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U. S. Nuclear Regulatory Commission
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Quad Cities Nuclear Power Station, Units 1 and 2
Renewed Facility Operating License Nos. DPR-29 and DPR-30
NRC Docket Nos. 50-254 and 50-265

Subject: Response to Request for Additional Information Related to Extended Power Uprate Operation Commitments

Reference:

1. Letter from M. Banerjee (U. S. NRC) to C. M. Crane (Exelon Generation Company, LLC), "Dresden Nuclear Power Station, Units 2 and 3, and Quad Cities Nuclear Power Station, Units 1 and 2 – Request For Additional Information Related to Exelon Generation Company, LLC's Extended Power Uprate Operation Commitments (TAC Nos. MD2932 and MD2933)," dated September 21, 2006

2. Letter from K. R. Jury (Exelon Generation Company, LLC) to U. S. NRC, "Commitments and Plans Related to Extended Power Uprate Operation," dated January 26, 2006

In Reference 1, the NRC requested additional information related to Acoustic Side Branch modification installations and subsequent startup tests performed at Quad Cities Nuclear Power Station (QCNPS), Units 1 and 2. Attachments 1 and 2 of this letter provide the additional information requested in Reference 1. Attachment 3 provides a summary of data collected subsequent to the initial startup tests on each QCNPS unit. This subsequent data was collected during periodic monitoring described in Attachment 1.

As discussed in Reference 1, upon NRC review of this additional information, the final technical conference call will be scheduled to discuss this response. Following resolution of these technical issues, Exelon Generation Company, LLC (EGC) will meet with NRC management to discuss the results of evaluations performed to support long-term operation of QCNPS, Units 1 and 2, at the extended power uprate power level. These actions are consistent with the EGC commitments made in Reference 2.

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There are no regulatory commitments contained in this letter. If you have any questions concerning this letter, please contact Mr. David Gullott at (630) 657-2819.

Respectfully,

Kenneth M. Nicely

Kenneth M. Nicely
Manager – Licensing

Attachments:

1. Additional Information Related to Extended Power Uprate Operation
2. High Frequency Plots for QCNPS Unit 2 MSL Strain Gage Measurements
3. Quad Cities Steam Line Routine Monitoring Data Summary

ATTACHMENT 1

Additional Information Related to Extended Power Uprate Operation

Request 1

How will Exelon monitor the performance of the acoustic side branches (ASBs) installed at QC1 and QC2 in maintaining acceptable main steam line (MSL) pressure fluctuations and vibrations during long-term operation up to extended power uprate (EPU) conditions? For example, what are the plans for monitoring MSL strain gage and accelerometer data; performing plant walkdowns of the ASBs and MSL piping and components; inspecting and testing of MSL components (such as ASBs and electromatic relief valves); and conducting steam dryer inspections? What are the consequences associated with the loss of ASB performance (such as clogging by debris or wear of the wire mesh)? How will ASB performance degradation be addressed?

Response 1

ASB/Electromatic Relief Valve (ERV) Testing Prior to Installation

Prior to installation at Quad Cities Nuclear Power Station (QCNPS), both the ASB and ERV actuator modification designs were subject to significant laboratory testing. The ERV actuator test plans, acceptance criteria reports, test reports, and design considerations were previously provided to the NRC in Reference 1. The pre-installation ASB scale model testing and results were discussed with the NRC during a March 16, 2006 meeting (Reference 2).

ASB Effectiveness Monitoring

Periodic Vibration/Strain Gage/Pressure Monitoring

Following initial installation of the ASB modifications, vibration/strain/pressure measurements were taken to establish the new baseline performance of the Main Steam (MS) system piping. These parameters were monitored on a bi-weekly frequency for the first two months. Since no significant variations occurred during these first two months, the monitoring frequency was reduced to monthly. The monthly frequency will continue until the next refueling outage on each unit. Additional monitoring will be performed for the affected valve, following ERV / Safety Relief Valve (SRV) actuations, or MS system transients (e.g., Turbine stop valve closure).

Outage Examinations

At the first scheduled refueling outage following initial ASB installation, a visual examination of the ASB Foreign Material Exclusion (FME) barrier will be performed. The first set of examinations for each unit will be performed on six (i.e., 50%) of the installed population of ASBs. The objectives of these ASB examinations are:

1. Identify fatigue cracking, degradation (e.g., erosion, wash-out), wear, or distortion of the components associated with the FME barrier noted below.

   - Canister Retaining Ring
   - FME Barrier Retainer Ring
   - FME Barrier
   - Outer Coarse Sintered Stainless Steel Mesh

2. Identify signs of blockage of the FME barrier or stainless steel mesh with foreign material or debris.

3. Verify alignment of the drainage channel.

These examinations can be performed in place or following removal of the cylinder using remote or direct visual examination techniques with resolution consistent with Visual Test (VT) VT-1 and VT-3 methods. These visual examinations are not required by the American Society of Mechanical Engineers Section XI Code and do not require VT certified examiners. The results of these examinations will be evaluated by Engineering. Expansion of the examination population from six to the entire population will occur if the visual examinations indicate signs of cracking or loss of cylinder functional integrity. In the event of an ERV/SRV actuation, or MS system transient, a visual examination will be performed within the defined cycle (i.e., at the next refueling outage), and included as part of the sample population.

ASB Long-Term Examination Description

QCNPS will continue with a minimum sample of six ASB visual examination per refuel outage until all ASBs have been inspected once. Based on the examination results after these fuel cycles, changes to the examination frequency and sample size will be evaluated. Provided examination results are satisfactory, QCNPS expects to reduce the visual examination sample size to one ASB per refuel outage.

After the first refuel outage on each unit, the frequency of reactor pressure vessel (RPV) level instrumentation pressure oscillation monitoring and comparison to the baseline data will be reduced from monthly to quarterly. Based upon the results of this monitoring and the long-term examination results, the monitoring frequency of RPV level instrumentation may be adjusted as required.

ERV Inspections/Preventive Maintenance (PM)

The following ERV inspections and PMs will be performed:

- A new PM has been implemented to stroke each ERV three times at beginning of each refuel outage to demonstrate operation of actuator solenoids.
- The following existing PMs will continue to be performed in conjunction with ERV maintenance actions:
  - Actuator replacement each outage with new or refurbished actuators
  - Replacement of pilot valve internals on two ERVs each outage (valves opposite of those being fully replaced) – coupled with the action below ensures every valve has new pilot valve each outage
  - Replacement of two entire ERVs each outage (including new pilot) with new or refurbished valves – this frequency ensures all main valves are replaced every two cycles
  - General area walkdowns of the steam affected zones by operations and engineering, with the system manager observing the conditions of the ERVs

The frequency and sample size of existing PMs may be adjusted in the future depending on the results of the inspection activities.

Steam Dryer Inspections

Baseline inspections of the new steam dryers required by BWRVIP-139, "BWR Vessel and Internals Project Steam Dryer Inspection and Flaw Evaluation Guidelines," are complete. For the interim, General Electric (GE) re-inspection recommendations will be followed for subsequent steam dryer inspections with specific locations identified by GE. The examination techniques used will be in accordance with the requirements of BWRVIP-139. Future steam dryer inspections will be performed in accordance with the guidance of BWRVIP-139, following the addition of re-inspection requirements to a planned revision of BWRVIP-139.

Consequences of the Loss of ASB Performance

The loss of ASB performance due to mechanisms such as clogging by debris or wear of the wire mesh would be detected by the monitoring methods described above. A change in ASB effectiveness would be detected by a change in the instrumentation pressure monitoring root mean square (rms) values and/or a change in the frequency spectra of these readings. It should be noted, that MS system components that were impacted by pressure fluctuation and vibrations from EPU (i.e., the steam dryer and ERVs), have been hardened to be able to withstand the forces and vibration levels from pre-ASB EPU operation. However, a change in ASB performance would be documented and evaluated through the corrective action process. The evaluation would include addressing the necessary actions both short-term and long-term.

Request 2

What are the sources of new acoustic resonance peaks that appear in the MSL strain gage data discussed in Exelon Report AM-2006-002 (Revision 0), "Quad Cities Unit 2 Main Steam Line Acoustic Source Identification and Recommendations for Load Reduction," and Exelon Report AM-2006-003 (Revision 0), "Quad Cities Unit 1 Main Steam Line Acoustic Source Identification and Load Reduction," submitted in Exelon letters dated May 3 and August 2, 2006, respectively, following return of the QC units to EPU operation with the ASB modifications? For example, see the resonance peak at 36 Hz in the QC1 MSL strain gage data, and the resonance peaks between 22 and 25 Hz, and at 158 Hz, in QC2 MSL strain gage data. What are the plans to ensure that such peaks do not cause unacceptable pressure loads on the steam dryer and vibrations in MSL components?

Response 2

The intermittent low frequency (i.e., less than 50 Hz) peaks are not associated with the steam line acoustic resonances. These frequencies are too low to be caused by the acoustic coupling of branch opening vortex shedding with the branch line column resonance. Also, the peaks are not seen consistently in the same pipe at the same flow rates. The 36 Hz peak in the Fast Fourier Transform (FFT) for the QCNPS Unit 1 "A" main steamline (MSL) upper location in Attachment A of Exelon Report AM-2006-003 (Reference 3) is seen in the 2912 MWt data set, but not seen in the second data set at an almost identical power level of 2907 MWt. At the lower location on the "A" MSL, the 36 Hz magnitudes are consistent at both power levels and remain lower than pre-ASB measurements. Similar behavior is seen for the 36 Hz content in the "C" MSL with the 36 Hz being present in the lower MSL measurement only. Also, it should be noted that the 36 Hz peak is not seen in the "B" or "D" MSL measurements.

