



Model 1095E

Acid Aerosol Freezer Chiller

Instruction Manual



TABLE OF CONTENTS

1.0	RECEIVING AND STORAGE	3
2.0	DEFINITION OF SYMBOLS	4
3.0	SPECIFICATIONS	5
4.0	DESCRIPTION AND PRINCIPAL OF OPERATION	6
4.1	TOUCH-SCREEN USER INTERFACE	8
4.1.1	<i>MAIN DISPLAY/Operator interface</i>	<i>8</i>
4.1.2	<i>SYSTEM STATUS AND ALARMS</i>	<i>9</i>
4.1.3	<i>MAIN MENU.....</i>	<i>10</i>
4.1.4	<i>SYSTEM CONTROL SCREEN.....</i>	<i>11</i>
4.1.5	<i>SEQUENCE TIMES SCREEN</i>	<i>12</i>
5.0	INSTALLATION	13
6.0	START-UP	14
7.0	SHUTDOWN	15
8.0	MAINTENANCE	16
8.1	MAINTENANCE SCHEDULE	16
8.2	MAINTENANCE PROCEDURES	16
8.2.1	<i>REPLACEMENT OF PERISTALTIC TUBING (IF EQUIPPED)</i>	<i>16</i>
8.2.2	<i>REPLACEMENT OF SAMPLE PUMP DIAPHRAGM</i>	<i>16</i>
8.2.3	<i>INSTALLING OR REPLACING HEAT EXCHANGERS</i>	<i>17</i>
8.2.4	<i>INSPECT/ CLEAN HEAT SINK FINS.....</i>	<i>17</i>
9.0	TROUBLESHOOTING	18
10.0	DRAWINGS AND SPARE PARTS	20
11.0	STANDARD TERMS & CONDITIONS OF SALE AND WARRANTY	21

1.0 RECEIVING AND STORAGE

The Universal Analyzers Model 1095E Acid Aerosol Freezer Chiller is completely pre-assembled. No assembly is necessary when received on-site.

Carefully inspect the product and any special accessories included with it immediately on arrival by removing them from the packing and checking for missing articles against the packing list.

Check the items for any damage in transit and, if required, inform the shipping insurance company immediately of any damage found.

Storage Location should be protected from the elements. Although all components provided are designed to resist corrosion, additional protection from heat (>140°F/ 60°C) and humidity is recommended.

2.0 DEFINITION OF SYMBOLS



CAUTION, RISK OF DANGER SYMBOL INDICATES INJURY MAY OCCUR IF MANUFACTURER'S INSTRUCTIONS ARE NOT ADHERED TO. PLEASE READ MANUAL CAREFULLY WHEN SYMBOL IS DISPLAYED



CAUTION, HOT SURFACE SYMBOL INDICATES EXPOSED SURFACE TEMPERATURE CAN CAUSE BURNS OR PERSONAL INJURY. CARE SHOULD BE TAKEN WHEN CONTACT IS REQUIRED.



CAUTION, RISK OF ELECTRICAL SHOCK SYMBOL INDICATES ELECTRICAL SHOCK MAY OCCUR. CAUTION SHOULD BE TAKEN BEFORE DISCONNECTING OR CONTACTING ANY ELECTRICAL CONNECTIONS.



PROTECTIVE CONDUCTOR TERMINAL SYMBOL INDICATES THE TERMINAL LOCATION FOR THE PROTECTIVE CONDUCTOR. FAILURE TO CONNECT TO THE PROTECTIVE CONDUCTOR TERMINAL MAY RESULT IN A SHOCK HAZARD.

3.0 SPECIFICATIONS

OPERATING SPECIFICATIONS	
Sample Flow Rate	0 to 5 l/m total (at STP)
Maximum Inlet Temperature	
Stainless Steel Heat Exchanger	700°F (351°C)
Kynar/Glass Heat Exchanger	280°F (138°C)
Maximum Inlet Gas Dew Point	178°F (81°C)*
Maximum Inlet Water Concentration	50%*
Minimum Ambient Temperature	34°F (1°C)
Maximum Ambient Temperature	105°F (41°C)*
Maximum Cooling Power	540 BTUs per hour (160 watts/hr.)
Outlet Sample Dew Point	-13°F (-25°C)
Gas Sample Inlet Fitting	3/8" tubing fitting
Gas Sample Outlet Fitting	1/4" tubing fitting
Bottom Condensate Drain Fitting	3/8" tubing fitting
Maximum Input Power	900 watts
Voltage (Factory Configured)	115/230VAC, 50/60 Hz
Electrical Classification	General Purpose, NEMA 1
Dimensions	27" H x 21" W x 14 1/4" D
Weight	75 lbs (34kg)
Soluble Gas Removal Rates	NO 0% loss NO <10% loss SO ₂ < 2% loss CO 0% loss CO ₂ < 2% loss

*At reduced flow rate.

4.0 DESCRIPTION AND PRINCIPAL OF OPERATION

Application

The Universal Analyzers Model 1095E Acid Aerosol "Freezer Chiller" is a system on a 21" x 27" plate designed to achieve an exit dew point of negative 13°F(-25°C). It is designed to remove moisture to a level of 650 PPM. This reduces the chances of low levels of acid formation therefore protecting downstream components as well as minimizing losses of measured components.

