



## LC-Auto Switch Version 3.4

### Installation, Operation, and Maintenance Instructions

P/N 7000009 – 2 Valves

P/N 7000010 – 3 Valves

P/N 7000011 – 4 Valves

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## 1.0 Acronyms

DHCP	Dynamic Host Configuration Protocol
GUI	Graphical User Interface
IP	Internet Protocol
ISP	Internet Service Provider
IT	Information Technology
LAN	Local Area Network
LCAS	Liquid Cylinder Auto-Switch
LN <sub>2</sub>	Liquid Nitrogen
PC	Personal Computer
SMS	Short Message Service (a text message)

## 2.0 Introduction

### 2.1 General

The LCAS is an automated LN<sub>2</sub> supply tank switching system. When a cylinder (LN<sub>2</sub> supply tank or Dewar) is depleted, the controller closes the valve to that empty cylinder's supply line and opens a valve to the next connected cylinder. This ensures a constant supply of LN<sub>2</sub> to a freezer while requiring no attendant to manually switch from the empty cylinder to a full one (unless, of course, all connected cylinders are empty). This system was developed primarily to supply LN<sub>2</sub> storage freezers, but can be used to supply any device that uses LN<sub>2</sub> at pressures under 35 psi at a rate similar to LN<sub>2</sub> freezers.

### 2.2 System Description

The system is composed of four parts: the control panel, the plumbing manifold, the supply lines, and the feed line.

- The control panel houses the controller, indicator lights, audio alarm, and power supply.
- The plumbing assembly contains piping, check valves, solenoid valves, and relief valves.
- The supply lines are the input hoses from the cylinders to the plumbing manifold.
- The feed line is the output hose from the plumbing manifold to the freezer(s).

The LCAS operates by measuring the downstream pressure and temperature in the feed line to determine if a cylinder is feeding or empty. A cylinder is determined empty if the temperature is warmer than its setpoint *and* the pressure is lower than its setpoint. Note

that both input conditions must be true for the switch to activate. When the active cylinder becomes empty, that cylinder's valve closes and the valve to the next non-empty cylinder in the supply queue opens. The empty cylinder is then stored in memory with an *empty* flag and displayed on the screen and by a flashing indicator light.



If the next cylinder in the supply queue has already been flagged empty, then that cylinder will be skipped. The controller then waits a timed delay (factory preset at two minutes, adjustable) for the new cylinder to supply the feed line. If, after the time delay, both pressure and temperature setpoints still evaluate to the empty condition, then the controller switches over to the next non-empty cylinder in the queue and again waits the timed delay. The process repeats until all connected cylinders are flagged as empty.

The controller is programmed to manage two to four valves/cylinders in the supply queue, although the most common system contains three valves. Each solenoid valve is normally closed, so turning the controller off or disconnecting the power will effectively cut-off all LN<sub>2</sub> supply to the feed line.

### 2.3 Control Panel



Indicator lights are located on the control panel underneath the controller screen. There is one indicator light for each solenoid valve (or intended cylinder) numbered from left to right 1, 2, 3, and 4. An audio alarm is located on the right side of the controller and has the option of sounding when all three cylinders are empty.

- When a cylinder is feeding, its indicator light turns on.
- When a cylinder is empty, its indicator light blinks.
- When a cylinder is full and not feeding, its indicator light is off.
- When all cylinders are empty, all three indicator lights blink and the audio alarm sounds (although the audio alarm can be deactivated).
- An Ethernet port is provided on the bottom of the control panel to send alerts over the internet.

### 3.0 Installation and Setup

#### 3.1 Power Connection

The system comes with a 6 ft standard domestic US power cord (NEMA 5-15P plug). The input power requirements are 110-120VAC, 60HZ, 2.0A. A 5A breaker is located inside the control panel, 1.5A fuses protect the controller and solenoid valves, and an On/Off selector switch is mounted on the front of the control panel.

#### 3.2 Weight

The following table lists the weights for two, three, and four valve systems. Weights are without supply and feed hoses attached.

Part Number	Valve Number	Weight	
		(lbs)	(kg)
7000009	2	60	27
7000010	3	85	39
7000011	4	110	50

#### 3.3 Mounting

The LCAS assembly shall be mounted and secured to studs in the wall or steel supports supplied by the user. Four 5/16" holes are located on the mounting plate to be used for securing the frame to a vertical structure.

#### 3.4 Location

To mitigate asphyxiation hazards in the event of an LN<sub>2</sub> leakage, locate the LCAS and LN<sub>2</sub> cylinders in an area that provides ample ventilation of nitrogen gas.

### 3.5 Liquid Cylinder Connection

The plumbing manifold connects the cylinders, solenoid valves, and the feed line to the freezer(s). Each port on the manifold uses a standard LN<sub>2</sub> transfer hose connections (1/2" [1.3cm] ODT 37° JIC Flare). When connecting hoses to the ports, apply just enough torque to prevent pressure leak. All connections should be leak-checked when the system is pressurized to prevent wasted LN<sub>2</sub> and ensure safety.

