THERMOCUBE PAO

Thermoelectric Chiller for Leak-Free Temperature Control of Aircraft Hydraulic Fluid (PAO)

Product Manual

Solid State COOLING SYSTEMS
Temperature Control...Precisely.

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*Temperature Control...***Precisely.**

CE Declaration of Conformity

We: Solid State Cooling Systems
167 Myers Corners Road
Wappingers Falls, NY 12590
USA

declare under our sole responsibility that the

ThermoCube 200, 300, 300A, 400, 400A, 500, PAO (All Models)

meets the provisions of the directives:

Electromagnetic Compatibility (EMC) Directive 2014/30/EU
Low-Voltage (Safety) Directive 2014/35/EU
RoHS Directive 2015/863/EU – R: RoHS Option ONLY

Emissions:
EN 61326-1: 2013 per EN 55011:2009 + A1: 2010 Group 1 Class A

Immunity:
EN 61326-1: 2013 Electrical Equipment for Measurement, Control, and Laboratory Use - EMC
EN 61000-3-2 Harmonics Emissions Class A
EN 61000-3-3 Voltage Fluctuations and Flicker
EN 61000-4-2 Electro-Static Discharge
EN 61000-4-3 Radiated Radio Frequency (RF) Immunity
EN 61000-4-4 Electrical Fast Transient/Burst Immunity
EN 61000-4-5 Surge Immunity
EN 61000-4-6 Conducted RF Disturbance Immunity
EN 61000-4-11 Voltage Dips, Interruptions and Short Variations
EN 61000-6-2 Electromagnetic Compatibility Part 6-2: Immunity for Industrial Environments

Safety:
EN 61010-1: 2010/AMD1:2019 Low Voltage Directive Safety requirements for electrical Equipment for measurement, control, and laboratory use.

Lloyd F Wright Chief Technology Officer	
Date	August 19, 2020

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FCC/ICES/ACMA/UL Declaration of Conformity

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Emissions:
CFR Title 47 FCC Part 15 Subpart B, Class A
ICES-003, Issue 6, Class A
ACMA AS/NZS CISPR 11:2009 + A1:2010 Group 1 Class A

Safety:
UL 61010-1:2012/A1:2018-11 Electrical Equipment for Measurement, Control, and
CAN/CSA C22.2 No. 61010-1:2012/A1:2018 Laboratory Use; Part 1: General Requirements)

Lloyd F Wright Chief Technology Officer	
Date	August 19, 2020

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SAFETY PRECAUTIONS AND SYMBOLS

Read the SDS for the coolant used and follow **all** safety precautions listed in the SDS prior to removing coolant tubes or opening the fill cap as this could result in contact with the coolant inside.

Caution! Risk of electric shock. Disconnect the power cord prior to servicing. This includes changing a fuse or opening the cover for any reason.

CAUTION

- Never disassemble the chiller as irreparable damage may occur.
- Any attempt to open or repair the unit will void the warranty
- Never store the chiller over 70 °C.
- Never operate the chiller in ambient temperatures of 40 ºC or greater unless the unit has been customized for high ambient operation.
- Never operate the chiller within 5 ºC of the coolant's freezing point.
- Always use only proper coolants as specified in manual.
- Never ship the chiller with coolant inside the liquid cold plate as freezing temperatures may be encountered which would damage the unit. Always pump all coolant out of the chiller prior to shipping.

Symbols Used in this Manual

CAUTION

The red CAUTION equilateral triangle symbol appears throughout the manual. Please follow the important instructions accompanying this symbol to avoid significant damage to the chiller.

WARNING

The red WARNING equilateral triangle symbol appears throughout the manual accompanying certain maintenance and repair activities. Please follow the important instructions accompanying this symbol to avoid situations that could cause injury to the operator or other personnel.

Solid State COOLING SYSTEMS
*Temperature Control...***Precisely.**

PRODUCT MANUAL

THERMOCUBE PAO
FOR POLY-ALPHA-OLEFIN (PAO) COOLANTS
THERMOELECTRIC CHILLER

SECTION 1
INTRODUCTION

The ThermoCube PAO chiller is a thermoelectric temperature control system with full PID control of both heating and cooling. The wetted surfaces of this version of the ThermoCube are made from stainless steel or aluminum with Viton o-rings, making it compatible with all hydrocarbons based or silicone based coolants such as PAO. It provides 2 lpm of constant temperature coolant for controlling the operating temperatures of lasers, military test equipment, or other industrial applications requiring these coolants. It also has a cycling feature where two different temperature set points may be entered with a soak time at each temperature and the number of cycles desired. It does not use Freon or any other replacement gas. From conception, this chiller has been designed for long life and ease of use. The internal thermoelectric modules have lifetimes greater than 200,000 hours.

SECTION 2
SPECIFICATIONS

Operating Range (Set Point):	0°C to 65°C standard
Ambient Temperature Range:	10°C to 40°C non-condensing
Stability / Repeatability:	±0.05°C with constant load (even near ambient)
Cooling Capacity (typical[1]):	275 Watts @ 20°C in 20°C ambient air
Heating Capacity (typical):	400 Watts @ 20°C in 20°C ambient air
Noise Level (at 1 meter):	< 63 dBA
Coolant / Process Fluid:	Poly-alpha-olefin (PAO), Royco 602, silicone-based fluids
Process Fluid Fittings:	1/4” valved metal CPC (swage fittings also available)
Pumps:	1, 2, or 3 lpm Gear Pump
Tank Volume:	900 ml with level sensor
Wetted Materials:	All stainless steel
Dimensions (L x W x H):	13” x 11” x 13” (32cm x 28cm x 32cm)
Weight:	34 lbs (15.4 kg)
Power Input:	Universal: 100-240 VAC, 50/60 Hz, 7-5 amps max
Controls:	Digital PID controller for heating and cooling
Communications:	Keypad or Enhanced RS232 interface (standard)
Alarms	Temperature, fluid level, system or component failure (display and RS232 option)
Standards	TUV listed to UL, CAN/CSA and EN 61010-1, CE 61010-1 (RoHS compatibility is available with the "-R" option)
Other Options	(see Section 7 for available options)
Warranty	2 years