The use of a heated filter and a heated sample line are required to be installed between the sample extraction location and the input of the 1095E sample cooler. The temperature of the sample must be kept above the boiling point of water and above the dew point of any chemical reactions that would skew the desired analytical results.

Description

The Universal Analyzers Model 1095E Acid Aerosol "Freezer Chiller" contains a combination of Kynar and Glass/Kynar heat exchanger type heat exchangers. These are mounted within heat transfer blocks, which are cooled by thermoelectric elements utilizing the "Peltier Effect". The condensate is removed in multiple stages, one at the temperature of the ambient air surrounding the Freezer Chiller by flowing through the heat exchanger referred to as the Passive Channel, then by passing the sample into a heat exchanger cooled to 39°F(4°C) by the thermoelectric elements referred to as the Active Channel (or Channel 1). The sample gas is then further cooled by special cascaded Peltier elements to negative 13°F(-25°C) in the freezer channels (Channels 2 & 3) which alternate based on the user defined PLC settings.

In standard operation Channel 1 will always hold at 39°F(4°C) within a band of 1 to 2 degrees. Channel 2 and Channel 3 cycle their operation. The normal cycle operations (no alarms) are as follows:

Channel 2 Pre-Chill and Channel 3 Off: This cycle is the initial status upon startup. The switching valve selects Channel 2 and Channel 2 has power applied to the cooling elements until it has reached 14°F(-10°C) or the Pre-Chill time has elapsed.

Channel 2 Dwell and Channel 3 Off: This Cycle is the main cycle for the cooling elements on Channel 2 to chill and for sample to run through Channel 2. Note: It may need to be adjusted to be long enough for Channel 3 to properly defrost but shorter than the time for ice to build up in the outlet of Channel 2, causing the flow switch to trigger a 'Frozen Column' alarm.

Channel 2 Dwell and Channel 3 Pre-Chill: During this cycle Channel 2 Dwell Time completes, Channel 2 continues to cool, and sample continues to run through Channel 2. Channel 3 is triggered to cool for up to 30 minutes. If Channel 3 reaches 14°F(-10°C) before 30 minutes has elapsed this cycle will complete and move to the next cycle.

Channel 2 Off and Channel 3 Dwell: This Cycle is the main cycle for the cooling elements on Channel 3 to chill and for sample to run through Channel 3. Note: It may need to be adjusted to be long enough for Channel 2 to properly defrost but shorter than the time for ice to build up in the outlet of Channel 3, causing the flow switch to trigger a 'Frozen Column' alarm.

Channel 2 Pre-Chill and Channel 3 Dwell: During this cycle Channel 3 Dwell Time completes, Channel 3 continues to cool, and sample continues to run through Channel 3. Channel 2 is triggered to cool for up to 30 minutes. If Channel 2 reaches 14°F(-10°C) before 30 minutes has elapsed this cycle will complete and move to the next cycle.

A Moisture sensor is provided to sense the presence of condensate, should any exist in the tubing following the chiller. This CCSF (Condensate Carry-Over Sensor with Filter) includes a visible steel fiber filter. This allows the operator to inspect the condition of the filter. The integral moisture sensor with the sensing elements is located in the bottom of the filter bowl to provide an early warning if liquid carries over past the freezer chiller. If condensate is sensed, the Alarm Message "Condensate Carry-Over" is displayed. A condensate carry-over alarm will stop the Sample Pump.

A Vacuum switch is provided to monitor and alarm high inlet vacuum. The message "System Vacuum" will appear on the top system status line of the operator interface, if there is high inlet vacuum. This logic is often used to trigger an automatic blowback of the probe filter.

A Flow switch alarms on low flow. The message "Low Sys Flow" will appear on the top system status line of the operator interface, if there is low flow.

The heated head sample pump (oil-less diaphragm pump) is placed in the sample line between the 39°F(4°C) and negative 22°F(-30°C) heat exchangers. The first chilled heat exchanger takes enough of the water vapor from the sample to protect the pump. The freezer heat exchangers are under a slight pressure because they are on the discharge side of the pump. This will cause the dew point of the sample to be at its minimum. The pump has a sample pressure controller that is set at 10 PSI. A Teflon Solenoid valve is used to alternate which channel is online and which is in defrost mode. The active freezer column flow impedance is monitored by a Flow switch to sense column freeze-up. If a flow restriction is sensed before Online Dwell time out, the Alarm Message "Column Frozen" is displayed and after a time delay of 60 seconds the PLC will sequence to the other Freezer Column.

The offline column is pre-chilled to approximately 14°F(-10°C) before the column is brought online. Once the pre-chill column is below 14°F(-10°C), the program automatically advances to that column or after 30 minutes of pre-chill time the pre-chill channel goes online. If the column fails to cool for 15 minutes once it is online, the message "Ch2 or Ch3 Malfunction" will be displayed.

