# ENCLOSURE 2

## Attachment 7

## Structural Integrity Associates Letter KJO-05-004, "Vibration Comparison of Quad Cities Units 1 and 2 Power Ascension Accelerometer Spectra Data," dated July 14, 2005

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

Subject: Vibration Comparison of Quad Cities Units 1 and 2 Power Ascension Accelerometer Spectra Data

Dear Rob,

The intent of this review is to compare the amplitude and frequency of ERV-3B and ERV-3C accelerometer vibration data between Quad Cities Unit 1 (QC1) and Quad Cities Unit 2 (QC2). Data comparisons were made at common, higher power levels where frequency content is representative of full power operation. Additionally, frequency content will be compared to known acoustic frequencies present within the main steam (MS) piping systems.

## INTRODUCTION

QC1 and QC2 completed their maintenance outages and subsequent power ascensions in May and June 2005, respectively. During their 2005 outages, accelerometers were installed and/or reconnected and during each power ascension accelerometers were monitored at two ERV locations (ERV-3B and ERV-3C). Only ERV-3B and ERV-3C were common to both QC1 and QC2 (QC1 had accelerometers on ERV-3B and ERV-3C only, whereas, QC2 had accelerometers on all ERVs). Data monitoring consisted of recording accelerometer time histories at several power levels during power ascension. These accelerometer time histories were then converted to acceleration frequency spectra by Exelon.

This review provides a detailed assessment of both the amplitude and frequency content of these accelerometer spectra.

## INSTRUMENT TYPES AND LOCATIONS

The accelerometer spectra comparisons were limited to two locations; QC1 had accelerometers at two locations (ERV-3B and ERV-3C), whereas, QC2 had accelerometers at all ERVs, including ERV-3B and ERV-3C. This limited the frequency spectra comparisons to the two valve locations only.

QC1 – Power Ascension, June 2005

The vibration levels of two ERVs (ERV-3B and ERV-3C) were monitored during the June 2005 power ascension. These locations were selected because they had the highest amplitudes observed during the December 2003 power ascension. Six accelerometers were mounted on each valve inlet in the x, y, and z axes (two tri-axial mounts on either side of the valve inlet flange, Table 1 and Figures 1 through 3). QC1 accelerometers were in approximately the same locations as the QC2 accelerometers.

Vibration data was captured and processed by Exelon personnel and Structural Integrity Associates received frequency spectra for each of 10 power levels [1]. Spectra data was captured from 0-2887 MWth (87.3 – 910.7 MWe) [8], but only power levels greater than 85% power level (Table 3) were used in this comparison. Amplitude and frequency content for these spectra plots are more representative of full power operation.

QC2 – Power Ascension, April 2005

The vibration levels of four ERVs (ERV-3B, ERV-3C, ERV-3D, and ERV-3E) were monitored during the April 2005 power ascension. All locations had three accelerometers mounted on each valve inlet in the x, y, and z axes (one tri-axial mount on the valve inlet flange, Table 2 and Figures 1 and 2). QC1 accelerometers were in approximately the same locations as the QC2 accelerometers. Due to the fact, that QC1 had accelerometers at only two ERV locations, then the QC2 comparison was also limited to these two locations (even though more accelerometer data was available).

Vibration data was captured and processed by Exelon personnel and Structural Integrity Associates received frequency spectra for each of 17 power levels [2]. Spectra data was captured from 0-2887 MWth (119.7 – 930.4 MWe) [8], but only power levels greater than 85% power level (Table 3) were used in the comparison (as explained above).

## AMPLITUDE AND FREQUENCY COMPARISONS

The spectra plots for QC1 and QC2 at 2887 MWth are shown in Figures 4 through 15. Spectra plots were compared for each individual axis for ERV-3B and ERV-3C on both units (QC1 and QC2). Discrete frequency RMS amplitudes are shown in Table 4, whereas, overall composite amplitudes are shown in Table 5. The detailed assessments are provided below.

*ERV-3B Spectra Assessment*

Figures 4 through 9 show the acceleration spectra plots for ERV-3B for 2887 MWth. Inspection of each plot (x, y, and z axes), for Units 1 and 2, shows only two "significant" discrete frequencies that were common to both units; 139-140.5 Hz and 157 Hz (Table 4). These frequencies are very similar to the Quad Cities data taken during the last power ascensions (QC1 in December 2003 [3] and QC2 in April 2004 [4]) and are indicative of an acoustic phenomenon within the MS lines near the valves.

QC2 did show some frequency content between 140 and 160 Hz. These frequencies were sharp and had comparable amplitudes. Frequencies were observed at 151.5 and 160.5 Hz. These frequencies are believed to be associated with the modifications to the steam dryer, since they were not observed during the 2003/2004 power ascension spectra plots. No other "significant" frequency content was observed in these spectra plots.

The maximum QC1 composite amplitude was 0.48 grms for ERV-3B y-axis; whereas, the maximum QC2 composite amplitude was 0.54 grms for ERV-3B z-axis. The maximum discrete frequency amplitudes are shown in Table 4. These amplitudes do not exceed 0.25 grms and 0.44 grms at any discrete frequency for QC1 and QC2, respectively. Amplitudes at other frequencies (other than the discrete frequencies) were less than 0.02 grms (basically noise floor responses). Amplitudes below 0.1 grms are considered low, whereas, amplitudes between 0.1 and 0.5 grms are considered low-to-moderate. These amplitudes are not high enough to cause excessive wear.

*ERV-3C Spectra Assessment*

Figures 10 through 15 show the frequency spectra for ERV-3C for 2887 MWth. In general, inspection of each plot for each axes (x, y, and z), for Units 1 and 2, showed only two "significant" discrete frequencies that were common to both units; ~139 Hz and ~157 Hz (Table 4). These frequencies are similar to the Quad Cities data taken during the last power ascensions (QC1 in December 2003 [3] and QC2 in April 2004 [4]) and are indicative of an acoustic phenomenon within the MS lines near the valves. QC2 did show some low frequency content between 140 and 160 Hz; at 151.5 and 160.5 Hz. These frequencies were sharp and had comparable amplitudes. These frequencies are believed to be associated with the modifications to the steam dryer, since they were not observed during the 2003/2004 power ascension. Additionally, QC1 ERV-3C showed two discrete frequencies at 21 and 36 Hz. These frequencies were only observed on the x-axis. These frequencies are low and may be associated with a structural response of the valve. No other "significant" frequency content was observed in the spectra plots. Amplitudes at other frequencies were less than 0.02 grms (basically noise floor responses).

