Attachment 2 to PLA-6242
Non-Proprietary Version of the Request for Additional Information Responses

NRC Question 1:

In reference to the response to the NRC staff's Request for Additional Information (RAI) 3 in letter PLA-6167 dated April 27, 2007, PPL is requested to clarify the following:

(a) PPL is requested to specify as to which dryer stress analysis will be used for developing the Unit 1 dryer instrumentation limit curves - those based on current licensed thermal power (CLTP) conditions with all four main steam lines (MSLs) open, or those based on slowly closing a single MSL. Although MSL strain gauges will not be used to set limits for Unit 1 until 110.5% CLTP, PPL should submit interim limit curves for the MSLs prior to EPU approval, and compare the curves to current levels measured in the plant at original licensed thermal power (OLTP) conditions in order to review the approximate proposed increase in loading levels between CLTP and the extended power uprate (EPU).

(b) For Unit 1, PPL proposes to use the dryer instrumentation to check pressure, strain, and acceleration levels at 103.5% and 107% CLTP conditions, and then rely solely on MSL strain gauge limit curves at 110.5 and 114% CLTP conditions. Since the dryer in Unit 2 is not instrumented, MSL strain gauges will be monitored at all four steps (103.5, 107, 110.5, and 114% CLTP conditions), and not until the benchmarking of the stress analysis procedure is completed based on Unit 1 instrumentation at 107% CLTP. The benchmarked dryer stress analysis procedures and updated MSL limit curves shall be reviewed by the NRC prior to PPL proceeding to power levels higher than 107% CLTP in either Unit 1 or Unit 2. As such, PPL should provide a sufficient hold period at 107% CLTP.

(c) PPL is requested to explain how it plans to use the Unit 1 steam dryer measurements in benchmarking of the stress analysis procedure.

(d) PPL is requested to explain the rational for not using the Unit 1 steam dryer instrumentation to monitor stresses in the steam dryer for all four steps of power ascension to 114% CLTP. Operating experience shows that previous applications of an acoustic circuit analyses have determined pressure loads on steam dryers based on pressure fluctuation measurements in the main steam lines caused by downstream sources in the steam lines. The licensee indicates in Attachment 10, Section 4.2.5.1 of their submittal, that the pressure pulses measured in the main steam line are generated by hydrodynamic sources. The licensee's application does not provide the technical justification to show that the acoustic circuit analysis is reliable in determining SSES steam dryer pressure loads caused by such hydrodynamic sources.

(e) The benchmarking of dryer stress analysis as discussed in (b) may not be adequate because it may not include loading due to significant acoustic resonance that might only take place at power greater than 107% CLTP. Discuss the benchmarking of the dryer stress analysis for loading above 107% CLTP.

PPL Response:

(a) The interim MSL strain gauge limit curves have been developed using the [[

]]

Appendix 1 of this letter, "Susquehanna Limit Curve for MSL Acoustic Monitoring, July 2007," provides the interim limit curves for the eight monitoring locations on the Susquehanna Unit 1 main steam lines. The interim limit curves include comparisons with strain gauge data collected at 96% CLTP (slightly higher than OLTP conditions). Appendix 1 of this letter also includes the basis of the curve development.

(b) PPL will allow sufficient hold periods at 107% CLTP to facilitate reviews of steam dryer data. This hold period will be in accordance with the proposed License Conditions detailed in the response to RAI 11 of this letter.

(c) The steam dryer pressure and strain measurements will be used for benchmarking the analytical tools used in the stress analysis procedure. The pressure load definition used as input to the structural analysis will be benchmarked against the pressure measurements at each of the pressure sensor locations. The strain prediction results from the structural analysis will be benchmarked against the strain measurements at each of the strain gauge locations. Data will be collected at multiple power levels between 80% and 100% CLTP prior to EPU operations. This will include data collection during MSIV slow closure testing at 80% and 85% CLTP to simulate the plant conditions at 107% and 114% CLTP. Data will also be collected and evaluated at the 103.5% and 107% CLTP power steps. The predicted and measured amplitude and frequency content will be compared for each of the pressure, accelerometer, and strain gauge sensors. The measurement information will be used to confirm that the [[ ]] stress under-prediction factor (SUPF) assumed in the structural analysis is adequate to account for the load definition uncertainties. Measurements taken at different power levels during the power ascension will be used to confirm that the [[ ]] EPU scaling factor assumed in the structural analysis is adequate to account for the increased loads and stresses at full EPU conditions. If necessary, the analytical tools will be revised or improved in order to improve the accuracy of the predictions. These actions may consist of reevaluating the stress under-prediction factor or the EPU scaling factor, revising or refining the acoustic circuit model, revising or refining the finite element model, or performing more detailed stress calculations using finite element sub-models of individual dryer components or sections.

(d) The EPU at Unit 1 will be implemented over two operating cycles. From a practical standpoint, the steam dryer instrumentation can only be used during the cycle in which it is first installed. If the instrumentation were to be used for multiple cycles, the instrumentation cabling would have to be removed from the vessel head to allow the head and dryer to be removed for refueling. It is very difficult to remove and reinstall the cabling and to reestablish the cable penetration pressure boundary seal without damaging the cable insulation and compromising the operability of the instrumentation. In addition, the dryer instrumentation is operating in a harsh environment inside the reactor. The long-term operability of the sensors, in particular the strain gauges, cannot be assured over a full two-year cycle. Therefore, it was decided to remove the instrumentation at the end of the first cycle (after the first two power ascension steps). In recognition of these limitations, the power ascension test plan for Unit 1 includes the MSIV slow closure testing in order to approximate the steam line flow velocities, pressure loading and structural response at full EPU operation. All testing will be performed at the beginning of the cycle when the operability of the instrumentation can be assured.

The Unit 1 power ascension test plan provided in the response to RAI 3 in letter PLA-6176 dated April 27, 2007 (Reference 3) includes MSIV slow closure testing at 85% CLTP in order to approximate the steam line flow velocities at full EPU conditions in the remaining three open steam lines. The MSIV slow closure testing will be performed on each steam line. As described in the response to RAI 7 in PLA-6176, during this testing each steam line will be subjected to approximately full EPU flow velocities and each half of the dryer will be subjected to full EPU flow velocities over the outer hood region. This testing will excite all potential pressure load and potential acoustic resonance sources in the steam flow path at approximately full EPU conditions. As described in the response to RAI 3 in PLA-6200 dated June 1, 2007 (Reference 4), [[

]] This increase is consistent with the rate of increase expected through full EPU conditions. Therefore, the MSIV slow closure testing at 85% CLTP will produce the pressure loading and structural response expected at approximately full EPU conditions on the instrumented Unit 1 dryer.