Each LN<sub>2</sub> cylinder connected to the plumbing manifold should come standard with a maximum operating pressure between 22 – 35 PSI (150 – 240 kPa).

**DANGER:** A cylinder is considered *feeding* when it is not empty and its output valve is open. When the selector switch is turned on, it initializes the controller, which assumes all input and output connections are made and secure. The controller immediately opens the first valve in the supply queue, and begins feeding the freezer(s). While the system is on, if (1) the feed line is not connected to a freezer or manually isolated, and (2) *feeding* cylinders are connected to the plumbing manifold, then LN<sub>2</sub> will pour out of the feed line and create a serious safety hazard. LN<sub>2</sub> expands to gas at 700 times its liquid volume, and can cause asphyxiation by reducing the available oxygen supply. Furthermore, LN<sub>2</sub> is at -320 °F, and will cause severe cold burns upon contact with skin. Always make sure the controller is off and unplugged when the feed line is disconnected or not manually isolated to ensure all solenoid valves are closed.

### 3.6 Initialization

Once the unit is mounted, perform the following initialization procedure:

- 3.6.1 Connect all supply lines to the feed ports and cylinders.
- 3.6.2 Connect the feed line to the output port and freezer(s).
- 3.6.3 Plug in the power cord to the electrical source.
- 3.6.4 For remote access and alerts, connect one end of a standard Category 5 Ethernet cable to the white Ethernet port and the other end to the LAN.
- 3.6.5 Turn the On/Off selector switch to the On-position.
- 3.6.6 The controller screen will power up and open the first valve in the queue. A clicking noise indicates the solenoid valve opened. This feeding cylinder number will be indicated on the screen and by its respective indicator light.
- 3.6.7 Check the temperature setpoint. The factory preset is -290°F (adjustable).
- 3.6.8 Check the pressure setpoint. The factory preset is 5 psi (adjustable).
- 3.6.9 Open the manual ball valve on each cylinder. The active cylinder will now feed the freezer.

CryoPacific, Inc. LC AUTO-SWITCH		
	TEMP	PRESSURE
CURRENT	77 F	0 psi
SETPOINT	-290 F	5 psi
FEEDING: 1    EMPTY:		

- 3.6.10 Check the screen for changes in temperature and pressure to verify proper flow of LN<sub>2</sub>. Within two minutes, the temperature should fall below -290°F and the pressure should stabilize around 20-35 psi.
- 3.6.11 Leak-check all connections between the cylinder and the plumbing manifold.

### 3.7 Switch Test

After the system has been initialized, verify the switching operation is functioning properly by simulating empty cylinders.

- 3.7.1 Close the manual valve on all cylinders to simulate empty cylinders.
- 3.7.2 The terminal valve(s) to the freezer(s) must be open to vent the feed line of LN<sub>2</sub>.
- 3.7.3 Reset each cylinder's status from empty to non-empty by pressing the buttons 1, 2, 3, and 4 on the controller keypad.
- 3.7.4 On the screen, watch the temperature rise and the pressure fall. Depending on the venting pressure of the feed line, this may take between five to ten minutes.
- 3.7.5 Once the temperature rises above its setpoint and the pressure falls below its setpoint, the system flags the active cylinder as empty and switches to the next non-empty cylinder. The empty flag appears on the lower right corner of the screen, as well as a flashing indicator light for the corresponding cylinder below the screen.

CryoPacific, Inc. LC AUTO-SWITCH		
	TEMP	PRESSURE
CURRENT	76 F	0 psi
SETPOINT	-290 F	5 psi
FEEDING: 2    EMPTY: 1		

- 3.7.6 The controller shall wait a timed delay (factory preset at two minutes, adjustable) for the temperature to fall below its setpoint condition OR the pressure to rise above its setpoint condition to override flagging the newly activated cylinder as empty and switching to the next cylinder. Since every cylinder's manual valve

was closed on step 1, this newly activated cylinder will also be flagged as empty, and the system will switch over.

- 3.7.7 The delayed wait and ensuing switch should execute for all remaining cylinders until all cylinders are flagged as empty and the audio alarm sounds. If this is the case, the test indicates a well-performing system. If not, contact Technical Support.

CryoPacific, Inc. LC AUTO-SWITCH			
	TEMP	PRESSURE	
CURRENT	74 F	0	psi
SETPOINT	-245 F	5	psi
NO LIQUID DETECTED!      EMPTY: 1, 2, 3			

## 4.0 Operation

The LCAS is designed for minimal operator attention, smart usage tracking, and easy controller adjustment.

### 4.1 Operator Attention

When a cylinder becomes empty, the controller stores a flag in memory that prevents any attempt at switching over to that cylinder again. When the operator replaces the empty cylinder with a full one, the flag must be reset by pressing the corresponding cylinder's number on the keypad. For instance, if cylinder 2 is flagged empty, pressing the 2-button on the keypad will reset the flag. After pressing an empty cylinder's reset button, note how that cylinder's indicator light stops blinking and the flag number on the bottom right of the screen disappears.