The maximum QC1 composite amplitude was 0.32 grms for ERV-3B y-axis; whereas, the maximum QC2 composite amplitude was 0.78 grms for ERV-3B z-axis (Table 5). The maximum discrete frequency amplitudes are shown in Table 4. These amplitudes do not exceed 0.066 and 0.358 grms at any discrete frequency for QC1 and QC2, respectively. Amplitudes at other frequencies (other than the discrete frequencies) were less than 0.02 grms (basically noise floor responses). Amplitudes below 0.1 grms are considered low, whereas, amplitudes between 0.1 and 0.5 grms are considered low-to-moderate. These amplitudes usually are not high enough to cause excessive wear. The maximum composite amplitude of 0.78 grms is concentrated at 139 and 157 Hz frequencies and based upon Wyle Labs testing [7], no valve responses were observed in this frequency range.

## RESULTS AND CONCLUSIONS

A review of the acceleration frequency spectra for the most recent QC1 and QC2 power ascensions (June 2005 and May 2005, respectively), resulted in the following observations between QC1 and QC2 MS piping and their associated valve dynamic response:

1) Frequency content between QC1 and QC2 are similar.
   a. A comparison of the frequency spectra between QC1 and QC2 showed similar frequency responses in the 0-200 Hz frequency range. In general, the frequency spectra were comparable and had similar frequency content (Figures 4 through 15). Additionally, data from the previous QC1 and QC2 power ascensions [3, 4] appeared to be dynamically similar with respect to frequency content.
   b. In the 139-160 Hz frequency range for both QC1 and QC2, there are slight differences in the frequency of the spectral peaks. These frequency differences were ~2-5 Hz and most likely attributed to the steam dryer modifications, since they were not present in the previous power ascensions. Per References 5 and 6, most valve components have natural frequencies below this frequency range and would not respond.
   c. QC1 ERV-3C x-axis had two discrete frequencies (21 and 36 Hz) that were not observed on QC2 ERV-3C x-axis. Again these frequency differences were minor in that they occurred only on one vibration axis and based on frequency seemed to be unique to the valve.
2) The acceleration amplitudes (RMS) are similar in magnitude for both units, based on the maximum composite amplitudes (Table 5). The maximum composite amplitudes observed were 0.54 and 0.78 grms for QC1 and QC2, respectively. In general, both units had most of this energy concentrated at 139 and 157 Hz.

Based on this acceleration data and the resultant spectra plots, the dynamic behavior of QC1 and QC2 MS piping, and the responses of ERV-3B and ERV-3C valves are similar, both in amplitude and frequency content. Thus, the structural responses of the MS lines are similar between QC1 and QC2.

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

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**REFERENCES:**

1. Frequency spectra received from Exelon via ibackup.com, SI File No. QC-28Q-203.
2. Frequency spectra received from Exelon via ibackup.com, SI File No. QC-28Q-201.
3. Structural Integrity Associates Calculation No. QC-11Q-302, Revision 0, "Quad Cities Unit 1 Main Steam Line Vibration Data Reduction," SI File No. QC-11Q-302.
4. Structural Integrity Associates Calculation No. QC-16Q-303, Revision 0, "Quad Cities Unit 2 ERV Vibration Data Reduction," SI File No. QC-16Q-302.
5. Structural Integrity Associates Report No. SIR-05-198, Revision 0, "Assessment of Quad Cities Unit 1 Power Ascension Main Steam Line Vibration Frequency Spectra," SI File No. QC-28Q-402.
6. Structural Integrity Associates Report No. SIR-05-192, Revision 0, "Assessment of Quad Cities Unit 2 Power Ascension Main Steam Line Vibration Frequency Spectra," SI File No. QC-28Q-401.
7. Wyle Test Report No. 50584-01, dated 2/23/04, "Test Report – Vibration Endurance Test Program for a Dresser Electromatic Relief Valve Type 6" 1525-VX for Exelon Nuclear," SI File No. QC-16Q-202.
8. Exelon Transmittal of Design Information (TODI) No. QDC-05-031, Revision 0, "Quad Cities Startup Testing Test Conditions," SI File No. QC-28Q-204.

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QC-28Q-403

Table 1: QC1 Accelerometer Types and Location

| Channel Number | Type | Direction | Location |
|---|---|---|---|
| 1, 4 | Accelerometer | Parallel to MS flow (X) | Inlet Flange ERV 3B |
| 2, 5 | Accelerometer | Vertical (Y) | Inlet Flange ERV 3B |
| 3, 6 | Accelerometer | Perpendicular to MS flow (Z) | Inlet Flange ERV 3B |
| 7, 10 | Accelerometer | Parallel to MS flow (X) | Inlet Flange ERV 3C |
| 8, 11 | Accelerometer | Vertical (Y) | Inlet Flange ERV 3C |
| 9, 12 | Accelerometer | Perpendicular to MS flow (Z) | Inlet Flange ERV 3C |

Table 2: QC2 Accelerometer Types and Location

| Channel Number | Type | Direction | Location |
|---|---|---|---|
| 7 | Accelerometer | Parallel to MS flow (X) | Inlet Flange ERV 3B |
| 8 | Accelerometer | Vertical (Y) | Inlet Flange ERV 3B |
| 9 | Accelerometer | Perpendicular to MS flow (Z) | Inlet Flange ERV 3B |
| 13 | Accelerometer | Parallel to MS flow (X) | Inlet Flange ERV 3C |
| 14 | Accelerometer | Vertical (Y) | Inlet Flange ERV 3C |
| 15 | Accelerometer | Perpendicular to MS flow (Z) | Inlet Flange ERV 3C |

Table 3: QC1 and QC2 Accelerometer Data – Power Levels of Comparison

| **Quad Cities Power Levels** | |
|---|---|
| **Unit 1 [8]** | **Unit 2 [8]** |
| MWth (MWe) | MWth (MWe) |
| 2887 (911) TC15a | 2887 (930) TC41 |
| | 2831 (912) TC39 |
| 2854 (901) TC14 | 2800 (900) TC38 |
| 2765 (871) TC12 | 2754 (882) TC37 |
| 2642 (829) TC11 | 2573 (821) TC34 |
| 2508 (788) TC10 | 2493 (792) TC33 |

Table 4: QC1 and QC2 Discrete Frequency and Amplitude Comparison

| Accelerometer Location | Axis | QC-1 | | QC-2 | | QC-1 | | QC-2 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Frequency (Hz) | Amplitude (grms) | Frequency (Hz) | Amplitude (grms) | Frequency (Hz) | Amplitude (grms) | Frequency (Hz) | Amplitude (grms) |
| ERV-3B Inlet Flange | X | 140.5 | 0.043 | Bad Channel | | 157 | 0.092 | Bad Channel | |
| | Y | 140.5 | 0.116 | 139 | 0.049 | 157 | 0.189 | 160.5 | 0.130 |
| | Z | 140.5 | 0.036 | 139 | 0.170 | 157 | 0.149 | 151.5 | 0.202 |
| ERV-3C Inlet Flange | X | 139.5 | 0.042 | 139 | 0.125 | 157 | 0.066 | 160 | 0.045 |
| | Y | 139.5 | 0.023 | Bad Channel | | 157 | 0.011 | Bad Channel | |
| | Z | 139.5 | 0.057 | 140 | 0.358 | 158 | 0.065 | 150.2 | 0.256 |

