

## ***1. Introduction***

The Oxford Instruments Cryo-cooler is a closed loop liquid nitrogen cooler, which provides pure liquid nitrogen for cooling monochromator optics. Nitrogen vapour has been eliminated from the circulating liquid, so that there are no vibrations due to boiling liquid in the cooling circuit.

The single-phase liquid nitrogen is produced by immersing a copper coil carrying high pressure liquid nitrogen in a liquid nitrogen bath. The high pressure raises the boiling point of the liquid nitrogen circuit whilst the liquid nitrogen bath provides sufficient cooling to dissipate the heat load from the optical components and internal heat leaks. The closed loop circuit has a maximum design pressure of 10 bar absolute and the liquid nitrogen bath operates at 1 psi gauge.

### ***1.1 Principle of Operation***

When a monochromator crystal is heated, thermal gradients are set up across the crystal which cause the crystal to distort. These distortions can be minimised by optimising the cooling of the crystal. Cryogenic cooling of monochromator optics has advantages over simple water cooling. The ratio of the coefficient of thermal expansion,  $\alpha$ , to thermal conductivity,  $k$ , for silicon, is smaller at liquid nitrogen temperature than at room temperature. Distortions of the crystal due to thermal gradients are therefore reduced if the crystal is cooled to 80-100 K.

In order to provide adequate cooling of the crystal, liquid nitrogen is pumped around a closed loop circuit which passes through cooling channels in the optic crystal. This closed loop is under high pressure (up to 10 bar abs) to suppress boiling in the liquid. Heat taken up by the circulating liquid is dissipated in a sub-cooler coil immersed in a bath of liquid nitrogen at 1 psi above atmospheric pressure. The liquid level in this bath is continually topped up to replace the liquid boiled away.

### ***1.2 Scope of this Manual***

This operators manual refers to a modified series C cryocooler, known as a series C+ with Auto-Restart and phase angle heater control. The C+ has been derived from a series C but there are minor changes which make it differ from a standard series C cryocooler. These changes are listed below.

- An additional temperature sensor to monitor temperature at the pump outlet.
- An additional pressure transmitter to monitor pressure at the pump outlet.

- The temperature is displayed on a Lakeshore 819 display instead of an 818. The 819 model is a multi channel unit.
- An Auto-Restart circuit has been included that allows the system to re-start following a mains failure of less than 2 minutes.
- The heater control has been changed from 10 second, time proportional, to a full P.I.D. phase angle control.

This manual is intended to be used by the Cryo-Cooler Operator - the person who normally operates the Cryo-Cooler. The Operator is expected to be already familiar with the use of cryogenic substances and scientific instrumentation.

This manual gives information and instructions on the operation of the Cryo-Cooler and its component systems.

Section 2 provides important safety information about the Cryo-Cooler.

Section 3 describes the hardware of the Cryo-Cooler system.

Section 4 gives details of Operating Procedures - tasks that are carried out during normal operation of the Cryocooler.

Section 5 is a technical reference section which is included to assist the operator in fault finding procedures.

Section 6 gives details of Routine Maintenance procedures for which the Operator is responsible such as routine checks and replenishing consumable items. The Operator is not necessarily required to carry out these tasks personally, but is responsible for ensuring that they are carried out correctly and at the proper times.

Section 7 gives details of Trouble Shooting procedures including more complex maintenance and repair tasks

Section 8 gives details of the spare parts available for the Cryo-Cooler.

Section 9 gives details of Additional Documentation available which includes a list of third party manuals and a list of the data sheets available for items.

Ensure that you read and understand the information in Section 2 Safety before attempting any operations. Where particular hazards to either the Operator or the equipment might be encountered, they will be noted in the text.

The information contained in this manual is believed to be correct. However Oxford Instruments accept no liability for errors or omissions.