The "B" MSL upper location has a 48 Hz peak in the FFT for the Test Condition (TC) 18 data obtained at 2912 MWt. The magnitude of this peak was reduced by a factor of 2 in the data set obtained at 2907 MWt. At the lower location on the "B" MSL, the 48 Hz magnitudes are consistent at both power levels and remain lower than pre-ASB measurements. The intermittent 48 Hz peak is not seen in the other MSL measurements.

The higher frequency peaks seen in the QCNPS Unit 2 MSL strain gage data are all very small levels (i.e., less than 0.02 micro-strain rms) and are significantly less than pre-ASB levels. These small peaks are attributed to the branch-opening vortex shedding pressure oscillations, which are no longer being amplified by the branch line column resonance. The frequency of these peaks is consistent with the expected vortex shedding frequency and the frequency is seen to increase with increasing steam line flow velocity. To ensure the pressure in this frequency range does not increase beyond pre-ASB levels, the magnitude of the oscillating pressure will be monitored as defined in Response 1.

Based on these comparisons, the intermittent low frequency peaks are not caused by the oscillating pressure in the MSLs, but are likely the result of indirectly measuring pressure with strain gages at this location. These individual peaks are not contributing toward increased pressure magnitudes as seen in the rms and max-min tables and trend plots provided in References 3 and 4. The rms and max-min values are still significantly lower than the pre-ASB measurements. Since these intermittent, low frequency peaks are not attributed to the oscillating pressure in the MSLs, they will not lead to unacceptable pressure loads on the replacement steam dryers or vibration levels in the MSLs. EGC's plan for future load monitoring and steam dryer inspections, as stated in Response 1 above, is sufficient for ensuring acceptable steam dryer pressure loads and MSL vibrations.

Request 3

What are the plans to ensure that extended operation of QC1 and QC2 between original licensed thermal power (OLTP) and EPU conditions will not result in unacceptable acoustic-generated pressure fluctuations and vibrations? For example, see the resonance peaks at 127 and 143 Hz between OLTP and EPU conditions in the Structural Integrity Associates Report SIR-06-199 (May 1, 2006), "Quad Cities Unit 2 Strain Gage and Accelerometer Data Reduction Summary," referenced in Exelon Report AM-2006-002 enclosed with the licensee's submittal dated May 3, 2006.

Response 3

The higher frequency peaks seen in the QCNPS Unit 2 MSL strain gage data between 120 Hz and 140 Hz are at very small levels (i.e., less than 0.02 micro-strain rms) and are significantly less than pre-ASB OLTP and EPU levels. These small peaks, which are seen at intermediate flow velocities, are attributed to the branch-opening vortex shedding pressure oscillations. The frequency of these peaks is consistent with the expected vortex shedding frequency and the frequency is seen to increase with increasing steam line flow velocity. Also, these pressure oscillations are not being amplified by the branch line column resonance. The comparisons shown in Reference 5 are made to OLTP and EPU thermal power levels. The magnitude of the pressure oscillations at these lower thermal power levels is not expected to be greater than the pre-ASB magnitudes at similar thermal power levels or flow velocities. Consequently, the steam dryer pressure loads are not expected to be greater than previously experienced prior to the installation of the ASBs.

To ensure the pressure in this frequency range does not increase beyond pre-ASB levels, the magnitude of the oscillating pressure will be monitored as defined in Response 1 above.

Request 4

Figures 10 to 13 in Exelon Report AM-2006-002 show the QC2 MSL B vibration spectra at OLTP and EPU conditions prior to ASB installation for frequencies up to 1 kHz. The figures show harmonics at twice and three times the fundamental singing frequency (about 320 and 480 Hz). What is the potential impact of any new resonances that might be excited at higher frequencies due to the installation of the ASBs?

Response 4

The MSL strain gage data collected from QCNPS Unit 2 with the ASBs installed from TC 18 at 2874 MWt was used to assess the higher frequency content of the pressure oscillations in the MSLs. FFTs of the strain gage measurements from the "A" and "B" MSLs were calculated to 780 Hz, the maximum frequency available based on the data acquisition rate, and are provided in Attachment 2. The "A" MSL does not show frequency content above 200 Hz. The "B" MSL does contain multiples of the acoustic frequency at 155 Hz, but does not contain other higher frequency content. The magnitude of the 310 Hz and 465 Hz multiples are smaller in magnitude and will not generate significant load in the piping or the steam dome.

Functionally, the ASB performance improves with increasing frequency (i.e., oscillating pressure magnitudes are more effectively reduced at higher frequencies). Consequently, the higher frequency content of the pressure oscillations in the MSLs is not significant and will not cause a significant increase of the loading in the MSLs or on the steam dryer.

Request 5

In its EPU restart reports submitted on May 3 and August 6, 2006, Exelon does not include a revised steam dryer stress analysis for QC1 and QC2 using MSL strain gage data collected during EPU operation with the ASB modifications. As discussed in the past, the NRC staff has not accepted specific aspects of Exelon's steam dryer stress analysis. For example, the bias error and uncertainty assumptions for the acoustic circuit methodology (ACM) are not supported by a comparison of the QC2 steam dryer pressure loads calculated by the ACM during EPU operation before the ASB modifications to actual measured QC2 steam dryer data for specific frequencies intervals or steam dryer locations. Exelon has not justified the assumptions for damping applied in its steam dryer stress analysis in light of the data from the hammer tests of the replacement steam dryers. Also, the bias error/uncertainty assumptions associated with the finite element model stress-to-force transfer functions (based on comparison to dynamic hammer test data on the QC1 and QC2 replacement dryers) needs to be properly addressed. The exponent used by the licensee for the load extrapolation from maximum achieved thermal power to licensed EPU power is not clearly supported by data near the maximum achieved thermal power in the frequency range of interest. Some uncertainties in the steam dryer stress analysis, such as load extrapolation and time shifting, appear more appropriately addressed as bias errors. With the current effectiveness of the ASBs in reducing MSL pressure fluctuations and vibrations to less than OLTP levels prior to the ASB modifications, it is not necessary to resolve these issues with Exelon's steam dryer stress analysis at this time for EPU operation of QC1 and QC2. However, these issues might need to be addressed if the ASB effectiveness becomes degraded at QC1 or QC2, or if Exelon plans to use its steam dryer stress analysis approach, along with its bias error/uncertainty assumptions, for other plants.

Response 5

In a conference call on September 8, 200,6 between the NRC (M. Banerjee, T. Scarbrough, et al.) and EGC (D. Gullott, R. Gesior, et al.), the NRC confirmed that Request 5 does not require any action on EGC's part (i.e., no response or additional information is required).

The NRC provided Request 5 to inform EGC that the NRC's technical issues remain regarding the EGC steam dryer stress analysis, and that these technical issues are required to be addressed should the ASB effectiveness be reduced or the stress analysis approach is applied to other plants.

