USDT 2004
Installation and User's Guide

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Revision 7, November 2005

Introduction

Note: The information supplied in this manual is for guidance only - no part of this may be used for any agreement, whether express or implied, or to form any contract. Thermo Technologies reserves the right to change specifications without prior notice.

USDT 2004 is a powerful temperature differential control unit. It has *two programs and may be used in a wide range of applications:

PROGRAM 0 – This program is USDT 2004's basic program. Set at the factory, it uses two sensors to control a simple solar water heating system.

PROGRAM 1- This program allows the user to customize USDT 2004 for applications where a third sensor is required. With this program you may, for example, measure the flow rate or the temperature of the storage tank (T_3, top of the tank).

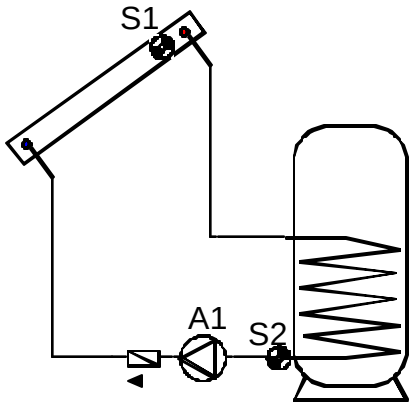
**USDT 2004 has additional programs available for a wide variety of advanced applications, these programs are not supported at this time.*

The control unit has the following functions:

- 2 inputs for temperature sensors (**PROGRAM 0**)
- 1 input for flow rate measurement or additional temperature sensor (**PROGRAM 1**)
- BTU meter capability for constant flow rate or with a flow meter
- Adjustable hysteresises dependant on temperature
- Adjustable (-3 ^{o} F to 41 ^{o} F) frost protection
- Adjustable (200 ^{o} F to 299 ^{o} F) overheating protection
- Adjustable (4.1 ^{o} F to 99 ^{o} F) temperature difference ?T
- Manual override of pump for system testing
- Digital display of all parameters
- System status and diagnostic displays

Program 0 – Two Sensor Operation (Factory Setting)

Program 0 monitors the collector temperature (T_1, at S_1) and the return temperature (T_2, at S_2, bottom of the storage tank). The solar loop circulation pump runs while the collector temperature exceeds the return temperature by an adjustable temperature difference ***diff***. To avoid overheating, the circulation pump stops if the return temperature (T_2) reaches the adjustable high limit (T_{MAX}) temperature. The temperature hysteresis (a lagging in the set-point) may over-ride ***diff*** to avoid pump cycling.



The pump A1 runs only when the temperature at the collector sensor **location S1** is higher than the return temperature at **location S2** by at least ***diff*** (?T). The pump stops if ***diff*** is less than the preset value or, when the temperature at location S2 has reached the T_{MAX}:

A1 (ON) only when S1 > (S2 + diff) & S2 < T max

INSTALLATION

Note: This installation procedure is for guidance only, and the installer should verify its suitability. Make sure that the solar system is physically installed, manually tested, and ready for controlled operation.

The following safety precautions are strongly recommended:

1. Before attempting to install and operate the unit read this instruction manual carefully.

2. Only suitably qualified personnel should carry out installation and required maintenance.

3. It is recommended that the unit be connected to the power supply via an isolating switch of 6 amp.

4. ***WARNING: When the unit is connected to the 115-volt power supply and the cover is opened, high voltage circuits will be exposed.*** When installing the unit, all required connections should be completed and the cover attached to the controller box before turning the power on. Ensure that all connections are secure. If any maintenance work is required isolate the unit from the power supply before removing the cover. ***Never leave the unit unattended if the cover has been removed and the power supply is connected.***

5. Do not exceed unit ratings of 3.15 amps (1/6 HP or 245 Watts pump).

6. It is advisable to route power cables away from sensor cables.

Sensor installation: Temperature sensors may be installed in fluid lines by mounting in a tee or strapping it to the piping directly. For the system to function correctly, it is essential that the sensors are located and installed properly. They MUST be pushed completely into the optional sensor pockets (Thermowell is not supplied). Sensors must be well insulated in order to prevent them from being influenced by the ambient temperature.