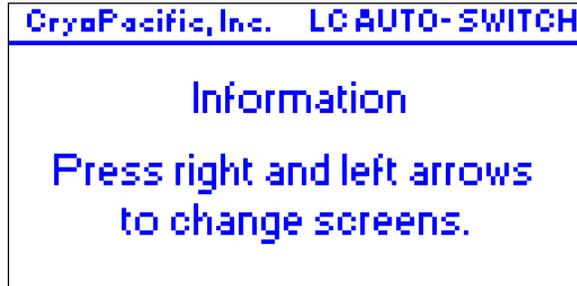
To extend the life of the relays controlling the indicator lights, do not allow the indicator lights to blink longer than necessary. As soon as possible, always:

- replace the empty cylinder with a full one and
- reset the cylinder by pressing the respective key on the keypad

This will reduce indicator light blinking and prolong relay life. See Section 5.1.1 for more information on extending relay life.

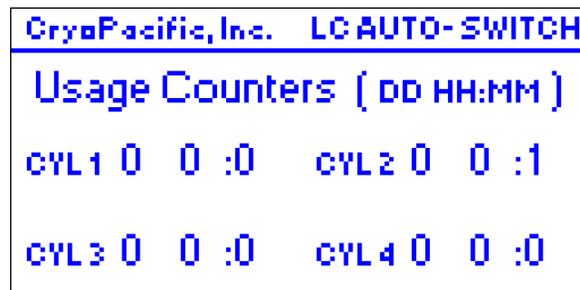
## 4.2 Usage Counters

Users often want to know how long each cylinder supplied the system in order to better estimate usage rate (how long it takes a cylinder to go from full to empty). The LCAS tracks how long each cylinder has supplied the feeding line before becoming empty.



To access this data, press the ⓘ button on the top left corner of the controller screen to reach the *Information* screen. Press the left arrow on the keypad once or until the *Usage Counters* screen is selected.

Usage timers for four cylinders are displayed. Note that some systems are set up for only two or three cylinders, leaving the third and/or fourth cylinder unused. The timer is reset to 00 00:00 when the cylinder's empty flag is reset by pressing the cylinder's corresponding button on the keypad. The timers are in the format:  
Days Hours : Minutes.



## 4.3 Controller Adjustment

The LCAS is shipped from the factory ready for use. However, users may wish to adjust various features to fit their needs. These adjustments include:

1. Activate/deactivate the audio alarm.
2. Change temperature units from Fahrenheit to Celsius.
3. Change temperature setpoint.
4. Change pressure units from pounds per square inch (psi) to kilopascals (kPa).
5. Change pressure setpoint.
6. Change switch timer.

All adjustments are made on the controller by simultaneously pressing press the ⓘ button on the top left corner of the controller screen AND the zero button. At the password prompt, press the ↵ (enter) key, type the password 32489, and then press ↵ again to



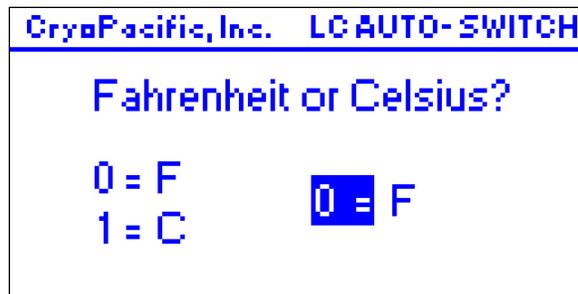
submit the password. The *Device Setup* screen will appear. Use the right and left arrows to scroll between screens. Press the ESC (escape) button on the top right of the controller to exit at any time.

### 4.3.1 Activating / Deactivating the Audio Alarm

To activate or deactivate the audio alarm, load the *Device Setup* screen, and select the screen titled *Audio Alarm*. Press F1 to toggle between activated and deactivated.

### 4.3.2 Temperature Units

To change the temperature units to Fahrenheit or Celsius, load the *Device Setup* screen, and select the screen titled *Fahrenheit or Celsius?* The default setting is Fahrenheit, which is indicated by a zero. To change to Celsius, press the ↵ (enter) key, and the 0 should highlight. Press the 1 key for Celsius, and then press the ↵ key again to save the setting. The *F* should change to *C*.



To reverse the units back to Fahrenheit, press the ↵ key to highlight the 1, press the 0 key, and then press the ↵ key to save the setting. The *C* should change back to *F*.

**NOTE:** Changing between Fahrenheit and Celsius requires adjusting the temperature setpoint to the equivalent units. See the next section (4.3.3) for instructions on changing the temperature setpoint.

