

Guidelines for Fluorocarbon Evaporative Cooling Systems Adopted for Use with Elementary Particle Detectors

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We discuss guidelines for the design of evaporative cooling systems dedicated to elementary particle detectors operating in high radiation environments. Although such systems share the same principles as classical cooling circuits their final configuration is quite different from the industry standard. The designer must meet many non-standard requirements while strictly following a path toward the highest efficiency, since the temperature sensitivity of the detectors at their point of use is particularly critical. The principal design differences originate from the requirement that such cooling systems operate in difficult environmental conditions - of high radiation levels and magnetic fields, with tight space constraints. The structures required to be cooled are very expensive with delicate electronic structures that can be easily damaged, even though small leaks. These limitations led to the use of saturated fluorocarbon fluids, due to their high dielectric performance, radiation hardness and chemical stability. The following fluids; perfluoro-n-propane ($n\text{-C}_3\text{F}_8$, refrigerant R218), perfluoro-n-butane ($n\text{-C}_4\text{F}_{10}$, refrigerant R610) and perfluoro-n-ethane ($n\text{-C}_2\text{F}_6$, refrigerant R116) have been used in evaporative cooling circuits. In some applications mixtures of these fluids must be considered. Oil-free compressor circuits are required for these cooling systems due to the long and complicated routings of the refrigerant lines (up to several hundred metres). Several specific designs will be presented including some with non-traditional positioning of the standard evaporative circuit elements. Our presentation is based on development work for experiments at the CERN Large Hadron Collider (LHC) during the last 15 years.