The standard drain, a peristaltic pump is a positive displacement pump that allows for use in either a pressure or vacuum sample. It provides for easy leak detection but does require periodic maintenance in replacement of the tubing. A preventative maintenance program replacing the tubing every 6 months is a good practice.

To assist with the flow control a 5 Liter per minute flowmeter with needle valve is provided. Many analyzers require between 1/2 Liter and 1 Liter per minute. Any extra flow can be sent into a bypass to increase the total flow which in turn decreases the response time of the system.

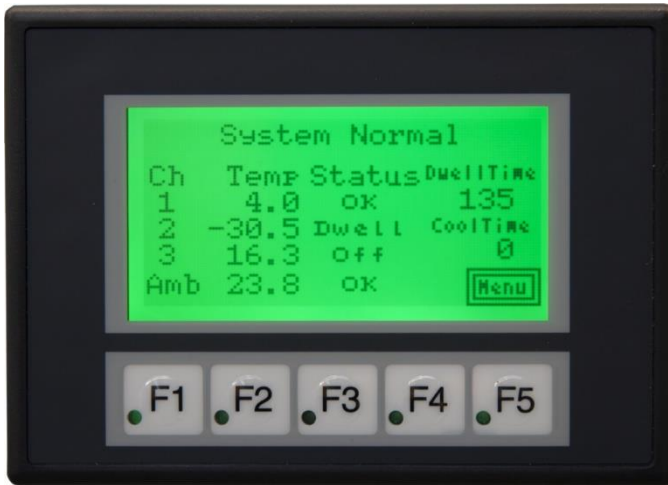
4.1 TOUCH-SCREEN USER INTERFACE

4.1.1 MAIN DISPLAY/OPERATOR INTERFACE

The Model 1095E "Freezer Chiller" is manually controlled through the Operator Interface located on the front of the unit, or remotely by the I/O inputs to the PLC. The 128x64 pixel operator interface (HMI) is used to display and manually operate the 1095E Chiller.

This is the main display screen of the touch Screen style user interface:

The top of the display contains the System Status or the current Alarm State.



4.1.2 SYSTEM STATUS AND ALARMS

Status and alarm messages displayed on top of screen:

MESSAGE	COMMENTS/NOTES
System Normal	
Condensate Carry-over	
Channel 1 Hi Temperature	39°F(4°C) Channel
Channel 2 Hi Temperature	-13°F(-25°C) Channel
Channel 3 Hi Temperature	-13°F(-25°C) Channel
Column 2 Frozen	Flow alarm before dwell timeout
Column 3 Frozen	Flow alarm before dwell timeout
Column 2 Malfunction	Freezer channel fails to cool in 15 minutes
Column 3 Malfunction	Freezer channel fails to cool in 15 minutes
Hi System Vacuum	
Low Sample Flow	
System Offline	
Column Held	From user input during calibration
RTD Failure	
High Ambient Temperature	

“Amb” measures the ambient temperature inside of the electronics enclosure.

The DwellTime displays the time remaining in whichever channel's status is dwell.

The CoolTime will display as zero during the defrost cycle and during the Pre-Chill cycle of a channel will display the time remaining on that Pre-Chill cycle. If the column reaches 14°F(-10°C), the cycle will automatically switch from Pre-Chill to Dwell. Below are the possible available status messages for each channel.

Note: “**” Indicates the active column (4 minutes remaining on Active Step)

Channel 1 Status Messages:

- OK
- Fault
- Warm

Channel 2 / Channel 3 Status Messages

- Offline
- Dwell (Channel on, normal cycle)
- Warm (not at temperature after chill cycle)
- Chill (pre-cooling before going online)
- Fault (not cooling or RTD failure)

Ambient Status Messages:

- OK
- Fault
- Warm

4.1.3 MAIN MENU

This menu provides access to the System Control Menu (System) and the Sequence Times Menu (Sequence). The Main button returns the user to the main display screen.



4.1.4 SYSTEM CONTROL SCREEN

The Acknowledge Alarms button is used to clear alarms displayed on the Main Display screen once the alarming condition has been corrected.

The System Online Set Logic button is used to change the logic of the System Online/Offline digital input between Normally Open and Normally Closed

The Advance Sequence button is used to advance the Freezer Channel cycle for troubleshooting.

The Turn System Online/Offline button is used to turn the Sample Pump on or off.

The Main button returns to the Main Display screen.

The Menu button returns to the Main Menu screen.



4.1.5 SEQUENCE TIMES SCREEN

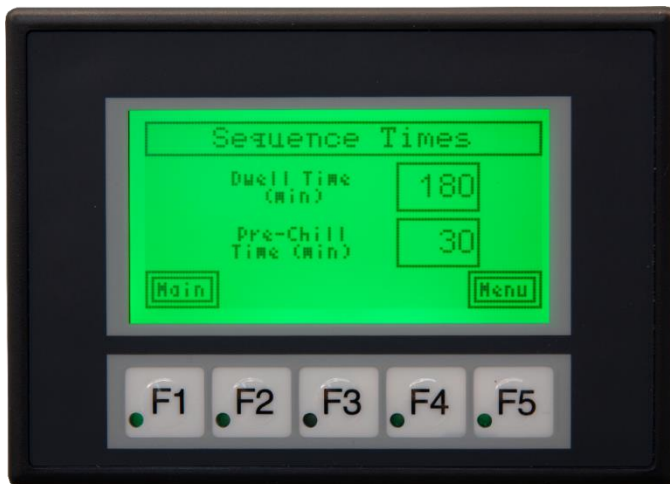
The Dwell Time Minutes button allows the user to adjust Freezer Channel sequence time between 50 and 180 minutes.

