ACTIVITY/PROJECT SPECIFIC PROCEDURE

SP 12-28
LVDT CALIBRATION BY COMPARISON METHOD
Revision 0

Effective Date: 04/28/10

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1.0 Purpose and Scope

This procedure prescribes the Sandia National Laboratories (SNL) Waste Isolation Pilot Plant (WIPP) process for the calibration of LVDTs (displacement transducers) using the comparison method with a Displacement Calibrator calibrated by Sandia National Laboratories Primary Standards Lab.

Calibration of displacement transducers will require each displacement transducer to be paired with a signal conditioner. The signal conditioner will supply the displacement transducer with excitation voltage and will condition the signal from the displacement transducer. The conditioned signal will be fed into the MTS 493.10 analog input and recorded by the system's Data Acquisition System (DAS) function. The MTS 493.10 analog input and DAS will be calibrated prior to the calibration of displacement transducers. A temperature measurement device will also be used to verify ambient temperature at time of calibration.

This document is not meant to substitute for the manufacturer's instruction manuals recommendations for the displacement transducers being calibrated. The user is responsible for reading and understanding the appropriate manuals for the items being calibrated and the equipment used.

Acronyms and definitions for terms used in this procedure may be found in the Glossary located at the Sandia National Laboratories (SNL) WIPP Online Documents web site.

2.0 Implementation Actions

2.1 Safety

The activities described in this SP shall conform to SNL Environmental Safety and Health Programs (ES&H). All activities described in this SP are subject to ES&H requirements governed by the WIPP Industrial Safety Program and the WIPP Industrial Hygiene Program.

As defined in ES&H 100 Corporate Policies, personnel will not be exposed to hazardous voltages. The voltage levels expected in the performance of this procedure should be 24 VDC or less.

Frame hydraulic power is not energized during this calibration procedure.

2.2 Responsibilities

The Principal Investigator (PI) and the Principal User, whose activities warrant the use of this procedure, shall be responsible for implementing the requirements of this procedure.

The Principal User is also responsible for assuring that the test system, displacement transducers, conditioners and Displacement Calibrator are in good working order.

The staff member performing the calibration is responsible for following the requirements of this procedure and shall verify that the latest revision of this procedure is being implemented.

If this procedure cannot be worked as written, the user has the responsibility to stop work and resolve all concerns with either the PI, Principal User or QA representative, as appropriate, prior to proceeding with the work.

2.3 Standards

The Displacement Calibrator will be used to control and apply the desired displacement to the transducer under test. The Displacement Calibrator consists of two Schaevitz displacement transducers mounted in a ridged platform. One displacement transducer is a Schaevitz .500 inch model GCA-121-500. The other is a Schaevitz .100 inch model LBB-375-TA-100. Each has its own dedicated conditioner and display. The output of the Displacement Calibrator will be fed into the MTS 493.10 analog input and displayed on the computer monitor associated with the test frame being used for the tests. The 493.10 analog inputs will be calibrated prior to the calibration of displacement transducers. The temperature during calibration will be monitored using a temperature sensor (Rotronic Hygrolog-D). Displacement Calibrator and temperature sensor used during the performance of this procedure shall be calibrated and traceable to NIST through the Sandia Primary Standards laboratory in Albuquerque, NM or an approved supplier. The serial number and expiration dates of the Displacement Calibrator and temperature sensor will be recorded in the applicable scientific notebook or scientific notebook supplement (SNS) and the calibration data sheet. Displacement Calibrator and temperature sensor shall not be used in the performance of this procedure if they are past their expiration date without prior approval of the PI or Principal User.

2.4 Frequency

The displacement transducers shall be calibrated at a frequency consistent with manufacturer's specifications or based on a performance history for the displacement transducer. If no baseline exists and the manufacturer has no specification, the displacement transducer will be calibrated annually (on twelve month intervals).

The PI or Principal User may elect to lengthen or shorten the calibration interval based on the results of previous calibrations and the stability of the equipment. Any deviations from the established calibration interval will be justified in the applicable scientific notebook/SNS.