Table 5: QC1 and QC2 Composite Amplitude Comparison

| Accelerometer Location | Axis | Composite Amplitude | |
|---|---|---|---|
| | | QC1 (grms) | QC2 (grms) |
| ERV-3B Inlet Flange | X | 0.19 | --- |
| | Y | 0.48 | 0.330 |
| | Z | 0.41 | 0.540 |
| ERV-3C Inlet Flange | X | 0.21 | 0.310 |
| | Y | 0.32 | --- |
| | Z | 0.25 | 0.780 |

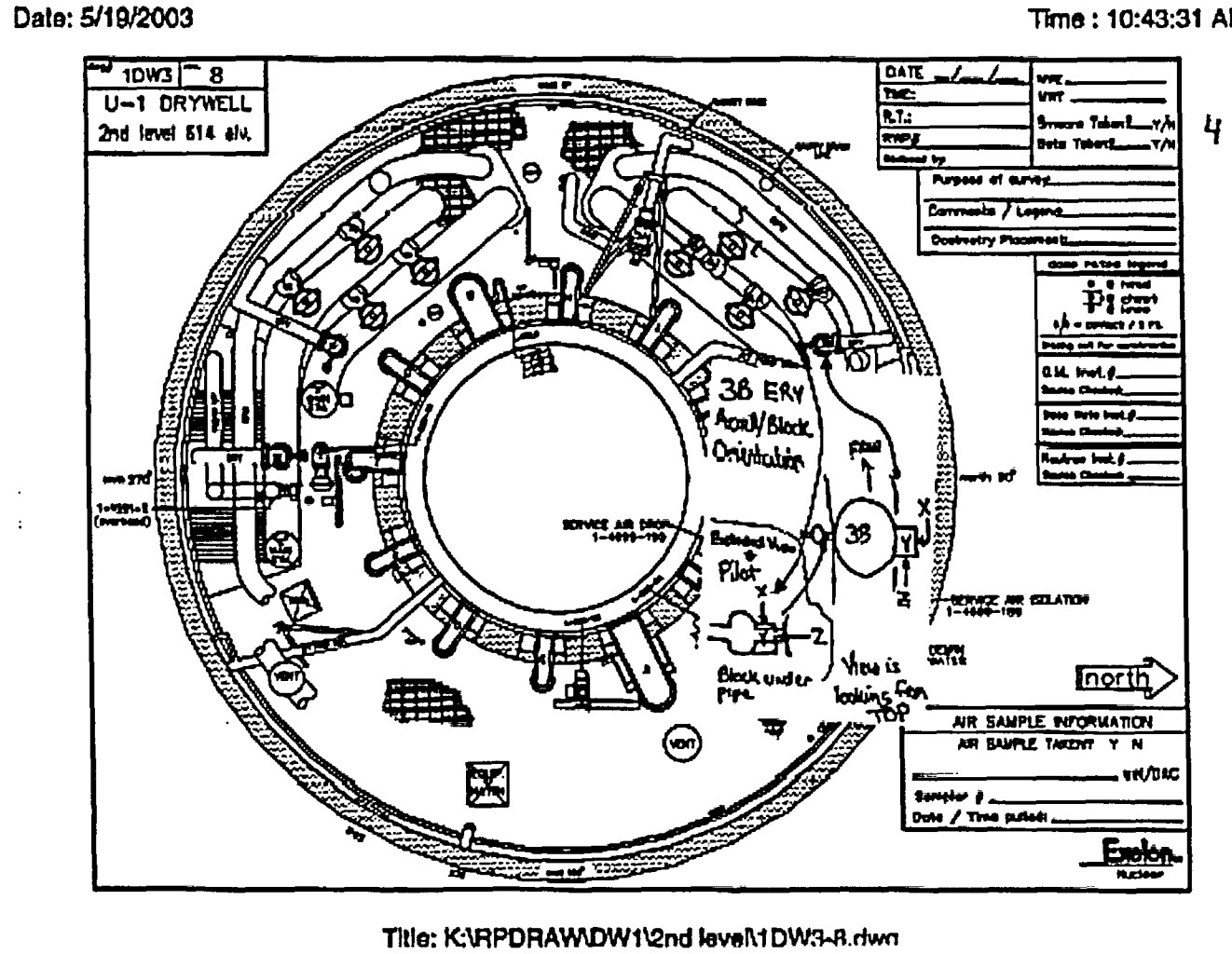



Figure 1: Accelerometer Locations for ERV-3B

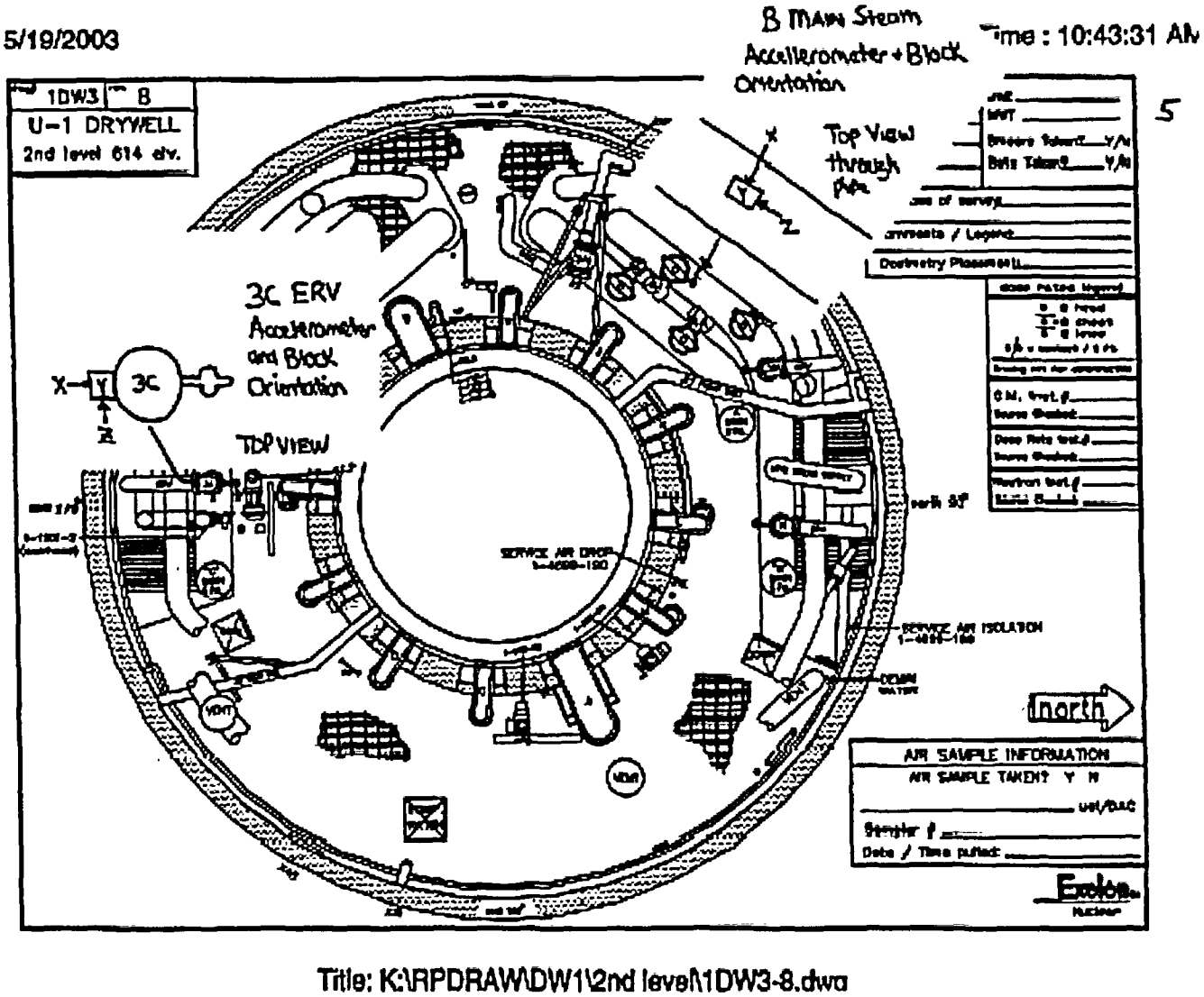
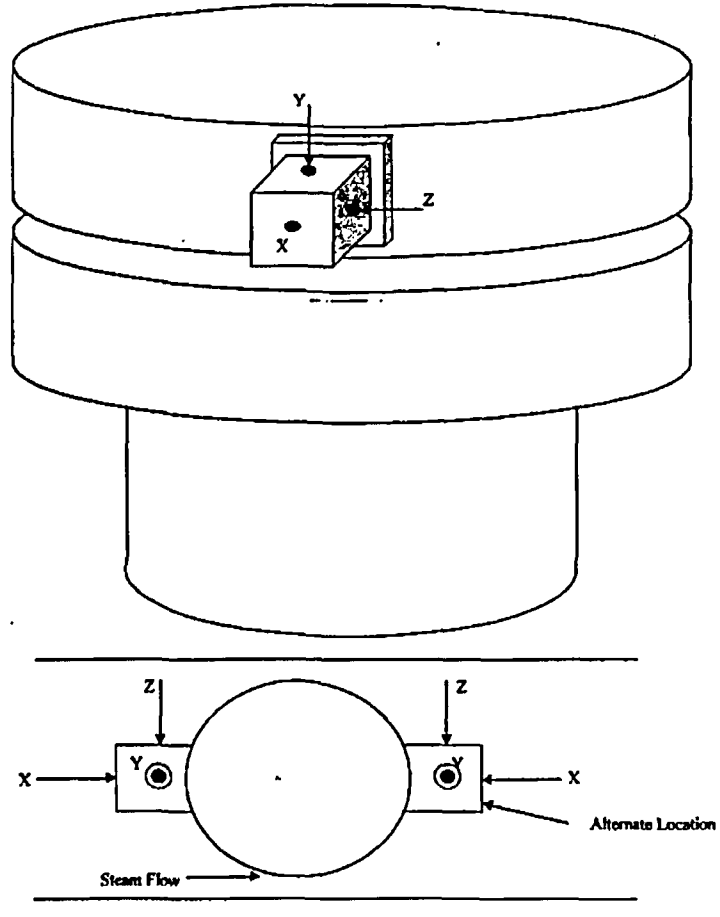



Figure 2: Accelerometer Locations for ERV-3C




| B ERV | | | |
|---|---|---|---|
| Direction | Label | Cable | Accel S/N |
| X | BX | TOD06 Pair 1 | 10537 |
| Y | BY | TOD06 Pair 2 | 10533 |