The Pre-Chill Time Minutes button allows the user to adjust the Next Up Channel pre-chill time between 20 and 40 minutes.

System Defaults:

The PLC will have following default values:

- Dwell: 180 Minutes - Length of time freezer Column is online
- Pre-Chill: 30 Minutes - Pre-Chill on the Offline Column, prepares the Column to become active.



5.0 INSTALLATION

The sample inlet is a 3/8" compression fitting supplied on the top of the first heat exchanger. The heat insulation on the heated tube bundle should be stripped no more than 3" to avoid plugging the exposed line. The sample outlets are 1/4" compressions fittings on the flowmeter.

A 3/8" tube is provided as the condensate drain connection. Two dual-head peristaltic pumps are used to withdraw the condensate from each heat exchanger. Care must be taken to drain the condensate into an appropriate drain because of the presence of condensed sulfuric acid.

The electrical power, maximum 8A at 115VAC or 4A at 230VAC should be supplied. Installation shall be in accord with the manufacturer's instructions and the national electric code (ANSI/NFPA70). Tampering and replacement with non-factory components may adversely affect the safe use of the system. Customer input power connections are on TB6. Customer 24VDC input signals to manually hold a column are on TB5-1 and TB5-2. Customer 24VDC input signals to manually activate the system offline function are on TB5-3 and TB5-4. The 24VDC output signal that signifies there is a system error, may be wired on TB5-5 and TB5-6.

6.0 START-UP



NOTE: IT IS IMPORTANT THAT THE HEATED PROBE AND HEATED SAMPLE LINE SHOULD BE AT OPERATING TEMPERATURE BEFORE STARTING THE CHILLER AND SAMPLE PUMP.

Apply power to the sample cooler. Channel 1 temperature should start to drop immediately. It will be below the overtemperature set points, 50°F(10°C), after several minutes, once Channel 2 reaches 14°F(-10°C) the sample pump will turn on as the system leaves startup mode and enters run mode. Channel 1 will operate at approximately 39°F(4°C).

For Touch-Screen User Interface See Page 8.

7.0 SHUTDOWN

Before removing power from the unit, ensure the system has been purged of any potentially hazardous components. To purge the system, perform the following:

1. Perform a manual blowback operation.
2. If feasible, provide instrument air to the probe via a cal gas line. If not, disconnect the sample line.
3. Allow the system to run for at least 10 minutes.
4. Once purging is complete disconnect and cap the sample outlet tube connections and disconnect power from the unit.

Note: If electrical wires are to be disconnected, follow applicable 'Lock Out/Tag Out' requirements.

8.0 MAINTENANCE

8.1 MAINTENANCE SCHEDULE

DAILY

1. Check alarm status for normal operation
2. Check chiller temperature indication
 - a. CH1 $4^{\circ}\text{C} \pm 1^{\circ}\text{C}$
 - b. Online Freezer - Cold
 - c. Offline Freezer - Warm
3. Check sample flow rate through chiller to be normal < 5 l/min

WEEKLY

1. Check Sample Pump for Normal Operation – 5-8 l/min @ <2" HG @ 10 PSIG
 - a. Pump Diaphragm replacement dependent on Load, Ambient Temperature and Sample Composition
2. Check Sample Filter by observing color and noting any flow restriction
 - a. Change as required

BIANNUALLY

1. Replace Tubing on Peristaltic Liquid Pump
2. Replace Diaphragm and Gaskets on Sample Pump
3. Check Pressure setting of Back Pressure Regulator on Sample Pump
4. Leak Check Sample System (@15 psig for fifteen minutes)

8.2 MAINTENANCE PROCEDURES

Before performing any maintenance on the cooler, ensure that all plant safety procedures are followed. As with any electrical device, ensure power is removed before performing any procedures.

The cooler is designed for maintenance free operation but if any is required, ensure power has been removed before maintenance or repair is performed.

8.2.1 REPLACEMENT OF PERISTALTIC TUBING (IF EQUIPPED)

1. Please refer to manufactures website for instructions:
http://www.masterflex.com/catalog/product_view.asp?-sku=0701520
2. YouTube: http://www.youtube.com/watch?v=zC1INbSnf8o&feature=player_embedded#at=242

8.2.2 REPLACEMENT OF SAMPLE PUMP DIAPHRAGM

1. Please refer to manufactures website for instructions: <http://www.airdimensions.com>

8.2.3 INSTALLING OR REPLACING HEAT EXCHANGERS

REMOVING THE HEAT EXCHANGER

1. Remove the inlet and outlet tubes by loosening the compression fittings. Always use a backup wrench on the fitting body to ensure no damage to the heat exchanger occurs.
2. Remove the drain fitting using the same procedure as the inlet/outlet. Remove the drain fittings from the exchanger. Use a backup wrench on the lower heat exchanger hex to prevent damage to the exchanger.

