 3.9.2.3 identifies the assessment program for STP 3 that addresses the flow modes, vibration monitoring and sensor types and locations, procedures and methods to be used to process and interpret the measured data, planned visual inspections, and planned comparisons of test results with analytical predictions. ~~In addition, scale model tests will also be used for the development of the analyses of the steam dryers for acoustic loads.~~

For STP 4 reactor internals components, an inspection program will be implemented in lieu of a vibration measurement program as discussed in paragraph C.3.1.3 of Regulatory Guide 1.20. Subsection 3.9.2.3 identifies the assessment program for the STP 4 non-prototype.

Also, as discussed in Regulatory Guide 1.20, Rev. 3, the main steam lines in STP 3 and 4 will be instrumented with strain gages to provide measurements of pressure fluctuations due to flow-induced vibrations. ~~The measurements will be used by the Acoustic Circuit Methodology to analytically predict the steam dryer flow-induced vibration loads. The predicted loads will then be used with a finite element model of the dryer to confirm the acceptability of the flow-induced vibration loads.~~

No later than ~~After~~ the first refueling outage ~~operating cycle~~ of STP 3 and STP 4, detailed inspections of the steam dryer will be performed to confirm the structural adequacy of the dryer for flow-induced vibration loads.

RAI 03.09.02-50

QUESTION:

The pressure spectra measured on the sub-scale dryer are compared with corresponding spectra obtained from the Japanese ABWR in CDI Technical Note # 10-21P, "Loads predicted on the full scale STP dryer at 100 percent power, based on pressure transducer measurements on a subscale model" dated November 2010. The staff determined that some of the spectral peaks measured on the Japanese dryer were filtered out in this comparison. In particular, two peaks near 20 and 40 Hz were removed from the Japanese spectra at location P3. The amplitudes of these peaks exceed the SMT dryer pressure which will be used to calculate the best estimate design load of the dryer. CDI explained that these peaks are likely generated by dryer vibration, and not pressure oscillations, and therefore they were filtered out from the pressure spectra. The staff finds this explanation unconvincing and therefore, STP is requested to include these peaks in the best estimate design load of the dryer.

RESPONSE:

As noted in the response to RAI 03.09.02-44, the NRC has indicated that the use of scale model test (SMT) results for development of full scale dryer loads could not be approved by the Staff. This conclusion was documented in RAI 03.09.02-49. As such, an alternate approach is being taken to develop these loads. Because the SMT is no longer a basis for the development of the STP 3&4 steam dryer loads, this question is no longer applicable.

There is no COLA change required as a result of this RAI response.