

QUANTUM HMI CONTROLS
P650 – University of Virginia
100 LHe Liquefier

MODEL Q16.1 – CONTROL
P6502023

MANUAL
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www.quantum-technology.com

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1. SAFETY

There are four principal hazards associated with operating this piece of equipment:

- helium displacing air resulting in an asphyxiation hazard
- On warming a closed vessel from low temperatures, the internal pressure will rise and may result in an explosion hazard.
- Freezing hazard if skin or eyes are in contact with cold parts or liquid (do not tap)
- Electrical equipment may present electrical hazards.

Only scientific laboratory personnel, trained in safe use of cryogenic liquids should operate this system.

2. INTRODUCTION

This document covers the basic operations performed by the HMI electronic control unit located on the front panel of the Helium Recovery System.

On the top of screen is a standard menu that provides high level information regarding the status of the system and basic information including operator information and time.

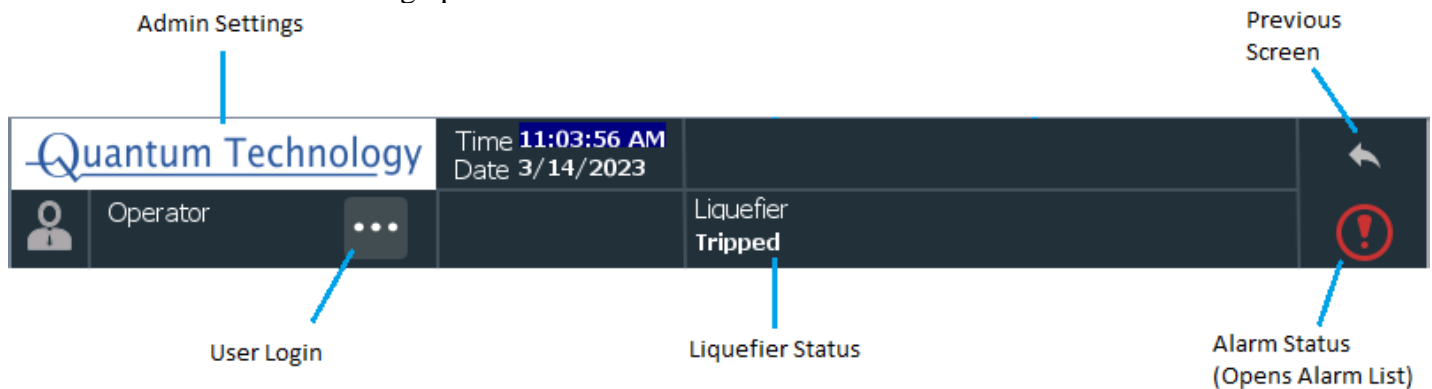


Figure 1 – Top Menu

3. LIQUEFIER INTERFACE

The Helium Liquefier Interface is primarily used to control the liquefier and their cold head compressors. Key parameters are shown on the screen.

