Reducing Refrigerant Emissions From Supermarket Systems

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arge refrigeration systems are used in applications such as supermarkets, cold storage warehouses and industrial processes. The sizes of these systems contribute to their high refrigerant leak rates because of the thousands of connections, the large areas over which refrigerant is moved and the large refrigerant charge sizes. While the examples given here for reducing refrigerant emissions are from the supermarket industry, the ideas and concepts behind these successful efforts can be applied to any large system.

Background

The leak rates of a supermarket store typically were not measured years ago, however, rates of 30% to 50% of the total system charge per year were values generally quoted by the industry. These large losses were a consequence of a variety of factors, including the design of the system (as mentioned before) and the fact that these systems were usually recharged rather than repaired due to the relatively cheap cost of refrigerant compared to maintenance time and labor. One of the primary drivers which changed this situation was the passage of regulations that impacted the use and production of the ozone-depleting substances, chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs).

One of the early regulations controlling CFCs was Rule 1415 established by the South Coast Air Quality Management District (SCAQMD) in southern California. One aspect of this rule required the documentation of repair events in the district. Audit records supplied to SCAQMD for 1993 contain information on 41 supermarkets. Of these, 36 stores had sufficient data (type of refrigerant, system charge size and amounts of refrigerant lost) to determine the store leak rates for CFC-12 and R-502 (an azeotrope of 48.8% HCFC-22 and 51.2% CFC-115). Those data are summarized in *Figure 1*. The average rates across all stores indicated 14% losses for CFC-12 and 13% losses for R-502, a significant improvement over losses in the past. However, approximately one-fourth of the stores had losses exceeding 20% of the charge per year.

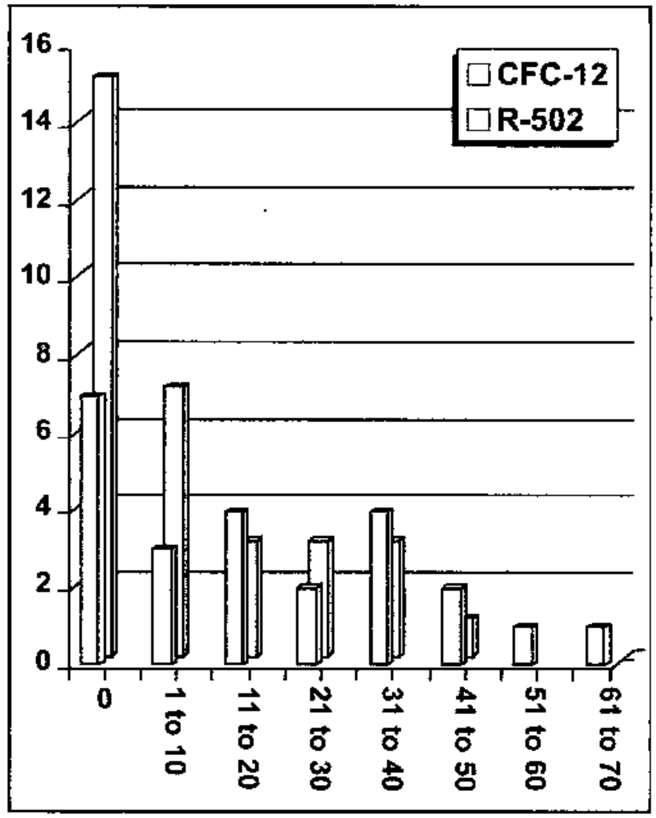

***Figure 1:** Refrigerant losses for 36 stores in the South Coast Air Quality Management District, Calif.*

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EPA Regulations

In response to the requirements of the Clean Air Act Amendments of 1990, the U.S. Environmental Protection Agency (EPA) implemented the National Recycling and Emission Reduction Program that went into effect in June of 1993.[1] Some of the issues in this regulation which impact large systems include:

- Prohibition on venting.
- Leak repair requirements.
- Required service practices for the recovery and recycling of refrigerant.

• Refrigerant record keeping.

The goal of this regulation was to maximize the recapture and the recycling of refrigerants during equipment maintenance, servicing and disposal. By recapturing the refrigerant instead of venting, releases to the atmosphere were prevented and the recovery of the stratospheric ozone layer could be hastened. By recycling the refrigerant, supplies of the chemicals could be maintained without additional production.

