Immediate Procedure Change (IPC) Cover

Section 1 – Originator Request

Document No.: ER-SOP-10010	Revision No.: Rev 1	IPC No.: 1

Title: Pressure Transducer Installation, Removal and Maintenance

Description of need requested action (Attach procedure mark-up and numbered additional sheets if needed.):

Revised Field Form

REMOVED Z# AND NAME FIELDS

Originator Name (print)	Organization	Z#	Date
Jolynn Martinez	ER-FS	197363	2/27/17

Section 2 –Reviews

Discipline	Name	Signature	Date
Field Tech Lead	Steve Pearson	Approved per discussion. MAA	2/27/17

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Section 3 – Final Approvals

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Responsible Line Manager Signature	Print Name and Title	Z#	Date
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ER-SOP-10010, R1

IPC-1

Pressure Transducer Installation, Removal, and Maintenance

Effective Date: 3/1/2017

Next Review Date: 3/1/2020

Hazard Class: ☐ Low ☒ Moderate ☐ High/Complex

Usage Mode: ☒ Reference ☐ UET ☐ Both UET & Reference

The Responsible Manager has determined that the following organizations' review is required for initial procedure release as well as subsequent major revisions. Review documentation is contained in the Document History File.

ER-FS Technical Field Lead	Quality Assurance
ER-FS Technical Operations Lead	Waste Management
ER-ES Technical Lead	ER-FS MT&E
Environmental Protection	Safety/IH

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Responsible Manager, Division and Title

Mike Alexander	/ 102267	/ /s/ Mike Alexander	/ 2/27/2017
Name (print)	Z#	Signature	Date

Revision History

Document No./Revision No.	Issue Date	Action	Description
0	5/05	New document. Supersedes ENV-WQH-SOP-16.3.	T
1	3/06	Incorporated references to ENV-DO procedures and ECR QA review comments. Procedure updated, minor changes made, steps were added to accommodate new pressure transducer equipment.	T
2	4/07	Document was revised to reflect organizational changes. Procedure for changing out desiccants was added. Requirements for one week transducer checks were removed. Removed references to single completion wells, as this procedure is appropriate for use in some multicompletion wells.	T
0	10/29/08	New document; supersedes ENV-DO-201.	0
0	11/08/11	New document control number issued; Supersedes SOP-5227, R0; Revised procedure to include operations for multiple parameter transducers.	T/E
0	5/16/16	New document number (previously EP-DIV-SOP-10010). Major editorial/technical revision.	T
1	9/14/2016	Updates to Field Form. Consolidated steps to match new form.	E
IPC-1	3/1/2017	Updates to Field Form.	E

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Attachments

1. PURPOSE

This standard operating procedure (SOP) states the responsibilities and describes installation, removal, and maintenance procedures for the pressure transducers that are placed in groundwater monitoring wells, piezometers, or surface water locations for monitoring and recording water-level and/or water quality data for the Los Alamos National Laboratory (LANL), Environmental Programs Directorate (ADEP).

2. SCOPE

The installation, removal, and maintenance requirements for pressure transducers are provided in this procedure. This procedure applies to all LANL and subcontractor personnel installing, removing, maintaining, or conducting performance checks on transducers.

3. REFERENCES

ER-SOP-20243, Manual Groundwater-Level Measurements
EP-AP-10003, Records Management
P-330-2, Control and Calibration of Measuring and Test Equipment (M&TE)
In-Situ, Inc. Operator's Manual, Level TROLL® 400, 500, 700, 700H Instruments
In-Situ, Inc. Care and Maintenance of Aqua TROLL® and Level TROLL® Instruction Sheet

4. APPLICABILITY

Transducer equipment is used to periodically measure water levels in individual wells or surface water locations at user-specified intervals and record these values in computer memory for later retrieval.

Two types of pressure transducer equipment are currently used in monitoring wells at LANL.

- "Compensated" or "gauged" pressure transducers have sensors that compensate for atmospheric pressure. One side of the pressure sensor diaphragm is vented to the atmosphere, thus compensating for changes in atmospheric pressure and only measuring water pressure (psig). When transducers are used, calculations of water depth above the transducer exclude atmospheric pressure considerations. These transducers employ a tube in the cabling to vent the transducer to the atmosphere and are used in most shallow monitoring wells and single-completion deep monitoring wells. Examples of "compensated" or "gauged" transducers include standard In Situ, Inc. MiniTroll and Level Troll transducers.

