

## Consulting Report

### Over-heated Transformer Investigation

#### 123 John Street, 5<sup>th</sup> Floor, Silicon Valley, CA

#### Introduction / Background

An infrared survey of the electrical distribution for 123 John St., Silicon Valley, California revealed a potential problem with the 75kVA transformer located on the 5<sup>th</sup> floor. Photo 1 below is the thermogram of the suspect transformer showing the phase C winding temperature of about 100°C. Table 1 summarizes the load readings from the 7-day monitoring period, the load readings taken during the IR survey and the temperature recordings from the thermogram (figure 1).

Photo 2 is a photo graph of the transformer and Table 2 is the design information from the transformer nameplate.

A Fluke RPM Power Recorder was installed on the output of the 5<sup>th</sup> floor 75kVA transformer for a 7-day period to determine if the apparent overheating was the result of power frequency harmonics

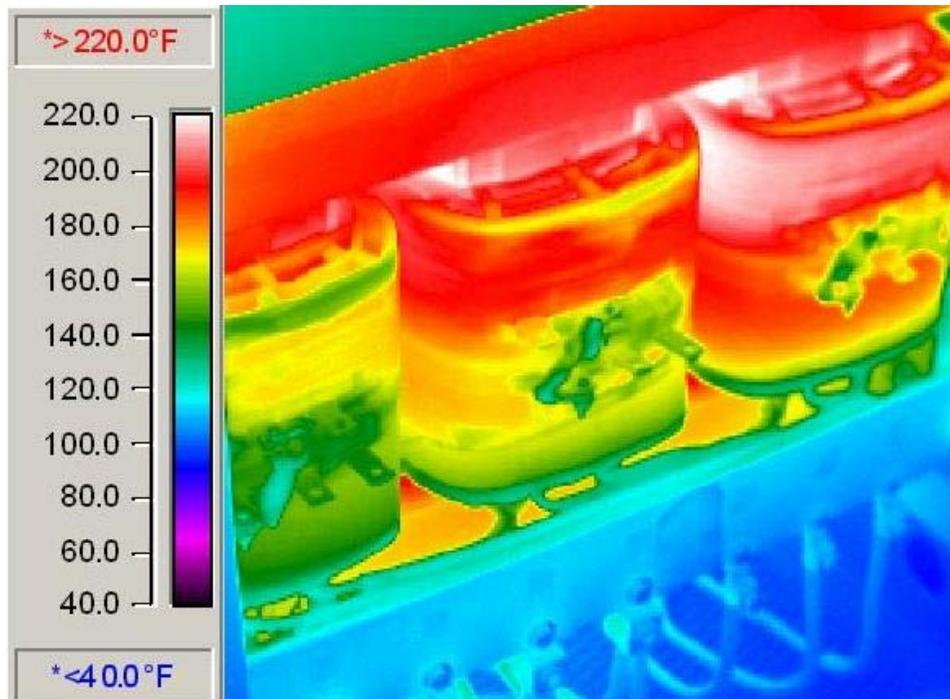


Photo 1 – Thermogram of 5<sup>th</sup> floor 75kVA transformer.

**Table 1 – Summary of load amps and IR survey transformer temperature.**

	Avg Load Amps—7-day Monitoring	IR Survey Load Amp	IR Survey Temp °F	IR Survey Temp °C
Phase A	64.06	83.6	169	76.1
Phase B	84.46	95.1	193	89.4
Phase C	84.93	131.4	209	98.3
Neutral	114.8	144.0		



**Photo 2 – Photograph of 5<sup>th</sup> floor 75kVA transformer shown in photo 1 thermogram.**

**Table 2 – Transformer nameplate information.**

Jeffries Transformer	75KVA
Cat. No.	480V-208Y/120V
Insulation Class	752-412-5H
Impedance	H 150°C Rise
	3.25% @ 75 C

## Key Findings & Recommendations

The amperage readings for the 7-day monitoring period were lower than that recorded at the time of the IR survey—Table 1—which indicates that there is significant load variations that are not reflected in the 7-day monitoring data.

The temperature of the phase C winding (right side of photos 1 and 2) is approximately 100°C with a corresponding load of 131Ams. The transformer is designed for a 150°C rise, which is composed of the 100°C winding temperature plus 30 to 40°C for ambient and a 10 to 20°C for hot-spot... The net is that

the transformer is sometimes operating at or very near its design limits. In addition the phase C winding, photo 2, shows some discoloration on the lower portion of the winding indicating that the winding may have experienced over-heating.

