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# Refrigerated Transportation: CFC's and the Environment

Dieter Fischer  
(202) 879-2900

**T**oday's supermarket contains a wealth of fresh and frozen products. We have come to expect a wide variety of fruits, vegetables, meats, and dairy products in top-quality condition at all times of the year. These products have one thing in common—they depend on refrigerated transportation and storage.

Perishable products are often produced far from where they are consumed and must be shipped and stored under controlled temperature conditions to maintain quality. The chemicals used as refrigerants and to produce insulation in the trucks that haul perishable foods are chlorofluorocarbons (CFC's). Because CFC's can damage the environment, the U.S. Government has passed laws to phase out their production by the end of the decade. The refrigerated trucking industry is searching for safe, reliable chemicals to replace CFC's.

The Government is encouraging the phase-out by mandating reduced production levels and levying taxes on CFC production. In 1995, for example, production of new CFC's will be limited to 65 percent of 1986 production, and a tax of \$2.65 per pound will be imposed. By 1999, production will be down to 15 percent with a tax of \$4.90 per pound.

The refrigerated transportation industry uses about 4 percent of the total worldwide production of CFC's (figure 1). The major use of CFC's in refrigerated transportation is for insulation production—about 4,000 tons annually (table 1). Maintenance of refrigerated transportation equipment requires 930 tons annually, and charging new refrigerated equipment uses 765 tons. Charging

trucks and trailers uses 1,200 tons of CFC's annually.

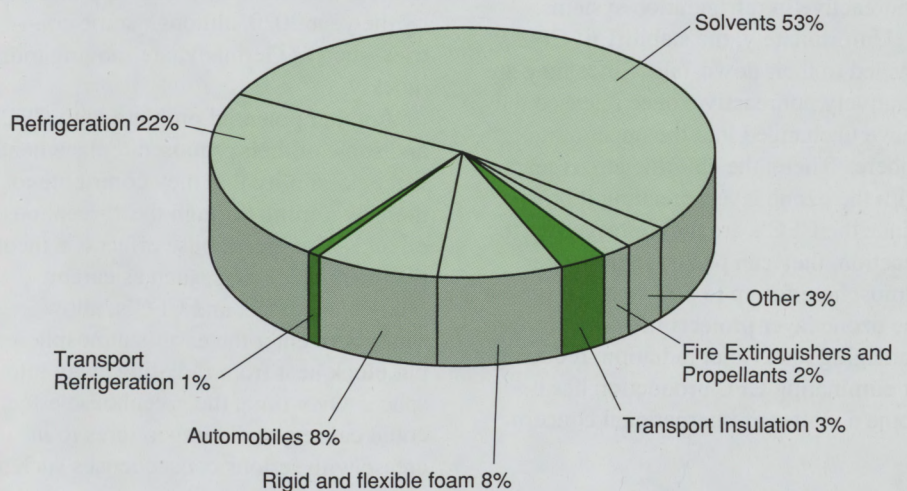
## Impact of Phasing Out CFC's

Refrigerated transportation and storage are such efficient links in the food distribution chain that the average consumer pays little attention to them. These links are being brought to the forefront, however, as the industry struggles to replace CFC's as refrigerants and insulation production materials. CFC's are such an integral part of the industry that their replacement will affect every aspect of the food distribution chain from producer to consumer.

The most immediate effect on the consumer will be an increased cost for perishable products. As the industry changes over to new refrigerants and insulating materials, the costs will eventually be passed on to consumers of products carried and stored under refrigeration.

These costs include an estimated \$1 billion to restructure the refrigerant manufacturing industry in the United States and \$100 billion to retrofit or replace the refrigerated equipment which depends on CFC's. A major U.S. producer of refrigerants has recently released a new line of non-CFC refrigerants.

Figure 1. Refrigerated Transportation Is a Minor Use for CFC's



Source: Statt, T.G. "Uses of CFC's in Refrigeration, Insulation, and Mobile Air Conditioning," *Status of CFC's- Refrigeration Systems and Refrigerant Properties*. International Institute of Refrigeration, pp. 354-357, 1989.

