

# Opt

for better

Kitchen Garden Produce reap the rewards of an innovative application by pioneering installer Welvent using Opteon™ XL40 (R-454A) from Chemours

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Opteon™

Kitchen Garden Produce are a premium supplier of foods to UK supermarkets, in particular shallots. Started in 1979 on a 22.5 acre site, the business has steadily grown and now supplies over 5,000 tonnes of shallots to the UK market. This represents c. 60% of the total UK market.

The remainder for UK market is imported from France. Customers include Sainsbury, Marks & Spencer, Tesco and Morrisons. These clients expect product to be supplied at highest quality, and with the best environmental credentials.

# Executive Summary

Within the European Union under the EU regulation 517/2014, refrigerants with a high Global Warming Potential (GWP) are coming under severe pressure due to the phasedown of available carbon dioxide equivalents (CO<sub>2-eq</sub>). This has led to a sharp rise in the price and availability of products such as R-404A, R-410A, R-407C and even R-134a and therefore refrigerants with a low GWP are being sought by end-users.

Opteon™ XL40 (R-454A) is an HFO/HFC blend and provides adequate performance to replace R-404A/R-507A, but with a GWP 94% lower than R-404A. With a GWP of just 239 (AR4), Opteon™ XL40 is sustainable with respect to the CO<sub>2-eq</sub> phasedown and therefore a good choice to replace R-404A/R-507A and even interim replacements such as R-407F and R-407A in refrigeration equipment that can meet the EN 378 safety requirements.

## Objective of case study.

To demonstrate benefits of innovative system design utilising low GWP refrigerant. In this case Opteon™ XL40 (R-454A, GWP 238) was chosen as the closest comparison in terms of performance to the legacy refrigerant R-407A.

## Major Findings

1. Environmental credentials
  - a. Low GWP
  - b. 89% reduction in tonnes CO<sub>2-eq</sub>
  - c. 3% reduction in charge size
2. Repeatability:

Plans proposed for new installations based on this site experience.
3. Improved environmental credentials with supermarket customers (KPI)

# Site Details and Process

Cold storage of 700 tonnes harvested shallots destined solely for UK market. Once harvested, the product is loaded into crates and packed into c. 5,000m<sup>3</sup> store room.

The store was fitted with a positive ventilation system incorporating a letter box duct, axial flow fans, propane fired gas burners, and a microprocessor-based control system. The fans are inverter driven to give speed control and airflow rate of up to 0.15m<sup>3</sup>/sec per ton when drying for a proportion of the crop, or 0.05m<sup>3</sup>/sec per ton for the whole crop.

It is important to maintain the humidity at the correct level in

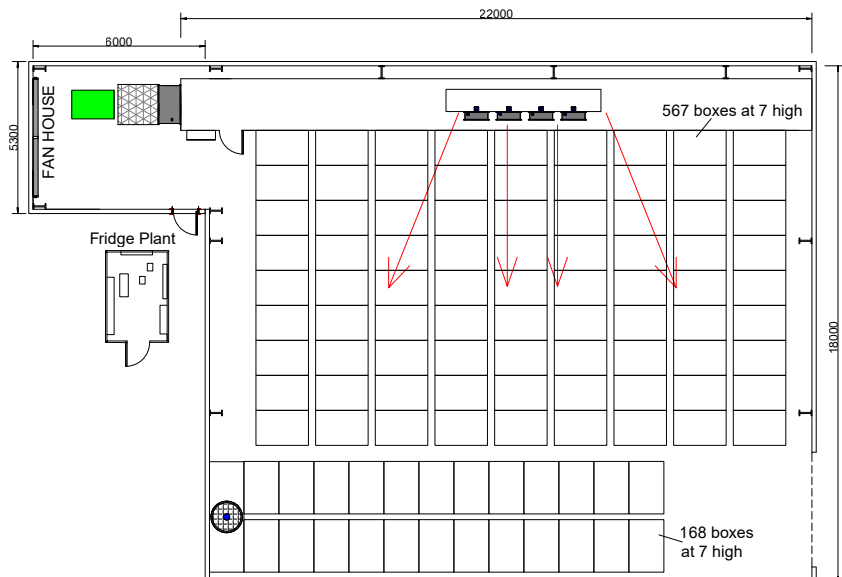


Figure 1: Store plan

the store to prevent moulding and rots, so the air on glycol  $\Delta t$  has to be controlled to give 70 to 77% humidity. This allows

maintaining high product quality, hence close control is important with room temperature range of 3 to 3.5°C.