4. APPLICABILITY (continued)

- "Absolute" or "uncompensated" pressure transducers measure absolute pressure (psia) and do not compensate for atmospheric pressure. Pressure measurements from this type of transducer include atmospheric pressure as a component; therefore, atmospheric pressure must be subtracted from the absolute measurement to determine the pressure from water. All transducers used with the Westbay MP multiple port monitoring system measure absolute pressure. Additionally, other manufacturers, including In-Situ, Inc., produce absolute pressure measuring transducers; thus, personnel must be aware of the type of transducer used so that data can be processed accordingly.

In addition to the two types of pressure transducers, transducers that are also capable of recording multiple water quality parameters, or 'multiple parameter' transducers, may also be utilized in monitoring wells. These transducers have the additional capability of measuring conductivity of groundwater or surface water; the conductivity measurements can be used to calculate supplementary water quality parameters such as resistivity, salinity, total dissolved solids, and density.

5. DEFINITIONS AND ABBREVIATIONS

5.1 Definitions

Absolute pressure – The total or absolute pressure measured by a sensor without correction for atmospheric pressure. A pressure measurement that includes atmospheric pressure is an absolute pressure. Units are expressed in psia (pounds per square inch absolute).

Bench test – A brief test performed to ensure that transducer equipment is working properly before installation in a monitoring well.

Conductivity – A measurement parameter of multiple parameter transducers, which report two conductivity measurements: actual conductivity and specific conductivity. Actual conductivity is a measure of the ability of an aqueous solution to carry an electric current. Actual conductivity is temperature dependent; as water becomes less viscous at high temperatures, ions move more easily. Specific conductivity is a means of expressing what the actual conductivity of a solution would be at a standard reference temperature, which is usually at 25° Celsius.

5.1 Definitions (continued)

Depth test – A test performed to evaluate the accuracy of a pressure transducer in which the actual known depth under the surface of water where a transducer is placed is compared to the reading given by the transducer.

Drift test – A test performed to evaluate the stability of a pressure sensor. A transducer is suspended at a known depth below water surface and is set to record values over a set period of time. Data are then evaluated to ensure the transducer has recorded stable water pressure values for the duration of the test. Any variation in values must be within the measurement precision of the instrument.

Gauge pressure – The pressure measured relative to atmospheric pressure. Measurements exclude atmospheric pressure and are said to be compensated or gauged for atmospheric pressure. A vented or gauge pressure transducer sensor uses a vent tube in the cable that exposes one side of the pressure sensor to atmospheric pressure, measuring pressure of the water column only. Units are expressed in psig (pounds per square inch gauged).

Ground elevation – The elevation of the ground surface of the well expressed in feet above mean sea level. If the well has a concrete surface pad, usually the elevation of the top of the concrete pad is used. If a brass cap is present to identify a well, usually the elevation of the brass cap in the concrete pad is used.

Field team member – LANS or subcontractor personnel trained to this procedure and authorized to conduct the work prescribed in this procedure.

Performance check – A check of the performance of the transducer to ensure the transducer is still within calibration. Performance checks consist of a bench test, drift test, and/or a depth test.

Pressure head – The pressure measured by the transducer in a well which can be used to calculate the height of the column of water above the transducer.

Pressure transducer (Transducer) – A device that measures pressure. There are two types of pressure transducers: those that measure absolute pressure and those that measure gauge pressure.

psi – Unit of pressure measurement in pounds per square inch.

5.1 Definitions (continued)

psia – Unit of pressure measurement in pounds per square inch absolute (see absolute pressure).

psig – Unit of pressure measurement in pounds per square inch gauged (see gauge pressure).

Raw data files – Electronic pressure transducer data files that are obtained from pressure transducers or data loggers at a well site. Raw data files are usually binary computer files that can be opened, read, and interpreted only by software developed by the transducer manufacturer. The raw data files must be stored and archived appropriately to protect the original data recorded by the pressure transducer. Raw data files contain the raw pressure measurements and date/time stamp from the transducer and may also contain information entered into the transducer software program at the time of installation, such as well name, date/time, measurement interval, reference water elevation at the time of installation, etc.

Reference level – The elevation of the surface of the water in a well at the time the transducer is installed. Determined by manual measurement of the groundwater elevation (GWE) according to ER-SOP-20243, Manual Groundwater-Level Measurements.

Water elevation (GWE) – The elevation of the surface of the water in a well, expressed in feet above mean sea level.

Water level – (1) Depth to water (DTW) in a well below ground surface expressed in feet, or (2) the water elevation expressed in feet above mean sea level. Refer to ER-SOP-20243, Manual Groundwater-Level Measurements for information about measuring groundwater level in a well.

6. PRECAUTIONS AND LIMITATIONS

Project personnel and subcontractors who work with pressure transducer equipment require training before implementing this procedure.

