STRATEGIES FOR COPING WITHOUT CFCS

A WHITE PAPER WRITTEN FOR DEVELOPMENT OF CORPORATE POLICY

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ABSTRACT

Chlorofluorocarbons (CFCs) are man-made chemicals used in the refrigeration and air conditioning industry as a Halogenated refrigerant. CFCs are so stable that they remain as an original chemical compound until exposed to ultraviolet radiation in the stratosphere. Chlorine atoms then separate from the compound and bond with oxygen atoms within the ozone layer. One single liberated chlorine atom may destroy up to 100,000 ozone molecules, thus depleting the ozone layer. Bromine atoms used in halons cause the same type of damage as chlorine. Damage caused by ozone depletion decreases the filtering process allowing more ultraviolet (UV) radiation to pass through to the Earth's surface.

THE PROBLEM

Only in the last 20 years was it discovered that CFCs were reaching the stratosphere and liberating their chlorine atoms. The chemical reaction stripping oxygen atoms in the ozone layer is the crux of the problem. This presents a serious worldwide environmental problem.

In 1985, Antarctica was found to have a massive "hole" in the ozone layer. This allows more UV light (radiation) to strike the surface of the Earth. Stratospheric ozone filters much of the UV radiation emitted by the Sun from hitting the Earth. With diminished UV filtering, there is a corresponding increase of skin cancer. There is also evidence that plant growth and crop yields will be inhibited due to the increase of UV radiation. Another damaging effect of ozone depletion is erosion of photoplankton, the very foundation of our food chain. According to scientists, photoplankton are responsible for about 80 percent of carbon dioxide absorption and about 60 percent of oxygen production in the world.

There is little debate regarding CFCs as the major cause of ozone depletion. Worldwide agreement led to provisions of the Montreal Protocol. Then in November 1990, President George Bush signed the Clean Air Act Amendment. Provisions in the Montreal Protocol and the Clean Air Amendment regulate the production of CFCs, halons, and HCFCs. At first there will be an escalating tax levied on both CFCs and HCFCs based on the ozone depletion potential (ODP) of the Halogenated refrigerants. These changes will impact current operations and new construction system design nationwide. Suspending the use of these chemicals has far reaching effects, but appears to be the best solution in mitigating further damage to the ozone layer.

The Clean Air Act calls for the total production ban of CFCs by the year 2000. Many other countries have committed to a total CFC phase-out by 1997. Additional restrictions mandate a total ban on production of Hydrochlorofluorocarbons (HCFCs) by the year 2030 or sooner. The Montreal Protocol signatories agreed to ban production of CFC refrigerants R-11, R-12, R-22, R-113, R-114, R-115 and R-500.

Urgency of Action

October 22, 1991, a panel of 80 atmospheric scientists presented a 300-page report to the United Nations Environment Programme. Based on data collected through March 1991, ozone losses were found to be more extensive than previously thought. Ozone losses have occurred over populated regions of the northern and southern hemispheres. Indications are that ozone layer depletion is occurring in the middle and high latitudes of both hemispheres in spring summer and winter. Data from this report and the existing pool of knowledge about man-made chlorine and bromine compounds combine to reaffirm that these compounds are the main cause of ozone depletion. There are continuing indicators that the depletion rate of stratospheric ozone is increasing which underscores the urgency for even more rapid action.

du Pont, the leading producer of CFCs, announced its support of acceleration of the phase-out schedules previously agreed to in the Montreal Protocol. The latest reports on the dangers of CFCs and HCFCs prompted du Pont and the scientific community to call for the phase-out dates to be moved up by at least three years. du Pont committed to:

- phase out CFC sales in developed countries by December 31, 1996
- phase out manufacture and sales of halons no later than December 31, 1994
- phase out of sales of all CFC and HCFC products for propellant by December 31, 1994
- discontinue sale of HCFC-22 for all but service/maintenance applications by January 1, 2005

Environmental Damage Potential

There are many types of CFCs and each can be rated for the level of damage it causes to the ozone layer. This unit of measure is called the ozone depletion potential (ODP). R-11 was chosen as the baseline for measurement of ODP with a rating of 1.0. A higher ODP rating indicates a more aggressive degradation of the ozone layer.

