2021

A Novel Distributed Scroll Booster Architecture for Supermarket Refrigeration

Mike Saunders
Emerson, United States of America, mike.saunders@emerson.com

Jason Born

Andre Patenaude

Rajan Rajendran

A Novel Distributed Scroll Booster Architecture for Supermarket Refrigeration

Michael SAUNDERS[1]*, Rajan RAJENDRAN[2], Jason BORN[3], Andre PATENAUDE[4]

[1]Emerson, The Helix Innovation Center
Dayton, Ohio, USA
Mike.Saunders@emerson.com

[2]Emerson, The Helix Innovation Center
Dayton, Ohio, USA
Rajan.Rajendran@emerson.com

[3]Emerson, The Helix Innovation Center
Dayton, Ohio, USA
Jason.Born@emerson.com

[4]Emerson, The Helix Innovation Center
Dayton, Ohio, USA
Andre.Patenaude@emerson.com

* Corresponding Author

ABSTRACT

Today's supermarket system architectures are being designed to minimize global warming potential (GWP) from both direct and indirect carbon emissions. To achieve this, many supermarkets are primarily employing one of two leading strategies: (1) designing and using systems that require smaller refrigerant charges, such as self-contained, secondary, or distributed systems; and (2) using lower-GWP refrigerants such as CO_2 in a transcritical system. While both strategies have proved effective, each approach leaves room for improvement.

The purpose of this paper is to introduce a third strategy: utilizing a distributed scroll booster system as an emerging alternative for distributed systems. The distributed scroll booster is configured to leverage A1 (R-134a like), low-pressure refrigerants, which enable several key benefits:

- Reduced refrigerant charge
- Higher system efficiencies
- Ability to use common refrigerants and components with which technicians are familiar
- Lower leak rates
- Future compatibility with A2L refrigerants such as R-516A and R-1234yf which have lower GWPs when codes and standards are updated

This paper will introduce how these benefits are realized through the system's design. It will cover strategies to manage:

- Use of low-pressure refrigerants in the distributed scroll booster
- Design flexibility and reliability of the distributed scroll booster
- Reducing the strain on compressors through the distributed scroll booster

1. INTRODUCTION

In 1987, the Montreal Protocol Treaty was enacted to ban the use of chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) refrigerants because of their ozone depletion potential (ODP). Since then, countries around the world embarked to phase out CFCs and HCFCs and replace them with hydrofluorocarbon

(HFC) refrigerants. While these measures have helped to significantly restore the ozone layer (NASA, 2019), the global proliferation of air conditioning and refrigeration has led to a significant rise in the use of high-GWP refrigerants, thus leading to greenhouse effect concerns.

To address this problem, the Kigali Amendment to the Montreal Protocol was agreed to by its parties on October 15, 2016, and went into effect on January 1, 2019 (UNIDO, 2020). Its goal was to phase down the weighted GWP of HFC refrigerants, with the target reduction of 80% or more beyond 2030. Many countries and regions have also passed their own HFC phase-down measures, such as the European Union's F-Gas Regulations. In the United States, where no federal mandate on HFCs is currently being enforced, states have started enacting their own HFC phase-down regulations. This has resulted in the development of new synthetic refrigerants, such as hydrofluroolefins (HFOs) with a GWP of 1, and low-GWP blends of HFCs and HFOs. Natural refrigerants CO_2 and propane (aka R-290) also have been identified as viable alternatives, although they require the use of electronic valves and controls for effective system operation.

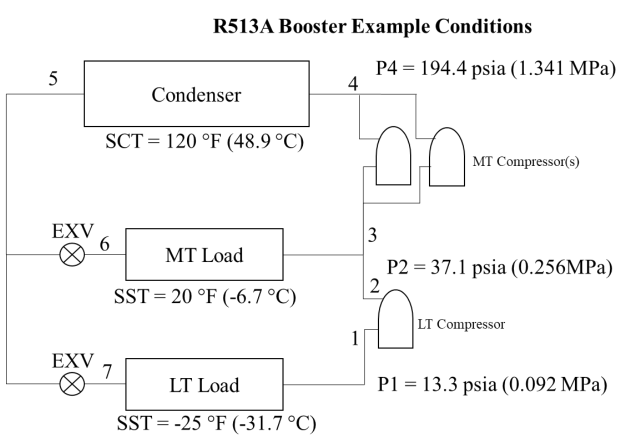
The net effect of these developments in the commercial refrigeration market - which already utilizes a wide variety of systems for many diverse applications - is that systems have become increasingly complex. Today, the need for a simpler system that uses known parts and familiar technologies and is easy to install and operate has become more important for commercial refrigeration end users than ever.

