ENCLOSURE 2

Attachment 1

Exelon Report Number AM-2005-013, "Quad Cities Unit 1 New Steam Dryer Outage Startup Test Report," Revision 0, dated July 28, 2005

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Quad Cities Unit 1 New Steam Dryer Outage Startup Test Report

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Quad Cities Unit 1 New Steam Dryer Outage Startup Test Report

1. Executive Summary

On May 28, 2005, through June 2, 2005, Quad Cities Unit 1 was shutdown for Maintenance Outage, Q1M18, to install its new steam dryer. The unit was started up and testing was in progress from June 2, 2005, until June 5, 2005. On June 5, the unit achieved 2900 MWt (98.1%) and 920 MWe. Main generator limitations at 920 MWe and mega-volt amps reactive (MVAR) (reactive power) limitations of the grid limited the power ramp. The unit maintained a power level above 900 MWe for 6 hours, while data was recorded and compared to conservative acceptance criteria. The power level on the unit was then decreased to 2410 MWt (81.5%) (750 MWe), to a value in which all main steam line strain gauges met their Level 2 criteria. The unit was held at this power level until June 8, 2005, when EC 355874, Revision 0, authorized operation at 2511 MWt (84.9%). The unit was held at 2511 MWt until July 26, 2005, when EC 356409, Revision 0, authorized operation at 2642 MWt (89.3%). Unit 1 is expected to remain at 2642 MWt until an alternate analysis can be completed in which it is demonstrated that the steam dryer loads are acceptable at full rated power of 2957 MWt.

Because the new Unit 1 steam dryer was not instrumented, a direct measurement of the dryer loading could not be made. Instead, strain gauges were installed on the main steam lines, in the drywell, in similar locations, as strain gauges that were installed on Unit 2. The strain gauges are used to determine the time variance of pressure inside the main steam line pipe. A process was benchmarked on Unit 2, in which the main steam line strain gauges were used as the input to an acoustic circuit model that predicts pressure loadings on the steam dryer. These pressure predictions were compared to actual measurements that were part of the Unit 2 instrumented dryer. Once the ability of main steam line strain gauges to accurately predict dryer pressures was validated, Unit 1 strain gauges were to be used to determine Unit 1 dryer pressure loadings. Unfortunately, 5 of the necessary 32 strain gauges failed during Unit 1 startup. These 32 strain gauges are needed to input to the acoustic circuit model. At each location where a pressure variance signal inside the main steam line is to be obtained, 4 strain gauges are arranged around the pipe. These are located at 2 locations on each of the 4 main steam lines for a total of 32 strain gauges providing input to the acoustic circuit model. When some strain gauges are inoperable, the data from the remaining strain gauge includes more than the pipe breathing modes due to acoustic pressure oscillations. This additional content due to pipe shell mode response produces a conservative pressure load definition when the acoustic circuit methodology is applied.

2. Startup Test Purpose

The purpose of the startup test procedure was to provide step-by-step instructions in carrying out the start-up test program to Extended Power Uprate (EPU) conditions, with the Replacement Reactor Vessel Steam Dryer (Steam Dryer) in place. The incremental power increase methodology was intended to ensure a careful, monitored approach to achieve each next targeted higher power level. First and foremost in the performance of the test was the safety of the reactor and nuclear plant. The startup test procedure was written with this specifically in mind, providing the necessary criteria, instruction, oversight, and precautions to successfully execute the Reactor Vessel Steam Dryer Replacement Power Ascension Test Program.

3. Startup Plan Overview

Reactor power was raised on Unit 1 to the pre-EPU power level of 2511 MWt over a 3.5-day period. Data was taken at 10 test conditions (TCs) up to 2511 megawatts thermal (MWt). A hold period of approximately 24 hours took place at TC 10 while:

1. An evaluation of the data taken up to that point was performed,
2. A presentation of the results of the evaluation was made to PORC, and
3. Approval is given by PORC and the Plant Manager to proceed with power ascension.

Power was then raised to the maximum achievable as limited by the generator. During this power increase, data was taken at an additional five TCs (TC 11 through TC 15). For power levels both above and below EPU, there were three primary methods to obtain data at each TC.

1. High-speed data recorders captured data from:
   - 3 reactor steam dome pressure sensors
   - 4 pressure measurements at the MSL flow venturis
   - 4 main turbine control valve positions
   - 12 accelerometers on MSL components in the drywell, and
   - 40 strain gauges installed on main steam line (MSL) piping in the drywell.

2. System equipment parameters were obtained by computer points and by Operator round inputs. This data was comprised of approximately 1000 data points.

3. Data was manually gathered using handheld instruments for local vibration levels on small bore piping on the feedwater system and local area

temperatures. This data was taken at only two of the TCs, namely the pre-EPU rated power level and the maximum EPU power level.

Data Acceptance Criteria:
There were three levels of acceptance criteria documented in the Startup Test Procedure:

1. Plant Equipment Acceptance Limits: Normal alarm points or established equipment operating limitations based upon historical performance data.

2. Level 2 Criteria: Exceeding this did not necessarily result in altering plant operation or test plan, but resulted in initiating an Issue Report (IR) to enter the station's Corrective Action Program.

3. Level 1 Criteria: Actions included the initiation of an IR and seeking immediate resolution. Power was held at a known safe level based on prior testing until the condition was resolved.

For Unit 1, acceptance criteria were developed for comparison of the MSL strain gauges on Unit 1 to readings recorded on Unit 2. The readings compared both peak-to-peak values and the comparison of frequency data of power spectral density (PSD) to symmetrical locations on Unit 2. Due to the steam lines not being exactly identical in configuration with respect to the number and placement of safety valves, relief valves, and steam supplies to High Pressure Coolant Injection (HPCI) / Reactor Core Isolation Cooling (RCIC), these comparisons were both a direct reflection (MSL 1A compared to 2A, 1B compared to 2B, etc.) and a mirror reflection (MSL 1A compared to 2D, 1B compared to 2C, etc.)

4. Startup Testing Results

Attachment 1 contains the startup testing timeline for Unit 1. This timeline provides the chronology of the major startup test related events that occurred during startup and provides all the exceptions that were observed.

Figure 1 provides the power ascension profile for Unit 1 and provides a comparison of the planned profile versus the actual ascension.

Figures 2 through 17 provide trends of the comparison of Unit 1 MSL strain gauges to similar locations on Unit 2 (both the directly reflected locations and symmetrical locations). Due to the steam lines not being exactly identical in configuration with respect to the number and placement of safety valves, relief valves, and steam supplies to High Pressure Coolant Injection (HPCI) / Reactor Core Isolation Cooling (RCIC), these comparisons were both a direct reflection (MSL 1A compared to 2A, 1B compared to 2B, etc.) and a mirror reflection (MSL 1A compared to 2D, 1B compared to 2C, etc.) Noteworthy, are Figures 3, 11, 12, and 16. Figure 11 (MSL C at the 651' elevation) and Figure 16 (MSL D at the 624' elevation) exceeded Level 1 criteria. Figure 3 (MSL A at the 651' elevation) and Figure 12 (MSL C at the 624' elevation) exceeded Level 2 criteria. These locations exceeded their criteria due to piping bending modes and not being able to have this bending subtract out due to failed strain gauges on Unit 1 as the strain gauges are combined. A PORC was held to discuss the issue and to approve TIC-1261. This revision to the startup test procedure allowed power ascension above 2410 MWt (the point where all criteria was satisfied) for up to 12 hours in order to record data at the maximum power level achievable. The procedure change was supported by Engineering Change (EC) 355836, Revision 0.

Figures 18 and 19 provide samples of Power Spectral Density (PSD) comparisons from Unit 1 to Unit 2. Figure 19 is for MSL C at the 651' elevation in which the criteria was not satisfied due to piping bending modes and not being able to have this bending subtract out due to failed strain gauges on Unit 1 as the strain gauges are combined. Note the peak at 80 Hertz, which was not observed on any other data measurement systems.

5. EPU Related Startup Testing Results

Moisture Carryover Data:
Figure 20 shows the Moisture Carryover (MCO) trend on Quad Cities Unit 1 and the time period after startup. The trend has been fairly steady with a tie to reactor thermal power, as expected.

Main Steam Line Flows/Reactor Parameters (Level/Pressure)/Feedwater Flow:
Figure 21 shows the Reactor Water Level trends of the various measurement channels for Unit 1. The trends are consistent with expectations. Step changes of these parameters were used in the past to indicate failure of the old steam dryers. The channels are trending consistent with each other. The refuel level indicator does take step changes, as expected, when recirculation flow is adjusted during power increases. Figure 22 shows the trends for Reactor Pressure and Turbine Throttle Pressure for Unit 1. Figure 23 shows the Main Steam Line flows for Unit 1. Figure 24 shows the Delta Pressure between the reactor and the main turbine, reactor pressure, and reactor power levels for Unit 1. These trends are within expectations with no anomalies detected. Figure 25 shows the Main Steam Line flow deviations from the average steam line flow for Unit 1. Figure 26 shows the feedwater flow/steam flow mismatch for Unit 1. These trends are also as expected and consistent with readings that have been recorded in the past. The indications demonstrate that there is no mismatch between feedwater flow and steam flow. Figure 27 shows the feedwater flows for Unit 1. On the trend indicated on this figure, the change in feedwater flow from starting the idle feedwater pump is evident. No issues are identified by these trends. Figure 28 shows the steam flow and feedwater flow trends for Unit 1.

Data From the Startup After the EHC Malfunction Scram – 06/19/2005
Figures 29 through 44 present frequency plots of peak-to-peak root mean square (RMS) and PSD plots of the Unit 1 Main Steam Line Strain Gauges compared to Unit 2. This data was obtained on Unit 1 on June 19, 2005, after returning to power from the Electro-Hydraulic Control (EHC) scram. During the startup, strain gauge pairs S1/S3 (MSL A-651'), S32/S34 (MSL C-651'), S36/S36A (MSL C-624'), S37/S39 (MSL D-651') failed. Data analysis taken at this power level determined that strain gauge S-31 (MSL C-651') also had failed. Data analysis from Q1F54 startup determined that, due to the number of lost strain gauges on MSL C, an acoustic circuit load definition could not be performed. The data from "B" MSL and remaining pairs on "A" and "D" MSLs were used for comparison purposes and presented to the NRC Staff on June 30, 2005.

Main Steam Line Flows:
The following data was taken on Unit 1 and Unit 2 with the units at maximum thermal power with the old dryer and with the new dryer. The comparisons show that there is no appreciable difference in main steam line flow with the installation of the new steam dryers. Tables 1 and 2 seem to provide reasonable results in that the normalized flow through Main Steam Lines "A" and "D" are higher than "B" and "C" for both units. This is expected since the "A" and "D" Lines are the shorter Main Steam Lines.

Table 1

Comparison of U1 Old Dryer to U1 New Dryer			
3 Hour Average MSL Flows	Old Normalized Flow	New Normalized Flow	Old vs New % Chg
	12/30/2003 14:00 to	6/5/2005 14:00 to	
MSL	12/30/2003 17:00	6/5/2005 17:00	
A	1.027	1.023	0.40%
B	0.978	0.975	0.28%
C	0.993	0.995	-0.15%
D	1.002	1.007	-0.54%

Table 2

Comparison of U2 Old Dryer to U2 New Dryer			
3 Hour Average MSL Flows	Old Normalized Flow	New Normalized Flow	Old vs New % Chg
	8/11/2004 15:00 to	5/22/2005 3:00 to	
MSL	8/11/2004 18:00	5/22/2005 6:00	
A	1.028	1.033	-0.45%
B	0.986	0.987	-0.05%
C	0.970	0.959	1.12%
D	1.015	1.021	-0.57%

Vibration Measurements

Engineering Change (EC) Evaluation (EVAL) 355773, Revision 0, evaluated in detail, the data and results from the vibration data recorded on Unit 1. Presented below is an excerpt from the detailed evaluation:

> **Results**
> The data obtained from the power ascension to 2887 MWth has been assessed against the previously completed evaluations and no concerns were identified. Details of the evaluation are provided below. Previous recommended actions are tracked under AR 194877 and are not changed by this current evaluation.
>
> **Detailed Evaluation:**
>
> **Component Damage Summary (Quad Unit 1)**
>
> Walkdowns of MSL affected components were performed during the recently completed Q1R18 (April 2005) to identify any components that exhibited vibration induced degradation. These walkdowns were conducted even though the unit did not operate at EPU power levels since the original walkdowns in 2003. Several IRs were initiated as a result of these walkdowns, for general loose nuts and bolts. The results are documented by the station and will not be repeated here. The MSL drain tie-back supports were found significantly damaged (see IR 315403). A failure analysis by Power Labs determined that the failure was caused by the installation of the c-clamps used to mount the accelerometers at this location combined with the vibration levels. Actions and resolution for that issue can be found in the AR documentation.
>
> The minor discrepancies found on other components were attributed as the result of normal aging or were historical in nature.
>
> **Acceptability of ERV Component Operation at EPU Levels**
>
> The four ERVs have virtually identical assemblies and are identical to the Unit 2 assemblies, which consist of the main ERV valve body, pilot valve, and solenoid actuator. The pilot valve is connected to the ERV by means of a turnbuckle and a pilot valve tube. Each valve has small diameter leak off piping that is routed back to the ERV discharge line.
>
> Details of the testing and results can be found in the documentation package supporting modification EC 343933. It was determined through testing that an independent structural mode of the actuator plunger assembly was responding to input vibrations, causing premature wear degradation of the bushing, spring and guide rod assembly due to vibration in the frequency range of 70-90 Hz. The valve assemblies installed in Unit 1 were upgraded with hardened components of X750 material for bushings and guide rods and a modified spring, with chamfered edges. These components underwent testing prior to their use to ensure that they would perform at measured vibration levels without experiencing degradation. Comparison of the vibration values used for the modification evaluations are bounding for the Unit 1 measured values in the frequency bands of concern and therefore, these valves are acceptable for full EPU power operation, per Attachment 1.

Evaluation of HPCI 4 Valve Operator

Based on comparison of the current vibration data to the data evaluated under EC 348316, the Unit 2 values in EC 355702 and testing results in EC 350691, the original evaluation and testing remain bounding and there are no concerns for acceptable long term operation of this actuator and limit switch. The maximum measure grms value was in the x direction at 1.3924, from channel 25 at 930 MWe on Unit 2, which bounded the HPCI location from the original component assessments. From page 7, section 4.2.1 of Calc- QDC-0200-M-1392 the testing input used was a grms value of 3.9, which related to a plant input of 0.45 grms equated to 21567 hours of operation. For the measured 1.3924 grms this results in approximately 6970 hours of operation (or just over one year). However, since the principle component in this grms value was at the high frequency of 138 Hz, and no component response except some bolt loosening was seen after this duration, the Limitorque actuator is deemed acceptable for continuous full power operation. Also, the recommended inspections from EC 346515 (documented under ATI 194877-33) will ensure that loosened connections are detected so that appropriate repairs can be made, each outage until sufficient experience allows for extension. The next performance of this inspection on Unit 1 will occur during Q1R19 in Spring 2007.

Evaluation of MSIVs

Comparison of the current measured vibration levels at the B & C ERVs indicates that the original assessment of the MSIV acceptability in EC 346515 for the B, A & D MSIVs remains bounding. For the C MSIV, the currently measured C ERV data is significantly less that the data taken in 2003 with grms value of 1.1007 versus the 2003 grms value of 4.16. Although this value remains higher than the other ERVs, it makes the extrapolation to the MSIV, by reduction factor of 3, produce a value of 0.333 grms. This places the values well below the values from the seismic aging test results used to evaluate these valves in EC 346515. Therefore all MSIVs are considered acceptable, and no further corrective actions are required. Inspections already developed in response to EC 346515 remain as recommendations. The only exception is the need to monitor the C MSIV with accelerometers, which is no longer a requirement.

Evaluation of Target Rock Valves

The Target Rock valve is evaluated in Attachment 1 and comparison to the original evaluation by comparing the measured data to the testing input values documented in EC 350693. Since the frequency domain of concern for valve response is between 20 – 100 HZ and the increased vibration response seen was in the domain of 100 – 200 Hz, there is no concern for long-term acceptability of the modified valve configuration. The hardened upgraded components were used in the replacement value installed during this outage Q1M03.

Conclusions / Findings:

This EC EVAL provides an Engineering Evaluation of MSL components supporting operation up to 2957 MWth. It has been determined that this full EPU power operation will not result in imminent failure or unacceptable degradation levels of any components. The conclusion is provided by evaluation of the measured vibration data, previous evaluations and test reports from laboratory testing.

Small-Bore Piping/Feedwater Sample Probes:

During Unit 1 startup, measuring local vibration data assessed small-bore piping. Vibration data was taken on small bore piping for Feedwater pump suction relief valves and discharge drain lines, Feedwater Reg. Station vents and drains, and HPCI Local Leak Rate Test (LLRT) line. The results were compared to acceptance criteria that was developed based on Exelon Corporation Nuclear Engineering Standard NES-MS-03-04, which utilizes a conservative Electric Power Research Institute (EPRI) model. All locations were satisfactory except for line 1-3417B-1", Feedwater Suction Isolation Bypass Line. The maximum allowable velocity amplitude is 2.70 in/sec and the measured resultant velocity was 2.75 in/sec (exceeds by less than 2%). This is documented in IR 341151. EC 355944, Revision 0, and Action Tracking Item 341151-02 will document the acceptability of the measured vibration levels.

Dresden Condition Report (CR) 190413 generated on 12/12/03 identified a Feedwater sample probe found missing. The probe in question had previously failed and was replaced in 2001 with a new probe designed per GE Service Information Letter (SIL) 257, which was supposed to fix the problem. Pieces of the probe were found in the feedwater sparger. Quad Cities CR 190513 reviewed the Dresden issue and an Operability Determination was performed even though there was no evidence of the probes breaking at Quad Cities. At subsequent outages, inspections were performed and probes were found to be intact. However, Quad Cities performed similar actions as Dresden. The Feedwater sample probe, 1-0632, was cut out and replaced with a new shorter probe design under Work Order (WO) 00689963. The old probe was inspected and found to be in good condition with 100% of the length intact and no indication of cracking or loss of material to the Reactor vessel. A new probe that is approximately 2" in length as compared to 13" for the old probe was installed. Similar results and actions were performed on Unit 2 under WO 00658382. These actions were performed during Q1R18 and Q2R17.

Operational Issues With Plant Systems/Components:

LLRT of the Drywell Personnel Hatch (X-2)

During startup of the units, operational issues were observed on the Drywell Personnel Hatch Local Leak Rate Test (LLRT) on Unit 1. The issue was documented on Issue Reports (IR) 340591 and IR 340898. Unit 1 Drywell Airlock X-2 Local Leak rate test (LLRT) per QCTS 600-04 exceeded TS (section 5.5.12 d.2.) admin Limit of 22.88 standard cubic feet per hour (scfh) with an indicated leakage of 50.81 scfh. Post-test investigation identified a leak within the test equipment. A retest was re-performed with different test equipment, however, the results still were not acceptable. Initially, a post-test visual inspection of the door gaskets, hand wheels and equalization valves failed to indicate any obvious sources for the indicated leakage. A detailed post-test visual inspection of the door gaskets after the second failed test identified that the inner door gasket had taken a significant permanent set in an area that also had a 6 inch tear outside but parallel the seal area. When closed, each doorframe has one gasket that gets depressed by the doors blunt knife-edge. The Vendor (VETIP) manual C0058 section 2.5.5 states, "The permanent set will increase with time until the door will no longer maintain a pressure tight seal. At this time the gasket will have to be replaced. The expected life of the gasket is a minimum of six months". A formal Apparent Cause Evaluation (ACE) is underway. Final corrective actions will be determined by the ACE, however, these actions will probably include a preventative maintenance predefine to replace the gasket on a periodic basis.

EHC Scram

On 06/17/05 at 1120, the Unit 1 reactor automatically scrammed from 85% power due to a valid high reactor pressure signal. This event is documented under IR 345152 and a formal root cause investigation is in progress. The maximum reactor pressure was approximately 1044 psig during the event. All control rods inserted to their full-in position. Initial indications are that the reactor pressure increase was caused by a malfunction of the Electro-Hydraulic Control (EHC) system, which resulted in closure of the main turbine control valves. The main turbine bypass valves (nine) opened as expected in response to the pressure increase. No reactor pressure vessel safety or relief valves were required to actuate during the event. Reactor water level decreased to approximately -20 inches, which resulted in automatic Group 2 and 3 isolations as expected. All systems responded properly to the event. A troubleshooting team was assembled to investigate and correct the cause of the event.

Initial corrective actions included the replacement of the circuit boards associated with the three low value gate circuits used in the control valve demand circuit.

(A) Control Valve Amplifier (Circuit Board A48) and Operational Amplifier (Circuit Board A49)
(B) Load Limit (Circuit Board A33) and Operational Amplifier (Circuit Board A34)
(C) Pressure Load Gate Amplifier (Circuit Board A58) and Operational Amplifier (Circuit Board A59)

In addition, there is increased monitoring of the control valve demand circuit. Included in this monitoring is the output of the load limit circuit and the control valve amplifiers. This will provide information on which of the low value gates is in control of the control valve demand signal in the event that this occurs again.

Valve 1-3508B, 1B Moisture Separator Drain Tank (MSDT) to 1D2 Heater Normal Level Control Valve (LCV), stuck greater than 33% open

During the placement of the feedwater (FW) heaters into operation, it was discovered that the 1-3508-B valve is stuck approximately 33% open. The governing procedure (QCOP 3500-02) requires the MSDT normal LCV's to be verified closed prior to unisolating LCV's. This event delayed startup on Unit 1 for six hours while the issue was investigated. It was determined that the startup could continue and the valve will be repaired at the next outage of sufficient duration. The valve is needed to stay nearly full open during normal operation and therefore it being unable to close down below 33% will have no operation impact. The valve will be repaired under Work Order (WO) 00817173.

Overall plant and system performance from personnel interviews and walkdowns

On Unit 1, at TC 15, 2888 MWt (97.6%), locally recorded data was obtained on various ventilation temperatures and area temperatures in the plant. All readings were acceptable except the Exhaust Air Temperature from the Reactor Feed Pump Motors. The acceptance criterion was 130 deg F and the 1A and 1C Reactor Feed Pump Motor Exhaust temperatures were 132 deg F. The procedure directed notification to the System Manager. The System Manager proposed this criterion to stay below the alarm point of 135 deg F, which was still met. At the present time, actions are underway under IR 348700 to improve the effectiveness of the turbine building ventilation system.

A shift manager made the following statement concerning his observations when Unit 2 was operating at the maximum thermal power:

> "I was on shift during the time U-2 was at 930 MWe and walked down some of the systems I was most concerned about. I am more concerned with the secondary side of the steam plant such as feedwater heating, equipment vibrations etc. more so than the reactor side. I was pleased to see that there were very few concerns identified while at the elevated power. I noted the areas of concern in my parameter review below. The point I tried to make with the flash tanks, is that they are very near full open, but they are still controlling. They are not max'd out. When U-1 was at a higher power (in the past) it seemed to have more problems with vibration and noise so I'll reserve comment on it until I see how it performs. It also remains to be seen how we will cope with the higher power levels when ambient is in the upper 90's and the river is hot, but we are off to a pretty good start. I have been an operator here at Quad since the early 80's when we had ALOT of vibration issues and recall them well. We certainly don't want to go back to those days. My crew and I are optimistic after seeing U-2 at 930 MWe."

The following is a statement made by the Operations Manager:

> "Several things have happened recently to mitigate a large portion of the "uncomfortable" feeling on the part of some Operators. The EPU technical forums allowed them to ask any and all questions related to EPU issues. We made sure that they all had access to the presentations or submitted written questions. Tapes of the forums were run on the ready room TV. They were given clear answers, including "we don't know, but this is how we are going to use the instrumentation to validate our design models". That kind of straightforwardness helped. Several Operators took the opportunity to look at the dryer while it was at JT Cullen. The structure is impressive. The test program was clearly communicated, and the fact that we did what we said, i.e. backed the unit down to within SG #7 criteria (we updated the instrumentation graphs for the control room crews shiftly) showed we have a clear plan. Finally, the fact that the Unit is relatively well behaved right now gives a measure of comfort. "

Attachment 1
Unit 1 Startup Testing Timeline

05/28/2005 00:01 -	Unit 1 is shutdown for Q1M18 to install its new steam dryer.
06/01/2005 17:35 -	Temporary/Interim Changes (TIC) procedure TIC-1252, Quad Cities Unit 1 Power Ascension Test Procedure for the Reactor Vessel Steam Dryer Replacement has all prerequisites complete.
06/02/2005 03:00 -	At Test Condition (TC) 1, Main Steam Line (MSL) strain gauges S6, S11A, and S31 are determined to be non-functional. This is documented in Issue Report (IR) 340618. In addition, recorder channels #1 (pair S1/S3) and #4 (pair S6/S6A) could not be balanced. Troubleshooting is being initiated to get the channels balanced.
06/02/2005 09:30 -	Unit 1 is synchronized to the grid, ending Q1M18.
06/02/2005 11:00 -	After discussions with Yokogawa and Hi-Tec (strain gauge supplier) appropriate resistors are added to balance the troublesome strain gauges. As documented above, main steam line strain gauge S-6 is determined to have failed.
06/03/2005 14:05 -	At TC 5, at 1768 MWt (59.8%), MSL strain gauge S-36 was determined to have failed. This is documented in IR 340929.
06/03/2005 18:05 -	At TC 8, at 2225 MWt (75.2%), MSL strain gauge data is taken.
06/03/2005 21:35 -	At TC 8, at 2225 MWt (75.2%), a Moisture Carryover Sample is taken. The results were later determined to be 0.003%
06/04/2005 00:04 -	At TC 9, at 2414 MWt (81.6%), MSL strain gauge S-3 was determined to have failed. This is documented in IR 340929.
06/04/2005 00:58 -	At TC 10, at 2508 MWt (84.8%), MSL strain gauge data is taken.
06/04/2005 05:35 -	At TC 10, at 2508 MWt (84.8%), a Moisture Carryover (MCO) sample is taken. The results were later determined to be 0.013%.
06/04/2005 05:45 -	The results of the analysis of the MSL strain gauge data indicates that strain gauge pair S32/S34 on C MSL at elevation 651', exceeded the "peak-to-peak" Level 1 acceptance criteria. Per TIC-1252 Section 5.1.1.1, the unit will be placed in a known safe condition based on prior testing. This issue is documented in IR 340961. At Test Condition 9, all data was evaluated as acceptable. Therefore, the unit is being taken to TC 9, 2410 MWt (81.5%) until a formal analysis can be completed.

Attachment 1

Unit 1 Startup Testing Timeline

06/04/2005 06:32 - Began to decrease Unit 1 power to 2410 MWt (81.5%) where all testing data was found to be acceptable.

06/04/2005 06:50 - Holding Unit 1 power at 2410 MWt (81.5%) 750 MWe.

06/04/2005 14:00 - A conference call with the NRC (Region III and NRR) is held at this power level to discuss the data taken and planned actions for the continued power ascension. It is decided that another update will be provided to the NRC on 06/05/2005.

06/05/2005 01:30 - The results have been received from the acoustic circuit analysis of data taken at TC 10, 2508 MWt (84.8%). The results, which are predicted dryer peak-to-peak pressures compared to actual corresponding values measured on Unit 2, showed that level 2 criteria was not met. This is documented in IR 341056.

06/05/2005 06:00 - A PORC is held to discuss the data taken up to this point in the startup and to approve TIC-1261. This revision to the startup test procedure allows power ascension above 2410 MWt (81.5%) for up to 12 hours to allow data to be recorded at the maximum power level achievable. The procedure change is supported by Engineering Change (EC) 355836, Revision 0.

06/05/2005 09:00 - A conference call with the NRC (Region III and NRR) is held at this power level to discuss the data taken and planned actions for the continued power ascension.

06/05/2005 10:08 - Beginning a Unit 1 power increase to above 2511 MWt (84.9%).

06/05/2005 10:15 - Power is increased above 2511 MWt (84.9%).

06/05/2005 10:24 - Holding Unit 1 power at TC 11, 2651 MWt (89.7%) 823 MWe.

06/05/2005 13:48 - Holding Unit 1 power at TC 15, 2887 MWt (97.6%) 910 MWe.

06/05/2005 14:00 - Drywell accelerometer data was taken on Main Steam Line Relief Valves. Structural Evaluation EC 355773, Revision 0, reviewed all the data taken during the startup testing and the EC concludes, "full EPU power operation will not result in imminent failure or unacceptable degradation levels of any components. The conclusion is provided by evaluation of the measured vibration data, previous evaluations and test reports from laboratory testing."

06/05/2005 14:40 - At TC 15, 2887 MWt (97.6%), vibration data was taken on small bore piping for Feedwater pump suction relief valves and discharge drain lines, Feedwater Reg. Station vents and drains, and

HPCI Local Leak Rate Test (LLRT) line. All locations were satisfactory except for line 1-3417B-1", Feedwater Suction Isolation Bypass Line. This is documented in IR 341151. EC 355944, Revision 0, and Action Tracking Item 341151-02 will document the acceptability of the measured vibration levels.

06/05/2005 15:00 - At TC 15, 2888 MWt (97.6%), locally recorded data was obtained on various ventilation temperatures and area temperatures in the plant. All readings were acceptable except the Exhaust Air Temperature from the Reactor Feed Pump Motors. The acceptance criterion was 130 deg F and the 1A and 1C Reactor Feed Pump Motor Exhaust temperatures were 132 deg F. The procedure directed notification to the System Manager. The System Manager proposed this criterion to stay below the alarm point of 135 deg F, which was still met. At the present time, actions are underway under IR 348700 to improve the effectiveness of the turbine building ventilation system.

06/05/2005 16:00 - At TC 15, at 2887 MWt (97.6%), a Moisture Carryover (MCO) sample is taken. The results were later determined to be 0.017%.

06/05/2005 17:17 - Within TC 15, power is increased to 2900 MWt (98.1%), 920 MWe. The power ramp is limited by Main Generator limitations at 920 MWe and MVAR limitations of the grid.

06/05/2005 17:32 - All necessary data has been obtained and a power reduction is begun.

06/05/2005 18:04 - Holding Unit 1 power at 2410 MWt (81.5%).

06/08/2005 07:00 - Power level on Unit 1 is raised to 2511 MWt (84.9%) based upon EC 355874, Revision 0.

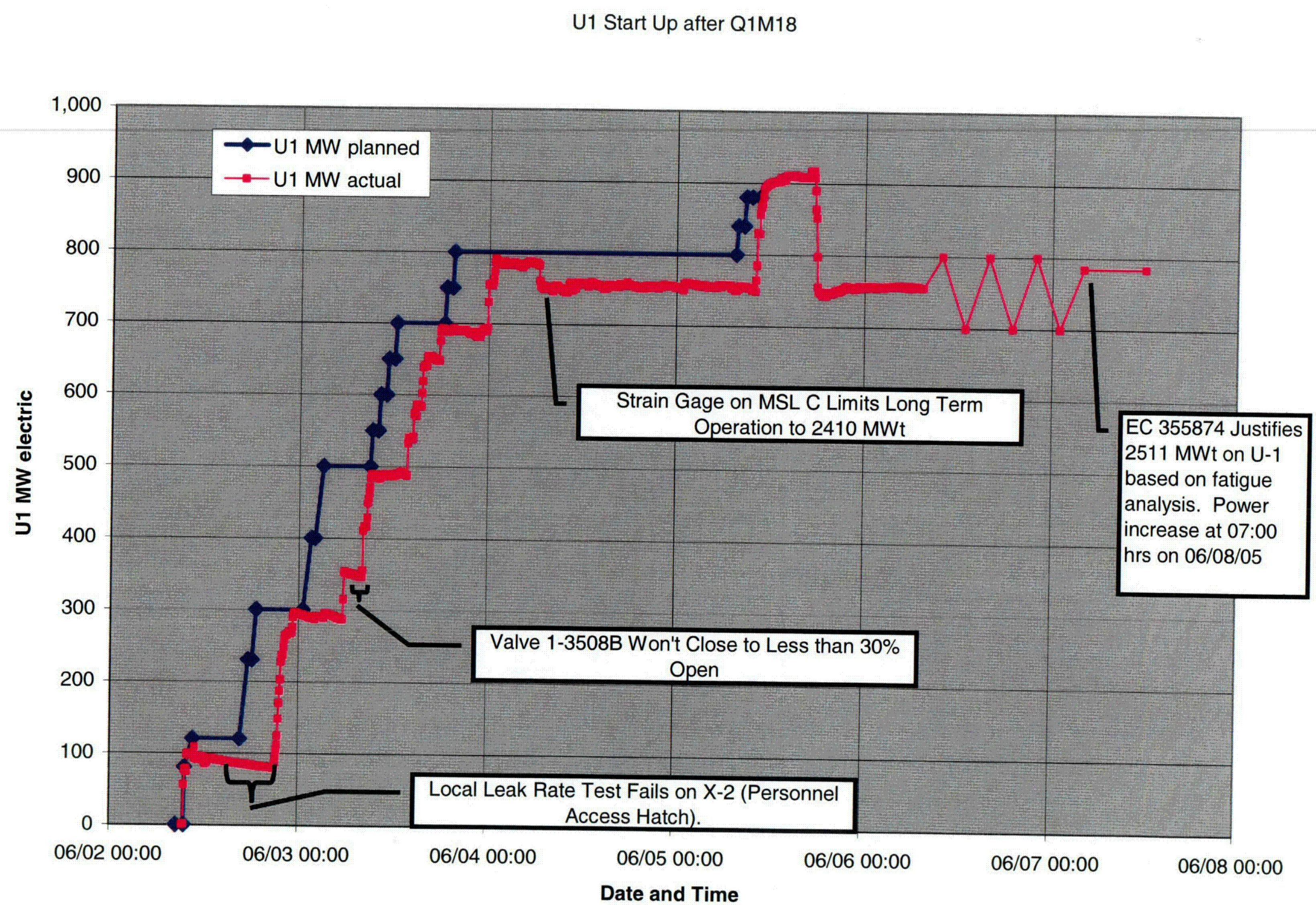
06/17/2005 11:20 - Unit 1 scrammed from 2511 MWt (84.9%) due to a failure of an Electro-Hydraulic Control (EHC) card unrelated to the steam dryer and unrelated to EPU. During the subsequent forced outage, an attempt was made to repair the failed MSL strain gauges.