The author is with Appropriate Technology International, Washington, DC, formerly with the Agricultural Marketing Service, USDA.

**Table 1. Insulation Production Is the Major World Use of CFC's in the Refrigerated Transportation Industry**

Refrigerated transportation mode	Annual use		Total
	New equipment	Maintenance	
		<i>tons</i>	
Cargo ships	200	50	250
Ocean containers	165	80	245
Trucks and trailers	400	800	1,200
Subtotal	765	930	1,695
Insulation production			4,000
<b>Total</b>			<b>5,695</b>

These new products, however, cost approximately twice as much as the chemicals they replace. Also, the new chemicals are not as efficient as the CFC's they are replacing, which will increase the cost of hauling perishable products even more.

### Why CFC's Are Being Phased Out

CFC's are a family of chlorine- and fluorine-containing chemicals that have been used for 40 years as refrigerants and to produce foam insulation. Until the late 1970's, CFC's were regarded as ideal chemicals because of their stability. Chemical stability means that CFC's are safe, nontoxic, nonflammable, and nonreactive in refrigeration systems.

Unfortunately, the stability of CFC's has led to their down-fall. Since they are relatively nonreactive, once released they move unchanged into the upper atmosphere. There, the chlorine atoms react with the ozone layer, breaking it down. Since the CFC's are not destroyed by the reaction, they can persist in the upper atmosphere for up to 500 years. Because the ozone layer protects life on earth from damaging ultraviolet radiation, reducing or eliminating CFC production has become a matter of international concern.

In the early 1980's, researchers discovered a hole in the ozone layer above Antarctica. In the 7 years from 1981 to 1988, the ozone concentration in the upper atmosphere above Antarctica decreased 30 percent. Other parts of the world saw smaller but still significant decreases.

The discovery that the ozone layer was decreasing galvanized world opinion and led to an agreement called the Montreal Protocol, completed in 1987. This agreement, which was strengthened last year, mandates the phase-out of all CFC's by the year 2000. Another class of chemicals with less ozone depletion potential, called HCFC's (CFC's with some of the chlorine atoms replaced by hydrogen atoms), may also be phased out by the year 2020, although some countries, such as Germany, are moving more quickly.

Another potential problem with CFC's and some of their proposed replacements is the possibility that they contribute to global warming through the "greenhouse effect." The greenhouse effect is a theory that manmade gases, such as carbon dioxide, methane, and CFC's, allow sunlight to enter the earth's atmosphere but block heat from radiating away into space. Over time, the greenhouse effect could cause global temperatures to increase with serious consequences such as

widespread coastal flooding. The global warming potential of CFC's is a matter for concern, but so far there are no international agreements to regulate greenhouse gases. Debate continues on the best approach to take towards global warming.

### Classes of CFC's

The term CFC is often used generically to refer to halogenated (chlorine- or fluorine-containing) carbon compounds. More precisely, these chlorine and fluorine carbon compounds can be divided into three groups, CFC's, HCFC's, and HFC's. Fully halogenated CFC's, such as CFC-11, 12, 113, 114, and 115, have the greatest ozone depletion potential (ODP) and greenhouse warming potential (GWP). HCFC's substitute some hydrogen for chlorine and thus have lower ODP and GWP. HFC's do not contain any chlorine and have a zero ODP and very low GWP. *Figures 2 and 3* show the ODP and GWP for the three classes of CFC's.