Figure 2: Store (left), fans (centre) and plenum chamber (right)



Figure 3: Cooler (left) and product (right)

## Evolution of Crop Storage Cooling

Item 3 being the subject of this case study

| <b>1</b> <b>R-404A</b><br>Classification A1<br>GWP 3922 (AR4)  | <b>2</b> <b>R-407A</b><br>Classification A1<br>GWP 2107 (AR4)  | <b>3</b> <b>R-454A (Opteon™ XL40)</b><br>Classification A2L<br>GWP 239 (AR4)   |
|--|--|--|
| <b>Technology</b><br>DX (Direct Expansion)<br><br><b>Refrigerant Charge size</b><br>80kg (313.8 t CO <sub>2-eq</sub> )<br><br><b>Challenges</b> <ul style="list-style-type: none"> <li>Humidity control (essential for product quality)</li> <li>Control of <math>\Delta t</math> across evaporator.</li> <li>Defrost</li> </ul> | <b>Refrigerant Charge Size</b><br>18kg (38 t CO <sub>2-eq</sub> )<br><br><b>Benefits</b> <ul style="list-style-type: none"> <li>Improved control of <math>\Delta t</math> across heat exchanger</li> <li>Improved control of humidity</li> <li>Improved product quality</li> <li>88% Reduction in tonnes CO<sub>2-eq</sub> v's R-404A</li> <li>76% reduction in charge size v's R-404A DX</li> </ul> | <b>Refrigerant Charge Size</b><br>17.5kg (4 t CO <sub>2-eq</sub> )<br><br><b>Benefits</b> <ul style="list-style-type: none"> <li>Improved control of <math>\Delta t</math> across heat exchanger</li> <li>Improved control of humidity</li> <li>Improved product quality</li> <li>c. 98% reduction in tonnes CO<sub>2-eq</sub> v's R-404A</li> <li>c. 89% reduction in tonnes CO<sub>2-eq</sub> v's R-407A</li> <li>78% Reduction in charge size v's R-404A DX</li> <li>3% reduction in charge size v's R-407A secondary system</li> </ul> |

### Plant Room and Equipment Description

- The plant room was fabricated offsite and installed externally to the store and is fully ventilated.
- Refrigeration system certified as PED Cat. III
- Secondary certified as PED SEP
- Installed/commissioned 15th October 2021
- Internal volume 18m<sup>3</sup>
- Risk assessments were considered in relation to using an A2L refrigerant and proved less onerous than initially anticipated.
- DSEAR/EN 378/PED(R)/ in consultation with Cool Concerns and HPI (CE)

### Operating Conditions

- $T_e = -1^{\circ}\text{C}$
- $T_c = 38^{\circ}\text{C}$
- S/H = 4 to 6K
- S/C = 3 to 4K
- Store room temperature 3 to 3.5 $^{\circ}\text{C}$

### Key Components

- Refrigerant: Opteon™XL40 (R-454A)
- Charge size: 17.5kg
- Compressor: Bitzer GSD60235VLB4-2 Inverter Driven Scroll.
- Condenser: N9 (A2L Approved) CD-STP-2.5-1900-1050-6R-42-V1
- Glycol Pump: Inverter Driven Pedrollo F32/160B pump
- Brazed Plate Heat Exchanger: Swep V120THx70/IP-SC-M Heat Exchanger
- EEV: Danfoss Colibri® electric expansion valve ETS 12C. 034G7S0R (A2L)
- Controller: Danfoss controller EKE 1C superheat controller



