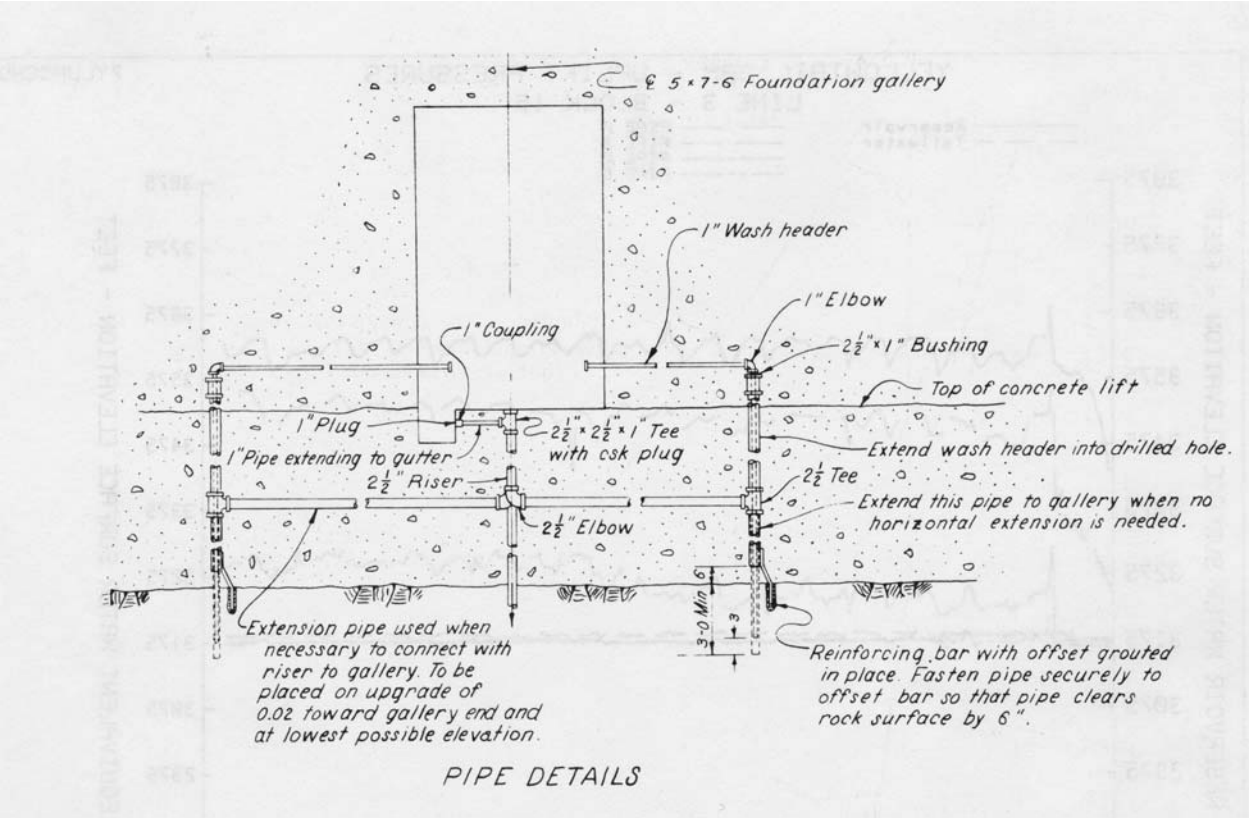
**General Considerations**. Uplift pressures are used to measure typical foundation pressures below concrete dams. Uplift pressure devices are mainly divided into two types of systems. (1) Open pressure systems and closed pressure systems. (1) Open pressure systems are typically installed in older structures and consist of the use of pipe place into the concrete during construction and extending into the foundation. (2) Closed system uplift pressures use a close system piezometer usually installed in a drill hole under the foundation of the dam before construction.