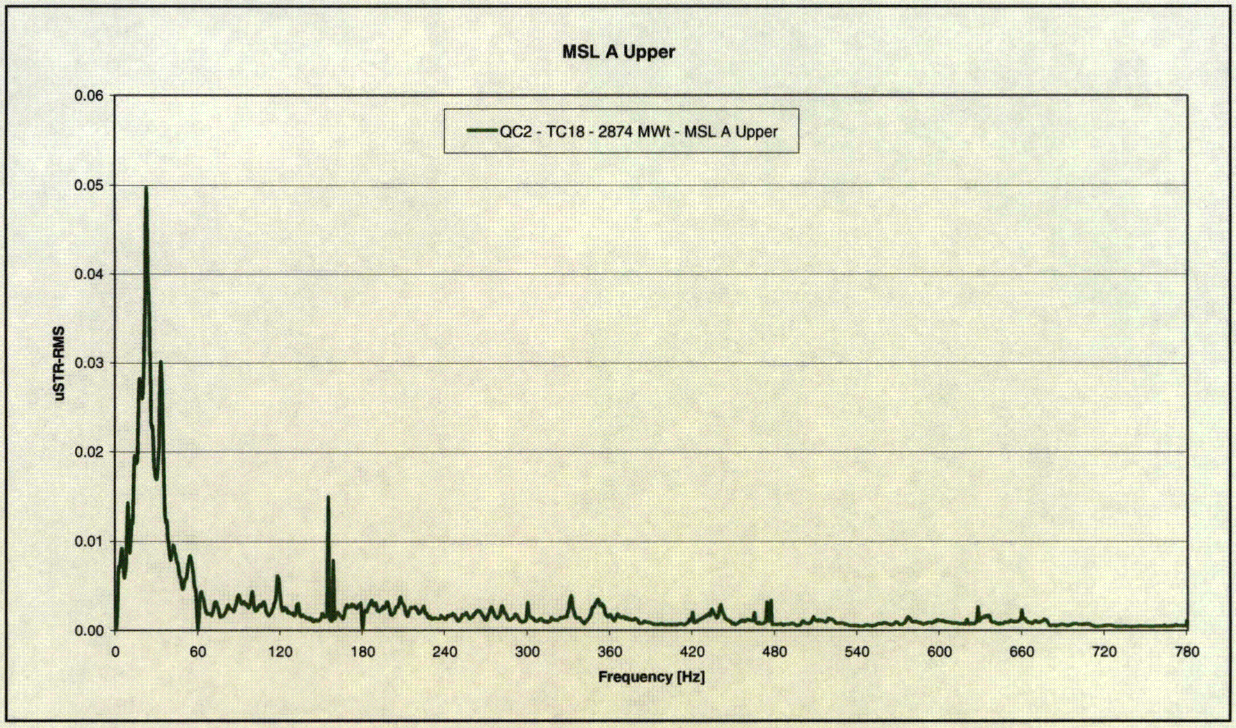
References

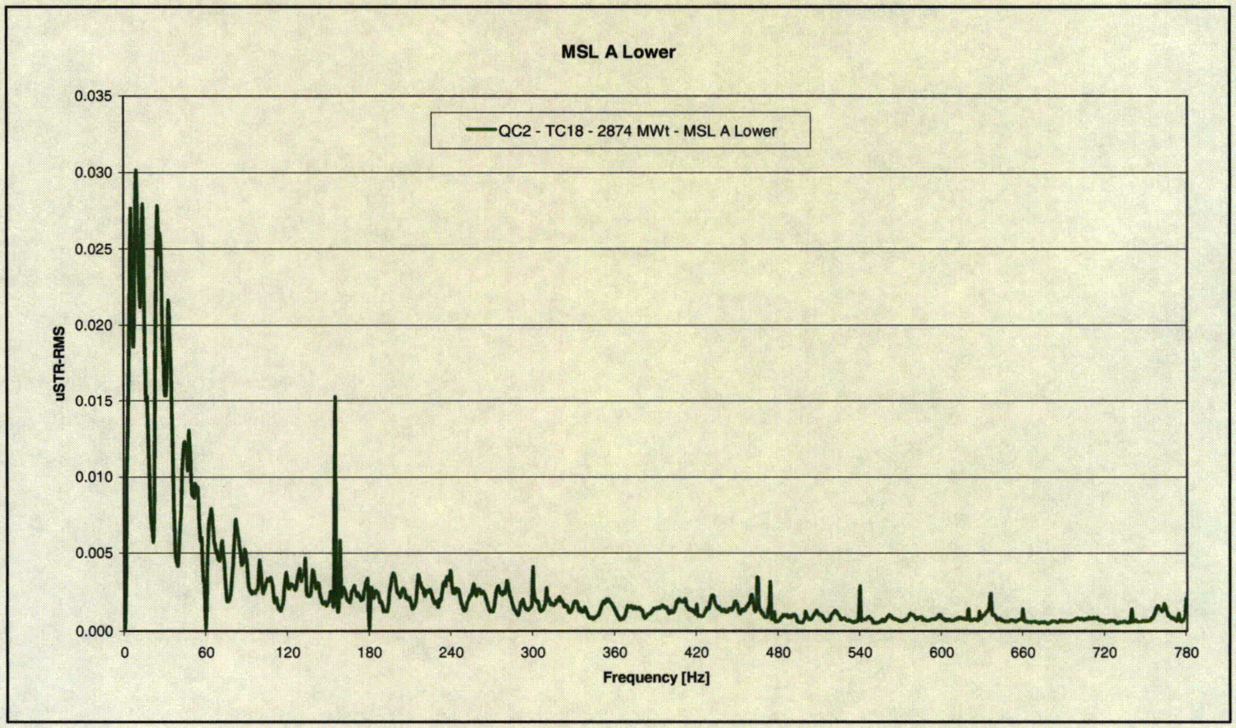
1. Letter from P. R. Simpson (Exelon Generation Company, LLC) to U. S. NRC, "Additional Information Regarding Quad Cities Unit 2 Steam Dryer Inspection, Start-up and Power Ascension Plan," dated April 27, 2006
2. Exelon Slides from Public Meeting dated March 16, 2006 (ML060820120)
3. Letter from K. M. Nicely (Exelon Generation Company, LLC) to U. S. NRC, "Quad Cities Unit 1 Startup and Power Ascension Testing Following Installation of Acoustic Side Branch Modifications," dated August 2, 2006
4. Letter from P. R. Simpson (Exelon Generation Company, LLC) to U. S. NRC, "Quad Cities Unit 2 Startup and Power Ascension Testing Following Installation of Acoustic Side Branch Modifications," dated May 3, 2006
5. SIA Calculation, SIR-06-199, "Quad Cities Unit 2 Strain Gage and Accelerometer Data Reduction Summary," Revision 1, May 2006

ATTACHMENT 2

High Frequency Plots for QCNPS Unit 2 MSL Strain Gage Measurements

A MSL Strain Gage Measurements

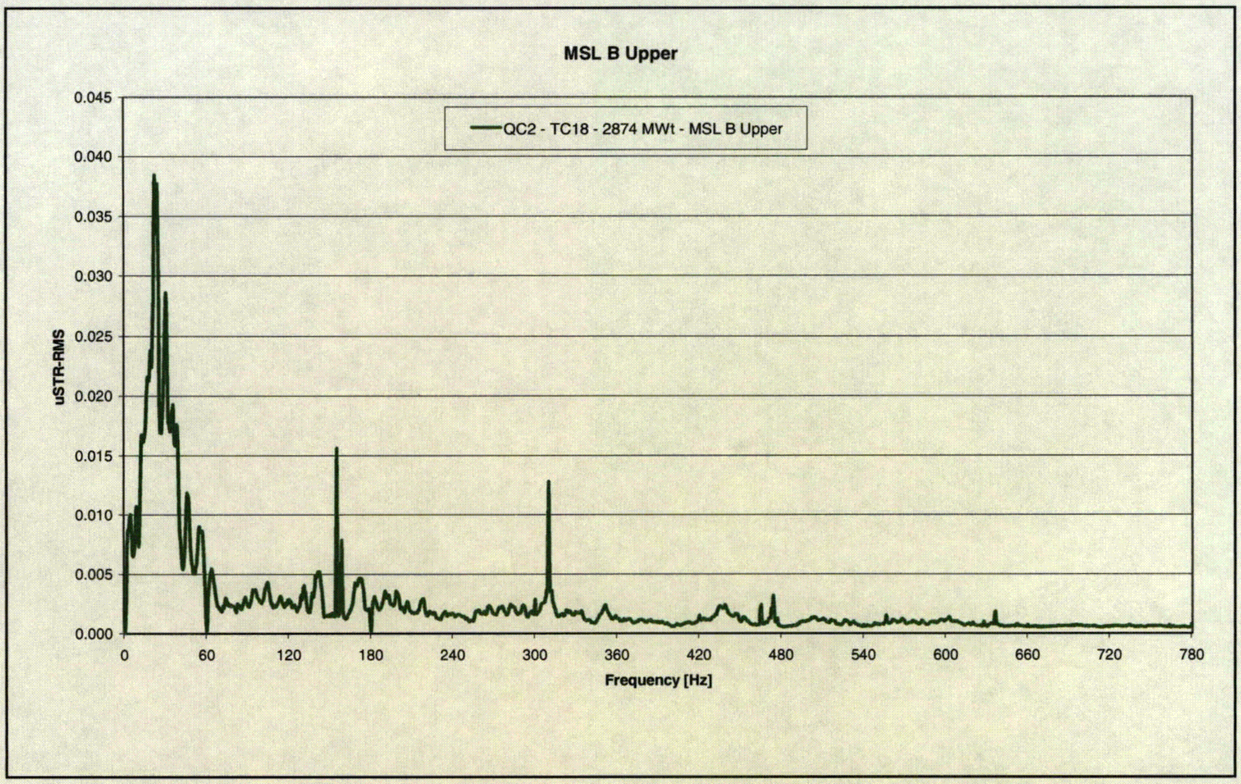


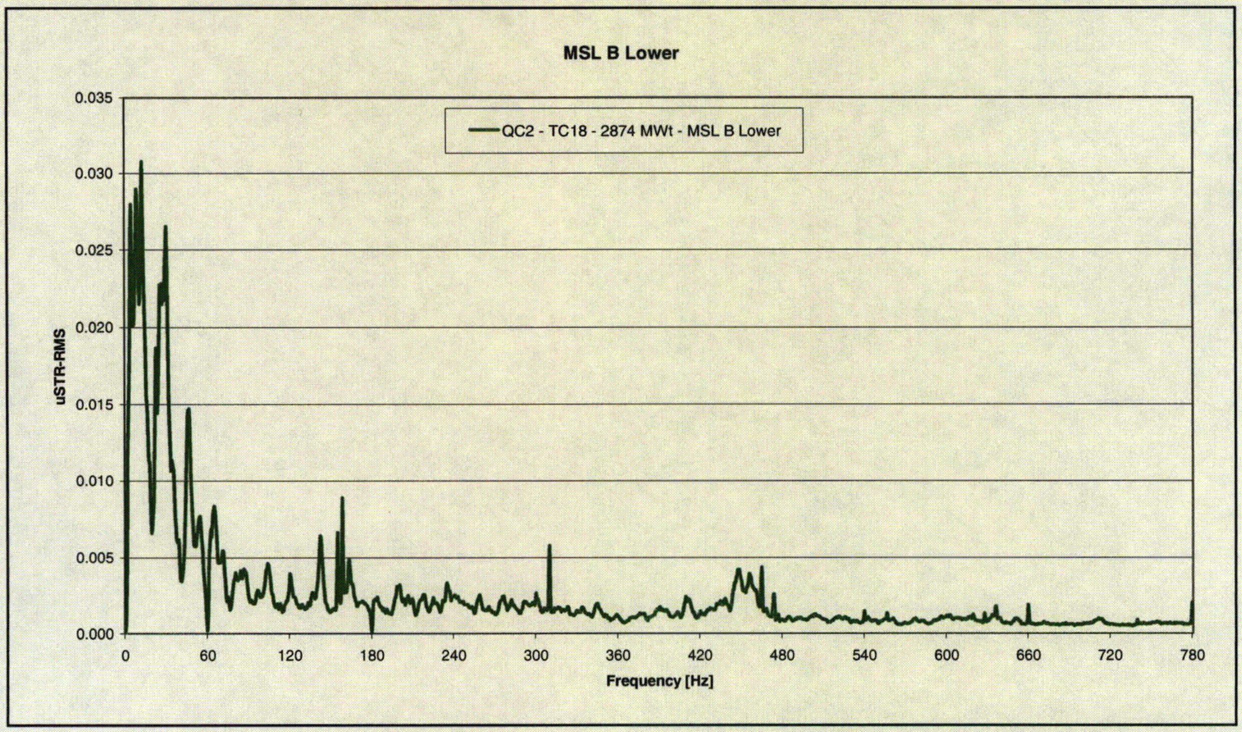


ATTACHMENT 2

High Frequency Plots for QCNPS Unit 2 MSL Strain Gage Measurements

B MSL Strain Gage Measurements





ATTACHMENT 3

Quad Cities Steam Line Routine Monitoring Data Summary

Since the initial post-Acoustic Side Branch (ASB) modification start-up tests, additional data has been collected on both units. The maximum thermal power at which data was collected on Quad Cities Nuclear Power Station (QCNPS) Unit 1 was 2955 MWt, or approximately 43 MWt higher than that collected during startup testing, and essentially at the maximum licensed thermal power allowable (i.e., 2957 MWt). The maximum thermal power at which data was collected on QCNPS Unit 2 was 2881 MWt. This attachment compares the additional data to the startup test limits, which are based on the pre-ASB measurements.

