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RECORD PRINT

INSTRUCTION MANUAL

THE AQUADUCER

HOSE SETTLEMENT GAGE

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Revision ABCDEFGH

Designed and manufactured by

Walter Nold Company
24 Birch Road
Natick, Massachusetts, U.S.A.

Telephone: 617-653-1635

7220-C79-4-1
Pg 1 of 55

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INDEX

7220-C79-4-1

NOTE:

The specific gravity of the ethylene glycol supplied with this Aquaducer apparatus is 1.06446 at 60°F as measured under laboratory conditions using a precision Mettler balance.

7220-C79-4-1

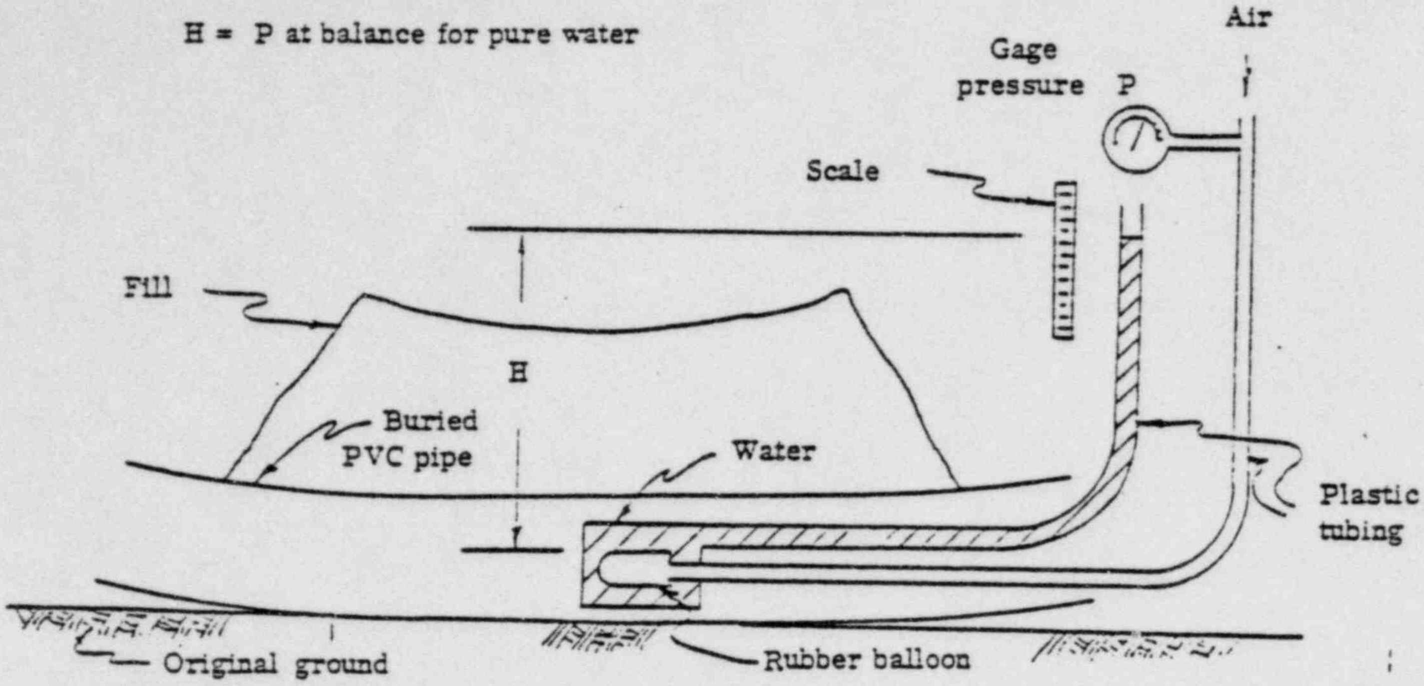


Figure 1

1.0 PRINCIPLE OF OPERATION

1.10 The principle of operation is quite simple, being based upon the achievement of a balance of pressure across a latex rubber balloon which is housed within a movable probe or torpedo.

1.20 In a balanced condition only, assuming the conditions of Figure 1, the dimension of the head of water, the height H, may be read directly on the gage, which is calibrated in inches of water.

7220-C79-4-1

Pg. 4

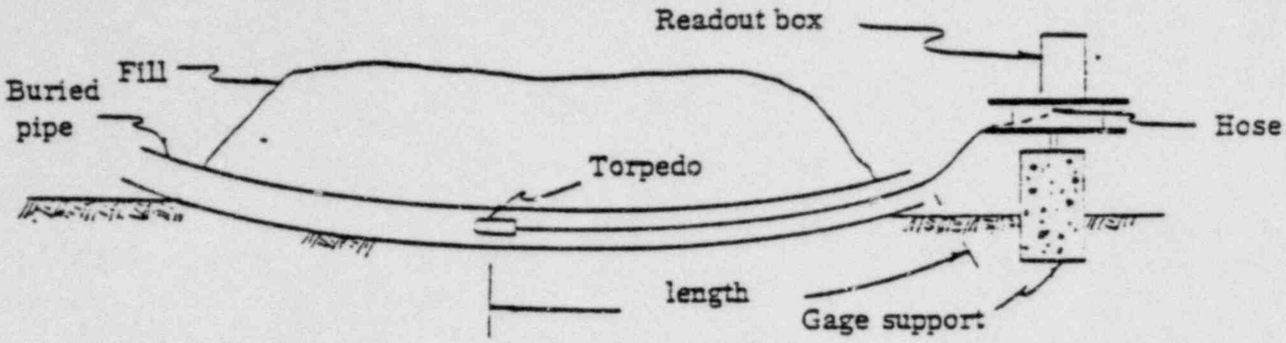


Figure 2

1.30 Referring to Figure 2, the end of the buried PVC pipe serves as the length reference relative to the instrument tubing to be inserted. The readout box, which contains the air pressure gage and the water level scale, is supported by a #7 (7/8" diameter) round steel rod anchored into the ground by means of a concrete block. The top of this bar becomes the surveyed height reference point of the system. By construction, the zero point of the water level scale is at the same level when the readout box is in the monitoring position.

1.40 In operation the torpedo is inserted into the PVC pipe for a length as measured by the hose markers. The upper surface of the fluid is opened to atmospheric pressure and its level adjusted to the zero mark of the scale by means of a manually operated water chamber piston. Through use of a medical type of squeeze bulb, air pressure is introduced into the system, causing the balloon within the torpedo to become inflated and the water level to rise within a standpipe. The water level is adjusted to any point on the scale between 2.5 and 5.0 inches.

1.50 The air-water balance condition exists at 3.7 inches. However, it is necessary only to adjust the level as stated above, which is the linear region of the instrument, and to make compensation for the difference.

1.60 In order to correlate the readings to the reference point of the system, the water level reading is subtracted from the air pressure to determine the height, H. Or:

$$H = P - S \qquad \text{(S = scale reading in inches)}$$

1.70 The specific gravity of anti-freeze solution, if used as the system fluid in place of water, must be divided into the air pressure, since the air gage is calibrated in terms of inches of water; not inches of anti-freeze solution. The terms are thus made compatible. The equation now becomes:

$$H = \frac{P}{\gamma_w} - S \qquad (\gamma_w = \text{fluid density})$$

Refer to Paragraph 15.50 when ethylene glycol is used.

7220-079-4-1

P.5

2.00 INSTALLATION

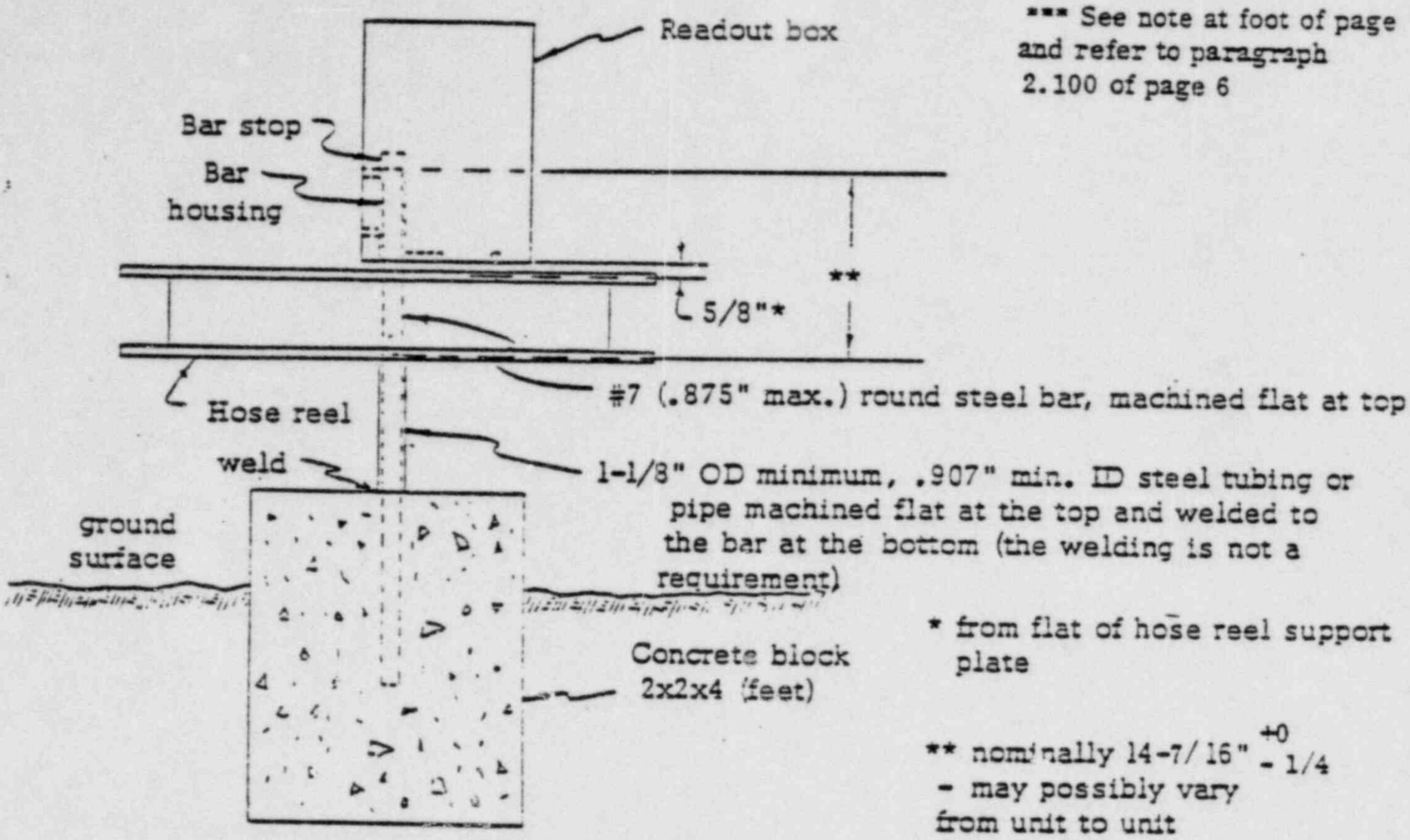


Figure 3

[This section is in outline form and must be adapted to the needs of the project.]

2.10 The following equipment is required:

Rigid grey PVC 1-1/2" diameter schedule 80 pipe in 20 ft. lengths with plain ends.

PVC 1-1/2" diameter schedule 80 socket couplings

PVC solvent, cement, and swab or brush

1/16" galvanized 7x7 wire

Pipe end caps, made from PVC couplings, having one end closed with casting resin

Settlement gage support, as in Figure 3

Trench excavation and compaction equipment

Pipe cutter (Rigid #133 or equivalent)

Level and rod

100 foot survey tape

***NOTE Make sure, with appropriate levelling devices, that the #7 steel bar remains in as vertical a position as possible. Any tilt will result in inaccuracy.

7220-C79-44

pg.6

2.20 Excavate a trench 18" wide and 18" deep. The trench should be as level as possible along its entire length. A folding rule and a hand level are useful for this purpose.

2.30 If necessary, place and compact a 3" layer of fine-grained bedding material.

2.40 Connect up and lay the PVC pipe in the trench. Pull the 1/16" galvanized wire through the pipe using an electrician's snake.

2.50 Construct a settlement gage support as shown in Figure 3. The exact dimension flagged by a double asterisk (**) is dependent upon the width of the hose reel, which may vary widely from unit to unit. For a specific Aquaducer and its mating reel, this dimension should be such that when the assembly is shown as in Figure 3, the readout box should be riding on the top of the support rod with the small 1/2" diameter hose reel pin engaged with sufficient clearance so that the box will turn with the hose reel and the cover to open without interference. In order for this to be accomplished the dimension flagged by a single asterisk would have to be 5/8" as measured from the top of any of the flat plate support arms of the reel to the bottom of the readout box. The actual dimension to be used may possibly be written in pen in the area of the double asterisk. Make sure the #7 bar remains in a true vertical position.

Once this dimension is determined, the bar assemblies could be made in the shop, with the 1-1/8" diameter tubing welded to the #7 rod, prior to embedment in the cement.

The close fitting 1-1/8" OD tubing (#12 B.W. gage wall, .907" ID) may be obtained from Joseph T. Ryerson, Inc., under their listing of Round Mechanical Tubing, Carbon Steel.

Place the settlement gage support at one end of the PVC pipe as shown in Figure 2. If access to the other end of the pipe will not subsequently be available, arrangements must be made to pass the galvanized steel wire over a pulley at that end so that the measuring torpedo can be passed along the whole length of pipe by working from one end only. If the length of PVC pipe is greater than the length of the measuring hose, access must be available from both ends, and two settlement gage supports will be required.

2.60 Cut the ends of the PVC pipe to length. Fit end caps to the pipe. Protect the ends from danger from vandalism.

2.70 Survey, to 0.01 foot accuracy, the elevation of the entire length of the top of the PVC pipe. Measurements should be taken every 5 feet and the positions of the couplings, as well as the total length of the PVC pipe, should be recorded.

7220-C29-4-1 pg.7

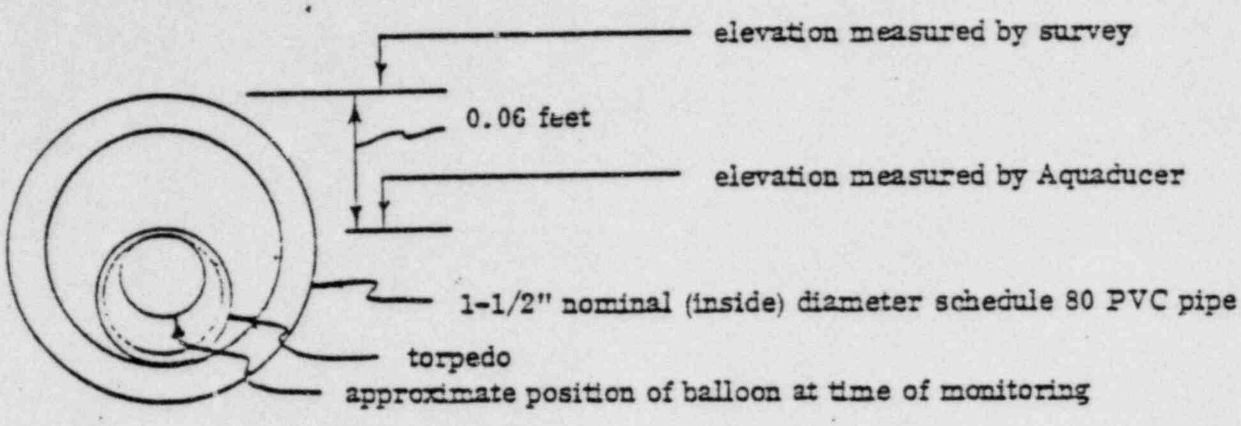


Figure 4

2.80 If the elevations measured by surveying means are used to form the initial set of readings for settlement purposes, an adjustment should be made to put them on the same base as would those taken by the Aquaducer. A value of 0.06 feet should be subtracted from these surveyed readings to make them compatible. This is illustrated in the above Figure 4. However, it would be advisable to make another set of measurements using the Aquaducer to establish a relationship between the two methods.