In monitoring wells open to the atmosphere at LANL, annual water level fluctuations may be less than 15 feet, which would indicate installation of a transducer with a pressure rating of 15 psi at a depth of 15 to 17 feet below the water level. Shallow alluvial wells may experience water-level fluctuations of 30 feet or more. However, use of 30 psi rated transducers in wells with less than 20 feet of groundwater level variability provides adequate accuracy and provides additional flexibility of use of the transducer equipment in other deeper wells as needed.

In monitoring wells adjacent to water supply wells or in water supply wells, the daily water-level drawdown might be 100 to 150 feet or more. Given an anticipated drawdown of 150 feet, a transducer with a pressure rating of 100 psi should be installed at a depth of 170 to 200 feet below the water surface.

7. PREREQUISITE ACTIONS

7.1 Special Tools, and Equipment, Parts, and Supplies

Suggested equipment for **installing and removing transducers** in monitoring wells or surface water locations:

- Transducer(s)
- Transducer cable
- Cable landing hardware (e.g., docking ring)
- Spool or rack for transducer cable
- Tripod and anchoring equipment (as necessary)
- Data logger (if required)
- Manufacturer operating manual
- Portable computer and appropriate transducer direct-cable connection
- Memory stick or other removable electronic media for data storage (Note: thumb drive or other removable storage devices are prohibited in security areas.)
- Extra batteries for transducers, water-level tape, and laptop computer
- Extra/new desiccant
- O-rings
- Silicon lubricating grease
- Waterproof ink pen(s)
- Water-level meter
- Well construction information
- MP diagrams
- Water level history of well (if known)
- Generator with ground fault circuit interrupt (as necessary)
- Electric extension cord (as necessary)
- Tripod or well head roller for installations with cable greater than 100 feet
- Deionized (DI) water
- Paper towels
- Nitrile gloves
- Trash bags
- Keys to wells & access gates where necessary
- Site-specific equipment permit (e.g.,WFO)
- Groundwater Level Field Form (Attachment 3)

7.1 Special Tools, and Equipment, Parts, and Supplies (continued)

Suggested equipment for **transducer maintenance and calibration performance checks**:

- Pressure transducer
- Transducer cable
- Portable computer and appropriate transducer direct-cable connection
- Tape measure graduated in 0.01 feet
- In Situ Transducer Performance Check and Maintenance Form (Attachment 1)
- Marking pen
- Silicon grease for O-ring lubrication
- Batteries for transducer equipment
- 100-feet steel measuring tape
- Standard conductivity solutions for performance checking multiple parameter transducers
- Capped polyvinyl chloride pipe or clear (acrylic polycarbonate) pipe (approximately 4 to 5 feet in length)

7.2 Training

Workers will complete all required training for performance of this procedure. Training will be determined through analysis and tracked in Utrain.

7.3 Field Preparation

Field Team Member

[1] **CHECK** data loggers or transducers for functionality before departing for the well site.

[2] **PREPARE** water-level meter according to ER-SOP-20243, Manual Groundwater-Level Measurements.

NOTE *Transducer equipment is typically installed in a specific well and dedicated to that well, therefore minimizing the potential for cross-contamination.*

NOTE *Transducer software clocks and internal clocks in the portable computer used with the transducer equipment must have the time set to Mountain Standard Time (MST) at all times, without any daylight saving time adjustment in the spring and fall.*

[3] **DISABLE** the automatic daylight saving time adjustment setting in Microsoft Windows-based computers used with transducer equipment to prevent the clock from changing to daylight saving time.

[4] **CHECK** the clocks on all portable computers before each use to ensure the time and date on the computer is correct and set to MST.

[5] **DISABLE** the daylight saving time function in transducer software.

8. PERFORMANCE – PRESSURE TRANSDUCER INSTALLATION, REMOVAL, AND MAINTENANCE

8.1 Transducer Installation

NOTE 1 *Submerging transducers in water pressures greater than the specific pressure rating provided by the manufacturer for each transducer can result in inaccurate readings from the transducer.*

NOTE 2 *At standard pressures and temperatures in water, a general pressure-depth conversion is 2.31 feet/psi. Attachment 4, Guidance for Maximum Water Depths of Transducers provides water depth guidance and indicates the measurement precision characteristic of different pressure rated transducers.*

NOTE 3 *It is not possible to measure total depth (TD) in any dual screen Baski wells or single screen intermediate and regional wells with dedicated transducer slave tubes. A manual measurement of the TD in a slave tube may be required to determine the appropriate transducer pressure rating in a well screen set deep in the aquafer.*

Field Team Member

[1] **MEASURE** the static groundwater level in accordance with ER-SOP-20243, Manual Groundwater-Level Measurements.

[2] **COMPLETE** Part 1: Well Site Information and Part 2: Manual Measurements of Attachment 3.