When used outdoors, water must not enter the immersion sleeves (lasting impedance change). Exposure to moisture (e.g. condensation) can diffuse through the cast resin and damage the sensor. In this event, heating at approx. 195 °F for one hour may reverse the damage.

When sensors are used in open loops or swimming pools, corrosion-resistant immersion sleeve, (sensor pockets), must be used.

- **Collector sensor (red cable with protective terminal box):** Either push into a thermowell, (sensor pocket), which is soldered or riveted directly to the manifold (vacuum tubes). Alternately,

strap the sensor to the collector outlet pipe or the absorber (flat plate collectors) that projects from the collector housing. Ideally, house the collector sensor (encased in a suitable sensor pocket) into a T-piece on the collector return outlet. Protect the sensor cable from UV and moisture.

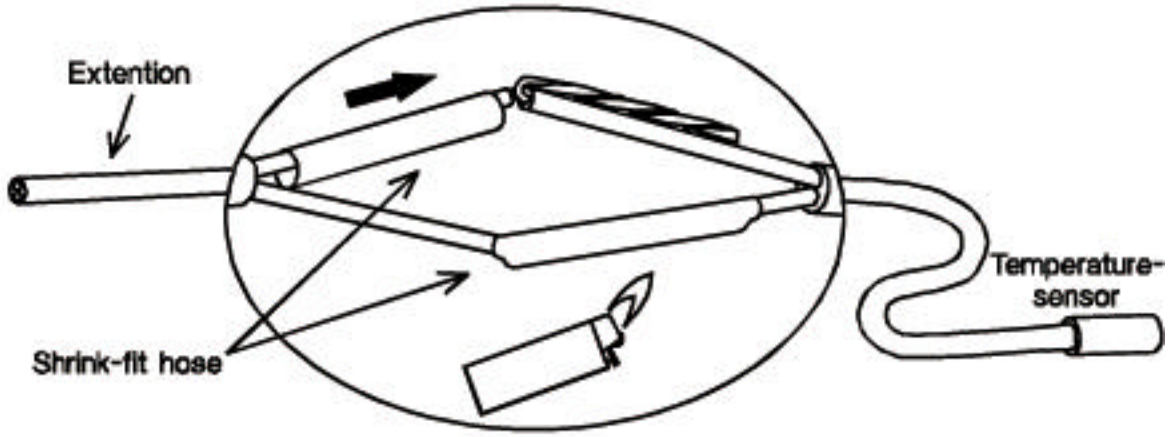
- **Return (tank) sensor (white cable):** The sensor required for the solar loop return is installed in the lower part of the storage tank. If there is no provision for this tank sensor, push the sensor beneath the insulation – keeping it close to the inner tank wall at the desire tank location.

For external heat exchangers, the tank sensor should be installed with an immersion sleeve in the return leg (cold side) of the heat exchanger. In tanks with integrated heat exchangers, the sensor pocket should be fitted at the exchanger's return to the collector.

- **Pool sensor installation:** Place a heat conductive T-piece on the suction line directly at the pool outlet and screw in the sensor with an immersion sleeve (check corrosion resistance of the material used). Alternately, attach the sensor with clips or adhesive tape, using the appropriate thermal insulation to guard against environmental influences.

- **Sensor cable extension:** Sensor cables (22/4 AWG telephone cable, you need only two wires of 4) can be extended up to 150 ft. A connection between the sensor and extension can be established as follows:

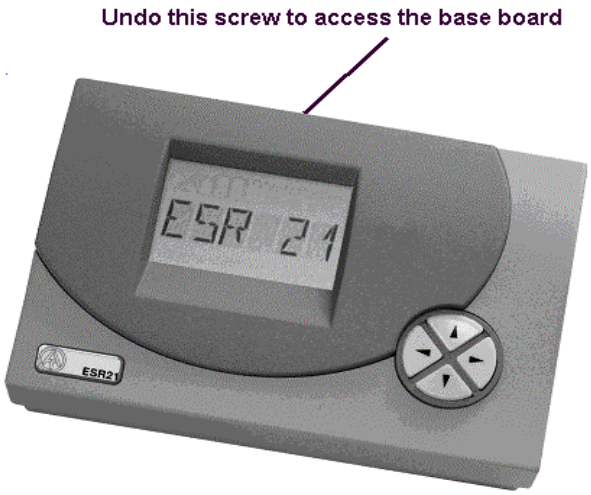
Cut the supplied heat-shrinkable tubing to desired length (about ½ "). Slide tubing over one end of wire to be sliced (after removing enough outer insulation to accept the tubing). Splice the wire and slide tubing over the splice. Heat gently all around until tubing shrinks tight.



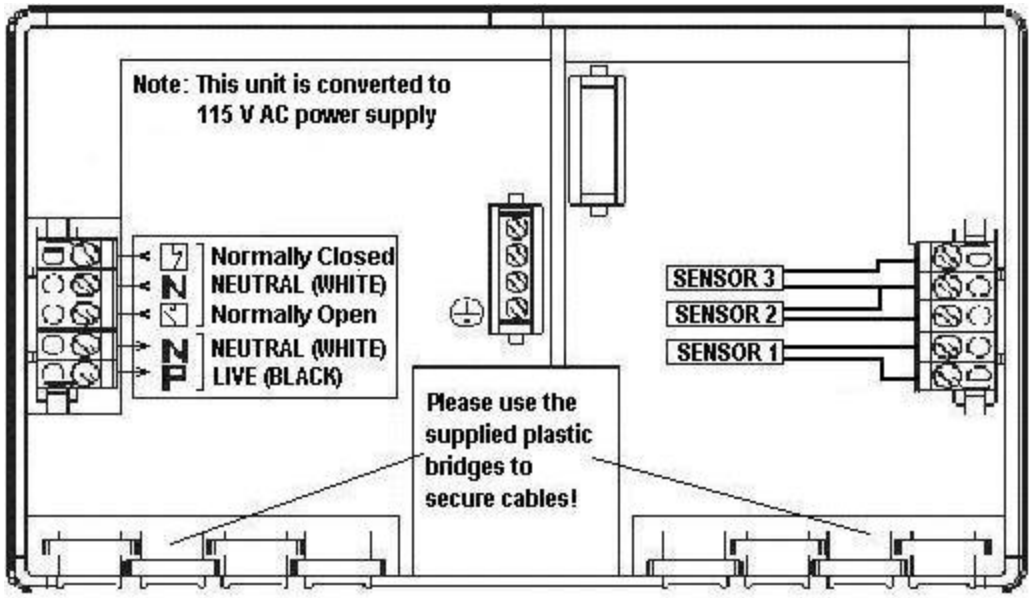
Slide larger tubing (about ¾ ") over the entire completed splice. Heat gently all around until tubing shrinks tight. This connection can then be drawn gently into the pipe work. Only two of the wires are required for the sensor cable; the other two wires are spare wires.

Caution: Do not overheat the tubing! Remove heat as soon as the tubing shrinks tight, as material will continue to shrink. With flame source, use even back and forth motion all around tubing. A heat gun may be used, if available. Let tubing cool for maximum strength.

Controller unit installation: For viewing comfort, the controller unit should be positioned at eye level. For optimum longevity, avoid extremes of temperature in the placement of electronic equipment. In addition, avoid heavy electrical loads, switches or contactors as these may cause electrical and electromagnetic interference with the unit (when switched on or off).



Undo the screw at the top of the housing. The control electronics are mounted on the enclosure cover. The controller enclosure can be screwed to the wall with cable entry grommets pointed downwards. Use the supplied plastic bridges to secure power and sensor cables.



Base of the unit to be mounted at eye-level and wired as shown above

Caution: Controller wiring should only be done when the unit is not energized. It is possible to damage the control unit if it is assembled under voltage. Miniaturized terminal blocks are used for making wiring connections. The wire is held in place within the terminal with screw that provides excellent contact without damage to the wire.