2.80 If the foregoing measured elevations are used as an initial set of readings for settlement purposes, an adjustment should be made to put them on the same base as the Aquaducer gage readings. A value of 0.06 feet should be subtracted from the survey readings to make them compatible with the hose gage readings. This is illustrated in the above Figure 4. However, it would be advisable to make another set of measurements using the Aquaducer to establish a basis of comparison between the two methods.

2.90 Backfill and compact as appropriate.

2.100 Note. The positioning and design will, of course, depend upon conditions at the site. Minimum requirements are given. The ideal condition would be one whereby the hose reel is about one foot higher in level or elevation than the end of the PVC pipe and yet remain in a comfortable position for the taking of readings. This condition is important enough to build a mock unit (which could later be used as a test stand for the Aquaducer), for accuracy of readings, under certain circumstances is directly related to the relative ease of monitoring.

7320-C79-4-1

3.93

3.00 TAKING SETTLEMENT READINGS

3.10 The following equipment is required:

* = not supplied

Aquaducer readout box
Aquaducer hose and torpedo on the hose reel
Data sheets and clipboard*
Small screwdriver*
A small bubble-type plumb level*
A small funnel and bottle containing system fluid
Thermometer*

3.20 Use the bubble-type plumb level to insure that the 7/8" diameter rod of the monument is truly vertical or plumb insofar as possible. Otherwise all readings will be in error, for the zero reference point of the fluid portion of the system (0" of the eight inch rule mounted on the panel) will not correspond with the surveyed system reference point which is the uppermost part of the 7/8" steel rod. The positioning of the monument, in such an event, must be corrected and re-surveyed before valid readings may take place.

3.30 Lower the reel on the settlement gage support rod (refer to Figure 3), with the small 1/2" diameter pin uppermost, so that it rests on the 1-1/8" diameter sleeve. Lower the readout box fully on to the rod, making sure that it is seated properly with the pin on the hose reel engaged in its mating female opening at the lower part of the instrument. The readout box should be riding on the top of the rod and not resting on the hose reel. There should be about 5/8" of clearance between the bottom of the readout box and the flat supporting arms of the hose reel. In this condition there is sufficient clearance for the cover to open without it contacting the rim of the hose reel. The readout box will now be free to rotate along with the hose reel.

3.40 Open the readout box. Note that the nut portion of the squeeze bulb assembly needs to be only finger-tightened to be leakproof. No further tightness is necessary.

3.50 Open the panel valve (part #104 of Figure 9 of Paragraph 8.2). Open the squeeze bulb valve (106) by turning its knob counter-clockwise. Squeeze the bulb gently two or three times to get the needle of the pressure gage (101) in motion. Note whether or not the needle, when at rest, indicates zero pressure, while making use of the mirror to eliminate the effects of parallax. If a zero condition is not indicated, remove the screw in the glass of the gage (<u>do not lose this item</u>). Adjust, by turning the inner screw, so that a true zero indication exists. Replace the outer screw in the glass.

3.60 Close the squeeze bulb valve (by turning its knob clockwise). By continually squeezing the bulb, pump air into the system until the gage indicates a pressure of from 250" to 280" (almost full scale). Allow the pressure to remain at this level for about a minute by closing the panel valve. (There may or may not be some leakage indicated during this operation, but this is not of any importance.)

1/2" = 12.7 mm   5/8" = 15.9 mm   7/8" = 22.225 mm   1-1/8" = 28.6 mm

250" to 280" of water = 635 to 711 cm of water

7320-C79-4-1

P9.9

3.60 (continued) Open the panel valve. Open the squeeze bulb valve slowly to prevent an abrupt fast return of the gage to a zero reading. Always remember that the gage is an expensive precision instrument and must be treated accordingly. It is never necessary to use the customary tapping of the glass with this type of gage.

3.70 Repeat the foregoing procedure two more times. This operation is called exercising the gage and must be accomplished at the beginning of each day of testing and at least once a month when the instrument is not in use.

3.80 Note the condition of the fluid section of the instrument. The standpipe (114) should be completely filled with fluid. The piston assembly acts as a fluid reservoir and the number of threads of the piston body (120) that are visible when the standpipe is filled is an indication of the amount of fluid which is in reserve. The system requires more fluid when only two or three threads are visible. If an ethylene glycol solution is employed, never add water to the system, or vice versa. This would change the specific gravity of the fluid and thus effect the accuracy.

3.80.10 If filling is necessary, attach the small funnel from the accessory box, to the short section of rubber tubing, which should also be attached to the end of the fluid shutoff valve at the top of the standpipe. Open this valve. Turn the shell of the piston assembly in a clockwise rotation until the fluid starts to appear at the bottom of the funnel. Then fill the funnel with fluid and turn the shell in a counter-clockwise rotation until the fluid reaches the bottom of the funnel. Repeat this operation until the shell can no longer be rotated in the counter-clockwise direction; an indication that the piston is filled. Bleed off a little fluid, using the shell of the piston, until the fluid level in the standpipe can be lowered to the zero level as indicated through use of the standpipe scale.

3.90 Connect the torpedo to the flexible wire leader in the buried PVC pipe and pull the probe to a point which is a little beyond the furthest desired monitoring position. Pull the tubing out of the PVC pipe until the end of the pipe corresponds with the dashed (-) marking of the dual tubes.

3.100 Open all valves; specifically the standpipe valve (110), the air line valve (104), and the squeeze bulb valve (106). Unscrew the shell of the piston assembly until the level of the fluid is at the zero level of the panel-mounted standpipe scale. The zero of the scale should coincide with the lowest part of the formed crescent-shaped meniscus at the air-fluid junction in the standpipe. When ascertaining a reading of the fluid with regard to the scale, the scale marking should be viewed through the transparent standpipe, which may be rotated for best clarity. The viewing angle should be the same for all such readings. The use of a flashlight focused on the scale may aid in taking readings in certain instances.

3.110 Open the panel valve (104) and close the squeeze bulb valve by turning the control knob of the bulb assembly clockwise. With a series of quick short applications of finger pressure on the bulb, build up pressure until the water level starts to rise and then generate more or less pressure as might be required to have the water level come to rest between 3.2 and 4.2 inches as indicated through use of the

7820-C79-4-1 Pg.10

3.110 (continued) standpipe scale. A range of 2.5 to 5 inches may be employed at the sacrifice of a small degree of accuracy. This water-pressure balance requires lots of practice before proficiency is attained. If the needle of the gage does not fall as rapidly as is usual, the panel valve may be closed, and opened only if more air must be vented to bring the level to within the prescribed limits. However the water level must never be allowed to fall during this monitoring stage; otherwise the complete reading cycle must be repeated, including the re-adjusting of the water level in the standpipe to the zero reference. A faster reading may be taken by applying more pressure than might normally be required; taking the chance that the surplus air may be bled off before the water rises above the limits. However, if the limits desired are, say between 3.2 and 4.2 inches, and the level rises above 4.2 inches, the entire test must be repeated. A valid reading may not be taken by allowing the water level to fall. The water level must always be on the rise or in a stabilized condition when readings are taken. Record all of the data sheet figures required, including the ambient temperature, and any further information which might seem pertinent.

3.110.10 Always be on the lookout for air bubbles in the fluid system. If the fluid level ever drops below the bottom of the standpipe, make sure that the crossbar assembly is free of bubbles when the fluid is again forced into the standpipe by working the shell of the piston assembly back and forth. Be equally concerned about the formation of water in the air line. This is more difficult to remove.

3.110.20 It is not always necessary to wait until complete stabilization has occurred. It should be noted that as the water level rises, the air pressure as indicated by the gage falls. This is because the distance between the surveyed point (the top of the steel rod of the monument, which is the level of the zero of the standpipe scale) and a predesignated point within the torpedo is the same as the gage pressure less the standpipe water level reading, in terms of inches (of water), when water is employed as the system fluid. If an ethylene glycol solution is used, for instance, a correction factor must be used to make such indication in terms of inches of ethylene glycol solution, to accomodate the difference in density or specific gravity.

3.110.30 When the system fluid is water and the hose length is 500 feet with a 60°F ambient temperature, the time required to take a complete reading and to move the tubing up to the next monitoring position should be about three minutes. For a hose length of 1200 feet the time required might be six or seven minutes for a settlement of 20 feet or so. The amount of time increases with the length of tubing, amount of settlement, and with lowered temperature.

3.110.40 The best accuracy can be obtained when the outside temperature is roughly the same as the earth temperature (generally 50 to 60°F) with no sun shining. It is always a good policy to take readings with the hose reel and the readout box in the shade and away from the heating effects of the sun, especially in hot days, if accuracy is a requirement. However, with care, the accuracy provided by the Aquaducer is generally far greater than that required for settlement measurements.

3.110.50 Note: When it is desired to drain water from the readout box, upon filling, all that is necessary is to depress the bottom of the male quick-connect fitting (when disconnected from its mating female) with the standpipe valve open. Also it is not necessary to use de-aired water in the readout box, since air bubbles that may form here are easily controlled through standard measuring procedures.

20 ft. = 6.1 m 500 ft = 152.4 m 1200 ft. = 365.8 m 60°F = 15.6°C

7220-279-4-1 11.89

3.120 After the last measurement has been taken for the day, or prior to moving the instrument to the next test location, open the panel valve and standpipe valve. Close the squeeze bulb valve and pump air into the system until a gage reading of 20" of water is indicated. Disconnect the water quick-connect fitting. Turn the shell of the piston assembly until a small drop of water emerges from the end of the standpipe valve, insuring that all air is expelled from the fluid system. Then turn the shell of the piston assembly two half turns in the opposite direction of rotation (counter-clockwise) to introduce a fixed amount of air into the system to allow for expansion. Turn the standpipe valve handle to a downward position to close. Disconnect the air quick-connect fitting. Open the panel valve and the squeeze bulb valve. Close and remove the readout box from the reel assembly. Connect both of the hose fittings to their respective mating fittings mounted on the hose reel. Fasten the torpedo securely on to the hose reel. Remove reel. Secure the plug into the PVC pipe (of the buried piping).

4.00 COMPUTATIONS

4.10 Measure the elevation of the top of the settlement gage support bar (the #7 bar in the sketch, Figure 3), by survey, and enter on the data sheet [a].

4.20 Enter under [b], the specific gravity of the fluid used in the system. If the fluid used is water, the specific gravity will be 1.0.

4.30 Enter under [c], the length of hose within the pipe as measured with the dash (-) mark on the marking aligned with the upper portion of the end of the buried pipe.

4.40 Enter the water level at the standpipe under [d] that exists at the stabilization or balance point. Always measure the water level in the same manner, relating the magnified scale marking to the lowest portion of the water surface.

4.50 Enter the gage pressure existing at the balance point under [e].

4.60 Repeat 4.50 and enter the same pressure under [f] only if water is used for the system fluid. If any other type of fluid is used, divide the gage pressure reading [e] by the specific gravity of the fluid used [b] and enter the result under [f].

4.70 Subtract the standpipe water level reading of [d] from the modified air pressure [f] and enter this figure under [g]. This is the dimension, in inches, which exists between the top of the #7 bar, or from zero of the panel mounted scale, and the torpedo (see Figure 4).

4.80 Divide this dimension [g], in inches, by 12, in order to convert to feet, and enter under [h].

4.90 Subtract this dimension [h] from the elevation [a] to obtain the existing elevation of the probe or torpedo, and enter under [j].

4.100 Enter the original probe elevation under [k]. This column should contain the measurements made under Paragraph 2.70.

4.110 In order to find the settlement, in feet, subtract the existing probe elevation [j] from the original elevation [k]. Enter this figure under [m].

4.120 The figures ascertained may be plotted as shown in Figure 5. (These are typical examples.)

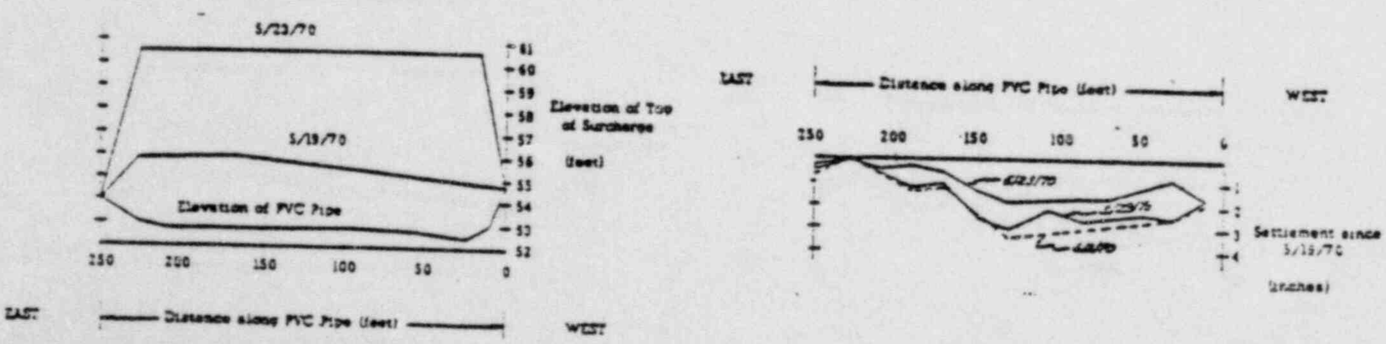


Figure 5

7220-C79-4-1

P.13

Company ______________________ **DATA SHEET FOR AQUADUCER HOSE SETTLEMEN . .GE**

Project ______________________ Line No. ______________________ Date ______________________

Elevation of top of bar [a] ________ feet Ambient Temp. _____ °F Specific Gravity of fluid used in system [b] ________ @ ________ °F

[c] Hose Graduation (feet)	[d] Standpipe Reading (inches)	[e] Air Gage Reading	[f] Modified Air Pressure f = e/b	[g] Dimension Between Scale Zero and Torpedo (inches) g = f - d	[h] Dimension Between Scale Zero and Torpedo (feet) h = g/12	[j] Measured Torpedo Elevation (feet) j = a - h	[k] Original Torpedo Elevation (feet)	[m] Settlement (feet) m = k - j

4-18? TYPICAL DATA SHEET

5.00 EXAMPLE CALCULATIONS

5.10 Assume the following conditions with reference to the data sheet coding:

[a] = 220.2 ft. (Elevation of top of bar or scale zero of instrument)

[b] = 1.038 (Specific gravity of fluid used in system - this corresponds to a 30% mixture of ethylene glycol, by volume, and water at room temperature of 70°F.)

[c] = 120 ft. (Length of hose contained within pipe.)

[d] = 5.2 inches (Standpipe reading - water level)

[e] = 43.70 inches (Air gage reading)

[k] = 217.47 feet (Original torpedo elevation for a hose depth into pipe of 120 ft.)

5.20 Calculation

Modified Air Pressure $f = e/b = 43.70/1.038 = 42.1$

Dimension Between Scale Zero and Torpedo $g = f - d = 42.1 - 5.2 = 36.9$ inches

Same as above only second column $h = g/12 = 36.9/12 = 3.075$ feet

Measured Torpedo Elevation $j = a - h = 220.2 - 3.075 = 217.125$ feet

Settlement $m = k - j = 217.470 - 217.125 = 0.345$ ft.

5.30 Assume the following conditions for a second example:

[a] = 220.2 ft.

[b] = 1.000 (in this case water is used for the system fluid)

[c] = 210 ft.

[d] = 5.4 inches

[e] = 51.0 inches

5.40 Calculation

[f] = 50.8 inches [Note that in this case the gage calibration units are the same units as for the measurement of the water level; viz: inches. For the prior example the gage calibration units were made compatible with the water level units by the division of the gage reading by the specific gravity of the fluid.]

