INSTRUCTION MANUAL
TB3 Heater Kit
Model TBH

HYQUEST SOLUTIONS

QUALITY SYSTEM

ISO: 9001

CERTIFIED

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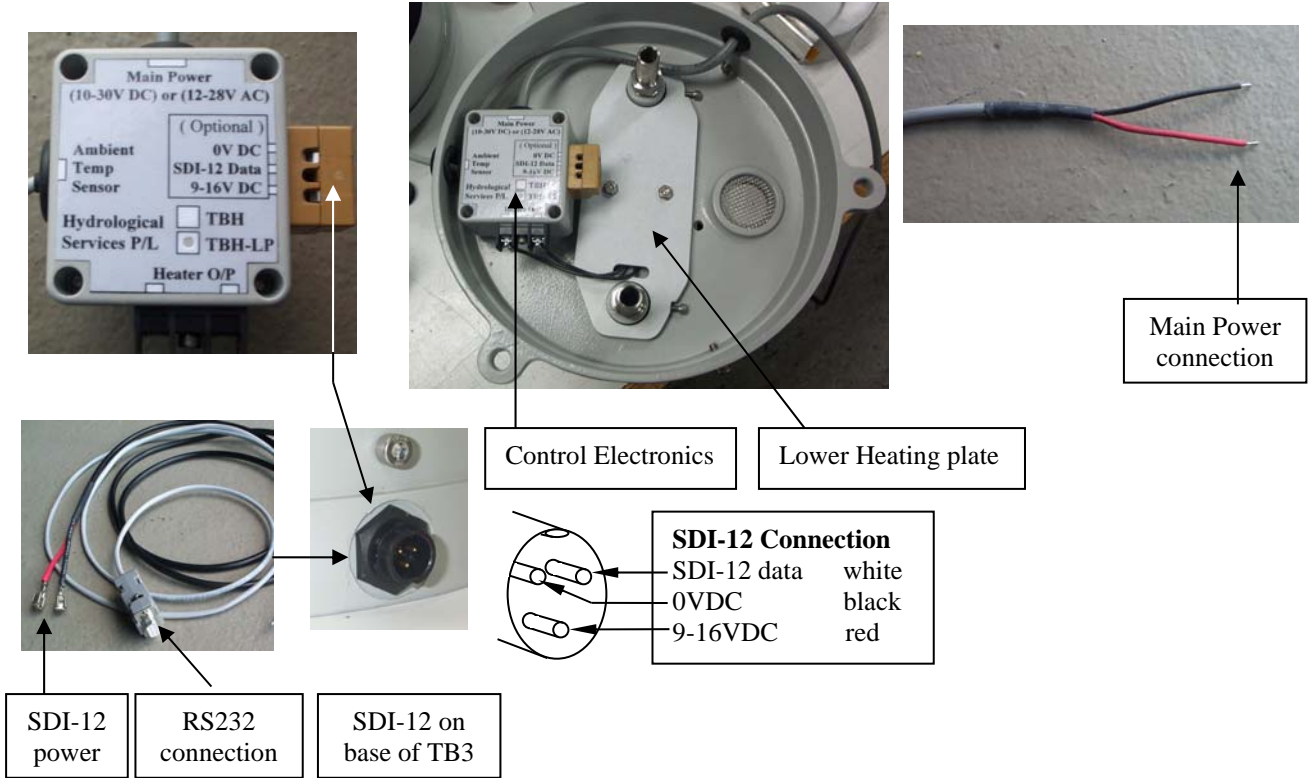
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1. INTRODUCTION

The HyQuest Solutions Tipping Bucket Heater has been designed for use with the HyQuest Solutions Tipping Bucket Raingauges. The device is a thermostatically controlled heating element that raises the temperature of the interior of the raingauge, funnel and catch to avoid the freezing of the gauge in cold climates with subsequent loss of precipitation records. When the ambient temperature drops below a preset value (+ 4°C), the snow sensor in the funnel is activated. The heating elements remain "**OFF**" until snow is detected in the catch area (funnel). The heating elements are turned on and off to keep the funnel temperature at the preset Setpoint temperature. (+ 10°C) This will continue for the Snow Run-on time (18 mins) after there is no snow detected in the catch. The heater will then be switched off and the unit will return to the "**WAIT**" mode until triggered by another snow event. The system will be de-activated when temperature drops below (-15 ^{o}C) or above (+4.5 ^{o}C) nominal. The combination of snow sensor and thermostatic control of the heater element is designed to conserve power.