### 4.3.3 Temperature Setpoint

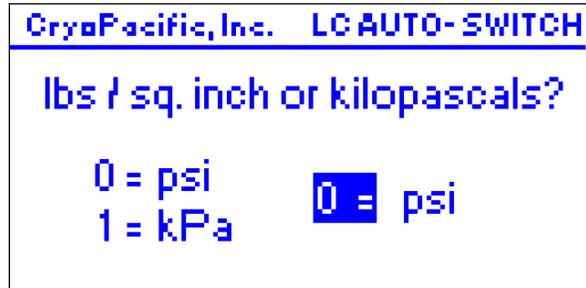
To change the temperature setpoint, load the *Device Setup* screen, and select the screen titled *Set Temperature Setpoint*. Press the ↵ key to highlight the current setpoint, and then use the keypad to enter the new setpoint. For converting from Fahrenheit to Celsius, use the formula  $^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times 5/9$ . For



converting from Celsius to Fahrenheit, use  $^{\circ}\text{F} = (^{\circ}\text{C} \times 9/5) + 32$ . Press the  $\leftarrow$  key to save the setpoint. The factory default is  $-290^{\circ}\text{F}$ .

#### 4.3.4 Pressure Units

To change the pressure units to psi or kilopascals, load the *Device Setup* screen, and select the screen titled *lbs / sq. inch or kilopascals?* The default setting is psi, which is indicated by a zero. To change to kilopascals, press the  $\leftarrow$  (enter) key, and the 0 should highlight. Press the 1 key for kilopascals, and then press the  $\leftarrow$



key again to save the setting. The *psi* should change to *kPa*. To reverse the units back to psi, press the  $\leftarrow$  key to highlight the 1, press the 0 key, and then press the  $\leftarrow$  key to save the setting. The *kPa* should change back to *psi*.

**NOTE:** Changing between psi and kPa requires adjusting the pressure setpoint to the equivalent units. See the next section (4.3.5) for instructions on changing the pressure setpoint.

#### 4.3.5 Pressure Setpoint

To change the pressure setpoint, load the *Device Setup* screen, and select the screen titled *Set Pressure Setpoint*. Press the  $\leftarrow$  key to highlight the current setpoint, and then use the keypad to enter the new setpoint. For converting from psi to kPa, use the formula  $^{\circ}\text{kPa} = \text{psi} \times 6.895$ . For converting from kPa to psi, use the



formula  $^{\circ}\text{psi} = \text{kPa} \times 0.145$ . Press the  $\leftarrow$  key to save the setpoint. The factory preset is 5 psi.

#### 4.3.6 Switch Timer

The switch timer is the delay the controller waits between switching valves. More precisely put, when the switch condition becomes true (temperature is warmer than setpoint *and* pressure is lower than setpoint), the



controller switches valves and waits the delay saved in the switch timer for the feed line to prime. When primed with LN<sub>2</sub>, the switch condition evaluates to false. The purpose of the switch timer is to prevent the system from rapidly switching through all the valves without giving the newly-switched cylinder enough time to prime the feed line.

To change the switch timer, load the *Device Setup* screen, and select the screen titled *Set Switch Timer*. Press the  $\leftarrow$  key to highlight the current setpoint, and then use the keypad to enter the new setpoint. The format is `Minutes:Seconds`. Press the  $\leftarrow$  key to save the setpoint. The factory preset is 2:00 minutes.

## 5.0 Remote Access and Alerts

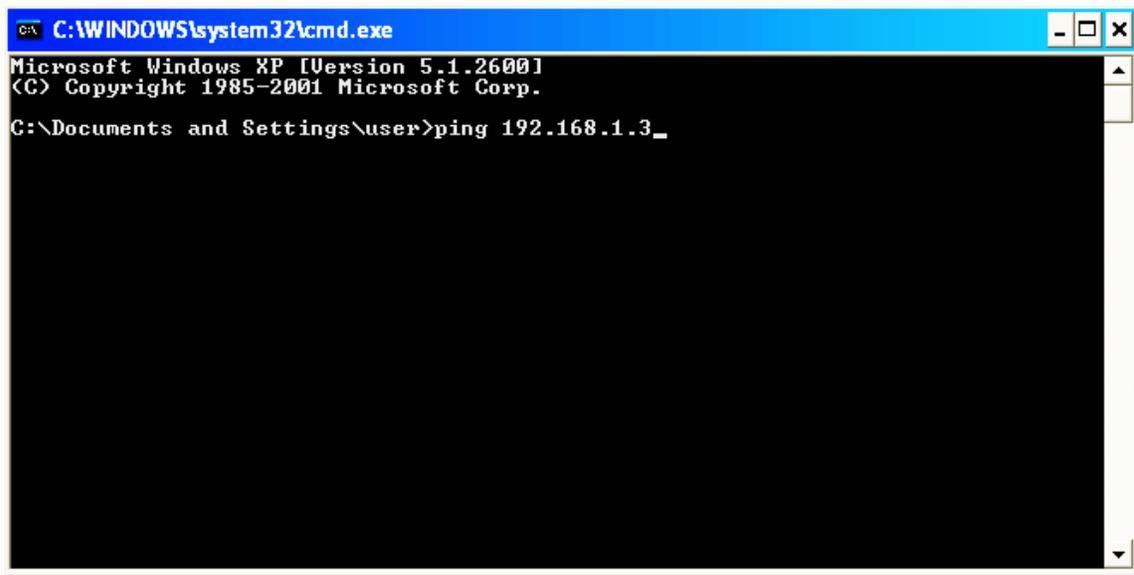
The LCAS can notify users via text message or email when all LN<sub>2</sub> cylinders are empty, and when each cylinder empties. The controller also hosts a webpage that provides real-time system information to a browser anywhere with an internet connection.