Figure 1: Cooling Capacity

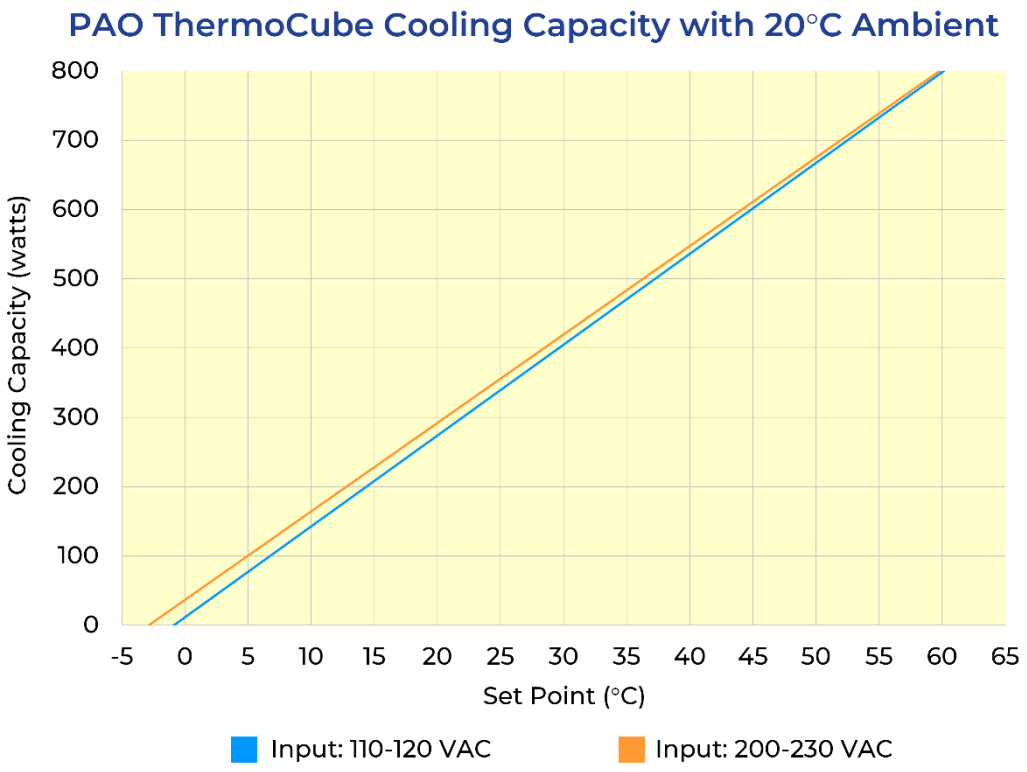
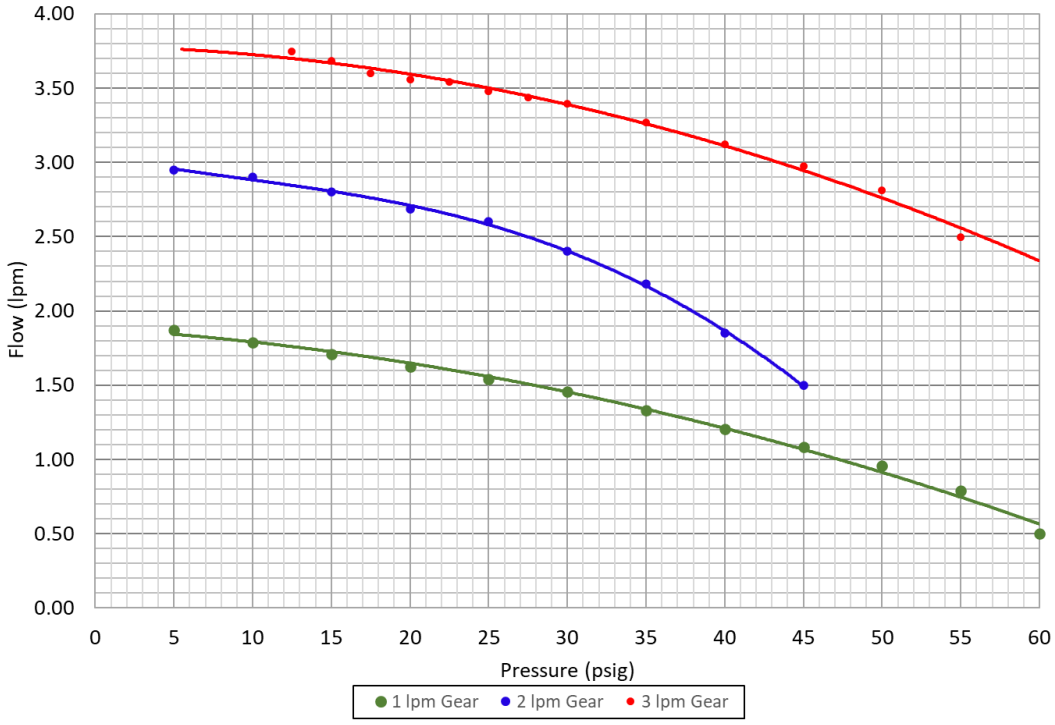


Figure 2: Pump Curves



SECTION 3
HOOK UP

3.1 ELECTRICAL CONNECTIONS

Power: Plug line cord into 115/230 VAC, +/- 10%, 50/60 Hz, continuous current draw is rated at 7amps (100 VAC) or 5 amps (230VAC) at 50/60 Hz.
Fuse: 10 amp (5mm x 20mm) GDB quick acting glass, meets IEC 127-2
Replacement Fuse: SSCS#20-22332-10, Allied Electronics #740-9575

Alarms: The ThermoCube has two normally closed 1 amp 250V dry contact alarm relays instead of the standard TTL alarms, one for system faults and one for temperature exceeding the alarm range. These contacts are wired to the 9-pin dsub connector as follows:

System Fault Alarm Common:	Pin 6
System Fault Alarm:	Pin 1
Temperature Alarm Common:	Pin 9
Temperature Alarm:	Pin 4

3.2 PLUMBING CONNECTIONS

The process fluid inlet (coolant return) and outlet (coolant supply) connections, located on the left side, are ¼" Colder Products metal quick disconnect fittings (female), model number LCD16004V. Note: Viton o-rings must be specified.

3.3 AIR CONSIDERATIONS

The air inlet and outlet are located on the left and right sides respectively. Restricting airflow into or out of the unit will impair performance. At least 3 inches of clearance is required on each side to ensure adequate airflow.

3.4 COOLANT FILL CAP

The coolant fill cap is located at the top rear of the unit. Twist off the cap counter-clockwise to open. Fill reservoir prior to starting unit. Close cap before operating.

