



Operation & Service Manual

940126-0002



pCO³ Programmable Logic Controller

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1 Startup

1.1 Overview

1.1.1 Buttons

Though the button layout and general appearance of your pCO³ may vary, there should be six primary buttons provide complete functional control your pCO³ PLC.

Alarm button: This bell-shaped button will flash red when the unit experiences a fault or receives an unexpected output from one of the sensors. Pressing the alarm button will display the list of alarms that the unit is currently experiencing. Pressing the alarm button twice will clear the alarm *if* the fault has cleared and will allow the unit to resume normal operation.

Prg button: Press this button to enter the main menu of the pCO³.

Esc button: The functionality of this button is similar to the “Back” button of most internet browsers; however, any parameter changes made by the user prior to pressing *Esc* will be saved. Its use is to back out of menus one level at a time.

Up and Down Arrow buttons: These provide straightforward scrolling within all layers of menus and allow the user to change both digital (generally on/off) and analog values of parameters. When changing an analog control’s setpoint, the value will change by one digit each time the (up or down) button is pressed; or, holding down the button will cause an accelerating (exponentially quickening) change in the value. (Also, the user may use the arrow buttons prior to pressing the *Prg* button in order to view the status of the compressor(s) and electronic expansion valve(s).)

Return Arrow button (Enter button): The return button allows the user to:

- enter the currently highlighted menu,
- enter the currently selected screen,
- enter the currently highlighted variable for editing,
- save the value of a variable and proceed to the next one on the screen.

1.1.2 Basics of Control

There are three layers of password protected control on your PLC:

level 1 – basic maintenance & I/O observation (no password protection),

level 2 – service menu: for contractors and maintenance personnel (first password-protected level; default is “0000”),

level 3 – manufacturer’s menu: only accessible by Colmac for initial unit configuration and setup (top level password protection).

There are a number of items that can be viewed on the pCO³ without having to enter the service password. These I/O include the current states of the digital outputs (compressor(s), pumps, etc.) and analog outputs (electronic expansion valve(s) and eTCV(s)), as well as the values of the analog sensors in the system and the status of protective devices such as the phase failure relay and the overload protection modules.

When power is supplied to the unit, the pCO3 PLC can shut down the unit such that all I/O can still be viewed (power will still be supplied to the sensors), but compressors, pumps, fans, and valves will enter their shutdown states. To achieve this, the Level 1 user simply presses the *Prg* button, then the return button at the On/Off Unit menu. Inside this menu, press return, then the up or down arrows to choose the desired state, then press return & *Esc*.

1.2 Resetting Faults and Alarms

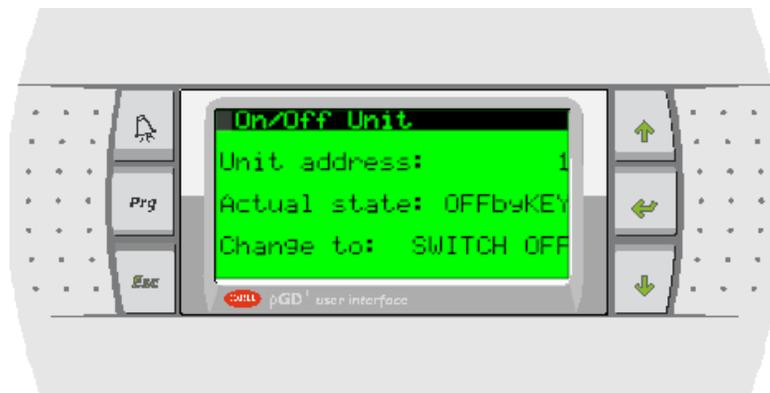
If the unit disables itself due to a fault such as phase failure, it will remain off until intervention is performed. The alarm button will also flash red until the fault is cleared and the alarm is reset. In the case of phase failure, if the phases of the incoming power have been restored to nominal conditions, then the user must simply press the alarm button, scroll down to ensure that phase failure is the only present fault, then press the alarm button twice more and the *Esc* button to clear the alarm and return to the title screen or operating screen.

2 Operation

2.1 Menus

2.1.1 A. On/Off Unit

This menu allows the user to manually turn off the system components of the unit as described in the last paragraph of section 1.1.2, Basics of Control. The On/Off menu only has one screen, as shown below.