### 5.1 Setting up the LAN-IP address

Before the LCAS can connect to the LAN or internet, the controller must be assigned a local IP address. Contact your IT department for an IP address, subnet mask, and default gateway that can be assigned to the controller. This IP address will be static to the controller; it will not be DHCP. To distinguish between the public-IP address discussed in Section 5.5, we will call this the “LAN-IP address.”

Once these three LAN\_IP addresses are made available, input them into the controller. Load the *Device Setup* screen (Section 4.3), and select the screen titled *Set IP Addresses*. Press the  $\leftarrow$  key to select the IP address block and use the number keys to enter the assigned IP address. Press  $\leftarrow$  to save the IP address block, and the up and down arrow keys to select the next block. Enter the subnet mask (Mask) and default gateway (Gate). Once all information is entered, press the ESC key until the home screen appears.

It is a good idea to test the Ethernet connection from any PC computer on the LAN by pinging the controller. For Windows users, open up the Command Prompt and type `ping` then a space then the LAN-IP address like so:

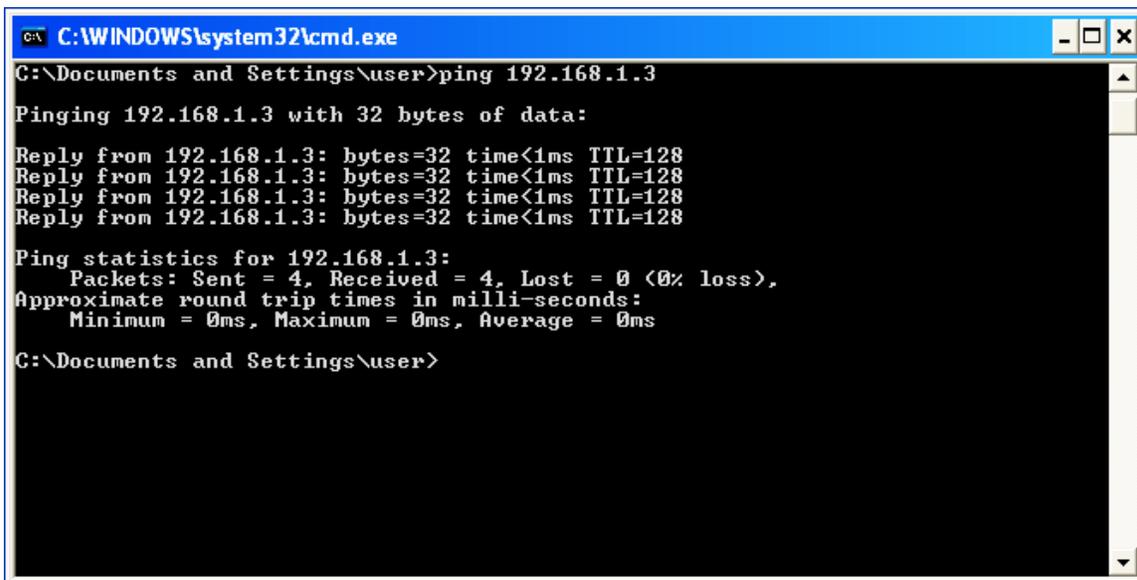


```
C:\WINDOWS\system32\cmd.exe
Microsoft Windows XP [Version 5.1.2600]
(C) Copyright 1985-2001 Microsoft Corp.

C:\Documents and Settings\user>ping 192.168.1.3_
```

**NOTE:** Your LAN-IP address will likely not be 192.168.1.3. This is the LAN-IP address we use at the factory to test the controller.

Press *Enter* on your PC's keyboard. A successful ping will indicate four replies from the controller. It will look like this:



```
C:\WINDOWS\system32\cmd.exe
C:\Documents and Settings\user>ping 192.168.1.3
Pinging 192.168.1.3 with 32 bytes of data:
Reply from 192.168.1.3: bytes=32 time<1ms TTL=128

Ping statistics for 192.168.1.3:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Documents and Settings\user>
```

If the ping is successful, congratulations on connecting the controller to the LAN! The hard part is over.

An unsuccessful ping will look like this:

```

C:\WINDOWS\system32\cmd.exe
Microsoft Windows XP [Version 5.1.2600]
(C) Copyright 1985-2001 Microsoft Corp.

C:\Documents and Settings\user>ping 192.168.1.3

Pinging 192.168.1.3 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 192.168.1.3:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),

C:\Documents and Settings\user>_

```

If the ping is unsuccessful, the LAN-IP addresses are incorrect, the Ethernet cable is faulty, or there is some other problem that is preventing a connection to your LAN. One way to verify if the Ethernet connection has a LAN-IP address (and if so, what it is) is to connect the Ethernet cable to a laptop. For Windows users, run the command prompt, and type `ipconfig`. Press *Enter*. If the LAN-IP address registers, compare it to the controller's for any discrepancy. If there is a discrepancy, change the controller's LAN-IP addresses to match the laptop's. If no IP address registers on the laptop, there is likely a faulty connection somewhere upstream. Contact your IT department for help before calling CryoPacific Technical Support, as these issues are usually LAN-related.

