# Model K63

Hotplate® Total Precipitation Gauge

Operation & Maintenance Manual


by

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# 1. Background

This report documents the installation, operating and maintenance procedures for the Hotplate® Total Precipitation Gauge, Pond Engineering Model Number K63. Information contained in this manual is proprietary to Pond Engineering and is provided for use by the purchaser exclusively for instructional and maintenance purposes; any other use is prohibited.

# 2. General Information and Operating Principles

This state-of-the-art precipitation gauge utilizes a solid-state precipitation sensing head with an integrated microprocessor-based control system to accurately measure and report precipitation events. When properly used, the system is capable of reporting frozen, freezing, and liquid precipitation at rates of up to 25mm/hr (liquid equivalent).

Designed and developed in conjunction with NCAR, the Model K63 Hotplate® Total Precipitation Gauge is based on patented technology licensed exclusively to Pond Engineering by UCAR. Utilizing a state-of-the-art single board microcontroller together with Pond Engineering's ultra-high precision temperature control technology, it independently controls the temperature of two thermally isolated plates in the solid-state sensing head. The upper plate, exposed to incident precipitation, is the sensor plate. The lower plate, which is substantially shielded from falling precipitation, is the reference plate. Precise temperature control and calibration of the temperature sensors on each plate to within ±0.3°C assures accurate and repeatable measurements. Precision power measurement circuitry and individual system calibration (uncertainty ±1.2W) together with data provided by an environmental sensor allows calculation of highly accurate liquid equivalent precipitation rates of rain or snow, as well as 24-hour accumulation totals.

Unlike traditional precipitation measurement systems, the Hotplate® system provides data with very low latency, reporting precipitation events as short as 1 minute in duration. Any incident precipitation is quickly evaporated and measured, allowing the system to quantify events that may have been missed by legacy precipitation measurement systems.

**Figure 1** shows the general configuration of the Hotplate® Total Precipitation Gauge to provide the reader a better visualization of its appearance, as well as a point of reference for location and use of the controls and service points discussed later in this manual.

**Figure 1 - System General Layout**

# 3. System Installation & Commissioning

## 3.1 Site Selection & Preparation

When selecting a site for the Model K63, there are several factors that must be considered in order to ensure maximum data integrity and safety. This section contains information to be considered when selecting and preparing a site for this system.

### 3.1.1 Wind Obstacles/Turbulence

Turbulent air flow over the sensor head can cause variations in thermal load for the sensor and reference plates respectively. These variations can cause the system to over- or under-report precipitation rates. To ensure accurate measurement of precipitation and wind speed, the system should be installed in a relatively large, flat area with few obstructions (i.e. structures, other instruments or met towers).

### 3.1.2 Ground Vegetation

During operation, the sensing head of the Model K63 is electrically heated and controlled at an elevated temperature (between 70°C and 90°C). Because of fire risks associated with an electrically heated apparatus, it is highly recommended that the ground immediately surrounding the system be cleared of any and all vegetation. As a guideline, all vegetation within 1.25x the installed height of the system (see **Figure 2** for reference) should be cleared and maintained clear or covered with a fireproof material.

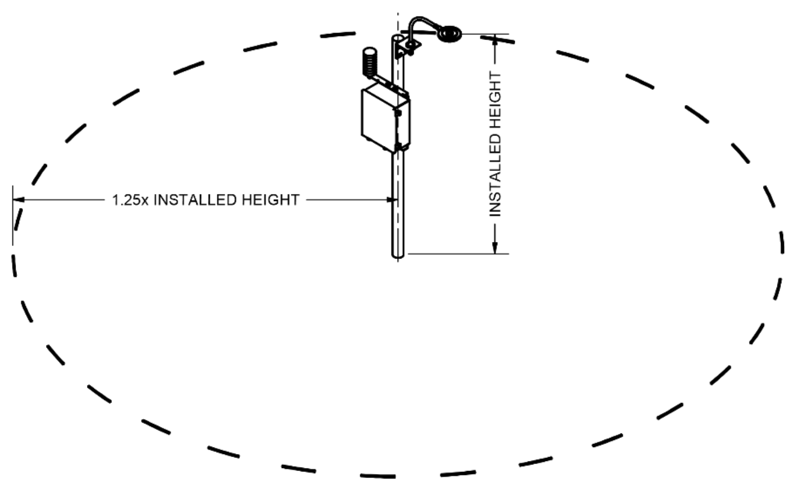


**Figure 2 - Fire Risk Area**

### 3.1.3 Wildlife/Animal Interaction

One advantage of the heated nature of this system is that birds, small rodents, and insects will tend not to nest and/or roost on or near the sensing head. This minimizes the need for small-animal deterrents, as well as cleaning/removal of nests, spider webs, etc.