06/19/2005 17:00 - Temporary/Interim Changes (TIC) procedure TIC-1263, Quad Cities Unit 1 Power Ascension Test Procedure for the Reactor Vessel Steam Dryer Replacement has all prerequisites complete. This version of the startup test procedure will re-perform test conditions 10 through 15. EC 355976, Revision 0, supported testing up to full EPU power level for the purpose of recording data. At this time, data is taken for TC 10, 2511 MWt (84.9%). At

	TC 10, strain gauge pairs S1/S3, S32/S34, and S36/S36A would not balance. IR 345443 documents the condition.
06/19/2005 18:41 -	At TC 11, 2657 MWt (89.9%), strain gauge pair S37/S39 would not balance. IR 345443 documents the condition.
06/19/2005 21:02 -	Achieved TC 13, 2902 MWt (98.1%). Power was limited to this power level due to main generator limitations. Data analysis taken at this power level determined that strain gauge S-31 had failed. Data analysis from Q1F54 startup determined that, due to the number of lost strain gauges on MSL C, an acoustic circuit load definition could not be performed. The data from "B" MSL and remaining pairs on "A" and "D" MSLs were used for comparison purposes and presented to the NRC Staff on June 30, 2005.
07/26/2005 10:00	A conference call was held with the NRC Technical Staff, NRR, and the Region to discuss plans to raise Unit 1 to 2642 MWt based upon finite element analysis of data that was gathered at TC 11 on June 5, 2005, during the initial startup with the new dryer.
07/26/2005 12:40	Power was raised to 2642 MWt after EC 356409, Revision 0, authorized operation at 2642 MWt (89.3%). Unit 1 is expected to remain at 2642 MWt until an alternate analysis can be completed in which it is demonstrated that the steam dryer loads are acceptable at full rated power of 2957 MWt.

Figure 1

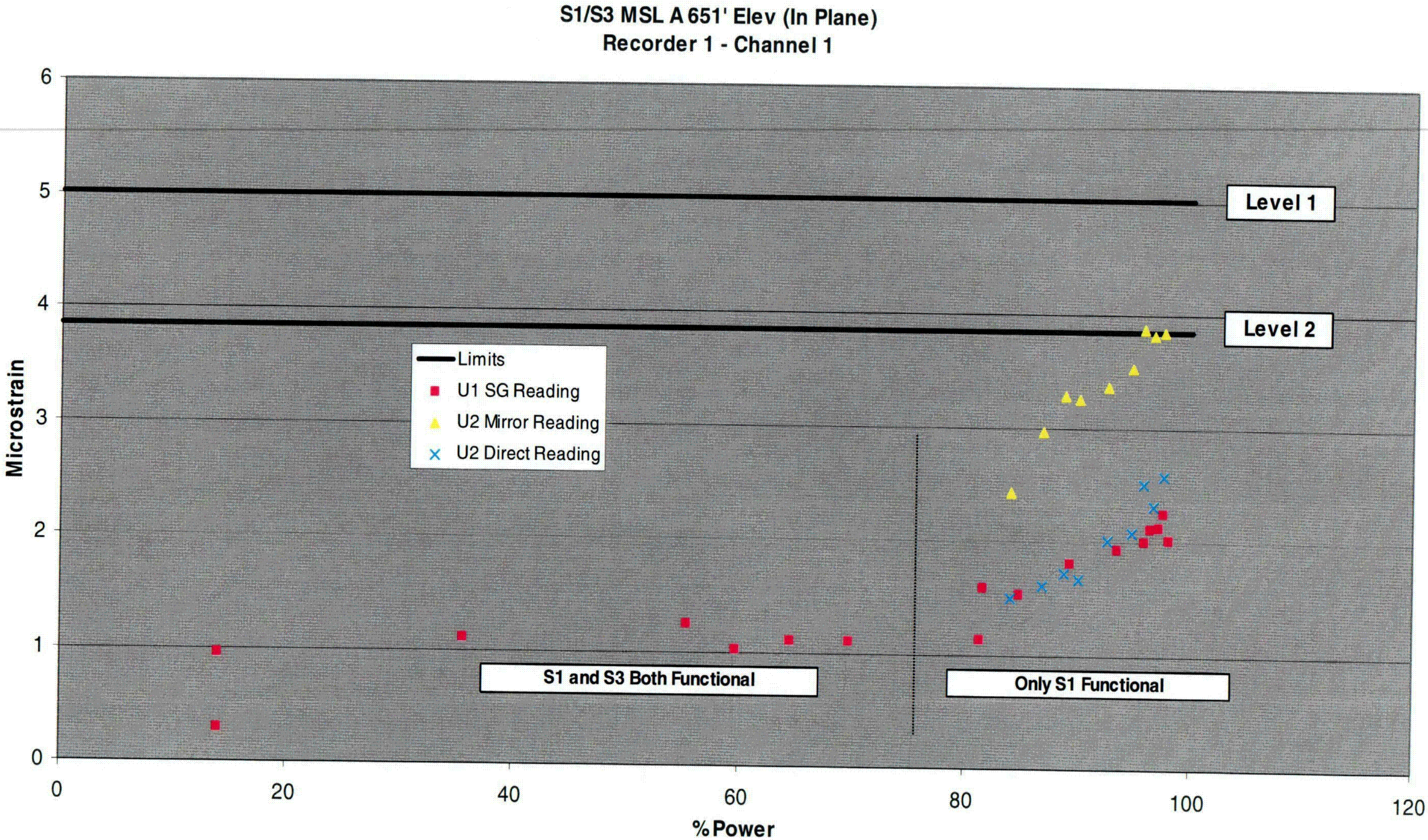
Unit 1 Startup Results



C01

Figure 2

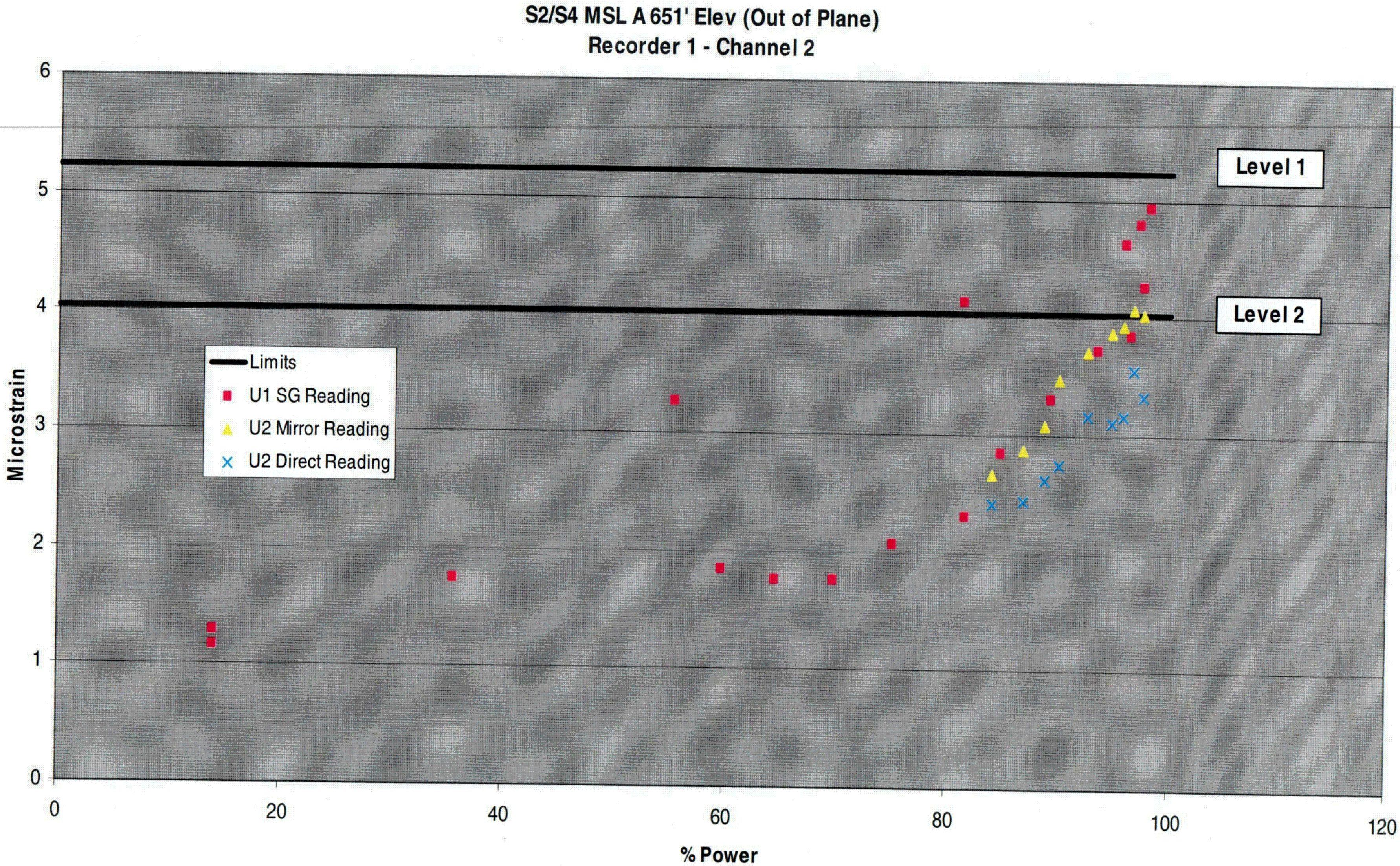
Unit 1 Startup Results



C02

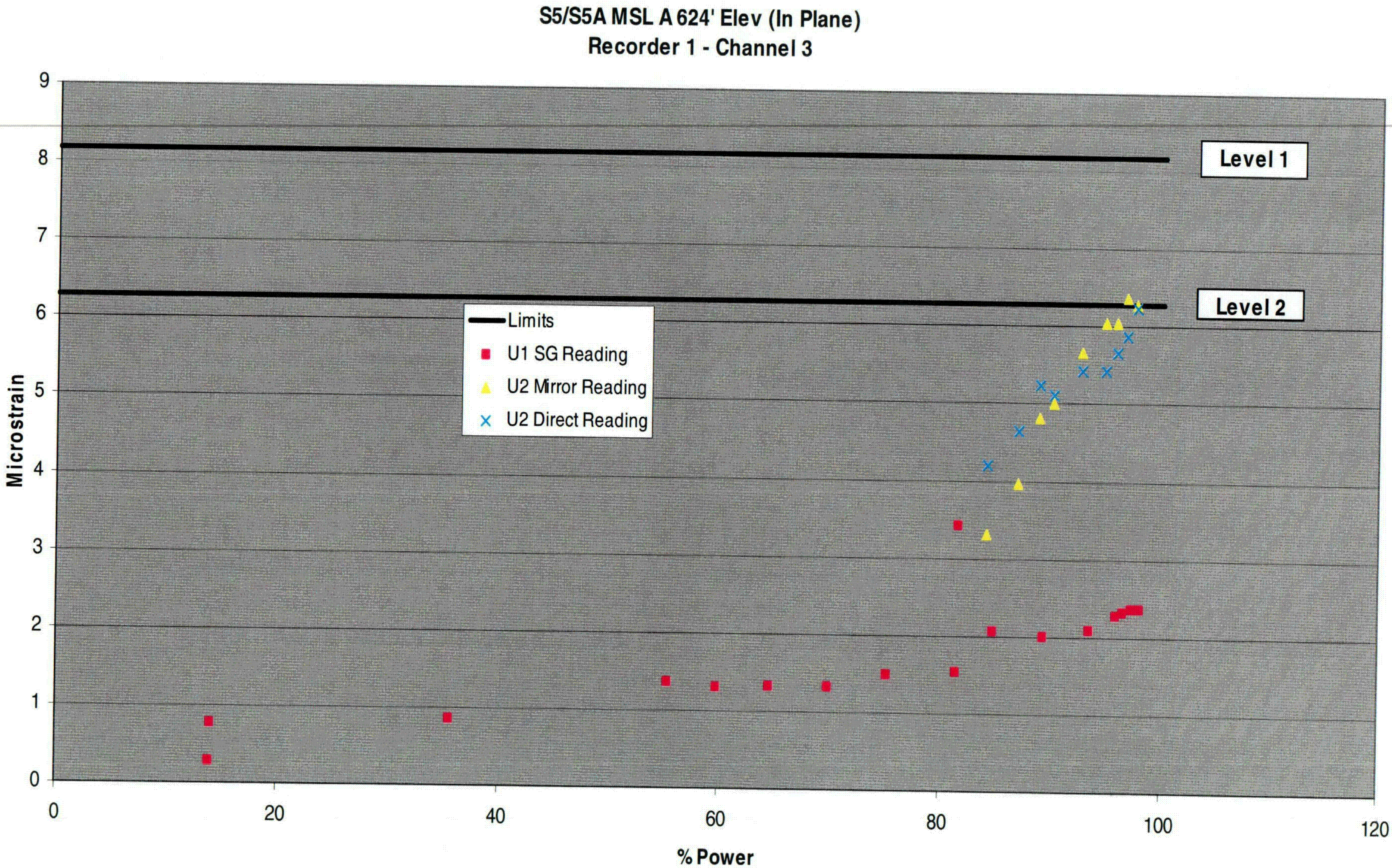
Figure 3

Unit 1 Startup Results



C03

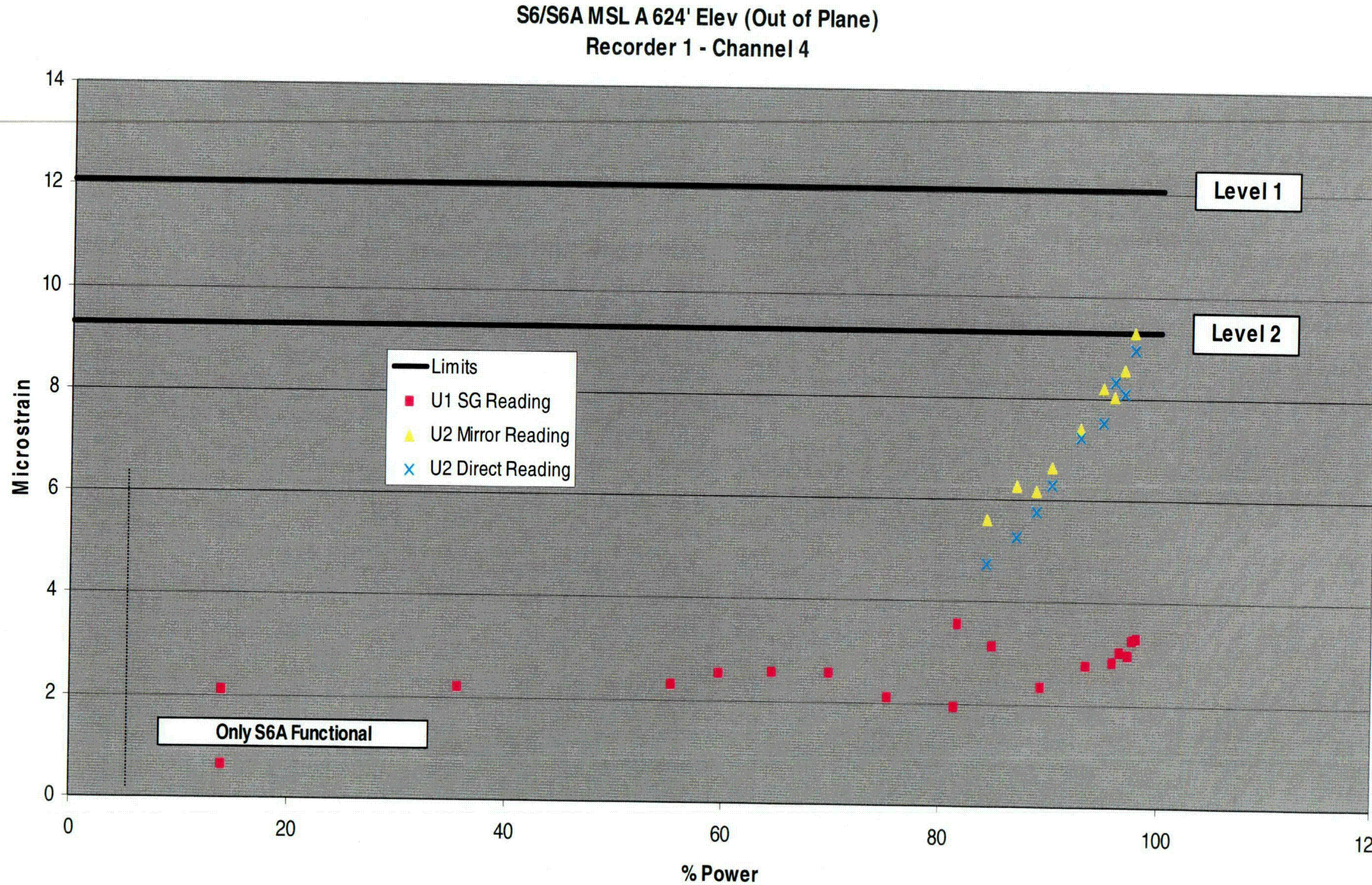
Figure 4


S5/S5A MSL A 624' Elev (In Plane)
Recorder 1 - Channel 3
Microstrain
% Power
0
1
2
3
4
5
6
7
8
9
0
20
40
60
80
100
120
Level 1
Level 2
Limits
U1 SG Reading
U2 Mirror Reading
U2 Direct Reading

C04

Figure 5

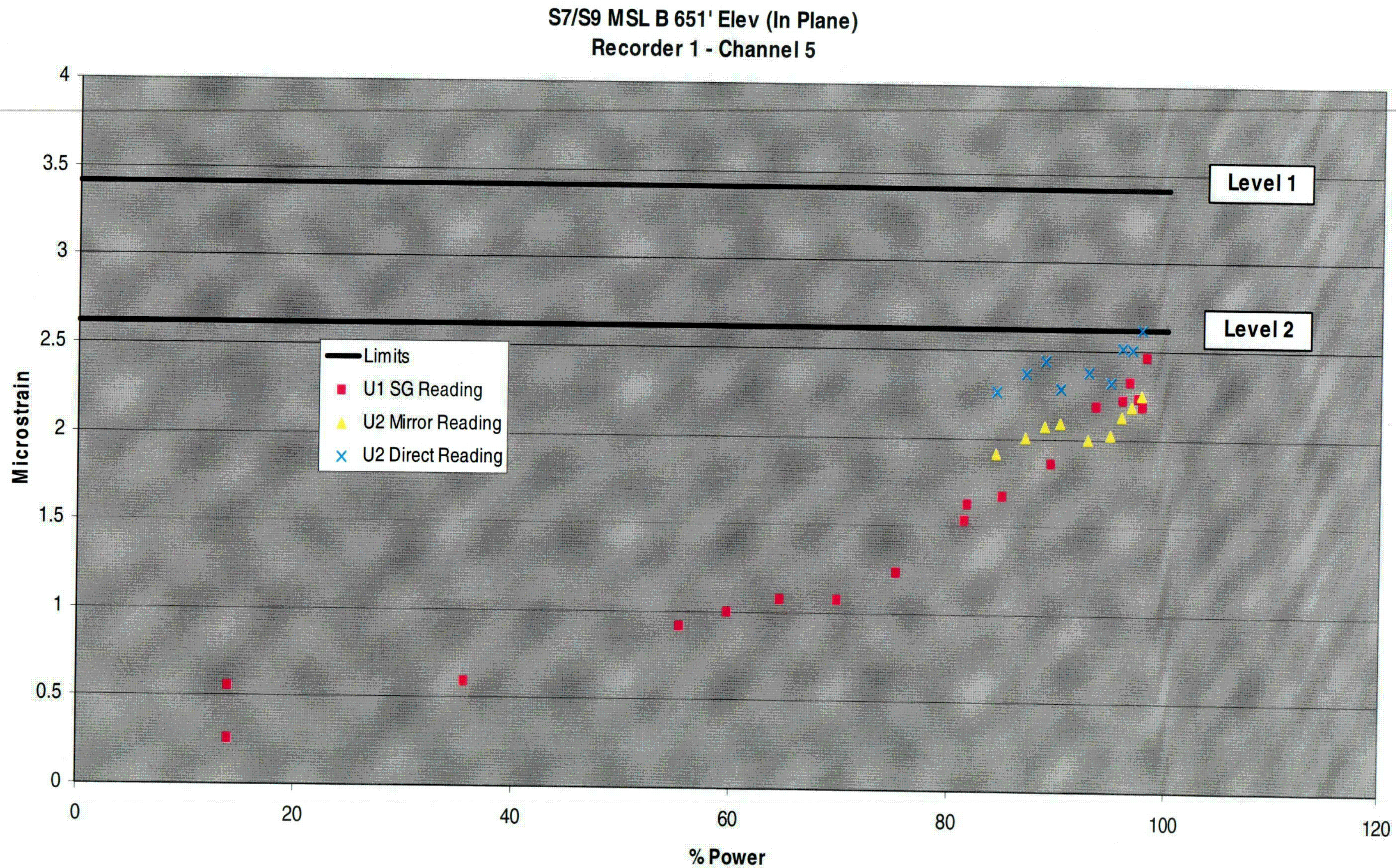
Unit 1 Startup Results



C05

Figure 6

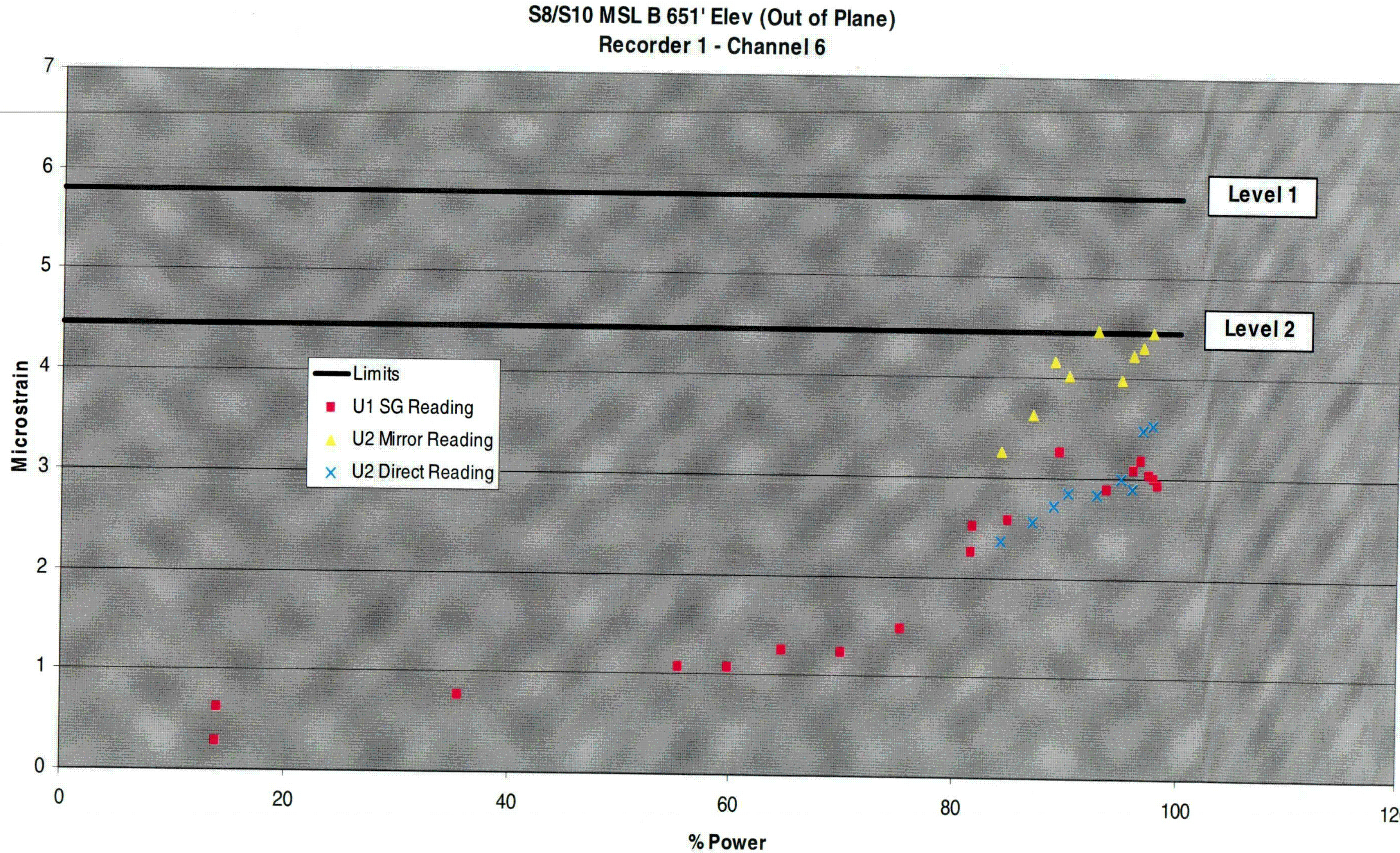
Unit 1 Startup Results



C06

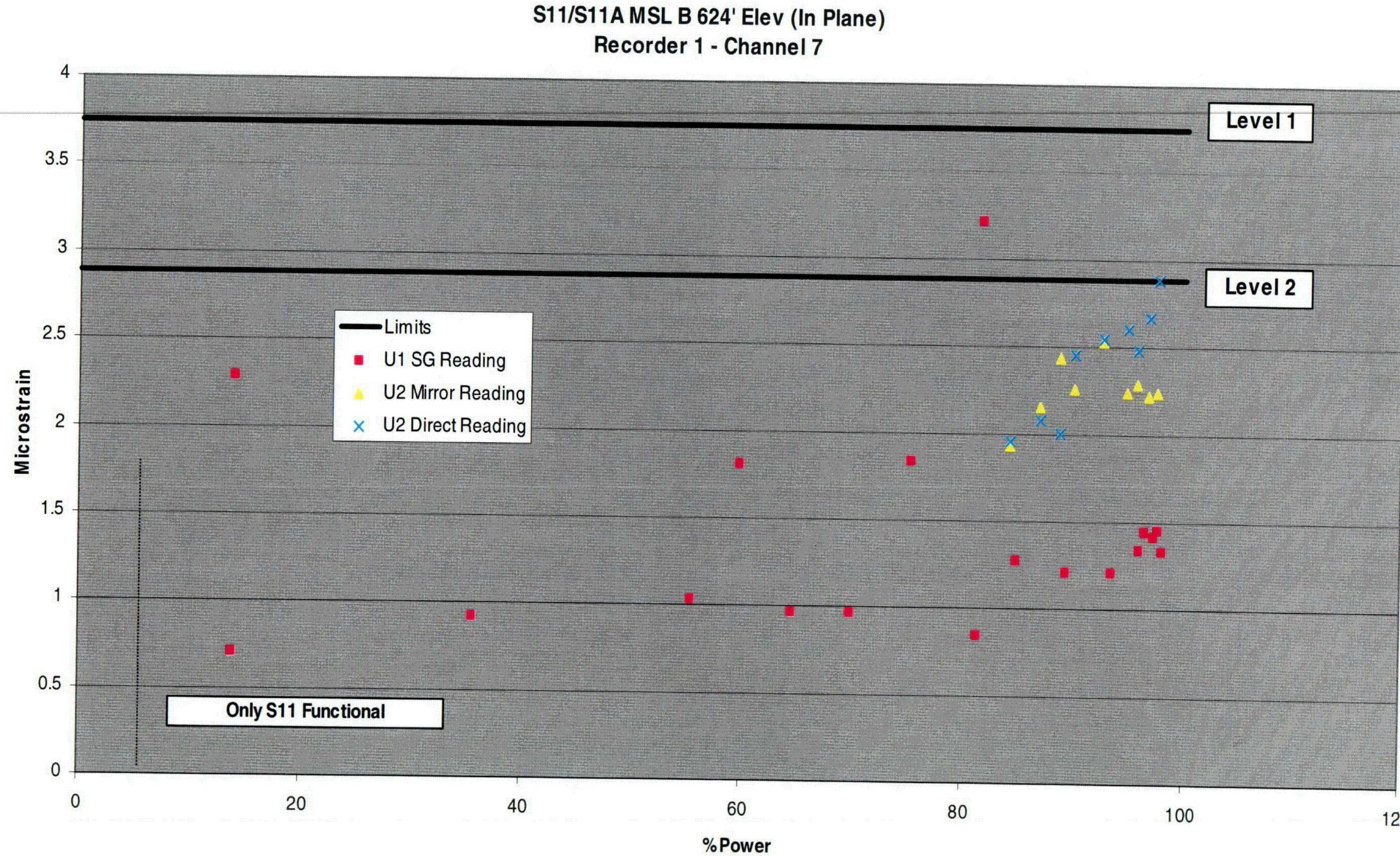
Figure 7

Unit 1 Startup Results



C07

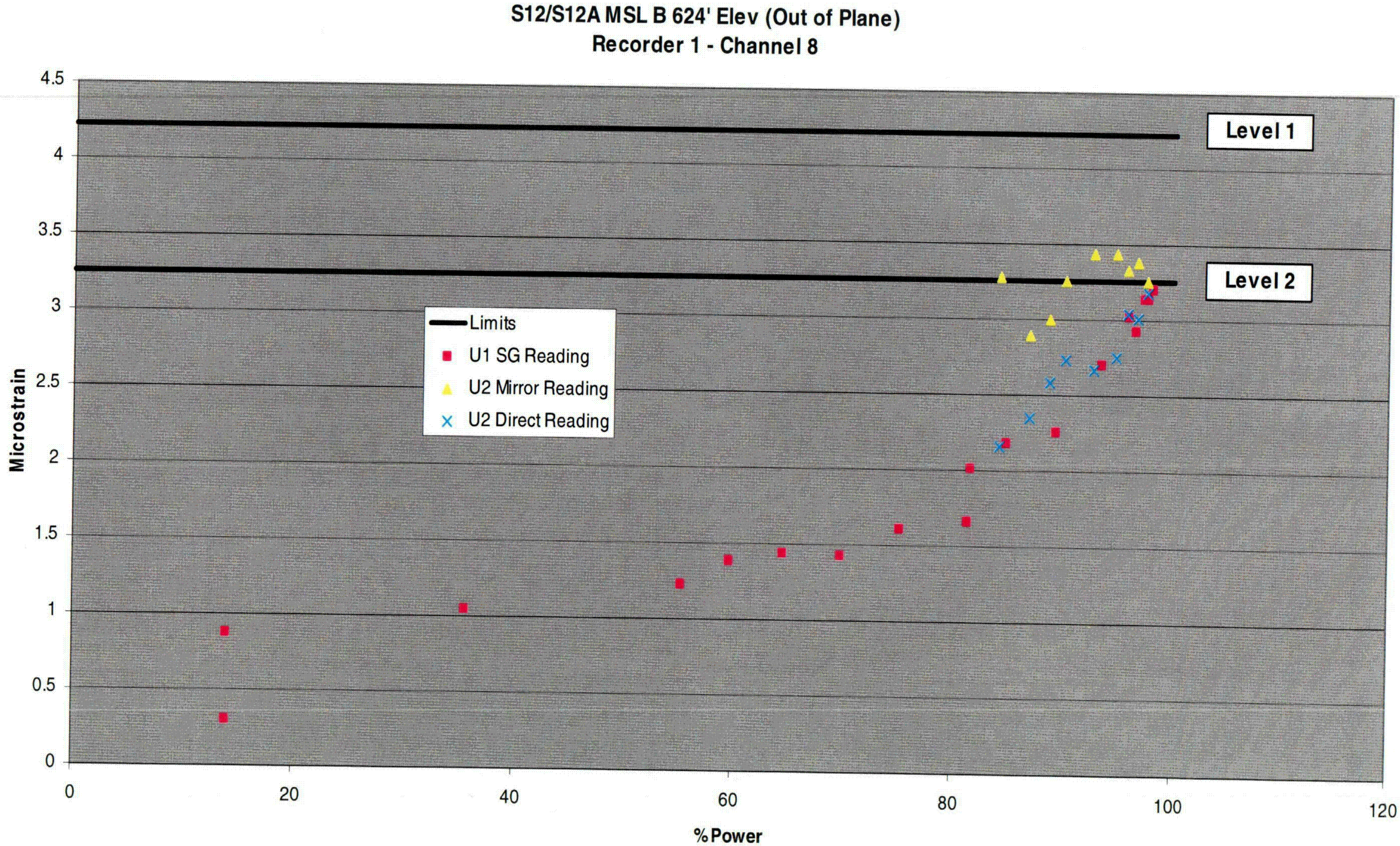
Figure 8


S11/S11A MSL B 624' Elev (In Plane)
Recorder 1 - Channel 7
Microstrain
%Power
0
0.5
1
1.5
2
2.5
3
3.5
4
0
20
40
60
80
100
120
Level 1
Level 2
Limits
U1 SG Reading
U2 Mirror Reading
U2 Direct Reading
Only S11 Functional