Figure 3A

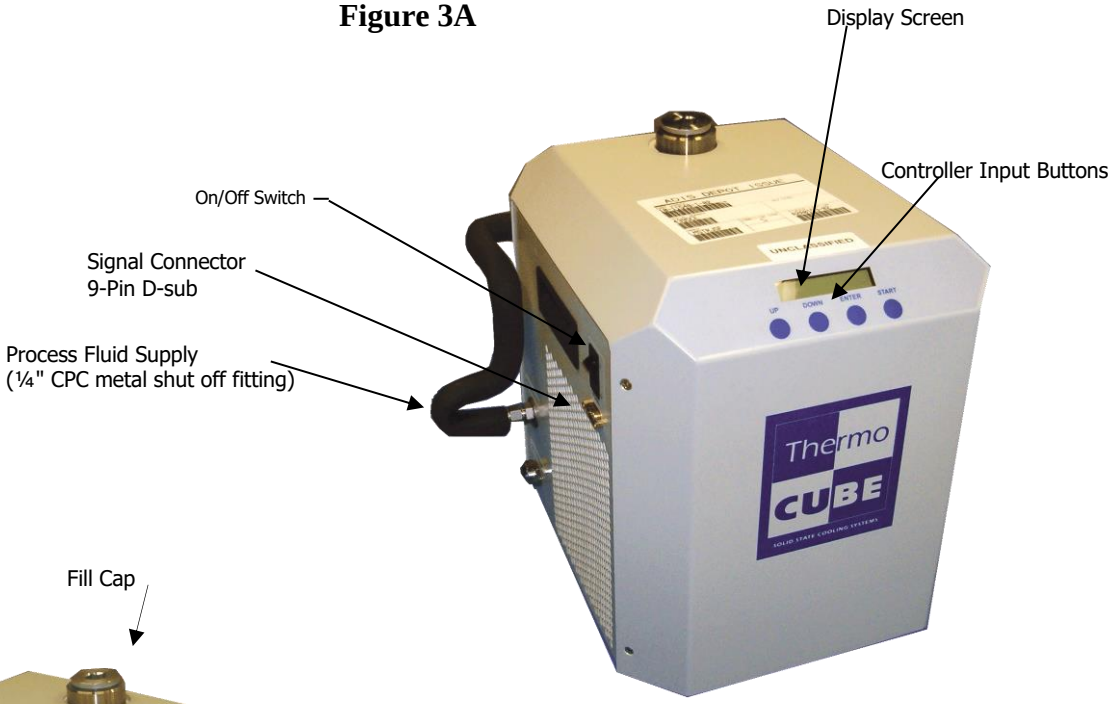


Figure 3B

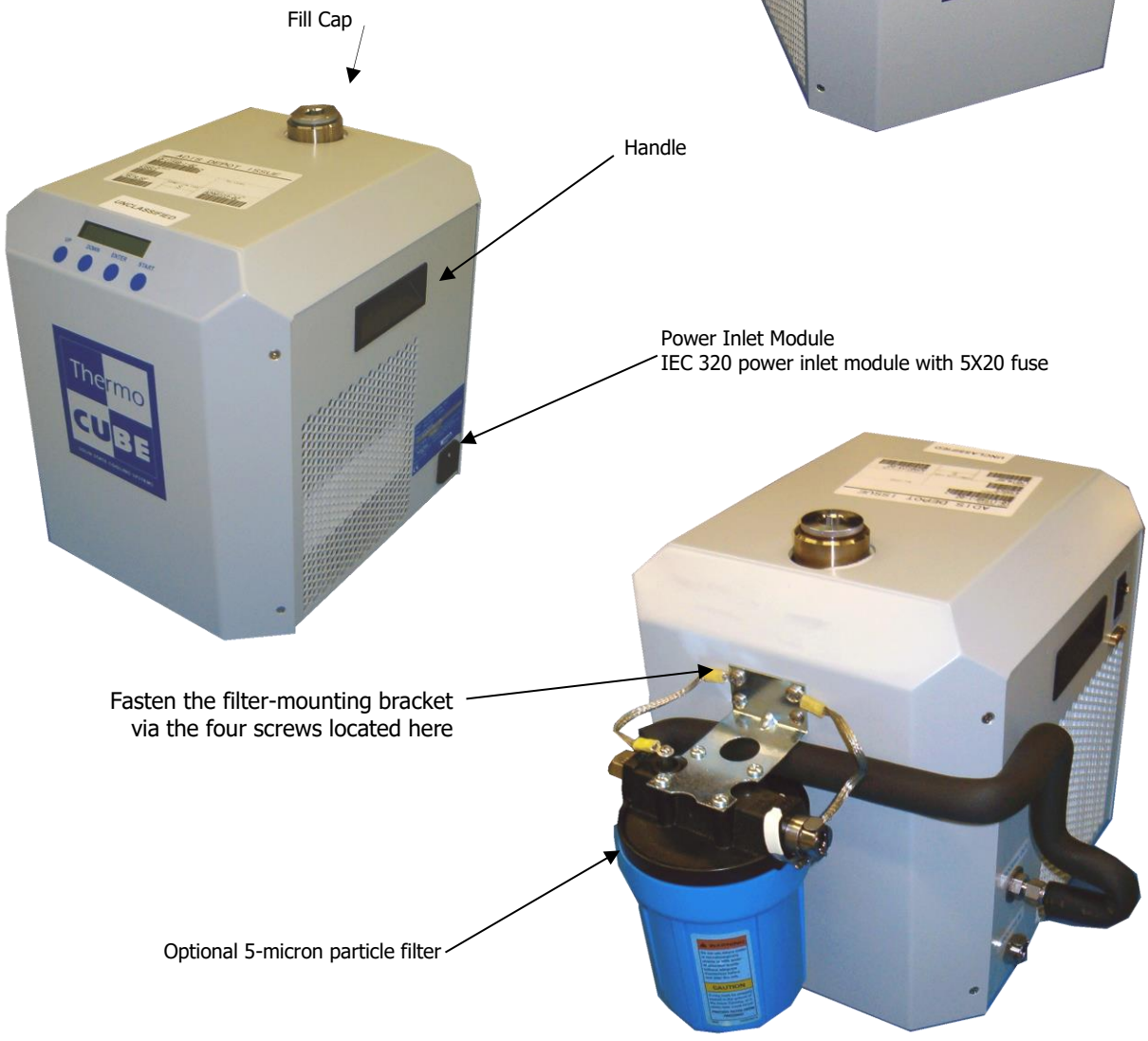


Figure 3C

SECTION 4
START UP

Note: In order to avoid injury or damage, operators must only use this product in the manner specified below.

WARNING

Electrical Shock Hazard: Never Plug in a Line Cord with Wet Hands

CAUTION

Running the ThermoCube dry (no fluid) may damage the pump

Start-up the ThermoCube using the following steps:

1) Connect coolant tubing to fluid connections located on the left side of the unit, labeled Process Out (supply) and Process In (return).
2) Connect Alarm Signal connector (if option chosen).
3) Remove the reservoir cap on top and fill the reservoir to just below the bottom of its neck with coolant. Replace cap.
4) Plug line cord into 100 - 240 VAC, 50/60 Hz.
5) Turn on switch located on the left side of the unit. The front display should read the current coolant temperature. If the front display reads "TANK LEVEL LOW", add more coolant to the reservoir until the display changes to read the coolant temperature.

Important Notes:

1) If the tank level low alarm persists, or if another alarm is displayed, consult section 6.0 of this manual.
2) If using an alcohol/water mixture, do not exceed 25% alcohol or the reservoir level float may not rise sufficiently when filled to turn off the tank level low alarm.

SECTION 5
OPERATION

The ThermoCube is operated via the control panel located on the front panel. The control panel has a 16-character LCD display and four input keys: UP, DOWN, ENTER, and START. These keys work as follows:

Key	Action
UP	Pressing the UP key raises the parameter value displayed.
DOWN	Pressing the DOWN key lowers the parameter value displayed
ENTER	Pressing the ENTER key momentarily enters the parameter changed.
ENTER	Pressing and holding the ENTER key for 3 seconds causes the chiller to change the display menu (see menu structure)
START/STOP	Pressing the START/STOP key turns on temperature control.
START/STOP	Pressing the START/STOP key while the chiller is operating turns off temperature control (Operating Mode = *).

5.1 SIMPLE OPERATION

The ThermoCube comes with preset operating parameters that will work well for most applications. If temperature control at one temperature is desired, follow the steps below.

1) Turn on the ThermoCube and wait for display to read TEMP.
2) Press the UP or DOWN keys to change SETTEMP1 to the desired set point.
3) Press ENTER to accept the value.
4) Press the START/STOP key to begin controlling to the temperature just entered (SETTEMP1). The Operating Mode will now show "–" (cooling) or "+" (heating).
5) Pressing START/STOP while the unit is controlling temperature will stop temperature control. The Operating Mode will now show "*" for Standby (not controlling).

Caution: Do not externally shut off the flow of coolant for more than a ten second period; pump damage will result if run deadheaded for extended periods of time.

The ThermoCube will now control to the set point temperature. To change the set point temperatures just press the UP or DOWN keys again to change SETTEMP 1 to the new set point, followed by ENTER and then START/STOP. The Operating Mode will now show "–" (cooling) or "+" (heating). If the Operating Mode shows "*", press START/STOP to begin controlling.

5.2 ADVANCED OPERATION

The ThermoCube controller has three menus: the Status Menu, the Temperature Input Menu and the Parameter Input Menu. The Status Menu shows the chiller operating status and current temperature of fluid leaving the chiller (see Figure 3). The Status Menu also allows input of new coolant temperature setpoints when the cycling feature is off. The Temperature Input Menu allows input of set point temperatures; soak times, number of cycles if cycling between two temperatures, and an alarm temperature. The Parameter Input Menu allows input of the temperature units; the time units for soak times, the PID parameters and the auto tune function.