| Z | BZ | TOD13 Pair 1 | 10445 |
| Alt X | BAX | TOD13 Pair 2 | 10532 |
| Alt Y | BAY | TOD12 Pair 1 | 10598 |
| Alt Z | BAZ | TOD12 Pair 2 | 10564 |

| C ERV | | | |
|---|---|---|---|
| Direction | Label | Cable | Accel S/N |
| X | CX | TOD03 Pair 1 | 10539 |
| Y | CY | TOD03 Pair 2 | 10565 |
| Z | CZ | TOD15 Pair 1 | 10557 |
| Alt X | CAX | TOD05 Pair 1 | 10550 |
| Alt Y | CAY | TOD05 Pair 2 | 10558 |
| Alt Z | CAZ | TOD16 Pair 1 | 10562 |

X = Parallel To Flow

Y = Vertical

Z = Perpendicular To Flow

Figure 3: QC1 ERV Accelerometer Location/Orientation – Tri-Axial Accelerometer Blocks

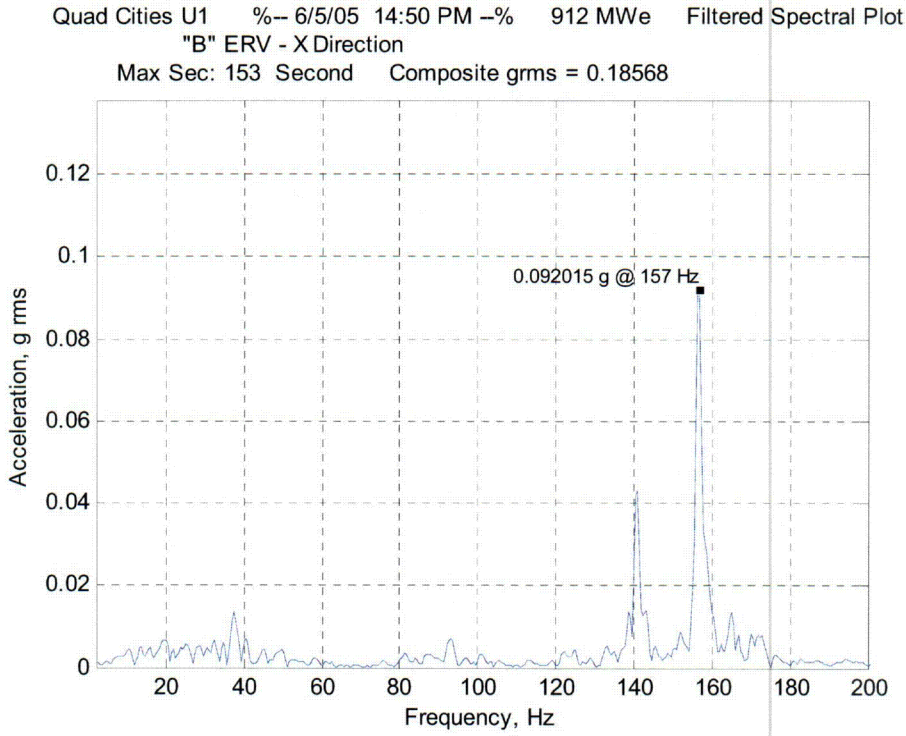



Figure 4: QC1 ERV-3B Accelerations – X-Axis (June 2005)