[g] = $f - d = 51.0 - 5.4 = 45.6$ inches

[h] = $g/12 = 45.6/12 = 3.8$ feet

[j] = $a - h = 220.2 - 3.8 = 216.40$ feet

[m] = $k - j = 217.47 - 216.40 = .107$ feet

5.50 If ethylene glycol is used, refer to Paragraph 15.50

6.00 FLUSHING AND REFILLING THE SYSTEM WITH FLUID

6.10 The following procedure is written under the premise that the system to be flushed had been filled with water and not an ethylene glycol solution and that distilled water had been prepared for the refilling. Details are given later in this section for the reverse situation.

6.20 Refer to Figures 6, 7 and 8 on page 14. Figure 6 is an 'O' Ring Screw (1/4-28 Pan Head) and Figure 7 is a Nose Adaptor. Both of these items are supplied in the spare parts kit. Also supplied is a Male Quick-Connect Fitting for allowing a connection to be made to the water line of the tubing. A large glass bottle or jug should be employed and having a sufficient wall thickness to withstand the forces of vacuum. A two gallon bottle is sufficient (eight liters), but one of a small capacity may be employed if necessary. The rubber tubing used should be similar to that employed for the vacuum lines of the DeAerator.

6.30 Set up the system more or less as shown under Figure 8 with the DeAerator at bench level, the hose reel at chair level and the bottle at floor level.

6.40 Remove the thinner-walled rubber tubing from one of the water lines of the DeAerator, and, using silicone grease if necessary as a lubricant, slide the heavier tubing over the fitting. Attach the other end of this (V4) line to the male quick-connect fitting. The V letters signify either valves or tubing clamps as used on the DeAerator tubing. The letter and number also signify a line run.

6.50 Take the torpedo apart. Remove and replace the bladder and its support with the 'O' Ring Screw per Figure 6 to effectively plug up the air line. Put the torpedo back together again replacing the nosepiece of the torpedo with the supplied Figure 7 Nose Adaptor. Complete the system as shown in Figure 8.

6.60 Open V1, on one of the vacuum lines, and close V2 on the second vacuum line of the DeAerator. Insert one end of one of the water lines from the DeAerator into a source of distilled water and open V3 of this line. Close V4, V5 and V6. Start water flowing through the aspirator (refer to DeAerator instruction manual) to create vacuum. Draw water into the DeAerator until the level is 1-1/2 inches lower than the top plate. At this point close V4. Energize the motor of the DeAerator and allow de-aeration to take place for a minimum of ten minutes (or longer if desired for greater purity). At the end of the de-aeration period, shut off the DeAerator power, close V1 and open V5. Allow about five minutes minimum for vacuum to develop in the bottle and then open V2, V4 and V6 in the given order. Water will then start to flow from the DeAerator, through the system hose, and into the bottle. <u>Do not allow the bottle to overflow</u>. In the event that a smaller bottle is employed, V6 should be closed in order that the bottle be drained, and reopened after the vacuum within the bottle is restored. Any bubbles of air that had been contained within the hose will be seen making their way through the tubing and into the bottle. After the contents of the DeAerator have passed through the hose, all of the bubbles should have been removed. If this condition does not exist, the foregoing process must be repeated until the lines are absolutely bubble-free.

1-1/2 inches = 38.1 mm

7220-C79-4.1

P.17

6.70 Empty the DeAerator and repeat the foregoing procedure only this time use the prepared colored distilled water. Continue filling the hose until the colored water starts to drain into the bottle. Make sure that no air bubbles are introduced while making the change to the prepared water. After the filling has been completed close V4, remove V6 tubing from the nose of the torpedo, and lift the torpedo to bench level. Take the torpedo apart and replace the 'O' Ring Adaptor with the bladder assembly that had previously been removed. Reassemble the torpedo except for the nose insert. Open V4 and lower to a level below the hose reel. Hold the torpedo in a vertical position. Air will be expelled from the torpedo and will be displaced by water. While water is flowing out of the nose of the torpedo screw the nose insert into the unit to complete the operation. Bottle some of the remaining water for later use.

6.80 For the readout box, open the standpipe valve and rotate the shell of the piston assembly to its maximum clockwise position. Turn the unit upside down and depress the end of the male quick-connect fitting of the water section. Water will run out of the standpipe valve. Accomplish this operation again several times using clear distilled water for flushing. Flushing water may be introduced into the unit through use of a funnel and tubing and by depressing the end of the quick-connect fitting to vent the trapped air. Flushing should continue until no trace of coloring remains from the solution being removed. Fill with the prepared water after the flushing operation is completed. The water for the readout box does not have to be de-aerated, since it is continually exposed to air or to the atmosphere.

6.90 If the Aquaducer had been filled with water and it is desired to replace this with an ethylene glycol solution, dismantle the torpedo and replace the bladder assembly with the 'O' Ring Screw and reassemble as before but do not use the supplied Nose Adaptor at this time. The torpedo must be open to the atmosphere. Through use of the male quick-connect fitting supplied with the spare parts, connect the hose to a source of compressed air and as much of the water in the hose should be blown out as is possible.

6.90.10 Set up the system as outlined in Figure 8 and repeat the flushing and refilling operation as previously outlined, only use the ethylene glycol solution instead of distilled water. It will be noted that a considerable amount of air is contained relative to water. The ethylene glycol solution must be de-aerated until all of the bubbles are removed. This may require a running time of about one hour instead of ten minutes for water.

6.90.20 For the readout box, remove as much water from the system as is possible by draining and then flush with the ethylene glycol solution several times before filling. Throw away the ethylene glycol solution that had been used for flushing, since it would have become diluted with the water that had remained after draining.

6.100 If the Aquaducer had been filled with ethylene glycol solution and it is desired to replace this with water, the same procedures should be followed as initially outlined in this section for flushing. The system should be flushed until there are no traces whatever of the coloring of the ethylene glycol solution. The distilled water to be employed should be of a different color than that of the ethylene glycol solution for identification purposes.

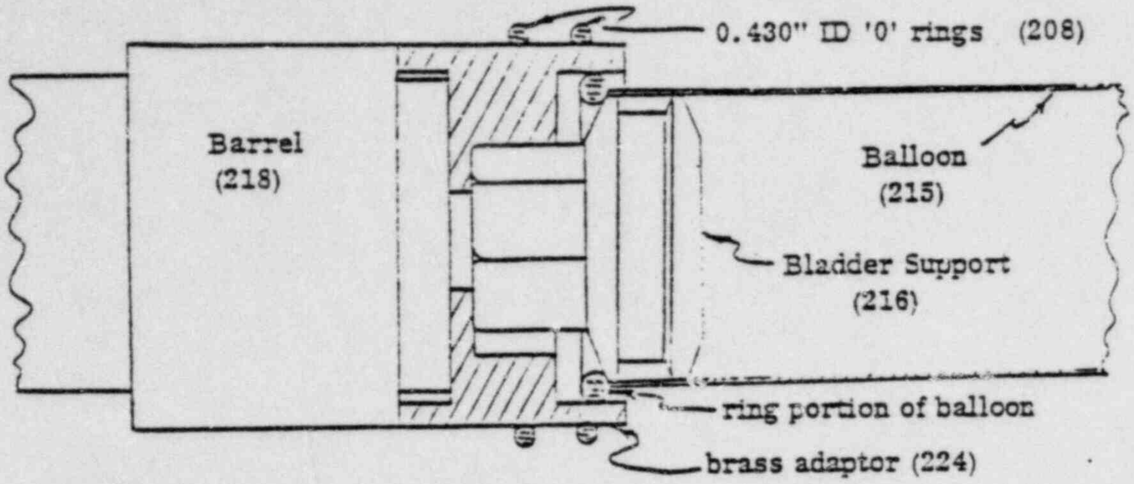


Figure 9

7.00 PROCEDURE FOR CHANGING THE BALLOON

7.10 Refer to Figure 9 above. The balloon, or bladder, the 'O' rings, and the brass adaptor are shown in section form. The adaptor may be found in the spare parts kit, as well as spare balloons and 'O' rings.

7.20 The balloon should be replaced at least once per year. It is assumed in this procedure that the balloon has not been leaking and that the change is being accomplished for reasons of preventative maintenance.

7.30 A portable test station similar to the settlement gage support of Figure 3 should be fabricated. Since it is quite awkward to use the complete system in the laboratory without a stand, a test station such as this will prevent trouble in the form of the readout box crashing to the floor. The bottom of the readout box should be at bench level when mounted on the test stand.

7.40 Remove the hose quick-connect fittings from the hose reel.

7.50 Open the standpipe valve. Connect the hose fittings to their respective mating quick-connect counterparts on the readout box.

7.60 Adjust the water level to a midpoint position in the standpipe. Work the shell of the piston assembly back and forth to remove any trapped bubbles.

7.70 Hold the torpedo vertically, nose upward, at bench level. Remove the threaded nosepiece insert (201). Increase the level of the torpedo to above that of the readout box to allow water contained within the torpedo to flow into the readout box. Adjust the piston assembly to accept this fluid. Close the standpipe valve when the water has emptied from the torpedo, as can be noted by an air-lock appearing in the water tubing.

7220-070-4-1

Pg. 19

7.80 Remove the setscrews holding the barrel (218) and the tailpiece (220) in position within the torpedo case. Pull on the hose to remove these parts.

7.90 Remove and discard the old balloon. Save the 0.430" ID 'O' rings. Remove the bladder support (216). Remove its small 'O' ring (217) and store the rings in a clean dust-free place.

7.100 Referring to Figure 11, connect the brass adaptor (224) in the position shown by screwing the threaded portion of the bladder support into the barrel.

7.110 Hook a portion of one of the 0.430" ID 'O' rings (225) over the bladder support and stretch it until it is possible to encompass the diameter of the adaptor as shown. Roll the 'O' ring back on to the barrel.. Repeat this procedure for the second 'O' ring.

7.120 Remove the bladder support and cover it with the end of the balloon. Holding the brass adaptor against the barrel with one hand, attach the bladder support to the barrel again so that the balloon will be in the position shown.

7.130 Work the balloon with the fingers until it is in line with the axis of the barrel.

7.140 Position both 'O' rings on the outside diameter of the brass adaptor by sliding them forward towards the balloon end of the assembly. By means of sliding the 'O' rings, make sure that they are both free of twists and are uniformly placed in position. With the balloon properly located, slide the first 'O' ring forward until it snaps off of the adaptor and on to the bladder support, thus holding the balloon in position. Do likewise with the second 'O' ring.

7.150 Unscrew the balloon assembly. Work the 'O' rings with the fingers, if necessary, until the are evenly placed within the groove of the bladder support.

7.160 Cut off the ringed portion of the balloon with a pair of small fingernail scissors.

7.170 Make sure that the small 'O' ring removed from the bladder support in the Paragraph 7.90 operation is perfectly clean. Place this 'O' ring on the bladder support and screw this assembly into the barrel. Store the brass adaptor in the spare parts kit.

7.180 Tighten the bladder support by means of an open-ended wrench. Tighten only to a snug fit.

7.190 Slide the tailpiece of the torpedo back on to the hose about eight inches. If this is difficult to accomplish, place some silicone grease on the hoses and then slide back the tailpiece.

7.200 Make sure the 'O' ring (209) is lying flat and in position against the stainless steel sleeve (206) within the torpedo. If this is so, slide the barrel into the the torpedo case.

7230-C20-4-1 p.20

7.210 With the nose of the torpedo against a surface of the workbench and pressure exerted against the hose end of the barrel to compress the 'O' rings (using a long screwdriver bearing against the flat portion of the barrel and not on the tubing fittings), insert and tighten the setscrews holding the barrel in position. Bear in mind that only moderatre pressure or torque is necessary when tightening the setscrews. Too much torque will strip the threads of the somewhat thin walls of the case.

7.220 Slide the tailpiece back over the tubing, set into the torpedo in position and insert the setscrews as required.

7.230 Hold the torpedo in a vertical position at bench level. Open the standpipe valve. Manipulate the level of the torpedo while maintaining the vertical positioning with the nose uppermost to control the flow of water from the readout box. The piston assembly should also be brought into play in order to replenish the supply of water from time to time, as indicated by the standpipe. It may become necessary to introduce more water through the standpipe valve. This procedure is outlined on page 8.

7.240 Allow a small stream of water to flow out of the nosepiece until no bubbles are present. While the cavity at the nose is still filled with water, screw in the nosepiece insert along with its small 'O' ring. The 'O' ring must be clean.

7.250 Turn the torpedo upside-down in a vertical position and look for the presence of bubbles in the water hose. If none, the changing operation has been accomplished in good order.

7.260 Connect the air quick-connect fitting to its counterpart at the readout box and open the panel and the squeeze bulb valves.

7.270 Follow the steps of Paragraph 3.120 on page 10 to complete the operation.

7.280 In the event of a leaking balloon, it becomes necessary to purge the air hose line of trapped water. A quick-connect fitting is provided in the spare parts kit to enable a connection to be made to the necessary supply of purging compressed air.

7.290 Follow the steps of Paragraphs 7.10 through 7.160

7.300 Connect the air line quick-connect fitting to a source of compressed air and completely blow out any and all water in the line. Dry nitrogen might be superior for this purpose if such is available.

7.310 Follow the procedure of Paragraphs 7.170 through 7.270 to complete the operation.

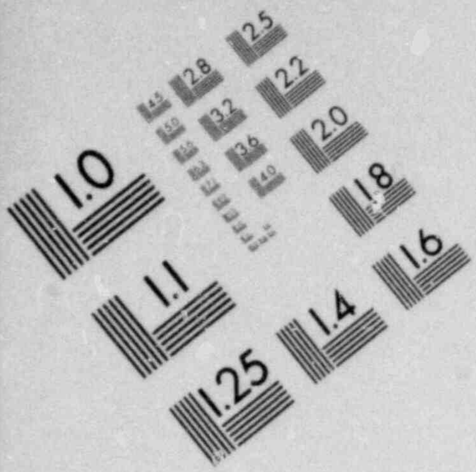
7220-C70-4-1

F-9.21

IMAGE EVALUATION
TEST TARGET (MT-3)

6"

MICROCOPY RESOLUTION TEST CHART



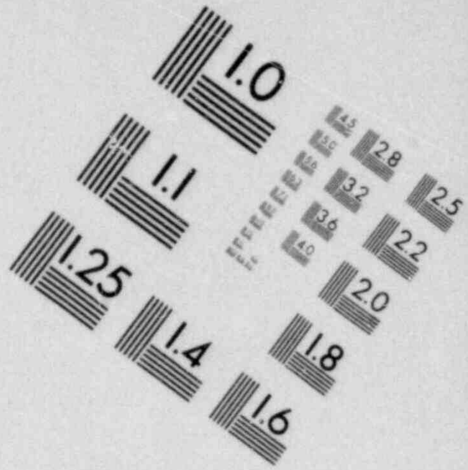
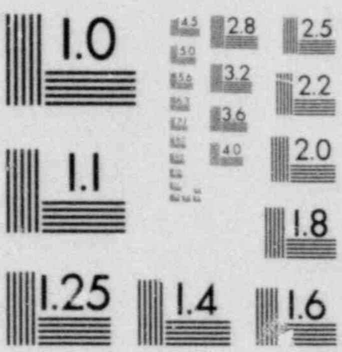
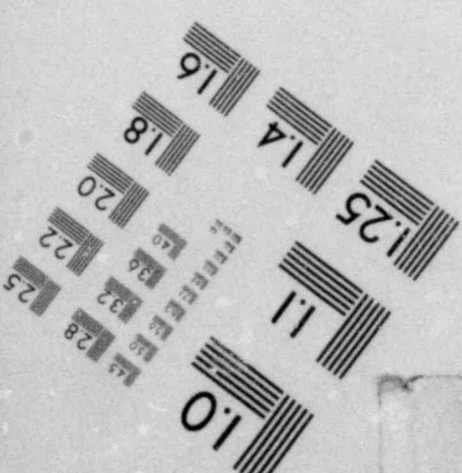