Figures 1 through 4 present the QCNPS Unit 1 main steamline (MSL) strain gage data at 2955 MWt compared to the acceptance criteria and the 2912 MWt data collected during the start-up test. A review of these figures in the low frequency range shows very consistent frequency content for all the MSL measurements that is below the pre-ASB measurements. In addition, the 36 Hz peak on the "A" MSL upper location and the 48 Hz peak at the "B" MSL upper location measured at 2912 MWt are reduced significantly in the 2955 MWt data at these locations.

In the high frequency range, very consistent frequency content is also seen for all of the MSL measurements. At 2955 MWt, the significant frequency content seen from 140 Hz to 160 Hz in the pre-ASB measurements has been eliminated, and only a single peak of lower amplitude is seen in some measurements. At those measurement locations that had a 159 Hz peak at 2912 MWt, the magnitude of the peak increased in the 2955 MWt measurements. At the "B" MSL upper location, the 159 Hz peak increased by a factor of 2, to a magnitude of 0.095 micro-strain. Although this appears to be a significant increase, the magnitude is still lower than the pre-ASB peaks in this frequency range and the increase is seen only at the upper location on the "B" MSL. At the lower location, the magnitude at this frequency remains very small (i.e., less than 0.015 micro-strain for the 2955 MWt measurements). This lack of propagation suggests that this frequency component may not be acoustic in nature. A consequence of applying strain gages to measure dynamic pressure, hoop strain, is a susceptibility to acquire pipe structural modal response and include it as a pressure component. Similar behavior is seen at the "C" MSL lower and "D" MSL upper locations with almost immeasurable content in the adjacent location on each MSL. Even with these increases, the magnitude of the pressure oscillations in the acoustic frequency range that had led to significant MSL vibration levels and steam dryer differential pressures are still insignificant when compared to the pre-ASB magnitudes.

The change in the max-min values for these MSL measurements supports this conclusion. The max-min strain gage data trend plots from each unit are provided in Figures 5 through 8 below. As seen from these plots, the MSL strain data on both units behave very similarly with increasing power levels. The max-min values increase following a flow velocity squared trend, without indication of higher order increases as seen when acoustic resonance was occurring in the MSLs. The velocity squared increase is suggestive of turbulence phenomena, as opposed to resonant acoustic response which tends to increase at a much higher rate with flow increase.

Based on the data presented, the following conclusions can be drawn:

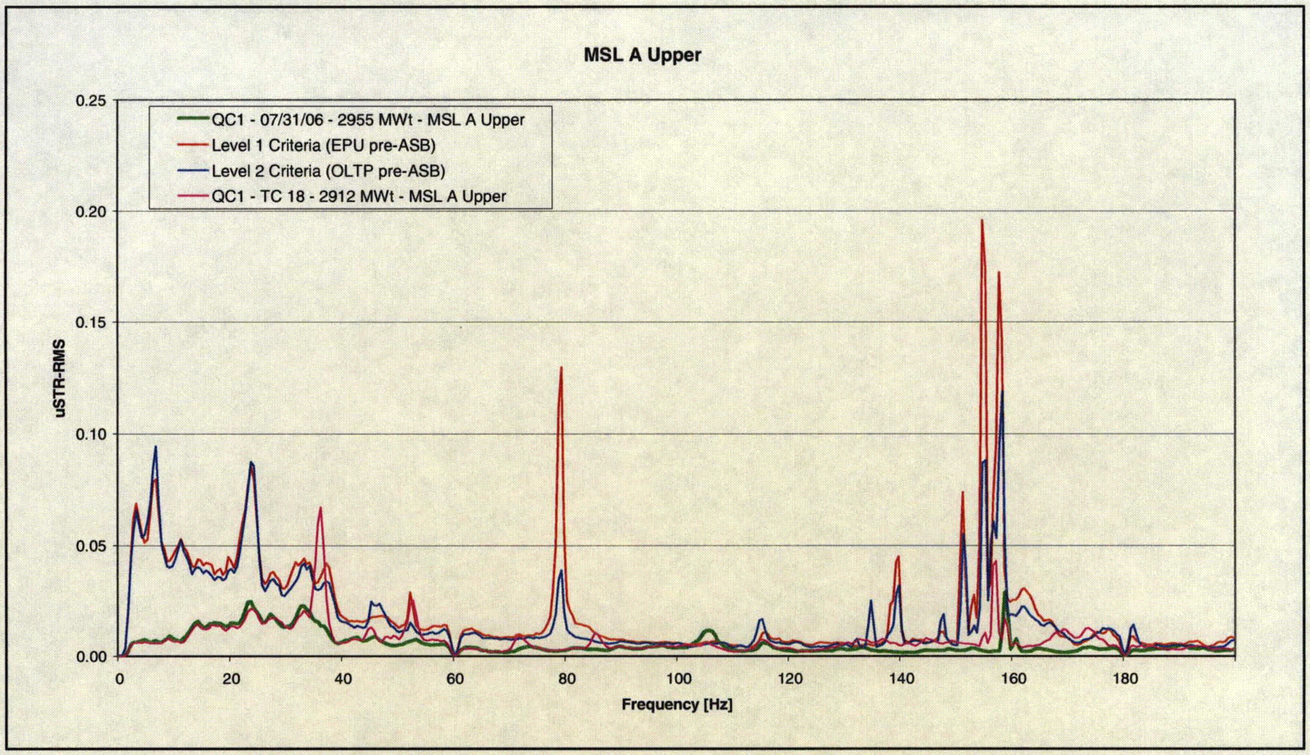
1. The plant has acquired data at full licensed thermal power levels.

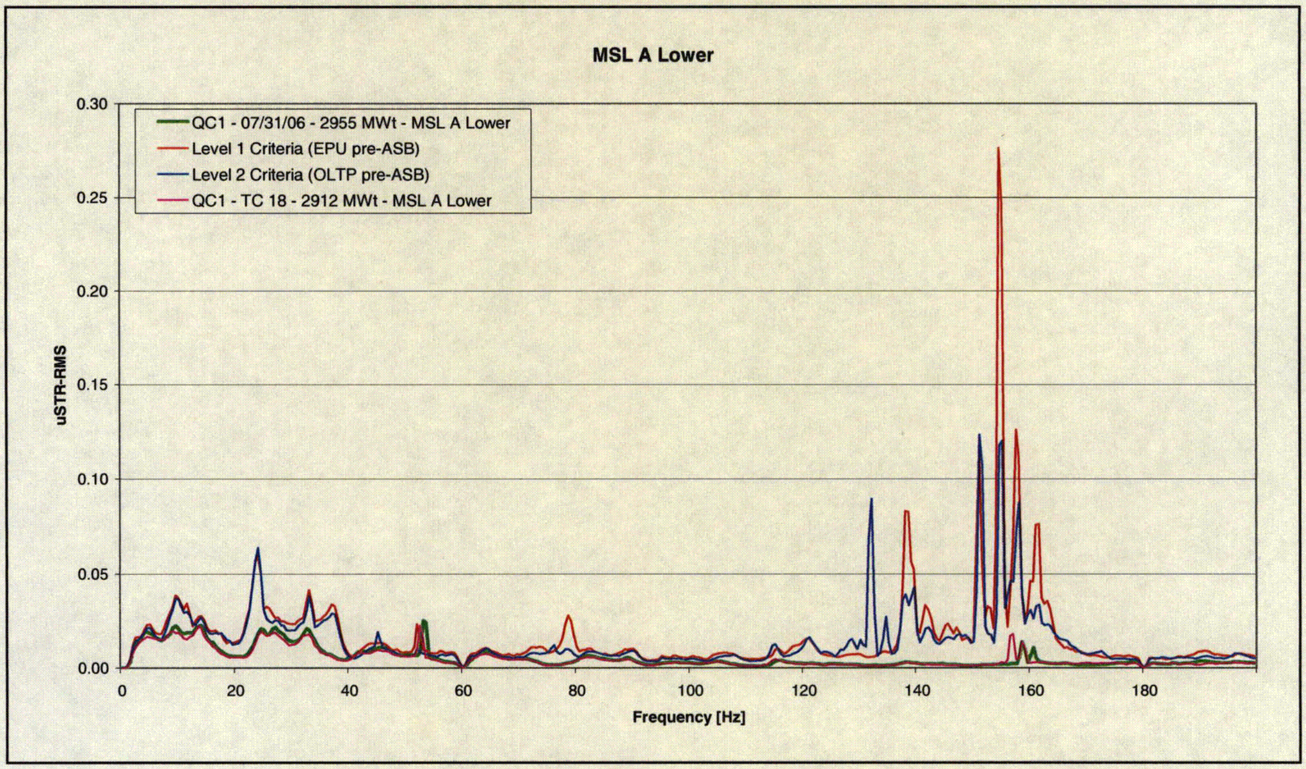
2. The data obtained when compared to post-ASB startup testing shows that the ASBs are effective through the entire range of power levels.
3. The data obtained shows that while predicted pressures increase with power, the increases are very small and reflective of increased dynamic pressure, without acoustic amplification.