C08

Figure 9

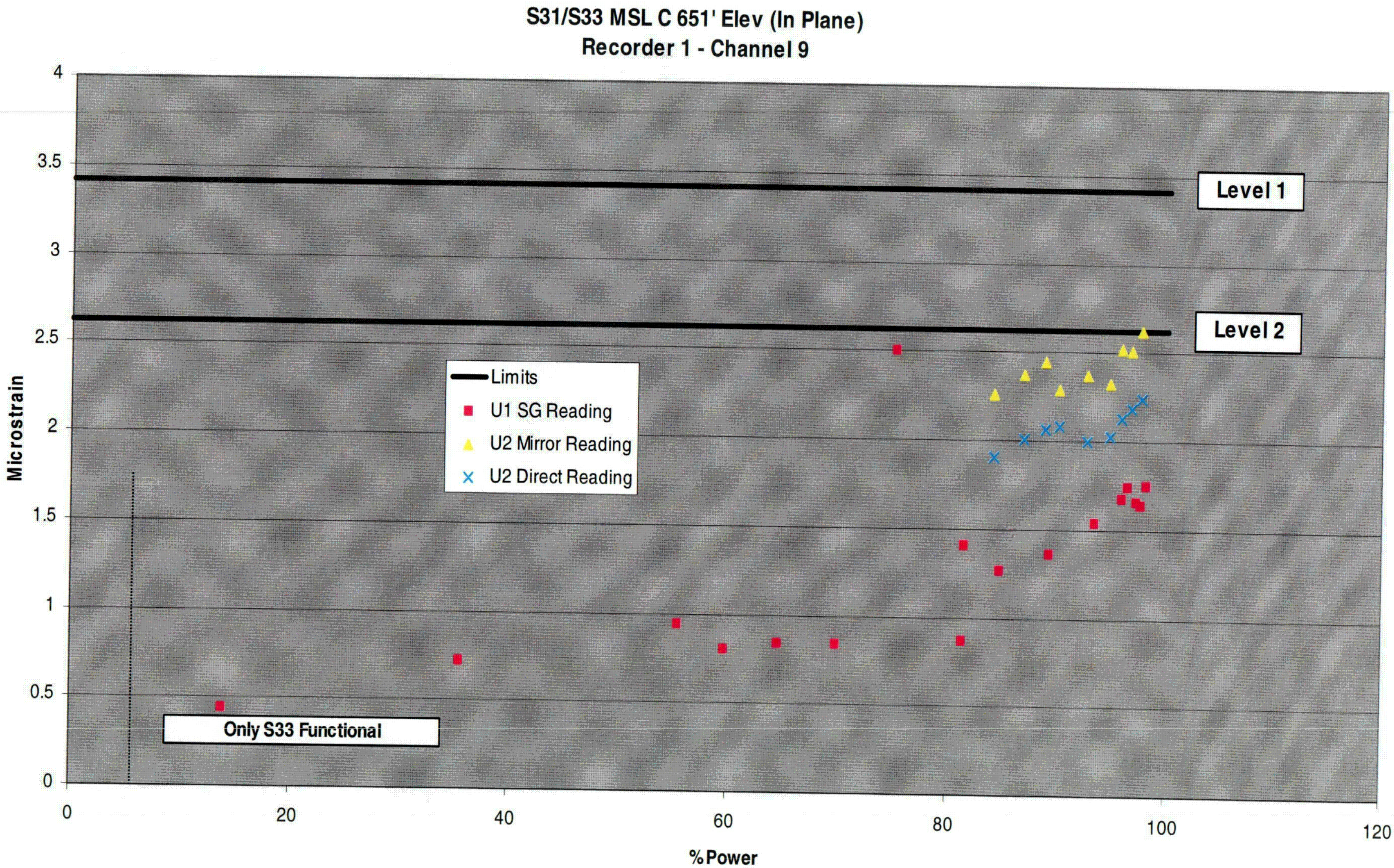
Unit 1 Startup Results



C09

Figure 10

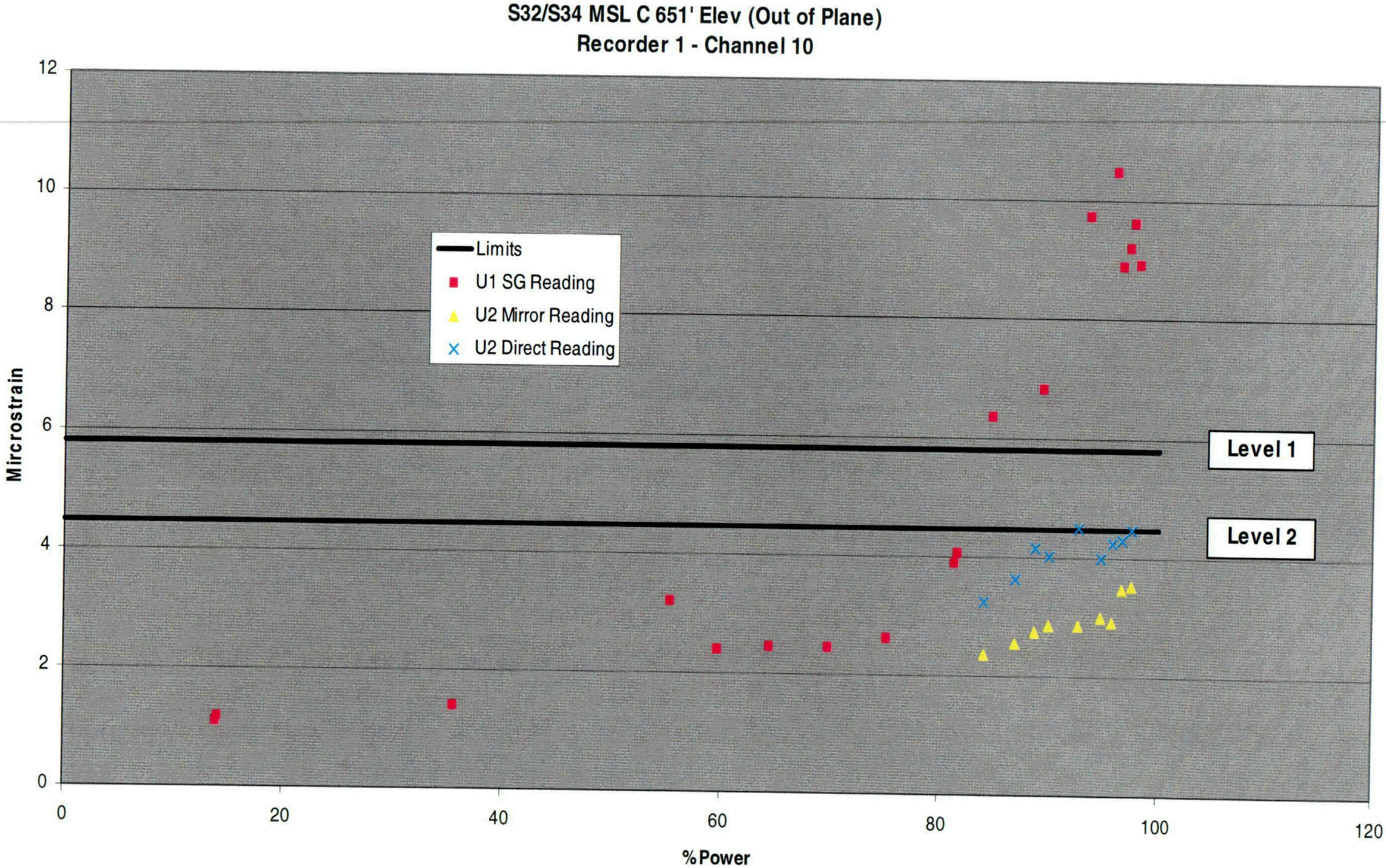
Unit 1 Startup Results



C10

Figure 11

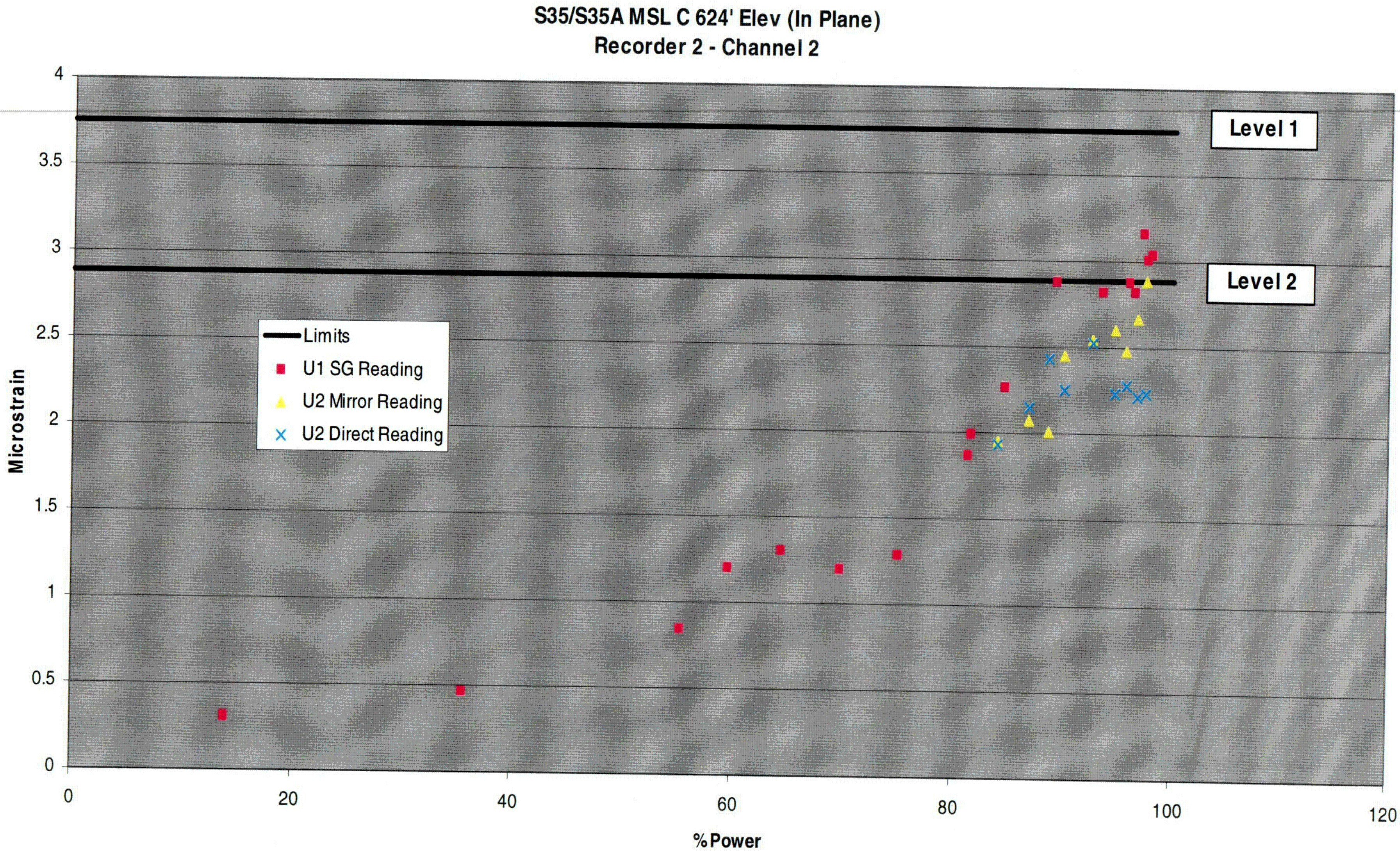
Unit 1 Startup Results



C11

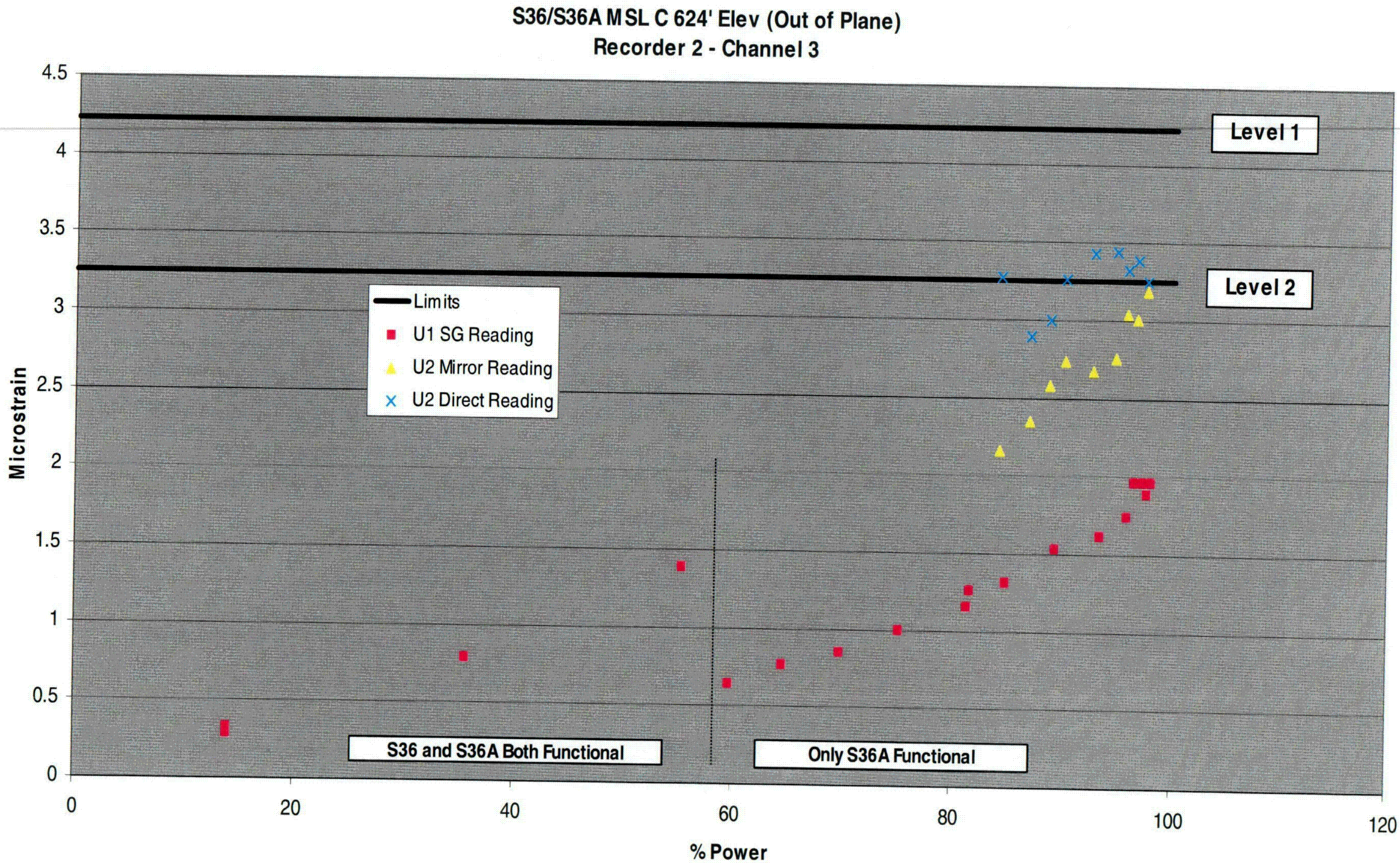
Figure 12

Unit 1 Startup Results



C12

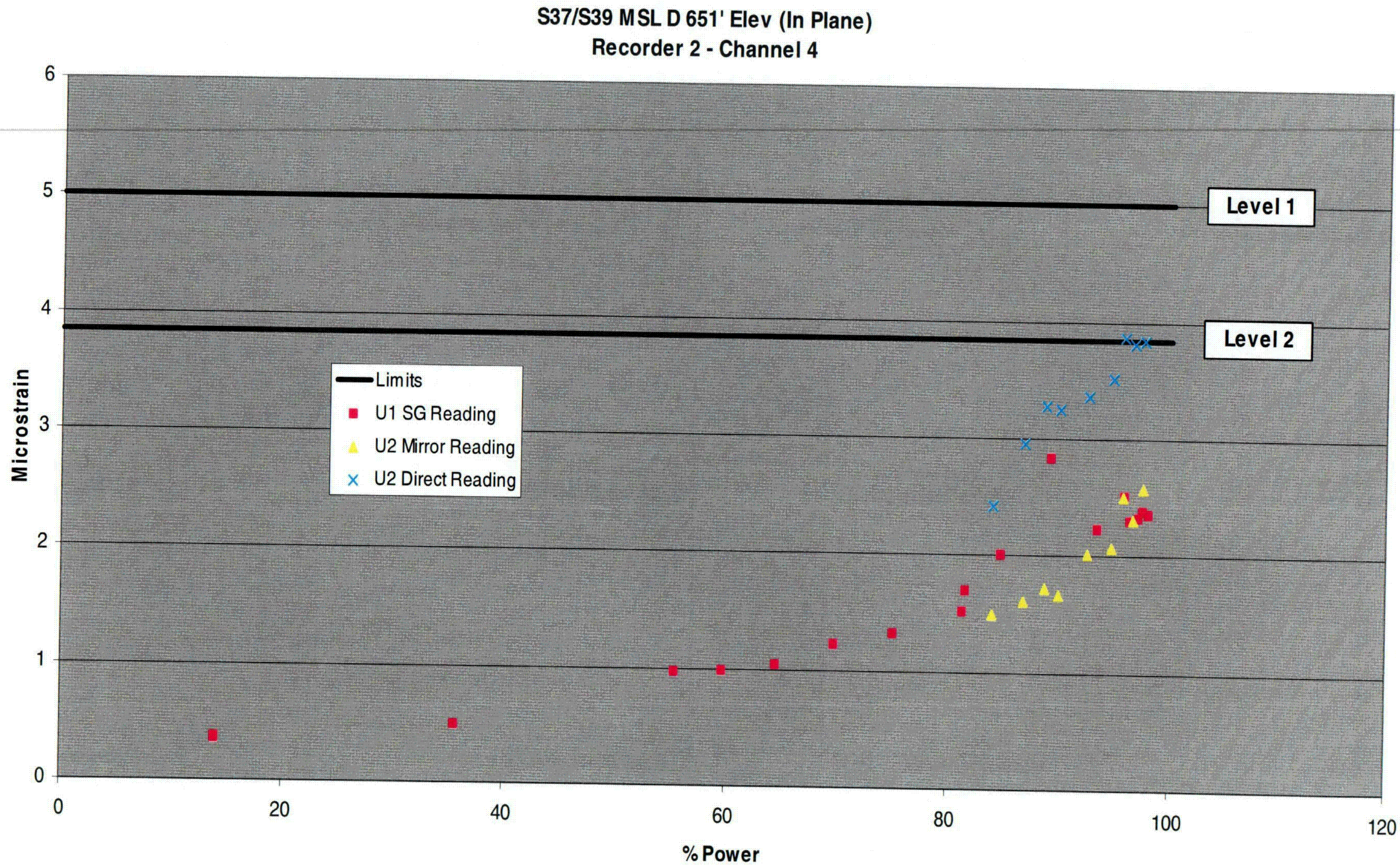
Figure 13



C13

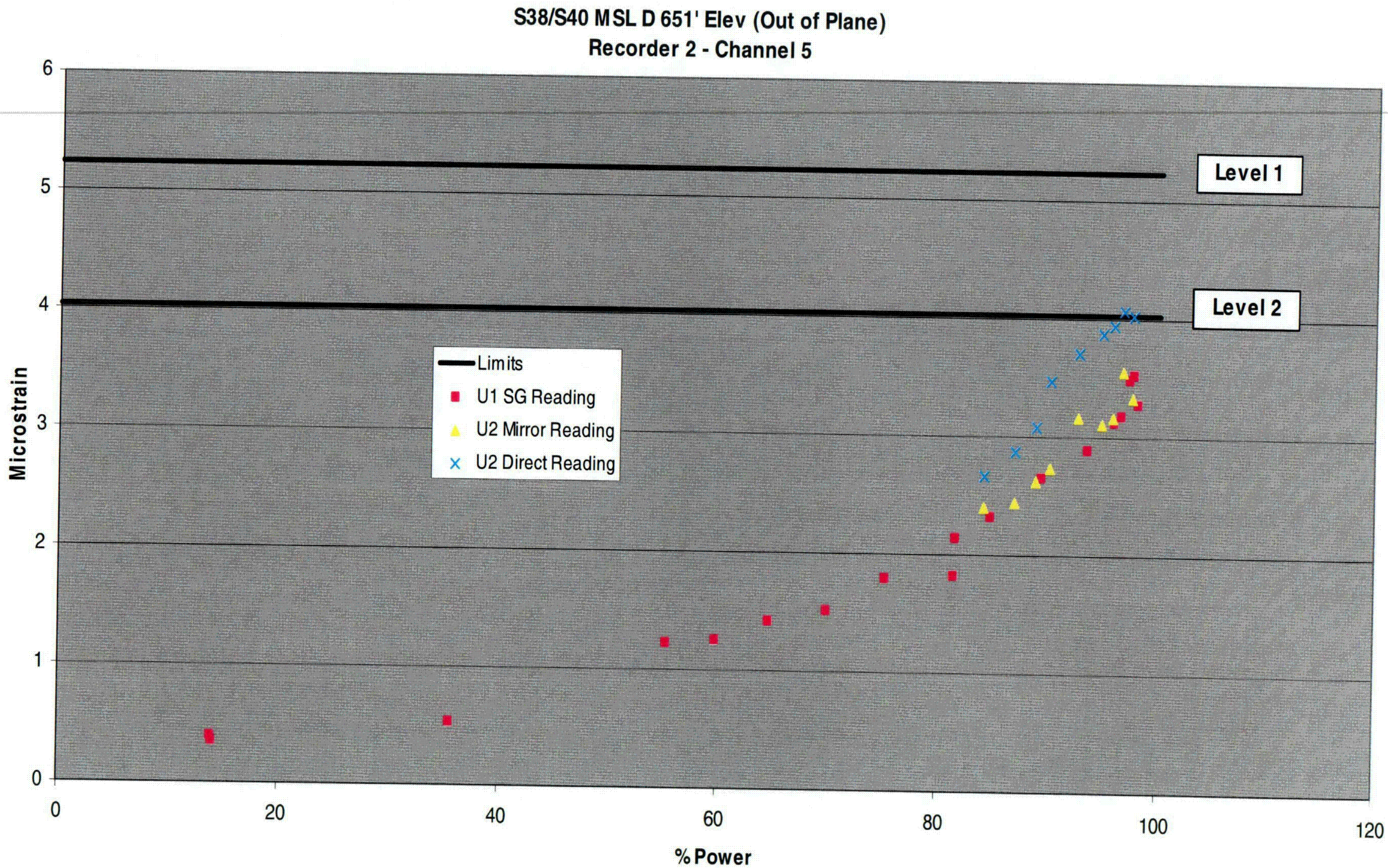
Figure 14

Unit 1 Startup Results



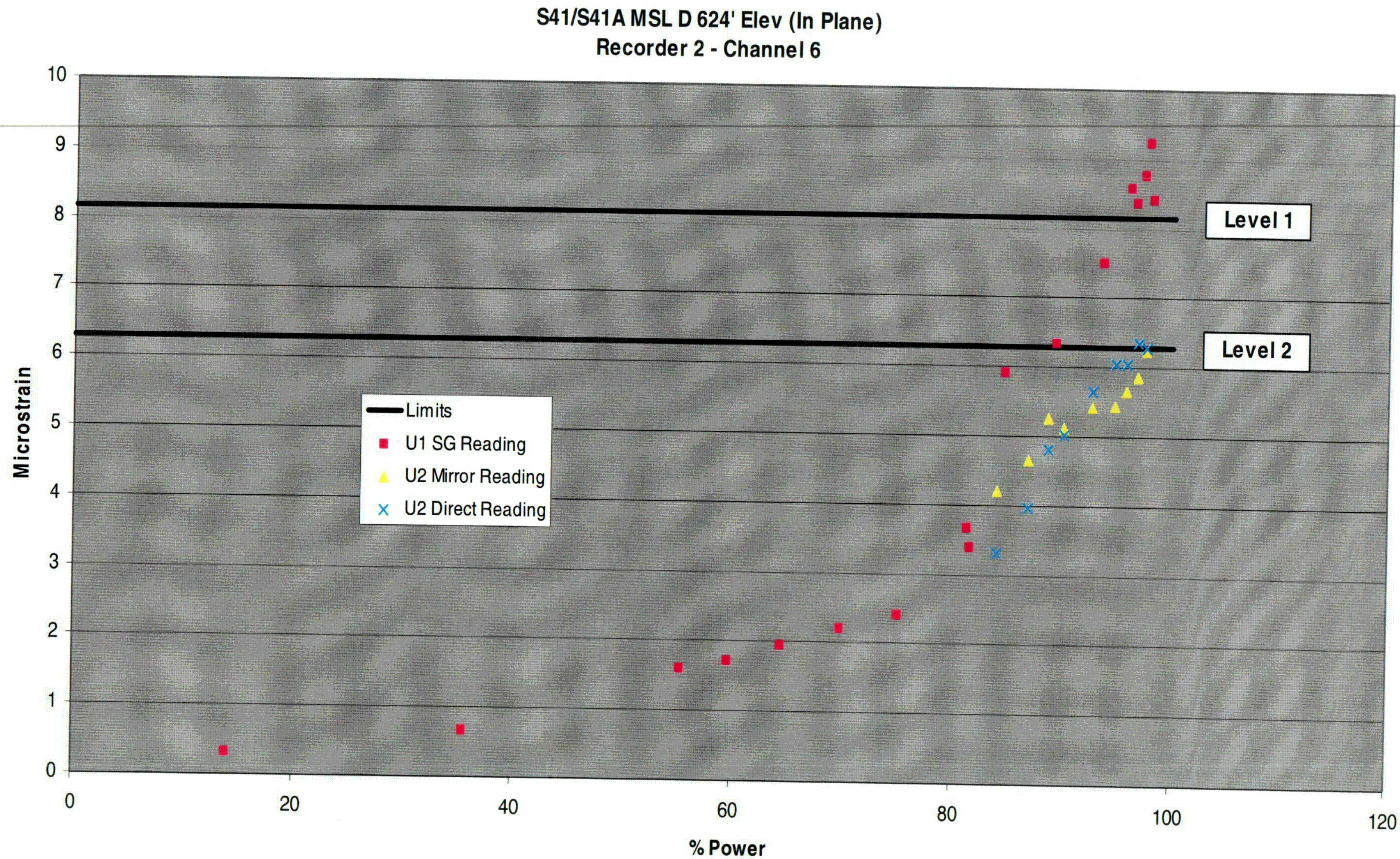
C14

Figure 15



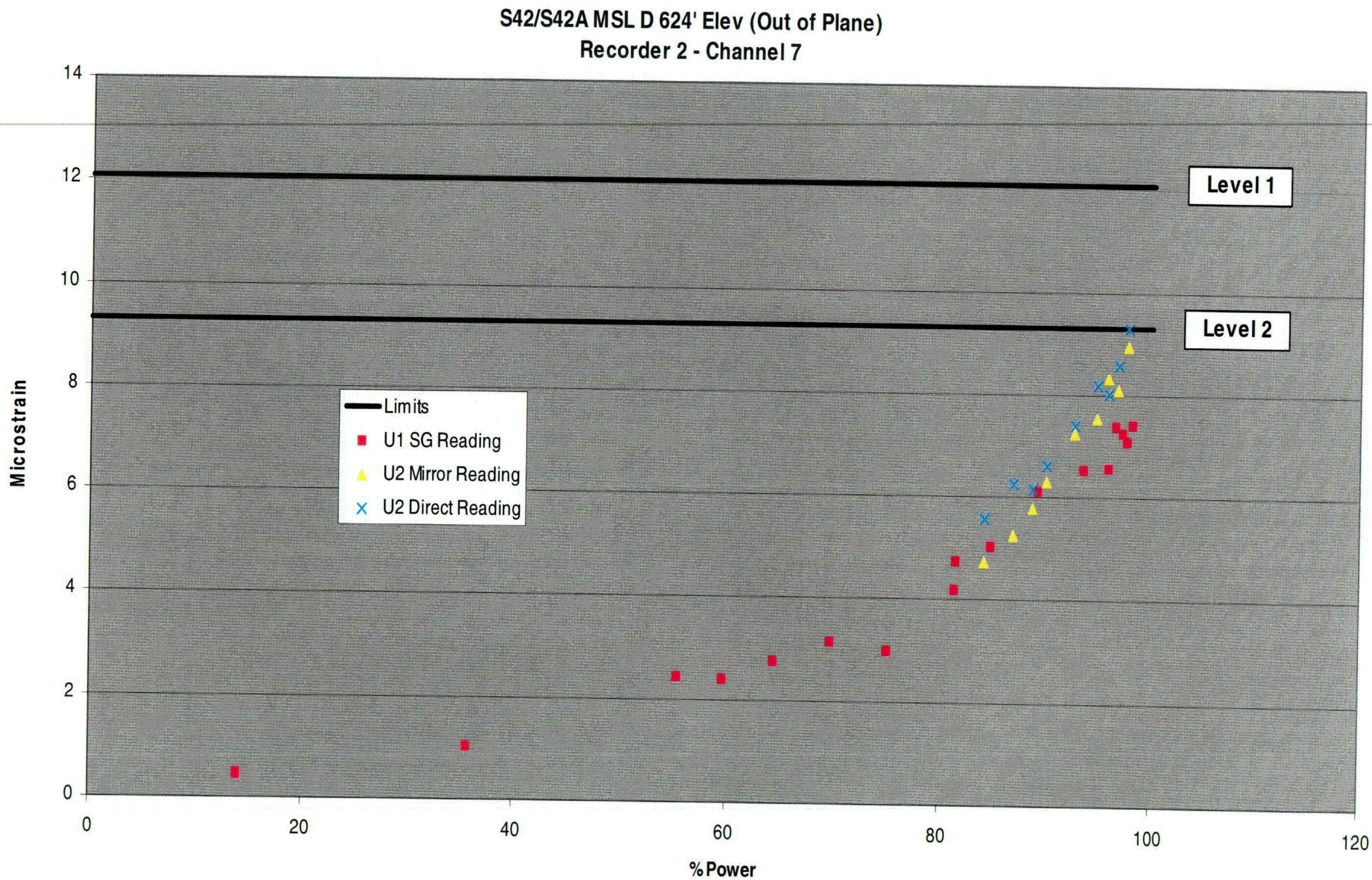
C15

Figure 16



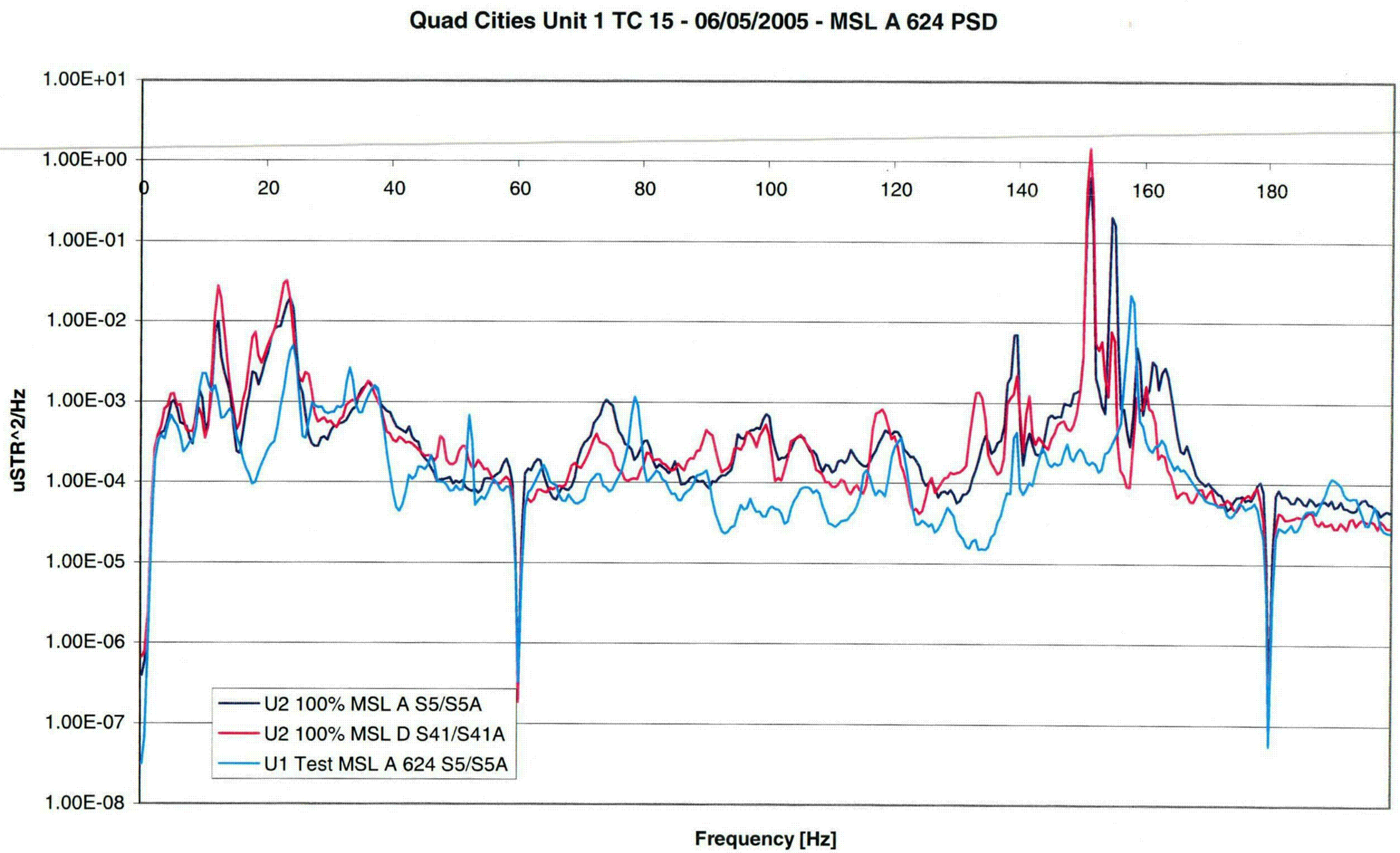
C16

Figure 17



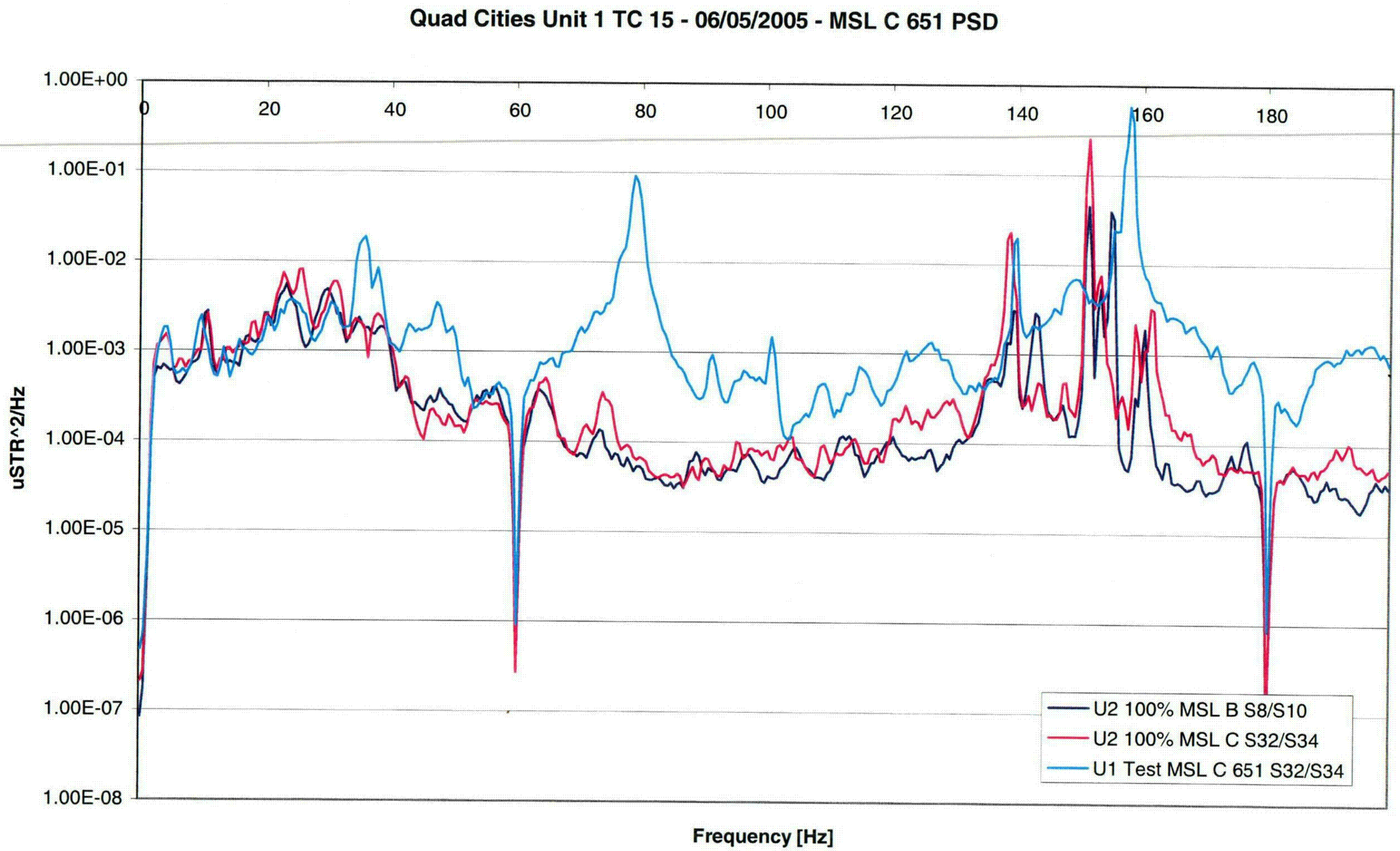
C17

Figure 18



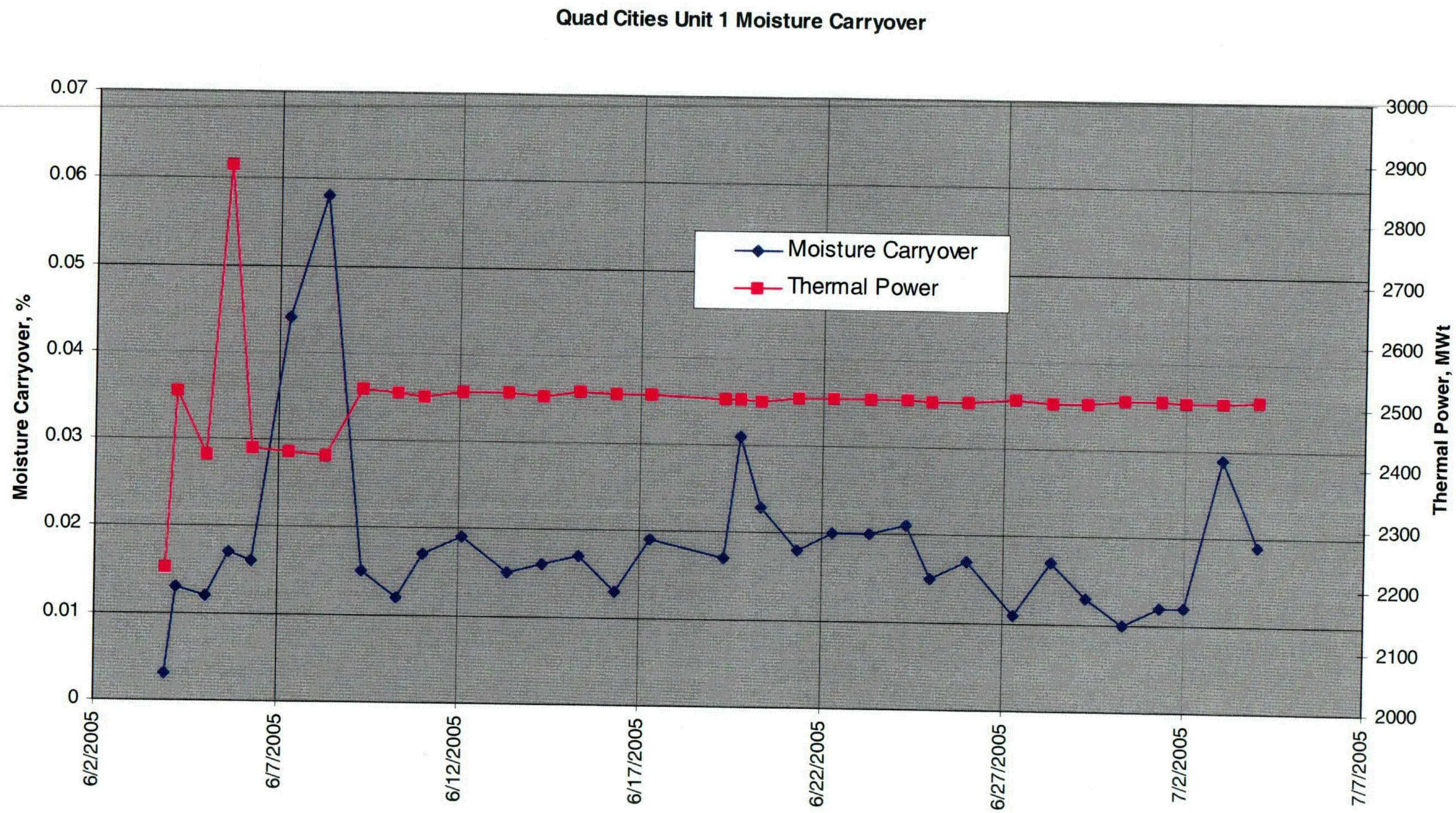
C18

Figure 19



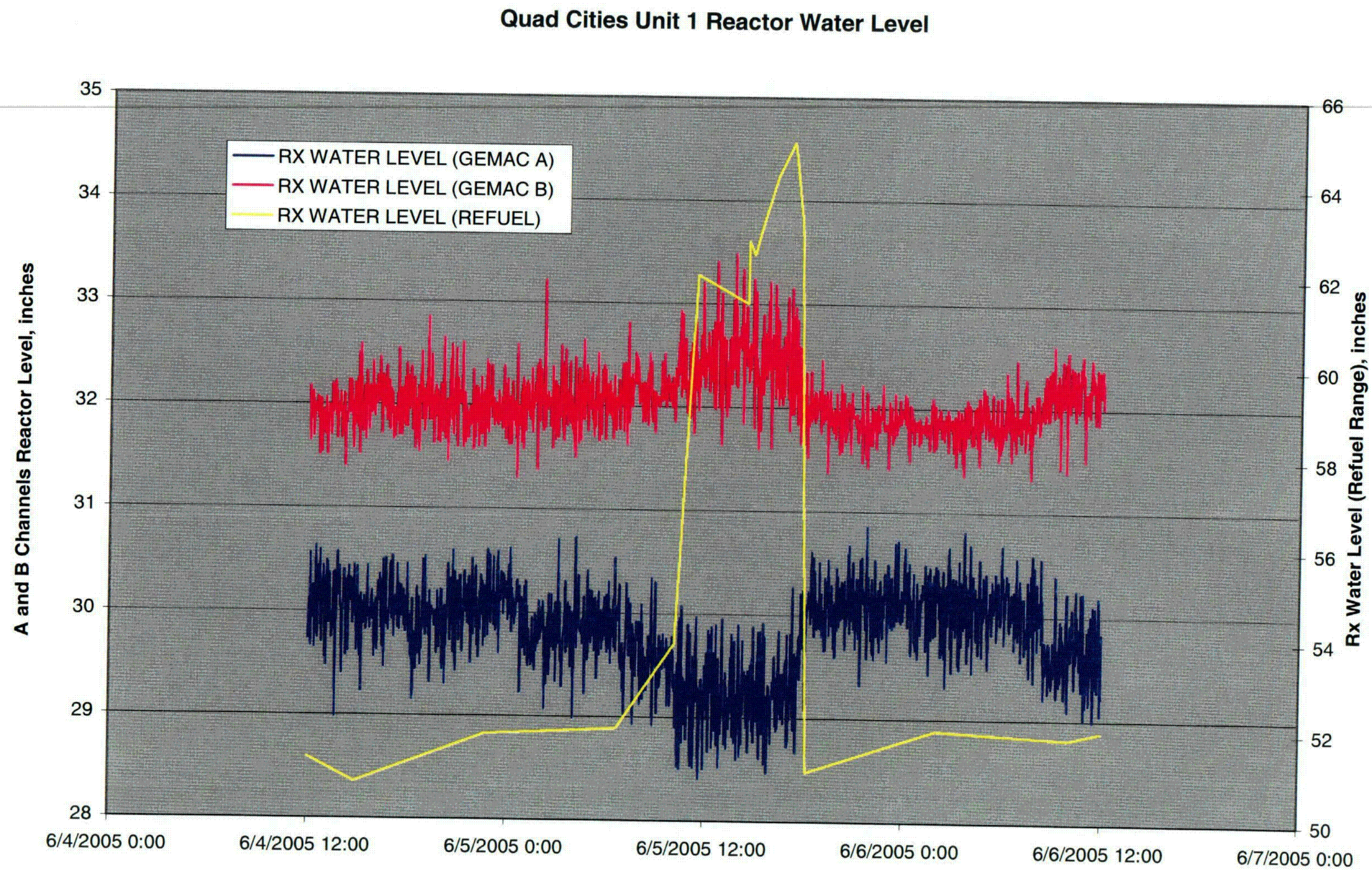
C19

Figure 20



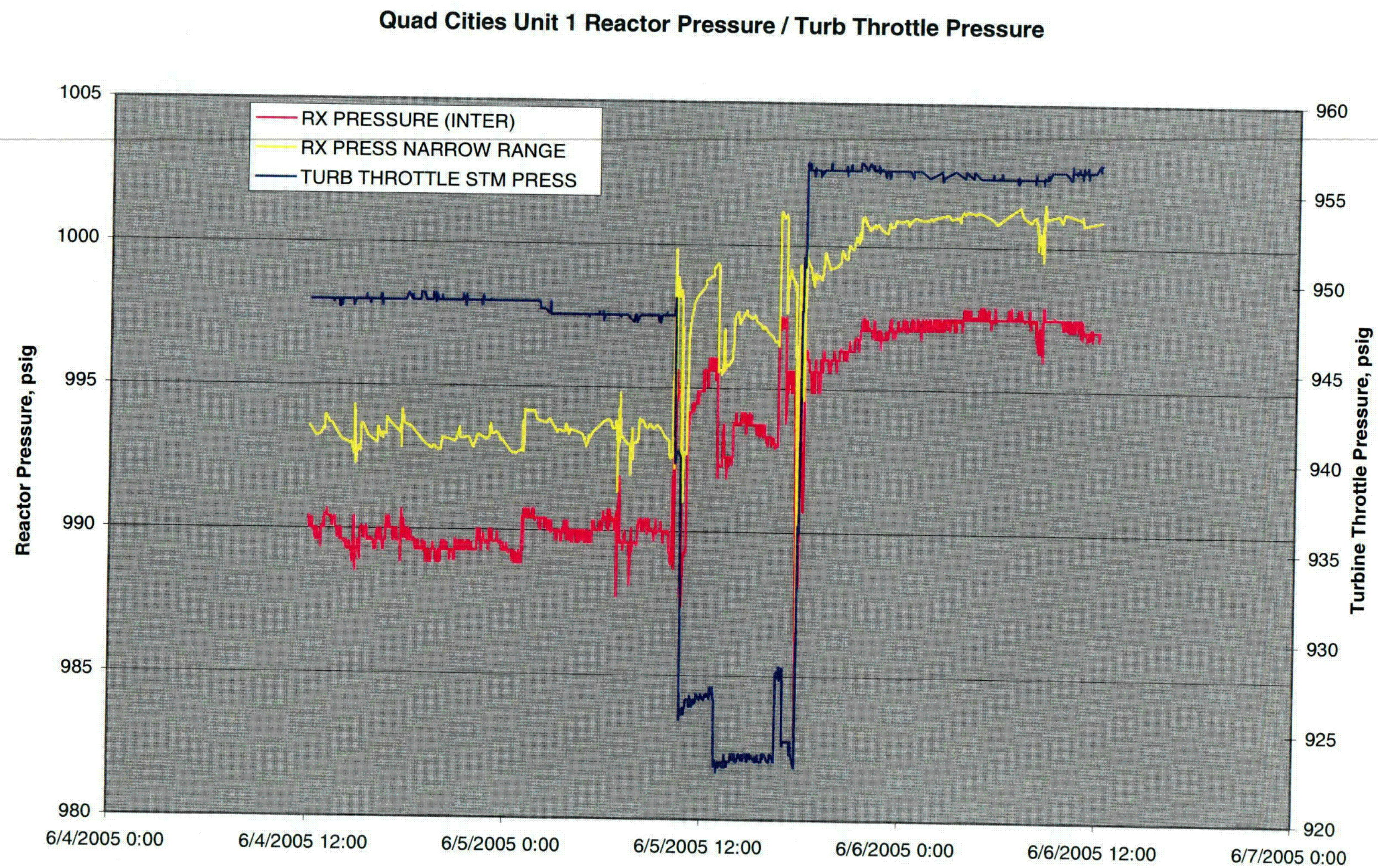
C20

Figure 21



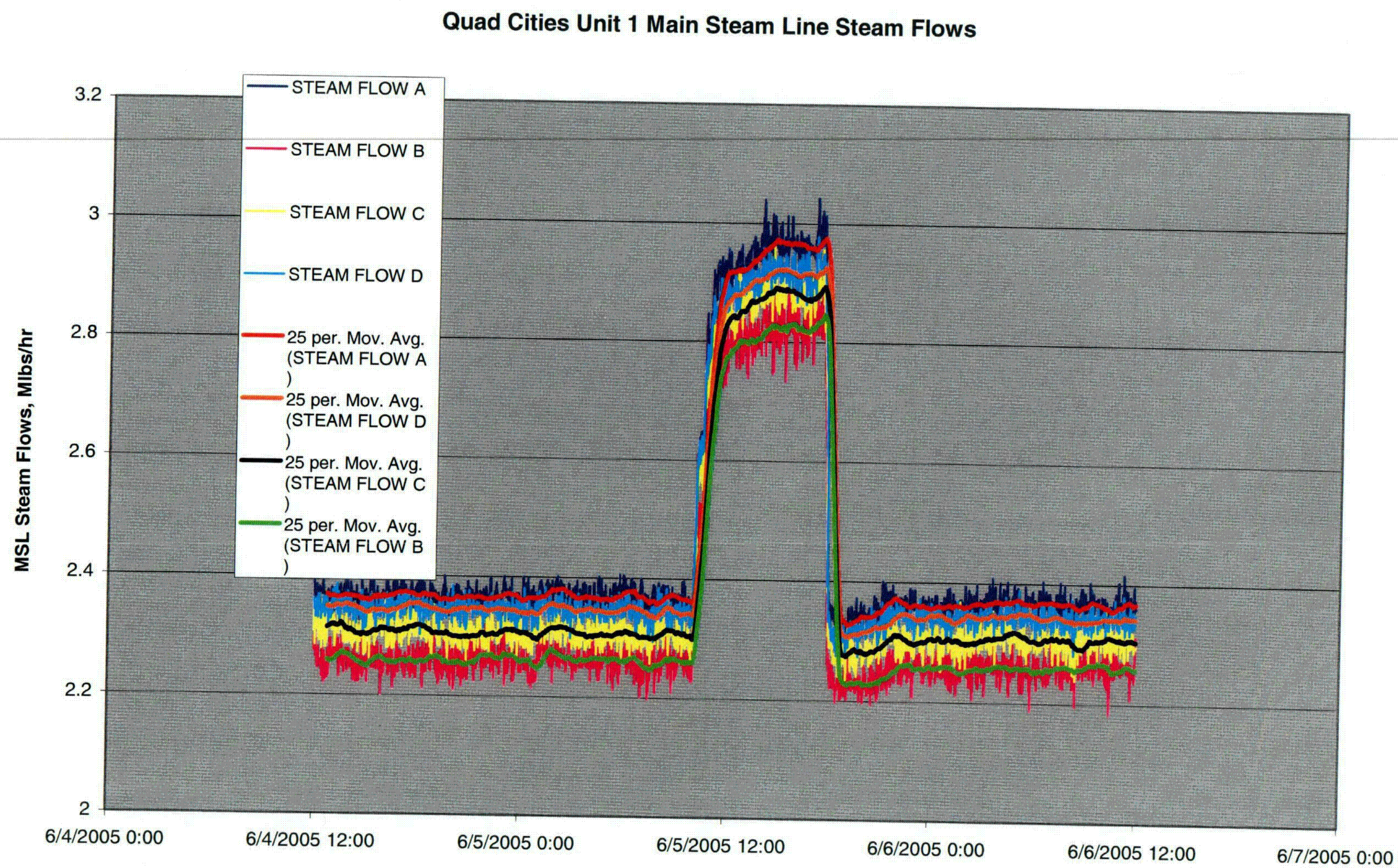
C21

Figure 22



C22

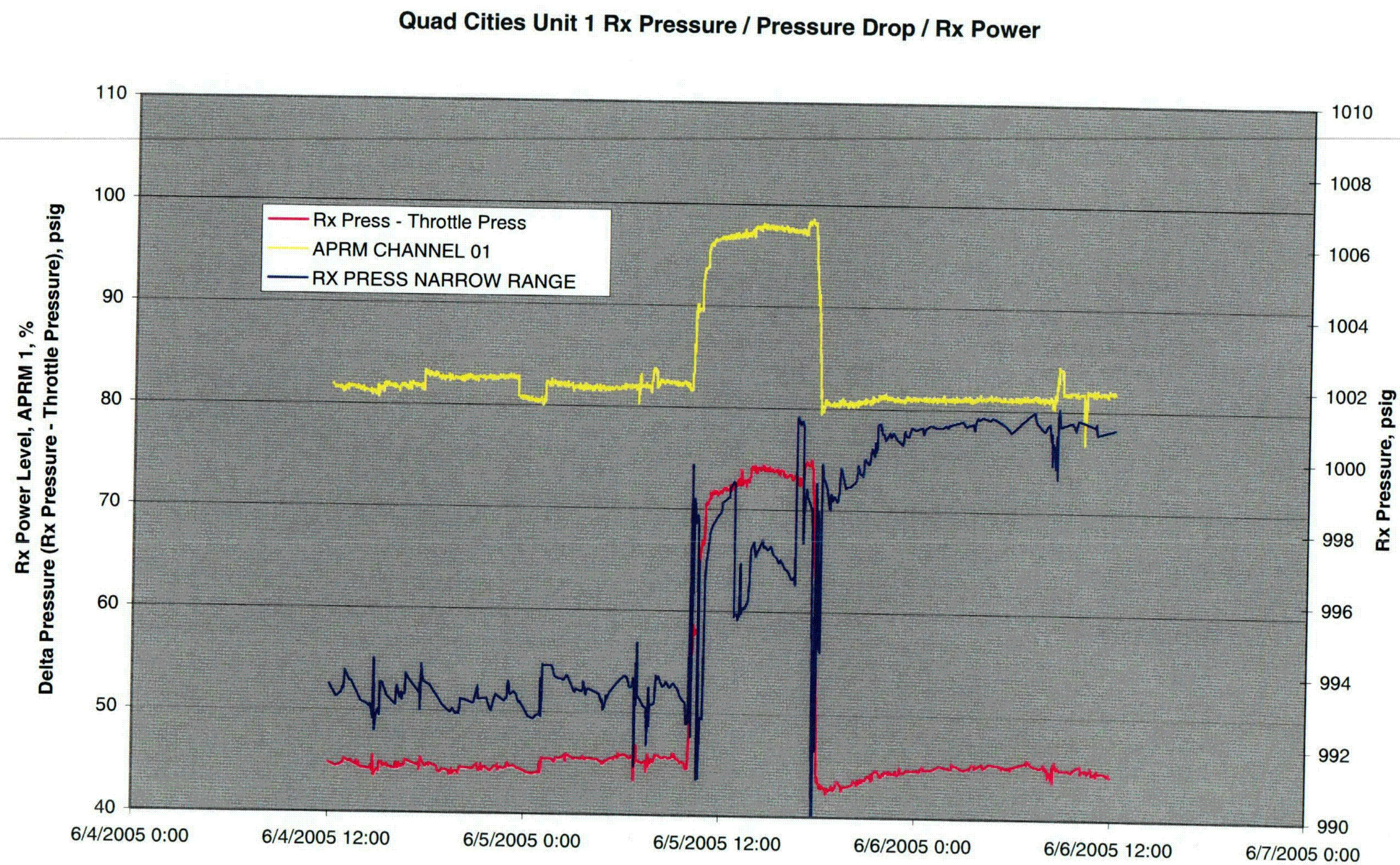
Figure 23



C23

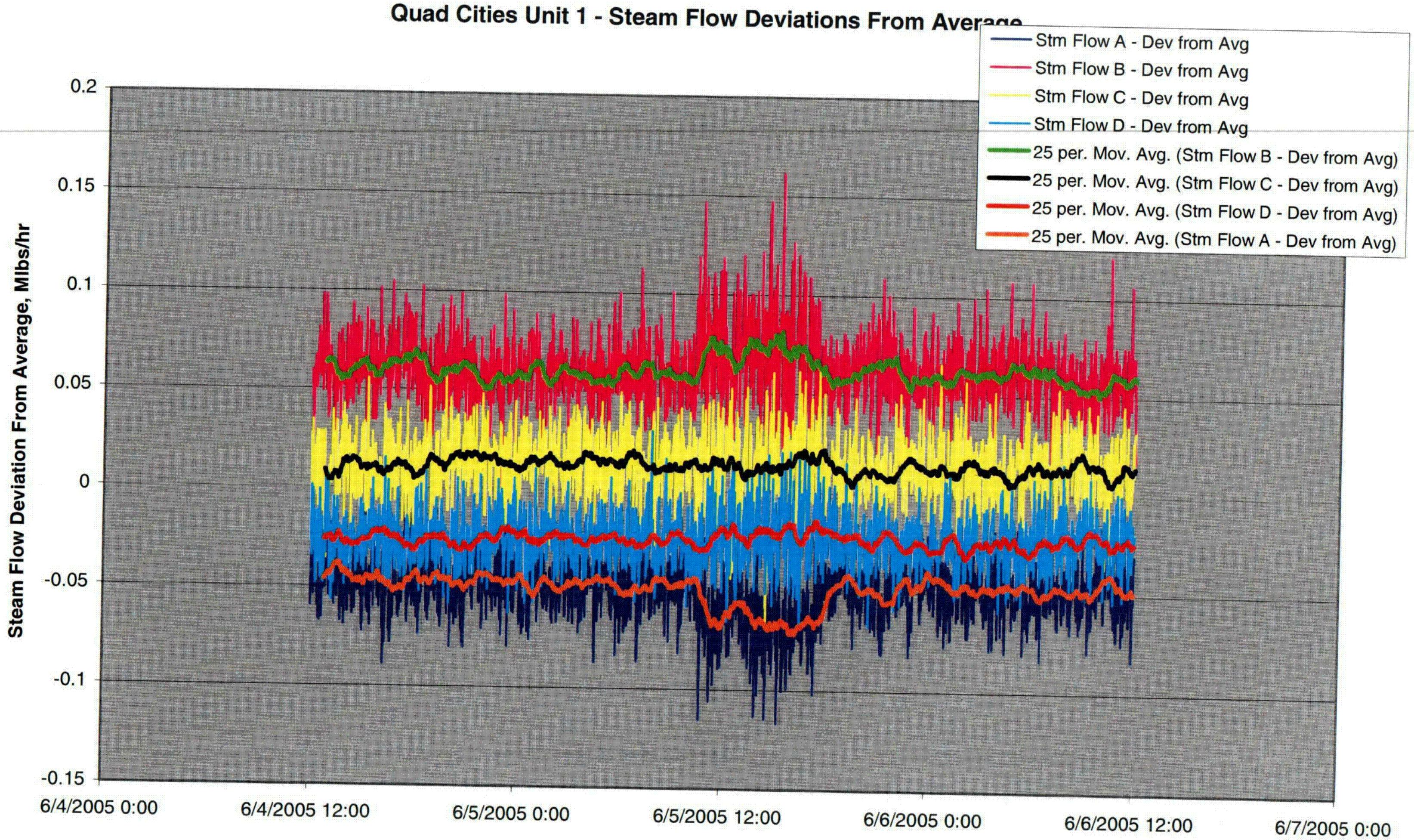
Figure 24

Unit 1 Startup Results



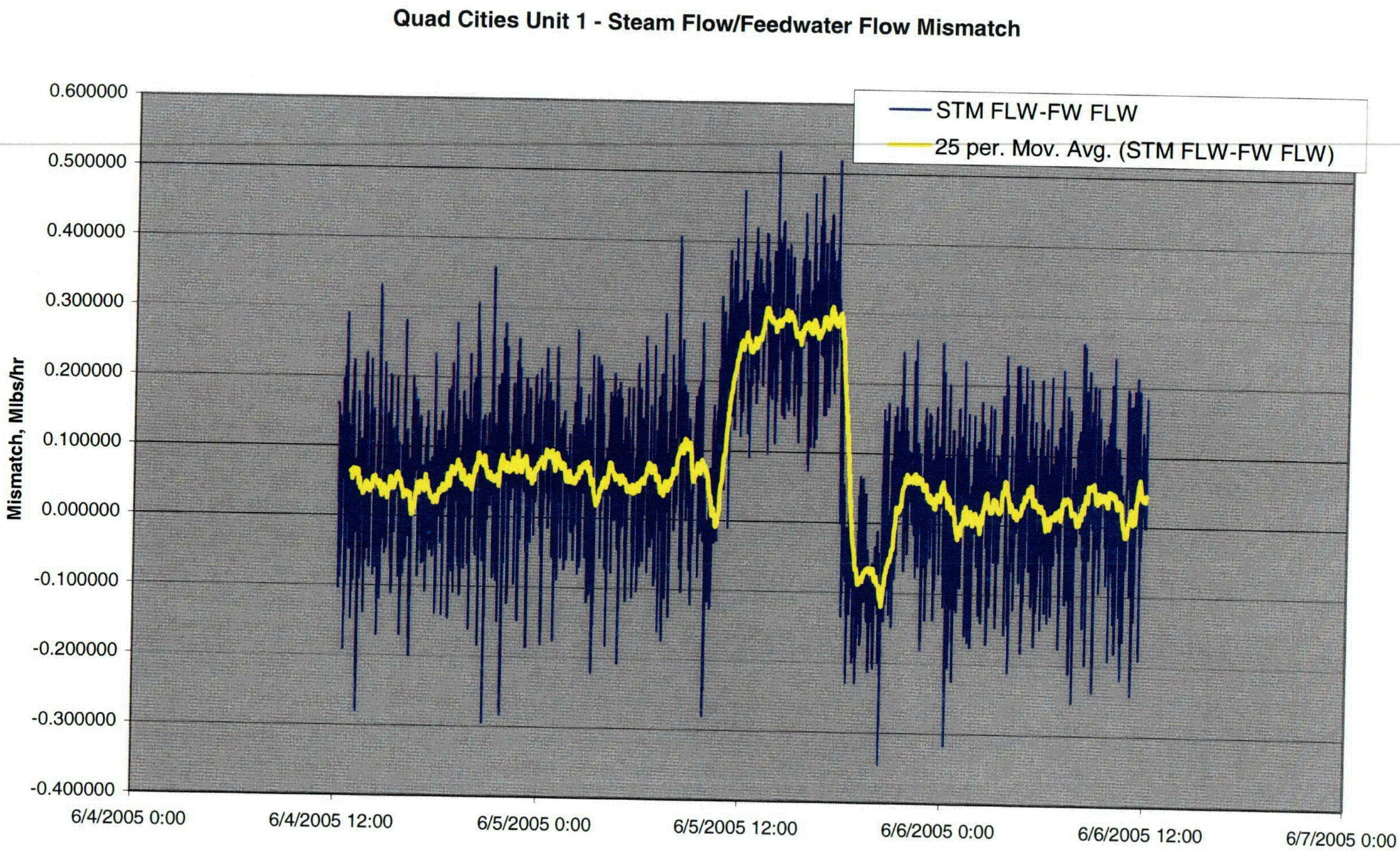
C24

Figure 25



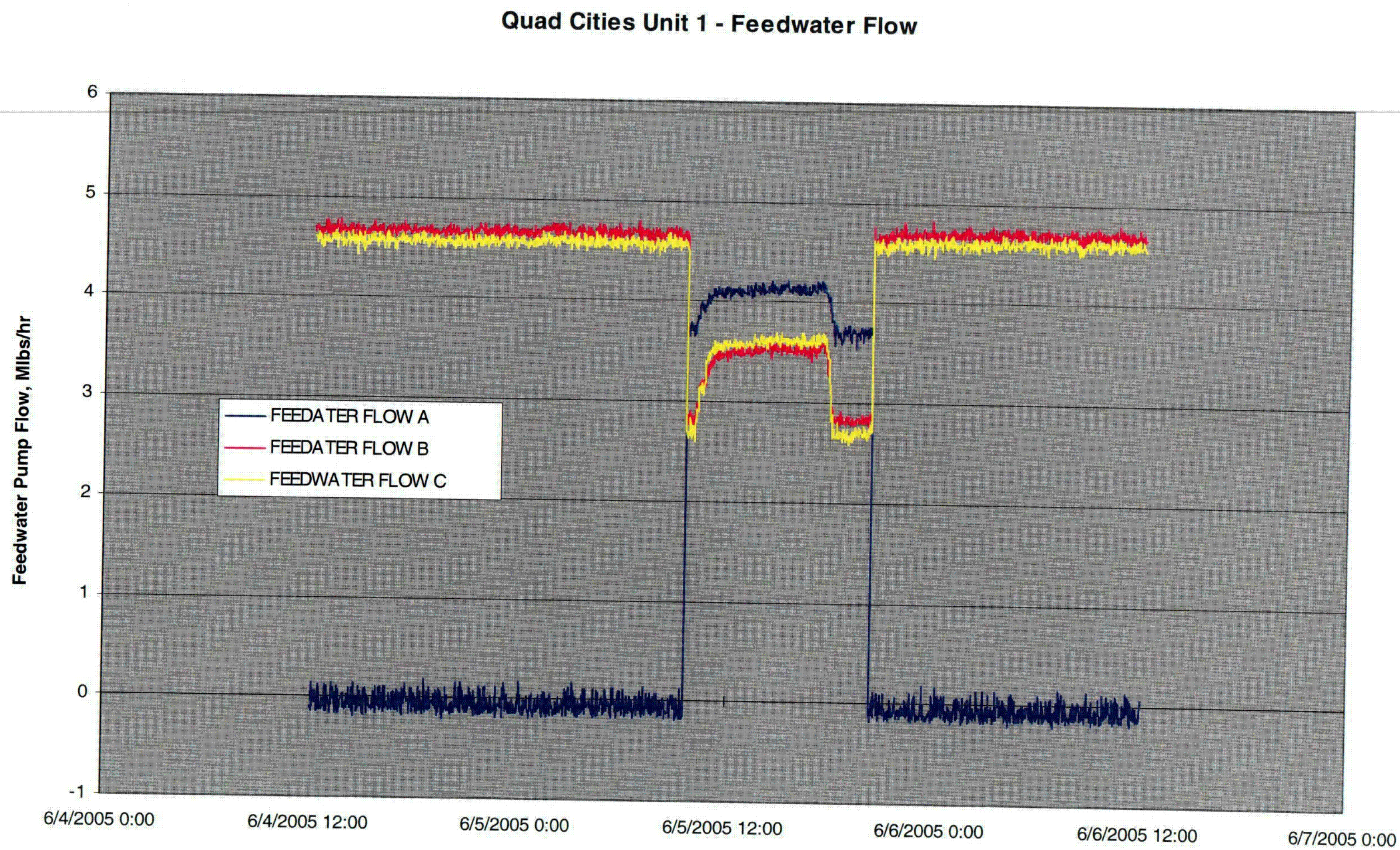
C25

Figure 26



C26

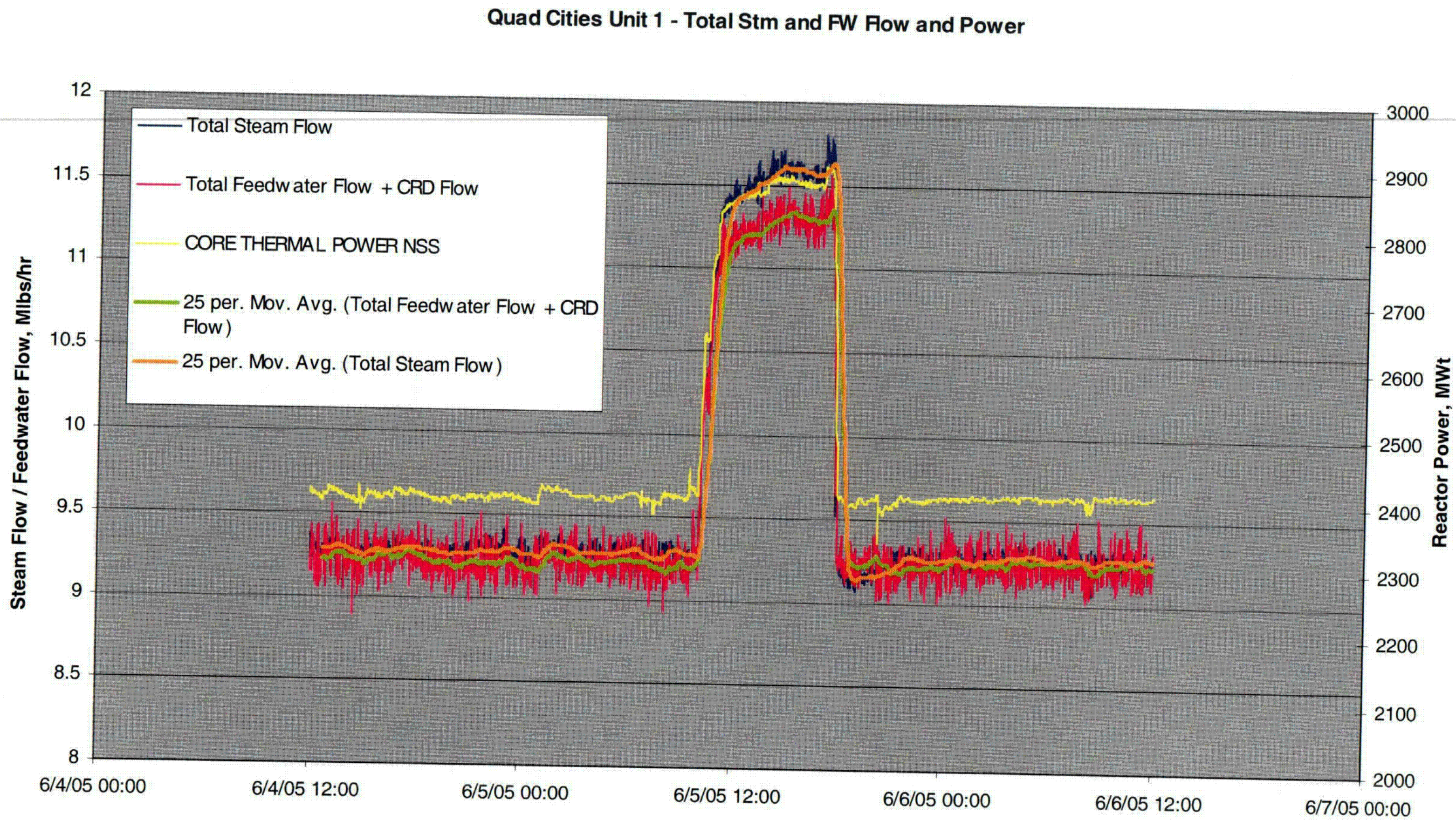
Figure 27



C27

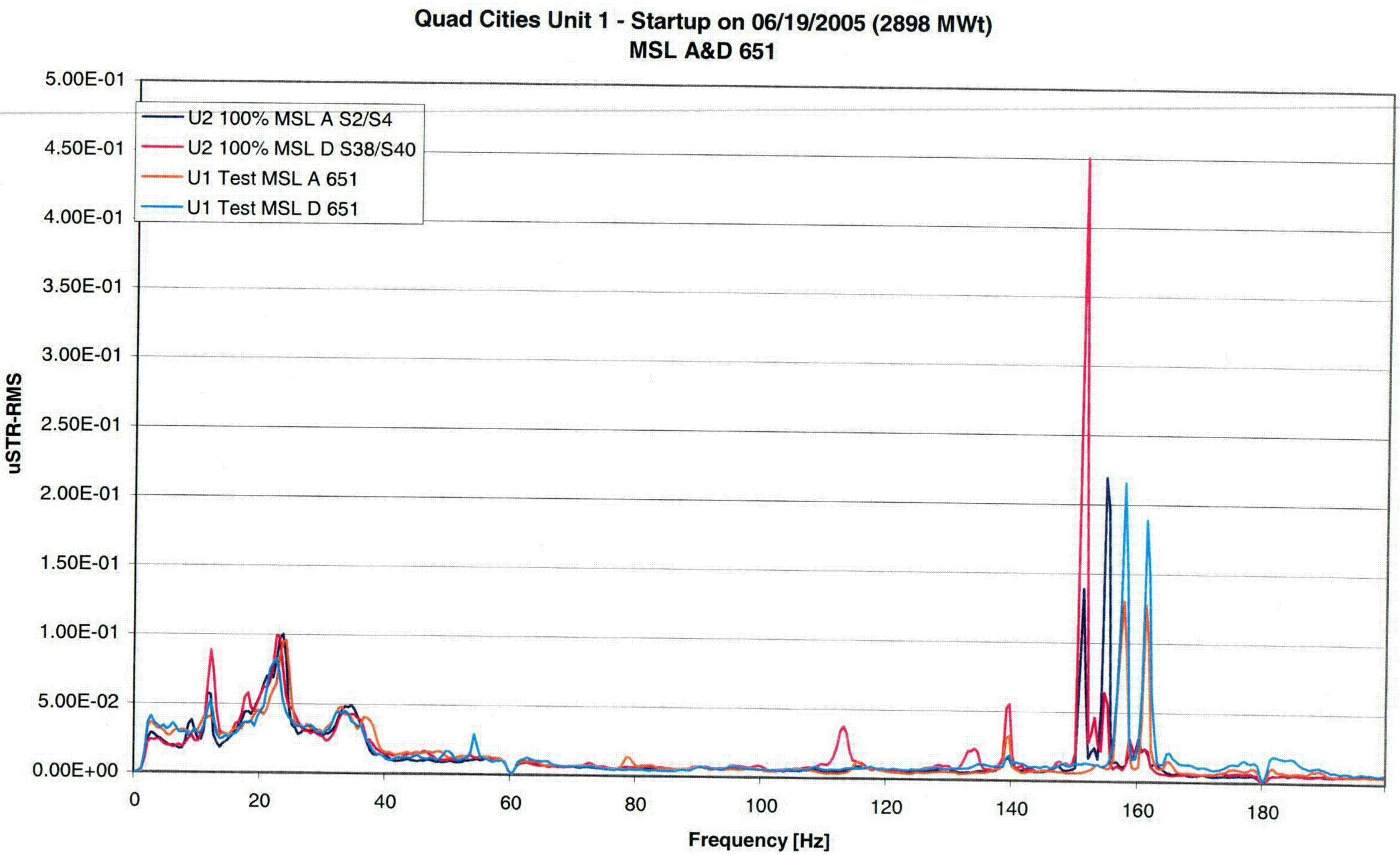
Figure 28

Unit 1 Startup Results



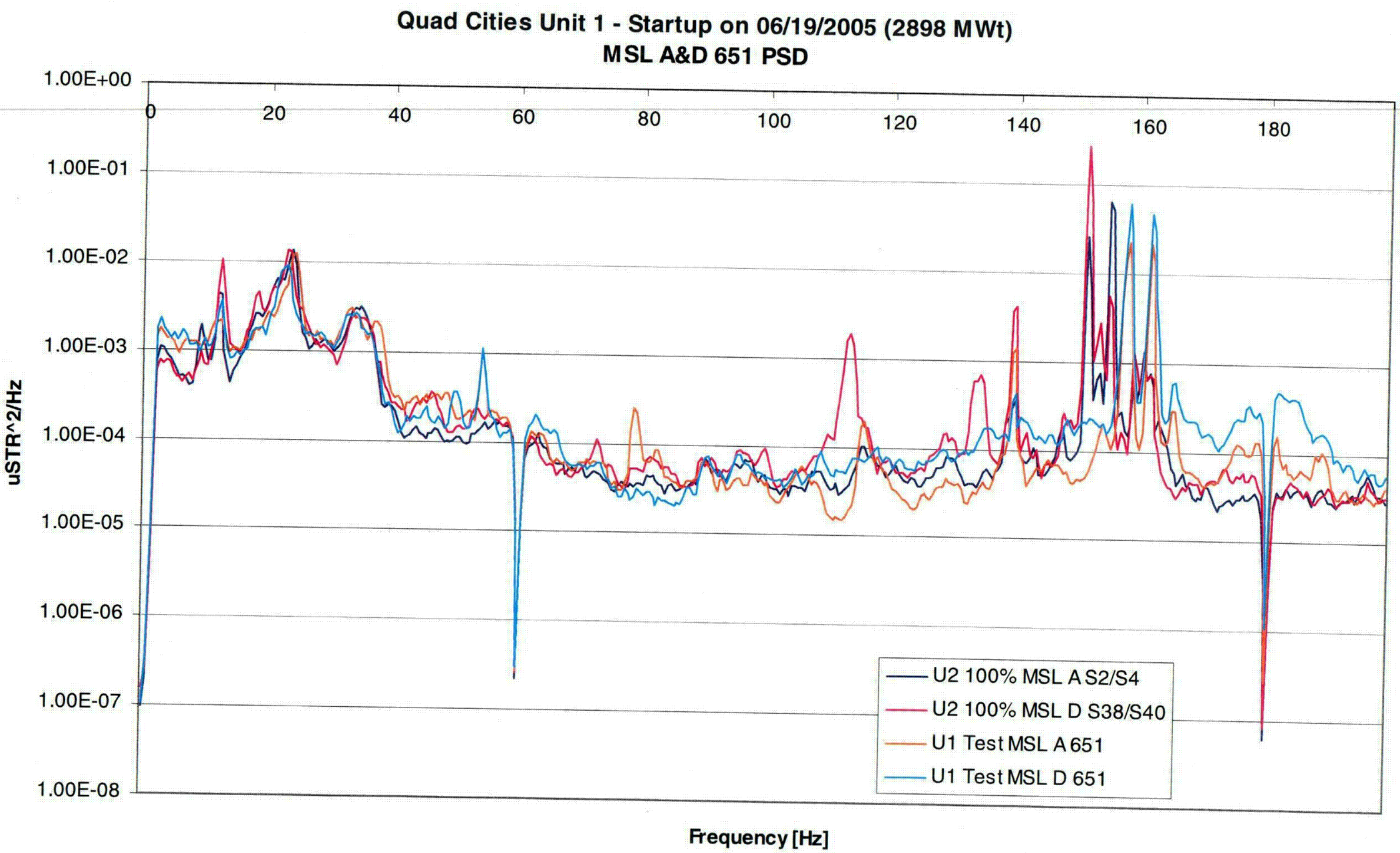
C28

Figure 29



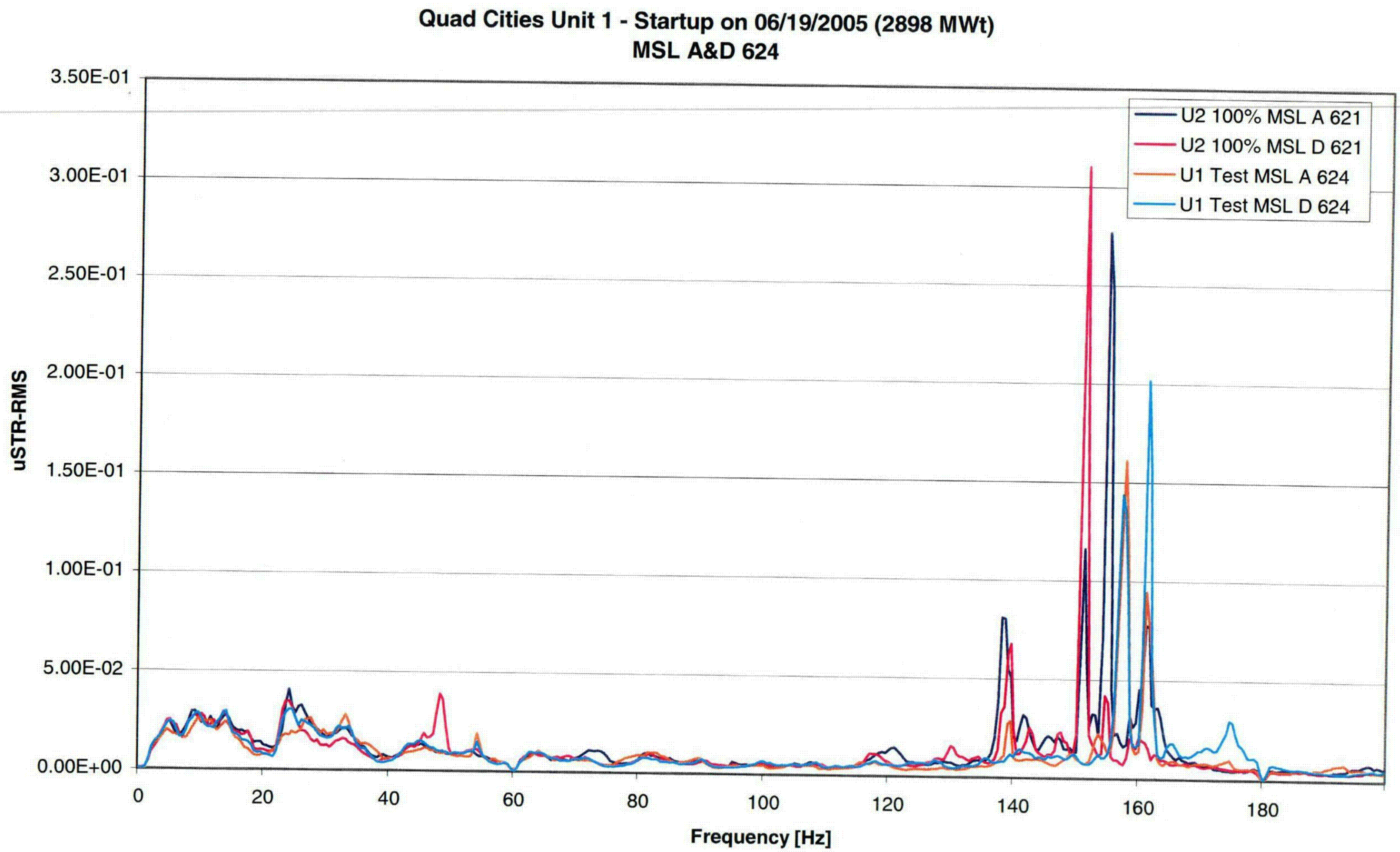
C29

Figure 30



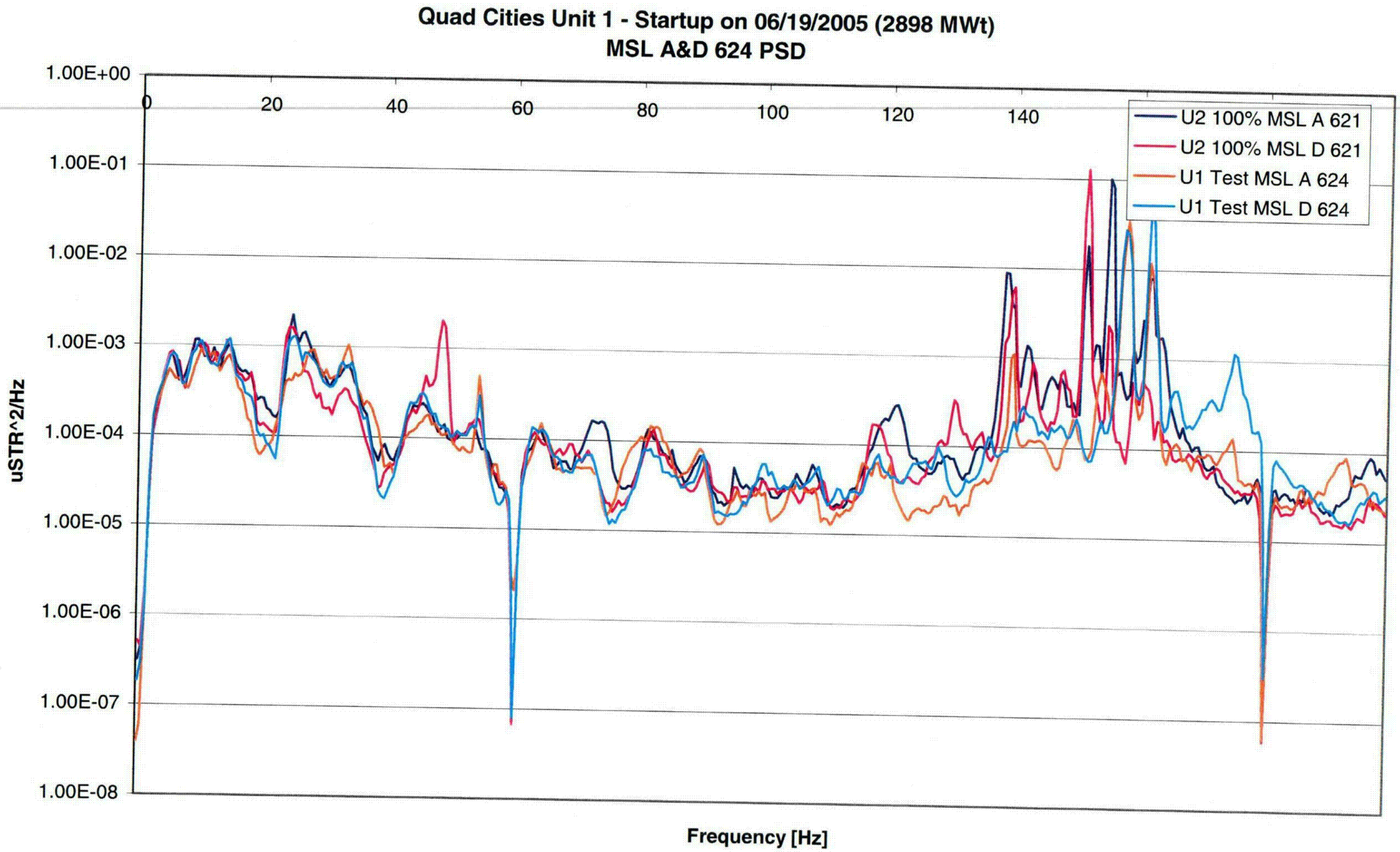
C30

Figure 31



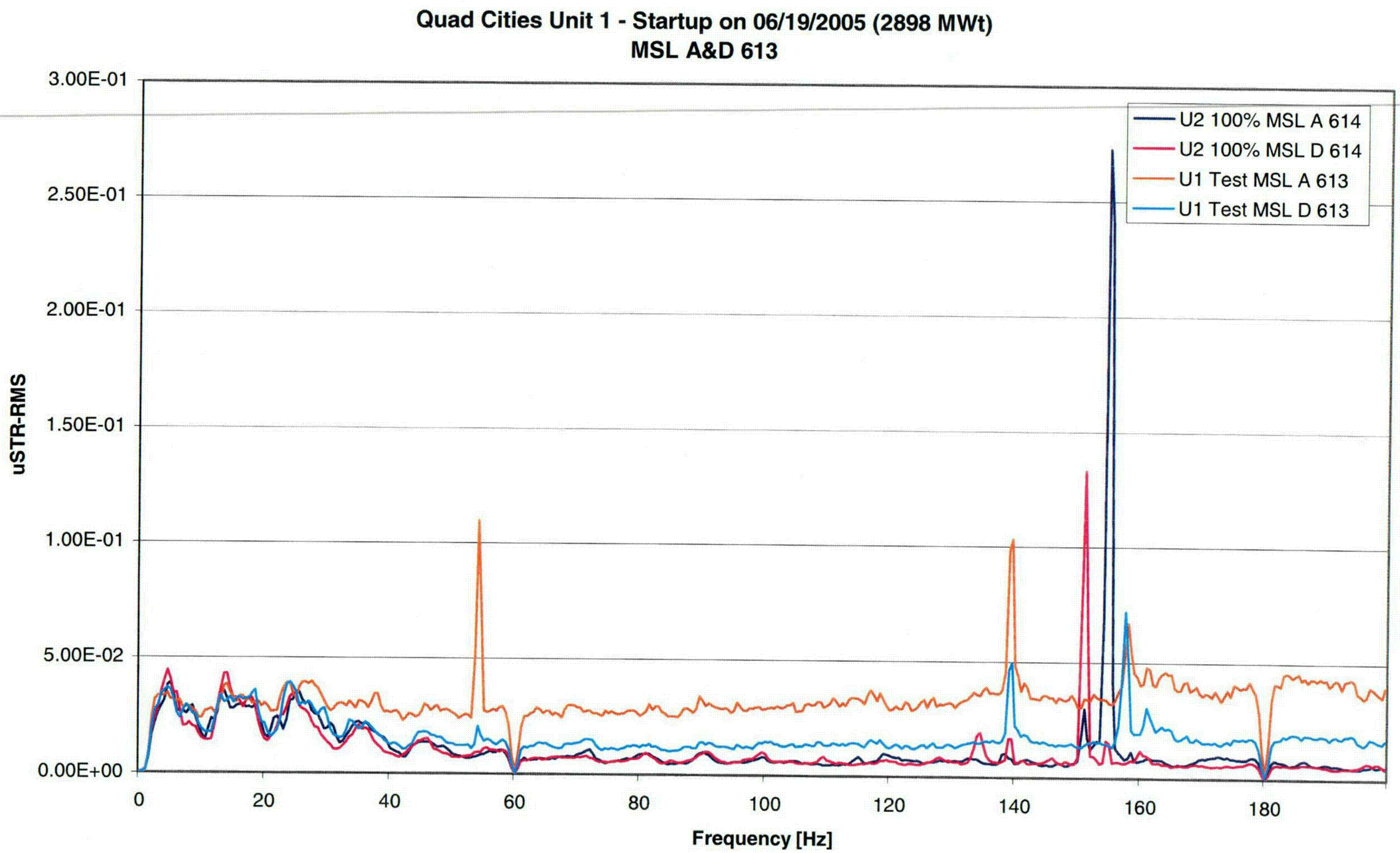
C31

Figure 32



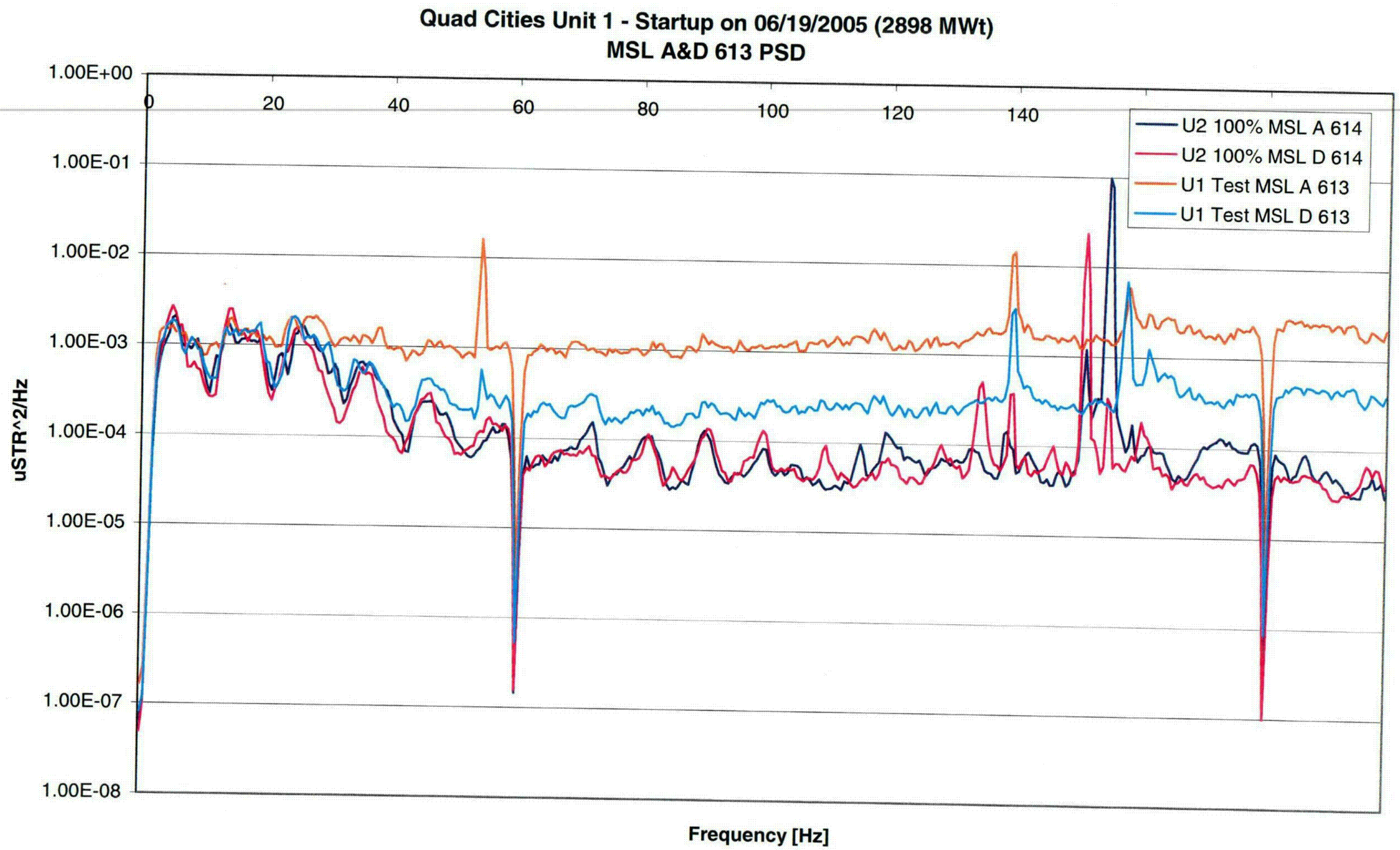
C32

Figure 33



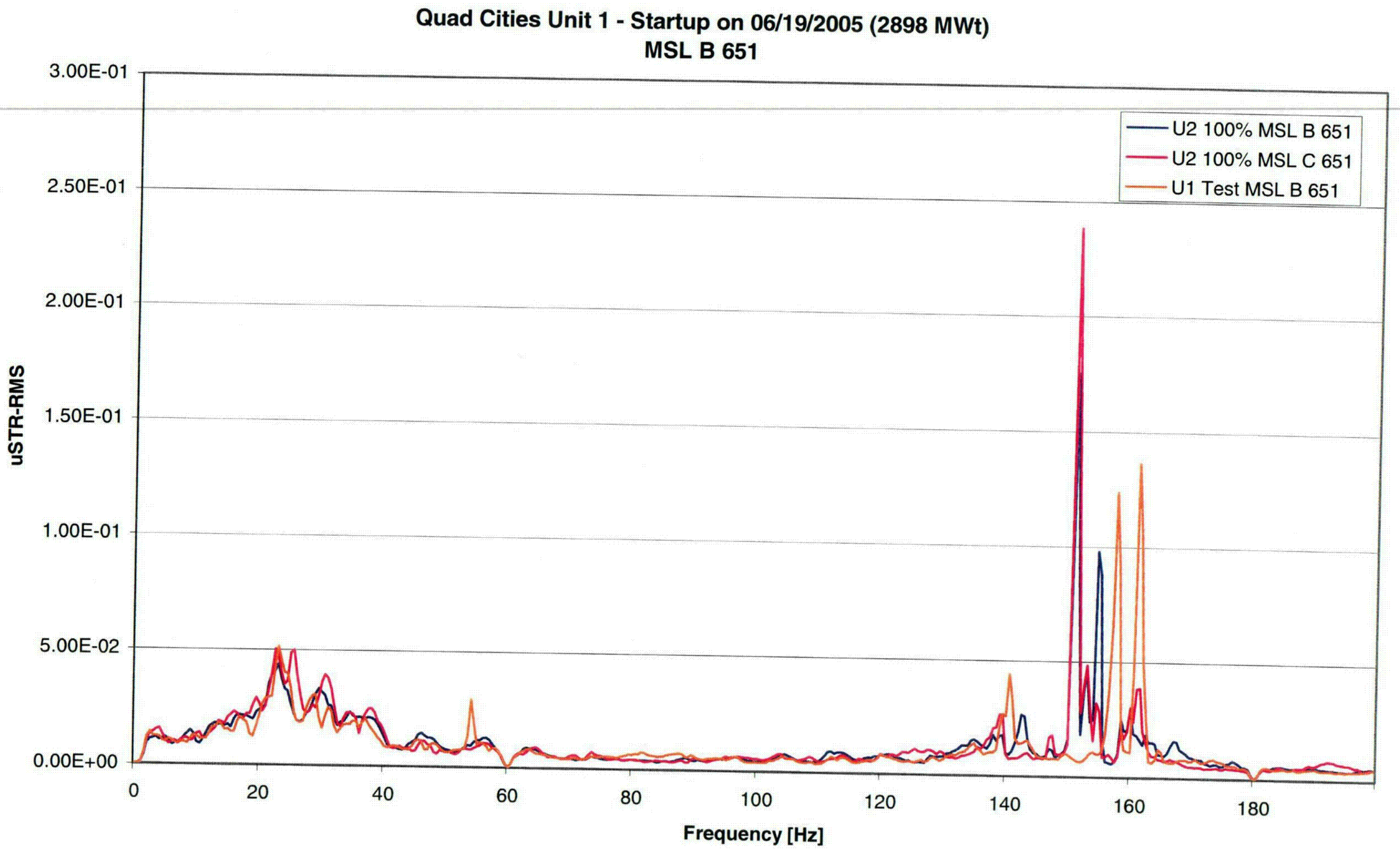
C33

Figure 34



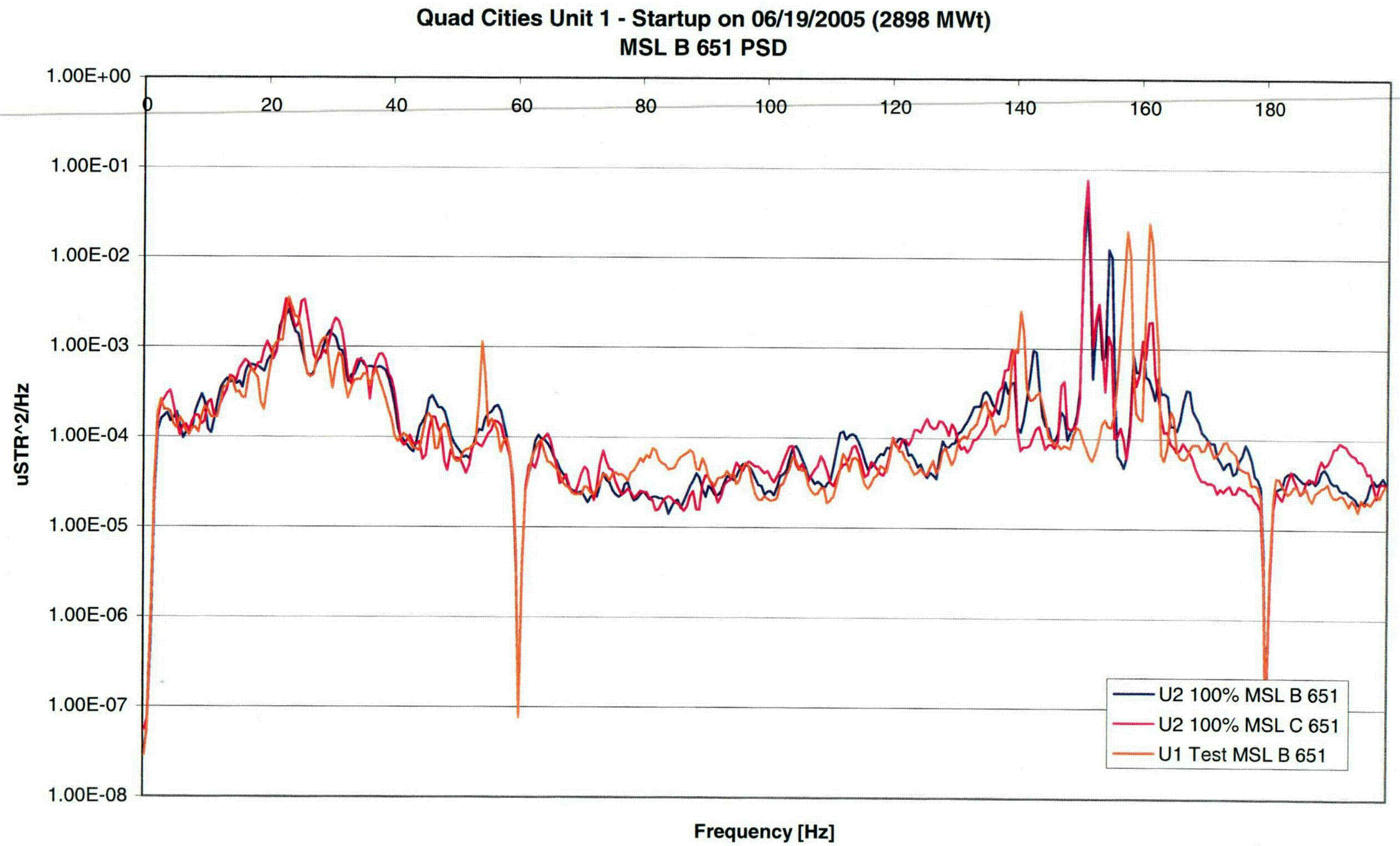
C34

Figure 35



C35

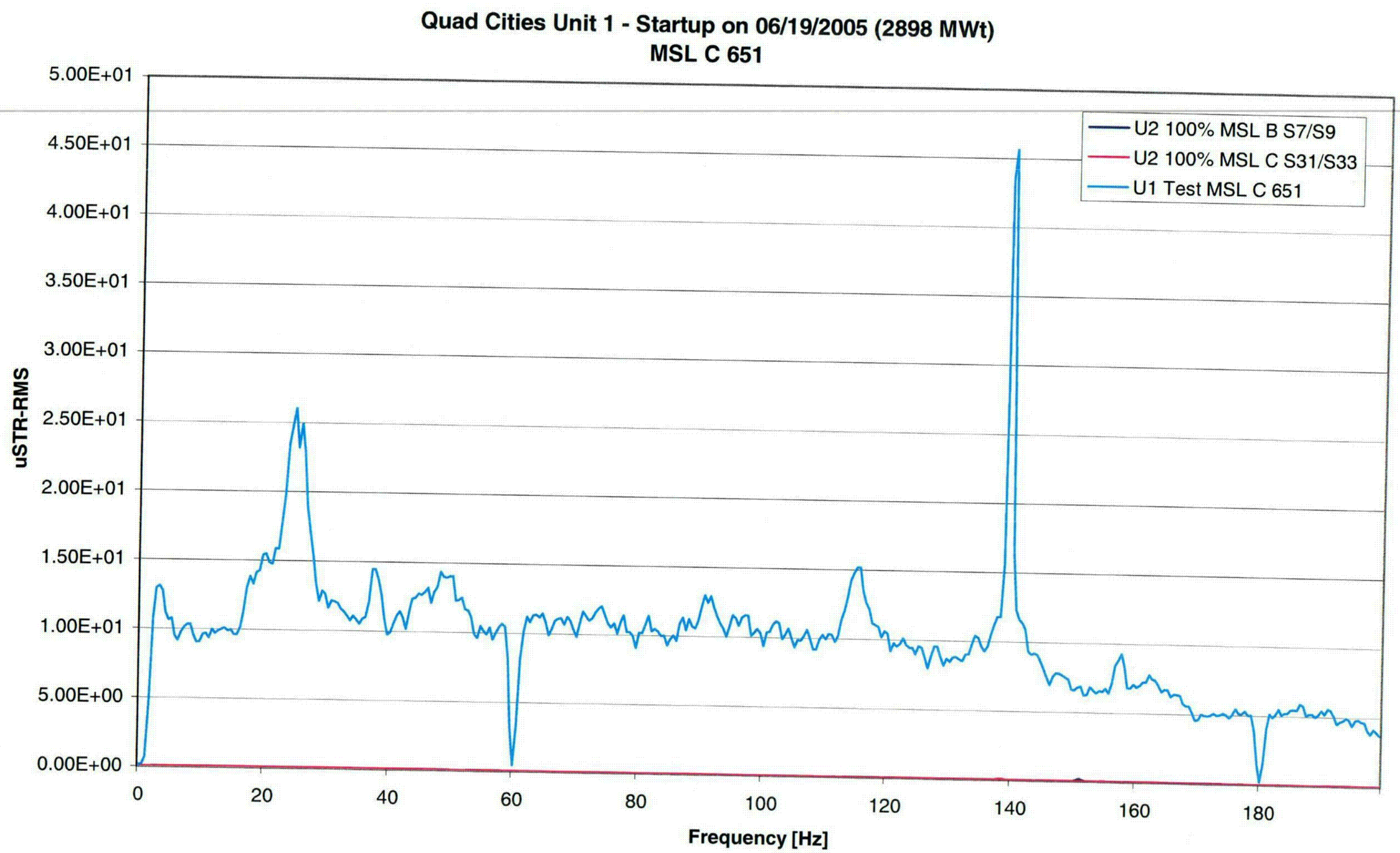
Figure 36



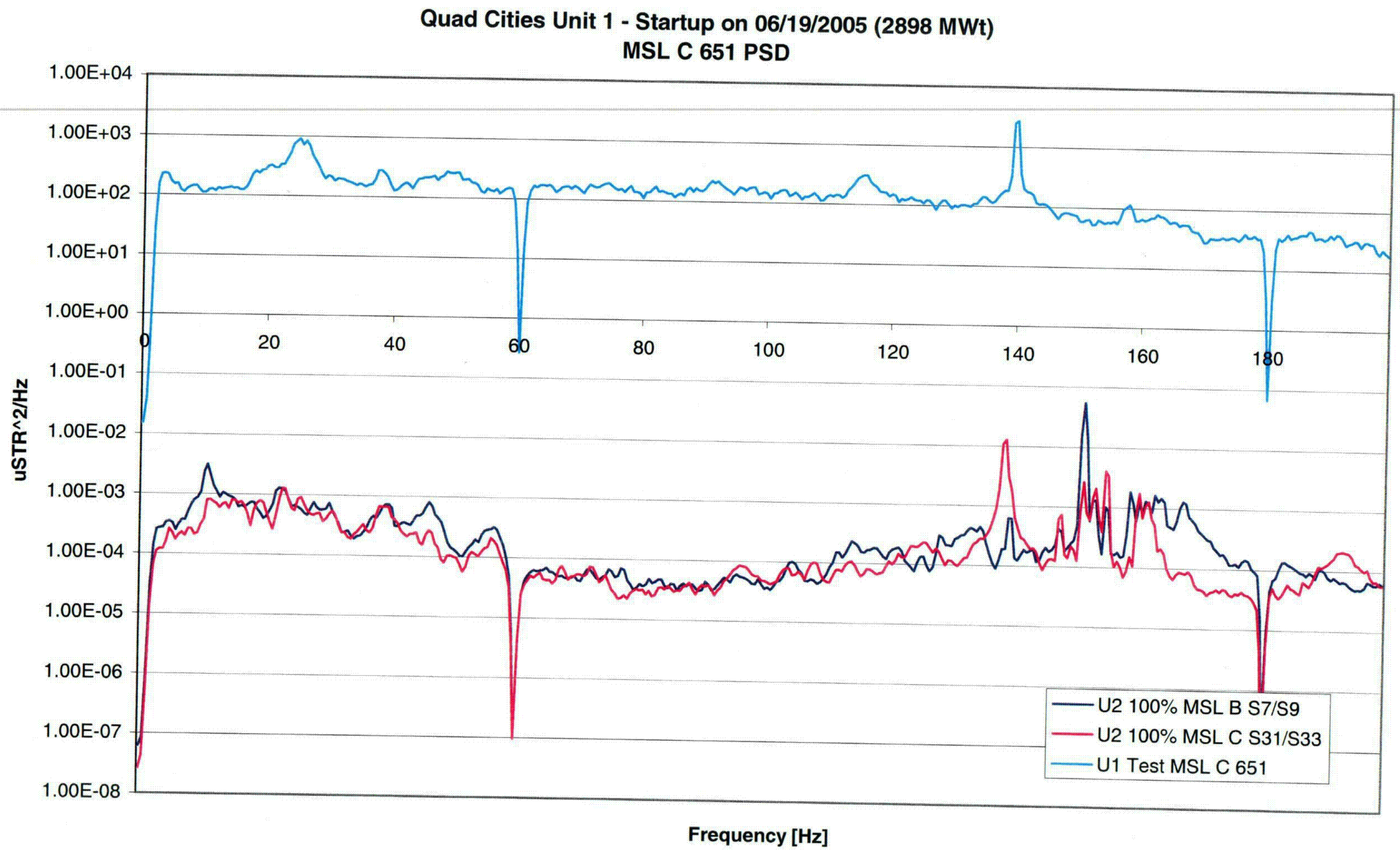
C36

Figure 37