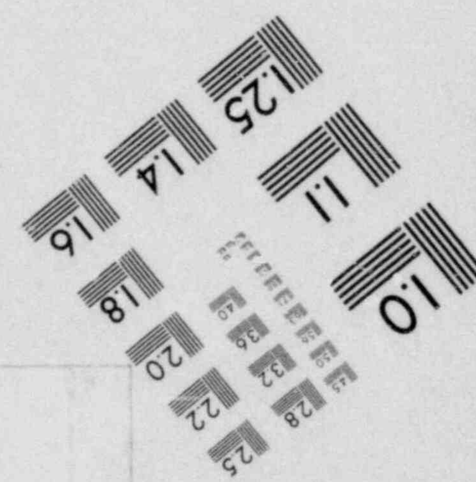
IMAGE EVALUATION TEST TARGET (MT-3)



6″

MICROCOPY RESOLUTION TEST CHART





8.00 LISTING OF PERTINENT PARTS

8.10 Torpedo

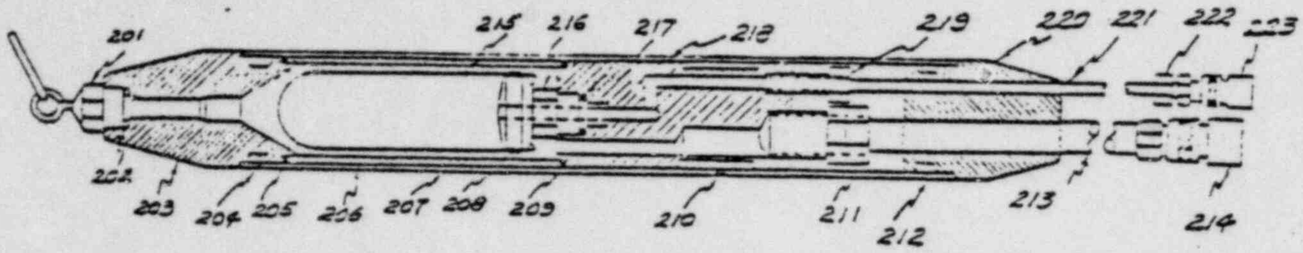


Figure 10

201	Nosepiece threaded insert
202	Nosepiece insert 'O' ring - two required in all
203	Nosepiece
204	Nosepiece 'O' ring
205	Setscrew - nine required total
206	Shell
207	Tubing
208	Bladder support 'O' ring, large, two required
209	Shell 'O' ring; same as 204
210	Setscrew - same as 205
211	Torpedo water line hose fitting
212	Setscrew - same as 205
213	Water line hose
214	Water line hose quick-connect fitting - female
215	Bladder
216	Bladder support
217	Bladder support 'O' ring - same as 202
218	Barrel
219	Torpedo air line hose fitting
220	Tailpiece
221	Air line hose
222	Air line hose to quick-connect adaptor fitting
223	Air line quick-connect fitting - female
224	Adaptor, bladder support - used only for installing 'O' rings, part 208

Note: Some earlier models employ a spacer which exists within the tubing 207 and positioned between the nosepiece and the shell. The need for this part no longer exists.

7220-C70-4-1

pg. 22

8.20 Readout box panel

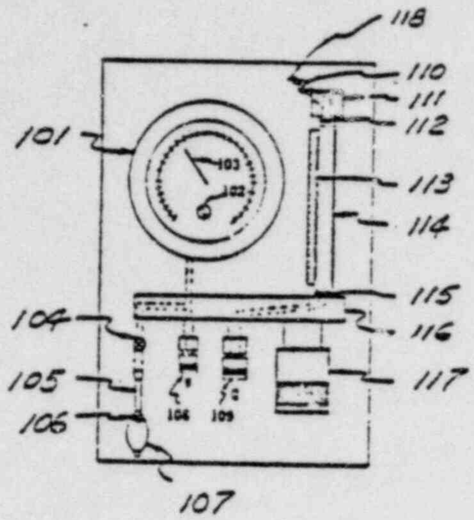


Figure 11

101 Air pressure gage
102 Gage zero adjust plug
103 Gage needle
104 Panel air valve
105 Squeeze bulb hose
106 Squeeze bulb valve
107 Squeeze bulb
108 Air line hose quick-connect fitting - male
109 Water line hose quick-connect fitting - male
110 Standpipe valve
111 Standpipe support
112 Standpipe 'O' ring - two required
113 Standpipe stainless steel scale
114 Standpipe
115 Standpipe 'O' ring - same as 112
116 Junction bar assembly
117 Water chamber piston assembly (see Paragraph 8.3)
118 Barbed water filling fitting (not permanently attached)

8.3 Water chamber piston assembly

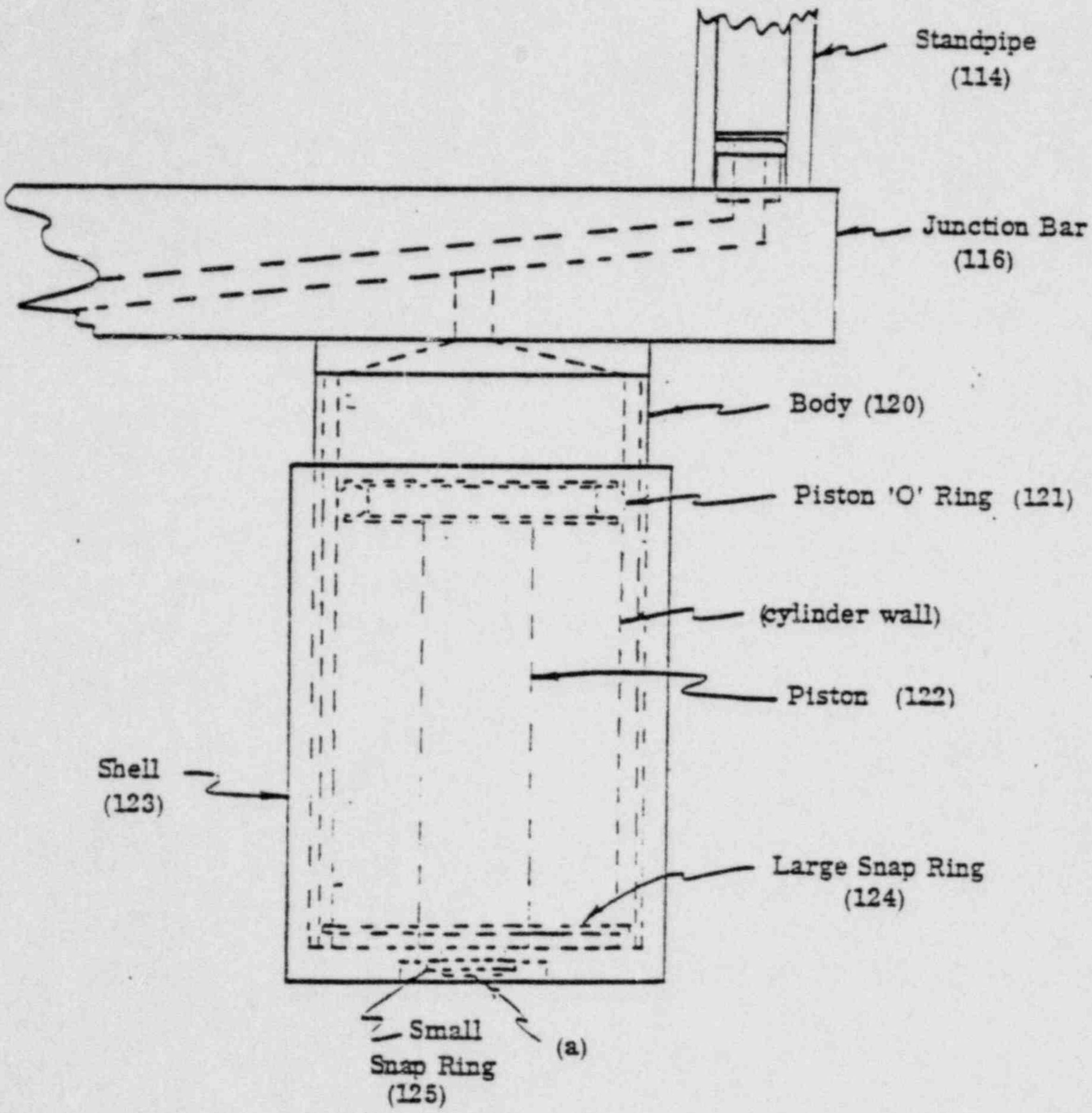


Figure 11A

7220-020-4-1

pg. 24

8.40 Readout Box Air System

8.50 As of January 1974, all Aquaducers utilize a pneumatic system connected by means of 1/8" OD soft copper tubing. This tubing is soldered whenever feasible. Otherwise the best possible line of fittings (Swagelok type, manufactured by the Crawford Fitting Company [USA]) are employed to minimize air leakage.

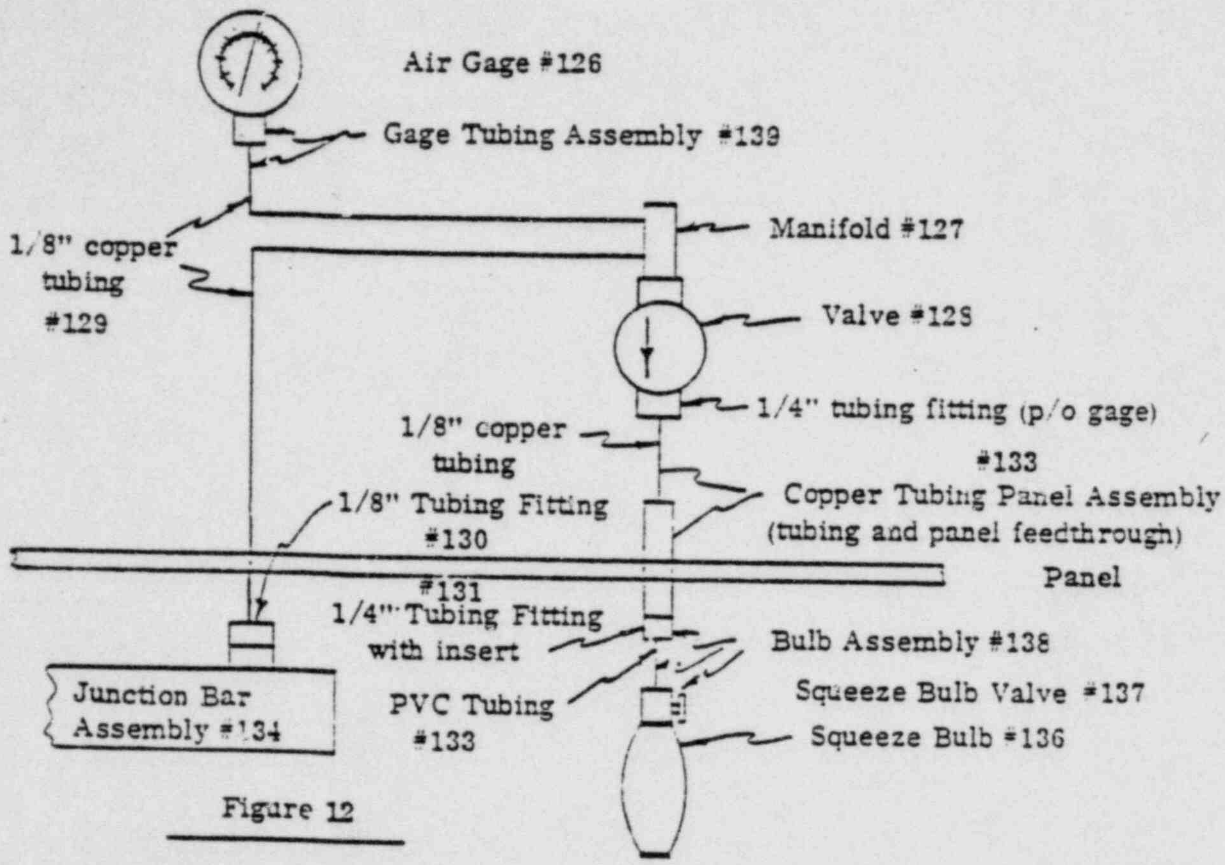


Figure 12

8.60 Parts Listing

Valve	Nupro 'tee' type B-4J-PM or right angle type B-4JA-PM
PVC Tubing	1/4" OD, 1/8" ID, clear flexible PVC tubing
Squeeze Bulb Valve	Propper type V301
Bulb	Bulb for above

8.70 It is best to order parts from the manufacturer as noted above, especially the Bulb Assembly #138. To assemble this unit it is necessary to obtain many varied parts. In addition a certain skill is required for assembly requiring special chemicals not ordinarily available.

B20-C70-4-1

F9.25

9.00 THE AIR PRESSURE GAGE

9.10 The air pressure gage used in the Aquaducer is a product of the Wallace & Tiernan Company of Belleville, New Jersey. It is their Series 1000 Model 62B-2C-0280 precision gage of a two scale type having a 0-280 inches of water calibration.

9.20 The balance of this section, to save space, has been typed directly from the instruction manual.

Installation

The instrument should be protected from shock and vibration. In some cases it may be necessary to provide shock mounted panels.

Operation

Exercising Before the instrument is used for precise measurements, it should be exercised by alternately increasing and decreasing the applied pressure over the entire range of the instrument at least 3 times. Maximum and minimum pressures should be held for 2 minute periods.

Readings Unless otherwise noted, the instrument is calibrated to be read with the dial in the vertical position. When the instrument has a mirror on the dial, the pointer and its image should coincide so that only the pointer may be seen. On two revolution instruments, an indicator shows the portion of the scale to be read.

All W&T instruments are calibrated on increasing pressure. To avoid any effect of hysteresis, readings should be taken on increasing pressure. Instruments are calibrated at 25° C. Unless wide temperature changes are experienced, the effect of temperature may be neglected. For further discussion, see "Calibration Check".

Precautions No instrument should be subjected to pressures beyond its range. Excessive pressure may distort the mechanism. Be sure all necessary pressure relief devices are installed. The maximum working pressure for the instrument is noted on the dial. [Note: the red plastic plug at the read of the instrument is a pressure snubber and has a small hole at its center which must be kept clear from dust.]

Maintenance

Filter Each instrument is furnished with a filter screwed into the pressure connection. The filter screen mau occasionally require cleaning. This may be done as follows:
1) Unscrew the filter plug by means of a screwdriver.
2) Clean the filter with trichlorethylene or other suitable solvent and moisten with oil. Remove excess oil and replace the filter. Do not use oil if the gage is used with fluids which may react with oil.

Lubrication The mechanism does not require oil. The oil will interfere with proper functioning and introduce serious errors. Do not oil the mechanism.

Performance Capability

Accuracy: 0.1% FS Sensitivity: 0.01% FS Hysteresis: 0.1% FS Max. Temp. Effect: 0.1% FS/10°C from 25°C

NOTE: %FS (full scale). "Full scale" is the difference between minimum and maximum dial reading. "Full scale" of an instrument with a calibrated range of 280 inches of water means the percentage applies to the 280 figure.

7220-070-44 pp.26

Calibration Check [Part of Para. 9.20]

It should be noted that the accuracy tolerance is the same at all points on the scale. Therefore, the pointer of a gage pressure instrument is not necessarily at an exact zero when the instrument is shipped from the factory. However, the deviation is never outside the guaranteed accuracy as shown in the table "Performance Capability".

A label affixed to the case indicates the deviation from zero when the instrument was adjusted to attain optimum accuracy over the full scale. This figure was obtained after the instrument was exercised as described under "Operation".

