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# User's Manual

## CentriVap<sup>®</sup> Refrigerated Centrifugal Concentrators

### Models

73100 Series

To receive important product updates,  
complete your product registration card  
online at [register.labconco.com](http://register.labconco.com)

Please read the User's Manual before operating the equipment.

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## **Warranty**

Labconco Corporation provides a warranty to the original buyer for the repair or replacement of parts and reasonable labor as a result of normal and proper use of the equipment with compatible chemicals. Broken glassware and maintenance items, such as filters, gaskets, light bulbs, finishes and lubrication are not warranted. Excluded from warranty are products with improper installation, erratic electrical or utility supply, unauthorized repair and products used with incompatible chemicals.

The warranty for CentriVap® Refrigerated Centrifugal Concentrators will expire one year from date of installation or two years from date of shipment from Labconco, whichever is sooner. Warranty is non-transferable and only applies to the owner (organization) of record.

Buyer is exclusively responsible for the set-up, installation, verification, decontamination or calibration of equipment. This limited warranty covers parts and labor, but not transportation and insurance charges. If the failure is determined to be covered under this warranty, the dealer or Labconco Corporation will authorize repair or replacement of all defective parts to restore the unit to operation. Repairs may be completed by 3<sup>rd</sup> party service agents approved by Labconco Corporation. Labconco Corporation reserves the rights to limit this warranty based on a service agent's travel, working hours, the site's entry restrictions and unobstructed access to serviceable components of the product.

Under no circumstances shall Labconco Corporation be liable for indirect, consequential, or special damages of any kind. This warranty is exclusive and in lieu of all other warranties whether oral, or implied.

## **Returned or Damaged Goods**

Do not return goods without the prior authorization from Labconco. Unauthorized returns will not be accepted. If your shipment was damaged in transit, you must file a claim directly with the freight carrier. Labconco Corporation and its dealers are not responsible for shipping damages.

The United States Interstate Commerce Commission rules require that claims be filed with the delivery carrier within fifteen (15) days of delivery.

## **Limitation of Liability**

The disposal and/or emission of substances used in connection with this equipment may be governed by various federal, state, or local regulations. All users of this equipment are required to become familiar with any regulations that apply in the user's area concerning the dumping of waste materials in or upon water, land, or air and to comply with such regulations. Labconco Corporation is held harmless with respect to user's compliance with such regulations.

## **Contacting Labconco Corporation**

If you have questions that are not addressed in this manual, or if you need technical assistance, contact Labconco's Customer Service Department or Labconco's Product Service Department at 1-800-821-5525 or 1-816-333-8811, between the hours of 7:30 a.m. and 5:30 p.m., Central Standard Time.

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# TABLE OF CONTENTS

<b>CHAPTER 1: INTRODUCTION</b>	1
Safety Symbols	2
<b>CHAPTER 2: PREREQUISITES</b>	3
Electrical Requirements	3
Location and Exhaust Requirements	4
Vacuum Pump Requirements	4
Vacuum Line Traps	5
Space Requirements	5
<b>CHAPTER 3: GETTING STARTED</b>	6
Unpacking Your CentriVap	7
CentriVap Components	7
Emergency Access Into the Chamber	8
Component Orientation & Hose Connections	9
Electrical Connection	10
Rotor Installation	10
Chemical Resistance of CentriVap Components	10
Solvent Safety Precautions	12
<b>CHAPTER 4: USING YOUR CENTRIVAP</b>	14
Planning	14
Glassware Selection	15
Loading Glassware into the CentriVap	15
Temperature Setting Guidelines	15
Time Setting Guidelines	15
CentriVap Controls	15
Operating the CentriVap Controls	16
Operating the CentriVap	17
Operational Note	18
Cycle Interruption	18
Safety Precautions	19

<b>CHAPTER 5: MAINTAINING YOUR CENTRIVAP</b>	20
<b>CHAPTER 6: ACCESSORIES FOR YOUR CENTRIVAP</b>	22
Installing a Glass Lid	24
Installing a Vacuum Gauge	24
Installing a CentriZap Strobe Light	25
<b>CHAPTER 7: TROUBLESHOOTING</b>	26
<b>APPENDIX A: CENTRIVAP COMPONENTS</b>	29
<b>APPENDIX B: CENTRIVAP DIMENSIONS</b>	31
<b>APPENDIX C: CENTRIVAP SPECIFICATIONS</b>	32
Electrical Specifications	32
Environmental Conditions	33
Evaporation Rates	34

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# Chapter 1:

## Introduction

Congratulations on your purchase of a Labconco CentriVap Refrigerated Concentrator. Models are available for operation on 115V or 230V.

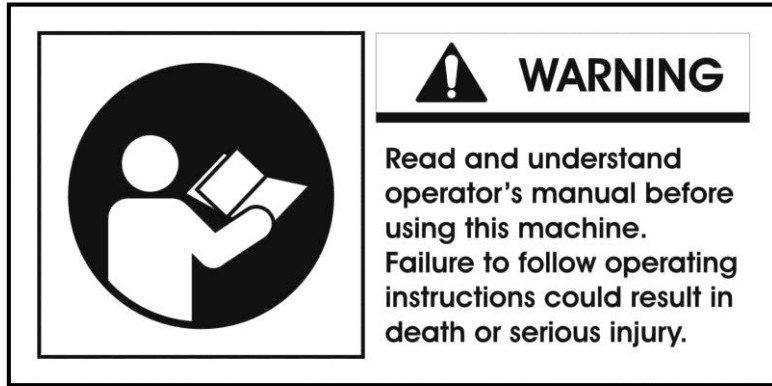
The CentriVap Refrigerated Concentrator, when combined with the CentriVap Cold Trap, uses centrifugal force and vacuum with or without heat to rapidly evaporate and condense solvents from biological and analytical samples. Centrifugation eliminates bumping and foaming as vacuum is applied and also concentrates the solute in the bottom of the vial. This allows recovery of solutes from sample volumes as small as a few microliters. The unique advantage of this concentrator is that it may be cooled to  $-4^{\circ}\text{C}$  to prevent damage to heat labile samples. For faster evaporation, the concentrator is equipped with a 300 watt heater to warm the chamber during processing. The concentrator may be placed on a benchtop or other laboratory work surface.

The microprocessor, which controls the operation of the heater and the motor, provides excellent regulation and reproducibility of protocols. The end of the run can be signaled by a manually preset timer. Nine different protocols can be stored in memory so exact test parameters can be easily repeated.

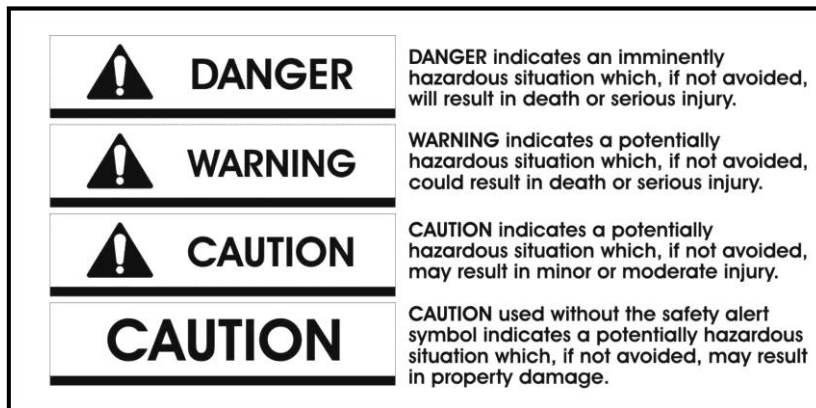
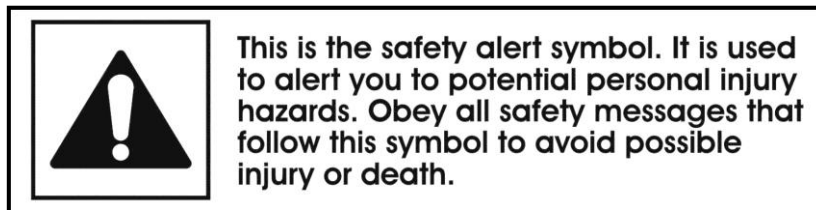
As the companion to the Concentrator, the CentriVap Cold Trap protects the vacuum pump by trapping moisture, vapors and corrosive fumes as they evaporate from the samples.

## Safety Symbols

Your Refrigerated CentriVap Concentrator was designed with safety in mind, however conditions may exist that could be hazardous.



Throughout this manual potentially hazardous conditions are identified using the following words and symbols.



It is important that you understand the warnings listed throughout this manual before you operate the CentriVap Concentrator.

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## Chapter 2: Prerequisites

Before you install your CentriVap Refrigerated Concentrator, you need to prepare your site for installation. You must be certain that the area is level and of solid construction. In addition, a means to exhaust the vacuum pump must be provided. An electrical source must be located near the installation site.

Carefully read this chapter to learn:

- The electrical supply requirements.
- The exhaust requirements.
- The vacuum pump requirements.

Refer to Appendix C: CentriVap Refrigerated Concentrator Specifications for complete electrical and environmental conditions, specifications and requirements.