[3] **EVALUATE** the range of expected water-level fluctuations in the well or surface water location.

[4] **DETERMINE** the depth below water surface that the transducer will be placed to measure the full range of expected fluctuation.

8.1 Transducer Installation (continued)

NOTE *Use a transducer with the lowest pressure rating possible for the specific application as measurement precision decreases with higher pressure ratings (see Attachment 4).*

[5] **COMPLETE** Part 3: Transducer Information of Attachment 3.

[6] **SECURE** Kellims Grip with zip tie, as necessary.

[7] **APPLY** silicone lubricant to O-rings on transducer connections following manufacturer instructions.

[8] **LOWER** the transducer into the water slowly, cleaning the cable with a damp cloth.

[9] **IF** using multiple parameter transducers,
THEN INSTALL the transducer within the screen interval; do not install in the sump, if possible.

[10] **INSTALL** pressure transducer at an appropriate depth to monitor the full range of expected water-level fluctuation (see Attachment 4).

CAUTION

Damage can be caused to the transducer by allowing the cable to rub against the sharp edge of metal casing, allowing the transducer to contact the water level at a high rate of speed, or submerging the transducer to a water depth pressure greater than the pressure rating of the transducer.

[11] **SECURE** the transducer cable at the top of the casing to prevent cable slippage, following manufacturer's instructions.

[12] **CONNECT** transducer cable to transducer and to data logger/portable computer according to manufacturer instructions.

[13] **ENSURE** the date and time on the portable computer and on the transducer is correct and set to MST.

8.1 Transducer Installation (continued)

CAUTION

The vent tube in a compensated transducer cable can be damaged if kinked or pinched.

[14] **INITIALIZE** measurement software/data logging software according to manufacturer instructions.

[15] **PROGRAM** the software for appropriate measurement reading interval for the intended purpose of the data.

[16] **COMPLETE** Part 4: Transducer Drift/Error Acceptance of Attachment 3.

NOTE 1 *Water level is considered stable when water level is no longer trending in one direction.*

NOTE 2 *Water level stabilization is especially important in the lower Baski system screens where stabilization of the water level in the gauge tubes may take up to 1 hour to equilibrate after transducers are removed or installed. If stabilization is difficult to achieve in an intermediate or regional well it is possible that the well is experiencing drawdown or recharge in response to activity at another nearby well.*

[17] **PROGRAM** the transducer reference level, when water level is stable, to an accuracy of 0.01 feet with the GWE measurement obtained before installation of the transducer as the reference level.

[18] **COMPLETE** Part 5: Programming of Attachment 3.

[19] **MONITOR** water level to ensure the well has equilibrated to the displaced water due to transducer installation.

[20] **WATCH** for cable straightening and groundwater equilibration for deep well installations where manual water levels are not possible after transducer is installed.

8.1 Transducer Installation (continued)

[21] **PROGRAM** software to begin measurements at one minute after the next hour after the water-level measurements stabilize (e.g., 12:01).

[22] **RECORD** the transducer measurement(s) every few minutes during this time on Attachment 3.

[23] **IF** using multiple parameter instruments,
THEN RECORD conductivity measurements every few minutes, along with the water level measurements, to ascertain that the measurements are stable.

[24] **REPLACE** current desiccant with new (blue) desiccant or connect back to telemetry box.

[25] **IF** performing a new transducer installation,
THEN MARK the transducer cable with permanent marker or tape to indicate cable placement and to aid in detecting cable slippage or tampering.

[26] **SECURE** well.

[27] **DISPOSE** of any contact waste generated during installation according to requirements in the Waste Characterization Strategy Form (WCSF) or Waste Profile Form (WPF) for each well.

8.2 Transducer Data Retrieval

NOTE *The frequency of retrievals will be determined by the work plan under which the data is collected.*

Field Team Member

[1] **RETRIEVE** transducer data from wells as scheduled to ensure the continued quality of the transducer data.

[2] **CONNECT** portable computer to data logging equipment or transducer cable and **START** manufacturer-provided software specific for the transducer equipment.

[3] **RECORD** the current transducer measurements in Part 1: Well Site Information of Attachment 3 prior to stopping or downloading a test.

NOTE *If a new data file is going to be started, stop logging to the current file prior to downloading, if possible.*

[4] **EXTRACT** the transducer data set according to manufacturer instructions.

[5] **DOCUMENT** data retrieval information in Part 1: Well Site Information of Attachment 3.

[6] **RECORD** any comments in the comments field.

[7] **IF** a manual groundwater level is going to be obtained,
THEN GO TO 8.2. [9].

[8] **IF** a manual groundwater level is not going to be obtained,
THEN GO TO 8.2 [11].

