

Refrigerant Selection

Introduction

Selection of refrigerant has been continually debated since the commercialisation of refrigeration technology. Recent amendments to the Montreal Protocol (particularly the Kigali Amendment, which seeks to phase down the production and consumption of hydrofluorocarbons, HFCs), the issuance of EU and UK ozone and F-gas regulations as well as the wider discussion over “net zero” encourages the selection of low GWP refrigerants. However, many of the low GWP options have additional safety and/or cost implications associated with them and therefore selection of refrigerant is not usually straightforward.

Refrigerant selection may be approached through several steps, considering environmental legal obligation, safety requirements, efficiency, material compatibility and availability of components, competent technicians and the refrigerant itself. These steps filter out refrigerant options, leaving a smaller group to choose from.

Currently in ISO 817 there are over 160 single compound and blend refrigerants.

Environmental legal obligations

Legislation prohibits certain refrigerants and in some cases for particular equipment and applications. In the UK, the Ozone-Depleting Substances and Fluorinated Greenhouse Gases Regulations 2019 prohibits substances with a significant ozone depleting potential, such as CFCs, HCFCs and others.¹ Similarly, HFCs with a GWP above certain thresholds are prohibited from various types of equipment.

Safety requirements

Various regulations impose requirements on the use of substances which may be used as refrigerants for certain situations. Primarily there are safety regulations, such as Pressure Equipment Safety Regulations 2016, Supply of Machinery (Safety) Regulations 2008 and Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016. In general, such regulations do not prohibit the use of any substances that may be used as refrigerants, but systems using refrigerants with higher operating pressures, higher toxicity or flammability can become more expensive. Safety standards (such as EN 378, EN 60335-2-40, EN 60335-2-89) tend to be more prescriptive and can disallow certain refrigerants being used for particular installations. However, safety standards are not mandatory provided alternative means can be used to satisfy the requirements of the safety regulations.

Efficiency

Refrigerants' thermophysical properties influence the efficiency of a cycle for a given temperature lift. Amongst the suitable refrigerants for a given temperature lift, cycle efficiency can vary by up to about $\pm 10\%$. However, many other aspects associated with the design of a system, such as type of cycle, heat exchanger design, compressor selection and control strategies can have a far greater impact on efficiency. For many types of equipment, there are minimum efficiency rules, so irrespective of the refrigerant used, equipment has to achieve or exceed some efficiency threshold. Whilst most refrigerants will be able to meet such requirements, some may require greater investment in system materials (e.g., greater heat exchanger size) than with others.

¹ As listed in Annex I of Regulation (EC) No 1005/2009

Materials compatibility

Materials such as oils, elastomers, plastics, etc. should be compatible with the refrigerant used in the system. Compatibility can refer to chemical stability (absence of strong chemical reactions), miscibility and solubility with oils and structural stability (minimal changes in properties due to adsorption). These are usually handled at screening stages before commercialisation of the refrigerant.

Component availability

System components should be suited to the refrigerant used. Sometimes components are unavailable for certain refrigerants and particular types of systems. This is often related to the above mentioned legal and safety requirements or that the refrigerant is in initial stages of commercialisation. Using refrigerants with components that are not approved for their use can invalidate warranties and be counter to legal requirements.

Refrigerant availability

Amongst the numerous medium and low GWP blends that have been assigned R-numbers, many are not commercially available. The same applies to some single compound refrigerants. Thus, local availability of refrigerant options can also limit choice. With the phase down imposed by the F gas regulation, certain high GWP refrigerants will have limited availability in the future.

Technician competence

Given the wide variety of refrigerants' characteristics, technicians seldom have competency to work on all refrigerants and any type of equipment. Therefore, when selecting a refrigerant, it must be ensured that the technicians available to work on those systems are suitably qualified.²

Concluding remarks

Considering the various "filters" identified above, the original list of 160+ refrigerants maybe narrowed down to about 20 – 30 refrigerants, which may be whittled down further when considering the specific application. However, as a general principle, whichever options are suitable, those with the lowest GWP should be prioritised provided the requisite safety and efficiency measures can be satisfied.

A more thorough discussion on these topics can be found in the RTOC reports³.

The IOR provides a range of Guidance Notes on the characteristics, design, installation, service and good practice use of all refrigerants. IOR policy is to promote the responsible use of refrigerants, for the public benefit. A responsible refrigerant use policy places a high emphasis on the elimination of leak sources, the efficiency of the overall system and the life cycle cost of ownership.

For further information refer to

https://ozone.unep.org/sites/default/files/2019-04/RTOC-assessment-report-2018_0.pdf

<https://www.gov.uk/government/collections/fluorinated-gas-f-gas-guidance-for-users-producers-and-traders>

Disclaimer

The Institute of Refrigeration accepts no responsibility for errors and omissions.

Issued free to members.

© Institute of Refrigeration 2021

² For example, the ACRIB Skillcard identifies the technicians' refrigerant skills

³ https://ozone.unep.org/sites/default/files/2019-04/RTOC-assessment-report-2018_0.pdf