CHANNEL CALIBRATION PROCEDURE

FOR

SFSI TEST STRUCTURE SYSTEM

MODEL RTMS-2001RN

CUSTOMER

University Of California Santa Barbara
Crustal Studies Department

SYSTEM LOCATION

GVDA

SYSTEM S/N

207

DATE OF TEST

August 1, 2009

PERFORMED BY (Print)

Dan Radulescu

SIGNATURE

[Signature]
CHANNEL CALIBRATION PROCEDURE
FOR
SFSI TEST STRUCTURE SYSTEM
MODEL RTMS-2001RN

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 DESCRIPTION

The RTMS-2001RN system is a multi-channels Data Acquisition system which is capable of locally recording events and continuously streaming data to multiple remote clients using TCP/IP protocol. The system has a total of 32 channels with a 24-bit resolution for each channel. A total of 28 different sensors are connected to the system. First 24 channels are connected directly to the A/D input and the last 8 channels are connected to the output of an Signal conditioning module Model 163 MK manufactured by CALEX. Table A1 in Appendix A shows the correspondence between the channel number and the sensor type, Model, and Manufacturer.

3.0 REFERENCES

- Digitexx SF5I Monitoring System – System Manual
- Applied MemS Calibration Data Card
- ATA Sensors Calibration Data Card
- Entran Calibration Data Card
- Scientific Technologies Inc. Calibration Data Card
- Calex Operating Manual for 163mk Signal Conditioning

It is recommended that this calibration be performed every 12 months
4.0 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).

5.0 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>199</td>
<td>±2Vdc and ±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>CALIB PROJECT</td>
<td>TT-1</td>
<td>± 180°</td>
</tr>
</tbody>
</table>

* FOR A/B CHECK:
- VOLTAGE GENERATOR, TOLERATOR, #1017
  RANGE ±1Vdc ±5Vdc ±9Vdc.
6.0 PRE-TEST CONDITIONS

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

  (Initials) [Signature]

- 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) [Signature]

NOTES: Axx_SN207_20090821_00304.axx

AS FOUND EVENT

SYSTEM FUNCTIONAL

SENSOR POWER SUPPLY FUNCTIONAL

(Initials) [Signature]
7.0 SYSTEM TEST

7.1 UNINTERRUPTIBLE POWER SUPPLY

a) Check the battery charging indicator. Mark FULL or indicate in % FULL (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) 9/13/08

NOTES: BATTERY INSTALLED LAST YEAR

UPS FULLY FUNCTIONAL
7.2 SENSOR POWER SUPPLY

a) Check the front LEDs to be ON (Y/N) YES

b) Check the battery voltage with AC connected (>12.5V) 12.87 (V)

c) Measure the output voltage on +12V side (+12V +/- 0.1) +12.05 (V)

d) Measure the output voltage on -12V side (-12V +/- 0.1) -12.05 (V)

e) Disconnect the AC and check the battery voltage (>12.3) 12.42 (V)

f) Reconnect the AC (Initials) [Signature]

NOTES: SENSOR Power Supply Functional

7.3 PC INDUSTRIAL COMPUTER

a) Check the overall functionality (Initials) [Signature]

b) Check the Server software for proper functionality (Initials) [Signature]

c) Check the Hard Disk Space 28.3 GB (MB)

d) Download all recorded events on a memory stick (Initials) [Signature]

 e) Check for OS updates and perform the OS update (Initials) [Signature]

f) Simulate AC power Loss and observe that the System comes UP and is operational (Initials) [Signature]

NOTES: OS MAINTAINED BY UCSB
AC Power Loss TESTED OK.
ALL EVENT FILES JUN 1, 2009 TO AUG 1, 2009 DOWNLOADED
7.4 A/D CALIBRATION CHECK

Using a voltage reference source, check the A/D reading connecting the source to each channel. Record in the table below the value read by each channel.