The TB Heater is supplied ready to be installed with no settings required. The TB Heater incorporates an SDI-12 interface that allows the operator to configure, monitor and manually control the TB Heater – depending on the system requirements. (It is not mandatory to use the SDI-12 interface – but only optional if more detailed information or control is required.) The SDI-12 interface is optically isolated from the control electronics, because the control electronics may be operated from AC and therefore have separate earthing. This is why the SDI-12 interface requires a separate 12V DC power source.

For information relating to the TB3 Tipping Bucket Raingauge, refer to the TB3 Instruction Manual.
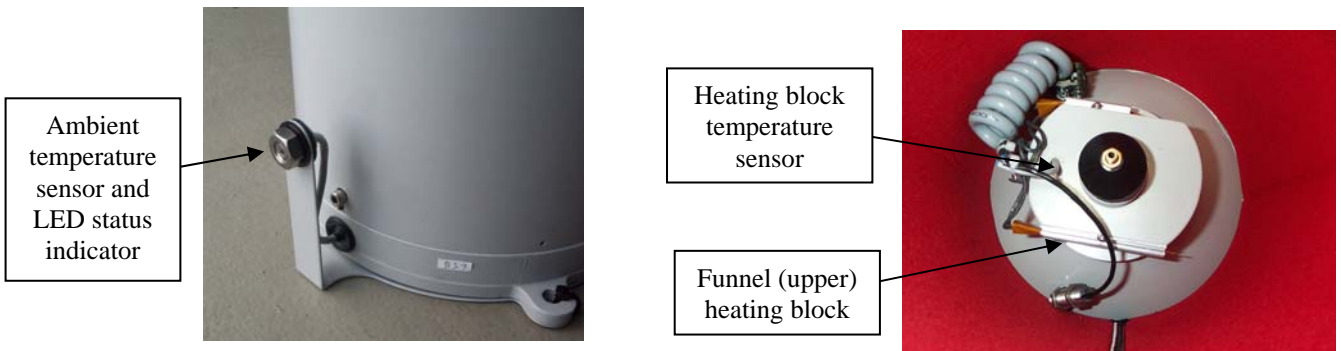
2. INSTALLATION

Simply connect the red and black "Main Power" to the power source (10-30V DC) or (12-28VAC). The red status LED will start flashing, indicating the unit has power. This is all that is required for a minimum installation. (*** See the next page for power cabling requirements ***)

Main Power
connection

Control Electronics

Lower Heating plate

SDI-12 Connection
SDI-12 data   white
0VDC   black
9-16VDC   red

SDI-12 power

RS232 connection

SDI-12 on base of TB3

If SDI-12 communications is required, then connect the logger or RTU to the 3 pin connector (Switchcraft brand) on the base of the TB3 raingauge, and supply SDI-12 power.

If RS232 communications is required, then connect the supplied RS232 adapter cable to the 3 pin connector on the base of the TB3 raingauge, and connect the SDI-12 power to a 12V battery and the DB9 RS232 connector to a PC.

Ambient temperature sensor and LED status indicator

Heating block temperature sensor

Funnel (upper) heating block

2.1 POWER CABLE - VERY IMPORTANT !

The TB Heater is supplied with a 3m power cable that is 0.75mm^2, designed to be directly connected to a power supply. If you wish to extend this power cable, you must use heavier gauge cable because the TB Heater draws 6Amps **when the heater elements are on**, resulting in a voltage drop on the power cable. If the power supply voltage is say 13.8V DC, then a voltage drop of 1.5V is quite acceptable - resulting in a TB Heater supply voltage of 12.3V.

The following table gives an indication of the cable gauge required for varying distances :
(This table assumes the power supply voltage is 13.8V DC)

Cable Length	Cable Gauge	Conductor Diameter	Cable Xsect Area	Voltage Drop	Final TBH Voltage
3m (10ft)	18AWG	1.0mm	0.75mm^2	1.6V	12.2V
10m (33ft)	12AWG	2.0mm	3.0 mm^2	1.3V	12.5V
20m (66ft)	10AWG	2.6mm	5.3 mm^2	1.6V	12.2V
30m (98ft)	8AWG	3.2mm	8.0 mm^2	1.5V	12.3V
40m (131ft)	6AWG	4.1mm	13.2mm^2	1.3V	12.5V
50m (164ft)	6AWG	4.1mm	13.2mm^2	1.6V	12.2V
60m (197ft)	4AWG	5.2mm	21 mm^2	1.2V	12.6V
70m (230ft)	4AWG	5.2mm	21 mm^2	1.4V	12.4V
80m (262ft)	4AWG	5.2mm	21 mm^2	1.6V	12.2V
90m (295ft)	4AWG	5.2mm	21 mm^2	1.8V	12.0V
100m (328ft)	3AWG	5.8mm	26 mm^2	1.6V	12.2V

You could refer to the website www.powerstream.com/wire_size.htm for a wire size calculator to assist in calculating the wire gauge for your system.   ******* Please remember to double the cable length in the wire size calculator to get the total round trip distance. The calculator will then give the voltage drop on the +ve power wire plus the voltage drop on the -ve power wire.