2.1.2 B. Input/Output

Here can be found the current values of all analog and digital inputs measured by the unit and all analog and digital outputs from the pCO³ to control the unit. (The screenshots depicted below display some of the standard I/O variables for a water-source unit with dual compressors; however, the analog values shown for these I/O are not necessarily normal operating values.)



It should be noted that the eTCV will never close more than a certain amount (usually 35% to 45%) whenever the unit is running normally. This is due to a minimum valve open position that is set individually on each heat pump in the factory. This setting, which is inaccessible

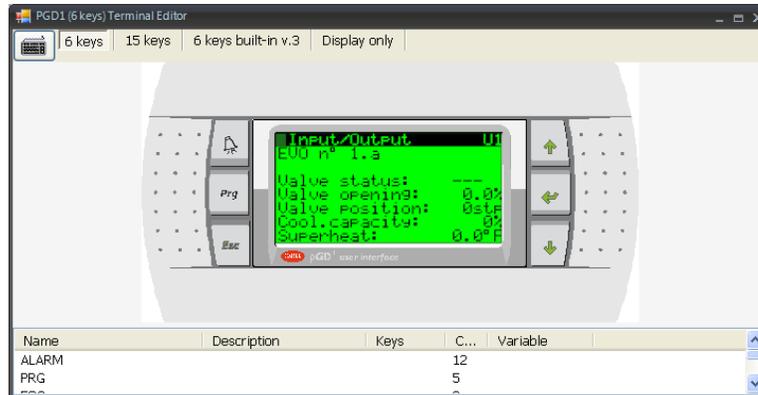
by the end user, allows the heat pump to maintain continuous potable water flow while quickly building up to the desired output temperature immediately upon startup. It should be noted that since the valve is intended to modulate such that the outlet potable temperature remains fairly constant, it will often be below 100% open. Normal operation can appear as continuous modulation or even as an apparent fixation anywhere from the minimum position to fully open.



Below is the general appearance of the first I/O screen of an air-source heat pump. (Though the actual analog inputs may have different nominal values from those depicted.)



The I/O also includes the electronic expansion valve(s) controlled by the attached EVD EVO Twin controller, with the available parameters depicted below.



2.1.3 C. Setpoint

The Setpoint menu is only applicable to units with the aquastat set to “Internal,” meaning the control of calls for heat is internal to the pCO³ and is driven by the tank temperature sensor. For units with this configuration, the setpoint menu only **displays** the tank temperature setpoint and the compressor differential temperature. To change these parameters, the user must enter the password-protected Service menu, as discussed in section 2.1.7, G. Service.

****The differential (Comp Diff) should always be kept at least 2.5°F below the setpoint to reduce the potential of compressor short cycling.****

*(The determination of which compressor is the first to turn on and which is first off will normally be controlled by the compressor staging mode in effect. More information on compressor staging can be found in section 2.2.3, Compressor Staging.)



The Setpoint menu will display the following for a two-compressor unit with aquastat set to “Internal”:



For units delivered after July 1, 2011, the compressor differential may be set for each compressor individually. Each compressor system in this case turns on when TTEMP drops to a temperature of [setpoint minus differential]. **NOTE: For dual compressor units, care should be taken to ensure that differentials are set such that at least a 2.5°F difference exists between these two temperatures to prevent simultaneous startup of the compressors.** This temperature difference is also important to reduce the potential of compressor short cycling.

If the aquastat is set to “External,” then the pCO³ may receive calls for heat through either a simple digital input or directly from a Building Management System (BMS). In the case of either external aquastat type, the Setpoint menu will display:



2.1.4 D. Clock

The Clock menu is another single-screen menu. Its sole use is to set the current date and time for the pCO³. This is used by the pCO³ for logging when faults/alarms occurred. The clock must reset after any instance where the unit loses incoming power completely.