REPLACING THE HEAT EXCHANGER

1. Dry and clean the heat exchanger opening in the heat transfer block using a dry, lint-free cloth (If reusing the heat exchanger, clean the outside as well.) Dried heat transfer paste can be removed by using a very fine abrasive pad wrapped around a drill bit
2. Apply a thin layer of heat transfer paste onto the outer diameter of the heat exchanger.
3. Gently push the heat exchanger into the heat transfer block until the head is fully seated against the insulation on top.
4. Reinstall the drain fitting. Ensure pipe tape is used on the pipe threads before installation. Use a backup wrench on the heat exchanger lower hex to prevent damage to the exchanger.
5. Reconnected the drain, inlet and outlet tubes.

8.2.4 INSPECT/ CLEAN HEAT SINK FINS

INSPECT HEAT SINK FINS

Using a flashlight (or other light source), shine a light through the heat sink fins. If the fins are unobstructed, you should be able to see the exhaust fan. If the fan is not visible or partial obstruction exists, clean the heat sink fins.

CLEAN HEAT SINK FINS

Using a soft bristled brush, gently remove to debris from the heat sink. Alternatively, a computer safe aerosol cleaner can be used to remove the debris. Clean any loose debris from the enclosure and blower motor using a vacuum or compressed air.

REPLACING PELTIER ELEMENT

Contact Factory for Peltier replacement options. It is recommended on the 1095E Freezer Chiller elements be replaced at the factory. In rare occurrences a procedure to replace the elements may be obtained.

9.0 TROUBLESHOOTING

The following table should give an overview of possible errors and an instruction to check and to repair them (is not valid for the starting-up period of cooler).



TROUBLESHOOTING SHOULD ONLY BE DONE BY AN TRAINED TECHNICIAN.

<i>Error</i>	<i>Possible reason</i>	<i>Check/Repair</i>
No display, no fans	Loss of AC power	Reestablish AC power
No display, no cooling		
Power supply	24VDC supply	Replace power supply
	Fuse blown	Replace fuse
PLC	Loose connector cable	Check cable connections
	PLC failure	Contact factory for replacement
No electronics fan	Fan failure	Replace fan
Sample pump not working	System offline	Place system online
	Water carry-over alarm	See 'Water carry-over' error
	Ch 1 high temperature alarm	See 'Ch1 temperature 10°C' error
	Sample pump malfunction	Repair/replace pump
'Condensate carry-over'	Liquid in CCSF	Clean CCSF sensor
	Chiller BTU load high	Reduce sample flow rate
	Peristaltic pump failure	Replace peristaltic tubing
	High ambient temperature	Replace peristaltic pump
		Cool enclosure <40°C
"Ch 'X' high temp"	Chiller just energized	Allow chiller to cool
Ch 1 temperature >10°C	Chiller BTU load high	Reduce sample flow rate
Ch 2 & Ch 3 >-10°C	High ambient temperature	Cool enclosure <40°C
	Heat sink fan failure	Replace heat sink fins
	Heat sink fins obstructed	Clean heat sink fins
	Peltier elements failure	Verify wire connections
		Replace elements
		Replace heat sink assembly
Column frozen	Online column frozen	Reduce dwell time
		Check peristaltic tubing

Column malfunction (not cooling)	Peltier devices not functioning	Check cable & wiring connections Replace peltier devices Replace heat sink assembly
High system vacuum	System inlet vacuum >5" HG	Blowback heated filter Replace heated filter for restriction
Low sample flow	Pump failure	Replace sample pump Replace pump diaphragm
RTD failure	Faulty RTD or connection	Check cable and wiring connections. Replace RTD Replace or exchange heat sink assembly
High ambient temperature	Temperature in electronics enclosure exceeds 50°C	Reduce ambient temperature in shelter Replace electronics enclosure fan
No temperatures being displayed, or system only runs through one cycle	PLC in wrong mode	Rear switch must be in the center "Term" position, not "Run". To fix, push switch all the way to the left, then all the way right, and finally place switch into center position.



THE PRESENCE OF WATER IN LIQUID FORM AFTER THE SAMPLE COOLER IS AN INDICATION OF A FAULT IN THE SYSTEM. REASONS FOR THE PRESENCE OF CONDENSATE IN THE SYSTEM AFTER THE SAMPLE COOLER COULD BE ONE OR MORE OF THE FOLLOWING:

1. Overloading of the cooling capacity of the cooler due to too much water vapor in the sample OR too great a sample flow rate.
2. The condensate removal equipment (peristaltic pump, eductor, or drain pot) may be faulty. The heat exchanger(s) may be full of condensate.
3. An air leak may be in the condensate removal system allowing air to enter and blow the condensate back into the heat exchanger. (This assumes the heat exchanger is under a slight vacuum.)
4. The temperature of the air passing through the cooler to cool the heat sink is too high. This could be due to placement of the cooler in a tightly sealed box.

10.0 DRAWINGS AND SPARE PARTS

For the current revision of all Model 1095E drawings and spare parts, visit the Universal Analyzers website.