**Installation descriptions and Operating Instructions for Open system Uplift Pressure Devices**

Depending on how the uplift pressure pipe system at a dam has been constructed, the method for collection of the uplift pressure data may differ. Drill holes with installed drain pipes extend below the concrete dam into the foundation both upstream and downstream of the grout curtain. These pipes extend into one or more of the lower galleries in the dam. The foundation drain pipes are extended into the gutter and up the upstream wall within these galleries. The pipes are usually fitted with a tee-section and a Bourdon-type pressure gauge for observing water pressures. A shut off valve is usually included on one leg of the tee. Thus the uplift pressures may be determined by either reading pressures on the pressure gauges or by sounding with a water level indicator probe down the drain pipes.

Below are figures that show how these pipes and gauges were typically installed within galleries of concrete dams. Details of these installations are shown from drawing number 465-D765 and 382-D-1350.



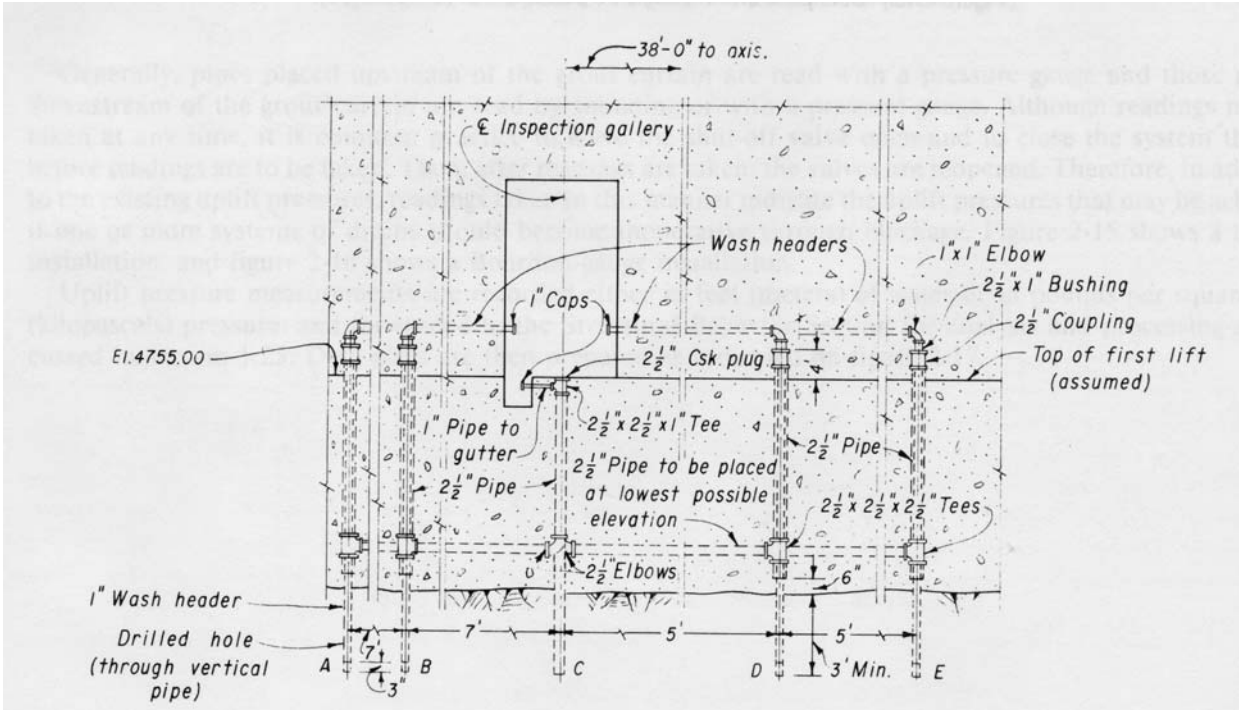



**Figure 2-15.—Typical installation of an uplift pressure measuring system. From 382-D-1350.**

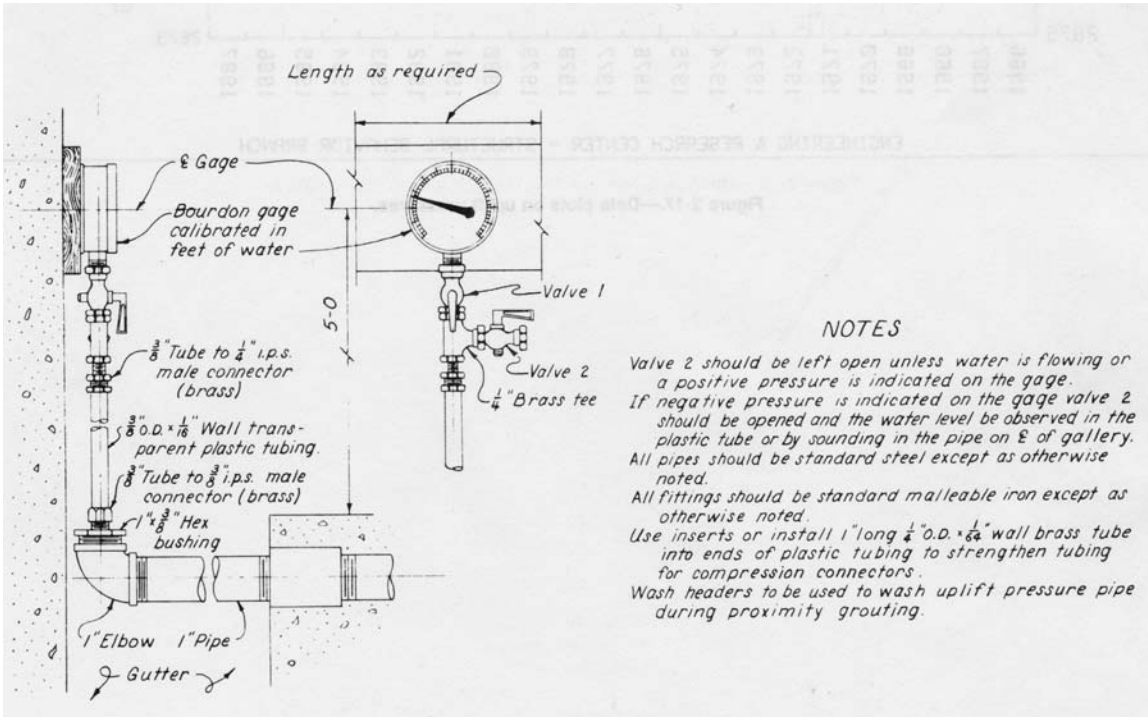



**Figure 2-16.—Typical Bourdon gauge installation. 465-D-765.**

Typical installation of an uplift pressure measuring system, from drawing 465-D-765 is shown above.

Below are some picture of typical uplift pressure pipes and pressure measuring gauge installations.

**Hoover Dam, pressure gauge and drain valve.**

**Pueblo Dam, pressure gauge, drains valve and clear plastic riser pipe.**

Hungry Horse Dam, pressure gauge, no drain valve and solid pipe.

**Procedures for Reading Uplift Pressure Pipes that are equipped with Pressure Gauges**

1. Close any open drain valves that may have been open and wait two days for pressures to build back up on each pipe.

2. After waiting the required time period, look at the dial face of the bourdon gauge. Make sure you understand the pressure scale that is being used. Typically the scale will be in feet of water or possibly the gauge will have a dual scale with feet of water and pounds per square inch (PSI). You should use the feet of water scale to take your readings.

3. Tap the gauge lightly with your hand before reading. This will make sure there is no stickson in the gauge at the time of measurement.

4. Use a field book to record the pressure reading, so that the previous water pressure can be compared to the present pressure reading or use the table provided with the limits of expected valves. The data should be than transferred onto a data form and should be recorded to an accuracy of 0.5 foot of water.