<table>
<thead>
<tr>
<th>CHANNEL #</th>
<th>VOLTAGE REFERENCE [V]</th>
<th>A/D READING [V]</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td></td>
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<td>4</td>
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<td></td>
<td></td>
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<tr>
<td>5</td>
<td></td>
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<td></td>
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<td>6</td>
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<td>9</td>
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<tr>
<td>10</td>
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<td></td>
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<tr>
<td>11</td>
<td></td>
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<td>12</td>
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<td></td>
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<td></td>
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<tr>
<td>32</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTES: See Appendix B for detailed values.

This time I used only 5 volts to check at the middle of the full scale.
## 7.5 SENSOR CALIBRATION

### ACCELEROMETERS

<table>
<thead>
<tr>
<th>CHANNEL #</th>
<th>SENSOR MODEL</th>
<th>SENSOR S/N</th>
<th>CALIBRATION [V/g]</th>
<th>AS FOUND</th>
<th>AS LEFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Triaxial Accelerometer</td>
<td>254</td>
<td>1.223</td>
<td>1.223</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>X-axis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Y-axis</td>
<td>254</td>
<td>1.220</td>
<td>1.220</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Z-axis</td>
<td>254</td>
<td>1.206</td>
<td>1.206</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Triaxial Accelerometer</td>
<td>255</td>
<td>1.192</td>
<td>1.192</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>X-axis</td>
<td>255</td>
<td>1.194</td>
<td>1.194</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Uniaxial Accelerometer</td>
<td>317</td>
<td>1.216</td>
<td>1.216</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Z-axis</td>
<td>316</td>
<td>1.226</td>
<td>1.226</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Uniaxial Accelerometer</td>
<td>314</td>
<td>1.200</td>
<td>1.200</td>
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<tr>
<td>10</td>
<td>Z-axis</td>
<td>312</td>
<td>1.206</td>
<td>1.206</td>
<td></td>
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<tr>
<td>11</td>
<td>Uniaxial Accelerometer</td>
<td>318</td>
<td>1.200</td>
<td>1.200</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>X-axis</td>
<td>320</td>
<td>1.204</td>
<td>1.204</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Uniaxial Accelerometer</td>
<td>321*</td>
<td>1.185</td>
<td>1.195</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>X-axis (Shaker)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Triaxial Downhole</td>
<td>0101**</td>
<td>1.204</td>
<td>1.204</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Accelerometer X-axis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Triaxial Downhole</td>
<td>0101**</td>
<td>1.232</td>
<td>1.232</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Accelerometer Y-axis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Triaxial Downhole</td>
<td>0101**</td>
<td>1.242</td>
<td>1.242</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Accelerometer Z-axis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**

* NOT CALIBRATED COULD NOT REMOVE FROM SHAKER REPORTED VALUE TAKEN FROM LAST CALIBRATION

** DOWNHOLE NOT CALIBRATED REPORTED VALUES ARE FROM INITIAL FACTORY CALIBRATION CERTIFICATE

** THREE (3) ACCELEROMETERS ON-SITE STAPES:

- S/N: 313, $S = 1.2063$ V/g
- S/N: 315, $S = 1.210$ V/g
- S/N: 319, $S = 1.2018$ V/g
## ROTATION

<table>
<thead>
<tr>
<th>CHANNEL #</th>
<th>SENSOR MODEL</th>
<th>SENSOR S/N</th>
<th>CALIBRATION [DEGREE/SEC]</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>ARS-09</td>
<td></td>
<td>AS FOUND</td>
</tr>
<tr>
<td>18</td>
<td>ARS-09</td>
<td></td>
<td>AS LEFT</td>
</tr>
<tr>
<td>19</td>
<td>ARS-09</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**
- SENSOR MAY REMOVED TO KEEP STATISTICAL DATA COLLECTION CONSISTENT
- SENSOR STAND-BY READINGS ARE NORMAL