ATTACHMENT 3

Quad Cities Steam Line Routine Monitoring Data Summary

Figure 1: Unit 1 MSL "A" Strain Gage Measurements at 2955 MWt

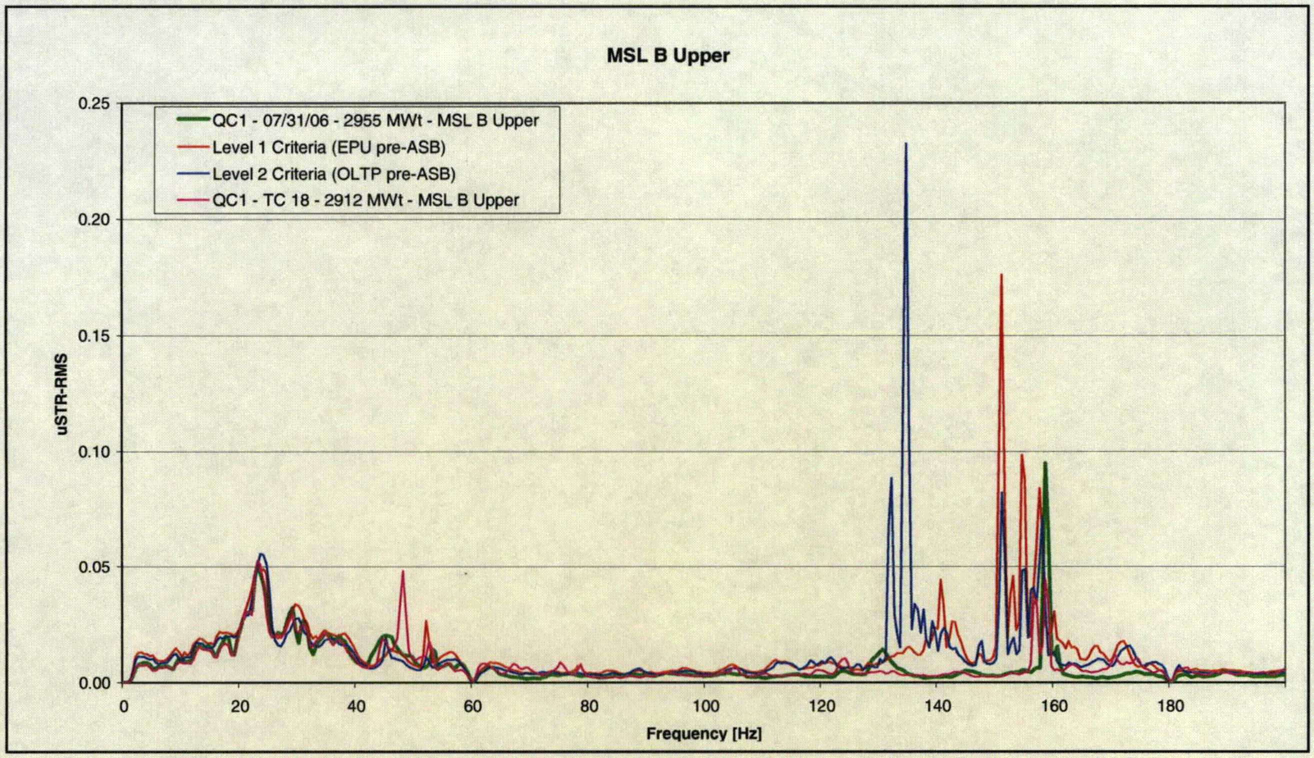


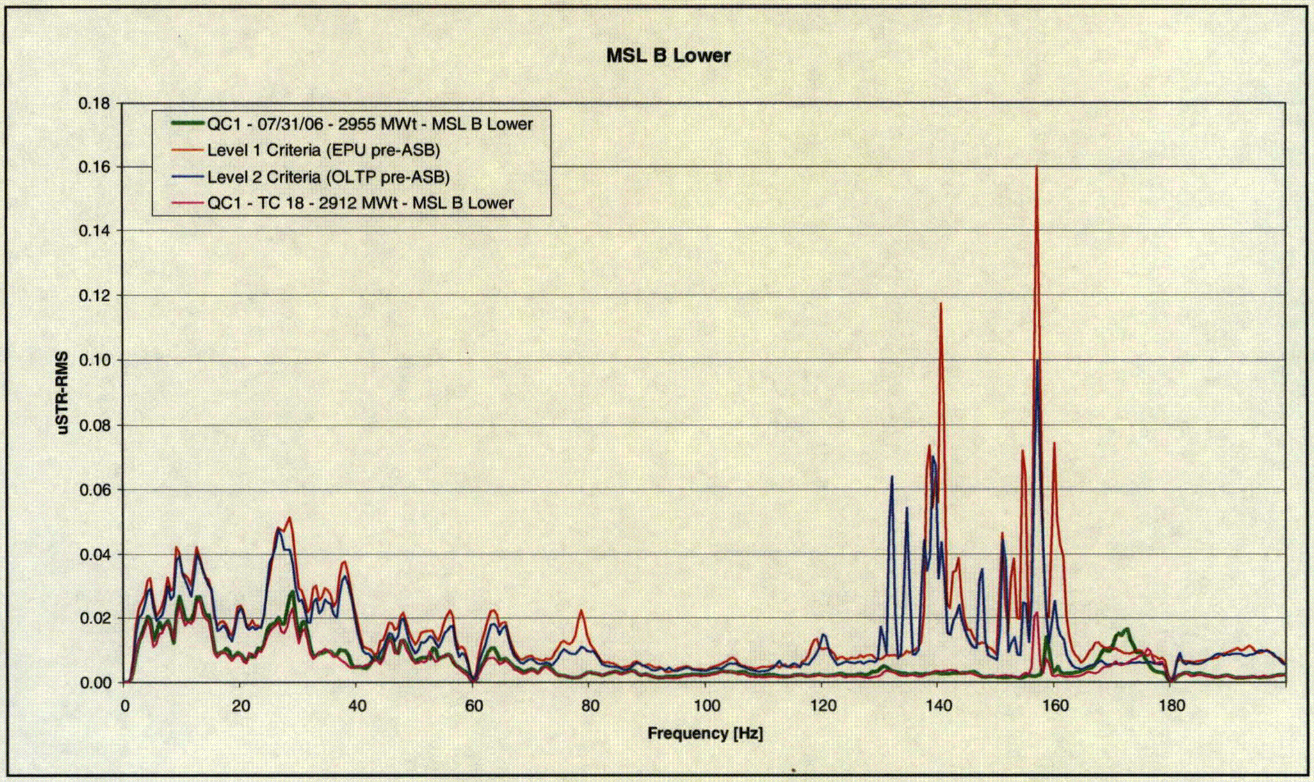


ATTACHMENT 3

Quad Cities Steam Line Routine Monitoring Data Summary

Figure 2: Unit 1 MSL "B" Strain Gage Measurements at 2955 MWt