There is another factor that is considered, the global warming potential (GWP). Halogenated chemicals contribute to GWP. In theory, global warming occurs when these gases allow more solar radiation to enter the atmosphere and simultaneously block outgoing thermal radiation (greenhouse effect) at night. Carbon dioxide is a major contributor to the greenhouse effect. The GWP potential is the measure of parallel damage created by the release of CFCS and HCFCs that block normal thermal reradiation. R-11 is again used as the baseline with a 1.0 rating. The next meeting in 1992 of the United Nations Environmental Programme will further discuss and define ODP and GWP, their interrelationship and interconnection, and the anticipated damage to the environment.

The following chart shows a comparative ozone depletion potential (ODP) and global warming potential (GWP) for each of the refrigerants.

Refrigerant	Application	ODP	GWP
	CFC		
CFC-11 R-11	Refrigerant in large centrifugal chillers providing air conditioning; blowing agent in rigid insulation.	1.0	1.0
CFC-12 R-12	Refrigerant in residential and small commercial refrigeration, water coolers, walk-in freezers and mobile refrigeration.	1.0	3.1
CFC-113 R-113	Refrigerant in large centrifugal chillers when less capacity is needed; cleaning agent in dry cleaning.	0.8	1.3
CFC-114 R-114	Refrigerant in small rotary compressors for refrigeration systems and large centrifugal compressors and air conditioning systems.	0.7	3.6
CFC-12 HFC-152a R-500	Refrigerant in small reciprocating compressors and large hermetic centrifugal compressors, residential and commercial air conditioning, refrigeration, and water coolers.	0.74	2.4
HCFC-12 CFC-115 R-502	Refrigerant for the storage and display of frozen food and some industrial low temperature cooling.	0.23	
	HCFC		
HCFC-22 R-22	Refrigerant in reciprocating chillers and direct expansion units for residential light commercial air conditioning, sometimes in very large centrifugal compressors and ice machines.	0.05	0.37
HCFC-123 R-123	Replacement for R-11	0.016	0.018
	HFC		
HFC-134a R-134a	Replacement for R-12 and R-500	0.00	0.285

Comparative Ozone Depletion Potential

Gas Fired Chillers

There are few remaining steam-absorption units in operation within our Region. These older gas fired absorption units are inefficient compared to modern gas absorption equipment. Currently several gas absorption units are specified for retrofit and new construction applications. Gas absorption equipment does not contain CFC's or HCFCs. Absorption chillers use a solution of lithium bromide and water, under low pressure, as the working fluid. Water is the refrigerant and lithium bromide is the absorbent.

Gas absorption chiller sizes range from10 tons to over 1,000 tons. Gas fired chillers are manufactured either in direct-fired or steam fired configurations. Some of the manufacturers are McQuay/Sanyo, Yazaki, Carrier, Mitsubishi, and York/Hitachi. Direct-fired chillers can use natural gas or propane.

Refrigerant Health and Safety Issues

In addition to concerns about ODP and GWP, there are significant health issues related to handling and exposure to HCFC-123 are only now being recognized. An ongoing research program called "Program for Alternative Fluorocarbon Toxicity Testing" (PAFT) was established to study CFC, HCFC, and HFC compounds. These programs are sponsored by the compound manufacturers.

For the past three years, they studied the health effects of HCFC-123. The results raised significant alarm for the producers of HCFC-123. Du Pont and Allied-Signal, producers of the compound, immediately revised their exposure limits to as little as 5-ppm for a 40-hour work week (by comparison exposure limit for HFC-134a is 1,000-ppm). Test animals were exposed to 5-ppm of HCFC-123 for two years. This was thought to be the maximum direct exposure workers might face during a lifetime. Preliminary results indicate that HCFC-123 caused benign tumors and sterility in male laboratory rats. The tumors appeared late in their lives but did not shorten their life span. Additional tests are being conducted with results expected in 1992.

HCFC-123 could well be labeled a "band-aid" solution for replacement of CFC-11. It appears this compound may have been brought to the marketplace before adequate testing was completed to fully identify health risks. It is not a good long-term replacement for CFC-11 due to the safety issues now coming forward, and the fact that it is due to be phased out with other CFC and HCFC compounds.