The first MSIV slow closure test will be performed at approximately 80% CLTP to simulate the plant conditions at 107% CLTP. The results from this testing will be compared against the dryer measurements taken at 107% CLTP in order to benchmark the composite pressure load definition used in the structural analysis. These results will also be used to confirm that the [[ ]] stress under-prediction factor assumed in the structural analysis is adequate to account for the load definition bias and uncertainties discussed in the responses to RAIs 13 and 28 in PLA-6176. The MSIV slow closure test at 85% CLTP will simulate the conditions at 114% CLTP. These measurements will be used to confirm the [[ ]] EPU scaling factor assumed in the structural analysis is adequate to account for the increased loads and stresses at full EPU conditions. The MSIV slow closure test at 85% CLTP will also be used to confirm the predictions that no acoustic resonances will occur at full EPU operating conditions.

Consideration was given to instrumenting the Unit 2 dryer instead of Unit 1. Unit 2 will be implementing EPU one year after Unit 1; however, Unit 2 will be implementing the full EPU (all four power ascension steps) in one cycle. This would have allowed taking dryer measurements at full EPU conditions, but little additional information would be gained over the information provided during the MSIV slow closure testing on Unit 1. Therefore, it was determined that it was acceptable to only instrument the first dryer put into service (Unit 1). This will allow for confirmation of the analytical predictions and, in the unlikely event modifications are needed, will allow for those modifications to be made to the Unit 2 dryer before it is put into service. The MSL power ascension limit curves will be validated against the Unit 1 dryer and MSL measurements at 107% CLTP. These validated limit curves will be used for the third and fourth power ascension steps to 114% CLTP for Unit 1 and for all power ascension steps to 114% CLTP for Unit 2.

PPL has acknowledged that the ACM does not reliably predict the magnitude of pressure loads caused by hydrodynamic sources. PPL has described how these uncertainties, which result from the ACM with respect to hydrodynamic sources, are addressed in the responses to RAIs 2 and 13 contained in PLA-6176. In addition to the analysis, which has been completed and presented to the NRC, the data resulting from the testing with the instrumented steam dryer will be used to further evaluate the capability of the ACM to predict hydrodynamic pressure loading. The results of this benchmarking effort could lead to adjustments or revisions to the ACM (see response to RAI 1(c) above).

(f) As described in the response to RAI 1(d) above, the MSIV slow closure testing at 85% CLTP will produce the steam line flow velocity, dryer pressure loading, and structural response expected at approximately full EPU conditions on the instrumented Unit 1 dryer. This testing will excite all potential pressure load and potential acoustic resonance sources in the steam flow path, in both the vessel and the steam lines that might take place at power levels above 107% CLTP. The dryer measurements taken during the MSIV slow closure testing will allow benchmarking of the dryer stress analysis at approximately the full EPU conditions. The main steam lines will be monitored during power ascension above 107% CLTP for both Unit 1 and Unit 2. In the unlikely event a new acoustic source appears that was not identified during the MSIV slow closure test, the MSL monitoring will identify this new source. If the new acoustic source is significant and challenges the Level 2 or Level 1 limit curves, the power ascension will be held at an acceptable power level and the impact of the new source on the dryer will be evaluated.

NRC Question 2:

(a) In the response to NRC staff's RAI 4 in letter PLA-6167 dated April 27, 2007, PPL supplies pressure time signals measured during the scale model testing (SMT) and inside the dead leg attached to line A (or D). The signals appear to be in phase, which supports the supposition of a standing quarter wavelength inside the dead leg. However, PPL does not comment on why the normalized power spectral density (PSD) is lower at the end cap than at the midpoint of the dead leg (Figs A.19 to A. 29 of Continuum Dynamics Inc. (CDI) Report No. 05-32, March 2006). These results contradict those shown in Fig. 8.2 of the same report, which shows higher root mean-square (RMS) pressure at the end cap. PPL is requested to explain this disagreement in the reported results.

(b) PPL also refers to the turbulent eddies at the inlets of MSLs as the excitation source of the low frequency components (16 and 32 Hz). While this is a plausible excitation source, PPL neglects the possibility of flow excitation at the mouth of the dead leg. Simple calculations based on f =16 Hertz (Hz), V = 153 fps, and 24" diameter pipe, gives a Strouhal number of about 0.21. This is close to the critical value for this geometry (see Figs. 12 & 13 of paper by Peters & Bokhorst 2000, "Flow-excited pulsations in pipe systems with closed branches, impact of flow direction," in Flow-Induced Vibration, Balkema 2000). However, the geometry of the T-junction edge is crucial. PPL is requested to (1) evaluate this possible excitation source; (2) provide information on the geometry of the T-junction edge (sharp or rounded and at what radius); and (3) explain whether the geometrical details of the T-junction edges and the length of MSL A were properly modeled in the SMT study.

(c) In its response to RAI 4 (and RAI 31), PPL supplied more details on the MSL geometry. It seems that the lower strain gauges on steam lines A and D are very close to (1) the T-junction at the mouth of the dead leg and (2) to a pressure node of the 16 Hz component. Concerning Item (1), PPL is requested to explain how it accounts for the effect of the pipe stiffening (being close to a T-junction) when relating the pipe strains to acoustic pressure. Regarding Item 2, the lower strain gauges on Lines A and D are nearly "blind" to the 16 Hz component, which is the strongest dynamic loading on the dryer. Since PPL is planning to use MSL measurements to evaluate the dryer stresses for the last two steps of power ascension to EPU of Unit 1, the measurement accuracy and uncertainties of the lower strain gauges should be re-assessed. First, the lower strain gauges are blind to the 16 Hz component and they are also close to the T-junction, which influences the conversion factor. PPL is requested to explain whether the lower strain gauges will be repositioned (away from the pressure node) or if additional strain gauges will be installed on lines A and D (i.e., use a 3-location measurement method for MSL pressures).

PPL Response:

(a) [[

]]

(b)(1) [[

]].

(b)(2) [[

]]

Finally, it should be noted that the results of the one-sixth SMT were not used in the development of the dryer load definition for the full CPPU conditions.

(b)(3) The one-sixth scale model was fabricated as near as practical to full scale. See the response for RAI 2(b)(2) above.

(c) There are no plans to reposition or install additional MSL strain gauges.

