



EN50160 Power Analysis Report

PowerCET Corporation
Santa Clara, CA

Introduction

This is a report of testing to the EN50160 standard that was performed on data recorded at the PowerCET Main 0 04/15/05 16:55 location of the PowerCET Corp. site. This report covers the interval from: Friday, April 15, 2005 16:55:41 to Friday, April 22, 2005 16:55:41

This report is composed of:

- **Summary of tests:** This section is a brief summary of the results of these tests.
- **Site and Location Information:** This section lists the monitor settings while the data was recorded.
- **Compliance limits:** This section contains the compliance limits over which this report was run.
- **Results:** This section contains the results of testing to the EN50160 standard. This includes the following charts and compliance tests:
 - Compliance test results
 - Power frequency
 - Supply voltage variations
 - Rapid voltage changes
 - Flicker severity
 - Supply voltage dips and interruptions
 - Temporary power frequency overvoltages between live conductors and earth
 - Transient overvoltages between live conductors and earth
 - Supply voltage unbalance
 - Harmonic voltage

The following tests are not included in this report:

- Interharmonic voltage
- Mains signaling voltage on the supply voltage

Summary of Test Results

Based on the tests that were run, this site is **not in compliance** with the EN50160 standard in the following area(s):

- Rapid voltage changes
- Supply voltage dips and interruptions



Site and Location Information

Site Information

| | |
|-----------------------------|------------------------------------|
| Name | PowerCET Corp. |
| Account Number | N/A |
| Date and Time | Friday, February 11, 2005 11:13:30 |
| Phone Number | (408) 988-1346 |
| Contact | Bruce Lonie |
| Memo | PQ Monitoring & Load Study |
| Problem Description | N/A |
| Date First Noticed | Thursday, February 10, 2005 |
| Problem Frequency | Unknown |
| How Problem Exhibits Itself | Unknown |
| Problem Cost | N/A |

Location Information

| | |
|----------------------|------------------------------------|
| Name | PowerCET Main 0 04/15/05 16:55 |
| Power Type | Three phase wye |
| Feed Phase | Unknown |
| Phone | (408) 988-1346 |
| Date and Time | Wednesday, April 27, 2005 15:57:24 |
| Nominal Voltage (Un) | 120 Volts |
| Nominal Frequency | 60 Hz |

Compliance Limits

This is a low voltage (lv) system (nominal rms value $\leq 1\text{kV}$) with a synchronous connection to an interconnected system. The table below indicates the limits or ranges of values required for each parameter to be in compliance with the EN50160 standard.

| Parameter | Limit for Compliance to pass |
|--|--|
| Power frequency | Mean value over 10 seconds <ul style="list-style-type: none"> • $\pm 1\%$ during 99.5% of a year • $+4\% / -6\%$ during 100% of the time |
| Supply voltage variations (under normal operating conditions, excluding situations arising from faults or voltage interruptions) | Mean rms over 10 minutes <ul style="list-style-type: none"> • Un $\pm 10\%$ during 95% of one week • Un $+10\% / -15\%$ during 100% of the time |
| Rapid voltage changes | Un $\pm 5\%$, Un $\pm 10\%$ with a short duration |
| Flicker severity | Plt ≤ 1 for 95% of the time |
| Supply voltage dips and interruptions | Dips Duration < 1 second <ul style="list-style-type: none"> • Concern: 60% to 90% Un • Severe concern: below 60% Un Duration ≥ 1 second <ul style="list-style-type: none"> • Concern: 60% to 90% Un • Severe concern: below 60% Un Interruptions Duration ≤ 180 seconds <ul style="list-style-type: none"> • Severe concern: below 1% Un Duration > 180 seconds <ul style="list-style-type: none"> • Severe concern: below 1% Un |
| Overvoltages between live conductors and earth | Temporary overvoltages <ul style="list-style-type: none"> • Fail: > 110% Un (normally $\leq 1.5\text{kV}$) Transient overvoltages <ul style="list-style-type: none"> • Fail: > 1.5kV (normally < 6kV) |
| Supply voltage unbalance (under normal operating conditions) | 10 minute mean rms value of negative phase sequence component <ul style="list-style-type: none"> • $\leq 2\%$ during 95% of one week |
| Harmonic voltage (under normal operating conditions) | 10 minute mean rms <ul style="list-style-type: none"> • Individual harmonics up to the 25th shall be less than or equal to the value in the following Harmonic Compliance Limits Table during 95% of one week • THD $\leq 8\%$ during 95% of one week |



Harmonic Compliance Limits Table

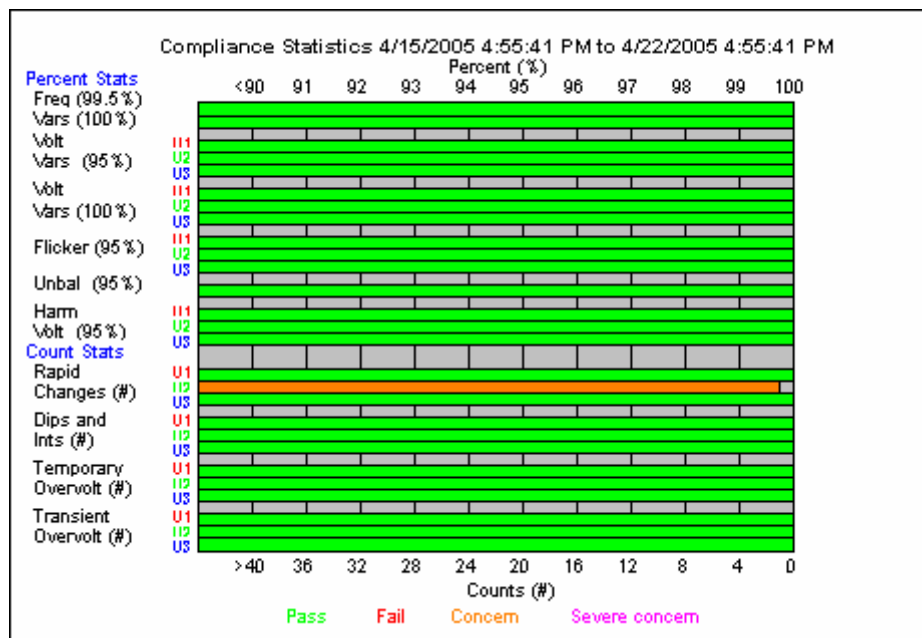
(Values of individual harmonic voltages in percent of Un)

