Low-GWP Alternatives in Commercial Refrigeration: Propane, CO$_2$ and HFO Case Studies
CASE STUDY

Waitrose Commercial Refrigeration

Name of the Store/facility:
Waitrose, Bromley South

Location:
Bromley, Kent, UK

Contact information:
Jim Burnett, jim_burnett@johnlewis.co.uk

Type of Facility:
Supermarket, Store Area =2,170 m², Groceries, Food.

Waitrose Limited is an upmarket chain of British supermarkets, forming the food retail division of Britain’s largest employee-owned retailer.

Refrigerant Used:
Honeywell Solstice™ ze, R-1234ze, HFO-1234ze.
This case study has the world’s first HFO chillers.

Project Background:
Bromley is near London and the store has a 2,170 m² sales area. The Bromley South store was opened in November 1996 and the plant was typical of systems built around that time. The existing system was R-404A and did not comply with the Waitrose policy of HFC reduction. Waitrose has signed on to the Consumer Goods Forums Resolution to start phasing out HFC refrigeration systems from 2015. Fig. 1 shows a photo of the store.

The new system is composed of two air-cooled HFO machines, each rated at 180 kW, which provide chilled water as a condensing medium for the in-store integral cases which run on propane. Waitrose is carrying out energy assessments on the chillers in the Bromley store to establish how they perform in relation to comparable chillers running on hydrocarbons. If the trial is successful as anticipated, Waitrose plans to adopt the HFO solution as part of its refrigeration platform for future stores.

Ambient conditions are typical of that around the UK and close proximity to London where the winter temperatures seldom fall below –4° C or rise above 14° C and the summer average temperature is 24° C.

The chilled water project was carried out in 2011 whereby the existing compressor refrigeration packs were made redundant and the chilled water system installed.

Waitrose had decided on a water-cooled refrigeration system as these both reduced the refrigerant charges in the branch (as each cabinet is integral) and the potential for leakage due to water being at a lower pressure and systems being of a small individual charge.

Jim Burnett of Waitrose said: "We believe the HFO solution shows great promise, as it combines good efficiency with very low global warming potential. This is obviously a highly desirable profile in a refrigerant. If the ongoing monitoring of energy continues to prove successful, we plan to include HFO-based chillers in our choice of refrigeration platforms for stores in the future".

New System/Installation:
1,3,3,3-Tetrafluoropropene (HFO-1234ze) is a hydrofluoroolefin. Solstice™ ze is a fluorinated gas from the HFO family that was developed as a “fourth generation” refrigerant to replace R-134a and other HFCs with high GWPs. HFO-1234ze has zero ozone-depletion potential and a low global-warming potential (GWP = 6).

Component selection information was very limited due to the pioneering use of this new refrigerant; reciprocating compressors were the only option at the time of installation.

The system is believed to be the world’s first supermarket installation of a packaged chiller using an HFO refrigerant. The Italian-made Geoclimachillers are based on Frascold reciprocating compressors and operate on refrigerant HFO R-1234ze from Honeywell.
Schematic for the installed compressors

Fig. 2. Schematics for the installed compressors
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Fig. 2 shows schematics for the installed compressors. Its specifications are provided in Table 1. The total cooling capacity of the chillers was 360 kW with 21°C/15°C secondary fluid temperatures using 30% propylene glycol and 35°C air on temperature, split equally between two machines.

The refrigerant mass flow is 0.59 kg/s per compressor x 2 compressors per chiller x 2 chillers; each compressor is using 23.2 kW of power at full load; the design evaporating temperature is 11°C; the design condensing temperature is 50.5°C. The overall chiller energy efficiency ratio (EER) at full load is 3.50, but it must be remembered that this is a free-cooling chiller, thus the fan energy consumption is relatively high due to the increased air resistance, but the overall annual energy consumption is relatively low due to this same free-cooling. Free-cooling chillers are designed when the need for cooling continues during colder ambient temperatures and that ambient temperature is lower than the return liquid temperature. In this case, there is a large potential to reduce the energy consumption of the liquid chillers by utilising the benefit of low ambient temperatures for substantial proportions of the year.

The system specifications and its capacity are presented in Table 2.

Since it is the first application of this new refrigerant in the world, very limited performance and design information is currently available. The new system has performed as expected so far, but better optimisation of the compressor motor / swept volume arrangement could lead to better EER.

Performance:
Since installation this plant has been performing well and no failures have been reported.

The first chillers using the new HFO refrigerants were tried at Waitrose in this supermarket.

This refrigerant has a GWP of 6, i.e. double that of propane (GWP=3.3) but still very low compared with HFCs in general.

The evaporators used with HFO-1234ze should be oversized by around 6% compared to R-134a. There is no discernible difference in the required condensing coil area or air volume. The refrigerant lines need to be generously sized in the gas phase when using HFO-1234ze. The expansion valve sizing is effectively the same as R-134a. The extra cost of the HFO-1234ze compared to R-134a is offset by the lower volume of refrigerant, due to the use of DX evaporators with the HFO-1234ze to deliver the same efficiency as R-134a with flooded evaporator.

All the components have performed as anticipated.