The transformer is loaded to approximately 40% of its rated capacity of 75kVA. Figure 1 shows the time plot for the total KVA during the 7-day monitoring period. Note that the loading on the transformer ranges from approximately 27.3kVA to a high of 37.1kVA or about 40% of the transformer's rated capacity. The load imbalance ranges from approximately 20% to 27%, but would be very difficult to correct (lower) because of the single-phase and cycling of the various loads.

Figure 2 is the time plot of the RMS load current, and associated neutral current, on the transformer secondary. Table 3 summarizes the minimum, average and maximum current readings for the 7-day monitoring period. The average neutral current exceeds the value of any of the individual phase currents indicating the presents of non-canceling neutral return currents from single phase connected computer loads.

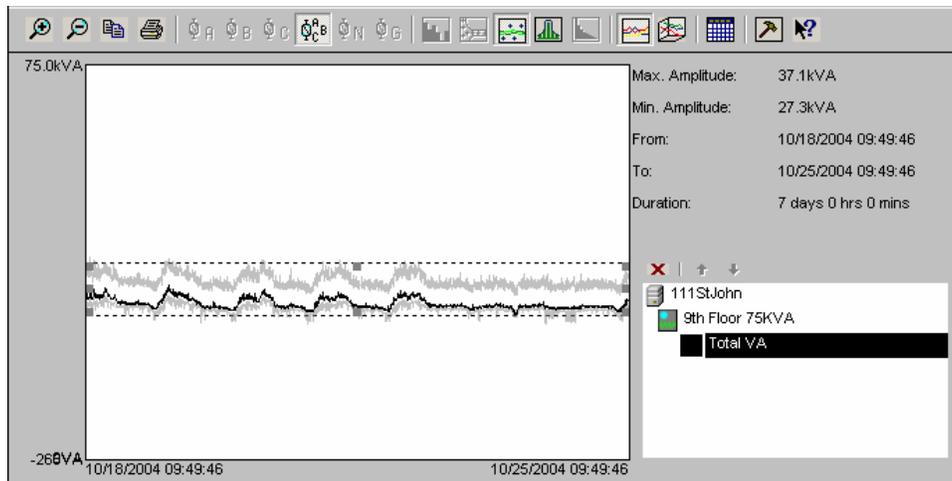


Figure 1 – Total KVA time plot showing loading for 7-day monitoring period to be between 37.1kVA and 27.3kVA.