8.2 Transducer Data Retrieval (continued)

[9] **IF** the well construction allows manual groundwater-level measurement without disturbing the transducer (separate access ports),
THEN perform the following steps:

[A] **MEASURE** the groundwater level manually.

[B] **RECORD** the GWE measurement on Attachment 3.

[C] **COMPARE** the GWE obtained from the manual measurement with the GWE measurement from the transducer.

[D] **IF** these values are off by more than the measurement precision of the transducer (see Attachment 4),
THEN RESET the reference level to the new GWE value obtained during the manual measurement provided the values are off by less than the maximum amount defined in 8.4, Calibration and Maintenance of Pressure Transducer Equipment.

NOTE *Do not reinstall a transducer that has failed a performance check.*

[E] **IF** the transducer values are off by at least the amount requiring a performance check as defined in sections 8.4 and 8.5,
THEN DOWNLOAD data and **SEND** files to Field Team Lead for evaluation before reinstalling or replacing the faulty transducer.

[10] **IF** the well does not have separate access tubes for the transducer and the water-level meter,
AND the well is due for a manual measurement,
THEN PERFORM the following steps:

[A] **REMOVE** the transducer in accordance with 8.3, Transducer Removal.

[B] **MEASURE** the groundwater level manually.

[C] **RECORD** the GWE measurement on Attachment 3.

[D] **REINSTALL** the transducer in accordance with 8.1, Transducer Installation.

8.2 Transducer Data Retrieval (continued)

[11] **ENSURE** that the transducer clock reads the correct time, set to MST, with no correction for daylight saving time.

[12] **IF** the transducer measurement is not accurate,
OR current test has been running for approximately six months or more,
THEN PERFORM the following steps:

[A] **RESTART** the data logger software following 8.1, Transducer Installation and **USE** the newly obtained GWE as the reference level.

[B] **DOCUMENT** activities on Attachment 3.

[13] **REPLACE** cable desiccant with new desiccant.

[14] **DISPOSE** of any contact waste generated during data retrieval according to requirements in the WCSF or WPF for each well.

[15] **SUBMIT** data file to Field Team Lead.

NOTE *Do not remove data file from portable computer or removable media before data is backed up on a server.*

Field Team Lead

[16] **TRANSMIT** data file to a backed up server for safe keeping.

[17] **ENSURE** that data file is secured and data transmittal is completed.

8.3 Transducer Removal

Field Team Member

[1] **STOP** the data logging program per manufacturer instructions.

[2] **RETRIEVE** and **RECORD** transducer data as described in 8.2, Transducer Data Retrieval.

[3] **MEASURE** the groundwater level manually according to ER-SOP-20243, Manual Groundwater-Level Measurements for a shallow installation.

[4] For deep well installations, **PERFORM** 8.3 [5] first,
THEN MEASURE the groundwater level manually.

[5] **REMOVE** the cable and transducer(s) from the well by performing the following steps:

[A] **REMOVE** cable, using cable-pulling system as necessary.

[B] **ENSURE** that the cable does not scrape against the sharp edges of well casing.

[6] **CLEAN** and **MAINTAIN** transducer equipment as described in Section 8.4, Calibration and Maintenance of Pressure Transducer Equipment.

[7] **PACKAGE** transducers for transportation according to the manufacturer instructions.

[8] **SECURE** well.

[9] **DISPOSE** of any waste generated during transducer removal according to requirements in the WCSF or WPF for each well.

8.4 Calibration and Maintenance of Pressure Transducer Equipment

NOTE *Factory calibration of InSitu Inc. instruments should be performed every 12 – 18 months or when the unit data appears to drift significantly. A transducer is considered to be properly calibrated as long as the transducer returns values that are within pre-determined measurement accuracy and precision specifications (see Attachment 4). InSitu transducers are being placed into the institutional calibration program, P-330-2, Control and Calibration of Measuring and Test Equipment (M&TE).*

Field Team Member

[1] **ENSURE** that pressure transducer equipment is properly maintained and calibrated according to the manufacturer's instructions.

[2] **IF** installing a transducer for the first time,
THEN PERFORM a Bench Test as described in 8.5, Performance Checks.

[3] **IF** re-installing a transducer,
THEN CHECK that the instrument measures 0.00 ± 0.1% gauged psi in air.

[A] **RESET** the transducer to air pressure for any offsets smaller than 0.2%.

[B] **RECORD** the pressures measured before and after resetting on Attachment 3.

[4] **IF** the offset is larger than 0.2%,
THEN CLEAN the transducer with a DI-soaked paper towel, **RESET** to 0.000 psi, and **RE-MEASURE** the pressure in air.