2. SYSTEM DESCRIPTION

2.1 Configuration

The new distributed scroll booster system is comprised of one or more medium-temperature compressors coupled with one or more low-temperature compressors. Figure 1 shows a basic schematic of how compressors and refrigeration loads can be arranged. Medium-temperature compressors can either be in a condensing unit or a rack of compressors. The system may have a remote or integrated condenser and can be placed indoors or outdoors. Low-temperature compressors are placed near the low-temperature evaporators. In the case of supermarket reach-in freezers, the compressor can be placed directly on top of or beside the case.

The net result of "boosting" the low-temperature compressor directly into the medium-temperature compressor(s) is an overall system efficiency gain. In addition, the work done by the low-temperature compressor(s) is very minimal. Figure 1 shows an example of pressures at various points in the system. This example shows the system using R-513A; the pressure ratios are 2.79 for the low-temperature (LT) compressor and 5.23 for the medium-temperature (MT) compressor as compared to a traditional R404A DX (Direct Expansion) system of 9.75 and 4.64 respectively.



	R513A Booster	R404A DX*
MT PR	5.23	4.64
LT PR	2.79	9.75

* MT Conditions: SST=20 °F (-6.7 °C) / SSC=120 °F (48.9 °C)
LT Condition: SST=-25 °F (-31.7 °C) / SSC=105 °F (40.6 °C)

Figure 1: Scroll booster with conditions

Table 1 is a summary of various refrigerants and their corresponding isentropic compression discharge temperatures by saturated suction temperature (SST), saturated condensing temperature (SCT), and superheat. Note that by using low-pressure gases such as R-513A and R-134a, the discharge temperatures are considerably lower with the low-temperature booster configuration than a traditional direct expansion (DX) system.

Table 1: Isentropic discharge temperatures

Refrigerant	SST Mid-point	SCT Mid-point	Superheat	Discharge Temp.
R-404A	-25 °F (-31.7 °C)	105 °F (40.6 °C)	20 °F (11.1 °C)	140.8 °F (60.4 °C)
R-407A	-25 °F (-31.7 °C)	105 °F (40.6 °C)	20 °F (11.1 °C)	167.7 °F (75.4 °C)
R-404A	20 °F (-6.7 °C)	120 °F (48.9 °C)	20 °F (11.1 °C)	149 °F (65 °C)
R-407A	20 °F (-6.7 °C)	120 °F (48.9 °C)	20 °F (11.1 °C)	167.5 °F (75.3 °C)
R-513A	-25 °F (-31.7 °C)	20 °F (-6.7 °C)	20 °F (11.1 °C)	46 °F (7.8 °C)
R-134a	-25 °F (-31.7 °C)	20 °F (-6.7 °C)	20 °F (11.1 °C)	52.9 °F (11.6 °C)
R-513A	20 °F (-6.7 °C)	120 °F (48.9 °C)	20 °F (11.1 °C)	139.2 °F (59.6 °C)
R-134a	20 °F (-6.7 °C)	120 °F (48.9 °C)	20 °F (11.1 °C)	149.1 °F (65 °C)

The distributed scroll booster system architecture lends itself to multiple configurations. Figure 2 shows potential variations of how to configure the medium-temperature and low-temperature compressors. While this is not an exclusive list of options, it demonstrates how flexible the scroll booster technology can be in terms of applications. Option 1 utilizes a medium-temperature rack coupled with low-temperature compressor units — a suitable option for large load requirements. Option 2 is nearly the same configuration, except that it uses a medium-temperature condensing unit instead of a rack of compressors, a good option for smaller-load applications. Option 3 places both the low-temperature and medium-temperature compressors side by side, which would be very beneficial in side-by-side coolers and freezers to minimize the equipment's footprint.

The distributed scroll booster unit also enables the low-temperature unit to operate as either a medium- or low-temperature load. In the low-temperature mode, the compressor would cycle and run as normal. To operate as a medium-temperature unit, the scroll compressor on the low-temperature case would be turned off. In addition, by utilizing electronic valves and controls, the setpoint of the case easily can be modified to operate as a medium- or low-temperature unit. The inherent scroll compressor design allows for suction gas to flow easily through the compressor when the compressor is off and/or the floating seal is unloaded.