3.1 Operation

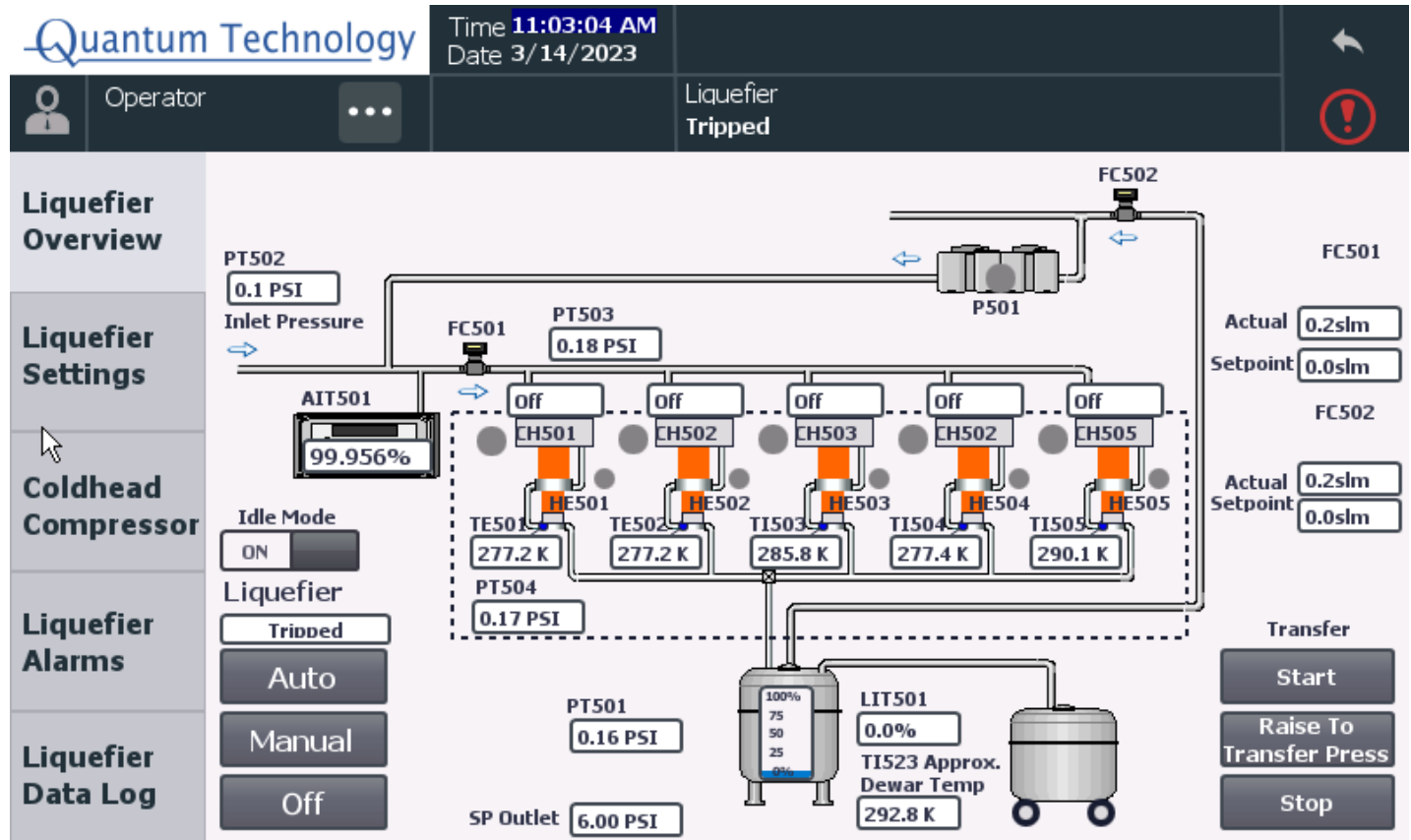


Figure 2 - Liquefier Overview

The left buttons on this screen allows the user to toggle various Liquefier modes. Depending on the physical state of the Liquefier, it can be in any of the following states.

Tripped

If there is a trip condition the Liquefier system enters a tripped state. In this state all the valves and compressor are turned off.

Off

After a trip reset or pressing the off button, the Liquefier is set to Off. In this state all the valves and compressor are turned off.

Manual

In manual mode, the valves can be toggled on and off by tapping the respective icons. The helium cold head

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compressor will be placed in Manual Mode as well. To access controls of the compressor, press on the He Compressor button on the left. Flow control settings of FC01 and FC02 can also be changed.

The following states occur when the system is in Auto mode.

Idle

The Liquefier enters this state when:

- Low Purity alarm occurs,
- if there is low inlet pressure,
- if Dewar Level is High
- or if toggled by the operator on the screen.

In this state the gas inlet to the system is closed off. The cold heads will stay running to liquefy any Dewar boiloff. The cold head heaters will turn on and off to maintain the correct Dewar pressure. To go back to Liquefying or Cooldown state, the Idle mode button can be toggled back to Off once the alarm condition has been corrected.