[5] **IF** the transducer still measures an offset larger than 0.2%,
THEN REPLACE with new transducer and **PERFORM** a performance test on the transducer that recorded the erroneous measurement (see 8.5, Performance Checks).

8.4 Calibration and Maintenance of Pressure Transducer Equipment (continued)

[6] **IF** using multiple parameter transducers,
THEN CHECK that the conductivity and associated measurements are within specifications, according to manufacturer instructions.

[7] **RECORD** transducer calibration date(s) on Attachment 1, In Situ Transducer Performance Check and Maintenance Form and on the transducer inventory.

[8] **PERFORM** transducer performance checks if a transducer is suspected of malfunctioning (see 8.5, Performance Checks).

[9] **DOCUMENT** the performance check on Attachment 1.

[10] **FOLLOW** the requirements of each equipment manufacturer (see Attachment 2, Manufacturer Operation Manuals) to maintain transducer equipment.

[11] **DOCUMENT** maintenance on Attachment 1.

[12] **PERFORM** routine checks each time a transducer is installed or removed from a well, and **CONDUCT** maintenance on an as-needed basis. Routine checks and maintenance activities include the following:

- **CHECK/LUBRICATE** O-rings.
- **CHECK** cables and vent lines.
- **ENSURE** cable, transducer, and equipment are clean and work area is uncluttered.
- **COMPLETE** a performance check if needed.
- For vented transducers, **REPLACE** desiccant capsule, if needed.
- **DISCONNECT** components and **PACKAGE** appropriately for transport and storage if the transducer is being removed.

NOTE *An off-the-shelf commercial-grade thermometer is of sufficient accuracy and precision for measuring the temperature of the oven. Most capsules will be dry within 3 days, but times will vary with saturation.*

[13] **ENSURE** that saturated transducer cable desiccants are dried and re-used.

[14] **DRY** desiccant capsules in the drying oven at a temperature no greater than 125° Fahrenheit.

8.5 Performance Checks

The following performance checks may be performed independently of one another, and are performed before transducer is installed or if a transducer failure has occurred.

8.5.1 Bench Test

Bench Test transducer equipment prior to installing new equipment and annually if transducer equipment has not been in use.

Field Team Member

[1] **CONNECT** the transducer to the cable to be used, if appropriate, or to a spare cable and **SECURE** the transducer in air.

[2] **PROGRAM** the transducer to record the pressure measurements in air at least every one minute for at least 15 minutes or preferably overnight while recording at a maximum of 15-minute intervals.

[3] **DETERMINE** the error tolerance of the transducer by multiplying the pressure rating of the transducer (psi) by 0.001 (0.1%).

[4] **STOP** test and **DOWNLOAD** the Bench Test data from the transducer and **SAVE** the test data file for the specific transducer serial number.

[5] **DETERMINE** that measurements are within the error tolerance and if steady drift in any direction is present.

[6] **RECORD** the transducer make, model, and serial number, cable serial number, cable length, bench test start and stop times, and the results of the bench test on Attachment 5, Transducer Bench Test Form.

[7] **IF** using multiple-parameter transducers,
THEN INSERT the transducer into standard solutions of known conductivity while obtaining conductivity measurements according to manufacturer instructions.

[8] **RECORD** the measurements on Attachment 5.

8.5.1 Bench Test (continued)

[9] **IF** measurements are not within error tolerance,
OR a noticeable drift occurs,
THEN PERFORM the following steps:

[A] **PERFORM** additional bench testing measurements as needed.

[B] **IF** the transducer does not measure within specifications,
THEN return transducer to manufacturer for calibration and/or repair.

[10] **SAVE** the bench test data file(s) for reference and **RECORD** results on Attachment 5 and in the forms maintained in the transducer files.

[11] **IF** there is a suspected malfunction with a transducer (see 8.4),
THEN additional performance checks may be performed:

[A] **PERFORM** a Depth Test (8.5.2) and/or a Drift Test (8.5.3) to conduct additional performance checks on a pressure transducer.

8.5.2 Depth Test

Field Team Member

[1] For compensated transducers, **OBTAIN** a pressure measurement with the transducer in the air.

NOTE *Measurements that are not 0 (pounds per square inch [psi]) may be caused by using a cable that has a blocked vent line.*

[2] **ENSURE** that the transducer measurement in air is 0 psi, within the measurement precision of the transducer.

[3] **IF** transducer is not measuring 0 psi,
THEN USE another cable to determine if the problem is with the transducer or the cable.

[4] **RECORD** the air measurement on Attachment 1.

8.5.2 Depth Test (continued)

[5] **PLACE** the transducer in the well or water column at the first position by performing the following steps:

[A] Temporarily **POSITION** the transducer 1 to 2 feet below water level.