## PORE PRESSURE

<table>
<thead>
<tr>
<th>CHANNEL #</th>
<th>SENSOR MODEL</th>
<th>SENSOR S/N</th>
<th>CALIBRATION [ ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td></td>
<td></td>
<td>AS FOUND</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AS LEFT</td>
</tr>
</tbody>
</table>

**NOTES:**
- NOT CALIBRATED
- MEAN VALUE: 3.43889-V  

## SOIL PRESSURE

<table>
<thead>
<tr>
<th>CHANNEL #</th>
<th>SENSOR MODEL</th>
<th>SENSOR S/N</th>
<th>CALIBRATION [mV/PSI]</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>EPX-V01-100P</td>
<td>04EO4EM-D28</td>
<td>1.2393 1.2393</td>
</tr>
<tr>
<td>26</td>
<td>EPX-V01-100P</td>
<td>04AO8705-K10</td>
<td>1.5969 1.5969</td>
</tr>
<tr>
<td>27</td>
<td>EPX-V01-100P</td>
<td>04AO8705-K08</td>
<td>1.8403 1.8403</td>
</tr>
<tr>
<td>28</td>
<td>EPX-V01-100P</td>
<td>04EO4EM-D28</td>
<td>1.1244 1.1244</td>
</tr>
</tbody>
</table>

**NOTES:**
- TEST FILE FOR PRESSURE SENSORS
- FUNCTIONALITY CHECK ONLY. CAL VALUES TAKEN FROM FACT. CAL CERT

---

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Channel Calibration Procedure Revision 0  
for SFSI Test Structure System Model RTMS-2001RN
## Relative Displacement

<table>
<thead>
<tr>
<th>Channel #</th>
<th>Sensor Model</th>
<th>Sensor S/N</th>
<th>Calibration [V/Inch]</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>DT-30-B</td>
<td>03-2823</td>
<td>0.0655</td>
</tr>
<tr>
<td>30</td>
<td>DT-30-B</td>
<td>03-2826</td>
<td>0.0631</td>
</tr>
<tr>
<td>31</td>
<td>DT-30-B</td>
<td>03-2824</td>
<td>0.0659</td>
</tr>
<tr>
<td>32</td>
<td>DT-30-B</td>
<td>03-2825</td>
<td>0.0672</td>
</tr>
</tbody>
</table>

**Notes:**

```
CALIBRATION FILE:
XXXSN204-20090801-13223, XXX
```

---

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Channel Calibration Procedure Revision 0  
for SFSI Test Structure System Model RTMS-2001RN
8.0 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)

- Return the system to functional state
  (Initials)

- Attach Final record to this document
  (Initials)

- List all test equipment
  (Initials)

- Inform the end user that the system is functional
  (Initials)

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

NOTES:

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

9.0 SUMMARY (Comments, Parts replaced, Deficiencies, etc.)

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________
10.0 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.

(yes/no)  YES

(Signature)

[Signature]

