



## Problem Investigation Report Motor Drive Tripping Problem

### Introduction

The client's office building has experienced a number of motor drive problems. Specifically the drives are reportedly tripping-off on an over-temperature (heating) alarm associated with the input rectifier section of the drives power supply. The problem has been occurring most frequently in the early morning hours shortly after the HVAC system are brought on-line in preparation for building occupancy.

PowerCET Corporation was retained to determine if the quality of the electric supply could be causing the operational problems with the motor drives.

### Methodology

A Dranetz-BMI PP4300 power monitor was installed at the electrical service entrance for a 17-day period. In addition a second PP4300 was installed on the line side of the panelboard (roof top location) serving the motor drives for a period of 6-days.

A third PP4300 was installed at the input to the drive associated with the air-handler (roof top location) for period of several hours during testing/cycling of the drive.

PP4300 channel assignments for voltage and current were as follows:

- Ch A Phase A (voltage & current)
- Ch B Phase B (voltage & current)
- Ch C Phase C (voltage & current)
- Ch D N/C

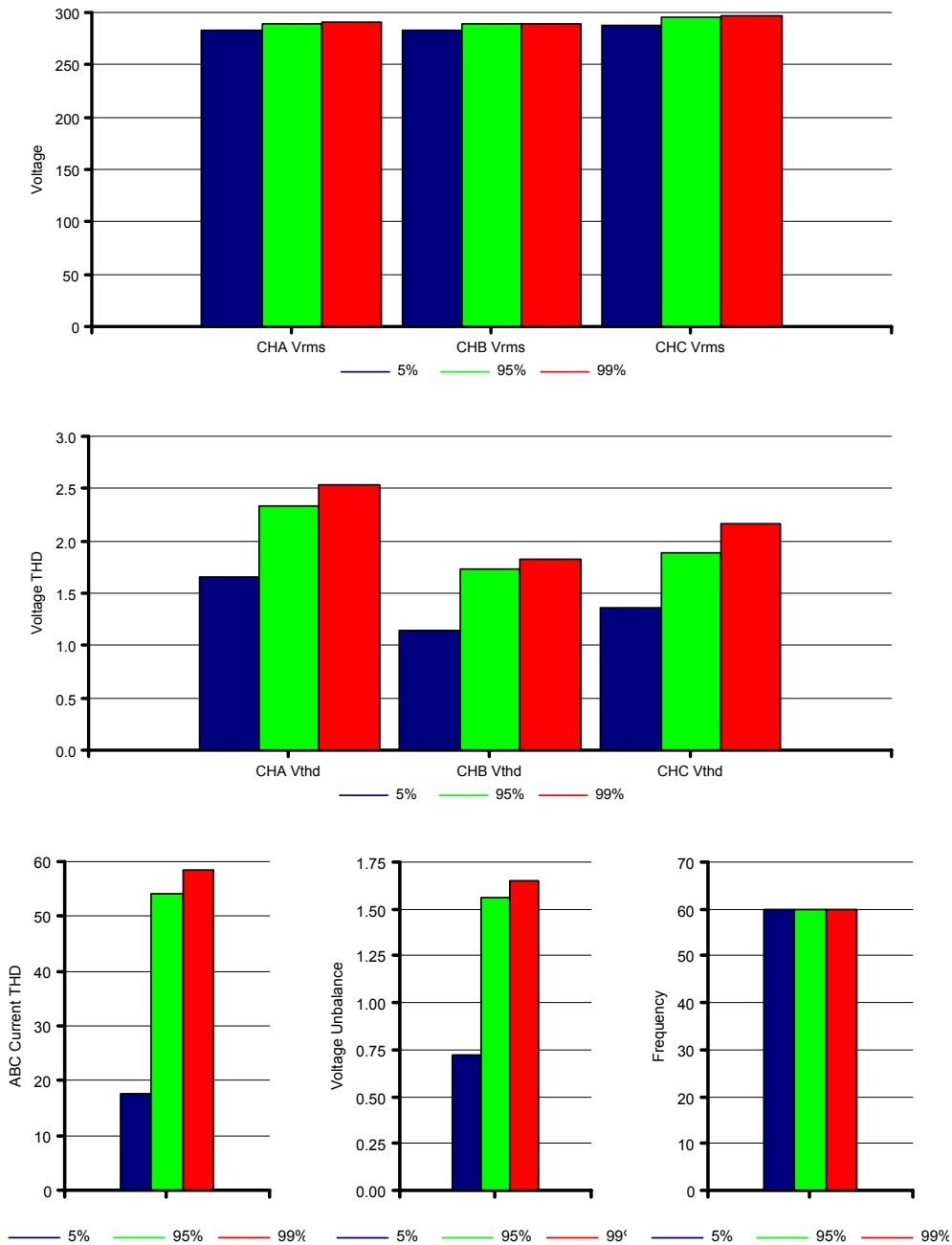
### Key Findings / Recommendations

Monitoring at both the main electrical service and the panelboard serving the rooftop drives revealed a high-line condition—see Table 1 below.