Figure 4: Plant room exterior



Figure 5: System



Figure 6: Ventilation

65kw Piping and Instrumentation Diagram  
R-454A - GWP 239

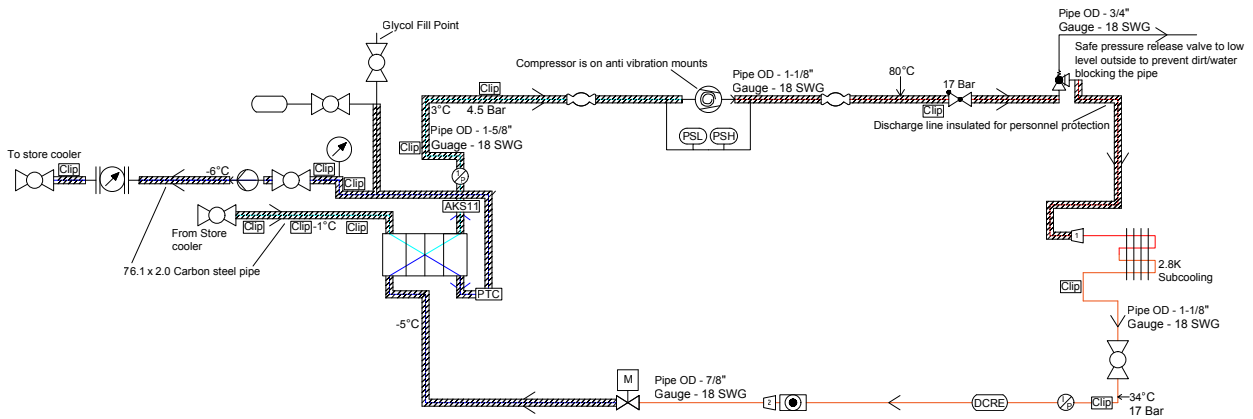


Figure 7: Schematic diagram

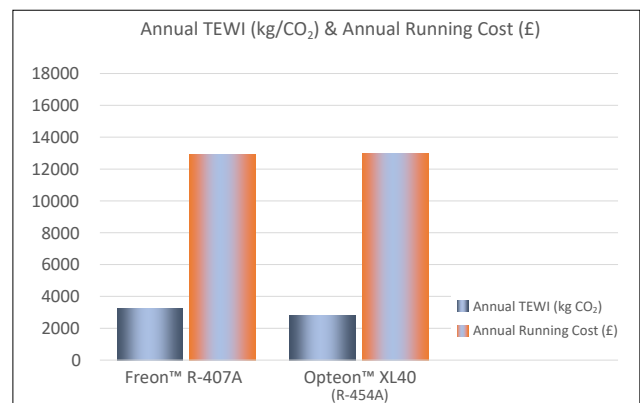
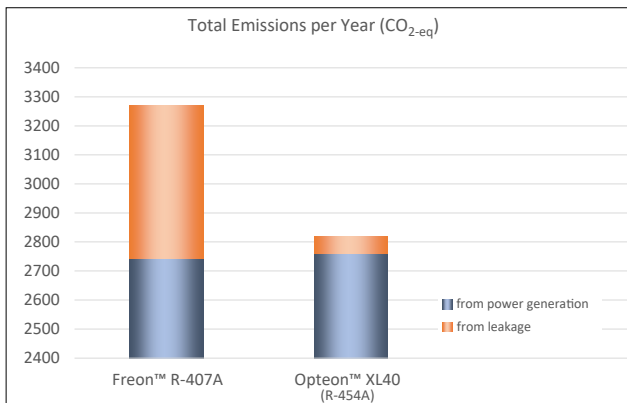
## Discussion and Conclusions

Although no records exist for comparison of power consumption, the customer reports that run times between option 2 and 3 are unchanged and it is possible to run a simulation showing the two fluids properties at the design conditions.