If, after the instrument has been exercised, the pointer deviation is as specified, no adjustment is necessary. A slight discrepancy may be corrected by adjusting the pointer as described below. [Note:- see paragraphs 3.50, 3.90 re zero position of pointer.]

A complete check of calibration of an instrument requires that it be exercised as above and compared with a standard having a verified accuracy at least five times greater and a scale comparable in length to the instrument being checked. The standard must be corrected for all its inherent errors and must be corrected to standard conditions of gravity (980.665 cm/sec^2) and temperature (0° C for mercury columns or 20° C for water columns) where applicable.

While aneroid instruments are not subject to changes in reading due to gravity, they are affected by temperature. W&T instruments read directly in terms of standard conditions (see preceding paragraph) at the temperature 25° C unless otherwise indicated. If the calibration check is conducted at 25°C, the effect of temperature on the W&T instrument need not be considered. At any other temperature, the temperature effect listed in the table "Performance Capability" must be considered. Note that this is not a correction factor but, rather, a tolerance that must be added to other tolerances being checked. When readings are taken on increasing pressures, they should fall within the specified accuracy tolerance given in the table. The difference between the up-scale reading and the down-scale reading is the hysteresis error and should fall within the specified limits.

Setting the Pointer. If a calibration check shows the readings on increasing pressures at various points over the entire range are out by the same angular distance, the pointer may be reset. Adjustment is limited to a pointer movement of about 10°.

Access to the pointer adjustment screw is obtained by removing a plug in the glass. The screw is flush with the face of the dial.

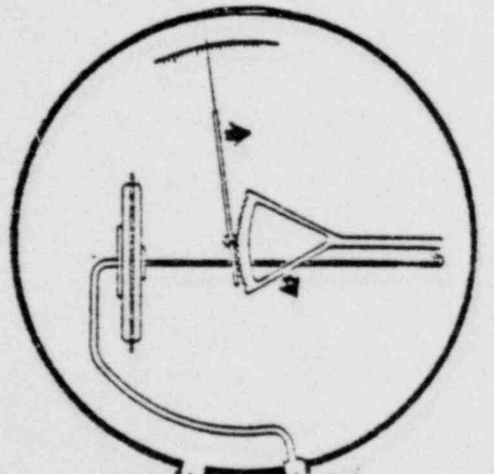


Figure 13

7330-C20-4-1

10.00 PREPARATION OF DE-AIRED WATER

10.10 The following is required:

Nold DeAerator, eight liter capacity
Distilled water, eight liters minimum
20 liter (5 gallon) container

10.20 The following material may be used if desired:

Liquid food coloring, or fountain pen ink
Hyamine 3500 germicide concentrate 50% by Rohm and Hass, Independence Mall West, Philadelphia, Pa. 19105

10.30 The germicide listed above is to be used only when the water is going to be left in the hose for extremely long periods of time (which is not recommended) or when growths in the water line are noted. It should be used sparingly, in the order of 10 drops from a standard American type medicine dropper, or 0.5 cc for each eight liters of water.

10.40 If ethylene glycol is normally used, the color of this prepared water should be of another color. Food coloring may be employed, but fountain pen ink is usually superior. If the former is employed, it must be dissolved in a small bit of warm water and then strained through filter paper, or many layers of cloth, to separate the dissolved from the undissolved dye. Much of either type of dye is required to arrive at a deep color.

10.50 De-aerate the colored solution in accordance with the DeAerator Instruction Manual. The water should be de-aired for a minimum of 15 minutes, but the longer the period of time employed the greater the purity. A running time of 15 minutes would produce about a 0.4 PPM DO purity. Another 15 minutes would lower this somewhat to about 0.2 PPM. If time is of no particular importance, allow it to run until no more bubbles are noted.

10.60 No additive should be added to the solution unless one is positive as to the results to be expected. This includes corrosion inhibitors, silicones, etc.

10.70 It is not necessary to prepare any more water than is necessary to accomplish the filling or flushing of the Aquaducer hose and to have on hand for possible replenishing the readout box as required. Water for the readout box does not need to be de-aired.

11.00 PREPARATION OF ANTI-FREEZE SOLUTION

11.10 Water is recommended as fluid for the DeAerator. However, if protection against freezing conditions is required, one of the six ethylene glycol concentrations listed at the foot of page 28 should be selected. It is advisable to choose the one which contains the least amount of ethylene glycol and yet accomplish the purpose.

11.20 Ethylene glycol of the automotive grade should not be employed unless it can be proven that silicone oil or anti-leak additives are not contained. The following brands have been investigated and found suitable for use:

Pahnol	Security
Wintrex	Eskimo
Telar	

The above are brands that are marketed in the United States. They contain bacterial growth and corrosion inhibitors as well as coloring dye. No further additive is required.

11.30 The mixing of the ethylene glycol with distilled water should be accomplished under laboratory conditions to approximate the figures listed under Section 12 as closely as possible. Mixing may be accomplished either by weight or by volume. Temperature is also a factor which must be considered in the mixing.

11.40 About 16 liters of the ethylene glycol solution should be made up at a time. After mixing the solution should be tested for specific gravity as outlined in Section 13, page 30. Storage bottles should be carefully labelled with all pertinent information contained.

11.50 The solution shou d now be de-aired in accordance with procedures outlined in the DeAerator .nstruction Manual.

11.60 The solution shall be de-aired in the DeAerator until all of the bubbles are removed with the unit still running. This may require a period of time of one hour.

7220-C70-4-1   p9.29

12.00 PROPERTIES OF ETHYLENE GLYCOL CONCENTRATIONS IN WATER

12.10 Temperature vs. Specific Gravity (Temperature in degrees Farenheit)

	%by weight		0	10	20	30	40	50	60
Temp.	% by volume		(water)	9.1	18.4	28.0	37.8	47.8	58.0
-50	-	-	-	-	-	-	-	-	1.110
-45	-	-	-	-	-	-	-	-	1.109
-40	-	-	-	-	-	-	-	-	1.108
-35	-	-	-	-	-	-	-	-	1.1065
-30	-	-	-	-	-	-	-	1.087	1.105
-25	-	-	-	-	-	-	-	1.0865	1.104
-20	-	-	-	-	-	-	-	1.086	1.103
-15	-	-	-	-	-	-	-	1.085	1.1015
-10	-	-	-	-	-	-	1.068	1.084	1.100
-5	-	-	-	-	-	-	1.067	1.08[illegible]	1.0985
0	-	-	-	-	-	-	1.066	1.082	1.097
5	-	-	-	-	-	-	1.065	1.081	1.096
10	-	-	-	-	-	1.048	1.064	1.080	1.095
15	-	-	-	-	-	1.0475	1.0635	1.0785	1.0935
20	-	-	-	-	1.031	1.047	1.063	1.077	1.092
25	-	-	-	-	1.0305	1.046	1.062	1.076	1.0905
30	-	-	-	1.015	1.030	1.045	1.061	1.075	1.089
35	-	-	1.000	1.0145	1.0295	1.0445	1.060	1.074	1.0875
40	-	-	1.000	1.014	1.029	1.044	1.059	1.073	1.086
45	-	-	1.000	1.0135	1.028	1.043	1.0575	1.0715	1.0845
50	-	-	1.000	1.013	1.027	1.042	1.056	1.070	1.083
55	-	-	.9995	1.0125	1.0265	1.041	1.055	1.0685	1.0815
60	-	-	.999	1.012	1.026	1.040	1.054	1.067	1.080
65	-	-	.9985	1.0115	1.025	1.039	1.0525	1.0655	1.078
70	-	-	.998	1.011	1.024	1.038	1.051	1.064	1.076
75	-	-	.9975	1.010	1.023	1.0365	1.050	1.0625	1.0745
80	-	-	.997	1.009	1.022	1.035	1.049	1.061	1.073

12.20	Freezing point (^{o}F)	32	26	17	5	-11	-32	-54

7220-020-4-1

79.20

12.30 In practice it is seldom possible to make up anti-freeze mixtures to exactly match those listed on the chart of page 28; at least to the exact specific gravity desired. For instance, it was desired to obtain a -11°F freeze point mixture. By using a 500 cc volumetric flask and a Mettler balance capable of measuring to hundredths of grams, the specific gravity was found to be 1.0555 at 65°F instead of the targeted 1.0525.

12.40 A new chart, listed under the following paragraph, was made up specifically for this solution, in increments of one degree in order to obtain the maximum accuracy from the Aquaducer under cold-weather conditions. It can be observed from the chart of page 28 that the specific gravity of the 50% concentration changes 0.0002 per degree Farenheit for the -10 to +10, 20 to 40, 50 to 60, 70 to 80 (and, extrapolating to 90 to 100) temperature segments. The other regions, 10 to 20, 40 to 50, 60 to 70 (and, extrapolating to 80 to 90, and 100 to 110) represent a specific gravity change of 0.0003 per degree. Starting with a solution having a specific gravity of 1.0555 at 65°F, the following chart reflects these changes.

Temp.	S. G.	Temp.	S. G.	Temp.	S. G.	Temp.	S. G.	Temp.	S. G.
-10	1.0730	10	1.0690	30	1.0640	50	1.0590	70	1.0540
-9	1.0728	11	1.0687	31	1.0638	51	1.0588	71	1.0538
-8	1.0726	12	1.0684	32	1.0636	52	1.0586	72	1.0536
-7	1.0724	13	1.0681	33	1.0634	53	1.0584	73	1.0534
-6	1.0722	14	1.0678	34	1.0632	54	1.0582	74	1.0532
-5	1.0720	15	1.0675	35	1.0630	55	1.0580	75	1.0530
-4	1.0718	16	1.0672	36	1.0628	56	1.0578	76	1.0528
-3	1.0716	17	1.0669	37	1.0626	57	1.0576	77	1.0526
-2	1.0714	18	1.0666	38	1.0624	58	1.0574	78	1.0524
-1	1.0712	19	1.0663	39	1.0622	59	1.0572	79	1.0522
0	1.0710	20	1.0660	40	1.0620	60	1.0570	80	1.0520
1	1.0708	21	1.0658	41	1.0617	61	1.0567	81	1.0517
2	1.0706	22	1.0656	42	1.0614	62	1.0564	82	1.0514
3	1.0704	23	1.0654	43	1.0611	63	1.0561	83	1.0511
4	1.0702	24	1.0652	44	1.0608	64	1.0558	84	1.0508
5	1.0700	25	1.0650	45	1.0605	65	1.0555	85	1.0505
6	1.0698	26	1.0648	46	1.0602	66	1.0552	86	1.0502
7	1.0696	27	1.0646	47	1.0599	67	1.0549	87	1.0499
8	1.0694	28	1.0644	48	1.0596	68	1.0546	88	1.0496
9	1.0692	29	1.0642	49	1.0593	69	1.0543	89	1.0493

12.50 A chart such as the above should be made up for each new batch of anti-freeze solution to be used with the Aquaducer. That is, if the resulting accuracy is required.

12.60 The ethylene glycol solution shipped with the Aquaducer is sometimes contained in plastic bottles in which anti-freeze of other makers, such as DuPont Prestone, was originally contained. This is done to allow identification of the contents by transportation concerns. Cans, once opened, cannot be resealed.

13.00 CALCULATION OF SPECIFIC GRAVITY

13.10 The accuracy of the calculation of this factor is dependent upon the technique of the laboratory technician and the accuracy of the weighing balances.

13.20 The balance to be employed should have a sensitivity of at least 0.1 grams at a capacity of 1250 grams. A volumetric flask is required having a capacity of 1000 cc or one liter.

13.30 The measurement should occur when the solution is in a temperature stabilized condition. Measure and record the temperature of the mixture.

13.40 Weigh the volumetric flask. Record the weight.

13.50 Pour exactly 1000 cc of the ethylene glycol solution as described in Section 11 into the volumetric flask. Weigh. From this subtract the weight of the flask. The difference is the weight of the contained solution. Record the weight in grams.

13.60 Divide the weight of 1000 cc of the solution, in grams, by 1000 (the weight of water) to obtain the specific gravity in terms of grams per cc. Make sure that the specific gravity and the temperature of the solution at the time of testing is written on each bottle which is to contain the mixture. Enter this data in pertinent record or data sheets.

13.70 Another method, although not recommended, would be to use any light weight bottle having a narrow neck and a capacity of about one quart or liter. Scratch a mark somewhere on the neck of the bottle. Weigh the bottle in its empty and dry condition and record the weight. Fill the bottle with the solution to be tested up to the scratch mark, being as exact as possible. Weigh. Subtract from this weight that of the empty bottle to find the weight of the contents.

Empty the bottle and thoroughly rinse with water. Fill the bottle with water up to the scratch mark, as exact as before, and weigh. Subtract the weight of the empty bottle to find the weight of the water.

Divide the weight of the ethylene glycol mixture obtained in the first paragraph by the weight of the water of equal volume as per the second paragraph. The resultant figure will be the specific gravity of the solution in the same terms: grams per cc.

14.00 FACTORS WHICH RELATE TO ACCURACY

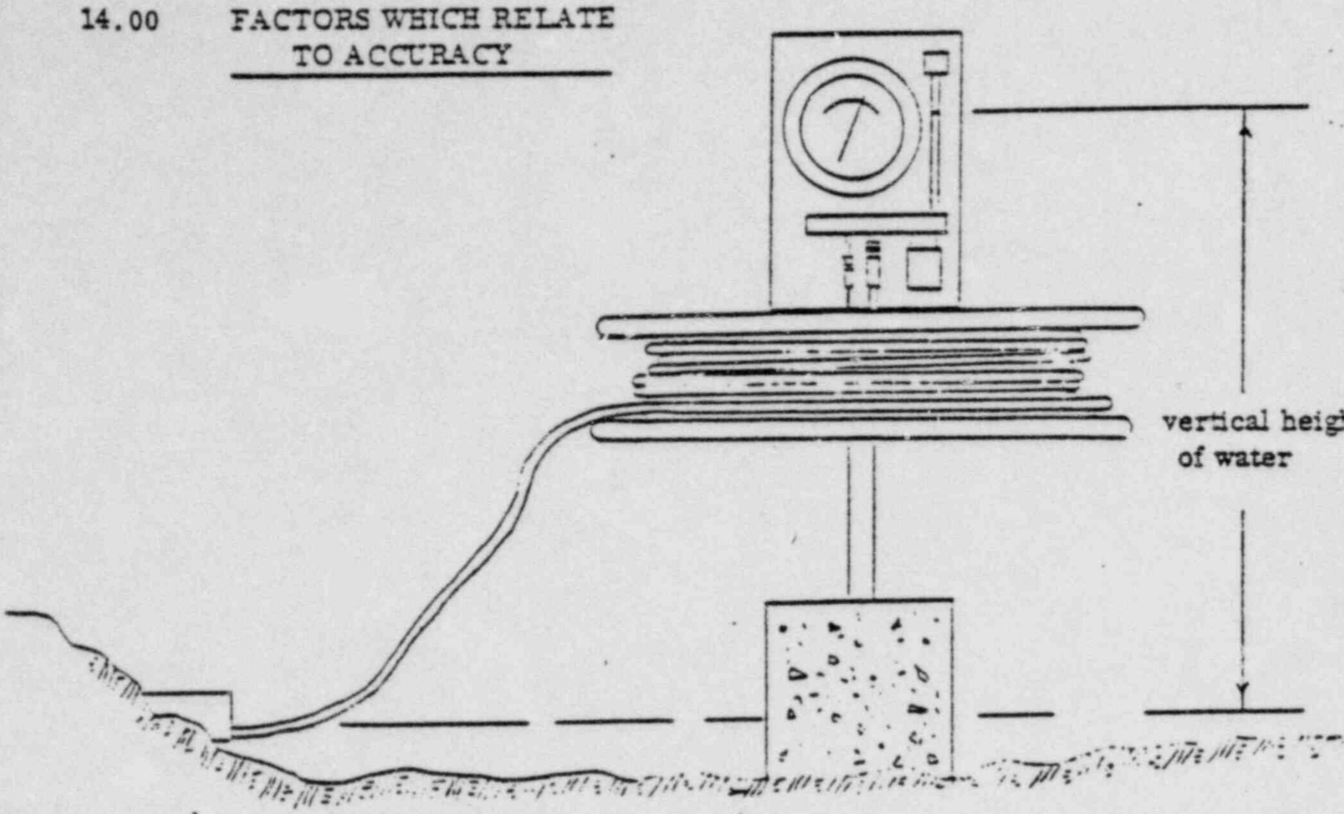


Figure 14

14.10 Referring to Figure 14, any air bubbles occurring in the vertical component of the water line would effect the vertical head of water. This would mean mainly the hose from the buried pipe to the reel, and the vertical section from the reel to the upper water level within the standpipe. A bubble one inch in length in a vertical part of the hose would cause a system error of one inch.

