

Closed-Loop Cryo Cooler

Cryotherm GmbH & Co. KG and Bruker ASC are closely cooperating in the field of cryo-cooled synchrotron optics. Bruker ASC is very pleased to exclusively promote the Closed-Loop Cryo Coolers worldwide and to integrate the Cryo Coolers into their systems. The cryo system, originally developed at Cryotherm, has been newly upgraded by Bruker ASC with an innovative control system including remotely controlled valves and automated functions to realize a complete remotely controllable system with several different interface options. Another important improvement of the entire system is the achieved pressure stability of the liquid flow (less than 20 mbar), which allows a very stable operation of the DCM.



Closed-Loop Cryo Coolers are typically used to cool down and maintain the crystals of a monochromator –or any other device- close to the temperature of liquid nitrogen. The system is able to absorb heat loads up to 2.500 Watts and to control the temperature with a stability below 0.1 K. More than 50 closed loop systems have been installed world wide at different synchrotron radiation facilities and some early versions of the systems are in operation since about 15 years.

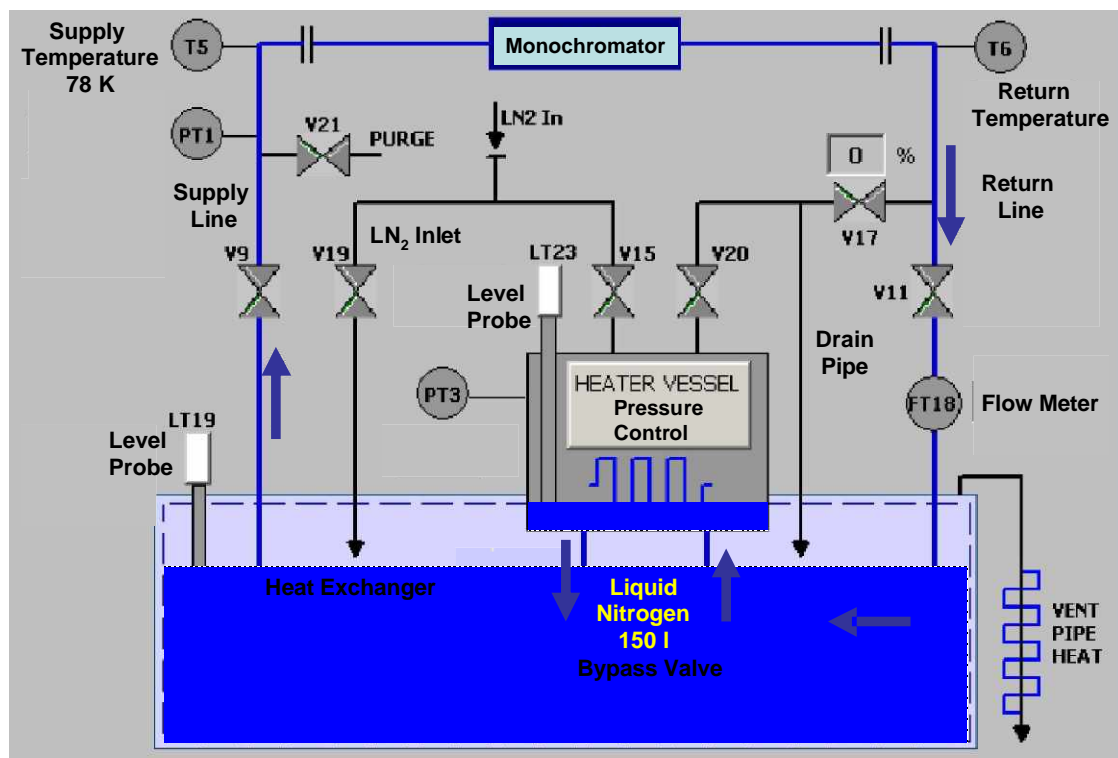
Principle of operation

A small reservoir of sub-cooled liquid nitrogen (max. 15 l of LN₂) inside the so called heater vessel is cycled in a closed loop and cools the consumer, e.g. the crystals of the monochromator or any other component (see figure below). A large LN₂ reservoir (200 l) at atmospheric pressure (77K) cools the 'warm' liquid nitrogen (79 to 90 K) which returns from the consumer (monochromator) by means of the heat exchanger. Heat load transferred to the large liquid nitrogen bath results in an evaporation of liquid nitrogen inside the large LN₂ reservoir. The large LN₂ reservoir can be automatically refilled either from a LN₂ network or by a separate Dewar.

Temperature sensors in the supply and return path are monitoring the LN₂ temperature directly in the path. In order to adjust and control the LN₂ pressure in the closed loop to constant elevated values, a heater is installed in the reservoir. The evaporated nitrogen causes a pressure increase in the closed loop and enables to work with sub-cooled LN₂ in order to avoid the boiling of Nitrogen and therefore allows a stable operation of the cooling.

Two flexible vacuum insulated transfer lines will connect the monochromator (DCM) with the Cryo Cooler. Additional valves in the forward and return path can be used to warm up the crystals by using nitrogen purge gas. The temperature in the supply and return path is directly and constantly monitored. The length of the flexible transfer lines can be as long as 20 m. The control system consists of a 19" rack and can be placed close to the cryo - system or in an external room. The touch screen can be removed from the control rack to operate the system close to the Cryo Cooler.