When extending the power cable, it is best to join the wires inside a junction box, and shorten the supplied 3m power cable (to less than 1m) to further reduce the voltage losses.
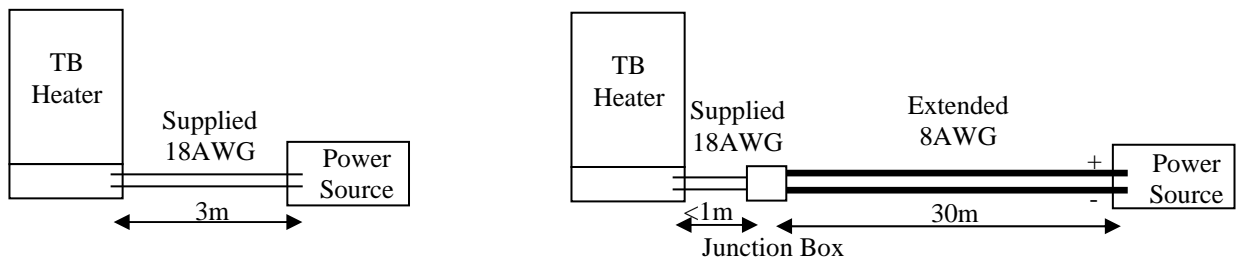
What happens if I use a cable that's not thick enough ?

If the voltage along the power cable drops too much when the heater elements turn on, then the microprocessor controlling the TB Heater will power down - this will be indicated by the status LED giving a long flash (powering up), then the usual short LED flashes (initialising), then the heater elements will attempt to turn on and the voltage will drop….. repeating this sequence over and over. This will result in the heater element never turning on and water freezing inside the rain gauge.

3.   OPERATION

The TB Heater has been configured with the following factory defaults :

External Control Off (=> Auto)   (X20 Command) = 0
Snow Sensor Enabled   (X22 Command) = 1
Active On Temperature +4ºC   (X23 Command)
Active Off Temperature +5ºC   (X24 Command)
Low Off Temperature –15ºC   (X25 Command)
Funnel Set Point Temp +10ºC   (X26 Command)
Snow Run-On Time 18 mins   (X27 Command)
Units ºC   (X28 Command) = 0
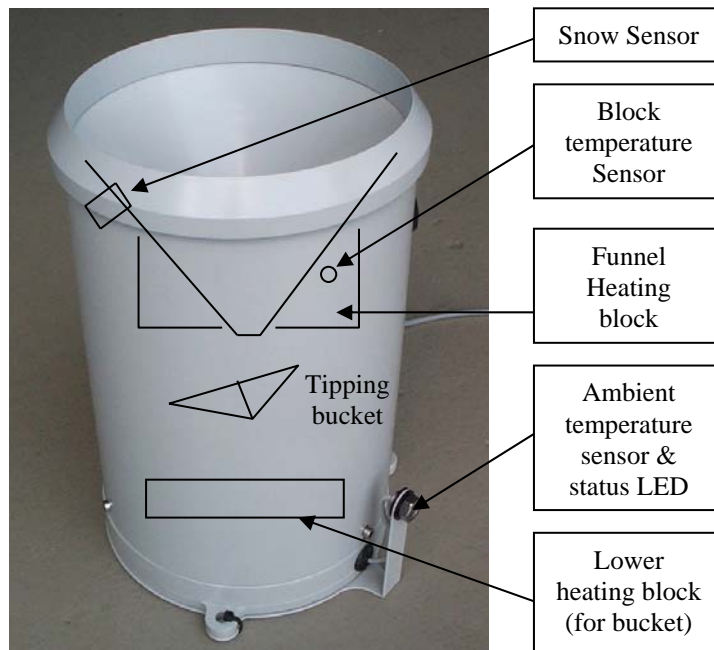
When the TB Heater is "**not** Active" the status LED flashes every 1.5 seconds.

When the ambient temperature sensor detects the temperature falling below the "Active On temperature" (+4ºC) then the system becomes "Active" and the snow sensor is enabled. (See the diagram on the following page) The status LED flashes slightly faster at 2 flashes per second – indicating the system is active.

