CHANNEL CALIBRATION PROCEDURE
FOR THE NEES@UCSB WILDLIFE LIQUEFACTION
ARRAY (WLA) AND 5210 SITE

CUSTOMER

University Of California Santa Barbara
Crustal Studies Department

SYSTEM LOCATION

WLA

SYSTEM S/N

207

DATE OF TEST

2/18/2012

PERFORMED BY (Print)

Robin Gee and Dan Radulescu

SIGNATURE

Robin Gee
CHANNEL CALIBRATION PROCEDURE
FOR THE WLA and 5210 SURFACE ARRAY

1.0 PURPOSE

The purpose of this procedure is the determination of the calibration factors for the entire system as described in the proposal No: DCR2006-001. The main components of the system will be checked for functionality and when needed a calibration factor will be determined. The sensors and the entire system shall be tested such that they respond within a specified range and accuracy to an input traceable to the National Bureau of Standards or an acceptable physical constant, (e.g., tilt testing of an accelerometer within the earth's gravitational field). This calibration will require temporary removal of the sensors from their normal location.

2.0 REFERENCES

- Kinematics Episensor (Model FBA ES-T) Guide
- WLA Instrumentation Guide (nees.ucsb.edu/facilities/wla)

It is recommended that this calibration be performed every 12 months

3.0 SYSTEM PERFORMANCE NOTES

- Because this procedure is intended to be used by a qualified person, step-by-step instructions are not given
- Test sequence may be changed as needed for safety and/or efficiency.
- Items for which quantitative measurements cannot or need not to be made shall be reported in a qualitative mode (e.g. Yes/No).
- Any activities performed outside the normal scope of this procedure shall be documented.
• When a deficiency is observed, the technician may undertake additional testing and install factory authorized and/or factory calibrated replacement parts to restore the proper operation of the instrument.

• Calibration readings are equally valid using either the internal batteries (>11.5 VDC under load) or using an external power supply (between 12.0 and 13.0 VDC).

4.0 TEST EQUIPMENT

<table>
<thead>
<tr>
<th>Instrument Type</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Voltmeter</td>
<td>FLUKE</td>
<td>189</td>
<td>24VAC &amp; 20VDC</td>
</tr>
<tr>
<td>Bubble Level</td>
<td>Pro Products</td>
<td>Pro-inclinometer</td>
<td>0° ± 180°</td>
</tr>
<tr>
<td>Tilt Table</td>
<td>Radu Project</td>
<td>TT-1</td>
<td>± 180°</td>
</tr>
</tbody>
</table>

**Note:** Inclinometer accuracy to ±1/2° (used to level tilt table)

5.0 PRE-TEST CONDITIONS

• Notify the End user that the system will be taken out of normal operation conditions

  (Initials) R6

• Check the overall system functionality and appearance. Document any observed anomaly. If a subassembly is not functional, document the findings, perform the repair first (if possible), and continue with the calibration

  (Initials) R6

NOTES:

System functional

Sensor power supply functional

(Initials) R6
6.0 SYSTEM TEST

6.1 UNINTERRUPTIBLE POWER SUPPLY

a) Check the battery charging Indicator. Mark FULL or indicate in % __________________ (Initials) ______

b) Disconnect the AC power cord and wait 10 minutes. The intermittent Battery operation sound should be present. The battery charging indicator shall stay on the same range. (Initials) ______

c) Reconnect the AC (Initials) ______

d) Document when the battery has been installed (dd/mm/yy) ______________

NOTES: Used 12V dc power supply

<table>
<thead>
<tr>
<th>LOCATION CODE #</th>
<th>SENSOR MODEL</th>
<th>S/N</th>
<th>CALIBRATION [V/g]</th>
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<td>1457</td>
<td>9.96</td>
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<tr>
<td></td>
<td>X-axis</td>
<td></td>
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<tr>
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<td>Z-axis</td>
<td></td>
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<tr>
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<td>Triaxial Accelerometer</td>
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<td>9.97</td>
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<td>X-axis</td>
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<td>Y-axis</td>
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<td></td>
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<td>11</td>
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<td>1458</td>
<td>9.84</td>
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<td>Z-axis</td>
<td></td>
<td></td>
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</table>
### 5210 SURFACE ACCELEROMETERS