The law requires that equipment with charge sizes greater than 50 lb (23 kg) be repaired when a "substantial" leak occurs. For retail food refrigeration systems, this occurs when the leak rate is greater than 35% of the charge per year. This rate was chosen for the supermarket industry as it was considered not to pose an economic hardship. When such a leak occurs, the owner has 30 days in which to either repair the leak or develop a plan to retire or retrofit the system. If the latter is chosen, the owner has one year in which to implement the plan.

The record keeping requirement assists the owner in developing a history of refrigerant use in each equipment unit. These servicing records must document the date and types of service rendered and include the quantity of refrigerant added. With this information the owner can determine when the system is leaking beyond the allowable rate. As an historical record of the system is developed, these records also have the potential to provide valuable information to assist the owner in deciding whether to continue to repair or to retire or retrofit the system. An example of service data from one chain with 110 stores is summarized in *Table 1*.

Condenser	6,410 (2914)	17	47
Hot gas defrost	6,163 (2801)	17	44
Expansion valves	3,879 (1763)	10	35
Liquid line solenoid valves	2,494 (1134)	7	22
Service valves, stem packings	2,285 (1039)	6	27
Pressure controls	2,120 (964)	6	19
Not properly charged	1,930 (877)	5	13
Suction line tubing	1,875 (852)	5	9
Liquid line tubing	1,555 (707)	4	8
Evaporator coils	1,470 (668)	4	8
Discharge header tubing	1,327 (603)	4	5
Compressor fitting, oil lines	1,265 (575)	3	14
Heat reclaim	1,240 (564)	3	14
Receiver relief valve	1,110 (505)	3	4
Sight glasses	1,084 (493)	3	9
Demand cooling valves (for HCFC-22)	430 (195)	1	3
Braided hoses	367 (167)	1	3
Filters and dryers	227 (103)	1	3
Totals	37,231 (16 924)	100	287

Table 1: One year of service data for a supermarket chain with 110 stores.

These regulations and changes in the marketplace (e.g., increased cost of the CFC refrigerants and reduced availability) led many of the supermarket chains to implement policies and procedures to reduce emissions of refrigerant from their stores. Although the production of CFCs has been banned since Jan. 1, 1996, speeding the conversion of stores to alternative refrigerants containing HCFCs and HFCs, the changes initially implemented to control CFC emissions have continued applicability for several reasons.

First, as supermarket chains continue the conversion to alternative refrigerants, management of recovered stocks of CFCs is critical to maintain the uninterrupted operation of stores further down the schedule for conversion. Second, since the HCFCs are also ozone depleting substances, emissions of alternatives containing these refrigerants are controlled by the existing regulations. Finally, for stores that have converted to HFCs, the price of these alternatives likely will remain high primarily because of their more costly production process compared to those of CFCs. This higher cost has encouraged the continuation of emission reduction policies as a cost-effective procedure. In addition, many of the HFCs are greenhouse gases and as such contribute to global warming. By controlling HFC losses the supermarket industry supports the Federal government's voluntary program to reduce greenhouse gas emissions.

In working to reduce the losses of refrigerant, the supermarket chains identified several areas of opportunity: design and construction, operations and maintenance, and corporate policies and practices. The following discussion presents some examples of their successful efforts in these areas to reduce emissions.

Design and Construction

One of the standard designs for supermarket refrigeration systems is a compressor rack system which uses individual supply and return lines for each case. These individual lines are joined at a common header in the equipment room. Some supermarkets have replaced this design with a loop piping or remote header system. This system uses two common pipes going to the store with shorter connecting pipes to the cases, and several advantages occur. Since the common pipes were larger and sturdier than the individual lines, they were more break resistant. In addition, pipe length and fittings were reduced by as much as two-thirds, resulting in 10% to 30% lower installation costs.

Hot-gas defrost is one method used to remove accumulated frost from the coils of low temperature display cases. One chain reconsidered its use of this technology. It was noticed that this technology required additional components and piping, which was believed provided an additional opportunity for leaks. The occurrence of thermal expansions and contractions during defrost cycling also provided added stress to pipes and connections.

In one store, servicing records indicated that four times a year, 100 lb (45 kg) of refrigerant had to be added to the system. The store attributed this to the hot-gas defrost system. Hot-gas defrost also impacted their ability to float the condenser pressure when ambient temperatures were lower, thus preventing them from using this energy saving option. As a consequence of these observations, the chain converted its defrost systems to electric, demand-defrost systems. Once implemented, more effective defrost was observed with an added advantage of reduced refrigerant charge requirements.

Another design and construction opportunity was the installation of isolation valves around large or frequently serviced components. The benefits included reduced emissions associated with the recovery and reduced downtime spent for refrigerant recovery.