Unit 1 Startup Results

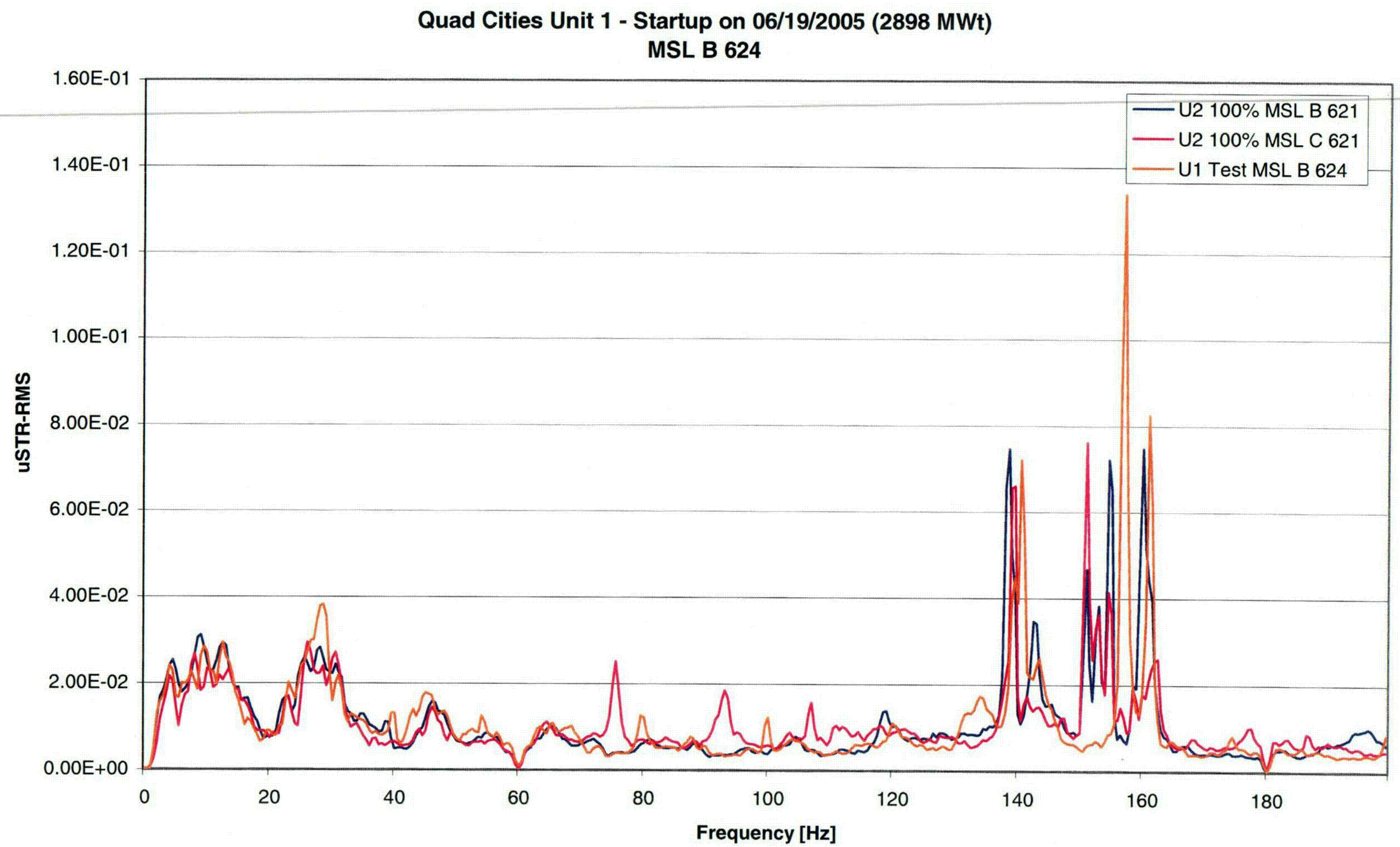


C37


Quad Cities Unit 1 - Startup on 06/19/2005 (2898 MWt)
MSL C 651 PSD
1.00E+04
1.00E+03
1.00E+02
1.00E+01
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
uSTR^2/Hz
0
20
40
60
80
100
120
140
160
180
Frequency [Hz]
U2 100% MSL B S7/S9
U2 100% MSL C S31/S33
U1 Test MSL C 651

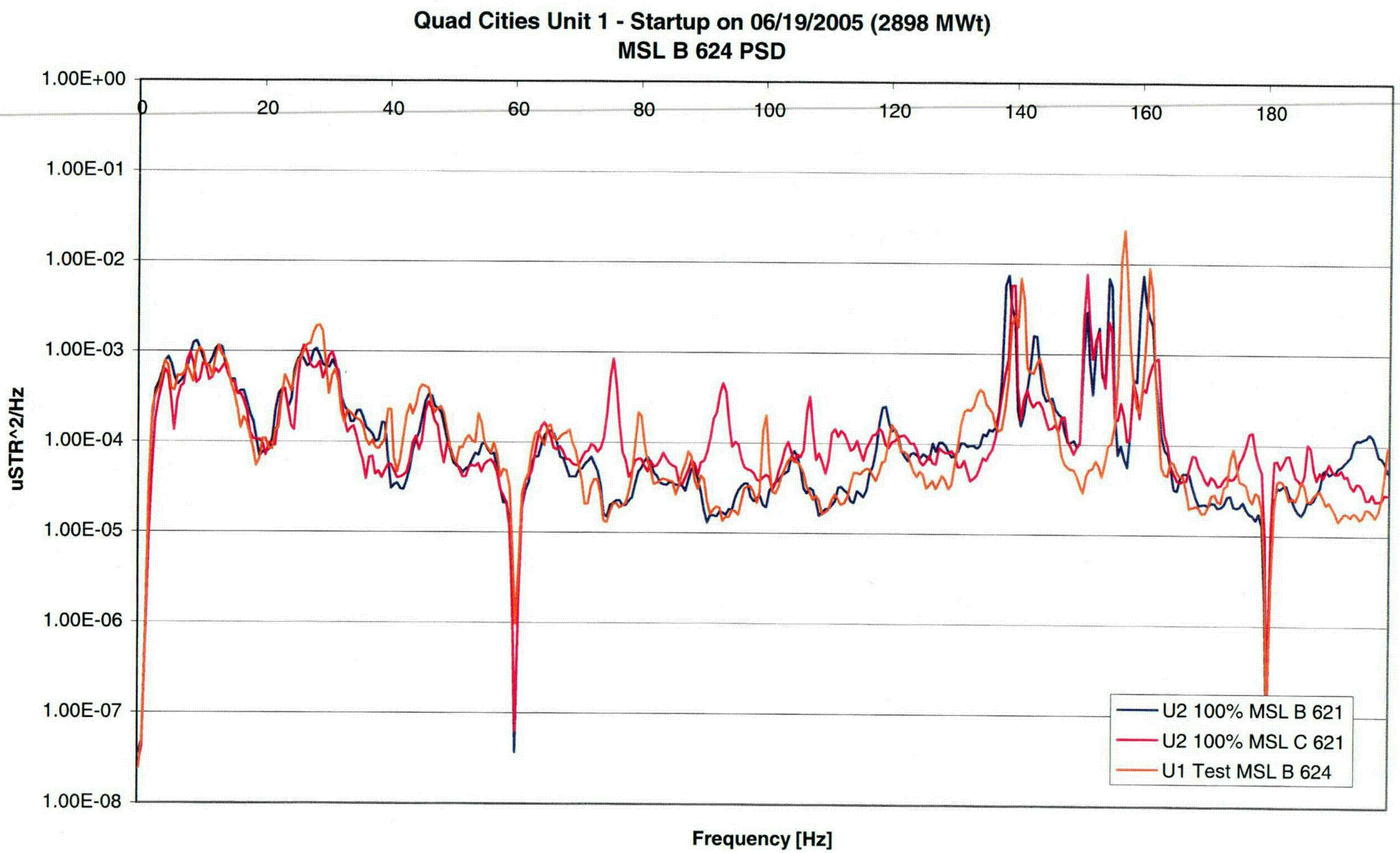
C38

Figure 39



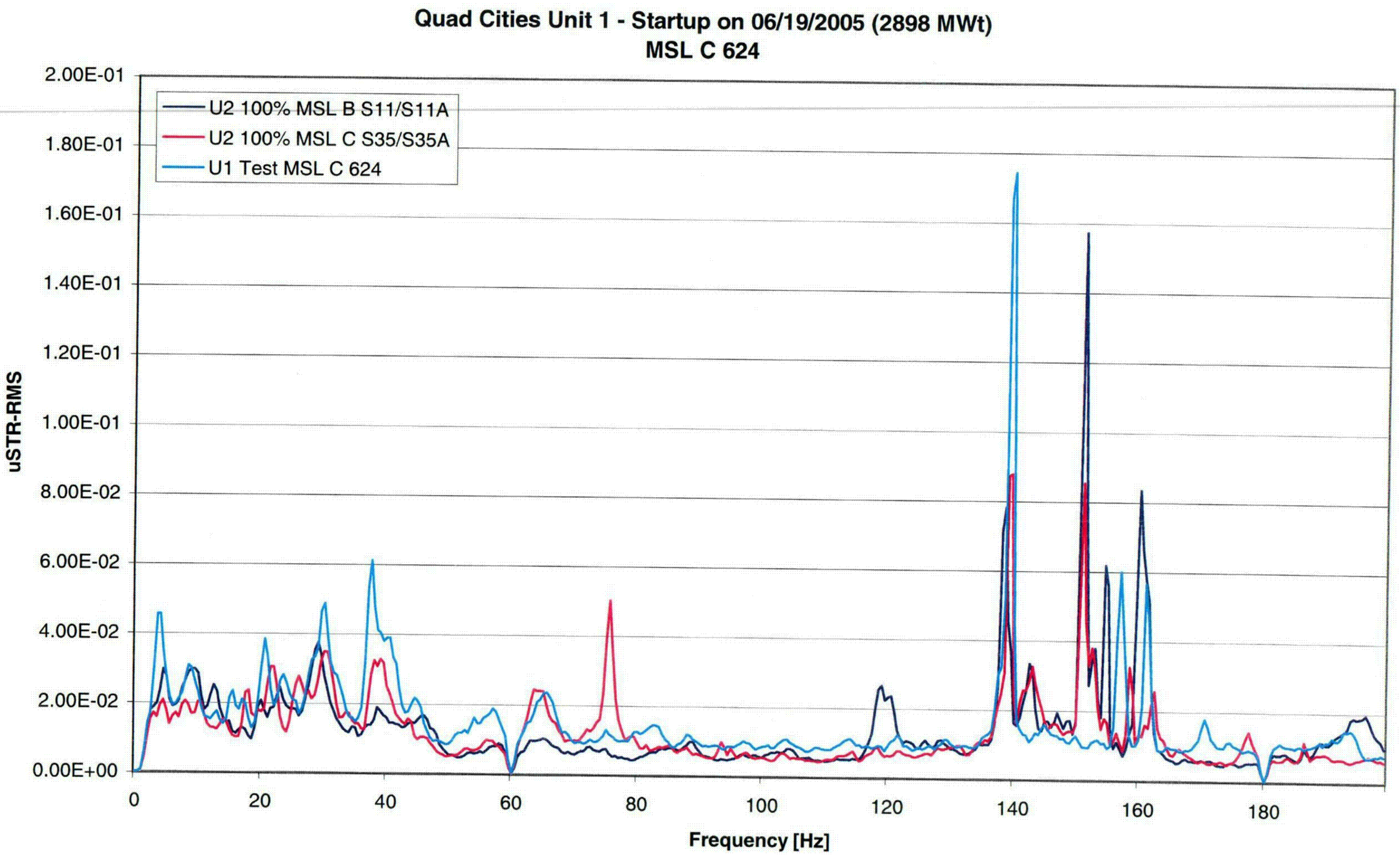
C39

Figure 40



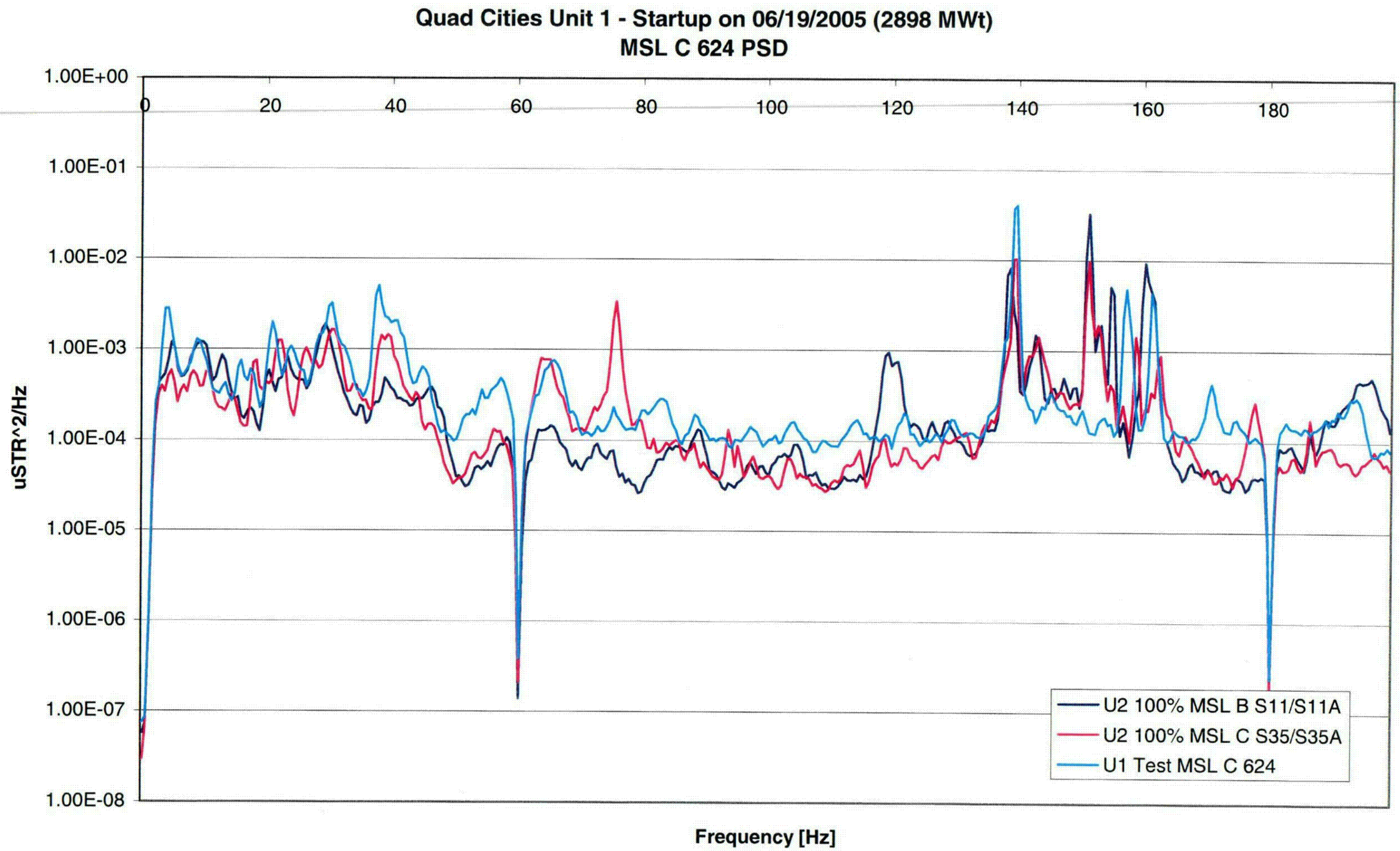
C40

Figure 41



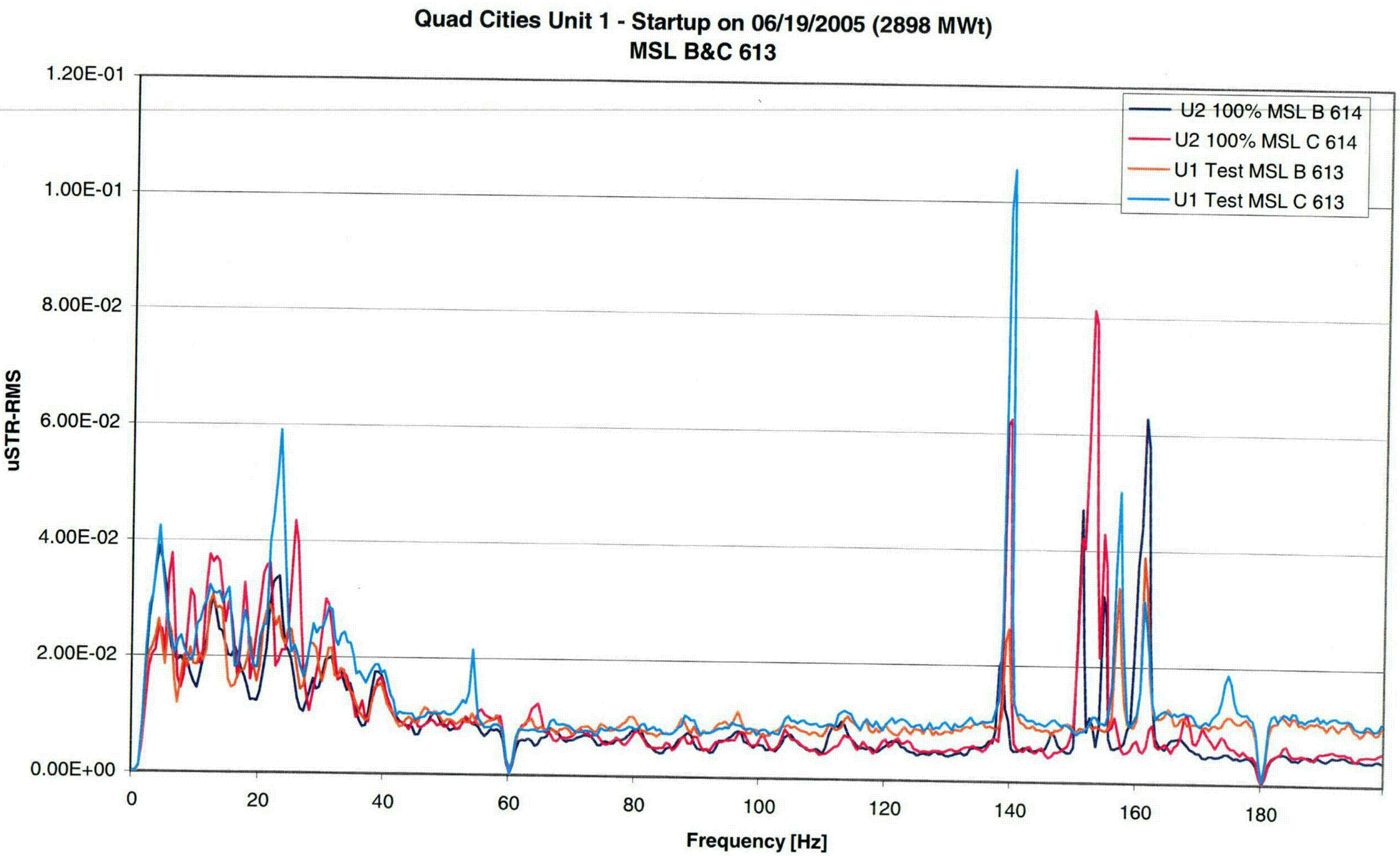
C41

Figure 42



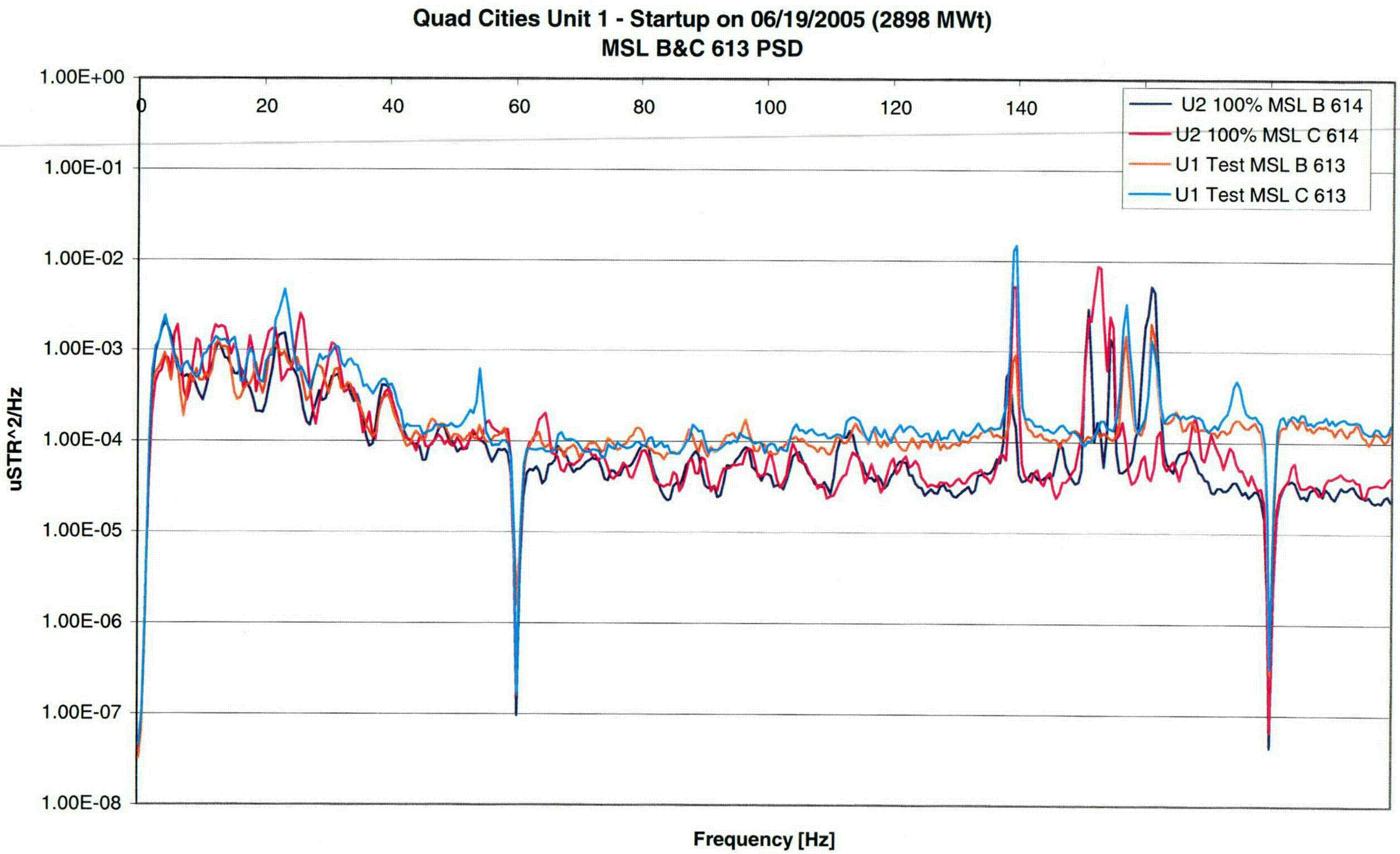
C42

Figure 43



C43

Figure 44



C44

ENCLOSURE 2

Attachment 2

Structural Integrity Associates Letter KKF-05-036, "Quad Cities Unit 1 Main Steam Line Strain Gage Reductions," dated July 6, 2005

Structural Integrity Associates, Inc.

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July 6, 2005
SIR-05-208 Revision 2
KKF-05-036

Mr. Robert Stachniak
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

Subject: Quad Cities Unit 1 Main Steam Line Strain Gage Reductions

Dear Rob:

This letter report contains an evaluation of the Quad Cities Unit 1 (QC1) main steam line C elevation 651' (MSL C 651) strain gage data obtained during the June 2005 power ascension. In addition, this revision contains the evaluation of the QC1 strain gage locations where one strain gage failed during the June 2005 power ascension.

Background

Main steam line strain gage data was obtained during the June 2005 power ascension at Quad Cities Unit 1 [1]. This data will be used to as input to the acoustic line analysis that determines the forcing function on the steam dryer. Prior to the power ascension, strain gages were installed on each of the four main steam lines (MSLs) at two axial locations. At each axial location two strain gage