# DB1 LIQUID LEVEL MEASUREMENT SENSOR
# OPERATOR'S MANUAL

**REVISION: 11/17/93**

## WARRANTY AND ASSISTANCE

The **DB1 LIQUID LEVEL MEASUREMENT SENSOR** is warranted by CAMPBELL SCIENTIFIC, INC. to be free from defects in materials and workmanship under normal use and service for twelve (12) months from date of shipment unless specified otherwise. Batteries have no warranty. CAMPBELL SCIENTIFIC, INC.'s obligation under this warranty is limited to repairing or replacing (at CAMPBELL SCIENTIFIC, INC.'s option) defective products. The customer shall assume all costs of removing, reinstalling, and shipping defective products to CAMPBELL SCIENTIFIC, INC. CAMPBELL SCIENTIFIC, INC. will return such products by surface carrier prepaid. This warranty shall not apply to any CAMPBELL SCIENTIFIC, INC. products which have been subjected to modification, misuse, neglect, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied, including warranties of merchantability or fitness for a particular purpose. CAMPBELL SCIENTIFIC, INC. is not liable for special, indirect, incidental, or consequential damages.

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**CAMPBELL SCIENTIFIC, INC.**
RMA#_____
815 West 1800 North
Logan, Utah 84321-1784

CAMPBELL SCIENTIFIC, INC. does not accept collect calls.

Non-warranty products returned for repair should be accompanied by a purchase order to cover the repair.


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# DB1 LIQUID LEVEL MEASUREMENT SENSOR

## 1. OVERVIEW

The double bubbler is a self-calibrating system for liquid level measurement. This manual focuses on water level measurement in stilling wells or open channels, but the information applies to other liquids as well. The system detects water level by measuring the pressure required to force a nitrogen gas bubble from a submerged tube. The nitrogen pressure in the tube is equal to the hydrostatic pressure created by the exiting bubble. Before each stage measurement, the pressure transducer is calibrated by measuring the hydrostatic pressure difference between two tubes installed a fixed vertical distance apart in the liquid to be measured. These values are used to calculate the multiplier value for the liquid level measurement. This self-calibration minimizes the effects of temperature and long-term drift on the pressure transducer, allowing a single pressure transducer to achieve a much higher measurement accuracy (±.05%). The self-calibration theory is discussed in detail by Dedrick and Clemmens (1984, 1986).

A single pressure transducer is used to measure three pressure lines (h1, h2, or offset). The line to be measured is controlled by the three 2-way solenoid valves on the manifold. The "bubble rate" is controlled by the two needle valves on the manifold assembly labeled #1 and #2. The needle valve labeled #1 controls the bubble rate for the pressure line used to measure h1. The needle valve labeled #2 controls the bubble rate for pressure line #2 used to measure h2. The needle valve is turned clockwise to decrease and counter-clockwise to increase the bubble rate. The suggested bubble rate is 1 to 3 bubbles/sec. The third solenoid valve is used to measure atmospheric pressure, which will be used as the offset value.

The manifold assembly requires considerably more power compared to a normal sensor. For this reason, an MSX 10 solar panel or AC power in conjunction with a sealed rechargeable battery is recommended for the DB1 system.

**References**


Dedrick, A.R. and A.J. Clemmens, Double-bubblers coupled with pressure transducers for water level sensing, Transactions of the ASAE, Vol. 27, No. 3, pp. 779-783, 1984.

Dedrick, A.R. and A.J. Clemmens, Instrumentation for monitoring water levels, Proc. of Agri- Mation Conference and Exposition, ASAE, March 3-5, Chicago, IL, pp. 148-152, 1986.