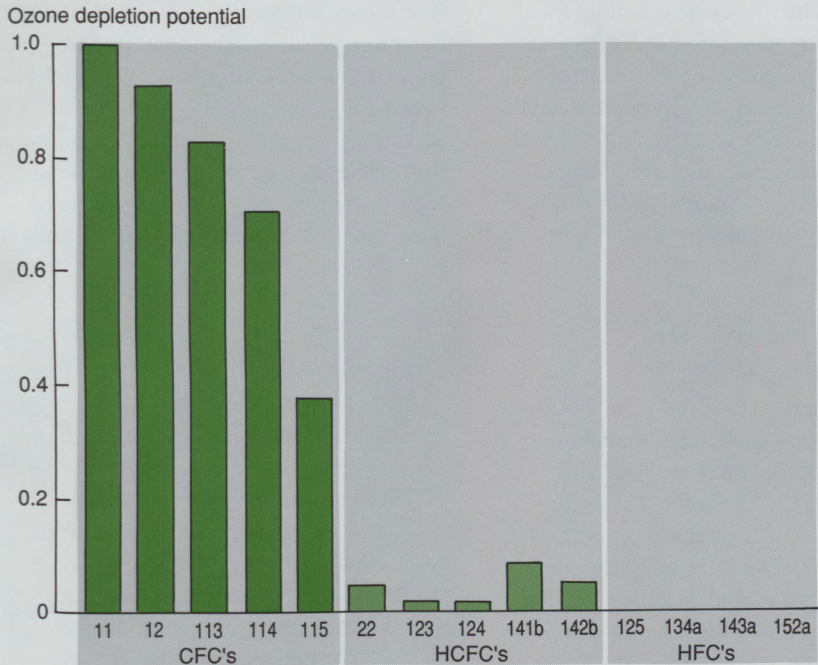
### CFC's as Refrigerants

Currently, trailer refrigeration units use CFC-12 or a mixture of CFC-12 and other HCFC's or HFC's. All of these units will have to be retrofitted or replaced by the end of the decade.

For retrofitting, the industry is using two mixtures, one using HCFC-22 and HCFC-142b, or another mixture which combines HFC's and HCFC's. With both mixtures, all the rubber hoses in the refrigeration unit are changed to ensure compatibility. There are also potential flammability problems which don't exist with CFC's.

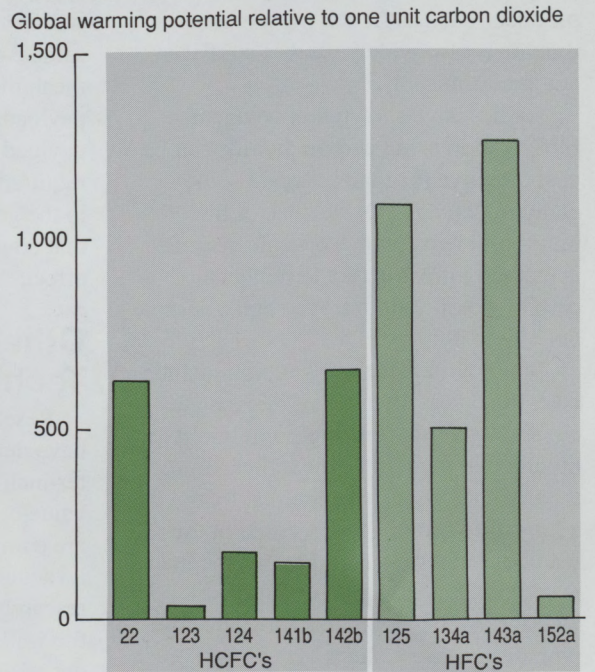
Plants will start to produce large quantities of these chemicals this year. However, the chemical industry is reluctant to invest too much in HCFC production since they have both GWP and ODP and may be targeted for phase-out in the future.

**Figure 2. CFC's Have Greater Ozone Depletion Potential Than HCFC's and HFC's**



Source: Fisch, Rick. "A World Without CFC's — Can the Industry Survive?" *Frozen Food Report*, July-August 1990.

**Figure 3. HCFC's and HFC's Have Much Greater Global Warming Potential Per Unit Than Carbon Dioxide**



Chlorofluorocarbons, used for refrigeration and insulation by trucks transporting perishable foods, are scheduled to be banned by Federal legislation by the end of the 1990's.

For new units, designers are focusing on HFC-134a. This compound has no ODP and a very low GWP. The downside is that HFC-134a has lower refrigerating capacity and efficiency than CFC-12, so units will have to be redesigned and possibly increased in size to achieve the same cooling power. Reduced efficiency also means that HFC-134a will probably not be suitable for refrigerated containers that operate in extremely harsh conditions. Finally, new lubrication compounds that are compatible with HFC-134a are still in the testing phase.