<table>
<thead>
<tr>
<th>LOCATION CODE #</th>
<th>SENSOR MODEL</th>
<th>S/N</th>
<th>CALIBRATION [V/g]</th>
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</thead>
<tbody>
<tr>
<td>00</td>
<td>Triaxial Accelerometer X-axis</td>
<td>2075</td>
<td>9.98</td>
</tr>
<tr>
<td>00</td>
<td>Triaxial Accelerometer Y-axis</td>
<td>2075</td>
<td>9.96</td>
</tr>
<tr>
<td>00</td>
<td>Triaxial Accelerometer Z-axis</td>
<td>2075</td>
<td>9.98</td>
</tr>
</tbody>
</table>

**NOTES:**

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### 7.0 FINAL STEPS

- Change the batteries from the UPS and SENSOR POWER SUPPLY if they are three (3) years old or more. If the batteries are not purchased, make a note and change them at the first maintenance visit.

  (Initials) _Rb_

- Return the system to functional state

  (Initials) _Rb_

- Attach Final record to this document

  (Initials) _Rb_

- List all test equipment

  (Initials) _Rb_

- Inform the end user that the system is functional

  (Initials) _Rb_

- Prepare the site (close the hat and the equipment)

  (Initials) _Rb_
8.0 SUMMARY (Comments, Parts replaced, Deficiencies, etc.)

System not functional

9.0 CERTIFICATION

All items included in this procedure have been performed unless noted above and were found or have been adjusted to be within the range required by this procedure.

[Signature]
Robin Gee
(Print)

10.0 ACTION REQUIRED (IF ANY)
APPENDIX A

Correspondence between the channel number and sensor type
Table A1: WLA SURFACE ARRAY INSTRUMENTS

<table>
<thead>
<tr>
<th>Location Code #</th>
<th>Sensor Type</th>
<th>Model / Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>Triaxial Accelerometer X,Y,Z-axis</td>
<td>Kinematics FBA ES-T</td>
</tr>
<tr>
<td>10</td>
<td>Triaxial Accelerometer X,Y,Z-axis</td>
<td>Kinematics FBA ES-T</td>
</tr>
<tr>
<td>11</td>
<td>Triaxial Accelerometer X,Y,Z-axis</td>
<td>Kinematics FBA ES-T</td>
</tr>
</tbody>
</table>

Table A2: 5210 SURFACE ARRAY INSTRUMENTS

<table>
<thead>
<tr>
<th>Location Code #</th>
<th>Sensor Type</th>
<th>Model / Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>Triaxial Accelerometer X,Y,Z-axis</td>
<td>Kinematics FBA ES-T</td>
</tr>
</tbody>
</table>

NOTE:
- Connected to the A/D Input through a Signal Conditioning board Model 163MK manufactured by CALEX
APPENDIX B

Recommended Calibration Methods
ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:
The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER

WLA 500
SN 1457

The following readings shall be taken in the indicated order:

1. Horizontal
   - 0.242 [V]
2. tilt to +30 degrees
   - 0.19 [V]
3. tilt to +90 degrees
   - 10.10 [V]
4. tilt back to horizontal
   - 0.239 [V]
5. tilt to -30 degrees
   - 1.75 [V]
6. tilt to -90 degrees
   - 9.83 [V]
7. tilt back to horizontal
   - 0.240 [V]

CALIBRATION FACTOR

\[
\frac{([\text{Read}3 - \text{Read}1]) + ([\text{Read}6 - \text{Read}4])}{2}
\]

For the vertical axis:
The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER

WLA 500
SN 1457

The following readings shall be taken in the indicated order:

1. Horizontal
   0.079 [V]
2. tilt to +60 degrees
   - 4.81 [V]
3. tilt to +90 degrees
   - 9.80 [V]
4. Continue to Horizontal
   - 19.86 [V]

CALIBRATION FACTOR

[Read 3 – Read 1]

\[
9.88 [V/g]
\]
ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:
The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER

The following readings shall be taken in the indicated order:

1. Horizontal
2. tilt to +30 degrees
3. tilt to +90 degrees
4. tilt back to horizontal
5. tilt to -30 degrees
6. tilt to -90 degrees
7. tilt back to horizontal

CALIBRATION FACTOR
\[ \frac{([\text{Read}3 - \text{Read}1]) + ([\text{Read}6 - \text{Read}4])}{2} \]

For the vertical axis:
The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER

The following readings shall be taken in the indicated order:

1. Horizontal
2. tilt to +60 degrees
3. tilt to +90 degrees
4. Continue to Horizontal

CALIBRATION FACTOR
\[ \text{[Read 3 - Read 1]} \]

\[ \text{[V/g]} \]
ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:
The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER

The following readings shall be taken in the indicated order:

1. Horizontal
2. tilt to +30 degrees
3. tilt to +90 degrees
4. tilt back to horizontal
5. tilt to -30 degrees
6. tilt to -90 degrees
7. tilt back to horizontal

CALIBRATION FACTOR

\[
\frac{(|\text{Read3} - \text{Read1}| + |\text{Read6} - \text{Read4}|)}{2}
\]

For the vertical axis:
The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER

The following readings shall be taken in the indicated order:

1. Horizontal
2. tilt to +60 degrees
3. tilt to +90 degrees
4. Continue to Horizontal

CALIBRATION FACTOR

\[
\text{|Read 3 - Read 1|}
\]
ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:
The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER
WLA 10  SN 1456

The following readings shall be taken in the indicated order:

1. Horizontal
   \[ -0.009 \] [V]
2. tilt to +30 degrees
   \[ -4.99 \] [V]
3. tilt to +90 degrees
   \[ -10.02 \] [V]
4. tilt back to horizontal
   \[ -0.012 \] [V]
5. tilt to -30 degrees
   \[ 4.96 \] [V]
6. tilt to -90 degrees
   \[ 0.90 \] [V]
7. tilt back to horizontal
   \[ 0.013 \] [V]

CALIBRATION FACTOR
\[ \frac{((\text{Read}3 - \text{Read}1)) + ((\text{Read}6 - \text{Read}4))}{2} \]
\[ 9.96 \] [V/g]

For the vertical axis:
The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER

The following readings shall be taken in the indicated order:

1. Horizontal
   \[ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_\_ \] [V]
2. tilt to +60 degrees
   \[ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_\_ \] [V]
3. tilt to +90 degrees
   \[ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_\_ \] [V]
4. Continue to Horizontal
   \[ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_\_ \] [V]

CALIBRATION FACTOR
[Read 3 – Read 1]
\[ \_ \_ \_ \_ \] [V/g]
ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:
The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER

The following readings shall be taken in the indicated order:

1. Horizontal
2. tilt to +30 degrees
3. tilt to +90 degrees
4. tilt back to horizontal
5. tilt to -30 degrees
6. tilt to -90 degrees
7. tilt back to horizontal

CALIBRATION FACTOR

\[
\frac{\left|\text{Read3} - \text{Read1}\right| + \left|\text{Read6} - \text{Read4}\right|}{2}
\]

For the vertical axis:
The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER

The following readings shall be taken in the indicated order:

1. Horizontal
2. tilt to +60 degrees
3. tilt to +90 degrees
4. Continue to Horizontal

CALIBRATION FACTOR

\[
\frac{\text{Read 3} - \text{Read 1}}{2}
\]
ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:
The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER

The following readings shall be taken in the indicated order:

1. Horizontal
2. tilt to +30 degrees
3. tilt to +90 degrees
4. tilt back to horizontal
5. tilt to -30 degrees
6. tilt to -90 degrees
7. tilt back to horizontal

CALIBRATION FACTOR

\[
\text{\small \{[(Read3 - Read1) + (Read6 - Read4)] / 2} \right.
\]

For the vertical axis:
The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER

The following readings shall be taken in the indicated order:

1. Horizontal
2. tilt to +60 degrees
3. tilt to +90 degrees
4. Continue to Horizontal

CALIBRATION FACTOR

\[
\text{\small \{Read 3 - Read 1} \right.
\]
ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:
The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER
5210 S06 SN 2075

The following readings shall be taken in the indicated order:

1. Horizontal
   - 0.168 [V]

2. tilt to +30 degrees
   - 5.21 [V]

3. tilt to +90 degrees
   - 10.25 [V]

4. tilt back to horizontal
   - 0.129 [V]

5. tilt to -30 degrees
   4.84 [V]

6. tilt to -90 degrees
   9.71 [V]

7. tilt back to horizontal
   0.137 [V]

CALIBRATION FACTOR
\[ \frac{(\text{Read3} - \text{Read1}) + (\text{Read6} - \text{Read4})}{2} \]

9.98 [V/g]

For the vertical axis:
The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER
5210 S06 SN 2075

The following readings shall be taken in the indicated order:

1. Horizontal
   - 0.035 [V]

2. tilt to +60 degrees
   - 4.96 [V]

3. tilt to +90 degrees
   - 10.01 [V]

4. Continue to Horizontal
   - 20.62 [V]

CALIBRATION FACTOR
\[ \text{Read 3} - \text{Read 1} \]

9.98 [V/g]
ACCELEROMETERS

Each unit (uniaxial or triaxial that can be removed temporarily for calibration will be calibrated using a tilt table).

For the horizontal axis:
The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER

The following readings shall be taken in the indicated order:

1. Horizontal
2. tilt to +30 degrees
3. tilt to +90 degrees
4. tilt back to horizontal
5. tilt to -30 degrees
6. tilt to -90 degrees
7. tilt back to horizontal

CALIBRATION FACTOR
\[ \frac{\{(\text{Read3} - \text{Read1}) + (\text{Read6} - \text{Read4})\}}{2} \]

For the vertical axis:
The unit shall be placed on a tilt table which has been leveled and checked with a mechanical angular device.

MODEL / SERIAL NUMBER

The following readings shall be taken in the indicated order:

1. Horizontal
2. tilt to +60 degrees
3. tilt to +90 degrees
4. Continue to Horizontal

CALIBRATION FACTOR
\[ \text{[Read 3 - Read 1]} \]
Certificate of Calibration

Date: 6/17/2011

Customer:
ENLEKIRK STRUCTURAL ENGINEERING CENTER
10201 POMERADO RD
SAN DIEGO, CA, 92131

MPC Control #: BL8539
Asset ID: N/A
Gage Type: TILT TABLE
Manufacturer: KINEMETRICS
Model Number: F100200-XX-PL
Size: N/A
Temp./RH: 21 °C / 55 %

Work Order: 120733
Serial Number: 172
Department: N/A
Performed By: PETER SINKS
Received Condition: IN TOLERANCE
Returned Condition: IN TOLERANCE
Cal Date: June 17, 2011
Cal. Interval: 12 MONTHS
Cal. Due Date: June 17, 2012

Found conditions meet or exceed manufacturer specifications.

*Calibration Notes:

Test Points

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<thead>
<tr>
<th>Description</th>
<th>Standard</th>
<th>Tolerance -</th>
<th>Tolerance +</th>
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<td>Deg</td>
<td>Pass</td>
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Standards Used To Calibrate Equipment

<table>
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<tr>
<th>I.D.</th>
<th>Description</th>
<th>Model</th>
<th>Serial</th>
<th>Manufacturer</th>
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<tbody>
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<td>PROTRACTOR</td>
<td>N/A</td>
<td>N/A</td>
<td>HELIOS</td>
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<td>T9186</td>
<td>HEIGHT GAGE</td>
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<td>1886</td>
<td>VERDICT</td>
<td>6/30/2011</td>
<td>1005841</td>
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</table>

Calibrating Technician: PETER SINKS

QC Approval: MAURICE HEATH

Unless Otherwise Noted, Uncertainties Estimated at 4:1. Uncertainties have been estimated at a 95 percent confidence level (K=2). Services rendered comply with ISO 17025, ISO 9001, ANSI NCSL 250-3, MPC Quality Manual, MPC CSO, and with customer purchase order instructions.

Calibration cycles and resulting due dates were submitted/approved by the customer. Any number of factors may cause an instrument to drift out of tolerance before the next scheduled calibration. Recalibration cycles should be based on frequency of use, environmental conditions and customer's established systematic accuracy. The information on this report pertains only to the instrument identified.