| Odd harmonics | | | | Even Harmonics | |
|--------------------|------------------|----------------|------------------|----------------|------------------|
| Not multiples of 3 | | Multiples of 3 | | Order h | Relative voltage |
| Order h | Relative voltage | Order h | Relative voltage | | |
| 5 | 6 % | 3 | 5 % | 2 | 2 % |
| 7 | 5 % | 9 | 1.5 % | 4 | 1 % |
| 11 | 3.5 % | 15 | 0.5 % | 6...24 | 0.5 % |
| 13 | 3 % | 21 | 0.5 % | | |
| 17 | 2 % | | | | |
| 19 | 1.5 % | | | | |
| 23 | 1.5 % | | | | |
| 25 | 1.5 % | | | | |

Results

Compliance tests overview

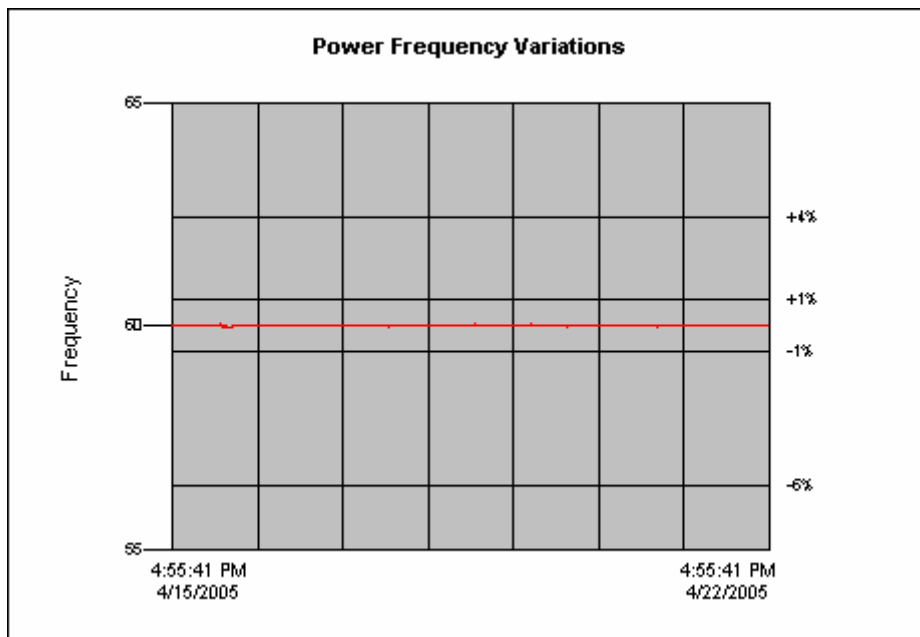
This chart displays a summary of the measured parameters for compliance to EN50160. A green bar indicates that the measurement is in compliance. An orange, magenta or red bar indicates that the measurement is not in compliance with the limits established for this report.



| EN50160 Results for this location | |
|---|---------|
| Power frequency | Pass |
| Supply voltage variations | Pass |
| Flicker | Pass |
| Supply voltage unbalance | Pass |
| Harmonics | Pass |
| Rapid voltage changes | Concern |
| Voltage dips and interruptions | Concern |
| Temporary overvoltages – conductor to earth | Pass |
| Transient overvoltages – conductor to earth | Pass |

Power frequency

This chart displays the mean value of the fundamental frequency measured over 10 seconds under normal operating conditions. This system has a synchronous connection to an interconnected system.

