ARG100
Tipping Bucket
Raingauge

User Guide

Issued 30.11.10

Guarantee

This equipment is guaranteed against defects in materials and workmanship. This guarantee applies for twelve months from date of delivery. We will repair or replace products which prove to be defective during the guarantee period provided they are returned to us prepaid. The guarantee will not apply to:

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Note that goods sent air freight are subject to Customs clearance fees which Campbell Scientific will charge to customers. In many cases, these charges are greater than the cost of the repair.

PLEASE READ FIRST

About this manual

Please note that this manual was originally produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

Area:	1 in^2 (square inch) = 645 mm^2	**Mass:**	1 oz. (ounce) = 28.35 g
			1 lb (pound weight) = 0.454 kg
Length:	1 in. (inch) = 25.4 mm		
	1 ft (foot) = 304.8 mm	**Pressure:**	1 psi (lb/in^2) = 68.95 mb
	1 yard = 0.914 m		
	1 mile = 1.609 km	**Volume:**	1 UK pint = 568.3 ml
			1 UK gallon = 4.546 litres
			1 US gallon = 3.785 litres

In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to European users.

Differences include the U.S standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. *Please note, however, that when a power supply adapter is ordered it will be suitable for use in your country.*

Reference to some radio transmitters, digital cell phones and aerials may also not be applicable according to your locality.

Some brackets, shields and enclosure options, including wiring, are not sold as standard items in the European market; in some cases alternatives are offered. Details of the alternatives will be covered in separate manuals.

Part numbers prefixed with a "#" symbol are special order parts for use with non-EU variants or for special installations. Please quote the full part number with the # when ordering.

Recycling information

At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories.

For further advice or support, please contact Campbell Scientific Ltd, or your local agent.

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ARG100 Raingauge

The ARG100 is a well-designed tipping bucket raingauge which combines durable construction with very reasonable cost. The gauge offers less resistance to air flow than most previous designs, which helps to reduce the sampling errors that inevitably occur during wind-driven rain. The gauge is manufactured for Campbell Scientific by Environmental Measurements Ltd. (under licence from the Institute of Hydrology), and will provide many years of reliable operation when carefully sited and installed.

1. Description

The ARG100 raingauge is constructed from UV-resistant, vacuum-moulded plastic and consists of a base and an upper collecting funnel. The base splits into two parts, the inner section supporting the tipping-bucket mechanism and the outer providing protection and allowing the unit to be bolted firmly to a suitable mounting plinth or concrete slab.

The tipping bucket arrangement is similar to most other gauges of this type; precipitation is collected by the funnel and is passed to one of the two buckets situated at either end of a short balance arm. The balance arm tips when the first bucket is full, emptying this bucket and positioning the second under the funnel. The tipping process repeats indefinitely as long as rain continues to fall, with each tip corresponding to a fixed quantity of rainfall. At each tip, the moving balance arm forces a magnet to pass a reed switch, causing contact to be made for a few milliseconds. A two-core cable is used to connect the gauge to the datalogger where the switch closures are counted.

The ARG100 is adjusted at manufacture to tip once for each 0.2 mm of rain (a sensitivity of 0.25 mm/tip is optional). More information on gauge calibration is given in Section 6.

2. Installation and Siting

2.1 Choice of Site

Site the gauge carefully, avoiding obvious sources of error such as nearby trees or buildings. A useful 'rule of thumb' is that the distance between the gauge and any obstruction should be at least as great as twice the height of the obstruction above the ground. For standard meteorological sites in the UK, the Meteorological Office specify the height at which the rim of a raingauge should be above a short grass surface, and the ARG100 should be exposed similarly if measurements are required for comparison with those from agrometeorological or synoptic sites.

NOTE
No two raingauge designs are ever likely to produce identical results, and identical raingauges can give slightly different catches even when sited within a metre of each other.

Research has shown that a raingauge obstructs the flow of air and that the flow accelerates and turbulence increases over the top of the funnel. This can cause less rain to be collected in the funnel than otherwise would have fallen on the ground. In most cases, this phenomenon is ignored but it may be corrected for

arithmetically or overcome physically by placing the gauge in a pit so that the rim of the funnel is level with the ground. The pit is covered by a grating to simulate

the aerodynamic roughness of the ground surface while preventing any splash into the funnel. There are obvious advantages with this method, but it is not always practical. The body of the ARG100 has a profile which has been designed to reduce drag and turbulence and it can therefore be sited conventionally on exposed sites with some confidence. Further details on the exposure of raingauges are given in HMSO (1956, 1982) and by Rodda (1967). Another useful text on exposure and associated errors is Painter (1976).