pairs are formed with two gages 180° apart. The two gages are connected to a Wheatstone bridge in the ½ bridge configuration where the two strain gages will sum to provide higher sensitivity and provide cancellation of the Poisson effect due to pipe bending. Figures 1a and 1b shows sketches of the strain gage locations for Quad Cities Unit 1 MSL A, B, C, and D. In addition, these sketches identify the strain gages that failed during the June 2005 power ascension [2].

The purpose of the strain gage measurement is to obtain an indirect measurement of the dynamic pressure pulsations in the main steam piping. The strain gages are used to measure the hoop strain that can then be converted into internal pressure. Due to the location of the strain gages, each individual gage will contain breathing mode strain as well as additional hoop strains associated with higher order shell responses. Due to the random nature of the pressure in the pipe, the strain bridges were averaged in the two orthogonal planes to provide a representative strain at each location.

The strain data is processed by averaging the time histories of the two orthogonal half bridges (sum and divide by 2) and processing (spectra, rms, maximum, minimum) the data for the averages. In general, the averaging provides a reduction of the rms, maximum and minimum values due to several of the primary frequencies (large amplitude peaks in the spectra) being nearly 180° out of phase between the orthogonal planes.

A problem occurred during the power ascension due to failure of individual strain gages. Specifically, strain gage S31 (located at MSL C 651) failed after test condition TC10 so the half bridge S31/33 data were unavailable for the higher power levels. For this case, an average of the orthogonal bridges was not possible and only the half bridge (S32/34) and the quarter bridge (S33) were available.

