Pneumatic Piezometers and Total Pressure Cells

Reading of pneumatic piezometers and total pressure cells using portable and manifold readout units.

Taking readings. -These two instruments can be grouped together since they are all read using the same basic concept, pneumatic or gas pressure measurements. These pneumatic instruments are read usually at some sort of readout location. Since all the instruments are buried in the dam, the readout locations can vary from an instrument house containing a pneumatic terminal manifold, which is a self-contained unit, a terminal pipe which is read using a portable readout unit, to a single connection which would be used during construction or installation which also uses this portable readout unit. To take the readings on these instruments, pressure is transmitted by compressed nitrogen gas through the tube bundle to the instrument. The gas pressure equalizes the water or earth pressure against a rubber diaphragm in the instrument. All excess gas pressure is vented to the atmosphere.

Each instrument requires a constant supply of gas. An initial supply pressure setting of 140 lb/in2 is recommended to allow an adequate flow rate. Once an initial output pressure gauge reading is established for a given transducer, a supply pressure reading of 30 to 40 lb/in2 above the output gauge reading may be used to conserve the air supply. For example, an initial output pressure gauge reading of 30 lb/in2 means that the input pressure for future readings need only be 60 to 70 lb/in2. The volume flowing through the flow meter directly affects gas supply conservation. Immediately after a reading is completed, another reading should be taken for verification; then shut down the flow.

The step-by-step procedure for reading pneumatic instruments using a **portable readout, portable readout attached to a terminal pipe, and a terminal manifold** are described in the following sections.

The step-by-step procedure for reading pneumatic instruments using a **portable readout** unit is as follows:

(1) The portable readout unit should be set flat on the ground or table, never inclined or on its side. The output pressure gauge is position sensitive.

(2) Check the zero setting on the output pressure gauge, then close all valves on the portable unit.

(3) Open the vent valve and adjust the supply pressure to 140 lb/in2 or to 30 to 40 lb/in2 above the previous reading for that cell.

(4) Adjust the metered input valve so that the flow meter indicates a flow rate of 0.1 SCFH (standard cubic feet per hour) with the input vent open. (The device was initially calibrated at this flow rate.) The flow for the initial reading on the cell can be at a higher flow rate to fill and pressurize the pneumatic tubes. Once the tubes are filled, the flow rate should be reduced to 0.1 SCFH.

(5) Open the transfer valve to connect the input circuitry to the output pressure gauge.

(6) Remove all the protective caps from the pneumatic tubes and couplers and wipe them clean.

(7) Connect the pneumatic input coupler to the black input tube on the cell. Leave the clear tube unconnected (this is the vent).

(8) Close the vent valve and read the pressure increase on the output pressure gauge.

(9) Wait for the output pressure gauge to stabilize, gently tap the gauge to ensure that the pointer is moving freely and record the pressure reading.

(10) Verify the reading by opening the vent valve until the pointers on the output pressure gauge starts to fall, then close the vent valve so that the flow rate can pressurize the instrument.

(11) Recheck the pressure measurement reading indicated on the output pressure gauge after the pointer is steady.

(12) The system may be shut down after reading by disconnecting the tube coupler, closing the supply pressure regulator, opening the vent and transfer valves to bring the output pressure gauge to zero, and then closing all valves except the metering valve. The protective caps must be replaced on the tubes leading from the instruments.

The most important considerations in using the portable unit are that the unit is set horizontal when measurements are made, and that the gas flow rate is set correctly. If the unit is set inclined, the zero changes on the data gauge. If the gas flow rate is set too high, the recorded pressure will be incorrect.

The step-by-step procedure for reading pneumatic instruments terminated at a **portable readout attached to a terminal pipe** is as follows:

(1) Pressure readings of piezometers and total pressure cells can be obtained at a terminal pipe. A terminal pipe contains the termination points of the ends of each instrument installed. Using the portable readout unit makes the readings.

(2) The portable readout should be set flat on the ground or table, never inclined or on its side. The output pressure gauge is position sensitive.

(3) Check the zero setting on the output pressure gauge, then close all valves on the portable indicator.

(4) Open the vent valve and adjust the supply pressure to 140 lb/in2 or to 30 to 40 lb/in2 above the previous reading for that cell.

(5) Adjust the metered input valve so that the flow meter indicates a flow rate of 0.1 SCFH (standard cubic feet per hour) with the input vent open. (The device was initially calibrated at this flow rate.) The flow for the initial reading on the cell can be at a higher flow rate to fill

and pressurize the pneumatic tubes. Once the tubes are filled, the flow rate should be reduced to 0.1 SCFH.

(6) Open the transfer valve to connect the input circuitry to the output pressure gauge.

