Thermonics

Process Chillers for Cannabis Extraction Applications

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ISO REGISTERED ITAR

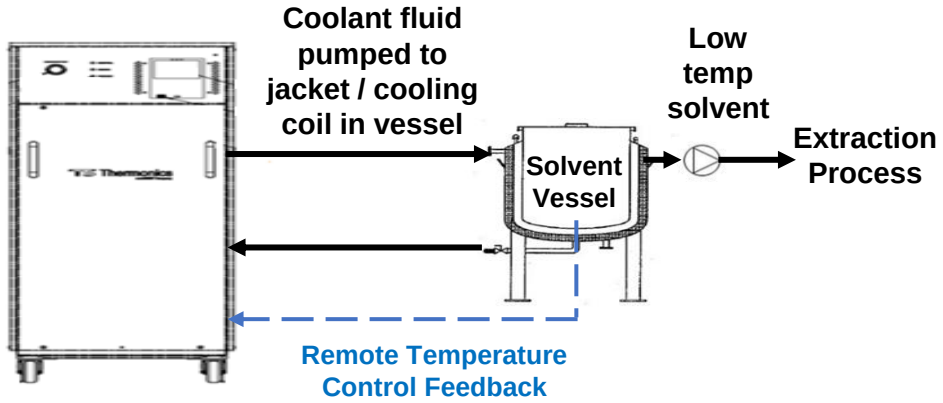
Hydrocarbon and Ethanol Cooling Solutions

Cooling hydrocarbons or ethanol to ultra low temperatures is key in the THC and CBD extraction process. Thermonics offers multiple solutions

- Cool solvents in bulk in a vessel with air cooled, water cooled or LN2 cooled fluid chillers
- Cool solvents “On Demand” using an external heat exchanger

Cooling Solvents in Vessel Using Air or Water-cooled Chillers

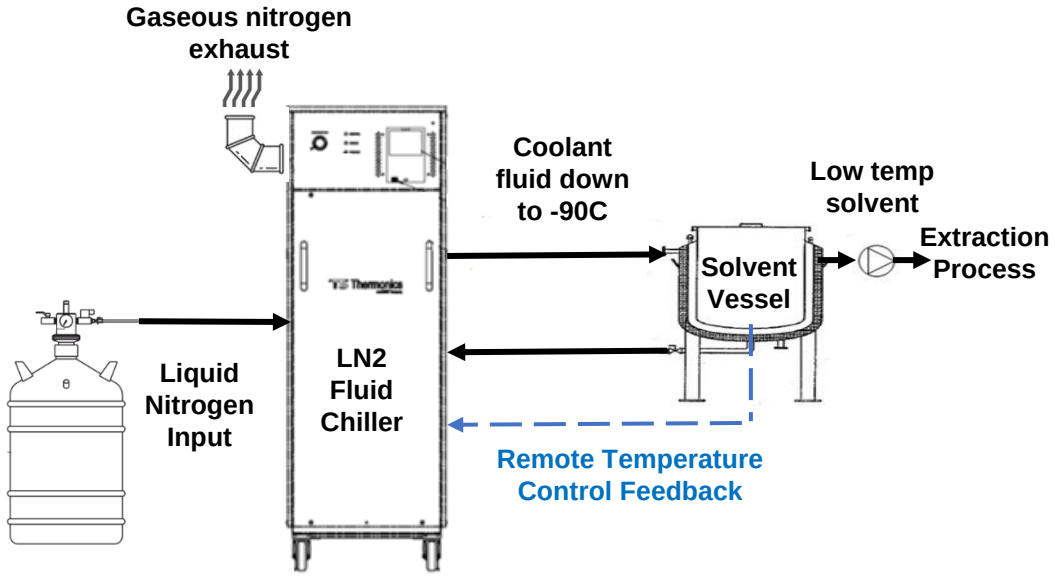
- The chiller provides low temperature cooling fluid to the vessel jacket to cool the solvent
- Solvent cooling time is dependent on volume of solvent, heat transfer efficiency of the vessel to solvent, and the temperature and cooling capacity of the chiller
- By adding a temperature sensor to the solvent and feeding back to the chiller, the user can program the desired solvent temperature and the chiller will automatically control the coolant fluid temperature to maintain the desired solvent temperature.

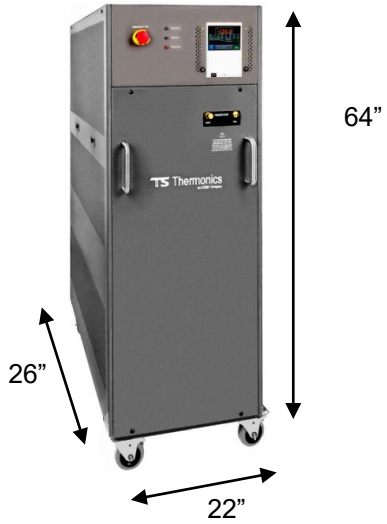


Air cooled -80C chiller

Cool solvents in vessel using an LN2 cooled chiller

- The -90C coolant fluid capability, combined with the 20kW of cooling capacity of the LN2 cooled fluid chiller will reduce the solvent cool down time in comparison with the air or water cooled chillers in a much smaller footprint.
- The LN2 chiller will automatically adjust the LN2 consumption to match the temperature and cooling capacity requirements. The size of the LN2 tank needs to be sized to match the LN2 consumption.