## 5.2 Remote Alerts

To receive alerts, enter up to five emails or mobile phone number-emails (SMS) into the controller. To begin, press and hold the  $\odot$  button and the zero (0) key to load the *Device Setup* screen. Press the right arrow to load the *Alerts* screen.



Press the  $\leftarrow$  key to edit the alerts. The

*Email 1* screen will appear. Press the  $\leftarrow$  key to change the email address. Press a key repeatedly to select the desired letter or number. For quicker typing, press the right arrow to advance the cursor one character space instead of waiting for it to advance on its own. Otherwise, pressing another key will overwrite the letter. The @-symbol and other symbols are located by pressing the 1 key twice, and then using the arrow keys to select it from the field of symbols. The period is located by pressing the (+/.) key three times. To delete, press the left arrow.

The bottom half of the screen holds the alert options. The user can choose to receive an alert when all cylinders are empty (recommended) and/or when each cylinder has emptied. The message for *Each Empty* contains the *Usage Counter* data described in 4.2. To activate/deactivate the *All Empty* alert, press F1. To activate/deactivate the *Each Empty* alert, press F2.



Press the right and left arrows to advance through the five email settings. Press ESC repeatedly to exit back to the home screen.

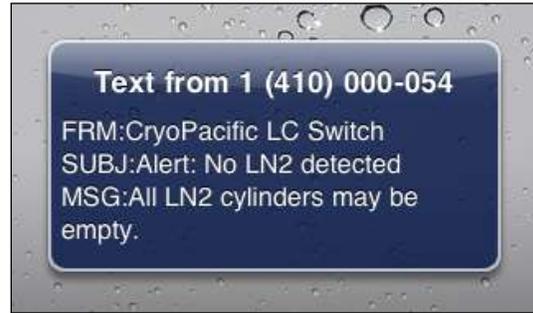
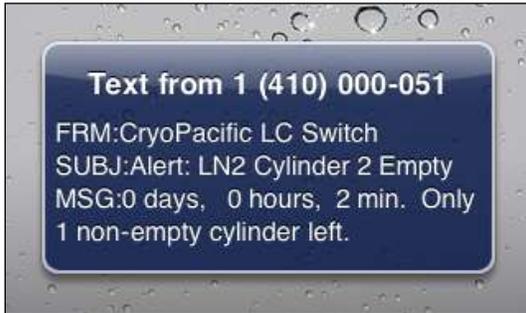
Most major mobile phone carriers provide text-messaging (SMS) capability via an email address using the mobile phone number at the carrier's domain. The following major carriers are listed here:

Carrier	Text Message Address
AT&T	cellnumber@txt.att.net
Verizon	cellnumber@vtext.com
T-Mobile	cellnumber@tmomail.net
Sprint PCS	cellnumber@messaging.sprintpcs.com
Virgin Mobile	cellnumber@vmobl.com
US Cellular	cellnumber@email.uscc.net
Nextel	cellnumber@messaging.nextel.com
Boost	cellnumber@myboostmobile.com
Alltel	cellnumber@message.alltel.com

To receive alerts via text message to a mobile phone, enter the mobile phone number followed by its carrier's domain (as indicated by the table) in the screen like so:

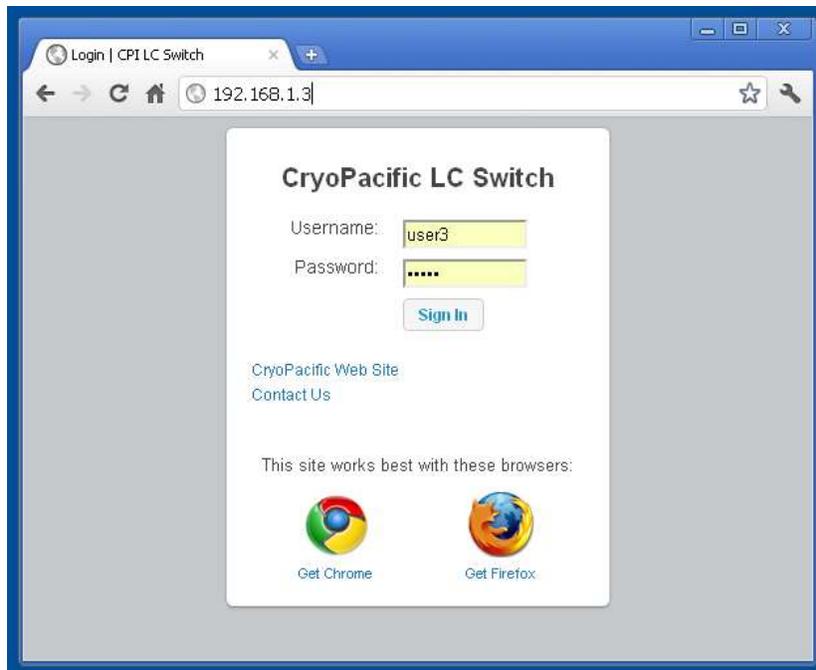


This option will send text messages like these:



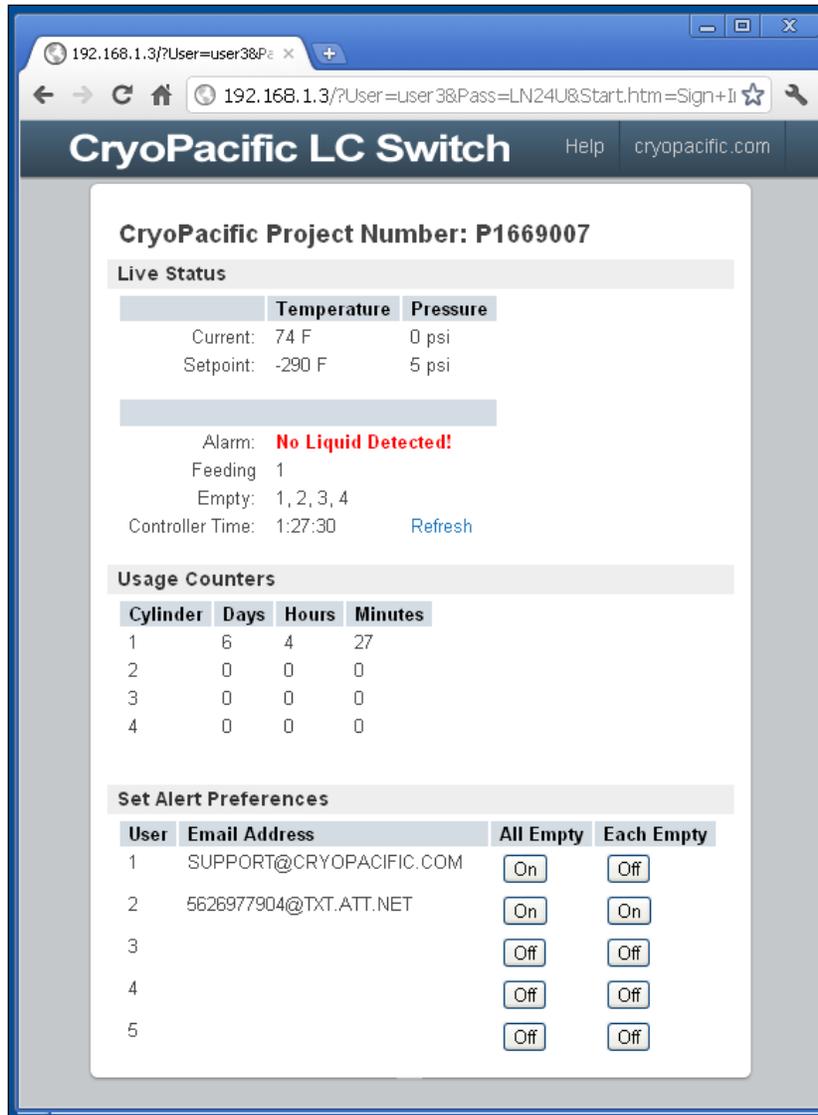
### 5.3 Remote Access from LAN

The controller can be accessed by any web browser on the LAN to view its live status, usage counters, and set alert preferences. To log into the controller's webpage, type the controller's LAN-IP address into the browser's address bar.



Login Page

The default username is USER1 and the password is PASS1. Both are case sensitive. The username and password can be changed in the *Device Setup*, which is discussed in Section 5.4. Click *Sign In* to view the home webpage. You will be directed here:



Home Page

To the right of “Controller Time” is a blue *Refresh* link. Clicking *Refresh* will reload the webpage and display the latest controller time.

At the bottom under the *Set Alert Preferences* heading, alert preferences can be toggled on and off with a click of the mouse. However, email addresses can only be set through the controller.

#### 5.4 Webpage Login Change

For added security, users can change the username and password to the webpage login.

To change the webpage username, load the *Device Setup* screen, and select the screen titled *Web Username*. Press the ← key to highlight the current username, and press the left arrow to delete the current username. Press a key repeatedly to select the desired letter or number. For quicker typing, press the right arrow to advance the cursor one character space instead of waiting for it to advance on its own. Otherwise, pressing another key will overwrite the letter. Press the left arrow to delete.

To change the webpage password, load the *Device Setup* screen, and select the screen titled *Web Password*. The process for changing the password is the same as the username.

**NOTE:** Both the username and password are case sensitive and must be exactly five characters long. Anything shorter or longer will not work.

## 5.5 Remote Access from the Internet

The LCAS can be accessed by any web browser from anywhere in the world with an internet connection. This may require the help of your IT department.

