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nEXO Underground LN2 Plant at SNOLAB

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nEXO is a tonne scale neutrinoless double beta decay experiment which will use 5,000 kg of Xenon-136 as its target fluid. nEXO will need to cool the liquid xenon (LXe) down to 165 K (-108.15 ℃) for ten years of continuous operation. nEXO will be located at SNOLAB, in its facility 2 km underground in Vale's Creighton nickel mine.

A 12,000-litre liquid nitrogen (LN2) plant will be required for maintaining the experiment temperature +/-0.1 K over ten years of operation. nEXO also requires a LXe recovery system, which needs a large volume of bulk cooling to be able to condense the LXe exterior to the detector.

SNOLAB's underground environment imposes severe spatial limitations, and designing an efficient LN2 plant within these confines requires creative solutions. Compactness becomes paramount, necessitating detailed layouts that maximize every square meter.

Maintaining the LN2 plant requires robust cooling power, the system must handle the experiment's transient heat load generated during: (1) condensation of GN2 to LN2, (2) the cooling the hydrofluoroether (HFE), and (3) condensation of GXe to LXe into the experiment's central volume. The plant design of 8 kW cooling capacity ensures sufficient margin during phase changes and losses in the system.

The system will circulate LN2 to two heat exchangers: one for LXe and one for the HFE. The HFE is used to maintain a stable temperature within the experiment's inner volume while being surrounded by a vacuum space in the outer vessel to maintain the HFE temperature.

nEXO requires high-purity LN2; the nitrogen plant will provide 99.999% pure nitrogen. Maintaining this purity throughout the system is essential for experiment background considerations. Any impurities could affect data integrity and compromise the scientific goals of the experiment. Rigorous quality control testing will ensure that the LN2 meets stringent purity standards.

Operating a LN2 plant underground provides usual safety concerns a unique twist. Ventilation systems must accommodate large volumes of boil-off nitrogen gas, which could displace breathable air. A safety challenge lies in ensuring efficient gas dispersion and supplying sufficient makeup air. In an underground environment, Oxygen Deficiency Hazards are of critical importance. Therefore, designing fail-safes to prevent accidental exposure to LN2/GN2 are always the highest priority.

SNOLAB is a global leader in low background astroparticle physics research and underground science. Having a dedicated LN2 plant located in the underground facility to supply nEXO's cooling needs without interruption shows SNOLAB's commitment to support world class science.

Submitters Country

Canada

Author: HILLIER, Tristan (SNOLAB)

Presenter: HILLIER, Tristan (SNOLAB)

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