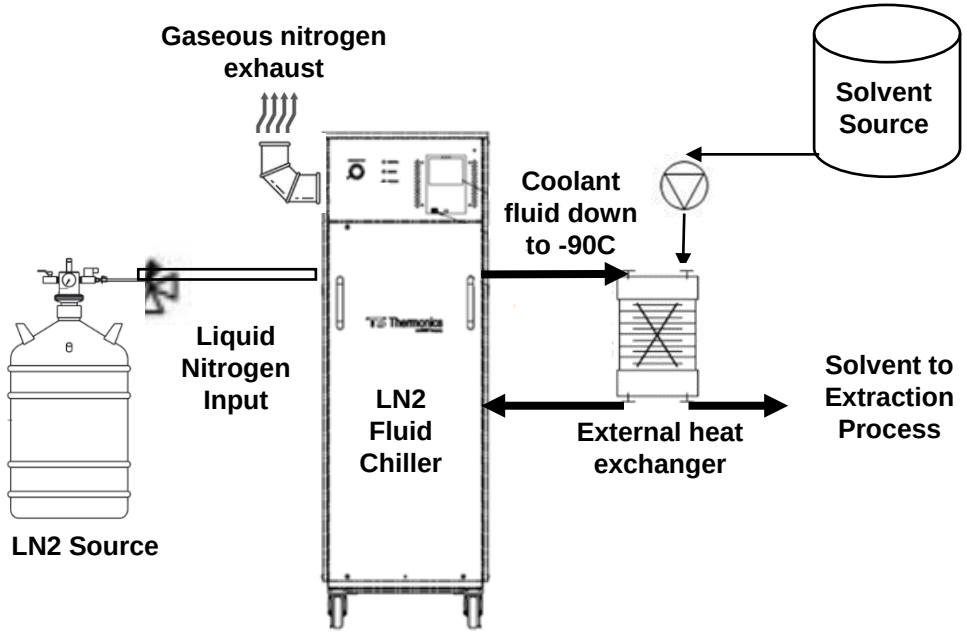


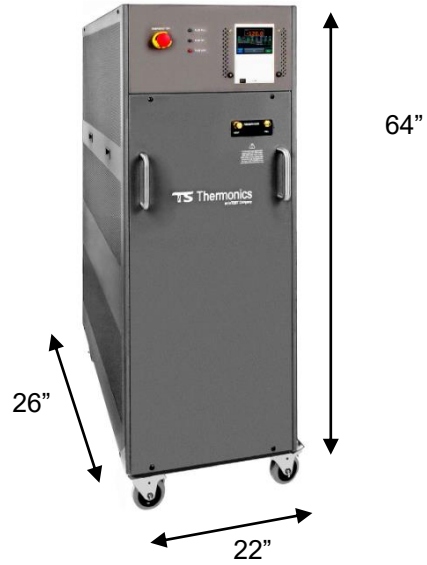


LN2 cooled -90C chiller

Chill an “On Demand” continuous flow of solvent using an LN2 cooled chiller

- Using the -90°C, 20 kW LN2 chiller with an external heat exchanger, a continuous flow of solvent can be cooled on demand.
- Thermonics can provide the external heat exchanger and fluid lines for a complete solution





Ethanol Heat Load +0C to -60C, 4.0 GPM	
Flow rate (4.0 GPM)	0.000252
Liquid density @ -20C (kG/m3)	822.9
mass flow	0.2073708
Cp @ -20C	2.06
ΔT	60
Q = Cp · m · ΔT (kW)	**25.63103088**

Thermonics Chiller Overview

- Air, water or LN2 cooled models available
- Temperature Ranges from -900C to +200C
- Cooling capacities from 500W to 30 kW
- Multiple pump sizes and types with programmable flow rate and pressure options
- Wide selection of process cooling fluids
- Powerful chiller controller
- Optional flow meter, programmable fluid pressure and flow, anti back flow and pressurized fluid purge
- Remote communications options (analog, RS-485, TCP/IP Ethernet)

Air and Water Cooled Chiller Features

Emergency Off Button (remote connection in rear)

Fluid reservoir level indicators

Operator Interface Screen

Low temperature chiller components mounted in super foam insulated enclosure to eliminate condensation

Sealed SS Fluid Reservoir to protect against fluid evaporation and contamination

Easily accessible chiller controller and power electronics

Reliable Copeland scroll compressors

All cold components and piping super insulated to minimize temp losses and eliminate condensation

Reliable SS magnetically coupled gear or turbine pumps

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Air and Water Cooled Chiller Models

Model	Temperature Range (°C)	Stability (°C)	Cooling Capacity (kW @ 25°C Ambient)								Pump Capacity (GPM/LPM)	Fluid Pressure (psig)
			25	0	-20	-40	-45	-60	-70	-80		
A-40-1100	-40 to +50	±0.5	6.6	6.6	4.0	1.1	0.5				4 (15)	50 or less
A-40-1900	-40 to +50	±0.5	9.5	9.5	5.4	1.9	0.7				6 (23)	50 or less
A-40-2700	-40 to +50	±0.5	14.5	14.5	9.6	2.7	1.2				10 (38)	50 or less
A-60-2700	-60 to +50	±0.5	3.9	3.9	3.6	3.1	3.0	2.7			2.8 (11)	50 or less
A-60-3000	-60 to +50	±0.5	4.6	4.6	3.7	3.5	3.4	3.0			6 (23)	50 or less
A-60-4600	-60 to +50	±0.5	6.7	6.7	6.1	5.3	5.1	4.6			8 (30)	50 or less
A-80-500	-85 to +50	±0.5	2.3	2.3	2.2	2.1	2.0	1.8	1.5	0.5	2.8 (11)	50 or less
A-80-1700	-85 to +50	±0.5	3.4	3.4	3.1	2.8	2.7	2.3	2.1	1.7	6 (23)	50 or less
A-80-2400	-85 to +50	±0.5	5.0	5.0	4.5	3.9	3.8	3.3	3.1	2.4	8 (30)	50 or less