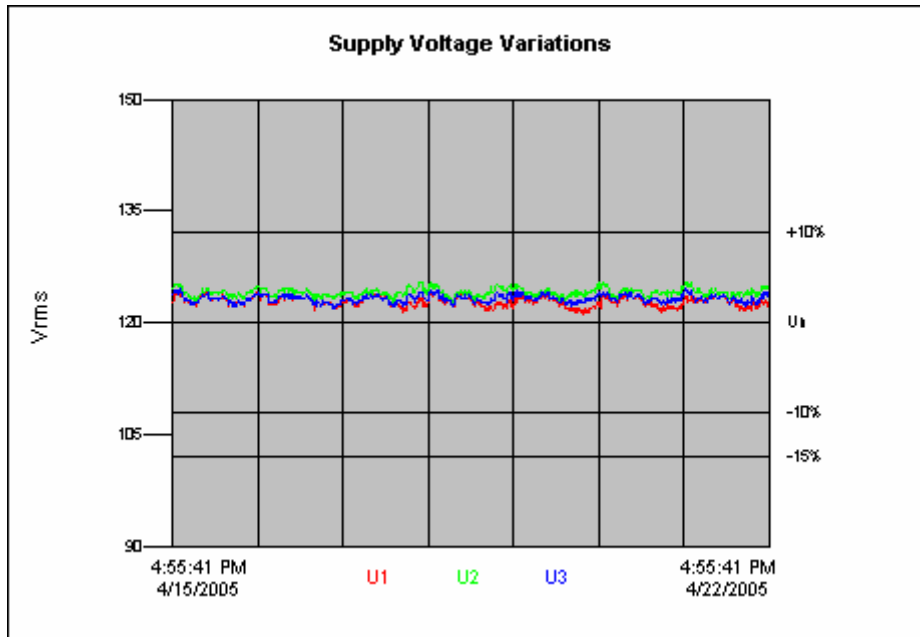


| Limit | Parameter for Compliance to Pass | Actual % | Result |
|-----------|----------------------------------|----------|--------|
| ±1 % | 99.5% of measurements | 100.0 | Pass |
| +4% / -6% | 100% of measurements | 100.0 | Pass |



Supply voltage variations

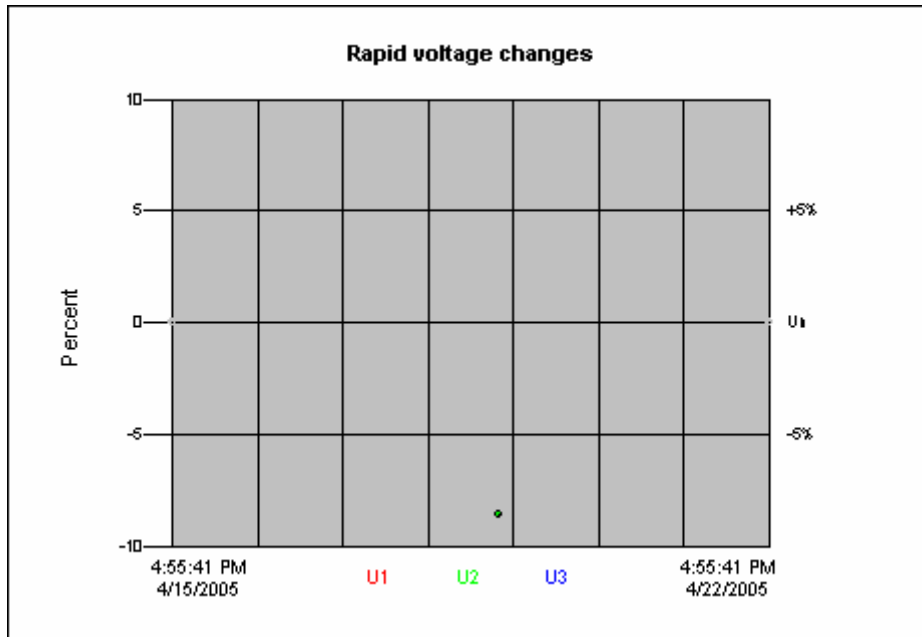
This chart displays the 10 minute mean rms value of the supply voltage under normal operating conditions, excluding situations arising from faults or voltage interruptions. Supply voltage variations are an increase or decrease of voltage normally due to variation of the total load of a distribution system or a part of it. This is a low voltage (lv) system (nominal rms value $\leq 1\text{kV}$).



| Limit | Parameter for Compliance to Pass | U1 % | U2 % | U3 % | Result |
|-----------------------|----------------------------------|-------|-------|-------|--------|
| $\pm 10\% \text{ Un}$ | 95% of measurements | 100.0 | 100.0 | 100.0 | Pass |
| +10% / -15% Un | 100% of measurements | 100.0 | 100.0 | 100.0 | Pass |

Rapid voltage changes

This chart displays the rapid voltage changes of the supply voltage. Rapid voltage changes are single rapid variations of the rms value of a voltage between two consecutive levels which are sustained for definite but unspecified durations. Rapid voltage changes are mainly caused either by load changes in customers' installations or by switching in the system.

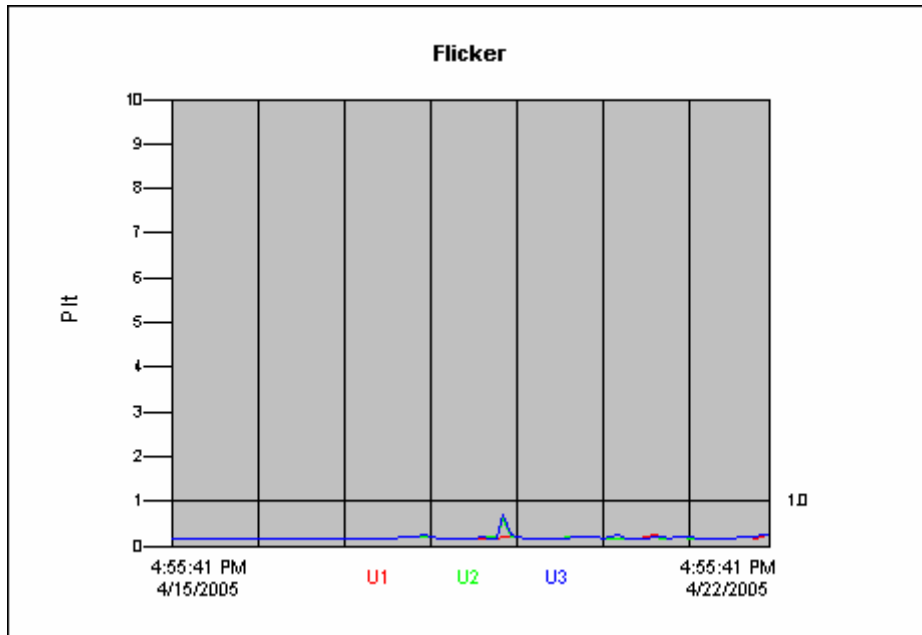


| Limit | Parameter for Compliance to Pass | U1 counts | U2 counts | U3 counts | Result |
|-------------------------------------|----------------------------------|-----------|-----------|-----------|----------------|
| Voltage changes > ±5% Un, ≤ ±10% Un | 0 counts | 0 | 1 | 0 | Concern |