Large animals such as moose, elk, bears, and even cattle may try to use the system as a scratching post and may cause damage to the installation. While a wind shield or fence is not required for this system to operate accurately, fencing may be necessary in order to protect the system from any local wildlife or animals.

## 3.2 System Installation

With the site prepared as outlined above, the system can now be installed. The following sections outline the process for system installation.

### 3.2.1 Control Box

The control box comes fitted with two (2) 1-1/2” angle mounting brackets attached to it. These mounting brackets have features to accommodate U-bolts ranging from 1-1/4” to 2-1/2” (32-64mm) inside diameter. Straight fasteners may also be used if preferred. Fasteners can be up to 5/16” (8mm) in diameter. Care should be taken to ensure that the control box is level (±5°) when mounted.

### 3.2.2 Environmental Sensor

Once the control box is mounted, the environmental sensor can be attached. First, remove the 1/2” conduit nut from the base of the environmental sensor. With the nut removed, insert the cable through the slot in the upper mounting bracket on the control box. Slide the threaded boss into the machined hole, re-install and tighten the nut. Typically, the nut can be adequately tightened by turning the sensor body while holding the nut stationary.

Electrical connection of the environmental sensor is accomplished by removing the 1/2” conduit nut from the cable feed-thru and feeding the cable through the appropriate hole in the bottom of the control box (see **Section 6.1** for reference). The feed-thru is then inserted into the hole in the control box. With the feed-thru in place, thread the nut over the connector and cable then re-install and tighten the nut. Plug the sensor connector into the appropriate socket on the control board (there is only 1 mating socket on the board).

### 3.2.3 Sensor Head Mounting Plate

A machined “L” bracket for mounting the sensor head is provided as part of the system. The sensor head is fitted with a 40” (1m) cable for connection to the control box. It is important that the sensor head mounting plate be positioned such that the sensor can be easily connected to the control box without resulting in unnecessary strain on the cable. The mounting bracket has features to accommodate mounting with U-bolts ranging from 1-1/4” to 2-1/2” (32-64mm) inside diameter. Straight fasteners may also be used if preferred. Fasteners can be up to 5/16” (8mm) in diameter. Typically, the plate is mounted with the vertical leg extending downward, but it can be used in either orientation. Care should be taken to ensure that the mounting plate is level (±5°) when mounted.

### 3.2.4 Sensor Head

The sensor head comes pre-assembled with the necessary washers and mounting nut in place. When placing the sensor head on the mount, ensure that the washers are in the correct locations, as shown in **Section 6.2**. Once in place, use a wrench to tighten the mounting nut. **DO NOT FULLY TIGHTEN AT THIS STAGE**. The sensor head should still be able to be adjusted and leveled at this point.

Orientation of the sensor head (i.e. which way it is “pointing”) is relatively inconsequential and can be adjusted to suit the installation setup.

Various methods can be used to level the sensing head. It is convenient to place a torpedo level on the top of the sensing head during leveling, rotating the level 90° to check both planes. Once level (±1°), the mounting nut should be tightened to a torque of 60 to 120 in-lbs, locking the sensor in position.

Electrical connection of the sensor head is accomplished by removing the 1” conduit nut from the cable feed-thru, threading the cable through the appropriate hole in the bottom of the control box (see **Section 6.1** for reference) and inserting the feed-thru into the hole. With the feed-thru in place, thread the nut over the connector and cable and re-install and tighten the nut. Plug the sensor into the appropriate socket on the control board (there is only 1 mating socket on the board).

### 3.2.5 Accumulation Jumper

By default, the K63 is configured to automatically reset the accumulation parameter at 00:00, based on the internal system clock. This feature can be disabled by reconfiguring a hardware jumper on the control circuit board as shown below. In either configuration, the accumulation can be reset manually via RS-232 command.