14.20 Air bubbles existing in the horizontal component of the water system would have little effect on the accuracy as such. However, a large quantity of air might make the achievement of a balance difficult.

14.30 The specific gravity [density, or weight per unit volume] of the system fluid can be a significant factor influencing the overall accuracy, since it changes with temperature. Such change will have an effect of the weight of fluid impressed upon the bladder within the torpedo and subsequently the amount of air pressure generated.

14.40 If water is used as the system fluid, specific gravity will have no effect whatever as long as its temperature remains between 33° and 50°F. Referring to the chart of Section 12, the specific gravity remains constant between these limits, but at 80°F there is a change from 1.000 to .997. If no compensation were made for temperature, and the temperature of the system fluid was 80°F, the reading or calculation, due to this effect, would be .186" higher than the one taken with the fluid under 50°F.

7220-C20-4-1 Pg.33

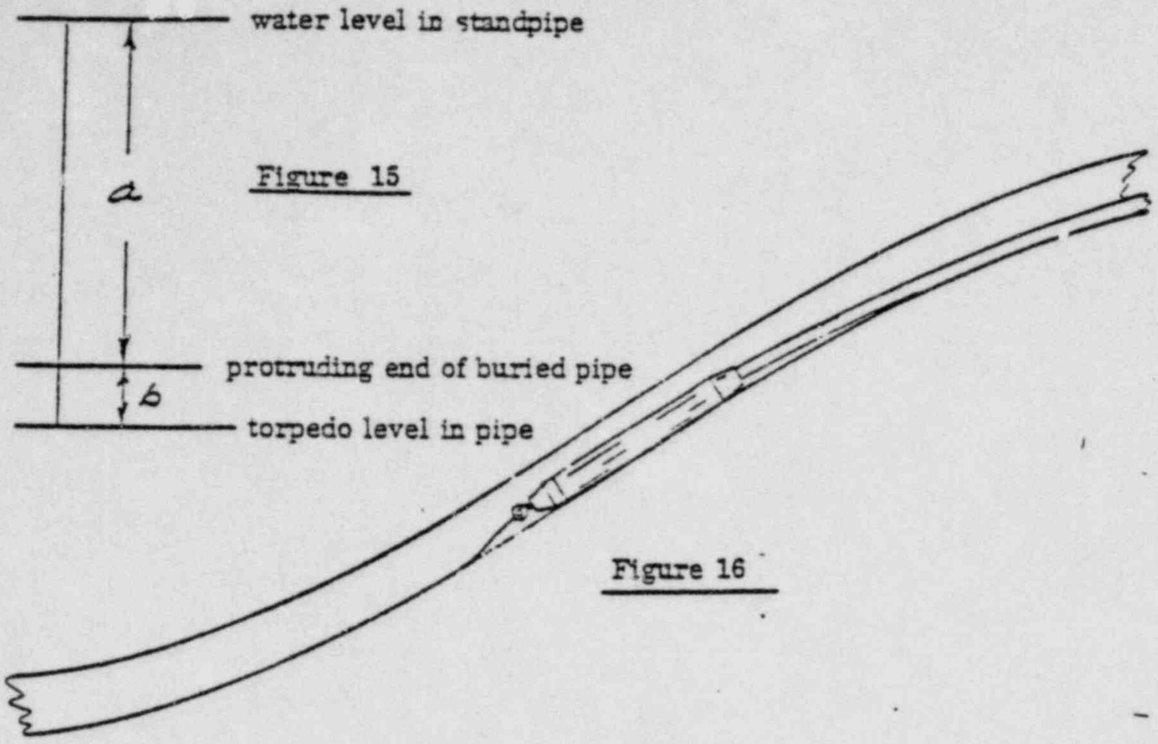


Figure 15

Figure 16

14.50	Example with given factors:	Data sheet entry of a Specific Gravity of 1.039 at 65°F (This would be a 30% concentration of ethylene glycol in water) No temperature compensation #1 reading taken with fluid temperature at 30°F #2 reading taken with fluid temperature at 80°F

Under the above stated conditions #1 reading would be too low by .277" and #2 reading would be too high by .186" .

14.60 It is the vertical component of the water system which is a large factor relating to accuracy under changing temperature conditions. This is outlined in Figure 15, which pictures the vertical component exposed to atmo-pheric changes [a], and in Figure 16, which compares the extent of this with that existing in the buried pipe [b]. As long as there is a difference of the temperature of the fluid in the hose within the pipe [b] and that exposed to the atmosphere [a], an effect on the accuracy will result.

14.70 Figure 13 ..ows a torpedo in a measuring position in a section of buried pipe which dips in a abrupt manner. Under such a condition, any variation in the length of hose within the pipe over that of the previous measurement would result in a difference in the position ng of the torpedo along the slope. A difference of length of 1" of hose might cause a 3/4" error, whereas on a fairly horizontal level it would have comparatively little effect.

7220-C20-4-1 PC-24

15.00 HOW TO IMPROVE INSTRUMENT ACCURACY

15.10 Some of the means of improving the accuracy of the Aquaducer, listed below, need not necessarily be employed. The extent of the accuracy required will dictate the amount of precaution to be taken and the methods to be used in the taking of settlement data.

15.20 Except for the readout box, use only fluid which has been suitably de-aired to within 0.1 to 0.5 parts per million of dissolved oxygen. There is only one commercial apparatus made that will accomplish this purity on a small quantity basis. This is the DeAerator which is furnished with the Aquaducer.

15.30 Always keep a watchful eye on the water hose for air bubbles and on the air hose for the presence of water. Bear in mind that a one inch column of water in the air line or a one inch bubble in the water line, when in a vertical segment of the line, will cause and error of one inch in the ultimate reading. For this reason, the air line must be purged from time to time to compensate for the slight leakage through the balloon by osmosis, and the water line flushed when bubbles begin to occur.

15.40 Use only the fluid which has been set aside for the Aquaducer. Never use tap water. Use anti-freeze (ethylene glycol) only when required for such type of protection. When such protection is no longer required, in the spring, the ethylene glycol solution should be removed and the system flushed and filled with colored distilled water. If the color of the anti-freeze used is normally blue, use a different color, such as red, for the distilled water.

15.50 Never add water to a system using ethylene glycol. Never add ethylene glycol to a system using water. Either of these will cause a change of specific gravity of the system fluid and will effect the accuracy until such a time when the fluid is changed again.

15.60 Minimize the effect of temperature when operating with ethylene glycol solutions (or when water is used at extremely high ambient temperatures). This may be accomplished by allowing the entire system to stabilize to the temperature conditions of the field. Reverse the procedure outlined in Paragraph 3.90 of page 8 and start the testing with the torpedo in the position nearest to the readout apparatus.

Make an estimated guess as to the temperature of the fluid within the water hose. If the existing temperature had remained relatively unchanged, the chances are good that the fluid would be stabilized to the existing ambient temperature. Continue the testing. Before proceeding on a test at another pipe location, make sure that sufficient time has elapsed for the water in the entire system to stabilize again.

One method to ascertain the temperature might be to dip a small immersion type thermometer in a one liter bottle filled with the ethylene glycol solution and to leave this exposed to the elements along with the balance of the Aquaducer apparatus. The temperature thus obtained would be more of an average figure, and more likely to be closer to that of the Aquaducer fluid than the fluctuating air, which is generally quite variable.

7220 · 070 - 4-1 99.25

15.60 (continued) For the best possible accuracy, a chart such as that shown on page 29 should be made up based upon the specific gravity of the ethylene glycol solution used. The specific gravity to be used in calculating the settlement should be taken from this chart and based upon the temperature recorded on the data sheet. Of course, the chart must be changed whenever a new mixture of anti-freeze is used. For this reason it is advisable to make up such anti-freeze solutions in 20 liter or five gallon quantities.

15.70 For best accuracy use water for the system fluid and do not use the Aquaducer when the temperature is extremely variable. Wait until a cloudy day comes along. The sun can heat the exposed water hose. That part of the hose that is buried will not be heated and will tend to have a different specific gravity, even though small in change, than that portion which is exposed to the sun. An ideal time to use the Aquaducer is when the ambient temperature is between 33° and 50°F with no sun shining. Refer to page 31.

15.80 Use as short a hose length as possible. Long lengths of hose mean longer lengths of time required to take measurements. This additional time can be quite trying and the possibility of human error is likely to occur more when using the Aquaducer at the lower extremes of temperature. Through use of the stainless steel 'Swagelok' type fittings various different lengths of hose can be used as required.

15.90 Make sure to be careful when aligning the dashed (-) part of the marker on the hose with the exposed end of the pipe when the torpedo is positioned on a sloped portion of the buried pipe. Suspect every measurement of this type.

15.100 Make sure that the pressure gage is exercised and that a true gage zero exists before the apparatus is placed in use per the requirements of Section 3.

15.110 Make sure that the pressure gage is exercised at least once per month whether or not the Aquaducer is being used for measuring purposes. This is necessary for the gage to retain its accuracy.

15.120 When not in use, store the readout box in a dry location.

7220-C70-4-1

pg. 36

16.00 DO NOT's

16.10 Do not leave the Aquaducer in a situation where freezing is likely to occur when the system fluid is water. One such occurrence completely ruined the expensive water chamber piston assembly. Another case resulted in the fracture of a window then used in the torpedo and the plastic standpipe.

16.20 Do not operate the water chamber piston assembly when the standpipe valve is closed. Under such conditions, with the assembly being screwed inward in a pressure mode, the water, being uncompressible, has to go someplace. If the hose is connected to the readout box, the water would act against the bladder. If the hose were not connected, the water would burst itself possibly through the 'O' ring seal at the standpipe. Damage might result.

16.30 Do not allow 'knob twisters' [those people not knowing the operation of the instrument or those not concerned with its use] to even touch the instrument, except under guidance. The Aquaducer is not a toy.

16.40 Do not exceed the pressure limits of the air gage. When exercising the gage it is necessary only to approach the 280" limit. Do not over-inflate the system.

16.50 Do not leave the Aquaducer unattended for any long length of time. The manufacturer of the air pressure gage recommends that it be exercised once per month minimum.

16.60 Do not attempt to take the air pressure gage apart under any circumstance. If the gage does not operate properly, repair can be accomplished only in the specialized laboratory where calibration equipment is a necessity. This is an expensive precision gage. The balance of the Aquaducer is of simple design and may be easily taken apart as required.

16.70 Do not overload the system fluid with chemicals which are supposed to overcome various and sundry faults. Adhere strictly with the instructions contained within this manual. A continual search goes on for new Aquaducer system fluids, but so far only water and ethylene glycol seem to be applicable.

16.70 Do not tighten the setscrews of the torpedo with too much torque. Bear in mind that the thickness of thread is only .065". Excessive tightening is not required and will only cause stripping of the threads. Use moderation.

16.80 Do not allow foreign substances or particles to accumulate in the system fluid. If the fluid is suspected, by all means flush out the old fluid and replace with the new. Flushing is so simple to accomplish and should be done at least twice a year.

16.90 Do not allow dust to accumulate inside the readout box. Such dust could find its way into the air pressure gage, even though this unit is protected from such.

16.100 Do not allow water in the air hose line. Correct this condition at once.

7220-CRO-4-1 pg.37

17.00 NOTES RELATING TO REPAIR AND MAINTENANCE

17.10 Tools required:

Open end wrenches, one each 1/2", 9/16", 11/16" and two each 7/16"

One each of Waldes Truarc external snap ring pliers #0200 and #0300

Miscellaneous sizes of screwdrivers

17.20 Referring to Figure 11A on page 22, the snap rings (124 and 125) may become difficult to remove without the snap ring pliers listed above. If it becomes necessary to take this unit apart, please inform the manufacturer and the required pliers will be sent on a load basis (or they may be easily purchased).

A screw might exist in the area designated by (a) in some models. This serves a purpose relating to a change of design only and need not be removed.

17.30 Manufacturer's Part Numbers (referring to Section 8, pages 20 and 21)

108	Swagelok SS-QC4-D-400
109	Swagelok SS-QC6-D-600
222	Swagelok SS-300-R-4
223	Swagelok SS-QC4-B-400
214	Swagelok SS-QC6-B-600
211	Eastman 260U-3/8 (brass sleeve only)
219	Eastman 260U-3/16 " " "
215	Davol Latex Surgical Finger Cots

17.40 It may become necessary to replace the air and water lines at the torpedo. Referring to Figure 10 of page 20, for the fitting 219 (air), the disassembly should be accomplished by preventing the lower part of the connector from twisting out of the barrel through use of one 7/16" open end wrench and by turning the other cap section using a second 7/16" wrench. For the water fitting (211) the same procedure is employed except using a 1/2" open end wrench for the low part and a 9/16" wrench for the cap portion. It is not possible to use the sleeves of these fittings again, so for this reason some spares are included in the spare parts kit.

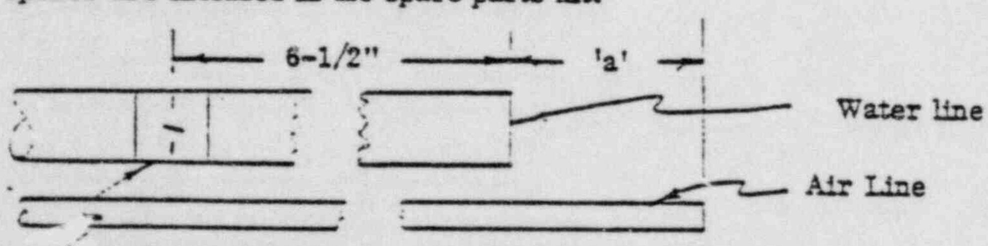


Figure 17

7320-C70-4-1 pg.37

17.50 When the torpedo and hose line were originally manufactured the dimension from the monitoring point within the torpedo was established as being 5-1/2" from the end of the water line tubing. If a new hose were to be made up, for instance (referring to Figure 1? of page 37), the dimension from the end of the water line to the first marker (let us assume a marker exists every foot) at the 1 foot position would be 6-1/2", or 9 ft. 6-1/2 inches to the ten foot marker. The dimension 'a', in making up a new line, should be a little more than one inch, and then cut back as required to establish a perfect fit. Dimension 'a' is generally 15/16", but may vary somewhat.

17.60 It is not generally recommended to cut off the ends of existing hose lines and to reconnect the torpedo. This practice would cause the length markers to be in error from previously recorded readings. For such an event, one in which the hose lines are in good order and the tips of the individual lines are in poor condition, it is recommended that new lines be connected to the old ones through use of brass or stainless steel 'Swagelok' fittings, to make up for the parts of the line which were removed. In this manner there would be no loss of accuracy. It might be a good idea to wrap electrical such splicing fittings with vinyl electrical tape to prevent any sharp corners from catching on the PVC pipe junctions. Such fittings should also be staggered to reduce any possible build-up of the cable diameter.