Model	Temperature Range (°C)	Stability (°C)	Cooling Capacity (kW @ 20°C Water Supply)								Pump Capacity (GPM/LPM)	Fluid Pressure (psig)
			25	0	-20	-40	-45	-60	-70	-80		
W-40-1100	-40 to +50	±0.5	8.0	8.0	4.6	1.1	0.6				4 (15)	50 or less
W-40-2000	-40 to +50	±0.5	10.0	10.0	6.0	2.0	1.0				6 (23)	50 or less
W-40-3100	-40 to +50	±0.5	15.5	15.5	10.0	3.1	1.4				10 (38)	50 or less
W-60-2800	-60 to +50	±0.5	4.0	4.0	3.7	3.2	3.1	2.8			2.8 (11)	50 or less
W-60-3100	-60 to +50	±0.5	4.7	4.7	4.3	3.7	3.6	3.1	1.1		6 (23)	50 or less
W-60-4700	-60 to +50	±0.5	6.8	6.8	6.2	5.4	5.2	4.7	4.0		8 (30)	50 or less
W-80-600	-85 to +50	±0.5	2.5	2.5	2.3	2.1	2.0	1.8	1.6	0.6	2.8 (11)	50 or less
W- 80-1800	-85 to +50	±0.5	3.5	3.5	3.2	2.9	2.8	2.4	2.2	1.8	6 (23)	50 or less
W-80-2500	-85 to +50	±0.5	5.1	5.1	4.5	4.0	3.9	3.4	3.2	2.5	8 (30)	50 or less

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LN2 Cooled Chiller Data Sheet

The Cryogenic Fluid Chiller uses Liquid Nitrogen (LN_2) to cool the Novec 7100 Heat Transfer Fluid (HTF) in an internal heat exchanger. The Heat Transfer Fluid is then pumped to your process, and the gaseous N2 is exhausted to the atmosphere.

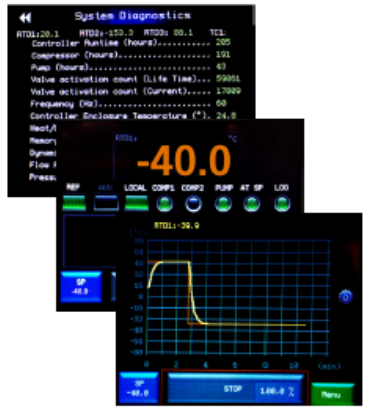
- Up to 25 kW of Cooling Power at -80C
- LN2 consumption automatically adjusted to meet temperature and cooling capacity demand
- Small Footprint and Low Cost
- Powerful controller with remote communications
- Built to UL 61010 and CE Requirements

Description	
LN2 cooled, liquid chiller to provide 20 kW of cooling @ -90C @ 8 GPM @ 30 psi	
General Specifications	
Heat Rejection	LN_2 Cooled
LN_2 Input	1/2" ID VJ Line @ 40 psi
GN_2 Exhaust Port	6" ID Duct
Power	220V, 3 Phase, 60 Hz, 15A Service
Process Fluid	3M Novec 7100 (not included)
Wetted Materials	Hard plumbed copper/stainless
Flow Rate	8.0 GPM @ 30 PSI
System Dimensions	64"H X 22"W X 28"D
Reservoir Size/Type	Sealed Stainless Steel
Ambient Temperature Range	18°C to 27°C (23°C Nominal)

Chiller Controller

The chiller controller provides precision temperature control with touch-screen operation, easy-to-read information, remote operation, and data logging.

Developed by our in-house engineering team, this controller provides flexible setup and customization not readily achievable with PLCs.



Controller Specifications

Temperature Measurement	Range: -210 to +680°C Resolution: 0.1°C full scale
User Interface	5.7" color touch-screen with temperature graphing and charting
Control Safety	High and low temperature limits, Independent fail-safe modules (IFM, optional)
Diagnostics	Runtime hours (controller, chiller, compressor, pump), system performance log, valve activation counts, enclosure temperature
Operating Environment	Temperature: 10 to 50°C Humidity: 0 to 50%
Temperature Sensors	Remote RTD (500 Ohm), thermocouple (type K)
Control Algorithms	Primary loop PID, Dual loop multiple RTD control mode
Communication Interfaces	Ethernet 10/100, Telnet, HTML web server, USB 2.0, RS232 (optional)
Alarms	Low flow, low pressure, low fluid reservoir, over temperature
Compliance	CE / RoHS / UL61010

Controller Features

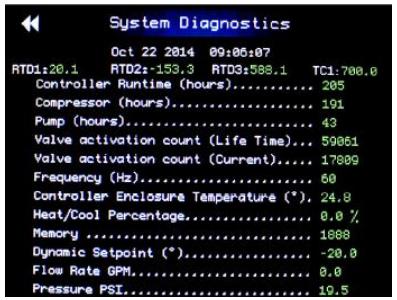
- Displays critical parameters such as fluid supply and return temperature and pressure (based on chiller options selected)
- Alarms for out-of-temperature range, low process flow, low reservoir level, and more
- Built-in diagnostics – valve counts, ambient temp, equipment runtimes
- Displays temperature graphs
- Communicates via Ethernet, USB, HTML Web server, RS-232 (optional)
- Logs system data and performance
- CE and RoHs compliant