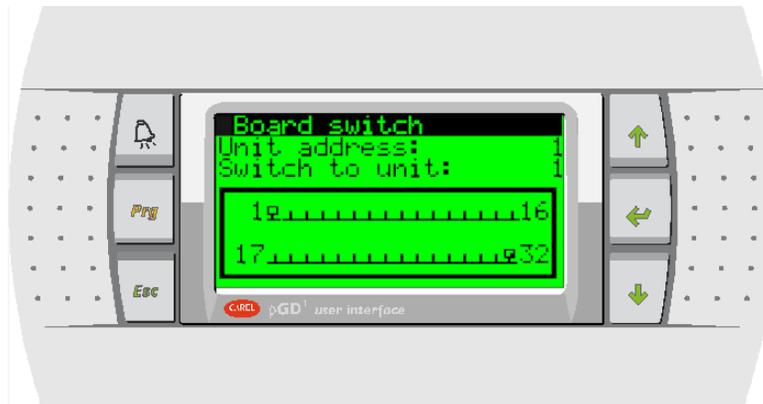
2.1.5 E. Alarm History

The Alarm History menu is the record of all alarms recorded by the pCO³. This record can be cleared by pressing both the *Prg* and *Esc* buttons simultaneously; however this is not necessary to free up memory space, and it is recommended that this record be kept as long as possible. Each logged entry contains the date and time that the alarm occurred as well as the tank temperature at that time.



2.1.6 F. Board Switch

This menu shows the current address and status of all components on the pCO³'s network (the pLAN). This menu is generally only useful to users with Master and Slave pCO³'s and more than two compressors in a networked unit.



2.1.7 G. Service

This menu provides the most extensive access to the controls and settings of the unit. It has two Level 1 submenus (no password), and four Level 2 submenus, which are password protected with a factory-set default password of "0000." The six submenus within the Service menu are described below.

2.1.7.1 a. Information

This Level 1 submenu provides read-only information such as version dates, some basic software information, and the date and time that the pCO³ itself last lost power.



2.1.7.2 b. Run Hours

Here the actual number of hours that each compressor has been on is logged as an integer. This Level 1 submenu also allows the user to reset the counter. ****Run hours are used to control compressor staging in order to maximize the lifespan of the compressors in units with two or more compressors. The counter should usually only be reset when a compressor is replaced.****

2.1.7.3 c. BMS

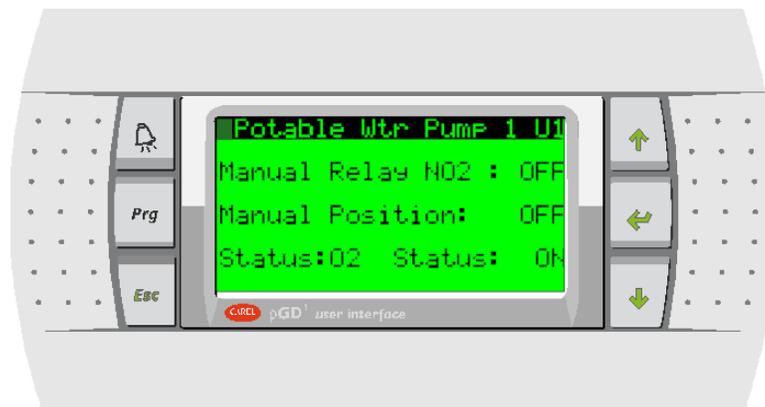
This Level 2 submenu should only be used if an external Building Management System (BMS) is to be given authority over the pCO³ in determining when a call for hot water (and/or a call for air cooling, in the case of some air-source units) is to be initiated.

This submenu allows the user to choose between the available communication protocols to match the user's installed system. The available protocols include: Carel (default), Modem, Modbus, pCOload, BACnet MSTP, BACnet IP/Eth, LON, or set to N/A.

More information will be supplied separately if the customer is utilizing BMS control. Carel also provides literature on applicable advanced connectivity solutions.

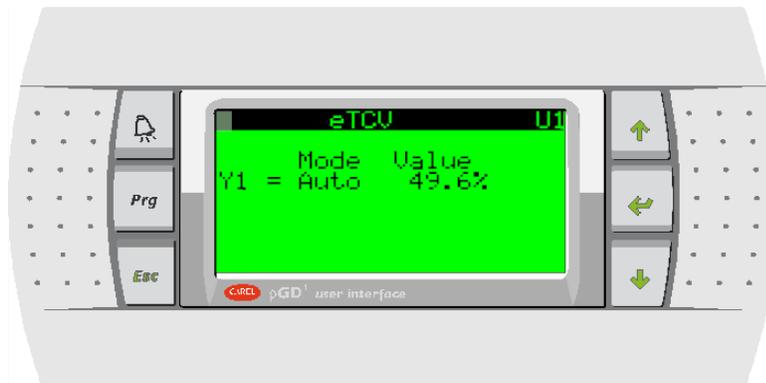
2.1.7.4 d. Manual Management

This Level 2 submenu provides manual control over some system components. Here pumps, fans, and optional devices such as auxiliary heat can be manually turned on when there is no call for hot water. (To turn on a digitally-controlled device manually, one must first turn on its relay, then set its manual position to On.)