Flicker severity (Plt)

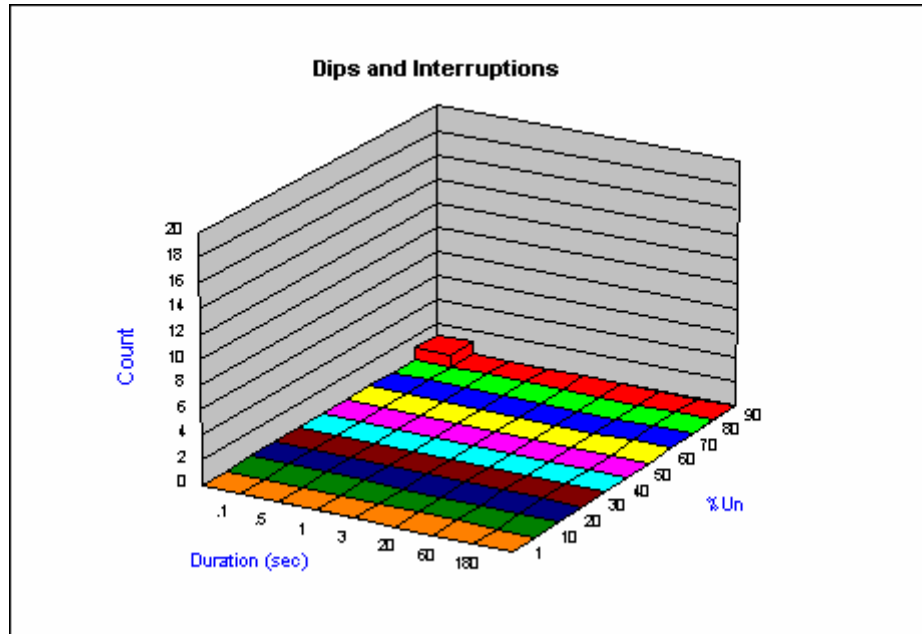
This chart displays the long term flicker severity caused by voltage fluctuations under normal operating conditions. Flicker is the impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time.



| Limit | Parameter for Compliance to Pass | U1 % | U2 % | U3 % | Result |
|--------------|----------------------------------|-------|-------|-------|-------------|
| $Plt \leq 1$ | 95% of measurements | 100.0 | 100.0 | 100.0 | Pass |

Supply voltage dips and interruptions

This chart displays the dips and interruptions of the supply voltage. Dips are a sudden reduction of the supply voltage to a value between 90% and 1% of the nominal voltage U_n , followed by a voltage recovery after a short period of time. Interruptions are a condition in which the voltage at the supply terminals is lower than 1% of the nominal voltage U_n . The results from all of the phases are consolidated for this presentation.

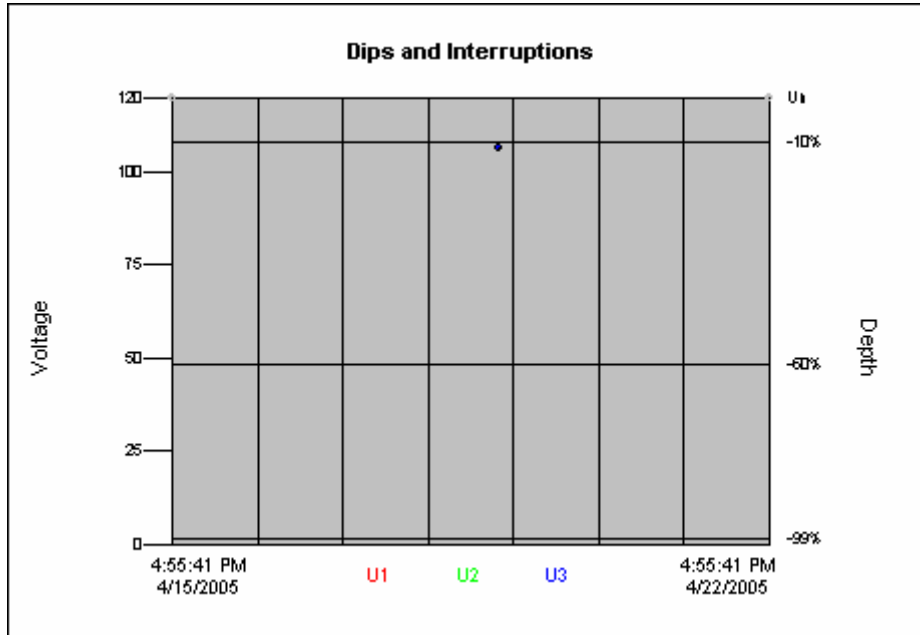


| % Un | Duration in seconds | | | | | | | |
|----------------------|---------------------|---------|-------|-----|------|-------|--------|------|
| | 0.01<0.1 | 0.1<0.5 | 0.5<1 | 1<3 | 3<20 | 20<60 | 60<180 | >180 |
| Dips | | | | | | | | |
| 85 < 90 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 70 < 85 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 < 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50 < 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40 < 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 < 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 < 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 < 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 < 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Interruptions | | | | | | | | |
| < 1% U_n | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |



Supply voltage dips and interruptions (cont'd)

For compliance testing to EN50160, the above results are presented in a different fashion to yield the following results:



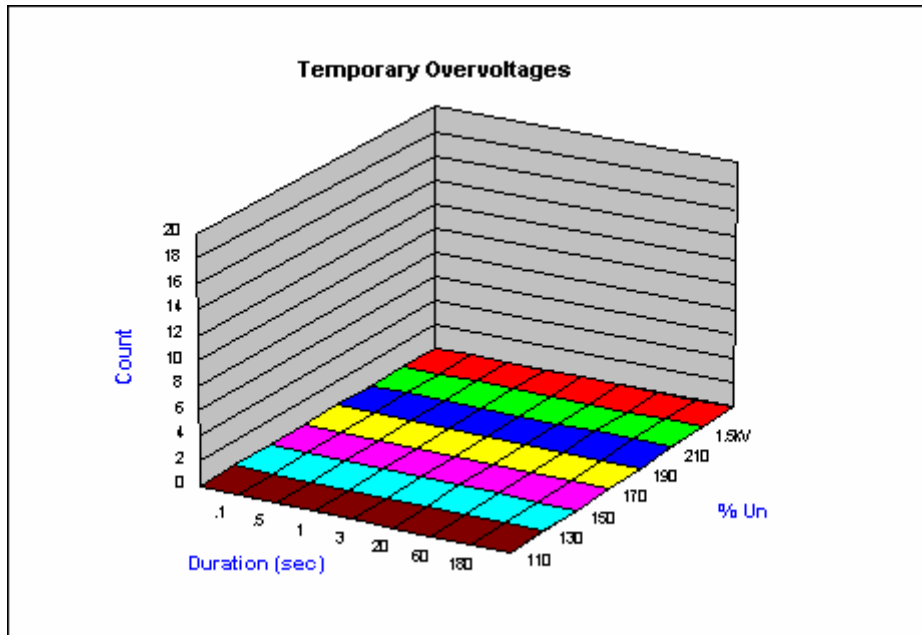
| Dips (%Un) ≤ 1 second | Parameter for Compliance to Pass | U1 counts | U2 counts | U3 counts | Result |
|-----------------------|----------------------------------|-----------|-----------|-----------|---------|
| 60% < 90% | Not specified | 0 | 0 | 1 | Concern |
| 1% < 60% | 0 counts | 0 | 0 | 0 | Pass |

| Dips(%Un) > 1 second | Parameter for Compliance to Pass | U1 counts | U2 counts | U3 counts | Result |
|----------------------|----------------------------------|-----------|-----------|-----------|--------|
| 60% < 90% | Not specified | 0 | 0 | 0 | Pass |
| 1% < 60% | 0 counts | 0 | 0 | 0 | Pass |

| Interruptions (< 1% Un) | Parameter for Compliance to Pass | U1 counts | U2 counts | U3 counts | Result |
|-------------------------|----------------------------------|-----------|-----------|-----------|--------|
| Short (≤ 180 seconds) | 0 counts | 0 | 0 | 0 | Pass |
| Long (> 180 seconds) | 0 counts | 0 | 0 | 0 | Pass |

Temporary power frequency overvoltages

This chart displays the temporary power frequency overvoltages. Temporary overvoltages generally appear during a fault in the public distribution system or in a customer's installation and disappear when the fault is cleared. The results from all of the phases are consolidated for this presentation.

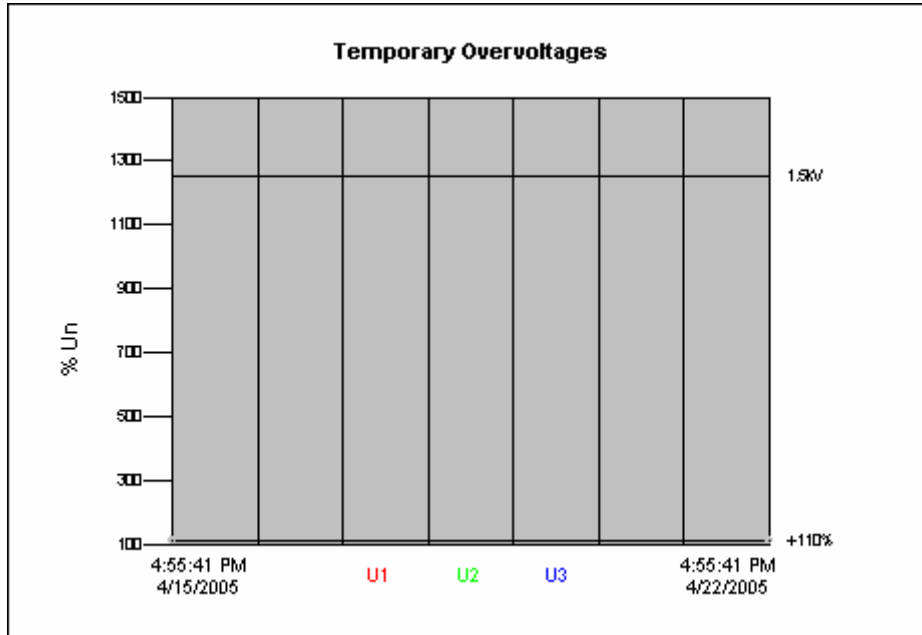


| Voltage Un (%) | Temporary overvoltages (seconds) | | | | | | | |
|----------------|----------------------------------|---------|-------|-----|------|-------|--------|------|
| | 0.01<0.1 | 0.1<0.5 | 0.5<1 | 1<3 | 3<20 | 20<60 | 60<180 | >180 |
| 110 < 130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 130 < 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 150 < 170 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 170 < 190 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 190 < 210 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 210 < 1.5kV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥ 1.5kV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |



Temporary power frequency overvoltages (cont'd)

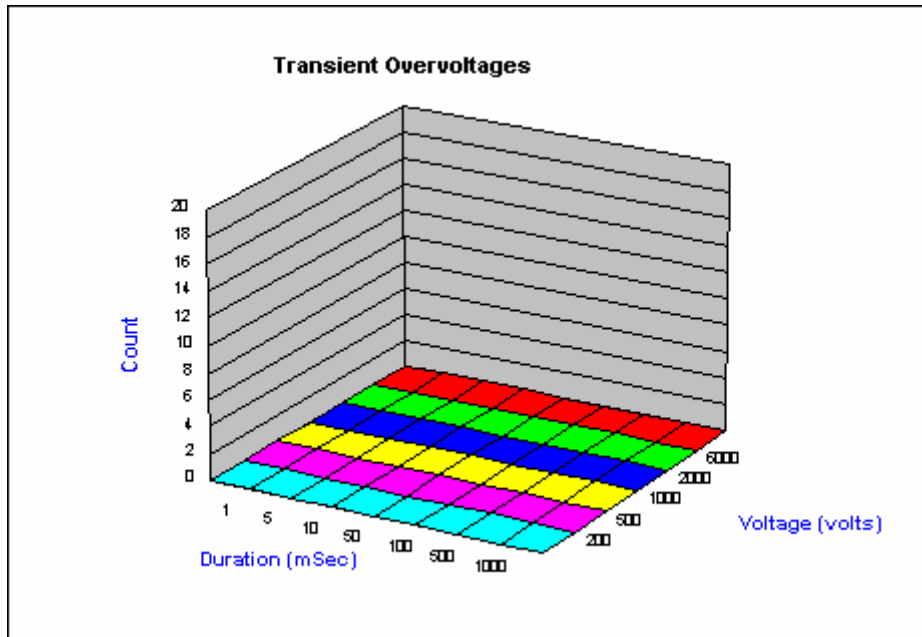
For compliance testing to EN50160, the above results are presented in a different fashion to yield the following results:



| Limit | Parameter for Compliance to Pass | U1 counts | U2 counts | U3 counts | Result |
|---------|----------------------------------|-----------|-----------|-----------|--------|
| > 1.1Un | 0 counts | 0 | 0 | 0 | Pass |

Transient overvoltages between live conductors and earth

This chart shows the transient overvoltages of the supply voltage. A transient overvoltage is a short duration oscillatory or non-oscillatory overvoltage usually highly damped and with a duration of a few milliseconds or less. Transient overvoltages are usually caused by lightning, switching or operation of fuses.

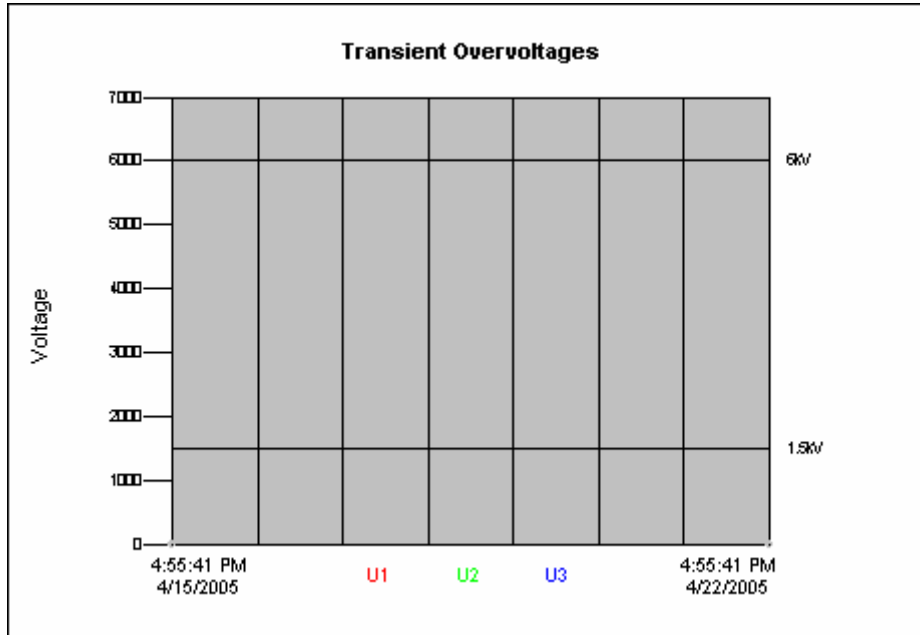


| Overvoltage | Duration (µSec) | | | | | | | |
|-------------|-----------------|-----|------|------|-------|-------|--------|--------|
| | < 1 | < 5 | < 10 | < 50 | < 100 | < 500 | < 1000 | > 1000 |
| 100 < 200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 200 < 500 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 500 < 1kV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1kV < 2kV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2kV < 6kV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥ 6kV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |



Transient overvoltages between live conductors and earth (cont'd)

For compliance testing to EN50160, the above results are presented in a different fashion to yield the following results:



| Limit | Parameter for Compliance to Pass | U1 counts | U2 counts | U3 counts | Result |
|---------|----------------------------------|-----------|-----------|-----------|--------|
| < 1.5kV | No limit | 0 | 0 | 0 | Pass |
| ≥ 1.5kV | 0 counts | 0 | 0 | 0 | Pass |