Using R-404A as a datum, we can see that like for like simulations at design conditions demonstrate improved performance and efficiency when employing lower GWP refrigerants.

|                                       | Freon™ 404A (R-404A) | Freon™ 407A (R-407A) | Opteon™ XL40 (R-454A) |
|---------------------------------------|----------------------|----------------------|-----------------------|
| GWP (AR5)                             | 3940                 | 1920                 | 238                   |
| GWP (AR4)                             | 3922                 | 2170                 | 239                   |
| Flammability                          | A1                   | A1                   | A2L                   |
| Pressure Equipment Directive, PED     | 2                    | 2                    | 1                     |
| Evaporating pressure (bar.g)          | 4.840                | 4.176                | 4.700                 |
| Compressor discharge temperature (°C) | 54.3                 | 64.8                 | 65.8                  |
| Mass flow (kg/s)                      | 0.606                | 0.466                | 0.439                 |
| Evaporator glide (K)                  | 0.4                  | 4.4                  | 4.7                   |
| Cooling C.O.P.                        | 3.6                  | 3.8                  | 3.8                   |

Condenser=38°C, Evaporator=-1°C, Subcool amount=4K, Total superheat=4K, Compressor efficiency=0.69



Values based on £0.14/kWhr, 50% running time and a notional 5% leakage rate  
Running costs are very similar to R-407A, but with a notable reduction in TEWI

## Key Benefits from Adoption of LGWP A2L Opteon™ XL40 (R-454A)

- Environmental credentials
  - Low GWP
  - 89% reduction in tonnes CO<sub>2-eq</sub>
  - 3% reduction in charge size
- Repeatability
  - Plans proposed for new installations based on this site experience.
  - Lessons learnt from this installation being easily transferrable to new projects
- Improved environmental credentials with supermarket customers (KPI)

Welvent were selected to provide this equipment and Lee Haith to lead the engineering team.

With exception of revisiting the extra points to be considered during the risk assessment, the installation of the system using Opteon™ XL40 (A2L) was no more problematic than installing a system operating on R-407A (A1).

The risk assessment was carried out by Cool Concerns, and although this proved initially

daunting for the contractor they are now in a confident and advantageous position to offer environmentally sustainable solutions to the rest of their clientel.

Feedback from the end user is that this has already led to new business opportunities. Initial concerns regarding glide proved unfounded. Correct Brazed Heat Exchanger selection and use of an Electronic Expansion Valve, maintained close control on suction superheat and evaporator capacity.

The system has performed as expected since commissioning without any reported problems and the calculations based on the measured data indicate that the system is performing better than R-407A or R-404A would have done if operating at the same system parameters.

Opteon™ XL40 has been proven to be a satisfactory replacement for R-404A/R-407A with improved performance as well as a c. 98% reduction in tonnes CO<sub>2-eq</sub> vs. R-404A.

## Client Feedback

Mike Sharp, Joint Managing Director of the manufacturer and installer (Welvent), was clear that as part of Welvent's commitment to offer clients sustainable technology they had been following the F-Gas phase down steps. First with the move from R-404A to R-407A and now to Opteon™ XL40 (R-454A). With the reduction in CO<sub>2-eq</sub> available for new install and service in the coming years the low GWP refrigerant was an excellent solution for the future. The properties of the refrigerant made it much easier to use, even with its low flammability, compared with other solutions available on the market.

Mike commented: "The whole project has been a real eye opener into the latest compliance and the new range of technology out there, I believe this

project has enabled us to lead the way within the industry. Having the can-do approach is a very important attitude in the industry. Performance wise from the refrigerant; duties and gas charge are very similar to our standard R-407A systems. With no issues of glide or original design predictions".

Chris Kitchen, the end user, emphasised how important it was that suppliers to the major supermarkets are able to show their environmental credentials and that they are regularly audited to ensure they are reducing their climate impact where possible. The use of a sustainable replacement product with very low GWP for refrigerating his crop was an important element.

## Credits



### End User

Chris Kitchen - Partner  
Freddie Grant - Farms Manager  
Amy Sharpe - Technical Manager

### Chemours

Mark Hughes - Business Development and Sales Manager  
David Sowden - Technical Marketing Specialist

### Welvent

Mike Sharp - Designer - Joint Managing Director  
William Gardiner - Refrigeration Director  
Lee Haith - Refrigeration Technical Support Engineer

### Wolseley

Peter Woods - Technical Sales Director  
Josh Smith - Area Sales Manager

### SWEP

Adam Raymond - Regional Manager



For more information on the Opteon™ family of low GWP products, visit [opteon.com](https://opteon.com)



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