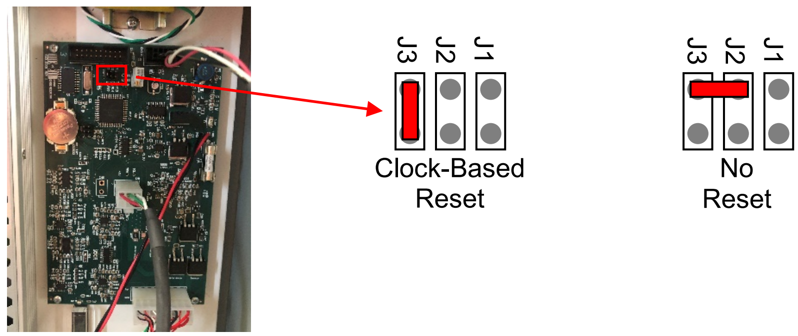


**Figure 3 - Accumulation Jumper Positions**

## 3.3 Communications

### 3.3.1 RS-232 Settings

The settings for RS-232 communications are as follows:

| | |
|---|---|
| Baud Rate | 9600 |
| Data Bits | 8 |
| Parity | None |
| Stop Bits | 1 |
| Flow Control | None |

### 3.3.2 RS-232 Command Set

The command set for the system is outlined in the following paragraphs. The commands are issued from the host computer which acts as the controller. Note that each command must be terminated with a CR (\r) for the command to be correctly received by the Model K63.

#### 3.3.2.1 1-Minute Data Transmit

Data maintained in 1-minute running averages can be retrieved by sending “T1” to the system. On receiving this command, the system will respond with a string of 84 characters containing the following data:

Time Stamp, precip rate,24 hour accumulated precip, ambient temperature, 1-minute barometric pressure, 1-minute relative humidity, wind speed, system status, 1-minute Sensor Plate power, 1-minute Ref. Plate power*CRC-16

The syntax for the interpretation of this data is:

T1\r\nmm/dd/yyyy(sp)hh:mm:ss,dd.dd,dddd.dd,±dd.dd,dddd.d,ddd.d,dd.d,d,ddd.d,ddd.d*hhhh

Below is a sample response to the “T1” command:

T1\r\n**02/24/2020\s20:24:42,00.00,0000.01,+22.96,0844.1,016.6,00.1,1,008.3,007.7***3A27\r\n

The last 4 bytes of the data transmission are a 16-bit CRC performed on the data in the transmission. In the above example, the bold characters are used in the calculation of the CRC. The polynomial used to generate this CRC is $x^{16}+x^{15}+x^2+1$ (hex code 0x8005), and the CRC register starts at hex 0x00.

Pond Engineering recommends terminating the “read” operation after the appropriate number of characters. For the “T1” command, the response will contain 84 characters. Alternatively, the user can specify a line-feed character (\n or 0x0A) as a termination character. If this is done, each query must consist of a write followed by 2 reads.

### 3.3.2.2 5-Minute Data Transmit

Data maintained in 5-minute running averages can be retrieved by sending “T5” to the system. On receiving this command, the system will respond with a string of 75 characters containing the following data:

Time Stamp, 5-minute avg precip rate, 5-minute avg ambient temperature, 5-minute barometric pressure, 5-minute relative humidity, 5-minute avg wind speed, system status, SP_Pwr_5, RP_Pwr_5*CRC-16

The syntax for the interpretation of this data is:

T5\r\nmm/dd/yyyy(sp)hh:mm:ss,dd.dd,±dd.dd,dddd.d,ddd.d,dd.d,d,ddd.d,ddd.d*hhhh

Below is a sample response to the “T5” command:

T5\r\n**02/24/2020\s20:32:04,00.00,+22.96,0844.1,016.6,00.1,1,008.2,007.5***B316\r\n

As with the 1-minute data, the 5-minute data is terminated by a 16-bit CRC that can be used to verify data integrity. See **Section 3.3.2.1** for more details on the CRC implementation.

Pond Engineering recommends terminating the “read” operation after the appropriate number of characters. For the “T5” command, the response will contain 75 characters. Alternatively, the user can specify a line-feed character (\n or 0x0A) as a termination character. If this is done, each query must consist of a write followed by 2 reads.

### 3.3.2.3 Read Individual Parameter

The "READ" command, called by sending an "R" (upper or lower case) followed by the two-digit address of the variable, enables the user to read or interrogate the current values for system variables. The syntax for the read command is "Rxx", where xx is the address of the variable to interrogate. The address must be two digits in length, therefore addresses less than 10 MUST HAVE LEADING ZEROS. After receiving a read command, the system will wait to be addressed as a talker to return the data over the bus. The system has a one second write time-out, thus the controller in charge must read from the system within one second after sending the "R" command to receive data. For example: If the user wants to see the value stored as the 1-minute average wind speed, the user would send the character string: R05. The controller in charge would then wait for the data to be returned.

****Note: Control of the K63 remains the highest priority even when the system is in remote mode and may put off responding to remote commands for as long as 500ms.**

Continuing with the above example, as soon as it is not performing control functions the K63 will return the 23-byte text string R05\r\n+1.840000e+01\s05\r\n. This indicates that the value 18.4 (m/sec) is the current value for Variable 05 (the 1-minute average wind speed). Values returned are always in the above scientific notation format followed by a space and address number for the given value.