**Table 1 - RMS voltage levels at main electrical service.**

|              | Min    | Max    | Median | 5%     | 95%    | 99%    |
|--------------|--------|--------|--------|--------|--------|--------|
| Phase A Vrms | 275.07 | 291.30 | 286.47 | 283.64 | 289.26 | 290.11 |
| Phase B Vrms | 275.24 | 291.45 | 286.17 | 283.73 | 288.92 | 280.79 |
| Phase C Vrms | 279.40 | 298.45 | 290.36 | 287.72 | 295.59 | 296.72 |
| Phs. ABC Avg | 276.77 | 293.67 | 287.69 | 285.09 | 291.22 | 292.15 |
| Phs A-B Vrms | 473.45 | 499.15 | 492.04 | 487.81 | 495.77 | 497.26 |
| Phs B-C Vrms | 481.55 | 512.17 | 499.75 | 495.46 | 507.32 | 509.22 |
| Phs C-A Vrms | 482.38 | 513.46 | 501.56 | 496.68 | 509.32 | 510.91 |
| 480V Average | 479.33 | 508.16 | 497.85 | 493.40 | 503.90 | 505.54 |

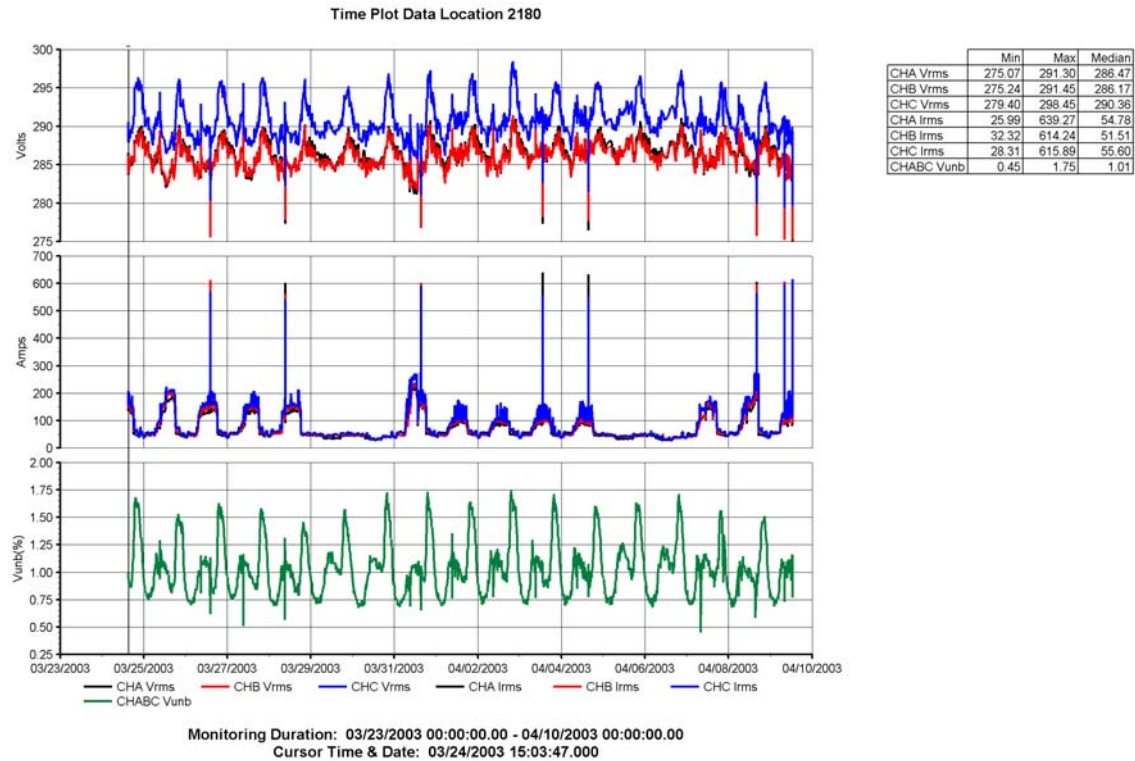
The following quality of supply graphs, Figure 1, summarize the general quality of the electrical supply. Both current and voltage harmonic distortion levels are within acceptable limits. The current harmonic distortion (I<sub>thd</sub>) is highest under the minimum load condition—when the building is not occupied. Voltage unbalance again is within an acceptable range and as with the current distortion is highest during non-operating hours and is dominantly utility related—the present building loads do not significantly impact the voltage unbalance.