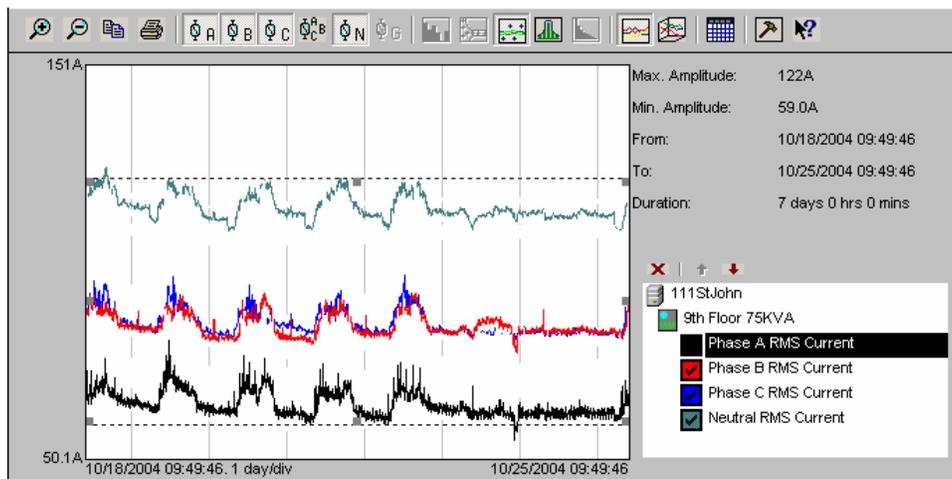


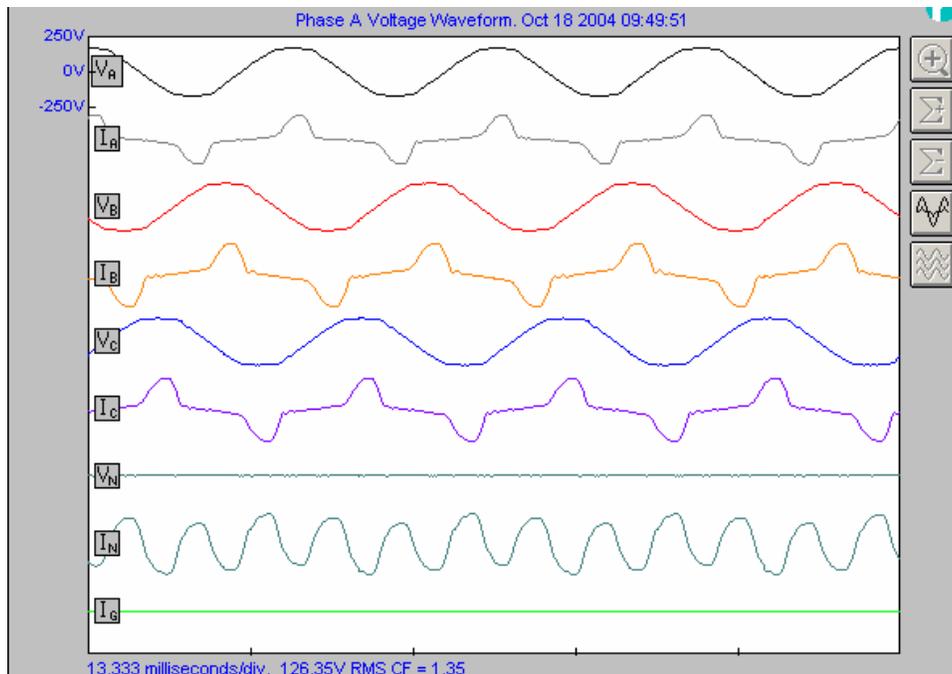
Figure 2 – Time plot of load current for individual phases and neutral for 7-day monitoring period.

**Table 3 – Minimum, average and maximum values for RMS load current for 7-day monitoring period.**

RMS. Currents	Value	Date and Time
Phase A minimum	52.55A	Oct 24 2004 07:59:46
<b>Phase A average</b>	<b>64.06A</b>	
Phase A maximum	90.64A	Oct 21 2004 11:04:46
Phase B minimum	71.41A	Oct 19 2004 21:19:46
<b>Phase B average</b>	<b>84.46A</b>	
Phase B maximum	124.1A	Oct 19 2004 14:54:46
Phase C minimum	74.89A	Oct 24 2004 08:09:46
<b>Phase C average</b>	<b>84.93A</b>	
Phase C maximum	112.6A	Oct 22 2004 12:09:46
Neutral minimum	98.33A	Oct 19 2004 06:49:46
<b>Neutral average</b>	<b>114.8A</b>	
Neutral maximum	130.0A	Oct 19 2004 18:39:46

Initial voltage and current snapshot waveforms, Figure 3, provide graphical evidence of the dominant type of load connected.

The voltage waveform is basically sinusoidal and approaching 5% total harmonic distortion (THD) which is at the level where further investigation or corrective action may be warranted. The dominant loads on this transformer are single-phase computer loads as demonstrated by the pulsed nature of the current waveform—see figure 3 below. Further the neutral current is (1) larger than any of the individual phase currents and (2) is 180-Hertz in frequency, which again is an indicator of they type of loads connected.



**Figure 3 – Initial snapshot of voltage and current waveforms.**

Figure 4 shows the voltage THD for the 7-day monitoring period with the daily variations. The voltage distortion is lowest, as would be expected, when the building is not occupied and peaks at just under 5% VTHD around noon on weekdays. Figure 5 shows the graphical representation of the harmonic content of the voltage waveform—3<sup>rd</sup>, 5<sup>th</sup> and 7<sup>th</sup> harmonics are dominant.

Figure 6 shows the current THD for the 7-day monitoring period with the daily variations. The current distortion is lowest during the work day which follows the VTHD increase. Higher voltage distortion generally results in lower current distortion, which is the case with this transformer, and it an indication that the source (transformer) is starting to distort the voltage in an effort to support the harmonic loads. The harmonic current distortion ranges between 50% and 70% ITHD. Figure 7 shows the graphical representation of the harmonic content of the current waveform—3<sup>rd</sup>, 5<sup>th</sup> and 7<sup>th</sup> harmonics are dominant.