### Electrical Requirements

The CentriVap Refrigerated Concentrator requires a dedicated grounded electrical outlet. This outlet requires a 20 Amp circuit breaker or fuse for models rated at 115V (60 Hz). An 8 Amp circuit breaker or fuse is required for models rated at 230V (50/60 Hz). 115V models are equipped with a 20 Amp NEMA 5-20P plug. 230V models are available with either a NEMA 6-20P plug for use in the United States or a PS1363 plug for use in the UK or a CHI-10P plug for use in China or a CEE7/7 plug for use in the EU. If this does not match with the available receptacle, remove this plug and replace it with an approved plug of the suitable style.

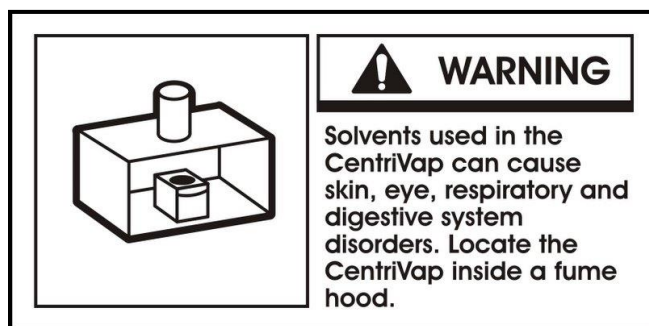
It is recommended that an emergency switch for disconnecting the mains in the case of a malfunction is located remote from the CentriVap. It should be outside the room in which the CentriVap is housed, or adjacent to the exit from that room.

## Location and Exhaust Requirements

The CentriVap Concentrator should be located on a surface that is stable, flat and level.

**WARNING:** The CentriVap System should be located within a fume hood if hazardous or flammable solvents are used. Heating of materials could lead to the liberation of hazardous gases. In all cases, regardless of the solvent used, it is strongly recommended that the vacuum pump is vented in a fume hood. An accessory secondary trap is available to minimize the exhausting of solvents into the atmosphere. This does not, however, negate the need to exhaust the vacuum pump into a fume hood. Failure to properly vent the CentriVap will expose personnel to potentially harmful chemicals.

The CentriVap Refrigerated Concentrator has not been evaluated by an approval agency for the use of biological, radio toxins or flammable liquids or materials.



## Vacuum Pump Requirements

A vacuum pump must be provided by the user. A vacuum pump with a free air flow rate of 90 liters per minute and  $2 \times 10^{-4}$  mBar ultimate pressure is adequate for aqueous samples. More volatile samples can be satisfactorily processed using a diaphragm pump with a free airflow of 75 liters per minute and 2 mbar vacuum. The inlet fitting on the vacuum pump must be suitable for 0.50 ID hose.

Vacuum pumps used with 115V models should be equipped with a 115V, 15 Amp NEMA 5-15P plug. Vacuum pumps used with 230V models should be equipped with a “reverse” IEC 320 plug. This will allow the vacuum pump to be plugged into the receptacle on the back of the CentriVap.

**IMPORTANT NOTE:** To ensure that aggressive samples used in the CentriVap Refrigerated Concentrator do not damage the vacuum pump, it is recommended that all internal wetted parts are PTFE or PTFE coated.



**When selecting the vacuum pump it is very important to consider the flammability of the solvent that will be used. If the solvents are flammable, an explosion-proof vacuum pump or one suitable for the solvents to be processed is recommended. See Chapter 3 Solvent Safety Precautions for solvents suitable for use in the CentriVap.**

## **Vacuum Line Traps**

When using a mechanical pump that is not corrosion resistant, the CentriVap Cold Trap or equivalent trap must be used in the vacuum line to prevent damage from solvent vapors. When evaporating acids, it is advisable to include an acid secondary trap in the vacuum line. This adds additional protection for the pump.

**NOTE: Several components within the CentriVap Refrigerated Concentrator are made from stainless steel or aluminum and can be degraded if exposed to acids. Contact Labconco before evaporating acids.**

A moisture trap, solvent trap and radioisotope trap are also available. Refer to Chapter 6: Accessories for Your CentriVap for ordering information.

## **Space Requirements**

Refer to Appendix C: CentriVap Refrigerated Concentrator Specifications for dimensional drawings of the CentriVap.

No person or any hazardous material should be within 12 inches of the CentriVap Concentrator while it is operating.

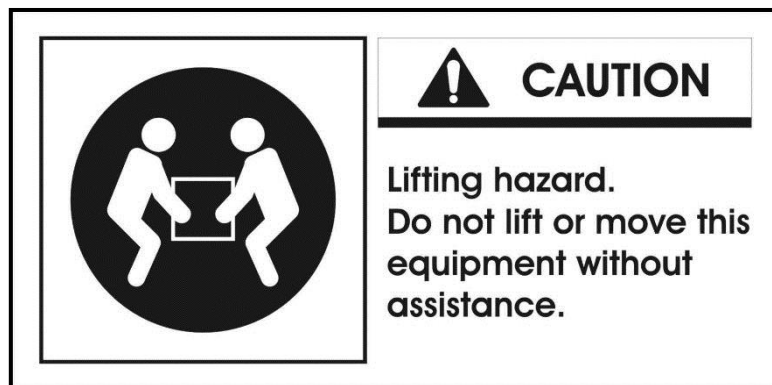
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## Chapter 3: Getting Started

Now that the site for your CentriVap is properly prepared, you are ready to unpack, inspect, install, and test your CentriVap. Read this chapter to learn how to:

- Unpack and move your CentriVap.
- Set up your CentriVap.
- Connect the electrical supply source to your CentriVap.
- Properly exhaust your CentriVap.
- Safely use solvents with your CentriVap.

**CAUTION: The CentriVap Refrigerated Concentrator weighs over 95 lbs. (43 Kg). The carton allows for lifting with a mechanical lift truck or hand truck. If you must lift the CentriVap manually, use at least two (2) persons and follow safe lifting guidelines.**



## Unpacking Your CentriVap

Carefully unpack your CentriVap and inspect it for damage that may have occurred in transit. If your CentriVap is damaged, notify the delivery carrier immediately and retain the entire shipment intact for inspection by the carrier.

The United States Interstate Commerce Commission rules require that claims be filed with the delivery carrier within fifteen (15) days of delivery.

Do not discard the carton or packing material for your CentriVap until you have checked all of the components and installed and tested the CentriVap.

**NOTE: Do not return goods without the prior authorization of Labconco. Unauthorized returns will not be accepted. If your CentriVap was damaged in transit, you must file a claim directly with the freight carrier. Labconco Corporation and its dealers are not responsible for shipping damage.**

## CentriVap Components

As previously mentioned, the CentriVap System is available in 115V or 230V. Locate the model of CentriVap you received in the following table. Verify that the components listed are present.

Catalog #	Product Description
7310020	CentriVap Refrigerated Concentrator – 115V/60Hz with Acrylic Lid – US
7310021	CentriVap Refrigerated Concentrator – 115V/60Hz with Glass Lid – US
7310022	CentriVap Refrigerated Concentrator – 115V/60Hz Acid Resistant – US
7310030	CentriVap Refrigerated Concentrator – 230V/50Hz with Acrylic Lid – EU
7310031	CentriVap Refrigerated Concentrator – 230V/50Hz with Glass Lid – EU
7310032	CentriVap Refrigerated Concentrator – 230V/50Hz Acid Resistant – EU
7310034	CentriVap Refrigerated Concentrator – 230V/50Hz Acid Resistant – UK
7310035	CentriVap Refrigerated Concentrator – 230V/50Hz with Acrylic Lid – UK
7310036	CentriVap Refrigerated Concentrator – 230V/50Hz with Glass Lid – UK
7310037	CentriVap Refrigerated Concentrator – 230V/50Hz with Acrylic Lid – China
7310038	CentriVap Refrigerated Concentrator – 230V/50Hz with Glass Lid – China
7310039	CentriVap Refrigerated Concentrator – 230V/50Hz Acid Resistant – China
7310040	CentriVap Refrigerated Concentrator – 230V/60Hz with Acrylic Lid – US
7310041	CentriVap Refrigerated Concentrator – 230V/60Hz with Glass Lid – US
7310042	CentriVap Refrigerated Concentrator – 230V/60Hz Acid Resistant – US

Plus the following:

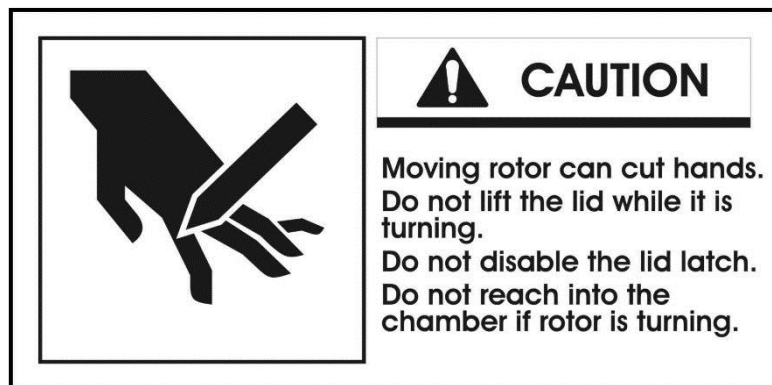
Part #	Component Description
7310605	User's Manual
1336400	Power Cord – 115V – US or
1332700	Power Cord – 230V – China or
1332600	Power Cord – 230V – UK or
1338000	Power Cord – 230V – US or
1336100	Power Cord – 230V – EU
7828606	Tubing
1488800	Clamp (2)
7397601	Coupling Insert or
7396206	Coupling Inert – Acid Resistant

If you do not receive one or more of the components listed for your CentriVap, contact Labconco Corporation immediately for further instructions.