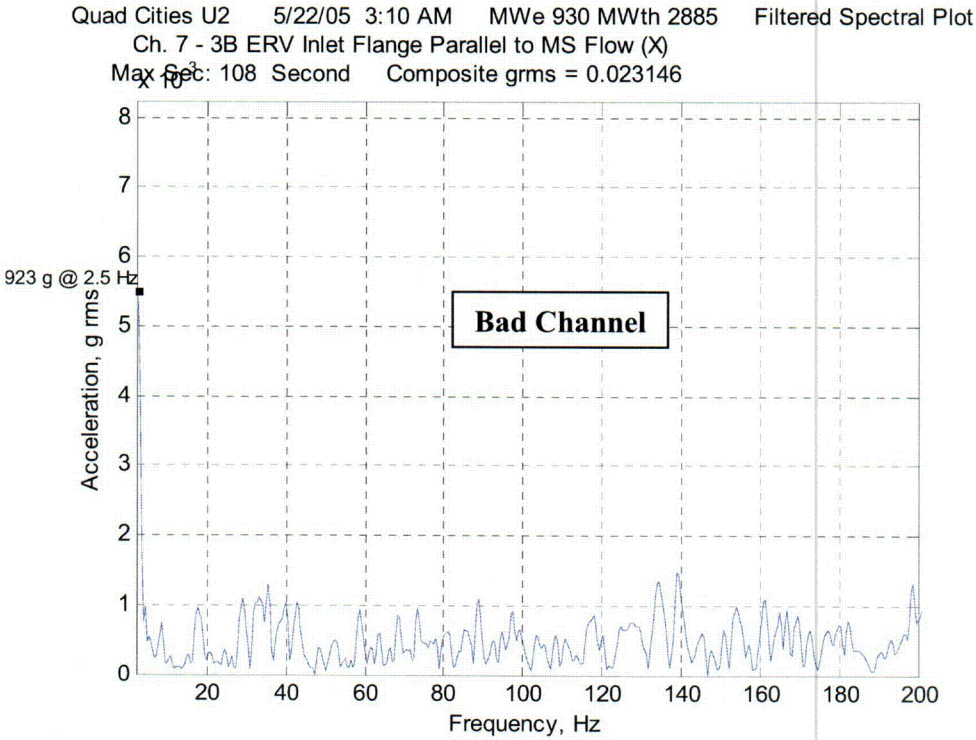



Figure 5: QC2 ERV-3B Accelerations – X-Axis (May 2005)

C01

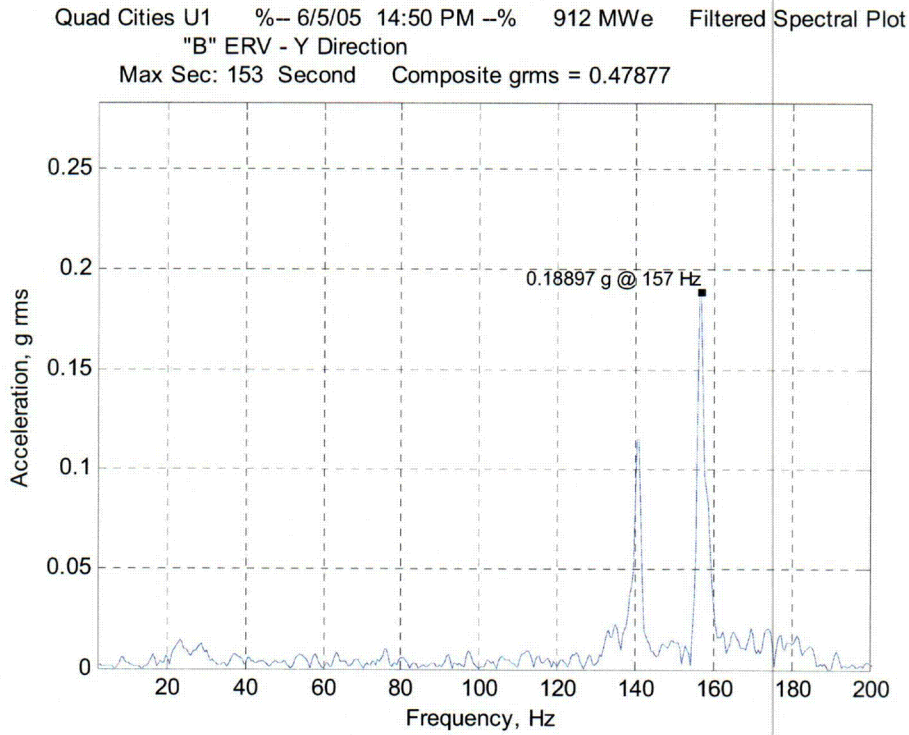



Figure 6: QC1 ERV-3B Accelerations – Y-Axis (June 2005)