Dewar Cooldown

During this state, the Liquefier is cooling down, which means that the outlet flow controller is venting a higher rate of helium to increase the heat transfer. The outlet flow is calculated based on a linear interpolation between “Outlet Flow Setpoint @ 300K” and “End Mode: Low Dewar Temperature” at “Outlet flow setpoint”.

The cooldown will end change to Liquefy state when any of the following conditions are true:

- The Dewar temperature is less than “Mode End: Low Dewar Temperature”
- All the cold head temperatures are below “Mode End: Low Cold head Temperature”
- The Dewar Level is above the “Mode End: Dewar Level”

For the opposite case, the state will go back into Cooldown.

Liquefy

In this state the Liquefier is liquefying as normal. The cold head should be running and the inlet feed flow is used to control the Dewar pressure. The vent flow rate is set to the “Outlet Flow Setpoint”.

3.2 Transfer

Pre-Transfer

When a transfer is triggered, by pressing the transfer button, then the state will enter Pre-Transfer. During this state, the Dewar pressure setpoint is lowered to the “Pre-Transfer Dewar Pressure” and the outlet flow is increased to reduce the pressure in the Dewar.

Transfer

Once the “Pre-Transfer Dewar Pressure” setpoint is reached and “Raise to Transfer Press” is pressed, then the state will change to Transfer. The Dewar pressure will be set to “Transfer Dewar Pressure” and the outlet flow rate is set to 0. This will start transferring the helium from the Dewar to the Transport Dewar if the operator has opened the transfer line valve. The transfer can be stopped any time by pressing Stop, which means the pressure will increase in the Dewar and will start to liquefy again.

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3.3 Dewar Pressure Control

The Dewar Pressure is normally controlled by the inlet flow controller, the flow setpoint is adjusted to maintain the Dewar pressure. If for some reason the Dewar pressure increases over the setpoint “Dewar pressure Vent Setpoint” then the vent flow will start to increase flow rate to bleed off the pressure. If the Dewar pressure drops below the “Enable Heater when Low Pressure” setpoint, then the cold head heaters will turn on.

3.4 Recovery Pump

The small recovery pump P501 is set to run whenever the Liquefier is in Cooldown or Liquefy state, as well as during a transfer.

3.5 Purity Meter

The system is equipped with a purity meter for monitoring the feed gas to the Liquefier. It is important that the purity stays high, so as to not contaminate the cold box with impurities.

3.6 Liquefier Cold head Compressors

The screenshot displays the Quantum Technology control interface. At the top, it shows the time as 11:03:56 AM and the date as 3/14/2023. The user is identified as 'Operator'. A red warning icon indicates a 'Liquefier Tripped' status. The main control area is organized into sections: 'Liquefier Overview', 'Liquefier Settings', 'Coldhead Compressor', 'Liquefier Alarms', and 'Liquefier Data Log'. The 'Coldhead Compressor' section is currently selected, showing a table of controls for five compressors (CH501, CH502, CH503, CH503, CH503). Each compressor has a 'Run Feedback' indicator (all are OFF), a 'Tripped' indicator (all are ON), an 'Alarm Status' indicator (all are OFF), and a 'Heater Status' indicator (all are OFF). Below these are buttons for 'Auto', 'Manual', 'Off', and 'Local'. The 'Manual Run' section shows 'OFF' for all. The 'Manual Heater' section shows 'OFF' for CH501, CH502, and CH503, and 'ON' for the two CH503 units. The 'Manual Pause' section shows 'OFF' for all. The 'Stage 2 Temp' section shows values: 277.2K, 277.2K, 285.8K, 277.4K, and 290.6K. The 'Compressor Hours' and 'Coldhead Hours' sections show values: 153.6 h, 153.6 h, 153.8 h, 153.7 h, and 153.7 h. The 'Alarm Reset' section has 'Reset' buttons for each compressor.