Low Emission Equipment is another tool which several stores used to reduce refrigerant losses. Achieving this involves working with the equipment manufacturers to design components that are delivered for installation as low emitting products. One supermarket chain found its manufacturers very willing to work towards this goal even though the chain represented only a small percentage of the manufacturer's sales. Any improvements made to the products can be available to other customers and have the potential to give the manufacturer a marketing edge.

Some examples of design changes that have been implemented to produce low emission products include the use of bent tubing instead of elbows, the use of sweat connections instead of flare connections on expansion valves in display cases, and the use of vertical receivers on compressor racks instead of horizontal racks.

Designing for Reduced Refrigerant Charge is another option that has an impact on refrigerant emissions. Vertical receivers and remote headers, besides having the advantages already mentioned, will result in lower refrigerant charge. One chain noted a 15% charge reduction from the use of remote headers. The condenser is another location in the system where design changes can be made to reduce the charge. One chain installed split condensers to take advantage of the fact that during the winter the refrigerant condenses more easily and thus needs less coil area. Splitting the condenser allowed sections of the condenser to be shut off and resulted in a refrigerant charge reduction of 15%.

This same chain was able to reduce the charge an additional 5% by installing a condenser bypass. The sensor for the bypass is triggered during the winter months when the refrigerant completely condenses in the related heat reclaim coil.

Operations and Maintenance

When the concept of reducing refrigerant emissions is mentioned, the operations and maintenance unit of the store is probably the first area that is considered. While the regulations had minimal recording requirements, a common practice among the supermarket companies was to develop computer programs for tracking the refrigerant usage. One company also established a database to monitor service needs. This allowed the company to readily identify the stores and components with the highest leak rates and thus to maximize their resources. The program also allowed for troubleshooting from the office to optimize service and maintenance practices.

Another company changed its maintenance program to ensure improved mechanical room conditions. This change was based on their determination that most maintenance occurred in the subsystems with the highest temperatures and pressures. Examples of their changes include increased ventilation in the compressor room to control heat gains, use of head cooling fans on compressors for low and medium temperature systems and regular cleaning of the condenser coils. During the store's regular inspections, the equipment was restored to original specifications to optimize the heat and pressure control features that were originally designed into the system.

Another effective practice was to coordinate maintenance activities. Since product had to be removed from the cases for cleaning, leak testing of valves and coils was scheduled to coincide with the cleaning. Thus, labor requirements were reduced.

Prioritizing Prevention was a significant strategy in all the efforts to reduce refrigerant emissions. Rather than just repairing leaks when they reached the limit set by regulations, all of the companies scheduled labor time specifically for leak identification and repair. In one chain, each mechanic was required to spend four to eight hours per month per store on leak identification and repair. Another chain assigned two mechanics to a leak elimination task force where their full-time job was to identify and repair leaks. In one instance it was found that labor hours were about the same as before, however the nighttime and nuisance repair calls were significantly reduced. A significant plus was that the systems ran better and more efficiently than before. Finally, all of the companies began using leak detection devices. Various types were employed, including stationary leak detectors, battery-operated, hand-held units and even fluorescent dyes and soap bubble solutions. Stationary leak detectors are often used as part of a central leak detection system to provide early detection of large and potentially catastrophic leaks.

Corporate Policies and Practices

The success of these leak reduction efforts came from the commitment of the companies at the corporate level where the policies for the company are established. Besides agreeing to changes in design and construction and in operations and maintenance, changes were made in the practices at the corporate level. In reviewing the service contracting records, one company found that service-only contracts which allowed for separate refrigerant billing had higher refrigerant consumption, while fixed-cost contracts had lower refrigerant usage. Its new policy ensured that all new contracts were fixed-cost which has proven to be a successful approach.

Another company found it beneficial to spend time and money training its repair contractors to perform in accordance with the procedures and schedules tailored for the company's systems. In addition all of the companies have made the commitment to replace consistently leaky equipment with state-of-the-art, leak resistant equipment.

Summary

Even though their refrigeration systems are very large, the supermarket industry has been successful in reducing refrigerant losses. Newer stores can achieve emission rates of 15% of the charge per year. Actions to reach this goal have been targeted in three areas: design and construction, operations and maintenance, and corporate policies and practices. Besides providing systems which are better than the existing regulations, their efforts have resulted in additional benefits including reduced construction costs, reduced refrigerant costs, reduced energy costs, and reduced maintenance calls.

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References

1. Federal Register. 58(92):28660–28734. May 1993.

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