When the proximity sensor detects snow (for 5 seconds continuously), the heater elements are turned on and the block temperature sensor is monitored. The heaters are controlled so that the temperature inside the funnel reaches the Set Point temperature (+10ºC) (Note that the actual block temperature will be higher than the setpoint as substantial heat is dissipated.) The lower heating block keeps the tipping bucket and the drain tubes from freezing up. While the heater elements are turned on, the status LED flashes even faster at 8 flashes per second.

When snow is last detected, a timer is left running, to keep the heater cycling so that any snow built up on the funnel will be melted. This "Snow Run-on" timer is factory preset to 18 minutes but may be extended as required.

The heater will cycle on and off for this "Run-on" time OR while ever snow is detected. (The diagram on the following page shows how this controls the heater.)

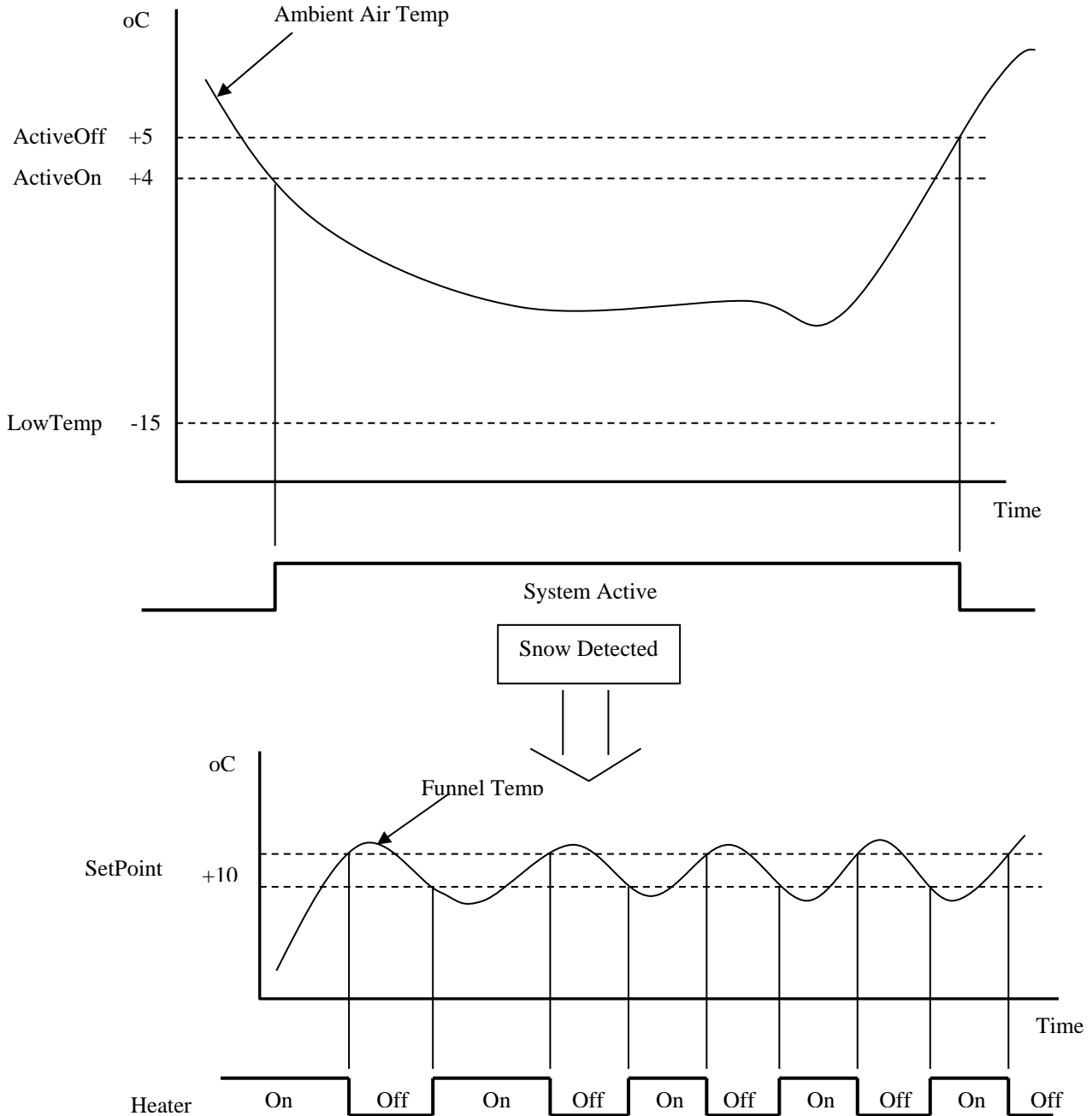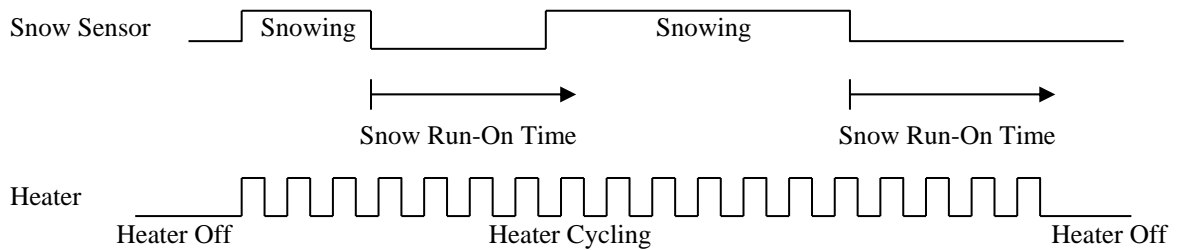The following 2 pictures show the overall operation diagrammatically :