5. Record the reservoir and tail water levels at the time as these observations. The elevation of the top of the uplift pressure pipe and center of the bourdon gauge should have been determined previously.

**Procedures for Reading Uplift Pipes that use a pressure gauge and solid drain pipe when no pressures are indicated on the pressure gauge at the time of the readings.**

1. Close any open drain valves that may have been opened and wait two days for pressures to build back up on each pipe.

2. After waiting the required time period (2 days), look at the dial face of the bourdon gauge. If pressure is indicated, read the pressure as described above.

3. If no pressure is indicated on the pressure gauge, open the ½-inch ball valve attached to the top of the drain pipe coming out of upstream gallery wall, gutter or gallery floor.

4. Taking a water level indicator (unit used to measure stand pipe piezometers or observation wells) and turn on the indicator switch and switch to the BATTERY CHECK position (if available) to determine the level of charge of the battery.

5. Check for proper operation of the unit by immersing the probe in water in the seepage in the gutter and noting whether the device registers a closed circuit using the voltmeter, light, or sound modes.

6. Lower the probe into the ball valve. At the level where the circuit is closed, note the length of probe wire required to reach the water level from the top of the ball valve. Use a field book to record the data, the data should be recorded as a negative number. The use of a field book allows for the use of comparing the previous water level depths measured to the present depth or use the table provided with the limits of expected valves. The data should be than transferred onto a data form and measurements should be recorded to an accuracy of 0.01 foot. The observer must use a separate pocket tape measure to obtain this accuracy. Measure the distance from the mark on the cable to the nearest footmark on the cable with the pocket tape.

7. Once you have withdrawn the cable from the ball valve, close this valve.

8. Record the reservoir and tail water levels at the time of these observations. The elevation of the top of the ball valve should have been determined previously.

Below is a typical picture of a ball valve that once opens the depth measurements are taken.

Below is a picture of a ball valve and a water level indicator probe.

**Procedures for Reading Uplift Pipes that use a pressure gauge and clear 3/8-inch plastic tubing when no pressure is indicated on the pressure gauge.**

1. Close any open drain valves that may have been open and wait for two days for pressures to build back up on each pipe.

2. After waiting the required time period, look at the dial face of the bourdon gauge. If pressure is indicated on the gauge, read the pressures as described above.

3. If no pressure is indicated on the pressure gauge but you can observe a water level in the clear plastic tubing below the gauge than use a rule to take a measurement. Starting at the center of the pressure gauge (usually there should be a line draw on the gallery wall at this center position) to the water level. This data should be recorded as a negative number.

4. Use a field book to record the data, so that the previous water level depth can be compared to the present depth or use the table provided with the limits of expected valves. The data shall than be transferred onto a data form and should be recorded to an accuracy of 0.1 foot. The observer must use a separate rule or pocket tape measure to obtain this accuracy.

5. Record the reservoir and tail water levels at the time of observation. The elevation of the middle or center of the uplift pressure gauge should have been determined previously

**Procedures for Reading Uplift Pipes that have no pressure gauges or clear 3/8-inch plastic tubing.**

1. These installations are very much like measuring an observation well or a piezometer standpipe.

2. Close any open drain valves that may have been open and wait two days for pressures to build

back up on each pipe.

3. After waiting the required time period, open the drain ball valve at the top of the drain pipe or remove it pipe cap or pipe plug.

4. Taking a water level indicator (unit used to measure stand pipe piezometers or observation wells) and turn on the indicator switch and switch to the BATTERY CHECK position (if available) to determine the level of charge of the battery.

5. Check for proper operation of the unit by immersing the probe in water in the seepage in the gutter and noting whether the device registers a closed circuit using the voltmeter, light, or sound modes.