	CH501	CH502	CH503	CH503	CH503
Run Feedback	●	●	●	●	●
Tripped	●	●	●	●	●
Alarm Status	●	●	●	●	●
Heater Status	●	●	●	●	●
Off	Off	Off	Off	Off	Off
Auto	Auto	Auto	Auto	Auto	Auto
Manual	Manual	Manual	Manual	Manual	Manual
Off	Off	Off	Off	Off	Off
Local	Local	Local	Local	Local	Local
Manual Run	OFF	OFF	OFF	OFF	OFF
Manual Heater	OFF	OFF	ON	OFF	ON
Manual Pause	OFF	OFF	OFF	OFF	OFF
Stage 2 Temp	277.2K	277.2K	285.8K	277.4K	290.6K
Compressor Hours	153.6 h	153.6 h	153.8 h	153.7 h	153.7 h
Coldhead Hours	153.6 h	153.6 h	153.8 h	153.7 h	153.7 h
Alarm Reset	Reset	Reset	Reset	Reset	Reset

Figure 3 - Liquefier Cold head Compressor

This displays the state of each of the cold head compressors. Each of the cold heads can be individually

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controlled, independent of the Liquefier, unless the liquefier is in a tripped state, then the cold heads are disabled. There are four modes of operation:

Auto

This is what the compressor mode should always be in. In this mode the Liquefier program controls the cold head, which means it can turn on, off or pause it, and control the heater.

Manual

In this mode the operator can turn on, off or pause the cold head compressor, and control the cold head heater. Note the heater is still limited to the “Cold head Heater Shutoff High Temperature”.

Off

The cold head compressor and heater are off.

Local

The cold head compressor can be controlled at the actual compressor. The heater is off.

3.7 Liquefier Settings

Section	Parameter	Value
Liquefier Overview	Dewar Pressure Feed Setpoint	6.0 PSI
	Dewar Pressure Vent Setpoint	8.0 PSI
	Enable Heater when Low Pressure	4.0 PSI
Liquefier Settings	Outlet Flow Setpoint @ 300K	60.0 SLPM
	Mode End: Dewar Level	10.0 %
	Mode End: Coldhead Temp	2.0 K
	Mode End: Dewar Temp	4.2 K
Coldhead Compressor	Outlet Flow Setpoint	5.0 SLPM
	Purity Meter Settings	
Liquefier Alarms	Pre Purifier Sample Time	5.0 m
	Post Purifier Sample Time	30.0 m
Liquefier Data Log	Line Purge Time	1.5 m
	Total helium liquefied based on Inlet flow minus Outlet Flow	40026.7 L(gas)

Figure 4 - Liquefier Settings

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Dewar Pressure Settings	Factory Setpoint	Site Setpoint	
Dewar Pressure Setpoint	6 PSI		This is the Dewar pressure setpoint, the inlet flow controller is used to maintain this Dewar pressure.
Dewar Pressure Vent Setpoint	8 PSI		This is based on the Dewar pressure, if the Dewar pressure increases above the Dewar Pressure Setpoint by more than this setpoint then the outlet flow controller will start to increase the vent flow rate to reduce the Dewar pressure.
Enable Heater when Low Pressure	4 PSI		This is based on the Dewar pressure, if the Dewar pressure drops below the Dewar Pressure Setpoint by more than this setpoint then the cold head heaters will be turned on to increase the Dewar pressure. Note, this is disabled during the Pre-Transfer state.
Cooldown Mode Settings			
Outlet Flow Setpoint @ 300K	100.0 slpm		During Cooldown, the outlet flow is varied, if the Dewar temperature is 300K then the flow will be this setpoint. As the temperature drops, the flow will decrease.
Mode End: Dewar Level	5.0%		If the Dewar reaches this level, then the cooldown will end and Liquefy will start.
Mode End: Low Cold head Temp	3.5 K		If all cold head temperatures drop below this temperature, then the cooldown will end and Liquefy will start.
Mode End: Low Dewar Temp	5.0 K		If the Dewar temperature drop below this temperature, then the cooldown will end and Liquefy will start. This is also used for the Outlet flow calculation during cooldown.
Liquefy Mode Settings			
Outlet Flow Setpoint	5.0 SLPM		During normal liquification this is the Dewar outlet flow rate
Transfer Settings			
Transfer Dewar Pressure	5.0 PSI		Once the pressure in the Dewar is reached, the transfer is initiated, at which point the Dewar pressure is increased to this setting to speed up the transfer.
Pre Transfer Dewar Pressure	2.0 PSI		Before a transfer, the Dewar pressure must be dropped to allow for slow initial helium transfer to the transport Dewar. The Dewar pressure setpoint is set to this value.
Pre Transfer Vent Flow	30 SLPM		To help drop the Dewar pressure during Pre-Transfer, the Dewar outlet flow is increased to this flow rate.
Minimum Dewar Level	20.0 %		In order to initiate a transfer the Liquefier Dewar level needs to be at least this high.