On the other hand, all-testing to date has shown HFC-134a to be safe and non-toxic. It does not require additional special construction of equipment rooms to include additional expensive monitoring and ventilation equipment to meet current ASHRAE Standard 15 guidelines. "It has no reported flammability, anesthetic, carcinogenic, or toxicity problems." (HVAC Product News, August 1990, page 25)

Our Course of Action

Kaiser Permanente of Southern California has almost 16 million square feet of conditioned space. The majority of chiller equipment used in the Southern California Region is electric chillers using centrifugal, reciprocating or screw compressors. Most chillers in the Region use R-11, R-12 or R-22. Manufacture of R-11 and R-12 will be phased out in the United States by 1995. R-22 is scheduled to be phased out by the year 2030. There are few options.

Phase-out can be accomplished in various ways. To extend the life cycle of present equipment, **recovery, reclamation and recycling of existing refrigerant is the most obvious option**. This option can be handled by certified onsite personnel, but typically will be performed by outside qualified service companies.

South Coast Air Quality Management District (AQMD) Rule 1415 requires compliance with reduction of chlorofluorocarbon emissions from stationary refrigeration and air conditioning systems beginning January 1, 1992, for any facility having refrigeration or air conditioning systems with 50 pounds or more of CFC refrigerant. We must comply with AQMD regulations and applicable provisions in the Clean Air Act in order to continue using CFCs. When equipment is taken out of service that uses CFCs or HCFCs, it should be reclaimed (processed to a level equivalent to new product specifications) for use in other existing units.

Retrofitting with HFC-134a equipment is a long-term option for aging equipment that needs replacement. The only other long term option available at this time would be to replace equipment with gas-fired chillers. While ammonia systems are often thought of as another option, there are serious health and safety concerns with these systems. Ammonia is the least expensive refrigerant on the market ($0.25/pound). Due to the refrigerant' s toxicity and flammability, it must be used as an indirect or thermal storage system. Ammonia is not considered an option for us at this time. Propane is currently being investigated as a possible refrigerant replacement. It has many of the same thermal transfer characteristics of CFC and HCFC compounds.

Immediate action is necessary for facilities that are about to order electric chillers. Kaiser Permanente needs to specify all new electric chiller equipment be capable of using HFC-134a or specify gas-fired equipment. Other facilities that require near-term replacement chillers should use or be able to convert to HFC-134a, or change to gas-fired chilling.

Centrifugal chillers using R-12 and R-500 can now be converted to HFC-134a. Since HFC-134a is not compatible with conventional lubricants, the chiller system must be flushed and compatible lubricant used. A gear drive change may be necessary that increases compressor speed in (most-but not all) low temperature applications. Increased energy consumption should be held to within a five- percent range. High-pressure units (centrifugal, screw and reciprocating compressors) will continue to rely on R-22 until the total ban currently set for the year 2030. This date may be changed to an earlier phase out date. There is not yet an effective replacement for R-22.

Trane and McQuay/Sanyo now have electric chiller equipment available that use the HFC-134a refrigerant. Currently, these Trane chillers are available in Europe (50Hz). Other equipment manufacturers may soon offer their electric chillers redesigned to use HFC-134a.

CONCLUSION

There is a problem with the use of CFCs and HCFCs in our electric chillers. The compounds contribute to ozone depletion and global warming. Present legislation requires total phase-out of these refrigerants. Kaiser Permanente must develop an acceptable strategy for an orderly and cost effective transition to implement the use of alternative refrigerants.

Coping without CFCs requires rethinking in the design and specification of chiller equipment and systems for new facilities and major remodel projects. The appropriate action is to change all equipment specifications away from CFCs and HCFCs. Immediate action is necessary in some cases to insure we do not order outdated equipment designed to use CFCs or HCFCs. Equipment should be capable of using either HFC-134a or lithium bromide, for electric or gas chilling equipment respectively.

For equipment using CFCs and HCFCs we must inspect and certify systems for leaks annually, keep required records of maintenance and employ strategies to recover, reclaim and recycle refrigerants. This may make it possible to continue operation of present equipment until a viable alternative refrigerant is developed at a cost effective price to replace CFC-11, CFC-22 and HCFC-123. Another potential option may be to "stock up" on CFCs that are being phased out in order to extend use of current chiller equipment. This may not be a viable option due to the cost, handling, storage and reporting requirements for these compounds.

Kaiser Permanente must continue to closely monitor developments in the HVAC industry. This includes advancements in replacement refrigerants and development of chiller equipment/systems. It will also be important to follow legislation such as the Clean Air Act and Amendments, Montreal Protocol and state and local regulations relating to CFCs and HCFCs.

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