## Emergency Access into the Chamber

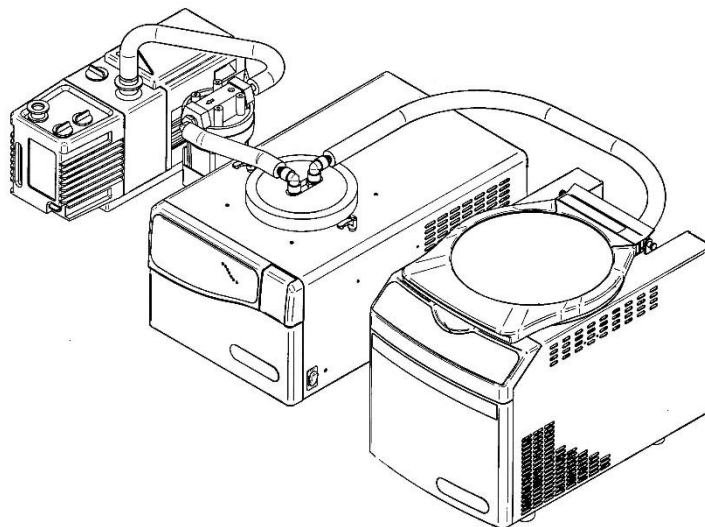
The CentriVap is designed to prevent access to the chamber in the event of a power disruption. If it is necessary to open the lid when there is no electrical power connected to the CentriVap, insert a small screwdriver or similar instrument into the small round hole on the left side of the case behind the control panel. This will unlock the lid latch mechanism. While holding the screwdriver in place, raise the lid with the other hand.

**CAUTION: Never attempt to defeat the latch or open the lid while the CentriVap is running. Personnel injury can result from moving parts and chemicals.**



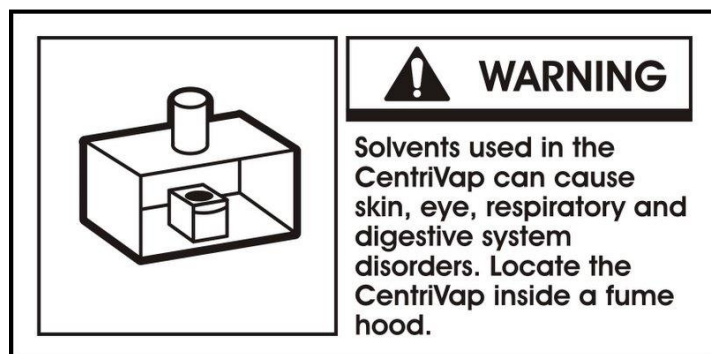
## Component Orientation & Hose Connections

The relative position of the CentriVap, Cold Trap and Vacuum Pump should be as shown to optimize the air flows of the refrigeration systems. There must be at least 6 inches between the Refrigerated CentriVap and the Cold Trap. More space is better. There must be at least 3 inches between the back of the refrigerated CentriVap and the adjacent wall surface. Restriction of the airflow through the cabinet during operation could adversely affect performance.



After positioning the components, it is necessary to join the system together using the hoses provided. Attach one hose to the tube that extends out the back of the Concentrator. Attach the other end of this hose to one of the barb fittings on the Cold Trap Cover. Secure the hoses with the clamps supplied. Attach another hose to the remaining barb fitting on the Cold Trap Cover and clamp securely. If the accessory Secondary Trap is not used, attach the other end of the hose to the inlet port on the vacuum pump. If the accessory Secondary Trap is used, install the Secondary Trap as explained in Chapter 6: Accessories for Your CentriVap. Then attach the hose from the Cold Trap Cover to the “out” connector on the Secondary Trap and clamp securely. Attach another hose from the remaining connector on the Secondary Trap to the inlet port on the vacuum pump and clamp securely.

**WARNING: It is recommended that the CentriVap be located inside a fume hood or other laboratory ventilation device if hazardous solvents are used in the CentriVap. If this is not possible, the vacuum pump should be located inside a hood or should have a hose attached to the exhaust port and the other end of the hose should be positioned inside the fume hood or ventilation device.**



## Electrical Connection

Plug the power cord into the receptacle on the back of the CentriVap Concentrator and plug the other end into a suitable power receptacle. Plug the power cord into the receptacle on the back of the CentriVap Cold Trap and plug the other end into a suitable power receptacle. Plug the power cord from the vacuum pump into the receptacle on the back of the Concentrator. If the vacuum pump has an off/on switch, turn the switch ON. The vacuum pump will be controlled by the Concentrator.

## Rotor Installation

Place the rotor onto the shaft of the Concentrator. Rotate the rotor slightly to engage the drive pin in the shaft with the slots in the rotor hub. The top of the shaft should be in line with the top of the rotor hub.

**IMPORTANT NOTE: Do not use a rotor if it shows any signs of damage. Failure of a spinning rotor could damage the CentriVap or cause samples to be lost.**

## Chemical Resistance of CentriVap Components

Your CentriVap Centrifugal Concentrator and Cold Trap are designed to be chemical resistant to most compounds that are commonly used in concentration processes. However, by necessity, the CentriVap is comprised of a number of different materials, some of which may be attacked and degraded by corrosive chemicals. The degree of degradation is obviously dependent on the concentration and duration of exposure. Some major components of the CentriVap that are susceptible to degradation are as follows:

COMPONENT	MATERIAL	Acids							Bases	Solvents														
		Acetic Acid 20%	Boric Acid	Formic Acid	Hydrobromic Acid 20%	Hydrochloric Acid 20%	Nitric Acid 20%	Sulfuric Acid 10%	Trifluoroacetic Acid (TFA)	Ammonium Hydroxide	Acetone	Acetonitrile	Chloroform	Dimethyl Formamide	Dimethyl Sulfoxide (DMSO)	Ethanol	Ethyl Acetate	Hexanes	Isopropanol	Methanol	Methylene Chloride	Methyl t-Butyl Ether (MTBE)	Toluene	Water
<b>Standard CentriVap</b>																								
Chamber	Epoxy coated Aluminum			C				D					C	D										
Lid	Acrylic							C	D	C		D	D	D	D	C			D	C	D		D	
Bearings	High Carbon Steel	D	D	D	D	D	D	D		D				D									D	D
Lid Gasket	EPDM					D	D	D				D		D							C	C	D	
Rotor Shaft	Stainless Steel				D	D	D																	
Valve	Stainless Steel				D	D	D																	
O Rings	Viton (Fluorocarbon)							C					C	C		D						C		
Fittings	Polypropylene	D														C								
Rotor	Anodized Aluminum				D	D																		
Rotor Hub	Acetal (Delrin)	C		C	C	D	D	D	C					D									C	
Tubing	PVC	D	C			D	D	D				D	D	D	D	D	C	D	D			D	D	
<b>Acid Resistant CentriVap</b>																								
Chamber	Teflon coated Aluminum																							
Lid	Glass																							
Bearings	Stainless Steel				D	D	D																	
Lid Gasket	EPDM						D	D				D		D							C	C	D	
Rotor Shaft	Hastelloy																							
Valve	Teflon																							
O Rings	Viton (Fluorocarbon)							C					C	C		D						C		
Fittings	Polypropylene	D														C								
Rotor	Teflon coated Aluminum																							
Rotor Hub	Polypropylene	D																						
Tubing	PVC	D	C			D	D	D				D	D	D	D	C	D	D				D	D	
<b>Cold Trap -50°C</b>																								
Chamber	Stainless Steel				D	D	D																	
Lid	Acrylic						C	D	C			D	D	D	D	C	D		D	C	D		D	
Cold Trap Gasket	Neoprene		D		D	C	D	D				C	D	D	D		D					D	C	D
<b>Cold Trap -84°C &amp; -105°C</b>																								
Chamber	Stainless Steel				D	D	D																	
Lid	Stainless Steel				D	D	D																	
Cold Trap Gasket	Neoprene		D		D	C	D	D				C	D	D	D		D					D	C	D
C- Moderate Degradation- Questionable use																								
D- Severe Degradation- Infrequent use recommended- immediate thorough cleaning required																								

Acid Resistant models have a number of enhancements to minimize chemical attack on components. The lid is glass, the chamber and rotors are PTFE coated, the rotor shaft is Hastelloy, bearing are stainless steel and the coupling insert is polypropylene, and all wetted parts in the vacuum release valve are made from PTFE. Even though parts in the Acid Resistant models are considerably more resistant to corrosion, it is very important that the CentriVap is immediately cleaned and neutralized.

- If a rotary vane vacuum pump is used, frequent oil changes are required. Most compounds used in the CentriVap will degrade the oil if allowed to enter to pump.

- Diaphragm vacuum pumps sold by Labconco have wetted parts either made from PTFE or protected by PTFE coatings and are suitable for nearly all procedures.
- When using compounds in the CentriVap that are hostile to the materials of construction, it is imperative that the equipment is appropriately maintained. After each run, clean up all residues, spills and materials that might have splashed in the chamber.
- Drain the Cold Trap immediately after the collected ice is melted to prevent corrosive liquids from residing in the trap. Flush out the trap with water after draining.

DO NOT chip ice off the Cold Trap walls as damage may occur.

DO NOT start a rotary vane pump when the Cold Trap contains any liquid. The liquid will be drawn into the pump and will contaminate the vacuum pump oil.