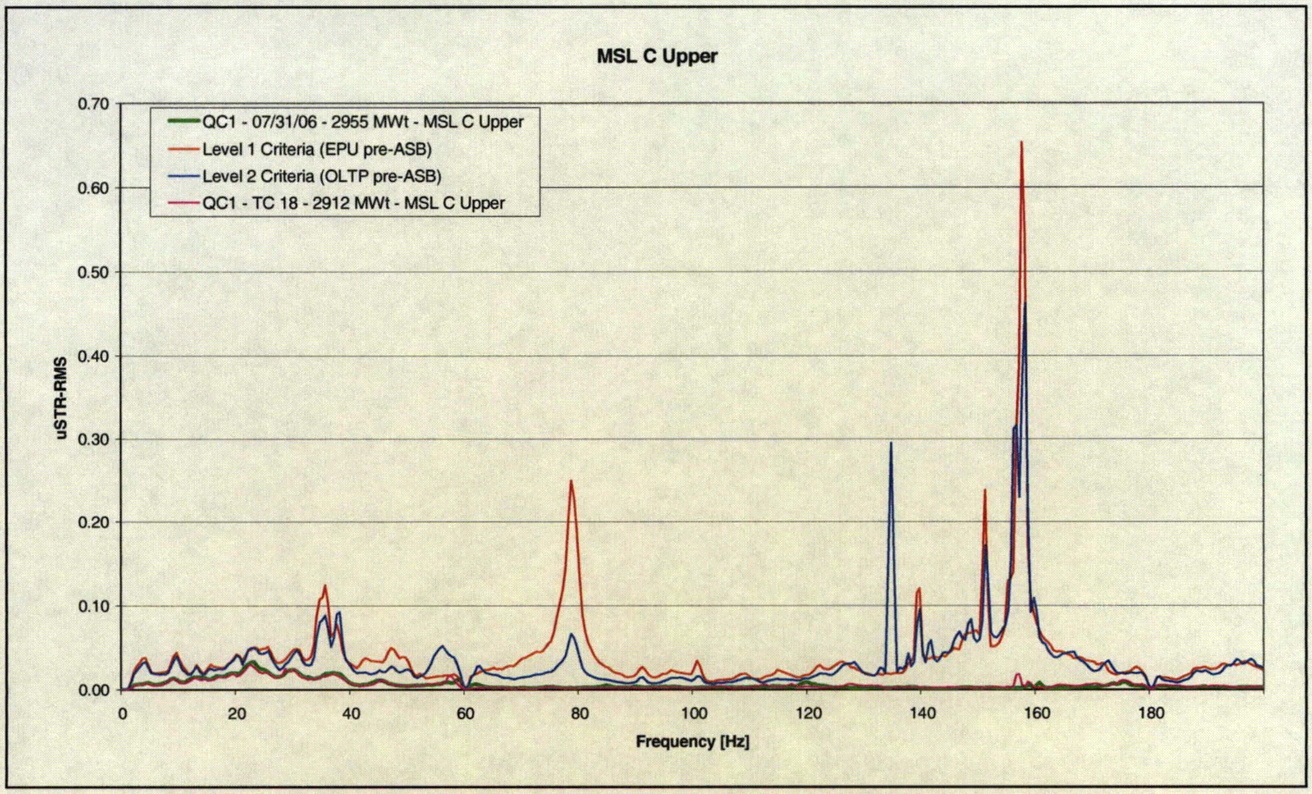




ATTACHMENT 3

Quad Cities Steam Line Routine Monitoring Data Summary

Figure 3: Unit 1 MSL "C" Strain Gage Measurements at 2955 MWt



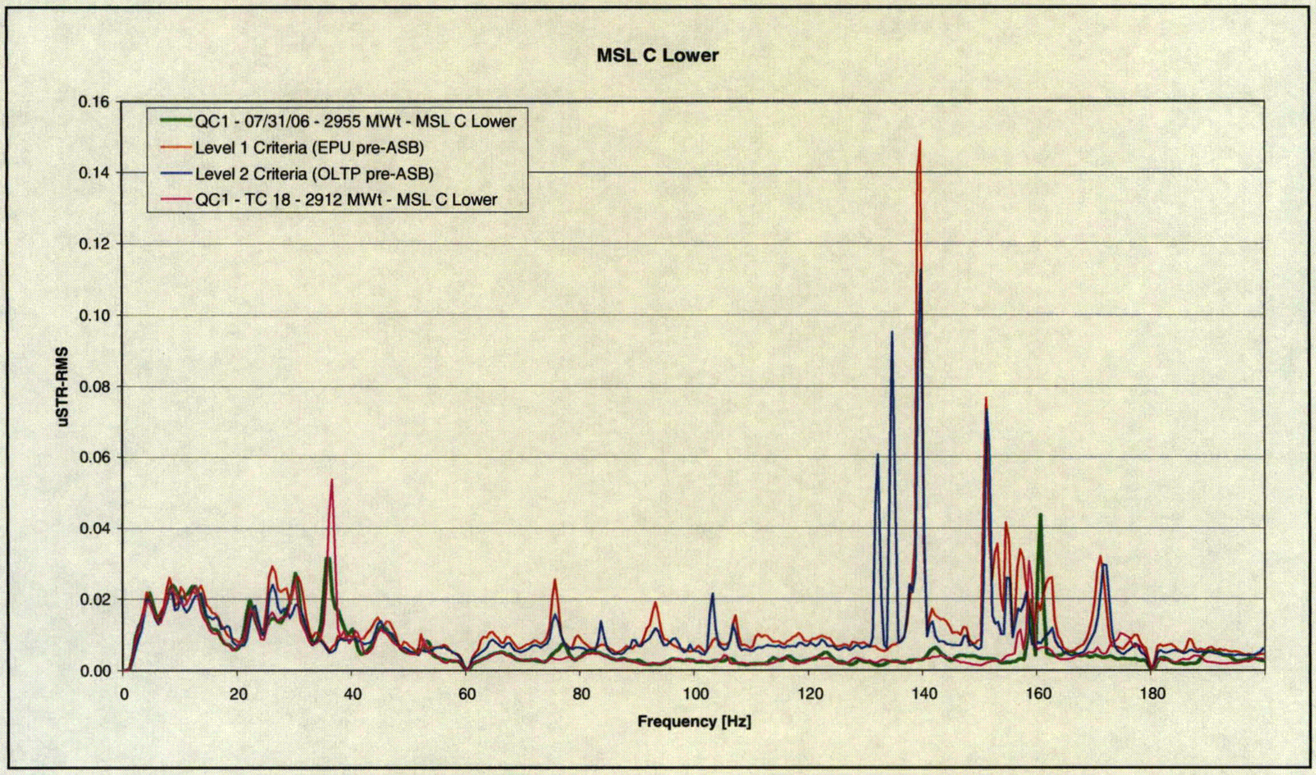
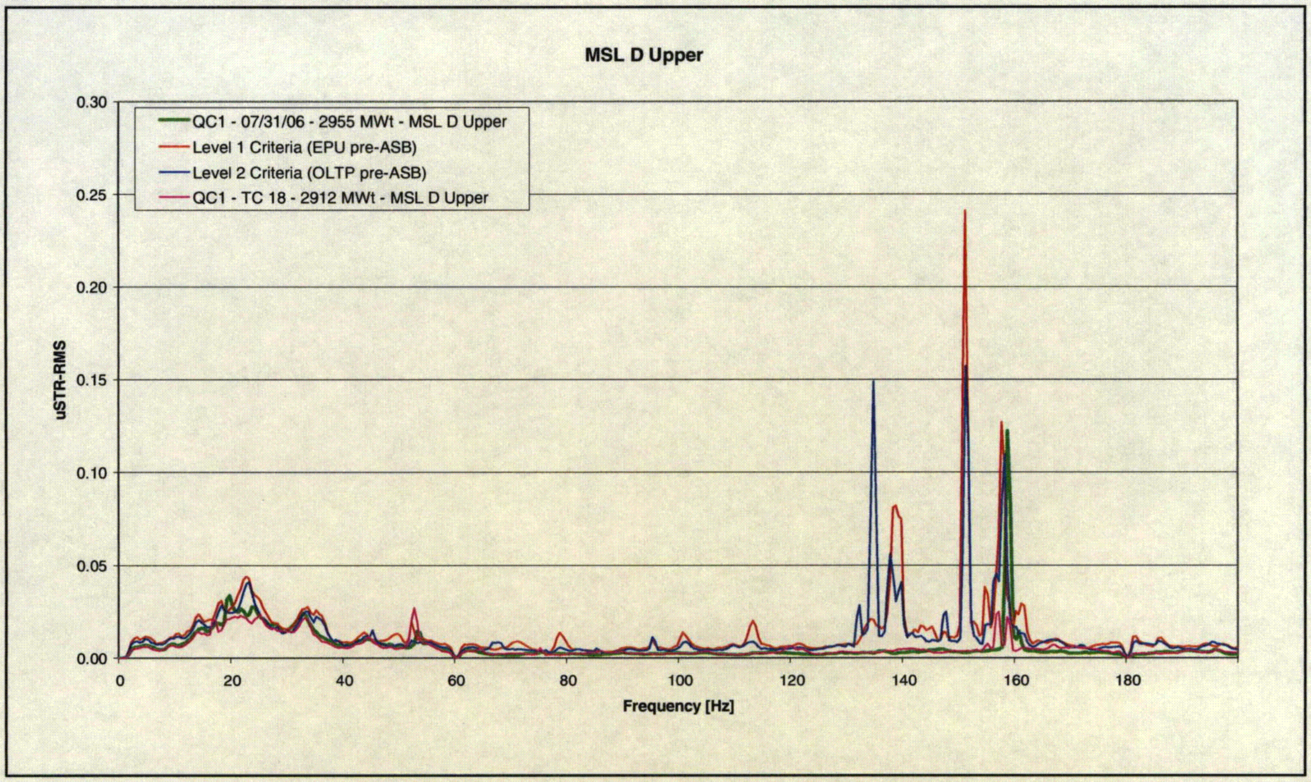
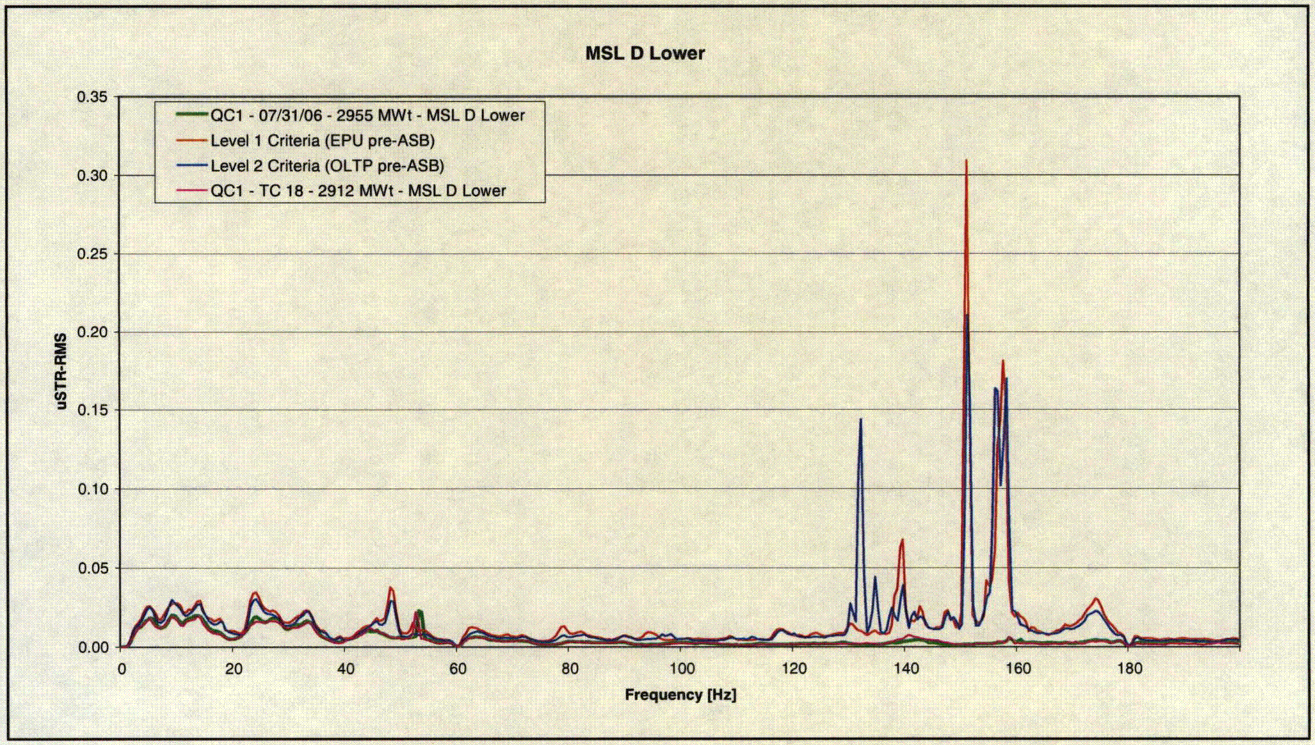