The PID parameters have been preset at the factory for most applications. If, however, temperature control in not sufficiently accurate or if overshoot is excessive, the PID parameters may be modified. Unless the user is well versed in PID theory, we recommend calling Solid State Cooling Systems technical support group for assistance.

MENU STRUCTURE:
UP = Increase Value
DOWN = Decrease Value
↵ Press Enter Momentarily
START/STOP = Alternately Starts or Stops temperature control
⟶ Press & Hold Enter Key 3 Sec to move from one menu to another

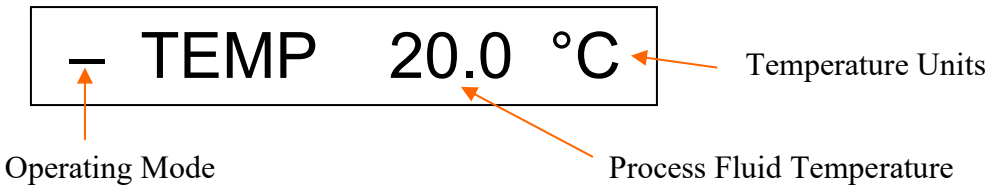
SIMPLE OPERATION	ADVANCED OPERATION	
STATUS MENU ⟶	TEMPERATURE INPUT MENU ⟶	PARAMETER INPUT MENU
TEMP: XX.X°C (current temp)	SETTEMP1 (set point 1)	TEMPUNIT
PRESS UP OR DOWN (change set point)	↵	↵
	SETTIME1 (time at set point 1) **Note: SETTIME1 must be set the same as SETTIME2**	TIMEUNIT
SETTEMP1 XX.X°C	↵	↵
↵	SETTEMP2 (set point 2)	AUTOTUNE
PRESS START/STOP (to begin controlling at SETTEMP1)	↵	↵
	SETTIME2 (time at set point2) **Note: SETTIME2 must be set the same as SETTIME1**	P1 HEAT
TEMP: XX.X°C (current temp)	↵	↵
PRESS START/STOP (to stop controlling temperature)	# OF CYCLES (default = 0)	I1 HEAT
	↵	↵
	ALARM TEMP	D1 HEAT
	↵	↵
	(return to top of menu)	P2 COOL
		↵
		I2 COOL
		↵
		D2 COOL
		↵
		(return to top of menu)

Press ENTER key once to scroll between menu items (↵).
Press and hold ENTER key for 3 seconds to move between menus (⟶).
Pressing and holding ENTER key while in the Parameter Input Menu will return you to the Status Menu.

Notes:
1. If the unit includes the AUTO RESTART option, the unit will begin temperature control when it is first turned on using whatever Set Point was entered when the unit was powered off.
2. If the user enters the temperature input or the parameter input menu and does not press a key for 10 seconds the display will revert back to the Status menu.
3. For temperature cycling (Temperature Input Menu), the dwell times SETTIME1 and SETTIME2 need to be set to the same time. If different times are entered SETTIME2 will be used for both dwell times.
4. If continuous control at one set-point temperature is desired, set # OF CYCLES to zero.

Status Menu: The status menu displays the chiller operating status and coolant temperature. The chiller operating mode is shown in the display's first character: (See Figure 5)

Figure 5: Operating Display



* = Standby mode, chiller is not controlling temperature
– = Cooling mode, chiller is controlling temperature and process fluid temperature is above the set point
\+ = Heating mode, chiller is controlling temperature and process fluid temperature is below the set point

The process fluid (coolant) outlet temperature is shown after TEMP in °C or °F.

Pressing the UP or DOWN keys with the # of cycles set to zero (default) will change the set point temperature upon pressing the ENTER, then the START/STOP key.

Temperature Input Menu: The temperature input menu allows input of operating temperatures, soak times, number of cycles desired, and an optional alarm temperature. Note: If # of cycles is set to zero, only TEMP 1 and ALARM TEMP will be used.

SETTEMP1 = Set-point of first control temperature.
If # OF CYCLES is set to zero, this is the control temperature.
SETTIME1 = Soak time at temperature 1.
Not used if # OF CYCLES is set to zero.
SETTEMP2= Set-point of second control temperature.
Not used if # OF CYCLES is set to zero.
SETTIME2 = Soak time at temperature 2.
Not used if # OF CYCLES is set to zero.
# OF CYCLES = Number of cycles between temperature 1 and temperature 2, 0-999 cycles. If set to zero, then the ThermoCube will continuously control at temperature 1.
ALARMTEMP = Alarm temperature range +/- set-point. The unit will output an alarm dry contact or TTL signals, but not RS-232.

Parameter Input Menu: The parameter input menu allows input of temperature units, time units, PID parameters, and turns on or off auto-tune.

TEMPUNIT = °C or °F

TIMEUNIT = s: seconds, m: minutes, h: hours

AUTOTUNE = ON/OFF.

ON turns on auto-tune where the controller determines PID parameters. Once PID parameters have been determined AUTO-TUNE reads OFF.

P1 HEAT = Proportional band for heating, 0-99.9 °C or °F.

P1 HEAT Factory Default Value = 5.6

I1 HEAT = Integral term for heating, 0-999 seconds

I1 HEAT Factory Default Value = 22

D2 HEAT = Derivative term for heating, 0-999 seconds

D2 HEAT Factory Default Value = 2

P2 COOL = Proportional band for cooling, 0-99.9 °C or °F

P2 COOL Factory Default Value = 2.8

I2 COOL = Integral term for cooling, 0-999 seconds

I2 COOL Factory Default Value = 22

D2 COOL = Derivative term for cooling, 0-999 seconds

D2 COOL Factory Default Value = 2

5.3 ALARMS

The ThermoCube chiller has two TTL level alarms, one for temperature and one for system failure:

Temperature:	TTL high (>4 VDC) fluid temp below alarm set point
	TTL low (<0.5 VDC) fluid temp above alarm set point
System:	TTL high (>4 VDC) system operating normally
	TTL low (<0.5 VDC) system failure has occurred

A list of system failures causing the system alarm to change to TTL low can be found in Section 6. In the event of a system failure, the alarm type will be shown on the front display.

5.4 AUTO-TUNING

Some ThermoCube models come with an automatic tuning (auto-tune) feature. Changing the PID parameters is normally not recommended unless the RTD probe is moved to a new location. However, the controller can calculate new PID parameters via the auto-tune function.

The following keystrokes initiate the auto-tune function:

1) Press and hold the Enter key until the Status Menu changes to the Temperature Input menu.
2) Press and hold the Enter key again until the Temperature Input menu changes to the Parameter Input menu.
3) Press the Enter key three times. The display should read AUTOTUNE off.
4) Press the Up key to change off to on.
5) Press and hold the Enter key until the parameter input menu returns to the Status Display.
6) Press the Start key once. The left most display character will show the letter A until the auto tune is complete. The ThermoCube will then begin controlling at the set point temperature.

5.5 MANUAL TUNING

For users well versed in PID theory, Solid State Cooling Systems recommends the closed-loop "Ziegler Nichols" method for manually tuning the controller. The method consists of three steps:

1) Turn off both the integral and derivative terms for heating and cooling by setting I1, I2, D1, and D2 to zero.
2) Set proportional band to 50 °C. Begin controlling the process at the desired set-point temperature. Look for a small-sustained oscillation in the coolant temperature. Observe the status menu operating mode character and note if system is heating (+) or cooling (-). If no oscillation occurs, lower the proportional band in 50% increments until a small oscillation occurs. Write down this proportional band setting (P)
3) Measure the "Natural Frequency" (t) of the system in seconds. This is the time required for the temperature oscillation to cycle from one maximum temperature to the next maximum temperature.