2.5 Acceptance Criteria

The accuracy of the displacement transducer will be based on manufacturer's specifications or the requirements of the PI or Principal User. If the calibration of the displacement transducer deviates from the manufacturer's or PI's specifications the calibration will be identified as 'Limited'. All displacement calibrations shall be performed with the temperature between 20-30ºC. The temperature shall also be stable, within +/-2ºC during the calibration of a displacement transducer. If

the temperature fluctuates beyond these values, abort the calibration and repeat when the temperature has stabilized.

2.6 Corrective Action

If the displacement transducer being calibrated cannot be brought into tolerance during the performance of this procedure or if the equipment becomes damaged, the faulty displacement transducer shall be tagged and taken out of service until repaired. If the displacement transducer cannot be repaired, it will be permanently removed from service. If during the performance of an As-Found calibration the displacement transducer is found to be out of tolerance, a Corrective Action Request (CAR) will be issued to document the results and impacts related to the change in displacement transducer performance. Corrective action could include evaluation and adjustment to any data collected by this displacement transducer, re-evaluation of the calibration interval, or an assessment of the process in which the instrument is being utilized. Results of all activities related to the out-of-tolerance condition will be summarized in the CAR.

2.7 As-Found Calibration / Verification

The calibration process includes the following general steps: (1) Perform an As-Found/As-Received Calibration at multiple points (a general guideline is 10 data points) along the displacement transducers range; (2) Calibration uncertainty will be calculated using the error between the Displacement Calibrator and measured signal output of the displacement transducer using a best straight line fit routine; (3) The resulting error will be compared with the established acceptance criteria (tolerances) to determine the adequacy of the calibration; and (4) Validate the calibration calculations per NP 9-1, *Analyses*. This calibration process and the equipment utilized are described below in greater detail.

Note: Displacement transducers that will be used for data collection should first undergo an as-found calibration to determine their received condition.

2.7.1 Turn on the equipment to be used in the performance of this procedure, allow the equipment to warm-up a minimum of 20 minutes before starting the calibration.

Note: For calibration of displacement transducers +/- .50 inches or less the displacement transducer and the Displacement Calibrator will typically start with 0 volts settings on both as the first data point taken and proceed to take data in either the maximum positive or negative voltage direction from 0. Once the maximum value has been reached (i.e. -10 Volts or 10 Volts) the next data point will be back toward 0. (i.e. -9 Volts or 9 Volts). Data will continue to be taken through 0 until the maximum value has been reached in that direction. The next data point after the maximum value will again be back toward 0. The last data point taken will be 0 Volts. (See Appendix A).

If the displacement transducer is greater then +/- .50 inches, the displacement transducer will start at 0 volts. The Displacement Calibrator will start at either -10 Volts or + 10 Volts and the calibration will proceed toward and through 0 Volts to the opposite maximum Volts (+ 10 volts or – 10 Volts). Once the maximum value has been reached (i.e. +10 Volts or - 10 Volts) the next data point taken will be back toward 0 volts on the Displacement Calibrator. (i.e. + 8 Volts or - 8 Volts). When the displacement transducer has reached the 0 Volt data point, the Displacement Calibrator should again read the maximum voltage that the calibration started with (- 10 Volts or + 10 Volts). To calibrate the opposite side of the displacement transducer it will be necessary to reset the Displacement Calibrator LVDT so that the calibration will start at the opposite maximum voltage and proceed toward and through 0 volts to maximum voltage in that direction.

Note: If the displacement transducer being calibrated has a displacement range greater than +/- .50 inches, proceed to step **2.7.3.a.** If it has a displacement range of .50 inches or less proceed, with step **2.7.2.a.**

2.7.2.a Physically center the Displacement Calibrator until its indicator reads zero.

2.7.2.b While the displacement transducer and Displacement Calibrator are warming up, mount the displacement transducer onto the Displacement Calibrator platform using the holes and setscrews provided. Before tightening the displacement transducer into place make sure it is reading zero.