A major U.S. chemical company has just made HFC-134a available in large quantities at about twice the cost of CFC-12, the chemical it replaces. The price is expected to drop somewhat over the next few years.

### Other Options for Refrigeration

The problems with CFC's may increase the use of other types of refrigeration such as cryogenics. In cryogenic refrigeration, liquid carbon dioxide or nitrogen is sprayed into the trailer where it becomes a gas and removes heat. The

gas is then vented out of the trailer. This method of refrigeration is gaining popularity for rail transport of deep frozen products, such as french fries. Carbon dioxide is also widely used as a refrigerant in air transport.

Studies have shown that cryogenic refrigeration using carbon dioxide can be cost effective for road transport, especially in delivery trucks. One of the major problems with cryogenic systems is that the infrastructure to replenish carbon dioxide and nitrogen tanks does not exist.

Other options for refrigeration include eutectic plates. In these systems, plates containing a low-freezing-point liquid are mounted in the roof of the trailer. Before the truck starts out, the liquid is frozen by a large refrigeration unit located in the warehouse. As the liquid melts, the load is cooled. Eutectic plates could work well for local delivery trucks where shipping distances are short.

## CFC's as Blowing Agents for Insulating Foam

Today, most trailer insulation is made from polyurethane foam blown into place with CFC-11. The CFC's are lost to the atmosphere either during manufacture, during the life of the trailer, or when it is scrapped. Carbon dioxide is also used as a blowing agent, but carbon dioxide blown foam may lose its insulating value more quickly than CFC blown foam and is somewhat less efficient.

In the future, HCF-123, 141b, and 134a may be used as blowing agents, but toxicity tests will not be complete for 1 or 2 years. Also, 141b is somewhat flammable and all three compounds produce foam that has about 10 percent less insulation value than CFC blown foam.

Lower insulation value poses a serious problem for the refrigerated trucking industry because it means trailer walls will have to be thicker to maintain the same cargo temperature. Thicker walls mean more weight and less space for payload. Increased weight and reduced payload will increase the amount of fuel required per ton per mile and will result in the generation of more carbon dioxide that could exacerbate the greenhouse effect.

## Other Insulation Technology

Researchers in Colorado and Germany have developed panels less than a quarter-inch thick that have the insulating value of 2 inches of foam. These panels are composed of two sheets of metal with a vacuum in between. One group of researchers is using glass beads to hold the walls apart, and the other uses a powder of diatomaceous earth. This technology shows promise. However, the technology to effectively mass produce the panels has not been developed and the insulation value drops to near zero at the wall joints and if the panels are punctured.

## The Challenges Ahead

The industry must find viable substitutes for CFC's and make them available in sufficient quantity well before the end of the decade. HCFC's will be useful as "bridge" compounds, but they may also be phased out in the foreseeable future. Any solutions to the CFC problem cannot greatly reduce thermal efficiency because this would lead to increased costs and carbon dioxide emissions.

The countries that signed the Montreal Protocol (mostly developed nations) must convince the rest of the world to phase

out CFC use and not bring new CFC plants on line. This will be difficult since refrigeration brings important advances in standards of living, and most lesser developed nations are adopting CFC technology and do not have the resources to produce alternatives.

Consumers will end up paying more for refrigerated products since the costs for research, development, new equipment, and lower efficiency will be passed on. ■

## Environmental Concerns Increase Intermodal Container Costs

The *Journal of Commerce* reports that stricter environmental regulations in Germany are adding \$600 to the cost of a 40-foot intermodal container, according to a German container manufacturer.

Government agencies and environmental groups are increasingly scrutinizing intermodal container construction. Container factories are often located in less developed countries in tropical regions. To construct the wooden floors, local lumber from rain forests is used. With 700,000 20-foot equivalent containers manufactured each year, the container industry is a contributor to rain forest depletion. Other types of flooring are available, but are more expensive. Also, refrigerated containers use CFC's as refrigerants. Environmentally safe refrigerants will cost about \$10 per pound while CFC's cost about \$3 per pound.