Sensor Cable Connection: Use up to an 18 AWG stranded wire to connect the sensor cables to the unit. The S1 terminal should be connected to the collector sensor (higher temperature); the S2 terminal is designated for the tank sensor (lower temperature). And the S3 terminal is reserved for the advanced usage of the unit such as third temperature sensor (in program mode 1) or flow meter input for BTU operation in advanced programming mode.

Power Connections: A small blade screwdriver may be used to fasten miniaturized terminal block screws while the corresponding wire is inserted.

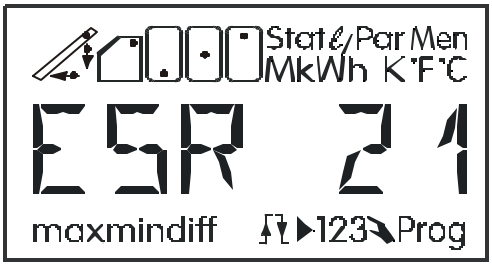
NOTE 1: ***Always disconnect the controller from power supply before opening the housing.***

NOTE 2: The controller should be properly grounded. ***Flexible wires, 18/3 AWG (gauge/conductor) simplify connection to the terminals.*** *The power terminal block will accommodate wire sizes to 14 AWG. All other connections should be secured and adequately tightened, as loose power connections will over-heat, and may cause fire.*

NOTE 3: It is important that the specified output loads (245 Watts) are not exceeded. Where these loads expect to exceed, external relays must be used. It is good practice to install a switch to disconnect the controller and pump from power. Always keep power cables away from sensor cables and other low voltage signal cables.

NOTE 4: To protect against lightning damage, the system must be grounded according local regulation. Sensor failures due to the weather or electrostatic are mostly due to poor grounding.

Your controller displays requested information one at a time. The unit display window has three lines to inform you about the system's status, unit of displayed parameter and its value.



Upper Line Display	Symbolic display of sensor location, reading unit, and operation domain
Center Line Display	Sensor ID and its reading in normal mode (user interface window)
Lower Line Display	Set-point indicator that illuminates only **during programming mode**

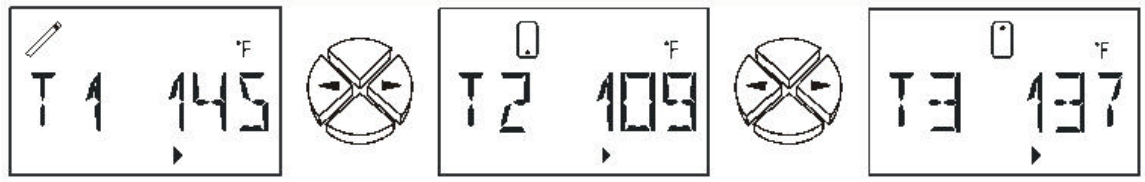
- ⇨ Push selection key once to move to the next selection; or increase the selected parameter by one unit.
- ⇦ Push selection key once to move to the previous selection; or decrease the selected parameter by one unit.
- ⇩ Push selection key once to enter the advanced (Par or *Men) mode. Once in selected mode, press one more time to select the parameter in that mode. Selected parameter blinks allowing the user to modify it. You can modify the selected parameter while the middle window blinks by pressing the ⇦ or ⇨ key.
- ⇧ Push selection key once to accept selection (blinking stops showing the new set-point steady) or go back to the previous selection.

* Menmode is for use in advanced applications only. See P.9.

Use selection keys ⇦⇨ during normal system operation to display the desired parameter:

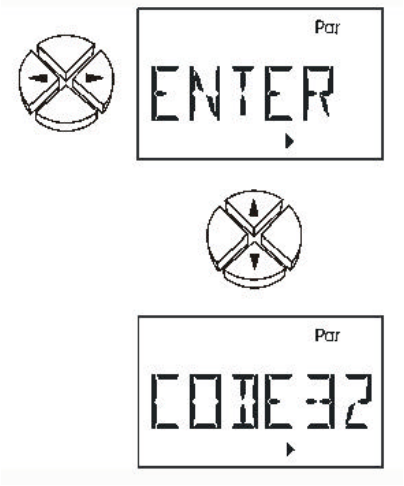
T1 xxx	Collector temperature in ^{o}F
T2 xxx	Tank temperature in ^{o}F
T3 xxx	Reading of the third sensor; if the third sensor is not used it displays a fixed reference temperature of 250 ^{o}F
XX xxx	Collector power in [kW]
YY xxx	Energy collected in [MWh]
ZZ xxx	Energy collected in [kWh]
GAL xx	Flow rate [gallon/h]