**Figure 1 - Quality of supply graphs for line-neutral RMS voltage.** [Note: *Quality of Supply Summary Graphs*—Interpretation of the Quality of Supply Summary Graphs (Figure 1) is sometimes confusing. It is best to think of the result as: for N% of the time the values are less than or equal to the N% value, for the remainder of the time it is greater (where N is 5, 95 or 99). Graphs are provided for Vrms, Vthd, ABC Current THD, Voltage Unbalance and Frequency.]

Figure 2 below is a time plot of the monitoring data from the main electrical service which shows the RMS voltage, RMS current and the phase voltage unbalance (phase-neutral, 277V). The eight voltage sags to approximately 275V are the result equipment cycling in the building—probably the compressor located in the rooftop equipment room.

Two weekends are shown in Figure 2 data and demonstrates that the phase voltage unbalance is approximately the same on weekends when the building loads are off. In addition the most severe unbalance condition occurs between 6PM and midnight. The nature of the utility grid in the immediate area may account for voltage unbalance timing, as there is a substantial residential area immediately adjacent to the business park.

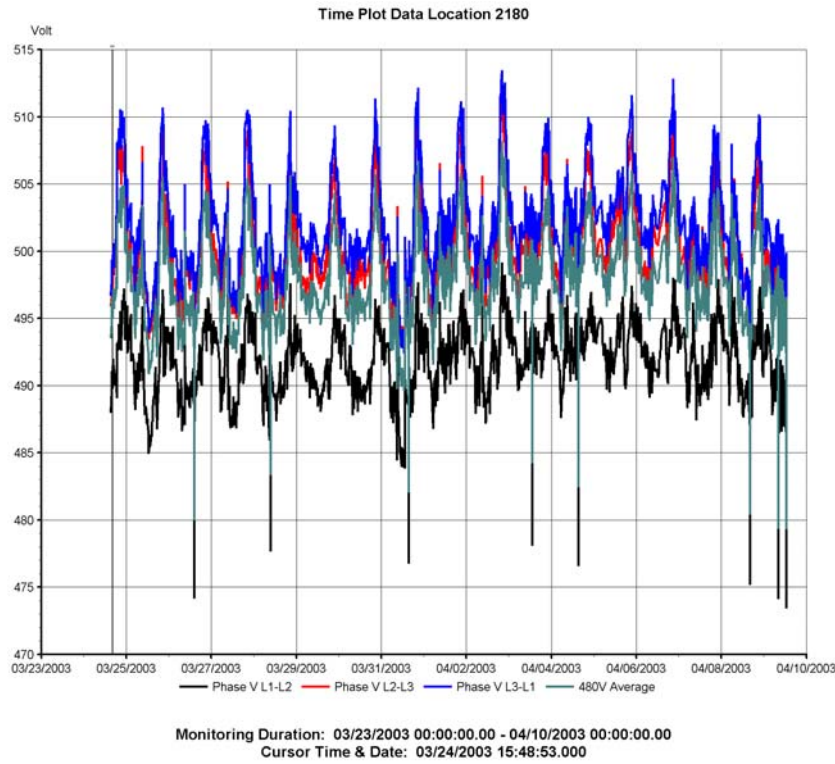


**Figure 2 - RMS voltage (phase-neutral, 277V), RMS current and voltage unbalance time plot at main electrical service.**