The following is a list of commonly accessed system variables and their locations.

**Table 1 - Commonly Accessed Variables**

| Vars Addr | Description | Units |
|---|---|---|
| 0 | Current Setpoint Temperature | °C |
| 1 | 24-hr Precip. Accumulation | mm (liquid equiv) |
| 2 | Instantaneous Ambient Temperature | °C |
| 3 | 1-Minute Average Ambient Temperature | °C |
| 4 | 5-Minute Average Ambient Temperature | °C |
| 5 | 1-Minute Average Wind Speed | m/sec |
| 6 | 5-Minute Average Wind Speed | m/sec |
| 7 | 1-Minute Average Precipitation Rate | mm/hr |
| 8 | 5-Minute Average Precipitation Rate | mm/hr |
| 9 | 1-Minute Average Precip. Rate – Corrected | mm/hr |
| 64 | Real-Time Clock Value – seconds | ss |
| 65 | Real-Time Clock Value – minutes | mm |
| 66 | Real-Time Clock Value – hours | hh |
| 67 | Real-Time Clock Value – day | dd |
| 68 | Real-Time Clock Value – month | mm |
| 69 | Real-Time Clock Value – year | yyyy |
| 96 | 1-Minute Average Barometric Pressure | mbar |
| 97 | 5-Minute Average Barometric Pressure | mbar |
| 98 | 1-Minute Average RH | %RH |
| 99 | 5-Minute Average RH | %RH |

### 3.3.3 Data Visualization Software

Available on request from Pond Engineering is a copy of the Model K63 Data Visualization Software. This software provides an intuitive interface for visualization of data as it is received from the instrument. While this software does not include data storage functionality, it provides a means to verify system functionality prior to implementing data collection and storage software. Custom software packages are also available to integrate the Model K63 as part of a more comprehensive met station or mesonet.

**Installation**

To begin the installation, open the *installer.exe* file received from Pond Engineering. From there, follow the prompts to install the software.

**Usage**

To start the software, go to Start – Program Files – Hotplate – K63 Data Visualizer. The screen should appear as shown in **Figure 9**. Be sure to set the "Resource Name" control to the appropriate COM port.

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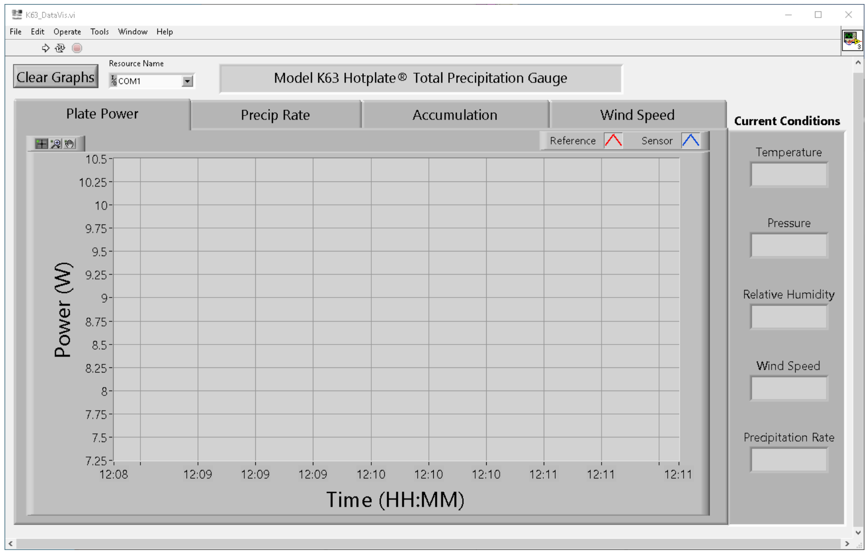



**Figure 4 – K63 Data Visualizer Screen**

# 4. Normal Operating Procedures

## 4.1 Initial Power-on and Warm-up

Once the K63 is connected to power, the sensing head will begin heating and the system will be operational. Typically, the system takes 2-4 minutes to stabilize at the setpoint. During this warm-up period, the status LED, located on the bottom surface of the control enclosure, will alternate red/green. Once stable at operating temperature, the status LED will change to solid green, with a brief off-period every second to indicate that the controller is active. While the sensor can provide precipitation data during the warm-up period, the data provided will be most accurate once the sensor is able to stabilize at the system setpoint.