Operation Mode – Example: Following chart displays system temperatures



At the **upper text line**, the icon for the text is always displayed. Program symbol is displayed during the setting of parameters at the **lower text line**. In addition, an arrow icon **>** is displayed while pump is running.

Program Mode - Pressing the selection key ⇨ several times allows you to enter into the program mode (Par). Push selection key ⇩ once to enter the program mode.



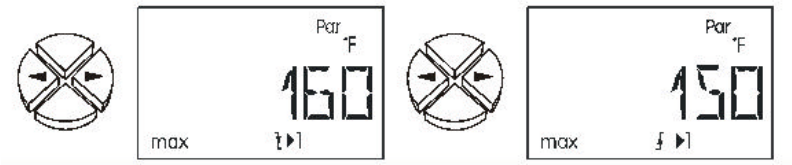
Basic Operation (Factory Setting for Only Two Sensors)

PROGRAM 0: (basic 2-sensor program)

Par Using the navigation key ⇦⇨ allows you to select the desired parameter while you are in the program mode. Press the selection key ⇩ once to select the parameter in the window. Selected parameter **blinks** allowing you to modify it. You can modify the selected parameter while **the middle window blinks** by pressing the ⇦ or ⇨ key. The unit accepts the new value by pressing the ⇧ key once. To avoid unintentional set-point changes, the user must enter the access code “32” to manipulate factory settings.

RUV X.X – This display shows the software revision number.
NR O – This is **PROGRAM 0** which indicates simple operation of unit as a **U**niversal **S**olar **D**ifferential **T**emperature (**USDT**) controller. Change this value to 1 (**NR 1**) for activation of the third sensor or pulse flow meter input **(PROGRAM 1)**.

Hysteresis Bandwidth

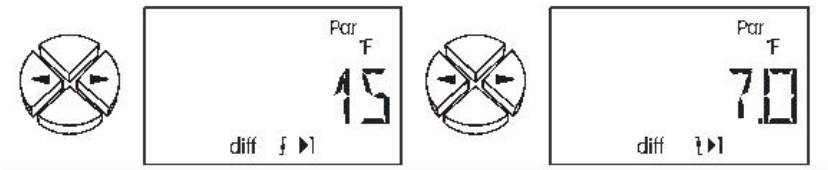


User can program hysteresis (temperature range for output control) by using max↴ and max↥.

For

max↴1 Pump stops above tank temperature (T2)
max↥1 Pump runs **again** below this set point (T2)

Delta T Adjustment



diff↥1 Pump runs when temperature difference between collector **T1** (collector) and **T2** (tank) exceeds this value. Factory setting is 15 °F. Consult your collector manufacturer for the recommended value.

diff↴1 Pump stops when temperature difference between collector **T1** (collector) and **T2** (tank) reaches this value. Factory setting is 7 °F. Consult your collector manufacturer for the recommended value.

Manual Operation Mode

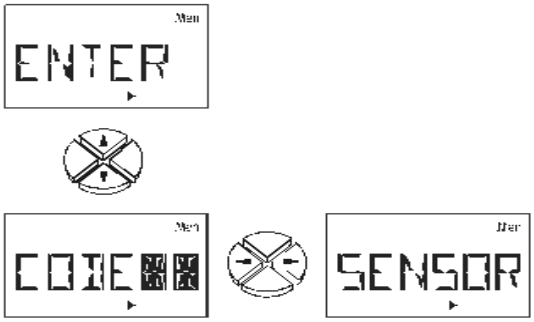
AUTO The above display indicates that the unit is working in automatic mode. The pump starts at a temperature difference of 15 °F and runs as long as ? T is above 7 °F. The ⇄ symbol appears in upper display line next to the collector

symbol while the pump is running. User can switch to manual mode by pressing ⇩ key. By pressing ⇨ key while centerline blinks, a hand symbol ☝ in lower line shows manual operation. Pressing ⇨ one more time lets you turn the pump **ON** or **OFF**. By pressing ⇧ key you change the pump operation.