2.2 Unpacking

Unpack the ARG100 carefully. The tipping mechanism is immobilised before shipping to prevent damage in transit. To release the mechanism:

1. Remove the funnel of the gauge from its base by unscrewing the three Allen screws with a 5/32" key.

2. Remove the small piece of tape which secures the balance arm to the central post and check the bucket mechanism for freedom of movement.

2.3 Mounting

The ARG100 is a light-weight instrument and it must therefore be bolted down securely. Three mounting holes are provided in the base of the gauge; access to these is gained by simply pulling the inner section upwards (it may be necessary to relieve the strain slightly by pushing a little more cable through the rubber grommet).

If you need to mount the ARG100 on concrete, we recommend the use of Rawl-bolts. Alternatively, a concrete paving slab may be more convenient as a base, in which case through-bolts or screws are suitable. Whichever is chosen, we recommend the use of large washers to spread the load more evenly around the mounting holes in the plastic base.

For fast, semi-permanent installations the optional RGB1 levelling baseplate can be used (see Appendix A).

2.4 Levelling

If the raingauge is tilted by more than a few degrees, the bucket mechanism may be thrown out of balance, significantly affecting its calibration. Furthermore, during wind-driven rain the response of a gauge with a tilted funnel collector will vary with wind direction.

Where a concrete slab is used, add sand underneath the slab to level the gauge. If the gauge is mounted on a concrete base using Rawlbolts, add packing material under the base before tightening the bolts. Use the internal bubble to check that the base of the gauge (with the funnel removed) is level; as an additional check, place a spirit level across the rim of the assembled ARG100.

3. Wiring

The raingauge is supplied with a 6m cable which may be extended if required. For most applications the ARG100 may be connected directly to a pulse counting input on the datalogger as shown in Figure 1. For a long cable, a significant capacitance can exist between the conductors, which discharges across the reed switch as it closes. As well as shortening the life of the switch, a voltage transient may be induced in any other wires which run close to the raingauge cable each time the gauge tips. A 100Ω resistor is fitted inside the gauge to protect the switch from arcing and prevent transients.
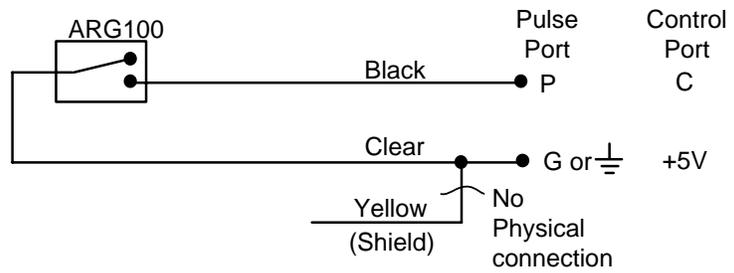
Figure 1 Wiring Diagram for ARG100

3.1 Wiring to a Pulse Channel

NOTE   When Short cut software is used to generate the datalogger program, the sensor should be wired to the channels shown on the wiring diagram created by Short Cut.

The ARG100 is typically wired to a datalogger's pulse channel (see Table 3-1).

Table 3-1. Wiring for Pulse Channel Input					
Colour	**Description**	**CR800 CR1000 CR3000 CR5000**	**CR500 CR510 CR10(X)**	**21X CR7 CR23X**	**CR200(X) Series**
Black	Signal	Pulse Channel	Pulse Channel	Pulse Channel	P_SW
Clear	Signal Return	$\perp$	G	$\perp$	$\perp$
Yellow	Shield				

3.2 Wiring to a Control Port

Dataloggers listed in Table 3-2 have the capability of counting switch closures on some of their control ports. When a control port is used, the return from the rain gauge switch must be connected to +5 volts on the datalogger.

Table 3-2. Wiring for Control Port Input					
Colour	**Description**	**CR800 CR1000 CR3000**	**CR500 CR510**	**CR10(X)**	**CR23X**
Black	Signal	Control Port	C2/P3	Control Port	Control Port
Clear	Signal Return	5 V	5 V	5 V	5 V
Yellow	Shield				

The CR10 does not support the use of control port inputs with the Pulse Count instruction.