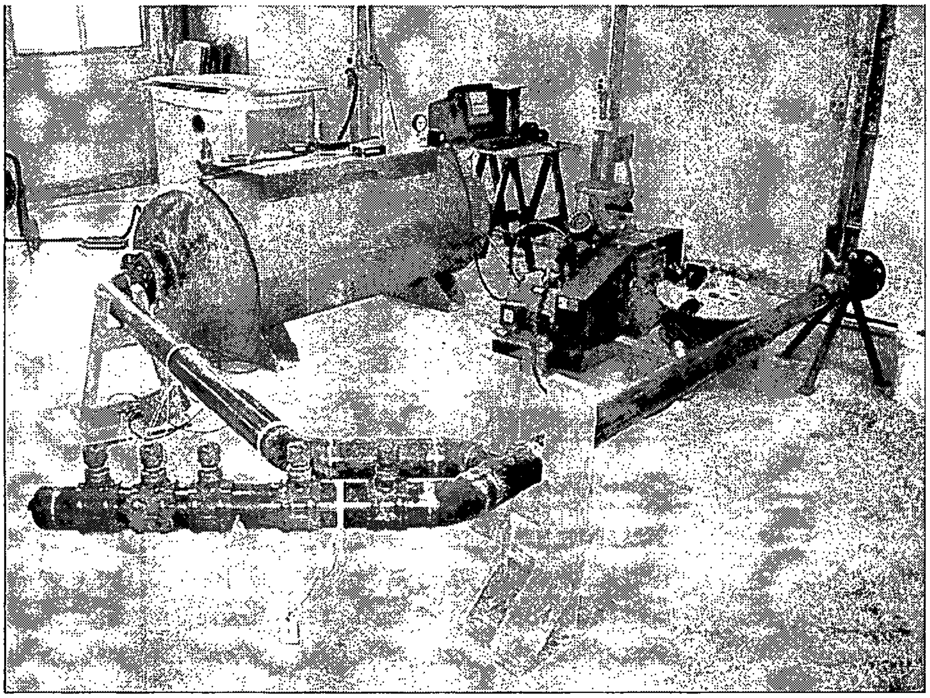
[[

]] In addition, when the strain gauges were installed, ultrasonic measurements were taken at their locations to determine the actual pipe thickness. These thickness measurements were used in the determination of the micro-strain to pressure conversion factors.

[[

]]

During the Unit 1 power ascension to 107% CLTP, data will be concurrently recorded from the dryer instrumentation, and main steam line strain gauges. This data will be used to assess the uncertainties associated with the entire suit of steam line strain gauge readings. If this review indicates that the relocation of the main steam line strain gauges is warranted, this action will be accomplished prior to increasing power above 107% CLTP.



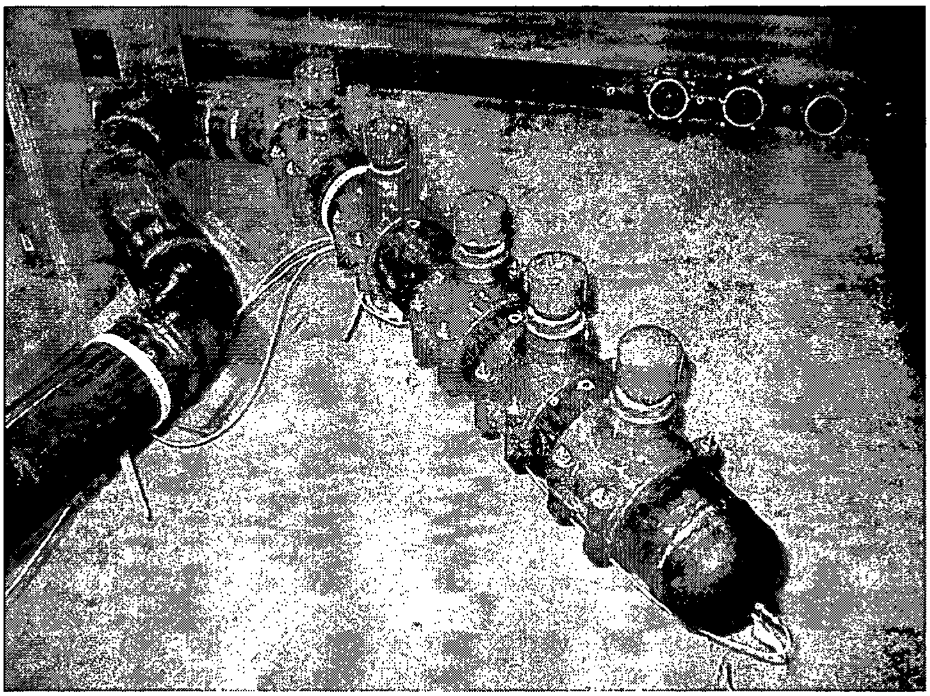
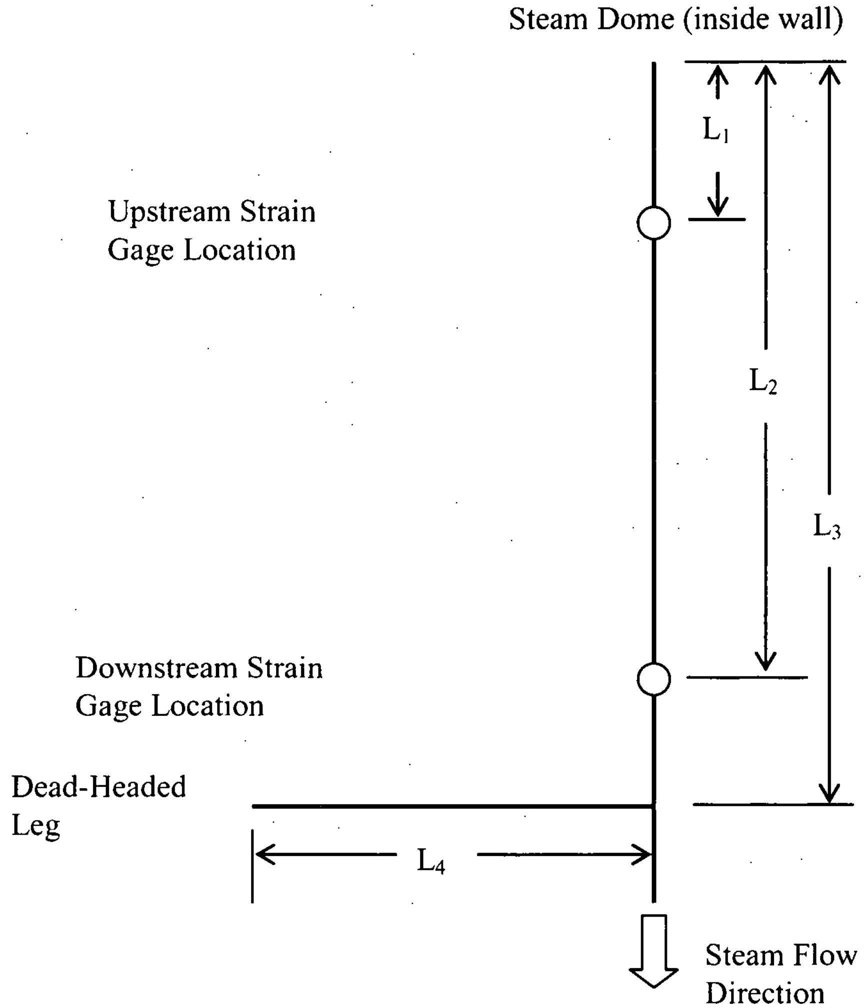


FIGURE 2-1 - Photographs Of Susquehanna Blowdown Facility: Entire Scaled Main Steam Lines A & D (Top); and Deadheaded Branch Line (Bottom)

[[

]]