11.0 ACTION REQUIRED (IF ANY)

UCSB TO CHECK PORE PRESSURE SENSORS

[Additional notes or actions if any]
APPENDIX A

Correspondence between the channel number and sensor type
<table>
<thead>
<tr>
<th>Channel #</th>
<th>Sensor Type</th>
<th>Model / Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Triaxial Accelerometer X-axis</td>
<td>SF3000 / AppliedMems</td>
</tr>
<tr>
<td>2</td>
<td>Triaxial Accelerometer Y-axis</td>
<td>SF3000 / AppliedMems</td>
</tr>
<tr>
<td>3</td>
<td>Triaxial Accelerometer Z-axis</td>
<td>SF3000 / AppliedMems</td>
</tr>
<tr>
<td>4</td>
<td>Triaxial Accelerometer X-axis</td>
<td>SF3000 / AppliedMems</td>
</tr>
<tr>
<td>5</td>
<td>Triaxial Accelerometer Y-axis</td>
<td>SF3000 / AppliedMems</td>
</tr>
<tr>
<td>6</td>
<td>Triaxial Accelerometer Z-axis</td>
<td>SF3000 / AppliedMems</td>
</tr>
<tr>
<td>7</td>
<td>Uniaxial Accelerometer Z-axis</td>
<td>SF3000 / AppliedMems</td>
</tr>
<tr>
<td>8</td>
<td>Uniaxial Accelerometer Z-axis</td>
<td>SF3000 / AppliedMems</td>
</tr>
<tr>
<td>9</td>
<td>Uniaxial Accelerometer X-axis</td>
<td>SF3000 / AppliedMems</td>
</tr>
<tr>
<td>10</td>
<td>Uniaxial Accelerometer Z-axis</td>
<td>SF3000 / AppliedMems</td>
</tr>
<tr>
<td>11</td>
<td>Uniaxial Accelerometer Z-axis</td>
<td>SF3000 / AppliedMems</td>
</tr>
<tr>
<td>12</td>
<td>Uniaxial Accelerometer X-axis</td>
<td>SF3000 / AppliedMems</td>
</tr>
<tr>
<td>13</td>
<td>Uniaxial Accelerometer X-axis (Shaker)</td>
<td>SF3000 / AppliedMems</td>
</tr>
<tr>
<td>14</td>
<td>Triaxial Downhole Accelerometer X-axis</td>
<td>D110-DH / Digitekxx</td>
</tr>
<tr>
<td>15</td>
<td>Triaxial Downhole Accelerometer Y-axis</td>
<td>D110-DH / Digitekxx</td>
</tr>
<tr>
<td>16</td>
<td>Triaxial Downhole Accelerometer Z-axis</td>
<td>D110-DH / Digitekxx</td>
</tr>
<tr>
<td>17</td>
<td>Rotation Sensor X-X</td>
<td>ARS-09 / ATA Sensors</td>
</tr>
<tr>
<td>18</td>
<td>Rotation Sensor Y-Y</td>
<td>ARS-09 / ATA Sensors</td>
</tr>
<tr>
<td>19</td>
<td>Rotation Sensor Z-Z</td>
<td>ARS-09 / ATA Sensors</td>
</tr>
<tr>
<td>20</td>
<td>Pore Pressure</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Spare channel</td>
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</tr>
<tr>
<td>22</td>
<td>Spare channel</td>
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<td>23</td>
<td>Spare channel</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Spare channel</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Soil Pressure Z-axis</td>
<td>EPX-V01-100P / ENTRAN</td>
</tr>
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<td>26</td>
<td>Soil Pressure Z-axis</td>
<td>EPX-V01-100P / ENTRAN</td>
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<td>27</td>
<td>Soil Pressure Z-axis</td>
<td>EPX-V01-100P / ENTRAN</td>
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<td>Soil Pressure Z-axis</td>
<td>EPX-V01-100P / ENTRAN</td>
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<td>29</td>
<td>Relative Displacement Transducer Z-axis</td>
<td>DT-30-B / STI</td>
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<td>Relative Displacement Transducer Z-axis</td>
<td>DT-30-B / STI</td>
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<td>31</td>
<td>Relative Displacement Transducer Z-axis</td>
<td>DT-30-B / STI</td>
</tr>
<tr>
<td>32</td>
<td>Relative Displacement Transducer Z-axis</td>
<td>DT-30-B / STI</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

The following readings shall be taken in the indicated order:

1. Horizontal  
   +0.023 [V]
2. tilt to +30 degrees  
   +0.629 [V]
3. tilt to +90 degrees  
   +1.251 [V]
4. tilt back to horizontal  
   +0.025 [V]
5. tilt to -30 degrees  
   -0.624 [V]
6. tilt to -90 degrees  
   -1.195 [V]
7. tilt back to horizontal  
   +0.024 [V]

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

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

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

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

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

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

\[
\text{CALIBRATION FACTOR} = \frac{678000 \times L/254 \times Z_{axi}'}{26000} \times \begin{array}{c}
+ 1.263 [V] \\
+ 0.630 [V] \\
+ 0.052 [V] \\
- 1.179 [V]
\end{array}
\]