## 2. SPECIFICATIONS

Measurement Range:

| | |
|---|---|
| Option - 5 | (0 to 5 psi/0 to 11.5 ft.) |
| Option - 15 | (0 to 15 psi/0 to 34.5 ft.) |
| Option - 30 | (0 to 30 psi/0 to 69 ft.) |

Maximum Overpressure Range:

| | |
|---|---|
| Option - 5 | 20 psi |
| Option - 10 | 45 psi |
| Option - 15 | 60 psi |

| | |
|---|---|
| Transducer Accuracy: | ± 0.05 % Full Scale |
| Temperature Range: | -25° to + 50°C |
| Supply Voltage: | 12V DC |
| System Current Drain: | 75 mA (Activated)<br>0.5 mA (Quiescent) |
| Valve Current Drain: | 40 mA (Activated)<br>0 mA (Deactivated) |

Maximum System Pressure: 100 psi

## 3. INSTALLATION

Mount the DB1 liquid level assembly to the enclosure back-plate using the supplied plastic screw grommets and Phillips screws. Using the supplied tubing cutter, cut sections of tubing for the nitrogen, h1, h2, and offset pressure lines. Insert the h1 pressure line into the elbow fitting below the valve marked #1. The line is installed correctly when it does not release without pressing the red fitting into the valve assembly. Insert the h2 pressure line into the elbow fitting below the valve marked #2. Insert the offset line into the elbow fitting to the right of the valve marked #2. Insert the nitrogen supply line into the elbow fitting on the right side of the manifold assembly.