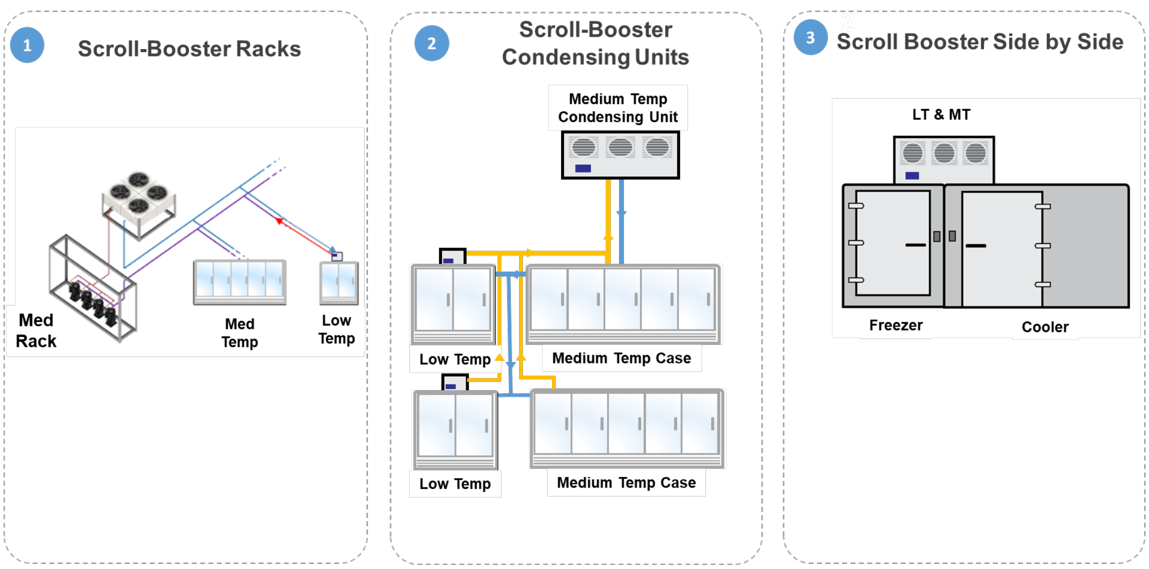


Figure 2: Other booster variations

2.2 Oil management

Because of the distributed nature of the system, additional measures must be taken to manage the oil in the system. In closed refrigeration systems, oil is circulated throughout. In small systems, an equilibrium is established once all the internal components are "wetted" with oil. In larger systems, such as racks, oil separators are added at the discharge of the compressors to capture oil. Through a series of pipes, floats and valves, the oil is fed back into the compressors as their oil levels drop.

Oil circulation rates also vary by compressor and operating condition. Oil separators are not 100% efficient; some of the oil will escape and pass through the entire system. The lower the evaporator pressure, the lower the oil circulation rates will be. Scroll compressors typically have oil circulation rates less than 2%. Because of the dynamic nature of the system - and how the low-temperature compressors are coupled with the medium-temperature compressors – it is possible for the low-temperature compressor to lose or gain excessive oil in certain scenarios.

An oil separator is added to the low-temperature compressor to help capture oil as it leaves the compressor; it also can be used to replace lost oil. If a compressor should fill with oil, a purge sequence will be needed to remove excessive oil. This scenario can occur if more oil is entering a compressor than that which is exiting. If a compressor accumulates oil over time, this also may cause other compressors in the system to run out of oil.

There are several ways to purge oil from a low-temperature compressor, but one way is to raise the suction pressure while closing off the compressor discharge. Scroll compressors utilize an oil float mechanism with a solenoid valve for fill. Once the suction pressure is higher than the discharge pressure, this solenoid valve can be opened to force oil out of a compressor back into the oil separator. Activating the defrost of a low-temperature evaporator is a typical method for raising the suction pressure of the compressor.

2.3 Other considerations

When using a low-pressure refrigerant such as R-134a or R-513A, compressor sizing is a key consideration. The capacity provided by a compressor with equal displacement is less than it would be using medium-pressure refrigerants such as R-404A or R-407A. For example, the theoretical capacity difference between R-404A and R-134a is 53%. Additional displacement must be used to account for this difference compared to a medium-pressure refrigerant. In the low-temperature compressors, this difference can be offset by using sub-cooling on the liquid being supplied to the low-temperature loads. Figure 3 shows the compressor capacity impact of lowering liquid temperature. This is for a condition of low-temperature (LT) saturated suction temperature (SST) = -25 °F (-31.7 °C), medium-temperature (MT) saturated condensing temperature (SCT) = 105 °F (40.6 °C), MT SST = 20 °F (-6.7 °C). In addition to being able to use smaller displacement compressors because of the lower liquid temperatures, liquid refrigerant line sizes also can be decreased because of the lower liquid mass flow requirements.