4. Datalogger Programming

NOTE   This section is for users who write their own programs. A datalogger program to measure this sensor can be generated using Campbell Scientific's Short Cut Program Builder software. You do not need to read this section to use Short Cut.

Precipitation is measured using a Pulse Count with a switch closure configuration code. The multiplier used in the Pulse Count instruction determines the units in which rainfall is reported (see Table 4-1).

Table 4-1. Multipliers	
Rain Gauge	**1 mm**
ARG100	0.2

4.1 Pulse Channel Example Programs

The following example programs use a pulse channel to read the output from the precipitation gauge. The CR1000 example will also work with the CR800, CR850, CR3000, and CR5000. CR9000(X) programming is similar to the CR1000 except it has an additional parameter in the PulseCount instruction to specify the pulse module's slot.

The CR10X program will also work with the CR500, CR510, CR10, 21X or CR23X. CR7 programming is similar to the CR10X but has an additional parameter in the PulseCount instruction to specify the slot that the Pulse Card is in.

4.1.1 CR1000 Example Program

```
'CR1000

'ARG100 Tipping      Blk > P1
'                    Clr > ground

Public Rain_mm
Units Rain_mm=mm
DataTable(Rain,True,-1)
    DataInterval(0,60,Min,0)
    Totalize(1,Rain_mm,FP2,0)
EndTable

BeginProg
    Scan(1,Sec,1,0)
        PulseCount(Rain_mm,1,1,2,0,0.2,0)
        CallTable(Rain)
    NextScan
EndProg
```

4.1.2 CR200(X) Series Example Program

```
'CR200(X) Series

'ARG100 Tipping      Blk > P_SW
'                    Clr > ground

'Declare Variables and Units

Public Rain_mm

Units Rain_mm=mm

'Define Data Tables
DataTable(Rain,True,-1)
    DataInterval(0,60,Min)
    Totalize(1,Rain_mm,0)
EndTable

'Main Program
BeginProg
    Scan(1,Sec)

        'ARG100 Rain Gauge measurement Rain_mm:
        PulseCount(Rain_mm,P_SW,2,0,0.2,0)

        'Call Data Tables and Store Data
        CallTable(Rain)
    NextScan
EndProg
```

4.1.3 CR10X Example Program

```
;{CR10X}
*Table 1 Program
  01:  1.0000      Execution Interval (seconds)

1: Pulse (P3)
  1:   1           Reps
  2:   1           Pulse Channel 1
  3:   2           Switch Closure, All Counts
  4:   3           Loc [ Rain_mm ]
  5:   0.2         Multiplier
  6:   0           Offset

2: If time is (P92)
  1:   0           Minutes (Seconds --) into a
  2:   60          Interval (same units as above)
  3:   10          Set Output Flag High (Flag 0)

3: Set Active Storage Area (P80)
  1:   1           Final Storage Area 1
  2:   101         Array ID

4: Real Time (P77)
  1:   1220        Year,Day,Hour/Minute (midnight = 2400)

5: Totalize (P72)
  1:   1           Reps
  2:   3           Loc [ Rain_mm ]

*Table 2 Program
  01:  0           Execution Interval (seconds)

*Table 3 Subroutines

End Program
```

4.2 Control Port Example

The following example programs use a control port to read the output from the precipitation gauge. The CR1000 example will also work with the CR800, CR850, and CR3000. The CR10X program will also work with the CR500, CR510, or CR23X.

4.2.1 CR1000 Example Program

```
'CR1000

'ARG100 Tipping      Blk > C4
'                    Clr > 5v

'Declare Variables and Units
Public BattV
Public Rain_mm

Units BattV = Volts
Units Rain_mm =mm

DataTable(OneMin,True,-1)
     DataInterval(0,1,Min,10)
     Totalize (1,Rain_mm,FP2,False)
EndTable

'Define Data Tables
DataTable(OneDay,True,-1)
DataInterval(0,1440,Min,10)
     Minimum(1,BattV,FP2,False,False)
     Totalize (1,Rain_mm,FP2,False)                    'ARG100 tipping bucket
EndTable

'Main Program
BeginProg
     Scan(5,Sec,1,0)
          'Default Datalogger Battery Voltage measurement BattV
          PanelTemp (PTemp,_50Hz)
          Battery(BattV)

          'ARG100 Rain Gauge measurement Rain_mm
          PulseCount(Rain_mm,1,14,2,0,0.2,0)

          'Call Data Tables and Store Data
          CallTable(OneMin)
          CallTable(OneDay)
     NextScan
EndProg
```