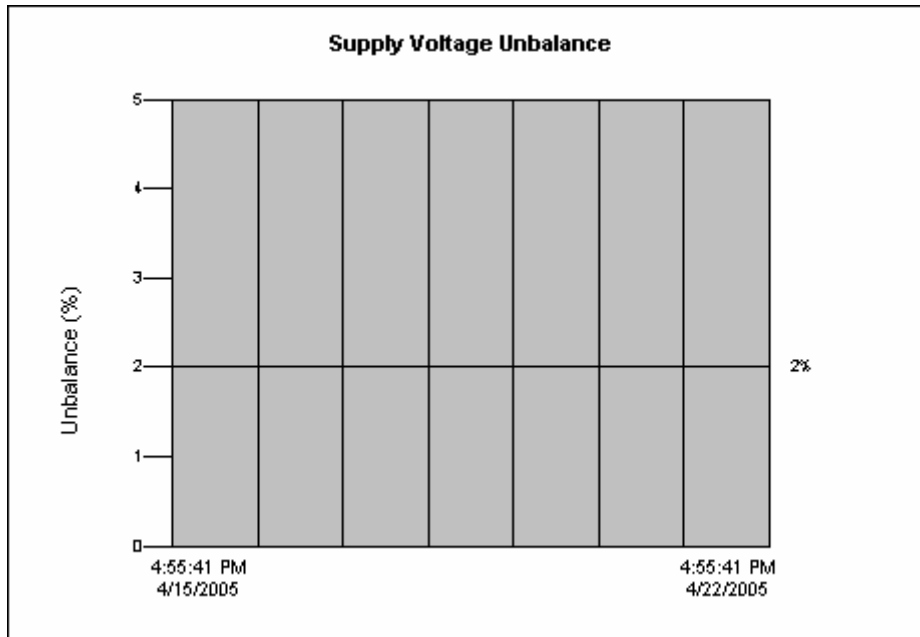
Supply voltage unbalance

This chart shows the unbalance of the 10 minute mean rms values of the supply voltage under normal operating conditions. Unbalance is the condition in which the rms values of the phase voltages or the phase angles between consecutive phases are not equal.

For this report, the negative sequence component is calculated according to EN61000-4-30/FDIS using the equation:

$$u_2 = \sqrt{\frac{1 - \sqrt{3 - 6\beta}}{1 + \sqrt{3 - 6\beta}}} * 100\% \text{ with } \beta = \frac{U_{12\ fund}^4 + U_{23\ fund}^4 + U_{31\ fund}^4}{(U_{12\ fund}^2 + U_{23\ fund}^2 + U_{31\ fund}^2)^2}$$

(U_{ij fund} = phase i to phase j fundamental voltage)

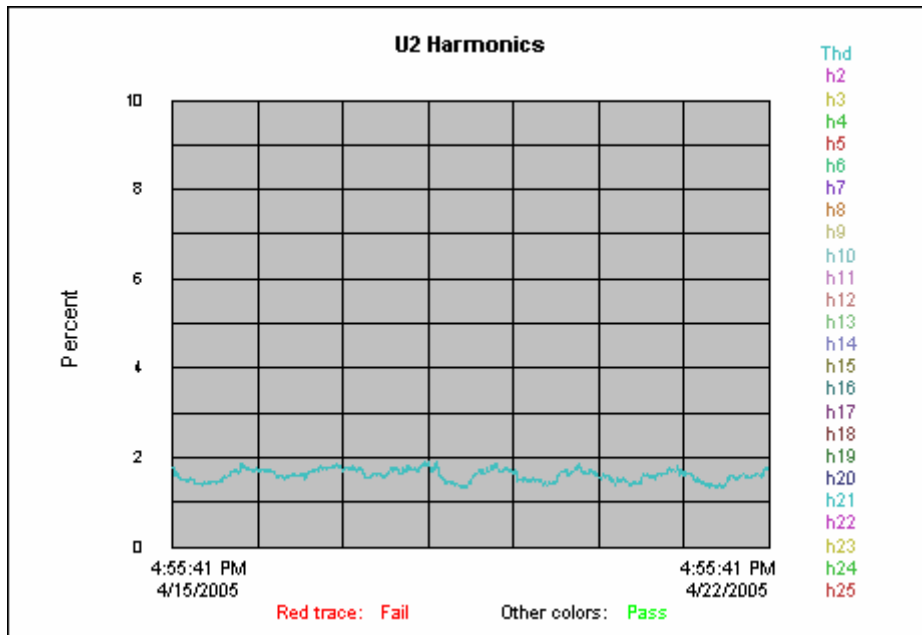
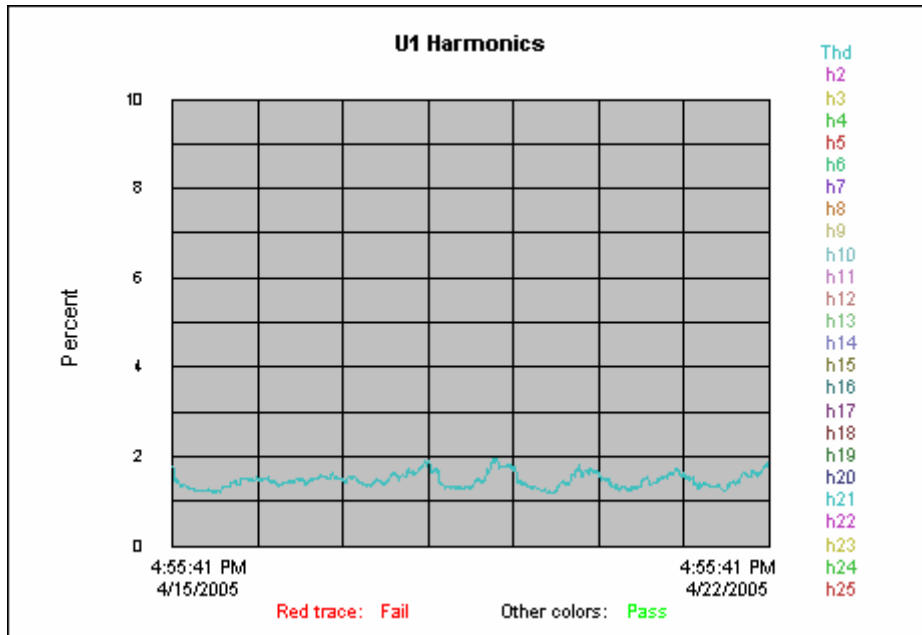


| Limit | Parameter for Compliance to Pass | Actual % | Result |
|-------|----------------------------------|----------|--------|
| ≤ 2 % | 95% of measurements | 100.0 | Pass |