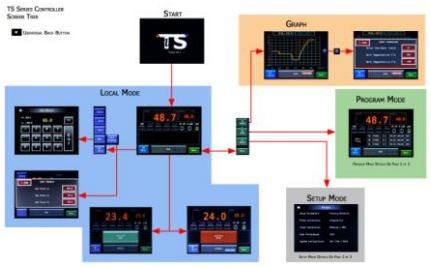
Chiller Features and Options

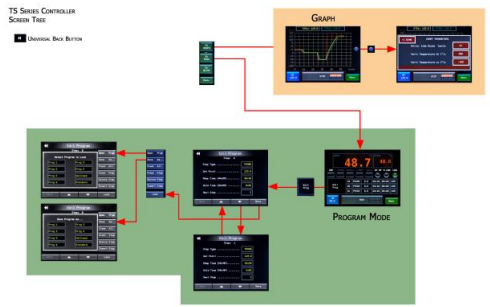
The following slides contain information on the following chiller features and options:

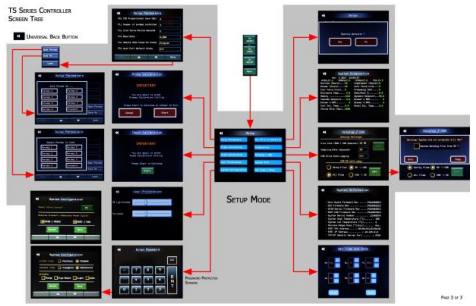
- Chiller Controller
- Programmable Fluid Pressure and Flow
- Communications and Remote Control
- Data logger and Chiller Performance Monitoring
- Chiller Remote Temperature Control
- Anti Backflow Option
- Fluid Purge Option

Powerful Chiller Controller





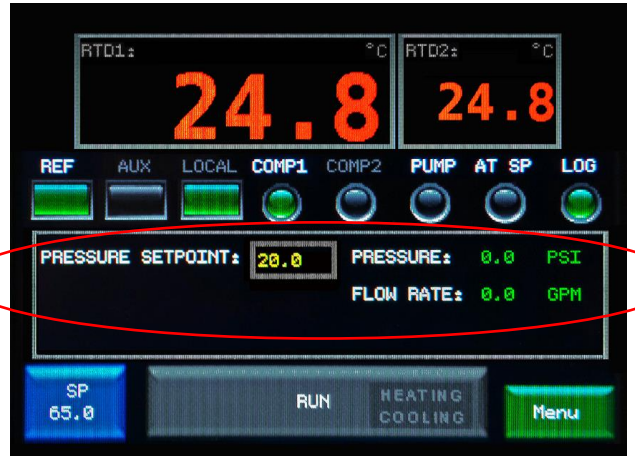


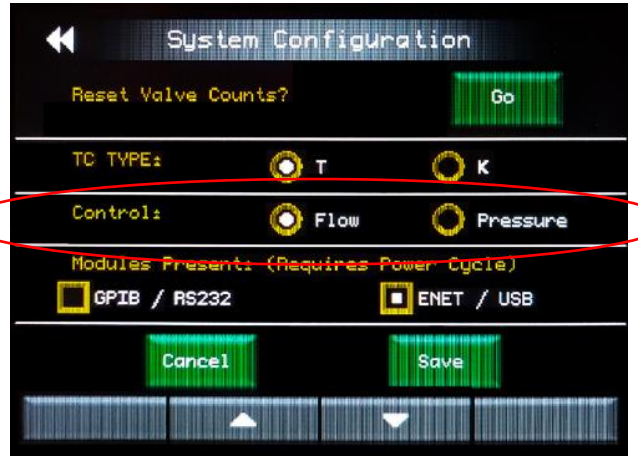


Features include:

- Color Touch Screen
- Graphing
- System Diagnostics
- Data Logging
- Ethernet and RS-232 Remote Control Software
- PID Tuning

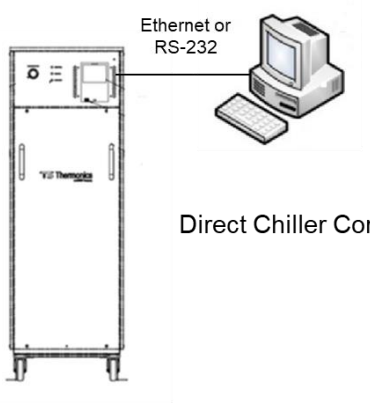
Programmable Fluid Pressure and Flow



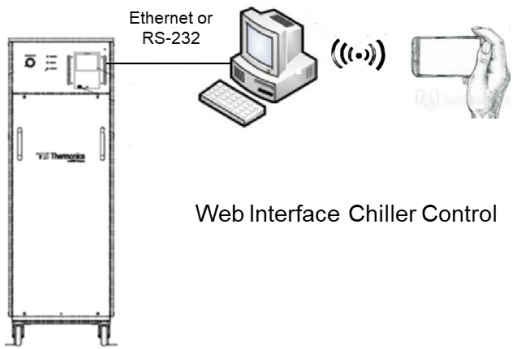


- Adding a Variable Frequency Drive (VFD) to the chiller pump motor allows the user to program and display the fluid output pressure.
- Adding a flow meter to the chiller allows the user to program and read the output flow rate
- The chiller can be configured to run in programmable pressure or programmable flow rate mode
- Pressure and Flow can be remotely controlled