Figure 4: Unit 1 MSL "D" Strain Gage Measurements at 2955 MWt

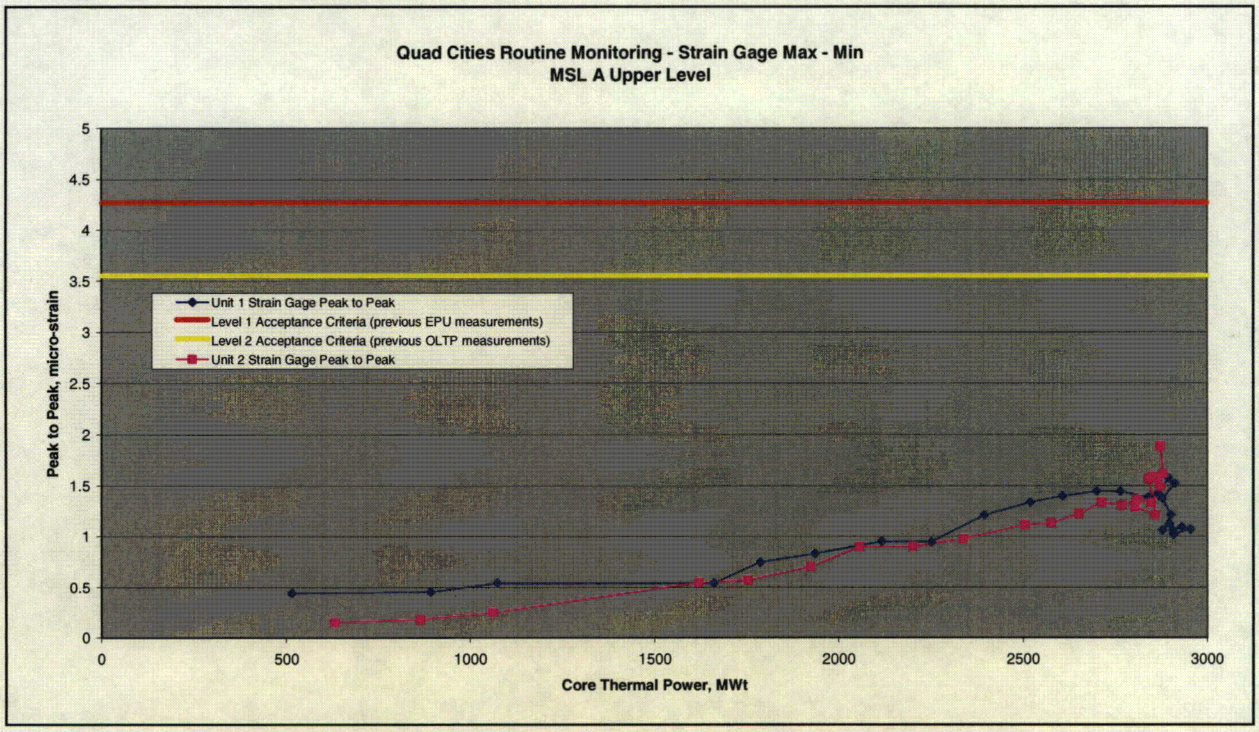


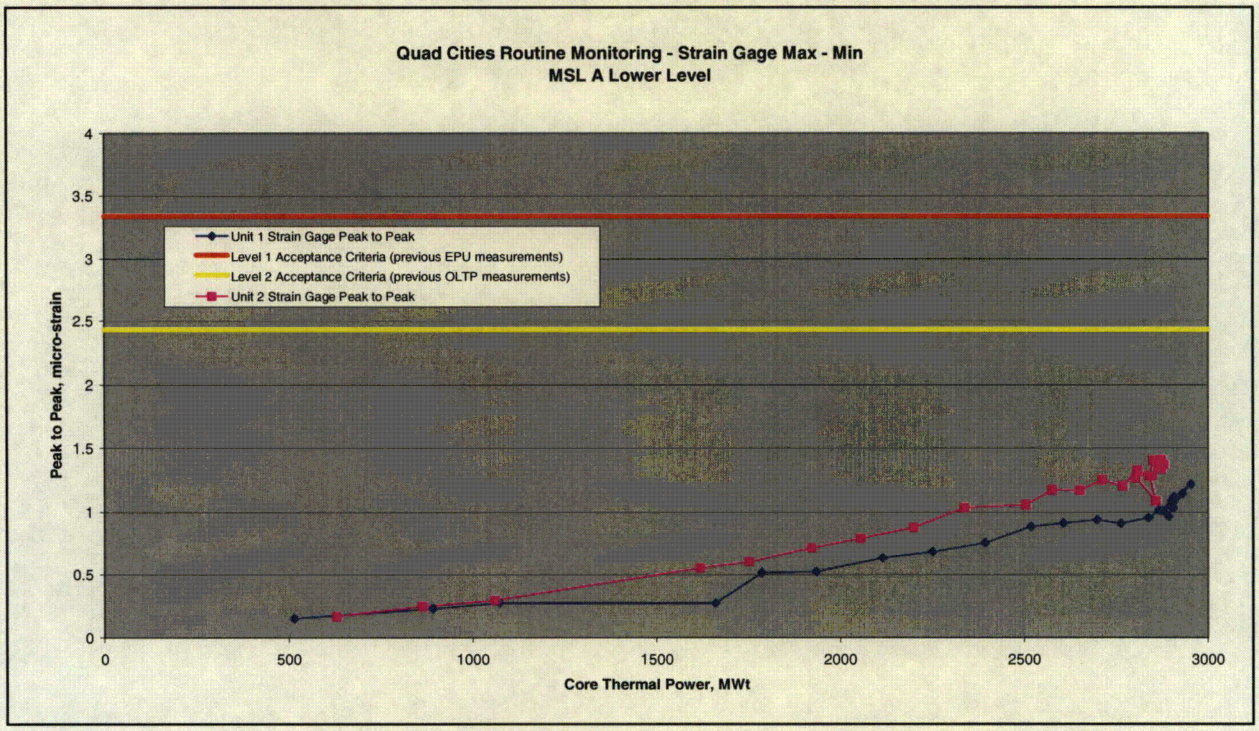


ATTACHMENT 3

Quad Cities Steam Line Routine Monitoring Data Summary

Figure 5: Unit 1 and Unit 2 "A" MSL Strain Gage Max-Min Trend Plots Through 8/22/06