Diagram showing how the "Snow Run-On" timer controls the heater.

High Power Operation

If the Snow Sensor is disabled (X22 command set to 0) then the heater will cycle continually when the ambient temperature falls below the "Active On" temperature (X23 command) and is above the Low Off Temperature (X25 command) (That is while the system is active) In this mode the TB Heater will consume more power, and is recommended for AC connection only.

External Control

The TB Heater is supplied set to Automatic control – where the heater monitors the ambient temperature and the snow sensor and operates the heater automatically. In some systems, a full weather station may monitor the ambient temperature and the snowfall, and this system may control the tipping bucket heaters directly. Simply set the X20 command to 1 for External Control, and then use the X29 command to enable the heaters to cycle on/off (=1) or disable the cycling (=0). The ambient temperature, block temperature, snow sensor and state of the heaters can be measured using the M, R or the C command, as normal. Also note that the Setpoint Temperature is the required temperature of the funnel – and not the block temperature read from M and the R command. (The relationship between the funnel temperature, block temperature and ambient temperature has been determined through extensive testing.)

There is an alternate external control mode, whereby the controlling system can actually turn the heating elements on and off. This is done using the X21 command, with heater "on" (=1) and heater "off" (=0). Note that if the heating elements are left turned on, the funnel temperature may reach a point where the snow evaporates before it hits the funnel. So this mode should be used with extreme caution !

Units

The default units are °C. Simply use the SDI-12 X28 command with data = 1 to set the units to °F.

Status LED

The Status LED, within the ambient temperature sensor probe, flashes to indicate the mode that the TB Heater is in.

Mode	Flash Rate	Description
Long Flash	LED on for 0.5 sec	Controller powering5 up.
Slow Flash	1 flash every 1.5 secs	In standby mode waiting for a heating cycle.
Medium Flash	2 flashes per second	Within a Heating Cycle and the Heating Elements are presently turned **OFF**. Waiting for snow to be present before turning on heaters.
Fast Flash	8 flashes per second	Within a Heating Cycle and the Heating elements are presently turned **ON.**

Snow Sensor

The snow sensor is actually a capacitive proximity sensor that registers any material object within a few mm range. The sensor has power applied or removed to save power, and has power applied under the conditions tabled below.

The state of the snow sensor (snow detected) is read using the Measure (aM!) and Data (aD0!) commands (4th value).

Note: The snow sensor must detect snow continuously for 5 seconds before the detected flag is set to "1". And conversely, snow must be absent for 5 seconds continuously before the detected flag is reset to "0". (This debouncing prevents a premature heating cycle when in the automatic mode.)

Mode (X20 command)	Snow Enabled X22 command	Description
Auto	0	Snow sensor doesn't have power applied. Cannot detect real snow, however it indicates snow is always present.
	1	Snow sensor only has power applied when the Ambient temperature is below the Active On temperature. Can only detect snow when temperature is in this range.
Manual	0	Snow sensor doesn't have power applied. Cannot detect real snow, however it indicates snow is always present.
	1	Snow sensor always has power applied, and can detect snow at any time.

4. SDI-12 INTERFACE

The SDI-12 protocol has very strict timing requirements. The operator may use the SDI-12 to RS232 adaptor cable and then communicate using RS232 from a PC. This special mode is enacted on each command by proceeding each SDI-12 command with an ascii '*' rather than a "break". When the ascii '*' is detected, all of the timing/break requirements of the SDI-12 are removed. Commands may be typed from a terminal program such as "Hyperterminal".