(7) Remove the protective cover from the terminal pipe.

(8) Remove all the protective caps from the pneumatic tubes and couplers and wipe them clean.

(9) Connect the pneumatic input coupler to the input connector on the cell. Connecting a special jump lead from the input coupler to the input coupler on the terminal pipe makes this connection.

(10) Close the vent valve and read the pressure increase on the output pressure gauge.

(11) Wait for the output pressure gauge to stabilize, and gently tap the gauge to ensure that the pointer is moving freely and record the pressure reading.

(12) Verify the reading by opening the vent valve until the pointers on the output pressure gauge starts to fall, then close the vent valve so that the flow rate can pressurize the instrument.

(13) Recheck the pressure measurement reading indicated on the output pressure gauge after the pointer is steady.

(14) Reduce the pressure on the portable unit so the jump lead can be disconnected from it instrument. If pressure is left in the line, reconnecting the jump lead to another instrument may not be possible.

(15) The system should be shut down after reading by disconnecting the special jump lead, closing the supply pressure regulator, opening the vent and transfer valves to bring the output pressure gauge to zero, and then closing all valves except the metering valve. The protective caps must be replaced on the terminal pipe and locked.

The step-by-step procedure for reading pneumatic instruments using a **terminal manifold** is as follows:

(1) **Pressurizing**. -The terminal manifold will operate with any compressed, dry gas (except oxygen and oil-pumped nitrogen). Water pumped nitrogen and carbon dioxide are the two gases most generally available. Nitrogen is obtainable through industrial gas or welding supply outlets. Carbon dioxide is available at industrial gas or fire extinguisher suppliers. A fill hose with fittings for nitrogen tanks is provided with the instrument. This filler hose should be of high-pressure hose material (working range 2,750 lb/in2).

(a) **Maximum safe working pressure**. -The maximum safe working pressure for the manifold is 2,200 lb/in2. This pressure can be monitored on the TANK PRESSURE

gauge. **Do not exceed 2,200 lb/in2** or serious damage to the instrument may result.

(b) **Minimum tank pressure**. -During operation the tank pressure will gradually be depleted. To ensure proper operation, the tank pressure should be at least 300 lb/in2. When the tank pressure reaches this point refill it.

(c) **Pressurizing with bottled gas**. -

(aa) Connect the fill hose to the cylinder tightening the nut securely.

(bb) Connect the fill hose to the manifold bulkhead connector.

(cc) Open the cylinder valve.

(d) **Changing tanks.** -When the tank supply pressure has reached 300 lb/in2, change tanks. Turn off the cylinder valve. Loosen the fill hose at the cylinder to bleed the pressure and then remove it. Replace the spent cylinder with a fully charged cylinder.

(2) **Pressure readings**. - Pressure readings of piezometers and total pressure cells can be obtained with this manifold. In addition, a MONITOR valve has been installed to allow a portable readout unit to operate in conjunction with the manifold if a problem occurs within the manifold.

(a) **Piezometer and total pressure cell readings**. -

(aa) Turn the SUPPLY valve ON.

(bb) Adjust the SUPPLY PRESSURE regulator to between 240 and 260 lb/in2, monitoring with the SUPPLY PRESSURE gauge. Pressures are typically higher now because the dam construction is completed.

(cc) Turn the SENSOR SELECT valve to PIEZOMETER.

(dd) Turn ON the piezometer to be monitored.

(ee) Turn ON piezometer MANIFOLD SUPPLY. NOTE: If the MANIFOLD SUPPLY is ON and all the piezometer valves are OFF, pressure will build up in the system to the regulated SUPPLY PRESSURE (240 to 260 lb/in2) could damage the DATA GAUGE.

(ff) Turn the FLOW SELECT valve to BYPASS to pressurize the sensor. Adjust the BYPASS flow rate using the BYPASS RATE valve. Monitor the BYPASS rate with the FLOWMETER. Set the BYPASS rate to between 0.1 and 0.2 SCFH.

(gg) Watch the DATA GAUGE pointer. When the ascent of the needle slows or stops, turn the FLOW SELECT valve to FLOW CONTROLLER. The flow controller has been factory set at 30 to 40 SCCM (standard cubic centimeters per minute).

(hh) Allow the gauge to stabilize, tap the gauge and record the reading.

(ii) Turn the MANIFOLD SUPPLY valve OFF.

(jj) Turn ON the next sensor to be read and follow steps ff-ii.

(kk) When finished taking readings, turn OFF the SUPPLY valve.