Table 1 – Liquefier Setpoints

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3.8 Liquefier Alarms

Liquefier Alarms

Parameter	Status	Setpoint
Low Dewar Pressure	Red	4.0 PSI
High Dewar Level (idle)	Green	95.0 %
Low Inlet Pressure (Idle)	Green	0.0 PSI
He Compressor in Local Mode	Green	
Low Coldhead Temp	Green	3.5 K
Pressure Differential Over Coldbox	Green	2.00 PSI
Low Liquefaction Rate	Green	9.0 SLPM
Flow Differential	Green	2.0 SLPM

Liquefier Trips

Parameter	Status	Setpoint
System Trip (ESD)	Green	
Dewar Low Low Pressure	Red	1.0 PSI
No Compressor Feedback	Green	

Purity Meter Alarms

Parameter	Status	Setpoint
Low Purity	Green	99.000 %
Low Purity (Idle)	Green	99.000 %
Faulty Purity Meter	Green	

Faulty Conditions

- Faulty Inlet Pressure
- Faulty Colbox Feed Pressure
- Faulty Coldbox Pressure
- Faulty Deware Pressure
- Faulty Inlet Flow Feedback
- Faulty Outlet Flow Feedback
- Faulty Liq. Dewar Temperature
- Faulty Liq. Dewar Level
- Faulty Coldhead Box 501 Temp.
- Faulty Coldhead Box 502 Temp.
- Faulty Coldhead Box 503 Temp.
- Faulty Coldhead Box 504 Temp.
- Faulty Coldhead Box 505 Temp.

Figure 5 - Liquefier Alarm Settings

The Liquefier Alarms screen shows current and past trips. After the alarm condition has ended the trip must be reset for the liquefier can operate again. This screen also shows any current alarms.

Liquefier Alarm Settings	Factory Setpoint	Site Setpoint	
Dewar Low Pressure	1.5 PSI		This is based on the Dewar pressure, if the Dewar pressure drops below the setpoint an alarm is displayed on the screen.
Dewar Level High	95 %		If the Dewar level goes above the alarm setpoint, then the liquefier will be set to idle mode, and an alarm is displayed on the screen.
Low Inlet Pressure	2.0 PSI		If the inlet pressure drops below this alarm setpoint then an alarm is displayed on the screen, and the liquefier will be set to Idle mode
He Compressor not in Auto Mode			An alarm is displayed if any of the Coldhead compressor are not in Auto mode

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Low Cold head Temp	3.5 K		If any of the cold head temperatures drop below this alarm setpoint then an alarm is displayed on the screen. This is an indication that the cold head is fouled, and may need to be regenerated.
Pressure Differential Over Coldbox	2 PSI		If any of the pressure drop across the coldbox rises to above this alarm setpoint then an alarm is displayed on the screen. This is an indication that the cold head is fouled, and may need to be regenerated. The pressure drop is based on the coldbox pressure and Dewar pressure.
Low Liquefaction Rate	30 slpm		If the feed flow rate drops below this alarm setpoint for more than an hour, then an alarm is displayed on the screen.
Flow Differential	5.0 slpm		If the requested vs actual feed rate deviates by more than this setpoint, then an alarm is displayed. A deviation can be an indication of fouling in either purifier or liquefier coldbox.
Any Faulty Transmitter			If the signal is out of normal range (<3.7 or >20.75 mA), then an alarm is displayed on the screen.
Liquefier Trip Settings			
System Trip			If the Emergency buttons is pressed, then the entire system is tripped, and an alarm is displayed on the screen.
Low Low Dewar Pressure	1.0 PSI		If the Dewar pressure drops below this low low setting, then the liquefier is tripped, and an alarm is displayed on the screen.
No Compressor Running Feedback			If the Liquefier is in Auto and none of the compressors are running, then the Liquefier is tripped
Purity Meter			
Low Purity	99.99		This is based on the feed purity to the liquefier. If the purity falls below the purity low alarm setting then an alarm is displayed on the screen.
Low Purity (Idle)	99.98%		This is based on the feed purity to the liquefier. If the purity falls below the purity low alarm setting, the liquefier is placed in Idle state, and an alarm is displayed on the screen.