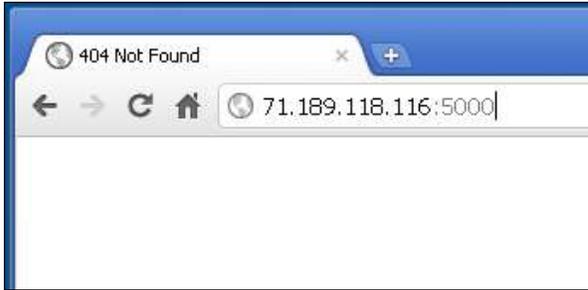
In Section 5.1 we identified the LAN-IP address as an IP address assigned to the controller by your office or lab's local area network (i.e. your main router). We will now introduce the "public-IP address," which is assigned to your office or lab by your internet service provider. Get your public-IP address by visiting [www.ipchicken.com](http://www.ipchicken.com).



Get the public-IP address

Port 80 is the default web hosting port number for most web servers, including the LCAS. For your lab or office, it is likely that this port number is registered to another web server (such as your router's GUI). If port forwarding is desired, there will likely be a conflict between two or more web servers hosting on port 80. Therefore, the port number on the LCAS must be changed to another port, say 5000. To do this, load the Device Setup screen, and select the screen titled *13. Set Web Hosting Port*. Press the ← key to highlight the port number, enter the new port number, and press ← again to set it. Initialize the new port number by restarting the controller by turning it on and off.

The main router that connects your LAN to the internet must have "Port Forwarding" capability. Log into your main router to set up Port Forwarding. This is usually done by entering the *Default Gateway* LAN-IP address into your browser. The port number discussed in the preceding paragraph is the *port* that *forwards* the user from the public-IP address to the controller's webpage located on the LAN-IP address.



Enter the public-IP address:Port Number into the browser

By way of example, note that our factory's public-IP address is 71.189.118.116. Say we have a hypothetical LCAS hooked up at our factory, and we want to check the LCAS webpage from home or cell phone to verify the system is on and working properly. We would set up Port Forwarding on our router by logging into the router and assigning a port number, say 5000, to point to the controller,

which is assigned a LAN-IP address of 192.168.1.3 (see Section 5.1). When the Port Forward is established, users can access the LCAS webpage from the internet by entering into their browser's address bar their public-IP address, a colon, and the assigned port number (in our example port 5000). To access our hypothetical factory-based LCAS, we type 71.189.118.116:5000 into our browser's address bar as if we were entering the address of any website. After pressing *Enter*, the browser would take us to the login page, as shown in Section 5.3.

## 6.0 Maintenance

The LCAS is designed and built for robust system performance. With proper inspection, detection, and correction of incipient failures before they develop into major defects, the LCAS will provide many years of reliable service.

### 6.1 Control Panel

The control panel houses the controller, indicator lights, audio alarm, selector switch, and power supply.

#### 6.1.1 Internal Relays

Inside the controller are relays that switch on and off the valves, audio alarm, and indicator lights. Like all relays, the controller's internal relays have a limited switching life, and are rated for 20 million mechanical cycles. The most wear on the relays comes from the indicator lights, which blink when a cylinder is empty. The longer the indicator light blinks, the shorter the life of the relay. With a two second cycle time, a relay will reach twenty million cycles in 463 days of continuous blinking. Therefore, to prolong relay life, it behooves the user to reduce blinking by pressing the corresponding cylinder's reset button sooner rather than later.

### **6.1.2 Fuses**

The controller and solenoid valves are protected by 1.5 amp fast-acting glass fuses. If a valve fails to open or the controller does not turn on, check the fuses inside the fuse blocks for connectivity.

## **6.2 Plumbing Assembly**

The plumbing assembly sits behind the control panel. It houses the solenoid valves, check valves, pressure relief valves, and measurement devices.

When the system is primed with LN<sub>2</sub>, the plumbing assembly will frost over from incumbent moisture in the air. This is normal.

Whenever an empty cylinder is replaced, conduct a cursory inspection of the plumbing assembly. Listen for hissing sounds that may indicate leaks. Buzzing sounds may indicate a failing solenoid coil or insufficient voltage to the solenoid. Check all transfer hose connections for leaks, re-tighten as necessary. To leak-check, fill a spray bottle with water and a little soap, and spray each connection while the system is pressured BUT NOT cold. If the plumbing assembly is cold, the water from the leak check will freeze on the plumbing and no bubbles will appear. If bubbles appear over a connection, tighten the connection to seal the leak. Maintaining a leak-tight system is imperative for efficient use of the LN<sub>2</sub> supply.

## **6.3 Preventive Maintenance Service**

Every two or three years (depending on usage) the system should be given a detailed preventive maintenance service to include:

- Verify accuracy of thermocouple and temperature reading
- Calibrate pressure to certified pressure gauge
- Replace all solenoids
- Replace all relays
- Leak-check all plumbing connections
- Tighten electrical connections
- Test check valves for backflow
- Test relief valves
- Upgrade software

## 6.4 Replacement Parts



2-valve Plumbing Assembly

Item #	Part Number	Description
1	1000218	RTD Thermocouple
2	1000611	Solenoid Valve
3	2000347	Check Valve
4	1000220	Relief Valve
5	1000221	Pressure Transducer