Also, devices controlled by analog output, such as eTCVs (see following image), can be manually adjusted. To do so, the user must hit the return button to enter the device's settings, press the down arrow to change the mode from Auto to Hand, press return to move to value adjustment, scroll with the arrows to the desired percentage of fully open, and press return again to set the value.

****Activation of system components and manual adjustment of analog outputs should only be performed under the direction of a Colmac representative. Be sure to turn the manual relay and manual position back to the off position and reset analog values to their defaults when finished testing.****



2.1.7.5 e. Service Settings

The Service Settings submenu (Level 2 password required) contains some of the customer's most influential controls within the pCO³ PLC. These controls include:

- units of measure for pCO³ control and display
- adjustment of analog settings (eTCV and other setpoints and some cycle times)
- setting of aquastat control mode and input type
- superheat control for the electronic expansion valve (EEV)

The units of measure available are Fahrenheit or Celsius and psi or bars.



The following screens depict the display of a unit set to have an “Internal” aquastat. Each compressor’s differential is individually settable (a Colmac heat pump can have up to 8 compressors) as well as the differential at which the compressor will turn off. *****It is recommended to leave Differential Control set to “On” any time that an Internal aquastat setting is used, even if the user’s heat pump only has one compressor.*****



The differentials and “Off” differentials are all temperature differences from (below) the single Tank Setpoint temperature, so their actual temperature will vary with this setpoint. Example: If the tank setpoint is 135.0°F, and the Compressor Differential for C1 is 2.5°F, and C1’s Compressor Off Differential is 0.0°F, then compressor 1 will turn on when the tank’s temperature probe reads 132.5°F and it will turn off when the probe reaches 135.0°F. Likewise, if Comp Diff for C2 is 5.0°F, and Comp Off Diff for C2 is 2.5°F, then Comp 2 will turn on when tank temp drops to 130.0°F at the probe and will turn off at 132.5°F. Which physical compressor corresponds to C1, C2, etc. is determined by the compressor staging mode in effect at the time.

It is useful to keep the Compressor Off Differentials in a sequential order (as opposed to setting them all to 0.0°F, where they would all turn off at the setpoint) because of the rapid nature of the temperature increase as it approaches the setpoint. Staggered off differentials allow the unit to reach the setpoint at a relatively constant rate and will prevent significant overshoot of the setpoint.

“Aquistat Type” is the type of aquastat input that the pCO³ should expect to receive (a Digital Input or BMS control) if Aquastat is set to “External.”



The heat pump's eTCV(s) may be enabled and disabled using the following screen, and its/their modulating control may be chosen here as well. It is recommended that the eTCV's control mode be left on “Pressure” instead of by Temperature, because modulation about a pressure setpoint will produce more stable modulation. If an eTCV is turned “Off” on this screen, its output signal will be 100% any time the unit is running. That is, any time there is a call for heat and no alarms, the corresponding eTCV's output will open the eTCV completely (100%), and it will not modulate.



Please note that the screenshots shown below do not necessary depict the default or recommended setpoints or even the parameters available on every unit. Colmac takes great care to specify the appropriate default values for each of our customers as well as

which optional controls are appropriate to meet every customer's specifications.

Remember that changing any parameter from its default setpoint may result in inefficient or incorrect operation.

Please consult Colmac if you have any concerns when changing system parameters.



The Thermoregulation screens allow the user to set the amount of superheat that each electronic expansion valve (EEV) is to modulate about; that is, each expansion valve will modulate incrementally open & close to maintain the specified level of superheat.



2.1.7.6 f. User DEV/PW

This allows the user to set a new device password, that is, a new service password (level 2 password) specifically for the pCO³ in question. (If the unit has networked master & slave pCO³s, the passwords must be set on these individually.)

Another very important feature within this menu is that the default settings may also be restored within this submenu for all Colmac-specified parameters. Or, level 2 password users may change parameters and save these as the new default, should future adjustments be made.



2.1.8 H. Manufacturer

The manufacturer menu is a password-protected menu only accessible by Colmac (Level 3). The configuration and parameters set within this menu are entered according to customer specifications and Colmac’s proprietary standards. *****If for any reason a user obtains access to this menu, please do not change any of this menu’s settings unless express permission from Colmac is granted. Failure to do so could result in incorrect or inefficient operation, could damage relays or fuses, or could even render the unit inoperable.*****

2.2 Operating Conditions

2.2.1 Factory Settings

Colmac heat pumps have some factory settings that the end user and servicing contractors will not have access to but should be aware of. Among the most important of these settings are the heat pump’s delays.