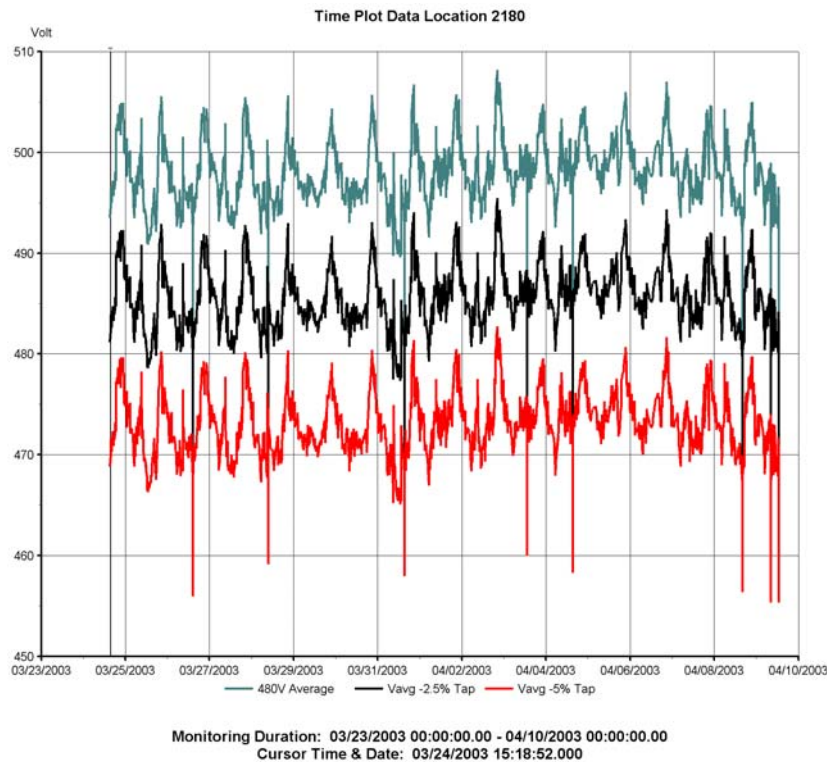
Figure 3 shows the RMS voltage time plots for the phase-to-phase (480V) supply at the main electrical service. The average voltage level for the 480V supply is approximately 497 Volts. The median voltage levels for two of the phase combinations are approximately 500 Volts, which is high enough to cause potential problems for the power supply of the drives.

The nominal voltage level supplied from the utility has probably increased as the loads in the nearby office complexes have decreased. The client's building is an example as its maximum-recorded load during the monitoring period was approximately 200 Amps per phase—the facility has a 1000 Amp utility service.

- 1. RECOMMENDATION:** There is a high probability that tapping the transformer down 2.5% to 5% would resolve the problems being experienced with the motor drives. Since the building is virtually shutdown during weekends it would be an ideal time to accomplish a transformer tap change. The local utility representative should be contacted to arrange for the change. Figure 4 shows the time plot of the average value for the 480V supply and corresponding time plots for a 2.5% and 5% voltage reduction. The present monitoring data indicates that a 5% reduction would be possible, but give the time-of-year and possibility that the summer air-conditioning season could provide additional voltage drop a 2.5% reduction is a more conservative approach at this time with a reasonable probability of resolving the operational problems with the motor drives.