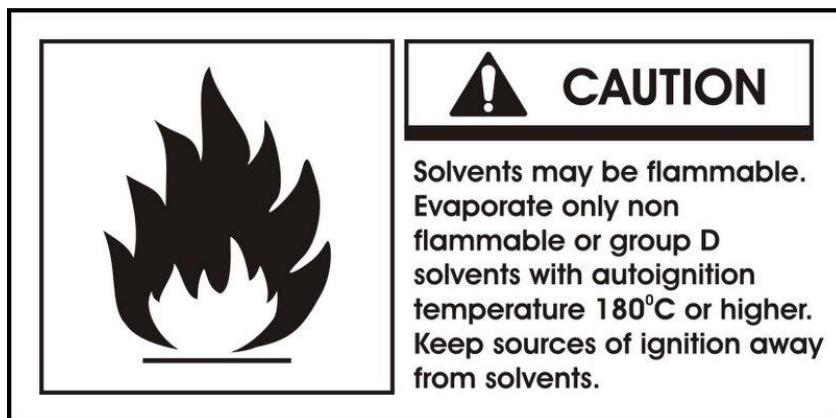
- If the compounds used attack acrylic, consider using the optional glass chamber lid. See Chapter 6: Accessories for Your CentriVap.
- If the compounds used attack stainless steel, consider using the optional Glass Trap insert in the Cold Trap. See Chapter 6: Accessories for Your CentriVap.
- When using a rotary vane vacuum pump the oil in the pump should be checked often. It must be changed if it is cloudy, shows particles or is discolored. The useful life of vacuum pump oil can be extended if the vacuum pump is operated for an extended period of time after the CentriVap run is over. This allows contaminants to be purged from the hot oil. This must be done with the inlet to the pump blocked off to prevent air from free flowing through the pump. Close the lid and press the RUN button. If the pump is operated at an elevated vacuum level, oil will be expelled from the pump and damage will occur.
- If optional secondary traps are used, monitor their condition often and replace them when they are saturated. A new acid trap is off-white and changes color to purple when used up. A new moisture trap is blue and changes color to pink when used up. The solvent trap molecular sieve does not change color when saturated so extra care must be taken to determine when a replacement cartridge should be installed.

## Solvent Safety Precautions

**CAUTION: The CentriVap is not classified as “explosion proof.” It has been designed with safety as a primary consideration and should be used in a prudent manner using “good laboratory practices.” It has been designed for use with compounds as described in the United States National Electrical Code Class I, Group D. The heater may be programmed to run as hot as 100°C, however, the heater element may normally run at 110°C. A thermal fuse limits the heater to a maximum temperature of 141°C. It is important**



that the solvents used are compatible with these temperatures. Do not evaporate solvents that have an autoignition temperature below 180°C. Do not evaporate solvents that are classified as Group A, B, or C by the National Electrical Code. Evaporate only non-flammable or Group D solvents with autoignition temperatures 180°C or above. Use of other compounds could cause an explosion.



**CAUTION:** Solvents used in the CentriVap may be flammable or hazardous. Use extreme caution and keep sources of ignition away from the solvents. When using flammable or hazardous solvents, both the CentriVap and the vacuum pump should be operated inside a fume hood.

If a sample is spilled in the chamber it must immediately be cleaned up. Hazardous materials, such as strong acids or bases, radioactive substances and volatile organics, must be handled carefully and promptly cleaned up if spilled.

Do not store flammable or hazardous solvents within 12 inches (300 mm) of the CentriVap.

**IMPORTANT NOTE:** The disposal of substances used in connection with this equipment may be governed by various Federal, State or local regulations. All users of this equipment are urged to become familiar with any regulations that apply in the user's area concerning the dumping of waste materials in or upon water, land or air and to comply with such regulations.

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# Chapter 4:

## Using Your CentriVap Refrigerated Concentrator

After your CentriVap has been installed as detailed in Chapter 3: Getting Started, you are ready to begin using your CentriVap. Read this chapter to learn how to:

- Set operating parameters.
- Operate the controls.
- Properly select and position glassware inside your CentriVap.
- Understand the display.
- Interrupt a cycle after it has begun.

**NOTE: See Appendix C: CentriVap Refrigerated Concentrator Specifications for electrical requirements.**

**NOTE: Do not store or stack supplies or equipment on top of the CentriVap.**

## Planning

Thoroughly understand procedures and the equipment operation prior to beginning work. The unique performance of the CentriVap is dependent upon the proper balance of heat, vacuum and centrifugal force. If the proper balance is not established, it is possible to damage or lose a portion of the sample. Therefore, if you are unfamiliar with the CentriVap or are attempting a new protocol, it may be helpful to make a trial run that is void of the sample you are attempting to concentrate.

## Glassware Selection

Normally, sample tubes should be filled no more than approximately half full. Select the size of the sample tube so it is compatible with the rotor and the desired sample size. Tubes should not be excessively loose in the rotor. Rotors are available with holes for various size tubes. Refer to Chapter 6: Accessories for Your CentriVap for available rotor sizes.

## Loading Glassware into the CentriVap

Smooth operation of the CentriVap is dependent upon proper balance of the machine. Therefore, if less than a full load of samples is run, it is important to load samples into the CentriVap in a fairly symmetrical manner distributing the weight of the samples evenly in the sample rotor.

## Temperature Setting Guidelines

The evaporation rate achieved by the CentriVap is dependent upon a variety of factors. These include the nature of the solvent, the temperature and the pressure in the vacuum system.

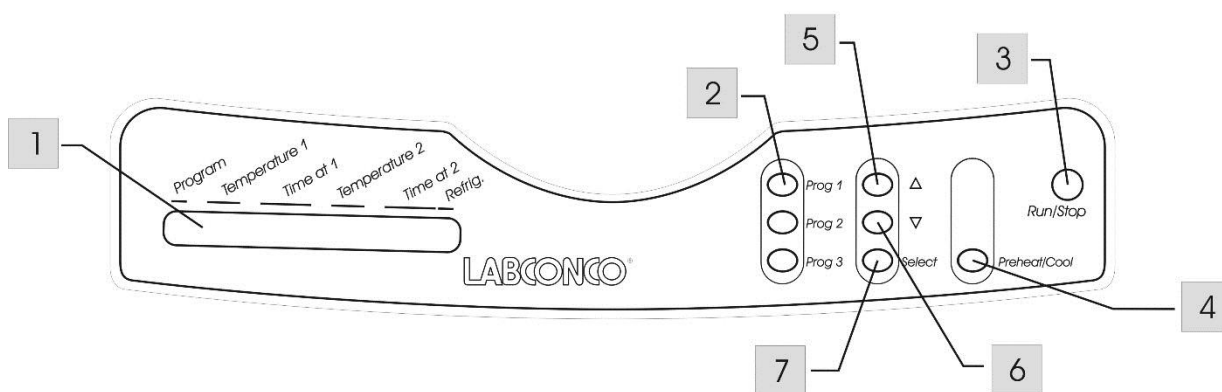
As a general guideline, to speed the evaporation process, the CentriVap temperature should be set as high as possible as long as the temperature will not damage the sample or cause the sample to bump.

## Time Setting Guidelines

The Refrigerated CentriVap allows two different temperatures to be programmed for user specified periods of time. If sequential temperatures are not desired, set Time at 2 to “0”. When both programmed times expire, the rotor will stop, the heater and refrigeration systems shut off, the vacuum pump stops and vacuum is purged from the chamber. An alarm sounds until any control button is pressed.

## CentriVap Controls

The control panel for the CentriVap is shown below with a description about its function.



1. Display – The liquid crystal display (LCD) shows set point parameters and actual measured conditions.
2. Program Buttons – Used to initiate the start of a run with the use of just one button.
3. Run/Stop Button – Press this to start or stop a run.
4. Preheat/Cool Button – Used to turn on the heater or refrigeration system to heat or cool the chamber prior to loading samples.
5. Increase Button – When pressed, the last selected set point will increase.
6. Decrease Button – When pressed, the last selected set point will decrease.
7. Set Point Select Button – To select a parameter to change, press the select button. Arrows on the display will point to the parameter that may be altered.

## Operating the CentriVap Controls

### Preheat/Cool:

To preheat or precool the chamber, press the “PREHEAT/COOL” button. The display will show:

SP:   XXX   ACT:   XXX

Press the increase or decrease button until the desired set point (SP) is displayed. The actual chamber temperature, (ACT) is displayed to the right. When power is being supplied to the heaters, a bar under the actual temperature will illuminate. The chamber will continue to maintain the set point temperature until either the “PREHEAT/COOL” button is pressed again or the “RUN” button is pressed.

### Select existing program:

Operating parameters can be stored in memory so protocols can be repeated. Nine programs can be stored. To select a program, press the set point “SELECT” button until arrows point to the program number indicating that this set point can be run or altered. To change the program number, press the increase or decrease button until the desired program number is displayed. When the program number is changed, all its set points change also to indicate the last entered parameters for that program.

Store frequently run protocols in program 1, 2, or 3. Then, by pressing “PROG 1,” “PROG 2” or “PROG 3,” the stored program will be initiated without having to press any other button. Pressing just the one button starts the rotor, the heater, refrigeration system, the timers and the vacuum pump.