Now set the controller input parameters as follows:

P1 HEAT = 2*P if system was heating in step 2.
P1 HEAT = 4*P if system was cooling in step 2.
I1 HEAT = 1.2*t
D1 HEAT = t/8
P2 COOL = P if system was heating in step 2.
P2 COOL = 2*P if system was cooling in step 2.
I2 COOL = 1.2*t
D2 COOL = t/8

5.6 DRAIN PROCEDURE

WARNING

Read the Coolant SDS prior to draining the chiller

1. Disconnect the external coolant lines at the quick disconnect fittings of the Thermocube and external filter (do not touch the tubing between the filter and Thermocube)
2. Attach a hose with the proper fitting to the "Process Out" port of the filter and place the end of the hose into a container with at least a 3 liter capacity.
3. Remove tank cap and turn on the Thermocube (making sure to hold the drain hose in place) and run the Thermocube until air starts to shoot out of the hose. Turn off Thermocube.
4. With Thermocube off, attach the drain hose with proper fitting to the "Process In" port of the Thermocube to allow liquid in the Thermocube's lines to drain into container
5. Replace and tighten the tank cap, then remove the drain hose.
6. To remove PAO from the external filter, place a container under the external filter and carefully unscrew the housing of external filter. Carefully pour out the PAO into the container
7. Dispose of the coolant in manner consistent with local regulations.
8. Install proper size plugs or caps onto the "Process In" and "Process Out" fittings unless fittings are quick disconnect fittings

SECTION 6
SYSTEM ALARMS/TROUBLESHOOTING

WARNING

Electrical Shock Hazard: Always unplug the unit before removing the cover.

WARNING

Do not attempt to service or repair the unit beyond the troubleshooting checks described in this section without first contacting Solid State Cooling Systems

The ThermoCube has multiple system alarms that when triggered will show on the display. When an alarm is displayed the system will not attempt to heat or cool the coolant.

Alarms:

Tank Level Low: Liquid reservoir level is too low. *Unless filling for the first time, check all outside plumbing lines for leaks. Once all leaks are sealed, remove the cap and add more coolant until the alarm disappears.*

RTD Open: The temperature sensor has failed or its connector has come loose. *Turn off the chiller and disconnect the AC power cord. Contact SSCS for a replacement RTD, or for a RMA number to return the unit for RTD replacement.*

Fan Fail: Fan is supplying insufficient air to cool the thermoelectric heat exchanger. *Either the fan has failed or the airflow into or out of the system is blocked. Check that the side air inlet and outlet gratings are not blocked. The ThermoCube requires at least 3 inches of clearance around these gratings. If airflow is not blocked, contact SSCS for a replacement fan, or for a RMA number to return the unit for fan replacement.*

Pump Fail: The liquid heat exchanger plate temperature is either too hot or too cold, indicating pump failure, a blockage in the external plumbing lines or operation outside the normal 5°C to 50°C coolant temperature (without –LT or –HT options). *Turn off the ThermoCube and disconnect the AC power cord. Verify that no kinks or blockages exist in plumbing line, both outside and inside the ThermoCube. If no coolant flow blockages exist, contact SSCS for a replacement pump, or for a RMA number to return the unit for pump replacement.*

No Display: If the liquid crystal display does not illuminate upon turning on the ThermoCube, the internal 12 or 24VDC power supply has failed, the diaphragm pump has failed, or the LCD display has failed. *Contact SSCS for a RMA number to return the unit for replacement of the power supply, diaphragm pump, or display.*

Temperature Control Poor: If no other alarms are present, poor temperature control indicates the heat load is too great for the chiller, the TE cooling/heating engine is not receiving power, the PID constants have been corrupted or the chiller needs repair. *First check the PID constant values shown section 5.2 match the factory defaults. If not, change the values to the default values. Otherwise, contact SSCS for technical support.*

Important: The tank level low alarm will automatically reset when the tank is filled. The RTD, Fan and Pump failure alarms will not reset until the system power is turned off.

SECTION 7
THERMOCUBE OPTIONS

7.1 THERMOCUBE PAO OPTIONS AND PART NUMBER

The ThermoCube PAO is configured with many standard options, including: -CPM (metal CPC fittings), -ES (Enhanced RS232 communications), -EF (External Fluid Filter), -SS (all stainless steel plumbing and tank), -LT (Low Temperature operation), -HT (High Temperature operation) and -DC (Dry Contact alarms). Additional available options are shown below:

ThermoCube P/N: 10 – 400 – PP – X – FF – YY – OO

PP: Pump Type; X: Power Cord; FF: Fluid; YY: Fittings; OO: Other Options

PP = Pump Type (choose one):

Price	PP	Description
$0	-1G	>1 lpm @ 35 psig magnetic drive gear (low vibration, 25,000 hr MTBF) with stainless steel head
Std	-2G	>2 lpm @ 35 psig magnetic drive gear (low vibration, 25,000 hr MTBF)
$250	-3G10	>3 lpm @ 30 psig magnetic drive gear (low vibration, 25,000 hr MTBF) 10 = adjusted flow rate to 1 lpm
$250	-3G20	>3 lpm @ 30 psig magnetic drive gear (low vibration, 25,000 hr MTBF) 20 = adjusted flow rate to 2 lpm
$250	-3GXX	>3 lpm @ 30 psig magnetic drive gear (low vibration, 25,000 hr MTBF) XX = other adjusted flow rate

Note: Extra strength magnets are available for the 3G pump through a CES. This option is recommended for any system which might have restricted flow. (Contact SSCS for more information)

X = Power Cord (select one)

X	Country / Region	Part No.
1	**USA/Canada**	**22-22333-1**
2	**Europe**	**22-22332-2**
3	**Japan**	**22-22333-3**
4	**UK**	**22-22333-4**
5	**Israel**	**22-22800-1**
6	**Australia**	**22-23213-1**
7	**Korean**	**22-23526-1**
8	**China (3 prong)**	**22-23661-1**
9	**NEMA 6-15 208 US Straight**	**16-23918-1**
10	**NEMA L6-15 208 US Twist**	**16-23918-2**

FF = Fluid Type:

Price	FF	Description
Std	PA	PAO (Poly-Alpha-Olefin)
Call	FL	Fluorinert
Call	GA	Galden
Call	SI	Silicone

YY = Inlet/Outlet Fitting Options:

Price	YY	Description
Std	blank	1/4" CPC metal (CPM)
$50	SW	1/4" Swagelok kit
$70	S2	3/8" Swagelok kit

OO = Other Options:

Price	OO	Description
$75	-VD	Vibration dampening material added
$50	-AR	Auto restart – software
$TBD	-YY	Custom engineered special (sequential number assigned by Engineering)

7.2 ENHANCED RS-232 COMMUNICATIONS (STANDARD)

ThermoCube PAO comes with an Enhanced RS232 communication port. The chiller uses this port to communicate a comprehensive set of control parameters with a Host PC - these parameters are outlined below. This port is a 9-pin female d-sub connector and is found on the rear panel of the chiller (see Figure 3C and 3D).