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

The following readings shall be taken in the indicated order:

1. Horizontal 0.051 [V]
2. tilt to +30 degrees 0.618 [V]
3. tilt to +90 degrees 1.257 [V]
4. tilt back to horizontal +0.054 [V]
5. tilt to -30 degrees -0.527 [V]
6. tilt to -90 degrees -1.137 [V]
7. tilt back to horizontal +0.052 [V]

CALIBRATION FACTOR
{(Read3 - Read1) + (Read6 - Read4)} / 2

1.192 [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 N/A [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
   +0.021 [V]

2. tilt to +30 degrees
   +0.632 [V]

3. tilt to +90 degrees
   +1.226 [V]

4. tilt back to horizontal
   +0.022 [V]

5. tilt to -30 degrees
   -0.521 [V]

6. tilt to -90 degrees
   -1.180 [V]

7. tilt back to horizontal
   0.022 [V]

CALIBRATION FACTOR

\( \frac{\text{Read}_3 - \text{Read}_1 + \text{Read}_6 - \text{Read}_4}{2} \)

1.203 [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

---

Page 16 of 20

Channel Calibration Procedure Revision 0

for SFSI Test Structure System Model RTMS-2001RN
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
   \[ \text{Read 1} \]
   \[ \text{Read 3} \]
   \[ \text{Read 4} \]
   \[ \text{Read 5} \]
   \[ \text{Read 6} \]
   \[ \text{Read 7} \]

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
   \[ +1.169 \text{[V]} \]
2. tilt to +60 degrees
   \[ +0.582 \text{[V]} \]
3. tilt to +90 degrees
   \[ +0.004 \text{[V]} \]
4. Continue to Horizontal
   \[ -1.219 \text{[V]} \]

CALIBRATION FACTOR
\[ 1.19 \text{[V/g]} \]
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  
   +0.099 [V]
2. tilt to +30 degrees  
   +0.694 [V]
3. tilt to +90 degrees  
   +1.322 [V]
4. tilt back to horizontal  
   +0.092 [V]
5. tilt to -30 degrees  
   -0.522 [V]
6. tilt to -90 degrees  
   -1.110 [V]
7. tilt back to horizontal  
   +0.092 [V]

CALIBRATION FACTOR

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

\[1.216 [V/g] \]

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  
   N/A
3. tilt to +90 degrees  
   ____ [V]
4. Continue to Horizontal  
   ____ [V]

CALIBRATION FACTOR

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

____ [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  
   +0.089 [V]
2. tilt to +30 degrees  
   +0.211 [V]
3. tilt to +90 degrees  
   +1.319 [V]
4. tilt back to horizontal  
   +0.089 [V]
5. tilt to -30 degrees  
   -0.515 [V]
6. tilt to -90 degrees  
   -1.133 [V]
7. tilt back to horizontal  
   +0.089 [V]

CALIBRATION FACTOR  

\{(\text{Read3} - \text{Read1}) + (\text{Read6} - \text{Read4})\} / 2  

\[ 1.226 \text{[V/g]} \]

**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  
   \[
   \begin{array}{c}
   \text{N/A} \\
   \text{N/A}
   \end{array}
   \] [V]
2. tilt to +60 degrees  
   \[
   \begin{array}{c}
   \text{N/A} \\
   \text{N/A}
   \end{array}
   \] [V]
3. tilt to +90 degrees  
   \[
   \begin{array}{c}
   \text{N/A} \\
   \text{N/A}
   \end{array}
   \] [V]
4. Continue to Horizontal  
   \[
   \begin{array}{c}
   \text{N/A} \\
   \text{N/A}
   \end{array}
   \] [V]

CALIBRATION FACTOR  

Read 3 - Read 1  

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

\[
\text{CALIBRATION FACTOR} = \frac{(\text{Read}_3 - \text{Read}_1) + (\text{Read}_6 - \text{Read}_4)}{2}
\]

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

Read 3 – Read 1

\[
\text{CALIBRATION FACTOR} = \text{Read}_3 - \text{Read}_1
\]
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

SF 3000C/312 UNIAXIAL
CH.10.