Communications and Remote Control



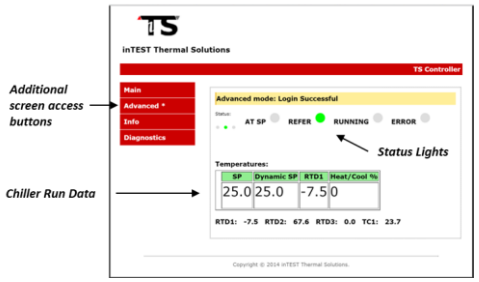
Direct Chiller Control



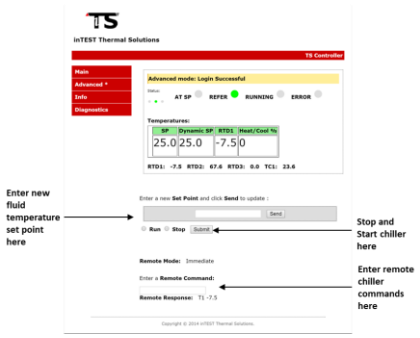
Web Interface Chiller Control

Mobile Device Web Interface Screens

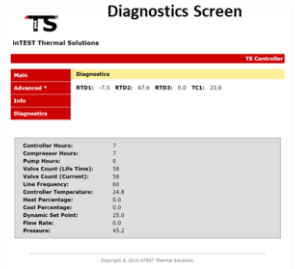
Main Screen



Advanced Screen



Diagnostics Screen



Information Screen

The chiller has the ability to be remotely controlled via Ethernet or RS-232.

Remote commands include, but are not limited to:

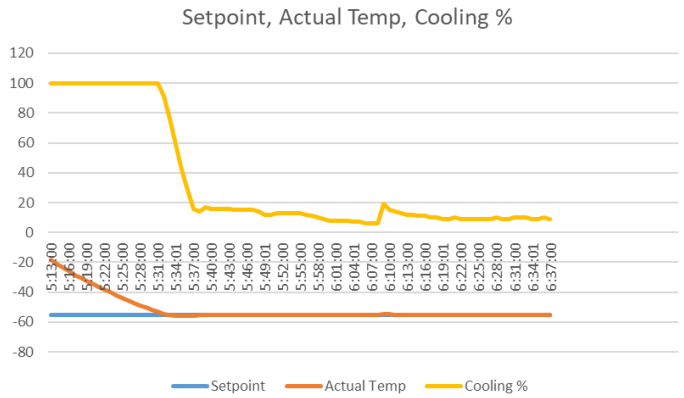
- **Remotely turn the chiller on / off**
- **Remotely set fluid temperature**
- **Read current fluid temperature**
- **Remotely set fluid pressure**
- **Read actual fluid pressure**
- **Receive chiller alarms**
- **Access diagnostic information**
- **Execute other chiller commands**

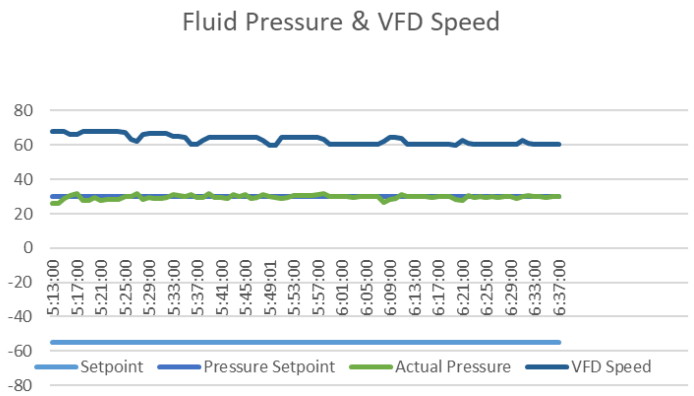
Our Chiller Web Interface allows the user to control and monitor the chiller in real time using a remote computer or mobile device via the internet.