-ES: Enhanced RS-232 Communications (Standard, not shown in part number)

Wiring: Proper wiring depends upon whether the equipment being cooled (the Host) is wired as Data Computer Equipment (DCE) or Data Terminal Equipment (DTE)

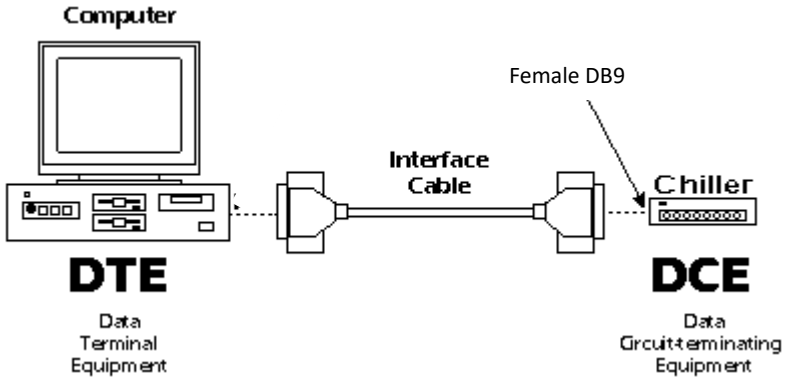


Table 1A: Signal definition and wiring for Host wired as DTE

Computer/Host/Master Male 9-Pin D-sub Pin #	**Chiller / Slave** Female 9-Pin D-sub Pin#
2 (Receive – RXD)	2 (Transmit – TXD)
3 (Transmit – TXD)	3 (Receive – RXD)
5 (Ground)	5 (Ground)

Note: Use a null modem cable if your RS-232 is set up as a DCE.

Communication Specification

Speed:	9600 baud
Data Flow Control:	None
Data Format:	8-bit serial
Number of Stop bits:	1
Parity:	None
Transmission Breakdown:	One command byte followed by zero, one, or two data bytes depending on data type.
Master/Slave:	ThermoCube is always the SLAVE (DTE)
Interrupts Reported:	None, must be polled for status
Transmission Length:	$\leq$ 15 meters
Data Update Frequency:	Once per second
Maximum Polling Frequency:	Three commands per second

RS-232 Communication Protocol

Table 2: Command and Data Bytes

	Bit Position	Description	Bit =1	Bit = 0
Command Byte	Bit 7 (MSB)	Set Remote Control	remote control	local control (chiller)
	Bit 6	Remote On/Off	chiller On	chiller in standby
	Bit 5	Communication Direction	remote to chiller (command from master)	chiller to remote (status from chiller)
	Bits 4 – 0	Parameters being communicated (see table 2)		
Data Bytes	1 or 2 bytes depending on parameter (see tables 3 and 4)			

Timing: ThermoCube PAO can accept a maximum of three commands per second

Table 3: Control Parameter

Bits 4 – 0	Parameter	No of Data Bytes
00001	Chiller set point 1 temperature	2
01001	Current fluid temperature at chiller coolant output	2
01000	Faults from chiller (fan, pump, RTD failure, etc.)	1

Table 4: Temperature Data Bytes (2 bytes)

The 2 data bytes for the temperature set point and transmission of the current temperature represent the value of the temperature in 0.1°F increments. For example:

Temperature (examples)	High Byte	Low Byte	Hexadecimal
0.1 °F	00000000	00000001	0001
1.0 °F	00000000	00001010	000A
10.0 °F	00000000	01100100	0064
20.0 °F	00000000	11001000	00C8
30.0 °F	00000001	00101100	012C
40.0 °F	00000001	10010000	0190
50.0 °F	00000001	11110100	01F4
60.0 °F	00000010	01011000	0258
70.0 °F	00000010	10111100	02BC

Table 5: Faults Data Byte (1 byte)

0 = OK, 1 = Fault

Bit Position	Fault Assigned	Hex value when fault is present
0	Tank Level Low	01
1	Fan Fail	02
2	Unassigned	N/A
3	Pump Fail	08
4	RTD open	10
5	RTD short	20
6	Unassigned	N/A
7	Unassigned	N/A

Notes:

1) Each data set is independent and can be run separately
2) The command byte is always active, so be careful when sending that the three most significant bits (bits 5-7) are set correctly. Bit 7 is remote operation (1 = remote), bit 6 is ON/OFF (1 = ON = unit controlling temperature), bit 5 is Data direction (1 = host to controller, e.g. host sends set point to controller).
3) The ThermoCube PAO can store 8 bytes of transmission and can only handle up to 3 commands per second.
4) The ThermoCube does not echo back commands from the host.
5) If RS-232 communications does not seem to be functioning, cycle the main power to reset.

RS-232 Communication Examples:

Example	Communications Sequence
1) Send set point of 25°F to chiller	Host sends command byte = E1 (hex)
	Host sends LOW data byte = FA (hex)
	Host sends HIGH data byte = 00 (hex)
2) Receive chiller set point	Host sends command byte = C1 (hex)
	Chiller sends LOW data byte = set point value in hex (LB)
	Chiller sends HIGH data byte = set point value in hex (HB)
3) Receive RTD temperature	Host sends command byte = C9
	Chiller sends LOW data byte = actual temp in hex (LB)
	Chiller sends HIGH data byte = actual temp in hex (HB)
4) Receive the faults table	Host sends command byte = C8
	Chiller sends faults data byte = fault data in hex
5) Send Remote Start only	Host sends command byte = E0
6) Send Remote Stop only	Host sends command byte = A0

7.3 OTHER OPTIONS WHICH COME STANDARD WITH THE THERMOCUBE PAO

-DC: Dry Contact Alarm Option

The ThermoCube can be configured with two normally closed 1 amp 250V dry contact alarm relays instead of the standard TTL alarms, one for system faults and one for temperature exceeding the alarm range. These contacts are wired to the 9-pin dsub connector as follows:

System Fault Alarm Common:	Pin 6
System Fault Alarm:	Pin 7
Temperature Alarm Common:	Pin 8
Temperature Alarm:	Pin 9

If the RS232 option is chosen with dry contact alarm option, then the dry contacts are wired to the 9-pin female dsub connector as follows:

System Fault Alarm Common:	Pin 6
System Fault Alarm:	Pin 1
Temperature Alarm Common:	Pin 9
Temperature Alarm:	Pin 4

-EF: External Filter Option

This option adds an external 5 micron filter to the ThermoCube coolant outlet for systems sensitive to particulate matter in the coolant. Note that this option also dampens coolant flow pulses, producing a smoother coolant flow.

-HT: High Temperature Operation Option

The ThermoCube normally has a 55 °C thermostat on its liquid cold plate that shuts off heating to protect against hot coolant damaging the operator's equipment. The –HT option replaces this thermostat with a 70 °C thermostat and adds insulation to allow operation up coolant temperatures of 65 °C

-LT: Low Temperature Operation Option

The ThermoCube normally has a 5°C thermostat on its liquid cold plate that shuts off cooling to prevent freeze damage when using water as a coolant. The –LT option removes this thermostat and adds insulation to allow operation below the freezing point of water (0°C). Select this option if you plan to regularly run at setpoints below 8-10°C. When selecting this option, the operator must ensure coolants are selected that will not freeze within 5°C of set point. Repairs to thermoelectric heat exchangers damaged by freezing water in Thermocubes with this option selected will not be covered by warranty.

-SS: Stainless Steel Plumbing and Tank Option – Required/Included with PAO

With this option the standard tank and plumbing are replaced with all stainless steel tank and plumbing. Note: This configuration option is only available with gear pumps.