6. Lower the water level indicator's probe into the drain pipe. At the level where the circuit is closed, note the length of probe wire required to reach the water level from the top of the drain pipe or valve. Use a field book to record the data, so that the previous water level depth can be compared to the present depth or use the table provided of expected limits. The data is then transferred onto a data form and should be recorded to an accuracy of 0.1 foot. The observer must use a separate pocket tape measure to obtain this accuracy. Measure the distance from your mark on the cable to the nearest footmark on the cable with the pocket tape.

7. Record the reservoir and tail water levels at the time of observation. The elevation of the top of the drain pipe or ball valve should have been determined previously.

8. Replace the pipe plug or pipe cap or close the ball valve.

**Procedures for Reading Uplift Pipes that have vibrating-wire piezometers attached.**

1. These installations are very much like measuring any vibrating-wire instrument installed at the dam.

2. Close any open drain valves that may have been open and wait two days for pressures to build back up on each pipe.

3. After waiting the required time period, connect the vibrating-wire readout unit at the terminal location for this instrument. This terminal location may be at the uplift pressure pipe location or at a central terminal location where a number of uplift piezometers are monitored. Below is a typical vibrating-wire piezometer installation. The readout should be connected so that the red and black connectors from the piezometer are connected to the red and black connectors from the readout. The green and white wires from the piezometer are used to measure temperature and are typically not required to be measured.

4. When using the Geokon GK-401 or 403 readout unit, place the rotary switch on the front panel of the unit in position B. Connect the alligator clip leads on the piezometer wires. Again, the red and black wires are used to measure the pressure on the piezometer. These connections can be reversed on this circuit and measurements can still be made.

5. When taking measurements from the manual switch box, connect the alligator clips from the GK-401 or 403 readout unit to the pair of lugs on the front panel labeled readout unit. Rotate the rotary switch that corresponds to the piezometer you are monitoring. The uplift pressure pipe switch locations are indicated by a list placed with the door of the box. The two rotary switches are numbered 1-8 on the first past through the first switch, then 9-16 for the second past through this switch, if there is that number of uplift pipes attached to this switch box. Below is a picture of a terminal box unit.

6. Use a field book to record the data, so that the previous frequency measurement can be compared to the frequency or use the table provided of expected limits. The data is then transferred onto a data form and should be recorded in a frequency squared times 10,000 unit of measure; this measurement is displayed when the readout unit is set in position B.

7. Record the reservoir and tail water levels at the time of observation. The elevation of the top of the vibrating-wire piezometer should have been determined previously.

8. If the installation is equipped with a pressure gauge, this measurement is not required when the typical monthly measurement is taken. The pressure gauge should be read yearly as a check on the vibrating-wire piezometer. To read these pressure gauges, follow the instructions above Procedures for Reading Uplift Pressure Pipes that are equipped with Pressure Gauges**.**

**Installation of Vibrating-wire Piezometers in Uplift Pressure Pipes**

The installation of vibrating-wire piezometers on the top of and within uplift pressure pipes is described below.

This procedure is intended to provide an accurate zero pressure frequency value at the site of a vibrating-wire piezometer installation.

Nomenclature:

F0 = Readout box display at zero or atmospheric pressure. For Geokon Model GK-401 or GK-403, set the rotator switch to position 'B'. For Geokon Model GK-404, set the mode switch to ‘Dg’ (units in digits). All three readout units will display frequency squared times 10E-3 or units called digits.

Fc = Computed corrected value for Fo. Units are same as Fo.

F1 = Readout box display for which the pressure acting upon the piezometer is desired to be determined. When position 'B' is used, all units are same as Fo.

T0 = Temperature at zero pressure. Units are degrees Celsius.

Tw = Temperature of water in drill hole or standpipe. Units are degrees Celsius.

T1 = Temperature when F1 is obtained. Units are degrees Celsius. This measurement is not necessary on a routine basis.

G = Gauge factor provide by manufacturer or determined in field calibration procedures. Units are PSI per F where: PSI = pounds per square inch and units are frequency squared times 10E-3, called digits.