All standards are traceable to the National Institute of Standards and Technology (NIST). Services rendered include proper manufacturer's service instructions and are warranted for no less than thirty (30) days. This report may not be reproduced in part or in whole without the prior written approval of the issuing MPC lab.
Certificate of Calibration

Date: 6/17/2011

Certificate #: 1404392

Procedures Used In This Event:

<table>
<thead>
<tr>
<th>Procedure Name</th>
<th>Description</th>
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<tbody>
<tr>
<td>ANGLE PLATE</td>
<td>ANGLE PLATES - PROC# CP00206</td>
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</tbody>
</table>

Calibrating Technician:  

PETER SINKS

QC Approval:  

MAURICE HEATH

Unless Otherwise Noted, Uncertainties have been estimated at ± 4 x 10^-6. Uncertainties have been estimated at a 95 percent confidence level (k=2). Services rendered comply with ISO 17025:2005, ISO 9001:2008, ANSI/NCSL Z540-2. The Quality Manual, MPC CSD, and with customer purchase order instructions.

Calibration cycles and resulting due dates were submitted/approved by the customer. Any number of factors may cause an instrument to drift out of tolerance before the next scheduled calibration. Recalibration cycles should be based on frequency of use, environmental conditions, and customer's established systematic accuracy. The information on this report pertains only to the instrument identified.

All standards are traceable to the National Institute of Standards and Technology (NIST). Services rendered include proper manufacturer's service instructions and are warranted for no less than thirty (30) days. This report may not be reproduced in part or in whole without the prior written approval of the issuing MPC lab.
Micro Precision Calibration Inc.

Certificate of Calibration

Date: 12/19/2011
Lab #: 935.10

Customer:
ENGLEKIRK STRUCTURAL ENGINEERING CENTER
10201 POMERADO RD
SAN DIEGO, CA, 92131

MPC Control #: BL3668
Asset ID: N/A
Gage Type: DIGITAL MULTIMETER
Manufacturer: FLUKE
Model Number: 85 III
Size: N/A
Temp./RH: 19.4 °C / 47 %

Work Order: 134240
Serial Number: 46450375
Department: N/A
Performed By: FRANCISCO OLIVEROS
Received Condition: IN TOLERANCE
Returned Condition: IN TOLERANCE
Cal Date: December 12, 2011
Cal. Interval: 12 MONTHS
Cal. Due Date: December 12, 2012

Found conditions meet or exceed manufacturer specifications.

*Calibration Notes:
Data and units attached.

Standards Used To Calibrate Equipment

I.D. Description Model Serial Manufacturer Cal. Due Date Traceability #
BC3293 METER CALIBRATOR 5700A 5990310 FLUKE 8/31/2012 1254320
T9825 UNIVERSAL CALIBRATOR 9100 40144 WAVETEK 4/30/2012 1342582

Procedures Used In This Event:

Procedure Name Description
MULTIMETER (FLUKE) GENE MULTIMETER, DIG 33K8-4-14-1 (FLUKE)

Calibrating Technician: FRANCISCO OLIVEROS
QC Approval: Ricardo Morris


Calibration cycles and resulting due dates were submitted/approved by the customer. Any number of factors may cause an instrument to drift out of tolerance before the next scheduled calibration. Recalibration cycles should be based on frequency of use, environmental conditions and customer's established systematic accuracy. The information on this report, pertains only to the instrument identified.

All standards are traceable to the National Institute of Standards and Technology (NIST). Services rendered include proper manufacturer's service instructions and are warranted for no less than thirty (30) days.

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COMMENTS:
Uncertainty Analysis Report
12-Dec-11

Englekimk
Submitted by: Francisco Oliveros
Approved By: Ricardo Morris
Asset: BL3668
Subject Unit: Multimeter
Manufacturer: Fluke Corp.
Model Number: 85 III

Uncertainty Results:

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The expanded uncertainty presented in this report is consistent with the 1993 ISO Guide to the Expression of Uncertainty in Measurement. The expanded Uncertainty is not to be confused with a tolerance limit for the user during application.