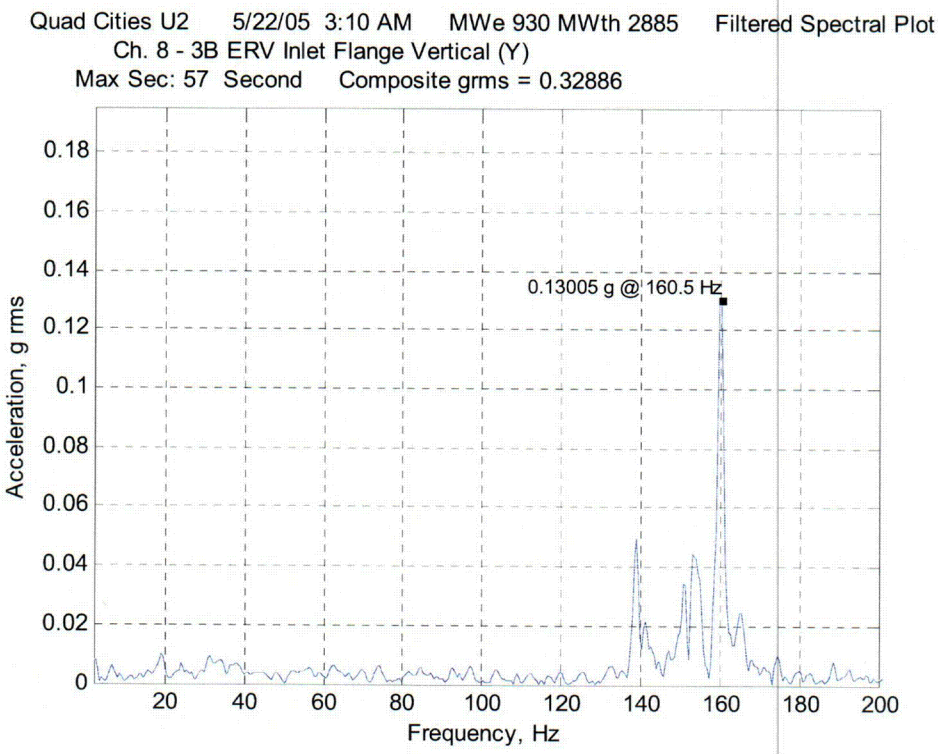



Figure 7: QC2 ERV-3B Accelerations – Y-Axis (May 2005)

C02

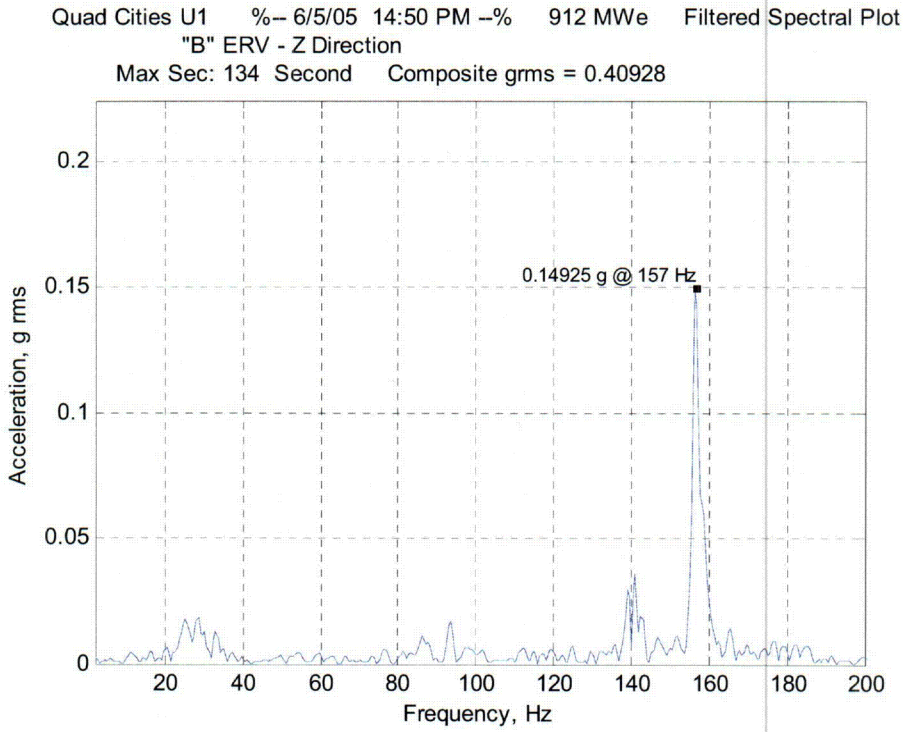



Figure 8: QC1 ERV-3B Accelerations – Z-Axis (June 2005)

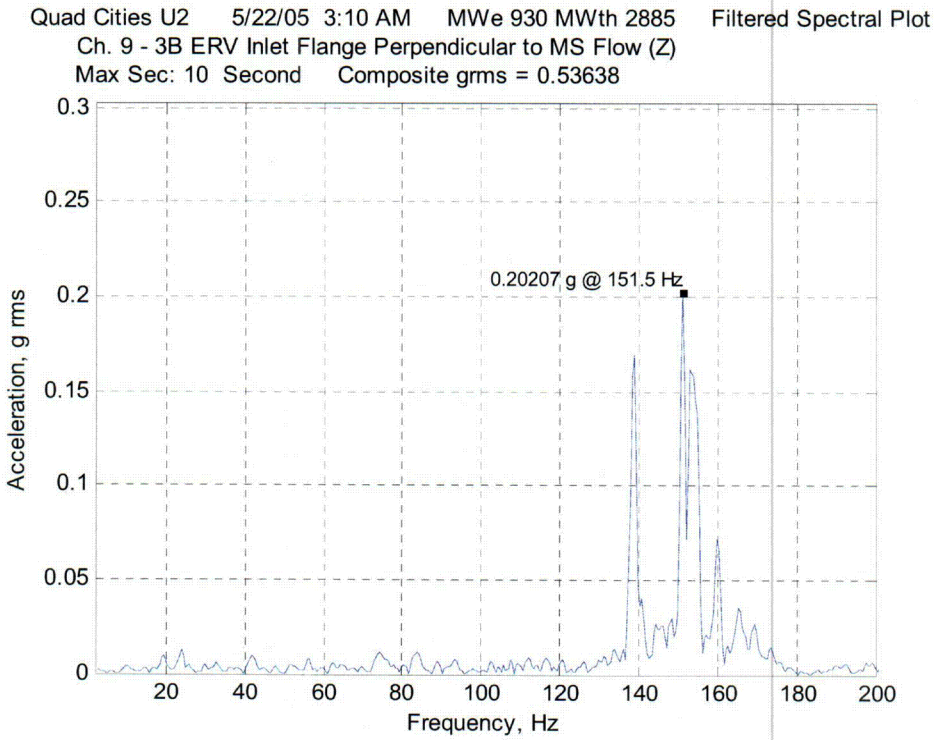



Figure 9: QC2 ERV-3B Accelerations – Z-Axis (May 2005)