FIGURE 2-2 - Fabrication Drawing Of Susquehanna A & D Main Steam Line Dead-Headed Branch



Length	MSL A (ft)	MSL B (ft)	MSL C (ft)	MSL D (ft)
Distance from steam dome (inside wall) to upstream SG location (L_1)	22.8	22.8	22.8	22.8
Distance from steam dome (inside wall) to downstream SG location (L_2)	52.7	49.6	48.3	52.6
Distance from steam dome (inside wall) to dead-headed leg location (L_3)	56.7	NA	NA	56.7
Length of dead-headed leg (L_4)	24.1	NA	NA	24.2

FIGURE 2-3 - Corrected Susquehanna Main Steam Line Schematic

[[

]]

FIGURE 2-4 - Mode Shape At 15 Hz In The Susquehanna Main Steam Line

NRC Question 3:

With regard to its response to NRC staff's RAI 9 in letter PLA-6167 dated April 27, 2007, PPL is requested to provide plots for each MSL at CLTP conditions which compare the PSDs of the unfiltered and filtered (where coherence between upper and lower MSL locations is used to compute coherent PSDs) conditions. The comparison should be on a common plot, with the two curves clearly distinguishable from each other or can be presented as 8 total plots – unfiltered data and filtered data at each strain gauge (8). The unfiltered data should be shown prior to the removal of any "exclusion" frequencies.

PPL Response:

These curves are shown in Figures 3-1 to 3-4. Coherence filtering has been applied to the filtered signals as requested.

[[

]]

FIGURE 3-1 - PSD Comparison Of Strain Gauge Data At CLTP Power, Converted To Pressure, For The Unfiltered (Black) And Filtered (Red) Signals For Main Steam Line "A"

[[

]]

FIGURE 3-2 - PSD Comparison Of Strain Gauge Data At CLTP Power, Converted To Pressure, For The Unfiltered (Black) And Filtered (Red) Signals For Main Steam Line "B"

[[

]]

FIGURE 3-3 - PSD Comparison Of Strain Gauge Data At CLTP Power, Converted To Pressure, For The Unfiltered (Black) And Filtered (Red) Signals For Main Steam Line "C"

[[

]]

FIGURE 3-4 - PSD Comparison Of Strain Gauge Data At CLTP Power, Converted To Pressure, For The Unfiltered (Black) And Filtered (Red) Signals For Main Steam Line "D"

NRC Question 4:

In the response to NRC staff's RAI 10 in letter PLA-6167 dated April 27, 2007, [[

]]

PPL addresses the [[

]]

PPL Response:

[[

]]

NRC Question 5:

(a) In its response to NRC staff's RAI 13 in letter PLA-6167 dated April 27, 2007, PPL states that "the ACM model used computes only the acoustic loads on the dryer. The loads acting on the Susquehanna dryer are primarily hydrodynamic in nature. In order to obtain a true representative load definition, the acoustic and hydrodynamic loads should be combined." This statement contradicts the foundation of CDI Report No. 06-22, Revision 0, September 2006. In this report, "Hydrodynamic loads at OLTP, CLTP,...," CDI uses ACM to predict the "hydrodynamic" loads on the dryer. The first item in the conclusion section of this report, Page 40, states that "the acoustic circuit analysis determines that steam dryer peak differential hydrodynamic loads at 113% OLTP power are less than 0.37 psid." PPL should explain this apparent contradiction and, if necessary, revise CDI Report No. 06-22 so that it reflects what is measured. In addition, if the ACM methodology will be used to monitor dryer loads during power ascension from 107% to 114% CLTP, PPL should explain how the hydrodynamic loads will be assessed.

(b) In response to RAI 13(b), PPL refers to Section 6.3 of General Electric (GE) report GENE-0057-4166-R1-P for incorporation of the stress under-prediction factor in the fatigue analysis of Susquehanna steam dryer. However, during the February 27, 2007, meeting, PPL informed the Nuclear Regulatory Commission (NRC) staff that it does not plan to use GENE-0057-4166-R1-P in the design development of the SSES replacement dryers. PPL is requested to clarify its use of the mentioned GE report in response to RAI 13(b).

PPL Response:

(a) [[

]]

PPL has acknowledged that the ACM does not reliably predict the magnitude of pressure loads caused by hydrodynamic sources. PPL has described how these uncertainties, which result from the ACM with respect to hydrodynamic sources, are addressed in the responses to RAIs 2 and 13 contained in PLA-6176. In addition to the analysis, which has been completed and presented to the NRC, the data resulting from the testing with the instrumented steam dryer will be used to further evaluate the capability of the ACM to predict hydrodynamic pressure loading. The results of this benchmarking effort could lead to adjustments or revisions to the ACM (see response to RAI 1(c) above).

(b) PPL is not using the structural analysis results documented in the GE report GENE-0057-4166-R1-P (submitted in Reference 1) to justify the structural adequacy of the original dryers for EPU operation or as a basis for designing modifications to the original dryers. The benchmarking of the analysis predictions against the 1985 test data and the resulting scaling factors in GENE-0057-4166-R1-P do remain applicable to the design development of the Susquehanna replacement dryers and are incorporated by reference in the replacement dryer stress analysis report GE-NE-0000-0061-0595-P-R1 (submitted in Reference 5). The applicability of the 1985 benchmarking, stress under-prediction factor and EPU scaling factor described in GENE-0057-4166-R1-P to the design development of the replacement dryers are further clarified in the responses to RAIs 7, 13(b), 20(a) and (c), and 24(b) in PLA-6176.

NRC Question 6:

(a) In its response to NRC staff's RAI 24(a) in letter PLA-6167 dated April 27, 2007, PPL is requested to provide a summary of the stress analysis report (bounding licensing case, for the replacement steam dryer. The summary should discuss the overall model, analysis assumptions, results, deviations from final geometry/as-designed finite element evaluation, and identification of relevant locations of high stress with respect to the allowable ASME code limit of 13,600 pounds per square-inch (psi). The summary should include specific discussion of the weld factors used in estimating the alternating stresses at the toes of the fillet welds when joining plates of equal and unequal thicknesses. The proposed bounding (or 'licensing') stress report should also identify as-built features which are not included in the interim finite element solution, and explain how those features are expected to decrease dryer stresses.

(b) In addition to toes of the fillet welds, the roots of the fillet welds are also susceptible to stress concentration and fatigue cracking. According to Hechmer and Kuhn, "Fatigue Strength Reduction Factors for Welds Based on Nondestructive Examination," Journal of Pressure Vessel Technology, 1999, Vol. 121, pages 6-10, the fatigue strength reduction factor (FSRF) for the root of a fillet weld varies between 3 and 4. PPL is requested to explain how it accounts for the FSRF for the roots of the fillet welds in the fatigue analysis of the replacement steam dryer for Susquehanna Units 1 and 2.