Advanced Operation (Setting for Three Sensors and Flow Rate Input)

To change the factory setting of two sensors you need to advance to the **Men** domain using access code "64":

Navigation of advanced features of the unit and selection of parameters is the same as before by using ⇦⇩⇧⇨ keys:



Advancing – Press the Advance key ⇦⇨ briefly to advance to the next selection or to increase/decrease the set point of the selected parameter. Hold it down for fast change.

Acceptance – Press Set-Up key ⇩ once to select the parameter. Press ⇧ key to accept the selection or the set point.

Three-Temperature Sensor Setting **(PROGRAM 1)**:

USDT 2004 accepts two different sensor types or a reference value. Press the Advance key ⇦⇨ briefly until **SENSOR** appears in centerline and press the key ⇩. Select S3 sensor and change the **250** reference value to read **KTY** sensor:

Note: Tank over heating protection in program mode 1 (**NR 1**) controls the pump operation based on temperature reading by T2 and T3 sensor readings.

Selection:

S3 Sensor 3 (tank) selection

Designation:

KTY Thermistor sensor (2000 O at 25 ^{o}C)

Accept this setting by pressing ⇧ key. If you wish to change set points for pump operation, follow instruction explained in Basic Operation section (these changes are made in **Par** domain).

max↴1 Pump stops above tank temperature (T2)
max↥1 Pump runs **again** below this set point (T2)

max↴2 Pump stops above tank temperature (T3)

max↴2 Pump runs **again** below this set point (T3)

Energy calculation mode **(PROGRAM 1)**:

USDT 2004 computes the energy production as a function of the temperature differential and fluid volume. In addition, the system anti-freeze (Glycol) percentage should be entered as it affects the thermal conductivity and heat transfer rate. Press the Advance key ⇦⇨ briefly until **BTU** appears in centerline and press the key ⇩. Designate sensor inputs for example T1 as collector inlet and T2 as collector outlet temperature. F SEN can be connected to a flow meter or be a constant number in a closed loop solar system.

BTU	Energy calculation mode
S IN	Sensor port selection for inlet temperature (1, 2, 3, --)
S OUT	outlet temperature (1, 2, 3, --)
F SEN	Sensor port selection for flow rate (1, 2, 3, --)

Energy calculation will be initiated only after temperature sensor ports are designated. Flow rate can be either a constant number to be entered by user, or from a flow meter input. To activate the energy calculation without using the flow meter's impulse input, a dash (-) must be selected for F SEN channel followed by the constant flow rate in gph (gallon per hour) unit.

LLP	Flow meter rate impulse number in liter per pulse, if flow meter is used
GAL	Constant flow rate in gph instead of flow meter reading in (-) sensor mode
GLYCOL	Anti-freeze percentage
CLEAR	Sets the BTU meter's counter to zero
DIF	Sensor calibration

The output of USDT 2004 unit is kW for system power and kWh or MWh for collected energy.

Advanced Mode – USDT 2004 is extremely powerful. It can be used in wide range of applications such as a BTU meter, a boiler fuel optimizer, a swimming pool temperature differential controller, a greenhouse temperature regulator, an air handler, and more. Factory settings are exclusively for solar water heating systems in the USA market. However, all its parameters can be changed to meet the unique requirements of other applications. The user may use access code "64" to modify the USDT 2004 program mode and its parameters.

Men This mode is for advanced applications

The factory setting will be retrieved by pressing and holding ⇩ key during powering of the unit. A "RESTOR" displays for three seconds while factory settings are restored.

Selection of different sensor types, energy collection calculation parameters, system protection and optimization can be can be modified in advanced (Men Domain) mode.