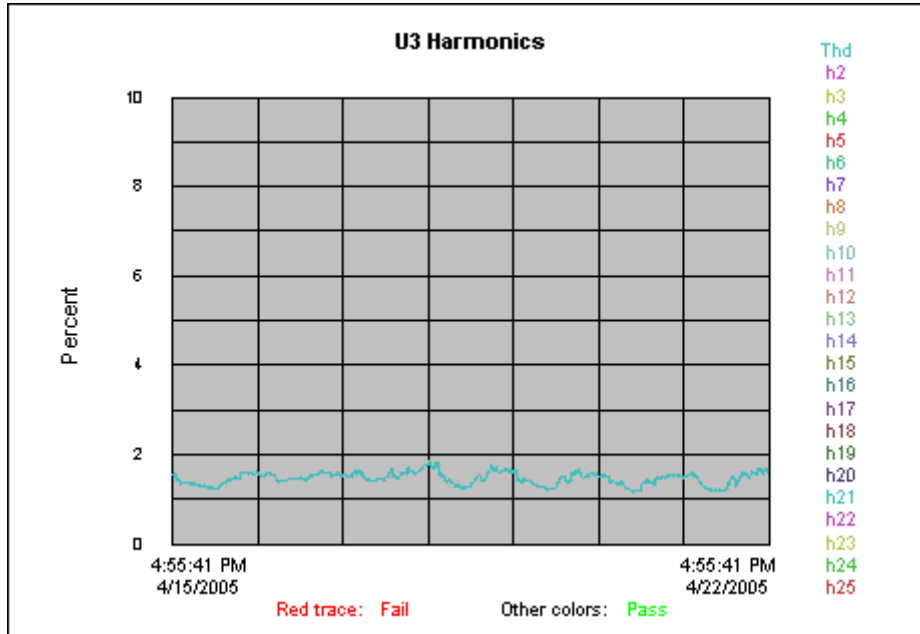


Harmonic voltage

These charts show a summary of the results of the 10 minute mean rms values of the supply voltage THD and harmonics under normal operating conditions. Harmonics are caused mainly by customers' non-linear loads connected to all voltage levels of the supply system.



Harmonic voltage (cont'd)



| Harmonic number | Parameter for Compliance to Pass: 95% of measurements | U1 % | U2 % | U3 % | Result |
|-----------------|---|-------|-------|-------|--------|
| THD | ≤ 8.0 % | 100.0 | 100.0 | 100.0 | Pass |
| 2 | ≤ 2.0 % | 100.0 | 100.0 | 100.0 | Pass |
| 3 | ≤ 5.0 % | 100.0 | 100.0 | 100.0 | Pass |
| 4 | ≤ 1.0 % | 100.0 | 100.0 | 100.0 | Pass |
| 5 | ≤ 6.0 % | 100.0 | 100.0 | 100.0 | Pass |
| 6 | ≤ 0.5 % | 100.0 | 100.0 | 100.0 | Pass |
| 7 | ≤ 5.0 % | 100.0 | 100.0 | 100.0 | Pass |
| 8 | ≤ 0.5 % | 100.0 | 100.0 | 100.0 | Pass |
| 9 | ≤ 1.5 % | 100.0 | 100.0 | 100.0 | Pass |
| 10 | ≤ 0.5 % | 100.0 | 100.0 | 100.0 | Pass |
| 11 | ≤ 3.5 % | 100.0 | 100.0 | 100.0 | Pass |
| 12 | ≤ 0.5 % | 100.0 | 100.0 | 100.0 | Pass |
| 13 | ≤ 3.0 % | 100.0 | 100.0 | 100.0 | Pass |
| 14 | ≤ 0.5 % | 100.0 | 100.0 | 100.0 | Pass |
| 15 | ≤ 0.5 % | 100.0 | 100.0 | 100.0 | Pass |
| 16 | ≤ 0.5 % | 100.0 | 100.0 | 100.0 | Pass |
| 17 | ≤ 2.0 % | 100.0 | 100.0 | 100.0 | Pass |
| 18 | ≤ 0.5 % | 100.0 | 100.0 | 100.0 | Pass |
| 19 | ≤ 1.5 % | 100.0 | 100.0 | 100.0 | Pass |
| 20 | ≤ 0.5 % | 100.0 | 100.0 | 100.0 | Pass |
| 21 | ≤ 0.5 % | 100.0 | 100.0 | 100.0 | Pass |
| 22 | ≤ 0.5 % | 100.0 | 100.0 | 100.0 | Pass |
| 23 | ≤ 1.5 % | 100.0 | 100.0 | 100.0 | Pass |
| 24 | ≤ 0.5 % | 100.0 | 100.0 | 100.0 | Pass |
| 25 | ≤ 1.5 % | 100.0 | 100.0 | 100.0 | Pass |