The Helium Problem

Helium used to be relatively cheap and available in both liquid and gas form. This is no longer true. As a result, universities and laboratories are increasingly using 4 K coolers and helium liquefiers based on coolers.

Introduction

Cooling and cooling-down a magnet with coolers is different from cooling a magnet with a conventional helium refrigerator. When a large helium refrigerator is used, col gas from an expander or J-T valve is delivered to the magnet cryostat at a constant flow and under pressure. When the system is cold enough liquid helium is collected. When the boil-off helium is returned to the cold box cold the machine operates as a refrigerator. When the gas is returned to the system warm it behaves like a liquefier. A cooler delivers refrigeration to the device being cooled by conduction to the cold heads. The connection between the cold head and the magnet can be through a copper strap or some form of a cooling loop or heat pipe. The latter approach requires that there be a connection through gas or combined liquid and gas in the cooling loop.

Cryogen-free Conduction Cooling

The refrigeration delivered by a cooler is a function of the cooler cold head temperature. That is true for single-stage or two-stage coolers. For heat to flow to the cooler cold heads there is a temperature drop across the strap connected to the load and there is a temperature drop within the load. The total allowable temperature drop at 4 K between the hot spot in a magnet to the cooler cold head should be < 0.5 K. For coolers operating on loads at higher temperatures the total allowable temperature drop is increased.

Coooling Loops can use other Cryogens besides He

Any fluid can be used to transfer heat to a cooler when there is two-phase cooling. We looked at hydrogen and neon along with helium. While cooling-down a load, hydrogen is a little less cold than helium. In a two-phase cooling cycle hydrogen is cold enough to liquefy the helium, and the liquid can be stored in a cryostat. If a load requires less than 3.6 MW the hydrogen can be used to liquefy the helium. If the load requires more than 3.6 MW the load can be cooled using a cryogen other than helium.

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