Chiller Data Logger

Raw Data

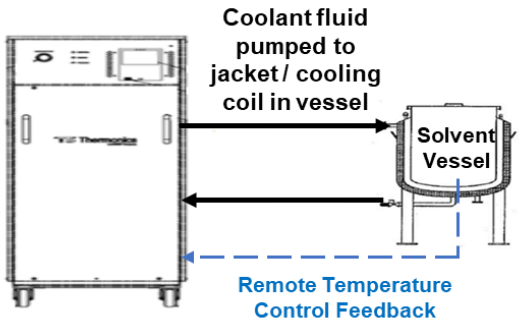
Date	Time	Setpoint	Actual Temp	RTD2	RTD3	TC1	Out24V	Out5V	In24V	In5V	Ht%	Cl%	TempCJ	TempCtrl	Err1	Err2	Valve Cnt	Linef	DynSP	Pressure Setpoint	Actual Pressure	VFD Speed
Dec 18 16	5:13:00	-55	-18.6	700	0	701.5	be	8	7	2	0	100	24.9	38	0	0	688100	50	-55	30	26.2	68
Dec 18 16	5:14:00	-55	-21.2	700	0	701.5	be	8	7	2	0	100	24.9	38	0	0	688100	50	-55	30	26	68
Dec 18 16	5:15:00	-55	-23.6	700	0	701.5	be	8	7	2	0	100	24.9	38	0	0	688100	50	-55	30	28.8	67.8
Dec 18 16	5:16:00	-55	-25.9	700	0	701.5	be	8	7	2	0	100	24.9	38	0	0	688100	50	-55	30	30.4	66.3
Dec 18 16	5:17:00	-55	-28.3	700	0	701.5	be	8	7	2	0	100	24.9	38	0	0	688100	50	-55	30	31.6	65.9
Dec 18 16	5:18:00	-55	-30.4	700	0	701.5	be	8	7	2	0	100	24.8	38	0	0	688101	50	-55	30	27.6	68
Dec 18 16	5:19:00	-55	-32.4	700	0	701.5	be	8	7	2	0	100	24.8	38	0	0	688101	50	-55	30	27.5	68
Dec 18 16	5:20:00	-55	-34.4	700	0	701.5	be	8	7	2	0	100	24.9	38	0	0	688101	50	-55	30	29.5	67.7
Dec 18 16	5:21:00	-55	-36.4	700	0	701.5	be	8	7	2	0	100	24.9	38	0	0	688102	49	-55	30	27.8	68
Dec 18 16	5:22:00	-55	-38.4	700	0	701.5	be	8	7	2	0	100	24.9	38	0	0	688102	50	-55	30	28.3	68
Dec 18 16	5:23:00	-55	-40.2	700	0	701.5	be	8	7	2	0	100	24.9	38	0	0	688102	50	-55	30	28.5	68
Dec 18 16	5:24:00	-55	-42	700	0	701.5	be	8	7	2	0	100	24.9	38	0	0	688103	50	-55	30	28.5	68
Dec 18 16	5:25:00	-55	-43.8	700	0	701.5	be	8	7	2	0	100	24.8	38	0	0	688103	50	-55	30	30.1	67.2
Dec 18 16	5:26:00	-55	-45.5	700	0	701.5	be	8	7	2	0	100	24.8	38	0	0	688103	50	-55	30	30.2	63.1
Dec 18 16	5:27:00	-55	-47.3	700	0	701.5	be	8	7	2	0	100	24.8	38	0	0	688103	50	-55	30	32	62
Dec 18 16	5:28:00	-55	-48.9	700	0	701.5	be	8	7	2	0	100	24.9	38	0	0	688103	50	-55	30	28.4	66
Dec 18 16	5:29:00	-55	-50.4	700	0	701.5	be	8	7	2	0	100	24.8	38	0	0	688103	50	-55	30	29.6	66.5
Dec 18 16	5:30:00	-55	-51.8	700	0	701.5	be	8	7	2	0	100	24.8	38	0	0	688103	50	-55	30	29	66.7
Dec 18 16	5:31:00	-55	-53.2	700	0	701.5	be	8	7	2	0	100	24.8	38	0	0	688105	50	-55	30	29.1	66.7
Dec 18 16	5:32:00	-55	-54.4	700	0	701.5	bf	8	7	2	0	91	24.8	39	0	0	688110	50	-55	30	29.2	66.7
Dec 18 16	5:33:00	-55	-55.3	700	0	701.5	bf	8	7	2	0	76	24.8	39	0	0	688116	50	-55	30	31.3	65.2
Dec 18 16	5:34:01	-55	-55.7	700	0	701.5	bf	8	7	2	0	59	24.8	39	0	0	688122	50	-55	30	30.8	65
Dec 18 16	5:35:00	-55	-56	700	0	701.5	bf	8	7	2	0	42	24.8	39	0	0	688128	50	-55	30	30.1	64.6
Dec 18 16	5:36:00	-55	-56	700	0	701.5	bf	8	7	2	0	28	24.8	39	0	0	688134	50	-55	30	31	60.3
Dec 18 16	5:37:00	-55	-55.9	700	0	701.5	bf	8	7	2	0	16	24.8	39	0	0	688140	50	-55	30	29.5	60.2
Dec 18 16	5:38:00	-55	-55.5	700	0	701.5	bf	8	7	2	0	14	24.8	39	0	0	688146	50	-55	30	29.4	62.9
Dec 18 16	5:39:00	-55	-55.1	700	0	701.5	bf	8	7	2	0	17	24.8	39	0	0	688152	50	-55	30	31.7	64.2
Dec 18 16	5:40:00	-55	-55.1	700	0	701.5	bf	8	7	2	0	16	24.7	39	0	0	688158	50	-55	30	29.5	64.6
Dec 18 16	5:41:00	-55	-55.1	700	0	701.5	bf	8	7	2	0	16	24.8	39	0	0	688164	50	-55	30	29.5	64.6
Dec 18 16	5:42:00	-55	-55	700	0	701.5	bf	8	7	2	0	16	24.8	39	0	0	688170	50	-55	30	28.9	64.7
Dec 18 16	5:43:00	-55	-55	700	0	701.5	bf	8	7	2	0	16	24.8	39	0	0	688177	50	-55	30	31	64.3
Dec 18 16	5:44:00	-55	-55	700	0	701.5	bf	8	7	2	0	15	24.8	39	0	0	688183	50	-55	30	30.2	64.4
Dec 18 16	5:45:00	-55	-55	700	0	701.5	bf	8	7	2	0	15	24.7	39	0	0	688189	50	-55	30	30.9	64.3
Dec 18 16	5:46:00	-55	-55	700	0	701.5	bf	8	7	2	0	15	24.6	39	0	0	688195	50	-55	30	28.9	64.7
Dec 18 16	5:47:00	-55	-55	700	0	701.5	bf	8	7	2	0	15	24.6	39	0	0	688201	49	-55	30	29.3	64.6
Dec 18 16	5:48:00	-55	-55	700	0	701.5	bf	8	7	2	0	14	24.5	39	0	0	688207	50	-55	30	31.1	63