4.2.2 CR10X Example Program

```
;{CR10X}
;
*Table 1 Program
  01: 1              Execution Interval (seconds)

1: Pulse (P3)
  1:  1             Reps
  2:  8             Control Port 8 (switch closure only)   ;Black wire connect to C8
  3:  2             Switch Closure, All Counts
  4:  1             Loc [ Rain_mm ]
  5.  0.2           Multiplier
  6:  0             Offset

2: If time is (P92)
  1:  0             Minutes (Seconds --) into a
  2:  60            Interval (same units as above)
  3:  10            Set Output Flag High (Flag 0)

3: Set Active Storage Area (P80)
  1:  1             Final Storage Area 1
  2:  101           Array ID

4: Real Time (P77)
  1:  1220          Year,Day,Hour/Minute (midnight = 2400)

5: Totalize (P72)
  1:  1             Reps
  2:  1             Loc [ Rain_mm ]

*Table 2 Program
  02: 0.0000        Execution Interval (seconds)

*Table 3 Subroutines

End Program
```

Output Instruction 72, Totalize, is used in the output section of the program to output the total rainfall over the output interval. This section should be executed every scan and not placed in a subroutine or conditional statement.

5. Maintenance

To ensure reliable and accurate measurements, we recommend that the following checks be carried out every month if possible:

1. Inspect the funnel for any damage or blockage and check the integrity of the connecting cable. At certain times of the year, leaves may accumulate in the bottom of the funnel, clogging the filter and preventing the flow to the buckets beneath, or reducing the flow rate to a slow drip. The obstruction is best cleared by inverting the funnel (after removal from the base) and pouring water back through from the spout beneath the collecting surface. Note that the plastic filter in the bottom of the funnel is *not* removable on the ARG100.

2. Check that the gauge is still level. It is surprisingly easy for an apparently immovable gauge to become tilted as a result of small ground movements, vandalism or just inquisitive fingers.

3. Check that the balance arm is free to move. This can be done by slowly pouring a measured quantity of water (say 25 cm^3) through the gauge and counting the tips. It is worthwhile carrying this out at regular weekly intervals (for example, every Monday at 0900) while leaving the gauge connected to the datalogger. Providing a significant volume of water is used, these weekly checks can easily be identified in the logged measurements. This simple procedure confirms that the gauge is functioning, detects any marked change in the calibration and (if carried out punctually) introduces an independent time check into the records.

6. Calibration

The sensitivity of the ARG100 is set at manufacture to approximately 0.2 mm/tip (optionally 0.25 mm/tip) and each gauge is subsequently calibrated as described in Section 6.1. The calibration factor is given on a certificate and is also recorded on the inside of the raingauge. For precise measurements use this value in your program instead of the nominal value of 0.2.

6.1 Static Adjustment and Calibration

The following procedure is carried out during manufacture and may be repeated if the calibration appears to have shifted:

1. Install the gauge over a sink unit as illustrated in Figure 2, ensuring that it is correctly levelled.

2. Adjust the two calibration screws under the tipping buckets until the balance arm tips in response to the correct amount of water dripped from a burette or pipette (10.13 cm^3 for 0.2 mm sensitivity, 12.67 cm^3 for 0.25 mm).

It is not possible to set the screws very precisely using this method, but it should be done with as much care as possible. It is obviously very important to ensure that both buckets tip in response to the same amount of water. Many manufacturers and users of tipping bucket gauges aim to adjust the bucket settings until exactly the correct calibration is achieved. However, a dynamic test (see below) is required to check this calibration precisely after each readjustment and the process becomes very time-consuming. In any case, it is virtually impossible to get the adjustments absolutely correct, and it is generally preferable to adjust the settings as closely as is reasonably practical, and then to derive a calibration factor for each gauge individually.