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
{(Read3 – Read1) + (Read6 – 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 Horiztonal

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  SF-3000 1/318 UNIAXIAL

The following readings shall be taken in the indicated order:

1. Horizontal  + 0.003 [V]
2. tilt to +30 degrees  + 0.602 [V]
3. tilt to +90 degrees  + 1.202 [V]
4. tilt back to horizontal  + 0.002 [V]
5. tilt to -30 degrees  - 0.600 [V]
6. tilt to -90 degrees  - 1.198 [V]
7. tilt back to horizontal  + 0.002 [V]

CALIBRATION FACTOR
((Read3 – Read1) + (Read6 – Read4)) / 2

1.200 [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 + 0.225 [V]
2. tilt to +30 degrees + 0.833 [V]
3. tilt to +90 degrees + 1.427 [V]
4. tilt back to horizontal + 0.228 [V]
5. tilt to -30 degrees - 0.376 [V]
6. tilt to -90 degrees - 0.991 [V]
7. tilt back to horizontal + 0.228 [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

The following readings shall be taken in the indicated order:

1. Horizontal N/A [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: 8F3000L1315/uniaxial SPARE

The following readings shall be taken in the indicated order:

1. Horizontal: -0.0154 [V]
2. tilt to +30 degrees: -0.647 [V]
3. tilt to +90 degrees: -1.2304 [V]
4. tilt back to horizontal: -0.015 [V]
5. tilt to -30 degrees: +0.602 [V]
6. tilt to -90 degrees: +1.189 [V]
7. tilt back to horizontal: -0.015 [V]

CALIBRATION FACTOR
{(Read3 - Read1) + (Read6 - Read4)} / 2

1.210 [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: 
2. tilt to +60 degrees: N/A [V]
3. tilt to +90 degrees: 
4. Continue to Horizontal: 

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  
   \( +0.003 \) [V]
2. tilt to +30 degrees  
   \( -0.6228 \) [V]
3. tilt to +90 degrees  
   \( -1.210 \) [V]
4. tilt back to horizontal  
   \( 0.002 \) [V]
5. tilt to -30 degrees  
   \( +0.601 \) [V]
6. tilt to -90 degrees  
   \( +1.202 \) [V]
7. tilt back to horizontal  
   \( 0.002 \) [V]

CALIBRATION FACTOR
\( \{(\text{Read}3 - \text{Read}1) + (\text{Read}6 - \text{Read}4)\} / 2 \)
\( 1.206 \) [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
2. tilt to +60 degrees
3. tilt to +90 degrees
4. Continue to Horizontal

CALIBRATION FACTOR
\( \text{Read} 3 - \text{Read} 1 \)
\( \) [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 $+0.116$ [V]
2. tilt to +30 degrees $-0.510$ [V]
3. tilt to +90 degrees $-1.010$ [V]
4. tilt back to horizontal $+0.120$ [V]
5. tilt to -30 degrees $+0.211$ [V]
6. tilt to -90 degrees $+1.302$ [V]
7. tilt back to horizontal $+0.119$ [V]

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
Read 3 – Read 1
RELATIVE DISPLACEMENT

MODEL / SERIAL NUMBER

Take a metallic pin with the Diameter = 0.316"

Measure the exact diameter of the pin using the caliper [D1] 0.332 [in]

Start the system to take a record
Filename of the record

Turn the string (wire) of the sensor once
Around the metal pin and wait 10 seconds (Initials)

Turn the string (wire) of the sensor one more turn
Around the metal pin and wait 10 seconds (Initials)

Un-wind one turn of the wire from the metal pin
and wait 10 seconds (Initials)

Un-wind the last turn of the wire from the metal pin
Wait 10 seconds and stop the recording (Initials)

Typical record should look like this:

![Graph of Channel 29 Displacement]

CAL RECORD DONE FOR CH. 29.
Starting from the left we have five readings (READ1, READ2, READ3, READ4, READ5).