C03

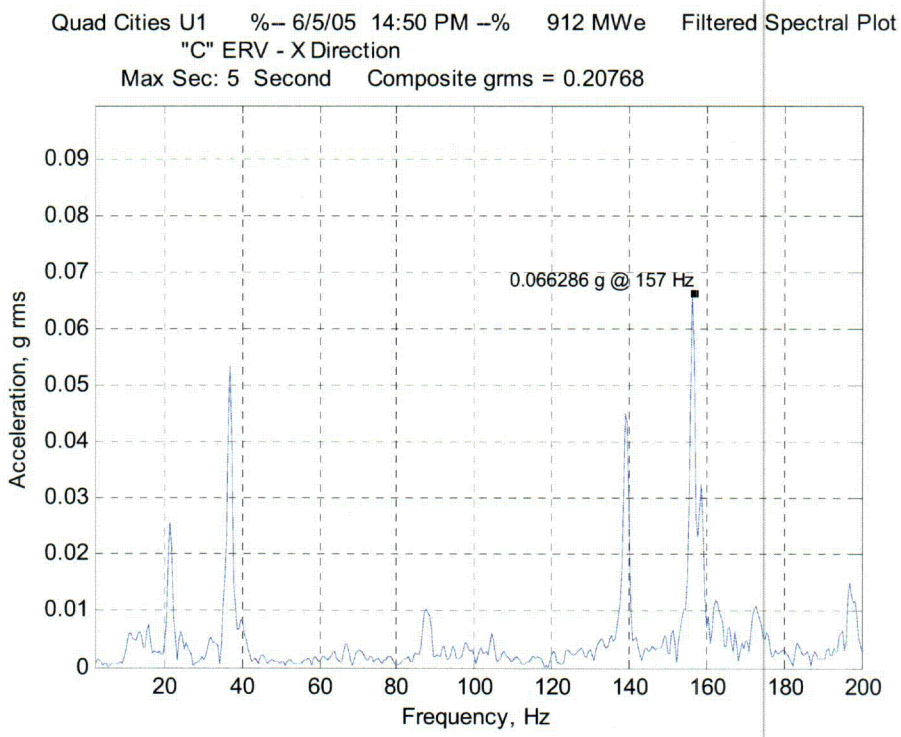



Figure 10: QC1 ERV-3C Accelerations – X-Axis (June 2005)

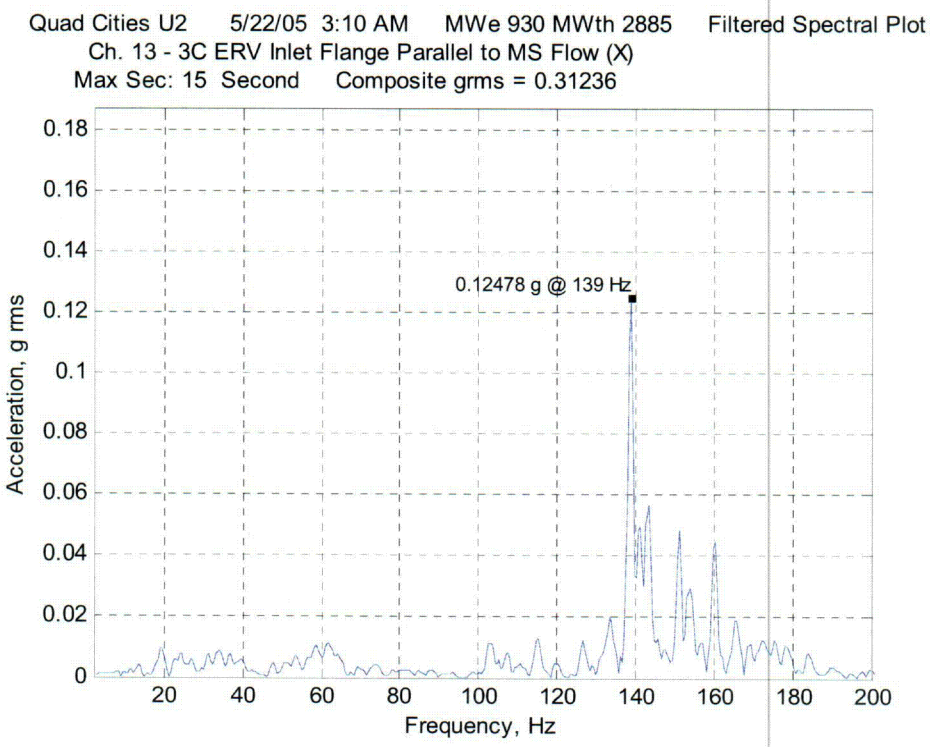



Figure 11: QC2 ERV-3C Accelerations – X-Axis (May 2005)

C04

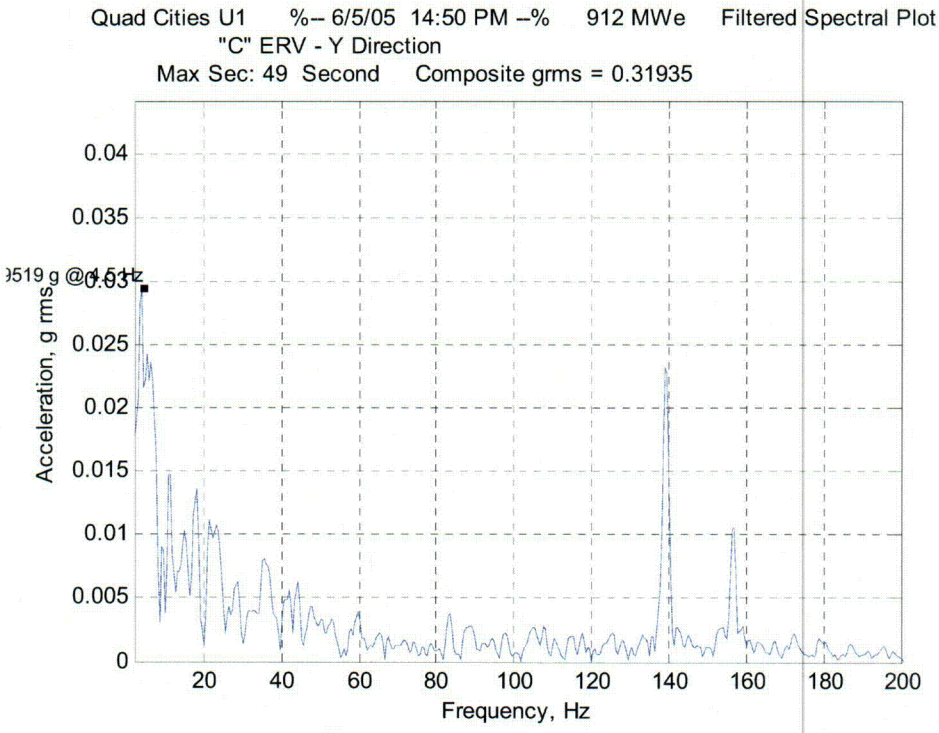



Figure 12: QC1 ERV-3C Accelerations – Y-Axis (June 2005)