Permanently install h1 and h2 a fixed vertical distance apart in the water (see Figure 2, delta h). Maximize the fixed distance between h1 and h2, while keeping h1 at least six inches below the surface of the lowest anticipated water level. If the water level drops below h1 you will get irregular data readings. The accuracy of the water level measurement is affected by the exactness of the delta h measurement. To increase measurement accuracy, cut the end of the submerged tubing at a 60 degree angle to decrease the gas bubble deformation as it exits the tube.

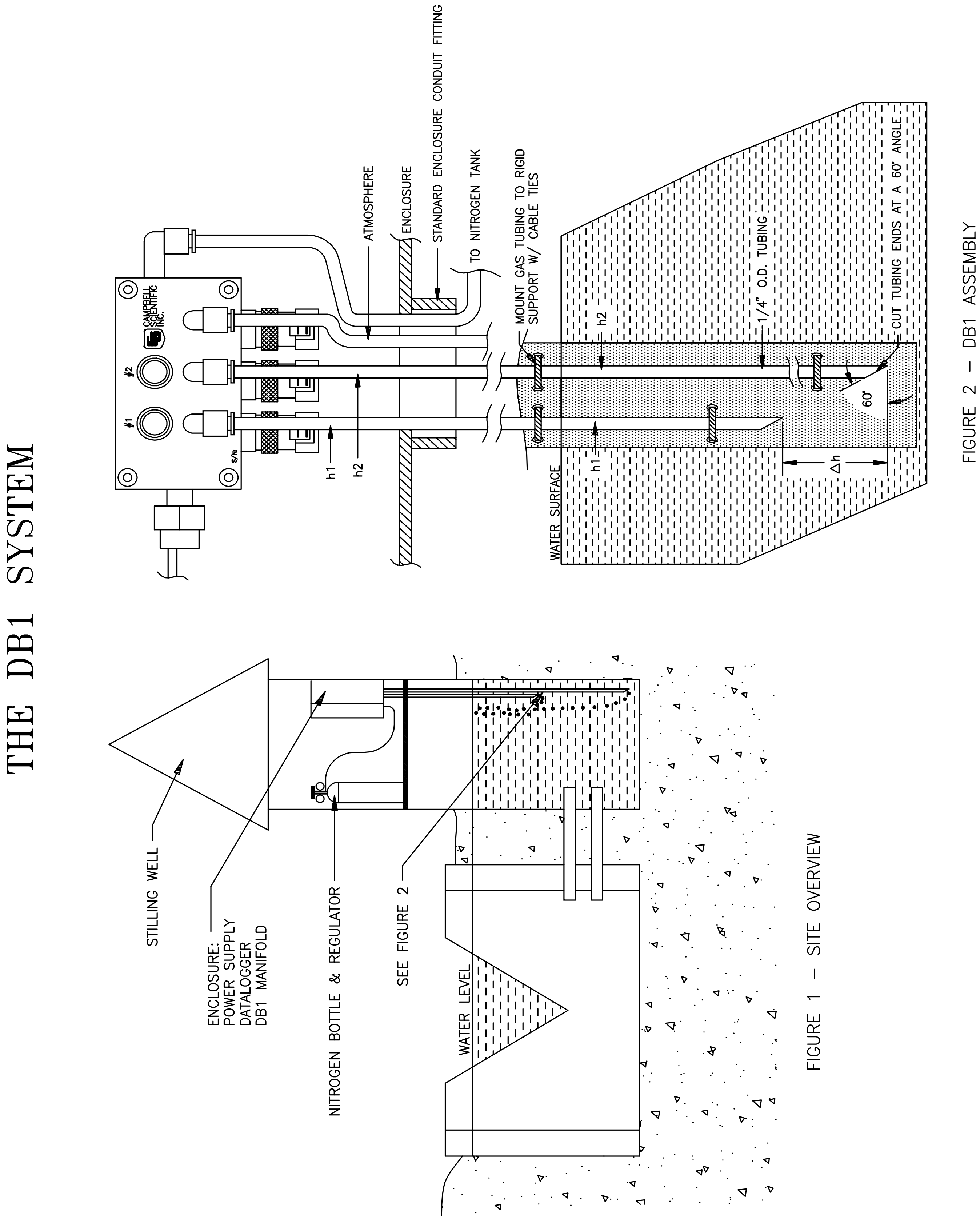
The DB1 Liquid Level System requires a compressed gas supply. The most common gas is a 225 $ft^3$ nitrogen bottle with an appropriate "automatic pressure relieved" pressure regulator. The pressure range set on the regulator depends on the water level to be recorded. For example, if the DB1 system is installed in a stilling well to measure stream level, and the stream level fluctuates between 5 and 15 ft (2.2 and 6.5 psi), set the pressure regulator above 7 psi (read 10 psi) to ensure adequate pressure.