### Change “Temperature” Set Points:

To change the “Temperature” set point, press the set point “SELECT” button until arrows point to the “Temperature” set point, which can be changed from -4°C up to 99°C by pressing the increase or decrease buttons. The set point is 100°C if the display shows “HI.” The last entered set point is stored in memory.

### **Change “Run Time” set points:**

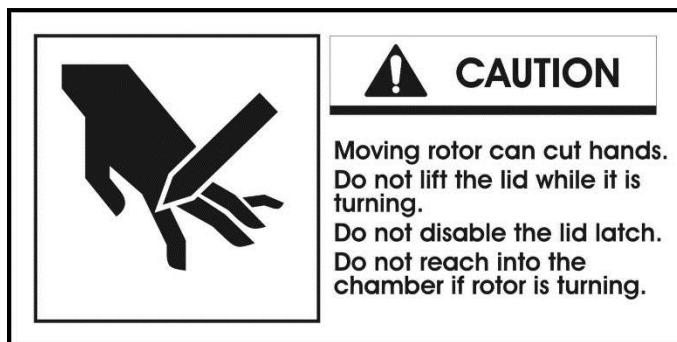
To change the time set points, press the set point “SELECT” button until arrows point to the “Time at 1” or “Time at 2” set point which can be changed from 1 to 999 minutes by pressing the increase or decrease buttons. If it is desired to have the CentriVap run continuously without alarming at the end of a time period, press the increase button until the “Time” display says “ON.” The last entered set point is stored in memory.

If during a run the “STOP” button is pressed, the timers remember the time at which stop occurred. If “RUN” is then pressed, the timers continue to count down from the time at which they were stopped. If running program 1, program 2 or program 3, pressing “PROG 1,” “PROG 2” or “PROG 3” resets the timers to the original set point time and the CentriVap starts a new run.

To reset the timers to the original set point time when running programs other than program 1, program 2 or program 3, press the start button and hold it for five seconds. The display will indicate that the timer is reset.

## **Operating the CentriVap**

**CAUTION: To avoid injury; Do not operate the CentriVap if the lid is scratched, nicked or shows signs of damage. A damaged lid could fail under vacuum.**



**While the CentriVap Concentrator is operating, do not lean on the lid, do not stand near it longer than necessary and do not place hazardous materials within 12 inches.**

1. Press the Cold Trap “ON” switch. The top amber indicator will illuminate. Additional indicators will illuminate, as the Cold Trap gets colder. A green indicator will illuminate when the Cold Trap reaches operating temperature.
2. Press the CentriVap “ON” switch.
3. Select a program or set the set point parameters.
4. Preheat/precool the chamber if desired.
5. Place samples in vials. Normally the vials should be no more than half full. Place vials in a rotor.

6. Load the rotor with samples into the chamber.
7. Close the lid. A safety switch prevents the CentriVap from starting when the lid is open.
8. Press “RUN.” If the display was showing set point parameters, it will change to show actual parameters. Press “RUN” again. The “S” (STOP) in the display changes to “R” (RUN). The program on the display alternately displays “R” or the number of the program that is running. If you intend to run program 1, 2 or 3, simply press “PROG 1,” “PROG 2” or “PROG 3” to start the CentriVap. A latch will activate to lock the lid closed, the rotor will start, the vacuum break valve will close and the vacuum pump will start after the rotor reaches operating speed.
9. Set point parameters can be altered at any time during a run by first selecting the parameter using the set point “SELECT” button and then pressing the “INCREASE” or “DECREASE” switch.
10. If the time set point is used, at the end of the set time an alarm sounds. All functions cease.
11. Press “STOP” to terminate operation if the CentriVap has not already stopped itself.
12. When the evaporation is complete, allow the rotor to stop moving, lift the lid and remove the samples.

### **Operational Note**

When the CentriVap power switch is turned ON, the CentriVap returns to the same mode (“RUN” or “STOP”) that it was in when the power switch was turned OFF. If the CentriVap was in the “RUN” mode when the power switch was turned OFF, when the power switch is turned ON, the CentriVap attempts to return to the programmed set points and continue the run.

### **Cycle Interruption**

At any time during a run, the cycle may be stopped by pressing the “STOP” button. This shuts off all operating functions. After the rotor stops, the lid may be opened. If it is necessary to re-start the CentriVap, close the lid and press “RUN.” The CentriVap resumes operation at the same set point parameters and the timer continues to count down from the time at which the CentriVap was stopped.

## Safety Precautions

Special precautions must be observed if the materials used in the CentriVap Concentrator are known to be hazardous, toxic, radioactive, or contaminated with pathogenic micro organisms. These actions should include but are not limited to the following:

- Refer to the World Health Organization Laboratory Biosafety Manual, paying special attention to information about centrifuges and the handling of hazardous materials.
- Operate or vent the CentriVap Concentrator inside a suitable fume hood or ventilation device. Load rotors in a ventilation device.
- Periodically inspect all parts of the CentriVap Concentrator including the lid, gasket, chamber, plumbing components and rotors.

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## Chapter 5:

# Maintaining Your CentriVap Refrigerated Concentrator

Under normal operation, the CentriVap requires little maintenance. The following maintenance schedule is recommended. Before servicing the CentriVap Refrigerated Concentrator, disconnect electrical power. Special precautions must be observed if materials used in the CentriVap Concentrator are known to be hazardous, toxic, radioactive or contaminated with pathogenic micro organisms. Before servicing, the CentriVap Concentrator must be suitably decontaminated. Wear appropriate eyewear, gloves and other safety apparel.

### As needed:

Before using any cleaning or decontamination method except those recommended by the manufacturer, users should check with the manufacturer that the proposed method will not damage equipment.

1. Clean up all spills; remove liquids from the chamber. Clean or decontaminate all surfaces using agents suitable for the substance spilled.
2. Clean lid and gasket using soft cloth, sponge or chamois and a mild, non-abrasive soap or detergent.
3. Check oil level of the vacuum pump, if applicable. It should be between MIN and MAX. If the oil level is less than an inch (25.4 mm) above MIN, add oil to proper level.
4. If oil shows cloudiness, particles or discoloration, drain the pump and replace with fresh oil.
5. Utilization of acids requires immediate cleaning and neutralization after a run or physical damage to the collection chamber will result.
6. Check the Cold Trap for condensed or frozen solvents and dispose of appropriately. Completely empty the trap before the next run. The Cold Trap cover is removed by first lifting and rotating the two retainers that secure the lid in place. If solvents are frozen in the glass trap, run it under cold water immediately after operating.

**NOTE: IF THE ICE HAS MELTED, THE GLASS TRAP INSERT MUST BE EMPTIED BEFORE THE COLD TRAP IS STARTED AGAIN.**



7. If the Glass Trap is used, check to see that the ethanol in the stainless steel trap is free of ice or water. Drain the ethanol and replace it with fresh ethanol.
8. If the media in the cartridge in the optional clear canister has changed color, discard and replace the insert with a new insert. For the radiochemical trap insert, no indicator exists; therefore, it should be discarded after each use. In radioactive applications, the system should be monitored with a Geiger counter.
9. Check rotors for loose or missing parts. Tighten or replace as required. Do not use defective rotors.
10. Inspect the chamber to insure that there are no cracks or structural damage. Call Labconco if defects exist.
11. Check continuity of the protective earth between the ground terminal on the power inlet and a bare metal housing panel. Contact Labconco if there is no continuity.
12. Repair any defects to the surface where the CentriVap is installed.

### **Monthly:**

1. The rubber components on the CentriVap may eventually deteriorate and require replacement. The effective life of rubber parts depends upon both their usage and the surrounding environment. Check all hoses and gaskets and replace any that show signs of hardening, permanent set or deterioration.
2. Using a soft cloth, sponge or chamois and a mild, non-abrasive soap or detergent, clean the glass lid.
3. Using a soft cloth, sponge, or chamois and a mild, non-abrasive soap or detergent, clean the exterior surfaces of the unit. Liquid spray cleaners and polishes may be used on the exterior surfaces. Do not use solvents to remove stains from the exterior surfaces as they may damage the finish.

### **Annually:**

1. Every 12 months, or more often, if the Refrigerated CentriVap or Cold Trap is operated in a dusty environment, the refrigeration system condenser should be cleaned. Using a vacuum cleaner with brush attachment, clean the condenser to ensure proper airflow for peak performance. Disconnect power before removing covers.

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## **Chapter 6:**

# **Accessories for Your CentriVap**

The configuration of your CentriVap can be changed to accommodate your needs. If the solvents used in the CentriVap degrade the acrylic lid, it may be replaced with an optional glass lid to gain added chemical resistance. To observe the samples while they are processing, an optional CentriZap Strobe light may be installed. Read this chapter to learn how to:

- Install a glass lid
- Install a vacuum gauge.
- Install a CentriZap™ strobe light.

The following accessories are available for the CentriVap Concentrator and Cold Trap System.