Mode	Operation
SENSOR	Selects sensor type
SGUARD	Protects system from overheating and frost

START Starts pump at pre-set insolation (solar radiation intensity)
ALARM Enables/Disables protection functions
BTU Energy calculation and setting

Sensor Designation – USDT 2004 accepts two different sensor types or a reference value . User can program a constant reference temperature instead of a sensor output. The factory-preset sensor is the thermistor (KTY 10) type. The KTY 10 tank sensor, white wire, should be used in a conditioned environment and will not be permanently damaged up to 360 ^{o}F.

Selection:

S1 Sensor 1 (collector outlet) selection
S2 Sensor 2 (collector inlet) selection
S3 Sensor 3 (tank) selection

Designation:

PT PT 1000 sensor (1000 O at 0 ^{o}C, not available in US market)
KTY Thermistor sensor (2000 O at 25 ^{o}C)
250 250 ^{o}F reference temperature
- 4 - 4 ^{o}F reference temperature

Sensor wires can receive electromagnetic pulses, which can result in a wrong temperature reading. The USDT 2004 reads sensor values every 50 ms. It can bundle several readings and process their average.

AV 1 Sensor 1 average
AV 2 Sensor 2 average
AV 3 Sensor 3 average

The numbers of samples can be programmed from 4 to 20. The impedance characteristics of sensors temperature dependencies are represented in the following table:

T	0	10	20	25	30	40	50	60	70	80	90	100°C
R(KTY)	1630	1772	1922	2000	2080	2245	2417	2597	2785	2980	3182	3392 W

Frost and overheating protections - Pump operation can be manipulated by the user in both collector stagnation and frost conditions. The set-up is possible in System Guard, **SGUARD**, domain.

Overheating protection – The Circulation pump may not be powerful enough to circulate the heat transfer fluid in the solar loop with air pockets. User can program the pump to stop at a desired maximum collector temperature, shown by ↴ symbol, to protect the pump. The USDT 2004 will take over the normal operation after the temperature decreases to an acceptable working temperature, shown as ↥. This feature is disabled at 299 ^{o}F set point.

Frost Protection – Frost protection in the sun-belt region is provided by circulating water in the solar loop when freezing conditions exist. Regardless of the temperature difference ? T, the

circulation pump runs when the collector temperature is below a programmable **minimum** temperature, shown by ⮥ symbol. The pump stops as soon as the temperature in the solar loop reaches a safe region programmed by the ⮧ symbol. This feature is also disabled at the factory by entering - 4 ^{o}F.

min⮥ Pump runs below this temperature
min⮧ Pump stops above this temperature

Start functions - The Circulation pump can be programmed to start on low insolation level. The Start function feature is useful when heat transferred to the collector sensor is not fast enough for early start; especially when the collectors are flat mounted.

The enabled start function runs the pump at a given solar radiation or programmed temperature difference. The feature is disabled at the factory.

START	Start function screen
ENABL	Enable start function
DISAB	Disable start function

If this feature is selected, following parameters must be adjusted for proper operation:

SENS	Pyranometer port designation (radiation monitoring sensor port)	
	1	Sensor 1
	2	Sensor 2
	3	Sensor 3
	--	Manual input in next step
INS	Radiation threshold in W/m^2	
CIRC	Pump runtime in seconds	
INT	Maximum interval time in second	
FLU	Number of flushes	

The following example activates the circulation pump at 200 W/m^2 and runs it for 15 seconds. If △T condition is met within the time period, the pump stays on.

INS 20
CIRC 15

Alarm functions - User can enable the alarm function of the USDT 2004 in the **ALARM** screen. Status of sensors and circulation pump can be viewed if alarm function is active.