(c) In its response to RAI 24(b) regarding stress under-prediction factor, PPL refers to scale model testing. However, during the February 27, 2007, meeting PPL informed the staff that it does not plan to use the GE report [GENE-0000-0054-2552-01-P ((1/17th SMT)] or CDI report [05-32, Rev. 0 9 (1/6th SMT)] in the design development of the SSES 1 and 2 replacement dryers. PPL is requested to clarify its use of the mentioned GE and CDI report in response to RAI 24(b).

PPL Response:

(a) GE report GE-NE-0000-0061-0595-P-R1, June 2007, Susquehanna Replacement Steam Dryer Fatigue Analysis, (submitted in Reference 5) provides the results of the bounding licensing evaluation for the replacement steam dryer. Section 5.1 of GE-NE-0000-0061-0595-P-R1 provides a description of the finite element model used in the analysis. As stated in section 5.1 of GE-NE-0000-0061-0595-P-R1, the finite element model included increased plate thickness [[

]] All other dryer components in the FEA model presented in GE-NE-0000-0061-0595-P-R1 had continued to use the plate thickness of the current Susquehanna steam dryer and the FEA analysis continued to use weld fatigue factors of the current Susquehanna steam dryer geometry. Section 6.1 of GE-NE-0000-0061-0595-P-R1 provides a summary of the analysis approach for the evaluation of the Susquehanna replacement steam dryer. Section 6.3 of GE-NE-0000-0061-0595-P-R1 describes the application of weld fatigue factors to the component stress intensities determined by the FEA model. The justification for the application of weld fatigue factors in the dryer structural evaluation is described in part (b) to this RAI response. The results of the Susquehanna steam dryer fatigue evaluation are contained in Table 6-1 and Table 7-1 of GE-NE-0000-0061-0595-P-R1.

The key assumptions in GE-NE-0000-0061-0595-P-R1 with respect to the structural analysis results of the steam dryer components is that the replacement steam dryer for Susquehanna will include fabrication improvements beyond those assumed in the analysis that will either eliminate or reduce plate thickness mismatches that would require the application of additional factors for determining the weld stresses at these junctions.

Appendix 3 of this letter provides a comprehensive listing of all fabrication improvements pertaining to the new Susquehanna replacement dryers. Table 1 of Appendix 3 shows the component thickness and weld fatigue factors used in the FEA analysis presented in GE-NE-0000-0061-0595-P-R1 and the corresponding component thickness and weld fatigue factors in the Susquehanna replacement steam dryer design.

In summary, the analysis documented in GE-NE-0000-0061-0595-P-R1 provides a conservative assessment of the Susquehanna replacement steam dryers for operation at EPU conditions. Additional design improvements are being incorporated into the replacement dryer that increase the margin to structural limits and reduce the susceptibility to stress corrosion cracking. All fabrication improvement have been and will continue to be evaluated with detailed finite element modeling and full dryer analysis to ensure they increase the fatigue design margin. The dryer will be dynamically tested prior to installation (hammer tested) and the finite element model and associated modeling assumptions benchmarked against the measured response. Finally, the replacement dryer will be instrumented with pressure transmitters, accelerometers and strain gages to allow benchmarking of dynamic loads and the structural analysis.

Note that Items 8, 10, 11 and 12 of Table 1 of Appendix 3 are the components where the increased plate thickness of the replacement dryer design was implemented in the finite element model used in the analysis presented in GE-NE-0000-0061-0595-P-R1. [[

]] Some examples are provided below as already discussed at the PPL meeting with the NRC on June 29, 2007.

[[

]]

(b) The justification for the use of the weld fatigue factors applied to the finite element model stress results is contained in the document GENE Report, DRF GE-NE 0000-0039-4817-1, Class II, April 2005, "Recommended Weld Quality and Stress Concentration Factors for use in the Structural Analysis of Exelon Replacement Steam Dryer", which is provided as Appendix 4 of this letter. Revision 0 of GE-NE 0000-0039-4817 was previously referenced in docketed GE-Hitachi Nuclear Energy (GEH) stress report submittals to the USNRC for the GEH dryer evaluations for Quad Cities and Vermont Yankee. Revision 1 of GE-NE 0000-0039-4817 only contains editorial corrections from Revision 0. Although GE-NE 0000-0039-4817 was originally produced to support the design of the Quad Cities replacement dryers, it is also applicable to the GEH method of evaluation of all steam dryers. Section 2.3 of GE-NE 0000-0039-4817-1 justifies the GEH use of a 1.8 weld fatigue factor for fillet welds and a 1.4 factor for full penetration welds when these concentration factors are applied to the [[ ]] as the alternating stress intensity. As stated in Section 2.3 of GE-NE 0000-0039-4817-1 a weld fatigue factor of 4.0 must be applied if a nominal plate stress is extracted from the finite element analysis for determining the stress intensity at the weld. For the Susquehanna steam dryer structural analysis performed by GEH, no nominal plate stress intensities were used in the determination of the fatigue stress intensity at welded connections.

The construction of Susquehanna replacement dryer requires that the first pass of any multiple pass weld be examined for weld quality using liquid penetrant testing (PT). This requirement is in addition to the requirement that the final welds are also examined using PT. This testing requirement provides additional confidence in the weld quality for the Susquehanna replacement steam dryer. Therefore, GEH considers that the GEH method, as documented in GE-NE 0000-0039-4817-1, for applying weld fatigue factors and weld quality factors is completely consistent with Subsection NG of the ASME Boiler and Pressure Code.

(c) The response to RAI 24(b) of PLA-6176 does not refer to scale model testing with respect to the stress under-prediction factor. The second part of the response to RAI 24(b) referred to the response to RAI 7 for supporting evidence, including scale model testing, that justified the basis for the [[ ]] EPU load scaling factor. As described in the response to RAI 6, the scale model test results documented in GENE-0000-0054-2552-01-P are being used to: 1) provide supporting evidence that SRV acoustic resonances are not expected in the EPU operating range for SUSQUEHANNA and 2) provide supporting evidence that the low frequency pressure loads are expected to increase proportionally to the square of the steam flow velocity at power levels above CLTP.

NRC Question 7:

With regard to the response to NRC staff's RAI 26 in letter PLA-6167 dated April 27, 2007, confirm whether the visual dryer inspections at refueling outages will be performed following EPU approval to ensure pump vane passing frequency tones do not cause fatigue damage to the dryer.

PPL Response:

Proposed license conditions/regulatory commitments with respect to inspection plans for the replacement dryers are provided in the response to RAI 11. An inspection plan specific to the replacement dryer design will be developed. Because there is no previous operating experience with the specific design used in the replacement dryers, the inspection plan is more extensive than the operating dryer inspection recommendations provided in GE SIL 644 Rev. 2 and BWRVIP 139. As recommended in SIL 644 Rev. 2, a thorough visual inspection of each replacement dryer will be performed during each refueling outage during EPU implementation until at least two full operating cycles at the final uprated power level have been achieved.