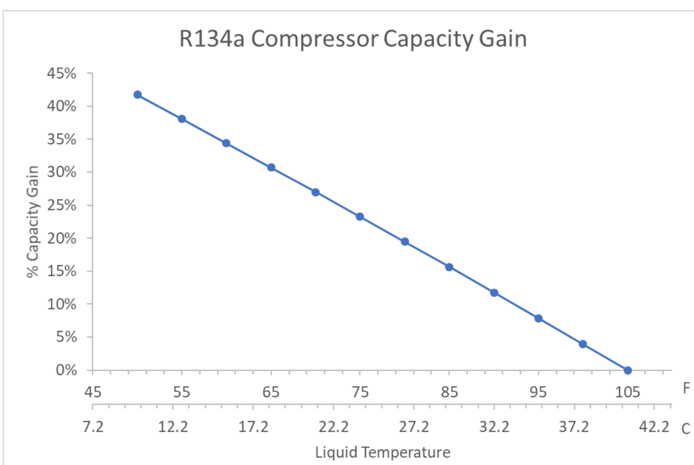


Figure 3: Capacity gain vs. liquid temperature

2.4 Performance analysis

A thermodynamic analyses of various supermarket refrigeration architectures was performed. The model used for annual energy calculation was based on weather bin data. Compressor performance data used was provided by the compressor manufacture. Steady state conditions were assumed for each weather bin. The peak power consumption is based on the hottest day of the year. The life cycle climate performance (LCCP) analysis considers the indirect and direct emission. Manufacturing and end of life components were not included in the totals. They are assumed to be small and similar for each type of system relative to the indirect and direct emissions due to refrigerant leakage and power consumption.

A centralized DX is used as the baseline for comparison to a variety of common system architectures. The loads used for analysis are 100,000 Btu/hr (29.3 kW) for the medium-temperature, and 33,000 Btu/hr (9.67 kW) for low-temperature. SST for the low-temperature is -25 °F (-31.7 °C) and 20 °F (-6.7 °C) for the medium-temperature. Installation location is in Atlanta.

The result of the model can be seen in Figures 4 & 5. The annual energy consumption of the distributed scroll booster system is estimated to save about 20% over a centralized system. Peak energy has a reduction of 12.9% vs the centralized system and the annual CO2 emissions are reduced by 57.5% vs the centralized system.

Other systems were included in the analysis for comparison purposes, R407A distributed scroll, R407A secondary glycol with pumped CO2 for the LT, R134a cascaded to CO2 for the LT, and a CO2 transcritical booster system.

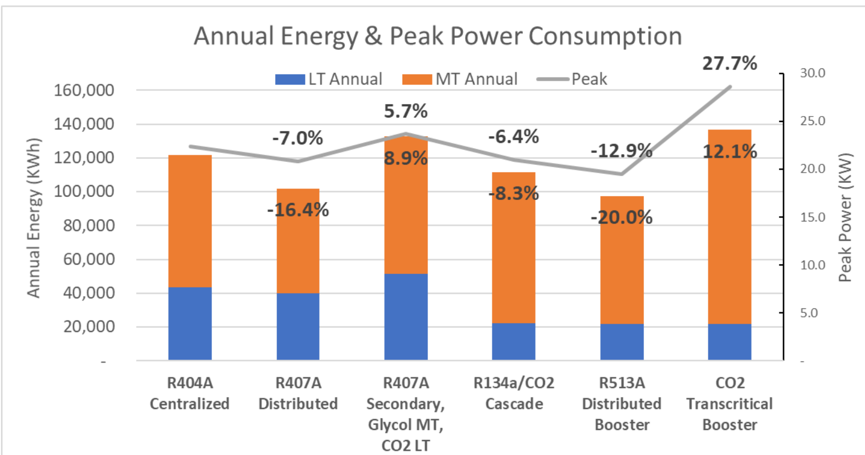


Figure 4: Annual energy and peak power consumption

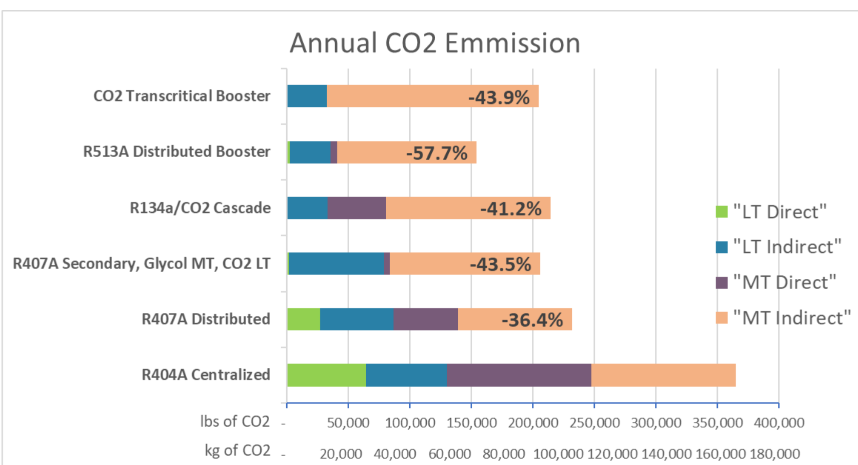


Figure 5: LCCP

3. DISTRIBUTED BOOSTER SYSTEM BENEFITS

The design requirements for distributed scroll booster system sought to leverage the benefits of each individual component in order to deliver higher value as an integrated solution:

3.1 Reduced total cost of ownership (TCO)

The goals of the architecture design were threefold: (1) meet North American refrigerant regulations; (2) keep it as simple as possible; (3) increase system reliability while leveraging the existing features of system components to drive higher energy savings and lower maintenance costs.

