

Design and 1st year operating experience of the novel 30kW cooling system for the INFN Icarus project



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CONCLUSIONS / EXECUTIVE SUMMARY

A novel closed loop LN₂ re-liquefaction system, to operate continuously for 10 years, has been designed and build, based on Stirling's SPC-4 cryogenerators for the Icarus neutrino detector project in Italy. Its design capacity is adjustable and ranges from 18 to 30kW @ 84K. The (initial) system consist of 10 SPC-4 cryogenerators with control, 2 LN₂ pumps, 3 intermediate (1,000ltr) and 2 main vessels (30,000ltr), interconnection piping, commissioning and start-up etc.

The philosophy behind this system is to have redundant, individual, components for a specific task (cooling, pumping, control, storage, piping) and connect them in such a way that in case of failure (or maintenance) of a (or more) individual component still sufficient cooling can be guaranteed, by making sure that everything is interconnected.

The system has been commissioned in March 2009 and has been fully operational since April 2010, successfully proving its concept.

The system takes about 11.9kW of electrical power to produce 1kW of cold at 84K. Investment cost were in the range of EUR 85 – 113 per watt provided. At Icarus the total operating cost are in the range of EUR 2.22 per kW of cold produced, which includes power, spare parts and labor. The largest component in this is the local power cost.

They supply temperature of the LN₂ is very stable: normally $\pm 0.1K$ of its set point (max. $\pm 0.2K$).

After commissioning the specified 30kW cooling power appeared to be insufficient, due to the, higher then anticipated, heat load of the application. However, as it is based on a modular set up, it could easily be extended with an additional 8.2kW, which was installed in February 2011, without compromising the continuous supply of cooling.

The system survived the 2009 L'Aquila earthquake without any damage.

During the installation/commissioning several modifications/improvements have been implemented to improve and fine tune operations.

The first maintenance cycle was expedited and executed without compromising the continuous supply of cooling. Maintenance is due every 6,000 operating hours of each individual cryogenerator (8,000 hrs for the LN₂ pumps).

Operating experience and recommendations are shared.

The system set-up/philosophy is very suitable to apply on other demanding cooling applications like HTS power cables, to provide uninterrupted and highly reliable, continuous cryogenic cooling.