C = Thermal factor provided by manufacturer. Units are PSI per degree Celsius.

P = Pressure on piezometer tip.  Units are PSI (lbs. /square inch).

1.  If the pressure end of the vibrating-wire piezometer is to be attached to a **quick connect at the collar of the uplift pressure pipe in the gallery**, the piezometer must first be vented to atmosphere to obtain the initial (F0) (black and red wires) or zero pressure reading.  This can be accomplished by inserting a separate half of the quick connect into the connector attached to the piezometer or if the mounting plumbing has a bleed to atmosphere it should be opened.  The typical quick connector used is a valve, both male and female halves close when they have been disconnected from the other half of the connection.  This procedure should be accomplished adjacent to the top of the uplift pressure pipe within the gallery.

2.  After a few minutes wait an initial pressure reading (F0) should be taken and recorded.

3.  Once the initial measurement is taken, remove the venting quick connection and attach the piezometer to the quick connection on the uplift pressure pipe or close the bleed value.  Initial measurement of the pressure (F1) should be taken after a 1 hour wait.

4.  The piezometer **tip elevation** should be the elevation of the top of the pipe plus the addition of the quick connection plus any additional height to the bottom of the piezometer.  This measurement should be made with a measuring tape.

5.  For future computations use this formula:

F = (G * (F0 - F1) (see step 12 below for an example)

6.  If the vibrating-wire piezometer is to be installed **within the uplift pressure pipe**, first measure and record depth to water from top of the uplift pipe using a water level indicator or other device.

7.  Next measure and record F0 (black and red wires) and T0 (green and white wires) for the piezometer while it is adjacent to the top of the pipe within the gallery.  An initial temperature measurement T0 is required for only pipes 23-3 through 23-6.  Keep the piezometer out of direct sunlight when measuring T0.  Using a digital multimeter set to the '20K-ohm' scale; convert the resistance to temperature, degree Celsius, using a resistance-temperature chart (or conversion table, see piezometer manual).  Record both F0 and T0 measurements.  Do not place piezometer in water, measure only air pressure.  The value T0 should be obtained by reading the resistance of the thermistor inside the piezometer.  Using a digital multimeter set to the '20K-ohm' scale; convert the resistance to temperature, degrees Celsius, using a resistance-temperature chart (or conversion table).  Allow 15 seconds for the multimeter to stabilize.

8.  Install the piezometer in the pipe at the desired installation elevation.  To do this it is best to measure the desired depth to the piezometer tip from the top of the pipe and mark this distance upon the piezometer cable which is then lowered into the hole to the mark.  Record the depth to the piezometer tip from the top of the pipe.  Read F1 of the piezometer at this time.  Read the thermistor also for pipes 23-3 through 23-6, measure and record Tw by reading the resistance of the thermistor and computing the temperature as described in step 7.  The piezometer must be

immersed in water in the pipe for at least 15 minutes before measuring Tw.

9. Compute the piezometer **tip elevation** by subtracting the result obtained in step 8 from the elevation of the top of the uplift pipe.

10. Once the piezometers have been connected to their final switch location, using a digital multimeter place on a '2K ohm' scale, measure and record the resistance of the completed piezometer circuit.

11. Compute Fc = F0 - (C * (Tw-T0)/G)

12. For future computations use this formula:
(Values for T0 and Tw were converted from the table on page 21 for the piezometer manual.

F = (G * (Fc - F1)

Example:

Given: F0 = 9000 T0 = 30
G = 0.10 Tw = 20
C = -0.05

Compute: Fc = F0 - (C * (Tw-T0)/G)

Fc = 9000 - (-.05 * (20 - 30) / 0.1)

Fc = 9000 - (-.05 * (-10) / 0.1)

Fc = 9000 - (.05 / 0.1)

Fc = 9000 - (5)

Fc = 8995 Use this for all future computations.