Table 2 – Liquefier Alarm Setpoints

3.9 Liquefier Data Log

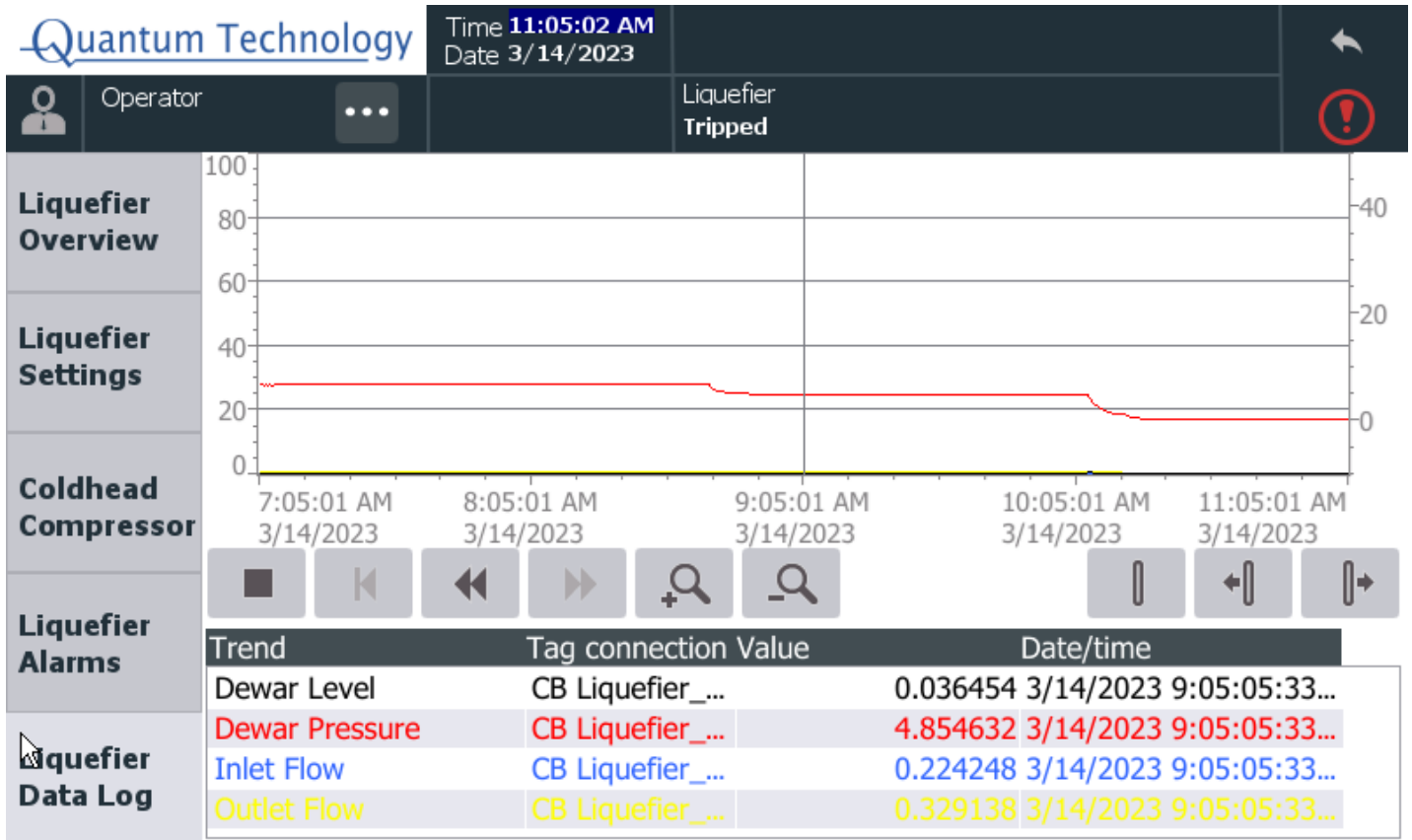


Figure 6 - Liquefier Datalog

The Liquefier System Datalog screen shows the historical values of the Dewar Level, Dewar Pressure, Inlet Flow and Outlet Flow.

4. Signal Connections

4.1 Ethernet to Control Computer

Duplicated HMI on Control Computer if applicable to the system.

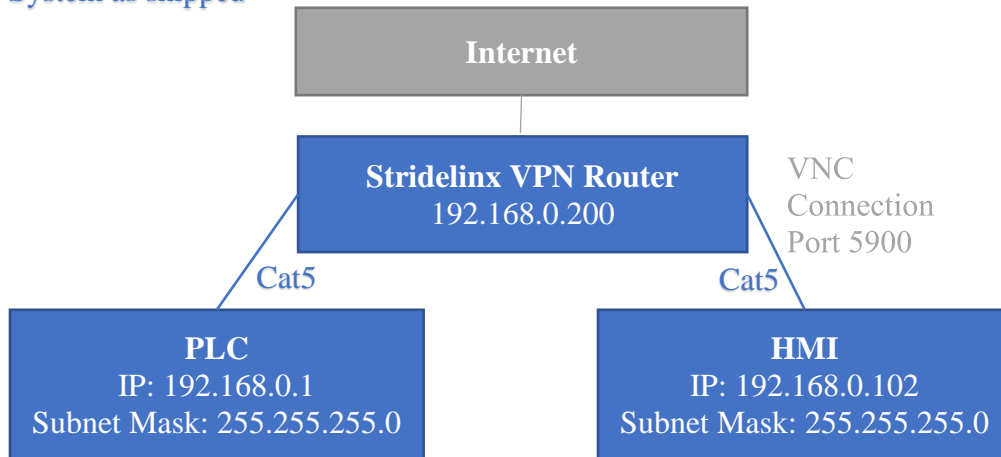
Minimum requirements:

- Computer with Siemens Sm@rtClient application or another preferred VNC client installed.
- Cat5 ethernet cables