Note: Make sure the displacement transducer is snug. Do not over tighten as this could damage the displacement transducer.

2.7.2.c If the Displacement Calibrator and/or the displacement transducer are not at zero after the warm up, it may be necessary to re-center them.

2.7.2.d Using the displacement adjustment wheel located on the Displacement Calibrator platform assembly, run the displacement transducer from zero to maximum displacement for the range being calibrated, and back to zero 3 times.

2.7.2.e On the third run back to zero, go past zero and then slowly bring it back to the Displacement Calibrator zero. Record the zero reading of both the displacement transducer and Displacement Calibrator. Also record the temperature at this time.

Note: To reduce the error in displacement measurement due to internal backlash of the testing machine, associated fixtures and/or apparatus, make sure to approach the starting zero position of the testing machine from a point less than zero and in the direction for which the resultant verification data will be acquired.

2.7.2.f Adjust the Displacement Calibrator to the first test value and record both the displacement transducer and the Displacement Calibrator readouts. If the test value is over shot adjust the Displacement Calibrator back to a value half way between zero and the first test value for the displacement transducer. Approach the first test value stopping at the value.

2.7.2.g Repeat step 2.7.2.f until all test values have been reached and the corresponding displacement transducer signal output has been measured and recorded in the applicable scientific notebook or SNS and calibration data sheet.

Proceed to step 2.7.4

2.7.3.a Adjust the Displacement Calibrator to read maximum Volts in either the +10 volt or – 10 volt direction.

2.7.3.b While the displacement transducer and Displacement Calibrator are warming up, mount the displacement transducer onto the Displacement Calibrator platform using the holes and setscrews provided. Before tightening the displacement transducer into place make sure it is reading zero.

Note: Make sure the displacement transducer is snug. Do not over tighten as this could damage the displacement transducer.

2.7.3.c If either the Displacement Calibrator or the displacement transducer is not reading the correct voltage after the warm up, it may be necessary to re-adjust them.

2.7.3.d Using the displacement adjustment wheel located on the Displacement Calibrator platform assembly, run the displacement transducer from zero to maximum displacement for the range being calibrated, and back to zero 3 times.

2.7.3.e On the third run back to zero, go past zero and then slowly bring it back to the displacement transducer zero. Record the reading of both the displacement transducer and Displacement Calibrator. Also record the temperature at this time.

Note: To reduce the error in displacement measurement due to internal backlash of the testing machine, associated fixtures and/or apparatus, make sure to approach the starting zero position of the displacement transducer from a point less than zero and in the direction for which the resultant verification data will be acquired.

2.7.3.f Adjust the Displacement Calibrator to the first test value and record both the displacement transducer and the Displacement Calibrator readouts. If the test value is over shot adjust the Displacement Calibrator back to a value half way between zero and the first test value for the displacement transducer. Approach the first test value stopping at the value.

2.7.3.g Repeat step 2.7.3.f until all test values have been reached and the corresponding displacement transducer signal output has been measured and recorded in the applicable scientific notebook or SNS and calibration data sheet.

2.7.4 Calculate the performance of the displacement transducer using a product like Excel's Regression Analysis Tool to develop a best straight line fit calculation for the calibration results. The displacement transducer calibration performance shall be equal to or better than the manufacturer's or PI's specifications. If the displacement transducer performance does not meet specifications issue a CAR. If the displacement transducer cannot be adjusted and the results fail to meet specifications, the unit can either be returned to the manufacturer for repair or derated by assigning a 'Limited' calibration. Initiate a CAR per the requirements of NP 16-1, *Corrective Action*, to document the failure of the displacement transducer to meet the established acceptance criteria.

2.7.5 If the As-Found displacement transducer calibration results are acceptable, no further calibration will be required. Proceed to section 3.0

Note: The PI or Principal User may decide to accept an As-Found calibration that exceeds the stated acceptance criteria. The PI or Principal User will need to document this decision and any impact on data collected with this displacement transducer in the scientific notebook or SNS. Both the displacement transducer calibration tag and the applicable scientific notebook or SNS shall document the limited calibration.