Eg.   0M!   SDI-12 command with strict break timing
               *0M!   RS232 command with all timing removed

*** Note ***   you must use **1200 baud, 7 bits, even parity** and no handshaking.
               The "**a**" is the sensor address in the displayed commands.
               The TB Heater is set to address "0" when shipped.

SDI-12 V1.2 COMPLIANT COMMAND SET   –   Go to   www.sdi-12.org

Name	Command	Response
Break	Continuous spacing for at least 12 milliseconds	None
Acknowledge Active	a!	a<CR><LF>
Send Identification	aI!	allccccccccmmmmmmvvvxxx...xx<CR><LF> (Refer Note 1.)
Change Address	aAb!	b<CR><LF>
Address Query	?!	a<CR><LF>
Start Measurement	aM!	atttn<CR><LF> a0009 => (9 measurements in 0 secs)
Send Data	aD0!	(Response from Measurement and Concurrent commands) (Refer to Note 4) a<value1><value2> ….. <value8><CR><LF> value1 = Ambient temperature (°C or °F) value2 = Block temperature (°C or °F) value3 = Units (0=°C : 1=°F) value4 = 0=no snow : 1=snow detected value5 = 0=Snow sensor disabled : 1=enabled value6 = 0=Heater Off : 1=Heater elements on value7 = 0=Automatic Control : 1=Manual Control value8 = 0=Cycle Disabled : 1=Cycle Enabled value9 = Low Power Heater cycle time left (mins)
Continuous Measurement	aR0!	Same reply as the D command
Start Verification	aV!	Atttn<CR><LF> (Refer Note 2)
Start Concurrent Measurement	aC!	atttnn<CR><LF> a00009 =>(9 measurements in 0 secs)

Note 1.

a12HydrServTBHeat4.112345<CR><LF>
```
 -- ------------ --------- --- ------
| |     |            |     |    |
| |     |            |     |   ---        5 digit Sensor ID (eg 12345)(as set in aX4 command)
| |     |            |    ---------       S/W Revision (eg 4.1)
| |     |        ----------------         Model (TBHeat)
| |     --------------------------        Company ID (HydrServ)
| ----------------------------------      SDI-12 Version V1.2 Compliant
----------------------------------            --       Unit Address
```

Note 2.

The measurement command "M" and the concurrent command "C" will both return a time "ttt" of 000 indicating that the measurement will be ready in 0 seconds (immediately).

Note 3.

aV!<u>Initiate Verify Command</u>

The TB Heater returns a0001<CR><LF> indicating that there is 1 measurement available and it will be ready in 0 seconds. When the Data command aD0! is issued the TB Heater will reply with :
```
a+0<CR><LF>
  |
  -----------        Fixed reply
```

Note 4.

Data Command Reply Format

0-06.5+33.3+0+1+1+0+0+0+05\<CR\>\<LF\>
-- ---- ---- -- -- -- -- -- -- --

```
 |   |     |   |   |   |   |  |  |   |
 |   |     |   |   |   |   |  |  |   -----    Heater Cycle Time Left
 |   |     |   |   |   |   |  |  |            (5  mins  in  this  example)   (only  in  Automatic
Control  mode)
 |   |     |   |   |   |   |  |  ----------   Cycle  0=>  Disabled : 1=>  Enabled  (only  in
Manual                                                                      Control)
 |   |     |   |   |   |  |                   (Only  in  S/W  Rev  4.1  and  above  See  X29
Command)
 |   |     |   |   |   |  -------------        Control 0=> Automatic : 1=> Manual  (See  X20
Command)
 |   |     |   |   |  ----------------         Heater Elements 0=> Power Off : 1=> Power On
 |   |     |   |  --------------------         Snow Sensor 0=> Disabled : 1=> Enabled  (See
X22 Command)
 |   |     |  -----------------------         Snow   0=>No Snow  : 1=> Snow Detected
 |   |  ---------------------------           Units 0=> ºC : 1=> ºF  (See X28 Command)
 |   ----------------------------------       Block Temperature +33.3 ºC
 ----------------------------------------     Ambient Temperature –6.5 ºC
-----------------------------------------     Unit Address (0 in this example)
```

Special – X Commands

The SDI-12 X commands allow device specific data to be read and set. The following commands are unique to the TB Heater.

*** NOTE*** **In the following commands "a" is the address of the TB Heater – set to "0" at the factory**

User ID   **– X04 Command**
aX04!   Get the transducer ID using the aD0! command
aX04+12345!   Set the transducer ID to 12345. Acceptable values 0-65535.
This value appears in the Identify command.