A ON	Alarm function enable
A OFF	Alarm function disable

The status of the system can be monitored in the **Stat Mode** only if the corresponding feature is active. The following example shows a system condition with a circulation problem:

OT OFF	Overheating feature disable
OT OK	No overheating
1 SHORT	Short circuit in sensor 1 wiring
2 SHORT	Short circuit in sensor 2 wiring
1 OPEN	Disconnection in sensor 1 wiring

2 OPEN	Disconnection in sensor 2 wiring
OK	System operates normal
NO CIRC	△ T is more than 108 ^{o}F in last 30 minutes
OK CIRC	Pump is running
CLEAR	Clears NO CIRC display after correction

Energy calculation - Energy gain is calculated by obtaining the temperature increase of heat transfer fluid across the solar collector. The amount of fluid flow through the collector is registered by an in-line flow meter. USDT 2004 computes the energy production as a function of the temperature differential and fluid volume. In addition, the system anti-freeze (Glycol) percentage should be entered as it affects the thermal conductivity and heat transfer rate.

BTU	Energy calculation mode
S IN	Sensor port selection for inlet temperature (1, 2, 3, --)
S OUT	outlet temperature (1, 2, 3, --)
F SEN	Sensor port selection for flow rate (1, 2, 3, --)

Energy calculation will be initiated only after temperature sensor ports are designated. Flow rate can be either a constant number to be entered by user, or from a flow meter input. To activate the energy calculation without using the flow meter's impulse input, a dash (-) must be selected for F SEN channel followed by the constant flow rate in gph (gallon per hour) unit.

LLP	Flow meter rate impulse number in liter per pulse, if flow meter is used
GAL	Constant flow rate in gph instead of flow meter reading in (--) sensor mode
GLYCOL	Anti-freeze percentage
CLEAR	Sets the BTU meter's counter to zero
DIF	Sensor calibration

The output of USDT 2004 unit is kW for system power and kWh or MWh for collected energy.

The energy calculation dependents on flow meter accuracy, the temperature sensors class, and their locations. The flow meter is a mechanical device and its accuracy fluctuates over time. Therefore, the user should calibrate the flow meter and incorporate temperature sensor tolerance.

The supplied Thermistor sensor has an accuracy of ± 2 ^{o}F. **DIF** represents the temperature difference between two sensors. User can increase the accuracy of reading by adjusting the DIF parameter. The energy calculation becomes accurate at temperature range that this reading adjustment is made.

Troubleshooting

In general, all of the settings in the menus Par and Men and the terminal should first be checked if there is a malfunction.

Malfunction, but "realistic" temperature values:

- Check program number.
- Check the switch-on and switch-off thresholds and the set differential temperatures. Have the thermostat and differential thresholds already been reached?
- Were the settings in the submenus (Men) changed?
- Can the pump (output) be switched on and off in manual mode? If a forced pump “ON” and “OFF” lead to the appropriate reaction at the output, the unit is certainly in order.
- Are all of the sensors connected with the right terminals? Heat up the sensor using a cigarette lighter and watch the display.
- Did you change the reference temperature 250 (three sensor operation) to KTY?

Incorrect display of temperature(s):

- Displayed values such as -999 if a sensor short-circuits
- or 999 if there is an interruption do not necessarily mean a material or terminal error.
- Are the right sensor types (KTY or PT1000) selected in the menu Men under SENSOR? The factory settings set all inputs to KTY.

The sensor can also be checked without a measuring instrument by connecting the presumed defective sensor to a terminal that works and checking the display. The resistance measured by an ohmmeter should have the following value depending on the temperature:

T	0	10	20	25	30	40	50	60	70	80	90	100°C
R(KTY)	1630	1772	1922	2000	2080	2245	2417	2597	2785	2980	3182	3392 W

The settings of the parameters and menu functions ex works can be restored any time by pressing the down arrow (enter) while powering the controller. The sign that appears for three seconds on the display is RESTOR for load factory settings.

If the system is not in operation while connected to the power supply, the 3.15A quick-blowing fuse that protects the control system and the output should be checked and exchanged if necessary.

As the programs are constantly being improved, there may be a difference in the sensor, pumps, and program descriptions. Only the enclosed manual (identical serial number) applies for the equipment supplied. The program version for the manual must correspond to the equipment version.

If the control system is found to be malfunctioning despite the checks described above, please contact your retailer or Thermo Technologies directly. The cause of the error can only be determined if the settings of the unit is known. The schematic diagram of the system in question is a great help to isolate the potential problem.