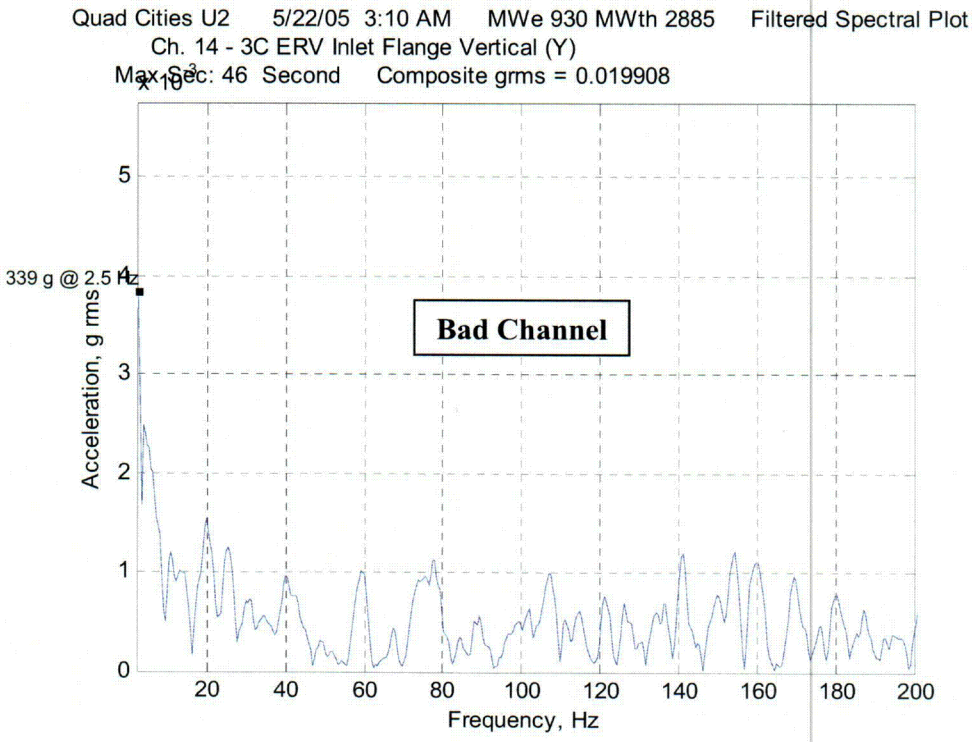



Figure 13: QC2 ERV-3C Accelerations – Y-Axis (May 2005)

C05

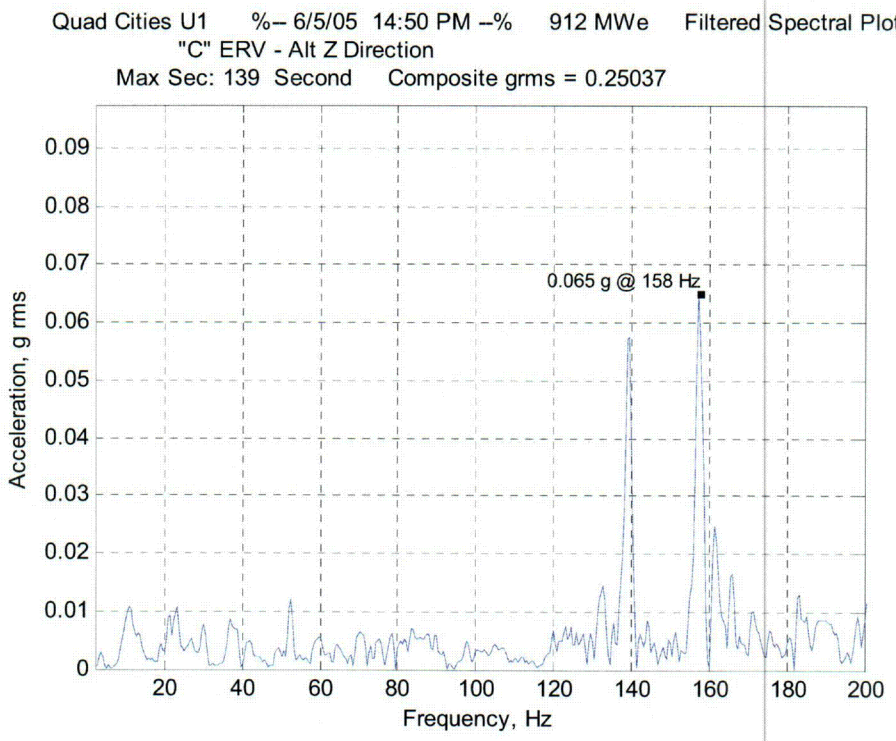



Figure 14: QC1 ERV-3C Accelerations – Z-Axis (June 2005)

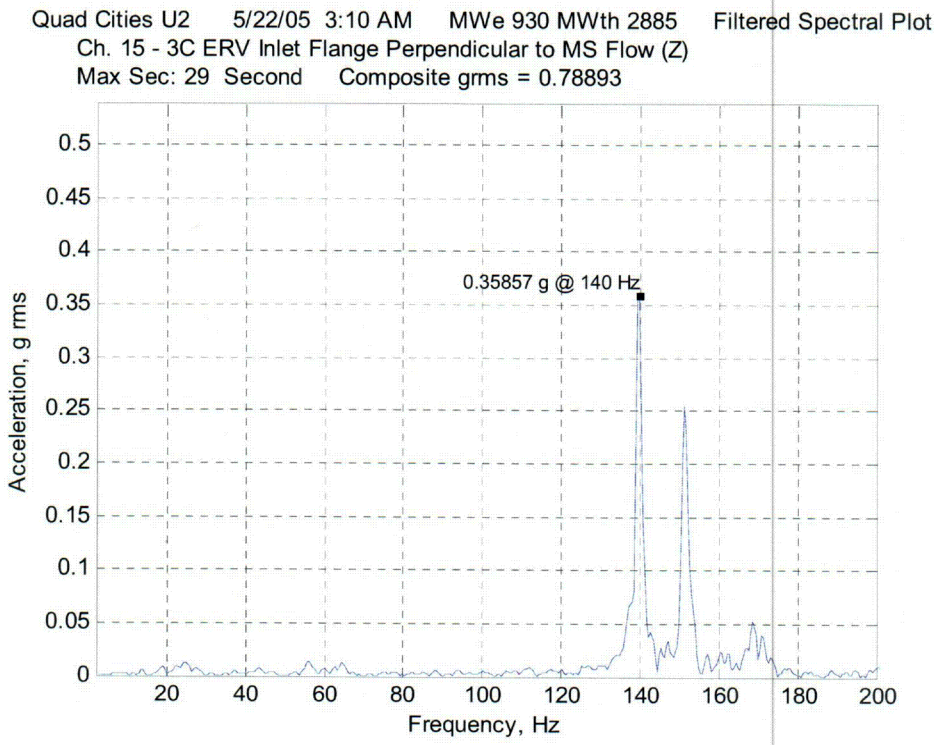



Figure 15: QC2 ERV-3C Accelerations – Z-Axis (May 2005)

C06