There is a compressor startup delay, which will generally be set to 5 minutes. This delay begins when the pumps are started in order to allow flow to develop before compressor(s) start and to provide a more sequential startup of system components. More functionally important though is that this delay limits the number of startups per hour in order to extend compressor longevity. However, if your unit is satisfying calls for heat after only a few minutes of run time, it is highly recommended that you increase the compressor start differential temperature and increase its difference from the “Off” differential temp (see section 2.1.7.5e. Service Settings), and possibly increase your hot water storage tank size and/or move the tank temperature probe closer to the bottom of the storage tank. Please consult a Colmac engineer for further guidance if you encounter these or similar design issues.

A Minimum On time may also be set. Currently, this delay is generally left at 0 minutes except for custom units, because its usage is similar to that of the comp start delay:

Minimum On time works to prevent short-cycling of the compressor as well as to minimize the number of compressor startups, thereby extending compressor lifespan without significantly affecting heat pump performance.

There is also a compressor staging delay that is ≥ 10 seconds which prevents simultaneous startup of compressors in units with > 1 compressor. For units with only one compressor, this delay is disabled and has no effect.

2.2.2 Usage Tips

The status screen depicted below provides a very useful overview of the current state of the heat pump. The “Status” shows whether the unit is allowed by the pCO³ to turn on as controlled through the On/Off Unit menu discussed previously (see sections 1.1.2 and 2.1.1). The  symbol will change to  if the corresponding compressor’s output is on. Finally, the descriptor “Normal” will vary for air-source heat pumps to give the current mode of the unit, depending on the customer’s optional controls. For instance, if entering air temperature drops below the freeze protect setpoint (typically 32°F), the descriptor will change to “Frz Prot”, indicating that the unit has entered Freeze Protection mode.



2.2.3 Compressor Staging

If your Colmac heat pump has two or more compressors, it will have a compressor staging protocol in effect. If staging were turned off, the compressors would be allowed (under certain conditions) to turn on simultaneously, producing dangerously large locked rotor amperages. The two modes of staging are Last In—First Out (LIFO) and Lead/Lag.

LIFO is used on Colmac heat pumps designated as “Modular.” A modular heat pump will have its potable (heated) water circuit pass through both compressor circuits in **series**. Modular units therefore only have one eTCV and one, if any, potable water pump. The advantage of a modular unit is an improved coefficient of performance (COP), which is primarily because the water is heated more efficiently by passing through both circuits during each pass through the heat pump. LIFO mode is necessary for modular units because the

single eTCV must modulate according to the high pressure reading from the second compressor circuit in the series in order to account for the total amount of heat added to the potable water. The characteristic of LIFO staging is that this second compressor in the series (which is actually designated Comp1) will always be the first compressor to turn on and the last compressor to turn off, since it is the “controlling” compressor. (The other compressor will then be the last to turn on and the first to turn off, hence the name “Last In—First Out.”) The only downside to modular units is that Comp1 may have a shorter lifespan than Comp2 unless the setpoints and differentials are set such that Comp2 is enabled nearly as frequently as Comp1.

The primary advantage of “Non-modular” units is that they may utilize the Lead/Lag staging mode instead of LIFO. Non-modular units will have their potable water circuits in a parallel configuration through the compressor circuits, and so will have two eTCVs and up to two potable water pumps. In Lead/Lag mode, the compressor with fewer run hours will be the first to start and the last to turn off. During normal operation, the compressors will generally alternate which is the “Lead” compressor because the “Lag” compressor will usually gain fewer running hours during each run cycle. The expected lifespans of the two compressors are thereby automatically equalized by using Lead/Lag mode.

It should be noted that the compressor staging mode in effect is set in the factory for each heat pump and cannot be changed or turned off by the customer or servicing contractors.

3 Servicing the Unit

3.1 General Instructions

It is always a good idea to switch the unit “off by key” in the On/Off Unit menu, then to disconnect the power to the heat pump altogether prior to servicing. This will ensure that the pCO³ PLC does not turn on system components as soon as power is restored and the pCO³ boots up. This simply provides a more controlled startup, helping the user check startup and operating conditions in a more orderly manner and will reduce risk of electric shock.