PART #	DESCRIPTION
7462900 7462901*	Rotor (DNA) Holds (72) 0.5 ml microcentrifuge tubes and (60) 1.5 ml microcentrifuge tubes or (60) 2.0 ml microcentrifuge tubes
7450700 7450701*	Rotor (1.5 ml) Holds (132) 1.5 ml microcentrifuge tubes or (132) 2.0 ml microcentrifuge tubes
7455000 7455001*	Rotor (15 ml) Holds (44) 12 x 55 mm tubes or (36) 12 x 75 mm tubes or (36) 12 x 95 mm tubes or (36) 13 x 75 mm tubes or (36) 13 x 100 mm tubes and (24) 16 x 100 mm tubes or (18) 16 x 120 mm conical tubes or (18) 17 x 95 mm tubes or (18) 17 x 100 mm centrifuge tubes or (18) 17 x 120 mm tubes
7455100 7455101*	Rotor (12-13 mm) Holds (40) 1.5 ml microcentrifuge tubes or (40) 2.0 ml microcentrifuge tubes and (16) 12 x 55 mm tubes or (100) 12 x 75 mm tubes or (64) 12 x 95 mm tubes or (100) 13 x 75 mm tubes or (64) 13 x 100 mm tubes
7455200 7455201*	Rotor (50 ml) Holds (32) 1.5 ml microcentrifuge tubes or (32) 2.0 ml microcentrifuge tubes and (12) 28 x 115 mm conical tubes or (12) 28 x 135 mm conical tubes or (12) 28 x 140 mm conical tubes
7461900 7461901*	Rotor (96 well plate) Holds (4) Standard 96 well plates or (2) Deep well 96 well plates
7460900	Clear Canister – Accommodater inserts listed below: 7814800 Acid Trap Insert 7814900 Moisture Trap Insert 7815000 Radiochemical Trap Insert 7815200 Solvent Trap Insert 7995600 Ammonia Trap Insert
7397605	Glass Trap for Cold Trap

\*PTFE Coated

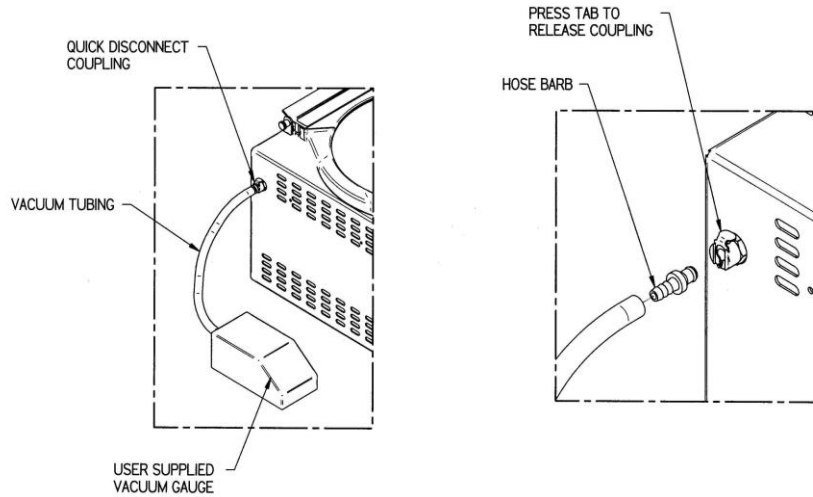
1467700	Vacuum Pump – 195 liters/minute capacity with gas ballast. Ultimate pressure $1.3 \times 10^{-4}$ mBar. 115 VAC, 60 Hz, single phase, 7.8 amp.
1472100	Vacuum Pump – 117 liters/minute pumping capacity with gas ballast. Ultimate pressure $1.3 \times 10^{-4}$ mBar. 115 VAC, 60 Hz, single phase, 4.6 amp.
7739402	Vacuum Pump – 117 liters/minute. Same as 1472100 except 220/208-230 VAC, 50/60 Hz, single phase, 2.4 amp operation.
7739403	Vacuum Pump – 195 liters/minute. Same as 1467700 except 220/208-230 VAC, 50/60 Hz, single phase, 4.0 amp operation.
1473400	Pump Exhaust Filter – Disposable filter that removes visible oil mist and odor from vacuum pump exhaust. Fits vacuum pumps 1467700, 1472100, 7739402 and 7739403
1473200	Replacement Element, Oil Mist, Pump Exhaust Filter – Fits pump exhaust filter 1473400.
1473300	Replacement Element, Odor, Pump Exhaust Filter, package of 5 – Fits pump exhaust filter 1473400 or vacuum pumps 1472100, 1467700, 7739402 and 7739403.
1988000	Vacuum Pump Oil, 1 Liter – A molecularly distilled hydrocarbon oil low vapor pressure. For vacuum pumps 1467700, 1472100, 7739402 and 7739403.
7393000	Vacuum Pump – 75 liters/minute @ 50Hz, 82 liters/minute @ 60Hz Ultimate pressure < 2 mBar, 115V, 50/60 Hz, 3.5 Amp
7393001	Vacuum Pump – 75 liters/minute @ 50Hz, 82 liters/minute @ 60Hz Ultimate pressure < 2 mBar, 230V, 50/60 Hz, 2.0 Amp
7539902	Vacuum Pump – 200 liters/minute @ 60Hz, 183 liters/minute @ 50Hz Ultimate vacuum < $1 \times 10^{-3}$ mBar, 230V, 50/60 Hz
7584000	Vacuum Pump – 110 liters/minute @ 60Hz, 96 liters/minute @ 50Hz Ultimate vacuum < $2 \times 10^{-3}$ mBar, 115V, 50/60 Hz
7584002	Vacuum Pump – 110 liters/minute @ 60Hz, 96 liters/minute @ 50Hz Ultimate vacuum < $2 \times 10^{-3}$ mBar, 230V, 50/60 Hz
7456600	Glass Lid for Concentrator – Direct replacement for standard equipment acrylic lid. For use with chemicals that could craze acrylic.
7464300	CentriZap™ Strobe Light – For observing samples while the rotor is spinning.

## Installing a Glass Lid

Turn off the CentriVap. Pull outward on the hinge pin knob. Lift and remove the old lid. To install the new lid, reverse the process.

## Installing a Vacuum Gauge

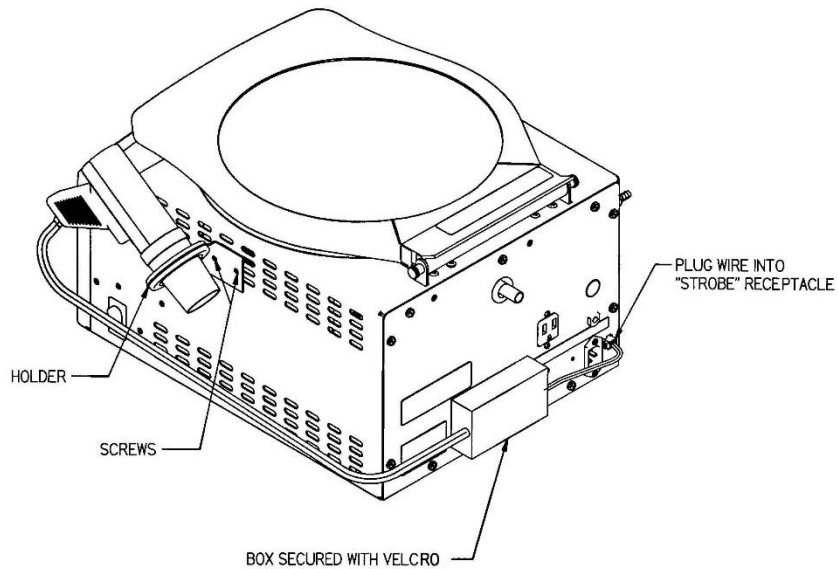
A user-supplied vacuum gauge may be attached to the CentriVap to monitor the vacuum level. Attach the vacuum gauge to the barb end of the Quick Disconnect Coupling fitting that was supplied with the CentriVap using a length of suitable rubber hose. The Quick Disconnect Coupling fitting can then be pushed into the mating connector on the left side of the CentriVap located towards the rear. The Quick Disconnect Coupling fitting can be removed from the mating connector by pressing on the tab on the connector and then pulling out the insert fitting. Always remove the Quick Disconnect Coupling from the CentriVap when a vacuum gauge is not attached to it.



## Installing a CentriZap™ Strobe Light

An accessory strobe light is available to enable you to see the samples as they are rotating in the rotor. Attach the holder to the right hand side of the CentriVap Concentrator using the screws provided. Plug the connector on the strobe light harness into the receptacle on the back of the CentriVap marked “STROBE OUTLET.” Peel the protective backing off the enclosed Velcro® and attach it to the back of the Concentrator. Secure the power supply box on the harness to the Velcro. Place the light in the holder.

To use the strobe light while the CentriVap is operating, remove the light from its holder, press the trigger and shine the light on the samples in the rotor.



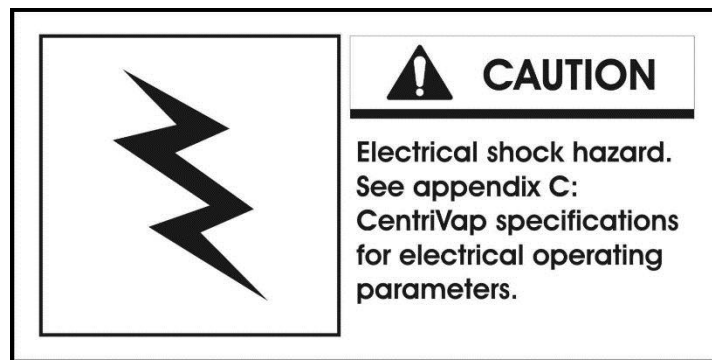
\*Velcro is a registered trademark of Velcro Industries B.V.

