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Strategies for Lowering Refrigerant Charge

Reduce your carbon footprint and explore the advantages of lower-charge refrigeration

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In an industry where refrigerants are often the focus of environmental regulations and sustainability initiatives, the need to reduce refrigerant charge is a goal shared by many supermarket retailers and operators. From an environmental perspective, the reason for seeking charge reductions is clear: lower refrigerant charges lessen the potential for refrigerant leaks and their associated environmental impacts. But from an operational perspective, there are also more pragmatic motivations for lowering refrigerant charges — from improving refrigeration system energy efficiency, performance and reliability to meeting stated corporate sustainability objectives and reduced replacement costs.

As part of its GreenChill program, the Environmental Protection Agency (EPA) recommends refrigerant charge reductions as a strategy for lowering emissions from leaks of hydrochlorofluorocarbon (HCFC) and hydrofluorocarbon (HFC) refrigerants. They estimate that the average centralized direct-expansion (DX) system is charged with 3,000–4,000 pounds of refrigerant and can leak more than 20% of its charge annually.

These leaks represent both a significant risk to the environment — based on a refrigerant's global warming potential (GWP) or ozone depletion potential (ODP) — and a substantial cost to supermarket operators.

Global regulatory efforts to transition away from higher-GWP HFC refrigerants are well underway; in California, state regulations are being enforced to accelerate this transition. But for most supermarket operators in other regions of the United States, their centralized R-404A systems may be in service for many years to come. Lowering the refrigerant charge in these existing systems is an excellent way to meet sustainability objectives, improve system performance and capacity, and prepare for future regulations.

Let's examine some of the leading strategies for reducing the refrigerant charge in existing systems.

Implement variable-speed condenser fan control

Most centralized DX systems are designed for peak summer heat and use mechanical head pressure control valves to maintain fixed pressure in the condenser equivalent to 105 °F condensing. But in cooler seasonal conditions, this approach creates a considerably oversized condenser, where a substantial portion of the condenser volume is being used to store liquid in order to build pressure up to 105 °F minimum condensing. Depending on the ambient temperature, this idle liquid refrigerant could account for a significant percentage of the total refrigerant charge.

A potential fix to remedying this situation is to remove the mechanical head pressure control valve. Instead of operating with a minimum fixed head pressure, install a variable-frequency drive (VFD) to control the condenser fan's speed — and potentially change the condenser fan motors — to provide variable head pressure throughout the year. This alone would allow the system to operate with less refrigerant by removing the need to have a "winter charge" to flood the condenser in low ambient conditions.

Image source:
Hussmann Corporation

And if the condenser needs to be replaced, an additional charge reduction can be achieved from implementing a split condenser design. The split condenser approach helps maintain system pressure effectively by cutting the condenser surface area in half as ambient temperatures drop. The net reduction in condenser surface area further lowers the system charge.

In addition, during the summer months when the condenser utilizes every inch of its surface area, excess liquid refrigerant can be stored in a large receiver tank designed to hold both the summer and winter charges. In older systems, where receivers are often undersized, service technicians must add winter refrigerant charge in the fall and remove it again in the spring or risk overcharging the system and the potential shut-off of high-pressure safety switches. When a low condensing approach is used in combination with an efficient liquid subcooling strategy, these techniques can help lower system refrigerant charges and help maximize system performance energy efficiency and reliability.

Retrofit doors on medium-temperature cases

One often overlooked strategy for lowering refrigerant charge is to retrofit open, medium-temperature display cases with transparent doors. This strategy is often promoted as a means of lowering energy consumption, but it also has beneficial effects on increased refrigeration system performance and the reduction of refrigerant charge. Depending on how many cases are retrofitted, supermarket operators could achieve refrigeration load reductions by up to 70% per case — which would enable a corresponding reduction in refrigerant charge.

Adopt a looped piping strategy

Conventional centralized DX systems have individual liquid refrigerant and return suction lines fed from the refrigeration rack to each case in a supermarket. This method requires a proportionate amount of refrigerant to support the refrigeration loads of all cases. An alternative to this approach would be to adopt a looped piping strategy during a new store install or remodel, where a few large lines are run to various sections of the store, from which smaller lines are branched off to individual cases.

For example, instead of running 30 individual long lines to cases, the system could be equipped with refrigerant line loops to support four to five primary sections of the store. Then, much smaller lines could be branched off these loops to feed the individual cases. In doing so, store operators can reduce piping, lower leak rates, and achieve a significant reduction in refrigerant charge.

Disconnect and re-distribute remote refrigeration loads

Providing adequate refrigeration for cases that are located farthest from the refrigeration machine room is another common challenge for many supermarket operators. If the system is not operating properly, the refrigerant traveling along those long liquid lines often loses its liquid quality and develops flash gas bubbles by the time it reaches these distant cases — all of which results in a variety of issues, which can ultimately increase the amount of refrigerant needed and impact case temperatures.

One potential solution is to disconnect these cases from the DX system and install segments of distributed equipment to handle them individually. Removing these problematic cases from their suction group reduces the refrigerant charge in the centralized DX system and allows the system to operate more efficiently. The Copeland™ digital outdoor refrigeration unit, X-Line series is ideal for servicing these remote cases or supporting new refrigeration requirements, such as walk-in coolers for click-and-collect fulfillment. In addition, the Copeland indoor modular solution provides flexible options for spot merchandizing cases, which could also be disconnected from a DX system.

Transition to distributed architectures

The prospect of large-scale leak events is always a possibility in large centralized DX systems charged with up to 4,000 pounds of refrigerant. If even half of that charge were to be emitted in a catastrophic leak, operators would face potential environmental penalties and excessive refrigerant replacement costs. All the strategies explored in this article are intended to mitigate those risks.

But it is important to note that centralized DX systems are no longer the only option for large supermarket refrigeration. In their place is an emerging variety of distributed architectures designed to lower refrigerant charges, deliver improved energy efficiencies, and operate using lower-GWP refrigerants. Our next article in this series will examine some of these leading system alternatives.