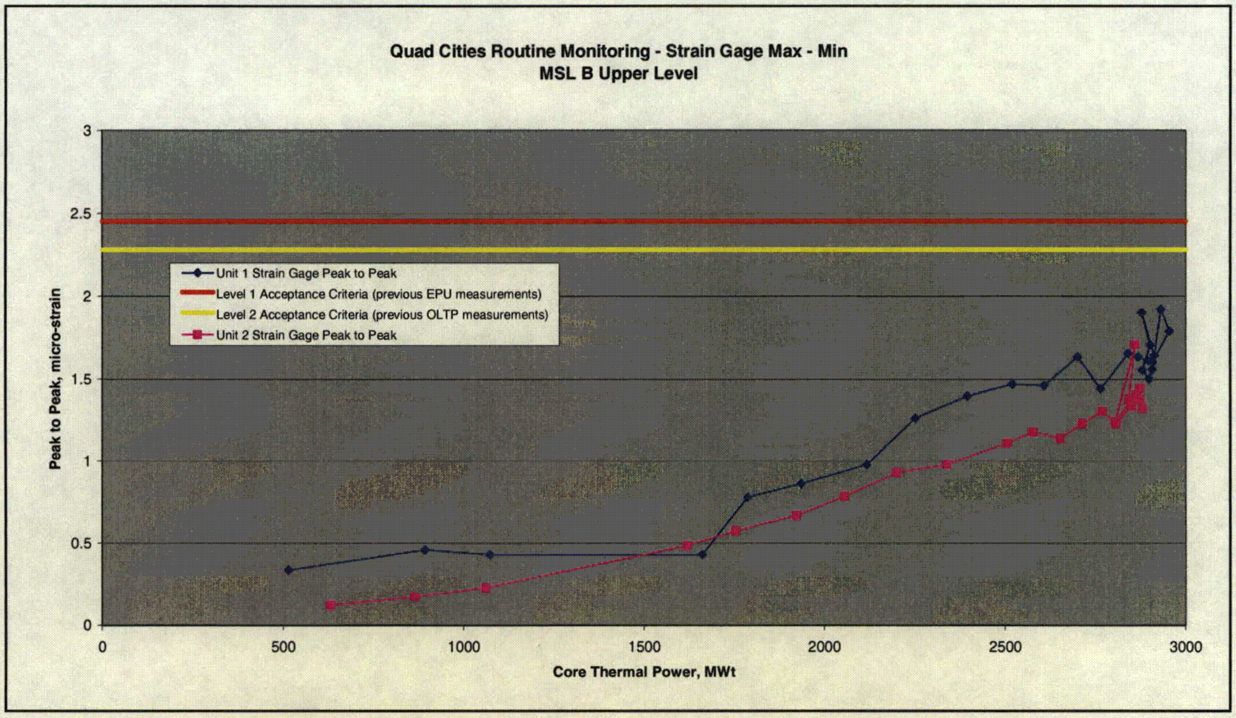


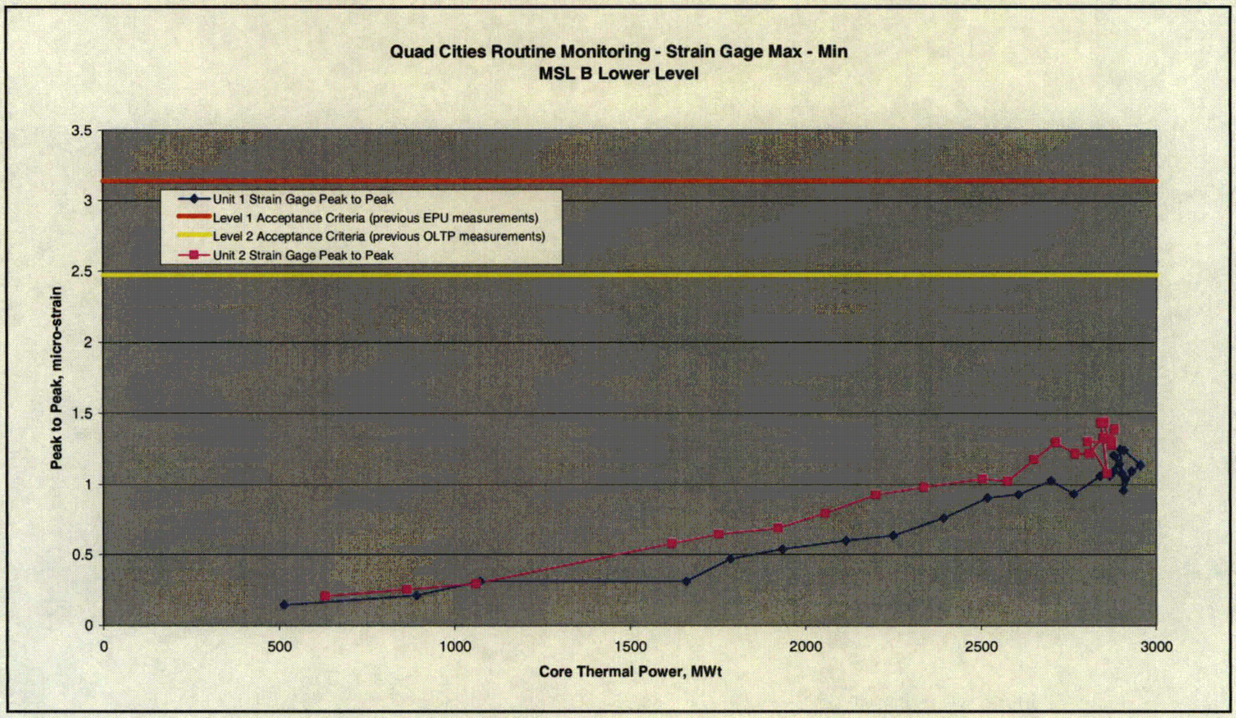


ATTACHMENT 3

Quad Cities Steam Line Routine Monitoring Data Summary

Figure 6: Unit 1 and Unit 2 "B" MSL Strain Gage Max-Min Trend Plots Through 8/22/06

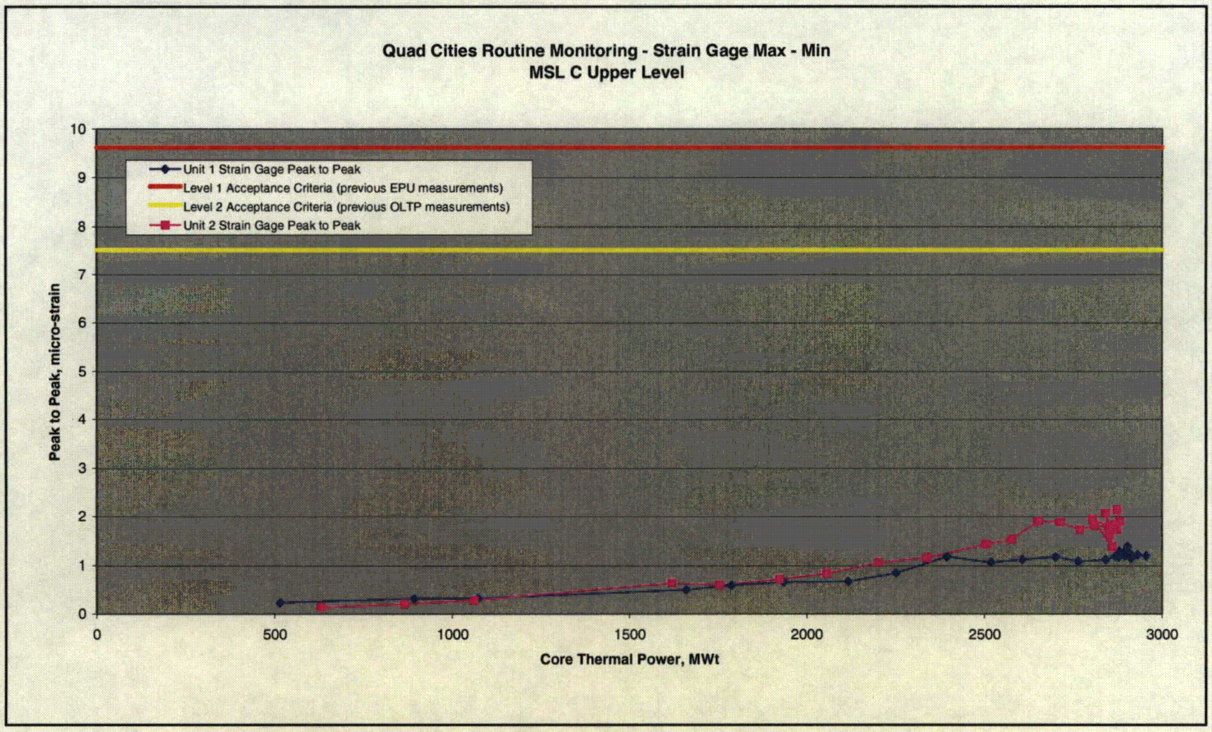


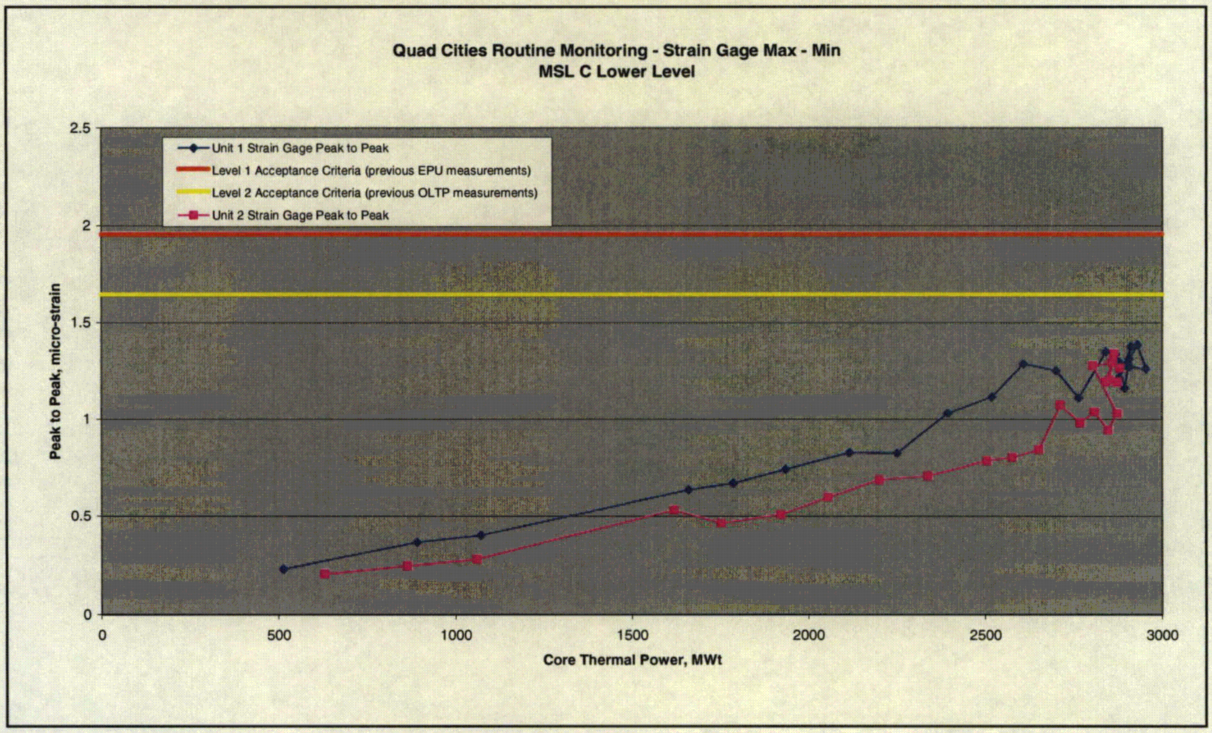


ATTACHMENT 3

Quad Cities Steam Line Routine Monitoring Data Summary

Figure 7: Unit 1 and Unit 2 "C" MSL Strain Gage Max-Min Trend Plots Through 8/22/06





ATTACHMENT 3

Quad Cities Steam Line Routine Monitoring Data Summary

Figure 8: Unit 1 and Unit 2 "D" MSL Strain Gage Max-Min Trend Plots Through 8/22/06