The scope of the inspection includes a general examination of the dryer over the areas that are accessible from the exterior of the steam dryer to confirm that the replacement steam dryer has no obvious cracking, significant deformation or missing parts. Detailed inspections will be made of exterior weld and base metal locations that may be susceptible to high stresses and fatigue, regardless of the source of the loading (including vibrations induced by the recirculation pump vane passing frequency). These locations will be determined based on the structural analysis results for the replacement dryer, any potential fabrication issues, and on the accumulated inspection experience for BWR dryers.

The inspections will also include the design and fabrication improvements implemented for the replacement dryer in order to confirm that these improvements are performing as expected. The scope and frequency of subsequent inspections will be determined based on the successful results of the initial inspection program.

NRC Question 8:

From the review of PPL's responses presented in PLA-6176, it is not clear which dryer stress analysis will be used to define limit curves during power ascension: (1) analysis based on CLTP conditions, or (2) analysis based on slow closure of a single MSL. Please clarify.

PPL Response:

The interim main steam line limit curves are provided in Appendix 1 of this letter, and the dryer instrumentation acceptance limits are provided in Appendix 5. These criteria are based on [[

]]

NRC Question 9:

PPL is requested to submit limit curves for the replacement dryer and/or MSL instrumentation that will be monitored during power ascension for NRC review prior to constant pressure power uprate (CPPU) approval. The limit curves need to be substantiated by an updated dryer stress analysis report.

PPL Response:

The interim main steam line limit curves and the dryer instrumentation acceptance limits are provided as Appendices 1 and 5, respectively, of this letter. The main steam line limit curves and dryer acceptance limits are based on [[

]] See response to RAIs 1(a) and 8 above.

NRC Question 10:

In the response to NRC staff's RAI 18 in Attachment 1 to PLA-6200, PPL notes that: "The interaction formula is a commonly used relationship of forces and moments that are applied to rotating equipment." Please specify the standard.

PPL Response:

The source of the interaction formula that is a commonly used relationship of forces and moments applied to rotating equipment is section 2.4 and Appendix F of ANSI/API 610-1989, "Centrifugal Pumps for General Refinery Service" American Petroleum Institute, 7th Edition, February 1989.

NRC Question 11:

The NRC staff is considering license conditions and regulatory commitments for monitoring, evaluating, and taking prompt action in response to potential adverse flow effects as a result of EPU operation on plant structures, systems, and components (including verifying continued structural integrity of the steam dryer), and interacting with the NRC staff during power ascension, for SSES 1 and 2 if an EPU license amendment is approved. The staff considers license conditions and regulatory commitments similar to those placed on the Vermont Yankee nuclear power plant in the EPU license amendment issued on March 2, 2006, to also be appropriate for a Susquehanna EPU license amendment. PPL is requested to propose license conditions and/or regulatory commitments and indicate where those license conditions and regulatory commitments should be modified to reflect power ascension plans for SSES 1 and 2.

PPL Response:

Proposed Unit 1 License Conditions and separate proposed Unit 2 License Conditions are provided below. These have been modeled after those placed on the Vermont Yankee nuclear plant EPU license amendment issued March 2, 2006. Due to the power ascension plan to instrument the dryer up to 107 % of 3489 MWt on Unit 1 and not on Unit 2, unit specific License Conditions are appropriate.

PPL Susquehanna Unit 1 Proposed License Conditions

These license conditions provide for monitoring, evaluating, and taking prompt action in response to potential adverse flow effects as a result of power uprate operation on plant structures, systems, and components (including verifying the continued structural integrity of the steam dryer).

1. The following requirements are placed on operation of the PPL Susquehanna, LLC (PPL) facility above the licensed thermal power (CLTP) level of 3489 megawatts thermal (MWt):

   (a) PPL shall obtain at each 3.5% power ascension step up to 107% of 3489 MWt, dryer strain gauge data and compare it to the acceptance criteria during power ascension above 3489 MWt. PPL shall obtain at each 3.5% power ascension step above 107% of 3489 MWt, main steam line strain gauge data and compare it to the limit curve for the dryer strains during power ascension.

   (b) PPL shall monitor the main steam line (MSL) strain gauges during power ascension testing above 3489 MWt for increasing pressure fluctuations in the steam lines.

   (c) PPL shall hold the facility at each 3.5% ascension step to collect data from Condition 1.a and conduct plant inspections and walk-downs, and evaluate steam dryer performance based on the data; shall provide the evaluation to the NRC staff by facsimile or electronic transmission to the NRC project manager upon completion of the evaluation; and shall not increase power above each hold point until 96 hours after the NRC project manager confirms receipt of the transmission.

   (d) If any acceptance criteria for steam dryer strains at each 3.5% power ascension step up to 107% of 3489 MWt or frequency peak from the MSL strain gauge data exceeds the limit curve for the dryer strains above 107% of 3489 MWt, PPL shall return the facility to a power level at which the acceptance criteria is not exceeded. PPL shall resolve the discrepancy, document the continued structural integrity of the steam dryer, and provide that documentation to the NRC staff by facsimile or electronic transmission to the NRC project manager prior to further increases in reactor power.

   (e) In addition to evaluating the dryer instrumentation data and MSL strain gauge data, PPL shall monitor reactor pressure vessel water level instrumentation and MSL piping accelerometers during power ascension above 3489 MWt . If resonance frequencies are identified as increasing above nominal levels in proportion to instrumentation data, PPL shall stop power ascension, document the continued structural integrity of the steam dryer, and provide that documentation to the NRC staff by facsimile or electronic transmission to the NRC project manager prior to further increases in reactor power.

   (f) Following CPPU start-up testing, PPL shall resolve any discrepancies in the steam dryer analysis and provide that resolution to the NRC staff by facsimile or electronic transmission to the NRC project manager. If the discrepancies are not resolved within 90 days of identification, PPL shall return the facility to a power level at which the discrepancy does not exist.

2. PPL shall implement the following actions:

(a) PPL shall provide to NRC the as-built dryer stress reconciliation and load limit curves 45 days prior to operation above 3489 MWt.

(b) After the dryer stress analysis is benchmarked to the Unit 1 startup test data (Unit 1 data taken up to 107% of 3489 MWt), the benchmark results and updated MSL limit curves shall be provided to the NRC 90 days prior to operation above 107% of 3489 MWt.

(c) In the event that acoustic signals are identified that challenge the limit curve during power ascension above 107% of CLTP, PPL shall evaluate dryer loads and re-establish the acceptance criteria based on the new data, and shall perform an assessment of ACM uncertainty at the acoustic signal frequency.

(d) After reaching 107 % of CLTP , PPL shall obtain measurements from the steam dryer instrumentation and establish the steam dryer flow-induced vibration load fatigue margin for the facility, update the dryer stress report, and re-establish the limit curve with the updated ACM load definition and revised instrument uncertainty, which will be provided to the NRC staff.