17.70 If the air gage ever creates a problem, especially if it is slow to react to pressure changes, it might be wise to see if the filter is clogged (see instructions under Section 9). Also the small hole in the center of the red plastic plug of the gage must be kept clear.

17.80 Parts contained in the Spare Parts Kit (numbers refer to those of Section 8)

One	(125)	Snap ring, small	
One	(121)	'O' ring for the piston assembly	
Two	(202, 217, 112, 115)	'O' ring, for nose insert, etc.	
Two	(205, 209)	'O' ring, medium, for torpedo inserts	
Two	(208)	Bladder 'O' rings	
Two	(215)	Bladders or balloons	
One	(224)	Adaptor for bladder installation	
Two		Allen wrenches for torpedo setscrews	
Ten	(205, etc.)	Allen setscrews, cup point, SS, 8-32x1/8"	
One	(Fig. 6)	'O' Ring Screw	(per page 14)
One	(Fig. 7)	Nose Adaptor	" " "

17.90 Two quick-connect fittings, Swagelok 1/8 MPT-1/4 QC-200 and 1/4 MPT-3/8-QC-200, modified, are used as part of the hose reel to accept the female hose fittings. These are of plated brass construction.

7220-C20-4-1

pg.34

18.00 SIGNIFICANCE OF DISSOLVED AIR IN WATER

18.10 The effects of air in hydraulic systems, or, the effects of the use of de-aired water in hydraulic systems, are not generally well known. Somewhat of a controversy continues to exist year after year, without pertinent data being brought to light. However the following notes might tend to clear up this situation at least with regard to the Aquaducer.

18.20 An air bubble in the vertical component of the hose system of the Aquaducer will mean less weight applied to the balloon. The end result, if such a bubble occupied a one inch length of tubing, would mean a one inch error in settlement measurement; the amount of error being proportional to the length of bubble in the vertical position. Such a bubble would not result in any error whatever if it were truly parallel with the horizontal plane, but, since this condition would seldom exist while meansurements are being taken it is safe to assume rightly that such air bubbles do cause errors.

18.30 The DeAerator will reduce the dissolved oxygen (DO) content is water from 10 parts per million to less than 1 part per million (actually about 0.6 ppm) at sea level conditions at a rate of six liters per five minutes. Levels of 7 to 10 ppm DO may be considered average for non de-aired water. However, this content can vary widely with temperature and altitude.

1 ppm DO is equivalent to 0.7 cc/liter in terms of volume

The DeAerator will reduce the amount of dissolved oxygen in water from 10 ppm to less than 1 ppm, for instance, for a 9 ppm reduction. This is equivalent to a 0.7 x 9 = 6.3 cc/liter or a 0.63 reduction of total water volume.

Air contains 21% oxygen by volume.

Under the hypothesis that the same relationship between nitrogen and oxygen exist in water in dissolved form as exists in the atmosphere (there is a difference which will effect the figures only slightly) or 21% oxygen by volume, the volume of air removed would be:

$$0.63 \times \frac{100}{21} = 3\%$$

The 3% figure represents the amount of air equivalent to a 15 foot air lock in a 500 foot length of tubing.

18.40 The above does not mean that a 15 ft. air lock would necessarily form if water were used that had not been suitably de-aired, but such is possible with time.

18.50 Regardless, without a means of de-airing water the operator of the Aquaducer or any other similar instrument would be troubled with air bubbles which would in turn effect the accuracy.

7230-020-4-1 99.40

19.00 **LATEST NOTES**

19.10 These notes over-rule any statement made in this Instruction Manual which may be conflicting.

19.20 The linearity of the Aquaducer may easily be determined by allowing the torpedo to remain in a fixed position and adjusting the water level to the zero point (using water as the system fluid) of the standpipe scale. Apply air pressure by means of the squeeze bulb and allow the water to settle at various points along the eight inch scale. Never allow the water level to fall while accomplishing this test. A graph is plotted with the air pressure as the ordinate and the scale reading as the abcissa. The portion of the curve which is in the form of a straight line is the region of linearity of the instrument. The section of the curve will form at 45° when the ordinate and the abscissa are both represented by identical graph units.

WN Company

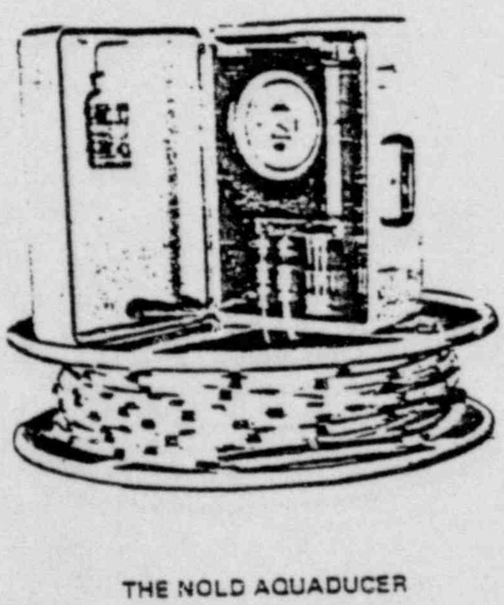
GEOPHYSICAL INSTRUMENTATION

THE SEISMITRON®

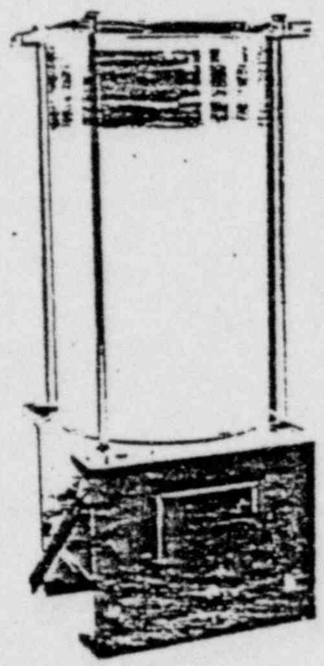
THE WALTER NOLD COMPANY

Since 1940 Walter E. Nold, founder of The Walter Nold Company, has been designing and developing new products to meet the varied needs of the industrial community. A few of the products as listed here give a clue as to the wealth of the company's experience in product design and development:

- an original model of the ball point pen (not marketed due to the development of a low cost but inferior model by competitors)
- a conductivity tester, utilized by the U.S. Navy in all submarines
- a hairspring timing device
- a photographic cutting machine
- a density comparitor for typewriter ribbons and carbon paper



THE NOLD AQUADUCER



THE NOLD DeAERATOR

WALTER NOLD COMPANY

7230-C70-4-1

Company

geotechnical instrumentation

THE NOLD DeAERATOR

FEATURES

- Produces extremely pure deaerated water
- Fast and efficient
- Economical
- Simple, safe, easy to operate
- Portable

  Model shown is the 6 liter unit (7.5 X 7.5 X 20"); larger units designed upon special request.

TYPICAL APPLICATIONS

- Closed hydraulic system
- Specific gravity and permeability
- Manometer and settlement gages
- Milk and food degasification
- Chemical stripper
- Oil distillation

GENERAL

The principles employed by the DeAerator were discovered in 1970 as a result of a research and development program. A phenomenon, known as cavitation, was employed to literally beat gaseous and volatile components out of their dissolved state to amazingly high purity levels. The generally accepted method of deairing water, prior to the discovery, was boiling under a vacuum and then allowing to cool. Usually the results were unreliable, and typically 4 liters of water at 5 PPM DO purity would take approximately 45 minutes to prepare. *With the cavitation process 6 liters of 0.6 PPM DO water can be produced in 5 minutes.*

Degasification of liquids has now been commercially harnessed in the birth of the DeAerator.

7220-C20-4-1

89.44

The Seismitron

The Seismitron is a portable instrument which has been in use for over twenty years for the prediction of rock falls in tunnels and mines, and for the determination of failure of slopes at earth dams and mountain-sides. It is also used to justify the need for roof bolting or to verify the effectivity when used. The Seismitron is based on the microseismic phenomenon discovered by Drs. Obert and Duval of the U.S. Bureau of Mines in 1939.

The principle of operation is based on the frequency of occurrence of microseisms (erroneously called 'rock noises' or 'acoustic emissions') which are, in effect, slippages of the crystals or grains making up the material creating the effect. Microseisms occur at audio frequencies and, when amplified, sound like 'clicks' akin to the creaking of stairways or diving boards. Almost any hard material, such as salt, rock, shales, sandstone, brick, glass, wood, steel, concrete, sand or sugar will produce microseisms.

For convenience some geophones (sensors) are permanently buried, such as at the slopes of the North and West Cuts of the Tarbela Dam. In tunnels, however, holes are bored 100 feet apart and the geophone is inserted at each of the stations only for the 15 minute monitoring period which may take place weekly or monthly as conditions warrant. Microseisms are made audible through use of a low-noise amplifier. The microseisms are counted manually, since other factors (such as raindrops) would trip an electrical counter or an event recorder. A history is established for each location by plotting the microseismic rate against the dated time. Prediction of failure, which may be up to 45 days in advance of actual time under ideal conditions, is determined by extrapolation of the plots to the point representing breakdown. At any time, a collapse is imminent when the microseismic rate doubles within a 24 hour period.

The Seismitron is certified for coal mine use by the U.S. Bureau of Mines for the United States and by the Department of Mines and Technical Surveys for Canada.

The Seismitron is manufactured by the Walter Nold Company, 24 Birch Road, Natick, Massachusetts 01760, U.S.A.

24 birch road, natick, massachusetts, u.s.a. 01760 617 — 653-1635

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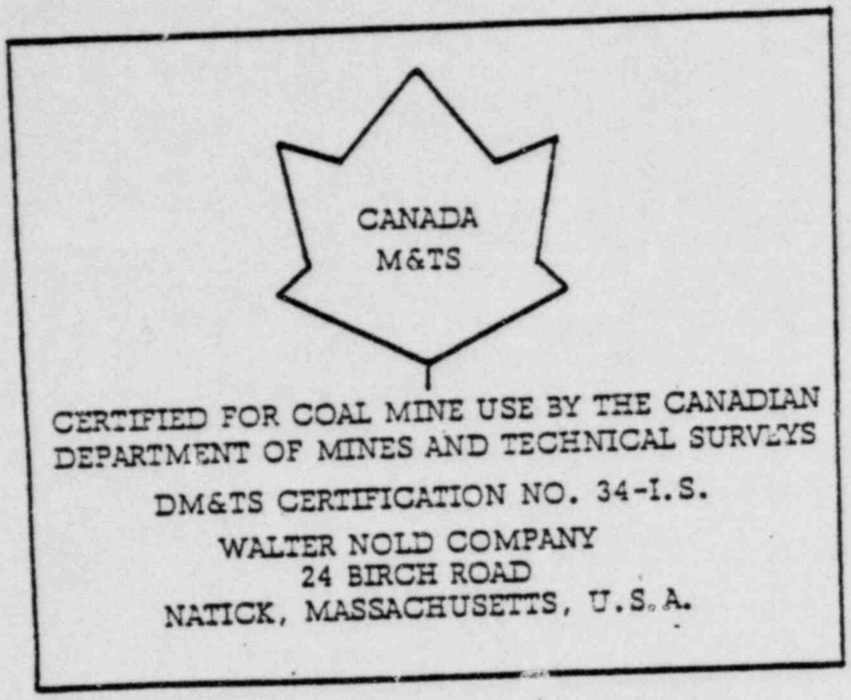
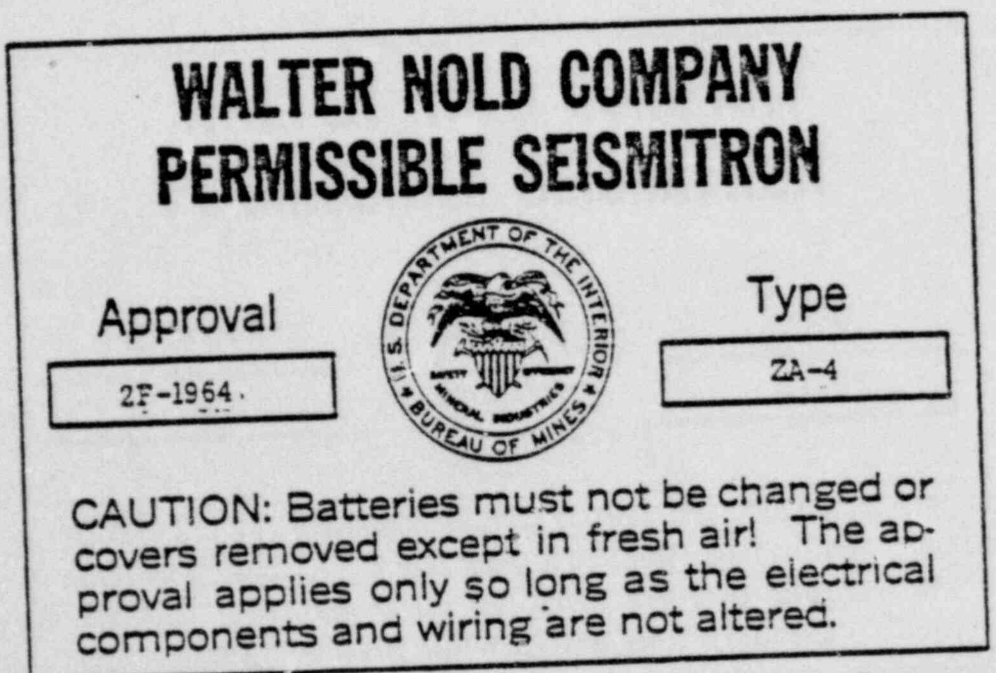
NAMEPLATES - APPROVED SEISMITRONS FOR COAL MINE USE



FOR CANADA



FOR THE UNITED STATES

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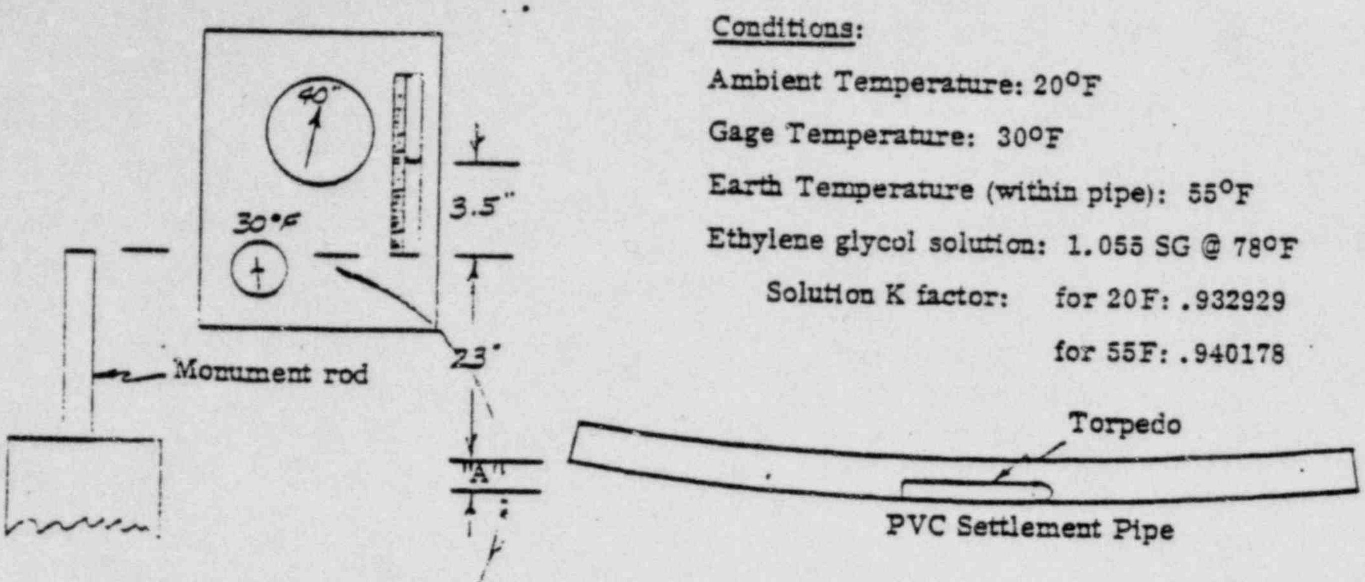
Example of Calculation



Conditions:

Ambient Temperature: 20°F

Gage Temperature: 30°F

Earth Temperature (within pipe): 55°F

Ethylene glycol solution: 1.055 SG @ 78°F

Solution K factor: for 20F: .932929

for 55F: .940178

The dimension from the top of the monument to the lower inside of the protruding PVC settlement pipe. For the purpose of this calculation the dimension is 23". This dimension, which may roughly be accomplished, will remain constant for all further monitoring for this particular location.