RECORD The overall Channel amplification factor \[ AF = 50.36 \]

COMPUTE: \[ OUT [V] = ((READ2 - READ1) + (READ3 - READ1)/2) / (2 * AF) \]

COMPUTE THE CIRCLE LENGTH OF THE PIN
\[ L [IN] = \pi \times (D1 + D2) \] (where D2 is the diameter of the wire)
\[ L = 1.0585 \in \]

CAL FACTOR [V/inch] = \[ OUT [V] / L [IN] \]
\[ 0.0655 V/\in \]

Print a separate page for each sensor
\[ 0.29 \]
RELATIVE DISPLACEMENT

MODEL / SERIAL NUMBER

Take a metallic pin with the Diameter = 0.316"

Measure the exact diameter of the pin using the caliper [D1]

Start the system to take a record
Filename of the record

Turn the string (wire) of the sensor once
Around the metal pin and wait 10 seconds (Initials)

Turn the string (wire) of the sensor one more turn
Around the metal pin and wait 10 seconds (Initials)

Un-wind one turn of the wire from the metal pin
and wait 10 seconds (Initials)

Un-wind the last turn of the wire from the metal pin
Wait 10 seconds and stop the recording (Initials)

Typical record should look like this:

Channel 30 Displacement

CAL RECORD DONE FOR CH. 30
Starting from the left we have five readings (READ1, READ2, READ3, READ4, READ5).

RECORD The overall Channel amplification factor \( AF = \frac{50.10}{100} \)

COMPUTE: \( \text{OUT} [V] = \frac{(\text{READ2} - \text{READ1}) + (\text{READ3} - \text{READ1})/2}{2 \times AF} \)

COMPUTE THE CIRCLE LENGTH OF THE PIN
\( L [\text{in}] = \pi \times (D1 + D2) \) (where D2 is the diameter of the wire)

\( \text{CAL FACTOR [V/inch]} = \frac{\text{OUT}[V]}{L[\text{in}]} \)

Print a separate page for each sensor
**RELATIVE DISPLACEMENT**

**MODEL / SERIAL NUMBER**

Take a metallic pin with the Diameter = 0.316"

Measure the exact diameter of the pin using the caliper [D1]

Start the system to take a record
Filename of the record

Turn the string (wire) of the sensor once
Around the metal pin and wait 10 seconds (Initials) [J]

Turn the string (wire) of the sensor one more turn
Around the metal pin and wait 10 seconds (Initials) [J]

Un-wind one turn of the wire from the metal pin and wait 10 seconds (Initials) [J]

Un-wind the last turn of the wire from the metal pin
Wait 10 seconds and stop the recording (Initials) [J]

Typical record should look like this:

![Channel 31 Displacement Graph]

CAL RECORD DONE FOR CH. 31
Starting from the left we have five readings (READ1, READ2, READ3, READ4, READ5).

RECORD The overall Channel amplification factor \( AF = 50.05 \)

COMPUTE: \( OUT[V] = ((READ2 - READ1) + (READ3 - READ1)/2) / (2 \times AF) \)

COMPUTE THE CIRCLE LENGTH OF THE PIN
\( L[IN] = \pi \times (D1 + D2) \) (where D2 is the diameter of the wire) \( 1.0585 \)

CAL FACTOR [V/inch] = \( OUT[V] / L[IN] \) \( 0.0659 \) V/inch

Print a separate page for each sensor
RELATIVE DISPLACEMENT

MODEL / SERIAL NUMBER

Take a metallic pin with the Diameter = 0.316"

Measure the exact diameter of the pin using the caliper [D1]

Start the system to take a record
Filename of the record  

Turn the string (wire) of the sensor once
Around the metal pin and wait 10 seconds

Turn the string (wire) of the sensor one more turn
Around the metal pin and wait 10 seconds

Un-wind one turn of the wire from the metal pin
and wait 10 seconds

Un-wind the last turn of the wire from the metal pin
Wait 10 seconds and stop the recording

Typical record should look like this:

![Channel 32 Displacement Graph]

CAL RECORD DONE FOR CH. 32
Starting from the left we have five readings (READ1, READ2, READ3, READ4, READ5).