3.2 Meeting current and future refrigerant regulations

After close evaluation of refrigerants, a low-pressure, low-GWP A1 option was selected for both medium- and low-temperature loads: R-513A (631 GWP). Its usability in all climate zones and ability to address supermarket retailers' operational requirements for safety, simplicity, serviceability, stability and sustainability made it an excellent choice. By using R-513A, the distributed scroll booster provides a scalable refrigeration platform that meets the Environmental Protection Agency's (EPA) Significant New Alternatives Policy (SNAP) Rules 20 and 21 with approved refrigerants, where applicable — with the potential to adapt to larger charges in regions without limits. From a long-term perspective, a low-pressure, future-proof refrigerant architecture supports the ongoing transition to lower-GWP options of less than 150 GWP. Several A2L candidates such as R-516A (142 GWP) and R-1234yf (4 GWP) — could be future options if appropriate codes and standards are enacted and followed.

3.3 Low-pressure refrigerant advantages

Using a low-pressure refrigerant such as R-134a or R-513A provides additional advantages for the booster system. The lower discharge temperatures of the low-temperature units are advantageous, since they discharge into the medium-temperature suction. This minimizes the suction gas temperature of the medium-temperature unit and allows the medium-temperature compressors to operate within their design limits without the need for additional cooling, such as liquid injection. However, with a medium-pressure refrigerant such as R-407A, because it has a higher heat of compression, the suction gas temperatures would be higher and possibly damage the medium-temperature compressors if used without a de-superheater or other method of cooling the suction gas temperature.

When using low-pressure refrigerants, it's important to consider the effect that pressure drops can have on the compressor or system efficiency, especially at low pressures. Figure 6 shows the effect that pressure drops have on efficiency. Note that as the evaporating temperature decreases, so does the efficiency. With as little as a 3 psi (20.7 KPa) pressure drop, there can be as much as 18% loss in system efficiency at very low evaporator temperatures. To mitigate this issue, the low-temperature booster compressors are placed close to the low-temperature evaporator loads in a distributed fashion (see Figure 7). In a supermarket, this could be on top of the display cases, in a mechanical room, or even on a rooftop directly above the cases if the refrigerant lines are short enough to not impact the overall system efficiency.