During the onset of heavy precipitation, it is reasonable to expect the system to return to its warm-up state until it can re-establish control after compensating for the precipitation. As such, precipitation rates during the onset and termination of a significant precipitation event may be under- or over-reported.

# 5. Handling and Maintenance

## 5.1 System Maintenance

The Hotplate® Total Precipitation Gauge is designed and fabricated to require minimal periodic maintenance. The following information is provided to guide the user in maintaining the system.

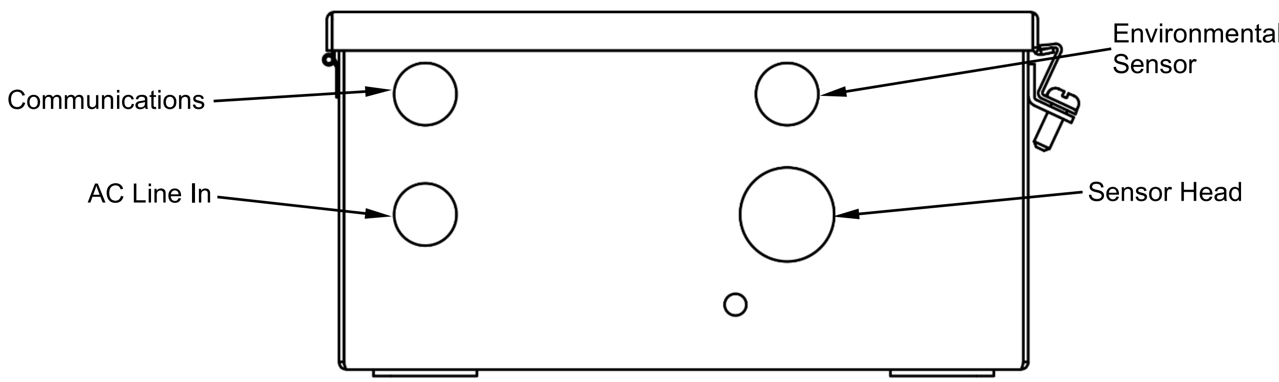
#### 5.1.1 Cleaning

In environments where there is significant mineral content in the water, a residue may accumulate on the sensor plate over time. While this residue should not influence system performance, it may be beneficial to remove the residue periodically. The system should be unplugged and allowed to cool before handling or cleaning the sensor head.

# 6. System Hardware Description

A brief description of system hardware is provided in this section as a reference to aid the user in periodic maintenance of the system. In the event significant maintenance or repair is required, it is recommended that Pond Engineering be contacted prior to replacing or modifying major system components.

## 6.1 Control Box



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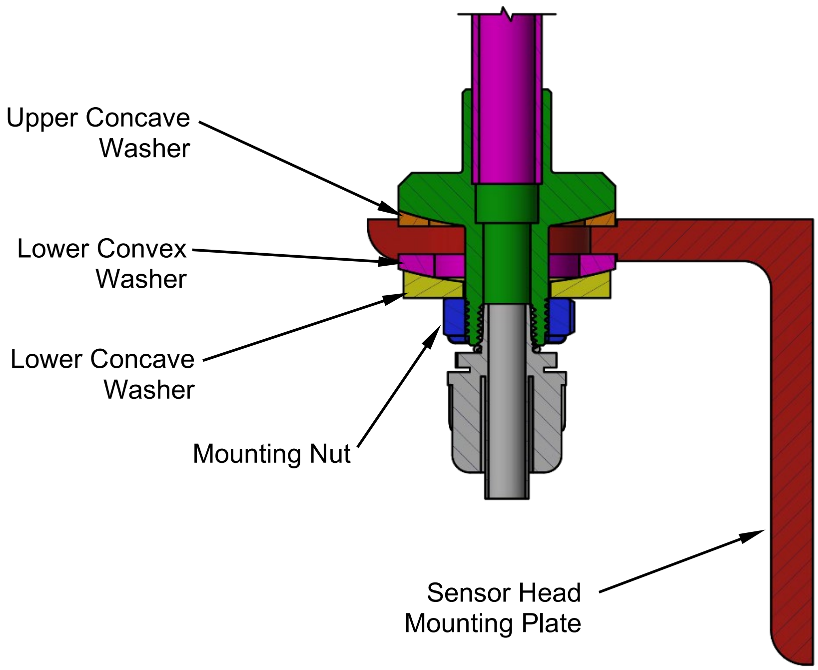
## 6.2 Sensor Head Mount



## 6.3 Top Level Schematic

This page is intentionally left blank. The following page contains a schematic diagram of the Model K63 electrical systems.