

ALTERNATIVE NON-CFC REFRIGERANTS FOR LOW TEMPERATURE REFRIGERATION APPLICATIONS

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Expanding knowledge on adverse environmental implications of chlorinated refrigerants (CFCs) has intensified the global search for suitable alternatives for a vast number of refrigeration applications. Ban on the use CFCs as a part of global phase out mechanism made two of the widely used low temperature refrigerants; R13 and R503, completely unavailable for the future use. This left the low temperature refrigeration industry in a difficult situation with regard to the finding, of suitable alternatives. However, only a very limited number of potential replacements are commercially available for a range of different low temperature refrigeration applications. Unlike familiar cooling applications around 0 °C, when working at very low temperatures limitations of the refrigerants themselves appear, such as considerable variation of thermal-physical properties, rendering the selection process more difficult.

The selection criterion of refrigerants for a specified application is made up of aspects on thermal-physical properties, environmental and safety concerns. However, when selecting a refrigerant for a specified vapour compression application, an inherent balance exists between the capacity and the efficiency that depends on the location of the range of operating temperature in relation to the critical point of the fluid concern. Based on a comprehensive screening process of currently available refrigerants, this paper assesses the suitability of certain selected refrigerants for low temperature applications. The evaluation criterion is based on thermal-physical properties and the performance of the refrigerants in the low temperature circuit of cascade refrigeration systems at evaporating temperatures below -50 °C.

Screening criterion identified R14, R170, R116, R41 and R504 as potential replacements for R13 and R503. From the performance evaluation, two fluorocarbons R116 and R14, and hydrocarbon R170 are identified as potential non-CFC refrigerants for low temperature circuit of new cascade refrigeration systems. Among these, R116 exhibits the lowest compressor discharge temperatures and R14 has the highest volumetric refrigerating capacity (kJ/m^3). Further, fluorocarbon R116 and currently marketed R508A, R508B are found to be good candidates for R13 or R503 retrofits, i.e. conversions of existing CFC based systems. In addition, with appropriate designs, R14 is found to be a suitable refrigerant for applications even below -100 °C. Further, it was understood that R14 makes a good candidate for mixing with other refrigerants to obtain an environmentally friendly zeotropic mixture for cooling applications operating between -60 °C to -100 °C, producing much lower compressor discharge temperatures compared with those of R508A and R508B under similar operating conditions. With all the identified potential refrigerants, de-superheating of low temperature circuit's compressor discharge becomes an essential system requirement for applications below about -80 °C.