# Chapter 7:

## Troubleshooting

Refer to the following if your CentriVap fails to operate properly. If the suggested corrective actions do not solve your problem, contact Labconco for additional assistance. The following failure codes may appear on the display when problems are sensed by the internal self check system.

**CAUTION: Disconnect power before servicing the CentriVap.**



DISPLAY ERROR CODE	CAUSE	CORRECTIVE ACTION
Heat Sensor	Sensor failure	Replace sensor assembly.
	Connection failure	Repair connection.
Close Lid	Lid open	Close lid.
Latch Fail	Solenoid failure	Check component.
	Switch or sensor failure	Check connections.
Mem Fail P1	Memory failure	Push program button #1.
	New memory IC chip	Push program button #1.
	Bad memory IC chip	Call Labconco – Replace IC chip or control PCB.
MOTOR ERROR	Defective motor	Replace motor.
	Hall effect sensor failure	Replace sensor.
	Wire failure	Replace wire.



## Chapter 7: Troubleshooting

Other corrective actions for potential problems are as follows:

PROBLEM	CAUSE	CORRECTIVE ACTION
Unit will not operate	Unit not connected to electrical power	Connect unit to proper electrical receptacle.
	Circuit breaker blown	Correct electrical problem and reset circuit breaker by pressing button.
	Lid open	Close lid.
Excessive vibration	Sample tubes not located symmetrically in rotor	Reposition sample tubes.
Sample odor in lab	Vent hose exhausting into lab area	Redirect hose to fume hood.
Evaporation rate is reduced	Heater inoperable	Contact Labconco.
	Vacuum pump failure	Check pump.
	Obstruction in hose	Remove obstruction or replace hose.
	Lack of adequate vacuum	See below.
No vacuum/poor vacuum	Pump not on	Turn on pump.
	Control valve open	Check control valve.
	Leaks in lines or connectors or gasket	Locate and repair.
	Foreign material on lid gasket	Clean gasket and lid.
	Pump is not functioning properly	Check pump by locating vacuum gauge closer to pump and close off rest of system. Check pump oil for cloudiness or particles and change.  If pump is faulty, seek authorized service or replace pump.
	Cold Trap or Concentrator gasket is not sealing properly	Check gasket for cleanliness. Adjust gasket as needed.
	Cold Trap lid not seated	Hold lid down until vacuum is initiated.
	Ice formed on Cold Trap lid sealing surface	Defrost and wipe dry.
	Secondary Trap Canister not fitted properly	Tighten all connections to and from the Secondary Trap Canister.
	Secondary Trap Insert is spent	Replace with new insert.
	New Secondary Trap has moisture in it	Run vacuum pump for 24 hours to remove moisture.



PROBLEM	CAUSE	CORRECTIVE ACTION
Frequent oil change needed in pump	Secondary Trap insert is spent	Change insert often.
	Cold Trap is not emptied after each run and dried	Empty the traps (glass or stainless steel) after each run and replace.
	Vacuum too strong for chemical	Use a Secondary Trap insert and diaphragm pump.
Unit starts and shuts off	Latch optical sensor improperly calibrated	Unplug power cord. Wait 10 seconds. Plug in power cord.

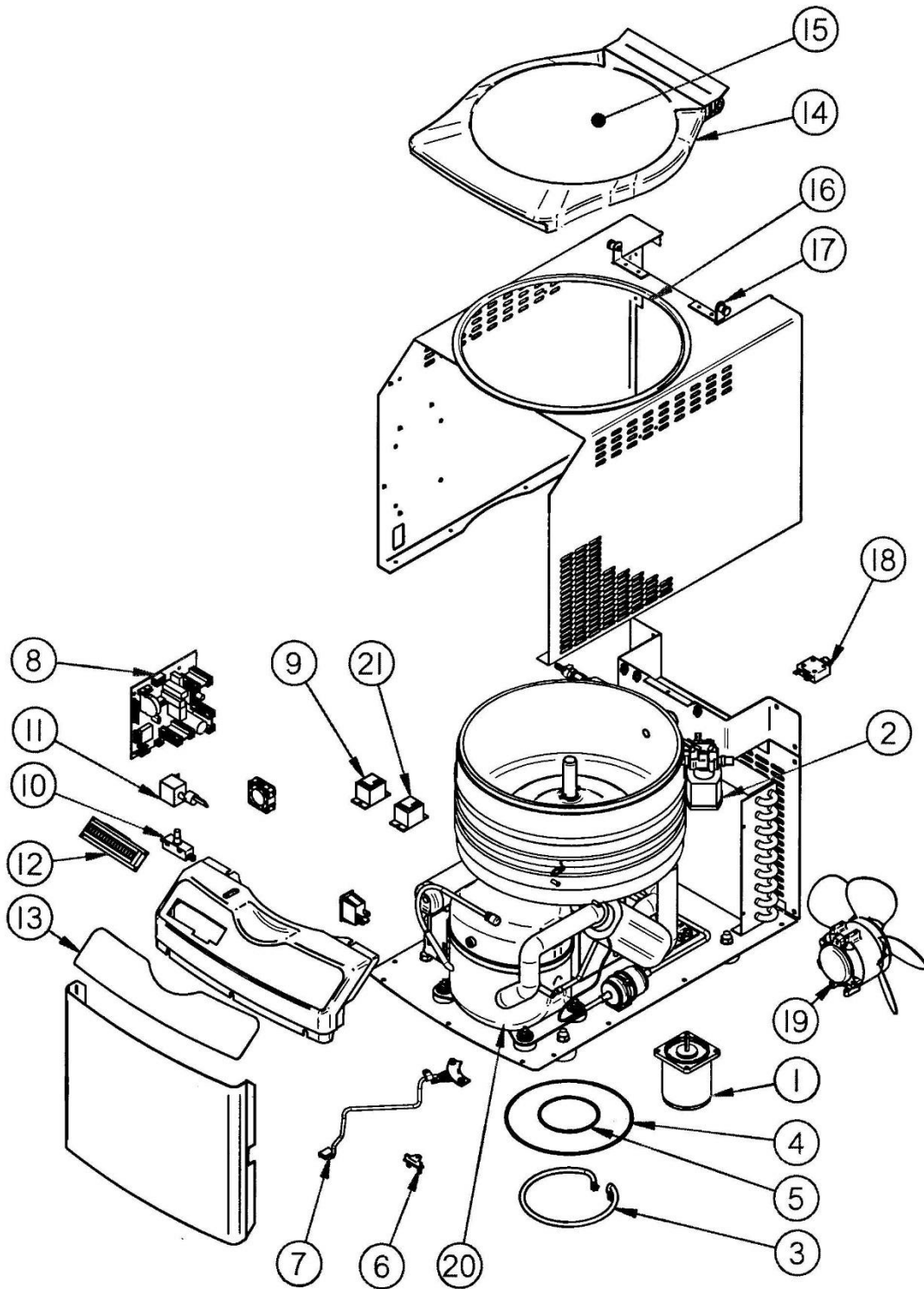
# Appendix A:

## CentriVap Refrigerated Concentrator Components

The following pages list components that are available for your CentriVap. The parts shown are the most common replacement parts. If other parts are required, contact Product Service.