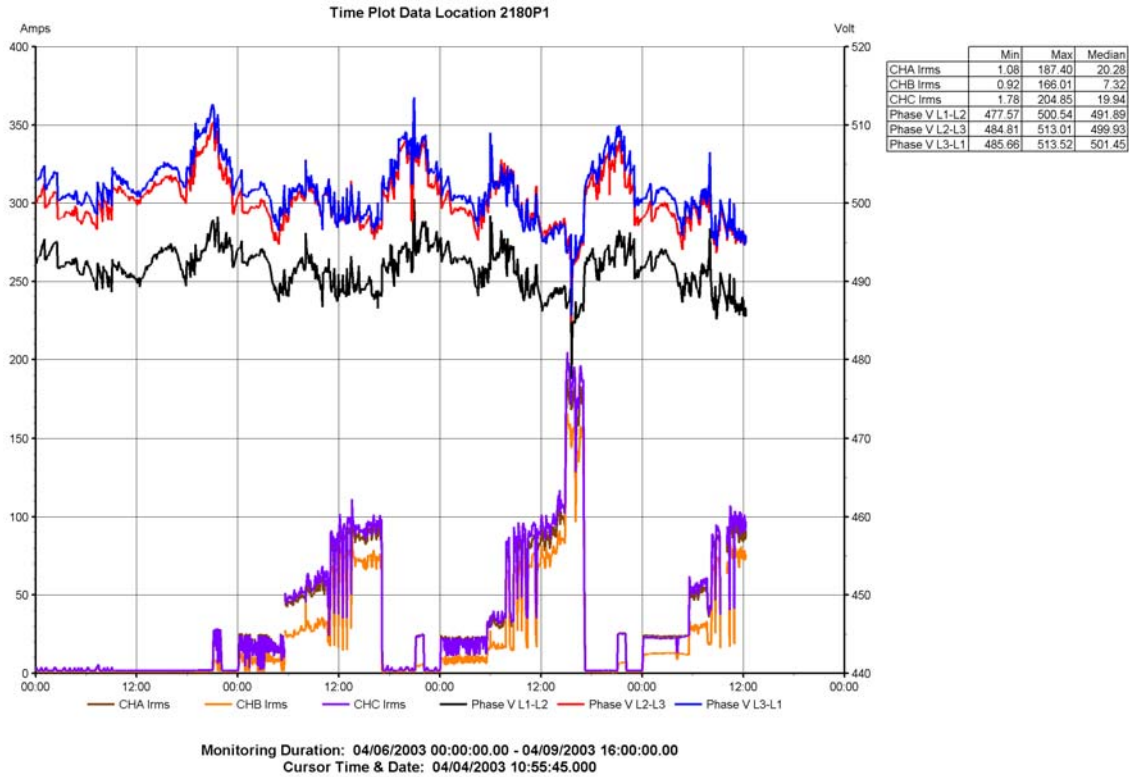


**Figure 3 - RMS voltage time plot (phase-to-phase, 480V) at main electrical service.**



**Figure 4 - 480V electric utility supply tap comparison—black -2.5% and red -5%.**

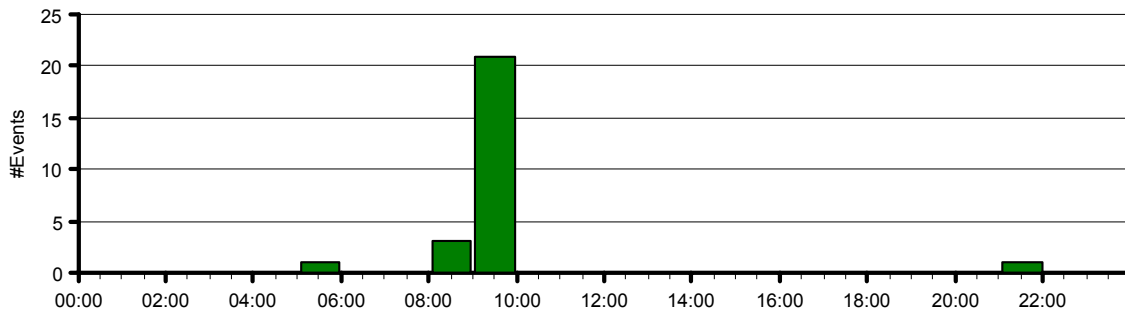
Figure 5 shows the 4-day RMS current and voltage time plot comparison at the panelboard in the rooftop equipment room serving the motor drives. As was the case with the voltage levels at the electrical service the nominal 480V levels are excessive and should be reduced which will likely resolve the performance issue with the motor drives.