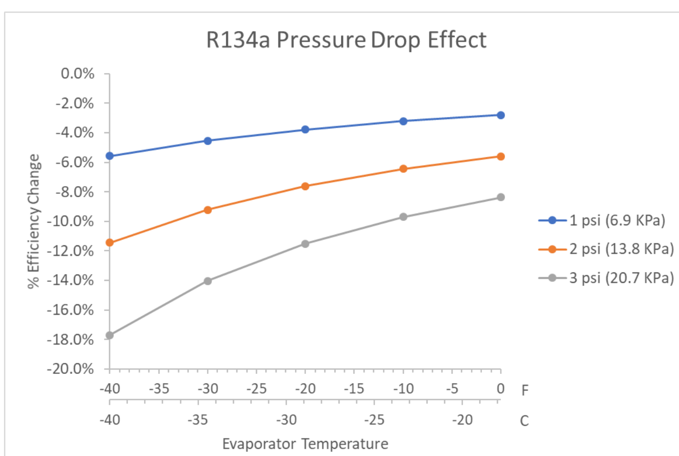


Figure 6: Pressure drop impacts on efficiency

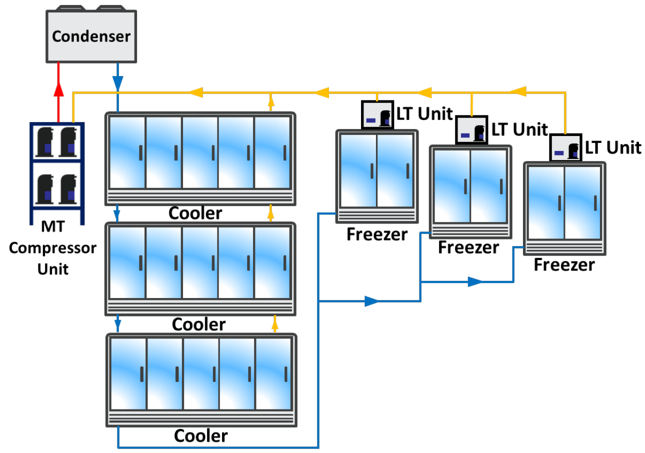


Figure 7: Distributed booster

3.4 Low-pressure drop system and leak reduction

The distributed scroll booster system was developed to operate with the lowest pressure drop possible. The key to maximizing energy efficiency and reducing leaks is to minimize or eliminate additional components, such as: pressure regulators, liquid line solenoid valves, hot gas and suction line solenoid valves. Each additional valve in a system introduces potential leaks and maintenance issues — and added costs and complexity. The pressure drops attributed to these components also introduce system inefficiencies and oil and gas flow interruptions. To maximize load flexibility and energy efficiency under all operating conditions, the distributed scroll booster can utilize electronic expansion valves (EXV) at every MT/LT case or unit cooler.

3.5 Reducing refrigerant charge in line sets

In the distributed scroll booster system, R-513A is used for both the medium- and low-temperature applications within the same system to minimize refrigerant charge and piping costs. This architecture utilizes a single condenser to manage the total heat of rejection of both the medium- and low-temperature loads. This is accomplished by having two or more medium-temperature compressors in parallel discharging into an air- or water-cooled condenser. The liquid leaving the condenser travels to all the MT and LT cases via a main liquid line. This line exits the condensing unit — rather than each evaporator having its own separate lines — and is directed toward a central area near the MT and LT loads. From there, individual liquid lines branch off to feed the individual evaporators.

3.6 Benefits of locating the LT compressor at the LT case or walk-in case

By locating the LT compressor close to the LT loads, the distributed scroll booster design delivers multiple benefits, such as: reduced need to run discharge and suction piping to the outdoor condenser; reduced refrigerant charge; reduced material and labor costs of installing and insulating suction lines (and nitrogen purge); reduced potential carbon residue from brazing, improved reliability and cleaner systems; eliminates parasitic losses in long suction runs from high suction superheat and return gas temperatures (see Figure 2).

3.6.1 Dual temperature capability: The distributed scroll booster system is designed with dual temperature capability to enable a simple and reliable way of leveraging the scroll compressor properties to switch seamlessly from LT to MT control. The compressor utilizes a fixed and orbiting scroll set and a floating seal, which optimizes contact between the two when loaded. When the compressor is operating, the orbiting scroll flanks are in constant contact with the fixed scroll and ensure continuous compression. When the compressor is off (i.e., not pumping) and the floating seal is unloaded, the scroll flanks disengage with one another to allow an air gap between fixed and orbiting scrolls. The distributed scroll booster takes advantage of the “non-contact” of the scroll sets when off, allowing suction gas to flow freely through the compressor. As a result, MT refrigeration is possible, even when the LT scroll is off. Proper selection of EXVs is essential for enabling this value-added feature, since it must be able to switch seamlessly from LT or MT setpoints.

3.6.2 MT redundancy: If the LT booster scroll stops working due to an issue or a control lockout, the distributed scroll booster system automatically generates an alarm and the setpoint immediately shifts from LT to MT. At this point, the EXV is enabled and controls superheat based on an MT suction setpoint. This provides temporary, limited operation at an MT setpoint to allow time to empty contents of cases and/or dispatch a service technician.

3.6.4 Quick pulldown capability: A fast initial pulldown of a walk-in freezer can be achieved by leveraging the distributed scroll booster system's higher MT mass flow. This is accomplished by enabling the EXV while leaving the LT compressor off until the freezer temperature reaches MT setpoint. Once the MT setpoint is achieved, the control scheme switches to LT settings.

3.6.5 Eliminating high compression ratios and discharge temperatures: The net result of boosting the LT compressor directly into the MT compressor(s) is an overall system efficiency gain while keeping the mechanical load on the low-temperature compressor very low. This minimal workload on the LT compressor(s) results in a low discharge temperature and minimal total heat of rejection to the MT compressor (see Figure 1 for compression ratios of R-513A). This scroll booster architecture eliminates the need for specialized LT compressors designed to handle high compression ratios and discharge temperatures. Liquid and/or vapor injection and head cooling fans are not needed.