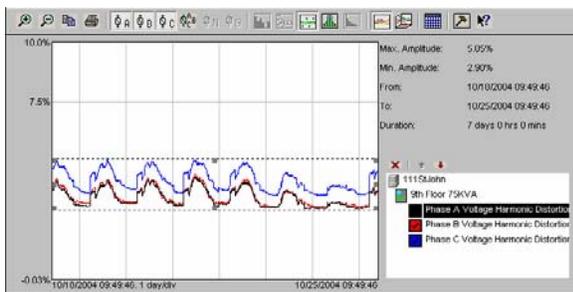


Figure 4 – Time plot of VTHD showing normal workday variations.

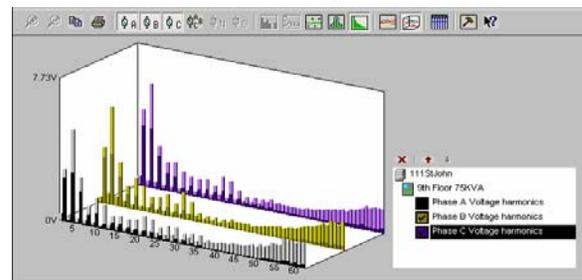


Figure 5 – Graphical representation of voltage harmonic spectrum. Dominant harmonics are 3<sup>rd</sup> and 5<sup>th</sup>.

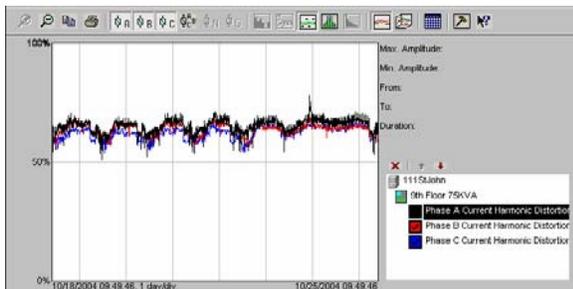


Figure 6 – Time plot of ITHD showing normal workday variations

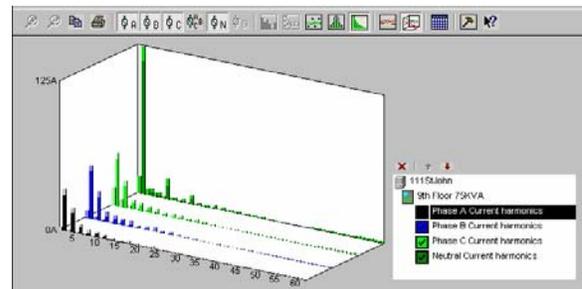


Figure 7 – Graphical representation of current harmonic spectrum. Dominant harmonics are 3<sup>rd</sup> and 5<sup>th</sup>.

The nature of the dominant loads, single phase computers, are rich in the 3<sup>rd</sup> (180Hz), 5<sup>th</sup> (300Hz) and 7<sup>th</sup> (420Hz) harmonic of the 60Hz fundamental. The transformer is primarily designed for 60Hz and the higher frequency harmonics from the computer loads create higher inductive losses within the transformer resulting in the higher winding temperature identified in the IR Survey.

Basically the transformer is not capable of supporting significant levels of single phase computer loads, which appears to be the dominant loading on the transformer at this time. As additional computer loads are added to the transformers distribution the heating will become a more severe problem. Left unaddressed there will eventually be insulation failure in a winding resulting in a breaker tripping and possible damage to loads connected to the transformer. Depending on the breaker coordination and the nature of the fault it, the main service breaker could trip.

## Recommendations

1. Add venting or an air-conditioning supply to the room to lower the ambient temperature. (Note: This is only a short term or temporary measure.)
2. Forced (fan) cooling on the transformer. (Note: This is only a short term or temporary measure and carries the additional problem of blowing dust/dirt into the transformer case and windings.)
3. Replace the transformer with a K-factor rated distribution transformer. A K13 or K20 would probably be appropriate. Be aware that some of the newer K-Factor transformers are 6% or 7% impedance and there may be significant voltage distortion with the types of loads being supported—the existing transformer's impedance is 3.25%.

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