[B] **RECORD** the water depth (PH1 [feet]) on Attachment 1.

[C] **SECURE** the cable and **MARK** the transducer cable at the top of casing or at another convenient measuring point.

[D] **MEASURE** a specific length of the remaining cable that extends from the well using the 100-ft steel tape and a measured length that is within the rated capacity of the transducer.

[6] **RECORD** the length measured on the cable (cable length [feet]).

[7] **USE** the full range of the transducer for the calibration check if the well/water column depth allows.

[8] **PLACE** transducer in the well or water column at the second position by performing the following steps:

[A] **LOWER** the transducer and cable in the well or water column the measured length as determined above.

[B] **POSITION** the measured mark on the cable at the top of the casing/water column at the previously used measuring point.

[C] **RECORD** the measured water depth (PH2 [feet]) provided by the transducer on Attachment 1.

[9] **VERIFY** that the difference between the transducer depth measurements (PH2 – PH1) corresponds with the length measured on the cable within the measurement precision of the transducer (see Attachment 4).

8.5.2 Depth Test (continued)

[10] **IF** it does not correspond,
THEN CHECK the cable or transducer to ensure that it hangs freely in the well or water column and **REPEAT** the calibration check.

[11] **IF** the transducer does not pass the depth test,
THEN DISCONTINUE use and **SHIP** the transducer to the manufacturer for calibration.

8.5.3 Drift Test

Field Team Member

[1] **SECURE** the transducer at a known depth in a contained water column.

[2] **RECORD** the pressure measurements every one minute for at least 15 minutes (preferably overnight).

[3] **DETERMINE** the error tolerance of the transducer by multiplying the pressure rating of the transducer (psi) by 0.001 (0.1%).

[4] **CHECK** for measurements beyond the error tolerance or steady drift in one direction.

[5] **IF** measurements are not within error tolerance,
OR a noticeable drift occurs,
THEN RECHECK the pressure measurements.

[6] **IF** there is a possibility that the water column was disturbed during the drift test,
THEN REPEAT the test.

[7] **IF** the transducer does not pass the drift test,
THEN RETURN transducer to manufacturer for calibration and/or repair.

[8] **RECORD** results on Attachment 1.

8.5.4 Multiple Parameter Performance Check

NOTE 1 *Multiple parameter instruments such as the In Situ AquaTroll 200 measure conductivity as the primary measurement.*

NOTE 2 *According to manufacturer, "the conductivity cell of the In-Situ AquaTroll 200 does not require a user calibration to achieve the highest degree of instrument accuracy."*

NOTE 3 *Performance checks are often used after instrument cleaning to measure instrument drift. A simple one-point or two-point check is performed by measuring a conductivity standard using the default factory calibration.*

Field Team Member

[1] **FOLLOW** manufacturer recommendations for performance checking multiple parameter instruments (e.g., Aqua TROLL 200).

[2] At the beginning and end of critical deployments, **CONDUCT** a quick performance check to ensure the instrument is performing to its specifications.

[3] **PREPARE** one to three solutions of known conductivity that are within the range of fresh water applications known to be present at LANL, typically <2000 uS/cm.

[4] **INSERT** the transducer into the solution(s) according to manufacturer recommendations and gently **STIR** or **SHAKE** to remove any air bubbles from the sensors and to allow the temperature of the sensor and solution to equilibrate.

[5] **RECORD** the specific conductivity measurements on Attachment 5.

[6] **CHECK** that measurements are within the combined theoretical error of the calibration solution and the instrument.

[7] **IF** measurements are not within error tolerance,
OR a noticeable drift occurs**,**
THEN RECHECK the conductivity measurements.

[8] **IF** the transducer does not measure appropriate values,
THEN RETURN transducer to manufacturer for calibration and/or repair.

9. POST-PERFORMANCE ACTIVITY

9.1 Records Management

Maintain equipment maintenance records and calibration data with project records to provide defensible quality data from transducer equipment.

Maintain and submit the following records and/or documents, generated as a result of this procedure, to the Records Processing Facility in accordance with EP-AP-10003, Records Management.

