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The Ice Filter – A Unique Approach to Volatile Organic Compound Emissions

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ABSTRACT

The ice filter is a low temperature solids filtration technique that is completely unique in the Volatile Organic Compound (VOC) emissions market. The principal is to clean gaseous waste streams by condensing and freezing out VOC's and then remove the solid via a filter media. The filter is periodically cleaned by a *reverse jet* (or blow back) of high-pressure nitrogen gas, allowing continuous 24hour operation.

The ice filter principle was first demonstrated with the removal of water ice down to a level of 1.5ppb (-110°C dew point). Actual operation was then simulated using trichloroethylene, an industrial solvent, which freezes at –87°C. The development programme focused on treating a gas stream saturated with trichloroethylene at 15°C. The results show we reduced the VOC content to practically zero ppm operating at temperatures below –105°C. Furthermore we matched the theoretical temperature-VOC concentration relationship for a wide range of temperatures (30°C).

The development of the ice filter has been driven by the tightening and closer enforcement of environmental legislation concerning the emission of VOC's. Air Products is already a market leader in the cryogenic condensation of VOC's with over 60 Cryo-Condap® installations worldwide. In the past legislation was such that levels could be met by purely condensing VOC's, but now levels of *20mg/m³* are common which require freezing to achieve the correct vapour pressure. For example an emission level of 20mg/m³ for Methylene Chloride equates to an operating temperature of –120°C, however its freeze point is –95°C.

All cryogenic condensation systems including Cryo-Condap® operate using an indirect heat exchanger, commonly a shell and tube design, which all face the same problem: *Solid Build Up*. Frozen VOC builds up on the tubes of the heat exchanger which reduces the heat transfer and increases pressure drop across the heat exchanger. The standard solution common to all equipment is to use two parallel paths, such that when one heat exchanger is iced up the process is switched to the other path, the 'iced up' heat exchanger is then regenerated. This greatly increases the size and cost of the equipment.

There is another problem: At the cold end of the heat exchanger solid VOC's do not adhere to the liquid nitrogen tubes (similar to the *Zero Adhesion Technology*). Solid VOC 'snow' tends to become entrained in the gas stream and into the process exhaust, enough to breach emission limits. Demisters are currently used to try and remove the snow however they cannot achieve the filter efficiency of 100% at 1micron to guarantee emission limits. Demisters also are difficult to keep cold and regenerate effectively.

The ice filter solves both these problems at a cheaper capital cost: it can operate as a stand-alone system or as an addition Cryo-Condap® or even a competitors system. It will also open up the low flow market where Cryo-Condap® has previously been too expensive. It offers the only cryogenic solution to tougher environmental legislation in line with Air Products ethic on Responsible Care® and will be proven shortly by the first full-scale prototype.