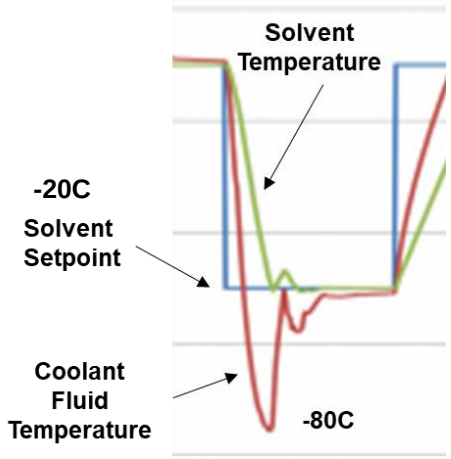




- Thermonics chillers have the unique ability to log many chiller parameters over a long period of time
- Analyzing key chiller parameters can be used to monitor chiller health
- Data logs are also commonly used to aid in debugging chiller failures in the field

Remote Temperature Control





Programmed solvent temperature

Coolant fluid temperature

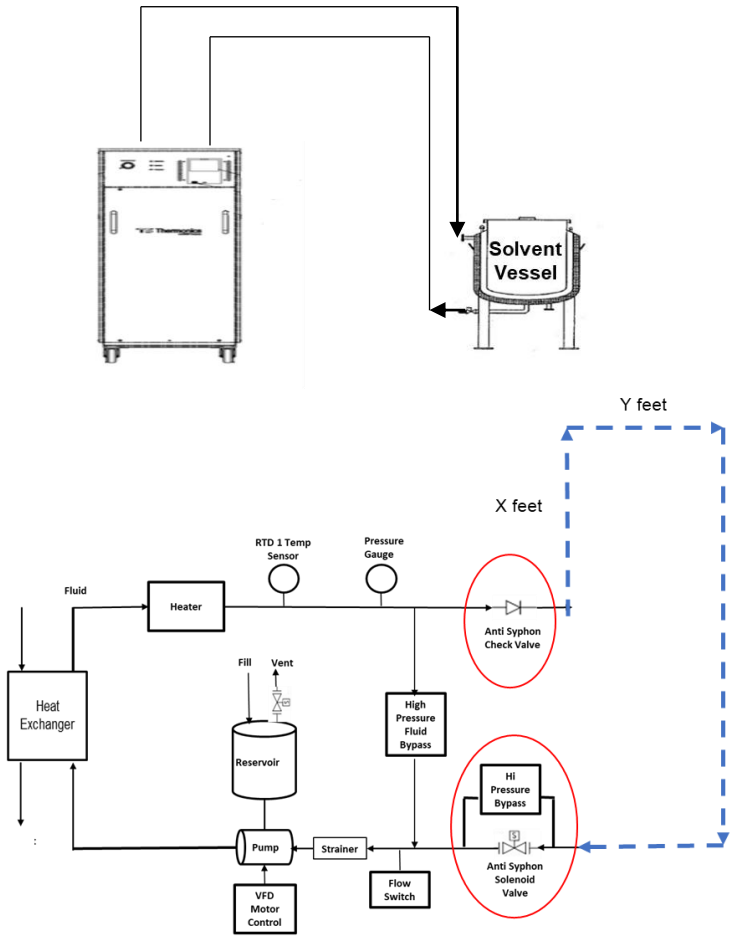
To use Remote Temperature Control, a temperature sensor must be placed at the point to control the temperature

During the transition from warm to cold, the chiller will automatically drive the coolant fluid to it's maximum low temperature to minimize the ramp down time.

The max low temperature during ramp down is programmable.

Once the solvent has reached the desired temperature, the chiller will automatically control the coolant fluid temperature to maintain the solvent temperature.

Anti Backflow Option



When the chiller supply and return lines are not run at the same level from the chiller to the process, the potential exists for fluid to flow from the process back to the chiller when the pump is turned off.

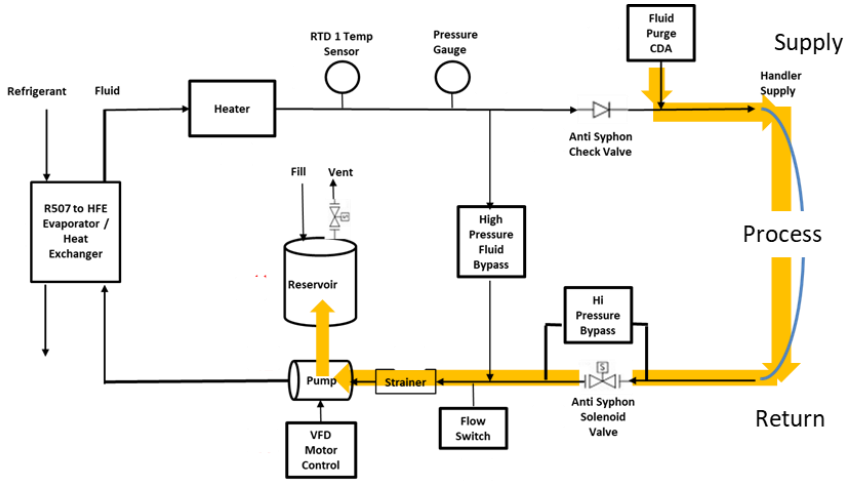
This could cause the reservoir to overfill, and possibly create air pockets in the fluid loop.

To prevent fluid backflow, a check valve is placed in the supply line, and a software controlled solenoid valve is placed on the return line.

When the pump is turned off , the solenoid valve automatically closes, and fluid is prevented from back flowing to the chiller.