A review of the TC15a data at QC1 MSL C 651 where strain gage S31 failed shows that S32/34 provides unusually high peaks (Figures 4 and 5) at 157.7 Hz (0.78 $\mu\varepsilon_{rms}$) and 78.6 Hz (0.26 $\mu\varepsilon_{rms}$). This paper discusses the feasibility of determining a method to combine the strain gages where there is only ¼ and ½ bridge data.

Approach

An approach is to use the actual QC1 plant data obtained during the June 2005 power ascension and combine the ½ bridge (S32/S34) strain gage time history with the ¼ bridge (S33) strain gage time history to obtain the frequency spectra for QC Unit 1 (QC1) MSL C 651. This approach is a reasonable and conservative method for determining the pressure induced measurement at QC1 MSL C 651 and is based on the structural similarities between QC1 and QC Unit 2 (QC2).

The relationship between the pressure loading and the response of the two units at a particular strain location appears to be largely independent of the pressure loading. In other words, the structures respond to pressure loadings based on a set of fixed transfer functions that are the same for both units. The relationship between orthogonal strain measurements, in- and out-of plane at a particular location, is also determined by these transfer functions.

In comparing QC2 MSL C 651 (Figures 2 and 3), where both bridges are functioning as ½ bridges, to QC1 MSL C 651 (Figures 4 and 5), where there is a ½ bridge (S32/34) and a ¼ bridge (S33), the similarity in relative amplitudes between S32/34 to S31/33 is striking. The maximum values in the 140 to 160 Hz range are also comparable per strain gage pair. Figures 1 through 4 are composed of the individual strain measurements in the orthogonal planes and the average (QC1 S31 failed of the strain gage pair S31/33, so only a ¼ bridge is available for that pair).