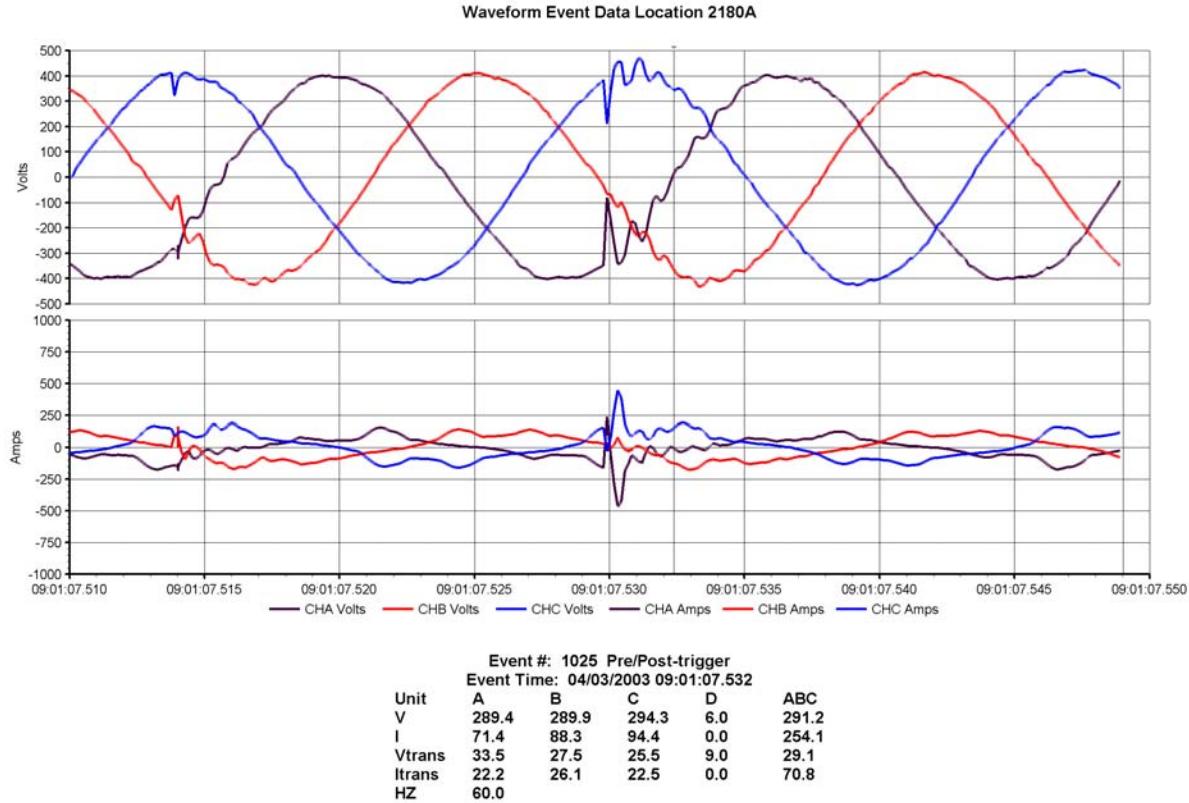
**Figure 5 - RMS voltage and current time comparison.**

Voltage Transients

During the monitoring period a series of voltage transients were recorded—approximately 25 in total. The bulk of the transients occur between 9AM and 10AM each day and are most likely associated with utility power factor capacitor switching. Figure 6 shows the frequency of occurrence of the transients and Figure 7 is a representative example of the transient event recorded by the monitoring equipment at the main electrical service.



**Figure 6 - Voltage transient occurrence by quantity and time of day.**



**Figure 7 - Representative waveform event of utility power factor switching event.**

- RECOMMENDATION: At this time the transients do not appear to be impacting the buildings operation. In the future should specific loads react to this type of event then mitigation equipment should be employed on a case-by-case basis. Generally an on-line (double conversion) UPS will provide the necessary conditioning to mitigate this type of problem on small computer and electronic loads. No action required at this time.**

## Summary

There were no reported drive problems during the monitoring period. On April 9, 2003 arrangements were made to coordinate a monitoring activity on a single drive for a period of several hours. The experiment did document the voltage levels and load unbalance, but no operational problems were experienced with the drive.

Other than the high line conditions there are no power anomalies that would account for the drive problems. Re-tapping the utility supply transformer—recommendation #1—down by 2.5% or 5% will in all likelihood resolve the drive performance problems.

Another possibility would be to install line reactors on the drives and see if the increased circuit impedance (and corresponding voltage drop) would be sufficient to achieve the same result as re-tapping the utility transformer. Trans-Coil Inc's KLR Series Line Reactors (<http://www.transcoil.com>) are representative of the type of product that would be appropriate for this application. It would be possible to temporarily the installation of a line reactor and run the drives in normal operation as an experiment to see if reactors are a viable solution to the problem.

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