External Control   **– X20 Command**
aX20!   Get the External Control state using the aD0! command
aX20+0!   Set the External Control state to 0 => Automatic Control
aX20+1!   Set the External Control state to 1 => External Control

Heater Control   **– X21 Command (Only operates if "External Control" set to 1)**
aX21!   Get the heater state using the aD0! command
aX21+0!   Set the Heater Control state to 0 => Heater Elements Off
aX21+1!   Set the Heater Control state to 1 => Heater Elements On
         (Changing this state forces X29 Cycle Enable to 0=>disabled)

Snow Sensor Enabled   **– X22 Command**
aX22!   Get the snow sensor enabled state using the aD0! command
aX22+0!   Set the Snow Sensor Enable state to 0 => Snow sensor Disabled
(When the snow sensor is disabled, the unit reports snow as detected to force a heating cycle when the Ambient is less than the Active On temperature when in Automatic mode)
aX22+1!   Set the Snow Sensor Enable state to 1 => Snow Sensor Enabled

ActiveOn Temperature   **– X23 Command**
aX23!   Get the ActiveOn temperature using the aD0! command
aX23+04.0!   Set the ActiveOn temperature to +4.0ºC (if X28 set to 0)
aX23+39.2!   Set the ActiveOn temperature to +39.2ºF (if X28 set to 1)

ActiveOff Temperature   **– X24 Command**
aX24!   Get the ActiveOff temperature using the aD0! command
aX24+05.0!   Set the ActiveOff temperature to +5.0ºC (if X28 set to 0)
aX24+41.0!   Set the ActiveOff temperature to +41.0ºF (if X28 set to 1)

LowOff Temperature   **– X25 Command**
aX25!   Get the LowOff temperature using the aD0! command
aX25-15.0!   Set the LowOff temperature to -15.0ºC (if X28 set to 0)
aX25+05.0!   Set the LowOff temperature to +5.0ºF (if X28 set to 1)

SetPoint Temperature   **– X26 Command**
aX26!   Get the funnel SetPoint temperature using the aD0! command

aX26+10.0!   Set the funnel SetPoint temperature to +10.0°C (if X28 set to 0)
aX26+50.0!   Set the funnel SetPoint temperature to +50.0°F (if X28 set to 1)

Snow Run-On Time   – X27 Command
aX27! Get the "Snow Run-on" time after snow is detected using aD0!
aX27+18!   Set the "Snow Run-on" time to 18 mins

Celcuis / Farenheit   – X28 Command
aX28!   Get the °C / °F state using the aD0! command
aX28+0!   Set to Celcius   (data = 0)
aX28+1!   Set to Farenheit (data = 1)

Cycle Enable   – X29 Command (Only operates if "External Control" set to 1)
aX29!   Get the Cycle Enable state using the aD0! command
aX29+0!   Set the Cycle Enable state to 0 => Heating Cycle Off
aX29+1!   Set the Cycle Enable state to 1 => Heating Cycle On
                            (Changing this state forces X21 Heater Control to 0=> Off)
                            (This command is only available in S/W Rev 4.1 and above)

Preset / Calibrate Ambient Temperature Sensor – X91 Command
aX91!   Get the Ambient temperature sensor using the aD0! command
aX91+22.3!   Set the Ambient temperature sensor to +22.3°C (if X28 set to 0)
aX91+72.1!   Set the Ambient temperature sensor to +72.1°F (if X28 set to 1)

Preset / Calibrate Funnel Temperature Sensor   – X92 Command
aX92!   Get the Funnel temperature sensor using the aD0! command
aX92+18.6!   Set the Funnel temperature sensor to +18.6°C (if X28 set to 0)
aX92+65.5!   Set the Funnel temperature sensor to +65.5°F (if X28 set to 1)

Set Factory Defaults   – X99 Command
aX99+1!   Set the factory defaults (only when data is +1)

Operating Modes

The TB Heater can be put into Automatic or Manual Operation Modes. The following table describes how the modes are entered and the operation of the modes.