Open the nitrogen bottle valve, set the pressure regulator, and adjust the nitrogen flow by adjusting the two needle valves. The suggested bubble rate is 1 to 3 bubbles/sec. The nitrogen gas bottle, regulator, and tubing (Campbell P/N 7566) are available from any welding supply store. Use common sense when installing pressure lines, checking for leaks, moisture, kinks, etc. in the lines.

## 4. WIRING

Wiring connections for CR10, 21X, and BDR320 dataloggers are shown in Figure 3. The channel numbering in the wiring diagram matches the channel usage in the program examples. The pressure transducer within the DB1 has four conductors (white, green, red, black). The white lead connects to the high side and the green lead connects the low side of any analog channel (e.g. 1H and 1L ). The red lead connects to any excitation channel and the black lead connects to any AG channel.

The three relay cable assemblies have three conductors for each valve. The green wires connect to control ports C1 (Valve #1), C2 (Valve #2), and C3 (Valve #3) as used in the program example that follow. The red wires connect to 12 volts, and the black wires connect to ground. The cable assemblies have been provided with extra lead length to enable the user to cut the cables to length to accommodate different size enclosures.




**FIGURES 1 and 2. The DB1 System**

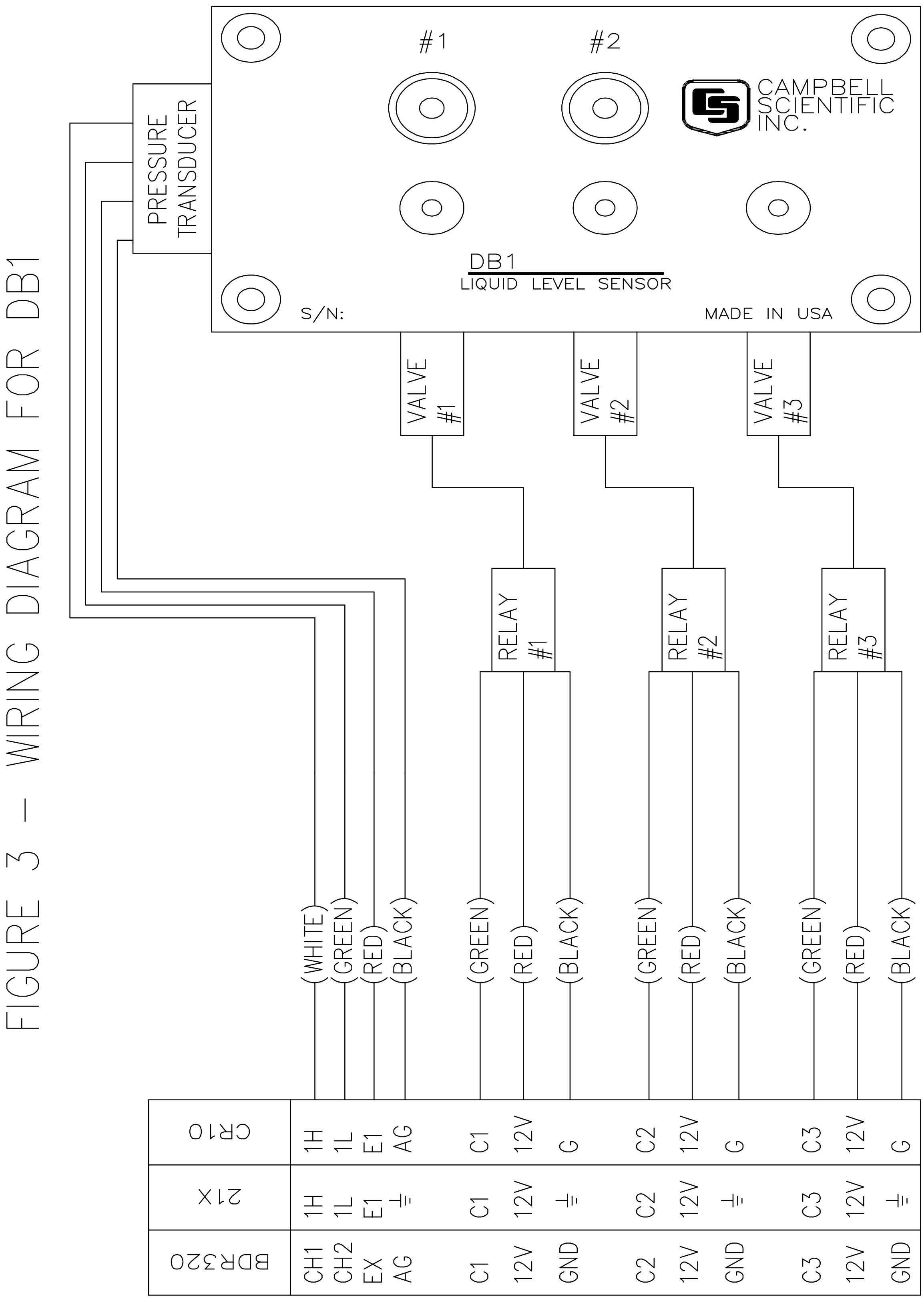



**FIGURE 3. Wiring Diagram for DB1**

## 5. PROGRAMMING

Every 60 seconds, the following program examples calculate the pressure transducer multiplier, measure the offset, and measure the liquid level. The average liquid level is stored in final memory every 15 minutes.