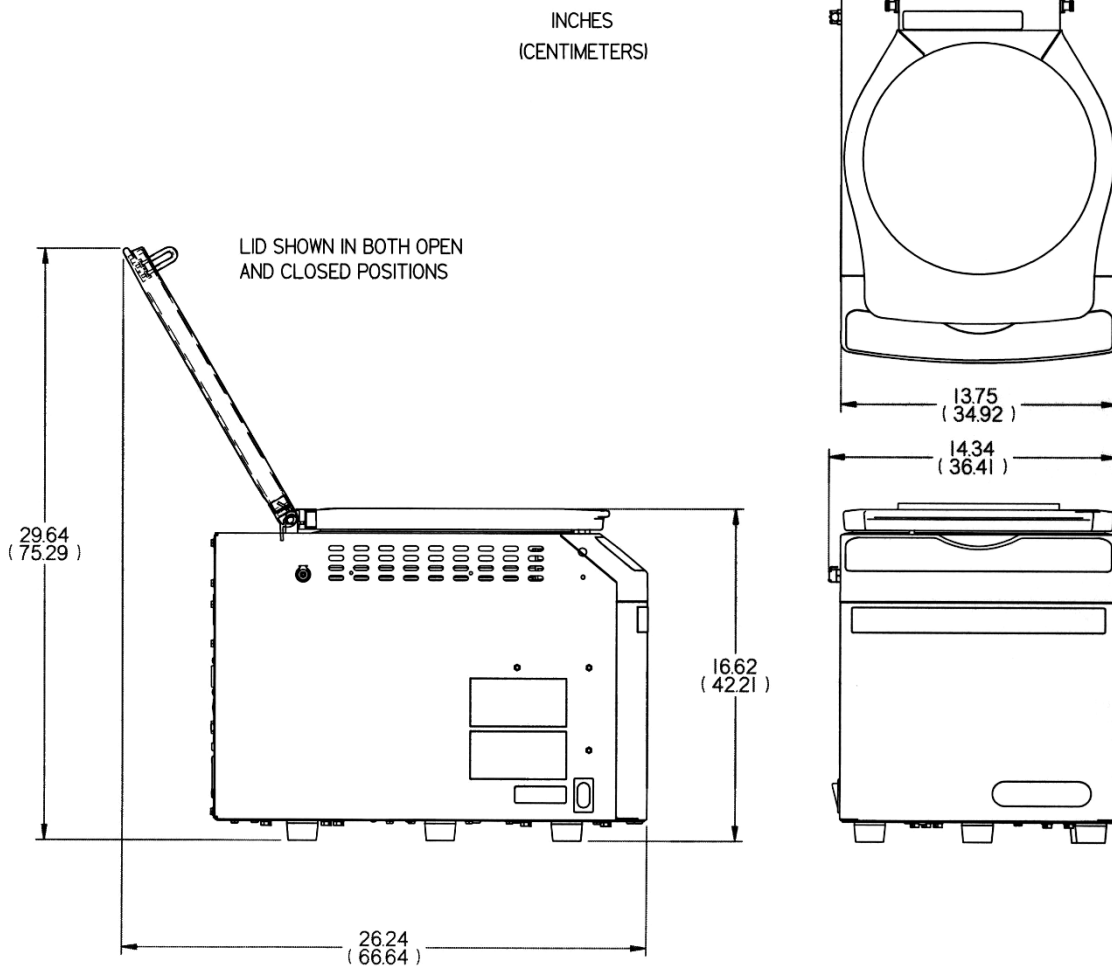
Item	Quantity	Part No.	Description
1	1	7310601	Motor w/Capacitor
2	1	7546700	Valve, Vacuum Break (115V)
2A	1	7446701	Valve, Vacuum Break (230V)
2B	1	7396308	Valve, Vacuum Break Acid Resistant
3	1	7453500	Heater (115V)
3A	1	7453501	Heater (230V)
4	1	1647106	O-Ring, Outer
5	1	1647105	O-Ring, Inner
6	1	7975902	Fuse, High Temp Limiter
7	1	7456000	Harness, Temp & Speed Sensor
8	1	7441002	Printed Circuit Board
9	1	1289200	Relay Vacuum Pump (115V)
9A	1	1289100	Relay Vacuum Pump (230V)
10	1	7826000	Switch, Latch
11	1	7478700	Solenoid, Latch
12	1	7403701	Display
13	1	7310602	Label/Switch Pad
14	1	7452600	Gasket, Lid
15	1	7456600	Lid, Glass
15A	1	7452500	Lid, Acrylic
16	42.2 inch	7451700	Extrusion
17	2	7452200	Hinge, Bracket Assembly
18	1	1289320	Circuit Breaker (115V)
18A	2	1289310	Circuit Breaker (230V)
19	1	7953800	Motor Fan 115V
19A	1	7953801	Motor Fan 230V
20	1	7437700	Compressor 115V 60Hz
20A	1	7437701	Compressor 230V 50Hz
20B	1	7437702	Compressor 230V 60Hz
21	1	1289200	Relay Refrigeration 115V and 230V
Not Shown	1	1336400	Power Cord (115V) – US
Not Shown	1	1332700	Power Cord (230V) – China
Not Shown	1	1332600	Power Cord (230V) –UK
Not Shown	1	1338000	Power Cord (230V) – US
Not Shown	1	1336100	Power Cord (230V) – EU





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# Appendix B: CentriVap Refrigerated Concentrator Dimensions



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# Appendix C:

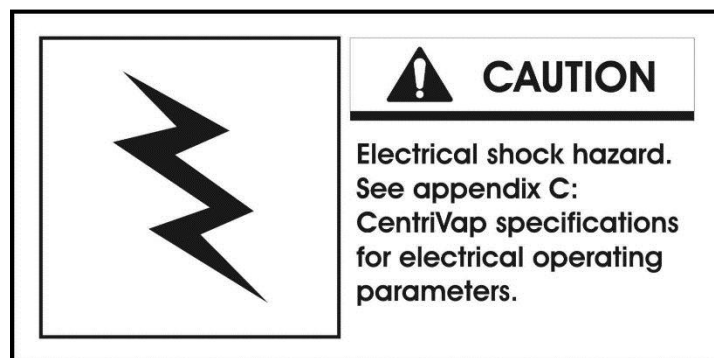
## CentriVap Refrigerated Concentrator Specifications

This Appendix contains technical information about the CentriVap including specifications, environmental operating conditions, and evaporation rates.

### Electrical Specifications

- Nominal amperage for 115V CentriVap Concentrator (model 7310020 series) (excluding vacuum pump): 3.1 amps (with vacuum pump) 12.00A max.
- Nominal amperage for 230V CentriVap Concentrator (model 7310030 & 7310040 series) (excluding vacuum pump): 1.6 amps (with vacuum pump) 6.0 amps max.
- Heater Power: 300 watts
- Phase: Single
- Rotor Speed: Up to 1,725 RPM

**CAUTION: Do not use the CentriVap in a manner not specified by the manufacturer. The electrical protection properties of the CentriVap may be impaired if the CentriVap is used inappropriately.**



## Environmental Conditions

- Indoor use only.
- Maximum altitude: 6562 feet (2000 meters).
- Ambient temperature range: 41° to 104°F (5° to 40°C).
- Maximum relative humidity: 80% for temperatures up to 88°F (31°C), decreasing linearly to 50% relative humidity at 104°F (40°C).
- Main supply voltage fluctuations not to exceed  $\pm 10\%$  of the nominal voltage.
- Transient overvoltages according to Installation Categories II (Overvoltage Categories per IEC 1010). Temporary voltage spikes on the AC input line that may be as high as 1500V for 115V models and 2500V for 230V models are allowed.
- Used in an environment of Pollution degrees 2 (i.e., where normally only non-conductive atmospheres are present). Occasionally, however, a temporary conductivity caused by condensation must be expected, in accordance with IEC 664.

# Evaporation Rates

Tube Size (ml)	Number of Samples	Sample Size (ml)	Heater Temp (C)	Vacuum Pump	Time to Dry (min)	Cold Trap	Rate Overall (ml/min)
<b>Methylene Chloride</b>		<b>bp 40</b>					
50	12	25	45	Diaphragm	80	no	3.75
15	18	10	45	Diaphragm	45	no	4.00
<b>Toluene</b>		<b>bp 111</b>					
50	12	25	45	Diaphragm	204	no	1.47
50	12	25	100	Diaphragm	96	no	3.13
15	18	10	45	Diaphragm	119	no	1.51
15	18	10	100	Diaphragm	42	no	4.29
<b>Acetonitrile</b>		<b>bp 82</b>					
50	12	25	45	Diaphragm	184	no	1.63
50	12	25	100	Diaphragm	81	no	3.70
15	18	10	45	Diaphragm	106	no	1.70
15	18	10	100	Diaphragm	52	no	3.46
1.5	132	1	45	Diaphragm	55	no	2.40
1.5	90	1	45	Diaphragm	47	no	1.92
1.5	132	1	60	Diaphragm	37	no	3.57
1.5	132	1	75	Diaphragm	33	no	5.74
1.5	132	1	100	Diaphragm	21	no	6.29
<b>Methanol</b>		<b>bp 65</b>					
50	12	25	45	Diaphragm	233	no	1.29
15	18	10	45	Diaphragm	141	no	1.28
1.5	132	1	35	Diaphragm	88	no	1.50
1.5	132	1	45	Diaphragm	64	no	2.06
1.5	132	1	60	Diaphragm	50	no	2.64
1.5	90	1	75	Diaphragm	38	no	2.37
1.5	132	1	75	Diaphragm	39	no	3.38
1.5	132	1	100	Diaphragm	25	no	5.28
<b>Water</b>		<b>bp 100</b>					
50	12	25	45	Diaphragm	1397	no	0.21
50	12	25	100	Diaphragm	445	no	0.67
15	18	10	45	Diaphragm	841	no	0.19
1.5	132	1	45	Diaphragm	427	no	0.30
1.5	132	1	60	Diaphragm	303	no	0.44
1.5	132	1	75	Diaphragm	196	no	0.67
1.5	132	1	100	Diaphragm	117	no	1.13
50	12	25	45	Rotary vane	1002	yes	0.30
50	12	25	100	Rotary vane	424	yes	0.70
15	18	10	45	Rotary vane	565	yes	0.32
15	18	10	60	Rotary vane	456	yes	0.39
1.5	132	1	45	Rotary vane	299	yes	0.44
1.5	132	1	75	Rotary vane	207	yes	0.64
1.5	132	1	100	Rotary vane	131	yes	1.01
1.5	132	1	25	Rotary vane	627	yes	0.21
1.5	132	1	15	Rotary vane	794	yes	0.17
1.5	132	1	5	Rotary vane	1160	yes	0.11
1.5	132	1	-4	Rotary vane	1485	yes	0.09
<b>Ethanol</b>							
1.5	132	1	100	Rotary vane	34	yes	3.88
1.5	132	1	75	Rotary vane	45	yes	2.93
1.5	132	1	60	Rotary vane	55	yes	2.40
1.5	132	1	45	Rotary vane	70	yes	1.89
1.5	132	1	25	Rotary vane	95	yes	1.39
1.5	132	1	15	Rotary vane	120	yes	1.10
1.5	132	1	5	Rotary vane	160	yes	0.83
1.5	132	1	-4	Rotary vane	190	yes	0.70

Vacuum Pumps:

Chamber preheated prior to each run to run temp.

Diaphragm – Rated at 12 mbar ultimate vacuum and 34 L/min displacement

Rotary vane – Rated at  $2.0 \times 10^{-3}$  mbar ultimate vacuum and 195 L/min displacement