Our Heat Pump Water Heater IOM Manual, ENG00018586, is another crucial resource to consult to ensure correct operation of your Colmac heat pump. It may be downloaded for free from our website at:

<http://www.colmaccoil.com/HeatPumps/PDF/ENG00018586.pdf>

3.1.1 pCO³ Control Issues

Please contact Colmac right away if you believe your heat pump is operating incorrectly. Colmac takes great pride in this product line, and we are more than happy to work through any concerns with our valued customers.

3.2 Other Suggestions

For units with two or more compressors, whenever the user is modifying setpoints that will control compressor startup times, care should be taken to ensure the setpoints differ slightly in order to prevent both compressors from starting simultaneously. Preventing simultaneous startup is important as it would cause locked rotor amperages from multiple compressors to occur simultaneously.

All Colmac pCO³-controlled heat pumps are programmed to modulate the eTCV about a *pressure* setpoint by default. All customers have the option of requesting this be changed to a temperature-driven modulation; however, this is not recommended because of the PLC's control characteristics. PID control is able to modulate about a pressure setpoint simply because it is a more gradually changing variable in heat pumps.

If the unit is not starting up when there is a call for heat, be sure to check the On/Off Unit menu under the Main menu. Under certain circumstances, such as after an Initialization or when factory default settings have been restored, the unit may default to the condition "OFFbyKEY." This default allows the user to verify that the settings are correct and appropriate for their application before the heat pump starts automatically.

4 Default Values

This section specifies a range of default values in case the user wishes to return to the factory-specified I/O.

4.1 Water-Source

Service Settings:

BMS

Protocol: Carel
 Address: 1
 Baud Rate: 2400

Modulating Setup

*Please do not modify any parameters on the three Modulating Setup screens.

Band 10.0
 Integration Time: 60
 Dead Band: Off
 Above Setpoint 0.0
 Below Setpoint 0.0

Temperature (units): °F

Pressure (units): PSI

Comp Staging: ******(This setting is dependent on each customer's specific requirements.)

eTCV Pr Set: 190.0 to 220.0 psi (The eTCV's pressure setpoint varies dependent on the size and configuration of the heat pump as well as the customer's desired leaving potable water temperature. For many units, a setting of ~200psi will produce hot water near 140°F.)

*eTCV Tmp Set: 140.0°F *eTCVs are only set to modulate about a temperature setpoint by customer request. ****Modulation by pressure is preferable to modulation by temperature because PID control devices such as this PLC are able to produce more stable and consistent modulation about a pressure setpoint than a temperature one in a refrigeration system. Pressure**

*modulation will still yield potable water at a very nearly constant output temperature.***

Aquastat: (Aquastat mode and input type is dependent on the final environment's HVAC infrastructure. The available options are as follows:

Aquastat: Internal

This option allows the user to set a temperature setpoint and differential temp within the pCO³.

Aquastat: External

Aquastat type: Dig In (Digital Input)

Here, an external aquastat will supply a digital input to the pCO³, telling it that there is either a "call" or "no call" for potable hot water.

Aquastat: External

Aquastat type: BMS (Building Management System)

A BMS provides more robust control over the capabilities of the heat pump. The user must choose between specific protocols of BMS control according to the

Thermoregulation (for EEV a.):

Setpoint SH (superheat):	10.0°F
LowSH threshold:	5.0
LOP threshold:	10
MOP threshold:	65

*Thermoregulation (for EEV b.): *(when 2nd expansion valve is present)

Setpoint SH (superheat):	(Same as for valve a.)
LowSH threshold:	"
LOP threshold:	"
MOP threshold:	"

Default Service password (Level 2 access): 0000

*Default EVD EVO Twin password: 0022 *This only applies if the customer has purchased a separate, detachable interface for the EVO Twin controller. (This interface is not necessary if the customer has a pCO³ to control the EVO Twin controller.)

4.2 Air-Source

The Service Settings and default passwords should have the same values, in general, as those of water-source units. There are additional **optional** controls, depending on customer requirements, which will have default values as follows:

Auxiliary Heat Setpoint:	35.0°F
Air Defrost setpoint:	40.0°F
Frost cycle time:	10 minutes
Defrost cycle time:	20 minutes



Colmac reserves the right to change product design and specifications without notice.

For more information on Colmac products call us at 1-800-926-5622 or visit us online at:

WWW.COLMACWATERHEAT.COM