RECORD The overall Channel amplification factor \[ \text{AF} = \frac{50.05}{2} \]

COMPUTE: \[ \text{OUT} [V] = \frac{(\text{READ2} - \text{READ1}) + (\text{READ3} - \text{READ1})/2}{2 \times \text{AF}} \]

COMPUTE THE CIRCLE LENGTH OF THE PIN \[ L \text{ [IN]} = \pi \times (D1 + D2) \] (where D2 is the diameter of the wire) \[ L \text{ [IN]} = 1.0585 \]

CAL FACTOR \[ \text{[V/\text{inch}]} = \frac{\text{OUT}[V]}{L[\text{in}]} \] \[ \text{CAL FACTOR} = 0.0672 \text{ V/\text{in}}. \]

Print a separate page for each sensor.
A/D CHANNEL CALIBRATION

Use one calibrated digital voltmeter and a reference voltage source. Remember that the A/D is set for +/-10V full-scale and it is a 24-bit resolution. This calibration is relative since the calibrated source must be one order of magnitude higher than the device to be calibrated. In our case we check each channel for correct functionality. The reading taken with a regular Digital Voltmeter will have the mV precision and the A/D shall have the same reading up to milivolts. A +/-2mV is acceptable due to possible electrical noise during reading. The unit is calibrated under field conditions not under laboratory conditions.

For first 24 channels of the system, disconnect the existing sensor cable from the connector panel and connect the voltage source between PIN A and PIN B. Take a reading with the Digital Voltmeter and with the A/D Server software (set the calibration factor temporarily to 981. so the reading will be in volts. Record both readings in the table below:
<table>
<thead>
<tr>
<th>Channel #</th>
<th>Zero Reading</th>
<th>1V IN ±10mV</th>
<th>5V IN ±10mV</th>
<th>9V IN ±10mV</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>REF</td>
<td>A/D</td>
<td>REF</td>
<td>A/D</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>-5.006</td>
<td>+5.006</td>
<td>-5.006</td>
<td>+5.006</td>
</tr>
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<td>+5.009</td>
</tr>
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<td></td>
<td>-4.985</td>
<td>+4.986</td>
<td>-4.985</td>
<td>+4.985</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>-4.986</td>
<td>+4.985</td>
<td>-4.986</td>
<td>+4.985</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>-4.984</td>
<td>+4.982</td>
<td>-4.984</td>
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</tr>
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<td></td>
<td>-4.983</td>
<td>+4.985</td>
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<td>+4.985</td>
</tr>
<tr>
<td>7</td>
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<td>-4.984</td>
<td>+4.984</td>
<td>-4.984</td>
<td>+4.984</td>
</tr>
<tr>
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CHECKED LAST YEAR FOR SYMETRIAL DENT ONLY MID SCALE

Initials: 21
### A/D CHANNEL CALIBRATION

For channels 25 through 32, connect the reference voltage source to the second Connector Panel at the BNC connector for each channel located at the top of the panels. Record the readings in the table below.

For this channels check the amplification factor of the 163MK Signal conditioning

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<th>Channel #</th>
<th>Zero Reading</th>
<th>1V IN ±10mV</th>
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<th>9V IN ±10mV</th>
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Initials ________________________

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### 163MK Amplification Factor

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<th>OUTPUT VOLTAGE [mV]</th>
<th>GAIN</th>
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Initials ________________________

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Channel Calibration Procedure Revision 0
for SFSI Test Structure System Model RTMS-2001RN