6.2 Dynamic Calibration

1. Set up the gauge as illustrated in Figure 2, carefully levelled and connected to the datalogger.

2. Fill the water container with 810.4 cm^3 of water for a 0.2 mm calibration (1013.4 cm^3 for a 0.25 mm setting). This is usually achieved most precisely and consistently by weighing the water on a balance capable of measuring to 0.1 g (0.1 cm^3). An alternative is to use a good quality graduated measuring cylinder.

3. Allow the water to drip slowly into the gauge (allowing approximately 100 minutes for the container to empty). This is a rate equivalent to a rainfall of 10 mm/hour, as recommended in BS7843 Section 2.1 for calibration purposes. At the end of this period approximately 80 tips will have occurred. The exact number is obtained from the datalogger, together with a visual inspection of what fraction of a 'tip' is left in whichever bucket is still filling as the flow of water finishes.
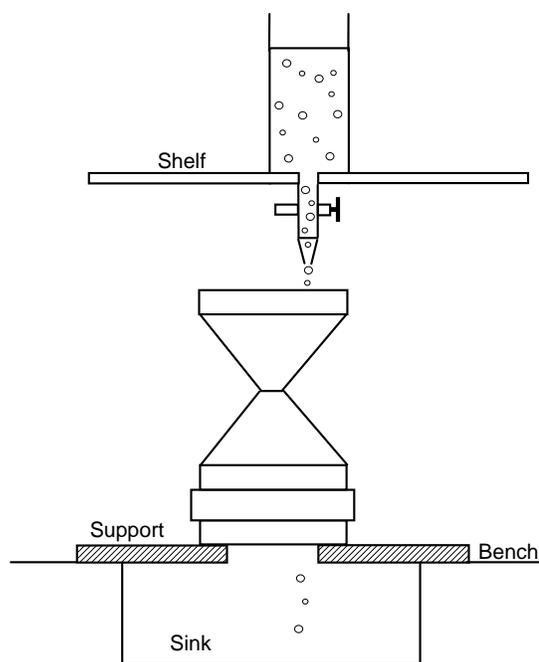
Figure 2 Arrangement for Setting and Calibrating the Raingauge

If N is the number of tips (together with the fractional part left in the one bucket), the calibration factor (CF) is then

CF = 0.2 (optionally 0.25) x 80/N

For example, if N = 78.8, then

CF = 0.2 (optionally 0.25) x 80/78.8

= 0.203 mm/tip

The amount of rainfall in any particular interval is obtained by multiplying the number of recorded tips by the calibration factor.

This type of dynamic calibration gives repeatable results indoors, but it is not a true representation of the gauge's sensitivity to natural precipitation. Useful results can be obtained by comparing the output from the ARG100 with the catches from a standard 'Snowdon pattern' gauge (HMSO, 1956) sited nearby; if this comparison is carried out with care, a calibration factor for natural rainfall can be calculated from the slope of a graphical plot of (number of tips) against (catch from Snowdon gauge in mm).

7. Advantages and Limitations of a Tipping Bucket Gauge

Gauges which operate on the tipping bucket principle provide a digital output, which simplifies connection to a datalogger. The pulses returned during rainfall may be counted over any time interval desired allowing accurate determination of the rainfall rate (this variable, sometimes called 'intensity', is frequently used in soil erosion studies and is relevant to some aspects of crop pathology).

When the ARG100 is used primarily to measure rainfall rates, the resolution of the gauge may be too coarse to detect the significant changes in rate which normally occur from minute to minute in moderately heavy rain. In this case the gauge may be adjusted to improve the resolution slightly (see Section 6.1); alternatively, the bucket volume may be reduced by adding plasticine (or possibly candle wax). It is generally much more satisfactory and convenient to improve the resolution by increasing the collecting area of the gauge. This can be achieved by attaching a funnel with a diameter greater than 25.5 cm over the instrument and avoids the need for internal modifications.

A tipping bucket gauge responds to discrete quanta of rainfall, and the accuracy and reproducibility of this quantum are determined not only by factors such as friction in the bearings, etc. but also by the rate of fill of the buckets. When the rainfall rate is high, a bucket may *start* to tip when the necessary volume of water has been collected, but while the bucket is moving away from the funnel outlet, an extra volume will have been collected and lost through spillage. The resulting degradation in accuracy is of the order of 4% at rainfall rates of 25 mm/hr and 8% at 133 mm/hr for most gauges (Parkin et al, 1982). This is important when results from gauges of different designs are compared. These errors worsen when gauge sensitivity is increased. It follows that gauge design is always a compromise between the need for good resolution and good overall accuracy in rainfall totals.