<https://www.universalanalyzers.com/>

Navigate to: Products -> Sample Conditioning Systems -> Model 1095E Chiller System

Links to all current drawings and spare parts for standard chiller systems are provided at the bottom of the page.

11.0 STANDARD TERMS & CONDITIONS OF SALE AND WARRANTY

THE FOLLOWING TERMS/CONDITIONS, TOGETHER WITH ANY OTHER TERMS/CONDITIONS SPECIFICALLY AGREED TO IN WRITING BY SELLER, SHALL APPLY TO ALL ORDERS ("Order(s)") FROM, AND SALES OF PRODUCTS ("Products") OR SERVICES ("Services") TO BUYER. ANY ACCEPTANCE OF ANY ORDER OF BUYER IS CONDITIONED UPON THESE TERMS/CONDITIONS. ANY ADDITIONAL OR DIFFERENT TERMS/CONDITIONS PROPOSED BY BUYER IN ANY DOCUMENT ARE OBJECTED TO AND SHALL NOT BE BINDING UPON SELLER. No salesperson is authorized to bind Seller to any promise or understanding not expressed herein.

I. PRICES

All prices are subject to change without notice in the event of any changes in cost of materials or labor, specifications, quantities, delivery schedules, customs duties, other factors beyond Seller's control, or in the event of delays caused by instructions of the Buyer, or failure of the Buyer to give Seller adequate information. Further, prices payable by the Buyer shall be subject to immediate increase, should the Seller as a result of governmental action or regulation including, without limitation, those contemplated by an investigation under Section 232 of the Trade Expansion Act of 1962 (19 U.S.C. §1862), incur additional duties, tariffs or restrictions on products sold hereunder, or on the raw materials that are used in making such products. In no event shall prices include any amounts imposed on the Buyer in connection with Buyer's purchases from Seller, such as taxes, including but not limited to Value Added Tax (VAT) or excise taxes, duties, tariffs, or any other costs assessed against the Buyer by a governmental authority.

II. DELIVERY

Delivery dates are approximate and are dependent on prompt receipt by Seller of all necessary information. Seller may deliver all or any part of Products/ Services as early as 30 days in advance of agreed schedule. The point of delivery shall be "Exworks" Seller's premises, unless otherwise specified by Seller. Upon delivery, title to Products and all risk of loss or damage thereto shall pass to Buyer. Where Buyer notifies Seller that it cannot take timely delivery of the Products, Seller may place such Products in storage, at the risk of Buyer, and Buyer shall reimburse Seller for all expenses incurred in connection with such storage. Buyer shall dispose of the packing materials for Products at its own expense, and shall defend, indemnify and hold harmless Seller from any legal obligations in connection with such packing waste.

III. PAYMENT

A. The term of payment shall be net 30 days from date of Seller's invoice, unless otherwise specified. Payments shall be made by Buyer without any deduction or set-off. Unless otherwise agreed, payment shall be made in U.S. dollars. Seller may charge late payment fees at the rate of 1.5% per month, or the highest rate permitted by law, whichever is less, accruing daily.

B. If the financial condition of Buyer is unsatisfactory to Seller, Seller may require full or partial payment in advance, or satisfactory security, in the form of a letter of

credit or otherwise. In the event of bankruptcy or insolvency of Buyer, Seller may immediately cancel any Order then outstanding.

C. Buyer grants Seller a purchase money security interest in Products located in the United States, or Services, as well as any proceeds, for the purpose of securing the obligations of Buyer hereunder. Buyer authorizes Seller to execute on Buyer's behalf and file such financing statements as Seller deems appropriate to perfect and notify Buyer's creditors of Seller's security interest.

IV. VARIATIONS IN QUANTITY; CHANGES.

Buyer shall accept delivery of quantities greater or smaller than the quantity specified in Order(s), provided that any such variation shall not exceed 5% of the quantity originally specified, or 2 units, whichever is greater. Seller shall not be required to give notice of any such variations other than in the applicable shipping notice and invoice. Seller reserves the option to make changes to Products or Services which do not affect form, fit, or function, and shall deliver Products to the latest configuration part number at the time of delivery.

V. EXPORT CONTROLS; FCPA; ANTI-BOYCOTT

A. Buyer shall not make any disposition of the Products, by way of transshipment, re-export, diversion or otherwise, except as applicable U.S. export laws and regulations may expressly permit, and other than in and to the ultimate country of destination specified on Order(s) or declared as the country of ultimate destination on Seller's invoices or in the End Use Statement that Buyer supplies Seller. Seller shall not be named as shipper or exporter of record or U.S. principal party-in-interest (USPPI) unless specifically agreed to in writing by Seller in which case, Buyer shall provide Seller with a copy of the documents filed by Buyer for Export clearance purposes. At Seller's request, Buyer shall supply end-use and end-user information to determine export license applicability. Failure of Buyer to comply with this section shall constitute a material default allowing Seller to cancel related Order(s) without liability.