Another example of similar local strain behavior between QC2 to QC1 strain measurements is found by reviewing the orthogonal amplitudes for QC2 MSL D 624, Figure 6, and QC1 MSL D 624 Figures 7. For QC2 MSL D 624, the amplitudes of the orthogonal pair are similar in magnitude (Figure 6) particularly in the frequency range of 140 to 160 Hz. A comparison of the amplitudes between QC2 MSL D 624 (Figure 6) and QC1 MSL D 624 (Figure 7) shows that the magnitudes of the orthogonal pairs are also similar between the two plants in the frequency range of 140 to 160 Hz and both yield much lower average amplitudes at these frequencies. In addition, the amplitudes for QC1 and QC2 MSL D 624 (Figures 6 and 7) are greater than the amplitudes in the frequency range of 140 – 160 Hz, for QC1 and QC2 MSL C 651 (Figures 3 and 5). It should be noted that the combined result for QC1 MSL C 651, Figure 5, using S32/34 and S33, reduces the strain amplitudes in the 140 – 160 Hz range less than the reduction for MSL D 624 using two ½ bridges. Based on the amplitude reductions seen from the QC1 and QC2 MSL D 624 averages, it appears that the three strain gages averaged together at QC1 MSL C 651 is still conservative in this frequency range.

Given the structural similarities between the two units in addition to the strain measurement analysis results above and the fact that the strain gages on opposite sides of the piping cross-section should respond similarly (as they do in at least one case where individual gages are available), the combined average of S33 and S32/34 for TC15A (Figures 4 and 5) can be used as a conservative representation of the pressure induced measurement at QC1 MSL C 651. This will provide an overall RMS reduction factor of nearly 1.7 (Table 1) and an individual reduction factor of 1.7 at 157.7 Hz and a reduction factor of 1.7 at 78.6 Hz.

Table 1 contains the rms, peak-peak, and rms spectral values at 157.7 Hz and 78.6 Hz for the ¼ and ½ bridges. The averaged ¼ and ½ bridge rms, peak-peak, and rms spectral values at 157.7 Hz and 78.6 Hz are also listed in Table 1 and are identified as MSL C-651 [avg(S33+S32/S34)]. In addition, the ratio of the ¼ and ½ bridge results divided by the MSL C-651 results are also listed in Table 1.

A review of Table 1 shows the overall reduction of 1.6 to the rms values for S32/34 versus the averaged MSL C-651 rms value. In addition, the spectral peaks at 157.7 Hz and 78.6 Hz are also reduced by factors of 1.7 for both frequencies.

Table 1. QC1 MSL C 651 Strain Gage Data

	TC 15a (1/2 Bridge Data) (με)			
Unit 1 MSL C 651			**157.7 Hz**	**78.6 Hz**
	rms	**pk-pk**	**rms**	**rms**
(S33) In-plane	0.40	3.26	0.13	0.04
Ratio [(S33)]/MSL C-651	**0.58**	**0.56**	**0.32**	**0.28**
(S32/34) Out of plane	1.11	9.63	0.66	0.26
Ratio [(S32/34)]/MSL C-651	**1.60**	**1.66**	**1.67**	**1.72**
MSL C-651 [avg(S33+S32/34)]	0.69	5.80	0.40	0.15

In addition to the failure of strain gage S31, strain gages S3, S6, S11A, and S36 failed during the June 2005 power ascension [2]. These failed strain gages correspond to locations QC1 MSL A 651 (S3), QC1 MSL A 624 (S6), QC1 MSL B 624 (S11A), and QC1 MSL C 624 (S36). Using the same methodology to combine the ¼ and ½ bridge for these locations results in a reduction at 157.7 Hz. Table 2 lists the rms and peak-peak values for these locations for the ¼ and ½ bridges.

Table 2. QC1 MSLs A 651, A 624, B 624, and C 624

	MSL A 651	rms	pk-pk	MSL A 624	rms	pk-pk	MSL B 624	rms	pk-pk	MSL C 624	rms	pk-pk
	(S1) In-plane	0.76	4.81	(S5/5A) In-plane	0.31	3.15	(S11) In-plane	0.38	6.30	(S35/35A) In-plane	0.41	3.50
Ratio	[(S1)]/MSL A-651	1.55	1.31	[(S5/5A)]/MSL A 624	0.58	0.24	[(S11)]/MSL B 624	1.14	1.16	[(S35/35A)]/MSL C 624	1.23	2.76
	(S2/4) Out of plane	0.52	4.93	(S6A) Out of plane	1.02	23.40	(S12/12A) Out of plane	0.41	5.55	(S36A) Out of plane	0.49	4.11
Ratio	[(S2/4)]/MSL A-651	1.06	1.35	[(S6A)]/MSL A 624	1.88	1.81	[(S12/12A)]/MSL B 624	1.22	1.02	[(S36A)]/MSL C 624	1.50	3.24
	MS A-651 avg[S1+S2/4]	0.49	3 66	MSL A 624 avg [S5/S5A+S6A]	0.54	12.90	MSL B 624 avg [S11+S12/S12A]	0.34	5 45	MSL C 624 avg [S35/35A+S36A]	0.33	1.27

There appears to be a minimal reduction for MSL B 624, this is due to a residual amplitude at 60 Hz that still exists after the application of a notch filter.

Raw Data Conversion Factor for CDI

The conversion factor (CF) to be used by CDI to convert from the raw, recorded strain (με) data to pressure (psi) is applied to strain data acquired using a half bridge configuration. The Yokogawa data acquisition system (DAS) was set up to initially record data from ¼ bridges. After the initial DAS setup, the strain gage configuration was modified to two pairs of ½ bridges at each location. The settings on the DAS were not changed so the data was recorded as if each channel was configured as a ¼ bridge. Thus, for this system configuration, if a quarter bridge is used in conjunction with a half bridge, as is the case for MSL C 651, then the following equation must be used to convert this combination to the average pressure ($P_{33+32/34}avg$).

$$P_{33+32/34}avg = \{\ [2 * S33 + (S32 + S34)] \div 2\} \times CF$$

where CF is the conversion factor for MSL C 651(CF=1.94) and $P_{33+32/34}avg$ will be in psi. Table 3 lists the conversion factors for the other main steam line locations that contained ¼ -½ bridge combinations.

Table 3. QC1 Conversion Factors

Location	CF
MSL A 624	1.896
MSL A 651	1.914
MSL B 624	1.821
MSL C 624	1.893

Conclusion

Using actual data obtained during June 2005 for QC1 MSL C 651 where only one ½ bridge (S32/34) and one ¼ bridge (S33) is available; the strain gage measurement can be conservatively determined by averaging the ½ bridge data with the ¼ bridge data. Similarities discussed above in the QC1 and QC2 strain gage data demonstrate that the ¼ and ½ bridge strain gage combination at QC1 MSL C 651 results in conservative pressures for the frequencies of concern. This results in an overall reduction of 1.6 to the overall rms values over the bandwidth of 2 – 200 Hz for S32/34 versus the averaged MSL C-651 rms value. In addition, the spectral peaks at 157.7 Hz and 78.6 Hz are also reduced by factors of 1.7 for both frequencies.

Additionally, for the other locations that had one strain gage fail (QC1 MSL A 624, QC1 MSL A 651, QC1 MSL B 624, and QC1 MSL C 624), the actual measured data for the ¼ and ½ bridges can also be combined which results in an overall reduction of the rms values and spectral peaks.

If you have any questions, please do not hesitate to contact me at (303) 792-0077.

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2. Exelon TODI No. ODC-05-0225, "Main Steam Line Strain Gauge Failures During Quad Cities Unit 1 Startup Testing," SI File No. EXLN-20Q-201.

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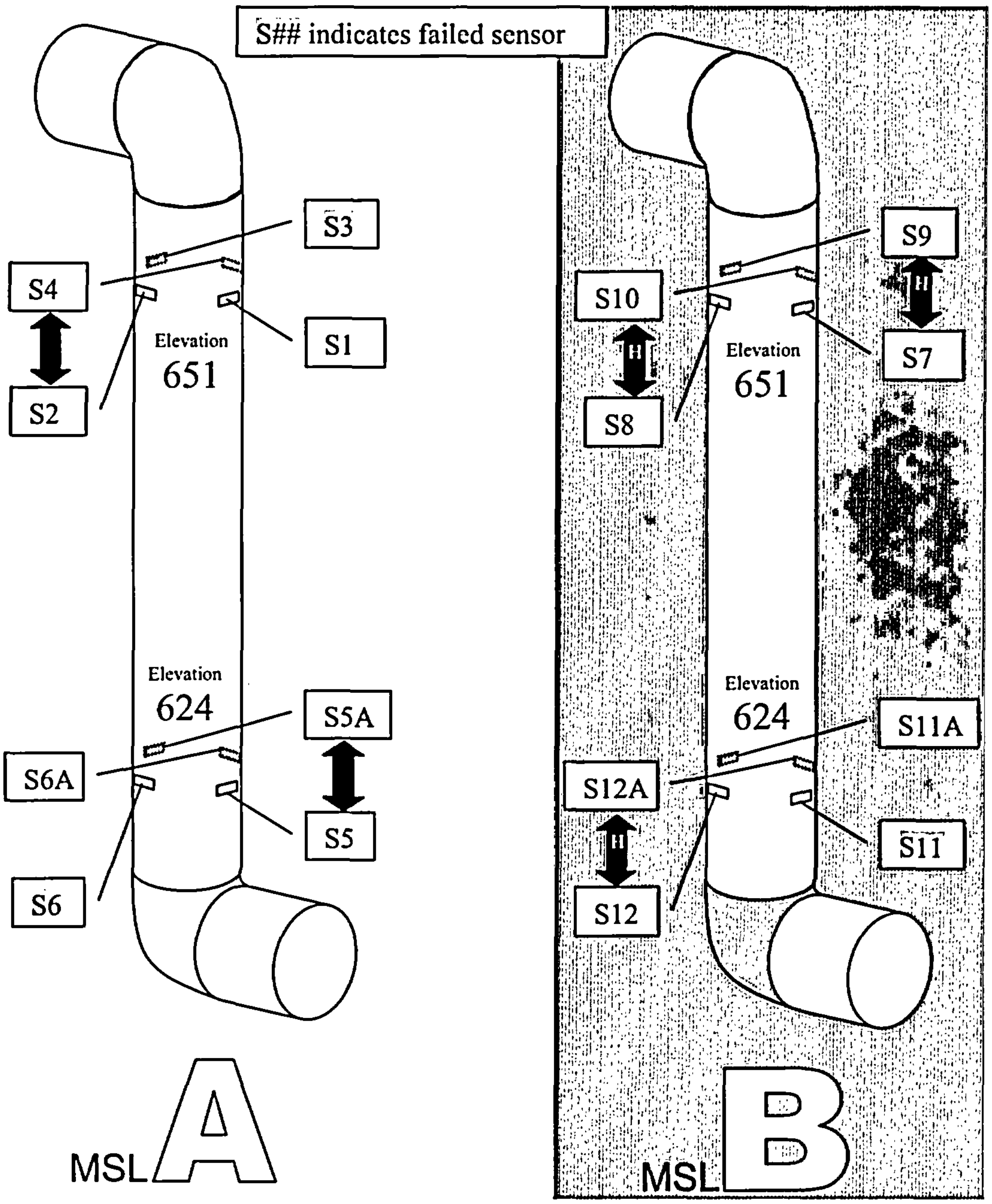

Figure 1a. Location of Failed Strain Gages on QC1 MSLs A and B

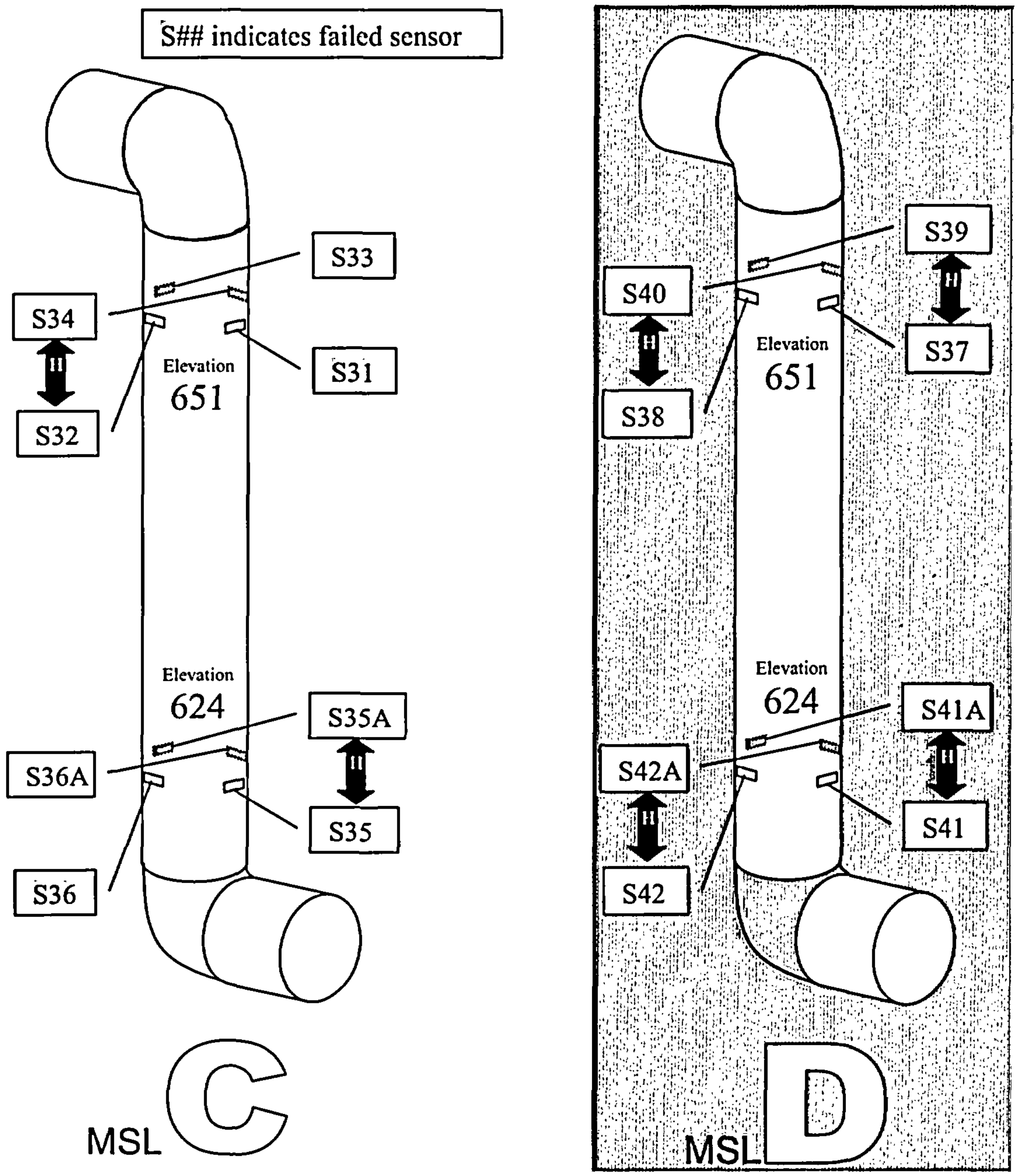

Figure 1b. Location of Failed Strain Gages on QC1 MSLs C and D

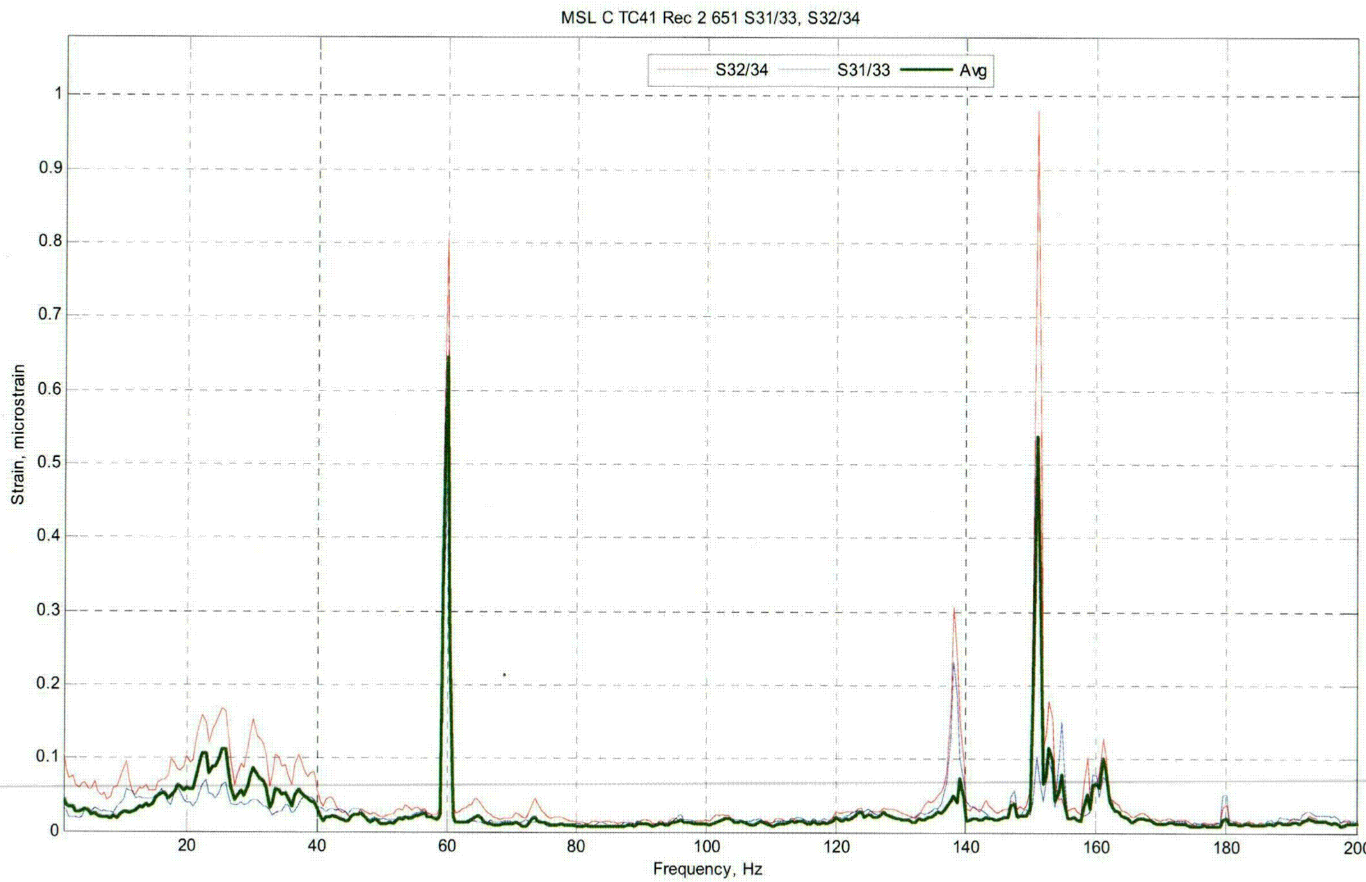

Figure 2. QC2 MSL C 651 Combined

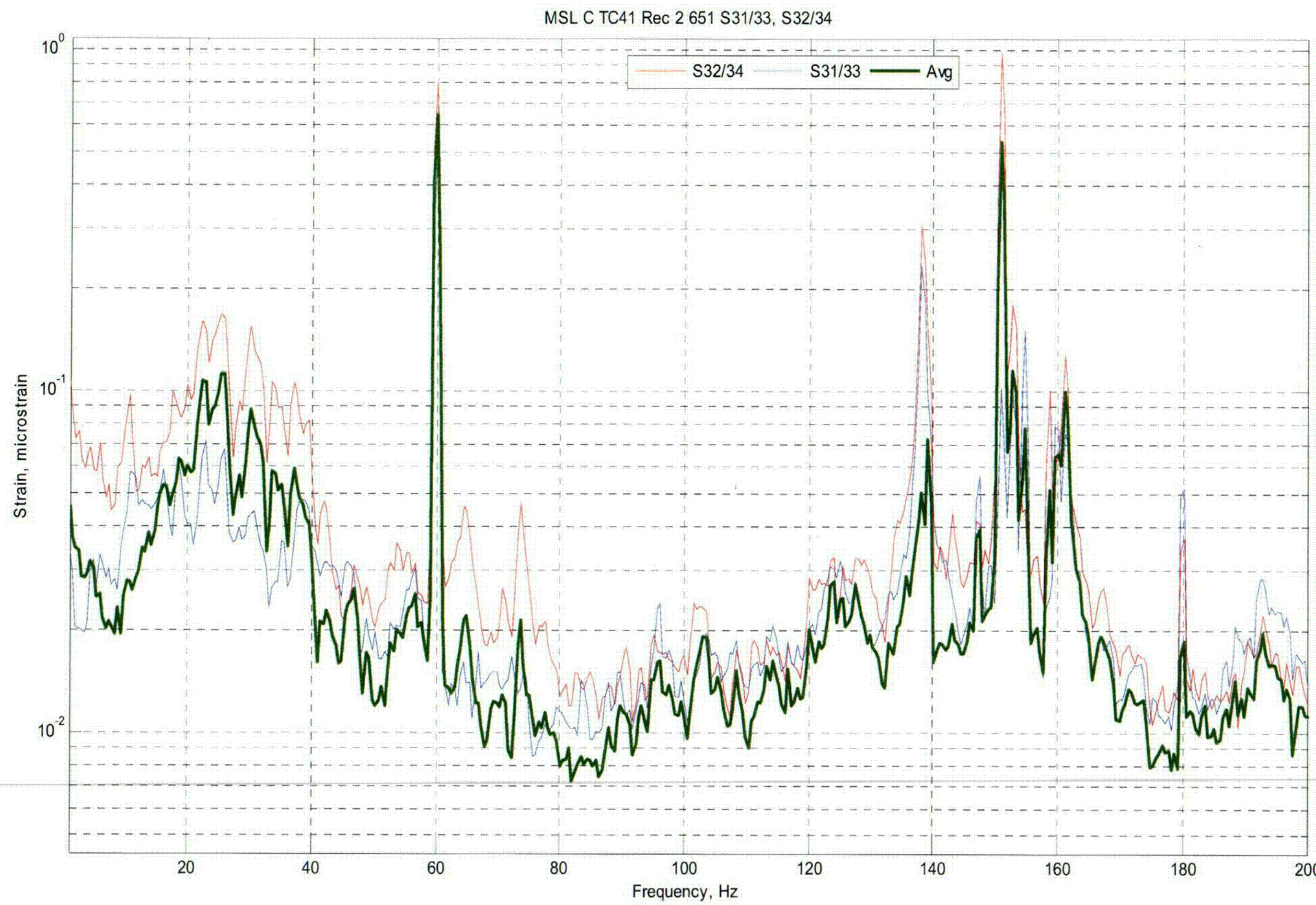

Figure 3. QC2 MSL C 651 Combined

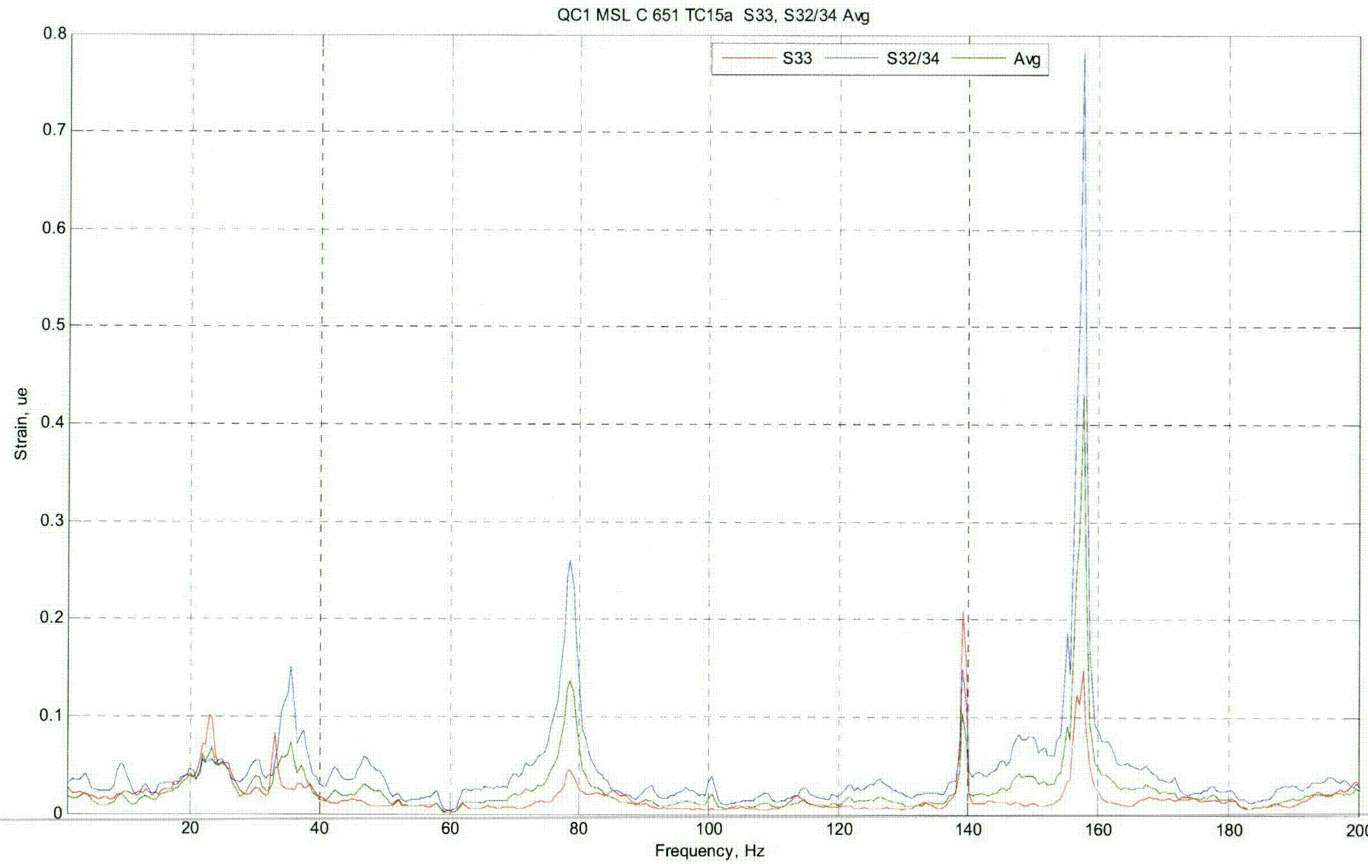

Figure 4. QC1 MSL C 651 S33 & S32/34 Combined

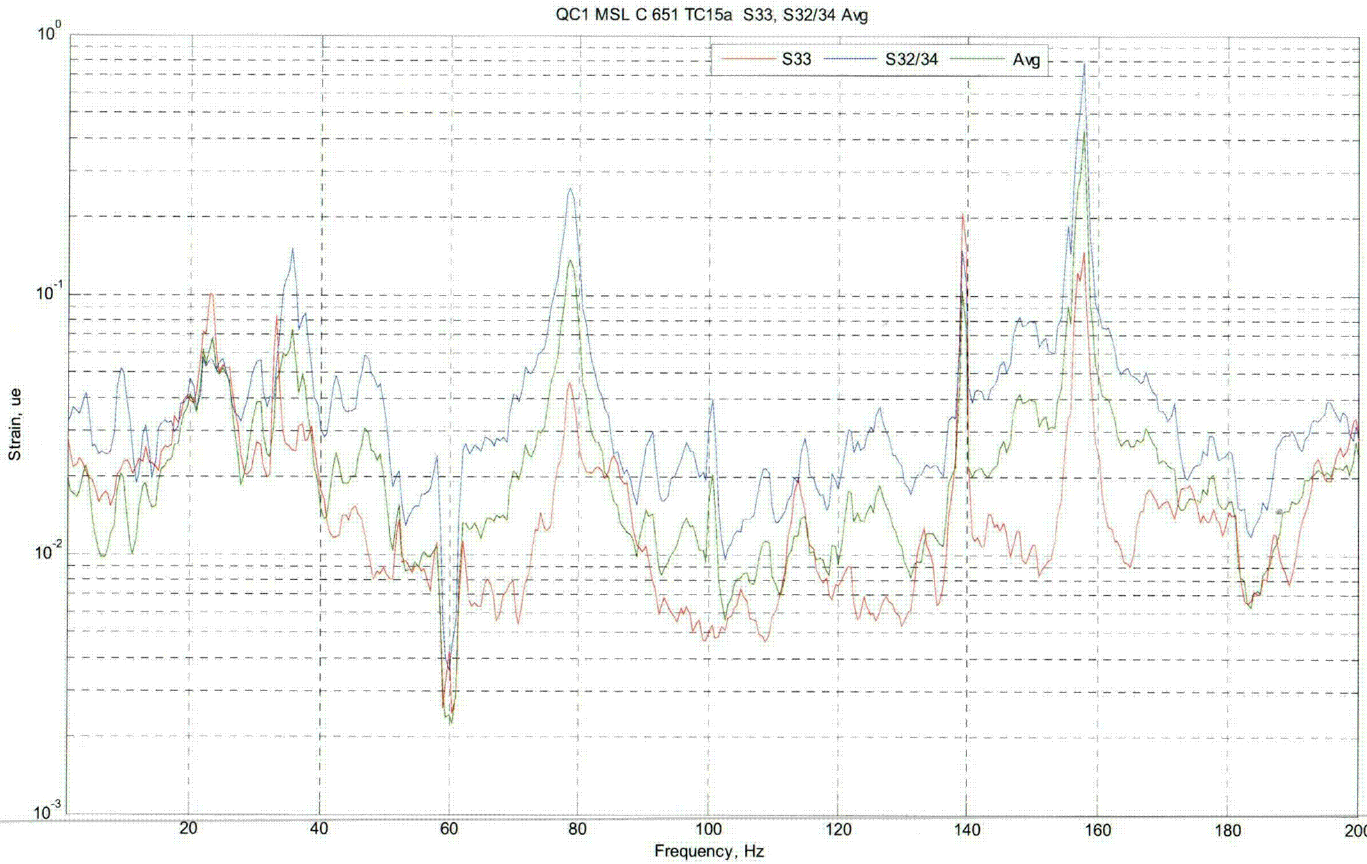

Figure 5. QC1 MSL C 651 S33 & S32/34 Combined

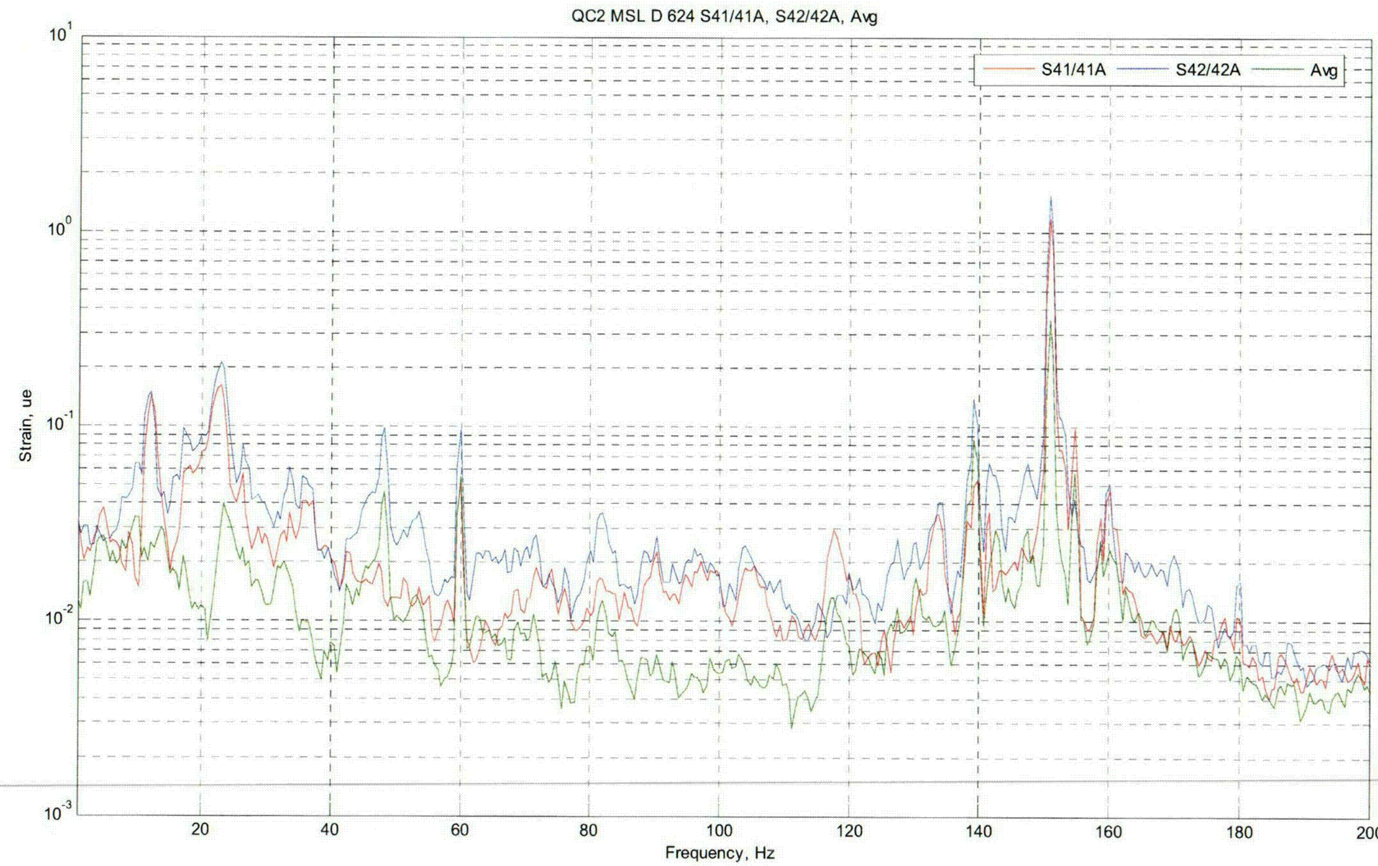

Figure 6. QC2 MSL D 624 Combined (Both ½ Bridges)