The system is located on the 192.168.0.x subnet, make sure the control computer has an IP address on the same subnet. The remote connection uses the standard VNC protocol on Port 5900.

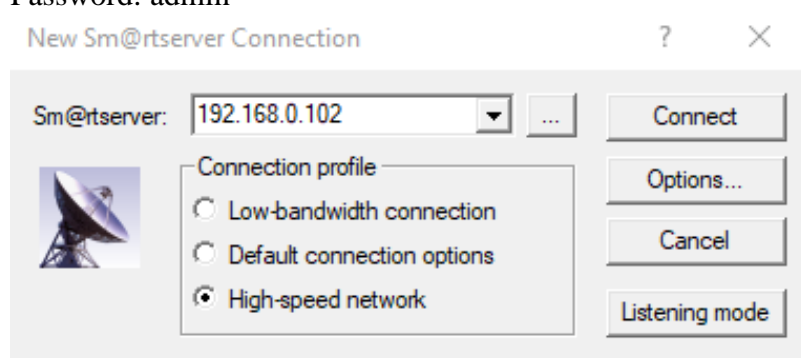
The system comes with a Stridelinx VPN Router, if it is connected to the internet, it allows remote access by Quantum Service to help with any troubleshooting. It also can be set up for your system operators to remotely monitor the system.

Blue: System as shipped



The HMI Screen IP: 192.168.0.102

Password: admin



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