B. Buyer warrants that it shall not violate or cause the Seller to violate the U.S. Foreign Corrupt Practices Act of 1977 (FCPA), as amended, the United Kingdom Bribery Act (UKBA) of 2010, as amended, or their respective implementing regulations in connection with Buyer's sale or distribution of the Products and/or Services, and that Buyer does not know or have reason to believe that any consultant, agent, representative or other person retained by Buyer in connection with the sale and/or distribution of Products/Services has violated, nor caused Seller to violate the FCPA and/or the UKBA. Where Buyer

learns of or has reason to know of any violation of FCPA and/or or UKBA in connection with the sale or distribution of Products/Services, Buyer shall immediately advise Seller.

C. Buyer further warrants that Buyer shall not violate or cause Seller to violate the U.S. Antiboycott Provisions of the U.S. Export Administration Regulations issued pursuant to the U.S. Export Administration Act of 1979, as amended, in connection with Buyer's purchase of Products/Services and that Buyer shall not request or require Seller to make statements or certifications against countries that are not subject to boycott by the U.S.

VI. WARRANTIES

A. Seller warrants that Products manufactured by Seller, when delivered, shall be free from defects in material/workmanship. Seller warrants that Services shall be performed in accordance with generally accepted industry practice. Seller's obligations under this warranty shall be limited exclusively to repairing or replacing, at Seller's option, any part of Products which, if properly installed, used and maintained, proved to have been defective in material or workmanship within 1 year from the date of shipment or re-performing the Services. Seller warrants for a period of 1 year from the date of shipment that software or firmware, when used with Products, shall perform in accordance with Seller's published specifications. Seller makes no warranty, express or implied, that the operations of the software or firmware shall be uninterrupted or error-free, or that functions contained therein shall meet or satisfy the Buyer's intended use/requirements. Buyer shall notify Seller of any defect in the quality or condition of Products (including software/firmware) or Services within 7 days of the date of delivery or performance, unless the defect was not apparent on reasonable inspection, in which case, within 7 days after discovery of the defect. If Buyer does not provide such timely notification, it shall not be entitled to reject Products (including software/firmware) or Services, and Seller shall have no liability for such defect.

B. Seller's warranty obligations shall not apply to Products which (1) have been altered or repaired by someone other than Seller, or (2) have been subjected to misuse, neglect, or improper use or application, or (3) are normally consumed in operation, or (4) have a normal life inherently shorter than the warranty period stated therein.

C. No Products may be returned unless authorized in advance by Seller, and then only upon such conditions to which Seller may agree. Buyer must obtain a Return Material Authorization (RMA) number from Seller prior to any return shipment, and such RMA number must appear on the shipping label and packing slip. Buyer shall be responsible for returned Products until such time as Seller receives the same at its facility, and for all charges for packing, inspection, shipping, transportation or insurance associated with returned Products.

D. This section VI sets forth the exclusive remedies and obligations for claims based upon defects in or nonconformity of Products/Services, whether the claim is in contract, warranty, tort (including negligence of any degree or strict liability) or otherwise. THE FOREGOING WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES, WHETHER ORAL, WRITTEN, EXPRESS, IMPLIED OR STATUTORY. NO IMPLIED OR STATUTORY WARRANTIES OF MERCHANTABILITY OR FITNESS FOR PARTICULAR PURPOSE SHALL APPLY.

VII. PATENTS/INDEMNITY

If Buyer receives a claim that Products, or part thereof manufactured by Seller infringes a patent, Buyer shall notify Seller promptly in writing and give Seller information, assistance and exclusive authority to evaluate, defend and settle such claim. Where Buyer has furnished specifications/designs for the manufacture of the allegedly infringing Products, Buyer shall defend, indemnify and hold harmless Seller against third-party claims for infringement arising out of Seller's use of such specifications/designs.

VIII. LIMITATION OF LIABILITY

The total liability of Seller on any claim, whether in contract, tort (including negligence of any degree and strict liability) or otherwise arising out of, connected with, or resulting from the manufacture, sale, delivery, resale, repair, replacement or use of any Products/Services, shall not exceed the price allocable to the Products/Services or part thereof which gives rise to the claim. IN NO EVENT, WHETHER AS A RESULT OF BREACH OF CONTRACT, WARRANTY, TORT, (INCLUDING NEGLIGENCE OF ANY DEGREE, STRICT LIABILITY OR PATENT INFRINGEMENT) OR OTHERWISE, SHALL SELLER, ITS AFFILIATES, SUBCONTRACTORS, OR SUPPLIERS BE LIABLE FOR ANY LOSS OF PROFIT OR REVENUES, LOSS OF USE OF THE PRODUCTS OR SERVICES, OR ANY ASSOCIATED EQUIPMENT, COST OF CAPITAL, COST OF SUBSTITUTE GOODS, FACILITIES, SERVICES OR REPLACEMENT POWER, DOWNTIME COSTS OR CLAIMS OF BUYER'S CUSTOMERS FOR DAMAGES OR FOR ANY SPECIAL, PROXIMATE, CONSEQUENTIAL, INCIDENTAL, INDIRECT OR EXEMPLARY DAMAGES. If Buyer transfers title to, or leases Products sold hereunder to, or otherwise permits or suffers use by, any third party, Buyer shall obtain from such third party a provision affording Seller and its subcontractors/suppliers the protection of the preceding sentence. Any action against Seller must be brought within 18 months after cause of action accrues.