4 SYSTEM ENHANCEMENTS: LEVERAGING BEST PRACTICES

4.1 Reducing refrigerant charge in the condenser

In traditional refrigeration systems, flooding the head pressure control valves to maintain a minimum head pressure and ensure adequate flow and superheat control is often achieved using mechanical expansion valves. Artificially maintaining high minimum head pressure limits the energy savings and requires an increased refrigerant charge, which is mechanically backed up into the condenser during periods of low ambient conditions to reduce its effective surface area and artificially keep pressures up. The increased charge also requires larger, more expensive receivers. In a distributed scroll booster system, flooded head pressure control is not required above -20 °F (-28.9 °C) ambient. To deal with low ambient temperatures, the system uses variable condenser fan speed control as well as a split condenser. The EXV's ability to modulate varying load and head pressure requirements, as well as liquid quality, results in optimum system performance at low head pressures. These strategies minimize the amount of refrigerant in the condenser at any given time and reduce the size of the receiver required to maintain a liquid seal. Additional strategies for maximizing energy efficiency and liquid quality in distributed scroll booster systems include sub-cooling condenser loops and boil-out suction accumulators.

4.2 Floating head pressure/low-condensing refrigeration to improve energy efficiency

Floating the head pressure, also known as *low-condensing refrigeration*, refers to the practice of maintaining the system's head pressure at 10 °F to 20 °F (5.6 °C to 11.1 °C) above the ambient temperature, thereby providing users enhanced flexibility, efficiency and savings. The distributed scroll booster system is controlled by changing the speed of the condenser fan motors and using EXVs at the evaporator to operate effectively over a wide range of condensing temperatures. As the head pressure adjusts or floats down with falling ambient temperatures, EXVs digest any flash gas that may be produced. For example, as the ambient temperature starts to drop in the evening/overnight/early morning hours, the system's head pressure floats down with it. This results in an increase in compressor capacity at a time when typical refrigeration loads also decline. Therefore, the need for variable-capacity compressors and EXVs is paramount for successful capacity modulation and lower energy usage. Because the system is no longer operating at maximum capacity, it operates in a more efficient manner that saves energy and prolongs equipment life. And as compressor power decreases due to lower ambient conditions, capacity typically increases proportionately. Note that a minimum saturated condensing temperature (SCT) must be designated because the system typically will not operate efficiently below this point.

For approximately 75% of a working day, operators can realize lower costs through energy-efficiency improvements from 15 to 20% for every 10 °F (5.6 °C) decrease in SCT, depending on the compressor used. For additional details on the benefits of low-condensing operation, please refer to this Refrigeration Service Engineers Society (RSES) article (RSES, 2014).

4.3 Benefits of EXVs at every evaporator

The hermetically sealed EXVs act as expansion devices as well as positive shutoff valves, thereby eliminating the need for liquid line solenoid valves at every case. To maximize energy savings, the distributed scroll booster architecture can float head pressure to a very low level without losing control. The low head pressure is enabled by the EXV's ability to digest flash gas at low condensing pressure while maintaining desired superheat.

4.3.1 The key to maintaining proper evaporator control with very low head pressure: When equipped with variable-speed scroll compressors, the distributed scroll booster is capable of floating head pressure down to 50 psig (446 KPa) with only 23 psig (260 KPa) of MT suction pressure. This provides high liquid enthalpy for fast and efficient heat removal and enables the lowest possible energy consumption. All evaporators, however, need to be equipped with EXVs and properly sized Venturi-Flo™ refrigerant distributors rather than orifice types to assure evaporator circuits are equally fed under all operating conditions.

5. EXPERIENTIAL FIELD DATA

Field trials of the distributed booster system are already proving its ability to address a full spectrum of end user challenges. Table 2 depicts installations in various cities in North America, demonstrating the system's operability in a wide range of climates and ambient conditions. System capacities range from 11–200 Thousand British Thermal Units per Hour (MBH), showing the system's ability to address the widely varying types of applications found in the commercial refrigeration space. The embodiments or architecture configurations and the LT compressor locations further demonstrate the distributed booster system's flexibility and scalability, as each configuration adapts to the specific installation requirements of each location.