2.8 References

- MTS Flex Test GT System Controller - Operator Manual
- Schaevitz – Product Manual
- Operating Procedure for the 0.1 MN (22KIP) MTS Load Frame, OP-6315-22
- Operating Procedure for the 1 MN (220KIP) Triaxial Testing System, OP-6315-220
- Operating Procedure for General Laboratory Activities, OP-6315-GLA
- ES&H100 Corporate Policies

3.0 Records

The following QA records, generated through implementation of this procedure, shall be prepared and submitted to the WIPP Records Center in accordance with NP 17-1 (Records):

QA Record

- Corrective Action Request (CAR), Form NP 16-1-1, if required
- Scientific Notebook or Scientific Notebook Supplement
- Calibration Data Sheet (See Appendix A)

4.0 Appendices

Appendix A: LVDT Calibration Data Sheet

Appendix A

LVDT Calibration Data By Comparison Method

For: 849 geolab

Did UUT Meet Calibration Specifications? _____

Expiration Date_____

Date: 6/23/2009
By: jhh 6735

UUT Model #: Dual 500 pair
UUT s/n: 13107 - 1318
Conditioner ATA-101, s/n 3918

Displacement Calibrator, File SNL-7716, exp 06/3/11
MTS 220 Kip frame

Temperature/Humidity
Temp 23.1C
RH% 30.00 %

Indicator Model #: Rotronic 8303
Indicator S/N; 60189152/150013
File SNL-6566785, EXP 09/29/10

MTS Settings
Total Gain: 1.00 Excitation: na
Phase: na Polarity: na
Delta K: na

Sensitivity: 20.30473 v/in
Offset: -0.00063 v

alt Sensitivity: 0.049250 in/v

displacement in	measured output v	Calculated displ in	Deviation: % reading	Deviation: % full scale
0.00003	-0.00067	-0.00066		-0.17
0.05006	1.02289	0.04975	-0.62	-0.08
0.10002	2.04779	0.10023	0.21	0.05
0.15007	3.07202	0.15067	0.40	0.15
0.20006	4.09659	0.20113	0.54	0.27
0.25024	5.11847	0.25146	0.49	0.30
0.30005	6.12323	0.30094	0.30	0.22
0.35058	7.13034	0.35054	-0.01	-0.01
0.40003	8.11261	0.39892	-0.28	-0.28
0.40027	8.11899	0.39923	-0.26	-0.26
0.35002	7.12095	0.35008	0.02	0.01
0.30015	6.12659	0.30111	0.32	0.24
0.25029	5.12082	0.25157	0.51	0.32
0.20011	4.09827	0.20121	0.55	0.28
0.15013	3.07404	0.15077	0.42	0.16
0.10068	2.06290	0.10097	0.29	0.07
0.05004	1.02524	0.04987	-0.35	-0.04
0.00003	0.00201	-0.00053		-0.14
-0.05023	-1.02423	-0.05107	1.67	-0.21
-0.10019	-2.04376	-0.10128	1.09	-0.27
-0.15012	-3.05994	-0.15133	0.81	-0.30
-0.20003	-4.06671	-0.20091	0.44	-0.22
-0.25081	-5.09229	-0.25142	0.24	-0.15
-0.30027	-6.08228	-0.30018	-0.03	0.02
-0.35033	-7.07831	-0.34923	-0.31	0.27
-0.40030	-8.07233	-0.39818	-0.53	0.53
-0.40062	-8.07971	-0.39855	-0.52	0.52
-0.35009	-7.07630	-0.34913	-0.27	0.24
-0.30045	-6.08933	-0.30052	0.02	-0.02
-0.25042	-5.08792	-0.25120	0.31	-0.19
-0.20073	-4.08383	-0.20175	0.51	-0.25
-0.15017	-3.06363	-0.15151	0.89	-0.34
-0.10014	-2.04544	-0.10136	1.22	-0.31
-0.04865	-0.99503	-0.04963	2.02	-0.25
0.00002	-0.00101	-0.00067	na	-0.17