References

HMSO (1956) *Handbook of Meteorological Instruments*, Part 1, Met.0. 577.

HMSO (1982) *Observers Handbook*, Met.0. 933.

Painter, R.D. (1976) in *Methods of Plant Ecology* pp 369-410. Ed. by S.B.Chapman, Blackwell Scientific Press, Oxford

Parkin, D.A., King, W.D. and Shaw, D.E. (1982) *An automatic raingauge network for a cloud seeding experiment* J.Appl.Meteorol. p 228.

Rodda, J.C., (1967) *The rainfall measurement problem* Proc. IAHS Gen. Ass. Bern, IAHS Pub. No. 78, 215-231

Appendix A. Optional RGB1 Levelling Baseplate

The RGB1 levelling baseplate is *only* supplied with the ARG100 raingauge when specifically ordered. It is suitable for fast, semi-permanent installations on soft ground. Install the RGB1 as follows:

1. Take the funnel assembly off the raingauge.

2. Drill out the three holes in the raingauge base to 6.5mm diameter and debur.

3. Screw one 6mm full nut on each stud and screw the studs into the baseplate flush with the bottom surface. Tighten the nut up to the baseplate to lock the studs in position.

4. Screw on the lower plastic thumb nuts and slide the raingauge over the studs until it is sitting on top of the thumb nuts.

5. Complete the assembly as shown below for each stud.

6. Fix the baseplate to the ground using the four pegs provided through the four outer holes. If force is needed, remove the raingauge first, fit the base, and then replace the raingauge.

7. Adjust the thumb nuts to level the gauge. Ensure that the thumb nuts are tightened to secure the gauge.

8. Replace the funnel and check operation of the gauge.
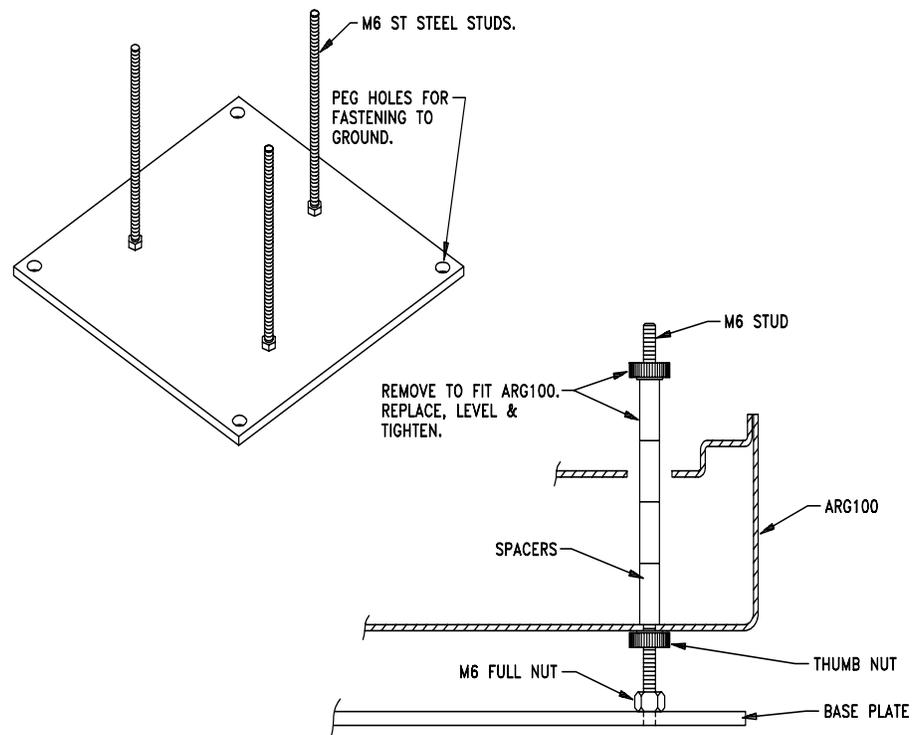
Figure A-1 Installation of RGB1

ARG100 Tipping Bucket Raingauge

The serial number and calibration factor for this gauge are as follows:
(the serial number is also affixed to the gauge base and beneath the funnel)

Serial No.   _____

Calibration Factor: _____

Date: _____

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