Problems with readings and readout equipment. - Problems with taking readings on pneumatic instruments are usually few but these problems can greatly affect the readings. The biggest problem we will consider first is using the wrong gas flow rate (above 0.1 SCFH) at the time of the lift off of the diaphragm or the point where the gas pressure equalizes the water or earth pressure against the diaphragm. These pneumatic piezometers are designed to use the least amount of flow (30 SCCM) to accomplish this equalization. When too much flow is used, the area at the instrument where the monitoring is occurring is changed and the data becomes invalided. Therefore, the correct gas flow at the readout unit (0.1 SCFH) must be used.

Another problem that can occur with reading pneumatic instruments is when water has entered either the inlet tube or the vent tube. This water entry can occur during installation or through loose connections at terminal locations. The instrument readings will indicate an increasing pressure followed by a sudden drop in pressure. Another increase in pressure will occur soon after this drop. The gas pressure builds behind the water is blocking the tubes. The gas will displace the water, causing the pressure to drop as soon as the gas goes by the water and the pressure starts building again. To remove this water requires the use of a continuous flushing system. This system uses CO2 instead of the usual nitrogen gas, because CO2 is a dry gas will remove the water. The flushing system is attached to the instrument containing the water on the input side of the instrument. It is then flushed as long as necessary to remove the water. It may be necessary to flush the instrument two to three times to remove all water.

Plugged or broken lines can also occur over time. A broken input line is easy to detect since no pressure will build up on the gauge. Plugged or restricted lines can cause real problems because they sometimes do not allow for easy detection. Plugs or restrictions in the vent line can allow readings to occur because input pressures can vent at equilibrium but with time the recorded pressures will rise because complete venting cannot take place. Nothing can be done to repair plugged or broken lines.

Taking readings on total pressure cells require greater care. The gas flow rates are even more critical than for piezometers. The gas flow rate while reading the settlement sensor or total pressure cell should be 30 to 40 SCCM. If the flow is greater than, as we discussed with the pneumatic piezometers, diaphragm lifting (or equalization of pressure) can deform the pressure system and produce incorrect data. With these instruments, the area being monitored is a confined space allows the diaphragm movement to disturb this space more than with a piezometer. Another problem caused by the gas flow is friction building up in the roto meters (the glass sight tube used to set the gas flow rates). This friction can cause the flowing ball in the roto meter to become stuck at a height the operator may believe to be the correct flow when in reality the flow is incorrect. To stop this problem, allow more time to take the readings.

Maintenance. - As described before, no maintenance can be performed on the instruments installed within the structures. The only maintenance required is the readout units and the external connections.

(1) The portable units and manifolds have all been tested at the factory for leaks throughout. All pipes, connections, and valves have been tested for tight seals and sprayed with lacquer to resist corrosion. Quick connects should be kept clean and free of dirt buildup.

Clean the inside surfaces of the female quick connect periodically with acetone or equivalent solvent. Spare "O" rings have been provided for the quick connects. Replace when required.

Gauges should remain maintenance free. Keep the windows clean for ease of reading. The Heise gauge can be zeroed with the adjusting knob on the bezel.

(2) Leaks. - Leaks are the most common problem in a pneumatic system. Once a leak is located, repairs can be done or the faulty part replaced.

(a) Identifying. - Erratic gauge readings, rapid depletion of the gas supply, or unusual noises usually indicate the presence of a leak.

(b) Locating. - Leaks may be located by using a liquid leak detector. We recommend Snoop Liquid Leak Detector, manufactured by NUPRO Company. Place the liquid leak detector on potential leak locations and look for bubbles. Most common places for leaks are at fitting junctions, connecting lines, valve stems, and quick connects seats.

(c) Repair. -

(aa) Fittings. Retightening or replacement if cracked or broken repairs -Leaky fittings. Use a pipe sealant or Teflon tape when retightening pipefitting joints. Tube fittings can be sealed by tightening a quarter turn or until resealed. Do not over tighten tube fittings.

(bb) Valve packing. - Tighten the valve-packing nut on the Whitey ball valves. A special tool may be needed for this repair and can be obtained from the Whitey Company.

(cc) Quick connects. - Replace the "O" rings in the female connector when worn or when leaks occur while in use.

(dd) Damaged lines. - Replace with the appropriate tubing, using new ferrules.

Other problems. -

Gauges. - A relief valve has been installed in the DATA GAUGES to prevent over pressurization. Excessive vibration to the units may loosen the adjustment. If DATA GAUGES relieve at pressures below their full range, resetting the relief valve is necessary. Nupro relief valves are set using an Allen wrench. Loosening the lock ring on the adjusting knob and resetting set Norgren relief valves. Relief valves should be set 2 to 3 lb/in2 above the DATA GAUGE range.