Auto/ Manual X20	Cycle Enable X29	Heater On/Off X21	Snow Enabled X22	Snow	Description
0	X	X	1	0 / 1	Auto Mode : When the Ambient temperature falls below the Active On temperature X23, and Snow is detected, then a Heating Cycle is started. (That is, the heater elements are switched on and off to keep inside the funnel at the SetPoint temperature X26.) This is a low power mode, as the heater cycle only begins when snow is detected !
0	X	X	0	1	Auto Mode : Same as above, but because the snow sensor is disabled the snow detected flag is always set. The Heating Cycle is started when the Ambient temperature fall below the Active On temperature X23. This mode uses more power and should only be used when the system is supplied by mains power.
1	0 / 1	0	X	X	Manual Mode : The Cycle Enable flag X29 is used to force a Heating Cycle. This is set or cleared by another system at the site – as it determines whether heating is required. When the Cycle Enable flag is "0" the heaters are off. When the Cycle Enable flag is "1" then the Heating Cycle is started. (That is, the heater elements are switched on and off to keep inside the funnel at the SetPoint temperature X26.) The snow sensor state can be read using the measure/data commands, but its state is ignored when controlling the heaters.
1	0	0 / 1	X	X	Manual Mode : The heater elements can be controlled directly with the Heater On/Off flag X21. When the flag is "0" the heaters are off, and when the flag is "1" the heaters are on. Note that the heaters must be cycled by the controlling system in order to control the funnel temperature. This mode must be used with caution !

(X = Don't Care)

5. SPECIFICATIONS

Melts snow / ice in the temperature range   -20ºC to +5ºC (-4ºF to +41ºF)

Snow sensor and heater are programmable
through SDI-12.   Factory Setting :   Heater operates between
                                               -15ºC and +5ºC   (5ºF and 41ºF)

Average power generated   35 watts (70 watts during initial warm up)

Voltage requirements

                    Main Power   10VDC to 30VDC   OR
                                               12VAC to 28VAC

                    SDI-12 Power   9.6VDC to 16VDC (SDI-12 standard)
                                               (9VDC to 16VDC allowable)

Power Cabling   3m to Power Source   Factory supplied 0.75mm^2 power cable
                  > 3m to Power Source   Heavy gauge cable required - See Sect 2.1

SDI-12 Interface   Optically Isolated
                                               1200 baud, 7 bits, even parity.

Power generated and current requirements
12 V DC
45 watts average (70 watts when heater is on)
3.7 amps average (approx 65% duty cycle) (5.8 amps when the heater is on)

Average weekly energy consumption
Assume 4 x 10 hour snow storms in a week
Energy = 4 x 10 x 45W = 1800 Watt hours / week

AmpHours = 4 x 10 x 3.7A = 150 AmpHours (over 1 week)
Which averages to 150Ah / (24 x 7) = 0.9 Amps (Averaged over a week)

IMPORTANT:
If the TB Heater is being driven from a power supply, it is recommended that the power supply can deliver at least 10 Amps, and does not current limit at a level less than this. If the TB Heater is being driven from a battery / charger combination, then the battery will deliver the required current. **If running the power cable over a long distance, heavy gauge cable MUST be used to reduce for the cable voltage drop as the heater elements draw 6Amps when on - see Sect 2.1**

NOTE : Heating elements are self-limiting.

6. APPENDIX 1 – SAMPLE CONTROL FROM A PC

Use HyperTerm on a PC and set to 1200 baud, 7 bits, even parity and local echo off. Connect to the SDI-12 to RS232 adapter, and provide +12V DC power to the SDI-12 interface. (In the following example it is assumed the SDI-12 address is set to "0")

NOTE : <CR> = Carriage Return   and   <LF> = Line Feed

Proving Communications is working

Type *0! and you should get a "0 <CR> <LF>" reply, indicating the comms is operating.

Taking a Measurement

Type *0M! and you will get "00009 <CR> <LF>"   reply indicating there are 9 measurements ready in 0 secs

Type *0D0! and you will get "0+03.5+14.2+0+1+1+1+0+0+00 <CR> <LF>" reply with the parameters "addr AmbientT BlockT Units Snow SnowEn Heater ExtCtrl CycEn TimeLeft" (Refer to the SDI-12 Interface section for details on these parameters.)

Example of Manual Mode Operation

Type *0X20+1!   to enter manual mode and you will get a "00001<CR><LF>" reply indicating there is 1 data value ready in 0 secs.

Type *0X29+1!   to start a heating cycle and you will get a "00001<CR><LF>" reply indicating there is 1 data value ready in 0 secs. The heaters will start cycling on and off to keep inside the funnel at the Setpoint temperature X26. The status LED will flash medium (2 flashes/sec) when the heater elements are off and flash fast (8 flashes/sec) when the heater elements are on.

Type *0X29+0!   To stop a heating cycle and you will get a "00001<CR><LF>" reply indicating there is 1 data value ready in 0 secs. The heaters will turn off and the status LED will slow flash (1 flash every 1.5 secs).

Refer to the SDI-12 Interface section for details of other commands.