A high pressure bypass is included around the solenoid valve to prevent pressure building due to fluid expansion

Fluid Purge Option

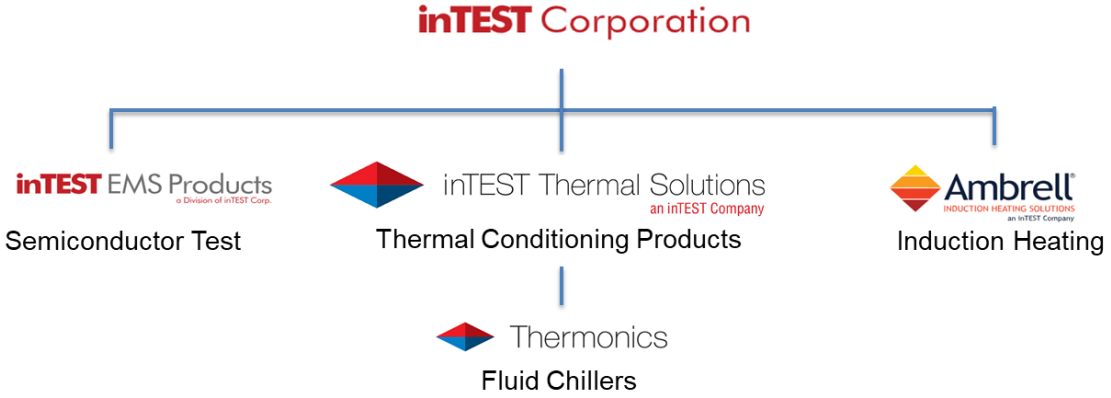


In some applications, it is necessary to rapidly drain the fluid from the supply / return lines and process plumbing.

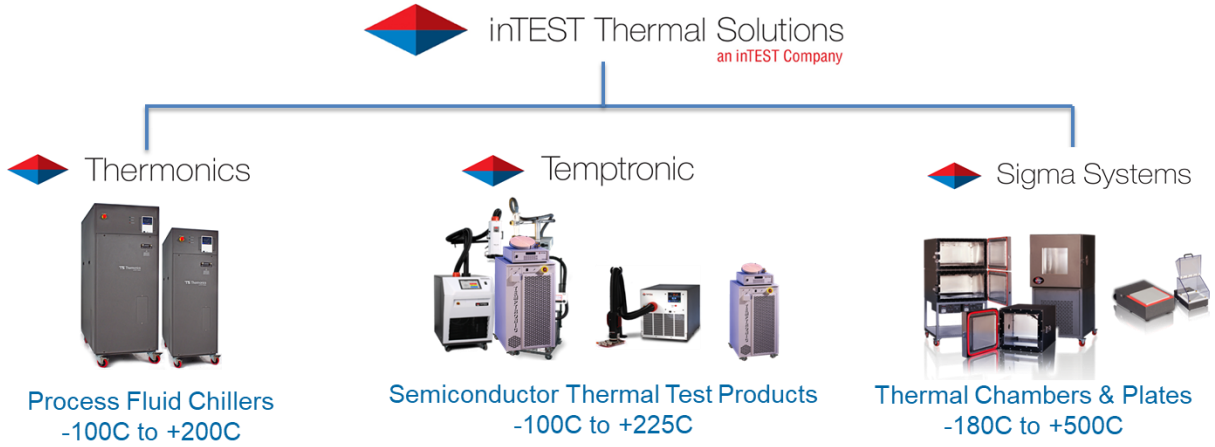
To facilitate this, Thermonics chillers have a Fluid Purge Option. Compressed dry air, or N2 gas is connected to the chiller. Upon activating the fluid purge remotely or from the operator screen, the following sequence occurs:

1. **Pump is turned off**
2. **Anti Syphon Solenoid valve is opened.**
3. **Reservoir solenoid valve vent is opened.**
4. **Purge gas turned on and fluid is forced into reservoir.**
5. **After a programmable duration, the purge gas is turned off and Anti Syphon Solenoid valve closed.**
6. **Lines are now purged and can be disconnected**

About Our Company



- Parent company inTEST Corp founded in 1981
- Yearly revenue approximately $60M
- Publicly traded on NYSE (INTT)
- ≈ 300 employees worldwide



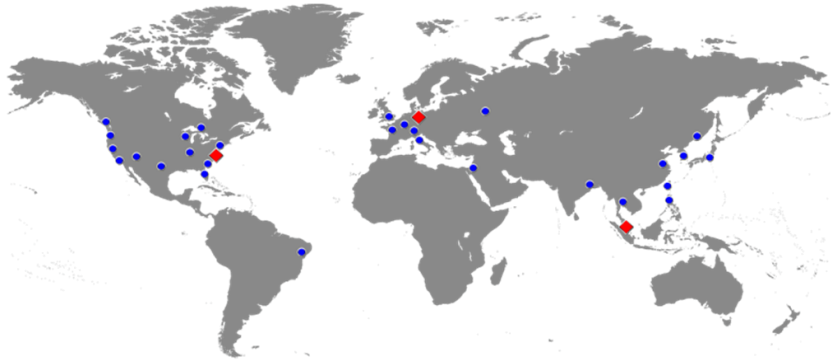
Precise thermal control over extreme temperature ranges

About Our Company

Mansfield MA Manufacturing Facility

- 50,000 sq ft production area
- ISO 9001:2008 certified
- Ship > 500 systems per year

Worldwide Sales and Service



- Direct Sales and Service Offices in Mansfield MA, San Jose CA, Muellrose Germany and Singapore
- Trained third party service providers available in other areas.