IX. EXCUSABLE DELAYS

A. Seller shall not be liable for delays in delivery or failure to perform due directly or indirectly to causes beyond Seller's reasonable control including but not limited to: acts of God; war; terrorism; civil commotion; riots; embargoes; government regulations, orders, instructions or priorities; port congestion; acts of or failure to act on the part of Buyer or its agents/employees; fires; floods; sabotage; nuclear incidents; earthquakes; storms; epidemics; strikes; lockouts or other labor difficulties; shortages of or inability to timely obtain proper labor, materials, components, shipping space or transportation, fuel, supplies or power at current prices; or due to limitations imposed by the extent of availability of Seller's normal manufacturing facilities.

B. If a delay excused per the above extends for more than 90 days and the parties have not agreed upon a revised basis for continuing providing Products/Services at the end of the delay, including adjustment of the price, then either party (except where delay is caused by Buyer, in which event only Seller) upon thirty (30) days' notice may terminate the Order with respect to the unexecuted portion of the Products/Services, whereupon Buyer shall promptly pay Seller its reasonable termination charges upon submission of Seller's invoices thereof.

X. SOFTWARE/TECHNICAL/PROPRIETARY INFORMATION

A. Buyer shall not acquire any rights to any software which may be delivered with Products, except as granted in Seller's standard software license. Any software license granted in connection with Products shall be an interim license, which may be withdrawn, pending payment for Products in full.

B. The purchase of Products shall not include any right to supply of technical information such as drawings or specifications.

C. Proprietary information, including drawings, documents, technical data, reports, software, designs, inventions and other technical information supplied by Seller in connection herewith (hereinafter called "Data"), shall remain Seller's sole property and shall be held in confidence by Buyer. Data shall not be reproduced, used or disclosed to others by Buyer without Seller's prior written consent. Upon completion of Order, Buyer shall promptly return all Data to Seller together with all copies or reprints thereof then in Buyer's possession or control, and Buyer shall thereafter make no future use, either directly or indirectly, of any Data or any information derived therefrom without Seller's prior written consent. The foregoing shall in no way obligate Seller to provide or supply Data.

XI. DIES, TOOLS, PATTERNS

Seller's charges for dies, molds, patterns and the like represent the Buyer's proportionate cost thereof, it being expressly understood that they remain the property of Seller.

Modifications made to dies, molds, patterns and the like in order to manufacture Products shall be at the discretion of Seller.

XII. GENERAL

A. The rights and obligations of the Buyer and Seller hereunder shall be governed in all respects by the law of the Commonwealth of Pennsylvania, U.S.A. The exclusive forum for adjudication of any disputes shall be the federal or state courts of the Commonwealth of Pennsylvania, and Buyer/Seller hereby consent to personal jurisdiction and venue in such courts in any proceeding. The United Nations Convention on the International Sale of Goods shall not apply.

B. These Terms and Conditions of Sale together with any other terms specifically agreed to in writing by Seller constitute the entire agreement between Buyer and Seller and supersede any prior or contemporaneous representations, agreements, proposals, warranties, or understandings, oral or written, express or implied. No waiver, modification, amendment, rescission or other change to these Terms and Conditions of Sale shall be binding unless specifically agreed to in writing by an authorized representative of Seller.

C. The invalidity, of any part hereof shall not affect the validity of the remainder. The failure of Seller to assert any right at any time hereunder shall not prevent Seller's subsequent assertion of the same or different rights.

D. Buyer may not assign this contract without the prior written approval of the Seller.

XIII. PROHIBITION FOR HAZARDOUS USE

Products sold hereunder are not intended for application in, and shall not be used by Buyer in construction or application of a nuclear installation or in connection with use or handling of nuclear material or for any hazardous activity or critical application, where failure of a single component could cause

substantial harm to persons or property, unless Products have been specifically approved for such activity or application. Seller disclaims all liability for loss or damage resulting from such unauthorized use and Buyer shall defend, hold harmless and indemnify Seller against any such liability, whether arising under breach of contract, warranty, tort (regardless of the degree of fault or negligence), strict liability or otherwise. Where Seller approves the application of the Products in a nuclear facility, the Buyer shall, before such use or provision, arrange for insurance or governmental indemnity protecting the Seller against liability and hereby releases and agrees to indemnify the Seller and its suppliers for any nuclear damage, including loss of use, in any manner arising out of a nuclear incident, whether alleged to be due, in whole or in part to the negligence or otherwise of the Seller or its suppliers.

XIV. STATUTORY REQUIREMENTS

Seller reserves the right to make any changes in the general specifications of the Products which are required for the Products to conform to any statutory requirement.

XV. GOVERNMENT CONTRACTS

Only Federal Acquisition Regulation ("FAR") supplement clauses expressly accepted in writing by Seller shall be included or incorporated by reference herein. Seller shall not be bound by and makes no representation of compliance with any FAR or FAR supplement clauses that Seller shall not have expressly accepted in writing.