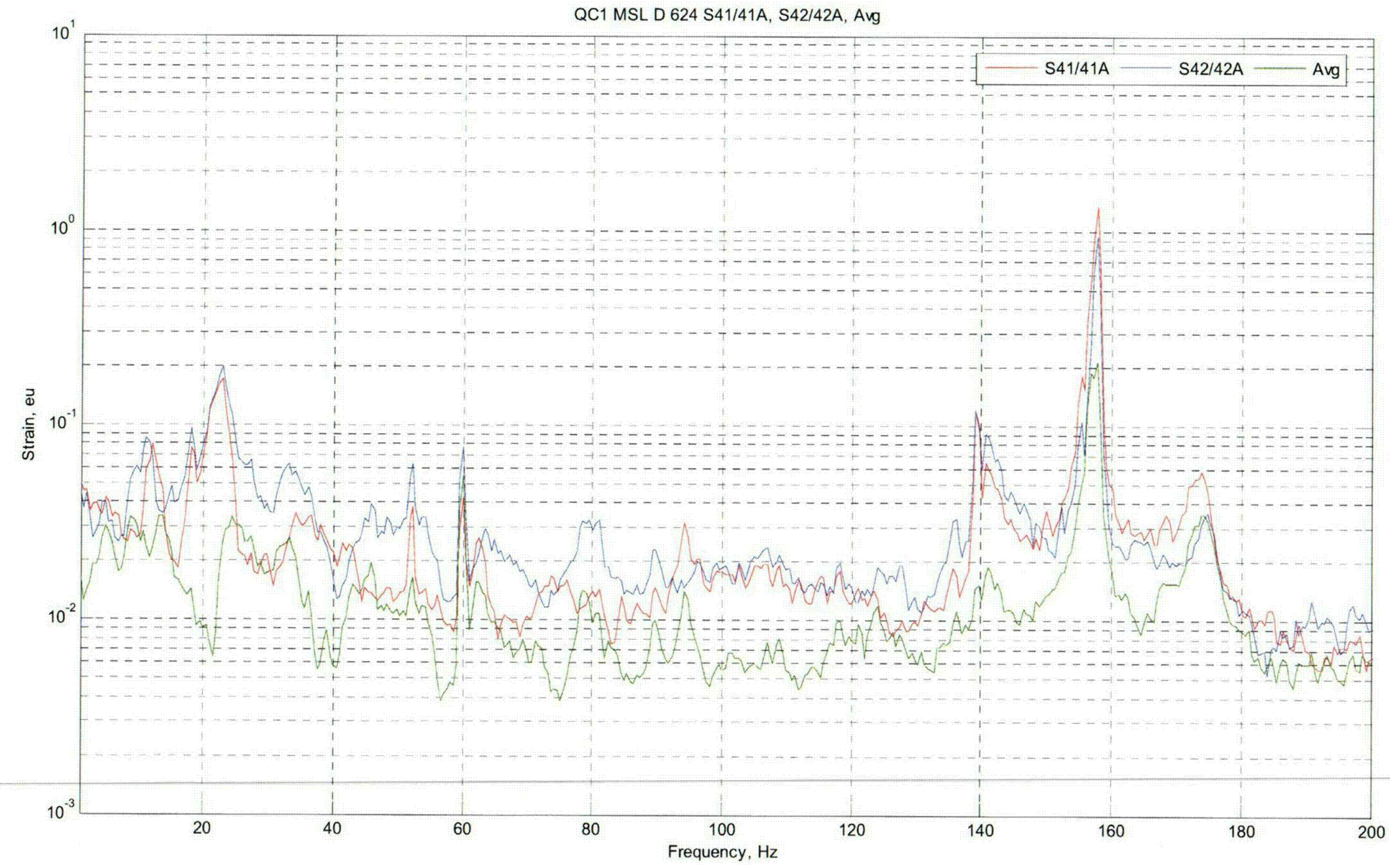

Figure 7. QC1 MSL D 624 Combined (Both ½ Bridges)

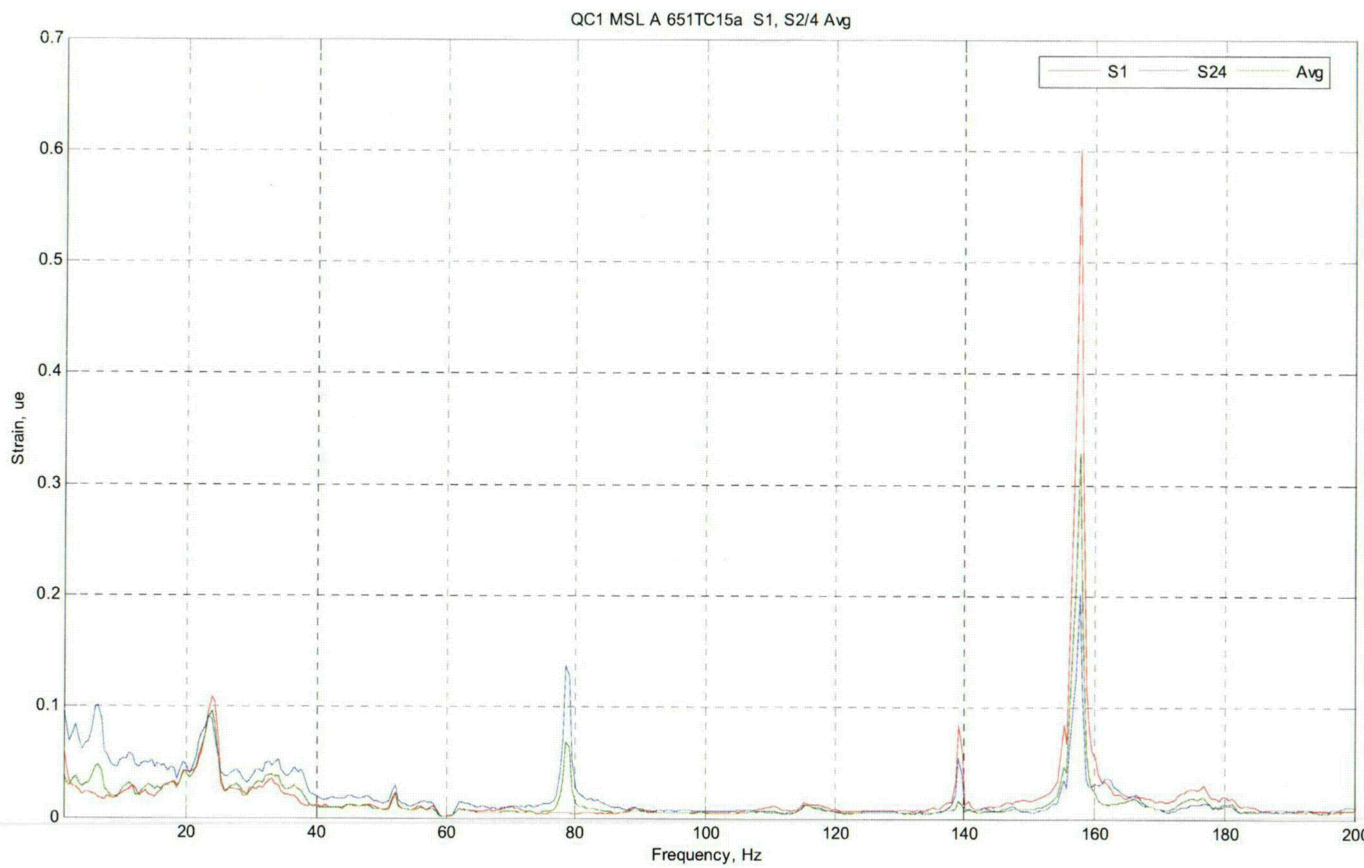

Figure 8. QC1 MSL A 651 S1 & S2/4 Combined

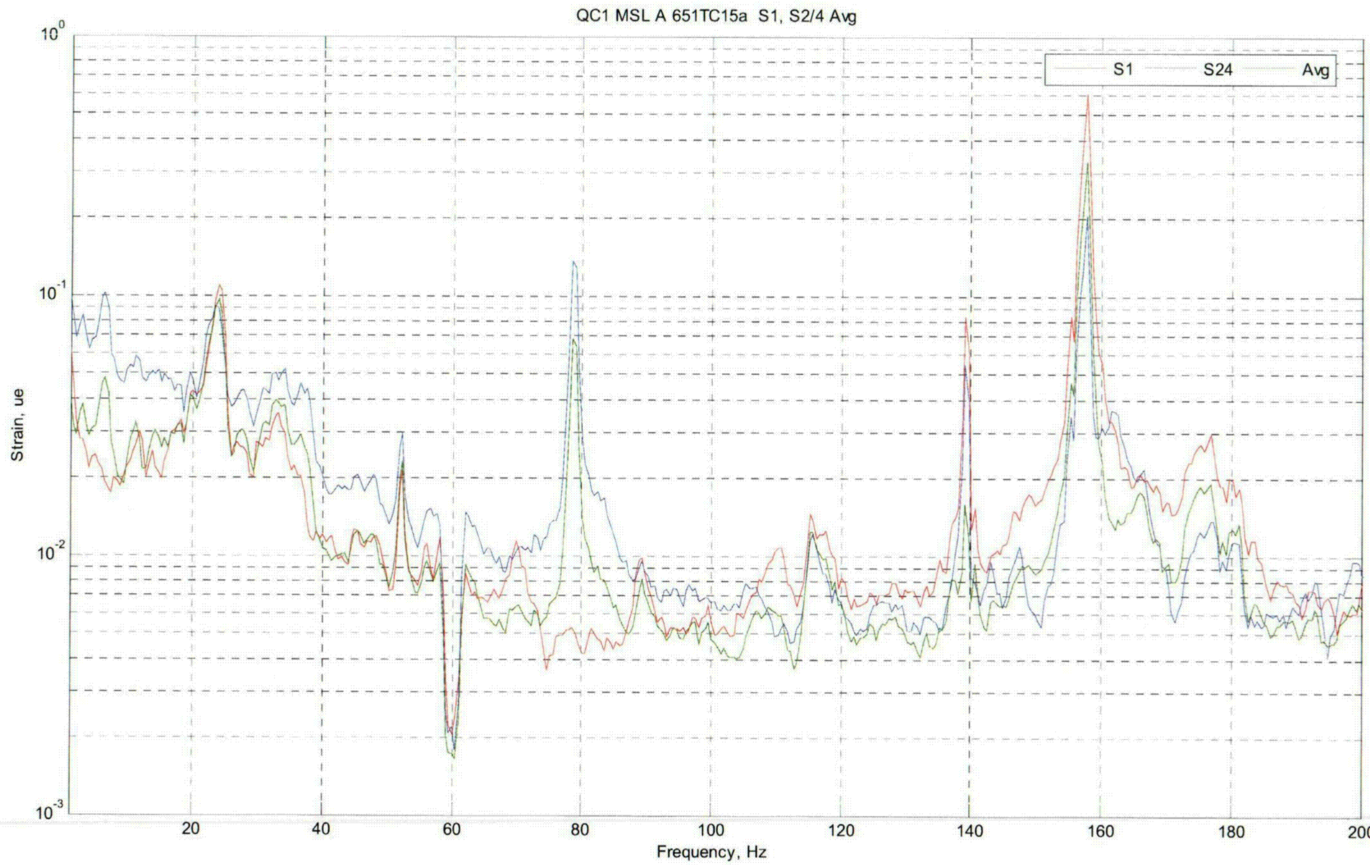

Figure 9. QC1 MSL A 651 S1 & S2/4 Combined

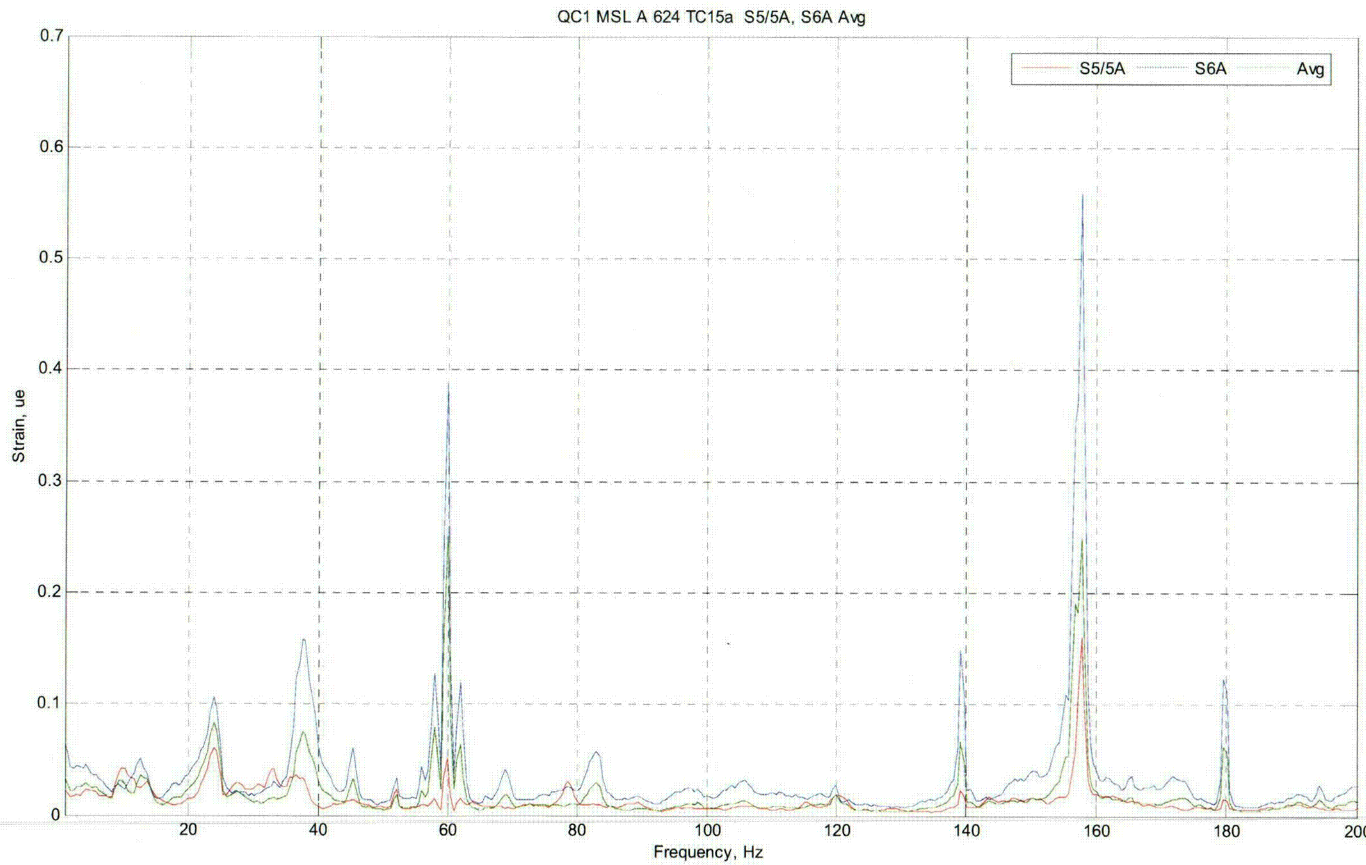

Figure 10. QC1 MSL A 624 S5/5A & S6A Combined

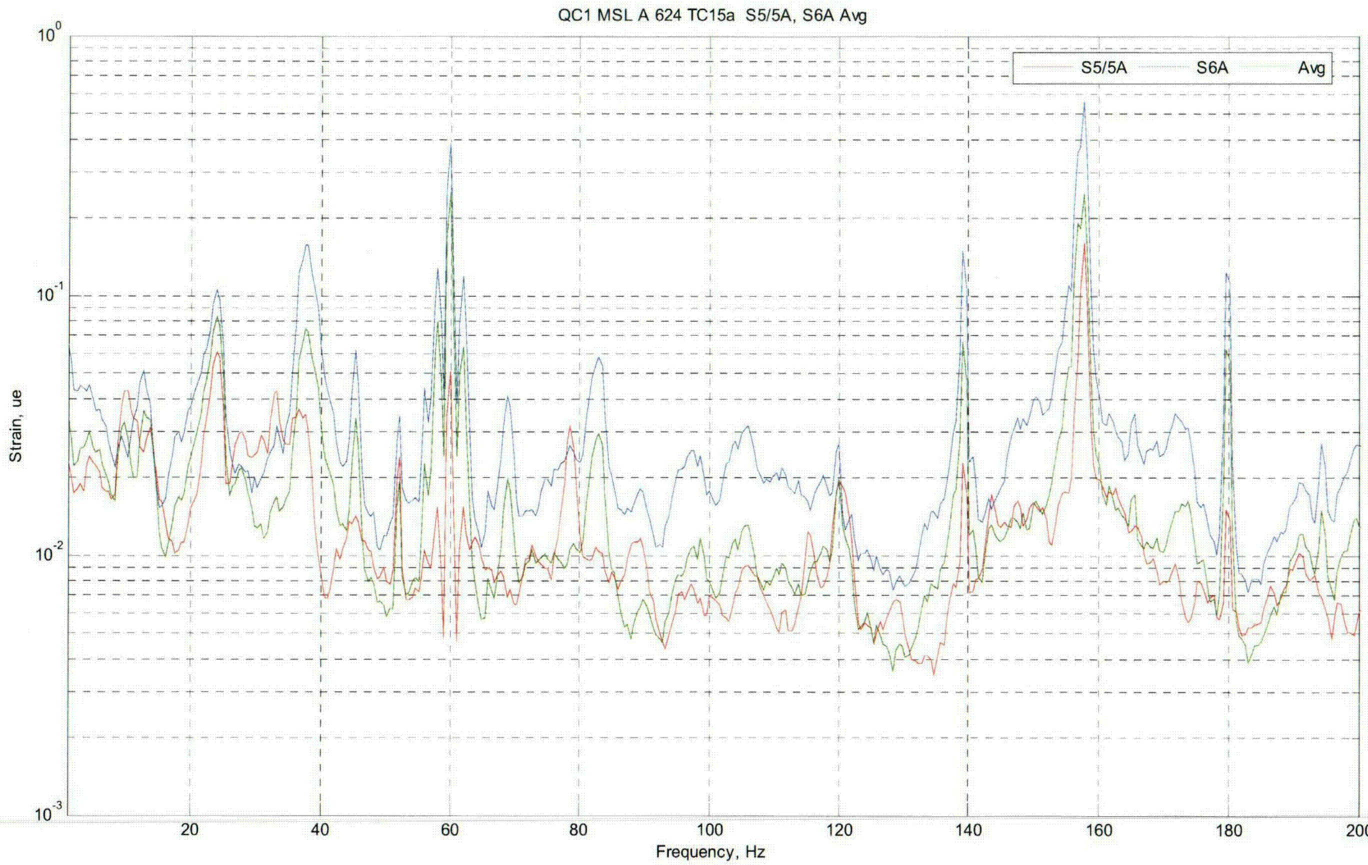

Figure 11. QC1 MSL A 624 S5/5A & S6A Combined

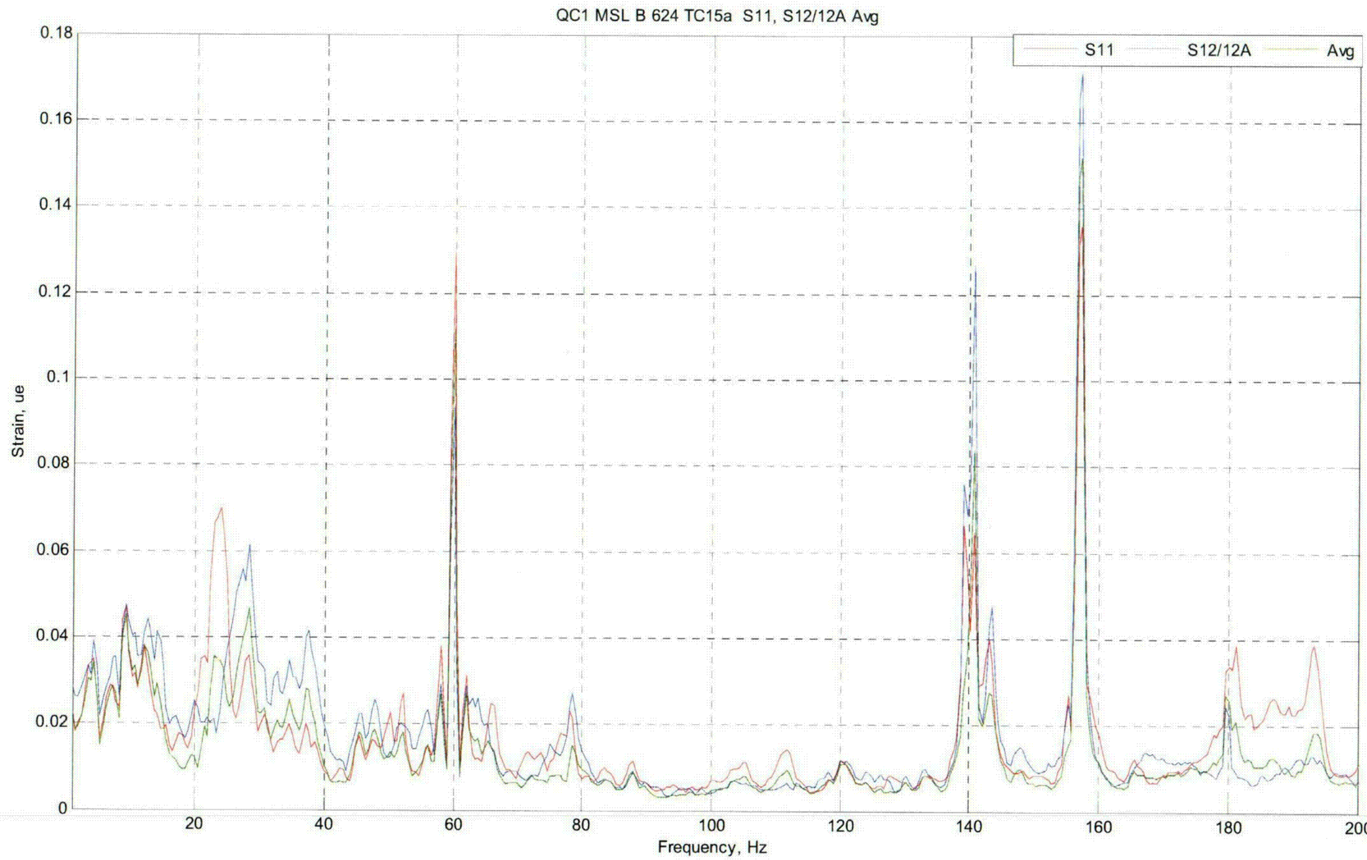

Figure 12. QC1 MSL B 624 S11 & S12/12A Combined

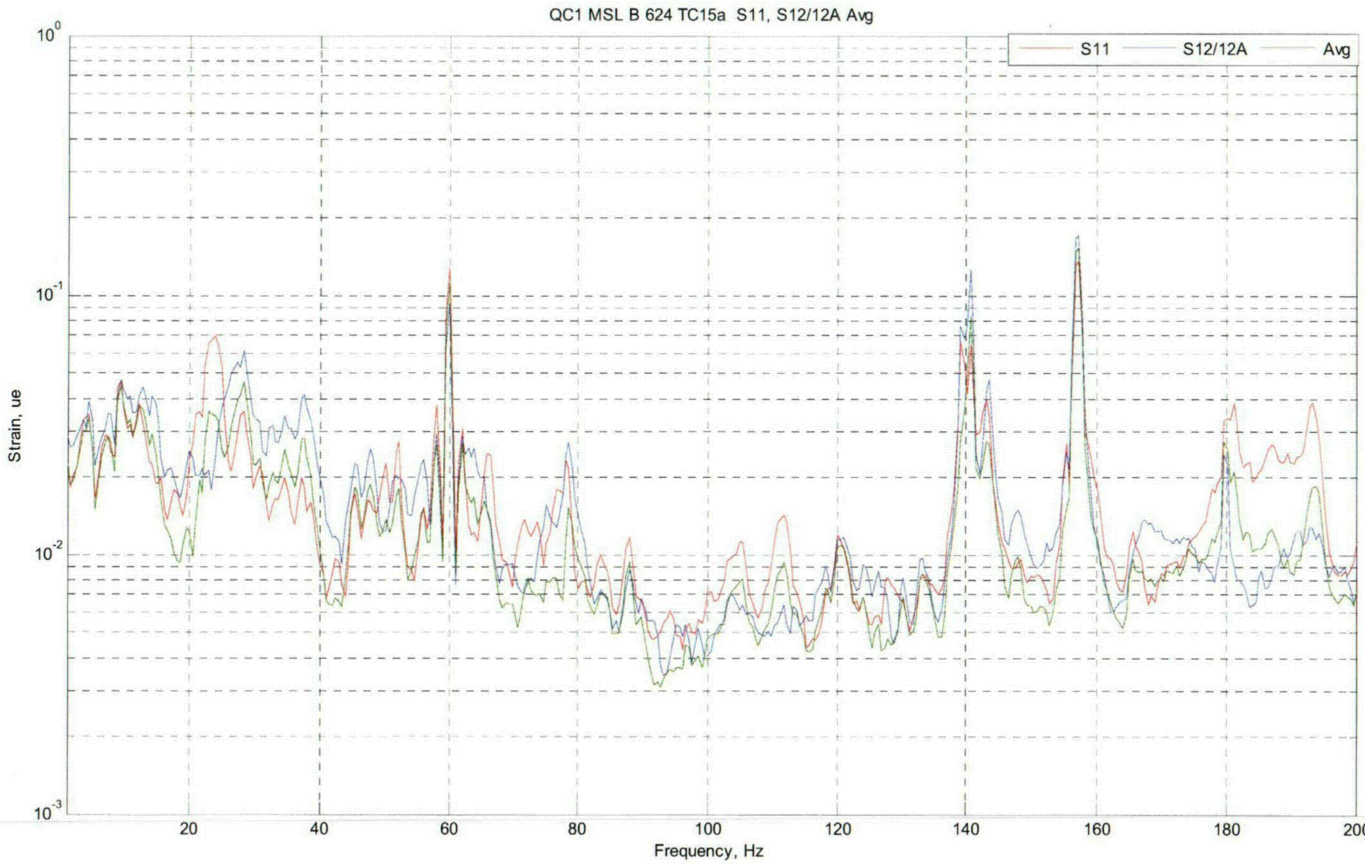

Figure 13. QC1 MSL B 624 S11 & S12/12A Combined

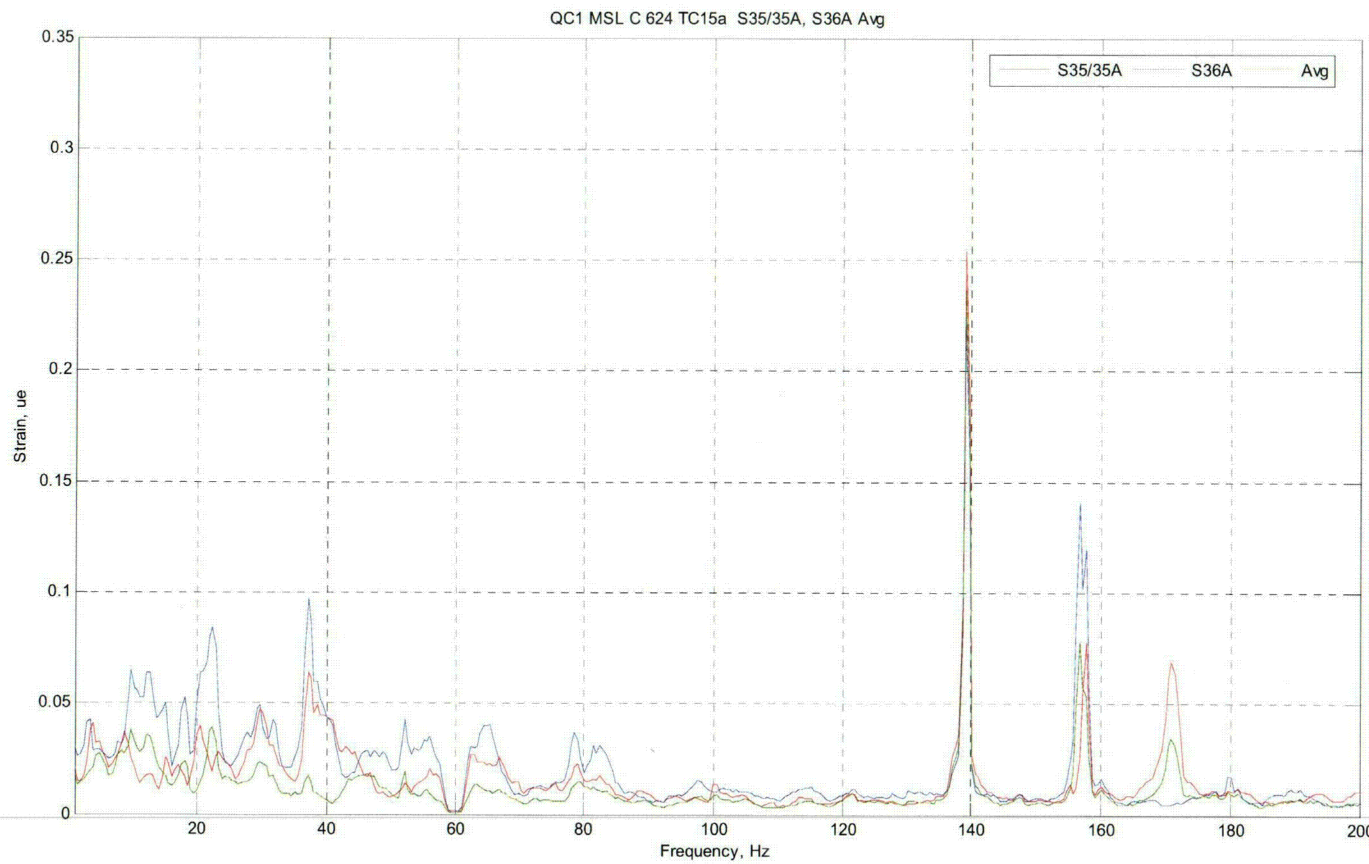

Figure 14. QC1 MSL C 624 S35/35A &S36A Combined

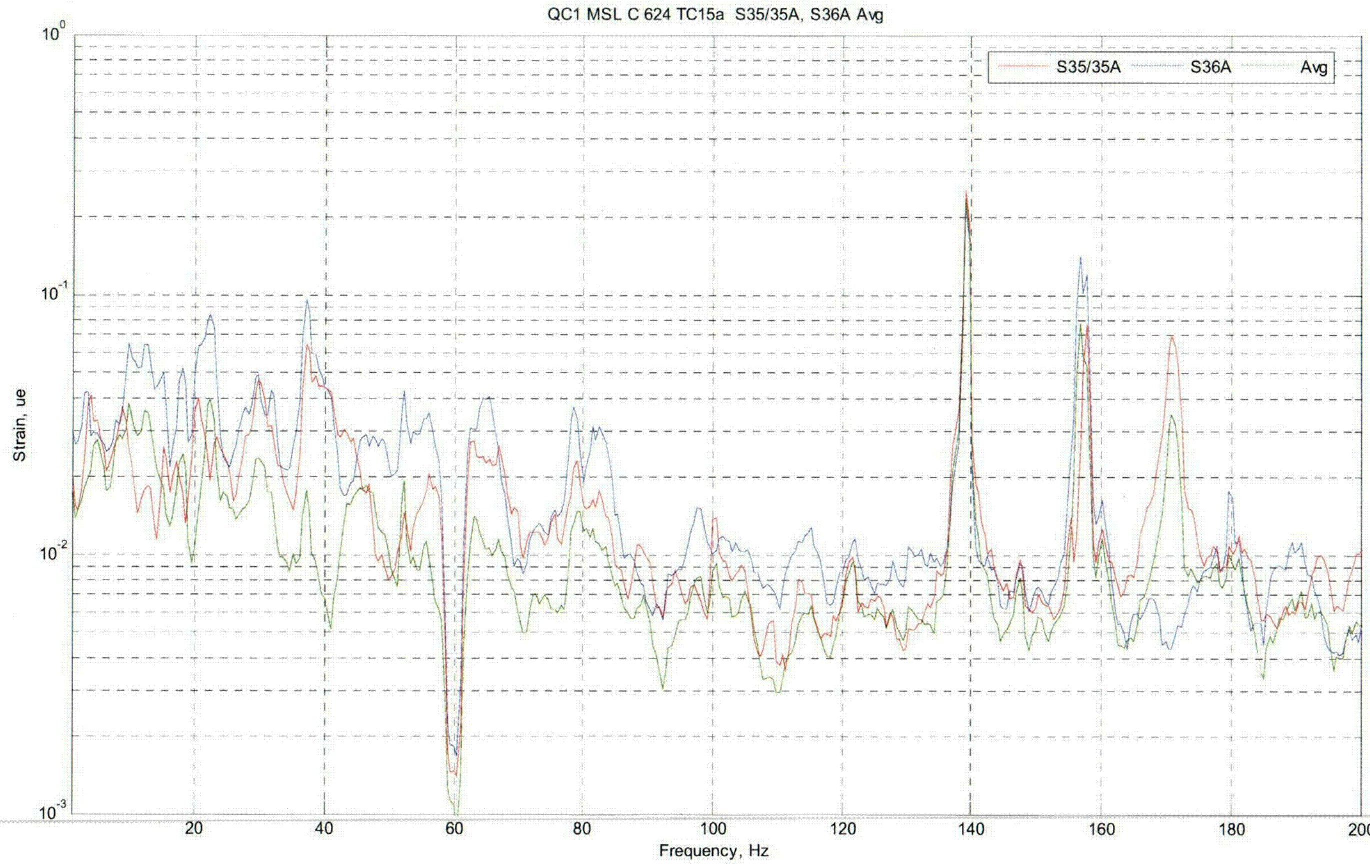

Figure 15. QC1 MSL C 624 S35/35A & S36A Combined