**CR10 Example:**

Input Location Usage:

| **LOCATION** | **LABEL** |
|---|---|
| #1: | Liquid Level |
| #4: | Multiplier |
| #5: | Offset |
| #6: | mv/V |
| #7: | Sum |
| #8: | Avg. Level |
| #9: | mV/V#1 |
| #10: | mV/V#2 |
| #11: | mV/V#3 |
| #12: | Delta V |
| #13: | Delta h |

```
*          1       Table 1 Programs
  01:     60       Sec. Execution Interval

01:      P86       Do
  01:      2       Call Subroutine 2

02:      P86       Do
  01:     42       Set high Port 2

03:      P22       Excitation with Delay
  01:      1       EX Chan
  02:      0       Delay w/EX (units=.01sec)
  03:    150       Delay after EX
                   (units=.01sec)
  04:      0       mV Excitation
```

*Subroutine 1 measures the pressure in the tubing connected to the second value:*

```
04:      P86       Do
  01:      1       Call Subroutine 1

05:      P86       Do
  01:     52       Set low Port 2
```

*The following instructions convert the mV readings to engineering units:*

```
06:      P36       Z=X*Y
  01:      8       X Loc AVG LEVEL
  02:      4       Y Loc MULT.
  03:      1       Z Loc [:LEVEL#1  ]

07:      P33       Z=X+Y
  01:      1       X Loc LEVEL#1
  02:      5       Y Loc OFFSET
  03:      1       Z Loc [:LEVEL#1  ]

08:      P92       If time is
  01:      0       minutes into a
  02:     15       minute interval
  03:     10       Set high Flag 0 (output)

09:      P77       Real Time
  01:    110       Day,Hour-Minute

10:      P71       Average
  01:      1       Rep
  02:      1       Loc LEVEL#1

11:        P       End Table 1

*          3       Table 3 Subroutines
```

*Pressure Transducer Measurement Routine:*

```
01:      P85       Beginning of Subroutine
  01:      1       Subroutine Number

02:      P30       Z=F
  01:      0       F
  02:      0       Exponent of 10
  03:      7       Z Loc [:SUM     ]

03:      P87       Beginning of Loop
  01:      0       Delay
  02:     25       Loop Count

04:       P6       Full Bridge
  01:      1       Rep
  02:     23       25 mV 60 Hz rejection Range
  03:      1       IN Chan
  04:      1       Excite all reps w/EXchan 1
  05:   2500       mV Excitation
  06:      6       Loc [:mV/V     ]
  07:      1       Mult
  08:      0       Offset

05:      P33       Z=X+Y
  01:      7       X Loc SUM
  02:      6       Y Loc mV/V
  03:      7       Z Loc [:SUM     ]

06:      P95       End
```

```
07:   P37      Z=X*F
  01:    7     X Loc SUM
  02:     .04  F
  03:    8     Z Loc [:AVG LEVEL]

08:   P95      End
```

*Subroutine 2 activates values #1 - #3, measures h1, h2, and atmospheric pressure, and calculates the multiplier and offset:*

```
09:   P85      Beginning of Subroutine
  01:    2     Subroutine Number

10:   P87      Beginning of Loop
  01:    0     Delay
  02:    3     Loop Count

11:   P86      Do
  01:   41--   Set high Port 1
```

*Note: The dashes (--) after 41 indicate at the next loop port 2 will be set high, then port 3.*

```
12:   P22      Excitation with Delay
  01:    3     EX Chan
  02:    0     Delay w/EX (units=.01sec)
  03:  150     Delay after EX (units=.01sec)
  04:    0     mV Excitation

13:   P86      Do
  01:    1     Call Subroutine 1
14:      P     31  Z=X
  01:    8     X Loc AVG LEVEL
  02:    9--   Z Loc [:mV/V #1  ]

15:   P86      Do
  01:   51--   Set low Port 1

16:   P95      End

17:   P35      Z=X-Y
  01:   10     X Loc mV/V #2
  02:    9     Y Loc mV/V #1
  03:   12     Z Loc [:DELTA V  ]
```