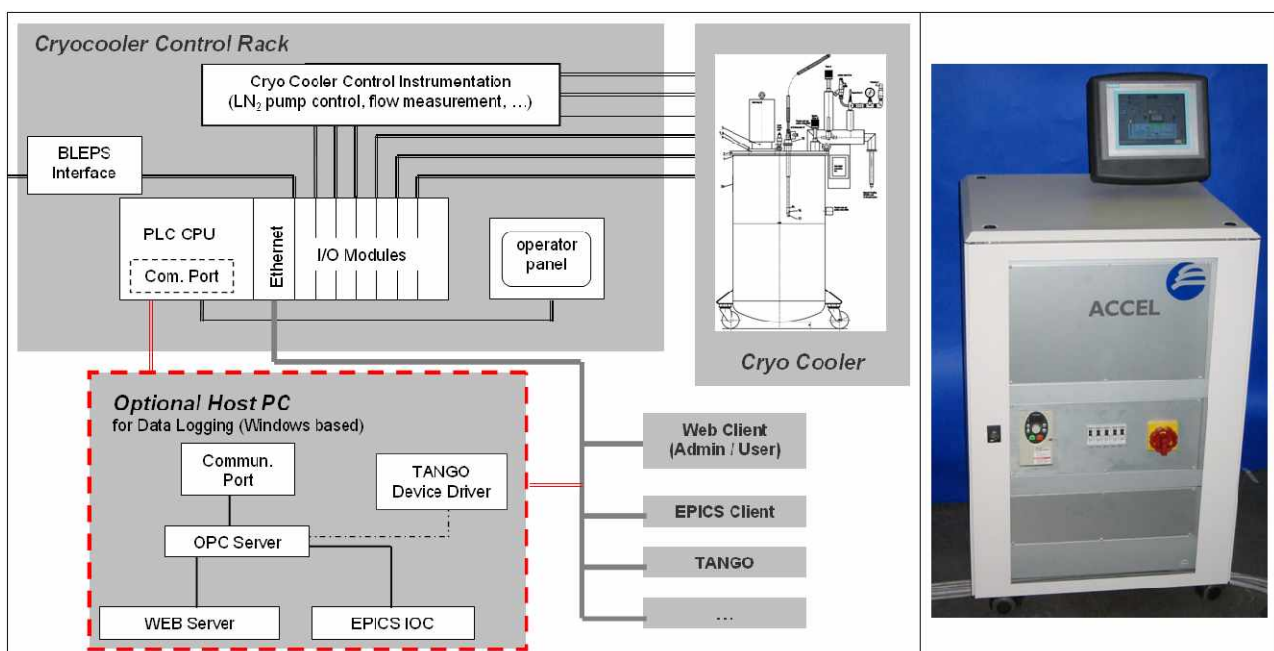
Closed Loop System: Principle of operation / Touch screen layout



Control System

- Full remote control of all valves, closed loop pressure and pumping frequency
- Automated functions such as:
 - Automated refill of large LN₂ reservoir
 - Automated refill of closed loop reservoir
 - Automated cool down
 - Automated warm up
- PLC based controller
- Safety interlocks and connection to equipment protection system (EPS)
- PLC touch screen for direct access
- Remote access via direct Ethernet connection or optional Host PC
- Communication through Web client, EPICS, TANGO, ...
- Secure operation through password protection of operation modes
- Customizing of operating parameters at the touch screen
- Adjustable warning- and alarm triggers
- Automatic reboot after power failure
- Removable touch screen with extension
- Mobile by easy-running castors with locking device
- Compact dimensions (19" cabinet with ~ 1.2 x 0.6 x 0.6 m³)
- Also available 19" modular rack mounts for installation into customers controls cabinet

Architecture of the control system



Technical Data of the Cooler

Cooling power	0 -2500 W
Cooling temperature	78 -100 K
Temperature stability	< 0.1 K
Pressure stability	< 20 mbar
Flow rate	Up to 1400 l/h
Max. operating pressure	Up to 10 bar
Total height	2.0 m
Total width	0.7 m
Total length	1.1 m

Complete system consisting of Cryo cooler, controller (old version) and monochromator



Advantages

- No boiling liquid at the crystals' heat exchanger
- Vibration-free operation
- Continuous operation
- Closed-loop system
- Low liquid Nitrogen consumption
- High efficiency
- Large cooling power reserve
- Mobile by easy-running castors with locking device and fork lift truck-slots
- High flexibility
- Fully automated operation and data logging
- Integrated automatic functions
- High reliability and safety (pressure relief valves at each volume at cryogenic temperature)

Options

- Host PC (Windows based) for data logging including 60 GB hard disk
- Forward Heater for increased temperatures in the forward stream of the closed loop
- Customized design of LN₂ transfer lines and interface to consumer
- Refrigerator to enable autonomous operation (LN₂ consumption reduced to a negligible minimum) of the Cryo Cooler system for consumer heat loads of up to 200 Watts

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