(e) During power ascension above 107 % CLTP , if an engineering evaluation is required because a level 1 acceptance criteria is exceeded, PPL shall perform the structural analysis to address frequency uncertainties up to ±10% and assure that peak responses that fall within this uncertainty band are addressed.

(f) PPL shall revise the Post Constant Pressure Power Uprate (CPPU) Monitoring & Inspection Program to reflect long-term monitoring of plant parameters potentially indicative of steam dryer failure; to reflect consistency of the facility's steam dryer inspection program with General Electric Services Information Letter 644, Revision 2 and to identify the NRC Project Manager for the facility as the point of contact for providing PATP information during power ascension.

(g) PPL shall submit CPPU steam dryer reports to the NRC. Two written reports will be provided to the NRC. These reports will be issued following completion of testing of Unit 1 power ascension to 107% CLTP and 114% CLTP. Each report will include evaluations or corrective actions that were required to assure steam dryer structural integrity. Additionally, they will include relevant data collected at each power step, comparisons to performance criteria (design predictions), and evaluations performed in conjunction with steam dryer structural integrity monitoring.

(h) PPL shall submit the flow-induced vibration related portions of the CPPU startup test procedure to the NRC, including methodology for updating the limit curve, prior to initial power ascension above 3489 MWt. .

3. PPL shall prepare the CPPU startup test procedure to include the:

(a) steam dryer strain gauge acceptance criteria to be used up to 107 % of CLTP and the main steam line stain gauge limit curves to be applied for evaluating steam dryer performance above 107% CLTP;

(b) specific hold points and their duration during CPPU power ascension;

(c) activities to be accomplished during hold points;

(d) plant parameters to be monitored;

(e) inspections and walk-downs to be conducted for steam, feedwater, and condensate systems and components during the hold points;

(f) methods to be used to trend plant parameters;

(g) acceptance criteria for monitoring and trending plant parameters, and conducting the walk-downs and inspections;

(h) actions to be taken if acceptance criteria are not satisfied; and

(i) verification of the completion of commitments and planned actions specified in its application and all supplements to the application in support of the CPPU license amendment request pertaining to the steam dryer prior to power increase above 3489 MWt . PPL shall provide the related CPPU startup test procedure sections to the NRC by facsimile or electronic transmission to the NRC project manager prior to increasing power above 3489 MWt.

4. The following key attributes of the PATP shall not be made less restrictive without prior NRC approval:

(a) During initial power ascension testing above 3489 MWt, each test plateau increment shall be approximately 3.5% of 3489 MWt;

(b) Level 1 performance criteria; and

(c) The methodology for establishing the stress criteria used for the Level 1 and Level 2 performance criteria.

Changes to other aspects of the PATP may be made in accordance with the guidance of NEI 99-04.

5. During each scheduled refueling outage until at least two full operating cycles at full CPPU conditions have been achieved, a visual inspection shall be conducted of all accessible, susceptible locations of the steam dryer in accordance with BWRVIP-139 and General Electric inspection guidelines.

6. The results of the visual inspections of the steam dryer shall be reported to the NRC staff within 60 days following startup. The results of the PATP shall be submitted to the NRC staff in a report within 60 days following the completion of all CPPU power ascension testing.

7. This license condition shall expire upon satisfaction of the requirements in paragraphs 5 and 6 provided that a visual inspection of the steam dryer does not reveal any new unacceptable flaw or unacceptable flaw growth that is due to fatigue.

PPL Susquehanna Unit 2 Proposed License Conditions

These license conditions provide for monitoring, evaluating, and taking prompt action in response to potential adverse flow effects as a result of power uprate operation on plant structures, systems, and components (including verifying the continued structural integrity of the steam dryer).

1. The following requirements are placed on operation of the PPL Susquehanna, LLC (PPL) facility above the licensed thermal power (CLTP) level of 3489 megawatts thermal (MWt):

    (a) PPL shall obtain at each 3.5% power ascension step main steam line strain gauge data and compare it to the limit curve for the dryer strains during power ascension.

    (b) PPL shall monitor the main steam line (MSL) strain gauges during power ascension above 3489 MWt for increasing pressure fluctuations in the steam lines.

    (c) PPL shall hold the facility at each 3.5% ascension step to collect data from Condition 1.a and conduct plant inspections and walk-downs, and evaluate steam dryer performance based on the data; shall provide the evaluation to the NRC staff by facsimile or electronic transmission to the NRC project manager upon completion of the evaluation; and shall not increase power above each hold point until 96 hours after the NRC project manager confirms receipt of the transmission.

    (d) If any frequency peak from the MSL strain gauge data exceeds the limit curve for dryer strains above 3489 MWt, PPL shall return the facility to a power level at which the acceptance criteria is not exceeded. PPL shall resolve the discrepancy, document the continued structural integrity of the steam dryer, and provide that documentation to the NRC staff by facsimile or electronic transmission to the NRC project manager prior to further increases in reactor power.

    (e) In addition to evaluating the dryer strain and MSL strain gauge data, PPL shall monitor reactor pressure vessel water level instrumentation or MSL piping accelerometers during power ascension above 3489 MWt . If resonance frequencies are identified as increasing above nominal levels in proportion to instrumentation data, PPL shall stop power ascension, document the continued structural integrity of the steam dryer, and provide that documentation to the NRC staff by facsimile or electronic transmission to the NRC project manager prior to further increases in reactor power.

(f) Following CPPU start-up testing, PPL shall resolve the discrepancies in the steam dryer analysis and provide that resolution to the NRC staff by facsimile or electronic transmission to the NRC project manager. If the discrepancies are not resolved within 90 days of identification, PPL shall return the facility to a power level at which the discrepancy does not exist.

2. PPL shall implement the following actions:

(a) Prior to operation above 3489 MWt., PPL shall provide to NRC the as-built dryer stress analysis and load limit curves 45 days prior to operation above 3489 MWt.

(b) After the dryer stress analysis is benchmarked to the Unit 1 startup test data (Unit 1 data taken up to 107% of 3489 MWt), the benchmarked PATP and MSL limit curves shall be provided to the NRC 90 days prior to operation above 107% of 3489 MWt.

(c) In the event that acoustic signals are identified that challenge the limit curves during power ascension above 3489 MWt, PPL shall evaluate dryer loads and re-establish the acceptance criteria based on the new data, and shall perform an assessment of ACM uncertainty at the acoustic signal frequency.

(d) After reaching full CPPU, PPL shall obtain measurements from the MSL strain gauges and establish the steam dryer flow-induced vibration load fatigue margin for the facility, update the dryer stress report, if required, and re-establish the limit curve with the updated ACM load definition and revised instrument uncertainty, which will be provided to the NRC staff.

(e) During power ascension above 3489 MWt, if an engineering evaluation is required because a Level 1 acceptance criteria is exceeded, PPL shall perform the structural analysis to address frequency uncertainties up to ±10% and assure that peak responses that fall within this uncertainty band are addressed.