*Note: On the next command, enter the measured Delta h value for F, using the units (e.g. inches, cm, etc.) you want the data to be in on your printout.*

```
18:   P30      Z=F
  01:    0     F
  02:    0     Exponent of 10
  03:   13     Z Loc [:DELTA H  ]

19:      P     38  Z=X/Y
  01:   13     X Loc DELTA H
  02:   12     Y Loc DELTA V
  03:    4     Z Loc [:MULT.    ]

20:   P36      Z=X*Y
  01:   11     X Loc mV/V #3
  02:    4     Y Loc MULT.
  03:    5     Z Loc [:OFFSET   ]

21:   P37      Z=X*F
  01:    5     X Loc OFFSET
  02:   -1     F
  03:    5     Z Loc [:OFFSET   ]

22:   P95      End

23:      P         End Table 3
```

## 6. MAINTENANCE

The user should review the Installation and Maintenance section in the appropriate datalogger manual (14 for the CR10 and 21X, OV4.2 for the BDR). This section discusses maintenance required for components specific to the DB1 sensor.

### 6.1 PERIODIC MAINTENANCE:

* Inspect submerged bubbler tubes for sediment or other debris. Remove debris and clean tubes as required.

* Replace submerged bubbler tubes if cracked or damaged.

* Replace nitrogen bottle every 2 to 3 months depending on bubble rate.

* Inspect valves for leaks every 2 to 3 months and tighten or replace as required (refer to discussion on valves below).

* Inspect fittings for leaks every 2 to 3 months and replace as required.

* Inspect desiccant indicator cards and replace desiccant when card begins to change color from blue to pink.

### 6.2 SOLENOID VALVE

Over time, the knurled ring on the solenoid valve may become loose due to expansion and contraction. This problem is corrected by simply turning the knurled ring clockwise until finger tight. Two other possible problems are contamination or complete failure. In the case of contamination, the valve would not open or close properly, resulting in deviant pressure measurements.

The solenoid valve can be disassembled to inspect for possible contamination by removing the top half of the valve. Turn the knurled ring counter-clockwise until the threads are disengaged and pull upward on the top half of the valve assembly. There are two parts inside the valve, a very thin washer and a spring plate. Be aware, the washer may stick to the top half of the valve during disassembly. Clean any contamination from the valve or spring plate. Inspect the rubber seal on the spring plate for cracks or damage (replace valve if seal is damaged). Reassemble by placing the spring plate in the base (rubber seal down) followed by the washer. Re-insert the top half and tighten the knurled ring finger tight. If the spring plate is damaged the valve will need to be replaced (see Section 7).

### 6.3 FITTINGS

The seals in the fittings may eventually become dry and cracked, resulting in leaks and inaccurate pressure measurements. If this occurs, the fittings will need to be removed and replaced (order P/N 7397: 1/4 inch tubing x 1/8 npt 90 degree elbow and P/N 5199: thread sealant). Apply a small amount of thread sealant to the threads on the fitting and thread fitting in finger tight. Using a torque wrench, tighten fitting between 5 to 6.5 ft-lbs.

### 6.4 NEEDLE VALVE

The needle valves should not require any maintenance. The seals should perform properly for several years. A light film of vacuum grease was applied to the seals and should prevent them from drying and cracking. If a valve is damaged simply remove and replace the valve order P/N 7558 or return the DB1 to Campbell Scientific for repair .

## 7. REPLACEMENT PARTS

| Part # | Description | QTY IN DB1 |
|---|---|---|
| 5199 | SWAK THREAD SEALANT | 1 |
| 7397 | TUBE FITTING<br>ELL 1/4 O.D.x 1/8NPT | 4 |
| 7558 | NEEDLE VALVE ASSEMBLY | 2 |
| 7561 | 2-WAY NC SOLENOID VALVE | 3 |
| 7571 | PLUG PIPE 1/8NPT TEFCOAT | 2 |
| 6078 | MOUNTING SCREW (6/32 x 2.00in) | 4 |
| 7596 | DB1 MANIFOLD BLOCK | 1 |
| 7680 | TUBE CUTTER | 1 |
| 7667 | RELAY CABLE ASSEMBLY | 3 |
| 7566 | PRESSURE LINE (BLUE)<br>PER FT | |