Table 2: Distributed booster system installations

Installed	City, State or Province	Capacity MBH (kW)	Embodiment	LT Compressor Location	Installed
The Emerson Helix	Dayton, OH	21 (5.9)	Condensing Unit	Case	April 2017
The Emerson Helix	Dayton, OH	11 (3.2)	Condensing Unit	In MT Unit	Nov. 2017
End User; Click & Collect	Hamilton, OH	24 (7.2)	Condensing Unit	In MT Unit	March 2018
Norwich Bakery	Norwich, ON	33 (9.7)	Mini Rack - Remote Cond.	Case Location	April 2018
Harley Market	Harley, ON	35 (10.3)	Mini Rack - Remote Cond.	In MT Unit	June 2018
Emerson Mexico	Mexico City	21 (6.15)	Condensing Unit	Case Location	June 2018
Vennesa Meat	Vennesa, ON	125 (36.6)	Outdoor Rooftop Package	In MT Unit	April 2019
Vennesa Meat	Vennesa, ON	200 (58.6)	Outdoor Rooftop Package	In MT Unit	Dec. 2019
Planned					
OEM Lab Testing	St Louis, MO	35 (10.3)	Mini Rack - Remote Cond.	Case	Spring 2020
Emerson Mexico	Mexico City	20 (5.9)	Condensing Unit	Case	Spring 2020
Supermarket Remodel	New York State	90 (26.3)	Mini Rack - Remote Cond.	Case	Summer 2020
Emerson Learning Centre	Brantford, ON	40 (11.7)	Condensing Unit	Case	Summer 2020
Meat Processor	Ontario, Canada	2 System @ 150 (44)	Outdoor Rooftop Package	In MT Unit	Summer 2020
Small Supermarkets	Dayton, OH	2 System @ 100 (29.3)	Mini Rack - Remote Cond.	Case	Fall 2020
Medium-size Supermarket	Arizona	6 System at 90 (26.3)	Mini Rack - Remote Cond.	Case	Fall 2020
Walk-in Cooler and Freezer	Texas	60 (17.6)	Condensing Unit	Case	Fall 2020
Small Supermarkets	Ontario, Canada	2 System @ 150 (44)	Outdoor Rooftop Package	In MT Unit	Fall 2020
Small Supermarkets	Ontario, Canada	2 System @ 125 (36.6)	Outdoor Rooftop Package	In MT Unit	Fall 2020

6. CONCLUSIONS

The new distributed scroll booster system provides a robust architecture that addresses the many challenges facing commercial refrigeration system owners and operators, both today and in the future. As retailers and operators make decisions on which emerging technologies and architectures will help them navigate a rapidly changing landscape of regulations and refrigerant choices, the distributed scroll booster system checks their most important evaluation criteria.

6.1 Simplicity

Simplicity requires system technologies to remain as close as possible to those that are already in the practice, without excess complexity and moving parts. The distributed scroll booster leverages preferred technologies and the most basic components. It does not need liquid injection or other sub-cooling techniques to achieve ideal operating pressures/temperatures. Its distributed architecture reduces the need for long line runs to a common condensing unit or rack, thus reducing charge sizes, labor and installation costs.

6.2 Serviceability

Serviceability dictates that systems be designed with commonplace replacement parts, are easy to operate and maintain, and are familiar to technicians. The distributed scroll booster system leverages commonly used refrigerants and components while redefining what is possible with low-pressure refrigerants by leveraging the benefits of typical booster systems. Its flexible system design enables a wide variety of configurations and placement of components.

6.3 Sustainability

Sustainability refers to both ecologic and economic concerns; refrigeration systems must balance the needs of regulations while keeping costs low and efficiencies high. Simply put, the distributed scroll booster enables operators to meet regulations and lower operating costs simultaneously. It utilizes lower-GWP, A1 refrigerants while providing the flexibility to transition to even lower-GWP A2L refrigerants in the future. Compared to a standard DX rack system, it can achieve up to 10–20% energy savings with additional installation savings from a 10–30% reduction in line runs and refrigerant charge.

6.4 Stability

Stability is imperative for any refrigeration system, and the distributed scroll booster system has the potential to be one of the most stable systems available. The system is designed so that each component operates within its designed range to maintain reliable, efficient operation. LT compressors provide consistent suction temperature/pressure while operating at a very low compression ratio. It also features inherent redundancy. In the event of an LT compressor failure, the system will not completely shut down. Instead, it will run as an MT system, allowing for extra time for a technician to service the issue.

6.5 Safety

Every refrigeration system needs to be safe for operators, service technicians and customers. Generally speaking, this refers to its ability to operate within safe ranges and use non-flammable, non-toxic and low-pressure refrigerants. The distributed scroll booster system allows for familiar A1 refrigerants to be used, providing the industry with a safe alternative to the many caveats associated with many low-GWP natural and synthetic refrigerants.

6.6 Smart

Stakeholders are demanding more intelligent functionalities from refrigeration systems. In the distributed scroll booster system, this intelligence originates from the control structure. Its smart controls intuitively can operate the system and provide insight on its performance. The system also can incorporate modulation for improved capacity control as well as EXVs for quick pulldown capability, low-condensing operation and tighter overall control of the system.

REFERENCES

NASA (2019, September 8). 2019 Ozone Hole is the Smallest on Record. Retrieved from https://earthobservatory.nasa.gov/images/145747/2019-ozone-hole-is-the-smallest-on-record

Patenaude, A., (2014, April). EEVs Enabling Low Condensing Refrigeration. Retrieved from https://www.rses.org/assets/rses_journal/0414_Condensers.pdf

UNIDO (2020). The Montreal Protocol evolved to fight climate change. Retrieved from https://www.unido.org/our-focus/safeguarding-environment/implementation-multilateral-environmental-agreements/montreal-protocol/montreal-protocol-evolves-fight-climate-change