(f) PPL shall revise the Post Constant Pressure Power Uprate (CPPU) Monitoring & Inspection Program to reflect long-term monitoring of plant parameters potentially indicative of steam dryer failure; to reflect consistency of the facility's steam dryer inspection program with General Electric Services Information Letter 644, Revision 2; and to identify the NRC Project Manager for the facility as the point of contact for providing PATP information during power ascension.

(g) PPL shall submit a CPPU steam dryer report to the NRC. The report will be issued following completion of Unit 2 ascension to 114% CLTP. The report will include evaluations or corrective actions that were required to assure steam dryer structural integrity. Additionally, it will include relevant data collected at each power step, comparisons to performance criteria (design predictions), and evaluations performed in conjunction with steam dryer structural integrity monitoring.

(h) PPL shall submit the flow-induced vibration related portions of the CPPU startup test procedure to the NRC, including methodology for updating the limit curve, prior to initial power ascension above 3489 MWt. .

3. PPL shall prepare the CPPU startup test procedure to include the:

(a) main steam line strain gauge limit curves to be used up to 114 % of CLTP;

(b) specific hold points and their duration during CPPU power ascension;

(c) activities to be accomplished during hold points;

(d) plant parameters to be monitored;

(e) inspections and walk-downs to be conducted for steam, feedwater, and condensate systems and components during the hold points;

(f) methods to be used to trend plant parameters;

(g) acceptance criteria for monitoring and trending plant parameters, and conducting the walk-downs and inspections;

(h) actions to be taken if acceptance criteria are not satisfied; and

(i) verification of the completion of commitments and planned actions specified in its application and all supplements to the application in support of the CPPU license amendment request pertaining to the steam dryer prior to power increase above 3489 MWt . PPL shall provide the related CPPU startup test procedure sections to the NRC by facsimile or electronic transmission to the NRC project manager prior to increasing power above 3489 MWt.

4. The following key attributes of the PATP shall not be made less restrictive without prior NRC approval:

(a) During initial power ascension testing above 3489 MWt, each test plateau increment shall be approximately 3.5% of 3489 MWt;

(b) Level 1 performance criteria; and

(c) The methodology for establishing the stress criteria used for the Level 1 and Level 2 performance criteria.

Changes to other aspects of the PATP may be made in accordance with the guidance of NEI 99-04.

5. During the first two scheduled refueling outages after reaching full CPPU conditions, a visual inspection shall be conducted of all accessible, susceptible locations of the steam dryer in accordance with BWRVIP-139 and General Electric inspection guidelines.

6. The results of the visual inspections of the steam dryer shall be reported to the NRC staff within 60 days following startup. The results of the PATP shall be submitted to the NRC staff in a report within 60 days following the completion of all CPPU power ascension testing.

7. This license condition shall expire upon satisfaction of the requirements in paragraphs 5 and 6 provided that a visual inspection of the steam dryer does not reveal any new unacceptable flaw or unacceptable flaw growth that is due to fatigue.

Attachment 2 to PLA-6242
Appendix 1

Susquehanna MSL Limit Curves for Dryer Acoustic Monitoring

July 2007

Summary of Limit Figures Provided:

Figures 4a through 4h provide main steam line limit curves that are to be used for monitoring steam line strain signals during EPU power ascension testing. PPL will monitor steam line strain signals and compare the power spectral density spectra from the steam lines with these limit curves to assure that acoustic signals in the steam lines do not exceed the Level 1 limit curve on each of the 8 monitoring locations.

Figures 4a through 4h also include strain gauge data collected at OLTP and the baseline curves developed from 113% OLTP data. This additional data allows review of the proposed increase in loading levels between OLTP and EPU.

Figure 5 provides a [[

]]

Basis for Developing the Susquehanna MSL limit Curves:

[[

]] During EPU power ascension, monitoring and maintaining the measured strain gauge spectra below the limit curve spectra will help assure that that peak stress anywhere in the dryer is maintained below 13,600 psi.

This assessment considered bias and uncertainty contributions based on

[[

]]

The Susquehanna Unit 1 dryer will also be instrumented and monitored from 80% CLTP to 107% CLTP. MSIV slow closure testing will be performed at approximately 80% and 85% CLTP to simulate the steam flow velocities, pressure loading, and dryer structural response at 114% CLTP. This will allow evaluation of the dryer pressure data and dryer strain data to allow reassessment of the load definition and structural model prior to relying on these curves alone for acoustic monitoring. The rationale for the power ascension test plan using the Unit 1 instrumented dryer is discussed further in the response to RAIs 1(d) and 1(e) of this letter.

Figure 1 provides [[

]]

Table 1 summarizes the results from the load definition bias assessment [[

]]

Figures 4a through 4h included the limit curves for Susquehanna power ascension monitoring.

References

1. GE-NE-0000-0061-0595-R1, "Susquehanna Replacement Steam Dryer Fatigue Analysis," June 2007.
2. C.D.I. Report No. 06-22 Rev. 0, "Hydrodynamic Loads at OLTP, CLTP, and 113% OLTP on Susquehanna Unit 1 Steam Dryer to 250 Hz," September 2006.
3. Hirschberg, P, SIA Calculation Package: Susquehanna Unit 1 Main Steam Line Strain Gauge Data Reduction; File No. SSES-23Q-302, Project No. SSES-23Q. Revision 3, 7/10/07.
4. Structural Integrity Associates, Inc. File No.: SSES-23Q-301, "Susquehanna Unit 1 Strain Gauge Uncertainty Evaluation and Pressure Conversion Factors", April 29, 2006, Rev 0.
5. GE-NE-0000-0057-4166-R1-P. "Susquehanna Steam Dryer Fatigue Analysis," September 2006.
6. MDE #199-0985, "Susquehanna – 1 Steam Dryer Vibration Steady State and Transient Response," October 1985.

Table 1

[[

]]

Table 2: Summary of Bias, Uncertainty and [[ ]]

[[

]]

Table 3: [[ ]]

[[

]]

[[

]]

Figure 1

[[

]]

Figure 2

[[

]]

Figure 3

[[

]]

Figure 4a: OLTP Data, Baseline Curve, and Limit Curves, MSL-A-Upper

[[

]]

Figure 4b: OLTP Data, Baseline Curve, and Limit Curves, MSL-A-Lower

[[

]]

Figure 4c: OLTP Data, Baseline Curve, and Limit Curves, MSL-B-Upper

[[

]]

Figure 4d: OLTP Data, Baseline Curve, and Limit Curves, MSL-B-Lower

[[

]]

Figure 4e: OLTP Data, Baseline Curve, and Limit Curves, MSL-C-Upper

[[

]]

Figure 4f: OLTP Data, Baseline Curve, and Limit Curves, MSL-C-Lower

[[

]]

Figure 4g: OLTP Data, Baseline Curve, and Limit Curves, MSL-D-Upper

[[

]]

Figure 4h: OLTP Data, Baseline Curve, and Limit Curves, MSL-D-Lower

[[

]]

Figure 5 [[ ]]