7.3 OTHER AVAILABLE OPTIONS

-AR: Auto-Restart Option

Normally upon power up, the ThermoCube does not start controlling the coolant temperature until the START/STOP button is pressed. With this option selected, the ThermoCube begins controlling the coolant temperature automatically upon power up. After start-up, the START/STOP button operates like normal: pressing this button while running puts the ThermoCube in standby mode (no heating or cooling), pressing this button while in standby mode initiates coolant temperature control.

- R: RoHS Compliance

With this option we can configure the ThermoCube to use only RoHS 2 compliant components. RoHS certificates are available with this option upon request.

-VD: Vibration Dampening Option

This option adds vibration dampening material to interior sheet metal surfaces for applications such as scanning electron microscopes that are highly sensitive to vibrations from pumps and fans. This option is usually combined with the –EF external filer option which dampens vibrations in the coolant flow.

SECTION 8
CLEANING YOUR CHILLER

The exterior surfaces of the ThermoCube may be cleaned with a non-shedding wipe dipped in isopropyl alcohol.

SECTION 9
TECHNICAL SUPPORT

Delighting our customers is our highest priority. Please contact us immediately for technical assistance whenever you have questions or concerns.

Hours: 8 a.m. to 5 p.m. Eastern Time, Monday - Friday
Telephone: (845) 296-1300
Fax: (845) 296-1303
E-mail: info1@sscooling.com

SECTION 10
MSDS FOR COOLANTS

Material Safety Data Sheet
ROYCO(R) 602

SECTION 1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Common Name : ROYCO(R) 602

Supplier : Anderol Inc.
215 Merry Lane
East Hanover, NJ 07936
Tel: (973) 887-7410
Fax: (973) 887-8422

Synonym : Not available.

Trade Name : ROYCO(R) 602

Material Uses : Lubricant.

Manufacturer : Anderol Inc.
215 Merry Lane
East Hanover, NJ 07936
Tel: (973) 887-7410
Fax: (973) 887-8422

MSDS# : 740078-04

Validation Date : 8/26/2003

Print Date : 9/1/2003.

In Case of Emergency
CHEMTREC: 800-424-9300
(United States).

SECTION 2. COMPOSITION, INFORMATION ON INGREDIENTS

Name	CAS #	% by Weight	UN Number
1-Decene, Dimer, Hydrogenated	68649-11-6	70-100	Not applicable.

This material is classified hazardous under OSHA regulations in the United States, the WHMIS Controlled Product Regulation in Canada, the NOM-018-STPS-2000 in Mexico and Brazil NBR 14725:2001.
See Section 8 for Exposure Limits.
See Section 11 for Toxicological Data.

SECTION 3. HAZARDS IDENTIFICATION

Physical State and Appearance : Liquid. (Clear sparkling liquid)

Emergency Overview : CAUTION!
MAY BE HARMFUL IF INHALED.
Avoid breathing vapor or mist. Keep container closed. Use only with adequate ventilation.

Routes of Entry : Inhalation. Ingestion.

Potential Acute Health Effects

Eyes : Non-irritating to the eyes.

Skin : Non-irritant for skin. Non-sensitizer for skin.

Inhalation : Hazardous in case of inhalation.

Ingestion : Not available.

Potential Chronic Health Effects	:	Carcinogenic Effects: Not applicable. Mutagenic Effects: Not available. Teratogenic Effects: Not available.
Medical Conditions Aggravated by Overexposure	:	Repeated or prolonged exposure is not known to aggravate medical condition.
Overexposure /Signs/Symptoms	:	Not available.

See Toxicological Information (Section 11)

SECTION 4. FIRST AID MEASURES

Eye Contact :	Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 20 minutes. Cold water may be used. Get medical attention if irritation occurs.
Skin Contact :	In case of contact, immediately flush skin with plenty of water. Get medical attention.
Inhalation:	If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.
Ingestion :	Do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Have conscious person drink several glasses of water or milk.
Notes to Physician :	Not available.

SECTION 5. FIRE FIGHTING MEASURES

Flammability of the Product	:	May be combustible at high temperature.
Auto ignition Temperature	:	Not available.
Flash Points	:	OPEN CUP: 176.67°C (350°F) (Cleveland.).
Flammable Limits	:	Not available.
Products of Combustion	:	These products are carbon oxides (CO, CO2). Thermal decomposition products are dependent on temperature conditions.
Fire Hazards in Presence of Various Substances	:	Not available
Explosion Hazards in Present of various Substances	:	Risks of explosion of the product in presence of mechanical of impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.
Fire Fighting Media and Instructions	:	SMALL FIRE: Use dry chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.
Protective Clothing (Fire)	:	Fire fighters should wear positive pressure self-contained breathing apparatus (SCBA) and full turnout gear. Be sure to use a MSHA/NIOSH approved respirator or equivalent.
Special Remarks on Fire Hazards	:	Container explosion may occur under fire conditions or when heated. Cool closed containers exposed to fire with water.

SECTION 6. ACCIDENTAL RELEASE MEASURES

Small Spill and Leak : Absorb with an inert material and put the spilled material in an appropriate waste disposal.

Large Spill and Leak : Absorb with an inert material and put the spilled material in an appropriate waste disposal. Do not allow any potentially contaminated water including rain water, runoff from fire fighting or spills to enter any waterway, sewer or drain. Note: See section 8 for personal protective equipment and section 13 for waste disposal.

SECTION 7. HANDLING AND STORAGE

Handling : Avoid breathing vapors or spray mists. After handling always wash hands thoroughly with soap and water. Avoid contact with eyes skin and clothing. Use with adequate ventilation.

Storage : Keep container tightly closed. Store in a dry cool and well-ventilated area.

SECTION 8. EXPOSURE CONTROLS, PERSONAL PROTECTION

Engineering Controls: Good general ventilation should be sufficient to control airborne levels. Ensure that eyewash stations and safety showers are proximal to the work-station on location.

Personal Protection

Eyes : Safety glasses.

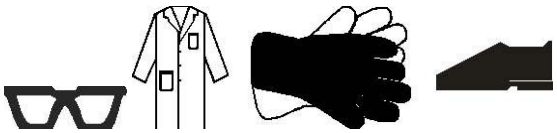
Body : Lab coat.

Respiratory : A respirator is not needed under normal and intended conditions of product use.

Hands : Chemical resistant gloves.

Feet : Shoes.

Protective Clothing : (Pictograms)



Personal Protection in Case of a Large Spill : Splash goggles. Full suit. Vapor respirator. Boots. Chemical resistant gloves. A self-contained breathing apparatus should be used to avoid inhalation of the product.

ROYCO(R) 602

Exposure Limits

1-Decene, Dimer, Hydrogenated	Not available.

Consult local authorities for acceptable exposure limits.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State and appearance	:	Liquid. (Clear sparkling liquid)
Color	:	Not available.
Odor	:	Odorless.
Molecular Weight	:	Not applicable
Molecular Formula	:	Not applicable.
pH (1% Soln/Water)	:	Not available.
Boiling/Condensation Point	:	Not available.
Pourpoint	:	-73.33°C (-100°F)
Specific Gravity	:	0.799 (Water = 1)

Vapor Pressure	:	Not available.
Vapor Density	:	Not available
Volatility	:	Not available.
Odor Threshold	:	Not available.
Evaporation Rate	:	Not available.
VOC	:	Not available
Viscosity	:	Not available.
LogK ow	:	Not available.
Solubility	:	Very slightly soluble in cold water, hot water.

SECTION 10. STABILITY AND REACTIVITY

Stability and Reactivity	:	The product is stable.
Conditions of Instability	:	Not available.
Incompatibility with Various Substances	:	Reactive with oxidizing agents.
Hazardous Decomposition Products	:	Not available.
Hazardous Polymerization	:	Will not occur.