Torpedo is pulled to its furthermost point and readout box and reel installed on monument rod. At least twenty minutes must occur before readings are taken to allow the fluid to reach acceptable temperature conditions. Assume a reading has just been taken.

1. Pressure gage reads 40" and temperature gage reads 30F. By referring to the calibration chart for the pressure gage, the corrected reading for 30F is found to be 40.1"

2. 3.5 x 1/K (@ 20F) = 3.5/K = 3.5/.932929 = 3.752" (apparent [what the gage indicates]) [The 3.5" is the standpipe reading of the fluid at 20F. 1/K is greater than one; K being the factor taken for the fluid at 20F from the K Factor Sheet. This means that 3.5" fluid weighs more than 3.5" of water and the gage indicates that additional weight, or 3.752".]

3. 23 x 1/K (@ 20F) = 23/K = 23/.932929 = 24.653" (apparent) [The 23" figure represents the balance of the segment (vertical) of the tubing which is exposed to the ambient temperature (20F). The pressure gage will indicate more than 23" for this dimension, since the fluid weighs more than plain water. The K factor for the fluid at 20F is the same as for the above (.932929).

4. 40.1 - 3.752 = 36.348" (apparent) This is part of the monitoring procedure and is the corrected apparent dimension between the readout box and the torpedo. It is the gage reading (corrected) from which the standpipe reading (corrected) has been subtracted.

5. 36.348 - 24.653 = 11.695" (apparent) This is the apparent "A" dimension.

6. 11.695 x K (@ 55F) = 11.695 x .940178 = 10.995" (real) This represents the real dimension of the vertical segment of the fluid within the settlement pipe. Since the temperature within the pipe is 55F, the K for the fluid at this temperature is taken from the K Factor Chart for 55F.

7. 10.995 + 23.000 = 33.995" (real) This is the final figure for the dimension between the top of the monument rod and the torpedo within the settlement pipe.

7220-C20-4-1

CALIBRATION OF AQUADUCER GAGE, SERIAL NO. YY10440

PRESSURE IN INCHES OF WATER AT VARIOUS TEMPERATURES (°F)

For Midland Power Plant **Bechtel Power Corporation**

(°F)	5°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°
	0	0	0	0	0	0	0	0	0	0	0
	10.000	10.000	10.000	10.050	9.950	10.000	10.000	10.000	10.000	9.950	10.000
	20.025	19.975	19.975	20.025	19.975	20.025	19.975	20.000	20.025	19.950	19.975
	29.975	30.050	29.925	30.000	30.000	29.950	29.900	30.000	30.025	29.750	29.800
	40.100	39.975	40.000	40.100	39.900	40.050	39.900	40.000	40.125	39.700	39.850
	50.125	50.050	50.050	50.100	49.900	50.000	49.900	50.000	50.025	49.900	49.800
	60.150	60.100	60.150	60.125	60.000	60.050	59.950	60.000	60.050	59.950	59.900
	70.150	70.100	70.100	70.125	69.950	70.050	69.975	70.000	70.050	69.950	69.900
	80.075	80.025	80.100	80.000	79.925	80.050	79.900	80.000	79.950	79.825	79.800
	90.250	90.175	90.100	90.100	90.050	90.100	90.050	90.000	90.000	89.850	89.850
	100.175	100.250	100.150	100.150	100.000	100.075	100.025	100.000	100.000	99.800	99.800
	110.175	110.200	110.175	110.225	110.025	110.100	109.925	110.000	109.925	109.925	109.875
	120.275	120.225	120.150	120.250	120.000	120.050	120.000	120.000	119.950	119.900	119.800
	130.300	130.350	130.275	130.225	130.500	130.025	130.025	130.000	130.000	129.875	129.825
	140.350	140.350	140.350	140.300	140.175	140.150	140.100	140.000	140.000	139.850	139.850
	150.450	150.450	150.450	150.400	150.100	150.225	150.025	150.000	149.950	149.950	149.875
	160.450	160.450	160.400	160.375	160.200	160.200	160.150	160.000	159.975	159.950	159.900
	170.200	170.250	170.200	170.200	170.150	170.125	169.950	170.000	169.900	169.800	169.725
	180.450	180.450	180.375	180.450	180.200	180.150	180.050	180.000	180.000	179.925	179.850
	190.425	190.425	190.425	190.425	190.250	190.175	190.025	190.000	189.975	189.875	189.825
	200.400	200.400	200.350	200.325	200.100	200.175	199.900	200.000	199.975	199.875	199.850
	210.450	210.450	210.425	210.375	210.200	210.200	210.025	210.000	209.950	209.900	209.800
	220.500	220.500	220.350	220.325	220.075	220.150	220.000	220.000	220.000	219.800	219.700
	230.450	230.450	230.350	230.350	230.150	230.250	229.950	230.000	229.850	229.800	229.800
	240.425	240.350	240.350	240.325	240.100	240.275	240.975	240.000	239.800	239.750	239.700
	250.675	250.525	250.450	250.425	250.325	250.325	250.225	250.000	250.025	249.925	249.825
	260.475	260.525	260.475	260.475	260.275	260.375	260.075	260.000	259.975	259.850	259.775
	270.450	270.400	270.400	270.400	270.225	270.300	270.075	270.000	269.900	269.800	269.700
	280.475	280.500	280.450	280.450	280.250	280.225	280.025	280.000	279.950	279.800	279.700

Explanation of the K Factor

The pressure gage is calibrated in terms of inches of water at 20C (68F).

Ethylene glycol and water mixtures weigh more than water by an amount indicated in the Specific Gravity and K Factor Chart as listed under Specific Gravity.

The Specific Gravity of water at 68F is .9982343. A liter (1000 cc) of water, for instance, weighs 998.2343 grams.

If, for instance, a vertical column of water of 40" at 68F existed, the pressure gage would theoretically measure what it sees; 40" of water at 68F, and would read 40".

However, if this same column were substituted by a fluid having a specific gravity of 1.0581 at 68F, the reading would be higher, since the weight of the fluid would be heavier than water by a factor of 1.0581.

The reading would be higher by a factor or ratio of the specific gravity of the fluid at 68F (1.0581) to the specific gravity of water at the calibrated 68F (.9982343) or:

$$1.0581/.9982343 = 1.059971$$

For this particular example the reading indicated for the ethylene glycol mixture would be:

$$40'' \times 1.059971 = 42.399''$$

To bring this figure back to a true dimension, it would be necessary to divide the 42.399" by 1.059971, or:

$$42.399/1.059971 \quad \text{or} \quad 42/1 \times 1/1.059971 = 40''$$

1/1.059971 = .943422, which is the reciprocal of 1.059971, and is a more convenient form to employ as a multiplying factor K. The K for the above ethylene glycol and water mixture for 68F, as listed in the K Factor Chart, is .943422.

$$42.399 \times K\ (@68F) = 42.399 \times .943422 = 40''$$

7230-C20-4-1

pg. 50

Specific Gravities and K Factors for Ethylene Glycol and Water Solution at 1.055 @ 78°F

°F	S.G.	K	°F	S.G.	K
0	1.074	.929455	50	1.06300	.939073
1	1.0738	.929628	51	1.06275	.939294
2	1.0736	.929801	52	1.06250	.939515
3	1.0734	.929974	53	1.06225	.939736
4	1.0732	.930148	54	1.06200	.939957
5	1.0730	.930321	55	1.06175	.940178
6	1.0728	.930494	56	1.06150	.940400
7	1.0726	.930668	57	1.06125	.940621
8	1.0724	.930841	58	1.06100	.940843
9	1.0722	.931015	59	1.06075	.941065
10	1.0720	.931189	60	1.06050	.941286
11	1.0718	.931362	61	1.0602	.941553
12	1.0716	.931536	62	1.0599	.941819
13	1.0714	.931710	63	1.0596	.942086
14	1.0712	.931884	64	1.0593	.942353
15	1.0710	.932058	65	1.0590	.942620
16	1.0708	.932232	66	1.0587	.942887
17	1.0706	.932406	67	1.0584	.943154
18	1.0704	.932580	68	1.0581	.943422
19	1.0702	.932754	69	1.0578	.943689
20	1.0700	.932929	70	1.05750	.943957
21	1.0698	.933104	71	1.05725	.944180
22	1.0696	.933278	72	1.05700	.944403
23	1.0694	.933453	73	1.05675	.944627
24	1.0692	.933626	74	1.05650	.944850
25	1.0690	.933802	75	1.05625	.945082
26	1.0688	.933977	76	1.05600	.945298
27	1.0686	.934151	77	1.05575	.945521
28	1.0684	.934326	78	1.05550	.945745
29	1.0682	.934501	79	1.05525	.945969
30	1.0680	.934676	80	1.05500	.946194
31	1.0678	.934851	81	1.0547	.946463
32	1.0676	.935026	82	1.0544	.946732
33	1.0674	.935202	83	1.0541	.947001
34	1.0672	.935377	84	1.0538	.947271
35	1.0670	.935552	85	1.0535	.947541
36	1.0668	.935727	86	1.0532	.947810
37	1.0666	.9[illegible]5903	87	1.0529	.948081
38	1.0664	.936078	88	1.0526	.948351
39	1.0662	.936254	89	1.0523	.948621
40	1.0660	.936430	90	1.05200	.948892
41	1.0657	.936694	91	1.05165	.949208
42	1.0654	.936957	92	1.05130	.949524
43	1.0651	.937221	93	1.05095	.949840
44	1.0648	.937485	94	1.05060	.950156
45	1.0645	.937749	95	1.05025	.950473
46	1.0642	.938014	96	1.04990	.950790
47	1.0639	.938278	97	1.04955	.951107
48	1.0636	.938543	98	1.04920	.951424
49	1.0633	.938807	99	1.04885	.951742

File #2220-QA-7

GZD JOB NO. 2220 MIDLAND PLANT

PROCEDURE FOR AS RECEIVED INSPECTION OF NOLD SETTLEMENT GAGE

INSPECTION PROCEDURE NO. 5

1. Check the length measurements on the settlement gage hose and document on Form NS-I-1.

2. Check that the couplings on the settlement gage hose mate with the couplings on the readout panel and document on Form NS-I-1.

3. Check that the fluid shutoff valve at the top of the standpipe is operational and document on Form NS-I-1.

4. Check that the panel air valve is operational and document on Form NS-I-1.

5. Check that the squeeze bulb valve is operational and document on Form NS-I-1.

6. Check that the fluid in the Aquaducer hose is free of air bubbles and document on Form NS-I-1.

7. Check the fluid level in the standpipe section of the readout unit as per Section 3.80 of INSTRUCTION MANUAL and document on Form NS-I-1.

8. Following the steps outlined in the INSTRUCTION MANUAL, set up the probe alongside a vertical surveyor's levelling rod and record the survey rod graduation on Form NS-I-2.

9. Record the settlement gage reading on Form NS-I-2, following the method detailed in READING PROCEDURE No. 5.

10. Raise or lower the probe a distance of one foot and record the survey rod graduation and gage reading on Form NS-I-2.

11. Compare the change in height as measured with the survey rod and with the settlement gage and compare with manufacturer's calibration.

12. Repeat steps 8 through 11 for a minimum of three other pairs of probe elevations and document on Form NS-I-1.

13. Document the settlement gage inspection, add the inspection date and signed approval of the inspector as provided on Form NS-I-1.

14. Send a copy of the completed Forms NS-I-1 and NS-I-2 to GZD home office, retaining a copy on-site during the monitoring program.

Signed: William R. Beloff
William R. Beloff

Rev. No.	Date	Description	By
0	12/26/78		WRB

2220-C20-4-1

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File No. 2220-QA-7

GZD JOB NO. 2220, MIDLAND PLANT
PROCEDURE FOR READING NOLD SETTLEMENT GAGE
READING PROCEDURE NO. 5

1. Read and become familiar with the material contained in INSTRUCTION MANUAL-THE AQUADUCER HOSE SETTLEMENT GAGE supplied by the gage manufacturer, The current edition of this manual includes revision C.

2. Complete instrument number, date, initials of operator and fluid type as provided on Form NS-R-1.

3. Determine the elevation of the top of the bar, from Benchmark No. 9 as provided on Form NS-R-1. Elevation shall be determined to the nearest 0.001 foot and recorded to the nearest 0.01 foot.

4. Record the Ambient Air temperature for the vertical height of exposed hose as provided for on Form NS-R-1.

5. Record the Estimated Ground temperature as provided for on Form NS-R-1. This is best accomplished by inserting a thermometer to the midlength of the buried pipe, allowing it to remain there for approximately 30 minutes, then remove the thermometer quickly and note the indicated temperature.

6. Follow the reading procedure detailed in Section 3 of the INSTRUCTION MANUAL-THE AQUADUCER HOSE SETTLEMENT GAGE. Readings shall be taken at 10 foot intervals along the buried pipe. For each reading, complete columns (d) thru (j) as provided on Form NS-R-1.

7. Transpose data from Form NS-R-1 onto Form NS-R-2 and calculate probe elevation as provided on the Form. Note that the "K" Factor valves for various temperatures are contained in the INSTRUCTION MANUAL.

8. Send a copy of Forms NS-R-1 and NS-R-2 to the GZD home office, retaining a copy of each on site during the measuring period.

Signed William R. Beloff
William R. Beloff

Rev. No.	Date	Description	By
0	12/26/78		WRB

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File #2220-QA-8

DIESEL GENERATOR BUILDING, MIDLAND PLANT

GZD JOB NO. 2220 - INSTRUMENT INSPECTION

RECORD OF AS-RECEIVED INSPECTION OF NOLD SETTLEMENT GAGE

Settlement Gage Serial No.________________

Pressure Gage Serial No.____________

DESCRIPTION OF CHECK	CHECKED BY	YES	NO	DATE
Length markers on hose acceptable				
Hose couplings mate with readout couplings				
Fluid shutoff valve on standpipe operational				
Panel air valve operational				
Squeeze bulb valve operational				
Hose free of air bubbles				
Standpipe fluid level acceptable				
Spot check on manufacturers calibration acceptable				

Signed________________________

Date__________________________

Form NS-I-1

7220-C70-44

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DIESEL GENERATOR BUILDING, MIDLAND PLANT
GZD JOB NO. 2220 - INSTRUMENT INSPECTION
NOLD SETTLEMENT GAGE

RECORD OF AS-RECEIVED SPOT CHECK CALIBRATION

DATE	CHECKED BY	SURVEY ROD GRADATION	PRESSURE GAGE READING	STANDPIPE GAGE READING	CALCULATED HEIGHT	SURVEY ROD GRADATION	PRESSURE GAGE READING	STANDPIPE GAGE READING	CALCULATED HEIGHT	SURVEY ROD CHANGE	SETTLEMENT GAGE CHANGE

Settlement Gage Serial Number__________ Pressure Gage Serial Number__________ Fluid Type__________

Pressure Gage Temperature__________ Ambient Air Temperature__________ __________

Vertical Height of Hose Exposed to Ambient Air__________

Signed__________

Date__________