Records include the following:

- In Situ Transducer Performance Check and Maintenance Form
- Groundwater Level Field Form
- Transducer Bench Test Form
- Raw water level data electronic file on electronic media (data transfer)
- Other associated information

10. ATTACHMENTS

Attachment 1, In Situ Transducer Performance Check and Maintenance Form
Attachment 2, Manufacturer Operating Manuals
Attachment 3, Groundwater Level Field Form
Attachment 4, Guidance for Maximum Water Depths of Transducers
Attachment 5, Transducer Bench Test Form

ATTACHMENT 1

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Los Alamos National Laboratory

In Situ Transducer Performance Check and Maintenance Form

						Performance Check							
Date	Time	Well Name	Inspector Name	Serial Number	Battery Voltage Check/ Replace	Factory Cali-bration Date	Air Pressure (psi)	PH 1 (ft)	Cable Length (ft)	PH 2 (ft)	PH 2 – PH 1 (ft)	Check OK?	Equipment Condition, Comments, Describe Maintenance, Calibration Check

Note: To convert pressure measurements to ft, use conversion factor: 2.31 ft/psi

ATTACHMENT 2

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Manufacturer Operating Manuals

1. In-Situ, Inc. Operator's Manual, Level TROLL® 400, 500, 700, 700H Instruments
2. In-Situ, Inc. Care and Maintenance of Aqua TROLL® and Level TROLL® Instruction Sheet
3. MiniTROLL Operator's Manual for MiniTROLL Model SSP-100
4. WinSitu 4.0 User's Guide
5. Hermit 3000 Data Logger Operator's Manual
6. In-Situ Inc. Data Manager Software Operator Manual
7. Solinst Level Logger Manual
8. In Situ Aqua Troll 200 Operator's Manual
9. In Situ Aqua Troll 200 Conductivity Performance Check

ATTACHMENT 3

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Groundwater Level Field Form

IPC-1

Groundwater Level Field Form

PART 1: Well Site Information					
Well Name :		Date:	Time onsite (MST):	Activity:	
Personnel:				Cable Length(ft):	Cable SN:
Telemetry: Yes \ No	Pull Transducer: Yes \ No	New Transducer Needed: Yes \ No New LT SN:		Memory % remaining:	Battery % remaining:
Connect Time:	Transducer SN:	New LT PSI Rating:	Manufacture Date:	Log Note Memory %	Log Note Battery %
Water Level (ft)		P (psi):	T [C]	Stop Test: Yes \ No	Change Desicant: Yes \ No \ NA
Last Start Date:		Data File Name:			

PART 2: Manual Measurements				
Measuring Point: TOC (top outer casing) TIC (inner)		Stick-up Measured on Site ☐	Previous MP Used ☐	
Time (MST):		Water Level Meter Serial No.		***Notes:***
DTW (ft bMP):		Measurements in feet		
Time (MST):		LSD ft.		
DTW (ft bMP):		MP Height ft.	+	
Time (MST):		MP Elevation	=	
DTW (ft bMP):		DTW:	-	
Time (MST):		Groundwater Elevation (GWE) Reference Level		
TD (ft bMP):				
		Zip Tie on Kellim's Grip:		

Example

Transducer Performance and Programming					
Part 3: Transducer Error\Drift Acceptance		Part 4: Programming & Final Readings			
WL Reading Time (MST):		Progamming Time:		Time (MST):	Reading
WL (transducer reading) (ft):		New Test Name:			
GWE from MM		Reference Level :			
Difference in value:		Current Depth:			
Error tolerance of transducer:		Meas. Interval:			
☐ Within Error Tolerance		Start Date:			
☐ Outside Error Tolerance		Start Time:			
15 PSI-0.03ft. 30 PSI-0.07 ft. 100 PSI-0.23 ft. 500 PSI-1.16 ft.			Synch Clocks: Yes \ No		
Deleted Tests:					QA: Date and Initial:

ATTACHMENT 4

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Guidance for Maximum Water Depths of Transducers

Pressure Rating (psi)	**Maximum Depth Below Water Surface (feet)**	**Measurement Precision (feet) (±0.1% Full Scale)**
15	34.7	0.03
30	69.3	0.07
50	115.5	0.12
100	231.0	0.23
200	462.0	0.46
250	577.5	0.58
300	693.0	0.69
500	1155.0	1.16
1000	2310.0	2.31

ATTACHMENT 5

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Transducer Bench Test Form

Transducer Bench Test Form	
DATE:	
Transducer Serial Number:	
SN Calibration Date	
Cable Serial Number:	
Cable Length (ft):	
Transducer Make and Model:	
Transducer Pressure rating (PSI):	
Transducer Accuracy (% Full Scale)	0.1%
Transducer pressure error tolerance (PSI):	
Transducer pressure error tolerance (FT)	
Bench Test Start Date Time:	
Bench Test End Date Time:	
Bench Test Time (Hr):	
Bench Test data Rate (min):	
Bench Test Data File Name:	
Variation in pressure (PSI):	
Temperature variation (C)	
Variation in temperature reasonable:	
Pressure/Temperature Pass or Fail:	
Reason for Fail:	
Conductivity in Air (uS/cm)	
Standard Solution Concentration (uS/cm)	
Conductivity in Standard Solution (uS/cm)	
Conductivity Pass or Fail	
Tester:	