SECTION 11. TOXICOLOGICAL INFORMATION

Toxicity Data

Ingredient Name	Test	Result	Route	Species
1-Decene, Dimer, Hydrogenated	LC50	1.17 mg/l (4 hours)	Inhalation	Rat

Chronic Effects on Humans	:	Not available.
Other Toxic Effects on Humans	:	Hazardous in case of inhalation. Non-irritant for skin. Non-sensitizer for skin. Non-irritating to the eyes.
Special Remarks on Toxicity to Animals	:	Not available.
Special Remarks on Other Toxic Effects on Humans	:	Not available.

SECTION 12. ECOLOGICAL INFORMATION

Ecotoxicity Data

Ingredient Name	Species	Period	Result
1-Decene, Dimer, Hydrogenated	Not available.	Not available.	Not available.

BOD and COD	:	Not available.
Biodegradable/OECD	:	Not available.
Mobility	:	Not available.

ROYCO(R) 602

Products of Degradation	:	Not available.
Toxicity of the Products of Biodegradation	:	Not available.
Special Remarks on the Products of Biodegradation	:	Not available.

SECTION 13. DISPOSAL CONSIDERATIONS

Waste Information Waste must be disposed of in accordance with federal, state and local environmental control regulations. Incinerate waste materials.
Consult your local or regional authorities.

SECTION 14. TRANSPORT INFORMATION

Regulatory Information	UN Number	Proper Shipping Name	Class	Packing Group	Label	Additional Information
United States (DOT)	Not regulated.	-	-	-		-
Canada (TDG)	Not regulated.	-	-	-		-
Mexico (NOM-004-SCT2-1994)	Not regulated.	-	-	-		-
Brazil	Not regulated.	-	-	-		-
IMDG Code	Not regulated.	-	-	-		-
IATA-DGR Class	Not regulated.	-	-	-		-

NAERG : Not applicable.

SECTION 15. REGULATORY INFORMATION

HCS Classification : Class: Toxic.
U.S. Federal Regulations : TSCA 8(b) inventory: All components listed.

SARA 302/304/311/312 extremely hazardous substances: No ingredient was found.
SARA 302/304 emergency planning and notification: No ingredient was found.
SARA 302/304/311/312 hazardous chemicals: No ingredient was found.
SARA 311/312 MSDS distribution - chemical inventory - hazard identification: 1-Decene, Dimer, Hydrogenated: Immediate (Acute) Health Hazard

SARA 313 toxic chemical notification and release reporting: No ingredient was found.
Clean Water Act (CWA) 307: No ingredient was found.
Clean Water Act (CWA) 311: No ingredient was found.

Clean Air Act (CAA) 112 accidental release prevention: No ingredient was found.
Clean Air Act (CAA) 112 regulated flammable substances: No ingredient was found.
Clean Air Act (CAA) 112 regulated toxic substances: No ingredient was found.

State Regulations :

California Prop. 65: No ingredient was found.

WHMIS (Canada) : Class D-1B: Material causing immediate and serious toxic effects (TOXIC). CEPA DSL: All components listed.
This product has been classified in accordance with the hazard criteria of the Canadian CPR, the United States OSHA, the Mexican NOM -018-STPS-2000 and the Brazilian NBR 14725:2001. This MSDS contains all the information required by the CPR, OSHA, the American National Standard Institute (ANSI) Z400.1, NOM -018-STPS-2000 and NBR 14725:2001.

Hazardous Ingredients Classification of the Degree of Risk (Mexico) :

Ingredient Name	Health	Flammability	Reactivity	Other
1-Decene, Dimer, Hydrogenated	2	1	0	

International Lists : All components are listed on major international inventories or exempted from being listed in Australia (AICS), Europe (EINECS/ELINCS), Korea (TCCL), Japan (METI/MOL), Philippines (RA6969).

SECTION 16. OTHER INFORMATION

Label Requirements		MAY BE HARMFUL IF INHALED
Hazardous Material Information System (U.S.A.)	:	Health 2 — National Fire Protection Association (U.S.A.) Fire Hazard 1 Reactivity 0 Personal Protection B

References : -Manufacturer's Material Safety Data Sheet. -Material Safety Data Sheet issued by: la Commission de la Santé et de la Sécurité du Travail du Québec. -Canada Gazette Part II, Vol. 122, No. 2 Registration SOR/88-64 31 December, 1987 Hazardous Products Act "Ingredient Disclosure List".-Provisional Domestic Substances List, Canadian Environmental Protection Act, Volume 1-Registry Number Index, April 1990; Environment Canada. - Official Mexican Standards NOM-018-STPS-2000 and NOM-004-SCT2-1994. -"Regulations respecting the handling, offering for transport and transporting of dangerous goods." Extract from the Canada Gazette Part II, dated February 6, 1985. Registration SOR/85-77 18 January, 1985. - 29CFR Part1910.1200 OSHA MSDS Requirements. - 49CFR Table List of Hazardous Materials, UN#, Proper Shipping Names, PG.

Other Special Considerations	:	Not available.
Responsible Name	:	Mr. Max Naggar
Date of Printing	:	9/1/2003.
Date of Issue		8/26/2003.
Date of Previous Issue	:	2003-01-31
Version	:	1.1

Notice to Reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above named supplier nor any of its subsidiaries assumes any liability whatsoever for the accuracy or completeness of the information contained herein. Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist

WARRANTY

This ThermoCube PAO chiller is covered under a two-year parts and labor warrant. The length of a warranty is product-specific, depending on the type and planned usage of the product, but will be specified in the quotation upon which a purchase order is made. Prototypes are not warranted, but will be repaired/adjusted after original shipment until they meet the agreed-upon specifications.
Malfunctioning products should be returned to Solid State Cooling Systems by the method described below. Solid State Cooling Systems will provide a Failure Analysis Report to the customer and will determine if the problem is covered under the warranty.
Warranty Coverage:

Products with defects in components or manufacturing which are reported to Solid State Cooling Systems before the end of the warranty period will be repaired or replaced at no cost (see below for reporting requirements). The warranty period begins on the date the product was initially shipped from Solid State Cooling System's factory.

Excluded from Warranty:

Excluded from warranty is any damage caused to the product occurring during, but not limited to, such events as shipment, installation, storage, or usage occurring during a situation specifically cautioned against or noted in the product manual.

Specific situations, which invalidate the warranty, include (but are not limited to):

- Removing the serial number label.
- Any disassembly (partial or complete) of a heat exchanger, which includes removing the tape on the sides, loosening or removing the bolts, or separating the heat sinks.
- Subjecting a heat exchanger to temperatures below the freezing point of the heat transfer fluid contained inside the unit.
- Subjecting a heat exchanger to unfiltered water.
- Subjecting any product to temperature, voltage, current, or pressure (internal or external) greater than that specified in the product manual.
- Employing pulse-width-modulated control at less than 1000 Hz.
- Operation of a power supply with a non-original enclosure or any replacement components. As well as voiding the warranty, these actions will also void the CE Mark (Switchback 6600 CE model power supply).
- Any actions prohibited in the "Caution" section of the product manual.

Returned Goods Procedure and Reporting Requirements

Before a failed product is returned to the factory, a Returned Materials Authorization (RMA) number must be obtained from Customer Service at (845) 296-1300. The date the RMA is requested will be the reporting date noted and relevant to the warranty. Products, which have received an RMA, must be received at Solid State Cooling System's factory within 30 days or the reporting date will be moved ahead 30 days and a new 30-day waiting period will begin.